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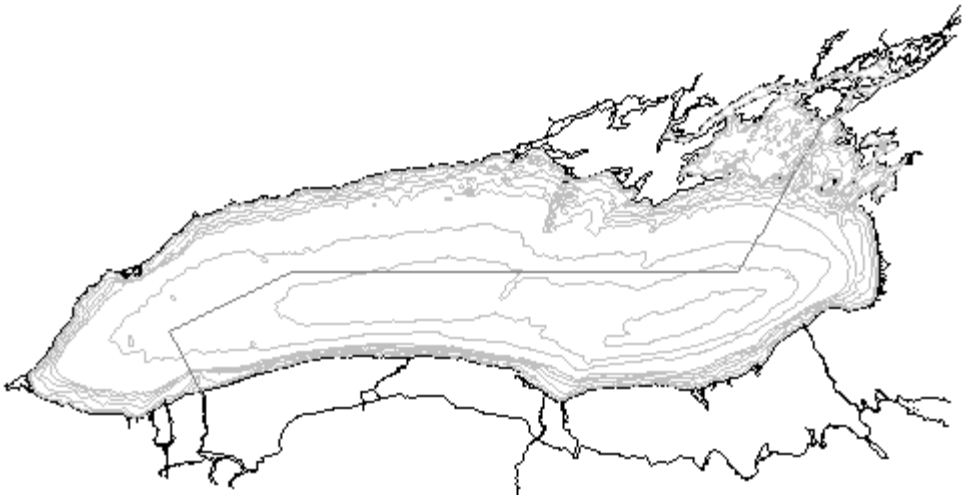
Division of Fish, Wildlife and Marine Resources

2014 ANNUAL REPORT

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

SECTIONS 1, 2, 3, 4, 5, 10, 12, 14, 16, 19, AND 20

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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 2014** *(Connerton)*	NYSDEC
2	**2014 Lake Ontario Fishing Boat Survey** *(Lantry J., Eckert)*	NYSDEC
3	**Update on Mass Marking of Chinook Salmon in Lake Ontario 2014** *(Connerton, Balk, Prindle, Lantry J., Daniels, Bowlby, Yuille, Bronte, Holey)*	NYSDEC OMNR USFWS
4	**Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1976-2014** *(Lantry J.)*	NYSDEC
5	**Lake Trout Rehabilitation in Lake Ontario, 2014** *(Lantry B., Lantry J.)*	USGS NYDEC
6	**Thousand Islands Warmwater Fish Stock Assessment** *(McCullough, Gordon)*	NYSDEC
7	**2014 Lake St. Lawrence Warmwater Fisheries Assessment** *(Klindt, Gordon)*	NYSDEC
8	**2014 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 2014** *(Prindle, Bishop)*	NYSDEC
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11	**Sea Lamprey Control in Lake Ontario in 2014** *(Sullivan, Adair)*	DFO USFWS
12	**Status of Important Prey Fishes in the U.S. Waters of Lake Ontario, 2014: Alewife, Rainbow Smelt, Sculpins, and Round Goby** *(Walsh, Weidel, Connerton, Holden)*	USGS NYSDEC
13	**Cormorant Management Activities in Lake Ontario's Eastern Basin** *(McCullough, Mazzocchi, Bleau)*	NYSDEC
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15	**Lake Sturgeon Tagging Study 2014** (*Klindt, Gordon)*	NYSDEC
16	**2014 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	**Administrative Program Summary Report for the Sportfishing Restoration & Spending Plan for the Lake Ontario System** (*Balk)*	NYSDEC
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Executive Summary

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

Habitat and water quality degradation, overfishing, and the introduction of exotic species played major roles in the decline of the native fish community. By the 1960's, these impacts culminated in the virtual elimination of large piscivores, the reduction or extinction of other native fishes, and uncontrolled populations of exotic alewife, smelt, and sea lamprey (Stewart et al. 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* have deteriorated markedly, likely due to range expansion of quagga mussels into deeper waters. The exotic round goby was first documented in New York waters of Lake Ontario in 1998, and 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 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 will continue its investigations with the assistance of experts from academia and other agencies.

Maintaining balance between predators and prey, primarily salmonids (predominately Chinook salmon) and alewife, remains a substantive challenge in the face of lower trophic level disturbances and ongoing ecosystem changes resulting from invasive species. This report summarizes cooperative research and monitoring activities conducted on Lake Ontario and the 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 2014.

Lower Trophic Level Monitoring

From 1995-2014, 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. It averaged 7.8 parts per billion (ppb) in the nearshore and 5.6 ppb in the offshore in 2014, 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 nearshore and offshore habitats. Offshore summer chlorophyll-*a* declined significantly in both the short- (2000-2014) and long-term (1981-2014) time series at a rate of 4-6% per year. Nearshore chlorophyll *a* increased after 2003 but then declined again after 2009. Epilimnetic (upper water column) chlorophyll *a* averaged between 0.6 and 1.6 ppb across sites with no difference between nearshore and offshore habitats. Average seasonal Secchi depth ranged from 13.1 to 35.4 ft at individual sites and was higher in the offshore (average 29.930 ft) than nearshore (19.4 ft) in 2014.
- Summer nearshore zooplankton density and biomass have declined significantly since 1995 at rates of 9-10% per year but have remained stable since 2005; however, bosminids and daphnids increased in 2013 and 2014. Summer offshore zooplankton density and biomass declined significantly in the long-term (since 1981), but remained at a lower stable level 2000 – 2014. A positive change point in 2013 is due to increases in bosminids, cyclopoid copepods, and daphnids.
- 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 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.
- The observed longer term decline in zooplankton biomass in the epilimnion may be due in part to redistribution of zooplankton throughout the water column. In July and

September, an average of 89% of the zooplankton biomass at deep offshore sites resided below the thermocline. Nighttime tows taken in mid-July show 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 12) and hydroacoustics (sonar; Section 14)
  - In spring 2014 bottom trawl surveys, both the abundance (number) and weight (pounds) indices for adult alewife (age-2 and older) in U.S. waters of Lake Ontario declined slightly from 2013 levels. The age-1 alewife abundance index in spring 2014 was the 8th lowest observed in the 37 year time series. In 2014, adult alewife condition declined from higher values observed during 2003-2013 by 10% and 13% in spring and fall, respectively (Section 12).
  - In 2014, the abundance index for age-1 and older rainbow smelt decreased relative to 2013 and was only 20% of the 10-year average (Section 12).
  - Species-specific assessments found slimy and deepwater sculpin abundances increased slightly in 2014 relative to 2013, while changes in round goby abundance differed between spring and fall surveys (Section 12).
  - The 2014 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 in 2014. 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 varying degrees of a decline in alewife abundance in 2014. The rainbow smelt abundance estimate was the lowest observed in the history of the survey (Section 14).

Coldwater Fisheries Management

- Fish stocking in the New York waters of Lake Ontario in 2014 included 1.97 million Chinook salmon, 130,000 coho salmon, 563,200 rainbow trout, 970,664 lake trout (442,700 yearling; and 527,964 experimental fall fingerlings), 464,060 brown trout, 141,746 Atlantic salmon, 20,000 bloater, and 144,670 cisco or lake herring. Over 125,500 brown trout and 442,700 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 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. Fish "condition" (a measure of "stoutness") also can also provide insight into predator-prey balance. 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. The August 2014 mean length (36.5 in) of age-3 Chinook salmon from the open lake boat fishery was 0.3 in shorter than the long term average. In 2014, condition of the seven, two-inch groups evaluated were slightly below their respective long-term averages. The decrease in condition was greatest for larger Chinooks, e.g. 36- and 40-inch fish were 0.8 and 1.2 pounds lighter than their long-term averages, respectively. Reduced growth and condition is partly attributed to colder water temperatures in summer 2014 and a decrease in alewife condition (Section 12), the

primary forage for Chinook salmon.

- At the Salmon River Hatchery, the mean weight of age-1 Chinook males (jacks) sampled in 2014 (4.5 lbs) was very near the long term average. Age-2 males (13.1 lbs) and females (12.9 lbs) were 0.3 and 1.9 pounds below average, respectively. Age-3 males were 2.0 lbs below average (17.2 lbs) and age-3 females were 3.1 lbs below average (16.0 lbs).
- Chinook salmon condition estimated at the Salmon River Hatchery in fall 2013 and 2014 was at the historical average (Section 9).
- Steelhead are sampled in the spring and, unlike Chinook and coho salmon, do not reflect growth during the 2014 growing season. Weights reported here reflect conditions prior to and including 2014. The mean weights of age-3 males and females were 6.0 and 6.5 lbs, respectively; nearly the same as in 2013 (approximately 0.2 and 0.3 pound more than their respective long-term averages). The mean weights of age-4 males and females were 8.6 lbs (0.2 lbs below average) and 8.9 lbs (0.3 pounds below average) (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. The mean peak catch in 2014 of 327 YOY per haul was slightly above the survey average of 280 YOY per haul (Section 8).
- The seventeenth 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 60,400 Washington strain steelhead were raised at eight pen sites, comprising 11.6% of DEC's Lake Ontario rainbow steelhead stocking allotment in 2014. Eight pen-rearing sites raised a total of 505,990 Chinook salmon, representing 26% of DEC's 2014 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).
    - Percentages of wild Chinook salmon in Lake Ontario varied by year class and age and among regions from 2009-2014, but overall, wild Chinook were an important component of the Lake Ontario fishery averaging 47% of the age 2 and 3 lake harvest.
    - Returns of Chinook salmon at the Salmon River Hatchery from the 2008-2010 year classes suggest a high degree of homing by fish stocked at the Salmon River and a low degree of straying from other stocking sites, with estimated average straying rates of 12.4%, 8.4%, and 10.9%, respectively.
    - Preliminary results of the relative performance of Chinook salmon pen-reared and direct stocked in 2010 and 2011 indicate that pen-reared fish 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.

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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 a variety of surveys measure progress toward lake trout rehabilitation (Section 5).

- Adult lake trout abundance in index gill nets increased each year from 2008-2014. Adult abundance in 2014 exceeded the 1999-2004 mean, which at the time appeared to be the new stable abundance following the 1993 stocking cuts.
- The rate of wounding by sea lamprey on lake trout caught in gill nets was 1.65 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 2011 and 2013 (2010 and 2012 year classes, respectively) were similar and the highest observed since the 1990 year class.
- Naturally produced lake trout were produced in 20 years since 1994. The largest catch of naturally produced lake trout occurred in 2014, with 47 age-1 and 70 age-2 wild lake trout caught.
- Adult lake trout condition has generally remained at a high level during 2007-2014.
- In 2014, angler catch (33,108 fish) and harvest (15,870 fish) were 122.7% and 154.2% increases compared to previous 10-year averages, respectively, and remained at levels observed in the early to mid-1990s for a second consecutive year. 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 2014, ten Lake Ontario tributaries (four Canada, six New York) were treated with lampricides. Treatments in New York included Lindsey Creek, Salmon River, Little Salmon River, Ninemile Creek, Sandy Creek, and Oak Orchard Creek (Marsh Creek).
- Trout Brook (Salmon River tributary) was treated further upstream from the historical upper distribution of larvae.
- Orwell Brook (Salmon River tributary) was treated upstream of the new barrier for the second time since 2012 to target a residual population established prior to construction. This stream will not be treated again in 2015, as larval surveys did not indicate the presence of residual larvae or recruitment above the barrier.
- A total of 4,072 sea lampreys were trapped at 12 sites on 11 tributaries.
- The estimated population of adult sea lampreys was 19,482 (95% CI; 16,880-24,032), lower than the fish-community objective target range and the lowest in the time series.
- Larval assessments were conducted on a total of 49 tributaries (27 Canada, 22 NY). Surveys to estimate abundance of larval sea lampreys were conducted in nine tributaries (five Canada, four NY). Surveys to detect the presence of new larval sea lamprey populations were conducted in seven Canadian tributaries; no new populations were detected.
- Post-treatment assessments were conducted in 10 tributaries (four Canada, six U.S.) to determine the effectiveness of lampricide treatments conducted during 2013 and 2014.

- Surveys to evaluate barrier effectiveness were conducted in 10 tributaries (eight Canada, two U.S.).
- The rate of wounding by sea lamprey on lake trout caught in gill nets was 1.65 fresh (A1) wounds per 100 lake trout was below the target of 2 wounds per 100 lake trout (Section 5). There were an estimated 14.9 lamprey observed per 1,000 trout or salmon caught by anglers, the lowest estimated since 2002, however, still about 2.5-fold higher than the 1986-1995 average rate (Section 2).

Warmwater Fisheries

- A total of 97,760 fingerling walleye were stocked in the lower Niagara River (23,200) and Sodus Bay (74,560) (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 2014 was 20.6 fish/gill net, a 37.6% decrease compared to the 2009-2013 (previous five year) average. The decrease is largely attributed to decreased catches of yellow perch and smallmouth bass, and may be due in part to cooler water temperatures which can affect fish distribution. White perch (38.2%), smallmouth bass (24.3%), and yellow perch (8.3%) were the most commonly caught species (Section 4).
    - Smallmouth bass abundance was 5.0 fish/net, the lowest catch since 2004. 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 24.4% compared to the 2009-2013 average. The walleye population is expected to remain stable for several more years due to strong 2003, 2005 and 2008 year classes well-represented in 2014 catches.
    - Following six years of improved yellow perch catches, yellow perch CPUE (1.7 fish/net) declined to the lowest level observed. This decrease may be attributable to water temperature patterns and catch variability; however, angler reports also suggest lower yellow perch abundance.
    - In 2008, Eastern Basin white perch abundance reached its highest level since 1991 and was the third most commonly caught species 2008-2013. In 2014, white perch CPUE (7.9) was similar to 2008.
    - Round gobies first appeared in this assessment in 2005 in both gillnet catches and smallmouth bass diets. In 2014, gobies were present in 76% of the 135 non-empty smallmouth bass stomachs processed. Gobies were present in walleye diets each year from 2006-2010 and 2012-2014, 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 14 of the last 20 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 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 since. Catch in 2012 reached its highest level since 1988, declined 28% in 2013, and declined further in 2014. Yellow perch abundance increased substantially in 2006, remained high in 2007 and 2008, and then declined. Perch abundance fell to a record-low level in 2012, and remained low in 2013 and 2014. From 1996 to 2014, northern pike abundance has remained relatively low. Ongoing poor recruitment is likely related to degraded spawning habitat resulting from water level regulation, and possibly predation by Double-crested cormorants.

- Lake St. Lawrence yellow perch abundance declined 52% from 2012 to 2013, and was relatively unchanged in 2014. Smallmouth bass catch has been variable since 2005, reached its' second highest level in 2013, and declined 36% in 2014. The 2011 year class was particularly well represented for a second consecutive year. Walleye abundance fell below the long-term average for the first time in seven years.

- Abundance of spawning adult and young-of-the-year northern pike in the Thousand Islands region of the St. Lawrence River continues to be suppressed. Overall, natural reproduction at natural and managed spawning marshes remains poor, likely due to habitat degradation resulting from long-term management of Lake Ontario/St. Lawrence River water levels (Section 20).
- Muskellunge population indices in the Thousand Islands region of the St. Lawrence River continue to show signs of stress. Spring trap net surveys, summer seining surveys and an angler diary index all indicate reduced adult and young-of-the-year abundance. It is plausible that adult muskellunge mortality events attributed to outbreaks of the invasive Viral Hemorrhagic Septicemia virus (VHSv) 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, the mouth of the Oswegatchie River, and the St. Lawrence River in 2014 produced a total catch of 245 fish. Passive integrated transponder (PIT) tags, which allow for future identification of individual fish, were implanted in 83 fish to monitor fish growth, movements, and to manage brood stock genetics in restoration stocking efforts. Forty previously tagged sturgeon were re-captured in 2014, including a fish tagged by Cornell University staff on Oneida Lake in 2005. This fish was re-captured in Black River Bay, a minimum movement of 92 miles (Section 15).

Sport Fishery Assessment

Each year from 1985-2014 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).

- During 2014, 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). With the variety of trout and salmon species present in Lake Ontario, anglers were able to target another species when the preferred target was not available. This resulted in an excellent total trout and salmon catch rate. Total trout and salmon fishing success (charter catch per angler hour=0.23) was the sixth highest in the 30-year data series. Total trout and salmon catch (200,763 fish) and harvest (106,880 fish) were dominated by Chinook salmon (38.2% and 44.8%, respectively), lake trout (16.5% and 14.8%, respectively), brown trout (22.2% and 19.3%, respectively), and rainbow trout (18.7% and 15.7%, respectively).
- The twelve highest Chinook salmon catch rates among charter boats occurred during 2003-2014. Chinook fishing quality among charter boats in 2014 (0.09 fish/hour) was a slight decrease (-9.5%) compared to the previous 10-year average, but 35.5% above the long term average.
- Charter boat catch rate of coho salmon (0.008 fish/hour) was well below the long-term average (-27.8%).

- Charter boats caught 0.04 rainbow trout per angler hour, the sixth highest on record and 31.5% above the long term average.
- The charter boat catch rate for brown trout in 2014 was 0.05 fish/hour, 16.2% above the long-term mean.
- In 2013 the charter boat catch rate of lake trout was 0.05 fish/hour, similar to the long term average (+2.2%).
- In 2014, total estimated fishing effort was 58,554 fishing boat trips (980,409 angler hours), among the lowest observed and primarily attributed to a decrease in smallmouth bass angling effort since 2001. Effort targeting trout and salmon, however, has remained relatively stable for more than a decade. An estimated 49,434 boat trips targeted trout and salmon in 2014 (84.4% of fishing boat trips), similar to the previous 5-year average.
- Smallmouth bass was the most commonly caught species in the survey each year 1985-2006. In 2014, smallmouth bass was the 5th most commonly caught species.
- Fishing quality for smallmouth bass along the south shore peaked in 2002 and declined to record low levels. An estimated 6,878 fishing boat trips targeted smallmouth bass during the 2014 traditional open season (3rd Saturday in June through September 30 when the creel survey ends), the highest since 2009 and a 16.7% increase compared to the previous 5-year average. Increased effort in 2014 may be partly attributable to increased fishing quality. Bass catch rates were relatively stable from 1985 through the early 1990s (mean=1.0 bass per angler hour), then increased to the highest level in 2002 (2.0 bass per angler hour). Smallmouth bass catch rate per angler hour in 2014 was 0.57, a 26.6% increase compared to the previous 5-year average, but 71.7% below the 2002 record high. Several factors may have contributed to poor fishing quality, including expansion of round goby populations and possible smallmouth bass mortality from VHSv.

Diets of Double-crested Cormorants and Impacts on Sportfish Populations

- Cormorant population management, along with a major cormorant diet shift to round goby, has advanced progress towards meeting objectives for protecting fish populations, other colonial waterbird species, private property and other ecological values (Section 13).
  - For the 16th consecutive year, cormorant population control was continued through oiling of eggs with food grade vegetable oil at the Little Galloo Island colony, and culling of adult birds by shooting was employed again in 2014 (n=150). Nest destruction was employed to discourage nesting on Gull Island (n=603), 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 2014, cormorant feeding days at the Little Galloo Island colony were estimated at 818,666, above the target of 780,000, but somewhat below the 874,876 estimate in 2013.
  - Despite continued cormorant management, reduced consumption of yellow perch and smallmouth bass, and recent improved catches of these species in assessment netting, abundance indices for these species declined in 2014 indicating additional factors are currently affecting those populations (Section 4).

Sportfishery Restoration and Spending Plan for the Lake Ontario System

- The Sportfishing Restoration & Spending Plan for the Lake Ontario System (Plan) was prepared by the DEC in its capacity as Trustee for New York's natural resources. The Plan identifies projects selected to restore injuries to sportfishing resulting from chemical contamination of fish in the New York waters of the Lake Ontario system. Section 17 reports on progress to date on execution of the Plan, as well as future direction for the program.

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New York Lake Ontario and Upper St. Lawrence River Stocking Program 2014

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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 2014 by species, strain, and life stage, and compares those totals with the 2014 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 1991-2014. New York stocking history from 1968-1990 is reported in Eckert (2000). Table 3 provides specific information for each group of fish stocked in 2014. 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
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 2004 are 2005 year class).

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

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

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).

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 and 2014. 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

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

New York College of Environmental Science and Forestry in 2014 were produced from a captive broodstock held at Bald Creek Fish Culture Station, VT.

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 2011-2014 by TUN from eggs originating from Ed Weed Fish Culture Station, VT (2011-2014), Casco Fish Hatchery, ME (2013) and from NYSDEC Adirondack Hatchery in 2014.

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 and 2013 year classes, stocked as yearlings in 2013 and 2014 respectively. 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. 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, 2012-2014), 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 2014 stocking policy.

Species	Stage		Strain	DEC Stocking Policy	Actual Number Stocked
Atlantic Salmon	Ylg		LC-D	50,000	50,000
	fry	[1]	MEP	-	3,672
	FF	[2]	SEB	-	71,000
	fry	[1]	SEB	-	2,074
	Ylg	[2]	SEB	-	15,000
Atlantic Salmon Total				50,000	141,746
Bloater	FF	[2]	LM	-	20,000
Brown Trout	AF	[3]	RL-D	-	40,500
	FF	[3]	RL-D	-	26,950
	Ylg	[4]	RL-D	392,000	396,610
Brown Trout Total				392,000	464,060
Chinook Salmon	SF	[5]	SAL-W	1,761,600	1,969,790
Cisco	FF	[2]	LO	-	144,670
Coho Salmon	FF	[5]	SAL-W	155,000	-
	Ylg		SAL-W	90,000	130,000
Coho Salmon Total				245,000	130,000
Lake Sturgeon	FF		SLR	4,250	4,250
	SF	[3]	SLR	-	5,000
Lake Sturgeon Total				4,250	9,250
Lake Trout	FF	[6]	HPW	120,000	122,775
	FF	[6]	LCH-D	120,000	120,699
	Ylg		LCH-D	80,000	72,840
	FF	[6]	SEN	200,000	202,329
	Ylg		SEN	240,000	243,980
	FF	[6]	SKW	80,000	82,161
	Ylg		SKW	120,000	125,880
Lake Trout Total		[7]		960,000	970,664
Rainbow Trout	Ylg	[8]	FL-W	7,500	1,200
	Ylg	[9]	RA-D	75,000	37,650
	Ylg	[9]	RA-W	-	3,000
	Ylg		SKA-W	43,000	26,500
	Ylg		WAS-W	497,700	494,850
Rainbow Trout Total				623,200	563,200
Walleye	fry		ONL-W	40,000	40,000
	PF		ONL-W	97,200	97,760
Walleye Total				137,200	137,760
Grand Total				**4,173,250**	**4,551,140**

[1] Atlantic salmon stocked by SUNY ESF for research project.

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

[3] Surplus stockings

[4] Brown trout stocking policy in 2014 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.

[5] Coho salmon egg and fry survival was poor in fall 2013 which led to a stocking shortfall of 155,000 fall fingerlings in fall 2014. All coho salmon produced from the 2014 year class were stocked as spring yearlings at Salmon River in spring 2015 to maintain brood stock collections at the Salmon River hatchery. Surplus Chinook salmon were stocked in spring 2014 at sites that normally receive coho fall fingerlings to make up for the coho shortfall.

[6] Experimental stocking in 2014 to evaluate the relative survival of fall fingerlings vs spring yearlings.

[7] According to the the lake trout management plan finalized in 2014, annual stocking target was set at 800,000 spring yearling equivalents. Numbers stocked at each location will vary each year depending on experimental objectives.

[8] High mortality at Powder Mill Pond hatchery in 2014 due to merganser predation.

[9] Shortage of domestic strain rainbow trout in 2014. Surplus brown trout, or domestic/hybrid rainbow trout (RA-W) were stocked at sites that normally receive domestic rainbow trout to make up for shortfall (see Table 3 for details).

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 2014. Numbers of salmon, trout, and other species stocked in New York water of Lake Ontario and the St. Lawrence River from 1968-1990 can be found in Eckert (2000).

Spp & Life Stage	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Co Ylg	97	94	96	92	119	98	95	90	90	99	101	105	95	95	99	110	90	124	95	114	141	120	69	130
Co FF	132	155	100	223	172	196	155	155	137	155	155	155	155	155	155	155	155	104	155	155	155	0	155	0
Co AF	0	290	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Co f	0	0	0	0	0	0	0	0	0	0	0	4	7	0	0	0	0	0	0	0	0	0	0	0
Ck f	2835	2798	1603	1000	1150	1300	1605	1596	1596	1654	1629	1633	1622	1836	1809	1827	1813	799	1757	1531	1769	1511	1772	1970
Ck FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LT Ylg	818	508	501	507	500	350	500	426	476	490	500	500	500	457	224	118	453	501	511	332	488	0	523	443
LT FF	160	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	122	0	123	0	528
LT Ad	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BT Ylg	382	415	445	402	382	361	426	426	429	421	405	382	414	367	391	391	385	370	418	409	424	419	331	397
BT FF	0	0	0	0	0	0	0	0	25	0	0	136	39	0	66	0	0	0	70	57	6	0	0	27
BT AF	0	0	0	0	0	0	0	0	0	0	114	0	0	0	10	0	0	50	6	116	0	0	0	41
BT f	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0	0	46	0	0	0	0	0
RT Ylg	82	85	88	92	24	70	93	92	97	75	60	71	75	64	75	72	68	74	78	80	82	82	83	42
RT FF	0	0	0	0	0	0	0	14	0	0	20	10	0	0	0	0	0	0	15	0	27	0	0	0
RT f	29	0	0	0	0	0	0	0	0	0	0	14	40	0	0	0	0	0	0	0	30	0	0	0
RT Ad	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sthd Ad	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sthd Ylg	551	515	454	487	534	543	555	528	521	533	583	535	560	558	570	572	538	570	561	702	615	554	546	521
Sthd FF	40	0	0	0	50	60	110	0	107	0	0	15	0	0	0	0	0	0	80	188	0	337	0	0
Sthd f	175	0	0	0	0	0	0	0	0	0	0	1	6	0	0	0	0	0	0	0	0	0	0	0
ST FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ST SF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	54	0	0	0	0	0
AS Ad	0	0	0	0	2	2	1	4	6	1	<1	<1	<1	1	0	0	0	0	0	0	0	0	0	0
AS Ylg	178	169	135	151	130	97	76	73	84	78	75	75	50	51	50	29	52	49	50	50	50	60	67	65
AS FF	0	0	30	38	34	34	25	25	25	25	25	0	0	0	0	0	0	0	24	37	66	73	61	71
AS AF	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	14	0	0
AS f	0	0	0	0	60	171	73	0	156	84	62	17	32	0	0	0	0	0	0	0	0	0	0	6
Sal Total	5479	5029	3453	2997	3158	3282	3715	3430	3749	3615	3729	3655	3594	3619	3450	3263	3554	2641	3920	3891	3853	3293	3557	4239
Wal AF	122	52	202	100	104	264	250	194	155	129	10	10	211	71	104	123	31	50	118	12	118	23	149	138
Wal FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0		0	0	0	0
Stur FF	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	9
Bloat FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	20
Cisco FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	9	145
TOTAL	5601	5081	3655	3097	3262	3546	3964	3623	3904	3745	3739	3665	3807	3691	3555	3382	3585	2696	4037	3903	3972	3327	3773	4551

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
Bloat: Bloater

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

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2014.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Atlantic Salmon	Beaverdam Brook	O.53-8	4/23/2014	AD	2013	LC-D	13.9	Ylg	53.4	none	30,000	
Atlantic Salmon	Beaverdam Brook	O.53-8	10/14/2014	TUN	2014	SEB	7.2	FF	7.6	AD	12,386	Egg source AD hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	10/15/2014	TUN	2014	SEB	7.3	FF	10.7	AD	9,065	Egg source AD hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	10/15/2014	TUN	2014	SEB	7.3	FF	10.9	AD	9,073	Egg source AD hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	10/16/2014	TUN	2014	SEB	7.3	FF	10.9	AD	7,808	Egg source AD hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	10/16/2014	TUN	2014	SEB	7.3	FF	10.7	AD	7,756	Egg source AD hatchery
Atlantic Salmon	Salmon River	O.53-8	10/17/2014	TUN	2014	SEB	7.3	FF	10.6	AD	7,872	Egg source AD hatchery
Atlantic Salmon	Salmon River	O.53-8	10/20/2014	TUN	2014	SEB	7.4	FF	10.5	AD	7,779	Egg source AD hatchery
Atlantic Salmon	Salmon River	O.53-8	10/21/2014	TUN	2014	SEB	7.5	FF	10.7	AD	9,261	Egg source AD hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	4/29/2014	TUN	2013	SEB	13.9	Ylg	66.3	AD-VIE	2,558	Yellow elastomer tag behind right eye, Egg source EW
Atlantic Salmon	Beaverdam Brook	O.53-8	4/29/2014	TUN	2013	SEB	13.9	Ylg	66.3	AD-VIE	2,555	Yellow elastomer tag behind right eye, Egg source EW
Atlantic Salmon	Beaverdam Brook	O.53-8	4/30/2014	TUN	2013	SEB	14.0	Ylg	66.3	AD-VIE	2,499	Yellow elastomer tag behind right eye, Egg source EW
Atlantic Salmon	Beaverdam Brook	O.53-8	4/30/2014	TUN	2013	SEB	14.0	Ylg	66.3	AD-VIE	2,543	Yellow elastomer tag behind right eye, Egg source EW
Atlantic Salmon	Salmon River	O.53-8	5/1/2014	TUN	2013	SEB	14.0	Ylg	66.3	AD-VIE	2,449	Yellow elastomer tag behind right eye, Egg source EW- stocked in upper fly zone
Atlantic Salmon	Salmon River	O.53-8	5/2/2014	TUN	2013	SEB	14.0	Ylg	66.3	AD-VIE	2,396	Yellow elastomer tag behind right eye, Egg source EW- stocked in upper fly zone
Atlantic Salmon	Rice Creek	O.67-P62a	6/18/2014	ESF	2014	MEP	3.3	fry	0.6	LV	1,506	SUNY ESF research project, origin of fish- BH; held at MC from 3/21/2014 to stocking
Atlantic Salmon	Rice Creek	O.67-P62a	6/26/2014	FC	2014	SEB	2.5	fry	1.4	none	1,145	Research project by SUNY ESF, origin of fish- CC; held at FC from Jan, 2014 until stocking
Atlantic Salmon	Eightmile Creek	O.70-P64	6/18/2014	MC	2014	MEP	3.3	fry	0.6	LV	1,719	Research project by SUNY ESF, origin of fish- BH; held at MC from 3/21/14 until stocking
Atlantic Salmon	Eightmile Creek	O.70-P64	6/26/2014	FC	2014	SEB	2.5	fry	1.4	none	929	Research project by SUNY ESF, origin of fish- CC held at FC from Jan, 2014 until stocking
Atlantic Salmon	Little Creek	O.78-P79	6/26/2014	MC	2014	MEP	3.6	fry	0.6	LV	447	Research project by SUNY ESF, origin of fish- BH; held at MC from 3/21/14 until stocking
Atlantic Salmon	Point Breeze	713	5/21/2014	AD	2013	LC-D	14.8	Ylg	61.5	none	20,000	Stocked By Boat
Atlantic Salmon Advanced Fry Total									0.9		5,746	
Atlantic Salmon Fall Fingerlings Total									10.2		71,000	
Atlantic Salmon Yearling Total									58.8		65,000	
Atlantic Salmon Total									**32.1**		**141,746**	

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SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Brown Trout	Black River	O.19	5/7/2014	SR	2013	RL-D	16.8	Ylg	80.2	none	4,300	Dexter
Brown Trout	Henderson Bay	O.19	5/13/2014	SR	2013	RL-D	17.0	Ylg	79.2	none	14,640	Barge/LCM stocked off Stony Point
Brown Trout	Stony Point	423	5/13/2014	SR	2013	RL-D	17.0	Ylg	82.8	none	32,730	Barge/LCM
Brown Trout	Stony Creek	O.40	5/7/2014	SR	2013	RL-D	16.8	Ylg	81.1	none	2,590	
Brown Trout	Selkirk Shores	623	5/14/2014	SR	2013	RL-D	17.1	Ylg	82.2	none	31,010	Barge/LCM stocked off Scriba Launch
Brown Trout	Selkirk Shores	623	5/28/2014	CA	2013	RL-D	17.5	Ylg	136.6	none	4,000	surplus stocked at Town of Scriba Launch
Brown Trout	Oswego	622	5/15/2014	SR	2013	RL-D	17.1	Ylg	80.3	none	31,010	Barge/LCM
Brown Trout	Fair Haven	720	5/15/2014	SR	2013	RL-D	17.1	Ylg	78.3	none	31,010	Barge/LCM
Brown Trout	Sodus Point	819	5/6/2014	SR	2013	RL-D	16.8	Ylg	78.2	none	27,560	
Brown Trout	Sodus Point	819	6/11/2014	RM	2013	RL-D	18.5	Ylg	115.1	none	7,020	Surplus: make up for dom. rainbow shortage
Brown Trout	Pultneyville	818	5/7/2014	SR	2013	RL-D	16.8	Ylg	80.1	none	16,060	
Brown Trout	Pultneyville	818	6/11/2014	RM	2013	RL-D	18.5	Ylg	115.1	none	4,610	
Brown Trout	Webster	816	6/3/2014	CD	2013	RL-D	17.3	Ylg	130.3	none	11,630	
Brown Trout	Webster	816	6/5/2014	CD	2013	RL-D	17.3	Ylg	109.8	none	11,630	
Brown Trout	Webster	816	6/11/2014	RM	2013	RL-D	18.5	Ylg	115.1	none	7,900	Surplus: make up for dom. rainbow shortage
Brown Trout	Irondequoit	815	5/29/2014	CD	2013	RL-D	17.1	Ylg	118.1	none	23,250	
Brown Trout	Rochester	815	5/1/2014	RM	2013	RL-D	17.2	Ylg	99.5	none	15,500	
Brown Trout	Rochester	815	5/2/2014	RM	2013	RL-D	17.2	Ylg	98.4	none	7,750	
Brown Trout	Braddocks Bay	815	5/2/2014	RM	2013	RL-D	17.2	Ylg	98.4	none	7,750	
Brown Trout	Braddocks Bay	815	5/5/2014	RM	2013	RL-D	17.3	Ylg	95.1	none	15,500	
Brown Trout	Braddocks Bay	815	10/21/2014	CD	2014	RL-D	10.5	FF	26.5	none	26,950	surplus
Brown Trout	Hamlin	713	4/28/2014	CD	2013	RL-D	17.1	Ylg	95.5	none	7,750	
Brown Trout	Hamlin	713	4/29/2014	RM	2013	RL-D	17.1	Ylg	101.5	none	6,600	Lake too rough. Fish stocked in Sandy Creek
Brown Trout	Hamlin	713	4/30/2014	RM	2013	RL-D	17.1	Ylg	103.3	none	8,900	
Brown Trout	Point Breeze	711	5/30/2014	CD	2013	RL-D	17.1	Ylg	121.9	none	10,910	
Brown Trout	Point Breeze	711	6/4/2014	CD	2013	RL-D	17.3	Ylg	121.3	none	10,910	
Brown Trout	Point Breeze	711	6/2/2014	CD	2013	RL-D	17.2	Ylg	123.3	none	10,910	
Brown Trout	Olcott	708	6/10/2014	CD	2013	RL-D	17.5	Ylg	114.0	none	15,280	
Brown Trout	Olcott	708	6/9/2014	CH	2013	RL-D	17.5	Ylg	142.2	none	2,830	
Brown Trout	Wilson	707	6/9/2014	CD	2013	RL-D	17.5	Ylg	133.8	none	10,770	
Brown Trout	Lower Niagara R.	O.158	5/13/2014	CD	2013	RL-D	16.6	Ylg	116.0	none	4,300	
Brown Trout	Lower Niagara R.	O.158	7/15/2014	CA	2014	RL-D	6.8	AF	7.5	none	40,500	surplus
Brown Trout Yearlings									97.4		396,610	
Brown Trout Advanced Fingerlings									7.5		40,500	
Brown Trout Fall Fingerlings									26.5		26,950	
Brown Trout Total									**85.4**		**464,060**	

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Chinook Salmon	Black River	O.19	5/9/2014	SR	2014	SAL-W	4.1	SF	3.7	none	159,000	
Chinook Salmon	S. Sandy Creek	O.45	5/2/2014	SR	2014	SAL-W	3.9	SF	3.7	none	100,000	
Chinook Salmon	Salmon River	O.53	6/4/2014	SR	2014	SAL-W	5.0	SF	7.2	none	360,000	
Chinook Salmon	Oswego River	O.65	5/22/2014	SR	2014	SAL-W	4.5	SF	4.5	none	97,810	
Chinook Salmon	Oswego River	O.65	5/13/2014	SR	2014	SAL-W	4.3	SF	5.0	none	41,890	In pens 4/22/14 @120/lb 43ºF
Chinook Salmon	Little Sodus Bay	O.74	5/17/2014	SR	2014	SAL-W	4.4	SF	5.4	none	25,000	In pens 4/24/14@125/lb 41ºF
Chinook Salmon	Sterling Creek	O.73	5/8/2014	SR	2014	SAL-W	4.1	SF	3.7	none	87,200	
Chinook Salmon	Sodus Bay	O.84-P96	5/21/2014	SR	2014	SAL-W	4.5	SF	4.5	none	94,000	
Chinook Salmon	Sodus Bay	O.84-P96	5/15/2014	SR	2014	SAL-W	4.3	SF	5.7	none	50,000	In pens 4/22/14@120/lb 49ºF
Chinook Salmon	Genesee River	O.117	5/20/2014	SR	2014	SAL-W	4.5	SF	4.6	none	113,250	
Chinook Salmon	Genesee River	O.117	5/7/2014	SR	2014	SAL-W	4.1	SF	5.5	none	85,250	In pens 4/14/14 120/lb 48ºF
Chinook Salmon	Sandy Creek	O.130	5/7/2014	SR	2014	SAL-W	4.1	SF	6.3	none	55,000	In Pens 4/16/14@130/lb 46ºF
Chinook Salmon	Sandy Creek	O.130	5/16/2014	SR	2014	SAL-W	4.4	SF	4.3	none	89,000	
Chinook Salmon	Oak Orchard Crk.	O.138	5/19/2014	SR	2014	SAL-W	4.5	SF	4.4	none	97,940	
Chinook Salmon	Oak Orchard Crk.	O.138	5/7/2014	SR	2014	SAL-W	4.1	SF	5.6	none	106,750	In pens 4/14/14@125/lb 52ºF
Chinook Salmon	Eighteenmile Crk.	O.148	5/16/2014	SR	2014	SAL-W	4.4	SF	4.3	none	105,100	
Chinook Salmon	Eighteenmile Crk.	O.148	5/13/2014	SR	2014	SAL-W	4.3	SF	6.6	none	67,100	In pens 4/22/14@120/lb 55ºF
Chinook Salmon	lower Niagara R.	O.158	6/4/2014	SR	2014	SAL-W	5.0	SF	7.4	none	75,000	In pens 5/12/14 @104.2/lb. 46ºF
Chinook Salmon	lower Niagara R.	O.158	5/23/2014	SR	2014	SAL-W	4.6	SF	4.5	none	160,500	
Chinook Salmon Spring Fingerling Total									**5.2**		**1,969,790**	

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SPECIES	LOCATION	GD/KY	DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Coho Salmon	Beaverdam Brook	O.53-8	5/22/2014	SR	2013	SAL-W	15.9	Ylg	28.3	none	130,000	
Coho Salmon Fall Fingerlings									0.0		-	No FF stocked in 2014 due to poor egg survival at hatchery in fall 2013
Coho Salmon Yearlings									28.3		130,000	
Coho Salmon Total									**28.3**		**130,000**	
Lake Trout	Stony Point	423	5/13/2014	EI	2013	LCH-D	14.2	Ylg	31.3	AD CWT	22,184	CWT #600183, Barge/LCM
Lake Trout	Stony Point	423	5/13/2014	EI	2013	LCH-D	14.2	Ylg	31.3	AD CWT	19,833	CWT #600184, Barge/LCM
Lake Trout	Stony Point	423	5/13/2014	AL	2013	SEN	14.4	Ylg	34.7	AD CWT	40,580	CWT #600263, Barge/LCM
Lake Trout	Oswego	622	5/14/2014	EI	2013	LCH-D	14.3	Ylg	31.3	AD CWT	9,062	CWT #230119, Barge/LCM
Lake Trout	Oswego	622	5/14/2014	EI	2013	LCH-D	14.3	Ylg	31.3	AD CWT	21,761	CWT #600252, Barge/LCM
Lake Trout	Oswego	622	5/14/2014	AL	2013	SEN	14.5	Ylg	28.7	AD CWT	40,730	CWT #600260, Barge/LCM
Lake Trout	Oswego	622	5/15/2014	AL	2013	SKW	15.8	Ylg	46.8	AD CWT	42,980	CWT #600255, Barge/LCM
Lake Trout	Sodus	819	5/16/2014	AL	2013	SKW	15.8	Ylg	48.7	AD CWT	42,190	CWT #600254, Barge/LCM
Lake Trout	Sodus	819	5/16/2014	AL	2013	SEN	14.5	Ylg	24.8	AD CWT	40,510	CWT #600259, Barge/LCM
Lake Trout	Point Breeze	711	5/20/2014	AL	2013	SEN	14.6	Ylg	32.6	AD CWT	40,640	CWT #600261, Barge/LCM
Lake Trout	Point Breeze	711	5/20/2014	AL	2013	SEN	14.6	Ylg	28.9	AD CWT	40,290	CTW #600262, Barge/LCM
Lake Trout	Olcott	708	5/19/2014	AL	2013	SEN	14.6	Ylg	29.1	AD CWT	41,230	CWT #600258, Barge/LCM
Lake Trout	Olcott	708	5/19/2014	AL	2013	SKW	15.9	Ylg	45.4	AD CWT	40,710	CWT #600253, Barge/LCM
Lake Trout	Stony Point	708	10/23/2014	AL	2014	SKW	9.1	FF	14.8	AD CWT	41,100	CWT #640590, Association Island Cut
Lake Trout	Stony Point	708	10/23/2014	AL	2014	SKW	9.1	FF	14.8	AD CWT	41,061	CWT #640591, Association Island Cut
Lake Trout	Stony Point	708	10/23/2014	AL	2014	SEN	7.7	FF	9.9	AD CWT	40,196	CWT #640598, Association Island Cut
Lake Trout	Stony Point	708	10/23/2014	AL	2014	SEN	7.7	FF	9.9	AD CWT	40,040	CWT #640595, Association Island Cut
Lake Trout	Oswego	708	10/22/2014	AL	2014	SEN	7.7	FF	10.8	AD CWT	40,588	CWT #640594, Town of Scribe Launch
Lake Trout	Oswego	708	10/22/2014	AL	2014	SEN	7.7	FF	10.8	AD CWT	40,794	CWT #640592, Town of Scribe Launch
Lake Trout	Oswego	708	10/22/2014	AL	2014	SEN	7.7	FF	10.8	AD CWT	40,711	CWT #640593, Town of Scribe Launch
Lake Trout	Sodus	708	10/21/2014	AL	2014	HPW	8.0	FF	8.9	AD CWT	41,407	CWT #640606, Pultneyville Mariners Club
Lake Trout	Sodus	708	10/21/2014	AL	2014	HPW	8.0	FF	8.9	AD CWT	40,216	CWT #640604, Pultneyville Mariners Club
Lake Trout	Sodus	708	10/21/2014	AL	2014	HPW	8.0	FF	8.9	AD CWT	41,152	CWT #640688, Pultneyville Mariners Club
Lake Trout	Oak Orchard	708	10/28/2014	EI	2014	LCH-D	8.5	FF	10.7	AD CWT	40,346	CWT #640581, Oak Orchard Creek near start of breakwall
Lake Trout	Oak Orchard	708	10/28/2014	EI	2014	LCH-D	8.5	FF	10.7	AD CWT	40,116	CWT#640582, Oak Orchard Creek breakwall
Lake Trout	Oak Orchard	708	10/28/2014	EI	2014	LCH-D	8.5	FF	10.7	AD CWT	40,237	CWT#640583, Oak Orchard Creek breakwall
Lake Trout Fall Fingerlings									10.8		527,964	
Lake Trout Spring Yearlings									34.9		442,700	
Lake Trout Total									**21.8**		**970,664**	

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Rainbow Trout	Black River	424	4/30/2014	SR	2013	WAS-W	10.3	Ylg	13.0	none	36,000	
Rainbow Trout	Black River	O.19	4/30/2014	SR	2013	WAS-W	10.3	Ylg	13.0	none	36,000	
Rainbow Trout	Stony Creek	O.40	4/11/2014	SR	2013	WAS-W	9.7	Ylg	15.9	none	20,700	
Rainbow Trout	South Sandy Creek	O.45	4/11/2014	SR	2013	WAS-W	9.7	Ylg	15.9	none	28,750	
Rainbow Trout	Beaverdam Brook	O.53-8	5/19/2014	SR	2013	WAS-W	10.9	Ylg	30.8	none	120,000	Stocked 5/19,5/20,5/21
Rainbow Trout	Beaverdam Brook	O.53-8	5/22/2014	SR	2013	SKA-W	11.0	Ylg	25.9	AD	26,500	
Rainbow Trout	Grindstone Creek	O.54	4/16/2014	SR	2013	WAS-W	9.8	Ylg	18.1	none	5,000	
Rainbow Trout	Little Salmon River	O.58	5/15/2014	SR	2013	WAS-W	10.8	Ylg	22.7	none	2,100	In pens 4/24/14@25/lb 45ºF
Rainbow Trout	Oswego River	O.66	4/16/2014	SR	2013	WAS-W	9.8	Ylg	18.1	none	20,000	
Rainbow Trout	Sterling Creek	O.73	4/3/2014	SR	2013	WAS-W	9.4	Ylg	17.7	none	4,600	
Rainbow Trout	Sterling Valley Crk.	O.73-3	4/3/2014	SR	2013	WAS-W	9.4	Ylg	17.7	none	4,600	
Rainbow Trout	Little Sodus Bay	O.74	5/17/2014	SR	2013	WAS-W	10.8	Ylg	0.0	none	6,000	In pens 4/24/14@25/lb 41ºF
Rainbow Trout	Maxwell Creek	O.85	5/5/2014	SR	2013	WAS-W	10.5	Ylg	13.7	none	20,000	
Rainbow Trout	Irondequoit Creek	O.108	5/1/2014	SR	2013	WAS-W	10.3	Ylg	13.0	none	27,500	
Rainbow Trout	Genesee River	O.117	4/14/2014	SR	2013	WAS-W	9.8	Ylg	18.1	none	12,100	
Rainbow Trout	Genesee River	O.117	5/3/2014	SR	2013	WAS-W	10.4	Ylg	26.5	none	10,000	In pens 4/14/14@25/lb 48ºF
Rainbow Trout	Salmon Creek	O.125	5/2/2014	SR	2013	WAS-W	10.4	Ylg	13.7	none	5,050	
Rainbow Trout	Sandy Creek	O.130	5/2/2014	SR	2013	WAS-W	10.4	Ylg	13.8	none	7,350	
Rainbow Trout	Sandy Creek	O.130	5/7/2014	SR	2013	WAS-W	10.5	Ylg	26.6	none	7,300	In pens 4/16/14@25/lb 46ºF
Rainbow Trout	Oak Orchard Creek	O.138	4/15/2014	SR	2013	WAS-W	9.8	Ylg	18.1	none	7,000	
Rainbow Trout	Oak Orchard Creek	O.138	5/7/2014	SR	2013	WAS-W	10.5	Ylg	23.7	none	14,000	In pens 4/15/14@25/lb 52ºF
Rainbow Trout	Marsh Creek	O.138-1	5/2/2014	SR	2013	WAS-W	10.4	Ylg	13.7	none	7,100	
Rainbow Trout	Johnson Creek	O.139	5/2/2014	SR	2013	WAS-W	10.4	Ylg	13.7	none	6,700	
Rainbow Trout	Eighteenmile Crk.	O.148	4/22/2014	SR	2013	WAS-W	10.0	Ylg	18.1	none	6,500	Steelhead from Keg Creek stocked here too.
Rainbow Trout	Eighteenmile Crk.	O.158	5/12/2014	SR	2013	WAS-W	10.7	Ylg	26.2	none	3,500	In pens 4/22/14@25lb 55ºF
Rainbow Trout	Twelvemile Crk. E Branch	O.152	4/18/2014	SR	2013	WAS-W	9.9	Ylg	15.1	none	10,500	Steelhead from Fourmile Creek stocked here too.
Rainbow Trout	Twelvemile Creek	O.152A	4/18/2014	SR	2013	WAS-W	9.9	Ylg	15.1	none	12,000	
Rainbow Trout	Twelvemile Creek (Wilson)	O.152	5/8/2014	SR	2013	WAS-W	10.5	Ylg	33.6	none	7,500	In pens 4/18/14 @30/lb 45ºF
Rainbow Trout	lower Niagara R.	O.158	4/18/2014	SR	2013	WAS-W	9.9	Ylg	15.1	none	37,000	
Rainbow Trout	lower Niagara R.	O.158	6/4/2014	SR	2013	WAS-W	11.4	Ylg	38.6	none	10,000	In pens on 5/12/14 @25/lb 46ºF
Rainbow Trout	Irondequoit Creek	O.108	4/9/2014	PMP	2013	FL-W	9.6	Ylg	30.2	none	1,200	Powder Mill Pond release, No WAS strain after 2006
Rainbow Trout	Sodus	819	6/9/2014	VH	2013	RA-D	17.5	Ylg	137.8	none	5,170	
Rainbow Trout	Sodus	819	6/10/2014	VH	2013	RA-D	17.5	Ylg	137.8	none	1,800	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2014.

SPECIES	LOCATION	GD/KY	DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Rainbow Trout	Hamlin	713	5/8/2014	CS	2013	RA-D	16.4	Ylg	162.0	none	8,840	
Rainbow Trout	Hamlin	713	5/6/2014	BA	2013	RA-W	10.9	Ylg	95.0	none	3,000	Hybrid Finger Lakes rainbow trout makeup for RA-D shortage
Rainbow Trout	Hamlin	713	5/6/2014	BA	2013	RA-D	16.4	Ylg	145.8	none	3,950	
Rainbow Trout	Olcott	708	5/9/2014	CS	2013	RA-D	16.5	Ylg	170.6	none	7,500	
Rainbow Trout	Olcott	708	6/9/2014	CH	2013	RA-D	17.5	Ylg	174.5	none	520	
Rainbow Trout	Wilson	707	5/7/2014	CS	2013	RA-D	16.4	Ylg	168.0	none	9,870	
Washington Steelhead Yearlings									20.4		494,850	
Skamania Steelhead Yearlings									25.9		26,500	
Rainbow Trout Yearlings (Randolph strain)									20.3		37,650	
Rainbow Trout Yearlings (Finger Lakes/Randolph Hybrid strain)									95.0		3,000	
Rainbow Trout Yearlings (Finger Lakes W strain)									30.2		1,200	
Rainbow Trout Total									**30.4**		**563,200**	
Walleye	lower Niagara River	EN-P0000	6/20/2014	CQ	2014	ONL-W	1.4	PF	0.3	none	23,200	
Walleye	lower Niagara River	EN-P0000	5/12/2014	ON	2014	ONL-W	0.1	fry	0.0	none	40,000	
Walleye	Sodus Bay	O-P0096	7/2/2014	CA	2014	ONL-W	1.8	PF	0.6	none	17,750	surplus
Walleye	Sodus Bay	O-P0096	7/2/2014	SO	2014	ONL-W	1.7	PF	2.6	none	1,179	surplus
Walleye	Sodus Bay	O-P0096	6/27/2014	SO	2014	ONL-W	1.6	PF	0.6	none	8,631	surplus
Walleye	Sodus Bay	O-P0096	6/23/2014	CQ	2014	ONL-W	1.5	PF	0.5	none	47,000	
Walleye Fry									<0.1		40,000	
Walleye Fingerling Total									0.5		97,760	
Walleye Total											**137,760**	
Bloater	Oswego	621	11/4/2014	TUN	2014	LM	7.5	FF	8.5	CAL	20,000	Stocked off Oswego at 100m contour by USGS RV/Kaho.
Cisco	Irondequoit Bay	815	9/18/2014	TUN	2014	LO	7.4	FF	7.5	CAL	57,210	Stocked by region 8 by pontoon boat in bay.
Cisco	Irondequoit Bay	815	9/19/2014	TUN	2014	LO	7.4	FF	7.2	CAL	61,290	Stocked by region 8 by pontoon boat in bay.
Cisco	Irondequoit Bay	815	11/17/2014	TUN	2013	LO	9.3	FF	15.6	CAL	26,170	Stocked by region 8 by pontoon boat in bay.
Bloater Total									8.5		20,000	
Cisco Total									8.9		144,670	
Coregonine Total									**8.8**		**164,670**	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2014.

SPECIES	LOCATION	GD/KY	DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Lake Sturgeon	Genesee River	O.117	2-Oct-14	ON	2014	SLR	3.0	FF	12.7	CWT-VIE-SCU	1,000	CWT #600138,SCUTE CLIP, ELASTOMER TAG
Lake Sturgeon	Chaumont Bay	324	9-Sep-14	GN	2015	SLR	2.3	FF	4.3	CWT-VIE-SCU	3,250	CWT#055382,SCUTE CLIP, ELASTOMER TAG
Lake Sturgeon	North Sandy Pond	623	13-Aug-14	GN	2015	SLR	2.3	FF	4.3	OTC-VIE	5,000	surplus
Lake Sturgeon Total											**9,250**	
Salmonine Total											**4,239,460**	
Total All Species											**4,551,140**	

2014 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 1985-2014 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 (1985-2014). This report focuses on 2014 results and on comparisons of 2014 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 2005-2014 and a 20-year average for 1985-2004.

Methods

Sampling Design and Data Collection

Methods and procedures have changed little throughout the 30 years surveyed. For 20 of the 30 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 2014). 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

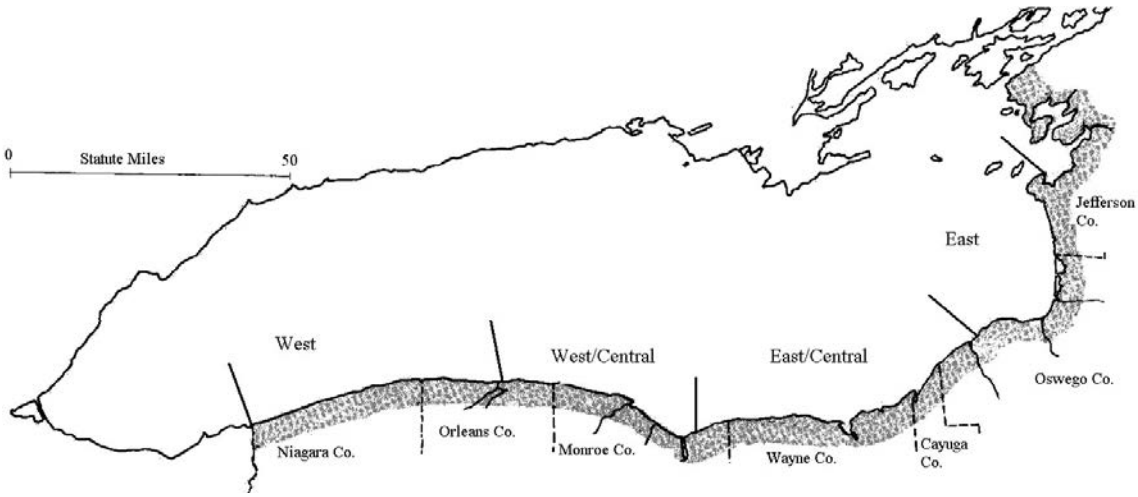

Figure 1. Lake Ontario's New York shoreline (shaded in gray), the seven New York counties that border the lake, and the four geographic areas used in analysis of the survey data.

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 2010-2014

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 2014 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

Fishing effort from April 15-September 30, 2014 was estimated at 58,554 ($\pm$13.8) completed boat trips (Figure 2, Table A2), among 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; Lantry and Eckert 2014). The total estimated number of fishing boat trips increased from 1985-1990, then decreased through 1996. The largest declines in fishing effort occurred shortly after the peak, with declines of 31,751 trips between 1990 and 1991, 42,112 trips between 1991 and 1992, and 12,740 trips between 1995 and 1996. Over the 10-year period from 2005-2014 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 2014, as measured by angler trips and angler hours, was 174,079 and 980,409, 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 2.8 with an increasing trend during the last 10 years (Table A2). The increased number of anglers per boat trip may have been due to cost-saving efforts given the cost of gas, current status of the economy, and the increase in trout and salmon fishing effort relative to effort targeting smallmouth bass (i.e., boats targeting trout and salmon typically have more anglers onboard than bass trips). The 2014 average trip length of 5.6 hours per boat trip was comparable to previous 5-year (+3.9%) and 10-year averages (+8.3%).

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 (2005-2014 10-year averages: April 15-April 30: 4.2%, May: 15.5%, June: 12.3%, July: 21.3%, August: 29.2%, and September: 17.5%). Fishing effort during April 2014 was the lowest estimated in the 30-years surveyed and a 34.3% decrease compared to the previous 10-year April average. This decrease is primarily attributed to the long, cold winter, relatively late ice-out for many Lake Ontario embayments, cold days and relatively frequent, inclement lake conditions during April 2014.

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 26 of the last 30 years (Table A2). In 2014,

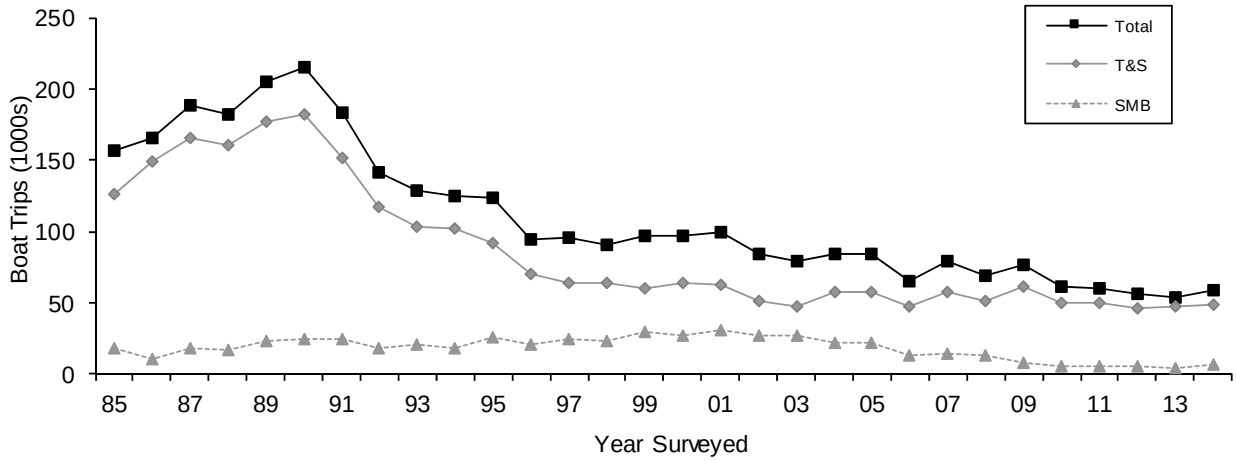

Figure 2. Estimated number of total fishing boat trips, trips targeting trout and salmon (T&S; April 15-September 30), and trips targeting smallmouth bass (SMB) during the traditional open season (3rd Saturday in June-September 30 when the survey ended), 1985-2014.

the greatest amount of effort occurred in the east area (19,215 boat trips, 32.8% of all fishing effort) and east/central area (18,455 boat trips, 31.5% of all effort). Effort in the west was estimated at 13,674 boat trips. For each of the 30 years surveyed, the lowest fishing effort occurred in the west/central area (7,210 boat trips in 2014 and 12.3% 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 59,149 vessel excursions and 39.8% of the total vessel traffic in 2014 (Table A2). Non-fishing power boats were estimated at 70,311 excursions in 2014 (47.3% of the total vessel traffic). Non-fishing power boat traffic peaked and declined similar to that described for fishing boats over the 30-year survey period.

Sailboats, the smallest component of vessel traffic, showed a downward trend through much of the time series (1985-2006) but increased in recent years. In 2014, sailboats accounted for 19,104 excursions and represented 12.9% of vessel traffic. This was a 46.5% increase over 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 (1985-2014 range: 59.7% [2003] to 90.0% [1986]; 1985-2014 average = 76.5%; Figure 2, Table A2), and trends in total fishing effort were largely attributed to trout and salmon anglers (1985-late 1990s). Over the last 10 years, however, effort targeting trout and salmon remained relatively stable with no trend while total fishing effort declined over the same time period. In 2014, trout and salmon anglers accounted for 84.4% of total fishing boat trips, 89.4% of angler trips, and 93.6% of angler hours (Table A2).

In 2014, fishing effort targeting trout and salmon was estimated at 49,434 (±14.7%) boat trips, comparable to the previous 5-year (+1.9%) and 10-year averages (-6.2%; Table A2). Estimated monthly fishing effort targeting trout and salmon was comparable to the previous 5-year averages May through September (range: -7.8% [July] to +9.1% [June]), and was below the previous 5-year average in April (-19.9%; Table A2). Unlike most years when trout and salmon anglers stated they were targeting a mix of two or more species, the

majority of those interviewed each year since 2005 were specifically targeting Chinook salmon (2005-2013 average=49.1%). During 2014, 45.1% of salmonine anglers were specifically targeting Chinook salmon, 31.1% were targeting a mix of two or more species, and 9.6% were specifically targeting brown trout.

Smallmouth Bass Targeted Effort

Pre-Season Catch and Release Period:

For the eighth consecutive year, few anglers targeted bass during the pre-season catch and release period. Prior to October 1, 2006, NYSDEC fishing regulations established the open bass season in Lake Ontario from the third Saturday in June through November 30 and allowed anglers to harvest a daily limit of five smallmouth bass with a minimum length of 12 inches. The smallmouth bass regulation was changed effective October 1, 2006, establishing pre-season catch and release 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, before the new regulation permitting pre-season catch and release was in effect, 3.5% of total effort occurred pre-season (an estimated 500 boat trips). Since the regulation change, effort targeting bass during the pre-season catch and release period remained low (range: 191 boat trips [2013] – 644 trips [2009]) and a minor component of total bass effort occurring April 15 - September 30 (range: 2.8% [2008] to 7.7% [2012]). In 2014, effort remained low with an estimated 295 boat trips targeting smallmouth bass during the pre-season catch and release period. This represented 4.1% of the total bass effort occurring April 15 - September 30, 2014 (Table A2).

Traditional Open Season:

The traditional open season for bass begins the third Saturday of June. Each year since 1985, smallmouth bass was the primary species targeted by anglers not seeking trout or salmon (Figure 2, Table A2). 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 2014, smallmouth bass anglers fishing during the traditional open season accounted for 11.8% of all fishing boat trips (April 15 – September 30), 8.2% of angler trips, and 5.2% of angler hours. In 2014, the average number of anglers per bass boat trip (2.1 anglers) was comparable to (-2.8%) the previous 5-year average. The number of hours per boat trip (3.6 hours), however, was the highest since 1989 (3.63 hours).

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 at a level 81.0% below the 2001 peak (2011-2014 average = 5,903). In 2014, however, smallmouth bass fishing effort during the traditional open season (June 21 to September 30) was an estimated 6,878 ($\pm$37.9%) boats trips, the highest since 2009 and a 16.7% increase compared to the previous 5-year average (Figure 2, Table A2). Increased effort in 2014 may be partly attributable to increased fishing quality (see section "Smallmouth Bass *Fishing Quality*" of this report). Smallmouth bass fishing effort increased in all areas compared to recent years, with the greatest increases occurring in the east and west areas (Table A2). Bass fishing effort increased in the east area for the fourth consecutive year and was a 57.1% increase compared to the previous 5-year average. Effort in the west area was the highest estimated since 2009 and was a 27.9% increase compared to the previous 5-year average. Effort in the west/central and east/central areas of the lake decreased compared to the previous 5-year averages (-15.5% and -16.9%, respectively). Fishing effort for smallmouth bass was above previous 5-year averages in June (+68.7%) and August (+31.7), was below average in July (-

14.2%), and comparable to the previous 5-year average in September (-5.3%; 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 2014, however, trips targeting these species only represented 1.5% of the total fishing boat trips on Lake Ontario (Table A2). The "all others" category, which represented 1.7% of 2014 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 2014, charter boats accounted for 16.6% of the total number of fishing boat trips (19.6% of trout and salmon fishing boat trips; Figure 3). With more anglers on board and longer trips, charter boats accounted for 29.5% and 35.3% of the angler trips and angler hours, respectively (captains and mates counted as anglers; Table A2). Although charter boats accounted for only 16.6% of total fishing boat effort, they accounted for 46.7% of the total salmonine catch in 2014. 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 the last decade (2003-2014; Figure 3, Table A2). The 2014 estimated charter boat effort was 9,718 (±29.0%) trips, slightly above previous 5-year (+11.4%) and 10-year (+7.7%) averages. Estimated monthly charter fishing effort in 2014 was above the previous 5-year averages May-June and August-September (range: +11.5% [May] to +23.2% [June]), comparable to the previous 5-year average in July (+1.9%), and below previous 5-year average in April (-30.9%; Table A2).

Angler Residency

Lake Ontario's worldclass sportfishery has attracted anglers from all 50 states (38 in 2014) and many different countries over the last 30 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

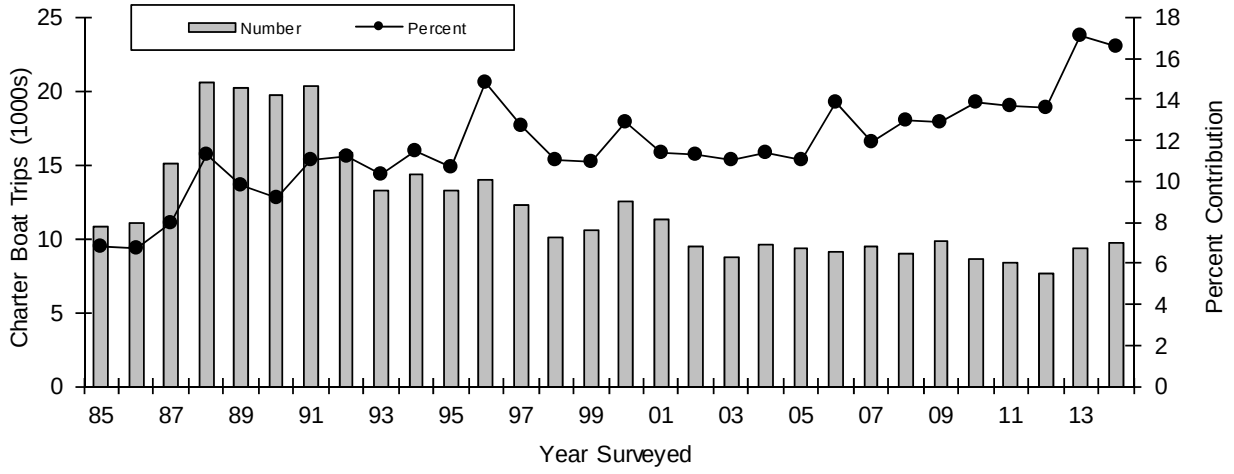

Figure 3. Estimated number of charter fishing boat trips and their percent contribution to total fishing boat trips, April 15- September 30, 1985-2014.

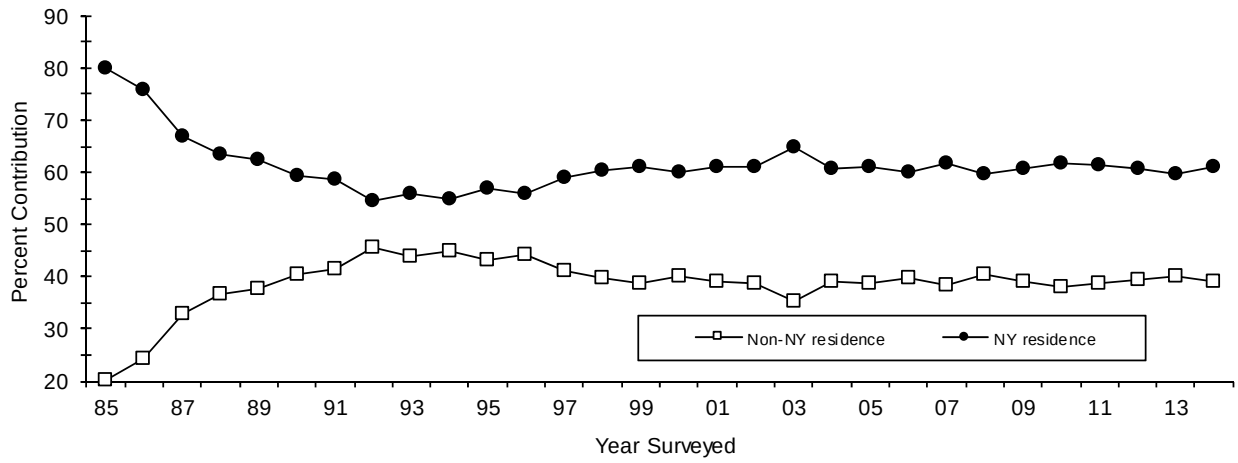

Figure 4. Percent contribution of anglers with and without New York state residency.

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 1987-2014. Over the last 10 years, an average of 60.8% of Lake Ontario anglers resided in NYS (60.9% in 2014; Table A4).

Contribution of nonresident anglers increased after 1985 (20.2%), 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 2014, non-NYS residents comprised 39.1% of the boat anglers interviewed, comparable to previous 5-year and 10-year averages (+3.1% and -10.5%, respectively; Figure 4; Table A2, Table A4). Pennsylvania represented the largest component of nonresident anglers for each of the 30 years surveyed (21.0% of the all anglers in 2014). The highest proportions of Pennsylvania anglers occurred each year 2010-2014 (the lowest [8.5%] occurred in 1985; Table A4). Other major sources of non-NYS anglers in 2014 were Ohio (3.6%), New Jersey (2.9%), Massachusetts (2.8%), Vermont (2.3%) and New Hampshire (1.3%; Table A4).

Throughout the 30-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 the lowest level recorded (56.0% of NY anglers interviewed). 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 2014 (Table A4). Other counties representing important components of the open lake boat fishery in 2014 were Oswego (12.8%), Niagara (8.6%), Wayne (7.7%), Onondaga (5.9%), Erie (4.1%), and Orleans (5.3%; Table A4).

<u>Total Salmonines: Catch, Harvest and Fishing Quality</u>

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 200,763 (±17.4%) fish, which was comparable to (+2.6%) the previous 5-year average and a 15.8% increase compared to the previous 10-year average (Figure 5, Table 1, Table A5a). Each year since 2003, Chinook salmon dominated total trout and salmon catch (2003-2014 average: 78,874 Chinook caught and 46.0% of total catch) and harvest (2003-2014

Table 1. Harvest and catch estimates for April 15 – September 30, 2014 from the NYSDEC Lake Ontario fishing boat survey.

	Number Harvested	Number Caught
Coho salmon	5,653	8,442
Chinook salmon	47,935	76,626
Rainbow trout	16,729	37,462
Atlantic salmon	66	639
Brown trout	20,626	44,487
Lake trout	15,870	33,108
Smallmouth bass (includes pre-season)	12,538	31,807
Yellow perch	6,066	17,966
Walleye	182	421
Round goby	4,222	6,704
Other fish	1,517	8,127

average: 46,213 Chinook harvested representing 47.6% of total harvest). For eight of those years, brown trout was the second most commonly caught fish. From 2008 to 2010, rainbow trout was the second most commonly caught and harvested salmonine. Total trout and salmon catch in 2014 was 38.2% Chinook salmon, 22.2% brown trout, 18.7% rainbow trout, 16.5% lake trout, 4.2% coho salmon, and 0.3% Atlantic salmon. In 2014, anglers harvested 53.2% of all trout and salmon caught, which was a comparable to (-1.7%) the previous 5-year average. Estimated salmonine harvest was 106,880 (±19.9%) fish, and comparable to (+1.4%) the 2009-2013 average (Figure 5, Table 1, Table A5a). The 2014 percent contributions of each species to the total trout and salmon harvest were 44.8% Chinook salmon, 19.3% brown trout, 15.7% rainbow trout, 14.8% lake trout, 5.3% coho salmon, and 0.1% 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 2014, there were periods and locations of excellent fishing quality and periods and locations of poor fishing quality (e.g., Figure 5b). With the variety of trout and salmon species present in Lake Ontario, anglers were able to target another species when the preferred target was not available. This resulted in an excellent total trout and salmon catch rate and is 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 2014 compared to recent years (see below).

The quality of trout and salmon fishing in Lake Ontario, as measured by catch rate, was variable but relatively stable from 1985-2002; however, increased substantially in 2003 and remained at a higher variable level since (Figure 5). Anglers experienced six consecutive years (2009-2014) of record high trout and salmon catch rates. The catch per boat trip in 2014 was the third highest estimated in the survey (4.1 fish caught per boat trip) and comparable to (+5.6%) the previous 5-year average

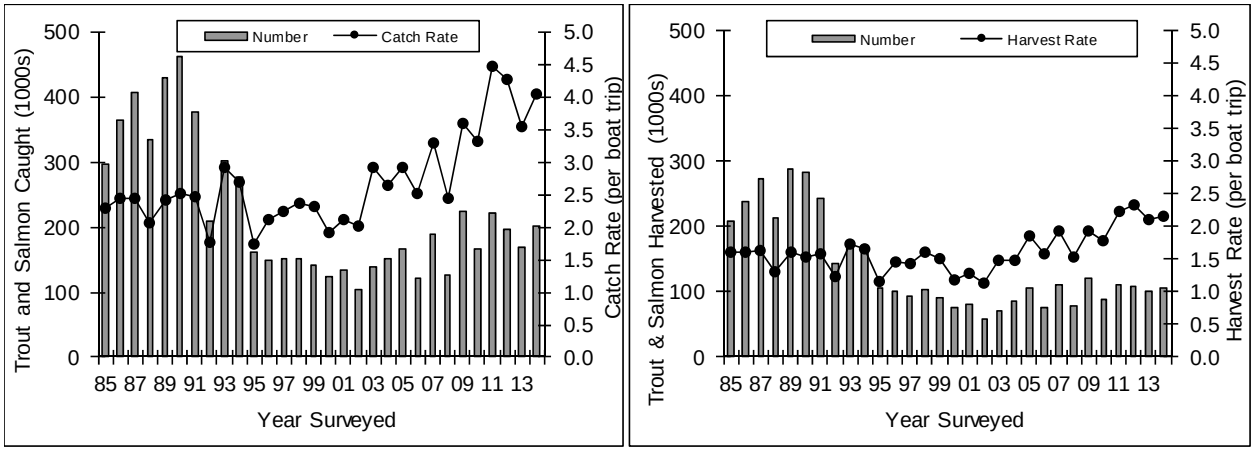

Figure 5. Total trout and salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985 - 2014.

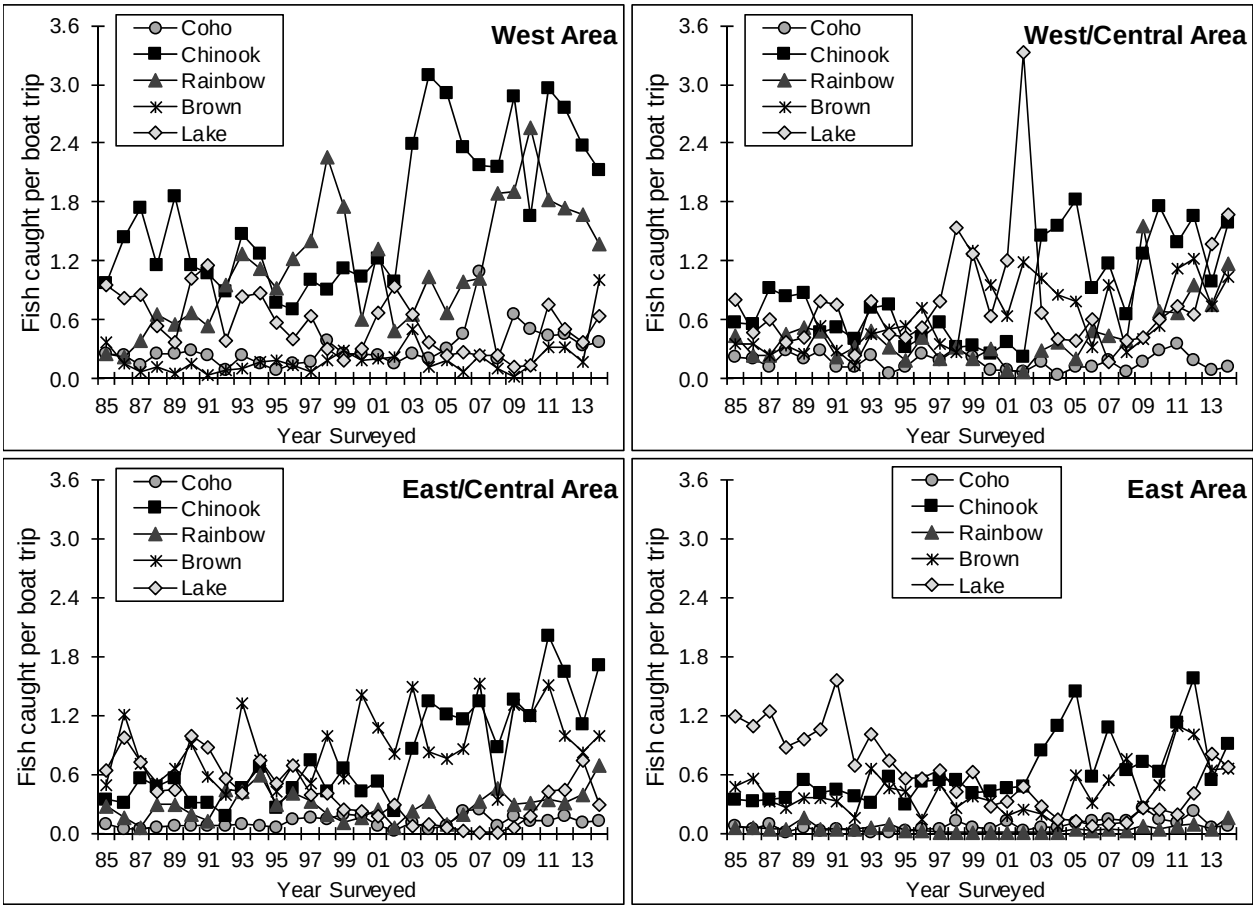

Figure 5b. Trout and salmon catch rate per boat trip by species for boats seeking trout and salmon in the West, West/Central, East/Central, and East areas, April 15 – September 30, 1985 – 2014. Note: Species-specific catch rates varied by month within each area.

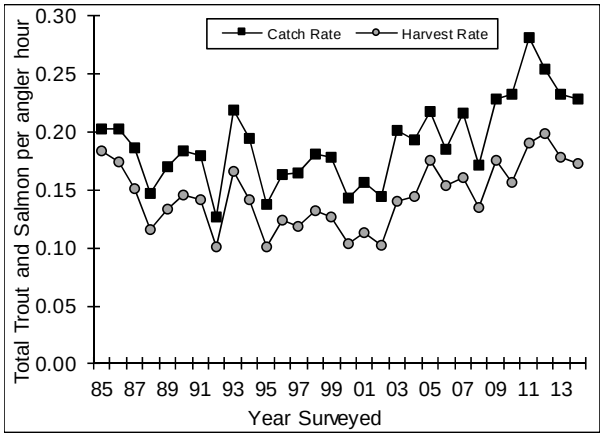

Figure 5c. Charter boat catch rate and harvest rate per angler hour for total trout and salmon, April 15 – September 30, 1985 - 2014.

(Figure 5, Table A5b). Nine of the ten highest catch rates occurred between 2003 and 2014. During this time period anglers have experienced high species-specific catch rates (Chinook salmon highest rates each year 2003-2014, Coho salmon record high for six of the last nine years, rainbow trout record or near record each year 2008-2014, and five of the last eight years were record high for brown trout). The 2014 total trout and salmon harvest rate for all boats specifically targeting trout and salmon was 2.2 fish per boat trip and comparable to (+4.1%) to the 2009-2013 average harvest rate (Figure 5, Table A5b). Catch and harvest rate data (fish per boat trip) were also evaluated by month. In 2014, catch rates were above previous 5-year averages April-June (range: +30.7% [May] to +125.5% [April]), were comparable to previous averages during August (-9.9%) and September (+9.2%), and was below average during July (-25.2; Table A5b).

In 2014, charter boats targeting trout and salmon accounted for 46.7% and 59.8% of all salmonines caught and harvested, respectively, but represented only 19.6% of trout and salmon fishing boat effort, 32.9% of angler trips and 37.7% of angler hours directed at trout and salmon. Charter boat total trout and salmon catch rate (8.1 fish per boat trip; fourth highest recorded) and harvest rate (6.2 fish per boat trip; fifth highest recorded) were increases compared to long-term averages (+19.5% and +19.4%, respectively; Table A5b). Charter catch rate per angler hour was 0.23 salmonines, the sixth highest in the 30-year data series and comparable to previous 5-year and 10-year averages (-7.4% and +3.0%, respectively; Figure 5c; Table A5b).

Noncharter fishing boats caught an average of 3.1 salmonines per boat trip (0.21 fish caught per angler hour) in 2014, comparable to (+6.2%) the previous 5-year average (Table A5b). Among noncharter boats fishing for trout and salmon, the 2014 lake-wide harvest rate was 1.2 salmonines per boat trip, which is also comparable to (+-3.7%) the previous 5-year average (Table A5b).

Additional metrics reflect angling quality, such as percentage of boats with zero harvest and 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 harvest or catch 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 2014, 29.4% of boats targeting trout and salmon caught zero salmonines, the third lowest. The nine years with the lowest proportions of boats with zero trout and salmon catch occurred since 2003. This indicates that, in recent years, the majority of boats targeting trout and salmon caught one or more trout and salmon.

Angler harvest is affected by angler catch rates, harvest regulations, and angler desire to keep or release fish. Inter-annual comparisons of boats that harvested the maximum daily limit were compromised by fishing regulation changes that occurred between the 1996 and 1997 seasons and the 2006 and 2007 seasons; however, they can provide another indication of angling quality (Table A6). From 1985-1996, anglers were allowed a daily limit of five trout and salmon per angler, with no more than three lake trout and no more than one Atlantic salmon. Beginning with the 1996 and 1997 seasons, the daily limit was changed

to a maximum of seven trout or salmon, with no more than three lake trout, no more than one Atlantic salmon, and no more than three fish of coho salmon, Chinook salmon, rainbow trout or brown trout in combination (popularly known as the 3-3-1 limit). The most recent regulation changes affected harvest of two trout species. Effective October 1, 2006, the rainbow trout size limit was increased to 21 inches and the lake trout daily limit was reduced to two fish per angler but allowing no more than one within the slot limit (25-30 inches).

Some variables examined did indicate that angling quality was lower in 2014, despite the total trout and salmon catch rate among charters being the sixth highest on record. In 2014, 11.5% of the charter boats targeting trout and salmon harvested the maximum daily limit of three coho salmon, Chinook salmon, rainbow trout, or brown trout in combination for their customers (Table A6). This was the lowest percentage since 2002 and a 39.8% decrease compared to the previous 10-year average. The highest percentage 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 in 2009). During 2014 and of the charter boats that harvested the three in any combination limit for their customers, 57.7% went on to harvest additional fish permitted under the fishing licenses held by the boat's captain and mate(s). Among all charter boat trips, only 0.9% 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 2014, 1.5% harvested the maximum daily limit of three coho salmon, Chinook salmon, rainbow trout, or brown trout in combination, a 22.7% decrease compared to the previous 10-year average.

Limits of lake trout were consistently less common than aggregate limits for the other four species. In 2014, 8.5% of charter boats interviewed harvested the legal limit of lake trout for their customers. Of the charter boats that harvested the legal limit of lake trout for their customers, 37.3% went on to harvest additional fish permitted under the fishing licenses held by the boat's captain and mate(s), and 8.8% harvested the limit for all anglers (0.8% of all charter boat trips). Among noncharter boats, none harvested the maximum daily limit of lake trout in 2014.

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), but none did so in 2014. No boats interviewed during 1997-2014 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 2014, coho salmon was the fifth most commonly caught and harvested salmonine in the boat fishery (4.2% and 5.3% of total catch and harvest, respectively; Table 1, Table A7a). Estimated coho salmon catch (8,442 [±41.0%] fish) in 2014 was a 35.8% decrease compared to the long-term average (1985-2013; Figure 6). Approximately 67% of coho salmon caught were harvested. Coho salmon harvest in 2014 was an estimated 5,653 (±49.8%) fish and a 41.0% decrease compared to the long-term average (Figure 6, Table A7a). During 2014, estimated catch of coho salmon was below the long-term average during April and June-August (range: -65.8% [August] to -43.6% [July]), and comparable to the long-term average during May (+0.8%) and September (-7.7; Table A7a).

Fishing Quality

Coho salmon catch rates and harvest rates were excellent during six of the nine years from 2006-2014 (Table 7b, Figure 6, Figure 6b). In 2014, coho salmon catch rate (0.17 fish per boat trip) was well below rates observed in recent years, however, was comparable to (+4.2%) the long-term average (Figure 6, Table A7b). Harvest rate (0.11 fish per boat trip) was also comparable to (-1.9%) the long-

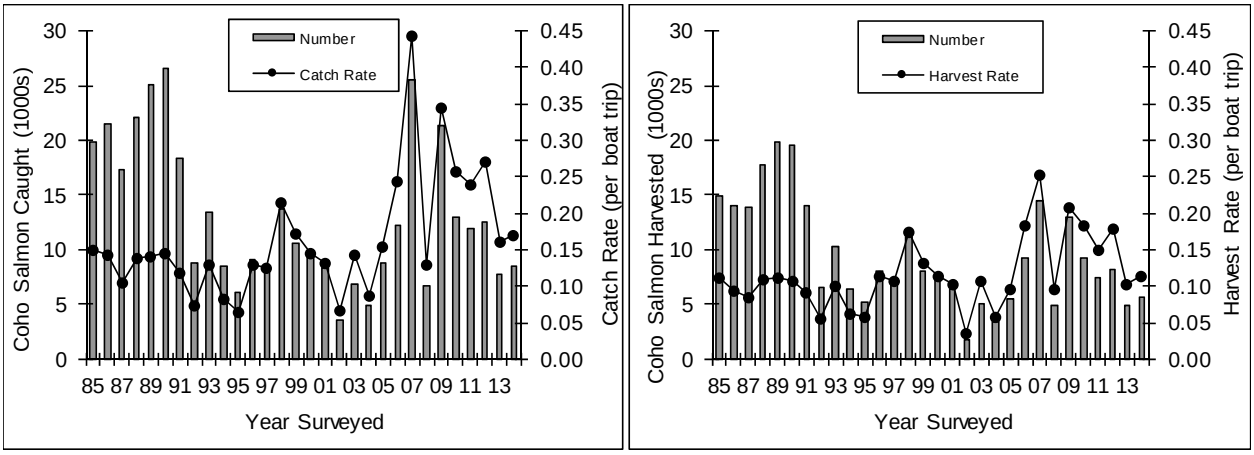

Figure 6. Total coho salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2014.

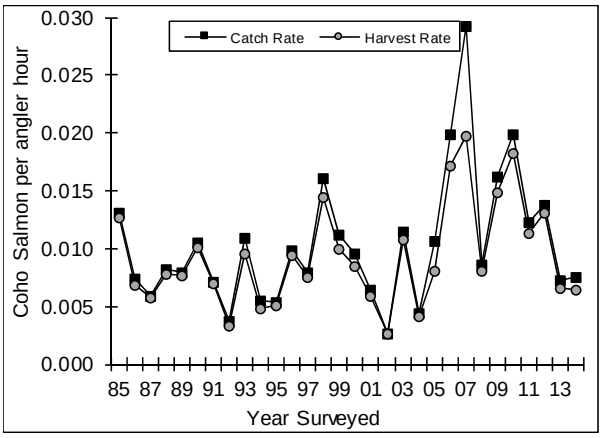

Figure 6b. Charter boat catch rate and harvest rate per angler hour for coho salmon, April 15 – September 30, 1985-2014.

term average. In 2014, charter boats targeting trout and salmon caught 33.9% of the coho salmon caught by all trout and salmon fishing boats. Among charter boats, coho salmon catch and harvest rates (0.008 and 0.006 fish per angler hour, respectively) were well below long-term averages (-27.8% and -31.4%, respectively; Figure 6b, Table A7b). Among noncharter boats, the 2014 catch and harvest rates were 0.010 and 0.006 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 5b and 6c). For the 17th consecutive year, the west area experienced the highest coho salmon catch rate among all regions (0.37 fish per boat trip; more than 4.5-fold higher than in the east area). The lowest coho salmon catch rate occurred in the east area (0.08 fish per boat trip; comparable to [+6.6%] the long-term average; Figure 5b). Catch rate was highest during April (0.63 per boat trip, 52.2% above the April long-term average), May (0.42 per boat trip, 61.8% above the May long-term average), and September (0.25 per boat trip, 83.1% above the long-term average; Figure 6c). Coho salmon catch rates per boat trip were well below respective long-term averages each month June - August (range: -27.3% [June] to -67.3% [July]; Table A7b).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2014, weight: 1988-2014, scale samples for age determination: 2000-2014). 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 2000-2014, were determined using monthly length frequency distributions, and age and length data derived from fish aged by scales collected in the respective year.

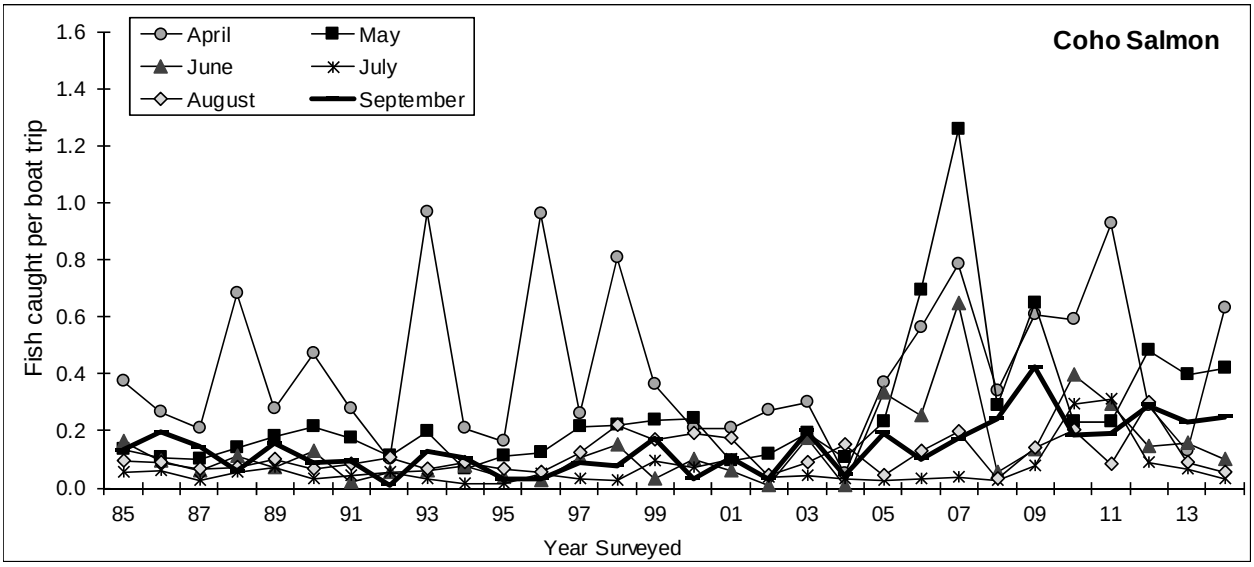

Figure 6c. Coho salmon caught per boat trip April through September, 1985-2014. Note: Catch rate varied by month within each area surveyed.

Each year, the majority (>73.8%) of coho salmon harvested in the open lake were age 2 (30-year average = 95.5% of those harvested were age 2; Table A8). In 2014, 97.2% of coho salmon sampled were age 2. There were no age-1 coho sampled during 2010-2014. This was the sixth 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 and angler desire to keep small coho salmon). 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 25 out of 30 years surveyed. In 2014, 2.8% of coho salmon sampled were age 3.

Condition indices for coho salmon in 2014, as determined from predicted weights of standard length fish, were below previous 26-year averages for smaller sized fish (1988-2013; range: -7.2% [18-in] to -0.3% [24-in]) but were above average for larger sized fish (1988-2013; range: +1.6% [26-in] to +5.2% [30-in]; Table A8). Condition of coho salmon in the largest size groups (28-in and 30-in) were among the highest in the time series. Mean length of age-2 coho salmon sampled in April 2014 was 18.3 inches, the lowest April mean length in the data series. The mean length of age-2 in September 2014 was 26.3 in, the third lowest in the data series. Despite the relatively small size of coho salmon in April and September, growth through the season was good (1.9 in per month and the third best in the data series; Table A8).

Chinook Salmon

Catch and Harvest

Chinook salmon dominated the catch and harvest of trout and salmon in New York's Lake Ontario boat fishery annually since 2003, and was the most commonly captured salmonine in 19 of the 30 years surveyed. From 1985-2002 Chinook salmon represented an average of 28.3% of the total salmonid catch among trout and salmon boats. From 2003-2013, 46.7% of all salmonines caught were Chinook salmon. In 2014, Chinook salmon catch was an estimated 76,626 fish (±23.8%), representing 38.2% of the total 2014 salmonine catch (Figure 7, Table 1, Table A9a).

Of Chinook salmon caught in 2014, 62.6% 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 (2003-2014 average percent harvest=58.7%) was 15.2% lower than during the 1985-2002 time period (average=73.9%). The recent decline in percent

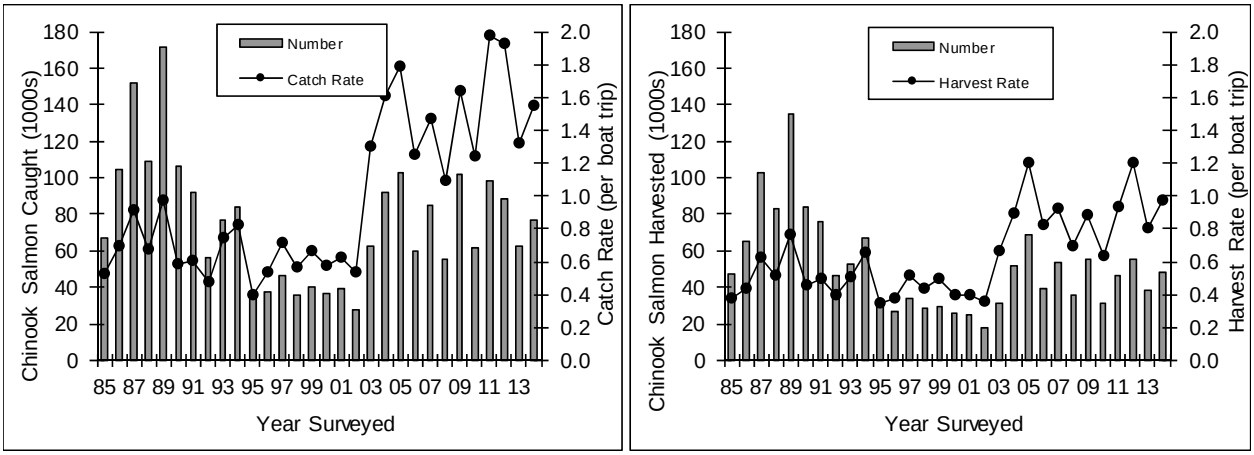

Figure 7. Total Chinook Salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2014.

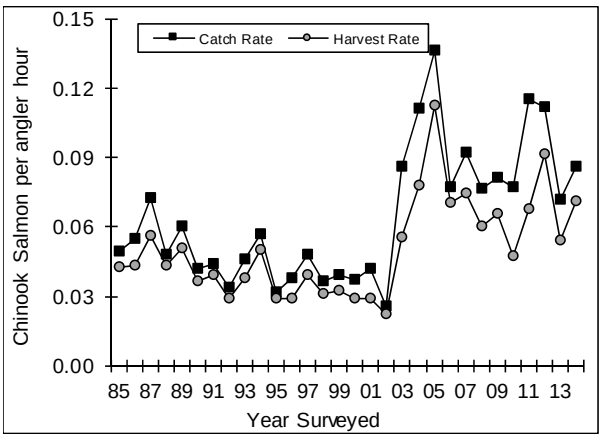

Figure 7b. Charter boat catch rate and harvest rate per angler hour for Chinook salmon, April 15 – September 30, 1985-2014.

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 2014 was estimated at 47,935 Chinook salmon (±28.7%), which represented 44.9% of the total salmonine harvest (Figure 7, Table 1, Table A9a).

As is typically observed, the majority of the Chinook salmon catch and harvest in 2014 occurred during August (29,562 and 16,908, respectively; Table A9a). The highest regional contribution of Chinook salmon catch typically occurs in the west area (27 of 29 years 1985-2013); however, in 2014 highest catch occurred in the east/central area (35.3% of total Chinook salmon catch). The west area had the second highest catch (33.4% in 2014) for only the third time in the 30 years surveyed (Table A9a).

Fishing Quality

The highest Chinook salmon fishing quality occurred for twelve consecutive years (2003-2014) in the 30-year data series (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 2014 lake-wide catch rate among all boats fishing for trout and salmon was 1.6 Chinook salmon per boat trip, comparable to (+1.4%) the previous 10-year average and 59.3% above the long-term average (Figure 7, Table A9b). In 2014, charter boats targeting trout and salmon caught 47.6% of the Chinook salmon caught by all trout and salmon anglers. Among charter boats, the 2014 Chinook salmon catch rate was 3.1 fish per boat trip, a 39.5% increase compared to the long-term average (Table A9b). Charter catch rate per angler hour was 0.09 Chinook salmon, a slight decrease (-9.5%) compared to the previous 10-year average, but 35.5% above the long-term average and more than two times higher than during 1985-2002 (1985-

2002 average=0.045; Figure 7b). Among noncharter boats, the 2014 catch rate was 1.2 Chinook salmon per boat trip and 0.08 per angler hour, which were among the highest rates experienced by noncharter anglers (Table A9b).

Chinook salmon harvest rates were also the highest estimated in recent years, with the 2003-2014 estimates 86.5% higher, on average, than those prior to 2003 (1985-2002 average = 0.48 fish per boat trip, 2003-2014 average = 0.89; Figure 7, Figure 7b, Table A9b). The 2014 lake-wide harvest rate among boats seeking trout and salmon was 1.0 Chinook salmon per boat trip, a 59.3% increase compared to the long-term average (Figure 7, Table A9b). Among charter boats, the 2014 lake-wide harvest rate of 2.5 Chinook salmon per boat trip was a 43.0% increase compared to the long-term average (Figure 7b, Table A9b). Charter boats harvested 0.07 Chinook salmon per angler hour in 2014 (Figure 7b). Among noncharter boats, the harvest rate was 0.6 Chinook salmon per boat trip, a 38.8% increase compared to the long-term average (Table A9b).

As with the other species, Chinook salmon catch rates vary by region and season. In general, 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 5b and 7c). 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 2014 was highly dependent on where and when anglers were fishing. Fishing quality was good to excellent April to mid-June, relatively poor from mid-June through mid-August, then improved for the remainder of the open lake season.

Fishing quality through the season also differed between areas. The 2014, Chinook salmon catch rate in the west area was 15.9% lower than the 2003-2013 (i.e. the years of highest catch rates) average and the second lowest for that time period in that area, but did remain the highest among the 4 areas (2.1 Chinook per boat trip; Figure 5b). The west/central and east/central areas experienced April-September catch rates (1.6 and 1.7 Chinook per boat trip, respectively) above 2003-2013 averages (+19.7% and +33.1%, respectively); however, fishing quality depended on the month (e.g., worst July catch rate in the west/central area for the 2003-2014 time period, third best May and June for the west/central area; Figure 7c). East area catch rate of Chinook salmon was comparable to (-2.4%) the 2003-2013 average (Figure 5b. In 2014, the highest Chinook salmon catch rate in the east did not occur until September. Monthly catch rates were well below the 2003-2013 averages for April (-57.6%) and July (-20.8%), were above average in May (+18.2%), June (+17.6%), and September (+24.5%), and catch rate was comparable to the 2003-2013 average in August (-3.0%).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2014, weight: 1988-2014, scale samples for age determination: 1991-2014). 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 1991-2014, 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 27 of the 30 years surveyed, Chinook salmon sampled from angler harvest were dominated by age-2 and age-3 fish (1985-2014 averages: age-2 = 38.4%, age-3 = 47.0% of fish sampled; Table A10). In 2014, angler harvest consisted of 52.7% age-2 fish and 36.5% age-3 fish. Ages 1 and 4 typically represent small components of angler harvest (age 1=8.3% and age 4=2.5% in 2014).

To evaluate Chinook salmon growth, we determined mean length-at-age by month for samples collected July through September (data collected from 1991-2014; Figure A1, Table A11). Growth was good to excellent in recent years, however, was below average in 2014. Average length of age-1 Chinook salmon was below average each month July-September. The 2014 August mean length of age-1 was 19.6 inches, 0.3 inches shorter than the long-term (1991-2013) mean. Of the ten longest age 1s sampled from 1991-2010, eight were collected in 2010, including the top three. No record length age-1 Chinook salmon were sampled during 2012-2014. 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 in 2013 (31.1 in), then again in 2014 to 30.0 (0.6 in shorter than the 1991-2013 mean; Figure A1, Table A11). Mean length of age 3s was also below average in 2014 (August mean 36.5 in, 0.3 in shorter than the long-term mean).

The oldest Chinook salmon sampled in Lake Ontario are age-4 and comprised a small percentage of the total Chinook salmon sampled (n=20 or 2.5% of all Chinooks processed in 2014; 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.

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 1988-2014 (Table A10) and showed no statistically significant trends over the 27-year data series. In 2014, predicted weights of all seven lengths were below their respective long-term averages (range: -4.3% to -2.2%; Table A10). The decrease in condition was greatest for the larger Chinooks salmon, e.g. 36- and 40-inch fish were 0.8 and 1.2 pounds lighter than the long-term average for fish the same length. Reduced growth and condition is partly attributed to colder than typical water temperatures and a decrease in condition of alewife (Walsh et al. 2015), the primary forage for Chinook salmon (Lantry 2001).

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 (Connerton et al. 2015). 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. (2011, 2012, 2013, 2014, 2015) report the percentages of unmarked (i.e., wild) Chinook salmon determined from data collected during this survey (i.e., Lake Ontario Fishing Boat Survey) and additional sampling efforts conducted in New York and Ontario waters. The percentage of wild Chinook salmon (ages 2-4) differed between the three areas that Connerton et al. (2014) evaluated (i.e., Ontario waters, NY west region [includes Fishing Boat Survey sites in the west and west/central areas], and NY east region [includes Fishing Boat Survey sites in the east/central and east areas]; Table A1). Wild Chinook were an important component of the Lake Ontario fishery averaging 47% of the age-2 and age-3 Chinook salmon harvested in the lake. More detailed discussions of the mass marking program, methods, and 2010-2014 results of open lake and tributary collections are reported in Connerton et al. (2011, 2012, 2013, 2014. 2015).

Stocking Level Verses Relative Harvest

To permit between year comparisons of harvest-at-

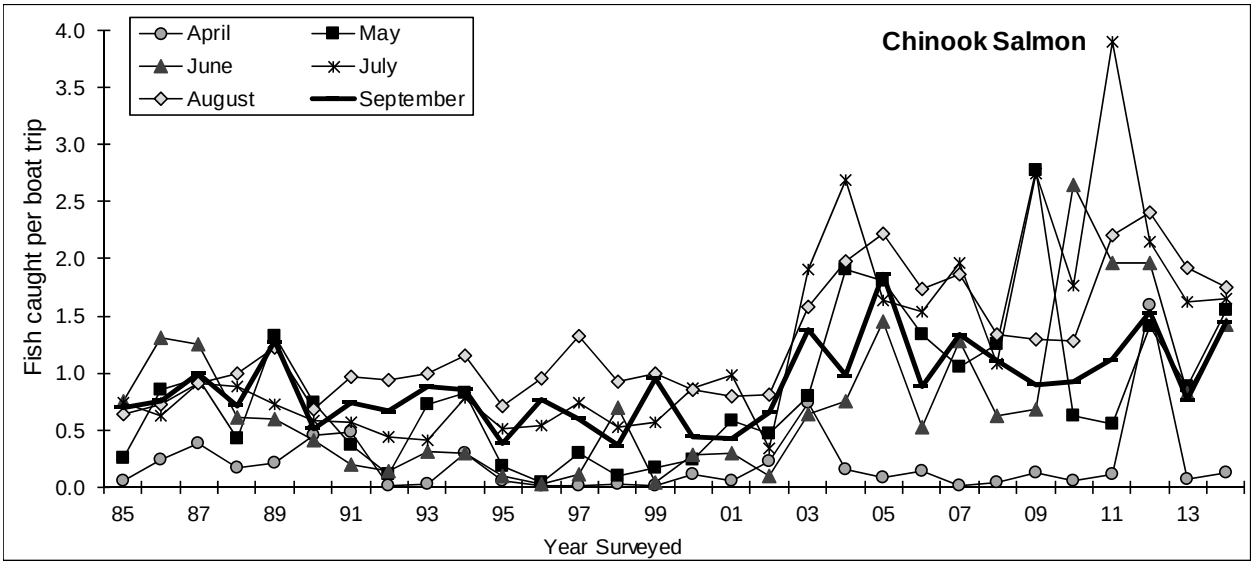

Figure 7c. Chinook salmon caught per boat trip April through September, 1985-2014. Note: Catch rate varied by month within each area surveyed.

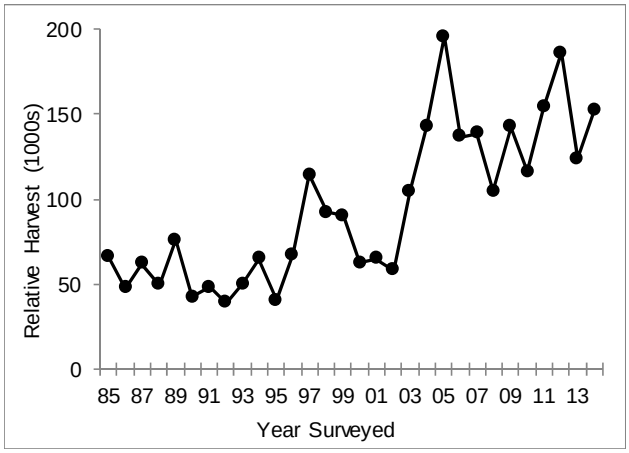

Figure 8. Relative harvest of Chinook salmon per 150,000 boat trips targeting trout and salmon, per 2,000,000 fingerling equivalents stocked.

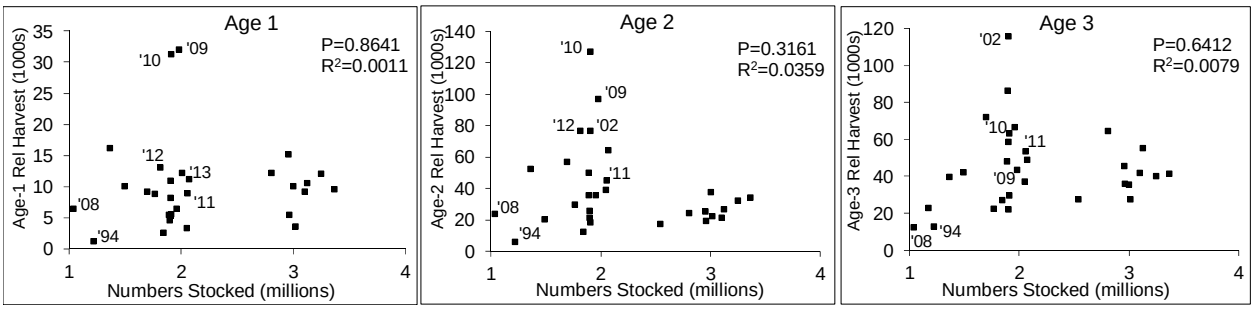

Figure 9. Number of fingerling equivalents stocked and relative harvest of age-1 (1984-2013 year classes), age-2 (1983-2012 year classes), and age-3 (1982-2011 year classes) Chinook salmon.

age data, we calculated age-specific harvest rates (age-specific numbers of Chinook salmon harvested per 150,000 boat trips April 15 - September 30; Table A12; Eckert 2007), hereafter termed relative harvest. Determination of percent contribution by age of Chinook salmon harvested during 1985-2014 was described above.

Chinook salmon relative harvest (harvest per 150,000 targeted fishing boat trips; Table A12) was variable and appeared most affected by year class strength. The year class-specific total relative harvest of age-1 through age-4 fish (1984-2010 year classes) varied from a high of 224,787 fish for the 2010 year class (harvested at ages 1 to 4 from 2011 to 2014, respectively) to a low of 20,497 fish for the 1994 year class (harvested at ages 1 to 4 from 1995 to 1998, respectively), a 10.9 fold difference (Table A12). By comparison, survey year-specific total relative harvest (1985-2014 survey years) varied from the high of 179,857 fish in 2005 to a low of 52,112 fish in 1995, only a 3.5 fold difference. Twelve of the fourteen highest total relative harvest estimates occurred during 2003-2014 (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 between 862,840 (1981 year class) and 3,368,296 (1987 year class) fingerling equivalents. The 2014 total relative harvest (145,452 fish) was the third highest in the 30-year data series (Table A12). This is primarily attributed to the seventh highest return of age-1 fish (2013 year class), fourth highest return of age-2 fish (2012 year class), and ninth highest returns of age-3 and age-4 fish (2011 and 2010 year classes, respectively). To date, returns of age-1 to age-4 fish from the 2010 year class was the highest on record (224,787 fish) and was 10.9% higher than returns of the 2002 year class (202,709 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). Regression analysis of 1985-2014 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 and/or increased relative contribution of wild fish. The age-specific relative harvest data per unit number of fingerling equivalents stocked (Figure A2) showed that this trend was due to increased relative harvest of age 1s (2009-2010 year classes), age 2s (2002-2003, 2005-2006, 2009-2010, and 2012 year classes), and age 3s (2002-2004, 2006, and 2010 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 ($P=0.8641$ and $R^2=0.0011$), age 2 ($P=0.3161$ and $R^2=0.0359$), or age 3 ($P=0.6412$ and $R^2=0.0079$; 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 1993-2013 year classes (1.04-2.08 million fingerling equivalents stocked; Figure 9, Table A13). The lowest and highest age-1 (1994 and 2009 year classes, respectively), age-2 (1994 and 2010 year classes, respectively) and age-3 (2008 and 2002 year classes, respectively) relative harvest estimates occurred after the 1993 stocking cuts. The 2008 year class was stocked at the lowest level (1,038,844 fingerling equivalents) since the 1981 year class (862,840 fingerling equivalents), yet relative harvests at age 1 and age 2 were well within the range of values determined for other year classes that were stocked at levels as high as approximately 3 million fish (Figure 9, Table A13). By age 3, however, relative harvest (12,123 fish) was the lowest in the data series. Relative harvest of the 2008 year class at age 4 (296 fish) was the third lowest in the data series.

Based on relative harvest, the 2009 and 2010 year classes were two of the strongest produced (Figure

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

The 2010 year class performed similar to the 2009 year class, in that relative harvest estimates at ages 1 and 2 (31,194 and 127,157 fish, respectively) were the highest in the data series. Similar to the 2009 year class, hatchery returns of the 2010 year class indicate that a majority may have matured at age 2 (Prindle and Bishop 2014), also consistent with growth and condition data. Relative harvest of the 2010 year class at age 3 (62,817 fish) was the sixth highest, another indication that a majority may have matured at age 2. Relative harvest of this year class at age 4 was the ninth highest (3,620 fish). Additionally, 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 (traditional and/or pen reared fish), improved production and/or survival of wild fish, or a combination of these factors.

Several variables were evaluated to determine which, if any, could predict subsequent age-specific harvest, including all reasonable combinations of stocking levels and age-specific relative harvests. Twenty relationships were tested and ten were significant (p-values$\leq$0.0498). The R^2 values for these relationships ranged between 0.2017 and 0.5787, indicating that although some of the variation could be accounted for, approximately 42%-80% of variation was unaccounted for (i.e., additional factors were contributing to data variability and determining age-specific relative harvest).

Factors contributing to the observed increased relative harvest and the lack of relationship between numbers stocked and fishing quality include: 1) improved survival of stocked fish, 2) increased production and contribution of wild fish in recent years, 3) increased catchability of Chinook salmon (e.g., due to changing preyfish populations, improved angling conditions or techniques, or increased numbers of fish available thereby allowing anglers to harvest more fish from a population of the same relative size), or 4) a combination of these factors. Clipping and tagging stocked Chinook salmon will allow us to estimate relative survival of stocked fish and the contribution of wild fish to the population and the fishery (see Connerton et al. 2015). This information is needed to better manage Lake Ontario's fishery.

Rainbow Trout

Catch and Harvest

Rainbow trout was the third most commonly caught and harvested salmonine in 2014, and represented 18.7% and 15.7% of the total trout and salmon catch and harvest, respectively (Figure 10, Table 1, Table A14a). Estimates peaked in 1989, declined to the lowest levels in 2002, and then showed an upward trend. Rainbow trout catch in 2014 was an estimated 37,462 ($\pm$31.7%) fish. Anglers harvested 44.7% of the rainbow trout that they caught (16,729 $\pm$33.6%), comparable to the previous 5-year average (-2.0%, respectively), but a decrease compared to years prior to 2007 (i.e., the years prior to the October 1, 2006 regulation change that increased the minimum harvestable size from 15 in to 21 in). Prior to the regulation change (1985-2006) an average of 69.7% of all rainbow trout caught by anglers (all fishing boat trips) were harvested. In 2002, when catch and catch rate were the lowest estimated, 80.9% of all rainbow trout caught were harvested. Following the 2006 regulation change an average of 47.5% (2007-2014) rainbow trout caught were harvested.

For 29 consecutive years (1986-2014), the majority of rainbow trout caught and harvested were in the

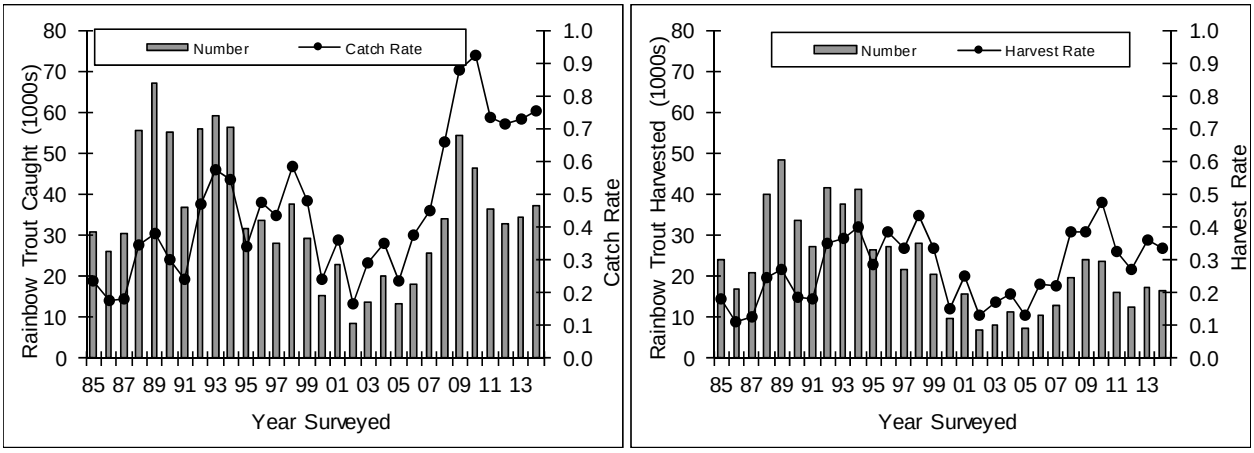

Figure 10. Total rainbow trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2014.

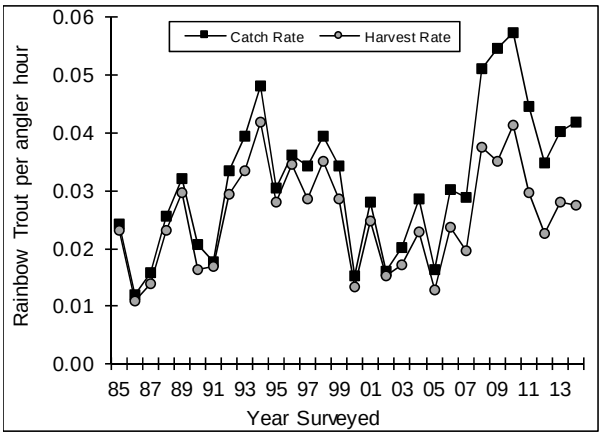

Figure 10b. Charter boat catch rate and harvest rate per angler hour for rainbow trout, April 15 – September 30, 1985-2014.

west area (Lantry and Eckert 2011, Table 14a). In 2014, 44.3% of all rainbow trout caught and 55.1% of those harvested were from the west area. Typically, the majority of rainbow trout were caught and harvested during August (2001-2010 and 2013 averages: 37.5% and 39.9%, respectively). During 2011 and 2012, however, the majority of rainbow trout were caught during July (50.5% and 33.7%, respectively; Table A14a). During 2014, the majority of rainbow trout were caught in June (36.7%; 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 2014 rainbow trout catch rate was the third highest observed (0.76 rainbow trout per boat trip), was comparable to (-4.9%) the previous 5-year average (i.e., years of the highest rates on record), and a 70.4% increase compared to the long-term average (Figure 10, Table A14b). In 2014, charter boats caught 41.9% of all rainbow trout caught by trout and salmon boats. Charter boats caught 1.5 rainbow trout per boat trip (0.04 per angler hour), the sixth highest on record and 31.5% above the long-term average (Figure 10b). Catch rates were the fifth highest on record among noncharter boats (0.6 rainbow trout per boat trip and 0.04 fish per angler hour; Table A14b).

The 2014 lake-wide harvest rate among all boats fishing for trout and salmon (0.34 rainbow trout per boat trip) was comparable to (-7.6%) the previous 5-year average and a 23.8% increase compared to the long-term average (Figure 10, Table A14b). Among charter boats fishing for trout and salmon, the harvest rate was 0.97 rainbow trout per boat trip (Table A14b). Charter boats harvested 0.03 rainbow trout per angler hour (Figure 10b), comparable to (+7.6%) the long-term average. Among noncharter boats fishing for trout and salmon, the harvest rate was 0.18 rainbow trout per boat trip (0.01 fish per angler hour) which was 17.8% above the long-term average (Table A14b).

Rainbow trout monthly and geographical catch rate and harvest rate trends for most years showed monthly rates highest during the summer and lower in April, and geographical rates highest in the west

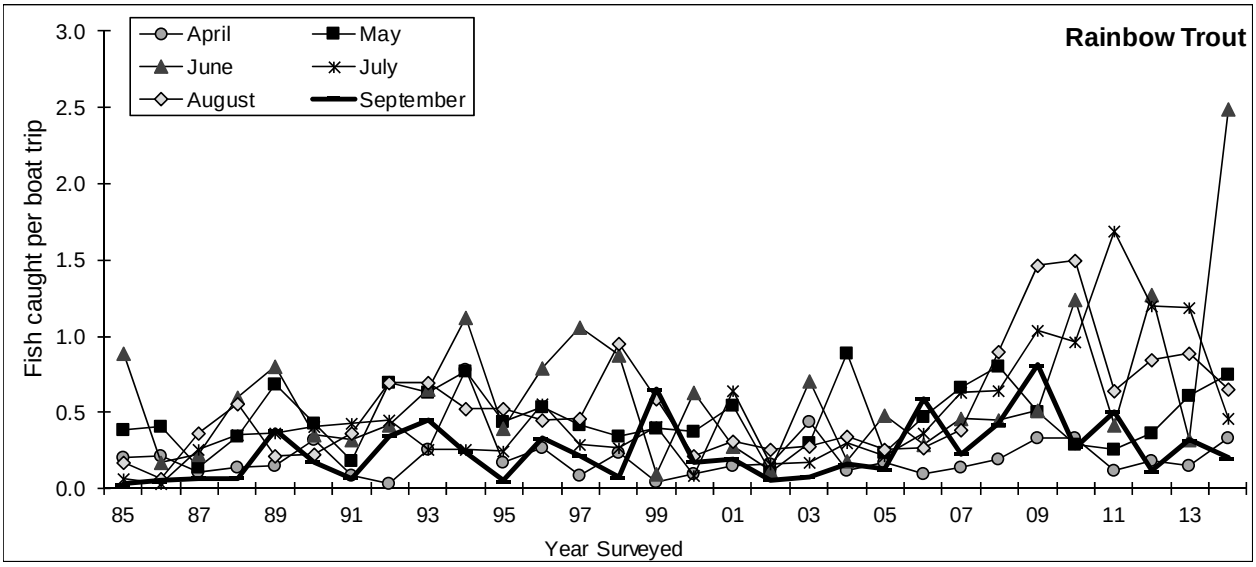

Figure 10c. Rainbow trout caught per boat trip April through September, 1985-2014. Note: Catch rate varied by month within each area surveyed.

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 5b and 10c). In 2014, however, area-specific catch and harvest rates differed from those typically observed. The west area did experience the highest catch rate (1.4 rainbow trout per boat trip) compared to the other areas, however, it was the lowest catch rate that area experienced since 2007 (Figure 5b. The west/central area catch rate (1.2 fish per boat trip) was the second highest experienced for that area and well above the long-term average (+175.3%). The east/central and east areas had catch rates (0.69 and 0.16, respectively) lower than the west and west/central areas, however, those rates were more than 2.5- and 3.4-fold higher than respective long-term averages (Figure 5c).

Seasonal trends in rainbow trout catch rate also differed from those typically observed (Figure 10c). Rather than the highest catch rates occurring in July and August, the highest catch rates occurred during May (0.75 fish per boat trip and fourth highest May estimated) and June (2.50 fish per boat trip and the highest observed; Table A14b). Rainbow trout catch rates were above previous 5-year monthly averages April – June (range: +48.2% [May] to +344.0% [June]) and rates were below previous 5-year averages July - September (range:-62.2% [July] to -38.7% [August]).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2014, weight: 1988-2014). Scale samples were collected from rainbow trout processed for biological data each year 1996-2014; 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 2014 open lake season was the eighth 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 eight years since the regulation (2007-2014) was 10.6%, a significant decrease compared to the eight years prior to the regulation change (2000-2006) when 19.8% of rainbow trout processed were <21.0 in (Chi-square analysis: $X^2 = 56.254 > \chi^2_{[1](.005)} = 7.879$). During 2014, 13.1% of harvested rainbow trout were below the legal 21 in minimum harvestable size.

Weight data were collected each year from 1988-2014 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.

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 2009-2014, and in addition to the NYSDEC stockings, the USGS Tunison Laboratory of Aquatic Sciences reared and conducted experimental stockings of Atlantic salmon (Connerton 2010, 2011, 2012, 2013, 2014, 2015).

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

Fewer Atlantic salmon were caught and harvested 2012-2014 than during 2009-2011, however, those estimates remained well above 1995-2008 levels. During 2014, estimated catch (639 ±59.8%) was a 98.1% increase compared when estimated catch

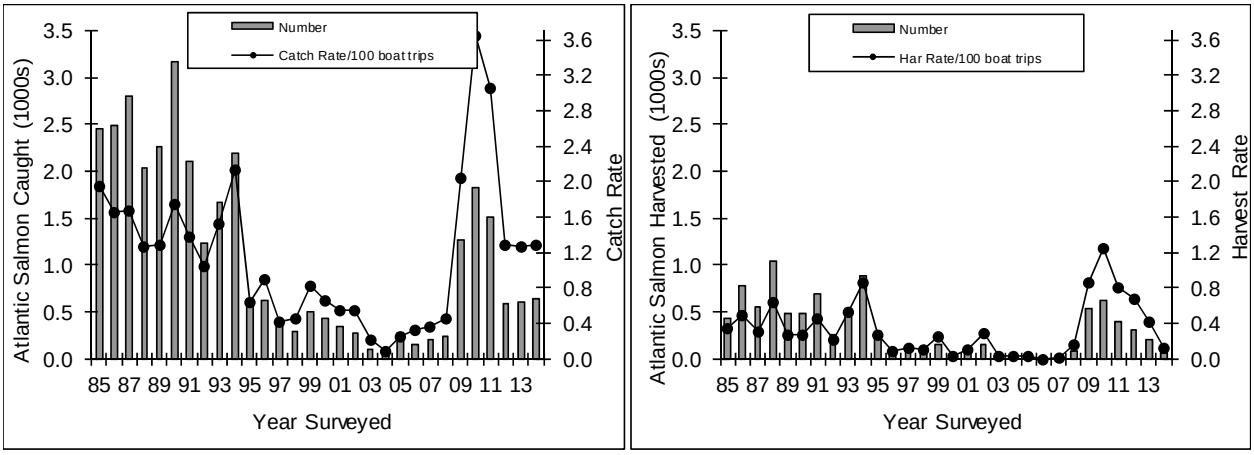

Figure 11. Total Atlantic salmon catch and catch rate, and harvest and harvest rate per 100 boat trips for boats seeking trout and salmon, April 15 – September 30, 1985-2014.

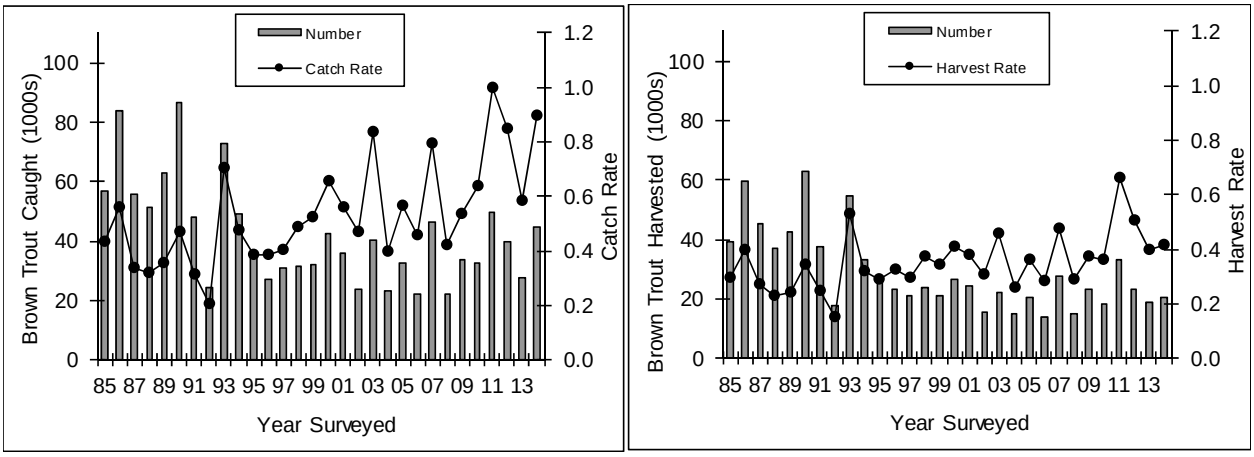

Figure 12. Total brown trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2014.

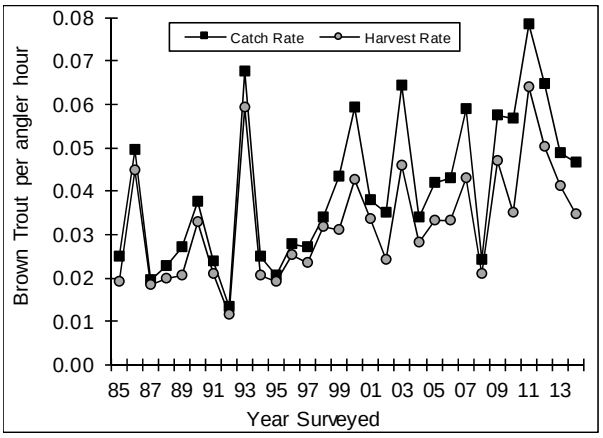

Figure 12b. Charter boat catch rate and harvest rate per angler hour for brown trout, April 15 – September 30, 1985-2014.

was the lowest on record (1995-2008; Figure 11, Table 1, Table A16). Anglers harvested an estimated 66 [±109.1%] Atlantic salmon in 2014. The 2014 Atlantic salmon catch rate (1.3 fish per 100 boat trips seeking trout and salmon) was comparable to levels observed during the late 1980s-early 1990s and was more than 2.6-fold higher than 1995-2008 average rate (average = 0.48 per 100 boat trips). Harvest rate in 2014 (0.13 fish per 100 boat trips seeking trout and salmon) was comparable to 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 (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).

Brown Trout

Catch and Harvest

Brown trout was the second most commonly caught and harvested salmonine in 2014, accounting for 22.2% and 19.3% 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 2014,

estimated catch (44,487 fish [±25.2%]) was a 21.5% increase compared to the previous 5-year average. Estimated harvest (20,626 fish [±24.0%]) was an 11.6% decrease compared to the same time period (Figure 12, Table 1, Table A17a). In 2014, 46.4% of brown trout caught were harvested, a 27.3% decrease compared to both the previous 5-year and 10-year averages.

The east/central area typically accounted for the highest proportions of brown trout catch and harvest (1985-2007, 2009-2011, and 2013-2014 average = 52.5% of total catch; 35.4% in 2014). 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). For only the second year in the data series, the 2014 estimated catch in the west area was the second highest among the four areas surveyed (27.3% of total brown trout catch), and was the highest estimate observed for the west area (2014: 12,153 brown trout caught; 1985-2013 average = 3,930). The majority of brown trout catch during 2014 occurred during April and May (64.9% of total catch; Table A17a).

Fishing Quality

Brown trout catch rates (lake-wide, charter and noncharter) were variable over the 30-year data series with no trend (Figure 12, Figure 12b, Table A17b). In 2014, among trout and salmon fishing boats, brown trout catch rate (0.9 fish per boat trip) was well above the long-term average (+72.3%). Trout and salmon charter boats caught 58.2% of brown trout caught in 2014. Catch rate among charter boats was 1.7 brown trout per boat trip in 2014, comparable to (-4.8%) the previous 10-year average and a 16.1% increase compared to the long-term average (Figure 12b, Table A17b). The charter boat catch rate per angler hour was 0.05, a 16.2% increase compared to the long-term average (Figure 12b). Noncharter boats caught an estimated 0.7 brown trout per boat trip (0.05 per angler hour), a 101.7% increase compared to the long-term average (Table 17b).

Brown trout harvest rates (lake-wide, charter and noncharter) were also variable and showed no trends over time. (Figure 12, Figure 12b, Table 17b). Among boats seeking trout and salmon, the 2014 lake-wide harvest rate was 0.4 brown trout per boat trip, an 18.5% increase compared to the long-term average (Figure 12, Table A17b). Among charter boats fishing for trout and salmon, the 2014 harvest rate was 1.2 brown trout per boat trip (0.05 fish per angler hour), comparable to (+6.2%) the long-term average (Figure 12b, Table A17b). Among noncharter boats fishing for trout and salmon, the 2014 harvest rates were 0.22 brown trout per boat trip and 0.02 fish per angler hour.

Brown trout monthly and geographical catch and harvest rate trends for most years showed rates highest in April and May, declining from April through September, and highest in the east/central area (Lantry and Eckert 2013; Table A17b, Figures 5b and 12c). During 2014, seasonal trends were typical, with brown trout catch rates highest in April (7.0 per boat trip, highest observed) and May (1.8 fish per boat trip, second highest observed). Record and near record rates in April and May are partly attributed to increased catch rates in the western half of the lake compared to previous years. The June 2014 brown trout catch rate was a 75.6% decrease compared to the long-term average and was the lowest in the data series (Figure 12c). Catch rates improved for the remaining months and were well above long-term averages (range: +17.1% [August] to +201.3% [September]; Table A17).

Unlike all previous years when catch rate was highest in the east/central area, the highest brown trout catch rates in 2014 occurred in the western half of the lake (Table A17b; Figure 5b). The west/central area had the highest catch rate (1.05 fish per boat trip) which was among the highest recorded for that area and a 71.0% increase compared to that areas' long-term average. The west area catch rate (1.00 fish per boat trip) was the highest observed in the west area and was 5.7 times higher than the long-term average. When interviewed, anglers indicated that they targeted brown trout when other species were not available. Catch rates in the east/central (0.99 fish per boat

trip) and east (0.66 fish per boat trip) areas were +11.5% and 52.5% increases, respectively, compared to respective long-term averages (Table A17, Figure 5b). The east area has experienced higher brown trout catch rates over the last 10 years (2005-2014 average = 0.44 per boat trip) compared to the earlier time period (1985-2004 average = 0.26 per boat trip).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2014, weight: 1988-2014). Scales were collected from nearly all brown trout processed by creel agents during 1993-2014 (i.e., 22 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 2011-2014, none of the brown trout sampled were age-1 (Table A18); the majority were age 2. During 1993-2012, 66.0% (2004) to 88.8% (1993) of all brown trout harvested were age-2 fish. In 2013 and 2014, age-2 brown trout represented the lowest percentages observed from 1993-2014 (60.0% and 62.6% were age 2, respectively). Conversely, the 2013 and 2014 contributions of age-3 brown trout (34.6% and 28.8%, respectively) were the highest observed from 1993-2014. For nearly all years, <4% of brown trout harvested were age-4 fish; however, in 2014 7.8% of browns were age-4, the highest observed from 1993-2014. From 1993-2014, age-5 or older brown trout comprised an average of 0.7% (0.8% in 2014; Table A18). Few brown trout age 6 or older were observed, and in the 22 years that scale samples were aged, only nine age-6 and one age-7 brown trout were observed.

We evaluated brown trout condition by determining predicted weights of seven standard length groups (16-28 in, by 2-in length increments; Table A18). Predicted weights for all lengths evaluated were record low values among the 27 years where weight data were collected. Reduced growth and condition was also observed for Chinook salmon, coho salmon, and 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 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

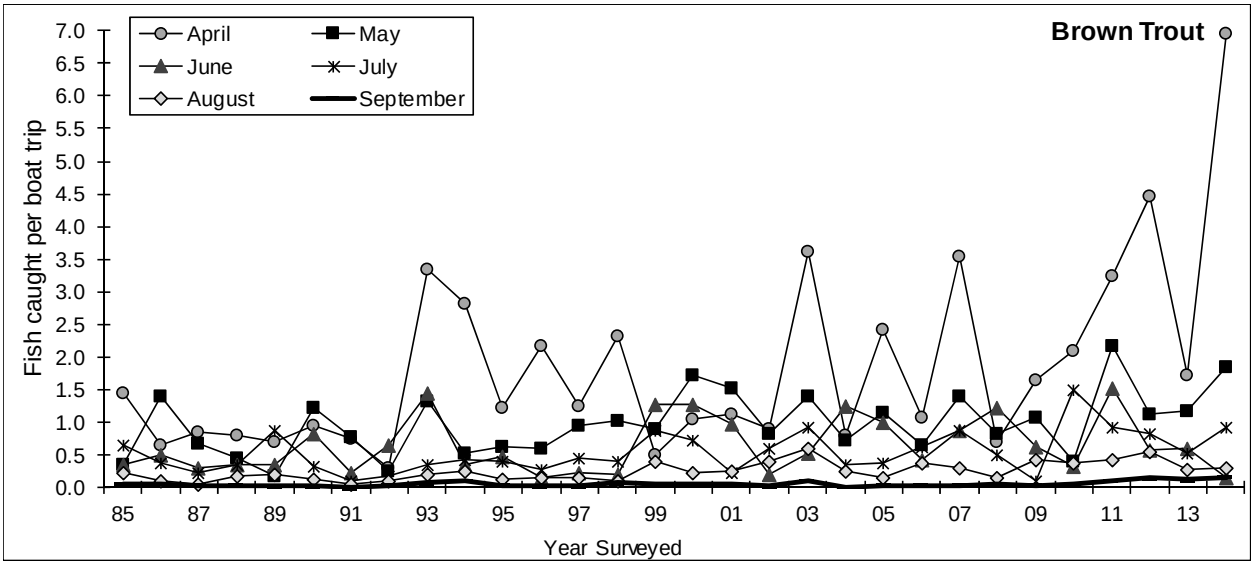

Figure 12c. Brown trout caught per boat trip April through September, 1985-2014. Note: Catch rate varied by month within each area surveyed.

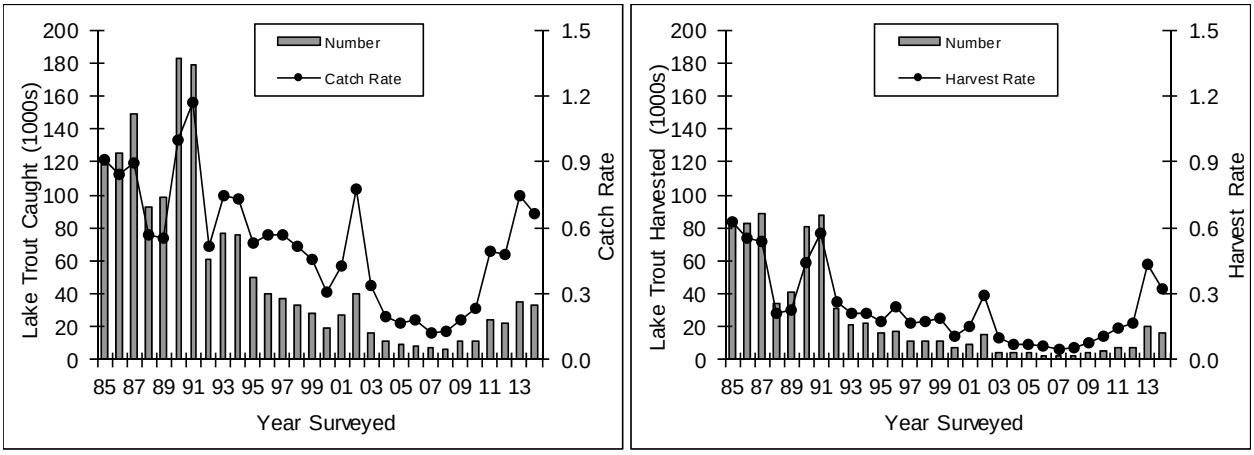

Figure 13. Total lake trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2014.

could be within the 25-30 inch slot. In 2014, lake trout was the fourth most commonly caught and harvested trout or salmon species, contributing 16.5% and 14.8% of the total salmonine catch and harvest, respectively (Table 1, Table A19a). In 2014, estimated lake trout catch (33,108 [±31.3%] fish) and harvest (15,870 [±33.5%]) were 122.7% and 154.2% increases compared to previous 10-year averages, respectively (Figure 13, Table 1, Table A19a), and remained at levels observed in the early to mid-1990s for a second consecutive year. 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 2015). Increased lake trout catch, which began in 2011, is most likely attributed to increased lake trout abundance in recent years (Lantry and Lantry 2015), although some anglers reported specifically targeting lake trout when fishing quality for other species (e.g., brown trout and Chinook salmon) was considered low in 2013 and 2014.

Prior to 2001, the east area accounted for the highest proportion of lake trout catch and harvest for nearly every survey year (Lantry and Eckert 2011; Table A19a). Since 2001, the majority of lake trout were caught in the west or west/central areas (11 of the 13 years 2001-2013). In 2014, the

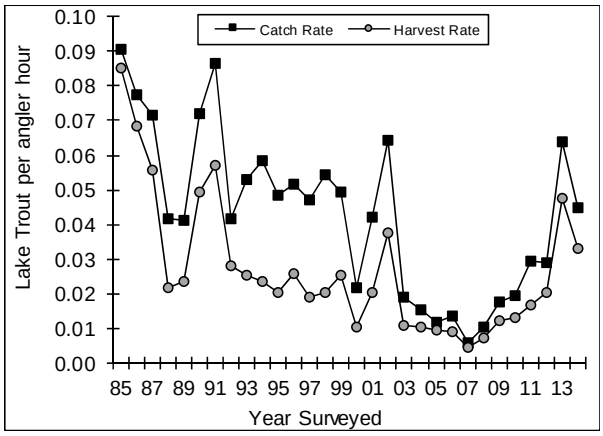

Figure 13b. Charter boat catch rate and harvest rate per angler hour for lake trout, April 15 – September 30, 1985-2014.

majority of lake trout were caught in the west/central area (10,454 fish), the highest estimated for that area since 2001 (+38.9% compared to the long-term average; Table A19a). The east area experienced the second highest catch of lake trout in 2014 (10,262 fish) and the highest estimated catch for that area since 1999. The 2014 monthly catch and harvest estimates were above previous 10-year averages each month April-August (catch range: +51.6% [May] to +282.2% [August]; harvest range: +47.5% [May] to +378.0% [August]) and were below 10-year averages during September (catch: -23.6, harvest -58.3%; Table A19a).

Fishing Quality

Low lake trout abundance during the mid-2000s (Lantry and Lantry 2015) 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). Catch rates increased each year 2008-2011 (0.13 to 0.48 fish per boat trip), then increased again in 2013 (0.75 per boat trip) to the highest rate since 2002 (Figure 13, Figure 13b, Table A19b). In 2014, catch rate remained near the 2013 level (0.67 fish per boat trip) and 26.0% above the long-term average. The recent increase coincided with low but consecutive increases in the adult lake trout abundance index (Lantry and Lantry 2015). In 2014, 43.6% 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 (1.6) and per angler hour (0.05) and were comparable to the long-term averages (+4.0% and +2.2%, respectively; Table A19b, Figure 13b). Catch rate among noncharter boats fishing for trout and salmon was 0.44 lake trout per boat trip and 0.03 fish per angler hour (Table A19b).

The 2014 lake-wide harvest rate among boats seeking trout and salmon was 0.32 lake trout per boat, the seventh highest in the data series (Figure 13, Table A19b). Among charter boats fishing for trout and salmon, the 2014 harvest rate was 1.2 lake trout per boat trip (0.03 per angler hour; Figure 13b, Table A19b). Among noncharter boats fishing for trout and salmon, the harvest rate was 0.11 lake trout per boat trip (0.01 per angler hour; Table A19b).

For 17 of the last 18 years (1997-2014), the west/central area experienced the highest lake trout catch rate (Table A19b, Figure 5b). In 2014, anglers fishing the west/central area experienced the highest catch rate (1.7 lake trout per boat trip and the highest in the data series for the west/central area) and harvest rate (1.0 per boat trip) of the four areas (Table A19b). Catch rate per boat trip was a 190.3% increase compared to that area's previous 10-year average and a 121.9% increase compared to the long-term average. Anglers fishing the east area experienced a catch rate of 0.7 lake trout per boat trip, the second highest area-specific catch rate in 2014, and a 13.6% increase compared to the long-term average. Lake trout catch rate in the west area of the lake (0.63 per boat trip) was a 15.9% increase compared to the long-term average. East/central area catch rate (0.29 per boat trip) declined from recent years and was a 28.9% decrease compared to the long-term average. Comparisons by month showed that catch rates were well above their respective long-

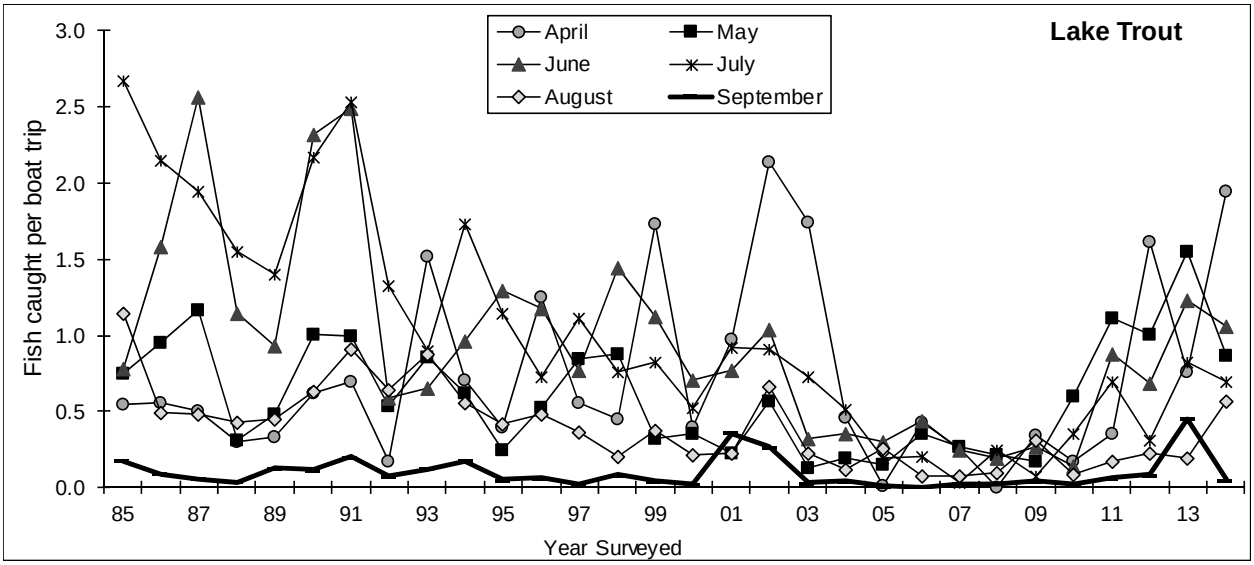

Figure 13c. Lake trout caught per boat trip April through September, 1985-2014. Note: Catch rate varied by month within each area surveyed.

term averages during April-June and in August (range: +12.0% [June] to +181.6% [April]; Table A19b), and below average in July (-31.5%) and September (-44.5%; Figure 13c).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2014, weight: 1988-2014). The 2014 fishing season was the eighth 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) 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 seven years after the regulation change (2007-2013), an average of 41.4% 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). In 2014, 59.9% of all lake trout harvested were within the 25-30 inch slot, the highest observed. In 2014, the majority of tagged lake trout in angler harvest were from the 2008-2010 year classes (2008 year class at age 6: 33.3%, 2009 year class at age 5: 20.0%, 2010 year class as age 4: 16.0%). The 2006 and 2007 year classes continued to be well represented (11.3 and 12.7% of tagged lake trout harvested, respectively) in 2014.

Smallmouth Bass

Catch and Harvest

Prior to October 1, 2006, NYSDEC fishing regulations established the smallmouth bass open season in Lake Ontario from the third Saturday in June through November 30 and allowed anglers to harvest a daily limit of five smallmouth bass with a minimum length of 12 inches. The regulation was changed effective October 1, 2006, establishing pre-season catch and release of smallmouth bass from December 1 through the Friday preceding the third Saturday in June (excluding Jefferson County's Lake Ontario waters). April 15 through June 20, 2014 was the eighth pre-season catch and release period covered by this survey. During that period, there were an estimated 295 (±69.5%) fishing boat trips targeting smallmouth bass with effort occurring during May (73 boat trips) and June 1-20 (222 boat trips; Table A2).

Among all fish species, smallmouth bass was the most commonly caught species each year 1985 and 1987-2006. In 2007, smallmouth bass became the third most commonly caught species in the open lake boat fishery, preceded by yellow perch and Chinook salmon (Table A21a). Since 2009, smallmouth bass was the fifth most commonly caught species. The 2014 catch estimate of 31,807 fish (±57.3%; April 15 - September 30) was a 76.2% increase compared to the 2010 record low; however, was 83.8% below the long-term average (Table 1, Table A21a). During the traditional open fishing season, 29,187 smallmouth bass were caught and 42.3% of those were harvested (12,339 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 increased in 2013 and 2014, but remains among the lowest rates observed. Catch and harvest rates during the 2014 traditional bass season were 4.2 and 1.8 bass per boat trip, respectively (Figure 14, Table A21b) and were comparable to 2013 estimates (-2.1% and +7.6%, respectively). Since 1985 the ten lowest smallmouth bass catch rates occurred during 2005-2014. Smallmouth bass catch rate per angler hour in 2014 was 0.57, a 26.6% increase compared to the previous 5-year average but 71.7% below the 2002 record high (Figure 14b, Table A21b).

Comparisons of 2014 month- and area-specific catch and harvest rates with their respective 2009-2013 averages (Table A21b) showed above average fishing quality during June (+179.2%) and

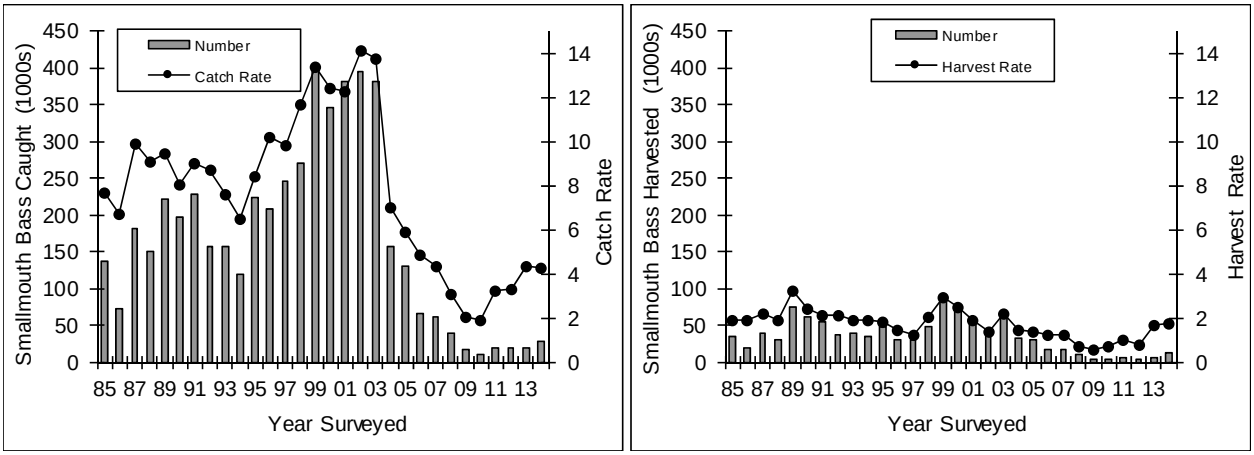

Figure 14. Total smallmouth bass catch and catch rate, and harvest and harvest rate per boat trip for boats seeking smallmouth bass during the traditional open season.

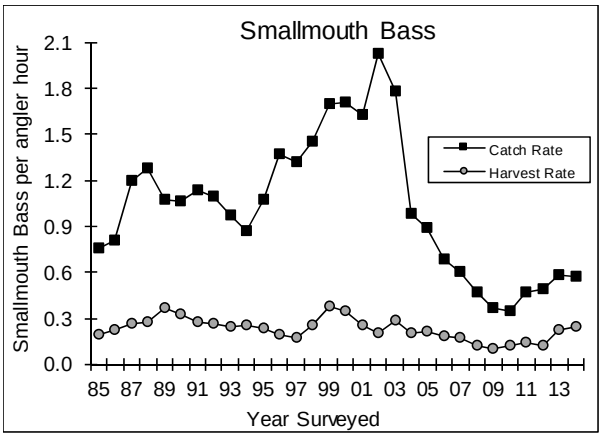

Figure 14b. Smallmouth bass catch rate and harvest rate per angler hour among anglers targeting bass during the traditional open season, 1985-2014.

August (+52.7%), and rates below previous 5-year averages in July (-50.1%), and September (72.2%). The 2014 catch rate was above the previous 5-year average in the west (+13.6%) and east (+31.1%) areas, comparable to average in the west-central area (+0.4%), and was below average in the east-central area (-27.9%; Table A21b).

Additional measures of fishing quality were evaluated. In 2014, 40.0% of boats specifically targeting smallmouth bass during the traditional open season failed to catch at least one bass, the ninth highest value observed (Table A6, Part B), indicating continued poor fishing quality (Table A6). Each year a relatively low percentage of boats harvests the daily creel limit of five bass per angler (1985-2003 average=6.3%). Since catch rates began decreasing after 2003, an even lower percentage of bass boats harvested their limit of bass (2004-2014 average=2.8%). In 2014, 5.8% 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 continue 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 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

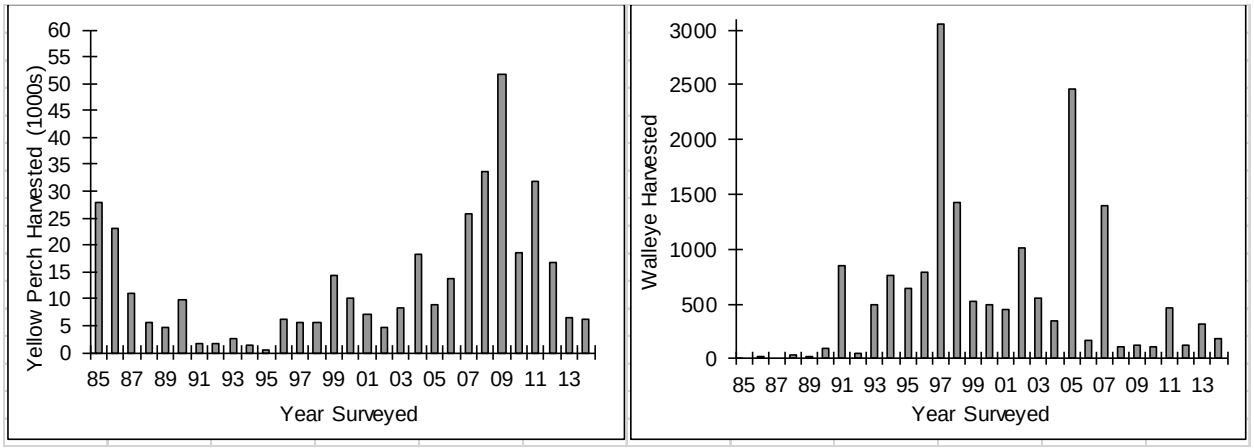

Figure 15. Total yellow perch and walleye harvested by all fishing boats, April 15-September 30 1985-2014.

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 2014 estimated catch (17,966 [±97.1%] fish) and harvest (6,066 [±96.0%] fish) were well below long-term (1985-2013) averages (-39.3% and -53.3%, respectively; Figure 15, Table 1, Table A22). Yellow perch are distributed along much of the Lake Ontario shoreline, however, each year 1996-2014 the greatest proportion of catch occurred in the east/central area by relatively few fishing boats targeting perch (58.1% of total catch in 2014; 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 2015). Similarly, lower estimated catches during 2013 and 2014 coincide with reduced catches in gillnetting assessments 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 2015). 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 2014, there were an estimated 421 walleye caught and 182 harvested in Lake Ontario (±126.4% and ±144.5%, respectively; Figure 15, Table A23). Fisheries assessment data (Lantry 2015) 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 2014, 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 2014 were: northern pike (255 caught, 35 harvested) and largemouth bass (106 caught, 26 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. Cisco (a.k.a lake herring; 297 caught, 270 harvested) were reported in angler creel for the fifth consecutive year (2010-2014). 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 2014, round goby was the eighth most commonly caught species (6,704 [±40.4%] caught, 4,222 [±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 2014, there were an estimated 2,998 (±28.5%) lampreys observed in the fishing boat survey, comparable to 2013 (+2.4%) but a 31.6% decrease compared to the previous 10-year average and the period of time of increased observations (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 2015). Lamprey attack rate decreased from the 2007 peak and, in 2014, there were an estimated 14.9 lamprey per 1,000 trout or salmon caught (Figure 16, Table A24). This rate is the lowest estimated since 2002 however, is still about 2.5-fold higher than the 1986-1995 average rate.

For 11 of the last 14 years (2001-2014) the majority of lamprey observations occurred on Chinook salmon (2001-2014 average=57.9%), which was due, in part, to the large number of Chinook salmon caught by anglers (e.g., 2001-2014 average=43.4% of total trout and salmon catch; Table A5a, Table A9a). In 2014, 58.1% of lamprey attacks were on Chinook salmon (Table A5a, Table A17a, Table A24). Other host salmonines in 2014 were rainbow trout (18.8% of attacks), brown trout (17.9% of attacks), lake trout (2.6% of attacks), and coho salmon (2.6% of attacks; Table A24). There were two reports of lamprey observed on fishing gear in 2014. Among the 29 years of lamprey observation data, there were a total of 36 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

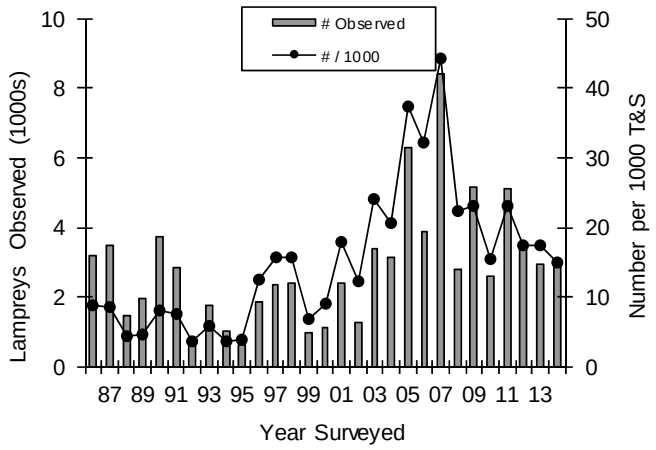

Figure 16. Total lamprey observed, and lampreys observed per 1,000 trout and salmon caught, April 15-September 30, 1985-2014.

caught by anglers was observed with a lamprey attached (range of 1986-1995 averages: 0.02% [coho salmon] – 0.63% [Chinook salmon]). By 1996, the percentage of angler caught salmonines with an attached lamprey increased for all species examined. On average, during 1996-2014, lampreys were observed on 1.1% of coho salmon, 2.6% of Chinook salmon, 1.2% of rainbow trout, 6.0% of Atlantic salmon, and 2.2% of brown trout caught in Lake Ontario. 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 2015). Since 2007, the decrease in attack rate (Figure 16) coincides with a reduced lake trout wounding rate as determined from September gill netting, fewer lampreys observed attached to lake trout in the creel survey, and seven consecutive years of increased lake trout catches in gill nets (Lantry and Lantry 2015).

Acknowledgments

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2014 Lake Ontario Fishing Boat Survey

Appendix Tables and Figures

Table A1. The four geographic areas (Roman numerals) used in analysis of the 1985-2014 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 1985-2014 NYSDEC fishing boat surveys.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Part A: Effort for all fishing boats.											
Seasonal (5½ month) estimates of fishing effort for all fishing boats:											
Fishing Boat Trips	132,102	84,045	65,495	79,167	69,687	76,838	62,104	60,943	56,182	54,605	58,554
Boat Angler Trips	364,721	225,593	182,153	219,647	194,658	221,925	175,820	171,519	160,363	161,620	174,079
Boat Angler Hours	1,980,855	1,101,896	930,174	1,113,767	985,898	1,229,977	905,357	898,339	848,905	937,822	980,409
Anglers/Boat Trip	2.75	2.68	2.78	2.77	2.79	2.89	2.83	2.81	2.85	2.96	2.97
Hours/ Boat Trip	5.35	4.88	5.11	5.07	5.06	5.54	5.15	5.24	5.29	5.80	5.63
Monthly estimates of boat trips for all fishing boats:											
April	11,668	2,524	4,058	3,014	3,131	3,230	2,680	2,529	2,409	2,672	1,935
May	19,916	13,581	8,558	11,796	7,784	15,360	11,111	8,605	9,540	8,368	8,652
June	15,903	11,670	6,941	11,174	8,650	8,351	5,489	6,183	8,128	7,608	8,002
July	23,493	19,512	15,265	16,316	15,507	12,735	12,703	15,024	12,024	11,950	11,234
August	36,835	20,826	18,602	23,131	21,147	19,815	21,764	17,315	15,096	17,404	19,666
September	24,288	15,932	12,071	13,736	13,468	17,346	8,356	11,286	8,986	6,603	9,061
Seasonal estimates of boat trips among four geographic areas for all fishing boats:											
West	31,082	16,734	13,068	18,543	14,276	20,404	16,269	16,248	14,145	14,602	13,674
West/Central	19,388	11,592	9,358	11,461	7,722	10,746	7,011	6,890	7,412	7,648	7,210
East/Central	42,941	31,161	25,153	25,300	25,094	25,448	22,318	19,926	17,410	17,368	18,455
East	38,691	24,558	17,916	23,863	22,594	20,239	16,506	17,879	17,215	14,988	19,215
Part B: Seasonal estimates of total boat excursions (traffic).											
Power Boats:											
Fishing Boats	136,214	85,292	66,243	80,405	70,525	77,410	62,435	61,383	56,979	55,116	59,149
Nonfishing Boats	115,603	86,487	57,544	76,672	80,479	86,372	84,587	69,943	71,318	89,530	70,311
Sail Boats	30,327	12,918	12,186	18,126	19,750	22,224	23,914	23,782	20,703	21,432	19,104
Part C: Seasonal estimates of boat angler trips by residence.											
NY Resident	226,019	138,117	109,629	135,400	115,936	134,954	108,712	105,145	97,153	96,610	106,088
Nonresident	138,702	87,476	72,524	84,247	78,722	86,971	67,108	66,374	63,210	65,010	67,991
% NY Resident	61.6%	61.2%	60.2%	61.6%	59.6%	60.8%	61.8%	61.3%	60.6%	59.8%	60.9%
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	103,594	57,510	47,812	57,620	51,229	62,028	50,059	49,548	46,059	47,520	49,434
Boat Angler Trips	299,157	169,125	142,264	172,001	152,905	189,796	151,747	147,775	138,687	146,900	155,656
Boat Angler Hours	1,758,234	928,097	806,572	968,752	868,237	1,143,095	843,037	831,675	785,271	889,719	917,662
Anglers/Boat Trip	2.90	2.94	2.98	2.99	2.98	3.06	3.03	2.98	3.01	3.09	3.15
Hours/ Boat Trip	5.86	5.49	5.67	5.63	5.68	6.02	5.56	5.63	5.66	6.06	5.90
Monthly estimates of boat trips for boats seeking trout and salmon:											
April	11,524	2,397	4,024	2,998	2,874	3,610	2,610	2,518	2,366	2,575	1,920
May	18,987	12,945	7,959	11,009	7,262	14,731	9,401	8,050	8,388	7,911	8,417
June	10,243	5,363	2,733	5,862	4,760	5,201	3,878	4,313	5,138	6,333	5,489
July	14,129	10,862	8,259	10,212	9,261	8,743	9,233	10,903	9,255	9,651	8,827
August	28,706	14,090	14,496	16,674	16,485	15,192	18,080	14,123	12,910	15,910	16,917
September	20,004	11,853	10,340	10,864	10,586	14,552	6,858	9,642	8,002	5,141	7,864
Seasonal estimates of boat trips among four geographic areas for boats seeking trout and salmon:											
West	26,935	14,363	11,029	16,119	12,440	18,562	14,258	14,715	12,671	13,674	12,092
West/Central	14,345	7,139	6,828	6,962	4,293	7,725	5,574	5,047	5,584	6,634	6,251
East/Central	30,690	17,434	16,768	16,507	17,094	19,173	16,740	15,137	13,596	15,259	15,852
East	31,624	18,574	13,187	18,031	17,403	16,568	13,487	14,649	14,208	11,954	15,239
Percent of total seasonal fishing effort by boats seeking trout and salmon:											
Fishing Boat Trips	75.6%	68.4%	73.0%	72.8%	73.5%	80.7%	80.6%	81.3%	82.0%	87.0%	84.4%
Boat Angler Trips	79.5%	75.0%	78.1%	78.3%	78.6%	85.5%	86.3%	86.2%	86.5%	90.9%	89.4%
Boat Angler Hours	86.8%	84.2%	86.7%	87.0%	88.1%	92.9%	93.1%	92.6%	92.5%	94.9%	93.6%

Table A2 (continued). Summary of effort statistics.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
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	22,805	22,108	13,586	14,509	12,786	8,666	5,855	6,257	6,203	4,273	6,878
Boat Angler Trips	52,432	47,220	30,938	33,135	28,548	18,885	12,106	13,758	13,505	9,082	14,223
Boat Angler Hours	177,533	146,449	96,062	103,494	83,434	48,847	32,603	42,718	41,972	31,569	51,006
Anglers/Boat Trip	2.30	2.14	2.28	2.28	2.23	2.18	2.07	2.20	2.18	2.13	2.07
Hours/ Boat Trip	3.40	3.10	3.10	3.12	2.92	2.59	2.69	3.10	3.11	3.48	3.59
Monthly estimates of boat trips for boats seeking smallmouth bass during the traditional open season:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	3,963	4,626	2,915	2,879	2,325	1,284	634	935	1,525	637	1,900
July	8,013	7,736	5,881	4,738	4,979	2,517	2,212	2,704	2,303	1,403	1,786
August	7,182	6,115	3,743	4,778	3,579	2,878	2,139	1,724	1,646	959	2,312
September	3,647	3,631	1,048	2,114	1,903	1,987	870	894	728	1,275	880
Seasonal estimates of boat trips among four geographic areas for boats seeking smallmouth bass during the traditional open season:											
West	2,640	1,623	1,237	1,561	1,001	1,370	1,051	815	984	352	1,101
West/Central	3,775	3,574	1,512	2,621	2,426	1,453	642	784	1,006	564	609
East/Central	10,547	11,331	6,912	6,649	5,451	3,638	2,768	2,809	2,289	1,174	1,801
East	5,843	5,580	3,925	3,677	3,908	2,204	1,394	1,849	1,924	2,183	3,367
Percent of total seasonal fishing effort by boats seeking smallmouth bass during the traditional open season:											
Fishing Boat Trips	19.8%	26.3%	20.7%	18.3%	18.3%	11.3%	9.4%	10.3%	11.0%	7.8%	11.7%
Boat Angler Trips	16.6%	20.9%	17.0%	15.1%	14.7%	8.5%	6.9%	8.0%	8.4%	5.6%	8.2%
Boat Angler Hours	10.7%	13.3%	10.3%	9.3%	8.5%	4.0%	3.6%	4.8%	4.9%	3.4%	5.2%
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	97	0	73	224	0	0	78	46	29	78	22
SMB pre-opener	207	184	500	496	367	644	292	239	521	191	295
Largemouth Bass	27	0	0	52	16	0	0	13	13	197	62
Yellow Perch	896	717	769	1,203	1,914	1,800	1,901	1,794	1,556	779	712
Walleye	453	570	278	1,210	373	270	470	384	233	249	137
All Other	3,984	2,957	2,476	3,853	3,003	3,863	3,449	2,662	1,568	1,319	1,015
% Northern Pike	0.08%		0.11%	0.28%			0.13%	0.08%	0.05%	0.14%	0.04%
% SMB pre-opener	0.19%	0.22%	0.76%	0.63%	0.53%	0.84%	0.47%	0.39%	0.93%	0.35%	0.50%
% Largemouth Bass	0.05%			0.07%	0.02%			0.02%	0.02%	0.36%	0.11%
% Yellow Perch	0.67%	0.85%	1.17%	1.52%	2.75%	2.34%	3.06%	2.94%	2.77%	1.43%	1.22%
% Walleye	0.55%	0.68%	0.42%	1.53%	0.54%	0.35%	0.76%	0.63%	0.41%	0.46%	0.23%
% All Other	3.17%	3.52%	3.78%	4.87%	4.31%	5.03%	5.55%	4.37%	2.79%	2.42%	1.73%
Part G: Charter fishing boats.											
Seasonal (5½ month) estimates of fishing effort for charter boats:											
Fishing Boat Trips	13,666	9,284	9,099	9,448	9,012	9,885	8,612	8,332	7,632	9,343	9,718
Boat Angler Trips	68,845	47,406	45,872	48,726	47,015	50,142	44,773	43,124	38,880	48,694	51,351
Boat Angler Hours	507,488	311,993	310,568	340,751	322,072	347,188	288,231	275,652	256,420	338,688	345,925
Anglers/Boat Trip	5.00	5.11	5.04	5.16	5.22	5.07	5.20	5.18	5.09	5.21	5.28
Hours/ Boat Trip	7.33	6.58	6.77	6.99	6.85	6.92	6.44	6.39	6.60	6.96	6.74
Monthly estimates of boat trips for charter boats:											
April	854	186	505	401	210	331	428	300	599	426	281
May	2,383	1,590	1,572	1,299	1,227	1,712	1,425	1,119	733	1,607	1,401
June	1,545	1,063	531	1,221	930	974	657	873	648	965	1,028
July	2,105	1,457	2,037	2,237	1,455	1,917	2,112	2,174	1,826	2,252	2,141
August	4,485	3,038	2,791	2,732	3,588	2,949	3,259	2,513	2,622	3,060	3,620
September	2,294	1,950	1,664	1,559	1,602	2,002	731	1,353	1,203	1,032	1,247
Seasonal estimates of boat trips among four geographic areas for charter boats:											
West	3,611	2,759	1,870	2,810	2,371	2,624	2,837	2,658	2,060	2,572	2,234
West/Central	1,497	1,094	954	1,387	472	1,056	933	842	813	1,120	1,321
East/Central	4,866	3,280	4,283	3,292	3,854	4,235	3,512	3,263	2,879	3,935	4,254
East	3,692	2,152	1,993	1,960	2,315	1,971	1,329	1,570	1,880	1,715	1,910
Percent of total seasonal fishing effort by charter boats:											
Fishing Boat Trips	10.7%	11.0%	13.9%	11.9%	12.9%	12.9%	13.9%	13.7%	13.6%	17.1%	16.6%
Boat Angler Trips	19.5%	21.0%	25.2%	22.2%	24.2%	22.6%	25.5%	25.1%	24.2%	30.1%	29.5%
Boat Angler Hours	26.9%	28.3%	33.4%	30.6%	32.7%	28.2%	31.8%	30.7%	30.2%	36.1%	35.3%

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, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of fish harvested:											
Unidentified Fish	3	33	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	31	0	0	0	0	365	0	14	72	0
Gizzard Shad	4	0	0	0	0	0	0	0	0	0	0
Cisco	27	0	0	0	0	0	76	187	247	221	270
Lake Whitefish	0	0	0	0	0	0	11	13	0	0	0
Pink Salmon	3	0	0	23	0	0	0	0	0	0	0
Unidentified Salmonine	14	0	0	0	0	0	0	0	0	0	0
Northern Pike	85	0	135	0	40	0	0	14	132	0	35
Chain Pickerel	0	0	0	0	0	0	0	0	0	67	0
Common carp	5	0	0	0	0	0	0	0	45	0	0
Unidentified Redhorse	0	0	0	15	0	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	112	0	45	0	0	0	0	0	0	0	53
Channel Catfish	69	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	1,830	0	0	0	0	0	20	0	0	0	115
White Bass	323	0	0	0	0	0	0	0	0	0	22
Rock Bass	3,211	133	473	363	1,115	526	131	135	688	134	478
Pumpkinseed	486	228	658	0	95	29	20	0	0	0	0
Bluegill	101	0	562	29	79	87	140	329	0	0	368
Largemouth Bass	95	0	269	108	149	88	32	0	132	22	26
Black Crappie	32	0	1,301	0	0	0	0	0	26	0	151
Freshwater Drum	499	158	76	0	0	0	0	0	0	0	151
Round Goby	443	10,996	16,807	28,974	39,611	36,003	13,138	12,770	9,182	7,546	4,222
Seasonal (5½ month) estimates of fish caught:											
Unidentified Fish	35	48	0	48	250	213	0	19	24	23	0
Lake Sturgeon	2	0	0	0	0	0	0	0	27	0	0
Longnose Gar	0	43	0	0	0	72	0	0	0	0	0
Bowfin	21	0	45	0	0	0	0	0	0	0	0
American Eel	89	0	0	0	0	0	0	0	0	0	0
Alewife	432	31	32	0	45	43	736	220	27	403	163
Gizzard Shad	12	0	0	0	0	0	0	0	14	0	0
Cisco	37	0	0	0	0	0	181	229	375	221	297
Lake Whitefish	0	0	0	0	0	0	11	13	0	0	0
Pink salmon	3	0	0	23	0	0	0	0	0	0	0
Unidentified Salmonine	306	32	251	31	281	14	106	113	0	0	0
Rainbow Smelt	11	0	0	0	0	0	0	0	0	0	0
Northern Pike	348	44	166	2,191	235	1,370	900	62	204	130	255
Muskellunge	3	0	0	0	0	0	0	0	0	0	0
Chain Pickerel	0	0	0	0	690	422	32	0	0	290	0
Common Carp	98	61	15	19	114	38	62	26	72	70	0
White Sucker	28	0	29	14	14	0	36	13	0	0	26
Unidentified Redhorse	12	0	0	45	0	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	153	0	45	0	0	0	0	0	0	25	53
Channel Catfish	162	0	0	0	198	0	15	0	19	0	0
Threespine Stickleback	3	0	0	0	0	0	0	0	0	0	0
White perch	4,825	0	0	30	606	0	83	101	0	12	115
White Bass	1,432	31	111	72	14	257	20	25	2,533	0	49
Rock Bass	15,959	3,381	2,731	4,608	4,495	2,546	991	818	1,840	1,088	5,371
Pumpkinseed	1,641	461	1,994	1,369	2,774	577	222	28	36	322	436
Bluegill	285	429	1,198	306	284	146	349	1,257	77	225	869
Largemouth Bass	534	82	1,306	1,177	1,313	594	190	227	516	456	106
Black Crappie	79	21	1,390	18	0	0	0	0	26	0	0
Freshwater Drum	8,369	1,914	1,255	686	360	266	701	240	525	256	388
Round Goby	929	20,371	34,336	62,615	63,407	58,310	21,033	25,290	13,484	12,659	6,704

Table A4. Residency for boat anglers interviewed April 15 – September 30, 1985-2014. Shown are percent contributions of the most common states or provinces, and for the most common counties among New York resident anglers.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	State or Province of Residence - Percent Frequency										
Connecticut	2.1	1.7	1.8	2.4	1.6	1.7	1.6	1.3	1.5	1.3	0.8
Florida	0.3	0.4	0.3	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5
Maine	0.7	1.0	1.3	1.0	0.9	0.9	0.8	0.7	0.7	1.0	0.5
Maryland	0.3	0.2	0.5	0.1	0.2	0.1	0.2	0.2	0.3	0.8	0.4
Massachusetts	4.0	3.3	3.1	2.9	3.3	3.3	3.0	2.7	2.6	2.6	2.8
Michigan	0.3	0.4	0.1	1.2	0.3	0.3	0.4	0.6	0.2	0.6	0.5
New Hampshire	1.2	1.1	1.5	1.3	1.2	1.2	1.1	0.8	0.9	1.0	1.3
New Jersey	4.4	3.3	3.8	3.8	3.3	3.8	3.0	3.0	2.6	2.2	2.9
New York	61.6	61.2	60.2	61.6	59.6	60.8	61.8	61.3	60.6	59.8	60.9
Ohio	4.4	3.2	3.0	2.8	4.5	3.5	2.6	4.0	3.9	4.7	3.6
Pennsylvania	16.5	19.2	19.5	17.6	19.8	18.9	20.4	20.4	21.9	20.8	21.0
Province of Ontario	0.2	0.0	0.0	0.4	0.1	0.4	0.3	0.3	0.1	0.2	0.2
Province of Quebec	0.2	0.1	0.1	0.0	0.2	0.1	0.1	0.1	0.0	0.1	0.3
Vermont	2.1	3.0	2.4	2.8	2.0	2.8	2.3	2.1	2.5	2.2	2.3
Virginia	0.2	0.3	0.2	0.2	0.3	0.2	0.2	0.2	0.1	0.3	0.1
West Virginia	0.4	0.3	0.3	0.3	0.7	0.4	0.3	0.4	0.5	0.4	0.3
Total of all Listed States & Provinces:	99.0	98.7	98.3	98.7	98.5	98.7	98.4	98.4	98.9	98.5	98.4
	County of Residence Among NY Anglers - Percent Frequency										
County Bordering Lake Ontario:											
Cayuga	2.3	2.7	3.7	2.9	4.2	3.0	3.3	2.6	2.2	2.2	2.6
Jefferson	2.5	2.4	2.0	2.3	2.4	2.2	1.6	1.5	3.2	3.6	3.3
Monroe	24.8	23.2	20.0	21.9	18.8	20.0	18.7	16.5	16.2	16.5	15.7
Niagara	8.7	9.0	7.9	9.5	6.6	7.3	7.8	10.9	9.4	9.7	8.6
Orleans	3.7	4.0	3.1	2.9	4.0	3.8	4.9	4.2	4.1	4.8	5.3
Oswego	10.4	11.0	13.5	11.3	12.8	13.0	13.1	13.6	12.5	12.8	12.8
Wayne	10.8	11.5	12.4	11.4	11.5	9.5	9.5	9.6	10.3	8.7	7.7
Border Co. Total	63.2	63.9	62.7	62.3	60.4	58.8	58.8	59.0	57.9	58.4	56.0
Other NY Counties:											
Albany	1.3	1.1	1.5	2.0	1.2	1.0	1.1	1.0	1.0	0.8	1.9
Broome	1.9	1.9	2.0	1.6	1.4	2.1	2.5	1.9	1.8	1.5	1.8
Dutchess	1.0	1.3	1.2	0.7	0.5	0.6	0.6	0.3	0.3	0.7	0.7
Erie	4.3	3.5	3.7	4.1	3.4	3.4	3.8	5.8	5.2	4.9	4.1
Genesee	1.5	1.7	1.4	1.1	1.2	1.9	2.1	1.6	2.5	1.8	2.3
Livingston	0.8	0.7	0.7	0.7	0.8	0.7	0.6	0.6	1.0	0.7	0.8
Oneida	2.1	1.0	2.1	1.9	1.9	1.8	1.8	2.1	1.4	2.0	2.0
Onondaga	5.8	5.7	5.5	5.6	6.9	5.4	6.0	6.4	6.4	5.7	5.9
Ontario	1.5	1.6	1.6	1.5	1.1	1.5	1.7	1.6	1.7	2.0	1.8
Orange	0.9	0.8	1.2	1.1	1.7	1.3	1.2	0.5	0.8	0.9	1.2
Saratoga	1.0	0.7	0.7	0.7	0.6	1.0	0.8	0.7	0.6	0.9	0.9
Total of all Listed Counties:	85.2	83.9	84.3	83.1	81.1	79.5	80.9	81.5	80.7	80.3	79.4

Table A5a. Trout and salmon catch and harvest data collected April 15 – September 30, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	155,345	106,900	76,075	111,200	78,060	120,477	89,092	110,196	107,456	100,047	106,880
Catch	243,003	167,707	120,785	189,916	125,686	223,316	167,405	221,977	196,625	168,837	200,763
% Harvested	63.2	63.7	63.0	58.6	62.1	53.9	53.2	49.6	54.7	59.3	53.2
Monthly estimates of harvest for all fishing boats:											
April	17,822	4,940	5,720	8,197	2,432	6,635	5,939	5,050	10,045	4,580	6,329
May	33,081	27,268	16,436	22,638	12,493	29,432	11,638	16,139	16,015	22,142	20,118
June	17,451	7,949	2,919	12,419	6,896	5,050	8,025	10,387	10,135	11,467	11,777
July	24,414	16,650	14,072	22,507	12,851	24,171	21,904	36,207	22,706	21,311	22,955
August	43,199	28,142	24,148	30,604	28,919	32,685	34,636	29,189	34,770	33,670	33,092
September	19,378	21,949	12,781	14,835	14,471	22,504	6,950	13,225	13,785	6,878	12,609
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	51,750	33,572	24,718	39,131	32,750	49,310	37,266	33,864	32,631	34,524	31,103
West/Central	17,311	10,214	8,650	9,618	2,901	8,174	6,523	8,356	9,216	11,694	13,696
East/Central	46,723	28,760	30,505	37,160	20,158	40,795	29,674	39,819	31,076	34,445	37,861
East	39,561	34,353	12,200	25,291	22,250	22,197	15,629	28,157	34,535	19,382	24,217
Monthly estimates of catch for all fishing boats:											
April	27,765	7,325	9,360	14,246	3,709	11,261	8,804	12,236	19,347	7,328	19,368
May	51,557	46,320	28,660	51,039	24,727	76,635	20,573	35,558	37,204	36,786	46,026
June	31,020	19,353	5,366	20,947	12,552	11,836	18,745	22,222	24,230	20,076	28,848
July	44,234	26,838	22,868	36,489	23,301	35,487	46,270	82,252	42,491	41,130	33,587
August	63,633	41,412	37,709	47,626	41,721	55,836	62,916	50,484	55,996	53,802	56,224
September	24,794	26,458	16,823	19,567	19,676	32,261	10,096	19,225	17,357	9,715	16,710
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	85,713	62,223	46,148	77,192	57,467	103,965	72,072	93,566	73,727	67,993	66,682
West/Central	33,128	23,987	17,028	20,602	7,754	30,121	22,128	22,100	26,231	26,378	35,306
East/Central	67,609	38,344	42,280	57,450	31,072	62,190	51,736	67,426	49,058	49,025	60,635
East	56,553	43,150	15,328	34,674	29,398	27,040	21,471	38,885	47,609	25,440	38,141
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.4	99.9	99.2	99.6	99.8	99.9	99.8	99.9	100.0	100.0	99.9
% Catch	99.3	99.8	99.2	99.7	99.6	99.8	99.6	99.8	99.7	99.9	99.9
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	46.4	50.5	61.0	47.9	53.7	50.5	50.3	47.3	47.5	59.4	56.0
% Catch	38.6	39.7	46.2	37.5	42.6	35.5	39.9	34.8	33.3	46.0	39.2

Table A5b. Trout and salmon catch and harvest rate data collected April 15 – September 30, 1985-2014. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.461	1.858	1.578	1.922	1.520	1.940	1.776	2.222	2.332	2.104	2.159
Catch/Boat Trip	2.319	2.910	2.506	3.286	2.444	3.593	3.329	4.473	4.258	3.549	4.056
Harv/Angler Trip	0.506	0.632	0.530	0.644	0.509	0.634	0.586	0.745	0.774	0.681	0.686
Catch/Angler Trip	0.802	0.990	0.842	1.101	0.819	1.174	1.098	1.500	1.414	1.148	1.288
Harv/Angler Hour	0.087	0.115	0.094	0.114	0.090	0.105	0.105	0.132	0.137	0.112	0.116
Catch/Angler Hr.	0.137	0.180	0.149	0.195	0.144	0.195	0.198	0.266	0.250	0.190	0.219
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.751	2.061	1.421	2.734	0.847	1.838	2.275	2.006	4.246	1.779	3.296
May	1.679	2.105	2.001	2.056	1.720	1.998	1.238	2.005	1.909	2.799	2.390
June	1.597	1.482	1.035	2.083	1.418	0.949	2.052	2.396	1.973	1.811	2.131
July	1.648	1.529	1.704	2.195	1.386	2.765	2.363	3.321	2.448	2.203	2.595
August	1.504	1.997	1.666	1.828	1.752	2.150	1.971	2.065	2.693	2.116	1.956
September	0.913	1.852	1.236	1.366	1.367	1.546	1.006	1.372	1.723	1.338	1.603
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.946	2.336	2.242	2.428	2.630	2.657	2.614	2.300	2.575	2.523	2.572
West/Central	1.191	1.431	1.267	1.377	0.676	1.059	1.170	1.656	1.650	1.763	2.191
East/Central	1.507	1.650	1.787	2.233	1.171	2.128	1.765	2.631	2.282	2.256	2.385
East	1.175	1.847	0.919	1.397	1.277	1.331	1.154	1.919	2.431	1.621	1.584
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	2.972	3.056	2.326	4.752	1.291	3.119	3.373	4.859	8.177	2.837	10.088
May	2.672	3.577	3.498	4.636	3.397	5.201	2.188	4.400	4.435	4.650	5.458
June	2.823	3.581	1.930	3.527	2.568	2.227	4.809	5.117	4.644	3.166	5.241
July	2.964	2.456	2.769	3.564	2.511	4.059	4.948	7.544	4.581	4.252	3.799
August	2.244	2.939	2.600	2.845	2.528	3.668	3.480	3.569	4.335	3.382	3.322
September	1.205	2.232	1.621	1.800	1.859	2.210	1.464	1.994	2.169	1.885	2.123
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	3.288	4.321	4.163	4.789	4.617	5.601	5.055	6.344	5.818	4.967	5.506
West/Central	2.522	3.339	2.485	2.950	1.800	3.898	3.969	4.379	4.697	3.976	5.644
East/Central	2.203	2.200	2.486	3.456	1.801	3.227	3.051	4.448	3.587	3.208	3.822
East	1.669	2.322	1.155	1.918	1.682	1.624	1.586	2.650	3.337	2.126	2.498
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	4.846	5.970	5.239	5.816	4.800	6.170	5.245	6.319	6.690	6.417	6.162
Catch/Boat Trip	6.355	7.365	6.297	7.787	6.136	8.044	7.826	9.359	8.583	8.385	8.115
Harv/Angler Trip	0.973	1.170	1.037	1.131	0.921	1.216	1.006	1.211	1.313	1.233	1.167
Catch/Angler Trip	1.272	1.443	1.247	1.514	1.177	1.585	1.500	1.794	1.685	1.611	1.536
Harv/Angler Hour	0.133	0.176	0.153	0.161	0.134	0.175	0.156	0.190	0.198	0.178	0.173
Catch/Angler Hr.	0.174	0.217	0.184	0.216	0.172	0.229	0.233	0.282	0.254	0.232	0.228
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.913	1.091	0.746	1.187	0.846	1.140	1.062	1.404	1.466	1.060	1.182
Catch/Boat Trip	1.653	2.080	1.644	2.436	1.686	2.750	2.404	3.497	3.399	2.378	3.064
Harv/Angler Trip	0.358	0.430	0.298	0.461	0.335	0.426	0.411	0.554	0.565	0.411	0.450
Catch/Angler Trip	0.650	0.820	0.657	0.945	0.667	1.027	0.931	1.379	1.309	0.922	1.166
Harv/Angler Hour	0.067	0.085	0.058	0.090	0.065	0.075	0.079	0.104	0.107	0.073	0.082
Catch/Angler Hr.	0.121	0.162	0.127	0.185	0.129	0.180	0.179	0.259	0.247	0.164	0.213

Table A6. Parameters used to assess angling quality among boats interviewed April 15 – September 30, 1985-2014. 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 2004-2014.

	Year Surveyed										
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Part A: Boats seeking any or all species of trout and salmon.											
Percent boats with zero harvest of:											
Any Trout or Salmon	52.3%	48.1%	57.4%	49.1%	55.6%	51.1%	51.6%	45.3%	44.9%	50.5%	46.5%
Any Fish Species	52.2%	47.9%	57.2%	48.9%	55.3%	50.8%	51.5%	45.2%	44.8%	50.3%	46.4%
Percent boats with zero catch of:											
Any Trout or Salmon	37.3%	32.6%	41.6%	31.5%	41.1%	32.4%	35.1%	26.7%	24.3%	31.4%	29.4%
Any Fish Species	35.1%	30.2%	40.2%	30.8%	39.6%	31.9%	34.5%	26.1%	23.8%	30.5%	29.0%
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	0.0%	0.3%	0.9%	1.1%	2.1%	3.1%	1.2%	2.6%	5.3%	11.8%	8.5%
Charters-All Anglers	0.0%	0.0%	0.0%	0.0%	0.7%	1.9%	0.6%	0.0%	2.0%	1.9%	0.8%
Noncharter Boats	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.5%	0.0%	0.4%	0.0%
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	16.0%	22.8%	16.1%	21.8%	12.1%	24.2%	19.5%	21.4%	22.1%	14.3%	11.5%
Charters-All Anglers	3.4%	3.5%	1.9%	3.6%	1.9%	3.1%	4.3%	2.8%	4.6%	3.0%	0.9%
Noncharter Boats	1.5%	2.0%	0.5%	2.7%	0.9%	1.4%	1.9%	3.0%	3.7%	1.3%	1.5%
Part B: Boats seeking smallmouth bass during the traditional open season.											
Percent boats with zero harvest of:											
Smallmouth Bass	71.6%	72.1%	77.2%	77.2%	82.1%	84.7%	79.0%	82.7%	79.7%	76.5%	71.1%
Any Fish Species	68.2%	66.6%	67.8%	59.6%	65.6%	71.2%	65.0%	72.3%	63.9%	67.4%	63.5%
Percent boats with zero catch of:											
Smallmouth Bass	30.8%	29.0%	42.8%	43.1%	50.3%	53.6%	56.2%	58.8%	53.6%	45.8%	40.0%
Any Fish Species	27.5%	24.8%	28.2%	22.4%	27.7%	36.5%	37.6%	35.1%	34.6%	31.4%	27.6%
Percent boats harvesting the daily bag limit of 5 smallmouth bass per angler:											
All Boats Combined	6.8%	3.4%	3.7%	2.8%	1.0%	0.3%	1.2%	2.6%	0.6%	2.5%	5.8%

Table A7a. Coho salmon harvest and catch data collected April 15 – September 30, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	10,047	5,487	9,255	14,541	4,912	12,931	9,223	7,380	8,259	4,871	5,653
Catch	13,092	8,849	12,198	25,510	6,666	21,376	12,908	11,915	12,494	7,704	8,442
% Harvested	76.4	62.0	75.9	57.0	73.7	60.5	71.5	61.9	66.1	63.2	67.0
Monthly estimates of harvest for all fishing boats:											
April	2,823	673	1,634	1,604	618	1,446	1,178	968	392	266	349
May	1,993	1,820	4,759	6,168	1,176	3,087	1,353	946	1,787	1,646	2,101
June	548	357	178	2,515	33	441	918	653	163	454	369
July	422	36	214	265	143	476	1,864	2,362	503	235	238
August	2,464	439	1,644	2,367	513	1,816	2,860	853	3,437	1,170	691
September	1,797	2,163	824	1,622	2,429	5,666	1,049	1,599	1,978	1,100	1,906
											5,653
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	4,344	1,816	3,110	9,014	1,310	5,692	5,269	3,635	3,001	2,365	2,541
West/Central	1,785	565	681	910	111	566	772	765	411	201	310
East/Central	2,397	1,097	3,831	2,702	1,251	2,727	1,537	1,546	1,968	1,594	1,566
East	1,521	2,009	1,633	1,915	2,240	3,945	1,645	1,434	2,880	711	1,235
Monthly estimates of catch for all fishing boats:											
April	3,898	875	2,269	2,352	976	2,183	1,543	2,324	686	332	1,209
May	2,801	3,025	6,022	13,798	2,107	9,559	2,164	1,926	4,047	3,145	3,537
June	817	1,788	698	3,799	255	685	1,542	1,277	734	986	547
July	638	301	263	386	242	686	2,734	3,357	830	627	286
August	2,879	591	1,881	3,313	513	2,096	3,652	1,190	3,888	1,434	897
September	2,059	2,268	1,064	1,863	2,573	6,167	1,272	1,840	2,308	1,179	1,965
											8442.000
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	5,884	4,368	5,062	17,668	2,517	12,152	7,285	6,476	5,875	4,642	4,450
West/Central	2,744	924	876	1,383	304	1,354	1,636	1,837	1,072	592	801
East/Central	2,816	1,495	4,501	3,960	1,506	3,388	2,050	1,922	2,350	1,728	1,955
East	1,648	2,061	1,759	2,499	2,340	4,482	1,937	1,679	3,197	742	1,237
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.5	100.0	94.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.4	100.0	95.8	100.0	100.0	100.0	100.0	99.5	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	40.4	44.8	56.3	44.8	51.4	39.8	56.9	42.1	40.6	45.6	39.2
% Catch	33.5	36.8	49.4	37.9	40.6	26.2	44.2	28.2	28.5	31.5	30.9

Table A7b. Coho salmon harvest and catch rate data collected April 15 – September 30, 1985-2014. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.097	0.095	0.183	0.252	0.096	0.208	0.184	0.149	0.179	0.103	0.114
Catch/Boat Trip	0.125	0.154	0.244	0.443	0.130	0.345	0.258	0.239	0.271	0.162	0.171
Harv/Angler Trip	0.033	0.032	0.061	0.085	0.032	0.068	0.061	0.050	0.060	0.033	0.036
Catch/Angler Trip	0.043	0.052	0.082	0.148	0.044	0.113	0.085	0.080	0.090	0.052	0.054
Harv/Angler Hour	0.006	0.006	0.011	0.015	0.006	0.011	0.011	0.009	0.011	0.005	0.006
Catch/Angler Hr.	0.007	0.010	0.014	0.026	0.008	0.019	0.015	0.014	0.016	0.009	0.009
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.275	0.281	0.406	0.535	0.215	0.401	0.451	0.384	0.166	0.103	0.182
May	0.109	0.141	0.533	0.560	0.162	0.210	0.144	0.118	0.213	0.208	0.250
June	0.053	0.067	0.065	0.429	0.007	0.085	0.237	0.151	0.032	0.072	0.067
July	0.032	0.003	0.026	0.026	0.015	0.054	0.202	0.217	0.054	0.024	0.027
August	0.090	0.031	0.113	0.142	0.031	0.120	0.158	0.060	0.266	0.074	0.041
September	0.082	0.182	0.080	0.149	0.229	0.389	0.153	0.166	0.247	0.214	0.242
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.159	0.126	0.283	0.559	0.105	0.307	0.370	0.247	0.237	0.173	0.210
West/Central	0.106	0.079	0.100	0.131	0.026	0.073	0.139	0.152	0.074	0.030	0.050
East/Central	0.084	0.063	0.196	0.164	0.073	0.142	0.092	0.102	0.145	0.104	0.099
East	0.051	0.108	0.124	0.106	0.129	0.238	0.122	0.098	0.203	0.059	0.081
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.370	0.365	0.564	0.784	0.340	0.605	0.591	0.923	0.290	0.129	0.630
May	0.153	0.234	0.692	1.253	0.290	0.649	0.230	0.232	0.482	0.398	0.420
June	0.078	0.333	0.255	0.648	0.054	0.132	0.398	0.296	0.143	0.156	0.100
July	0.047	0.028	0.032	0.038	0.026	0.078	0.296	0.308	0.090	0.065	0.032
August	0.105	0.042	0.130	0.199	0.031	0.138	0.202	0.084	0.301	0.090	0.053
September	0.097	0.191	0.103	0.171	0.243	0.424	0.185	0.191	0.288	0.229	0.250
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.218	0.304	0.460	1.096	0.202	0.655	0.511	0.436	0.464	0.339	0.368
West/Central	0.170	0.129	0.129	0.199	0.071	0.175	0.294	0.364	0.192	0.089	0.128
East/Central	0.098	0.086	0.236	0.240	0.088	0.177	0.122	0.127	0.173	0.113	0.123
East	0.055	0.111	0.134	0.139	0.134	0.271	0.144	0.115	0.225	0.062	0.081
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.279	0.272	0.588	0.712	0.289	0.522	0.614	0.377	0.440	0.240	0.228
Catch/Boat Trip	0.301	0.361	0.680	1.056	0.310	0.569	0.668	0.407	0.467	0.261	0.269
Harv/Angler Trip	0.056	0.053	0.116	0.138	0.056	0.103	0.118	0.072	0.086	0.046	0.043
Catch/Angler Trip	0.061	0.071	0.135	0.205	0.059	0.112	0.128	0.078	0.092	0.050	0.051
Harv/Angler Hour	0.008	0.008	0.017	0.020	0.008	0.015	0.018	0.011	0.013	0.007	0.006
Catch/Angler Hr.	0.008	0.011	0.020	0.029	0.009	0.016	0.020	0.012	0.014	0.007	0.008
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.066	0.063	0.091	0.166	0.056	0.149	0.096	0.103	0.128	0.069	0.086
Catch/Boat Trip	0.096	0.115	0.145	0.327	0.093	0.302	0.174	0.206	0.232	0.138	0.147
Harv/Angler Trip	0.026	0.025	0.036	0.064	0.022	0.056	0.037	0.041	0.049	0.027	0.033
Catch/Angler Trip	0.038	0.045	0.058	0.127	0.037	0.113	0.067	0.081	0.089	0.054	0.056
Harv/Angler Hour	0.005	0.005	0.007	0.013	0.004	0.010	0.007	0.008	0.009	0.005	0.006
Catch/Angler Hr.	0.007	0.009	0.011	0.025	0.007	0.020	0.013	0.015	0.017	0.010	0.010

Table A8. Total length (inches), weight (lbs), and age statistics for coho salmon sampled April 15 - September 30 during the 1985-2014 NYSDEC Lake Ontario fishing boat surveys.

	Year Sampled										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Mean length and weight data for coho salmon sampled April 15 - September 30:											
Mean Length (in)	23.9	24.7	24.6	24.6	25.5	23.9	25.1	24.0	26.1	25.0	23.8
Mean Weight (lbs)	-	6.90	6.47	6.64	8.09	6.30	7.15	6.27	8.29	6.70	6.37
Estimated weight (lbs) for standard length coho salmon sampled April 15 - September 30:											
Standard Length											
18.0 inches	-	1.74	1.90	1.80	1.97	1.90	1.84	1.87	2.01	1.97	1.84
20.0 inches	-	2.63	2.81	2.67	2.92	2.82	2.75	2.79	2.92	2.84	2.76
22.0 inches	-	3.82	3.99	3.83	4.16	4.04	3.96	4.01	4.11	3.95	4.00
24.0 inches	-	5.36	5.50	5.32	5.75	5.61	5.52	5.57	5.60	5.35	5.60
26.0 inches	-	7.33	7.40	7.19	7.75	7.59	7.50	7.54	7.45	7.07	7.64
28.0 inches	-	9.74	9.67	9.46	10.15	9.98	9.90	9.92	9.66	9.10	10.13
30.0 inches	-	12.83	12.54	12.33	13.18	13.00	12.96	12.95	12.41	11.61	13.30
Percent length composition of coho salmon sampled April 15 - September 30:											
<15.0 in	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15.0-15.9 in	0.8%	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%	0.0%	0.9%	0.7%	0.0%	0.0%	0.0%	0.0%	3.8%
17.0-17.9 in	2.3%	0.0%	0.0%	1.5%	1.8%	4.3%	0.0%	1.4%	0.0%	0.0%	7.7%
18.0-18.9 in	3.7%	0.9%	0.0%	2.5%	6.4%	6.1%	0.5%	7.7%	0.8%	2.4%	10.3%
19.0-19.9 in	6.4%	6.6%	0.9%	6.5%	10.1%	7.6%	3.3%	6.3%	3.1%	4.9%	5.1%
20.0-20.9 in	10.0%	13.2%	6.6%	8.5%	2.8%	7.2%	1.9%	10.6%	7.7%	4.9%	5.1%
21.0-21.9 in	12.1%	12.3%	11.9%	15.9%	0.9%	10.1%	12.2%	9.6%	7.7%	8.5%	3.8%
22.0-22.9 in	9.9%	11.3%	17.7%	9.0%	1.8%	10.4%	7.5%	5.3%	7.7%	13.4%	2.6%
23.0-23.9 in	8.2%	7.5%	15.0%	5.0%	3.7%	2.2%	9.9%	6.7%	4.6%	8.5%	3.8%
24.0-24.9 in	6.4%	5.7%	9.7%	3.0%	3.7%	4.0%	15.0%	9.6%	3.8%	9.8%	7.7%
25.0-25.9 in	6.1%	1.9%	6.6%	1.0%	5.5%	6.8%	11.7%	11.1%	5.4%	8.5%	5.1%
26.0-26.9 in	6.5%	0.0%	4.4%	8.0%	15.6%	11.2%	9.9%	5.8%	6.2%	6.1%	16.7%
27.0-27.9 in	7.2%	9.4%	8.4%	11.9%	15.6%	15.5%	8.5%	8.7%	14.6%	11.0%	15.4%
28.0-28.9 in	7.0%	13.2%	8.0%	13.4%	17.4%	9.4%	5.6%	9.1%	16.9%	4.9%	7.7%
29.0-29.9 in	5.4%	9.4%	7.5%	7.5%	8.3%	3.6%	7.5%	4.8%	9.2%	11.0%	2.6%
30.0-30.9 in	3.8%	5.7%	1.3%	6.0%	2.8%	0.7%	3.8%	2.4%	8.5%	1.2%	1.3%
31.0-31.9 in	1.7%	2.8%	1.8%	0.5%	0.0%	0.0%	1.4%	0.5%	3.1%	2.4%	0.0%
32.0-32.9 in	1.0%	0.0%	0.0%	0.0%	1.8%	0.0%	1.4%	0.0%	0.0%	2.4%	0.0%
>32.9 in	0.4%	0.0%	0.0%	0.0%	0.9%	0.4%	0.0%	0.5%	0.8%	0.0%	1.3%
Percent age composition of coho salmon sampled April 15 - September 30:											
Age-1	4.8%	1.0%	2.6%	1.6%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%
Age-2	94.4%	97.9%	97.4%	93.8%	93.3%	99.6%	99.9%	99.3%	98.0%	100.0%	97.2%
Age-3	0.8%	1.1%	0.0%	4.6%	6.7%	0.0%	0.1%	0.7%	2.0%	0.0%	2.8%
Length data (inches) for age-2 coho salmon sampled April 15 - September 30:											
April Mean	20.56	20.7	21.3	20.6	18.7	18.5	21.4	19.4	21.0	20.5	18.3
September Mean	28.05	28.6	28.6	28.2	27.4	27.2	29.3	28.2	28.2	28.1	26.3
Avg Monthly Gain	1.65	1.67	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, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	53,081	68,957	39,439	53,336	35,520	54,964	31,676	46,333	55,137	38,292	47,935
Catch	73,732	102,792	59,606	84,842	55,776	101,427	61,960	97,899	88,851	62,570	76,626
% Harvested	71.8	67.1	66.2	62.9	63.7	54.2	51.1	47.3	62.1	61.2	62.6
Monthly estimates of harvest for all fishing boats:											
April	1,950	80	381	15	117	200	156	86	2,180	115	0
May	7,254	14,209	4,513	4,422	4,385	12,978	3,932	1,594	5,358	4,102	8,067
June	2,324	1,747	586	3,584	1,334	887	3,804	2,166	4,858	2,277	3,133
July	6,708	11,931	8,241	13,883	5,293	16,984	5,282	17,509	11,004	8,560	11,074
August	21,597	22,685	18,228	20,112	16,195	13,086	13,909	16,885	21,746	20,670	16,908
September	13,248	18,304	7,489	11,320	8,195	10,829	4,592	8,093	9,991	2,568	8,754
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	22,573	24,747	14,083	17,947	14,790	23,605	10,927	14,042	17,459	17,417	13,314
West/Central	5,739	5,601	3,643	4,072	880	2,957	1,750	2,047	3,277	2,223	2,458
East/Central	11,743	16,211	15,177	16,863	11,126	18,057	12,160	17,550	16,097	13,258	20,796
East	13,027	22,398	6,535	14,454	8,724	10,345	6,839	12,694	18,305	5,394	11,367
Monthly estimates of catch for all fishing boats:											
April	2,770	195	591	45	117	448	156	267	3,781	164	232
May	11,416	23,378	10,597	11,611	9,057	40,831	5,866	4,511	11,827	6,948	13,020
June	5,152	7,880	1,425	7,531	2,999	3,537	10,250	8,483	10,058	5,200	7,829
July	10,595	17,884	12,689	20,033	9,946	23,944	16,280	42,582	19,848	15,682	14,608
August	28,041	31,298	25,089	31,108	21,965	19,623	23,084	31,239	31,097	30,649	29,562
September	15,757	22,157	9,216	14,514	11,692	13,043	6,307	10,817	12,239	3,926	11,375
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	35,226	41,953	26,022	35,059	26,841	53,358	23,577	43,599	34,937	32,474	25,615
West/Central	9,445	13,027	6,333	8,209	2,810	9,887	9,774	7,038	9,223	6,622	10,001
East/Central	14,667	21,049	19,532	22,138	14,994	26,077	20,061	30,606	22,321	16,963	27,082
East	14,395	26,763	7,719	19,436	11,132	12,105	8,548	16,657	22,370	6,511	13,928
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.8	99.9	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.8	99.8	99.9	99.9	100.0	100.0	100.0	99.9	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	40.2	49.9	53.9	46.1	52.8	41.6	42.8	40.2	42.7	47.1	51.5
% Catch	35.4	40.7	39.3	36.0	43.0	27.8	35.8	32.3	32.3	38.3	38.9

Table A9b. Chinook salmon harvest and catch rate data collected April 15 – September 30, 1985-2014. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.505	1.198	0.825	0.925	0.693	0.886	0.633	0.935	1.197	0.806	0.970
Catch/Boat Trip	0.726	1.784	1.246	1.472	1.089	1.635	1.238	1.975	1.928	1.316	1.550
Harv/Angler Trip	0.175	0.407	0.277	0.310	0.232	0.290	0.209	0.314	0.398	0.261	0.308
Catch/Angler Trip	0.251	0.607	0.419	0.493	0.365	0.534	0.408	0.662	0.640	0.426	0.492
Harv/Angler Hour	0.030	0.074	0.049	0.055	0.041	0.048	0.038	0.056	0.070	0.043	0.052
Catch/Angler Hr.	0.043	0.111	0.074	0.088	0.064	0.089	0.073	0.118	0.113	0.070	0.083
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.121	0.033	0.095	0.005	0.041	0.055	0.060	0.034	0.921	0.045	0.000
May	0.355	1.098	0.567	0.402	0.604	0.881	0.418	0.198	0.639	0.519	0.958
June	0.201	0.326	0.214	0.611	0.280	0.171	0.981	0.502	0.946	0.360	0.571
July	0.479	1.095	0.998	1.359	0.572	1.943	0.572	1.606	1.189	0.886	1.255
August	0.750	1.610	1.257	1.204	0.982	0.860	0.769	1.196	1.684	1.299	0.999
September	0.611	1.544	0.724	1.042	0.774	0.744	0.670	0.839	1.249	0.500	1.113
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.792	1.723	1.277	1.113	1.189	1.272	0.766	0.954	1.378	1.274	1.101
West/Central	0.340	0.784	0.534	0.580	0.205	0.383	0.314	0.406	0.587	0.335	0.393
East/Central	0.390	0.930	0.905	1.022	0.651	0.941	0.726	1.159	1.184	0.868	1.312
East	0.429	1.204	0.496	0.802	0.501	0.624	0.507	0.867	1.288	0.451	0.746
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.187	0.081	0.147	0.015	0.041	0.124	0.060	0.106	1.598	0.064	0.121
May	0.568	1.806	1.331	1.055	1.247	2.772	0.624	0.560	1.410	0.878	1.547
June	0.447	1.445	0.521	1.285	0.630	0.680	2.643	1.967	1.958	0.821	1.426
July	0.818	1.643	1.536	1.962	1.074	2.739	1.763	3.906	2.145	1.624	1.655
August	1.007	2.221	1.731	1.864	1.332	1.291	1.278	2.208	2.407	1.926	1.746
September	0.752	1.869	0.888	1.334	1.104	0.896	0.920	1.122	1.529	0.764	1.446
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.315	2.911	2.359	2.175	2.158	2.875	1.654	2.959	2.757	2.375	2.118
West/Central	0.626	1.825	0.928	1.172	0.655	1.280	1.753	1.394	1.652	0.998	1.596
East/Central	0.508	1.207	1.163	1.341	0.877	1.359	1.198	2.022	1.640	1.111	1.708
East	0.484	1.439	0.585	1.078	0.640	0.731	0.634	1.137	1.575	0.545	0.914
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.465	3.808	2.403	2.685	2.148	2.319	1.588	2.260	3.087	1.946	2.542
Catch/Boat Trip	1.824	4.628	2.645	3.335	2.749	2.859	2.596	3.838	3.765	2.588	3.069
Harv/Angler Trip	0.293	0.746	0.476	0.522	0.412	0.457	0.304	0.433	0.606	0.374	0.481
Catch/Angler Trip	0.365	0.907	0.524	0.649	0.527	0.563	0.498	0.736	0.739	0.497	0.581
Harv/Angler Hour	0.040	0.112	0.070	0.074	0.060	0.066	0.047	0.068	0.092	0.054	0.071
Catch/Angler Hr.	0.050	0.137	0.077	0.092	0.077	0.081	0.077	0.116	0.112	0.072	0.086
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.350	0.712	0.466	0.593	0.395	0.615	0.436	0.670	0.822	0.529	0.586
Catch/Boat Trip	0.547	1.254	0.928	1.120	0.748	1.403	0.958	1.603	1.564	1.009	1.178
Harv/Angler Trip	0.137	0.281	0.186	0.230	0.156	0.230	0.169	0.264	0.316	0.205	0.223
Catch/Angler Trip	0.216	0.494	0.371	0.434	0.296	0.524	0.371	0.632	0.602	0.391	0.448
Harv/Angler Hour	0.026	0.055	0.036	0.045	0.030	0.040	0.033	0.050	0.060	0.036	0.041
Catch/Angler Hr.	0.041	0.098	0.072	0.085	0.057	0.092	0.072	0.119	0.114	0.070	0.082

Table A10. Total length (inches), weight (lbs), and age statistics for Chinook salmon sampled April 15 - September 30 during the 1985-2014 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Mean length and weight data for chinook salmon sampled April 15 - September 30:											
Mean Length (in)	31.9	32.4	32.9	32.6	32.1	31.6	29.7	29.6	31.4	32.6	31.1
Mean Weight (lbs)	-	15.3	15.9	14.5	15.4	14.5	13.4	12.8	14.1	15.6	13.5
Estimated weight (lbs) for standard length chinook salmon sampled July & August:											
Standard Length:											
16.0 inches	-	1.37	1.42	1.37	1.47	1.31	1.47	1.36	1.34	1.47	1.38
20.0 inches	-	2.85	2.90	2.81	3.01	2.77	3.04	2.89	2.82	2.98	2.85
24.0 inches	-	5.22	5.24	5.07	5.47	5.15	5.55	5.39	5.23	5.34	5.18
28.0 inches	-	8.66	8.59	8.33	9.00	8.65	9.18	9.09	8.76	8.72	8.55
32.0 inches	-	13.48	13.25	12.84	13.92	13.62	14.27	14.35	13.77	13.38	13.25
36.0 inches	-	19.93	19.40	18.82	20.44	20.32	21.04	21.46	20.50	19.52	19.49
40.0 inches	-	28.17	27.21	26.40	28.74	28.97	29.69	30.64	29.17	27.27	27.44
Percent length composition of chinook salmon sampled April 15 - September 30:											
<16.0 in	1.4%	0.4%	0.1%	0.6%	0.3%	0.3%	0.2%	0.9%	0.5%	0.5%	0.9%
16.0-17.9 in	3.0%	1.3%	0.7%	0.3%	1.2%	1.3%	2.4%	3.5%	0.8%	1.7%	1.9%
18.0-19.9 in	3.5%	2.1%	3.4%	0.8%	1.9%	3.1%	9.1%	7.8%	1.6%	2.8%	1.9%
20.0-21.9 in	3.3%	0.6%	3.7%	0.8%	1.9%	2.1%	8.9%	5.7%	3.5%	2.8%	3.0%
22.0-23.9 in	3.5%	2.2%	3.4%	1.7%	3.6%	3.0%	8.7%	3.9%	3.0%	2.8%	2.6%
24.0-25.9 in	4.5%	4.5%	3.2%	3.8%	6.3%	5.6%	5.5%	4.3%	5.3%	2.6%	4.4%
26.0-27.9 in	6.3%	6.7%	4.8%	6.0%	7.0%	6.4%	5.9%	5.8%	6.8%	4.9%	10.4%
28.0-29.9 in	7.3%	6.2%	7.2%	8.6%	6.4%	7.9%	5.7%	6.7%	12.8%	9.2%	10.3%
30.0-31.9 in	8.0%	10.7%	7.3%	15.2%	12.1%	12.6%	6.3%	13.7%	14.0%	9.9%	16.4%
32.0-33.9 in	10.7%	17.6%	9.9%	17.5%	12.6%	17.5%	10.2%	21.2%	17.7%	14.4%	15.0%
34.0-35.9 in	13.8%	22.0%	16.6%	22.1%	17.1%	19.9%	12.9%	16.2%	15.9%	15.5%	13.6%
36.0-37.9 in	17.4%	19.4%	23.1%	15.7%	17.1%	14.7%	12.6%	7.5%	9.6%	16.2%	11.6%
38.0-39.9 in	12.2%	5.5%	12.4%	6.1%	11.1%	4.7%	7.0%	1.9%	6.1%	12.3%	7.1%
40.0-41.9 in	4.5%	0.8%	4.1%	0.7%	1.3%	0.8%	4.3%	0.8%	2.2%	3.8%	1.1%
42.0-43.9 in	0.6%	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.0%	0.1%	0.5%	0.0%
>43.9 in	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Percent age composition of chinook salmon sampled April 15 - September 30:											
Age-0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Age-1	12.0%	3.5%	9.0%	3.2%	3.1%	4.8%	33.7%	22.2%	5.0%	10.7%	8.3%
Age-2	35.7%	31.6%	28.9%	46.4%	47.9%	29.5%	24.9%	68.9%	70.8%	37.0%	52.7%
Age-3	48.4%	64.1%	57.8%	47.7%	46.6%	64.8%	38.6%	8.6%	24.1%	52.0%	36.5%
Age-4	3.9%	0.7%	4.3%	2.7%	2.3%	0.9%	2.8%	0.2%	0.2%	0.3%	2.5%
Age-3&4 combined	52.3%	64.9%	62.1%	50.4%	49.0%	65.7%	41.4%	8.8%	24.2%	52.3%	39.0%

Table A11. Mean length at age data (total length in inches) for Chinook salmon sampled July-September during the 1991-2014 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)
	91-'13 avg	19.31	(442)	19.84	(680)	21.53	(302)
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)
	91-'13 avg	29.25	(1502)	30.59	(2342)	31.98	(1135)

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)
	91-'13 avg	35.60	(1221)	36.75	(2979)	36.85	(1908)
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)
	91-'13 avg	38.13	(55)	38.59	(205)	39.12	(97)

Table A12. Chinook salmon relative harvest (age-specific harvest per 150,000 boat trips) by year class and year sampled, from the 1985-2014 NYSDEC Lake Ontario fishing boat surveys.

Year	Fing Equiv	Chinook Salmon Harvested Per 150,000 Boat Trips				
Class	Stocked	Age-1	Age-2	Age-3	Age-4	Total
1981	862,840				1,594	
1982	1,175,354			22,529	1,177	
1983	2,544,180		17,511	27,129	3,802	
1984	2,957,230	15,066	25,040	45,305	3,555	88,996
1985	3,252,830	11,971	32,146	39,890	7,435	91,443
1986	2,810,771	12,077	24,115	63,952	3,337	103,481
1987	3,368,296	9,445	34,039	41,097	5,713	90,330
1988	3,104,104	9,050	21,120	41,277	2,353	73,891
1989	3,018,754	3,483	22,269	27,327	3,714	56,794
1990	2,964,722	5,336	19,283	35,704	3,651	63,974
1991	3,129,453	10,412	26,706	54,789	3,464	95,371
1992	3,004,329	10,003	37,467	35,071	7,934	90,637
1993	1,846,892	2,465	12,505	26,866	3,170	45,006
1994	1,221,491	1,072	5,928	12,405	1,092	20,497
1995	1,364,090	16,070	52,594	39,323	2,384	110,370
1996	1,495,138	10,003	20,263	42,021	0	72,287
1997	1,911,040	5,462	18,568	29,401	453	53,884
1998	1,903,929	10,849	21,047	21,477	627	54,000
1999	1,767,524	8,722	29,542	22,215	193	60,671
2000	1,906,543	8,149	25,685	58,334	977	93,144
2001	1,893,686	5,322	35,518	47,586	1,320	89,858
2002	1,908,002	5,254	76,817	115,363	5,275	202,709
2003	1,700,374	9,060	56,861	71,548	3,785	141,254
2004	1,962,565	6,310	35,774	66,249	2,437	110,770
2005	2,075,169	11,131	64,365	48,487	1,196	125,180
2006	1,898,083	4,449	49,807	86,156	2,618	143,031
2007	2,055,075	3,270	39,227	36,675	244	79,415
2008	1,038,844	6,339	23,630	12,123	296	42,388
2009	1,981,055	31,988	96,707	43,212	347	172,254
2010	1,911,756	31,194	127,157	62,817	3,620	224,787
2011	2,060,874	8,899	44,765	53,071		
2012	1,816,778	12,942	76,708			
2013	2,010,290	12,056				

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

Year Sampled	Salmonid Boat Trips	Chinook Salmon Harvested Per 150,000 Boat Trips				
		Age-1	Age-2	Age-3	Age-4	Total
1985	126,155	15,066	17,511	22,529	1,594	56,700
1986	148,950	11,971	25,040	27,129	1,177	65,316
1987	165,678	12,077	32,146	45,305	3,802	93,366
1988	160,805	9,445	24,115	39,890	3,555	77,097
1989	177,223	9,050	34,039	63,952	7,435	114,477
1990	181,867	3,483	21,120	41,097	3,337	69,038
1991	152,357	5,336	22,269	41,277	5,713	74,594
1992	118,054	10,412	19,283	27,327	2,353	59,536
1993	103,125	10,003	26,706	35,704	3,714	76,125
1994	102,718	2,465	37,467	54,789	3,651	98,372
1995	92,346	1,072	12,505	35,071	3,464	52,112
1996	70,151	16,070	5,928	26,866	7,934	56,796
1997	64,351	10,003	52,594	12,405	3,170	78,174
1998	64,060	5,462	20,263	39,323	1,092	66,138
1999	60,573	10,849	18,568	42,021	2,384	73,825
2000	64,589	8,722	21,047	29,401	0	59,170
2001	63,026	8,149	29,542	21,477	453	59,730
2002	50,826	5,322	25,685	22,215	627	53,848
2003	47,622	5,254	35,518	58,334	193	99,298
2004	57,397	9,060	76,817	47,586	977	134,440
2005	57,510	6,310	56,861	115,363	1,320	179,857
2006	47,812	11,131	35,774	71,548	5,275	123,731
2007	57,620	4,449	64,365	66,249	3,785	138,848
2008	51,229	3,270	49,807	48,487	2,437	104,005
2009	62,028	6,339	39,227	86,156	1,196	132,917
2010	50,059	31,988	23,630	36,675	2,618	94,916
2011	49,548	31,194	96,707	12,123	244	140,267
2012	46,059	8,899	127,157	43,212	296	179,564
2013	47,520	12,942	44,765	62,817	347	120,871
2014	49,434	12,056	76,708	53,071	3,620	145,452

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

							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

Table A14a. Rainbow trout harvest and catch data collected April 15 – September 30, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	25,390	7,557	10,750	12,861	19,685	24,060	23,856	16,131	12,617	17,203	16,729
Catch	35,742	13,528	17,959	25,892	33,943	54,501	46,249	36,533	32,975	34,611	37,462
% Harvested	70.8	55.9	59.9	49.7	58.0	44.1	51.6	44.2	38.3	49.7	44.7
Monthly estimates of harvest for all fishing boats:											
April	1,304	259	186	228	262	473	463	56	199	76	101
May	5,692	1,320	1,872	2,619	2,481	1,698	1,548	410	939	2,099	2,315
June	3,771	1,038	526	1,112	978	813	2,406	1,095	2,156	965	5,102
July	3,207	1,584	1,901	3,666	2,889	5,816	4,831	7,299	4,301	5,488	2,461
August	8,705	2,274	1,948	3,613	9,800	10,096	13,568	4,587	4,381	7,567	5,670
September	2,711	1,082	4,318	1,622	3,275	5,164	1,040	2,684	640	1,009	1,080
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	15,036	5,144	6,763	8,537	14,945	19,388	18,973	11,637	8,622	11,437	9,225
West/Central	2,915	594	1,516	1,578	760	1,728	1,447	2,023	1,245	2,333	1,871
East/Central	6,148	1,171	2,102	2,335	3,603	2,221	3,065	2,340	1,852	3,036	4,800
East	1,292	648	369	411	377	722	370	131	898	397	833
Monthly estimates of catch for all fishing boats:											
April	2,202	415	399	429	565	1,197	867	305	442	379	649
May	8,293	3,100	3,736	7,264	5,840	7,418	2,724	2,060	3,100	4,824	6,341
June	5,437	2,567	787	2,708	2,197	2,676	4,828	1,813	6,515	2,077	13,747
July	4,380	2,291	3,004	6,504	6,026	9,053	8,856	18,448	11,100	11,489	4,050
August	11,609	3,628	3,912	6,520	14,823	22,335	27,121	9,037	10,858	14,198	11,072
September	3,822	1,526	6,120	2,467	4,492	11,822	1,851	4,869	960	1,644	1,603
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	20,897	9,664	10,945	16,537	23,556	35,347	36,512	26,897	22,064	23,021	16,603
West/Central	5,052	1,437	3,383	3,130	1,727	12,065	3,891	3,377	5,355	5,055	7,394
East/Central	8,201	1,595	3,249	5,382	8,040	5,824	5,166	5,164	4,195	5,957	10,976
East	1,592	832	382	843	620	1,266	681	1,096	1,361	578	2,489
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.7	99.8	100.0	100.0	99.8	100.0	100.0	99.8	100.0	100.0	99.7
% Catch	99.6	99.9	100.0	99.9	99.7	99.8	99.9	99.9	100.0	99.9	99.9
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	50.1	52.0	66.3	50.0	59.4	50.7	49.8	50.2	45.9	54.3	56.5
% Catch	40.2	36.8	51.1	36.8	47.0	34.7	35.5	33.5	27.1	39.0	38.7

Table A14b. Rainbow trout harvest and catch rate data collected April 15 – September 30, 1985-2014. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.256	0.131	0.225	0.223	0.384	0.388	0.477	0.325	0.274	0.362	0.337
Catch/Boat Trip	0.359	0.235	0.376	0.449	0.661	0.877	0.923	0.737	0.716	0.728	0.757
Harv/Angler Trip	0.088	0.045	0.076	0.075	0.129	0.127	0.157	0.109	0.091	0.117	0.107
Catch/Angler Trip	0.123	0.080	0.126	0.150	0.221	0.287	0.305	0.247	0.238	0.235	0.240
Harv/Angler Hour	0.015	0.008	0.013	0.013	0.023	0.021	0.028	0.019	0.016	0.019	0.018
Catch/Angler Hr.	0.021	0.015	0.022	0.027	0.039	0.048	0.055	0.044	0.042	0.039	0.041
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.115	0.108	0.046	0.076	0.091	0.131	0.177	0.022	0.084	0.030	0.053
May	0.302	0.101	0.235	0.238	0.342	0.115	0.165	0.051	0.112	0.265	0.275
June	0.367	0.194	0.192	0.190	0.199	0.156	0.620	0.254	0.420	0.152	0.920
July	0.229	0.146	0.230	0.359	0.312	0.665	0.523	0.669	0.465	0.569	0.279
August	0.313	0.161	0.134	0.217	0.594	0.665	0.750	0.323	0.339	0.476	0.335
September	0.139	0.091	0.418	0.149	0.309	0.355	0.152	0.278	0.080	0.196	0.137
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.669	0.357	0.613	0.530	1.201	1.044	1.331	0.789	0.680	0.836	0.763
West/Central	0.167	0.083	0.222	0.227	0.177	0.224	0.260	0.401	0.223	0.352	0.299
East/Central	0.194	0.067	0.125	0.141	0.209	0.116	0.183	0.155	0.136	0.199	0.303
East	0.034	0.035	0.028	0.023	0.022	0.044	0.027	0.009	0.063	0.033	0.052
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.206	0.173	0.099	0.143	0.197	0.332	0.332	0.121	0.187	0.147	0.338
May	0.451	0.238	0.469	0.660	0.804	0.504	0.290	0.256	0.370	0.610	0.753
June	0.534	0.479	0.288	0.459	0.449	0.515	1.238	0.417	1.268	0.328	2.495
July	0.301	0.211	0.364	0.637	0.647	1.035	0.959	1.692	1.199	1.188	0.459
August	0.413	0.257	0.270	0.391	0.899	1.465	1.500	0.638	0.841	0.892	0.654
September	0.195	0.129	0.592	0.227	0.424	0.811	0.270	0.505	0.120	0.320	0.204
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.918	0.672	0.992	1.026	1.893	1.904	2.561	1.826	1.741	1.682	1.373
West/Central	0.313	0.201	0.495	0.447	0.399	1.559	0.698	0.669	0.959	0.762	1.183
East/Central	0.263	0.091	0.194	0.326	0.466	0.300	0.307	0.340	0.309	0.390	0.692
East	0.042	0.045	0.029	0.047	0.036	0.076	0.050	0.075	0.096	0.048	0.160
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.905	0.435	0.805	0.702	1.340	1.236	1.391	0.981	0.759	1.008	0.973
Catch/Boat Trip	1.027	0.551	1.035	1.040	1.828	1.919	1.925	1.484	1.169	1.455	1.494
Harv/Angler Trip	0.180	0.085	0.159	0.136	0.257	0.244	0.267	0.188	0.149	0.194	0.184
Catch/Angler Trip	0.204	0.108	0.205	0.202	0.351	0.378	0.369	0.284	0.230	0.280	0.283
Harv/Angler Hour	0.024	0.013	0.024	0.019	0.037	0.035	0.041	0.030	0.023	0.028	0.027
Catch/Angler Hr.	0.028	0.016	0.030	0.029	0.051	0.055	0.057	0.045	0.035	0.040	0.042
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.145	0.074	0.093	0.133	0.187	0.227	0.289	0.194	0.178	0.206	0.182
Catch/Boat Trip	0.245	0.176	0.226	0.337	0.421	0.680	0.717	0.587	0.626	0.552	0.577
Harv/Angler Trip	0.057	0.029	0.037	0.052	0.074	0.085	0.112	0.077	0.068	0.080	0.069
Catch/Angler Trip	0.096	0.069	0.090	0.131	0.167	0.254	0.278	0.232	0.241	0.214	0.220
Harv/Angler Hour	0.011	0.006	0.007	0.010	0.014	0.015	0.022	0.014	0.013	0.014	0.013
Catch/Angler Hr.	0.018	0.014	0.017	0.026	0.032	0.045	0.054	0.044	0.046	0.038	0.040

Table A15. Length (total length in inches) and weight (lbs) statistics for rainbow trout sampled April 15 – September 30 during the 1985-2014 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Mean length and weight data for rainbow trout sampled April 15 - September 30:											
Mean Length (in)	24.3	24.4	24.2	24.9	25.1	25.0	25.3	24.7	24.9	24.5	24.6
Mean Weight (lbs)	-	6.0	5.9	6.0	6.2	6.0	6.8	6.1	5.9	6.0	5.9
Estimated weight (lbs) for standard length rainbow trout sampled April 15 - September 30:											
Standard Length:											
18.0 inches	-	2.42	2.43	2.07	2.22	2.10	2.40	2.09	2.05	2.21	2.31
20.0 inches	-	3.25	3.26	2.86	3.02	2.89	3.26	2.92	2.83	3.04	3.10
22.0 inches	-	4.25	4.25	3.83	3.99	3.85	4.30	3.95	3.80	4.06	4.05
24.0 inches	-	5.41	5.42	5.00	5.13	5.00	5.53	5.21	4.97	5.28	5.17
26.0 inches	-	6.77	6.78	6.38	6.47	6.36	6.97	6.71	6.35	6.73	6.46
28.0 inches	-	8.29	8.30	7.97	7.99	7.92	8.60	8.46	7.94	8.39	7.91
30.0 inches	-	10.05	10.06	9.85	9.77	9.75	10.51	10.53	9.82	10.34	9.60
32.0 inches	-	12.03	12.04	12.00	11.78	11.84	12.67	12.92	11.98	12.58	11.50
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%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16.0-16.9 in	1.1%	0.0%	0.5%	0.0%	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.9%
17.0-17.9 in	2.3%	1.5%	1.0%	0.4%	0.3%	1.5%	0.3%	1.3%	0.5%	0.5%	2.3%
18.0-18.9 in	4.6%	3.7%	2.9%	3.5%	3.8%	1.2%	1.1%	1.3%	0.5%	0.5%	3.6%
19.0-19.9 in	6.8%	5.2%	5.4%	2.6%	1.4%	3.2%	1.6%	3.3%	1.6%	1.1%	4.5%
20.0-20.9 in	8.2%	7.5%	8.3%	7.5%	4.8%	5.4%	4.1%	4.6%	5.3%	8.1%	1.8%
21.0-21.9 in	9.2%	5.2%	9.3%	9.7%	8.7%	8.2%	8.5%	12.8%	7.4%	9.7%	7.7%
22.0-22.9 in	8.7%	17.9%	7.8%	8.4%	10.4%	9.2%	11.8%	12.1%	10.1%	14.1%	7.7%
23.0-23.9 in	8.7%	9.0%	15.6%	15.4%	6.2%	9.9%	11.5%	10.8%	16.0%	15.1%	7.7%
24.0-24.9 in	7.6%	9.0%	13.2%	5.3%	9.3%	7.7%	10.4%	7.5%	12.2%	9.2%	14.4%
25.0-25.9 in	6.9%	6.7%	8.3%	5.3%	8.7%	12.6%	8.5%	7.9%	11.2%	10.8%	13.5%
26.0-26.9 in	6.1%	8.2%	5.4%	7.5%	12.5%	10.1%	11.8%	11.1%	7.4%	8.1%	10.8%
27.0-27.9 in	6.9%	8.2%	6.8%	8.4%	12.5%	9.4%	9.0%	8.2%	12.8%	7.6%	7.7%
28.0-28.9 in	5.9%	4.5%	6.3%	10.1%	9.3%	9.9%	7.4%	9.5%	5.3%	5.4%	9.5%
29.0-29.9 in	5.0%	6.7%	4.4%	6.2%	6.6%	5.0%	4.9%	4.3%	3.7%	5.9%	4.5%
30.0-30.9 in	4.4%	1.5%	2.4%	4.4%	2.8%	4.0%	4.9%	3.6%	3.2%	1.1%	1.4%
31.0-31.9 in	3.2%	2.2%	1.5%	2.6%	1.4%	1.7%	1.4%	1.3%	1.1%	0.5%	2.3%
32.0-32.9 in	1.9%	1.5%	0.0%	1.8%	0.0%	0.7%	1.9%	0.0%	0.5%	0.5%	0.0%
33.0-33.9 in	1.0%	1.5%	0.5%	0.4%	0.3%	0.0%	0.5%	0.3%	1.1%	0.5%	0.0%
>33.9 in	0.8%	0.0%	0.5%	0.0%	0.7%	0.0%	0.3%	0.0%	0.0%	1.1%	0.0%

Table A16. Atlantic salmon harvest and catch data collected April 15 – September 30, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	355	15	0	14	79	532	624	398	310	200	66
Catch	1,303	270	158	214	233	1,273	1,826	1,519	592	599	639
% Harvested	27.5	5.6	0.0	6.5	33.9	41.8	34.2	26.2	52.4	33.4	10.3
Monthly estimates of harvest for all fishing boats:											
April	67	15	0	0	0	105	98	128	29	0	28
May	154	0	0	0	28	222	79	95	183	175	25
June	52	0	0	14	0	15	24	54	46	0	0
July	30	0	0	0	16	66	301	76	51	25	14
August	45	0	0	0	0	124	108	25	0	0	0
September	7	0	0	0	35	0	15	21	0	0	0
Seasonal estimates of harvest among four geographic areas for all fishing boats:											
West	88	0	0	14	51	226	205	236	126	51	39
West/Central	60	0	0	0	0	161	182	0	0	44	0
East/Central	101	15	0	0	0	74	204	106	93	105	0
East	106	0	0	0	28	71	33	56	91	0	27
Monthly estimates of catch for all fishing boats:											
April	242	15	31	0	0	201	273	296	56	48	180
May	425	0	17	72	88	430	223	439	387	251	215
June	171	47	0	114	64	66	231	171	46	77	0
July	212	171	0	28	16	211	648	212	90	165	162
August	179	37	110	0	30	365	372	340	13	58	82
September	75	0	0	0	35	0	79	62	0	0	0
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	306	34	72	116	52	363	560	526	242	186	121
West/Central	225	131	31	70	36	337	397	366	46	77	112
East/Central	400	60	0	0	47	509	650	339	211	255	209
East	372	44	55	28	98	63	219	287	93	81	197
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.7	100		100	100	100	100	100	100	100	100
% Catch	97.9	54.8148	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	0.288	0.026	0.000	0.024	0.154	0.858	1.247	0.803	0.673	0.421	0.134
Catch/Boat Trip	1.047	0.257	0.330	0.371	0.455	2.052	3.648	3.066	1.285	1.261	1.293
Harv/Angler Trip	0.100	0.009	0.000	0.008	0.052	0.280	0.411	0.269	0.224	0.136	0.042
Catch/Angler Trip	0.365	0.088	0.111	0.124	0.152	0.671	1.203	1.028	0.427	0.408	0.411
Harv/Angler Hour	0.017	0.002	0.000	0.001	0.009	0.047	0.074	0.048	0.039	0.022	0.007
Catch/Angler Hr.	0.062	0.016	0.020	0.022	0.027	0.111	0.217	0.183	0.075	0.067	0.070

Table A17a. Brown trout harvest and catch data collected April 15 – September 30, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	32,412	20,702	13,667	27,855	14,989	23,148	18,311	32,937	23,305	18,969	20,626
Catch	45,714	32,709	21,957	46,258	22,030	33,484	32,604	49,661	39,507	27,793	44,487
% Harvested	70.5	63.3	62.2	60.2	68.0	69.1	56.2	66.3	59.0	68.3	46.4
Monthly estimates of harvest for all fishing boats:											
April	8,647	3,912	3,304	5,795	1,420	4,023	3,855	3,558	5,802	2,730	5,094
May	11,417	9,655	4,117	9,083	3,828	11,256	2,266	12,255	5,436	7,810	5,404
June	4,391	3,867	1,068	4,052	4,164	2,393	611	4,941	1,456	3,315	612
July	3,954	2,187	3,630	4,570	3,280	576	7,782	6,695	5,631	2,656	5,202
August	3,405	744	1,398	4,100	1,945	4,538	3,543	4,968	4,307	2,197	3,593
September	597	337	150	256	352	362	255	519	672	259	721
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	2,662	1,376	453	2,633	1,052	209	1,153	2,563	2,006	1,649	4,267
West/Central	3,199	1,713	1,164	2,667	541	1,744	1,487	2,163	2,792	1,566	2,958
East/Central	17,896	9,905	9,322	15,145	3,969	17,399	11,156	16,327	8,932	9,850	8,199
East	8,654	7,708	2,727	7,410	9,427	3,796	4,515	11,883	9,575	5,903	5,202
Monthly estimates of catch for all fishing boats:											
April	11,774	5,795	4,342	10,656	1,996	5,997	5,501	8,160	10,558	4,450	13,369
May	15,498	14,907	5,181	15,302	5,983	15,838	3,913	17,584	9,446	9,329	15,497
June	5,826	5,442	1,262	5,337	6,110	3,463	1,342	6,658	3,345	3,918	913
July	6,133	4,025	5,225	9,167	4,692	888	14,421	10,026	7,751	5,169	8,331
August	5,568	2,163	5,567	5,347	2,654	6,720	6,993	6,193	7,236	4,284	5,048
September	915	377	381	449	595	579	434	1,041	1,171	643	1,330
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	4,157	2,829	828	3,828	1,408	344	2,043	4,760	4,122	2,451	12,153
West/Central	6,328	5,688	2,273	6,652	1,162	3,182	3,005	5,710	6,836	4,933	6,544
East/Central	24,155	13,170	14,537	25,705	6,117	25,272	20,730	22,945	13,860	12,722	15,761
East	11,074	11,022	4,319	10,073	13,344	4,686	6,826	16,246	14,689	7,687	10,028
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.8	100.0	99.3	98.6	98.9	99.4	98.9	99.8	99.8	99.8	99.6
% Catch	98.4	100.0	99.1	98.9	98.3	98.9	97.8	99.8	98.8	99.5	99.8
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	44.7	49.4	73.2	51.1	43.9	70.3	54.7	53.3	55.6	72.9	57.9
% Catch	37.7	39.2	59.1	42.2	34.1	59.6	49.8	43.4	42.3	58.7	36.4

Table A17b. Brown trout harvest and catch rate data collected April 15 – September 30, 1985-2014. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.323	0.360	0.284	0.477	0.289	0.371	0.362	0.664	0.505	0.398	0.416
Catch/Boat Trip	0.464	0.568	0.455	0.794	0.423	0.534	0.637	1.000	0.848	0.582	0.898
Harv/Angler Trip	0.112	0.122	0.095	0.160	0.097	0.121	0.119	0.223	0.168	0.129	0.132
Catch/Angler Trip	0.161	0.193	0.153	0.266	0.142	0.175	0.210	0.335	0.282	0.188	0.285
Harv/Angler Hour	0.019	0.022	0.017	0.028	0.017	0.020	0.021	0.040	0.030	0.021	0.022
Catch/Angler Hr.	0.028	0.035	0.027	0.047	0.025	0.029	0.038	0.060	0.050	0.031	0.048
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.985	1.632	0.821	1.933	0.494	1.114	1.477	1.413	2.452	1.060	2.653
May	0.629	0.746	0.517	0.825	0.527	0.764	0.241	1.522	0.648	0.987	0.642
June	0.451	0.721	0.357	0.655	0.851	0.438	0.140	1.134	0.283	0.523	0.106
July	0.298	0.201	0.440	0.438	0.352	0.066	0.834	0.614	0.603	0.272	0.583
August	0.127	0.053	0.096	0.240	0.116	0.298	0.196	0.352	0.334	0.138	0.212
September	0.030	0.028	0.015	0.024	0.033	0.025	0.029	0.054	0.084	0.050	0.092
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.112	0.096	0.041	0.163	0.082	0.011	0.081	0.174	0.158	0.119	0.353
West/Central	0.273	0.240	0.170	0.383	0.126	0.226	0.267	0.429	0.500	0.236	0.473
East/Central	0.599	0.568	0.556	0.899	0.226	0.908	0.658	1.079	0.653	0.645	0.514
East	0.262	0.415	0.200	0.406	0.541	0.220	0.330	0.808	0.674	0.494	0.339
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.379	2.418	1.079	3.555	0.695	1.661	2.108	3.241	4.462	1.719	6.963
May	0.876	1.152	0.644	1.390	0.816	1.074	0.416	2.184	1.126	1.179	1.841
June	0.597	1.012	0.428	0.867	1.228	0.617	0.329	1.518	0.579	0.615	0.161
July	0.457	0.371	0.633	0.888	0.505	0.102	1.498	0.920	0.827	0.529	0.938
August	0.214	0.154	0.383	0.312	0.158	0.441	0.387	0.439	0.560	0.269	0.298
September	0.049	0.032	0.034	0.041	0.056	0.035	0.056	0.108	0.146	0.120	0.167
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.175	0.197	0.075	0.237	0.111	0.019	0.143	0.323	0.325	0.176	1.004
West/Central	0.568	0.794	0.324	0.955	0.268	0.413	0.539	1.131	1.224	0.744	1.047
East/Central	0.820	0.755	0.865	1.533	0.345	1.306	1.201	1.513	1.000	0.830	0.991
East	0.335	0.593	0.320	0.554	0.760	0.274	0.501	1.105	1.020	0.641	0.656
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.046	1.132	1.129	1.556	0.754	1.650	1.174	2.128	1.698	1.492	1.231
Catch/Boat Trip	1.264	1.421	1.465	2.131	0.862	2.022	1.903	2.611	2.187	1.760	1.667
Harv/Angler Trip	0.209	0.222	0.224	0.302	0.145	0.325	0.225	0.408	0.333	0.287	0.233
Catch/Angler Trip	0.253	0.278	0.290	0.414	0.165	0.398	0.365	0.500	0.429	0.338	0.316
Harv/Angler Hour	0.029	0.033	0.033	0.043	0.021	0.047	0.035	0.064	0.050	0.041	0.035
Catch/Angler Hr.	0.035	0.042	0.043	0.059	0.024	0.057	0.057	0.079	0.065	0.049	0.047
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.200	0.216	0.092	0.273	0.194	0.129	0.195	0.371	0.268	0.134	0.216
Catch/Boat Trip	0.326	0.410	0.226	0.542	0.332	0.253	0.377	0.678	0.582	0.297	0.710
Harv/Angler Trip	0.079	0.085	0.037	0.106	0.077	0.048	0.075	0.146	0.103	0.052	0.082
Catch/Angler Trip	0.129	0.161	0.090	0.210	0.131	0.094	0.146	0.267	0.224	0.115	0.270
Harv/Angler Hour	0.015	0.017	0.007	0.021	0.015	0.008	0.015	0.027	0.020	0.009	0.015
Catch/Angler Hr.	0.024	0.032	0.017	0.041	0.025	0.017	0.028	0.050	0.042	0.020	0.049

Table A18. Length (inches), weight (lbs), age, and fin clip statistics for brown trout sampled April 15 – September 30 during the 1985-2014 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Mean length and weight data for brown trout sampled April 15 - September 30:											
Mean Length (in)	20.1	19.9	20.5	20.0	20.0	19.0	20.8	20.7	20.4	21.1	20.2
Mean Weight (lbs)	-	4.39	5.33	4.62	4.59	3.70	5.39	5.30	4.92	5.87	4.48
Estimated weight (lbs) for standard length brown trout sampled April 15 - September 30:											
16.0 inches	-	2.04	2.33	2.01	2.11	1.99	2.32	2.16	1.96	2.32	1.89
18.0 inches	-	2.97	3.32	2.98	3.06	2.88	3.30	3.15	2.89	3.30	2.76
20.0 inches	-	4.18	4.61	4.28	4.30	4.05	4.54	4.44	4.13	4.56	3.90
22.0 inches	-	5.70	6.18	5.94	5.83	5.50	6.06	6.06	5.70	6.10	5.33
24.0 inches	-	7.56	8.09	8.01	7.71	7.27	7.89	8.04	7.64	7.96	7.08
26.0 inches	-	9.81	10.36	10.55	9.96	9.41	10.06	10.44	10.00	10.16	9.21
28.0 inches	-	12.42	12.97	13.54	12.58	11.89	12.54	13.23	12.78	12.69	11.68
Percent length composition of brown trout sampled April 15 - September 30:											
<15.0 in	1.6%	0.0%	0.6%	0.0%	0.0%	0.4%	0.2%	0.1%	0.0%	0.3%	1.2%
15.0-15.9 in	2.0%	0.4%	0.3%	1.7%	1.3%	3.3%	0.2%	0.1%	1.7%	1.7%	3.5%
16.0-16.9 in	6.1%	3.4%	4.8%	5.0%	7.0%	16.7%	3.1%	1.6%	4.8%	3.5%	8.9%
17.0-17.9 in	12.3%	15.3%	10.3%	11.6%	11.4%	21.1%	8.3%	7.0%	17.4%	8.7%	16.1%
18.0-18.9 in	17.8%	27.5%	17.0%	17.5%	17.8%	20.7%	14.0%	16.6%	15.7%	16.7%	13.2%
19.0-19.9 in	16.0%	17.9%	12.8%	18.0%	16.9%	10.3%	14.0%	19.3%	14.8%	14.2%	9.3%
20.0-20.9 in	12.3%	11.1%	13.1%	17.0%	14.1%	8.6%	18.8%	16.9%	10.2%	10.4%	9.3%
21.0-21.9 in	9.2%	5.8%	14.1%	11.0%	10.8%	4.4%	13.3%	11.4%	7.6%	7.6%	9.5%
22.0-22.9 in	6.9%	6.6%	8.7%	6.6%	7.7%	4.2%	10.2%	10.1%	5.7%	6.3%	8.8%
23.0-23.9 in	4.9%	3.8%	5.1%	4.6%	3.5%	3.9%	7.1%	6.9%	6.3%	9.0%	6.0%
24.0-24.9 in	3.6%	3.0%	5.4%	2.9%	4.2%	3.3%	2.4%	3.9%	5.9%	6.9%	5.6%
25.0-25.9 in	2.8%	2.1%	4.5%	2.0%	3.1%	1.7%	2.6%	2.0%	3.9%	5.6%	2.9%
26.0-26.9 in	2.1%	1.3%	2.2%	1.1%	2.0%	0.9%	3.8%	2.0%	1.7%	4.5%	2.3%
27.0-27.9 in	1.0%	1.1%	0.6%	0.5%	0.2%	0.4%	1.0%	1.0%	2.0%	2.8%	1.6%
28.0-28.9 in	0.7%	0.4%	0.0%	0.1%	0.0%	0.0%	0.7%	0.6%	1.5%	0.7%	1.0%
>28.9 in	0.6%	0.4%	0.3%	0.4%	0.0%	0.2%	0.2%	0.4%	0.7%	1.0%	0.6%
Percent fin clip composition of brown trout sampled April 15 - September 30:											
No Clips	74.8%	67.2%	80.4%	86.6%	88.4%	81.4%	87.6%	88.7%	92.4%	91.0%	88.1%
LV	2.0%	5.5%	2.9%	2.0%	0.2%	3.0%	2.9%	1.2%	0.4%	1.0%	0.4%
LV-Ad	4.0%	7.5%	3.5%	1.9%	3.1%	6.1%	2.6%	0.6%	1.7%	1.0%	1.9%
LP	2.9%	3.6%	1.0%	0.3%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%
LP-Ad	4.2%	4.1%	3.5%	2.6%	1.7%	1.1%	2.6%	4.3%	2.2%	2.1%	1.2%
Ad	2.0%	2.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
RV	3.9%	4.0%	3.5%	2.8%	4.8%	4.4%	2.1%	0.6%	0.7%	3.5%	6.2%
RV-Ad	0.3%	0.8%	1.3%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
RP	4.4%	3.0%	2.9%	2.0%	1.4%	2.6%	1.0%	2.6%	1.5%	1.0%	1.4%
RP-Ad	0.0%	0.2%	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%
Misc.	1.2%	2.1%	1.0%	1.7%	0.4%	0.9%	1.2%	1.9%	1.1%	0.3%	0.4%
Percent age composition of brown trout sampled April 15 - September 30:											
Age-1	-	0.0%	0.5%	0.0%	0.0%	0.2%	0.4%	0.0%	0.0%	0.0%	0.0%
Age-2	-	81.9%	72.5%	85.6%	78.9%	80.0%	80.6%	78.7%	74.6%	60.0%	62.6%
Age-3	-	14.4%	23.6%	11.6%	19.6%	17.2%	15.2%	17.2%	21.3%	34.6%	28.8%
Age-4	-	3.2%	3.4%	2.2%	1.0%	2.4%	3.4%	3.9%	3.3%	2.7%	7.8%
Age-5+	-	0.5%	0.0%	0.5%	0.5%	0.2%	0.4%	0.3%	0.7%	2.6%	0.8%
Mean length (inches) of aged brown trout sampled in April 15-30:											
Age-2	-	18.1	17.8	18.4	17.7	17.4	18.2	18.6	17.9	18.0	17.4
Age-3	-	23.1	22.5	21.7	23.2	21.8	23.1	22.8	23.1	23.3	21.7

Table A19a. Lake trout harvest and catch data collected April 15 – September 30, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	34,042	4,181	2,964	2,570	2,875	4,842	5,403	7,017	7,829	20,511	15,870
Catch	73,111	9,527	8,656	7,147	6,757	11,241	11,753	24,336	22,206	35,533	33,108
% Harvested	41.6	43.9	34.2	36.0	42.5	43.1	46.0	28.8	35.3	57.7	47.9
Monthly estimates of harvest for all fishing boats:											
April	3,027	0	215	555	15	388	188	255	1,442	1,393	757
May	6,570	264	1,173	345	594	190	2,461	840	2,311	6,311	2,207
June	6,365	940	560	1,142	387	501	262	1,478	1,456	4,455	2,561
July	10,091	913	86	122	1,229	254	1,845	2,266	1,216	4,346	3,967
August	6,973	2,000	930	390	465	3,026	648	1,871	899	2,066	6,230
September	1,017	64	0	15	184	483	0	308	505	1,941	148
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	7,041	489	309	963	602	190	739	1,751	1,417	1,605	1,717
West/Central	3,613	1,741	1,646	391	609	1,018	885	1,358	1,491	5,327	6,099
East/Central	8,428	361	73	115	209	317	1,552	1,950	2,134	6,602	2,500
East	14,961	1,590	936	1,101	1,454	3,318	2,227	1,959	2,786	6,977	5,553
Monthly estimates of catch for all fishing boats:											
April	6,829	30	1,728	765	15	1,235	464	885	3,823	1,955	3,728
May	13,021	1,910	2,855	2,993	1,539	2,558	5,660	8,956	8,397	12,288	7,417
June	13,580	1,615	1,193	1,457	927	1,395	552	3,789	3,533	7,818	5,812
July	22,252	2,166	1,688	371	2,276	705	3,247	7,626	2,871	7,971	6,150
August	15,285	3,676	1,151	1,285	1,712	4,699	1,678	2,484	2,903	3,178	9,563
September	2,143	129	40	275	288	649	151	596	679	2,323	438
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	19,131	3,362	2,968	3,962	2,924	2,387	2,095	11,226	6,487	5,219	7,740
West/Central	9,264	2,780	4,132	1,158	1,681	3,296	3,346	3,772	3,699	9,099	10,454
East/Central	17,310	956	461	265	289	1,120	3,079	6,419	6,121	11,400	4,652
East	27,406	2,428	1,094	1,763	1,864	4,438	3,233	2,920	5,899	9,815	10,262
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	60.0	69.7	93.7	56.7	81.3	88.7	69.6	64.9	67.2	77.9	72.5
% Catch	43.2	38.0	47.4	26.7	48.0	55.0	48.1	33.1	33.5	60.2	46.8

Table A19b. Lake trout harvest and catch rate data collected April 15 – September 30, 1985-2014. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.278	0.073	0.062	0.045	0.056	0.078	0.108	0.142	0.170	0.432	0.321
Catch/Boat Trip	0.632	0.166	0.181	0.124	0.132	0.181	0.235	0.491	0.482	0.748	0.668
Harv/Angler Trip	0.097	0.025	0.021	0.015	0.019	0.026	0.036	0.047	0.056	0.140	0.102
Catch/Angler Trip	0.219	0.056	0.061	0.042	0.044	0.059	0.077	0.165	0.160	0.242	0.212
Harv/Angler Hour	0.017	0.005	0.004	0.003	0.003	0.004	0.006	0.008	0.010	0.023	0.017
Catch/Angler Hr.	0.037	0.010	0.011	0.007	0.008	0.010	0.014	0.029	0.028	0.040	0.036
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.248	0.000	0.053	0.185	0.005	0.107	0.072	0.101	0.609	0.541	0.394
May	0.278	0.020	0.147	0.031	0.082	0.013	0.262	0.104	0.276	0.798	0.262
June	0.521	0.175	0.205	0.195	0.081	0.096	0.068	0.343	0.283	0.703	0.467
July	0.608	0.084	0.010	0.012	0.133	0.029	0.200	0.208	0.131	0.450	0.449
August	0.222	0.142	0.064	0.023	0.028	0.199	0.036	0.132	0.070	0.130	0.368
September	0.051	0.005	0.000	0.001	0.017	0.033	0.000	0.032	0.063	0.378	0.019
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.210	0.034	0.028	0.060	0.048	0.010	0.052	0.119	0.112	0.117	0.142
West/Central	0.302	0.244	0.241	0.056	0.142	0.132	0.159	0.269	0.267	0.803	0.976
East/Central	0.238	0.021	0.004	0.007	0.012	0.017	0.093	0.129	0.157	0.433	0.158
East	0.396	0.086	0.071	0.061	0.084	0.200	0.165	0.134	0.196	0.584	0.364
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.802	0.013	0.429	0.255	0.005	0.342	0.178	0.351	1.616	0.759	1.942
May	0.600	0.148	0.359	0.272	0.212	0.174	0.602	1.113	1.001	1.553	0.871
June	1.151	0.301	0.437	0.249	0.195	0.268	0.142	0.879	0.688	1.234	1.059
July	1.327	0.199	0.204	0.036	0.246	0.081	0.352	0.699	0.310	0.826	0.697
August	0.496	0.261	0.079	0.077	0.104	0.309	0.093	0.176	0.225	0.200	0.565
September	0.109	0.011	0.004	0.025	0.027	0.045	0.022	0.062	0.085	0.452	0.056
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.646	0.234	0.269	0.246	0.235	0.129	0.147	0.763	0.512	0.382	0.633
West/Central	0.825	0.389	0.605	0.166	0.392	0.427	0.600	0.747	0.662	1.372	1.673
East/Central	0.500	0.055	0.027	0.016	0.017	0.058	0.184	0.424	0.450	0.747	0.293
East	0.741	0.131	0.083	0.098	0.107	0.268	0.240	0.199	0.415	0.821	0.673
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.145	0.323	0.314	0.159	0.268	0.435	0.440	0.552	0.690	1.724	1.185
Catch/Boat Trip	1.915	0.401	0.463	0.208	0.372	0.626	0.662	0.976	0.975	2.309	1.596
Harv/Angler Trip	0.233	0.063	0.062	0.031	0.051	0.086	0.084	0.106	0.135	0.331	0.224
Catch/Angler Trip	0.385	0.079	0.092	0.041	0.071	0.123	0.127	0.187	0.191	0.444	0.302
Harv/Angler Hour	0.032	0.010	0.009	0.004	0.007	0.012	0.013	0.017	0.020	0.048	0.033
Catch/Angler Hr.	0.052	0.012	0.014	0.006	0.010	0.018	0.020	0.029	0.029	0.064	0.045
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.149	0.026	0.005	0.023	0.013	0.010	0.040	0.060	0.067	0.119	0.110
Catch/Boat Trip	0.428	0.122	0.117	0.108	0.083	0.097	0.147	0.394	0.384	0.370	0.441
Harv/Angler Trip	0.058	0.010	0.002	0.009	0.005	0.004	0.015	0.024	0.026	0.046	0.042
Catch/Angler Trip	0.167	0.048	0.047	0.042	0.033	0.036	0.057	0.155	0.148	0.143	0.168
Harv/Angler Hour	0.011	0.002	0.000	0.002	0.001	0.001	0.003	0.004	0.005	0.008	0.008
Catch/Angler Hr.	0.031	0.009	0.009	0.008	0.006	0.006	0.011	0.029	0.028	0.025	0.031

Table A20. Length and weight statistics for lake trout sampled April 15 - September 30 during the 1985-2014 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Mean length and weight of lake trout sampled April - September:											
Mean Length (in)	25.0	26.8	24.5	26.8	26.5	25.1	23.4	25.5	26.3	25.9	27.2
Mean weight (lbs)	-	8.24	6.28	8.61	8.03	6.81	5.71	7.37	8.00	7.41	8.45
Percent length composition of lake trout sampled April - September:											
<15.0 inches	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.5%
15-15.9 inches	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%
16-16.9 inches	0.3%	0.0%	0.0%	1.9%	0.0%	1.3%	1.6%	0.0%	0.0%	0.4%	0.0%
17-17.9 inches	1.1%	2.6%	0.0%	1.9%	0.0%	0.0%	4.1%	0.8%	0.9%	2.5%	0.0%
18-18.9 inches	1.7%	0.0%	2.6%	1.9%	0.0%	3.8%	7.3%	2.5%	3.4%	2.9%	0.0%
19-19.9 inches	3.6%	2.6%	10.3%	3.8%	2.0%	10.1%	2.4%	4.2%	1.7%	2.5%	1.8%
20-20.9 inches	5.0%	2.6%	7.7%	5.7%	0.0%	7.6%	10.6%	4.2%	2.6%	3.6%	0.9%
21-21.9 inches	8.7%	2.6%	5.1%	5.7%	6.0%	3.8%	13.0%	6.7%	6.8%	4.7%	1.4%
22-22.9 inches	11.0%	10.5%	2.6%	3.8%	14.0%	3.8%	9.8%	7.5%	4.3%	4.3%	5.1%
23-23.9 inches	13.6%	5.3%	20.5%	3.8%	14.0%	3.8%	14.6%	10.8%	3.4%	6.1%	4.1%
24-24.9 inches	13.8%	18.4%	15.4%	5.7%	6.0%	10.1%	4.9%	8.3%	6.8%	8.7%	8.8%
25-25.9 inches	9.6%	7.9%	17.9%	3.8%	6.0%	11.4%	3.3%	15.0%	14.5%	10.5%	11.5%
26-26.9 inches	5.8%	7.9%	2.6%	3.8%	6.0%	5.1%	5.7%	7.5%	11.1%	8.7%	13.8%
27-27.9 inches	2.9%	2.6%	0.0%	9.4%	10.0%	17.7%	1.6%	11.7%	15.4%	15.5%	10.6%
28-28.9 inches	2.3%	0.0%	0.0%	13.2%	12.0%	8.9%	7.3%	1.7%	5.1%	10.8%	12.9%
29-29.9 inches	3.8%	2.6%	0.0%	11.3%	6.0%	1.3%	4.1%	2.5%	4.3%	7.9%	11.1%
30-30.9 inches	5.9%	7.9%	5.1%	9.4%	4.0%	3.8%	4.1%	4.2%	7.7%	4.7%	7.8%
31-31.9 inches	4.8%	7.9%	2.6%	7.5%	0.0%	2.5%	1.6%	3.3%	7.7%	1.8%	3.7%
32-32.9 inches	2.3%	7.9%	2.6%	0.0%	6.0%	3.8%	2.4%	5.0%	0.9%	2.2%	1.4%
33-33.9 inches	2.1%	2.6%	2.6%	0.0%	4.0%	1.3%	0.0%	1.7%	0.0%	1.1%	2.8%
34-34.9 inches	1.0%	7.9%	0.0%	1.9%	2.0%	0.0%	0.0%	1.7%	2.6%	1.1%	1.4%
>34.9 inches	0.4%	0.0%	2.6%	5.7%	2.0%	0.0%	0.0%	0.8%	0.9%	0.0%	0.5%
30.0+ inches	16.5%	34.2%	15.4%	24.5%	18.0%	11.4%	8.1%	16.7%	19.7%	10.8%	17.5%
25.0-29.9 inches	24.5%	21.1%	20.5%	41.5%	40.0%	44.3%	22.0%	38.3%	50.4%	53.4%	59.9%

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, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	50,884	32,816	17,759	19,058	11,104	6,833	4,892	6,442	5,683	7,536	12,538
Catch	261,588	145,172	73,781	78,661	50,727	30,494	18,048	25,795	24,032	21,446	31,807
% Harvested	20.6	22.6	24.1	24.2	21.9	22.4	27.1	25.0	23.6	35.1	39.4
Monthly estimates of harvest for all fishing boats:											
April	1	34	0	0	0	2	0	0	0	0	0
May	61	0	0	0	0	0	0	0	0	0	0
June	8,363	7,186	3,392	2,651	4,721	1,565	1,258	268	1,178	1,073	6,740
July	15,044	8,571	6,240	7,280	2,084	647	1,643	668	2,702	3,846	2,520
August	17,853	10,012	7,139	5,987	2,687	1,695	1,727	3,331	1,377	853	2,928
September	9,562	7,013	989	3,139	1,612	2,923	265	2,176	426	1,764	350
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	3,902	382	384	1,048	882	163	182	254	800	556	208
West/Central	3,529	2,105	320	626	376	108	43	261	36	48	176
East/Central	25,868	22,220	5,864	9,579	3,522	3,250	1,785	700	1,940	1,214	589
East	17,586	8,109	11,191	7,805	6,324	3,312	2,882	5,227	2,907	5,718	11,566
Monthly estimates of catch for all fishing boats:											
April	479	236	1,955	91	979	240	136	22	82	438	480
May	6,619	5,883	691	915	1,180	1,264	483	1,299	1,558	350	364
June	33,291	30,540	11,643	15,557	16,685	5,734	2,159	1,604	4,987	2,859	12,380
July	82,966	40,646	28,348	19,726	12,168	3,983	4,437	8,026	9,561	10,239	7,057
August	94,227	43,948	24,084	32,958	13,757	11,115	8,571	10,407	5,611	2,732	8,957
September	44,005	23,919	7,060	9,414	5,958	8,159	2,263	4,437	2,234	4,829	2,570
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	24,804	3,204	2,825	6,354	6,400	1,610	2,565	2,459	5,768	3,009	4,818
West/Central	38,548	21,694	3,664	10,043	2,140	2,143	384	799	1,048	634	672
East/Central	131,353	83,054	40,039	42,400	22,653	15,862	9,462	5,830	6,648	5,916	4,088
East	66,882	37,219	27,253	19,864	19,534	10,878	5,638	16,706	10,567	11,888	22,229
Percent of seasonal harvest and catch made by boats seeking smallmouth bass during the **traditional open season**:											
% Harvest	92.1	96.1	96.4	92.8	87.6	69.0	83.8	96.4	88.5	94.5	98.4
% Catch	87.5	89.9	89.7	79.7	77.7	58.2	62.6	78.1	85.9	86.4	91.8
Estimates of catch by boats seeking smallmouth bass during the **catch and release season**:											
April		-	-	0.0	0.0	0.0	0.0	0.0	0	0	0
May		-	-	0.0	196.0	422	28	0	196	0	0
June		-	-	3482.0	88.0	24	55	502	24	146	195
Total		-	-	3482	284	446	83	502	220	146	195
Percent of seasonal catch made by boats seeking smallmouth bass during the **catch and release season**:											
% Catch		-	-	442.7%	56.0%	146.3%	46.0%	194.6%	91.5%	68.1%	61.3%

Table A21b. Smallmouth bass harvest and catch rate data collected April 15 – September 30, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal rates of harvest and catch for boats seeking smallmouth bass during the **traditional open season**:											
Harv/Boat Trip	2.042	1.426	1.260	1.219	0.760	0.544	0.700	0.992	0.811	1.667	1.794
Catch/Boat Trip	9.790	5.905	4.873	4.323	3.082	2.047	1.928	3.219	3.327	4.337	4.244
Harv/Angler Trip	0.884	0.668	0.553	0.534	0.341	0.250	0.339	0.451	0.372	0.784	0.868
Catch/Angler Trip	4.267	2.765	2.140	1.893	1.380	0.939	0.933	1.464	1.528	2.040	2.052
Harv/Angler Hour	0.261	0.215	0.178	0.171	0.117	0.097	0.126	0.145	0.120	0.226	0.242
Catch/Angler Hr.	1.265	0.891	0.689	0.606	0.472	0.363	0.346	0.471	0.492	0.587	0.572
Monthly harvest rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	1.851	1.474	1.069	0.885	1.807	0.877	1.948	0.259	0.701	1.188	3.514
July	1.740	1.078	1.006	1.460	0.401	0.125	0.694	0.225	0.943	2.716	1.355
August	2.307	1.554	1.907	1.152	0.702	0.399	0.498	1.886	0.829	0.823	1.256
September	2.309	1.889	0.902	1.283	0.530	1.070	0.305	2.353	0.585	1.384	0.384
Seasonal harvest rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	1.269	0.233	0.314	0.521	0.783	0.118	0.169	0.312	0.605	1.577	0.126
West/Central	0.888	0.608	0.144	0.238	0.107	0.074	0.065	0.333	0.000	0.085	0.289
East/Central	2.160	1.857	0.862	1.306	0.538	0.584	0.388	0.209	0.720	0.991	0.280
East	2.791	1.422	2.688	2.055	1.470	1.053	2.013	2.761	1.449	2.454	3.421
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	6.186	5.725	3.625	2.514	6.279	2.796	2.907	0.612	2.940	2.256	6.299
July	9.382	5.057	4.568	3.690	2.148	0.932	1.581	2.871	3.766	7.177	3.292
August	11.763	6.861	6.221	6.358	2.628	2.236	2.058	4.803	3.210	2.326	3.808
September	10.187	6.334	5.235	3.606	2.473	2.701	1.779	3.944	3.016	3.759	2.881
Seasonal catch rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	7.126	1.681	1.463	2.758	5.000	0.796	1.605	1.450	5.397	6.534	3.585
West/Central	8.393	6.088	1.470	2.292	0.732	1.031	0.514	0.739	0.534	1.043	0.775
East/Central	10.481	6.285	5.278	5.434	2.881	2.499	1.545	1.103	2.086	4.285	1.661
East	10.120	6.246	6.545	4.428	4.329	2.748	3.585	8.264	5.204	4.862	6.468
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
Catch/Angler Trip		-	-	3.831	0.402	0.417	0.153	1.887	0.170	0.327	0.293
Catch/Angler Hr.		-	-	1.625	0.151	0.181	0.099	1.035	0.072	0.188	0.124
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **catch and release season**:											
April		-	-	-	-	-	-	-	-	-	-
May		-	-	0.000	4.558	1	0.118	0.000	0.590	0	0.000
June		-	-	9.949	0.272	0.074	1.000	2.523	0.127	1.390	0.878

Table A22. Yellow perch harvest and catch data collected April 15 – September 30, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	8,492	8,942	13,858	25,630	33,589	51,653	18,405	31,830	16,701	6,572	6,066
Catch	17,468	33,209	39,801	87,736	67,342	102,442	61,816	65,394	35,836	15,345	17,966
% Harvested	55.3	26.9	34.8	29.2	49.9	50.4	29.8	48.7	46.6	42.8	33.8
Monthly estimates of harvest for all fishing boats:											
April	10	0	0	0	29	0	1,198	0	2,653	972	0
May	990	1,588	0	1,220	1,357	0	7,656	112	4,203	2,016	0
June	1,353	2,933	7,360	7,566	10,349	34,963	3,665	2,194	6,116	973	0
July	2,069	486	1,476	5,039	3,612	2,810	1,906	5,637	1,913	304	2,453
August	1,662	232	2,233	5,149	6,114	7,816	3,648	16,979	1,755	2,040	3,535
September	2,409	3,703	2,789	6,656	12,128	6,064	332	6,908	61	267	78
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	2,019	3,575	521	15	61	-	468	-	14	-	0
West/Central	912	110	1,240	908	3,824	1,035	1,080	30	2,816	1,136	-
East/Central	4,043	4,979	8,499	24,252	26,845	19,372	9,762	22,363	7,814	4,227	3,050
East	1,519	278	3,598	454	2,858	31,246	7,094	9,438	6,057	1,209	3,016
Monthly estimates of catch for all fishing boats:											
April	48	30	186	-	69	143	1,962	-	5,293	2,172	-
May	1,566	6,152	462	5,980	3,443	95	37,864	112	10,211	4,420	-
June	3,324	12,984	16,614	17,363	25,153	52,025	5,287	5,055	13,440	1,921	1,800
July	3,821	7,733	10,323	16,158	8,637	10,792	4,371	14,419	2,508	923	7,691
August	3,970	1,261	3,631	18,513	10,494	23,739	11,735	29,676	4,298	5,642	8,241
September	4,738	5,049	8,585	29,722	19,545	15,648	596	16,132	86	267	234
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	2,706	5,263	1,737	1,405	77	2,444	906	-	49	-	0
West/Central	1,875	2,314	3,232	2,878	5,999	1,749	2,026	193	4,384	3,890	45
East/Central	9,812	23,855	26,915	78,438	51,333	58,517	40,091	50,878	20,510	9,527	10,439
East	3,074	1,777	7,917	5,016	9,933	39,732	18,793	14,323	10,893	1,928	7,482

Table A23. Walleye harvest and catch data collected April 15 – September 30, 1985-2014.

	Year Surveyed										
	1985-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	583	2,465	164	1,403	116	123	106	458	130	318	182
Catch	718	2,715	408	4,508	130	147	301	531	130	388	421
% Harvested	74.3	90.8	40.2	31.1	89.2	83.7	35.2	86.3	100.0	82.0	43.2
Monthly estimates of harvest for all fishing boats:											
April	0	0	0	0	0	0	0	0	0	0	0
May	105	106	73	0	28	14	0	16	50	0	50
June	61	0	0	1,112	32	0	0	26	0	23	12
July	51	0	15	114	28	0	0	88	80	0	0
August	264	2,340	15	77	28	109	44	160	0	27	120
September	103	19	62	101	0	0	62	168	0	267	0
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	59	0	72	187	29	44	106	86	84	0	92
West/Central	2	0	0	45	32	0	0	0	22	21	0
East/Central	56	24	77	34	56	14	0	0	0	0	40
East	466	2441	15	1137	0	66	0	372	24	297	50
Monthly estimates of catch for all fishing boats:											
April	13	0	31	0	0	10	0	15	0	0	0
May	122	146	286	0	28	28	0	16	50	0	50
June	70	0	0	3,991	32	0	0	26	0	23	12
July	87	47	15	142	28	0	0	147	80	70	0
August	313	2,458	15	199	42	109	213	160	0	27	338
September	113	64	62	176	0	0	87	168	0	267	22
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	89	132	286	413	43	47	180	142	84	59	163
West/Central	4	0	0	62	32	0	0	0	22	22	165
East/Central	86	24	107	66	55	29	0	20	0	0	41
East	539	2559	15	3967	0	71	121	369	24	306	51

Table A24. Estimates of sea and silver lampreys observed by boat anglers April 15 – September 30, 1986-2014.

	Year Surveyed										
	1986-04 avg	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
April 15 - September 30 estimated numbers of lamprey observed:											
April	213	355	138	564	87	218	429	558	575	68	100
May	562	2,033	731	2,117	688	1,769	551	1,618	1,266	835	595
June	316	800	178	1,059	296	150	372	769	294	353	384
July	323	891	1,288	2,147	390	1,358	486	1,155	460	789	567
August	546	1,120	1,173	2,009	954	1,142	697	842	707	829	951
September	128	1,072	381	528	399	526	64	184	138	53	401
Total	2,087	6,272	3,889	8,423	2,814	5,164	2,599	5,125	3,441	2,927	2,998
April 15 - September 30 estimated numbers of lamprey observed among four geographic areas:											
West	879	1881	1381	2830	1,194	2026	946	1,163	1,147	969	894
West/Central	267	654	530	713	18	540	338	565	609	396	308
East/Central	529	1865	1572	3051	845	2126	799	1,812	1,007	1,242	976
East	413	1872	406	1829	757	472	516	1,585	678	320	819
Percentage of lamprey observed that were attached to angler caught trout and salmon:											
Percent	99.1%	98.5%	98.3%	98.5%	98.3%	97.0%	98.9%	96.8%	97.9%	98.4%	98.3%
April 15 - September 30 estimated number of lamprey attached to angler caught trout & salmon, per 1000 trout & salmon caught:											
April	8.81	48.50	14.74	39.57	23.32	19.36	48.73	45.60	29.72	9.28	5.16
May	11.96	43.89	25.51	41.48	27.82	23.08	26.78	45.50	34.03	22.70	12.93
June	11.27	41.34	33.17	50.56	23.58	12.67	19.85	34.61	12.13	17.58	13.31
July	9.74	33.20	56.32	58.84	16.74	38.27	10.50	14.04	10.83	19.18	16.88
August	9.71	27.05	31.11	42.18	22.87	20.45	11.08	16.68	12.63	15.41	16.91
September	6.66	40.52	22.65	26.98	20.28	16.30	6.34	9.57	7.95	5.46	24.00
Total	10.18	37.40	32.20	44.35	22.39	23.12	15.53	23.09	17.50	17.34	14.93
April - Sept. estimated number of lamprey attached to angler caught trout & salmon by geographic area, per 1000 trout & salmon caught:											
West	11.78	30.23	29.93	36.66	20.78	19.49	13.13	12.43	15.56	14.25	13.41
West/Central	10.36	27.26	31.13	34.61	2.32	17.93	15.27	25.57	23.22	15.01	8.72
East/Central	8.90	48.64	37.18	53.11	27.19	34.19	15.44	26.87	20.53	25.33	16.10
East	9.62	43.38	26.49	52.75	25.75	17.46	24.03	40.76	14.24	12.58	21.47
April 15 - September 30 percent composition of host species to which the lampreys were attached:											
Coho Salmon	2.5%	1.6%	2.7%	3.4%	4.3%	2.6%	3.2%	3.4%	2.9%	1.6%	2.6%
Chinook Salmon	36.7%	60.4%	78.8%	58.6%	64.3%	73.1%	51.6%	37.4%	60.0%	68.8%	58.1%
Rainbow Trout	7.4%	5.2%	3.5%	5.6%	10.4%	10.9%	14.0%	5.6%	8.6%	5.6%	18.8%
Atlantic Salmon	0.7%	0.0%	0.0%	0.0%	0.0%	0.0%	3.2%	0.0%	2.1%	0.0%	0.0%
Brown Trout	16.4%	28.6%	14.2%	31.7%	20.0%	13.5%	26.9%	47.5%	22.1%	13.6%	17.9%
Lake Trout	36.3%	4.2%	0.9%	0.7%	0.9%	0.0%	1.1%	6.1%	4.3%	10.4%	2.6%
April 15 - September 30 percent of total host-specific angler catch with attached lampreys:											
Coho Salmon	0.6%	1.1%	0.8%	1.1%	1.8%	0.6%	0.6%	1.4%	0.8%	0.6%	0.9%
Chinook Salmon	1.2%	3.6%	5.0%	5.7%	3.1%	3.5%	2.1%	1.9%	2.3%	3.1%	2.2%
Rainbow Trout	0.7%	2.4%	0.8%	1.8%	0.8%	1.0%	0.8%	0.8%	0.9%	0.5%	1.5%
Atlantic Salmon	5.2%	0.0%	0.0%	0.0%	0.0%	0.0%	4.5%	0.0%	12.2%	0.0%	0.0%
Brown Trout	0.9%	5.4%	2.5%	5.6%	2.4%	2.0%	2.1%	4.7%	1.9%	1.4%	1.2%
Lake Trout	1.2%	2.7%	0.4%	0.9%	0.3%	0.0%	0.2%	1.3%	0.7%	0.8%	0.2%

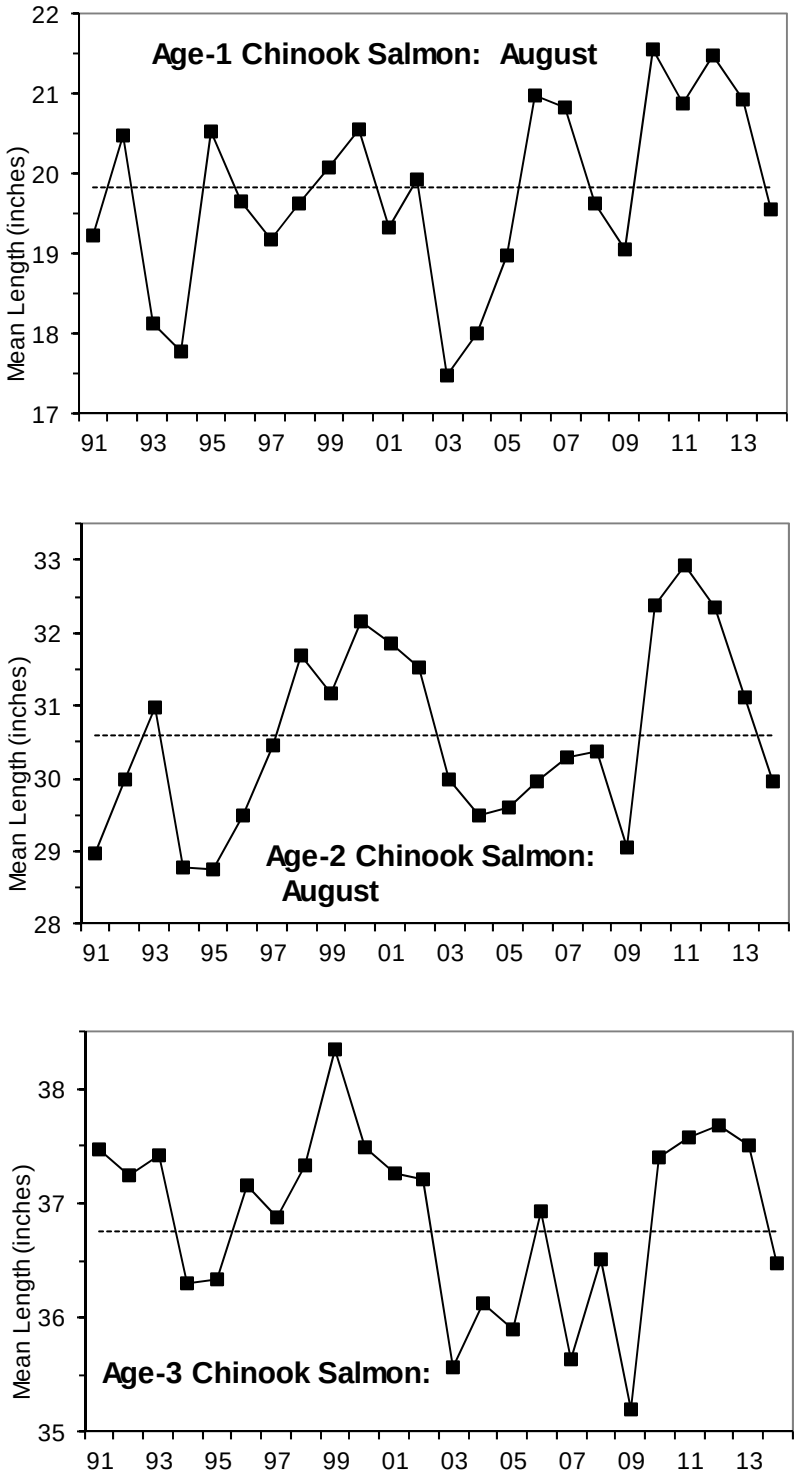

Figure A1. Mean length (total length in inches) of age-1, age-2, and age-3 Chinook salmon sampled in August during the 1991-2014 NYSDEC Lake Ontario fishing boat surveys.

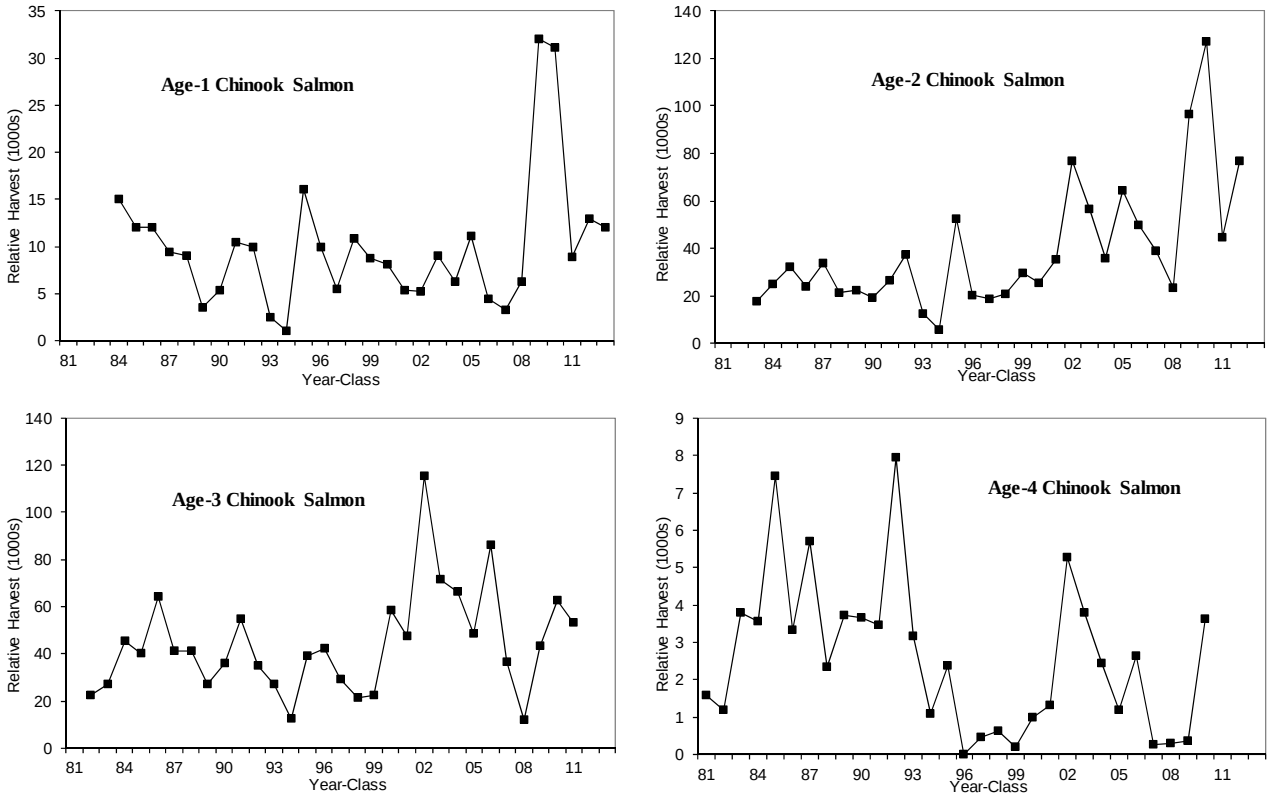

Figure A2. Relative harvest (age-specific harvest per 150,000 fishing boat trips, per 2,000,000 fingerling equivalents stocked) of age-1, age-2, age-3, and age-4 Chinook salmon from the 1985-2014 NYSDEC Lake Ontario fishing boat surveys.

Update on Mass Marking Studies of Chinook Salmon in Lake Ontario 2014

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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 (OMNR) stock 2.3 million Chinook salmon into Lake Ontario at dozens of sites around the Lake. An unknown number of wild smolts are also produced in tributaries from natural spawning, 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. 2015). Chinook salmon raised in net pens are typically released at larger sizes than salmon

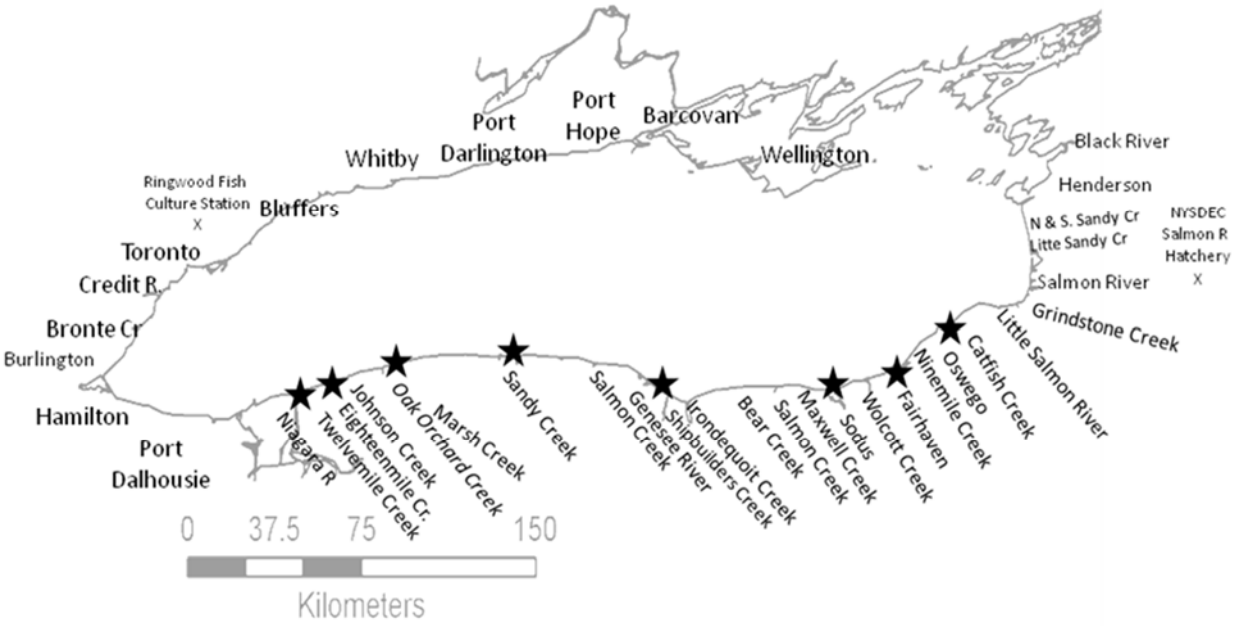

Figure 1. Map of Lake Ontario showing sampling regions and other locations in this report. Sites where Chinook salmon were raised in pens are noted with stars.

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; and 3) to compare the relative contributions of pen vs. direct stocked Chinook salmon to the lake and 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 captured later in the fishery or in the hatchery without an AD clip were considered wild. The combined annual stocking target for Lake Ontario was 2.3 million Chinook salmon during the study period (NY: 1.76 million from SRH; ON: 550K from Ringwood Hatchery); however, conditions at SRH led to unplanned NY stocking reductions in 2008 and 2010, with 799,000 and 1.583 million Chinook salmon stocked, respectively (Bishop and Prindle 2008, Connerton 2012). OMNR stocked their annual target of approximately 550,000 in 2008 and 2009, and stocked 669,442 fish in 2010 that included an additional 96,653 surplus fish (marked with AD clip and CWT) stocked in the Niagara River (OMNR 2011). CWTs are 1/25 inch (1.1 mm) long and are inserted into the salmon's snout prior to stocking. A number engraved on the CWT identifies a fish's stocking origin.

To determine the degree of homing and straying to SRH (i.e. the broodstock water), fish stocked at the Salmon River, NY received AD clips and unique CWTs from 2008-2010. Fish stocked at other stocking sites in NY and ON were marked with an AD clip only or an AD clip and some other unique CWT. Despite the unplanned stocking reductions in New York in 2008 (by 50%) and in 2010 (by 12%), stocking levels at Salmon River were maintained in those years at about 350,000 fish to ensure adequate future broodstock returns to SRH (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	**# CWT fish**	**AD only**	**Pen Total**	**#lots**	**# Pens**	**Pen Density**	**#CWT Fish**	**AD only**	**Direct Total**	**#lots**	**Total**
Black River	-	-	-	-	-	-	-	159,000	159,000	-	159,000
South Sandy	-	-	-	-	-	-	-	100,000	100,000	-	100,000
Salmon River	-	-	-	-	-	-	-	352,000	352,000	-	352,000
Oswego River	37,500	4,390	41,890	1	2	20,945	37,500	60,310	97,810	1	139,700
Fairhaven	25,000		25,000	1	1	25,000	25,000	62,200	87,200	1	112,200
Sodus Bay	37,500	12,500	50,000	1	2	25,000	37,500	22,500	60,000	1	110,000
Genesee R	75,000	10,250	85,250	2	4	21,313	75,000	10,250	85,250	2	170,500
Sandy Cr	37,500	17,500	55,000	1	2	27,500	37,500	17,500	55,000	1	110,000
Oak Orchard	75,000	31,653	106,653	2	5	21,313	63,937	0	63,937	2	170,590
Eighteenmile	67,100		67,100	2	3	22,367	67,100	0	67,100	2	134,200
Niagara River	75,000	-	75,000	2	1	75,000*	75,000	53,500	128,500	2	203,500
Total	**429,600**	**76,293**	**505,893**	**12**	**19**		**418,537**	**837,260**	**1,255,797**	**12**	**1,761,690**

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

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

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

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

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

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

Marking Quality Control

The AutoFish system's built-in quality control features which verified removal of the adipose fin and checked for the presence of a CWT for each fish. Fish marked AD-CWT were returned to the hatchery, but fish without an AD clip and/or CWT were rejected and sent to a holding area where they were clipped and tagged manually. In addition, marking quality was manually verified by agency staff during AutoFish operation from 2008-2013. Each raceway of fish received a unique CWT code. For each raceway, the operator checked 100 fish

from each of the six marking lines to ensure clip quality and CWT presence, and to detect any problems with individual marking lines. Samples of fish were also checked when exiting the trailer prior to entering the hatchery (100 fish per day), in raceways after entering the hatchery (100 fish per raceway), and at pens prior to release (approximately 100 fish per pen per year 2010-2011, and 2013).

Although rare, tagged fish are most likely to shed their CWTs up to 30 days after initial tagging. To estimate CWT retention for this study and to check clip quality each year, samples of Chinook salmon at SRH and at stocking sites were checked for an AD clip and a CWT at least 30 days post-tagging and prior to stocking using a portable CWT detector. At pen and direct stocking sites from 2010-2011, and in 2013, clipping quality and CWT retention 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 to verify CWT codes at each site. In 2010 and 2011, samples for CWT code verification were collected from tanks at the hatchery during loading of hatchery trucks, and in 2013 samples were collected 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, 2009-2014 (Lantry and Eckert 2015). Two technicians were also deployed by the U.S. Fish and Wildlife Service (Service) from July-October 2010-2011, and in 2014 (hereafter referred to as 'headhunters'), specifically to process Chinook salmon for clip and CWT recovery during the lake and tributary angling seasons. In 2012 and 2013, NYSDEC deployed two headhunters from June-October, and an additional two headhunters from July-October particularly to increase sampling effort for recovery of CWTs. In each year of the study, Chinook salmon were measured for total length (TL) and weight, examined for fin clips and CWTs, and a sample of scales was collected from each fish for determining age. Headhunters focused on high-use angling ports, fishing derbies, cleaning stations, and pen evaluation sites. At some ports, groups of anglers at marinas were contacted periodically by phone and arrangements were made to sample the day's harvest at private docks.

During fall tributary fishing (Sept. 15-Nov. 5, 2010-2014), headhunters focused on major tributaries and pen evaluation sites in New York including the Niagara River, Eighteenmile Creek, Oak Orchard Creek, Sandy Creek, and Genesee River in the western region, and Maxwell Creek, Sodus Bay tributaries (Sodus Creek and Second Creek), Sterling Creek, Oswego River, South Sandy Creek and Salmon River in the east (Figure 1). Since most fish were sampled from cleaning stations, anglers were asked where their fish were caught to identify and record capture locations. Recovery efforts also included walking streams to sample anglers' harvest, sampling salmon carcasses in the streams (2012-2014), and electrofishing some streams (2013-2014).

Most Chinook salmon collected in New York waters were aged from impressions of fish scales on acetate film by counting annuli using 2x-10x magnification (n= 3,593 in 2010, 4,587 in 2011, 4,485 in 2012, 3,102 in 2013, and 2,120 in 2014). 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, and 2,274 in 2014). In 2012-2014, some samples were aged using monthly stratified age-

length keys (n=2,003 in 2012, n=2000 in 2013, and 3,775 in 2014). 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), 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 (2012: n=683, 2013: n=283, 2014: n=517) were measured for TL, checked for AD clips and CWTs. Those without CWTs (n=530 in 2012, 128 in 2013, and 361 in 2014) were aged using monthly stratified age-length keys created based on each year's scale ageing. Also in 2011-2014, freezers were placed at six locations along the Lake for cooperating anglers to place Chinook salmon heads. Freezers were checked periodically, all snouts were scanned for the presence of a CWT and if present, were sent to the Service's Great Lakes Fish Tag and Recovery Laboratory in New Franken, WI (GLFTRL) for processing. These samples were only included in analyses of CWT recoveries.

In Ontario, samples came from three sources: 1) angler caught fish sampled at high-use ports from June 25-September 4, 2010; 2) OMNR's western Lake Ontario angler survey conducted from May-August, 2011-2013 at selected ports; and 3) tournaments and derbies throughout the summer 2011-2014 (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 (OMNR 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, OMNR 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.

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 [2015] for TL, weight and age distribution results). In 2010 and 2011, jacks were sampled (total of 93 in 2010 and 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 <30.1 inches TL in 2010 and <27.7 in TL in 2011). In 2012, age-1 jacks (2011 YC) were not part of the SRH homing study; however, sampling of these fish was conducted as part of regular annual reporting of biological characteristics of salmon at the hatchery (see Prindle and Bishop 2013) and they were checked for the presence of an AD clip (indicating fish stocked at Salmon River or some other site) and AD-CWTs (indicating a stray from another site). In 2013, jacks (2012 YC) entering the hatchery were not clipped or tagged because no marking occurred in 2012. For 2014, jacks were scanned for CWTs as part of regular sampling and annual reporting at the hatchery (see Prindle and Bishop 2015) and to identify strays from pen and direct stocked sites.

In 2014, additional samples of AD clipped salmon 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). For all sampling from 2009-2014, 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 2009-2014 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.

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 2011-2014 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 2011-2014 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 for the pen study. Only the 2010 and 2011 year classes were fully recruited to the fishery in 2014 (as ages 3-4); 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). Only Lake returns were compared in 2014 for the 2010 and 2011 YCs in this report. Tributary returns for 2010-2011, and 2013 YCs will be compared in future reports.

Results and Discussion

Quality Control

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

At pen sites from 2010-2011 and in 2013, clipping quality and tag retention was monitored by NYSDEC regional biologists prior to stocking. Approximately 50-150 fish per pen were checked for an AD clip and CWT in each year of tagging. Clipping quality at pen sites was excellent: in 2010 2,537 fish were examined in 19 pens with an average clipping percentage of 99.6% (standard deviation (σ) =1.0%); in 2011 1,932 fish were examined in 18 pens with average clipping percentage of 98.9% (σ=1.7%); and in 2013 1,331 fish were examined in 15 pens with an average of 98.0% (σ=1.0%). Tag retention was also high. As previously described, not all Chinook stocked at pen and direct stocked sites were tagged (Table 2); therefore the percentages of tagged fish recorded at each site during QC checks were compared against expected. For all sites in all years the percentages of tagged fish were within +/- 1% of expected indicating high tag retention (99%).

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

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

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				NT	
CWT	698	1174	1000		NT
% AD Clipped	99.7	99.1	ND	ND	NM
% with CWT	98.7	98.6	99.1	NT	NM
% no AD clip,no CWT	0.3	0.1	ND	NT	NM
% AD clipped, no CWT	1.4	1.3	ND	NT	NM

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

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 three year-classes (2008-2010), with one year of data collection remaining for the 2011 YC (age 4 in 2015). The percentages of unclipped (wild) Chinook salmon are presented in Table 4 for each year class sampled from 2009-2014.

For details about 2010-2013 sample collection and sample distributions among ages, see Connerton et al. (2011, 2012, 2013, 2014 respectively). In 2014, a total of 3,538 Chinook salmon harvested by anglers in the open lake were sampled in Ontario and New York from April 15-September 15. Of these, 354 fish (10%) were age-1 (2013 YC), 1,469 (41.5%) were age-2 (2012 YC), 1,662 (46.9%) were age-3 (2011 YC), and 53 (1.5%) were age-4 (2010 YC).

Percentages of wild Chinook salmon were calculated for ages 3-4 in 2014 (Table 4). Age-1 and age-2 fish were not part of the study. The percentage of wild age-3 Chinook salmon observed in the Ontario region (48.8%) was slightly higher than NY west (36.5%) and NY east 39.4%) regions but were not significantly different (χ^2=3.48, df=2, P=0.175). Sample size of age 3s from the Ontario region (n=60) was lower than in previous years because OMNR did not have a Lake creel survey in 2014 and only conducted sampling at a few Lake tournaments. Likewise sample size for age 4 (n=1) was low from the Ontario region and no more analysis was done for this region. The percentages wild of age-4 Chinook in NY west (52.6%) and NY east (66.7%) regions were not significantly different (χ^2=1.0, df=1, P=0.31).

Differences among regions in 2014 were unlike results in 2010-2013 (Connerton et al. 2013) when Ontario and eastern regions were significantly different at some ages. These differences may relate to regional differences in wild reproduction in tributaries, distribution patterns of wild age-1 salmon, or distribution of wild adults returning to natal tributaries prior to spawning. For example, the ON and NY east regions consistently had higher proportions of wild age-1 fish in the Lake fishery for the 2009-2011 YCs and these regions, especially the Salmon River, are likely the largest sources of wild Chinook. The proportions of wild fish at ages 2 and 3 in the NY east region significantly increased in August/September, 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 likely lower (Connerton et al. 2013). More research is needed to understand dispersal and distribution of wild and hatchery Chinook salmon.

The percentages of wild Chinook also varied by year class and age from 2009-2014 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 52.6% to 100% (Table 4). Some year classes had higher proportions of wild at each age than other year classes. The 2010 year class was a particularly strong year for wild reproduction (Bishop et al. 2014) in the Salmon River and this was reflected in the percentages of wild fish in the Lake data (Table 4). Similarly, 2008 was a particularly weak year for wild reproduction at Salmon River (Bishop et al. 2014) and this year class was also poorly represented in the Lake. Noteworthy is that only 50% of the stocking target was stocked by New York in 2008 which would have inflated the proportion of wild fish in that year class compared to the other marked year classes, assuming equal survival. On the other hand, a higher proportion of pen fish were stocked by New York in 2008 and pen fish may survive better (based on preliminary results of the 2010 and 2011 YC), so equal survival may not be assumed. While mass marking provides valuable information, unfortunately proportions of wild and hatchery fish vary for several reasons including varying wild and hatchery production, and differing survival of hatchery and wild smolts. More research is needed to estimate numbers of wild Chinook and survival rates of hatchery and wild fish, and to evaluate factors impacting that variability.

Another interesting pattern apparent in the data may relate to size differences between hatchery and wild Chinook at early ages (Connerton et al. 2012). For example, in each year class marked for the wild study, the percentage of wild Chinook in the open Lake angler catch increased from age-1 to age-2 within a year class. The percentage wild at age-1 is likely biased low because wild fish start out smaller (Everitt 2006) and presumably recruit to a harvestable size ($\geq$15 in.) later than hatchery reared Chinook, which would under-represent wild fish in sampling at age-1 (Connerton et al. 2011). The percentages of wild fish also increased from age-2 to age-3 in two of the year classes examined. Hatchery Chinook were significantly larger than wild Chinook at age-2 by 1.5 inches in June-July, but not always in subsequent months and never at age 3 (Connerton et al. 2012). The proportions of wild Chinook may change from age-2 to age-3 for two reasons: higher proportions of hatchery

Chinook may mature at earlier ages because of their size and leave the population at age 1 or age 2 in higher proportion than wild fish, and/or hatchery fish may be harvested in greater proportion at younger ages because of their size leaving more wild fish in the year class at ages 2 and 3. More research is needed to understand if size at stocking, harvest and age at maturity influences the proportion of wild fish in the population.

Overall from 2009-2014, 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 across all years and regions sampled. These ages make up the majority of the Chinook harvest each year. Results of this study are important for fisheries managers when considering how their stocking decisions can influence population dynamics and predator prey balance in Lake Ontario.

Percent Wild in New York Tributaries

In New York, major tributaries were sampled during the fall Chinook salmon spawning season from September 15-November 5 each year from 2010 to 2014. Some sampling was also done in fall 2009 in the Salmon River. For details about 2010-2013 sample collection and sample distributions among ages and tributaries, see Connerton et al. (2011, 2012 2013, and 2014 respectively). The percentages of unclipped (wild) Chinook salmon are presented in Table 5 for each year class sampled from 2009-2014.

In 2014, a total of 4,474 Chinook salmon were sampled from 26 NY tributaries including 515 salmon carcasses sampled directly from streams. Of the 4,474 salmon, 131 (3%) were age-1, 1,066 (42%) were age-2, 3,237 were age-3 (54%), and 49 (1%) were age-4. All fish were fin-clipped from 2008-2011, therefore the percentages of wild Chinook salmon in 2014 were calculated for ages 3-4 (Table 5).

In western tributaries (total n=2,518), most samples came from Orchard Creek (27.4%), Eighteenmile Creek (19.9%), Sandy Creek (19.4%), and the Niagara River (18.3%), with smaller samples collected from Genesee River (6.0%), Marsh Creek (3.9%), Johnson Creek (3.5%), Irondequoit Creek (1.0%), Shipbuilders Creek (0.3%), Allen Creek (0.2), and Salmon Creek west of Genesee River (0.1%). The percentages of wild Chinook salmon in western tributaries in 2014 were 20% for age-3, and 77.8% for age-4 Chinook salmon; sample size was low for age-4 fish, however, which resulted in wide confidence intervals.

Samples from eastern Lake Ontario tributaries (total n=1,429) were from the Oswego River (40.4%), Sterling Creek (20.2%), Maxwell Creek (6.9%), South Sandy Creek (7.6%), Wolcott/Furnace Creek (3.5%), Little Salmon River (11.6%), and the Black River (3.1%), with smaller samples from Second Creek (1.2%), Bear Creek (0.6%), Salmon Creek east of Genesee River (2.2%), Little Sandy (0.1%), North Sandy Creek (1.8%), and Catfish Creek (0.8%). The proportions of wild Chinook salmon observed in eastern tributaries were generally higher than western streams with 29.2% of age-3, and 50% of age-4 Chinook salmon unclipped (Table 5). Small sample sizes of age-4 fish in all sampling resulted in wide confidence intervals (Table 5).

In 2014, the percentages of wild Chinook salmon ages 3-4 in tributaries were significantly different among regions (age-3: χ^2=148.0, df=2, P= <0.0001; age-4: χ^2=11.7, df=2, P=0.0028). In particular, the percentages of wild Chinook salmon for ages 3-4 at the Salmon River (54.0%, 77.8% respectively) were significantly higher than NY west tributaries (age-3: χ^2=114.2, P<0.0001; age-4: χ^2=54.8, P<0.0001) and for age 3 in NY east tributaries (age 3: χ^2=95.6, P<0.0001) but not for age 4 (age-4: χ^2=1.92, P=0.38). In addition, the percentages of wild fish in the NY west region were significantly lower than the NY east region for age 3 salmon (χ^2=27.6, P<0.0001) but not for age 4 (χ^2=3.96, P=0.14). Ages-1 and 2 fish in 2014 were not part of this study.

Relatively low proportions of wild fish in western streams compared with other regions were consistent with results in 2010-2013 (Table 5) and may result from several factors including warm temperatures, limited habitat and impassible barriers present in many western NY region tributaries. High angling pressure in these tributaries may also negatively affect levels of natural reproduction, either directly by harvest or as a result of high pre-spawn mortality caused by catch and release angling in warm streams (Everitt 2006).

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 2009-2014. All stocked Chinook salmon were adipose clipped from 2008-2011 and only data from marked year classes and ages recruited to the fishery are shown.

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

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

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

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

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

b. Sample size was small therefore no further analyses was done.

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 2009-2014. 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]

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 also consistent with results in 2010-2013 (Connerton et al. 2011, 2012, 2013, 2014). 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. Everitt (2006) estimated that 5 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. More research is needed, however, to understand the cumulative wild production of all tributaries including in the Province of Ontario.

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 to minimize straying back to SRH. 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 and tributaries

In 2014, only the 2010 year class remained as part of the SRH homing study as age-4 fish. Age-4 salmon are rare in the Lake Ontario population and only 9 were sampled from the Salmon River harvest in 2014. Of these, only 2 were clipped and both had tags indicating they were stocked at the Salmon River, so no more analyses were pursued. 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). Even so, the estimated straying rates from other sites to the River for age-2 Chinook were 7.0%, 14.3% and 16% for the 2008-2010 year classes, respectively, based on the harvest sample. Straying to the Salmon River certainly occurs but straying rates in the SRH and in Salmon River angler harvest do not indicate that it is a concern for fisheries managers. We will continue to track tagged pen and direct stocked fish returning to the hatchery until 2017, which will provide a more complete picture of the sources of these strays.

Fish stray not only *to* the Salmon River to spawn, but some also stray *from* the Salmon River to other tributaries. 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 in 2015-2017.

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 2011-2014 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 contribution 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 8). 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). 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 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

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 Stocked	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	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		Recovery Ratio
Site	**Stocking Method**	**Number Stocked**	**2012**	**2013**	**2014**	**Total**	**X^2**	**P**	**X^2**	**P**	**(Pen:Direct)**
Niagara	Pen	75,960	3	17	30	49	0.82	0.6621	22.7	1.91E-06*	2.88
	Direct	75,790	1	7	9	17					
Eighteenmile	Pen	67,490	10	61	59	130	2.82	0.2437	46.61	8.65E-12*	2.61
	Direct	66,000	3	18	29	50					
Oak Orchard	Pen	75,330	13	56	59	129	7.89	0.0194*+	13.01	0.000309*	2.47
	Direct	64,244	9	13	30	52					
Sandy Creek	Pen	38,750	19	54	54	128	1.14	0.5634	36.92	1.23E-09*	3.45
	Direct	37,865	4	13	20	37					
Genesee River	Pen	75,350	8	48	17	72	1.06	0.5883	24.23	8.53E-07*	2.36
	Direct	73,530	5	18	8	31					
Sodus Bay	Pen	37,720	9	37	62	109	1.3	0.5229	22.62	1.97E-06*	2.67
	Direct	38,120	1	17	22	41					
Fairhaven	Pen	25,520	4	27	157	188	0.12	0.9428	9.82	0.001726*	1.71
	Direct	25,040	2	14	94	110					
Oswego	Pen	37,690	4	19	36	58	1.18	0.552	0.33	0.5672	1.16
	Direct	36,910	1	20	28	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

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 in 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 2011-2014, 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 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.

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 2012-2014. For sites with P-values <0.05, returns of pen-stocked and direct stocked fish were significantly different at α=0.05.

	# Stocked in 2011		# Recovered 2012		# Recovered 2013		# Recovered 2014		# Recovered per 50,000 stocked			
Stocking Site	**Pen**	**Direct**	**Pen**	**Direct**	**Pen**	**Direct**	**Pen**	**Direct**	**Pen**	**Direct**	**χ2**	**P**
Niagara	75,960	75,790	0	0	2	0	3	4	3	3	0	1
Eighteenmile	67,490	66,000	0	1	0	7	1	16	1	18	19.85	<0.00001
Oak Orchard	75,330	64,244	0	14	6	40	4	65	7	93	108.95	<0.00001
Sandy Creek	38,750	37,865	2	9	2	3	4	12	10	32	7.38	0.0066
Genesee	75,350	73,530	5	2	3	4	5	22	9	19	8.91[a]	0.0028
Sodus	37,720	38,120	9	2	12	4	32	30	70	47	3.04	0.08105
Fairhaven	25,520	25,040	3	1	5	1	3	3	22	10	1.47	0.2256
Oswego	37,690	36,910	1	0	2	4	3	6	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.

For a detailed summary of 2010 YC strays from pen and direct stocking sites to SRH, see Connerton et al. (2014). 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 9). 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).

Summary

1. Only fish from the 2010 and 2011 year classes remained in 2014 as part of the wild study. The percentages of wild age-3 and age-4 Chinook salmon in the Lake Ontario fishery were 38.8% and 60.4% respectively, in 2014.

2. Percentages of wild Chinook salmon in Lake Ontario varied by year class, age, and among regions from 2009-2014, but overall wild Chinook were an important component of the Lake Ontario fishery averaging 47% of the age 2-3 Lake harvest.

3. In 2014, the percentage of wild age-3 Chinook salmon at the Salmon River (54%) was significantly higher than NY west (20%) and NY east (29%) tributaries, which were also significantly different. Regional differences in tributaries are consistent with observations from 2010-2013 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.

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Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1976-2014

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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 2014 abundance indices as they relate to previous years, and summarizes occurrence of round goby (*Neogobius melanostomus*) in predator diets, smallmouth bass age and growth trends, and age structure of walleye caught 2011-2014.

Methods

A standardized, stratified random design gillnetting assessment was conducted annually from 1976 through 2014 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 2014, 29 randomly chosen netting locations were determined prior to initiation of the assessment on July 29. From July 29 through August 8, 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 2003-2014 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 (1976-2014) and otoliths (2004-2014) 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

2014 Water Temperature

In 2014, bottom temperatures for all nets set in depth strata 1 (12-30 ft) and 2 (31-50 ft) ranged from 66.9°F-73.0°F and 65.7°F-71.4°F, respectively. For nets set in stratum 3 (51-100 ft) bottom temperatures ranged from 44.8°F-68.0°F. These temperatures were much colder than those recorded during 2012 and 2013, when temperatures in the mid-70s (°F) occurred as deep as approximately 70 ft and 95 ft, respectively. Two unbiased net sets in depth stratum 3 may have experienced some periods of water temperatures <50°F, given that seven coldwater fish (three species) 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 2014, 889 fish were captured in unbiased net sets, representing 16 warm and cool water species (882 fish) and three coldwater species (7 fish). The greatest species richness (17 species; CPUE=68.9) occurred in depth stratum 1, followed by depth strata 2 (11 species; CPUE=26.9) and 3 (5 species; CPUE=2.0). 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). This change in composition was primarily attributed to a decline in yellow perch CPUE (1.7 fish per net and an 86.8% decrease compared to the previous 5-year average), and an increase in white perch CPUE (7.9 fish per net; a 92.9% increase compared to the previous 5-year average).

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 2000-2014. 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. Gobies were present in walleye diets each year from 2006-2010 and 2012-2014. 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 14 of the 20 years. Lake sturgeon remain rare in the survey.

Occurrence of Chain Pickerel

Chain pickerel (*Esox niger*) presence in Ontario waters was confirmed in 2008 (Hoyle and Lake 2011). It 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 2015). Occurrence of chain pickerel in recent years is attributed to range expansion (Hoyle and Lake 2011). No chain pickerel were captured in 2014.

Index of Abundance: Total Warmwater Catch

The abundance index for warmwater fish in the New York waters of Lake Ontario's eastern basin was highest during the early years of the assessment (1976-1979 mean stratified CPUEs: 209-257) then declined (1984-1986 mean CPUE=68.7; Table 1, Figure 2). The decline in warmwater fish abundance was primarily due to declining indices for white perch (1976-1979 mean CPUE=90.1, 1984-1986 mean CPUE=15.7), yellow perch (1976-1979 mean CPUE=51.8, 1984-1986 mean CPUE=17.6), gizzard shad (1976-1979 mean CPUE=34.7, 1984-1986 mean CPUE=0.6), and rock bass (1976-1979 mean CPUE=13.5, 1984-1986 mean CPUE=6.2; Table 1, Figures 3-6). The mean stratified CPUE for all warmwater species reached a record low level in 1995 when CPUE was 14.9 and 94% lower than the 1976-1979 average (Table 1, Figure 2). Since 1996, mean stratified CPUE for total warmwater fish varied without trend averaging 26.9 and ranging between 14.9 (1995) and 44.4 (2008; Table 1, Figure 2). In 2014, the mean stratified CPUE of 20.6 was the lowest since 2004 and a 34.3% decrease compared to the previous 10-year (2004-2013) average. The 2014 decrease is largely attributed to decreased catches of yellow perch and smallmouth bass.

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

White Perch Index of Abundance

The most notable declines in species abundance between the late 1970s and mid 1980s occurred with white perch and gizzard shad, the two most abundant species in 1977 and 1978. White perch declined 83% from the 1976-1979 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. 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).

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. The 2014 CPUE (1.7) was the lowest observed in the time series (Table 1). This decrease may be attributable to water temperature patterns and catch variability; however, angler reports (anecdotal and as reported in Lantry and Eckert 2015) 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=21.1%), and is likely attributable to the schooling nature of perch. For 2014, yellow perch RSE (38.5%) was comparable to (+3.0%) the long-term average.

As was documented for smallmouth bass (Chrisman and Eckert 1999, Lantry et al. 2002), the yellow perch population in the eastern basin was impacted by DCC predation (O'Gorman and Burnett 2001). Fall trawl sampling in the eastern

basin showed that relatively strong year classes of yellow perch were produced in the early 1990s, however, anticipated increases in assessment CPUE at older ages did not occur. Analyses indicated increased mortality of age 0-2 perch during that time period which was attributed, in part, to increased predation by DCC (O'Gorman and Burnett 2001). Since then, 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 DCC, further reducing predation pressure on yellow perch in recent years (Johnson et al. 2014).

In 2014, yellow perch total lengths ranged between 7.2 in (183 mm) and 11.9 in (302 mm), and averaged 8.6 in (218 mm). Approximately 26% of perch captured were ≥ 9 in (≥ 228.6 mm; Figure 17). Weights of yellow perch captured in 2014 ranged from 2.5 oz (70.9 g) to 12.7 oz (360.0 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.

Rock Bass Index of Abundance

Rock bass CPUE peaked in 1978 at 22.1, declined through the early 1980s, varied without trend through the early 1990s, then declined again to a relatively stable level through 2011 (Figure 6). In 2014, the rock bass CPUE (1.2) was a 31.5% decrease compared to the previous 5-year average.

Alewife Index of Abundance

Alewife CPUE varied without trend through 1988, averaging 9.0 (Figure 7). CPUE subsequently declined and was ≤1 each year 1993-2008. In 2009, alewife CPUE (1.2) was the highest observed since 1992, but well below levels observed through the 1970s and 1980s. No alewife were caught during the 2010 or 2013 assessments. The 2014 alewife CPUE was 0.3 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, and has fluctuated without trend (Figure 8). The 2014 CPUE of 1.6 was a 24.4% decrease compared to the previous 5-year average. The walleye population is expected to remain stable for several more years because strong 2003, 2005 and 2008 year classes remained well-represented in 2014 netting (see below), and Ontario Ministry of Natural Resources and Forestry (OMNRF) assessments indicated relatively strong natural reproduction in 2011 and 2014 (OMNRF 2015). 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 1990-2014 (average RSE=26.8%).

Otoliths collected from walleye were aged and indicated that strong year classes were produced in 2003, 2005, and 2008 (Figure 18). In 2014, these year classes (ages 11, 9, and 6, respectively in 2014) dominated the catch and represented 14.3%, 15.6%, and 16.9% of the catch,

respectively (Figure 18). The 2003 year class were first captured as age 1s in 2004 when they represented 25.9% of the catch (n=21 age-1 fish; a record-high; Eckert 2005). Prior to 2004, age 1 walleye were rare in this assessment (n=17 during 1976-2003). Assessments in Ontario waters of Lake Ontario and New York waters of Lake Erie also identified a strong 2003 walleye year class (Einhouse et al. 2010, Ontario Ministry of Natural Resources [OMNR] 2011a and 2011b). Good to strong 2005 and 2008 year classes were also produced in Ontario waters (OMNR 2009, 2010, 2011a, 2012). Fall young-of-the-year (YOY) bottom trawling in the Bay of Quinte indicated that a strong 2011 year class was produced there (OMNR 2012). To date, there is little evidence of a strong 2011 year class in NY waters (0% of catch in 2012 [age 1], 5.7% in 2013 [age 2] and 5.2% in 2014 [age 3]; Figure 18).

In 2014, walleye total lengths ranged between 18.2 in (463 mm) and 31.7 in (805 mm), and averaged 25.3 in (642 mm; Figure 17). Walleye weights ranged from 2.3 lb (1,022 g) to 12.1 lb (5,492 g) and averaged 6.9 lb (3,132 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 has improved in recent years from record lows; however, it has not returned to levels that would be 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. 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 ≥ 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). Only poor to weak year classes were produced after 2005. This contributed to a decline in the 2014 smallmouth bass CPUE (5.0; 2014 RSE=17.0%) to the lowest level since 2004. Currently, only weak or poor year classes are present in the eastern basin smallmouth bass population.

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 ≤ 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 21and 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. Since the mid-2000s, mean length-at-age remained at or near record high for all ages 2-10 (Figure 21). Unlike early years of this survey, gill nets now effectively sample many age-2 and age-3 bass, and likely all age-4 bass. These changes confound comparisons of "historic" (prior to mid-1990s) data with more recent data, including age-specific CPUE and survival.

In 2014, smallmouth bass total lengths ranged between 8.0 in (202 mm) and 20.9 in (532 mm), and averaged 15.0 in (380 mm; Figure 17). Bass weights ranged from 0.24 lb (111 g) to 6.5 lb (2,950 g) and averaged 2.4 lb (1,099 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 smaller bass (≤ 12 in TL) was low in 2014 relative to recent years; however, condition of larger bass (≥ 13 in TL) remained near record high levels (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 ≥ 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 (2006-2014 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., ≥ 4 lb) in assessments nets was documented (Figure 25). Prior to 1991, no bass >4 lbs were caught. The first bass ≥ 4 lbs was caught in 1992 (0.2% of total [n=483] catch). Beginning in 1998, bass ≥ 4 lbs were caught with increasing regularity. In 2014, 18.6% of all smallmouth bass caught (n=236) were ≥4 lbs, the highest contribution on record (Figure 25). Bass weighing ≥ 5 lbs were caught each year since 2005. Approximately 5.5% of all smallmouth caught in 2014 weighed ≥5 lbs. Bass ≥6 lbs were first caught in the 2005 survey (0.2% of total smallmouth bass caught), and again in 2011. Each year 2011-2014, 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 (1996-2014) 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 59.1% mature during 1996-2014 (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 (1996-2014), mean CPUE was 69.0% 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 (1995-2015 mean CPUE=3.7) relative to 1976-1994 (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 averaged 4.0, 26.9% 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).

I further evaluated age composition of smallmouth bass ≥ 12 in TL because they are both fully vulnerable to assessment nets across the entire 39-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 1997-2014, between 50.5% (2009) and 94.2% (2004) of the bass ≥ 12 in TL were age 5 and older (1997-2005 average=82.2%; 2006-2014 average=73.8%). 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 21.9% since 1997 (1997-2005 average=17.9%; 2006-2014 average=26.0%; 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 ≥ 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).

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 1976-2014 warmwater assessment netting conducted late July through mid-August in New York waters of Lake Ontario's eastern basin.

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

Table 1 (continued). Stratified mean catch per unit effort data from the 1976-2014 warmwater assessment netting conducted late July through mid-August in New York waters of Lake Ontario's eastern basin.

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

Table 1 (continued). Stratified mean catch per unit effort data from the 1976-2014 warmwater assessment netting conducted late July through mid-August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang												
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Lake Sturgeon	0	0.04	0.02	0.02	0.09	0.10	0	0	0.08	0.02	0	0.02	0
Longnose Gar	0	0	0.06	0.17	0.12	0.08	0.10	0.21	0.75	0.62	0.02	0.23	0.44
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	0.02	0.08	0	0	0.07	0.14	0.19	1.19	0	0.16	0.46	0	0.31
Gizzard Shad	0.06	0	0	0	0	0	0	0.10	0	0.12	0.19	2.08	0.32
Northern Pike	0.19	0.15	0.17	0.19	0.08	0.06	0.23	0.09	0.10	0.02	0.02	0.12	0.12
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	0	0.06	0
Muskellunge	0	0	0.02	0.02	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	0.02	0.15	0.14	0.11	0.02	0.05	0.10	0.02	0.02	0	0.15	0.11
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	0.08	0.02
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	0.78	1.66	0.41	1.03	0.72	0.573	0.65	1.31	0.48	0.25	2.35	0.19	0.16
Silver Redhorse	0.17	0.10	0.42	0.33	0.02	0.02	0.08	0.07	0.04	0	0.06	0.06	0
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	0.21	0.40	0.35	0.48	0.31	0.54	2.12	0.81	1.48	0.42	0.82	1.97	1.54
Channel Catfish	0.21	0.12	0.79	0.81	0.15	0.12	0.57	0.54	0.42	0.17	0.21	0.42	0.07
Stonecat	0	0	0	0.06	0.02	0	0	0	0.04	0.02	0.02	0	0
Trout-perch	0	0	0	0	0	0	0	0	0	0	0	0	0
White Perch	1.09	0.42	1.18	1.94	0.92	0.81	7.75	3.02	6.22	3.72	1.04	6.41	7.87
White Bass	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Bass	1.10	1.84	2.09	2.70	2.43	0.70	3.27	2.52	1.54	1.31	0.75	1.21	1.00
Pumpkinseed	0.46	0.46	0.52	0.50	1.15	0.21	0.10	0.28	0.04	0.21	0.29	0.38	0.02
Bluegill	0	0	0	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass	3.76	5.43	3.84	11.33	10.45	6.39	9.27	9.81	7.90	6.09	8.12	7.65	5.01
Largemouth Bass	0	0	0.02	0.02	0.02	0	0	0.03	0.02	0	0	0.02	0
Black Crappie	0.06	0	0.02	0.06	0	0.04	0.05	0.03	0.04	0.04	0.02	0.06	0.02
Yellow Perch	9.65	9.82	6.74	8.93	9.13	13.95	16.91	7.37	16.31	15.29	14.99	10.32	1.70
Walleye	1.08	2.12	1.69	2.38	1.94	1.33	2.33	2.65	1.91	1.97	2.38	1.34	1.55
Freshwater Drum	0.23	0.27	0.60	0.19	0.32	0.23	0.26	0.36	0.08	0.19	0.19	0.29	0.34
Round Goby	0	0	0	0.04	0.10	0.26	0.42	0.95	0.36	0.08	0.07	0.02	0
Total	19.06	22.92	19.1	31.36	28.16	25.6	44.36	31.44	37.84	30.73	32.02	33.09	20.62

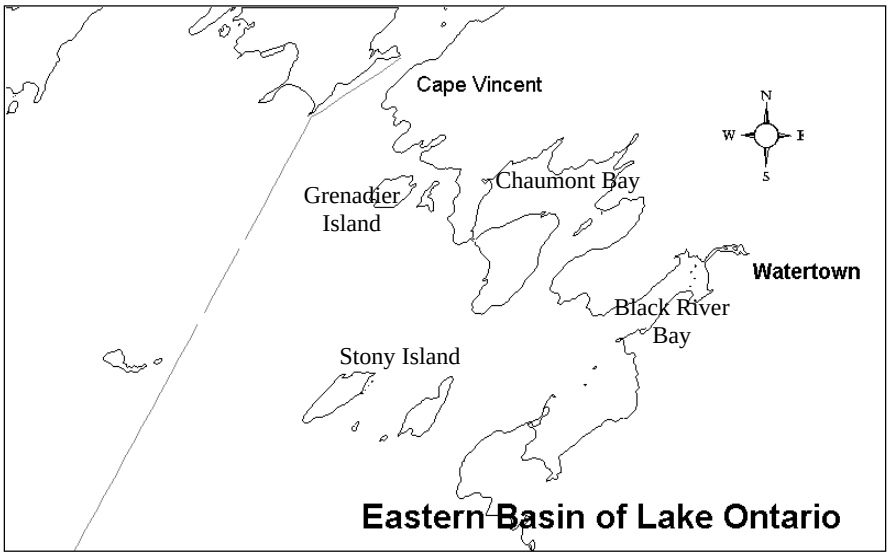

Figure 1. Map of New York waters of Lake Ontario's eastern basin showing five area strata used in the 1980-2014 warmwater assessment.

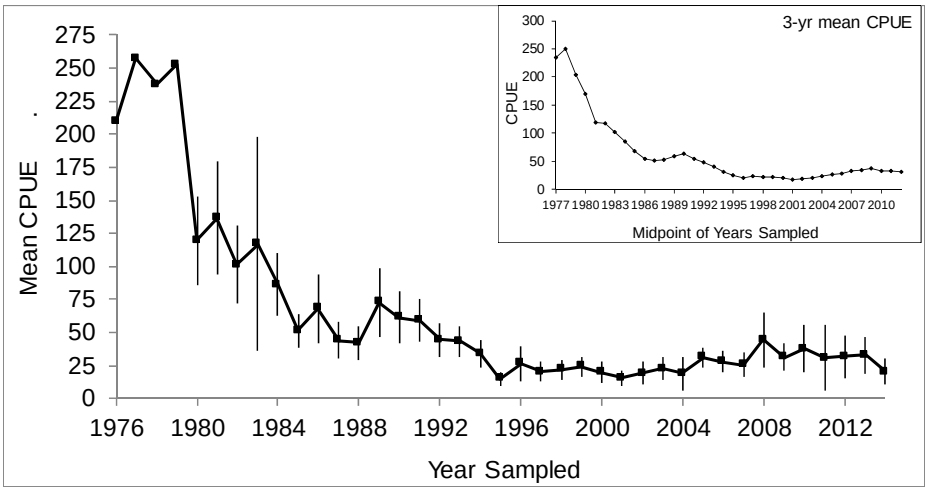

Figure 2. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for all warmwater fish from the 1976-2014 assessments.

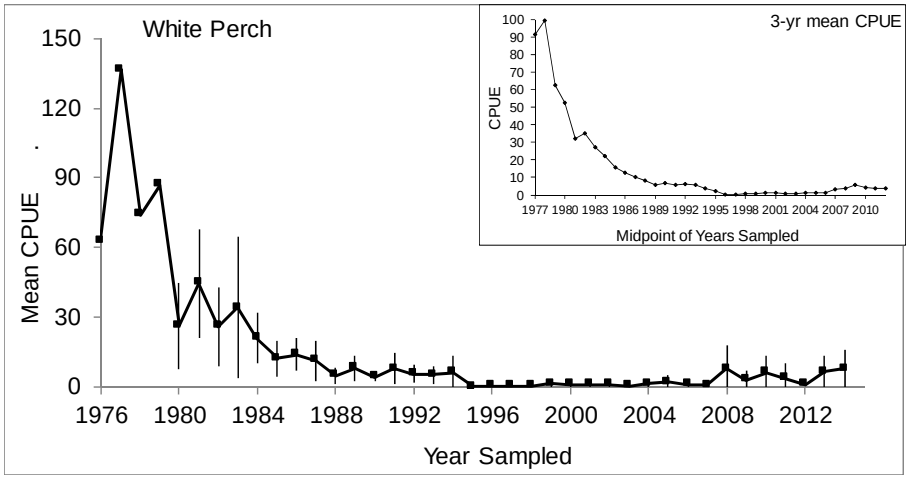

Figure 3. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for white perch, 1976-2014.

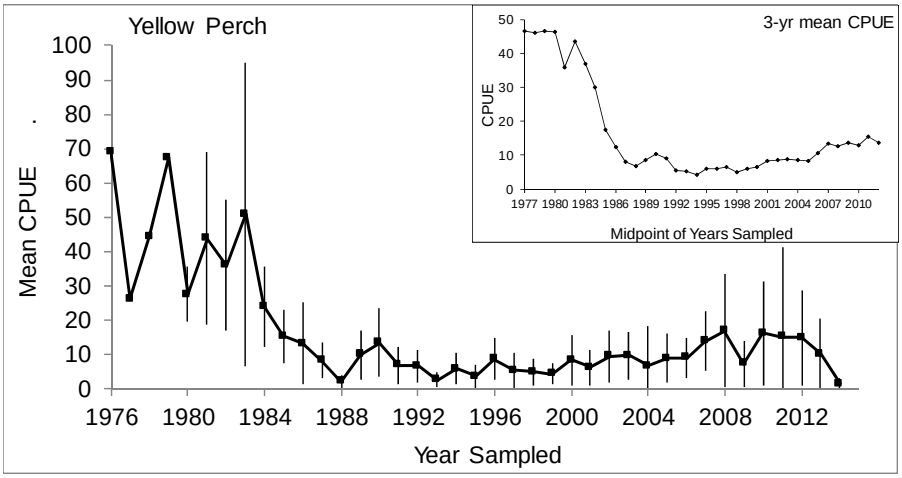

Figure 4. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for yellow perch, 1976-2014.

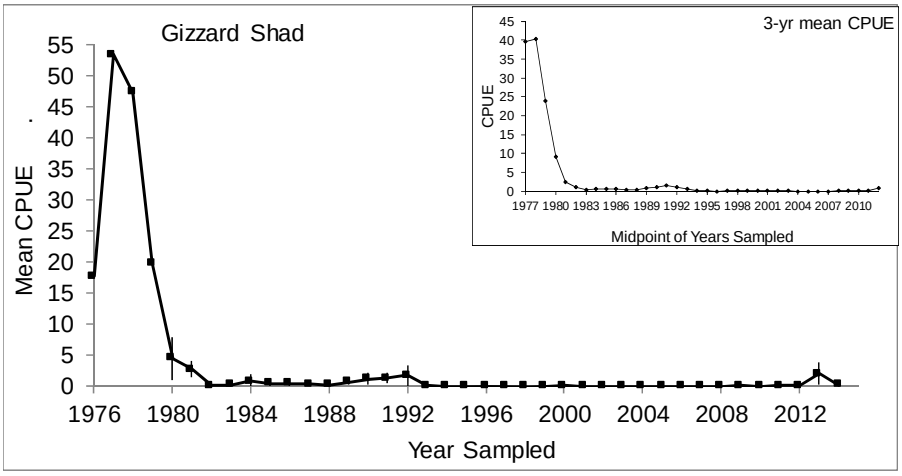

Figure 5. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for gizzard shad, 1976-2014.

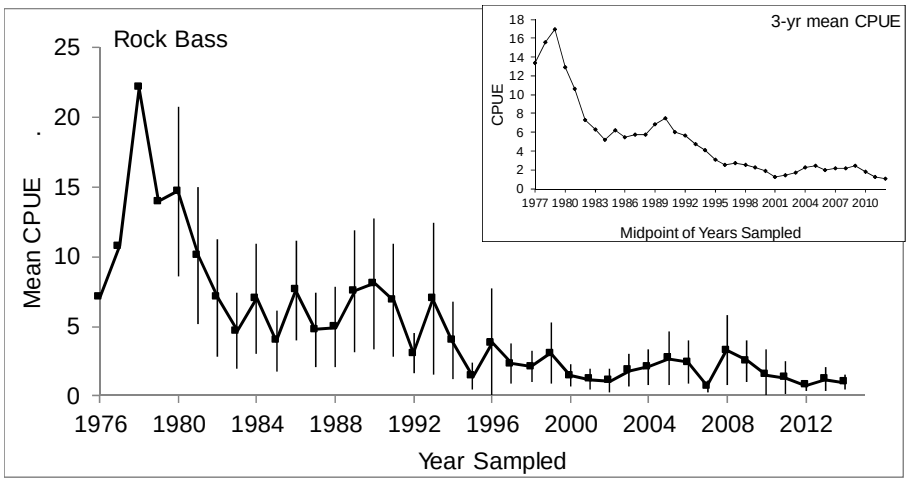

Figure 6. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for rock bass, 1976-2014.

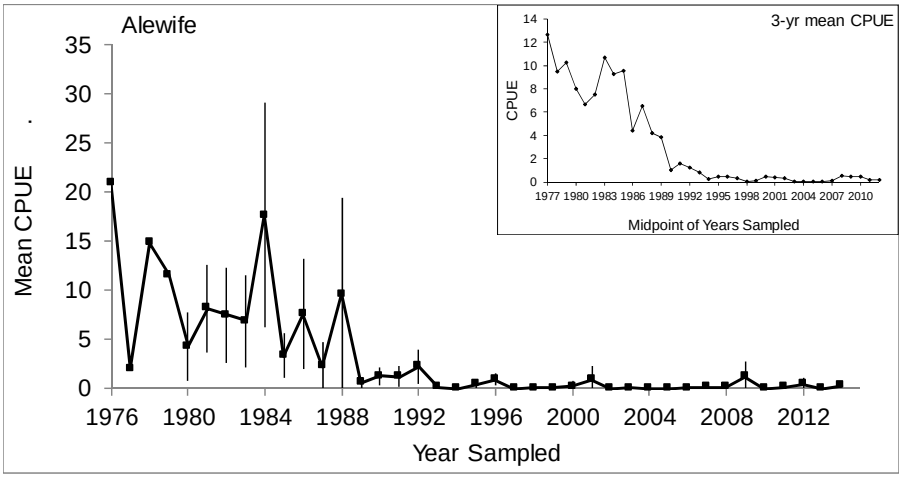

Figure 7. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for alewife, 1976-2014.

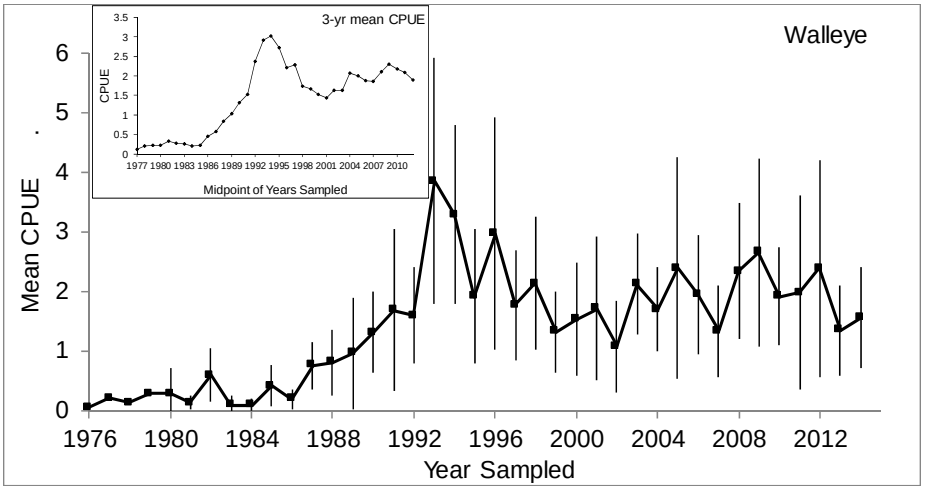

Figure 8. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for walleye, 1976-2014.

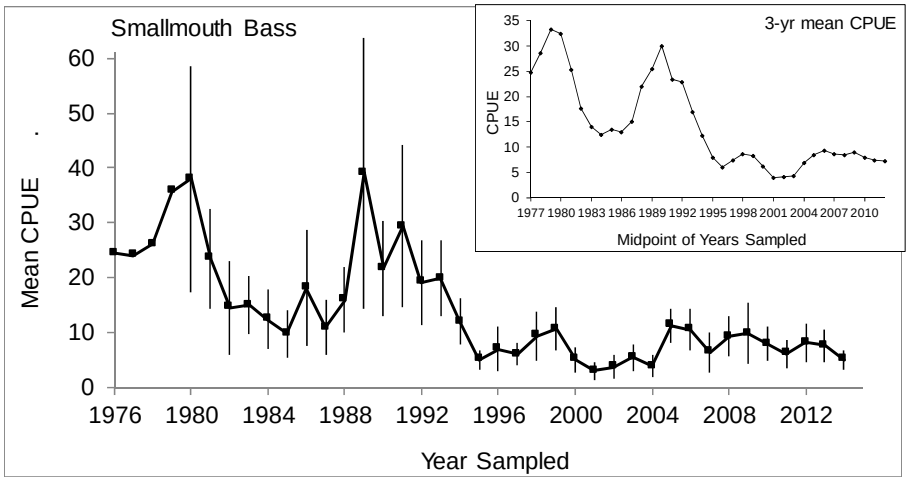

Figure 9. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for smallmouth bass, 1976-2014.

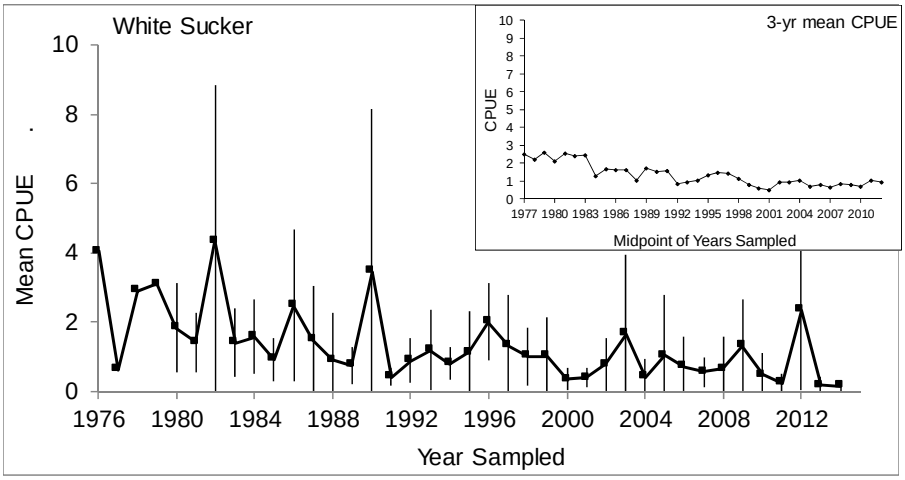

Figure 10. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for white sucker, 1976-2014.

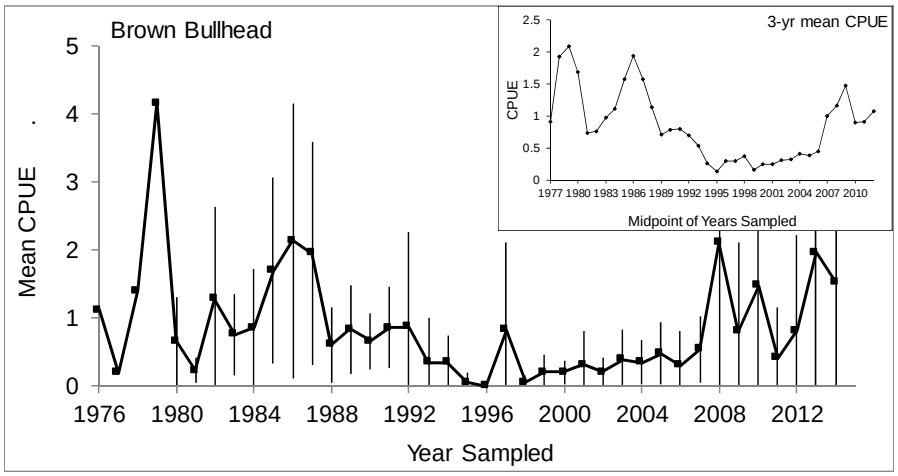

Figure 11. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for brown bullhead, 1976-2014.

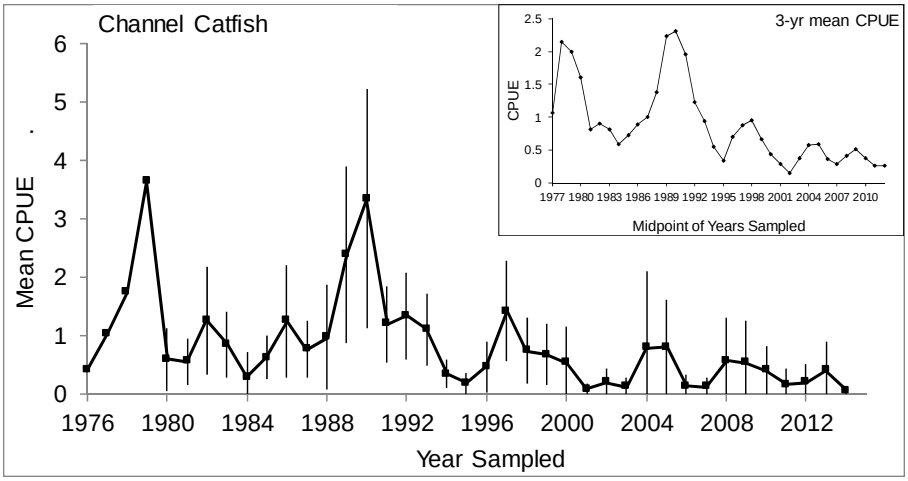

Figure 12. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for channel catfish, 1976-2014.

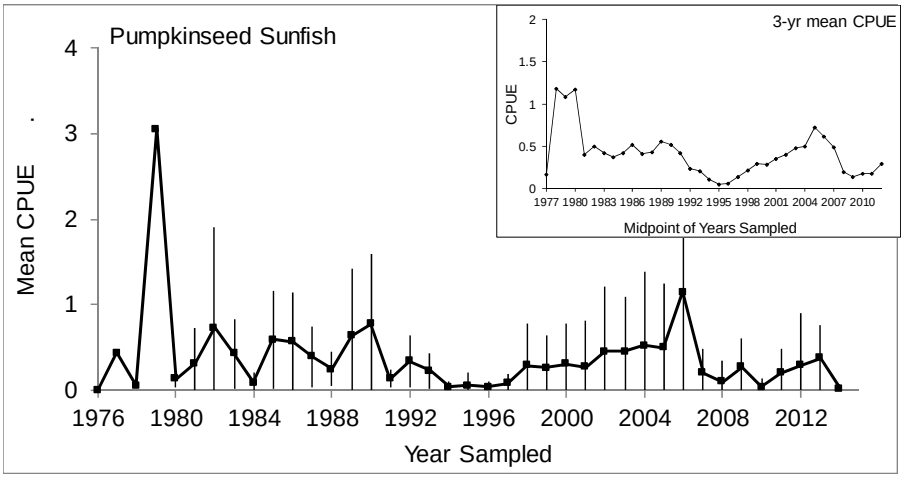

Figure 13. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for pumpkinseed sunfish, 1976-2014.

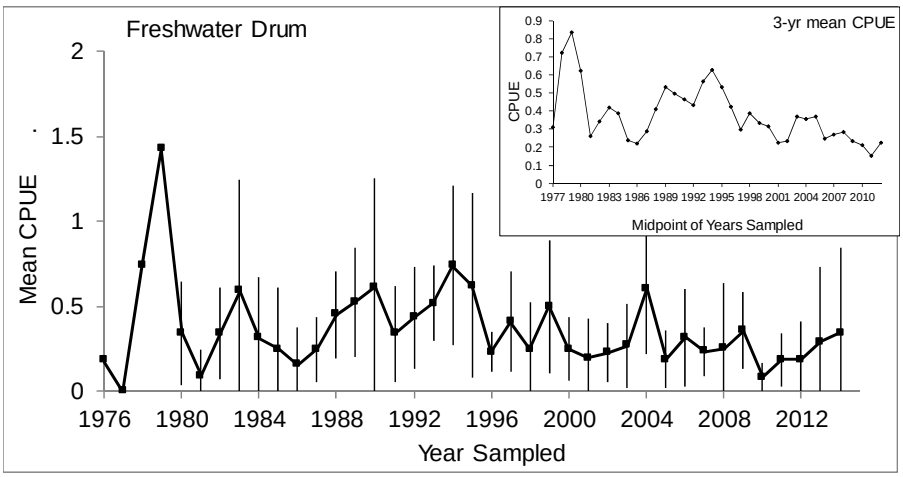

Figure 14. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for freshwater drum, 1976-2014.

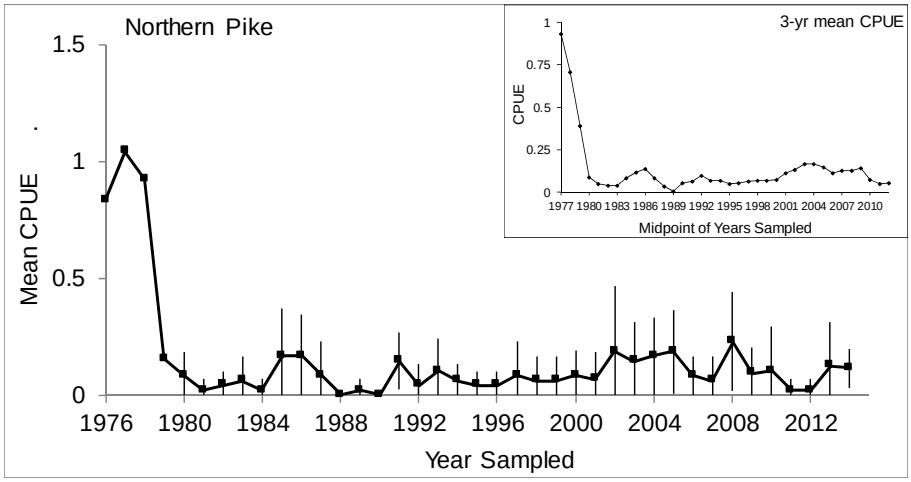

Figure 15. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for northern pike, 1976-2014.

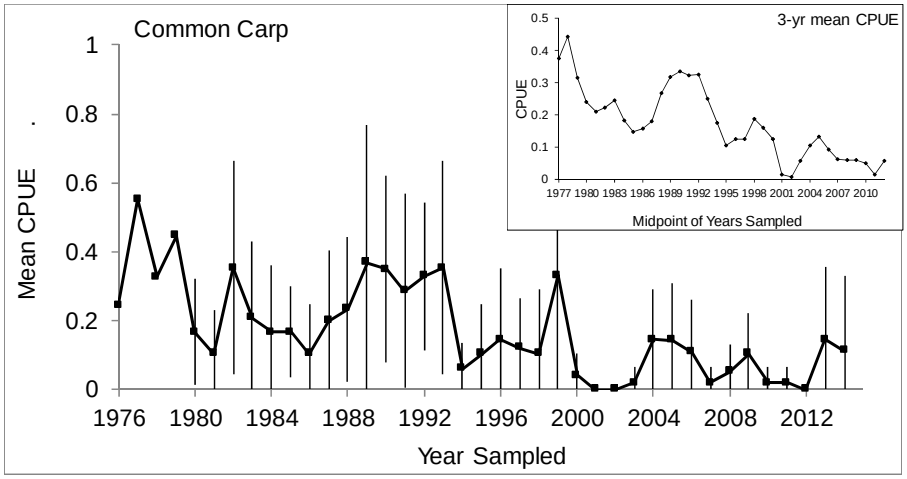

Figure 16. Stratified mean catch per 450 ft gill net gang and 95% confidence intervals for common carp, 1976-2014.

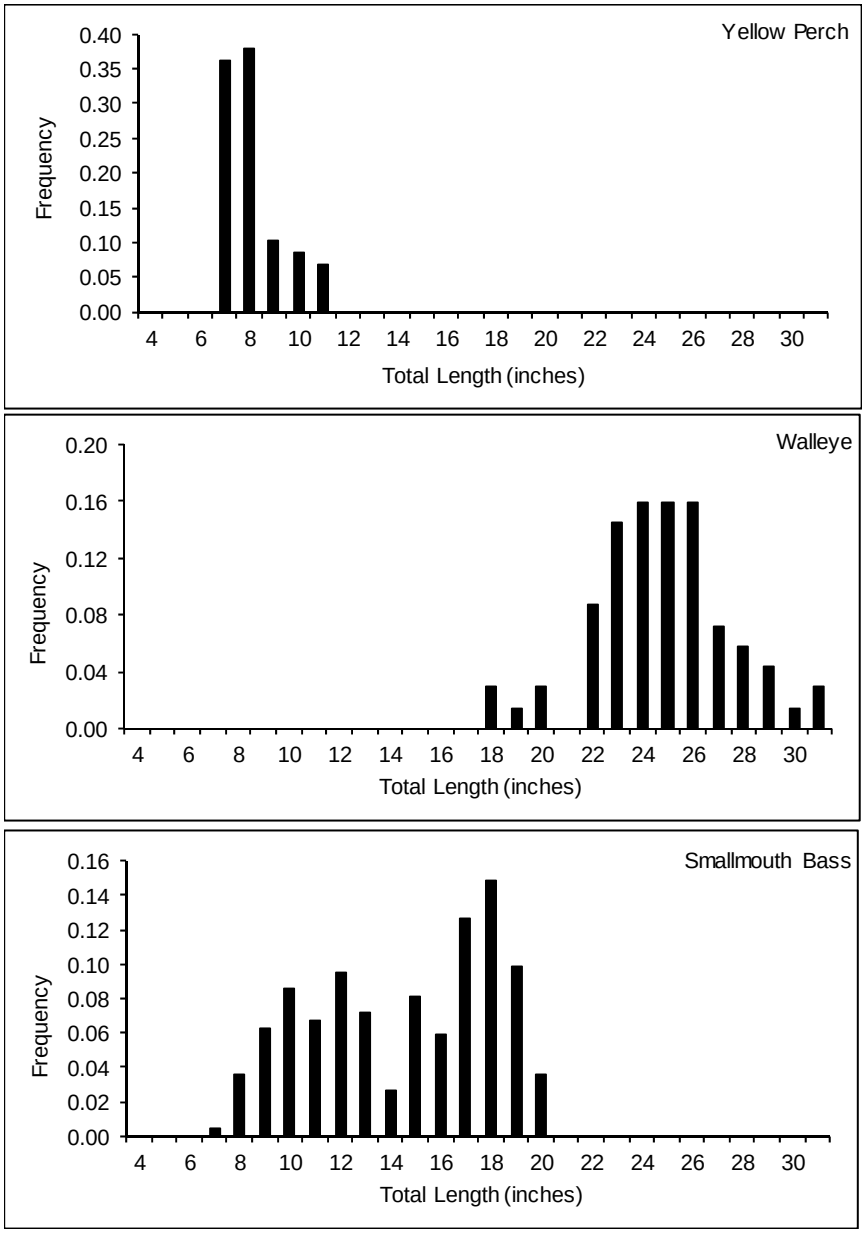

Figure 17. Length frequency distribution of yellow perch, walleye, and smallmouth bass collected during the warmwater assessment in 2014.

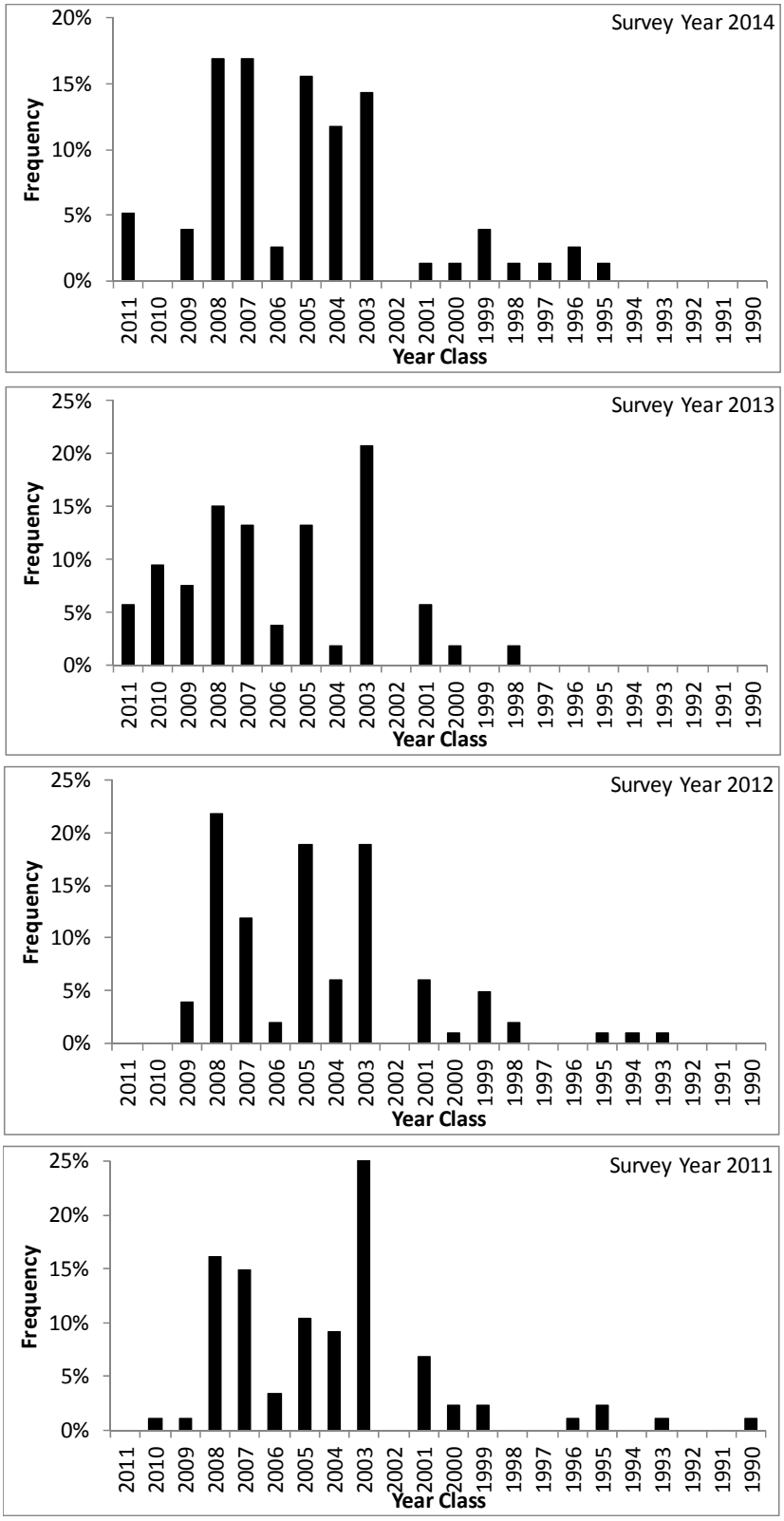

Figure 18. Year class frequency distribution of walleye collected during the warmwater assessment in 2011-2014.

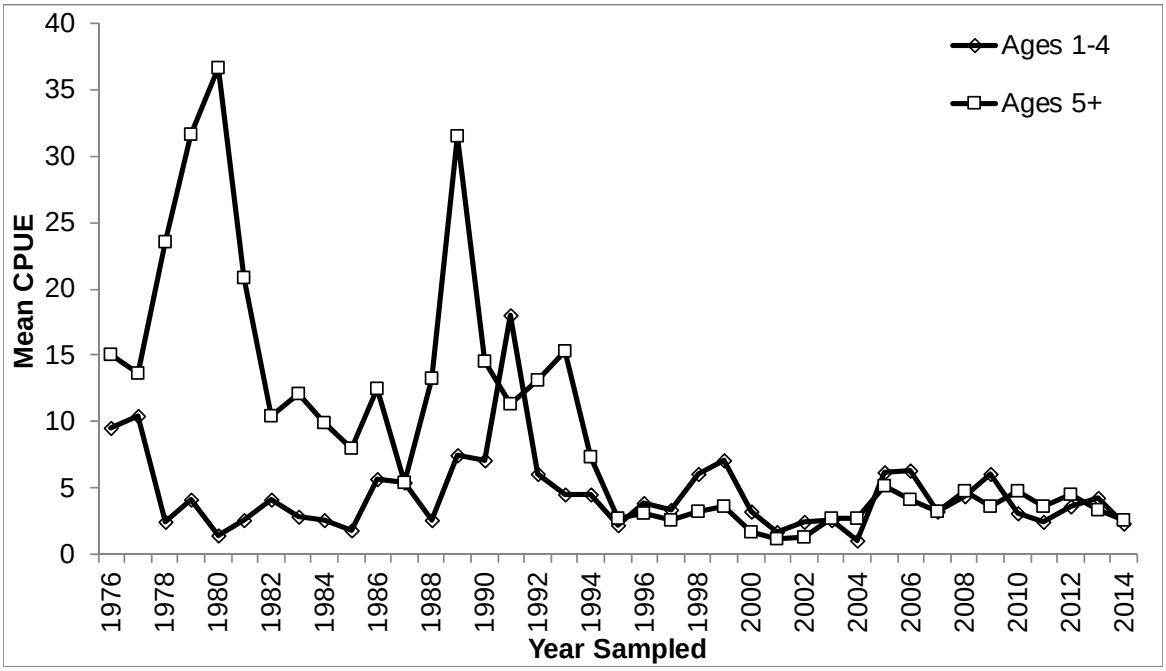

Figure 19. Stratified mean catch per 450 ft gill net gang for catch of bass ages ≤ 4 and ages ≥ 5, 1976-2014. Note: Increased growth and changes in net catchability confound inter-annual comparisons of age-specific CPUE.

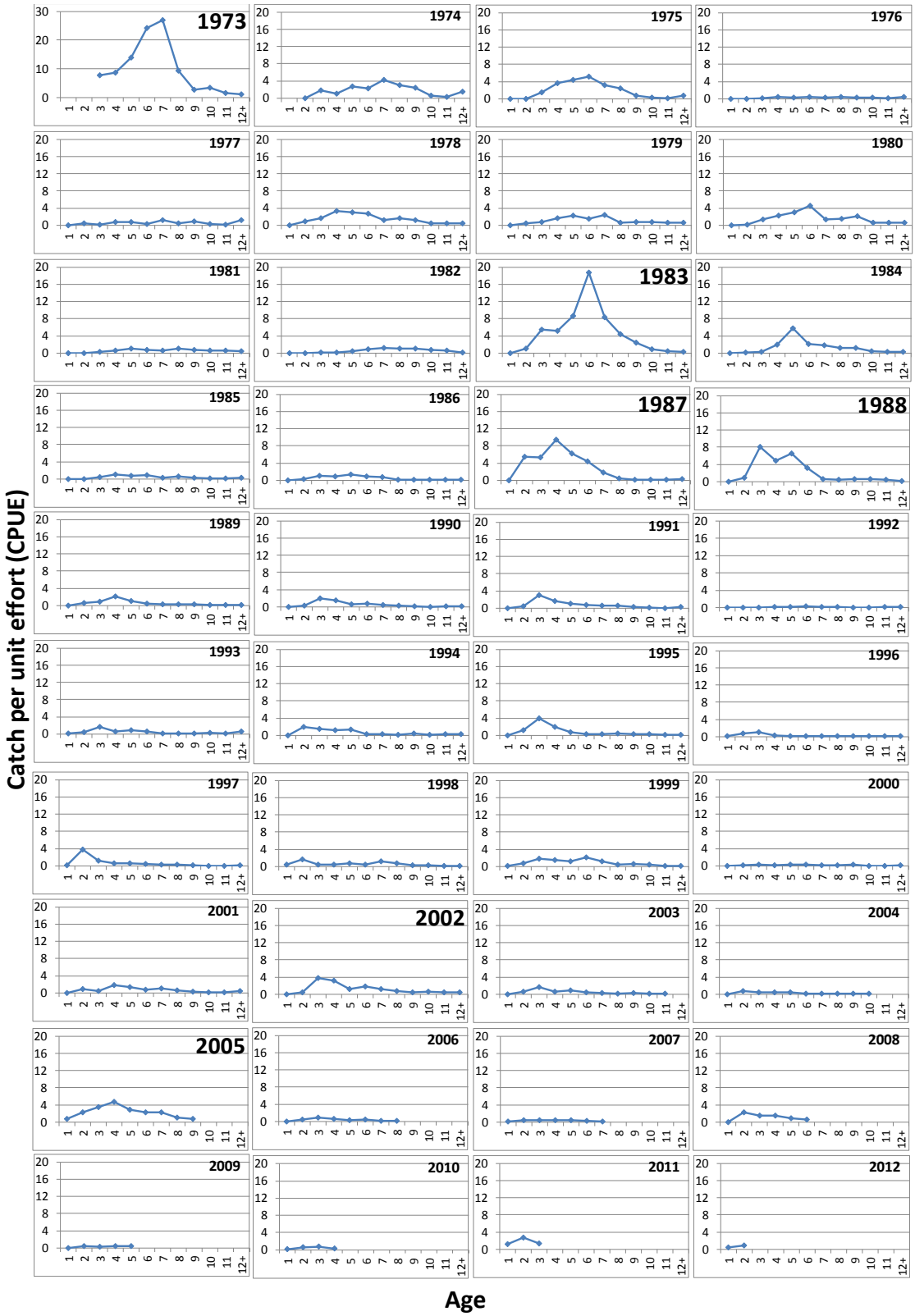

Figure 20a. Year class-specific catch curves (CPUE by age), 1973-2012 year classes. Note the difference in y-axis scale for the 1973 year class vs. the y-axis scale 1974-2012 year classes.

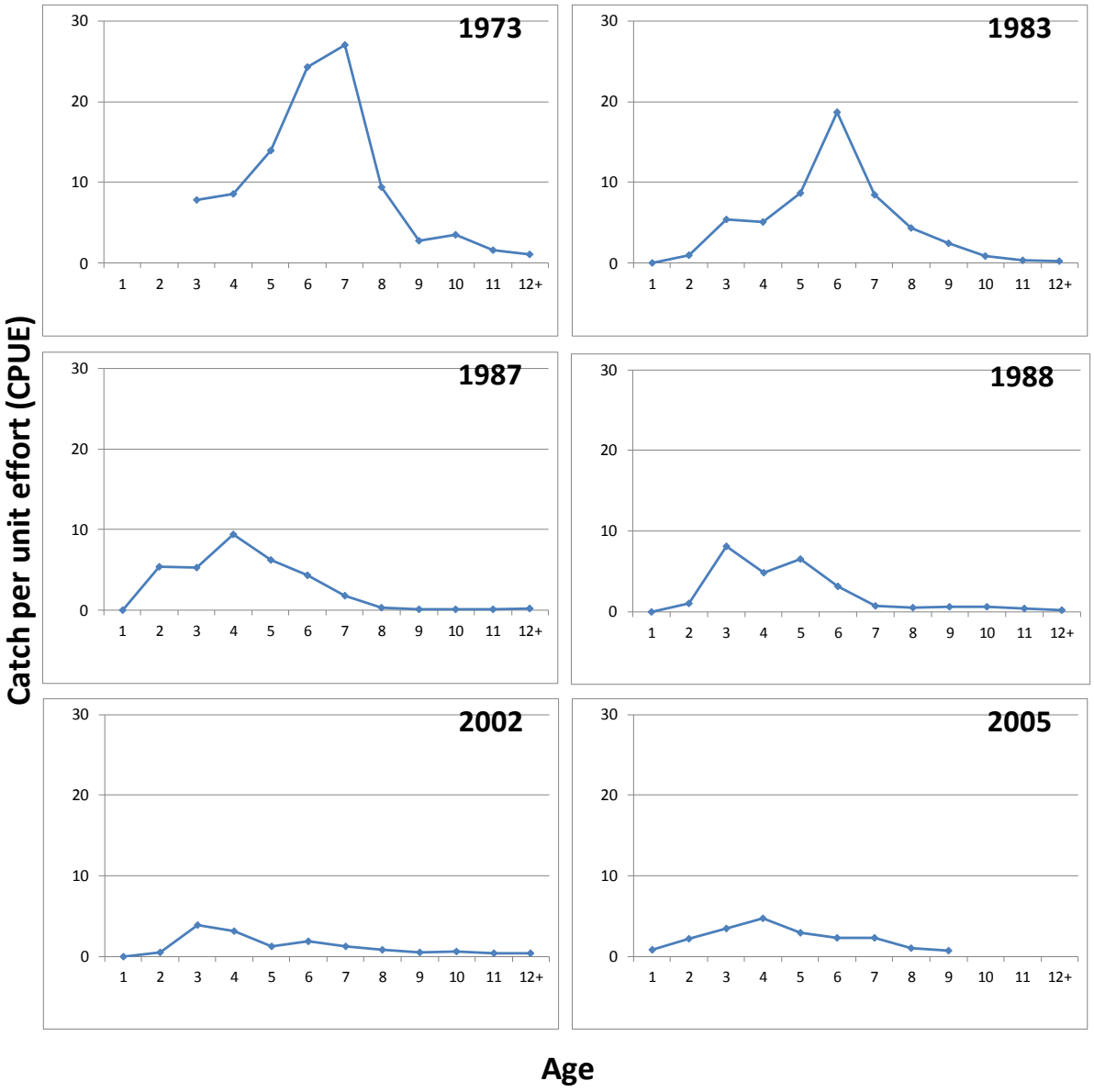

Figure 20b. Year class-specific catch curves (CPUE by age) for the 1973, 1983, 1987, 1988, 2002, and 2005 year classes.

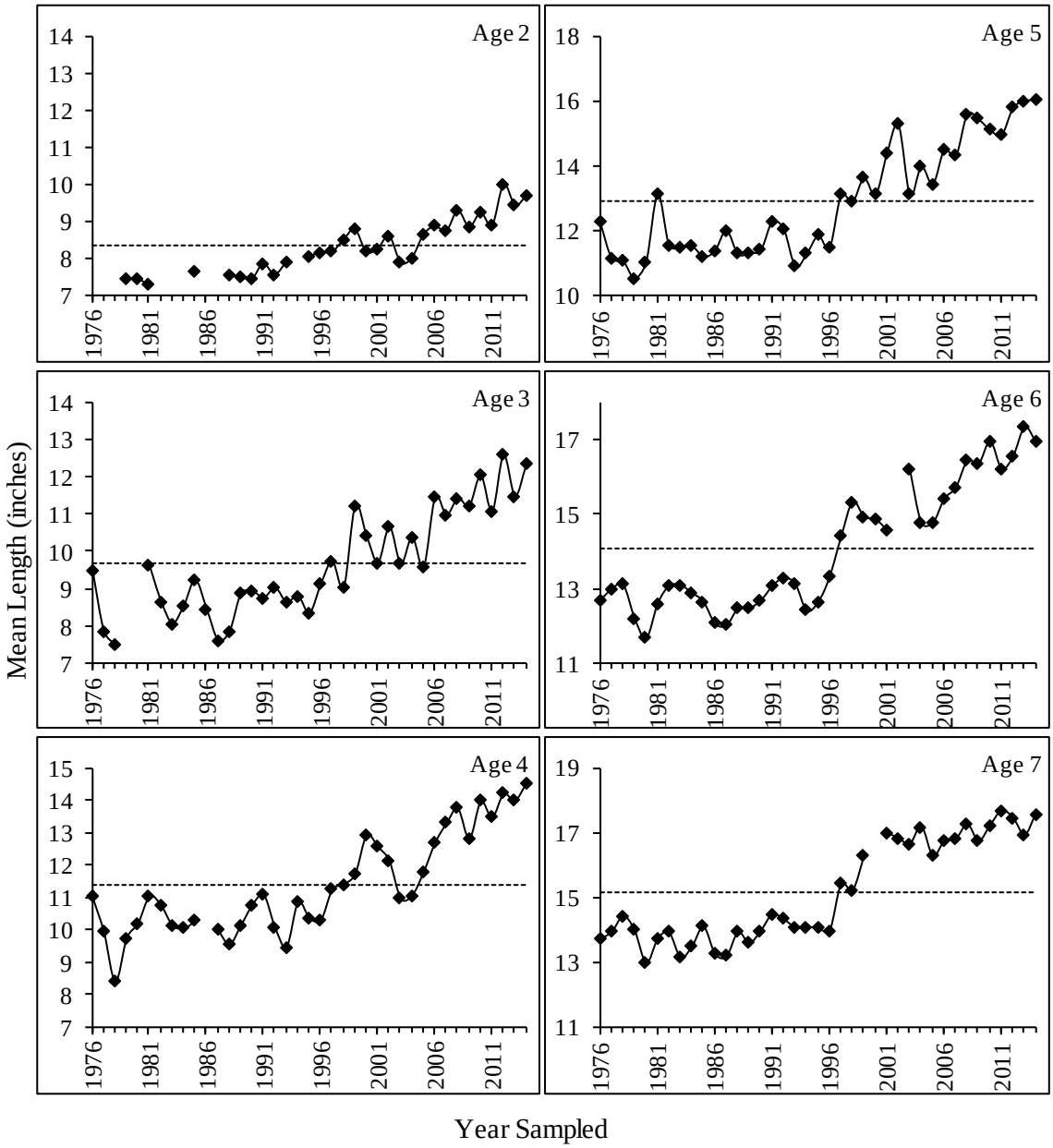

Figure 21. Mean length at age (age 2-13) by year sampled (1976-2014) for smallmouth bass collected during the warmwater assessment (continued on next page). Dotted lines represent longterm mean lengths.

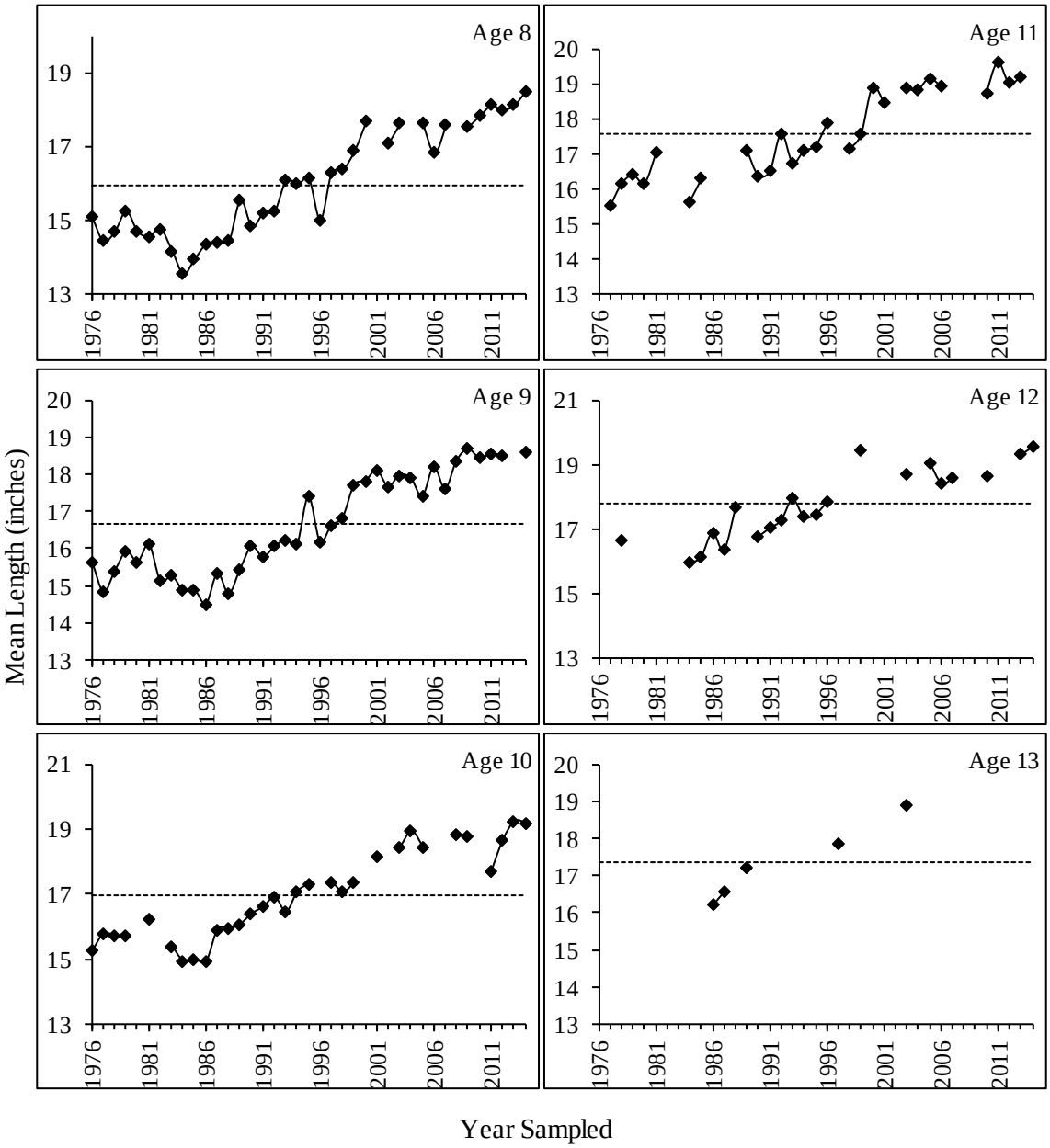

Figure 21 (continued). Mean length at age (age 2-13) by year sampled (1976-2014) for smallmouth bass collected during the warmwater assessment. Dotted lines represent the longterm mean lengths.

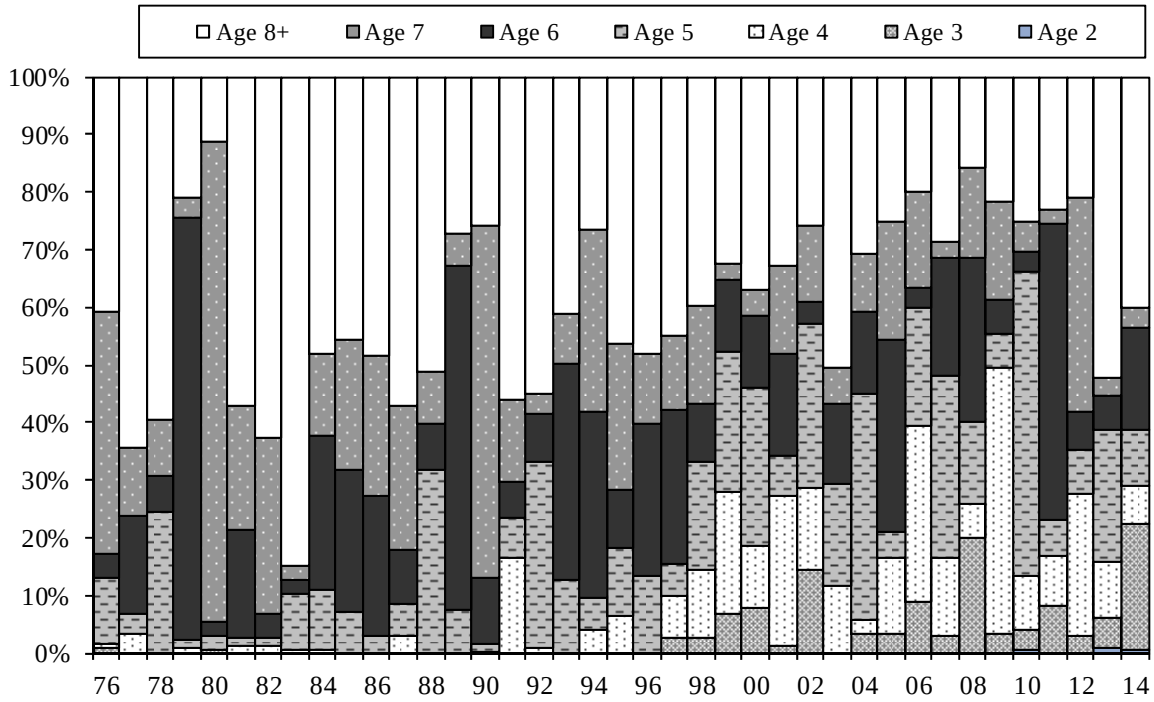

Figure 22. Age composition of smallmouth bass ≥ 12 inches in the warmwater assessment (1976-2014).

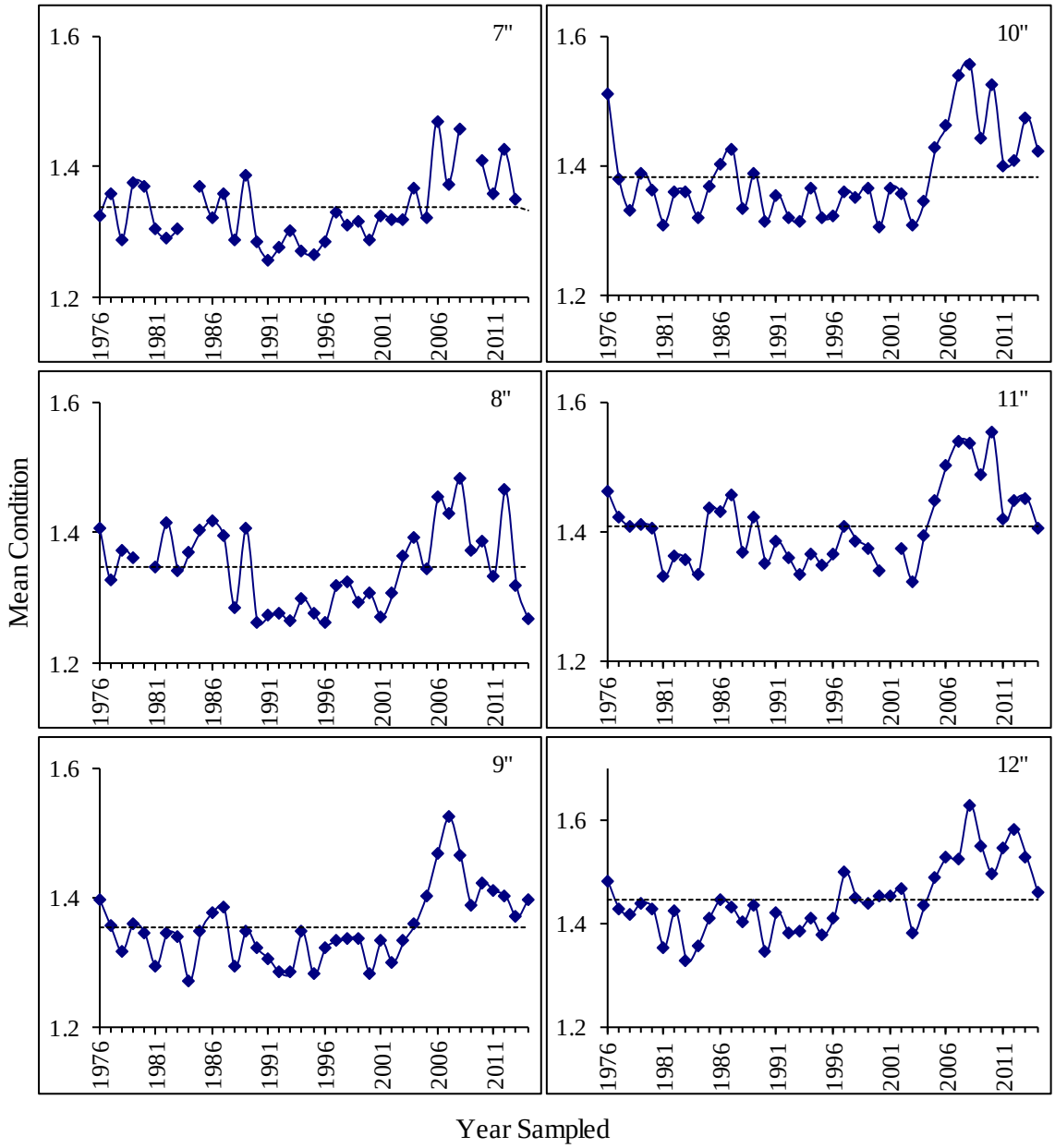

Figure 23. Mean condition (7-18 inch increments) by year sampled (1976-2014) for smallmouth bass collected during the warmwater assessment (continued on next page).

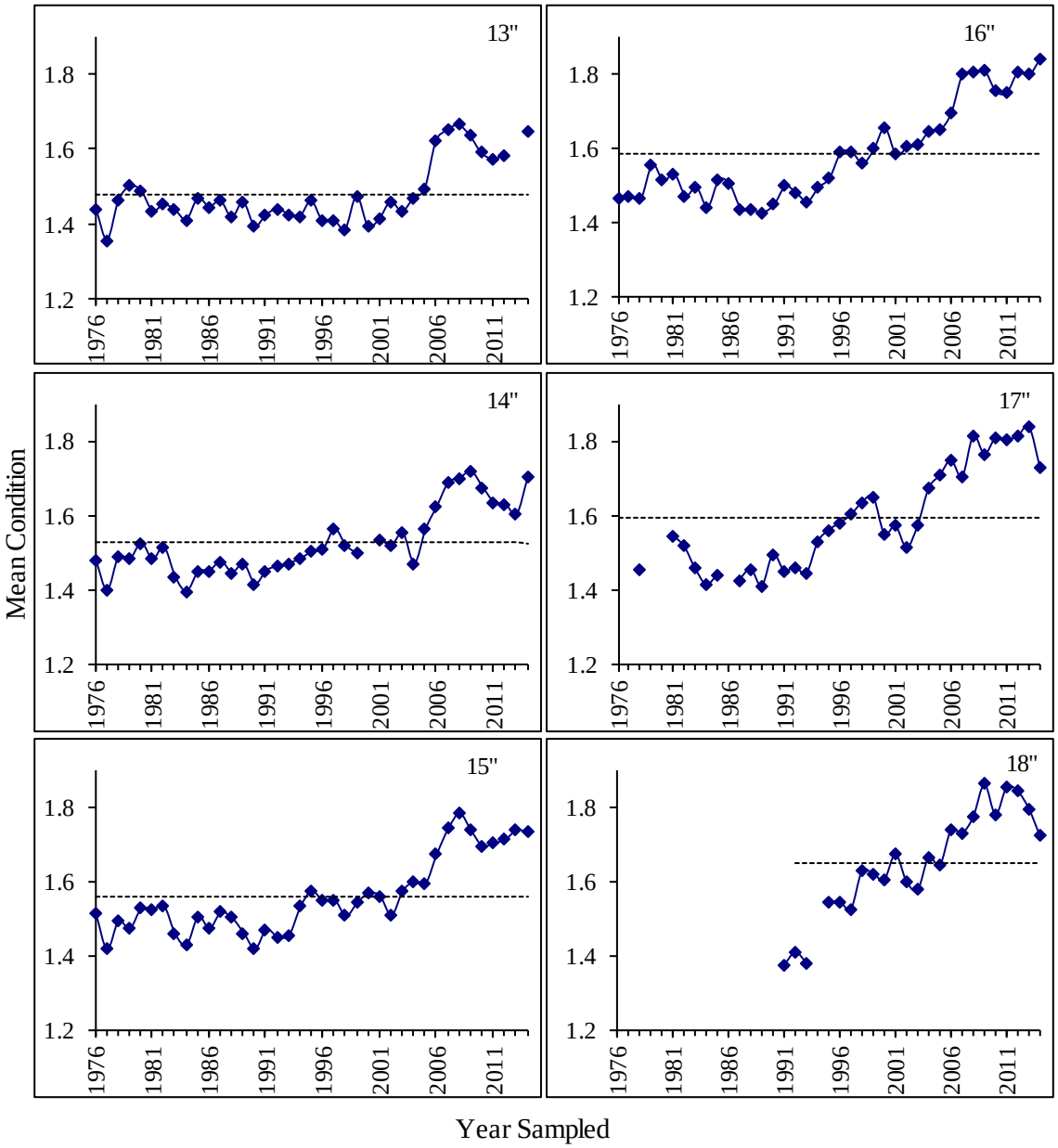

Figure 23 (continued). Mean condition (7-18 inch increments) by year sampled (1976-2014) for smallmouth bass collected during the warmwater assessment.

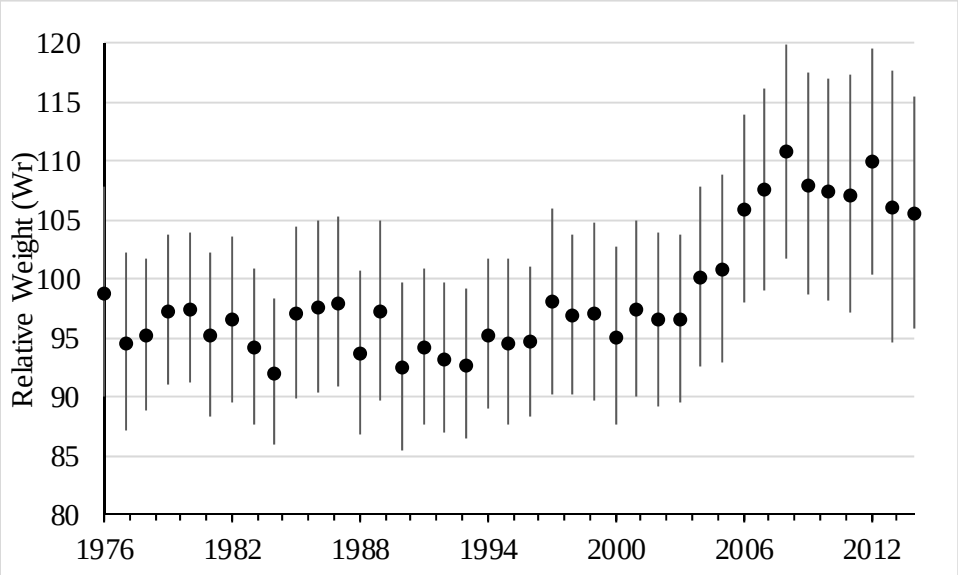

Figure 24. Mean relative weight of smallmouth bass caught in the warmwater assessment (1976-2014) (± 1 standard deviation).

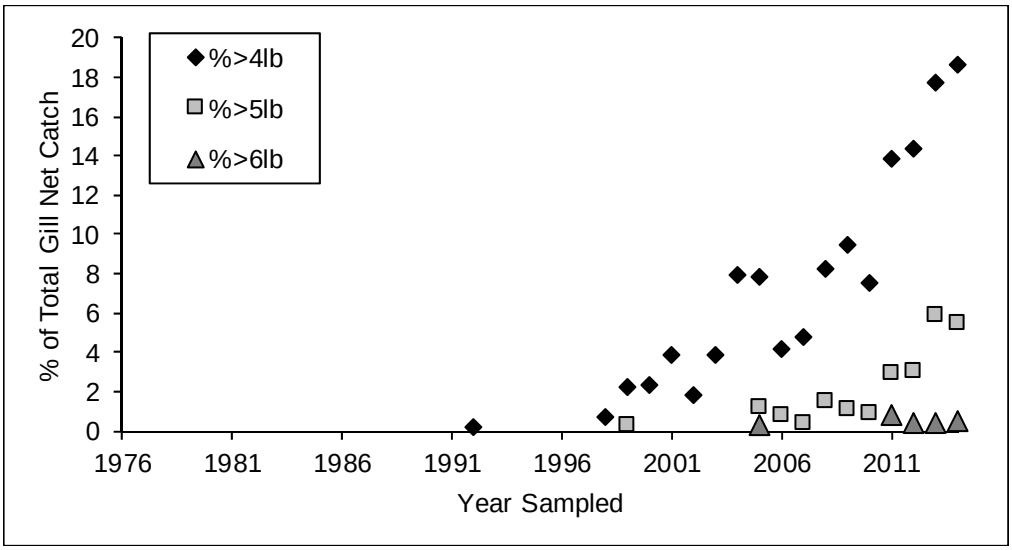

Figure 25. Percentage of total smallmouth bass catch during the warmwater assessment (1976-2014 catches) that were >4lb, >5lb, and >6lb.

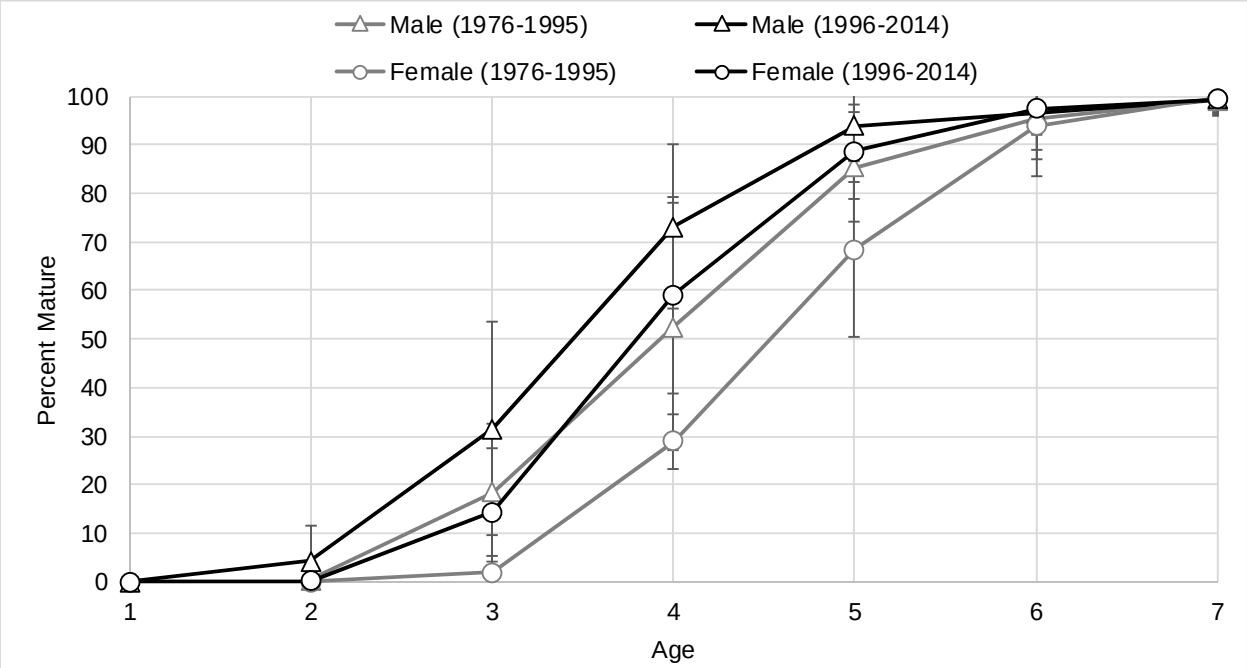

Figure 26. Average (± 1 standard deviation) percent maturity of age-1 to age-7 male and female smallmouth bass sampled during survey years 1976-1995 and 1996-2014.

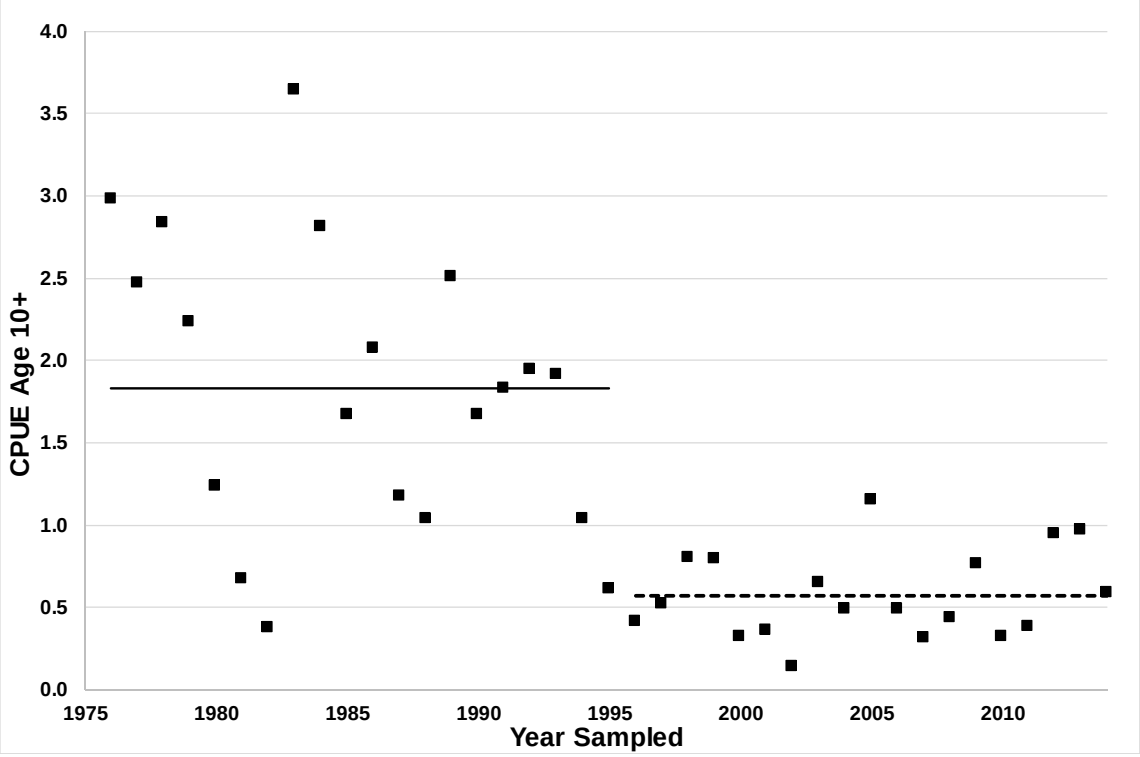

Figure 27. CPUE of smallmouth bass ages 10+, 1976-2014 sample years.

Lake Trout Rehabilitation in Lake Ontario, 2014

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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 2010 and 2012 year classes sampled in 2012 and 2014 were similar and represented the greatest values observed since the 1990 year class was sampled in 1992. 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 2014 exceeded the level of the 1999-2004 mean which at the time appeared to be the new stable abundance following from the 1993 stocking cuts. The 2014 rate of wounding by sea lamprey* (Petromyzon marinus) *on lake trout caught in gill nets (1.65 A1 wounds per 100 lake trout) was below target (2 wounds per 100 lake trout). Estimates from the NYSDEC fishing boat survey indicated 2014 angler catch and harvest rates were more than six times higher than the lows observed in 2007. Adult lake trout condition (indexed from annual length–weight regressions) has generally remained at a high level during 2007-2014. Condition of juvenile lake trout indexed from annual length-weight regressions returned to a high level in 2014, while Fulton's K for age-2 fish (0.85) remained low. 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 2009-2014. Twenty cohorts of naturally produced lake trout have been collected since 1994. The largest catch of naturally produced lake trout occurred in 2014, with 47 age-1 and 70 age-2 wild lake trout caught.*

Introduction

Restoration of a naturally reproducing population of lake trout (*Salvelinus namaycush*) is the focus of a major international effort in Lake Ontario. Coordinated through the Lake Ontario Committee of the Great Lakes Fishery Commission, representatives from cooperating agencies (New York State Department of Environmental Conservation [NYSDEC], United States Geological Survey [USGS], United States Fish and Wildlife Service [USFWS], and Ontario Ministry of Natural Resources [OMNR]) developed the Joint Plan for Rehabilitation of Lake Trout in Lake Ontario (Schneider et al. 1983, 1997) 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 2014.

Methods

Adult Gill Net Survey

During September 1983-2014, adult lake trout were collected with gill nets at random transects within each of 14 to 17 geographic areas distributed uniformly within U.S. waters of Lake Ontario. Survey design (size of geographic areas) and gill net construction (multi- vs. mono-

filament netting) has changed through the years. For a description of survey history including gear changes and corrections see Elrod et al. (1995) and Schneider et al. (1994).

During September 2014, 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 each of two sites in the eastern basin, one and three nets, respectively, were fished in waters from 30 to 50 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. 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), 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 1982-2014. 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 2015). 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, 1985-2014.

Juvenile Trawl Survey

From mid-July to early-August 1980-2014, 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; Connerton 2014) and thus no U.S. stocked age-2 lake trout were present in 2013. Effort returned to routine levels in 2014 with trawling conducted at 14 locations during July 8- August 11, 2014. 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 trends in the index for age-2 lake were similar to gill net CPUEs adjusted for numbers stocked for age-3 lake trout from the same year class. 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 2010 year classes were, however, adjusted for numbers stocked. Most untagged fish stocked since 1997 received paired fin clips that facilitated year class identification through at least age 4. Numbers of age-2 lake trout within catches of unmarked fish and fish with poor clips were estimated with age-length and age-weight 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 equivalents released declined by about 22% between the stockings of the 1981 and 1988 year

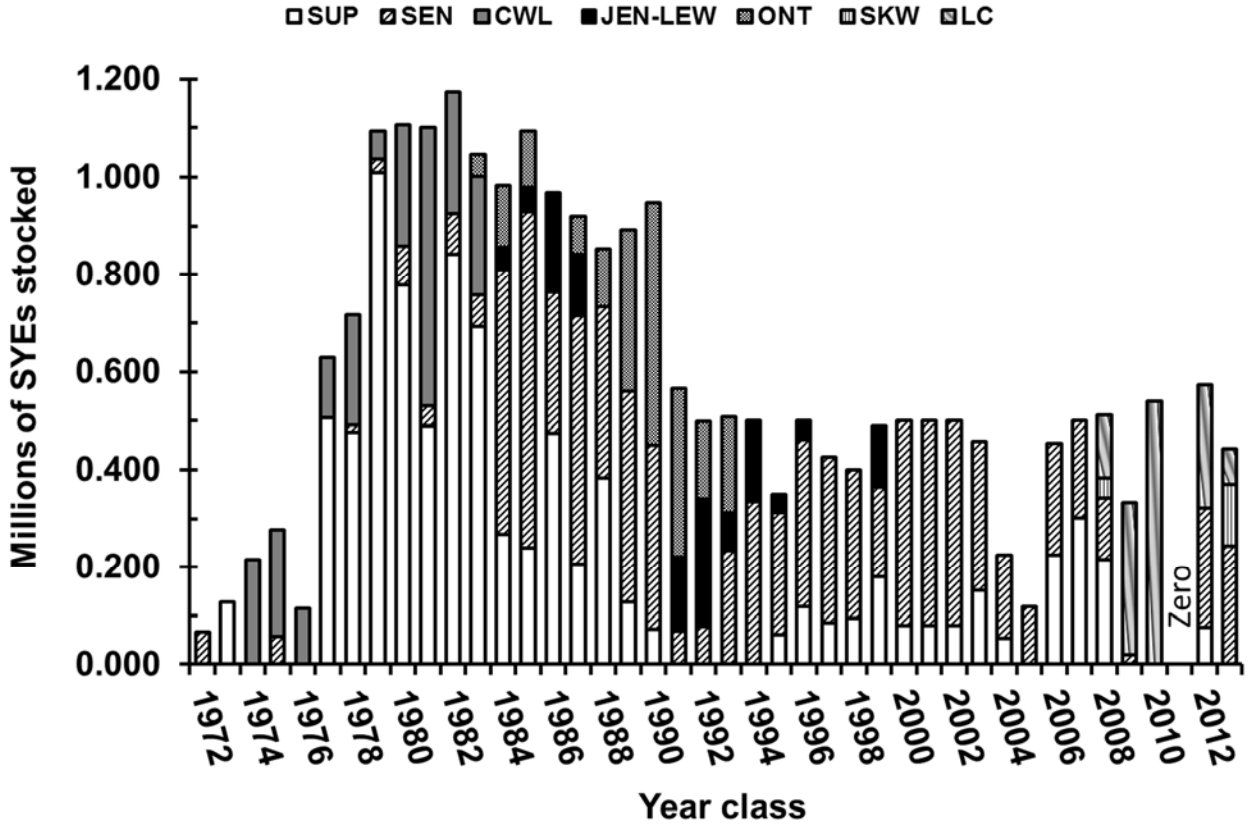

Figure 1. Total spring yearling equivalents (SYE) for lake trout strains (strain descriptions for ONT, JEN-LEW, CWL, SEN, LC, SUP, and SKW appear in Appendix 1) stocked in U.S. waters of Lake Ontario for the 1972 – 2013 year classes. MIX were unknowns. SYE = 1 spring yearling or 2.4 fall fingerlings (Elrod et al. 1988). No lake trout from the 2011 year class were stocked in 2012.

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 the next 22 years (Figure 1). The USFWS Alleghany National Fish Hatchery (ANFH) was closed in 2005 due to an outbreak of infectious pancreatic necrosis and remained closed for fish production through summer 2011. Completion of disinfection, renovation and disease trials permitted fish production to resume at ANFH in fall 2011. Lake trout stocked in 2006 were raised at the NYSDEC Bath Fish Hatchery. Lake trout for 2007 and 2008 stockings were raised at the USFWS Pittsford (the name was changed in 2009 to: Eisenhower (ENFH)) and White River National Fish Hatcheries (WRNFH) in Vermont. In 2010, 94% of the stocked lake trout were raised at WRNFH and 6% were raised at NYSDEC Bath Fish Hatchery. All lake trout from stockings in 2009 and 2011 were raised at the USFWS WRNFH. In late August 2011, flooding of WRNFH from the adjacent White River during tropical storm Irene led to the USFWS decision to depopulate the hatchery over serious concerns of raceway contamination with didymo (*Didymosphenia geminate*) from the adjacent White River. As a result, no lake trout from the 2011 year class were stocked into Lake Ontario in May 2012. Combined production of the 2012 year class at ANFH and ENFH resulted in stocking of nearly 123,000 fall fingerlings and over 520,000 spring yearlings (Connerton 2014). In 2014, fish managers increased the lake trout stocking target to 800,000 spring yearling equivalents (Lantry et al. 2014). During 2014, combined production of the 2013 year class at ANFH and ENFH resulted in stocking of approximately 442,000 spring yearlings (Connerton 2015).

Survival to age-2

The first-year survival index was relatively high for the 1979-1982 year classes but then declined by about 32% and fluctuated without trend for the 1983-1989 year-classes (Figure 2). The index declined further for the 1990 year class and continued to decline for the 1991-1996 year classes. The average index value for the 1994-1996 year classes at age 2 was only 6% of the average for the 1979-1982 year classes and only 9% of the average for the 1983-1989 year classes. The survival index was quite variable during 1995 to 2011 (1993 – 2009 year classes) fluctuating by greater than 40-fold with no general trend apparent. The survival indices for the 2010 and 2012 year classes sampled in 2012 and 2014 were similar and represented the greatest values observed since the 1990 year-class was sampled in 1992. No lake trout from the 2011 year class were stocked in U. S. waters during 2012 and thus no-U. S. stocked age-2 lake trout were present/captured in 2013.

Abundance of age-3 and older Lake Trout

A total of 816 lake trout were captured in the September 2014 gill net survey resulting in a total CPUE (#/lift) of mature adults of 14.0 (Figure 3). Catches of lake trout among sample locations were similar within years with the RSE for the CPUE of adult males and females (generally ages 5 and older) averaging only about 9.2% and 10.8%, respectively, for the entire data series (Figure 4). The CPUE of mature lake trout had remained relatively stable from 1986 to 1998, but then declined by 31% between 1998 and 1999 due to the poor recruitment of the 1993 year class. Declines in adult numbers after 1998 were likely due to poor survival of hatchery fish in their first year post-stocking and lower numbers of fish stocked since the early 1990's. After the 1998-1999 decline, the CPUE for mature lake trout remained relatively stable during 1999-2004 (mean = 11.0) appearing to reflect a new stable equilibria established subsequent to the stocking reductions in 1993, but then abundance declined further (by 54%) in 2005. The 2005-2007 CPUEs of mature lake trout were similar to the 1983-1984 values which pre-dated effective sea lamprey control. The CPUE of mature lake trout, however, increased each year 2008-2014. Adult abundance in 2014 (CPUE: 14.0) exceeded 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%

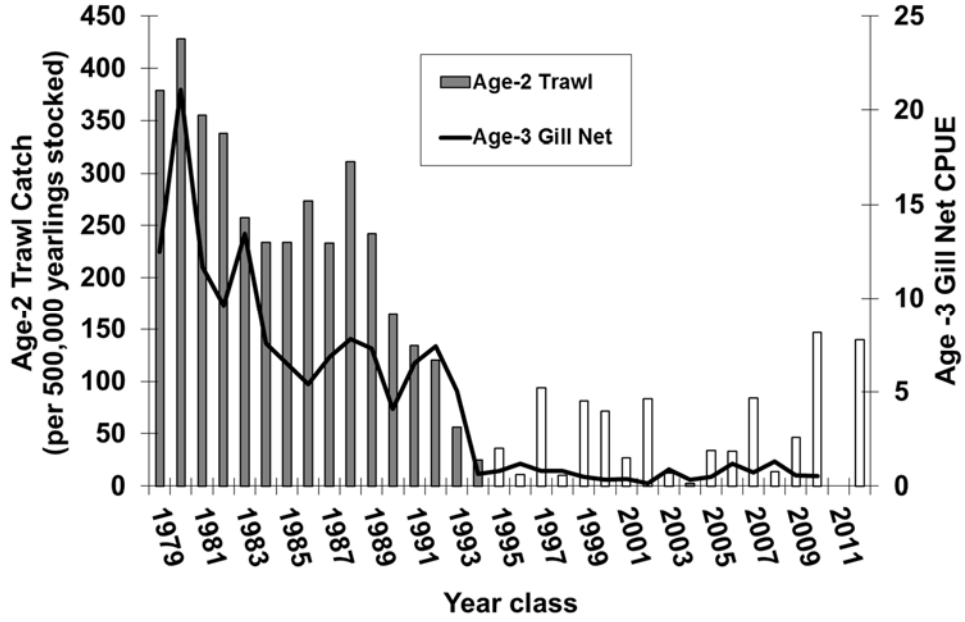

Figure 2. Survival indices for age-2 lake trout stocked in U.S. waters of Lake Ontario in 1980 – 2013 (no 2011 year-class lake trout were stocked into U. S. waters in 2012). Survival was indexed at age 2 as the total catch from bottom trawls fished in July-August per 500,000 fish stocked (Note: White 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).

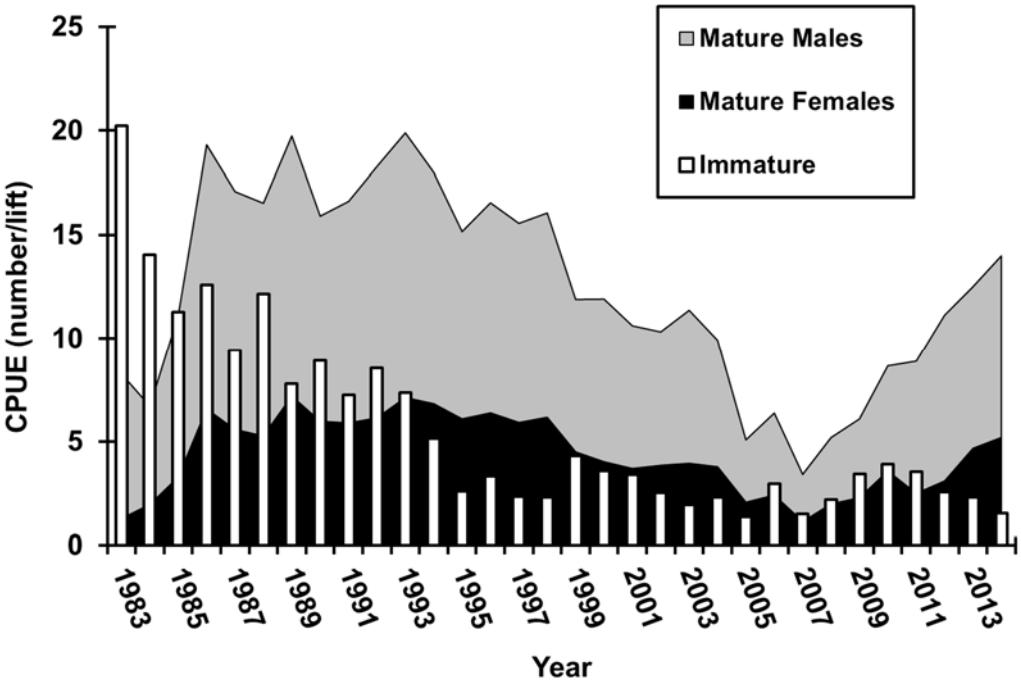

Figure 3. Abundance of mature (generally males ≥ age 5 and females ≥ age 6) and immature (sexes combined) lake trout calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2014. CPUE (number/lift) was calculated based on four strata representing net position in relation to depth of the sets.

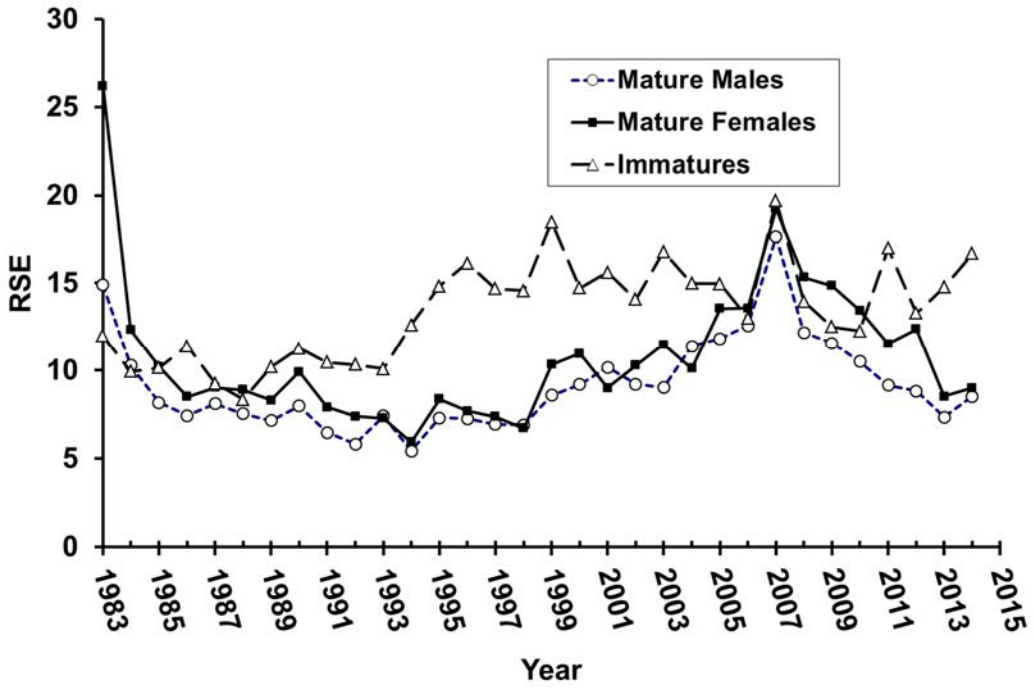

Figure 4. Relative standard error (RSE = {SE / Mean}*100) of the annual CPUE for mature and immature (sexes combined) lake trout caught with gill nets set in U.S. waters of Lake Ontario, during September 1983 – 2014.

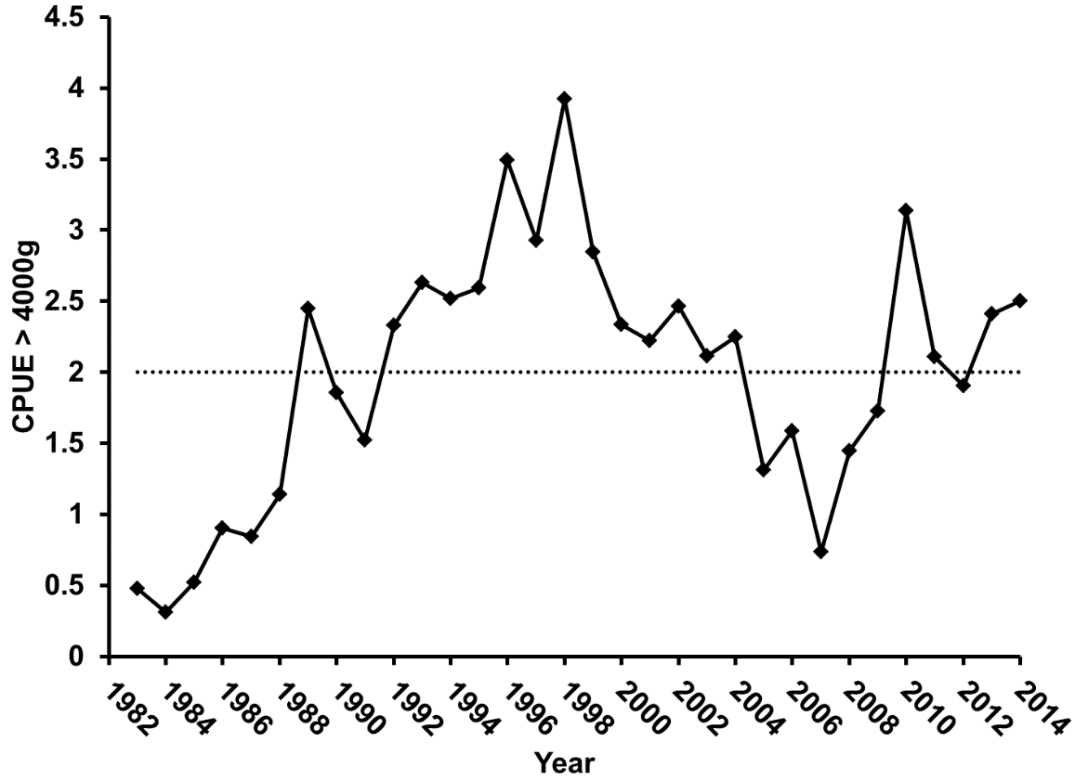

Figure 5 Abundance of mature female lake trout >4000g calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2014. The dashed line represents the target CPUE from Schneider et al. (1997).

between the 1989-1993 (CPUE: 8.0) and the 1995-2004 intervals (CPUE: 2.9). Low CPUEs continued in 2014 (CPUE: 1.5).

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 2010-2014 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 has been 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 2015). 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 2015). In 2007, catch and harvest rates (0.12 and 0.05 lake trout per boat trip, respectively) and total harvest (2,570 fish) reached the lowest levels in the NYSDEC Fishing Boat Survey data series (Lantry and Eckert 2015). 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 2014 catch and harvest rates were more than six times higher than the lows observed in 2007 (Lantry and Eckert 2015). In 2014, angler catch (33,108 fish) and harvest (15,870 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 and 2014.

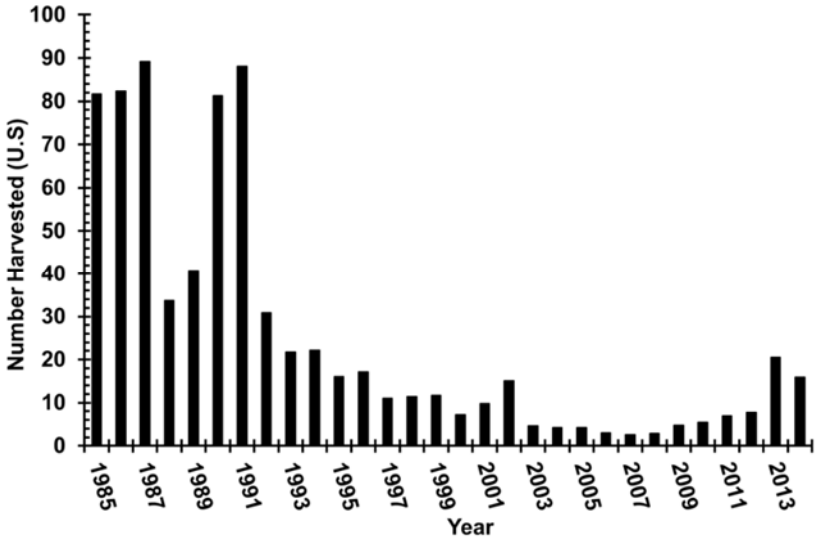

Figure 6. Estimated total annual harvest of lake trout by boat anglers from U.S. waters of Lake Ontario, during April 15 – September 30, 1985 – 2014 (Lantry and Eckert 2015). Beginning with the 2012 report, all harvest values have been reported reflecting a 5.5 month sampling interval. Prior reports were based on a 6 month sampling interval (April 1 – September 30).

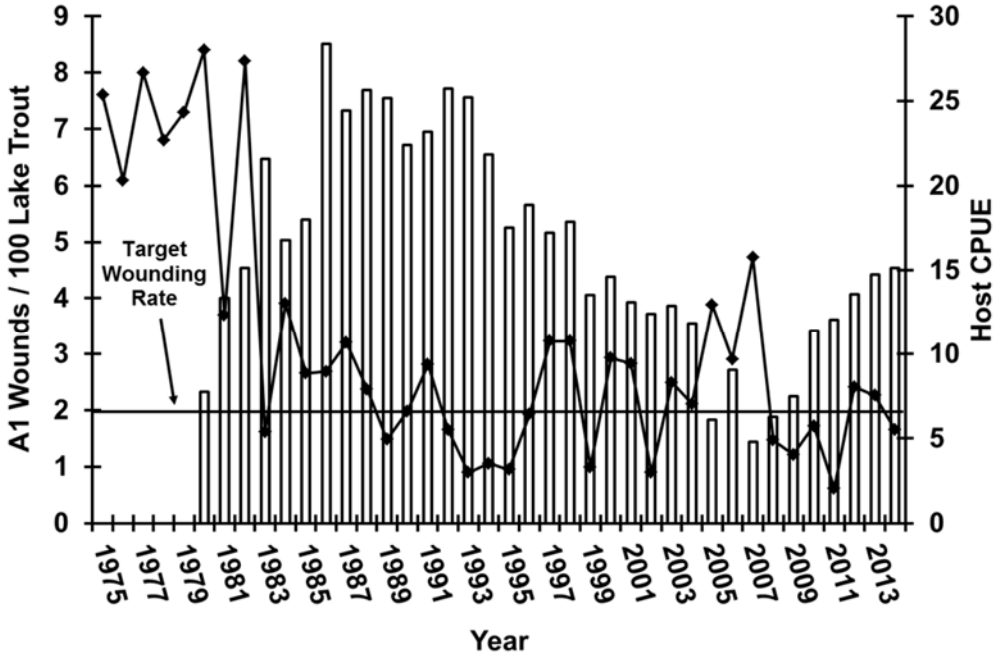

Figure 7. Wounding rates (A1 wounds per 100 lake trout, line) inflicted by sea lamprey on lake trout ≥ 433 mm (17.1 in) TL and the gill net CPUE of lake trout hosts (≥ 433 mm TL, bars) collected from Lake Ontario in fall, 1975 – 2014.

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).

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.

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

Table 1. Annual survival of various strains (strain descriptions appear in Appendix 1) of lake trout, U.S. waters of Lake Ontario, 1985-2014. 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	7-10	0.67	-	-	-	-	

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 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 2007-2014.

Predicted weights of 400-mm lake trout, based on bottom trawl catches of 250-500 mm fish, (Figure 9) appeared to be related to both total numbers stocked and the CPUE of immature fish captured with gill nets in September (Figures 1 and 3). Early stockings during 1973-1979 ranged from 66,000 to 728,240 yearling equivalents (Figure 1) and immature lake trout condition was high during 1979-1981. Stocking first exceeded 1,000,000 yearling equivalents in 1980 and between 1980 and 1981 the CPUE of immature lake trout from gill net catches doubled. From 1981 to 1983 predicted weight fell by 69 g (2.4 oz) and remained relatively constant (mean = 576 g, 1.3 lb) through 1992. Stocking rate remained at a relatively constant level from 1980 to 1991 (846,260 to 1,165,530 fish) and then declined to its' current target level (500,000 fish) in 1992. Predicted weight rose in 1993 and the 1993-1998 mean was 4% (22 g, 0.8 oz) higher than the mean for 1983-1992. Increased condition of young lake trout during 1993 - 1998 occurred after stocking was reduced and immature abundance declined in both bottom trawl and gillnet catches. During 1999-2005, condition declined to a level similar to the mid-1980's without associated changes in stocking or abundance, but paralleling declines in native benthic prey resources (Weidel et al. 2014). Predicted weight increased during 2005-2008 paralleling increases in round goby (*Neogobius melanostomus)* abundance (Weidel et al. 2014) which are now common in lake trout diets. Condition of immature fish fell again in 2009 (591.3 g, 1.3 lb.) to a level near the long term mean for the data series, but condition during 2010 - 2013 (2010-2013 mean = 555.53 g or 1.22 lb) was among the lowest recorded for the data series. Condition in 2014 returned to a high level (619.99 g) while Fulton's K for age-2 fish (0.85) remained at a low level.

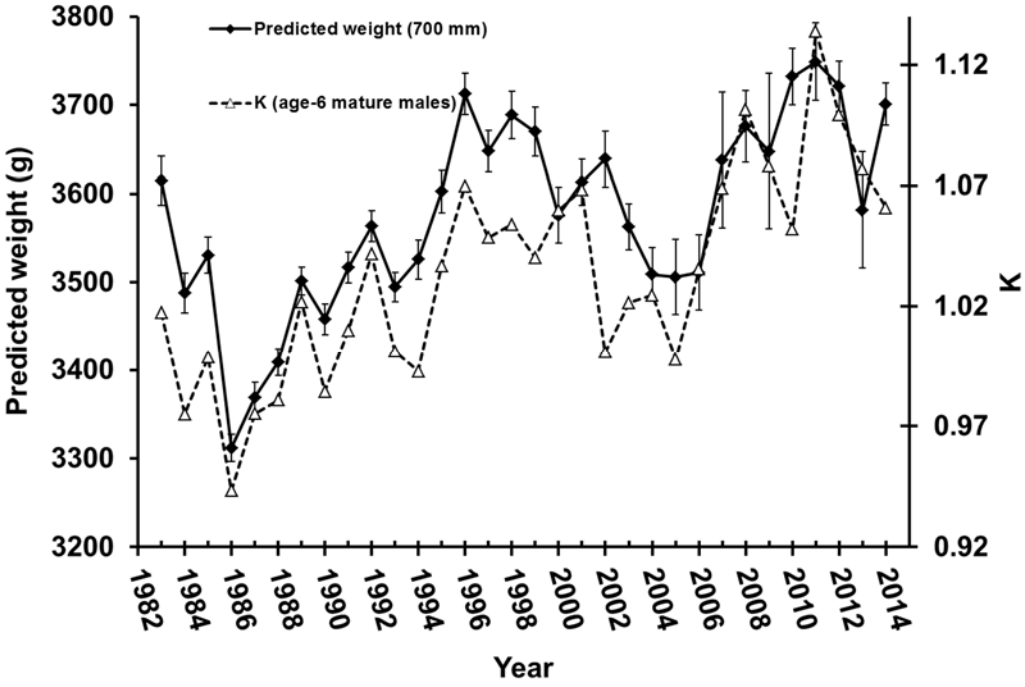

Figure 8. Lake Ontario lake trout condition (K) for age-6 mature males and predicted weight at 700-mm (27.6 in) TL from weight-length regressions calculated from all fish collected during each annual gill net survey, September 1983 – 2014. Error bars represent the regression confidence limits for each annual value.

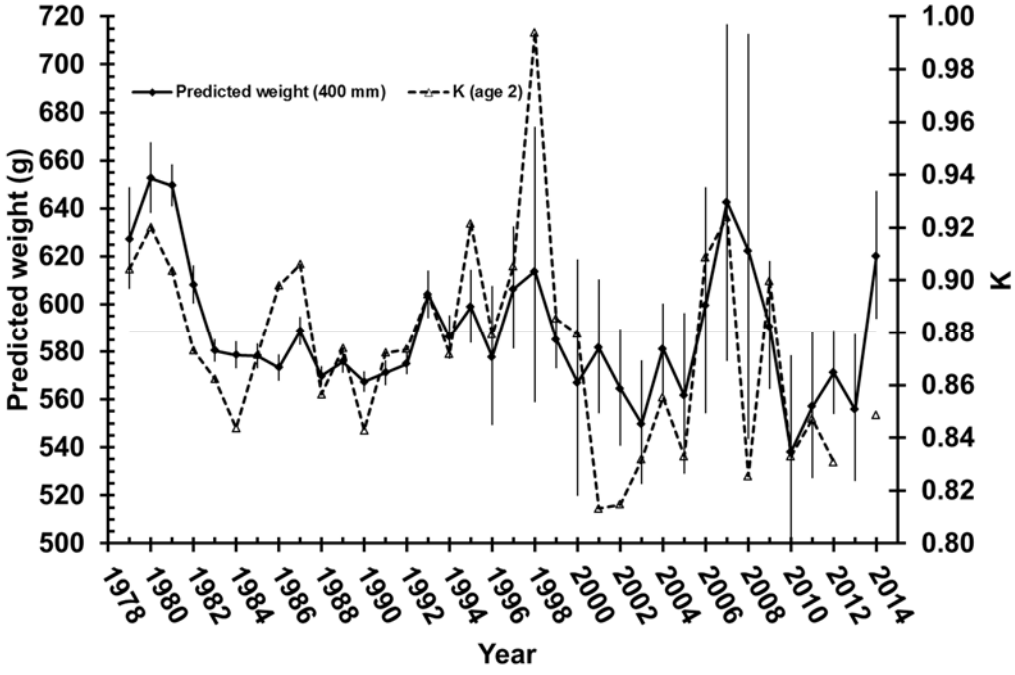

Figure 9. Lake Ontario lake trout predicted weight at 400-mm (15.8 in) TL from annual weight-length regressions calculated from fish 250 mm-500 mm (9.8 to 19.7 in). All lake trout were sampled from bottom trawls, July -August 1978 – 2014. The horizontal line represents the mean predicted weight across all years. Sample sizes for regressions were ≥ 39 except for 1997, 2000, 2005, 2006, 2007, 2008 and 2013 (n = 13, 15, 19, 11, 14, 20 and 12, respectively). Error bars represent the regression confidence limits for each annual value.

Reproductive Potential

Temporal patterns in the egg deposition index (Figure 10) differed considerably from temporal abundance patterns in the CPUE of all mature females (Figure 3). The CPUE of all mature females suggested that reproductive potential quadrupled from 1983 to 1986 and then fluctuated around a high level through 1998. In contrast, the egg index suggested that reproductive potential quadrupled from 1985 to 1993 and then remained high through 1999. The CPUE of mature females declined by 31% between 1998 and 1999, yet a change in reproductive potential was delayed by one year, dropping by 27% between 1999 and 2000. Trends more closely agreed between the egg deposition index and the CPUE of mature females ≥ 4,000 g than between the index and the CPUE of all females, reflecting the effects of population age structure on fecundity. Strain composition of the eggs was mostly SUP during 1983-1990 and mostly SEN during 1991-2002. After 2002, it became increasingly difficult to assess strain-specific contribution to the egg deposition index because only portions of cohorts stocked during 1997 and 2003 recieved 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 for 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%

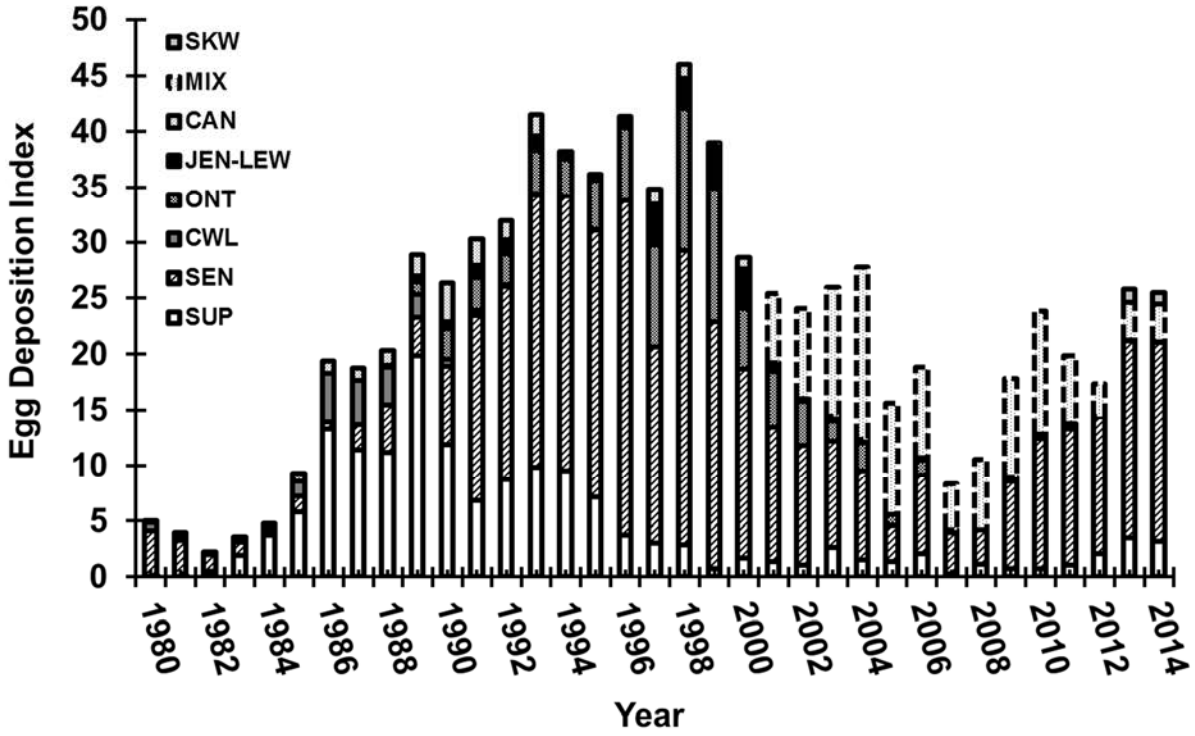

Figure 10. Egg deposition indices by strain (strain descriptions for ONT, JEN-LEW, CWL, SEN, SUP and SKW are provided in Appendix 1) for lake trout in U.S. waters of Lake Ontario during 1980-2014. CAN represents a mix of the strains stocked by OMNR and MIX represents values for untagged females stocked since 1997 for which strain could not be determined.

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 and 2014 egg deposition indices were similar to 2001-2004 values and, for the first time, included contributions from age-5 and 6 Klondike strain (SKW) lake trout from the 2008 year class (see Appendix 1 from strain descriptions).

Natural Reproduction

Survival of naturally produced lake trout past the summer/fall fingerling stage occurred in each year during 1993-2013 (Figure 11) except 2008, representing production of 20 year classes. 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 2010-2014 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 distribution of catches of wild fish suggests that lake trout are reproducing throughout New York waters of Lake Ontario (Figure 12). Catches from at least 20 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.

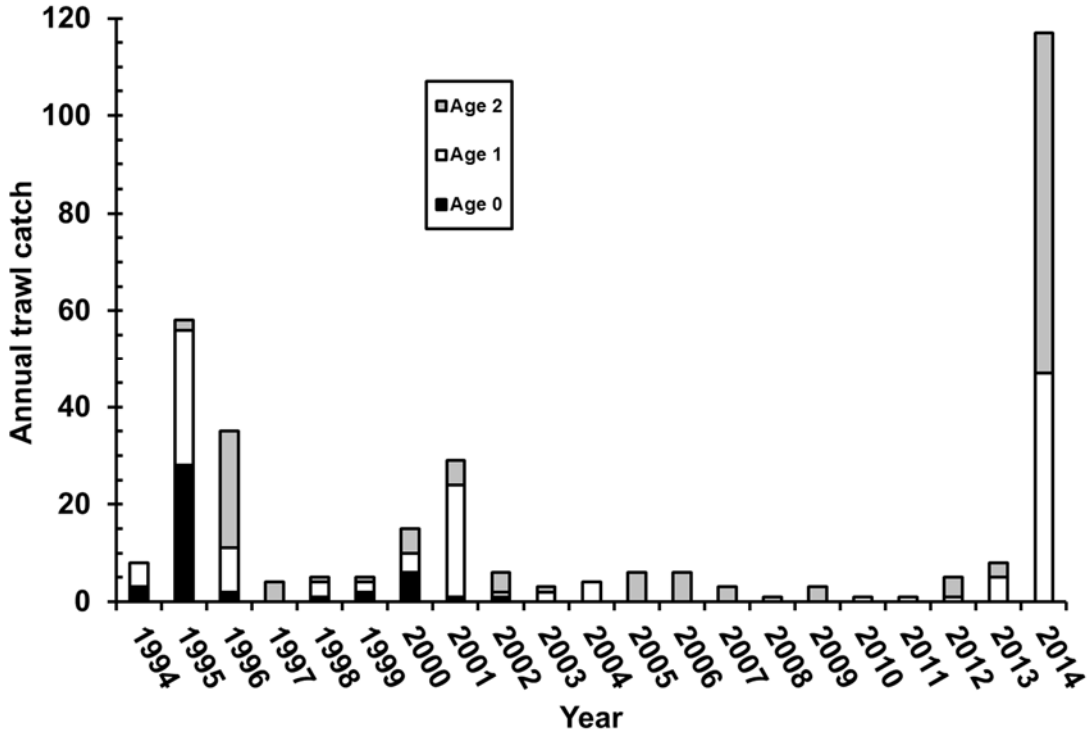

Figure 11. Numbers and ages of naturally produced (wild) lake trout captured with bottom trawls in Lake Ontario by NYSDEC and USGS, 1994-2014. During 1980-1993, only one naturally produced lake trout was captured with bottom trawls.

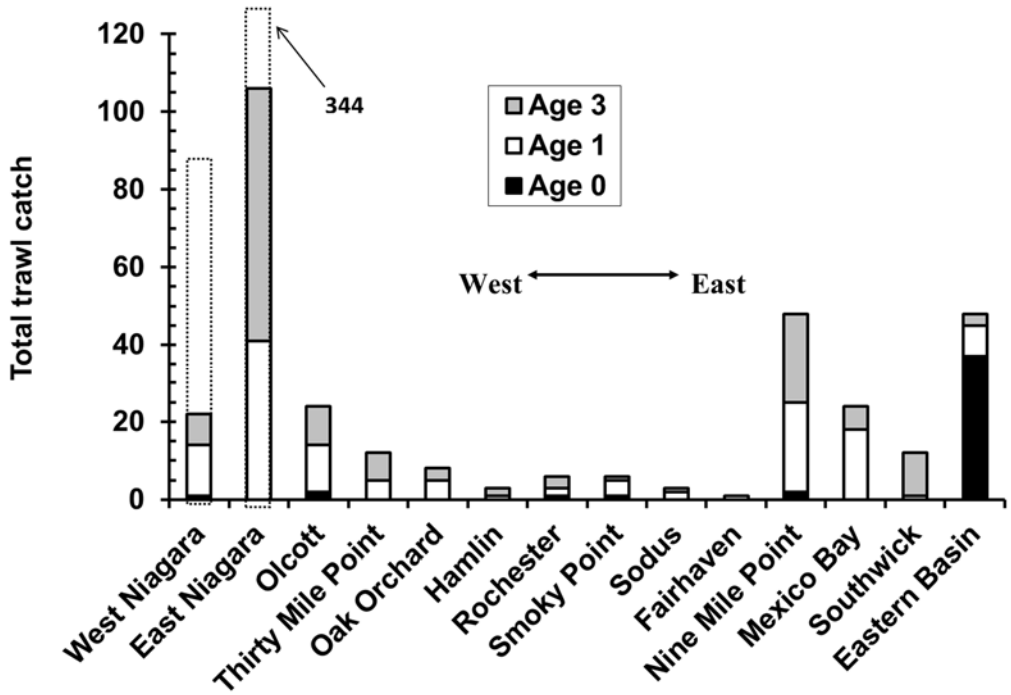

Figure 12. Numbers of wild lake trout (age 0 to 2) captured with bottom trawls at various locations in Lake Ontario by NYSDEC and USGS, 1994 – 2014. (Note: east and west Niagara are only sampled once per year whereas the other locations are usually sampled four times per year. Dashed lines show these catches adjusted for effort).

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Appendix 1.

Strain Descriptions

SEN - Lake trout descended from a native population that coexisted with sea lamprey in Seneca Lake, NY. A captive 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 (also known as Klondikes) 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).

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 2014 was slightly lower than in recent years at 68-71°F (20-22°C). Bottom temperature at 36 ft (11 m) was 70°F (23.6°C). Prior to colonization by dreissenid mussels, summer water transparency (Secchi depth) ranged down to about 10 ft (3 m , S. LaPan, pers. communication) and was not considered a significant influence on catchability. By 1995 it was apparent that significant increases in transparency had occurred, and transparency data are now collected during fish sampling. Secchi depths during the sampling period have ranged from 55 ft (16.8 m) in 1999 to 14.1 ft (4.3 m) in 1997. In 2014, transparency was high with mean Secchi depth at 39.5 ft (12.0 m) (Table 1).

Stock composition

A total of 37 species have been represented in Thousand Islands gill net sampling between 1977 and 2014 (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 2014 was a record low at 735 individuals (adjusted to multifilament standard); diversity was moderate, with 18 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*) comprising 90% of the sample in 2013 (Figure 1).

Primary recreational fishery targets

Smallmouth Bass. Smallmouth Bass are the most sought-after sport fish in the New York Thousand Islands fishery (McCullough 1987, Klindt 2011). Abundance of Smallmouth Bass was relatively high in the late 1970's, declined through 1982, then increased to its highest recorded level in 1988. After 1988 bass abundance generally declined and was low from 1996 through 2004 (Figure 2). The 2005 catch increased and has varied at relatively high levels since. Catch in 2012 reached its highest level since 1988, but this apparent increase did not persist in 2013 or 2014. The trend in Smallmouth Bass abundance is complicated by a disproportionate representation of younger fish since 2006. Abundance of age-5 and older fish, which have historically constituted the bulk of the catch, has generally remained low in recent years. (Figure 3). An expanding Double-crested Cormorant (*Phalacrocorax auritus*) population was implicated in suppression of Smallmouth Bass recruitment in the nearby Eastern Basin of Lake Ontario (Lantry et al. 1999). Cormorants may also have affected Thousand Islands bass. Cormorant predation pressure has lessened since 2005 due to lower cormorant numbers and a cormorant diet shift to predominantly Round Goby at St. Lawrence River cormorant colonies (Johnson et al. 2008). Younger bass, ages 3-4, have generally been more abundant since 2006 relative to earlier years. This may indicate increased abundance of these fish, but more likely reflects a change in catchability of young bass due to increased growth rates. The 2007 year class, which appeared to be very strong in 2012, was apparently of average abundance in 2013 and 2014 (Figure 4).

Smallmouth Bass growth changed little between 1977 and 1998. Since then, faster growth has produced an overall increasing trend in size of age-5 bass. Bass are now generally reaching legal size, 12" (305 mm), before age-5. In 2014 age-5 bass averaged a record 15.7 inches (399 mm) (Figure 5). Smallmouth Bass growth has also increased recently in Lake Ontario's Eastern Basin (Lantry 2010), in Lake St. Lawrence (Klindt 2010) and in Lake Erie (Einhouse et al. 2005). The most recent increase in growth is probably related to abundance of round goby as prey, although a density dependent effect may also be involved, particularly in Lake Ontario.

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

Northern Pike growth varies over the data series with the highest mean total length of age-4 fish occurring prior to 1983 and the lowest in 1994 (Figure 8). Mean length increased through the late 1990s and mid2000s. Unlike most other St. Lawrence River piscivorius fishes, growth (mean length at age-4) of pike has not increased after establishment of Round Goby. (Figure 8).

Yellow Perch. Yellow Perch abundance peaked in the late 1970's then went into an irregular decline through 1992. The general decline through the early 1990's may have been connected with relatively high Alewife populations at that time, which have been linked to high Yellow Perch larval mortality (Abraham 1994). From 1992 through 1999, yellow perch abundance tended to increase. After 1999, Yellow Perch catch generally declined, falling to its lowest recorded (adjusted) level in 2005. Catches increased in 2006 and remained moderately high in 2007 and 2008. Abundance then declined to a record low in 2012 and remained relatively low in 2013 and 2014 (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 age 4 fish (2010 year class) in 2014 was well above the 1997-2006 average (Figure 10).

Growth rate of age-4 Yellow Perch has generally increased since 1994 (Figure 11), and increased at a higher rate after 2009. Increased growth may be attributable to the availability of Round Goby as forage. Mean total length of age-4 perch reached a record high of 8.6 inches (218 mm) in 2013 and declined slightly in 2014.

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).

<u>Other species of interest</u>

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 (Figure 13) but declined close to the background level by 2014. 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 nine 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 about one third of their previous abundance,

and were near record low abundance in 2014 (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 2014. Channel Catfish have been sampled regularly throughout the survey period. They have generally been present at about one fourth the abundance of Brown Bullhead, but with the decline in bullhead abundance in recent years (Figure 14), the two species were about equally abundant in 2013 and 2014. 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 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*) are sampled in very low numbers in about half the sample years.

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Table 1. Water temperature and secchi depth.

Sample Year	Water Temperature Range °C (°F)	Secchi Depth m (ft)	Sample Year	Water Temperature Range °C (°F)	Secchi Depth m (ft)
1977	22-23 (72-73)		1996	21-21 (70-70)	8.8 (29)
1978	21-22 (70-72)		1997	20-22 (68-72)	4.3 (14)
1979	25-26 (77-79)		1998	22-24 (72-75)	8.0 (27)
1980	20-22 (68-72)		1999	23-24 (74-76)	16.8 (55)
1981	20-22 (68-72)		2000	21-22 (70-71)	13.4 (44)
1982	18-19 (64-66)		2001	20-24 (68-75)	6.2 (20)
1983	22-23 (72-73)		2002	21-23 (70-73)	7.3 (24)
1984	19-21 (66-70)		2003	21-24 (69-76)	6.5 (21)
1985	20-21 (68-70)		2004	21-22 (69-71)	8.1 (26.5)
1986	19-21 (66-70)		2005	22-24 (72-75)	11 (36)
1987	19-21 (66-70)		2006	22-24 (72-75)	8.8 (29)
1988	22-24 (72-75)		2007	21-22 (69-72)	7.8 (22.5)
1989	19-22 (66-72)		2008	20-24 (68-75)	10.4 (34)
1990	22-24 (72-75)		2009	21-23 (69-73)	9.5 (31)
1991	23-23 (73-73)		2010	23-25 (74-77)	6.0 (20)
1992	18-19 (64-66)		2011	23-24 (74-76)	8.8 (29)
1993	21-24 (70-75)		2012	23-25 (73-75)	9.3 (30.5)
1994	21-24 (70-75)		2013	23-25 (73-75)	6.5 (21.3)
1995	22-24 (72-75)		2014	20-22 (68-71)	12.0 (39.5)

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

* 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				
Longnose Gar	0	0	0	0	0	0	0	0	0	0				
Bowfin	.03	0	0	0	0	.03	0	.03	.03	.03				
Alewife	.09	.03	2.25	.59	8.78	2.13	2.56	.50	.41	.13				
Gizzard Shad	0	0	0	0	0	0	0	0	0	0				
Coho Salmon	0	0	0	0	0	0	0	0	0	0				
Brown Trout	0	0	0	0	0	0	0	0	0	0				
Lake Trout	0	0	0	0	0	0	0	0	0	.03				
Rainbow Smelt	0	0	.06	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				
Muskellunge	0	0	0	0	0	0	0	0	0	0				
Common Carp	.12	.19	.16	.19	.09	.06	.16	.160	.22	.03				
Rudd	0	0	0	0	0	0	0	0.22	0	0				
Golden Shiner	0	0	.03	0	.03	.03	.03	0	0	0				
Fallfish	0	0	0	0	0	0	0	.03	.06	1				
Longnose Sucker	0	0	0	0	0	0	0	0	0	0				
White Sucker	1.10	1.16	.88	.81	.63	.34	.69	.53	.78	.31				
Silver Redhorse	.03	.06	.03	.03	.03	.19	.03	.03	.03	.41				
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0				
Greater Redhorse	0	0	0	0	.16	0	0	0	.03	.03				
Brown Bullhead	1.53	2.47	1.22	.81	1.56	.72	.75	.97	.50	.19				
Yellow Bullhead	0	0	0	0	0	0	0	.03	0	0				
Channel Catfish	.38	.44	.25	.31	.84	1.06	0.03	.31	.34	.31				
Stonecat	0	0	0	0	0	0	0	0	0	0				
Burbot	0	0	0	0	0	0	0	0	0	0				
White Perch	0	.03	0	0	0	0	0	0	0.13	0				
White Bass	0	.03	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*				
Pumpkinseed	1.88	2.41	.97	.88	.81	.72	.69	.47	.94	.09				
Bluegill	.06	.03	.13	.06	0	.06	.09	.25	.09	.03				
Smallmouth Bass	4.75	7.84	5.13	6.69	4.19	7.5	5.0	8.91	6.41	4.59				
Largemouth Bass	0	0	.19	0	0	.03	0	.31	.06	0				
Black Crappie	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*				
Walleye	.75	.81	1.34	.84	1.03	.84	1.06	.47	.81	1.22				
Freshwater Drum	.06	0	.13	0	0	0	.09	.06	0.03	0				
Round Goby	0	0	.09	.53	.19	.16	.75	.06	0	.37				

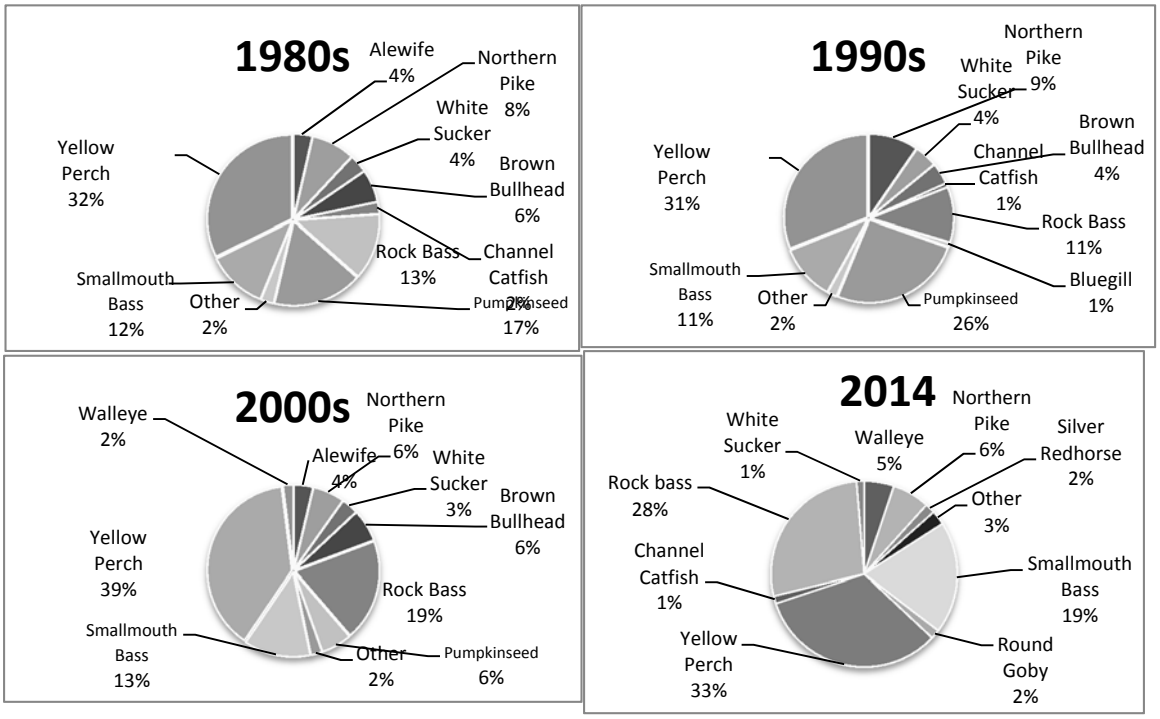

Figure 1. Composition of the warm/coolwater fish stock assessment sample from mid- depths of the St. Lawrence River Thousand Islands area.

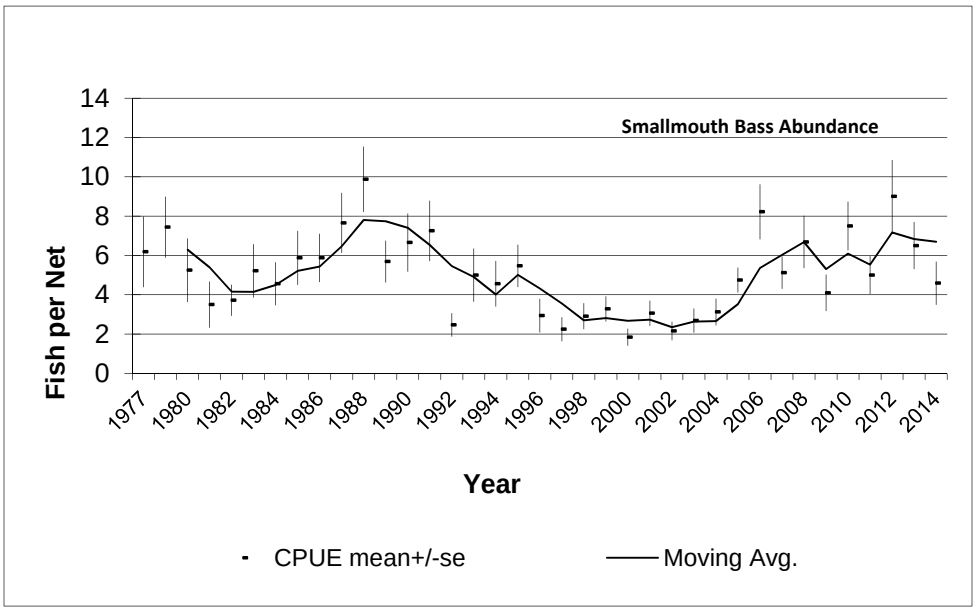

Figure 2. Smallmouth bass abundance index in the St. Lawrence River Thousand Islands area (Catch per Unit Effort +/- SE and 3-year moving average).

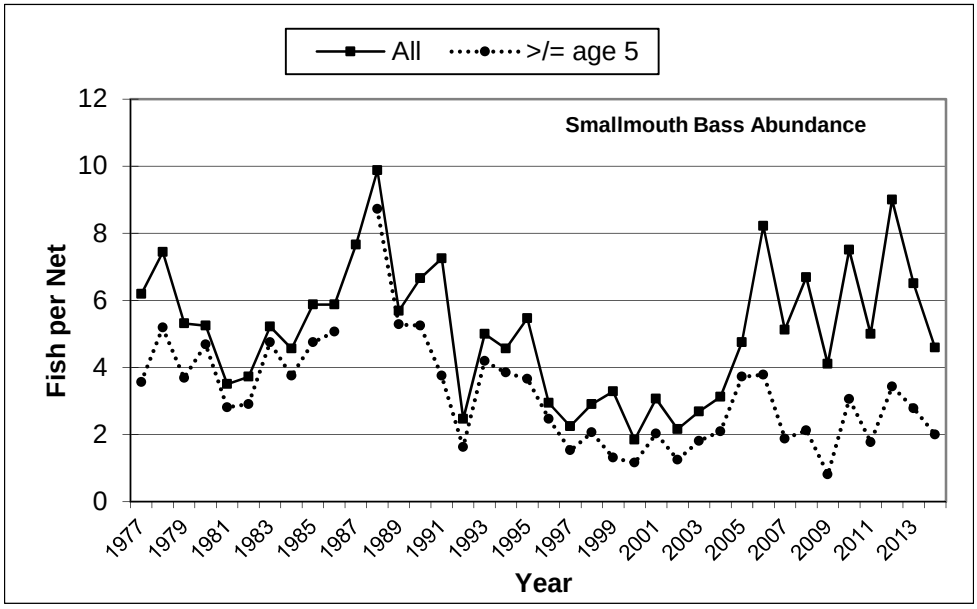

Figure 3. Smallmouth Bass abundance index in the St. Lawrence River Thousand Islands area (all bass sampled and bass greater than or equal to age 5).

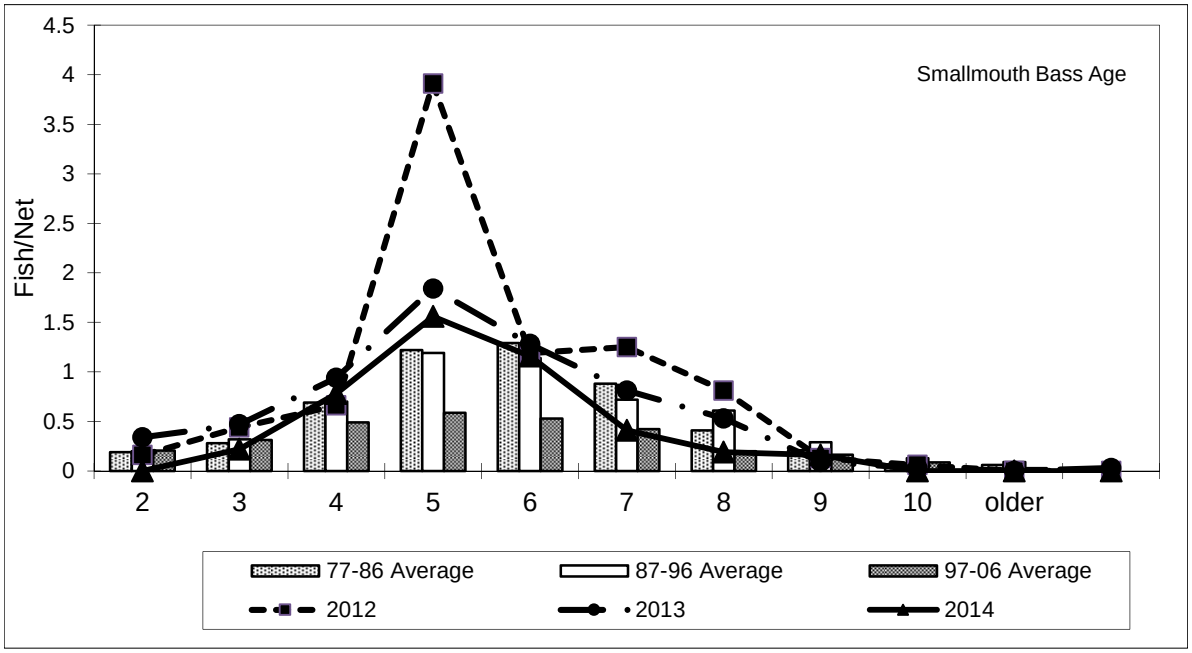

Figure 4. Smallmouth Bass age distribution in the St. Lawrence River Thousand Islands area.

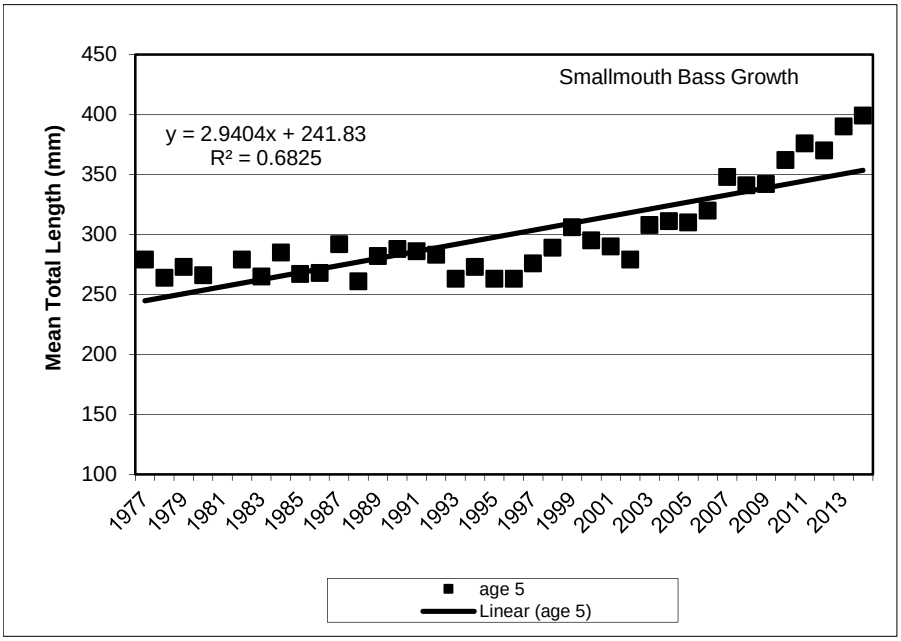

Figure 5. Mean total length of Smallmouth Bass at age 5 in the St. Lawrence River Thousand Islands area.

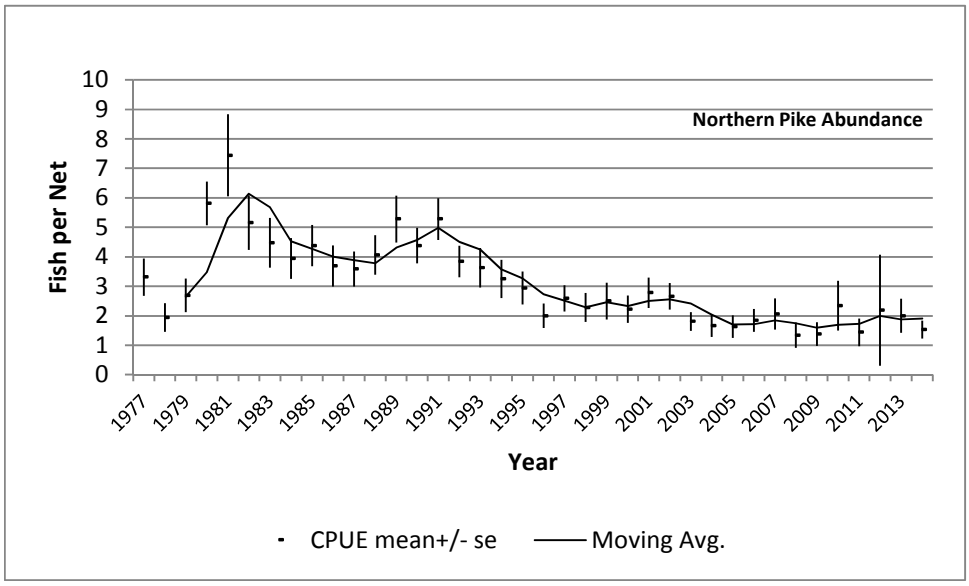

Figure 6. Northern Pike abundance index in the St. Lawrence River Thousand Islands area.

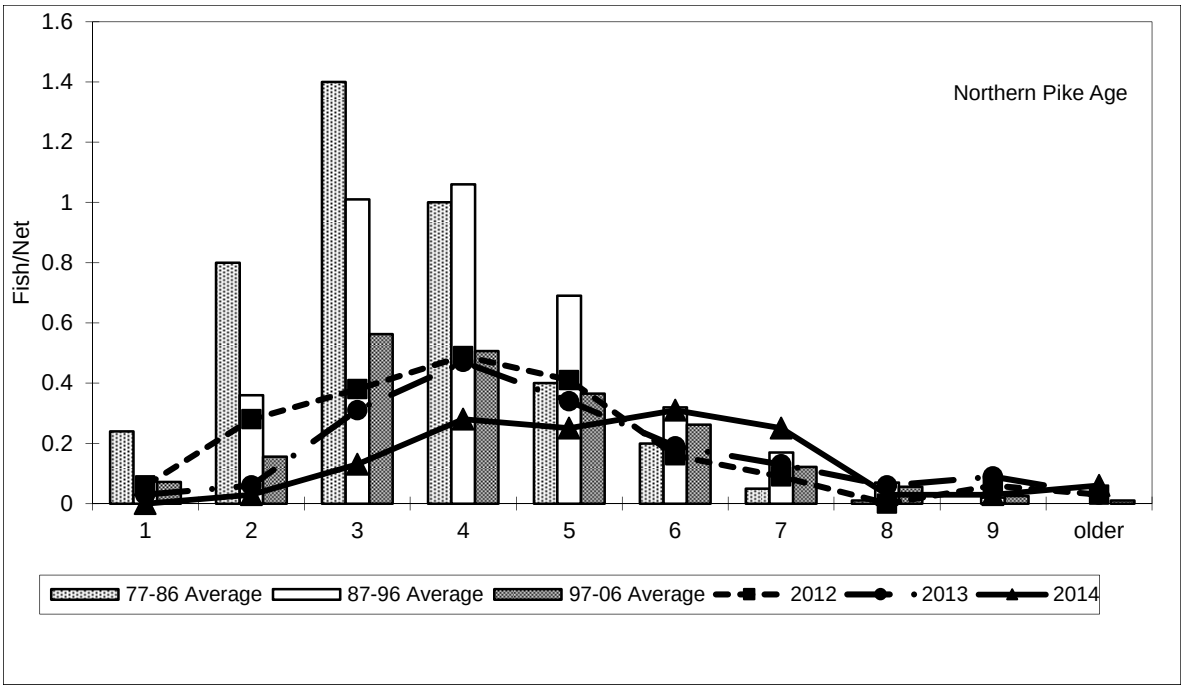

Figure 7. Northern Pike age distribution in the St. Lawrence River Thousand Islands area.

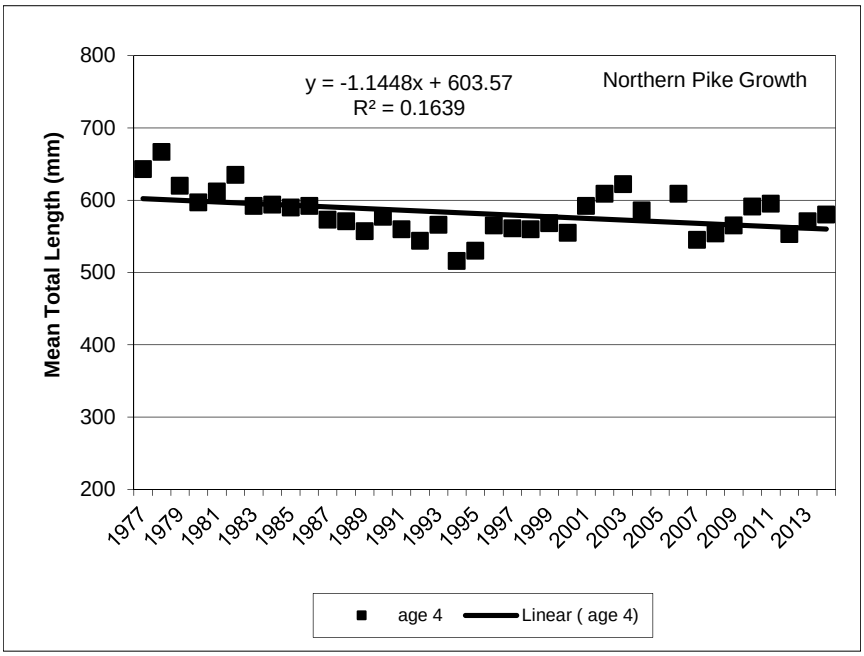

Figure 8. Mean total length of Northern Pike at age 4 in the St. Lawrence River Thousand Islands area.

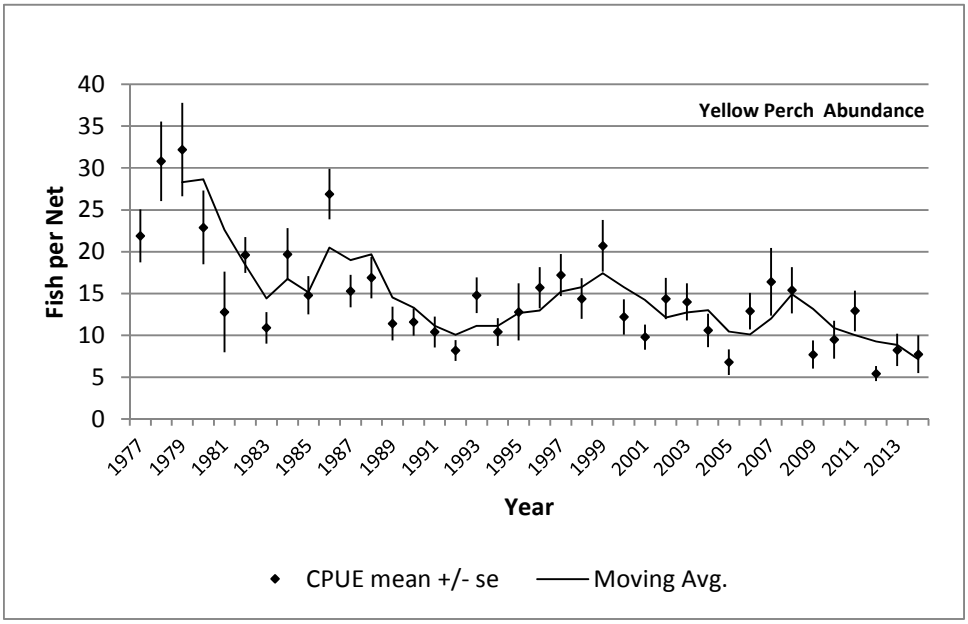

Figure 9. Yellow Perch abundance index in the St. Lawrence River Thousand Islands area.

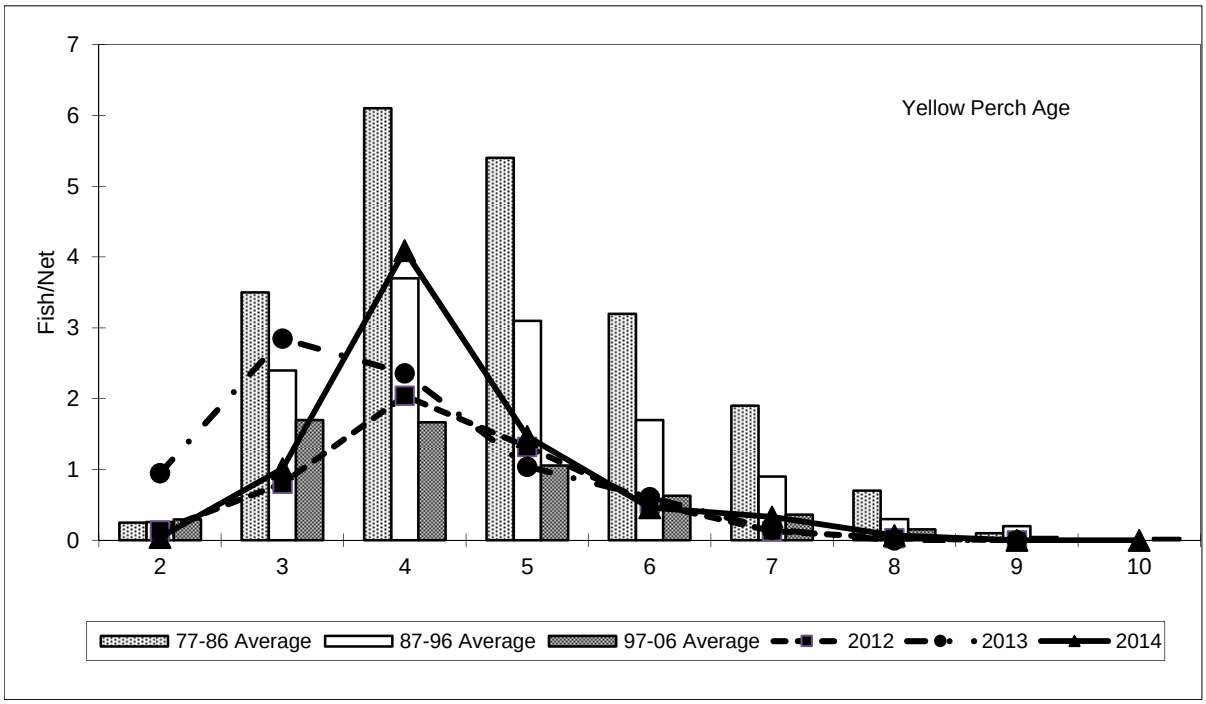

Figure 10. Yellow Perch age distribution in the St. Lawrence River Thousand Islands area.

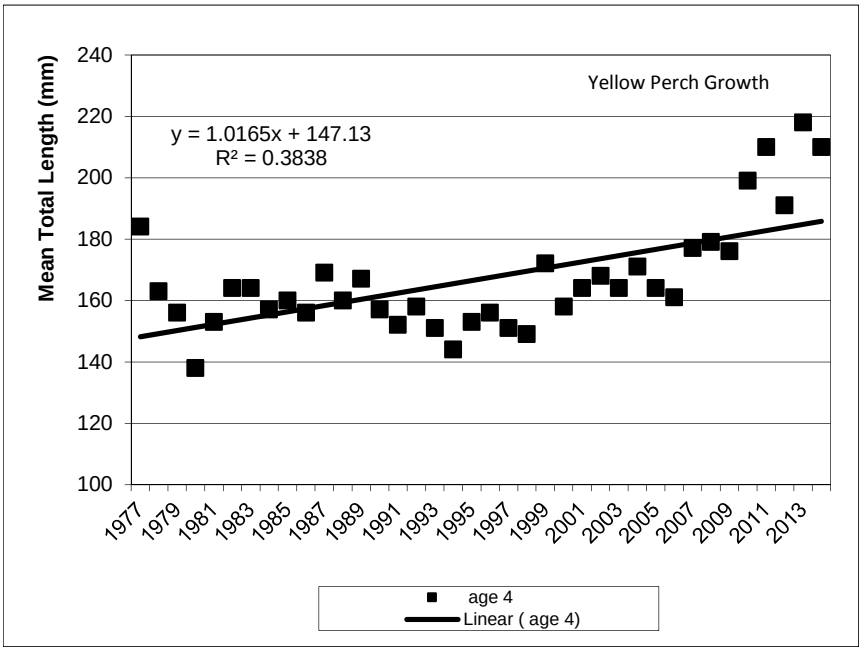

Figure 11. Mean total length at age 4 for Yellow Perch in the St. Lawrence River Thousand Islands area.

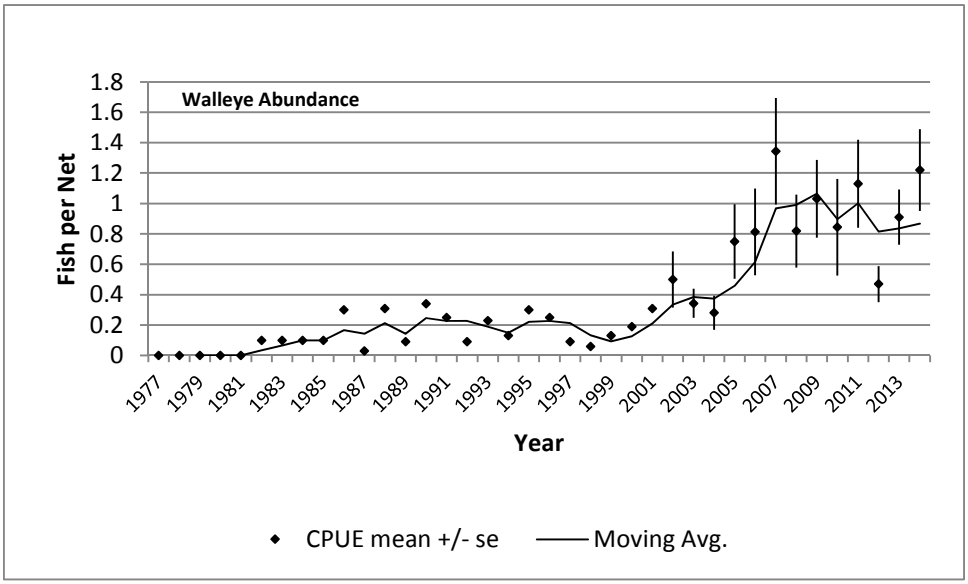

Figure 12 Walleye abundance index in the St. Lawrence River Thousand Islands area.

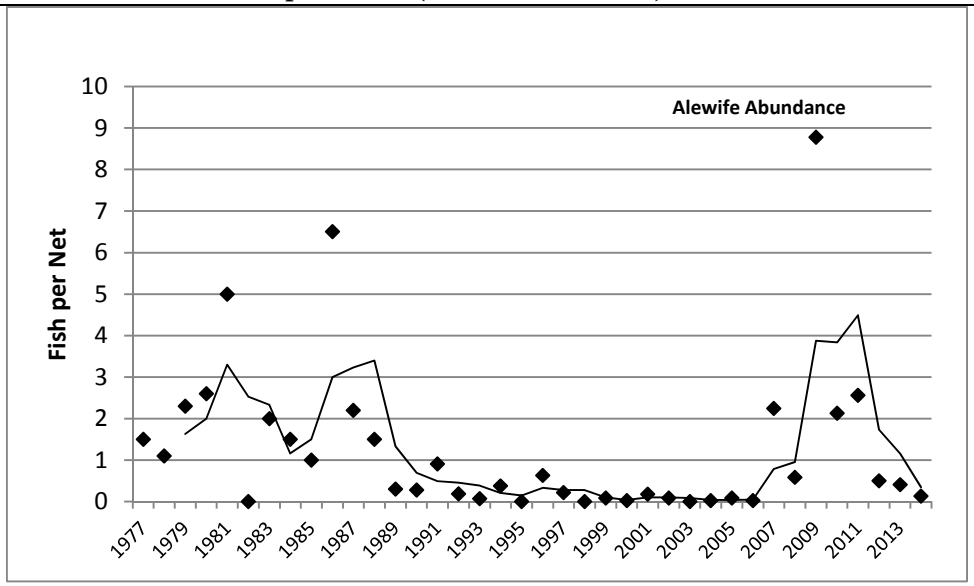

Figure 13. Abundance index for Alewife in the St. Lawrence River Thousand Islands area (with 3-year moving average).

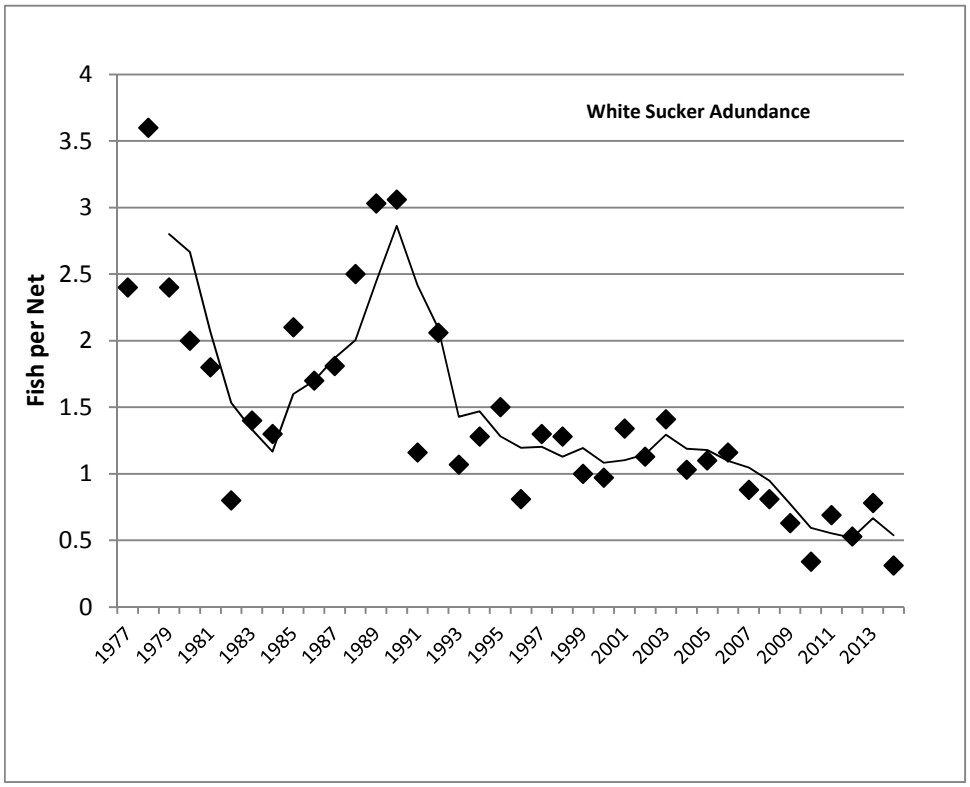

Figure 14. Abundance index for White Sucker in the St. Lawrence River Thousand Islands area (with 3-yr moving average).

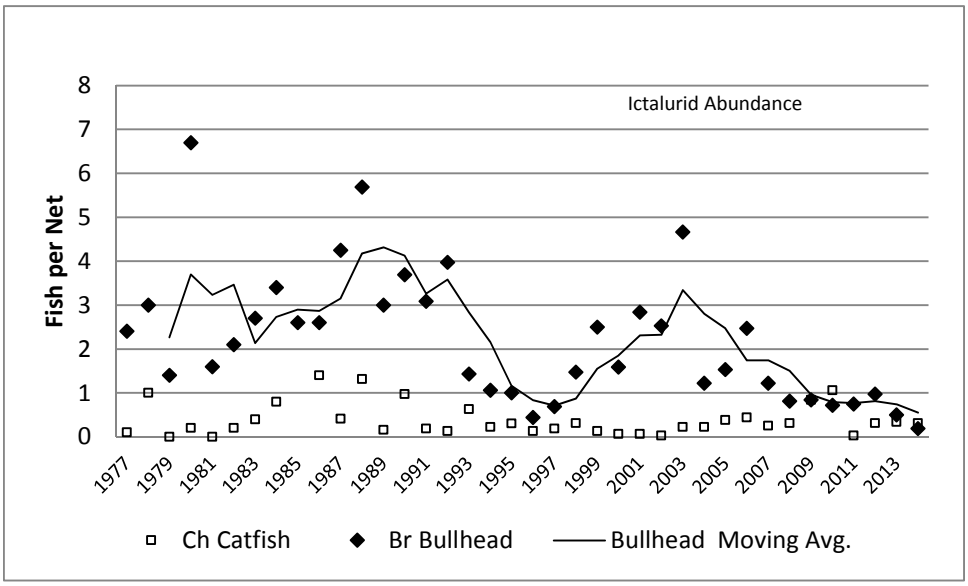

Figure 15. Abundance index for Brown Bullhead and Channel Catfish in the St. Lawrence River Thousand Islands area.

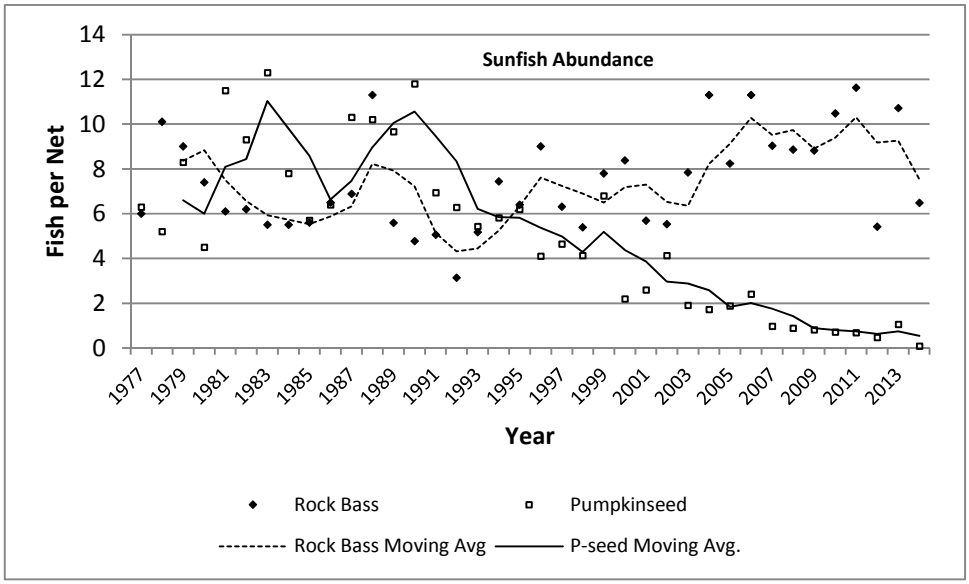

Figure 16. Abundance index for Rock Bass and Pumpkinseed sunfish in the St. Lawrence River Thousand Islands area (with 3-year moving averages).

2014 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 (DEC) 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 DEC.

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 18.5 hours (SD=0.69) 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 DEC 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 2014 Lake St. Lawrence assessment was conducted from 15 to 18 September. Surface water temperatures ranged from 63-66°F (17.2-18.9^{o}C). A sample of 697 fish comprising 16 species was collected (Table 1). The catch was dominated by yellow perch (34.4%), rock bass (24.0%) and white perch (15.6%). White perch were collected in record numbers in 2014, which displaced smallmouth bass to the fourth most abundant species.

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

Total CUE decreased by 5.0% from 22.93 in 2013 to 21.78 in 2014, which is the fifth highest catch since 1985 (Figure 2). Total CUE is generally driven by fluctuations in yellow perch catch. In this case the total CUE remained relatively high based on the record catch of white perch.

Yellow perch CUE decreased by 6% from 7.94 in 2013 to 7.5 in 2014 (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).

Few perch <6" were collected in this assessment, while a high proportion of fish >9" (28.0%) were present (Figure 4). From 2006 to 2014, perch >9" have comprised 19.8-33.9% of the catch. Yellow perch ages 3 and 4 comprised the majority of fish collected (Figure 5).

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 =0.54), an increasing growth rate trend remains apparent. 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 was below the long term average of 2.26 in 2014 and fell just below the median (Figure 7). Unlike most years the length distribution is relatively uniform, without the dominant abundance of large fish (Figure 8). The 2011 year class, which dominated catches as age-2 fish in 2013, remained strong as age-3 fish in 2014 (Figure 9). 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 continues to be weak (r^2=0.22), however, it shows 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 (1.38) decreased 33% in 2014 and fell close to the long term average of 1.45 fish/net night (Figure 11). Length-frequency distribution of the walleye catch (Figure 12) was dominated by 16-19 inch fish. Catch was dominated by age 2 and 3 fish, from the apparently strong 2012 and 2011 year classes, respectively (Figure 13). 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).

Northern pike CUE (0.09) in 2014 fell to the second lowest recorded catch as only three fish were collected (Figure 14). Total length of northern pike ranged from 8.7-29.3 in (Figure 15). Fish aged 0, 4 and 9 were represented in the catch (Figure 16). Age 0 fish are collected sporadically, however, seining data (2014) from Lake St. Lawrence esocid studies indicate that young of the year pike were abundant (DEC Statewide Fisheries Database v51). Northern pike CUE continues its decline which began in the early 2000s. Netting strata were not designed to take advantage of limited littoral zone habitat in Lake St. Lawrence, therefore northern pike are poorly represented in this assessment.

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Table 1. Relative abundance (number of fish per net night) and long term average (LT Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2014.

	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, 1983-2014 (continued).

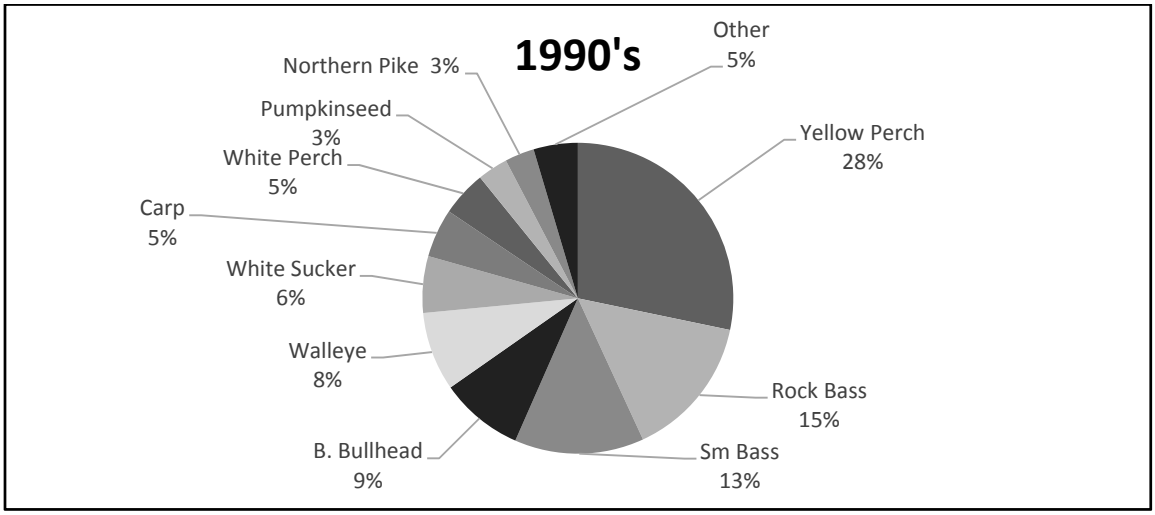
	Year	1993	1994	1995	1996	1997	1998	1999	2000	2001
SPECIES	**# Nets**	47	32	47	32	32	32	32	32	32
Lake Sturgeon		x	0.03	x	x	0.09	x	x	x	x
Bowfin		x	x	x	x	x	x	x	0.03	0.03
Alewife		0.02	0.28	0.43	x	x	x	x	0.03	x
Gizzard Shad		0.32	x	x	0.09	x	x	0.13	0.03	x
Rainbow Trout		x	x	x	x	x	x	x	x	x
Brown Trout		0.02	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

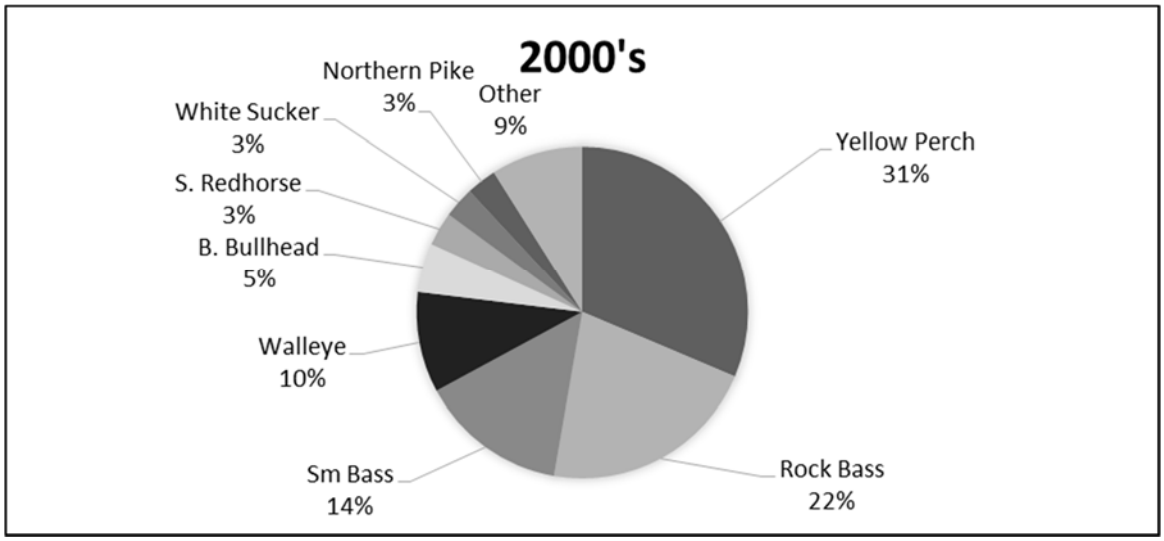
Table 1. Relative abundance (number of fish per net night) and long term average (LT Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2014 (continued).

	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, 1983-2014 (continued).

	Year	2010	2011	2012	2013	2014	LT Avg.
SPECIES	**#**	32	32	32	32	32	
Lake Sturgeon		0.06	0.03	x	x	x	0.01
Bowfin		0.03	x	x	0.03	x	0.01
Alewife		x	0.03	0.09	x	0.03	0.18
Gizzard Shad		0.06	0.03	0.63	0.44	x	0.11
Rainbow Trout		x	x	x	x	x	0.00
Brown Trout		x	x	x	x	x	0.01
Lake Trout		x	x	x	x	x	0.00
Rainbow Smelt		x	x	x	x	x	0.00
Northern Pike		0.28	0.31	0.19	0.28	0.09	0.45
Muskellunge		x	0.03	x	x	x	0.00
Lake Chub		x	x	x	x	x	0.00
Carp		0.19	0.16	0.41	0.25	0.09	0.61
Golden Shiner		x	x	0.03	x	x	0.00
Fallfish		0.19	0.19	0.16	0.47	0.16	0.14
White Sucker		0.44	0.53	1.22	0.72	0.59	0.82
Silver Redhorse		0.19	0.63	0.44	0.38	0.25	0.44
Shorthead Redhorse		x	x	x	0.03	x	0.02
Greater Redhorse		0.06	0.03	x	0.03	0.03	0.01
Yellow Bullhead		x	x	x	x	x	0.00
Brown Bullhead		0.16	0.22	0.66	0.31	0.78	0.98
Channel Catfish		0.03	0.09	0.09	0.09	0.06	0.07
White Perch		0.41	1.03	1.75	2.16	3.41	0.89
White Bass		x	x	x	x	x	0.03
Rock Bass		8.03	3.41	5.16	3.97	5.22	2.94
Pumpkinseed		0.19	0.09	0.16	0.38	0.16	0.36
Bluegill		x	x	x	x	x	0.00
Smallmouth Bass		2.22	1.34	2.66	3.09	1.97	2.26
Largemouth Bass		0.22	0.22	0.69	0.09	0.03	0.07
Black Crappie		x	x	x	0.03	x	0.04
Yellow Perch		18.78	9.03	16.69	7.94	7.50	6.67
Walleye		2.75	1.81	2.09	2.06	1.38	1.45
Freshwater Drum		0.03	x	0.03	0.03	x	0.03
TOTAL CATCH		34.25	19.34	33.16	22.93	21.78	18.62





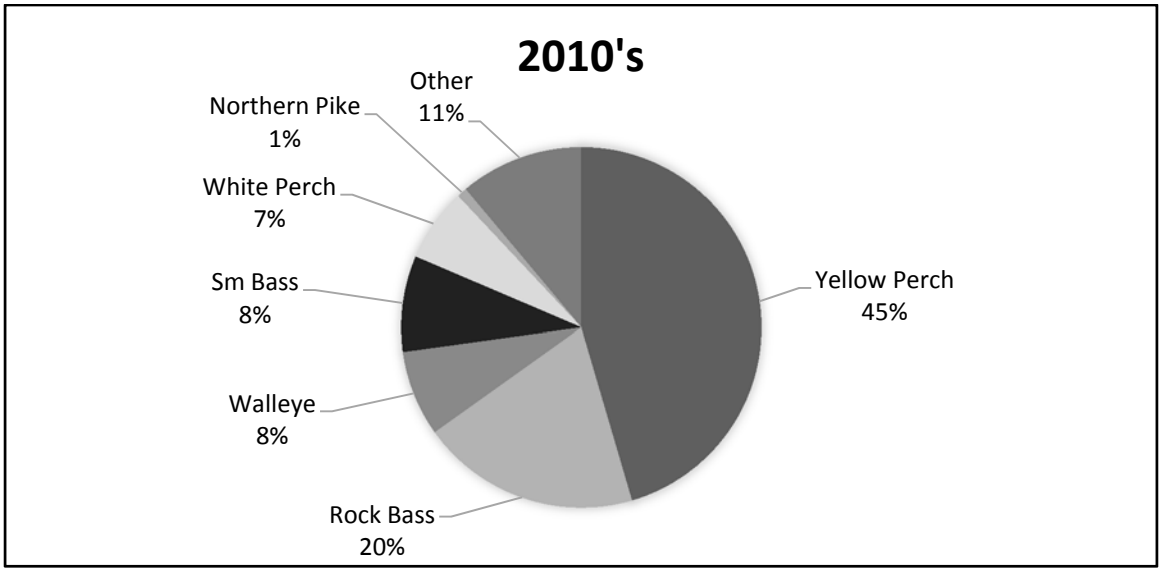


Figure 1. Composition of the Lake St. Lawrence fish community sampled by gill nets and presented by decade.

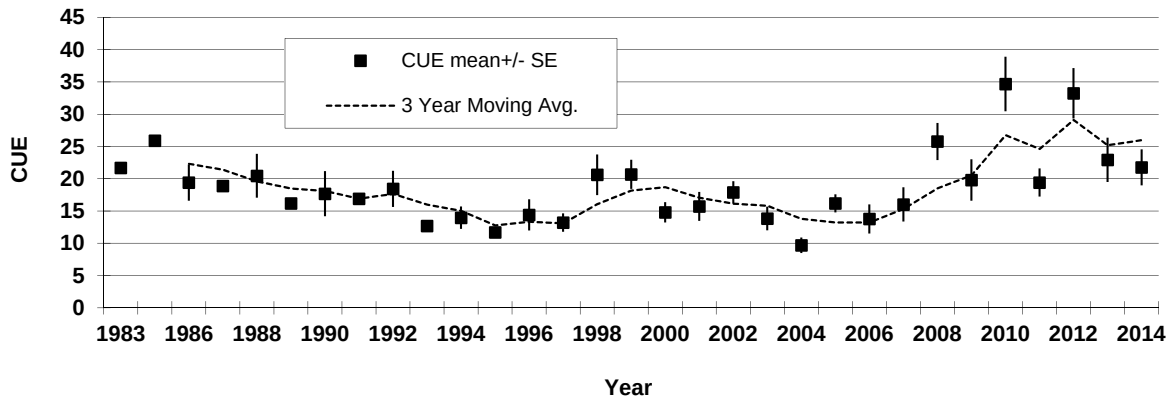


Figure 2. Total catch per gill net night (CUE) for Lake St. Lawrence, 1983-2014.

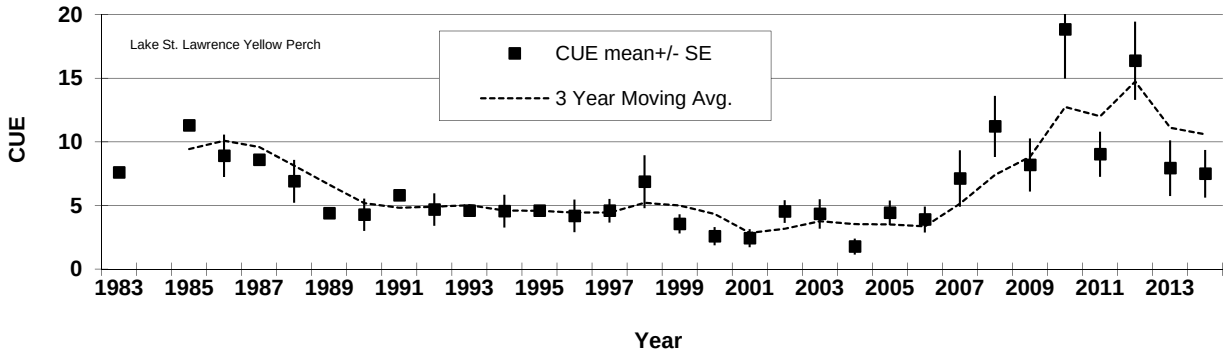


Figure 3. Yellow perch total catch per gill net night (CUE) for Lake St. Lawrence, 1983-2014.

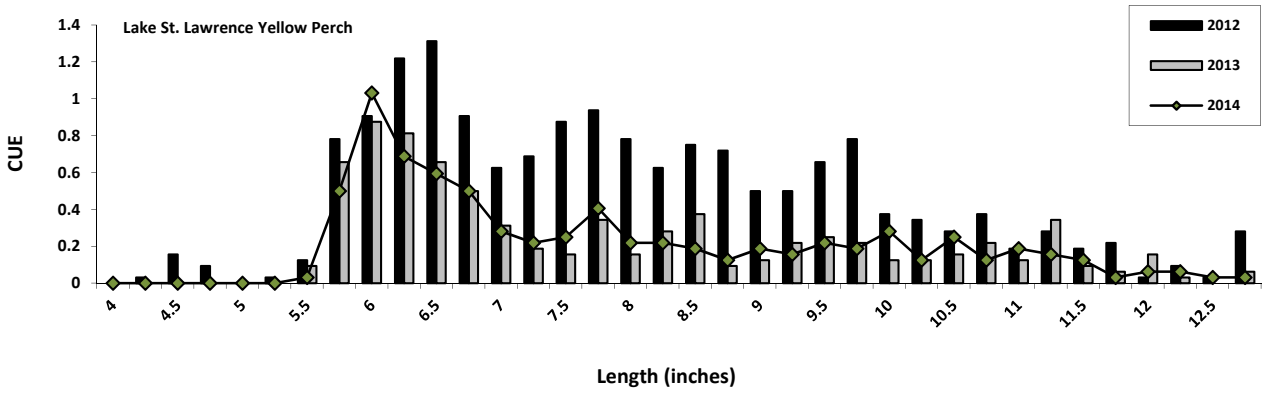


Figure 4. Yellow perch length-frequency distribution for Lake St. Lawrence.

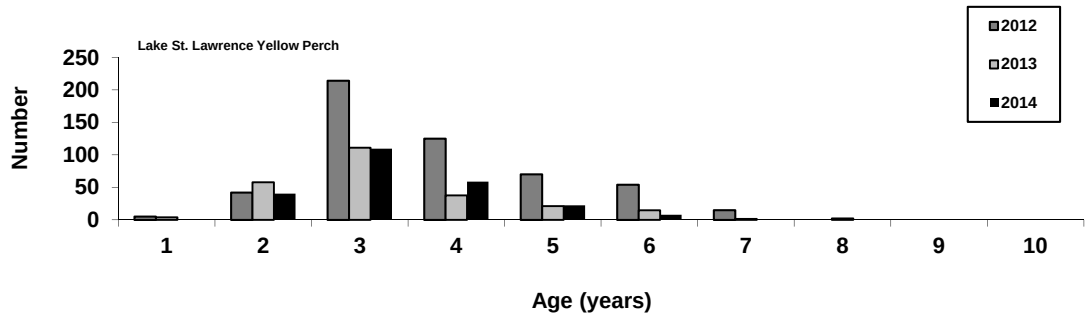


Figure 5. Yellow perch age-frequency distribution for Lake St. Lawrence.

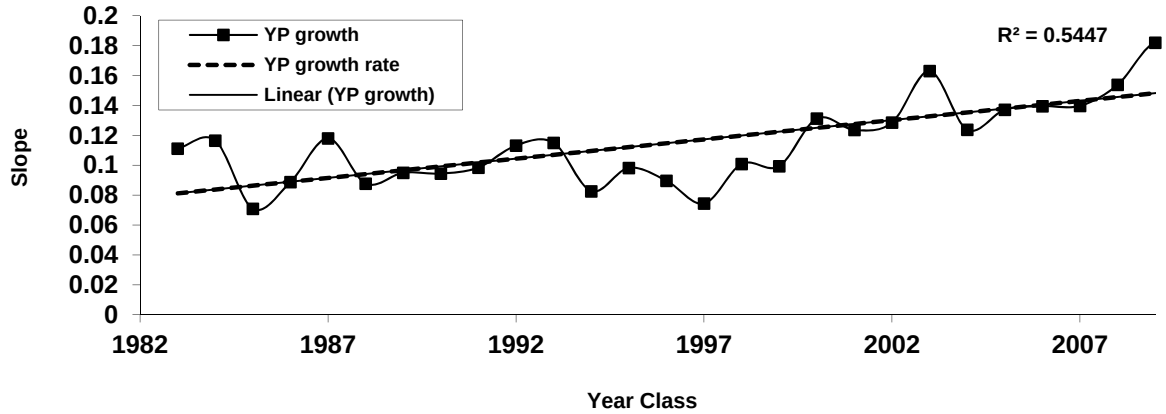


Figure 6. Yellow perch growth rates by year class using fish ages 2-7.

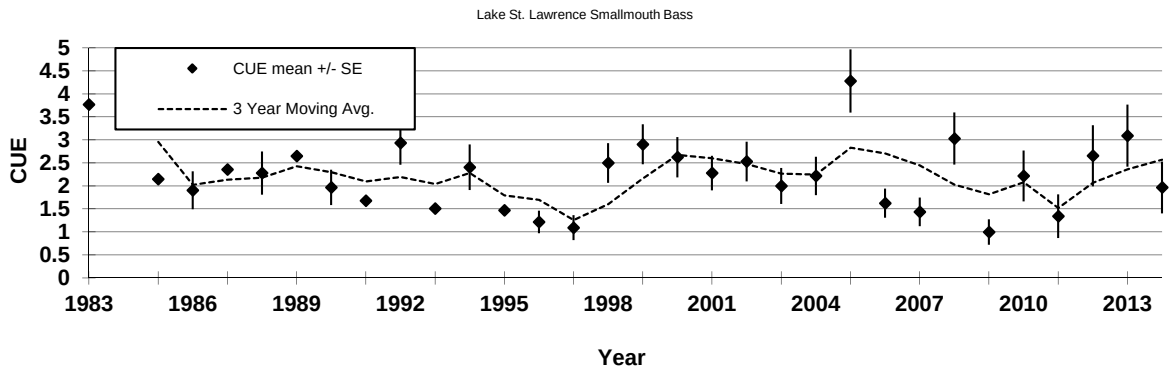


Figure 7. Total catch per gill net night (CUE) for smallmouth bass in Lake St. Lawrence, 1983-2014.

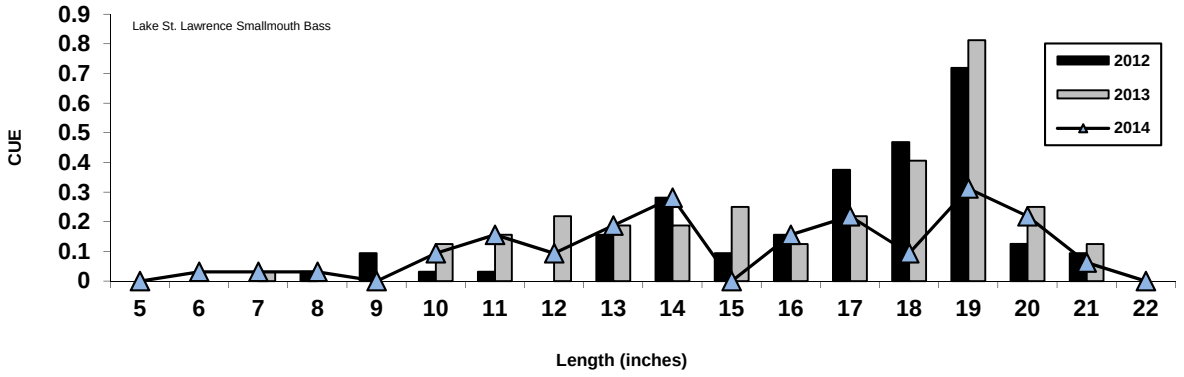


Figure 8. Smallmouth bass length-frequency distribution for Lake St. Lawrence.

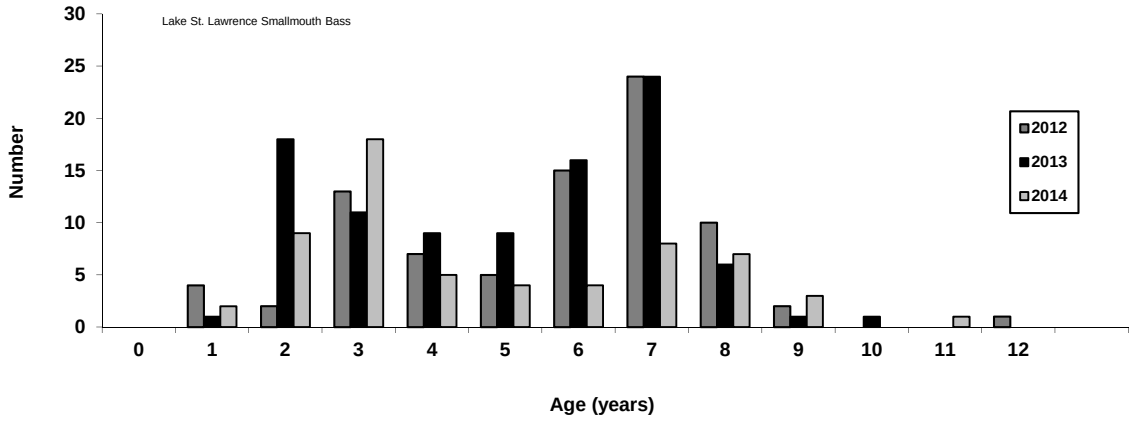


Figure 9. Smallmouth bass age-frequency distribution for Lake St. Lawrence.

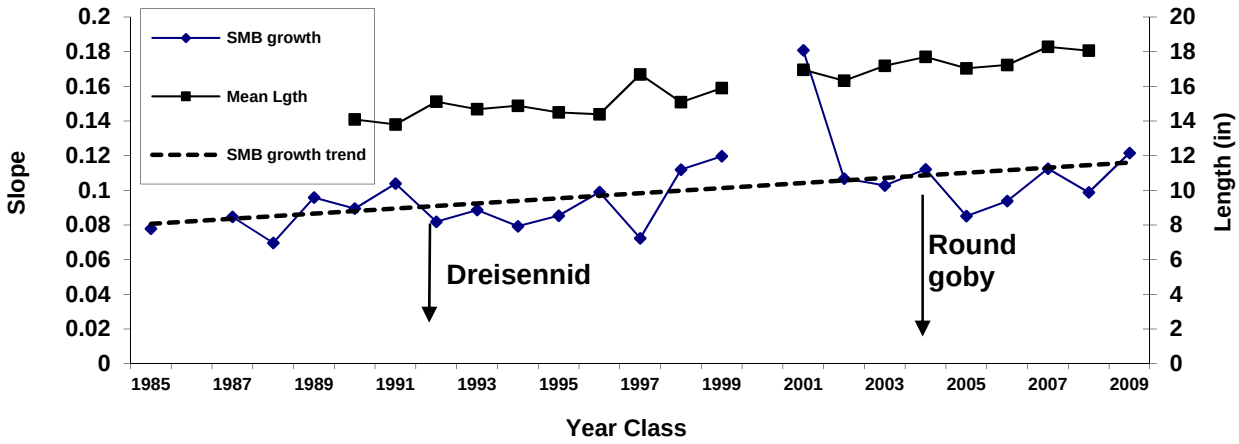


Figure 10. Smallmouth bass growth by year class described using two methods: growth rate (slope) using fish ages 3-7 and mean length (in) at age-6.

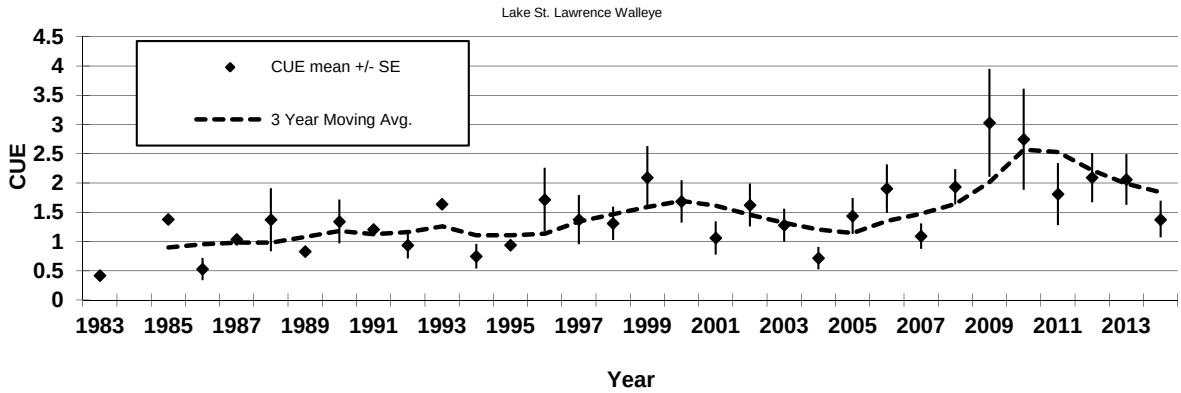


Figure 11. Total catch per gill net night (CUE) for walleye in Lake St. Lawrence, 1983-2014.

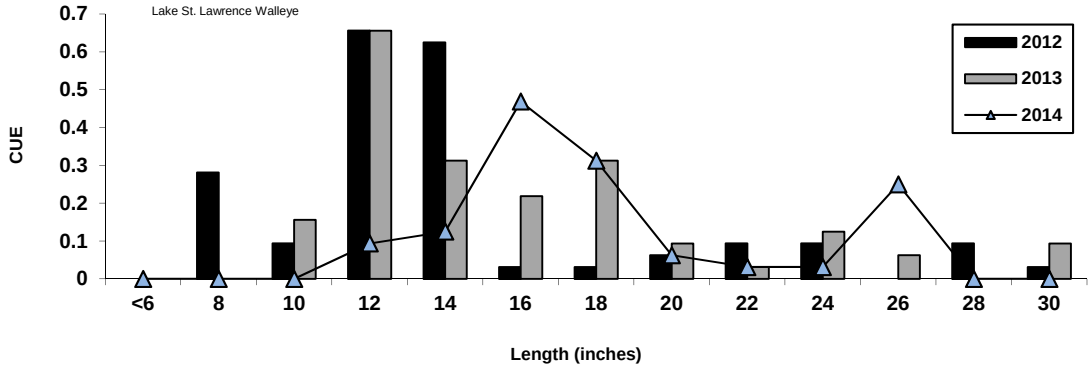


Figure 12. Walleye length-frequency distribution for Lake St. Lawrence.

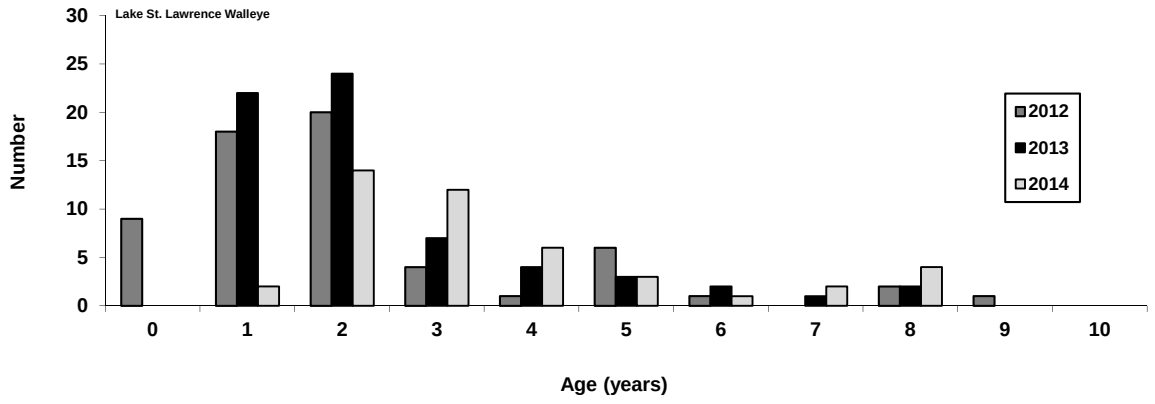


Figure 13. Walleye age-frequency distribution for Lake St. Lawrence.

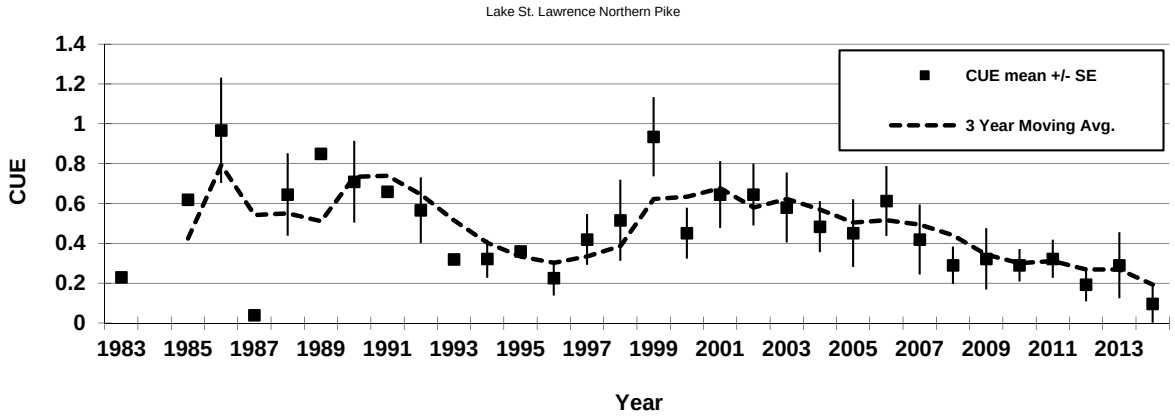


Figure 14. Total catch per gill net night (CUE) for northern pike in Lake St. Lawrence, 1983-2014.

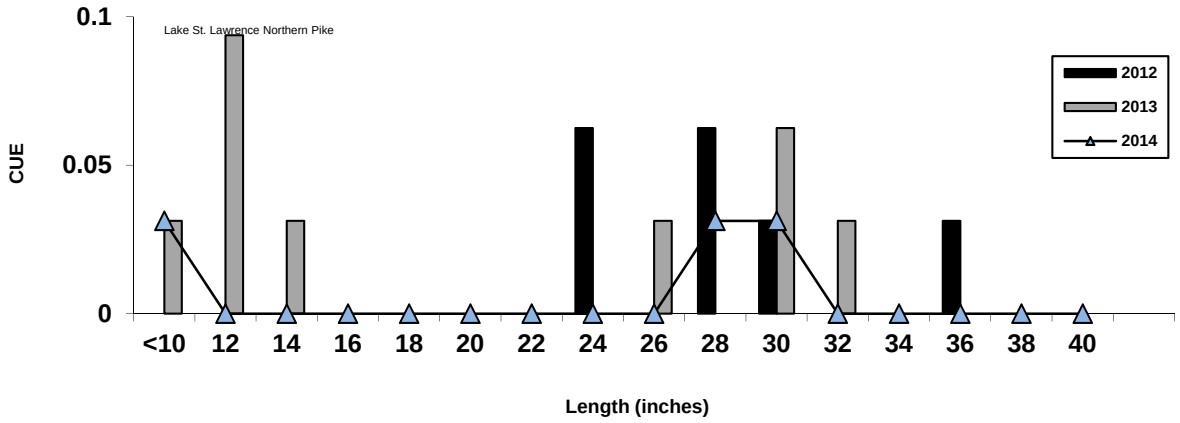


Figure 15. Northern pike length-frequency distribution for Lake St. Lawrence.

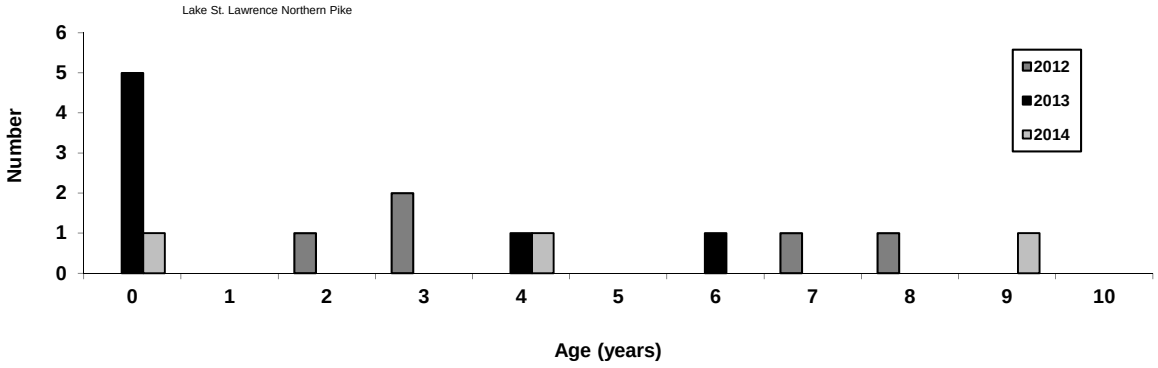


Figure 16. Northern pike age-frequency distribution for Lake St. Lawrence.

2014 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

Weekly seine hauls were conducted at four sites (Altmar, Pineville, County Rt. 2A, and Douglaston, Figure 1) from 14 May through 20 June. The bag seine was 20 feet wide by 6 feet deep with 1/8 inch bar mesh. Hauls were made by stretching the seine perpendicular to the current and sweeping toward one bank to a suitable landing area. A sample consisted of one seine haul per site. Obstacles on the river bottom and differences in the lengths of the hauls prevented the use of catches per unit of effort as precise density estimates but the range of numbers captured between sites and dates do provide 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 flow events the first week of May and the last week of June in 2014 prevented surveys during those weeks but occurred on either side of the three peak weeks we use to index relative annual production. The mean peak catch in 2014 of 327 YOY per haul was slightly above the survey average of 280 YOY per haul, 2001-2013. (Figure 2). There was a relatively concentrated peak occurring the fourth week of May (Figure 3). The single highest catch was 1,176 at Pineville during the last week of May (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 have the potential to disturb redds due to the moving of bed load. 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.

Production was positively correlated with mean spawning flows ($r = 0.65$, $p = 0.01$) and

negatively correlated with maximum incubation flows ($r = -0.63$ $p = 0.01$) for the 14 year study period. Correlation between the mean spawning and maximum incubation flows was weak and insignificant ($r = -0.27$ $p = 0.36$). 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 production (from $r^2 = 0.35$ to $r^2 = 0.47$ with $p = 0.03$ in both cases). Combining the polynomial mean spawning flows and maximum incubation flows in a single model yielded the following regression ($r^2 = 0.66$, $p = 0.01$):

$$y = -0.411x^2 + 5.597x - 0.847z - 6.246$$

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 and 2014 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 supports 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 two years of highest production were 2010 and 2012, the years with the lowest maximum flow event during the incubation period. 2012 was near baseflow for spawning and 2010 was well above it. This further indicates that extreme low flows during the spawning period can result in too few fish reaching the upper river to produce large year classes, and large flow events during the incubation period can also reduce resulting production.

We are rapidly gaining an understanding of the role of naturally reproduced fish in the Lake Ontario and Salmon River systems. Results of the mass marking study have shown that wild fish comprise a substantial portion of the angler harvest in the Salmon River system (Connerton et al. 2015, section 3 of this report). From 2010-14, an average of 58% of age-2 and age-3 Chinook salmon in Lake Ontario and Salmon River harvests were wild. The proportions of wild age-2 and age-3 Chinook salmon in other New York tributaries were lower (3.3% - 23.8%) 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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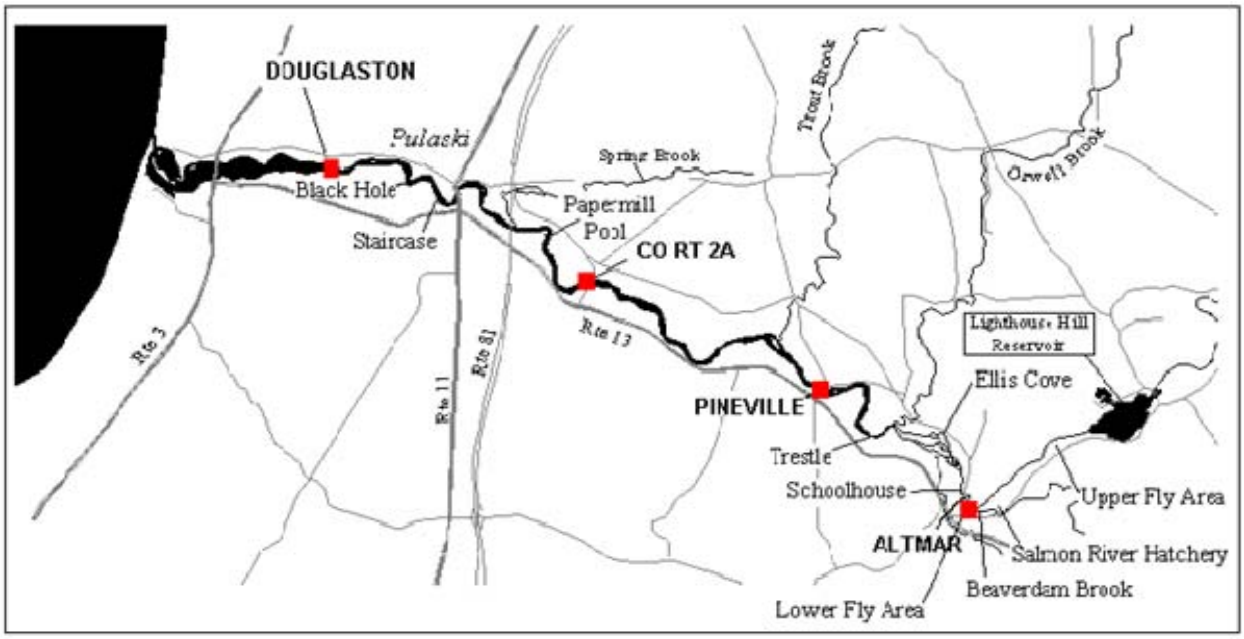


Figure 1. Sampling sites for the USGS/DEC Salmon River seining program.

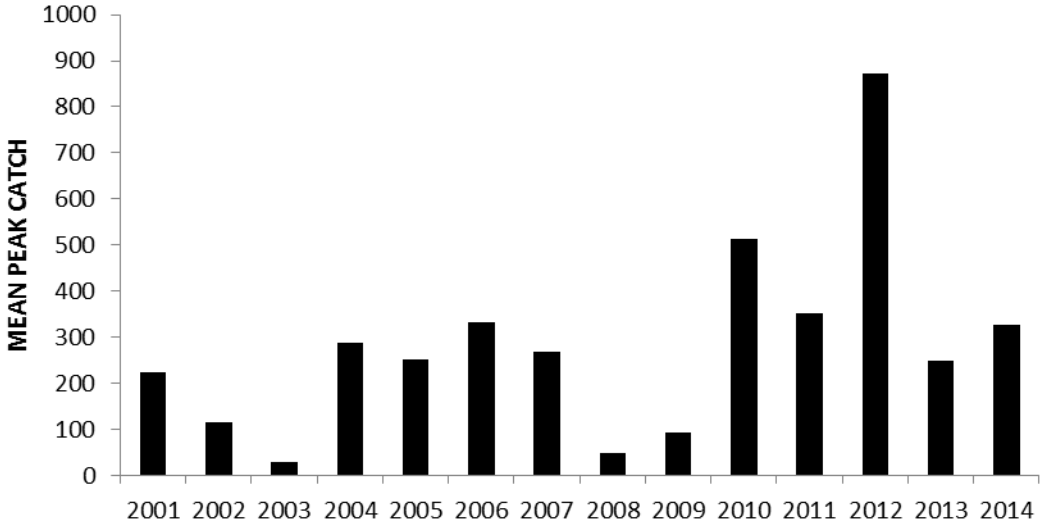


Figure 2. Mean peak catches of YOY Chinook salmon (mean number per seine haul) captured in the three consecutive weeks with the highest catches from the USGS/DEC Salmon River seining program 2001-2014.

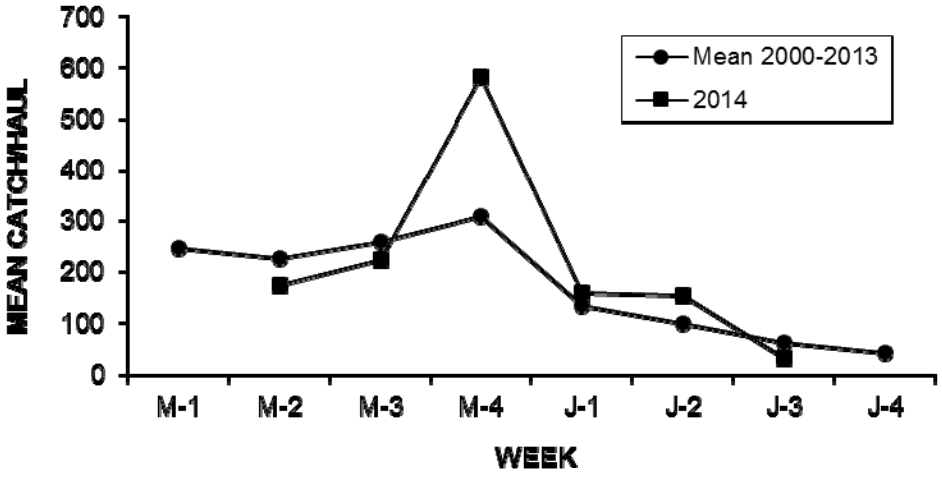


Figure 3. Mean numbers of YOY Chinook salmon captured per seine haul by week in the USGS/DEC Salmon River seining program for 2000-2013 and 2014 (M=May, J=June).

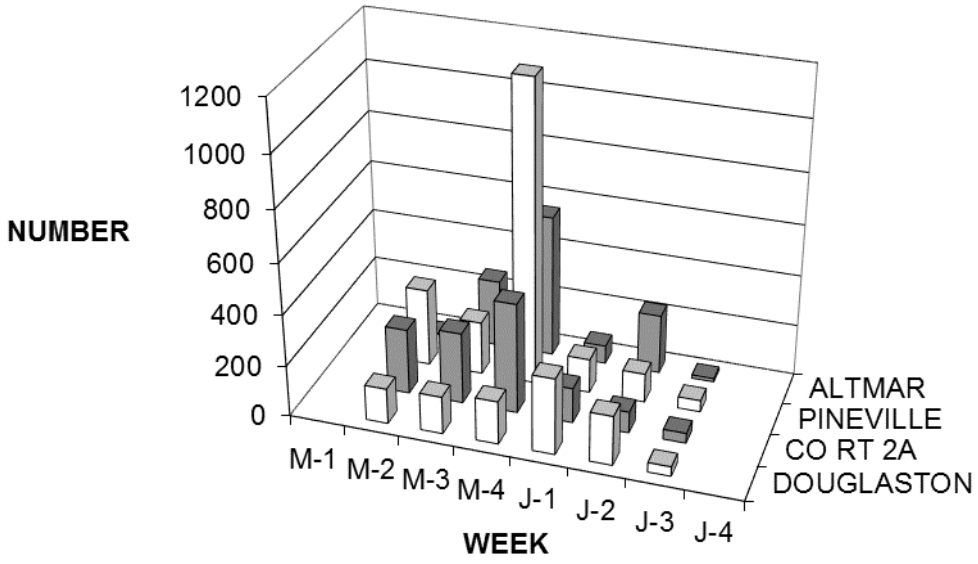
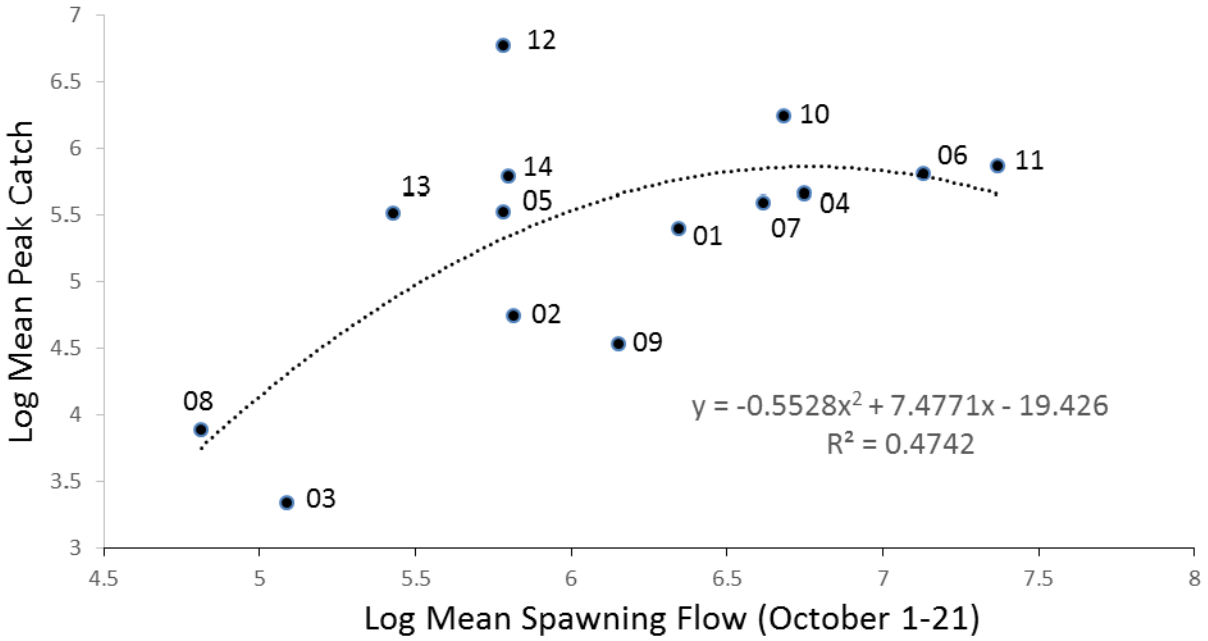


Figure 4. Numbers of YOY Chinook caught by week and site from the USGS/NYSDEC seining program 2014.



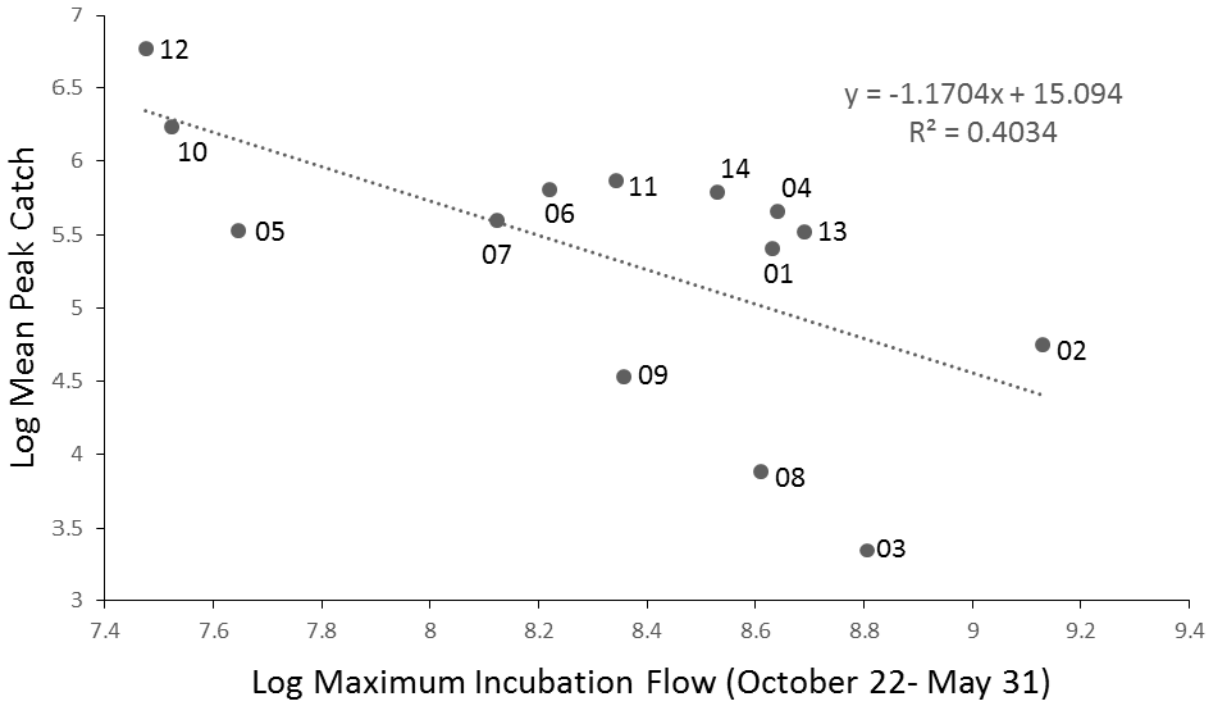


Figure 5. Mean spawning flows and maximum incubation flows predicting mean peak catches of YOY Chinook salmon from the USGS/NYSCEC seining program 2001-2014. Combining both flow factors in a single regression model yields (r^2 = 0.66 p = 0.01).

Population Characteristics of Pacific Salmonines Collected at the Salmon River Hatchery 2014

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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 3,367 steelhead during spring 2014 spawning operations (Nelson 2014). Adult Washington strain (Chamber's Creek) winter run fish comprised 94% (3,161) of the returns. Marked Skamania strain summer run fish (left pelvic) accounted for 206 fish. There were an additional 31 "jack" (yearling) steelhead that entered the hatchery, but were not processed.

A total of 2.0 million Washington strain steelhead eggs were taken from 695 females. The Skamania egg total was 185,000 from 81 females. Biological data were collected from 322 Washington strain steelhead.

Returns of Pacific salmon in fall 2014 included 2,899 Chinook salmon (907 females) and 3,542 coho salmon. Biological data were collected at the hatchery from 675 Chinook salmon and 256 coho salmon. The egg totals were 4.34 million Chinook salmon from 900 females and 1.51 million coho salmon from 566 females (Nelson 2014a).

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 2014 was very near the long term average (4.5 pounds; Figure 1, Table 1). Age 2 males were 0.3 pounds below average (13.1 lbs) with fish in eight years being significantly heavier. Females were 1.9 pounds below average (12.9 lbs), with only two years being significantly lighter (2004 and 2007) (Figure 2). Age 3 males were 2.0 lbs below average (17.2 lbs), significantly lighter than the results from 17 years. Age 3 females were 3.1 lbs less than the long term average (16.0 lbs) and 3.5 lbs lighter than 2013. Mean lengths and weights at age for all species sampled in 2014 appear in Table 1.

Wet weight condition of large Chinook was measured by predicting the weight of a 36 inch fish from linear regressions on natural log transformed lengths and weights. The predicted weight was 16.5 pounds in 2013 and 2014, which is also the historical average. This is the seventh consecutive year of at or above average condition, following six consecutive years of below average condition (Figure 3).

Relatively low weights of Chinook salmon in 2014 may have been influenced by reduced body condition and energy content of alewife, the primary prey for Chinook, in 2014. Alewife entered the winter of 2013/2014 in above-average body condition, however, relatively colder winter water temperatures appear to have contributed to reduced alewife body condition observed in the spring of 2014 (Walsh et al. 2015). Average body condition of alewife sampled in fall 2014 was also relatively low, suggesting that predators

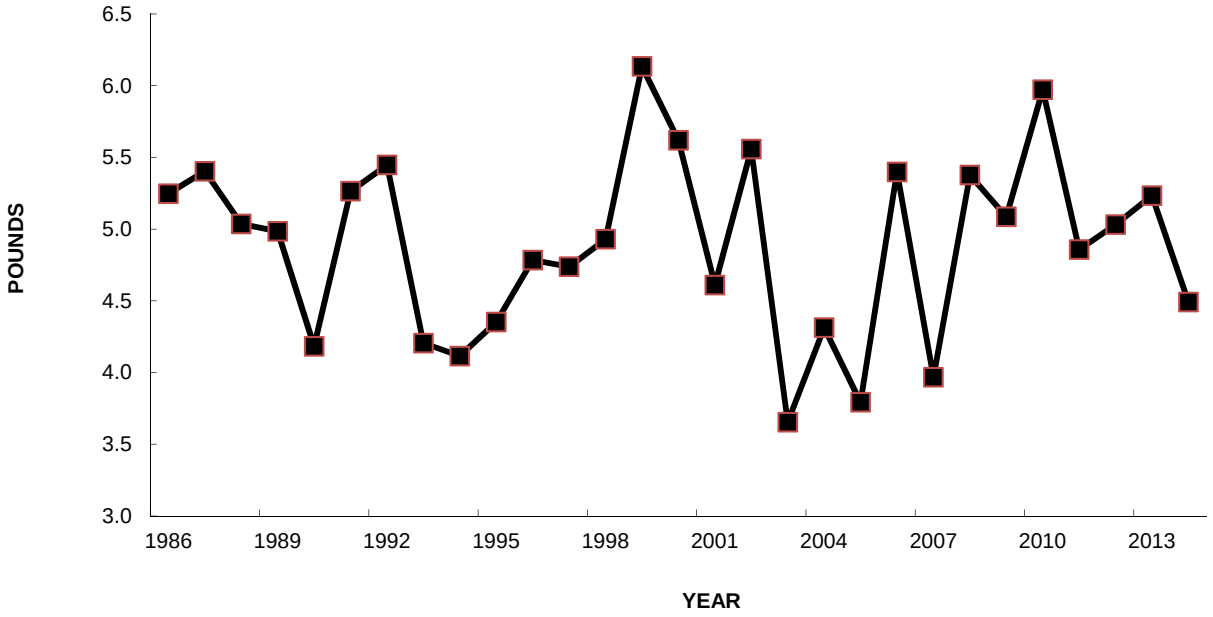

Figure 1. Mean weights of Chinook jacks at Salmon River Hatchery, 1986-2014.

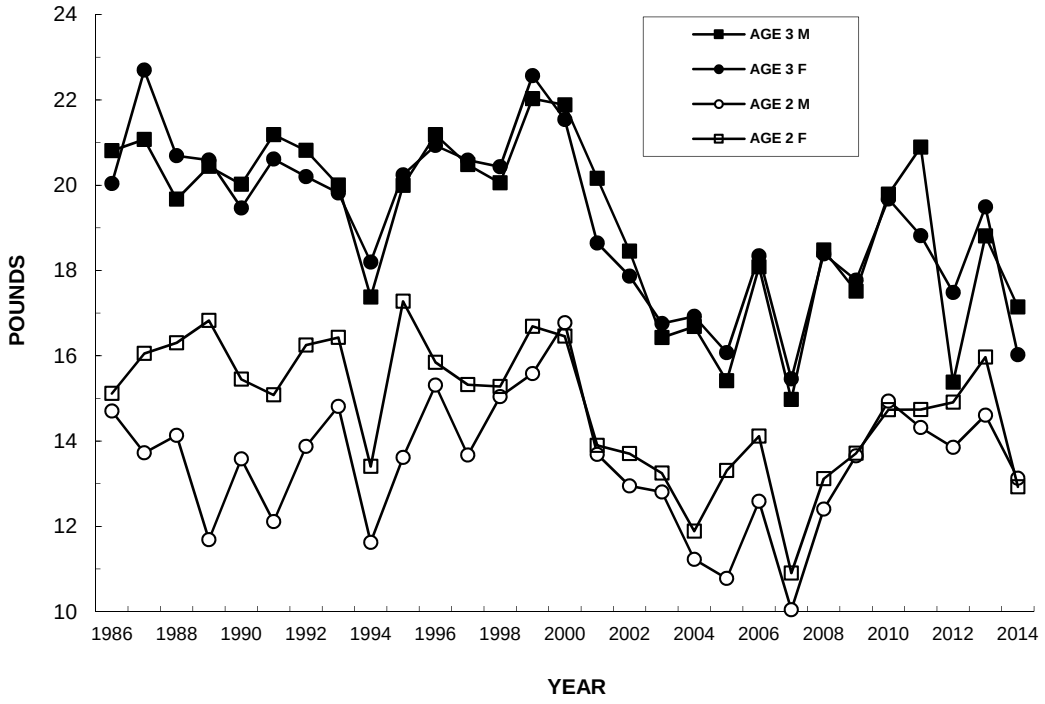

Figure 2. Mean weights of Chinook salmon ages 2-3 at Salmon River Hatchery, 1986-2014.

Table 1. Mean lengths and weights of Chinook salmon, coho salmon and Washington steelhead sampled at Salmon River Hatchery 2014 (STD= standard deviation).

AGE	SEX	N	MEAN LENGTH (in)	STD	MEAN WEIGHT (lbs)	STD
			CHINOOK SALMON			
1	M	61	22.9	1.5	4.5	0.9
2	M	233	33.5	2.0	13.1	2.6
2	F	151	32.4	1.5	12.9	2.0
3	M	82	37.0	2.8	17.2	3.9
3	F	130	34.8	2.5	16.0	3.4
			COHO SALMON			
1	M	6	19.2	1.9	2.6	0.8
2	M	149	27.7	2.7	7.3	2.1
2	F	100	27.0	2.0	7.2	1.6
			WASHINGTON STEELHEAD			
3	M	114	25.6	2.0	6.0	1.6
3	F	98	25.9	2.2	6.5	1.9
4	M	30	28.9	2.6	8.6	2.0
4	F	60	29.0	2.0	9.0	1.8
5	M	2	32.1	0.3	10.9	.04
5	F	7	29.3	1.3	9.4	1.7

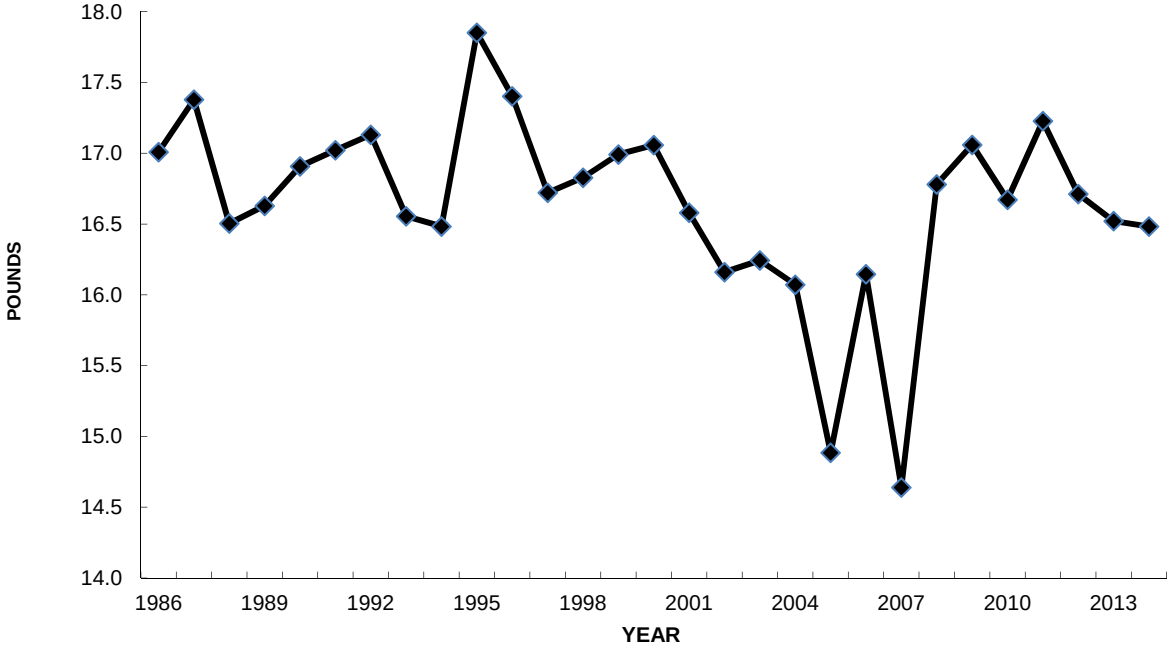

Figure 3. Estimated weights of a 36-inch Chinook salmon from the Salmon River Hatchery fall (October) collections 1986-2014.

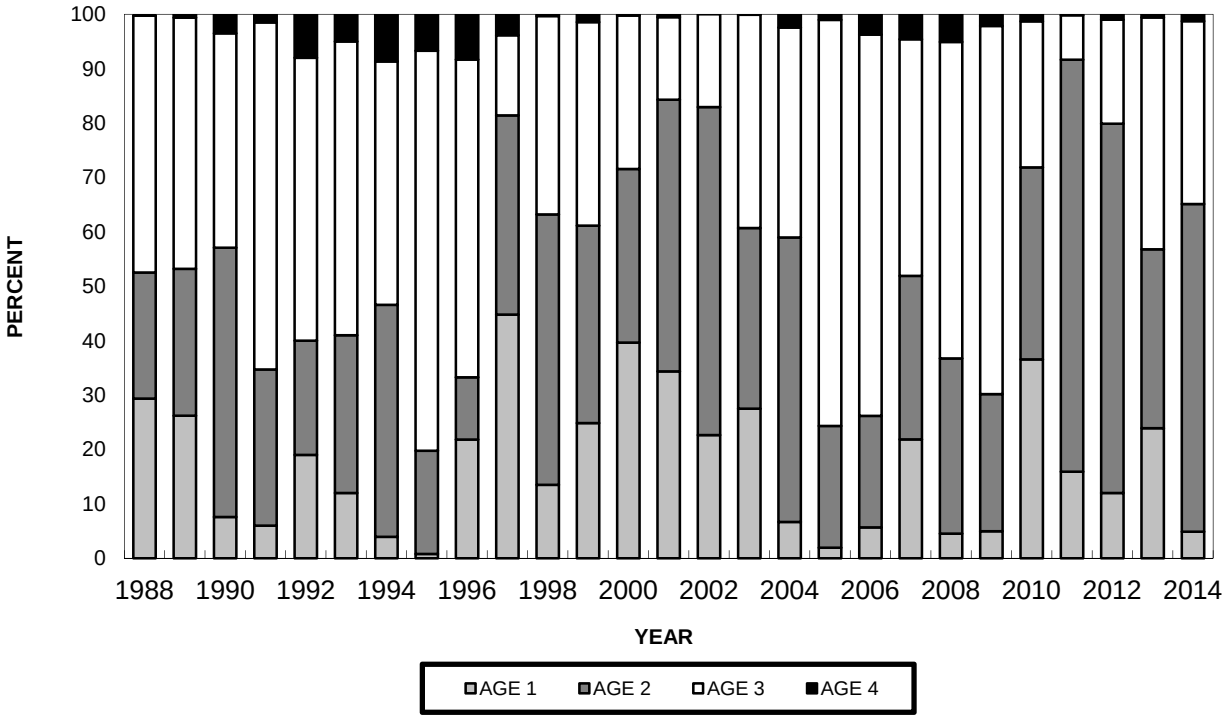

Figure 4. Estimated age structures of Chinook salmon runs at Salmon River Hatchery 1989-2014.

feeding on alewife during the summer of 2014 received relatively smaller energy benefits than in recent years. Relatively colder water temperatures in 2014 also may have directly impacted Chinook growth.

Age Structure

The estimated age structure of the 2014 Chinook salmon run to the Salmon River Hatchery was 5% age-1 males, 60% age-2, 33% age-3, and 1% age-4 (Figure 4). These are typical results, following the pattern of either age-2 or age-3 fish comprising the majority of the run in a given year.

Coho Salmon

Growth

The average weight of age-2 female coho salmon in 2014 (7.2 pounds) was approximately 1.3 pounds less than the long term average (8.5 lbs, Figure 5). Age-2 males (7.3 pounds) weighed 1.0 pounds less than the long term average (8.3 lbs., Figure 5). While males were smaller than average they were not significantly different from those sampled in 20 of the 30 years in the time series, including 2011-2013. While female coho were second smallest in the time series (only 1990 was lower) they were not significantly different from fish sampled in 18 of 30 years, including 2011-2013.

Washington Steelhead

Growth

Steelhead are sampled in the spring and, unlike Chinook and coho salmon, do not reflect growth during the 2014 growing season. Weights reported here reflect conditions prior to and including 2013. The mean weights of age-3 males and females were 6.0 and 6.5 lbs, respectively; nearly the same as in 2013 (approximately 0.2 and 0.3 pound more than their respective long-term averages) (Figure 6). The mean weights of age-4 males and females were 8.6 lbs and 8.9 lbs, respectively, with males 0.2 lbs and females 0.3 lbs lighter than their long-term averages. The females increased 1.2 lbs from 2013. Only age-3 females in 2001 (8.7 lbs.) were significantly heavier than those in 2014. Age 3 males weighed significantly more than in nine years, but significantly less than those in three years. Age 4 males were not significantly heavier than any of the years, but

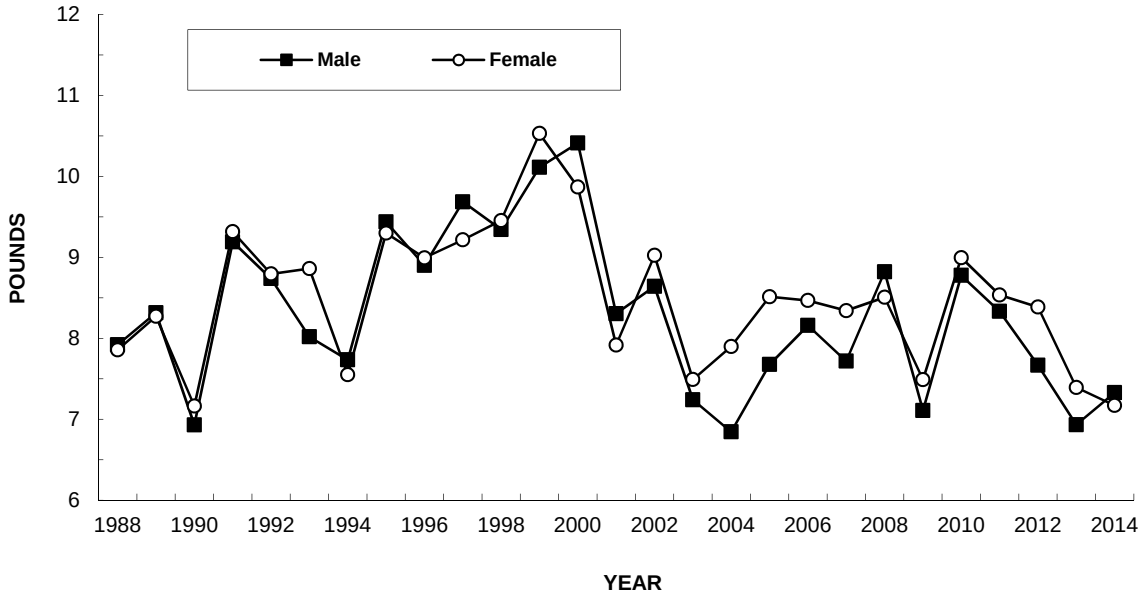

Figure 5. Mean weights of age-2 coho salmon at Salmon River Hatchery, 1988-2014.

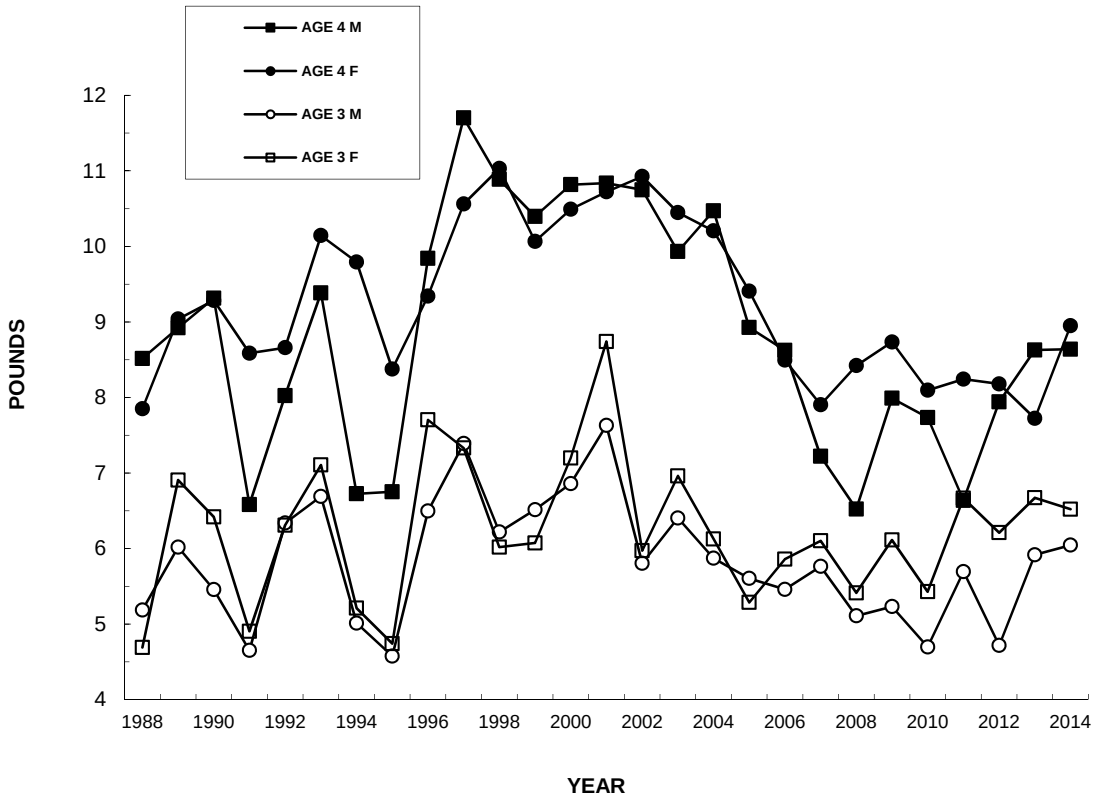

Figure 6. Mean weights of Washington steelhead ages 3-4 at Salmon River Hatchery, 1988-2014.

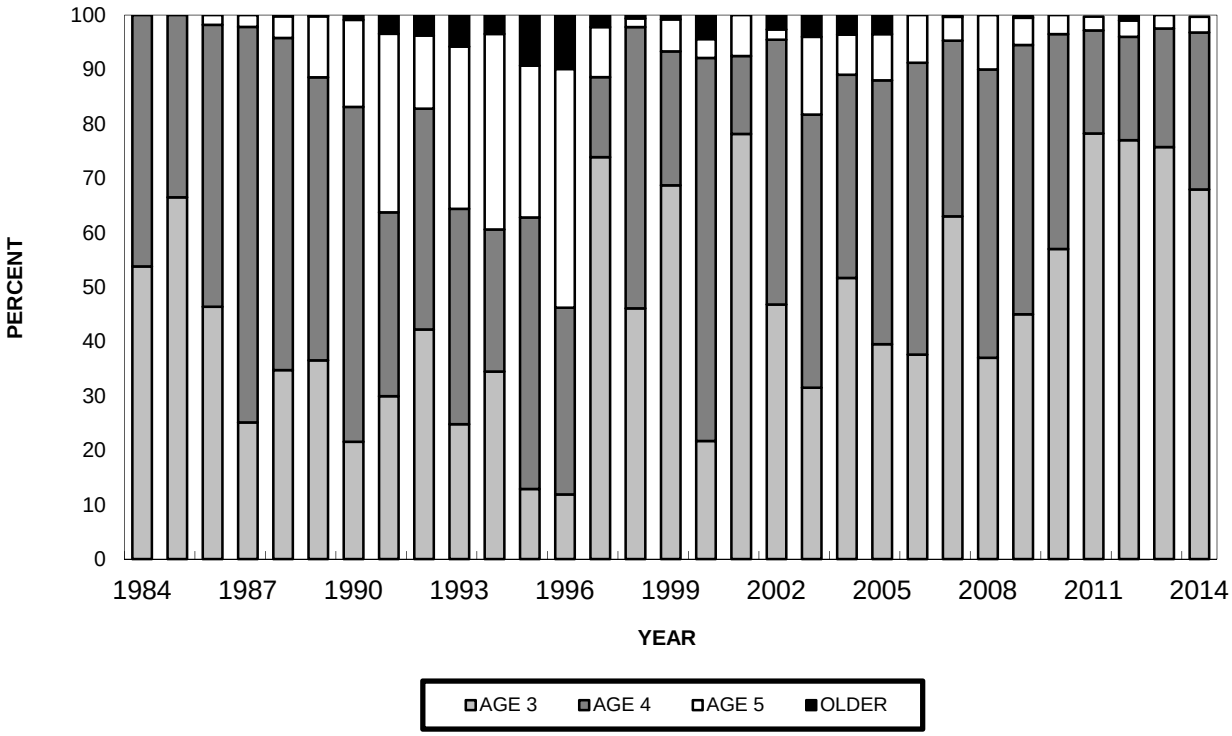

Figure 7. Age structures of Washington steelhead samples at Salmon River Hatchery, 1989-2014.

only 1997 fish weighed significantly more. Age 4 female weight fell in the middle of the time series range, and was not significantly different than 15 of the 25 years.

Age Structure

Similar to age structures observed in recent years, age-3 and age-4 steelhead dominated the run again in 2014 (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 fish sampled was 68% age-3, 29% age-4, and 2.9% age-5.

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2014 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.

This report summarizes pen-rearing activities and results for 2014, the seventeenth year of pen projects along the New York shoreline of Lake Ontario.

Methods

Pen rearing was conducted at ten sites along New York's coastline of Lake Ontario in 2014. 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 2014 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. 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. Since 2013 was the final year of the study, Chinook salmon were not marked or tagged in 2014.

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 60,400 steelhead (58,300 Washington strain and 2,100 Skamania strain) were raised at eight pen sites, comprising 8% of DEC's Lake Ontario steelhead stocking allotment in 2014. (Table 3). Observed mortalities were relatively low at most steelhead pen sites, ranging from 0.15 to 0.95%. Results for all steelhead pen projects are summarized in Table 3.

Seven pen-rearing sites raised a total of 505,990 Chinook salmon fingerlings, representing 29% of NYSDEC's 2014 Chinook salmon stocking allotment. At sites where salmon were penned, observed mortalities were also low ranging from 0.004 to 0.12%. Results for all Chinook salmon pen projects are provided in Table 3.

At the Olcott, Sandy Creek, and Little Salmon River pen sites, water temperatures approached the 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

Skamania strain steelhead for the Little Salmon River project were placed in a pen on 24 April at 25 fish per lb. The steelhead were released 22 days later on 15 May at a weight of 20 fish per lb. Twenty 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 23 April, weighing 120 fish per lb. Salmon were released on 13 May after 21 days at a weight of 91 per lb. Eighteen mortalities were observed.

Little Sodus Bay

At Little Sodus Bay**,** steelhead weighing 25 fish per lb. were delivered to pens on 24 April. Steelhead were released on 13 May weighing 18 fish per lb. Pens were towed to the bay outlet for fish release. Only 9 mortalities were observed.

Chinook salmon were also delivered to the pen site on 24 April. Salmon weighed 125 fish per lb when delivered and weighed 84 fish per lb when released on 13 May. Salmon pens were towed to the bay outlet for fish release. Only 4 mortalities were observed.

Sodus Bay

Low water levels in spring 2013 necessitated adjusting the pens' location to deeper water within Arney's Marina. The same location was used in 2014. Chinook salmon were placed into pens on 22 April and grew from 120 to 79 fish per lb after 24 days. Average length of released salmon was 3.4 in. Sixty mortalities were recorded. The salmon were released on 15 May at a water temperature of 58°F.

Genesee River

Steelhead were placed into pens on 14 April and held for 20 days. They were released on 3 May weighing 17 fish per lb, compared to a delivery weight of 25 fish per lb. Fifty mortalities were observed.

Chinook salmon were delivered to Shumway Marina at a weight of 120 fish per lb on 14 April. They were held in pens for 24 days and released on 7 May weighing 82 fish per lb. One hundred twelve mortalities were observed.

Sandy Creek
Steelhead were delivered at a weight of 25 fish per lb on 16 April. They were held in the pen for 22 days and released on 7 May weighing 17 fish per lb. Fifty one steelhead mortalities were observed.

Chinook salmon were also delivered on 16 April at a weight of 130 fish per lb. They were held in the pen for 22 days and released on 7 May weighing 72 fish per lb. Chinooks averaged 3.4 in. in length at release. Twenty nine Chinook salmon mortalities were observed. Water temperature at release was 62°F.

Oak Orchard Creek
Steelhead were delivered at a weight of 25 fish per lb on 15 April. They were held for 23 days and released on 7 May weighing 19 fish per lb with an average total length of 5.3 in. Fifty-three mortalities were observed.

Chinook salmon were delivered at a weight of 125 fish per lb on 15 April. They were held for 23 days and released on 7 May weighing 82 fish per lb with an average total length of 3.2 in. Salmon and steelhead pens were towed to the lake to release fish. Water temperature was 60°F on the release date. One hundred twenty six mortalities were observed.

Olcott Harbor
Steelhead were delivered at a weight of 25 fish per lb. on 22 April. They were held for 21 days and released on 12 May weighing 17 fish per lb. Fish were released at the pen site, and water temperature was approximately 63°F at release time. Only 10 mortalities were observed.

Chinook salmon were delivered at a weight of 120 fish per lb. on 22 April. They were held for 22 days and released on 13 May weighing 69 fish per lb. Water temperature was at the release threshold of 65°F at release. Eighty-one mortalities were observed.

Wilson Harbor
Steelhead were delivered at a weight of 30 fish per lb on 18 April. They were held in the pen for 21 days and released on 8 May weighing 14 fish per lb. Water temperature at release was 53°F. Mortalities were not recorded.

Lower Niagara River
The lower Niagara River pen site is typically last to receive fish due to slowly warming water temperatures. In 2014, 10,000 steelhead were delivered into a single, large pen on 12 May, weighing about 25 fish per lb. Steelhead were released 24 days later on 4 June at the pen site, weighing 12 fish per lb. Approximately 17 steelhead mortalities were observed.

Chinook salmon were loaded into a single, large pen also on 12 May, and weighed 104 fish per lb on delivery. Salmon were released 24 days later on 4 June weighing 61 fish per lb. Water temperatures were not routinely monitored at the lower Niagara River pen site, however, water temperature was approximately 61°F when the steelhead and Chinook salmon were released. Seventeen steelhead and only 3 Chinook salmon mortalities were observed.

Conclusions

Of the eight locations where steelhead were penned, target weights (12-15 fish per lb) were reached at only two (Lower Niagara River and Wilson) sites in 2014. Results at other sites ranged from 20 – 17 per lb.

Chinook target weights (90 fish per lb) were exceeded at seven sites, and approximated at Oswego (91 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 seventeenth 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 2014 Lake Ontario pen project locations and sponsors.

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

Table 2. Methods used at 2014 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	Hydraulic transfer	6	5	once/day	Pens towed to mouth of creek; cable ties cut to release fish.
Oak Orchard Creek	Hydraulic transfer	5	2	every five days	Pens towed to lake; cable ties cut to release fish
Olcott Harbor	Hydraulic transfer	5	5	weekly	Fish released at pen site
Lower Niagara River	Hydraulic transfer	5	0	twice	Fish released at pen site
Wilson	Hydraulic transfer	5	0	not noted	Fish released at pen site

Table 3. Results of 2014 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	14 Apr	120	7 May (24)	82	112	0.13
Little Sodus	Chinook	25,000	1	24 Apr	125	13 May (20)	84	4	0.016
Lower Niagara	Chinook	75,000	1	12 May	104	4 Jun (24)	61	3	0.004
Oak Orchard	Chinook	106,750	5	15 Apr	125	7 May (23)	82	126	0.12
Olcott	Chinook	67,100	3	22 Apr	120	13 May (22)	69	81	0.12
Oswego	Chinook	41,890	2	23 Apr	120	13 May (21)	91	18	0.04
Sandy Creek	Chinook	55,000	2	16 Apr	130	7 May (22)	72	29	0.05
Sodus	Chinook	50,000	2	22 Apr	120	15 May (24)	79	60	0.12
Genesee	steelhead	10,000	2	14 Apr	25	3 May (20)	17	50	0.5
Little Salmon	steelhead	2,100	1	24 Apr	25	15 May (22)	20	20	0.95
Little Sodus	steelhead	6,000	1	24 Apr	25	13 May (20)	18	9	0.15
Lower Niagara	steelhead	10,000	1	12 May	25	4 Jun (24)	12	17	0.17
Oak Orchard	steelhead	14,000	3	15 Apr	25	7 May (23)	19	53	0.38
Olcott	steelhead	3,500	1	22 Apr	25	12 May (21)	17	10	0.29
Sandy Creek	steelhead	7,300	1	16 Apr	25	7 May (22)	17	51	0.70
Wilson	steelhead	7,500	2	18 Apr	30	8 May (21)	14	na	-

na not available

Sea Lamprey Control in Lake Ontario 2014

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Introduction

This report outlines the actions undertaken during 2014 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 target for Lake Ontario Sea Lamprey abundance was first calculated using the same marking statistics as the other lakes (A1-A3 marks). During 2006, the target and range were revised using A1 marks exclusively, which have been more consistently recorded on Lake Ontario. Also, the target marking rate of less than 2 A1 marks per 100 Lake Trout was explicitly identified as producing tolerable mortality in the Lake Trout rehabilitation plan. The target and range of adult Sea Lamprey for Lake Ontario was calculated from the average abundance estimated for the 5-year period, 1993-1997, when marking rates were closest to 2 marks per 100 Lake Trout >431 mm (1.6 A1 marks per fish >431 mm). The calculated target adult abundance in Lake Ontario is 31,433 ± 3,962 Sea Lampreys.

The performance of the SLCP is annually evaluated by contrasting adult Sea Lamprey abundance with the Lake Trout marking rates against these targets. Lake-wide adult abundance is estimated by the Service and Department using a combination of mark-recapture and trapping efficiency estimates of adults in streams with traps, and regression model-predicted estimates in streams without traps. Lake Trout marking rates are assessed and collected by the member agencies that comprise the lake committees and their technical committees.

During 2014, adult Sea Lamprey abundance in Lake Ontario was estimated to be 19,482 (95% CI; 16,880-24,032), which was lower than the fish-community objective target range and the lowest in the time series. The number of A1 marks on Lake Trout from standardized fall assessments in 2014 has not yet been analyzed.

Lampricide Control

Tributaries harboring larval Sea Lampreys are treated periodically with lampricides to eliminate or reduce larval populations before they recruit to the lake as feeding juveniles. Service and Department 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 areas. Specialized equipment and techniques are employed to provide concentrations of lampricides that eliminate about 95% of the Sea Lamprey larvae while minimizing the risk to non-target organisms.

Lake Ontario has 659 tributaries (405 Canada, 254 U.S.). Sixty-six tributaries (31 Canada, 35 U.S.) have historical records of larval Sea Lamprey production, and of these, 36 tributaries (16 Canada, 20 U.S.) have been treated with lampricides at least once during 2005-2014. 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 2014 are found in Table 1 and Figure 1.

- Lampricide applications were conducted in 10 streams (4 Canada, 6 U.S.).
- Credit River was added to the treatment list after larval surveys in 2014 confirmed it was necessary.
- Trout Brook (Salmon River tributary, NY) was treated further upstream from the historical upper distribution of larvae.
- Orwell Brook (Salmon River tributary, NY) was treated upstream of the barrier for the second time since 2012 to target a residual population established prior to construction. This stream will not be treated again in 2015, as larval surveys did not indicate the presence of residual larvae or recruitment above the barrier.

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 2014, 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 are compatible with a system's watershed plan; and
   d. are compatible with a system's watershed plan.

Table 1. Details on the application of lampricides to tributaries of Lake Ontario during 2014 (letter in parentheses corresponds to location of stream in Figure 1).

Tributary	Date	Discharge (m^3/s)	Distance Treated (km)	Liquid TFM (kg)[1]	Solid TFM (kg)[1]	Wettable Powder Bayluscide (kg)[1]	Emulsifiable Concentrate Bayluscide (kg)[1]	Granular Bayluscide (kg)[1]
Canada								
Credit R. (A)	19-Jun	9.7	41	1764.1	---	---	23.6	0.9
Bowmanville Cr. (B)	23-May	2.6	19.7	733.3	---	---	---	---
Grafton Cr. (C)	25-May	0.4	0.3	81.1	---	---	---	---
Colborne Cr. (D)	25-May	0.8	0.9	180.1	---	---	---	---
Total (Canada)		**13.5**	**61.9**	**2758.6**	---	---	**23.6**	**0.9**
United States								
Lindsey Cr. (E)	26-May	0.5	10.4	75.4	0.2	---	---	---
Salmon R. (F)	1-May	27.4	59.8	1976.6	2.3	---	---	0.1
Little Salmon R. (G)	30-May	1.44	38.8	242.8	2.5	---	---	0.1
Ninemile Cr. (H)	23-May	0.9	26.1	226.3	4.2	---	---	---
Sandy Cr. (I)	28-Apr	3.1	27.8	1049.3	---	---	---	0.1
Oak Orchard R. (J) Marsh Cr.	27-Apr	1.24	10.4	316.3	---	---	---	0.1
Total (United States)		**34.6**	**173.3**	**3886.7**	**9.2**	---	---	**0.4**
Total for Lake		**48.1**	**235.2**	**6645.3**	**9.2**	---	**23.6**	**1.3**

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

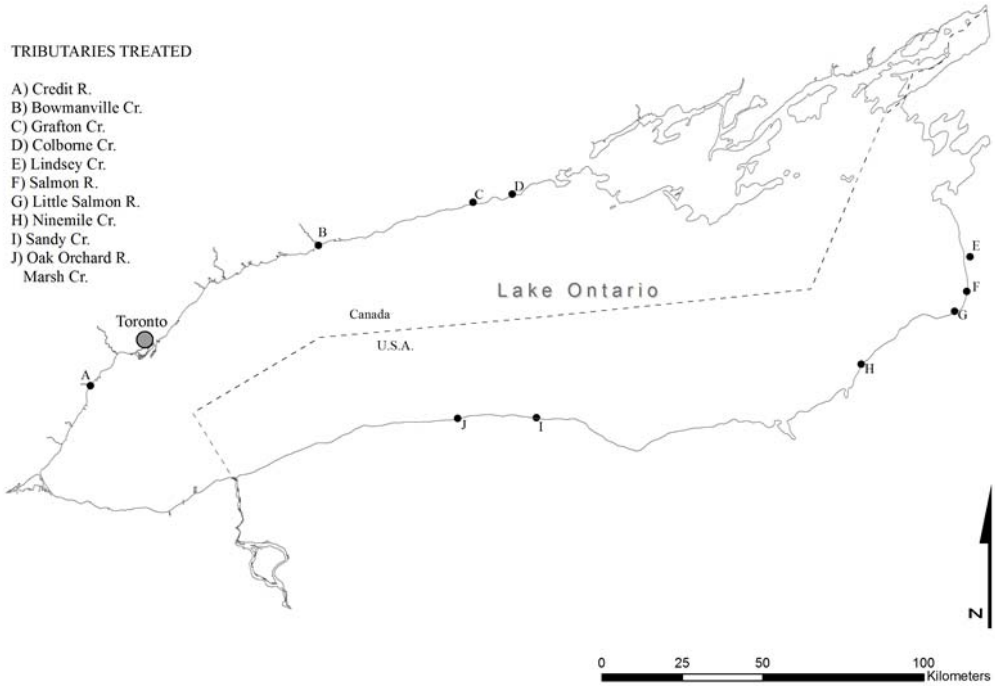

***Figure 1. Location of Lake Ontario Tributaries treated with lampricides (corresponding letters in Table 1) during 2014.**

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

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

Barrier Inventory and Project Selection System

- Field crews visited 73 structures on tributaries to Lake Ontario to assess Sea Lamprey blocking potential and to improve the information in the BIPSS.

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 barriers:
  - Graham Creek – The water intake box and 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

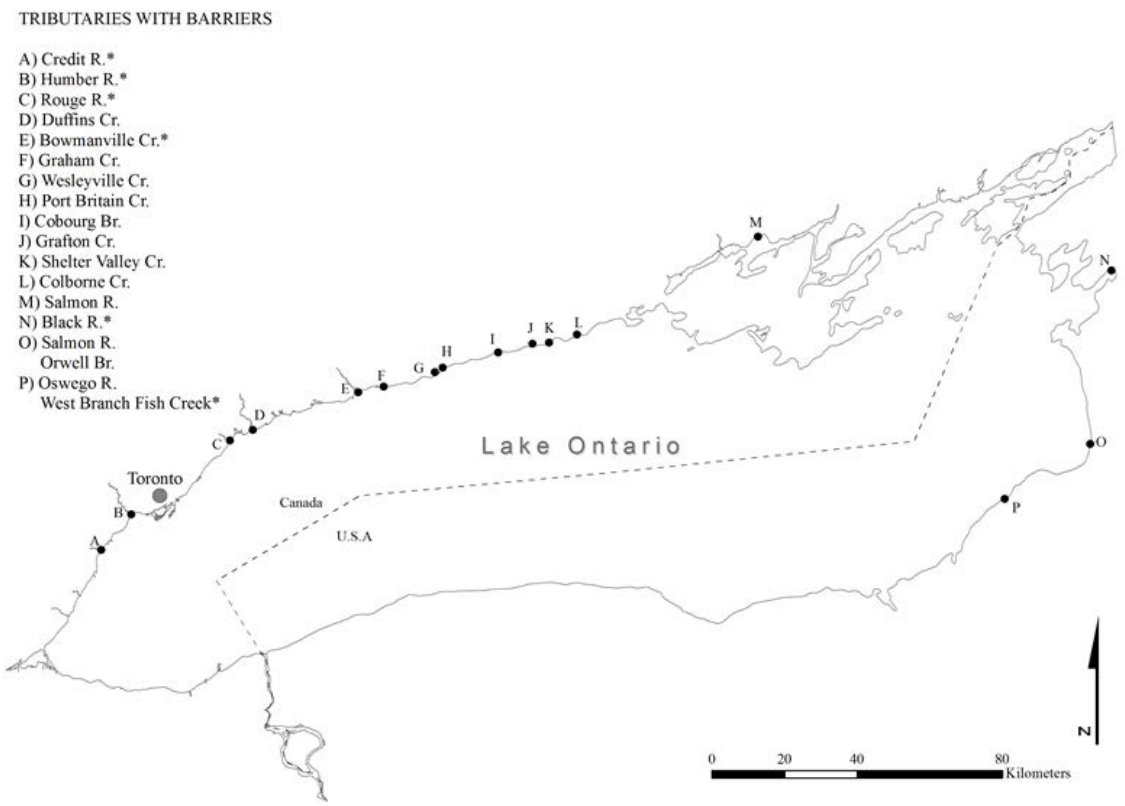

Figure 2. Location of Lake Ontario tributaries with Sea Lamprey barriers. Structures that were not constructed by the Commission, but have been modified to prevent the upstream migration of Sea Lampreys are indicated by an asterisk (*).

intake screen have only been partially successful. The situation will be monitored during the 2015 Sea Lamprey migration, and if performance continues to be compromised, a self-cleaning Johnson Screen will be installed in the fishway.

Ensure Blockage to Sea Lamprey Migration

- Duffins Creek – An investigation is underway to improve safety around the barrier while restoring its Sea Lamprey control function.
- Credit River – Two aluminum stop logs were fabricated and delivered to the Ontario Ministry of Natural Resources and Forestry (OMNRF), who installed them in the fishway to ensure the blockage of Sea Lampreys. In addition, OMNRF staff identified potential routes of escapement through holes in the main crest of the dam, which were subsequently sealed in the fall of 2014.
- Bowmanville Creek – The retrofit of the lamprey trap associated with the new fishway in Bowmanville Creek was completed and operational for the 2014 season. To monitor the Sea Lamprey control function of the new fishway, a data logger was installed to collect flow information.
- Ganaraska River – A stop log was provided to the Ganaraska Region Conservation Authority to prevent Sea Lamprey escapement through the fishway. The original upper stop log was washed away during a spring flood in 2013.
- No consultations to ensure blockage at barriers were completed with partner agencies during 2014.

New Construction

- No new construction projects were initiated or underway.

Assessment of Candidate Streams

- No assessments were conducted.

Assessment

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

1. Larval Assessment determines the relative abundance and distribution of sea lamprey larvae in streams and lentic areas. These data are used to predict where larvae greater than 100 mm total length will most likely be found by the end of the growing season during the year of sampling. These predictions are used to prioritize lampricide treatments for the following year.
2. Juvenile Assessment evaluates the lake-specific rate of lake trout marking inflicted by sea lamprey. These time series data are used in conjunction with adult assessment data to assess the effectiveness of the SLCP for each lake. In addition, several indices of relative abundance of feeding juveniles are used in some lakes to monitor sea lamprey populations over time.
3. Adult Assessment annually estimates the stock size of adult sea lampreys in each lake. Because this life stage is comprised of individuals that have either survived or avoided exposure to lampricides, the time series of adult abundance is the primary metric used to evaluate the effectiveness of the SLCP.

Larval Assessment

Tributaries considered for lampricide treatment during 2015 were assessed during 2014 to define the distribution and estimate the density and size structure of larval Sea Lamprey populations. Assessments were conducted with backpack electrofishers in waters <0.8 m deep, while waters ≥0.8 m in depth were surveyed with GB. Survey sites were randomly selected in each tributary, larval Sea Lamprey catches were adjusted for gear efficiency, and lamprey lengths were forecast to the estimated end of the growing season. The number of large larval Sea Lampreys in each infested area was estimated by multiplying the mean density of larvae ≥100 mm (number per m^2) by an estimated area of suitable habitat (m^2). Infested areas were ranked for treatment during 2015 based on the lowest cost per kill of larval Sea Lampreys ≥100 mm, as estimated using this index of abundance and average treatment costs. Additional surveys are used to define the distribution of Sea Lampreys within a stream, detect new populations, evaluate lampricide treatments, and to establish the sites for lampricide application.

- Larval assessments were conducted on a total of 49 tributaries (27 Canada, 22 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 nine tributaries (five Canada, four U.S.).
- Surveys to detect the presence of new larval Sea Lamprey populations were conducted in seven Canadian tributaries. No new populations were detected.
- Post-treatment assessments were conducted in 10 tributaries (4 Canada, 6 U.S.) to determine the effectiveness of lampricide treatments conducted during 2013 and 2014.
- Surveys to evaluate barrier effectiveness in 10 tributaries (8 Canada, 2 U.S.) revealed no evidence of escapement.
- An evaluation of production potential was conducted on the Humber River in Ontario, Canada. The purpose of this work was to evaluate the production potential for Sea Lamprey upstream from critical barriers by quantitatively assessing habitat and native lamprey populations as a surrogate for Sea Lampreys. Results from the evaluation are pending.
- A total of 1.7 ha of the Niagara River was surveyed with GB. Four larval Sea Lampreys were collected.
- Surveys were conducted in non-wadable lentic and lotic areas using 24.92 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 metric of the mortality inflicted on Lake Trout on a lake-wide basis.

Beginning in 2007, the Commission contracted with the Service's Green Bay Fish and Wildlife Conservation Office (GBFWCO) to calculate marking statistics and Lake Trout abundance and to evaluate and describe the consistency of indices used to understand the damage caused by Sea Lampreys. In the fall of 2010, the Commission and GBFWCO began a process to create an updated database that consolidates the most recent fisheries data to create the metrics used to assess Sea Lamprey impacts across the lakes. Data from survey and commercial sampling has been submitted from over 25 organizations and work is underway to continue to standardize the multiple data-sets into cohesive lake-wide databases. Included in these submissions is information pertaining to marking on other fish species that has recently become an area of concern and will be evaluated in the future. The most recent results of this effort related to Lake Trout are presented in Figures 3-5 and were calculated from un-weighted data for the whole lake (average number of marks calculated from all Lake Trout captured of a specific length range during a specific time period). The reason for the refresh of data sources was that calculation methods and the extent of data that were used to produce the previously used plots of marking rates were not consistent between the most recent graphs presented here and those presented in previous reports. Work continues to evaluate a number of ways to present the data, including weighting data based on characteristics of the individual lake units and possible separation of distinct regions within a lake, among other ideas. With this further analysis, it is hoped that a better understanding of Sea Lamprey impacts on the fish communities in the lakes and how they affect each other will be developed.

- Lake Trout marking data for Lake Ontario are provided by the U.S. Geological Survey, OMNRF, 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 2014 has not yet been analyzed as they are submitted in February of the following year (2015).
- Based on standardized fall assessment data, the marking rate during 2013 was 2.2 A1 marks per 100 Lake Trout >431 mm. The current marking rate is very close to target and has been since 2009 (Figure 3).

Table 2. Status of larval Sea Lampreys in Lake Ontario tributaries with a history of Sea Lamprey production and estimates of abundance from tributaries surveyed during 2014.

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	Aug-13	No	Yes	---	---	Unknown
Grindstone Cr.	Never	Jun-14	No	Yes	---	---	Unknown
Bronte Cr.	Jun-13	Aug-13	Yes	Yes	---	---	2016
Sixteen Mile Cr.	Jun-82	Jul-14	No	No	---	---	Unknown
Credit R.	Jun-14	Jun-14	No	No	---	---	2017
Humber R.	Never	Jun-14	---	No	---	---	Unknown
Rouge R.	Jun-11	Jul-14	No	Yes	2,245	1,313	***2015***
Petticoat Cr.	Sep-04	Jul-14	No	No	---	---	Unknown
Duffins Cr.	May-12	Jul-14	No	Yes	---	---	***2015[1]***
Carruthers Cr.	Sep-76	Jul-13	No	No	---	---	Unknown
Lynde Cr.	May-12	Jul-14	No	Yes	---	---	***2015[1]***
Oshawa Cr.	May-12	Jul-14	No	Yes	---	---	***2015[1]***
Farewell Cr.	Jun-12	Jul-14	No	Yes	---	---	***2015[1]***
Bowmanville Cr.	May-14	Jul-14	No	No	---	---	2017
Wilmot Cr.	May-12	Jul-14	No	Yes	---	---	***2015[1]***
Graham Cr.	May-96	Jul-13	No	No	---	---	Unknown
Wesleyville Cr.	Oct-02	Jul-14	No	No	---	---	Unknown
Port Britain Cr.	Apr-12	Jul-14	No	Yes	---	---	2016
Gage Cr.	May-71	Jul-13	No	No	---	---	Unknown
Cobourg Br.	Oct-96	Aug-13	No	No	---	---	Unknown
Covert Cr.	Jun-13	Sep-13	Yes	Yes	---	---	2016
Grafton Cr.	May-14	Jul-14	No	No	---	---	Unknown
Shelter Valley Cr.	Sep-03	Jul-13	No	No	---	---	Unknown
Colborne Cr.	May-14	Jul-14	No	No	---	---	Unknown
Salem Cr.	Apr-12	Jul-14	No	Yes	---	---	***2015[1]***
Proctor Cr.	Apr-12	Jul-14	No	Yes	---	---	***2015***
Smithfield Cr.	Sep-86	Jun-12	No	No	---	---	Unknown
Trent R. (Canal System)	Sep-11	May-14	No	Yes	---	---	Unknown
Mayhew Cr.	Apr-12	May-14	No	Yes	---	---	***2015[1]***
Moira R.	Jun-11	Jun-14	No	Yes	---	---	Unknown
Salmon R.	Jun-00	Jun-14	No	Yes	---	---	Unknown
Napanee R.	Never	Jul-13	---	No	---	---	Unknown

Table 2. *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
United States							
Black R.	Aug-12	Aug-14	No	Yes	---	---	***2015***[1]
Stony Cr.	Sep-82	Aug-14	No	No	---	---	Unknown
Sandy Cr.	Never	Aug-14	---	No	---	---	Unknown
South Sandy Cr.	Apr-13	Jul-13	No	Yes	---	---	2016
Skinner Cr.	Apr-05	Jul-13	No	No	---	---	Unknown
Lindsey Cr.	Jun-14	Aug-14	Yes	No	---	---	2017
Blind Cr.	May-76	Aug-14	No	No	---	---	Unknown
Little Sandy Cr.	May-13	Aug-13	No	Yes	---	---	2016
Deer Cr.	Apr-04	Aug-14	No	No	---	---	Unknown
Salmon R.	May-14	Aug-14	Yes	Yes	---	---	2017
Orwell Brook	May-14	Aug-14	Yes	No	---	---	2017
Trout Brook	May-14	Aug-14	Yes	Yes	---	---	2017
Grindstone Cr.	Apr-13	Aug-13	Yes	Yes	---	---	2016
Snake Cr.	Aug-14	Aug-12	No	Yes	---	---	***2015***[1]
Sage Cr.	May-78	Jul-13	No	No	---	---	Unknown
Little Salmon R.	Apr-12	Aug-14	No	Yes	---	---	Unknown
Butterfly Cr.	May-72	Apr-12	No	No	---	---	Unknown
Catfish Cr.	Apr-12	Aug-14	No	Yes	---	---	***2015***[1]
Oswego R.							
Black Cr.	May-81	Aug-14	No	No	---	---	Unknown
Big Bay Cr.	Sep-93	Apr-12	No	No	---	---	Unknown
Scriba Cr.	Jun-10	Apr-14	No	No	---	---	Unknown
Fish Cr.	Jun-13	Jul-13	No	No	---	---	2016
Carpenter Br.	May-94	Apr-12	No	No	---	---	Unknown
Putnam Br./ Coldsprings Cr.	May-96	Jul-13	No	No	---	---	Unknown
Hall Br.	Never	Oct-10	---	No	---	---	Unknown
Crane Br.	Never	Apr-12	---	No	---	---	Unknown
Skaneateles Cr.	Never	Oct-10	---	No	---	---	Unknown
Rice Cr.	May-72	Jul-13	No	No	---	---	Unknown
Eight Mile Cr.	Apr-07	Aug-14	No	Yes	28,728	3,010	***2015***
Nine Mile Cr.	May-11	Aug-14	No	Yes	---	---	Unknown
Sterling Cr.	May-12	Aug-14	No	Yes	---	---	***2015***[1]
Blind Sodus Cr.	May-78	Jul-13	No	No	---	---	Unknown
Red Cr.	Apr-10	Aug-14	No	Yes	7,112	3,556	***2015***
Wolcott Cr.	May-79	Aug-14	No	No	---	---	Unknown
Sodus Cr.	May-10	Aug-14	No	Yes	427	285	***2015***
Forest Lawn Cr.	Never	Aug-13	---	Yes	---	---	2016
Irondequoit Cr.	Never	Aug-14	---	No	---	---	Unknown
Larkin Cr.	Never	Aug-12	---	No	---	---	Unknown
Northrup Cr.	Never	Aug-12	---	No	---	---	Unknown
Salmon Cr.	Apr-05	Aug-13	No	Yes	---	---	Unknown
Sandy Cr.	Apr-14	Aug-14	No	Yes	---	---	Unknown

Table 2. *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-13	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 3. Status of larval sea lampreys in historically infested lentic areas of Lake Ontario during 2014.

Tributary	Lentic Area	Last Surveyed	Last Survey Showing Infestation	Last Treated
Canada				
Duffins Cr.	Duffins Cr. - lentic	Aug-12	Aug-12	Never[1]
Oshawa Cr.	Oshawa Cr. - lentic	Jul-13	Oct–81	Never[1]
Wilmot Cr.	Wilmot Cr. - lentic	Aug-11	Aug-11	Never[1]
United States				
Black R.	Black River Bay	Aug-14	Aug-14	Never[1]

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

Adult Assessment

The long-term effectiveness of the SLCP has been measured by the annual estimation of the lake-wide populations of adult Sea Lampreys. Traps and nets are operated to capture migrating adult Sea Lampreys during the spring and early summer. Lake-wide adult abundance estimates are calculated by the Service and Department by summing stream-specific population estimates from a given basin using a mark/recapture method, trap catch extrapolation using historic trapping efficiencies, and an adult/drainage area/treatment regression model (spawner model).

- A total of 4,072 Sea Lampreys were trapped at 12 sites on 11 tributaries (Table 4, Figure 4).
- The estimated population of adult Sea Lampreys was 19,482 (95% CI; 16,880-24,032), which was lower than the target range of 31,433 ± 3,962 (Figure 5).

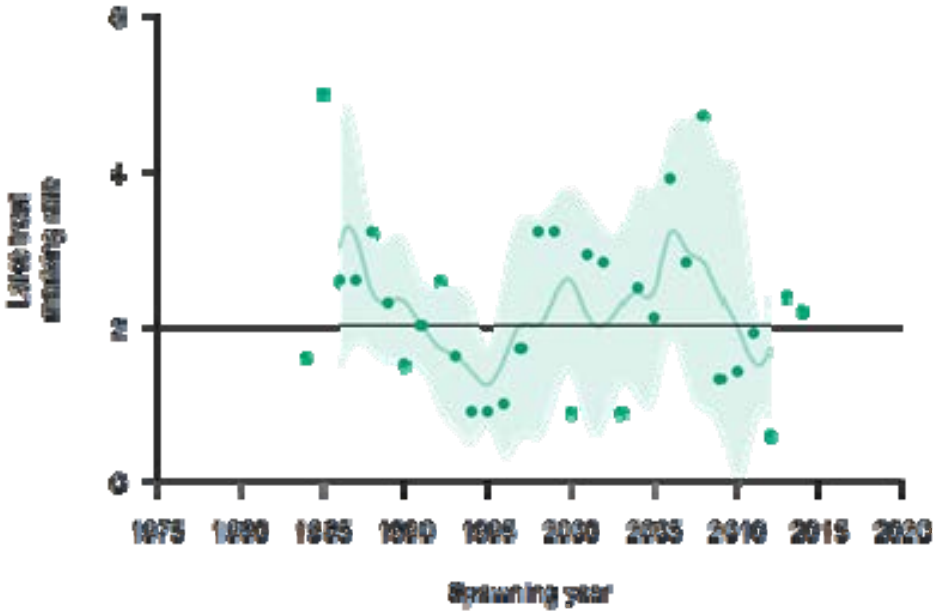

Figure 3. Number of A1 marks per 100 lake trout >431 mm from standardized fall assessments, plotted in the year that the juvenile cohort returned as adults (marking recorded in the fall is inflicted by the cohort of Sea Lampreys that spawns the next spring). The horizontal line represents the target of 2 A1 marks per 100 fish. The five-year moving average (green line) with 95% confidence intervals (shaded area), are provided for visual reference.

Table 4. Information collected regarding Sea Lamprey adults captured in assessment traps or nets in tributaries of Lake Ontario during 2014 (letter in parentheses corresponds to stream in Figure 4).

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)	2,536	4,100	62	254	45	482	480	252	256
Duffins Cr. (B)	399	1,032	39	40	55	492	478	257	246
Bowmanville Cr. (C)	211	677	31	67	58	503	498	276	278
Graham Cr. (D)	169	246	69	55	49	511	490	274	258
Cobourg Cr. (E)	175	265	66	66	48	489	486	246	261
Salmon R. (F)	2	---	---	1	100	---	---	---	---
Total or Mean (Canada)	**3,492**	---	---	**483**	**49**	**491**	**484**	**258**	**259**
United States									
Black R. (G)	95	---	---	---	---	---	---	---	---
Salmon R.(H)									
Orwell Br.	84	137	61	22	45	472	469	255	257
Grindstone Cr. (I)	47	---	---	---	---	---	---	---	---
Little Salmon R. (J)	93	391	24	10	80	517	492	298	279
Sterling Cr. (K)	216	847	25	18	72	500	540	292	311
Sterling Valley Cr.	45	161	28	3	67	457	438	270	221
Total or Mean (U.S.)	**580**	---	---	**53**	**62**	**493**	**488**	**281**	**271**
Total or Mean (for lake)	**4,072**	---	---	**536**	**50**	**491**	**484**	**261**	**260**

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

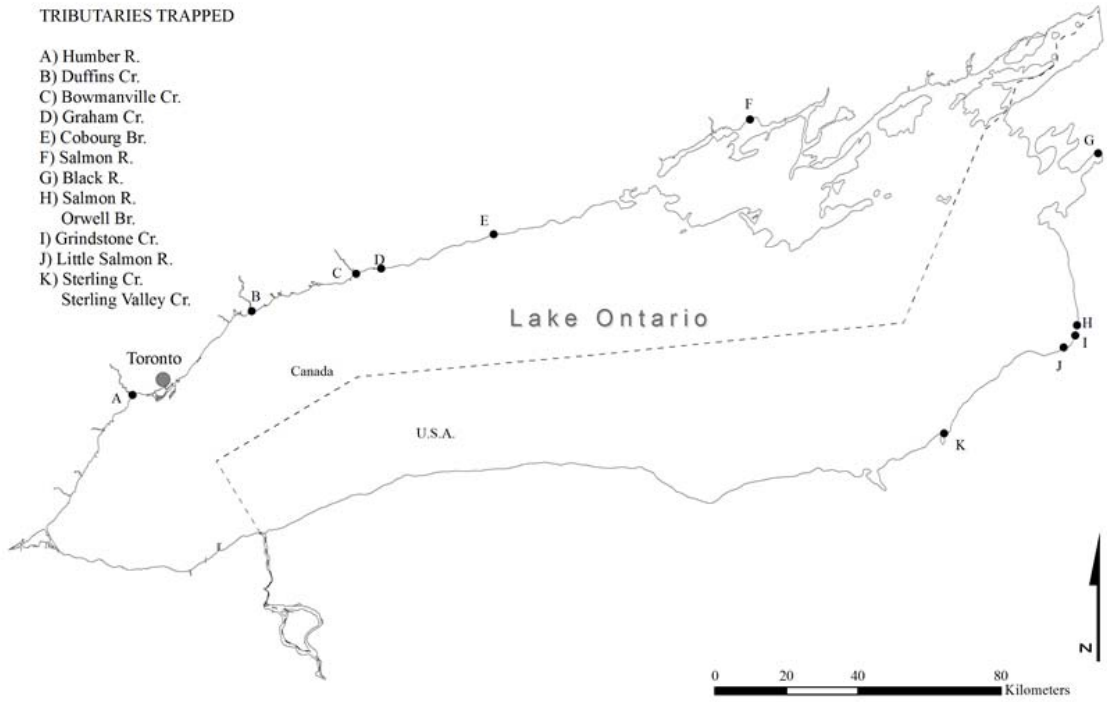

Figure 4. Location of Lake Ontario tributaries where assessment traps were operated (corresponding letters in Table 4) during 2014.

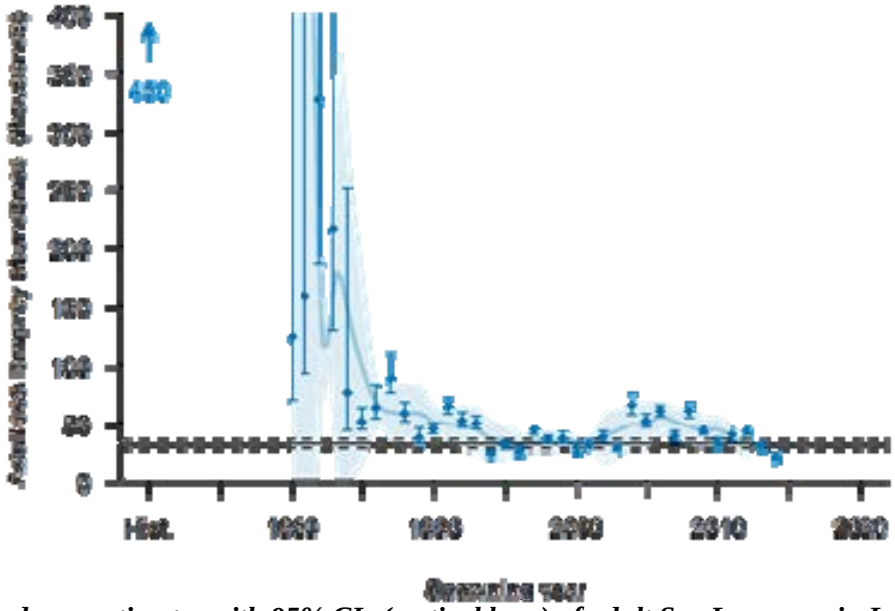

Figure 5. Abundance estimates with 95% CIs (vertical bars) of adult Sea Lampreys in Lake Ontario, including historic pre-control abundance and the five-year moving average (line) with 95% CIs (shaded area). Target abundance and 95% CI ranges (horizontal solid and dashed lines) were estimated from abundances during a period with acceptable marking rates.

Status of Alewife in the U.S. Waters of Lake Ontario, 2014

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Abstract

The adult Alewife abundance and weight indices in 2014 declined slightly from 2013 levels. Condition of adult Alewives also declined relative to the previous high condition measured from 2003-2013 and was slightly (-3.5%) below the long term average. Yearling abundance was the 8th lowest observed in the 37-year time series. Alewife year class strength at age-1 is related to the number of spawners, summer temperatures and winter duration in the first year after hatching. The number of spawners decreased in 2014, summer temperatures were slightly below average, and anticipated long winter duration in 2014-2015 could produce a 2014 year class that is well below average for the second year in a row. We expect adult Alewife abundance and biomass to decline in 2015.

Introduction

Non-native Alewife *Alosa psuedoharengus* 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, Weidel et al. in prep). When populations are abundant, Alewife alter zooplankton species composition, and can reduce recruitment of native species by predation on their larvae (Brandt et al. 1987; Johannsson et al. 1991). 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).

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 survey include indexing the abundance of Alewife adults and yearlings, tracking Alewife body condition, and projecting the future direction of the alewife population by providing our best estimate of the strength of the next year class.

Methods

Alewife populations are assessed annually in late April-May based on bottom trawl catches at 12 transects established at approximately 25-km intervals along the U.S. shoreline (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 the a precise estimate of relative abundance even though the variance of the estimated relative abundance will be biased (ICES 2004).

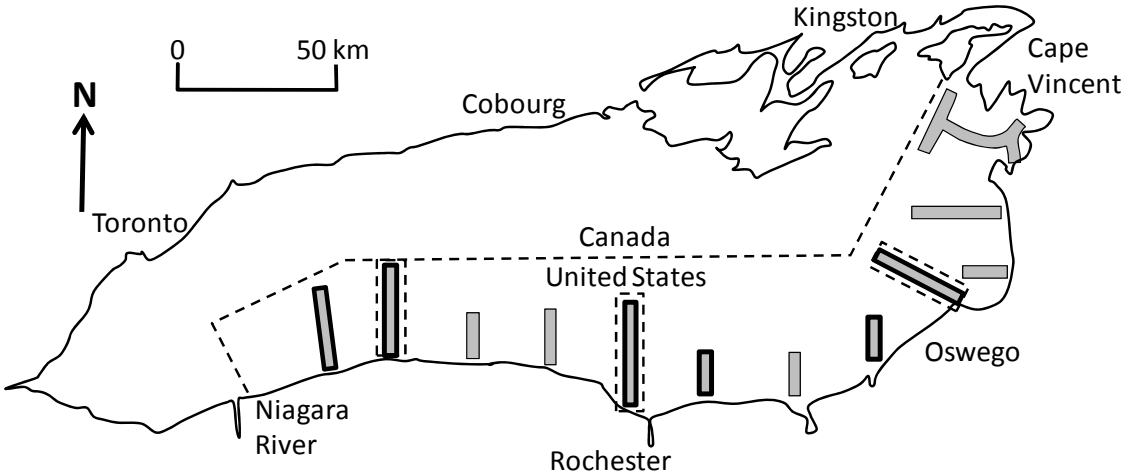

Figure 1. Lake Ontario showing 12 transects sampled in spring by USGS and NYSDEC with bottom trawls. Transect names, from west to east: Olcott, Thirty Mile Point, Oak Orchard, Hamlin, Rochester, Smoky Point, Sodus, Fair Haven, Oswego, Mexico Bay, Southwick, and Cape Vincent. The dashed outline denotes three "surveillance" transects.

The alewife index is expressed as depth stratified catch per unit effort for a 10-min bottom trawl tow. In our depth-stratified design, effort is allocated equally into western areas (Rochester and West, five transects) and eastern areas (Smoky Point and east, four full transects, two transects with depths available ≤70 m, and eastern basin sites ≤40 m). At all transects where depths are available, the following depths are trawled: 70, 85, 95, 105, 115, 125, 135, 150, 170 m. Sampling at ≤70 m is randomly allocated among depth strata within western and eastern areas. In total, approximately 100 tows are conducted annually during the survey.

To track the variability in abundance indices, we use the relative standard error (RSE; RSE = 100 * {standard error of the index / the index}). The sampling frame for Alewife was last modified in 2004, when it was expanded to include the 160-179 m (525-587 ft) depth stratum. This stratum was added in order to increase precision and to adapt the survey to Alewife shifting to deeper water after dreissenid mussels increased water clarity (e.g., O'Gorman et al. 2000). Calculations of the indices were modified concurrently with the sampling frame. See Walsh and Connerton (2011) and previous years for more detailed explanation of analytical methods for the sampling frame expansion, index calculations, and catch estimates for 2001 when the spring assessment could not be completed due to mechanical difficulties.

At each transect of the survey, Alewife are collected and measured for length, weight, sex and maturity. Otoliths are also extracted for estimating age (~1000 per year). To index Alewife adult condition annually, we use the wet weight of a 165-mm (6.5-in) alewife predicted from annual length-weight regressions collected in spring during the alewife survey and in fall during the benthic fish survey.

The original bottom trawl 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 with an 18-m (59 ft) headrope and slotted, metal, cambered V-doors. Paired tows were used to calibrate catches between the two sets of gears.

Remote sensors, known as trawl mensuration gear, have been used over the past decade to understand how the shape of the bottom trawl changes as it is deployed and fished. Sensors are attached at various points on the trawl 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 170m is three times greater than the area covered by the trawl at 8 m 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 Alewife density would be more useful to make inferences and comparisons between Lake Ontario and other Great Lakes or other inland lakes. However, additional research is needed to better understand the catchability and bottom orientation of Alewife.

Results and Discussion

In April – May 2014, both the abundance (number) and weight (kg) indices for adult Alewife (age-2 and older) in U.S. waters of Lake Ontario declined compared to 2013 (Figure 2). The 2014 adult abundance index (753) was 99% of the previous 10-year average (755) and about six times higher than the record low in 2010 (128). The weight index (21.5 kg) was 94% of the previous 10-year average and about six times higher than the record low from 2010 (5). The 2014 weight index declined more sharply than the abundance index simply because the population was comprised of a majority of smaller fish from the 2012 year class (i.e., age 2). Of the alewife caught in 2014, 55% and 20% were age 2 and 3 respectively, 18% were ages 4-5, and less than 1% were ages 6-8. In Lake Michigan where Alewife numbers were near historic lows in recent years, the age structure was truncated with less than 1% 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. By comparison 19% of the Lake Ontario Alewife population was older than age 3 with a maximum estimated age of 8 in 2014, suggesting that predation intensity is lower than in Lake Michigan.

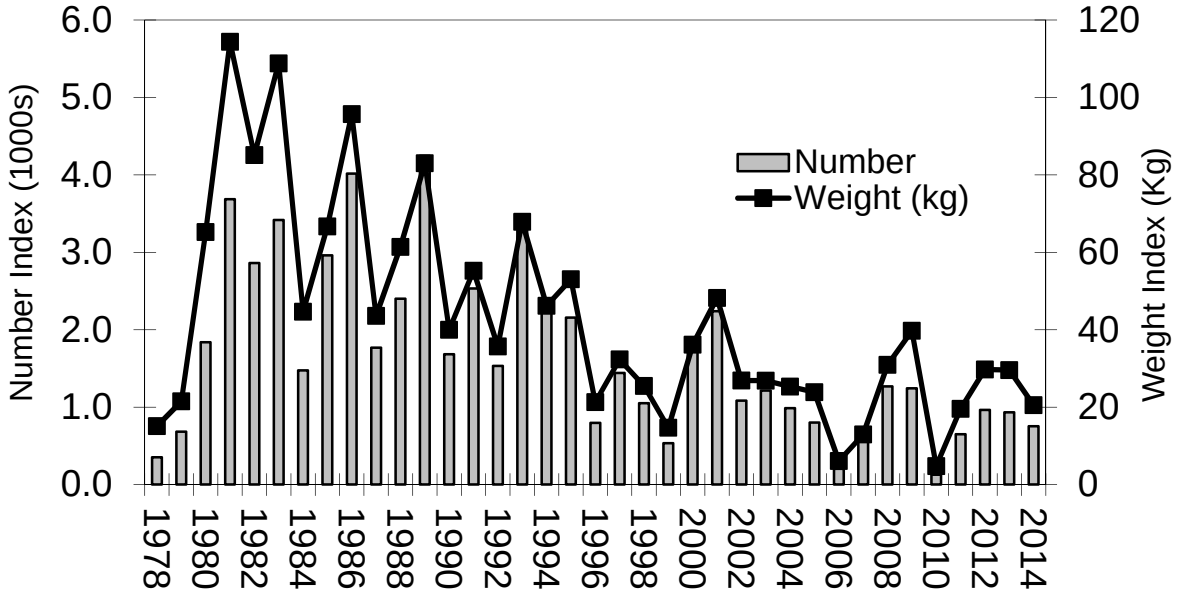

Figure 2. Abundance and weight indices (depth-stratified mean per 10-minute trawl tow) for adult (age-2 and older) Alewife in the U.S. waters of Lake Ontario during late April – early May, 1978-2014. 1 kg = 2.205 lbs.

The proportion of Alewife older than age 3 in Lake Ontario has declined over the entire time series though, averaging 22% of the population in the last ten years compared with 46% the previous ten years (p=0.002). On the other hand, during the recent period there have been some moderate to very strong year classes and as these fish age they should contribute to a larger proportion of older individuals in the population in the coming years.

In 2014, adult Alewife condition declined from higher values observed during 2003-2013 by 10% and 13% in spring and fall, respectively (Figure 3). Condition, measured as the weight of a 165 mm Alewife and are now about equal to the 37-year survey average. The drop from a consistent higher condition of adult Alewife during 2003-2013 may indicate a change in food availability or zooplankton community composition in 2014 (e.g., lower Bythrotrephes levels, Holeck et al. 2015). Lower condition of Alewife may have important implications for salmonine predators too because thiaminase activity has been shown to be inversely correlated with lipid levels or condition in Alewife (Fitzsimons et al. 2005).

The RSE of the adult and yearling indices in 2014 were 26% and 24%, respectively (Figure 4) which are near average for the duration of the survey (23% and 28% average since 1978). The RSE of the yearling index has fluctuated widely from 17% in 1994 to 57% in 2011 returning to more average values in 2013-2014.

Alewife abundance is influenced by reproduction and survival of young fish to adulthood. Since age-0 Alewives are not effectively captured by bottom trawls, 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 2014 (89) ranked as the 8th lowest value in the 37-year times series and it was 23% of the long term mean (390) (Figure 5). A weak 2013 year class may have been the result of below average summer 2013 temperatures and long winter duration of 2013-2014.

Alewife age 1 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) (O'Gorman et al. 2004). In 2014, below average summer temperatures and harsh winter conditions in 2014-2015 could have adversely affected survival of young fish and produced another

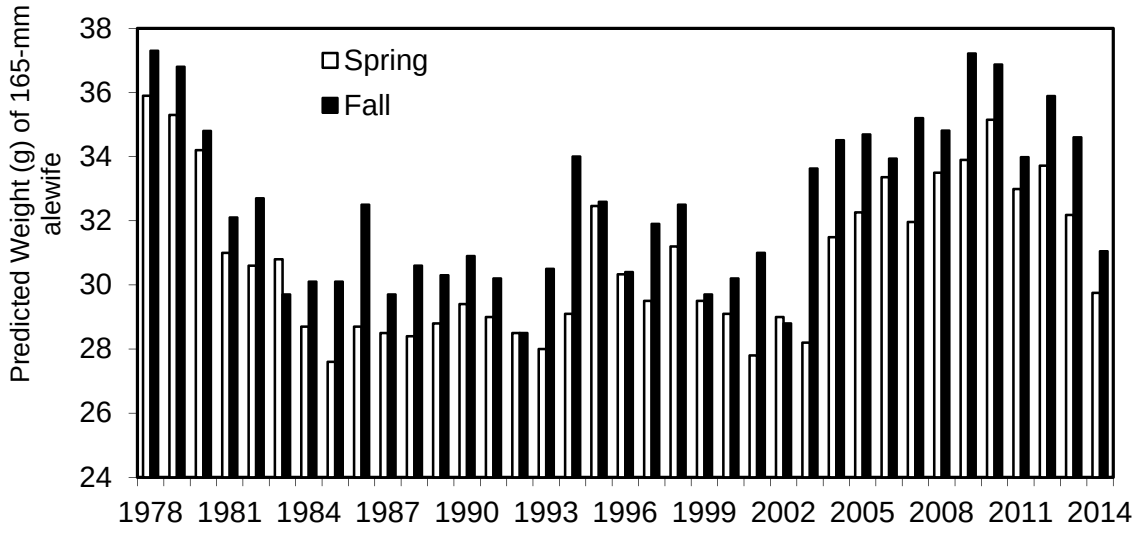

Figure 3. Wet weight of a 165-mm (6.5 in) Alewife (predicted from annual length-weight regressions) in spring and fall, Lake Ontario, 1978-2014. 1 gram = 0.035 ounce. Note that the x-axis is truncated to highlight relatively small differences among years.

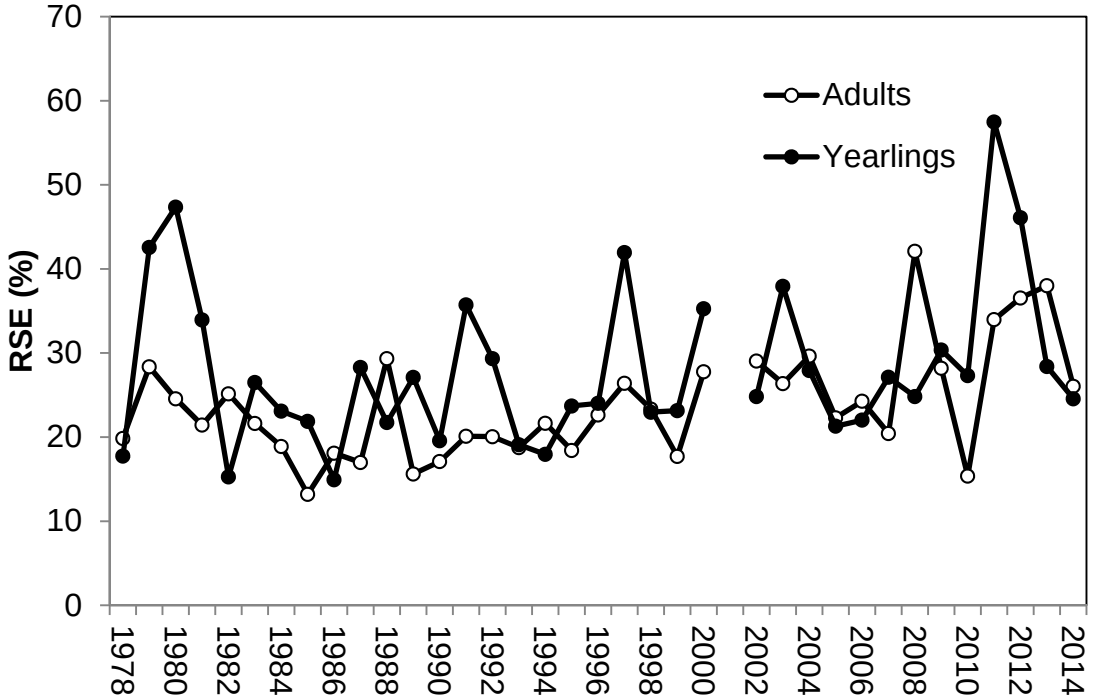

Figure 4. Relative standard error (RSE) for the yearling and adult Alewife abundance indices in U.S. waters of Lake Ontario, 1978-2014. The RSE (RSE = 100 * {standard error of the index / the index}) is a measure of variability in the indices of the index / the index}) is a measure of variability in the indices.

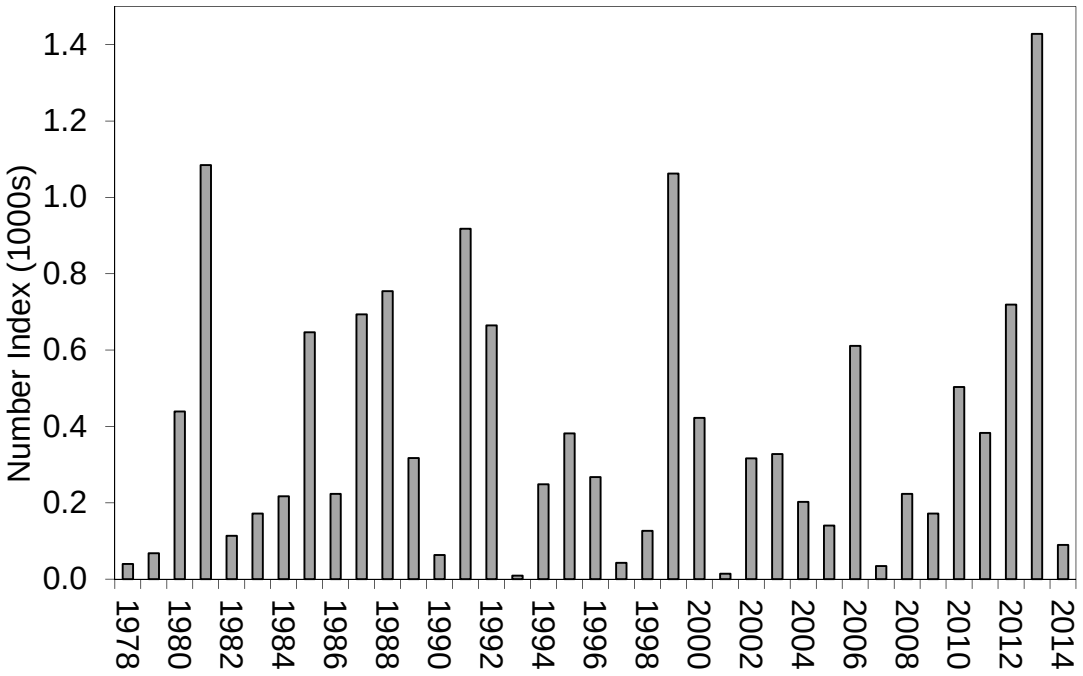

Figure 5. Abundance index (depth-stratified mean per 10-minute trawl tow) for yearling (age-1) Alewife in the U.S. waters of Lake Ontario during late April – early May, 1978-2014.

weak year class. Fourteen days in December 2014 had water temperature < 4° C, as well as likely all days in January-March, leading to a predicted winter index in the range of 104-134 days. Only six winters since 1977 have exceeded a winter duration index of 120 days including the winter of 2013-2014 with a winter duration index of 129 days. Our spawner-recruit model (O'Gorman et al 2004) predicted another below average year class in 2014 based on below average temperatures during summer of 2014 and the anticipated high winter severity of 2014-2015. Fortunately for the adult Alewife population, four relatively strong year classes were produced from 2010-2014 including a record high year class of 2012. The 2012 year class is predicted to dominate the age structure of the population and reach spawning size (>150mm) in 2015.

Generally, the adult Alewife population in Lake Ontario has remained stable for the last three years. The future direction of the Alewife adult population will depend on temperature conditions in 2015 and survival of the large 2012 year class as it recruits into the spawning population. If the summer is warm and the winter is short, conditions may be favorable for Alewife to produce a strong year class to sustain the population.

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Results and Comparisons of Rainbow Smelt Surveys in Lake Ontario

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Abstract

Nonnative Rainbow Smelt Osmerus mordax *are the second most abundant pelagic prey fish in Lake Ontario after Alewife* Alosa psuedoharengus. *The 2014 collaborative USGS and NYSDEC bottom trawl survey found Rainbow Smelt abundance decreased relative to 2013 and was only 20% of the 10-year average. Age-1 fish were 62% of the 2014 catch, however, the age-1 abundance index was among the lowest in the time series (20% of 10-year average). While the June-conducted Rainbow Smelt bottom trawl survey has provided insight into Rainbow Smelt dynamics, alternative surveys that catch and assess Rainbow Smelt may obviate the need for the standard survey. We compared Rainbow Smelt density, size, and depth distribution trends between the Rainbow Smelt bottom trawl survey, the mid-summer acoustic survey and the April Alewife bottom trawl survey. Across years, Rainbow Smelt densities from the standard survey were highly correlated to alternate survey densities (acoustic, $n = 17$, Pearson correlation coefficient = 0.88; Alewife, $n = 37$, Pearson correlation coefficient = 0.81). In 30 out of the 37 years Rainbow Smelt average weight from the Alewife survey was larger than the average Smelt weight on the Rainbow Smelt survey, refuting the hypothesis that Rainbow Smelt spawn timing reduces the number of adult smelt available to be caught during the Alewife survey. Rainbow Smelt length frequencies were significantly different between surveys (Kolmogorov-Smirnov, $p < 0.000$). The Alewife survey caught proportionally more adults, whereas the Smelt survey caught proportionally more age-1 fish. Size differences among survey catches likely result from larger Rainbow Smelt inhabiting deeper lake habitats than smaller fish, and differences in depths sampled between the Smelt survey (mean depth sampled = 55m) and the Alewife survey (mean depth sampled = 95m). These analyses suggest the Lake Ontario Rainbow Smelt population can be assessed by bottom trawls collected as part of the Alewife survey and verified by the mid-summer acoustic survey.*

Introduction

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, Nelbring 1989, Rooney and Patterson 2009). Since initial surveys from the 1960's, Rainbow Smelt have been the second most common pelagic prey fish behind Alewife (Wells 1969). Christie (1972) suggested Lake Ontario Rainbow Smelt negatively influenced native prey fish species, citing population increases in the 1940's coincident with declines of native Cisco populations in western lake regions. Historically, Rainbow Smelt were an important diet component of stocked and native Lake Ontario salmonids, as well as native Burbot (Elrod and O'Gorman 1991, Brandt 1986). Since 1978 the USGS and NYSDEC have assessed Rainbow Smelt population characteristics with a standard Rainbow Trout bottom trawl survey conducted in late May through early June in U.S. waters of Lake Ontario.

While the standard survey has provided valuable insight into Lake Ontario Rainbow Smelt dynamics, alternative surveys that catch and assess Rainbow Smelt may obviate the need for that targeted survey. A mid-summer acoustic survey has estimated Lake Ontario Rainbow Smelt abundance since 1997 and produced trends comparable to trawl data (Connerton et al. 2014). In addition, Rainbow Smelt are caught during the Alewife bottom trawl survey conducted in late April and early May, using nearly identical methods to the Rainbow Smelt survey. The initial prey fish bottom trawl surveys for Lake Ontario were timed to collect specific species when they were most vulnerable to sampling gear, and were informed by intensive, year-round trawling in 1972. At that time, it was hypothesized that adult Rainbow Smelt would be spawning in tributaries during the April Alewife bottom trawl survey, necessitating an additional mid-spring survey to accurately sample all life stages, however, those assumptions have never been evaluated.

The objectives of this report are to: 1) quantify Rainbow Smelt population characteristics in 2014 and compare them to the 37-year time series and 2) compare Rainbow Smelt population characteristics from the standard survey to Rainbow Smelt data collected on the Alewife and acoustic surveys in the same year. Specifically, we are interested in how Rainbow Smelt abundance, size distributions, and depth distributions compare between surveys.

Methods

Rainbow Smelt were assessed using bottom trawls across depths, ranging from 8 – 170 m, at 12 lake areas or transects extending from the Eastern Basin south and west to Olcott, NY. From 1978 to1996, the survey sampled Rainbow Smelt using a nylon Yankee bottom trawl with a 11.8 m long headrope and flat, rectangular wooden trawl doors (2.12m x 0.95m). In 1997, overly abundant catches of Dreissenid mussels led to the use of a polypropylene 3N1 bottom trawl with an 18m (59ft) headrope and slotted, metal, cambered V-doors. Sampling depths were redistributed in 2000 and again in 2006 to increase the abundance index precision in response to shifting Rainbow Smelt depth distributions. In 2012, deeper tows were added at three surveillance transects to better sample depth distribution for other prey fishes and potential deeper smelt distributions. Trawl catches are sorted to species then species are counted and weighed in aggregate. Subsamples for Rainbow Smelt length frequency, individual weight, stomach, and aging structures (fin rays) are collected.

The Rainbow Smelt abundance index is calculated as the mean number caught per 10-minute bottom trawl, weighted by catches in 11 depth strata. Uncertainty associated with the index is reported as the relative standard error (RSE =100*[standard error/abundance index]). Rainbow Smelt year-class strength in Lake Ontario is based on the catch of age-1 fish. The age-1 index is calculated as the product of the proportion of age-1 fish in the total catch and the stratified mean abundance index. The proportions of age-1 fish are estimated by statistically fitting age distributions to the length frequency data for every year in the time series (Weidel et al. 2011).

We created an alternative analysis to estimate Rainbow Smelt density in order to compare estimates in a common density unit across surveys that differed in sampling design and sampling effort among strata. For each bottom trawl survey in a given year, we fit nonlinear models to observed Rainbow Smelt catches, which predict density and/or biomass density based on fishing depth using the locally weighted scatterplot smoothing (loess) function and a smoothing coefficient of 0.5 (R Core Team 2013). We assumed that density at the maximum lake depth (244 m) and the minimum lake depth (1 m) correspond to our deepest and shallowest observations respectively in a given year. An overall lake-wide yearly mean density was calculated by weighting the model predictions at each 1 m depth interval by the proportional area of that 1 m interval in the lake. We compared correlations between our alternative density estimate and the historical, abundance-index density estimates from the Alewife survey and the summer-conducted acoustic survey. Acoustic methods are described by Connerton et al. (2014).

We compared Rainbow Smelt mean weight, length frequency distributions, and mean depth of capture to determine if the Alewife and Rainbow Smelt surveys were sampling different proportions of the Rainbow Smelt population. Rainbow Smelt captured during the Alewife survey were historically counted and weighed in aggregate. We calculated the difference in Rainbow Smelt mean weight between the Alewife and Rainbow Smelt surveys across all 37 years to determine how sample timing influenced the mean weight of Rainbow Smelt caught. In 2013 and 2014, we collected Rainbow Smelt length data from catches on the Alewife survey to compare the length frequencies between the surveys (Kolmogorov-Smirnov test). The yearly mean depth was calculated as the summed product of depth and number of Rainbow Smelt caught for each tow, divided by the total number of Rainbow Smelt caught in a given year.

Results and Discussion

The 2014 collaborative USGS and NYSDEC Rainbow Smelt survey consisted of 106 bottom trawls at 11 transects extending from Olcott, NY into the eastern basin and covering a depth range of 8 - 175m. In 2014, the abundance index for adult (age-1 and older) Rainbow Smelt declined relative to 2013 and abundance was similar to the lowest observation in the time series from 2008 (Figure 1). The abundance index was approximately 20% of the 10-year average.

The relative standard error of the Rainbow Smelt abundance index has increased in value over the past 20 years as abundance has declined (Figure 2). Length frequency based age analysis indicated that the age-1 Rainbow Smelt abundance index declined in 2014 relative to 2013, and was among the lowest age-1 abundance indices measured in the entire survey time series (Figure 3).

Our alternative analytical method to estimate Rainbow Smelt density closely tracked the area weighted stratified abundance index values used historically (Pearson correlation coefficient = 0.96, Figure 4). Using this alternative method on yielded Rainbow Smelt data from the Alewife survey density estimates were similar to the Rainbow Smelt survey (Figure 5). In addition, density estimates from the acoustic surveys closely matched the bottom trawl based density time series (Figure 5). Pearson correlation coefficients between the Rainbow Smelt survey and the Alewife or acoustic surveys were 0.81 and 0.88 respectively. Differences between the Alewife and Rainbow Smelt survey densities, especially in the 1980's and 1990's, may be a result of different depths sampled on the assessments and Rainbow Smelt depth distributions (see discussion below).

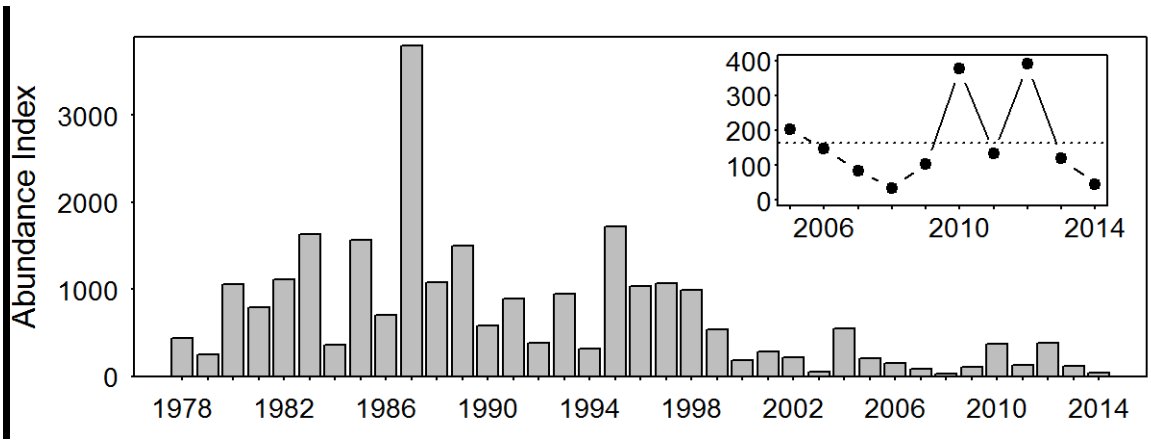

Figure 1. Stratified mean catch of Rainbow Smelt (age-1 and older) from bottom trawls in U.S. waters of Lake Ontario shoreward of the 175-m bottom contour in late May-early June, 1978 - 2014. The inset graph illustrates the last 10 years of data and the 10-year mean.

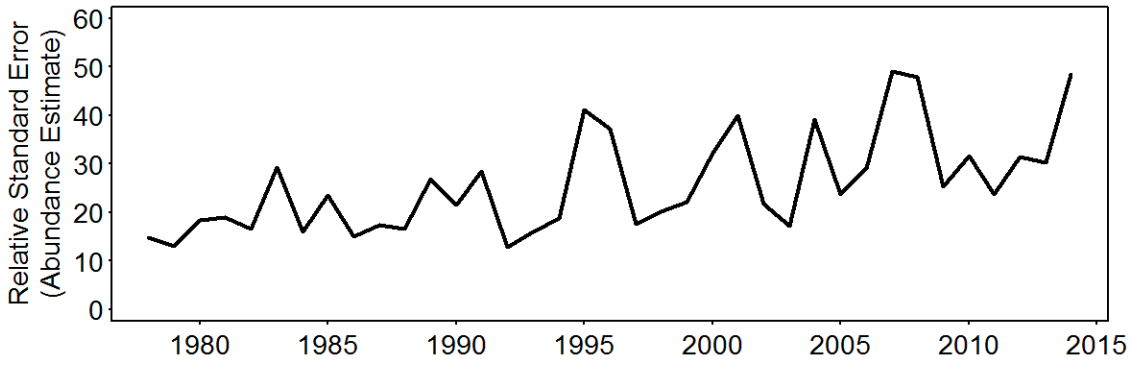

Figure 2. Relative standard error (RSE) for age-1 and older Rainbow Smelt abundance index (Figure 1) in U.S. waters of Lake Ontario, 1978 - 2014.

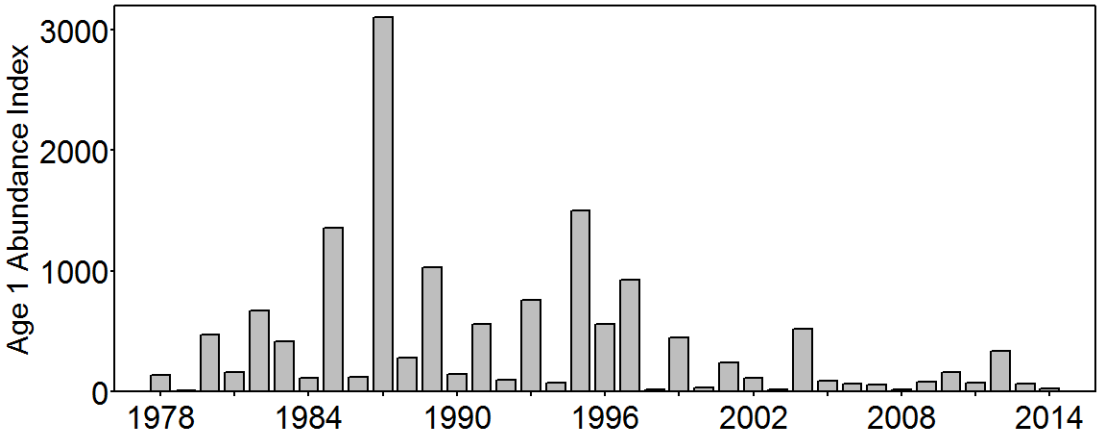

Figure 3. Stratified mean catch of age-1 Rainbow Smelt from bottom trawls in U.S. waters of Lake Ontario in late May-early June, 1978 - 2014.

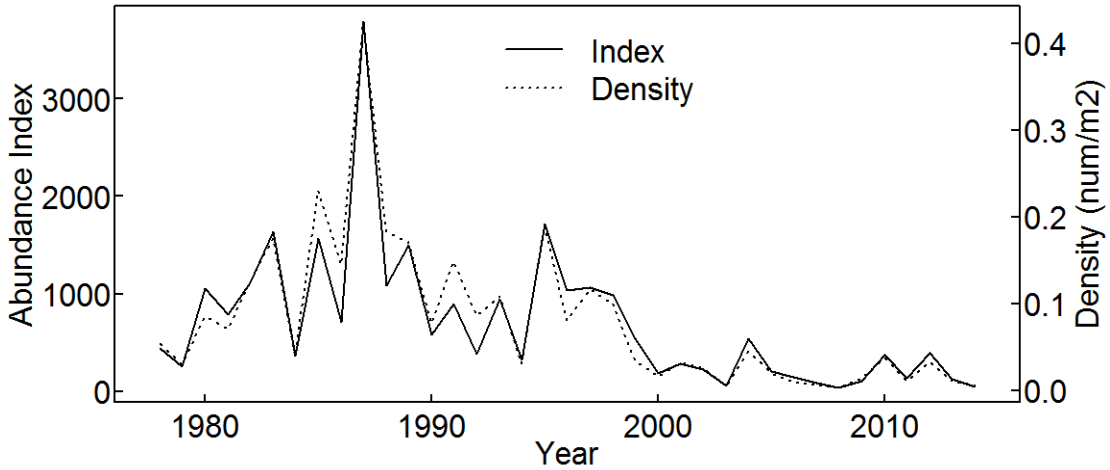

Figure 4. Alternative analyses yielded Lake Ontario Rainbow Smelt density estimates (dashed line) that closely tracked the historical abundance index (solid line, Pearson correlation coefficient = 0.96).

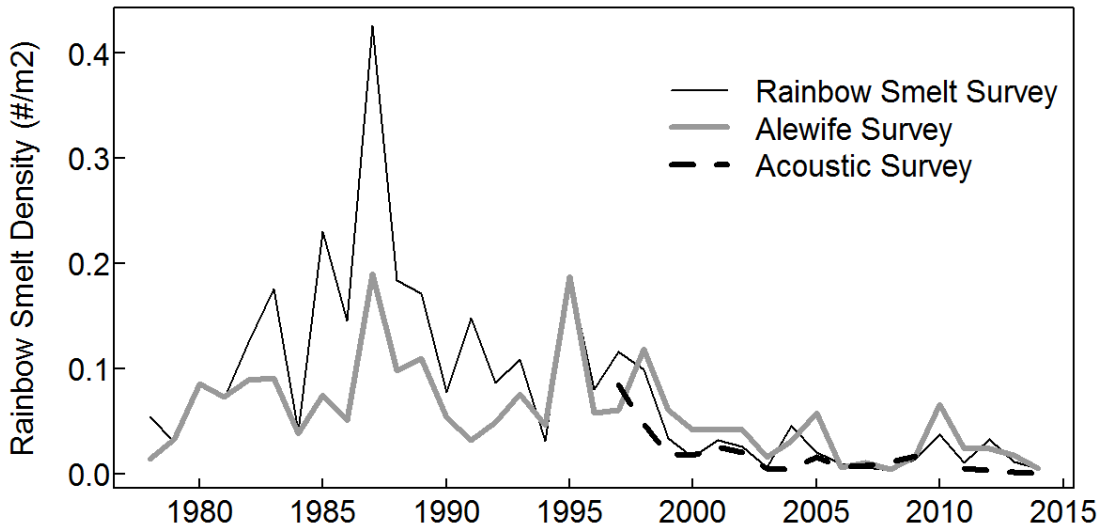

Figure 5. Time series of Lake Ontario Rainbow Smelt density estimates based on two bottom trawl surveys and an acoustic survey. Pearson correlation coefficients between the Rainbow Smelt survey and the Alewife or acoustic surveys were 0.81 and 0.88 respectively.

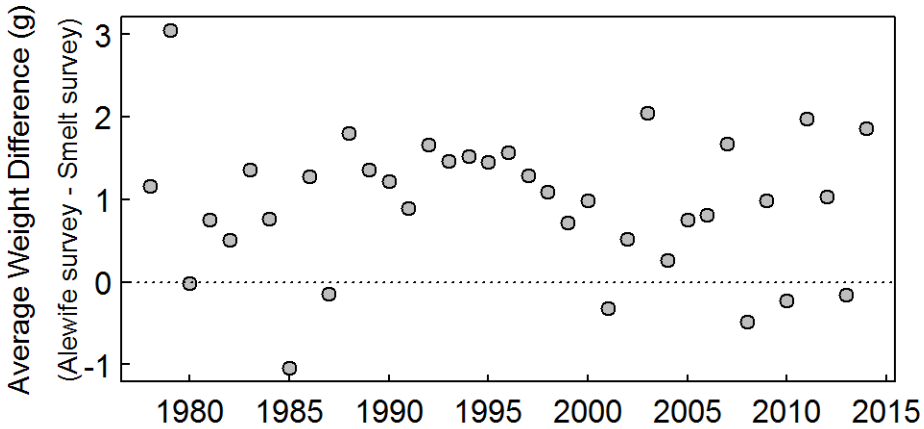

Figure 6. The difference between the average weight of a Lake Ontario Rainbow Smelt caught on the Alewife and Rainbow Smelt surveys is mostly positive across the entire time series (1978-2014).

In 30 out of the 37 years the average weight of Rainbow Smelt caught on the Alewife survey was larger than that caught on the Rainbow Smelt survey (Figure 6). These data do not support the assumption that Smelt spawn timing reduces the proportion of larger, adult smelt to be caught during the Alewife survey.

Unfortunately, standard procedures on the Alewife survey historically did not include Rainbow Smelt length measurements; therefore, in 2013 and 2014 we subsampled and measured Rainbow Smelt on the Alewife survey to compare to the Rainbow Smelt survey. Rainbow Smelt length frequencies were significantly different between the two surveys (Kolmogorov-Smirnov, $p < 0.000$, Figure 7). The Alewife survey caught proportionally more adults, whereas the Smelt survey caught proportionally more age-1 fish. (Figure 7).

Length frequency differences between surveys could influence estimates of Rainbow Smelt year-class strength as assessed by age-1 density, therefore we calculated and compared age-1 fish density from the Alewife and Rainbow Smelt surveys. For a given year and survey, Age-1 Rainbow Smelt density was the product of the proportion of age-1 fish in the population based on length frequency distribution modeling and that year's density estimate. Across the entire Rainbow Smelt time series Age-1 density ranged from 0.001 to 0.348 fish·m^2. Comparing estimates between surveys in a given year we found similar densities in the 2013 Alewife and Rainbow Smelt survey (0.006 vs 0.006 fish·m^2, respectively), however they differed slightly in 2014 (0.003 vs 0.002 fish·m^2, respectively).

Differences in the size of Rainbow Smelt caught may be partially explained by the depths sampled on each survey. The mean depth of all trawls on the Rainbow Smelt survey was originally 45m (1970's and 1980's) and was shifted to approximately 55m, whereas the Alewife survey mean depth was originally approximately 65 m and was shifted more recently to 95 m. Figure 8 illustrates that generally, on the Rainbow Smelt survey, age-1 fish are caught at shallower depths than larger adults. Interestingly, Rainbow Smelt mean depth captured on the Alewife survey is deeper than on the Rainbow Smelt survey, suggesting an inshore movement during the spring. Each of these mean-depth time series illustrates a similar pattern of increasing mean depth over time, first noted by O'Gorman et al. (2000). This pattern is potentially related to increasing water clarity, owing to lake-wide mineral nutrient reductions and dreissenid mussel filtering.

These analyses suggest that Lake Ontario Rainbow Smelt dynamics can be assessed by bottom trawls collected as part of the Alewife survey and the mid-summer acoustic survey. Additional shallow bottom trawls should be included in the Alewife survey to sample more evenly both adult and yearling Rainbow Smelt.

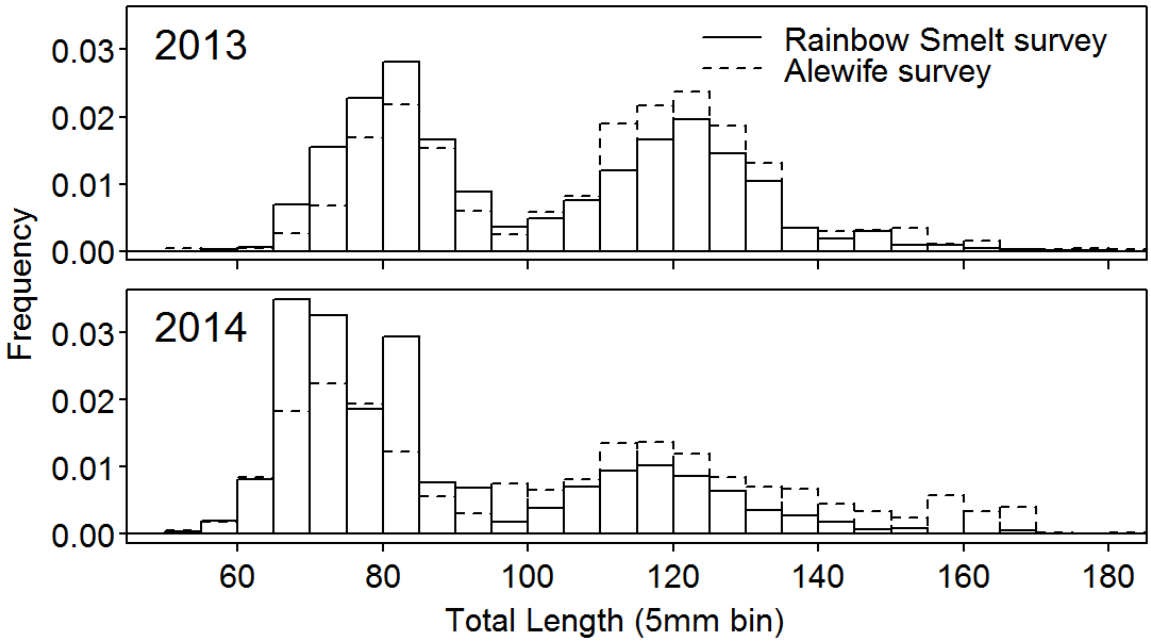

Figure 7. Lake Ontario Rainbow Smelt length frequency based on the USGS and NYSDEC Alewife (April/May) and Rainbow Smelt (Bay/June) bottom trawl surveys. In both years the Alewife survey collected proportionally more adult (~ greater than 90 mm) Rainbow Smelt, while the Smelt survey collected proportionally more age-1 Rainbow Smelt (total length range 40 – 90 mm).

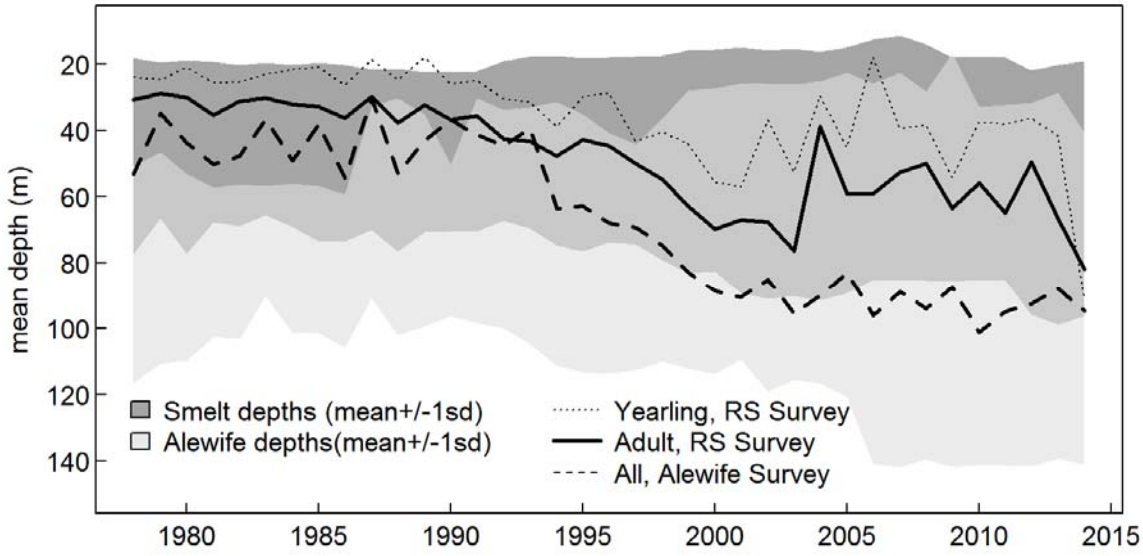

Figure 8. Lake Ontario Rainbow Smelt mean depth for yearling (small dash) and adult (solid) fish collected on the Rainbow Smelt survey and all (thick dash) Rainbow Smelt caught on the Alewife survey. The shaded regions illustrate the range of depths sampled on each survey, plotted as the mean ± 1 standard deviation. The medium gray shaded area is where the two ranges of depths overlap.

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Lake Ontario Benthic Prey Fish Assessment, 2014

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Abstract

Benthic prey fishes are an important component of the Lake Ontario fish community and serve as vectors that move energy from benthic invertebrates into native and introduced sport fishes. Since the 1970's, the USGS Lake Ontario Biological Station has assessed benthic fish populations and community dynamics with bottom trawls at depths ranging from 8 m out to depths of 150-225 m along the south and eastern shores of Lake Ontario. From the late 1970's through the early 2000's the benthic fish community was dominated by Slimy Sculpin Cottus cognatus, *but in 2004 non-native Round Goby* Neogobius melanostomus *abundance increased and, since then Round Goby have generally been the dominant benthic species. Over the past 10 years the native Deepwater Sculpin* Myoxocephalus thompsonii, *once considered absent from the lake, have increased. Presently their lake-wide biomass density is equal to, or larger than, Slimy Sculpin. Species-specific assessments found Slimy and Deepwater Sculpin abundance increased slightly in 2014 relative to 2013, while changes in Round Goby abundance differed between spring and fall survey. Recent survey modifications have increased our understanding of benthic prey fish abundance and behavior in Lake Ontario. For instance, increasing the maximum tow depth to 225 m in 2014 improved our understanding of Deepwater Sculpin distribution in this rarely sampled lake habitat.*

Introduction

Benthic prey fish community changes over the past four decades have coincided with species introductions such as Round Goby, and are also likely linked to bottom-up changes in the benthic invertebrate community. As a prey fish, slimy sculpin were an important diet item for juvenile Lake Trout *Savelinus namaycush*, but since the decline of Slimy Sculpin, Round Goby have become the important benthic prey fish for Lake Trout (Elrod and O'Gorman 1991; Rush et al. 2012). This USGS bottom trawl survey tracks dynamics of the benthic fish community and species of interest in Lake Ontario. Data are reported to partner agencies and also serve as a primary data source to assess the bi-national Lake Ontario Committee Fish Community objectives.

Objectives of this report are: 1) to quantify change within the Lake Ontario benthic prey fish community and within specific populations 2) to discuss survey modifications that have expanded our understanding of Lake Ontario benthic fish dynamics and 3) identify future research needs. This research is funded through the Status and Trends program within the USGS Ecosystems Mission Area.

Methods

The original Lake Ontario benthic fish survey was developed to assess Slimy Sculpin population dynamics and sampled six transects along the southern shore of Lake Ontario from Olcott, NY to Oswego, NY. Trawls were typically 10 minutes and sample depths from 8 m to 150 m, which at the time, spanned the entire range of depths inhabited by Slimy Sculpin. The original sampling gear was a nylon-constructed, Yankee bottom trawl with an 11.8-m headrope and flat, rectangular wooden trawl doors (2.12m x 0.95m). Species-specific abundances were based on area-weighted means from two strata: a shallow stratum from 8 m to 55 m (461 km^2) and a deep stratum from 60 m to 160 m (670 km^2). In the early 2000's, 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 extremely low and variable catchability for benthic fishes and the alternative trawl doors

influenced net morphometry. Since 2011, the survey has used the standard 11.8-m headline Yankee trawl and reduced tow times to avoid overly large mussel catches. Beginning in 2011, the survey has sampled deeper habitats (maximum tow depth = 220 m in 2014) to assess more accurately the Deepwater Sculpin population. In 2014, two new transects were added to the sampling program (Niagara Bar & Mexico Bay) to sample more completely the available benthic fish habitat. In addition to the fall survey, Round Goby abundance is also assessed using the spring bottom trawl survey. This survey focuses on deeper waters (55 m to 170 m) and uses a "3N1" bottom trawl that is less effective for capturing benthic fishes due to the addition of a rubber cookie sweep and foot rope designed to stay above the lake bottom. Additional detail on that survey can be found in the Alewife section of this report.

Historically, benthic fish population dynamics were reported with 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 ($N \cdot m^{-2}$) and biomass density ($g \cdot m^{-2}$) units (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. Since 2011, we evaluated our sampling design and analyses to provide more accurate and appropriate statistics on Lake Ontario benthic fishes. Currently, species-specific density and biomass density are calculated for each trawl using catch data and a trawl fishing depth to trawl area swept relationship (Weidel and Walsh 2013). For each species, nonlinear models that predict density and biomass density based on fishing depth are fit using the *loess* smoothing function and a smoothing parameter value of 0.5 (R Core Team 2013). Trawl observations typically range from 8 m to 170 m or deeper, however in order for models to predict catches across the entire Lake Ontario depth range (1 m to 244 m) we assume density and biomass density at the maximum depth and zero depth correspond to our deepest and shallowest observations respectively in a given year. The overall yearly mean density is calculated by weighting the model predictions for density and biomass density at each 1-m depth interval by the proportional area of that 1m interval in the entire lake.

Results and Discussion

From the late 1970's through the early 2000's the benthic fish community was dominated by Slimy Sculpin, but in 2004 non-native Round Goby abundance increased, and since then Round Goby have generally been the dominant benthic species captured in USGS bottom trawls (Figure 1). Coincidentally, with the community shift to Round Goby, catches of native benthic fishes including Trout-perch *Percopsis omiscomaycus*, Johnny Darter *Etheostoma nigrum* and Spottail Shiner *Notropus hudsonius* declined precipitously.

Over the past 34 years, Slimy Sculpin abundance in Lake Ontario has fluctuated, but ultimately decreased by two orders of magnitude, with a substantial decline occurring in the past 10 years (Figure 2). Owens and Dittman (2003) attributed declines in the 1990's to reductions in the native amphipod *Diporeia sp*. More recent declines in Slimy Sculpin density coincide with Round Goby introduction, although the mechanisms for this potential negative interaction have not been explored. In 2014, Slimy Sculpin density increased slightly relative to 2013 (Figure 2, left panel inset).

Deepwater Sculpin, once considered absent from the lake, have increased, and based on bottom trawl catches their lake-wide density and biomass density is equal to, or larger than, Slimy Sculpin (Figure 2). The lack of bottom trawl sampling during the 1940's through 1960's complicates our understanding of how and why Deepwater Sculpin declined, however, declines appeared to occur prior to the 1950s (Lantry et al. 2007). Lantry et al. (2007) and others have proposed Deepwater Sculpin increases may have resulted from reduced predation on the pelagic larvae by the depressed alewife population in the 2000's.

The range of depths sampled with bottom trawls influences our understanding of benthic fish dynamics in Lake Ontario. Figure 3 shows Slimy Sculpin are primarily captured between

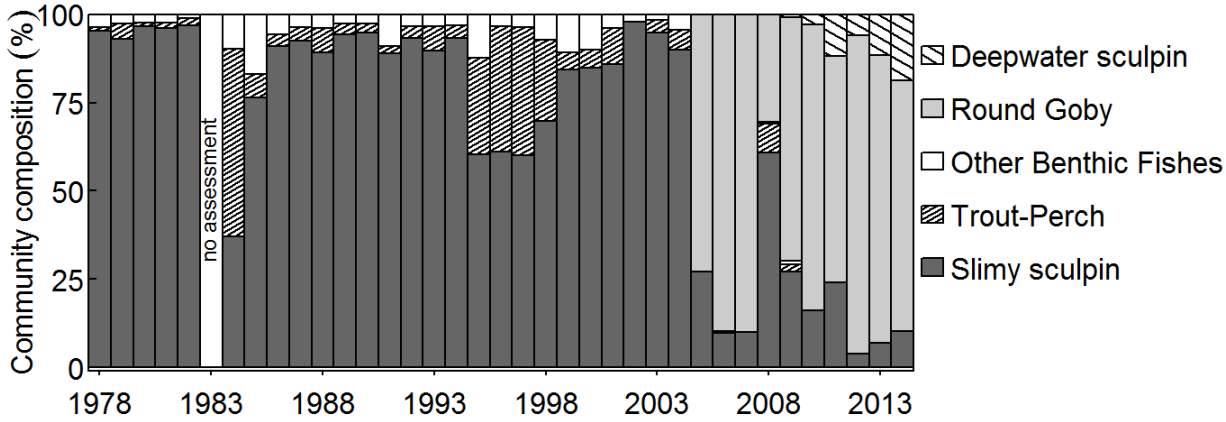

Figure 1. Lake Ontario benthic fish community composition (based on biomass density) from the USGS bottom trawl survey 1978-2014. Other benthic fishes category includes Johnny Darter and Spottail Shiner.

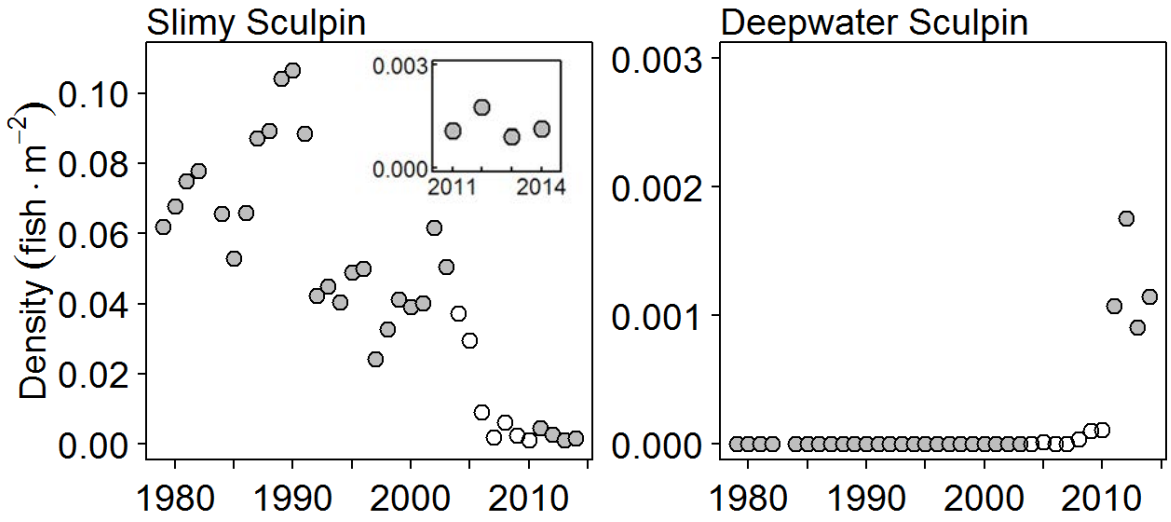

Figure 2. Lake Ontario Slimy Sculpin(left) and Deepwater Sculpin (right)density time series based on the USGS bottom trawl survey. Filled circles represent the standard Yankee trawl, while open circles represent alternative bottom trawls. The inset graph illustrates the last four years of Slimy Sculpin densities and is scaled similarly to the Deepwater Sculpin panel.

50 and 170 meters with the highest catches occurring around 100 meters. In contrast, Deepwater Sculpin abundances increase substantially beyond 170 m, yet that depth had historically represented the deepest trawls for benthic fishes. Expanding the range of bottom depths sampled on the benthic fish survey has increased our understanding of Deepwater Sculpin population dynamics and habitat use (Figure 3, upper right panel). If the 225 m trawl observation is removed from the 2014 observations, the lake-wide estimate for Deepwater Sculpin density declines by 30%. Future surveys should attempt to include multiple observations from this rare and important deep lake habitat.

Round Goby were first detected in the Great Lakes Basin in the St. Clair River between Lakes Huron and Erie in 1990 (Jude et al. 1992), and first reported in southwestern Lake Ontario in 1998 near the entrance to the Welland Canal

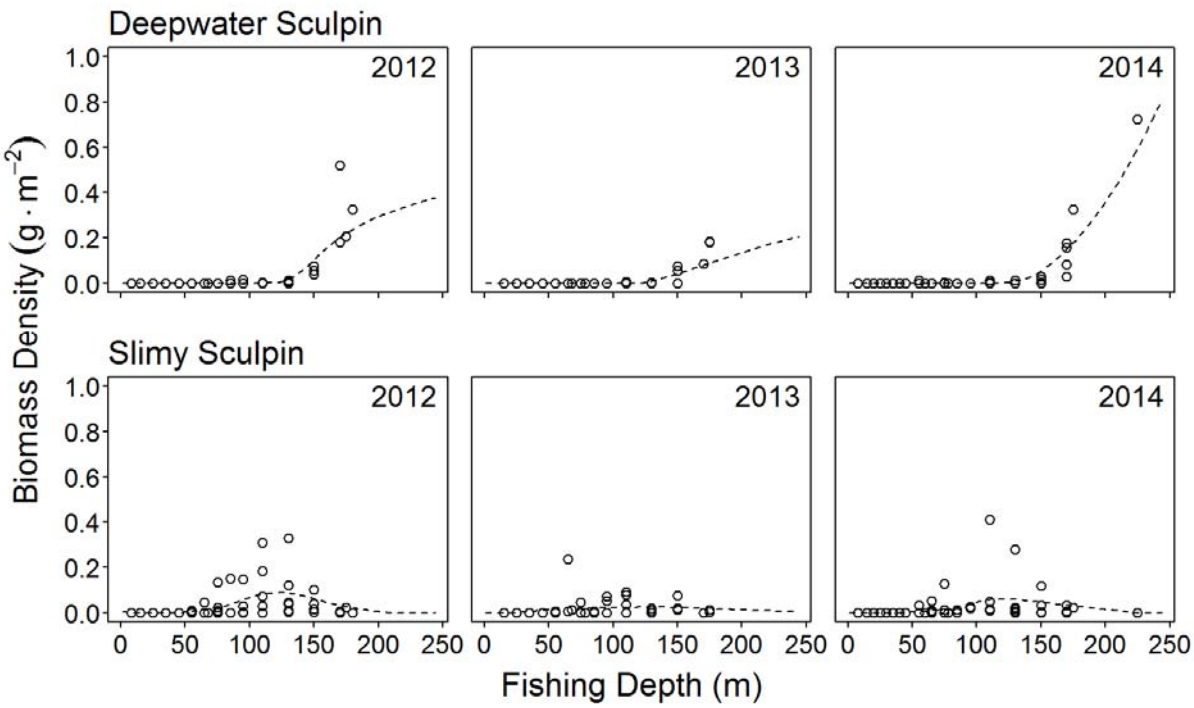

Figure 3. Lake Ontario Deepwater and Slimy Sculpin biomass density patterns illustrated by fishing depth (m) based on the 2014 Benthic Fish Survey. The dashed line represents a locally weighted scatterplot smoothing (loes) model used to estimate lake-wide biomass density. The addition of a 225m tow and high Deepwater Sculpin biomass density confirmed the importance of the deepest lake habitats to this native species.

(Owens et al. 2003). Round Goby were first caught in the USGS and NYSDEC bottom trawl survey in 2002, and since then their population has expanded substantially, with the highest population densities in U.S. waters just east of the Niagara River mouth (Walsh et al. 2007). In the 2014 spring Alewife survey, both the abundance and weight indices decreased relative to 2013 (Figure 4, left panel). In contrast, the fall survey-based estimates illustrated little change in Round Goby density from 2013 to 2014 (Figure 4, right panel). Video observations confirm that the polypropylene 3N1 trawl used in the spring survey has less contact with the lake bottom compared to the fall-used Yankee trawl, potentially explaining why spring Round Goby densities are lower than fall densities. Future analyses must reconcile differences in Round Goby densities associated with survey timing and different gears in order to interpret Lake Ontario Round Goby population dynamics.

In addition to season and or gear effects on our Round Goby density estimates, our assumptions about trawl and fish behavior (catchability) could bias density estimates relative to the true density. Gear catchability is the number of fish caught relative to the true number of fish present in the area sampled. We assume catchability is equal to one when calculating density estimates, yet it is likely this proportion is less than one, biasing our observations lower than the true fish density. Kocovsky et al. (2011) used duplicate bottom trawling in Lake Erie to estimate catchability for a similar benthic prey fish, the Trout-perch, and found catchability ranged from 0.76-0.88 depending on time of day and presence of Dreissenid mussels. In contrast to a low bias, our assumed effective trawl path width may inflate our observed densities relative to actual densities. We assume our trawl mensuration wing spread measurements represent the width of bottom sampled. Fish herding from the trawl doors and bridles may force fish into the trawl from a wider path than is represented by the wing measurements which would increase our area swept estimate and decrease benthic fish density. Evidence from marine systems suggests herding effects are species specific but are consistently observed in

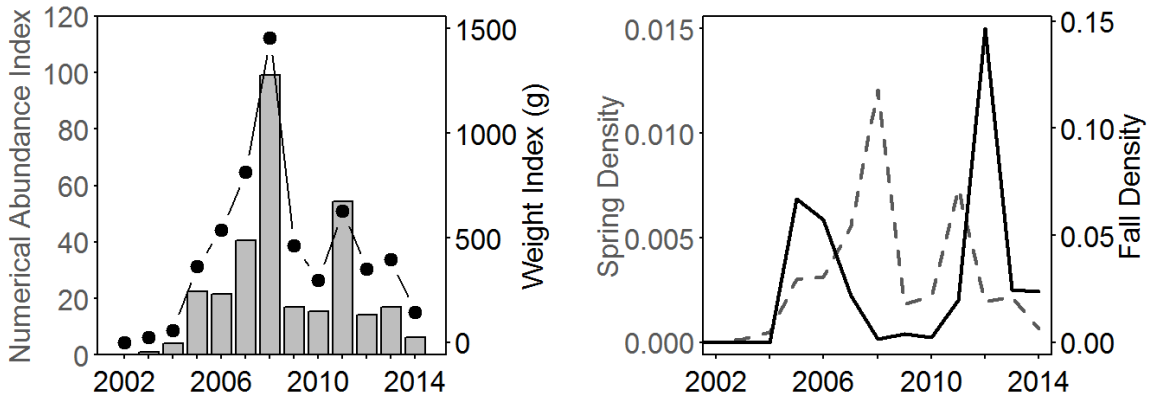

Figure 4. (left panel) Lake Ontario Round Goby abundance (gray bar and axis) and weight indices (black points and scale) based on the spring USGS bottom trawl survey. (right panel) Round Goby density time series from spring (dashed gray line) and fall (solid black line) bottom trawl surveys vary in both scale (different vertical axes ranges) and peak abundance timing.

bottom-oriented species (Ramm and Xiao 1995; Sommerton 2004). It should be noted, even if fish herding influences our area swept and density estimates, the consistent methods employed across the survey suggests the year to year trends would remain accurate. Future surveys should use repeated trawling and video cameras on trawl wings to evaluate the strength of these assumptions and potential bias on benthic fish density estimates.

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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 contain several colonial waterbird colonies (Table 1), some, but not all, of which were monitored annually. Management and monitoring activities were carried out by Region 6 NYSDEC staff, sometimes with assistance of U.S. Department of Agriculture, Wildlife Services personnel.

Nest removal 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 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 2014 on Gull Island, a total of 603 nests were removed over six visits between 12 May and 1 August. No birds were culled. Peak one day nest removal was 235 (Table 2). The total count of nests removed decreased by 44% and the peak count decreased 15% relative to 2013.

Eggs were oiled on five occasions at Little Galloo Island between 7 May and 16 July 2014. The peak number of nests oiled on Little Galloo Island was 1,625 (Table 2), and 150 cormorants were culled in 2014. [Please note that peak number of nests oiled on Little Galloo were incorrectly reported in 2012 and 2013. The numbers in the current report have been corrected.] There were 296 unoiled tree and control nests. Peak nest count was 2,283, including control subcolonies, tree, and “empty” but apparently occupied, nests (Table 1). Peak nest count was 229 nests (16%) higher than in 2013. Note that peak nest counts do not necessarily correspond to nest numbers reported in Canadian Wildlife Service trend reports, which may or may not represent peak nesting. Hatching success (number of chicks hatched per number of eggs counted) for oiled nests was estimated to be less than 1%.

We estimated that approximately 500 cormorants fledged on Little Galloo Island this year, mostly from a control (unoiled) subcolony of

approximately 250 nests, some from tree nests, and a few from incidentally untreated ground nests.

We estimated 818,666 feeding-days occurred at the Little Galloo Island colony in 2014, above the target of 780,000, but somewhat below the 874,876 estimate in 2013 (Figure 1). Since nest counts and feeding day estimates were near target and showed relatively little change this year (Figure 1), substantial adjustment of management efforts may not be needed in 2015.

Nest counts for other colonial waterbirds except ring-billed gulls were conducted in 2014 on the four eastern basin islands. Bass Island hasn't supported any colonial waterbird nesting since 2007. Great Black-backed Gulls have not been detected since 2008 and Black-crowned Night Herons have only been found on Gull Island since 2007. Common Terns on the other hand nested on Little Galloo Island for the first time in 2013 and again in 2014 (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 for the first time in 2010. The project has been operating at maintenance level since 2007.

Reduced population levels at Little Galloo Island, probably related to egg oiling, became noticeable in 2002. Johnson et al. (2004) reported a substantial decline in fish consumption at this colony due both to lack of consumption by chicks and lower numbers of feeding adults resulting from reduced recruitment. This reduction has continued (Johnson 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 are for active nests after management activity and may not match Canadian Wildlife Service trend numbers (dash indicates not checked for given species).

Species	Island	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Double-crested Cormorant	Little Galloo Island	5,681	5,119	5,440	4,780	4,251	3,967	3,401	2,692	2,959	2,492	2,751	1,758	2,831	2,227	2,387	2,283
	Gull Island	0	0	0	0	0	1			0	0	0	0	0	0	0	0
	Bass Island	0	0	0	0	35	12	5	5	5	0	0	0	0	0	0	0
	Calf Island	-	-	-	-	-	0	-	-	-	0	0	0	0	0	0	0
Ring-billed Gull	Little Galloo Island	53,000	-	-	-	60,000	-	-	-	-	37500	-	-	-	43324	-	-
	Gull Island	0	-	-	-	0	-	-	-	-	0	-	0	-	0	0	0
	Bass Island	2,300	-	-	-	2,500	-	-	-	-	0	-	0	-	0	0	0
Herring Gull	Little Galloo Island	275	-	-	-	313	-	-	367	0	375	356	364	459	512	645	979
	Gull Island	45	-	-	-	42	-	-	40	67	58	42	89	91	52	89	109
	Bass Island	10	-	-	-	10	-	-	10	16	0	0	0	0	0	0	0
Great Black-backed Gull	Little Galloo Island	8	-	19	15	12	-	-	4	1	1	0	0	0	0	0	0
	Gull Island	0	-	0	1	0	-	-	0	0	9	0	0	0	0	0	0
	Bass Island	0	-	0	0	0	-	-	0	0	9	0	0	0	0	0	0
Caspian Tern	Little Galloo Island	1,445	1,350	1,590	1,585	1,658	1,560	1,788	1,589	1,580	1,376	1,499	1,472	1,934	2,332	1848	2436
Black-crowned Night Heron	Little Galloo Island	1	1	1	1	3	3	4	0	0	1	0	0	0	0	0	0
	Gull Island	41	20	50	24	35	78	81	77	127	78	78	105	151	44	56	79
	Bass Island	9	36	13	36	47	17	46	32	0	0	0	0	0	0	0	0
	Calf Island	6	-	0	-	-	0	-	-	-	-	13	0	0	0	0	0
Common Tern	Little Galloo Island	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	34

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	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Little Galloo Island	Peak nests oiled	5,627	4,301	3,865	3,707	3,389	3,359	2,896	2,275	2,502	1,804	2,166	1,104	2,000	1,600	1,456	1,625
	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
Bass Island [2]	Peak nests oiled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nests removed	37 (37)	793 (757)	0 (0)	986 (279)	260 (117)	959 (348)	935 (600)	477 (174)	470 (110)	0 (0)	0(0)	0(0)	0(0)	0 (0)	0 (0)	0
	DCCO culled	-	-	-	-	-	167	281	200	124	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	146 (111)	574 (478)	21 (21)	157 (77)	1,427 (486)	485 (188)	0 (0)	113 (110)	273 (137)	671 (266)	741 (261)	604 (275)	659 (302)	711 (391)	1,072 (276)	603 (235)
	DCCO culled	-	-	-	-	-	3	0	0	20	2	0	0	0	29	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

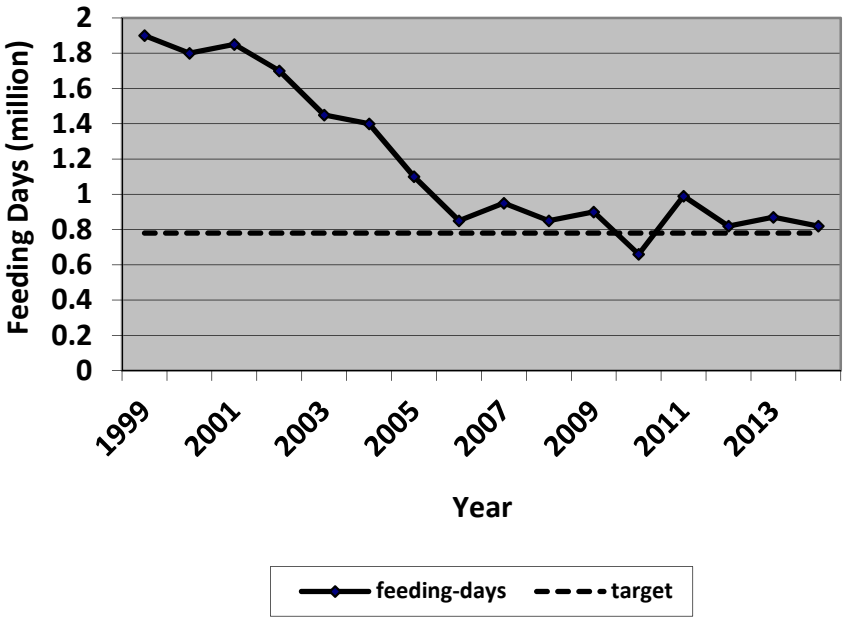

Figure 1. Trend in cormorant feeding days for the Little Galloo Island colony.

Acoustic Assessment of Pelagic Planktivores, 2014

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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*), and for double-crested cormorants. 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. 2015, Weidel et al. 2015) 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 has done that by using 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=0.66) 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=0.68), 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 we conducted during 2008-2013 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 and transducer depth create a near-field acoustic “blind-spot” in the first four meters 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. This report provides a summary of preliminary up-looking hydroacoustic results. 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.

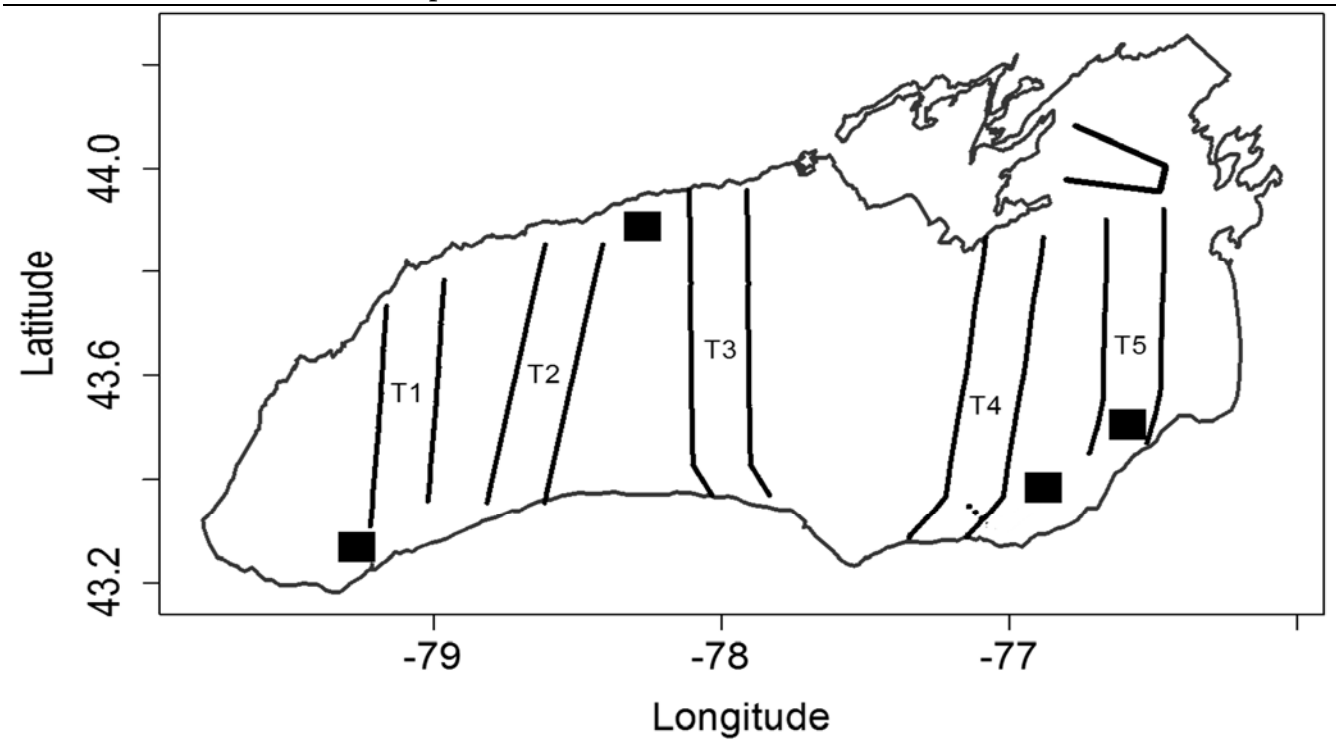

Figure 1. The Lake Ontario Lake-wide prey fish survey uses cross-lake hydroacoustic transects. Transect corridors are logistically constrained but utilize a random starting point within the corridor for each annual survey. The filled squares represent additional transects that were used in 2014 for comparison 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 2014 was 6, meaning that transects were offset 0.6 times the width of the corridors from their eastern boundaries. In addition to the 5 cross-lake transects, a U-shaped transect is surveyed each year in the eastern basin (Figure 1); however, no offset is applied to this transect.

In earlier survey years, mid-water trawls were conducted to collect fish for validating vertical distribution of fish species and for estimating average size of Alewife and Rainbow Smelt for whole-lake prey fish biomass calculations. Since 2010, floating, vertical gillnets were more commonly used to improve characterization of preyfish vertical distribution. From 2010-2014, a total of 31 vertical gillnet sets were conducted by floating the nets adrift above 60-100m bottom depth for approximately 4 hours each set. Nets, extended from the surface to approximately 20-40 meters depth depending on thermocline conditions with the net always extending below the 10°C depth line. For details of net dimensions see Connerton et al. (2014).

The 2014 hydroacoustic survey was conducted from July 20-30 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 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 transects in 2014, four transects (8-24 km long spanning 40 m to 120 m bottom depth) were added for comparisons between mobile down-looking and up-looking acoustics (Figure 1). 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 depth with the transducer facing towards the surface. The trawl door acted as a depresser for the towfish and pulled it off to the port side of the vessel approximately 75 m. to avoid surface-noise and bubbles generated by the vessel wake.

Limnological sampling were also conducted at five stations for the Lake Ontario Biomonitoring project, which indexes phosphorus and plankton levels in the Lake annually (see Holeck et al. 2015); and as an on-going partnership with Cornell University to investigate the potential for estimating plankton biomass acoustically. A temperature profile was measured at several points along each transect.

Analytical methods for estimating Alewife and Rainbow Smelt abundance have varied somewhat throughout the hydroacoustic program (1997-2014), but in general, hydroacoustic data were stratified by thermal layer (2 layers, upper: $\geq 10^{o}$C to surface, and lower: $<10^{o}$C to 100m 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. 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). 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.

We are currently exploring alternative methods for analyzing hydroacoustic survey data to improve estimates of whole-lake abundance. Three analytical approaches were compared for each species. For Rainbow Smelt, these 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, 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 200 m 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 estimate of the abundance and the sampling distribution (e.g., confidence intervals). An abundance estimate is derived for each 200m 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, analyses 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 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 TL);

3) BO- using the bootstrap method, with targets between -50 and -35 dB.

We are also used up-looking acoustics to establish a correction factor for surface-oriented fish missed in the nearfield acoustic "blind spot" (i.e., 0-4 m) of the down-looking transducer. Since the down-looking and up-looking acoustic transducers may measure different numbers of fish targets (by chance or if Alewife avoid the vessel), the correction factor was based on up-looking targets only, and calculated as the number of targets measured from the 10^0C depth line to the surface divided by the number of targets measured from 4 m depth to the 10^0C depth line. The 10^0C depth line varied from 12m to 18m on the four nights surveyed in 2014. Down-looking transducer data were used for comparing the vertical distribution and numbers of targets measured by the up-looking transducer simultaneously. The correction factor was not applied to survey index values, but future reports may do this once we gain a better understanding of the variability and factors that determine the proportion of Alewife near the surface.

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 1997-2014 (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 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.

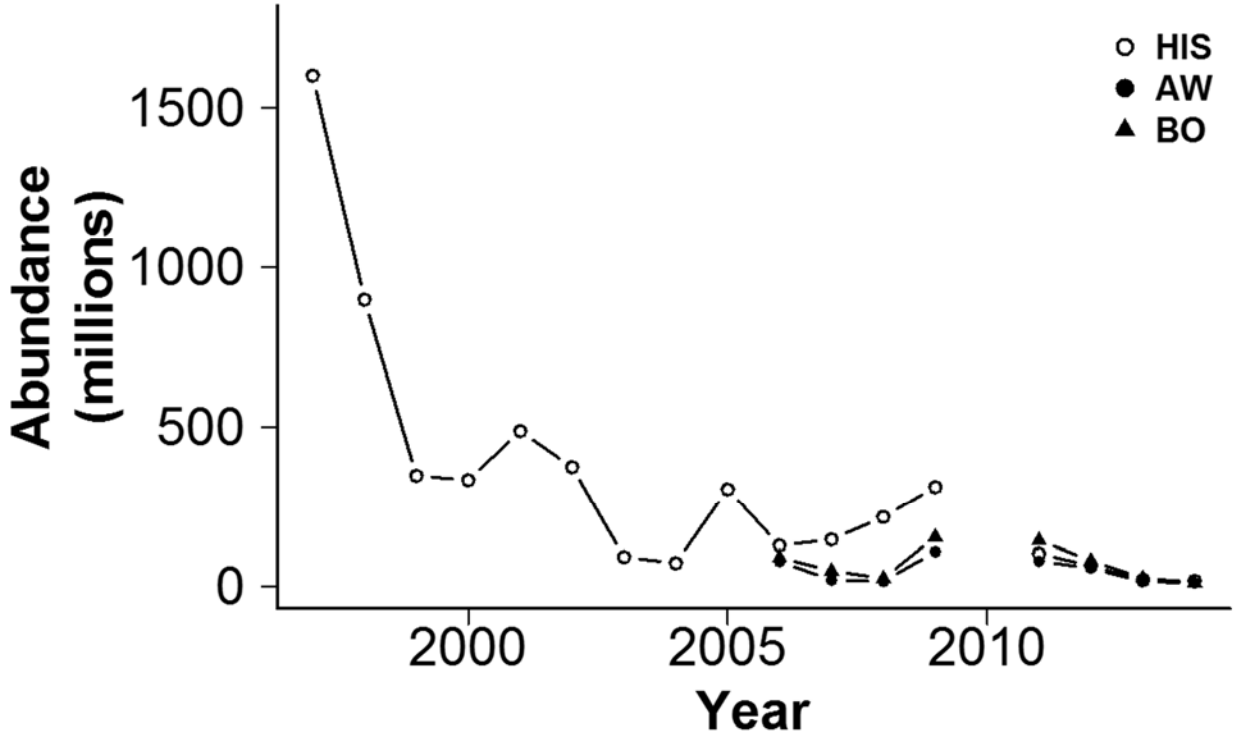

Figure 2. Abundance (in millions of fish) of yearling-and-older Rainbow Smelt from 1997-2014. Abundance estimates for 2006-2014 are presented for three different methodologies: the traditional area-weighted abundance of targets between -55 and -28 dB (HIS, open circles); area-weighted abundance of targets 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.

Results and Discussion

Rainbow Smelt

YAO Rainbow Smelt abundance indices using the three different analyses are presented in Figure 2. All three estimates show a decline in Rainbow Smelt abundance in 2014 and all three estimates are the lowest observed in the time series (2006-2014, 1997-2014 for HIS). For 2014, the HIS method produced the highest estimate (16.0 million fish) followed by BO (10.7 million) and AW (9.6 million). Mean Rainbow Smelt weight, determined from bottom trawl catches in June 2014, declined from 5.8 g in 2013 to 3.7 g in 2014, resulting in mean biomass estimates of 0.03 (HIS), 0.01 (AW), and 0.02 kg/ha (BO) (Figure 4a). Similar to 2013 (Connerton et al. 2014), Rainbow Smelt distribution remained highest in the eastern areas of the lake in 2014 (Figure 5a.).

All three methods were correlated for the time series studied (2006-2014, except 2010; HIS/AW R=0.69; HIS/BO R=0.73; AW/BO R=0.94). Throughout the time series the HIS method generally produced higher estimates as would be expected considering the broader target strength range. BO produced estimates slightly higher than AW in all years. Target strength was likely the main driver behind the differences between the HIS and AW/BO methods as AW and BO used the same TS range. The differences between HIS and the other two methods was greater from 2006-2009 than from 2011-2014 which may be primarily attributed to disproportionately more targets between -55 and -52 dB in the earlier years. Abundance estimates were less sensitive to inclusion of target strengths between -39 and -28 dB. For example in 2014, changing target strength thresholds from -28 to -39 produced a 16% change in estimated abundance, whereas including target strengths from -55 dB to -53dB affected the abundance estimate by 32%.

The AW method improved the correlation between the hydroacoustic and bottom trawl surveys for the 2006-2014 period but this result was based on only eight years of data. The HIS method and the bottom trawl index over the entire time series are well correlated (from 1997-2014, r=0.81, Weidel et al. 2015). We will continue to use the HIS method, but will continue evaluating all three methods until 1997-2005 survey years are reanalyzed.

Alewife

Three analytical approaches to estimate YAO Alewife were applied from 2006-2014 for comparison purposes. Alewife abundance in 2014 declined using all three analyses, however, estimates varied between methods (Figure 3). The SR method estimated a 70% decline in abundance from 2013 to 2014 (682 million to 199 million). The declines estimated using AW and BO (600 million and 753 million, respectively) are more conservative (33% and 13%, respectively) and more consistent with that estimated in the bottom trawling survey (Walsh et al. 2015). Despite an increase in mean Alewife size from 20.6 g to 21.7g measured in the bottom trawl survey, overall biomass estimates indicate a decline from 2013 (SR = 70%, AR = 19%, BO = 9%).

Throughout the time series (2006-2014) estimates from BO were marginally different than AW but are highly correlated ($R = 0.94$, $p < 0.001$) and both tended to produce estimates that were higher than SR. AW was more correlated with SR (R=0.53) than BO (R=0.34). As with Rainbow Smelt, all three methods will be used in analyzing Alewife data from 1997-2005, with results correlated to bottom trawl indices. We also hope to gain more understanding regarding Alewife orientation effects on target strength and overall abundance estimates.

Alewife distribution during the survey period is presented in Figure 5b. There were no discernable consistent geographic patterns in Alewife distribution in 2014 or in 2013 (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.

Results of up-looking acoustics and vertical gillnetting suggested that a substantial portion of the Alewife occupied the down-looking acoustic blindspot. Vertical gillnet data from 2010-2014 indicated that 50% of the Alewife were caught in this layer (n=1,017 Alewife, 31 total net nights) which resulted in a blindspot correction factor of 2.1. Comparing target densities between up and down-looking echograms during simultaneous pinging also supports the hypothesis that a substantial number of fish inhabit the 0-4 m layer (Figure 6). For the single transect represented in Figure 6, traditional down-looking estimates would need to be corrected by a factor of 1.66 to account for targets in the 0-4 m layer identified by up-looking acoustics.

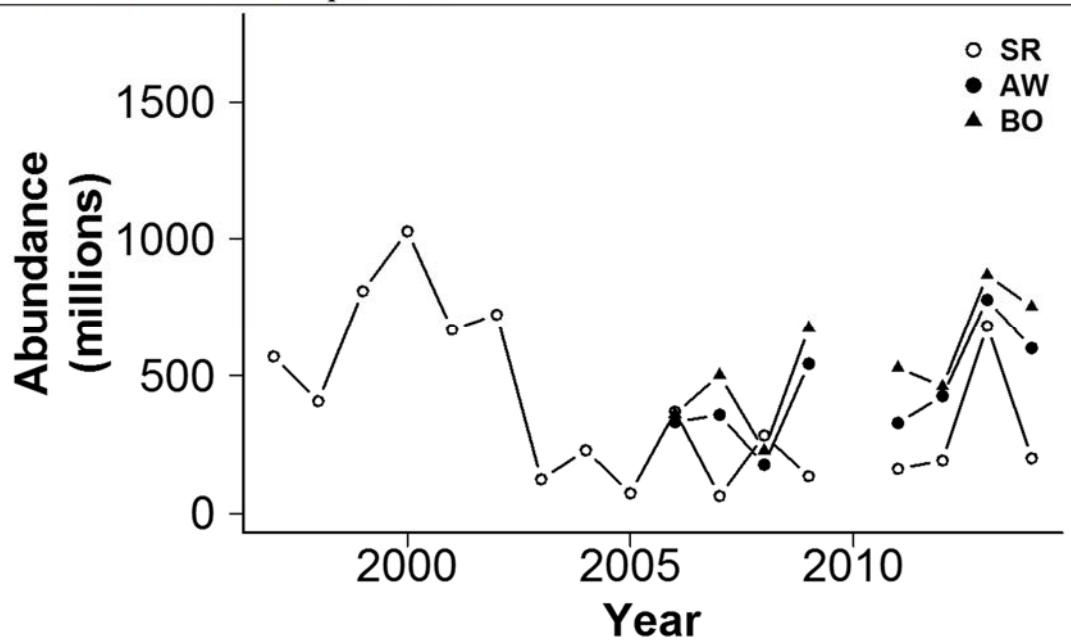

Figure 3. Abundance (in millions of fish) of yearling-and-older Alewife from 1997-2014. Abundance estimates are presented for three different methodologies: area-weighted estimates using a solver routine to identify Alewife sized targets (SR, open circles); area-weighted abundance of targets between -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.

The total number of targets detected by up-looking acoustics was also higher in 8-16m on this particular transect, but that was not a consistent result on other transects. Based on four transects conducted in 2014, the average correction factor was 2.3 (range=1.66-3.16). Based on comparisons 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=0.7 in comparable portions of the water column (4m-10°C 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. Experiments to determine the importance of boat avoidance by Alewife are planned by the USGS Lake Ontario Biological Station for 2015. While hydroacoustics has it 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 feasible with bottom trawling. We will continue to work towards improving the application of this technology.

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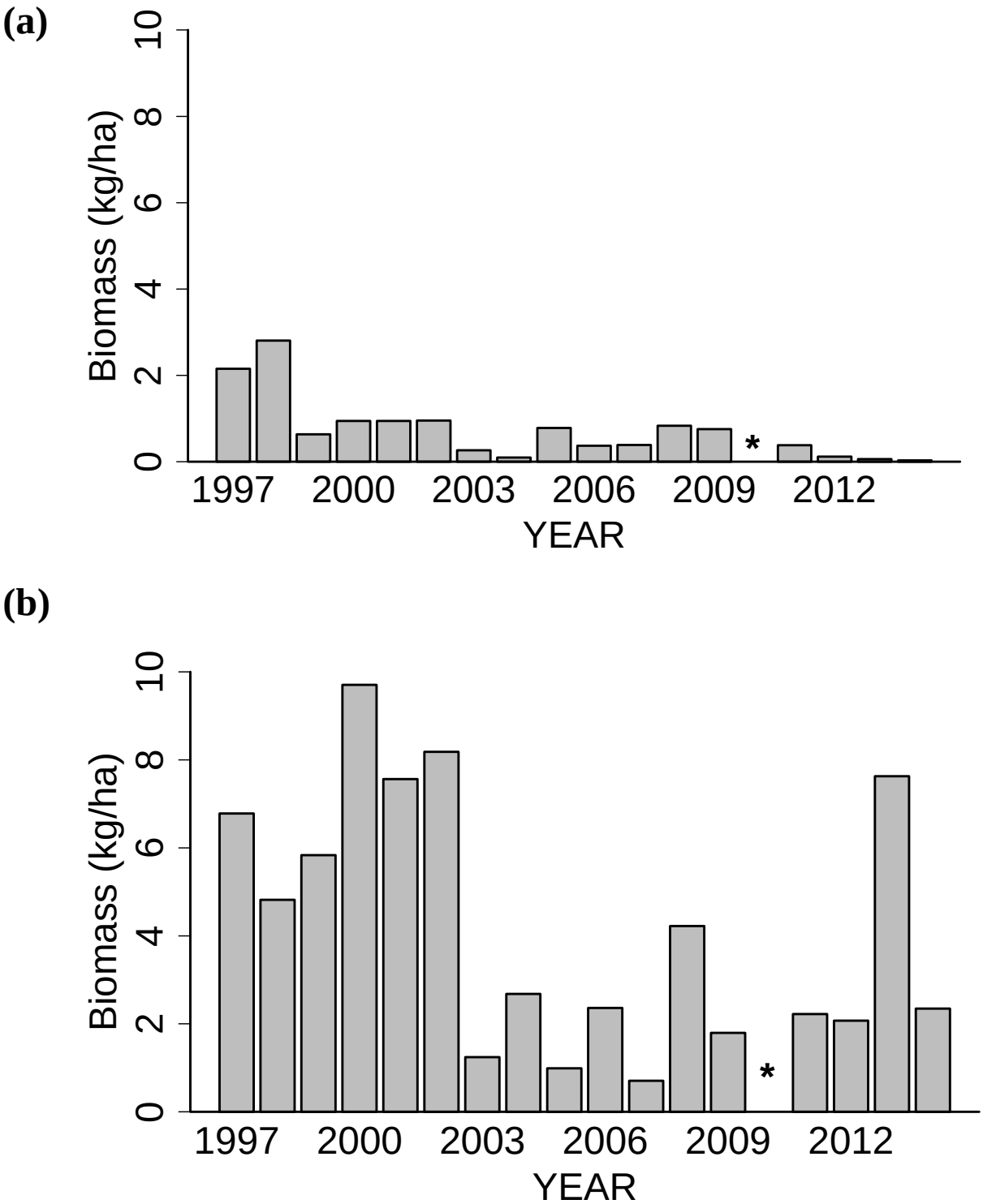
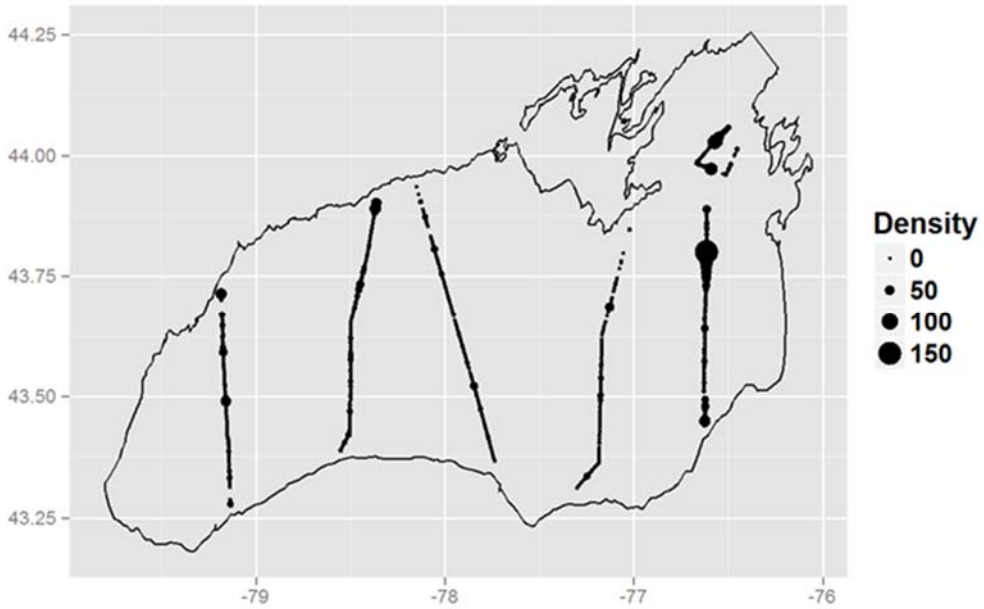


Figure 4. Biomass (kg/ha) of Rainbow Smelt (a) and Alewife (b) from 1997-2014. Biomass estimates were obtained by multiplying the area-weighted whole-lake hydroacoustic abundance estimates by the average weights of Alewife or Rainbow Smelt measured during bottom trawling surveys. The acoustic survey was not conducted in 2010.

(a)



(b)

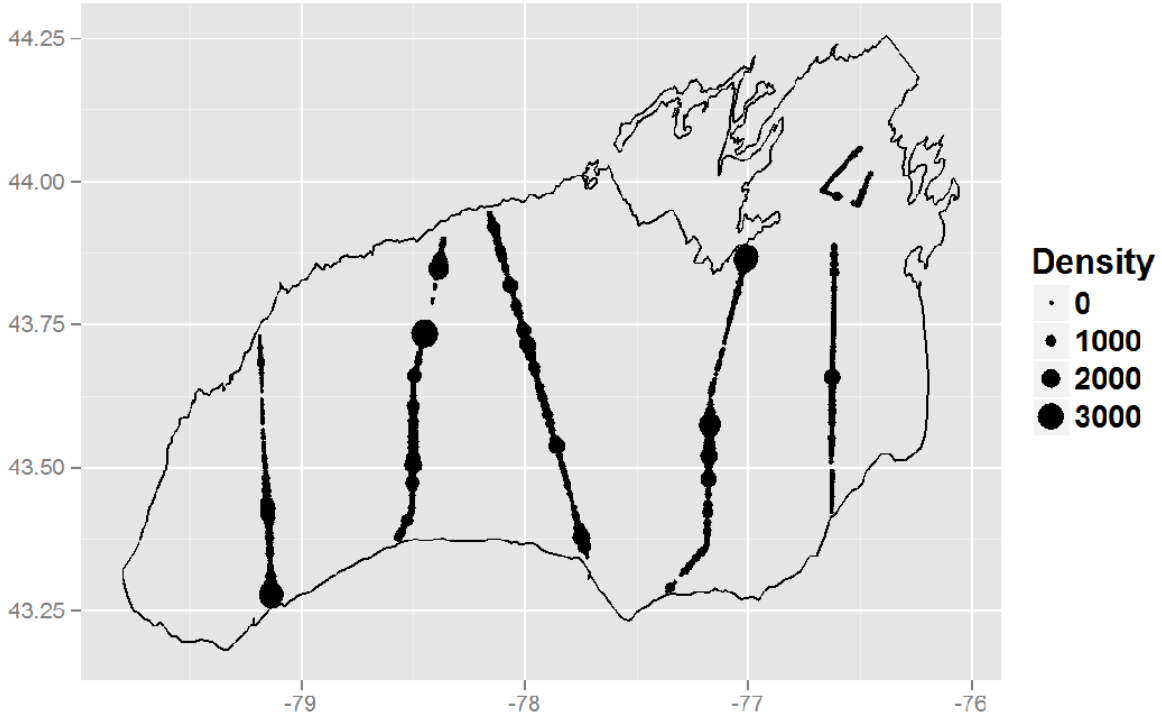


Figure 5. Relative distribution (fish/ha) of Rainbow Smelt (a) and Alewife (b) observed during the hydroacoustic survey in July 2014.

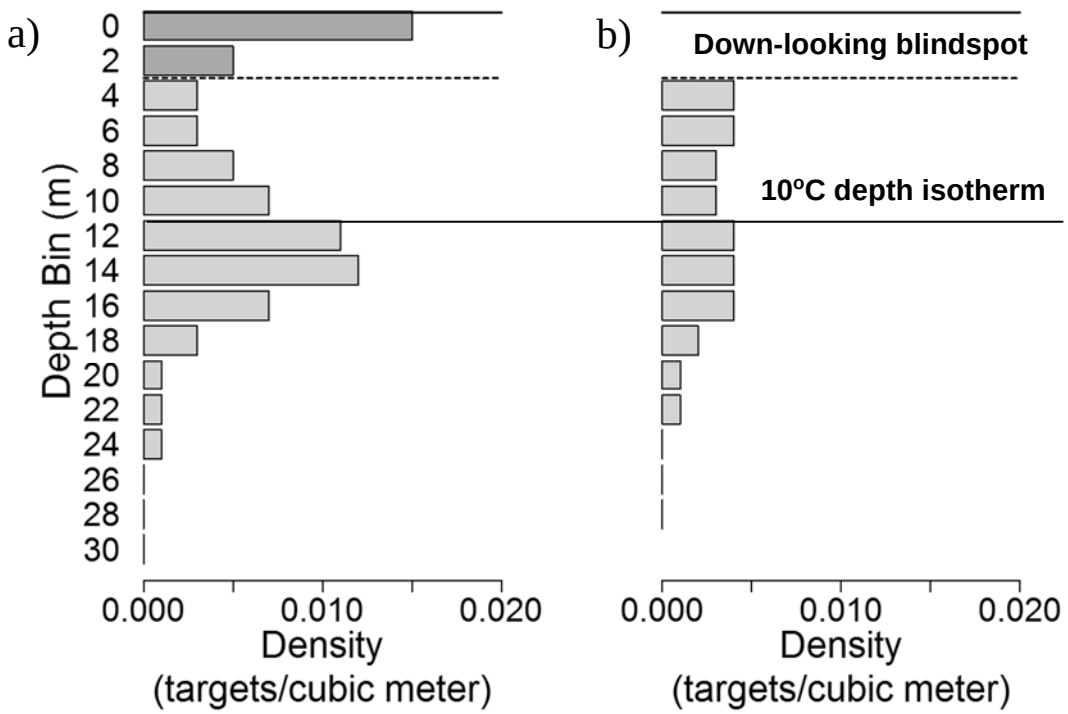


Figure 6. Comparison of depth stratified estimates of Alewife (targets m^3 from simultaneous towed (a) up-looking and (b) down-looking acoustics. The dashed line represents the acoustics "blindspot" of downlooking transducers. Alewife are assumed to occupy temperatures above 10°C.

Lake Sturgeon Tagging Study 2014

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Lake Sturgeon (*Acipenser fulvescens*) were historically an abundant and widely distributed species in New York State (NYS). Overharvest, habitat degradation, and migratory impediments (dams) resulted in drastic decline of the species by the early 1900s. Due to severely depleted stocks, the Lake Sturgeon fishery was closed in NYS in 1976. Lake Sturgeon were listed as a threatened species by NYS 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 methodology 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 was the final year of a five year project funded in part by the U.S. Fish and Wildlife Service's Fish Enhancement, Mitigation and Research Fund (FEMRF) to tag Lake Sturgeon with permanent individual markers. Lake Sturgeon were collected annually (2010-2014) at various sites in the St. Lawrence River and Eastern Basin of Lake Ontario. 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.

Methods

Geographic Area

Project boundaries encompass the U.S. portions of the St. Lawrence River and the Eastern Basin of Lake Ontario. The U.S. portion of the St. Lawrence includes approximately 84 mi^2 of water, of which a very small portion is both suitable for netting activity and overlaps with suitable sturgeon habitat.

Near shore areas of eastern Lake Ontario encompass waters from the southern boundary of Jefferson County near Montario Point, north to the beginning of the St. Lawrence River at Cape Vincent, approximately 800 mi^2. Water less than 100 feet in depth was considered suitable for Lake Sturgeon sampling.

Collection

Lake Sturgeon were collected from April-June in 2014. Lake Sturgeon 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), the upper St. Lawrence at the mouth of the Oswegatchie River, and in the St. Lawrence River immediately downstream of the Moses Power Dam at Massena, NY (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 netting sites are shown in Figure 1.

All fish were collected with monofilament gill nets fished from 3.0 – 24.7 hours in waters from

13-57 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. Tags were placed under the fourth dorsal scute, the standard location for the NYS Department of Environmental Conservation (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 2008-2009 when a limited number of tags were made available to DEC Region 6. In 2010 a FEMRF grant provided 1,000 tags and related equipment for large scale tagging of sturgeon in the St. Lawrence River and Eastern Basin of Lake Ontario.

Overall 2014 Results

DEC personnel captured a total of 245 Lake Sturgeon throughout the sampling area in 2014. PIT tags were applied to 205 sturgeon (90% St. Lawrence River; 10% Lake Ontario), ranging in length from 31.5-68.5 inches TL and weighing from 5.5-100 pounds. Length-weight relationships were constructed using data from all sturgeon collected from 2010-2014 (Figure 2) and separated by sex (Figure 3). Sturgeon body form can be quite variable as demonstrated by the relationships. A total of 40 recaptures were recorded in 2014, three from historic collections (SUNY College of Environmental Science and Forestry (ESF), 1995-1998) and 37 from 2005-2013 collections. The majority of recaptured fish came from the general area of initial tagging. Two fish had traveled extensive distances, however, and are described below.

Males (N=133) accounted for 54.3% of the catch while females (N=18) constituted 7.3%. The remaining fish were either immature or of undetermined sex (N=94, 19.5%). 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). Annual sampling since 2005 has targeted spawning fish to acquire biological information and apply Floy® or PIT tags.

Due to high discharge in the Black River (range 6,200-42,000 cfs, USGS gage 04260500, Watertown) from April – May 6, 2014, no attempt was made to collect fish. The effective flow limit of 6000 cfs for effective netting was exceeded throughout the entire sampling period. Effort was shifted to Black River Bay to collect staging sturgeon prior to entering the river.

A total of 24 lake sturgeon were captured in Black River Bay from April 17- May 1, 2014. Water temperature was relatively stable and ranged from 47-49 °F. A total effort of 259.7 net-hrs was expended resulting in a catch per unit effort (CUE) = 0.09 fish/hr (Table 2). Sturgeon ranged in length from 40.9-59.6 in. and weight from 22.0-71.6 lbs. Sex could not be determined for any of the fish collected. 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. This suggests that Black River Bay likely serves as a staging area for fish that will later migrate to spawning sites upstream.

Eight fish tagged from 2005-2011 were recaptured in the Black River Bay, seven of which were initially tagged in that area. This suggests a relatively small spawning population using the Black River. One recaptured fish possessed a Carlin tag (# 0229) applied by Cornell University staff on Oneida Lake in 2005 (Tom Brooking, personal communication). The approximate, minimum travel distance from Oneida Lake to the recapture point in Black River Bay is 92 miles.

The annual index gill net survey conducted by the Lake Ontario Unit (Cape Vincent, NY) in the eastern basin collected no sturgeon in 2014. Nets were fished at 25 sites with a total effort of 467.4 net-hrs (Table 2).

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, both potential migrating spawners and resident fish.

Broodstock collection at the Moses Power Project (South Channel) accounts for 80-90% of the annual Lake Sturgeon catch. Netting effort has ranged from 204.6-825.9 net-hours from 2010-2014, which was primarily driven by the collection of fish for egg take purposes. It is assumed that adult spawning fish stage in the South Channel, therefore making them vulnerable to gill netting.

A total of 199 sturgeon were collected from May 22-June 10, 2014 at four net sites with an effort of 825.9 net-hrs (Table 2). Water temperature in the South Channel ranged from 56-60°F during the sampling period. Overall netting effort was the highest since the recent egg take began in 2009. Catch rate in 2014 (0.24 fish/hr) was similar to 2013, but remains lower than previous years (CUE range 2009-2012; 0.37-0.59 fish/hr). Males (N=121) represented 60.8% of the catch whereas females (N=14) represented 7.0%. Sturgeon collected in 2014 ranged in length from 31.5-63.0 in and in weight from 5.5-63.0 lb. Fish used for the 2014 egg take (females N=4, males N=13) were taken from this group.

There were 27 recaptures at this location in 2014 which were classified as either historic (N=3) or recent (N=24). 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 2006-2013.

One recaptured fish was originally tagged by USGS in 2009 in the Oswegatchie River between Ogdensburg and Eel Weir. Total minimum distance between the capture and recapture site is approximately 45 miles. This was the third PIT tagged fish known to have either been entrained through the Dam, or migrated through the Wiley-Dondero Canal (Eisenhauer and Snell locks).

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 1230.11 net-hrs (62 net-nights) in 2014 did not collect any sturgeon (Table 2).

The only targeted effort at collecting sturgeon in the St. Lawrence River above the Dam in 2014 focused on the mouth of the Oswegatchie River. Previous work by USGS and DEC (2009-2013) identified a concentration of spawning sturgeon at this location. Four nets set May 13-14 (53.5 net-hrs) yielded 22 sturgeon, five of which were recaptures from 2010 netting by USGS.

Ripe males (N=12) comprised the bulk of the catch. Females (N=4) were mostly ripe (N=3) with one fish that was ripe-running, indicating that a spawning event likely occurred. Sex could not be assigned for the remaining sturgeon (N=6). Sturgeon ranged in length from 46.6-68.5 in and in weight from 23.6-100 lbs.

Previous efforts by USGS staff to collect sturgeon eggs at the mouth of the Oswegatchie River were unsuccessful. The presence of adult sturgeon in spawning condition implies that sturgeon are likely using spawning habitat in the lower Oswegatchie, making this an area of interest for more intensive investigations.

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 beyond this study.

From 2010-2014 a total of 870 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. Six sturgeon collected through the five year project are known to have made long movements from initial capture sites. Five 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 only as it had consistent effort throughout the 5 year period. Regardless of netting effort in a particular year, the recapture rate remained static at 3-4% of catch annually.

One goal of this project was to determine spawning periodicity of sturgeon in Lake Ontario and the St. Lawrence River. Only 44 individual fish have been collected multiple times which limits conclusions. One female was collected twice, changing in reproductive status from “unknown” to ripe over a span of two years. Males were the predominant recaptures (N=43) with four fish having been caught in three of the five years. Five males were ripe in successive years (11.6%) and ten were ripe (23.3%) on alternate years.

The overall results of this 5 year study suggest that Lake Sturgeon populations in Eastern Lake Ontario and the St. Lawrence River have been recovering for several decades. 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 effort on known spawning concentrations: Black River, SLR below the Moses Power Dam.

2. Continue efforts to collect juvenile sturgeon in Black River Bay and the Coles Creek area utilizing gill nets and trawls.

3. Continue to focus effort on areas of the St. Lawrence River with demonstrated concentrations of Lake Sturgeon such as Oak Point, Morristown, and Coles Creek.

4. Continue exploratory netting in areas of Lake Ontario around Point Peninsula, Grenadier Island, and Henderson Bay.

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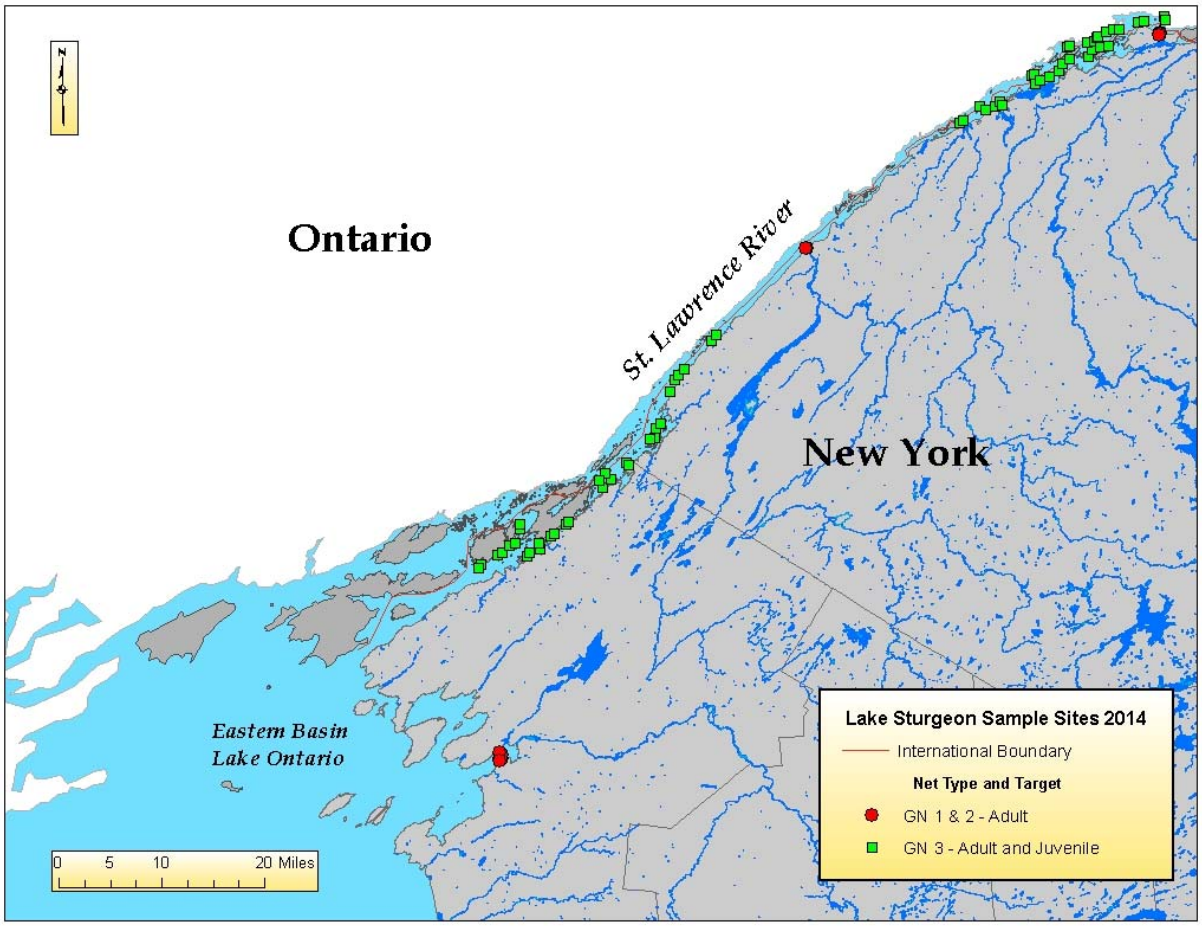

Figure 1. Lake Sturgeon collection locations and targets for 2014. Adults were targeted with large mesh gill nets only (GN1 & 2). Existing index projects in the Thousand Islands and Lake St. Lawrence potentially targeted "Both", juveniles and adults, utilizing primarily experimental gill nets (GN3). Net site location data for the Eastern Basin Lake Ontario gill net assessment (GN4) were not available for this figure.

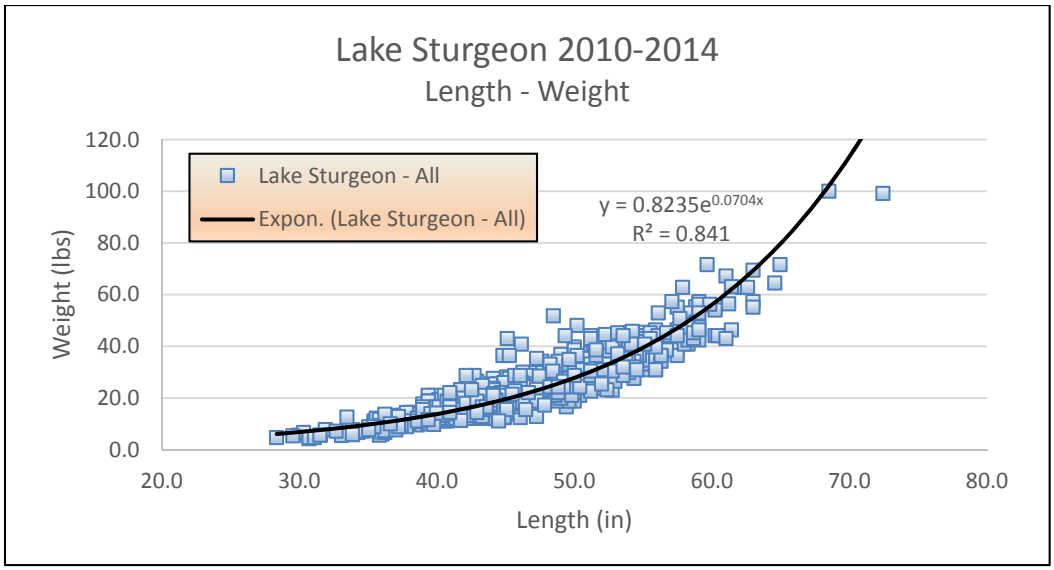

Figure 2. Length-weight relationship for Lake Sturgeon collected by DEC from 2010-2014. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined with no differentiation to sex.

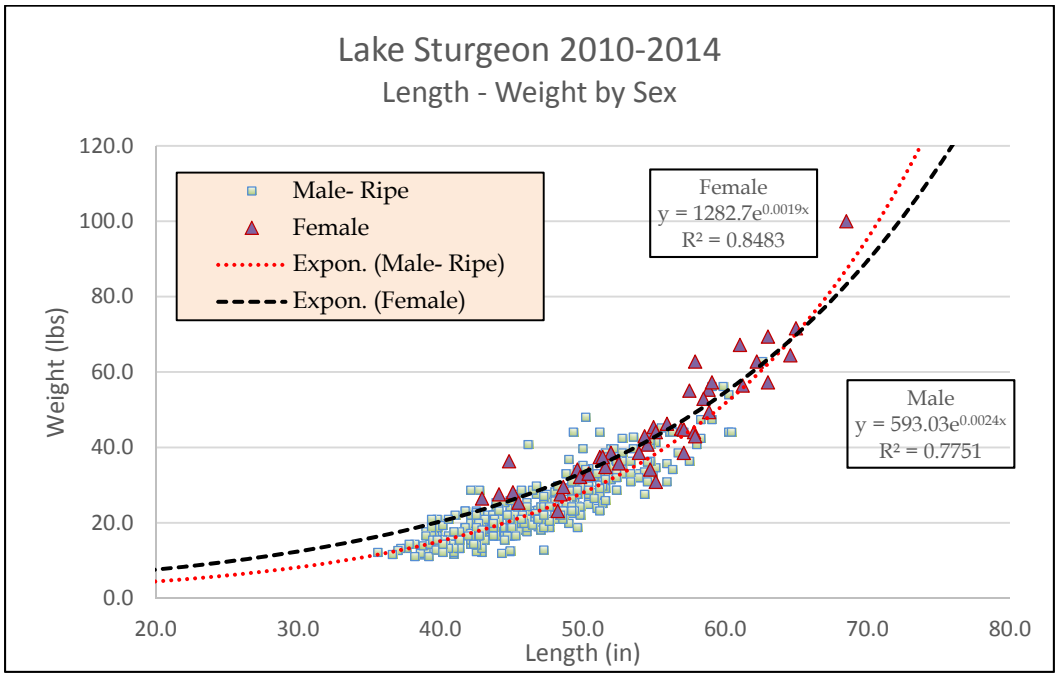

Figure 3. Length-weight relationship for Lake Sturgeon collected by DEC from 2010-2014 separated by sex. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined. Only female and ripe male sturgeon are presented.

Table 1. Net specifications used for collecting Lake Sturgeon in 2014. 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 2014. Targeted surveys specifically attempted to collect sturgeon. Existing project surveys targeted the major fish assemblage with sturgeon as a possible component.

Location	Dates	# Sites	Target	Net Code	Effort (hrs)	Catch	CUE (fish/hr)
Targeted							
Black River Bay	4/17-5/1/2014	13	A	GN1 & GN2	259.7	24	0.09
SLR @ Osw. R.	5/13-14/2014	3	A	GN1 & GN2	53.5	22	0.41
SLR@ South Channel	5/22-6/10/2014	4	A	GN1 & GN2	825.9	199	0.24
Existing projects							
SLR- TI	7/20-25/2014	32	B	GN3	638.97	0	0.00
LO Gill Net	7/29-8/9/2014	29	B	GN4	467.35	0	0.00
SLR- LSL	9/15-18/2014	32	B	GN3	591.14	0	0.00

Table 3. Total unique Lake Sturgeon catch from 2010-2014. Due to inconsistencies in sex determination fish labeled as Male-green (N=164) in the database were included in the Unknown category. Recapture data suggests that under most circumstances the Male-green information is accurate.

Sex	Number	Percentage
Male	400	46.0
Female	45	5.1
Unknown	425	48.9

Table 4. Tagging and recapture locations for six 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

2014 Status of the Lake Ontario Lower Trophic Levels

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Significant Findings for Year 2014:

1) Soluble reactive phosphorus (SRP) concentrations have been stable in nearshore and offshore habitats since 1998 (0.4 – 3.3 µg/L). SRP concentrations were low in 2014; Apr/May – Oct mean values were <1 µg/L at most sites. Spring TP concentrations at individual sites exceeded 10 µg/L on occasion, but spring means were below the 10 µg/L target set by the Great Lakes Water Quality Agreement of 1978 for offshore waters of Lake Ontario. TP concentrations were low at both nearshore and offshore locations; Apr/May – Oct mean values from individual sites ranged from 4.6 – 9.1 µg/L. Spring TP has declined significantly in the longer data series (since 1981), but not since 1995 indicating stable nutrient loading into Lake Ontario for nearly two decades. It averaged 7.8 µg/L in the nearshore and 5.6 µg/L in the offshore in 2014.
2) Chlorophyll-*a* and secchi depth values are indicative of oligotrophic conditions in nearshore and offshore habitats. Offshore summer chlorophyll-*a* declined significantly in both the short- (2000-2014) and long-term (1981-2014) time series at a rate of 4-6% per year. Nearshore chlorophyll-*a* increased after 2003 but then declined again after 2009. Epilimnetic chlorophyll-*a* averaged between 0.6 and 1.6 µg/L across sites with no difference between nearshore and offshore habitats. Apr/May – Oct Secchi depth ranged from 4.0 m to 10.8 m at individual sites and was higher in the offshore (average 9.1 m) than nearshore (5.9 m).
3) In 2014, Apr/May – Oct epilimnetic zooplankton density, size, and biomass were not different between the offshore and the nearshore, and there were no differences in epilimnetic biomass between offshore and nearshore areas for any of the zooplankton groups.
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 increased significantly since 1995.
5) The predatory cladoceran *Cercopagis* continued to be abundant in the summer, peaking at ~10 mg/m^3 in the offshore. *Bythotrephes* biomass was at its lowest level since 2005 in both offshore and nearshore habitats.
6) Summer nearshore zooplankton density and biomass have declined significantly since 1995 at rates of 9-10% per year but have remained stable since 2005. However, bosminids and daphnids increased in 2013 and 2014.
7) Summer offshore zooplankton density and biomass declined significantly in the long-term (since 1981), but remained at a lower stable level 2000 – 2014. A positive change point in 2013 is due to increases in bosminids, cyclopoid copepods, and daphnids.
8) The observed decline in zooplankton biomass may be due in part to redistribution of zooplankton throughout the water column. Most of the zooplankton biomass was in the metalimnion and hypolimnion during the stratified period in 2014. By October, the bulk of the biomass was in the epilimnion.

Introduction

This report presents data on the status of lower trophic levels of the Lake Ontario ecosystem (zooplankton, phytoplankton, nutrients) in 2014 and compares the 2014 data with long-term data from several sources. Lower trophic levels are indicators of ecosystem health (as identified by the Lake Ontario Pelagic Community Health Indicator Committee [EPA 1993] and presented in the biennial State of the Lake Ecosystem Conference [SOLEC] reports) and determine the lake's ability to support the prey fish upon which both wild and stocked salmonids depend. Understanding the production potential of lower trophic levels is integral to ecosystem-based management. Currently there are competing concerns regarding lake productivity. First, there is a question about the ability of the lake to support current alewife production in the offshore due to declining nutrient levels and zooplankton biomass. At the same time, high nutrient levels close to shore are contributing to excessive growth of attached algae (e.g., *Cladophora*) in some shoreline and beach areas. The collapse of the alewife population and decline in Chinook salmon fishery in Lake Huron in 2003 may have been due to declines in lower trophic levels (Barbiero et al. 2011, Bunnell et al. 2012). Alewives have not returned to Lake Huron as of 2014 (Gorman and Weidel 2015), and concerns of a similar crash in Lake Michigan led to a decision to decrease Chinook stocking rates in that lake.

From 1995-2014 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 are assessed from spring through fall because each indicator has particular importance at a specific time of the year. Springtime (Apr-May) represents a time of peak nutrient levels in many systems, 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 2014, included the New York State Department of Environmental Conservation (NYSDEC) Lake Ontario Unit and Region 6, 7 and 8 at Watertown, Cortland, and Avon; the U.S. Fish & Wildlife Service Lower Great Lakes Fishery Resources Office (USFWS); the U.S. Geological Survey–Lake Ontario Biological Station (USGS); and Cornell University.

Report Objectives

Using data from 1995 to 2014, we address the following questions:

(1) What is the status of Lake Ontario's lower trophic levels in 2014, and what differences exist between nearshore and offshore sites this year?
(2) What are the time trends in key indicators, and are there sudden changes in these trends (regression and change-point analysis). How does the year 2014 compare to these time trends (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 predation, changes in predatory invertebrates (*Cercopagis*, *Bythotrephes*, *Mysis*, *Hemimysis*) or decreased overall productivity of the lake?

Methods

<u>Sampling</u>

We measured total phosphorus (TP), soluble reactive phosphorus (SRP), chlorophyll-*a* (chl-*a*), water temperature, 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 2014 (12 potential sampling weeks). Inclement weather precluded sampling during one week at Galloo Island (GIL); during two weeks at Chaumont Bay (CBL), Niagara East (NEL), and Niagara West (NWL); and on three occasions at Sandy Pond (SPL) and Oak Orchard (OOL); all nearshore sites were sampled on at least 9 occasions. Offshore samples were collected during late April-early May, late May-early June, July, and September by the R/V Seth Green, and approximately monthly (April–October) by the R/V Kaho. In addition, five stations were sampled at night in July during the hydroacoustic survey conducted by the R/V Seth Green. Nearshore sites had depths ranging from 8.5 m to 15.0 m (28 to 49 ft), and offshore sites ranged from 17 m to 217 m (56 to 712 ft). Offshore sampling totaled 33 daytime samples taken from eight sites and four nighttime samples from four sites.

Water Chemistry

Water samples were collected for analysis of chl-*a*, TP, and SRP. Each sample was obtained by using an integrated water sampler (1.9 cm inside diameter Nalgene tubing) lowered to a depth of 10 m or bottom minus 1 m where site depth was 10 m or less. The tube was then closed off at the surface end and the column of water transferred to 2 L Nalgene containers. From each sample, a 100 mL unfiltered aliquot was frozen for later analysis of TP (Menzel and Corwin 1965). We also filtered 1-2 L of water through a Whatman 934-AH glass fiber filter that was frozen for later analysis of chl-*a* using acetone extraction followed by fluorometry (EPA 2013). A 100 mL aliquot of filtered water was frozen for later analysis of SRP (Strickland and Parsons 1972). TP and SRP samples were analyzed at the Upstate Freshwater Institute (UFI). Chl-*a* was analyzed at CBFS using a calibrated Turner 10-AU benchtop fluorometer and the EPA standard operating procedure SOP LG 405 (Revision 9, March 2013). In 2014, TP and SRP standard curves (for all years) were adjusted to reflect a y-intercept of zero. This adjustment caused changes in TP and SRP values reported previously but did not affect long-term trends or interpretation of the data.

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 7 to 10 m. At offshore sites, tow depths ranged from 6 to 39 m (to the thermocline when stratification was present, epilimnetic sample). At offshore sites less than 100 m bottom depth (four daytime site and one nighttime site) a total water column sample (bottom minus 2 m) was collected in addition to the epilimnetic sample. At sites greater than 100 m bottom depth (four daytime sites and three nighttime sites), one 50 m and one 100 m tow were obtained in addition to the standard epilimnetic sample. Zooplankton were anesthetized with antacid tablets and then preserved in the field with 95% ethyl alcohol. At nearshore sites, single samples were collected on a biweekly basis from May to October with the exception of July and August during which duplicate samples were collected on each sampling date. Mean values from these duplicates were used in all analyses.

At CBFS, each sample was strained through a 1.02 mm mesh cup to separate *Cercopagis* and other larger organisms (>1 mm in length) from smaller zooplankton (<1 mm). This was done because *Cercopagis* and *Bythotrephes* form clumps in the sample, making the usual random sub-sampling of 1 mL samples inappropriate. For each sample that contained clumps of *Cercopagis* or *Bythotrephes*, two analyses were performed - one on the smaller zooplankton and one on the larger zooplankton (including

Cercopagis and *Bythotrephes*) that were caught in the 1.02 mm mesh strainer. At least 100 larger zooplankton (or the whole sample) were measured and enumerated by sub-sampling organisms from a gridded, numbered Petri dish in which the sample had been homogeneously separated. In some cases, different subsamples were used for *Bythotrephes* and *Cercopagis*. To calculate the total number of large crustaceans and *Cercopagis* in the clumped part of the sample, we used a ratio of wet weights of the sub-sample to wet weights of the total sample. Wet weights were determined using a Sartorius balance.

For smaller-sized zooplankton, we counted and measured at least 100 organisms from one or more 1 mL random sub-samples. The sub-sample was examined through a compound microscope at 10-40X magnification. Images from the sample were projected onto a digitizing tablet that was interfaced with a computer. Zooplankton were measured on the digitizing tablet and identified to species (with the exception of nauplii and copepodites) (Pennak 1978, Balcer et al. 1984). In earlier years of this project an electronic touch screen (1995-1997) and a 20X microprojector (1998-2000) were used for measuring the zooplankton (Hambright and Fridman 1994). We then used length:dry-weight regression equations (CBFS standard set, Watkins et al. 2011) to estimate zooplankton biomass. Densities from all counts of the same sample (large and small animals) were summed to yield an overall density of all organisms in each sample.

Data Analyses

We compared April/May to October mean TP, SRP, chl-*a*, SD, zooplankton density, size, and biomass, and zooplankton group biomass between the two habitats by first averaging across sites for each month (nearshore, n=7; offshore, n=7) and then comparing the two habitats using paired comparisons by month (n=5; Wilcoxon signed rank test). Offshore data collected in late April was analyzed with May nearshore data and offshore data collected in late May was analyzed with June nearshore data because of the proximity of nearshore to offshore sampling dates for 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 on long-term trends in two time stanzas (1995–2014 and 1981–2014) to test for breaks in the data. These 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 10,000 times to construct confidence intervals based on the inherent variability in the data series, and testing if and when the observed data series differ significantly from these confidence intervals. Regression analyses (JMP Pro v10.0.2, SAS Institute Inc. 2012) were performed on the same two time stanzas (1995–2014 and 1981–2014) using spring TP, summer chl-*a*, summer epilimnetic zooplankton density and biomass, and zooplankton group biomass. We note that reports published prior to 2013 incorporated nighttime zooplankton data from 1995 – 1999 in the regression and change point analyses; nighttime samples were removed from those analyses starting in 2013. 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 5 to 16% (mean of 15%) for TP and from 7 to 47% (mean of 24%) 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 3 to 23% (mean of 12%), the CV for SRP ranged from 29 to 78% (mean of 59%), and the CV for chl-*a* ranged from 12 to 48% (mean of 28%). 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 (0.2 – 1.7 µg/L) where a small difference in absolute concentration could result in a large CV. Values were averaged for later analyses.

2014 Water Quality

May through October mean chl-*a*, TP, SRP, and SD were similar across nearshore sites in 2014 (Table 1). Chl-*a* and TP were highest at the site east of the Niagara River (NEL; 1.9 µg/L chl-*a*, 9.1 µg/L TP) and lowest at Galloo Island (GIL; 0.8 µg/L chl-*a*, 6.1 µg/L TP). SD was shallower at NEL (4.0 m) than at GIL (8.7 m). SRP was highest at Sandy Pond (SPL, 1.6 µg/L) and lowest at GIL (0.6 µg/L) (Table 1). Measurements of the same parameters at offshore locations also showed low variability. Chl-*a* ranged from 0.6 µg/L (Main Duck) - 1.6 µg/L (Smoky Point-O), TP ranged from 4.6 µg/L (Oak Orchard-O) - 6.3 µg/L (Smoky Point-O), SRP ranged from 0.3 µg/L (Smoky Point-O and Smoky Point-N) – 1.2 µg/L (Tibbetts Point), and SD ranged from 7.0 m (Tibbetts Point) – 10.8 m (Oak Orchard-O) (Table 1).

Seasonal trends were also observed for most variables. Nearshore SD was about 6 m Apr – Sep (range 4.0 – 8.7 m) then decreased in Oct, while offshore SD declined from approximately 12 m in the spring to 7.5 m in July and September (Figure 2a). Monthly chl-*a* concentrations were low at both nearshore and offshore locations (0.7 – 1.4 µg/L) and exhibited no clear pattern (Figure 3a). Nearshore monthly TP concentrations were stable (7.2 – 8.0 µg/L) while offshore concentrations increased from a low of 4.1 µg/L in Apr/May to a high of 7.3 µg/L in September (Figure 4a). SRP concentrations showed a similar pattern with stable nearshore concentrations (0.8 – 1.0 µg/L) and with offshore concentrations increasing from an Apr/May low of 0.5 µg/L to a high of 1.0 µg/L in September, followed by a decline in Oct (0.2 µg/L) (Figure 5a). While spring TP concentrations at individual sites exceeded 10 µg/L on occasion, average spring TP concentrations at nearshore (8.0 µg/L) and offshore (4.1 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).

Total phosphorus, chl-*a*, and SD are typically correlated, as all are potential indicators of phytoplankton abundance. This was evident at the individual sites in 2014, but not in the comparison of Apr/May - Oct mean values between habitats; there was no difference in TP, SRP, SD or chl-*a* between nearshore and offshore habitats (Tables 1 and 2).

Water Quality Trends Since 1995

Comparisons with data collected since 1995 show that 2014 had average SD (Figure 2b) and below average chl-*a* concentrations (Figure 3b). Nearshore TP was average, but offshore TP, offshore SRP, and nearshore SRP were all below average (Figure 4b, 5b). Summer chl-*a* decreased significantly 2000 – 2014 in the offshore, and there was a negative change point in 2012. There was no trend in summer chl-*a* in the nearshore, but there was a positive change point in 2003 and a negative change point in 2009 (Table 3). Nearshore SRP showed a positive change point in 1992 (Table 3).

2014 Zooplankton

In 2014, mean Apr/May-Oct zooplankton density did not differ significantly between nearshore and offshore sites (Table 2, Figure 6). Density and biomass were highest during September in both habitats (Figure 6). This coincided with peaks in calanoid copepod, daphnid, and *Holopedium* biomass (Figure 7). Zooplankton biomass and mean size were not significantly different between nearshore and offshore sites (Table 2, Figure 6).

As with total epilimnetic zooplankton biomass, individual group biomasses were not significantly different between nearshore and offshore habitats (Table 2; Figure 7). Cyclopoid copepods (primarily *Diacyclops thomasi*) represented the greatest proportion of biomass in the offshore (28%) while a single species, *Holopedium gibberum*, accounted for the greatest proportion of biomass in the nearshore (23%). The proportion of *Holopedium* biomass in the offshore (14%) rivaled that of all calanoids (19%) and all daphnids (18%).

In 2014, *Cercopagis* and *Bythotrephes* were detected in samples from both habitats (Figures 7 and 8, Table 2). *Cercopagis* was first detected in late May in the nearshore and in mid-July in the offshore. *Cercopagis* peaked during late-July in the nearshore and offshore (Figure 7). *Bythotrephes* was present in early May in the nearshore, was absent until mid-August, and peaked in early September. It did not appear until late September at offshore locations and its biomass was very low (Figure 7). Combined biomass of *Cercopagis* and *Bythotrephes* represented 4% of the zooplankton community at nearshore sites and 2% at offshore sites.

Ilyocryptus sp. was found in the sample taken at OOL on 5/21/2014. This was the first occurrence of this species in BMP zooplankton collections. A detailed description of Ilyocryptus morphology and taxonomy can be found in Kotov and Williams (2000).

Zooplankton Trends Since 1995

From 1995-2014 total summer epilimnetic zooplankton biomass declined significantly at nearshore sites but was only marginally significant at offshore sites (Figure 9, Table 3). Change point analysis showed that a 2005 negative break occurred in offshore total zooplankton density and biomass (Figures 9 and 10, Table 3). Change points in the offshore were also evident with cyclopoid copepods (2005) and bosminids (2004), and coincided with an increase in *Bythotrephes* (2006; Figure 8; discussion in Rudstam et al. 2015). A positive change point occurred with the offshore total density in 2013, coinciding with increased cyclopoid copepods and bosminids. In the nearshore, declines in zooplankton biomass (1998 change point) and density (1998 and 2005 change points) coincided with significant declines in bosminids and cyclopoid copepods (Table 3). Those same groups showed downward trends in the offshore, but their decline was not significant. Calanoid copepods increased significantly in the offshore but remained stable in the nearshore. At the same time, *Bythotrephes* and *Cercopagis* biomass increased marginally in the offshore but not in the nearshore (Table 3; Figure 8). However, *Bythotrephes* biomass peaks in the fall and it has shown a steady downward trend during Sep-Oct since 2009. In 2014, *Bythothrephes* had the lowest biomass observed since 2004 (Figure 8B).

Longer term trends (1981-2014) were significant for three offshore lower trophic level indicators. These trends were evaluated by adding BMP data to available data series from the Department of Fisheries and Oceans Canada, and point data from the Lake Ontario Trophic Transfer and Lake Ontario Lower food web Assessment studies (Table 3). Significant offshore long-term trends were decreases in spring TP, summer chl-*a*, and summer zooplankton density (Figures 3b, 4b, and 10; see also Mills et al. 2003; Holeck et al. 2008, 2015). Despite the long-term decrease in summer epilimnetic zooplankton density, a positive breakpoint occurred in 2013; this break was evident in the short-term (2000 – 2014) data as well (Table 3).

Stratified Zooplankton Hauls

Comparison of epi-, meta-, and hypolimnetic daytime zooplankton tows showed that the highest concentrations occurred in the metalimnion during the stratified period (July and September) (Figure 11). Exceptions

occurred at Smokey Point-O 7/21 and Olcott 9/14 where half or more of the biomass was found in the hypolimnion. Epilimnetic biomass represented only 2 – 29% of total water column biomass during the stratified period (Figure 11). At sites less than 100 m bottom depth, epilimnetic biomass ranged from 21 – 97% with higher percentages occurring during the stratified period (e.g., Main Duck 7/14 and Smoky Point-O 9/2). In July and September, an average of 89% of the zooplankton biomass at deep offshore sites resided below the thermocline. Nighttime tows taken in mid-July show a more even distribution of zooplankton above and below the thermocline (Figure 12). This pattern was also evident in late fall daytime samples (10/1/14) (Figure 11).

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 13). Most zooplankton biomass occurred in the metalimnion in July and September but shifted to the epilimnion by October. In the epilimnion, cyclopoids and bosminids represented the greatest biomass in July. By September there was a more even mix of species in the epilimnion; *Limnocalanus* and daphnia represented slightly over half the biomass at that time, followed by bosminids (20%), *Cercopagis* (15%), and *Holopedium* (8%). By October, cyclopoids and daphnia dominated the epilimnion. Cyclopoids dominated zooplankton biomass in the metalimnion during July, September, and October. *Limnocalanus* and cyclopoids dominated the hypolimnion in July. This shifted to *Limnocalanus* and other calanoids by September, and to a mix of cyclopoids, *Holopedium* and *Limnocalanus* by October (Figure 13).

Discussion

Secchi depth, chl-*a*, and total phosphorus are indicators of lake trophic status (Carlson 1977). In 2014, average Apr-Oct values for all sites ranged from 4.0 to 10.6 m SD, 0.6 to 1.9 µg/L chl-*a*, 4.6 to 9.1 µg/L TP, and 0.3 to 1.6 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 and EPA's lower trophic level assessments in 2003, 2008, and 2013. Spring TP has been below the goal of 10 µg/L set by the Great Lakes Water Quality Agreement of 1978 at offshore sites since 1996 (not all years available) and close to that goal at nearshore sites (Figure 4b). Interestingly, summer chl-*a* declined since 1996 but spring TP did not. This paradox may be associated with phosphorus being retained in the deep chlorophyll layer (see below) or retained in the bottom waters by quagga mussels. In any case, the lack of change in epilimnetic TP since 1996 is indicative of stable nutrient loading into Lake Ontario over the last 19 years.

The seasonal trend in 2014 indicated that zooplankton density and biomass were low at both nearshore and offshore sites from Apr/May through late June and peaked in September. Average size in the nearshore was smallest in late June-early July, coinciding with alewife concentrating in the nearshore to spawn and their predation on the larger zooplankton (O'Gorman et al. 1991, Klumb et al. 2003). Increased density and biomass in September was due to large numbers of *Holopedium* in nearshore waters, and due to *Holopedium* and cyclopoid copepods in offshore waters. *Holopedium* biomass in Lake Ontario's nearshore showed a significant increase since 1995 (Table 3). Jeziorski et al. (2014) noted replacement of calcium-rich daphnid species by calcium-poor *Holopedium* in Canadian lakes where calcium (Ca) concentrations had declined. Chapra et al. (2012) noted a significant decline in Ca concentrations in Lake Ontario 1970 – 2009 but it is unlikely this decline is responsible for the observed increase in *Holopedium* because the reduced Ca concentrations in Lake Ontario (i.e., 34-42 mg/L) were well above the

low levels reported by Jeziorski et al. (1-3 mg/L; 2014). Chapra et al. (2012) also reported stable Ca concentrations in Lake Ontario since 2000. However, *Holopedium* began increasing in the nearshore after 1995 (Table 3). 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.* Fall biomass of *Bythotrephes* in 2014 was at its lowest level since 2004. The reason for the high biomass of *Holopedium* in 2014 remains unclear.

Epilimnetic crustacean zooplankton density and biomass were low at nearshore and offshore sites in 2014 compared to the long-term mean (Figures 9 and 10). Significant declines occurred in nearshore density and biomass, 1995 – 2014. Significant declines in nearshore biomass were due in large part to declines in cyclopoid copepods and bosminids which coincides with increases in the invasive predatory cladocerans *Cercopagis* and *Bythotrephes* (Table 3). These trends are consistent with observed effects of these predatory zooplankton in Lake Ontario and elsewhere (Lehman and Caceres 1993, Yan et al. 2001, Pangle et al. 2007, Bunnell et al. 2011, Benoit et al. 2002, Laxson et al. 2003, Warner et al. 2006). Similar declines were not evident in offshore waters, possibly due to a lack of daytime offshore data from 1995 – 1999. Nighttime data were available from 1995 – 1999, but were not used in the offshore analysis in 2014 because zooplankton migrate upward in the water column at night (Rudstam et al. 2012; Figure 11; Figure 12), introducing a bias toward higher epilimnetic values. Significant declines in offshore density and biomass were reported in previous years and the inclusion of nighttime data in those analyses could be the reason for those results. Regression analysis of only nighttime density and biomass (offshore) from 1995 – 2014 showed no significant declines. While the long-term decline (1981 – 2014) in summer offshore epilimnetic density is significant, increases in density of bosminids and cyclopoids since 2005 have weakened the overall negative trend such that it is no longer significant.

The observed decline in zooplankton biomass could be due in part to the redistribution of zooplankton throughout the water column. Results from summer (July) stratified zooplankton hauls indicated that epilimnetic biomass represented only 12% of the total biomass. Most (58%) zooplankton were found in the metalimnion at this time. During the stratified period (July and September), areal biomass (mg/m^2) was higher in the metalimnion on five of seven sampling occasions and in the hypolimnion on two of seven sampling occasions. This is not unexpected since the volume of water sampled in the metalimnion and hypolimnion was greater than that in the epilimnion; depth-stratified tows typically sampled 20 m of epilimnion, 30 m of metalimnion, and 50 m of hypolimnion. Zooplankton biomass dominated the metalimnion on a volumetric basis as well; metalimnetic waters averaged 94 mg/m^3, while hypo- and epilimnetic waters averaged 43 and 33 mg/m^3, respectively. We found an average of 74% of the zooplankton biomass to be below the thermocline (or 20 m when no thermocline was present) throughout the year. *Limnocalanus* dominated the hypolimnion while other calanoids were found mostly in the metalimnion, as were cyclopoids and nauplii. Bosminids, daphnids, *Cercopagis*, *Holopedium*, and *Polyphemus* were dominant in the epilimnion. We do not have long-term data for meta- and hypolimnetic zooplankton biomass. However, a sampling program that examined summer zooplankton biomass from whole water column (100m) tows indicated no significant decline in biomass in the eastern basin, 1997 - 2011 (Barbiero et al. 2015). This and the fact that we observed no significant decline in nighttime biomass 1995 – 2014 support the idea that the epilimnetic decline is a result of vertical redistribution.

Zooplankton abundance, distribution, and species composition can influence abundance and condition of planktivorous fish. In 2014, abundance and condition of adult alewife declined slightly from levels observed in 2013, and condition is now below the long-term mean (Walsh et al. 2015). The decline in *Bythotrephes* biomass could indicate possible decreased food availability for alewife in 2014.

Johannsson et al. (1991) reported higher abundances of larger cladocerans (*D. mendotae*, *P. pediculus*, *H. gibberum*, *Leptodora*, and *Bythotrephes*) in a year with reduced alewife abundance. We noted increases in *P. pediculus* and *H. gibberum* in 2014 but not in *D. mendotae* or *Bythotrephes*. Johannsson et al. (1998) also noted increased cyclopoid abundance with declining alewife populations. In recent years (2011-2014), adult alewife abundance remained relatively stable at a time when good to strong year classes were produced (2010-2012; Walsh et al. 2015). However, low catch of yearling alewife in 2014 indicated a weak 2013 year class. In 2014, the invertebrate predator, *Bythotrephes*, was at its lowest level since 2004. Both of these factors (i.e., potentially reduced predation) may have resulted in increased cyclopoid biomass 2013-2014. The mixed results in species composition between our study and others along with the reversal of trends in several zooplankton groups since 2005 (increases in bosminids and cyclopoids; decreases in *Bythotrephes*) may be a sign that zooplankton in Lake Ontario are in a transitional period.

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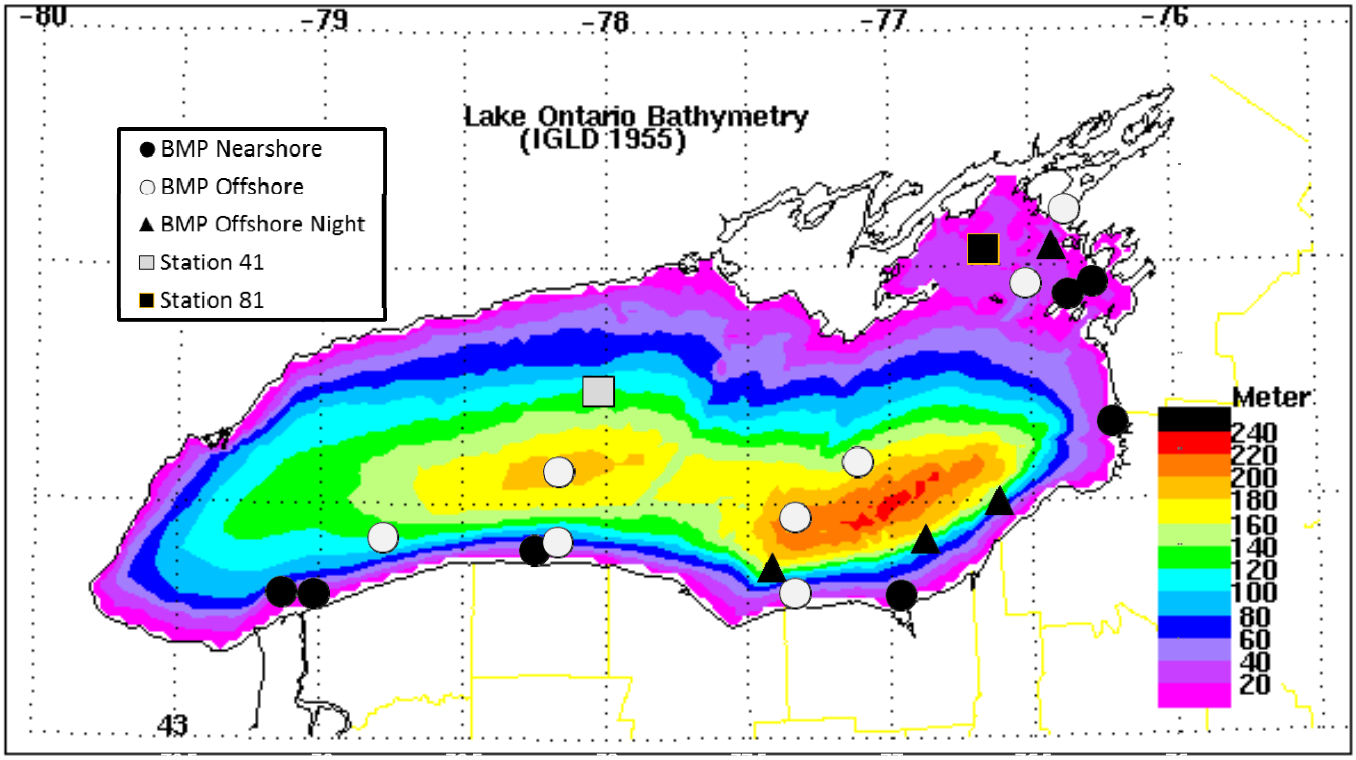

Figure 1. Map of Biomonitoring Program sites, 2014. Station 41 and station 81 are locations sampled by the Department of Fisheries and Oceans Canada's Bioindex Program (1981 – 1995) and are included here as reference for long-term data included in subsequent figures.

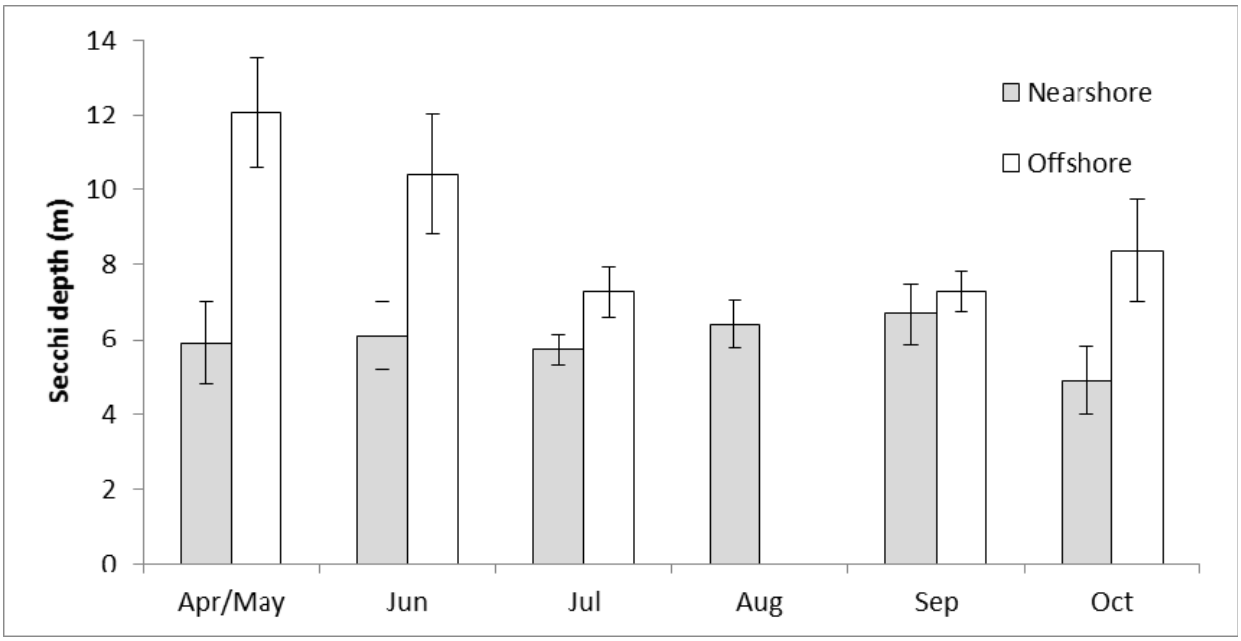

Figure 2a. Mean monthly Secchi depth (meters) for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2014. Error bars are ± 1SE.

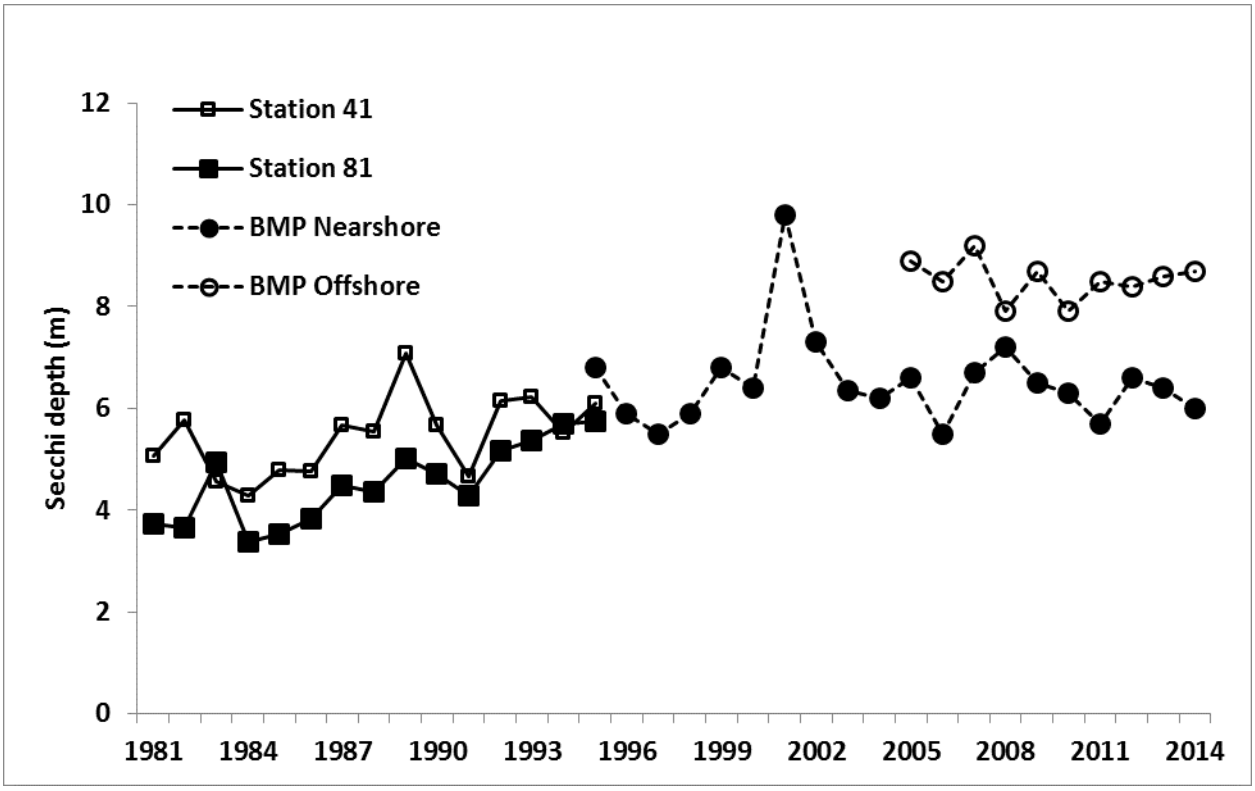

Figure 2b. Long-term mean Apr/May – Oct Secchi depth (meters) in Lake Ontario, 1981 – 2014. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2014 are from the US Biomonitoring Program (BMP).

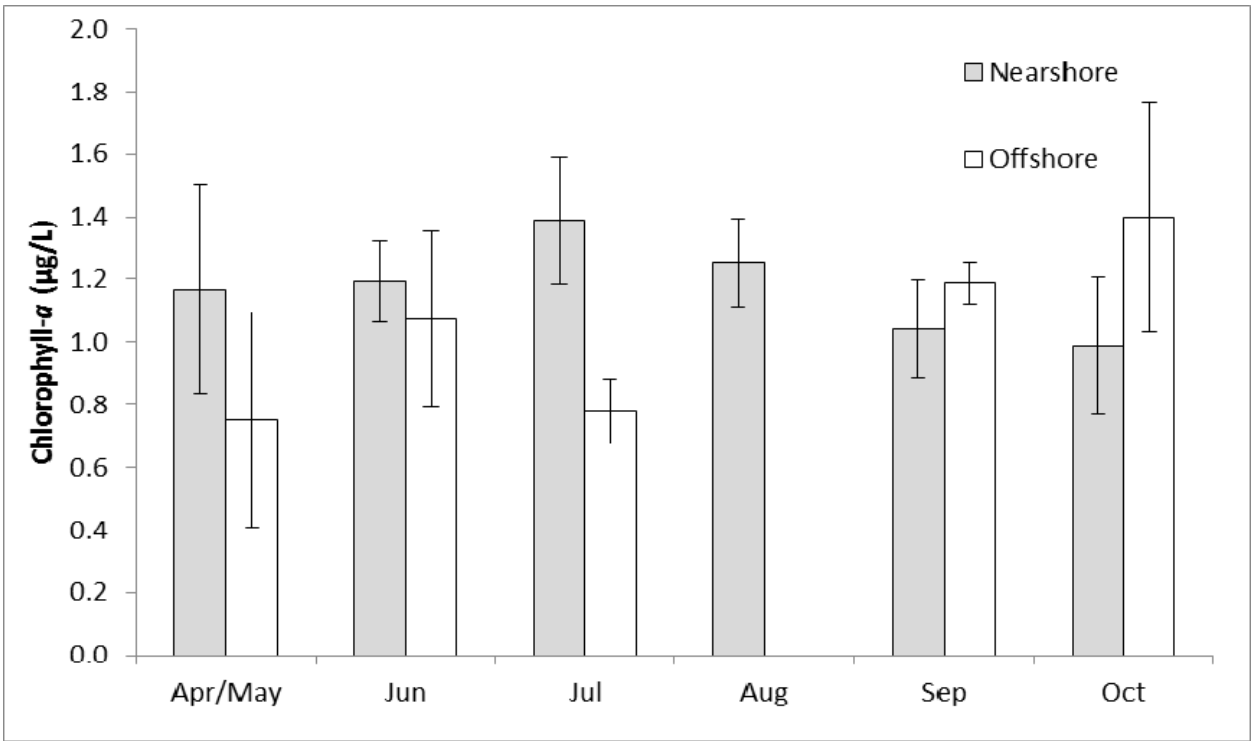

Figure 3a. Mean monthly epilimnetic chlorophyll-a concentrations for nearshore and offshore habitats in Lake Ontario, Apr/ May - October, 2014. Error bars are ± 1SE.

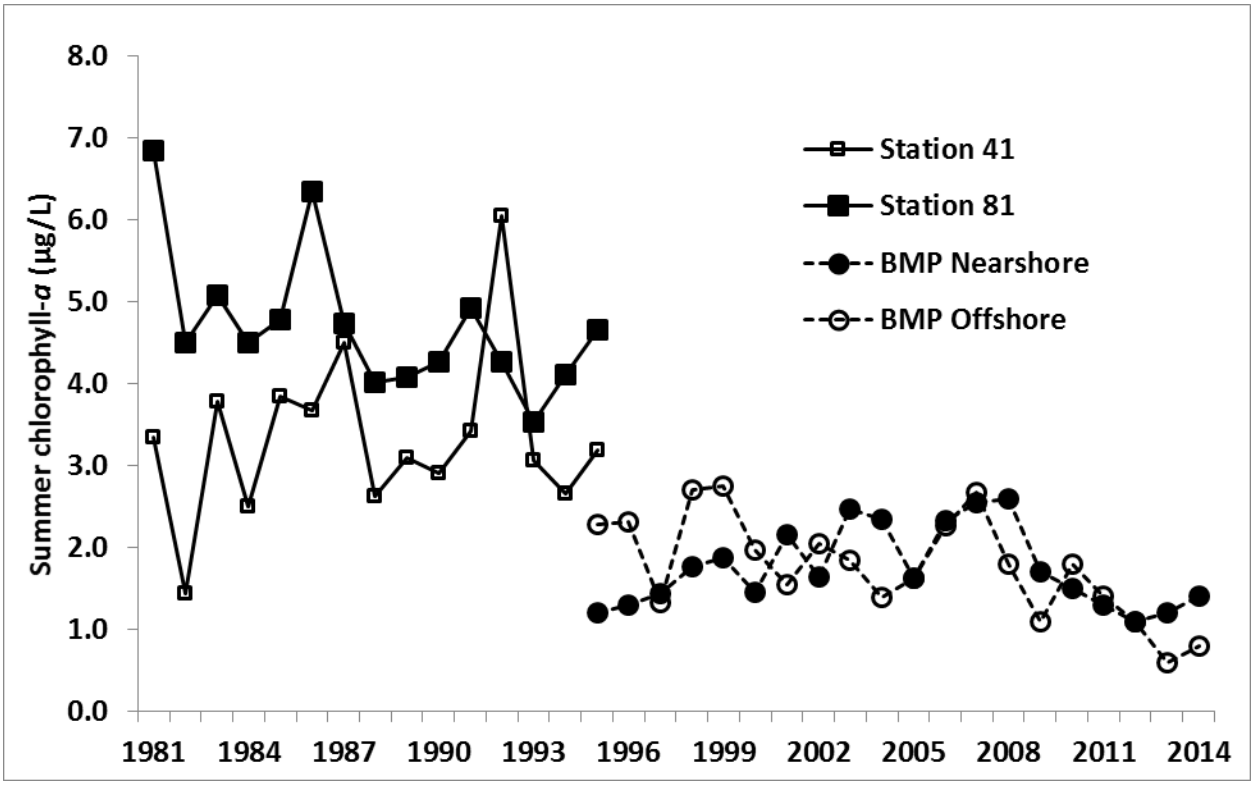

Figure 3b. Long-term summer (Jul – Aug) epilimnetic chlorophyll-a concentrations in Lake Ontario, 1981 - 2014. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2014 are from the US Biomonitoring Program.

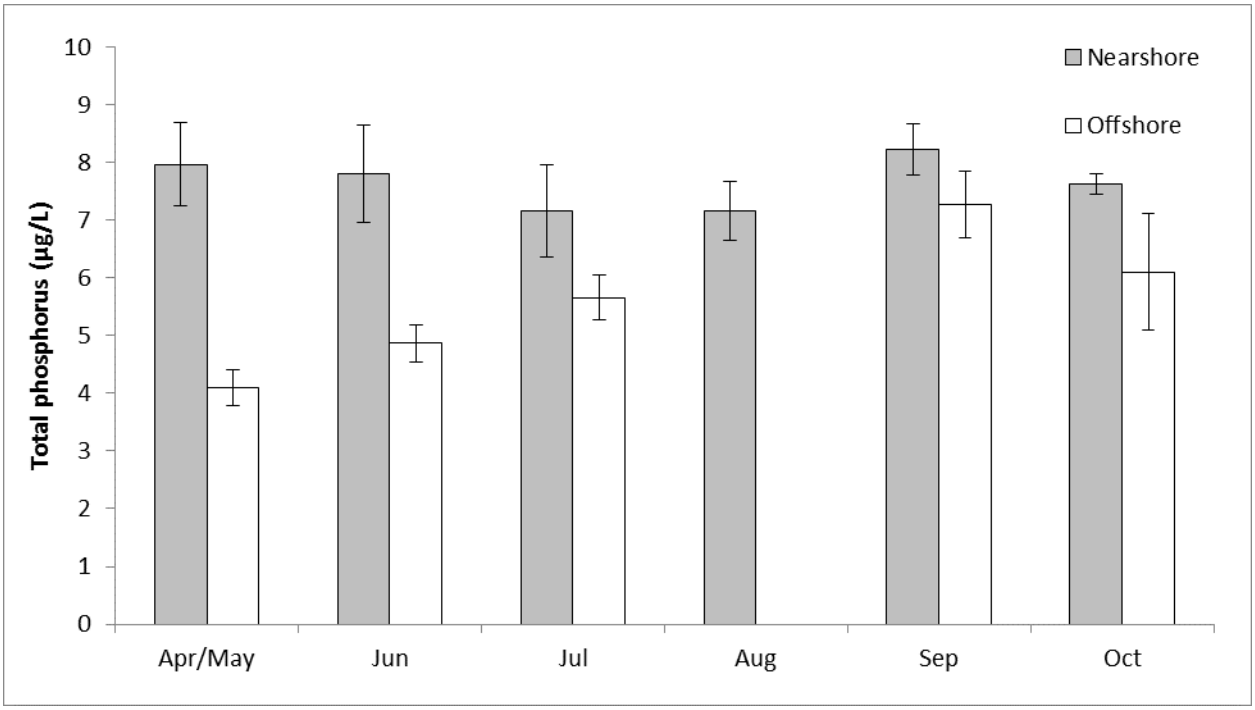

Figure 4a. Mean monthly total phosphorus concentrations for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2014. Error bars are ± 1SE.

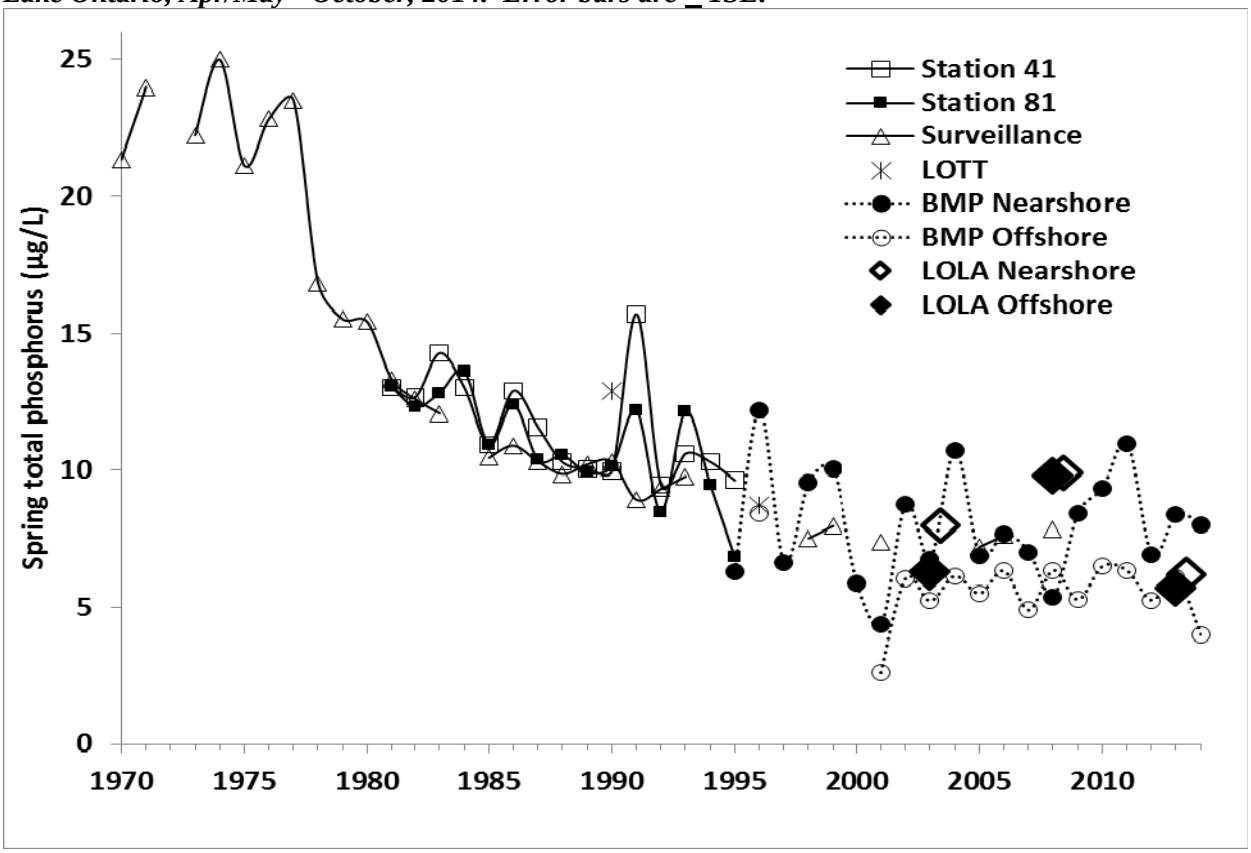

Figure 4b. Long-term spring (Apr – May) epilimnetic total phosphorus concentrations in Lake Ontario, 1970 - 2014. Data from 1970 – 2001 are from Environment Canada's Surveillance Program. Station 41 and 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. LOTT data is from the Lake Ontario Trophic Transfer Project. LOLA data is from the Lake Ontario Lower Food Web Assessment. Data from 1995 – 2014 are from the US Biomonitoring Program.

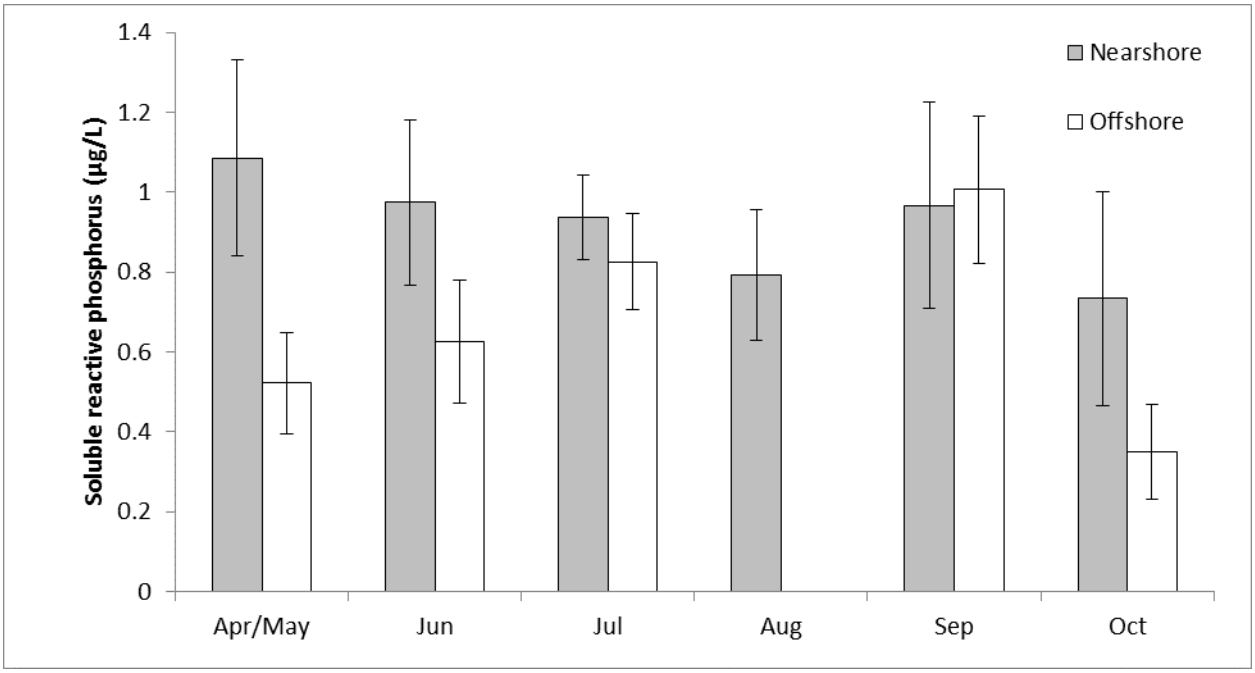

Figure 5a. Mean monthly soluble reactive phosphorus concentrations for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2014. Error bars are ± 1SE.

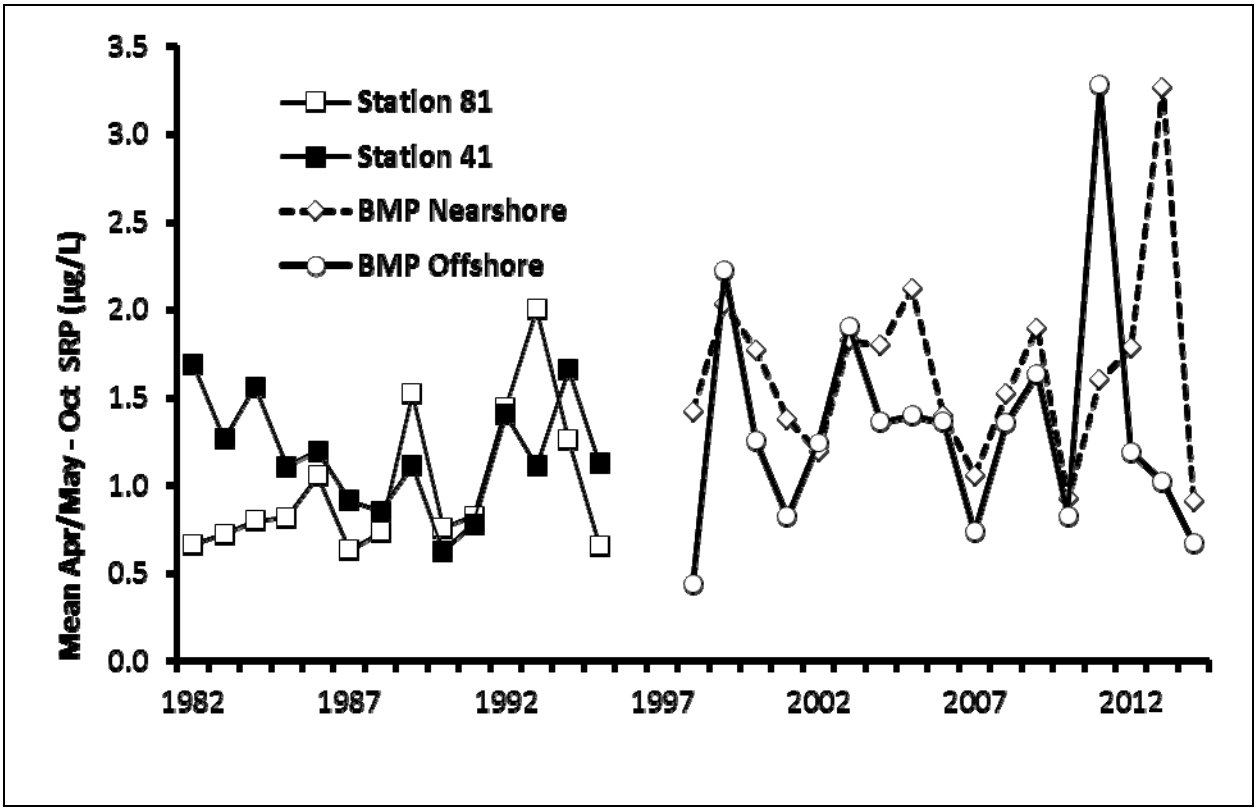

Figure 5b. Long-term mean Apr/May – Oct soluble reactive phosphorus concentrations in Lake Ontario, 1981 – 2014. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1998 – 2014 are from the US Biomonitoring Program (BMP).

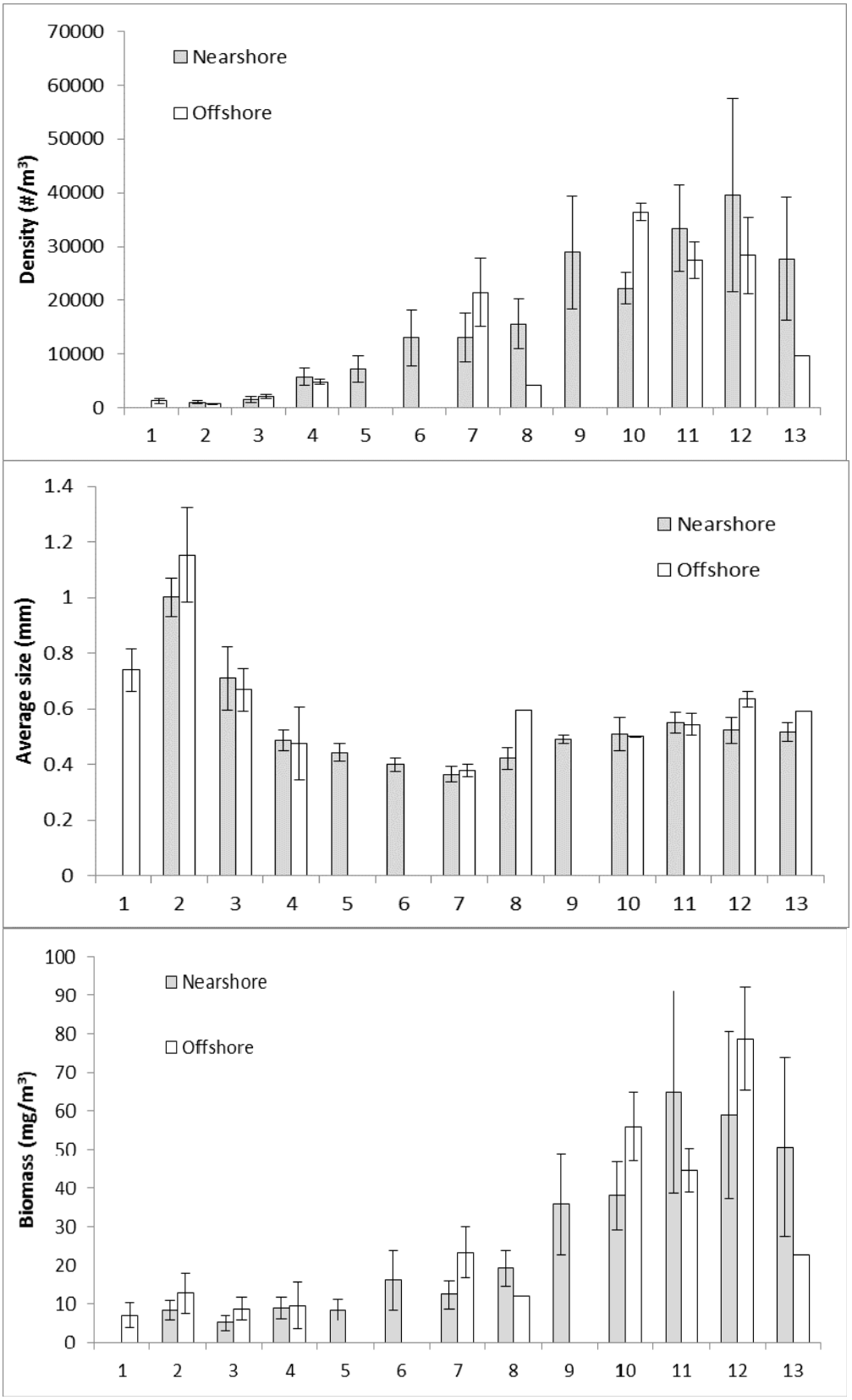

Figure 6. Biweekly means (± 1 SE) of epilimnetic zooplankton density, size, and dry biomass for April through October 2014, nearshore and offshore sites on Lake Ontario. On the x-axis, biweeks are designated by the numbers 1-13.

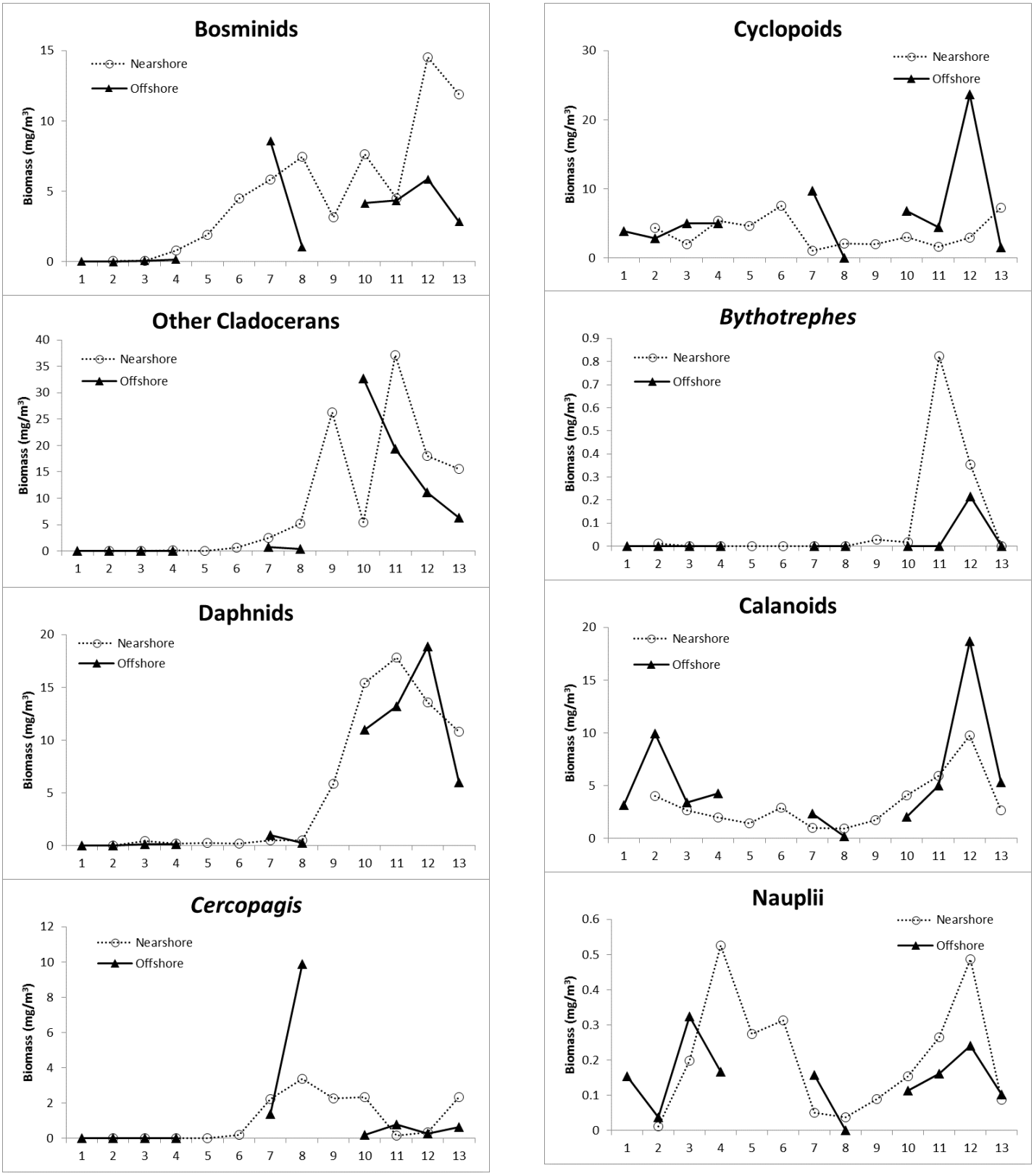

Figure 7. Epilimnetic dry biomass of zooplankton community groups for nearshore and offshore areas of Lake Ontario, Apr - October 2014 (biweeks 1-13 on x-axis). Note different y-axis scales.

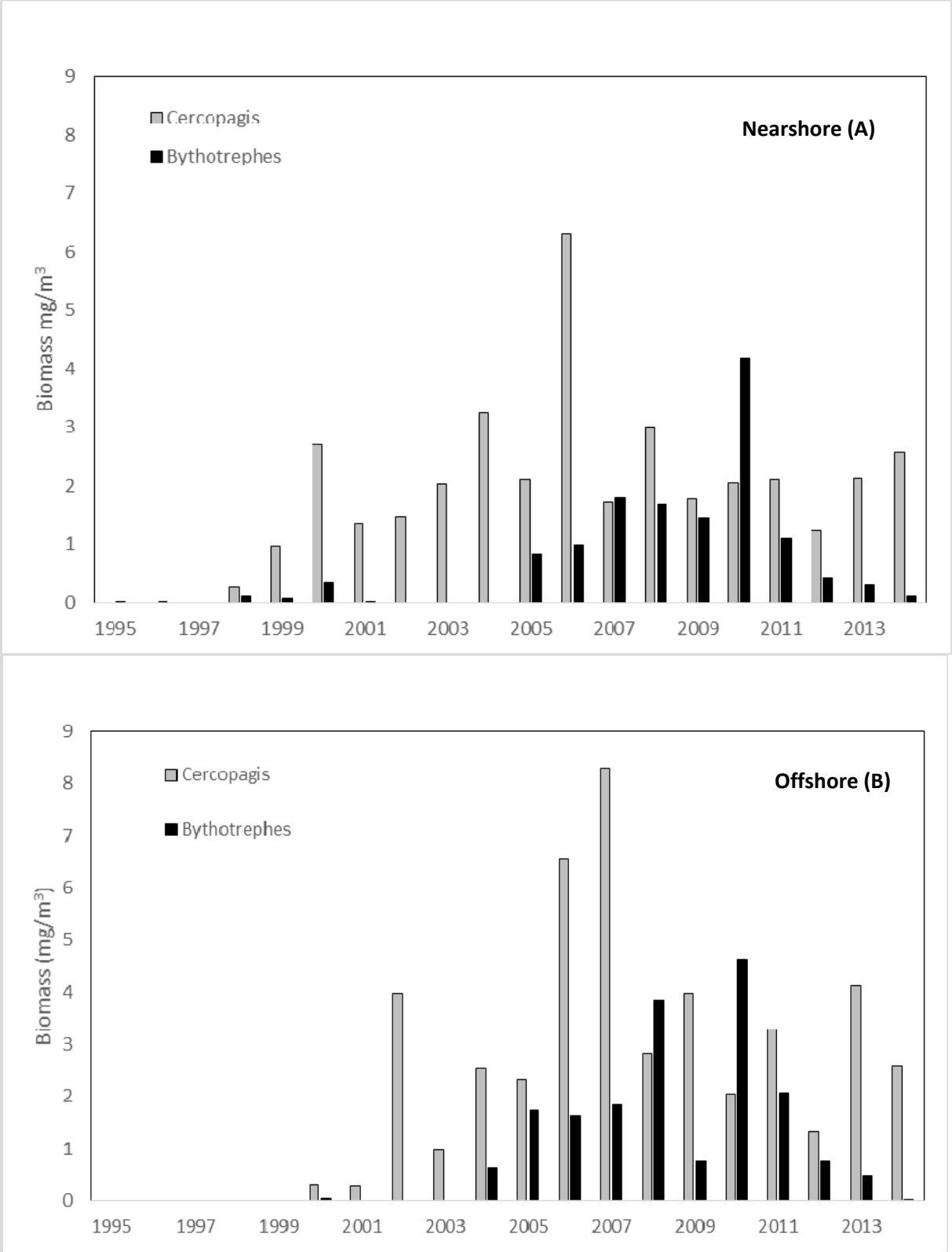

Figure 8. Daytime nearshore (A) and offshore (B) fall (September and October) Bythotrephes and summer (July) Cercopagis biomass in Lake Ontario, 1995 – 2014.

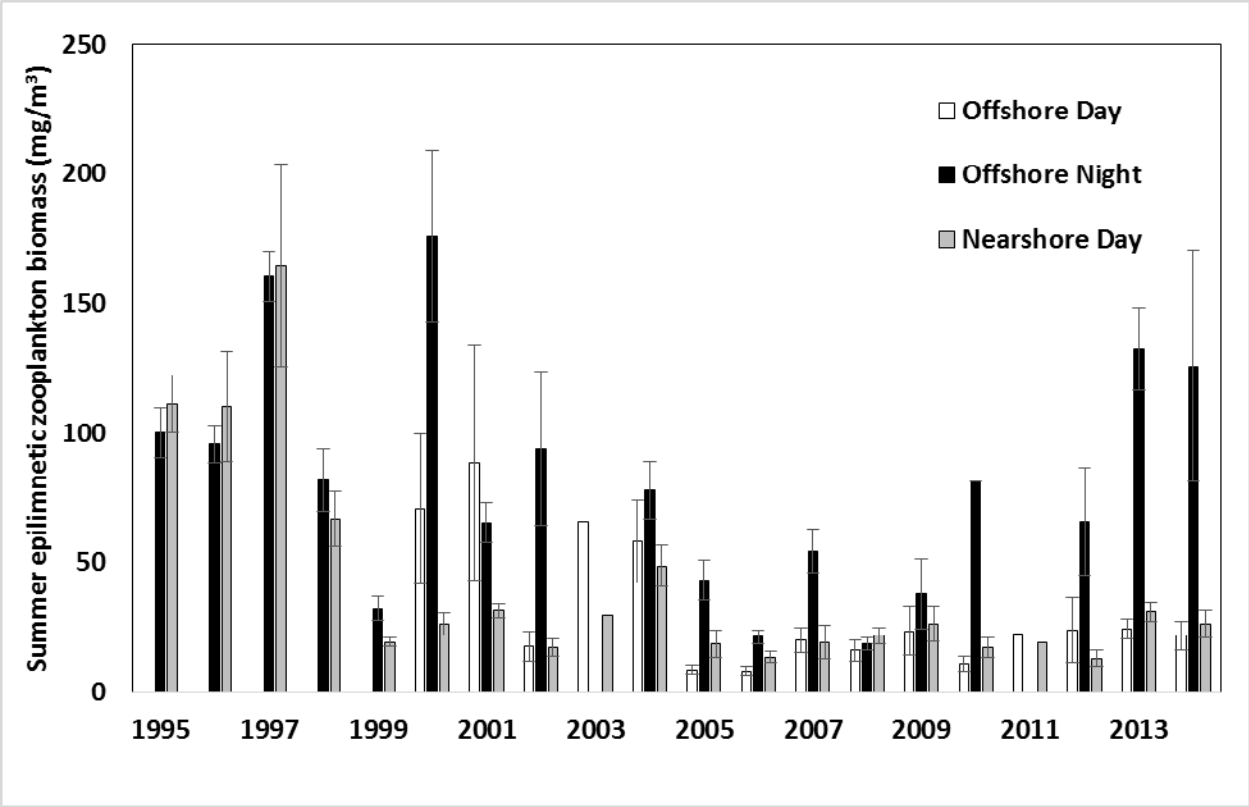

Figure 9. Mean summer (Jul – Aug) epilimnetic zooplankton biomass in nearshore and offshore habitats in Lake Ontario, 1995 - 2014.

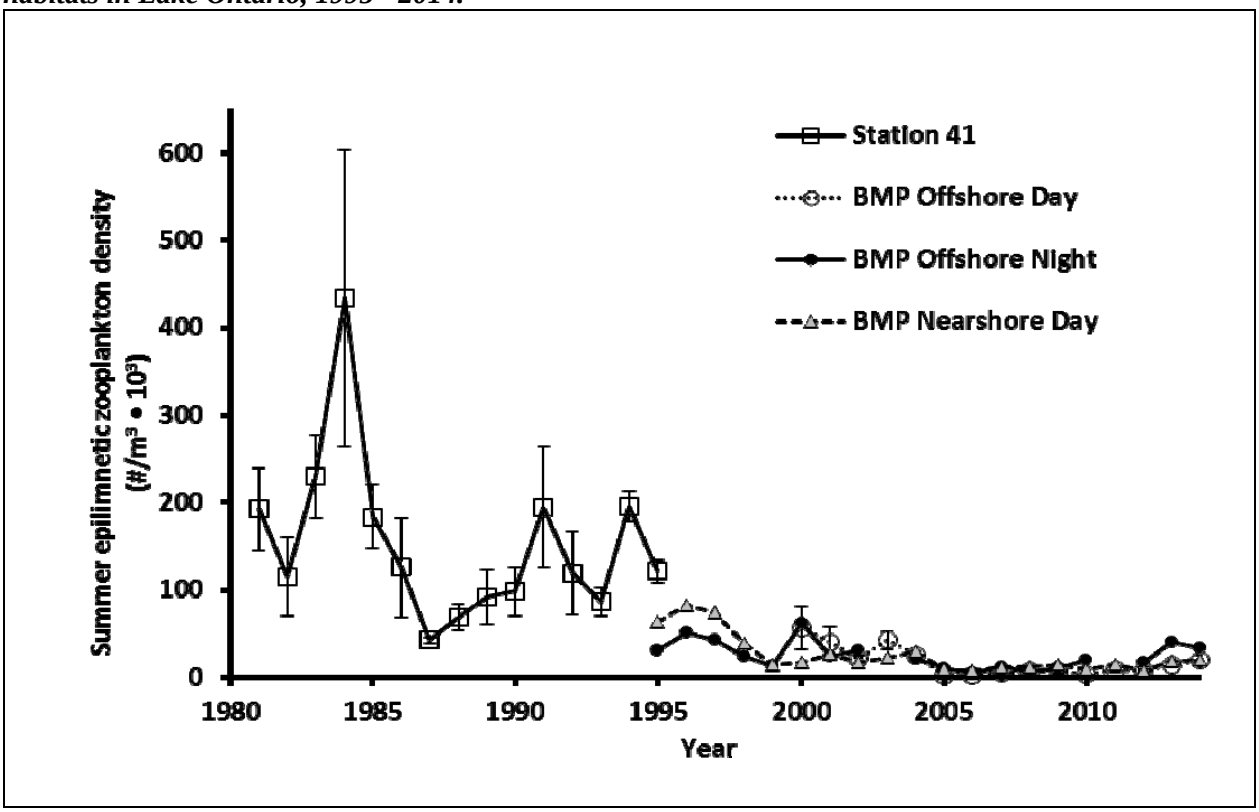

Figure 10. Mean daytime summer (Jul-Aug) epilimnetic zooplankton density in Lake Ontario's offshore, 1981 – 2014. Station 41 is from the Department of Fisheries and Oceans Canada's Bioindex Program.

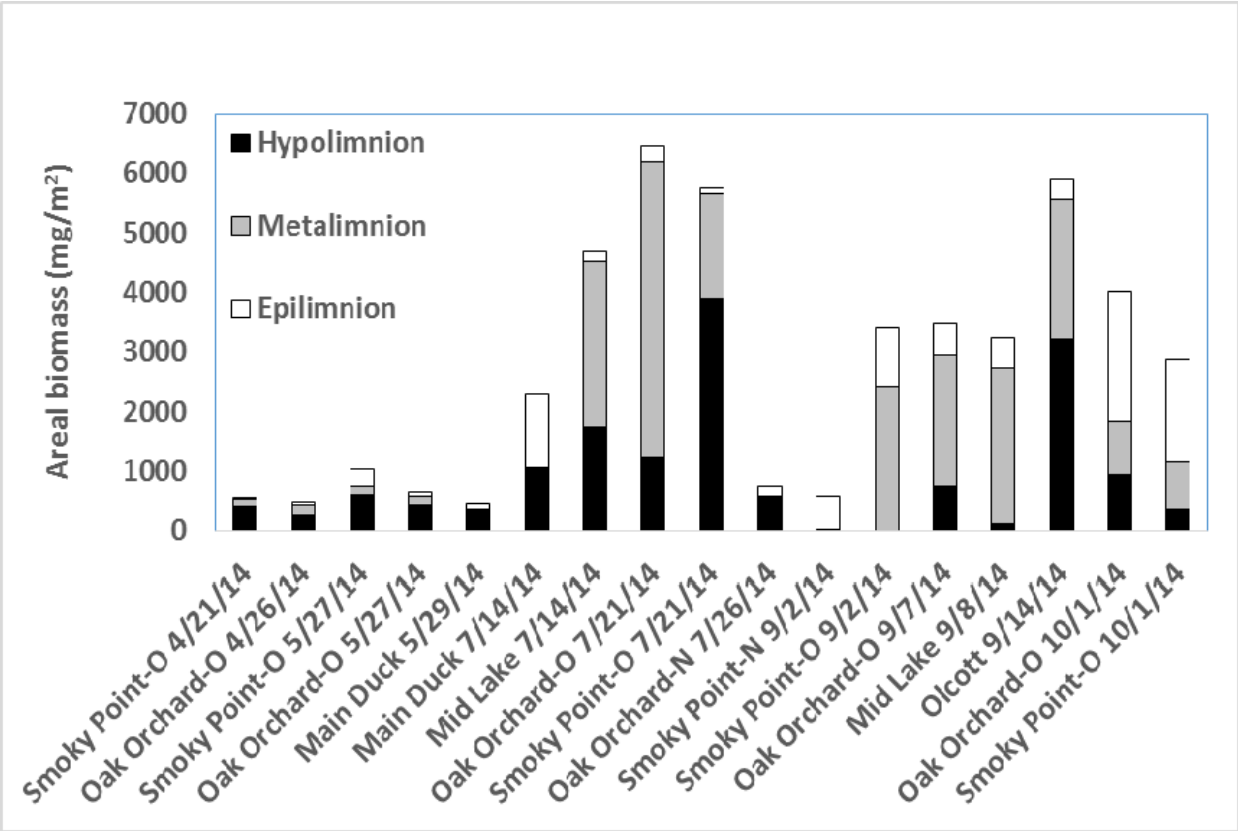

Figure 11. Daytime epilimnetic, metalimnetic, and hypolimnetic zooplankton dry biomass in Lake Ontario's offshore, 2014. Epilimnetic values determined directly from the epilimnetic tow. Metalimnetic values determined by subtracting epilimnetic tow values from the metalimnetic tow. Hypolimnetic values determined by subtracting metalimnetic tow values from the hypolimnetic tow. Stations without metalimnetic values are from shallower stations where only two tows were performed (Main Duck 5/29 and 7/14, Oak Orchard-N 7/26, and Smoky Point-N 9/2). Stations without hypolimnetic values are from a site where hypolimnetic values were negative (Smoky Point-O 9/2) due to variation in catch of zooplankton between metalimnetic and hypolimnetic tows.

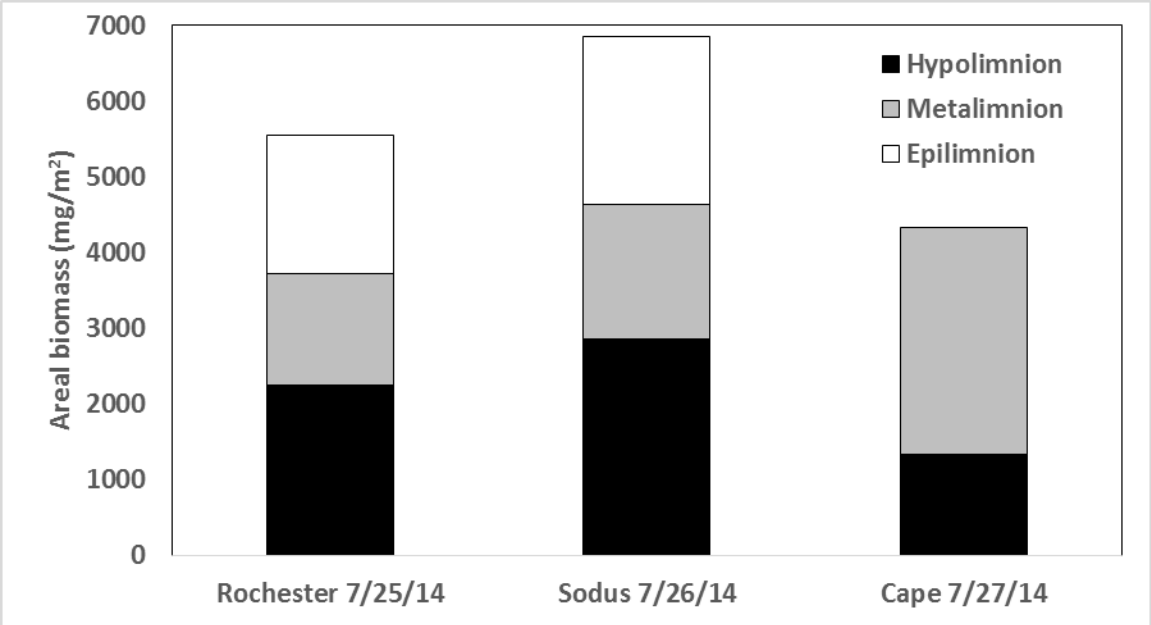

Figure 12. Nighttime epilimnetic, metalimnetic, and hypolimnetic zooplankton dry biomass in Lake Ontario, July 2014. Epilimnetic values determined directly from the epilimnetic tow. Metalimnetic values determined by subtracting epilimnetic tow values from the metalimnetic tow. Hypolimnetic value determined by subtracting metalimnetic tow value from the hypolimnetic tow. The epilimnetic sample from Cape 7/27/14 was lost.

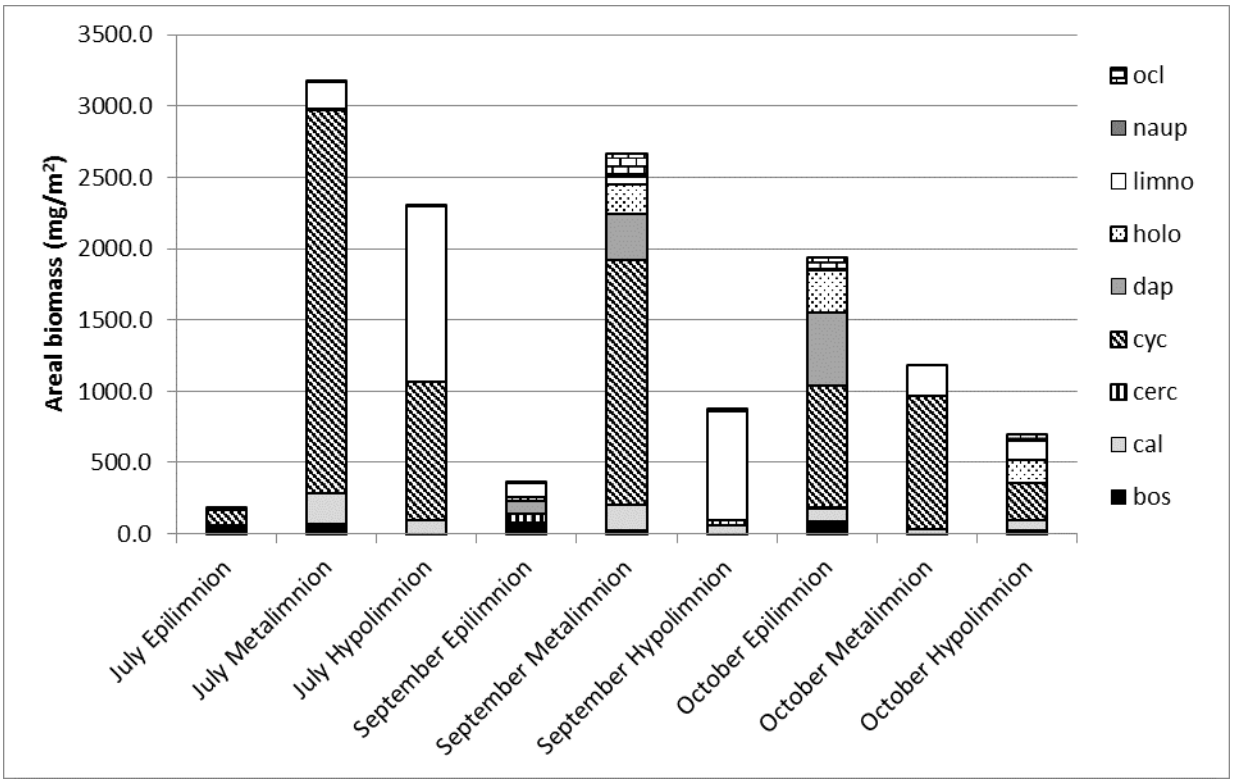

Figure 13. Comparison of mean zooplankton biomass (dry) in epilimnetic, metalimnetic, and hypolimnetic samples taken from deep (>100m) sites in Lake Ontario's offshore, July, September, and October 2014. The epilimnetic strata includes zooplankton from the thermocline (6 – 20 m) up to the surface, the metalimnetic strata includes zooplankton from 20 m or 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.

Table 1. Mean chl a, TP, SRP and Secchi depth (± 1 SE) for nearshore and offshore sites, Apr – Oct 2014.

	Mean ± 1 SE			
Sites	Chlorophyll-*a* (µg/L)	Total phosphorus (µg/L)	Soluble reactive phosphorus (µg/L)	Secchi depth (m)
Nearshore				
Chaumont Lake (CBL)	1.3± 0.2 (n=10)	7.2± 0.7 (n=10)	0.9± 0.2 (n=10)	6.5± 0.4 (n=10)
Galloo Island (GIL)	0.8± 0.1 (n=11)	6.1± 0.5 (n=11)	0.6± 0.1 (n=11)	8.7± 0.4 (n=11)
Oak Orchard (OOL)	1.5± 0.3 (n=9)	7.7± 0.5 (n=9)	0.7± 0.1 (n=9)	5.3± 0.5 (n=9)
Sodus Lake (SOL)	1.1± 0.1 (n=12)	7.4± 0.5 (n=12)	0.7± 0.1 (n=12)	8.2± 0.6 (n=12)
Sandy Pond Lake (SPL)	0.9± 0.2 (n=9)	8.3± 0.8 (n=9)	1.6± 0.1 (n=9)	5.4± 0.5 (n=9)
Niagara East Lake (NEL)	1.9± 0.2 (n=10)	9.1± 1.3 (n=10)	1.2± 0.2 (n=10)	4.0± 0.3 (n=11)
Niagara West Lake (NWL)	1.1± 0.1 (n=10)	7.8± 1.1 (n=10)	0.8± 0.1 (n=10)	4.5± 0.5 (n=11)
Offshore				
Kaho				
Oak Orchard-N	0.8± 0.1 (n=5)	5.8± 1.2 (n=5)	0.4± 0.1 (n=5)	8.9± 1.6 (n=5)
Oak Orchard-O	1.1± 0.3 (n=5)	4.6± 0.5 (n=5)	0.4± 0.1 (n=5)	10.8± 2.0 (n=5)
Smoky Point-N	1.4± 0.4 (n=5)	5.2± 0.6 (n=5)	0.3± 0.1 (n=5)	8.7± 1.9 (n=5)
Smoky Point-O	1.6± 0.4 (n=5)	6.3± 0.9 (n=5)	0.3± 0.1 (n=5)	9.6± 1.6 (n=5)
Seth Green				
Main Duck	0.6± 0.2 (n=5)	5.3± 1.0 (n=5)	1.1± 0.2 (n=5)	10.6± 2.3 (n=5)
Mid Lake	0.8± 0.1 (n=4)	5.4± 0.6 (n=4)	0.9± 0.2 (n=4)	9.7± 1.2 (n=4)
Tibbetts Point	0.9± 0.2 (n=4)	6.1± 0.9 (n=4)	1.2± 0.1 (n=4)	7.0± 0.9 (n=4)

Table 2. Comparison of nearshore and offshore sites Apr/May-October, 2014 using Wilcoxon signed rank tests on Apr/May – Oct mean values. Values shown are arithmetic means across months 4/5, 6, 7, 9, and 10. Month 8 was removed from the analysis because the offshore was not sampled during that time. All offshore data are for the epilimnion (zooplankton) or the top 10 m (water chemistry).

Parameter		Mean		p-value
		Nearshore	Offshore	
	Total phosphorus (µg/L)	7.8	5.6	0.0625
	Soluble reactive phosphorus (µg/L)	0.9	0.6	0.0625
	Chlorophyll *a* (µg/L)	1.2	1.1	0.625
	Secchi depth (m)	5.9	9.1	0.0625
Total zooplankton:				
	Density (#/m^3)	17246	13854	0.1875
	Size (mm)	0.55	0.62	0.0625
	Biomass (mg dw/m^3)	28.4	29.3	0.8125
Group biomass (mg dw/m^3):				
	Bosminids	5.5	3.4	0.1875
	Daphnids	5.1	5.8	0.8125
	Calanoid copepods (excluding *Limnocalanus*)	2.6	4.1	0.3125
	Cyclopoid` copepods	4.2	8.8	0.1875
	Other cladocerans (excluding *Holopedium*)	2.9	2.2	0.3125
	Cercopagis pengoi	1.0	0.7	0.8125
	Bythotrephes longimanus	0.03	0.01	0.5
	Holopedium gibberum.	6.4	4.5	0.0625
	Limnocalanus macrurus	0.4	2.0	0.25

Table 3. Results of regression and change point analyses performed on data from two time stanzas in Lake Ontario, 1995 - 2014 and 1981 – 2014. All 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. % change is average annual change.

	Regression				Change Point Analysis	
Offshore	2000 – 2014	% change	1981 – 2014	% change	2000 – 2014	1981 - 2014
Apri/May – Oct SRP (µg/L)	ns		ns		no breaks	no breaks
Spring TP (µg/L)	ns		**(-) p<0.0001**	**3**	no breaks	(-) 1996
Summer chlorophyll *a* (µg/L)	**(-) p=0.0093**	**6**	**(-) p<0.0001**	**4**	(-) 2012	(-) 1994, (-)2009
Summer epilimnetic zooplankton density (#/L)	ns		**(-) p<0.0001**	**12**	(-) 2005, (+) 2013	(-) 1986, (-)2005, (+) 2013
Summer epilimnetic zooplankton biomass (µg/L)	(-) p=0.0896		not tested		(-) 2005	not tested
Summer epilimnetic zooplankton group biomass						
Bosminids	ns		not tested		(-) 2004	not tested
Bythotrephes longimanus	(+) p=0.096		not tested		(+) 2006	not tested
Calanoid copepods	**(+) p=0.0379**	**17**	not tested		(+) 2007	not tested
Cercopagis pengoi	(+) p=0.0794		not tested		no breaks	not tested
Cyclopoid copepods	ns		not tested		(-) 2005	not tested
Daphnids	ns		not tested		no breaks	not tested
Other Cladocera	ns		not tested		no breaks	not tested
Limnocalanus	ns				no breaks	not tested
Holopedium	ns				no breaks	not tested

	Regression		Change Point Analysis
Nearshore	1995 - 2014	% change	1995 - 2014
Apri/May – Oct SRP (µg/L)	ns		(+) 1992
Spring TP (ug/L)	ns		no breaks
Summer chlorophyll *a* (µg/L)	ns		(+) 2003, (-) 2009
Summer epilimnetic zooplankton density (#/L)	**(-) p=0.0002**	**10**	(-) 1998, (-) 2005
Summer epilimnetic zooplankton biomass (µg/L)	**(-) p=0.0008**	**9**	(-) 1998
Summer epilimnetic zooplankton group biomass			
Bosminids	**(-) p=0.0011**	**10**	(-) 1998, (-) 2005
Bythotrephes longimanus	ns		(+) 2006
Calanoid copepods	ns		(-) 1996
Cercopagis pengoi	ns		(+) 1999
Cyclopoid copepods	**(-) p<0.0001**	**18**	(-) 1998, (-) 1999
Daphnids	**(-) p=0.0276**	**7**	no breaks
Other Cladocera	ns		no breaks
Limnocalanus	**(-) p=0.0371**	**6**	(-) 1997
Holopedium	**(+)p=0.0004**	**8**	(+) 2003

ERRATUM

Figure 12 from the 2013 report was in error. Data for the hypolimnetic and metalimnetic tows were transposed. The corrected figure appears below the original figure.

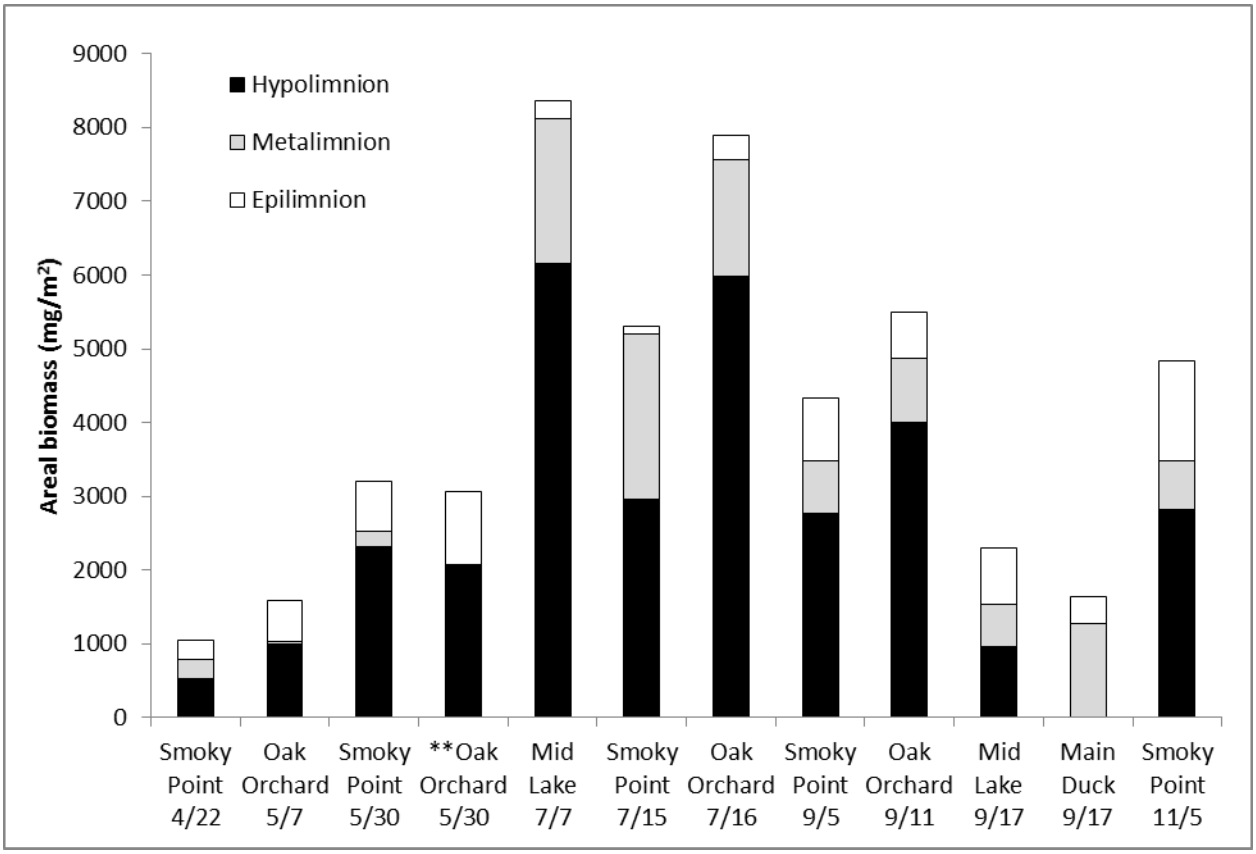

Figure 12. Epilimnetic, metalimnetic, and hypolimnetic zooplankton dry biomass in Lake Ontario's offshore, 2013. Epilimnetic values determined directly from the epilimnetic tow. Metalimnetic values determined by subtracting epilimnetic tow values from the metalimnetic tow. Hypolimnetic values determined by subtracting metalimnetic tow values from the hypolimnetic tow. Stations without hypolimnetic values are from shallower stations where only two tows were performed. **indicates a site where metalimnetic values were negative (not shown) due to variation in catch of zooplankton between metalimnetic and hypolimnetic tows.

CORRECTED FIGURE

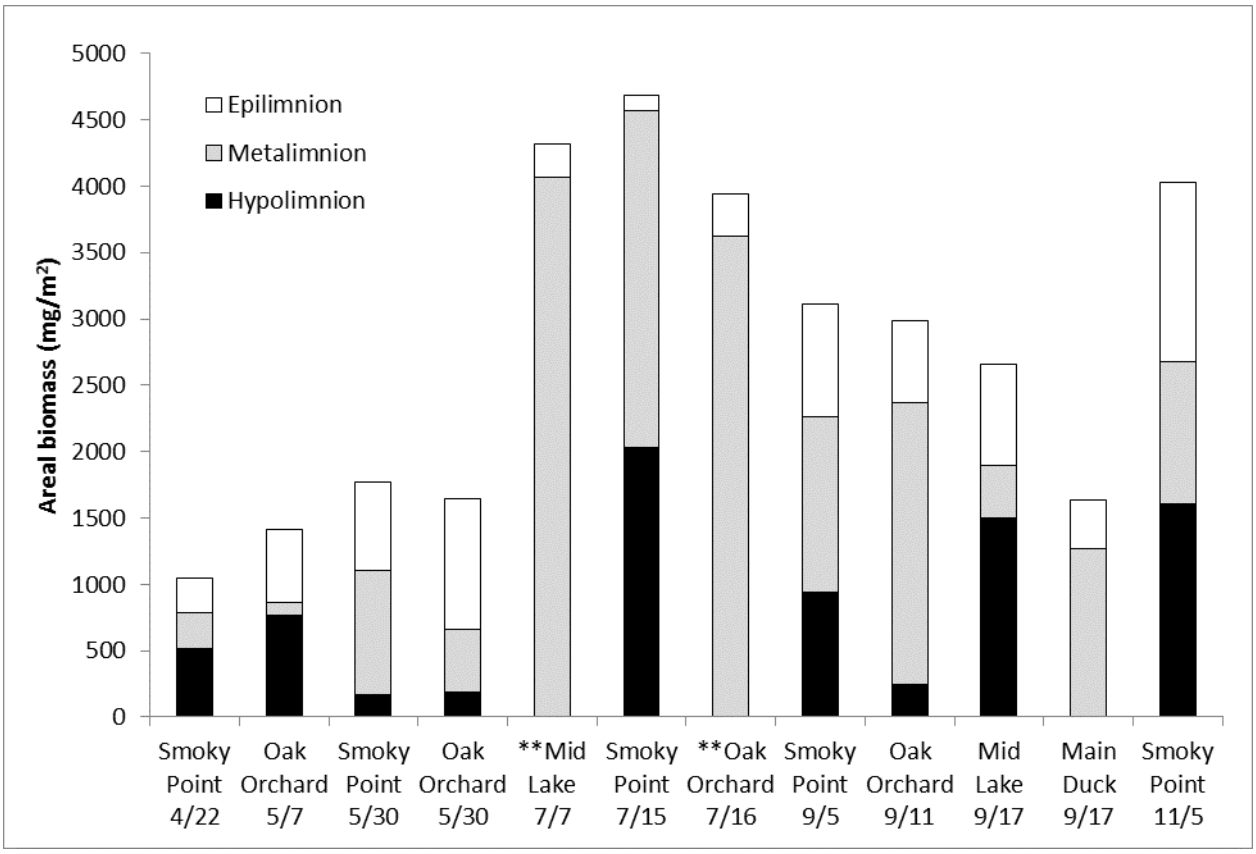

Figure 12. Daytime epilimnetic, metalimnetic, and hypolimnetic zooplankton dry biomass in Lake Ontario's offshore, 2013. Epilimnetic values determined directly from the epilimnetic tow. Metalimnetic values determined by subtracting epilimnetic tow values from the metalimnetic tow. Hypolimnetic values determined by subtracting metalimnetic tow values from the hypolimnetic tow. Stations without hypolimnetic values are either from shallower stations where only two tows were performed (Main Duck 9/17) or from stations (indicated by **) where hypolimnetic values were negative (not shown) due to variation in catch of zooplankton between metalimnetic and hypolimnetic tows.

Administrative Program Summary Report for the Sportfishing Restoration & Spending Plan for the Lake Ontario System

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

Background

In June of 2006, New York State (NYS) announced that the Department of Environmental Conservation (DEC) and the Office of the Attorney General had reached a $12 million settlement with Occidental Chemical Corporation (OCC) on the State's Natural Resources Damages (NRD) claim for the Lake Ontario system. The claim was originally filed in 1983 against Hooker Chemical, the predecessor of Occidental Chemical Corporation, for compensation for the release of harmful chemical contaminants into the Lake Ontario system, which includes the Lower Niagara River, Lake Ontario, the St. Lawrence River, and tributaries to these waters upstream to the first barrier impassable to fish (hereafter referred to as the Lake Ontario system). The settlement was based on an assessment of lost recreational fishing benefits resulting from the imposition of fish consumption advisories due to the presence of contaminants in the fish.

There are several federal statutes, as well as NYS law, that authorize federal and NYS officials to act on behalf of the public to restore natural resources affected by releases of contaminants. This claim arose under the federal *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)* of 1980, and NYS common law, holding parties accountable for contaminating the environment and causing injury to natural resources. NRD funds provide compensation for the injury to, loss of, loss of the use of, or destruction of New York's natural resources, including land, biota, air, surface and ground waters.

Natural Resources Damages Assessment

The NRD assessment process seeks to ensure that the public is compensated for losses experienced as a result of injuries to their natural resources resulting from environmental contamination. This process determines the nature and extent of injury to the natural resources, and then aims to restore the use and enjoyment of either the injured or lost natural resources, or the services provided by these resources.

Funds recovered as a result of a NRD claim are to be used to restore/enhance either the injured natural resources themselves, or the services provided by the lost or injured natural resources. The general hierarchy for the use of NRD funds, in order of greatest to least preference, is to restore or replace the injured resources. If neither of these approaches is possible or practical, then equivalent resources could be acquired.

In this case, restoring the injured resource by reducing contaminant levels in fish to pre-contamination levels would be impracticable and cost prohibitive. A restoration effort of this magnitude would require extensive sediment dredging/disposal that would far exceed the resources available through the Lake Ontario NRD (LONRD) program, as these contaminants now reside in sediments and biota throughout the entire system. In addition, toxic "hot spots" within the Lake Ontario system have already been identified, and efforts to remediate contamination in these areas are being coordinated through individual Remedial Action Plans (RAPs).

The damages were calculated by measuring the difference between the value to anglers for fishing for contaminated fish in the Lake Ontario system, and what the value would have been if the fish had not been contaminated. This $12 million settlement is one of the largest NRD claim settlements in the nation based on lost recreational

fishing use. The $12 million settlement was apportioned to include $10.8 million for projects and $1.2 million for fund administration.

Restoration Planning and Public Outreach

The Sportfishing Restoration & Spending Plan for the Lake Ontario System (*Plan*), was prepared by DEC in its capacity as trustee for New York's natural resources. The *Plan* describes projects selected to restore injuries to sportfishing in the New York waters of the Lake Ontario system. The *Plan* also describes the public's role in *Plan* development and provides rationale for eliminating certain proposed projects from inclusion in the *Plan*.

DEC staff developed four project proposal categories to restore/enhance recreational sportfisheries:

Public Fishing Access - improvement to or creation of boat launch sites, fishing piers, access channel improvements and purchase of public fishing rights.

Habitat Restoration - creation/enhancement of habitats that support warmwater, coolwater and coldwater fishes and/or their prey, such as walleye spawning bed improvements, stream bank stabilization, fish passage, and lamprey barriers.

Angler Outreach and/or Education - fishing hotlines, outreach addressing where and how to fish, instruction on reducing exposure to contaminants when eating Great Lakes fish, visitor center interpretive displays, sportfishing promotion, etc.

Fish Population Management and/or Enhancement - improvements to existing DEC hatchery facilities that will improve DEC's ability to effectively manage Lake Ontario system fisheries. Proposed projects must result in a defensible benefit to sportfisheries in the Lake Ontario system.

Cost estimates were developed for each project to develop a project list that could be funded with the $10.8 million. The final project list included 42 projects totaling $11,117,500, exceeding the $10.8 million allocation by $317,500. The proposed project list totaled more than the project fund allocation since some projects may not be implemented due to various reasons for impasse.

Status of Projects and Project Fund Accounts

The $10.8 million in project implementation funds have been or are planned to be expended as follows: approximately $4.78 million has been spent or is encumbered.; approximately $3.9 million will be spent on ongoing projects; and $1.95 million is planned to be re-allocated to higher-ranking projects (e.g. $1.4 million from project #19, Cape Vincent hatchery improvements, to the #1 ranked Salmon River Hatchery project).

As anticipated by the *Plan*, issues relating to engineering, availability of other funding sources, land acquisition, contract bidding, project planning and development, and other practical concerns hindered efforts to implement all projects in priority order, and prevented implementation of some projects altogether. Funds from those projects found to be impracticable are being used for implementation of other projects, as provided by the *Plan*.

Enhancing the Value of this Settlement

Many projects enabled partnerships and cost sharing to contribute to, or in some cases substantially enhance, their value. The majority of projects have been or will be improved through additional funding and in-kind services (e.g. labor and equipment use, project administration and oversight, design and engineering) provided by the DEC Bureau of Fisheries (BOF), DEC Division of Operations (OPS), the New York State Environmental Protection Fund (EPF), other agencies including the United States Fish and Wildlife Service (Service) and United States Geological Survey (USGS), municipalities, non-governmental organizations and programs such as the Fish Enhancement, Mitigation and Research Fund (administered by the Service). These contributions, acknowledged in the project summaries listed below, resulted in more cost effective project implementation and/or expanded project scope.

Completed Projects

Projects described in this section are complete or nearly so, with funds fully encumbered through executed contracts or memoranda of understanding. Incomplete projects will require minimal time requirements in the future (i.e. project inspections for payment approval) or will be pursued by regional BOF staff. Projects are described below and listed with their project priority number from the *Plan*. A summary of to date/future anticipated expenditures is presented in Table 1.

2. **Purchase Automated Fish Marking Trailer –** The AutoFish tagging trailer was purchased from Northwest Marine Technology in 2008. The acquisition of this technology has enabled the BOF to mark and/or tag (i.e. coded wire tag) every Chinook salmon stocked into Lake Ontario from 2008-2011, and conduct other trout and salmon (salmonid) marking studies annually since 2008. This purchase was a first for fisheries science in the Great Lakes Basin, and provided the opportunity to gain knowledge of Lake Ontario fisheries that was previously impracticable.

   To date, $1,447,856 of the $1.5 million allocated to this project has been expended. With new marking and tagging projects in development, the remaining funds will be used by the end of fiscal year (FY) 16.

3. **Lindsey and Stony Creeks Angler Parking Areas, Jefferson Co. -** The five-car Stony Creek angler parking area on Jefferson County Rt. 152 was completed in September 2011, and the six-car Lindsey Creek angler parking area on Jefferson County Rt. 87 was completed in October 2012 by DEC Region 6 OPS staff. These projects required $11,686 of the $20,000 allotment. In-kind permanent personal services from Region 6 OPS staff contributed to these projects.

4. **Four fishing access related projects in New York State Parks of the Niagara Region (#s 4, 11, 20 & 32). –** These angler access improvement projects include Artpark's river trails as well as trails associated with the Whirlpool area and the Schoelkopf ruins site. A Memorandum of Understanding with the New York State Office of Parks, Recreation and Historic Preservation (ORRHP) has been executed, with all of these projects either in the final design phase or nearly ready to be tendered for bid. Work is set to begin in the 2015 construction season on Fort Niagara boat launch/docking improvements. The combined NRD funding for these projects is $425,000. Funds and in-kind services in excess of $1.5 million will be provided through OPRHP capital funding and design, engineering and administrative work, as well as the New York Power Authority Greenway Fund.

6. **Village of Lewiston Boat Launch, Niagara Co. -** This project was completed as described in the *Plan* through a state assistance contract with the Village of Lewiston and resulted in the replacement of the existing two-lane boat launch and docks, improvements to the fish cleaning station, and improvements to restroom facilities. This project expended $74,550 of its $75,000 LONRD fund allotment. Additional services and funds included BOF-funded design and administrative oversight from the Village of Lewiston.

7. **Golden's Marina Renovation, Jefferson Co. -** Located in the Town of Lyme at "the Isthmus" on County Rt. 57, this boat launch site renovation included the construction of a new two-lane concrete boat launch, associated parking for 25 cars and trailers, and ten additional parking spaces. New dockage was installed and a universally accessible fishing site was created. The cost for this project was $653,000, $353,000 greater than the original project estimate. Per consultation with DEC Office of General Counsel, $353,000 were transferred from project #38, Port Bay access road ($500,000 allocated), which was deemed infeasible

based on engineering concerns. The marina was purchased with EPF, and the site designed with BOF-funded engineering efforts. Construction was executed through a competitive bidding process.

8. **Boat Launch/Ice-fishing Access on Sandy Pond, Oswego Co. –** In June 2014, DEC completed acquisition of the former Groman Shores property on Sandy Pond at a cost of $209,800 ($500,000 allocated). Design work is completed for the site, and construction by DEC Region 7 OPS staff is planned for 2015. In the unlikely event that construction costs exceed the remaining $290,200, a request will be made to re-allocate funds from lower ranking projects. Additional in-kind services were provided through BOF-funded engineering and design work.

9. **Chaumont Bay Boat Launch Sites and Ice-fishing Access, Jefferson Co. –** The former Bachy's Marina in the Village of Three-mile Bay was acquired using EPF funds, and was developed into a waterway access site featuring a single-lane boat launch with floating docks, parking for five cars and trailers, and parking for 10 cars for shoreline fishing access (total cost $270,174 of $500,000 allocation). The remaining $229,826 will be used to acquire a suitable ice-fishing access site for Chaumont Bay. Additional services/funds were provided through BOF-funded engineering and design work, and removal of existing buildings by DEC Region 6 OPS staff. Construction was executed through a competitive bidding process.

10. **Sandy Creek Fishing Access Site, Monroe Co.** This 50 car and trailer launch site was re-surfaced as described in the *Plan.* This project used $34,410 in LONRD project funds, $9,410 more than the project estimate. Additional funds were transferred from the defunct Port Bay West Project (#38). Construction was executed through a competitive bidding process.

12. **Fisheries Promotion Assistance -** This project entailed a collaboration with the Lake Ontario Sport Fishing Promotion Council to update, print and distribute the new Great Lakes Fishing brochure. This project used $39,000 of its $100,000 allotment. To cover ineligible costs related to promotion of Lake Erie and Upper Niagara River fisheries in the brochure, $10,000 of Federal Aid in Sport Fish Restoration funds were contributed to the project. Additionally, in-kind efforts were provided by DEC Office of Communication Services staff, Central Office BOF staff, and regional BOF staff.

13. **Enhance Fish Island Access Site at Dexter, Jefferson Co. –** This project was completed through a state assistance contract with the Village of Dexter. Improvements to this Black River access site include a new floating dock with a universally accessible canoe and kayak launch, pathways, lighting, as well as picnic and pavilion area enhancements. This project utilized its full $45,000 budget allotment. Personal service time from BOF-funded engineering and design work, and Region 6 OPS staff contributed in-kind services for this project.

14. **Maxwell Creek Fishing Access Site, Wayne Co. –** Paving this 40 car gravel/dirt parking lot was completed as described in the *Plan*. This project used $53,114 in LONRD project funds, $3,114 more than its initial allotment. Additional funds were transferred from the defunct Port Bay West Project (#38). Construction was executed through a competitive bidding process.

15. **Port Bay (East) Fishing Access Site, Wayne Co. –** The development of this small, five-car lot to allow access to the north end, east side of Port Bay was delayed for several construction seasons due to wave-related erosion concerns and staff availability to complete the work. DEC Region 8 OPS staff plan to complete this project during the 2015 construction season. This project is expected to require its full, $2,000 allotment.

17. **Town of Wilson Boat Launch, Niagara Co. –** This project was completed through a state assistance contract with the Town of Wilson, resulting in the replacement of a single lane boat launch, new floating dockage and protective armoring installed. The new floating docks have improved overall use and enhanced universal accessibility. This project used its $30,000 LONRD allotment and approximately $14,205 of additional funds from the Town of Wilson. BOF-funded engineering/design work provided in-kind services. Construction was executed through a competitive bidding process.

18. **Boat Launch at Mud Bay, Jefferson Co. –** This project was completed by Region 6 OPS staff and is located on Bates Road in the Town of Cape Vincent. This newly developed fishing access site features two gravel parking lots and a 20' wide car-top boat launch. The upper parking lot (240' x 50') accommodates approximately fourteen cars and trailers. The lower lot (100' x 200') accommodates approximately ten cars and trailers. This site also provides public access to a popular walleye ice fishery in Mud Bay. The project used $50,010 of its $100,000 allotment, and personal service time from Region 6 OPS staff contributed to this project.

21. **Slater Creek Fishing Access Site, Monroe Co.** – The parking area at this site was reduced in size to better reflect typical site use, and the un-used parking area was reclaimed into green space to provide picnic/recreation space. Following project completion by Region 8 OPS staff, DEC transferred operation and maintenance responsibilities for the site through an agreement with the Town of Greece. This site now features a newly paved 40 car parking area and accessible fishing platform enhancements. This project used $33,620 of its $75,000 allocation. Parking lot re-surfacing was executed through a competitive bidding process.

22. **Lake Ontario Watershed Display at the Niagara Falls Aquarium, Niagara Co. –** This project is underway and will be completed largely as described in the *Plan* through an executed state assistance contract with the Aquarium of Niagara. The *Plan* described the construction of this display in an expansion of the Aquarium. Funding for that expansion was never secured, and a decision was made to repurpose and renovate existing displays. As specified in the contract, reimbursement for qualified expenses is not to exceed the $300,000 allocation. In-kind services from Aquarium staff, as well as other funding sources are contributing to this project. Project completion is anticipated by November 2015.

25. **Irondequoit Creek Streambank Stabilization, Monroe Co. –** This project will be completed through an executed state assistance contract with the County of Monroe, and with the Service as an additional partner, will improve over 2,000 lineal feet of stream bank and stream habitat. Work is set to commence in summer/fall 2015. LONRD funding for the project is $250,500, with additional funds and in-kind services from the County of Monroe (property acquisition and staff time) and the Service (engineering and staff time).

26. **Deepwater Cisco Reintroduction in Lake Ontario** – DEC, in partnership with the Great Lakes Fishery Commission (GLFC), the Ontario Ministry of Natural Resources and Forestry (OMNRF), USGS and the Service implemented this project and will use the $50,000 allocated to this project via a technical service contract with the GLFC. Efforts to date include the stocking of 97,500 deepwater ciscoes and the development of a broodstock that is being held at an OMNRF facility. Additional funds and in-kind services are provided by the OMNRF, DEC, GLFC, Service and USGS.

27. **Public Access Improvements, Village of Morristown, St. Lawrence Co.** -This project was completed through a state assistance contract with the Village of Morristown and resulted in the replacement of the existing 2 lane boat launch and installation of new floating docks. This project used all of its $50,000 LONRD fund allotment with more than half of the total project costs paid for by the Village of Morristown. Additional services/funds were provided through BOF-funded engineering and design work, and construction was executed through a competitive bidding process.

29. **Pen Rearing Program Assistance –** Support for the existing nine salmonid pen rearing project locations along Lake Ontario and the Lower Niagara River is ongoing. To date, $13,149 of this project's $20,000 allocation has been used, and all funds will be expended by the end of FY 2018-19. Sportsmen's groups have contributed substantial funding and volunteer time in pen construction and maintenance.

30. **Salmon River Hatchery Aquaria/ Interpretive Displays, Oswego Co. –** Two elements of this project as described in the *Plan* were omitted as the funding allocation for the entire initial project was insufficient. Defunct aquaria in the hatchery lobby have been replaced with a state of the art aquarium system serving as the center piece of the public displays at this important hatchery facility. Video equipment that will enable the public to view migrating fish underwater has been purchased and will be installed in the 2015 construction season. The entire $100,000 LONRD fund allocation was used for this project, with an additional $40,485 in BOF funding. In-kind services were provided through BOF-funded engineering and design work and Salmon River Hatchery staff time. Aquaria purchase and installation was executed through a competitive bidding process.

33. **Multi-frequency Acoustic Analysis for Estimating Alewife Abundance in Lake Ontario -** A Biosonics echo sounder (or sonar device) used to estimate preyfish abundance in Lake Ontario has been acquired by the DEC Lake Ontario Fisheries Unit. This equipment employs state of the art technology that has improved the accuracy of Lake Ontario hydroacoustic preyfish surveys. This equipment purchase accounted for $47,388 of the project's $55,000 allocation.

34. **Olcott Pier Access Improvements, Niagara County -** This project was implemented through a state assistance contract with the Town of Newfane. Improvements to this popular fishing pier at the mouth of 18 Mile Creek included the re-paving of the forty-car parking lot, paving the 700' access trail, re-surfacing a portion of the pier, and construction of a new, 17' x 9', universally accessible restroom at the parking lot. This project expended $53,803 of its $100,000 allocation, and was completed by Town of Newfane staff.

35. **Improvements to Cape Vincent Aquaria/Interpretive Displays –** To date, new fish display placards highlighting life history descriptions for each of the fish species on display at the aquarium have been developed, printed and installed. New static displays are currently being developed and two new computers have been purchased that will serve as interactive, interpretive displays at the visitor center. To date, $1,628 of the project's $40,000 has been spent. Staff time from DEC's Office of Communication Services for display design and development provides in-kind services for this project.

37. **Locate Areas Where Lake Trout Spawn in the Lower Niagara River** – This research study partnership between DEC and the Service required the purchase of acoustic telemetry tags and receivers to track the location of spawning lake trout. This project used $48,221 of its $50,000 LONRD fund

allocation, and has been augmented through substantial Service funds and staff time.

39. **Sea Lamprey Control Barrier on Orwell Brook -** The GLFC completed construction of a sea lamprey barrier on Orwell Brook (Oswego Co.) in fall 2012. The barrier was operational in spring 2013 and will greatly reduce the need for chemical control of sea lampreys in the Orwell Brook system. The entire $60,000 allocation of LONRD funds was expended on this project through a technical service contract with the GLFC. GLFC contributions to the project included approximately $28,000 for design and $377,000 for construction costs, and construction was competitively bid.

Table 1. Summary of expenditures to date and future, anticipated expenditures for "completed projects." Completed projects include those with funds fully encumbered through executed contracts or memoranda of understanding.

Rank #	Project title	Allocation	Current Expenditures or Encumbrances	Anticipated Expenditures	Funds Re-allocated from Other Projects	Balance or Anticipated Balance
	"Completed" Projects (includes ongoing with known, fixed costs)					
2	Mass marking/tagging trailer	$1,500,000	$1,447,857	$1,500,000		$0
3	Lindsey and Stony Creek Angler Parking Areas	$20,000	$11,687	$11,687		$8,313
4	Lower Niagara River Access Trails in Artpark	$150,000	$150,000	$150,000		$0
6	Village of Lewiston Boat Launch Improvements	$75,000	$74,551	$74,551		$449
7	Golden's Marina Renovation	$300,000	$648,486	$648,486	$348,486	$0
8	Boat Launch/Ice-fishing Access on Sandy Pond	$500,000	$209,800	$500,000		$0
9	Chaumont Bay Boat Launch Sites and Ice-fishing Access	$500,000	$270,174	$500,000		$0
10	Sandy Creek Fishing Access Site	$25,000	$34,411	$34,411	$9,411	$0
11	OPRHP Trails; Schoelkopf/ Whirlpool/ Devil's Hole	$150,000	$150,000	$150,000		$0
12	Fisheries Promotion Assistance	$100,000	$39,000	$39,000		$61,000
13	Enhance Fish Island Access Site at Dexter	$45,000	$45,000	$45,000		$0
14	Maxwell Creek Fishing Access Site	$50,000	$53,115	$53,115	$3,115	$0
15	Port Bay (East) Fishing Access Site	$2,000	$0	$2,000		$0
17	Town of Wilson Boat Launch improvements	$30,000	$29,952	$29,952		$48
18	Boat Launch at Mud Bay	$100,000	$50,010	$50,010		$49,990
20	OPRHP Fort Niagara Boat Launch	$50,000	$50,000	$50,000		$0
21	Slater Creek Fishing Access Site	$75,000	$33,620	$33,620		$41,380
22	Lake Ontario Watershed Display at the Niagara Falls Aquarium	$300,000	$300,000	$300,000		$0
25	Irondequoit Creek Stream bank Stabilization	$250,500	$250,500	$250,500		$0
26	Deepwater Cisco Reintroduction in Lake Ontario	$50,000	$50,000	$50,000		$0
27	Public Access Improvements, Village of Morristown	$50,000	$50,000	$50,000		$0
29	Pen Rearing Program Assistance	$20,000	$13,149	$20,000		$0
30	Salmon River Hatchery Aquaria/ Interpretive Displays	$100,000	$100,000	$100,000		$0
32	OPRHP Four Mile Creek State Park, Niagara Co.	$75,000	$75,000	$75,000		$0
33	Multifrequency Acoustic Analysis for Estimating Alewife Abundanc	$55,000	$47,431	$47,431		$7,569
34	Olcott Pier Access Improvement	$100,000	$53,803	$53,803		$46,197
35	Improvements to Cape Vincent Aquaria/Interpretive Displays	$40,000	$1,628	$40,000		$0
37	Locate Lake Trout Spawning areas in the Lower Niagara River	$50,000	$48,221	$48,221		$1,779
39	Sea Lamprey Control Barrier Fund	$60,000	$60,000	$60,000		$0
		$4,822,500	**$4,347,394**	**$4,966,786**	**$361,012**	**$216,726**

Ongoing Projects

Projects described in this section are in various stages of development and implementation. BOF staff hold annual public meetings and meet with organized Great Lakes angler groups more than five times annually, and provide annual updates on the status of LONRD projects. The projects below remain fully relevant for the constituencies this program serves and BOF objectives for Lake Ontario system sportfisheries. These projects will

be implemented by BOF staff. A summary of current and anticipated expenditures is presented in Table 2.

1. **Improvements to the DEC Salmon River Fish Hatchery. –**The Salmon River Hatchery provides most of the trout and salmon stocked into Lake Ontario by New York State, yet the hatchery's water quantity and quality are inadequate to consistently rear trout and salmon at desired production levels. During the summer, rearing water temperatures are substantially warmer than desirable, resulting in frequent disease outbreaks. During winter, hatchery water temperatures are colder than desired, resulting in slower fish growth and additional disease issues. The hatchery uses well water in an attempt to buffer the effects of the sub-optimal temperature regime of its river water source, however, chronic shortages of well water persist.

   Improving the water supply for the hatchery has proven to be rather complex. When OPS engineers and BOF staff assessed the issues affecting the hatchery's water supply, it became apparent that a number of investigations were needed, and most required significant engineering - resulting in lengthy project implementation delays (i.e. development of scopes of work, bidding documents, contract development, and short calendar year work windows to accommodate fish production requirements).

   A hydrogeological resistivity survey to identify underground water resources and a well field maintenance survey have been completed. The resistivity survey ultimately resulted in the development of a new well, however, the quantity of well water remains insufficient. Surveys of existing wells identified equipment replacement and well rehabilitation needs, and locations where new production wells might be developed. The main Salmon River Reservoir pipeline supplying the hatchery with surface water has experienced a significant reduction in flow capacity, and an internal video inspection determined that sludge and sediments have accumulated in the pipeline. A project is currently in development to clean the pipeline and restore its original flow capacity.

   A feasibility study to evaluate a water recirculation and treatment system allowing re-use of well water has been completed, and design work for the system is underway. The anticipated cost of this project is likely to greatly exceed the project's $2.2 million allocation, however, the $1.4 million allotment for Cape Vincent Hatchery improvement project (#19; see "Cancelled Projects" below) could be re-allocated to cover additional costs. BOF staff will consult with DEC's Office of General Counsel (OGC) should this re-allocation become necessary. To date, $433,593 have been spent or encumbered on this project. Substantial in-kind services have been provided by OPS engineering and contract development/management, and BOF staff time.

5. **Salmon River stream bank stabilization/trail project –** This project requires final conveyance of land parcels to New York State, which is expected to occur in FY 2015. Each fall/winter the Salmon River supports an intense sport fishery, supporting more than one million anglers hours in 2011. This project will address erosion problems stemming from foot traffic near and along the river's banks. A trail system will be designed to reduce angler traffic on the more susceptible banks and encourage access at less vulnerable points along the river. Also, in-stream structures designed to facilitate sediment transport will be installed that will create and enhance fish habitat (i.e., pools, runs, etc.). Completion of this project will improve trout and salmon habitat and make angling along the Salmon River safer and more pleasant for participants. This project is anticipated to use

its entire $500,000 allotment. In-kind services are anticipated from the Service.

16. **Northern Pike Spawning Marsh Rehabilitation –** DEC netting surveys in the Thousand Islands region have documented a decline in northern pike populations over the past 20+ years, coincident with angler complaints regarding the quality of northern pike fishing. Northern pike require healthy wetland habitats for successful reproduction, and Lake Ontario/St. Lawrence River water level regulation is strongly implicated in degradation of wetland habitats.

    This project was postponed pending results of an experimental wetland enhancement program funded by the Fish Enhancement, Mitigation, and Research Fund (New York Power Authority re-licensing settlement with the Service; "FEMRF" Fund) at DEC's French Creek Wildlife Management Area. This program was done collaboratively with the SUNY College of Environmental Science and Forestry (SUNY ESF) and the Service. Recent post-project evaluations of wetland enhancement techniques including water level control structures and creation of potholes connected by channels have documented improved northern pike reproduction. Juvenile pike production in marshes managed with water level control structures was initially high, however, production declined markedly several years after construction.

    In the light of successful results with creation of potholes and channels in marshes, we anticipate contributing all $200,000 towards a future St. Lawrence River marsh enhancement project, possibly with additional funds from the Service.

23. **Repair Cranberry Creek Marsh Water Control Structure –** For the same reasons discussed in Project #16 above, the goal of this project is to provide quality spawning habitat for northern pike in the Thousand Islands region. Given evaluations of juvenile pike production in managed spawning marshes using water control structures discussed above, BOF staff will consult with OGC staff regarding the transfer of the $50,000 allocated for this project to Project #16.

24. **Upgrade Hatchery Pond Complex at Lisbon, NY –** Since the mid-1980s, the St. Lawrence Valley Sportsman's Club (Club) has used a former DEC hatchery currently owned by OPRHP to raise walleye fingerlings for stocking into the St. Lawrence River. The project entails the rehabilitation and clay-lining of two additional one-acre ponds to increase existing walleye production. OPRHP and DEC staff have worked with the Club to improve the ponds, however, a series of logistic and administrative hurdles have delayed implementation.

    A recent proposal is currently being considered to enhance spawning habitat in the nearby Oswegatchie River in lieu of improving the ponds, an alternative more acceptable to DEC staff. There are $100,000 in funds available for this project.

28. **Sodus Bay boat launch, Wayne Co. –** DEC Region 8 BOF staff recently identified a marina on Sodus Bay for sale, suitable for development of a public waterway access site, and have begun the process to acquire this property. This project will require its entire $500,000 allocation, as well as re-allocated funds from projects that will not be implemented (primarily project #42, see below). BOF staff will consult with OGC staff should this re-allocation become necessary.

31. **Walleye Spawning Habitat Enhancement Fund** – DEC Region 6 and Lake Ontario Unit staff, and USGS staff have identified several areas of the Black River at Dexter suitable for enhancing walleye spawning habitat. Necessary planning and permitting activities are underway. This project is not

expected to use its full $200,000 allocation initially, however, additional habitat enhancements would be pursued pending successful evaluations at Dexter. Additional funds and in-kind services for this project will come from BOF, USGS and Service staff time. The Service's FEMRF could also contribute to this project, as well as future projects in other tributaries.

36. Additional ice-fishing access on Sodus and Blind Sodus Bays –The $50,000 allocation for this project would be required for project #28 above, which would also provide public ice fishing access.

Table 2. Summary of expenditures to date and future, anticipated expenditures for "ongoing projects." Ongoing projects include those in various stages of development and implementation. These projects remain fully relevant for the constituencies this program serves and DEC Bureau of Fisheries (BOF) objectives for Lake Ontario system sportfisheries.

Rank #	Project title	Allocation	Current Expenditures or Encumbrances	Anticipated Expenditures	Funds Likely to be Re-allocated	Balance or Anticipated Balance
	"Ongoing" Projects					
1	Improvements to the NYSDEC Salmon River Fish Hatchery	$2,200,000	$433,593	$3,600,000	$1,400,000	$0
5	Salmon River Stream bank Stabilization/Trail Project	$500,000	$0	$500,000		$0
16	Northern Pike Spawning Marsh Rehabilitation	$200,000	$0	$200,000		$0
23	Repair Cranberry Creek Marsh Water Control Structure	$50,000	$0	$50,000		$0
24	Upgrade Hatchery Pond Complex at Lisbon, NY	$100,000	$0	$50,000		$50,000
28	Sodus Bay boat launch, Wayne Co.	$500,000	$0	$1,200,000	$700,000	$0
31	Walleye Spawning Habitat Enhancement Fund	$200,000	$0	$200,000		$0
36	Add. ice-fishing access on Sodus and Blind Sodus Bays,	$50,000	$0	$50,000		$0
		$3,800,000	$433,593	$5,850,000	$2,100,000	$50,000

Cancelled Projects

Two projects met significant impasse and are no longer under consideration for implementation:

38. The Port Bay (west) access road project, which proposed measures to improve access road conditions during winter, will not be implemented. After reviewing the project description and site conditions, DEC engineers determined that the scope and costs of this project far exceed its $500,000 allocation. Additionally, there are significant regulatory hurdles that would make this project extremely difficult, if not impossible, to undertake. Through consultation with OGC staff, the following re-allocations were executed: $348,486 to project #7, $9,410 to project #10, and $3,114 to project #14.

41. The Waterport Dam tailrace project proposed reconfiguration of the dam tailrace and bypassed reach to alleviate fish stranding. During periods of high water flow, water crests the dam and increases flow in the bypassed reach, attracting migrating fish into that reach. Once flows attenuate to normal operational levels, fish in the bypassed reach can become stranded. The fish are then subjected to unsportsmanlike fishing practices, or perish due to lack of water flow. While this project was deemed worthy in the project review process, OGC staff determined that it would be inappropriate to use New York State funds to remediate a problem at a facility owned and operated by one of DEC's regulated entities. The $50,000 allocated to this project should be re-allocated to a higher ranking project.

Based on evaluation subsequent to the initial project evaluation and listing, and a lack of pier/breakwall walkway proposals submitted, three additional projects are no longer under consideration for implementation:

19. **Hatchery Improvements at Cape Vincent Fisheries Station –** Proposed capital improvements to the defunct hatchery infrastructure at the Cape Vincent Fisheries Station were deemed unnecessary and impracticable for a host of reasons. Walleye populations in Eastern Lake Ontario and the St. Lawrence River are relatively high and stable, and currently provide quality fisheries. Walleye spawning habitat enhancements (project #31) can be much more successful and cost-effective, including a recent project completed on Kents Creek (Lake Ontario tributary in Jefferson County) using FEMRF funds. Rearing other species at this facility would require additional human and fiscal resources from the BOF in an era when meeting the needs of the existing, 12 hatchery system is challenging. Lastly, repairs required at the facility were underestimated and would likely require funds exceeding the project allocation. Considering the above, the $1.4 million appropriated to this project will be reallocated to augment funding for improvements at the Salmon River Hatchery (SRH). The SRH improvement project is the highest ranked project and will require funding beyond its original allocation. The SRH rears the majority of trout and salmon stocked into Lake Ontario, and stakeholders continue to express concerns that improvements to SRH have not been completed.

40. **Experimental Techniques to Enhance Submergent Vegetation Growth and Efficacy of Artificial Spawning Habitat –** This project was deemed impracticable by SUNY ESF researchers, and the $45,000 should be transferred to project #16 to achieve the same objectives.

42. **Construct walkways on any existing piers or breakwalls –** To date, no project proposals have been received, and it is recommended that the funds in this category ($500,000) be re-allocated to the higher-ranked Sodus Bay Boat Launch project (#28).

Lake Ontario Commercial Fishery Summary, 2000-2014

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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 2014. Commercial harvest generally targets yellow perch (*Perca flavescens*) and brown bullhead (*Ameurus nebulosus*), however, harvest of lake herring (*Coregonus artedii*), white perch (*Morone Americana),* rock bass *(Ambloplites rupestris),* and burbot (*Lota lota*) was also reported in 2014. 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 on two licenses (Table 2) in 2014. 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 2014 commercial catch from the New York waters of Eastern Lake Ontario (*estimated mean value, as price fluctuates throughout the year).

SPECIES	TOTAL POUNDS	PRICE/POUND*	TOTAL VALUE
Yellow Perch	44,143	$1.96	$ 86,885

Table 2. Reported* commercial fish catch in pounds from the New York waters of Eastern Lake Ontario, 2000-2014.

	# Lic.	YP	BBH	WP	RB	SF	CRP	WTF	CAT	DRM	CSCO
2000	7	59,928	5,709	383	280	3,571	308	-	-	-	-
2001	6	40,323	5,875	442	15	16	-	-	-	-	-
2002	6	37,223	4,435	-	-	-	-	-	-	-	-
2003	6	6,153	5,815	-	-	-	-	-	-	-	-
2004	3	37,066	1,200	-	-	-	-	-	-	-	-
2005	3	6,354	1,040	-	-	-	-	-	-	-	-
2006	3	4,274	500	-	-	-	-	-	-	-	-
2007	3	34,343	535	-	-	-	-	-	-	-	-
2008	3	14,428	735	-	-	-	-	-	-	-	-
2009	3	41,338	31	-	20	-	-	-	-	-	347**
2010	2	44,008	75	546	-	-	-	16	-	-	465
2011	3	77,238	105	3,736	-	-	-	-	-	-	613
2012	3	59,989	105	1,130	-	-	-	18	-	-	44
2013	3	20,589	0	1,820	-	-	-	-	-	-	12
2014	2	44,143	63	815	22						20

*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

Monitoring and Management of Upper St. Lawrence River Muskellunge

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The upper St. Lawrence River is well known for its world-class Great Lakes strain muskellunge (*Esox masquinongy*, Mitchell) fishery. This population has been proactively managed through the efforts of an international St. Lawrence River Esocid Working Group and guidance by muskellunge management plans (Panek 1980, LaPan and Penney 1991, Farrell et al. 2003). The goal for management is: "To perpetuate the muskellunge as a viable, self-sustaining component of the fish community in the St. Lawrence River and to provide a quality trophy fishery" (with a catch rate of 0.1 fish per hour). The Esocid Working Group, composed of resource managers from the US and Canada, meets periodically to discuss recently completed studies, research needs, and potential management actions. Attention to muskellunge management and research needs has served as a long-term management model (Farrell et al. 2007) that is now focused on trends related to significant population reductions subsequent to an invasive viral hemorrhagic septicemia (VHSV) outbreak in the mid-2000s.

As recommended by management plans, monitoring of adult and young-of-year (YOY) muskellunge has been ongoing since 1990 and recent population changes have been detected using this data series. The first was an apparent positive response to the improved management strategies of the late 1990s and early 2000s with increased numbers of YOY on nursery grounds and higher adult catch rates. Beginning in 2005, however, widespread mortality of adult muskellunge was observed and attributed to VHSV introduction to the Great Lakes (Elsayed et al. 2006). Since these adult muskellunge mortality events, substantial declines have been observed in adult catch rates in the spring spawning survey and YOY abundance on the nursery grounds later in the summer.

Monitoring is important to understanding the population's response to perturbations such as disease-induced mortality as well as changes to habitat such as vegetation or fish community structure. For example, invasions by nonnative species such as round goby, (*Neogobius melanostomus*) are now known to include littoral nursery habitats of muskellunge. Maintenance of productive critical habitats is imperative to ensure sustained natural muskellunge reproduction (Dombeck et al. 1986). In order to address these needs, monitoring in nursery areas and research targeting factors influencing reproductive success continues to be of high importance. Significant progress has been made in these areas in previous work (summarized in Farrell et al. 2007), including studies of spawning ecology (LaPan et al. 1995, Farrell 1991, Farrell et al. 1996), nursery habitat requirements (Werner et al. 1990, Clapsadl 1993, Jonckheere 1994, Farrell and Werner 1999, Murry and Farrell 2007, Woodside 2008), dietary characteristics of YOY (Kapuscinski et al. 2012), and their response to invasions by non-native prey fish (Kapuscinski and Farrell 2014). The information obtained in these studies will be used to develop a more comprehensive understanding of muskellunge habitat and population dynamics, and guide enhancement strategies.

Our objective here is to report current research and monitoring efforts with annual updates pertinent to muskellunge management.

Methods

Spring trapnetting survey

Standardized trapnet surveys to monitor adult muskellunge at a set of spawning bays were conducted in 1997-2000, 2003, and since 2006 for a minimum of four weeks during the spawning period. In 2014, sixteen nets, including 3' hoop nets and 6' Oneida trap nets were fished near shore in eleven

known muskellunge spawning bays from May 12th to June 19th (Table 1). An additional sixteen sites were surveyed using a roving net design in an attempt to increase catch of spawning muskellunge.

Data collected include total length (TL), sex, spawning condition, and weight when possible (Table 2). All adult muskellunge were tagged with Passive Integrated Transponder (PIT) tags. A fin tissue sample was retained for future genetic analysis. Catch data are used to monitor trends in abundance, size and age distribution, and sex ratios of spawning muskellunge. Data on muskellunge recaptured in this survey and by angler collaborators are used to examine growth and fish movements, particularly as it may pertain to spawning site fidelity.

Summer seining surveys

In 1990, a standardized seining procedure was initiated at six sites to monitor YOY muskellunge in the upper St. Lawrence River. Since 1997, monitoring the relative abundance of YOY muskellunge during the nursery period has continued with two surveys per year at each of eleven sites between Cape Vincent and Alexandria Bay, NY. Survey procedures are further detailed in Farrell and Werner (1999). Data collected include geographic coordinates detailing the location of each haul and habitat features (depth, temperature, vegetation type, and coverage). Juvenile esocid data comprises abundance, distribution, and total length (mm). Seining survey data are used to monitor trends in abundance, growth between periods, and monitor fish assemblage/habitat relationships at muskellunge nursery locations. Concomitant with collecting muskellunge-specific data, all other fishes are identified and enumerated to characterize fish assemblages present at muskellunge spawning sites.

In addition to the standardized survey at index sites, continued identification of critical habitats is conducted at *exploratory* sites. These are areas where muskellunge were not previously detected (habitats in Eastern Lake Ontario downstream through Lake St. Lawrence) or have not been sampled in recent years using the standardized procedures for seining and data collection.

Muskellunge larval survival study

To estimate survival of YOY muskellunge in nursery sites we repeated the stocking study conducted in the 1990s (Farrell and Werner 1999) to compare contemporary patterns to the 5 years of evaluation conducted during 1990-92, 1994 and 1996. Eggs were stripped and fertilized from adult muskellunge captured in the monitoring phase of the contract, when possible. Embryos were cultured in the wet laboratory at TIBS and fry were fed *Artemia* to ~25mm and were released into study bays and survival evaluated in subsequent field surveys. For 2014, eggs were stripped and fertilized and additional male milt was used (Buck Bay 5/20) from a spawning pair of adult muskellunge (Flynn Bay 5/21) captured in the spawning adult monitoring phase of the contract. Eggs were stripped, fertilized, and incubated to advanced fry (Mean =26 mm; SD=0.84 mm) at the Thousand Islands Biological Station. Fry were immersed in 700 ppm oxytetracycline for 8 hours to produce an identifiable mark in the otolith. Subsamples of immersed fry were retained to evaluate mark quality. Muskellunge sac fry were tested for the presence of three viral pathogens (via cell culture) and two bacterial pathogens (via plate culture) using AFS Blue Book standards. No pathogens were detected (insp. BD14-20). A total of 3,891 fry in excellent condition were released in four bays (Affluence – 790, Boscobel – 1108, Deer – 522, and Rose – 1371) on June 30th and their success estimated during subsequent seining surveys beginning 6 weeks post-release and extending to September 2.

Angler diary program

Thousand Islands Biological Station (TIBS) staff continues to maintain an angler diary program with participants ranging in angling frequency from casual though dedicated muskellunge anglers to a professional guide with multiple record catches to his credit. Cooperators are selected based on quality of information volunteered in previous diary projects. They are asked to record information on daily effort (rod hours), catch and harvest rates, total lengths, and approximate location of angled muskellunge. We are working towards creating a website where participants can access current program information, join the program, and enter their diary information.

Muskellunge Catch and Release Program

A partnership with a local environmental advocacy group, Save the River, continued through 2014 sponsoring the Muskellunge Catch and Release Program. This program aims to both educate and involve the angling community in the conservation of the local adult muskellunge population by rewarding anglers who release a legal-size muskellunge with a limited edition, signed muskellunge print by St. Lawrence River artist Michael Ringer. Data are

collected on each participant's total muskellunge catch and effort expended in hours, as well as information for the specific released fish submitted for the reward. Those details include location caught, water depth, weather conditions, date, time of day, weight of line used, bait or lure type, and total length of the muskellunge.

Muskellunge mortality

Throughout the field season, TIBS staff, collaborators, and other members of the Thousand Islands community who are familiar with the TIBS's mission, contribute to muskellunge mortality monitoring by reporting and/or collecting dead fish. When possible, dead and moribund fish are processed to record details on size, weight, potential cause of death, and stomach contents. During this necropsy, the cleithrum bone is removed and preserved for later age determination. Fish that are moribund or recently deceased are placed on ice and immediately transported to Dr. Rod Getchell at the Cornell Veterinary College for necropsy and testing for VHSV presence using their qRT-PCR method developed specifically for the type IVb isolates (Hope et al. 2013).

Results and Discussion

Spring trapnetting survey

A total of ten muskellunge were captured (catch rate = 0.016 fish/net night) in 2014, continuing a trend of decline since the 2005 outbreak of VHSV (Figure 1). The mean number of muskellunge caught in the spring trapnetting survey before the VHSV outbreak was 28.0 (SD=10.5), but a mean of 11.0 (SD=6.2) muskellunge have been captured in subsequent years. The 2014 catch rate of 0.016 muskellunge per trap net night (Table 1) was less than that of 2013 and slightly higher than in 2011 and 2012, but lower than historic levels. There were no recaptured muskellunge in 2014.

Summer seining surveys

The seventeenth consecutive annual standardized YOY muskellunge seining index was completed in 2014 (Table 3, Figure 2). A total of 11 bays were sampled during July with a fine-mesh seine (92 hauls) and during August with a large-mesh seine (90 hauls). A total of 30 (22 at stocked sites) YOY muskellunge (CPUE = 0.32 fish/haul) were captured in the fine-mesh index seine survey. The large-mesh seining series in August resulted in a catch of 27 (23 at stocked sites) YOY muskellunge in 90 seine hauls (CPUE = 0.30).

For the exploratory seining series, a total of 57 hauls were completed in the Thousand Islands during July, resulting in a catch of 5 YOY muskellunge out of eight sites sampled (CPUE = 0.09) (Table 3).

YOY muskellunge abundance within nursery areas remains suppressed even though catch rates were higher this year. This is the second consecutive year since 2008 where there has been an increase in catch rates, however catch rates still remain significantly lower than historical values. This seven-year decline in YOY abundance appears to signal a series of weak year-classes and potentially poor recruitment to the adult population.

Muskellunge larval survival study

No age-0 muskellunge were recaptured at Affluence Bay and only one from Deer Island and was retained for OTC analysis. Lack of late summer optimal habitat at these locations may have been a factor in the lack of recruitment. During fry release on June 30 early submersed aquatic vegetation was apparent and composed of several common *Potamogeton* species. Visual prey observations suggested low abundance at all sites with the exception of Rose Bay where schools of newly hatched fry where apparent and released muskellunge were videotaped feeding on them. Seining evaluation of stocked muskellunge show higher catch rates at the four stocked (CPUE=0.63) relative to six non-stocked sites (CPUE=0.14) sampled with the 30' seine. During the 15-31 August 60' seining catch rates increased slightly for stocked sites (CPUE=0.69) but declined for the non-stocked sites (CPUE=0.08). Only one individual fish was available from Boscobel and Deer Islands, they were retained for OTC mark detection to determine origin. A larger sample was available from Rose Bay (n=15), otoliths of all fish were removed and compared to tank fry to determine presence of OTC mark. Due to unknown circumstances the fish failed to retain an OTC mark on their otoliths. However visual comparison of otoliths extracted from captured fish show a similar stocking mark. Rose Bay produced numerous age-0 muskellunge that were likely composed of fry stocked origin. Overall with the 60' seine, 66 age-0 muskellunge were captured in 42 hauls at Rose Bay (CPUE=1.57). These fish appeared to benefit from a large submersed aquatic vegetation bed of water celery (*Vallisneria americana*) at the center of the bay, where most fish were captured. Gastric lavage indicated that several age-0 muskellunge had consumed young round goby (*Neogobius melanostomus*).

Angler diary program

In 2014, angler diary program anglers spent 587 hours of effort for 17 muskellunge captured (0.029 fish/hour; Figure 3). The catch rate was a slight decrease over 2013 where 23 muskellunge where captured in 632 hours of effort (0.036 fish/hour), but continues greatly reduced quality of the muskellunge fishery. Regardless of the increase in participants, catch rates remain well below the management goal of 0.1 fish per hour.

Muskellunge Catch and Release Program

In 2014, six anglers participated in the Muskellunge Catch and Release program with TIBS and Save the River. Catches ranged in size from 48 to 54 inches. By the point in the season at which the anglers participated in this program, their angling effort ranged from 1 to 100 hours, with an average of 18.9 angler hours.

Muskellunge mortality

Fish health was monitored and a photographic record of each fish maintained. Non-lethal fin tissue samples were taken from each fish and stored in 95% non-denatured ethanol for analysis at Dr. Rod Getchell's laboratory for VHSV at the Cornell Veterinary College. Fin biopsies were collected during 2014 field surveys from 10 adult muskellunge and 67 juvenile muskellunge (YOY) and tested with the qRT-PCR method. None of these muskellunge tested positive for the VHS virus by qRT-PCR method. One hundred seventy-four other fish such as round gobies, rock bass, pumpkinseeds, yellow perch, brown bullhead, and bluegill were captured during these TIBS collections and assayed for VHSV using the same qRT-PCR method. Two round gobies, one yellow perch, and one pumpkinseed tested positive for VHSV IVb in the 2014 samples. Testing of SLR fish in 2013 also detected VHSV in fish associated with muskellunge sites where three VHS virus positive fish, included a yellow perch, a rock bass and a black crappie.

An adult muskellunge found dead by TIBS sampling crews near a trap net set in Garlock Bay on the St. Lawrence River on 6/15/2014 was tested at Cornell University. The quantitative RT-PCR test specific for viral hemorrhagic septicemia virus type IVb was performed on combined kidney, spleen, liver, and heart homogenate as well as a separate sample from the brain, and a positive result was obtained for both samples. The copy number measured in the brain tissue was significantly higher than the level measured from the pooled organs. Viral isolation in cell culture was attempted by Dr. Emily Cornwell was repeated two times to capture the current endemic strains of VHSV in this region of the river. No viral isolation could be detected via cell culture to determine the isolate variant.

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Table 1. Locations, site type, sampling period, trapnet effort (net nights), muskellunge catch, and CPUE in St. Lawrence River bays, 2014.

Site	Type	# Nets	Effort	Musky	CPUE
Blind Bay	Index	2	75	0	0.000
Cobb Shoal	Index	1	32	1	0.031
Densmore Bay	Index	1	36	1	0.028
Flynn Bay	Index	3	56	4	0.071
Frinks Bay	Index	1	29	0	0.000
Garlock Bay	Index	1	36	1	0.028
Lindley Bay	Index	1	36	0	0.000
Millens Bay	Index	1	31	0	0.000
Peos Bay	Index	1	35	0	0.000
Rose Bay	Index	2	67	1	0.015
Swan Bay	Index	1	36	0	0.000
Site	Type	# Nets	Effort	Musky	CPUE
A1	Roving	1	8	0	0.000
A2	Roving	1	9	0	0.000
Buck Bay	Roving	1	21	1	0.048
Chippewa Bay	Roving	1	2	0	0.000
Delaney	Roving	1	13	0	0.000
French Bay	Roving	1	2	0	0.000
Goose Bay	Roving	1	2	0	0.000
Long Point	Roving	1	13	0	0.000
Mead Island	Roving	1	8	0	0.000
Thurso Bay	Roving	1	29	0	0.000
Sub-Total	Index	15	469	8	0.017
Sub-Total	Roving	10	107	1	0.009
Total			**576**	**9**	**0.016**

Table 2. Summary of location of catch, total length (TL-mm), weight (kg), sex, reproductive stage, and tag number, and recapture history of spawning adult muskellunge in trapnets in St. Lawrence River bays, 2013. The tag entry number is for PIT type tags. No previously tagged muskellunge were recaptured this year.

Date	Location	Sex	Stage	TL (mm)	Weight (kg)	Recap Tag no.	Tag No.
5/11/2013	Rose	M	R	1020	7.86	-	900118001356930
5/13/2013	Flynn	F	H	1080	n/a	-	900118001354776
5/14/2013	Blind	F	R	1470	20.99	-	900118001105076
5/14/2013	Blind	F	R	1350	>25	-	900118001355082
5/14/2013	Thurso	F	S	1320	n/a	-	900118001106638
5/15/2013	Rose	M	R	1040	n/a	-	900118001105674
5/17/2013	Rose	M	R	1000	n/a	-	900118001357410
5/17/2013	Flynn	M	R	1140	n/a	-	900118001105988
6/4/2013	Peos	M	R	1200	28	-	900118001102006
6/4/2013	Peos	M	S	950	12	-	900118001104583
6/4/2013	Lindley	M	R	1240	34	-	900118001106135
6/5/2013	Blind	F	R	1350	n/a	-	900118001353286
6/5/2013	Blind	M	R	1311	34	-	900118001106147

Table 3. Seining catch summary for 2013 sampling using a 1/16" fine-mesh 30' bag seine in index sites (top), exploratory sites (middle), and a1/4" large-mesh bag seine targeting esocids. Highlighted lines represent sites that were stocked.

2014 30' Index Seining					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Affluence Bay	7	0	0	0.00	0.00
Boscobel	7	0	0	0.00	0.00
Cobb Shoal	12	2	0	0.17	0.00
Deer Island	6	5	0	0.83	0.00
Frinks	10	0	0	0.00	0.00
Garlock	10	3	2	0.30	0.20
Lindley	6	2	0	0.33	0.00
Millens	10	0	0	0.00	0.00
Peos	8	0	0	0.00	0.00
Rose	10	17	0	1.70	0.00
Salisbury	6	1	3	0.17	0.50
Total	**92**	**30**	**5**	**0.33**	**0.05**

Table 3 Continued. Highlighted lines represent sites that were stocked.

2014 60' Index Seining					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Affluence Bay	6	0	0	0.00	0.00
Boscobel	6	6	0	1.00	0.00
Cobb Shoal	12	5	1	0.42	0.08
Deer Island	6	1	0	0.17	0.00
Frinks	10	0	2	0.00	0.20
Garlock	10	0	3	0.00	0.30
Lindley	6	1	4	0.17	0.67
Millens	10	0	0	0.00	0.00
Peos	8	0	0	0.00	0.00
Rose	10	16	0	1.60	0.00
Salisbury	6	0	6	0.00	1.00
Total	**90**	**29**	**16**	**0.32**	**0.18**
2014 30' Exploratory Seining					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Delaney	12	0	12	0.00	1.00
Densmore	4	0	0	0.00	0.00
Flynn	20	5	8	0.25	0.40
Goose Bay (Clayton)	3	0	1	0.00	0.33
Whitehouse	4	0	1	0.00	0.25
Goose Bay	4	0	2	0.00	0.50
Fergusons Cove	2	0	0	0.00	0.00
Carrier	8	0	3	0.00	0.38
Total	**57**	**5**	**27**	**0.09**	**0.47**

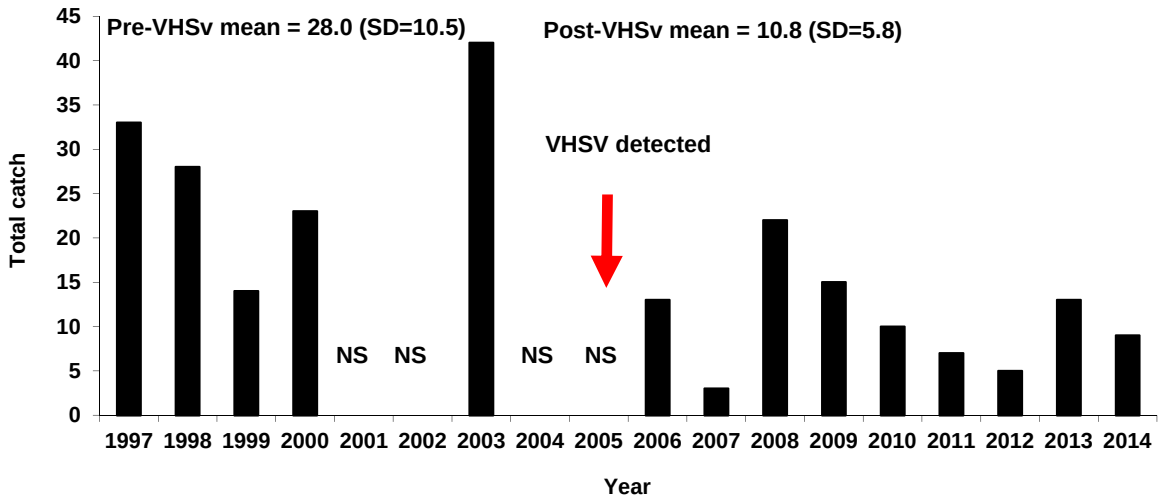

Figure 1. Total catch of muskellunge during spring trapnet sampling during 1997- 2014. Sites and effort are approximately equal over the series. Samples were not collected in 2001-02 and 2004-05 (NS) because of a decision of the Esocid Working Group to monitor muskellunge every third year. Following VHSV outbreak it was decided to resume annual monitoring.

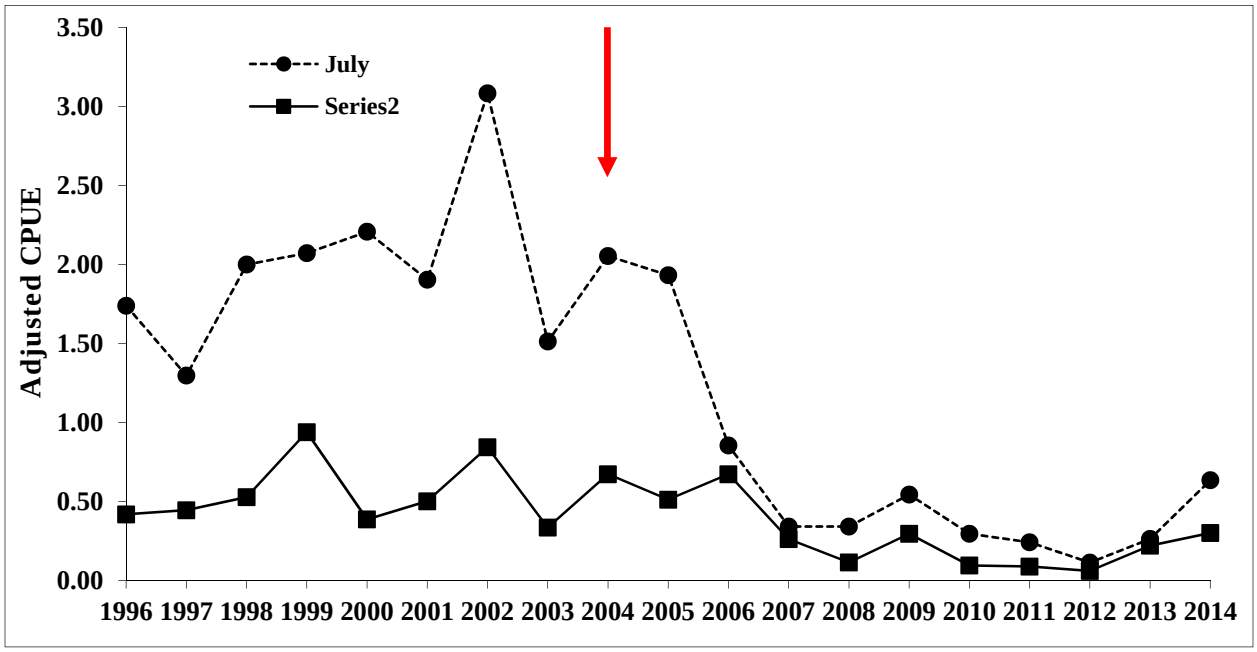

Figure 2. Catch per unit effort of YOY muskellunge captured in standardized seine hauls in eleven upper St. Lawrence River nursery sites from 1996 to 2014. A 9.14 m fine-mesh seine was used from July 15-31 and an 18.3 m large-mesh seine was used from August 15-31. The fine-mesh seine CPUE was doubled to standardize the area swept among the two gears. The arrow indicates the year prior to detection of VHSV (2004) and widespread mortality of muskellunge in the upper River.

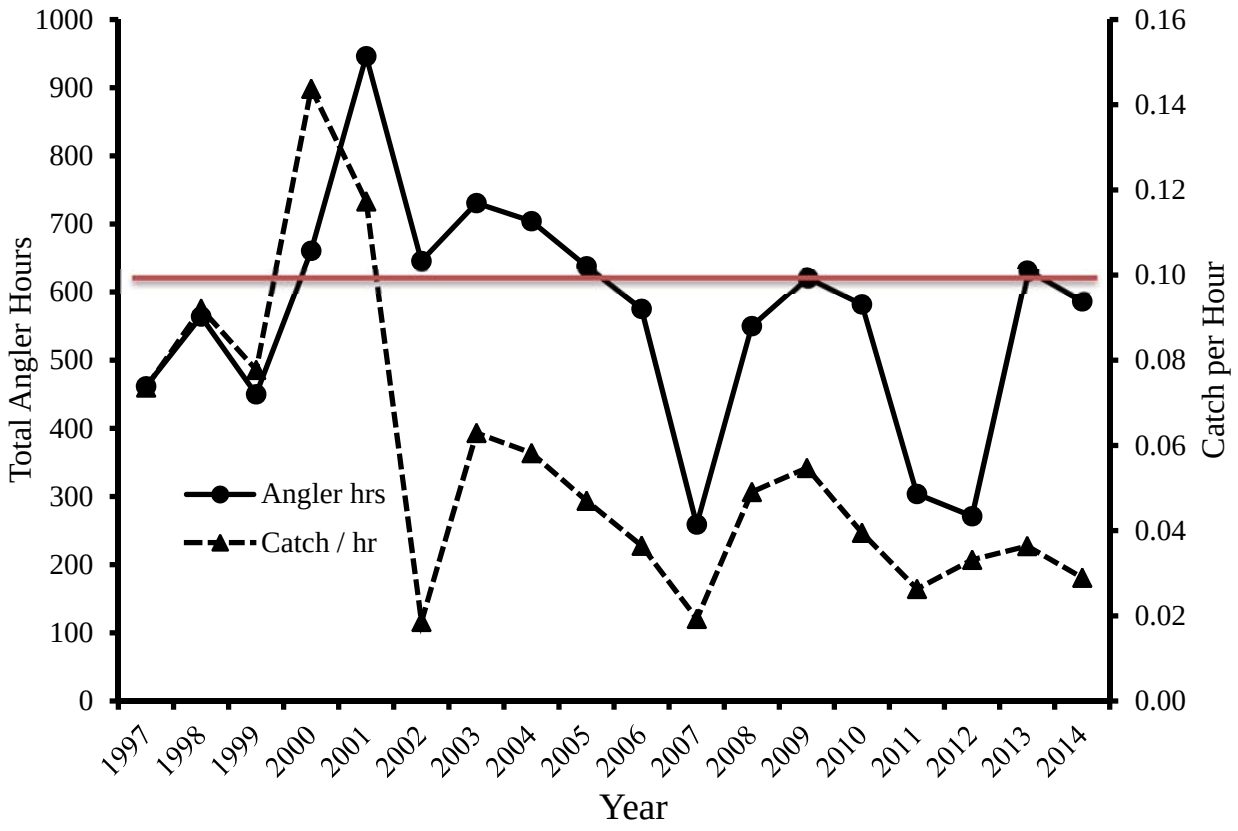

Figure 3. Angler hours compared to catch per angler hour. Red line denotes the target goal of 0.1 fish per angler hour.

Northern Pike Monitoring and Management in the Thousand Islands Section of the St. Lawrence River

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Northern pike abundance in the NYS Department of Environmental Conservation's (DEC) Thousand Islands Warmwater Fish Stock Assessment (McCullough and Gordon 2013) continues to 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 water-depth) and 4-6 week delays in the egg deposition period (Farrell 2001). Deep-water spawning behavior is believed to be maladaptive and has created a significant reproductive sink, as field studies and simulations indicate poor growth and survival of pike in this habitat (Farrell et al. 2006). Nearshore pike spawning has been negatively affected by water level regulation by preventing spawner access to wetlands and via the expansion of hybrid cattail (*Typha* x *glauca*) into riparian wet meadow habitats (Farrell et al. 2010).

To provide improved spawning habitat conditions at the local scale, water level controlled spawning marshes have been used in an attempt to increase natural recruitment (Forney 1968). Three natural spawning marshes have been managed in the Thousand Islands region to provide improved spring water level conditions with a goal of enhancing regional pike reproduction. Despite some early indications of success with managed marshes demonstrating significant production of emigrating fingerlings (Farrell et al. 2003), it is hypothesized that low numbers of spawning adults and female skewed sex ratios have resulted in low levels of YOY production at managed marshes.

Northern pike YOY have been monitored in eleven seining survey sites also used to index muskellunge (Farrell and Runner 2014a) and more recently in larger bays and in tributaries. Overall YOY production has declined significantly from levels observed in the 1980s and early 1990s. Continued monitoring is necessary to track pike reproductive success and evaluate responses to management activities (managed marshes and habitat enhancements). Other needs fulfilled by the project include a better understanding of early life history processes for northern pike in tributary systems, and the influence of IJC regulated water levels on habitat dynamics and northern pike recruitment processes. Research regarding habitat restoration efforts, in addition to providing options for northern pike management, will be critical to maintaining future populations.

Our objective is to provide an update of current research and monitoring activities related to northern pike management.

Methods

Spawning run trapnet survey

Monitoring of adult northern pike during spring spawning occurred in five index tributaries and 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 (19.7 in). Recaptured fish yielded information on distribution, individual growth, and spawning site fidelity. A scale sample was retained from each fish and notes on any physical abnormalities were recorded. Captured pike were transferred upstream of each net following processing. The sex ratio (females to each male) was compared for each site.

Water levels were held intentionally higher (~0.6 m or about 2 feet) at Carpenters Branch, Butterfield Marsh and Delaney Marsh. Butterfield and Delaney marshes were not included in the spring spawning survey because of their remote locations, but were surveyed for emigrating YOY pike, wetland vegetation, and other indices. The site water level management strategy is intended to prevent the fall drawdown associated with the IJC's water level regulation Plan 1958D (Farrell et al. 2010). Managing for higher water levels promotes more natural muskrat populations within sites, resulting in the creation of openings in dense invasive cattail mats within the marsh (Toner et al. 2010). Higher water levels also provide improved spring water level conditions for spawning pike.

Each year YOY pike are surveyed while emigrating from marshes by capture in spillway traps set and emptied daily. In 2014, traps were maintained at Delaney marsh from 6/11 to 7/2, at Butterfield marsh from 6/12 to 7/1, and Carpenter's Branch from 6/4 to 7/1. All fish captured were identified and enumerated. Northern pike were measured for total length (mm), and a pelvic fin was removed to evaluate the presence of marsh-origin fish during subsequent summer seining surveys and future spring adult trapnetting surveys.

Summer seining surveys

Standardized seining for YOY northern pike was conducted in conjunction with YOY muskellunge monitoring. A total of 11 bays were sampled during July with a fine-mesh 9.1 m (30') seine (90 hauls) and during August with a large-mesh 18.3 m (60ft) seine (90 hauls) (for methods details see Murry and Farrell 2007). In addition, eight 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 37 northern pike were captured at five index sites from April 14th to May 1st, 2014, comprising an effort of 98 net nights, and resulting in a catch per unit of effort (CPUE) of 0.44 fish/night (Table 1). The catch of spawning northern pike at index sites remains low since a significant peak in 2008 (3.36 fish per night; n=5; Figure 2). Catches were relatively higher at Cranberry Creek (18 pike in 16 net-nights, 1.13 fish per night). The catch of northern pike was considerably higher at French Bay (92 pike in 4 net-nights, 23 fish per night) compared to all of the tributary sites.

Only one northern pike was captured at the managed marsh, Carpenter's Branch. Current and past trapnet catches 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 from managed marshes

The Delaney Marsh site yielded slightly higher productivity over recent years but still remains suppressed compared to historic levels at 153 northern pike YOY over 21 days of monitoring (Table 2). Carpenter's Branch had its lowest catch ever recorded with only 1 northern pike YOY captured over 27 days of monitoring. All fish over 80mm (3.2 in) were marked by removal of the left ventral fin. Overall catch per unit effort at Carpenter's Branch was 0.04 northern pike emigrating per day. Delaney catch rate increased to 7.29 fish emigrating per day, highest among sites, yet still much lower than observed at similar sites early in the program. Catch in Butterfield Marsh was a fraction of that observed at Delaney at 0.74 fish per night. Low production of northern pike from the Carpenter's and Delaney spawning marshes has continued for seven consecutive years (Figure 3).

Summer seining surveys

The YOY seining survey at eleven index sites targeting muskellunge produced 5 northern pike YOY from the 30' seine series in 92 hauls (standardized CPUE = 0.05 fish; Table 3) and 16 in the 60' seine series in 90 hauls (standard CPUE = 0.18 fish/haul). Eight upper St. Lawrence River bays were sampled during exploratory seining and 27 YOY pike were captured (N=57 hauls; CPUE=0.47). Seine hauls at Delaney Bay (N=12) resulted in a catch of twelve YOY pike (CPUE = 1.00).

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. Relationships of low spawner density and YOY out-migrants were the impetus for transplanting fish in a 1:1 M:F ratio from French Bay to increase numbers at the Carpenter's Branch marsh in 2011; however, techniques employed failed to improve production of YOY. In 2014, no transfers occurred and strength of adult runs and YOY production was low. Recent habitat enhancements using created spawning pools with connectivity enhancements by Ducks Unlimited were evaluated by SUNY-ESF for YOY northern pike densities (Farrell et al. 2014). Spawning pools have had greater recent success in YOY northern pike production relative to the managed marshes. Spawning pools excavated in cattail (*Typha*) dominated habitats at French Creek Wildlife management area and at Point Vivian Marsh near Alexandria Bay produced high catch rates in 2014. It was also demonstrated during spawning pool monitoring over three years that YOY northern pike catch was lower in years of poor habitat suitability, such as the drought of 2012, demonstrating the influence of environmental conditions on production.

Steps continue to be taken by DEC, the US Fish and Wildlife Service (FWS) and Ducks Unlimited (DU) to restore critical spawning and nursery habitat. In an attempt to promote natural vegetation growth, managed marshes were drawn down in mid-summer to reflect natural drought periods. It is recommended that fish handling during trap and transfer operations be limited to only collecting length, sex and condition data to reduce fish stress, or to consider allowing fish passage systems to operate without trapping and only monitor outmigration of young pike. It is also recommended that a northern pike larval stocking assessment for spawning marshes be considered to assess survival independent of spawner density and effects of skewed gender ratios.

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. We are engaged in a study designed to identify northern pike sex determining genes (SDGs) to use in development of a molecular diagnostic tool (using PCR) to determine gender for early life stages. A known gender set of males (N=3) and females (N=5) was sampled to sequence the entire genome. Based on next generation sequencing data, a complimentary or cDNA library was developed to produce gender specific transcriptomes whereby male linked markers were tested but no markers have yet been identified. A histological approach has been developed in consultation with Dr. Geofrey Wolfe at the University of Virginia to determine gender in fish of about 70mm (2.7 in) TL. This method will be used with experimental trials to test environmental factors hypothesized to influence expected sex ratios. Specifically, we will investigate the effect of temperature and xenoestrogen treatments on sex ratio for northern pike eggs and larvae. We will incubate batches of fertilized eggs in controlled treatments and compare sex ratio outcomes using the gender determination test. Pike will be raised in each of 3 treatments, increased temperature, xenoestrogen treatment (estradiol), and a control. Understanding the presence and influence of these environmental factors on northern pike development will provide insight for future management practices.

The long-term monitoring developed in this study will serve as an important indicator to assess effects of a water level regulation plan change, if adopted, and to help guide the IJC adaptive management process.

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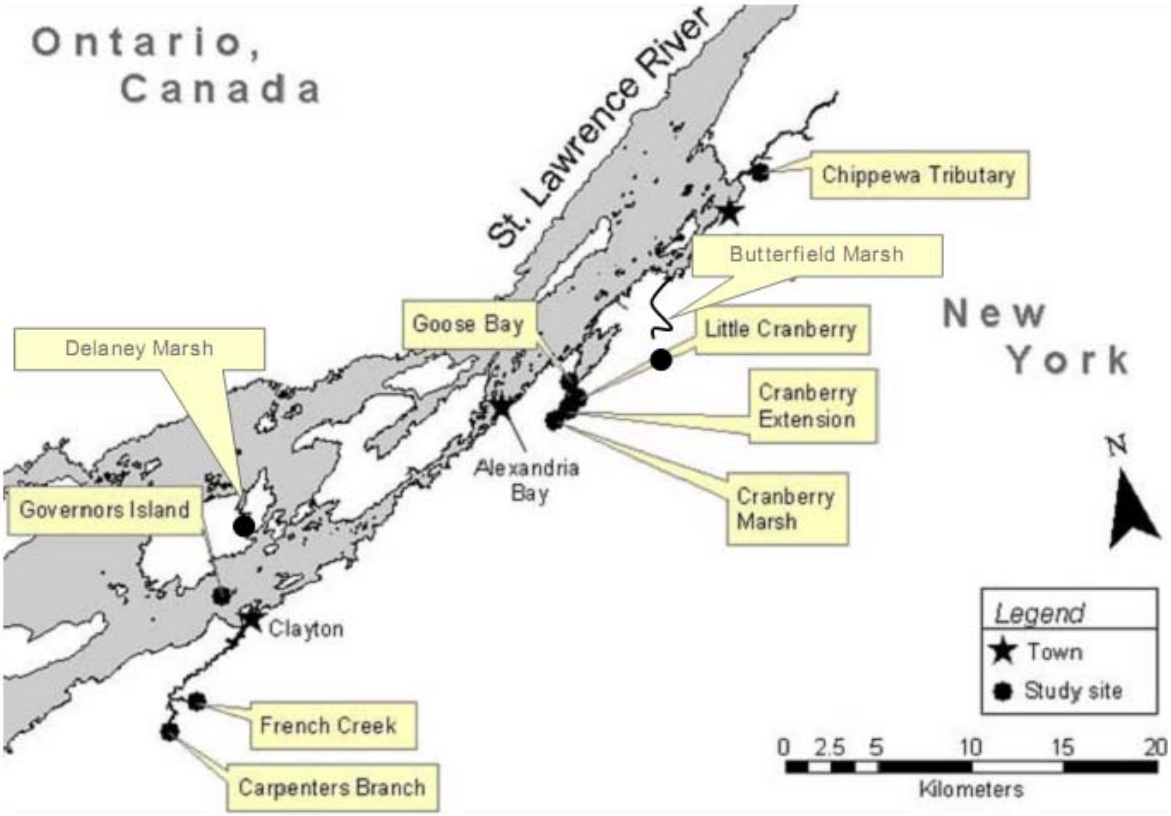

Figure 1. Study sites in the Thousand Islands Region of the upper St. Lawrence River in Clayton and Alexandria Bay, New York, including spawning marshes at Carpenters Branch (French Creek Wildlife Management Area) and Delaney Marsh (Grindstone Island) and sampling index locations at French Creek, Little Cranberry Creek, Cranberry Extension, and Chippewa (Creek) Tributary. Governors Island is the location of the Thousand Islands Biological Station. A spawning marsh at Butterfield Marsh at Crooked Creek has been repaired by the US Fish and Wildlife Service. Additional seining locations (not shown) are index YOY muskellunge monitoring sites and other regional embayments including Goose Bay.

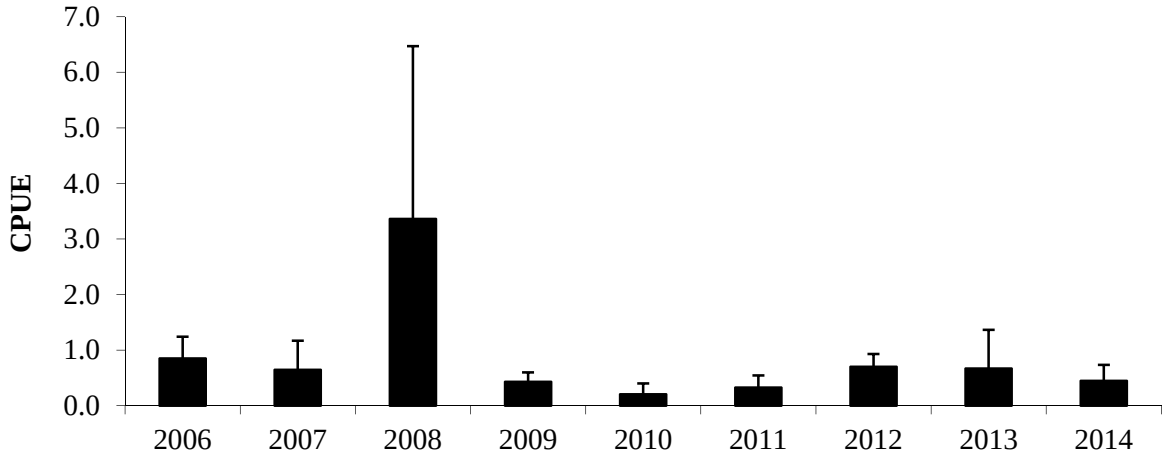

Figure 2. Average catch per net-night of northern pike in five spring spawning index trapnetting locations from 2006 to 2014 with 90% confidence limits.

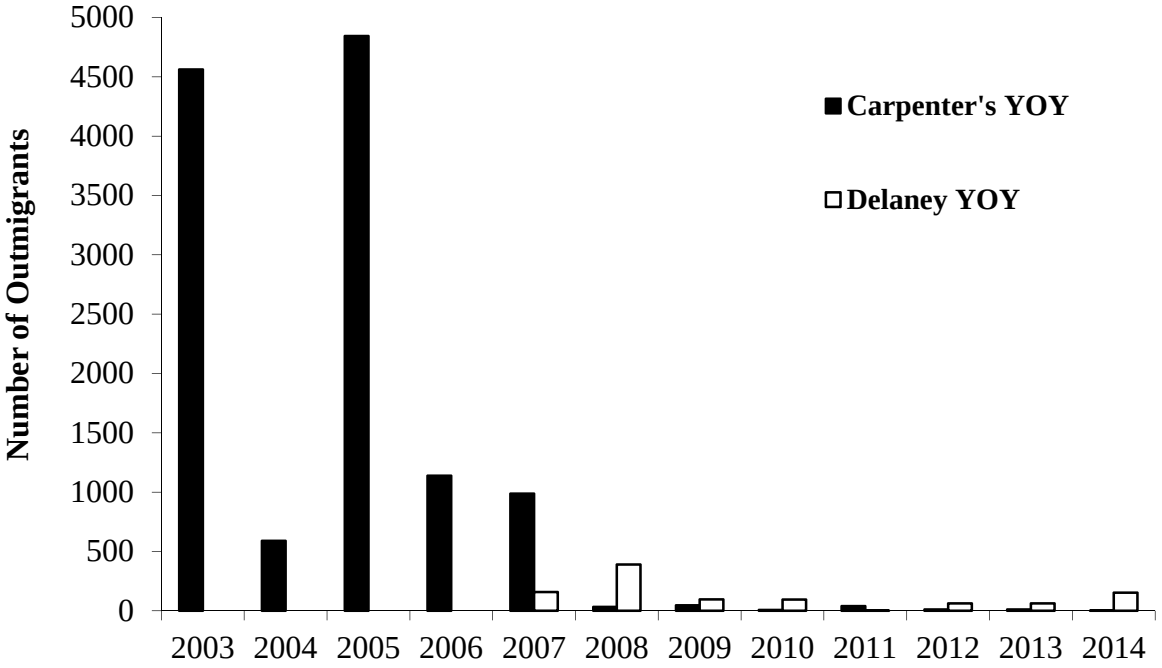

Figure 3. Number of out-migrant northern pike YOY from managed spawning marshes at Carpenter's Branch (2003 to 2014) and Delaney Marsh (2007 to 2014).

Table 1. 2013 upper St. Lawrence River northern pike spawning survey effort and results by site. Only Carpenters Branch managed marsh was sampled in 2014.

2014 NP Spawning						
Site	Gear	Start Date	End Date	Net Nights	NP Catch	CPUE
Chippewa Tributary	Hoop	4/14/2014	5/1/2014	17	5	0.29
Cranberry Creek	Oneida	4/14/2014	4/30/2014	16	18	1.13
Cranberry Ext.	Hoop	4/14/2014	4/30/2014	16	6	0.38
French Creek	Hoop	4/14/2014	5/1/2014	17	2	0.12
Little Cranberry	Hoop	4/14/2014	4/30/2014	16	5	0.31
Managed Marsh						
Carpenters Branch	Hoop	4/14/2014	4/30/2014	16	1	0.06
Supplemental Site						
French Bay	Oneida	4/26/2014	4/30/2014	4	92	23.00
Total				**102**	**129**	**1.26**

Table 2. Catch of YOY northern pike in emigration traps set at spillways associated with three managed spawning marshes at Carpenters Branch of French Creek, Delaney Marsh on Grindstone Island, and the Butterfield Marsh of Crooked Creek.

2014 NP Emigration					
Location	**Set Date**	**End Date**	**Net Nights**	**NP Catch**	**CPUE**
Butterfield Marsh	6/12/2014	7/1/2014	19	14	0.74
Carpenter's Branch	6/4/2014	7/1/2014	27	1	0.04
Delaney Marsh	6/11/2014	7/2/2014	21	153	7.29
Total			**67**	**168**	**2.51**

Table 3. Seining catch summary for 2014 sampling using a 1/16" 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 2013.

2014 30' Index Seining					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Affluence Bay	7	0	0	0.00	0.00
Boscobel	7	0	0	0.00	0.00
Cobb Shoal	12	2	0	0.17	0.00
Deer Island	6	5	0	0.83	0.00
Frinks	10	0	0	0.00	0.00
Garlock	10	3	2	0.30	0.20
Lindley	6	2	0	0.33	0.00
Millens	10	0	0	0.00	0.00
Peos	8	0	0	0.00	0.00
Rose	10	17	0	1.70	0.00
Salisbury	6	1	3	0.17	0.50
Total	**92**	**30**	**5**	**0.33**	**0.05**

Table 3. Continued

2014 60' Index Seining					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Affluence Bay	6	0	0	0.00	0.00
Boscobel	6	6	0	1.00	0.00
Cobb Shoal	12	5	1	0.42	0.08
Deer Island	6	1	0	0.17	0.00
Frinks	10	0	2	0.00	0.20
Garlock	10	0	3	0.00	0.30
Lindley	6	1	4	0.17	0.67
Millens	10	0	0	0.00	0.00
Peos	8	0	0	0.00	0.00
Rose	10	16	0	1.60	0.00
Salisbury	6	0	6	0.00	1.00
Total	**90**	**29**	**16**	**0.32**	**0.18**
2014 30' Exploratory Seining					
Bay	Hauls	Muskie	NP	CPUE M	CPUE NP
Delaney	12	0	12	0.00	1.00
Densmore	4	0	0	0.00	0.00
Flynn	20	5	8	0.25	0.40
Goose Bay (Clayton)	3	0	1	0.00	0.33
Whitehouse	4	0	1	0.00	0.25
Goose Bay	4	0	2	0.00	0.50
Fergusons Cove	2	0	0	0.00	0.00
Carrier	8	0	3	0.00	0.38
Total	**57**	**5**	**27**	**0.09**	**0.47**