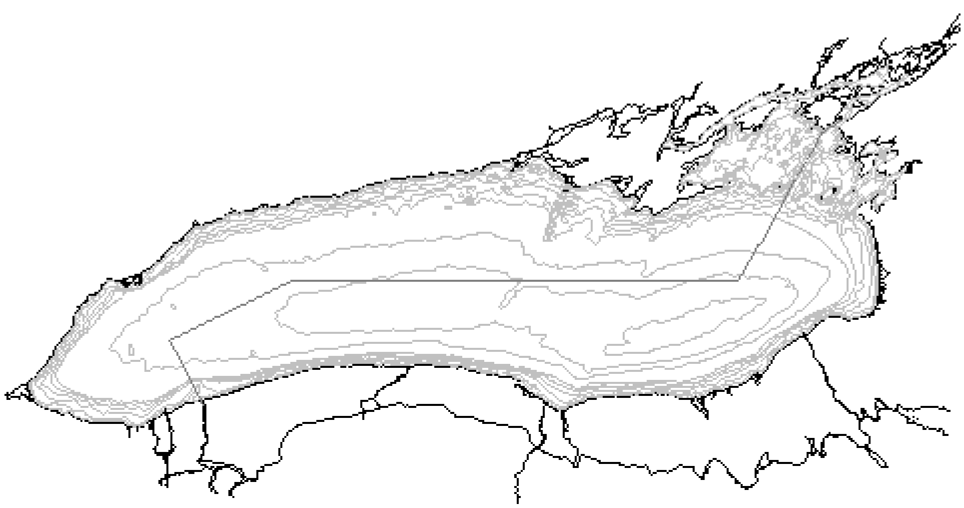
2017 ANNUAL REPORT

Bureau of Fisheries

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



MARCH 2018

New York State Department of Environmental Conservation
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New York State Department of Environmental Conservation
Lake Ontario and St. Lawrence River Units
Cape Vincent, NY 13618 and Watertown, NY 13601

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Markham, Ontario
March 27-28, 2018

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

SECTIONS 1, 2, 3, 4, 5, 8, 9, 10, 12, 14 and 15

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 coregonines (whitefish) 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. 2017). Since the early 1970's, water quality improvements resulting from the Great Lakes Water Quality Agreement (International Joint Commission 1994), sea lamprey control, and extensive fish stocking programs in New York and Ontario have resulted in increased diversity in the Lake Ontario fish community and a robust sportfishery. In 2007, anglers fishing Lake Ontario and its tributaries contributed over $114 million to the New York State economy (Connelly and Brown 2009).

In the 1990s, the Lake Ontario ecosystem experienced dramatic changes resulting primarily from the introduction of exotic zebra and quagga mussels. In addition, improvements in wastewater treatment have reduced excessive nutrient concentrations in the open lake to historic, more natural levels, thereby lowering the productive capacity of the Lake Ontario ecosystem. Zooplankton biomass in Lake Ontario's offshore upper thermal layer declined drastically over the last 30 years (as much as 99% by the early 2000s), attributable to reduced lake productivity and invasive predatory zooplankton (i.e., *Bythotrephes* and *Cercopagis*, discovered in 1985 and 1998, respectively). Since 2005, offshore zooplankton biomass improved but remains well below historic levels. The abundance and distribution of the native deepwater amphipod, *Diporeia* deteriorated markedly, likely due to range expansion of quagga mussels into deeper waters. The exotic round goby was first documented in New York waters of Lake Ontario in 1998, and spread throughout Lake Ontario and the St. Lawrence River rapidly. Goby abundance and biomass grew exponentially, then stabilized at lower levels. Round goby have dominated the diets of Double-crested Cormorants from colonies in eastern Lake Ontario and the St. Lawrence River for nearly a decade. Goby 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.

Maintaining balance between predators and prey, primarily salmonines (predominately Chinook salmon) and alewife, remains a substantive challenge in the face of lower trophic level disturbances and ongoing ecosystem changes. Two consecutive severe winters (2013/2014 and 2014/2015) followed by below average summer water temperatures resulted in very small 2013 and 2014 (record low) alewife year classes, which contributed to a markedly reduced adult alewife population in 2016 and 2017. Concerns over the impacts of the two consecutive poor alewife year classes to the future adult alewife population prompted the NYS Department of Environmental Conservation (DEC) and the Ontario Ministry of Natural Resources and Forestry (OMNRF) to reduce Chinook salmon and lake trout stocking by 20% each in 2017 and 2018.

This report summarizes cooperative research and monitoring activities conducted on Lake Ontario and the St. Lawrence River by the DEC, U.S. Geological Survey, OMNRF, U.S. Fish and Wildlife Service, Fisheries and Oceans Canada, and the SUNY College of Environmental Science and Forestry in 2017.

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 15).
- In 2017, 341 (204 spring, 137 fall) bottom trawls were performed in U.S. and Canadian waters.
- The 341 total trawls represents a substantial increase in effort from historic methods, and beginning in 2016 the depth range sampled (20 ft – 738 ft) increased relative to historic surveys. The 2016-2017 distribution of trawl tows across depths more closely matches the distribution of depths available in the lake.
- In spring 2017 bottom trawl surveys, abundance of adult (age-2 and older) alewife increased from 2016 levels in US waters, but declined in Canadian waters. Abundance of yearling (age-1) alewife increased to a record high level in US waters.
- Adult alewife condition, measured in the fall of 2017, was well below the 10-year average, which may be a due to large numbers of age-1 alewife.
- Abundance indices for rainbow smelt, cisco, and emerald hiner either declined or remained at low levels in 2017.
- Round goby abundance declined in 2017, and for the first time, deepwater sculpin were the most abundant benthic prey fish caught in the fall bottom trawl survey. Slimy sculpin abundance continued to decline and reached a record low in 2017.
- The 2017 hydroacoustic survey of Lake Ontario preyfish populations consisted of the typical five cross-lake transects and an Eastern Basin transect, as well as six additional mid-water trawling transects. Estimated yearling and older alewife abundance increased by 140% in 2017. Beginning in 2016 the survey was expanded to include mid-water trawling targeting cisco. In 2017, the majority of cisco catches occurred within the eastern portion of the sampling area but one cisco was caught near Cobourg, ON. Midwater trawl catches of cisco declined in 2017 relative to 2016, however, the lakewide acoustic estimate of cisco density (18 fish per acre) increased relative to 2016. The rainbow smelt abundance estimate (15.1 million) declined in 2017.
- 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.

Coldwater Fisheries Management

- Fish stocking in the New York waters of Lake Ontario in 2017 included 1.35 million Chinook salmon, 232,020 coho salmon, 656,505 rainbow trout, 201,147 lake trout, 411,890 brown trout, 127,011 Atlantic salmon, 93,553 bloater, and 408,873 cisco. Of these, 134,480 brown trout and

139,302 lake trout were stocked offshore by military landing craft in an ongoing effort to reduce predation on newly stocked fish by Double-crested Cormorants and predatory fish (Section 1).

- Average weights and condition (a measure of "stoutness") of salmonines at a given age serve as a potential index of relative balance between the number of predators (primarily salmonines) and preyfish; however, water temperatures also influence fish growth and condition. Average weights and condition are calculated for salmonines examined from the open lake fishery (Section 2) and as spawning adults at the Salmon River Hatchery (Section 9).
- Chinook salmon growth measured from the open lake fishery was below average in 2014 – 2017. The August 2017 mean length (35 in) of age-3 Chinook salmon was over 1.7 in shorter than the long-term average. However, Chinook salmon condition or relative "stoutness" in 2017 was one of the heaviest values observed for Chinook salmon ≥ 28 in. Below average summer temperatures may have negatively impacted growth in length, however, the good condition of Chinook salmon ≥ 28inches indicated that alewife (the primary forage of Chinook salmon) abundance was sufficient to maintain Chinook condition (Section 2).
- At the Salmon River Hatchery, average weight of age-1 Chinook males (jacks) sampled in 2017 was 5.3 pounds, the 12th highest value in the time series. Age-2 males (12.8 lbs) were 0.5 pounds below average and age-2 females (13.2 lbs) were 1.4 pounds below average. Age-3 males (15.8 lbs) and females (15.9 lbs) were both approximately 3 pounds below the long-term average. Chinook salmon condition (based on the predicted weight of a 36 inch long Chinook salmon) in fall 2017 was 0.7 pounds below to the long term average and the third lowest in the data series (Section 9).
- Steelhead are sampled in the spring at the Salmon River Hatchery and, unlike Chinook and coho salmon, do not reflect growth during the 2017 growing season. Weights reported here reflect conditions prior to and including 2016. The mean weights of age-3 males and females were 5.6 and 7.0 lbs, respectively. The males were 0.2 lighter and the females were 0.7 heavier than their respective long-term averages. The mean weights of age-4 males (6.4 lbs) and females (8.4 lbs) were both below their long-term averages (Section 9).
- Since the institution of seasonal base flows in the Salmon River in 1996, natural reproduction of Chinook salmon continues to be documented by an annual seining index conducted weekly during May and June at four sites. In 2017, the mean catch per seine haul (467 fish/haul) was estimated using the catches from the third week of May through the second week of June, and was the fifth highest on record (Section 8).
- The twentieth 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 fish reaching target weights. A total of 21,600 Washington strain steelhead were raised at seven pen sites, comprising 3.7% of DEC's Lake Ontario yearling steelhead stocking allotment in 2017. Seven pen-rearing sites raised a total of 303,420 Chinook salmon, representing 22.5% of DEC's 2017 Chinook salmon stocking allotment (Sections 1 and 10).

Lake Trout Restoration

- Restoration of a naturally reproducing population of lake trout is the focus of a major international effort in Lake Ontario. Each year several surveys measure progress toward lake trout rehabilitation (Section 5).
- Adult lake trout abundance in index gill nets increased each year from 2008-2014, recovering from historic lows recorded during 2005-2007, then declined each year 2015-2017. Adult abundance in 2017 was 35% below the 2014 peak.
- The sea lamprey wounding rate on lake trout caught in gill nets was 0.5 fresh (A1) wounds per 100 lake trout, the lowest value in the data series and well below the target of 2.0 wounds per 100 lake trout.

- The survival indices for age 2 lake trout stocked in 2016 (2015 year class) declined by 64% relative to the 2014 year class, which was the highest observed since 1990.
- Naturally reproduced lake trout were documented in 23 years since 1994. The largest catches of naturally produced lake trout occurred from 2014 – 2017.
- Adult lake trout condition (measured by the predicted weight of a 27.6 in fish) in 2017 was the highest observed for the 1984 – 2017 time series. Condition of juvenile lake trout in 2017 was above average for the 1979 – 2017 time series.
- In 2017, angler catch (15,444 fish) and harvest (8,592 fish) of lake trout were both below the previous 5-year average. The decrease in lake trout catch and harvest may be partially attributed to excellent fishing quality for other salmonines (i.e., fewer anglers specifically targeting lake trout).

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 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 2017, eight Lake Ontario tributaries (three Canada, five NY) were treated with lampricides. Treatments in New York included South Sandy Creek, Lindsey Creek, Salmon River, Little Salmon River and Nine Mile Creek. A total of 5,006 sea lamprey were trapped in eight tributaries, five of which are index locations.
- The estimated population of adult sea lamprey was 12,536, slightly above the fish community objective target of 11,368.
- Larval assessments were conducted on a total of 62 tributaries (35 Canada, 27 NY). Surveys to estimate abundance of larval sea lampreys were conducted in 10 tributaries (3 Canada, 7 NY). Surveys to detect the presence of new larval sea lamprey populations were conducted in 16 tributaries (13 Canada, 3 NY), with no new populations detected.
- Post-treatment assessments were conducted in nine tributaries (4 Canada, 5 NY) to determine the effectiveness of lampricide treatments conducted during 2016 and 2017. Surveys in New York's Salmon River and Lindsey Creek found many residuals and both systems are scheduled for re-treatment in 2018.
- Surveys to evaluate barrier effectiveness were conducted in 10 tributaries (7 Canada, 3 U.S.).
- The rate of wounding by sea lamprey on lake trout caught in gill nets was 0.5 fresh (A1) wounds per 100 lake trout, well below the target of 2 wounds per 100 lake trout (Section 5). There were an estimated 14.7 lamprey observed per 1,000 trout or salmon caught by anglers, comparable to the previous five-year average (Section 2).

Warmwater Fisheries

- A total of 170,000 fingerling walleye were stocked in the lower Niagara River (23,200), Sodus Bay (73,900), Irondequoit Bay (62,500), and Port Bay (10,400) (Section 1).
- The Eastern Basin warmwater index gill netting survey is conducted annually to assess relative abundance and population characteristics of warm and coolwater fish species. Total catch-per-unit-effort (CPUE or relative abundance) of all species in 2017 was 36.1 fish/gill net, a 107.9% increase from 2014-2016. Yellow perch and smallmouth bass were the most commonly caught species (Section 4).

- Smallmouth bass abundance (6.8 fish/net) remained low but was 13% higher than the previous 5-year average. 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. Despite 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 in 2017 was 2.0 fish/net night, 12% higher than the previous 10-year average.
- Yellow perch CPUE (15.21 fish/net) improved in 2017 and was 51% higher than the previous 10-year average.
- Round goby first appeared in this assessment in 2005 in both gillnet catches and smallmouth bass diets. In 2017, 77.0% of the 139 non-empty bass stomachs contained round goby. Round goby have also been found in walleye, northern pike, brown trout, lake trout, and lake whitefish.
- At least one lake sturgeon was collected in the Eastern Basin gill netting survey in 17 of the last 23 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).
- Thousand Islands smallmouth bass abundance increased from low 1996-2006 levels, varied at relatively high levels from 2007 to 2012, then declined to a near record low by 2015. Abundance in 2016 and 2017, however, was moderate suggesting that the very low 2015 value may have been a sampling anomaly. Yellow perch abundance remained low in 2017 and was similar to the previous five-year average. From 1996 to 2017, northern pike abundance has remained relatively low. Ongoing poor recruitment of northern pike is likely related to spawning habitat limited by water level regulation, and possibly by Double-crested Cormorant predation (Section 6).
- Lake St. Lawrence yellow perch abundance was variable at a higher level from 2007-2017 as compared to most years during the 1990s and 2000s. Smallmouth bass catch has been variable since 2005, reached its second highest level in 2013, and was slightly below the long-term average in 2017. Catches of age 1 and age 2 smallmouth bass were well above the previous ten-year average in 2016 and 2017, suggesting potentially strong year classes. Walleye abundance increased 13% in 2017, but remained below the long-term average (Section 7).
- Abundance of spawning adult and young-of-the-year (YOY) northern pike in the Thousand Islands region of the St. Lawrence River continues to be suppressed likely due to habitat degradation resulting from long-term management of Lake Ontario/St. Lawrence River water levels. Overall, natural reproduction at natural and managed spawning marshes remains poor, due to low abundance of spawning adults and sex ratio dominance of females. Habitat restoration efforts including excavated channels and spawning pools have improved natural reproduction of YOY at many sites. (Section 17).
- Muskellunge population indices in the Thousand Islands region of the St. Lawrence River continue to show signs of stress. Spring trap net surveys, summer seining surveys and an angler diary index all indicate reduced adult and YOY abundance. It is plausible that adult muskellunge mortality events attributed to outbreaks of the invasive Viral Hemorrhagic Septicemia virus are contributing to lower adult muskellunge numbers and reduced natural reproduction (Section 19).
- Targeted gill net sampling for lake sturgeon in Lake Ontario, Black River Bay, and the St. Lawrence River in 2017 produced a total catch of 159 fish. Passive integrated transponder (PIT) tags, which allow for future identification of individual fish, were implanted in 122 fish to monitor fish growth, movements, and to manage brood stock genetics in restoration stocking efforts. Thirty-seven previously tagged sturgeon were re-captured in 2017 (Section 16).

Sport Fishery Assessment

- Each year from 1985-2017 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).
- Overall during 2017, fishing quality for trout and salmon was good to excellent. The four most sought after species are Chinook salmon, brown trout, rainbow trout, and coho salmon, and regulations allow a daily harvest limit of "3 in any combination" of these four species. In 2017, charter boat fishing quality (catch rate = number of fish caught per hour of angling) for these four species combined increased 45% from 2016 to the third highest level on record.
- Chinook salmon fishing quality among charter boats has been excellent from 2003-2017. Fishing quality in 2017 (0.14 fish/hr) was the highest recorded, primarily due to good to excellent fishing during July and August in all regions.
- The charter boat catch rate for coho salmon in 2017 (.02 fish/hr) was among the best in the 33 years surveyed.
- Rainbow trout fishing quality was at record high levels each year 2008-2014; however, declined markedly during 2015 and 2016. The 2017 carter boat catch rate (0.03 fish/hr) improved 46% from the 2015 low and was similar to (-9%) the long-term average.
- For the third consecutive year, fishing quality for brown trout was among the lowest recorded. Although fishing quality for brown trout was excellent in May (third best recorded), charter boat catch rates were well below average during much of the open lake season resulting in an overall 2017 catch rate (0.03 fish/hr) that was 20% below the long-term average.
- Following the 2007 record low, lake trout fishing quality improved each year 2008-2013, remained relatively stable from 2013-2016, then declined in 2017 (25% below the long-term average). The decline is partly attributed to good to excellent fishing quality for other trout and salmon species (i.e., Chinook salmon, coho salmon and rainbow trout) which may have reduced fishing effort specifically targeted at lake trout.
- Fishing quality for Atlantic salmon remained relatively high and was 12.6 times higher than the 1995-2008 average (i.e., the period of lowest catch rates; catch rates are very low when compared to other salmonines).
- An estimated 162,341 trout and salmon were caught (primarily Chinook salmon [59%] and rainbow trout [14%]). Trout and salmon harvest was estimated at 93,524 fish, dominated by Chinook salmon (58%) and rainbow trout (13%)
- Fishing effort directed at trout and salmon remained relatively stable from the early 2000s through 2015, then declined in 2016 and 2017. Effort in 2017 was the lowest level on record (35,865 boat trips targeting trout and salmon). The decline is partly attributed to extremely high water levels on Lake Ontario that persisted into early July, hindering boating activity.
- From early May to early July numerous public and private launches along the entire NY shoreline were closed or available for limited use only, many docks were nearly or completely submerged and not usable, many boaters were concerned about floating debris, and reduced boat speed limits were established along the entire shoreline. All of these factors contributed to record low boating activity of all types on Lake Ontario in 2017, including fishing (39,964 boat trips), recreational (52,445 excursions), and sailing (10,013 excursions).
- The number of lamprey observed per 1,000 trout and salmon caught was estimated at 14.7 in 2017 (comparable to [-5%] the previous 5-year average), indicating effective sea lamprey control.
- The estimated number of fishing boat trips targeting smallmouth bass during the traditional open season (3rd Saturday in June through September 30 when the creel survey ends) was 2,294 bass trips in 2017,

the lowest recorded and partly attributed to extremely high water levels on Lake Ontario. Bass fishing quality in 2017 (0.7 fish/hr) was the highest since 2006 and a 94% increase compared to the 2010 record low.

- NYSDEC initiated a Salmon River angler survey in September 2017 that will continue through mid-May 2018. Total estimated fishing effort from September – November was 96,456 angler trips totaling 655,706 angler hours, the second highest effort estimate on record (2011 - 751,127 angler hours).
- Chinook salmon was the most abundant species caught in fall 2017 with an estimated 109,840 fish caught and 34,934 harvested, the highest estimated since the early 1990s.
- Steelhead was the second most caught species during the fall season with an estimated 17,165 fish caught and 2,344 harvested, a substantial increase from the low numbers estimated in fall 2015 (6,378 caught and 837 harvested) the last time the survey was conducted.
- Estimated catch and harvest of coho salmon during fall 2017 was 15,167 and 5,746, respectively, also a substantial increase from the low estimates in fall 2015 (5,380 caught and 2,163 harvested).
- Fewer brown trout and Atlantic salmon were caught (1,399 and 36 fish, respectively) during September - November.

Double-crested Cormorant Management and Impacts on Sportfish Populations

- Cormorant population management, along with a major cormorant diet shift to round goby, was essentially meeting objectives related to cormorant predation for protecting fish populations, other colonial waterbird species, private property and other ecological values. However, cormorant management activities were suspended in 2016 and the future impacts to fish populations are unknown in the absences of an effective cormorant management program (Section 13).
- In May 2016, a U.S. Federal Court decision vacated an extension of the Public Resource Depredation Order, which had allowed DEC and other agencies to conduct cormorant management activities. As a result, only limited cormorant management activities were done in 2016 and no cormorant management was conducted in 2017.
- The number of cormorant feeding days at the Little Gallo Island colony were near or below the management target of 780,000 from 2010 - 2015. However, the number of feeding days increased in 2016 and 2017 primarily due to large numbers of chicks that resulted from reduced cormorant management activity. The estimated number of feeding days in 2017 (1,044,278) was well above the management target.

References

Christie, W.J. 1973. A review of the changes in the fish species composition of Lake Ontario. Great Lakes Fishery Commission Technical Report 23. 66 p.

Connelly, N.A. and T.L. Brown. 2009. New York statewide angler survey 2007, Report 1: Angler effort and expenditures. NYS Department of Environmental Conservation, Bureau of Fisheries. 109pp.

International Joint Commission United States. 1994. Great Lakes Water Quality Agreement of 1978, Agreement with Annexes and Terms of Reference between the United States and Canada signed at Ottawa, November 22, 1978, and Phosphorus Load Reduction Supplement signed October 16, 1983, as amended by Protocol signed November 18, 1987. Office Consolidation, International Joint Commission, United States and Canada, reprinted February 1994.

Smith, S.H. 1995. Early changes in the fish community of Lake Ontario. Great Lakes Fishery

Commission Technical Report 60. 38 p.

Stewart, T.J., A. Todd and S.R. LaPan. 2017. Fish community objectives for Lake Ontario. http://www.glfc.org/lakecom/loc/LO-FCO-2013-Final.pdf

New York Lake Ontario and Upper St. Lawrence River Stocking Program 2017

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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 2017 by species, strain, and life stage, and compares those totals with the 2017 New York Department of Environmental Conservation (NYSDEC) stocking policy. Table 2 provides totals by species and life stage, summarizing the New York stocking history from 2000-2017. New York stocking history from 1968-1999 is reported in Eckert (2000). Table 3 provides specific information for each group of fish stocked in 2017. 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 seventh edition of *Common and Scientific Names of Fishes from the United States, Canada, and Mexico* (Page et al. 2013).

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
FC	Fish Creek Club, Point Rock, NY
EW	Ed Weed Fish Culture Station, VT
MC	Morrisville College, Morrisville, NY
NAA	Niagara River Anglers Association
PMP	Powder Mill Park Hatchery, Monroe Co.
TUN	USGS Tunison Laboratory of Aquatic Sciences

U.S. Fish and Wildlife Service Hatcheries:

AL	Allegheny National Fish Hatchery, PA
BK	Berkshire National Fish Hatchery, MA
EI	D.D. Eisenhower National Fish Hatchery, VT
GN	Genoa National Fish Hatchery, WI
IR	Iron River National Fish Hatchery, WI
LAM	Lamar Northeast Fishery Center

PT[1] Pittsford National Fish Hatchery, VT
SC Sullivan Creek National Fish Hatchery, MI
WR White River National Fish 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 2015 are 2016 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. Fall fingerling HPW were stocked in 2014 and 2015 by AL. HPW yearlings were stocked in 2015-2017 by AL.

LC (Little Clear): Landlocked strain of Atlantic salmon. Includes both a feral broodstock maintained in Little Clear Lake, NY, as well as a captive broodstock held at the NYSDEC Adirondack Hatchery and derived from eggs taken from Little Clear Lake. Originally included Swedish Gull Spang strain, as well as West Grand Lake (outlet spawners) and Sebago (inlet spawners) strains from Maine. Beginning in 2007, Adirondack Hatchery began to transition both feral (held in the lake) and broodstock LC to Sebago strain only (see SEB below). In 2015-2016, AD stocked SEB/LC hybrids. In 2017, the 2016 year class was fully transitioned to SEB, and was designated as New York Sebago strain (NSB).

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 2013-2017. LCH-D fall fingerlings were stocked by EI in 2015. This strain has been abbreviated as FL-HYB and LC in the NYSDEC stocking database; LC and SLWVT in the USFWS stocking database; and as LCH and SNVT in the NYSDEC Lake Ontario Unit annual reports.

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

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

from the West Grand Lake, ME strain, an outlet spawner. Fry stocked by State University of New York College of Environmental Science and Forestry in 2014 were produced from a captive broodstock held at BH.

NSB- (New York Sebago): Landlocked SEB strain of Atlantic salmon maintained in Little Clear Lake and at AD hatchery as broodstock. Beginning in 2007, Adirondack Hatchery began to transition both feral LC (held in the lake) and broodstock LC to Sebago strain only (see SEB below). That transition was complete with the 2015 egg collection (2016 year class), which were stocked in Lake Ontario in 2017 as yearlings. New York Sebago were derived from SEB eggs taken from Casco Hatchery in Maine.

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

SEB (Sebago): Landlocked strain of Atlantic salmon derived from Maine. SEB were stocked in 2011-2015 by TUN from eggs originating from Ed Weed Fish Culture Station, VT (2011-2015), Casco Fish Hatchery, ME (2013), Bald Hill Fish Culture Station (2015) and from NYSDEC Adirondack Hatchery (2014-2017). In 2015, TUN stocked fry from BH, fall fingerlings from AD, and yearlings from EW. In 2016, TUN stocked fall fingerling and yearling SEB from AD and BH sources. In 2017, TUN stocked fall fingerlings and yearlings from AD. All SEB stocked by TUN from AD (2014-2017) were eggs taken from SEB broodstock held at AD. Note that AD transitioned from LC to SEB strain, and this was completed in 2016. AD designated these SEB as New York Sebago (NSB) and were stocked as yearlings in 2017.

SLR (St. Lawrence River): Population of Lake Sturgeon in the St. Lawrence River. Eggs have been taken from wild adults below the dam at Massena, NY and raised at GN or ON since 1996. Prior to 1996, eggs were taken from adults in the Riviere de Prairie near Montreal. Stocking has taken place in Lake Ontario since 2013.

SEN (Seneca Lake strain): Lake trout descended from a native population that coexisted with sea lamprey in Seneca Lake, NY. Until 2005, a captive broodstock was maintained at the U.S. Fish and Wildlife Service (USFWS) Alleghany National Fish Hatchery (AL), which began rearing lake trout for stocking in Lakes Erie and Ontario beginning with the 1978 year class. Through 1997, eggs were collected from fish in Seneca Lake and used to supplement broodstocks held at the AL and the SC. Beginning in 1998, SEN strain broodstocks were supplemented using eggs collected from both Seneca and Cayuga Lakes. Since 2003, eggs were collected exclusively from Cayuga Lake. After the 2005 stocking of the 2004 year class, an outbreak of Infectious Pancreatic Necrosis (IPN) required that all fish, including broodstock be destroyed and AL was closed for disinfection and renovation. The 2005 year class originated from eggs collected from Cayuga Lake and fish were reared at the NYSDEC Bath Fish Hatchery. The 2006 year class originated from both the NYSDEC Bath Hatchery egg take in Cayuga Lake and broodstock held at SC, and these fish were raised at the USFWS White River National Fish Hatchery (WR) and USFWS Dwight D. Eisenhower National Fish Hatchery (EI). Concerns over potential viral hemorrhagic septicemia virus (VHSv) introduction to WR prevented transfer of eggs from Cayuga Lake to WR following the fall 2005 egg take. SC provided eggs for the 2007 and 2008 year classes stocked in 2008 (reared at WR and EI) and 2009 (reared at WR only). The 2009 year class (stocked as Ylg in 2010) originated from the fall 2008 Cayuga Lake egg take, and was reared at the NYSDEC Bath Hatchery. Production of SEN strain at AL resumed with the 2012 year class, and AL stocked SEN as yearlings in 2013-2017 and as fall fingerlings in 2015. This strain has been abbreviated as FL and FLW in the NYSDEC stocking database; SLW in the USFWS stocking database; and as SEN and SLW in the NYSDEC Lake Ontario Unit annual reports.

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

SKW (Klondike Reef): This strain originated from a native, deep spawning "humper" morphotype of Lake Superior lake trout that are intermediate in fat content to lean and fat (Siscowet) morphotypes. Eggs for the 2008 year class raised at WR were obtained from the broodstock held at SC. Disease concerns prevented transfer of eggs from SC to WR in fall 2008 (2009 year class). Stocking of SKW resumed in 2014 with fall fingerlings produced at AL (eggs from broodstock at IR). Stocking of SKW by AL also occurred in 2015 as fall fingerlings and in 2015-2017 as yearlings. In 2017, 304 SKW broodstock adults were available from BK and stocked in December. 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 State (Chambers Crk. strain) to New York through 1980. Feral Lake Ontario broodstock was 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 adipose 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 "Remarks" in Table 3. Some marks or tags are not visible without specialized equipment including:

ALZ alizarin chemical mark
CAL calcein chemical mark
CWT coded wire tag
OTC oxytetracycline - 6 hour immersion
PIT passive integrated transponder tag

Visible marks and tags include:
AD adipose fin clip
JAW jaw tag
LV left ventral fin clip
LP left pectoral fin clip
RV Right ventral fin clip
RP Right pectoral fin clip
SCU Scute clip (sturgeon)
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, 2012-2017), 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. Up until 2016, only coho salmon were stocked using this method. In fall 2017, Atlantic salmon from TUN were experimentally marked and stocked into the smolt release pond. The fish are regularly monitored and fed. Downstream gates on the pond were removed, allowing the fish to voluntarily migrate into Beaverdam Brook at any time. The date the fish were stocked into the pond is shown in parentheses in the comments section. Date stocked corresponds to the date the smolt release pond was drained, forcing all remaining fish into Beaverdam Brook.

References

Eckert, T.H. 2000. Lake Ontario stocking and marking program 1999. Section 1 *in* NYSDEC 1999 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Keller, M., K. D. Smith, and R. W. Rybicki. 1990. Review of salmon and trout management in Lake Michigan. Michigan Department of Natural Resources, Fisheries Special Report 14, Ann Arbor.

Page, L, M., H. Espinosa-P´erez, L. T. Findley, C. R. Gilbert, R.N. Lea, N. E. Mandrak, R. L Mayden, and J. S. Nelson. 2013. *Common and Scientific Names of Fishes from the United States, Canada, and Mexico. Committee on Names of Fishes*, 7th edition. Bethesda, MD: American Fisheries Society.

Weeder, J.A. 1997. A Genetic Comparison of Lake Michigan Chinook Salmon (Oncorhynchus tshawytscha) to Their Source Population. Michigan Department of Natural Resources, Fisheries Division Fisheries Research Report 2032. Ann Arbor.

Table 1. Summary of stocking in New York waters of Lake Ontario, the lower Niagara River, and the upper St. Lawrence River during 2017, and comparisons with the NYSDEC 2017 stocking policy.

Species	Stage		Strain	DEC Stocking Policy	Actual Number Stocked
Atlantic Salmon	Ylg	1	NSB	50,000	50,000
	Ylg		SEB	-	26,509
	FF	1	SEB	-	50,502
Atlantic Salmon Total				50,000	127,011
Bloater	FF	1	LM	-	93,553
Brown Trout	Ylg	2,3	RL-D	404,670	411,890
Chinook Salmon	SF	4,5	SAL-W	1,330,039	1,350,380
Cisco	SF	1	LO	-	242,576
	AF	1	LO	-	78,567
	FF	1	LO	-	87,730
Cisco Total			LO	-	408,873
Coho Salmon	FF		SAL-W	155,000	139,020
	Ylg		SAL-W	90,000	93,000
Coho Salmon Total		6		245,000	232,020
Lake Sturgeon	FF		SLR	-	3,198
Lake Trout	Ylg		HPW	80,000	35,710
	Ylg		LCH-D	120,000	88,270
	Ylg		SEN-W	80,000	0
	Ylg		SKW	120,000	76,863
	Adult		SKW	0	304
Lake Trout Total		7,8		400,000	201,147
Rainbow Trout	Ylg		FL-W	7,500	7,000
	Ylg		RA-D	75,000	71,725
	Ylg		SKA-W	43,000	58,440
	Ylg	4	WAS-W	497,700	519,340
Rainbow Trout Total				623,200	656,505
Walleye	PF		ONL-W	69,600	170,000
Salmon and Trout Total				**3,052,909**	**2,978,953**
Grand Total				**3,122,509**	**3,654,577**

Notes: See Table 3 for details.

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

2 Brown trout stocking policy was adjusted to 86.1% of the prior policy based on the previous ten-year average of brown trout stocked into Lake Ontario. This policy reflects a more realistic production capacity of the hatcheries since the 2-year old brown trout program was instituted statewide. In 2017, 12,900 brown trout were added to the previous policy number (4,305) at Niagara River.

3 In 2017, high water prevented the LCM/Barge from accessing some launches, therefore stocking locations of barge stocked brown trout were adjusted: brown trout slated for barge stocking off Selkirk were barge stocked east of Oswego; 2/3 of the browns slated for Fairhaven were barge stocked west of Oswego; and 1/3 were barge stocked off Fairhaven.

4 No Chinook salmon or steelhead were stocked into pens at Genesee, Oak Orchard, and Niagara River, and no steelhead were stocked into pens at Sandy Creek due to lack of suitable conditions at these sites in 2017. All fish at these sites were direct stocked. A new pen site was created at Wilson in 2017. Some Chinook salmon were shifted from the Niagara allotment to accommodate this new site.

5 Chinook salmon stocking policy was reduced in 2017 over concerns about the prey fish (Alewife) population after extremely cold winters in 2014 and 2015 led to poor Alewife reproduction.

6 After the normal allotment of coho salmon were moved to the smolt release pond (SRP) at Salmon River hatchery in 2017, high water temperatures and fish health concerns forced early release of these fish into Beaverdam Brook; therefore an additional 90,000 were moved into the SRP, and coho fall fingerlings slated for Sodus, Genesee, Sandy Creek and lower Niagara River were not stocked in 2017.

7 Lake trout stocking policy in 2017 was reduced to 400,000 over concerns about the prey fish (Alewife) population after extremely cold winters in 2013 and 2014 led to poor Alewife reproduction.

8 High mortality at Alleghany Hatchery beginning fall 2016 led to a stocking shortfall in 2017. In 2017, 304 SKW broodstock adults were available from BK and stocked in December.

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 2017. Numbers stocked from 1968-1999 can be found in Eckert (2000).

Species Life Stage	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Co Ylg	97	94	96	92	119	98	95	90	90	99	101	105	95	95	99
Co FF	132	155	100	223	172	196	155	155	137	155	155	155	155	155	155
Co AF	0	290	0	0	0	0	0	0	0	0	0	0	0	0	0
Co f	0	0	0	0	0	0	0	0	0	0	0	4	7	0	0
Ck f	2835	2798	1603	1000	1150	1300	1605	1596	1596	1654	1629	1633	1622	1836	1809
Ck FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LT Ylg	818	508	501	507	500	350	500	426	476	490	500	500	500	457	224
LT FF	160	0	0	5	0	0	0	0	0	0	0	0	0	0	0
LT Ad	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
BT Ylg	382	415	445	402	382	361	426	426	429	421	405	382	414	367	391
BT FF	0	0	0	0	0	0	0	0	25	0	0	136	39	0	66
BT AF	0	0	0	0	0	0	0	0	0	0	114	0	0	0	10
BT f	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0
RT Ylg	82	85	88	92	24	70	93	92	97	75	60	71	75	64	75
RT FF	0	0	0	0	0	0	0	14	0	0	20	10	0	0	0
RT f	29	0	0	0	0	0	0	0	0	0	0	14	40	0	0
RT Ad	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0
Sthd Ad	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
Sthd Ylg	551	515	454	487	534	543	555	528	521	533	583	535	560	558	570
Sthd FF	40	0	0	0	50	60	110	0	107	0	0	15	0	0	0
Sthd f	175	0	0	0	0	0	0	0	0	0	0	1	6	0	0
ST FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*ST SF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS Ad	0	0	0	0	2	2	1	4	6	1	<1	<1	<1	1	0
AS Ylg	178	169	135	151	130	97	76	73	84	78	75	75	50	51	50
AS FF	0	0	30	38	34	34	25	25	25	25	25	0	0	0	0
AS AF	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
AS f	0	0	0	0	60	171	73	0	156	84	62	17	32	0	0
Wal PF	122	52	202	100	104	264	250	194	155	129	10	10	211	71	104
Wal FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stur FF	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Bloater FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cisco FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sal Subtotal	5479	5029	3453	2997	3158	3282	3715	3430	3749	3615	3729	3655	3594	3619	3450
TOTAL	5601	5081	3655	3097	3262	3546	3964	3623	3904	3745	3739	3665	3807	3691	3555

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

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

Table 2. Approximate numbers (1000s) of trout, salmon, and other species stocked in New York waters of Lake Ontario, the lower Niagara River, and the upper St. Lawrence River from 1991 to 2017. Numbers stocked from 1968-1990 can be found in Eckert (2000).

Species Life Stage	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Co Ylg	110	90	124	95	114	141	120	69	130	90	99	93
Co FF	155	155	104	155	155	155	0	155	0	141	158	139
Co AF	0	0	0	0	0	0	0	0	0	0	0	0
Co f	0	0	0	0	0	0	0	0	0	0	59	0
Ck f	1827	1813	799	1757	1531	1769	1511	1772	1970	1762	1883	1350
Ck FF	0	0	0	0	0	0	0	0	0	0	0	0
LT Ylg	118	453	501	511	332	488	0	523	443	521	384	201
LT FF	0	0	0	0	122	0	123	0	528	455	0	0
LT Ad	0	0	0	0	0	0	0	0	0	0	0	0.3
BT Ylg	391	385	370	418	409	424	419	331	397	449	464	412
BT FF	0	0	0	70	57	6	0	0	27	0	31	0
BT AF	0	0	50	6	116	0	0	0	41	0	0	0
BT f	0	0	0	46	0	0	0	0	0	0	0	0
RT Ylg	72	68	74	78	80	82	82	83	42	76	75	79
RT FF	0	0	0	15	0	27	0	0	0	0	0	0
RT f	0	0	0	0	0	30	0	0	0	0	0	0
RT Ad	0	0	0	0	0	0	0	0	0	0	0	0
Sthd Ad	0	0	0	0	0	0	0	0	0	0	0	0
Sthd Ylg	572	538	570	561	702	615	554	546	521	382	583	578
Sthd FF	0	0	0	80	188	0	337	0	0	149	0	0
Sthd f	0	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
*ST SF	0	0	0	54	0	0	0	0	0	0	0	0
AS Ad	0	0	0	0	0	0	0	0	0	0	0	0
AS Ylg	29	52	49	50	50	50	60	67	65	70	82	77
AS FF	0	0	0	24	37	66	73	61	71	74	74	51
AS AF	0	0	0	0	0	0	14	0	0	0	0	0
AS f	0	0	0	0	0	0	0	0	6	8	0	0
Wal PF	123	31	50	118	12	118	23	149	138	70	68	170
Wal FF	0	0	5	0		0	0	0		0	0	0
Stur FF	0	0	0	0	0	0	0	1	9	9	0.5	3
Bloater FF	0	0	0	0	0	0	1	7	20	62	149	94
Cisco FF	0	0	0	0	0	0	9	9	145	100	22	88
Cisco AF	0	0	0	0	0	0	0	0	0	0	0	79
Cisco SF	0	0	0	0	0	0	0	0	0	0	0	243
Sal Subtotal	3263	3554	2,641	3920	3891	3853	3293	3606	4239	4177	3900	2979
TOTAL	3382	3585	2696	4037	3903	3972	3327	3773	4551	4417	4140	3655

Abbreviations:

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

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

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2017.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Atlantic Salmon	Beaverdam Brook	O.53-8	17-Apr-17	AD	2016	NSB	13.9	Ylg	46.5	none	30,000	
Atlantic Salmon	Salmon River	O.53-8	6-Aug-17	TUN	2017	SEB	5.5	FF	8.6	AD	8,183	source of eggs AD SEB broodstock
Atlantic Salmon	Trout Brook	O.53-5-BT	6-Aug-17	TUN	2017	SEB	5.5	FF	8.6	AD	7,505	source of eggs AD SEB broodstock
Atlantic Salmon	Orwell Brook	O.53-6-BT	6-Aug-17	TUN	2017	SEB	5.5	FF	8.6	AD	7,225	source of eggs AD SEB broodstock
Atlantic Salmon	Salmon River	O.53-8	19-Sep-17	TUN	2017	SEB	6.9	FF	13.3	AD	27,589	stocked behind hatchery in Salmon River, source of eggs AD SEB broodstock
Atlantic Salmon	Salmon River	O.53-8	22-Mar-17	TUN	2016	SEB	12.8	Ylg	48.2	AD--RV	24,146	stocked behind hatchery in Salmon River, source of eggs AD SEB broodstock.
Atlantic Salmon	Beaverdam Brook	O.53-8	23-Mar-17	TUN	2016	SEB	13.4	Ylg	49.1	AD-LV	2,363	source of eggs from feral Atlantic salmon caught in Salmon River in 2015.
Atlantic Salmon	Point Breeze	713	17-May-17	AD	2016	NSB	14.8	Ylg	52.6	none	20,000	stocked into Oak Orchard Creek near mouth; too windy for boat stocking
Atlantic Salmon Fall Fingerlings Total									**11.2**		**50,502**	
Atlantic Salmon Yearling Total									**48.7**		**76,509**	
Atlantic Salmon Total									**33.8**		**127,011**	
Brown Trout	Black River	O.19	8-May-17	SR	2016	RL-D	17.9	Ylg	66.2	none	4,130	
Brown Trout	Black River	O.19	7-Jun-17	SR	2016	RL-D	18.8	Ylg	69.8	none	5,300	surplus
Brown Trout	Stony Point	423	16-May-17	SR	2016	RL-D	18.1	Ylg	63.6	none	31,350	Barge/LCM
Brown Trout	Henderson Bay	423	16-May-17	SR	2016	RL-D	18.1	Ylg	63.7	none	14,030	Barge/LCM stocked off Stony Point
Brown Trout	Stony Creek	O.40	8-May-17	SR	2016	RL-D	17.9	Ylg	66.2	none	2,480	
Brown Trout	Selkirk	623	7-Jun-17	SR	2016	RL-D	18.8	Ylg	69.8	none	3,950	surplus, stocked at State Park
Brown Trout	Selkirk	623	18-May-17	SR	2016	RL-D	18.2	Ylg	65.7	none	29,700	Barge/LCM could not get into launch due to flooding, fish stocked by barge off Oswego
Brown Trout	Oswego	622	18-May-17	SR	2016	RL-D	18.2	Ylg	77.3	none	29,700	Barge/LCM
Brown Trout	Fair Haven	720	18-May-17	SR	2016	RL-D	18.2	Ylg	74.9	none	29,700	Barge/LCM could not get into Fairhaven due to flooding, roughly 2/3 of fish were stocked by barge just west of Oswego, 1/3 stocked off Fairhaven by barge.
Brown Trout	Sodus Point	819	9-May-17	RM	2016	RL-D	17.5	Ylg	93.9	none	18,000	off west pier
Brown Trout	Sodus Point	819	22-May-17	RM	2016	RL-D	17.9	Ylg	94.3	none	8,400	off west pier
Brown Trout	Pultneyville	818	3-May-17	RM	2016	RL-D	17.3	Ylg	94.1	none	15,000	
Brown Trout	Pultneyville	818	22-May-17	RM	2016	RL-D	17.9	Ylg	94.3	none	4,800	
Brown Trout	Webster	816	5-May-17	RM	2016	RL-D	17.3	Ylg	95.9	none	15,000	Off Joe Abrahams
Brown Trout	Webster	816	24-May-17	RM	2016	RL-D	17.9	Ylg	93.3	none	7,280	Off Joe Abrahams
Brown Trout	Irondequoit	815	10-May-17	RM	2016	RL-D	17.5	Ylg	98.4	none	15,000	Off Peter Frank's
Brown Trout	Irondequoit	815	24-May-17	RM	2016	RL-D	17.9	Ylg	93.3	none	7,280	Off Peter Frank's
Brown Trout	Rochester	815	15-May-17	RM	2016	RL-D	17.6	Ylg	92.7	none	15,000	Kodak Water Treatment Plant

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SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Brown Trout	Rochester	815	25-May-17	RM	2016	RL-D	18.0	Ylg	96.7	none	7,280	Kodak Water Treatment Plant
Brown Trout	Braddocks Bay	815	8-May-17	RM	2016	RL-D	17.4	Ylg	96.9	none	15,000	
Brown Trout	Braddocks Bay	815	25-May-17	RM	2016	RL-D	18.0	Ylg	96.7	none	7,280	
Brown Trout	Hamlin	713	4-May-17	RM	2016	RL-D	17.3	Ylg	98.2	none	15,000	
Brown Trout	Hamlin	713	26-May-17	RM	2016	RL-D	18.0	Ylg	95.5	none	7,280	
Brown Trout	Point Breeze	711	12-May-17	SR	2016	RL-D	18.0	Ylg	66.2	none	21,650	
Brown Trout	Point Breeze	711	30-May-17	CD	2016	RL-D	17.2	Ylg	175.8	none	8,630	
Brown Trout	Olcott	708	23-May-17	SR	2016	RL-D	17.4	Ylg	63.0	none	17,800	
Brown Trout	Olcott	708	23-May-17	SR	2016	RL-D	18.4	Ylg	66.7	none	2,830	different lot than 1st delivery
Brown Trout	Olcott	708	5-Jun-17	SR	2016	RL-D	18.8	Ylg	69.8	none	3,280	surplus
Brown Trout	Wilson	707	11-May-17	SR	2016	RL-D	17.0	Ylg	61.3	none	20,630	
Brown Trout	Fort Niagara	806	27-Apr-17	RA	2016	RL-D	16.1	Ylg	84.0	none	8,470	Fish stocked at Youngstown Boat Launch
Brown Trout	Fort Niagara	806	27-Apr-17	CD	2016	RL-D	16.1	Ylg	144.0	none	6,530	Fish stocked at Youngstown Boat Launch
Brown Trout	Lower Niagara River	O.158/EN-T0000	27-Apr-17	CD	2016	RL-D	16.1	Ylg	144.0	none	4,130	Fish stocked at Youngstown Boat Launch
Brown Trout	Lower Niagara River	O.158/EN-T0000	6-Jun-17	SR	2016	RL-D	18.8	Ylg	69.8	none	10,000	surplus, Lewiston Sand Docks
Brown Trout Yearlings Total									**83.0**		**411,890**	
Chinook Salmon	Black River	O.19/OB-T0000	4-May-17	SR	2017	SAL-W	3.5	SF	4.6	none	124,180	below Dexter Falls
Chinook Salmon	South Sandy Creek	O.45/LO-T0000	4-May-17	SR	2017	SAL-W	3.5	SF	4.6	none	78,100	below Rt. 3 bridge
Chinook Salmon	Salmon River	O.53/LO-T0000	31-May-17	SR	2017	SAL-W	4.4	SF	6.8	none	319,340	
Chinook Salmon	Oswego River	O.65	5-May-17	SR	2017	SAL-W	3.5	SF	4.6	none	22,220	
Chinook Salmon	Oswego River	O.65	8-May-17	SR	2017	SAL-W	3.6	SF	7.4	none	64,390	In pens 4/18/17 @118/lb 51ºF
Chinook Salmon	Little Sodus Bay	O.74	9-May-17	SR	2017	SAL-W	3.7	SF	9.1	none	47,500	In pens 04/14/17 @ 115/lb. 45ºF
Chinook Salmon	Sterling Creek	O.73	5-May-17	SR	2017	SAL-W	3.5	SF	4.6	none	17,630	Old State Road
Chinook Salmon	Sodus Bay	O.84-P96	25-Apr-17	SR	2017	SAL-W	3.2	SF	3.9	none	21,480	Sodus Point: Off West Pier
Chinook Salmon	Sodus Bay	O.84-P96	15-May-17	SR	2017	SAL-W	3.9	SF	7.8	none	50,000	In pens 4/25/17 @115/lb 50ºF.
Chinook Salmon	Genesee River	O.117	27-Apr-17	SR	2017	SAL-W	3.3	SF	3.9	none	47,910	
Chinook Salmon	Genesee River	O.117	27-Apr-17	SR	2017	SAL-W	3.3	SF	3.9	none	85,250	No Pens in 2017. All shore stocked.
Chinook Salmon	Genesee River	O.117	10-May-17	SR	2017	SAL-W	3.7	SF	4.7	none	3,000	
Chinook Salmon	Sandy Creek	O.130	21-Apr-17	SR	2017	SAL-W	3.1	SF	4.0	none	12,050	

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Chinook Salmon	Sandy Creek	O.130	27-Apr-17	SR	2017	SAL-W	3.3	SF	4.0	none	64,430	In Pens 4/21/17@113/lb 50ºF
Chinook Salmon	Oak Orchard Creek	O.138	24-Apr-17	SR	2017	SAL-W	3.2	SF	3.9	none	26,600	
Chinook Salmon	Oak Orchard Creek	O.138	24-Apr-17	SR	2017	SAL-W	3.2	SF	3.9	none	106,560	No Pens in 2017. All shore stocked.
Chinook Salmon	Oak Orchard Creek	O.138	10-May-17	SR	2017	SAL-W	3.7	SF	4.7	none	3,000	
Chinook Salmon	Eighteenmile Creek	O.148	2-May-17	SR	2017	SAL-W	3.5	SF	3.9	none	32,710	
Chinook Salmon	Eighteenmile Creek	O.148	3-May-17	SR	2017	SAL-W	3.5	SF	6.4	none	67,100	In pens 4/17/2017 @ 120/lb. 56ºF
Chinook Salmon	Twelvemile Creek (Wilson)	O.152	8-May-17	SR	2017	SAL-W	3.6	SF	7.4	none	10,000	In pens 4/19/2017 @ 113/lb. 51ºF. New pen project in 2017 (some fish shifted from Niagara stocking)
Chinook Salmon	lower Niagara River	O.158/EN-T0000	3-May-17	SR	2017	SAL-W	3.5	SF	4.6	none	75,000	No pens- all shore stocked in 2017
Chinook Salmon	lower Niagara River	O.158/EN-T0000	3-May-17	SR	2017	SAL-W	3.5	SF	4.6	none	68,930	
Chinook Salmon	lower Niagara River	O.158/EN-T0000	10-May-17	SR	2017	SAL-W	3.7	SF	4.7	none	3,000	
Chinook Salmon Spring Fingerling Total									**5.3**		**1,350,380**	
Coho Salmon	Beaverdam Brook	O.53-8	12-May-17	SR	2016	SAL-W	15.6	Ylg	28.4	AD CWT	93,000	CWT #64, transferred to smolt release pond 10/20/2016
Coho Salmon	Beaverdam Brook	O.53-8	18-Oct-17	SR	2017	SAL-W	8.9	FF	15.2	AD CWT	90,020	CWT #64, initially moved to smolt release pond, then released into Beaverdam Brook after high mortality (number accounts for 1640 fish lost)
Coho Salmon	Oak Orchard Creek	O.138	6-Nov-17	SR	2017	SAL-W	9.5	FF	24.0	AD CWT	11,200	CWT#640957, larger group
Coho Salmon	Oak Orchard Creek	O.138	6-Nov-17	SR	2017	SAL-W	9.5	FF	24.0	AD CWT	2,924	CWT#600149, larger group
Coho Salmon	Oak Orchard Creek	O.138	6-Nov-17	SR	2017	SAL-W	9.5	FF	17.0	AD CWT	7,676	CWT#640958, smaller group
Coho Salmon	Eighteenmile Creek	O.148	7-Nov-17	SR	2017	SAL-W	9.5	FF	22.0	AD CWT	12,025	CWT#640954, larger group
Coho Salmon	Eighteenmile Creek	O.148	7-Nov-17	SR	2017	SAL-W	9.5	FF	22.0	AD CWT	5,677	CWT#600140, larger group
Coho Salmon	Eighteenmile Creek	O.148	7-Nov-17	SR	2017	SAL-W	9.5	FF	12.0	AD CWT	8,963	CWT#640953, smaller group
Coho Salmon	Eighteenmile Creek	O.148	7-Nov-17	SR	2017	SAL-W	9.5	FF	12.0	AD CWT	535	CWT#600146, smaller group
Coho Salmon Fall Fingerlings									**16.9**		**139,020**	
Coho Salmon Yearlings									**28.4**		**93,000**	
Coho Salmon Total									**21.5**		**232,020**	
Lake Trout	Stony Point	422	16-May-17	EI	2016	LCH-D	26.0	Ylg	31.0	AD CWT	39,460	Barge/LCM, CWT#640728
Lake Trout	Stony Point	422	16-May-17	EI	2016	LCH-D	26.0	Ylg	31.0	AD CWT	38,150	Barge/LCM, CWT#640729
Lake Trout	Oswego	623	17-May-17	AL	2016	SKW	28.0	Ylg	44.3	AD CWT	24,761	Barge/LCM, CWT#640738
Lake Trout	Oswego	623	17-May-17	AL	2016	SKW	28.0	Ylg	44.3	AD CWT	26,316	Barge/LCM, CWT#640737
Lake Trout	Oswego	622	17-May-17	EI	2016	LCH-D	26.9	Ylg	32.7	AD CWT	10,660	Barge/LCM, CWT#640320

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Lake Trout	Sodus	819	19-May-17	AL	2016	SKW	28.0	Ylg	44.5	AD CWT	25,786	CWT#640736, Barge/LCM cancelled due to weather. All fish stocked into channel off pier.
Lake Trout	Sodus	819	19-May-17	AL	2016	HPW	27.4	Ylg	51.5	AD CWT	11,827	CWT#640749, Barge/LCM cancelled due to weather. All fish stocked into channel off pier.
Lake Trout	Sodus	819	19-May-17	AL	2016	HPW	27.4	Ylg	38.4	AD CWT	23,883	CWT#640750, Barge/LCM cancelled due to weather. All fish stocked into channel off pier.
Lake Trout	Oswego	622	1-Dec-17	BK	2012	SKW	69.3	Ad	2041.2	AD-CWT-JAW	304	CWT#64, Jaw Tags 2-271 and 276-309, surplus broodstock from Berkshire Hatchery
Lake Trout Spring Yearlings									**38.3**		**200,843**	
Lake Trout Adults									**2041.2**		**304**	
Lake Trout Total									**41.3**		**201,147**	
Rainbow Trout	Black River	424	8-May-17	SR	2016	WAS-W	11.0	Ylg	10.1	none	36,000	Sacketts Harbor
Rainbow Trout	Black River	O.19	8-May-17	SR	2016	WAS-W	11.0	Ylg	10.1	none	36,000	below Dexter Falls
Rainbow Trout	Stony Creek	O.40	10-Apr-17	SR	2016	WAS-W	10.1	Ylg	14.9	none	20,700	
Rainbow Trout	South Sandy Creek	O.45	10-Apr-17	SR	2016	WAS-W	10.1	Ylg	14.5	none	28,750	
Rainbow Trout	Beaverdam Brook	O.53-8	9-May-17	SR	2016	WAS-W	11.0	Ylg	25.3	none	131,240	stocked between 5/9 and 5/11/2017
Rainbow Trout	Beaverdam Brook	O.53-8	12-May-17	SR	2016	SKA-W	11.1	Ylg	12.6	AD	58,440	
Rainbow Trout	Grindstone Creek	O.54	7-Apr-17	SR	2016	WAS-W	10.0	Ylg	14.5	none	5,000	
Rainbow Trout	Little Salmon River	O.58	9-May-17	SR	2016	WAS-W	11.0	Ylg	34.9	none	4,600	In pens 4/18/2017 @ 31.9 /lb 52ºF
Rainbow Trout	Oswego River	O.66	18-Apr-17	SR	2016	WAS-W	10.4	Ylg	10.0	none	20,000	
Rainbow Trout	Sterling Creek	O.73	7-Apr-17	SR	2016	WAS-W	10.0	Ylg	15.0	none	4,600	
Rainbow Trout	Sterling Valley Ck	O.73-3	7-Apr-17	SR	2016	WAS-W	10.0	Ylg	15.0	none	4,600	
Rainbow Trout	Little Sodus Bay	O.74	9-May-17	SR	2016	WAS-W	11.0	Ylg	34.9	none	6,000	In pens 4/14/17@ 35.7/lb 45ºF
Rainbow Trout	Maxwell Creek	O.85	11-Apr-17	SR	2016	WAS-W	10.1	Ylg	14.6	none	19,950	
Rainbow Trout	Irondequoit Creek	O.108	1-May-17	SR	2016	WAS-W	10.8	Ylg	10.6	none	27,500	
Rainbow Trout	Genesee River	O.117	11-May-17	SR	2016	WAS-W	11.1	Ylg	10.1	none	3,600	surplus
Rainbow Trout	Genesee River	O.117	27-Apr-17	SR	2016	WAS-W	10.6	Ylg	9.0	none	12,100	
Rainbow Trout	Genesee River	O.117	27-Apr-17	SR	2016	WAS-W	10.6	Ylg	10.9	none	10,000	No pens. All shore stocked
Rainbow Trout	Salmon Creek	O.93	26-Apr-17	SR	2016	WAS-W	10.6	Ylg	10.1	none	5,050	
Rainbow Trout	Sandy Creek	O.130	21-Apr-17	SR	2016	WAS-W	10.5	Ylg	14.8	none	7,350	
Rainbow Trout	Sandy Creek	O.130	21-Apr-17	SR	2016	WAS-W	10.5	Ylg	14.9	none	7,300	No pens. All shore stocked
Rainbow Trout	Oak Orchard Creek	O.138	11-May-17	SR	2016	WAS-W	11.1	Ylg	10.1	none	3,600	surplus
Rainbow Trout	Oak Orchard Creek	O.138	24-Apr-17	SR	2016	WAS-W	10.5	Ylg	15.0	none	7,000	

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Rainbow Trout	Oak Orchard Creek	O.138	24-Apr-17	SR	2016	WAS-W	10.5	Ylg	15.0	none	14,000	No pens. All shore stocked
Rainbow Trout	Marsh Creek	O.138-2	26-Apr-17	SR	2016	WAS-W	10.6	Ylg	10.2	none	7,100	
Rainbow Trout	Johnson Creek	O.139	26-Apr-17	SR	2016	WAS-W	10.6	Ylg	9.7	none	6,700	
Rainbow Trout	Eighteenmile Creek	O.148	17-Apr-17	SR	2016	WAS-W	10.3	Ylg	17.9	none	6,500	
Rainbow Trout	Eighteenmile Creek	O.158	2-May-17	SR	2016	WAS-W	10.8	Ylg	22.3	none	3,500	In pens 4/17/17@24.3/lb 56ºF
Rainbow Trout	Twelvemile Creek E Br	O.152	19-Apr-17	SR	2016	WAS-W	10.4	Ylg	13.8	none	10,500	
Rainbow Trout	Twelvemile Creek (Wilson)	O.152	10-May-17	SR	2016	WAS-W	11.1	Ylg	22.1	none	7,500	In pens 04/19/2017 @31.25/lb
Rainbow Trout	Twelvemile Creek	O.152A	19-Apr-17	SR	2016	WAS-W	10.4	Ylg	9.7	none	12,000	
Rainbow Trout	lower Niagara River	O.158	3-May-17	SR	2016	WAS-W	10.8	Ylg	10.1	none	37,000	
Rainbow Trout	lower Niagara River	O.158	11-May-17	SR	2016	WAS-W	11.1	Ylg	10.1	none	3,600	surplus
Rainbow Trout	lower Niagara River	O.158	3-May-17	SR	2016	WAS-W	10.8	Ylg	10.1	none	10,000	No pens. All shore stocked
Rainbow Trout	Irondequoit Creek	O.108	11-Apr-17	PMP	2016	FL-W	11.1	Ylg	30.2	none	7,000	Powder Mill Pond release, No WAS strain after 2006
Rainbow Trout	Sodus	819	18-May-17	CH	2016	RA-D	17.0	Ylg	107.0	none	20,000	
Rainbow Trout	Webster	815	11-May-17	CH	2016	RA-D	16.8	Ylg	98.0	none	10,000	
Rainbow Trout	Hamlin	713	10-May-17	CH	2016	RA-D	16.7	Ylg	107.0	none	20,000	
Rainbow Trout	Olcott	708	2-May-17	CS	2016	RA-D	16.3	Ylg	148.2	none	3,480	
Rainbow Trout	Olcott	708	5-Jun-17	CS	2016	RA-D	17.4	Ylg	151.7	none	4,545	
Rainbow Trout	Olcott	708	5-Jun-17	VH	2016	RA-D	17.4	Ylg	148.6	none	1,200	
Rainbow Trout	Wilson	707	1-May-17	CS	2016	RA-D	16.2	Ylg	135.8	none	12,500	
Washington Steelhead Yearlings									**15.9**		**519,340**	
Skamania Steelhead Yearlings									**12.6**		**58,440**	
Rainbow Trout Yearlings (Randolph strain)									**116.3**		**71,725**	
Rainbow Trout Yearlings (Finger Lakes W strain)									**30.2**		**7,000**	
Rainbow Trout Total									**26.8**		**656,505**	
Walleye	Port Bay	O-P0089	23-Jun-17	ON	2017	ONL-W	1.7	PF	0.5	OTC	10,400	
Walleye	Sodus Bay	O-P0096	9-Jun-17	CQ	2017	ONL-W	1.4	PF	0.3	none	73,900	
Walleye	Irondequoit Bay	O-P0113	12-Jun-17	CQ	2017	ONL-W	1.5	PF	0.3	none	26,500	
Walleye	Irondequoit Bay	O-P0113	12-Jun-17	CQ	2017	ONL-W	1.5	PF	0.4	none	36,000	
Walleye	lower Niagara River	EN-P0000	8-Jun-17	CQ	2017	ONL-W	1.4	PF	0.3	none	23,200	
Walleye Fingerling Total									**0.3**		**170,000**	

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Bloater	Oswego	621	7-Nov-17	TUN	2017	LM	6.4	FF	5.1	CAL	93,553	stocked off Oswego at 100m contour by USGS RV/Kaho, marked with calcein
Cisco	Sodus Bay	815	29-Jun-17	LAM	2017	LO	4.8	SF	1.3	CAL	62,824	stocked by pontoon boat, single marked with calceine May 17
Cisco	Sodus Bay	815	30-Jun-17	LAM	2017	LO	4.8	SF	1.4	CAL	62,974	stocked by pontoon boat, single marked with calceine May 17
Cisco	Sodus Bay	815	5-Jul-17	TUN	2017	LO	4.5	SF	1.9	CAL	60,014	stocked by pontoon boat, single marked with calceine
Cisco	Sodus Bay	815	6-Jul-17	TUN	2017	LO	4.5	SF	2.0	CAL	56,764	stocked by pontoon boat, single marked with calceine
Cisco	Sodus Bay	815	23-Aug-17	TUN	2017	LO	6.1	AF	6.6	CAL	34,799	stocked into channel, double marked with calceine
Cisco	Sodus Bay	815	25-Aug-17	TUN	2017	LO	6.2	AF	6.1	CAL	9,697	stocked into channel, double marked with calceine
Cisco	Sodus Bay	815	28-Aug-17	TUN	2017	LO	6.3	AF	5.7	CAL	34,071	stocked into channel, double marked with calceine
Cisco	Sodus Bay	815	31-Oct-17	LAM	2017	LO	8.8	FF	18.5	CAL	19,327	stocked by pontoon boat, single marked with calceine May 17
Cisco	Sodus Bay	815	1-Nov-17	LAM	2017	LO	8.8	FF	18.5	CAL	16,635	stocked by pontoon boat, single marked with calceine May 17
Cisco	Sodus Bay	815	31-Oct-17	TUN	2017	LO	8.3	FF	13.4	CAL	26,148	stocked by pontoon boat, double marked with calceine
Cisco	Sodus Bay	815	1-Nov-17	TUN	2017	LO	8.4	FF	13.7	CAL	25,620	stocked by pontoon boat, double marked with calceine
Bloater Total									**5.1**		**93,553**	
Cisco Total									**5.5**		**408,873**	
Coregonine Total									**5.4**		**502,426**	
Lake Sturgeon	Genesee River	O.117	19-Oct-17	ON	2017	SLR	4.3	FF	11.8	CWT-PIT-SCU	998	CWT #600137 in 3rd scute left side, Pit Tagged and #5&6 scutes clipped
Lake Sturgeon	Chaumont Bay	324	26-Sep-17	ON	2017	SLR	3.6	FF	2.8	CWT	2,200	CWT #600137 in 3rd scute left side, stocked at Long Point State Park
Lake Sturgeon Total									**5.6**		**3,198**	
Salmonine Total											**2,978,953**	
Total All Species											**3,654,577**	

2017 Lake Ontario Fishing Boat Survey

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

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 1985-2017 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 (1985-2017). This report focuses on 2017 results and on comparisons of 2017 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 2008-2017 and a 23-year average for 1985-2007.

Methods

<u>Sampling Design and Data Collection</u>

Methods and procedures have changed little throughout the 33 years surveyed. For 20 of the 33 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 2017). 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 after sunrise during April and September only) and

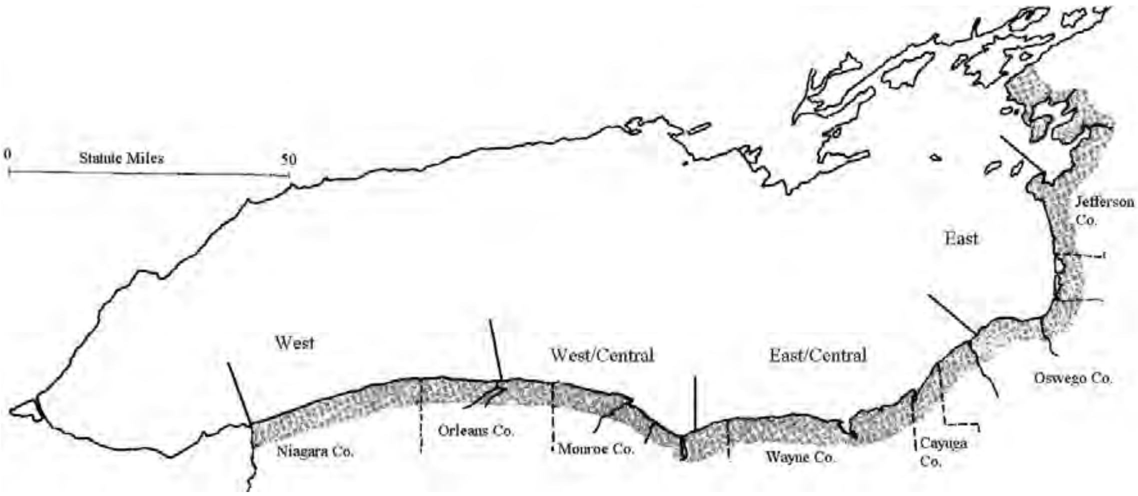

Figure 1. Lake Ontario's New York shoreline (shaded in gray), the seven New York counties that border the lake, and the four geographic areas used in analysis of the survey data.

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 to the lake. 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 2010-2017

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 (e.g., length, age) 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).

Geographic Area Comparisons
Regional comparisons were made by dividing the New York shoreline into four approximately equal areas (Table A1; Figure 1), 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 area-specific catch rate and harvest rate for each month was not possible. Lantry and Eckert (2011) did, however, evaluate relative harvest within specific areas and months as compared to previous 5-year averages and general trends, typically observed each year, are reiterated here. This report, documents relative catch within specific areas and months for 2012-2017 and compares 2017 results with general trends observed in previous years. In this report we discuss 2017 5½ month regional results with general trends observed in previous years of the survey reported in Lantry and Eckert (2011) and with relative catch within specific areas and months during the previous five years (2012-2016).

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
The estimated number of all fishing boat trips increased from 1985-1990, then decreased through 1996 (Figure 2). 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. Effort remained relatively stable until the early 2000s when a declining trend in total fishing effort was apparent. Until recently, the declining trend was attributed to a decline in effort targeting smallmouth bass (see *Smallmouth Bass Targeted Effort* in this section). Fishing effort targeting trout and salmon, however, was relatively stable from the early 2000s through 2015, then declined in 2016 and 2017 (Figure 2). In 2016, total fishing effort (46,339 boat trips) declined by approximately 6,800 boat trips from 2015, likely attributed to reduced effort targeting trout and salmon due to undesirable weather patterns and reduced fishing quality for some species (i.e., effort targeting trout and salmon was down about 7,400 boat trips from 2015; Table A2; Figure 2).

Total fishing effort declined further in 2017 to a new record low (39,964 boat trips [±13.6%], a 26% decrease compared to the previous 5-year average). This decrease was largely attributed to extremely high water levels on Lake Ontario that persisted into July. From early May to early July numerous public and private launches along the entire NY shoreline were closed or only available for limited use, many docks were nearly or completely submerged and not usable, many boaters were also concerned about floating debris, and boating speed limits were reduced. All of these factors contributed to reduced boating activity during portions of 2017.

Total fishing effort in 2017, as measured by angler trips and angler hours, was 121,041 and 709,638, respectively (Table A2). The average number of anglers per boat trip ranged from 2.5 (1985) to 3.0 (2017 was highest in data series), and averaged 2.9 with an increasing trend during the last 10 years (Table A2). The 2017 average trip length of 5.9 hours per boat trip was comparable to the previous 5-year average (+4.6%).

We evaluated the contribution to total fishing effort for each month April through September (Table A2). The greatest amount of fishing effort occurred during the second half of the open lake fishing season (2008-2017 10-year averages: April 15-30: 4.6%, May: 15.4%, June: 11.4%, July: 21.1%, August: 29.8%, and September: 17.7%). In

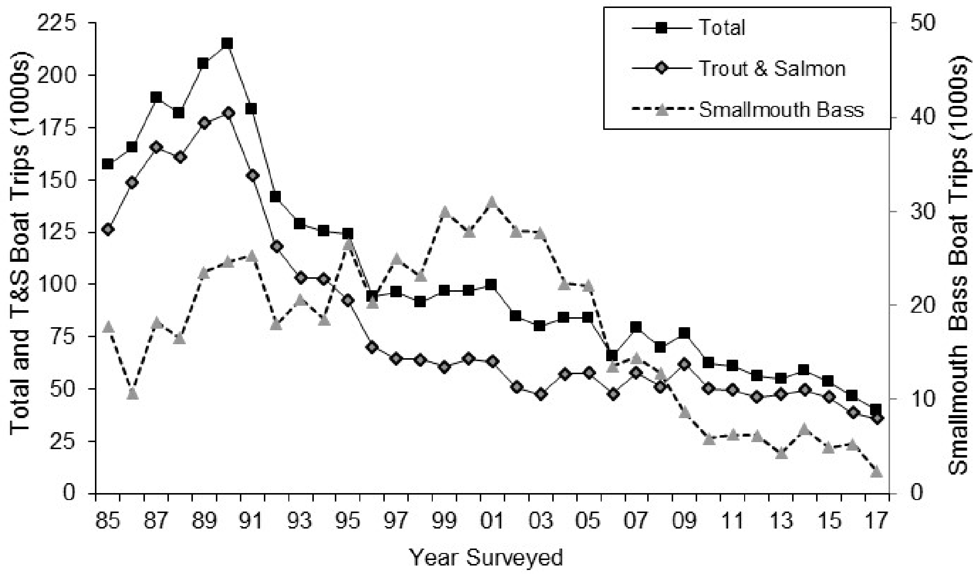

Figure 2. Estimated number of total fishing boat trips, trips targeting trout and salmon (T&S; April 15-September 30), and trips targeting smallmouth bass (SMB) during the traditional open season (3rd Saturday in June-September 30 when the survey ended), 1985-2017.

2017, total fishing effort estimates were at the lowest levels (May-July) or near the lowest levels (April and August [second lowest], September [third lowest]) in the 33 years surveyed. Effort was well below respective previous 10-year averages (range: -56.3% to -24.9%) for all months.

Geographic Area Fishing Effort

We evaluated regional contributions to total 5.5-month fishing effort (Table A2). The most fishing effort occurred in the east/central area for 29 of the last 33 years (14,145 boat trips in 2017, 35.4% of fishing effort; Table A2). For all 33 years surveyed, the lowest fishing effort occurred in the west/central area (4,051 boat trips in 2017, 10.1% of fishing effort). In 2017, fishing effort declined in each of the four areas to the lowest levels in the 33 years surveyed (range: -48.1% [west/central] to -28.8% [west] decreases compared to respective previous 10-year averages).

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. In 2017, boating activity of all types was at the lowest levels on record, primarily because high water levels in the lake limited access and boating activity. Power boaters who spent at least a portion of their time fishing on Lake Ontario accounted for 40,156 vessel excursions and 39.1% of the total vessel traffic in 2017 (Table A2), a 14.1% decrease compared to 2016 and the lowest recorded. Non-fishing power boats (i.e., recreational boaters) were estimated at 52,445 excursions in 2017 (51.1% of the total vessel traffic), a 45.5% decrease compared to 2016 and a record low. Sailboats, the smallest component of vessel traffic, showed a downward trend through much of the time series. In 2017, sailboats accounted for 10,013 excursions (lowest recorded) and represented 9.8% of vessel traffic (Table A2).

Trout and Salmon Targeted Effort

Trout and salmon were the primary target of boat anglers interviewed each year since 1985 (1985-2017 average = 77.4%; range: 59.7% [2003] to 90.0% [1986]; Table A2; Figure 2). There was no significant trend in effort directed at trout and salmon for the 15 years (2001-2015); however, effort declined in 2016 and again in 2017 to a record low level (35,865 [±14.8%] boat trips) that was 28.0% lower than the previous 10-year average (Table A2). In 2017, trout and salmon anglers accounted for 89.7% of total fishing boat trips, 92.9% of angler trips, and 96.6% of angler hours (Table A2). Estimated monthly fishing effort targeting trout and salmon in 2017 was below previous 10-year averages during all months, with the greatest declines during May and June (-58.2% and -39.7% compared to previous 10-year averages, respectively; Table A2). The majority of anglers interviewed each year since 2005 were specifically targeting Chinook salmon (2005-2016 average=47.7%). During 2017, 54.1% of salmonine anglers interviewed were specifically targeting Chinook salmon, 36.7% were targeting a mix of two or more species, and 8.1% were specifically targeting brown trout.

Smallmouth Bass Targeted Effort

Pre-Season Catch and Release Period:

Fishing effort targeting smallmouth bass before the traditional open lake season (i.e., beginning the third Saturday of June) has remained low since it became legal to do so. An October 1, 2006 regulation change established a catch and release bass season from December 1 through the Friday preceding the third Saturday in June (except in Jefferson County waters of Lake Ontario's eastern basin). Prior to this regulation change some anglers admitted to targeting smallmouth bass before the traditional season opening (third Saturday in June) and, with the exception of 2006, accounted for nearly 1% of the April 15 - September 30 total smallmouth bass fishing effort (Table A2). In 2006, prior to the new pre-season catch and release regulation taking effect, 3.5% of total effort occurred pre-season (an estimated 500 boat trips). Since the regulation change, effort targeting bass during the pre-season catch and release period remained low (range: 164 boat trips [2015] – 644 trips [2009]) and a minor component of total bass fishing effort occurring from April 15 - September 30 (range: 2.8% [2008] to 8.1% [2012]). Pre-season effort targeting smallmouth bass in 2017 was an estimated 198 boat trips (7.9% of total bass effort; Table A2).

Traditional Open Season:

The traditional open season for bass begins the third Saturday of June. Each year since 1985, smallmouth bass was the primary species targeted by Lake Ontario anglers not seeking trout or salmon (Table A2; Figure 2). Among all fishing boat trips (April 15 - September 30) on Lake Ontario, the percent contribution of smallmouth bass trips (traditional season) varied and ranged from a low of 5.7% of all fishing boat trips in 2017 (a record low) to a high of 34.8% in 2003. In 2017, smallmouth bass anglers fishing during the traditional open season accounted for 4.0% of angler trips, and 2.0% of angler hours. The total number of angler hours spent targeting bass on Lake Ontario in 2017 was the lowest recorded and 63.3% lower than the previous 5-year average. In 2017, the average number of anglers per bass boat trip (2.1 anglers) was comparable to (-0.5%) the previous 5-year average. The number of hours per boat trip (2.9 hours) was 11.3% below average.

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 ($P<0.05$; Table A2; Figure 2). 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). From 2010 through 2016, effort remained at a low and relatively stable level that was about 82% lower than the 2001 peak (2001: 31,035 boat trips; 2010-2016 average = 5,661 boat trips). In 2017, however, smallmouth bass fishing effort (2,294 [±39.5%]) during the traditional open season (June 17 to September 30) declined 59.5% from the 2010-2016 level to a record low (Table A2; Figure 2). This reduced effort is attributed to limited access to the lake due to high water levels negatively impacting access to the lake and boating activity. Fishing effort for smallmouth bass was lower than the previous 5-year average June through September (range: -74.5% [June] to -28.0% [September]). Effort was also well below recent averages in all four areas surveyed (range: -85.1% [west] to -52.2% [west/central]; 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 2017, however, trips targeting these species only represented 1.6% of the total fishing boat trips on Lake Ontario (Table A2). The "all others" category, which represented 2.3% of 2017 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 2017, charter boats accounted for 17.8% of all fishing boat trips (Figure 3). With more anglers on board and longer trips, charter boats accounted for 30.2% and 34.2% of the angler trips and angler hours, respectively (captains and mates counted as anglers; Table A2). Although charter boats accounted for only 17.8% of total fishing boat trips, they accounted for 37.4% of the total salmonine catch in 2017. Differences between charter and noncharter catch, harvest, and fishing quality are discussed in the “Total Salmonines: Catch, Harvest, and Fishing Quality” section of this report.

The highest charter fishing effort occurred 1988-1991, then declined and has remained relatively stable for over ten years (Table A2; Figure 3). The 2017 estimated charter boat effort was 7,102 (±20.2%) trips, 21.4% and 21.5% lower than the previous 5-year and 10-year averages. Estimated monthly charter fishing effort in 2017 was below the previous 5-year averages April through August (range: -37.1% [April] to -11.0% [July]), and comparable to average in September (+2.0%; Table A2).

Angler Residency

Lake Ontario’s world-class sport fishery has attracted anglers from all 50 states (33 in 2017) and many different countries (3 in 2017) over the last 33 years. Residency of anglers fishing Lake Ontario changed little over the time series with New York State (NYS) anglers consistently dominated the open lake boat fishery (Table A4; Figure 4). The most notable change in angler residency occurred during the first few years of the survey. In 1985 and 1986, NYS residents comprised 79.8% and 75.7% of all anglers interviewed, respectively (Figure 4). Over the last 31 years, there was no trend in the percentage of anglers residing in NYS. Over the last 10 years, an average of 60.0% of Lake Ontario anglers resided in NYS (56.4% in 2017; Table A4).

Contribution of nonresident anglers increased after 1985 when 20.2% of Lake Ontario open lake anglers were not NYS residents (Figure 4). This increase was likely due to increasing awareness of the Lake Ontario trout and salmon sport fishery. Since the early 1990s the percentage of anglers who reside outside of NYS ranged from 35.2% (2003) to 45.6% (1992). In 2017, non-NYS residents comprised 43.6% of the boat anglers interviewed, a slight increase compared to the previous 5-year and 10-year averages (+9.3% and +10.6%, respectively; Tables A2, A4; Figure 4). Pennsylvania represented the largest component of nonresident anglers for each of the 33 years surveyed. The highest percentage of Pennsylvania anglers occurred in 2017 (22.7%) and the lowest (8.5%) occurred in 1985 (Table A4). Other major sources of non-NYS anglers in 2017 were Ohio (5.2%), New Jersey (2.6%), Vermont (2.6%), Massachusetts (2.4%), Connecticut (1.5%), Maine (1.3%), and New Hampshire (1.0%; Table A4).

Throughout the 33-year survey period, 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 the lowest levels recorded 2014-2017 (55.2% in 2017). As was observed each year of the survey, Monroe County remained the most important source of residents in the boat fishery, representing 14.3% of all NYS anglers interviewed in 2017 (Table A4). Other counties representing important components of the open lake boat fishery in 2017 were Oswego (14.1%), Niagara (8.5%), Onondaga (7.3%) Wayne (6.6%), Orleans (6.1%), and Erie (5.2%; Table A4).

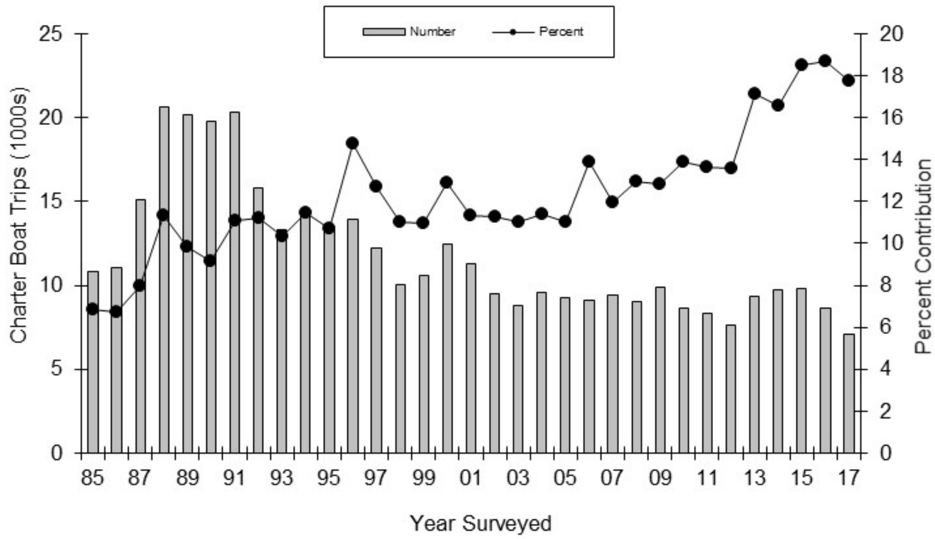

Figure 3. Estimated number of charter fishing boat trips and their percent contribution to total fishing boat trips, April 15- September 30, 1985-2017.

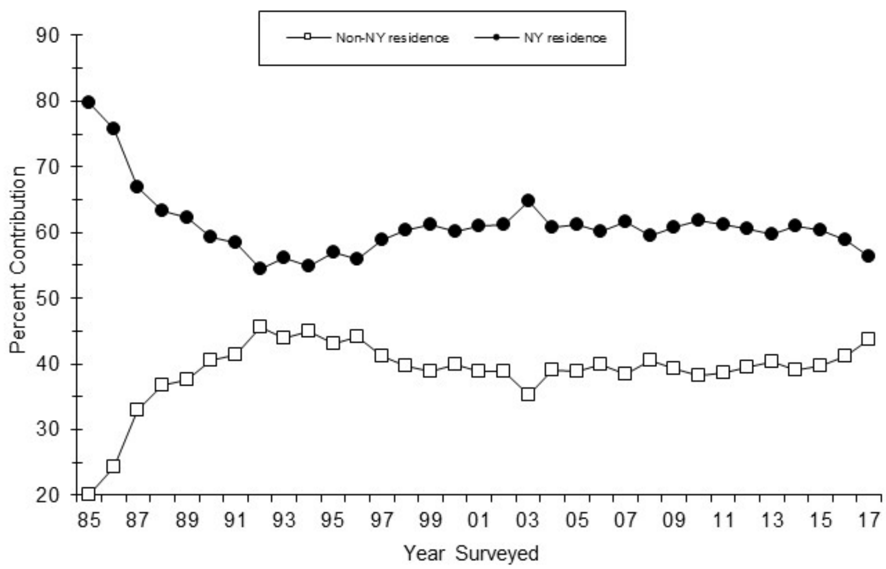

Figure 4. Percent contribution of anglers with and without New York state residency, 1985-2017.

<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 162,341 (±21.4%) fish, a 17.4% increase from the 2016 record low and comparable to (-9.2%) the previous 10-year average (Tables 1, A5a; Figure 5). In 2017, anglers harvested 57.6% of the catch, similar to the long-term average (60.7%). Estimated salmonine harvest was 93,524 (±19.0%) fish, also comparable to (-4.6%) the previous 10-year average (Tables 1, A5a; Figure 5).

Each year since 2003, Chinook salmon dominated the trout and salmon catch (2017: 96,226 [±26.2%] fish, 59.3% of total catch) and harvest (2017: 53,871 [±24.7%] fish, 57.6% of total harvest). Brown trout or rainbow trout have often been the second most commonly caught and harvested species. In 2017, rainbow trout was the second most commonly caught (22,556 [±41.6%] fish) and harvested (12,015 [±39.6%] fish) species, followed by brown trout (17,092 [±35.9%] and 10,604 [±38.3%] fish, respectively). Lake trout represented about 9% of angler catch and harvest (15,444 [±37.4%] caught, 8,592 [±44.6%] harvested) in 2017. Coho salmon represented 6.5% of trout and salmon captured (10,630 [±32.2%] fish) and 8.9% harvested (8,291 [±35.3%] fish). Atlantic salmon represented a relatively small component of the fishery (0.2% of total catch and harvest).

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, angler experience (e.g., best lure, fishing depths), water temperature patterns, recent wind patterns, distance from shore, fish distribution, and species targeted. Quality experienced also varies with when (e.g., specific day, week, month, year) and where anglers are fishing (e.g., west, west/central, east/central, east). With the variety of trout and salmon species present in Lake Ontario, anglers can target another species when catch rates for their preferred target are lower than desired. In 2017, catch rate was excellent for all trout and salmon combined (4.5 fish per boat trip) and is largely due to the excellent Chinook salmon catch rate (2.7 fish per boat trip). Species-specific rates are discussed in greater detail in the species-specific sections of this report.

The quality of trout and salmon fishing in Lake Ontario, as measured by catch rate of all species combined, was variable but relatively stable from 1985-2002; however, increased substantially in 2003 and remained at a higher variable level since (Figure 5). Anglers experienced nine consecutive years (2009-2017) of record high trout and salmon catch rates. The catch per boat trip in 2017 was the highest in the survey (4.5 fish caught per boat trip) and was a 20.6% increase compared to the previous 5-year average (Table A5b; Figure 5). Twelve

Table 1. Harvest and catch estimates for April 15 – September 30, 2017 from the NYSDEC Lake Ontario fishing boat survey.

	Number Harvested	*Number Caught*
Coho salmon	8,291	10,630
Chinook salmon	53,871	96,226
Rainbow trout	12,015	22,556
Atlantic salmon	151	394
Brown trout	10,604	17,092
Lake trout	8,592	15,444
Smallmouth bass (includes pre-season)	2,305	12,079
Yellow perch	5,204	19,459
Walleye	152	208
Round goby	3,986	5,817
Other fish	189	1,036

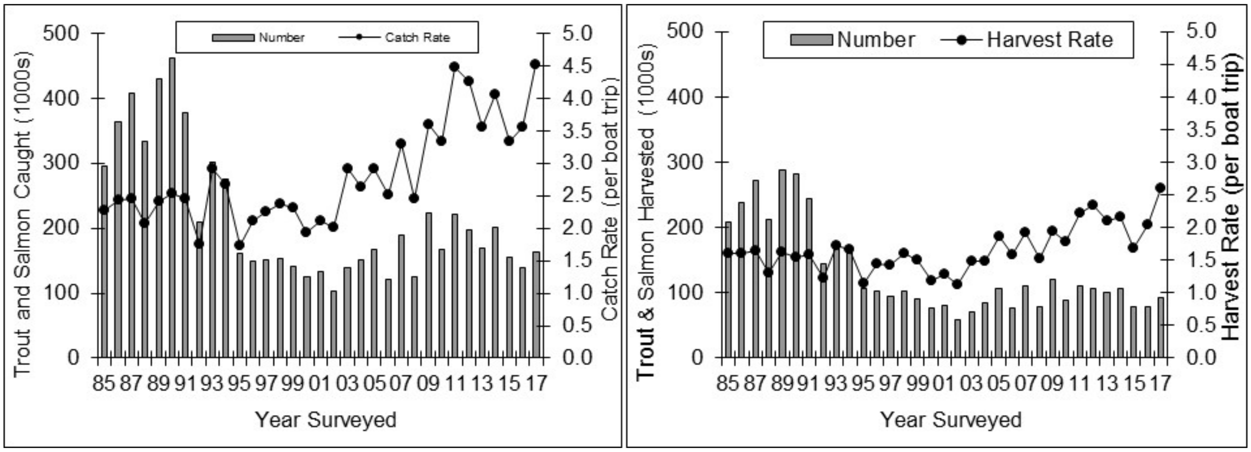

Figure 5. Total trout and salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985 - 2017.

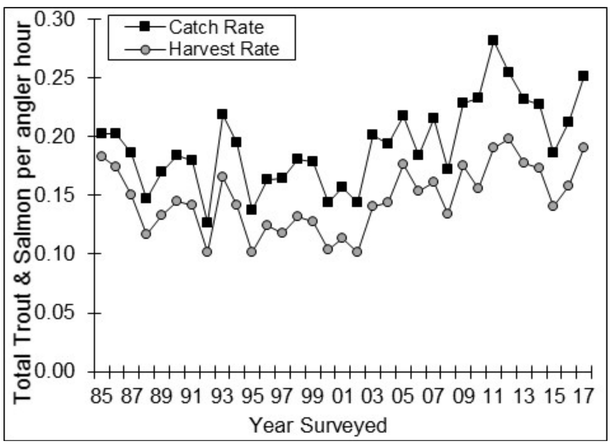

Figure 5c. Charter boat catch rate and harvest rate per angler hour for total trout and salmon, April 15 – September 30, 1985 - 2017.

of the thirteen highest catch rates occurred between 2003 and 2017. During this time period anglers experienced high species-specific catch rates (Chinook salmon 2003-2017; coho salmon 2006-2007, 2009-2012, 2017; rainbow trout 2008-2014; brown trout 2007, 2011-2012, and 2014; and lake trout 2013-2016). The 2017 total trout and salmon harvest rate for all boats targeting trout and salmon was 2.6 fish per boat trip, the highest in the data series, and a 26.2% increase compared to the 2012-2016 average harvest rate (Table A5b; Figure 5). Catch and harvest rate data (fish per boat trip) were also evaluated by month. In 2017, catch rates were above respective previous 5-year averages July through September (range: +34.4% [July] to +66.0% [August]), and were below average in April through June (range: -40.0% [April] to -11.4% [May]; Table A5b).

In 2017, charter boats targeting trout and salmon accounted for 37.4% and 49.4% of all salmonines caught and harvested, respectively, but represented only 17.8% of trout and salmon fishing boat effort, 30.2% of angler trips and 34.2% of angler hours directed at trout and salmon. Charter boat total trout and salmon catch rate (8.6 fish per boat trip) and harvest rate (6.6 fish per boat trip) were both 10.2% increases compared to previous 5-year averages (Table A5b). Charter catch rate per angler hour was 0.25 salmonines, a 12.7% increase compared to the previous 5-year average and a slight increase compared to (+11.8%) the previous 10-year average (Table A5b; Figure 5c).

Noncharter fishing boats caught an average of 3.5 salmonines per boat trip (0.23 fish caught per angler hour) in 2017, a 27.9% increase compared to the previous 5-year average (Table A5b). Among noncharter boats fishing for trout and salmon, the 2017 lake-wide harvest rate was 1.6 salmonines per boat trip, a 47.5% increase compared to the previous 5-year average (Table A5b).

Additional metrics reflect angling quality, such as percentage of boats with zero catch (indicator of poor angling quality), and percentage of boats that harvested the maximum daily limit (indicator of good angling quality; Table A6). 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 2017, 23.6% of boats targeting trout and salmon caught zero salmonines, the lowest in the data series, a 24.6% decrease compared to 2016, and 25.5% lower than the previous 10-year average, indicating improved fishing quality compared to recent years. The eleven years with the lowest proportions of boats with zero trout and salmon catch occurred since 2003, also indicating fishing quality has generally been good relative to the years prior to 2003 (Table A6). 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 1997 open lake season, the daily limit was changed to a maximum of seven trout or salmon, with no more than three lake trout; no more than three fish of coho salmon, Chinook salmon, rainbow trout or brown trout in combination; and no more than one Atlantic salmon (popularly known as the 3-3-1 limit). The most recent regulation changes affected harvest of two trout species. Effective October 1, 2006, the rainbow trout size limit was increased to 21 inches, and the lake trout daily limit was reduced to two fish per angler but allowing no more than one within the slot limit (25-30 inches).

Another indicator of improved fishing quality in 2017 was the proportion of charter and non-charter boats that harvested the maximum daily limit of the three in any combination species (i.e., coho salmon, Chinook salmon, rainbow trout, and/or brown trout; Table A6). In 2017, 21.2% of charter boats harvested the limit of these species for their customers, the fifth highest in the data series. The highest percentage of charters with the maximum daily limit occurred in 2009, when 24.2% of all charter boats interviewed harvested the three in combination limit for their customers (i.e., indicating excellent fishing quality). In 2017, of the charter boats that harvested the three in any combination limit for their customers, 41.0% went on to harvest additional fish on the captain and mate licenses, and 5.5% harvested the three in any combination limit for all anglers (i.e. fishing licenses) on the boat. Among noncharter boats fishing for trout and salmon in 2017, 3.7% harvested the maximum daily limit of three coho salmon, Chinook salmon, rainbow trout, or brown trout in combination, a 102.6% increase compared to the previous 10-year average.

Limits of lake trout were consistently less common than aggregate limits for the other four species through 2012 (2007-2012 average = 2.5%). From 2013-2016, 8.5%-13.5% (i.e., the highest percentages on record) of charter boats harvested the limit of lake trout for their party (Table A6). In 2017, 5.9% of charter boats harvested the legal limit of lake trout for their party. Of those that harvested the legal limit of lake trout for their customers, 45.5% went on to harvest additional lake trout on the captain and mate licenses, and 1.1% of charter boats harvested the limit for all anglers. Among noncharter boats, 0.4% harvested the maximum daily limit of lake trout in 2017.

Fishing regulations permit each license holder to harvest as many as six trout and salmon species; two lake trout, one Atlantic salmon and three in any combination of the other salmonid species. No boats interviewed during 1997-2017 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). Some charter boats harvested the limit of lake trout and the three fish in any combination for each angler in the charter party (e.g., 2012: 147 trips, 2013: 234 trips, 2015: 14 trips, 2016: 147 trips). No charter boats harvested the limit of lake trout and three in any combination in 2017.

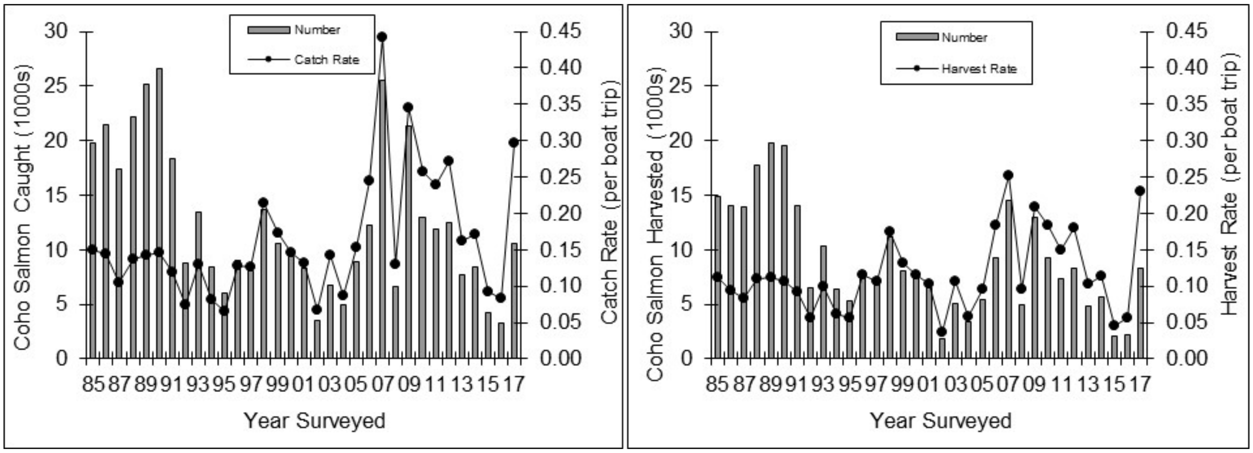

Figure 6. Total coho salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2017.

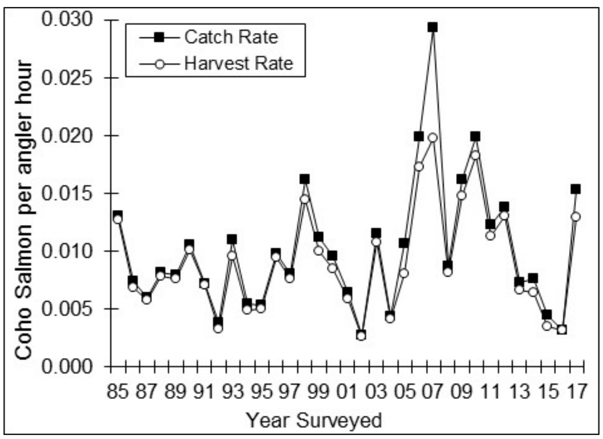

Figure 6b. Charter boat catch rate and harvest rate per angler hour for coho salmon, April 15 – September 30, 1985-2017.

<u>Coho Salmon</u>

Catch and Harvest

In 2017, coho salmon was the fifth most commonly caught and harvested salmonine in the boat fishery (6.5% and 8.9% of total catch and harvest, respectively; Tables 1, A7a). Estimated coho salmon catch (10,630 [±32.2%] fish) in 2017 was 14.4% lower than the long-term average (1985-2016; Figure 6). Approximately 78% of coho salmon caught were harvested. Coho salmon harvest was an estimated 8,291 (±35.3%) fish and comparable to (-7.8%) the long-term average (Table A7a; Figure 6). During 2017, estimated catch of coho salmon was above the long-term average during August (+15.6) and September (+64.5), comparable to average in July (+9.1%), and below average each month April through June (range: -56.5% [May] to -31.4% [June]; Table A7a).

Fishing Quality

Coho salmon catch rates and harvest rates were generally at or near record levels from the mid-2000s to mid-2010s (Table A7b; Figures 6, 6b). Rates declined to near record lows in 2015 and 2016. In 2017, however, coho salmon catch rate (0.3 fish per boat trip) increase to the highest since 2009 and the third highest in the 33-years surveyed (Table A7b; Figure 6). Harvest rate (0.2 fish per boat trip) was the highest since 2007 and second highest in all years surveyed. In 2017, charter boats targeting trout and salmon caught 34.9% of all coho salmon caught by trout and salmon fishing boats. Among charter boats, coho salmon catch and harvest rates were 0.015 and 0.013 fish per angler hour, respectively (Figure 6b), and well above long-term averages (+53.8% and +46.1%, respectively; Table A7b; Figure 6b). Among noncharter boats, the 2017 catch and harvest rates were 0.016 and 0.012 coho salmon per angler hour, respectively (Table A7b).

Coho salmon catch and harvest rates are typically highest during April and May and in the western portion of the lake (Lantry and Eckert 2011; Table A7b; Figures 6c, 6d, A1). For the twentieth consecutive year, the west area experienced the highest coho salmon catch rate among all areas (0.53 fish per boat trip). Catch rates increased in

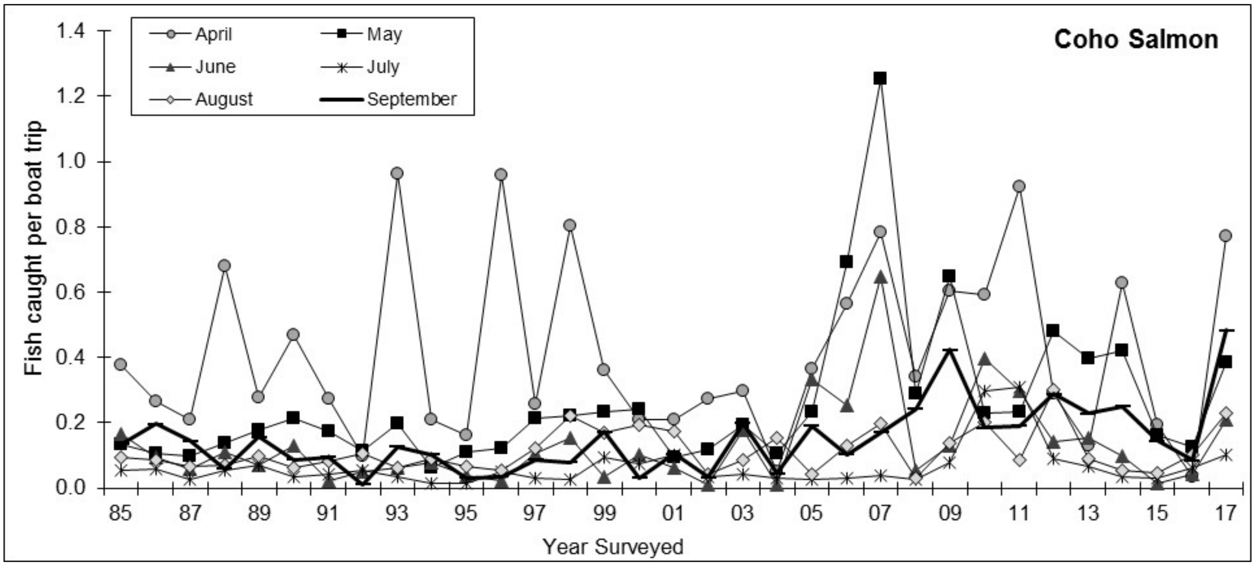

Figure 6c. Coho salmon caught per boat trip April through September, 1985-2017. Note: Catch rate varied by region within each month surveyed.

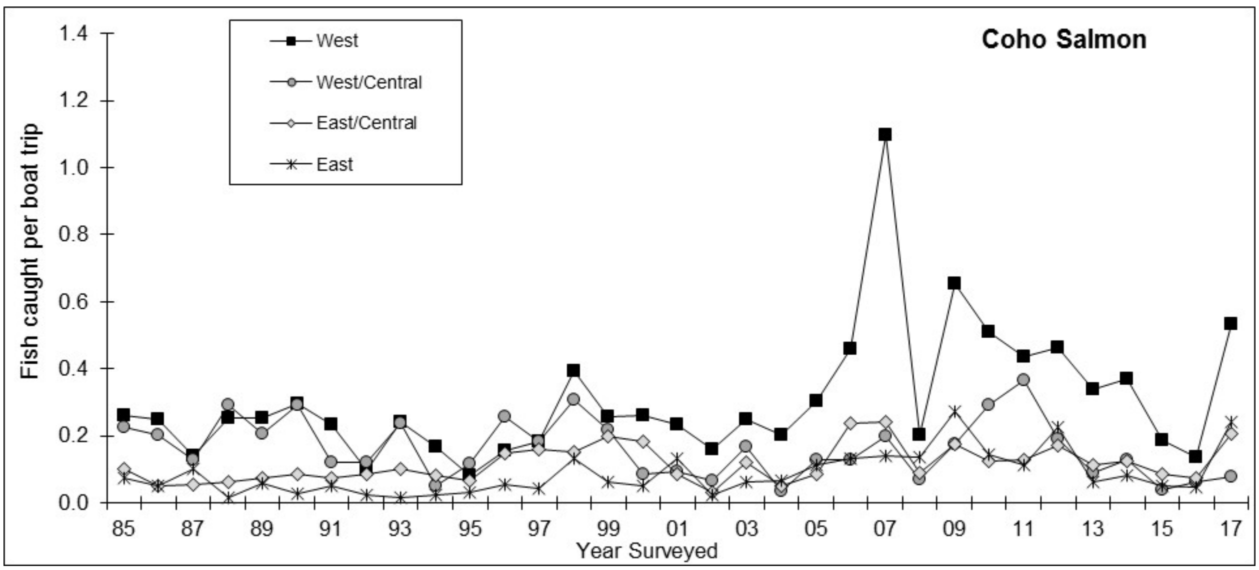

Figure 6d. Coho salmon caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2017. Note: Catch rate varied by month within each area surveyed.

all four areas surveyed as compared to the 2015-2016 time period, and were well above long-term averages in the west (+78.7%), east/central (+82.4%), and east (+197.9%) areas (Figure 6d). The lowest coho salmon catch rate occurred in the west/central area (0.08 fish per boat trip, 53.7% lower than the long-term average; Figure 6d). As is typically observed, the highest catch rate occurred in April (0.77 fish per boat trip; Figures 6c, A1). Coho salmon catch rates per boat trip were well above respective long-term averages each month April through September (range: -+50.2% [May] to +248.7% [September]; Table A7b).

Biological Data

Biological data analysis presented below includes fish processed during April 15 - September 30 (length: 1985-2017, weight: 1988-2017, scale samples for age determination: 2000-2017). 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 2000-2017, 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, the majority (>73.8%) of coho salmon harvested in the open lake were age 2 (33-year average = 95.8% of those harvested were age 2; Table A8). In 2017, 98.1% of coho salmon sampled were age 2, 1.1% were age-1 (first age 1s processed since 2009), and 0.8% were age-3. 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 28 out of 33 years surveyed.

Condition indices for coho salmon in 2017, as determined from predicted weights of standard length fish, were below previous 29-year (1988-2016) averages for each inch group evaluated from 18 in to 26 in (range: -15.5% [18-in] to -2.2% [26-in]). Predicted weights of the smallest inch groups (i.e., 18-in, 20-in, and 22-in fish) were the lowest on record, indicating relative poor condition compared to previous years for fish of the same length. For the largest inch groups evaluated, predicted weights were slightly above average (+0.7% [28-in] and +3.5% [30-in]; Table A8). Mean length of age-2 coho salmon sampled in April 2017 was 21.0 inches, 0.7 inches longer than the long-term average. The mean length of age-2 coho salmon in September 2017 was 27.9 in, and equal to the long-term average (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 22 of the 33 years surveyed. From 1985-2002 Chinook salmon represented an average of 28.3% of the total salmonid catch among trout and salmon boats. From 2003-2016, 45.3% of all salmonines caught were Chinook salmon. In 2017, Chinook salmon catch was an estimated 96,226 fish (±26.2%), representing 59.3% of the total salmonine catch (Tables 1, A9a; Figure 7).

Of all Chinook salmon caught in 2017, 56.0% were harvested (Table A9a). The highest percent harvest occurred in 1995 when 87.3% of all Chinook

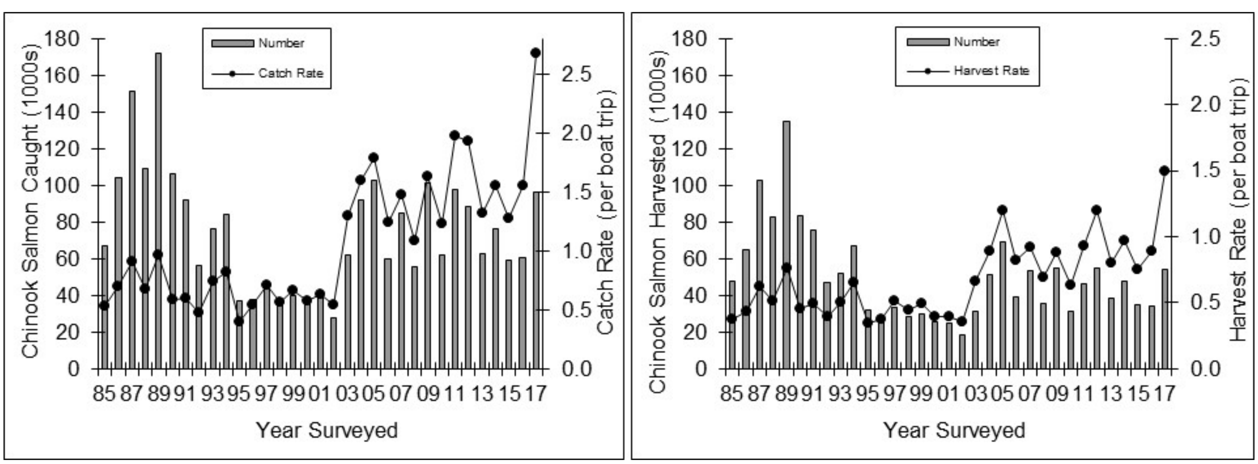

Figure 7. Total Chinook Salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2017.

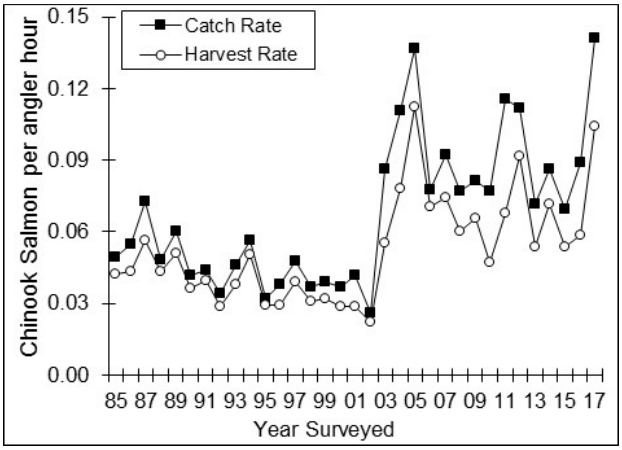

Figure 7b. Charter boat catch rate and harvest rate per angler hour for Chinook salmon, April 15 – September 30, 1985-2017.

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 (2003-2017 average percent harvest=58.5%) was 20.8% lower than during the 1985-2002 time period (average = 73.9%). The recent decline in percent harvest is likely attributable to both improved catch rates (i.e., with increased catch rates the anglers can be more selective with the fish harvested and still harvest their limit of fish) and increasing numbers of anglers practicing catch and release. Harvest in 2017 was estimated at 53,871 (±24.7%) Chinook salmon, which represented 57.6% of the total salmonine harvest (Tables 1, A9a; Figure 7).

Typically, the majority of the Chinook salmon catch and harvest occurs during August (Table A9a). This was observed in 2017 when the highest catch and harvest estimates occurred in August (49,700 and 27,749 fish, respectively), representing nearly 52% of all Chinook salmon caught and harvested. Estimated August catch was the second highest in the 33 years surveyed (1989 was the highest). In 2017, catch estimates were above respective long-term monthly averages in July (+105.0%) and August (+83.5%), and below average during the other months (range: -88.5% [April] to -18.7% [September]). The highest regional contribution of Chinook salmon catch typically occurs in the west area (28 of 32 years 1985-2016); however in 2017, estimated catch was highest in the east/central area (37,409 fish, 38.9% of all Chinook salmon caught; +117.6% compared to the long-term average). Catch estimates were average in the other three areas surveyed (range: -5.4% [east] to +6.8% [west]; Table A9a).

Fishing Quality

The highest Chinook salmon fishing quality occurred the last 15 consecutive years (2003-2017) with 2017 marking the best year of Chinook salmon fishing on record (Table A9b; Figures 7, 7b). 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 2.4-fold higher than those observed in years prior to 2003. The 5.5 month 2017 average Chinook salmon catch rate was positively influenced by good to excellent fishing during July and August for all areas, and was 2.7 Chinook salmon per boat trip. That is a 78.4% increase compared to the previous 10-year average, and the highest in the 33 years surveyed (Table A9b; Figure 7).

In 2017, charter boats targeting trout and salmon caught 35.5% of the Chinook salmon caught by all trout and salmon anglers. Among charter boats, the 2017 Chinook salmon catch rate was 4.9 fish per boat trip, a 59.9% increase compared to the previous 10-year average and the highest in 33 years surveyed (Table A9b). Charter boat catch per angler hour of Chinook salmon (0.14 in 2017) was the highest on record and 54.3% above the 2003-2016 average (Figure 7b). Among noncharter boats, the 2017 catch rates were 2.2 Chinook salmon per boat trip and 0.14 per angler hour, both well above previous 10-year averages (+84.6% and +66.9%, respectively; Table A9b).

Similar to catch rates, the highest Chinook salmon harvest rates occurred during 2003-2017 (i.e., an average of 93.4% higher than those prior to 2003; 1985-2002 average = 0.48 fish per boat trip, 2003-2017 average = 0.92; Table A9b; Figures 7, 7b). The 2017 lake-wide harvest rate among boats seeking trout and salmon was 1.5 Chinook salmon per boat trip, a 72.9% increase compared to the previous 10-year average (Table A9b; Figure 7). Among charter boats, the 2017 harvest rate (3.6

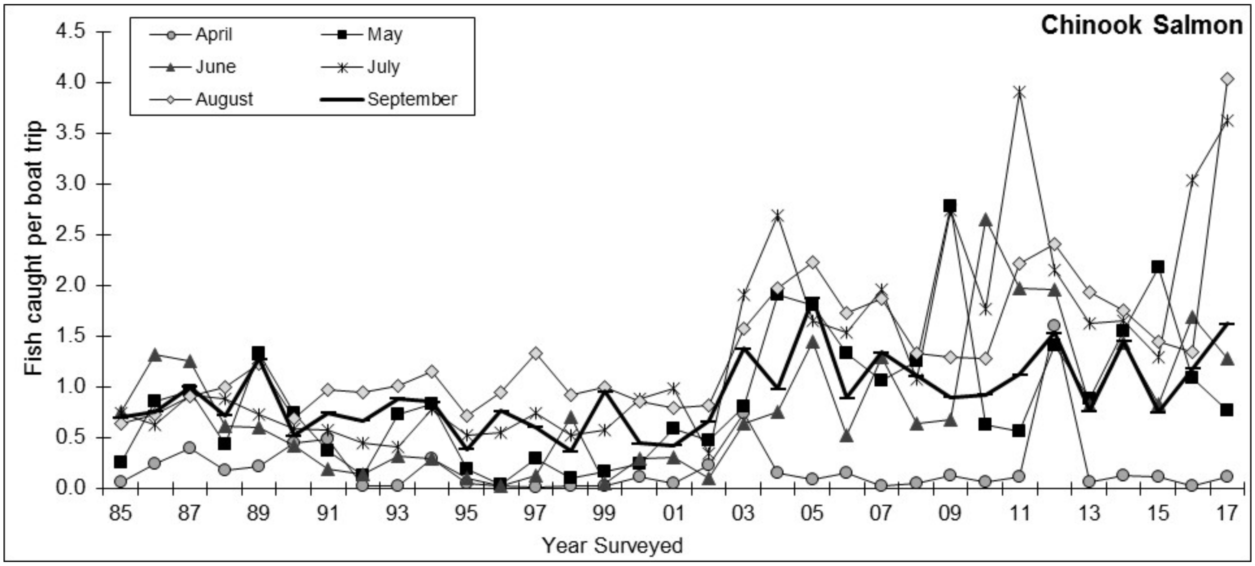

Figure 7c. Chinook salmon caught per boat trip April through September, 1985-2017. Note: Catch rate varied by month within each area surveyed.

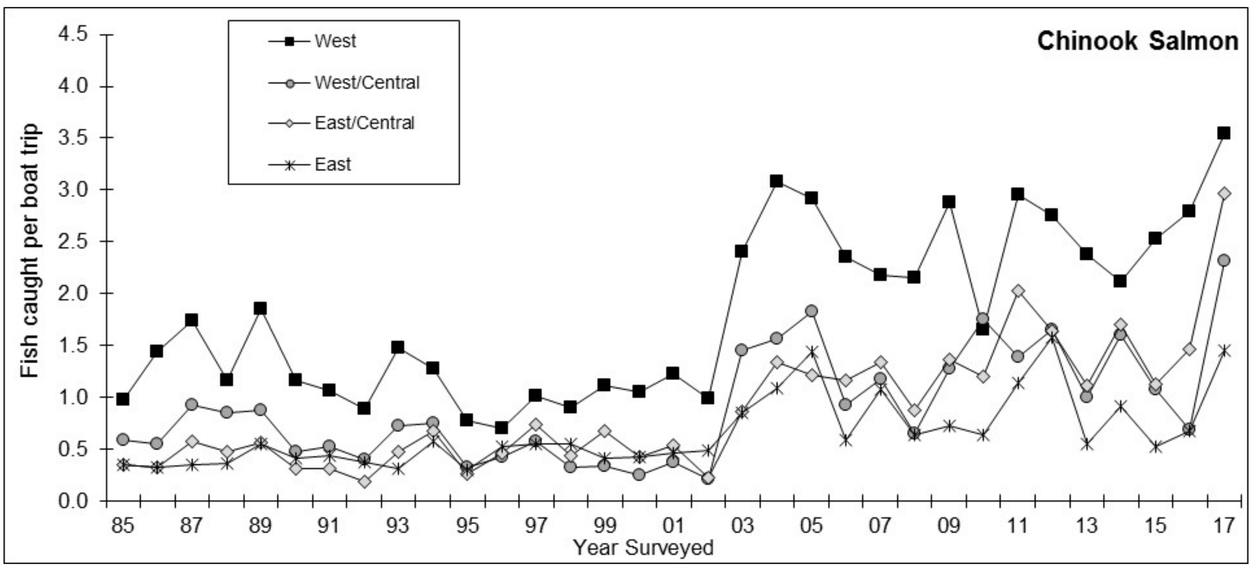

Figure 7d. Chinook salmon caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2017. Note: Catch rate varied by month within each area surveyed.

Chinook salmon per boat trip) was a 59.2% increase comparable to the previous 10-year average (Table A9b; Figure 7b). Charter boats harvested 0.10 Chinook salmon per angler hour in 2017 (Figure 7b). Among noncharter boats, the harvest rate was 1.0 Chinook salmon per boat trip, a 61.7% increase compared to the previous 10-year average (Table A9b).

As with other salmonids, Chinook salmon catch rates vary by region and season. Typically, April-June catch rates of Chinook salmon in the western half of the lake are relatively higher than those toward the eastern half (Lantry and Eckert 2011; Figures 7c, 7d, A2). 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. In 2017, the

5.5 month average catch rate was positively influenced by good to excellent fishing during July and August in all areas (Table A9b; Figure A2). The highest monthly catch rate among all months survey from 1985 through 2017 occurred in August 2017 when 4.0 Chinook salmon were caught per boat trip (Figure 7c). Monthly catch rates were well above respective previous 10-year averages July through September (range: +46.7% [September] to +139.2% [August]), were below average in April (-51.1%) and May (-43.2%), and average in June (-7.9%; Table A9b; Figure 7c). The 2017 Chinook salmon catch rates were above previous 10-year averages in all areas surveyed (range: +45.6% [west] to +114.2% [east/central]; Figure 7d).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2017, weight: 1988-2017, scale samples for age determination: 1991-2017). 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 1991-2017, 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 30 of the 33 years surveyed, Chinook salmon sampled from angler harvest were dominated by age-2 and age-3 fish (1985-2016 averages: age 2 = 38.8%, age 3 = 47.0% of fish sampled; Table A10). In 2017, angler harvest consisted of 47.9% age-2 fish and 33.0% age-3 fish. Ages 1 and 4 typically represent small components of angler harvest. In 2017, 18.4% of Chinook salmon processed were age 1, the highest since 2011 and 65.3% above the long-term average. The oldest Chinook salmon sampled in Lake Ontario are age-4 and comprised a small percentage of the total Chinook salmon sampled in 2017 (0.7% of all Chinooks processed; Table A10). Scale growth patterns suggest that the fastest growing individuals of any year class are more likely to mature and spawn at age 2 or 3, thereby removing themselves from the lake population, and that many of the age-4 fish are among the slower growing members of their cohort.

To evaluate Chinook salmon growth, we determined mean length-at-age by month for samples collected July through September (data collected from 1991-2017; Table A11; Figure A3). Following two consecutive years of relatively poor growth of age-1 fish (i.e., mean lengths among the lowest recorded), the 2017 mean lengths were above average (+1.0 in, +0.5 in, +1.0 inches above average in July, August and September, respectively). The 2017 August mean length of age-1 fish was 2.8 inches longer than the record low in 2015 (17.3 in).

The longest average lengths of age-2 Chinook salmon during August occurred each year 2010-2012 (average = 32.6 in). Average length of age 2s in August then declined each year, falling to 29.3 inches in 2016 (Table A11; Figure A3). In 2017, length of age-2s in August increased nearly 0.7 inches from 2016; however, remained about 0.5 inches shorter than the long-term average. Conversely, mean length of age-3 Chinook salmon declined to the shortest lengths recorded for July (33.8 in) and August (35.0 in; both over 1.7 inches shorter than the long-term mean). The slower growth in length of Chinook salmon in recent years is partly attributed to the two consecutive long and cold winters (2013-2014 and 2014-2015) followed by below average temperatures the following summers. In 2017, the age-3 and age-4 fish (2013 and 2014 year class, respectively) were the two year classes impacted by both time periods.

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 1988-2017 (Table A10) and showed no statistically significant trends over the 30-year survey period. Predicted weights of Chinook salmon in 2017 were among the heaviest in the data series for fish 28 in and longer, and were heavier than respective long-term averages (28 in: +0.13 lbs; 32 in: +0.28 lbs; 36:in: +0.51 lbs; 40 in: +0.84 lbs). Estimates for the shorter fish were comparable to respective long-term averages (Table A10). Mean length at age data and predicted weights indicate that the recent long, cold winters may have negatively impacted growth in length of the older fish; however, the good condition of Chinook salmon ≥28 inches indicates that alewife (the primary forage of Chinook salmon; Lantry 2001) abundance was sufficient to maintain Chinook weight.

Stocking Level Verses Relative Harvest

To permit between year comparisons of harvest-at-age data, we calculated age-specific harvest rates, hereafter termed relative harvest (Table A12). Beginning with 2016 data, relative harvest was calculated as the age-specific number of Chinook salmon harvested per 50,000 boat trips April 15 - September 30 (i.e., as compared to adjustments of harvest to 150,000 boat trips reported previously; e.g., Eckert 2007, Lantry and Eckert 2015) for two reasons: 1) because estimated fishing effort was about 50,000 boat trips per year for more than a decade; and 2) effort is not expected to increase to the relatively high levels observed in earlier surveys (Figure 2). Age composition of Chinook salmon harvested during 1985-2017 was described above.

Chinook salmon relative harvest (harvest per 50,000 targeted fishing boat trips; Table A12) was variable and appeared most affected by year class strength. The year class-specific total relative harvest of age-1 through age-4 fish (1984-2013 year classes) varied from a high of 74,929 fish for the 2010 year class (harvested at ages 1 to 4 from 2011 to 2014, respectively) to a low of 6,832 fish for the 1994 year class (harvested at ages 1 to 4 from 1995 to 1998, respectively; Table A12). By comparison, survey year-specific total relative harvest (1985-2017 survey years) varied from the high of 75,102 fish in 2017 to a low of 17,371 fish in 1995. The eleven highest total relative harvest estimates occurred since 2004 (Tables A9b, A12), and based on the age-specific relative harvest, were due to high numbers of returns from each year class 2002-2006 and 2009-2016. 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 for most of these year classes (Tables A12, A13). Stocking levels varied from 862,840 (1981 year class) and 3,368,296 (1987 year class) fingerling equivalents (previously described in Eckert 2007). The 2017 relative harvest (75,102 fish) was the highest in the 33-year data series (Table A12). To date, returns of age-1 to age-4 fish from the 2010 year class was the highest on record (74,929 fish) and was 10.9% higher than returns of the 2002 year class (67,570 fish and the previous record high; Table A12).

To control for changes in stocking levels and allow for between year comparisons, relative harvest data were adjusted to a common base of 2,000,000 fingerling equivalents stocked (Figure 8). Regression analysis of 1985-2017 data resulted in a significant ($P<0.0001$) upward trend, indicating that in recent years returns to the fishery were higher than expected when both effort and stocking level were accounted for. This could be due, in part, to improved survival of stocked fish (e.g., improved survival of pen-reared fish; Connerton et al. 2017) and/or increased relative contribution of wild fish. The age-specific relative harvest data per unit number of fingerling equivalents stocked (Figure A4) showed that this trend was mostly due to increased relative harvest of age 1s (2009-2010, and 2016 year classes), age 2s (2002-2003, 2005, 2009-2010, 2012, and 2015 year classes), and age 3s (2002-2004, 2006, 2010 and 2012-2014 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 ($P=0.9307$ and $R^2=0.0002$), age 2 ($P=0.2591$ and $R^2=0.0409$), or

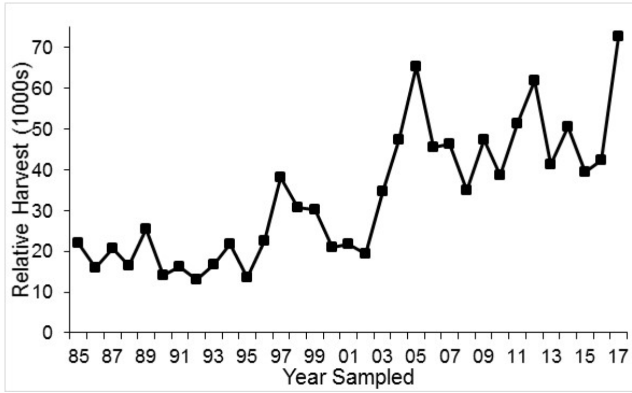

Figure 8. Relative harvest of Chinook salmon per 50,000 boat trips targeting trout and salmon, per 2,000,000 fingerling equivalents stocked.

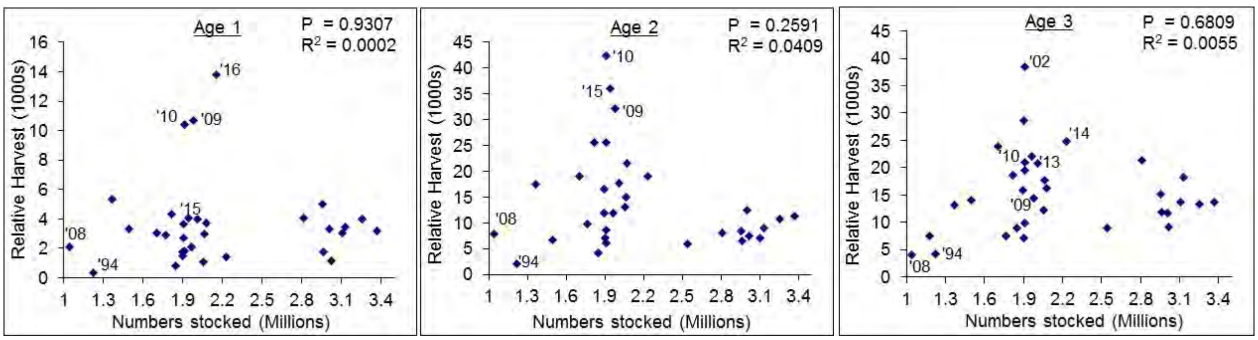

Figure 9. Number of fingerling equivalents stocked and relative harvest of age-1 (1984-2016 year classes), age-2 (1983-2015 year classes), and age-3 (1982-2014 year classes) Chinook salmon.

age 3 (P=0.6809 and R^2=0.0055; Figure 9). Data patterned into two groups of vertical scatter separated by stocking levels for the 1984-1992 year classes (2.81-3.37 million fingerling equivalents stocked) and the 1993-2016 year classes (1.04-2.23 million fingerling equivalents stocked; Table A13; Figure 9). The lowest and highest age-1 (1994 and 2016 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 (Table A13; Figure 9). By age 3, however, relative harvest of the 2008 year class (4,041 fish) was the lowest in the data series and relative harvest at age 4 (99 fish) was the fourth lowest. The 2008 year class was among the fastest growing fish in the data series as indicated by mean size at age 2 (2010) and age 3 (2011; Figure A3).

Factors contributing to the observed increased relative harvest and the lack of relationship between numbers stocked and fishing quality include: 1) improved survival of stocked fish, 2) increased production and contribution of wild fish in recent years, 3) increased catchability of Chinook salmon (e.g. due to changing preyfish populations, improved angling conditions or techniques, or increased numbers of fish available thereby allowing anglers to harvest more fish from a population of the same relative size), or 4) a combination of these factors. Clipping and tagging stocked Chinook salmon allows us to estimate relative survival of stocked fish (e.g., shore stocked vs. pen reared fish) and the contribution of wild fish to the population and the fishery (see Connerton et al. 2017). This provides valuable information for managing Lake Ontario's fishery.

Based on relative harvest at age 1, the 2016 year class appears to be the strongest produced in the data series (Table A12; Figure 9). This may be partly attributed to substantial wild production in the Salmon River as indicated by the highest record catches of young-of-year Chinook salmon in the spring 2016 Salmon River seining program (Bishop et al. 2017). Bishop et al. (2017) attributed the high catches, in part, to the relative mild winter of 2015-2016, and possibly favorable flows during the spawning and incubation periods.

Prior to the 2016 year class, the 2009 and 2010 year classes were two of the strongest produced (Table A12; Figure 9). Relative harvest estimates for the 2009 year class at age 1 (10,663 fish) was the second highest in the data series, and at age 2 (32,236 fish) was the third highest in the data series. Relative harvest of the 2009 year class at age 3 (14,404 fish) was the fifteenth highest. The 2010 year class performed similar to the 2009 year class, in that relative harvest estimate at age 1 (10,398 fish) was the third highest in the data series, and the age 2 estimate (42,386 fish) was the highest for that age. Relative harvest of the 2010 year class at age 3 (20,939 fish) was the seventh highest. The Salmon River wild young-of-year Chinook salmon seining program indicated possible production of a strong 2010 year class. The high river flow during May 2009 may have reduced sampling efficiency and hindered the ability to detect a strong 2009 year class (Bishop et al. 2011). The cause(s) of record high relative harvest of the 2009, 2010, and 2016 year classes is unclear, but may be partly attributable to improved survival of stocked fish (shore stocked and/or pen reared fish; Connerton et al. 2017), 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$0.0282). The R^2 values for these relationships ranged between 0.2137 and 0.4990, indicating that although some of the variation could be accounted for, approximately 50%-79% of variation was unaccounted for (i.e., additional factors were contributing to data variability and determining age-specific relative harvest).

Rainbow Trout

Catch and Harvest

Rainbow trout was the second most commonly caught and harvested salmonine in 2017, and represented 13.9% and 12.8% of the total trout and salmon catch and harvest, respectively (Tables 1, A14a; Figure 10). Estimates peaked in 1989, declined to the lowest levels in the early 2000s, then improved from about 2008-2014. More recently, estimated catch was similar to levels observed in the early 2000s. Rainbow trout catch in 2017 was an estimated 22,556 ($\pm$41.6%) fish, 33.3% lower than the long-term average. Anglers harvested 12,015 ($\pm$39.6%) rainbow trout (53.3% of those caught), 44.1% lower than the long-term average. Reduced catch of rainbow trout in recent years (i.e., 2015-2017; Figure 10) may be at least partly due to a reduced population size. A prolonged rainbow trout mortality event attributed to thiamine deficiency occurred in the Salmon River, NY from fall 2014 and into winter 2015. This event and possibly additional mortality in the lake may have reduced the numbers of rainbow trout in the lake during the 2015 and 2016 fishing seasons. Another indication of a reduced population is the size of the run at the Ganaraska River. The rainbow trout run at the Ganaraska Fishway in Ontario has traditionally been used as an index of abundance, which was markedly lower in spring 2014 and 2015 (OMNRF 2016). Run size declined further in spring 2016 to the lowest level since 2009 (OMNRF 2017). During spring 2017, however, the rainbow trout run at the Ganaraska River Fishway increased 39% from the 2016 run size indicating a higher population level in 2017.

For 32 consecutive years (1986-2017), the majority of rainbow trout caught and harvested were in the west area (Lantry and Eckert 2011; Table 14a). In 2017, 67.2% of all rainbow trout caught and 75.3% of those harvested were from the west area. The majority of rainbow trout catch (52.1%) and harvest (56.3%) occurred during August (Table A14a).

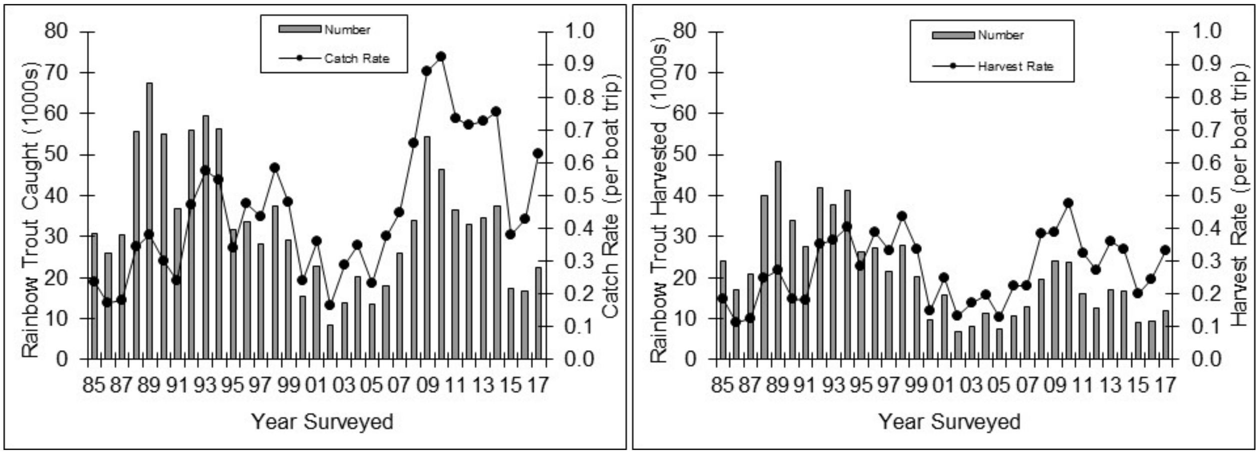

Figure 10. Total rainbow trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2017.

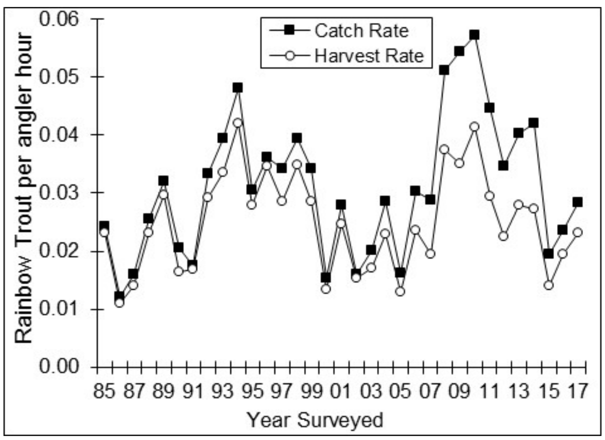

Figure 10b. Charter boat catch rate and harvest rate per angler hour for rainbow trout, April 15 – September 30, 1985-2017.

Fishing Quality

For seven consecutive years, from 2008 to 2014, anglers experienced the highest rainbow trout catch per boat trip in the history of the survey. The 2015 and 2016 catch rates (0.38 and 0.43 fish per boat trip), however, declined to the lowest since 2006. The 2017 catch rate (0.63 fish per boat trip) improved 46.5% from 2016, 39.2% higher than the long-term average and only 18.5% lower than the 2008-2014 time period (i.e., years of the highest rates on record; Table A14b; Figure 10). In 2017, charter boats caught 30.4% of all rainbow trout caught by trout and salmon boats. Charter boats caught 0.97 rainbow trout per boat trip, 13.4% lower than the long-term average (Figure 10b). Charter boat catch per angler hour (0.03 fish per hour) was comparable to (-9.0%) the long-term average but remained 39.0% lower than during 2008-2014. Anglers fishing onboard noncharter boats caught 0.54 rainbow trout per boat trip and 0.04 fish per angler hour (Table A14b).

The 2017 lake-wide harvest rate among all boats fishing for trout and salmon (0.34 rainbow trout per boat trip) was 23.3% higher than the long-term average (Table A14b; Figure 10). Among charter boats fishing for trout and salmon, the harvest rate was 0.80 rainbow trout per boat trip (Table A14b). Charter boats harvested 0.02 rainbow trout per angler hour (Figure 10b), comparable to (-6.7%) the long-term average. Among noncharter boats fishing for trout and salmon, the harvest rate was 0.22 rainbow trout per boat trip (0.01 fish per angler hour) which was 44.3% 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 in the western end of the lake and lowest in the east area (Lantry and Eckert 2011; Table A14b; Figures 10c, 10d, A5). As compared to the previous 5-year averages, the 2017 rainbow trout catch rate was above average in August (+39.3%) and September (+127.0%), average in July (-0.3%), and below average during the other months (April [-58.4%], May [-64.6%], and June [-70.3%]; Table A14b). Catch rate was average (+6.6%) in the west area, above average in the west/central area (+24.1%),

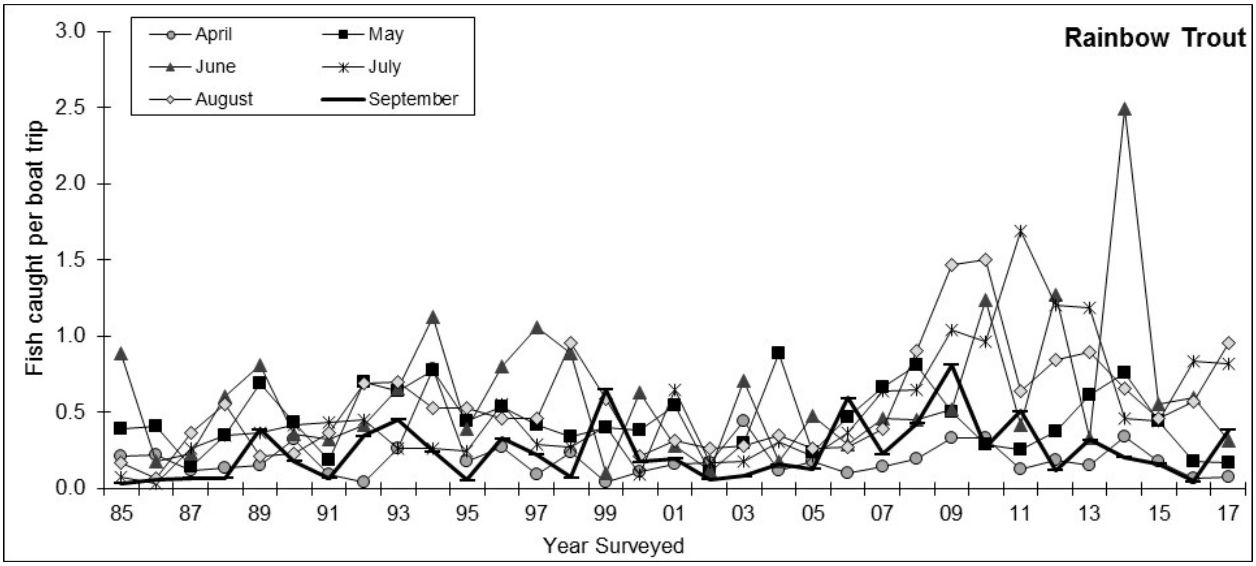

Figure 10c. Rainbow trout caught per boat trip April through September, 1985-2017. Note: Catch rate varied by month within each area surveyed.

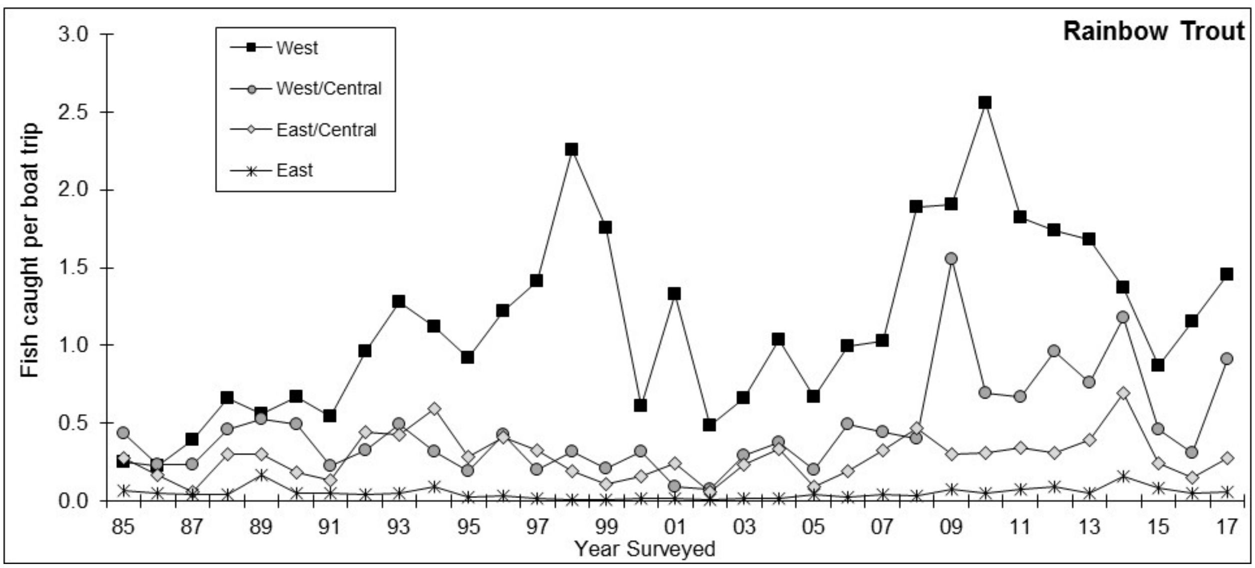

Figure 10d. Rainbow trout caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2017. Note: Catch rate varied by month within each area surveyed.

and below average in the east/central (-23.7%) and east areas (-32.1%; Figure 10d).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2017, weight: 1988-2017). Scale samples were collected from rainbow trout processed for biological data each year 1996-2017; 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 2017 open lake season was the eleventh 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 eleven years since the regulation (2007-2017) was 10.3%, and significantly lower than the eleven years prior to the increased minimum size limit (1996-2006) when 17.9% of rainbow trout processed were <21.0 in (Chi-square analysis: $X^2 = 59.826 > \chi^2_{[1](.005)} = 7.879$). During 2017, 2.9% of harvested rainbow trout were shorter than the legal 21 in minimum harvestable size.

Weight data were collected each year from 1988-2017 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 generally declined to record and near record lows. In 2017, condition improved for all inch groups evaluated relative to recent years. Condition of smaller fish (18-, 20-, 22-, and 22-inch groups) increased to the highest level since 2003. Improved condition of the larger fish (i.e., 26-, 28-in, 30-in, and 32-in) was less pronounced; however, this is not unexpected as this group of fish were those who survived both the fall/winter 2014/2015 mortality event observed in the Salmon River and the two consecutive long, cold winters (2013/2014 and 2014/2015) followed by summers with below average temperatures. Both factors could have contributed to reduced growth and condition.

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 (Eckert 1998; Table A16; Figure 11). 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 decision to replace the Atlantic salmon stockings in the Black River with an equivalent number of brown trout. Each year 2009-2017, and in addition to the NYSDEC stockings, the USGS Tunison Laboratory of Aquatic Sciences reared and conducted experimental stockings of Atlantic salmon (Connerton 2010, 2018).

Each year from 2003 through 2008, few Atlantic salmon were reported in angler catch or harvest,

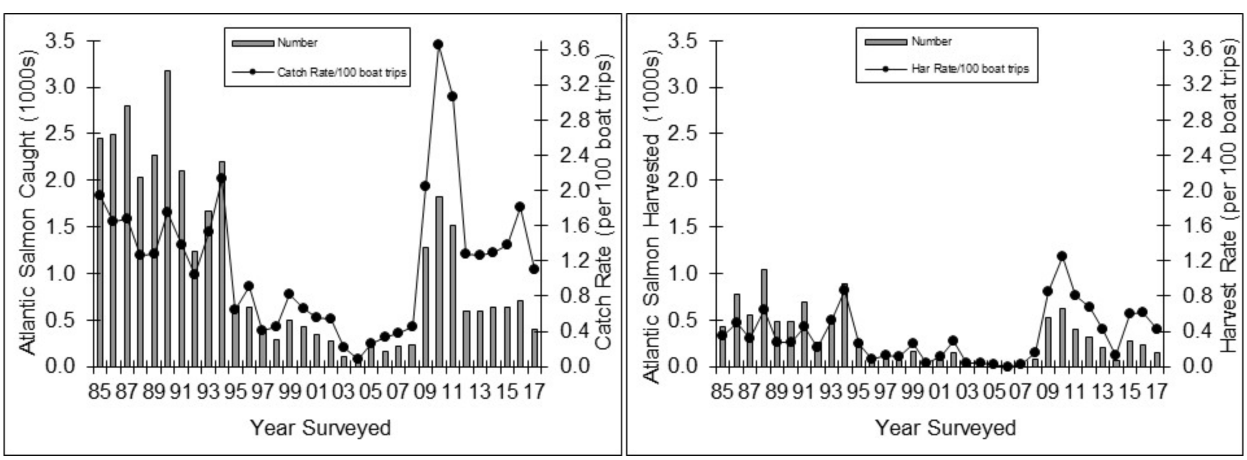

Figure 11. Total Atlantic salmon catch and catch rate, and harvest and harvest rate per 100 boat trips for boats seeking trout and salmon, April 15 – September 30, 1985-2017.

and ≤1 was observed in the boat fishery by creel agents, resulting in harvest estimates of less than 80 fish per year and catch estimates of less than 250 fish per year (Lantry and Eckert 2010; Table A16; Figure 11). Beginning in 2009, anglers began catching Atlantic salmon in greater frequency than in the previous decade. For three consecutive years (2009-2011), estimated lake-wide catch and harvest were the highest since 1994 (Table A16; Figure 11). Since then, fewer Atlantic salmon were caught and harvested, however, estimates remained well above 1995-2008 levels. During 2017, estimated catch (394 [±61.9%] fish) was 37.9% lower than the previous 5-year average and may be partly attributed to low fishing effort into early July (Tables 1, A16; Figure 11). Anglers harvested an estimated 151 (±84.8%) Atlantic salmon in 2017. The 2017 Atlantic salmon catch rate (1.1 fish per 100 boat trips seeking trout and salmon) was the lowest recorded in recent years (i.e., 2009-2016 average = 2.0) but was more than 2.2-fold higher than the 1995-2008 average rate (average = 0.48 per 100 boat trips). Harvest rate in 2017 (0.42 fish per 100 boat trips seeking trout and salmon) was more than 3.7-fold higher than the 1995-2008 average (0.11 fish harvested per 100 boat trips).

Many factors may have contributed to the increased occurrence of Atlantic salmon in angler catches. Survival of stocked Atlantic salmon may have improved. Wild, young-of-year Atlantic salmon were captured in the Salmon River each year 2009-2011, 2013 and 2016 (none were captured in 2012, 2014, 2015 or 2017; 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 from New York anglers 2009-2016 indicated that, 86.5% were from NYSDEC stockings, 4.3% were from OMNRF stockings and 9.2% were undetermined (Chris Wilson, OMNRF, personal communication; samples collected in 2017 are not yet processed).

<u>Brown Trout</u>

Catch and Harvest

Brown trout was the third most commonly caught and harvested salmonine in 2017, accounting for 10.5% and 11.3% of the total catch and harvest, respectively (Tables 1, A17a). Both catch and harvest declined from the mid-1980s to the mid-1990s and varied without trend since 1995 (Table A17a; Figure 12). In 2017, estimated catch (17,092 [±32.5%] fish) was the lowest recorded and 58.1% lower than the long-term average. Estimated harvest (14,608 [±37.3%] fish) was also the lowest in the data series and was 61.9% lower than the long-term average (Tables 1, A17a; Figure 12). In 2017, 62.0% of brown trout caught were harvested,

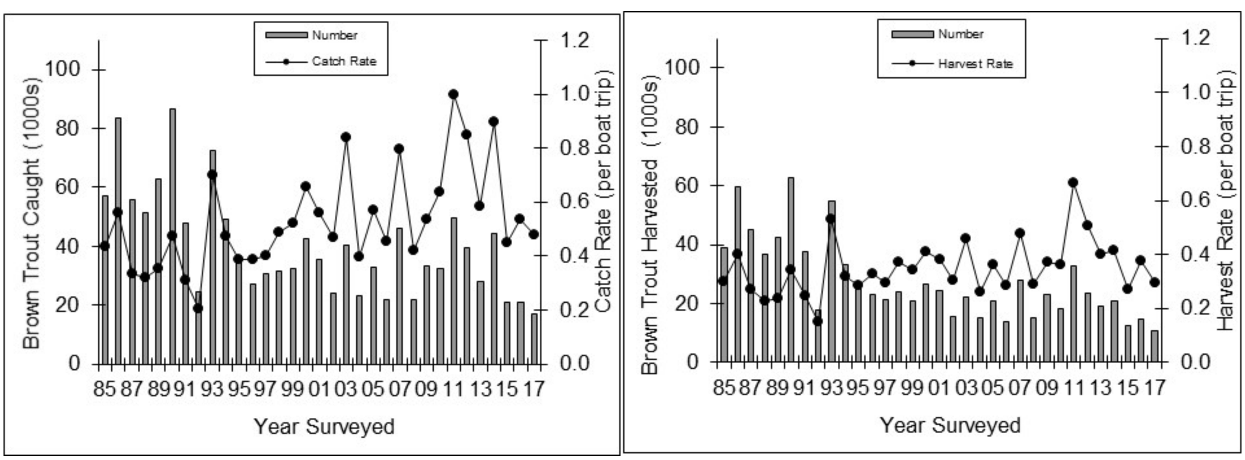

Figure 12. Total brown trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2017.

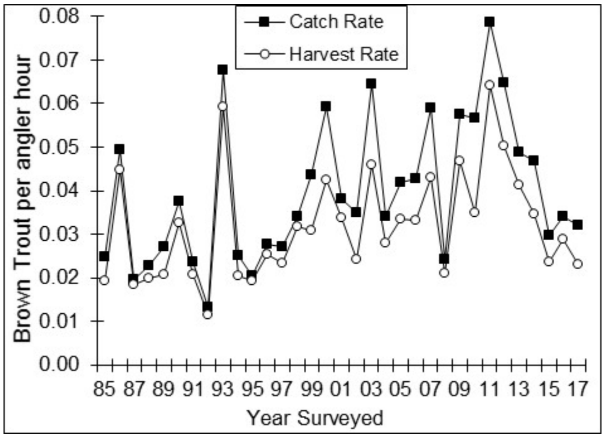

Figure 12b. Charter boat catch rate and harvest rate per angler hour for brown trout, April 15 – September 30, 1985-2017.

comparable to (-8.1%) the long-term average. Typically, the majority of brown trout are caught during April and May, and in the east/central area. Over 62% of the 2017 brown trout catch occurred during April and May, and over 55% were caught in the east/central area (Table A17a). In 2008 and 2012 the majority of brown trout were caught and harvested in the east area (60.6% and 37.2% of total catch, respectively) where brown trout fishing was good throughout much of the open lake fishing season (Lantry and Eckert 2011).

Fishing Quality

Brown trout catch rates (lake-wide, charter and noncharter) were variable over the 33-year data series with no trend (Table A17b; Figures 12, 12b). In 2017, among trout and salmon fishing boats, brown trout catch rate (0.48 fish per boat trip) was a slightly lower than (-10.3%) the long-term average and 28.9% lower than the previous 10-year average. Charter boats targeting trout and salmon caught 45.3% of all brown trout in 2017. Catch rate among charter boats was 1.1 brown trout per boat trip in 2017, 22.6% lower than the long-term average (Table A17b; Figure 12b). The charter boat catch rate per angler hour was 0.03, 19.9% lower than the long-term average (Figure 12b). Noncharter boats caught an estimated 0.32 brown trout per boat trip (0.02 per angler hour), slightly lower than (-10.3%) the long-term average (Table 17b).

Brown trout harvest rates (lake-wide, charter and noncharter) were also variable and showed no trends over time (Table A17b; Figures 12, 12b). Among all boats seeking trout and salmon, the 2017 lake-wide harvest rate was 0.30 brown trout per boat trip, 15.8% lower than the long-term average (Table A17b; Figure 12). Among charter boats fishing for trout and salmon, the 2017 harvest rate was 0.79 brown trout per boat trip (0.02 fish per angler hour; Table A17b; Figure 12b). Among noncharter boats fishing for trout and salmon, the 2017 harvest rates were 0.18 brown trout per boat trip and 0.01 fish per angler hour.

Brown trout monthly and geographical catch and harvest rate trends for most years showed rates highest in April and May and lower and/or declining through September, and highest in the east/central area (Lantry and Eckert 2011; Table A17b; Figures 12c, 12d, A6). During 2017, brown trout catch rates were highest in April (2.1 per boat trip) and May (1.7 fish per boat trip). The April rate, although comparable to the long-term average (+8.8%) was 30.7% lower than the previous 10-year average. Fishing quality during May was the third highest for that month and an 81.6% higher than the long-term average (Table A17; Figure 12c). Catch rates were below average June through August (range: -46.8% [August] to -26.8% [July]) but was above the long-term average in September (+47.3%; Table A17; Figure 12c). Similar to estimated catch, the highest catch rate typically occurs in the east/central area. In 2017, however, despite the east/central area having the highest estimated catch it did not have the highest catch rate. The highest 2017 catch rate occurred in the west/central area (0.83 fish per boat trip and 31.1% higher than the long-term average). The second highest catch rate occurred in the east/central area (0.75 fish per boat trip), 15.2% lower than the long-term average (Table A17b; Figure 12d). The lowest 2017 catch rates occurred in the west and east areas (0.12 and 0.36 fish per boat trip, respectively; Table A17b; Figure 12d).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2017, weight: 1988-2017). Scales

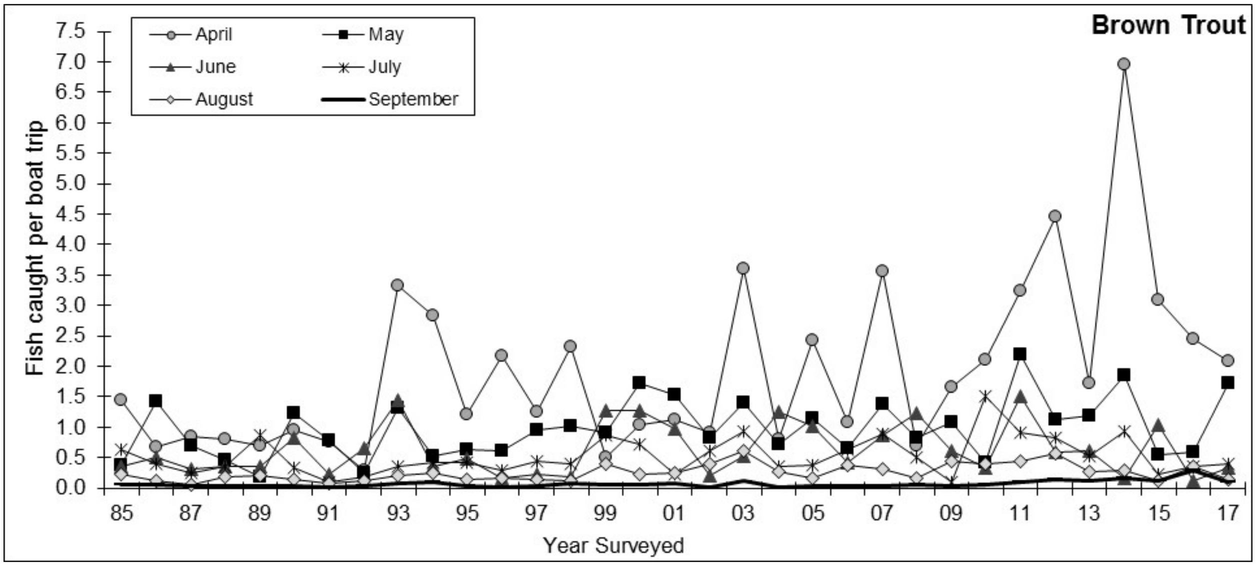

Figure 12c. Brown trout caught per boat trip April through September, 1985-2017. Note: Catch rate varied by month within each area surveyed.

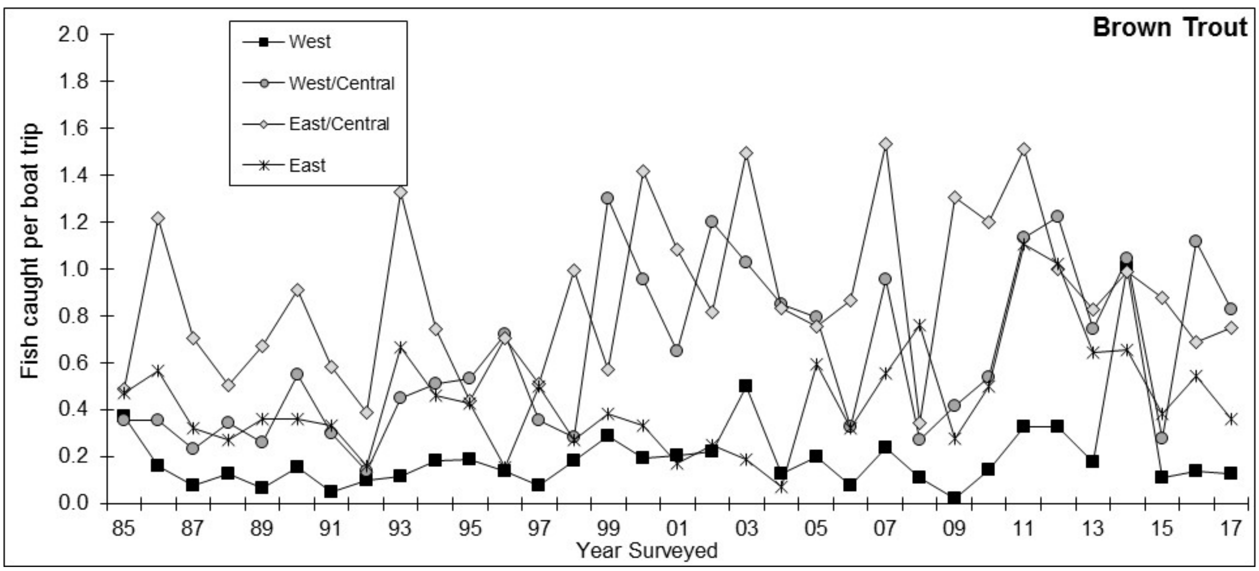

Figure 12d. Brown trout caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2017. Note: Catch rate varied by month within each area surveyed.

were collected from nearly all brown trout processed by creel agents during 1993-2017 (i.e., 25 years). Each year very few brown trout sampled are age 1 (0.0%-3.3%) due to their small size (i.e., mostly shorter than the 15 inch minimum size limit) and angling strategies (e.g., species targeted, lure type). Each year 2011-2017, none of the brown trout sampled were age-1 (Table A18); the majority were age 2. During 1993-2012, 66.0% (2004) to 88.8% (1993) of all brown trout harvested were age-2 fish. Each year 2013-2015, age-2 brown trout dominated angler harvest, however, contributions of age 2s were the lowest recorded (range: 58.3% - 62.6%) and contributions of age 3s were the highest recorded (range: 28.8%-34.6%). In 2017, 79.7% of brown trout harvested were age-2 fish, comparable to (+6.0%) the long-term average. Nearly 17% of the harvested brown trout were age-3 fish. For most years, <4% of brown trout harvested were age-4 fish. The highest contributions of age-4 fish occurred in 2014 and 2015 (7.8% and 9.2% of harvest, respectively). In 2017, 3.3% of the brown trout were age-4 fish. From 1993-2017, age-5 or older brown trout comprised an average of 0.7% (0.3% in 2017; Table A18). Few brown trout age 6 or older were observed, and in the 25 years that scale samples were aged, only fourteen age-6 and one age-7 brown trout were observed.

Each year we determine the mean length of brown trout sampled April 15-30. Each year from 2014 to 2016, lengths of age-2 brown trout were among the lowest levels recorded. Growth rates of those fish were likely negatively impacted by two consecutive long and cold winters followed by below average summer temperatures. Milder weather since then and a relatively strong 2016 year class of alewife may have contributed to improved growth observed in 2017. In 2017, average length of an age-2 brown trout in April was 18.5 in, the longest since 2011 and fourth longest recorded since we began collecting length data in 1993 (Table A18). Mean length of age-3 brown trout in April 2017 was 23.8 in, the second longest recorded.

We evaluated brown trout condition by determining predicted weights of seven standard length groups (16-28 in, by 2-in length increments; Table A18). Each year 2014 to 2016, brown trout condition was at or near record low values for all sizes examined. In 2017, however, condition improved for all sizes evaluated. Predicted weights of the 16-in and 18-in fish were the highest observed since 1999, and were 22.1% and 17.6% higher than the previous 5-year averages, respectively (Table A18). Predicted weights of the 20-in and 22-in fish were the highest since 2006, and were 13.7% and 10.2% higher than the previous 5-year averages, respectively. Condition of the three largest size groups increased to the highest levels since 2013. Growth and condition of brown trout was likely positively influenced by milder weather conditions and increased prey availability in 2016 and 2017 (Weidel et al. 2018).

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 was limited by a slot size limit designed to increase the number and ages of spawning adults. In 1993, the slot limit was set at 25-30 inches total length. Until fall 2006, Lake Ontario anglers could harvest three lake trout outside of the 25-30 inch slot limit. Effective October 1, 2006, the lake trout creel limit was reduced to two fish per day per angler, one of which could be within the 25-30 inch slot. In 2017, lake trout was the fourth most commonly caught and harvested trout or salmon species, contributing 9.5% and 9.2% of the total salmonine catch and harvest, respectively (Tables 1, A19a). In 2017, estimated lake trout catch (15,444 [±37.4%] fish) and harvest (8,592 [±44.6%] fish) were 57.0% and 47.2% lower than the previous 5-year averages, respectively (Tables 1, A19a; Figure 13). 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 2018). Increased lake trout catch, which began in 2011, is most likely attributed to increased lake trout abundance in recent years (Lantry and Lantry 2018). Additionally, some anglers reported specifically targeting lake trout when fishing quality for other species (e.g., brown trout, Chinook salmon) was considered low during 2013-2016. Fishing quality for some species was greatly improved in 2017 (e.g., Chinook salmon, coho salmon and rainbow trout) which likely resulted in fewer anglers (and/or less time spent) specifically targeting lake trout.

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 2000, the majority of lake trout were caught in the west or west/central areas (15 of the 17 years 2001-2017). In 2017, the majority of lake trout were caught in the west/central area (5,552 fish, 35.9% of all lake trout; Table A19a). The 2017 monthly catch

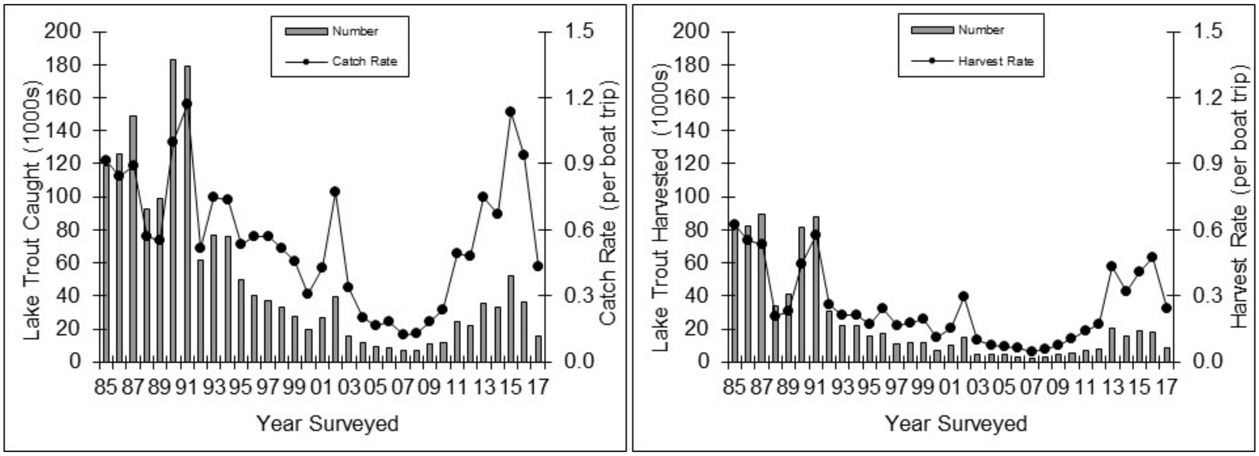

Figure 13. Total lake trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2017.

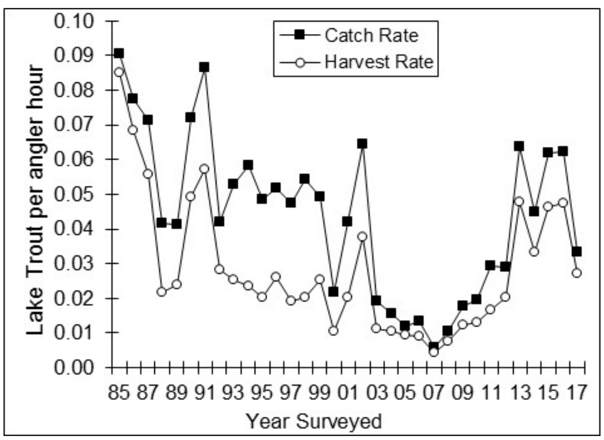

Figure 13b. Charter boat catch rate and harvest rate per angler hour for lake trout, April 15 – September 30, 1985-2017.

estimates were below previous 5-year averages each month April-September (range: -73.2% [September] to -25.3% [July]; Table A19a).

Fishing Quality

Low lake trout abundance during the mid-2000s (Lantry and Lantry 2018) 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 = 0.2 per boat trip; Table A19b; Figures 13, 13b). Since then, catch rates increased reaching 1.1 per boat trip in 2015 (second highest on record) and remained high in 2016 (0.9 per boat trip, fourth highest on record; Table A19b; Figure 13). This increase coincided with an increased population of adult lake trout in recent years as well as a likely increase in angler effort targeting lake trout during periods of relatively lower catch rates for other species (2014-2016). In 2017, catch rate declined to 0.43 fish per boat trip and was 23.9% lower than the long-term average. This coincides with good to excellent fishing quality for other trout and salmon species (i.e., Chinook salmon, coho salmon, rainbow trout) which may have reduced effort specifically targeting lake trout as compared to recent years.

In 2017, 52.1% of all lake trout caught by trout and salmon anglers were caught on board charter boats. Among charter boats fishing for trout and salmon, the lake-wide catch rates per boat trip (1.1) and per angler hour (0.03) were 38.2% and 36.5% lower than previous 5-year averages, respectively; Table A19b; Figure 13b). Catch rate among noncharter boats fishing for trout and salmon was 0.3 lake trout per boat trip and 0.02 fish per angler hour (Table A19b).

The 2017 lake-wide harvest rate among boats seeking trout and salmon was 0.24 lake trout per boat trip, comparable to (-3.2%) the long-term average (Table A19b; Figure 13). Among charter boats fishing for trout and salmon, the 2017 harvest rate was 0.93 lake trout per boat trip (0.03 per angler hour; Table A19b; Figure 13b). Among noncharter boats fishing for trout and salmon, the harvest rate was 0.07 lake trout per boat trip (0.01 per angler hour; Table A19b).

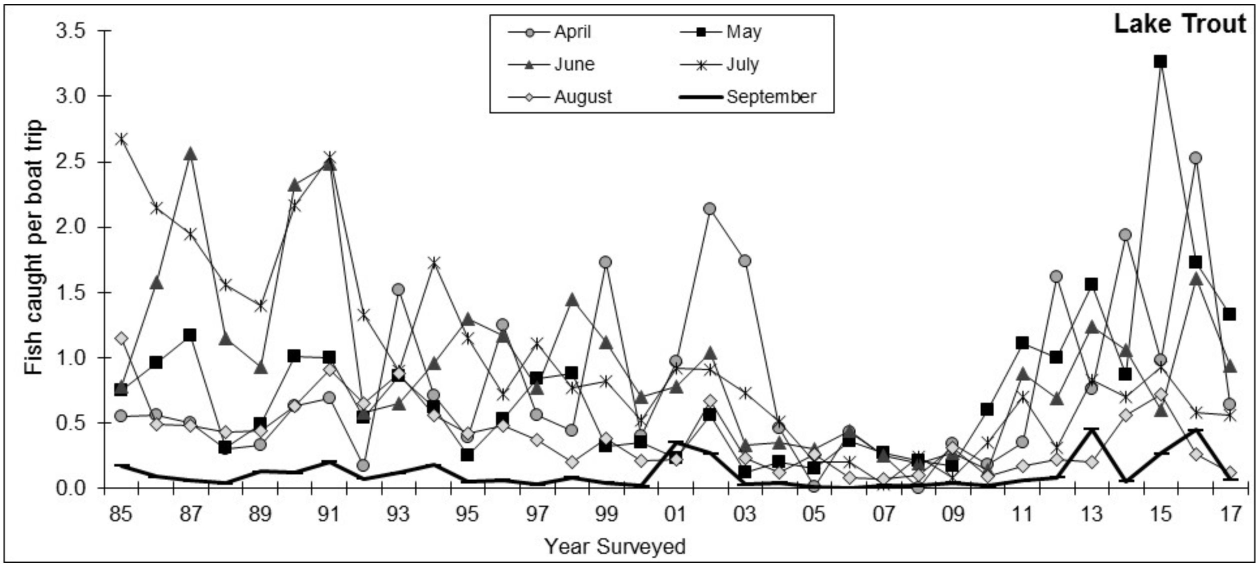

Figure 13c. Lake trout caught per boat trip April through September, 1985-2017. Note: Catch rate varied by month within each area surveyed.

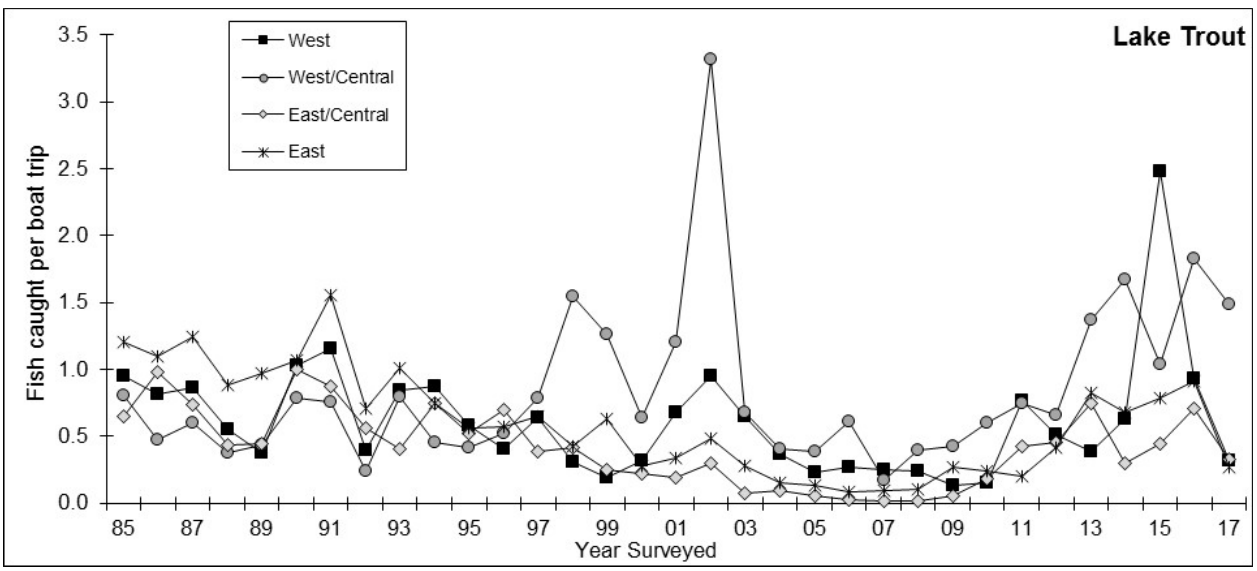

Figure 13d. Lake trout caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2017. Note: Catch rate varied by month within each area surveyed.

Comparisons by month showed that catch rates were below their respective previous 5-year averages during all months (range: -73.0% [September] to -15.6% [July]) except June (-9.2%; Table A19b; Figure 13c). For nearly all years since 1997, the west/central area experienced the highest lake trout catch rate (Table A19b; Figures 13d, A7). In 2017, anglers fishing the west/central area caught 1.5 lake trout per boat trip, the fourth highest recorded and 80.5% higher than the long-term average for that area. The highest harvest rate also occurred in the west/central area (0.6 per boat trip; Table A19b). Catch rates in the other areas surveyed were below average (range: -68.0% [west] to -37.5% [east /central]).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2017, weight: 1988-2017). The 2017 fishing season was the eleventh season affected by the October 2006 regulation change permitting each angler to keep two lake trout per day with no more than one between 25 and 30 inches. From 1993-2006, 9.8% (1998) to 26.6% (1993; 1993-2006 average = 17.0%) of the lake trout harvested were within the 25-30 inch slot, due in part to measurement errors and location of capture (fish harvested in Ontario waters are exempt from New York regulations; Table A20). Given the regulation change we expected to see increased harvest of slot limit sized fish. As was expected, during the first five years after the regulation change (2007-2011) the percentage of harvested lake trout within the 25-30 inch slot increased to an average of 37.2% (Table A20). From 2012 through 2016, an average of 53.2% of lake trout harvested were within the slot limit. In 2017, 40.5% of all lake trout harvested were within the 25-30 inch slot. In 2017, 33.3% of lake trout harvested were shorter than and 26.2% harvested were greater than the 25-30 inch slot.

<u>Smallmouth Bass</u>

Catch and Harvest

Prior to October 1, 2006, NYSDEC fishing regulations established the smallmouth bass open season in Lake Ontario from the third Saturday in June through November 30 and allowed anglers to harvest a daily limit of five smallmouth bass with a minimum length of 12 inches. A regulation change effective October 1, 2006 established a pre-season catch and release period for smallmouth bass from December 1 through the Friday preceding the third Saturday in June (excluding Jefferson County's Lake Ontario waters). April 15 through June 16, 2017 was the eleventh pre-season catch and release period covered by this survey. During that period, there were an estimated 198 (±80.8%) fishing boat trips targeting smallmouth bass with effort occurring during April (20 boat trips), May (79 boat trips) and June 1-16 (100 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). From 2009-2017, catch of smallmouth bass remained low. Estimated catch and harvest of smallmouth bass April 15 – September 30, 2017 was 12,079 (±47.2%) and 2,305 (±88.2%) fish, respectively (Tables 1, A21a). During the traditional open fishing season, 9,342 (±55.4%) smallmouth bass were caught and 24.0% of those were harvested (2,240 [±91.1%] fish; Table A21a; Figure 14).

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 2.02 per angler hour; Eckert 2005; Table A21b; Figure 14), then declined to the lowest level recorded in 2010 (1.9 per boat trip and 0.35 per angler hour; Figure 14). The number of smallmouth bass caught and harvested improved slightly in 2017 (4.1 and 1.0 bass caught and harvested per bass boat trip, respectively). Smallmouth bass catch per angler hour in 2017 was 0.67, the highest since 2006 and 94% higher than the 2010 record low (Table A21b; Figure 14b).

Comparisons of 2017 month- and area-specific catch and harvest rates with their respective 2012-2016 averages (Table A21b) showed above average fishing quality each month July through September (range: +13.9% [July] to +26.0% [August]) and below average in June (-56.9%). The 2017 catch rates were above average in the west/central (+32.8%) and east/central (+65.7%) areas, was below average in the west area (-94.1%), and comparable to average in the east area (-9.1%; Table A21b).

In 2017, 43.7% of boats specifically targeting smallmouth bass during the traditional open season failed to catch any bass, which is the same as 2016 and slightly better than most recent years, but well above levels observed prior to 2006 (Table A6, Part B), indicating continued poor fishing quality (Table A6). Each year a relatively low percentage of bass boats harvested the daily creel limit of five bass per angler (1985-2003 average=6.3%). Since

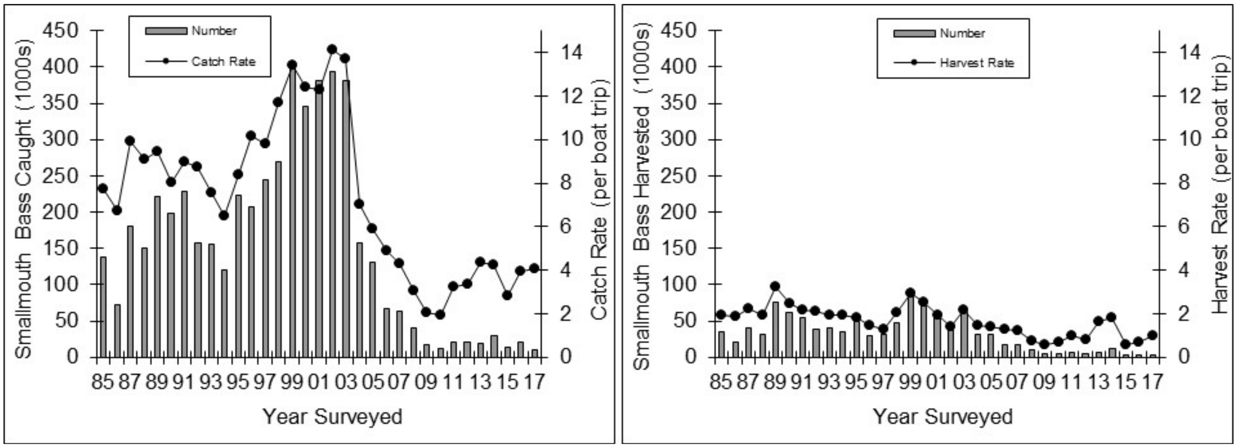

Figure 14. Total smallmouth bass catch and catch rate, and harvest and harvest rate per boat trip for boats seeking smallmouth bass during the traditional open season, 1985-2017.

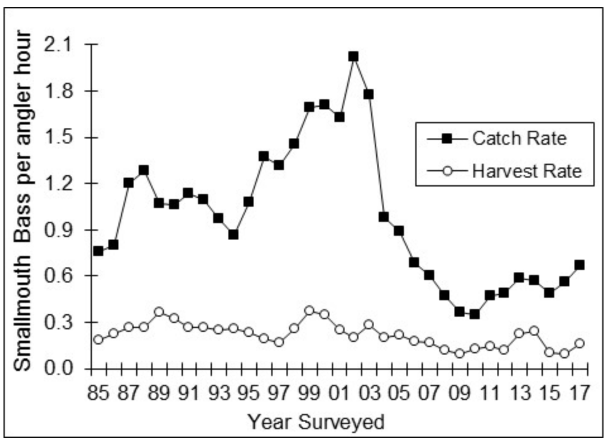

Figure 14b. Smallmouth bass catch rate and harvest rate per angler hour among anglers targeting bass during the traditional open season, 1985-2017.

catch rates began decreasing after 2003, an even lower percentage of bass boats harvested their limit of bass (2004-2017 average=2.3%). In 2017, for the second consecutive year, none of the boats specifically targeting bass 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).

Smallmouth bass 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 bass populations in Lake Ontario's Eastern Outlet Basin, the St. Lawrence River and Lake Erie. Unlike the southern shore, however, these regions have generally continued to provide acceptable bass catch rates.

A Lake Ontario bass angler diary program, conducted 2010-2013, surveyed bass anglers fishing Lake Ontario and its embayments and tributaries. Catch rates experienced by diarists (0.39-0.63 bass per angler hour) were similar to rates reported in this survey for the same time period (0.35-0.59 bass per angler hour; Sanderson and Lantry 2014; Table A21b). The angler diary program was discontinued following the 2013 season due to low participation (Sanderson and Lantry 2014).

<u>Yellow Perch</u>

Yellow perch catch and harvest estimates are highly variable because few anglers 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 2017 estimated catch (19,459 [±112.9%] fish) and harvest (5,204 [±89.2%] fish) were below long-term (1985-2016) averages (-31.7% and -58.4%, respectively), but catch was the highest since 2012 (Tables 1, A22; Figure 15). Reduced angler catch reported in this survey 2014 to 2016

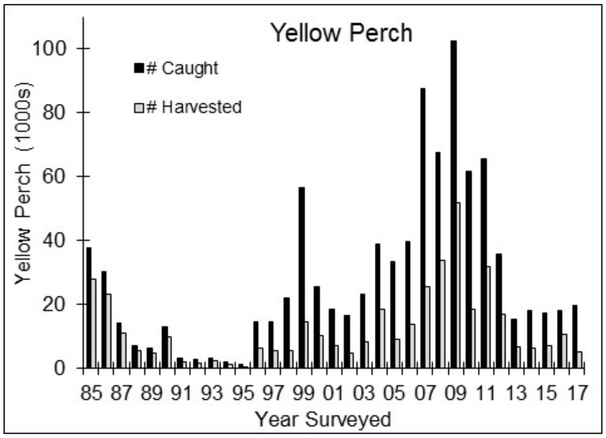

Figure 15. Estimated number of yellow perch caught and harvested by all fishing boats, April 15-September 30, 1985-2017.

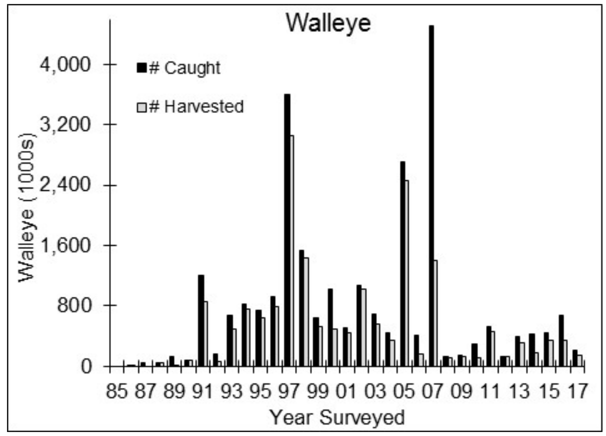

Figure 16. Estimated number of walleye caught and harvested by all fishing boats, April 15-September 30, 1985-2017.

coincided with reduced catch in the Eastern Basin gillnetting assessment (Lantry 2018) and anecdotal angler reports of lower catches in areas not covered by this survey, suggesting that perch populations in recent years were likely lower than those during 2007-2012 (i.e., when angler and gill net catches were relatively high; Lantry 2018; Figure 15). The 2017 increase in angler catch coincides with increased gillnet catches in the Eastern Basin (Lantry 2018) indicating the population status may have improved. Yellow perch are distributed along much of the Lake Ontario shoreline, however, each year 1996-2017 the greatest proportion of catch occurred in the east/central area by relatively few fishing boats targeting perch (52.4% of total catch in 2017; Table A22).

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 2018). 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 2017, there were an estimated 208 (±118.8%) walleye caught and 152 (±163.2%) harvested in Lake Ontario (Table A23; Figure 16). Assessment data (Lantry 2018) and anecdotal angler reports suggest that walleye populations and fisheries are greatly underestimated by this survey and estimated catch and harvest of them are of limited value.

“Other Fish”

The “other fish” category includes a variety of species, including unidentified fish. In 2017, as in previous years, “other fish” was dominated by warm water species (Tables 1, 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 2017 were northern pike (44 caught, 0 harvested) and largemouth bass (247 caught, 61 harvested). Lake sturgeon were reported in angler catch during only two of the 33 years surveyed, 2001 (44 fish) and 2012 (27 fish). Chain pickerel were only recently reported in angler catch (caught each year 2008-2010, 2013, 2017) with 216 captured in 2017. Cisco (a.k.a lake herring; 70 caught, 14 harvested) were reported in angler creel for the eight consecutive years (2010-2017). 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 this 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 2017, round goby was the eighth most commonly caught species (5,817 [±58.6%] caught; 3,986 [±80.6%] harvested; Tables 1, 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 2017, there were an estimated 2,380 (±30.8%) lampreys observed in this survey, 11.3% lower than the previous 5-year average and 71.7% lower than the 2007 record high (Table A24; Figure16). 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 2018). Lamprey attack rate decreased from the 2007 peak and, in 2017, there were an estimated 14.7 lamprey per 1,000 trout or salmon caught (Table A24; Figure 16). This rate was comparable to (-5.2%) the previous 5-year average, and over 2-fold higher than the 1986-1995 average rate.

For 14 of the last 17 years (2001-2017) the majority of lamprey observations occurred on Chinook salmon (2001-2017 average=58.1%), which was due, in part, to the large number of Chinook salmon caught by anglers (e.g., 2001-2017 average=44.1% of total trout and salmon catch; Tables A5a, A9a). In 2017, 51.0% of lamprey observed by anglers were on Chinook salmon (Tables A5a, A17a, A24). Other host salmonines in 2017 were brown trout (35.7% of observations), rainbow trout (8.2%), coho salmon (2.0%), lake trout (2.0%), and Atlantic salmon (1.0%; Table A24). There were no reports of lamprey observed on fishing gear in 2017. Among the 32 years of lamprey observation data, there were a total of 40 lampreys reported on fishing gear.

Host-specific attack rate on Lake Ontario's trout and salmon (e.g., the proportion of brown trout caught by anglers with a lamprey attached; Table A24) was determined each year. Prior to 1996, lamprey attack rate on "other" salmonines (i.e., excluding lake trout) was low and, on average, fewer than 1% of each species caught by anglers was observed with a lamprey attached (range of 1986-1995 averages: 0.02% [coho salmon] – 0.63% [Chinook salmon]). By 1996, the percentage of angler-caught salmonines with an attached lamprey increased for the "other" salmonines. On average, during 1996-2017, lampreys were observed on a much higher percentage of angler catch (range: 1.0% [coho salmon] to 6.2% [Atlantic salmon]). 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 2018). The lower attack rates since 2007 (Figure 16) coincide with a reduced lake trout wounding rate as determined from September gill

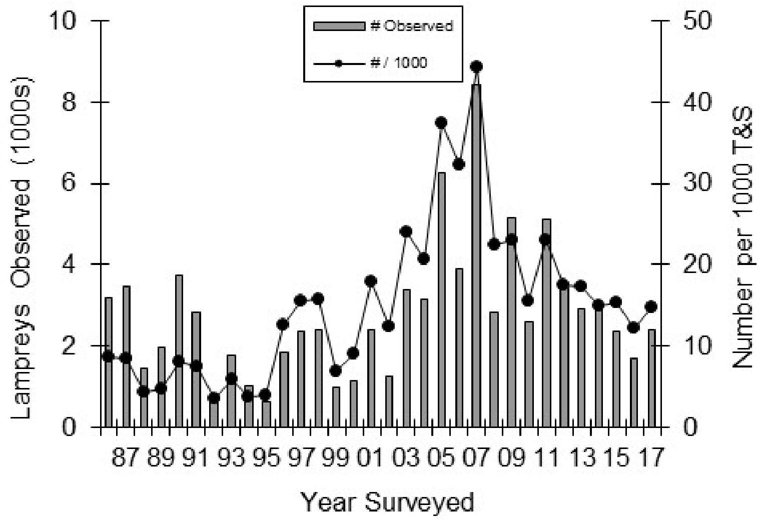

Figure 16. Total lamprey observed, and lampreys observed per 1,000 trout and salmon caught, April 15-September 30, 1985-2017.

netting, fewer lampreys observed attached to lake trout in the creel survey, and an increased lake trout population (Lantry and Lantry 2018).

Acknowledgments

We would like to acknowledge the help and cooperation of staff from the U.S. Geological Survey's Oswego Station and the NY State Department of Transportation at Spencerport and Braddock Bay, who provided field headquarters from which the creel agents operated. NYSDEC fisheries staff in Regions 6-9 provided additional logistical support. Special thanks to the 2017 creel agents, Jeffrey Meyer, Benjamin Little, Adam Soules-Petote, Edward Scheppard, Cameron Heasley, and Edward Hogan; and to Vicki Southwell who assisted with data entry.

References

Bishop, D.L., S.E. Prindle, and J.H. Johnson. 2017. 2016 Salmon River wild young-of-year Chinook salmon seining program. Section 8 *in* NYSDEC 2016 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Bishop, D.L., S.E. Prindle, and J.H. Johnson. 2011. 2010 Salmon River wild young-of-year Chinook salmon seining program. Section 8 *in* NYSDEC 2010 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Cochran, W.G. 1977. Sampling Techniques, 3rd edition. John Wiley and Sons, New York.

Connerton, M.J. 2010. New York Lake Ontario and upper St. Lawrence River stocking program 2009. Section 1 *in* NYSDEC 2009 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Connerton, M.J. 2018. New York Lake Ontario and upper St. Lawrence River stocking program 2017. Section 1 *in* NYSDEC 2017 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Connerton, M.J., C.J. Balk, S.E. Prindle, J.R. Lantry, J.N. Bowlby, M. Yuille, C.R. Bronte and M.E. Holey. 2017. Relative survivial and tributary returns of pen and direct-stocked Chinook salmon in Lake Ontario. Section 3 *In* NYSDEC 2016 Annual Report, Bureau of Fisheries Lake Ontario

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

Eckert, T.H. 1998. Lake Ontario fishing boat census 1997. Section 2 *in* NYSDEC 1997 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Eckert, T.H. 1999. Lake Ontario fishing boat census 1998. Section 2 *in* NYSDEC 1998 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Eckert, T.H. 2000. Lake Ontario stocking and marking program 1999. Section 1 *in* NYSDEC 1999 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Eckert, T.H. 2005. Lake Ontario fishing boat census 2004. Section 2 *in* NYSDEC 2004 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Eckert, T.H. 2007. Lake Ontario fishing boat census 2006. Section 2 in NYSDEC 2006 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Kuele, R.O. 1994. Statistical principles of research design and analysis. Duxbury Press, Wadsworth Inc. Belmont, CA. 686pp.

Lantry, J.R. 2001. Spatial and temporal dynamics of predation by Lake Ontario trout and salmon. M.S. Thesis. State University of New York College of Environmental Science and Forestry. 235pp.

Lantry, J.R. 2018. Eastern basin of Lake Ontario warmwater fisheries assessment, 1976-2017. Section 4 *in* NYSDEC 2017 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Lantry, J.R. and T.H. Eckert. 2010. 2009 Lake Ontario fishing boat survey. Section 2 *in* NYSDEC 2009 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Lantry, J.R. and T.H. Eckert. 2011. 2010 Lake Ontario fishing boat survey. Section 2 *in* NYSDEC 2010 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Lantry, J.R. and T.H. Eckert. 2013. 2012 Lake Ontario fishing boat survey. Section 2 *in* NYSDEC 2012 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Lantry, J.R. and T.H. Eckert. 2015. 2014 Lake Ontario fishing boat survey. Section 2 *in* NYSDEC 2014 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Lantry, B.F. and J.R. Lantry. 2018. Lake trout rehabilitation in Lake Ontario, 2017. Section 5 *in* NYSDEC 2017 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Ontario Ministry of Natural Resources and Forestry. 2016. Lake Ontario Fish Communities and Fisheries: 2015 Annual report of the Lake Ontario Management Unit. Ontario Ministry of Natural Resources, Picton, Ontario, Canada.

Ontario Ministry of Natural Resources and Forestry. 2017. Lake Ontario Fish Communities and Fisheries: 2016 Annual report of the Lake Ontario Management Unit. Ontario Ministry of Natural Resources, Picton, Ontario, Canada.

Sanderson, M.J. and J.R. Lantry. 2014. Assessment of Lake Ontario black bass fishery using cooperator angler diaries. Section 22 *in* NYSDEC 2013 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

SAS Institute Inc. 2011. Release 9.3. Cary, NC, USA.

Walsh, M.G., D.E. Dittman, and R. O'Gorman. 2007. Occurrence and food habits of the round goby in the profundal zone of southwestern Lake Ontario. Journal of Great Lakes Research 33:83-92.

Weidel, B.C., M.G. Walsh, and M.J. Connerton. 2013. Sculpin and round goby assessment, Lake Ontario 2012. Section 12 *in* NYSDEC 2012 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Weidel, B.C., M.J. Connerton, and J.P. Holden. 2018. Bottom trawl assessment of Lake Ontario preyfishes. Section 12 *in* NYSDEC 2017 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

2017 Lake Ontario Fishing Boat Survey

<u>Appendix Tables and Figures</u>

Table A1. The four geographic areas (Roman numerals) used in analysis of the 1985-2017 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 1985-2017 NYSDEC fishing boat surveys.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Part A: Effort for all fishing boats.											
Seasonal (5½ month) estimates of fishing effort for all fishing boats:											
Fishing Boat Trips	124,815	69,687	76,838	62,104	60,943	56,182	54,605	58,554	53,154	46,339	39,964
Boat Angler Trips	344,427	194,658	221,925	175,820	171,519	160,363	161,620	174,079	157,151	138,434	121,041
Boat Angler Hours	1,859,258	985,898	1,229,977	905,357	898,339	848,905	937,822	980,409	879,681	787,588	709,638
Anglers/Boat Trip	2.75	2.79	2.89	2.83	2.81	2.85	2.96	2.97	2.96	2.99	3.03
Hours/ Boat Trip	5.31	5.06	5.54	5.15	5.24	5.29	5.80	5.63	5.60	5.69	5.86
Monthly estimates of boat trips for all fishing boats:											
April	10,564	3,131	3,230	2,680	2,529	2,409	2,672	1,935	2,251	3,257	2,032
May	18,794	7,784	15,360	11,111	8,605	9,540	8,368	8,652	9,147	7,299	4,269
June	15,123	8,650	8,351	5,489	6,183	8,128	7,608	8,002	5,190	5,231	3,585
July	22,650	15,507	12,735	12,703	15,024	12,024	11,950	11,234	10,904	10,305	8,907
August	34,750	21,147	19,815	21,764	17,315	15,096	17,404	19,666	14,085	12,284	13,035
September	22,935	13,468	17,346	8,356	11,286	8,986	6,603	9,061	11,577	7,963	8,136
Seasonal estimates of boat trips among four geographic areas for all fishing boats:											
West	29,130	14,276	20,404	16,269	16,248	14,145	14,602	13,674	12,543	11,649	10,848
West/Central	18,268	7,722	10,746	7,011	6,890	7,412	7,648	7,210	7,407	4,561	4,051
East/Central	40,889	25,094	25,448	22,318	19,926	17,410	17,368	18,455	16,964	17,508	14,145
East	36,528	22,594	20,239	16,506	17,879	17,215	14,988	19,215	16,240	12,622	10,920
Part B: Seasonal estimates of total boat excursions (traffic).											
Power Boats:											
Fishing Boats	128,532	70,525	77,410	62,435	61,383	56,979	55,116	59,149	53,812	46,747	40,156
Nonfishing Boats	110,121	80,479	86,372	84,587	69,943	71,318	89,530	70,311	97,066	96,268	52,445
Sail Boats	28,251	19,750	22,224	23,914	23,782	20,703	21,432	19,104	13,905	12,789	10,013
Part C: Seasonal estimates of boat angler trips by residence.											
NY Resident	213,197	115,936	134,954	108,712	105,145	97,153	96,610	106,088	94,785	81,559	68,245
Nonresident	131,230	78,722	86,971	67,108	66,374	63,210	65,010	67,991	62,366	56,875	52,796
% NY Resident	61.6%	59.6%	60.8%	61.8%	61.3%	60.6%	59.8%	60.9%	60.3%	58.9%	56.4%
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	97,166	51,229	62,028	50,059	49,548	46,059	47,520	49,434	46,142	38,776	35,865
Boat Angler Trips	281,153	152,905	189,796	151,747	147,775	138,687	146,900	155,656	142,816	121,828	112,503
Boat Angler Hours	1,646,439	868,237	1,143,095	843,037	831,675	785,271	889,719	917,662	838,730	735,716	685,818
Anglers/Boat Trip	2.91	2.98	3.06	3.03	2.98	3.01	3.09	3.15	3.10	3.14	3.14
Hours/ Boat Trip	5.83	5.68	6.02	5.56	5.63	5.66	6.06	5.90	5.87	6.04	6.10
Monthly estimates of boat trips for boats seeking trout and salmon:											
April	10,430	2,874	3,610	2,610	2,518	2,366	2,575	1,920	2,251	3,198	1,993
May	17,898	7,262	14,731	9,401	8,050	8,388	7,911	8,417	8,656	6,770	3,783
June	9,514	4,760	5,201	3,878	4,313	5,138	6,333	5,489	4,322	3,785	2,959
July	13,562	9,261	8,743	9,233	10,903	9,255	9,651	8,827	8,140	8,403	7,797
August	26,929	16,485	15,192	18,080	14,123	12,910	15,910	16,917	12,340	9,997	12,338
September	18,832	10,586	14,552	6,858	9,642	8,002	5,141	7,864	10,433	6,622	6,995
Seasonal estimates of boat trips among four geographic areas for boats seeking trout and salmon:											
West	25,227	12,440	18,562	14,258	14,715	12,671	13,674	12,092	11,350	11,061	10,412
West/Central	13,384	4,293	7,725	5,574	5,047	5,584	6,634	6,251	6,447	3,914	3,729
East/Central	28,891	17,094	19,173	16,740	15,137	13,596	15,259	15,852	13,937	13,830	12,613
East	29,664	17,403	16,568	13,487	14,649	14,208	11,954	15,239	14,408	9,972	9,111
Percent of total seasonal fishing effort by boats seeking trout and salmon:											
Fishing Boat Trips	75.0%	73.5%	80.7%	80.6%	81.3%	82.0%	87.0%	84.4%	86.8%	83.7%	89.7%
Boat Angler Trips	79.2%	78.6%	85.5%	86.3%	86.2%	86.5%	90.9%	89.4%	90.9%	88.0%	92.9%
Boat Angler Hours	86.7%	88.1%	92.9%	93.1%	92.6%	92.5%	94.9%	93.6%	95.3%	93.4%	96.6%

Table A2 (continued). Summary of effort statistics.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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	22,013	12,786	8,666	5,855	6,257	6,203	4,273	6,878	4,868	5,295	2,294
Boat Angler Trips	50,432	28,548	18,885	12,106	13,758	13,505	9,082	14,223	9,900	11,944	4,868
Boat Angler Hours	169,420	83,434	48,847	32,603	42,718	41,972	31,569	51,006	28,115	37,167	13,917
Anglers/Boat Trip	2.29	2.23	2.18	2.07	2.20	2.18	2.13	2.07	2.03	2.26	2.12
Hours/ Boat Trip	3.36	2.92	2.59	2.69	3.10	3.11	3.48	3.59	2.84	3.11	2.86
Monthly estimates of boat trips for boats seeking smallmouth bass during the traditional open season:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	3,899	2,325	1,284	634	935	1,525	637	1,900	543	904	281
July	7,766	4,979	2,517	2,212	2,704	2,303	1,403	1,786	2,376	1,498	822
August	6,882	3,579	2,878	2,139	1,724	1,646	959	2,312	1,148	1,931	522
September	3,467	1,903	1,987	870	894	728	1,275	880	801	962	669
Seasonal estimates of boat trips among four geographic areas for boats seeking smallmouth bass during the traditional open season:											
West	2,488	1,001	1,370	1,051	815	984	352	1,101	793	263	104
West/Central	3,618	2,426	1,453	642	784	1,006	564	609	370	138	257
East/Central	10,254	5,451	3,638	2,768	2,809	2,289	1,174	1,801	2,233	2,800	928
East	5,654	3,908	2,204	1,394	1,849	1,924	2,183	3,367	1,473	2,094	1,005
Percent of total seasonal fishing effort by boats seeking smallmouth bass during the traditional open season:											
Fishing Boat Trips	20.1%	18.3%	11.3%	9.4%	10.3%	11.0%	7.8%	11.7%	9.2%	11.4%	5.7%
Boat Angler Trips	16.8%	14.7%	8.5%	6.9%	8.0%	8.4%	5.6%	8.2%	6.3%	8.6%	4.0%
Boat Angler Hours	10.7%	8.5%	4.0%	3.6%	4.8%	4.9%	3.4%	5.2%	3.2%	4.7%	2.0%
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	0	78	46	29	78	22	0	49	36
SMB pre-opener	231	367	644	292	239	521	191	295	164	356	198
Largemouth Bass	26	16	0	0	13	13	197	62	29	0	13
Yellow Perch	896	1,914	1,800	1,901	1,794	1,556	779	712	623	422	477
Walleye	484	373	270	470	384	233	249	137	348	368	176
All Other	3,868	3,003	3,863	3,449	2,662	1,568	1,319	1,015	980	1,073	905
% Northern Pike	0.09%			0.13%	0.08%	0.05%	0.14%	0.04%	0.00%	0.11%	0.09%
% SMB pre-opener	0.23%	0.53%	0.84%	0.47%	0.39%	0.93%	0.35%	0.50%	0.31%	0.77%	0.50%
% Largemouth Bass	0.02%	0.02%			0.02%	0.02%	0.36%	0.11%	0.05%	0.00%	0.03%
% Yellow Perch	0.74%	2.75%	2.34%	3.06%	2.94%	2.77%	1.43%	1.22%	1.17%	0.91%	1.19%
% Walleye	0.60%	0.54%	0.35%	0.76%	0.63%	0.41%	0.46%	0.23%	0.65%	0.79%	0.44%
% All Other	3.28%	4.31%	5.03%	5.55%	4.37%	2.79%	2.42%	1.73%	1.84%	2.32%	2.26%
Part G: Charter fishing boats.											
Seasonal (5½ month) estimates of fishing effort for charter boats:											
Fishing Boat Trips	13,094	9,012	9,885	8,612	8,332	7,632	9,343	9,718	9,831	8,653	7,102
Boat Angler Trips	66,040	47,015	50,142	44,773	43,124	38,880	48,694	51,351	51,311	45,496	36,558
Boat Angler Hours	483,177	322,072	347,188	288,231	275,652	256,420	338,688	345,925	334,663	314,553	242,992
Anglers/Boat Trip	5.01	5.22	5.07	5.20	5.18	5.09	5.21	5.28	5.22	5.26	5.15
Hours/ Boat Trip	7.26	6.85	6.92	6.44	6.39	6.60	6.96	6.74	6.52	6.91	6.65
Monthly estimates of boat trips for charter boats:											
April	790	210	331	428	300	599	426	281	353	607	285
May	2,266	1,227	1,712	1,425	1,119	733	1,607	1,401	1,941	954	915
June	1,466	930	974	657	873	648	965	1,028	707	981	615
July	2,080	1,455	1,917	2,112	2,174	1,826	2,252	2,141	1,724	2,431	1,846
August	4,272	3,588	2,949	3,259	2,513	2,622	3,060	3,620	3,407	1,946	2,154
September	2,220	1,602	2,002	731	1,353	1,203	1,032	1,247	1,700	1,735	1,287
Seasonal estimates of boat trips among four geographic areas for charter boats:											
West	3,463	2,371	2,624	2,837	2,658	2,060	2,572	2,234	2,401	2,426	2,139
West/Central	1,451	472	1,056	933	842	813	1,120	1,321	1,283	922	586
East/Central	4,704	3,854	4,235	3,512	3,263	2,879	3,935	4,254	3,732	3,411	2,912
East	3,476	2,315	1,971	1,329	1,570	1,880	1,715	1,910	2,415	1,894	1,464
Percent of total seasonal fishing effort by charter boats:											
Fishing Boat Trips	10.9%	12.9%	12.9%	13.9%	13.7%	13.6%	17.1%	16.6%	18.5%	18.7%	17.8%
Boat Angler Trips	19.9%	24.2%	22.6%	25.5%	25.1%	24.2%	30.1%	29.5%	32.7%	32.9%	30.2%
Boat Angler Hours	27.4%	32.7%	28.2%	31.8%	30.7%	30.2%	36.1%	35.3%	38.0%	39.9%	34.2%

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, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of fish harvested:											
Unidentified Fish	4	0	0	0	0	0	0	0	0	0	0
Bowfin	1	0	0	0	0	0	0	0	0	0	0
American Eel	6	0	0	0	0	0	0	0	0	0	0
Alewife	29	0	0	365	0	14	72	0	20	53	12
Gizzard Shad	3	0	0	0	0	0	0	0	0	0	0
Cisco	23	0	0	76	187	247	221	270	48	15	14
Lake Whitefish	0	0	0	11	13	0	0	0	0	0	0
Pink Salmon	4	0	0	0	0	0	0	0	0	0	0
Unidentified Salmonine	12	0	0	0	0	0	0	0	0	0	0
Northern Pike	80	40	0	0	14	132	0	35	0	84	0
Chain Pickerel	0	0	0	0	0	0	67	0	0	0	0
Common carp	4	0	0	0	0	45	0	0	0	0	0
Unidentified Redhorse	1	0	0	0	0	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	100	0	0	0	0	0	0	53	0	30	20
Channel Catfish	60	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	1,591	0	0	20	0	0	0	115	0	0	0
White Bass	280	0	0	0	0	0	0	22	0	0	0
Rock Bass	2,834	1,115	526	131	135	688	134	478	12	25	70
Pumpkinseed	461	95	29	20	0	0	0	0	0	0	0
Bluegill	114	79	87	140	329	0	0	368	13	0	12
Largemouth Bass	99	149	88	32	0	132	22	26	0	0	61
Black Crappie	84	0	0	0	0	26	0	151	0	0	0
Freshwater Drum	444	0	0	0	0	0	0	151	0	0	0
Round Goby	2,854	39,611	36,003	13,138	12,770	9,182	7,546	4,222	4,683	5,015	3,986
Seasonal (5½ month) estimates of fish caught:											
Unidentified Fish	34	250	213	0	19	24	23	0	41	0	0
Lake Sturgeon	2	0	0	0	0	27	0	0	0	0	0
Longnose Gar	2	0	72	0	0	0	0	0	0	0	0
Bowfin	20	0	0	0	0	0	0	0	24	0	0
American Eel	77	0	0	0	0	0	0	0	0	0	0
Alewife	378	45	43	736	220	27	403	163	127	223	36
Gizzard Shad	10	0	0	0	0	14	0	0	13	0	0
Cisco	32	0	0	181	229	375	221	297	120	84	70
Lake Whitefish	0	0	0	11	13	0	0	0	0	0	0
Pink salmon	4	0	0	0	0	0	0	0	0	0	0
Unidentified Salmonine	279	281	14	106	113	0	0	0	60	26	0
Rainbow Smelt	9	0	0	0	0	0	0	0	0	0	0
Northern Pike	407	235	1,370	900	62	204	130	255	36	84	44
Muskellunge	2	0	0	0	0	0	0	0	0	0	0
Chain Pickerel	0	690	422	32	0	0	290	0	0	0	216
Common Carp	89	114	38	62	26	72	70	0	0	0	0
White Sucker	26	14	0	36	13	0	0	26	0	0	0
Unidentified Redhorse	13	0	0	0	0	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	135	0	0	0	0	0	25	53	0	30	20
Channel Catfish	141	198	0	15	0	19	0	0	0	0	0
Threespine Stickleback	3	0	0	0	0	0	0	0	0	0	0
White perch	4,197	606	0	83	101	0	12	115	0	40	180
White Bass	1,255	14	257	20	25	2,533	0	49	0	0	0
Rock Bass	14,343	4,495	2,546	991	818	1,840	1,088	5,371	596	555	199
Pumpkinseed	1,593	2,774	577	222	28	36	322	436	0	267	0
Bluegill	332	284	146	349	1,257	77	225	869	25	0	12
Largemouth Bass	575	1,313	594	190	227	516	456	106	425	160	247
Black Crappie	130	0	0	0	0	26	0	0	0	0	0
Freshwater Drum	7,445	360	266	701	240	525	256	388	163	393	12
Round Goby	5,909	63,407	58,310	21,033	25,290	13,484	12,659	6,704	6,297	12,982	5,817

Table A4. Residency for boat anglers interviewed April 15 – September 30, 1985-2017. Shown are percent contributions of the most common states or provinces, and for the most common counties among New York resident anglers.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
State or Province of Residence											
Connecticut	2.1	1.6	1.7	1.6	1.3	1.5	1.3	0.8	1.2	0.9	1.5
Florida	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.3
Maine	0.8	0.9	0.9	0.8	0.7	0.7	1.0	0.5	0.7	1.3	1.3
Maryland	0.3	0.2	0.1	0.2	0.2	0.3	0.8	0.4	0.5	0.8	0.3
Massachusetts	3.9	3.3	3.3	3.0	2.7	2.6	2.6	2.8	2.5	3.3	2.4
Michigan	0.4	0.3	0.3	0.4	0.6	0.2	0.6	0.5	0.3	0.4	0.6
New Hampshire	1.2	1.2	1.2	1.1	0.8	0.9	1.0	1.3	0.9	1.4	1.0
New Jersey	4.3	3.3	3.8	3.0	3.0	2.6	2.2	2.9	3.5	2.7	2.6
New York	61.6	59.6	60.8	61.8	61.3	60.6	59.8	60.9	60.3	58.9	56.4
Ohio	4.2	4.5	3.5	2.6	4.0	3.9	4.7	3.6	4.6	4.3	5.2
Pennsylvania	16.8	19.8	18.9	20.4	20.4	21.9	20.8	21.0	20.6	21.2	22.7
Province of Ontario	0.2	0.1	0.4	0.3	0.3	0.1	0.2	0.2	0.1	0.3	0.3
Province of Quebec	0.2	0.2	0.1	0.1	0.1	0.0	0.1	0.3	0.2	0.3	0.4
Vermont	2.2	2.0	2.8	2.3	2.1	2.5	2.2	2.3	2.1	1.5	2.6
Virginia	0.2	0.3	0.2	0.2	0.2	0.1	0.3	0.1	0.3	0.4	0.3
West Virginia	0.4	0.7	0.4	0.3	0.4	0.5	0.4	0.3	0.4	0.3	0.4
Total of all Listed States & Provinces:	99.0	98.5	98.7	98.4	98.4	98.9	98.5	98.4	98.7	98.5	98.4
County of Residence Among NY Anglers											
County Bordering Lake Ontario:											
Cayuga	2.4	4.2	3.0	3.3	2.6	2.2	2.2	2.6	3.1	4.4	3.2
Jefferson	2.5	2.4	2.2	1.6	1.5	3.2	3.6	3.3	2.5	2.7	2.2
Monroe	24.4	18.8	20.0	18.7	16.5	16.2	16.5	15.7	15.7	16.0	14.3
Niagara	8.7	6.6	7.3	7.8	10.9	9.4	9.7	8.6	9.1	6.5	8.5
Orleans	3.7	4.0	3.8	4.9	4.2	4.1	4.8	5.3	4.7	5.2	6.1
Oswego	10.6	12.8	13.0	13.1	13.6	12.5	12.8	12.8	13.1	12.8	14.1
Wayne	10.9	11.5	9.5	9.5	9.6	10.3	8.7	7.7	9.4	9.5	6.6
Border Co. Total	63.2	60.4	58.8	58.8	59.0	57.9	58.4	56.0	57.7	57.1	55.2
Other NY Counties:											
Albany	1.3	1.2	1.0	1.1	1.0	1.0	0.8	1.9	1.2	1.4	1.9
Broome	1.9	1.4	2.1	2.5	1.9	1.8	1.5	1.8	1.8	2.0	1.3
Dutchess	1.0	0.5	0.6	0.6	0.3	0.3	0.7	0.7	0.8	0.7	0.8
Erie	4.2	3.4	3.4	3.8	5.8	5.2	4.9	4.1	4.0	4.7	5.2
Genesee	1.5	1.2	1.9	2.1	1.6	2.5	1.8	2.3	0.9	1.5	1.4
Livingston	0.8	0.8	0.7	0.6	0.6	1.0	0.7	0.8	0.7	0.7	0.5
Oneida	2.0	1.9	1.8	1.8	2.1	1.4	2.0	2.0	2.2	2.1	1.8
Onondaga	5.8	6.9	5.4	6.0	6.4	6.4	5.7	5.9	5.9	6.0	7.3
Ontario	1.5	1.1	1.5	1.7	1.6	1.7	2.0	1.8	1.7	1.5	1.6
Orange	0.9	1.7	1.3	1.2	0.5	0.8	0.9	1.2	1.4	1.3	1.3
Saratoga	1.0	0.6	1.0	0.8	0.7	0.6	0.9	0.9	1.1	1.4	1.3
Total of all Listed Counties:	85.0	81.1	79.5	80.9	81.5	80.7	80.3	79.4	79.4	80.6	79.6

Table A5a. Trout and salmon catch and harvest data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	147,873	78,060	120,477	89,092	110,196	107,456	100,047	106,880	77,887	79,334	93,524
Catch	232,107	125,686	223,316	167,405	221,977	196,625	168,837	200,763	154,411	138,231	162,341
% Harvested	63.0	62.1	53.9	53.2	49.6	54.7	59.3	53.2	50.4	57.4	57.6
Monthly estimates of harvest for all fishing boats:											
April	16,317	2,432	6,635	5,939	5,050	10,045	4,580	6,329	4,151	7,502	5,203
May	31,650	12,493	29,432	11,638	16,139	16,015	22,142	20,118	20,314	12,618	8,274
June	16,188	6,896	5,050	8,025	10,387	10,135	11,467	11,777	6,361	7,968	5,697
July	23,544	12,851	24,171	21,904	36,207	22,706	21,311	22,955	13,148	24,090	22,618
August	41,168	28,919	32,685	34,636	29,189	34,770	33,670	33,092	23,111	16,992	38,957
September	19,006	14,471	22,504	6,950	13,225	13,785	6,878	12,609	10,800	10,165	12,774
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	49,236	32,750	49,310	37,266	33,864	32,631	34,524	31,103	24,548	28,763	32,234
West/Central	16,291	2,901	8,174	6,523	8,356	9,216	11,694	13,696	9,191	7,982	7,568
East/Central	44,821	20,158	40,795	29,674	39,819	31,076	34,445	37,861	25,431	26,296	36,444
East	37,525	22,250	22,197	15,629	28,157	34,535	19,382	24,217	18,715	16,295	17,278
Monthly estimates of catch for all fishing boats:											
April	25,488	3,709	11,261	8,804	12,236	19,347	7,328	19,368	10,395	16,341	7,373
May	50,311	24,727	76,635	20,573	35,558	37,204	36,786	46,026	57,178	25,076	16,652
June	28,960	12,552	11,836	18,745	22,222	24,230	20,076	28,848	13,203	15,382	9,176
July	42,212	23,301	35,487	46,270	82,252	42,491	41,130	33,587	23,984	41,384	42,959
August	60,844	41,721	55,836	62,916	50,484	55,996	53,802	56,224	34,527	26,494	67,495
September	24,293	19,676	32,261	10,096	19,225	17,357	9,715	16,710	15,123	13,553	18,687
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	82,601	57,467	103,965	72,072	93,566	73,727	67,993	66,682	70,100	57,104	62,329
West/Central	31,486	7,754	30,121	22,128	22,100	26,231	26,378	35,306	18,565	15,641	20,996
East/Central	64,793	31,072	62,190	51,736	67,426	49,058	49,025	60,635	39,116	43,077	57,252
East	53,227	29,398	27,040	21,471	38,885	47,609	25,440	38,141	26,630	22,408	21,766
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.5	99.8	99.9	99.8	99.9	100.0	100.0	99.9	100.0	100.0	100.0
% Catch	99.4	99.6	99.8	99.6	99.8	99.7	99.9	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	47.2	53.7	50.5	50.3	47.3	47.5	59.4	56.0	60.2	61.8	49.4
% Catch	39.0	42.6	35.5	39.9	34.8	33.3	46.0	39.2	40.1	47.6	37.4

Table A5b. Trout and salmon catch and harvest rate data collected April 15 – September 30, 1985-2017. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.504	1.520	1.940	1.776	2.222	2.332	2.104	2.159	1.688	2.046	2.607
Catch/Boat Trip	2.395	2.444	3.593	3.329	4.473	4.258	3.549	4.056	3.345	3.563	4.526
Harv/Angler Trip	0.518	0.509	0.634	0.586	0.745	0.774	0.681	0.686	0.545	0.651	0.831
Catch/Angler Trip	0.825	0.819	1.174	1.098	1.500	1.414	1.148	1.288	1.081	1.134	1.443
Harv/Angler Hour	0.089	0.090	0.105	0.105	0.132	0.137	0.112	0.116	0.093	0.108	0.136
Catch/Angler Hr.	0.142	0.144	0.195	0.198	0.266	0.250	0.190	0.219	0.184	0.188	0.237
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.793	0.847	1.838	2.275	2.006	4.246	1.779	3.296	1.844	2.346	2.611
May	1.728	1.720	1.998	1.238	2.005	1.909	2.799	2.390	2.347	1.864	2.187
June	1.589	1.418	0.949	2.052	2.396	1.973	1.811	2.131	1.472	2.105	1.921
July	1.669	1.386	2.765	2.363	3.321	2.448	2.203	2.595	1.614	2.867	2.901
August	1.546	1.752	2.150	1.971	2.065	2.693	2.116	1.956	1.873	1.700	3.157
September	0.987	1.367	1.546	1.006	1.372	1.723	1.338	1.603	1.035	1.535	1.826
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.997	2.630	2.657	2.614	2.300	2.575	2.523	2.572	2.163	2.600	3.096
West/Central	1.213	0.676	1.059	1.170	1.656	1.650	1.763	2.191	1.426	2.039	2.029
East/Central	1.557	1.171	2.128	1.765	2.631	2.282	2.256	2.385	1.825	1.901	2.888
East	1.203	1.277	1.331	1.154	1.919	2.431	1.621	1.584	1.298	1.634	1.896
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	3.025	1.291	3.119	3.373	4.859	8.177	2.837	10.088	4.618	5.110	3.699
May	2.833	3.397	5.201	2.188	4.400	4.435	4.650	5.458	6.606	3.702	4.402
June	2.848	2.568	2.227	4.809	5.117	4.644	3.166	5.241	3.044	4.064	3.097
July	2.959	2.511	4.059	4.948	7.544	4.581	4.252	3.799	2.945	4.925	5.510
August	2.316	2.528	3.668	3.480	3.569	4.335	3.382	3.322	2.798	2.645	5.470
September	1.293	1.859	2.210	1.464	1.994	2.169	1.885	2.123	1.450	2.047	2.671
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	3.436	4.617	5.601	5.055	6.344	5.818	4.967	5.506	6.176	5.163	5.986
West/Central	2.575	1.800	3.898	3.969	4.379	4.697	3.976	5.644	2.880	3.996	5.630
East/Central	2.269	1.801	3.227	3.051	4.448	3.587	3.208	3.822	2.803	3.111	4.538
East	1.686	1.682	1.624	1.586	2.650	3.337	2.126	2.498	1.847	2.246	2.389
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	4.955	4.800	6.170	5.245	6.319	6.690	6.417	6.162	4.792	5.742	6.566
Catch/Boat Trip	6.458	6.136	8.044	7.826	9.359	8.583	8.385	8.115	6.321	7.719	8.626
Harv/Angler Trip	0.991	0.921	1.216	1.006	1.211	1.313	1.233	1.167	0.919	1.093	1.273
Catch/Angler Trip	1.289	1.177	1.585	1.500	1.794	1.685	1.611	1.536	1.212	1.469	1.672
Harv/Angler Hour	0.137	0.134	0.175	0.156	0.190	0.198	0.178	0.173	0.141	0.158	0.191
Catch/Angler Hr.	0.178	0.172	0.229	0.233	0.282	0.254	0.232	0.228	0.186	0.212	0.251
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.925	0.846	1.140	1.062	1.404	1.466	1.060	1.182	0.852	1.003	1.641
Catch/Boat Trip	1.706	1.686	2.750	2.404	3.497	3.399	2.378	3.064	2.544	2.391	3.525
Harv/Angler Trip	0.363	0.335	0.426	0.411	0.554	0.565	0.411	0.450	0.338	0.394	0.621
Catch/Angler Trip	0.670	0.667	1.027	0.931	1.379	1.309	0.922	1.166	1.008	0.939	1.334
Harv/Angler Hour	0.068	0.065	0.075	0.079	0.104	0.107	0.073	0.082	0.061	0.071	0.107
Catch/Angler Hr.	0.126	0.129	0.180	0.179	0.259	0.247	0.164	0.213	0.183	0.170	0.229

Table A6. Parameters used to assess angling quality among boats interviewed April 15 – September 30, 1985-2017. 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 33-year data series; therefore, data on bag limits are presented only for 2007-2017.

	Year Surveyed										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Part A: Boats seeking any or all species of trout and salmon.											
Percent boats with zero harvest of:											
Any Trout or Salmon	49.1%	55.6%	51.1%	51.6%	45.3%	44.9%	50.5%	46.5%	52.4%	49.1%	41.8%
Any Fish Species	48.9%	55.3%	50.8%	51.5%	45.2%	44.8%	50.3%	46.4%	52.3%	48.9%	41.7%
Percent boats with zero catch of:											
Any Trout or Salmon	31.5%	41.1%	32.4%	35.1%	26.7%	24.3%	31.4%	29.4%	34.3%	31.4%	23.6%
Any Fish Species	30.8%	39.6%	31.9%	34.5%	26.1%	23.8%	30.5%	29.0%	33.7%	30.9%	23.4%
Percent boats harvesting the daily bag limit - 2 lake trout per angler in 2007-present:											
Charters-Party Only	1.1%	2.1%	3.1%	1.2%	2.6%	5.3%	11.8%	8.5%	11.1%	13.5%	5.9%
Charters-All Anglers	0.0%	0.7%	1.9%	0.6%	0.0%	2.0%	1.9%	0.8%	3.6%	2.6%	1.1%
Noncharter Boats	0.1%	0.1%	0.0%	0.0%	0.5%	0.0%	0.4%	0.0%	0.2%	0.3%	0.4%
Percent boats harvesting the daily bag limit of 3 coho salmon, Chinook salmon, rainbow trout, or brown trout, in aggregate, per angler:											
Charters-Party Only	21.8%	12.1%	24.2%	19.5%	21.4%	22.1%	14.3%	11.5%	5.8%	9.5%	21.2%
Charters-All Anglers	3.6%	1.9%	3.1%	4.3%	2.8%	4.6%	3.0%	0.9%	0.4%	1.3%	1.2%
Noncharter Boats	2.7%	0.9%	1.4%	1.9%	3.0%	3.7%	1.3%	1.5%	0.8%	1.3%	3.7%
Part B: Boats seeking smallmouth bass during the traditional open season.											
Percent boats with zero harvest of:											
Smallmouth Bass	77.2%	82.1%	84.7%	79.0%	82.7%	79.7%	76.5%	71.1%	86.3%	78.4%	78.2%
Any Fish Species	59.6%	65.6%	71.2%	65.0%	72.3%	63.9%	67.4%	63.5%	70.6%	68.2%	63.6%
Percent boats with zero catch of:											
Smallmouth Bass	43.1%	50.3%	53.6%	56.2%	58.8%	53.6%	45.8%	40.0%	50.2%	43.7%	43.7%
Any Fish Species	22.4%	27.7%	36.5%	37.6%	35.1%	34.6%	31.4%	27.6%	37.6%	28.4%	34.9%
Percent boats harvesting the daily bag limit of 5 smallmouth bass per angler:											
All Boats Combined	2.8%	1.0%	0.3%	1.2%	2.6%	0.6%	2.5%	5.8%	1.5%	0.0%	0.0%

Table A7a. Coho salmon harvest and catch data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	10,009	4,912	12,931	9,223	7,380	8,259	4,871	5,653	2,078	2,173	8,291
Catch	13,408	6,666	21,376	12,908	11,915	12,494	7,704	8,442	4,260	3,219	10,630
% Harvested	74.9	73.7	60.5	71.5	61.9	66.1	63.2	67.0	48.8	67.5	78.0
Monthly estimates of harvest for all fishing boats:											
April	2,625	618	1,446	1,178	968	392	266	349	12	108	1,024
May	2,287	1,176	3,087	1,353	946	1,787	1,646	2,101	94	272	831
June	609	33	441	918	653	163	454	369	37	87	441
July	389	143	476	1,864	2,362	503	235	238	121	348	420
August	2,336	513	1,816	2,860	853	3,437	1,170	691	417	800	2,486
September	1,763	2,429	5,666	1,049	1,599	1,978	1,100	1,906	1,397	557	3,092
								5,653			
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	4,383	1,310	5,692	5,269	3,635	3,001	2,365	2,541	458	834	3709
West/Central	1,646	111	566	772	765	411	201	310	-	51	216
East/Central	2,416	1,251	2,727	1,537	1,546	1,968	1,594	1,566	959	891	2331
East	1,564	2,240	3,945	1,645	1,434	2,880	711	1,235	661	398	2035
Monthly estimates of catch for all fishing boats:											
April	3,628	976	2,183	1,543	2,324	686	332	1,209	440	108	1,534
May	3,429	2,107	9,559	2,164	1,926	4,047	3,145	3,537	1,412	851	1,463
June	984	255	685	1,542	1,277	734	986	547	61	160	619
July	596	242	686	2,734	3,357	830	627	286	261	526	793
August	2,755	513	2,096	3,652	1,190	3,888	1,434	897	584	1,016	2,842
September	2,016	2,573	6,167	1,272	1,840	2,308	1,179	1,965	1,502	557	3,380
								8442.000			
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	6,294	2,517	12,152	7,285	6,476	5,875	4,642	4,450	2,119	1,518	5,538
West/Central	2,525	304	1,354	1,636	1,837	1,072	592	801	238	236	284
East/Central	2,881	1,506	3,388	2,050	1,922	2,350	1,728	1,955	1,194	1,016	2,596
East	1,708	2,340	4,482	1,937	1,679	3,197	742	1,237	709	450	2,212
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.3	100.0	100.0	100.0	99.5	100.0	100.0	100.0	100.0	100.0	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	41.5	51.4	39.8	56.9	42.1	40.6	45.6	39.2	55.0	44.2	37.8
% Catch	34.5	40.6	26.2	44.2	28.2	28.5	31.5	30.9	35.0	29.8	34.9

Table A7b. Coho salmon harvest and catch rate data collected April 15 – September 30, 1985-2017. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.107	0.096	0.208	0.184	0.149	0.179	0.103	0.114	0.045	0.056	0.231
Catch/Boat Trip	0.146	0.130	0.345	0.258	0.239	0.271	0.162	0.171	0.092	0.083	0.296
Harv/Angler Trip	0.037	0.032	0.068	0.061	0.050	0.060	0.033	0.036	0.015	0.018	0.074
Catch/Angler Trip	0.050	0.044	0.113	0.085	0.080	0.090	0.052	0.054	0.030	0.026	0.094
Harv/Angler Hour	0.006	0.006	0.011	0.011	0.009	0.011	0.005	0.006	0.002	0.003	0.012
Catch/Angler Hr.	0.009	0.008	0.019	0.015	0.014	0.016	0.009	0.009	0.005	0.004	0.015
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.292	0.215	0.401	0.451	0.384	0.166	0.103	0.182	0.005	0.034	0.514
May	0.148	0.162	0.210	0.144	0.118	0.213	0.208	0.250	0.011	0.040	0.220
June	0.070	0.007	0.085	0.237	0.151	0.032	0.072	0.067	0.009	0.023	0.149
July	0.030	0.015	0.054	0.202	0.217	0.054	0.024	0.027	0.015	0.041	0.054
August	0.091	0.031	0.120	0.158	0.060	0.266	0.074	0.041	0.034	0.080	0.201
September	0.089	0.229	0.389	0.153	0.166	0.247	0.214	0.242	0.134	0.084	0.442
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.181	0.105	0.307	0.370	0.247	0.237	0.173	0.210	0.040	0.075	0.356
West/Central	0.105	0.026	0.073	0.139	0.152	0.074	0.030	0.050	0.000	0.013	0.058
East/Central	0.091	0.073	0.142	0.092	0.102	0.145	0.104	0.099	0.069	0.064	0.185
East	0.059	0.129	0.238	0.122	0.098	0.203	0.059	0.081	0.046	0.040	0.223
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.396	0.340	0.605	0.591	0.923	0.290	0.129	0.630	0.195	0.034	0.770
May	0.228	0.290	0.649	0.230	0.232	0.482	0.398	0.420	0.163	0.126	0.387
June	0.122	0.054	0.132	0.398	0.296	0.143	0.156	0.100	0.014	0.042	0.209
July	0.045	0.026	0.078	0.296	0.308	0.090	0.065	0.032	0.032	0.063	0.102
August	0.107	0.031	0.138	0.202	0.084	0.301	0.090	0.053	0.047	0.102	0.230
September	0.104	0.243	0.424	0.185	0.191	0.288	0.229	0.250	0.144	0.084	0.483
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.271	0.202	0.655	0.511	0.436	0.464	0.339	0.368	0.187	0.137	0.532
West/Central	0.168	0.071	0.175	0.294	0.364	0.192	0.089	0.128	0.037	0.060	0.076
East/Central	0.110	0.088	0.177	0.122	0.127	0.173	0.113	0.123	0.086	0.073	0.206
East	0.064	0.134	0.271	0.144	0.115	0.225	0.062	0.081	0.049	0.045	0.243
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.311	0.289	0.522	0.614	0.377	0.440	0.240	0.228	0.117	0.113	0.446
Catch/Boat Trip	0.353	0.310	0.569	0.668	0.407	0.467	0.261	0.269	0.152	0.113	0.526
Harv/Angler Trip	0.062	0.056	0.103	0.118	0.072	0.086	0.046	0.043	0.022	0.021	0.086
Catch/Angler Trip	0.071	0.059	0.112	0.128	0.078	0.092	0.050	0.051	0.029	0.021	0.102
Harv/Angler Hour	0.009	0.008	0.015	0.018	0.011	0.013	0.007	0.006	0.003	0.003	0.013
Catch/Angler Hr.	0.010	0.009	0.016	0.020	0.012	0.014	0.007	0.008	0.004	0.003	0.015
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.071	0.056	0.149	0.096	0.103	0.128	0.069	0.086	0.026	0.040	0.179
Catch/Boat Trip	0.109	0.093	0.302	0.174	0.206	0.232	0.138	0.147	0.076	0.075	0.240
Harv/Angler Trip	0.028	0.022	0.056	0.037	0.041	0.049	0.027	0.033	0.010	0.016	0.068
Catch/Angler Trip	0.043	0.037	0.113	0.067	0.081	0.089	0.054	0.056	0.030	0.029	0.091
Harv/Angler Hour	0.005	0.004	0.010	0.007	0.008	0.009	0.005	0.006	0.002	0.003	0.012
Catch/Angler Hr.	0.008	0.007	0.020	0.013	0.015	0.017	0.010	0.010	0.005	0.005	0.016

Table A8. Total length (inches), weight (lbs), and age statistics for coho salmon sampled April 15 - September 30 during the 1985-2017 NYSDEC Lake Ontario fishing boat surveys.

	Year Sampled										
	1985-07 avg.	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mean length and weight data for coho salmon sampled April 15 - September 30:											
Mean Length (in)	24.0	25.5	23.9	25.1	24.0	26.1	25.0	23.8	23.7	25.6	25.5
Mean Weight (lbs)	-	8.1	6.3	7.2	6.3	8.3	6.7	6.4	6.6	7.7	7.6
Estimated weight (lbs) for standard length coho salmon sampled April 15 - September 30:											
Standard Length											
18.0 inches	-	1.97	1.90	1.84	1.87	2.01	1.97	1.84	1.99	1.78	1.66
20.0 inches	-	2.92	2.82	2.75	2.79	2.92	2.84	2.76	3.06	2.67	2.55
22.0 inches	-	4.16	4.04	3.96	4.01	4.11	3.95	4.00	4.52	3.87	3.76
24.0 inches	-	5.75	5.61	5.52	5.57	5.60	5.35	5.60	6.45	5.42	5.35
26.0 inches	-	7.75	7.59	7.50	7.54	7.45	7.07	7.64	8.94	7.39	7.41
28.0 inches	-	10.15	9.98	9.90	9.92	9.66	9.10	10.13	12.02	9.79	9.95
30.0 inches	-	13.18	13.00	12.96	12.95	12.41	11.61	13.30	16.01	12.86	13.24
Percent length composition of coho salmon sampled April 15 - September 30:											
<15.0 in	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.6%	0.0%	0.0%
15.0-15.9 in	0.7%	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%	0.9%	0.7%	0.0%	0.0%	0.0%	0.0%	3.8%	0.0%	0.0%	0.0%
17.0-17.9 in	2.1%	1.8%	4.3%	0.0%	1.4%	0.0%	0.0%	7.7%	0.0%	1.9%	0.0%
18.0-18.9 in	3.4%	6.4%	6.1%	0.5%	7.7%	0.8%	2.4%	10.3%	2.6%	1.9%	0.4%
19.0-19.9 in	6.2%	10.1%	7.6%	3.3%	6.3%	3.1%	4.9%	5.1%	2.6%	3.8%	5.2%
20.0-20.9 in	10.0%	2.8%	7.2%	1.9%	10.6%	7.7%	4.9%	5.1%	2.6%	7.5%	6.9%
21.0-21.9 in	12.2%	0.9%	10.1%	12.2%	9.6%	7.7%	8.5%	3.8%	5.3%	3.8%	7.8%
22.0-22.9 in	10.2%	1.8%	10.4%	7.5%	5.3%	7.7%	13.4%	2.6%	21.1%	5.7%	6.9%
23.0-23.9 in	8.3%	3.7%	2.2%	9.9%	6.7%	4.6%	8.5%	3.8%	7.9%	3.8%	6.9%
24.0-24.9 in	6.4%	3.7%	4.0%	15.0%	9.6%	3.8%	9.8%	7.7%	23.7%	3.8%	5.6%
25.0-25.9 in	5.7%	5.5%	6.8%	11.7%	11.1%	5.4%	8.5%	5.1%	18.4%	9.4%	6.9%
26.0-26.9 in	6.1%	15.6%	11.2%	9.9%	5.8%	6.2%	6.1%	16.7%	5.3%	9.4%	12.1%
27.0-27.9 in	7.6%	15.6%	15.5%	8.5%	8.7%	14.6%	11.0%	15.4%	5.3%	22.6%	9.9%
28.0-28.9 in	7.6%	17.4%	9.4%	5.6%	9.1%	16.9%	4.9%	7.7%	0.0%	11.3%	14.2%
29.0-29.9 in	5.7%	8.3%	3.6%	7.5%	4.8%	9.2%	11.0%	2.6%	2.6%	9.4%	12.1%
30.0-30.9 in	3.9%	2.8%	0.7%	3.8%	2.4%	8.5%	1.2%	1.3%	0.0%	5.7%	3.4%
31.0-31.9 in	1.7%	0.0%	0.0%	1.4%	0.5%	3.1%	2.4%	0.0%	0.0%	0.0%	1.7%
32.0-32.9 in	0.8%	1.8%	0.0%	1.4%	0.0%	0.0%	2.4%	0.0%	0.0%	0.0%	0.0%
>32.9 in	0.3%	0.9%	0.4%	0.0%	0.5%	0.8%	0.0%	1.3%	0.0%	0.0%	0.0%
Percent age composition of coho salmon sampled April 15 - September 30:											
Age-1	4.4%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%
Age-2	94.6%	93.3%	99.6%	99.9%	99.3%	98.0%	100.0%	97.2%	100.0%	100.0%	98.1%
Age-3	1.0%	6.7%	0.0%	0.1%	0.7%	2.0%	0.0%	2.8%	0.0%	0.0%	0.8%
Length data (inches) for age-2 coho salmon sampled April 15 - September 30:											
April Mean	20.6	18.7	18.5	21.4	19.4	21.0	20.5	18.3	-	18.87	21.0
September Mean	28.1	27.4	27.2	29.3	28.2	28.2	28.1	26.3	24.1	27.6	27.9
Avg Monthly Gain	1.6	1.89	1.97	1.72	1.93	1.59	1.68	1.90	-	1.94	1.56

Table A9a. Chinook salmon harvest and catch data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	53,183	35,520	54,964	31,676	46,333	55,137	38,292	47,935	34,951	34,405	53,871
Catch	74,411	55,776	101,427	61,960	97,899	88,851	62,570	76,626	58,870	60,435	96,226
% Harvested	71.3	63.7	54.2	51.1	47.3	62.1	61.2	62.6	59.4	56.9	56.0
Monthly estimates of harvest for all fishing boats:											
April	1,794	117	200	156	86	2,180	115	0	145	70	80
May	7,445	4,385	12,978	3,932	1,594	5,358	4,102	8,067	9,138	3,235	1,088
June	2,219	1,334	887	3,804	2,166	4,858	2,277	3,133	955	2,454	2,124
July	7,015	5,293	16,984	5,282	17,509	11,004	8,560	11,074	6,857	14,596	14,699
August	21,494	16,195	13,086	13,909	16,885	21,746	20,670	16,908	12,030	7,850	27,749
September	13,216	8,195	10,829	4,592	8,093	9,991	2,568	8,754	5,826	6,201	8,132
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	22,286	14,790	23,605	10,927	14,042	17,459	17,417	13,314	14,349	16,444	17,526
West/Central	5,637	880	2,957	1,750	2,047	3,277	2,223	2,458	3,593	872	2,867
East/Central	12,102	11,126	18,057	12,160	17,550	16,097	13,258	20,796	10,808	12,269	23,284
East	13,158	8,724	10,345	6,839	12,694	18,305	5,394	11,367	6,200	4,820	10,195
Monthly estimates of catch for all fishing boats:											
April	2,554	117	448	156	267	3,781	164	232	261	70	221
May	11,923	9,057	40,831	5,866	4,511	11,827	6,948	13,020	18,854	7,318	2,867
June	5,107	2,999	3,537	10,250	8,483	10,058	5,200	7,829	3,594	6,366	3,830
July	11,022	9,946	23,944	16,280	42,582	19,848	15,682	14,608	10,525	25,456	28,274
August	28,055	21,965	19,623	23,084	31,239	31,097	30,649	29,562	17,823	13,432	49,700
September	15,751	11,692	13,043	6,307	10,817	12,239	3,926	11,375	7,813	7,793	11,334
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	35,113	26,841	53,358	23,577	43,599	34,937	32,474	25,615	28,640	30,833	36,955
West/Central	9,466	2,810	9,887	9,774	7,038	9,223	6,622	10,001	6,896	2,676	8,630
East/Central	15,178	14,994	26,077	20,061	30,606	22,321	16,963	27,082	15,710	20,206	37,409
East	14,653	11,132	12,105	8,548	16,657	22,370	6,511	13,928	7,624	6,720	13,232
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.8	100.0	100.0	100.0	99.9	100.0	100.0	100.0	100.0	100.0	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	41.3	52.8	41.6	42.8	40.2	42.7	47.1	51.5	50.9	53.0	46.9
% Catch	35.8	43.0	27.8	35.8	32.3	32.3	38.3	38.9	39.4	45.5	35.5

Table A9b. Chinook salmon harvest and catch rate data collected April 15 – September 30, 1985-2017. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.551	0.693	0.886	0.633	0.935	1.197	0.806	0.970	0.757	0.887	1.502
Catch/Boat Trip	0.798	1.089	1.635	1.238	1.975	1.928	1.316	1.550	1.276	1.559	2.683
Harv/Angler Trip	0.190	0.232	0.290	0.209	0.314	0.398	0.261	0.308	0.245	0.282	0.479
Catch/Angler Trip	0.275	0.365	0.534	0.408	0.662	0.640	0.426	0.492	0.412	0.496	0.855
Harv/Angler Hour	0.033	0.041	0.048	0.038	0.056	0.070	0.043	0.052	0.042	0.047	0.079
Catch/Angler Hr.	0.048	0.064	0.089	0.073	0.118	0.113	0.070	0.083	0.070	0.082	0.140
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.116	0.041	0.055	0.060	0.034	0.921	0.045	0.000	0.064	0.022	0.040
May	0.398	0.604	0.881	0.418	0.198	0.639	0.519	0.958	1.056	0.478	0.288
June	0.207	0.280	0.171	0.981	0.502	0.946	0.360	0.571	0.221	0.648	0.718
July	0.531	0.572	1.943	0.572	1.606	1.189	0.886	1.255	0.842	1.737	1.885
August	0.813	0.982	0.860	0.769	1.196	1.684	1.299	0.999	0.975	0.785	2.249
September	0.658	0.774	0.744	0.670	0.839	1.249	0.500	1.113	0.558	0.936	1.163
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.857	1.189	1.272	0.766	0.954	1.378	1.274	1.101	1.264	1.487	1.683
West/Central	0.369	0.205	0.383	0.314	0.406	0.587	0.335	0.393	0.557	0.223	0.769
East/Central	0.438	0.651	0.941	0.726	1.159	1.184	0.868	1.312	0.775	0.887	1.846
East	0.467	0.501	0.624	0.507	0.867	1.288	0.451	0.746	0.430	0.483	1.119
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.181	0.041	0.124	0.060	0.106	1.598	0.064	0.121	0.116	0.022	0.111
May	0.659	1.247	2.772	0.624	0.560	1.410	0.878	1.547	2.178	1.081	0.758
June	0.495	0.630	0.680	2.643	1.967	1.958	0.821	1.426	0.832	1.682	1.282
July	0.888	1.074	2.739	1.763	3.906	2.145	1.624	1.655	1.293	3.029	3.626
August	1.095	1.332	1.291	1.278	2.208	2.407	1.926	1.746	1.444	1.344	4.028
September	0.809	1.104	0.896	0.920	1.122	1.529	0.764	1.446	0.749	1.177	1.620
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.435	2.158	2.875	1.654	2.959	2.757	2.375	2.118	2.523	2.788	3.549
West/Central	0.694	0.655	1.280	1.753	1.394	1.652	0.998	1.596	1.070	0.684	2.314
East/Central	0.570	0.877	1.359	1.198	2.022	1.640	1.111	1.708	1.127	1.461	2.966
East	0.532	0.640	0.731	0.634	1.137	1.575	0.545	0.914	0.529	0.674	1.452
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.614	2.148	2.319	1.588	2.260	3.087	1.946	2.542	1.820	2.138	3.587
Catch/Boat Trip	1.989	2.749	2.859	2.596	3.838	3.765	2.588	3.069	2.370	3.226	4.860
Harv/Angler Trip	0.322	0.412	0.457	0.304	0.433	0.606	0.374	0.481	0.349	0.407	0.695
Catch/Angler Trip	0.397	0.527	0.563	0.498	0.736	0.739	0.497	0.581	0.454	0.614	0.942
Harv/Angler Hour	0.045	0.060	0.066	0.047	0.068	0.092	0.054	0.071	0.054	0.059	0.104
Catch/Angler Hr.	0.055	0.077	0.081	0.077	0.116	0.112	0.072	0.086	0.070	0.089	0.141
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.371	0.395	0.615	0.436	0.670	0.822	0.529	0.586	0.472	0.534	0.993
Catch/Boat Trip	0.596	0.748	1.403	0.958	1.603	1.564	1.009	1.178	0.982	1.088	2.151
Harv/Angler Trip	0.146	0.156	0.230	0.169	0.264	0.316	0.205	0.223	0.187	0.210	0.376
Catch/Angler Trip	0.235	0.296	0.524	0.371	0.632	0.602	0.391	0.448	0.389	0.427	0.814
Harv/Angler Hour	0.028	0.030	0.040	0.033	0.050	0.060	0.036	0.041	0.034	0.038	0.065
Catch/Angler Hr.	0.045	0.057	0.092	0.072	0.119	0.114	0.070	0.082	0.071	0.077	0.140

Table A10. Total length (inches), weight (lbs), and age statistics for Chinook salmon sampled April 15 - September 30 during the 1985-2017 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-07 avg.	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mean length and weight data for chinook salmon sampled April 15 - September 30:											
Mean Length (in)	32.0	32.1	31.6	29.7	29.6	31.4	32.6	31.1	31.1	30.1	29.5
Mean Weight (lbs)	-	15.4	14.5	13.4	12.8	14.1	15.6	13.5	13.6	13.5	12.2
Estimated weight (lbs) for standard length chinook salmon sampled July & August:											
Standard Length:											
16.0 inches	-	1.47	1.31	1.47	1.36	1.34	1.47	1.38	1.33	1.40	1.39
20.0 inches	-	3.01	2.77	3.04	2.89	2.82	2.98	2.85	2.83	2.95	2.92
24.0 inches	-	5.47	5.15	5.55	5.39	5.23	5.34	5.18	5.26	5.46	5.39
28.0 inches	-	9.00	8.65	9.18	9.09	8.76	8.72	8.55	8.84	9.13	8.98
32.0 inches	-	13.92	13.62	14.27	14.35	13.77	13.38	13.25	13.93	14.31	14.06
36.0 inches	-	20.44	20.32	21.04	21.46	20.50	19.52	19.49	20.79	21.28	20.86
40.0 inches	-	28.74	28.97	29.69	30.64	29.17	27.27	27.44	29.64	30.23	29.58
Percent length composition of chinook salmon sampled April 15 - September 30:											
<16.0 in	1.2%	0.3%	0.3%	0.2%	0.9%	0.5%	0.5%	0.9%	1.2%	1.9%	0.6%
16.0-17.9 in	2.7%	1.2%	1.3%	2.4%	3.5%	0.8%	1.7%	1.9%	0.8%	2.5%	2.5%
18.0-19.9 in	3.3%	1.9%	3.1%	9.1%	7.8%	1.6%	2.8%	1.9%	1.6%	4.3%	5.6%
20.0-21.9 in	3.1%	1.9%	2.1%	8.9%	5.7%	3.5%	2.8%	3.0%	1.0%	5.0%	6.2%
22.0-23.9 in	3.4%	3.6%	3.0%	8.7%	3.9%	3.0%	2.8%	2.6%	2.5%	7.9%	4.5%
24.0-25.9 in	4.4%	6.3%	5.6%	5.5%	4.3%	5.3%	2.6%	4.4%	7.9%	6.8%	6.6%
26.0-27.9 in	6.2%	7.0%	6.4%	5.9%	5.8%	6.8%	4.9%	10.4%	8.3%	5.4%	8.1%
28.0-29.9 in	7.3%	6.4%	7.9%	5.7%	6.7%	12.8%	9.2%	10.3%	11.8%	9.3%	9.6%
30.0-31.9 in	8.4%	12.1%	12.6%	6.3%	13.7%	14.0%	9.9%	16.4%	15.9%	9.3%	16.0%
32.0-33.9 in	11.3%	12.6%	17.5%	10.2%	21.2%	17.7%	14.4%	15.0%	18.6%	12.4%	17.0%
34.0-35.9 in	14.6%	17.1%	19.9%	12.9%	16.2%	15.9%	15.5%	13.6%	16.9%	12.8%	13.8%
36.0-37.9 in	17.6%	17.1%	14.7%	12.6%	7.5%	9.6%	16.2%	11.6%	9.5%	14.7%	6.9%
38.0-39.9 in	11.6%	11.1%	4.7%	7.0%	1.9%	6.1%	12.3%	7.1%	3.3%	6.6%	2.2%
40.0-41.9 in	4.2%	1.3%	0.8%	4.3%	0.8%	2.2%	3.8%	1.1%	0.8%	1.2%	0.5%
42.0-43.9 in	0.5%	0.0%	0.1%	0.4%	0.0%	0.1%	0.5%	0.0%	0.0%	0.0%	0.0%
>43.9 in	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Percent age composition of chinook salmon sampled April 15 - September 30:											
Age-0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Age-1	11.1%	3.1%	4.8%	33.7%	22.2%	5.0%	10.7%	8.3%	3.7%	9.1%	18.4%
Age-2	35.7%	47.9%	29.5%	24.9%	68.9%	70.8%	37.0%	52.7%	46.5%	43.0%	47.9%
Age-3	49.5%	46.6%	64.8%	38.6%	8.6%	24.1%	52.0%	36.5%	49.1%	46.9%	33.0%
Age-4	3.7%	2.3%	0.9%	2.8%	0.2%	0.2%	0.3%	2.5%	0.7%	1.0%	0.7%
Age-3&4 combined	53.2%	49.0%	65.7%	41.4%	8.8%	24.2%	52.3%	39.0%	49.8%	47.9%	33.7%

Table A11. Mean length at age data (total length in inches) for Chinook salmon sampled July-September during the 1991-2017 NYSDEC Lake Ontario fishing boat surveys.

	Year	July		August		September	
Age	Sampled	Mean Length	(n)	Mean Length	(n)	Mean Length	(n)
Age-1	1991	18.74	(8)	19.23	(22)	22.52	(9)
	1992	18.93	(38)	20.49	(53)	22.04	(35)
	1993	18.44	(9)	18.14	(61)	19.37	(33)
	1994	16.40	(1)	17.79	(9)	18.59	(12)
	1995	18.62	(6)	20.53	(4)	-	(0)
	1996	18.58	(15)	19.66	(74)	21.85	(24)
	1997	19.06	(9)	19.18	(45)	20.43	(23)
	1998	20.12	(10)	19.63	(22)	21.13	(3)
	1999	20.58	(19)	20.08	(26)	23.69	(12)
	2000	20.53	(24)	20.56	(17)	23.20	(10)
	2001	18.75	(25)	19.33	(22)	21.65	(10)
	2002	17.86	(10)	19.94	(9)	21.75	(6)
	2003	18.83	(3)	17.48	(10)	21.20	(6)
	2004	18.00	(6)	18.00	(36)	19.84	(23)
	2005	18.12	(25)	18.98	(14)	19.93	(3)
	2006	19.61	(37)	20.97	(38)	23.57	(9)
	2007	18.82	(6)	20.82	(9)	21.84	(14)
	2008	18.51	(8)	19.62	(6)	21.10	(1)
	2009	19.34	(13)	19.05	(25)	22.40	(1)
	2010	20.53	(55)	21.56	(67)	23.42	(30)
	2011	19.31	(77)	20.88	(49)	22.11	(20)
	2012	19.61	(11)	21.48	(12)	24.30	(1)
	2013	19.46	(14)	20.94	(26)	24.98	(5)
	2014	17.85	(13)	19.55	(24)	20.48	(12)
	2015	18.33	(3)	17.34	(12)	17.97	(3)
	2016	18.54	(21)	19.00	(9)	22.13	(3)
	2017	19.93	(16)	20.18	(60)	22.70	(60)
	91-'17 avg	18.94		19.64		21.70	
Age-2	1991	27.40	(30)	28.96	(75)	31.58	(24)
	1992	28.69	(32)	30.00	(122)	32.42	(47)
	1993	29.57	(22)	30.98	(121)	31.61	(43)
	1994	27.27	(60)	28.77	(80)	28.85	(100)
	1995	28.14	(42)	28.74	(49)	31.94	(7)
	1996	31.90	(2)	29.50	(27)	30.52	(12)
	1997	29.95	(61)	30.45	(239)	32.14	(52)
	1998	30.93	(32)	31.68	(77)	33.87	(15)
	1999	29.68	(12)	31.17	(38)	32.95	(41)
	2000	30.28	(28)	32.17	(49)	33.82	(17)
	2001	30.14	(61)	31.86	(67)	32.34	(32)
	2002	30.35	(6)	31.52	(55)	32.54	(36)
	2003	28.64	(56)	29.98	(35)	31.93	(26)
	2004	28.26	(126)	29.48	(203)	30.71	(106)
	2005	28.18	(102)	29.60	(118)	31.65	(78)
	2006	29.15	(75)	29.96	(106)	30.93	(30)
	2007	29.87	(131)	30.29	(163)	32.09	(91)
	2008	27.62	(68)	30.36	(102)	32.13	(82)
	2009	27.33	(80)	29.04	(68)	31.12	(33)
	2010	29.64	(39)	32.39	(36)	33.73	(20)
	2011	30.80	(185)	32.92	(180)	34.09	(86)
	2012	30.33	(121)	32.34	(155)	34.02	(76)
	2013	30.49	(48)	31.12	(75)	33.09	(18)
	2014	29.36	(83)	29.97	(104)	32.00	(63)
	2015	27.63	(81)	29.39	(80)	31.10	(50)
	2016	25.73	(81)	29.33	(31)	29.87	(36)
	2017	28.91	(76)	29.99	(158)	31.31	(71)
	91-'17 avg	29.12		30.44		32.01	

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

	Year	July		August		September	
Age	Sampled	Mean Length	(n)	Mean Length	(n)	Mean Length	(n)
Age-3	1991	36.81	(44)	37.47	(105)	38.15	(148)
	1992	36.12	(40)	37.24	(124)	37.74	(129)
	1993	37.09	(20)	37.42	(211)	36.90	(110)
	1994	35.86	(91)	36.30	(204)	36.24	(107)
	1995	35.97	(74)	36.34	(134)	36.96	(113)
	1996	36.39	(9)	37.15	(98)	37.89	(76)
	1997	35.21	(7)	36.87	(58)	37.72	(18)
	1998	36.92	(41)	37.33	(194)	37.35	(31)
	1999	36.67	(15)	38.35	(111)	38.29	(85)
	2000	36.20	(23)	37.49	(108)	37.96	(37)
	2001	36.23	(42)	37.26	(51)	37.77	(20)
	2002	38.70	(1)	37.21	(51)	37.17	(42)
	2003	35.14	(28)	35.57	(64)	35.71	(112)
	2004	34.78	(52)	36.12	(160)	35.88	(69)
	2005	34.65	(111)	35.90	(278)	35.86	(172)
	2006	35.77	(107)	36.93	(231)	36.71	(121)
	2007	35.19	(127)	35.63	(168)	35.95	(127)
	2008	35.24	(44)	36.51	(132)	37.09	(83)
	2009	34.35	(147)	35.19	(148)	35.59	(141)
	2010	35.53	(23)	37.41	(79)	37.97	(27)
	2011	36.18	(28)	37.58	(17)	38.79	(12)
	2012	36.66	(35)	37.69	(71)	38.37	(21)
	2013	36.72	(64)	37.50	(124)	37.32	(27)
	2014	35.58	(48)	36.47	(58)	36.70	(80)
	2015	34.82	(60)	35.88	(67)	35.04	(47)
	2016	34.92	(57)	36.18	(50)	36.68	(73)
	2017	33.84	(44)	34.97	(109)	35.13	(80)
	91-'17 avg	35.83		36.74		37.00	
Age-4	1991	39.42	(6)	39.87	(21)	39.77	(10)
	1992	40.78	(4)	39.74	(9)	39.25	(12)
	1993	37.37	(3)	38.27	(22)	39.06	(7)
	1994	38.40	(5)	38.55	(15)	39.05	(4)
	1995	38.57	(9)	37.83	(15)	37.78	(5)
	1996	37.50	(2)	39.14	(29)	40.37	(23)
	1997	-	(0)	39.52	(18)	39.68	(4)
	1998	-	(0)	37.97	(6)	-	(0)
	1999	-	(0)	39.73	(6)	39.30	(5)
	2000	-	(0)	-	(0)	-	(0)
	2001	37.20	(2)	-	(0)	41.40	(1)
	2002	-	(0)	36.75	(2)	42.10	(1)
	2003	-	(0)	-	(0)	37.00	(1)
	2004	36.10	(1)	37.36	(5)	37.80	(1)
	2005	35.80	(2)	38.63	(4)	36.00	(2)
	2006	37.54	(7)	38.68	(21)	37.10	(2)
	2007	37.13	(3)	36.63	(11)	37.71	(8)
	2008	36.67	(3)	37.69	(9)	37.20	(2)
	2009	39.50	(1)	36.68	(4)	-	(0)
	2010	37.60	(2)	37.08	(4)	39.85	(2)
	2011	36.70	(1)	-	(0)	-	(0)
	2012	-	(0)	40.00	(1)	-	(0)
	2013	40.50	(1)	-	(0)	-	(0)
	2014	37.73	(3)	37.17	(3)	37.61	(7)
	2015	-	(0)	39.00	(1)	-	(0)
	2016	36.65	(2)	37.20	(1)	39.30	(1)
	2017	38.95	(2)	36.60	(1)	36.20	(1)
	91-'17 avg	37.90		38.19		38.68	

Table A12. Chinook salmon relative harvest (age-specific harvest per 50,000 boat trips) by year class and year sampled, from the 1985-2017 NYSDEC Lake Ontario fishing boat surveys.

Year Class	Fing Equiv Stocked	Chinook Salmon Harvested Per 50,000 Boat Trips Age-1	Age-2	Age-3	Age-4	Total
1981	862,840				531	
1982	1,175,354			7,510	392	
1983	2,544,180		5,837	9,043	1,267	
1984	2,957,230	5,022	8,347	15,102	1,185	29,665
1985	3,252,830	3,990	10,715	13,297	2,478	30,481
1986	2,810,771	4,026	8,038	21,317	1,112	34,494
1987	3,368,296	3,148	11,346	13,699	1,904	30,110
1988	3,104,104	3,017	7,040	13,759	784	24,630
1989	3,018,754	1,161	7,423	9,109	1,238	18,931
1990	2,964,722	1,779	6,428	11,901	1,217	21,325
1991	3,129,453	3,471	8,902	18,263	1,155	31,790
1992	3,004,329	3,334	12,489	11,690	2,645	30,212
1993	1,846,892	822	4,168	8,955	1,057	15,002
1994	1,221,491	357	1,976	4,135	364	6,832
1995	1,364,090	5,357	17,531	13,108	795	36,790
1996	1,495,138	3,334	6,754	14,007	0	24,096
1997	1,911,040	1,821	6,189	9,800	151	17,961
1998	1,903,929	3,616	7,016	7,159	209	18,000
1999	1,767,524	2,907	9,847	7,405	64	20,224
2000	1,906,543	2,716	8,562	19,445	326	31,048
2001	1,893,686	1,774	11,839	15,862	440	29,953
2002	1,908,002	1,751	25,606	38,454	1,758	67,570
2003	1,700,374	3,020	18,954	23,849	1,262	47,085
2004	1,962,565	2,103	11,925	22,083	812	36,923
2005	2,075,169	3,710	21,455	16,162	399	41,727
2006	1,898,083	1,483	16,602	28,719	873	47,677
2007	2,055,075	1,090	13,076	12,225	81	26,472
2008	1,038,844	2,113	7,877	4,041	99	14,129
2009	1,981,055	10,663	32,236	14,404	116	57,418
2010	1,911,756	10,398	42,386	20,939	1,207	74,929
2011	2,060,874	2,966	14,922	17,690	284	35,862
2012	1,816,778	4,314	25,569	18,581	453	48,917
2013	2,010,290	4,019	17,609	20,797	498	42,922
2014	2,229,494	1,400	19,079	24,797		
2015	1,939,992	4,036	35,994			
2016	2,149,062	13,816				

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

Year Sampled	Salmonid Boat Trips	Chinook Salmon Harvested Per 50,000 Boat Trips				
		Age-1	Age-2	Age-3	Age-4	Total
1985	126,155	5,022	5,837	7,510	531	18,900
1986	148,950	3,990	8,347	9,043	392	21,772
1987	165,678	4,026	10,715	15,102	1,267	31,122
1988	160,805	3,148	8,038	13,297	1,185	25,699
1989	177,223	3,017	11,346	21,317	2,478	38,159
1990	181,867	1,161	7,040	13,699	1,112	23,013
1991	152,357	1,779	7,423	13,759	1,904	24,865
1992	118,054	3,471	6,428	9,109	784	19,845
1993	103,125	3,334	8,902	11,901	1,238	25,375
1994	102,718	822	12,489	18,263	1,217	32,791
1995	92,346	357	4,168	11,690	1,155	17,371
1996	70,151	5,357	1,976	8,955	2,645	18,932
1997	64,351	3,334	17,531	4,135	1,057	26,058
1998	64,060	1,821	6,754	13,108	364	22,046
1999	60,573	3,616	6,189	14,007	795	24,608
2000	64,589	2,907	7,016	9,800	0	19,723
2001	63,026	2,716	9,847	7,159	151	19,910
2002	50,826	1,774	8,562	7,405	209	17,949
2003	47,622	1,751	11,839	19,445	64	33,099
2004	57,397	3,020	25,606	15,862	326	44,813
2005	57,510	2,103	18,954	38,454	440	59,952
2006	47,812	3,710	11,925	23,849	1,758	41,244
2007	57,620	1,483	21,455	22,083	1,262	46,283
2008	51,229	1,090	16,602	16,162	812	34,668
2009	62,028	2,113	13,076	28,719	399	44,306
2010	50,059	10,663	7,877	12,225	873	31,639
2011	49,548	10,398	32,236	4,041	81	46,756
2012	46,059	2,966	42,386	14,404	99	59,855
2013	47,520	4,314	14,922	20,939	116	40,290
2014	49,434	4,019	25,569	17,690	1,207	48,484
2015	46,142	1,400	17,609	18,581	284	37,873
2016	38,776	4,036	19,079	20,797	453	44,364
2017	35,865	13,816	35,994	24,797	498	75,102

Table A13. Number of fingerling equivalents and average size (grams) of Chinook salmon stocked into Lake Ontario from 1982-2017 (1981-2016 year classes) by NYSDEC, Ontario Ministry of Natural Resources and pen-rearing cooperators. Calculations previously described in Eckert (2007).

	DEC Stocked Fish						OMNR Stocked Fish				Total Lake Ontario Chinook Salmon	
	Salmon River		Caledonia		Pen Reared		Hatchery		Pen Reared			
Year Class	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size
1981	379,941	1.8	479,300	3.1			3,599	2.3			862,840	2.4
1982	888,400	2.1	184,000	3.7			102,954	2.5			1,175,354	2.3
1983	2,064,260	3.8	455,000	4.2			24,920	1.8			2,544,180	3.8
1984	2,609,750	3.5	195,000	2.0			152,480	2.0			2,957,230	3.1
1985	2,957,800	4.8					295,030	4.4			3,252,830	4.7
1986	1,848,800	4.2	663,200	4.5			298,771	4.9			2,810,771	4.4
1987	2,495,000	4.9	616,330	4.6			256,966	4.2			3,368,296	4.8
1988	2,305,000	4.5	543,000	4.5			256,104	5.1			3,104,104	4.6
1989	2,212,200	4.5	540,000	4.9			266,554	4.4			3,018,754	4.6
1990	2,180,000	5.3	540,000	4.5			244,722	4.1			2,964,722	5.0
1991	2,794,000	5.1			41,000	4.1	294,453	4.8			3,129,453	5.1
1992	2,655,691	4.6			46,260	3.9	302,378	5.0			3,004,329	4.7
1993	1,557,300	4.5			40,000	3.8	249,592	5.1			1,846,892	4.6
1994	944,000	5.0			40,000	3.9	237,491	4.5			1,221,491	4.8
1995	1,136,666	4.6					227,424	4.3			1,364,090	4.5
1996	1,300,000	4.6					195,138	3.8			1,495,138	4.4
1997	1,604,980	5.1					306,060	4.6			1,911,040	4.9
1998	1,546,000	5.0			49,763	7.6	308,166	4.6			1,903,929	4.9
1999	1,183,000	4.7	90,000	4.5	315,000	4.5	179,524	4.3			1,767,524	4.6
2000	1,252,300	4.7	90,000	4.1	300,000	4.8	264,243	4.1			1,906,543	4.5
2001	1,202,800	4.9	118,610	3.9	300,000	5.0	272,276	4.0			1,893,686	4.6
2002	1,211,000	5.3	123,000	4.3	299,496	5.4	274,506	4.4			1,908,002	5.0
2003	1,167,240	4.7	110,400	3.5	189,356	4.5	223,233	3.9	10,145	5.4	1,700,374	4.4
2004	928,160	4.7	451,030	3.9	322,269	5.3	251,103	4.1	10,004	5.2	1,962,565	4.5
2005	994,660	5.3	421,280	4.1	386,599	5.3	262,621	4.7	10,010	6.0	2,075,169	5.0
2006	1,035,680	3.9	342,200	3.5	313,100	6.1	197,107	3.9	9,997	5.7	1,898,083	4.1
2007	1,477,670	5.1			313,100	6.7	254,307	4.7	9,998	5.7	2,055,075	5.2
2008	559,524	6.0			224,702	5.9	241,875	4.1	12,743	6.6	1,038,844	5.3
2009	1,411,957	4.9			313,600	7.2	233,820	4.5	21,678	4.4	1,981,055	5.1
2010	1,024,046	5.6			506,560	6.4	341,390	4.9	39,820	8.9	1,911,756	5.7
2011	1,260,584	5.3			508,670	6.4	249,079	4.3	42,541	7.7	2,060,874	5.4
2012	1,013,110	6.6			497,970	6.3	245,758	6.5	59,940	10.7	1,816,778	6.7
2013	1,212,907	4.7			443,566	5.5	294,324	5.6	59,494	8.4	2,010,290	5.2
2014	1,394,560	4.9			505,990	6.0	246,124	5.6	82,820	8.1	2,229,494	5.5
2015	1,181,352	4.6			450,800	5.9	220,275	5.3	87,565	8.1	1,939,992	5.3
2016	1,431,700	4.6			450,800	6.6	154,095	7.5	112,467	9.2	2,149,062	5.8

Table A14a. Rainbow trout harvest and catch data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	23,434	19,685	24,060	23,856	16,131	12,617	17,203	16,729	9,212	9,487	12,015
Catch	33,574	33,943	54,501	46,249	36,533	32,975	34,611	37,462	17,509	16,639	22,556
% Harvested	68.8	58.0	44.1	51.6	44.2	38.3	49.7	44.7	52.6	57.0	53.3
Monthly estimates of harvest for all fishing boats:											
April	1,163	262	473	463	56	199	76	101	127	65	0
May	5,202	2,481	1,698	1,548	410	939	2,099	2,315	1,773	451	330
June	3,396	978	813	2,406	1,095	2,156	965	5,102	614	1,228	539
July	3,100	2,889	5,816	4,831	7,299	4,301	5,488	2,461	1,750	4,097	3,377
August	7,911	9,800	10,096	13,568	4,587	4,381	7,567	5,670	3,876	3,531	6,768
September	2,663	3,275	5,164	1,040	2,684	640	1,009	1,080	1,072	113	1,001
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	13,964	14,945	19,388	18,973	11,637	8,622	11,437	9,225	6,143	7,764	9,049
West/Central	2,695	760	1,728	1,447	2,023	1,245	2,333	1,871	1,057	485	651
East/Central	5,589	3,603	2,221	3,065	2,340	1,852	3,036	4,800	1,442	1,016	1,920
East	1,185	377	722	370	131	898	397	833	570	222	395
Monthly estimates of catch for all fishing boats:											
April	1,969	565	1,197	867	305	442	379	649	387	214	151
May	7,824	5,840	7,418	2,724	2,060	3,100	4,824	6,341	3,816	1,191	629
June	4,991	2,197	2,676	4,828	1,813	6,515	2,077	13,747	2,384	2,245	932
July	4,321	6,026	9,053	8,856	18,448	11,100	11,489	4,050	3,560	7,005	6,401
August	10,706	14,823	22,335	27,121	9,037	10,858	14,198	11,072	5,701	5,689	11,752
September	3,763	4,492	11,822	1,851	4,869	960	1,644	1,603	1,661	296	2,692
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	19,787	23,556	35,347	36,512	26,897	22,064	23,021	16,603	9,899	12,792	15,151
West/Central	4,738	1,727	12,065	3,891	3,377	5,355	5,055	7,394	2,949	1,207	3,396
East/Central	7,576	8,040	5,824	5,166	5,164	4,195	5,957	10,976	3,456	2,099	3,462
East	1,474	620	1,266	681	1,096	1,361	578	2,489	1,204	541	547
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.8	99.8	100.0	100.0	99.8	100.0	100.0	99.7	100.0	100.0	99.9
% Catch	99.6	99.7	99.8	99.9	99.9	100.0	99.9	99.9	100.0	100.0	99.9
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	50.9	59.4	50.7	49.8	50.2	45.9	54.3	56.5	50.3	63.3	46.8
% Catch	40.4	47.0	34.7	35.5	33.5	27.1	39.0	38.7	36.8	44.1	30.4

Table A14b. Rainbow trout harvest and catch rate data collected April 15 – September 30, 1985-2017. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.248	0.384	0.388	0.477	0.325	0.274	0.362	0.337	0.200	0.245	0.335
Catch/Boat Trip	0.358	0.661	0.877	0.923	0.737	0.716	0.728	0.757	0.379	0.429	0.629
Harv/Angler Trip	0.085	0.129	0.127	0.157	0.109	0.091	0.117	0.107	0.065	0.078	0.107
Catch/Angler Trip	0.123	0.221	0.287	0.305	0.247	0.238	0.235	0.240	0.123	0.137	0.200
Harv/Angler Hour	0.015	0.023	0.021	0.028	0.019	0.016	0.019	0.018	0.011	0.013	0.018
Catch/Angler Hr.	0.021	0.039	0.048	0.055	0.044	0.042	0.039	0.041	0.021	0.023	0.033
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.110	0.091	0.131	0.177	0.022	0.084	0.030	0.053	0.056	0.020	0.000
May	0.288	0.342	0.115	0.165	0.051	0.112	0.265	0.275	0.205	0.067	0.087
June	0.344	0.199	0.156	0.620	0.254	0.420	0.152	0.920	0.142	0.324	0.178
July	0.231	0.312	0.665	0.523	0.669	0.465	0.569	0.279	0.215	0.488	0.433
August	0.294	0.594	0.665	0.750	0.323	0.339	0.476	0.335	0.314	0.353	0.549
September	0.149	0.309	0.355	0.152	0.278	0.080	0.196	0.137	0.103	0.017	0.143
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.647	1.201	1.044	1.331	0.789	0.680	0.836	0.763	0.541	0.702	0.869
West/Central	0.168	0.177	0.224	0.260	0.401	0.223	0.352	0.299	0.164	0.124	0.175
East/Central	0.183	0.209	0.116	0.183	0.155	0.136	0.199	0.303	0.103	0.073	0.151
East	0.034	0.022	0.044	0.027	0.009	0.063	0.033	0.052	0.040	0.022	0.043
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.197	0.197	0.332	0.332	0.121	0.187	0.147	0.338	0.172	0.067	0.076
May	0.452	0.804	0.504	0.290	0.256	0.370	0.610	0.753	0.441	0.176	0.166
June	0.518	0.449	0.515	1.238	0.417	1.268	0.328	2.495	0.552	0.593	0.311
July	0.315	0.647	1.035	0.959	1.692	1.199	1.188	0.459	0.437	0.834	0.821
August	0.399	0.899	1.465	1.500	0.638	0.841	0.892	0.654	0.462	0.569	0.953
September	0.210	0.424	0.811	0.270	0.505	0.120	0.320	0.204	0.159	0.045	0.385
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.916	1.893	1.904	2.561	1.826	1.741	1.682	1.373	0.872	1.156	1.455
West/Central	0.322	0.399	1.559	0.698	0.669	0.959	0.762	1.183	0.457	0.308	0.911
East/Central	0.256	0.466	0.300	0.307	0.340	0.309	0.390	0.692	0.248	0.152	0.273
East	0.042	0.036	0.076	0.050	0.075	0.096	0.048	0.160	0.084	0.054	0.060
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.872	1.340	1.236	1.391	0.981	0.759	1.008	0.973	0.474	0.704	0.799
Catch/Boat Trip	1.007	1.828	1.919	1.925	1.484	1.169	1.455	1.494	0.659	0.860	0.973
Harv/Angler Trip	0.173	0.257	0.244	0.267	0.188	0.149	0.194	0.184	0.091	0.134	0.155
Catch/Angler Trip	0.200	0.351	0.378	0.369	0.284	0.230	0.280	0.283	0.126	0.164	0.189
Harv/Angler Hour	0.024	0.037	0.035	0.041	0.030	0.023	0.028	0.027	0.014	0.019	0.023
Catch/Angler Hr.	0.027	0.051	0.055	0.057	0.045	0.035	0.040	0.042	0.019	0.024	0.028
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.139	0.187	0.227	0.289	0.194	0.178	0.206	0.182	0.126	0.115	0.221
Catch/Boat Trip	0.245	0.421	0.680	0.717	0.587	0.626	0.552	0.577	0.304	0.308	0.544
Harv/Angler Trip	0.055	0.074	0.085	0.112	0.077	0.068	0.080	0.069	0.050	0.045	0.084
Catch/Angler Trip	0.096	0.167	0.254	0.278	0.232	0.241	0.214	0.220	0.120	0.121	0.206
Harv/Angler Hour	0.010	0.014	0.015	0.022	0.014	0.013	0.014	0.013	0.009	0.008	0.014
Catch/Angler Hr.	0.018	0.032	0.045	0.054	0.044	0.046	0.038	0.040	0.022	0.022	0.035

Table A15. Length (total length in inches) and weight (lbs) statistics for rainbow trout sampled April 15 – September 30 during the 1985-2017 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-07 avg.	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mean length and weight data for rainbow trout sampled April 15 - September 30:											
Mean Length (in)	24.4	25.1	25.0	25.3	24.7	24.9	24.5	24.6	25.3	24.6	24.8
Mean Weight (lbs)	-	6.2	6.0	6.8	6.1	5.9	6.0	5.9	6.1	5.9	6.3
Estimated weight (lbs) for standard length rainbow trout sampled April 15 - September 30:											
Standard Length:											
18.0 inches	-	2.22	2.10	2.40	2.09	2.05	2.21	2.31	2.17	2.37	2.51
20.0 inches	-	3.02	2.89	3.26	2.92	2.83	3.04	3.10	2.94	3.16	3.36
22.0 inches	-	3.99	3.85	4.30	3.95	3.80	4.06	4.05	3.87	4.10	4.37
24.0 inches	-	5.13	5.00	5.53	5.21	4.97	5.28	5.17	4.97	5.19	5.56
26.0 inches	-	6.47	6.36	6.97	6.71	6.35	6.73	6.46	6.25	6.46	6.93
28.0 inches	-	7.99	7.92	8.60	8.46	7.94	8.39	7.91	7.70	7.87	8.47
30.0 inches	-	9.77	9.75	10.51	10.53	9.82	10.34	9.60	9.39	9.49	10.24
32.0 inches	-	11.78	11.84	12.67	12.92	11.98	12.58	11.50	11.30	11.32	12.24
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%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%
16.0-16.9 in	1.0%	0.3%	0.2%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%
17.0-17.9 in	2.1%	0.3%	1.5%	0.3%	1.3%	0.5%	0.5%	2.3%	0.0%	0.0%	0.0%
18.0-18.9 in	4.5%	3.8%	1.2%	1.1%	1.3%	0.5%	0.5%	3.6%	2.0%	0.0%	0.0%
19.0-19.9 in	6.5%	1.4%	3.2%	1.6%	3.3%	1.6%	1.1%	4.5%	2.0%	3.0%	1.0%
20.0-20.9 in	8.1%	4.8%	5.4%	4.1%	4.6%	5.3%	8.1%	1.8%	2.9%	10.1%	1.9%
21.0-21.9 in	9.0%	8.7%	8.2%	8.5%	12.8%	7.4%	9.7%	7.7%	5.9%	6.1%	5.7%
22.0-22.9 in	9.1%	10.4%	9.2%	11.8%	12.1%	10.1%	14.1%	7.7%	9.8%	15.2%	15.2%
23.0-23.9 in	9.3%	6.2%	9.9%	11.5%	10.8%	16.0%	15.1%	7.7%	9.8%	15.2%	22.9%
24.0-24.9 in	7.8%	9.3%	7.7%	10.4%	7.5%	12.2%	9.2%	14.4%	13.7%	9.1%	13.3%
25.0-25.9 in	6.9%	8.7%	12.6%	8.5%	7.9%	11.2%	10.8%	13.5%	10.8%	15.2%	12.4%
26.0-26.9 in	6.2%	12.5%	10.1%	11.8%	11.1%	7.4%	8.1%	10.8%	11.8%	5.1%	6.7%
27.0-27.9 in	7.0%	12.5%	9.4%	9.0%	8.2%	12.8%	7.6%	7.7%	8.8%	4.0%	8.6%
28.0-28.9 in	6.0%	9.3%	9.9%	7.4%	9.5%	5.3%	5.4%	9.5%	6.9%	5.1%	5.7%
29.0-29.9 in	5.1%	6.6%	5.0%	4.9%	4.3%	3.7%	5.9%	4.5%	7.8%	4.0%	1.9%
30.0-30.9 in	4.2%	2.8%	4.0%	4.9%	3.6%	3.2%	1.1%	1.4%	3.9%	5.1%	1.0%
31.0-31.9 in	3.1%	1.4%	1.7%	1.4%	1.3%	1.1%	0.5%	2.3%	2.0%	2.0%	2.9%
32.0-32.9 in	1.8%	0.0%	0.7%	1.9%	0.0%	0.5%	0.5%	0.0%	1.0%	0.0%	0.0%
33.0-33.9 in	1.0%	0.3%	0.0%	0.5%	0.3%	1.1%	0.5%	0.0%	0.0%	0.0%	0.0%
>33.9 in	0.7%	0.7%	0.0%	0.3%	0.0%	0.0%	1.1%	0.0%	0.0%	1.0%	1.0%

Table A16. Atlantic salmon harvest and catch data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	310	79	532	624	398	310	200	66	275	236	151
Catch	1,161	233	1,273	1,826	1,519	592	599	639	638	704	394
% Harvested	24.5	33.9	41.8	34.2	26.2	52.4	33.4	10.3	43.1	33.5	38.3
Monthly estimates of harvest for all fishing boats:											
April	59	0	105	98	128	29	0	28	24	15	61
May	133	28	222	79	95	183	175	25	24	54	38
June	46	0	15	24	54	46	0	0	12	27	0
July	26	16	66	301	76	51	25	14	169	140	41
August	39	0	124	108	25	0	0	0	25	0	12
September	6	35	0	15	21	0	0	0	20	0	0
Seasonal estimates of harvest among four geographic areas for all fishing boats:											
West	77	51	226	205	236	126	51	39	0	41	48
West/Central	52	0	161	182	0	0	44	0	0	0	51
East/Central	88	0	74	204	106	93	105	0	136	102	15
East	92	28	71	33	56	91	0	27	139	93	37
Monthly estimates of catch for all fishing boats:											
April	212	0	201	273	296	56	48	180	132	62	61
May	373	88	430	223	439	387	251	215	194	66	120
June	156	64	66	231	171	46	77	0	37	87	0
July	193	16	211	648	212	90	165	162	209	397	65
August	162	30	365	372	340	13	58	82	25	92	69
September	65	35	0	79	62	0	0	0	41	0	80
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	276	52	363	560	526	242	186	121	26	112	112
West/Central	206	36	337	397	366	46	77	112	0	-	49
East/Central	350	47	509	650	339	211	255	209	368	445	171
East	329	98	63	219	287	93	81	197	244	147	63
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.8	100	100	100	100	100	100	100	100	100	100
% Catch	96.2	100	100	100	100	100	100	100	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	0.253	0.154	0.858	1.247	0.803	0.673	0.421	0.134	0.596	0.609	0.421
Catch/Boat Trip	0.952	0.455	2.052	3.648	3.066	1.285	1.261	1.293	1.383	1.816	1.099
Harv/Angler Trip	0.088	0.052	0.280	0.411	0.269	0.224	0.136	0.042	0.193	0.194	0.134
Catch/Angler Trip	0.332	0.152	0.671	1.203	1.028	0.427	0.408	0.411	0.447	0.578	0.350
Harv/Angler Hour	0.015	0.009	0.047	0.074	0.048	0.039	0.022	0.007	0.033	0.032	0.022
Catch/Angler Hr.	0.057	0.027	0.111	0.217	0.183	0.075	0.067	0.070	0.076	0.096	0.057

Table A17a. Brown trout harvest and catch data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	30,890	14,989	23,148	18,311	32,937	23,305	18,969	20,626	12,590	14,608	10,604
Catch	44,140	22,030	33,484	32,604	49,661	39,507	27,793	44,487	20,780	20,871	17,092
% Harvested	69.4	68.0	69.1	56.2	66.3	59.0	68.3	46.4	60.6	70.0	62.0
Monthly estimates of harvest for all fishing boats:											
April	8,085	1,420	4,023	3,855	3,558	5,802	2,730	5,094	3,247	5,180	3,221
May	10,922	3,828	11,256	2,266	12,255	5,436	7,810	5,404	3,138	3,377	3,893
June	4,209	4,164	2,393	611	4,941	1,456	3,315	612	3,591	339	796
July	3,890	3,280	576	7,782	6,695	5,631	2,656	5,202	1,188	1,957	1,536
August	3,232	1,945	4,538	3,543	4,968	4,307	2,197	3,593	1,045	2,775	942
September	552	352	362	255	519	672	259	721	380	980	216
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	2,509	1,052	209	1,153	2,563	2,006	1,649	4,267	560	1,010	898
West/Central	3,023	541	1,744	1,487	2,163	2,792	1,566	2,958	503	2,534	1,429
East/Central	17,056	3,969	17,399	11,156	16,327	8,932	9,850	8,199	7,903	6,545	5,830
East	8,302	9,427	3,796	4,515	11,883	9,575	5,903	5,202	3,624	4,519	2,447
Monthly estimates of catch for all fishing boats:											
April	11,142	1,996	5,997	5,501	8,160	10,558	4,450	13,369	6,962	7,802	4,136
May	15,016	5,983	15,838	3,913	17,584	9,446	9,329	15,497	4,657	3,957	6,541
June	5,590	6,110	3,463	1,342	6,658	3,345	3,918	913	4,516	446	1,008
July	6,134	4,692	888	14,421	10,026	7,751	5,169	8,331	1,876	3,053	3,022
August	5,410	2,654	6,720	6,993	6,193	7,236	4,284	5,048	1,498	3,672	1,678
September	848	595	579	434	1,041	1,171	643	1,330	1,271	1,940	706
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	3,940	1,408	344	2,043	4,760	4,122	2,451	12,153	1,249	1,494	1,279
West/Central	6,138	1,162	3,182	3,005	5,710	6,836	4,933	6,544	1,785	4,364	3,085
East/Central	23,327	6,117	25,272	20,730	22,945	13,860	12,722	15,761	12,243	9,579	9,465
East	10,735	13,344	4,686	6,826	16,246	14,689	7,687	10,028	5,504	5,434	3,263
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.8	98.9	99.4	98.9	99.8	99.8	99.8	99.6	99.9	100.0	100.0
% Catch	98.5	98.3	98.9	97.8	99.8	98.8	99.5	99.8	99.8	99.8	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	46.4	43.9	70.3	54.7	53.3	55.6	72.9	57.9	62.6	61.1	52.4
% Catch	38.9	34.1	59.6	49.8	43.4	42.3	58.7	36.4	47.4	50.4	45.3

Table A17b. Brown trout harvest and catch rate data collected April 15 – September 30, 1985-2017. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.329	0.289	0.371	0.362	0.664	0.505	0.398	0.416	0.273	0.377	0.296
Catch/Boat Trip	0.482	0.423	0.534	0.637	1.000	0.848	0.582	0.898	0.450	0.537	0.477
Harv/Angler Trip	0.114	0.097	0.121	0.119	0.223	0.168	0.129	0.132	0.088	0.120	0.094
Catch/Angler Trip	0.166	0.142	0.175	0.210	0.335	0.282	0.188	0.285	0.145	0.171	0.152
Harv/Angler Hour	0.020	0.017	0.020	0.021	0.040	0.030	0.021	0.022	0.015	0.020	0.015
Catch/Angler Hr.	0.029	0.025	0.029	0.038	0.060	0.050	0.031	0.048	0.025	0.028	0.025
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.047	0.494	1.114	1.477	1.413	2.452	1.060	2.653	1.442	1.620	1.616
May	0.638	0.527	0.764	0.241	1.522	0.648	0.987	0.642	0.363	0.499	1.029
June	0.468	0.851	0.438	0.140	1.134	0.283	0.523	0.106	0.831	0.090	0.269
July	0.306	0.352	0.066	0.834	0.614	0.603	0.272	0.583	0.144	0.233	0.197
August	0.127	0.116	0.298	0.196	0.352	0.334	0.138	0.212	0.085	0.278	0.076
September	0.029	0.033	0.025	0.029	0.054	0.084	0.050	0.092	0.036	0.148	0.031
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.110	0.082	0.011	0.081	0.174	0.158	0.119	0.353	0.049	0.091	0.086
West/Central	0.272	0.126	0.226	0.267	0.429	0.500	0.236	0.473	0.078	0.647	0.383
East/Central	0.608	0.226	0.908	0.658	1.079	0.653	0.645	0.514	0.567	0.473	0.462
East	0.272	0.541	0.220	0.330	0.808	0.674	0.494	0.339	0.251	0.453	0.269
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.506	0.695	1.661	2.108	3.241	4.462	1.719	6.963	3.093	2.440	2.075
May	0.900	0.816	1.074	0.416	2.184	1.126	1.179	1.841	0.538	0.584	1.729
June	0.619	1.228	0.617	0.329	1.518	0.579	0.615	0.161	1.039	0.118	0.341
July	0.480	0.505	0.102	1.498	0.920	0.827	0.529	0.938	0.229	0.363	0.388
August	0.223	0.158	0.441	0.387	0.439	0.560	0.269	0.298	0.121	0.362	0.136
September	0.047	0.056	0.035	0.056	0.108	0.146	0.120	0.167	0.122	0.293	0.101
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.175	0.111	0.019	0.143	0.323	0.325	0.176	1.004	0.110	0.135	0.123
West/Central	0.584	0.268	0.413	0.539	1.131	1.224	0.744	1.047	0.277	1.115	0.827
East/Central	0.850	0.345	1.306	1.201	1.513	1.000	0.830	0.991	0.877	0.689	0.750
East	0.355	0.760	0.274	0.501	1.105	1.020	0.641	0.656	0.381	0.545	0.358
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.075	0.754	1.650	1.174	2.128	1.698	1.492	1.231	0.805	1.047	0.790
Catch/Boat Trip	1.317	0.862	2.022	1.903	2.611	2.187	1.760	1.667	1.008	1.234	1.101
Harv/Angler Trip	0.214	0.145	0.325	0.225	0.408	0.333	0.287	0.233	0.154	0.199	0.153
Catch/Angler Trip	0.263	0.165	0.398	0.365	0.500	0.429	0.338	0.316	0.193	0.235	0.213
Harv/Angler Hour	0.030	0.021	0.047	0.035	0.064	0.050	0.041	0.035	0.024	0.029	0.023
Catch/Angler Hr.	0.036	0.024	0.057	0.057	0.079	0.065	0.049	0.047	0.030	0.034	0.032
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.199	0.194	0.129	0.195	0.371	0.268	0.134	0.216	0.129	0.188	0.175
Catch/Boat Trip	0.334	0.332	0.253	0.377	0.678	0.582	0.297	0.710	0.299	0.340	0.324
Harv/Angler Trip	0.078	0.077	0.048	0.075	0.146	0.103	0.052	0.082	0.051	0.074	0.066
Catch/Angler Trip	0.132	0.131	0.094	0.146	0.267	0.224	0.115	0.270	0.119	0.134	0.123
Harv/Angler Hour	0.015	0.015	0.008	0.015	0.027	0.020	0.009	0.015	0.009	0.013	0.011
Catch/Angler Hr.	0.025	0.025	0.017	0.028	0.050	0.042	0.020	0.049	0.022	0.024	0.021

Table A18. Length (inches), weight (lbs), age, and fin clip statistics for brown trout sampled April 15 – September 30 during the 1985-2017 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mean length and weight data for brown trout sampled April 15 - September 30:											
Mean Length (in)	20.1	20.0	19.0	20.8	20.7	20.4	21.1	20.2	20.0	19.7	20.4
Mean Weight (lbs)	-	4.59	3.70	5.39	5.30	4.92	5.87	4.48	4.21	4.25	5.20
Estimated weight (lbs) for standard length brown trout sampled April 15 - September 30:											
16.0 inches	-	2.11	1.99	2.32	2.16	1.96	2.32	1.89	1.71	1.86	2.38
18.0 inches	-	3.06	2.88	3.30	3.15	2.89	3.30	2.76	2.55	2.75	3.36
20.0 inches	-	4.30	4.05	4.54	4.44	4.13	4.56	3.90	3.69	3.94	4.60
22.0 inches	-	5.83	5.50	6.06	6.06	5.70	6.10	5.33	5.14	5.43	6.11
24.0 inches	-	7.71	7.27	7.89	8.04	7.64	7.96	7.08	6.97	7.30	7.91
26.0 inches	-	9.96	9.41	10.06	10.44	10.00	10.16	9.21	9.21	9.56	10.05
28.0 inches	-	12.58	11.89	12.54	13.23	12.78	12.69	11.68	11.87	12.23	12.48
Percent length composition of brown trout sampled April 15 - September 30:											
<15.0 in	1.4%	0.0%	0.4%	0.2%	0.1%	0.0%	0.3%	1.2%	0.3%	0.3%	0.4%
15.0-15.9 in	1.9%	1.3%	3.3%	0.2%	0.1%	1.7%	1.7%	3.5%	6.3%	4.7%	0.4%
16.0-16.9 in	5.9%	7.0%	16.7%	3.1%	1.6%	4.8%	3.5%	8.9%	12.9%	16.2%	3.1%
17.0-17.9 in	12.3%	11.4%	21.1%	8.3%	7.0%	17.4%	8.7%	16.1%	17.4%	17.8%	9.7%
18.0-18.9 in	18.1%	17.8%	20.7%	14.0%	16.6%	15.7%	16.7%	13.2%	10.8%	13.1%	19.0%
19.0-19.9 in	16.0%	16.9%	10.3%	14.0%	19.3%	14.8%	14.2%	9.3%	6.3%	9.1%	19.5%
20.0-20.9 in	12.5%	14.1%	8.6%	18.8%	16.9%	10.2%	10.4%	9.3%	6.3%	8.8%	16.8%
21.0-21.9 in	9.3%	10.8%	4.4%	13.3%	11.4%	7.6%	7.6%	9.5%	9.1%	5.4%	6.2%
22.0-22.9 in	7.0%	7.7%	4.2%	10.2%	10.1%	5.7%	6.3%	8.8%	8.4%	5.7%	8.0%
23.0-23.9 in	4.9%	3.5%	3.9%	7.1%	6.9%	6.3%	9.0%	6.0%	8.0%	6.4%	4.4%
24.0-24.9 in	3.6%	4.2%	3.3%	2.4%	3.9%	5.9%	6.9%	5.6%	4.9%	3.7%	3.5%
25.0-25.9 in	2.8%	3.1%	1.7%	2.6%	2.0%	3.9%	5.6%	2.9%	5.2%	3.4%	5.3%
26.0-26.9 in	2.1%	2.0%	0.9%	3.8%	2.0%	1.7%	4.5%	2.3%	2.8%	1.7%	2.7%
27.0-27.9 in	1.0%	0.2%	0.4%	1.0%	1.0%	2.0%	2.8%	1.6%	1.0%	1.0%	0.0%
28.0-28.9 in	0.6%	0.0%	0.0%	0.7%	0.6%	1.5%	0.7%	1.0%	0.3%	1.7%	0.4%
>28.9 in	0.6%	0.0%	0.2%	0.2%	0.4%	0.7%	1.0%	0.6%	0.0%	1.0%	0.4%
Percent fin clip composition of brown trout sampled April 15 - September 30:											
No Clips	75.3%	88.4%	81.4%	87.6%	88.7%	92.4%	91.0%	88.1%	91.3%	89.0%	84.5%
LV	2.2%	0.2%	3.0%	2.9%	1.2%	0.4%	1.0%	0.4%	0.7%	0.3%	0.4%
LV-Ad	4.1%	3.1%	6.1%	2.6%	0.6%	1.7%	1.0%	1.9%	1.4%	0.3%	0.9%
LP	2.8%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LP-Ad	4.1%	1.7%	1.1%	2.6%	4.3%	2.2%	2.1%	1.2%	2.8%	6.2%	4.4%
Ad	1.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%
RV	3.8%	4.8%	4.4%	2.1%	0.6%	0.7%	3.5%	6.2%	2.1%	2.1%	4.4%
RV-Ad	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%
RP	4.2%	1.4%	2.6%	1.0%	2.6%	1.5%	1.0%	1.4%	0.3%	1.4%	1.3%
RP-Ad	0.0%	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Misc.	1.3%	0.4%	0.9%	1.2%	1.9%	1.1%	0.3%	0.4%	1.4%	0.7%	4.0%
Percent age composition of brown trout sampled April 15 - September 30:											
Age-1	0.6%	0.0%	0.2%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Age-2	77.2%	78.9%	80.0%	80.6%	78.7%	74.6%	60.0%	62.6%	58.3%	73.8%	79.7%
Age-3	18.6%	19.6%	17.2%	15.2%	17.2%	21.3%	34.6%	28.8%	30.9%	19.2%	16.7%
Age-4	3.0%	1.0%	2.4%	3.4%	3.9%	3.3%	2.7%	7.8%	9.2%	5.8%	3.3%
Age-5+	0.6%	0.5%	0.2%	0.4%	0.3%	0.7%	2.6%	0.8%	1.6%	1.2%	0.3%
Mean length (inches) of aged brown trout sampled in April 15-30:											
Age-2	-	17.7	17.4	18.2	18.6	17.9	18.0	17.4	17.0	17.3	18.5
Age-3	-	23.2	21.8	23.1	22.8	23.1	23.3	21.7	21.6	22.1	23.8

Table A19a. Lake trout harvest and catch data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	31,272	2,875	4,842	5,403	7,017	7,829	20,511	15,870	18,780	18,426	8,592
Catch	67,291	6,757	11,241	11,753	24,336	22,206	35,533	33,108	52,294	36,336	15,444
% Harvested	41.4	42.5	43.1	46.0	28.8	35.3	57.7	47.9	35.9	50.7	55.6
Monthly estimates of harvest for all fishing boats:											
April	2,761	15	388	188	255	1,442	1,393	757	596	2,063	817
May	6,038	594	190	2,461	840	2,311	6,311	2,207	6,148	5,228	2,095
June	5,854	387	501	262	1,478	1,456	4,455	2,561	1,151	3,833	1,797
July	9,219	1,229	254	1,845	2,266	1,216	4,346	3,967	3,062	2,951	2,546
August	6,472	465	3,026	648	1,871	899	2,066	6,230	5,718	2,036	1,004
September	928	184	483	0	308	505	1,941	148	2,105	2,314	333
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	6,437	602	190	739	1,751	1,417	1,605	1,717	3,038	2,670	1,004
West/Central	3,438	609	1,018	885	1,358	1,491	5,327	6,099	4,038	4,040	2,354
East/Central	7,682	209	317	1,552	1,950	2,134	6,602	2,500	4,183	5,473	3,064
East	13,716	1,454	3,318	2,227	1,959	2,786	6,977	5,553	7,521	6,243	2,169
Monthly estimates of catch for all fishing boats:											
April	6,288	15	1,235	464	885	3,823	1,955	3,728	2,214	8,084	1,271
May	12,054	1,539	2,558	5,660	8,956	8,397	12,288	7,417	28,246	11,692	5,032
June	12,473	927	1,395	552	3,789	3,533	7,818	5,812	2,611	6,078	2,787
July	20,405	2,276	705	3,247	7,626	2,871	7,971	6,150	7,553	4,920	4,404
August	14,115	1,712	4,699	1,678	2,484	2,903	3,178	9,563	8,836	2,594	1,455
September	1,956	288	649	151	596	679	2,323	438	2,834	2,968	496
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	17,680	2,924	2,387	2,095	11,226	6,487	5,219	7,740	28,107	10,329	3,294
West/Central	8,736	1,681	3,296	3,346	3,772	3,699	9,099	10,454	6,697	7,158	5,552
East/Central	15,800	289	1,120	3,079	6,419	6,121	11,400	4,652	6,145	9,732	4,149
East	25,075	1,864	4,438	3,233	2,920	5,899	9,815	10,262	11,345	9,116	2,449
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	99.5	100.0	100.0	100.0	100.0	100.0	100.0	99.7	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	62.0	81.3	88.7	69.6	64.9	67.2	77.9	72.5	82.0	80.0	76.4
% Catch	43.2	48.0	55.0	48.1	33.1	33.5	60.2	46.8	39.5	53.1	52.1

Table A19b. Lake trout harvest and catch rate data collected April 15 – September 30, 1985-2017. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.259	0.056	0.078	0.108	0.142	0.170	0.432	0.321	0.407	0.475	0.240
Catch/Boat Trip	0.590	0.132	0.181	0.235	0.491	0.482	0.748	0.668	1.133	0.937	0.431
Harv/Angler Trip	0.090	0.019	0.026	0.036	0.047	0.056	0.140	0.102	0.131	0.151	0.076
Catch/Angler Trip	0.204	0.044	0.059	0.077	0.165	0.160	0.242	0.212	0.366	0.298	0.137
Harv/Angler Hour	0.016	0.003	0.004	0.006	0.008	0.010	0.023	0.017	0.022	0.025	0.013
Catch/Angler Hr.	0.035	0.008	0.010	0.014	0.029	0.028	0.040	0.036	0.062	0.049	0.023
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.228	0.005	0.107	0.072	0.101	0.609	0.541	0.394	0.265	0.645	0.410
May	0.260	0.082	0.013	0.262	0.104	0.276	0.798	0.262	0.710	0.772	0.554
June	0.491	0.081	0.096	0.068	0.343	0.283	0.703	0.467	0.266	1.013	0.607
July	0.557	0.133	0.029	0.200	0.208	0.131	0.450	0.449	0.376	0.351	0.327
August	0.211	0.028	0.199	0.036	0.132	0.070	0.130	0.368	0.463	0.204	0.081
September	0.047	0.017	0.033	0.000	0.032	0.063	0.378	0.019	0.202	0.349	0.048
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.193	0.048	0.010	0.052	0.119	0.112	0.117	0.142	0.268	0.241	0.096
West/Central	0.297	0.142	0.132	0.159	0.269	0.267	0.803	0.976	0.626	1.032	0.631
East/Central	0.217	0.012	0.017	0.093	0.129	0.157	0.433	0.158	0.300	0.396	0.243
East	0.367	0.084	0.200	0.165	0.134	0.196	0.584	0.364	0.522	0.626	0.238
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.750	0.005	0.342	0.178	0.351	1.616	0.759	1.942	0.984	2.528	0.638
May	0.568	0.212	0.174	0.602	1.113	1.001	1.553	0.871	3.263	1.725	1.330
June	1.080	0.195	0.268	0.142	0.879	0.688	1.234	1.059	0.599	1.606	0.942
July	1.225	0.246	0.081	0.352	0.699	0.310	0.826	0.697	0.928	0.586	0.565
August	0.467	0.104	0.309	0.093	0.176	0.225	0.200	0.565	0.716	0.259	0.118
September	0.100	0.027	0.045	0.022	0.062	0.085	0.452	0.056	0.272	0.448	0.071
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.610	0.235	0.129	0.147	0.763	0.512	0.382	0.633	2.476	0.934	0.316
West/Central	0.795	0.392	0.427	0.600	0.747	0.662	1.372	1.673	1.039	1.829	1.489
East/Central	0.458	0.017	0.058	0.184	0.424	0.450	0.747	0.293	0.439	0.704	0.329
East	0.684	0.107	0.268	0.240	0.199	0.415	0.821	0.673	0.787	0.913	0.269
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.070	0.268	0.435	0.440	0.552	0.690	1.724	1.185	1.574	1.727	0.933
Catch/Boat Trip	1.780	0.372	0.626	0.662	0.976	0.975	2.309	1.596	2.111	2.262	1.144
Harv/Angler Trip	0.218	0.051	0.086	0.084	0.106	0.135	0.331	0.224	0.302	0.329	0.181
Catch/Angler Trip	0.358	0.071	0.123	0.127	0.187	0.191	0.444	0.302	0.405	0.431	0.222
Harv/Angler Hour	0.030	0.007	0.012	0.013	0.017	0.020	0.048	0.033	0.046	0.048	0.027
Catch/Angler Hr.	0.049	0.010	0.018	0.020	0.029	0.029	0.064	0.045	0.062	0.062	0.033
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.137	0.013	0.010	0.040	0.060	0.067	0.119	0.110	0.093	0.122	0.070
Catch/Boat Trip	0.400	0.083	0.097	0.147	0.394	0.384	0.370	0.441	0.870	0.563	0.257
Harv/Angler Trip	0.053	0.005	0.004	0.015	0.024	0.026	0.046	0.042	0.037	0.048	0.027
Catch/Angler Trip	0.156	0.033	0.036	0.057	0.155	0.148	0.143	0.168	0.344	0.221	0.097
Harv/Angler Hour	0.010	0.001	0.001	0.003	0.004	0.005	0.008	0.008	0.007	0.009	0.005
Catch/Angler Hr.	0.029	0.006	0.006	0.011	0.029	0.028	0.025	0.031	0.062	0.040	0.017

Table A20. Length and weight statistics for lake trout sampled April 15 - September 30 during the 1985-2017 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mean length and weight of lake trout sampled April - September:											
Mean Length (in)	25.1	26.5	25.1	23.4	25.5	26.3	25.9	27.2	27.5	27.5	26.9
Mean weight (lbs)	-	8.03	6.81	5.71	7.37	8.00	7.41	8.46	8.82	8.76	8.71
Percent length composition of lake trout sampled April - September:											
<15.0 inches	0.1%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.5%	0.0%	0.3%	0.0%
15-15.9 inches	0.1%	0.0%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%
16-16.9 inches	0.4%	0.0%	1.3%	1.6%	0.0%	0.0%	0.4%	0.0%	1.7%	0.0%	0.0%
17-17.9 inches	1.2%	0.0%	0.0%	4.1%	0.8%	0.9%	2.5%	0.0%	2.6%	1.2%	0.0%
18-18.9 inches	1.7%	0.0%	3.8%	7.3%	2.5%	3.4%	2.9%	0.0%	2.6%	1.8%	3.6%
19-19.9 inches	3.9%	2.0%	10.1%	2.4%	4.2%	1.7%	2.5%	1.8%	0.9%	2.1%	4.8%
20-20.9 inches	5.1%	0.0%	7.6%	10.6%	4.2%	2.6%	3.6%	0.9%	0.0%	2.6%	2.4%
21-21.9 inches	8.1%	6.0%	3.8%	13.0%	6.7%	6.8%	4.7%	1.4%	0.0%	5.3%	3.6%
22-22.9 inches	10.3%	14.0%	3.8%	9.8%	7.5%	4.3%	4.3%	5.1%	3.0%	5.6%	4.8%
23-23.9 inches	13.1%	14.0%	3.8%	14.6%	10.8%	3.4%	6.1%	4.1%	3.0%	2.9%	3.6%
24-24.9 inches	13.7%	6.0%	10.1%	4.9%	8.3%	6.8%	8.7%	8.8%	5.7%	1.8%	10.7%
25-25.9 inches	9.6%	6.0%	11.4%	3.3%	15.0%	14.5%	10.5%	11.5%	8.7%	5.9%	8.3%
26-26.9 inches	5.7%	6.0%	5.1%	5.7%	7.5%	11.1%	8.7%	13.8%	9.6%	7.6%	2.4%
27-27.9 inches	3.0%	10.0%	17.7%	1.6%	11.7%	15.4%	15.5%	10.6%	13.5%	13.2%	7.1%
28-28.9 inches	2.6%	12.0%	8.9%	7.3%	1.7%	5.1%	10.8%	12.9%	9.6%	9.7%	16.7%
29-29.9 inches	3.9%	6.0%	1.3%	4.1%	2.5%	4.3%	7.9%	11.1%	14.3%	10.0%	6.0%
30-30.9 inches	6.1%	4.0%	3.8%	4.1%	4.2%	7.7%	4.7%	7.8%	9.1%	11.1%	8.3%
31-31.9 inches	5.0%	0.0%	2.5%	1.6%	3.3%	7.7%	1.8%	3.7%	6.5%	5.3%	6.0%
32-32.9 inches	2.5%	6.0%	3.8%	2.4%	5.0%	0.9%	2.2%	1.4%	2.2%	4.4%	4.8%
33-33.9 inches	2.1%	4.0%	1.3%	0.0%	1.7%	0.0%	1.1%	2.8%	3.9%	3.2%	6.0%
34-34.9 inches	1.3%	2.0%	0.0%	0.0%	1.7%	2.6%	1.1%	1.4%	0.9%	4.1%	1.2%
>34.9 inches	0.7%	2.0%	0.0%	0.0%	0.8%	0.9%	0.0%	0.5%	2.2%	1.8%	0.0%
30.0+ inches	17.6%	18.0%	11.4%	8.1%	16.7%	19.7%	10.8%	17.5%	24.8%	29.9%	26.2%
25.0-29.9 inches	24.9%	40.0%	44.3%	22.0%	38.3%	50.4%	53.4%	59.9%	55.7%	46.3%	40.5%

Note: 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, a 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, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	47,275	11,104	6,833	4,892	6,442	5,683	7,536	12,538	2,942	3,701	2,305
Catch	240,407	50,727	30,494	18,048	25,795	24,032	21,446	31,807	16,821	26,719	12,079
% Harvested	21.0	21.9	22.4	27.1	25.0	23.6	35.1	39.4	17.5	13.9	19.1
Monthly estimates of harvest for all fishing boats:											
April	3	0	2	0	0	0	0	0	0	0	0
May	53	0	0	0	0	0	0	0	0	0	0
June	7,847	4,721	1,565	1,258	268	1,178	1,073	6,740	0	520	157
July	14,042	2,084	647	1,643	668	2,702	3,846	2,520	1,306	1,164	677
August	16,531	2,687	1,695	1,727	3,331	1,377	853	2,928	738	797	389
September	8,800	1,612	2,923	265	2,176	426	1,764	350	899	1,220	1,082
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	3,472	882	163	182	254	800	556	208	118	-	-
West/Central	3,201	376	108	43	261	36	48	176	-	-	-
East/Central	24,132	3,522	3,250	1,785	700	1,940	1,214	589	1,078	978	744
East	16,471	6,324	3,312	2,882	5,227	2,907	5,718	11,566	1,746	2,723	1,561
Monthly estimates of catch for all fishing boats:											
April	516	979	240	136	22	82	438	480	60	781	121
May	6,081	1,180	1,264	483	1,299	1,558	350	364	1,564	1,470	667
June	31,459	16,685	5,734	2,159	1,604	4,987	2,859	12,380	2,296	6,792	1,645
July	76,002	12,168	3,983	4,437	8,026	9,561	10,239	7,057	4,831	4,720	3,795
August	86,327	13,757	11,115	8,571	10,407	5,611	2,732	8,957	5,187	7,691	2,369
September	40,022	5,958	8,159	2,263	4,437	2,234	4,829	2,570	2,884	5,266	3,482
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	22,107	6,400	1,610	2,565	2,459	5,768	3,009	4,818	3,059	2,744	105
West/Central	35,059	2,140	2,143	384	799	1,048	634	672	1,013	253	298
East/Central	121,415	22,653	15,862	9,462	5,830	6,648	5,916	4,088	7,265	12,720	5,790
East	61,825	19,534	10,878	5,638	16,706	10,567	11,888	22,229	5,484	11,002	5,886
Percent of seasonal harvest and catch made by boats seeking smallmouth bass during the **traditional open season**:											
% Harvest	92.5	87.6	69.0	83.8	96.4	88.5	94.5	98.4	99.2	96.7	97.2
% Catch	87.3	77.7	58.2	62.6	78.1	85.9	86.4	91.8	82.4	78.6	77.3
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
May	-	196	422	28	0	196	0	0	1116	1293	449
June	-	88	24	55	502	24	146	195	48	1571	952
Total	-	284	446	83	502	220	146	195	1164	2864	1401
Percent of seasonal catch made by boats seeking smallmouth bass during the **catch and release season**:											
% Catch	-	0.6%	1.5%	0.5%	1.9%	0.9%	0.7%	0.6%	6.9%	10.7%	11.6%

Table A21b. Smallmouth bass harvest and catch rate data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal rates of harvest and catch for boats seeking smallmouth bass during the **traditional open season**:											
Harv/Boat Trip	1.945	0.760	0.544	0.700	0.992	0.811	1.667	1.794	0.599	0.676	0.976
Catch/Boat Trip	9.170	3.082	2.047	1.928	3.219	3.327	4.337	4.244	2.847	3.969	4.072
Harv/Angler Trip	0.845	0.341	0.250	0.339	0.451	0.372	0.784	0.868	0.295	0.300	0.460
Catch/Angler Trip	4.006	1.380	0.939	0.933	1.464	1.528	2.040	2.052	1.400	1.759	1.919
Harv/Angler Hour	0.251	0.117	0.097	0.126	0.145	0.120	0.226	0.242	0.104	0.096	0.161
Catch/Angler Hr.	1.195	0.472	0.363	0.346	0.471	0.492	0.587	0.572	0.493	0.565	0.671
Monthly harvest rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	1.759	1.807	0.877	1.948	0.259	0.701	1.188	3.514	0.000	0.548	0.559
July	1.667	0.401	0.125	0.694	0.225	0.943	2.716	1.355	0.550	0.748	0.824
August	2.206	0.702	0.399	0.498	1.886	0.829	0.823	1.256	0.621	0.385	0.621
September	2.185	0.530	1.070	0.305	2.353	0.585	1.384	0.384	1.122	1.268	1.617
Seasonal harvest rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	1.150	0.783	0.118	0.169	0.312	0.605	1.577	0.126	0.150	0.000	0.000
West/Central	0.816	0.107	0.074	0.065	0.333	0.000	0.085	0.289	0.000	0.000	0.000
East/Central	2.054	0.538	0.584	0.388	0.209	0.720	0.991	0.280	0.472	0.330	0.726
East	2.695	1.470	1.053	2.013	2.761	1.449	2.454	3.421	1.186	1.267	1.558
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	5.895	6.279	2.796	2.907	0.612	2.940	2.256	6.299	3.368	5.489	1.754
July	8.737	2.148	0.932	1.581	2.871	3.766	7.177	3.292	2.017	3.095	4.409
August	11.074	2.628	2.236	2.058	4.803	3.210	2.326	3.808	3.958	3.397	4.209
September	9.518	2.473	2.701	1.779	3.944	3.016	3.759	2.881	3.360	5.048	4.525
Seasonal catch rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	6.454	5.000	0.796	1.605	1.450	5.397	6.534	3.585	3.227	0.897	0.231
West/Central	7.726	0.732	1.031	0.514	0.739	0.534	1.043	0.775	0.122	1.833	1.144
East/Central	9.853	2.881	2.499	1.545	1.103	2.086	4.285	1.661	2.807	4.119	4.956
East	9.549	4.329	2.748	3.585	8.264	5.204	4.862	6.468	3.384	4.294	4.402
Seasonal catch rates for boats seeking smallmouth bass during the **catch and release season**:											
Catch/Boat Trip	-	0.774	0.693	0.284	2.100	0.422	0.764	0.661	7.098	8.045	7.076
Catch/Angler Trip	-	0.402	0.417	0.153	1.887	0.170	0.327	0.293	3.660	3.788	2.895
Catch/Angler Hr.	-	0.151	0.181	0.099	1.035	0.072	0.188	0.124	1.257	0.867	0.802
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **catch and release season**:											
April	-	-	-	-	-	-	-	-	-	-	-
May	-	4.558	1.323	0.118	0.000	0.590	0.000	0.000	10.731	13.061	5.684
June	-	0.272	0.074	1.000	2.523	0.127	1.390	0.878	0.800	6.113	9.520

Table A22. Yellow perch harvest and catch data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	9,490	33,589	51,653	18,405	31,830	16,701	6,572	6,066	6,960	10,483	5,204
Catch	22,178	67,342	102,442	61,816	65,394	35,836	15,345	17,966	17,384	18,176	19,459
% Harvested	52.0	49.9	50.4	29.8	48.7	46.6	42.8	33.8	40.0	57.7	26.7
Monthly estimates of harvest for all fishing boats:											
April	8	29	0	1,198	0	2,653	972	0	0	0	840
May	983	1,357	0	7,656	112	4,203	2,016	0	0	25	88
June	1,953	10,349	34,963	3,665	2,194	6,116	973	0	24	1,150	56
July	2,103	3,612	2,810	1,906	5,637	1,913	304	2,453	6,042	7,062	1,848
August	1,777	6,114	7,816	3,648	16,979	1,755	2,040	3,535	12	40	1,041
September	2,666	12,128	6,064	332	6,908	61	267	78	882	2,205	1,332
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	1,934	61	-	468	-	14	0	0	0	0	1,188
West/Central	891	3,824	1,035	1,080	30	2,816	1,136	-	759	2,014	-
East/Central	5,156	26,845	19,372	9,762	22,363	7,814	4,227	3,050	6,104	8,411	2,810
East	1,509	2,858	31,246	7,094	9,438	6,057	1,209	3,016	97	58	1,205
Monthly estimates of catch for all fishing boats:											
April	51	69	143	1,962	0	5,293	2,172	-	0	0	1,120
May	1,909	3,443	95	37,864	112	10,211	4,420	-	0	476	88
June	4,933	25,153	52,025	5,287	5,055	13,440	1,921	1,800	264	2,115	80
July	4,810	8,637	10,792	4,371	14,419	2,508	923	7,691	13,740	9,766	3,086
August	4,470	10,494	23,739	11,735	29,676	4,298	5,642	8,241	781	511	6,440
September	6,005	19,545	15,648	596	16,132	86	267	234	2,599	5,307	8,646
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	2,719	77	2,444	906	-	49	-	0	0	0	1,601
West/Central	1,997	5,999	1,749	2,026	193	4,384	3,890	45	2,411	5,399	332
East/Central	14,150	51,333	58,517	40,091	50,878	20,510	9,527	10,439	14,131	12,303	10,187
East	3,313	9,933	39,732	18,793	14,323	10,893	1,928	7,482	842	474	7,339

Table A23. Walleye harvest and catch data collected April 15 – September 30, 1985-2017.

	Year Surveyed										
	1985-07 avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seasonal (5½ month) estimates of harvest and catch for all fishing boats:											
Harvest	682	116	123	106	458	130	318	182	350	349	152
Catch	956	130	147	301	531	130	388	421	446	671	208
% Harvested	71.5	89.2	83.7	35.2	86.3	100.0	82.0	43.2	78.5	52.0	73.1
Monthly estimates of harvest for all fishing boats:											
April	0	0	0	0	0	0	0	0	0	0	0
May	99	28	14	0	16	50	0	50	26	63	88
June	101	32	0	0	26	0	23	12	0	0	0
July	50	28	0	0	88	80	0	0	0	0	0
August	335	28	109	44	160	0	27	120	252	286	0
September	97	0	0	62	168	0	267	0	72	0	64
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	63	29	44	106	86	84	0	92	246	247	0
West/Central	4	32	0	0	0	22	21	0	0	0	0
East/Central	54	56	14	0	0	0	0	40	0	12	17
East	561	0	66	0	372	24	297	50	104	91	135
Monthly estimates of catch for all fishing boats:											
April	12	0	10	0	15	0	0	0	12	0	0
May	125	28	28	0	16	50	0	50	26	63	132
June	235	32	0	0	26	0	23	12	0	0	0
July	84	28	0	0	147	80	70	0	0	0	12
August	388	42	109	213	160	0	27	338	336	608	0
September	111	0	0	87	168	0	267	22	72	0	64
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	113	43	47	180	142	84	59	163	327	572	49
West/Central	6	32	0	0	0	22	22	165	0	0	0
East/Central	84	55	29	0	20	0	0	41	0	11	31
East	753	0	71	121	369	24	306	51	119	88	128

Table A24. Estimates of sea and silver lampreys observed by boat anglers April 15 – September 30, 1986-2017.

	Year Surveyed										
	1986-07 avg.	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
April 15 - September 30 estimated numbers of lamprey observed:											
April	232	87	218	429	558	575	68	100	118	199	260
May	707	688	1,769	551	1,618	1,266	835	595	775	363	505
June	365	296	150	372	769	294	353	384	212	92	102
July	476	390	1,358	486	1,155	460	789	567	460	730	589
August	667	954	1,142	697	842	707	829	951	767	199	685
September	201	399	526	64	184	138	53	401	63	97	237
Total	2,647	2,814	5,164	2,599	5,125	3,441	2,927	2,998	2,375	1,680	2,380
April 15 - September 30 estimated numbers of lamprey observed among four geographic areas:											
West	1,036	1194	2026	946	1,163	1147	969	894	1,251	766	634
West/Central	317	18	540	338	565	609	396	308	267	49	405
East/Central	752	845	2126	799	1,812	1007	1,242	976	510	728	1,027
East	543	757	472	516	1,585	678	320	819	347	137	314
Percentage of lamprey observed that were attached to angler caught trout and salmon:											
Percent	99.0%	98.3%	97.0%	98.9%	96.8%	97.9%	98.4%	98.3%	99.1%	96.6%	100.0%
April 15 - September 30 estimated number of lamprey attached to angler caught trout & salmon, per 1000 trout & salmon caught:											
April	12.28	23.32	19.36	48.73	45.60	29.72	9.28	5.16	11.35	12.18	35.26
May	15.37	27.82	23.08	26.78	45.50	34.03	22.70	12.93	13.55	14.48	30.33
June	15.42	23.58	12.67	19.85	34.61	12.13	17.58	13.31	16.06	5.98	11.12
July	15.15	16.74	38.27	10.50	14.04	10.83	19.18	16.88	19.18	17.64	13.71
August	12.95	22.87	20.45	11.08	16.68	12.63	15.41	16.91	22.21	7.51	10.15
September	9.85	20.28	16.30	6.34	9.57	7.95	5.46	24.00	4.17	7.16	12.68
Total	13.98	22.39	23.12	15.53	23.09	17.50	17.34	14.93	15.38	12.15	14.66
April - Sept. estimated number of lamprey attached to angler caught trout & salmon by geographic area, per 1000 trout & salmon caught:											
West	14.57	20.78	19.49	13.13	12.43	15.56	14.25	13.41	17.85	13.41	10.17
West/Central	13.17	2.32	17.93	15.27	25.57	23.22	15.01	8.72	14.38	3.13	19.29
East/Central	14.00	27.19	34.19	15.44	26.87	20.53	25.33	16.10	13.04	16.90	17.94
East	13.89	25.75	17.46	24.03	40.76	14.24	12.58	21.47	13.03	6.11	14.43
April 15 - September 30 percent composition of host species to which the lampreys were attached:											
Coho Salmon	2.5%	4.3%	2.6%	3.2%	3.4%	2.9%	1.6%	2.6%	0.0%	0.0%	2.0%
Chinook Salmon	40.7%	64.3%	73.1%	51.6%	37.4%	60.0%	68.8%	58.1%	64.8%	60.7%	51.0%
Rainbow Trout	7.1%	10.4%	10.9%	14.0%	5.6%	8.6%	5.6%	18.8%	10.2%	7.1%	8.2%
Atlantic Salmon	0.6%	0.0%	0.0%	3.2%	0.0%	2.1%	0.0%	0.0%	0.0%	1.2%	1.0%
Brown Trout	17.6%	20.0%	13.5%	26.9%	47.5%	22.1%	13.6%	17.9%	12.0%	19.0%	35.7%
Lake Trout	31.6%	0.9%	0.0%	1.1%	6.1%	4.3%	10.4%	2.6%	13.0%	11.9%	2.0%
April 15 - September 30 percent of total host-specific angler catch with attached lampreys:											
Coho Salmon	0.6%	1.8%	0.6%	0.6%	1.4%	0.8%	0.6%	0.9%	0.0%	0.0%	0.5%
Chinook Salmon	1.7%	3.1%	3.5%	2.1%	1.9%	2.3%	3.1%	2.2%	2.6%	1.6%	1.3%
Rainbow Trout	0.8%	0.8%	1.0%	0.8%	0.8%	0.9%	0.5%	1.5%	1.4%	0.7%	0.9%
Atlantic Salmon	4.5%	0.0%	0.0%	4.5%	0.0%	12.2%	0.0%	0.0%	0.0%	2.7%	6.2%
Brown Trout	1.4%	2.4%	2.0%	2.1%	4.7%	1.9%	1.4%	1.2%	1.4%	1.4%	5.0%
Lake Trout	1.2%	0.3%	0.0%	0.2%	1.3%	0.7%	0.8%	0.2%	0.6%	0.5%	0.3%

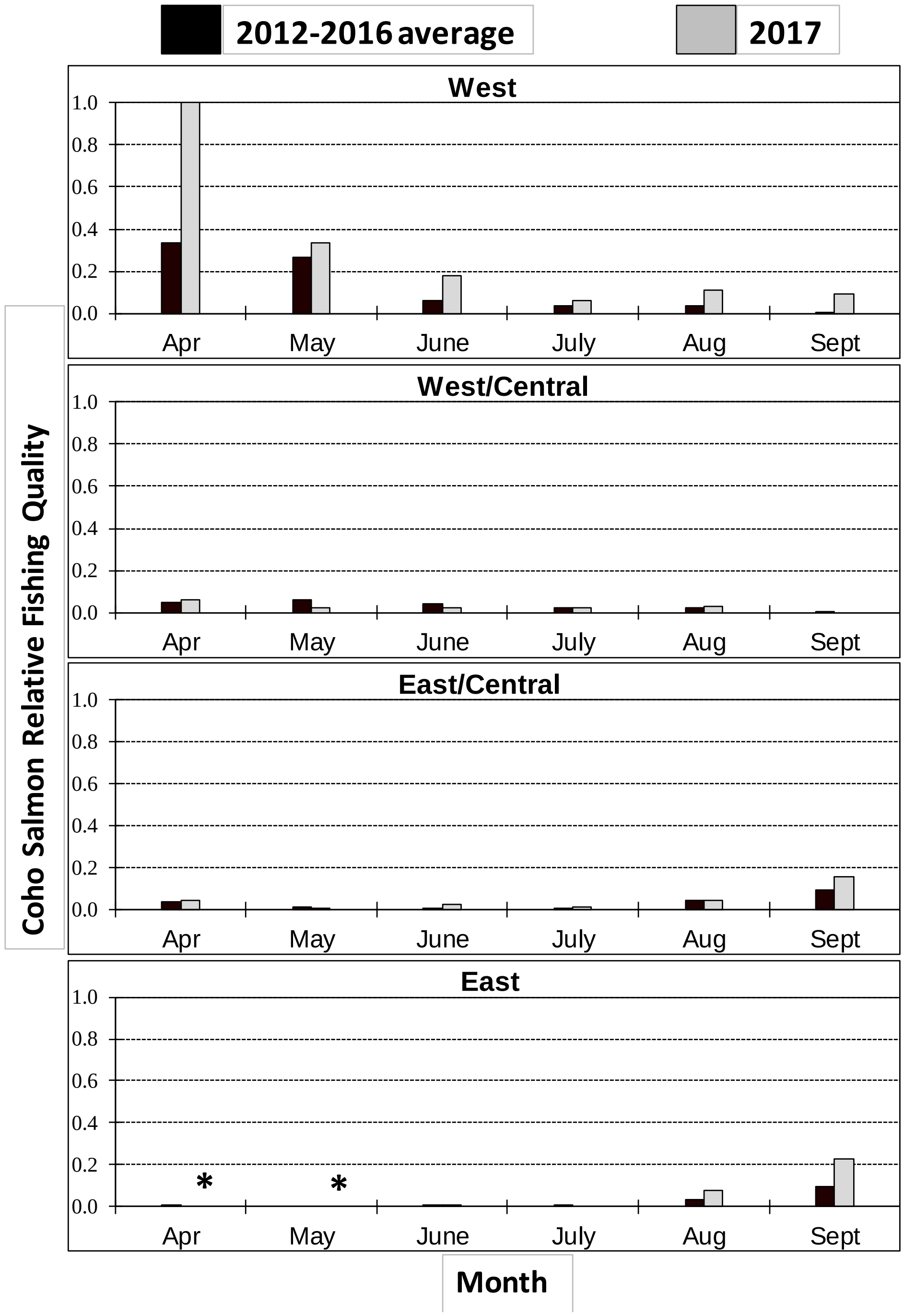

Figure A1. Coho salmon relative fishing quality in the West, West/Central, East/Central, and East areas of Lake Ontario, April - September 2017 and the previous 5-year average (2012-2016). * indicates low sample size; i.e., 7 and 11 interviews from boats targeting trout and salmon in the East region during April and May 2017, respectively.

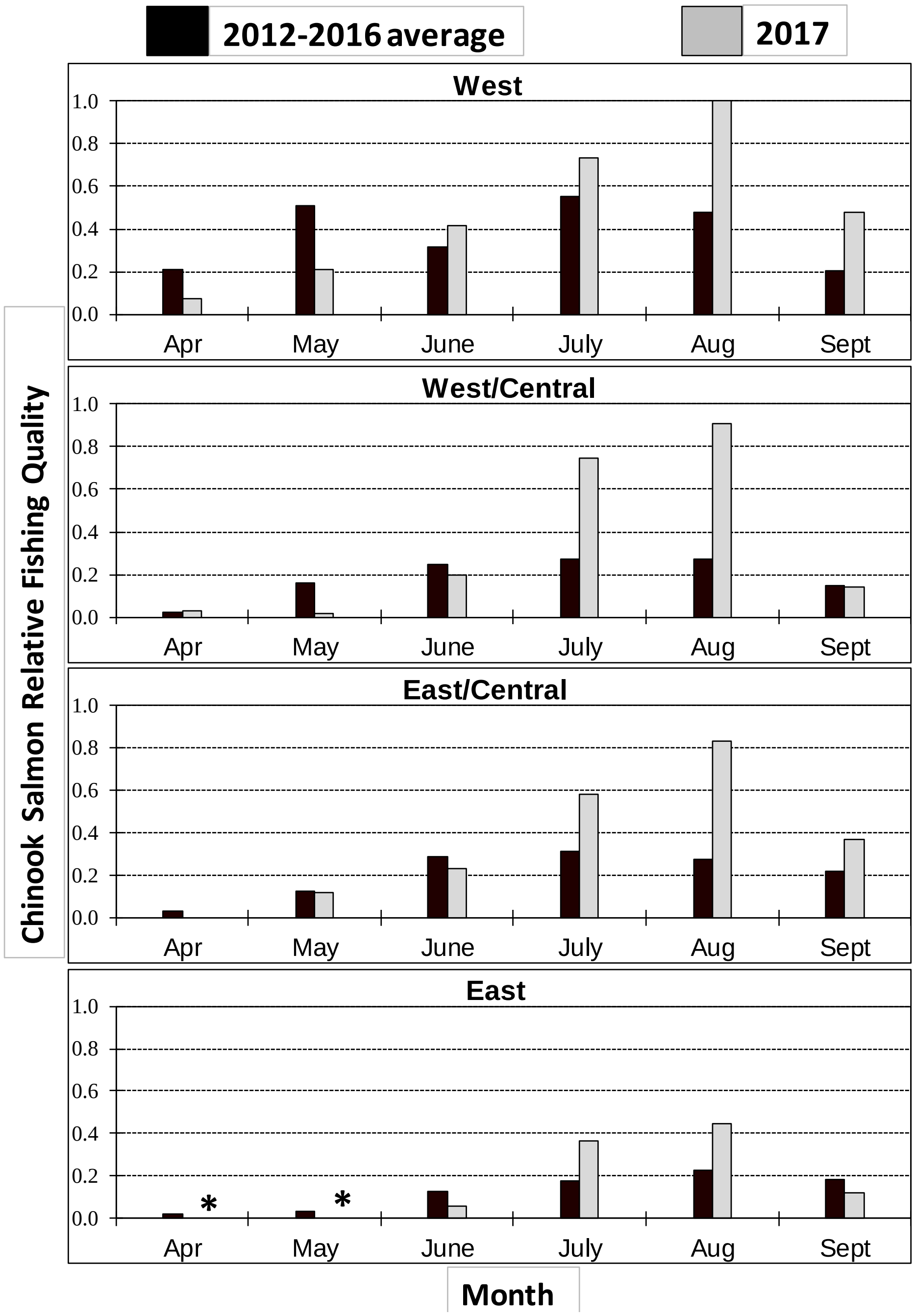

Figure A2. Chinook salmon relative fishing quality in the West, West/Central, East/Central, and East areas of Lake Ontario, April - September 2017 and the previous 5-year average (2012-2016). * indicates low sample size; i.e., 7 and 11 interviews from boats targeting trout and salmon in the East region during April and May 2017, respectively.

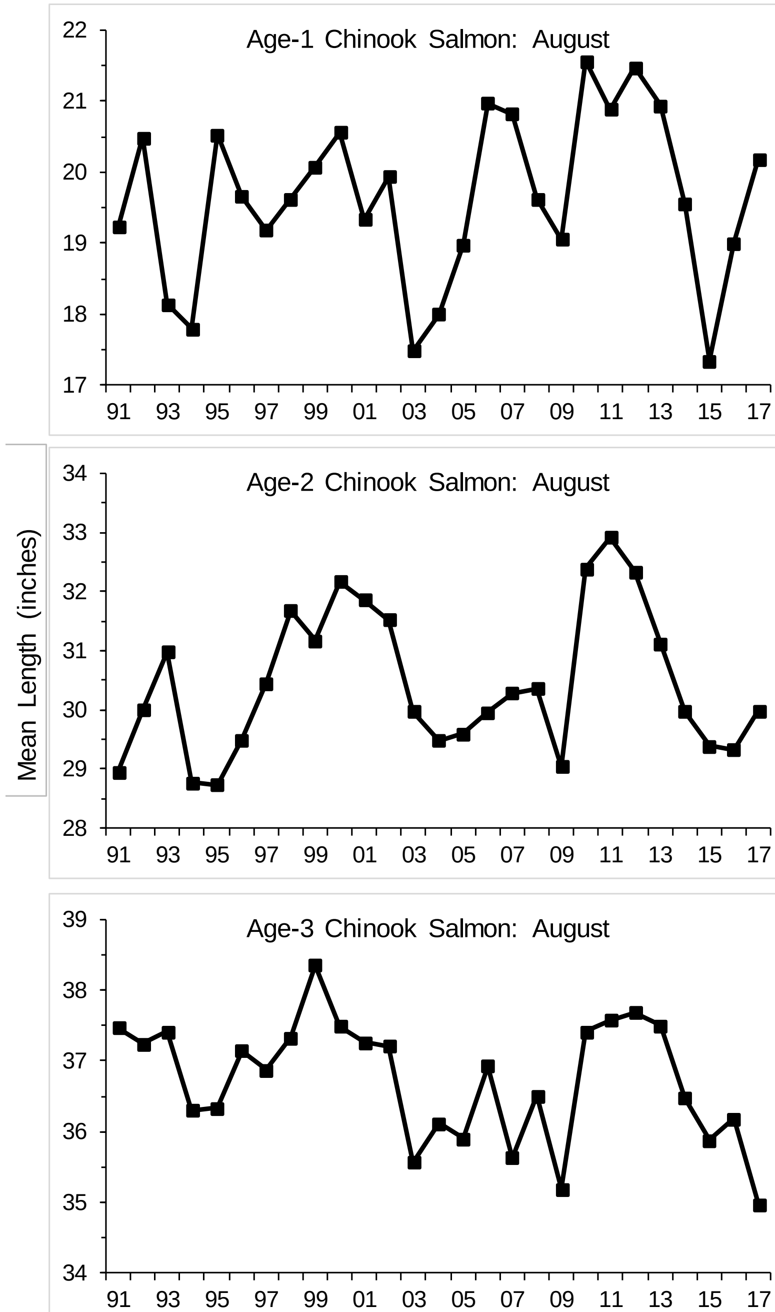

Figure A3. Mean length (total length in inches) of age-1, age-2, and age-3 Chinook salmon sampled in August during the 1991-2017 NYSDEC Lake Ontario fishing boat surveys.

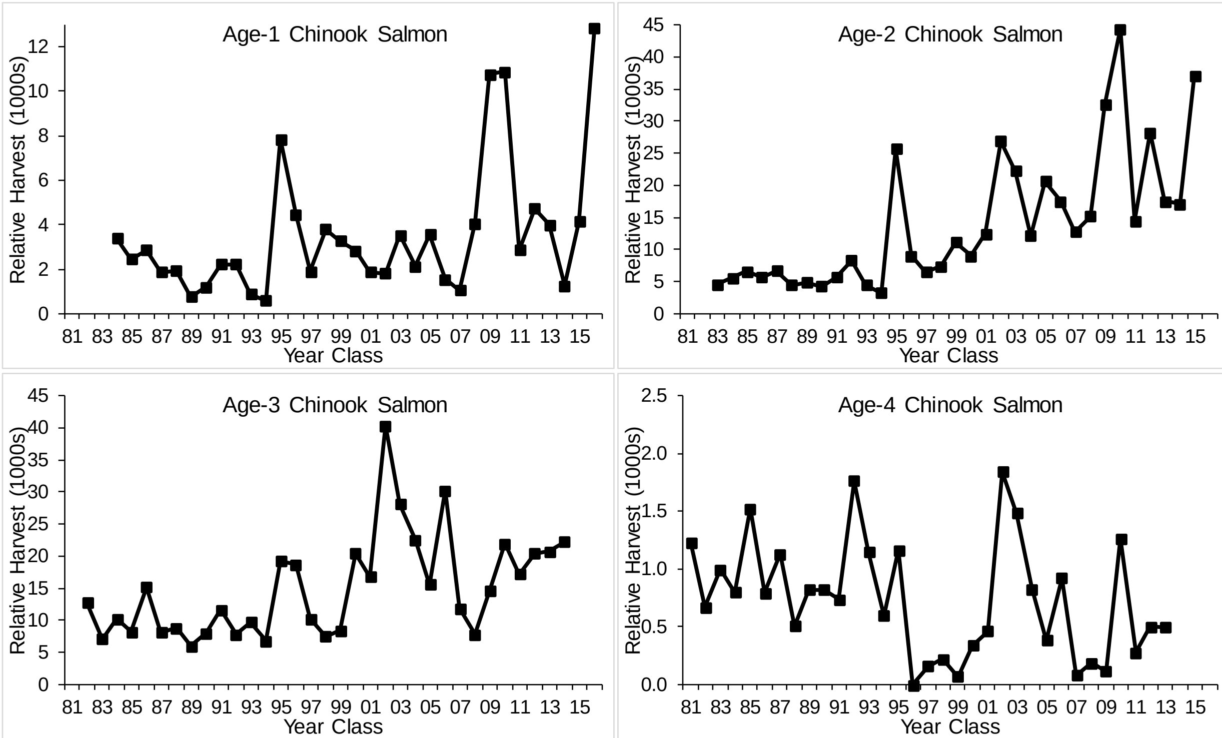

Figure A4. Relative harvest (age-specific harvest per 50,000 fishing boat trips, per 2,000,000 fingerling equivalents stocked) of age-1, age-2, age-3, and age-4 Chinook salmon from the 1985-2017 NYSDEC Lake Ontario fishing boat surveys.

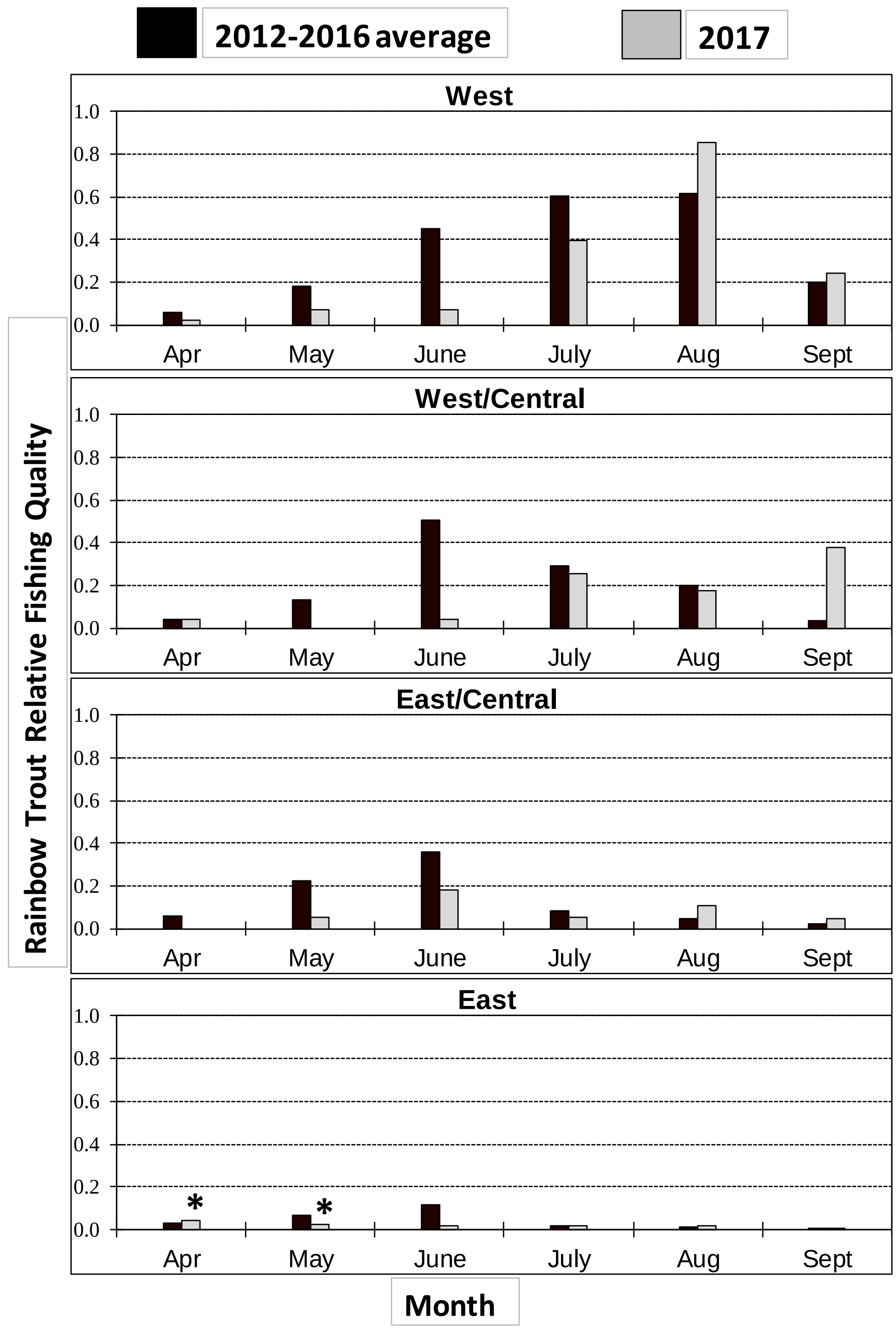

*Figure A5. Rainbow trout relative fishing quality in the West, West/Central, East/Central, and East areas of Lake Ontario, April - September 2017 and the previous 5-year average (2012-2016). * indicates low sample size; i.e., 7 and 11 interviews from boats targeting trout and salmon in the East region during April and May 2017, respectively.*

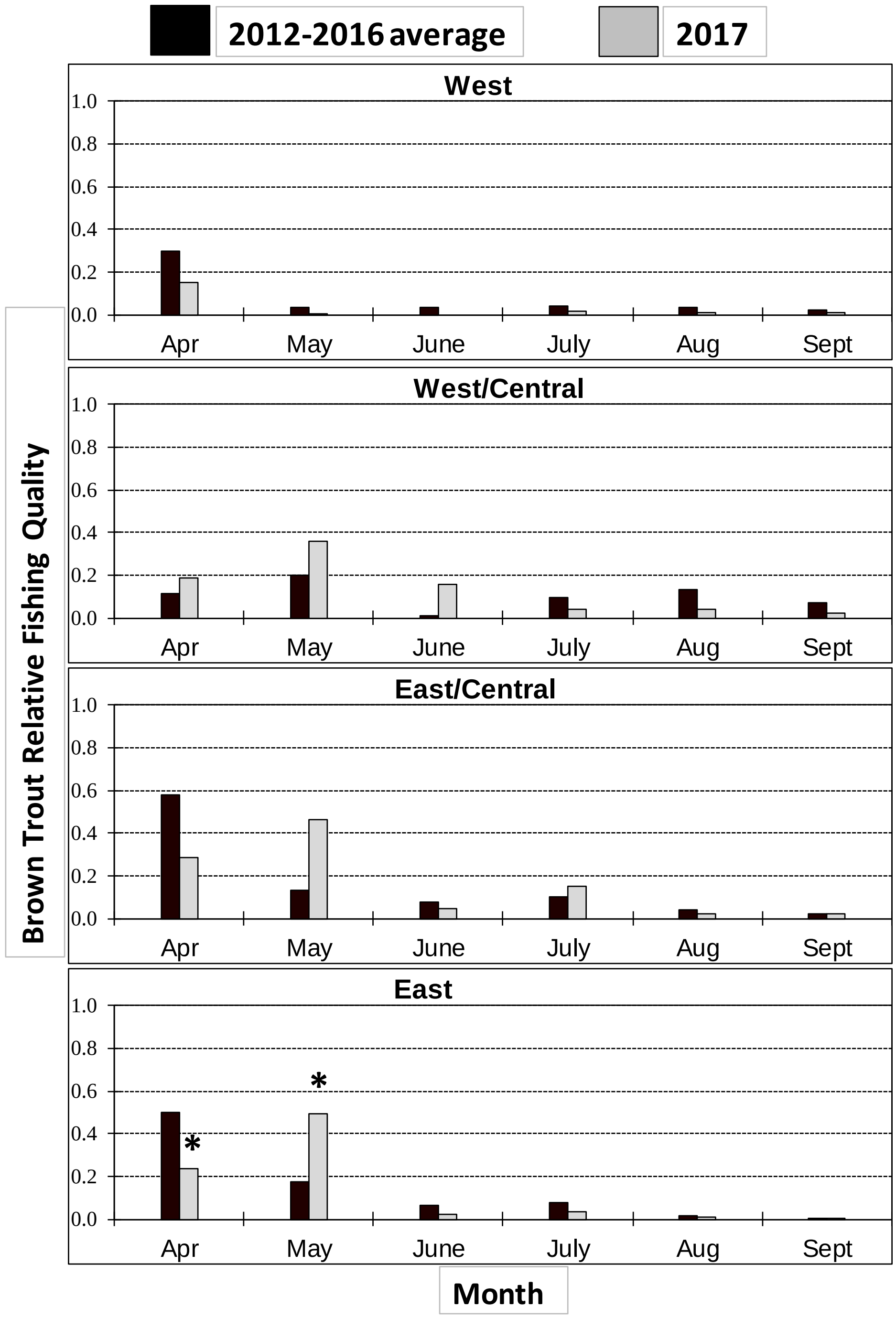

Figure A6. Brown trout relative fishing quality in the West, West/Central, East/Central, and East areas of Lake Ontario, April - September 2017 and the previous 5-year average (2012-2016). * indicates low sample size; i.e., 7 and 11 interviews from boats targeting trout and salmon in the East region during April and May 2017, respectively.

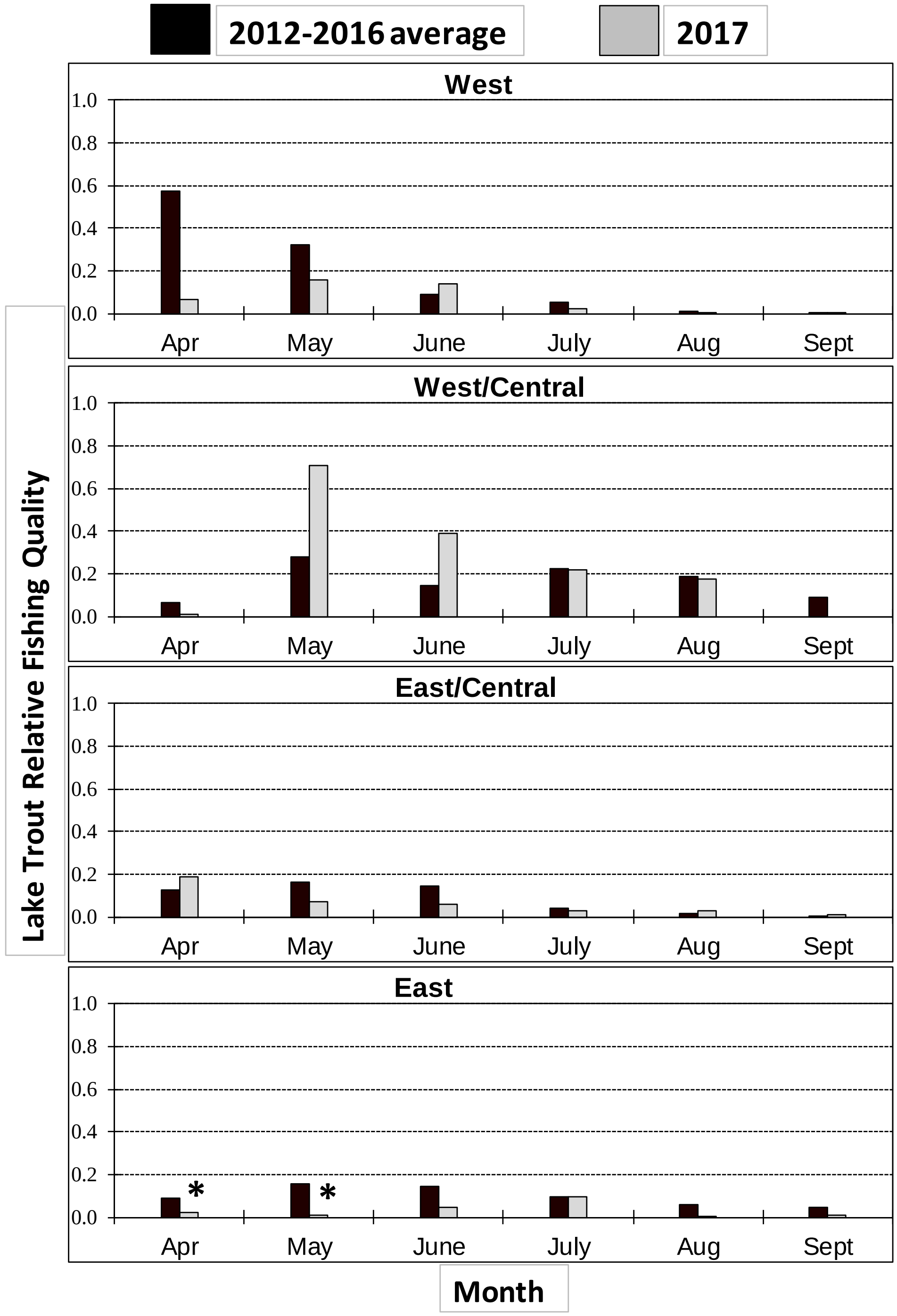

*Figure A7. Lake trout relative fishing quality in the West, West/Central, East/Central, and East areas of Lake Ontario, April - September 2017 and the previous 5-year average (2012-2016). * indicates low sample size; i.e., 7 and 11 interviews from boats targeting trout and salmon in the East region during April and May 2017, respectively.*

Relative Straying of Pen-Reared and Direct-Stocked Chinook Salmon in Lake Ontario

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Chinook salmon (*Oncorynchus tshawytscha)* is the top predator in Lake Ontario and supports a multi-million dollar sportfishery in New York State and the Province of Ontario, Canada. Each year, the New York State Department of Environmental Conservation (NYSDEC) and the Ontario Ministry of Natural Resources and Forestry (OMNRF) stock 2.3 million Chinook salmon into Lake Ontario at dozens of sites around the lake. An unknown number of wild Chinook salmon 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. 2017). Recent mass marking studies in Lake Ontario determined that wild Chinook salmon makeup an important component of the lake and tributary Chinook fisheries averaging 47% of the lake fishery for the three year classes studied (Connerton et al. 2016).

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 (i.e. "homing") at the site where they smolted. Stocking size may be one factor affecting imprinting since this generally occurs during parr-smolt transformation (Keefer and Caudill 2012, 2014). 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 stocking strategies attempt to balance the benefits of higher survival gained by stocking larger fish against the risks of stocking fish after they have imprinted on the hatchery's water.

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 approximately 350,000 Chinook salmon annually at the Salmon River to provide a fishery and an adequate supply of spawning fish to the SRH. Fingerlings for SRH 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 Salmon River in June. Fingerlings stocked at other sites around the lake are stocked prior to smolting in April-May to maximize imprinting to the stocking site.

One strategy used by NYSDEC since 1998 to increase imprinting to stocking sites and improve survival of stocked fish is pen-rearing, a technique in which small Chinook salmon (120 fish/lb, ~3.5 g) are stocked into net pens and fed by volunteers for about 3 weeks until they reach a target size (i.e., 90 fish/lb, ~5 g). Chinook salmon pen-rearing projects currently exist at nine sites in New York (Figure 1; (Todd et al. 2018). Chinook salmon smolts raised in net pens are released at sizes larger than salmon stocked directly from the hatchery on or about the same date. Pen-reared salmon also become better acclimated to environmental conditions at stocking sites and were assumed to exhibit higher survival and better imprinting to the stocking site. These assumptions were tested by studies conducted by NYSDEC on the 2010, 2011, and 2013 Chinook salmon year classes (Connerton et al. 2017). Pen-rearing provided an average of 2.1 greater contribution per number stocked to the lake fishery than direct-stocking for the three year classes studied, suggesting that pen-rearing improved survival. After accounting for survival differences in the lake, average return ratios to tributaries by pen-reared vs. direct-stocked salmon averaged 1.1 for those year classes, with significantly better returns to tributaries by pen-

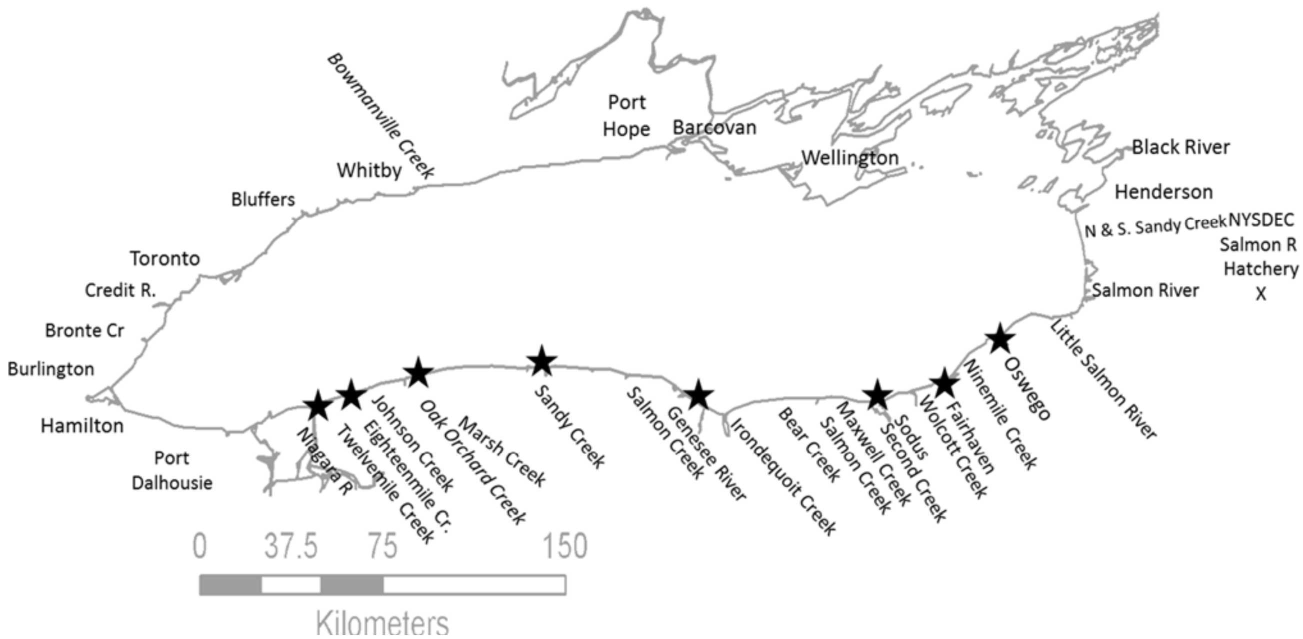

Figure 1. Map of Lake Ontario showing sampling regions and other locations in this report. Sites where Chinook salmon were raised in pens are noted with stars.

reared fish at some sites in some years, but imprinting differences between stocking methods were not conclusive overall. In general, results of returns to tributary stocking sites indicated that both pen-reared and direct-stocked fish were imprinting to the tributary at which they were stocked. Moreover, when straying occurred, the majority of strays typically returned to nearby tributaries, and contributed to local fisheries.

The degree that stocked fish stray or home to SRH or to other stocking sites in Lake Ontario and the inter-annual or among-site variability was previously unknown; however, Connerton et al. (2016) estimated that straying from NY stocking sites to the SRH averaged 10.6% for the 2008-2010 year classes. These results necessarily assumed equal survival and straying among all stocking sites because fish were clipped but not all were tagged, so identification of individual stocking sites was not possible. However, we know now that survival is not equal among sites or stocking strategies (Connerton et al. 2017), and the level of straying by pen-reared and direct-stocked fish to the SRH, or among sites, may also be different. In this report we compare straying by pen-reared and direct-stocked fish to SRH or to other sites while accounting for differential lake-survival. Our objectives were: 1) to compare the relative numbers of pen-reared and direct-stocked Chinook straying in tributaries; and 2) to compare the relative numbers of pen-reared and direct-stocked Chinook straying to the SRH.

Methods

<u>Mass Marking</u>

In 2008, NYSDEC purchased an automated fish-marking trailer (AutoFish) from Northwest Marine Technology Incorporated. The AutoFish system can clip the adipose (AD) fin and/or apply coded wire tags (CWTs) to salmon and trout automatically at a high rate of speed and accuracy (referred to as "mass marking"). Mass marking of Lake Ontario Chinook salmon was conducted from 2008-2013 (Table 1) by NYSDEC and OMNRF for various studies summarized previously (Connerton et al. 2016, 2017, and OMNRF 2015).

Previous reports described mass marking methods, marking quality control, field and hatchery sampling, and data analyses (Connerton et al. 2015, Connerton et al 2017). For this report, we briefly describe each, and include additional details for data analysis since these were somewhat different than previous reports.

To meet pen study objectives, Chinook salmon were AD clipped and tagged with unique CWTs at each of eight pen-reared and direct-stocked sites (16 total) in 2010, 2011, and 2013 (Table 2). Marking and tagging of pen-reared and direct-stocked Chinook 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 (Table 1). At Oswego in 2013, AD-CWT fish in pens were released three days after being stocked into pens because of warm temperatures. Approximate numbers of marked fish for this study are provided in Table 2, but actual stocking numbers varied slightly, and these numbers are provided in Connerton (2011, 2012, and 2014). A ninth NY pen site at Wilson was added after the study was conducted (Todd et al 2018).

Different sites have different numbers of Chinook 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. We also planned for adequate numbers of marked fish to maximize the chances of recapturing enough fish to detect at least a 20% difference (if one exists) between treatments at $\alpha=0.05$ with a power of at least 80%. This threshold 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-reared 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 target for the site, some fish with only an AD clip were added to meet the stocking target for that site (Table 2).

Pen-reared 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 one aim of this study. For details of locations, pen-rearing sizes and dates of stocking and release, see (Wilkinson et al. 2011, 2012, and 2014).

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

Notes: No marking was done in 2012.
*Sandy Creek Pen/Direct site was not marked in 2013.

Mean stocking dates at direct sites were May 14th, 12th, and 24th; and mean dates of release at pen sites were May 8th, 13th, and 18th in 2010, 2011, and 2013, respectively.

Marking Quality Control

The AutoFish system's built-in quality control features verified removal of the adipose fin and checked for the presence of a CWT for each fish. Fish marked AD-CWT were returned to the hatchery, but fish without an AD clip and/or CWT were rejected and sent to a holding area where they were manually clipped and tagged. In addition, marking quality was manually verified by agency staff during AutoFish operation from 2008-2013. Each raceway of fish received a unique CWT code. Although tagged fish rarely shed their CWT, it is most likely to occur within 30 days after 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.

Field and Hatchery Sampling

In New York, angler harvested Chinook salmon were sampled as part of the New York Lake Ontario Fishing Boat Survey which conducted stratified random

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-reared vs. direct stocking methods.

	Pen-reared						**Direct-stocked**				
Site	**# fish AD-CWT**	**# Fish AD only**	**Pen Total**	**#lots**	**# Pens**	**# Fish/Pen**	**# fish AD-CWT**	**# Fish AD only**	**Direct Total**	**#lots**	**Total**
Black River	-	-	-	-	-	-	-	159,000	159,000	-	159,000
South Sandy	-	-	-	-	-	-	-	100,000	100,000	-	100,000
Salmon River	-	-	-	-	-	-	-	352,000	352,000	-	352,000
Oswego River	37,500	4,390	41,890	1	2	20,945	37,500	60,310	97,810	1	139,700
Fairhaven	25,000		25,000	1	1	25,000	25,000	62,200	87,200	1	112,200
Sodus Bay	37,500	12,500	50,000	1	2	25,000	37,500	22,500	60,000	1	110,000
Genesee River	75,000	10,250	85,250	2	4	21,313	75,000	10,250	85,250	2	170,500
Sandy Creek[#]	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).

[#] Sandy Creek pen site was too warm in 2013 so pen-reared and direct-stocked fish were not marked or tagged at this site in 2013.

sampling of low, medium, and higher effort channels from April - September each year of the study (Lantry and Eckert 2017). An additional 2-4 technicians were deployed in each year of the study specifically to process Chinook salmon for clip and CWT recovery during the lake and tributary angling seasons. Their efforts focused on high-use angling ports, fishing derbies, cleaning stations, and pen evaluation sites. At some ports, charter captains 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, 2011-2016), additional technicians (6-8) were assigned to visit each pen site tributary at least 15 days during the spawning run. Recovery efforts 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).

Other smaller tributaries were also sampled either directly by technicians or indirectly via angler harvest. Since most fish were sampled from fish cleaning stations, anglers were asked where their fish were caught to identify and record capture locations. Recovery efforts also included walking streams to sample anglers' harvest, sampling salmon carcasses in the streams (2012-2016), and electrofishing some streams (2013-2016). All Chinook salmon sampled were measured for length, checked for clips and scanned for the presence of a CWT. Also, in 2011-2016, freezers were placed at six locations along the lake for cooperating anglers to place Chinook salmon heads. All snouts with CWTs were sent to the U.S. Fish and Wildlife Service's Great Lakes Fish Tag and Recovery Laboratory (GLFTRL) in New Franken, WI for processing.

At the SRH, Chinook salmon were randomly sampled as part of annual monitoring of growth and condition from 2011-2017 (Prindle and Bishop 2018). Some additional adipose-clipped Chinook were also sorted annually at SRH and checked for the presence of a coded wire tag to increase sample size for comparing strays of pen-reared and direct-stocked salmon from individual sites, and for evaluating the percent composition of strays at the hatchery from all sites.

<u>Data Analyses</u>

We were principally interested in three questions: 1) do direct-stocked Chinook salmon stray to the SRH more than pen-reared Chinook salmon; 2) do direct-stocked Chinook salmon stray more among tributaries than pen-reared Chinook salmon; and 3) do fish from some stocking sites stray to the hatchery consistently more than others? Since size has been shown to be a factor in parr-smolt transformation and imprinting (Keefer and Caudill 2012), theoretically, if direct-stocked salmon are held in the hatchery longer, a greater proportion of these fish may undergo parr-smolt transformation and imprinting to the hatchery than pen-reared fish which are typically moved to stocking sites about three weeks earlier. Therefore, we would expect relatively more strays from the direct group. However, this may depend on the stocking timing and the size of the direct-stocked salmon at stocking time relative to size of pen-reared fish when transferred to rearing pens. Conversely, since pen-reared salmon are moved to the site earlier and at a smaller size than direct-stocked salmon at stocking time, the pen group may imprint to the stocking site and stray less among tributaries and to the hatchery than the direct group. A third possible outcome would be if both groups are moved to the site prior to parr-smolt transformation so that no difference is observed in the numbers of strays.

Straying by Pen-reared vs Direct-stocked Chinook salmon to SRH

To compare straying of pen-reared and direct-stocked Chinook salmon from the eight pen-rearing sites (Figure 1, Table 2) to the SRH, we sampled Chinook salmon at SRH in each year from 2011-2017 to recover CWTs from straying Chinook. For each site, and each year class (YC), we tested whether the observed ratios of pen-reared to direct-stocked Chinook salmon strays at SRH were different than expected based on stocking ratios. For each tagging location and for each stocking origin (pen or direct), the total number of salmon recovered was divided by the numbers stocked according to their stocking origin (pen or direct) to adjust for different numbers stocked at the sites and to permit comparison of straying.

Since we were interested in evaluating straying only, numbers of straying pen-reared (P) and direct-stocked (D) fish were also adjusted to account for differential, open lake-survival of these treatments. Previous analysis showed that the Chinook population in Lake Ontario from April-July during the study was mixed, i.e., harvest at ports consisted of fish stocked at many locations (Connerton et al 2017), so recoveries during this period were considered unbiased towards any specific site. Therefore, we tabulated recoveries from April-July each year and determined the recoveries per number tagged (R) for each treatment (YC, site, and stocking method) and age to represent relative lake-survival of Chinook salmon. Since this ratio changed with age within a single YC, we used the age specific recovery ratios for each site and YC for survival adjustments.

To permit comparisons of straying to the hatchery by pen-reared (P) and direct-stocked (D) Chinook salmon while accounting for differential lake-survival, we standardized numbers of strays (S) for each site, YC, and age by multiplying the number of direct strays (N_D) times the ratio of pen to direct lake recoveries for that site, YC and age using equation (1):

$$S_{D(site,YC,age)} = N_{D(site,YC,age)} \text{ x } P_{(site,YC,age)}/D_{(site,YC,age)} \quad (1)$$

Straying by Pen-Reared vs Direct-Stocked Chinook salmon in Tributaries

To compare straying of pen-reared and direct-stocked Chinook salmon from the eight pen-rearing sites (Figure 1, Table 2) to other tributaries, we sampled Chinook salmon from September to November 2011-2016 at each pen site tributary and at additional streams (Figure 1). For each tagged Chinook sampled, we determined the stocking origin (as above), age, and year class from the retrieved CWT. We classified each recovered fish as being caught where stocked, nearby (within 20 miles of its stocking location), or at a site distant to the stocking location (>20 miles). We classified strays at nearby and distant sites separately because we hypothesized that the results may be different if incomplete homing (Keefer and Caudill 2012, 2014) was happening in which stocked Chinook were imprinting to stocking locations and to nearby watersheds. We considered fish as strays if they were caught in streams other than where they were stocked (nearby and distant) and compared the total number of strays in tributaries from pen-rearing and direct stocking methods for each of eight stocking sites.

As done with the strays to the hatchery, for each treatment, the total number of salmon recovered was divided by the number tagged according to their stocking origin to adjust for different numbers stocked at the sites and to permit comparison of straying. Since we were interested in evaluating straying only, numbers of straying pen-reared and direct-stocked salmon were adjusted to account for differential, open lake-survival of these treatments. We standardized the number of strays for each YC by multiplying the number of strays by the ratio of pen-reared and direct-stocked recoveries for that site from the lake fishery (equation 1).

For both SRH and tributary comparisons, pooling samples across years (i.e., across ages within treatments) would not be appropriate if survival or catchability of the fish from the pen or 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. If not homogenous, samples were tested separately for differences. The recovery ratios of pen-reared to direct-stocked salmon sampled at each tributary were calculated and compared to stocking ratios using chi-square Goodness of Fit tests. Logically, recovery ratios should equal stocking ratios if no differences in returns (i.e., imprinting) exist between the stocking methods. We assumed that recoveries were not biased toward fish of either group and that early hatchery rearing was identical prior to stocking (Elrod and Frank 1990). All statistical analyses were conducted using R software version 3.3.2 (R Core Development Team 2016). Post-hoc tests for homogeneity among ages were done using the R package *fifer* (Fife 2017).

Percent Composition of Strays at SRH by Site

Previous research estimated straying rates from all stocking sites to the SRH averaged 10.6% from 2008-2010 (Connerton et al. 2015). That analysis necessarily assumed fish from all sites survived and strayed equally, but we know now that this is not true based on comparisons of pen and direct Chinook salmon recoveries in the Lake (Connerton et al., 2017). From 2011-2017, tagged Chinook salmon were sampled at SRH, and recoveries were compared to provide insights into site specific straying to the hatchery. The number of strays were tabulated for each treatment (YC, stocking site, method) by age and standardized for differential lake-survival among treatments as described above. However, instead of using the R_P:R_D ratio for each YC, site, and age to adjust for lake-survival, we determined the maximum R in one YC and age among all sites and then calculated the ratio of the maximum R (R_{max}) to the R for each treatment ($R_{Treatment}$). This ratio, $R_{max}/R_{(Treatment,\ Age)}$ was multiplied by the number of strays for each treatment and age to standardize the number of strays among all sites within one YC, and then divided by the number tagged for each treatment. Percent composition of each treatment was calculated to provide insights into the relative straying of sites and pen-reared and direct-stocked Chinook to the hatchery. Percent composition was calculated as the total number of strays for each treament divided by the total numbers of strays from all sites for each YC (each adjusted for numbers tagged and differential lake-survival).

Table 3. Quality control results during operation of the AutoFish trailer at Salmon River Hatchery and post tagging in 2010, 2011 and 2013.

Quality Control	**Year***		
During Operation	2010	2011	2013
# fish checked for AD	17,620	22,978	7,157
% AD clipped	99.2	99.7	99.5
# fish checked for CWT	13,539	12,097	7,157
% with CWT	99.6	99.8	99.8
% no AD clip, no CWT	0.04	0.12	0.17
% AD clipped, no CWT	0.13	0.04	0.18
Checked 30 days post-tagging			
# of Fish Checked CWT	2537	1932	1331
% AD Clipped	99.6	98.9	98.0
% with CWT	99.1	99.4	99.0

* No fish were marked in 2012

Results and Discussion

Marking 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 (Table 3). Results were previously detailed in Connerton et al. (2017). Numbers tagged were adjusted based on QC results.

Straying by Pen-reared vs Direct-stocked Chinook Salmon to SRH

We compared the relative straying of pen-reared and direct-stocked Chinook salmon to SRH during fall spawning from 2011-2016 from the eight stocking sites, hereafter referred to as Direct:Pen (D:P) straying ratios (Tables 4-6).

Recoveries of tagged Chinook salmon at SRH from 2011-2016 (none in 2017) totaled 1,774 including 985, 382, and 407 from 2010, 2011 and 2013 YCs, respectively. In 2010, Chinook salmon stocked at Salmon River were also tagged as part of a homing/straying study (Connerton et al. 2016) which accounted for the 81% of the sample and the higher overall sample totals from that YC. It should also be noted that sample totals reported in Connerton et al. (2016, table 6) for the 2010 YC (n=1,119) were higher because they also included AD clipped only fish since not all the fish counted as strays were tagged in those analyses (Table 1). However, the analyses of strays presented herein necessarily only included tagged fish.

Direct-stocked Chinook salmon generally strayed to the hatchery in greater frequency than pen-reared salmon (Tables 4, 5, and 6). The null hypothesis of no difference in straying between pen-reared and direct-stocked fish was rejected in 61% of the cases for the three year classes evaluated. The number of strays from direct-stocked fish were significantly higher than pen-reared fish in 14 of 23 cases for the three YCs evaluated. At alpha≤ 0.1, straying was significantly higher by direct stocked Chinook at an additional 2 sites.

After adjusting for lake-survival, the 2010 YC had significantly greater straying by direct-stocked Chinook salmon (p-values≤0.05) from four sites including Niagara River, Oak Orchard Creek, Genesee River and Sodus Bay, and weaker evidence (0.05≥p-values≤ 0.1) for higher straying by direct-stocked Chinook from Eighteenmile Creek and Sandy Creek (Table 4). D:P ratios were not significantly different from stocking ratios at Oswego and Fairhaven. Recoveries of pen-reared fish from Oak Orchard were significantly higher than direct-stocked Chinook for this yearclass.

After adjusting for lake-survival, the 2011 YC had significantly greater straying by direct-stocked salmon from 6 of 8 sites (Table 5). Direct vs Pen (D:P) straying ratios (Table 5) at these six sites ranged from 2.1 to 68.9 showing considerable variability among sites and large differences in straying between direct and pen-reared fish from some sites. These results coincided with previous analyses showing higher imprinting to tributaries by pen-reared fish to these sites, except at Sodus where there were no imprinting differences (Connerton et al. 2017). Results indicating no straying differences between direct-stocked and pen-reared Chinook from Oswego (Table 5) are also consistent with results of previous imprinting evaluations (Connerton et al. 2017). There was also no significant difference in straying to the hatchery by direct and pen-reared Chinook salmon from Fairhaven (Table 5); however previous analysis of returns to Fairhaven tributaries indicated an imprinting advantage for direct-stocked fish at that site which was contrary to our hypothesis. The Fairhaven site is unusual because pens are held at a marina in Little Sodus Bay and are not associated with any tributary, whereas direct-stocked fish are stocked into Sterling Creek resulting in potential imprinting there (Connerton et al. 2017).

Table 4. Relative straying of pen-reared and direct-stocked Chinook salmon from eight sites in New York to the Salmon River Hatchery for the 2010 YC. Numbers* of strays at SRH were adjusted by numbers tagged and by the age-specific lake recovery ratio (pen:direct) for each site to evaluate straying to the hatchery. (See Methods for more explanation). For sites with P-values ≤0.05 (in bold), strays of pen-reared and direct-stocked fish were significantly different at α=0.05.

Stocking Site	# Tagged		Strays Per 50,000 Tagged		Direct: Pen Straying Ratio	X^2	P-value
	Direct	Pen	Direct	Pen			
Niagara River	73835	73817	9.0	3.4	2.7	3.8	**0.05**
Eighteenmile Creek	65779	64742	3.5	0.5	6.7	2.9	0.09
Oak Orchard Creek	75449	61152	2.9	12.2	0.2	7.4	**0.01**
Sandy Creek	36877	37097	13.8	5.4	2.5	2.7	0.10
Genesee River	75300	71463	16.2	7.3	2.2	5.0	**0.03**
Sodus Bay	37800	37294	55.6	18.5	3.0	13.9	**1.88E-04**
Fairhaven	24200	24895	32.1	18.6	1.7	1.8	0.19
Oswego River	37307	37061	12.0	18.1	0.7	0.9	0.34

* Note that the numbers of strays reported in Table 4 do not represent an absolute number of strays per 50,000 tagged; rather the values are relative to each other within and across sites. Likewise comparisons across year classes do not represent relative numbers of strays since recoveries are affected by sample sizes from 2011-2017.

Table 5. Relative straying of pen-reared and direct-stocked Chinook salmon from eight sites in New York to the Salmon River Hatchery for the 2011 YC. Numbers* of strays at SRH were adjusted by numbers tagged and by the age-specific lake recovery ratio (pen:direct) for each site to evaluate straying to the hatchery. (See Methods for more explanation). For sites with P-values <0.05 (in bold), strays of pen-reared and direct-stocked fish were significantly different at α=0.05.

Stocking Site	**# Tagged**		**Strays Per 50,000 Tagged**		**Direct: Pen**	X^2	**P-value**
	Direct	**Pen**	**Direct**	**Pen**	**Straying Ratio**		
Niagara River	72997	74654	10.8	4.1	2.6	4.4	**0.04**
Eighteenmile Creek	66208	64680	52.0	0.8	68.9	65.9	**4.71E-16**
Oak Orchard Creek	71940	63280	267.8	8.3	32.1	348.3	**1.00E-77**
Sandy Creek	37898	37108	136.7	10.6	13.0	81.6	**1.64E-19**
Genesee River	73918	73530	32.0	5.4	5.9	27.9	**1.25E-07**
Sodus Bay	35872	38120	145.4	69.7	2.1	19.5	**1.03E-05**
Fairhaven	23989	25040	27.9	33.4	0.8	0.2	0.63
Oswego River	37101	36333	12.7	7.4	1.7	1.0	0.31

* Note that the numbers of strays reported in Table 4 do not represent an absolute number of strays per 50,000 tagged; rather the values are relative to each other within and across sites. Likewise, comparisons across year classes (Tables 5-8) do not represent relative numbers of strays since recoveries are affected by sample sizes from 2011-2017.

After adjusting for lake-survival, the 2013 YC had significantly greater straying to the hatchery by direct-stocked fish at three of eight sites (Table 6) including Eighteenmile Creek, Genesee River and Sodus Bay with D:P straying ratios of 2.8, 4.5, and 1.8 respectively. There was insufficient evidence to reject the null hypotheses of no difference based on numbers of strays from Niagara River and Oak Orchard Creek although D:P straying ratios were 1.4 for both sites. Previous imprinting analysis (Connerton et al. 2017) of relative returns to tributaries for this YC indicated significantly better imprinting by pen-reared Chinook at Niagara, Eighteenmile, and Oak Orchard while imprinting differences were not significant at Genesee River or Sodus Bay after accounting for lake-survival.

There was no straying difference between stocking methods from Oswego (D:P ratio=1), which is consistent with previous imprinting evaluations that indicated no imprinting difference between pen-reared and direct-stocked Chinook salmon at that site (Connerton et al. 2017). This result also makes sense given that Oswego released its pen fish after only 3 days in the pens in 2013. The D:P ratio (0.6) from Fairhaven (2013 YC) indicated significantly more strays from pen-rearing, which is also consistent with previous imprinting evaluations at Fairhaven tributaries. Poorer imprinting by pen-reared Chinook salmon at Fairhaven is probably due to the reasons mentioned above (i.e., the pen site is not in a tributary); however, pen-rearing still provides improved lake-survival at that site.

Percent Composition of Strays at SRH by Site

It should be noted that the percent composition of strays (standardized for stocking and survival) is not the same thing as a “straying rate” previously reported by Connerton et al. (2016), which was estimated to be 10.9% for the 2010 YC based on the relative proportions in the sample of tagged SRH “broodstock” fish and strays (identified by adipose-clipped only and CWTs from other sites).

We calculated percent composition of each treatment (standardized for lake-survival and numbers tagged by site) to provide insights into the relative straying of Chinook from sites and methods to the SRH (Figure 2). Mirroring the comparisons in the previous section of this report (Tables 4, 5, and 6), direct-stocked salmon strayed relatively more than pen-reared salmon to the SRH, representing from 2-34% of the total standardized samples compared with pen-reared fish, which represented 0.1-14.6% of the standardized samples across all year classes.

Strays from Sodus Bay direct stocking consistently made up a relatively high percentage of the samples at SRH with 17.6%, 17.7% and 31.2% of the 2010, 2011 and 2013 YCs, respectively. This site is unusual because “direct” fish are stocked at the outlet of Sodus Bay, and no tributaries are within 1-3 miles. Sodus Bay tributaries also frequently experience very low water conditions preventing salmon migration until late in the fall, perhaps influencing straying. Still, imprinting by both pen-reared and direct-stocked fish occurred there based on tributary returns, and contributed to local fisheries (Connerton et al. 2017).

Table 6. Relative straying of pen-reared and direct-stocked Chinook salmon from eight sites in New York to the Salmon River Hatchery for the 2013 YC. Numbers* of strays at SRH were adjusted by numbers tagged and by the age-specific lake recovery ratio (pen:direct) for each site to evaluate straying to the hatchery. (See Methods for more explanation). For sites with P-values <0.05 (in bold), strays of pen-reared and direct-stocked fish were significantly different at α=0.05.

Stocking Site	# Tagged		Strays Per 50,000 Tagged		Direct: Pen Straying Ratio	X^2	P-value
	Direct	Pen	Direct	Pen			
Niagara River	75554	75453	21.9	16.2	1.4	1.3	0.26
Eighteenmile Creek	65840	66584	23.3	8.4	2.8	9.3	**2.31E-03**
Oak Orchard Creek	75111	64753	36.3	26.3	1.4	9.3	0.14
Genesee River	74967	74441	52.3	11.6	4.5	9.3	**4.50E-10**
Sodus Bay	36979	37483	164.0	89.2	1.8	16.4	**5.19E-05**
Fairhaven	25359	25790	88.6	140.5	0.6	9.3	**1.42E-02**
Oswego River	37102	38019	27.1	28.1	1.0	0.0	0.90

* Note that the numbers of strays reported in Table 4 do not represent an absolute number of strays per 50,000 tagged; rather the values are relative to each other within and across sites. Likewise, comparisons across year classes do not represent relative numbers of strays since recoveries are affected by sample sizes from 2011-2017.

Although strays from Oak Orchard Creek direct stocking in the 2011 YC made up a higher percentage (34%) of the sample from any one YC than Sodus Bay, this site only represented 1.4-4.2% of the samples from the 2010 and 2013 YCs, so a pattern of higher relative straying cannot be concluded. Similarly, Fairhaven strays from combined pen and direct stocking sites made up 25.5% of the 2013 YC sample but did not make up a relatively higher percentage of the samples from the other YCs.

Only a few of the other sites represented more than 10% of the sample from any YC including Sandy Creek direct-stocked sites (12% of 2010 and 11% of 2011 YC), Sodus Bay pen site (11.4% of 2013 YC), and Oak Orchard pen site (10.1% 2010 YC). In fact, few other patterns can be generalized except that the western-most sites strayed the least. Pen and direct strays from Eighteenmile Creek and Niagara River represented a consistently low percentage (<5%) of the standardized samples in all three year classes (Figure 2). Overall the percent composition of strays at the SRH indicated that straying from individual sites was variable; and except for Sodus Bay, no site stood out as consistently representing a high percentage of the strays at SRH. However, direct-stocked fish generally strayed to the hatchery more than pen-reared Chinook salmon.

<u>Straying by Pen-reared vs Direct-Stocked Chinook Salmon to Other Tributaries</u>

We compared the relative straying of penned and direct-stocked Chinook salmon from the eight stocking sites to other nearby and distant tributaries during fall spawning from 2011-2016 (Table 7). The numbers of direct-stocked vs pen-reared salmon were adjusted for lake performance and the D:P straying ratios were compared with stocking ratios (see methods).

Recoveries of penned and direct-stocked Chinook salmon in tributaries from 2011-2016 (none in 2017) totaled 6,489 of which 2,538 were classified as strays (i.e., capture location ≠ stocking location) including 1,310 strays at nearby sites, and 1,228 at distant sites. Of the strays captured at nearby sites, 360, 501, and 449 were from the 2010, 2011 and 2013 YCs, respectively, amounting to 19.7%%, 20.6%% and 20.1%, of the total returns to tributaries in each year class. A total of 453, 409, and 366 from each year class was captured at distant sites amounting to 16-25% of the total returns to tributaries (i.e., 24.8%, 16.6%, and 16.4% respectively). These straying rates are similar to other straying estimates (~34%, range 10-60%) in a recent review by Keefer and Caudill (2012) for fall spawning, ocean-type Chinook salmon which is the type stocked in Lake Ontario (Weeder et al. 2005). After adjusting for lake performance, results indicated little differences in straying by pen-reared and direct-stocked Chinook salmon to tributaries. D:P straying ratios averaged 0.95, 0.85 and 0.75 for the 2010, 2011 and 2013 YCs respectively (Table 7).

Only 6 out of 23 cases indicated significant straying differences between pen-reared and direct-stocked Chinook among tributaries. In all these cases, results indicated significantly higher numbers of strays from pen-reared Chinook including from Niagara River (2010 YC), Oak Orchard Creek (2010 YC), Fairhaven (2011 and 2013 YCs), and Sodus Bay (2011 and 2013

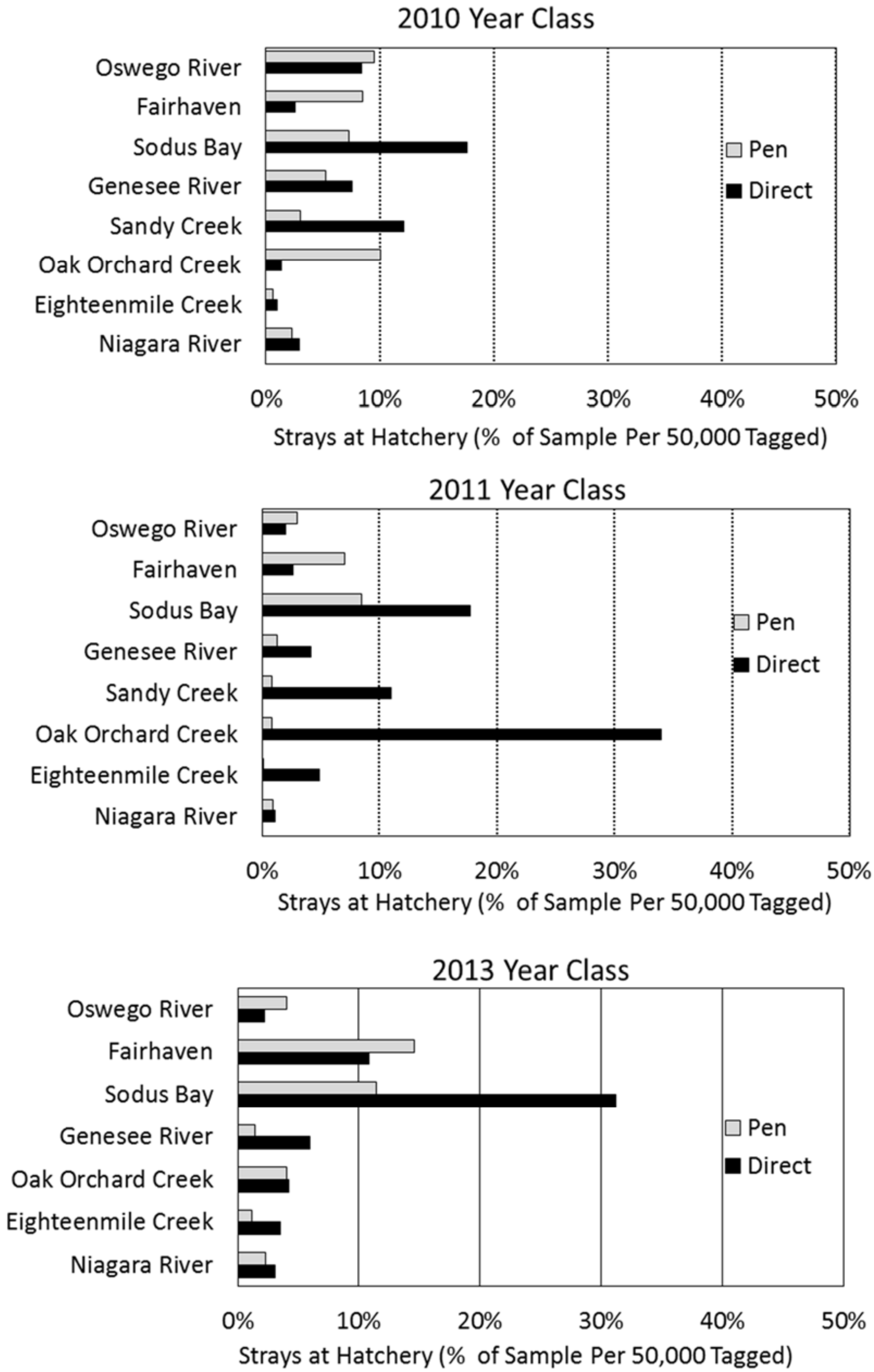

Figure 2. Percent composition of strays at the Salmon River Hatchery from pen reared and direct-stocked Chinook salmon from the 2010, 2011 and 2013 YCs. Composition was standardized for numbers tagged and differential lake-survival among treatments.

Table 7. Relative straying of pen-reared and direct-stocked Chinook salmon from eight sites in New York to tributaries for the 2010, 2011, and 2013 YCs. Numbers of strays were adjusted by numbers tagged and by the age-specific lake recovery ratio (pen:direct) for each site to evaluate straying among tributaries. (See Methods for more explanation). For sites with P-values <0.05 (in bold), strays of pen-reared and direct-stocked fish were significantly different at α=0.05.

Stocking Site	# Tagged		Strays Per 50,000 Tagged		Direct: Pen Straying Ratio	X²	P-value
	Direct	Pen	Direct	Pen			
2010 Year Class							
Niagara River	73835	73817	27	52	0.52	11.04	**8.92E-04**
Eighteenmile Creek	65779	64742	84	68	1.24	2.11	0.15
Oak Orchard Creek	75449	61152	41	68	0.61	7.83	**0.01**
Sandy Creek	36877	37097	59	84	0.70	2.91	0.09
Genesee River	75300	71463	44	46	0.94	0.08	0.78
Sodus Bay #	37800	37294	28	34	0.83	0.25	0.62
Fairhaven	24200	24895	92	60	1.54	2.92	0.09
Oswego River	37307	37061	44	34	1.27	0.61	0.44
2011 Year Class							
Niagara River Δ	72997	74654	8	9	0.85	0.04	0.85
Eighteenmile Creek	66208	64680	183	177	1.03	0.07	0.79
Oak Orchard Creek	71940	63280	127	101	1.26	3.72	0.05
Sandy Creek #	37898	37108	33	51	0.64	2.54	0.11
Genesee River	73918	73530	39	39	1.00	0.00	1.00
Sodus Bay +	35872	38120	28	62	0.46	8.79	**3.0E-03**
Fairhaven *	23989	25040	24	60	0.39	7.17	**0.01**
Oswego River	37101	36333	18	15	1.18	0.004	0.84
2013 Year Class							
Niagara River	75554	75453	33	41	0.8	1.20	0.27
Eighteenmile Creek	65840	66584	137	161	0.85	2.49	0.11
Oak Orchard Creek	75111	64753	111	136	0.82	3.16	0.08
Genesee River	74967	74441	34	31	1.09	0.11	0.74
Sodus Bay	36979	37483	66	118	0.56	10.11	**1.48E-03**
Fairhaven	25359	25790	76	134	0.57	7.70	**0.01**
Oswego River	37102	38019	22	41	0.53	3.89	0.05

Sodus 2010 YC recoveries were not homogenous among ages with 2013 significantly different from 2014 (post hoc Bonferroni adjusted P=0.004), so only recoveries from 2012 and 2014 were pooled and results are shown above. Recoveries from 2012 (age 2, D:P=75:41) were tested separately, and results indicated significantly higher straying by direct fish (X^2 =3.42, df =1, *P*=6.46e-02).

Δ Niagara River 2011 YC recoveries were not homogenous among ages with 2013 significantly different from 2014 (post hoc Bonferroni adjusted P=0.004), so only recoveries from 2012 and 2013 were pooled and results are shown above. Recoveries from 2014 (age 3, D:P=51:16) were tested separately, and results indicated significantly higher straying by direct fish (X^2 =18.6, df =1, *P*=1.64e-05).

Sandy Creek 2011 YC recoveries were not homogenous among ages with 2013 significantly different from 2014 (post hoc Bonferroni adjusted P=0.004), so only recoveries from 2012 and 2013 were pooled and results are shown above. Recoveries from 2014 (age 3, D:P=81:55) were tested separately, and results indicated significantly higher straying by direct fish (X^2 =8.3, df =1, *P*=3.92e-03).

+ Sodus 2011 YC recoveries were not homogenous among all ages (post hoc Bonferroni adjusted P: age 1 vs 2=0.004; age 1 vs 3=0.02; age 2 vs 3=0.02), so recoveries from 2013 and 2014 were tested separately. Recoveries from age 1 (9:1) were not analyzed. Recoveries from 2013 (age 2) are shown above. Recoveries from 2014 (age 3, D:P = 66:51) were tested separately and results indicated no significant differences (X^2 =0.87, df =1, *P*=0.35).

* Fairhaven 2011 YC recoveries were not homogenous among ages with 2013 significantly different from 2014 (post hoc Bonferroni adjusted P=0.001), so only recoveries from 2012 and 2013 were pooled and results are shown above. Recoveries from 2014 (age 3, D:P=49:33) were tested separately, and results indicated significantly higher straying by direct fish (X^2 =22.5, df =1, *P*=2.06E-06).

YCs). An average of 52% (+/- 9% standard error) of these pen strays were caught in nearby tributaries, still contributing to local fisheries.

Results at Oak Orchard Creek (Table 7, 2010 YC) showing higher straying by pen fish were consistent with results showing relatively higher numbers of pen strays at the SRH (Figure 2), however they were contrary to results of previous analysis indicating higher relative return of pen fish to Oak Orchard Creek for this YC (Connerton et al 2017). It is possible that relative lake-survival differences for this site and YC were underestimated which would have influenced standardization and results of comparisons at the SRH and in tributaries. Nonetheless, about 40% of the pen-reared strays from this site were caught in nearby tributaries e.g., Eighteenmile, Sandy, and Johnson creeks, contributing to local fisheries, and most of the evidence from this analysis and previous evaluations showed improved lake-survival and imprinting indicating that both stocking methods are achieving fisheries objectives at this site.

Similarly, even though straying was higher by Niagara River pen fish from the 2010 YC, there were no straying differences for the 2011 and 2013 YCs. These results, along with the consistently low relative numbers of strays to the SRH from this site (Figure 2), and previous results showing imprinting by pen-reared and direct-stocked Chinook to this site (Connerton et al. 2017) also suggest that stocking methods are achieving objectives at this site.

Pen-rearing at Sodus Bay and Fairhaven is unusual since pens are held in Sodus and Little Sodus Bay marinas, and are not associated directly with tributaries, which may affect pen imprinting outcomes at these sites. Significantly higher straying by 2011 and 2013 YC Fairhaven pen fish (D:P=0.39 and 0.57 respectively, Table 7) is consistent with previous evaluations by Connerton et al. (2017) that indicated significantly poorer imprinting to Fairhaven tributaries by pen-reared fish in all three YCs. At Sodus Bay, previous evaluations of the 2013 YC also indicated relatively lower imprinting by pen fish to Sodus tributaries, however differences were not significant (Connerton et al. 2017). In the current analysis, straying ratios indicated significantly higher straying by Sodus Bay pen fish for both 2011 and 2013 YCs (D:P= 0.46 and 0.56 respectively, Table 7). Although most of the evidence indicated that improved imprinting may not be entirely achieved at these sites, about 41% of the pen strays were caught in nearby tributaries and imprinting of both pen-reared and direct-stocked Chinook salmon is occurring at these sites (Connerton et al. 2017).

Summary

This report evaluated the relative straying of pen-reared and direct-stocked Chinook salmon to SRH and among tributaries of Lake Ontario. Results suggested that straying by pen-reared and direct-stocked salmon occurred both to the hatchery and among tributaries, however most fish imprinted to the stocking sites. This indicates that current stocking strategies have successfully balanced the benefits of higher survival gained by stocking larger fish against stocking fish prior to smolting so most fish imprint to stocking sites instead of the SRH. While results indicated higher straying to the SRH by direct-stocked salmon, probably due to longer holding times in the hatchery relative to pen-reared salmon, most salmon imprinted to the sites at which they were stocked or to nearby tributaries regardless of stocking method. Few differences were observed between the numbers of strays to tributaries. While fish from some sites strayed more than others in some years, there were no consistent patterns of straying from particular sites except from sites where salmon are not stocked in tributaries (i.e., Sodus Bay and Fairhaven); however, some imprinting of these fish still occurred, contributing to local fisheries.

Since returns to the tributaries or SRH by pen-reared or direct-stocked salmon could result from differences in survival, imprinting, straying or a combination, results of the current study and previous work (Connerton et al. 2017) emphasize the importance of sampling in the lake to understand survival differences between stocking methods, and considering these when evaluating returns to tributaries.

1. Straying to sites >20 miles from stocking locations amounted to 16-25% of total returns among tributaries. These straying rates are similar to those reported in native ranges for fall spawning Chinook salmon.
2. After accounting for differential lake-survival and stocking numbers, results indicated that direct-stocked fish strayed significantly more to the SRH than pen-reared fish in 13 of the 23 cases evaluated. This result was expected since direct-stocked fish are held in the hatchery longer.

Nonetheless both stocking methods led to imprinting at stocking sites or nearby sites.

3. Strays at the SRH were comprised of pen-reared and direct-stocked fish from all stocking sites. Most of the sites represented 5-10% of the total strays; however some sites strayed more, ranging from 10-34% of the total strays at SRH.

4. Strays from Sodus Bay direct stocking consistently made up a relatively high percentage of the samples at SRH with 17.6%, 17.7% and 31.2% of the 2010, 2011 and 2013 YCs, respectively. This site is unusual because direct fish are stocked at the outlet of Sodus Bay, and not associated with tributaries.

5. There were few straying differences between pen-reared and direct-stocked fish among tributaries. An average of 52% of the strays were caught in nearby tributaries, still contributing to local fisheries. Results suggest that direct-stocked fish are stocked early enough to imprint to tributaries in which they are stocked.

Acknowledgements

Funding for the purchase of the AutoFish trailer came from the Lake Ontario Sportfish Restoration Fund natural resources damages settlement. Additional funding for the study was provided by Federal Aid in Sportfish Restoration, Region 3 of the U.S. Fish and Wildlife Service, and the USEPA through a Great Lakes Restoration Initiative grant to the USFWS. Special thanks to the staff at NYSDEC Salmon River Hatchery and to NYSDEC Regions 6-9 for help with marking and sampling. Ringwood Fish Culture Station (operated by the Ontario Federation of Anglers and Hunters) and OMNRF staff also assisted with mass marking in Ontario. The Toronto Metro East Anglers provided critical volunteers for manual clipping at Ringwood.

References

Bishop, D.L., S.E. Prindle J.H. Johnson 2017. 2016 Salmon River Wild Young-of-the-Year Chinook Seining Program. Section 8 *In* 2016 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2017. NYSDEC, Albany, NY

Connerton, M.J. 2011. New York Lake Ontario and Upper St. Lawrence River Stocking Program 2010. Section 1 *In* 2010 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2011. NYSDEC, Albany, NY

Connerton, M.J. 2012. New York Lake Ontario and Upper St. Lawrence River Stocking Program 2011. Section 1 *In* 2011 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2012. NYSDEC, Albany, NY.

Connerton, M.J. 2014 New York Lake Ontario and Upper St. Lawrence River Stocking Program 2013. Section 1 *In* 2013 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2014. NYSDEC, Albany, NY

Connerton, M.J., C.J. Balk, S.E. Prindle, J.R. Lantry, M.E. Daniels, J.N. Bowlby, C.R. Bronte and M.E. Holey. 2014. 2013 Mass Marking of Chinook salmon in Lake Ontario. Section 3 *In* 2013 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2014. NYSDEC, Albany, NY.

Connerton, M.J., C.J. Balk, S.E. Prindle, J.R. Lantry,, J.N. Bowlby, M. Yuille, C.R. Bronte and M.E. Holey. 2015. 2014 Mass Marking of Chinook salmon in Lake Ontario. Section 3 In 2014 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2015. NYSDEC, Albany, NY.

Connerton, M.J., C.J. Balk, S.E. Prindle, J.R. Lantry,, J.N. Bowlby, M. Yuille, C.R. Bronte and M.E. Holey. 2016. 2015 Mass Marking of Chinook salmon in Lake Ontario. Section 3 In 2015 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2016. NYSDEC, Albany, NY.

Connerton, M.J., C.J. Balk, S.E. Prindle, J.R. Lantry,, J.N. Bowlby, M. Yuille, C.R. Bronte and M.E. Holey. 2017. Relative Survival and Imprinting of Pen and Direct-stocked Chinook Salmon in Lake Ontario. Section 3 In 2017 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the

Great Lakes Fisheries Commission's Lake Ontario Committee. March 2017. NYSDEC, Albany, NY.

Elrod, J.H., and A. Frank. 1990. Sample size requirements and analysis of tag recoveries for paired releases of lake trout. North American Journal of Fisheries Management 10: 196-201.

Everitt, D. W. 2006. Natural reproduction and spawning site characteristics of Chinook salmon (*Oncorhynchus tshawytscha*) in the Salmon River, New York. M.Sc. Thesis. State University of New York, College of Environmental Science and Forestry, Syracuse, NY.

Fife, D. 2017. Fifer: A Biostatisticians Toolbox for Various Activities, Including Plotting, Data Cleanup, and Data Analysis. R package version 1.1. https://CRAN.R-project.org/package=fifer

Keefer, M.L. and C.C. Caudill. 2012. A Review of Adult Salmon and Steelhead Straying with an Emphasis on Columbia River Populations. Department of Fish and Wildlife Resources College of Natural Resources, University of Idaho. Technical Report 2012-6.

Keefer, M.L. and C.C. Caudill, 2014. Reviews in Fish Biology and Fisheries 24:333-368.

Lantry, J.R. and T.H. Eckert. 2017. 2016 Lake Ontario Fishing Boat Survey. Section 2 *In* 2016 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2017. NYSDEC, Albany, NY.

Ontario Ministry of Natural Resources. 2015. Lake Ontario Fish Communities and Fisheries: 2014 Annual Report of the Lake Ontario Management Unit. Ontario Ministry of Natural Resources, Picton, Ontario, Canada

Prindle, S.E and D.L. Bishop. 2018. Population Characteristics of Pacific Salmonines Collected at the Salmon River Hatchery 2017. Section 9 In NYSDEC 2017 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee. March 2018. NYSDEC, Albany, NY.

R Development Core Team. 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Sanderson M. and M. Wilkinson 2006. Lake Ontario Chinook Salmon and Steelhead Cooperator Pen-Rearing Policy. NYSDEC. Albany, N.Y.

Todd, M., M. J. Sanderson and S.E. Prindle. 2018. 2017 New York Cooperative Trout and Salmon Pen-Rearing Projects. Section 10 In 2017 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2016. NYSDEC, Albany, NY.

Weeder, J. A., A. R. Marshall, and J. M. Epifanio. 2005. An assessment of population genetic variation in Chinook salmon from seven Michigan Rivers 30 years after introduction. North American Journal of Fisheries Management 25:861-875.

Wilkinson, M.A. M.J. Sanderson and S.E. Prindle. 2011. 2010 New York Cooperative Trout and Salmon Pen-Rearing Projects. Section 10 *In* 2010 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2011. NYSDEC, Albany, NY.

Wilkinson, M.A. M.J. Sanderson and S.E. Prindle. 2012. 2011 New York Cooperative Trout and Salmon Pen-Rearing Projects. Section 10 *In* 2011 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2012. NYSDEC, Albany, NY.

Wilkinson, M.A. M.J. Sanderson and S.E. Prindle. 2014. 2013 New York Cooperative Trout and Salmon Pen-Rearing Projects. Section 10 *In* 2013 Annual Report, Bureau of Fisheries Lake Ontario Unit and St Lawrence River Unit to the Great Lakes Fisheries Commission's Lake Ontario Committee. March 2013. NYSDEC, Albany, NY.

Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1976-2017

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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 also proved valuable for examining impacts of Double-crested cormorant (*Phalacrocorax auritus*; DCC) predation on smallmouth bass and yellow perch populations in the eastern basin (e.g., O'Gorman and Burnett 2001, Lantry et al. 2002), and evaluating changes in body condition post-round goby (*Neogobius melanostomus*) invasion (Crane et al. 2015). This report focuses on 2017 abundance indices as they relate to previous years; summarizes occurrence of round goby in predator diets; discusses walleye age structure through 2016; and discusses smallmouth bass condition through 2017, and age structure, growth, and maturity through 2016.

Methods

A standardized, stratified random design gillnetting assessment was conducted annually from 1976 through 2017 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 (Tibbets to Point Peninsula, Chaumont Bay, Black River Bay, Henderson Harbor, and Stony/Galloo 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 water (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 2017, 29 randomly chosen netting locations were determined prior to initiation of the assessment on July 31. From July 31 to August 10 we completed 27 unbiased net sets, two net sets were 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 gamefish (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 2003-2017, 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 (1976-2016) and otoliths (2004-2016) 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) average percent maturity was determined for male and female bass ages 1-7 (1976-2016).

Results and Discussion

<u>2017 Water Temperature</u>

In 2017, bottom temperatures for all nets set in depth strata 1 (12-30 ft) and 2 (31-50 ft) ranged from 67.1°F to 73.9°F and 57.0°F to 73.9°F, respectively. In stratum 3 (51-100 ft), bottom temperatures at net set locations ranged from 64.0°F to 72.9°F. One unbiased net set in depth stratum 2 and one unbiased net set in depth stratum 3 may have experienced some periods of water temperatures <50°F, given that three coldwater fish (one lake trout and two cisco) were captured in those nets.

<u>Species Richness and Composition</u>

Since 1976, 45 fish species (34 warm and cool water species) were captured during the eastern basin gillnetting assessment (Table 1). In 2017, 1,212 fish were captured in unbiased net sets, representing 18 warm and cool water species (1,209 fish) and two cold water species (three fish). The greatest species richness and CPUE (17 species; CPUE=73.1) occurred in depth stratum 1, followed by depth strata 2 (10 species; CPUE=38.8) and 3 (9 species; CPUE=22.4). 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%), then increased to an average of 11.8% of total catch (2008-2012). White perch was the first (2014), second (2015-2016) or third (2013, 2017) most commonly caught species over the last five years, primarily due to reduced catches of other species. Each year since 1986, smallmouth bass was the most or second most commonly caught species. In 2017, yellow perch was the most commonly caught species (42.2% of total catch) and smallmouth bass was the second most commonly caught species (18.9% of total catch).

Occurrence of Round Goby

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). By 2006, they were abundant, distributed across the entire New York shoreline, and captured from the nearshore zone to depths of at least 150m (Walsh et al. 2007). Round goby did not appear in this assessment until 2005 when two were captured. Since then, they appeared in low numbers (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.

Stomach contents from all predators captured were identified from 2000-2017. We first observed round goby in predator diets in 2005 (i.e., a total of 16 round goby 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. From 2014-2016, 71.7% - 78.9% of non-empty bass stomachs contained goby. In 2017, 77.0% of the 139 non-empty bass stomachs contained goby. Round goby were present in walleye diets each year from 2006-2010 and 2012-2016. Round goby were also observed in the diets of northern pike, brown trout (*Salmo trutta*), lake trout, lake whitefish (*Coregonus clupeaformis*, rock bass (*Ambloplites rupestris*), yellow perch, and white perch. DCC in the eastern basin also consume 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 through 2013 (i.e., the most recent year of cormorant diet analysis; Johnson et al. 2010, Johnson et al. 2012, Johnson et al. 2013, Johnson et al. 2014). Round goby 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).

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 1995-2017, at least one sturgeon was collected in 17 of the 23 years (four captured in 2017), suggesting improved population status. Improved status is likely attributable to restoration efforts (e.g., stocking and habitat improvement; Klindt and Gordon 2018).

Occurrence of Chain Pickerel

Chain pickerel (*Esox niger*) presence in Ontario waters was confirmed in 2008 (Hoyle and Lake 2011). This species was first captured in this assessment in 2013 when three were caught in two nets (each set in 15 ft water depth); however, none were captured since then. Capture in this assessment is rare 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, 2013 and 2017 (Table 1; Lantry and Eckert 2018). Occurrence of chain pickerel in recent years is attributed to range expansion (Hoyle and Lake 2011).

Index of Abundance: Total Warmwater Catch

The abundance index for warmwater fish in New York waters of Lake Ontario's eastern basin was highest during the early years of the assessment (1976-1979 mean CPUE=239) when the catch was dominated by white perch, yellow perch, and gizzard shad (1976-1979 mean CPUEs = 90.1, 51.8, and 34.7, respectively; Table 1, Figures 3-6). By 1984-1986, catch of these species declined nearly 80% (Table 1, Figure 2-6). The mean stratified CPUE for all warmwater species reached the lowest recorded in 1995 when CPUE was 14.9 and 94% lower than the 1976-1979 average (Table 1, Figure 2). Mean stratified CPUE for total warmwater fish remained at a low and variable level through the mid-2000s (Table 1, Figure 2). From 2008-2013 CPUE improved (mean CPUE = 34.9) to levels similar to those in the early 1990s (1992-1994 mean = 40.7). A decrease during 2014-2016 (mean = 17.4) was attributed to reduced catches of yellow perch, smallmouth bass and white perch. Below average eastern basin water temperatures during those years may have influenced fish distribution and production, contributing to reduced catches. In 2017, the mean stratified CPUE of 36.1 was a 107.9% increase from 2014-2016 and was similar (+3.3%) to the 2008-2013 time period.

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

<u>White Perch Index of Abundance</u>

The most notable declines in species abundance between the late 1970s and mid 1980s occurred with white perch and gizzard shad, the two most abundant species in 1977 and 1978. White perch declined 83% from the 1976-1979 to 1984-1986 time periods (Table 1, Figure 3). Abundance indices declined further, reaching a low CPUE of 0.06 in 1995, and remained low through 2007. In 2008, white perch CPUE was 7.7, a more than 6-fold increase over the previous 5-year average and the highest observed since 1991. CPUE has remained variable at about the same level since then (2008-2017 average = 4.8). In 2017, white perch CPUE was 4.8, comparable to the previous 5-year (+6.4%) and 10-year (+8.9%) averages.

<u>Yellow Perch Index of Abundance</u>

Yellow perch were commonly caught since the assessment began in 1976, however, abundance declined significantly through the early to mid-1980s, reaching a low CPUE of 2.2 in 1988 (Table 1, Figure 4). Subsequently, CPUE varied without trend and averaged 7.4 from 1989-2006 (range: 2.8 [1993] - 13.6 [1990]). Yellow perch CPUE increased in 2008 to the highest level (16.9) since 1984, and remained near that level through 2013. Then catches declined to among the lowest levels recorded in over two decades(2014-2016 CPUE range: 0.8 – 3.1 fish per net night; Table 1). Reduced population size and/or changes in distribution are likely contributing factors to the 2014-2016 reduced catches. Two consecutive long, cold winters (2013/2014 and 2014/2015) followed by below average summer temperatures may have influenced abundance and distribution. We do not attribute the reduced catches to DCC predation because effective cormorant management and a DCC dietary shift to round goby reduced predation pressure on yellow perch (Johnson et al. 2014, McCullough and Mazzocchi 2016). In 2017, catches in this survey increased to 15.2 fish per net night, a 50.8% increase compared to the previous 10-year average.

Variability of yellow perch catch in gill nets is relatively high (long-term average RSE=37.7%) when compared to smallmouth bass (long-term average RSE=20.8%), and is likely attributable to the schooling nature of perch. In 2017, yellow perch RSE (36.3%) was comparable to (-3.6%) the long-term average.

In 2017, yellow perch total lengths ranged between 5.6 in (143 mm) and 12.2 in (309 mm), and averaged 8.6 in (219 mm). Approximately 31% of perch captured were ≥ 9 in (≥ 228.6 mm; Figure

17). Weights of yellow perch captured in 2017 ranged from 1.0 oz (28.0 g) to 13.8 oz (392.0 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 (2.1) increased to the highest level since 1981 (CPUE=2.8), likely due to the warm winters in 2011-2012 and 2012-2013. From 2014-2016, gizzard shad CPUE was lower and variable (mean CPUE 2014-2016 = 0.7 fish per net night). CPUE increased in 2017 to 2.8 fish per net night.

Rock Bass Index of Abundance

Rock bass CPUE peaked in 1978 at 22.1, declined through the early 1980s, and varied without trend through the early 1990s. Abundance subsequently declined, and has been at a relatively stable level since 2011 (Figure 6). In 2017, the rock bass CPUE (1.8) was a 23.3% increase compared to the previous 10-year average.

Alewife Index of Abundance

Alewife CPUE varied without trend through 1988, averaging 9.0 (Figure 7). CPUE then declined and was $\leq$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. Catch of alewife was consistently low since the mid-1990s (2017 CPUE = 0.1 fish per net night).

Walleye Index of Abundance and Age Structure

Walleye is the only relatively common species that increased in abundance since the assessment was initiated in 1976 (Figure 8). Catches were lowest from the late 1970s through the mid-1980s (mean CPUE 1976-1986=0.2) and increased through the early 1990s with a peak CPUE of 3.8 in 1993 (Table 1). Subsequently, CPUE declined through the late 1990s, but has remained relatively stable since the late 1990s (Figure 8). The 2017 CPUE of 2.0 was a 32.2% increase compared to the previous 5-year average. The walleye population is expected to remain near levels observed during the last decade because of strong year classes produced in 2011, 2014 and 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 1990-2017 (average RSE=26.7%).

Walleye ages, interpreted from otoliths, indicated that strong year classes were produced in 2003, 2005, 2008, 2011, and 2014 (Figure 18). Age interpretations of samples collected in 2017 were not complete by the drafting of this report. The 2003 year class was first captured at age 1 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, OMNR 2011a and 2011b). By 2016, the 2003 year class represented only 2.0% of total catch and CPUE was only 0.02 indicating that few fish from that year class remain. Good to strong 2005 and 2008 year classes were produced in Ontario waters (OMNR 2009, 2011a) and were well represented in this assessment until recently.

Fall bottom trawling in the Bay of Quinte indicated that strong 2011, 2014 and 2015 year classes were produced there (OMNR 2012, OMNRF 2017). The 2015 and 2016 gillnet catches of age-4 and age-5 walleye in this assessment indicated good production of the 2011 year class in New York waters (15.4% and 6.1% of total walleye catch; Figure 18). In August 2016, the 2011 year class averaged 23 inches in length. Good production of the 2014 year class in New York waters was first evident in 2015 when 10.3% of the walleye catch in this assessment were age-1 (i.e., 2014 year class fish). In 2016, the 2014 year class represented 30.6% of the walleye catch (average length at age 2 = 16.3 inches in 2016). In 2017, this year class was age 3 and likely just over the legally harvestable length of 18 inches. Three age-1 fish from the 2015 year class (average length = 12.8 inches) were captured during 2016 netting.

In 2017, walleye total lengths ranged between 12.1 in (307 mm) and 31.5 in (801 mm), and averaged 24.1 in (613 mm; Figure 17). Walleye weights ranged from 8.5 oz (241 g) to 13.1 lb (5,939 g) and averaged 6.5 lb (2,937 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 impacted by many perturbations including reduced lake productivity, dreissenid mussel 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 2016). 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 improved during 2005-2013 from the 2000-2004 record lows; however, those levels were lower than expected following achievement of DCC population management objectives. In addition, smallmouth bass have not produced strong year classes relative to those produced in the 1970s and 1980s. Recently, year classes that appeared improved relative to other recent year class did not persist, and 2014-2016 CPUEs declined. Smallmouth bass CPUE in 2017 (6.8 fish per net night) improved 42.9% compared to the 2014-2016 time period but remained 20.2% below the 2005-2013 time period. Factors confounding comparisons of recent data 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 1976-2017

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, 19, 20a, 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, 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, 20a). Relatively high CPUE of young fish indicated production of moderately strong year classes in 1987 and 1988 (Chrisman and Eckert 1999, Eckert 2000, Casselman et al. 2002; Figures 19, 20a, 20b); however, increased CPUE of these year classes at older ages (i.e., ages $\geq$ 5) was not evident (Figures 19, 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).

From 2005 through 2013, average smallmouth bass CPUE (mean CPUE=8.6) was more than 2-fold higher than the 2000-2004 record lows (mean CPUE=4.2). These improved CPUEs, however, were similar to the 1994-1999 time period when catches were well below historic levels (-62.2%), fishing quality was relatively poor (Eckert 1999), and anglers and fishery managers were concerned about the status of the bass population (NYSDEC 1999; Figure 9). The CPUE increase in 2005 is attributed to the 2002 year class, which represented 33.8% of the catch in 2005 (age 3; Figure 20b). 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 2005 year class dominated 2008 and 2009 catches (ages 3 and 4, respectively), representing 37.1% and 48.3% of total smallmouth bass catch, respectively. Catch of the 2005 year class declined each year since 2009 and, by 2016 (age 11), CPUE was only 0.2 fish per net night (Figure 20b). The production of poor to weak year classes since 2005 resulted in the low CPUEs observed 2014 through 2016 (i.e., levels only 18.3% higher than the 2000-2004 average). CPUE in 2017 (CPUE = 6.8) was only 18.4% higher than the 2000-2004 time period.

Growth

Lake Ontario's eastern basin bass population experienced changes in growth rates over the 1976 to 2017 time period which confound comparisons of "historic" (prior to mid-1990s) data with more recent data, including age-specific CPUE and survival. Prior to the mid-1990s, assessment gill nets did not effectively sample age-2, -3, or -4 smallmouth bass because of their relatively small size (mean lengths-at-age $\leq$ 11.1 in; Figure 21). Bass are not fully vulnerable to assessment nets until approximately 12 in TL. Prior to the mid-1990s, bass reached 12 in TL by approximately age 5 or 6. Evidence of increased growth rates were observed in the mid-1990s which is before first reports of round goby in Lake Ontario (i.e., 1998 in the southwest portion of the lake and 1999 in Bay of Quinte). Increased growth rates at that time were likely due to ecosystem changes associated with dreissenid mussel proliferation and/or compensatory growth associated with a declining bass population (Figure 9). Age-1 bass first appeared in the assessment in 1994 and appeared in low numbers most years since. Beginning in 1997, at least a portion of bass as young as age 3 reached 12 in TL (Figures 21 and 22). By the mid to late 1990s age-specific annual mean TLs were generally above age-specific long-term means for all ages (2-13; Figure 21).

Mean length-at-age continued to increase following establishment of round goby in the system and in bass diets. By the mid-2000s, gill nets could effectively sample many age-2 and age-3 bass, and likely all age-4 bass (Figure 21). By 2010, a portion of bass sampled reached 12 in TL by age 2 (Figure 22). Average length of age-3 bass was over 12 in TL in 2010, 2012, and 2014. From the mid-2000s through 2014, mean length-at-age remained at or near record high for all ages 2-10. In 2016, mean length-at-age remained near record high levels for bass ages $\geq$ 4; however, for several of these age groups mean lengths declined relative to recent years (Figure 21). Age interpretations for 2017 samples were not complete when this report was drafted.

Record cold winters (2013/2014 and 2014/2015) followed by below average summer temperatures likely contributed to the substantial decrease in growth observed in young bass. In 2015, mean length-at-age remained at or near record highs for all ages except for age-2 bass, which was the shortest average (7.8 in) since 1992 (7.6 in) and approximately two inches shorter than the previous three years (Figure 21). In 2016, when those bass were caught at age 3, mean length was only 10.4 in, the shortest for age 3 bass since 2005. These bass hatched in 2013 and likely experienced only a few months of good growth before the record cold winter of 2013/2014, followed by below average summer 2014 temperatures. These fish were then subjected to a second, record cold winter (2014/2015), followed by below average temperatures in summer 2015. Colder water temperatures can slow metabolism, resulting in reduced growth rates. Growth rates of these age-2 bass may have also been impacted by prey availability during the extended period of cold temperatures.

In 2017, smallmouth bass total lengths ranged between 7.1 in (180 mm) and 20.8 in (529 mm), and averaged 14.8 in (377 mm; Figure 17). Bass weights ranged from 3.0 oz (84 g) to 6.3 lb (2,862 g) and averaged 2.5 lb (1,155 g).

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 all length groups by 2006 (Figure 23). Condition of bass in 2017 remained good and within the range of values observed in recent years (Figure 23). Crane et al. (2015) found a significant increase in smallmouth bass condition following invasion of round goby into lakes Ontario and Erie. Increased condition of bass ≥ 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 (2006-2017 average=107.7; Figure 24) 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, 5 lb, and 6 lb) in assessment 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 2017, 22.4% of bass caught weighed ≥ 4 lbs (n=245; Figure 25). Bass weighing ≥ 5 lbs were first caught in 1999, have been caught each year since 2005, and the percentage increased in 2017 to the highest recorded (7.8% of all bass caught). Bass ≥ 6 lbs were first caught in the 2005 survey (0.2% of total smallmouth bass caught) then again in 2011. Each year 2011-2017, 0.3-1.2% of bass caught weighed more than 6 lbs (1.2% in 2017). These increases are most likely attributed to good growth and condition (Figures 21, 23-25) and not increased abundance of older aged bass (Figure 19).

Maturity and Longevity

Fish populations with good 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 (1996-2016) 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 62.7% mature during 1996-2016 (Figure 26). For both time periods and sexes, ≥99.3% of the smallmouth bass sampled were mature by age 7. Across the time series, a higher percentage of male bass were mature at age 2-5 than female bass (Figure 26).

Life span is generally shorter where growth is faster (e.g., Carlander 1969, 1977, 1997; Heibo et al. 2005), further confounding population structure evaluations. CPUE of older bass was evaluated to determine if abundance of older bass declined following increased growth rates. During 1976-1995, mean CPUE of age 10+ smallmouth bass was 1.8 (range: 0.4-3.6; Figure 27). Since then (1996-2015), mean CPUE was 67.9% lower (mean CPUE=0.59; 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 3.2 and representing 47.7% of the total bass catch (80.2% and 34.9% decreases, respectively). There is no evidence of a year class persisting strongly at ages ≥5 since the 1983 year class (Figure 20a). CPUE of younger bass (ages ≤ 4) also decreased during 1995-2016 (mean CPUE=3.7) relative to 1976-1994 (mean CPUE=5.5; Figure 19), despite increased vulnerability to capture due to increased growth.

Most recently, size-selective predation by cormorants was likely not having a substantial impact on the bass population because of effective DCC population management and a shift in DCC diets to round goby. Despite reduced predation pressure, CPUE of bass ≤ age 4 was 33.0% below the earlier time period (1976-1994) when bass of the same age were less vulnerable to gill nets due to slower growth rates (Figures 19 and 21). In 2016, despite reduce mean length-at-age of age-3 and age-4 bass and possibly lower vulnerability to capture, CPUE of bass ≤ age 4 improved to 3.2 bass per net night from 2015 (i.e., the second lowest recorded; 2004 was the lowest).

I further evaluated age composition of smallmouth bass ≥ 12 in TL because they are both fully vulnerable to assessment nets across the entire 41-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 and 22). During 1997-2016, between 50.5% (2009) and 94.2% (2004) of the bass ≥ 12 in TL were age 5 and older (1997-2005 average=82.2%; 2006-2016 average=74.8%). The contribution of younger bass (i.e., ages 2-4) that were 12 in TL increased from an average of 1.9% prior to 1997 to 21.9% since 1997 (1997-2005 average=17.9%; 2006-2016 average=25.2%; Figure 22).

Discussion – Smallmouth Bass

Fish communities in Lake Ontario have been impacted by many perturbations that have altered habitat, productivity, food web linkages, and population dynamics. These include water level regulation, phosphorus declines, DCC population increases, and invasive species (e.g., dreissenid mussels, round goby, *Bythotrephes*, VHSv). Ongoing changes in the Lake Ontario ecosystem confound predictability. Although it is unlikely that the system will support bass abundance at pre-1990s levels, mostly due to an overall reduction in system productivity, the production of only poor to weak year classes in recent years occurred at a time when conditions appeared 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 2016, 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 20a). Below average summer temperatures during 2014 and 2015 likely resulted in two additional years of poor production.
A number of other factors can impact bass recruitment including condition of spawning

habitat, water clarity, 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 currently 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).

References

Adams, C.M., C.P. Schneider, and J.H. Johnson. 1999. Predicting the size and age of smallmouth bass (*Micropterus dolomieu*) consumed by Double-crested cormorants (*Phalacrocorax auritus*) in Eastern Lake Ontario, 1993-1994. Section 6 *in* Final Report: To assess the impact of double-crested cormorant predation on smallmouth bass and other fish of the eastern basin of Lake Ontario. NYSDEC Special Report - February 1, 1999. New York State Department of Environmental Conservation, Bureau of Fisheries, Albany, N.Y.

Anderson, R.O. and R.M. Neumann. 1996. Length, weight, and structural indices. Pp. 447-482 *in* Murphy, B.R. and W.W. Willis (eds). Fisheries Techniques. American Fisheries Society, Bethesda, Maryland.

Carlander, K.D., 1969. Handbook of Freshwater Fish Biology. Vol. 1. Iowa State University Press. 752 pp.

Carlander, K.D., 1977. Handbook of Freshwater Fish Biology. Vol. 2. Iowa State University Press. 431 pp.

Carlander, K.D., 1997. Handbook of Freshwater Fish Biology. Vol. 3. Iowa State University Press. 397 pp.

Casselman, J.M., D.M. Brown, J.A. Hoyle and T.H. Eckert. 2002. Effects of climate and global warming on year-class strength and relative abundance of smallmouth bass in eastern Lake Ontario. Pages 73-90 *in* D.P. Philipp and M.S. Ridgway, editors. Black Bass: ecology, conservation, and management. American Fisheries Society, Symposium 31, Bethesda, Maryland.

Chrisman, J.R. and T.H. Eckert. 1998. Population trends among Smallmouth Bass in the eastern basin of Lake Ontario, 1976-97. Section 3 *in* NYSDEC 1997 Annual Report, Bureau of Fisheries, Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Chrisman, J.R. and T.H. Eckert. 1999. Population trends among Smallmouth Bass in the eastern basin of Lake Ontario, 1976-97. Section 2 *in* Final Report: To assess the impact of double-crested cormorant predation on smallmouth bass and other fish of the eastern basin of Lake Ontario. NYSDEC Special Report - February 1, 1999. New York State Department of Environmental Conservation, Bureau of Fisheries, Albany, N.Y.

Crane, D.P., J.M. Farrell, D.W. Einhouse, J.R. Lantry, J.L. Markham. 2015. Trends in body condition of native piscivores following invasion Lakes Erie and Ontario by round goby. Freshwater Biology 60:111-124

Eckert, T.H. 1986. 1985 warm water assessment. Section 6 *in* NYSDEC 1986 Annual Report, Bureau of Fisheries, Great Lakes Fisheries Section, Lake Ontario Unit to the Lake Ontario Committee and the Great Lakes Fishery Commission.

Eckert, T.H. 1998. Summary of 1976-97 warm water assessment. Section 2 *in* NYSDEC 1997 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Eckert, T.H. 1999. Trends in Lake Ontario smallmouth bass sport fishery, 1985-1998. Section 8 *in* Final Report: To assess the impact of double-crested cormorant predation on smallmouth bass and other fishes of the eastern basin of Lake Ontario. NYSDEC Special Report - February 1, 1999. New York State Department of Environmental Conservation, Bureau of Fisheries, Albany, N.Y.

Eckert, T.H. 2000. Summary of 1976-99 warm water assessment. Section 4 *in* NYSDEC 1999 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Eckert, T.H. 2005. Summary of 1976-2004 warm water assessment. Section 4 *in* NYSDEC 2004 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Eckert, T.H. 2006. Summary of 1976-2005 warm water assessment. Section 4 *in* NYSDEC 2005 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Einhouse, D.W., W.J. Culligan, and J. Prey. 2002. Changes in the smallmouth bass fishery of New York's portion of Lake Erie with initiation of a spring black bass season. Pages 603-614 *in* D.P. Philipp and M.S. Ridgway, editors. Black Bass: ecology, conservation, and management. American Fisheries Society, Symposium 31, Bethesda, Maryland.

Einhouse, D.W., J.L. Markham, K.A. Kapuscinski, M.L. Wilkinson, M.T. Todd. 2010. 2009 Annual Report to the Lake Erie Committee. New York Department of Environmental Conservation, Albany, NY. 81 pp.

Flickinger, S.A. and F.J. Bulow. 1993. Small Impoundments. Pp 469-492 *in* Kohler, C.C. and W.A. Hubert, editors. Inland fisheries management in North America. American Fisheries Society, Bethesda, Maryland.

Heibo, E., C. Magnhagen, L. Ashjørn Vøllestad. 2005. Latitudinal variation in life history traits in Eurasian perch. Ecology 86(12):3377-3386.

Hoyle, J.A. and C. Lake. 2011. First occurrence of chain pickerel (*Esox niger*) in Ontario: Possible range expansion from New York waters of eastern Lake Ontario. Canadian Field-Naturalist 125(1):16-21.

Johnson, J.H., R.M. Ross, and C.M. Adams. 1999. Diet composition and fish consumption of double-crested cormorants in eastern Lake Ontario, 1998. Section 5-1 to 5-7 in Final Report: To Assess the Impact of Double-Crested Cormorant Predation on smallmouth bass and Other Fishes of the Eastern Basin of Lake Ontario. New York State Department of Environmental Conservation, Albany, NY.

Johnson, J.H., R.M. Ross, and R.D. McCullough. 2000. Diet composition and fish consumption of double-crested cormorants from the Little Galloo Island Colony of Eastern Lake Ontario in 1999. Section 3 *in* Impact of Double Crested Cormorant Predation 1999. New York State Department of Environmental Conservation Special Report. http://www.dec.ny.gov/animals/9388.html

Johnson, J.H., R.D. McCullough, R.M. Ross, B. Edmonds. 2005. Diet composition and fish consumption of double-crested cormorants from the Little Galloo Island colony of eastern Lake Ontario. Section 14 *in* NYSDEC 2004 Annual Report, Bureau of Fisheries Lake Ontario Unit and

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

Johnson, J.H., R.M. Ross, R.D. McCullough, B. Boyer. 2006. Diet composition and fish consumption of double-crested cormorants from the Little Galloo Island colony of eastern Lake Ontario in 2005. Section 14 *in* NYSDEC 2005 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Johnson, J.H., R.D. McCullough, and J.F. Farquhar. 2010. Double-crested cormorant studies at Little Galloo Island, Lake Ontario in 2009: diet composition, fish consumption and the efficacy of management activities in reducing fish predation Section 14 *in* NYSDEC 2009 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Johnson, J.H., R.D. McCullough, and I.M. Mazzocchi. 2012. Double-crested cormorant studies at Little Galloo Island, Lake Ontario in 2011: diet composition, fish consumption and the efficacy of management activities in reducing fish predation Section 14 *in* NYSDEC 2011 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Johnson, J.H., R.D. McCullough, and I.M. Mazzocchi. 2013. Double-crested cormorant studies at Little Galloo Island, Lake Ontario in 2012: diet composition, fish consumption and the efficacy of management activities in reducing fish predation Section 14 *in* NYSDEC 2012 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Johnson, J.H., R.D. McCullough, and I.M. Mazzocchi. 2014. Double-crested cormorant studies at Little Galloo Island, Lake Ontario in 2013: diet composition, fish consumption and the efficacy of management activities in reducing fish predation Section 14 *in* NYSDEC 2013 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Jolliff, T.M. and G.C. LeTendre. 1967. The eastern Lake Ontario-St. Lawrence River, New York, creel census of 1966. New York Conservation Department, Fisheries Research Station, Cape Vincent, NY (unpublished).

Klindt, R.M. and D.J. Gordon. 2018. Lake Sturgeon tagging study and egg take 2017. Section 16 *in* NYSDEC 2017 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Kolander, T.D., C.W. Willis and B.R. Murphy. 1993. Proposed revision of the standard weight (Ws) equation for Smallmouth Bass. North American Journal of Fisheries Management. 13:398-400.

Lantry, B.F., T.H. Eckert, C.P. Schneider, and J.R. Chrisman. 2002. The relationship between the abundance of smallmouth bass and double-crested cormorants in the eastern basin of Lake Ontario. Journal Great Lakes Research 28(2):193-201.

Lantry, J.R. and T.H. Eckert. 2018. 2017 Lake Ontario Fishing Boat Survey. Section 2 *in* NYSDEC 2017 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

McCullough, R.D. and D.W. Einhouse. 1999. Lake Ontario eastern basin creel survey, 1998. Section 4 *in* Final Report: To assess the impact of double-crested cormorant predation on smallmouth bass and other fish of the eastern basin of Lake Ontario. NYSDEC Special Report - February 1, 1999. New York State Department of Environmental Conservation, Bureau of Fisheries, Albany, N.Y.

McCullough, R.D. and D.W. Einhouse. 2004. Eastern basin of Lake Ontario creel survey, 2003. Section 22 *in* NYSDEC 2003 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

McCullough, R.D., and I.M. Mazzocchi. 2016. Cormorant management activities in Lake Ontario's eastern basin. Section 13 *in* NYSDEC 2015 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Mills, E.L. and 17 co-authors. 2005. A synthesis of ecological and fish community changes in Lake Ontario, 1970-2000. Great Lakes Fishery Commission Technical Report 67.

NYDEC (New York Department of Environmental Conservation), Bureau of Fisheries. 1989. 1984 New York State Great Lakes angler survey, Vol. I and II, Albany, NY.

NYSDEC (New York State Department of Environmental Conservation), Bureau of Fisheries. 1999. Final Report: To assess the impact of double-crested cormorant predation on smallmouth bass and other fishes of the eastern basin of Lake Ontario. NYSDEC Special Report - February 1, 1999. New York State Department of Environmental Conservation, Bureau of Fisheries, Albany, N.Y.

NYSDEC (New York State Department of Environmental Conservation), Bureau of Fisheries. 2001. Double-crested cormorant predation on smallmou6th bass and other fishes of the eastern basin of Lake Ontario: Summary of 2000 Studies. NYSDEC Special Report - March 1, 2001. New York State Department of Environmental Conservation, Bureau of Fisheries, Albany, N.Y.

O'Gorman, R., J.H. Elrod, R.W. Owens, C.P. Schneider, T.H. Eckert, and B.F. Lantry. 2000. Shifts in depth distributions of Alewives, rainbow smelt, and age-2 lake trout in southern Lake Ontario following establishment of dreissenid. Transactions of the American Fisheries Society 129: 1096-1106.

O'Gorman, R. and J.A.D. Burnett. 2001. Fish community dynamics in northeastern Lake Ontario with emphasis on the growth and reproductive success of yellow perch (*Perca flavescens*) and white perch (*Morone americana*), 1978 to 1997. Journal of Great Lakes Research 27(3): 367-383.

Ontario Ministry of Natural Resources. 2009. Lake Ontario Fish Communities and Fisheries: 2008 Annual report of the Lake Ontario Management Unit. Ontario Ministry of Natural Resources, Picton, Ontario, Canada.

Ontario Ministry of Natural Resources. 2011a. Lake Ontario Fish Communities and Fisheries: 2010 Annual report of the Lake Ontario Management Unit. Ontario Ministry of Natural Resources, Picton, Ontario, Canada.

Ontario Ministry of Natural Resources. 2011b. 2010 Status of Major Stocks. Lake Erie Management Unit. ISSN 1718-4924 (Print), ISBN 978-1-4435-6432-8 (Print, 2010 ed.), ISSN 1925-5454 (Online), ISBN 978-1-4435-6433-5 (PDF, 2010 ed.). 69pp.

Ontario Ministry of Natural Resources. 2012. Lake Ontario Fish Communities and Fisheries: 2011 Annual report of the Lake Ontario Management Unit. Ontario Ministry of Natural Resources, Picton, Ontario, Canada.

Ontario Ministry of Natural Resources and Forestry. 2017. Lake Ontario Fish Communities and Fisheries: 2016 Annual report of the Lake Ontario Management Unit. Ontario Ministry of Natural Resources, Picton, Ontario, Canada.

Panek, F.M. 1981. The warm water sport fishery of Eastern Lake Ontario. NY Fish and Game Journal 28:178-190.

Ross, R.M, J.H. Johnson, R.D. McCullough, B. Edmonds. 2003. Diet composition and fish consumption of double-crested cormorants from the Pigeon and Snake Island colonies of eastern Lake Ontario in 2002. Section 16 *in* NYSDEC 2002 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the

Great Lakes Fishery Commission's Lake Ontario Committee.

Ross, R.M, J.H. Johnson, R.D. McCullough, B. Edmonds. 2005. Diet composition and fish consumption of double-crested cormorants from the Pigeon and Snake Island colonies of eastern Lake Ontario in 2004. Section 16 *in* NYSDEC 2004 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Walsh, M.G., D.E. Dittman, and R. O'Gorman. 2007. Occurrence and food habits of the Round Goby in the profundal zone of southwestern Lake Ontario. Journal of Great Lakes Research 33:83-92.

Table 1. Stratified mean catch per unit effort data from the 1976-2017 warmwater assessment netting conducted late July through mid-August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang												
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Lake Sturgeon	0	0	0	0	0	0.02	0	0	0	0	0	0	0
Longnose Gar	0	0	0	0	0.04	0	0	0.04	0	1.19	0.04	0	0
Bowfin	0	0	0	0	0.02	0.02	0	0	0	0	0	0	0
American Eel	0	0	0.06	0.03	0	0	0	0	0	0	0	0	0
Alewife	20.96	2.07	14.83	11.57	4.30	8.18	7.53	6.90	17.65	3.35	7.61	2.32	9.64
Gizzard Shad	17.82	53.45	47.38	19.95	4.52	2.78	0.10	0.29	0.87	0.50	0.48	0.44	0.24
Northern Pike	0.83	1.04	0.93	0.16	0.08	0.02	0.04	0.06	0.02	0.17	0.17	0.08	0
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	0	0	0
Muskellunge	0	0	0	0	0	0	0	0	0	0	0	0	0
Goldfish X Carp	0	0	0	0.17	0	0	0	0	0	0	0	0	0
Common Carp	0.25	0.55	0.33	0.45	0.17	0.10	0.35	0.21	0.17	0.17	0.10	0.20	0.23
Golden Shiner	0	0	0	0	0.02	0	0	0	0.04	0.02	0	0	0
Spottail Shiner	0	0	0	0	0	0	0	0.15	0	0	0	0	0
Quillback	0	0	0	0.31	0.04	0.06	0	0.04	0	0	0.02	0	0.02
Longnose Sucker	0	0	0	0	0.02	0	0	0	0	0	0	0	0
White Sucker	4.04	0.63	2.90	3.11	1.84	1.42	4.34	1.40	1.58	0.93	2.47	1.49	0.91
Silver Redhorse	0.06	0.05	0.20	0.43	0.04	0.10	0.15	0.38	0.06	0	0.02	0.02	0.07
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	1.12	0.2	1.41	4.17	0.66	0.23	1.29	0.76	0.86	1.70	2.14	1.96	0.61
Channel Catfish	0.41	1.03	1.75	3.64	0.6	0.56	1.27	0.86	0.29	0.63	1.25	0.77	0.97
Stonecat	0	0.04	0.26	0.08	0	0.23	0.30	0.02	0.04	0.06	0.04	0	0
Trout-perch	0	0	0	0	0	0.15	0.15	0	0.08	0	0	0.08	0.15
White Perch	63	136.4	74.11	86.98	26.2	44.53	25.98	34.02	20.78	12.23	13.94	11.14	4.87
White Bass	0	0	0.13	0	0.02	0.06	0.26	0	0.06	0.02	0.06	0.06	0.13
Rock Bass	7.10	10.75	22.13	13.94	14.69	10.09	7.06	4.69	6.99	3.96	7.58	4.76	4.94
Pumpkinseed	0	0.44	0.06	3.06	0.14	0.32	0.73	0.43	0.09	0.59	0.57	0.40	0.25
Bluegill	0	0	0	0	0	0	0.04	0	0	0	0	0	0
Smallmouth Bass	24.51	24.05	26.04	35.74	38.02	23.47	14.55	14.96	12.44	9.76	18.14	10.89	15.92
Largemouth Bass	0	0	0	0	0	0	0	0	0	0	0	0	0
Black Crappie	0	0	0	0.04	0.02	0.02	0.02	0.06	0.02	0.1	0	0	0.02
Yellow Perch	69.09	26.20	44.44	67.32	27.63	43.81	36.07	50.85	24.02	15.35	13.32	8.36	2.19
Walleye	0.05	0.20	0.12	0.27	0.28	0.12	0.59	0.09	0.09	0.41	0.19	0.75	0.80
Freshwater Drum	0.19	0	0.74	1.43	0.34	0.09	0.34	0.59	0.31	0.25	0.16	0.25	0.45
Round Goby	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	209.4	257.1	237.8	252.8	119.7	136.4	101.2	116.8	86.50	51.38	68.30	43.98	42.42

Table 1 (continued). Stratified mean catch per unit effort data from the 1976-2017 warmwater assessment netting conducted late July through mid-August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang													
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Lake Sturgeon	0	0	0	0	0	0	0.02	0	0.02	0.06	0.04	0.10	0.02	0
Longnose Gar	0	0.08	0	0	0.48	0.35	0	0	0.02	0.02	0.08	0	0.02	0
Bowfin	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0
American Eel	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0
Alewife	0.59	1.29	1.27	2.26	0.18	0	0.48	0.92	0	0.06	0.12	0.26	0.95	0.02
Gizzard Shad	0.69	1.26	1.39	1.79	0.12	0.06	0	0	0	0.08	0.08	0.13	0	0.06
Northern Pike	0.02	0	0.15	0.04	0.10	0.06	0.04	0.04	0.08	0.06	0.06	0.08	0.07	0.19
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Muskellunge	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Goldfish X Carp	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Carp	0.37	0.35	0.29	0.33	0.35	0.06	0.10	0.15	0.12	0.10	0.33	0.04	0	0
Golden Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spottail Shiner	0	0	0	0.06	0	0	0	0	0	0	0	0	0	0
Quillback	0.04	0.04	0.08	0	0.04	0	0	0.04	0	0.04	0	0	0	0
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	0.75	3.47	0.41	0.88	1.18	0.81	1.13	2.01	1.31	1.02	1.02	0.35	0.38	0.78
Silver Redhorse	0.17	0.29	0.22	0.18	0	0.08	0.12	0.02	0.13	0.12	0.10	0.12	0.05	0.17
Shorthead Redhorse	0	0	0	0	0	0.02	0	0	0.02	0	0	0	0.02	0
Brown Bullhead	0.84	0.66	0.86	0.87	0.35	0.35	0.06	0	0.83	0.06	0.21	0.21	0.32	0.21
Channel Catfish	2.40	3.34	1.20	1.35	1.12	0.35	0.19	0.47	1.42	0.75	0.68	0.54	0.09	0.21
Stonecat	0.02	0	0.02	0	0	0	0	0	0	0	0	0	0	0
Trout-perch	0	0	0.12	0	0	0	0	0	0	0	0	0	0	0
White Perch	7.95	4.36	7.83	5.49	5.04	6.01	0.06	0.31	0.48	0.29	1.36	0.92	1.04	1.09
White Bass	0.08	0	0.10	0	0.02	0	0	0	0	0.04	0	0	0	0
Rock Bass	7.53	8.08	6.86	3.09	6.99	3.99	1.41	3.79	2.33	2.13	3.08	1.47	1.22	1.10
Pumpkinseed	0.64	0.78	0.14	0.34	0.23	0.04	0.06	0.04	0.08	0.29	0.27	0.31	0.28	0.46
Bluegill	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass	39.05	21.72	29.4	19.13	19.91	11.99	5.01	6.98	6.03	9.36	10.68	5.01	2.99	3.76
Largemouth Bass	0	0	0	0	0	0	0	0	0	0.02	0	0	0	0
Black Crappie	0.02	0.06	0	0	0.04	0	0	0	0	0.02	0	0	0	0.06
Yellow Perch	10.06	13.61	6.97	6.72	2.78	5.87	3.68	8.76	5.53	5.01	4.47	8.58	6.37	9.65
Walleye	0.96	1.31	1.68	1.59	3.84	3.29	1.91	2.97	1.76	2.13	1.32	1.53	1.70	1.08
Freshwater Drum	0.53	0.62	0.34	0.43	0.52	0.74	0.63	0.23	0.41	0.25	0.50	0.25	0.20	0.23
Round Goby	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	72.71	61.35	59.34	44.57	43.32	34.08	14.91	26.73	20.58	21.94	24.40	19.92	15.73	19.06

Table 1 (continued). Stratified mean catch per unit effort data from the 1976-2017 warmwater assessment netting conducted late July through mid-August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang														
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Lake Sturgeon	0.04	0.02	0.02	0.09	0.10	0	0	0.08	0.02	0	0.02	0	0.063	0.05	0.09
Longnose Gar	0	0.06	0.17	0.12	0.08	0.10	0.21	0.75	0.62	0.02	0.23	0.44	0.67	0	0
Bowfin	0	0	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	0	0
Alewife	0.08	0	0	0.07	0.14	0.19	1.19	0	0.16	0.46	0	0.31	0.47	0.02	0.09
Gizzard Shad	0	0	0	0	0	0	0.10	0	0.12	0.19	2.08	0.32	1.09	0.70	2.83
Northern Pike	0.15	0.17	0.19	0.08	0.06	0.23	0.09	0.10	0.02	0.02	0.12	0.12	0.02	0.02	0
Chain Pickerel	0	0	0	0	0	0	0	0	0	0	0.06	0	0	0	0
Muskellunge	0	0.02	0.02	0	0	0	0	0	0	0	0	0	0	0	0
Goldfish X Carp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Carp	0.02	0.15	0.14	0.11	0.02	0.05	0.10	0.02	0.02	0	0.15	0.11	0.05	0.08	0.07
Golden Shiner	0	0	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	0	0
Quillback	0	0	0	0	0	0	0	0	0	0	0.08	0.02	0.02	0.03	0.02
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	1.66	0.41	1.03	0.72	0.573	0.65	1.31	0.48	0.25	2.35	0.19	0.16	0.57	0.22	1.17
Silver Redhorse	0.10	0.42	0.33	0.02	0.02	0.08	0.07	0.04	0	0.06	0.06	0	0	0.05	0.05
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	0.40	0.35	0.48	0.31	0.54	2.12	0.81	1.48	0.42	0.82	1.97	1.54	0.46	0.60	0.12
Channel Catfish	0.12	0.79	0.81	0.15	0.12	0.57	0.54	0.42	0.17	0.21	0.42	0.07	0.31	0.13	0.05
Stonecat	0	0	0.06	0.02	0	0	0	0.04	0.02	0.02	0	0	0	0	0
Trout-perch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Perch	0.42	1.18	1.94	0.92	0.81	7.75	3.02	6.22	3.72	1.04	6.41	7.87	3.69	3.55	4.80
White Bass	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock Bass	1.84	2.09	2.70	2.43	0.70	3.27	2.52	1.54	1.31	0.75	1.21	1.00	1.06	1.43	1.82
Pumpkinseed	0.46	0.52	0.50	1.15	0.21	0.10	0.28	0.04	0.21	0.29	0.38	0.02	0.04	0.03	0.12
Bluegill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smallmouth Bass	5.43	3.84	11.33	10.45	6.39	9.27	9.81	7.90	6.09	8.12	7.65	5.01	4.36	4.98	6.83
Largemouth Bass	0	0.02	0.02	0.02	0	0	0.03	0.02	0	0	0.02	0	0	0	0
Black Crappie	0	0.02	0.06	0	0.04	0.05	0.03	0.04	0.04	0.02	0.06	0.02	0	0	0.23
Yellow Perch	9.82	6.74	8.93	9.13	13.95	16.91	7.37	16.31	15.29	14.99	10.32	1.70	0.82	3.15	15.21
Walleye	2.12	1.69	2.38	1.94	1.33	2.33	2.65	1.91	1.97	2.38	1.34	1.55	0.97	1.28	1.99
Freshwater Drum	0.27	0.60	0.19	0.32	0.23	0.26	0.36	0.08	0.19	0.19	0.29	0.34	0.26	0.16	0.52
Round Goby	0	0	0.04	0.10	0.26	0.42	0.95	0.36	0.08	0.07	0.02	0	0	0.06	0.07
Total	22.92	19.1	31.36	28.16	25.6	44.36	31.44	37.84	30.73	32.02	33.09	20.62	14.92	16.52	36.08

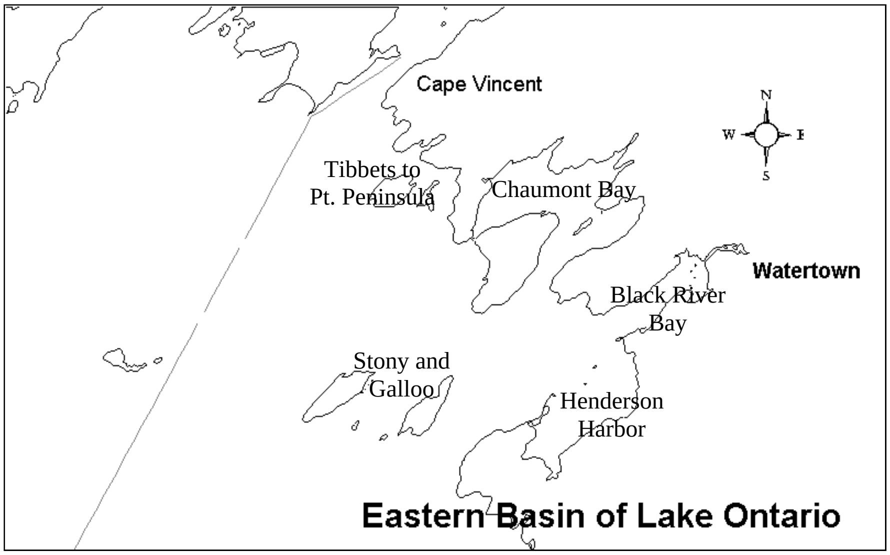

Figure 1. Map of New York waters of Lake Ontario's eastern basin showing five area strata used in the 1980-2017 warmwater assessment.

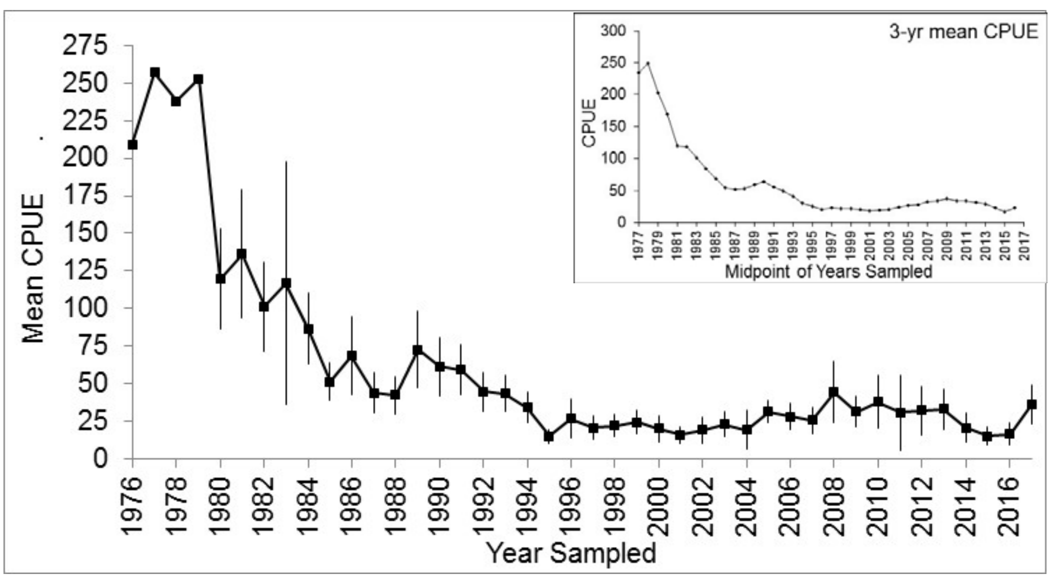

Figure 2. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for all warmwater fish from the 1976-2017 assessments.

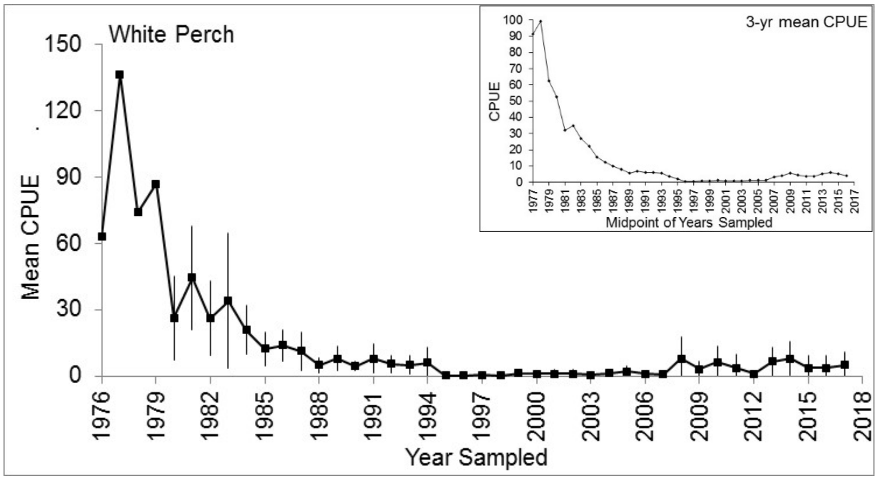

Figure 3. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for white perch, 1976-2017.

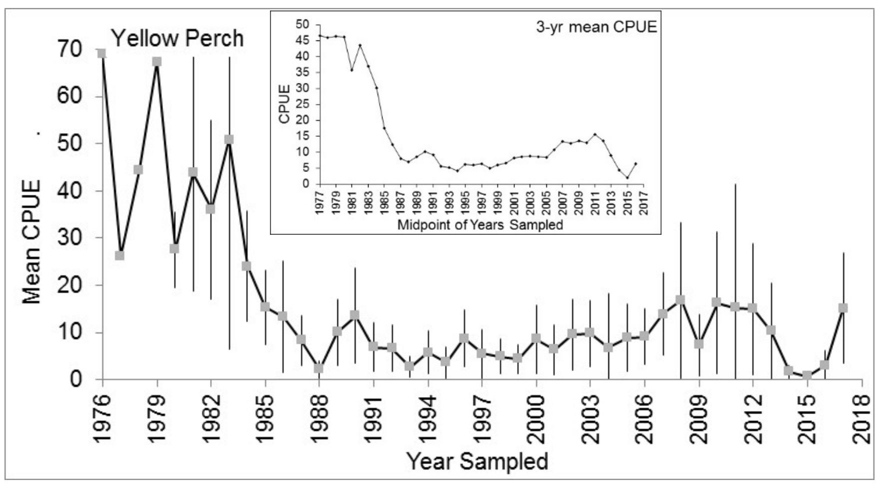

Figure 4. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for yellow perch, 1976-2017.

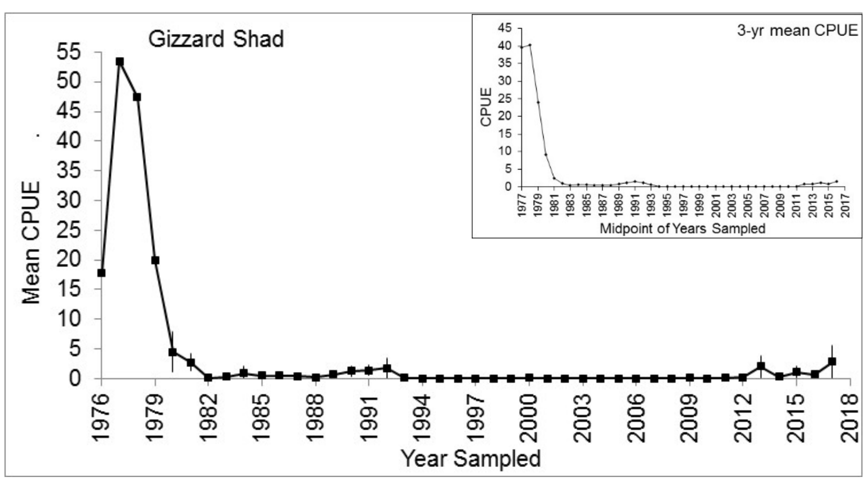

Figure 5. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for gizzard shad, 1976-2017.

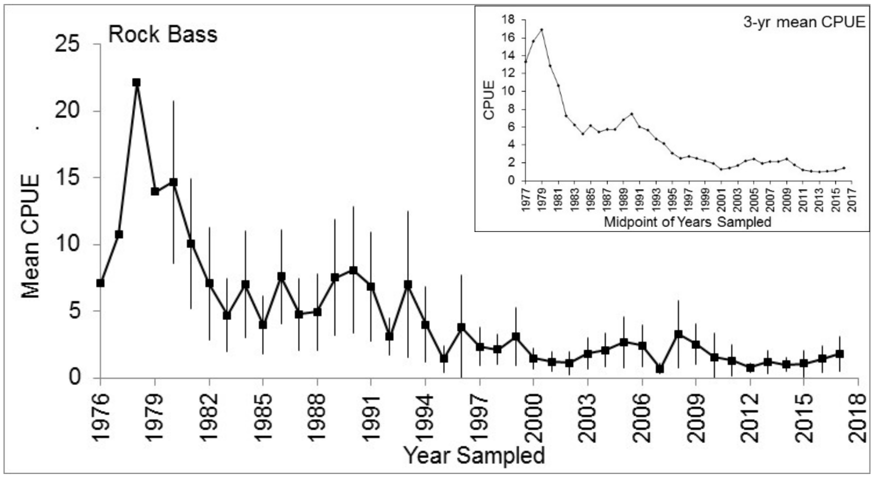

Figure 6. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for rock bass, 1976-2017.

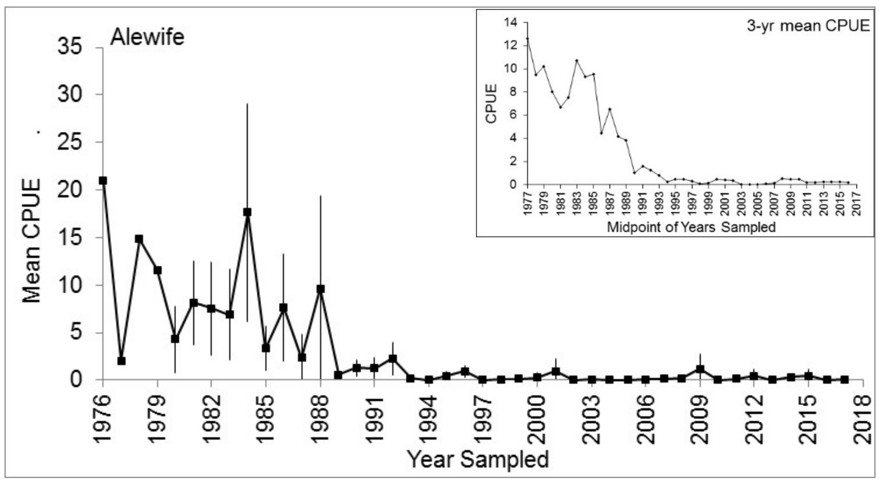

Figure 7. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for alewife, 1976-2017.

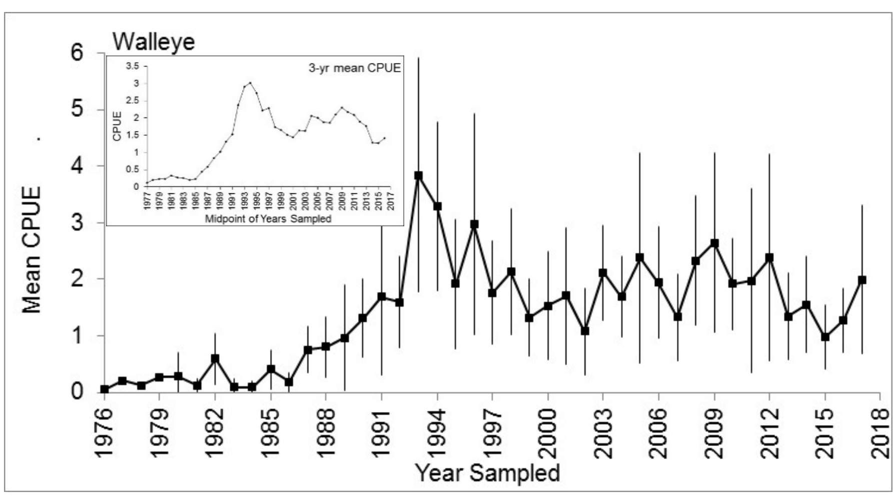

Figure 8. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for walleye, 1976-2017.

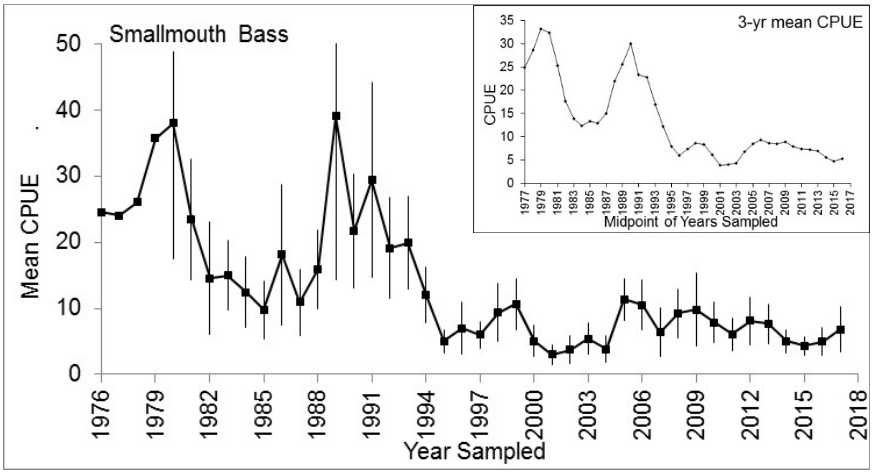

Figure 9. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for smallmouth bass, 1976-2017.

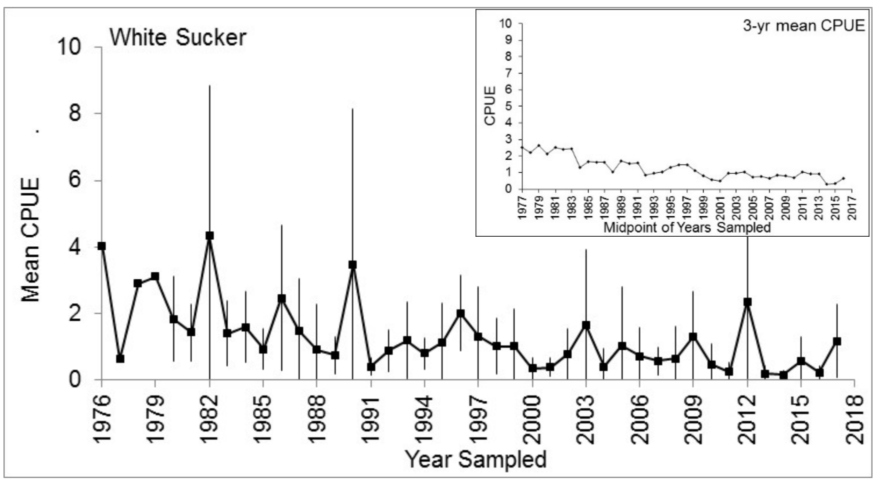

Figure 10. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for white sucker, 1976-2017.

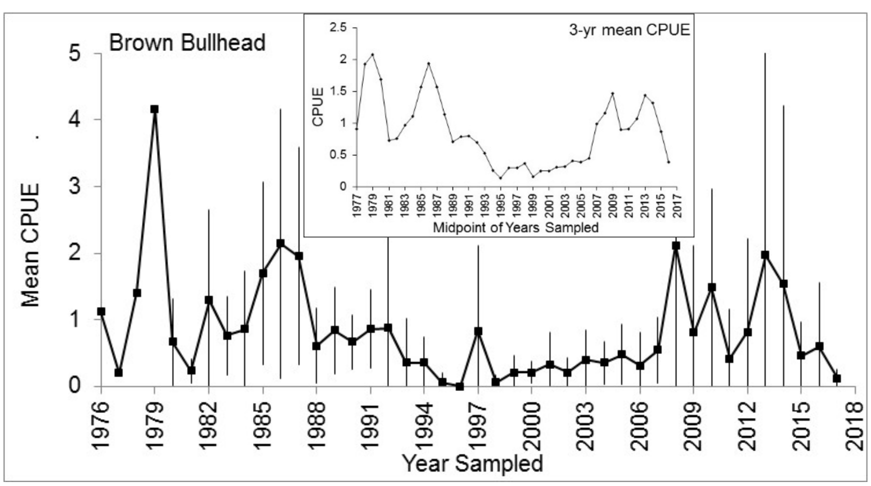

Figure 11. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for brown bullhead, 1976-2017.

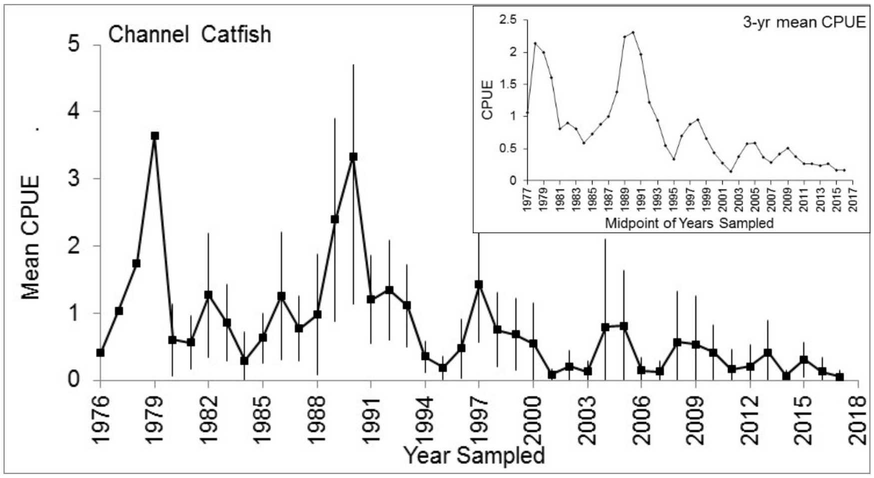

Figure 12. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for channel catfish, 1976-2017.

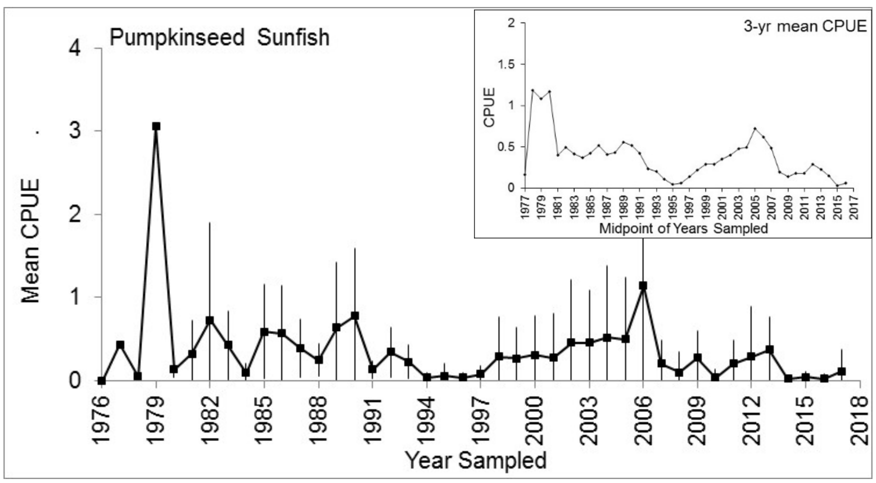

Figure 13. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for pumpkinseed sunfish, 1976-2017.

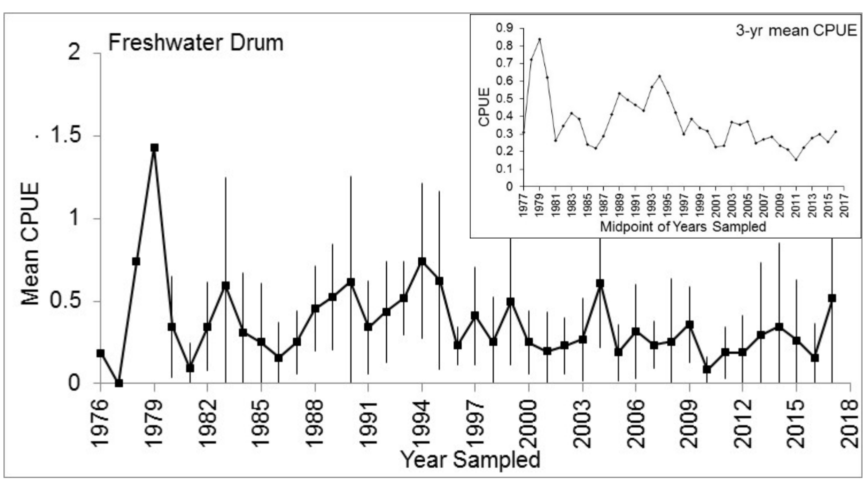

Figure 14. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for freshwater drum, 1976-2017.

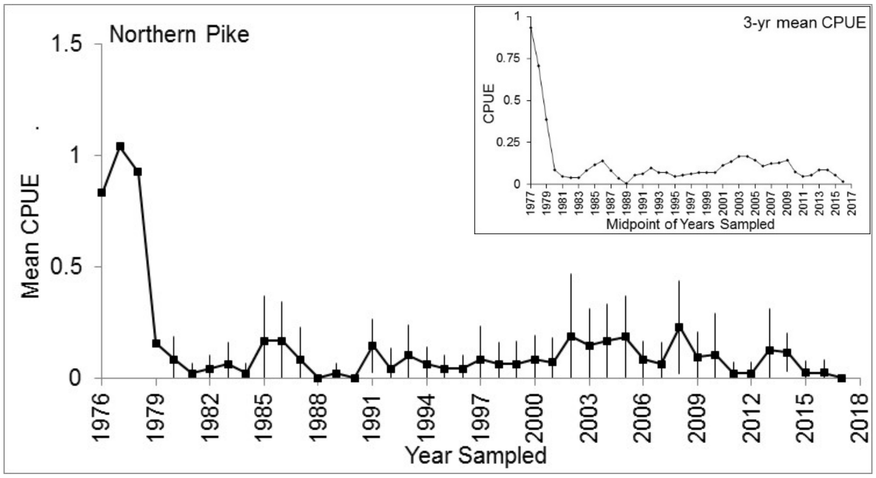

Figure 15. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for northern pike, 1976-2017.

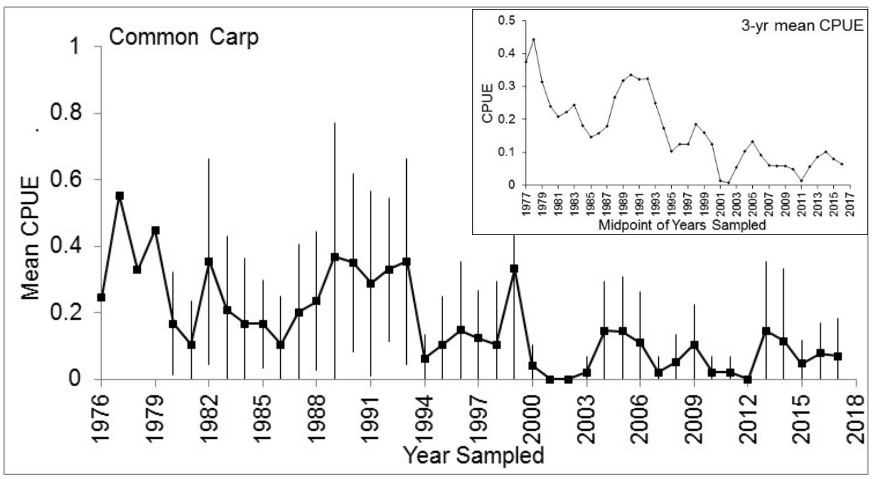

Figure 16. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for common carp, 1976-2017.

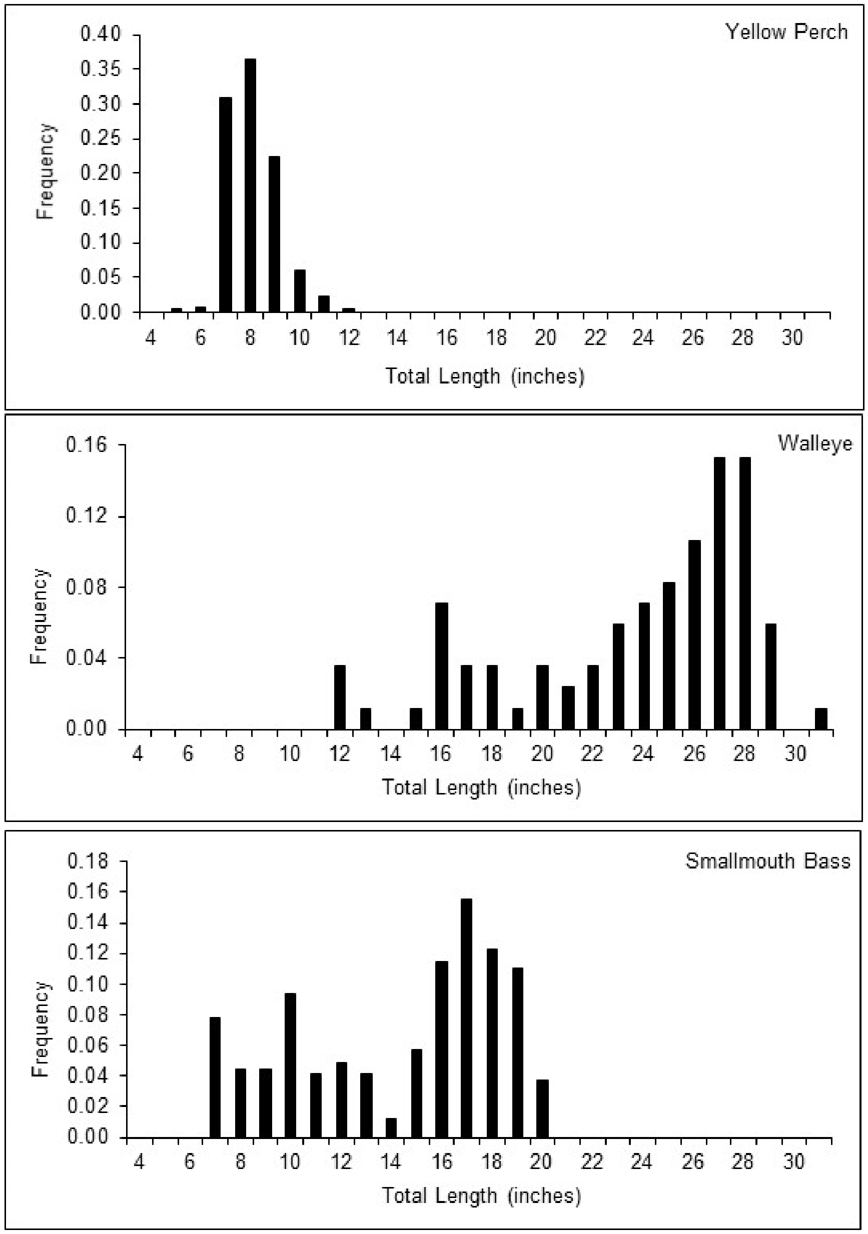

Figure 17. Length frequency distribution of yellow perch, walleye, and smallmouth bass collected during the warmwater assessment in 2017.

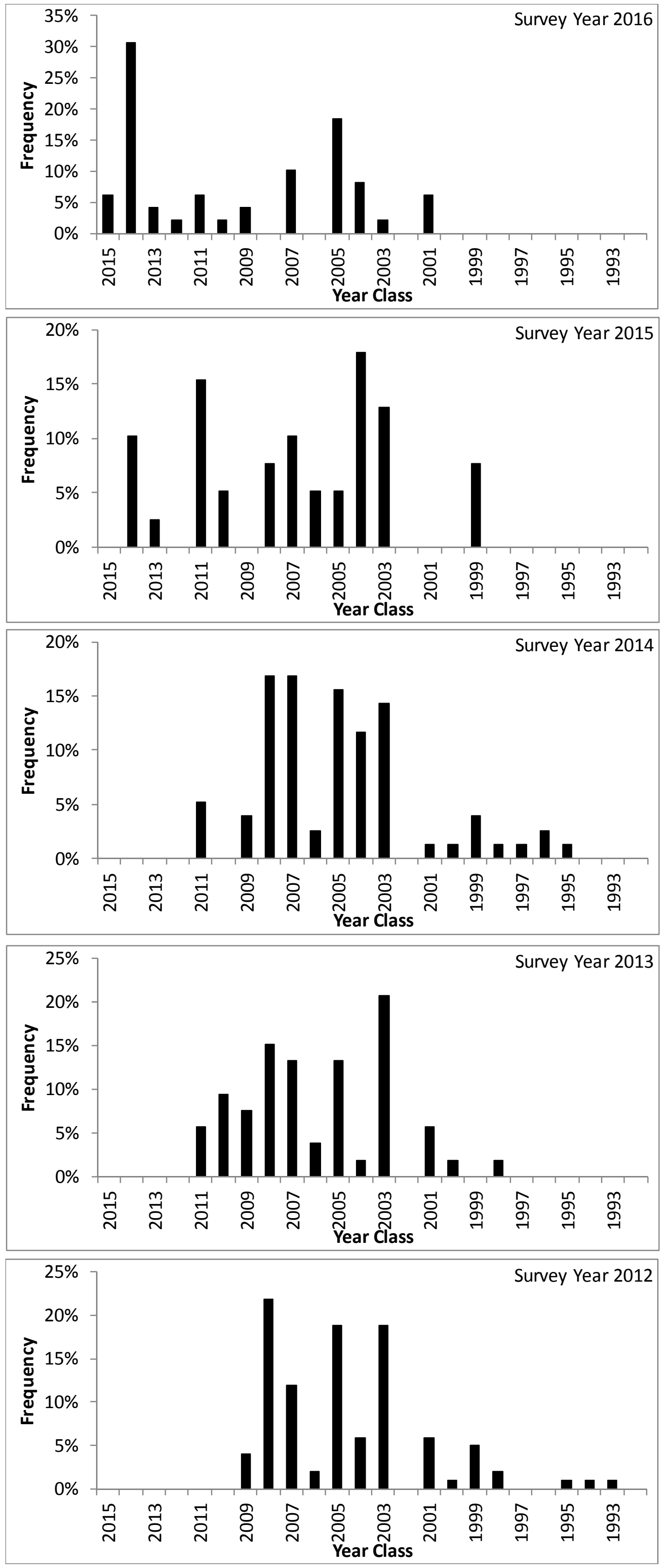

Figure 18. Year class frequency distribution of walleye collected during the warmwater assessment in 2012-2016.

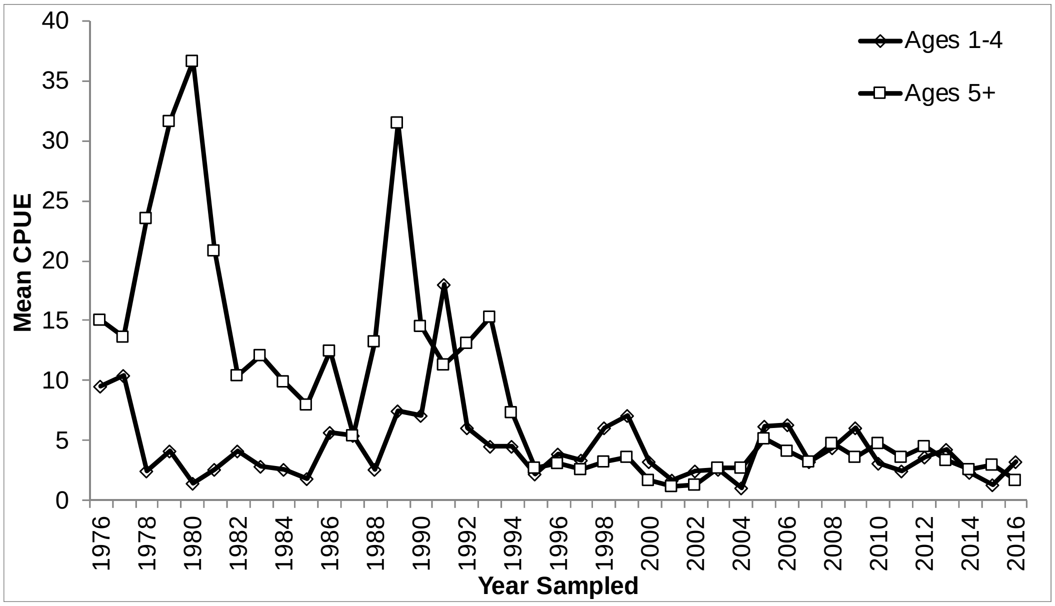

Figure 19. Stratified mean catch per 450 ft gill net gang (CPUE) of smallmouth bass ages ≤ 4 and ages ≥ 5, 1976-2016. Note: Increased growth and changes in net catchability confound inter-annual comparisons of age-specific CPUE.

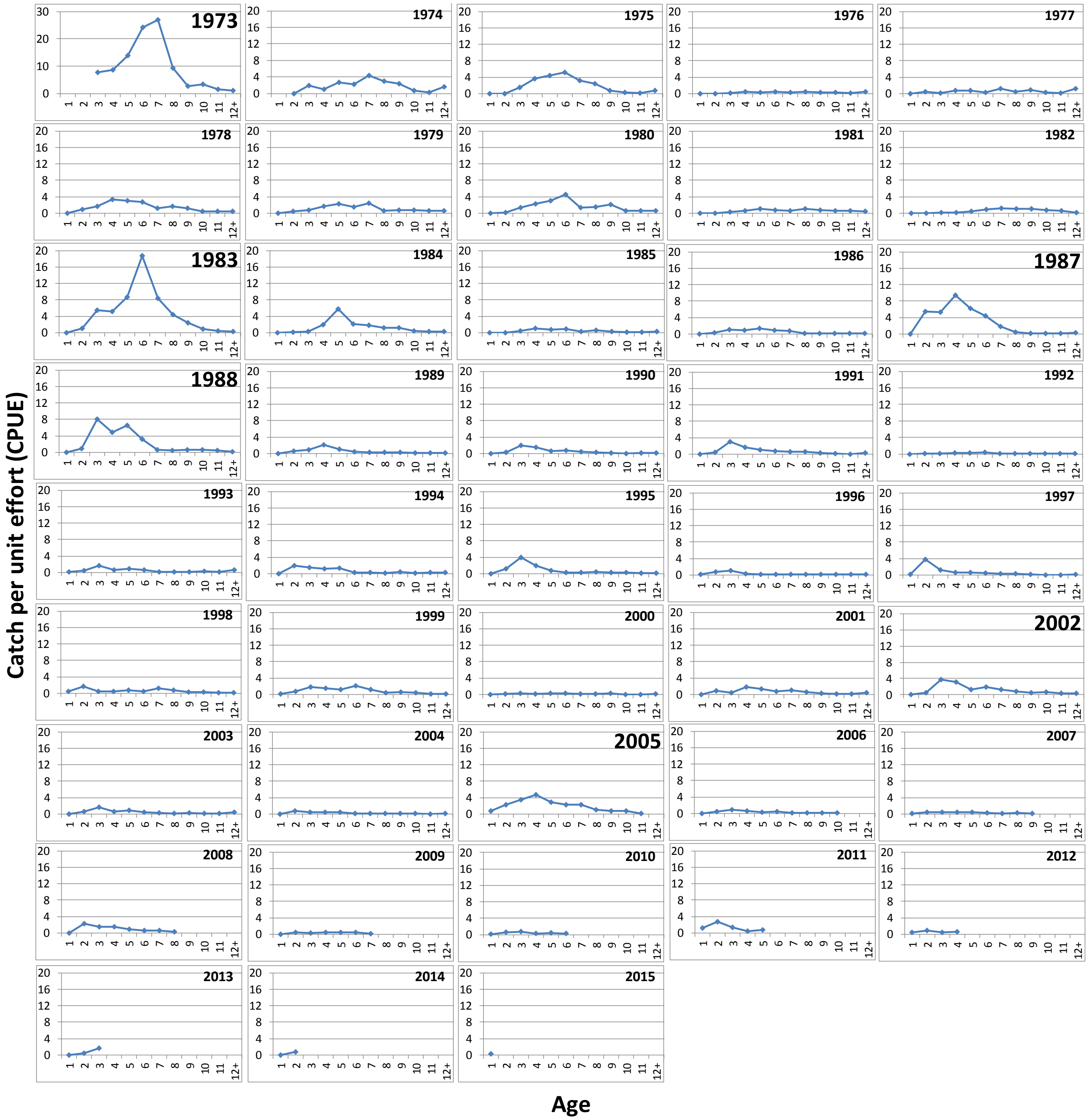

Figure 20a. Smallmouth bass year class-specific catch curves (CPUE by age), 1973-2015 year classes. Note the difference in y-axis scale for the 1973 year class vs. the y-axis scale 1974-2015 year classes.

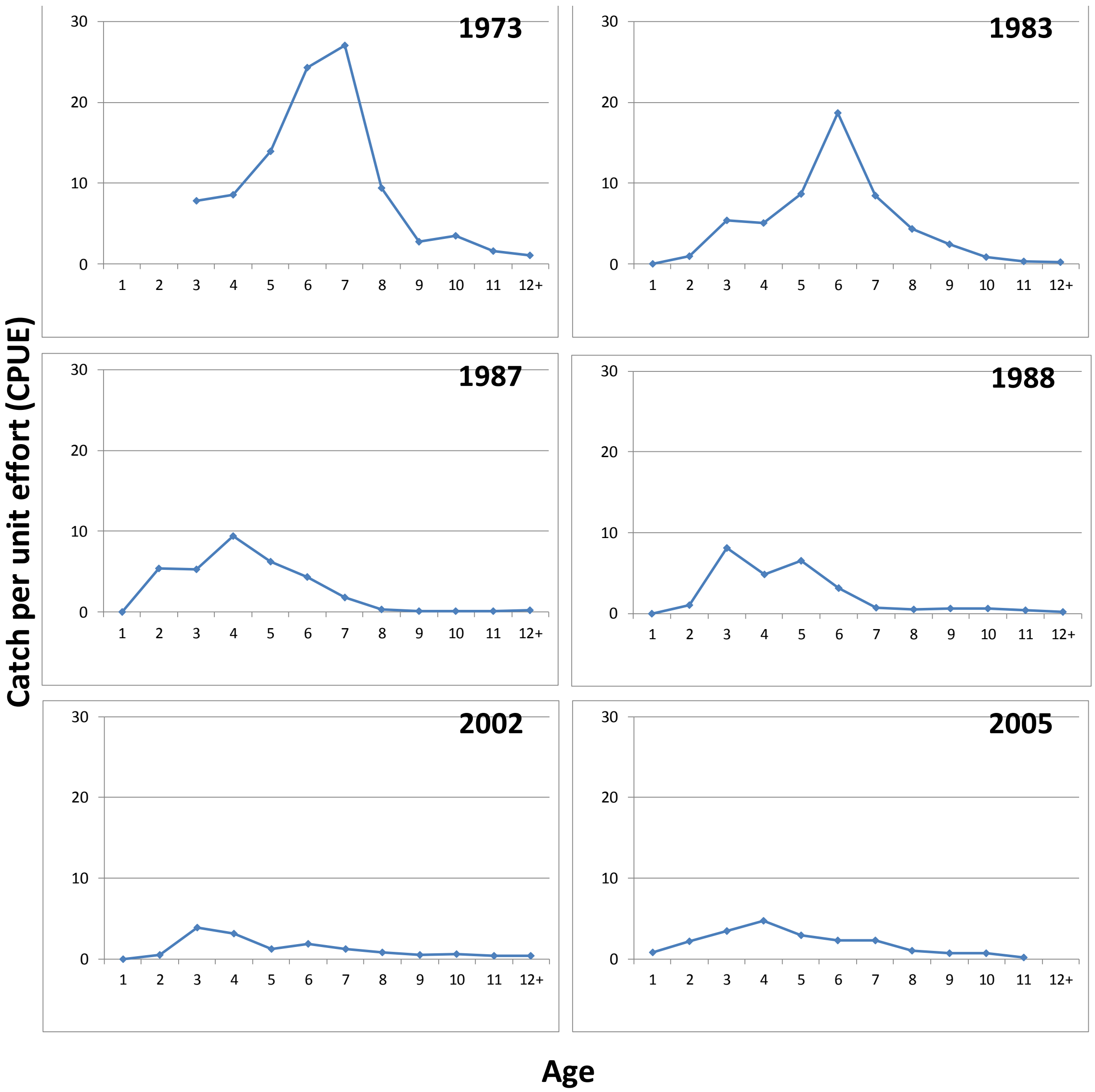

Figure 20b. Smallmouth bass year class-specific catch curves (CPUE by age) for the 1973, 1983, 1987, 1988, 2002, and 2005 year classes.

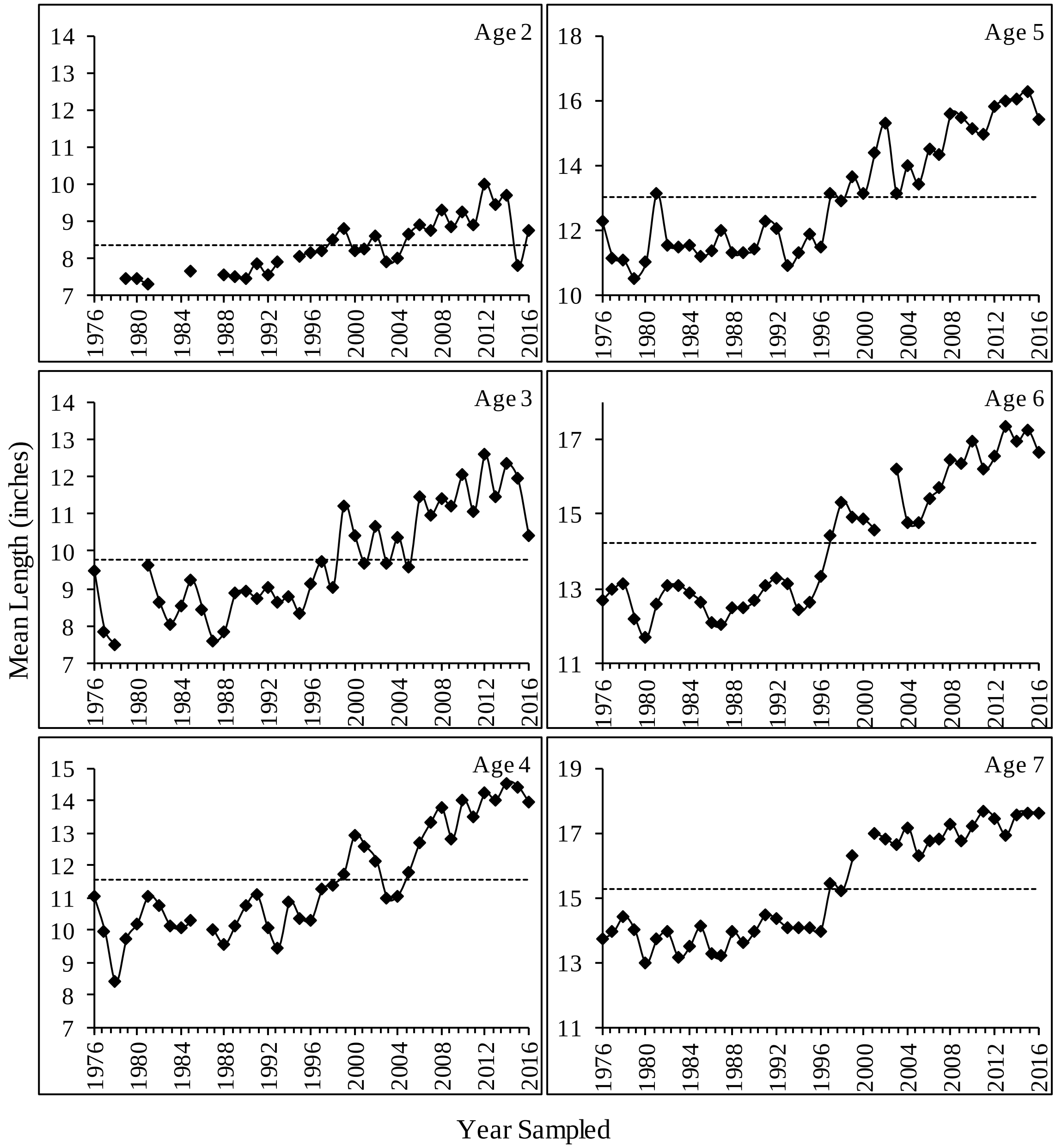

Figure 21. Mean length at age (age 2-13) by year sampled (1976-2016) for smallmouth bass collected during the warmwater assessment (continued on next page). Dotted lines represent longterm mean lengths.

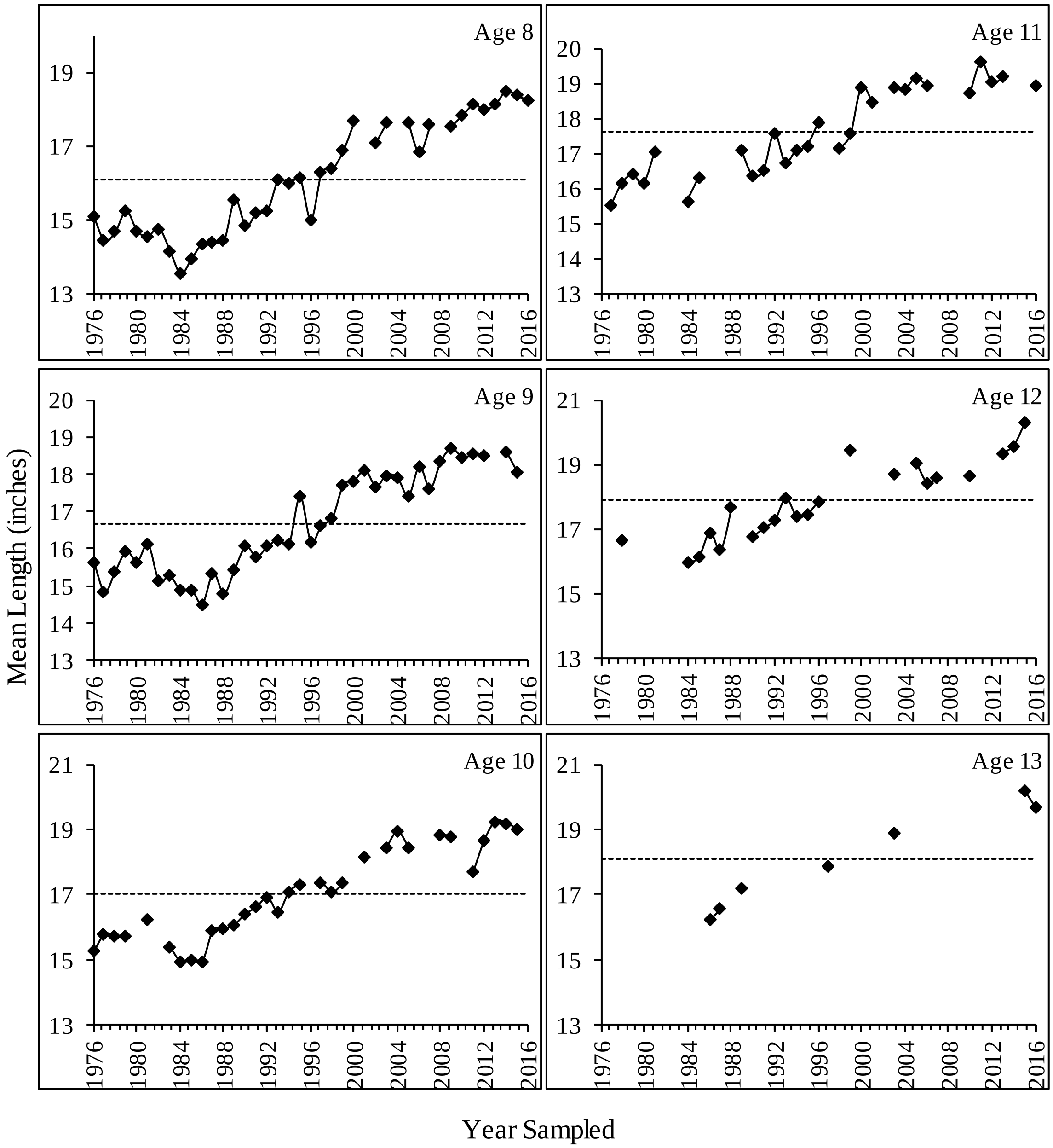

Figure 21 (continued). Mean length at age (age 2-13) by year sampled (1976-2016) for smallmouth bass collected during the warmwater assessment. Dotted lines represent the longterm mean lengths.

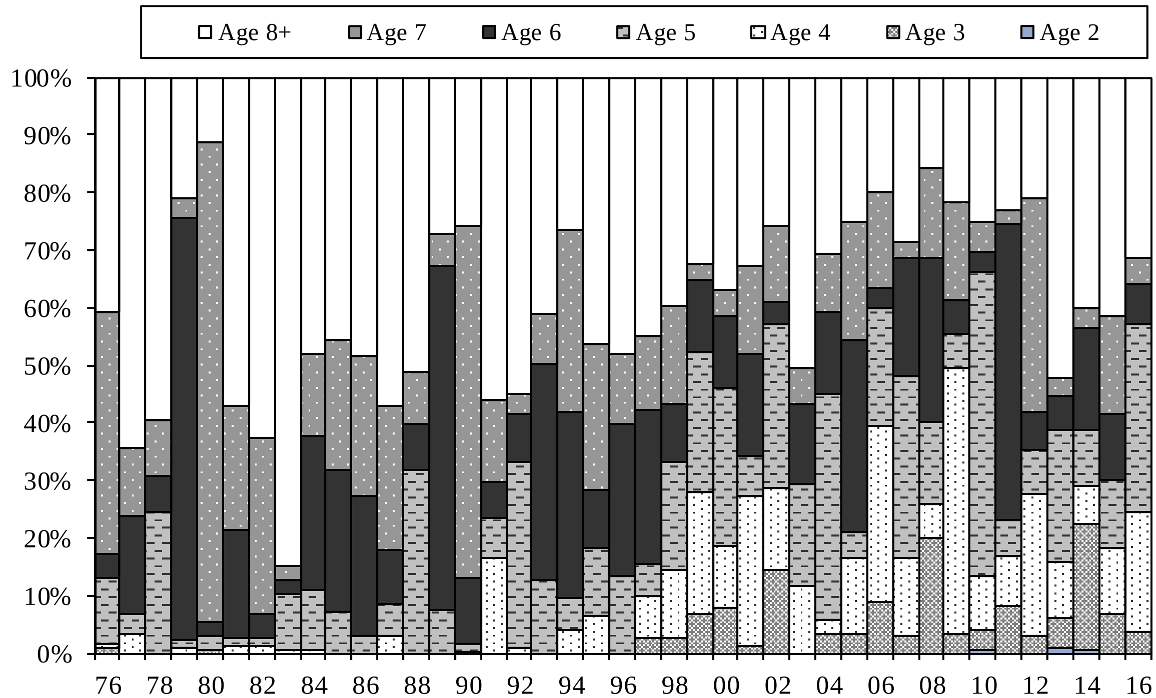

Figure 22. Age composition of smallmouth bass ≥ 12 inches in the warmwater assessment (1976-2016).

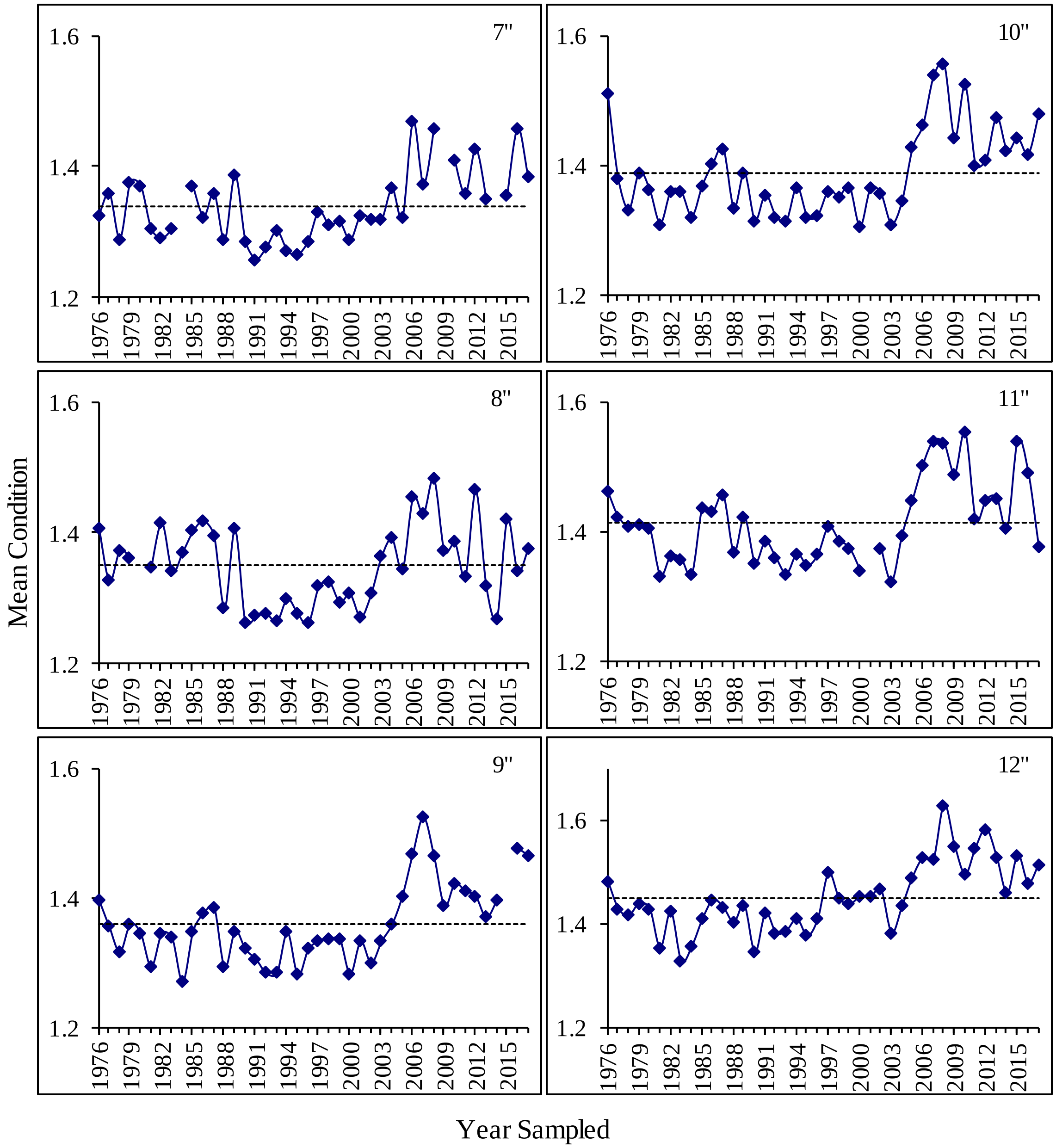

Figure 23. Mean condition (7-21 inch increments) by year sampled (1976-2017) for smallmouth bass collected during the warmwater assessment. Dashed line represents the long-term mean condition for the respective length increment.

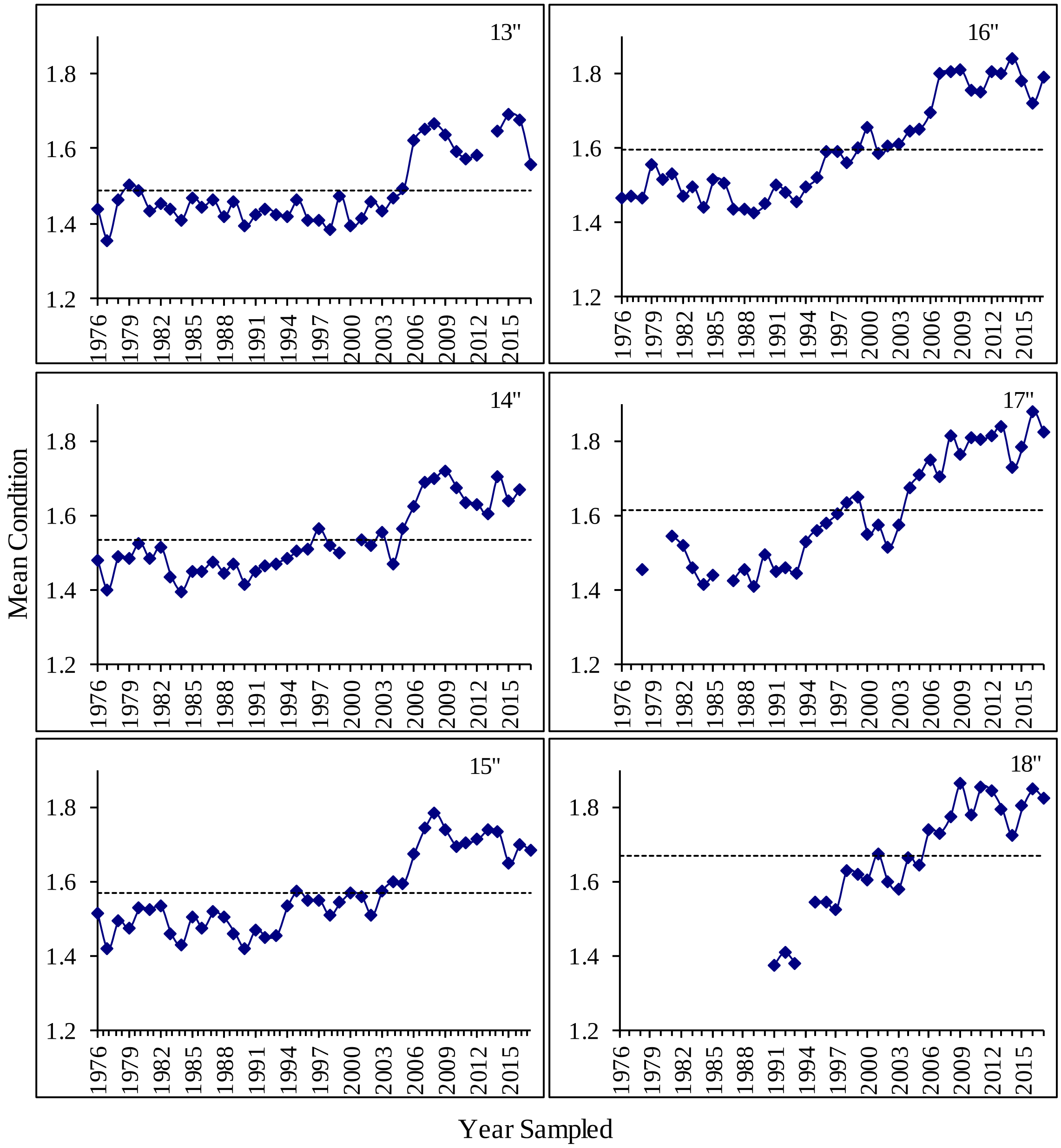

Figure 23 (continued). Mean condition (7-21 inch increments) by year sampled (1976-2017) for smallmouth bass collected during the warmwater assessment. Dashed line represents the long-term mean condition for the respective length increment.

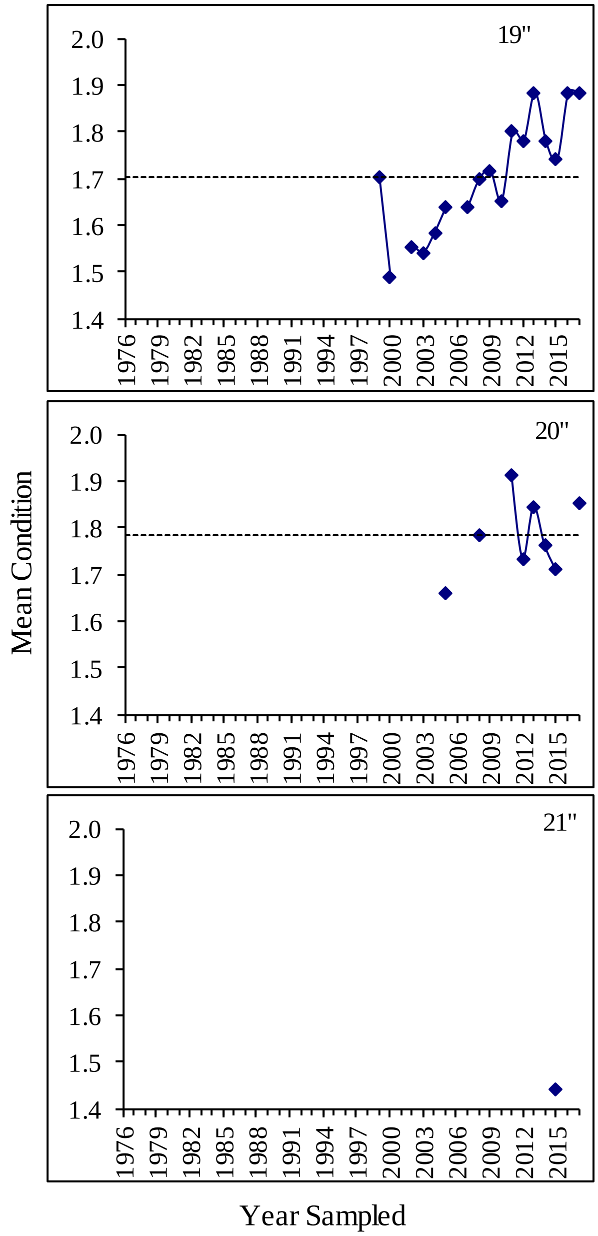

Figure 23 (continued). Mean condition (7-21 inch increments) by year sampled (1976-2017) for smallmouth bass collected during the warmwater assessment. Dashed line represents the long-term mean condition for the respective length increment.

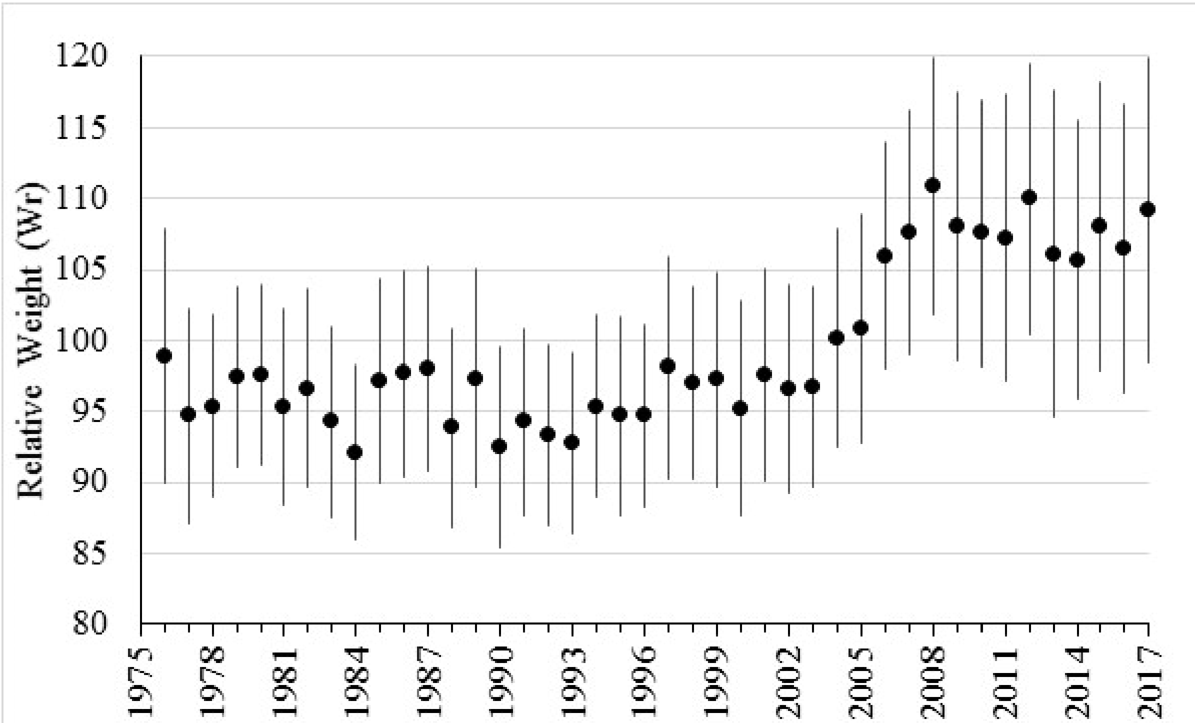

Figure 24. Mean relative weight of smallmouth bass caught in the warmwater assessment (1976-2017) (+ 1 standard deviation).

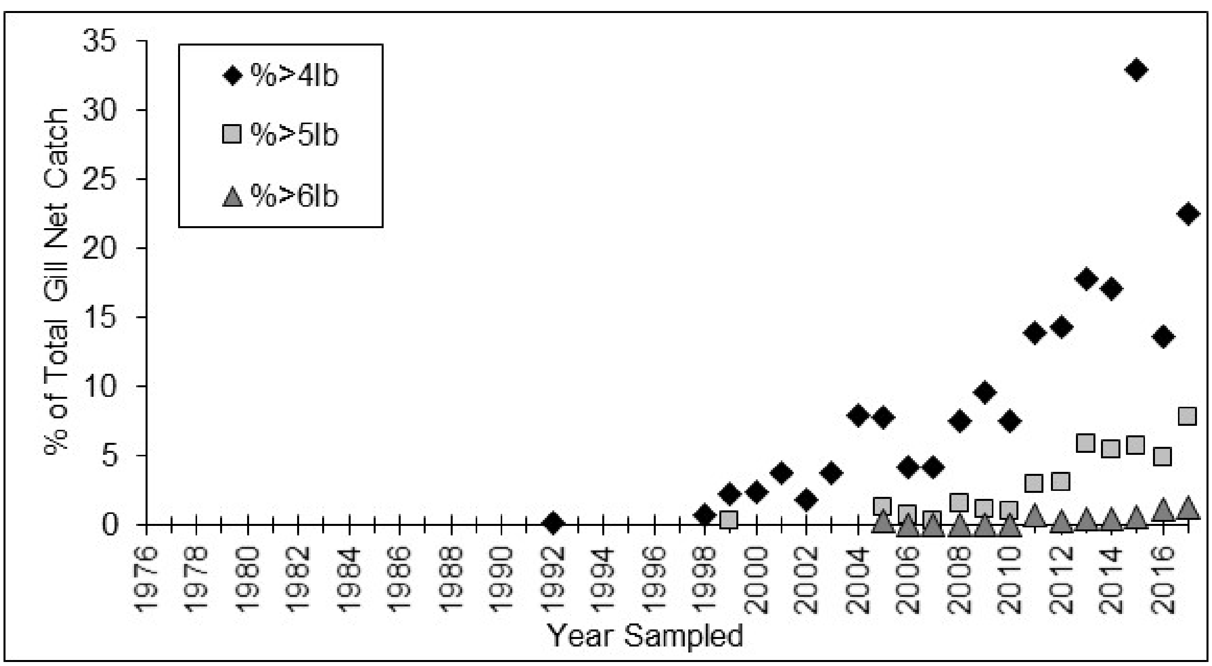

Figure 25. Percentage of total smallmouth bass catch during the warmwater assessment (1976-2017 catches) that were >4lb, >5lb, and >6lb.

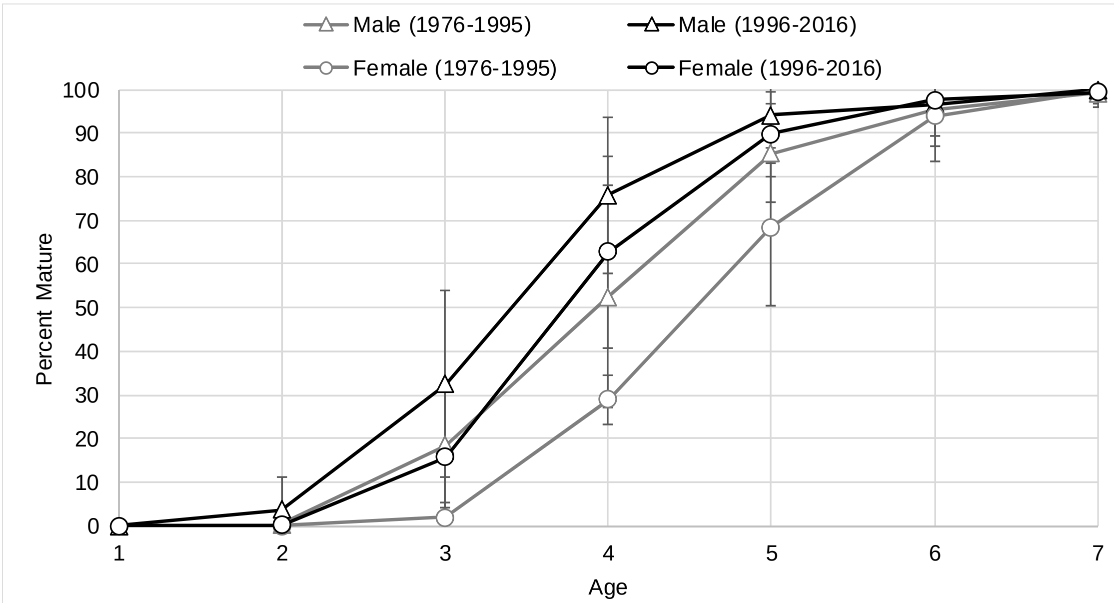

Figure 26. Average (± 1 standard deviation) percent maturity of age-1 to age-7 male and female smallmouth bass sampled during survey years 1976-1995 and 1996-2016.

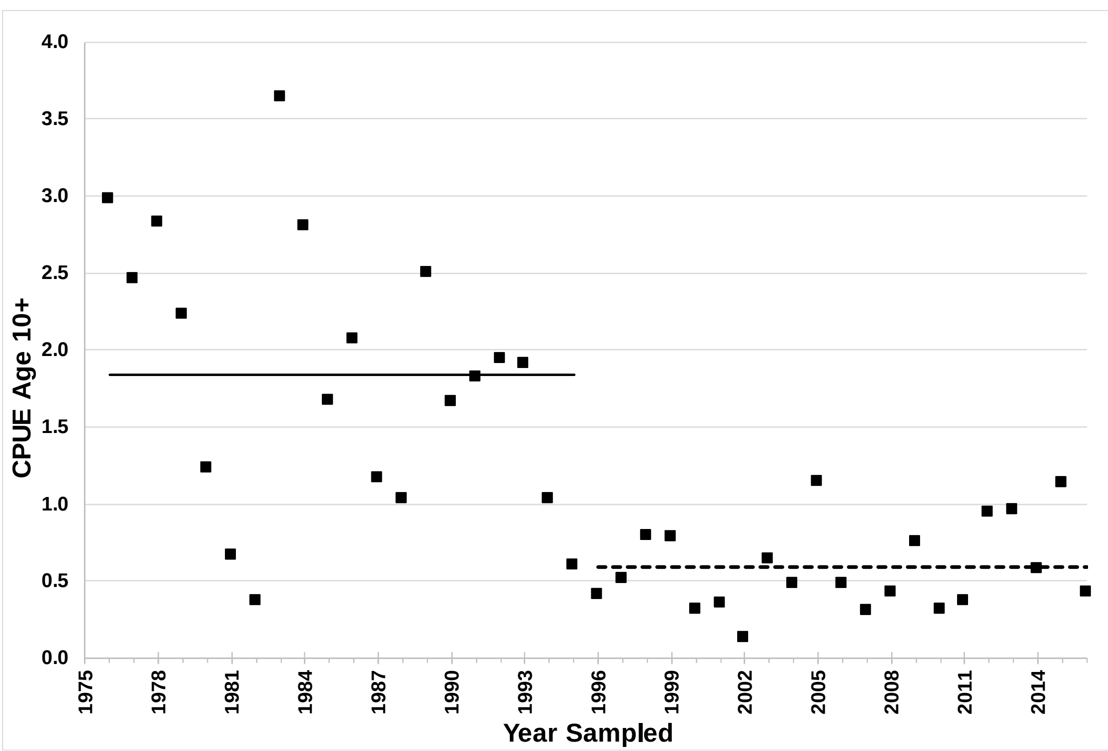

Figure 27. Stratified mean catch per 450 ft gill net gang (CPUE) of smallmouth bass ages 10+, 1976-2016 sample years. Solid line is the 1976-1995 average CPUE of age 10+ bass. Dashed line is the 1996-2016 average CPUE of age 10+ bass.

Lake Trout Rehabilitation in Lake Ontario, 2017

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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 2015 year-class of stocked lake trout (age 2 in 2017) was below the average for the 1993-2015 year-classes. The catch per unit effort of adult lake trout in gill nets increased each year from 2008-2014, recovering from historic lows recorded during 2005-2007. Adult abundances declined each year from 2015 to 2017; and in 2017 were about 35% below the 2014 peak and 17% below the 1999-2004 mean. The 2017 rate of wounding by sea lamprey* (Petromyzon marinus) *on lake trout caught in gill nets (0.50 A1 wounds per 100 lake trout) was below target (2 wounds per 100 lake trout). Estimates from the NYSDEC fishing boat survey indicated 2017 angler catch rate was nearly 3.5 times higher than the lows observed in 2007. Condition values for an adult lake trout, indexed in September from the predicted weight for a 700mm lake trout from annual length-weight regressions and Fulton's K for age-6 males, were among the highest levels observed for the 1983-2017 time series. July-August condition of juvenile lake trout indexed from the predicted weight of a 400 mm individual and Fulton's K for age-2 fish increased sharply from low values observed during 2015-2016. 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 2009-2017. Twenty three cohorts of naturally produced lake trout have been collected since 1994 with the largest catches occurring during 2014-2017.*

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], U.S. Geological Survey [USGS], U.S. Fish and Wildlife Service [USFWS], and Ontario Ministry of Natural Resources and Forestry [OMNRF]) developed the Joint Plan for Rehabilitation of Lake Trout in Lake Ontario (Schneider et al. 1983, 1997) which guided restoration efforts and evaluation through 2014. A revised document, A Management Strategy for the Restoration of Lake Trout in Lake Ontario, 2014 Update (Lantry et al. 2014), will guide future efforts. The present report documents progress towards restoration by reporting on management plan targets and measures through 2017.

The data associated with this report have not received final approval by the U.S. Geological Survey (USGS) and are currently under review. The Great Lakes Science Center (GLSC) is committed to complying with the Office of Management and Budget data release requirements and providing the public with high quality scientific data. The USGS research vessel data collected between 1958 and 2017 is publicly available from the GLSC website (http://doi.org/10.5066/F75M63X0). Please direct any immediate questions to our

Information Technology Specialist, Scott Nelson, at snelson@usgs.gov. All USGS sampling and handling of fish during research are carried out in accordance with guidelines for the care and use of fishes by the American Fisheries Society (http://fisheries.org/docs/wp/Guidelines-for-Use-of-Fishes.pdf). Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Methods

Adult Gill Net Survey

During September 1983-2017, adult lake trout were collected with gill nets at random transects within each of 14 to 17 geographic areas distributed uniformly within U.S. waters of Lake Ontario. Survey design (size of geographic areas) and gill net construction (multi- vs. mono-filament netting) has changed through the years. For a description of survey history including gear changes and corrections see Elrod et al. (1995).

During September 2017, 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 depth contours beginning at the 10ºC (50ºF) isotherm and proceeding deeper in 10-m (32.8-ft) increments. At two sites in the eastern basin, less than the standard four nets per site were fished due to thermocline depth. In the Black River Channel two nets were fished between 40 m and 44 m (131.2 – 144.4 ft); and in the St. Lawrence Channel three nets were fished between 34 to 52 m (111.5 – 170.6 ft).

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

A stratified catch per unit effort (CPUE) was calculated using four depth based strata, representing net position from shallowest to deepest. The unit of effort was one overnight set of one net. Depth stratification was used because effort was not equal among years and catch per net decreased uniformly with increasing depth below the thermocline (Elrod et al. 1995). To examine variability in CPUE between years, the relative standard error was calculated (RSE = 100 * {standard error / mean}).

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

Adult condition was indexed from both the predicted weights of a 700-mm (27.6 in) 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 in those comparisons were of the lean morphotype, the only morphotype stocked into Lake Ontario until 2009. Since 2009, five year-classes of the Klondike (SKW) strain lake trout (2008, 2013-2016) were stocked into Lake Ontario. The SKW 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 with the potential to have a higher condition factor than the leans. When the first year-class (2008) of SKWs reached maturity in 2014, however, their age-6 Fulton's K value (1.07) was almost identical to Seneca Lake strain (SEN's; 1.08), one of the most prominent strains in the population.

Lake trout fecundity changes with age and length (O'Gorman et al. 1998), and both mean age and mean length increased after effective control of sea lamprey (achieved during the mid-1980s) reduced size-selective mortality on lake trout ≥433 mm (17 in). 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-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 1982-2017. 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). Where susceptibility factors were lacking for some strains we substituted factors from other strains that were similar in geographic and genetic origin (i.e., we grouped Lake Champlain strains with SEN strain, and all Lake Superior lean strains with Superior Marquette Domestics (SUP)). The addition of the SKW strains to the stocking mix for Lake Ontario will necessitate reexamining fecundity relationships as the 2013-2016 year-classes begin to reach maturity in 2018.

<u>Creel Survey</u>

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 2018). 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, 1985-2017.

<u>Juvenile Trawl Survey</u>

From mid-July to early-August, 1980-2017, crews from USGS and NYSDEC used the R/V *Kaho* and the R/V *Seth Green* to capture juvenile lake trout (targeting age-2 fish) with bottom trawls. Trawling was generally conducted at 14 locations in U.S. waters distributed evenly along the southern shore and within the eastern basin, and at one location in Canadian waters off the mouth of the Niagara River. In 2013, effort was reduced because no lake trout from the 2011 year-class were stocked in U.S. waters during 2012 (Lantry and Lantry 2013) and thus no U.S. stocked age-2 lake trout were present in 2013. Effort returned to routine levels in 2014. In 2017, trawling was conducted at 14 locations during July 6 - 14. A standard tow was 10 min long. From 1980 to 1996, trawling was conducted with a 12-m (39.4-ft, headrope) trawl at 5-m (16.4-ft) depth intervals, beginning at the metalimnion (15°C, 59°F isotherm) and progressing into deeper water until few or no lake trout were captured. Because of an abrupt shift in the depth distribution of juvenile lake trout to deeper waters in 1993 (O'Gorman et al. 2000) and fouling of the gear by dreissenid mussels in 1996, the sampling scheme and gear were changed. In 1997 the 12-m (39.4-ft) trawl was replaced with a 3-in-1 trawl (18-m or 59-ft headrope, 7.6-m or 24.9-ft spread) equipped with roller gear along the footrope. In addition, effort was decreased at depths < 55 m (180.4 ft) and increased at depths > 70 m (229.6 ft). For years after 1997, the sampling protocol was modified by alternating between odd and even depths (5-m or 16.4-ft increments) between adjacent sites and adjacent years. At four sites where depth did not exceed 75 m (246.1 ft), all 5-m (16.4-ft) contours at and below the 15°C (59°F) isotherm were fished.

Data collection from trawl-captured lake trout was the same as that described above for fish captured with gill nets. Survival indices were calculated from catches of age-2 lake trout that were stocked in U.S. waters. Survival was assessed at age-2 because the trends in index were similar for age-2 lake trout caught in this survey and age-3 lake trout from the same year-class caught in the gill net survey. This indicated that recruitment of hatchery fish to the population was governed by survival during their first year in Lake Ontario. For 1981 to 1996 (1979-1994 year-classes), survival indices were calculated by adjusting total catch for strain, stocking location, and to reflect a total of 500,000 spring yearlings stocked (total catch * 500,000 / the number stocked). Data obtained on the 1995 year-class were not adjusted for strain or stocking location because of poor retention rates of CWTs. Among the age-2 lake trout caught in trawls in 1997, 36% of adipose-fin clipped individuals did not have tags. Data for year-classes stocked since 1997 were not adjusted for strain or stocking location because from 36% to 84% of fish stocked during 1997-2003 did not receive CWTs and stockings thereafter did not include the CWL strain or the Niagara River stocking location which were the factors that necessitated catch adjustment. Catches of the 1995 through 2015 year-classes were, however, adjusted for numbers stocked. Most untagged fish stocked since 1997 received paired fin clips that facilitated year-class identification through at least age 4. The ages of unmarked fish and fish with poor clips were estimated with age-length plots developed from CWT tagged fish.

To assess the condition of juvenile lake trout, we used the predicted weight of a 400-mm (15.8 in) fish. A 400-mm fish would be age 2 or 3. Weights were estimated each year from length-weight regressions calculated from annual trawl catches of lake trout ranging in total length from 250 mm to 500 mm (9.8 in to 19.7 in); and from Fulton's *K* (Ricker 1975, Nash et al. 2006) for age-2 lake trout of both sexes.

Results and Discussion

<u>Stocking</u>

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 (ANFH; 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 an annual 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-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 1993 target level in 18 of 25 years during 1993-2017 (Figure 1). 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

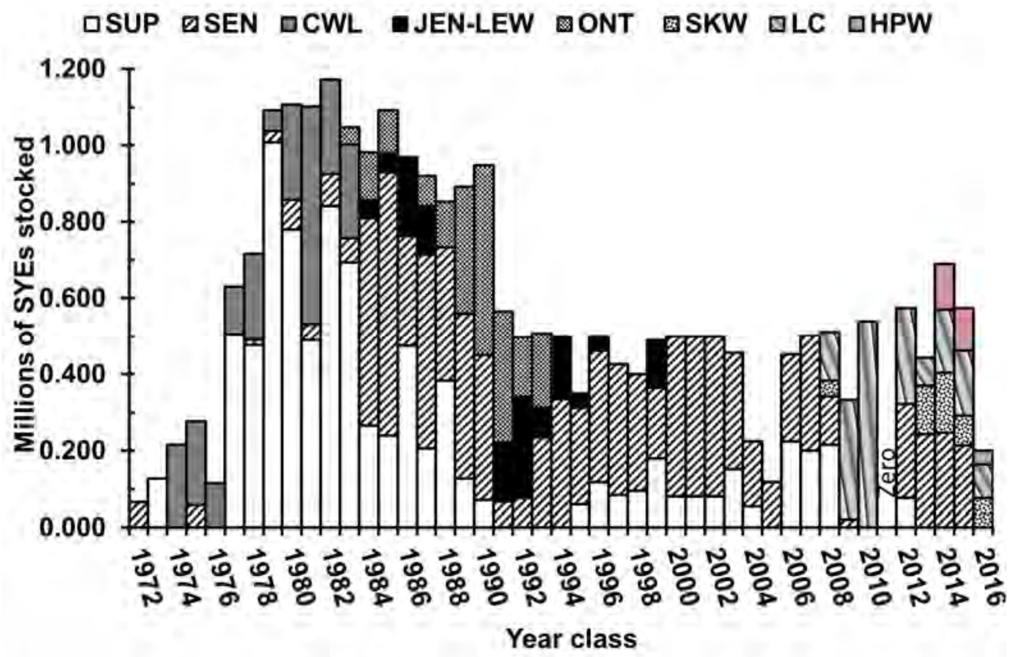

Figure 1. Total spring yearling equivalents (SYE) for lake trout strains (strain descriptions for ONT, JEN-LEW, CWL, SEN, LC, SUP, SKW, HPW appear in Appendix 1) stocked in U.S. waters of Lake Ontario for the 1972 – 2016 year-classes. For year-classes beginning in 2006, SUP refers to Lake Superior lean strains (SAW and STW) other than the Superior Marquette Domestics stocked prior to that time. 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.

permitted fish production to resume at ANFH in fall 2011. Lake trout stocked in 2006 were raised at the NYSDEC Bath Fish Hatchery. Lake trout for 2007 and 2008 stockings were raised at the USFWS Pittsford (the name was changed in 2009 to Eisenhower (ENFH)) and White River National Fish Hatcheries (WRNFH) in Vermont. In 2010, 94% of the stocked lake trout were raised at WRNFH and 6% were raised at NYSDEC Bath Fish Hatchery. All lake trout from stockings in 2009 and 2011 were raised at the USFWS WRNFH. In late August 2011, flooding of WRNFH from the adjacent White River during tropical storm Irene led to the USFWS decision to depopulate the hatchery over serious concerns of raceway contamination with didymo (*Didymosphenia geminate*) from the adjacent White River. As a result, no lake trout from the 2011 year-class were stocked into Lake Ontario in May 2012. Combined production of the 2012 year-class at ANFH and ENFH resulted in stocking of nearly 123,000 fall fingerlings and over 520,000 spring yearlings. During 2014, combined production of the 2013 year-class at ANFH and ENFH resulted in stockings of approximately 442,000 spring yearlings. That same year, fish managers increased the lake trout stocking target to 800,000 spring yearling equivalents (Lantry et al. 2014). Combined production of the 2014 year-class at ANFH and ENFH resulted in stocking of nearly 528,000 fall fingerlings and 521,000 spring yearlings (Connerton 2016). Combined ANFH and ENFH production of the 2015 year-class fish resulted in stocking of nearly 454,000 fall fingerlings and 384,000 spring yearlings (Connerton 2017). In fall 2016, fish managers reduced lake trout and Chinook salmon stocking targets to reduce predatory demand on alewife. The planned target stocking number of the 2016 year-class was 400,000 spring yearlings. No fall fingerling lake trout from the 2016 year-class were stocked. A mortality event at ANFH beginning in late fall 2016 further reduced the number of fish available for stocking, resulting in a combined ANFH and ENFH May 2017 stocking of 200,843 spring yearlings (Connerton 2018). The need to refresh broodstock at the Berkshire National Fish Hatchery also resulted in the release of 304 Klondike strain (SKW) adults from the 2012 year-class into the lake in December 2017.

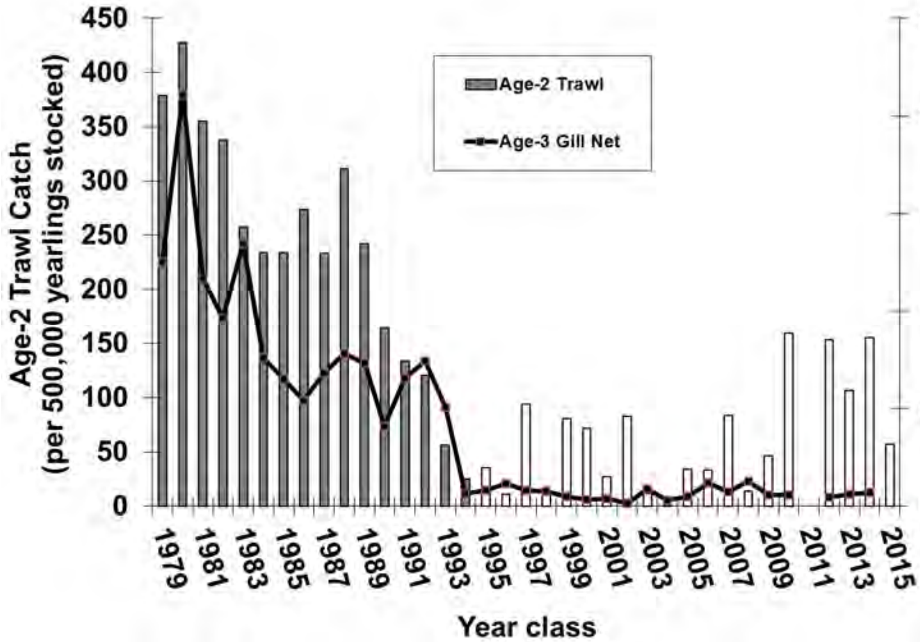

Figure 2. Survival indices for lake trout stocked in U.S. waters of Lake Ontario (no 2011 year-class lake trout were stocked into U. S. waters in 2012). Survival was indexed at age 2 as the total catch from bottom trawls (BTR) fished in July-August per 500,000 fish stocked (Note: White bars represent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

<u>Survival of Stocked Fish to Age-2</u>
The first-year survival index was relatively high for the 1979-1982 year-classes but declined by about 32% and fluctuated without trend for the 1983-1989 year-classes (Figure 2). The index declined further for the 1990 year-class and continued to decline for the 1991-1996 year-classes. The average index value for the 1994-1996 year-classes at age 2 was only 6% of the average for the 1979-1982 year-classes and only 9% of the average for the 1983-1989 year-classes. The survival index was quite variable for the 1993-2009 year-classes, fluctuating by greater than 40-fold with no general trend apparent. The survival indices for the 2010, 2012, 2013 and 2014 year-classes were high compared to the 1995-2009 year-classes. No lake trout from the 2011 year-class were stocked in U.S. waters during 2012, thus no U.S. stocked age-2 lake trout were present/captured in 2014. The survival indices for the 2010, 2012 and 2014 year-class were the highest observed since the 1989 year-class and higher than any other year-class since the early 1990's reductions in stocking. Survival for the 2015 year-class declined by 63%.

<u>Abundance of Age-3 and Older Lake Trout</u>
A total of 641 lake trout were captured in 53 nets during the September 2017 gill net survey, resulting in a total CPUE of mature adults of 9.16 (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 ≥ age 5) averaging only about 9.1% and 10.7% respectively, for the entire data series (Figure 4). The CPUE of mature lake trout had remained relatively stable from 1986 to 1998, but then declined by 31% between 1998 and 1999 due to the poor recruitment of the 1993 year-class. Declines in adult numbers after 1998 were likely due to poor survival of hatchery fish in their first year post-stocking and lower numbers of fish stocked since the early 1990s. After the 1998-1999 decline, the CPUE for mature lake trout remained relatively stable during 1999-2004 (mean = 11.1) appearing to reflect a new stable equilibrium 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

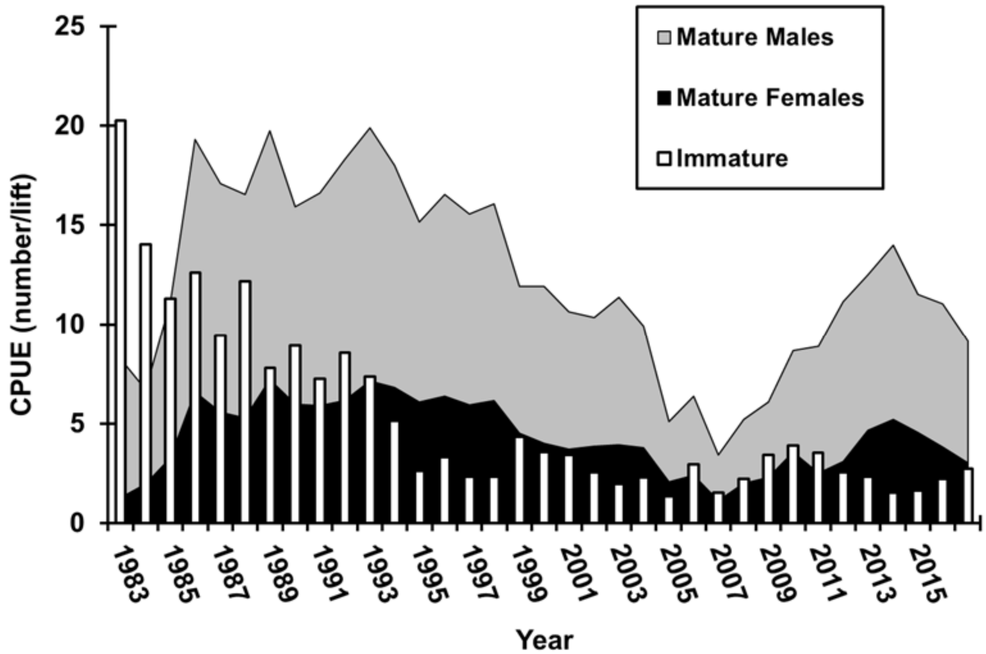

***Figure 3.** Abundance of mature (generally males ≥ age 5 and females ≥ age 6) and immature (sexes combined) lake trout calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2017. CPUE (number/lift) was calculated based on four strata representing net position in relation to depth of the sets.*

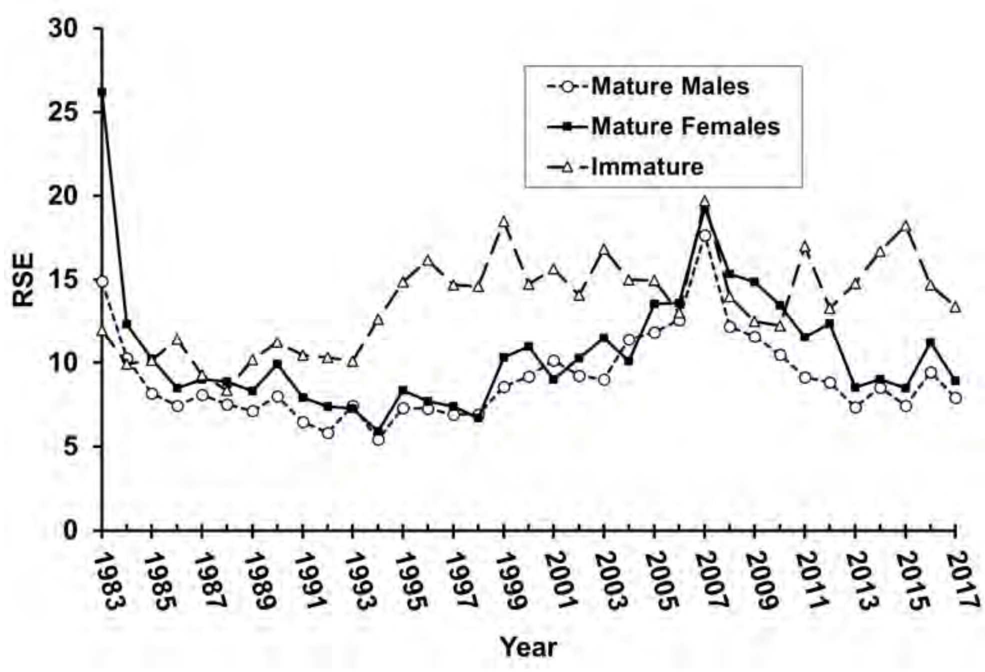

***Figure 4.** Relative standard error (RSE = {SE / Mean}*100) of the annual CPUE for mature and immature (sexes combined) lake trout caught with gill nets set in U.S. waters of Lake Ontario, during September 1983-2017.*

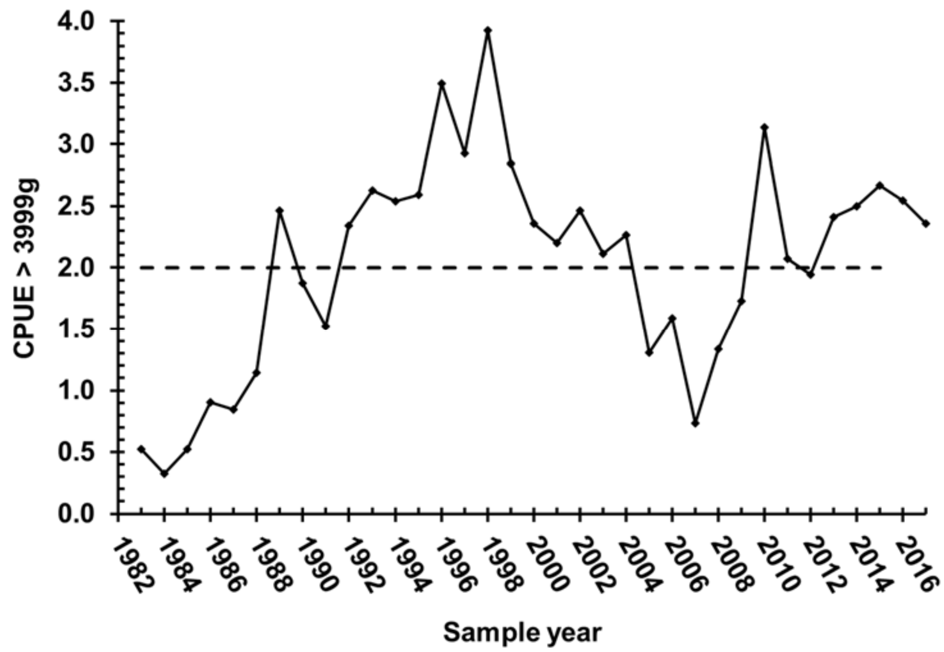

Figure 5. Abundance of mature female lake trout ≥4000g calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2017. The dashed line represents the target CPUE from Schneider et al. (1997) and Lantry et al. (2014).

sea lamprey control. The CPUE of mature lake trout, however, increased each year during 2008-2014, but then declined each year during 2015-2017. Adult abundance in 2017 was 35% below the 2014 peak and 17% below 1999-2004 average. Similar to the catch of age-2 lake trout from bottom trawls, the CPUE for immature lake trout captured in gill nets (generally ages 2 to 5) declined by 64% between 1989-1993 (CPUE: 8.0) and 1995 (CPUE: 2.6) and remained at the lower level thereafter with a mean of 2.6 for 1995-2017.

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 that 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. During 2010-2017, CPUEs of mature females 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, a slot size limit was instituted by managers to decrease harvest of mature fish and 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, only 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 2018). 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 reached the lowest levels in the NYSDEC Fishing Boat Survey data series (Lantry and Eckert 2018). Harvest at that time was more than 97% below the 1991 estimate. After 2007, however, catch because of their relatively high catch rates;

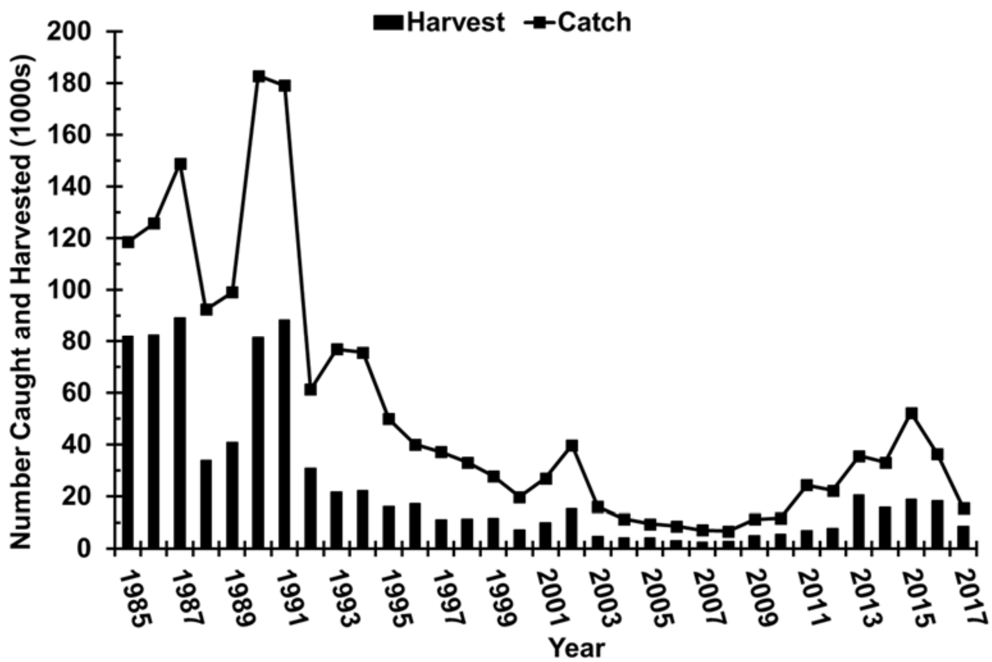

Figure 6. Estimated numbers of lake trout caught and harvested by boat anglers from U.S. waters of Lake Ontario, during April 15 – September 30, 1985-2017 (Lantry and Eckert 2018). Beginning with the 2012 report, all values have been reported reflecting a 5.5-month sampling interval. Prior reports were based on a 6-month sampling interval (April 1 – September 30).

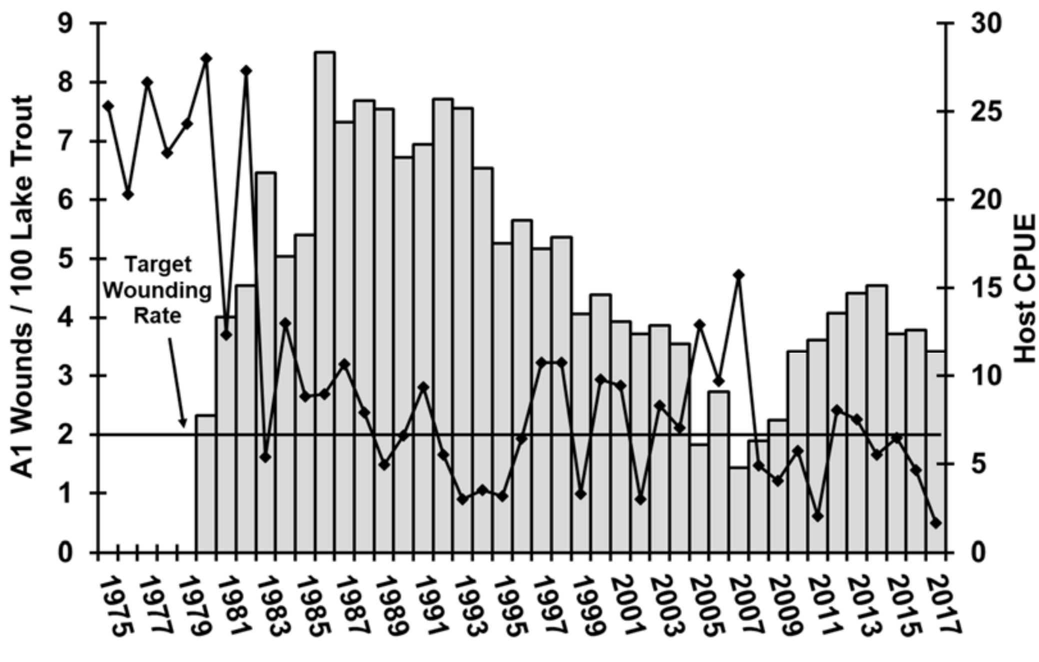

Figure 7. Wounding rates (A1 wounds per 100 lake trout, line) inflicted by sea lamprey on lake trout ≥ 433 mm (17.1 in) TL and the gill net CPUE of lake trout hosts (≥ 433 mm TL, bars) collected from Lake Ontario in fall, 1975-2017.

Lantry and Eckert 2018). In 2007, catch and harvest rates (0.12 and 0.05 lake trout per boat trip, respectively) and total harvest (2,570 fish) and harvest increased for six consecutive years, were relatively stable 2013-2016, then declined in 2017 (15,444 fish caught, 8,592 fish harvested). Increases from 2007 through 2016 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 (2013-2016).

While catch and harvest totals for the time trend have been low recently relative to the late 1980s, catch and harvest rates increased to near record high levels in 2015 and 2016 (e.g., catch rates were over 7.5 times higher than the 2007 record low). The 2017 catch rate declined 58.3% from 2015-2016, but was nearly 3.5 times higher than the lows observed in 2007. The 2017 harvest rate was more than 5.4 times higher than in 2007 (Lantry and Eckert 2018). The 2017 declines in catch, harvest, and catch and harvest rates coincide with good to excellent fishing quality for other trout and salmon species which may have reduced fishing effort directed at lake trout as compared to recent years.

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. Wounding 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 below target in 2014 (1.65), 2015 (1.94) and 2016 (1.40). The 2017 wounding rate (0.50) was the lowest for the data series.

Adult Survival

Survival of SEN strain lake trout (ages 7 to 11) was consistently greater (20-51%) than that of the SUP strain for the 1980-1995 year-classes (Table 1). Lower survival of SUP strain lake trout was likely due to higher mortality from sea lamprey (Schneider et al. 1996). Survival of both Jenny (JEN) and Lewis (LEW) strains were similar to the SUP strain, suggesting that those strains may also be highly vulnerable to sea lamprey. 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 and 2003-2008 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-classes (2003-2008) were all above target. The SEN strain survival and the population survival for the 2004 and 2005 year-classes are above target and are identical because the stockings for both year-classes were predominantly SEN. Stockings for both of those year-classes were also far below the 500K target with all 224K of the 2004 year-class being stocked at one site in the eastern basin and all 118K of the 2005 year-class released at one site in the western part of the lake. The SUP strain was no longer available in 2006 and while stockings for the 2006 to 2008 year-classes were back near the 500K target and more evenly distributed between SEN and SUP-like strains those strains from Lake Superior were now Traverse Island strain (STW) and Apostle Island strain (SAW). Strains from Seneca Lake origins now included SENs and feral (LCW) and domestic Lake Champlain strains (LCD). Survival for SENs (2006-2008 year-classes) continued to be high (≥74%) and survival for 2008 year-class of LCDs (72%, ages 7 to 9) resembled their mostly SEN origins. Only one year-class of LCWs was stocked (2009) and those disappeared from survey catches after age 8 preventing calculation of their survival values. Survival rates could also not be calculated for the first large stocking of STWs (225K of the 2006 year-class) which disappeared from survey catches after age 8. They were, however, represented in in population calculations for the 2006 cohort. Recent survival rates for STW

Table 1. Annual survival of various strains (strain descriptions appear in Appendix 1) of lake trout, sampled from U.S. waters of Lake Ontario, 1985-2017. Dashes represent missing values due to no or low numbers of tagged lake trout stocked for the strain, or when the strain was not in the US federal hatchery system. ALL is population survival of all strains combined using only coded wire tagged fish.

YEAR		STRAIN									
CLASS	AGES	JEN	LEW	ONT	SUP	SAW	STW	SEN	LCD	SKW	ALL
1978	7-10	-	-	-	0.40	-	-	-	-	-	-
1979	7-11	-	-	-	0.52	-	-	-	-	-	-
1980	7-11	-	-	-	0.54	-	-	0.85	-	-	-
1981	7-11	-	-	-	0.45	-	-	0.92	-	-	-
1982	7-11	-	-	-	0.44	-	-	0.82	-	-	-
1983	7-11	-	-	0.61	0.54	-	-	0.90	-	-	0.57
1984	7-11	0.39	-	0.61	0.48	-	-	0.70	-	-	0.65
1985	7-11	-	-	0.80	0.47	-	-	0.77	-	-	0.73
1986	7-11	0.57	-	-	0.43	-	-	0.81	-	-	0.62
1987	7-11	0.50	-	-	0.50	-	-	0.80	-	-	0.73
1988	7-11	-	-	0.77	0.61	-	-	0.73	-	-	0.68
1989	7-11	-	-	0.78	0.59	-	-	0.86	-	-	0.81
1990	7-11	-	-	0.64	0.60	-	-	0.75	-	-	0.68
1991	7-11	-	0.56	0.62	-	-	-	0.70	-	-	0.70
1992	7-11	-	0.51	-	-	-	-	0.81	-	-	0.60
1993	7-11	-	0.64	-	-	-	-	0.72	-	-	0.71
1994	7-11	-	0.73	-	-	-	-	0.45	-	-	0.56
1995	7-11	-	0.50	-	-	-	-	0.76	-	-	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	-	-	-	0.53	-	-	0.72	-	-	0.68
2004	7-11	-	-	-	-	-	-	0.78	-	-	0.78
2005	7-11	-	-	-	-	-	-	0.85	-	-	0.85
2006	7-11	-	-	-	-	-	-	0.74	-	-	0.72
2007	7-10	-	-	-	-	-	0.36	0.81	-	-	0.74
2008	7-9	-	-	-	-	0.53	0.42	0.76	0.72	0.064	0.65

(36%-42%, 2007 and 2008 year-classes) and SAW (53%, 2008 year-class) strains are low, and similar the original SUP strain, but based on small catches and only 3-4 years of data.

<u>Growth and Condition</u>

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 remained high through 2015. Predicted mean weight rose sharply after 2015 so that 2016-2017 mean (3803.1 g, 8.4 lb) was the highest level for the data series. The trend of improving condition through 1996 and from 2007 to 2017 corresponded to periods when the abundance of older lake trout in the population was increasing. 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. While both predicted weight and condition generally remained at a high level during 2007-2015, a declining trend from 2011 to 2015 was apparent. That trend reversed in 2016 with the second highest Fulton's K value recorded since the time series began in 1983. No value was calculated in 2017 as no fish were stocked from the 2011 year-class. Predicted weights of 400-mm lake trout, based on bottom trawl catches of 250-500 mm

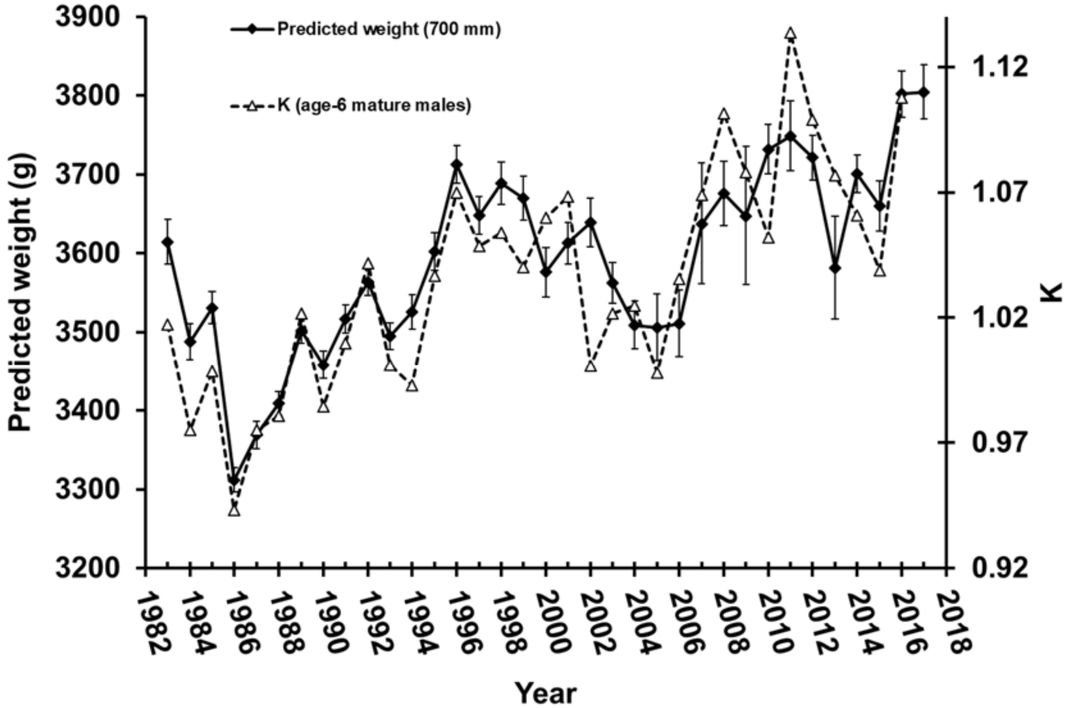

Figure 8. Lake Ontario lake trout condition (K) for age-6 mature males and predicted weight at 700-mm (27.6 in) TL from weight-length regressions calculated from all fish collected during each annual gill net survey, September 1983 – 2017. There were no fish stocked from the 2011 year-class in 2012 so age-6 K is not available in 2017. Error bars represent the regression confidence limits for each annual value.

fish, and Fulton's K for an age-2 lake trout changed between the late 1990s and early 2000s (Figure 9). The mean predicted weight during 1999-2016 declined by 15.4g below the 1979-1998 mean, paralleling declines in native benthic prey resources (Weidel et al. 2014). Predicted weight increased for a brief period during 2006-2008 paralleling increases in round goby (*Neogobius melanostomus)* abundance (Weidel et al. 2014) which are now common in lake trout diets. Condition of immature fish fell again in 2009 (591.3 g, 1.3 lb.) and in most years during 2010-2016, remained at values that were among the lowest for the time series, however condition was high in 2014 (620.0 g, 1.4 lb) and 2017 (617.5 g, 1.4 lb).

<u>Reproductive Potential</u>

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 (Figure 10) than between the index and the CPUE of all females, reflecting the effects of population age structure on fecundity. Strain composition of the eggs was mostly SUP during 1983-1990 and mostly SEN during 1991-2002. After 2002, it became increasingly difficult to assess strain-specific contribution to the egg deposition index because many fish stocked between 1997 and 2003 were not marked with coded wire tags. 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

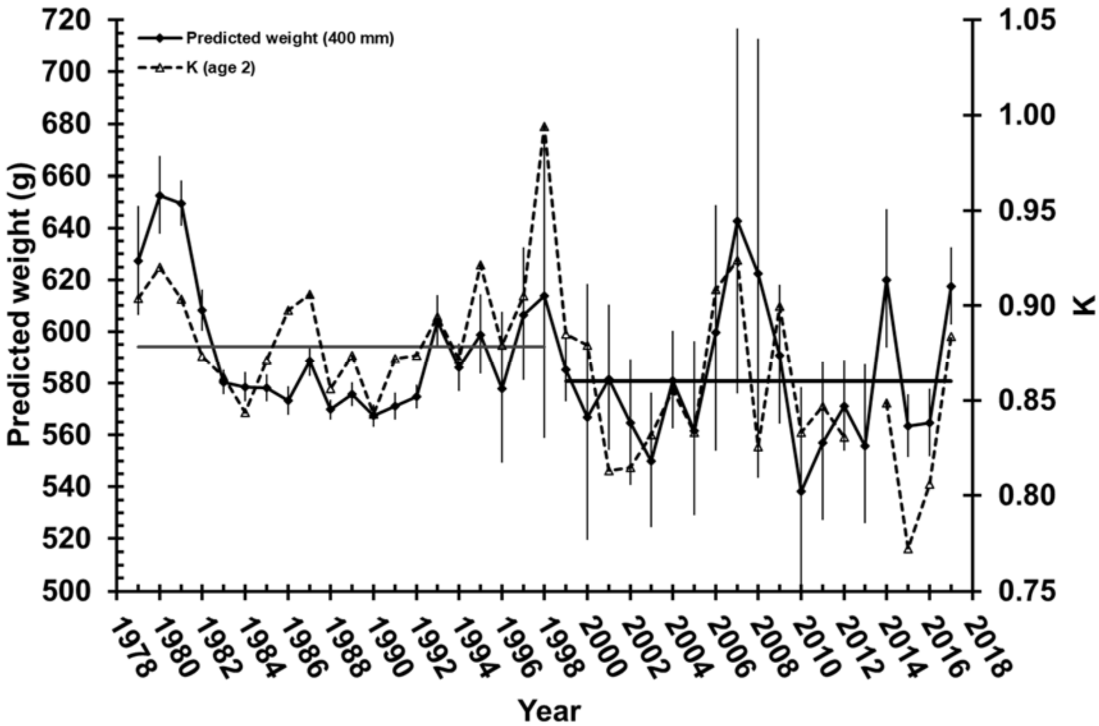

Figure 9. Lake Ontario lake trout condition (K) for age-2 coded wire tagged fish and predicted weight at 400-mm (15.8 in) TL from annual weight-length regressions calculated from fish 250 mm-500 mm (9.8 to 19.7 in). All lake trout were sampled from bottom trawls, July-August 1978-2017. The horizontal lines represent the mean predicted weights during 1979-1998 and during 1999-2017. 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). There were no fish stocked from the 2011 year-class in 2012 so age-2 K is not available in 2013. Error bars represent the regression confidence limits for each annual value.

estimation. We then applied strain-specific mortality correction factors to fecundity estimates of untagged fish and weighted them based on strain composition for specific cohorts at stocking.

The egg deposition index changed little between 2001 and 2004 and the average for those years was 42% lower than the average for 1993 to 1999. In 2005, the index dropped by 40% 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 2013-2017 egg deposition indices were similar to 2001-2004 values and, for the first time, included contributions from SKW lake trout from the 2008 year-class (see Appendix 1 for strain descriptions).

<u>Natural Reproduction</u>

Evidence of survival of naturally produced lake trout past the summer/fall fingerling stage occurred in each year during 1993-2017 (Figure 11) except 2008, representing production of 23 year-classes. Numbers caught represent the entire annual bottom trawl catch from four surveys occurring during April-October 1979-2017 (for a description of the surveys see O'Gorman et al. 2000 and Owens et al. 2003). In 2015, the June bottom trawl survey was discontinued, so total trawl effort decreased. Catch was not corrected for effort due to the low catch in most years and a relatively constant level of effort expended within the depth range (20m - 100m) where age-0 to age-2 naturally reproduced lake trout are most often encountered in Lake Ontario for most years. Low numbers of small (<100 mm, 3.9 in), wild fish captured during1997-2017 may have been due in part to a change in our trawl gear that was necessary to avoid

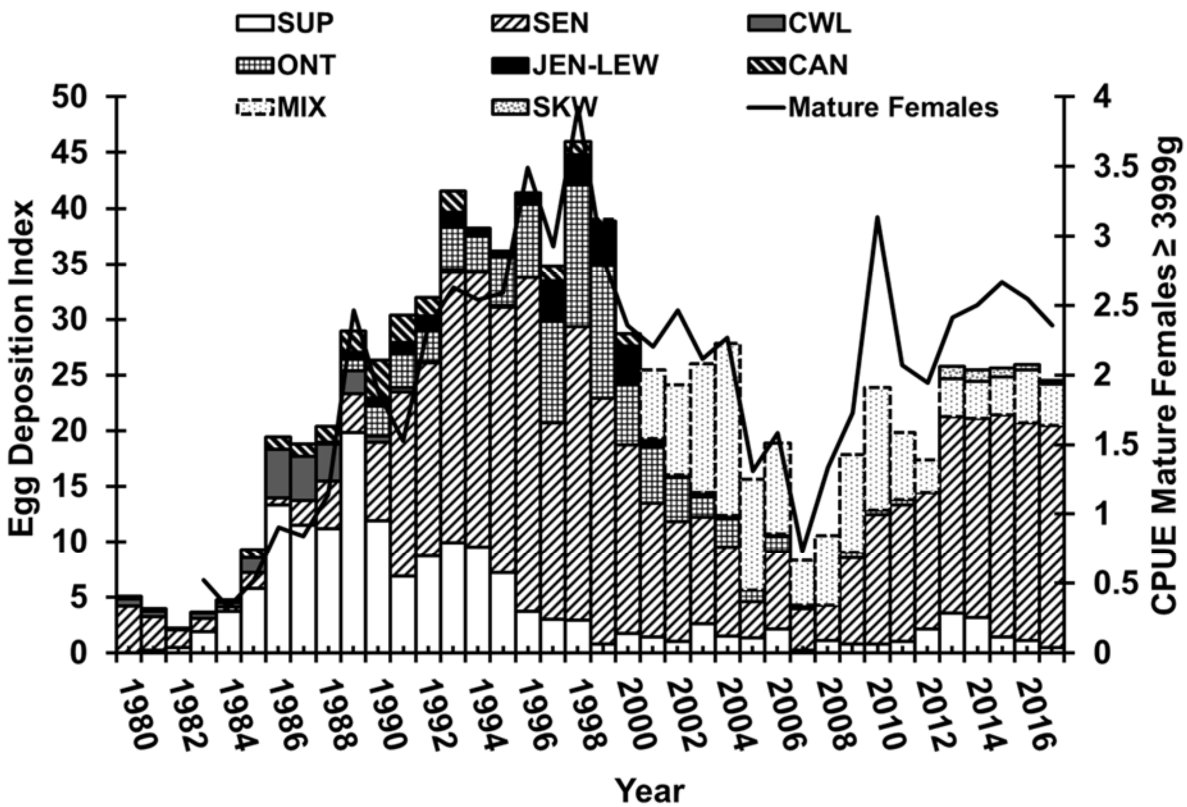

Figure 10. Egg deposition indices by strain (strain descriptions for ONT, JEN-LEW, CWL, SEN, SUP and SKW appear in Appendix 1) for lake trout in U.S. waters of Lake Ontario during 1980-2017. CAN represents a mix of the strains stocked by OMNRF and MIX represents values for untagged females stocked since 1997 for which strain could not be determined. The solid line is the CPUE of mature females ≥4000g.

abundant dreissenid mussels. The wild yearlings captured in 2010-2017 were the first wild yearlings caught since 2005. The four largest catches of the 24-year time-series occurred during 2014-2017 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 in 2014; 24 age-1 (94-147 mm, 3.7-5.8 in) and 48 age-2 (167-262 mm, 6.6-10.3 in) caught in 2015; 21 age-1 (87-169 mm, 3.5-6.6 in) and 30 age-2 (178-245 mm, 7.0-9.6 in) caught in 2016; and 8 age-1 (90-133 mm, 3.5-5.2 in) and 62 age-2 (148-265 mm, 5.8-10.4 in) caught in 2017.

The distribution of catches of wild fish suggests that lake trout are reproducing throughout New York waters of Lake Ontario with the greatest concentration coming off the Niagara Bar area at the mouth of the Niagara River (Figure 12). Catches from at least 23 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.

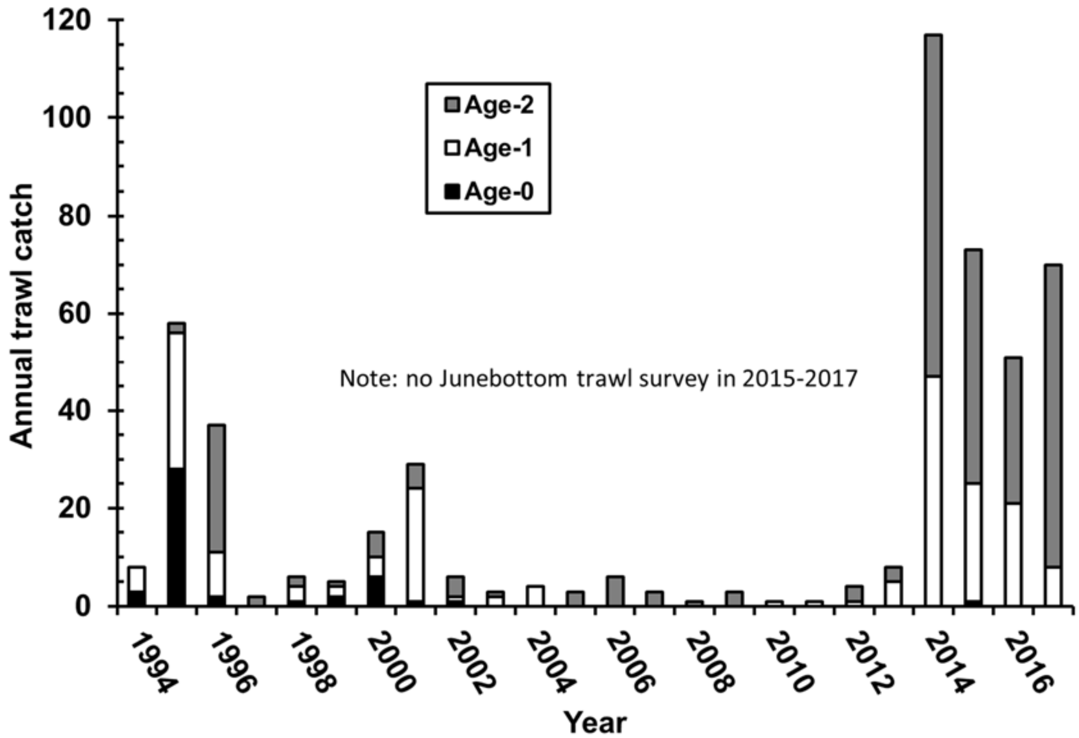

Figure 11. Numbers and ages of naturally produced (wild) lake trout captured with bottom trawls in Lake Ontario by NYSDEC and USGS, 1994-2017. During 1980-1993, only one naturally produced lake trout was captured with bottom trawls.

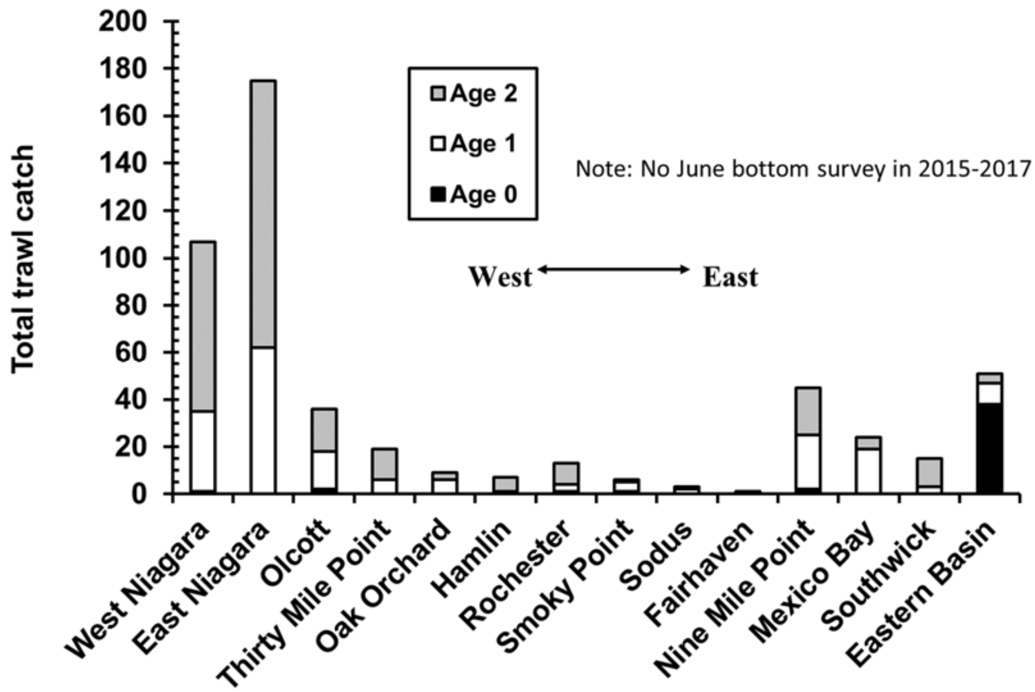

Figure 12. Numbers of wild lake trout (age 0 to 2) captured with bottom trawls at various locations in Lake Ontario by NYSDEC and USGS, 1994-2017. (Note: east and west Niagara are only sampled once per year whereas the other locations are usually sampled four times per year.

References

Bergstedt, R. A. and C. P. Schneider. 1988. Assessment of sea lamprey (*Petromyzon marinus*) predation by recovery of dead lake trout (*Salvelinus namaycush*) from Lake Ontario, 1982-85. Can. J. Fish. Aquat. Sci. 45:1406-1410.

Connerton, M. J. 2016. New York Lake Ontario and Upper St. Lawrence River Stocking Program 2015. Section 1 *In* 2015 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Connerton, M. J. 2017. New York Lake Ontario and Upper St. Lawrence River Stocking Program 2016. Section 1 *In* 2016 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Connerton, M. J. 2018. New York Lake Ontario and Upper St. Lawrence River Stocking Program 2017. Section 1 *In* 2017 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Ebener, M. P., E. L. King, Jr., and T. A. Edsall. 2006. Application of a dichotomous key to the classification of sea lamprey marks on Great Lakes Fish. Great Lakes Fishery Commission Miscellaneous Publication 2006-2.

Elrod, J. H., O'Gorman, R., Schneider, C. P., Eckert, T. H., Schaner, T., Bowlby, J. N., and L. P. Schleen. 1995. Lake trout rehabilitation in Lake Ontario. J. Great Lakes Res. 21 (Supplement 1):83-107.

Elrod, J. H., O'Gorman, R. and C. P. Schneider. 1996. Bathythermal distribution, maturity, and growth of lake trout strains stocked in U.S. waters of Lake Ontario, 1978-1993. J. Great Lakes Res. 22:722-743.

Elrod, J. H., Ostergaard, D. E. and C. P. Schneider. 1988. Comparison of hatchery-reared lake trout stocked as fall fingerlings and as spring yearlings in Lake Ontario. N. Amer. J. of Fish. Manage. 8:455-462.

King, E. L. Jr. and T. A. Edsall. 1979. Illustrated field guide for the classification of sea lamprey attack marks on Great Lakes lake trout. Great Lakes Fishery Commission Special Publication 70-1.

Krueger, C. C., Horrall, R. M., and Gruenthal, H. 1983. Strategy for use of lake trout strain in Lake Michigan. Report 17 of the Genetics Subcommittee to the Lake Trout Technical Committee for Lake Michigan, Great lakes Fish. Comm., Madison, WI.

Lantry, B. F. and Lantry, J. R. 2013. Lake trout rehabilitation in Lake Ontario, 2012. Section 5 *In* 2012 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission Lake Ontario Committee.

Lantry, B. F. and Prindle, S. P. 2006. Lake trout rehabilitation in Lake Ontario, 2005. Section 5 *In* 2005 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission Lake Ontario Committee.

Lantry, J. R. and Eckert, T. H. 2018. 2017 Lake Ontario fishing boat survey. Section 2 In 2017 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Lantry, J., Schaner, T., and Copeland T. 2014. A management strategy for the restoration of lake trout in Lake Ontario, 2014 Update. Available from http://www.glfc.org/lakecom/loc/lochome.php [accessed 03 March 2015].

Nash, D. M., A. H. Valencia, and A. J. Geffen. 2006. The origin of Fulton's condition factor – setting the record straight. Fisheries 31:236-238.

O'Gorman, R., Elrod, J. H., Owens, R. W., Schneider, C. P., Eckert, T. H. and B. F. Lantry. 2000. Shifts in depth distributions of alewives, rainbow smelt, and age-2 lake trout in southern Lake Ontario following establishment of dreissenids. Trans. Am. Fish. Soc. 129:1096-1106.

O'Gorman, R., Elrod, J. H. and C. P. Schneider. 1998. Reproductive potential and fecundity of lake trout strains in southern and eastern Lake Ontario, 1977-94. J. Great Lakes Res. 24:131-144.

Owens, R. W., O'Gorman, R., Eckert, T. H., and Lantry, B. F. 2003. The offshore fish community in southern Lake Ontario. Pages 407-441, in Munawar, M. (ed.), State of Lake Ontario: Past, Present, and Future. Ecovision World Monograph Series. Backhuys Publishers, Leiden, The Netherlands.

Page, K. S., Scribner, K. T., Bennett, K. R., and Garzel, L. M. 2003. Genetic assessment of strain-specific sources of lake trout recruitment in the Great lakes. Trans. Am. Fish. Soc. 132:877-894.

Schneider, C. P., Kolenosky, D. P. and D. B. Goldthwaite. 1983. A joint plan for the rehabilitation of lake trout in Lake Ontario. Great Lakes Fishery Commission, Lake Ontario Committee. Spec. Publ. 50 p.

Schneider, C. P., Owens, R. W., Bergstedt, R. A. and R. O'Gorman. 1996. Predation by sea lamprey (*Petromyzon marinus*) on lake trout (*Salvelinus namaycush*) in southern Lake Ontario, 1982-1992. Can. J. Fish. Aquat. Sci. 53:1921-1932.

Schneider, C. P., Schaner, T., Orsatti, S., Lary, S. and D. Busch. 1997. A management strategy for Lake Ontario lake trout. Report to the Lake Ontario Committee.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191:1-382.

Visscher, L. 1983. Lewis Lake lake trout. U. S. Fish Wild. Ser., Denver, CO.

Weidel, B. C., Walsh, M. G., and M.J. Connerton. 2014. Sculpins and round goby assessment in the U.S. waters of Lake Ontario, 2013. Section 12 *In* 2013 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission Lake Ontario Committee.

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 to supplement broodstocks were collected exclusively from Cayuga Lake.

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

SUP - Captive lake trout brood stocks derived from "lean" Lake Superior lake trout. Brood stock for the Lake Ontario stockings of the Marquette strain (initially developed at the USFWS Marquette Hatchery; stocked until 2005) was maintained at the USFWS Alleghany National Fish Hatchery until 2005. The Superior – Marquette strain is no longer available for Lake Ontario stockings. Lake Ontario stockings of "lean" strains of Lake Superior lake trout resumed in 2007 with Traverse Island strain fish (STW; 2006-2008 year-classes) and Apostle Island strain fish (SAW; 2008 and 2012 year-classes). Traverse Island strain originated from a restored "lean" Lake Superior stock. The STW brood stock was phased out of production at USFWS Iron River National Fish Hatchery (IRNFH) and is no longer be available as a source of eggs for future Great Lakes stockings. The Apostle Island strain was derived from a remnant "lean" Superior stock restored through stocking efforts, was phased out of production at USFWS Iron River National Fish Hatchery (IRNFH) and is no longer be available as a source of eggs for future Great Lakes stockings.

SKW - Originated from a native, deep spawning "humper" morphotype of Lake Superior lake trout that are intermediate in fat content to lean and fat (siscowet) morphotypes. Captive brood stocks have been held at the USFWS Sullivan Creek National Fish Hatchery and USFWS Iron River National Fish Hatchery. The USFWS Berkshire National Fish Hatchery developed a SKW brood stock to supply fertilized eggs to ANFH for rearing and stocking into Lake Ontario.

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

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

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

HPW - "Lean" lake trout strain originated from a self-sustaining remnant population located in Parry Sound on the Canadian side of Lake Huron in Georgian Bay. A captive HPW broodstock is maintained at the USFWS Sullivan Creek National Fish Hatchery and is the source of eggs for HPW reared at USFWS Alleghany National Fish Hatchery in Warren, Pennsylvania for stocking into Lake Ontario. The first HPW lake trout stocking into Lake Ontario occurred in fall 2014.

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

Thousand Islands Warmwater Fisheries 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, information on year class strength, and age and growth relationships. 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 fisheries 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 fisheries 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 (α= .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

<u>Environmental conditions</u>
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 2017 was similar to recent years at 68-71°F (20-22°C). Bottom temperature at 33 ft (10 m) was 70°F (21°C). Prior to colonization by dreissenid mussels, summer water transparency (Secchi depth) ranged down to about 10 ft (3 m, S. LaPan, NYSDEC, pers. communication) and was not considered a significant influence on catchability. By 1995 it was apparent that significant increases in transparency had occurred, and Secchi depths are now collected during fish sampling. Secchi depths during the sampling period have ranged from 14.1 ft (4.3 m) in 1997 to 55 ft (16.8 m) in 1999 . In 2017, the Secchi depth was 19.6 ft (6 m), the second lowest on record (Table 1).

<u>Species composition</u>
A total of 37 species have been represented in Thousand Islands gill net sampling between 1977 and

2017 (Table 2). These nets were not designed to catch small-bodied species so cyprinids, other than carp, are rarely captured. Total annual catch (for 32 net sets) has ranged from 847 fish in 2012 to 2,080 fish in 1988. Diversity has ranged from 13 species in 1995 to 20 species in 2016. Total adjusted catch in 2017 was below average at 906 individuals; diversity was moderate, with 16 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. A record high 26 individuals were sampled in 2017. 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 more recent years, abundance of pumpkinseed sunfish and brown bullhead have declined. In 2017, alewife (*Alosa pseudoharengus*), yellow perch, rock bass, and smallmouth bass, northern pike and walleye, made up over 90% of the catch (Figure 1).

<u>Primary recreational fishery targets</u>

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 catch increased in 2005 and varied at relatively high levels until 2012. Abundance then quickly declined, reaching a near record low in 2015. In 2016 and 2017 abundance was moderate suggesting that the very low 2015 value may have been a sampling anomaly. 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 historically constituted the bulk of the catch, has remained relatively low in recent years, while the sample abundance of age-3 and age-4 fish (and this year age-2 fish) has increased (Figure 3). Younger bass, ages 3-4, have generally been more abundant since 2006 relative to earlier years (Figure 4). This may indicate increased abundance of these fish, but more likely reflects an increased catchability of young bass due to increased growth rates.

The abundance of age 5, 6 and 7 bass, 2012, 2011 and 2010 year classes, were somewhat above average in 2017. During the 10 year period, 2007 through 2017, eight year classes (2004-2011) could be followed from ages 3 through 6. The 2009 year class appears to be the strongest year class currently detectable in the population (Table 4).

An expanding double-crested cormorant (*Phalacrocorax auritus*) population was implicated in suppression of smallmouth bass recruitment in the nearby Eastern Basin of Lake Ontario (Lantry et al. 1999) in the late 1990s and early 2000s. Cormorants may also have affected the Thousand Islands bass population. However, 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).

Smallmouth bass growth changed little between 1977 and 1998. Thereafter growth increased, possibly a density dependent effect (McCullough 2012), resulting in an overall increasing trend in size of age-5 bass from 1977 to 2004 (regression slope = 0.98, r^2 = 0.30). Bass are now generally reaching legal size, 12" (305 mm), before age-5. Since round goby establishment in 2005, mean total length at age 5 has increased more quickly (regression slope = 7.3, r^2 0.87; Figure 5). In 2017 age-5 bass averaged a near record 15.7 inches (398.4 mm). 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.

Smallmouth bass condition, reported as relative weight (Wr) followed a pattern similar to growth, condition began to increase after 1999 and continued to increase, though with a temporary decline, after 2005 (Figure 6).

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 7). From 2001 through 2005 abundance again generally declined and tended to vary without trend until 2013, then declined from 2014 – 2017 (Figure 7). 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. Age 5 fish were also noticeably less abundant than usual in 2017 (Figure 8). Older fish have thus far shown little decline, suggesting that survival of recruited fish remains similar to earlier years (Figure 8). Sample size for northern pike has declined to the point that determination of year class strength has become impractical.

Northern pike growth has varied over the data series with the highest mean total length of age-4 fish occurring prior to 1983 and the lowest in 1994 (Figure 9). Overall there has been a declining trend. Growth (mean total length at age-4) has improved somewhat since the establishment of round goby in 2005, but has been less notable than that of other St. Lawrence River piscivorous fishes.
Condition (Wr) of northern pike has shown a substantial increase beginning in the late 1990s. Unlike smallmouth bass, condition of pike did not continue to increase after 2005 except for a peak in 2009-2011 which coincided with relatively high alewife abundance (Figure 10).

Yellow Perch. Yellow perch abundance peaked in the late 1970s then went into an irregular decline through 1992. The general decline through the early 1990s 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, but to only a fraction of its previous level. After 1999, Yellow Perch catch generally declined until 2005. Catches increased somewhat in 2006 and remained at this level through 2008. Abundance then declined to a record low in 2012 and has remained low since (Figure 11).

Although overall abundance has declined the bulk of perch in the sample have consistently been ages 3-5 (Figure 12). There have been several reasonably strong yellow perch year classes detected from 2007-2017. Of the eight year classes (2004-2011) followed for ages 2-6 the 2004 year class was strongest and the 2011 year class was the weakest (Table 4).

Growth rate of age-4 yellow perch has generally increased over the survey period (Figure 13). Growth was relatively stable from 1977-2004 (linear regression slope=0.28, r^2=0.001) and then increased from 2005-2017 (linear regression slope = 4.06, r^2=0.63, Figure 13). Increased growth after 2005 may be attributable to the availability of round goby as forage. Total length of age-4 perch reached a record high of 218 mm (8.6 inches) in 2013 and has since declined moderately.

Although growth appears to have increased, condition (Wr), has been variable and shown no appreciable trend (Figure 14).

Walleye. Walleye were first captured in 1982 and were caught regularly in low numbers throughout the 1980s and 1990s. Abundance increased in the early 2000s and has remained at relatively higher levels since (Figure 15). As in lake Ontario's eastern basin, Walleye is the only sportfish species that has generally increased in abundance since the inception of this assessment (Lantry 2010).

<u>Other species of interest</u>

Lake Sturgeon. Lake sturgeon 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. Catches of lake sturgeon are generally rare, however, three sturgeon were sampled in 2016, the most ever captured in a single year of assessment netting. Two of these fish were confirmed to have coded wire tags, which indicate they were stocked. All 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) and in the St. Lawrence River at Ogdensburg (1996-2000, 2013-2015). Natural spawning has been observed in the upper St. Lawrence River (LaPan et al. 1997) however, and is thought to be a 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. Catches since 2006 have been highly variable. The catch rate in 2009 was the highest yet recorded, declined close to the background level by 2014, increased substantially in 2015-16 then declined to near background level in 2017 (Figure 16). Like salmonids, many of the alewives in the river probably strayed from Lake Ontario. Gizzard shad (*Dorosoma cepedianum)* were also 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 11 muskellunge have been caught since 1977, including one in 2015 and one in 2016. 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 although 10 were caught in 2017. Other minnows are usually not vulnerable to this sampling gear, but a few, such as fallfish (*Semotilus corporalis*) and golden shiner (*Notemigonus crysoleucas*), are caught occasionally. A single rudd (*Scardinius erythropthalmus*) was caught in 2000.

Suckers. White sucker (*Catostomus commersoni*) have been caught in substantial numbers (30 or more individuals) most years since 1977. However, they have been in general decline since 1990, are now found at much lower abundance (Figure 17). 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 sucker (*Catostomus catostomus*) were caught in 1982 and 1984.

Catfishes. Brown bullhead have experienced several cycles of abundance since 1977 (Figure 18). 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. Brown Bullhead were at record low abundance in 2015, increased to a more moderate, though still low level in 2016 but declined again in 2017. Channel catfish have been sampled regularly throughout the survey period. Through 2009 they had generally been present at substantially lower abundance than brown bullhead, but with the decline in bullhead in recent years (Figure 18) the two species were caught in approximately equal numbers from 2011 to 2017. 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. From 1977 through 1999 abundance of rock bass and pumpkinseed varied at somewhat comparable levels (Figure 19). From 2000 through 2011 rock bass generally increased while pumpkinseed decreased in abundance. Both species have been in a general decline since 2012 but rock bass remained an order of magnitude more abundant than pumpkinseed in 2017.

Both bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) are captured regularly. Typically they are caught in low numbers (fewer than 10 individuals) although over 30 bluegills were caught in 1981, 1983 and 1992. Sixteen largemouth bass were caught in 1983. The sample nets are probably set too deep to sample these species effectively in most years. Black crappie (*Pomoxis nigromaculatus*) were found in low numbers through 2003; none have been caught since.

References

Abraham, W.J. 1994. Failure of the 1993 year class of Yellow Perch in Sodus Bay, Lake Ontario. *In* 2003 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Bendig, A. 1995. 1994 Thousand Islands open water creel survey. *In* St Lawrence River Subcommittee Report to the Lake Ontario Committee, Great Lakes Fishery Commission, March 1995.

Connerton, M.A. 2003. Double-crested cormorant predation on Northern Pike in the eastern basin of Lake Ontario and the St. Lawrence River. State University of New York College of Environmental Science and Forestry, Syracuse New York.

Eaton, J.G., J.H. McCormick, B.E. Goodno, D.G. O'Brien, H.G. Stefany, M. Hondzo, and R.M. Scheller. 1995. A field information-based system for estimating fish temperature tolerances. Fisheries 20 (4); 10-18.

Einhouse, D.W. and 6 co-authors. 2005. NYSDEC 2004 NYSDEC Annual Report, Bureau of Fisheries Lake Erie Unit to the Great Lakes Fishery Commission's Lake Erie Committee.

Farrell, J.M. 2001. Reproductive success and spawning habitat of sympatric Northern Pike and Muskellunge in an upper St. Lawrence bay. Transactions of the American Fisheries Society 130: 796 –808.

Farrell, J.M., J.V. Mead and B.A. Murry. 2006. Protracted spawning of St. Lawrence River Northern Pike *(Esox lucius)*: simulated effects on survival, growth and production. Ecology of Freshwater Fish 15: 169-179.

Johnson, J.H., R.M. Klindt and A. Bendig. 2008. Diet composition and fish consumption of double-crested cormorants from three St. Lawrence River colonies in 2007. Section 17 *In* 2008 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Ketchen, K.S. 1949. Stratified subsampling for determining age distribution. Trans. Amer. Fish. Soc. 79:205-211.

Klindt, R.M. 2010. 2009 Lake St. Lawrence warmwater fisheries assessment. Section 7 *In* 2009 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Klindt, R.M. 2011. Survey of the recreational boat angler fishery on the U.S. portion of the St. Lawrence River, 2008-2009. Section 21 *In* 2010 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Lantry, B.F., T.H. Eckert, and C.P. Schneider 1999. The relationship between abundance of Smallmouth Bass and double-crested cormorants in the Eastern Basin of Lake Ontario. NYSDEC Special Report February 1999.

Lantry, J.R. 2010. Eastern Basin of Lake Ontario warmwater fisheries assessment. Section 4 *In* 2010 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

LaPan, S. R., A. Schiavone, and R. G. Werner. 1995. Spawning and post-spawning movements of the St. Lawrence River Muskellunge (*Esox masquinongy*) in Kerr, S. J. and C. H. Olver (eds.) Managing Muskies in the 90's. Workshop proceedings. OMNR, Southern Region Science and Technology Transfer Unit WP-007. 169 pp.

LaPan, S.R., R.M. Klindt, A. Schiavone and J.H. Johnson. 1997. Lake sturgeon spawning on artificial habitat in the St. Lawrence River. Section 13 *In* 1996 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

McCullough, R.D. 1987. The summer sport fishery of the St. Lawrence River 1982. *In* St. Lawrence River Subcommittee Report to the Lake Ontario Committee, Great Lakes Fishery Commission, March 1987.

McCullough, R.D. 2012. Smallmouth bass population in the New York waters of the St. Lawrence River Thousand Islands. Section 24 in Report to the Great Lakes Fishery Commission. New York State Department of Environmental Conservation, Albany, NY. 17 pp.

Smith, B.M., J.M. Farrell and H.B. Underwood. 2007. Year class formation of upper St. Lawrence River Northern Pike. North American Journal of Fisheries Management 27: 481-491.

Table 1. Water temperature and Scchi depth in the St. Lawrence River Thousand Islands Area 1977 - 2017.

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)		1998	22-24 (72-75)	8.0 (27)
1978	21-22 (70-72)		1999	23-24 (74-76)	16.8 (55)
1979	25-26 (77-79)		2000	21-22 (70-71)	13.4 (44)
1980	20-22 (68-72)		2001	20-24 (68-75)	6.2 (20)
1981	20-22 (68-72)		2002	21-23 (70-73)	7.3 (24)
1982	18-19 (64-66)		2003	21-24 (69-76)	6.5 (21)
1983	22-23 (72-73)		2004	21-22 (69-71)	8.1 (26.5)
1984	19-21 (66-70)		2005	22-24 (72-75)	11 (36)
1985	20-21 (68-70)		2006	22-24 (72-75)	8.8 (29)
1986	19-21 (66-70)		2007	21-22 (69-72)	7.8 (22.5)
1987	19-21 (66-70)		2008	20-24 (68-75)	10.4 (34)
1988	22-24 (72-75)		2009	21-23 (69-73)	9.5 (31)
1989	19-22 (66-72)		2010	23-25 (74-77)	6.0 (20)
1990	22-24 (72-75)		2011	23-24 (74-76)	8.8 (29)
1991	23-23 (73-73)		2012	23-25 (73-75)	9.3 (30.5)
1992	18-19 (64-66)		2013	23-25 (73-75)	6.5 (21.3)
1993	21-24 (70-75)		2014	20-22 (68-71)	12.0 (39.5)
1994	21-24 (70-75)		2015	20-22 (69-71)	8.0 (26.3)
1995	22-24 (72-75)		2016	23-24 (73-75)	15.2 (50)
1996	21-21 (70-70)	8.8 (29)	2017	20-22 (68-71)	6.0 (19.6)
1997	20-22 (68-72)	4.3 (14)			

Table 2. Total annual abundance index (catch/net-night), number of species sampled and number of individuals caught in the St. Lawrence River Thousand Islands Area 1977 - 2017.

Year	Index*	Species**	Individuals	Year	Index*	Species**	Individuals
1977	44.3	13	709	1998	32.6	17	1,044
1978	59.7	16	955	1999	44.9	19	1,437
1979	57.7	12	923	2000	30.0	18	959
1980	47.5	13	760	2001	29.1	17	932
1981	38.1	14	610	2002	34.9	16	1,077
1982	41.5	17	1,328	2003	35.5	18	1,137
1983	39.0	16	1,249	2004	30.3a	15	970a
1984	39.7	18	1,271	2005	27.5a	16	880a
1985	40.4	17	1,292	2006	41.9a	15	1,352a
1986	50.7	12	1,622	2007	40.4a	18	1,293a
1987	51.9	17	1,661	2008	39.1a	14	1,196a
1988	65.0	19	2,080	2009	36.7a	16	1,160a
1989	45.3	19	1,450	2010	36.2a	18	1,158a
1990	49.2	19	1,574	2011	37.9a	16	1,214a
1991	41.5	18	1,328	2012	26.5a	19	847a
1992	31.7	19	1,014	2013	31.8a	17	1,017a
1993	38.6	15	1,235	2014	23.6a	18	755a
1994	35.1	16	1,123	2015	23.5a	13	752a
1995	37.4	13	1,197	2016	25.8a	20	824a
1996	36.7	17	1,174	2017	28.3a	16	906a
1997	36.4	17	1,165				

* 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 in the St. Lawrence River Thousand Islands Area 1977 - 2017 (* net type correction applied).

Species	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Lake Sturgeon	0	0	0	0	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 in the St. Lawrence River Thousand Islands Area 1977 - 2017 (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 in the St. Lawrence River Thousand Islands Area 1977 - 2017 (continued).

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Lake Sturgeon	.03	0	0	0	.03	0	0	0	0	0	0	.09	0
Longnose Gar	0	0	0	0	0	0	0	0	0	0	0	0	0
Bowfin	.03	0	0	0	0	.03	0	.03	.03	.03	0	.03	.06
Alewife	.09	.03	2.25	.59	8.78	2.13	2.56	.50	.41	.13	3.59	2.47	.97
Gizzard Shad	0	0	0	0	0	0	0	0	0	0	0	0	0
Coho Salmon	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Trout	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Trout	0	0	0	0	0	0	0	0	0	.03	0	0	0
Rainbow Smelt	0	0	.06	0	0	0	0	0	0	0	0	0	0
Northern Pike	1.63	1.84	2.06	1.34	1.38	2.34	1.44	2.19	2.0	1.53	1.13	.94	1.16
Muskellunge	0	0	0	0	0	0	0	0	0	0	.03	.03	0
Common Carp	.12	.19	.16	.19	.09	.06	.16	.16	.22	.03	.06	.06	.06
Rudd	0	0	0	0	0	0	0	.22	0	0	0	0	0
Golden Shiner	0	0	.03	0	.03	.03	.03	0	0	0	0	.13	0
Fallfish	0	0	0	0	0	0	0	.03	.06	1	0	.09	0
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	1.10	1.16	.88	.81	.63	.34	.69	.53	.78	.31	.31	.44	.44
Silver Redhorse	.03	.06	.03	.03	.03	.19	.03	.03	.03	.41	0	.03	.03
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Redhorse	0	0	0	0	.16	0	0	0	.03	.03	0	0	.03
Brown Bullhead	1.53	2.47	1.22	.81	1.56	.72	.75	.97	.50	.19	.09	1.34	.38
Yellow Bullhead	0	0	0	0	0	0	0	.03	0	0	0	0	0
Channel Catfish	.38	.44	.25	.31	.84	1.06	0.03	.31	.34	.31	.13	.22	.13
Stonecat	0	0	0	0	0	0	0	0	0	0	0	0	0
Burbot	0	0	0	0	0	0	0	0	0	0	0	0	0
White Perch	0	.03	0	0	0	0	0	0	0.13	0	0	0	0
White Bass	0	.03	0	0	0	0	0	0	0	0	0	0	0
Rock Bass	8.23*[*]	11.3*	9.03*	8.87*	8.82*	10.46*	11.63*	5.47*	10.72*	6.48*	7.00*	5.41*	7.17*
Pumpkinseed	1.88	2.41	.97	.88	.81	.72	.69	.47	.94	.09	.09	.25	.34
Bluegill	.06	.03	.13	.06	0	.06	.09	.25	.09	.03	0	.06	0
Smallmouth Bass	4.75	7.84	5.13	6.69	4.19	7.5	5.0	8.91	6.41	4.59	1.88	5.25	5.91
Largemouth Bass	0	0	.19	0	0	.03	0	.31	.06	0	0	.13	.09
Black Crappie	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow Perch	6.82*[*]	12.95*	16.44*	15.4*	7.70*	9.48*	12.93*	5.7*	8.31*	7.75*	8.18*	7.94*	9.76*
Walleye	.75	.81	1.34	.84	1.03	.84	1.06	.47	.81	1.22	1.22	.69	.94
Freshwater Drum	.06	0	.13	0	0	0	.09	.06	0.03	0	0	0	0
Round Goby	0	0	.09	.53	.19	.16	.75	.06	0	.37	.13	.16	.81

Table 4. Smallmouth bass and yellow perch relative year class strengths (abundance of year class$_x$ relative to mean abundance of all year classes tested).

Species	Period	Ages	Year Class	Abundance (Σ N)	Proportion of Mean Abundance
SMB	2007-2017	3-6	2004	69	0.46
			2005	257	1.70
			2006	155	1.03
			2007	122	0.81
			2008	226	1.50
			2009	150	0.99
			2010	120	0.79
			2011	109	0.72
			mean	**151**	
YP	2007-2017	3-6	2004	1540	1.70
			2005	1201	1.32
			2006	749	0.83
			2007	1119	1.23
			2008	1242	1.37
			2009	470	0.52
			2010	681	0.75
			2011	253	0.28
			mean	**907**	

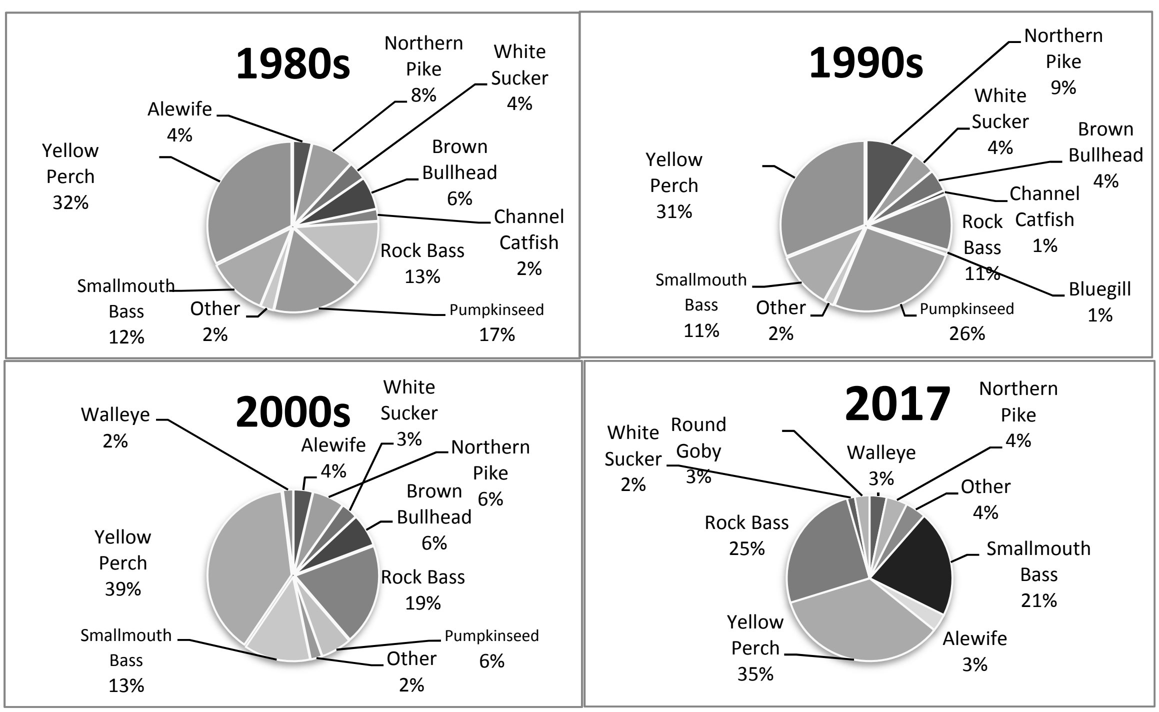

Figure 1. Composition of the warm/coolwater fisheries assessment sample from mid- depths of the St. Lawrence River Thousand Islands area.

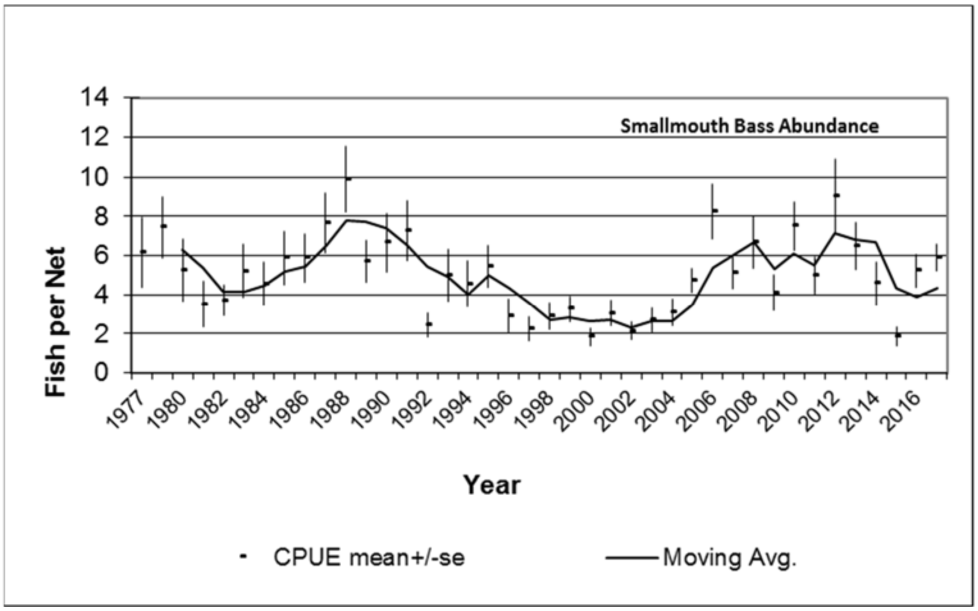

Figure 2. Smallmouth bass abundance index in the St. Lawrence River Thousand Islands area (Catch per Unit Effort +/- SE and 3-year moving average).

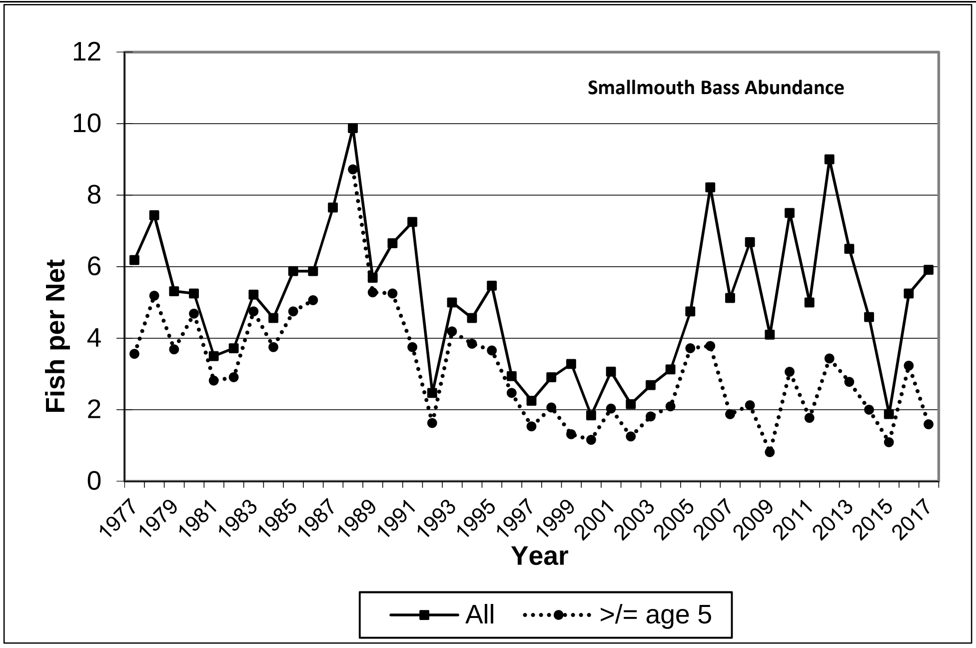

Figure 3. Smallmouth bass abundance index in the St. Lawrence River Thousand Islands area (all bass sampled and bass greater than or equal to age 5).

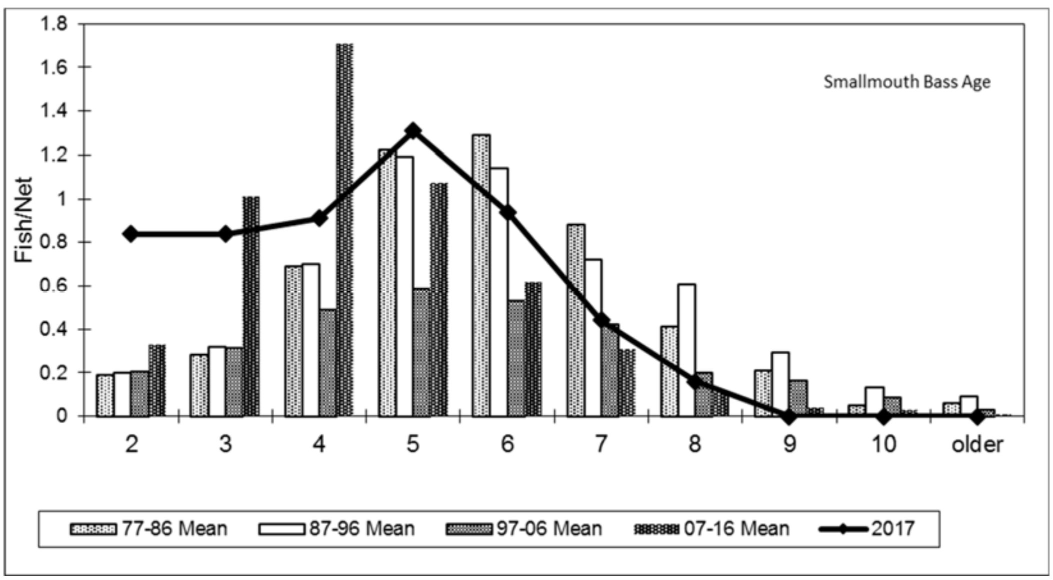

Figure 4. Smallmouth bass age distribution in the St. Lawrence River Thousand Islands area.

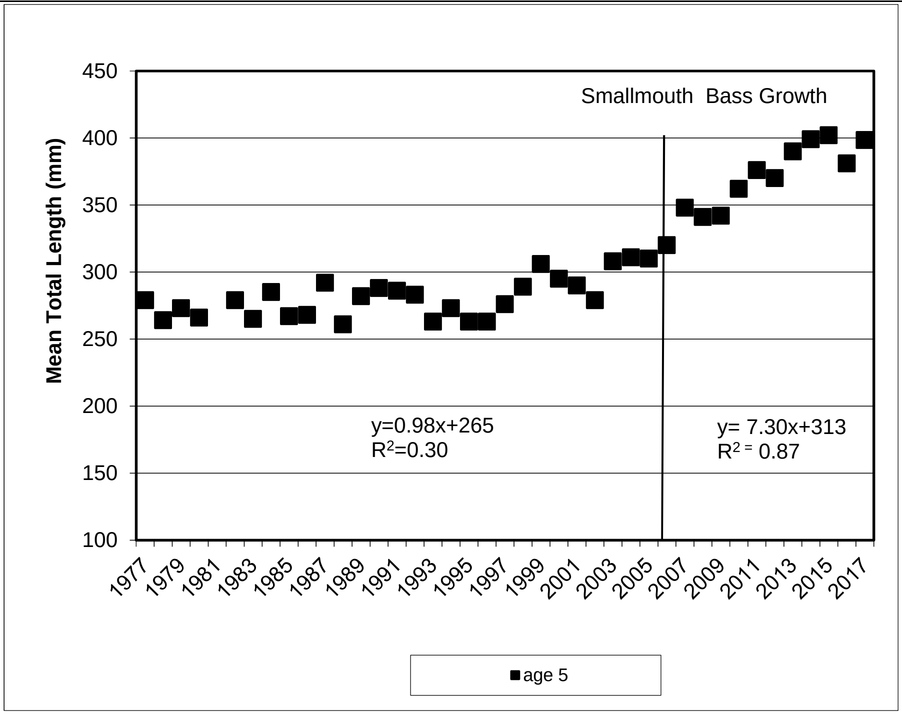

Figure 5. Mean total length of smallmouth bass at age 5 in the St. Lawrence River Thousand Islands area. Vertical line indicates establishment of abundant round goby-2005.

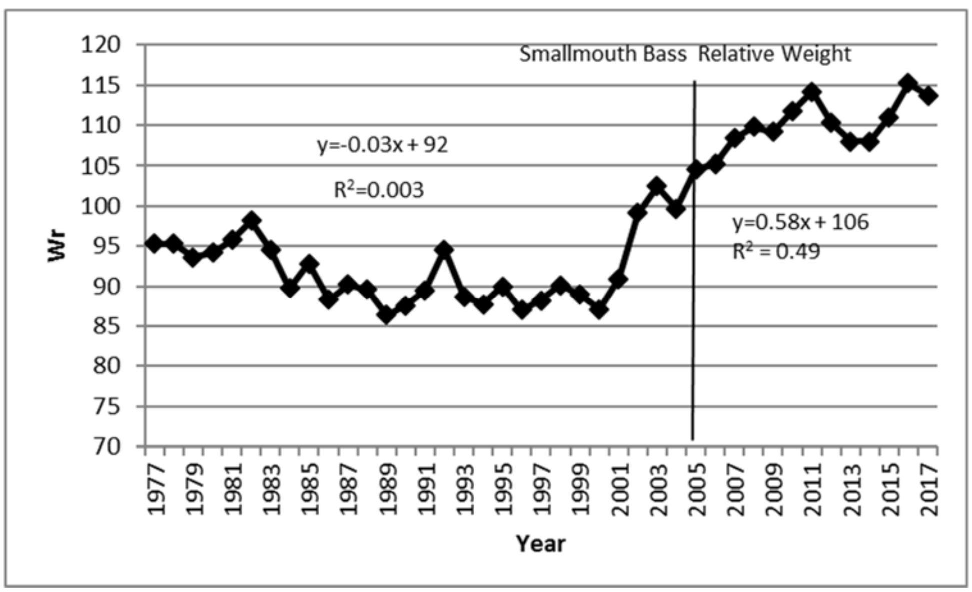

Figure 6. Condition (relative weight) of smallmouth bass in the St. Lawrence River Thousand Islands area. Vertical line indicates establishment of abundant round goby-2005.

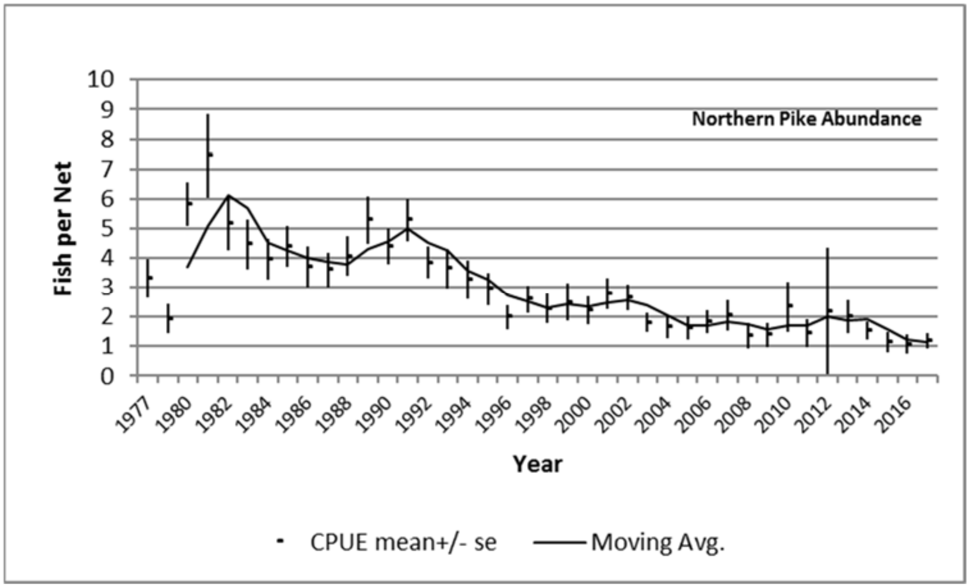

Figure 7. Northern pike abundance index in the St. Lawrence River Thousand Islands area. (Catch per Unit Effort +/- SE and 3-year moving average).

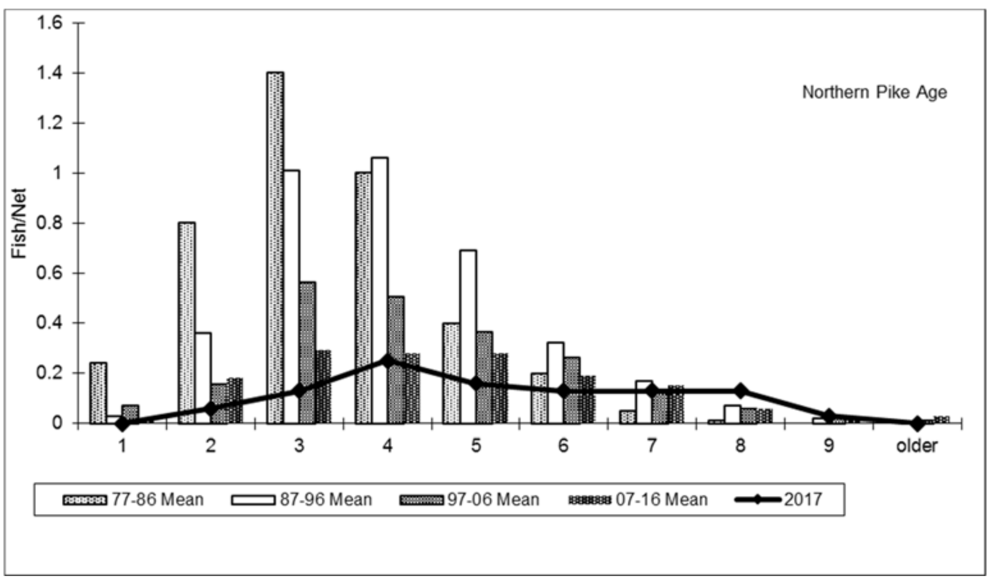

Figure 8. Northern pike age distribution in the St. Lawrence River Thousand Islands area.

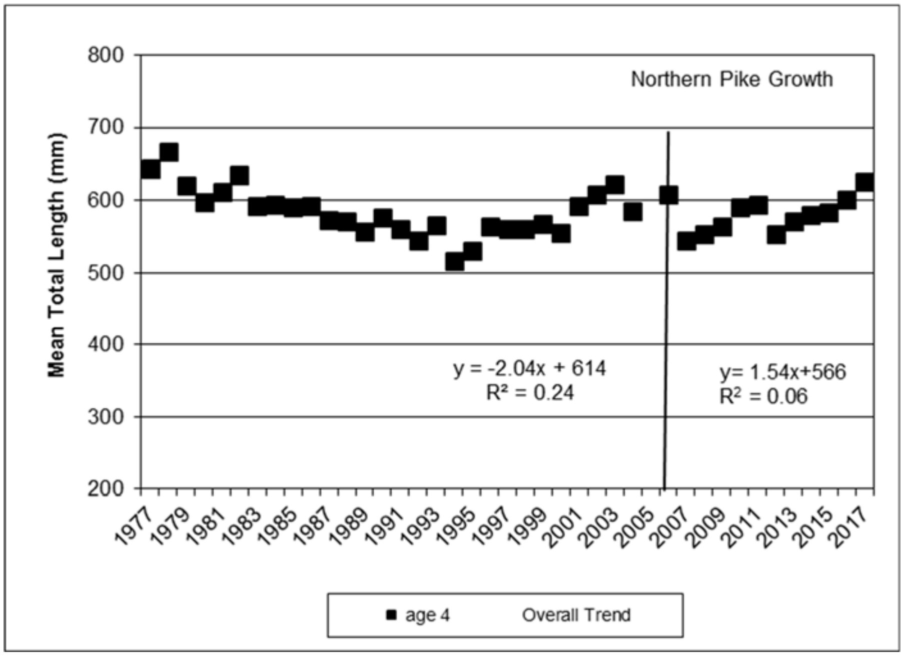

Figure 9. Mean total length of northern pike at age 4 in the St. Lawrence River Thousand Islands area. Vertical line indicates establishment of abundant round goby-2005.

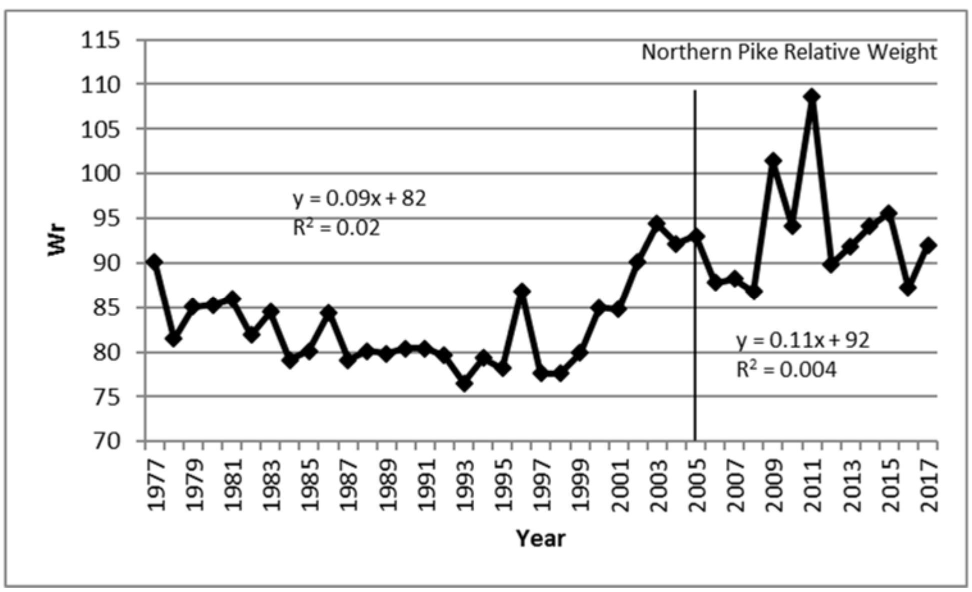

Figure 10. Condition (relative weight) of northern pike in the St. Lawrence River Thousand Islands area. Vertical line indicates establishment of abundant round goby-2005.

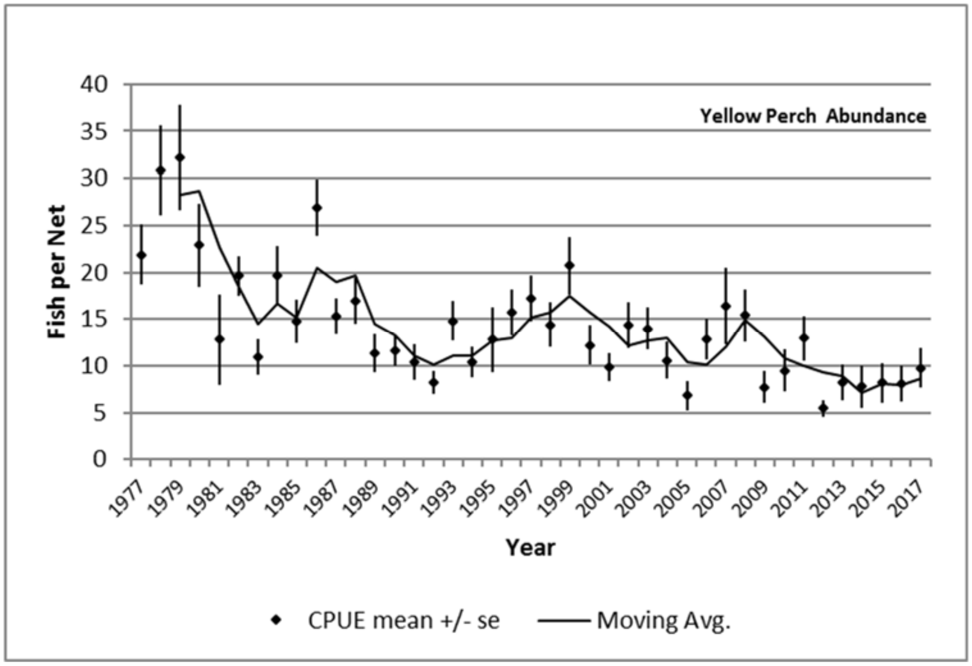

Figure 11. Yellow perch abundance index in the St. Lawrence River Thousand Islands area. (Catch per Unit Effort +/- SE and 3-year moving average).

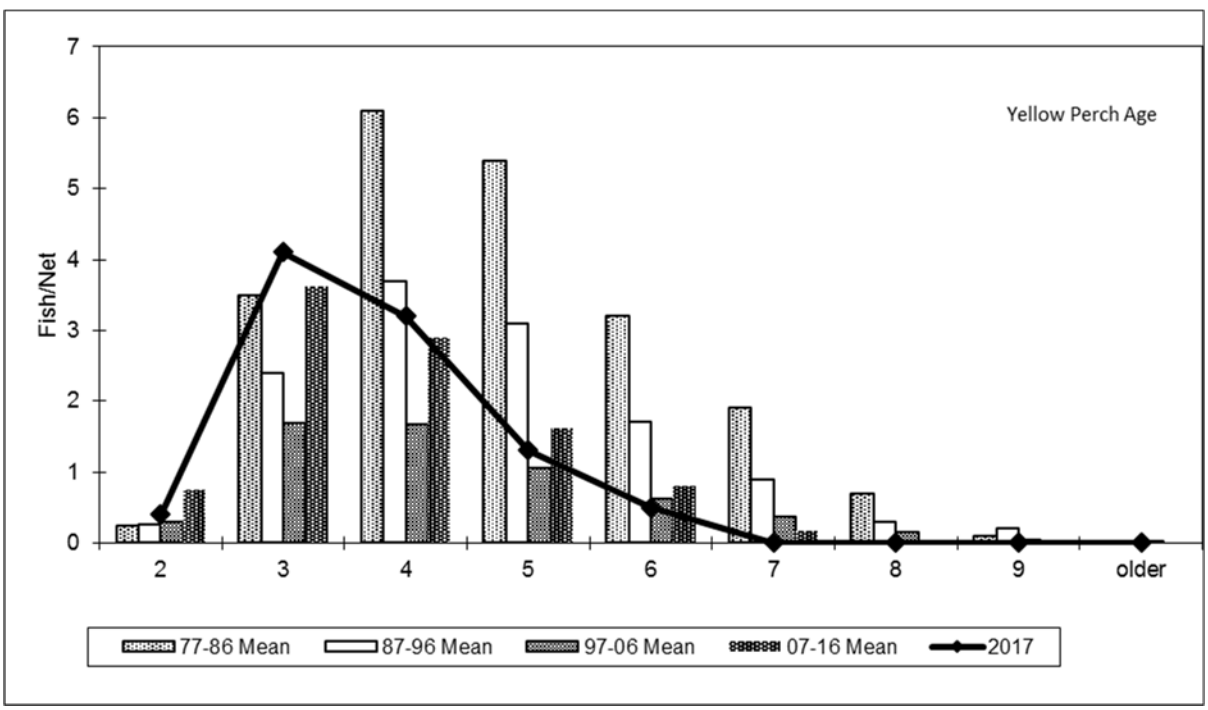

Figure 12. Yellow perch age distribution in the St. Lawrence River Thousand Islands area.

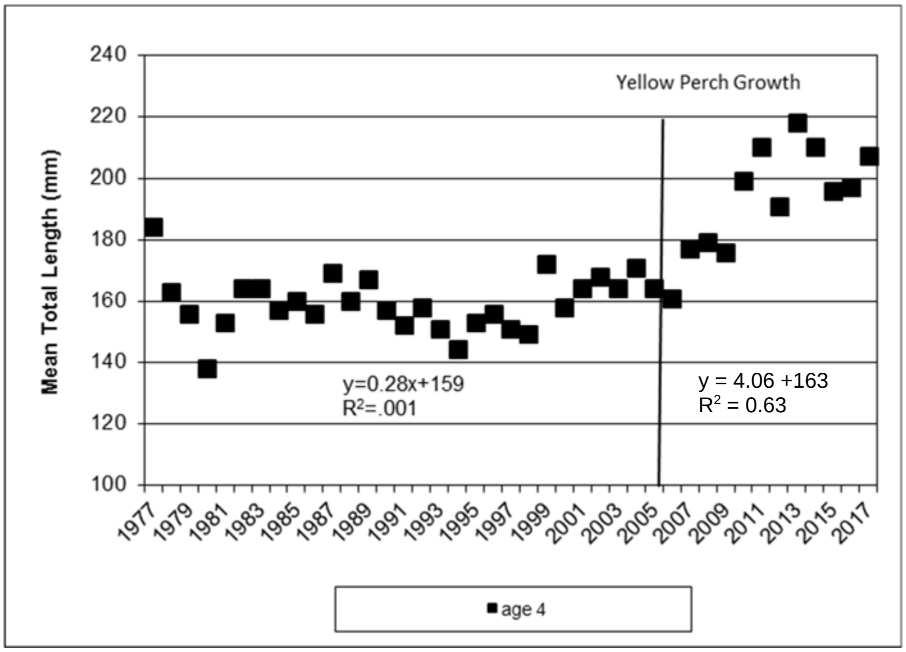

Figure 13. Mean total length at age 4 for yellow perch in the St. Lawrence River Thousand Islands area. Vertical line indicates establishment of abundant round goby-2005.

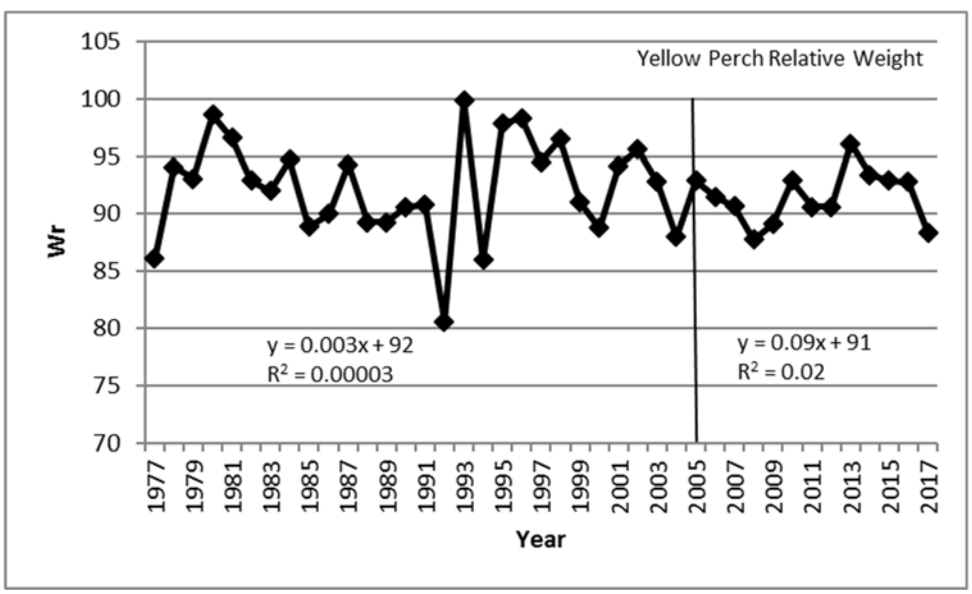

Figure 14. Condition (relative weight) of yellow perch in the St. Lawrence River Thousand Islands area. Vertical line indicates establishment of abundant round goby-2005.

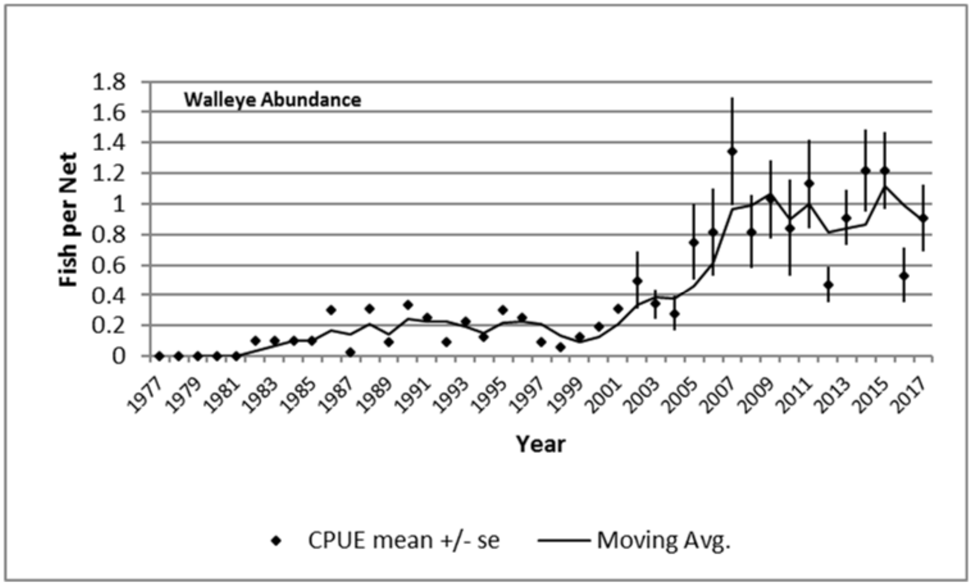

Figure 15. Walleye abundance index in the St. Lawrence River Thousand Islands area (Catch per Unit Effort +/- SE and 3-year moving average)..

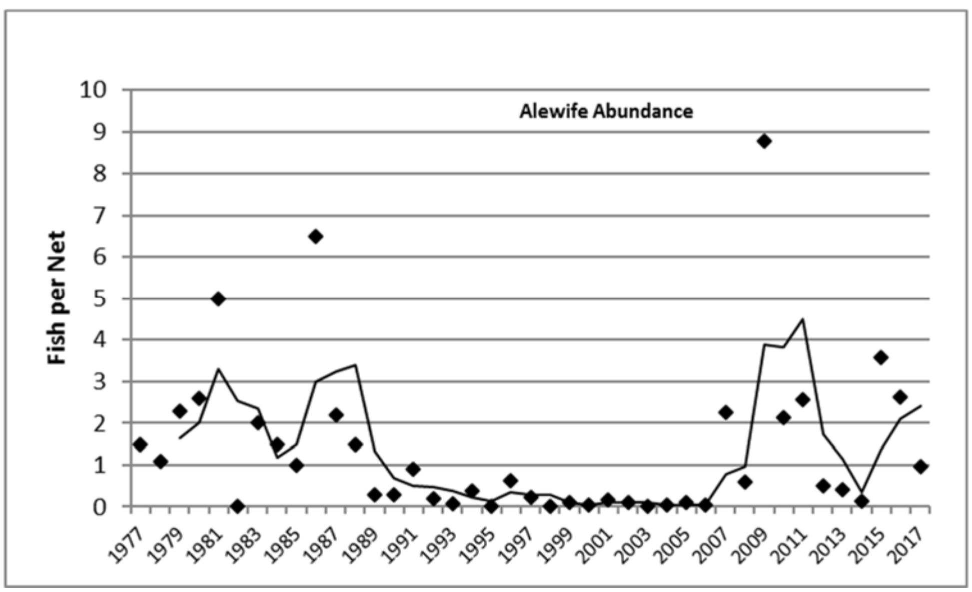

Figure 16. Abundance index for alewife in the St. Lawrence River Thousand Islands area (with 3-year moving average).

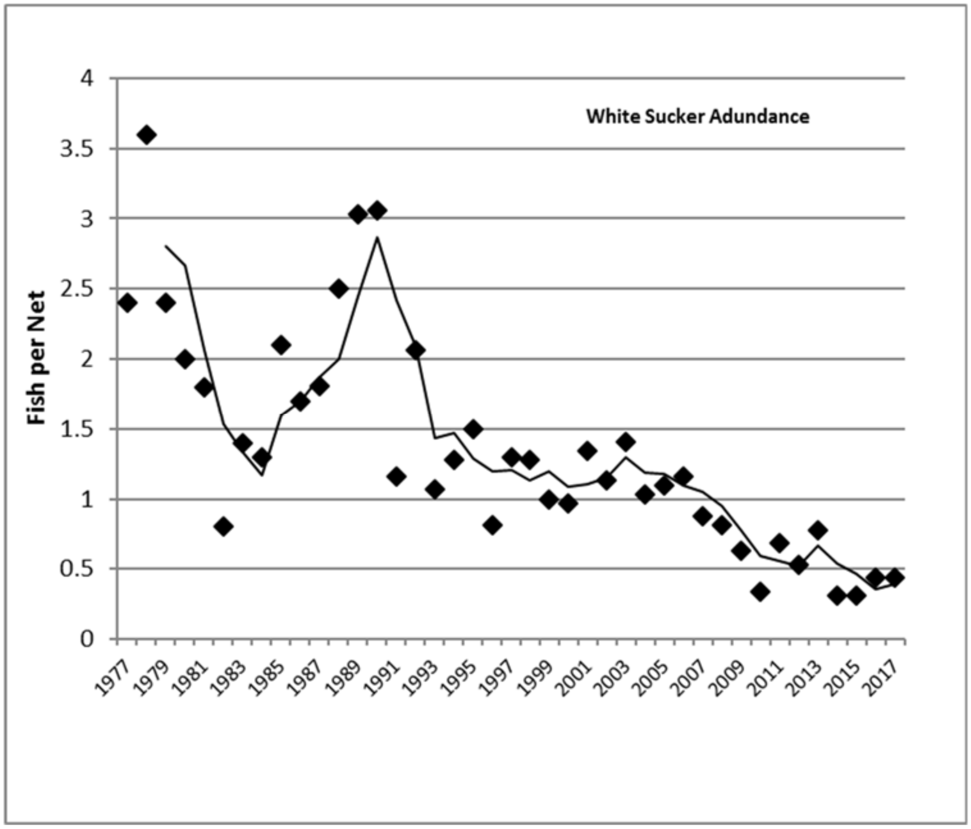

Figure 17. Abundance index for white sucker in the St. Lawrence River Thousand Islands area (with 3-yr moving average).

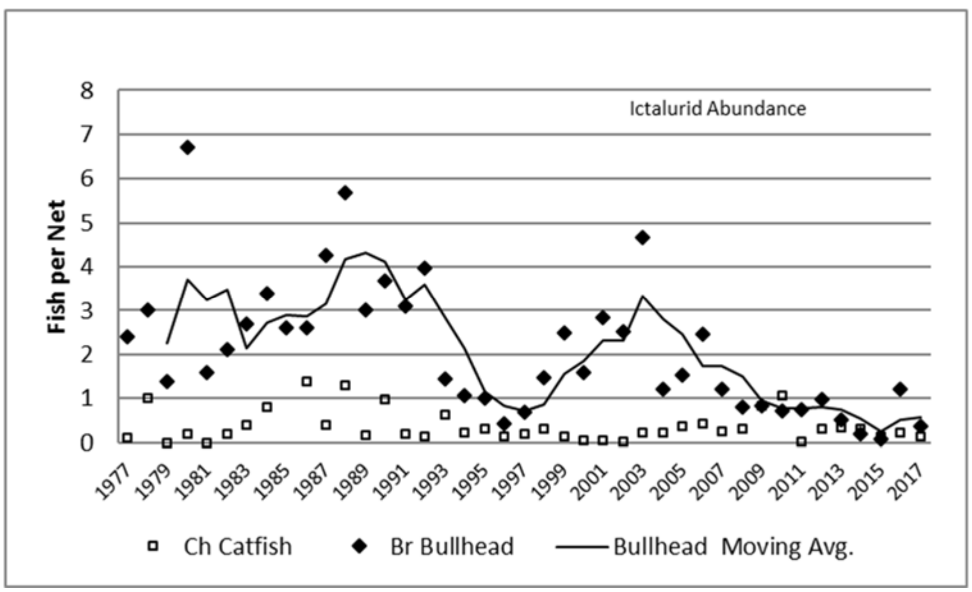

Figure 18. Abundance index for brown bullhead and channel catfish in the St. Lawrence River Thousand Islands area.

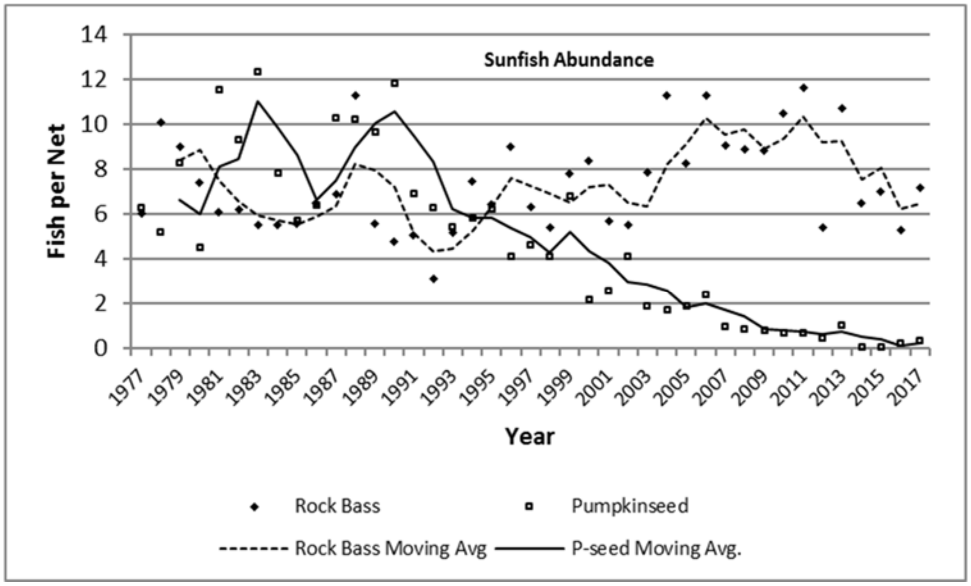

Figure 19. Abundance index for rock bass and pumpkinseed sunfish in the St. Lawrence River Thousand Islands area (with 3-year moving averages).

2017 Lake St. Lawrence Warmwater Fisheries Assessment

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

Methods

In 2005 gill nets were converted from multifilament to monofilament utilizing the same mesh dimensions, hanging ratios, and panel height/length of the previous net (Klindt 2006). Monofilament gill nets measuring 200 ft (61 m) long by 8 ft (2.4 m) deep having eight panels measuring 25 ft (7.6 m), with mesh arranged in increasing size from 1.5-6 in (38-152 mm) stretch measure were used for this assessment.

Gill nets were set overnight and fished an average of 18.2 hours (SE=0.14) at standard New York (N=16) and Ontario (N=16) sites described by Klindt and Town (2002). Net sites were stratified in equal number by depth as shallow and deep (12-25 ft and 30-50 ft, respectively).

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

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

Results and Discussion

The 2017 Lake St. Lawrence assessment was conducted from 11 to 14 September. Surface water temperature was consistent at 67^{o}F (19.4^{o}C). A sample of 684 fish comprising 19 species was collected (Table 1). The catch was dominated by yellow perch (44.2%), rock bass (15.9%) and smallmouth bass (9.6%).

While overall diversity of the fish community in Lake St. Lawrence remains relatively stable, the contribution of individual species appears to have changed over time. Figure 1 depicts species that comprise at least 3% of the total catch, and low-density gamefish <3%, 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 poorly represented in earlier surveys now make up even smaller proportions of the overall assemblage. Largemouth bass have been collected regularly since 2008 and in 2017 accounted for approximately 27% of the total black bass catch.

Total CUE increased by 8.7% from 19.65 fish/net night in 2016 to 21.4 in 2017. This survey ranked 7th highest since 1986 (Figure 2). The average CUE, for data collected by NYSDEC, for this period is 19.09 ± 1.07 (SE). Total CUE is generally driven by fluctuations in yellow perch catch.

Yellow perch CUE increased by 24% from 7.3 in 2016 to 9.1 in 2017 (Figure 3). From 2008-2012 the perch catch showed large annual fluctuations. Since 2012 the population has been relatively stable. Predation from Double-crested Cormorant (*Phalacrocorax auritus*; DCC) has been demonstrated to influence yellow perch numbers in Lake St. Lawrence in the past (Klindt and Gordon

2013). DCC diet data are no longer available for Lake St. Lawrence, however, cormorant nesting colonies will continue to play a role in altering the fishery as they have in the Thousand Islands (McCullough and Gordon 2013) and Lake Ontario (Lantry et al. 1999).

The majority of yellow perch collected ranged from 5.75-7.0" with few perch <5" and a high proportion of fish >9" (24.0%, Figure 4). From 2006 to 2017, perch >9" have comprised 19.8-33.9% of the catch. While age-3 yellow perch dominated the catch in 2017 (Figure 5), their numbers were below the previous 10 year average. Perch tend to leave the fishery by age-7.

Growth rates of yellow perch were determined by year class for fish ages 2-6 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=0.52), an increasing growth rate trend remains apparent for the entire data series. A more recent, short-term trend (2000-2012 year classes) implies that growth rate is stabilizing. Round goby have become a forage source for most piscivorous species in the river, and it is probable that increased growth rates seen since the expansion of goby (circa 2000) are a result of perch exploiting goby as forage.

Smallmouth bass CUE had been relatively stable from 1998-2004, fluctuated substantially from 2005 to 2013, and remained stable from 2014 to present. Smallmouth bass CUE (2.06) was below the long-term average of 2.2 in 2017 (Figure 7). The length frequency distribution shows two distinct peaks at 11 inches and from 16-20 inches (Figure 8). The proportion of bass <12 inches was approximately 27%. Age-1&2 bass were well represented and were well above the 10-year average, similar to the 2016 catch (Figure 9). The 2011-year class, which had been performing well, has not recruited well past age-4. However, the 2010 and 2012 year classes, at age-7 and 5, respectively, both appear above the 10-year average.

Growth rates of smallmouth bass were determined by year class for fish ages 3-7 years. The slope of the regression line of log transformed mean length at age for each year class is presented in Figure 10. The relationship is weak (r^2=0.12), however, it depicts an overall increase in growth rate. Data for the 1998, 1999 and 2001-2004 year classes demonstrate a marked increase in growth rate, likely due to foraging on round goby. Mean length at age-6 is also illustrated in Figure 10 to demonstrate a similar trend of increasing growth over the long-term. However, when considering only the 2002-2012 year classes, it appears that growth rate may be stabilizing.

Walleye CUE (1.0) increased 13% in 2017 but remained below the long-term average of 1.4 fish/net night (Figure 11). Abundance has been in decline since 2009, however, it appears to have stabilized since 2015. The length-frequency distribution of walleye has two distinct peaks in the 14-18 inch range and at 28 inches (Figure 12). Catch was dominated by age-3 & 7 fish representing the 2014 and 2010 year classes, respectively (Figure 13). Walleye in Lake St. Lawrence tend to fully recruit to our gear as age 3 fish as shown by the 10-year average age frequency. High densities of young of year or age 1 fish sometimes occur but do not always persist in the catch through time. All walleye have been aged using scales, which may have led to some inconsistencies in reporting age of older fish.

Netting strata were not designed to take advantage of limited littoral zone habitat in Lake St. Lawrence, therefore northern pike are poorly represented in this assessment. Northern pike CUE (0.2) in 2017 remained low but shows an increasing trend from the low of 0.09 observed in 2014 (Figure 14). Total length of northern pike ranged from 20.8-32.5 in (Figure 15). Fish age-1, 2, 6, and 7 were represented in the catch (Figure 16).

References

Klindt, R.M., and B. Town. 2002. 2001 Lake St. Lawrence warmwater fisheries assessment. Section 7 *In* 2001 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Klindt, R.M. 2006. 2005 Lake St. Lawrence warmwater fisheries assessment. Section 7 *In* 2005 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Klindt, R.M, and D. Gordon. 2013. 2012 Lake St. Lawrence warmwater fisheries assessment. Section7 *In* 2012 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Lantry, B.F., T.H. Eckert, and C.P. Schneider 1999. The relationship between abundance of Smallmouth Bass and double-crested cormorants in the Eastern Basin of Lake Ontario. NYSDEC Special Report February 1999.

McCullough, R.D., and D.J. Gordon 2013. Thousand Islands warmwater fish stock assessment. Section 6 *In* 2014 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2017.

	Year	1983	1985	1986	1987	1988	1989	Avg
Species	**# Nets**	48	47	32	47	32	46	
Lake Sturgeon		0.02	0.02	0	0	0	0	0.01
Bowfin		0	0	0	0	0.03	0	0.01
Alewife		0.73	1.15	1.50	0.11	0.06	0.06	0.60
Gizzard Shad		0	0	0	0.26	0.09	0.33	0.11
Rainbow Trout		0	0	0.03	0	0	0	0.01
Brown Trout		0	0	0.09	0.02	0	0	0.02
Lake Trout		0	0	0	0	0	0.06	0.01
Rainbow Smelt		0	0	0	0	0	0	0.0
Northern Pike		0.23	0.62	0.94	0.04	0.63	0.85	0.55
Muskellunge		0	0	0	0.02	0	0.02	0.01
Lake Chub		0	0	0	0.02	0	0	0.0
Carp		1.46	0.23	1.94	1.06	0.66	0.72	1.01
Golden Shiner		0	0	0	0	0	0	0.0
Fallfish		0.17	0.21	0.25	0.32	0.19	0.15	0.22
White Sucker		1.54	1.45	0.91	1.04	1.41	1.43	1.3
Silver Redhorse		0.58	0.21	0.06	0.23	0.44	0.15	0.28
Shorthead Redhorse		0	0	0	0	0	0	0.0
Greater Redhorse		0	0	0.03	0	0	0	0.01
Yellow Bullhead		0	0	0	0	0	0	0.0
Brown Bullhead		1.25	2.15	0.63	0.79	0.97	1.61	1.23
Channel Catfish		0.04	0.09	0	0	0.09	0.02	0.04
White Perch		1.23	1.06	0.38	0.96	3.00	0.87	1.25
White Bass		0.06	0.13	0	0.02	0	0.04	0.04
Rock Bass		2.19	1.23	2.41	1.36	1.84	1.02	1.68
Pumpkinseed		0.33	0.21	0.13	0.26	0.28	0.74	0.33
Bluegill		0	0	0	0	0	0	0
Smallmouth Bass		3.77	2.15	2.03	2.36	2.28	2.65	2.54
Largemouth Bass		0	0	0	0	0	0.02	0.0
Black Crappie		0.08	0.09	0	0.02	0.16	0.13	0.08
Yellow Perch		7.60	11.3	9.63	8.61	6.94	4.41	8.08
Walleye		0.42	1.38	0.53	1.04	1.38	0.83	0.93
Freshwater Drum		0.02	0.02	0	0	0	0.06	0.02
TOTAL CATCH		21.7	25.9	21.5	18.9	20.4	16.2	20.77

Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2017.

	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg
Species	**# Nets**	32	47	32	47	32	47	32	32	32	32	
Lake Sturgeon		0	0	0	0	0.03	0	0	0.09	0	0	0.01
Bowfin		0	0	0	0	0	0	0	0	0	0	0.00
Alewife		0.34	0.04	0.66	0.02	0.28	0.43	0	0	0	0	0.18
Gizzard Shad		0.13	0.21	0	0.32	0	0	0.09	0	0	0.13	0.09
Rainbow Trout		0	0	0	0	0	0	0	0	0	0	0.00
Brown Trout		0	0	0	0.02	0	0.21	0	0	0	0	0.02
Lake Trout		0	0.02	0	0.02	0	0	0	0	0	0	0.00
Rainbow Smelt		0	0	0.02	0	0	0	0	0	0	0	0.00
Northern Pike		0.69	0.66	0.53	0.32	0.31	0.36	0.22	0.41	0.5	0.91	0.49
Muskellunge		0	0	0.03	0	0	0	0	0	0	0	0.00
Lake Chub		0	0	0	0	0	0	0	0	0	0	0.00
Carp		1.06	0.87	1.13	0.64	0.75	0.43	0.56	0.41	1.16	0.78	0.78
Golden Shiner		0	0.02	0	0	0	0	0	0	0	0	0.00
Fallfish		0.19	0.09	0.09	0.06	0.63	0.13	0.09	0.06	0	0.03	0.14
White Sucker		1.47	0.89	1.06	0.87	0.94	0.55	1.28	0.47	0.53	1.16	0.92
Silver Redhorse		0.31	0.15	0.5	0.17	0.28	0.13	0.53	0.53	0.94	1.19	0.47
Shorthead Redhorse		0	0	0	0	0	0	0	0	0	0.28	0.03
Greater Redhorse		0	0	0	0	0.03	0	0	0	0	0	0.00
Yellow Bullhead		0	0	0	0	0	0	0	0	0	0.03	0.00
Brown Bullhead		2.06	2.55	2.28	0.21	0.31	0.36	0.63	0.81	1.34	2.69	1.32
Channel Catfish		0.03	0	0.03	0	0.16	0.02	0.06	0.03	0.09	0.03	0.05
White Perch		1.5	1.09	0.91	0.7	1.19	0.06	0.69	0.31	0.5	0.44	0.74
White Bass		0.03	0.11	0	0	0	0	0.06	0	0	0	0.02
Rock Bass		2.03	1.17	2	1.34	1.69	1.21	2.75	2.4	3.44	3.09	2.11
Pumpkinseed		0.19	0.21	0.34	0.02	0.31	0.36	0.28	0.63	1.16	0.78	0.43
Bluegill		0	0	0	0	0	0	0	0	0	0.03	0.00
Smallmouth Bass		1.97	1.68	2.94	1.51	2.41	1.47	1.22	1.09	2.78	3.28	2.04
Largemouth Bass		0.03	0.04	0	0.02	0	0	0	0	0	0	0.01
Black Crappie		0.09	0.04	0.22	0.11	0.03	0.04	0	0	0.06	0	0.06
Yellow Perch		4.34	5.83	4.72	4.62	4.56	4.57	4.19	4.59	6.97	3.66	4.81
Walleye		1.34	1.21	0.94	1.64	0.75	0.94	1.72	1.38	1.34	2.09	1.34
Freshwater Drum		0	0	0.03	0.06	0	0.21	0	0	0	0.03	0.03
TOTAL CATCH		17.8	16.9	18.5	12.7	14.1	11.7	14.4	13.2	20.9	20.6	16.08

Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2017.

	Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Avg
Species	**# Nets**	32	32	32	32	32	32	32	32	32	32	
Lake Sturgeon		0	0	0	0.06	0.03	0	0	0.06	0	0	0.02
Bowfin		0.03	0.03	0.06	0	0.03	0	0	0	0.06	0	0.02
Alewife		0.03	0	0.06	0	0	0	0	0	0	0	0.01
Gizzard Shad		0.03	0	0.03	0	0.06	0.06	0.06	0	0.53	0.06	0.08
Rainbow Trout		0	0	0	0	0	0	0	0	0	0	0.00
Brown Trout		0	0	0	0	0	0	0.03	0	0	0	0.00
Lake Trout		0	0	0	0	0	0	0	0	0	0	0.00
Rainbow Smelt		0	0	0	0	0	0	0	0	0	0	0.00
Northern Pike		0.44	0.59	0.63	0.56	0.47	0.44	0.59	0.41	0.28	0.31	0.47
Muskellunge		0	0	0	0	0	0	0	0	0	0	0.00
Lake Chub		0	0	0	0	0	0	0	0	0	0	0.00
Carp		0.38	0.47	0.91	0.41	0.19	0.5	0.25	0.31	0.41	0.06	0.39
Golden Shiner		0	0	0	0	0	0	0	0	0	0	0.00
Fallfish		0.09	0.06	0.03	0	0	0	0.06	0.16	0	0.25	0.07
White Sucker		0.69	0.66	0.66	0.25	0.16	0.25	0.31	0.44	0.81	0.59	0.48
Silver Redhorse		1.06	0.94	0.88	0.28	0.53	0.53	0.25	0.25	0.28	0.31	0.53
Shorthead Redhorse		0.03	0.13	0.06	0.03	0.03	0.06	0	0.09	0	0	0.04
Greater Redhorse		0.03	0	0	0	0	0	0	0	0.03	0.03	0.01
Yellow Bullhead		0	0	0	0	0	0	0	0	0	0	0.00
Brown Bullhead		0.56	2.94	2.47	0.56	0.44	0.22	0.22	0.19	0.06	0.09	0.78
Channel Catfish		0.06	0.41	0.06	0.09	0.16	0.03	0.03	0.09	0.09	0.09	0.11
White Perch		0.28	0.03	0.09	0	0.19	0	1.75	0	0.25	1.22	0.38
White Bass		0.13	0	0	0	0	0.06	0	0.06	0	0.09	0.03
Rock Bass		3.38	2.72	2.59	2.63	2.5	3.38	2.5	4.03	6.38	4.19	3.43
Pumpkinseed		0.56	0.75	0.56	1.41	0.09	0.03	0.16	0.16	0.16	0.13	0.40
Bluegill		0	0.03	0	0.03	0	0	0	0	0	0	0.01
Smallmouth Bass		2.56	2.31	2.53	2.06	2.22	4.28	1.63	1.44	3.03	1	2.31
Largemouth Bass		0.03	0	0.06	0	0.03	0.28	0.13	0	0.13	0.03	0.07
Black Crappie		0.03	0	0.03	0	0	0	0	0	0.06	0.03	0.02
Yellow Perch		2.59	2.44	4.53	4.34	1.78	4.44	3.78	7.13	11.22	8.16	5.04
Walleye		1.69	1.06	1.75	1.28	0.72	1.44	1.91	1.09	1.94	3.03	1.59
Freshwater Drum		0	0	0	0	0	0.13	0.06	0.06	0	0.03	0.03
TOTAL CATCH		14.7	15.6	17.9	14	9.69	16.19	13.78	15.96	25.75	19.67	16.32

Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of primary species collected in the assessment of Lake St. Lawrence, 1983-2017.

	Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg
Species	**# Nets**	32	32	32	32	32	32	32	32			
Lake Sturgeon		0.06	0.03	0	0	0	0	0	0	x	x	0.01
Bowfin		0.03	0	0	0.03	0	0.03	0	0	x	x	0.01
Alewife		0	0.03	0.09	0	0.03	0	0.31	0.16	x	x	0.08
Gizzard Shad		0.06	0.03	0.63	0.44	0	0.03	0.56	0	x	x	0.22
Rainbow Trout		0	0	0	0	0	0	0	0	x	x	0.00
Brown Trout		0	0	0	0	0	0	0	0	x	x	0.00
Lake Trout		0	0	0	0	0	0	0	0	x	x	0.00
Rainbow Smelt		0	0	0	0	0	0	0	0	x	x	0.00
Northern Pike		0.28	0.31	0.19	0.28	0.09	0.13	0.28	0.22	x	x	0.22
Muskellunge		0	0.03	0	0	0	0	0	0	x	x	0.00
Lake Chub		0	0	0	0	0	0	0	0	x	x	0.00
Carp		0.19	0.16	0.41	0.25	0.09	0.25	0.13	0.19	x	x	0.21
Golden Shiner		0	0	0.03	0	0	0	0	0.16	x	x	0.02
Fallfish		0.19	0.19	0.16	0.47	0.16	0.25	0.22	0.69	x	x	0.29
White Sucker		0.44	0.53	1.22	0.72	0.59	0.41	0.88	0.88	x	x	0.71
Silver Redhorse		0.19	0.63	0.44	0.38	0.25	0.31	0.22	0	x	x	0.30
Shorthead Redhorse		0	0	0	0.03	0	0.03	0	0	x	x	0.01
Greater Redhorse		0.06	0.03	0	0.03	0.03	0	0.03	0	x	x	0.02
Yellow Bullhead		0	0	0	0	0	0	0	0	x	x	0.00
Brown Bullhead		0.16	0.22	0.66	0.31	0.78	0.25	0.34	0.25	x	x	0.37
Channel Catfish		0.03	0.09	0.09	0.09	0.06	0.06	0	0.03	x	x	0.06
White Perch		0.41	1.03	1.75	2.16	3.41	1.59	1.25	1.97	x	x	1.70
White Bass		0	0	0	0	0	0	0	0	x	x	0.00
Rock Bass		8.03	3.41	5.16	3.97	5.22	3.5	3.78	3.41	x	x	4.56
Pumpkinseed		0.19	0.09	0.16	0.38	0.16	0.56	0.22	0.34	x	x	0.26
Bluegill		0	0	0	0	0	0.09	0.09	0.03	x	x	0.03
Smallmouth Bass		2.22	1.34	2.66	3.09	1.97	2.25	1.81	2.06	x	x	2.18
Largemouth Bass		0.22	0.22	0.69	0.09	0.03	0.44	1.18	0.75	x	x	0.45
Black Crappie		0	0	0	0.03	0	0.03	0.13	0.09	x	x	0.04
Yellow Perch		18.78	9.03	16.69	7.94	7.5	8.88	7.28	9.06	x	x	10.65
Walleye		2.75	1.81	2.09	2.06	1.38	0.84	0.91	1.03	x	x	1.61
Freshwater Drum		0.03	0	0.03	0.03	0	0.03	0.03	0.03	x	x	0.02
TOTAL CATCH		34.25	19.34	33.16	22.93	21.78	19.97	19.66	21.37	x	x	24.06

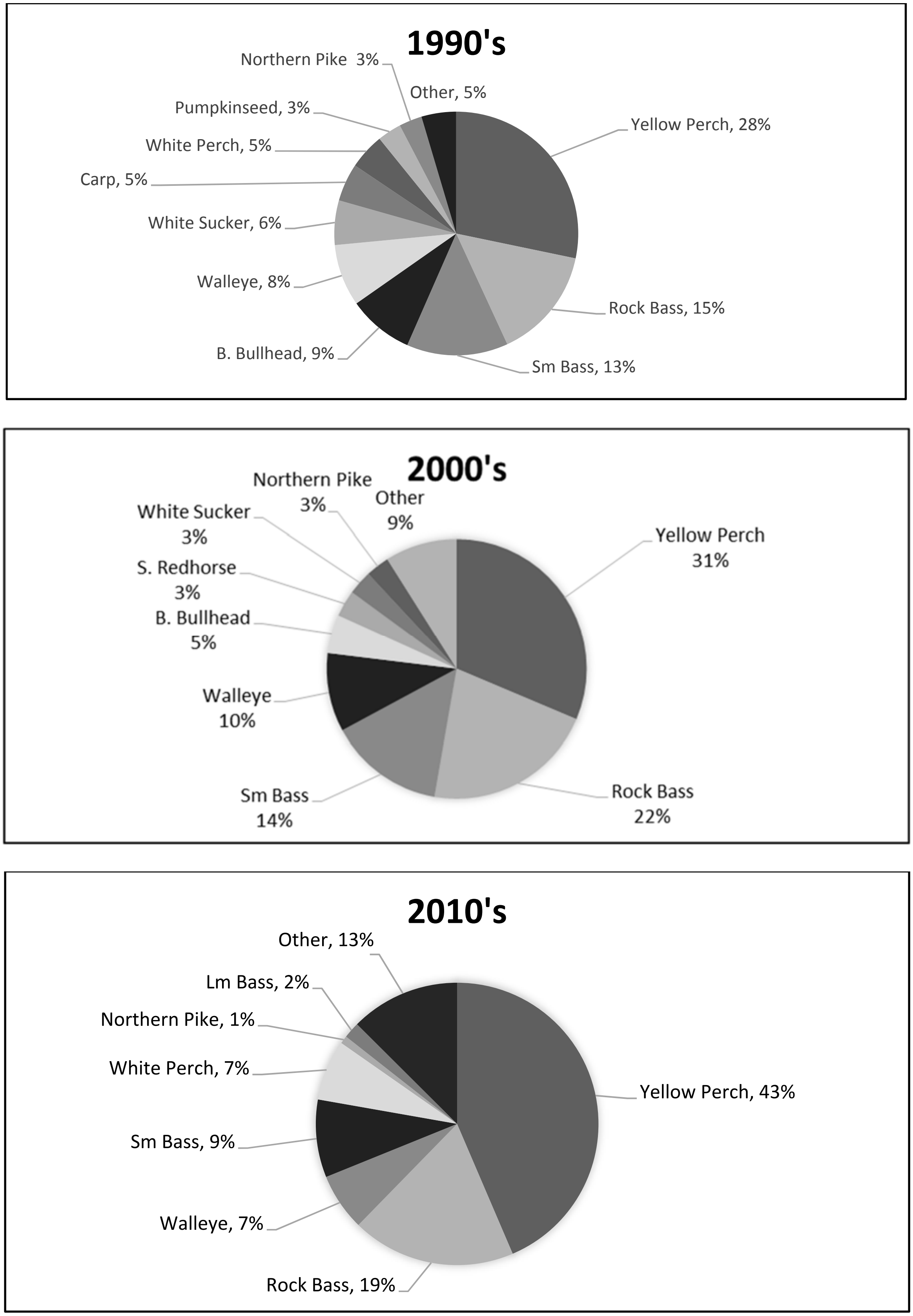


Figure 1. Composition of the Lake St. Lawrence fish community sampled by gill nets and presented by decade.

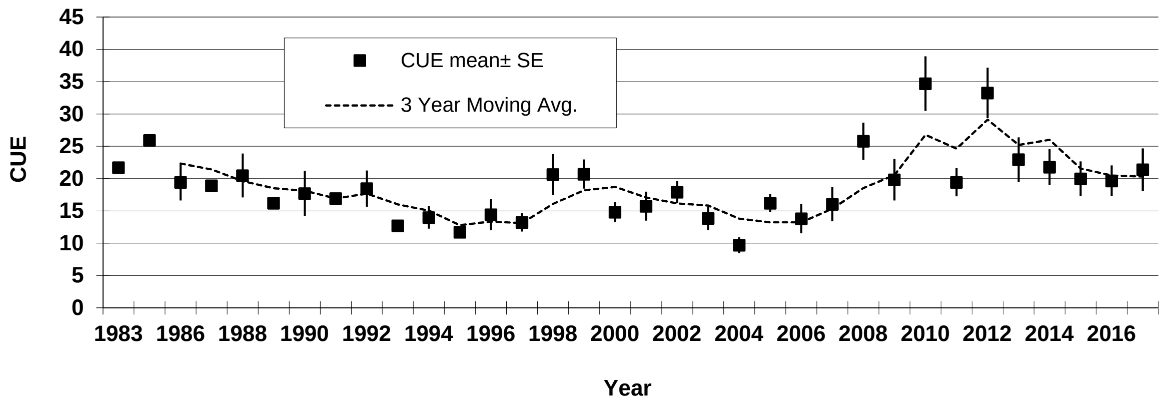
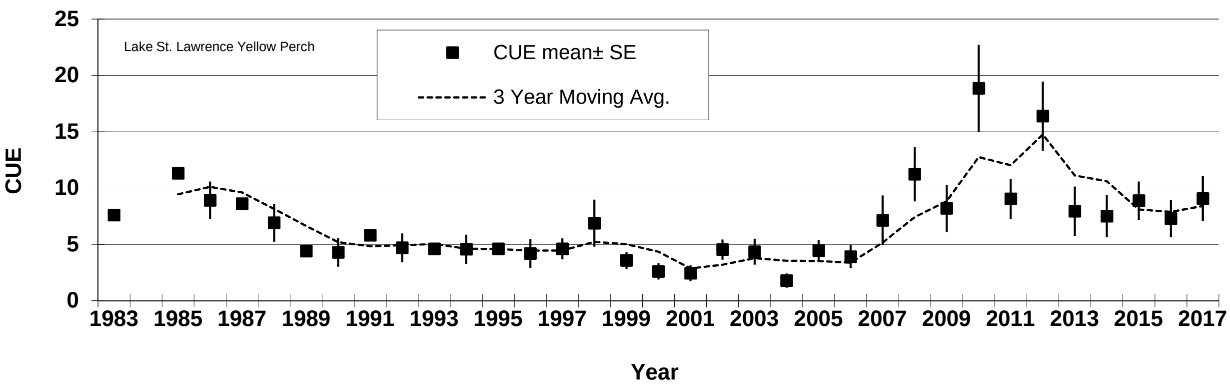


Figure 2. Total catch per gill net night (CUE) for Lake St. Lawrence, 1983-2017.

Figure 3. Yellow perch total catch per gill net night (CUE) for Lake St. Lawrence, 1983-2017.



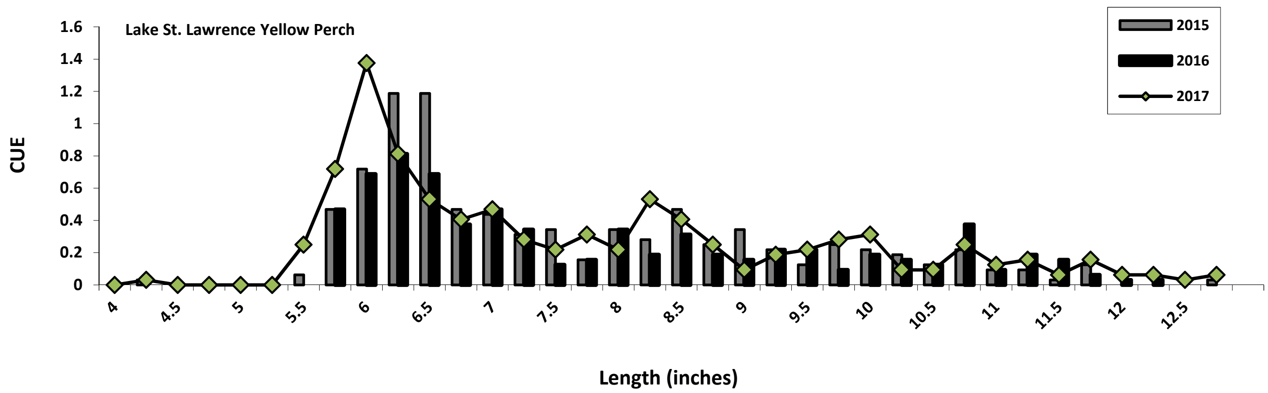


Figure 4. Yellow perch length-frequency distribution for Lake St. Lawrence.

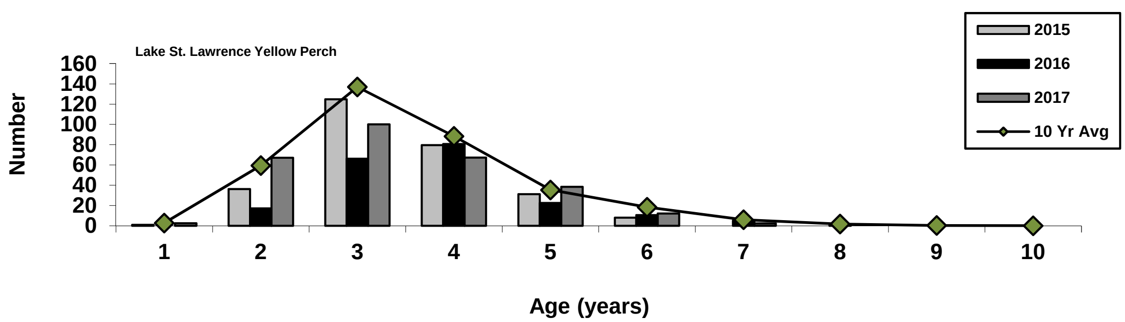


Figure 5. Yellow perch age-frequency distribution for Lake St. Lawrence.

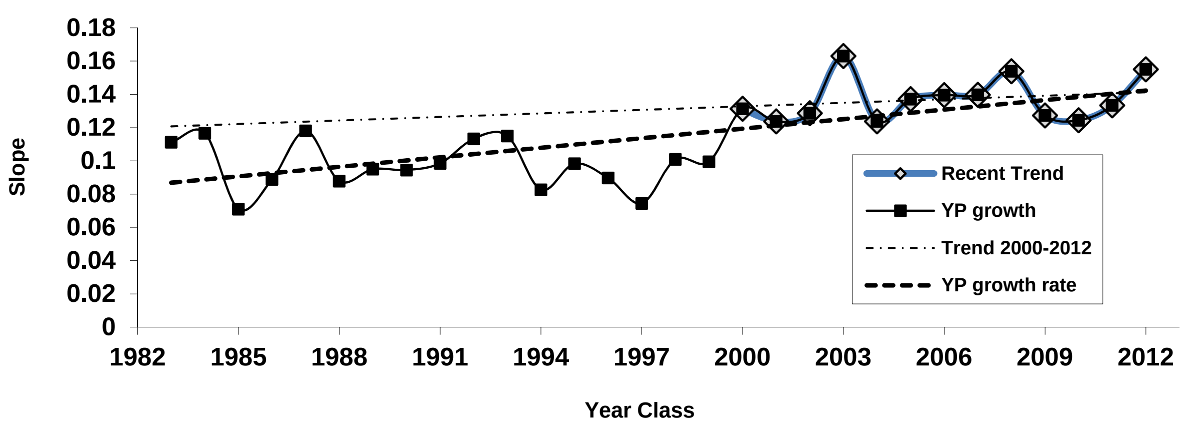


Figure 6. Yellow perch growth rates by year class using fish ages 2-6 for Lake St. Lawrence.

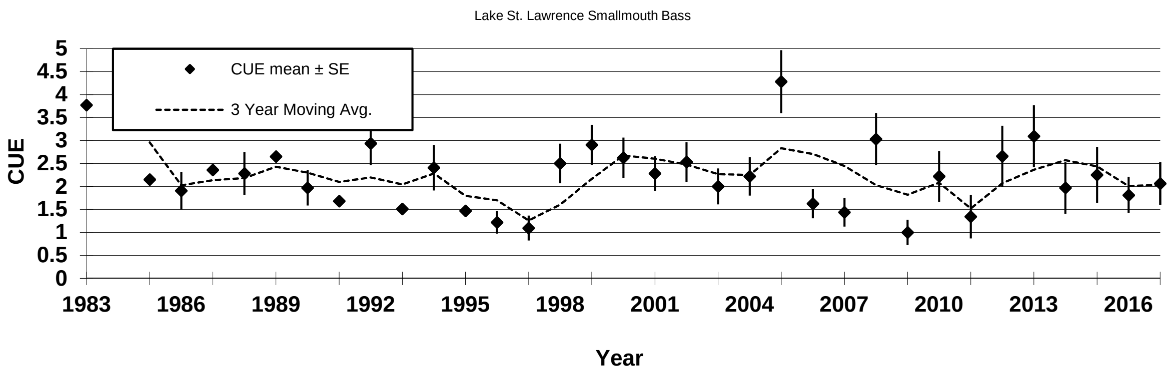


Figure 7. Total catch per gill net night (CUE) for smallmouth bass in Lake St. Lawrence, 1983-2017.

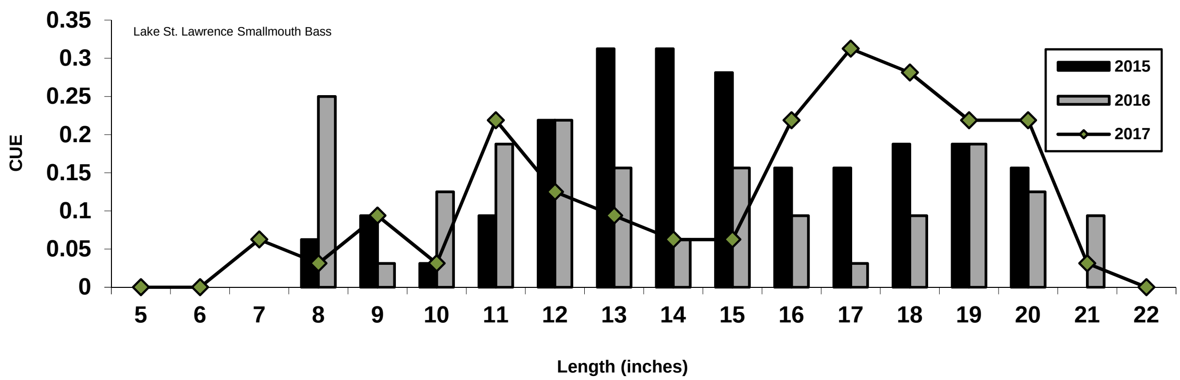


Figure 8. Smallmouth bass length-frequency distribution for Lake St. Lawrence.

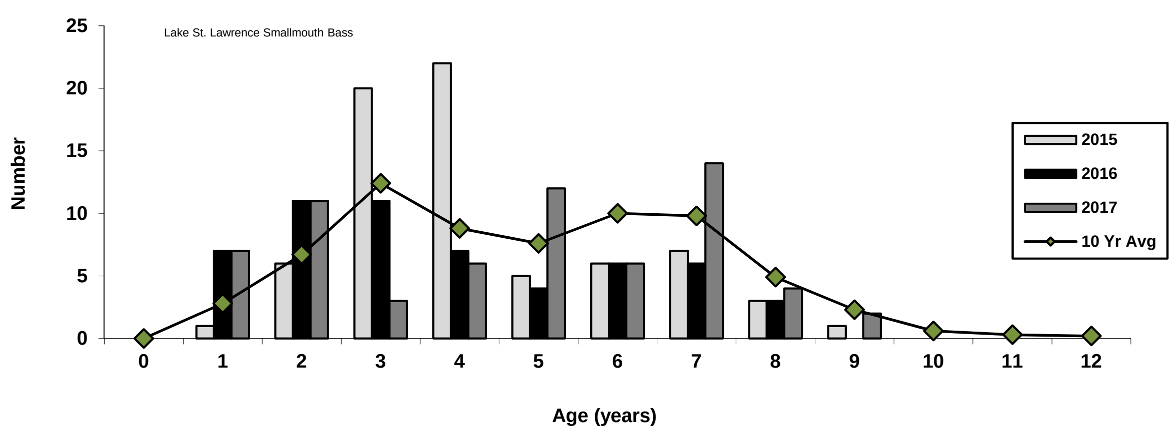


Figure 9. Smallmouth bass age-frequency distribution for Lake St. Lawrence.

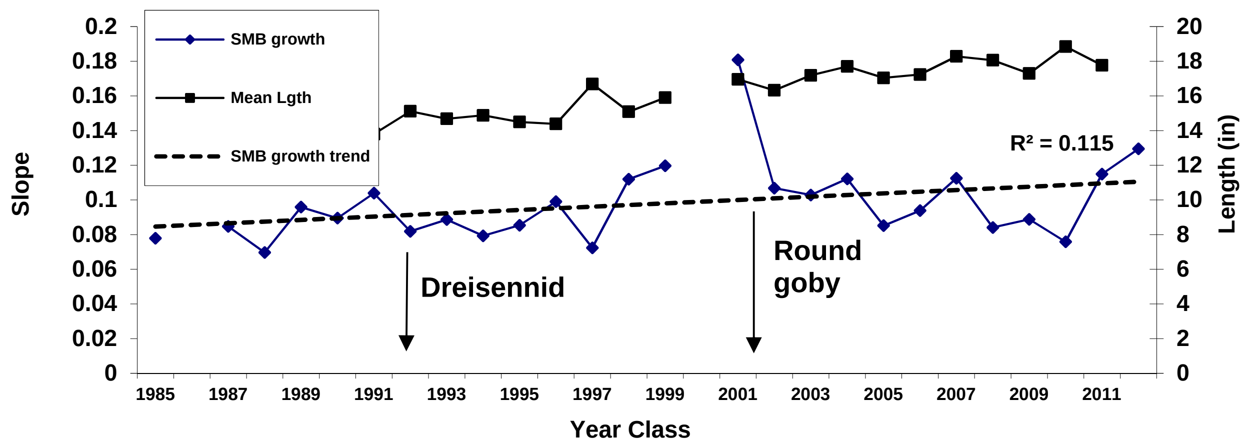


Figure 10. Smallmouth bass growth by year class described using two methods: growth rate (slope) using fish ages 3-7 and mean length (in) at age-6 for Lake St. Lawrence.

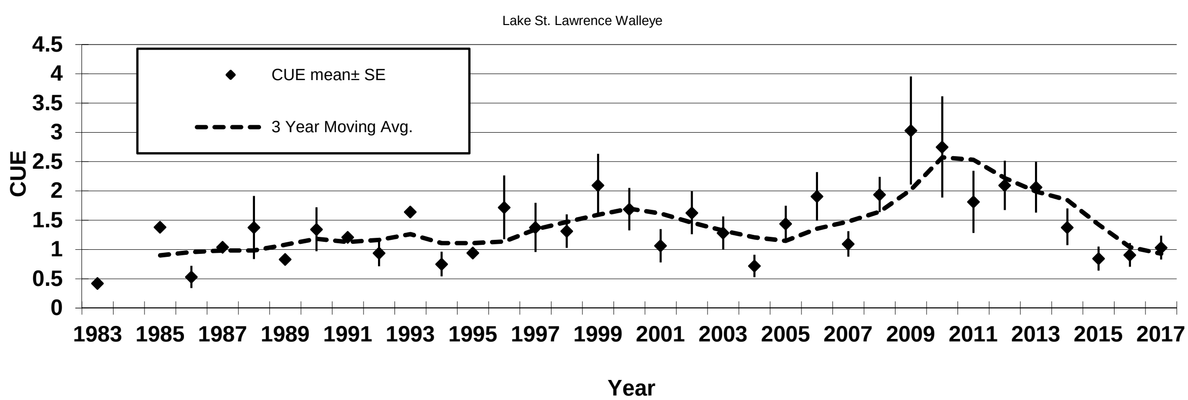


Figure 11. Total catch per gill net night (CUE) for walleye in Lake St. Lawrence, 1983-2017.

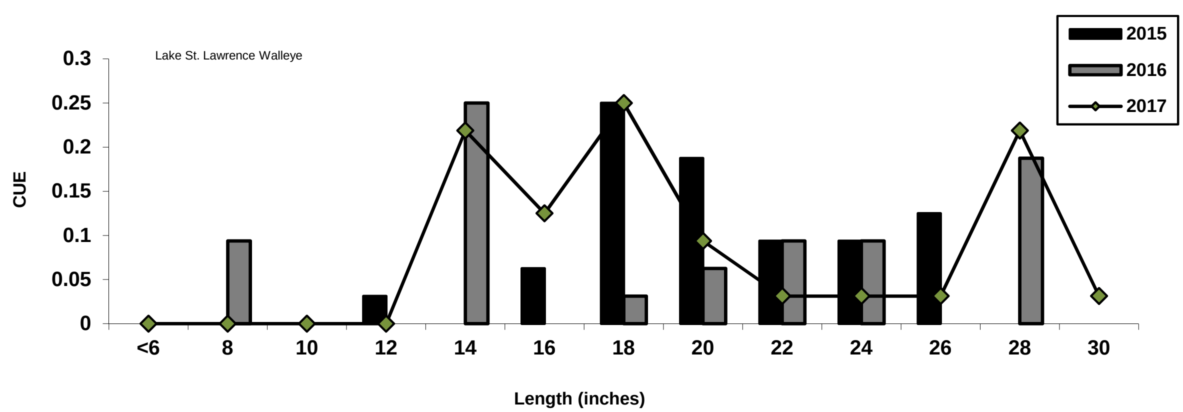


Figure 12. Walleye length-frequency distribution for Lake St. Lawrence.

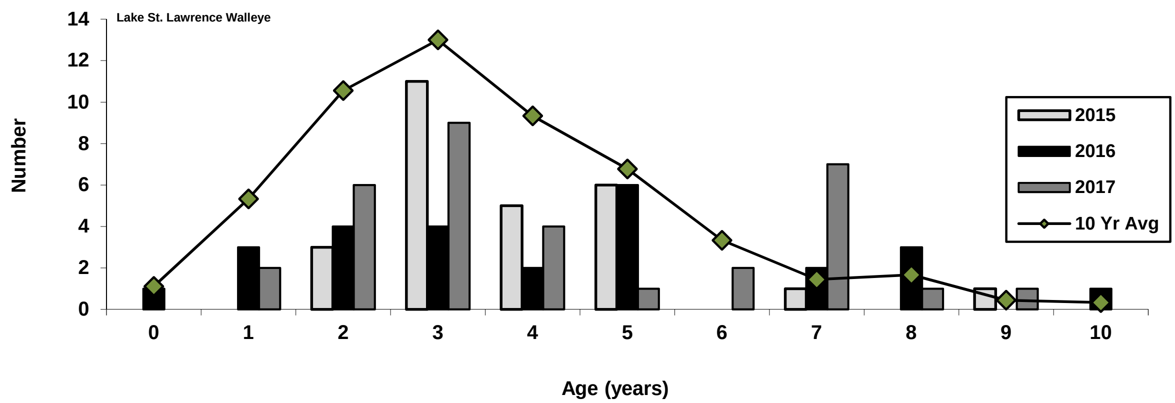


Figure 13. Walleye age-frequency distribution for Lake St. Lawrence.

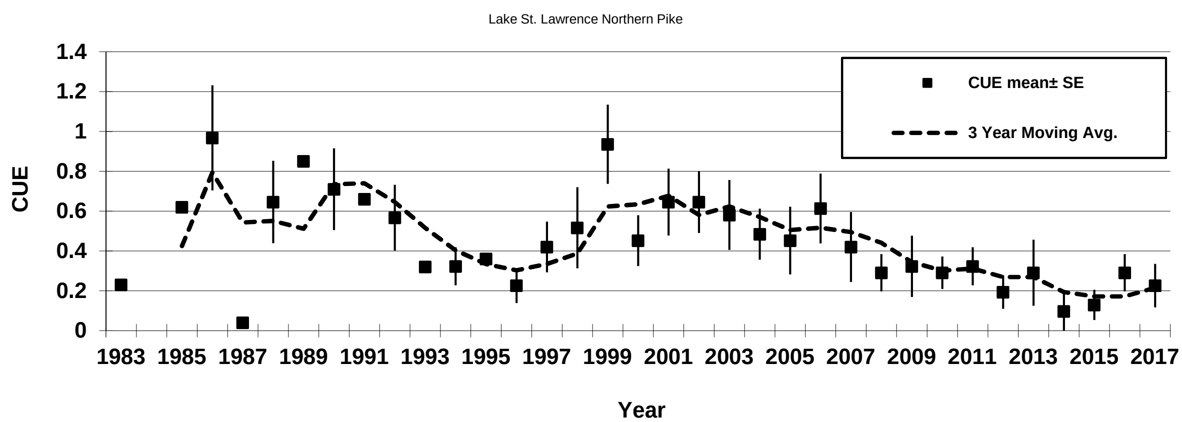


Figure 14. Total catch per gill net night (CUE) for northern pike in Lake St. Lawrence, 1983-2017.

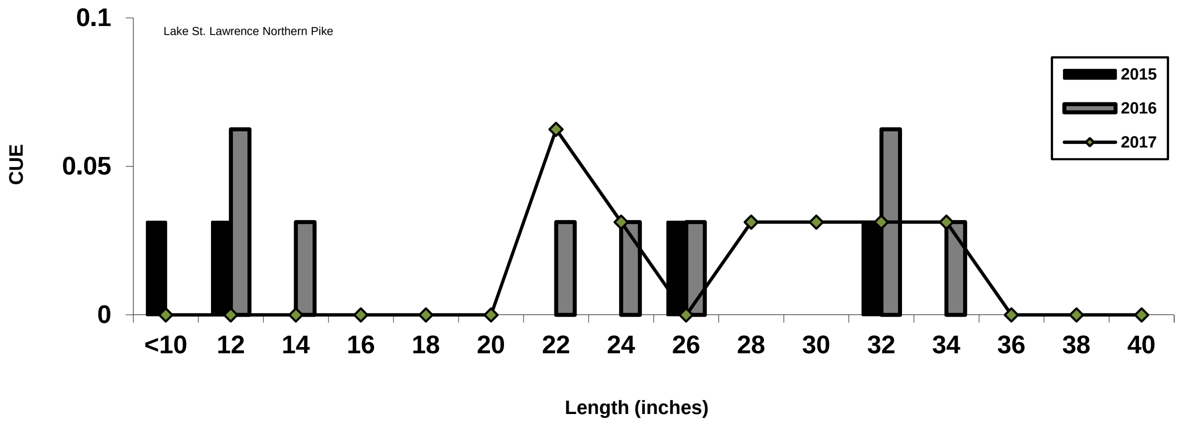


Figure 15. Northern pike length-frequency distribution for Lake St. Lawrence.

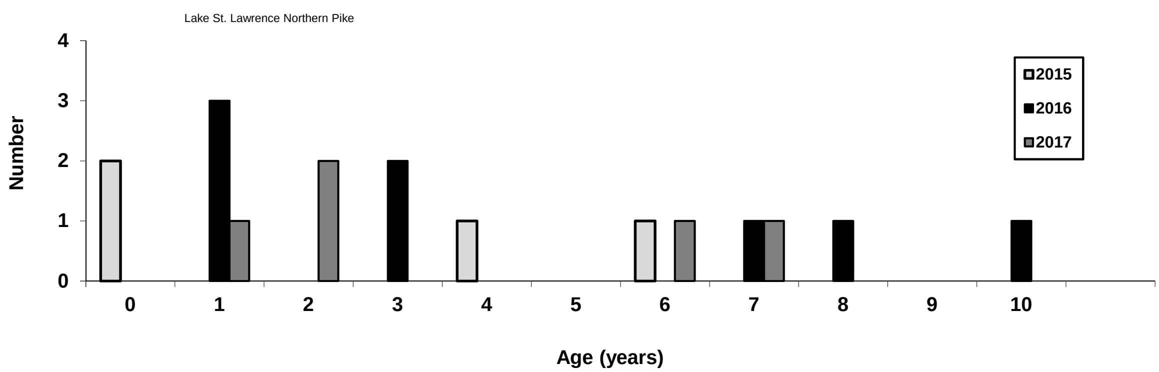


Figure 16. Northern pike age-frequency distribution for Lake St. Lawrence.

2017 Salmon River Wild Young-of-Year Chinook Salmon Seining Program

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

Methods

The survey design calls for weekly seine hauls during May and June at 4 sites: Altmar, Pineville, County Rt. 2A, and Douglaston (Figure 1). 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 peak week, 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. Various weeks were also missed in other years which did not influence mean peak catch estimates. 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

The mean peak YOY Chinook salmon catch in 2017 was 467 fish/haul, which was substantially below the 2016 record high, but was the fifth highest catch in the time series (Figure 2). The three weeks used to calculate the mean peak catch were the third week of May through the first week of June (Figure 3). The largest haul for a single site was 1,294 which occurred at Altmar on 1 June (Figure 4).

The highest catches for all sites combined occurred the first week of June which is relatively late. Reasons for the late hatch are unclear because the winter of 2016-2017 was milder than average. One potential explanation is that the Chinook spawning run in the fall of 2016 seemed to be later and more concentrated than normal. Relatively low water releases early in the spawning period (approximately 200 cfs) followed by an increase in flows at the end of the spawning period (flows increased to 600 cfs on 10/21 and remained high) may have contributed to a delayed run.

We have previously reported on the importance of adequate flows during the spawning period (October 1 – 21) to allow fish access to the upper river in the face of intense fishing pressure, and the negative effects of high flow events during the incubation period (October 22 through May 31) which potentially move bed load and disturb redds.

The relationships between flows and subsequent YOY production are not linear and we found the best correlations to be on natural log transformed flows and catches. Mean peak catches were positively correlated with mean spawning flows ($r = 0.39$, $p = 0.13$) and negatively correlated with maximum incubation flows ($r = -0.65$, $p < 0.01$) for the 17-year study period. The negative correlation between the mean spawning and maximum incubation flows was weak and insignificant ($r = -0.21$ $p = 0.42$). Additionally, fitting a second order polynomial (i.e., adding an x^2 term) to the spawning flow regression model (Figure 5) increased the explained variability in catch from $r^2 = 0.15$, $p = 0.13$ to $r^2 = 0.33$, $p = 0.06$. Combining the polynomial mean spawning flows and maximum incubation flows in a single model yielded the following regression ($r^2 = 0.57$, $p = 0.01$):

$$y = - 0.51103 x^2 + 6.63648 x - 0.98853 z -7.46634$$

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

YOY production in 2017 exceeded expectations based upon both the mean spawning flow, which was below base flow, and the maximum incubation flow, which was relatively high as depicted in Figure 5. The effect on the model was to decrease the explained variability in mean peak catches from $r^2 = 0.66$ for the first 16 years of the program to $r^2 = 0.57$ with the addition of the 2017 year class. Reasons for this are unclear although the relatively high maximum incubation flow was limited to a single event of short duration.

We also explored the use of mean daily air temperatures for Pulaski, NY from October through May as an additional predictor to account for thermal effects during the spawning and incubation periods. These data are available at: http://www.weatherdatadepot.com/?gclid=CLumudWty80CFYMehgod_JwLGQ. There was a weak and insignificant correlation between the mean daily temperatures during the spawning and incubation period and the log transformed peak mean catches ($r = 0.32$, $p = 0.21$) suggesting slightly higher production in warmer years. Addition of the temperature data to the above regression model increased the r-square from 0.57 to 0.61, but using Akaike's Information Criteria as a basis for "best" model selection resulted in its exclusion.

Note in Figure 5 that the 2002, 2005, 2012, 2014, 2015 and 2016 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 2016, and the 2002 year class was well below average. This suggests that the prescribed baseflow of 335 cfs generally allows sufficient numbers of fish to reach the spawning grounds, which are predominately located in the upper portion of the river. The strong year class produced in 2017 further suggests that mean spawning flows slightly below baseflow (227 cfs in fall 2016) can also produce a strong year class.

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, both year classes were subjected to relatively high maximum incubation flow events. There were, however, some relatively strong year classes produced which withstood maximum incubation flows similar to those of the 2008 year class, suggesting that the fall spawning flow in 2007 likely limited production. Not coincidentally, numbers of adult Chinook salmon reaching the Salmon River Hatchery in the fall 2007 were insufficient to meet NYSDEC's egg take quota.

The three years of highest production were 2012, 2015 and 2016. Spawning flows were at or near the prescribed base flow of 335 cfs in each of those years. The two years (2012 and 2016) with the lowest maximum flow event during the incubation period were also the years of highest production.

In summary, extreme low flows during the spawning period (1-21 October) result in low YOY Chinook salmon production. Spawning flows at, or perhaps slightly below, the prescribed baseflow and higher flows offer the potential to produce large year classes. Large maximum flow events during the incubation period (22 October through May) tend to reduce production and small maximum flows tend to increase production.

We now have an increased understanding of the role of naturally reproduced fish in the Lake Ontario and Salmon River systems. Results of a mass marking study have shown that wild fish comprise a substantial portion of the angler harvest in Lake Ontario (approximately 50%) and the Salmon River systems (Connerton et al. 2016). For the 2008 – 2011 year classes, an average of 58% of age-2 and age-3 Chinook salmon in the Salmon River harvest were wild. The proportions of wild age-2 and age-3 Chinook salmon in other New York tributaries were lower (3.3% - 24.2%), suggesting that the Salmon River is the largest single source of wild Chinook production in New York. More research is needed to understand the cumulative contribution of all tributaries including those in the Province of Ontario; 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.

References

Connerton, M.J., C.J. Balk, S.E. Prindle, J.R. Lantry, J.N. Bowlby, M. Yuille, C. Bronte and M.E. Holey. 2016. 2015 Mass Marking of Chinook Salmon in Lake Ontario. Section 3. *In* NYSDEC Lake Ontario Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Unit.

SAS Institute Inc., Copyright 2002-2010. 9.3 TS Level 1M2 W32_7PRO platform. Cary, NC, USA.

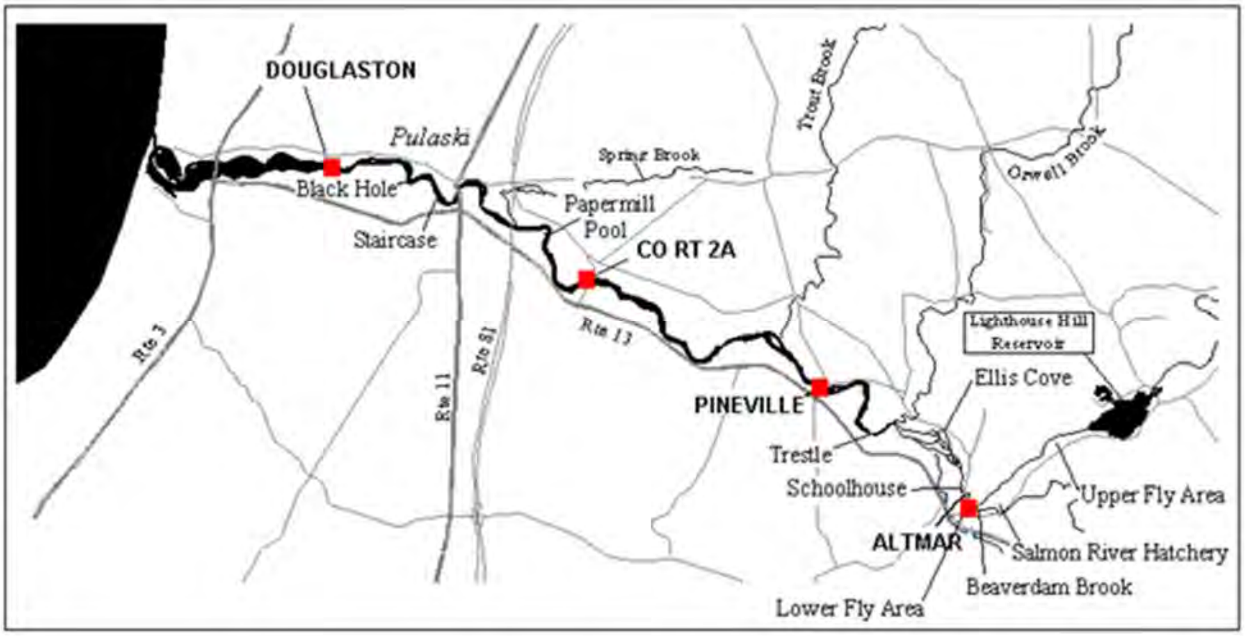


Figure 1. Sampling sites for the USGS/NYSDEC Salmon River seining program.

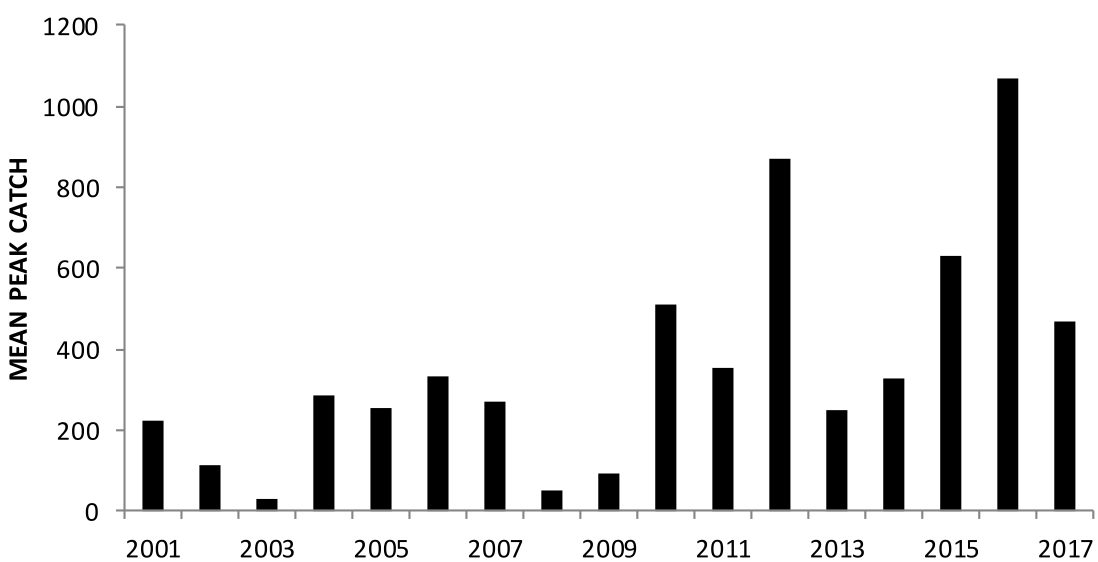


Figure 2. Mean peak catches of YOY Chinook salmon (mean number per seine haul) captured in the three consecutive weeks with the highest catches from the USGS/NYSDEC Salmon River seining program 2001-2017.

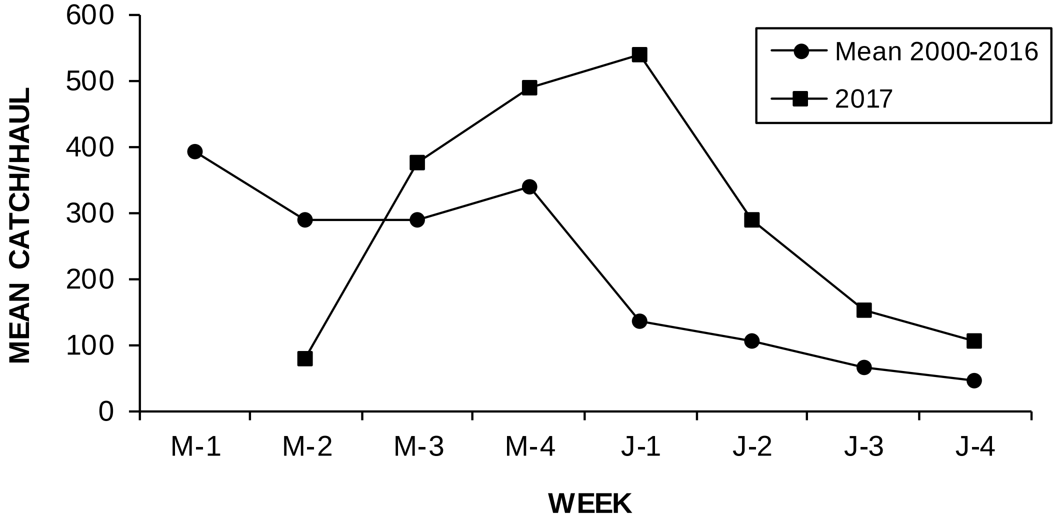


Figure 3. Mean numbers of YOY Chinook salmon captured per seine haul by week in the USGS/NYSDEC Salmon River seining program for 2001-2016 and 2017 (M=May, J=June).

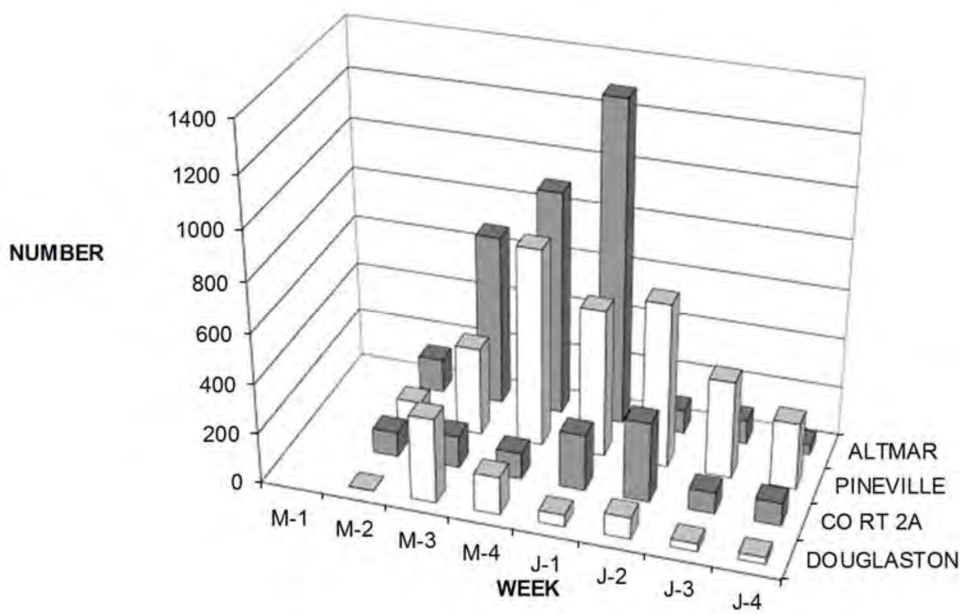
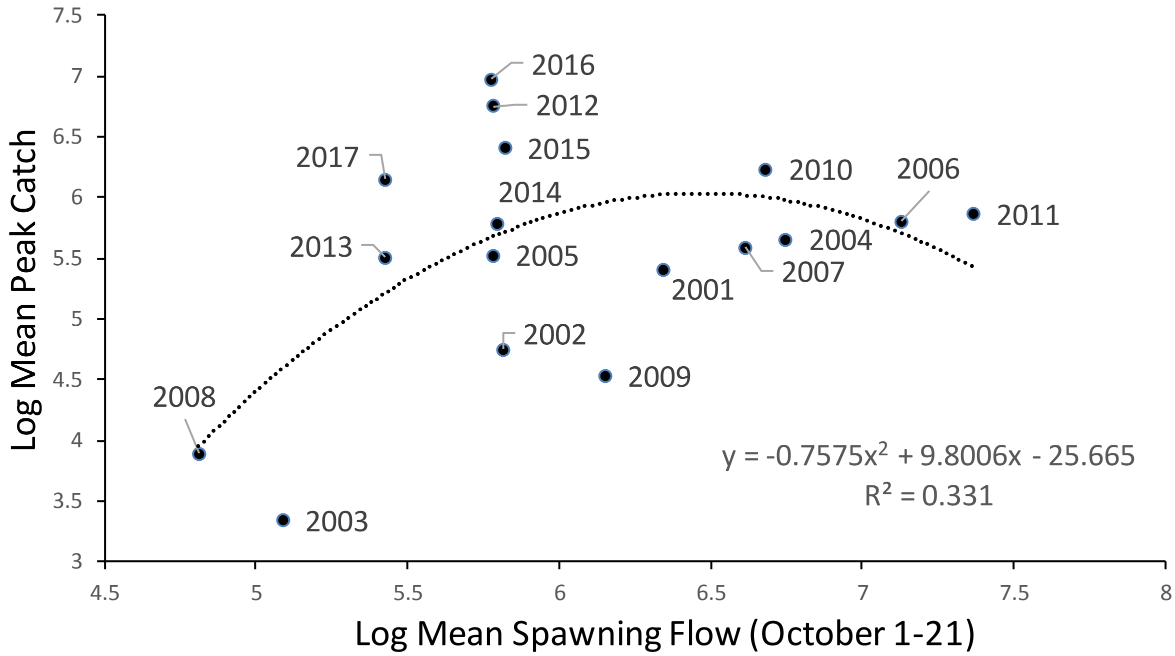


Figure 4. Numbers of YOY Chinook caught by week and site from the USGS/NYSDEC seining program 2017.



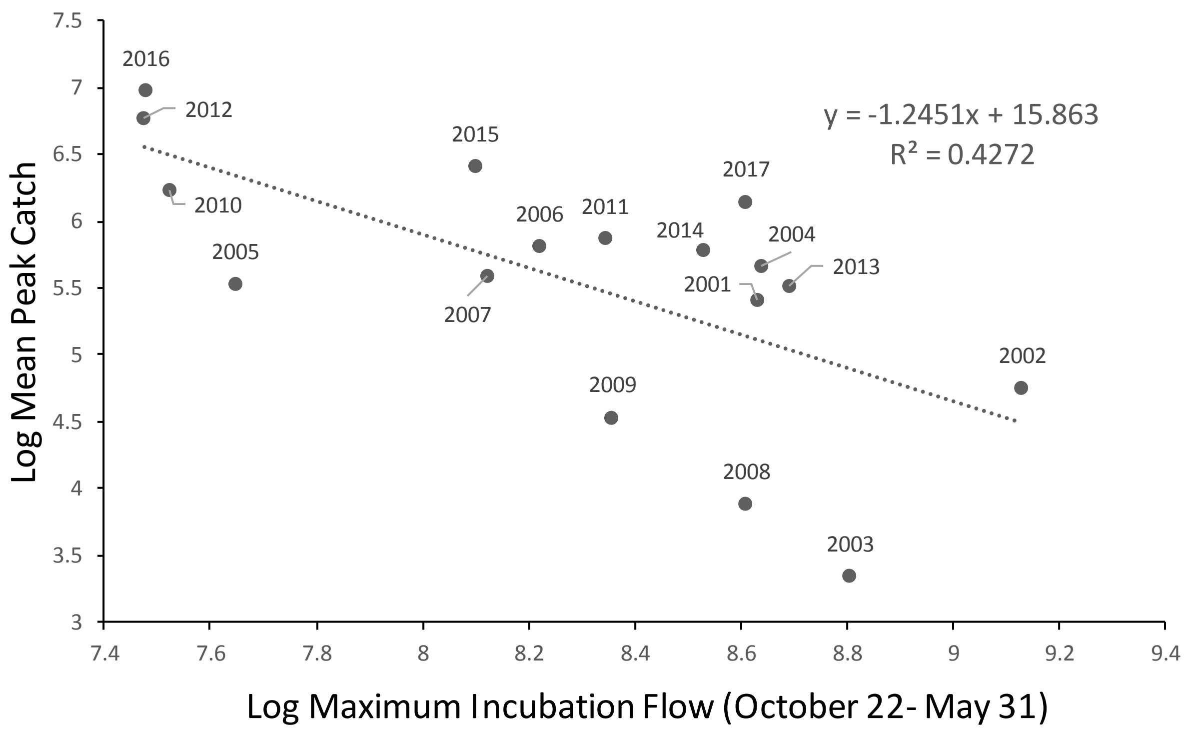


Figure 5. Mean spawning flows from fall of the previous year (top graph) and maximum incubation flows (bottom graph) predicting mean peak catches of YOY Chinook salmon from the USGS/NYSDEC seining program 2001-2017. Combining both flow factors in a single regression model yields ($r^2 = 0.57$ $p = 0.01$).

Population Characteristics of Pacific Salmonines Collected at the Salmon River Hatchery 2017

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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 1,967 steelhead during spring 2017 spawning operations (Nelson 2017a). Adult Washington strain (Chamber's Creek) winter run fish comprised 94% (1,850) of the returns. Marked Skamania strain summer run fish (left pelvic fin-clip) accounted for the remaining 6% (117).

A total of 2.2 million Washington strain steelhead eggs were taken from 611 females. The Skamania egg total was 149,000 from 39 females. Biological data were collected from 272 Washington strain steelhead.

Returns of Pacific salmon in the fall included 3,759 Chinook salmon (1,010 females) and 2,658 coho salmon. Biological data were collected at the hatchery from 729 Chinook salmon and 348 coho salmon. The egg totals were 4.3 million Chinook salmon from 966 females and 1.6 million coho salmon from 593 females (Nelson 2017b).

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 2017 was 5.3 pounds, the 12th highest value in the 1988-2017-time series (Figure 1) and weighing significantly more than 10 of the 31 years compared. Age 2 males were 12.8 pounds, 0.5 pounds below the long-term average with nine years being significantly heavier. Age 2 females were 13.2 pounds, 1.4 pounds below the long-term average, with only one year being significantly lighter (2007) (Figure 2). Age 3 males were 15.8 pounds, over 3.0 pounds below average, and significantly lighter than weights observed in 21 of 31 years compared. Age 3 females were 15.9 pounds, 3.0 pounds below the long-term average, and lower than every year except 2007, but not significantly from six of the 31 years (Figure 2). Mean lengths and weights at age for all species sampled in 2017 are provided in Table 1.

Wet weight condition of large Chinook salmon 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 15.9 pounds in 2017, 0.7 pounds below the long-term average, and only 2005 and 2007 had a lower predicted weight (14.9 and 14.6 pounds, respectively). This is the first year of below average condition following nine consecutive years of at or near average condition (Figure 3).

The relatively low weights of Chinook salmon sampled in 2014-2017 may have been influenced by the unusually cold winters of 2013/2014 and 2014/2015 followed by relatively cooler water temperatures during the summers of 2014 and 2015, which likely contributed to reduced growth rates.

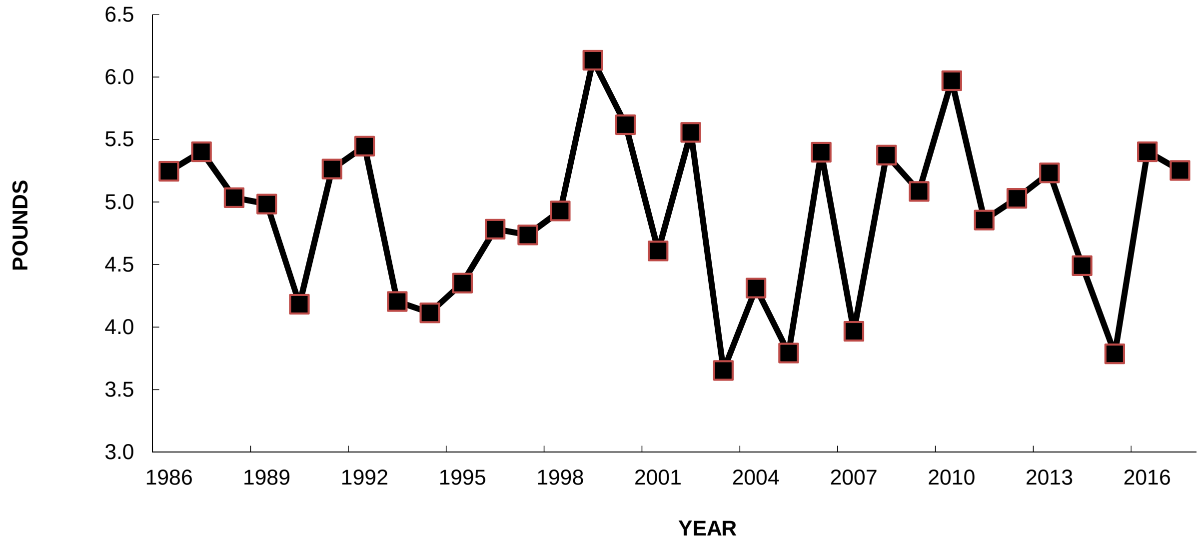

Figure 1. Mean weights of Chinook salmon jacks at Salmon River Hatchery, 1986-2017.

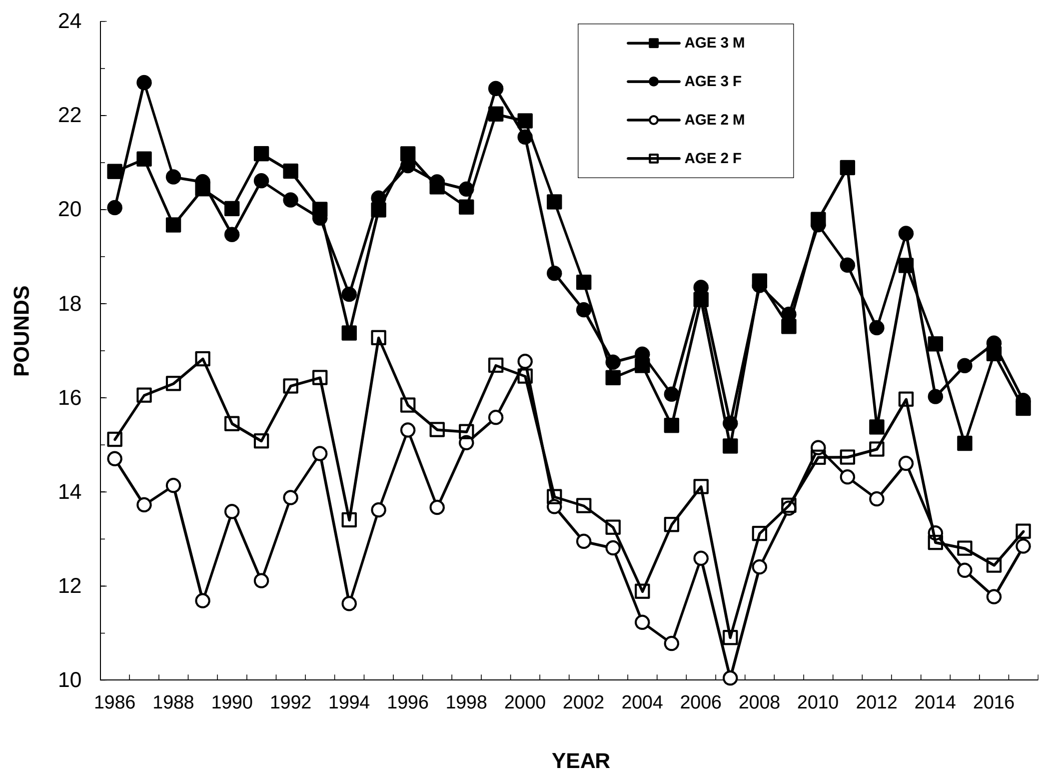

Figure 2. Mean weights of age 2 and 3 Chinook salmon at Salmon River Hatchery, 1986-2017.

Table 1. Mean lengths and weights of Chinook salmon, coho salmon and Washington steelhead sampled at Salmon River Hatchery 2017 (STD= standard deviation).

AGE	SEX	N	MEAN LENGTH (in)	STD	MEAN WEIGHT (lbs)	STD
			CHINOOK SALMON			
1	M	33	24.9	1.5	5.3	1.0
2	M	289	33.7	2.0	12.8	2.7
2	F	157	33.0	1.8	13.2	2.5
3	M	83	36.2	2.7	15.8	3.4
3	F	157	35.3	2.2	15.9	2.8
			COHO SALMON			
1	M	55	15.8	2.4	1.8	2.2
2	M	181	28.1	2.2	6.9	1.9
2	F	118	28.0	1.5	7.7	1.4
			WASHINGTON STEELHEAD			
3	M	108	25.3	2.8	5.6	1.9
3	F	63	26.7	2.6	7.0	2.0
4	M	29	26.5	3.1	6.4	2.5
4	F	48	28.6	1.8	8.4	1.7
5	M	2	27.4	1.3	6.8	0.8
5	F	7	28.5	2.2	8.2	1.9

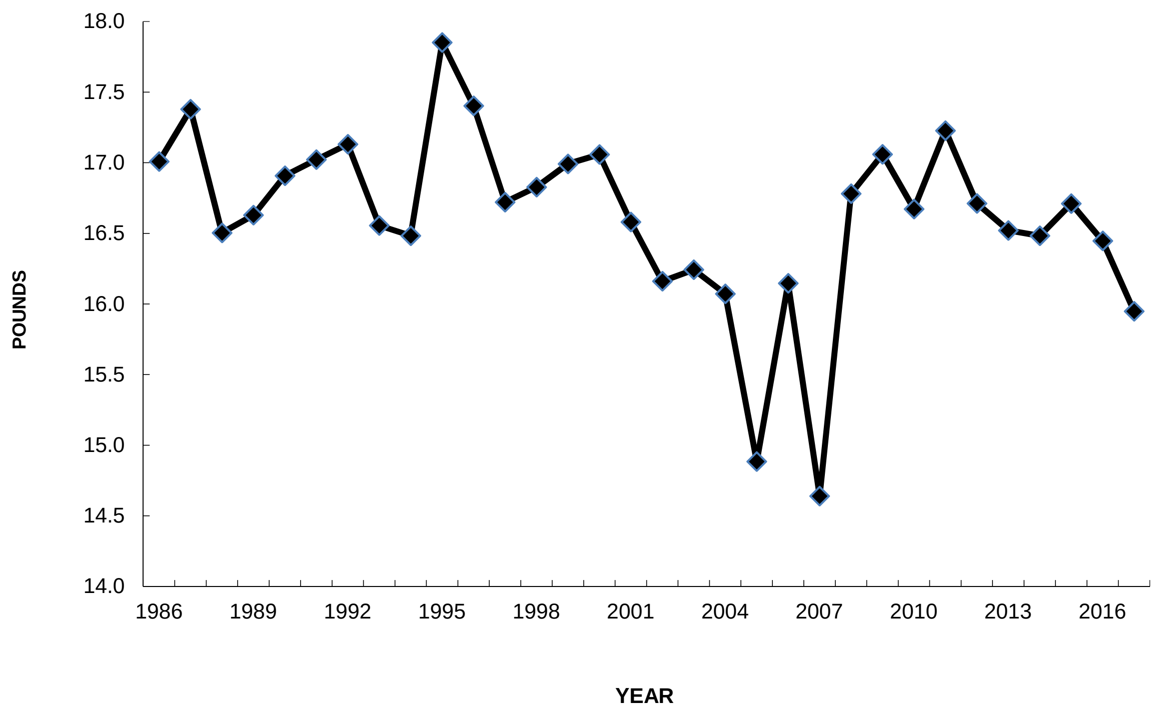

Figure 3. Estimated weights of a 36-inch Chinook salmon from the Salmon River Hatchery fall (October) collections 1986-2017.

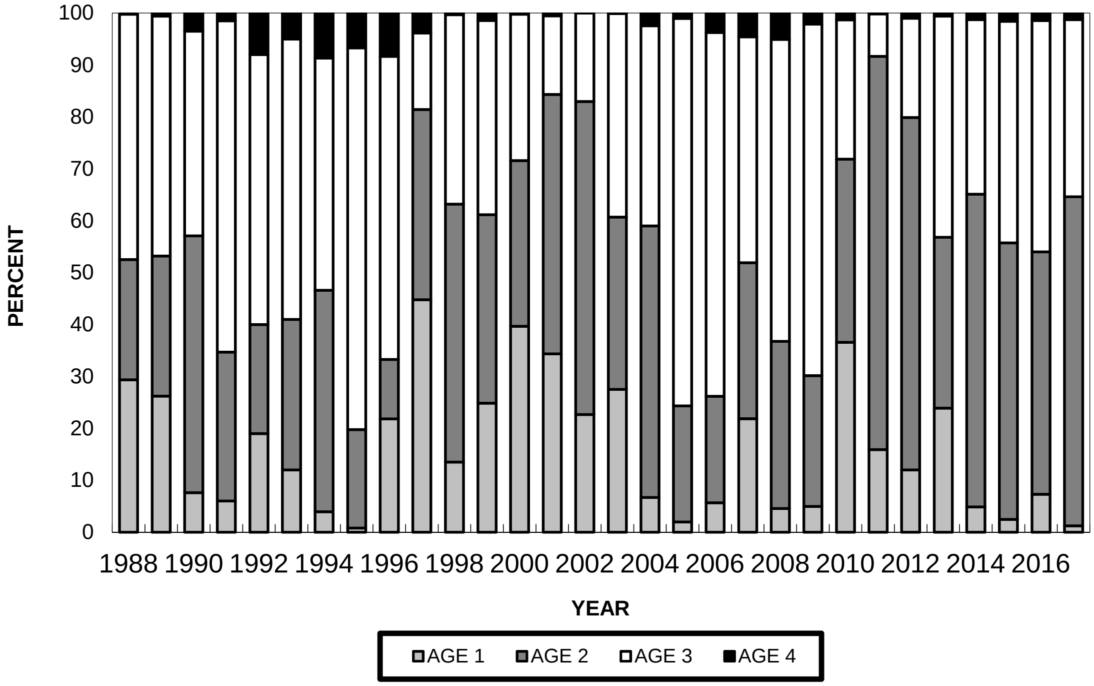

Figure 4. Estimated age structures of Chinook salmon runs at Salmon River Hatchery 1989-2017.

Prey abundance and/or distribution can also influence predator growth. Yearling alewife abundance was very low in 2014 and at record-low levels in 2015 (Weidel *et al.* 2017). Those two weak year-classes may decrease the density of adult alewife as the older year classes naturally decline.

Age Structure

The estimated age structure of the 2017 Chinook salmon run to the Salmon River Hatchery was 1.2% age-1, 63% age-2, 34% age-3, and 1.3% age-4 (Figure 4). Changes in the dominant age represented in the run are likely influenced strongly by relative Chinook salmon year class strength.

Coho Salmon

Growth

The average weight of age-2 female coho salmon in 2017 was 7.7 pounds, approximately 0.6 pounds less than the long-term average (8.3 pounds, Figure 5). Age-2 males weighed 6.9 pounds, 1.2 pounds less than the long-term average (8.1 lbs., Figure 5). The males were significantly heavier than 2015, but significantly less than fourteen other years in the time series. Female coho were only significantly heavier than the record low observed in 2015, and significantly lighter than fish sampled in seven of 31 years.

Washington Steelhead

Growth

Steelhead are sampled in the spring and, unlike Chinook and coho salmon, do not reflect growth during the 2017 growing season. Weights reported here reflect conditions prior to and including 2016. The mean weights of age-3 males and females were 5.6 and 7.0 pounds, respectively. The males were 0.2 pound lighter and females 0.6 pounds heavier than their respective long-term averages (Figure 6). The mean weights of age-4 males and females were 6.4 and 8.4 pounds, respectively, with males 2.3 and females 0.7 pounds lighter than their long-term averages (Figure 6). Only age-3 females in 2001 (8.7 lbs.) were significantly heavier than those in 2017. Age 3 males fell in the middle of observed weights, and weighed significantly less than only seven of those observations.

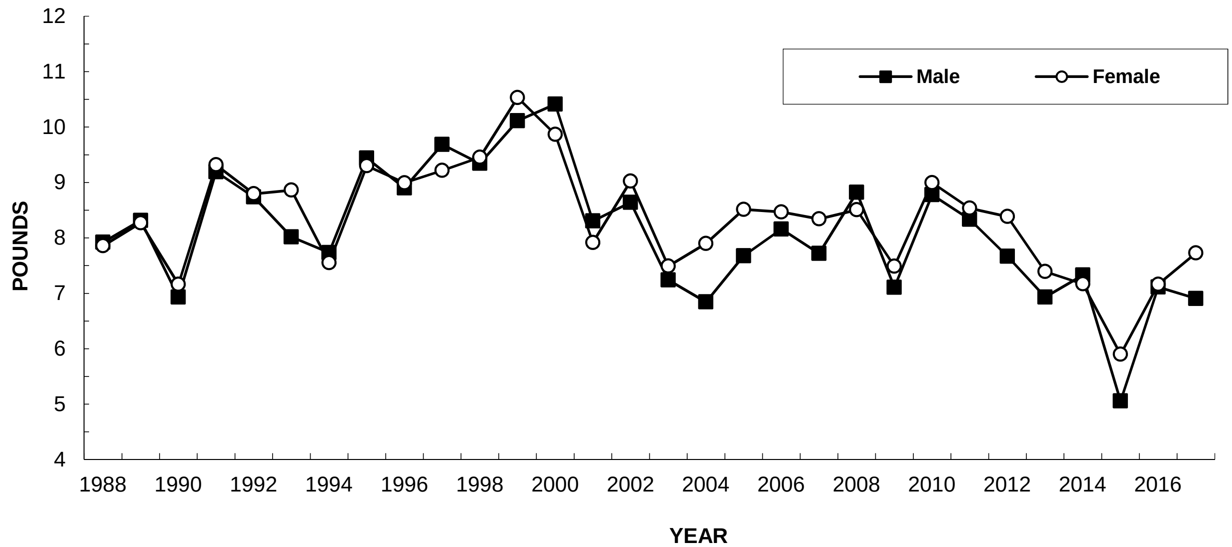

Figure 5. Mean weights of age-2 coho salmon at Salmon River Hatchery, 1988-2017.

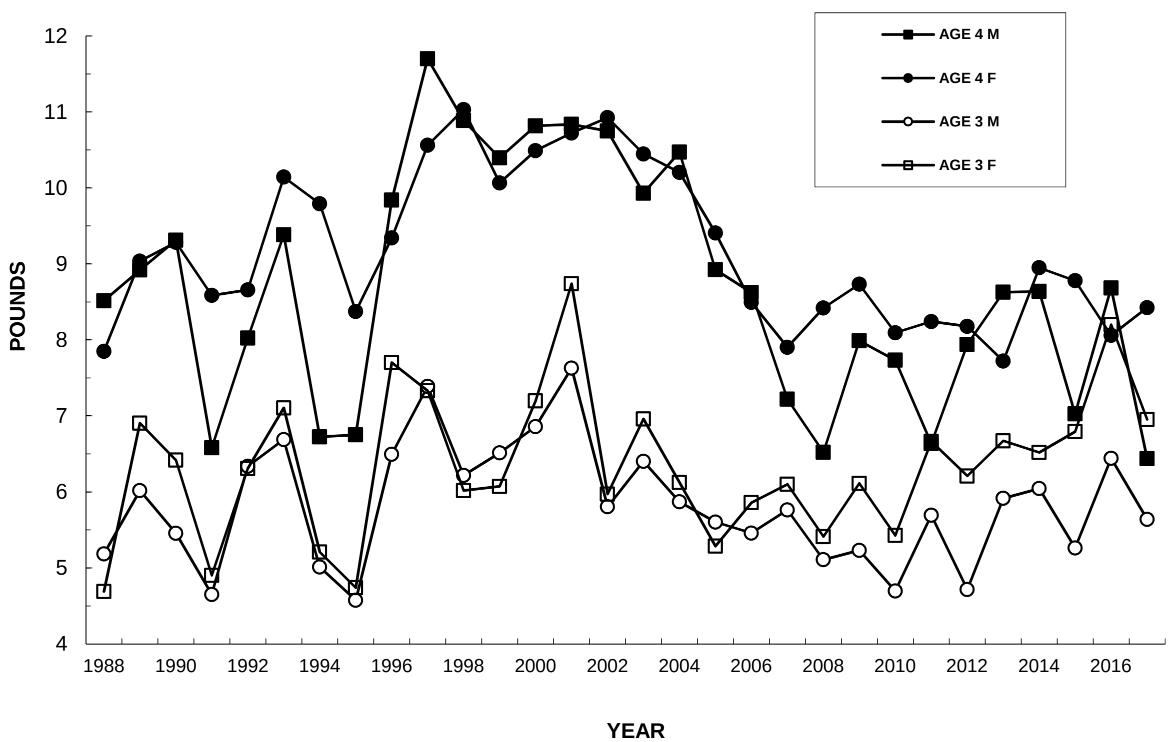

Figure 6. Mean weights of ages 3-4 Washington steelhead at Salmon River Hatchery, 1988-2017.

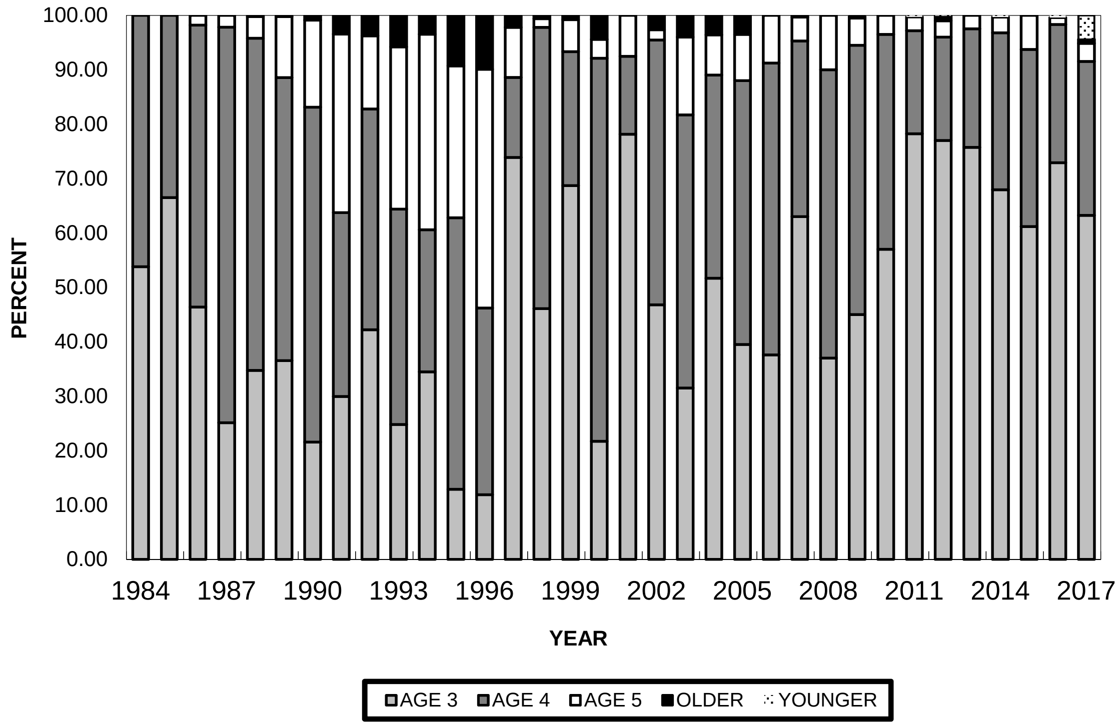

Figure 7. Age structures of Washington steelhead sampled at Salmon River Hatchery, 1984-2017.

Age 4 males weighed the least in the time series that dates to 1997 (6.4 pounds), but only weighed significantly less than 13 years. Age 4 female average weight was near the lower end of observed weights, but was not significantly different than 20 of the 29 years.

Age Structure

Similar to age structures observed in recent years, age-3 and age-4 steelhead dominated the run again in 2017 (Figure 7). As in the previous six years, age-3 fish comprised a noticeably higher proportion of the run. The age structure of the fish sampled was 63% age-3, 28% age-4, 3.3% age-5.

References

Nelson, R.M. 2017a. Spring 2017, Steelhead egg collection: spawning through eye-up. NYSDEC Salmon River Hatchery Altmar, NY.

Nelson, R.M. 2017b. Fall 2017, Pacific salmon egg collection: spawning through eye-up. NYSDEC Salmon River Hatchery, Altmar, NY.

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

Weidel, B.C., M.G. Walsh, M. J. Connerton, and J.P. Holden. 2017. Trawl-based assessment of Lake Ontario pelagic prey fishes including Alewife and Rainbow Smelt. Section 12a *in* 2016 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee.

2017 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 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. In 2006, a steelhead rearing project was initiated at Wilson Harbor on East Branch Twelvemile Creek, and Chinook salmon were added there in 2017. In 2009, a new pen site was added at Little Sodus Bay where both steelhead and Chinook salmon were reared. In 2010, Chinook salmon rearing resumed at the Sandy Creek pen project site for the first time since 2002. Brockport Yacht Club hosted the Sandy Creek Pen Project for the first time in 2017. 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 the Little Salmon River pen site in 2014, and Washington strain from 2015 to 2017.

This report summarizes pen-rearing activities and results for 2017, the twentieth year of pen projects along the New York shoreline of Lake Ontario.

Methods

Pen rearing was conducted at seven sites along the New York coastline of Lake Ontario in 2017. 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 2017 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.

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.

Chinook salmon stocked at all eight pen rearing sites in 2010, 2011 and 2013 (except Sandy Creek in 2013), were part of a multi-year mass marking study to assess the relative performance of pen-reared and direct-stocked salmon in open Lake Ontario and tributary sportfisheries (Connerton et al. 2017).

Results and Discussion

A total of 21,600 Washington strain steelhead were raised at four pen sites, comprising 4.2% of NYSDEC's Lake Ontario Washington strain steelhead stocking allotment in 2017 (Table 3). Observed mortalities were negligible at all steelhead pen sites, ranging from 0 to 0.09%. Results for all steelhead pen projects are summarized in Table 3.

Six pen-rearing sites raised a total of 303,420 Chinook salmon fingerlings, representing 22.5% of NYSDEC's 2017 Chinook salmon stocking allotment. Observed mortalities were relatively low ranging from 0 to 0.1%. Results for all Chinook salmon pen projects are provided in Table 3.

The Little Salmon River, Oswego, Little Sodus Bay, Sodus Bay, Sandy Creek, Olcott Harbor and Wilson Harbor pen projects are now using automated feeders on all their pens and they have worked well. The growth rates achieved using automatic feeders are comparable to hand feeding. However, only one person is needed to load the feed hopper and wind the spring in the morning and the feed is slowly dispensed over a 12-hour period, which has greatly reduced the amount of volunteer time required to feed the fish.

<u>Little Salmon River</u>
Washington strain steelhead were placed in a pen on 18 April at 32 fish per lb. The steelhead were released 21 days later on 9 May at a weight of 13 fish per lb. The pen was towed to river mouth for fish release. No mortality was reported.

<u>Oswego Harbor</u>
Chinook salmon were delivered to the pen site on 18 April, weighing 118 fish per lb. They were released after 20 days on 8 May at a weight of 60.6 per lb. Forty-two mortalities were reported.

<u>Little Sodus Bay</u>
Steelhead weighing 36 fish per lb. were delivered to the pen site on 14 April. Steelhead were released after 25 days on 9 May, weighing 13 fish per lb. Only 1 mortality was reported.

Chinook salmon were also delivered to the pen site on 14 April. Salmon weighed 115 fish per lb. when delivered, were held for 25 days, and released at a weight of 51 fish per lb. on 9 May. Fish were released at pen site. Ten mortalities were reported.

<u>Sodus Bay</u>
Chinook salmon were placed into pens on 25 April at 115 fish per lb, and held for 21 days. Fish were released on 15 May at 58 fish per lb. and were 3.6 inches long on average. Water temperature at the pen site was 56^{o}F at release. Ten mortalities were reported .

<u>Genesee River</u>
On scheduled Chinook salmon and steelhead delivery day of 27 April, air temperatures were in the 80's and forecasted to remain warm for several days. Due to high water levels and elevated water temperatures (62^{o}F) on delivery day, project coordinators chose not to pen-rear the fish. Instead, all Chinook salmon and steelhead were direct stocked into the Genesee River at Shumway Marina at 115 and 42 fish per lb., respectively.

<u>Sandy Creek</u>
Pen project coordinators elected not to pen rear steelhead in 2017, instead choosing to raise additional Chinook salmon. Chinook salmon were placed into pens on 21 April at 113 fish per lb. Pen site water temperature rose to 62 ^{o}F on 27 April and warm weather was expected to continue. Pen project coordinators elected to release the Chinook salmon on 27 April. Final weight was not obtained

due to emergency release.

Oak Orchard Creek
Prior to the 2017 pen rearing season, the Oak Orchard pen group decided to discontinue pen rearing of steelhead. On scheduled Chinook salmon delivery day of 24 April, air temperatures were in the 80's and forecasted to remain warm for several days. Due to high water levels and elevated water temperatures (62°F) on delivery day, project coordinators chose not to pen-rear the fish. Instead, all Chinook salmon were direct stocked at Lake Breeze Marina at 115 fish per lb.

Olcott Harbor
Steelhead were delivered at a weight of 24.3 fish per lb. on 17 April. They were held for 15 days and released on 2 May, weighing 20.3 fish per lb. The steelhead pen was towed to harbor outlet for release. No mortalities were reported.

Chinook salmon were delivered at a weight of 120 per lb. on 17 April. They were held for 16 days and released on 3 May, weighing 70.4 fish per lb. Chinook salmon were released at the pen site at dusk. Fourteen mortalities were reported.

Wilson Harbor
Steelhead were delivered at a weight of 31.3 fish per lb. on 19 April. They were held for 21 days and released on 10 May, weighing 20.5 fish per lb. Seven mortalities were reported.

Chinook salmon were pen-reared at Wilson Harbor for the first time in 2017. Chinook salmon were delivered at a weight of 113 fish per lb. on 19 April. They were held for 19 days and released on 8 May, weighing 61 fish per lb. Ten mortalities were reported.

Lower Niagara River
Due to exceptionally high water levels in the lower Niagara River in spring of 2017, pen project coordinators were unable to install the fixed pens at the site. Therefore, all Chinook salmon and steelhead were direct stocked into the river on 3 May.

Conclusions

Of the four locations where steelhead were penned, target weights (12-15 fish per lb.) were reached at two sites in 2017. Results at other sites were below target, at about 20 fish per lb.

Chinook target weights (90 fish per lb.) were exceeded at all pen sites where final weights were taken. Final weight was not obtained at the Sandy Creek site due to emergency release. 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 twentieth year of pen-rearing steelhead and Chinook salmon along the New York shoreline of Lake Ontario was successful due to low fish mortality, all measured Chinook salmon and half of the steelhead reaching or exceeding 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.

References

Bishop, D. L. and W. E. Pearsall. 1999. 1998 New York Cooperative Pen Rearing Projects. Section 12 *In* 1998 NYSDEC Annual Report Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Connerton, M.J., C.J. Balk, S.E. Prindle, J.R. Lantry, J.N. Bowlby, M. Yuille, C. Bronte and M.E. Holey. 2017. Relative Survival and Tributary Returns of Pen and Direct-stocked Chinook Salmon in Lake Ontario. . Section 3. *In* 2016 NYSDEC Lake Ontario Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Unit.

Sanderson, M. J. 2006. Revised Lake Ontario Chinook Salmon Cooperator Pen-Rearing Guidelines. NYSDEC. Avon, New York.

Wilkinson, M. A. 1999. Lake Ontario Chinook

Salmon Cooperator Pen-Rearing Guidelines. NYSDEC. Buffalo, New York.

Wilkinson, M. A., M. J. Sanderson and D. L. Bishop. 2005. 2004 New York Cooperative Trout and Salmon Pen-Rearing Projects. Section 18 *In* 2004 NYSDEC Annual Report Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Table 1. Description of 2017 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 and Independence Marina	Oswego Harbor Charter Captains Oswego Marina City of Oswego
Little Sodus Bay	Turtle Cove Resort and Marina	Fair Haven Charter Captains Turtle Cove Marina Phil Lucason
Sodus Bay	Arney's Marina	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	Brockport Yacht Club	Brockport Yacht Club Boy Scouts Genesee Charter Association Sandy Creek Shoot - Out Fishing Tournament S.U.N.Y. at Brockport
Oak Orchard Creek	Lake Breeze Marina	Lake Breeze Marina Oak Orchard Pen-Rearing Association Orleans County Department of Tourism
Olcott Harbor	Town of Newfane Marina	Lake Ontario Trout and Salmon Association Slippery Sinker Bait and Tackle Town of Newfane (including Town Marina)
Wilson Harbor	Bootlegger's Cove Marina	Town of Wilson Wilson Boat House Restaurant Bootlegger's Cove Marina
Lower Niagara River	Constitution Park, Youngstown	Niagara River Anglers Association Village of Youngstown Fox Fence Company

Table 2. Methods used at 2017 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	Automated	1	1 time	Pen towed to river mouth for fish release.
Oswego Harbor	Hydraulic transfer	Automated	1	1 time	Fish released at pen site.
Little Sodus Bay	Hydraulic transfer	Automated	1	2 times	Fish released at pen site.
Sodus Bay	Hydraulic transfer	Automated	1	Weekly	Pens towed to lake for fish release, pens inverted.
Genesee River	--	--	--	--	--
Sandy Creek	Hydraulic transfer	Automated	5	Weekly	Fish released at pen site.
Oak Orchard Creek	--	--	--	--	--
Olcott Harbor	Hydraulic transfer	Automated	5	2 times	Chinook salmon released at pen site. Steelhead towed to harbor mouth.
Lower Niagara River	--	--	--	--	--
Wilson	Hydraulic transfer	Automated	3	2/week	Fish released at pen site

Table 3. Results of 2017 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	0	0	--	--	--	--	--	--
Little Sodus	Chinook	47,500	2	14 Apr	115	9 May (25)	51	10	0.02
Lower Niagara	Chinook	0	0	--	--	--	--	--	--
Oak Orchard	Chinook	0	0	--	--	--	--	--	--
Olcott	Chinook	67,100	3	17 Apr	120	3 May (16)	70.4	14	0.02
Oswego	Chinook	64,390	5	18 Apr	118	8 May (20)	60.6	42	0.07
Sandy Creek	Chinook	64,430	3	21 Apr	113	27 Apr (6)	N/A	0	0.0
Sodus	Chinook	50,000	2	25 Apr	115	15 May (20)	58	10	0.02
Wilson	Chinook	10,000	1	19 Apr	113	8 May (19)	61	10	0.1
Genesee	steelhead	0	0	--	--	--	--	--	--
Little Salmon	steelhead	4,600	1	18 Apr	32	9 May (21)	13	0	0.0
Little Sodus	steelhead	6,000	1	14 Apr	36	9 May (25)	13	1	0.02
Lower Niagara	steelhead	0	0	--	--	--	--	--	--
Olcott	steelhead	3,500	1	17 Apr	24.3	2 May (15)	20.3	0	0.0
Wilson	steelhead	7,500	2	19 Apr	31.3	10 May (21)	20.5	7	0.09

N/A not available

SEA LAMPREY CONTROL IN LAKE ONTARIO 2017

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INTRODUCTION

This report summarizes Sea Lamprey (*Petromyzon marinus*) control activities conducted by Fisheries and Oceans Canada (Department) and the United States Fish and Wildlife Service (Service) as agents of the Great Lakes Fishery Commission (Commission) in Lake Ontario during 2017. 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 subsist on the blood and body fluids of large-bodied fish. It is estimated that about half of Sea Lamprey attacks result in the death of their prey and up to 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 annual performance of the SLCP is evaluated by contrasting lake-specific adult Sea Lamprey index estimates and Lake Trout marking rates with prescribed targets. Adult Sea Lamprey abundance indices are estimated by the Service and Department by summing mark-recapture estimates from a sub-set of streams that were selected based on a consistent trapping history and large Sea Lamprey spawning runs. The index approach was first used during 2015, replacing regression model estimates of lake-wide abundance that were derived from multiple variables. Lake Trout marking rates are assessed and collected by member agencies that comprise the lake committees and their technical committees.

The adult index target for Lake Ontario of 11,368 Sea Lampreys was calculated from the average abundance estimated for the 5-year period, 1993-1997, when marking rates were closest to 2 marks per 100 Lake Trout >431 mm (1.6 A1 marks per fish >431 mm).

Table 1. Details on the application of lampricides to tributaries of Lake Ontario during 2017 (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								
Bowmanville Cr. (A)	May-27	4.1	32.1	1602.5	1.5	---	---	0.4
Grafton Cr. (B)	Jun-06	0.5	0.3	170.5	---	---	---	---
Colborne Cr. (C)	Jun-05	1.3	0.9	237.5	---	---	---	---
Total (Canada)		**5.9**	**33.3**	**2010.5**	**1.5**	**0.0**	**0.0**	**0.4**
United States								
South Sandy Cr. (D)	Jun-01	6.2	14.8	449.2	---	---	5.1	0.1
Lindsey Cr. (E)	Apr-24	1.3	26.1	221.6	0.9	---	---	0.2
Salmon R. (F)	Apr-21	27.7	56.6	1976.7	6.0	---	---	0.2
Little Salmon R. (G)	Apr-30	9.1	41.6	591.6	1.5	---	---	0.2
Nine Mile Cr. (H)	May-29	1.2	25.4	182.4	2.0	---	---	0.2
Total (United States)		**45.4**	**164.5**	**3421.5**	**10.4**	**---**	**5.1**	**0.8**
Total for Lake		**51.3**	**197.8**	**5432.0**	**11.9**	**0.0**	**5.1**	**1.2**

During 2017, the index of adult abundance in Lake Ontario was estimated to be 12,536 (95% CI; 9,828 – 15,244), which is greater than the index target.
The target for Lake Ontario Sea Lamprey abundance was first calculated using the same marking statistics as the other lakes (A1-A3 marks). During 2017, 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 number of A1 marks on Lake Trout from standardized fall assessments in 2017 has not yet been analyzed.

LAMPRICIDE CONTROL

Tributaries harboring Sea Lamprey larvae are treated periodically with lampricides to eliminate or reduce larval populations before they recruit to the lake as feeding juveniles. During stream treatments, Service and Department control units administer and analyze several lampricide formulations including TFM or TFM mixed with Bayluscide (70% wettable powder or 20% emulsifiable concentrate). Specialized equipment and techniques are employed to maintain lampricide concentrations at levels that eliminate approximately 95% of resident Sea Lamprey larvae while minimizing risk to non-target organisms. To control larval populations that inhabit lentic areas and interconnecting waterways, field crews apply a bottom-release formulation of lampricide, Bayluscide 3.2% granular (gB), which is 75% effective on average.

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 (18 Canada, 18 U.S.) have been treated with lampricides at least once during 2008-2017. Twenty-eight tributaries (14 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 2017 are found in Table 1 and Figure 1.

- Lampricide applications were conducted in 8 streams (3 Canada, 5 U.S.).
- Bowmanville Creek was treated above the Goodyear Dam for the first time. Fish community assessment and benthic surveys were completed pre- and post-treatment. Non-target mortality was negligible.
- High lake levels caused issues with treatment effectiveness on all 8 tributaries treated in 2017.

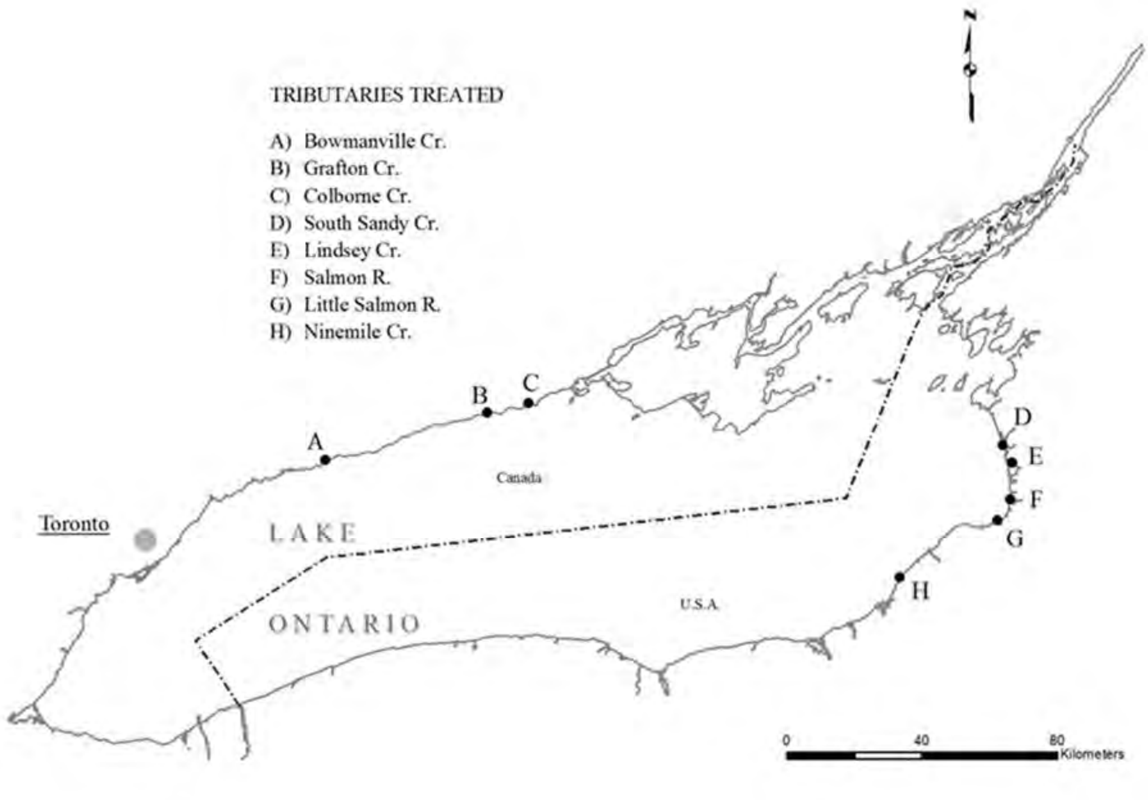

Figure 1. Location of Lake Ontario tributaries treated with lampricides (corresponding letters in Table 1) during 2017.

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 2017, 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), and new trap designs.

Barriers

The Sea Lamprey Barrier Program priorities are to:

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

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

Data gathered during field visits to assess the status of other dams and structures were recorded in the SLCP's Barrier Inventory and Project Selection System (BIPSS) and may be used to: 1) select barrier projects; 2) monitor inspection frequency; 3) schedule upstream larval assessments; 4) assess the effects of barrier removal or modifications on Sea Lamprey populations, or; 5) identify structures that are important in controlling Sea Lampreys.

Barrier Inventory and Project Selection System (BIPSS)

- Field crews visited one structure on a tributary to Lake Ontario to assess Sea Lamprey blocking potential and to improve the information in the BIPSS database.

Operation and Maintenance

- Routine maintenance, spring start-up, and safety inspections were performed on 12 barriers (9 Canada, 3 U.S.).

- Fish community assessments were conducted on Cobourg, Colborne, Grafton, Graham, Port Britain, Shelter Valley, and Wesleyville creeks to evaluate any changes that may be associated with the existence of purpose-built Sea Lamprey Barriers.

Ensure Blockage to Sea Lamprey Migration

- Bowmanville Creek – A new fishway at the Goodyear Dam was constructed in 2014. Since then, there has been upstream escapement of adult Sea Lampreys in successive years, leading to the establishment of a larval populationp Potential Sea Lamprey escapement routes and remediation options are being investigated including an old fishway/water intake on one side of the dam.

- Consultations to ensure blockage were conducted with partner agencies for one site during 2017 (Table 2).

New Construction

- Rouge River –Plans to conduct a Sea Lamprey barrier feasibility study are on hold, pending transfer of land from Toronto Regional Conservation Authority to Parks Canada, as part of the initiative to establish an Urban National Park on the Rouge River.

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

Mainstream	Tributary	Lead Agency	Project	SLCP Position	Comments
Oswego R.	Breakneck Cr.	TU[1]	Bishop Corners Rd. culvert	Concur	Limited upstream potential

[1]Trout Unlimited

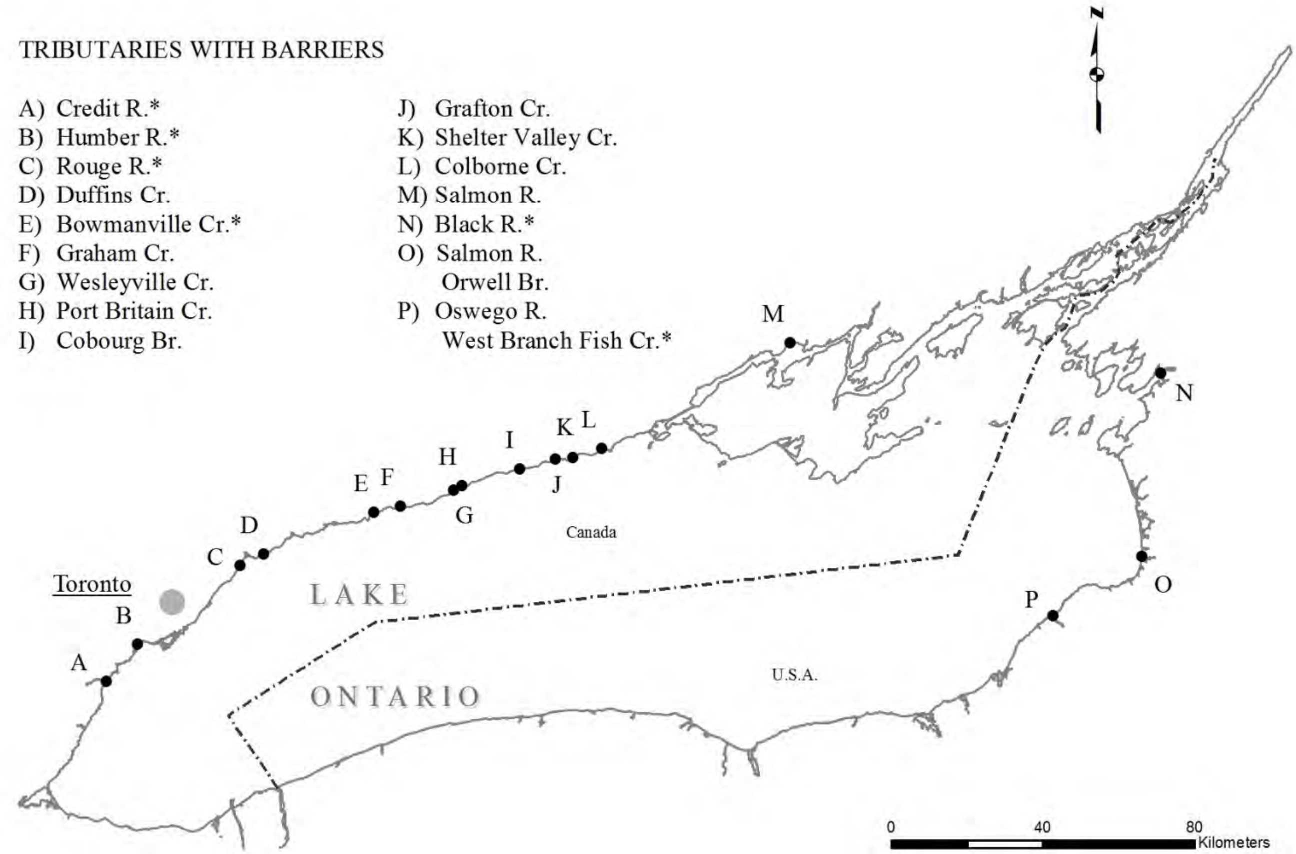

Figure 2. Location of Lake Ontario tributaries with Sea Lamprey barriers. Structures that were not constructed by the Commission, but have been modified to prevent the upstream migration of Sea Lampreys are indicated by an asterisk (*).

ASSESSMENT

The SLCP has three assessment components:

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 Lampreys. These time series data are used in conjunction with adult assessment data to assess the effectiveness of the SLCP for each lake. In addition, several indices of relative abundance of feeding juveniles are used in some lakes to monitor Sea Lamprey populations over time.

3. Adult assessment annually estimates an index of adult Sea Lamprey abundance in each lake. Because this life stage is comprised of individuals that have either survived or avoided exposure to lampricides, the time series of adult abundance indices is the primary metric used to evaluate the effectiveness of the SLCP.

Larval Assessment

Tributaries considered for lampricide treatment during 2018 were assessed during 2017 to define the distribution and estimate the abundance and size structure of larval Sea Lamprey populations. Assessments were conducted with backpack electrofishers in waters <0.8 m deep, while waters ≥0.8 m in depth were surveyed with gB or by deep-water electrofishing (DWEF). Additional surveys are used to define the distribution of Sea Lampreys within a stream, detect new populations, evaluate lampricide treatments, evaluate barrier effectiveness, and to establish the sites for lampricide application.

- Larval assessments were conducted on 62 tributaries (35 Canada, 27 U.S.). The status of larval Sea Lampreys in historically infested Lake Ontario tributaries and lentic areas is presented in Tables 3 and 4.

- Surveys to estimate abundance of larval Sea Lampreys were conducted in 10 tributaries (3 Canada, 7 U.S.).

- Surveys to detect the presence of new larval Sea Lamprey populations were conducted in 16 tributaries (13 Canada, 3 U.S.). No new populations were detected.

- Post-treatment assessments were conducted in 9 tributaries (4 Canada, 5 U.S.) to determine the effectiveness of lampricide treatments conducted during 2016 and 2017. Surveys on New York's Salmon River and Lindsey Creek found many residuals, resulting in the scheduling of both systems for treatment during 2018.

- Surveys to evaluate barrier effectiveness were conducted in 10 tributaries (7 Canada, 3 U.S.). All barriers assessed continue to be effective in blocking Sea Lampreys.

- Larval assessment surveys were conducted in non-wadable lentic and lotic areas using 20.24 kg active ingredient of gB (10.42 Canada; 9.82 U.S; Table 5).

- Surveys performed on Lake Ontario's Credit River in 2017 indicate larval Sea Lamprey growth that may justify a 2- year treatment cycle. The Credit River has ranked again for treatment in 2018.

Juvenile Assessment

The juvenile life stage is assessed through the interpretation of marking rates by juvenile Sea Lampreys on Lake Trout >431 mm. 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. The Commission contracts the Service's Green Bay Fish and Wildlife Conservation Office (GBFWCO) to calculate marking statistics and Lake Trout abundance estimates to better understand the damage caused by Sea Lampreys.

- Lake Trout marking data for Lake Ontario are provided by the U.S. Geological Survey, OMNRF, and the New York State Department of Environmental Conservation. The data is analyzed by the Service's GBFWCO.

- The number of A1 marks per 100 Lake Trout >431 mm from standardized fall assessments during 2017 were submitted in February 2018 and have yet to be analyzed.

- Based on standardized fall assessment data, the marking rate during 2016 (plotted as the 2017 sea lamprey spawning year) was 1.4 A1 marks per 100 Lake Trout >431 mm which is less than the target of 2 A1 marks per 100 Lake Trout (Figure 3).

Adult Assessment

An annual index of adult Sea Lamprey abundance is derived by summing individual population estimates from traps operated in a specific suite of streams (index streams) during spring and early summer. A mark-recapture estimate is attempted in each index stream, however, in the absence of an estimate due to an insufficient number of marked or recaptured Sea Lampreys, abundance is estimated using the annual pattern of adult abundance observed in all streams and years, and adjusted to the stream-specific average abundance estimate in the time series. The index targets are estimated as the mean of indices during a period within each lake when marking rate was considered acceptable, or the percentage of the mean that would be deemed acceptable.

- A total of 5,006 Sea Lampreys were trapped in 8 tributaries, 5 of which are index locations. Adult population estimates based on mark-recapture were obtained from each index location (Table 6, Figure 4).

- The index of adult Sea Lamprey abundance was 12,536 (95% CI; 9,828 – 15,244), which is higher than the target of 11,368 (Figures 5-6).

Table 3. Status of larval Sea Lampreys in Lake Ontario tributaries with a history of Sea Lamprey production and estimates of abundance from tributaries surveyed during 2017 using a quantitative method.

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-17	---	No	---	---	Unknown
Ancaster Cr.	May-03	Jun-17	---	No	---	---	Unknown
Grindstone Cr.	Never	Jun-16	---	No	---	---	Unknown
Bronte Cr.	Apr-16	Jun-16	No	---	---	---	2019[1]
Sixteen Mile Cr.	Jun-82	Aug-16	---	No	---	---	Unknown
Credit R.	Jun-16	Sept-17	No	Yes	262,957	124,982	***2018***
Humber R.	Never	Jun-17	---	No	---	---	Unknown
Rouge R.	Jun-11	Jul-17	---	No	---	---	Unknown
Little Rouge. R.	Jun-15	Jul-17	No	No	---	---	Unknown
Petticoat Cr.	Sep-04	Jun-16	---	Yes	---	---	Unknown
Duffins Cr.	Jun-15	Jul-17	No	Yes	---	---	***2018[1]***
Carruthers Cr.	Sep-76	Jul-16	---	No	---	---	Unknown
Lynde Cr.	Jun-15	Jul-17	No	Yes	---	---	2019[1]
Oshawa Cr.	Jun-15	Jul-17	Yes	Yes	---	---	***2018[1]***
Farewell Cr.	Jun-15	Jul-17	No	No	---	---	Unknown
Bowmanville Cr.	May-17	Jun-17	Yes	No	---	---	2020[1]
Wilmot Cr.	Jun-15	Jul-17	No	Yes	---	---	***2018[1]***
Graham Cr.	May-96	Jul-17	---	No	---	---	Unknown
Wesleyville Cr.	Oct-02	Jul-17	---	No	---	---	Unknown
Port Britain Cr.	Apr-16	Jun-16	No	---	---	---	2019
Gage Cr.	May-71	Jun-16	---	No	---	---	Unknown
Cobourg Br.	Oct-96	Jun-17	---	No	---	---	Unknown
Covert Cr.	Apr-16	Jun-16	Yes	---	---	---	Unknown
Grafton Cr.	Jun-17	Ju1-17	No	---	---	---	Unknown
Shelter Valley Cr.	Apr-16	Jun-16	No	---	---	---	Unknown
Colborne Cr.	Jun-17	Jul-17	No	---	---	---	Unknown
Salem Cr.	Jun-15	Jul-17	No	Yes	---	---	***2018[1]***
Proctor Cr.	Jun-15	Jul-17	No	Yes	403	403	***2018***
Smithfield Cr.	Sep-86	Jul-17	---	No	---	---	Unknown
Trent R. (Canal System)	Sep-11	Jul-17	---	No	---	---	Unknown
Mayhew Cr.	Jun-15	Jul-17	No	No	---	---	Unknown
Moira R.	Jun-15	Jul-17	Yes	No	---	---	Unknown
Salmon R.	Jun-16	Jul-17	No	---	---	---	Unknown
Napanee R.	Never	Jul-17	---	No	---	---	Unknown
United States							
Black R.	Aug-15	Aug-17	Yes	Yes	---	---	***2018[1]***
Stony Cr.	Sep-82	Aug-17	---	No	---	---	Unknown
Sandy Cr.	Never	Jul-16	---	No	---	---	Unknown
South Sandy Cr.	Jun-17	Aug-17	No	Yes	---	---	2020[1]
Skinner Cr.	Apr-05	Aug-17	---	No	---	---	Unknown
Lindsey Cr.	Apr-17	Aug-17	Yes	Yes	21,197	6,204	***2018***

Table 3. Continued. Status of larval Sea Lampreys in Lake Ontario tributaries with a history of Sea Lamprey production and estimates of abundance from tributaries surveyed during 2017 using a quantitative method.

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
Blind Cr.	May-76	Jul-16	---	No	---	---	Unknown
Little Sandy Cr.	May-16	Aug-17	Yes	Yes	---	---	Unknown
Deer Cr.	Apr-04	Jul-16	---	No	---	---	Unknown
Salmon R.	May-17	Aug-17	Yes	Yes	143,981	40,927	***2018***
Orwell Brook	May-17	Aug-17	No	No	---	---	Unknown
Trout Brook	May-17	Aug-17	Yes	Yes	---	---	***2018***
Altmar Cr.	May-17	Aug-17	No	No	---	---	***2018***
Grindstone Cr.	Apr-16	Aug-17	Yes	No	---	---	2019[1]
Snake Cr.	Apr-15	Aug-17	No	Yes	---	---	***2018[1]***
Sage Cr.	May-78	Jul-16	---	No	---	---	Unknown
Little Salmon R.	Jun-14	Aug-17	Yes	Yes	---	---	2020[1]
Butterfly Cr.	May-72	Jul-16	---	No	---	---	Unknown
Catfish Cr.	Apr-15	Aug-17	Yes	Yes	---	---	***2018[1]***
Oswego R.							
Black Cr.	May-81	Aug-17	---	No	---	---	Unknown
Big Bay Cr.	Sep-93	Aug-15	---	No	---	---	Unknown
Scriba Cr.	Jun-10	Apr-14	---	No	---	---	Unknown
Fish Cr.	May-16	Jul-16	No	No	---	---	2019[1]
Carpenter Br.	May-94	Jul-16	---	No	---	---	Unknown
Putnam Br./ Coldsprings Cr.	May-96	Aug-16	---	No	---	---	Unknown
Hall Br.	Never	Aug-15	---	No	---	---	Unknown
Crane Br.	Never	Aug-16	---	No	---	---	Unknown
Skaneateles Cr.	Never	Aug-16	---	No	---	---	Unknown
Owasco Outlet	Oct-15	Jul-16	Yes	Yes	---	---	Unknown
Rice Cr.	May-72	Aug-15	---	No	---	---	Unknown
Eight Mile Cr.	Apr-15	Aug-17	Yes	Yes	6,900	1,479	***2018***
Nine Mile Cr.	May-17	Aug-17	No	No	---	---	Unknown
Sterling Cr.	May-15	Aug-17	Yes	Yes	---	---	***2018[1]***
Blind Sodus Cr.	May-78	Aug-16	---	No	---	---	Unknown
Red Cr.	Apr-15	Aug-17	No	Yes	10,771	9,574	***2018***
Wolcott Cr.	May-79	Aug-17	---	No	---	---	Unknown
Sodus Cr.	Apr-15	Aug-17	No	No	---	---	Unknown
Forest Lawn Cr.	Never	Aug-17	---	Yes	69	41	Unknown
Irondequoit Cr.	Never	Aug-17	---	No	---	---	Unknown
Larkin Cr.	Never	Aug-15	---	No	---	---	Unknown
Northrup Cr.	Never	Aug-15	---	No	---	---	Unknown
Salmon Cr.	Apr-05	Aug-17	---	Yes	---	---	Unknown
Sandy Cr.	Apr-14	Aug-17	No	No	---	---	Unknown
Oak Orchard Cr.							
Marsh Cr.	Apr-14	Aug-17	No	No	---	---	Unknown
Johnson Cr.	Apr-10	Aug-16	---	No	---	---	Unknown
Third Cr.	May-72	Aug-17	---	No	---	---	Unknown
First Cr.	May-95	Aug-16	---	No	---	---	Unknown

[1]Stream is being treated based on stream-specific knowledge of sea lamprey recruitment and growth.

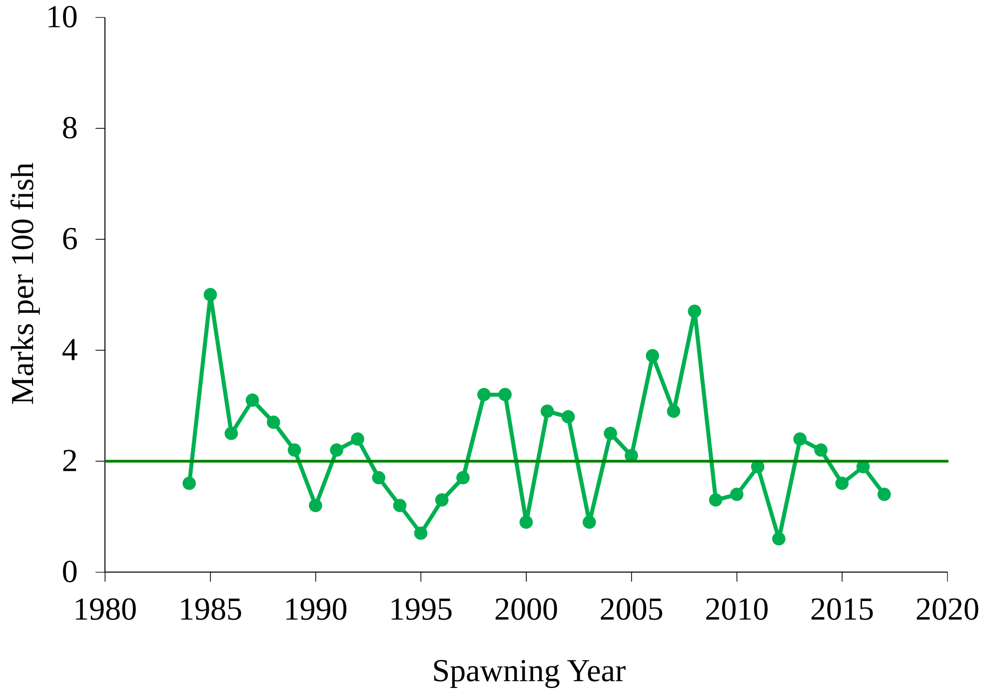

Figure 3. Number of A1 marks per 100 Lake Trout >431 mm from standardized fall assessments in Lake Ontario. The horizontal line represents the target of 2 A1 marks per 100 Lake Trout. The spawning year is used rather than the survey year (shifted by one year) to provide a comparison with the adult index.

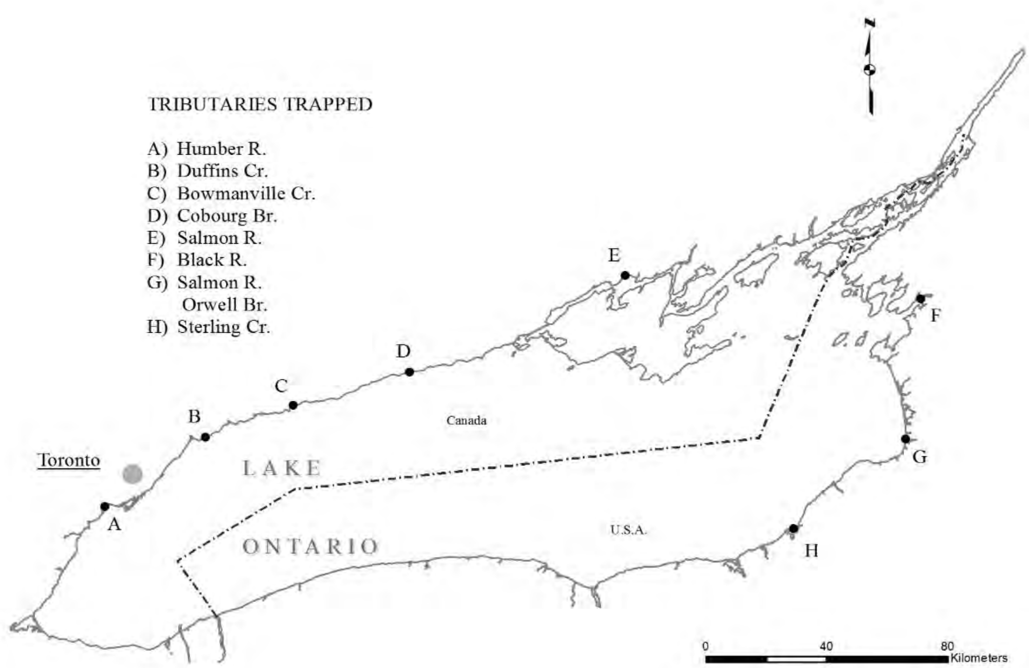

Figure 4. Location of Lake Ontario tributaries where assessment traps were operated (corresponding letters in Table 5) during 2017

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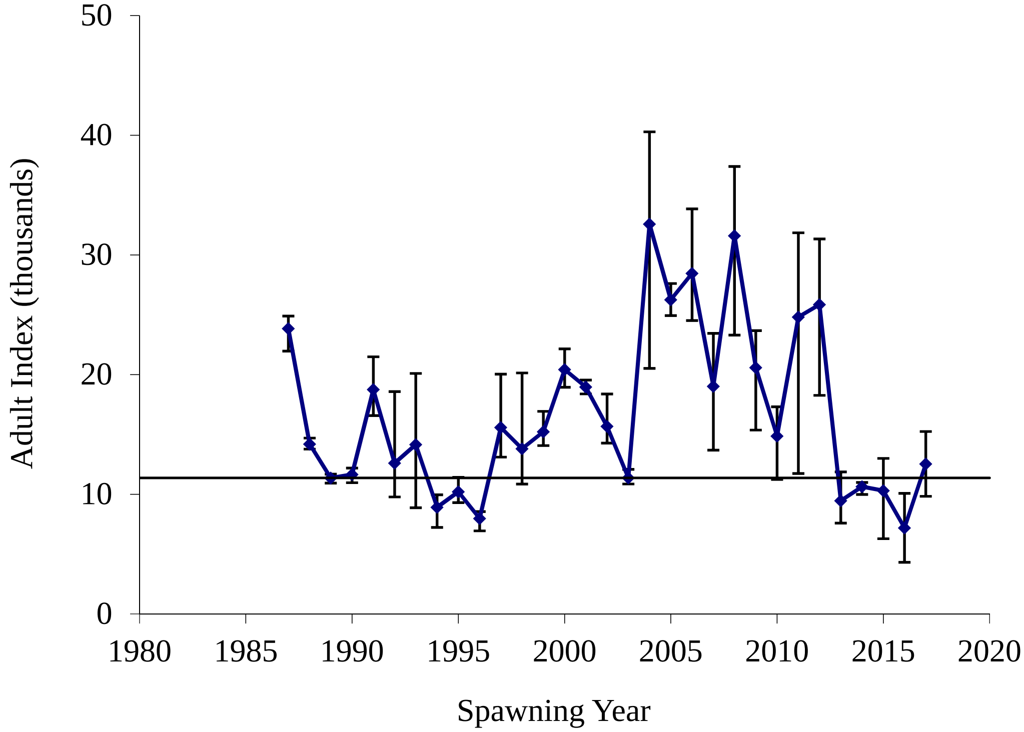

Figure 5. Index estimates with 95% confidence intervals (vertical bars) of adult Sea Lampreys. The adult index in 2017 was 12,536 (95% confidence interval 9,828-15,244). The point estimate did not meet the target of 11,368 (black horizontal line). The index target was estimated as the mean of indices during a period with acceptable marking rates (1993-1997).

Figure 6. LEFT: Estimated index of adult Sea Lampreys during the spring spawning migration, 2017. Circle size corresponds to estimated number of adults from mark-recapture studies. All index streams are identified. RIGHT: Maximum estimated number of larval Sea Lampreys in each stream surveyed during 1995-2012. Tributaries composing over half of the lake-wide larval population estimate are identified (Salmon 1,400,000; Little Salmon 970,000; Credit 590,000; Black 470,000).

Table 4. Status of larval Sea Lampreys in historically infested lentic areas of Lake Ontario during 2017.

Tributary	Lentic Area	Last Surveyed	Last Survey Showing Infestation	Last Treated
Canada				
Duffins Cr.	Duffins Cr. - lentic	Aug-15	Aug-12	Never[1]
Oshawa Cr.	Oshawa Cr. - lentic	Jul-13	Oct–81	Never[1]
Wilmot Cr.	Wilmot Cr. - lentic	Aug-11	Aug-11	Never[1]
United States				
Black R.	Black River Bay	Aug-17	Aug-17	Aug-15

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

Table 5. Details on application of granular Bayluscide to tributaries and lentic areas of Lake Ontario for larval assessment purposes during 2017.

Tributary	Bayluscide (kg)[1]	Area Surveyed (ha)
Canada		
Niagara R. (lotic)	4.42	0.79
Trent R. (lotic)	1.68	0.30
Moira R. (lotic)	1.12	0.20
Salmon R. (lotic)	1.68	0.30
Napanee R. (lotic)	0.92	0.17
Total (Canada)	**9.82**	**1.76**
United States		
Niagara R. (lotic)	3.36	0.6
Black R. (lentic)	0.56	0.10
Black R. (lotic)	1.12	0.20
Little Sandy Cr. (lotic)	1.12	0.20
Genesee R. (lotic)	2.24	0.40
Oak Orchard Cr. Marsh Cr. (lotic)	2.02	0.36
Total (United States)	**10.42**	**1.86**
Total for Lake	**20.24**	**3.62**

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

Bottom trawl assessment of Lake Ontario prey fishes

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Abstract

Managing Lake Ontario fisheries in an ecosystem-context requires prey fish community and population data. Since 1978, multiple annual bottom trawl surveys have quantified prey fish dynamics to inform management relative to published Fish Community Objectives. In 2017, two whole-lake surveys collected 341 bottom trawls (spring: 204, fall: 137), at depths from 8-225m, and captured 751,350 fish from 29 species. Alewife were 90% of the total fish catch while Deepwater Sculpin, Round Goby, and Rainbow Smelt comprised the majority of the remaining total catch (3.8, 3.1, and 1.1% respectively). The adult Alewife abundance index for US waters increased in 2017 relative to 2016, however the index for Canadian waters declined. Adult Alewife condition, assessed by the predicted weight of a 165 mm fish (6.5 inches), declined in 2017 from record high values observed in spring 2016. Spring 2017 Alewife condition was slightly less than the 10-year average, but the fall value was well below the 10-year average, likely due to increased Age-1 Alewife abundance. The Age-1 Alewife abundance index was the highest observed in 40 years, and 8-times higher than the previous year. The Age-1 index estimates Alewife reproductive success the preceding year. The warm summer and winter of 2016 likely contributed to the large year class. In contrast the relatively cool 2017 spring and cold winter may result in a lower than average 2017 year class. Abundance indices for Rainbow Smelt, Cisco, and Emerald Shiner either declined or remained at low levels in 2017. Pelagic prey fish diversity continues to be low since a single species, Alewife, dominates the catch.

Deepwater Sculpin were the most abundant benthic prey fish in 2017 because Round Goby abundance declined sharply from 2016. Slimy Sculpin density continued to decline and the 2017 biomass index for US waters was the lowest ever observed. Prior to Round Goby proliferation, juvenile Slimy Sculpin comprised ~10% of the Slimy Sculpin catch, but since 2004, the percent of juveniles within the total catch is less than 0.5%, suggesting Round Goby are limiting Slimy Sculpin reproduction. Despite Slimy Sculpin declines, benthic prey fish community diversity has increased as Deepwater Sculpin and Round Goby comprise more of the community.

Introduction

Managing Lake Ontario fisheries in an ecosystem-context requires reliable data on the status and trends of prey fishes that support predators and drive food web dynamics (Stewart et al., 2017). Alewife are the primary pelagic prey fish in Lake Ontario and support most of the lake's predators (Mills et al., 2003; Murry et al., 2010; Stewart and Sprules, 2011). Rainbow Smelt and Round Goby are also important diet items for various species and sizes of piscivores (Lantry, 2001; Rand and Stewart, 1998; Rush et al., 2012). The demersal, or benthic, prey fish community is primarily comprised of nonnative Round Goby, and native Deepwater and Slimy Sculpin.

The Lake Ontario pelagic prey fish community has undergone dramatic change. Historically, it is believed Cisco and Bloater were the primary prey fishes in Lake Ontario, and these species also supported commercial fisheries (Christie, 1972). In the early and mid-1900s, Cisco and Bloater populations declined due to overfishing, habitat alterations, and competition with introduced species (Christie, 1972). Alewife was first observed in Lake Ontario in 1873 and are believed to have gained entrance in the late 1800s after the opening of the Erie Canal system (Smith, 1985). Rainbow Smelt was first reported in Lake Ontario in 1929, and probably moved from the upstream Finger Lakes, where they were introduced (Greely 1939; Nellbring 1989; Rooney and Patterson 2009). Alewife, and to a lesser extent Rainbow Smelt, have dominated the Lake Ontario fish community during the modern period (1978-present) and they dominate piscivore diet consumption (Lantry, 2001; Murry et al., 2010; Stewart and Sprules, 2011).

The native Lake Ontario benthic fish community was believed to include Deepwater, Spoonhead, and Slimy Sculpin in deep habitats, while Spottail Shiner, Johnny Darter, and Trout-perch were abundant closer to shore (Christie, 1972, 1973). When trawl surveys began in 1978, Slimy Sculpin and the nearshore species comprised the benthic prey fish community. At that time, Spoonhead Sculpin and Deepwater Sculpin were rare or considered extirpated. Since the 1990s, Slimy Sculpin have fluctuated, but generally declined as dreissenid mussel and Round Goby introductions have changed the benthic fish and invertebrate community (Owens and Dittman, 2003; Weidel and Walsh, 2015). Slimy Sculpin were historically important in juvenile Lake Trout diets (Elrod and O'Gorman, 1991), but more recently Round Goby abundance has increased and are now common benthic prey found in Lake Trout (Rush et al., 2012). Finally, Deepwater Sculpin, a native species listed as "endangered" in New York State, has undergone a dramatic population recovery since the mid-2000s (Weidel et al., 2017).

Two prey fish bottom trawl surveys are collaboratively conducted each year in April and October to inform fisheries management decisions by improving the collective understanding of the Lake Ontario prey fish community. This report describes the status of Lake Ontario prey fishes with emphasis on information addressing the bi-national Lake Ontario Committee's Fish Community Objectives (Stewart et al., 2017).

Methods

Spring survey

The Lake Ontario spring bottom trawl survey has been collaboratively conducted by NYSDEC and USGS during April and May since 1978. The survey collects many species but targets Alewife at a time when their winter, bottom-oriented behavior maximizes their susceptibility to bottom trawls (Wells, 1968). Trawling is conducted during the day at fixed transect locations. Although random sampling is preferable for abundance estimates, it is not practical because of varied substrates that can prohibitively damage trawls at randomly selected sites (MacNeill et al., 2005). A team of fish sampling experts reviewed the Lake Ontario prey fish trawl program and found the fixed-station sampling design generated a suitable estimate of relative abundance (ICES, 2004; MacNeill et al., 2005). The original survey design sampled from 8-150m (26-495 ft) in US waters at 12 transects. Fish distribution changes and needs for lake-wide information have resulted in survey expansion. For instance, nutrient reductions and dreissenid mussel filtration resulted in increased water clarity and subsequently the early depth distributions of Alewife and other prey fish shifted deeper (O'Gorman et al., 2000). In 2004 trawling was expanded to 170m in US waters. In 2016, the survey effort expanded to a whole-lake design and the Ontario Ministry of Natural Resources and Forestry (OMNRF) research vessel joined the survey. Since 2016, trawls have been collected from 8-225m (26-743 ft), with sites organized in 23 transects or regions distributed around the lake (Figure 1).

The original survey used a nylon Yankee bottom trawl with an 11.8-m (39 ft) headrope and flat, rectangular, wooden trawl doors. Prohibitive catches of dreissenid mussels in the 1990s required changing to a "3N1" trawl, with an 18-m (59 ft) headrope and spread with slotted, metal, cambered V-doors. The survey adopted this new trawl design in 1997 and for consistency the time series statistics for the spring bottom trawl survey are illustrated from 1997 to present. Bottom trawl catches were separated to species, counted, and weighed in aggregate. Subsamples of all species were also measured for individual length and weight, and stomachs, muscle tissue, and various aging structures were removed for age interpretation and archives.

Abundance indices are based on the mean, lake area-weighted catch per 10-minute bottom trawl. Stratification is based on 20 meter (66 ft) stratification depth intervals and the proportional area of those depth intervals within the lake (Table 1). Separate indices are calculated for US and Canadian trawl catches. Mean and standard error calculations were from Cochrane (1977). The survey expansion complicates analyses because the proportions of lake area within each 20m-strata change as more strata area included (Table 1). Statistics reported for trawl catches in Canadian waters followed a similar analysis, however the area within 20m strata in Canada differed from U.S. waters (Table 1). Condition indices are estimated using a linear model that predicts weight based on length and illustrated as the average weight a 165-mm (6.5 inch) Alewife in the spring and fall over time. Statistics for community diversity calculations were based on the most commonly captured pelagic species and those species identified in Fish Community Objectives (Table 2). The Shannon index was used to describe pelagic and benthic community diversity based on the overall trawl catch (Shannon and Weaver, 1949).

Fall survey

From 1978-2011, the fall bottom trawl survey sampled six transects along the southern shore of Lake Ontario from Olcott to Oswego, NY and targeted benthic or demersal prey fish. Daytime trawls were typically 10 minutes and sampled depths from 8–150 m (26-495 ft). The original survey gear was a Yankee bottom trawl described above. Abundant dreissenid mussel catches led to a variety of alternate polypropylene bottom trawls and metal trawl doors being used from 2004-2010. Comparison towing indicated alternate trawls had low and variable catchability for benthic fishes and the alternative trawl doors influenced net morphometry (Weidel and Walsh, 2013). Since 2011, the survey has used the historical standard Yankee trawl and reduced tow times to reduce mussel catches. Experimental sampling at new transects and/or deeper habitats began in 2012. More notably, in 2015 the survey effort was doubled to include Canadian waters and the NYS Department of Environmental Conservation and OMNRF research vessels joined the survey. Benthic prey fish time series are illustrated from 1978 to present and no adjustments are available for data when the alternative trawls were used. Trawl catch processing are as described for the spring survey. In contrast to the spring survey results that are expressed as the average number per 10-minute tow, benthic fish abundance is represented as average biomass (units: kg/ha). The lake bottom area swept by the trawl varies according to depth (Weidel and Walsh, 2013). Reporting in these units provides data in a more readily useable form to address ecosystem questions and make species and community comparisons across lakes. Time series are still regarded as biomass indices since we lack estimates of trawl catchability (proportion of the true density captured by the trawl).

Results and Discussion

Alewife – The adult Alewife (Age-2 and older) abundance index for US waters increased in 2017 (1672 Alewife per 10 minute tow) relative to 2016 (746) but was below the 10-year average (10-yr avg =1940, Figure 2). The increase is relevant since the 2016 US adult Alewife abundance index value was likely the lowest observed since the current survey and trawl design began in 1997. A lower value was observed in 2010 (460 Alewife per 10 minute tow), but cohort analyses indicated that value was biased low. In contrast to the US index, the adult Alewife index in Canadian waters declined from 2016 to 2017 (Figure 2). The Age-1 Alewife abundance index for US waters increased in 2017 (3977 fish per 10 minute trawl) relative to 2016 (506) and was approximately 5 times higher than the 10-year average (2007:2016 average = 684; Figure 2).

The low Alewife abundance observed in 2016 is consistent with the two consecutive years of low Alewife reproductive success observed in 2013 and 2014. Alewife reproductive success for a given year is measured the following year, so those low year classes from 2013 and 2014 are illustrated in Figure 3 as low numbers of Age-1 Alewife captured in 2014 and 2015. The increased catch in adult Alewife, from 2016 to 2017 (US index) was attributable to the moderate 2015 Alewife year class, which first counted towards the adult index when they reached age-2 in 2017. Since the record high 2016 Alewife year class will be Age-2 in 2018, we expect the 2018 adult Alewife index value to increase relative to 2017. The relatively cool 2017 spring and cold winter may result in a lower than average 2017 year class since temperature has been shown to influence Alewife year class strength in Lake Ontario (O'Gorman et al., 2004).

The seasonal timing of trawl surveys, within a given year, has a strong influence on Lake Ontario Alewife catches. For example, in 2017, the average biomass of all Alewife captured in the spring trawls was 72 kilograms per hectare, while the average of the 137 fall trawls was 2 kilograms per hectare (Figure 4). In addition to the broad seasonal effects, survey timing within the spring survey period may also influence Alewife catches. An experimental effort in 2017 sampled the Oswego transect twice, 21 days apart, and the mean biomass value for that transect was 75% less during the second sampling. This may explain the relatively lower Alewife abundance index in Canadian waters in 2017, where trawling occurred slightly later than in US waters. The direction and magnitude of the differences in US and Canadian trawl indices in 2016 and 2017 accentuates the need for a lake wide survey. Seasonal effect on Alewife susceptibility to bottom trawls was also apparent in Lake Michigan in 1964 (Wells, 1968). Future research efforts should consider evaluating how Alewife behavior changes in the spring with respect to photoperiod and temperature and how those behavior changes influence abundance estimates.

Adult Alewife condition, assessed by the predicted weight of a 165 mm fish (6.5 inches) declined in 2017 from a record high spring value observed in 2016 (Figure 5). Condition in spring 2017 was slightly less than the 10-year average, but the fall value was well below the 10-year average, likely due to record high Age-1 Alewife abundance that would have increased competition for zooplankton resources (Figure 5).

Other Pelagic Fishes – Bottom trawl abundance indices for Rainbow Smelt, Cisco, and Emerald Shiner either declined or remained at low levels in 2017 (Figure 6). Alewife dominance relative to Rainbow Smelt in Lake Ontario trawl catches may be related to adult Alewife predation on Age-0 Rainbow Smelt and competition for zooplankton. The habitat distribution of Age-0 Rainbow Smelt overlaps with adult Alewife during the summer (Simonin et al., 2016). Increased Cisco catches observed in 2015 were not evident in 2017 (Figure 6), however bottom trawl surveys have been shown to underestimate Cisco abundance compared to acoustic and midwater sampling (Stockwell et al., 2006).

Demersal prey fishes - In 2017, Deepwater Sculpin were the most abundant benthic prey fish because Round Goby abundance declined sharply from 2016 (Figure 7). Deepwater Sculpin were once thought to be extirpated from Lake Ontario, but their abundance and weight indices have increased steadily since 2004 (Weidel et al., 2017). Slimy Sculpin density has continued to decline and the 2017 biomass index for US waters was the lowest observed (Figure 7). Slimy Sculpin declines in the 1990s were attributed to the collapse of their preferred prey, the amphipod *Diporeia* (Owens and Dittman, 2003). The declines that occurred in the mid-2000s appear to be related to Round Goby. Since Round Goby numbers have increased the proportion of juvenile Slimy Sculpin in the total catch of Slimy Sculpins dropped from ~10% to less than 0.5% (Figure 8). These data suggest Round Goby are limiting Slimy Sculpin reproduction or possibly recruitment of juvenile Slimy Sculpin to adult stages. Interestingly, Slimy Sculpin biomass is higher in Canadian waters but may also be declining although the time series only includes three years (Figure 7).

Prey fish diversity - Lake Ontario Fish Community Objectives call for increased prey fish diversity (Stewart et al., 2017). Bottom trawl data suggest that pelagic prey fish community diversity remains low since a single species, Alewife, dominates the catch (Figure 9). Actions to improve pelagic community diversity are currently underway in Lake Ontario, including Bloater restoration and Cisco rehabilitation. Despite Slimy Sculpin declines, benthic prey fish community diversity has generally increased over the time series. In the 1970s – 1990s a single species, Slimy Sculpin, dominated the catch, resulting in lower diversity values. More recently, increases in Deepwater Sculpin and the introduction of Round Goby, which make up more even portions of the catch, have caused the index value to increase (Figure 9).

Acknowledgements

Special thanks to all information, vessel, biological, and administrative support staff for their effort and flexibility conducting the 2017 Lake Ontario prey fish surveys. Funding for USGS sampling and analysis is from the Ecosystems area and the Fisheries and Status and Trends programs. Provincial funding to implement OMNRF sampling was from the Canada-Ontario Agreement on Great lakes Water Quality and Ecosystem Health and Ontario's Great Lakes Strategy. NYSDEC funding was from the Federal Aid in Sport Fish Restoration Program. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. Data herein are available from U.S. Geological Survey, Great Lakes Science Center, 2018, Great Lakes Research Vessel Operations 1958-2017 (ver. 2.0, March 2018): U.S. Geological Survey Data Release, https://doi.org/10.5066/F75M63X0. All USGS sampling and handling of fish during research are carried out in accordance with guidelines for the care and use of fishes by the American Fisheries Society (http://fisheries.org/docs/wp/Guidelines-for-Use-of-Fishes.pdf).

Literature Cited

Christie, W.J., 1973. A review of the changes in the fish species composition of Lake Ontario (Technical Report No. 23). Great Lakes Fishery Commission.

Christie, W.J., 1972. Lake Ontario: effects of exploitation, introductions, and eutrophication on the salmonid community. J. Fish. Board Can. 29, 913–929.

Cochrane, W.G., 1977. Sampling Techniques, 3rd ed. Wiley.

Elrod, J.H., O'Gorman, R., 1991. Diet of juvenile lake trout in southern Lake Ontario in relation to abundance and size of prey fishes, 1979–1987. Trans. Am. Fish. Soc. 120, 290–302.

ICES, 2004. Report of the Workshop on Survey Design and Data Analysis (WKSAD). Lantry, J.R., 2001. Spatial and temporal dynamics of predation by Lake Ontario trout and salmon. SUNY-ESF.

MacNeill, D.B., Ault, J.S., Smith, S., S., M., 2005. A technical review of the Lake Ontario forage base assessment program (No. YSGI-T-05-001). NY Sea Grant.

Mills, E.L., Casselman, J.M., Dermott, R., Fitzsimons, J.D., Gal, G., Holeck, K.T., Hoyle, J.A., Johannsson, O.E., Lantry, B.F., Makarewicz, J.C., others, 2003. Lake Ontario: food web dynamics in a changing ecosystem (1970 2000). Can. J. Fish. Aquat. Sci. 60, 471–490.

Murry, B.A., Connerton, M.J., O'Gorman, R., Stewart, D.J., Ringler, N.H., 2010. Lakewide Estimates of Alewife Biomass and Chinook Salmon Abundance and Consumption in Lake Ontario, 1989–2005: Implications for Prey Fish Sustainability. Trans. Am. Fish. Soc. 139, 223–240. https://doi.org/10.1577/T08-216.1

O'Gorman, R., Elrod, J.H., Owens, R.W., Schneider, C.P., Eckert, T.H., Lantry, B.F., 2000. Shifts in depth distributions of alewives, rainbow smelt, and age-2 lake trout in southern Lake Ontario following establishment of dreissenids. Trans. Am. Fish. Soc. 129, 1096–1106.

O'Gorman, R., Lantry, B.F., Schneider, C.P., 2004. Effect of Stock Size, Climate, Predation, and Trophic Status on Recruitment of Alewives in Lake Ontario, 1978–2000. Trans. Am. Fish. Soc. 133, 855–867. https://doi.org/10.1577/T03-016.1

Owens, R.W., Dittman, D.E., 2003. Shifts in the Diets of Slimy Sculpin (Cottus cognatus) and Lake Whitefish (Coregonus clupeaformis) in Lake Ontario Following the Collapse of the Burrowing Amphipod Diporeia. Aquat. Ecosyst. Health Manag. 6, 311–323. https://doi.org/10.1080/14634980301487

Rand, P.S., Stewart, D.J., 1998. Dynamics of salmonine diets and foraging in Lake Ontario, 1983-1993: a test of a bioenergetic model prediction. Can. J. Fish. Aquat. Sci. 55, 307–317.

Rush, S.A., Paterson, G., Johnson, T.B., Drouillard, K.G., Haffner, G.D., Hebert, C.E., Arts, M.T., McGOLDRICK, D.J., Backus, S.M., Lantry, B.F., Lantry, J.R., Schaner, T., Fisk, A.T., 2012. Long-term impacts of invasive species on a native top predator in a large lake system. Freshw. Biol. 57, 2342–2355. https://doi.org/10.1111/fwb.12014

Shannon, C.E., Weaver, W., 1949. The mathematical theory of communication. The University of Illinois Press, Urbana, IL.

Simonin, P.W., Parrish, D.L., Rudstam, L.G., Pientka, B., Sullivan, P.J., 2016. Interactions between Hatch Dates, Growth Rates, and Mortality of Age-0 Native Rainbow Smelt and Nonnative Alewife in Lake Champlain. Trans. Am. Fish. Soc. 145, 649–656.

https://doi.org/10.1080/00028487.2016.1143401

Smith, C.L., 1985. The inland fishes of New York state. New York State Department of Environmental Conservation.

Stewart, T.J., Sprules, W.G., 2011. Carbon-based balanced trophic structure and flows in the offshore Lake Ontario food web before (1987–1991) and after (2001–2005) invasion-induced ecosystem change. Ecol. Model. 222, 692–708. https://doi.org/10.1016/j.ecolmodel.2010.10.024

Stewart, T.J., Todd, A., Lapan, S., 2017. LOC Fish Community Objectives for Lake Ontario 2013.pdf.

Stockwell, J.D., Yule, D.L., Gorman, O.T., Isaac, E.J., Moore, S.A., 2006. Evaluation of Bottom Trawls as Compared to Acoustics to Assess Adult Lake Herring (Coregonus artedi) Abundance in Lake Superior. J. Gt. Lakes Res. 32, 280–292. https://doi.org/10.3394/0380-1330(2006)32[280:EOBTAC]2.0.CO;2

Weidel, B.C., Walsh, M.G., 2015. Lake Ontario benthic prey fish assessment, 2014 (2014 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission’s Lake Ontario Committee).

Weidel, B.C., Walsh, M.G., 2013. Estimating the area-swept by the 11.8 m Yankee bottom trawl in Lake Ontario (2012 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission’s Lake Ontario Committee).

Weidel, B.C., Walsh, M.G., Connerton, M.J., Lantry, B.F., Lantry, J.R., Holden, J.P.,

Yuille, M.J., Hoyle, J.A., 2017. Deepwater sculpin status and recovery in Lake Ontario. J. Gt. Lakes Res. https://doi.org/10.1016/j.jglr.2016.12.011

Wells, L., 1968. Seasonal depth distribution of fish in southeastern Lake Michigan. Fish. Bull. 67, 1–15.

Table 1. Lake Ontario area (square kilometers) within different depth strata in US and Canadian waters. The proportional area columns illustrate how the area-weighting of stratified abundance mean indices changes as additional depths are included in the survey.

			proportional Area US			proportional area CA
range (m)	area US	area CA	0-160m	0-180m	0-240m	0-160m
0-19	1155	1749	0.19	0.15	0.13	0.18
20-39	905	1616	0.15	0.12	0.10	0.16
40-59	680	1248	0.11	0.09	0.08	0.13
60-79	514	1426	0.08	0.07	0.06	0.14
80-99	441	1198	0.07	0.06	0.05	0.12
100-119	527	1293	0.09	0.07	0.06	0.13
120-139	822	964	0.13	0.11	0.09	0.10
140-159	1112	353	0.18	0.14	0.12	0.04
160-179	1598	0		0.21	0.18	
180-199	737	0			0.08	
200-219	448	0			0.05	
220-239	79	0			0.01	
240-243	>1	0				

Table 2. Species and number of fish captured in the spring and fall Lake Ontario prey fish bottom trawl surveys. All numbers represent total numbers caught in each survey except for Dreissena sp. mussels, which represent a total weight in kilograms. The Classification column denotes which species are used in pelagic and benthic community diversity index calculations.

Species	Spring	Fall	Classification
Alewife	671868	6863	pelagic
Deepwater sculpin	13273	15081	benthic
Round goby	12757	10271	benthic
Rainbow smelt	6513	1913	pelagic
Yellow perch	792	566	benthic
Slimy sculpin	587	1182	benthic
Trout-perch	203	1505	benthic
Spottail shiner	189	76	benthic
Threespine stickleback	87	255	pelagic
Lake trout	62	34	
White perch	42	960	pelagic
Lake whitefish	10	0	
Pumpkinseed	10	7	
Crayfish	2	0	
Cisco (lake herring)	1	1	pelagic
Emerald shiner	1	12	pelagic
Gizzard shad	1	52	pelagic
Sea lamprey	1	0	
Unidentified redhorse	1	0	
Walleye	1	1	
Brown bullhead	0	58	
Brown trout	0	3	
Carp	0	12	
Channel catfish	0	2	
Freshwater drum	0	58	
Johnny darter	0	5	benthic
Logperch	0	5	
Smallmouth bass	0	1	
White sucker	0	157	
Dreissena mussel weight (kg)	1515	3820	

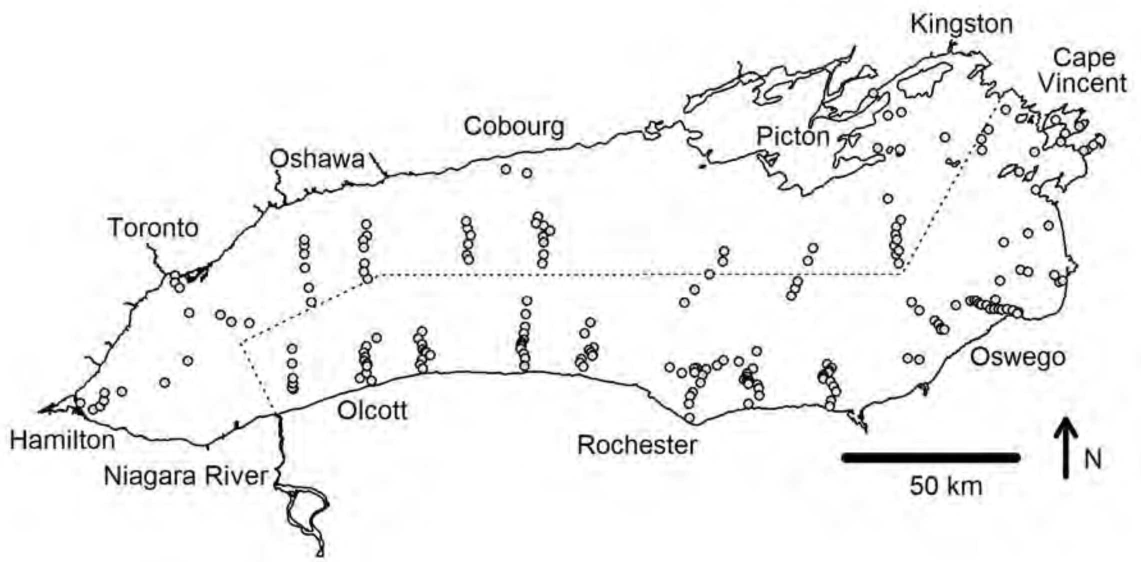

Figure 1. Lake Ontario sampling sites (N=204) from the 2017 spring bottom trawl survey collaboratively conducted by USGS, NYSDEC, and OMNRF. The fall survey that targets demersal or benthic prey fishes is sampled over a similar geographic area, but not all sites were trawled (N=137).

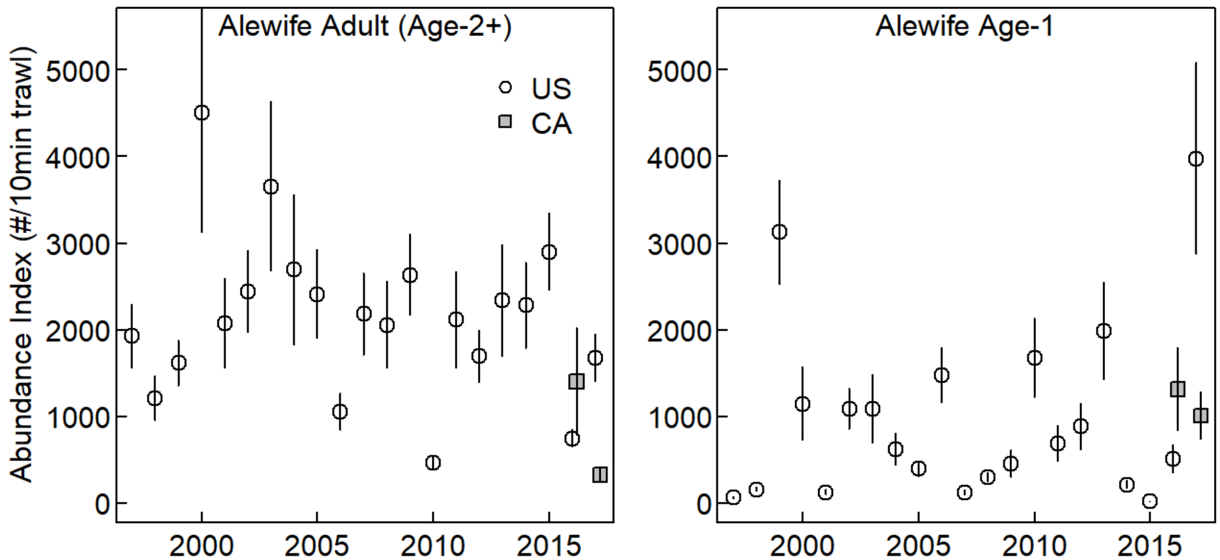

Figure 2. Lake Ontario spring bottom trawl-based abundance indices for adult Alewife (Age-2 and older, left panel) and Yearling or Age-1 Alewife (right panel). Values represent a stratified, area-weighted mean number of Alewife captured in a 10 minute trawl. Error bars represent one standard error of the mean. Trawling in Canadian waters began in 2016, but to maintain consistent comparisons through time, separate indices are illustrated for Canadian and US waters. (lake area: Canada-52% US-48%)

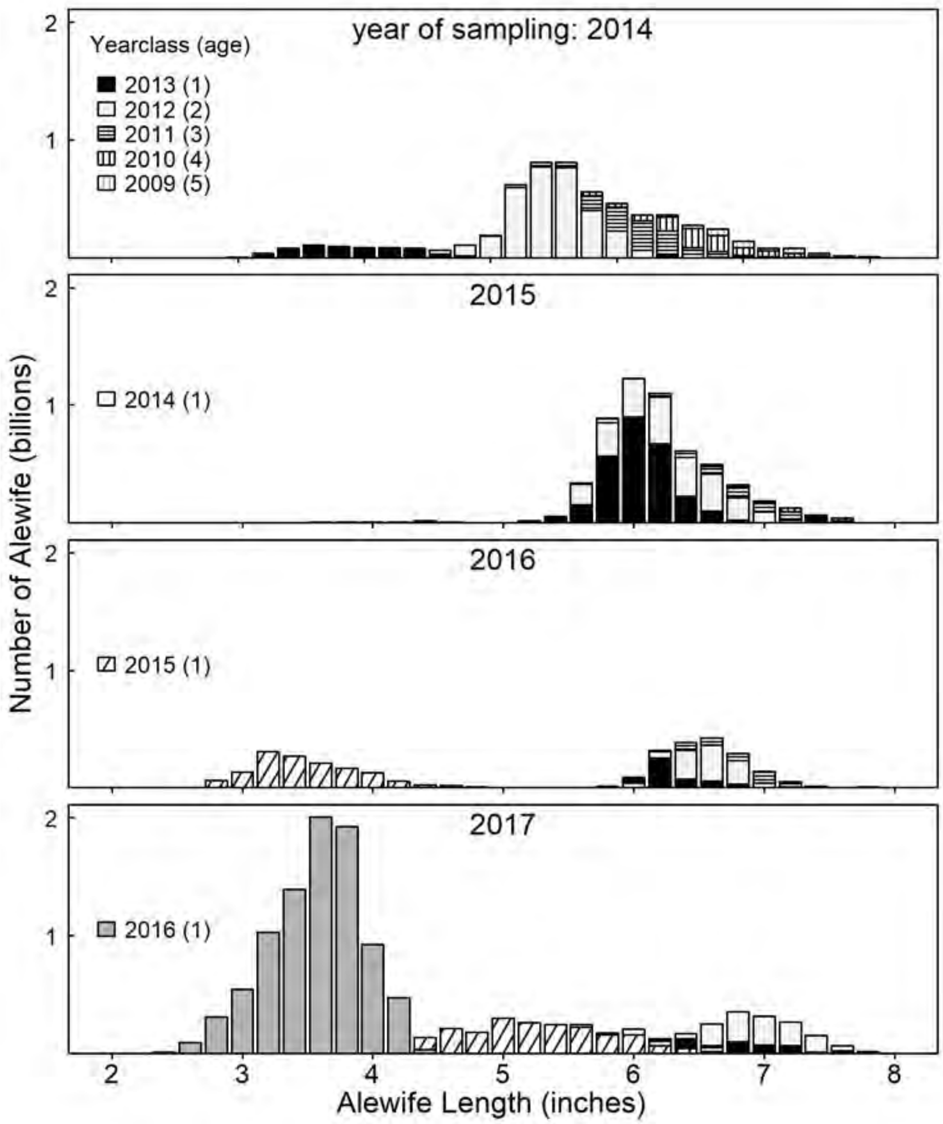

Figure 3. Alewife size and age distributions from spring bottom trawl surveys conducted in US waters of Lake Ontario, 2014-2017. Each Alewife year class (all the fish born in a given year) are represented by a consistent color or pattern. The low catches of Age-1 fish in 2014 and 2015 (1st and 2nd panels) contributed to management concerns that resulted in salmonid stocking reductions in 2017 and 2018. The catch of Age-1 fish in 2017 (2016 year class, bottom panel) was the largest observed in the survey.

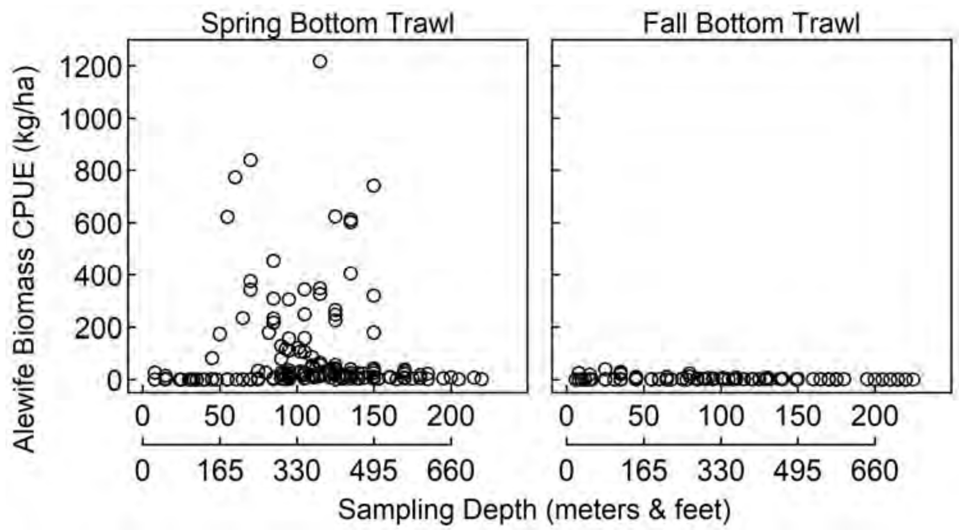

Figure 4. The biomass of all ages of Alewife caught in 2017 Lake Ontario bottom trawls varies across sampling depths and between the spring (left panel) and fall (right panel) surveys. Individual values represent Alewife weight according to the area of lake bottom swept by the bottom trawls. Note, different trawls are used on each survey and the abundance indices are calculated from the spring survey.

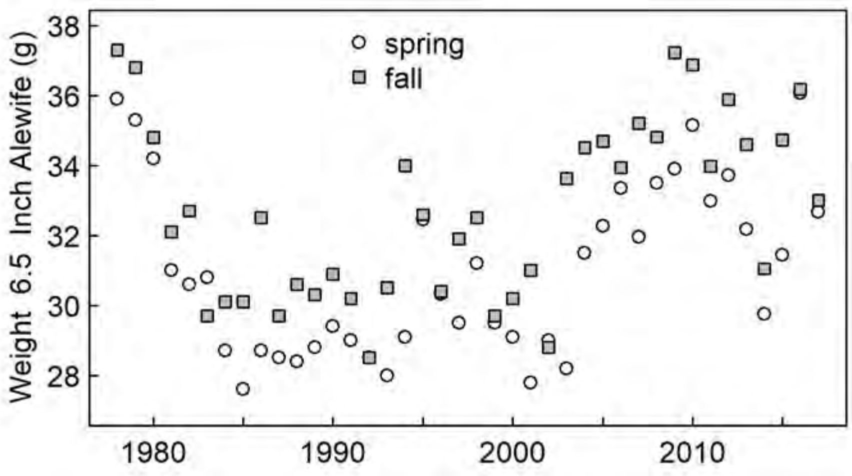

Figure 5. Alewife condition for spring and fall surveys illustrated as the predicted weight of a 165mm (6.5 inch) adult Alewife.

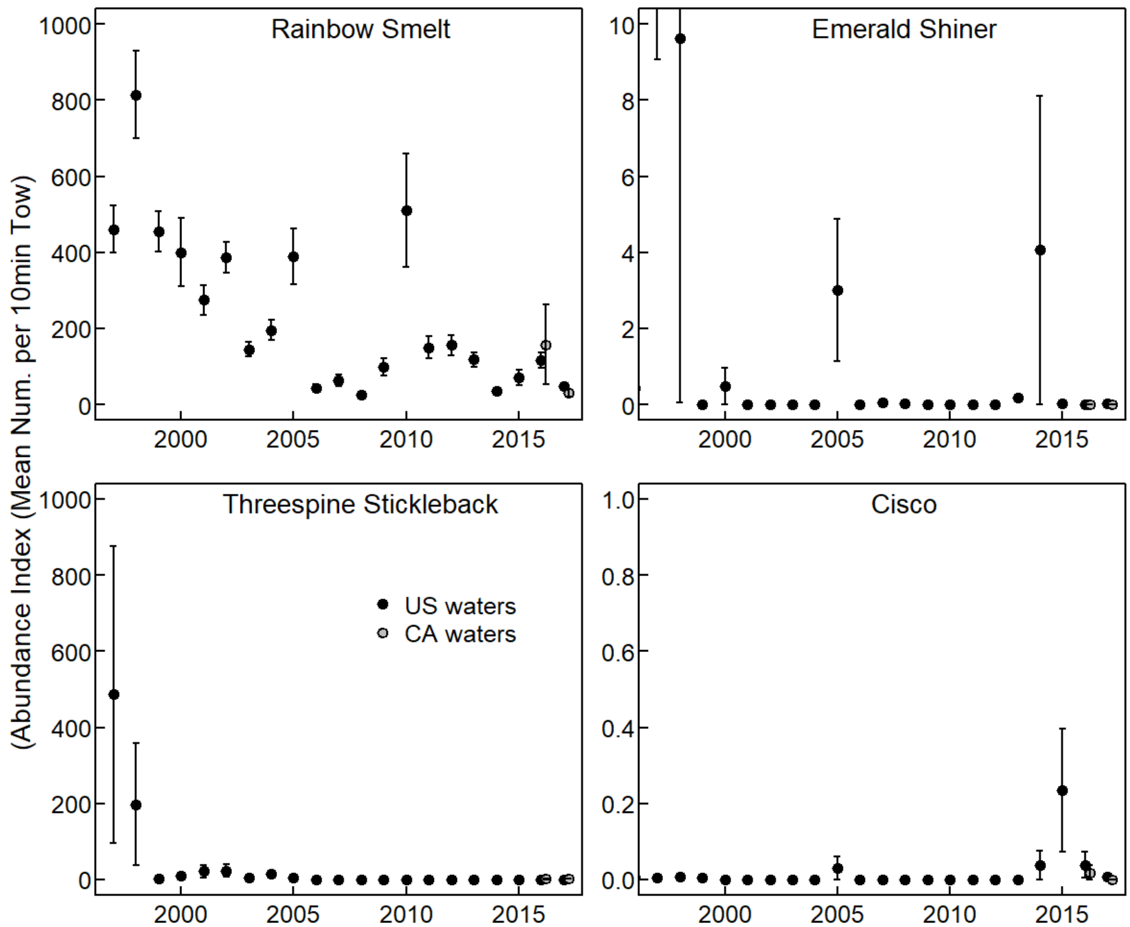

Figure 6. Abundance indices for other Lake Ontario pelagic prey fishes based on bottom trawls in U.S. and Canadian waters, 1997-2017. Error bars represent one standard error.

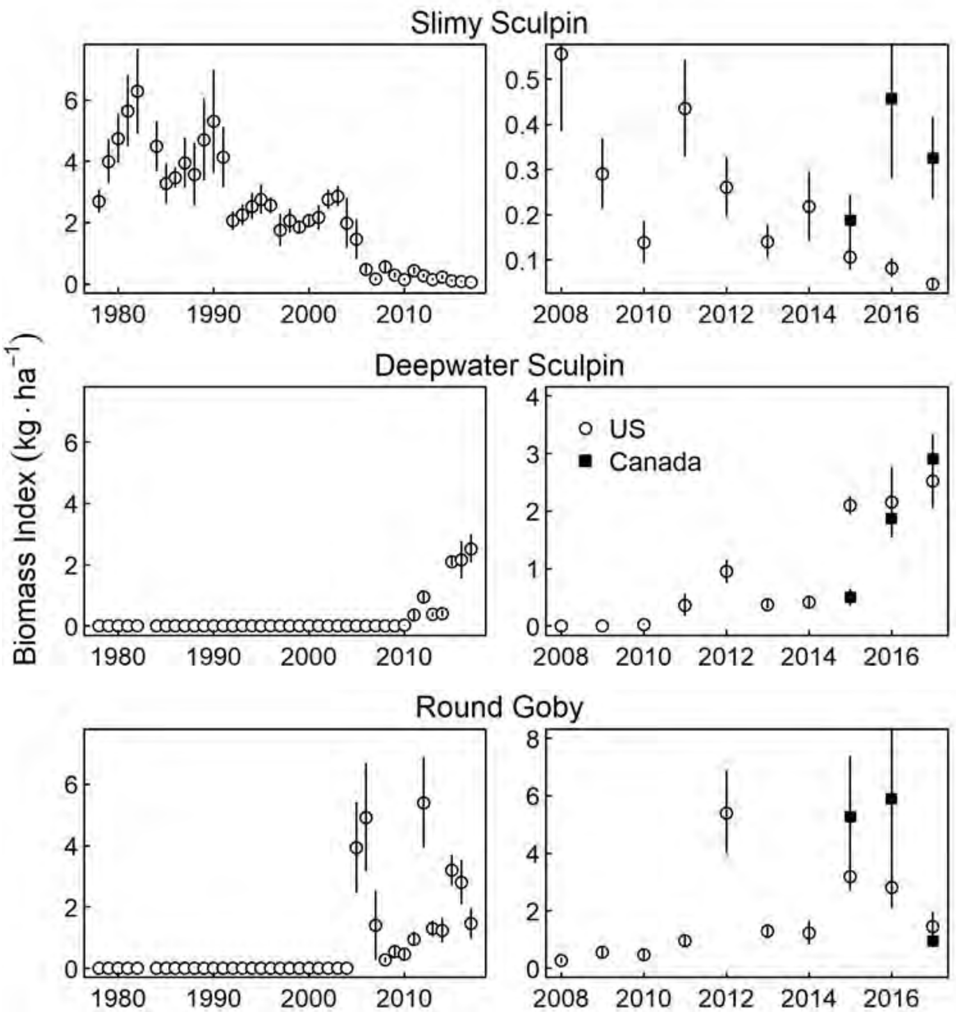

Figure 7. Lake Ontario prey fish trends for demersal or bottom-oriented species from 1978-2017 (left panels) and 2008-2017 (right panels). The survey is conducted in late-September and early-October and error bars represent one standard error. Sampling in Canadian waters began in 2015. Separate 20m stratified, lake area-weighted means are calculated separately for tows in US and Canadian waters to maintain comparability across the US index time series.

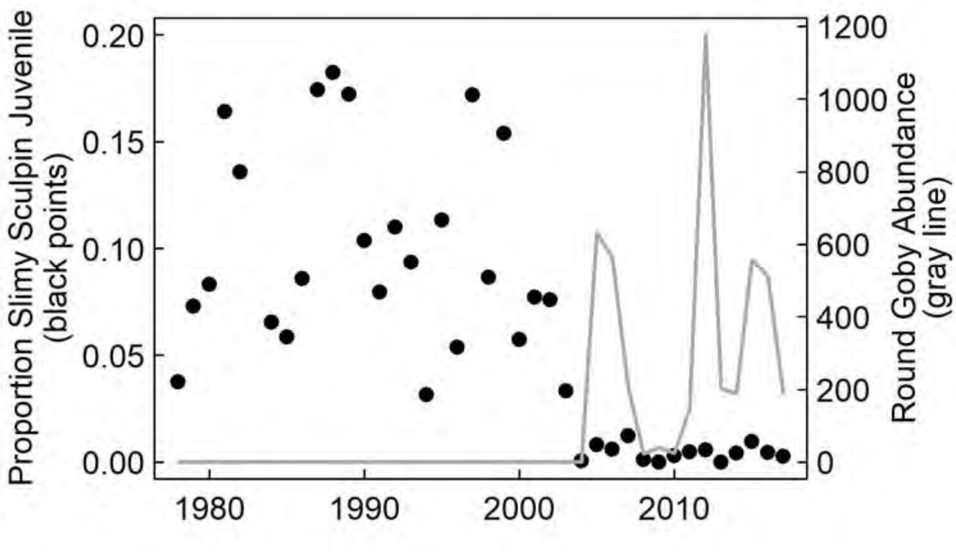

Figure 8. The proportion of Slimy Sculpin captured that were juveniles (<50mm or ~2 inches) continues to be low in Lake Ontario bottom trawl catches from the benthic prey fish survey. The proportion of the Slimy Sculpin catch that is juveniles (black filled circles) appears to drop once Round Goby catches increased (gray line). Round Goby were first collected in the spring trawl survey in 2002 and first collected in the fall survey in 2005.

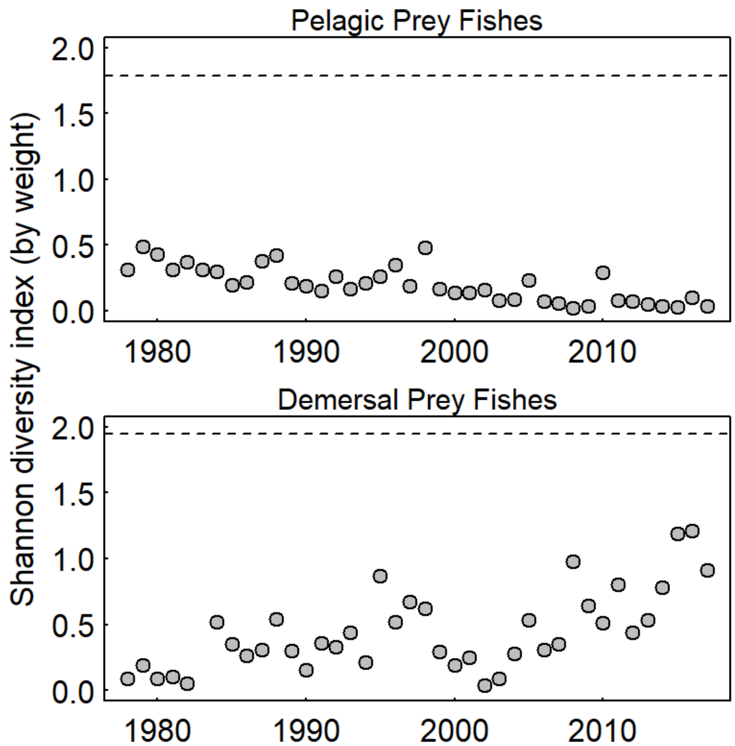

Figure 9. Lake Ontario prey fish diversity indices for pelagic and demersal prey fish communities based on bottom trawl catch weights 1978-2017. Species used for calculations are identified in Table 1. Diversity is represented with the Shannon index (Shannon and Weaver, 1949) using the seven most commonly encountered species in the spring (pelagic) and fall (benthic) surveys. The dashed lines represent the maximum diversity index value if all species considered made up equal proportions of the catch by weight. Lake Ontario Fish Community Objectives include improving pelagic and demersal prey fish diversity (Stewart et al., 2017).

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, an American site (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, other ecological values and private property followed this population expansion. Little Galloo Island currently supports the largest cormorant, Ring-billed Gull *(Larus delawarensis)* and Caspian Tern (*Sterna caspia*) colonies in New York State.

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.

In April 2000, NYSDEC accepted a Final Environmental Impact Statement (NYSDEC 2000) regarding eastern Lake Ontario cormorant management. The statement outlined a 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.

Through 2003 NYSDEC cormorant management was conducted under individual USFWS permits for each colony. Using techniques available during that period, 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 management by NYSDEC without applying for and receiving individual permits. Non-lethal management actions were continued and some lethal control (culling), which was permitted under the Depredation Order, was used to reduce cormorant numbers more rapidly, beginning in 2004.

In May 2016 a federal court decision vacated an extension of the Public Resource Depredation Order. As a result, all cormorant management activities were terminated in May of that year which resulted in a much reduced and less effective management effort that year. No cormorant population control efforts were undertaken in 2017.

Methods

Cormorant management in the New York waters of Lake Ontario's eastern basin has focused on Bass, Calf, Gull and Little Galloo Islands. These islands are located in Jefferson County, New York. Gull and Little Galloo Islands are owned by New York State and managed by NYSDEC. Bass and Calf Islands are privately owned. The islands historically contained several colonial waterbird colonies (Table 1), and most were monitored annually. Management and monitoring activities were carried out by Region 6 NYSDEC staff, sometimes with assistance of U.S. Department of Agriculture, Wildlife Services personnel. Cormorant management activities have included nest removal, egg oiling and culling. No cormorant management activities were conducted in 2017. However, nest counts were conducted on islands in the St. Lawrence River and the Eastern basin of Lake Ontario.

Nest removal efforts began on Gull and Bass Islands in 1994. Calf Island was included in removal activities following observation of cormorant nests on the island 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).

When the Depredation Order was in effect, 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. From 1999 through 2015 oil was applied to accessible nests three to five times per season, at roughly two week intervals. Oiling at two week intervals ensured that most nests would be treated at least twice during the incubation period. In 2016 only two oil applications were made because a federal court decision in May vacated the depredation order under which this activity is conducted. 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).

Under the Depredation Order, 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. No culling was conducted during 2015 – 2017. Most culling, when conducted, 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

Unless otherwise indicated, the productivity rate for unoiled nests was assumed to be 2.0 chicks fledged per nest (Sullivan et al. 2006).

No correction was made for in-season bird movements or natural mortality**.**

Results

Since the nest removal program began on Gull, Bass and Calf Islands in 1994, nesting attempts (including re-nests) on these islands have varied from year to year with a peak of 1,367 nests in 2000 (Table 2).

Since 2007, greatly increased landowner activity on Bass Island has prevented significant waterbird production and made active cormorant management unnecessary. Cormorants have not attempted to nest on Calf Island since 2010 (Table 2.)

Due to historic flooding of the river and lake in 2017 (about three feet above normal levels), many islands were 50% or more underwater. While nest counts on many islands were substantially less than previous years, however, overall DCCO nest counts were about the same as 2016 since many islands that are usually vacant were utilized in 2017, primarily in the St. Lawrence River. On Little Galloo island, the peak nest count was made on 15 June, and totaled 1999 apparently occupied nests which was a decrease of 8% from 2016.

We estimated that the Little Galloo Island colony generated 1,044,278 feeding-days in 2017, substantially above the target of 780,000 (Figure 1) and a 12% increase over the 934,552 feeding-days generated in 2016. There were approximately 368,000 feeding days attributed to chicks in 2017. Cormorant feeding days at Little Galloo Island remained within 10% of target most years from 2006 to 2015. In 2016, feeding days exceeded the target by 20% and in 2017 by 34% due largely to the presence of large numbers of chicks. Since feeding day estimates were well above target (Figure 1), management effort will be increased in 2018 if the federal regulatory situation allows.

Nest counts for other colonial waterbirds (except Ring-billed Gulls) were conducted in 2017 on three eastern basin islands. Bass Island hasn't supported any colonial waterbird nesting since 2007. Caspian Terns continued to maintain a stable colony on Little Galloo Island. Great Black-backed Gulls have not been detected on any of the islands since 2008. Common Terns nested on Little Galloo Island for the first time in 2013, 15 nests were counted in 2016 and 11 in 2017.

Black-crowned Night Herons have not been found on Little Galloo Island since 2008. Due to the lack of a Depredation Order in 2017, cormorant nests on Gull Island (Lake Ontario) were not removed as in previous years. This is usually done to reduce competition for nesting sites with Black-crowned Night Herons since Gull island is the only remaining Eastern basin island that they nest on. The June count on Gull Island totaled a record high of 508 DCCO nests on 15 June (64% increase from 2016). No night heron nests were found on the island in 2017 probably due to competition with cormorants for nesting habitat. This is the first year, since counting began in 1995, that there has been zero night heron nests on the island (Table 1).

Discussion

The DCCO population had been near, or below, the feeding-day target since 2006, and the management effort was operated at a maintenance level from 2007-2015 (Figure 1). However, the estimated feeding days increased in both 2016 and 2017.

Reduced cormorant population levels at Little Galloo Island, believed to be related to egg oiling, became noticeable in 2002. Johnson et al. (2004) reported a substantial decline in fish consumption at this colony due to lack of consumption by chicks, and lower numbers of feeding adults resulting from reduced recruitment. The reduction in feeding adults continued at least through 2013 (Johnson et al. 2014) and probably longer. In 2016 the production of numerous chicks resulted in an immediate increase in feeding days. Chick feeding days were estimated to be greater in 2017. Lacking management intervention, recruitment of breeding adults based on increased chick production can be expected to increase cormorant numbers in this, and possibly other, colonies in coming years.

Impacts on fish populations of recreational interest have thus far declined faster than fish consumption as a whole, because cormorant diet has become dominated by round goby (*Neogobius melanostomus*) (Johnson et al. 2014). Through 2015 cormorant population management, along with the major dietary shift, moved the system towards meeting objectives for protecting fish communities by substantially reducing consumption of smallmouth bass by cormorants at Little Galloo Island (Johnson et al. 2006). However, the continuation of this trend is presently uncertain.

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, Herring Gulls and Black-crowned Night Herons. Common Terns were first observed nesting on Little Galloo Island in 2013 and have continued to nest on the island. In 2016, Caspian Terns and Herring Gulls approached the record high nest counts seen in 2014. In the absence of effective cormorant management in 2016, nests of Black-crowned Night Herons on Gull Island declined by about 67% and were absent in 2017 (Table 1).

Many variables, in addition to the regulatory environment, can influence cormorant management results over time. 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 and raised the breeding population within New York waters of the basin.

Site-specific management is a 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. When allowed to proceed, efforts undertaken in New York have successfully met objectives for limiting production of cormorants on New York's Lake Ontario eastern basin islands, reducing predation on fishes of interest and protecting other waterbird populations.

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.

Acknowledgements

We would like to acknowledge the contribution of technicians Liz Truskowski, Adam Bleau, Cody Nichols, Nick Yerden and Hope Van Brocklin who performed much of the field work reported here.

References

Adams, C.M., C.P. Schneider and J.H. Johnson. 1999. Predicting the Size and Age of Smallmouth Bass (*Micropterus dolomieu*) consumed by Double- crested Cormorants, (*Phalacrocorax auritus*) in Eastern Lake Ontario, 1993-1994. In: Final Report: To Assess the Impact of Double-crested Cormorant Predation on the Smallmouth Bass and Other Fishes of the Eastern Basin Of Lake Ontario. NYSDEC Special Report. N.Y.S. Dep. Environ. Conserv. and U.S. Geol. Survey.

Hatch, J.J. 1995. Changing populations of Double-crested Cormorants. Colonial Waterbirds 18 (Special Publication):8-22.

Johnson, J.H., R.M. Ross and J. Farquhar. 2004. The Effects of Egg Oiling on Fish Consumption by Double- crested Cormorants on Little Galloo Island, Lake Ontario in 2003. *In* Double-crested Cormorant predation on smallmouth bass and other fishes of the Eastern Basin of Lake Ontario. Special Report N.Y. Dept. Environ. Conservation. Albany, N.Y.

Johnson, J.H., R.M. Ross, R.D. McCullough, and B. Boyer. 2006. Diet composition and fish consumption of double-crested cormorants from the Little Galloo Island colony of eastern Lake Ontario in 2005. Section 14 *in* NYSDEC Annual report 2005, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission Lake Ontario Committee.

Johnson, J.H., R.D. McCullough and I.M. Mazzocchi. 2014. Double- crested Cormorant studies at Little Galloo Island, Lake Ontario in 2013: diet composition, fish consumption and the efficacy of management activities in reducing fish predation. *in* NYSDEC Annual report 2013, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Lantry, B.F., T.H. Eckert, and C.P. Schneider. 2002. The relationship between the abundance of smallmouth bass and double-crested cormorants in the eastern basin of Lake Ontario. Journal of Great Lakes Research. 28(2):193-201.

Miller, R.L. 1998. Double-crested Cormorant. Pages 118-120 *in* E. Levine, editor, Bulls Birds of New York State. Comstock Publishing Associates, New York. NYSDEC. 2000. Application to the U.S. Fish and Wildlife Service for a Migratory Bird Depredation Permit for the take of cormorants on Lake Ontario Islands, New York.

NYSDEC 2000. Final environmental impact statement on proposed management of Double-crested Cormorants in U.S. waters of the eastern basin of Lake Ontario. NYSDEC Watertown NY.

Price, I.M. and D.V. Weseloh. 1986. Increased numbers and productivity of Double- crested Cormorants, *Phalacrocorax auritus*, on Lake Ontario. Canadian Field Naturalist 100:474-482.

Schiavone A. Jr. and R.D. Adams. 1995. Movement of sea lamprey past the Dexter Dam complex on the Black River, New York. 1995 Annual Report, NYSDEC Bureau of Fisheries Lake Ontario Unit to the Lake Ontario Committee and the Great Lakes Fishery Commission.

Shonk, K. 1998. The Effect of Oil Spraying of Double-crested Cormorants, *Phalacrocorax auritus*, and other egg laying parameters. B.S. Thesis, Wilfrid Laurier Univ.,Waterloo, ON.

Sullivan, K.L., P.D. Curtis, R.B. Chipman and R.D. McCullough. 2006. Cormorant: issues and management. Cornell University, Ithaca NY, 32 pp.

USFWS. 2003. Final Environmental Impact Statement, Double-crested Cormorant Management in the United States. U.S. Department of the Interior, Fish and Wildlife Service publication. 208 pp.

Weseloh, D.V. and B. Collier. 1995. The rise of the Double-crested Cormorant on the Great Lakes : winning the war against contaminants. Great Lakes Fact Sheet. Canadian Wildlife Service, Environment Canada, Burlington, ON.

Weseloh, D.V., P.J. Ewins, J. Struger, P. Mineau, C.A. Bishop, S. Postupalsky and J.P. Ludwig. 1995. Double- crested Cormorants of the Great Lakes: changes in population size, breeding distribution and reproductive output between 1913 and 1991. Colonial Waterbirds 18 (Special Publication):48-59.

Weseloh, D.V. and C. Pekanik 1999. Numbers of double-crested cormorant nests in Lake Ontario colonies, 1995-1999. Canadian Wildlife Service, Downsview, Ontario.

Table 1. Estimated breeding pair numbers for colonial waterbirds on eastern basin Lake Ontario islands. Numbers for cormorants on Bass and Gull Islands are for active nests after management activity and may not match Bureau of Wildlife trend numbers which are taken in mid June. *Dash indicates not checked for given species, LGI-Little Galloo Island.*

Species	Island	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Double-crested Cormorant	LGI	5,119	5,440	4,780	4,251	3,967	3,401	2,692	2,959	2,492	2,751	1,758	2,831	2,227	2,387	2,283	2,264	2,161	1999
	Gull I	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	323	508
	Bass Island	0	0	0	35	12	5	5	5	0	0	0	0	0	0	0	0	0	0
Ring-billed Gull	LGI	-	-	-	60,000	-	-	-	-	37,500	-	-	-	43,324	-	-	-	-	-
	Gull I	-	-	-	0	-	-	-	-	0	-	0	-	0	0	0	0	0	0
	Bass I	-	-	-	2,500	-	-	-	-	0	-	-	-	0	0	0	0	0	-
Herring Gull	LGI	-	-	-	313	-	-	367	0	375	356	364	459	512	645	979	784	971	579
	Gull	-	-	-	42	-	-	40	67	58	42	89	91	52	89	109	-	29	55
	Bass I	-	-	-	10	-	-	10	16	0	0	0	0	0	0	0	0	0	-
Great Black-backed Gull	LGI	-	19	15	12	-	-	4	1	1	0	0	0	0	0	0	0	0	0
	Gull I	-	0	1	0	-	-	0	0	9	0	0	0	0	0	0	0	0	0
	Bass I	-	0	0	0	-	-	0	0	9	0	-	-	0	0	0	0	0	0
Caspian Tern	LGI	1,350	1,590	1,585	1,658	1,560	1,788	1,589	1,580	1,376	1,499	1,472	1,934	2,332	1,848	2,436	2,084	2,354	2,511
Black-crowned Night Heron	LGI	1	1	1	3	3	4	0	0	1	0	0	0	0	0	0	0	0	0
	Gull I	20	50	24	35	78	81	77	127	78	78	105	151	44	56	79	106	39	0
	Bass I	36	13	36	47	17	46	32	0	0	0	0	0	0	0	0	0	0	0
	Calf I	-	0	-	-	0	-	-	-	-	13	0	0	0	0	0	0	0	0
Common Tern	LGI	0	0	0	0	0	0	0	0	0	0	0	0	0	20	34	30	15	3

Table 2. Number of cormorant nests removed or oiled and cormorant (DCCO) adults culled; nests with no intact eggs were not oiled. Cumulative nests removed. Number in ( ) is peak one day count, x-management unnecessary due to landowner activity.

Island		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Little Galloo I.	Peak nests oiled	4,301	3,865	3,707	3,389	3,359	2,896	2,275	2,502	1,804	2,166	1,104	2,000	1,600	1,456	1,625	1,546	914	0
	Nests removed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	DCCO culled	-	-	-	-	18	686	620	709	382	798	145	569	362	366	150	0	0	0
Bass I.	Peak nests oiled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Nests removed	793 (757)	0 (0)	986 (279)	260 (117)	959 (348)	935 (600)	477 (174)	470 (110)	x	x	x	x	x	x	x	x	x	x
	DCCO culled	-	-	-	-	167	281	200	124	x	x	x	x	x	x	x	x	x	x
Gull I.	Peak nests oiled	0	0	0	0	0	0	0	0	x	x	x	x	x	x	x	x	x	x
	Nests removed	574 (478)	21 (21)	157 (77)	1,427 (486)	485 (188)	0 (0)	113 (110)	273 (137)	671 (266)	741 (261)	604 (275)	659 (302)	711 (391)	1,072 (276)	603 (235)	769 (276)	149 (149)	0 (0)
	DCCO culled	-	-	-	-	3	0	0	20	2	0	0	0	29	0	0	0	0	0
Calf I.	Peak nests oiled	0	0	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	0	0
	DCCO culled	-	-	-	-	37	0	0	0	6	2	0	0	0	0	0	0	0	0

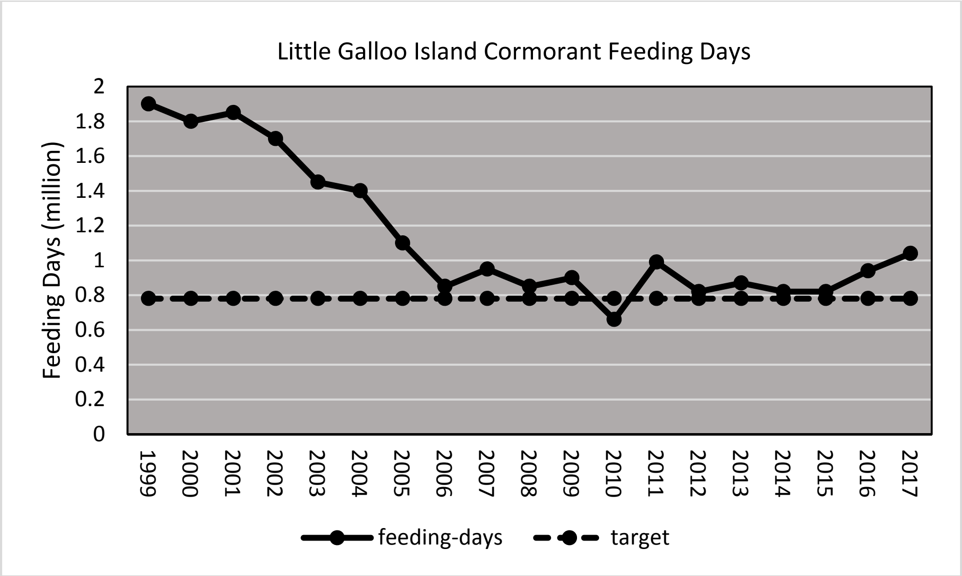

Figure 1. Trend in cormorant feeding days for the Little Galloo Island colony.

Salmon River Angler Survey
Fall 2017

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Introduction

Angler surveys of all the major tributaries to Lake Ontario in New York were conducted in 2005-2006 and 2006-2007 (Prindle and Bishop 2007). The purpose of these surveys was to provide baseline information for a longer-term data set consisting of periodic surveys to monitor trends in the Lake Ontario tributary fishery. The most recent comprehensive tributary survey was conducted in 2015-2016.

A Salmon River only angler survey is being conducted from September 2017 through mid-May 2018. This report is part of that study and covers the traditional "salmon season" from September through November. A subsequent final survey report will be produced in 2018.

Prior to the 2005 survey, the last comprehensive tributary survey was the 1984 New York State Great Lakes Angler Survey (NYSDEC 1984). Creel surveys of varying duration and purpose were also conducted on the Salmon River in 1989 (Connelly et al. 1989), 1992 (Bishop 1993), and 1997 through 2004 (Bishop 1998-2004, Bishop and Penney-Sabia 2005). The 1989 survey covered the fall fishery, through the salmon and early steelhead runs. The 1992 survey captured the salmon run, but ended on November 1st, missing most of the fall steelhead fishery. The 1997-2003 surveys were conducted from mid-October through the last weekend in November to examine the fall steelhead angling seasons. The 2004 survey ran from the day after Labor Day through the last weekend in November, to cover the fall salmon and steelhead fisheries. Several creel surveys have also been conducted on (non-Salmon River) eastern Lake Ontario tributaries since 1982 (McCullough and Einhouse 2003).

The Salmon River survey results presented here cover the period 1 September through 26 November, 2017

Methods

<u>Data Collection</u>

We used an instantaneous access site survey design on the Salmon River employed since 2004. Counts (numbers of anglers, vehicles and/or boats) and interviews were conducted from the estuary upstream to the Upper Fly Zone.

We estimated effort (numbers of angler hours and angler trips), catch and harvest (total numbers), and catch and harvest rates (fish per angler hour) for each fishing type (conventional regulations shore access, drift boat, special regulations catch and release fly fishing, tributary, and estuary boat) on the Salmon River. For interviews, we recorded site, date, interview time, residency, angler party size, start time, time taken for breaks, trip status (complete versus incomplete), species targeted, fish kept and released, weather effects, and any relevant comments made by the angler or survey agent. A set of angler satisfaction questions were also posed to the anglers. The proportion of non-NYS resident anglers was also calculated.

A detailed description of the statistical analyses used in this report is provided in Appendix 1. All statistical analyses were done with SAS release 8.0 (SAS Institute 1999).

The survey agent sampled three randomly selected weekdays and one weekend day each week. We used a staggered shift to cover the morning counts and interviews; the afternoon shift continued until ½ hour after sunset. Twenty-five sites were sampled for vehicle, angler, and boat (or boat trailer) counts, and angler interviews.

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

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

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

Time not spent conducting instantaneous counts during a shift was used to interview anglers. Interviews from anglers who had been fishing for at least ½ hour were used in the analyses. (Appendix 1).

Results and Discussion

Angler Effort

The estimated angler effort during fall 2017 on the Salmon River was 641,206 hours (Table 1). This was the second highest estimated effort of the surveys completed since 2005, with 2011 having 751,127 hours (Table 1). The estimated number of angler trips (95,121 trips) was also the second highest for recent surveys; again, second only to 2011 (112,109 trips; Tables 1 and 2).

As in previous surveys, the conventional regulation sections of the river had by far the highest estimated effort at 551,921 hours (84 % of the total) (Table 1). The special regulations fly fishing-only zones were a very distant second place accounting for just 7% of the estimated effort.

October remained the most intensively fished month on the Salmon River accounting for 361,464 angler hours in 2017, and 55% of the total estimated fall effort (Table 2). The September 2017 effort estimate was the highest for that month amongst recent surveys at 227,934 estimated hours, well above the next highest value of 148,389 in 2011 (Table 2). The first week in October had the highest weekly estimate of any week in the surveys completed since 2005, with an estimated 152,009 angler hours (Table 2).

The morning car count conducted on 7 October 2017 yielded 1,398 vehicles at the access locations. Each year the effort increases during September with a peak in either the first or second week in October. By the fourth week in October the effort drops substantially as spawning activities diminish. The trend in fishing effort over time for the Salmon River appears similar to that observed in the open lake boat fishery (Lantry and Eckert 2018), with a peak in the late 1980s and early 1990s (Table 3). Observed declines from peak effort were of similar magnitude (approximately 50%) for both the tributary and open lake fisheries. However, Salmon River angler effort returned to historic levels beginning in 2010.

The 2017 open lake boat fishing effort was estimated at 685,818 angler hours (Lantry and Eckert 2018). The 2017 Salmon River fall effort estimate was 96% of the 2017 open lake boat fishing effort estimate. The fall 2017 Salmon River fishery accounted for an estimated 96,456 trips (Table 1) while the

Table 1. Estimated angler effort by fishing type/area from the Salmon River angler surveys by year.

	2005			2006			2011			2015			2017		
Fishing type	Effort (angler hrs)	Mean trip length	Est. angler trips	Effort (angler hrs)	Mean trip length	Est. angler trips	Effort (angler hrs)	Mean trip length	Est. angler trips	Effort (angler hrs)	Mean trip length	Est. angler trips	Effort (angler hrs)	Mean trip length	Est. angler trips
Shore access (conv. regs.)	373,551	6.4	58,367	352,050	6.8	52,156	617,459	6.8	90,803	490,806	6.0	82,350	551,921	6.79	81,276
Drift boat	19,172	7.3	2,637	14,188	7.7	1,833	32,710	7.5	4,373	21,973	7.2	3,060	22,614	7.00	3,231
Special regs. Fly	44,435	6.4	6,900	40,187	6.5	6,164	58,086	6.9	8,480	51,429	6.2	8,268	44,374	6.67	6,654
Estuary boat	9,476	4.5	2,092	9,867	6.3	1,571	16,330	5.9	2,754	10,032	4.7	2,130	7,111	5.15	1,381
Tributaries	37,157	6.0	6,245	50,755	6.5	7,773	26,543	4.9	5,439	14,259	4.4	3,248	15,186	5.89	2,579
Total	483,792	6.4	75,593	467,048	6.8	69,049	751,127	6.7	112,109	588,498	6.5	90,818	641,206	6.80	95,121

Table 2. The estimated weekly, monthly, and seasonal angler effort (angler hours) for the Salmon River by year

	2005	2006	2011	2015	2017
Sept. 1	*	*	9,402	8,141	43,500
Sept. 2	20,928	7,385	27,661	11,120	25,171
Sept. 3	35,285	29,781	42,634	27,701	61,718
Sept. 4	57,408	42,766	68,692	48,602	97,545
All Sept.	107,789	79,931	148,389	95,564	227,934
Oct. 1	79,216	91,334	114,711	89,474	152,009
Oct. 2	104,841	110,372	143,938	113,105	98,979
Oct. 3	66,993	89,264	97,438	95,451	70,147
Oct. 4	38,681	39,763	64,173	52,071	33,624
Oct. 5	15,119	11,631	35,811	31,730	6,705
All Oct.	287,443	342,365	456,071	381,831	361,464
Nov. 1	22,966	8,963	42,536	37,087	13,353
Nov. 2	18,073	12,493	43,272	31,037	21,697
Nov. 3	15,178	8,456	31,233	22,640	16,330
Nov. 4	9,104	14,841	29,626	20,339	14,928
All Nov.	61,418	44,752	146,667	111,103	66,308
Fall total hrs	483,792	467,048	751,127	588,498	655,706
Fall total trips	75,985	83,409	112,109	101,465	95,121

Table 3. The number of interviews and percent of non-New York State residents from the Salmon River Angler Survey (Sept through Nov) by year.

Year	Number of interviews	% non-NYS resident
2005	1,786	64
2006	1,488	70
2011	2,468	63
2015	1,939	65
2017	1,019	67

estimated open lake boat trips in 2017 was 112,503 (Lantry and Eckert 2018).

High water levels in Lake Ontario during 2017 significantly impacted boating access well into July and likely contributed to decreased open lake fishing effort.

Interviews and Residency
A total of 1,019 interviews were obtained during the fall 2017 survey, down from previous studies (Table 3). However, during the 2017 survey the anglers were asked a series of additional questions which diminished the time available to obtain interviews.

Sixty-seven percent of Salmon River anglers interviewed during fall 2017 were non-New York State residents (Table 3), similar to previous surveys.

<u>Catch and Harvest</u>
Chinook Salmon
The estimated catch of Chinook salmon from the Salmon River in 2017 was 109,840 fish (Table 4), by far the highest catch since the 1980's. It also surpassed the estimated 2017 open water boat angler of 96,226 fish (Lantry and Eckert 2018). By comparison, the estimated 2015 Salmon River catch was only 23,940 Chinooks (Table 5).

The 2017 Chinook salmon harvest estimate was 34,934 fish (Table 6), This translates to a 68% release rate for a species that dies after spawning. In 2015, when the catch was markedly lower, the release rate was only 49%.

Chinook salmon catch by month in 2017 continued historic patterns, with the highest number of Chinook salmon caught in October (60% of total), followed by September (40% of total) (Table 5). One notable result from 2017 was the unusually precipitous decline in Chinook salmon caught in November (n=27; Table 5).

As in past Salmon River surveys, the conventional regulations section yielded by far the highest number of Chinook salmon caught and harvested (86,398 and 27,370 fish, respectively; Tables 7 and 8). The special regulations fly-only zone was the only other area that totaled more than 10,000 fish caught (12,858 fish; Table 7).

Coho Salmon
Coho salmon were a smaller component of the fishery in 2017, totaling only 15,167 fish caught (Table 5). While this result was roughly twice the estimated catch of 5,380 coho during the fall of 2015, it is still only half of the 2011 estimated catch (Table 5). The 2017 release rate was 62%, with 5,746 fish harvested (Table 6).

Unlike Chinook salmon, September and October vary as to which has the highest monthly catch of coho. Coho catch was considerably higher in October 2017 (n=9,727 fish) compared to September (n=5,400 fish; Table 5).

Steelhead
Steelhead is the primary species sought by post-salmon run Salmon River anglers. This fishery gains momentum in mid-October as fish enter the river and the salmon run begins to decline, and extends into mid-May with the "drop-back" fishery. Thus, steelhead are the most important species in the late fall through early spring fishery.

The estimated steelhead catch from the 2017 fall "salmon season" was 17,165 the second highest catch among recent surveys (Table 5). The estimated number of steelhead harvested in fall 2017 was 2,344, which equates to an 86% release rate (Table 6). The release rate typically increases as the salmon season wanes.

As with Chinook salmon, the conventional regulations portions of the river accounted for most of the fish landed with 11,855 (Table 7). Drift boats came in second, landing an estimated 3,656 steelhead during fall 2017 (Table 7). The conventional regulations section of the river also had the highest estimated harvest (1,645) (Table 8)

Table 4. Summary statistics for angler surveys conducted on the Salmon River since 1984

			Chinook salmon		Steelhead	
Year	Dates	Angler trips	Catch	Harvest	Catch	Harvest
1984	Sept-Nov	107,306	143,244	83,784	15,529	8,359
1984	Jan 1 to Dec 31	140,911	143,244	83,784	36,925	20,699
1989	Aug 17 to Dec 4	180,400	150,100	69,200	8,150	4,350
1992	Sept 3 to Nov 1	103,900	80,300	55,900		
1997	Oct 20 to Nov 30	7,061	----	----	1,543	554
1998	Oct 19 to Nov 29	7,009	----	----	2,830	523
1999	Oct 18 to Nov 28	11,372	----	----	4,751	1,010
2000	Oct 16 to Nov 26	11,231	----	----	2,870	806
2001	Oct 15 to Nov 25	12,563	----	----	3,660	746
2002	Oct 21 to Dec 1	9,381	----	----	2,743	555
2003	Oct 20 to Nov 30	6,183	----	----	1,960	357
2004	Sept 7 to Nov 28	90,825	85,251	24,360	6,924	1,314
2005	Sept 6 to Nov 30	75,985	89,448	25,998	7,738	1,441
2005-2006	Sept 6 to May 15	98,959	89,448	25,998	20,705	2,713
2006	Sept 9 to Nov 26	83,409	96,088	33,530	9,509	2,002
2006-2007	Sept 9 to May 16	87,539	96,088	33,530	21,489	3,869
2010	Sept 7 to Nov 28	113,747	66,134	28,914	32,146	3,954
2011	Sept 1 to Nov 27	112,109	85,106	31,516	39,697	3,657
2015	Sept 1 to Nov 29	101,465	23,940	12,305	11,334	1,401
2015-2016	Sept 1 to May 15	129,018	23,940	12,305	25,335	3,427
2017	Sept 1 to Nov 30	95,121	109,840	34,934	17,164	2,344

Table 5. Estimated catch rates with the associated estimated total catch by species and month.

Chinook Salmon	September		October		November		Overall*	
Year	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch	CPUE	Est. Catch
2005	0.215	39,431	0.250	43,114	0.026	1,668	0.185	84,213
2006	0.118	20,228	0.256	64,143	0.094	4,195	0.192	88,566
2011	0.072	18,915	0.164	55,703	0.009	1,347	0.115	75,965
2015	0.030	2,715	0.058	19,170	0.007	694	0.041	22,579
2017	0.195	44,424	0.181	65,389	0.000	27	0.165	109,840
Coho Salmon								
2005	0.022	4,002	0.01	1,558	0.004	245	0.012	5,805
2006	0.065	11,095	0.01	2,099	0.013	599	0.029	13,793
2011	0.062	16,314	0.04	12,771	0.008	1,213	0.039	30,298
2015	0.002	208	0.02	4,903	0.003	269	0.010	5,380
2017	0.024	5,400	0.03	9,727	0.001	40	0.023	15,167
Steelhead								
2005	0.007	1,256	0.004	929	0.084	5,169	0.016	7,354
2006	0.010	1,637	0.012	2,950	0.102	4,554	0.019	9,141
2011	0.008	2,152	0.030	10,062	0.144	20,983	0.054	33,197
2015	0.002	167	0.012	1,102	0.049	5,109	0.019	6,378
2017	0.002	467	0.023	8,198	0.128	8,499	0.028	17,165
Brown Trout								
2005	0.008	1,435	0.004	982	0.033	2,015	0.011	4,432
2006	0.009	1,548	0.003	630	0.005	208	0.005	2,386
2011	0.004	950	0.004	1,241	0.008	1,173	0.005	3,364
2015	0.002	204	0.002	518	0.006	635	0.003	1,357
2017	0.002	372	0.002	792	0.004	235	0.002	1,399
Atlantic Salmon								
2005	0.000	51	0.000	0	0.001	80	0.000	131
2006	0.000	32	0.000	82	0.001	40	0.000	154
2011	0.001	96	0.000	91	0.001	110	0.000	298
2015	0.001	800	0.000	165	0.000	88	0.000	1,053
2017	0.000	0	0.000	36	0.000	0	0.000	36

* = The overall total is a summation of the monthly catch estimates.

The overall CPUE values are based on all the interviews during the three-month survey.

Table 6. Estimated harvest rates with the associated estimated total harvest by species and month.

Chinook Salmon	September		October		November		Overall*	
Year	**HPUE**	**Est. Harv.**	**HPUE**	**Est. Harv.**	**HPUE**	**Est. Harv.**	**HPUE**	**Est. Harv.**
2005	0.046	8,425	0.075	15,812	0.004	240	0.054	24,477
2006	0.029	4,917	0.099	24,824	0.023	1,009	0.067	30,750
2011	0.022	5,834	0.061	20,784	0.002	350	0.042	26,968
2015	0.016	1,438	0.029	9,786	0.004	370	0.021	11,594
2017	0.061	13,854	0.049	17,813	0.049	3,268	0.047	34,934
Coho Salmon								
2005	0.007	1,331	0.004	844	0.001	83	0.005	2,258
2006	0.011	1,911	0.003	808	0.001	29	0.006	2,748
2011	0.016	4,303	0.016	5,420	0.004	514	0.014	10,237
2015	0.001	97	0.006	1,959	0.001	107	0.004	2,163
2017	0.012	2,742	0.008	2,964	0.001	40	0.009	5,746
Steelhead								
2005	0.000	71	0.001	223	0.009	575	0.003	869
2006	0.001	216	0.003	856	0.015	687	0.004	1,759
2011	0.002	594	0.003	1,176	0.010	1,522	0.005	3,292
2015	0.000	0	0.001	105	0.007	732	0.002	837
2017	0.001	324	0.004	1,413	0.009	607	0.004	2,344
Brown Trout								
2005	0.001	189	0.001	194	0.003	184	0.001	567
2006	0.003	488	0.000	93	0.000	0	0.001	581
2011	0.000	123	0.000	98	0.001	201	0.001	422
2015	0.001	48	0.000	43	0.000	11	0.000	102
2017	0.000	0	0.000	4	0.000	4	0.000	8
Atlantic Salmon								
2005	0.000	0	0.000	0	0.000	0	0.000	0
2006	0.000	0	0.000	0	0.000	0	0.000	0
2011	0.000	7	0.000	0	0.000	0	0.000	7
2015	0.000	0	0.000	47	0.000	0	0.000	47
2017	0.000	0	0.000	0	0.000	0	0.000	0

* = The overall total is a summation of the monthly catch estimates.

The overall HPUE values are based on all the interviews during the three-month survey.

Table 7. Estimated catch rates with the associated estimated catch by species, year and Salmon River section.

		2005		2006		2011		2015		2017	
Species	Fishing type	Est. catch rate*	Est. catch	Est. catch rate*	Est. catch	Est. catch rate*	Est. catch	Est. catch rate*	Est. catch	Est. catch rate*	Est. catch
Chinook salmon	Shore access-conv. regs	0.175	65,461	0.132	50,121	0.122	73,045	0.036	16,946	0.157	86,398
	Drift boat	0.215	4,129	0.104	1,465	0.056	2,037	0.043	895	0.138	3,112
	Special regs. Fly	0.118	5,226	0.070	2,949	0.110	6,287	0.061	2,950	0.290	12,858
	Estuary boat	0.008	76	0.455	4,490	0.063	1,058	0.045	426	0.097	687
	Tributaries	0.347	12,905	0.469	25,961	0.148	3,569	0.089	1,207	0.209	3,172
	All types[1]	0.185	84,213	0.192	88,566	0.115	75,965	0.041	22,579	0.165	109,840
Steelhead	Shore access-conv. regs	0.011	4,150	0.016	5,948	0.048	28,674	0.016	7,529	0.021	11,855
	Drift boat	0.083	1,591	0.143	2,007	0.135	4,909	0.066	1,367	0.162	3,656
	Special regs. Fly	0.041	1,829	0.033	1,390	0.098	5,628	0.038	1,867	0.045	1,991
	Estuary boat	0.000	0	0.072	707	0.048	807	0.003	25	0.000	0
	Tributaries	0.002	71	0.003	180	0.004	88	0.000	0	0.000	0
	All types[1]	0.016	7,354	0.019	9,141	0.054	33,197	0.019	6,378	0.028	17,165
Brown trout	All types	0.011	4,432	0.005	2,386	0.005	3,364	0.003	1,357	0.002	1,399
Coho salmon	All types	0.012	5,805	0.029	13,793	0.039	30,298	0.010	5,380	0.023	15,167
Atlantic salmon	All types	0.000	131	0.000	154	0.000	298	0.000	1,053	0.000	36

1 – The difference in the total catch and the sum of the fishing types are due to lacking interview data for some of the smaller strata
* = Rates are the number of fish caught / angler hour

Table 8. Estimated harvest rates with the associated estimated harvest by species, year and Salmon River section.

		2005		2006		2011		2015		2017	
Species	Fishing type	Est. harvest rate*	Est. harvest	Est. harvest rate*	Est. harvest	Est. harvest rate*	Est. harvest	Est. harvest rate*	Est. harvest	Est. harvest rate*	Est. harvest
Chinook salmon	Shore access-conv. regs	0.049	18,252	0.042	15,913	0.044	26,191	0.019	8,943	0.050	27,370
	Drift boat	0.049	937	0.052	729	0.025	905	0.027	568	0.089	2,009
	Special regs. Fly	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
	Estuary boat	0.007	66	0.117	1,153	0.047	776	0.045	426	0.066	472
	Tributaries	0.130	4,835	0.160	8,841	0.120	2,890	0.085	1,155	0.025	378
	All types[1]	0.054	24,477	0.067	30,750	0.042	26,968	0.021	11,594	0.047	34,934
Steelhead	Shore access-conv. regs	0.002	672	0.003	1,259	0.005	2,836	0.002	1,009	0.003	1,645
	Drift boat	0.013	243	0.045	640	0.020	713	0.014	289	0.029	652
	Special regs. Fly	0.000	0	0.000	0	0.000	0	0.000	0	0.000	0
	Estuary boat	0.000	0	0.000	0	0.002	26	0.003	25	0.000	0
	Tributaries	0.000	0	0.001	47	0.003	79	0.000	0	0.000	0
	All types[1]	0.003	869	0.004	1,759	0.005	3,292	0.002	837	0.004	2,344
Brown trout	All types	0.001	567	0.001	581	0.001	422	0.000	102	0.000	8
Coho salmon	All types	0.005	2,258	0.006	2,748	0.014	10,237	0.004	2,163	0.009	5,746
Atlantic salmon	All types	0.000	0	0.000	0	0.000	7	0.000	47	0.000	0

1 – The difference in the total harvests and the sum of the fishing types are due to lacking interview data for some of the smaller strata
* = Rates are the number of fish harvested / angler hour

Atlantic Salmon

An estimated 36 Atlantic salmon were landed in the Salmon River during fall 2017 (Table 5). This is a dramatic reduction from the 2015 estimate of 1,053 Atlantics caught in the same period (Table 5). However, the abundance of Chinook salmon may have altered the Atlantic salmon behavior and distribution in 2017. Based on numerous anecdotal reports from summer anglers, Atlantics were present in in above average numbers before the Pacific salmon moved into the river.

The estimated catches from the 2005, 2006, and 2011 surveys were 131, 154, and 298 fish, respectively (Table 5). No Atlantic salmon were reported as harvested during the angler interviews in 2017, so there was a 100% release rate (Table 6). Only the 2011 and 2015 surveys had less than 100% release, with 98% and 96%, respectively. There is no consistent pattern of monthly Atlantic salmon catches over the various surveys since 2005 (Table 5).

Brown Trout

An estimated 1,399 brown trout were caught in fall 2017 (Table 5). This was on the lower end of the catch range of the recent surveys, and consistent with lower catches in the open lake boat fishery (Lantry and Eckert 2018). The highest estimated catch occurred in 2005 with 4,432 brown trout landed (Table 5). The 2017 estimated harvest was only eight fish; therefore, the release rate was 99% (Table 6). Release rates in recent surveys varied from 77% in 2006 to 92% in 2015.

As with Atlantic salmon there was no monthly pattern of brown trout catches across the surveys. In 2017, October had the highest estimated catch with 792 fish, followed by September and November with 372 and 235 fish caught, respectively (Table 5).

Angler Opinions

A series of questions were posed to anglers to get their opinions in several important areas. Some of the results are presented in Table 9.

Anglers' overall opinion of the fishery was generally favorable, with 62% being "very satisfied" and only a combined 1% in the two "unsatisfied" categories (Table 9).

The level of law enforcement on the Salmon River question indicated 68% of the respondents were of neutral opinion (Table 9). Only 2% thought there was "too much" enforcement and 31% "not enough."

The availability of fish in the Salmon River during fall 2017 appeared to be adequate, as indicated by the 90% "good" rating (Table 9), which likely contributed to the high angler satisfaction results.

Other noteworthy highlights summarized in Table 9 were that the Salmon River angling regulations were not too complicated or numerous, and more were not needed. The results were evenly split on the opinions of whether the river is too crowded or not, with many indicating that at times it is. Most of the anglers have fished the Salmon River in the past and do so more than once a year. A surprising number of Salmon River anglers also fish Lake Ontario proper.

This survey will continue until 15 May 2018, and given the potential changes in angler demographics/values as the fishery transitions primarily to steelhead, it will be interesting to see if angler's response patterns change.

Acknowledgments

Pat Sullivan of Cornell University deserves recognition for his very helpful statistical guidance.

Table 9. Summary of the additional 2017 Salmon River Anger Survey questions

Opinion of overall fishery		
Rating	Number	Percentage
Very Satisfied	393	62%
Somewhat satisfied	160	25%
Neutral	70	11%
Somewhat unsatisfied	3	0.5%
Very unsatisfied	3	0.5%
Total	629	

Opinion of law enforcement level		
Rating	Number	Percentage
Neutral	400	68%
Too much	9	2%
Not enough	180	31%
	589	

Availability of fish in 2017		
Rating	Number	Percentage
Good	551	90%
Poor	60	10%
	611	

Question	Yes	No	Sometimes*
Are there too many regulations?	35	588	
Are the regulations too complicated?	58	565	
Is the river too crowded?	263	238	127
Do we need more regulations?	74	551	
Did you fish the S.R. in past years?	578	50	
Do you fish the SR more than once/year?	431	166	
Do you also fish Lake Ontario?	265	364	

* = not offered as an option

References

Bishop, D. L. and M. E. Penney-Sabia. 2005. 2004 Salmon River Creel Survey. Section 10 *in* 2004 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Bishop, D.L. 1998-2004. 1997-2003 Salmon River Access Site Creel Survey(s). Section 10 *in* the 1997-2003 NYSDEC Annual Report(s), Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Bishop, D.L. 1993. 1992 Salmon River Creel Census. Pages 160-166 *in* 1993 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Connelly, N., T. L. Brown, and C. Dawson. 1989. Evaluation of the Impacts of Proposed Changes in Snagging Regulations on the Salmon River. NYSDEC Report, Albany, NY. 95pp.

Lantry, J.L. and T.H. Eckert. 2018. 2017 Lake Ontario Fishing Boat Census. Section 2 *in* 2017 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

Lockwood, R.N., D.M. Benjamin, and J.R. Bence. 1999. Estimating Angling Effort and Catch from Michigan Roving and Access Site Angler Survey Data. Michigan Dept. Natural Resources Fisheries Div. Research Report 2044. Lansing, MI.

McCullough, R.D. and D.W. Einhouse 2003. Eastern Basin of Lake Ontario Creel Survey, 2003. Albany, NY. Section 22 *in* the 2003 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

New York State Department of Environmental Conservation 1984. New York State Great Lakes Angler Survey, Volume 1. NYSDEC, Albany, NY.

Prindle, S.E. and D.L. Bishop. 2007. Lake Ontario Tributary Creel Survey Fall 2005 – Spring 2006 *In* 2006 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lake Fishery Commission's Lake Ontario Committee.

SAS Institute Inc. 1999. Release 8.0 TS level 00M0. Cary, NC, USA.

Appendix 1. Calculations and Formulas

Effort estimates for the <u>Salmon River</u>

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

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

where:

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

A_t = the number of anglers counted in Pulaski

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

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

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

V_t = the number of vehicles counted at the tributary access points

D_b = the number of drift boat trailers counted. Note: the (Vsr + Vuf + Vt - Db) term accounts for one pickup vehicle per drift boat being left in a downstream parking area

P_{sh} = the mean size of shore access parties (anglers/vehicle)

P_{db} = the mean size of drift boat parties

B_e = the number of boats counted in the estuary

P_{be} = the mean party size (anglers/boat) for boat access fishermen in the estuary

$daylength_j$ = the number of hours from ½ hour before sunrise to ½ hour after sunset on day *j*.

The estimator for mean angler hours for all days sampled in stratum h is:

$$\hat{H}_h = \frac{\sum_{j=1}^{n_h} \hat{H}_{j,h}}{n_h}$$

n_h = the number of days sampled in stratum *h*

and the stratum variance is:

$$s_h^2 = \frac{\sum_{j=1}^{n_h} (\hat{H}_{j,h} - \hat{H}_h)^2}{n_h - 1}$$

and the variance of $\hat{H}_h$ is:

$$V(\hat{H}_h) = \frac{s_h^2}{n_h}\left(\frac{N_h - n_h}{N_h}\right)$$

where N_h is the total number of days in the stratum h and $\left(\frac{N_h - n_h}{N_h}\right)$ is the finite population correction factor, and the standard error of $\hat{H}_h$ is:

$$SE(\hat{H}_h) = \sqrt{V(\hat{H}_h)}$$

The estimated total for all angler hours is:

$$T_H = \sum_{h=1}^{L} N_h(\hat{H}_h)$$ where L is the total number of stratum and the variance of the total is:

$$V(T_H) = \sum_{h=1}^{L} N_h^2 V(\hat{H}_h)$$

and the standard error of the total is:

$$SE(T_H) = \sqrt{V(T_h)}$$

The effort estimates were partitioned by fishing type into boat fishing in the estuary, shore access and drift boat fishing in the normal regulations portion of the main stem, fishing in the tributaries, and fishing in the special regulations catch and release fly fishing only areas. This was done to provide appropriate weighting factors for stratification of the catch data.

Drift boat effort was calculated by taking the number of drift boat trailers counted and multiplying by the mean size of drift boat party (from the interview forms). Special regulations fly fishing effort was estimated by multiplying the number of vehicles in the upper fly fishing parking area by the mean size of shore fishing parties (again, from the interview forms) and adding the number of anglers counted in the lower fly fishing area in Altmar. Note that the overall estimate of angler effort accounts for special regulations area fly fishermen with vehicle counts only. We had to count the anglers in the lower fly fishing area for the estimate of effort for the special regulations fly fishing areas, however, because there was no way to know whether vehicles parked in Altmar belonged to anglers fishing the fly fishing area or the conventional regulations area of the river. We also had to count anglers in Pulaski and in the estuary because they did not all park in designated lots. Similar partitions of the data allowed us to estimate boat effort in the estuary and effort in the tributaries. Angler trips were estimated by dividing the estimates for angler hours by the mean lengths of completed trips for each fishing type and for the overall estimate.

Catch and Harvest

These parameters were stratified for the Salmon River the same as the effort data (by week for Sept. through Nov. and month for Dec. through May) and additionally by five fishing types: shore access (conventional regulations section of the river), special regulations fly fishing, drift boat fishing, boat fishing in the estuary, and tributary fishing.

Mean catch rates were calculated as follows with the ratio of means estimator being used for the Salmon River survey. The ratio of means estimator is appropriate for access site creel surveys and the calculations followed Lockwood *et al*. 1999.

Ratio of Means Stratified Catch Rate Estimator for all Salmon River interviews

y = fish caught or harvested, *x* = hours fished by angler *i* in stratum *h* and *L* is the total number of strata.

$\hat{R}_h = \frac{\bar{y}_h}{\bar{x}_h}$ is the rate in stratum *h* and $\hat{R} = \frac{\bar{y}_{st}}{\bar{x}_{st}}$ is the overall estimator

where:

$$\bar{y}_{st} = \frac{\sum_{h=1}^{L} N_h \bar{y}_h}{N} \quad \text{And} \quad \bar{x}_{st} = \frac{\sum_{h=1}^{L} N_h \bar{x}_h}{N}$$

and the variance of $\hat{R}_h$ is:

$$V(\hat{R}_h) = \left(\frac{N_h - n_h}{N_h} \right) \frac{\sum_{i=1}^{n_h} \left(y_{i,h} - \hat{R}_h x_{i,h} \right)^2}{n_h (n_h - 1) \bar{x}_h^2}$$

and the variance of $\hat{R}$ is:

$$V(\hat{R}) = \sum_{h=1}^{L} \left(\frac{N_h}{N} \right)^2 V(\hat{R}_h)$$

References used in creating Appendix 1

Schaeffer, R.L., W. Mendenhall, III. R.L. Ott. 1996. Elementary Survey Sampling 5th Edition. Duxbury.

Jones, C.M., D.S. Robson, H.D. Lakkis, and J. Kressel. 1995. Properties of Catch Rates Used in Analysis of Angler Surveys. Transactions of the American Fisheries Society 124:911-928.

Lockwood, R.N. 2005. New York State Angler Survey Workshop Manual. Univ. of Michigan, Ann Arbor

Mood, A.M., F.A. Graybill, and D.C. Boes. 1963. Introduction to the Theory of Statistics 3rd Edition. McGraw-Hill

Hydroacoustic Assessment of Pelagic Planktivores, 2017

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Alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*) are the most abundant pelagic planktivores in Lake Ontario (Weidel et al. 2018), and the most important prey for salmon and trout which support a multimillion dollar sportfishery. Alewife make up greater than 90% of the diet of the top predator, Chinook salmon (Lantry 2001, Brandt 1986), and are also important prey for warm water predators, notably Walleye (*Sander vitreus*) (Hoyle et al. 2017). The abundance of alewife and rainbow smelt has declined since the 1980s, likely due to reduced nutrient loading, proliferation of invasive dreissenid mussels, and predation by stocked salmon and trout. Cisco (*Coregonus artedi*) and Bloater (*C. hoyi)*, both native planktivores, historically dominated the offshore pelagic prey fish community of Lake Ontario, but their populations were severely reduced in the mid-20th century due to overfishing and competition with alewife and smelt (Christie 1973). Remnant cisco populations still exist, mostly in the eastern basin, producing strong year classes only once or twice per decade (Owens et al 2003), most recently in 2012 and 2014 (OMNRF 2017). Bloater was extirpated from Lake Ontario during the mid-20th century; however, from 2012-2017, this species has been stocked by Canadian and U.S. agencies in order to reestablish this species in the lake.

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 (Weidel et al. 2018) and provide whole-lake abundance indices for alewife and rainbow smelt. In addition, the results provide insights into the midsummer distribution of these species. We present results from the 2017 survey in this report.

Cisco was previously a minor component in midwater trawling conducted during the hydroacoustic survey from 1991-2005. Recent evidence of strong cisco year classes in OMNRF trawling surveys of juveniles in 2012 and 2014 (OMNRF 2017) and increasing cisco catches during bottom trawling by USGS and NYSDEC (Weidel et al., In review) suggest that cisco populations are increasing. Cisco are still relatively rare in existing surveys, although these surveys do not target this generally pelagic fish. In 2016 and 2017, the NYSDEC, OMNRF and USGS conducted midwater trawling along with hydroacoustics in eastern and central portions of Lake Ontario as a pilot effort to evaluate methods for assessment of native Coregonine species (cisco and bloater). The preliminary results of those efforts are also reported here.

The hydroacoustic survey indexes pelagic preyfish abundance, and like other assessments, this survey employs a 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. This information is important for fisheries managers when making decisions regarding predator stocking levels (Murry et al. 2010). As with other assessment gears (e.g. bottom trawls), making the transition from relative to absolute abundance with acoustics 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 (e.g., Weidel and Walsh 2013).

We have also been exploring the “catchability” of hydroacoustic gear. Experimental sampling with vertical gillnets and upward looking hydroacoustics conducted during 2008-2014 identified some limitations to using the traditional down-looking hydroacoustic approach for achieving accurate, whole-lake estimates of alewife abundance. Increasing evidence indicates that alewife can be oriented near the surface at night and potentially undetectable with traditional down-looking acoustics because vessel draft, transducer depth, and acoustic "cone" area create a near-field acoustic "blind-spot" in the first 4 m (13.1 ft) of surface water (Connerton and Holden 2015). 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 (TS), detectability and ultimately abundance estimates (Thorne 1983). NYSDEC and OMNRF have been experimentally towing submersible acoustic equipment suspended away from the boat hull in deep water with the transducer aimed upward to detect fish near the surface. Results of upward looking acoustics conducted from 2010-2014 suggested that an average of 50% of the alewife are near the surface during the survey and undetected by downlooking acoustic methods (Connerton and Holden 2015). The values for alewife reported herein do not include a conversion factor to account for this unmeasured biomass and thus should be treated as an index of abundance between years and not as a whole lake population estimate.

We also continue to explore other potential biases of this survey. For example, the hydroacoustic survey samples most depths in proportion to the lake area except for shallow habitats (<40 m or 131 ft). This may potentially bias the alewife estimate low if significant numbers of alewife occupy these habitats and the measured densities are highly variable. Although the survey has certain limitations for sampling inside of 10 m (32.8 ft) due to vessel draft, additional sampling is possible from 10-40 m (32.8-131 ft). In 2016, we sampled additional areas over 10-40 m bottom depths to test whether increased sampling in shallow water would significantly change the survey estimate, and found that the alewife acoustic estimate was about 15% higher compared with normal transects although this difference was not statistically significantly (Holden et al 2017). In 2017, we repeated this experiment and compared the results.

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 (9.3 mi) wide were established (Figure 1) based on logistical constraints, but within these corridors, transects were selected at random. A single east-west offset was randomly chosen each year 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 2017 was 0, meaning that transects were at the eastern most boundary of the corridor. In addition to the 5 cross-lake transects, a U-shaped transect is surveyed each year in the eastern basin (Figure 1); however, no offset is applied to this transect.

The 2017 hydroacoustic survey was conducted from July 18-29 using two research vessels (R/V), OMNRF's *R/V Ontario Explorer* and NYSDEC's *R/V Seth Green*. Acoustic data were collected using a BioSonics 120 kHz split-beam echosounder set at a rate of 1 ping per second and a pulse width of 0.4 milliseconds. Each night, sampling began approximately one hour after sunset at the 10 m (32.8 ft) depth contour on one end of the transect and continued across the lake to the 10 m depth contour on the opposite end or one hour before sunrise. A temperature profile was measured hourly at points along each transect.

Hydroacoustic data were stratified by thermal layer (2 layers, upper: ≥10 °C (50 °F) to surface, and lower: <10°C to 100 m (328 ft) and geographic zone (six zones: NW, SW, N-Central, S-Central, SE, NE), and whole-lake abundance estimates were calculated as the area-weighted average of these zones. The data were processed with Echoview software (Myriax Inc. version 8.0) using -64 decibels (dB) volume backscattering strength and target strength thresholds. Targets in the lower layer were assumed to be smelt or cisco, and targets in the upper layer were assumed to be alewife or cisco depending on target strength. Thermal separation of alewife and rainbow smelt was confirmed by historical midwater trawling data collected from 2000 to 2004 which showed a thermal separation between these species (also see Schaner and LaPan 2003). Midwater tows in depths where water temperatures were 9°C or warmer were dominated by catches of alewife (95% total catch weight of prey fish species) whereas tows in depths at temperatures below 9°C captured mostly rainbow smelt (84%).

In 2014 and 2015, Connerton and Holden (2016) explored alternative methods for analyzing hydroacoustic survey data to refine estimates of whole-lake abundance. Three analytical approaches were compared for each species and data were reanalyzed for the entire time series. In general, results produced by the three methods for rainbow smelt were well correlated with each other, were reasonably correlated with spring bottom trawls (r^2=0.68), and most of the differences between the methods' results were attributed to varying TS thresholds employed by each method (Connerton and Holden 2016). The favored method from this analysis included targets ranging from -52 to -39 decibels (dB) which, according to TS vs length relationships (Love 1977), represent the rainbow smelt size distribution (60-250 mm or 2.4-9.8 in total length [TL]) typically observed in Lake Ontario (Weidel et al. 2015). The preferred approach also used a bootstrapping procedure to iteratively estimate average density based on 500 m transect intervals, and to estimate more robust confidence intervals compared with the traditional area weighted approach (AW) for smelt which produced a standard deviation based on seven lake areas (Connerton and Holden 2016).

For alewife, the traditional analysis method split the scaled, integrated voltage estimates of total target abundance in the upper layer into 1 dB target strength (TS) bins according to results of single target analysis. This produced a histogram typically with three modes (e.g., Figure 3) assumed to be: 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 alewife were apportioned from the resulting target strength histograms by fitting normal curves to the three modes using a solver routine (SR) 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 included the proportion of the targets from -45 dB to -28 dB which were assumed to be YAO alewife (Warner et al. 2002, Love 1977). The solver routine, however, was sensitive to the approximation of initial starting conditions and the distribution of non-fish targets, and the results could be affected by user judgment which made it difficult to apply a standard method annually. Connerton and Holden (2016) instead favored using a new TS range (i.e., -50 to -35 dB) which better corresponded to alewife sizes encountered in Lake Ontario (54mm-240 mm [2.1-9.4 in TL) when compared with the traditional method (-45 to -28 dB), and because 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). Two new methods were evaluated in 2015: 1) The bootstrapping method (as with rainbow smelt above) using TS thresholds -50 to -35 dB; and 2) using the area weighted approach but eliminating the SR step, and using the new TS thresholds. The SR method index showed the best correlation (r^2=0.57) with the spring bottom trawling index using results from 1997-2015 (Connerton and Holden 2016), but in 2016, the bottom trawling survey's analytical methods and resulting time series indices underwent significant changes (Weidel et al 2017). New discoveries regarding the catch efficiency of age-1 and age-2 alewife by the bottom trawl, and the distribution of alewife in New York vs Ontario waters raised new questions about potential biases of that survey (Weidel et al. 2017).

For this report, we applied the area weighted method to estimate the alewife abundance index and the bootstrapping method for rainbow smelt abundance index for the entire time series. We used TS thresholds of -52 to -39 dB for rainbow smelt for targets in the lower temperature layer (<10^{o}C). Trawling results in 2016 (Holden et al. 2017) suggested that the previous upper target strength level for alewife (i.e., -35 dB) was generally too high, therefore we used TS of -50 to -39 dB for alewife for targets in the upper temperature layer (≥10^{o}C). Also in 2016, we began considering targets from -39 to -35 dB as cisco, since this species has recently become a more abundant component of the Lake Ontario pelagic fish community based on midwater trawling done by this survey in 2016, and recent catch increases observed in gillnetting and commercial fisheries in Ontario (OMNRF 2017).

To assess the distribution and abundance of Coregonines in 2016 and 2017, midwater trawling and additional hydroacoustic sampling was conducted by USGS *RV Kaho*, OMNRF *Ontario Explorer* and NYSDEC *RV Seth Green* (Holden et al. 2017). Trawling was conducted using a French midwater trawl (57m^2 [613.5 ft^2] net opening). Tows were 5 or 10 minutes duration and tows generally occurred above, within or below the metalimnion as determined by nightly temperature profiles and temperature loggers on the net's headrope, footrope or both. In 2017, mid-water trawling (58 total tows) was conducted at six locations. Five of the sites (i.e, Rochester, Fairhaven, Mexico Bay, Southwicks, and in the Eastern Basin) were similar to trawling sites visited in 2016 (Figure 1). A sixth area was added in 2017 and included three nights of sampling near Cobourg, ON (Figure 1). Mid-water trawl catches were primarily used to inform apportionment of generalized abundance estimates obtained from hydroacoustics to estimate species abundance. All fish were sorted, counted and weighed by species, and subsamples for length frequency were taken on all species. All cisco were frozen and later processed for length, weight, gonadosomatic index, diet, and samples of tissue were archived for future genetic, isotope and fatty acid analysis. Only acoustic data where both hydroacoustics and midwater trawls were conducted were used to estimate cisco abundance (Figure 1). Acoustic densities of cisco were estimated by calculating the average density of upper and lower layers per 500 m section (with TS of -39 to -35 dB), then averaging densities per area, and then calculating a grand mean of all six cisco areas.

Results and Discussion

The survey transects included acoustic data collected over 311 km (193 mi), plus an additional 247 km (154 mi) collected and paired with mid-water trawl tows (Figure 1). There were 58 mid-water tows conducted which captured seven species of fish. alewife, rainbow smelt and cisco were the most frequently caught and most abundant species (Table 1). Tows in the surface layer (≥ 10 ˚C) were 99% alewife. Tows in the deep layer (< 10 ˚C) were also 95% alewife; however, we hypothesize that catch contamination from the upper layer significantly impacted these results. Headrope and footrope temperatures were not recorded on all tows and thus a fishing temperature of 9˚C at the footrope and a net with a vertical opening of 5-7 m (16.4-23 ft) is likely fishing some portion of the net in temperatures greater than 9˚C. In the future we expect to have temperature loggers on both the footrope and headrope to better quantify this potential bias. We feel the potential for catch contamination is high while letting out and hauling in the trawl, as the net must pass through the warm portion of the water column to reach the target fishing depth. For instance, a tow conducted in 2016 with no fishing time (i.e. trawl let out to 34 m fishing depth then immediately returned) captured alewife, cisco and rainbow smelt which indicates that the net fishes during either or both the let out or haul in period of the tow. rainbow smelt and cisco were predominantly (88% for each) caught in tows conducted in water less than 9˚C.

Summary size data for all species are presented in Table 1. The length distribution shows a clear size separation between cisco and both alewife and rainbow smelt (Figure 2). The thermal separation between alewife and rainbow smelt and the size difference between these species and cisco supports the current approach of species apportionment of acoustic density estimates (Table 1).

<u>Cisco</u>

Catches of cisco were confined geographically within the eastern region of Lake Ontario in 2016 (Holden et al. 2017). The majority of cisco were also caught at eastern sites in 2017, although one cisco was caught near Cobourg, ON suggesting a broader distribution across the north shore than inferred by 2016 trawling (Figure 3). Cisco catches in 2017 (N = 15, mean CUE = 0.15 fish/5 min tow) were well below catches observed in 2016 (N = 361, mean CUE = 3.83 fish/5 min tow). Cisco occupied both upper and lower thermal layers in 2017 (Table 1) with trawl catches in water temperatures of 7-15 ˚C compared to 2016 when they were concentrated in the 10-15 ˚C layer (Holden et al. 2017). Length of captured cisco ranged from 260-380 mm (10.2-15 in).

Hydroacoustic data, using only transects where cisco were captured, estimated a mean density of 45 cisco per hectare, markedly higher than 2016 (25 cisco per hectare). Using the average cisco weight captured in midwater trawls (210g and 271 g in 2016 and 2017, respectively, Table 1), cisco biomass density was ~5.25 kg/ha and 11.9 kg/ha in 2016 and 2017, respectively. If we conservatively assume the limited area where cisco were observed represented 1/10th of the total lake area, and cisco were absent elsewhere, whole-lake biomass densities were 0.5 kg/ha in 2016 and 1.2 kg/ha in 2017. Biomass values are still well below comparable Lake Superior hydroacoustic estimates (5.5 kg/ha, Yule et al 2013).

<u>Rainbow Smelt</u>

Rainbow smelt abundance (15.1 million) in 2017 decreased relative to 2016 (Figure 4). However, inclusion of the additional near-shore transects in 2016 and 2017 resulted in a significantly larger population estimate (32 million and 50.3 million, respectively) than the traditional cross-lake transects would have estimated. The largest midwater trawl catches of rainbow smelt occurred in the eastern portion of the Lake (Mexico Bay), similar to previous analyses (Connerton and Holden 2014). Only one rainbow smelt was caught in OMNRF tows conducted near Cobourg.

Alewife

The YAO alewife abundance index in 2017 (1.183 billion) based on the area weighted method increased 140% relative to 2016 (Figure 5). This increase is likely explained by the moderate to strong alewife year classes produced in 2015 and 2016. Spring bottom trawls in 2017 caught record numbers of age-1 alewife in U.S. waters, moderate numbers of age-1 fish in 2016, and very low catches of age-1 fish in 2014 and 2015. Differences between acoustic target strength distributions throughout these years supports these observations (Figure 6), i.e. there was a noticeable lack of small targets in 2014 and 2015, followed by noticeable increases in small targets observed in 2016 and 2017, corresponding to weak year classes in 2013 and 2014, and then moderate and strong year classes in 2015 and 2016. While total alewife abundance may be higher than recent years, most of the population consists of either young alewife or fish age-5 and older (Figure 2 and Weidel et al. 2018), prompting concerns by fisheries managers about the future status of the population.

Alewife were spatially distributed throughout the lake but showed a bimodal distribution with bottom depth in 2017 (Figure 7). Distribution of alewife during the survey, however, varies from year to year. Previous analyses found no discernable consistent geographic patterns in alewife distribution in 2013-2014 (Connerton et al. 2014), nor any consistent regional trends from 2006-2014 (Holden et al. 2014). Distribution of alewife may be more related to recent physical (e.g. weekly prevailing winds) and biological factors (e.g. zooplankton blooms) but more research is needed in this area and we are currently exploring other factors potentially affecting distribution.

The inclusion of the additional nearshore transects in 2017 resulted in a marginally lower whole-lake estimate (1.102 billion) compared with the estimate using the traditional cross-lake transects. In 2016, additional nearshore sampling resulted in a 15% higher lakewide estimate than using cross-lake transects alone, although these estimates were not significantly different (Holden et al. 2017).

Midwater trawl catches in 2017 expanded to a whole-lake population abundance (1.743 billion) estimated a higher abundance than the acoustic estimate, but was likely biased high because trawling effort generally targeted concentrations of fish in areas where acoustics showed fish to be more abundant over depths from 30-70 m (98.4-229.6 ft, Figure 7).

The acoustic abundance of alewife is presented as an index as it produces a significantly lower abundance than spring bottom trawl estimates (e.g., ~4 kg/ha with acoustics [Connerton and Schaner 2012] vs 69 kg/ha with bottom trawls 2004-2006 [Murry et al 2009]). Vertical gillnets and towed up-looking acoustics show that a large proportion (on average 50%) of alewife occupy the near-surface portion of the water column (<4 m depth) and are not detectable with the down-looking transducer used in the survey. While a significant proportion of the alewife biomass is detected in this portion of the water column, the conversion still does not reconcile the difference between bottom trawl and acoustics population estimates. Stationary up-looking data is being analyzed to investigate the role that boat avoidance may contribute to explaining the differences.

Hydroacoustics remains an important method for indexing midsummer pelagic preyfish abundance. Midwater trawling has shown to be a useful method for informing species apportionment of this survey's acoustic data and for assessing Coregonines. Although the Lake Ontario offshore pelagic fish community is still dominated by alewife and rainbow smelt, cisco is a present and perhaps growing species of importance. While hydroacoustics has its challenges, this research has identified new opportunities, including estimating the abundance of other important animals in the Lake Ontario foodweb like Mysis (Watkins et al. 2015), zooplankton (Holbrook et al. 2006), and now cisco. Our results support previous conclusions of Owens et al. (2003) who proposed that cisco are mainly restricted to eastern portions of the Lake. Hydroacoustic surveys may also prove useful in assessing success of ongoing efforts to re-establish bloater in Lake Ontario.

Acknowledgements

Provincial funding to implement OMNRF sampling was from the Canada-Ontario Agreement on Great lakes Water Quality and Ecosystem Health and Ontario's Great Lakes Strategy. The USGS data associated with this report have not received final approval by the U.S. Geological Survey and are

currently under review. The Great Lakes Science Center (GLSC) is committed to complying with the Office of Management and Budget data release requirements and providing the public with high quality scientific data. We plan to make all USGS research vessel data collected between 1958 and 2017 publicly available from the GLSC website later in 2018. The anticipated citation will be http://doi.org/10.5066/F75M63X0. Please direct any immediate questions to our Information Technology Specialist, Scott Nelson, at snelson@usgs.gov. All USGS sampling and handling of fish during research are carried out in accordance with guidelines for the care and use of fishes by the American Fisheries Society (http://fisheries.org/docs/wp/Guidelines-for-Use-of-Fishes.pdf). Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

References

Brandt, S.B. 1986. Food of trout and salmon in Lake Ontario. Journal of Great Lakes Research 12: 200-205.

Brookings, T.E. and L.G. Rudstam. 2009. Hydroacoustic Target Strength Distributions of Alewives in a Net-Cage Compared with Field Surveys: Deciphering Target Strength Distributions and Effect on Density Estimates. Transactions of the American Fisheries Society 138:471–486.

Christie, W.J. 1973. A review of the changes in the fish species composition of Lake Ontario. Great Lakes Fishery Commission Technical Report. 23:1–57.

Connerton, M.J., J. Holden. and T. Schaner. 2012. Acoustic assessment of pelagic planktivores 2011. Section 28, *in* 2011 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Connerton, M.J., J. Holden. and T. Schaner. 2014. Acoustic assessment of pelagic planktivores 2013. Section 24, *in* 2013 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Connerton, M.J. and J. Holden. 2015 Acoustic assessment of pelagic planktivores 2014. Section 24, *in* 2014 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Connerton, M.J. and J. Holden. 2016 Acoustic assessment of pelagic planktivores 2015. Section 24, *in* 2015 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Holden, J.P., M.J. Connerton and T.Schaner. 2014. Changes in mid-summer distributions of rainbow smelt and alewife in Lake Ontario. International Association of Great Lakes Research 57th Annual Conference on Great Lakes Research at McMaster University. May 26-30, 2014.

Holden, J.P., M.J. Connerton, and B.C. Weidel. 2017. Acoustic assessment of pelagic planktivores 2016. Section 15, *in* 2016 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Hoyle, J.A, J.P.Holden, and M.J. Yuille. 2017. Diet and relative weight in migratory walleye (*Sander vitreus*) of the Bay of Quinte and eastern Lake Ontario, 1992-2015. Journal of Great Lakes Research. 43 (5): 779-978

Holbrook, B.V, T.R. Hrabik, D.K. Branstrator, D.L. Yule, and J.D. Stockwell. 2006. Hydroacoustic Estimation of Zooplankton Biomass at Two Shoal Complexes in the Apostle Islands Region of Lake Superior Journal of Great Lakes Research 32: 680-696

Lantry, J. R. 2001. Spatial and temporal dynamics of predation by Lake Ontario trout and salmon. M. S. thesis. State University of New York. Syracuse, NY.

Love, R. H. 1977. Target strength of an individual fish at any aspect. Journal of the Acoustical Society of America 62:1397–1403.

Murry BA, Connerton MJ, O'Gorman R, Stewart DS, Ringler NH. 2010. Lake-wide estimates of alewife biomass and chinook salmon abundance and consumption in Lake Ontario, 1989–2005: implications to prey fish sustainability. Transactions of the American Fisheries Society. 139:223–240

Ontario Ministry of Natural Resources and Forestry. 2017. Lake Ontario Fish Communities and Fisheries: 2016 Annual Report of the Lake Ontario Management

Unit. Ontario Ministry of Natural Resources and Forestry, Picton, Ontario, Canada.

Owens, R.W., O'Gorman, R., Eckert, T.H., and Lantry, B.F. 2003. The offshore fish community in southern Lake Ontario, 1972-1998. In State of Lake Ontario: past, present, and future. Edited by M. Munawar. Ecovision World Monograph Series. Aquat. Ecosyst. Health Manage. Soc., Backhuys Publishers, Leiden, The Netherlands. pp. 407-442.

Schaner T. and S.R. LaPan. 2003. Lake Ontario Pelagic Fish: Preyfish. Section 1 in Lake Ontario Fish Communities and Fisheries. 2002 Annual Report of the Lake Ontario Management Unit Prepared for the Lake Ontario Committee Meeting Great Lakes Fishery Commission. March 27-28, 2003. Queen's Printer for Ontario.

Thorne, R.E. 1983. Assessment of Population Abundance by Hydroacoustics, Biological Oceanography 2:2-4, 253-262

Warner, D. M., Rudstam, L. G. and Klumb, R. A. 2002. In situ target strength of alewives in freshwater. Transactions of the American Fisheries Society, 131: 212–223.

Weidel, B and M. Walsh. 2013. Estimating the area-swept by the 11.8 m Yankee bottom trawl in Lake Ontario. Section 12, pages 25-32, In 2012 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Weidel, B.C., M.G. Walsh, M.J. Connerton and J. Holden. 2015. Status of rainbow smelt in the U.S. waters of Lake Ontario, 2014. Section 12, pages 11-15, *in* 2013 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Weidel, B.C., M.G. Walsh, M.J. Connerton and J. Holden. 2017. Trawl-based assessment of Lake Ontario pelagic prey fishes including alewife and rainbow smelt. Section 12a i*n* 2016 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Weidel, B.C., J.P. Holden, and M.J. Connerton 2018. Bottom trawl assessment of Lake Ontario prey fishes. Section 12 i*n* 2017 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to Great Lakes Fishery Commission's Lake Ontario Committee. NYSDEC, Albany, NY

Weidel B.C., J. A. Hoyle, M.J. Connerton, J.P. Holden, M. Vinson. (In review), Lake Ontario cisco dynamics based on long-term surveys. Advances in Limnology.

Yule, D.L., Evrard, L.M., Cachera, S., Colon, M., Guillard, J., 2013. Comparing two fish sampling standards over time: largely congruent results but with caveats. Freshw. Biol. 58, 2074–2088. https://doi.org/10.1111/fwb.12192

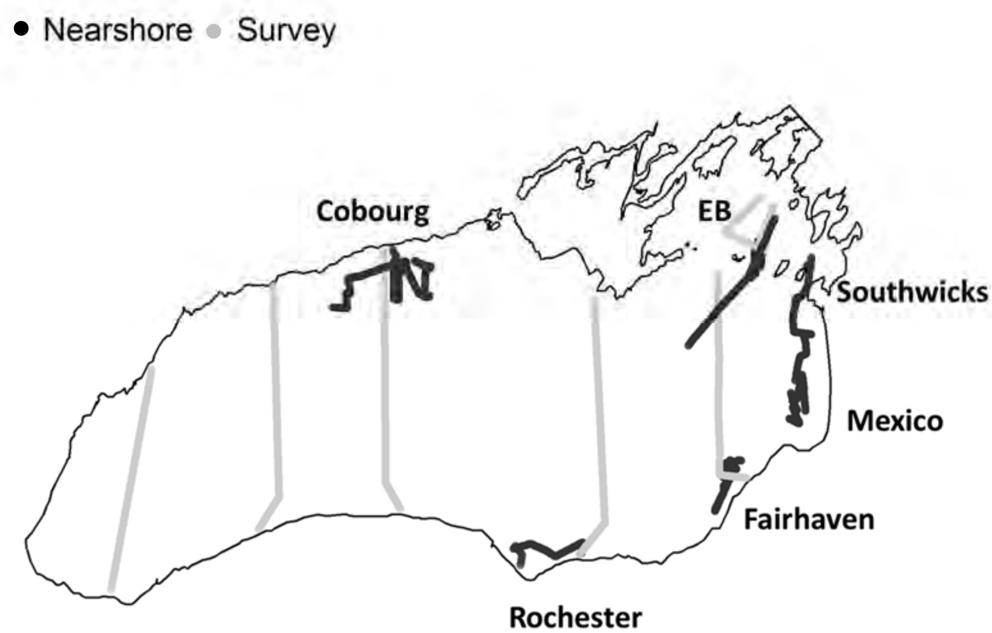

Figure 1. The Lake Ontario lake-wide prey fish survey uses cross-lake hydroacoustic transects (2017 transects shown in grey). In 2017, additional hydroacoustic sampling and midwater trawling was conducted in six areas (black lines). Notes: EB=eastern basin. USGS conducted midwater trawling west of Rochester but returned to port early due to a vessel mechanical problem. OMNRF collected hydroacoustic data near Rochester but conducted no midwater trawling.

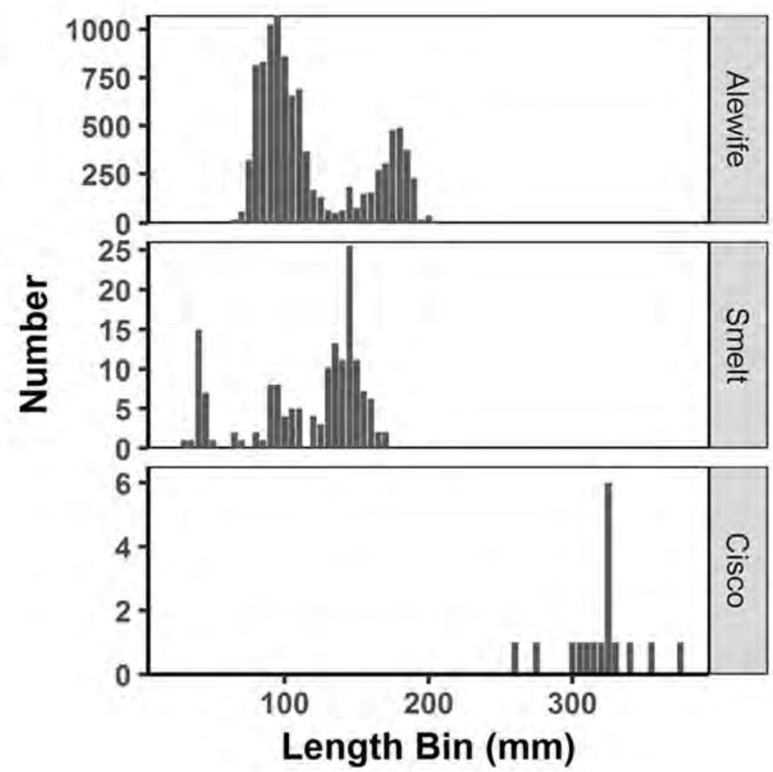

Figure 2. Length frequencies of alewife, rainbow smelt and cisco caught in midwater trawling in 2017.

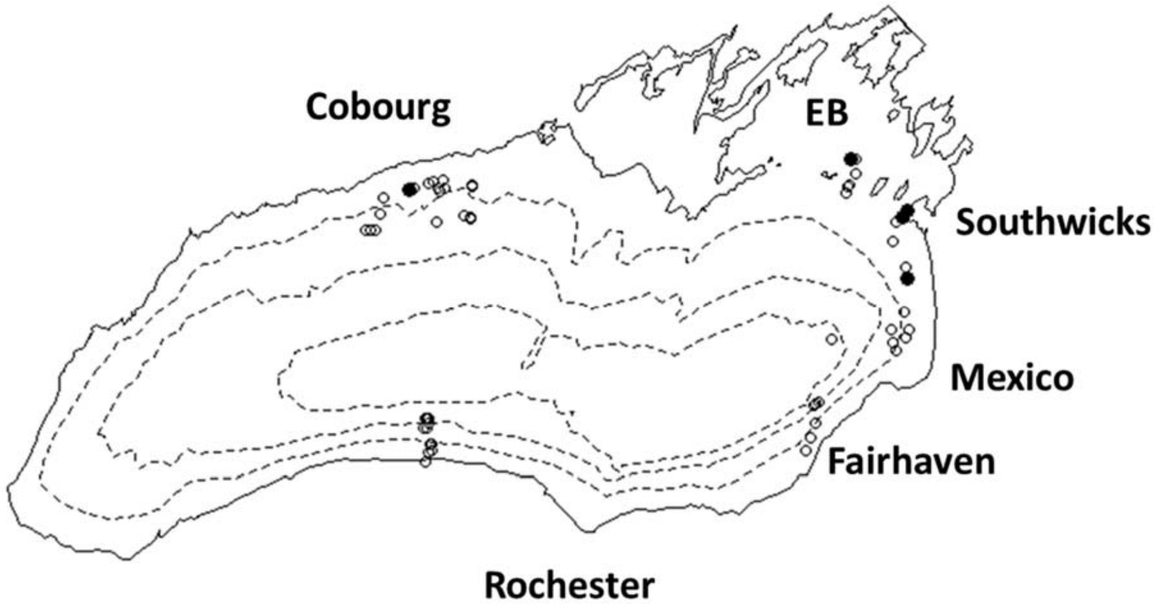

Figure 3. Distribution of cisco caught during midwater trawling in July, 2017. Acoustics and trawling were conducted at Rochester, Fairhaven, Mexico, Southwicks, Cobourg and eastern basin sites (EB). Open circles are trawl locations where no cisco were caught and closed circles are locations where cisco were caught. Note: USGS conducted midwater trawling west of Rochester but returned to Port early due to vessel mechanical failure. OMNRF collected hydroacoustic data near Rochester but conducted no midwater trawling.

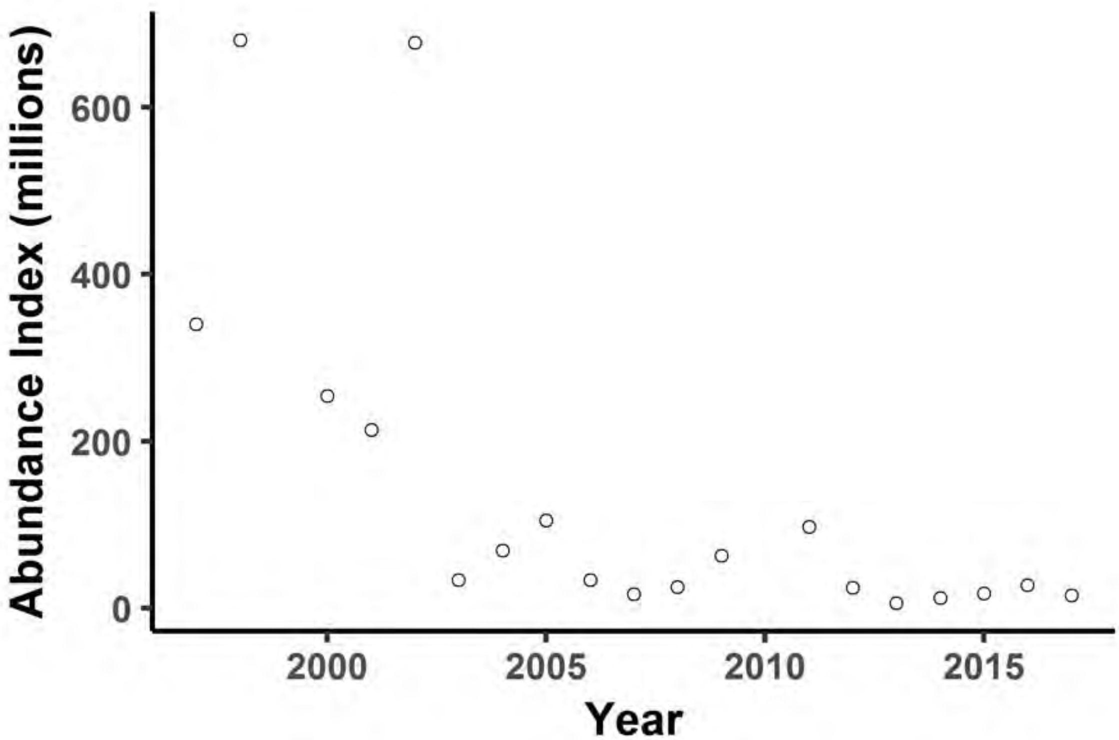

Figure 4. Abundance (in millions of fish) of yearling-and-older rainbow smelt in Lake Ontario from 1997-2017 as determined by the bootstrapping method. No acoustic survey was conducted in 1999 and 2010.

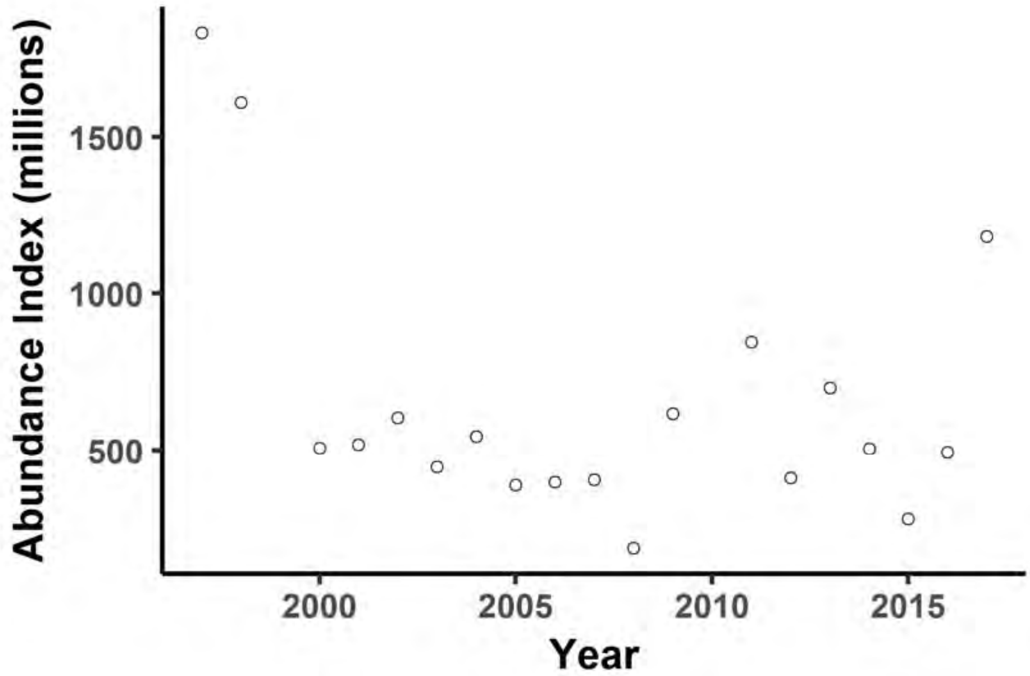

Figure 5. Abundance (in millions of fish) of yearling-and-older alewife in Lake Ontario from 1997-2017 as determined by the area weighted method. No acoustic survey was conducted in 1999 and 2010.

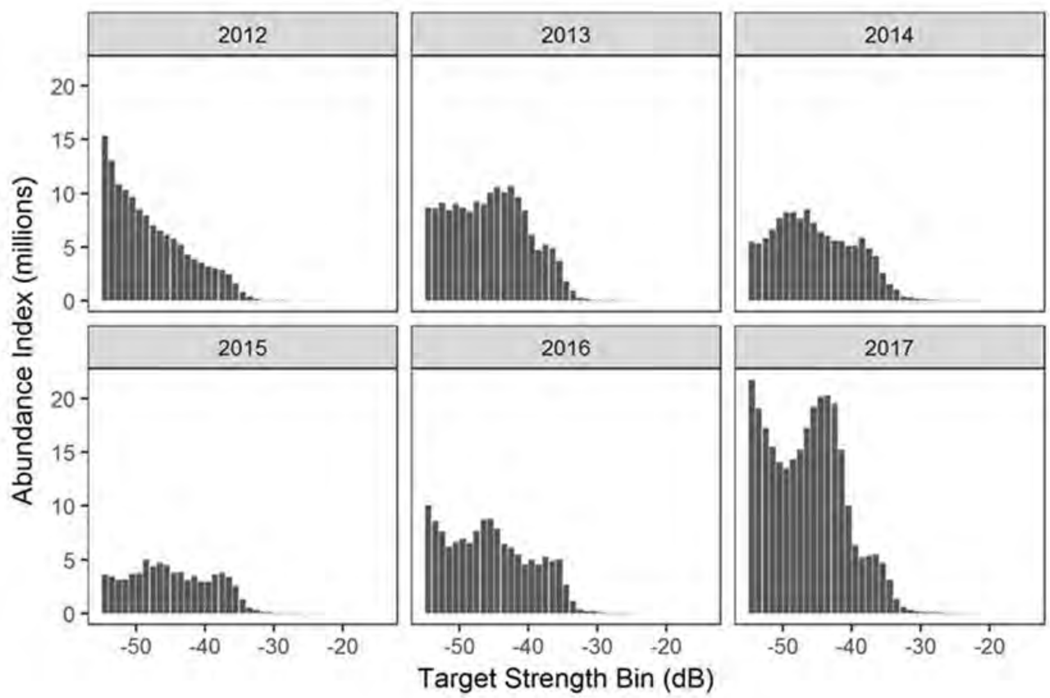

Figure 6. Target strength frequency histograms of single targets detected in the upper layer during summer hydroacoustic surveys conducted in July 2012-2017. Note the relatively low number of targets with small target strengths (i.e., small alewife) in 2014 and 2015, compared to the relatively large numbers of these targets in 2017. These targets correspond to the low numbers of age-1 alewife observed in Lake Ontario in 2014 and 2015, and the near record levels observed in 2017.

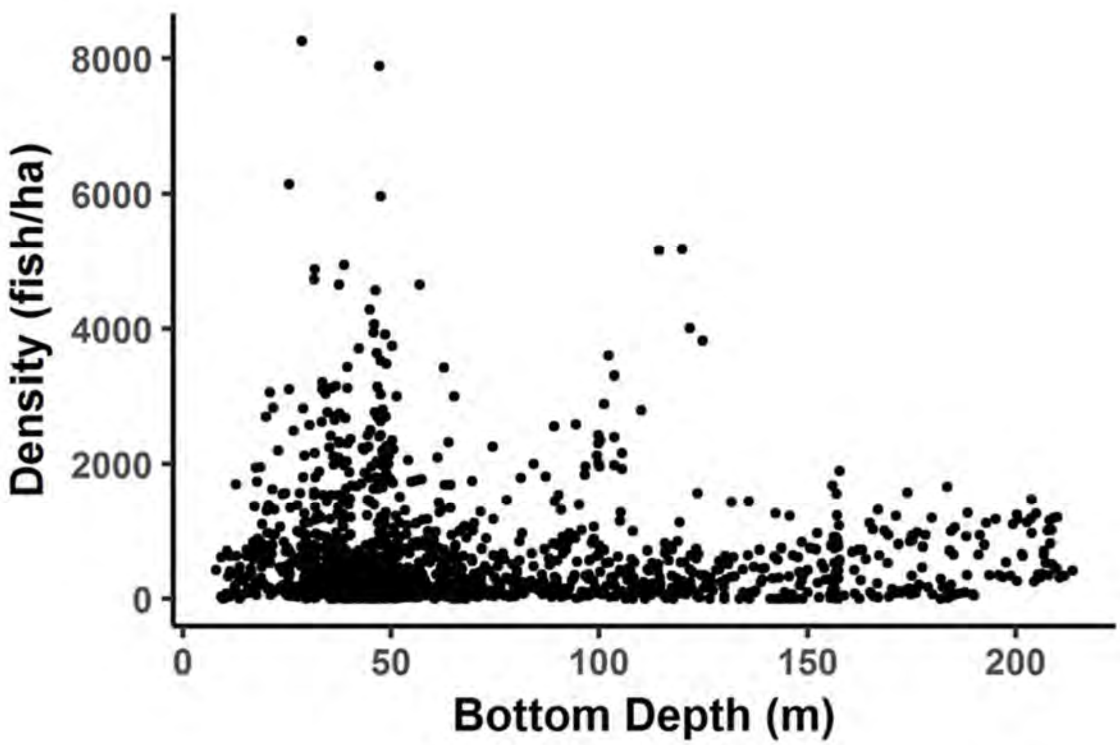

Figure 7. Distribution of alewife (fish per ha) relative to bottom depth as determined by acoustics.

Table 1. Summary of catch data for all species captured in mid-water trawls in 2017.

Species	Catch Total in Trawls below 10˚C	Catch Total in Trawls 10˚C and above	Number Sampled	Mean Total Length	Max. Total Length	Min. Total Length	Mean Weight
Alewife	3547	6433	227	146	201	25	24.8
Rainbow Smelt	138	19	45	85	169	30	7.0
Cisco	15	2	17	318	371	257	271.4
Chinook Salmon	2	1	3	508	860	140	3329.0
Round Goby	1	0	1	30	30	30	0.1
Gizzard Shad	0	1	1	145	145	145	27
Threespine Stickleback	0	1	0	-	-	-	-

Lake Sturgeon Tagging Study and Egg Take 2017

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Lake sturgeon (*Acipenser fulvescens*) were historically an abundant and widely distributed species in New York State (NYS). Overharvest, habitat degradation, and migratory impediments (dams) resulted in drastic decline of the species by the early 1900s. Due to severely depleted stocks, the lake sturgeon fishery was closed by the NYS Department of Environmental Conservation (DEC) in 1976. Lake Sturgeon were listed as a threatened species by NYSDEC in 1986, with lost, sparse or declining populations in 6 of the 9 watersheds where they historically occurred.

Little is known about lake sturgeon in the upper St. Lawrence River and the Eastern Basin of Lake Ontario. Restoration efforts, including stocking and habitat enhancement, benefit from tagging methodology that allows for long term fish identification, especially when considering broodstock genetics, and spawning site fidelity.

This project is a continuation of a project funded by the U.S. Fish and Wildlife Service's Fish Enhancement, Mitigation and Research Fund (FEMRF) to tag lake sturgeon with permanent individual markers. Lake sturgeon have been collected annually at various sites in the St. Lawrence River and Eastern Basin of Lake Ontario since 2010. Fish were evaluated for basic biological information and then scanned for Passive Integrated Transponder (PIT) tags to determine if they had been previously tagged. A PIT tag was applied to untagged fish for permanent individual identification. The goal is to create a long-term database of individual fish that will be used to support ongoing species rehabilitation.

Restoration of lake sturgeon has been ongoing in NYS since 1993 through propagation, stocking, and spawning site creation. Wild broodstock are collected downstream of the Moses Power Project (Massena, NY) adjacent to the South Channel annually. Gametes are collected, fertilized, and cultured at the Oneida Fish Culture Station (New York) and the Genoa National Fish Hatchery (Wisconsin). Progeny are stocked into the St. Lawrence River, various tributaries, and the Eastern Basin of Lake Ontario.

Methods

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

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

<u>Collection</u>
Lake sturgeon (sturgeon) were collected from April-August in 2017. Collections included netting targeting sturgeon, and existing annual gill net surveys to assess warmwater fish populations which occasionally capture sturgeon.

Spawning sturgeon were sampled in Lake Ontario (Black River Bay), Black River, and in the St. Lawrence River immediately downstream of the Moses Power Dam (Dam). Existing, long term index gill netting programs include two on the St. Lawrence River (Thousand Islands and Lake St. Lawrence) and one in the Eastern Basin of Lake Ontario. Netting sites for 2017 are shown in Figure 1.

All fish were collected with monofilament gill nets fished from 16.8 – 25.6 hours in waters from 13-55 feet in depth. Gill net configurations used are described in Table 1.

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 verified in fish captured during the spawning period through extrusion of gametes. Some fish captured for potential egg take were examined internally with a hypodermic extractor (Candrl et al. 2010) for confirmation that they were late stage, gravid females.

PIT tags were applied to fish captured for the first time or fish that were previously Floy® tagged. Tags were placed under the fourth dorsal scute, the standard location for the DEC, Ontario Ministry of Natural Resources and Forestry (OMNRF), and U.S. Geological Survey (USGS). All fish, with the exception of those held for egg and milt collections, were released immediately after tagging within 0.1 miles of their capture location. PIT tag data were shared with the Great Lakes Lake Sturgeon Database (USFWS) which will allow researchers to acquire information related to individual sturgeon they may encounter.

Results and Discussion

The DEC has sampled St. Lawrence River sturgeon since the early 1990s 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 broodstock in restoration efforts. As restoration efforts intensified and genetic investigations revealed distinct spawning stocks of sturgeon (Welsh et al. 2008), the need for reliable and permanent identification of individual fish became clear.

Use of PIT tags began in 2008 and continues to be the primary method of uniquely marking sturgeon. In 2010, a FEMRF grant provided tags and related equipment for large-scale tagging of sturgeon in the St. Lawrence River and Eastern Basin of Lake Ontario.

<u>Overall 2017 Results</u>

DEC personnel captured a total of 159 sturgeon throughout the sampling area in 2017. PIT tags were applied to 122 sturgeon (86% St. Lawrence River; 14% Lake Ontario), ranging in length from 20.1-68.1 inches and weighing up to 116.7 pounds. Four juvenile sturgeon were collected ranging from 20.1-25.6 inches, however, weights could not be acquired at time of capture. Length-weight relationships were constructed using data from all sturgeon collected (where lengths and weights were available) from 2010-2017 (Figure 2), and for adult fish separated by sex (Figure 3). Sturgeon body form can be quite variable as demonstrated by the relationships. A total of 37 recaptures were recorded in 2017. The majority of recaptured fish came from the general area of initial tagging. Four recaptures originated from outside the sampling area and are described below.

Males (N=42) accounted for 26.4% of the catch while females (N=13) constituted 8.2%. The remaining fish were either immature or of undetermined sex (N=104, 65.4%). Few juvenile sturgeon are represented in the catch, due to the large mesh size of gill nets used in targeted surveys. Index gill net surveys, which utilize nets with smaller mesh sizes, may not cover areas of preferred juvenile habitat.

<u>Black River</u>

Lake Sturgeon spawning in the Black River was first documented in 2005 (Klindt and Adams 2006). Sampling since 2005 has targeted spawning fish either in the Black River or Black River Bay, depending on environmental conditions, to acquire biological information and apply Floy® or PIT tags.

The Black River was sampled May 1, 2017 for a total of 2 net nights (41.25 hrs). Discharge in the

Black River fell below the maximum effective netting limit of 6000 cfs on 4/27 and remained in the acceptable range briefly until 5/2 when it rose to approximately 7000 cfs (USGS gage 04260500, Watertown).

One ripe male sturgeon was collected which was 53 inches and 33 pounds. This fish was originally captured and tagged in 2010 in the Black River. It had been recaptured in either the Black River or Black River Bay in 2012, 2014, and 2016, making 2017 the fifth time it had been handled.

Lake Ontario (Black River Bay & Eastern Basin)

A total of 28 sturgeon were captured in Black River Bay from April 17- May 1, 2017. Surface water temperature warmed through the period ranging from 49-55 ^{o}F. A total effort of 532.44 net-hrs was expended resulting in a catch per unit effort (CUE) of 0.05 fish/hr (Table 2). Sturgeon ranged in length from 41.7-68.1 inches. and weight from 17.6-116.7 pounds. Sex could not be determined for most fish. However, six fish were determined to be ripe males and three fish, while not confirmed by internal examination, presented the body form of gravid females and were recorded as such with appropriate notations concerning uncertainty.

Black River Bay serves as a staging area for some fish that will later migrate to spawning sites upstream. However, it is unclear whether all sturgeon in the bay are staging for migration to spawning areas, or simply aggregating in common near shore areas in the spring.

Fifteen fish were recaptures having been tagged from 2010-2015 in either Black River Bay or the Black River. Four of the recaptured fish were tagged significant distances from the bay having been originally tagged at Oneida Lake, the Genesee River, Onondaga Lake Outlet, and one of unknown origin (Table 4). The fish of unknown origin presented with broken Carlin Tag wires at the base of the dorsal fin. This fish was likely tagged by either Cornell University or SUNY ESF somewhere in the Oswego River system, as Carlin tags have been used in that area. In general, all significant movements documented have been downstream.

The annual index gill net survey conducted by the DEC's Lake Ontario Unit in the Eastern Basin collected four juvenile sturgeon 20.1-25.6 inches in 2017. Nets were fished at 29 sites with a total effort of 542.0 net-hrs (Table 2). Recent stockings of sturgeon have had Coded Wire Tag (CWT) implants. Unfortunately, these fish were not scanned for CWT, and their origin (hatchery vs. natural) could not be determined.

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 sturgeon brood stock source for the DEC since 1996 (LaPan et al. 1999). This area is considered a staging area for sturgeon spawning in the vicinity of the Dam. Net sites used for this collection typically produce large numbers of fish, accounting for 80-90% of the annual sturgeon catch, including both potential spawners and resident fish.

A total of 126 sturgeon were collected from May 23-June 5, 2017 at seven net sites with an effort of 467 net-hrs (Table 2). Water temperature in the South Channel ranged from 56-62°F during the sampling period. Catch rate in 2017 (CUE= 0.27 fish/hr) fell within the range of previous years (CUE range 2009-2016; 0.24-0.59 fish/hr). Record high water levels in 2017 made it necessary to open Long Sault Dam during to netting period, which altered the normal river currents experienced in previous years. Adjustments were made to net placement and orientation to allow for efficient capture but overall depression of the catch rate likely occurred.

Ripe males (N=35) represented 27.8% of the catch whereas ripe females (N=8) represented 6.0%. One hard female with eggs in stage 3 of development was identified as well as one spent female. Sex could not be determined for the remainder of the catch (N=81, 64.3%). Sturgeon collected in 2017 ranged in length from 31.7-67.7 inches and in weight from 6.6-76.9 pounds. Fish used for the 2017 egg take (females N=5, males N=18) were taken from this group.

There were 20 recaptures at this location in 2017 which were tagged between 2009-2016. The recapture rate in 2017 was 16.7%. In general, the recapture rate is showing an increasing trend (Figure 4).

The annual egg take took place on June 8, 2017. Prior to the egg take fish were collected and evaluated for gamete maturation. Fish selected (F=5, M=18) were treated with Carp Pituitary Hormone to induce ovulation and spermiation (Klindt 2014). Approximately 140,000 fertilized eggs were distributed between culture facilities in New York and Wisconsin. Fertilization rates ranged from 3.6-59.4% for different egg lots taken. Three of five injected fish produced eggs, the smallest one (32.4 lbs.) contributed eggs having the highest fertilization rate and subsequently produced the majority of fingerlings for 2017.

In October of 2017 approximately 12,700 CWT tagged fingerlings were stocked into various waters of NYS (Table 5). CWTs were inserted under the 3rd left scute, and are intended to simply identify hatchery vs. wild origin. Current stocking rates are intended to continue through 2023. The purpose of stocking is to enhance the genetic diversity of new and rehabilitated populations for future spawning success. Use of PIT tags below the Dam is particularly critical to effective management of broodstock genetics, as well as to provide insight into sturgeon biology, including spawning periodicity, growth rate, and population mixing.

<u>St. Lawrence River Above Moses Power Dam</u>

In contrast to the Dam netting site, targeted sturgeon sampling upstream of the Dam has been limited. In 2014, a targeted effort at the mouth of the Oswegatchie River identified a spawning concentration with both ripe male and female fish occupying the area (Klindt and Gordon 2015). Occasional catches prior to 2017 have occurred in the Thousand Islands (N=9) and Lake St. Lawrence (N=14) index gill net surveys (DEC regional Warm Water Assessment database). However, no sturgeon were collected as part of these surveys in 2017, despite a combined effort of 1223.3 net-hrs (64 net-nights) (Table 2).

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 is a long-term commitment which will continue.

From 2010-2017 a total of 1349 unique sturgeon have been PIT tagged by NYSDEC Region 6. 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, U.S. Fish and Wildlife Service, personal communication).

Recapture information to date indicates that most fish remain within a distinct population unit. However, fourteen sturgeon collected through this project are known to have made long movements from initial capture sites. Ten 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 (Figure 4). From 2009-2016 the recapture rate has averaged 11.1% with an increasing trend.

Several spawning congregations both in the St. Lawrence River and Lake Ontario have been identified, and, continually attract fish for reproduction. Past studies of age and growth (Jolliff and Eckert 1971, Johnson et al. 1998) would indicate that most sturgeon collected in this project range in age from 10-30 years.

Recommendations

1. Continue focused sampling effort on known spawning concentrations: Black River, SLR below the Moses Power Dam.

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

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

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

References

Candrl, J.S., D.M. Papoulias, and D.E. Tillitt. 2010. A minimally invasive method for extraction of sturgeon oocytes. North American Journal of Aquaculture 72:184–187.

Johnson, J.H., D. Dropkin, S. LaPan, J. McKenna Jr., R. Klindt. 1998. Age and growth of Lake Sturgeon in the Upper St. Lawrence River. J. Great Lakes Res. 24(1):474-478.

Jolliff, T.M. and Eckert, T.H. 1971. Evaluation of present and potential sturgeon fisheries of the St. Lawrence River and adjacent waters. Manuscript report. NYS DEC Cape Vincent Fisheries Station, Cape Vincent, NY.

Klindt, R.M. and R. Adams. 2006. Lake sturgeon spawning activity in the lower Black River. Section 21 *In* 2005 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Klindt, R.M. 2014. Lake sturgeon egg take 2014. Report to the Fish Enhancement Mitigation and Research Fund. USFWS, Cortland NY.

Klindt, R.M. and D. Gordon. 2015. Lake sturgeon tagging study 2014. Section 15 *In* 2014 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

LaPan, S.R., A. Schiavone, R. Klindt, S. Schlueter, and R. Colesante. 1999. 1998 Lake sturgeon restoration activities. Section 8 *In* 1999 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Welsh, A., T. Hill, H. Quinlan, C. Robinson, and B. May. 2008. Genetic assessment of lake sturgeon population structure in the Laurentian Great Lakes. North American Journal of Fisheries Management 28: 572-591.

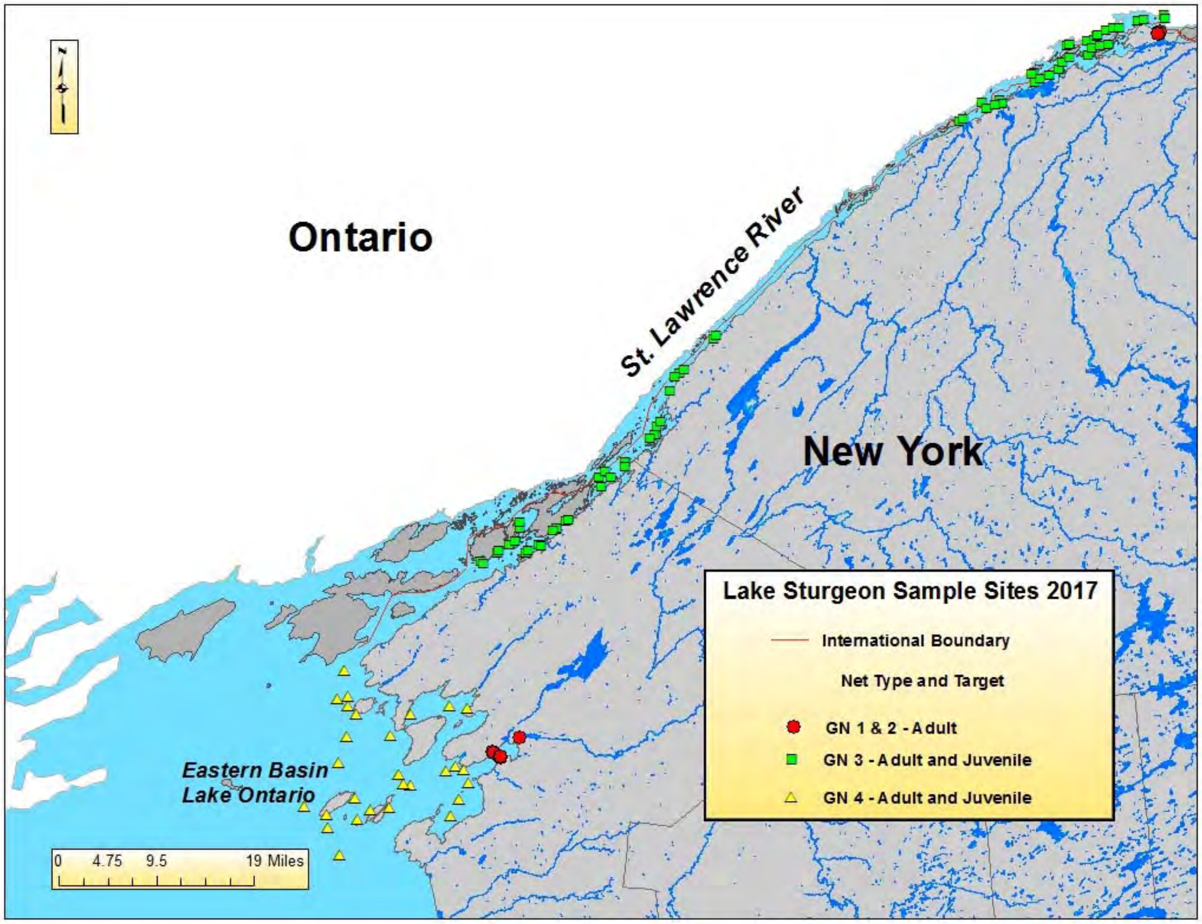

Figure 1. Lake sturgeon sampling locations and targets for 2017. Adults were targeted with large mesh gill nets only (GN1 & 2). Existing index projects in the Thousand Islands, Lake St. Lawrence, and Lake Ontario potentially targeted both juveniles and adults, utilizing experimental gill nets (GN3 & 4).

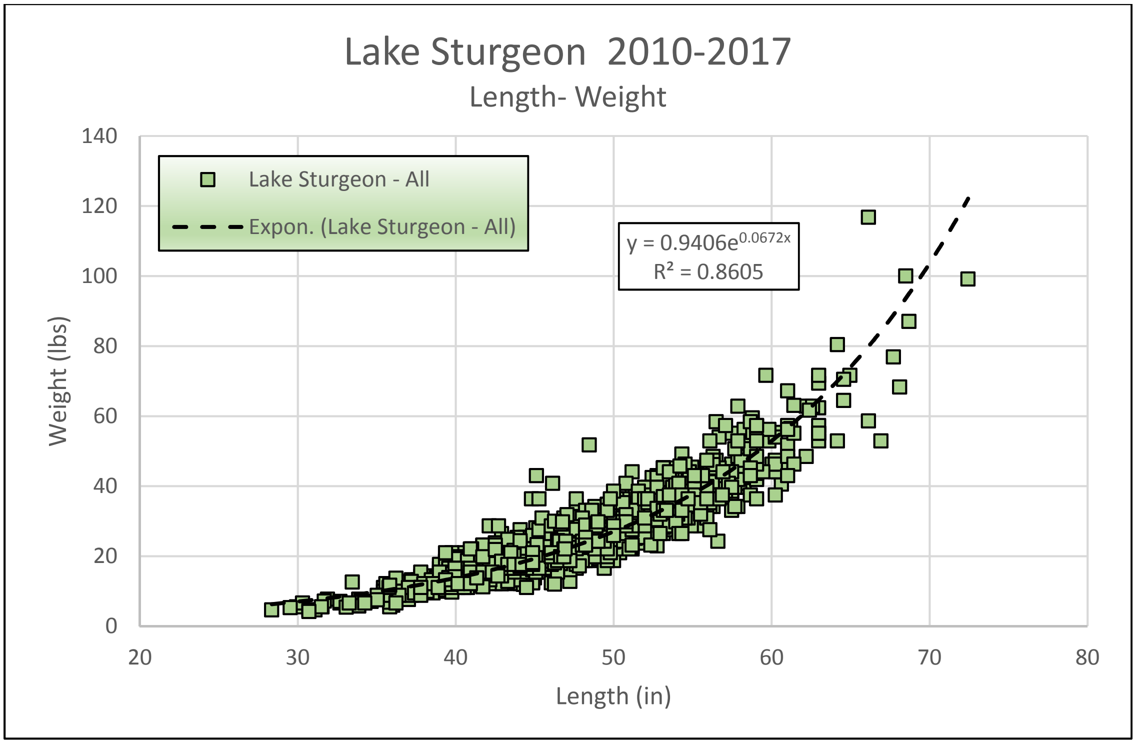

Figure 2. Length-weight relationship for lake sturgeon collected by DEC from 2010-2017. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined with no differentiation to sex.

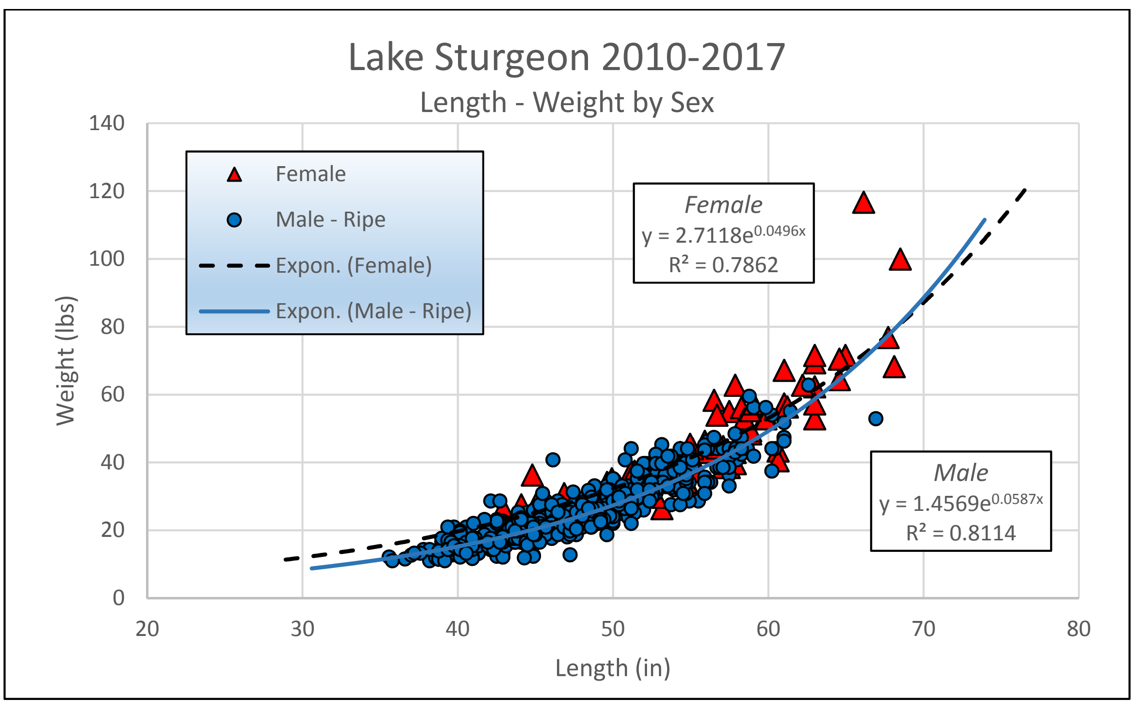

Figure 3. Length-weight relationship for lake sturgeon collected by DEC from 2010-2017 separated by sex. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined. Only female and ripe male sturgeon are presented.

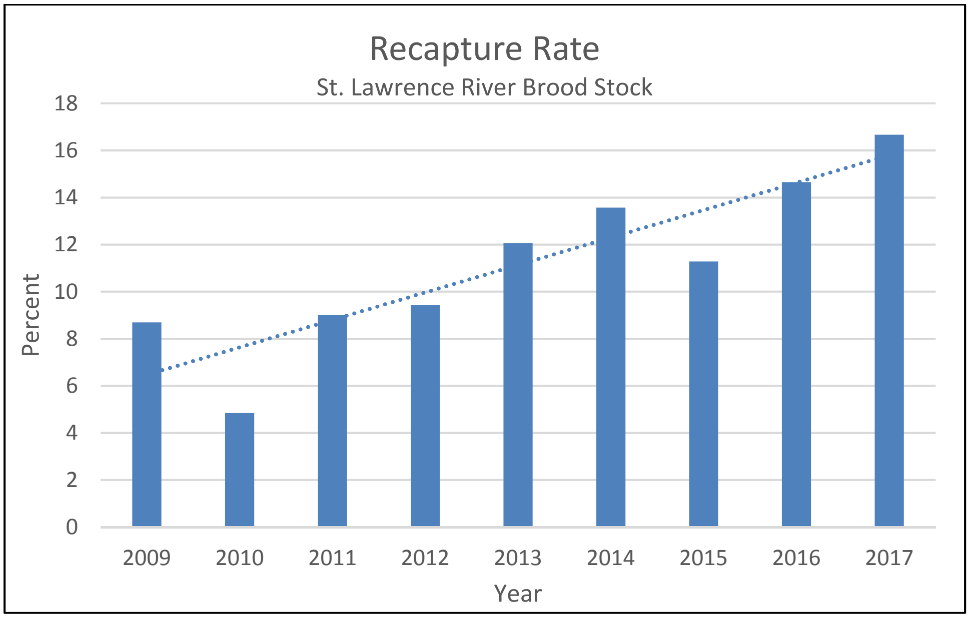

Figure 4. Lake sturgeon recapture rates from 2009-2017 during broodstock collection on the St. Lawrence River at the South Channel, Massena NY.

Table 1. Specifications of nets used for collecting lake sturgeon in 2017. 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, Lake Ontario, and the Black River in 2017. Targeted surveys specifically attempted to collect sturgeon. Existing project surveys targeted the major fish assemblage with sturgeon as a possible component (A=adult or B=both adult and juvenile).

Location	Dates	# Sites	Target	Net Code	Effort (hrs)	Catch	CUE (fish/hr)
Targeted							
Lake Ontario @ Black River Bay	4/17-5/1/2017	6	A	GN1 & GN2	532.4	28	0.05
Black River	5/1/2017	2	A	GN1	41.25	1	0.02
SLR@ South Channel	5/23-6/8/2017	7	A	GN1 & GN2	467	126	0.27
Existing projects							
SLR- TI	7/23-27/2017	32	B	GN3	641.9	0	0.00
LO Gill Net	7/31-8/10/2017	29	B	GN4	542.0	4	0.01
SLR- LSL	9/11-14/2017	32	B	GN3	581.4	0	0.00

Table 3. Total number of uniquely PIT tagged lake sturgeon from 2010-2017. Fish listed as Male or Female were confirmed via direct evidence of gametes. Fish that did not produce gametes through palpation or direct examination were listed as Unknown.

Sex	Number	Percentage
Male	532	39.4
Female	73	5.4
Unknown	744	55.2

Table 4. Tagging and recapture locations for 14 study fish that relocated substantial distances from initial capture. The "Dam" column indicates whether the fish had an interaction with a hydroelectric dam to reach its recapture point. Distance is the approximate straight-line water distance (miles) from initial tagging to the recapture point. Tag type indicates the tag used to identify the fish.

Initial Tagging Location (year)	Recapture Point (year)	Dam	Distance (mi) from Tag Location	Tag Type
Black River (2006)	SLR, Mth Oswegatchie River (2010)	N	85	Floy
SLR, Coles Creek (2008)	SLR, South Channel (2011)	Y	18.5	PIT
SLR, Mth Oswegatchie River (2009)	SLR, South Channel (2011)	Y	43	PIT
St. Regis River stocking at Brasher Falls (2003)	SLR, South Channel (2013)	Y	30	Floy
Oneida Lake (2005)	Black River Bay (2014)	Y	92	PIT
Oswegatchie River blw Eel Weir (2009)	SLR, South Channel (2014)	Y	45	PIT
SLR, Mth Oswegatchie River (2010)	SLR, South Channel (2015)	Y	43	Floy
Oneida Lake (2004, stocking)	Black River Bay (2016)	Y	92	Carlin
Genesee River (2004, stocking)	Black River Bay (2016)	N	100	PIT
Cayuga Lake Outlet (2008)	Black River Bay (2016)	Y	114	PIT
Onondaga Lake Outlet (2016)	Black River Bay (2017)	Y	74	Carlin
Oneida Lake ( )	Black River Bay (2017)	Y	92	Carlin
Genesee River (2013)	Black River Bay (2017)	N	100	PIT
Unknown	Black River Bay (2017)	?	?	Carlin

Table 5. Lake sturgeon stocking for New York in 2017. Most fish stocked received a coded wire tag (CWT) under the 3rd scute left side for the purpose of identifying their origin (hatchery vs. wild). Fish were stocked from 9/26 – 10/19/17.

Water	Number	Avg. Length at Stocking (in)	Date	Mark
Lake Ontario (Chaumont Bay)	2200	3.0	9/26/17	CWT
Black Lake	1079	7.2	10/18/17	CWT
Cayuga Lake	2319	4.5	10/17/17	CWT
Genessee River	998	5.5	10/19/17	PIT
Oneida Lake	497	6.5	10/5/17	CWT
Oswegatchie River (Oxbow, Elmdale)	1000	7.2	10/18/17	CWT
Raquette River	1000	7.2	10/18/17	CWT
Salmon River (Franklin Co.)	1000	7.2	10/18/17	CWT
St Regis River	1000	7.2	10/18/17	CWT
St. Lawrence River (Ogdensburg)	1100	7.2	10/18/17	CWT
St. Lawrence River (Massena, blw dam)	500	7.2	10/18/17	CWT

Northern Pike Research, Monitoring and Management in the Thousand Islands Section of the St. Lawrence River

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Northern pike abundance in the NYS Department of Environmental Conservation's (DEC) Thousand Islands Warmwater Fisheries Assessment (McCullough and Gordon 2018) 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 a corresponding low abundance for young of the year (YOY). Models of YOY northern pike production developed as part of the International Joint Commission (IJC) St. Lawrence River Water Levels Study indicated a negative relationship of water level regulation on northern pike reproduction (Farrell et al. 2006). Water level regulation and spawning habitat changes appear to have promoted deep-water pike spawning (over ~5 meters or 15') and 4-6 week delays in the egg deposition period (Farrell 2001). Deep water spawning behave occurs late in spring (May-June) and is believed to be maladaptive creating a significant reproductive sink. Nearshore pike spawning has been negatively affected by water level regulation by limiting spawner access to wetlands. A related effect is the expansion of hybrid cattail (*Typha* x *glauca*) into shallow riparian wet meadow habitats that northern pike prefer for spawning (Farrell et al. 2010).

To provide improved spawning habitat conditions at the local scale, water level controlled spawning marshes have been used in an attempt to increase natural recruitment (Forney 1968). Water levels at three spawning marshes have been managed in the Thousand Islands region to provide improved spring water level conditions with a goal of enhancing regional pike reproduction. Despite early indications of success with managed marshes demonstrating significant production of emigrating fingerlings (Farrell et al. 2003), it is hypothesized that low abundance of spawning adults and female skewed sex ratios have resulted in weak spawning runs and low levels of YOY production at managed marshes. Habitat improvements via excavation of spawning channels and pools have also been employed to increase connectivity in coastal marshes by the US Fish and Wildlife Service and Ducks Unlimited through the Fish Habitat Conservation Strategy (Farrell et al. 2017)

Northern pike YOY have been monitored in eleven seining survey sites (also used to index muskellunge) and in larger bays and in tributaries. Overall YOY production has declined significantly from historic levels. Continued monitoring is necessary to track pike reproductive success and evaluate responses to the habitat management activities and as a baseline to assess effects of IJC water level management Plan 2014 enacted in January 2017. Other needs fulfilled by the project include a better understanding of early life history processes for northern pike in drowned river mouth tributary systems and coastal bays. Research regarding habitat restoration efforts, in addition to providing options for northern pike management (Crane et al. 2015), 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

<u>Spawning run trapnet survey</u>

Monitoring of adult northern pike during spring spawning occurred in five index tributaries and one managed spawning marsh. Tributaries included French Creek, Cranberry Creek Marsh, 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.

Northern pike were captured in trapnets and assessed for sex/spawning condition (pre-spawn, ripe, and spent), 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 inches). 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. Additional data is collected for late spawning northern pike (during May and June) in embayment in sets targeting spawning muskellunge (Farrell et al. 2018). These fish were evaluated for spawning condition and the proportion spent was compared to spring water level conditions as an indicator of the degree of late spawning activity.

Water levels are typically held ~0.6 m or about 2 feet above main river level at Carpenters Branch and Delaney Marsh but high river levels experienced in 2017 were commonly above levels set at structures. Delaney Marsh was not included in the spring spawning survey because of its remote island location, but was surveyed for emigrating YOY pike. The water level management strategy for marshes is intended to prevent the fall drawdown (Farrell et al. 2010) experienced under IJC water level regulation.

<u>Emigration of YOY northern pike at managed marshes and excavated spawning pools</u>

During a related study funded by the US Fish and Wildlife Service, northern pike have been monitored and managed at habitat enhancement areas in the DEC French Creek Wildlife Management Area and provide a useful comparison to the spawning marsh monitoring program. Excavated marsh spawning pools were created by Ducks Unlimited, and the US Fish and Wildlife Service Partners for Fish and Wildlife Program restored channels connecting French Creek to remnant wet meadow habitats. Spawning pool and connecting channel sites were created in an attempt to increase YOY pike production through improved habitat and access for spawners (Farrell et al. 2017).

In early summer, YOY pike emigrating from marshes were captured in spillway traps and fine-mesh mini-hoopnets (i.e. emigration traps). This survey provides an index of emigration from nursery areas, and can be used as a metric of marsh productivity. Emigration traps are set in French Creek and include reference sites and restored spawning pool complexes. Emigration traps were also set at Cranberry Creek, Point Vivian Marsh, Ferguson's Cove, Blind / Chippewa Bay, Swan Bay, Delaney Marsh and Club Island to total 68 traps deployed (28 additional sites over 2016). All fish captured were identified and enumerated. Northern pike were measured for total length (mm), and a pelvic fin for all fish greater than 80 mm (2.3 in.) was removed to evaluate the presence of marsh-origin fish during subsequent summer seining surveys and future spring adult trapnetting surveys. Traps were emptied and re-set daily. In addition to northern pike and other fish catches, abundances of macroinvertebrates and amphibians were recorded. Environmental data collected included water temperature, dissolved oxygen and water level.

<u>Summer seining surveys</u>

Standardized seining for YOY northern pike was conducted in conjunction with YOY muskellunge monitoring. A total of 11 bays were sampled during July with a fine-mesh, 9.1 m (30') long seine (90 hauls) and during August with a large-mesh, 18.3 m (60') long seine (90 hauls); for methods details see Murry and Farrell 2007). In addition, 29 bays were sampled (180 hauls) in an exploratory series with a 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 77 northern pike were captured at five index tributary sites from April 3 to April 21, 2017. An effort of 102 net nights resulted in a CPUE (catch per unit effort) of 0.76 fish/night (Table 1). The catch of spawning northern pike at index sites remains low since a significant peak in 2008 (CPUE = 3.36; Figure 2). However, catches at Chippewa tributary (16 pike, 18 net-nights) and Cranberry Creek (15 pike, 12 net-nights) were considerably greater than catches in 2016 at those same sites; (0 pike, 14 net-nights and 2 pike, 15 net-nights, respectively). Newly excavated spawning pools and channels were created at Cranberry Creek early in 2017 (post-sampling) by the US Fish and Wildlife Service in an attempt to increase YOY pike production.

The proportion of post-spawn female northern pike captured after May 10 in embayments (during muskellunge spring netting) was greatest in 2017 (84%) when water level conditions were elevated (April 7 = 75.17 mIGLD, NOAA Alexandria Bay). This contrasts with data for 2011-2016 where an average of only 48% spawners were spent, SD = 20.2%) during lower spring water levels of (April 7 = 74.6 mIGLD, SD = 0.22) indicating a greater degree of late spawning activity.

Current and past trapnet catches continue to indicate a significant dominance of female pike in the early spawning run at the managed marsh sites. For 651 pike of known sex captured at Carpenters Branch in thirteen seasons since 2003, 452 were female or 2.25 females to each male. Similarly at Delaney Marsh from 2007 to 2011, 71 of 95 pike were female (2.96 female to male ratio).

Emigration of northern pike at managed marshes and excavated spawning pools

Emigration traps were used to capture YOY northern pike leaving spawning and nursery areas in French Creek from June 26 to July 29. A total of 2305 YOY northern pike (overall CPUE = 2.26) were captured leaving nursery areas (Table 2). This catch is notably greater than observations from 2016 (n = 18 sites; total catch 154; overall CPUE = 0.33). In both 2016 and 2017 habitat restoration sites had higher catch rates than other site types. Record water levels likely played a role in the high abundance of northern pike, as more quality habitat was available. Comparison of past northern pike emigration rates in relation to water level conditions show a strong positive relationship (r = 0.957, p = 0.003; Figure 3).

Summer seining surveys

The YOY seining survey at eleven index sites produced a catch of 13 YOY northern pike during the 30’ fine-mesh seine series in 90 hauls (standardized CPUE = 0.14 fish/haul, Table 3) and 22 in the 60’ large-mesh seine series in 90 hauls (standardized CPUE = 0.24 fish/haul). Twenty-nine additional upper St. Lawrence River bays were sampled by seining and 68 YOY pike were captured (n = 180 hauls; CPUE = 0.38). Seine hauls at Delaney Bay (n = 8) resulted in the capture of 11 YOY pike (Table 3). Trends in YOY northern pike abundance are beginning to show improvement and have sequentially increased since 2013 (Figure 4).

Conclusions and Recommendations

The flood of 2017 created favorable environmental conditions for spawning northern pike; data on northern pike reproductive condition for late spawners (high percentage of post-spawn individuals) and high abundance of emigrants in emigration traps showed a strong relation to this effect. Seining results indicated a modest improvement in catch rates of YOY northern pike, but crews were challenged in extremely deepwater seining conditions and catch efficiency may have been low. Additionally, quality habitat was available to YOY pike that could not be sampled due to greater water depths.

The contribution of the 2017 northern pike year-class to the adult population should be assessed over time using the NYSDEC Region 6 St. Lawrence River Warmwater Fisheries Assessment long-term gillnet series with methods previously developed (Smith et al. 2007). We also recommend use of field data collections from the spring trapnetting and seining indices be used to identify potential for a strong 2017 year-class through examination of age-1 northern pike abundance in 2018.

It is recommended that DEC, the US Fish and Wildlife Service (FWS) and Ducks Unlimited (DU) continue to enhance critical spawning and nursery habitat in the region. Emigration data indicated potentially strong contributions of young pike from the habitat restoration projects.

Acknowledgements

Funding for this project was provided by NYS Environmental Protection Fund administered by DEC. Spawning pool and channel excavations were funded by the Fish Enhancement, Mitigation, and Restoration Fund and completed by the US Fish and Wildlife Service and Ducks Unlimited. Many technicians, students and volunteers provided significant efforts to collect and maintain this field data. We are also indebted to the Thousand Islands Land Trust for their assistance in terms of personnel, equipment, and access to the Delaney Marsh. We thank NYSDEC for continued support of this research and for reviews conducted by Steve LaPan and contributions by Post-doctoral Associate JP Leblanc. This research was conducted at the Thousand Islands Biological Station near Clayton, NY.

References

Crane, D P., L. M. Miller, J. S. Diana, J. M. Casselman, J. M. Farrell, K. L. Kapuscinski**,** J. K. Nohner. 2015. Muskellunge and Northern Pike Ecology and Management: Important Issues and Research Needs. Fisheries 40:6, 258-267.

Farrell, J. M. 2001. Reproductive success of sympatric northern pike and muskellunge in an Upper St. Lawrence River bay. Transactions of the American Fisheries Society 130:796-808.

Farrell, J. M., J. A. Toner, B. A. Murry, A. D. Halpern, and A. Bosworth. 2003. Use of spawning marshes in rehabilitation of St. Lawrence River northern pike and muskellunge Populations. Final Report submitted to the NYS Great Lakes Protection Fund, Buffalo, NY. 36 pages.

Farrell, J. M., J. V. Mead, and B. A. Murry. 2006. Protracted spawning of St. Lawrence River northern pike (*Esox lucius*): simulated effects on survival, growth, and production. Ecology of Freshwater Fish 15:169-179.

Farrell, J. M., B. A. Murry, D. J. Leopold, A. Halpern, M. Rippke, K. S. Godwin, and S. D. Hafner. 2010. Water-level regulation and coastal wetland vegetation in the upper St. Lawrence River: inferences from historical aerial imagery, seed banks, and *Typha* dynamics. Hydrobiologia 647:127–144.

Farrell, J. M., J. P. Leblanc, and E. A. Augustyn. 2017. The St. Lawrence River Fish Habitat Conservation Strategy: Evaluation of Habitat Enhancements and Development of Novel Restoration Approaches. USFWS Cortland Field Office FEMRF Final Report.

Farrell, J. M., N. A. Satre, and K. Abbott. 2018. Research, Monitoring, and Management of Upper St. Lawrence River Muskellunge. Section 18 *In* 2017 NYCDEC Lake Ontario Annual Report.

Forney, J. L. 1968. Production of northern pike in a regulated marsh. New York Fish and Game Journal 15:143-154.

McCullough, R. D, and D. J. Gordon 2018. Thousand Islands Warmwater Fisheries Assessment. Section 6 *In* 2017 NYSDEC Lake Ontario Annual Report.

Murry, B. A., and J. M. Farrell. 2007. Quantification of native muskellunge nursery: influence of body size, fish community composition, and vegetation structure. Environmental Biology of Fishes 79:37-47.

Smith, B. M., J. M. Farrell, H. B. Underwood, and S. J. Smith. 2007. Year-class formation of upper St. Lawrence River northern pike. North American Journal of Fisheries Management 27(2): 481-491.

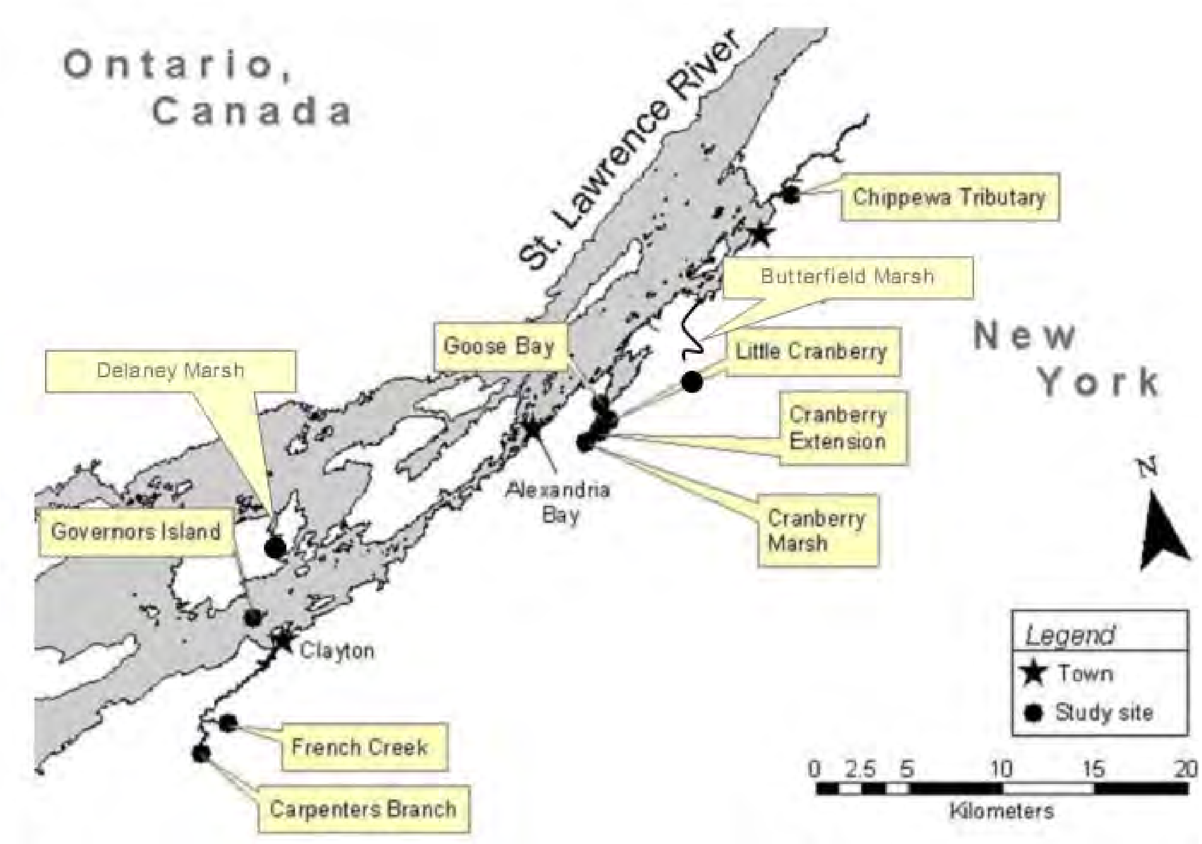

Figure 1. Study sites in the Thousand Islands Region of the upper St. Lawrence River in Clayton and Alexandria Bay, New York, including spawning marshes at Carpenters Branch (French Creek Wildlife Management Area) and Delaney Marsh (Grindstone Island) and sampling index locations at French Creek, Little Cranberry Creek, Cranberry Extension, and Chippewa (Creek) Tributary. Governors Island is the location of the Thousand Islands Biological Station. Additional seining locations (not shown) are index YOY muskellunge monitoring sites and other regional embayments.

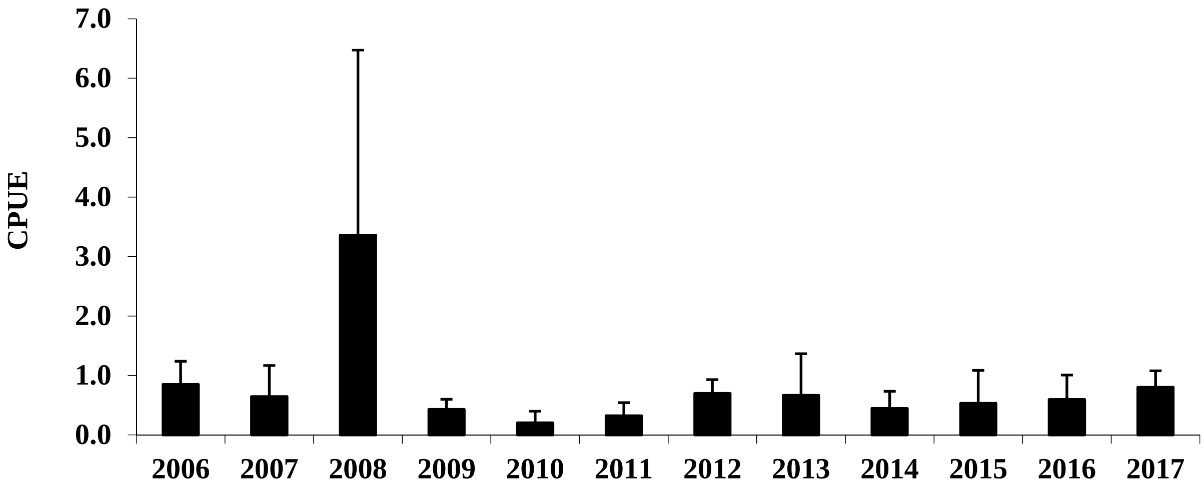

Figure 2. Average catch per net-night of northern pike in five spring spawning index trapnetting locations from 2006 to 2017 with 90% confidence limits.

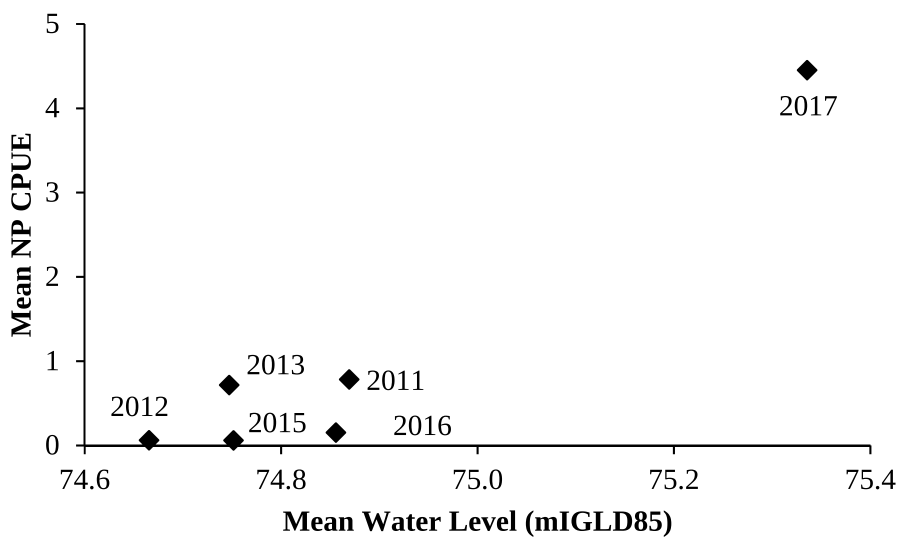

Figure 3. Northern pike emigration CPUE by year in relation to seasonal water level condition (March to July 2011-2013 and 2015-2017) at reference and habitat restorations sites (Farrell et al. 2017).

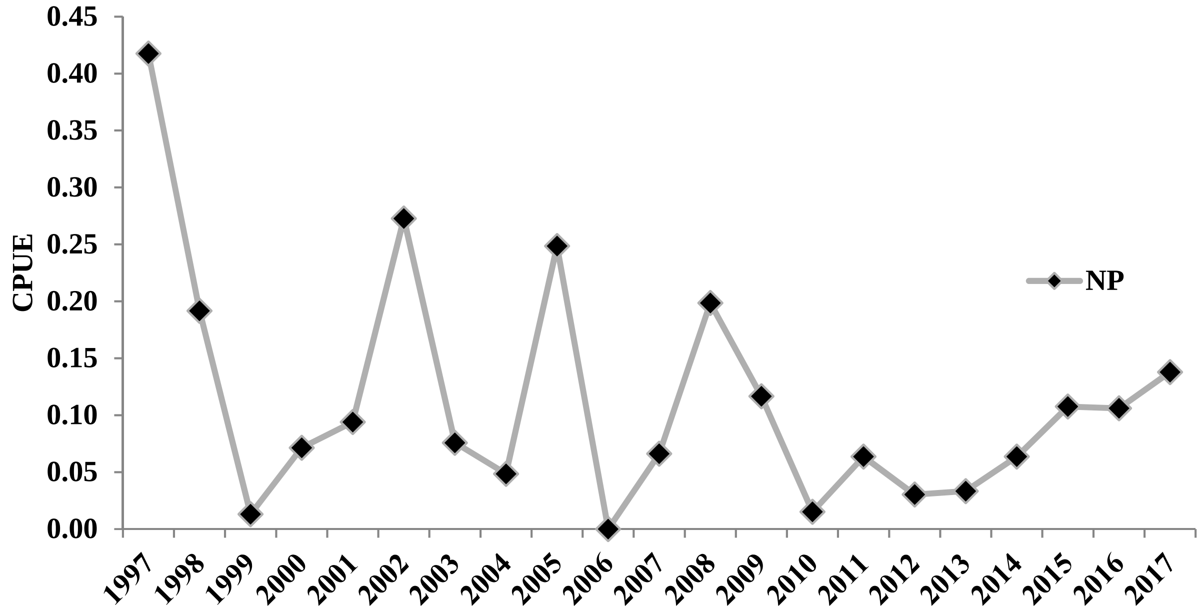

Figure 4. Catch per haul of northern pike sampled by seining during July from 1997-2017 with a fine-mesh, 9.1 m (30') long seine at Thousand Islands index sites.

Table 1. 2017 upper St. Lawrence River northern pike spawning survey effort and results by site from April 3 to April 21. Effort is defined as the total number of net-nights fished. F/M ratio is the ratio of female to male northern pike.

2017 NP Spawning						
Site	**Gear**	**Effort**	**Net nights**	**NP**	**CPUE**	**F/M ratio**
Bevins (French Creek)	Hoop	18	4/3-4/20	11	0.611	2.667
Carpenters (French Creek)	Hoop	18	4/3-4/20	14	0.778	0.556
Chippewa	Hoop	18	4/3-4/20	16	0.889	1.286
Cranberry	Oneida	12	4/3-4/14	15	1.250	1.500
Cranberry Extension	Hoop	18	4/3-4/20	4	0.222	0.333
Little Cranberry	Hoop	18	4/3-4/20	17	0.944	2.400
Total		**102**		**77**	**0.755**	**1.333**

Table 2. Summary of catch per unit effort for YOY northern pike captured during emigration netting. Site types include unaltered reference sites, habitat enhanced sites, and managed marshes. Effort is defined as the total number of net-nights fished.

2017 NP Emigration				
Locations	# Nets	Effort	NP	CPUE
REFERENCE				
French Creek	10	155	433	2.79
Point Vivian	2	31	62	2.00
Cranberry	3	42	13	0.31
Club Island	1	13	8	0.62
Swan Bay	2	18	3	0.17
Subtotal	**18**	**259**	**519**	**2.00**
SPAWNING POOLS AND CHANNELS				
French Creek	16	272	1451	5.34
Point Vivian Marsh	7	112	167	1.49
Ferguson Cove	2	32	10	0.31
Blind/Chippewa Bays	9	144	55	0.38
Cranberry	10	133	57	0.43
Club Island	3	39	35	0.90
Subtotal	**47**	**732**	**1775**	**2.43**
MANAGED MARSHES				
Carpenters Branch	1	14	4	0.29
Delaney Marsh	2	14	7	0.50
Subtotal	**3**	**28**	**11**	**0.39**
Total	**68**	**1019**	**2305**	**2.26**

Table 3. Seining catch summary for 2017 at index and exploratory sites using a fine-mesh 30' bag seine and a large-mesh 60' bag seine targeting esocids.

2017 30' Index Seining							
Site	Hauls	MKY	NP	GP	MKY CPUE	NP CPUE	GP CPUE
Affluence Bay	6	0	2	0	0.00	0.33	0.00
Boscobel Bay	6	0	0	0	0.00	0.00	0.00
Cobb Shoal	12	5	5	0	0.42	0.42	0.00
Deer Island	6	0	0	1	0.00	0.00	0.17
Frink's Bay	10	0	0	0	0.00	0.00	0.00
Garlock Bay	10	0	1	0	0.00	0.10	0.00
Lindley Bay	6	0	0	0	0.00	0.00	0.00
Millens Bay	12	1	2	2	0.08	0.17	0.17
Peos Bay	6	0	0	0	0.00	0.00	0.00
Rose Bay	10	0	0	0	0.00	0.00	0.00
Salisbury Bay	6	0	3	0	0.00	0.50	0.00
Total	**90**	**6**	**13**	**3**	**0.07**	**0.14**	**0.03**

2017 60' Index Seining							
Site	Hauls	MKY	NP	GP	MKY CPUE	NP CPUE	GP CPUE
Affluence Bay	6	0	0	0	0.00	0.00	0.00
Boscobel Bay	6	0	2	0	0.00	0.33	0.00
Cobb Shoal	12	0	2	0	0.00	0.17	0.00
Deer Island	6	0	1	0	0.00	0.17	0.00
Frink's Bay	10	0	3	0	0.00	0.30	0.00
Garlock Bay	10	0	2	0	0.00	0.20	0.00
Lindley Bay	6	0	4	0	0.00	0.67	0.00
Millens Bay	12	0	4	0	0.00	0.33	0.00
Peos Bay	6	0	0	0	0.00	0.00	0.00
Rose Bay	10	0	0	0	0.00	0.00	0.00
Salisbury Bay	6	0	4	0	0.00	0.67	0.00
Total	**90**	**0**	**22**	**0**	**0.00**	**0.24**	**0.00**

Table 3. Continued

2017 30' Exploratory Seining							
Site	Hauls	MKY	NP	GP	MKY CPUE	NP CPUE	GP CPUE
Whitehouse Bay	6	0	2	2	0.00	0.33	0.33
Flynn Bay	16	0	9	0	0.00	0.56	0.00
Grass Point	8	0	8	0	0.00	1.00	0.00
Blind Bay (Clayton)	16	1	5	0	0.06	0.31	0.00
Carrier Bay	6	0	2	0	0.00	0.33	0.00
Buck Bay	6	0	8	0	0.00	1.33	0.00
Delaney	8	1	11	4	0.13	1.38	0.50
Long Point	8	0	2	1	0.00	0.25	0.13
Plum Tree	5	0	0	8	0.00	0.00	1.60
Swan Bay	8	0	4	0	0.00	0.50	0.00
French Bay West	2	0	1	0	0.00	0.50	0.00
French Bay Marina	2	0	0	0	0.00	0.00	0.00
Point Vivian	10	0	5	0	0.00	0.50	0.00
Goose Bay	8	0	2	4	0.00	0.25	0.50
Point Marguerite Marsh	4	0	0	0	0.00	0.00	0.00
Ferguson's Cove	6	0	0	1	0.00	0.00	0.17
Aunt Janes Bay	6	0	2	0	0.00	0.33	0.00
Thurso Bay	6	0	0	0	0.00	0.00	0.00
Blind Bay (Chippewa)	6	0	2	2	0.00	0.33	0.33
Oak Point	7	0	0	0	0.00	0.00	0.00
Morristown Bridge	6	0	1	0	0.00	0.17	0.00
Chippewa Bay	4	0	0	0	0.00	0.00	0.00
Sheepshead Point	4	0	0	0	0.00	0.00	0.00
Jacques Cartier	5	0	0	0	0.00	0.00	0.00
Galop Island- East	2	1	3	0	0.50	1.50	0.00
Galop Island- West	2	0	0	0	0.00	0.00	0.00
Windsong Bay	6	2	1	0	0.33	0.17	0.00
Total	**173**	**5**	**68**	**22**	**0.03**	**0.39**	**0.13**

2017 30' Exploratory Seining – Lake St. Lawrence							
Site	Hauls	MKY	NP	GP	MKY CPUE	NP CPUE	GP CPUE
Waddington Beach- East	4	0	0	0	0	0	0
Waddington Beach- West	3	0	0	0	0	0	0
Total	**7**	**0**	**0**	**0**	**0.00**	**0.00**	**0.00**

Research, Monitoring, and Management of Upper St. Lawrence River Muskellunge

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The upper St. Lawrence River is well known for its world-class Great Lakes strain muskellunge (*Esox masquinongy*, Mitchell) fishery. This population has been proactively managed through the efforts of an international St. Lawrence River Esocid Working Group (EWG) and guidance by muskellunge management plans (Panek 1980, LaPan and Penney 1991, Farrell et al. 2003). The goal for management is: "To perpetuate the muskellunge as a viable, self-sustaining component of the fish community in the St. Lawrence River and to provide a quality trophy fishery" (with a catch rate of 0.1 muskellunge per hour fished). The EWG is composed of resource managers from the US and Canada and meets periodically to discuss recently completed studies, research needs, and potential management actions. Attention to muskellunge management and research needs has served as a long-term management model (Farrell et al. 2007) that is now focused on trends related to significant population risks subsequent to an invasive viral hemorrhagic septicemia (VHS) outbreak in the mid-2000s (Farrell et al. 2017).

As recommended by management plans, monitoring of adult and young-of-year (YOY) muskellunge has been ongoing since 1990 and recent population changes have been detected using this data series. The first was an apparent positive response to the improved management strategies of the late 1990s and early 2000s with increased numbers of YOY on nursery grounds and higher adult catch rates. From 2005 through 2008, however, widespread mortality of adult muskellunge was observed and attributed to VHSV, which had recently been introduced to the Great Lakes (Elsayed et al. 2006, Casselman et al. 2017). 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 (Farrell et al. 2017). Monitoring is important to understand the population's response to perturbations such as disease-induced mortality and changes to habitat or fish community structure. For example, the nonnative species, round goby, (*Neogobius melanostomus*) has invaded littoral nursery habitats of muskellunge (Farrell et al. 2010). Miano (2015) demonstrated in experimental treatments of northern pike and muskellunge habitats that round goby have the potential to be significant egg predators of esocids, a broadcast spawning species. Round goby are also known as reservoirs and vectors for VHSV (Groocock et al. 2007). Further, the St. Lawrence River esocid seining index has detected changes in the nearshore fish assemblage associated with the dominance of round goby that potentially affects esocid prey availability.

Because of these stressors, maintenance of productive spawning and rearing 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 continue to be of high importance. Significant progress has been made in these areas in previous work (summarized in Farrell et al. 2007), including studies of spawning ecology (LaPan et al. 1995, Farrell et al. 1996, Cooper 2000, Farrell 2001), nursery habitat requirements (Werner et al. 1990, Clapsadl 1993, Jonckheere 1994, Farrell and Werner 1999, Murry and Farrell 2007, Woodside 2008), dietary characteristics of YOY (Kapuscinski et al. 2012), YOY response to invasions by non-native prey fish (Kapuscinski and Farrell 2014) and fall movements and overwintering (Farrell et al. 2014, Gallagher et al. 2017). The information obtained in these studies is being used to develop a more comprehensive understanding of muskellunge habitat and population dynamics, and guide enhancement strategies. Our objective here is to report current research and monitoring efforts with annual updates pertinent to muskellunge management.

Methods

Spring trapnetting survey

Trapnet surveys have been used to monitor spring spawning adult muskellunge populations at a set of index bays for 16 years (1997-2000, 2003, and annually since 2006). In 2017, sixteen nets, including 3' and 4' hoop nets and 6' Oneida trapnets, were fished near shore in eleven muskellunge spawning bays between May 15 and June 13. An additional two sites (Buck Bay and Grass Point) were surveyed using roving net placement in an attempt to increase catch of spawning muskellunge.

Data collected from captured muskellunge included total length (TL), sex, spawning condition, and weight when possible. All adult muskellunge were tagged with Passive Integrated Transponder (PIT) tags. Catch data are reported as an index to monitor trends in relative abundance, size distribution, and sex ratios of spawning muskellunge. Data on muskellunge recaptured in this survey and by angler collaborators are used to examine fish movements, particularly as it pertains to spawning site fidelity. In addition to collecting muskellunge-specific data, all other fishes are identified and enumerated to characterize fish assemblages present at muskellunge spawning sites and this information will be summarized elsewhere.

Culturing and stocking

In collaboration with DEC and USFWS, a muskellunge fingerling culturing and stocking research plan was implemented in 2017, and is expected to continue until 2020. This program aims to experimentally test the reproductive homing abilities of YOY muskellunge, and to enhance the overall abundance and spawning potential of the SLR muskellunge population. In spring 2017, broodstock muskellunge were collected in the Thousand Islands region during index trapnetting as described above, and via USFWS trapnetting efforts in Lake St. Lawrence. Broodstock from the TI region were transported to the SUNY-ESF Thousand Islands Biological Station (TIBS) for gamete collection and fertilization, while Lake St. Lawrence gametes were collected in the field. Eggs were dry fertilized, with seven total 1:1 parental crossings to increase genetic diversity of stocked fish. Approximately 2 weeks after fertilization, eggs hatched into yolk-sac fry, which were subsequently transferred to separate aquaria based on parental origin. Fry were then transferred to raceways after swim-up and fed hatched *Artemia* sp. for 2 weeks. Fry were then transitioned to a dry diet until 4 – 5 inches in total length, and were converted to minnows until stocking (~ 6 inches).

In order to quantify movement, growth, and survival, each fingerling muskellunge was implanted with a MiniHPT8 Passive Integrated Transponder (PIT) tag in the dorsal musculature. In short, muskellunge were lightly anesthetized using tricane methanesulfonate (MS-222), measured for total length, lightly dried then weighed. Each unique identification number for each PIT tag was recorded per fish and related to the stocking location. Stocking efforts were concentrated in formerly productive spawning and nursery grounds that have experienced reproductive failure, ranging from Cape Vincent to Chippewa Bay (Table 5). In November, seining surveys for recaptures were conducted in select sites (Rose Bay, Point Vivian).

Summer seining surveys

In 1990, a standardized seining procedure was initiated at six sites to monitor YOY muskellunge in the upper St. Lawrence River. Since 1997, monitoring the relative abundance of YOY muskellunge during the nursery period has occurred, with two surveys per year at each of eleven sites between Cape Vincent and Alexandria Bay, NY. Survey procedures are further detailed in Farrell and Werner (1999). Habitat data collected include geographic coordinates, depth, temperature, vegetation type, and coverage. Juvenile esocid data collected comprises abundance, distribution, and total length (mm). Seining survey data are used to monitor trends in abundance and growth between periods, and to monitor fish assemblage/habitat relationships at muskellunge nursery locations. Diet information for YOY muskellunge was obtained from selected juveniles >80 mm or 3.2 in TL by gastric lavage (Farrell 1998, Kapuscinski et al. 2012).

A fin tissue sample was retained in 95% non-denatured ETOH for genetic analysis of all muskellunge sampled (both YOY and adults). These samples will continue to build on our current understanding of population and genetic structure of muskellunge in the upper St. Lawrence River, its tributaries, throughout the Great Lakes (Kapuscinski et al. 2013; Turnquist et al. 2017) and downriver Québec populations (Carrier et al. 2017).

<u>Angler diary program</u>

We continue to maintain an angler diary program (since 1997) with participants ranging in angling frequency from casual to dedicated muskellunge anglers, including several professional guides. Cooperators are selected based on the quality of information volunteered in previous diary projects and responses to requests for program assistance. New program participants are encouraged participate. Anglers are asked to record data on daily effort (rod hours), catch and harvest rates, total lengths, and approximate location of angled muskellunge.

<u>Muskellunge catch and release program</u>

A partnership with a local environmental advocacy group, Save The River, continued through 2017 sponsoring the Muskellunge Catch and Release Program. This program aims to both educate and involve the angling community in the conservation of the local adult muskellunge population by rewarding anglers who release a legal-size (54 inch) muskellunge with a limited edition, signed muskellunge print by St. Lawrence River artist Michael Ringer. Data are collected on each participant's total muskellunge catch and effort expended in hours, as well as information for the specific released fish submitted for the reward. Those details include location caught, water depth, weather conditions, date, time of day, weight of line used, bait or lure type, and total length of the muskellunge.

Results and Discussion

<u>Spring trapnetting survey</u>

A total of 7 spawning adult muskellunge were captured (catch rate = 0.016 fish/net night) in upper St. Lawrence River index sites in 2017 (Table 1 and 2; Figure 1). At roving locations, a single adult muskellunge was captured in 55 net-nights (catch rate = 0.018 fish/net night). The mean number of muskellunge caught in the spring trapnetting survey before the VHS outbreak (2005) was 0.063 muskellunge per net-night (SD = 0.032), but a mean of 0.018 (SD = 0.011) muskellunge per net-night have been captured in subsequent years (a 3.5 fold decline). The 2017 catch rate of 0.016 muskellunge per net-night was notably greater than that of 2016 (0.005) and comparable to the post-VHSV average (Figure 1).

In 2017, an effort was put forth to capture spawning adult muskellunge in Lake St. Lawrence to increase egg take numbers for the muskellunge fingerling culture and stocking research program. In total 4 adult muskellunge were captured (catch rate = 0.087 fish/net night) (Table 3 and 4) and processed following the methods listed above. Catch rates were greater compared to the TI region, but sets were only fished for a relatively short duration around the spawning peak.

<u>Culturing and stocking</u>

During the week of October 23, a total of 4545 YOY muskellunge were stocked at 51 nursery sites from Cape Vincent to

Chippewa Bay (stocking rate ~65 fish/ha of nursery habitat). Average total length and weight among stocked fish was 144.7 mm and 11.42 g (5.7 in and 0.025 pounds; Table 5). Prior to release, all fish were implanted with a PIT tag to indicate stocked origin. Field efforts to relocate these tagged fish will commence in 2018.

Summer seining surveys

The annual standardized YOY muskellunge seining index resulted in continued low CPUEs in 2017. Eleven bays were sampled during July with a 30' fine-mesh seine. A total of 6 YOY muskellunge were captured in 90 hauls (CPUE = 0.07 fish/haul) (Figure 2; Table 6). In August, a 60' large-mesh seine was employed in the same 11 bays, and for the first time on record, no YOY muskellunge were captured in 90 seine hauls (Figure 2; Table 6). In addition to annual index seining, exploratory seining using a 30' seine was conducted from July 25 to August 14 in known nursery sites from Cape Vincent to the Moses Saunders power dam. This survey lead to a catch of 5 muskellunge (CPUE 0.03) across 29 exploratory sites (Table 7). The greatest CPUE for age-0 muskellunge was at Galop Island East (exploratory site) with 0.50 fish per haul, and at Cobb Shoal (index site) with 0.42 fish per haul.

Angler diary program

In 2017, 7 anglers (including guides) from the angler diary program fished 691.25 hours of effort for 17 muskellunge captured (0.025 fish / hour; Figure 3). The catch rate was an increase from 2016 where 9 muskellunge were captured in 665 hours of effort (0.014 fish / hour), and less than 2015 where 28 muskellunge were captured in 770 hours of effort (0.036 fish / hour). Catch rates remain well below the management goal of 0.1 fish per hour.

Muskellunge catch and release program

In 2017, two anglers participated in the Muskellunge Catch and Release program with TIBS and Save The River. Anglers submitted only two muskellunge release award affidavits, for fish ranging from 54.5 to 55 inches. Anglers participating in this program estimated their angling effort ranging from 8 to 100 hours, with an average of 54 angler hours to catch a legal-size (54 inch) or greater muskellunge. Two muskies of 48 and 50 inches were also reported.

Acknowledgements

We wish to thank Steve LaPan of the NYSDEC Cape Vincent Fishery Station and Rodger Klindt of NYSDEC Watertown Region 6 Office for their long-term support of the St. Lawrence River Muskellunge Research and Management Program. We also thank Scott Schlueter of the USFWS New York Field Office and the numerous technicians and volunteers who have served on this project, as well as the full time staff who have contributed their personal time outside of their regular occupational obligations. A special recognition goes to John Paul Leblanc who undertook much responsibility and time toward the aquaculture and care of stocked muskellunge. The research is funded by the NYS Environmental Protection Fund and supported by the SUNY-ESF Federal Work-Study Program. This research was conducted at the Thousand Islands Biological Station near Clayton, NY.

References

Carrier, A., A.L. Ferchaud, P. Brodeur, J. Le Luyer, J. M. Farrell, and L. Bernatchez. 2017. Population genomics towards optimizing Muskellunge (*Esox masquinongy*) management and conservation in Québec Canada. American Fisheries Society Symposium 85:467-471.

Casselman, J. M., T. Lusk, J. M. Farrell, and C. Lake. 2017. Die-Off of Muskellunge in the Upper St. Lawrence River Caused by Viral Hemorrhagic Septicemia, 2005–2008. American Fisheries Society Symposium 85: 373-377.

Clapsadl, M.D. 1993. An examination of

habitat characteristics influencing the survival of stocked muskellunge, Esox masquinongy, in four St. Lawrence River embayments. Master's Thesis, State University of New York, College of Environmental Science and Forestry, Syracuse, NY, 63 p.

Cooper, J. E. 2000. Comparative development and ecology of northern pike (Esox Lucius) and muskellunge (Esox masquinongy) eggs and larvae in the upper St. Lawrence River and the implications of changes in the historical spawning habitat. Doctoral Thesis, State University of New York, College of Environmental Science and Forestry, Syracuse, New York.

Dombeck, M.P., B.W. Menzel, and P.N. Hinz. 1986. Natural reproduction in midwestern lakes. American Fisheries Society Special Publication 15:122-134.

Gallagher, A., P. Szekeres. S. Cooke, and J. M. Farrell. 2017. Tracking Young-of-Year Northern Pike and Muskellunge: Monitoring Behavior and Habitat Use During Fall Outmigration from Nursery Sites. American Fisheries Society Special Publication 85:167-170.

Groocock, G. H., R. G. Getchell, G. A. Wooster, K. L. Britt, W. N. Batts, J. R. Winton, R. N. Casey, J.W. Casey, and P. R. Bowser. 2007. Detection of viral hemorrhagic septicemia in round gobies in New York State (USA) waters of Lake Ontario and the St. Lawrence River. Diseases of Aquatic Organisms 76:187–192.

Elsayed, E., M. Faisal, M. Thomas, G. Whelan, W. Batts, and J. Winton. 2006. Isolation of viral haemorrhagic septicaemia virus from muskellunge, *Esox masquinongy* (Mitchill), in Lake St. Clair, Michigan, USA reveals a new sublineage of the North American genotype. Journal of Fish Diseases 29:611–619.

Farrell, J.M. 1998. Population ecology of sympatric age-0 Northern Pike and muskellunge in the St. Lawrence River. Doctoral dissertation. State University of New York, College of Environmental Science and Forestry, Syracuse, New York.

Farrell, J. M. 2001. Reproductive success of sympatric northern pike and muskellunge in an upper St. Lawrence River bay. Transactions of the America n Fisheries Society 130:796-808.

Farrell, J.M., R.G. Werner, S.R. LaPan, and K.A. Claypoole. 1996. Egg distribution and spawning habitat of northern pike and muskellunge in a St. Lawrence River marsh, New York. Transactions of the American Fisheries Society 125:127-131.

Farrell, J.M., and R.G. Werner. 1999. Abundance, distribution, and survival of age-0 muskellunge in Upper St. Lawrence River nursery embayments. North American Journal of Fisheries Management 19:310-321.

Farrell, J.M., R.M. Klindt, and J.M. Casselman. 2003. Update of the Strategic Plan for Management of the St. Lawrence River Muskellunge Population and Sportfishery. New York State Department of Environmental Conservation Report, Albany, New York, 40 pages.

Farrell, J.M., R.M. Klindt, J.M. Casselman, S. R. LaPan, R.G. Werner, and A. Schiavone. 2007. Development, implementation, and evaluation of an international muskellunge management strategy for the upper St. Lawrence River. Environmental Biology of Fishes 79:111-123.

Farrell, J. M., K. T. Holeck, E. L. Mills, C. E. Hoffman, and V. J. Patil. 2010. Recent Ecological Trends in Lower Trophic Levels of the International Section of the St. Lawrence River: A Comparison of the 1970s to the 2000s. Hydrobiologia 647:21–33.

Farrell, J. M., H. Brian Underwood, and K.L. Kapuscinski. 2014. Fine scale habitat use by age-1 stocked muskellunge and wild northern pike in an upper St. Lawrence

River bay. Journal of Great Lakes Research 40, Supplement 2:148-153.

Farrell, J. M., R. G. Getchell, K. L. Kapuscinski, and S. R. LaPan. 2017. Long-term Trends of St. Lawrence River Muskellunge: Effects of Viral Hemorrhagic Septicemia and Round Goby Proliferation Creates Uncertainty for Population Sustainability. American Fisheries Society Symposium 85:275-301.

Jonckheere, B.V. 1994. Production and survival of juvenile muskellunge (Esox masquinongy). Master's Thesis. State University of New York, College of Environmental Science and Forestry, Syracuse, New York.

Kapuscinski, K.L., J.M. Farrell, and B.A. Murry. 2012. Feeding strategies and diets of young-of-the-year muskellunge from two large river ecosystems. North American Journal of Fisheries Management 32:635-647.

Kapuscinski, K.L., Sloss, B.L., and J. M. Farrell. 2013. Genetic population structure of muskellunge in the Great Lakes. Transactions of the American Fisheries Society 142:1075-1089.

Kapuscinski, K. L, and J. M. Farrell. 2014. Habitat factors influencing fish assemblages at muskellunge nursery sites. Great Lakes Research 40, Supplement 2:135-147.

LaPan, S.R., and L. Penney. 1991. Strategic plan for management of the muskellunge population and sport fishery phase II: 1991-2000. New York State Department of Environmental Conservation and Ontario Ministry of Natural Resources, Watertown, New York.

LaPan, S.R., A. Schiavone, and R.G. Werner. 1995. Spawning and post-spawning movements of the St. Lawrence River muskellunge (Esox masquinongy) in Kerr, S. J. and C. H. Olver (eds.) Managing Muskies in the 90's. Workshop proceedings. OMNR, Southern Region Science and Technology Transfer Unit WP-007. 169 pp.

Miano, A. 2015. Invasive round goby diet patterns and egg predation on broadcast spawning fishes in Upper St. Lawrence River coastal habitats. Master's Thesis. State University of New York, College of Environmental Science and Forestry, Syracuse, New York.

Murry, B.A., and J. M. Farrell. 2007. Quantification of native muskellunge nursery: influence of body size, fish community composition, and vegetation structure. Environmental Biology of Fishes 79:37-47.

Panek, F. M. 1980. Strategic plan for management of the muskellunge population and sport fishery of the St. Lawrence River. NYS DEC, Albany, NY.

Turnquist; K. N., Wesley L., J. M Farrell, P. A. Hanchin, K. L.Kapuscinski; L. M. Miller; K.T Scribner; C. C. Wilson, and B. L. Sloss. 2017. Genetic structure of muskellunge in the Great Lakes region and the effects of supplementation on genetic integrity of wild populations. Journal of Great Lakes Research 43(6):1141-1152.

Werner, R., S.R. LaPan, R. Klindt, and J.M. Farrell. 1990. St. Lawrence River muskellunge investigations Phase I-final report: Identification of muskellunge spawning and nursery habitat. NYS DEC Publication. 47 p.

Woodside, K. 2008. Development and application of models predicting young of the year muskellunge presence and abundance from nursery features. Master Thesis, SUNY College of Environmental Science and Forestry, Syracuse NY. 101 p.

Table 1. Locations, number of trapnets, trapnet effort (net nights), muskellunge catch, and CPUE for index and roving bays in the upper St. Lawrence River, 2017.

Bay	# Nets	Effort	MKY	CPUE
Index				
Blind	1	28	1	0.036
Cobb Shoal	1	28	0	0.000
Densmore	1	24	0	0.000
Flynn	4	112	4	0.036
Frink's	1	28	0	0.000
Garlock	1	24	2	0.083
Lindley	1	27	0	0.000
Millen's	2	52	0	0.000
Peos	1	26	0	0.000
Rose	2	52	0	0.000
Swan	1	28	0	0.000
Sub-Total	16	429	7	0.016
Roving				
Buck	1	27	1	0.037
Grass Point	1	28	0	0.000
Sub-Total	2	55	1	0.018
Total	**18**	**484**	**8**	**0.017**

Table 2. Summary of location of catch, total length (TL-mm), sex, reproductive stage, tag number and recapture history of spawning adult muskellunge caught and released from trapnets in upper St. Lawrence River bays, 2017. The tag entry number is for PIT type tags.

Date	Bay	Sex	Stage	TL (mm)	Girth (mm)	Recap tag #	Tag #
5/16	Flynn	M	Ripe	1080		-	900118001347882
5/16	Flynn	F	Ripe	1270		900118001355001	
5/17	Flynn	M	Ripe	882		-	900118001346445
5/17	Flynn	F	Ripe	1086		-	900118001347040
5/17	Blind	F	Hard	1383	601	-	900118001348167
5/18	Buck	F	Ripe	1280	561	-	900118001344678

Table 2. Continued.

5/25	Garlock	M	Ripe	800	312	-	900118001345017
5/25	Garlock	F	Hard	1130	405	-	900118001071796

Table 3. Locations, number of trapnets, trapnet effort (net nights), muskellunge catch, and CPUE for bays in Lake St. Lawrence, 2017.

Bay	# Nets	Effort	MKY	CPUE
Brandy Brook	4	4	0	0.000
Leishman Point	1	8	0	0.000
Ogden Island	1	7	0	0.000
Waddington Beach	1	5	0	0.000
Whitehouse	1	8	3	0.375
Windsong	2	14	1	0.071
Total	**10**	**46**	**4**	**0.086**

Table 4. Summary of location of catch, total length (TL-mm), sex, reproductive stage, tag number and recapture history of spawning adult muskellunge caught and released from trapnets in Lake St. Lawrence bays, 2017. The tag entry number is for PIT type tags.

Date	Bay	Sex	Stage	TL (mm)	Girth (mm)	Recap tag #	Tag #
5/18	Windsong	F	Ripe	1244	571	-	900118001344995
5/20	Whitehouse	M	Ripe	1090	472	-	900118001346380
5/22	Whitehouse	F	Ripe	1360	528	-	900118001345000
5/23	Whitehouse	M	Ripe	1044	398	-	900118001346829

Table 5. Muskellunge stocking totals and average total length (mm) and weight (g) by site.

Site	Average TL (mm)	Average Weight (g)	Number stocked
Affluence	143.58	11.10	38
Allens Point	142.78	11.04	148
Atlantis	143.33	11.58	30
Aunt James	144.69	11.56	71
Back of Grindstone	142.11	10.86	73

Table 5. Continued.

Birch Island	148.15	12.40	20
Blind	145.27	11.40	409
Boscobel	143.08	10.78	12
Buck	144.53	11.55	91
Carrier	144.34	11.48	102
Chippewa Point	141.20	10.59	46
Cobb	143.73	11.46	89
CYC	155.38	13.91	13
Deer	137.81	9.83	27
Delaney	147.47	12.23	72
Densmore	148.23	11.99	113
Densmore 3	144.88	11.55	40
Eel Bay	152.52	13.18	61
Flynn	143.45	11.29	577
French Bay	146.92	12.26	62
French Cove	146.07	11.93	14
Frinks	133.96	9.03	27
Garden Island	147.87	11.85	78
Garlock	142.60	10.95	65
Grants	145.46	11.36	156
Jolly Island	144.27	10.83	11
Lindley	147.27	-	22
Long Point	144.02	11.17	222
Mead	149.21	12.71	14
Millens	148.51	12.35	223
Mink Island	144.16	11.10	43
Owatonna	148.25	11.81	72
Peos	149.06	12.06	16
Picton 1	149.43	12.41	23
Picton 2	151.97	13.19	36
Point Angiers	143.10	11.25	10
Point Marguerite	140.35	10.39	236
Point Vivian	144.64	11.24	107
Rabbit Island	141.32	10.44	66
Red Barn	145.42	11.75	26
Roods	145.17	11.25	18
Rose	141.70	10.90	174
Rusho	146.56	11.91	64
Salisbury	145.10	11.61	42
Sand Bay	141.99	11.06	139
Seven Isles	151.60	13.16	20
Shambo	148.77	12.48	88

Table 5. Continued.

Sheepshead	141.53	10.92	95
Swan	147.54	11.74	222
Thurso	141.94	10.94	49
Whitehouse	144.26	11.34	73
Total	**144.69**	**11.42**	**4545**

Table 6. Seining catch summary for 2017 sampling using a fine-mesh 30' bag seine (top) and a large-mesh 60' bag seine (bottom).

Index Seining (30')					
Site	Hauls	MKY	NP	MKY CPUE	NP CPUE
Affluence Bay	6	0	2	0.00	0.33
Boscobel Bay	6	0	0	0.00	0.00
Cobb Shoal	12	5	5	0.42	0.42
Deer Island	6	0	0	0.00	0.00
Frink's Bay	10	0	0	0.00	0.00
Garlock Bay	10	0	1	0.00	0.10
Lindley Bay	6	0	0	0.00	0.00
Millens Bay	12	1	2	0.08	0.17
Peos Bay	6	0	0	0.00	0.00
Rose Bay	10	0	0	0.00	0.00
Salisbury Bay	6	0	3	0.00	0.50
Total	**90**	**6**	**13**	**0.07**	**0.14**

Index Seining (60')					
Site	Hauls	MKY	NP	MKY CPUE	NP CPUE
Affluence Bay	6	0	0	0.00	0.00
Boscobel Bay	6	0	2	0.00	0.33
Cobb Shoal	12	0	2	0.00	0.17
Deer Island	6	0	1	0.00	0.17
Frink's Bay	10	0	3	0.00	0.30
Garlock Bay	10	0	2	0.00	0.20
Lindley Bay	6	0	4	0.00	0.67
Millens Bay	12	0	4	0.00	0.33
Peos Bay	6	0	0	0.00	0.00
Rose Bay	10	0	0	0.00	0.00
Salisbury Bay	6	0	4	0.00	0.67
Total	**90**	**0**	**22**	**0.00**	**0.24**

Table 7. Summary of 30' exploratory seining by bay from July 25 to August 14. Effort is defined as the total number of hauls completed per site. Data for northern pike captures are also shown.

Exploratory Seining (30')					
Site	Hauls	MKY	NP	MKY CPUE	NP CPUE
Whitehouse Bay	6	0	2	0.00	0.33
Flynn Bay	16	0	9	0.00	0.56
Grass Point	8	0	8	0.00	1.00
Blind Bay	16	1	5	0.06	0.31
Carrier Bay	6	0	2	0.00	0.33
Buck Bay	6	0	8	0.00	1.33
Delaney	8	1	11	0.13	1.38
Long Point	8	0	2	0.00	0.25
Plum Tree	5	0	0	0.00	0.00
Swan Bay	8	0	4	0.00	0.50
French Bay West	2	0	1	0.00	0.50
French Bay Dockside Marina	2	0	0	0.00	0.00
Point Vivian	10	0	5	0.00	0.50
Goose Bay	8	0	2	0.00	0.25
Point Margaritte Marsh	4	0	0	0.00	0.00
Ferguson's Cove	6	0	0	0.00	0.00
Aunt Janes Bay	6	0	2	0.00	0.33
Thurso Bay	6	0	0	0.00	0.00
Blind Bay (Chippewa)	6	0	2	0.00	0.33
Oak Point	7	0	0	0.00	0.00
Morristown Bridge	6	0	1	0.00	0.17
Chippewa Bay	4	0	0	0.00	0.00
Sheaphead Point (Chippewa)	4	0	0	0.00	0.00
Jacques Cartier	5	0	0	0.00	0.00
Galop Island- East	2	1	3	0.50	1.50
Galop Island- West	2	0	0	0.00	0.00
Windsong Bay	6	2	1	0.33	0.17
Total	**173**	**5**	**68**	**0.03**	**0.39**

Table 7. Continued

Exploratory Seining (30') – Lake St. Lawrence							
Site	Hauls	MKY	NP	GP	MKY CPUE	NP CPUE	GP CPUE
Waddington Beach- East	4	0	0	0	0	0	0
Waddington Beach- West	3	0	0	0	0	0	0
Total	**7**	**0**	**0**	**0**	**0.00**	**0.00**	**0.00**

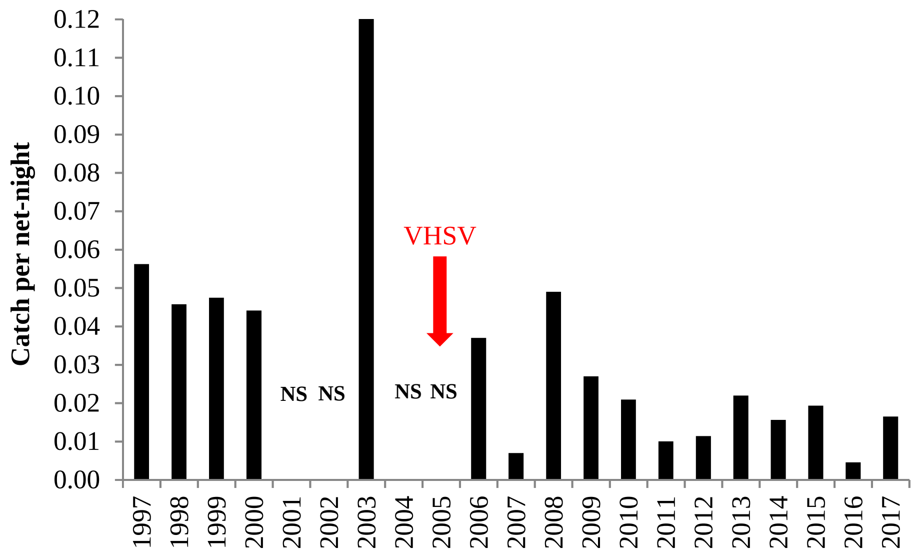

Figure 1. Total catch per net-night of muskellunge during spring trapnet sampling from 1997-2017 in the upper St. Lawerence River. Samples were not collected in 2001-02 and 2004-05 (NS) because of a decision of the Esocid Working Group to monitor muskellunge every third year. Following VHSV outbreak it was decided to resume annual monitoring.

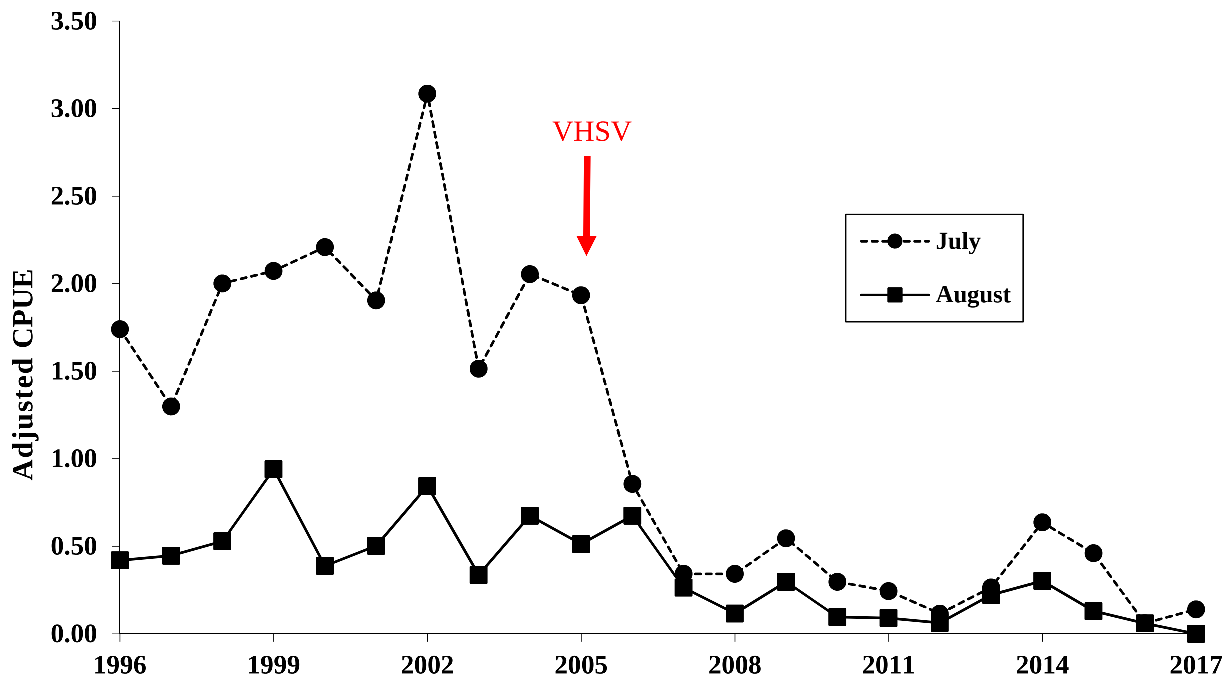

Figure 2. Catch per unit effort of YOY muskellunge captured in standardized seine hauls in eleven upper St. Lawrence River nursery sites from 1996 to 2017. A 9.14 m (30') fine-mesh seine was used during the month of July and an 18.3 m (60') large-mesh seine was used during the month of August. The fine-mesh seine CPUE was doubled to standardize the area swept among the two gears. Detection of VHSV occurred in 2005 and widespread mortality of muskellunge continued through 2008 in the upper River.

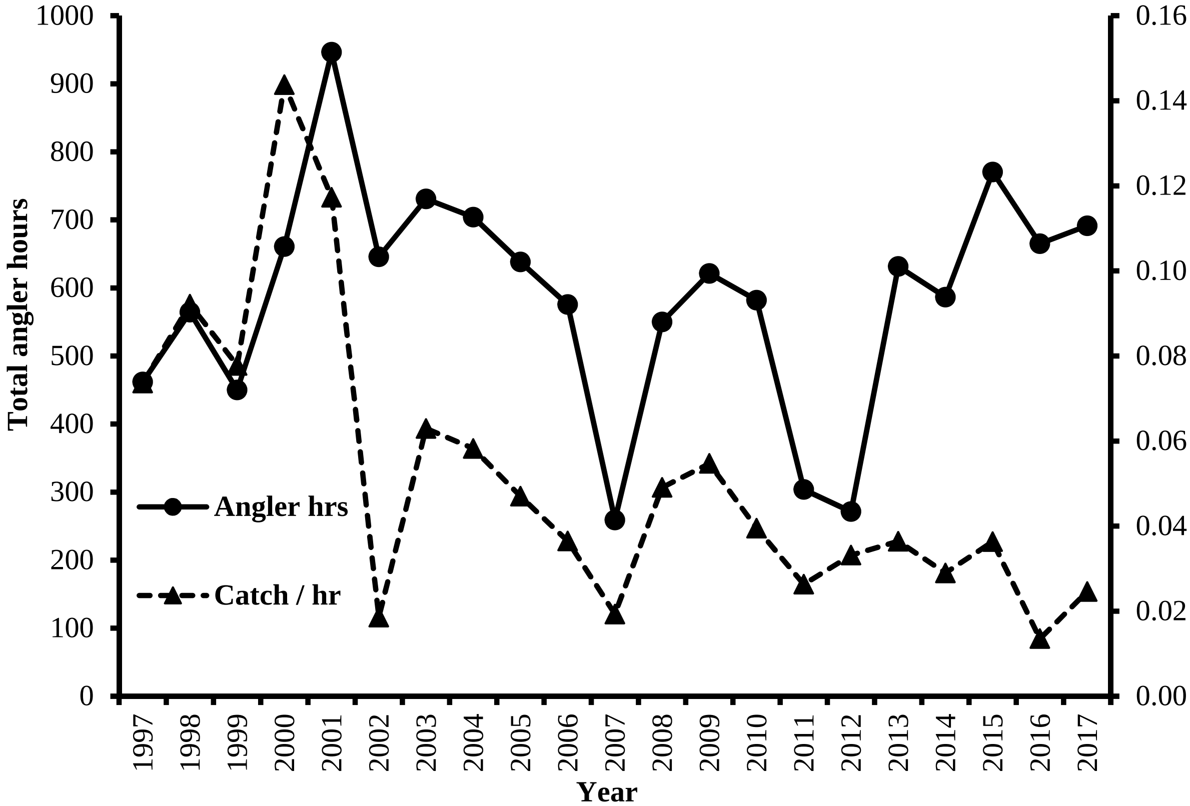

Figure 3. Thousand Islands Region Muskellunge Angler Diary Program data showing angler hours compared to average catch per angler hour. The management target goal is 0.1 fish per angler hour or 1 muskellunge per 10 hours fished. Note relationship between catch and effort over time, however, relatively high effort since 2012 has not produced large increases in catch of muskellunge.

Lake Ontario Commercial Fishery Summary, 2000 – 2017

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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 2017. Commercial harvest generally targets yellow perch (*Perca flavescens*), however, harvest of cisco (*Coregonus artedii*) was also reported in 2017 (Tables 1 and 2). Cisco harvest went unreported for many years, and fishers were reminded of reporting requirements (all fish caught, whether sold or not) in 2009. Of four licensed commercial fishermen, only two actively fished in 2017 (Table 2). Data from 1991-1999 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 2017 commercial catch from the New York waters of Eastern Lake Ontario (*estimated, weighted mean value, as price fluctuates throughout the year).

SPECIES	TOTAL POUNDS	PRICE/POUND*	TOTAL VALUE
Yellow Perch	67,435	$2.21	$149,095.35
Cisco	509	$0.50	$254.50

Table 2. Reported[*] commercial fish catch in pounds from the New York waters of Eastern Lake Ontario, 2000-2017.

	# Lic.	YP	BBH	WP	RB	SF	CRP	WTF	CSCO
2000	7	59,928	5,709	383	280	3,571	308	-	-
2001	6	40,323	5,875	442	15	16	-	-	-
2002	6	37,223	4,435	-	-	-	-	-	-
2003	6	6,153	5,815	-	-	-	-	-	-
2004	3	37,066	1,200	-	-	-	-	-	-
2005	3	6,354	1,040	-	-	-	-	-	-
2006	3	4,274	500	-	-	-	-	-	-
2007	3	34,343	535	-	-	-	-	-	-
2008	3	14,428	735	-	-	-	-	-	-
2009	3	41,338	31	-	20	-	-	-	347**
2010	2	44,008	75	546	-	-	-	16	465
2011	3	77,238	105	3,736	-	-	-	-	613
2012	3	59,989	105	1,130	-	-	-	18	44
2013	3	20,589	-	1,820	-	-	-	-	12
2014	2	44,143	63	815	22	-	-	-	20
2015	2	46,473	-	859	-	-	-	11	52
2016	2	67,405	-	494	-	-	-	210	1,806
2017	2	67,435	-	-	-	-	-	-	509

YP = Yellow Perch
BBH = Brown Bullhead
WP = White Perch
RB = Rock Bass
SF = sunfish (Pumpkinseed, Bluegill)
CRP = Black Crappie
WTF = Whitefish
CSCO= Cisco

*does not include documented illegal and/or unreported harvest
**known harvest in previous years was not reported
Lic. = number of active fishers