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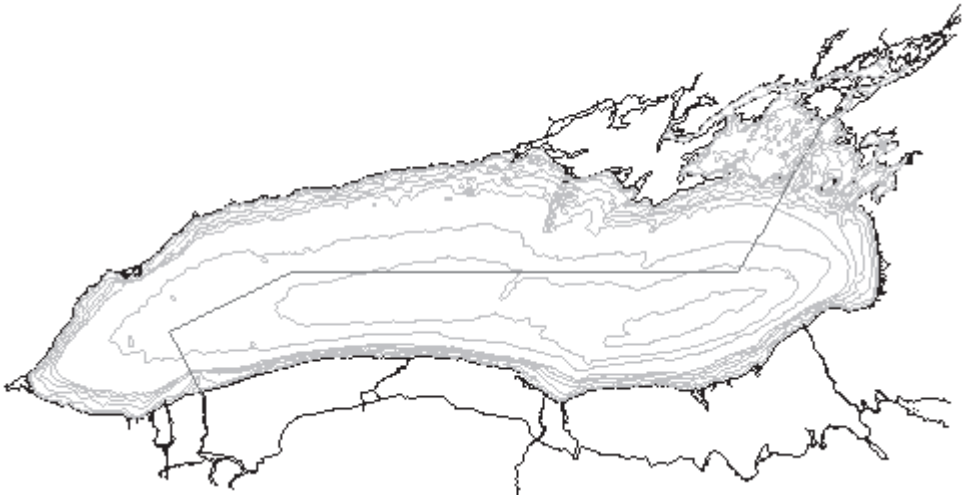
Bureau of Fisheries

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



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New York State Department of Environmental Conservation
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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

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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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SECTION	TITLE & AUTHORS	COOPERATING AGENCIES
1	**New York Lake Ontario and Upper St. Lawrence River Stocking Program 2018** *(Connerton)*	NYSDEC
2	**2018 Lake Ontario Fishing Boat Survey** *(Connerton., Eckert)*	NYSDEC
3	**2018 Status of the Lake Ontario Lower Trophic Levels** (*Holeck, Rudstam, Hotaling, Lemon, Pearsall, Lantry, J., Connerton, Legard, LaPan, Biesinger, Lantry, B., Weidel)*	Cornell Univ. NYSDEC USFWS USGS
4	**Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1976-2018** *(Connerton, Legard)*	NYSDEC
5	**Lake Trout Rehabilitation in Lake Ontario, 2018** *(Lantry B., Furgal, Connerton, Gorsky)*	USGS NYDEC USFWS
6	**Thousand Islands Warmwater Fisheries Assessment** *(Resseguie, Gordon)*	NYSDEC
7	**2018 Lake St. Lawrence Warmwater Fisheries Assessment** *(Klindt, Gordon)*	NYSDEC
8	**2018 Salmon River Wild Young-of-Year Chinook Salmon Seining Program** *(Bishop, Prindle, Verdoliva)*	NYSDEC USGS
9	**Population Characteristics of Pacific Salmonines Collected at the Salmon River Hatchery 2018** *(Prindle, Bishop)*	NYSDEC
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13	**Cormorant Management Activities in Lake Ontario's Eastern Basin** *(Resseguie, Mazzocchi)*	NYSDEC
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20	**Lake trout spawning and habitat assessment at Stony Island Reef** *(Furgal, Lantry B., Weidel, Farrell, Gorsky, Biesinger)*	USGS SUNY-ESF USFWS
21	**2018 Administrative Program Summary Report for the Sportfishing Restoration & Spending Plan for the Lake Ontario** **(***LaPan, Balk*)	NYSDEC
22	**Pugnose shiner range expansion in New York's St Lawrence River, 1931-2018** (*Carlson, Klindt, Maharan*)	NYSDEC

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 has been stable 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. Round 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. Round 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 years of poor alewife reproduction resulted in very small 2013 and 2014 (record low) alewife year classes, the 2017 year class was also below average, which contributed to a markedly reduced adult alewife population in 2016 - 2018. Concerns over the impacts of the 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. Chinook salmon stocking was reduced by an additional 20% in 2019.

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 2018.

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 2018, 322 (208 spring, 118 fall) bottom trawls were performed in U.S. and Canadian waters.
- The 322 total trawls represent 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 2016-2018 distribution of trawl tows across depths more closely matches the distribution of depths available in the lake.
- In spring 2018 bottom trawl surveys, abundance of adult (age-2 and older) alewife decreased from 2017 levels in U,S. waters, while the index in Canadian waters increased.
- The 2018 Age-1 or "yearling" alewife abundance index, which measures reproductive success the previous year, was the third lowest observed in U.S. waters over the past 22 years. Canadian values were higher than U.S. values.
- Alewife condition indices (a measure of body "fatness") were below the 10-year average for both the spring and fall indices.
- Abundance indices for rainbow smelt, cisco, and emerald shiner were similar to 2017.
- Deepwater sculpin and round goby were the most abundant benthic prey fish caught in the fall bottom trawl survey. Slimy sculpin abundance continued to be low in 2018.
- The 2018 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. The age-1 and older alewife index for 2018 was 1.97 billion fish, down from 4.48 billion fish in 2017. The rainbow smelt abundance estimate (99.7 million) increased in 2018 but remained well below values observed in the 1990s.

Coldwater Fisheries Management

- Fish stocking in the New York waters of Lake Ontario in 2018 included 1.29 million Chinook salmon, 158,034 coho salmon, 620,780 rainbow trout, 398,255 lake trout, 434,180 brown trout, 199,535 Atlantic salmon, 106,306 bloater, and 520,674 cisco. Of these, 141,810 brown trout and 239,679 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 of salmonids at a given age serve as a potential index of relative balance between the number of predators (primarily salmonids) and preyfish; however, water temperatures also influence fish growth and condition. Average weights and condition are calculated for 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 2018 mean length of age-3 Chinook salmon was 1.3 in shorter than the long-term average. 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). Predicted weights of Chinook salmon in 2018 were the second lowest in the 31-year data series for five out of seven standard lengths including 24-40 inches and were 3rd (20 in) and 4th (16 in) lowest for the other lengths. (Section 2).
- At the Salmon River Hatchery, the mean weight of age-1 Chinook salmon males (jacks) sampled in 2018 was 4.4 pounds, among the lowest observed values in the 1988-2018-time series. Age 2 Chinook salmon males averaged 13.4 pounds (0.5 pounds below average), while age 2 females averaged 12.6 pounds (2.0 pounds below average). Age 3 Chinook salmon males averaged 15.8 pounds (same as 2017; over 3.0 pounds below average) and age 3 females averaged 15.3 pounds (3.5 pounds below average) (Section 9).
- Steelhead are sampled in the spring at the Salmon River Hatchery and, unlike Chinook salmon, do not reflect growth during the 2018 growing season. Weights reported here reflect conditions prior to and including 2017. The mean weight of age-3 steelhead males was 5.7 pounds (0.2 pounds below average), while age-3 females averaged 5.6 pounds (0.7 pounds below average). The mean weight of age-4 steelhead males was 5.6 pounds (2.8 pounds below average), while females averaged 6.0 pounds (3.1 pounds below average) (Section 9).
- Since the institution of seasonal base flows in the Salmon River in 1996, natural reproduction of Chinook salmon continues to be documented by an annual seining index conducted weekly during May and June at four sites. In 2018, the mean catch per seine haul (49 fish/haul) was estimated using the catches from the fourth week of May through the second week of June, and was the second lowest on record (Section 8).

  The twenty first 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 48,680 Washington strain steelhead were raised at seven pen sites, comprising 9.2% of DEC's Lake Ontario yearling steelhead stocking allotment in 2018. Seven pen- rearing sites raised a total of 570,230 Chinook salmon, representing 44.3% of DEC's 2018 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 increased in 2018 by 51% over 2017 values and was equivalent to the prior peak observed in 2014.
- The sea lamprey wounding rate on lake trout caught in gill nets was 0.6 fresh (A1) wounds per 100 lake trout, one of the lowest values in the data series and well below the target of 2.0 wounds per 100 lake trout.
- Naturally reproduced lake trout were documented in 24 years since 1994. The largest catches of naturally produced lake trout occurred from 2014 – 2018.
- Adult lake trout condition (measured by the predicted weight of a 27.6 in fish) in 2016 - 2018 was the highest observed for the 1984 – 2018 time series. (Section 5).
- In 2018, angler catch (12,205 fish) and harvest (4,949 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). (Section 2).

Status of Sea Lamprey Control

- The sea lamprey is a destructive invasive species in the Great Lakes that contributed to the collapse of lake trout and other native species in the mid-20th century and continues to affect efforts to restore and rehabilitate the fish-community. Sea lampreys attach to large bodied fish and extract blood and body fluids. It is estimated that about half of sea lamprey attacks result in the death of their prey and an estimated 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 2018, 16 Lake Ontario tributaries (six Canada, ten NY) were treated with lampricides. Treatments in New York included Black River, Lindsey Creek, Little Sandy Creek, Salmon River, Grindstone Creek, Snake Creek, Catfish Creek, Eightmile Creek, Sterling Creek and Red Creek. A total of 5,428 sea lamprey were trapped in eight tributaries, five of which are index locations.
- The index of adult Sea Lamprey abundance was 11,666 (95% CI; 9,921 – 13,412), which is less than the target of 15,502
- Larval assessments were conducted on a total of 58 tributaries (32 Canada, 26 NY). Surveys to estimate abundance of larval sea lampreys were conducted in 10 tributaries (6 Canada, 4 NY). Surveys to detect the presence of new larval sea lamprey populations were conducted in 10 tributaries (7 Canada, 3 NY), with no new populations detected.
- Post-treatment assessments were conducted in 13 tributaries (6 Canada, 7 NY) to determine the effectiveness of lampricide treatments conducted during 2017 and 2018. Surveys in New York's Salmon River found many residuals and resulted in retreatment of many backwater areas during 2018.
- Surveys to evaluate barrier effectiveness were conducted in 28 tributaries (25 Canada, 3 U.S.).
- The rate of wounding by sea lamprey on lake trout caught in gill nets was 0.6 fresh (A1) wounds per 100 lake trout, well below the target of 2 wounds per 100 lake trout (Section 5). There were an estimated 21.1 lamprey observed per 1,000 trout or salmon caught by anglers, 39.4% to the previous ten-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 2018 was similar to the previous 10-year average. Yellow perch and smallmouth bass were the most commonly caught species representing 25% and 34% of the total catch, respectively.
- Smallmouth bass abundance (6.8 fish/net) remained low compared to the long-term average but was 25% 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 2018 was 35% below the previous 10-year average.
- Yellow perch CPUE declined in 2018 but was 58% higher than the previous 5-year average.
- At least one lake sturgeon was collected in the Eastern Basin gill netting survey in 18 of the last 24 years, suggesting improved population status. A record high nine lake sturgeon were caught in 2018.
- 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).
- After 1988, Thousand Islands smallmouth bass abundance index generally declined and was low from 1996 through 2004. However, the catch increased in 2005 and varied at relatively higher level through 2018. In 2018, catch per unit effort was the fourth highest on record, indicating, that the low 2015 value was likely a sampling anomaly. Yellow perch abundance has remained low since 2012, but did show a slight increase in 2018.. From 1996 to 2018, 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 2007-2018 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 2018. 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. However, the catches of these year classes did not persist in 2018. Walleye abundance remained below the long-term average in 2018 (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 2018 produced a total catch of 155 fish. Passive integrated transponder (PIT) tags, which allow for future identification of individual fish, were implanted in 120 fish to monitor fish growth, movements, and to manage brood stock genetics in restoration stocking efforts. Thirty-three previously tagged sturgeon were re-captured in 2018 (Section 16).

Sport Fishery Assessment

- Each year from 1985-2018 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 salmonine fishery and provide valuable information on other fish species (Section 2).
- Overall during 2018, fishing quality for trout and salmon was good to excellent. The four most sought after species were 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 2018, charter boat fishing quality (catch rate = number of fish caught per hour of angling) for these four species combined increased 25% from 2017 to the highest level on record.

- Chinook salmon fishing quality among charter boats has been excellent from 2003- 2018. Fishing quality in 2018 was the highest recorded, with record high catch rates in May, June, August and September, and record high seasonal catch rates in all regions.
- After three years of below average brown trout fishing quality, brown trout catch rates in 2018 improved to 43% above the long-term average. Fishing quality for brown trout was excellent in April and May (second best recorded), and catch rates were above average from July through September.
- Fishing quality for coho salmon in 2018 was average overall, with relatively poor catch rates in April, July and August, and above average catch rates in May, June and September.
- Rainbow trout fishing quality was at record high levels each year 2008-2014; however, declined markedly during 2015 and 2016. After temporarily improving in 2017, catch rates declined again in 2018 to 40% below the long-term average. However, the decline is partly attributed to excellent fishing quality for other trout and salmon species (i.e., Chinook salmon and brown trout) which may have reduced fishing effort specifically targeting rainbow trout.
- Following the 2007 record low, lake trout fishing quality improved each year 2008-2013, remained relatively stable from 2013-2016, then declined in 2017 and again in 2018 to 66% below the long-term average. Similar to rainbow trout, the decline is partly attributed to excellent fishing quality for other trout and salmon species (i.e., Chinook salmon and brown trout) which may have reduced fishing effort specifically targeting lake trout.
- Fishing quality for Atlantic salmon in 2018 remained relatively high and was 4.1 times higher than the 1995-2008 average (i.e., the period of lowest catch rates). However, catch rates for Atlantic salmon remain very low when compared to other salmonids.
- An estimated 252,976 trout and salmon were caught in 2018 (primarily Chinook salmon [69%] and brown trout [16%]). Total harvest of trout and salmon was estimated at 142,447 fish, dominated by Chinook salmon (71%) and brown trout (16%).
- After declining to a record low in 2017 (partially due to extremely high-water levels), fishing effort directed at trout and salmon in 2018 increased 33% and was equal to the previous 10-year average.
- The number of sea lamprey observed per 1,000 trout and salmon caught was estimated at 21.1 in 2018 (an increase from 2017 and 20% above the previous 10-year average); however, Lake Ontario sea lamprey control remains the most effective in the Great Lakes.
- 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 4,135 bass trips in 2018, an 80% increase from the record low observed in 2017. However, smallmouth bass fishing effort in 2018 was the 2nd lowest on record and 12% below the recent 5-year average. Bass fishing quality in 2018 increased 148% compared to the 2010 record low and was 71% above the previous 10-year average.

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.

- In 2018, NYSDEC applied for a USFWS depredation permit under Priority 3 of the permitting application (to alleviate management and conservation concerns associated with threatened, endangered and species of high conservation concern). NYSDEC was granted an annual permit authorizing the culling of up to 965 birds and destroying up to 4,980 nests statewide.
- 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 2018 (1,018,459) was well above the management target.

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New York Lake Ontario and Upper St. Lawrence River Stocking Program 2018

M. J. Connerton
New York State Department of Environmental Conservation
Cape Vincent, NY 13618

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 2018 by species, strain, and life stage, and compares those totals with the 2018 New York Department of Environmental Conservation (NYSDEC) stocking policy. Table 2 provides totals by species and life stage, summarizing the New York stocking history from 1991-2018. New York stocking history from 1968-1990 is reported in Eckert (2000). Table 3 provides specific information for each group of fish stocked in 2018. 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	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 of 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 2015-2018 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 2013-2018. 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.

LM (Lake Michigan): Wild, self-sustaining population of bloater from Lake Michigan. In each year from 2012-2017, 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. Beginning in 2012, wild eggs were also shipped to OMNRF White Lake Fish Culture Station (WLFCS) to produce fish for stocking in Canadian waters. Some portion of those fish were also held to develop captive broodstock because obtaining wild caught bloater eggs during winter required considerable effort, making it difficult to achieve annual stocking targets. In 2018, TUN received eyed eggs from WLFCS broodstock and produced FF Bloater for stocking in 2018.

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 2005-2008. From 2009-present, however no walleye production has occurred.

MEP (Lake Mephromagog): A naturalized freshwater strain of landlocked Atlantic salmon originally derived from the West Grand Lake, ME strain, an outlet spawner. Fry stocked by State University of New York College of Environmental Science and Forestry in 2014 were produced from a captive broodstock held at 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 2017-2018 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 (2014-2018). 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 2017-2018, TUN stocked fall fingerlings and yearlings from AD. All SEB stocked by TUN from AD (2014-2018) were eggs taken from SEB broodstock held at AD. Note that AD transitioned from LC to SEB strain, and this was completed in 2015 (2016 year class). AD designated these SEB as New York Sebago (NSB) and were stocked as yearlings in 2017-2018.

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 2013-2018 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 by collection of eggs from spawning runs of fin-clipped adults at SRH.

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 2015-2018 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.

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.

SR- Atlantic salmon collected from Salmon River, NY during summer or fall in 2016. Adults were collected from the river and held until spawning at TUN. These adults were presumably a mix of LC and SEB strains, resulting from either natural reproduction or from feral fish stocked by TUN or AD at an earlier life stage prior to 2015.

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. The term 50 day fingerling (FDF) is used for pond fingerlings held for at least 50 days. 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 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, 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 and 2018, 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.

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Table 1. Summary of stocking in New York waters of Lake Ontario, the lower Niagara River, and the upper St. Lawrence River during 2018, and comparisons with the NYSDEC 2018 stocking policy.

Species	Stage		Strain	DEC Stocking Policy	Actual Number Stocked
Atlantic Salmon	Ylg		NSB	50,000	102,514
	Ylg	1	SR-W	-	23,934
	FF	1	NSB	-	73,087
Atlantic Salmon Total				50,000	199,535
Bloater	FF	1	LM	-	87,674
	Ylg		LM	-	18,604
Bloater Total				-	106,306
Brown Trout	Ylg	2,3	RL-D	404,670	434,180
Chinook Salmon	SF	4,5	SAL-W	1,330,039	1,287,230
Cisco	FF	1	LO	-	520,674
Coho Salmon	FF	6	SAL-W	155,000	72,810
	Ylg		SAL-W	90,000	85,224
Coho Salmon Total				245,000	158,034
Lake Sturgeon	FF		SLR	-	3,255
Lake Trout	Ylg		HPW	80,000	79,439
	Ylg		LCH-D	80,000	80,810
	Ylg		SEN-W	120,000	119,277
	Ylg		SKW	120,000	118,729
Lake Trout Total		7,8		400,000	398,255
Rainbow Trout	Ylg	9	FL-W	7,500	-
	Ylg	10	RA-D	75,000	49,180
	Ylg		SKA-W	43,000	42,420
	Ylg		WAS-W	497,700	529,180
Rainbow Trout Total				623,200	620,780
Walleye	PF		ONL-W	107,600	107,600
Salmon and Trout Total				**3,052,909**	**3,098,014**
Grand Total				**3,160,509**	**3,835,849**

Notes: See Table 3 for details.

1 Stocked by U.S. Geological Survey- Tunison for research (Atlantic salmon and Cisco) or restoration (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 Barge stocking of brown trout occurred at Stony Point, Selkirk, Oswego, and Fairhaven.

4 A new pen site was created at Wilson beginning in 2017. Some Chinook salmon were shifted from the Niagara allotment to accommodate this new site.

5 Chinook salmon stocking policy was reduced in 2017-2018 over concerns about the prey fish (Alewife) population after extremely cold winters in 2014 and 2015 led to poor Alewife reproduction.

6 Lower than normal egg fertilization and survival of coho salmon at Salmon River hatchery during Fall 2017 led to a shortfall of fall fingerlings stocked in 2018. All sites prorated to 47% of policy.

7 Lake trout stocking policy in 2017-2018 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 Barge stocking of Lake trout at Olcott and Sodus Bay in 2018 was cancelled due to high winds at stocking time. All fish were shore stocked at these sites. Barge stocking was done at other sites.

9 Finger lakes wild strain rainbow trout were not available for Powermill Hatchery in 2018 due to lower than normal egg collection at Cayuga Lake inlet in 2017.

10 Shortfalls of domestic strain rainbow trout occurred statewide in 2018. Lake Ontario received surplus brown trout to compensate for shortfalls of domestic rainbow trout.

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 2018. Numbers stocked from 1968-1990 can be found in Eckert (2000).

Species Life Stage	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Co Ylg	97	94	96	92	119	98	95	90	90	99	101	105	95	95	99
Co FF	132	155	100	223	172	196	155	155	137	155	155	155	155	155	155
Co AF	0	290	0	0	0	0	0	0	0	0	0	0	0	0	0
Co f	0	0	0	0	0	0	0	0	0	0	0	4	7	0	0
Ck f	2835	2798	1603	1000	1150	1300	1605	1596	1596	1654	1629	1633	1622	1836	1809
Ck FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LT Ylg	818	508	501	507	500	350	500	426	476	490	500	500	500	457	224
LT FF	160	0	0	5	0	0	0	0	0	0	0	0	0	0	0
LT Ad	0	0	0	0	0	0	0	<1	0	<1	0	0	0	0	0
BT Ylg	382	415	445	402	382	361	426	426	429	421	405	382	414	367	391
BT FF	0	0	0	0	0	0	0	0	25	0	0	136	39	0	66
BT AF	0	0	0	0	0	0	0	0	0	0	114	0	0	0	10
BT f	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0
RT Ylg	82	85	88	92	24	70	93	92	97	75	60	71	75	64	75
RT FF	0	0	0	0	0	0	0	14	0	0	20	10	0	0	0
RT f	29	0	0	0	0	0	0	0	0	0	0	14	40	0	0
RT Ad	0	0	0	0	0	0	0	0	0	<1	0	0	0	0	0
Sthd Ad	0	0	0	0	0	0	0	<1	0	0	0	0	0	0	0
Sthd Ylg	551	515	454	487	534	543	555	528	521	533	583	535	560	558	570
Sthd FF	40	0	0	0	50	60	110	0	107	0	0	15	0	0	0
Sthd f	175	0	0	0	0	0	0	0	0	0	0	1	6	0	0
ST FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
*ST SF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS Ad	0	0	0	0	2	2	1	4	6	1	<1	<1	<1	1	0
AS Ylg	178	169	135	151	130	97	76	73	84	78	75	75	50	51	50
AS FF	0	0	30	38	34	34	25	25	25	25	25	0	0	0	0
AS AF	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
AS f	0	0	0	0	60	171	73	0	156	84	62	17	32	0	0
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
Bloater Ylg	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 2018. 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	2018
Co Ylg	110	90	124	95	114	141	120	69	130	90	99	93	85
Co FF	155	155	104	155	155	155	0	155	0	141	158	139	73
Co AF	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	59	0	0
Ck f	1827	1813	799	1757	1531	1769	1511	1772	1970	1762	1883	1350	1287
Ck FF	0	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	398
LT FF	0	0	0	0	122	0	123	0	528	455	0	0	0
LT Ad	0	0	0	0	0	0	0	0	0	0	0	0.3	0
BT Ylg	391	385	370	418	409	424	419	331	397	449	464	412	434
BT FF	0	0	0	70	57	6	0	0	27	0	31	0	0
BT AF	0	0	50	6	116	0	0	0	41	0	0	0	0
BT f	0	0	0	46	0	0	0	0	0	0	0	0	0
RT Ylg	72	68	74	78	80	82	82	83	42	76	75	79	49
RT FF	0	0	0	15	0	27	0	0	0	0	0	0	0
RT f	0	0	0	0	0	30	0	0	0	0	0	0	0
RT Ad	0	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	0
Sthd Ylg	572	538	570	561	702	615	554	546	521	382	583	578	572
Sthd FF	0	0	0	80	188	0	337	0	0	149	0	0	0
Sthd f	0	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	0
*ST SF	0	0	0	54	0	0	0	0	0	0	0	0	0
AS Ad	0	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	126
AS FF	0	0	0	24	37	66	73	61	71	74	74	51	73
AS AF	0	0	0	0	0	0	14	0	0	0	0	0	0
AS f	0	0	0	0	0	0	0	0	6	8	0	0	0
Wal PF	123	31	50	118	12	118	23	149	138	70	68	170	108
Wal FF	0	0	5	0		0	0	0		0	0	0	0
Stur FF	0	0	0	0	0	0	0	1	9	9	0.5	3	3
Bloater FF	0	0	0	0	0	0	1	7	20	62	149	94	88
Bloater Ylg	0	0	0	0	0	0	0	0	0	0	0	0	19
Cisco FF	0	0	0	0	0	0	9	9	145	100	22	88	521
Cisco AF	0	0	0	0	0	0	0	0	0	0	0	79	0
Cisco SF	0	0	0	0	0	0	0	0	0	0	0	243	0
Sal Subtotal	3263	3554	2,641	3920	3891	3853	3293	3606	4239	4177	3900	2979	3098
TOTAL	3382	3585	2696	4037	3903	3972	3327	3773	4551	4417	4140	3655	3836

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 2018.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Atlantic Salmon	Beaverdam Brook	O.53-8	4-Apr-18	AD	2017	NSB	13.5	Ylg	53.4	none	30,000	
Atlantic Salmon	Beaverdam Brook	O.53-8	11-Apr-18	AD	2017	NSB	13.7	Ylg	51.0	none	22,300	surplus
Atlantic Salmon	Salmon River	O.53-8	3-May-18	TUN	2017	NSB	14.2	Ylg	47.2	AD-RV	10,064	stocked at pumphouse behind hatchery, source of eggs from Adirondack Hatchery
Atlantic Salmon	Salmon River	O.53-8	2-May-18	TUN	2017	SR-W	14.5	Ylg	46.7	AD-LV	7,424	stocked at mouth of Salmon River at Lighthouse Marina, source of eggs from feral Atlantic salmon caught in Salmon River in 2016
Atlantic Salmon	Beaverdam Brook	O.53-7	2-May-18	TUN	2017	SR-W	14.5	Ylg	24.3	LV-CWT	16,510	CWT#43, stocked into smolt release pond on November 27, 2017, source of eggs from feral Atlantic salmon caught in the Salmon River in 2016, weights of fish recorded in November, 2017
Atlantic Salmon	Beaverdam Brook	O.53-8	2-May-18	TUN	2017	NSB	14.2	Ylg	24.6	AD-CWT	20,150	CWT#43, stocked into smolt release pond on November 2, 2017, source of eggs from Adirondack Hatchery, weights of fish recorded in November 2017
Atlantic Salmon	Beaverdam Brook	O.53-8	14-Nov-18	TUN	2018	NSB	8.8	FF	21.8	AD-CWT	30,398	CWT#43, stocked into smolt release pond -source of eggs from Adirondack Hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	17-Nov-18	TUN	2018	NSB	8.9	FF	21.9	AD-CWT	23,653	CWT#43, stocked into smolt release pond, source of eggs from Adirondack Hatchery
Atlantic Salmon	Beaverdam Brook	O.53-8	21-Nov-18	TUN	2018	NSB	9.1	FF	20.6	AD-CWT	19,036	CWT#43, stocked into smolt release pond, source of eggs from Adirondack Hatchery
Atlantic Salmon	Point Breeze	713	14-May-18	AD	2017	NSB	3.0	Ylg	64.9	none	20,000	stocked by pontoon boat
Atlantic Salmon Fall Fingerling Total									**21.5**		**73,087**	
Atlantic Salmon Yearling Total									**45.5**		**126,448**	
Atlantic Salmon Total									**36.7**		**199,535**	
Brown Trout	Black River	O.19	1-Jun-18	CH	2017	RL-D	18.2	Ylg	141.4	none	2,310	surplus
Brown Trout	Black River	O.19	23-Apr-18	SR	2017	RL-D	17.4	Ylg	79.6	none	4,350	Boat launch in Dexter
Brown Trout	Black River	O.19	25-May-18	SR	2017	RL-D	18.4	Ylg	75.6	none	7,970	surplus
Brown Trout	Stony Point	423	15-May-18	SR	2017	RL-D	18.1	Ylg	79.3	none	47,850	Barge/LCM stocked off Stony Point, includes BT slated for Henderson

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Brown Trout	Stony Point	423	8-Jun-18	RM	2017	RL-D	18.8	Ylg	99.7	none	15,000	Barge/LCM stocked off Stony Point, surplus
Brown Trout	Stony Creek	O.40	23-Apr-18	SR	2017	RL-D	17.4	Ylg	79.6	none	2,610	
Brown Trout	Selkirk	623	16-May-18	SR	2017	RL-D	18.1	Ylg	75.3	none	31,320	Barge/LCM
Brown Trout	Oswego	622	17-May-18	SR	2017	RL-D	18.1	Ylg	453.6	none	31,320	Barge/LCM
Brown Trout	Fair Haven	720	17-May-18	SR	2017	RL-D	18.1	Ylg	76.9	none	31,320	Barge/LCM
Brown Trout	Sodus Point	819	24-May-18	RM	2017	RL-D	18.4	Ylg	95.5	none	16,000	
Brown Trout	Sodus Point	819	31-May-18	RM	2017	RL-D	18.6	Ylg	97.5	none	11,840	
Brown Trout	Pultneyville	818	23-May-18	RM	2017	RL-D	18.3	Ylg	97.1	none	16,000	
Brown Trout	Pultneyville	818	4-Jun-18	RM	2017	RL-D	18.7	Ylg	97.5	none	4,880	
Brown Trout	Webster	816	3-May-18	CD	2017	RL-D	17.7	Ylg	145.4	none	11,745	
Brown Trout	Webster	816	29-May-18	RM	2017	RL-D	18.5	Ylg	98.8	none	11,745	Off Joe Abraham's
Brown Trout	Irondequoit	815	9-May-18	CD	2017	RL-D	17.9	Ylg	123.9	none	11,745	Off Peter Frank's
Brown Trout	Irondequoit	815	1-Jun-18	RM	2017	RL-D	18.6	Ylg	95.7	none	11,745	Off Knoll Property
Brown Trout	Rochester	815	10-May-18	CD	2017	RL-D	17.9	Ylg	130.7	none	11,745	Kodak Water Treatment Plant
Brown Trout	Rochester	815	30-May-18	CD	2017	RL-D	18.5	Ylg	99.5	none	11,745	Kodak Water Treatment Plant
Brown Trout	Braddocks Bay	815	9-May-18	CD	2017	RL-D	17.9	Ylg	128.9	none	11,745	
Brown Trout	Braddocks Bay	815	16-May-18	CD	2017	RL-D	18.1	Ylg	126.0	none	11,745	
Brown Trout	Hamlin	713	3-May-18	CD	2017	RL-D	17.7	Ylg	133.0	none	11,745	
Brown Trout	Hamlin	713	18-May-18	CD	2017	RL-D	18.2	Ylg	128.1	none	5,745	
Brown Trout	Hamlin	713	25-May-18	RA	2017	RL-D	17.0	Ylg	96.5	none	6,000	
Brown Trout	Point Breeze	711	4-May-18	RM	2017	RL-D	17.7	Ylg	97.3	none	14,830	
Brown Trout	Point Breeze	711	25-May-18	SR	2017	RL-D	18.4	Ylg	75.6	none	18,230	
Brown Trout	Olcott	708	15-May-18	RA	2017	RL-D	16.6	Ylg	84.0	none	21,750	
Brown Trout	Wilson	707	14-May-18	RA	2017	RL-D	16.6	Ylg	84.0	none	21,750	
Brown Trout	Fort Niagara	806	26-Apr-18	RA	2017	RL-D	17.5	Ylg	135.8	none	13,050	Fish stocked at Fort Niagara
Brown Trout	Lower Niagara R.	O.158/EN-T0000	27-Apr-18	CD	2017	RL-D	17.5	Ylg	134.2	none	4,350	Fish stocked at Fort Niagara
Brown Trout Yearlings Total									**122.8**		**434,180**	
Chinook Salmon	Black River	O.19/OB-T0000	14-May-18	SR	2018	SAL-W	3.8	SF	4.8	none	113,000	below Dexter Falls
Chinook Salmon	South Sandy Creek	O.45/LO-T0000	11-May-18	SR	2018	SAL-W	3.7	SF	4.8	none	70,560	below Rt. 3 bridge
Chinook Salmon	Salmon River	O.53/LO-T0000	31-May-18	SR	2018	SAL-W	4.4	SF	7.3	none	308,000	At NY Route 3
Chinook Salmon	Oswego River	O.65	10-May-18	SR	2018	SAL-W	3.7	SF	4.9	none	20,080	
Chinook Salmon	Oswego River	O.65	12-May-18	SR	2018	SAL-W	3.8	SF	5.7	none	64,390	In pens 4/16/18 @124/lb.

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Chinook Salmon	Little Sodus Bay	O.74	12-May-18	SR	2018	SAL-W	3.8	SF	5.2	none	47,500	In pens 04/12/18 @ 128/lb. at Anchor resort and marina at west bay road to be stocked at Bayside Marina
Chinook Salmon	Sterling Creek	O.73	10-May-18	SR	2018	SAL-W	3.7	SF	4.9	none	15,930	Old State Road
Chinook Salmon	Sodus Bay	O.84-P96	9-May-18	SR	2018	SAL-W	3.7	SF	4.7	none	19,410	Sodus Point: Off West Pier
Chinook Salmon	Sodus Bay	O.84-P96	4-May-18	SR	2018	SAL-W	3.5	SF	4.2	none	50,000	In pens 4/13/18 @127.6/lb.
Chinook Salmon	Genesee River	O.117	2-May-18	SR	2018	SAL-W	3.5	SF	4.6	none	85,250	In Pens 4/6/2018 @ 133 /lb.
Chinook Salmon	Genesee River	O.117	7-May-18	SR	2018	SAL-W	3.6	SF	4.5	none	43,290	
Chinook Salmon	Sandy Creek	O.130	4-May-18	SR	2018	SAL-W	3.5	SF	4.3	none	10,890	Stocked at Oak Orchard due to high water temperatures
Chinook Salmon	Sandy Creek	O.130	29-Apr-18	SR	2018	SAL-W	3.4	SF	4.3	none	64,430	In Pens 4/4/18@126.6/lb.
Chinook Salmon	Oak Orchard Creek	O.138	4-May-18	SR	2018	SAL-W	3.5	SF	4.5	none	24,000	
Chinook Salmon	Oak Orchard Creek	O.138	7-May-18	SR	2018	SAL-W	3.6	SF	4.5	none	106,560	In Pens 4/5/2018@132.2 /lb.
Chinook Salmon	Eighteenmile Creek	O.148	8-May-18	SR	2018	SAL-W	3.6	SF	4.8	none	29,550	
Chinook Salmon	Eighteenmile Creek	O.148	7-May-18	SR	2018	SAL-W	3.6	SF	5.4	none	67,100	In pens 4/9/2018@134.2/lb.
Chinook Salmon	Twelvemile Creek (Wilson)	O.152	8-May-18	SR	2018	SAL-W	3.6	SF	5.4	none	10,000	In Pens 4/10/18@134/lb.
Chinook Salmon	lower Niagara River	O.158/EN-T0000	23-May-18	SR	2018	SAL-W	4.1	SF	6.8	none	75,000	In Pens 4/25/2018@112/lb.
Chinook Salmon	lower Niagara River	O.158/EN-T0000	24-May-18	SR	2018	SAL-W	4.2	SF	5.6	none	62,290	
Chinook Salmon Spring Fingerling Total									**5.5**		**1,287,230**	
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD	17,045	moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	360	CWT#600141, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	1386	CWT#604959, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	4072	CWT#640959, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	9520	CWT#640960, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	1,312	CWT#600143, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	468	CWT#600146, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	5,401	CWT#640961, moved to smolt release pond 11/3/2017

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Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	10,338	CWT#640962, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	515	CWT#600134, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	2,703	CWT#600135, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	5,126	CWT#640955, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	9,919	CWT#640956, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	2,317	CWT#600150, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	4,599	CWT#640963, moved to smolt release pond 11/3/2017
Coho Salmon	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SAL-W	15.2	Ylg	32.9	AD CWT	10,144	CWT#640964, moved to smolt release pond 11/3/2017
Coho Salmon	Sodus Bay	O.84	31-Oct-18	SR	2018	SAL-W	9.3	FF	23.2	AD	12,200	
Coho Salmon	Genesee River	O.117	30-Oct-18	SR	2018	SAL-W	9.3	FF	22.8	AD	10,340	
Coho Salmon	Sandy Creek	O.130	29-Oct-18	SR	2018	SAL-W	9.3	FF	23.2	AD	12,200	
Coho Salmon	Oak Orchard Creek	O.138	30-Oct-18	SR	2018	SAL-W	9.3	FF	21.4	AD	12,220	
Coho Salmon	Eighteenmile Creek	O.148	29-Oct-18	SR	2018	SAL-W	9.3	FF	23.2	AD	14,100	
Coho Salmon	lower Niagara River	O.158	31-Oct-18	SR	2018	SAL-W	9.3	FF	22.7	AD	11,750	
Coho Salmon Fall Fingerlings									**22.8**		**72,810**	
Coho Salmon Yearlings									**32.9**		**85,224**	
Coho Salmon Total									**28.2**		**158,034**	
Lake Trout	Stony Point	422	15-May-18	EI	2017	LCH-D	13.8	Ylg	31.6	AD CWT	40,450	Barge/LCM, CWT#640698
Lake Trout	Stony Point	422	15-May-18	AL	2017	SKW	15.4	Ylg	38.1	AD CWT	39,270	Barge/LCM, CWT640632
Lake Trout	Oswego	623	16-May-18	AL	2017	HPW	15.0	Ylg	41.2	AD CWT	39,470	Barge/LCM, CWT#640758
Lake Trout	Oswego	623	16-May-18	EI	2017	LCH-D	13.9	Ylg	31.5	AD CWT	40,360	Barge/LCM, CWT#640730
Lake Trout	Sodus	819	18-May-18	AL	2017	SEN	15.1	Ylg	42.0	AD CWT	39,798	Barge cancelled = Shore plant, CWT#640751
Lake Trout	Sodus	819	18-May-18	AL	2017	SEN	15.1	Ylg	42.4	AD CWT	39,697	Barge cancelled = Shore plant, CWT#640735
Lake Trout	Oak Orchard	711	22-May-18	AL	2017	HPW	15.2	Ylg	41.8	AD CWT	39,969	Barge/LCM, CWT#640756
Lake Trout	Oak Orchard	711	22-May-18	AL	2017	SKW	15.6	Ylg	43.6	AD CWT	39,624	Barge/LCM, CWT#640731
Lake Trout	Olcott	708	21-May-18	AL	2017	SKW	15.6	Ylg	46.3	AD CWT	19,855	Barge cancelled = Shore plant, CWT#640316
Lake Trout	Olcott	708	21-May-18	AL	2017	SKW	15.6	Ylg	42.0	AD CWT	19,980	Barge cancelled = Shore plant, CWT#640315

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Lake Trout	Olcott	708	21-May-18	AL	2017	SEN	15.2	Ylg	42.0	AD CWT	39,782	Barge cancelled = Shore plant, CWT#640752
Lake Trout Spring Yearlings									**39.8**		**398,255**	
Lake Trout Total									**39.8**		**398,255**	
Rainbow Trout	Black River	424	20-Apr-18	SR	2017	WAS-W	10.4	Ylg	13.3	none	18,000	Sacketts Harbor
Rainbow Trout	Black River	O.19	20-Apr-18	SR	2017	WAS-W	10.4	Ylg	13.3	none	18,000	below Dexter Falls
Rainbow Trout	Stony Creek	O.40	9-Apr-18	SR	2017	WAS-W	10.1	Ylg	14.6	none	20,700	
Rainbow Trout	South Sandy Creek	O.45	26-Apr-18	SR	2017	WAS-W	10.6	Ylg	13.7	none	5,280	
Rainbow Trout	South Sandy Creek	O.45	9-Apr-18	SR	2017	WAS-W	10.1	Ylg	14.6	none	28,750	
Rainbow Trout	Beaverdam Brook	O.53-8	30-Apr-18	SR	2017	WAS-W	10.7	Ylg	23.8	none	129,720	2 ponds 4/30, 2 ponds 5/1
Rainbow Trout	Beaverdam Brook	O.53-8	2-May-18	SR	2017	SKA-W	10.8	Ylg	11.3	AD	42,420	
Rainbow Trout	Grindstone Creek	O.54	11-Apr-18	SR	2017	WAS-W	10.1	Ylg	15.1	none	5,000	
Rainbow Trout	Little Salmon River	O.58	12-May-18	SR	2017	WAS-W	11.1	Ylg	36.2	none	4,380	In pens 4/11/2018 @ 30 /lb.
Rainbow Trout	Oswego River	O.66	16-Apr-18	SR	2017	WAS-W	10.3	Ylg	17.4	none	20,000	
Rainbow Trout	Oswego River	O.66	26-Apr-18	SR	2017	WAS-W	10.6	Ylg	13.7	none	10,560	Surplus
Rainbow Trout	Sterling Creek	O.73	16-Apr-18	SR	2017	WAS-W	10.3	Ylg	16.8	none	4,600	
Rainbow Trout	Sterling Valley Ck	O.73-3	16-Apr-18	SR	2017	WAS-W	10.3	Ylg	16.8	none	4,600	
Rainbow Trout	Little Sodus Bay	O.74	12-May-18	SR	2017	WAS-W	11.1	Ylg	37.8	none	6,000	In Pens 4/12/18 @ 28/lb.
Rainbow Trout	Maxwell Creek	O.85	13-Apr-18	SR	2017	WAS-W	10.2	Ylg	17.4	none	19,950	
Rainbow Trout	Irondequoit Creek	O.108	17-Apr-18	SR	2017	WAS-W	10.3	Ylg	16.8	none	27,500	
Rainbow Trout	Genesee River	O.117	6-Apr-18	SR	2017	WAS-W	10.0	Ylg	14.6	none	12,100	
Rainbow Trout	Genesee River	O.117	26-Apr-18	SR	2017	WAS-W	10.6	Ylg	13.7	none	10,560	Surplus
Rainbow Trout	Genesee River	O.117	2-May-18	SR	2017	WAS-W	10.8	Ylg	20.4	none	10,000	In pens 4/6/2018 @ 31/lb
Rainbow Trout	Salmon Creek	O.93	18-Apr-18	SR	2017	WAS-W	10.4	Ylg	16.2	none	5,050	Victor
Rainbow Trout	Oak Orchard Creek	O.138	5-Apr-18	SR	2017	WAS-W	9.9	Ylg	14.6	none	7,000	
Rainbow Trout	Oak Orchard Creek	O.138	5-Apr-18	SR	2017	WAS-W	9.9	Ylg	14.6	none	14,000	No pens. All shore stocked
Rainbow Trout	Oak Orchard Creek	O.138	26-Apr-18	SR	2017	WAS-W	10.6	Ylg	13.7	none	10,560	Surplus
Rainbow Trout	Marsh Creek	O.138-2	18-Apr-18	SR	2017	WAS-W	10.4	Ylg	16.2	none	7,100	
Rainbow Trout	Sandy Creek	O.130	4-Apr-18	SR	2017	WAS-W	9.9	Ylg	14.6	none	7,350	
Rainbow Trout	Sandy Creek	O.130	25-Apr-18	SR	2017	WAS-W	10.6	Ylg	17.5	none	7,300	In Pens 4/4/18 @31/lb.
Rainbow Trout	Johnson Creek	O.139	18-Apr-18	SR	2017	WAS-W	10.4	Ylg	16.2	none	6,700	
Rainbow Trout	Eighteenmile Creek	O.148	9-Apr-18	SR	2017	WAS-W	10.1	Ylg	14.7	none	6,500	
Rainbow Trout	Eighteenmile Creek	O.148	25-Apr-18	SR	2017	WAS-W	10.6	Ylg	13.7	none	5,280	
Rainbow Trout	Eighteenmile Creek	O.158	6-May-18	SR	2017	WAS-W	10.9	Ylg	18.4	none	3,500	In pens 4/9/2018 @ 31/lb
Rainbow Trout	Twelvemile Creek E Br	O.152	10-Apr-18	SR	2017	WAS-W	10.1	Ylg	15.1	none	10,500	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2018.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Rainbow Trout	Twelvemile Creek (Wilson)	O.152	7-May-18	SR	2017	WAS-W	11.0	Ylg	27.7	none	7,500	In pens 04/10/2018 @30/lb
Rainbow Trout	Twelvemile Creek	O.152A	10-Apr-18	SR	2017	WAS-W	10.1	Ylg	15.1	none	12,000	
Rainbow Trout	lower Niagara River	O.158	25-Apr-18	SR	2017	WAS-W	10.6	Ylg	13.7	none	37,000	
Rainbow Trout	lower Niagara River	O.158	25-Apr-18	SR	2017	WAS-W	10.6	Ylg	13.7	none	16,140	Surplus
Rainbow Trout	lower Niagara River	O.158	25-May-18	SR	2017	WAS-W	11.5	Ylg	21.7	none	10,000	In pens 4/25/2018 @33/lb
Rainbow Trout	Sodus	819	29-May-18	CH	2017	RA-D	17.5	Ylg	130.3	none	15,030	
Rainbow Trout	Webster	815	1-Jun-18	VH	2017	RA-D	17.6	Ylg	125.3	none	6,950	
Rainbow Trout	Hamlin	713	10-May-18	CH	2017	RA-D	16.9	Ylg	116.6	none	10,880	
Rainbow Trout	Olcott	708	2-May-18	CS	2017	RA-D	16.7	Ylg	114.6	none	9,250	
Rainbow Trout	Wilson	707	1-May-18	CS	2017	RA-D	16.6	Ylg	135.0	none	7,070	
Washington Steelhead Yearlings									**18.0**		**529,180**	
Skamania Steelhead Yearlings									**11.3**		**42,420**	
Rainbow Trout Yearlings (Randolph strain)									**124.3**		**49,180**	
Rainbow Trout Yearlings (Finger Lakes W strain)									**-**		**-**	
Rainbow Trout Total									**26.0**		**620,780**	
Walleye	Port Bay	O-P0089	18-Jun-18	ON	2018	ONL-W	1.5	FDF	0.5	OTC	10,400	50-day old fingerlings
Walleye	Sodus Bay	O-P0096	14-Jun-18	CQ	2018	ONL-W	1.2	PF	0.3	none	45,600	
Walleye	Sodus Bay	O-P0096	2-Jun-18	SO	2018	ONL-W	0.8	FDF	0.9	none	28,400	50-day fingerlings
Walleye	lower Niagara River	EN-P0000	11-Jun-18	CQ	2018	ONL-W	1.1	PF	0.3	none	23,200	
Walleye Fingerling Total									**0.5**		**107,600**	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2018.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Bloater	Oswego	621	4-May-18	TUN	2017	LM	11.7	Ylg	9.8	AD-CAL	11,721	double calcein mark, stocked off USGS RV/Kaho, derived from broodstock
Bloater	Oswego	621	4-May-18	TUN	2017	LM	11.7	Ylg	9.8	CAL	6,911	double calcein mark, stocked off USGS RV/Kaho, derived from broodstock
Bloater	Oswego	621	9-Nov-18	TUN	2018	LM	6.4	FF	2.8	CAL	87,674	single calcein mark, stocked off USGS RV/Kaho, derived from broodstock
Bloater Fall Fingerling Total									**2.8**		**87,674**	
Bloater Yearling Total									**9.8**		**18,632**	
Bloater Total									**4.0**		**106,306**	
Cisco	Sodus Bay	O-P0096	23-Oct-18	LAM	2018	LO	8.4	FF	5.3	CAL	147,214	single calceine mark
Cisco	Sodus Bay	O-P0096	25-Oct-18	LAM	2018	LO	8.5	FF	4.6	CAL	131,766	single calceine mark
Cisco	Irondequoit Bay	O-P0113	22-Aug-18	TUN	2018	LO	6.5	FF	2.1	CAL	143,949	stocked by boat, double calceine mark
Cisco	Irondequoit Bay	O-P0113	14-Nov-18	TUN	2018	LO	9.2	FF	6.3	AD-CAL	97,745	stocked from shore at Newport Yacht Club, AD clip and single calceine mark
Cisco Total									**4.4**		**520,674**	
Lake Sturgeon	Genesee River	O.117	19-Oct-18	ON	2018	SLR	4.3	FF	6.0	CWT-PIT	300	CWT #600137 tagged in back of head near 1st scute
Lake Sturgeon	Genesee River	O.117	19-Oct-18	GN	2018	SLR	4.3	FF	23.3	CWT-PIT	700	CWT #055190 tagged in back of head near 1st scute
Lake Sturgeon	Chaumont Bay	324	26-Sep-18	GN	2018	SLR	3.6	FF	23.3	CWT	2,255	CWT #055190 tagged in back of head near 1st scute
Lake Sturgeon Total									**21.7**		**3,255**	
Salmonine Total											**3,098,014**	
Total All Species											**3,835,849**	

2018 Lake Ontario Fishing Boat Survey

M.J. Connerton and T.H. Eckert

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 1985-2018 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 (1985-2018). This report focuses on 2018 results and on comparisons of 2018 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 2009-2018 and a 24-year average for 1985-2008.

Methods

Sampling Design and Data Collection

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 2018). 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

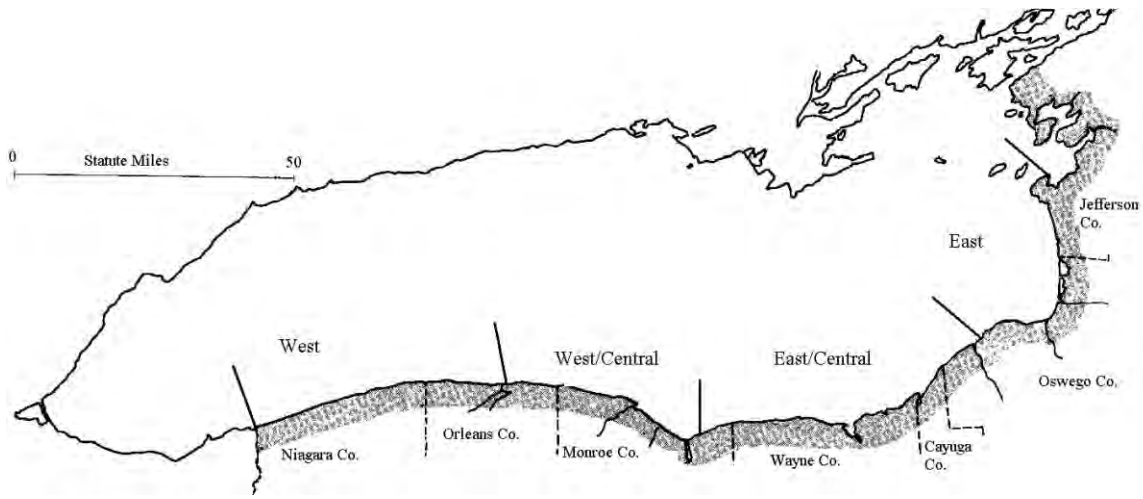


Figure 1. Lake Ontario's New York shoreline (shaded in gray), the seven New York counties that border the lake, and the four geographic areas used in analysis of the survey data.

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

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.

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. This report documents relative catch within specific areas and months for 2013-2018 and compares 2018 results with general trends observed in previous years.

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. 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 partly attributed to extremely high-water levels on Lake Ontario that persisted into July affecting launch access and boat navigability (Lantry and Eckert 2018).

Total fishing effort in 2018 rebounded from the record low of 2017 and was estimated at 168,084 boat trips (922,527 angler hours), only slightly below (-5.5%) the previous 10-year average (Table A2). The average number of anglers per boat trip ranged from 2.5 (1985) to 3.1 (2018 was highest in data series) and averaged 2.9 with an increasing trend during the last 10 years (Table A2). The 2018 average trip length of 5.5 hours per boat trip was identical to the previous 10-year average.

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 (2009-2018 10-year averages: April 15-30: 4.4%, May: 16.1%, June: 11.5%, July: 21.1%, August: 29.5%, and September: 17.6%). In

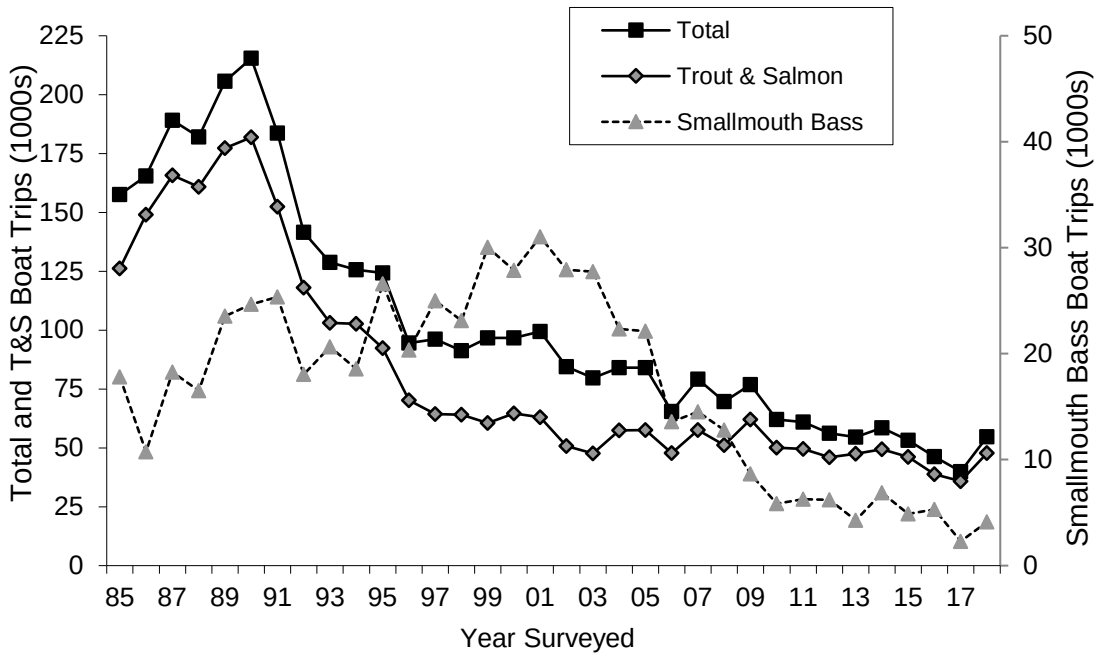


Figure 2. Estimated number of total fishing boat trips, trips targeting trout and salmon (T&S; April 15-September 30), and trips targeting smallmouth bass during the traditional open season (3rd Saturday in June-September 30 when the survey ended), 1985-2018.

2018, total fishing effort estimates were either at or below average for all months. April effort was the lowest ever recorded in the time series, which can be attributed partly to poor weather including an ice storm and windy conditions during the last two weeks of April. Effort in other months were similar to the previous 10-years average (range: -9.6% below in May to +5.6% in July).

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 30 of the last 34 years (18,803 boat trips in 2018, 34.3% of fishing effort; Table A2). For all 34 years surveyed, the lowest fishing effort occurred in the west/central area (9,052 boat trips in 2018, 16.5% of fishing effort), however, fishing effort in this region in 2018 was 28.1% above the previous 10-year average. Fishing effort in each of the other three areas was 3.4 to 17.7% below the 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 general, all power boats followed a similar trend: peaking between 1988-1990, followed by sharp declines until about 1993, then levelling off or declining slightly since then. When the survey began power boaters who spent at least a portion of their time fishing on Lake Ontario equaled or exceeded the number of non-fishing power boats. Beginning in 2009 until present, non-fishing power boats outnumbered fishing boats and the numbers of excursions stabilized while fishing boat excursions declined slightly. In 2018 power fishing boats accounted for 55,063 vessel excursions and 34.9% of the total vessel traffic in 2018 (Table A2), a 37%% increase compared to the record low observed in 2017. Non-fishing power boats (i.e., recreational boaters) were estimated at 89,221 excursions in 2018, 56.7% of the total vessel traffic, and a 37.1% increase compared to the record low in 2017. Sailboats, the smallest component of vessel traffic, showed a downward trend through much of the time series. In 2018, sailboats accounted for 13,105 excursions (up from the lowest recorded in 2017) and represented 8.3% 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 (1985-2018 average = 77.7%; range: 59.7% [2003] to 90.0% [1986]; Table A2; Figure 2). There was no significant trend in effort directed at trout and salmon from 2001-2015; however, effort declined in 2016 and again in 2017 to a record low level (Table A2). In 2018, effort rebounded to about 5% above the previous 10-year average. Trout and salmon anglers accounted for 87.5% of total fishing boat trips, 91.5% of angler trips, and 95.3% of angler hours (Table A2). Estimated monthly fishing effort targeting trout and salmon in 2018 was below previous 10-year averages during April (-41.2%) and May (-9.4%) partly due to bad weather. Effort was above average in June and July (by 15.4% and 20.1%, respectively; Table A2), and about average in the other months. During 2018, 60.9% of interviewed salmonine anglers were specifically targeting Chinook salmon, 26.9% were targeting a mix of two or more species, and 11.2% were specifically targeting brown trout.

Smallmouth Bass Targeted Effort

Pre-Season Catch and Release Period:

Fishing effort targeting smallmouth bass before the traditional open lake season (i.e., beginning the third Saturday of June) has remained low since it became legal to do so. An October 1, 2006 a 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, except for 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 2018 was an estimated 221 boat trips (5.1% 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 2018, smallmouth bass anglers fishing during the traditional open season accounted for 5.2% of angler trips, and 3.0% of angler hours.

From 1985-2001 effort targeting smallmouth bass increased significantly (P=0.0004), averaging a gain of 797 boat trips per year. During 2001-2010, however, smallmouth bass effort declined significantly ($P < 0.05$; 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 lower 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 declined 59.5% from the 2010-2016 level to a record low (Table A2; Figure 2). This reduced effort was partly attributed to limited access to the lake due to high water levels negatively impacting access to the lake and boating activity (Lantry and Eckert 2018).

In 2018, the total number of boat trips (4,135 ± 32.4%) spent targeting smallmouth bass on Lake Ontario in 2018 increased 80.3% from the record low in 2017; however, effort was still the second lowest on record and was 12.4% lower than the previous 5-year average. Fishing effort for smallmouth bass in all months was lower than the previous 5-year averages (range: -25.3% [August] to -2.1% [July]). Effort was also well below recent averages in most areas surveyed (west: -58.5%, west/central: -38.9%, east: -31.1%, Table A2) except in the east/central where it was 28.0% above the previous 5-year average. In 2018, the mean number of anglers per bass boat trip (2.1 anglers) and the numbers of hours per bass boat trip (3.2 hours) were near average.

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 2018, however, trips targeting these species only represented 1.5% of the total fishing boat trips on Lake Ontario (Table A2). The "all others" category, which represented 2.9% of 2018 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 2018, charter boats accounted for 21.4% of all fishing boat trips (Figure 3). With more anglers on board and longer trips, charter boats accounted for 37.3% and 42.1% of the angler trips and angler hours, respectively (captains and mates counted as anglers; Table A2). Although charter boats accounted for only 21.4% of total fishing boat trips, they accounted for 43.4% of the total salmonine catch in 2018. Differences between charter and noncharter catch, harvest, and fishing quality are discussed in the "Total Salmonines: Catch, Harvest, and Fishing Quality" section of this report.

The highest charter fishing effort occurred 1988-1991, then declined and has remained relatively stable for the last fifteen years (Table A2; Figure 3). The 2018 estimated charter boat effort was 11,683 (±26.1%) trips, 32.6% higher than the previous 10-year averages and the highest value observed since 2000. The percent contribution of charter boats to total fishing boat effort has increased over the last 10 years (Figure 3) and in 2018 was the highest ever in the time series. Estimated monthly charter fishing effort in 2018 was 14.5% below the previous 10-year average in April due partly to poor weather; however, charter effort was above the previous 10-year averages in all other months, especially in June (+35.8%), August (+60.2%, and September (40.8%; Table A2).

Angler Residency

Lake Ontario's world-class sport fishery has attracted anglers from all 50 states (37 in 2018) and many different countries (5 in 2018) over the last 33 years. Residency of anglers fishing Lake Ontario changed little over the time series with New York State (NYS) anglers consistently dominating 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 60.1% of Lake Ontario anglers resided in NYS (62.9% 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 2018, non-NYS residents comprised 37.1% of the boat anglers interviewed, a slight decrease compared to the previous 10-year average (Tables A2, A4; Figure 4). Pennsylvania represented the largest component of nonresident anglers for each of the 34 years surveyed. The highest percentage of Pennsylvania anglers occurred in 2017 (22.7%) and the lowest (8.5%) occurred in 1985 (Table A4). Other main sources of non-NYS anglers in 2018 were Ohio (4.8%), New Jersey (2.5%), Vermont (1.8%), Massachusetts (2.7%), Connecticut (1.3%), and Maine (1.2%, Table A4).

Throughout the 34-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 (58.1% in 2018). As was observed each year of the survey, Monroe County remained the most important source of residents in the boat fishery, representing 20.2% of all NYS anglers interviewed in 2018 (Table A4).

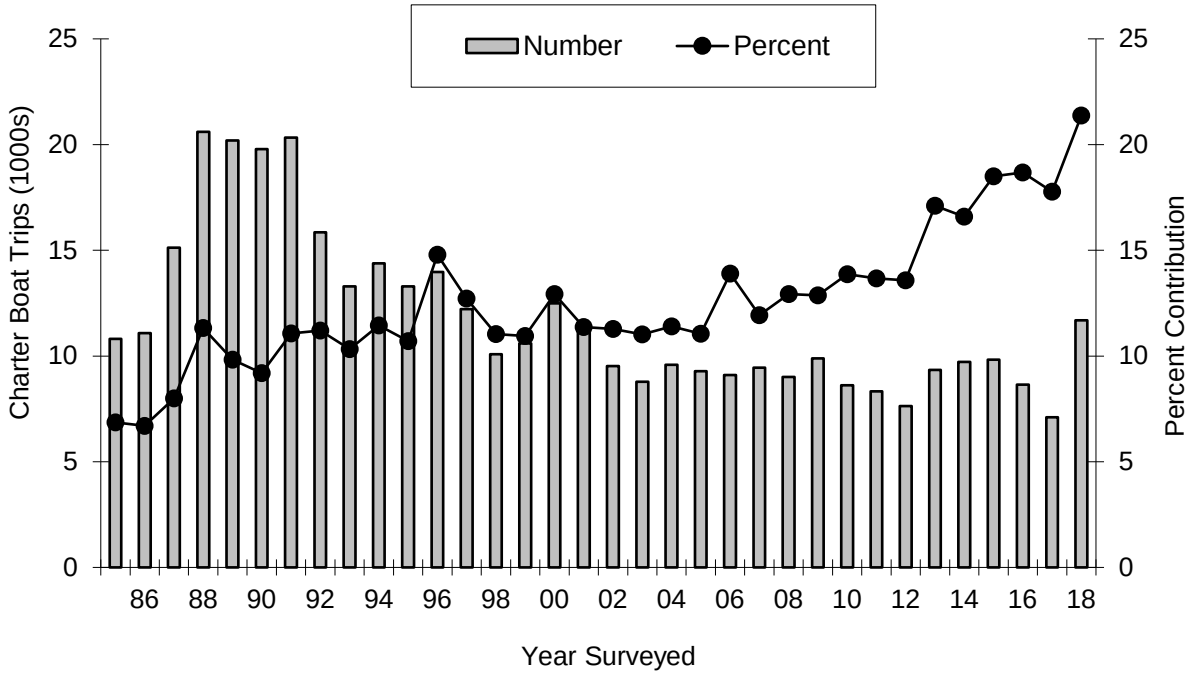


Figure 3. Estimated number of charter fishing boat trips and their percent contribution to total fishing boat trips, April 15- September 30, 1985-2018.

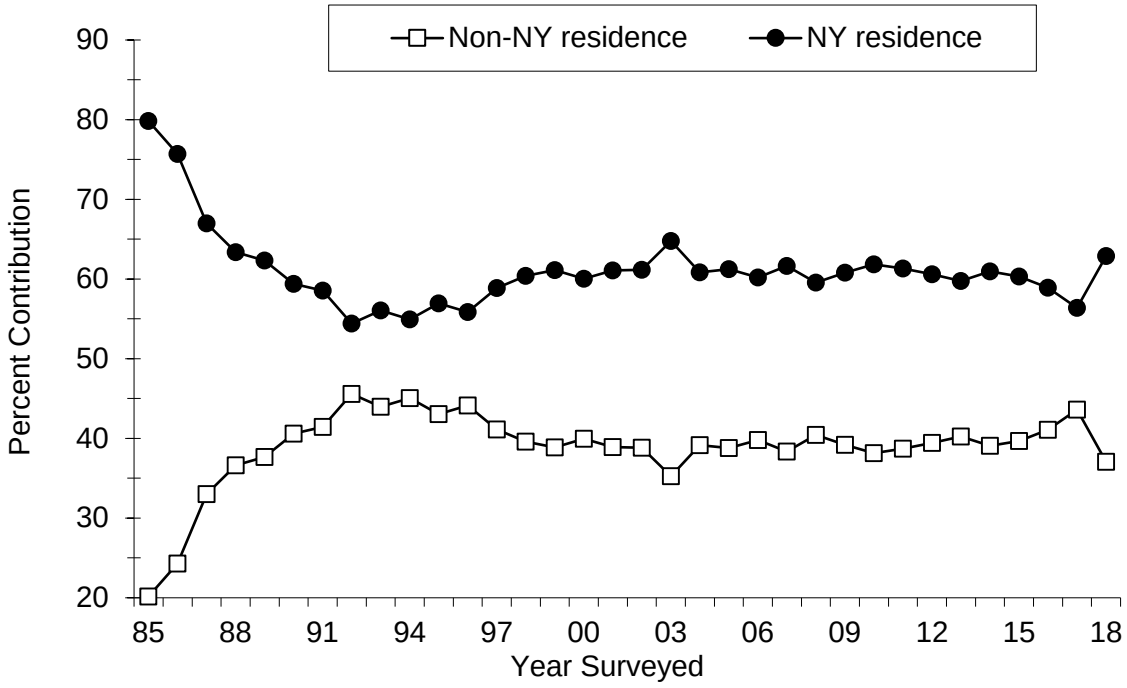


Figure 4. Percent contribution of anglers with and without New York state residency, 1985-2018.

Other counties representing important components of the open lake boat fishery in 2017 were Oswego (12.9%), Niagara (7.2%), Onondaga (6.0%) Wayne (9.1%), Orleans (4.0%), and Erie (5.0%; Table A4).

Total Salmonines: Catch, Harvest and Fishing Quality

Catch and Harvest

Trout and salmon are the most sought-after fish in Lake Ontario. The six species provide anglers with a diverse trout and salmon fishery throughout the open lake season and along the entire NY shoreline. This variety gives anglers the opportunity to target another species when their preferred target is not available. Total catch of all trout and salmon species was estimated at 252,976 (±19.4%) fish, a 55.8% increase from 2017 and 43.8% above the previous 10-year average (Tables 1, A5a; Figure 5). In 2018, anglers harvested 56.3% of the catch which is near the long-term average (60.7%). Estimated salmonine harvest was 142,447 (±21.9%) fish, also well above (+47.9%) the previous 10-year average (Tables 1, A5a; Figure 5).

Each year since 2003, Chinook salmon dominated the trout and salmon catch (2018: 173,691 [±22.3%] fish, 68.7% of total catch) and harvest (2017: 101,192 [±25.6%] fish, 71.0% of total harvest). Brown trout or rainbow trout have often been the second most commonly caught and harvested species. In 2018, brown trout was the second most commonly caught (39,763 [±32.7%] fish) and harvested (22,985 [±33.0%] fish) species, followed by rainbow trout (18,047 [±32.3%] and 8,411 [±39.3%] fish, respectively). Lake trout represented about 5% of angler catch and harvest (12,205 [±34.2%] caught, 4,949 [±32.9%] harvested) in 2018. Coho salmon represented 3.3% of trout and salmon caught (8,232 [±42.7%] fish) and harvested (4,761 [±50.0%] fish). Atlantic salmon represented a very small component of the fishery (0.4% 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 2018, catch rate was excellent for all trout and salmon combined (5.3 fish per boat trip) and is largely due to the record high Chinook salmon catch rate (3.6 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, catch rate increased substantially in 2003 and remained at a higher, variable level since then (Figure 5). Anglers experienced ten consecutive years (2009-2018) of record high trout and salmon catch rates. The catch per boat trip in 2018 was the highest ever in the survey (5.3 fish caught per boat trip) and was 42.1% higher than the previous 10-year average (Table A5b; Figure 5). Fourteen of the highest catch rates observed in the survey occurred between 2003 and 2018. During this period anglers experienced high species-specific catch rates for Chinook salmon (2003-2018), coho salmon (2006-2007, 2009-2012, 2017); rainbow trout (2008-2014), brown trout (2007, 2011, 2012, 2014, and 2018), and lake trout (2013-2016). The 2018 total trout and salmon harvest rate for all boats targeting trout and salmon was 3.0 fish per boat trip, the highest in the data series, and a 45.8% increase compared to the 2008-20017 average harvest rate (Table A5b; Figure 5). Catch and harvest rate data (fish per boat trip) were also evaluated by month. In 2018, catch rates were above respective previous 10-year averages in all months (range: +7.7% [July] to +94.1% [September]); Table A5b) with record high catch rates in May, June, and September (7.7, 5.5, and 3.9 fish per boat trip respectively).

Table 1. Harvest and catch estimates for April 15 – September 30, 2018 from the NYSDEC Lake Ontario fishing boat survey.

	Number Harvested	Number Caught
Coho salmon	4,761	8,232
Chinook salmon	101,192	173,691
Rainbow trout	8,411	18,047
Atlantic salmon	150	994
Brown trout	22,985	39,763
Lake trout	4,949	12,205
Smallmouth bass (includes pre-season)	3,111	26,875
Yellow perch	4,541	11,782
Walleye	0	0
Round goby	2,517	5,383
Other fish	0	0

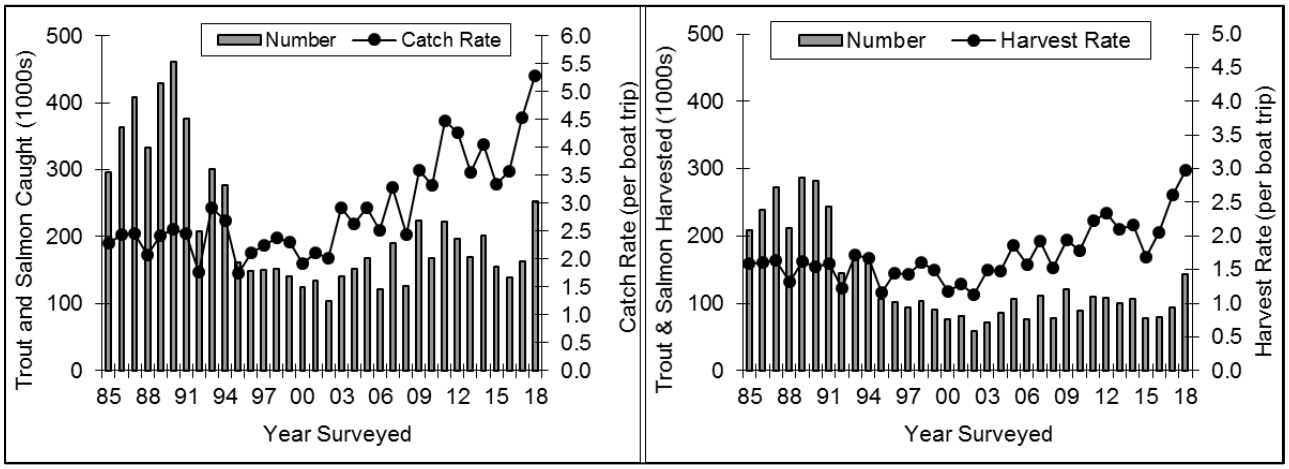


Figure 5. Total trout and salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985 - 2018.

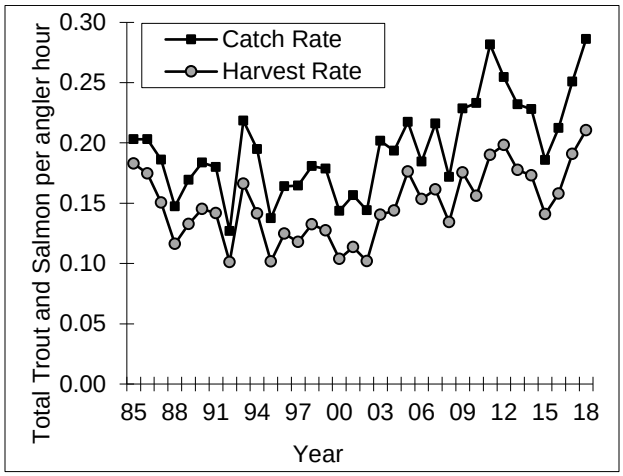


Figure 5b. Charter boat catch rate and harvest rate per angler hour for total trout and salmon, April 15 – September 30, 1985 - 2018.

In 2018, charter boats targeting trout and salmon accounted for 43.4% and 56.7% of all salmonines caught and harvested, respectively, but represented only 24.2% of trout and salmon fishing boat effort, 40.3% of angler trips and 43.6% of angler hours directed at trout and salmon. Charter boat total trout and salmon catch rate (9.5 fish per boat trip) and harvest rate (7.0 fish per boat trip) were both record highs, and 19.8% and 18.4% increases compared to the previous 10-year averages (Table A5b). Charter catch rate per angler hour was 0.29 salmonines, also a record, and a 25.6% increase compared to the previous 10-year average (Table A5b; Figure 5b).

Noncharter fishing boats also had a record year, catching an average of 3.9 salmonines per boat trip (0.29 fish caught per angler hour) in 2018, 42.5% higher than the previous 10-year average (Table A5b). The 2018 lake-wide harvest rate was 1.7 salmonines per noncharter boat trip (0.12 fish per angler hour, Table A5b) which is lower than the charter rate, however noncharter boats usually have smaller parties and tend to release more fish than charters.

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 1985-2017 the proportion of boats targeting trout and salmon with zero catch of any salmonine species ranged from 23.6% (2017; indicating excellent fishing quality) to 49.7% (1992; indicating relatively poor fishing quality; Table A6). In 2018, 18.3% of boats targeting trout and salmon caught zero salmonines, the lowest in the data series, a 22.7% decrease compared to the previous record low in 2017, and 40.9% lower than the previous 10-year average, indicating improved fishing quality compared to recent years. Eleven out of twelve 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 good fishing quality in 2018 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 2018, 27.6% of charter boats harvested the limit of these species for their customers, the highest in the data series. In 2018, of the charter boats that harvested the three in any combination limit for their customers, 40.0% went on to harvest additional fish on the captain and mate licenses, and 7.5% 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 2018, 6.0% harvested the maximum daily limit of three coho salmon, Chinook salmon, rainbow trout, or brown trout in combination, a 210.2% increase compared to the previous 10-year average.

Limits of lake trout on charters 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 2018, 1.6% of charter boats harvested the legal limit of lake trout for their party, returning to levels observed 2007-2012. Of those that harvested the legal limit of lake trout for their customers, 60% went on to harvest additional lake trout on the captain and mate licenses, and 0.4% of charter boats harvested the limit for all anglers. Among noncharter boats, 0.2% harvested the maximum daily limit of lake trout in 2018.

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 1997-2018 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). In 2018, 66 charter trips (0.1% of all charter trips) harvested the limit of lake trout and three in any combination.

Coho Salmon

Catch and Harvest

In 2018, coho salmon was the fifth most commonly caught and harvested salmonine in the trout and salmon boat fishery (3.2% and 3.3% of total catch and harvest, respectively; Tables 1, A7a). Estimated coho salmon catch (8,232 [±42.7%] fish) in 2018 was 33.4% lower than the long-term average (1985-2016; Figure 6). Approximately 58% of coho salmon caught were harvested which is lower than the previous 10-year average (66%).

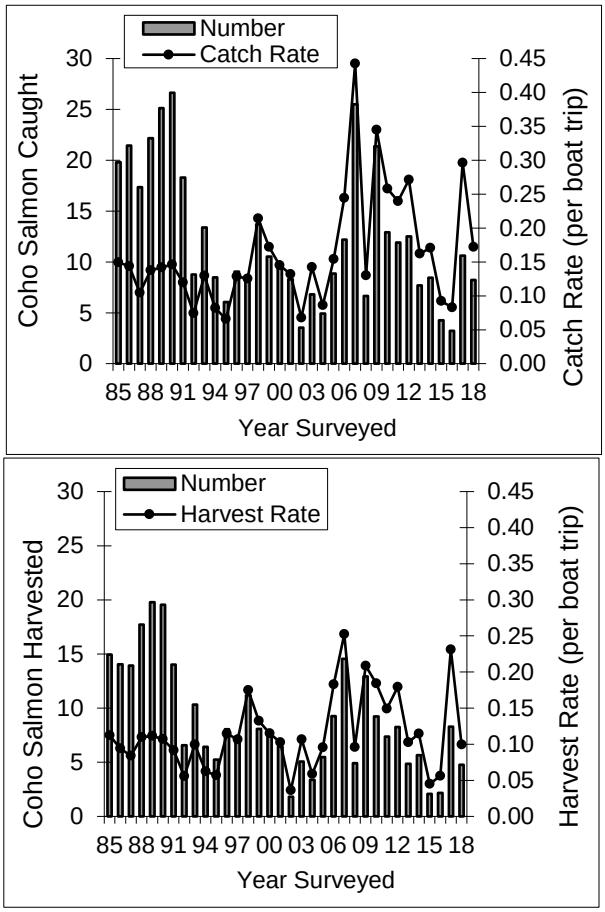


Figure 6. Total coho salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2018.

Coho salmon harvest was an estimated 4,761 (±50.0%) fish, which ranked as the 9th lowest in the 34-year survey (Table A7a; Figure 6). During 2018, estimated monthly catch of coho salmon was below the long-term averages especially in April (-95.5%), July (-30.2%), and August (51.5%) whereas catch was more typical in May (-2.4%), June (+3.5%), and September (+7.2%; Table A7a).

Fishing Quality

Coho salmon catch rates and harvest rates were generally at or near record levels from 2006-2012 (Table A7b; Figures 6, 6b). Rates declined to near record lows in 2015 and 2016, then rebounded in 2017 to the third highest in the series. In 2018, coho salmon catch rate (0.17 fish per boat trip) was similar (+5.2%) to the long-term average (Table A7b; Figure 6), whereas harvest rate was 14.2%

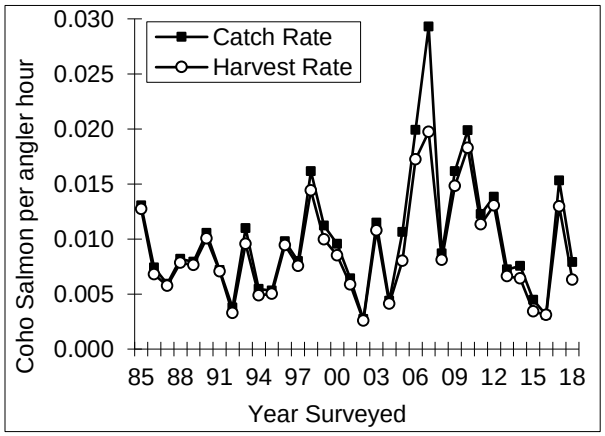


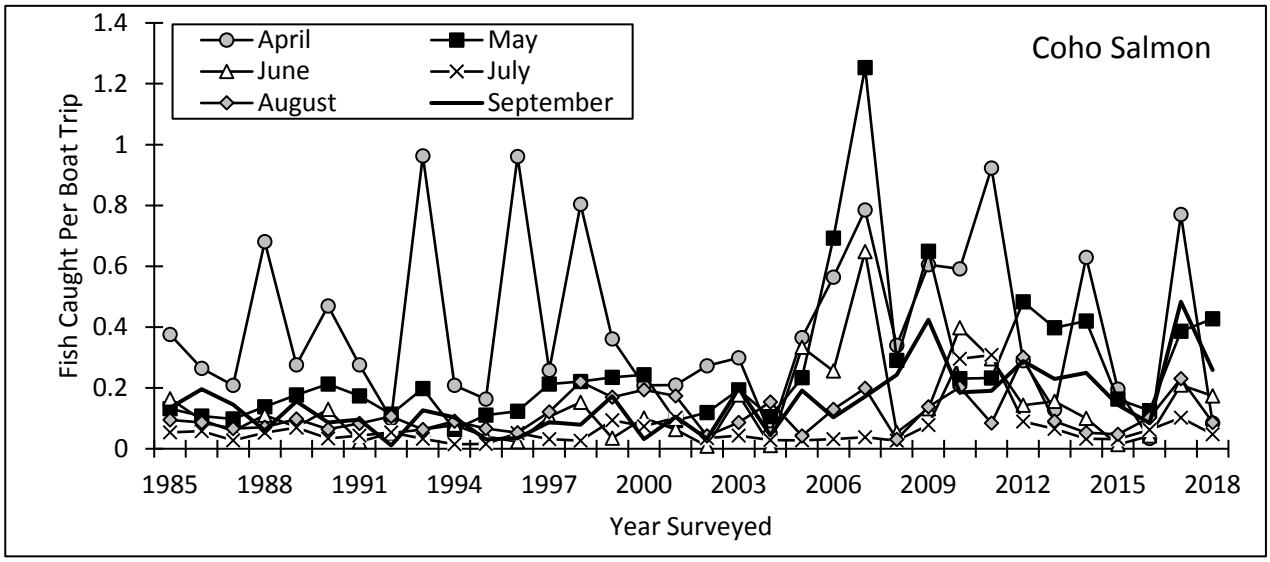
Figure 6b. Charter boat catch rate and harvest rate per angler hour for coho salmon, April 15 – September 30, 1985-2018.

below average, in part because a higher proportion of coho were released due to their small size (see *Biological Data).* In 2018, charter boats targeting trout and salmon caught 36.7% of all coho salmon caught by trout and salmon fishing boats. Among charter boats in 2018, coho salmon catch and harvest rates (0.008 and 0.006 fish per angler hour respectively) were 22.0% and 30% below the long-term averages respectively (Table A7b; Figure 6b). Among noncharter boats, the 2018 catch and harvest rates were 0.010 and 0.005 coho salmon per angler hour, respectively (Table A7b).

highest during April and May and in the western portion of the lake (Lantry and Eckert 2011; Table A7b; Figures 6c, 6d, A1). In 2018 coho salmon catch rate per boat trip in April was 79.7% below the long-term average and the third lowest in the 34 years surveyed. Catch rates in May, June and September were above average (63.4%, 31.9%, and 74.0% respectively) but catch rates were well below average in July (-27.3%) and August (-24.4%). For the 21st consecutive year, the west area experienced the highest coho salmon catch rate among all areas (0.32 fish per boat trip). Catch rates decreased in all four areas surveyed as compared to 2017, and were below long-term averages in the west central (-36.0%), and east/central (-15.4%) areas, well above average in the east (+98.1%) and about average in the west (+3.7%) area (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).

Biological Data

Biological data analysis presented below includes fish processed during April 15 - September 30 (length: 1985-2018, weight: 1988-2018, scale samples for age determination: 2000-2018). 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



Coho salmon catch and harvest rates are typically

1985-1999) using monthly length frequency

Figure 6c. Coho salmon caught per boat trip April through September, 1985-2018. Note: Catch rate varied by region within each month surveyed.

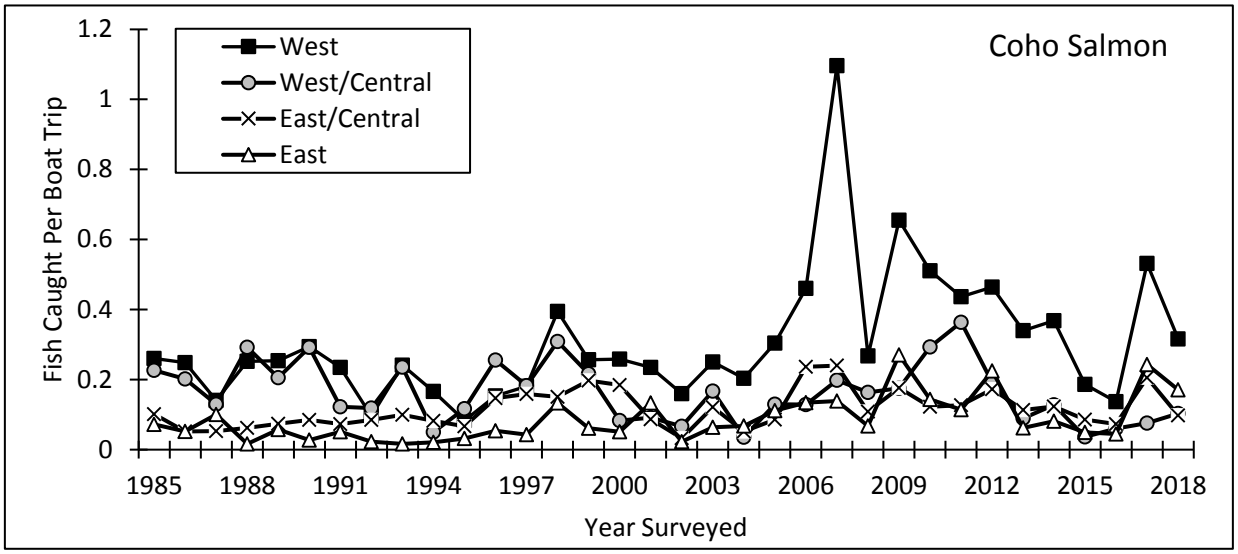


Figure 6d. Coho salmon caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2018. Note: Catch rate varied by month within each area surveyed.

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 2000-2018, 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 (34-year average = 95.8% of those harvested were age 2; Table A8). In 2018, 98.7% of coho salmon sampled were age 2, 1.3% were age-1, and 0% were age-3. Harvest of age 1s is influenced by harvest regulations (i.e., 15-inch minimum harvestable size and angler desire to release 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 29 out of 34 years surveyed.

Condition indices for coho salmon in 2018, as determined from predicted weights of standard-length fish, were below previous 30-year (1988-2017) averages for each inch group evaluated from 18 in to 24 in (range: -12.7% [18-in] to -2.0% [24-in]). Predicted weights of the smallest inch groups (i.e., 18-in, 20-in) from 2016-2018 were the among the lowest observed, with 2018 ranking 30th out of 34 years, and indicating relatively poor condition compared to previous years for fish of the same length (Table A8). For the largest inch groups evaluated, predicted weights were slightly above average (+4.0% [28-in] and +6.9% [30-in]; Table A8). Generally, the longer coho salmon are sampled later in the season when condition often improves. The mean length of age-2 coho salmon in September 2018 (25.9 in) was 7.1% below the long-term average (27.9 in, 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 caught salmonine in 22 of the 33 years surveyed. From 1985-2002 Chinook salmon represented an average of 28.3% of the total salmonine catch among trout and salmon boats. From 2003-2017, 46.2% of all salmonines caught were Chinook salmon. In 2018, Chinook salmon catch was an estimated 173,691 fish, representing 68.7% of the total salmonine catch (Tables 1, A9a; Figure 7). This was a new record in the 34-year survey, 130.9% above the long-term average, and 128.3% above the previous 10-year average.

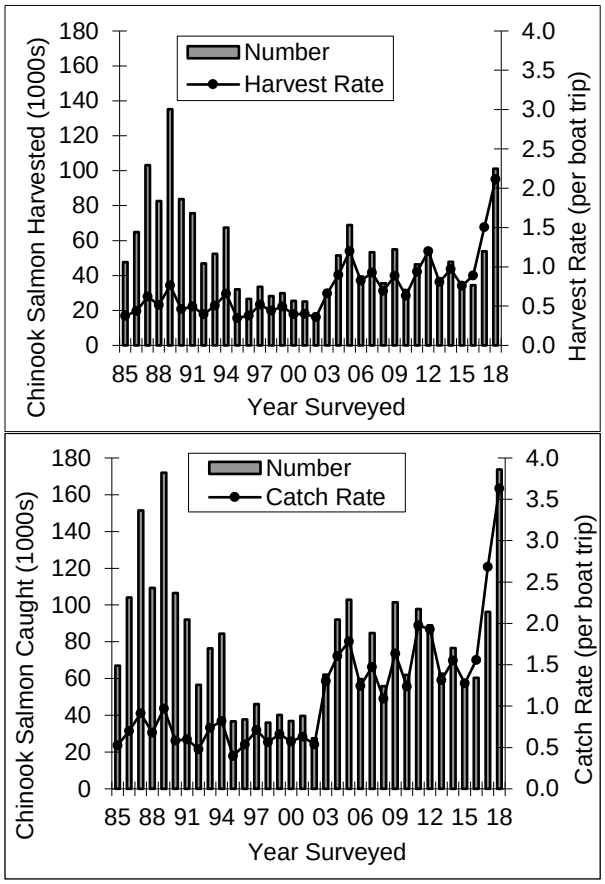


Figure 7. Total Chinook Salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2018.

Of all Chinook salmon caught in 2018, 58.3% were harvested (Table A9a). The highest percent harvest occurred in 1995 when 87.3% of all Chinook salmon caught were harvested. Since 2003, anglers have experienced the best Chinook salmon fishing quality on Lake Ontario and the percentage of Chinook salmon harvested (2003-2018 average percent harvest=58.5%) was 20.8% lower than during the 1985-2002 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 2018 was estimated at 101,192 (±25.6%) Chinook salmon, which represented 71.0% 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 again the case in 2018 when August catch and harvest estimates were 57,889 and 35,495 fish, respectively, representing 35% of all Chinook salmon caught and harvested. Estimated August catch was the second highest in the 34 years surveyed (1989 was the highest). In 2018, catch estimates were above respective long-term monthly averages in most months including in May [+145.8%], June [+279.5%], July [+169.0%], August [+108.4%], and September [+95.8%]. Only in April was catch below average (-97.9%) with a new record low. The highest regional contribution of Chinook salmon catch typically occurs in the west area (28 of 33 years 1985-2017). In 2018, estimated catch was again highest in the west area (66,017 fish, 38.0% of all Chinook salmon caught; +90.4% compared to the long-term average). Catch estimates were also exceptional in the other three areas surveyed. New record highs were set in the west/central and east/central areas (284.7% and 164.7% respectively above the long-term averages; Table A9a) and catch in the east was 95.8% above average.

Fishing Quality

The highest Chinook salmon fishing quality occurred during the last 16 consecutive years (2003-2018) with 2018 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, however beginning in 2003 lake-wide catch rates averaged more than 2.4-fold higher than those observed in years prior to 2003. The 2018 average Chinook salmon catch rate was 3.6 Chinook salmon per boat trip with good to excellent fishing in most months for all areas. That is a 123.5% increase compared to the previous 10-year average, and the highest in the 34 years surveyed (Table A9b; Figure 7).

In 2018, charter boats targeting trout and salmon caught 41.3% of the Chinook salmon caught by all trout and salmon anglers. Among charter boats, the 2018 Chinook salmon average catch rate was 6.2 fish per boat trip, a 93.9% increase compared to the previous 10-year average and the highest in 34 years surveyed (Table A9b). Charter boat catch per

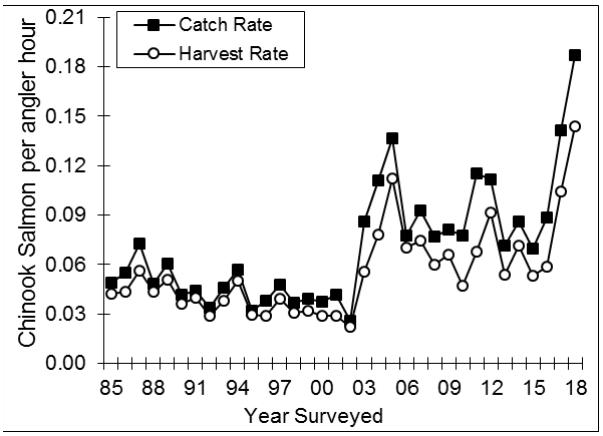


Figure 7b. Charter boat catch rate and harvest rate per angler hour for Chinook salmon, April 15 – September 30, 1985-2018.

angler hour of Chinook salmon (0.19 in 2018) was the highest on record and 97.0% above the 2003-2017 average (Figure 7b). Among noncharter boats, the 2017 catch rates were 2.8 Chinook salmon per boat trip and 0.21 per angler hour, both well above previous 10-year averages (+121.8% and +130.4%, respectively; Table A9b).

Like catch rates, the highest Chinook salmon harvest rates occurred during 2003-2018 (i.e., an average of 109.2%% higher than those prior to 2003; 1985-2002 average = 0.48 fish per boat trip, 2003-2018 average = 0.99; Table A9b; Figures 7, 7b). The 2018 lake-wide harvest rate among boats seeking trout and salmon was 2.1 Chinook salmon per boat trip, a new record, and 121.3% above the previous 10-year average (Table A9b; Figure 7). Both charter and non-charter boats experienced record high harvest rates in 2018. Among charter boats, the 2018 harvest rate (4.8 Chinook salmon per boat trip) was a 103% increase compared to the previous 10-year average (Table A9b; Figure 7b). Charter boats harvested 0.14 Chinook salmon per angler hour in 2018 (Figure 7b). Among noncharter boats, the harvest rate was 0.09 Chinook salmon per angler hour, a 118% 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). In all areas, Chinook salmon catch rates are typically highest in summer, lasting into early September in some years. In 2018, the seasonal average catch rate was positively influenced by good to excellent fishing during all months in all areas except in April when catch rates were low (Table A9b). The highest monthly catch rate among all months surveyed from 1985 through 2018 occurred in August 2018 when 4.2 Chinook salmon were caught per boat trip (Figure 7c). Catch rates in May, June, August and September

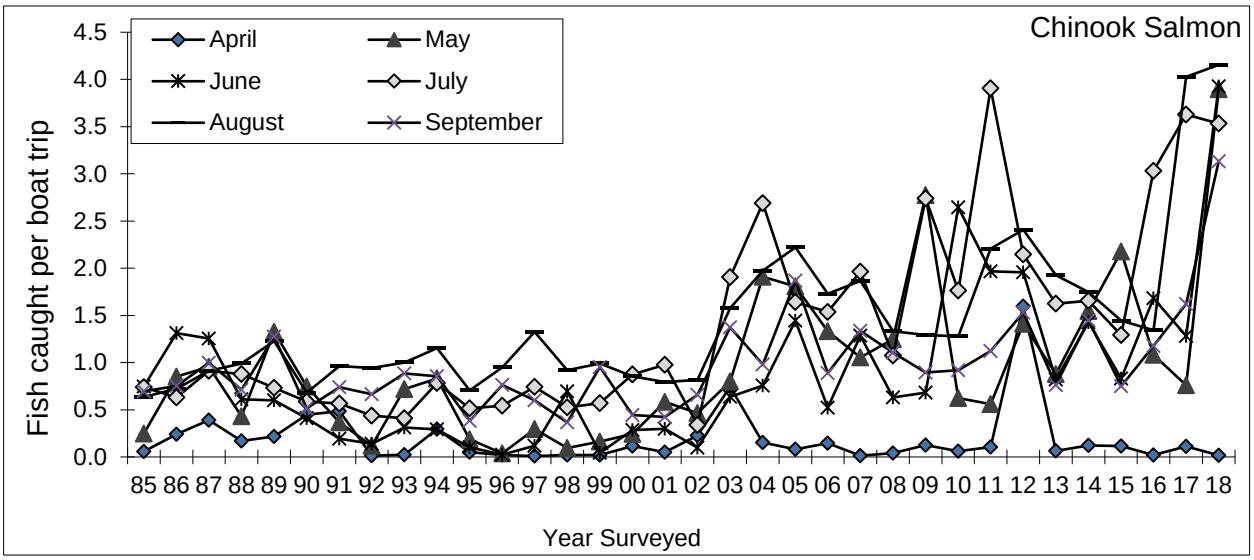


Figure 7c. Chinook salmon caught per boat trip April through September, 1985-2018. Note: Catch rate varied by month within each area surveyed.

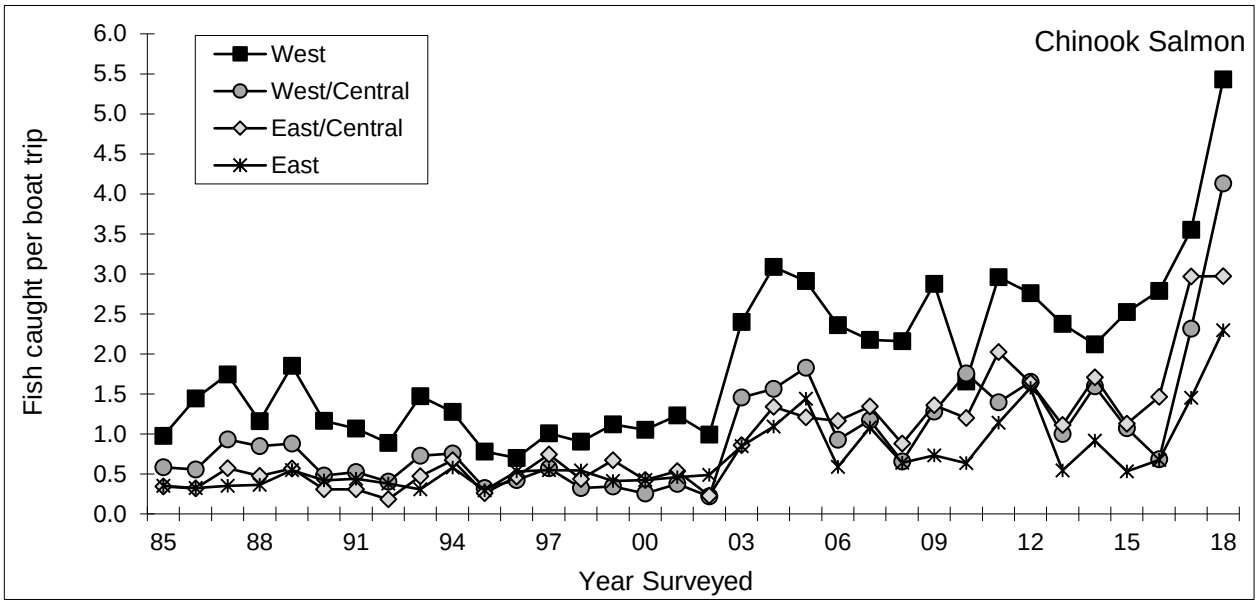


Figure 7d. Chinook salmon caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2018. Note: Catch rate varied by month within each area surveyed

set new record monthly highs, and were well above previous 10-year averages in all months except April (range: +54.6% [July] to +198.5% [May]; Table A9b; Figure 7c). The 2018 Chinook salmon catch rates also set new record highs and were well above previous 10-year averages in all areas surveyed (west: +129.1%, west/central: +360.3%, east/central: 87.1%, east:148.8%; Figure 7d).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2018, weight: 1988-2018, scale samples for age determination: 1991-2018). 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 1991-2018, 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 34 years surveyed, Chinook salmon sampled from angler harvest were dominated by age-2 and age-3 fish (1985-2017 averages: age 2 = 39.1%, age 3 = 46.6% of fish sampled; Table A10). In 2018, angler harvest consisted of 60.0% age-2 fish and 32.2% age-3 fish. Ages 1 and 4 typically represent small components of angler harvest. In 2018, 6.1% of Chinook salmon processed were age 1, which is 46.1% below the long-term average. Age-4 Chinook salmon typically comprise a small percentage of the total Chinook salmon sampled each year (1985-2017 average=2.9%), and in 2018 they represented 1.5% of all Chinooks processed (Table A10). In 2018, a 41.3-inch-long, age-5 Chinook salmon was sampled at Point Breeze, and its age confirmed by the presence of a coded wire tag indicating it had been pen stocked in the Niagara River in 2013. This was the first age-5 Chinook salmon ever documented by New York's fishing boat survey.

To evaluate Chinook salmon growth, we determined mean length-at-age by month for samples collected July through September (data collected from 1991-2018; Table A11; Figure A1).

The 2018 mean lengths of Chinook salmon were below average -0.9 in, -0.5 in, and -1.5 in in July, August and September, respectively. The 2018 August mean length of age-1 fish was 1.9 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 A1). In 2018, 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. Mean lengths of age-3s in 2018 were also below average in July, August and September by 0.8, 1.3 and 1.3 inches respectively and were among the lowest monthly average lengths at age-3 recorded in the survey.

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 1988-2018 (Table A10) and showed no statistically significant trends over the 30-year survey period. Predicted weights of Chinook salmon in 2018 were the second lowest in the 31-year data series for five out of seven standard lengths including 24-40 inches and were 3rd (20 in) and 4th (16 in) lowest for the other lengths. Predicted weights were below respective long-term averages in all seven categories (16 in: -0.09 lbs; 20 in: -0.18 lbs; 24 in: -0.31 lbs; 28 in: -0.51 lbs; 32 in: -0.79 lbs; 36:in: -1.15 lbs; 40 in: -1.62 lbs; Table A10). Overall, mean length at age and predicted weights indicated slower growth and poorer condition of Chinook salmon in 2018. This may be partly attributed to colder than average temperatures especially in spring 2018, however abundance of alewife, the primary forage of Chinook salmon in Lake Ontario (Lantry 2001) is currently low (Weidel et al. 2019) and may not be enough to maintain Chinook growth and condition at previously observed levels.

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). Relative harvest was calculated as the age-specific number of Chinook salmon harvested per 50,000 boat trips April 15 - September 30. 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 (1985-2018 survey years) varied from the high of 105,763 fish in 2018 to a low of 17,371 fish in 1995. The twelve 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) to 3,368,296 (1987 year-class) fingerling equivalents (previously described in Eckert 2007). The 2018 relative harvest (105,763 fish) was the highest in the 34-year data series (Table A12). To date, returns of age-1 to age-4 fish from the 2010 year-class were the highest on record (74,929 fish; Table A12); however, returns of the 2016 year-class from age-1 and age-2 Chinook thus far (total 77,303 fish) have already outpaced the 2010 year-class, and will set a new record once the other ages occur in future harvest years (2019 and 2020).

To control for changes in stocking levels and allow for between year comparisons, relative harvest data were adjusted to a common base of 2,000,000 fingerling equivalents stocked (Figure 8).

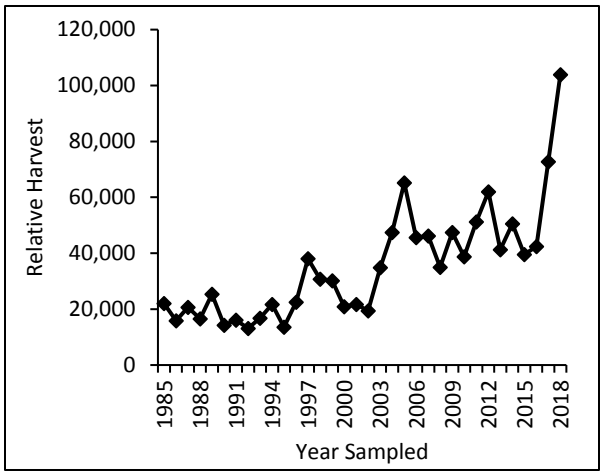


Figure 8. Relative harvest of Chinook salmon per 50,000 boat trips targeting trout and salmon, per 2,000,000 fingerling equivalents stocked.

Regression analysis of 1985-2018 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 A2) showed that this trend was mostly due to increased relative harvest of age 1s (2009-2010, and 2016-2017 year-classes), age 2s (2002-2003, 2005, 2009-2010, 2012, and 2015-2016 year-classes), and age 3s (2002-2004, 2006, 2010 and 2012-2015 year-classes).

Lantry and Eckert (2018) previously 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 R2=0.0002), age 2 (P=0.2591 and R2=0.0409), or age 3 (P=0.6809 and R2=0.0055; Figure 9). 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).

Factors contributing to the observed increased relative harvest and the lack of relationship between numbers stocked and fishing quality may 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.

Based on relative harvest at age 1 (13,816) and age 2 (63,487), the 2016 year-class appears to be the strongest produced in the data series (Table A12), followed by 2009 and 2010 year-classes. This may

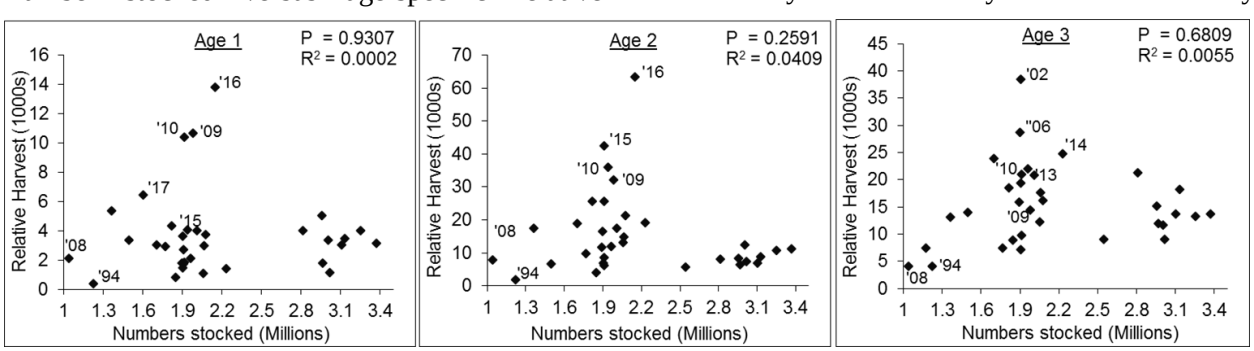


Figure 9. Number of fingerling equivalents stocked and relative harvest of age-1 (1984-2016 year-classes), age-2 (1983-2015 year-classes), and age-3 (1982-2014 year-classes) Chinook salmon.

be partly attributed to substantial wild production in the Salmon River as indicated by the highest recorded 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. The Salmon River wild young-of-year Chinook salmon seining program also indicated production of a strong 2010 year-class. The 2009 wild index value was lower; however, 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.

Rainbow Trout

Catch and Harvest

Rainbow trout was the third most commonly caught and harvested salmonine in 2018 and represented 7.1% and 5.9% of the total trout and salmon catch and harvest, respectively (Tables 1, A14a; Figure 10). Estimates of total catch and harvest 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 2018 was an estimated 18,047 (±32.3%) fish, 46.1% lower than the long-term average. Anglers harvested 8,411 (±39.3%) rainbow trout (46.6% of those caught), 60.3% lower than the long-term average. Reduced catch of rainbow trout in recent years (i.e., 2015-2016; Figure 10) was partly attributed to reduced population size after a prolonged rainbow trout mortality event related to thiamine deficiency in the Salmon River, NY from fall 2014 and into winter 2015 (Lantry and Eckert 2018). Another indication of a reduced population was 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 2014-2016. During spring of 2017 and 2018, however, the rainbow trout run at the Ganaraska River Fishway increased compared to the 2016 run size indicating a higher population level in 2017 and 2018 (OMNRF 2019). Rainbow trout catch in New York waters of Lake Ontario also increased in 2017; however, catch declined again in 2018 to levels lower than observed in 2015-2016. There have been no substantial reports of die-offs since 2014-2015, so reasons for the reduced catch in 2018 are unclear. Stocking of yearling rainbow trout in 2015 was 23% below target which may have impacted population abundance since those fish were age-4 in 2018 and fish from that age class represented 29% of the age structure on average from 2009-2018 (35% in 2018; Prindle and Bishop 2019). It is also possible that rainbow trout were targeted less by anglers in 2018 due to record high catch rates for Chinook salmon. Anglers will often target rainbow trout by going further offshore during periods when Chinook salmon are not available. In 2018, Chinook fishing was exceptional in May

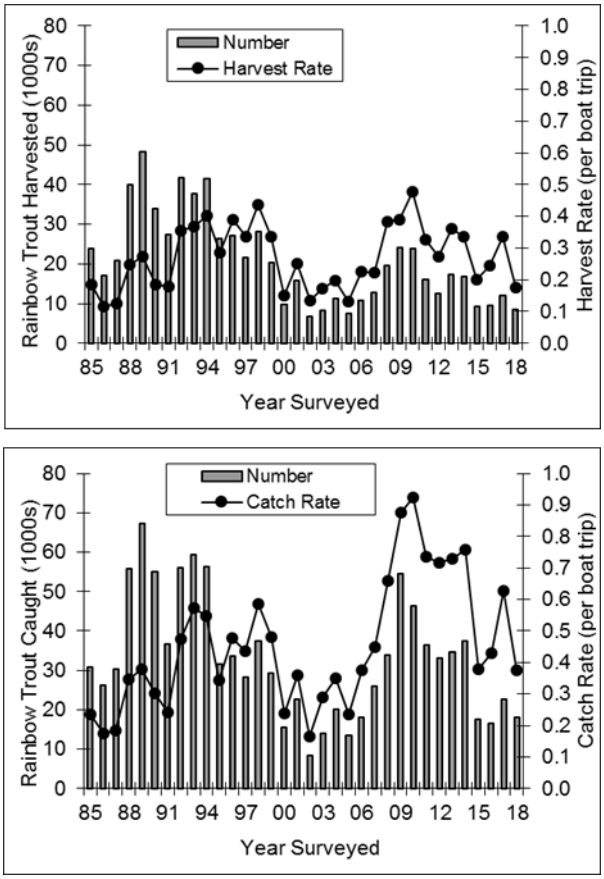


Figure 10. Total rainbow trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2018

through September (Figure 7c).

For 33 consecutive years (1986-2018), most rainbow trout were caught and harvested in the west area (Lantry and Eckert 2011; Table 14a). In 2018, 40.9%% of all rainbow trout caught and 35.4% of those harvested were from the west area, which is considerably lower than average (62.2% and 64.6% respectively). The majority of rainbow trout catch (43.2%) and harvest (49.4%) occurred during August (Table A14a). There have been significant downward trends ($p<0.001$) in the April/May percent contribution to harvest with April/May 2018 ranking 32nd out of 34 years; along with corresponding significant increases in percent contribution to total harvest in the other months, especially June/July ($p=0.0235$).

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 (average=0.77 fish per boat trip; Table A14b; Figure 10). The 2015 and 2016 catch rates (0.38 and 0.43 fish per boat trip), however, declined to the lowest since 2006. After catch rates temporarily improved in 2017, they dropped again in 2018 to 0.38 fish per boat trip which is 17.5% below the long-term average. In 2018, charter boats caught 39.3% of all rainbow trout caught by trout and salmon boats. Charter boats caught 0.61 rainbow trout per boat trip, 45.3% lower than the long-term average (Figure 10b). Charter boat catch per angler hour (0.02 fish per hour) was also well below (-40.4%) the long-term average. Anglers fishing onboard noncharter boats caught 0.30 rainbow trout per boat trip and 0.02 fish per angler hour (Table A14b). The 2018 lake-wide harvest rates among charter and non-charter boats followed similar trends as catch rates and were also well below long-term averages (Figure 10b, 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 long-term average, the 2018 rainbow trout monthly catch rates were below average in most months (April [-76.4%],

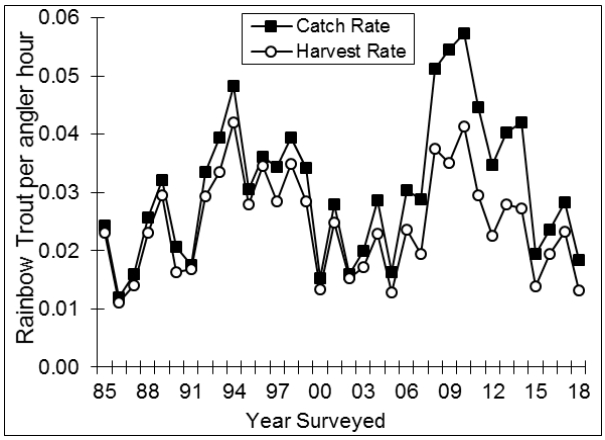


Figure 10b. Charter boat catch rate and harvest rate per angler hour for rainbow trout, April 15-September 30, 1985-2018.

May [-57.9%], June [-26.7%], July [-12.2%], September [-25.1%]) except in August when it was near average (+2.4%; Table A14b). Catch rate per boat trip in 2018 was especially low (-46.6%) in the west area. Seasonal catch rates in the west region are typically about 5 times higher than the average of the other three regions in a year but this was not the case in 2018. Lower rainbow trout catch rates in the west region may be partly due to exceptional Chinook fishing throughout the season which led to reduced targeting of rainbow trout during summer in the west. Catch rates per boat trip in the west/central area were 36.9% above average, near average in the east/central (0.3%) and 59.6% above average in east (Figure 10d).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2018, weight: 1988-2018). Scale samples were collected from rainbow trout processed for biological data each year 1996-2018; 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 2018 open lake season was the 12th year 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 twelve years since the regulation (2007-2018) was 9.9%, and significantly lower than the twelve years prior to the increased minimum size limit (1996-2006)

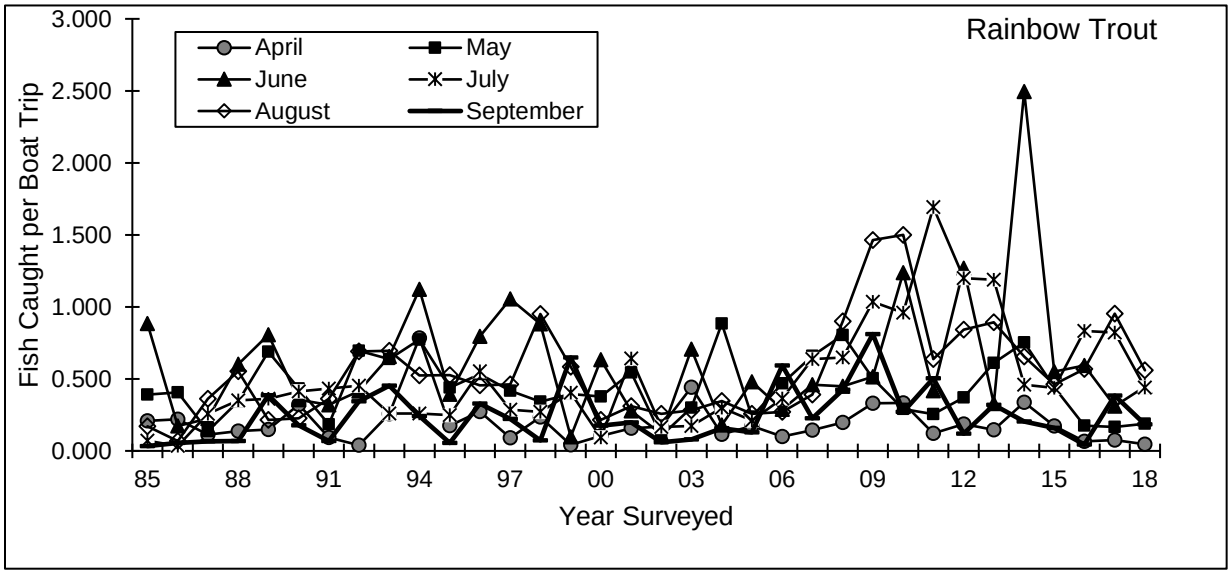


Figure 10c. Rainbow trout caught per boat trip April through September, 1985-2018. Note: Catch rate varied by month within each area surveyed.

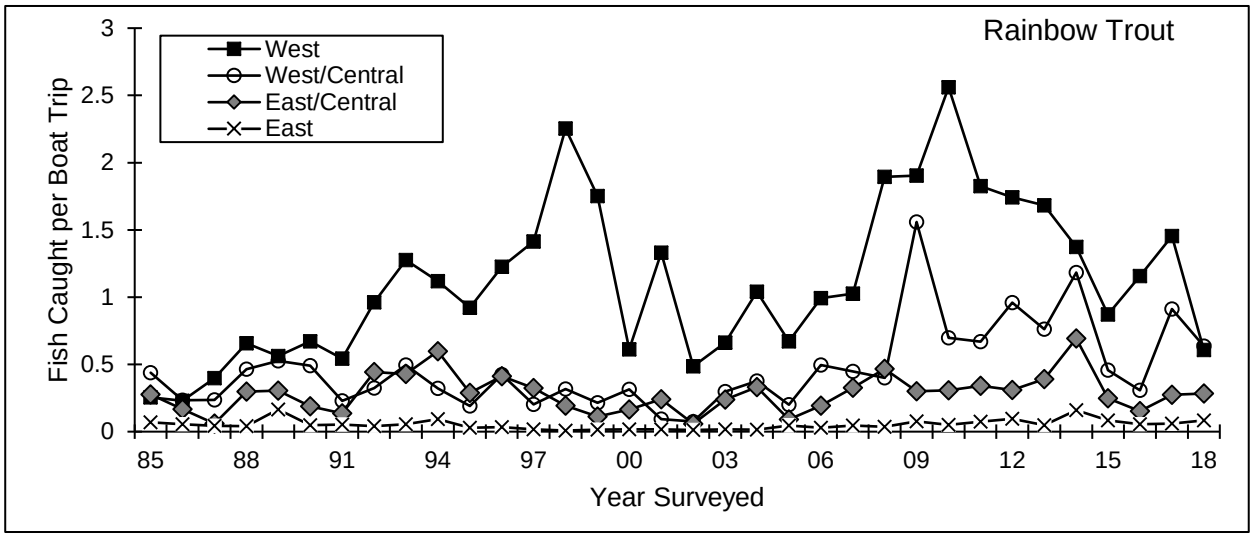


Figure 10d. Rainbow trout caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15-September 30, 1985-2018. Note: Catch rate varied by month within each area surveyed.

when 19.7% of rainbow trout processed were <21.0 inches (t=4.23; df=15, p-value = 0.0004). During 2018, 9.6% of harvested rainbow trout were shorter than the legal 21 in minimum harvestable size.

Weight data were collected each year from 1988-2018 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 by 2006. Since then condition of rainbow trout has varied at a lower level resulting in significant downward trends among all 30 years. In 2018, predicted weight (condition) was below average for all inch groups evaluated relative to long-term averages. Relative to more recent years,

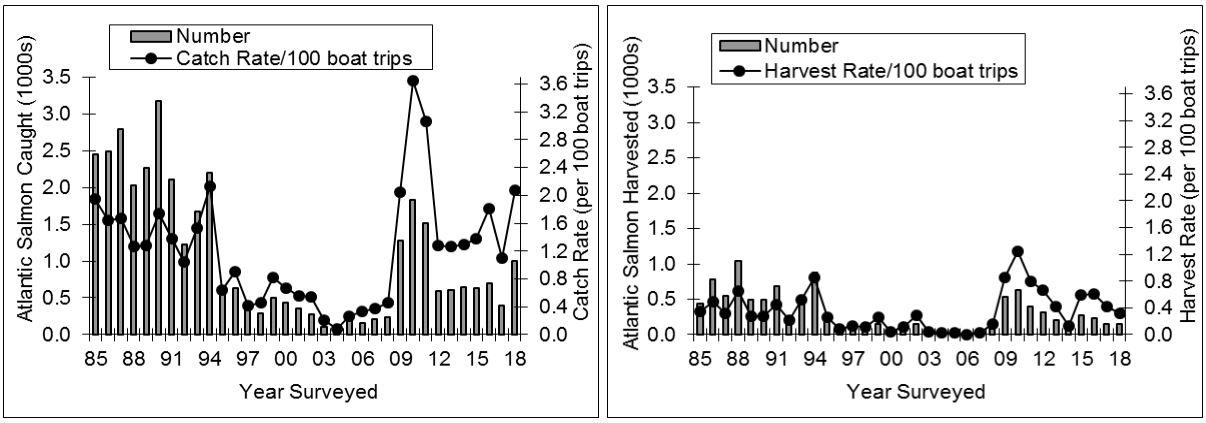


Figure 11. Total Atlantic salmon catch and catch rate, and harvest and harvest rate per 100 boat trips for boats seeking trout and salmon, April 15 – September 30, 1985-2018. Note the difference in scale (100 boat trips) compared with other species.

condition of smaller fish (18-in, 20-in, and 22- in groups) ranged from +4.9% to 1.3% above previous ten-year averages. Condition of the larger fish (i.e., 24-, 26-, 28-, 30-, 32 in groups) were near or below previous ten-year averages (range: -0.3% to -5.4%). The 28 to 32-inch predicted weights in 2018 were the 3rd lowest in the time series for all groups. Below average temperatures and reduced preyfish population could have contributed to reduced growth and condition of rainbow trout.

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 but 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 2009-2018, and in addition to the NYSDEC stockings, the USGS Tunison Laboratory of Aquatic Sciences reared and conducted experimental stockings of Atlantic salmon (Connerton 2010, 2019).

Each year from 2003 through 2008, few Atlantic salmon were reported in angler catch or harvest, and <1 was observed in the boat fishery by creel agents, resulting in harvest estimates of less than 80 fish per year and catch estimates of less than 250 fish per year (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 2018, estimated catch (994 [±40.1%] fish) was 67.1% higher than the previous 5-year average (Tables 1, A16; Figure 11). Anglers harvested an estimated 150 (+71.3%) Atlantic salmon in 2018. The 2018 Atlantic salmon catch rate (2.0 fish per 100 boat trips seeking trout and salmon) was 19.7% higher than the previous ten-year average and more than 4.3-fold higher than the 1995-2008 average rate (average = 0.48 per 100 boat trips). Harvest rate in 2018 (0.31 fish per 100 boat trips seeking trout and salmon) was more than 2.8-fold higher than the 1995-2008 average (0.11 fish harvested per 100 boat trips).

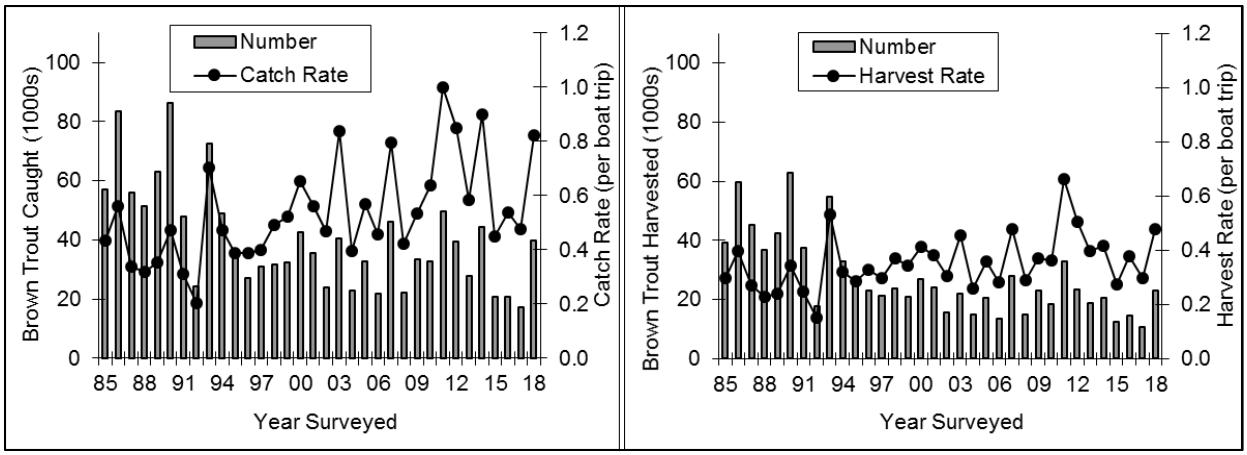


Figure 12. Total brown trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 September 30, 1985-2018.

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, 2017-2018; 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 (Lantry and Eckert 2018).

Brown Trout

Catch and Harvest

Brown trout was the second most commonly caught and harvested salmonine in 2018, accounting for 15.7% and 16.1% 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 2018, estimated catch (39,763 [±32.7%] fish) was 29.1% higher than the previous ten-year average. Estimated harvest (22,985 [±33.0%] fish) was 20.9% higher than the previous ten-year average (Tables 1, A17a; Figure 12). In 2018, 57.8% of brown trout caught were harvested, comparable to (-7.6%) the previous ten-year average. Typically, the majority of brown trout are caught during April and May, and in the east/central area. Over 54% of the 2018 brown trout catch occurred during April and May, and over 58% were caught in the east/central area (Table A17a).

Fishing Quality

Brown trout catch rates (lake-wide, charter and noncharter) were variable over the 34-year data series with no trend (Table A17b; Figures 12, 12b). In 2018, among trout and salmon fishing boats,

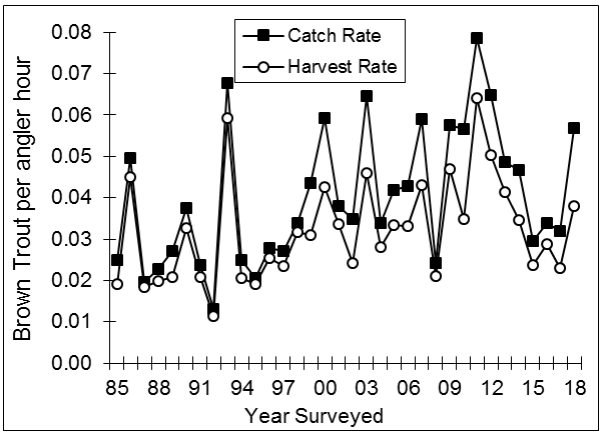


Figure 12b. Charter boat catch rate and harvest rate per angler hour for brown trout, April 15 – September 30, 1985-2018.

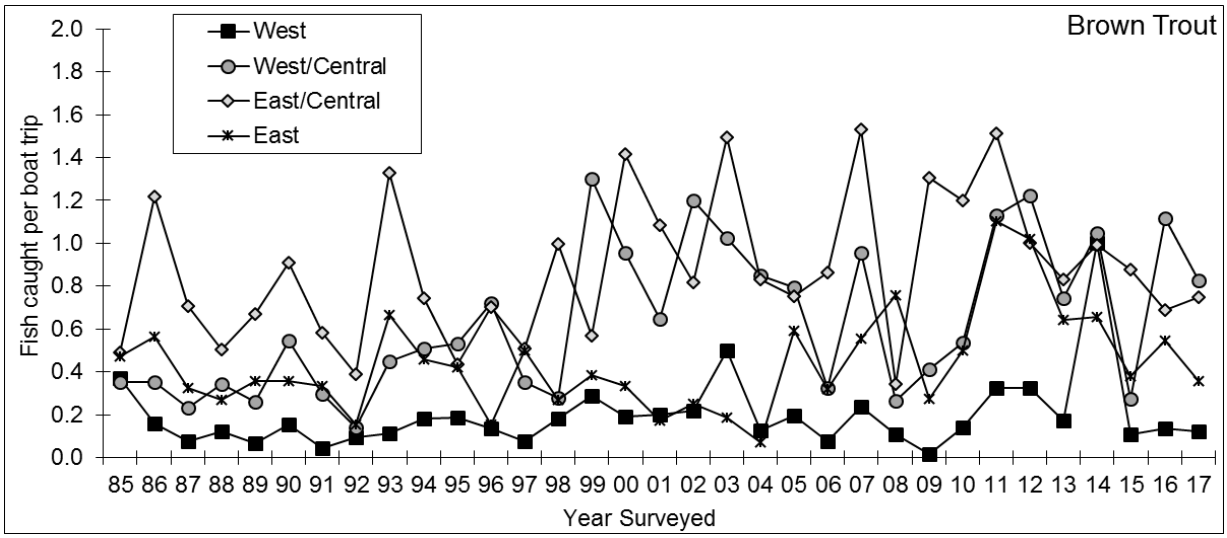


Figure 12c. Brown trout caught per boat trip April 15- September, 1985-2018. Note: Catch rate varied by month within each area surveyed.

brown trout catch rate (0.82 fish per boat trip) was 55.4% higher than long-term average and 28.9% higher than the previous 10-year average. Charter boats targeting trout and salmon caught 63.8% of all brown trout in 2018. Catch rate among charter boats was 1.9 brown trout per boat trip in 2018, the 9th highest out of 34 years, and 33.0% higher than the long-term average (Table A17b; Figure 12b).

The charter boat catch rate per angler hour was 0.06, 20.1% higher than the long-term average (Figure 12b). Noncharter boats caught an estimated 0.49 brown trout per boat trip (0.04 per angler hour), 34.7% above 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 2018 lake-wide harvest rate was 0.48 brown trout per boat trip, 36.6% higher than the long-term average (Table A17b; Figure 12). Among charter boats fishing for trout and salmon, the 2018 harvest rate was 1.3 brown trout per boat trip (0.04 fish per angler hour; Table A17b; Figure 12b). Among noncharter boats fishing for trout and salmon, the 2018 harvest rates were 0.23 brown trout per boat trip and 0.02 fish per angler hour. On average from 1985-2018, charters harvested 80.7% of the brown trout they caught compared with 66.7% for noncharters.

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 2018, brown trout catch rates were highest in April (4.7 per boat trip) and May (1.9 fish per boat trip). The April and May rates were both the 2nd highest observed in the 34-year survey and were 131.9% and 53.6% above long-term averages respectively (Table A17; Figure 12c). Catch rates were slightly below average in June (-8.2%) however they were above long-term averages in July through September (+51.0% in July; +11.0% in August; +156.3% in September). Similar to estimated catch, the highest catch rate typically occurs in the east/central area which was the case in 2018 with 1.43 fish caught per boat trip, 62.8% above the long-term average. The second highest catch rate occurred in the east (0.76 fish per boat trip) and was 73.4% above average. followed by the west/central area (0.61 fish per boat trip), which was near average (-2.9%). The lowest 2018 catch rate occurred in the west area (0.23 fish per boat trip) and was 15% above average. Table A17b; Figure 12d).

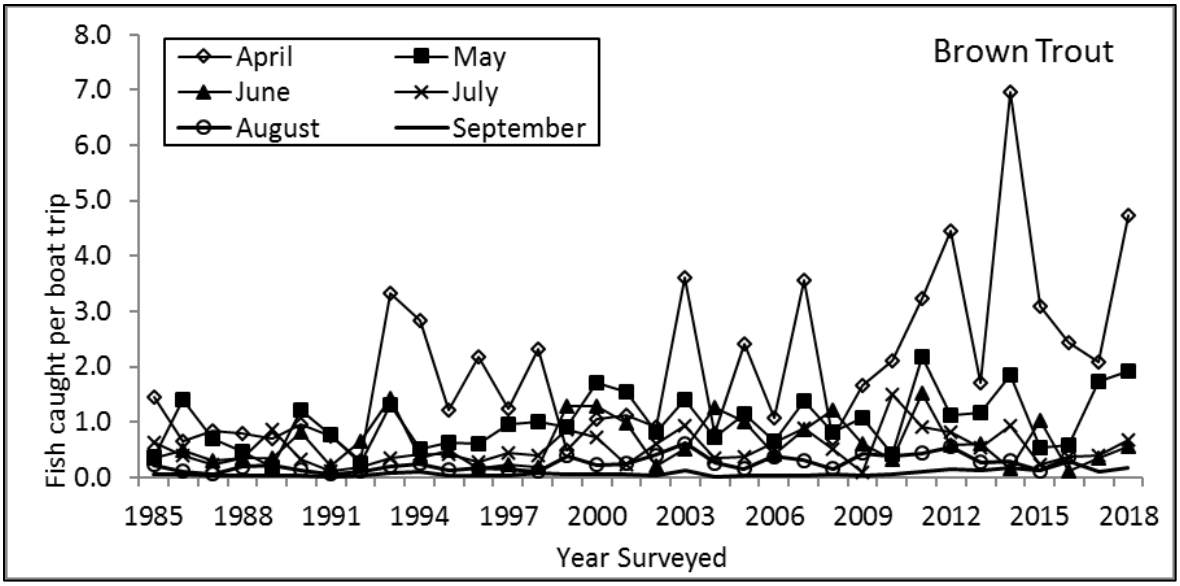


Figure 12d. Brown trout caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2018. Note: Catch rate varied by month within each area surveyed.

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2018, weight: 1988-2018). Scales were collected from nearly all brown trout processed by creel agents during 1993-2018 (i.e., 26 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 2018, 76.5% of brown trout harvested were age-2 fish, similar to (+1.4%) the long-term average. Nearly 20% 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 2018, 2.6% of the brown trout were age-4 fish. From 1993-2018, age-5 or older brown trout comprised an average of 0.7% (1.0% in 2018; Table A18). Few brown trout age 6 or older were observed, and in the 25 years that scale samples were aged, only sixteen age-6 and two age-7 brown trout were observed (two age 6 and one age 7 in 2018).

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 2018, average length of an age-2 brown trout was 17.8 in, nearly equal (-1.4%) to the long-term average (18.0 in, Table A18). Mean length of age-3 brown trout was 22.8 in, an inch shorter than 2017 however similar to the long-term average (22.7 in).

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. After temporarily improving in

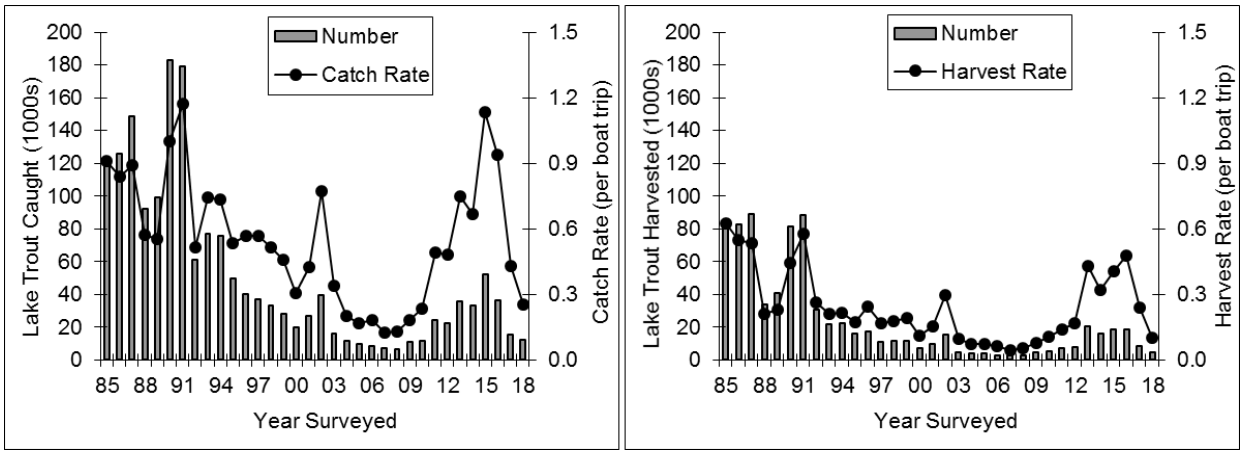


Figure 13. Total lake trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2018.

2017, condition of brown trout in 2018 declined again to among the lowest levels observed for the time series. Predicted weights of all sizes examined were below average (Table A18). Condition of the smallest fish (16-in,18-in and 20-in) were 7.0-9.1% below long-term averages. Predicted weights of the 22-in and 24-in fish were 10.1% and 11.0% below average respectively, and the second and third lowest ever observed for those categories. Condition of the two largest size groups (26- and 28-inch groups) were 11.8% and 12.6% respectively below long-term averages, and both were the lowest observed for each category in 31-years. Growth and condition of brown trout was likely negatively influenced by colder weather conditions and decreased prey availability in 2018 (Weidel et al. 2019).

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 2018, lake trout was the fourth most commonly caught and harvested trout or salmon species, contributing 4.8% and 3.5% of the total salmonine catch and harvest, respectively (Tables 1, A19a). In 2018, estimated lake trout catch (12,205 [±34.2%] fish) and harvest (4,949 [±32.9%] fish) were 64.7% and 69.9% 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, was 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

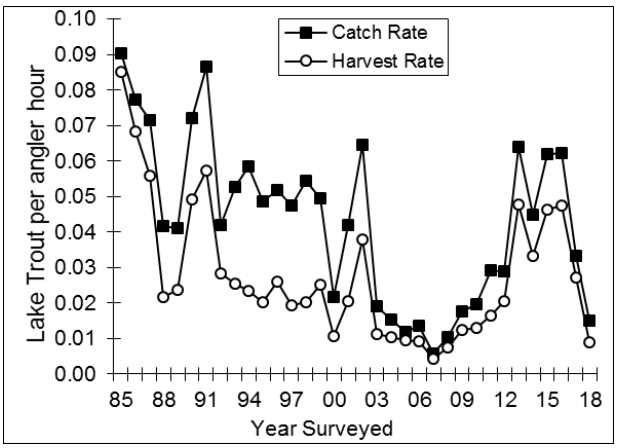


Figure 13b. Charter boat catch rate and harvest rate per angler hour for lake trout, April 15 – September 30, 1985-2018.

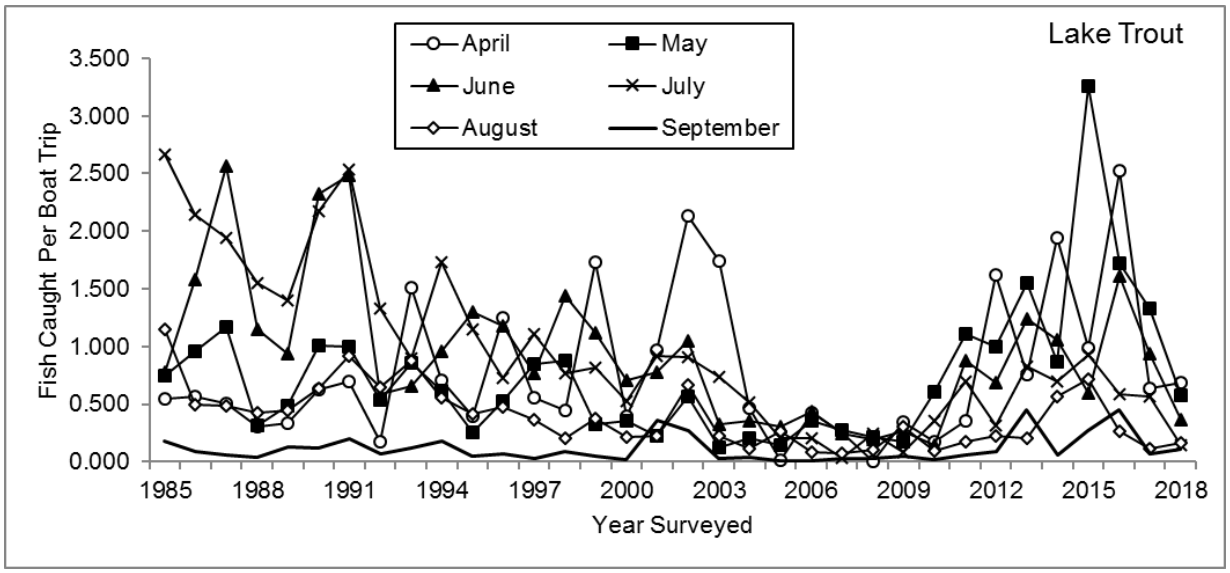


Figure 13c. Lake trout caught per boat trip April through September, 1985-2018. Note: Catch rate varied by month within each area surveyed.

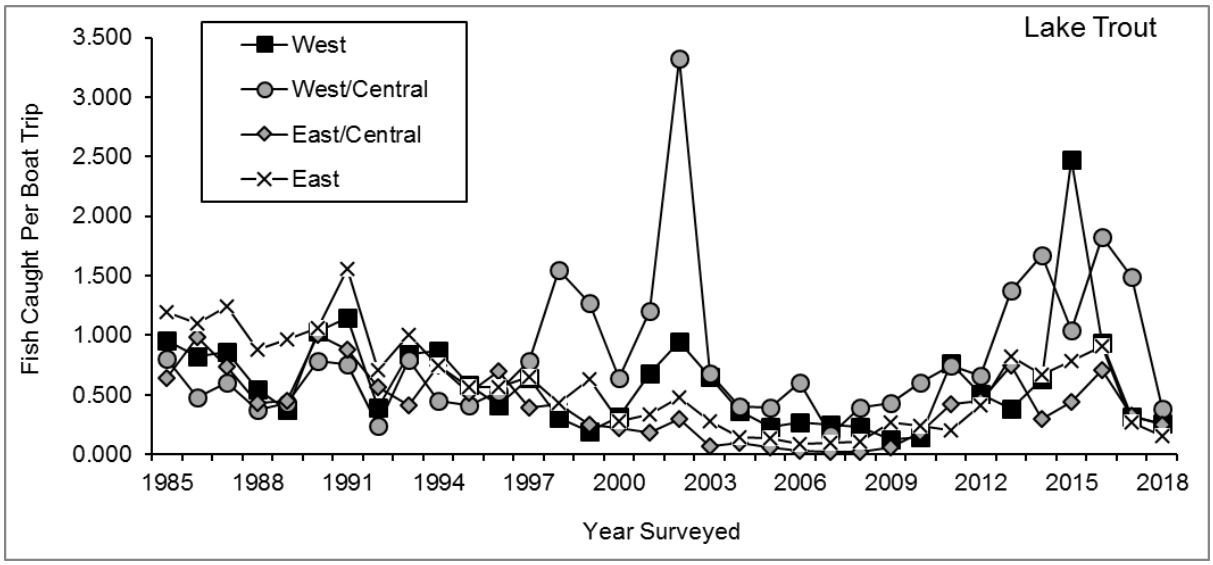


Figure 13d. Lake trout caught per boat trip in the west, west/central, east/central and east areas surveyed, April 15 – September 30, 1985-2018. Note: Catch rate varied by month within each area surveyed.

trout, Chinook salmon) was considered low during 2013-2017. Fishing quality for these species was excellent in 2018 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 2018, the majority of lake trout were caught in the east/central area (4,032 fish, 33.0% of all lake trout; Table A19a). The 2018 monthly catch estimates were below previous 5-year averages each month April-September (range: -84.0% [July] to -10.4% [April]; 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). From 2008-2016, 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 2018, catch rate declined to 0.25 fish per boat trip and was 54.7% lower than the long-term average. This coincides with good to excellent fishing quality for other trout and salmon species (i.e., Chinook salmon, brown trout) which may have reduced effort specifically targeting lake trout as compared to recent years.

In 2018, 47.1% 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 (0.5) and per angler hour (0.02) were 73.7% and 71.9% lower than previous 5-year averages, respectively; Table A19b; Figure 13b). Catch rate among noncharter boats fishing for trout and salmon was 0.2 lake trout per boat trip and 0.01 fish per angler hour (Table A19b) and were also well below recent averages.

The 2017 lake-wide harvest rate among boats seeking trout and salmon was 0.10 lake trout per boat trip, also well below (-58.5%) the long-term average (Table A19b; Figure 13). Among charter boats fishing for trout and salmon, the 2017 harvest rate was 0.30 lake trout per boat trip (0.01 per angler hour; Table A19b; Figure 13b). Among noncharter boats fishing for trout and salmon, the harvest rate was 0.04 lake trout per boat trip (0.003 per angler hour; Table A19b).

Comparisons by month showed that catch rates were below their respective previous 5-year averages during all months (range: -49.7% [April] to -80.4% [July]); 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 2018, anglers fishing the west/central area caught 0.38 lake trout per boat trip, the fourth lowest recorded and 55.1% lower than the long-term average for that area. Catch rates in the other areas surveyed were also well below average (range: -39.0% [east central] to -74.0% [east]).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2018, weight: 1988-2018). The 2018 fishing season was the twelfth 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 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 2017, an average of 51.0% of lake trout harvested were within the slot limit. In 2018, 46.2% of all lake trout harvested were within the 25-30 inch slot. In 2018, 32.1% of lake trout harvested were shorter than and 21.8% 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,

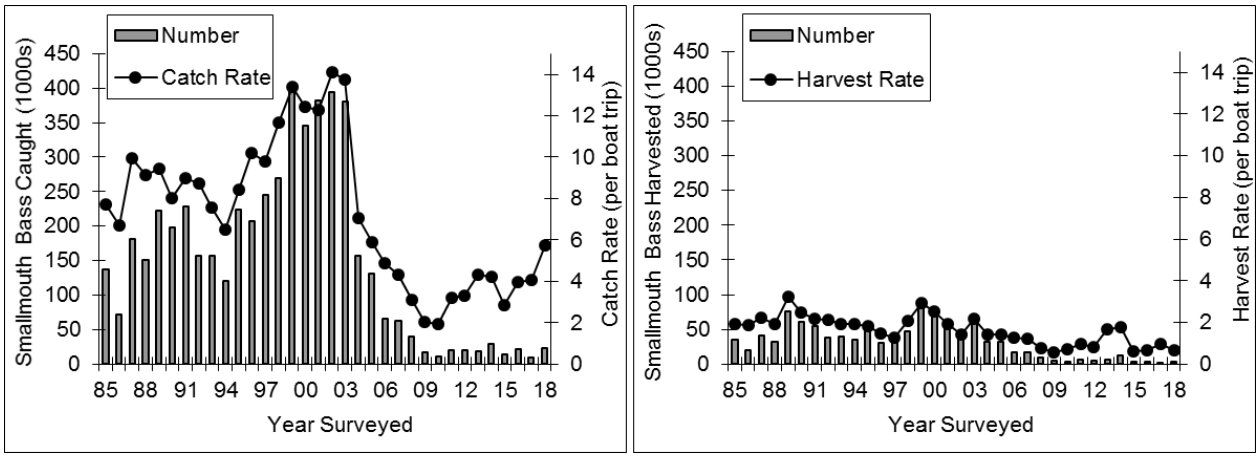


Figure 14. Total smallmouth bass catch and catch rate, and harvest and harvest rate per boat trip for boats seeking smallmouth bass during the traditional open season, 1985-2018.

2018 was the twelfth pre-season catch and release period covered by this survey. During that period in 2018, there were an estimated 221 (±95.0%) fishing boat trips targeting smallmouth bass (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 2009-2018, catch of smallmouth bass remained relatively low. Estimated catch and harvest of smallmouth bass April 15 – September 30, 2018 was 26,875 (±50.8%) and 3,111 (±83.8%) fish, respectively (Tables 1, A21a). During the traditional open fishing season, 23,805 smallmouth bass were caught and 11.8% of those were harvested (2,812) 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). Smallmouth bass catch rates have steadily improved since then, and in 2018, anglers targeting smallmouth bass averaged 5.8 and 0.7 bass caught and harvested per boat trip, respectively. Smallmouth bass catch per angler hour in 2018 was 0.86, the highest since 2005 and 70.9% above the previous 10-year average; however, catch rates were 12.7% below the long-term average, and 45% below the average observed during the 1995-2003 peak period (Table A21b; Figure 14b).

Comparisons of 2018 month- and area-specific catch and harvest rates with their respective 2013-2017 averages (Table A21b) showed above average fishing quality each month July through September (range: +27.6% [August] to +173.6% [September]) and below average in June (-51.2%). The 2018 catch rates were above average in the

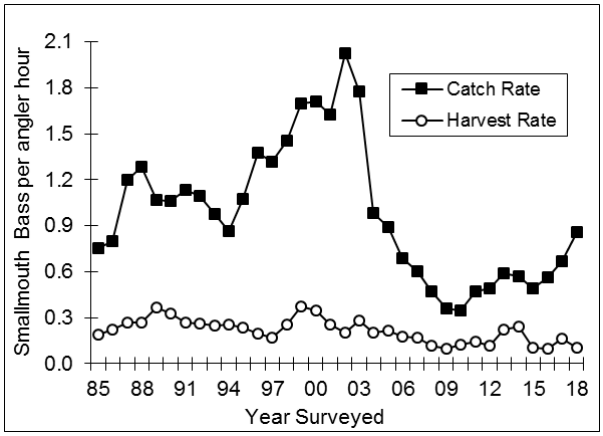


Figure 14b. Smallmouth bass catch rate and harvest rate per angler hour among anglers targeting bass during the traditional open season, 1985-2018.

west (+225.8%) and east (+108.3%) areas, below average in the west/central area (-100.0%), and average in the east/central area (-0.1%; Table A21b). Estimated seasonal catch rate in the west/central area was 0 bass per boat trip which was the lowest regional value ever recorded for the survey.

In 2018, 48.7% of boats specifically targeting smallmouth bass during the traditional open season failed to catch any bass, which is slightly less than the most recent years, but well above levels observed prior to 2006 (1985-2005 mean=24.7%; 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 catch rates began decreasing after 2003, an even lower percentage of bass boats harvested their limit of bass (2004-2018 average=2.2%). In 2018, 1.2% 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).

Yellow Perch

Yellow perch catch and harvest estimates are highly variable because few anglers with perch in their creel are interviewed, anglers targeting yellow 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 (11,782 [±71.0%] fish) and harvest (4,541 [±97.8%] fish) were below long-term (1985-2017) averages (-58.2% and -63.1%, respectively), and was the lowest since 2002 (Tables 1, A22; Figure 15). Reduced angler catch reported in this survey 2014 to 2018 coincided with reduced catch in the Eastern Basin gillnetting assessment (Connerton and Legard 2019) 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; Connerton and Legard 2019). The 2017 increase in angler catch and the decline in 2018 in the east area in this survey coincides with trends observed in gillnet catches in the Eastern Basin (Connerton and Legard 2019) indicating the population status may have improved slightly compared to 2016. Yellow perch are distributed along much of the Lake Ontario shoreline, however, each year 1996-2018 the greatest proportion of catch occurred in the east/central area by relatively few fishing boats targeting perch (86.0% of total catch in 2018; Table A22). In that area, perch catch has been relatively low since 2013 (average 2013-2018=11,120) compared with

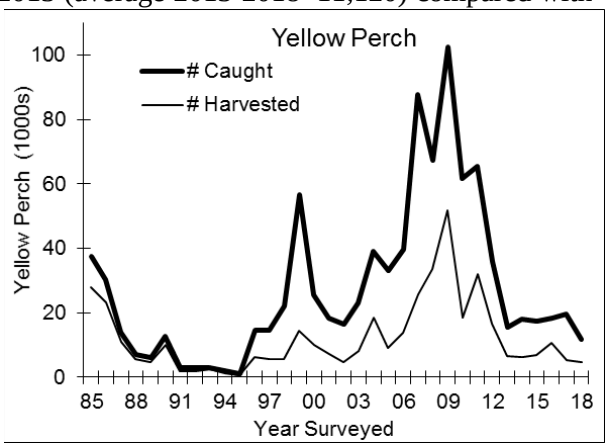


Figure 15. Estimated number of yellow perch caught and harvested by all fishing boats, April 15-September 30, 1985-2018.

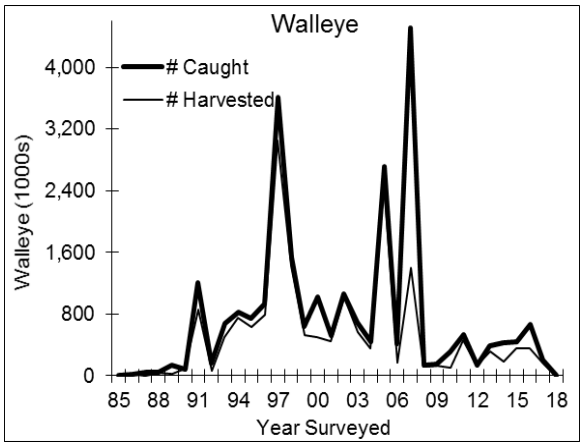


Figure 16. Estimated number of walleye caught and harvested by all fishing boats, April 15-September 30, 1985-2018.

the 2003-2012 average catch of 39,861 fish per year.

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 2019). 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 2018, there were an estimated 0 walleye caught and harvested in Lake Ontario (Table A23; Figure 16). Assessment data (Connerton and Legard 2019) 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 2018, 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 2018 were northern pike (291 caught, 0 harvested) and largemouth bass (259 caught, 50 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, and 2018) with 539 captured in 2018. Cisco (164 caught, 58 harvested) were reported in angler creel for nine consecutive years (2010-2018). Prior to that cisco were rare in this survey but were caught and harvested in low numbers 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 2018, round goby was the eighth most commonly caught species (5,383 [±61.8%] caught; 2,517 [±76.5%] 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

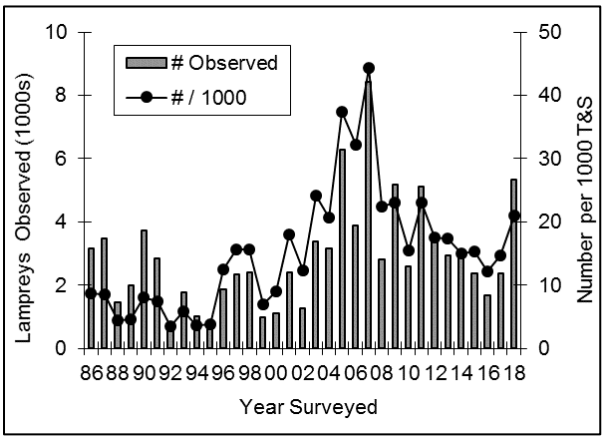


Figure 17. Total lamprey observed, and lampreys observed per 1,000 trout and salmon caught, April 15-September 30, 1985-2018.

attached to. When saved by anglers, the lampreys were examined and a length measurement taken.

In 2018, there were an estimated 5,327 (±27.9%) lampreys observed in this survey, 69.1% higher than the previous 10-year average, however, 36.8% lower than the 2007 record high (Table A24; Figure 17). 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 2018, there were an estimated 21.1 lamprey per 1,000 trout or salmon caught (Table A24; Figure 17). This rate was 39.4 % above the previous 10-year average, and 3.6 times higher than the 1986-1995 average rate.

For 15 of the last 18 years (2001-2018) the majority of lamprey observations occurred on Chinook salmon (2001-2018 average=58.9%), which was due, in part, to the large number of Chinook salmon caught by anglers (e.g., 2001-2018 average=44.6% of total trout and salmon catch; 68.7% in 2018; Tables A5a, A9a). In 2018, 71.7% of lamprey observed by anglers were on Chinook salmon which is the fourth highest on record (Tables A5a, A17a, A24). Other host salmonines in 2018 were brown trout (22.1% of observations), rainbow trout (3.1%), coho salmon (2.2%), lake trout (0.9%), and Atlantic salmon (0.0%; Table A24). Among the 33 years of lamprey observation data, there were a total of 45 lampreys reported on fishing gear out of 3171 total observations. Some lamprey were observed on fishing gear in 2018 representing 2.2% of observations.

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 1996-2018, lampreys were observed on a much higher percentage of angler catch (range: 0.8% [Atlantic salmon] to 9.5% [Rainbow trout]). 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 17) coincide with a reduced lake trout wounding rate as determined from September gill netting, fewer lampreys observed attached to lake trout in the creel survey, and an increased lake trout population (Lantry and Lantry 2018).

Acknowledgments

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2018 Lake Ontario Fishing Boat Survey

Appendix Tables and Figures

Table A1. The four geographic areas (Roman numerals) used in analysis of the 1985-2018 NYSDEC Lake Ontario fishing boat survey data.

I. West geographic area: Niagara River to Point Breeze. Access locations include Williams Marina, Fort 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: Bald 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 1985-2018 NYSDEC fishing boat surveys

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Part A: Effort for all fishing boats.											
Seasonal (5½-month) estimates of fishing effort for all fishing boats:											
Fishing Boat Trips	122,518	76,838	62,104	60,943	56,182	54,605	58,554	53,154	46,339	39,964	54,663
Boat Angler Trips	338,186	221,925	175,820	171,519	160,363	161,620	174,079	157,151	138,434	121,041	168,084
Boat Angler Hours	1,822,868	1,229,977	905,357	898,339	848,905	937,822	980,409	879,681	787,588	709,638	922,527
Anglers/Boat Trip	2.75	2.89	2.83	2.81	2.85	2.96	2.97	2.96	2.99	3.03	3.07
Hours/ Boat Trip	5.30	5.54	5.15	5.24	5.29	5.80	5.63	5.60	5.69	5.86	5.49
Monthly estimates of boat trips for all fishing boats:											
April	10,254	3,230	2,680	2,529	2,409	2,672	1,935	2,251	3,257	2,032	1,524
May	18,335	15,360	11,111	8,605	9,540	8,368	8,652	9,147	7,299	4,269	8,151
June	14,854	8,351	5,489	6,183	8,128	7,608	8,002	5,190	5,231	3,585	6,814
July	22,352	12,735	12,703	15,024	12,024	11,950	11,234	10,904	10,305	8,907	12,813
August	34,183	19,815	21,764	17,315	15,096	17,404	19,666	14,085	12,284	13,035	15,564
September	22,540	17,346	8,356	11,286	8,986	6,603	9,061	11,577	7,963	8,136	9,798
Seasonal estimates of boat trips among four geographic areas for all fishing boats:											
West	28,511	20,404	16,269	16,248	14,145	14,602	13,674	12,543	11,649	10,848	12,938
West/Central	17,829	10,746	7,011	6,890	7,412	7,648	7,210	7,407	4,561	4,051	9,052
East/Central	40,231	25,448	22,318	19,926	17,410	17,368	18,455	16,964	17,508	14,145	18,803
East	35,948	20,239	16,506	17,879	17215	14,988	19,215	16,240	12,622	10,920	13,869
Part B: Seasonal estimates of total boat excursions (traffic).											
Power Boats:											
Fishing Boats	126,115	77,410	62,435	61,383	56,979	55,116	59,149	53,812	46,747	40,156	55,063
Nonfishing Boats	108,886	86,372	84,587	69,943	71,318	89,530	70,311	97,066	96,268	52,445	89,221
Sail Boats	27,897	22,224	23,914	23,782	20,703	21,432	19,104	13,905	12,789	10,013	13,105
Part C: Seasonal estimates of boat angler trips by residence.											
NY Resident	209,144	134,954	108,712	105,145	97,153	96,610	106,088	94,785	81,559	68,245	105,780
Nonresident	129,042	86,971	67,108	66,374	63,210	65,010	67,991	62,366	56,875	52,796	62,304
% NY Resident	61.5%	60.8%	61.8%	61.3%	60.6%	59.8%	60.9%	60.3%	58.9%	56.4%	62.9%
Part D: Effort for boats seeking trout and salmon.											
Seasonal (5½-month) estimates of fishing effort for boats seeking trout and salmon:											
Fishing Boat Trips	95,252	62,028	50,059	49,548	46,059	47,520	49,434	46,142	38,776	35,865	47,839
Boat Angler Trips	275,809	189,796	151,747	147,775	138,687	146,900	155,656	142,816	121,828	112,503	153,774
Boat Angler Hours	1,614,014	1,143,095	843,037	831,675	785,271	889,719	917,662	838,730	735,716	685,818	879,499
Anglers/Boat Trip	2.91	3.06	3.03	2.98	3.01	3.09	3.15	3.10	3.14	3.14	3.21
Hours/ Boat Trip	5.82	6.02	5.56	5.63	5.66	6.06	5.90	5.87	6.04	6.10	5.72
Monthly estimates of boat trips for boats seeking trout and salmon:											
April	10,116	3,610	2,610	2,518	2,366	2,575	1,920	2,251	3,198	1,993	1,524
May	17,455	14,731	9,401	8,050	8,388	7,911	8,417	8,656	6,770	3,783	7,550
June	9,316	5,201	3,878	4,313	5,138	6,333	5,489	4,322	3,785	2,959	5,331
July	13,383	8,743	9,233	10,903	9,255	9,651	8,827	8,140	8,403	7,797	10,833
August	26,494	15,192	18,080	14,123	12,910	15,910	16,917	12,340	9,997	12,338	13,937
September	18,489	14,552	6,858	9,642	8,002	5,141	7,864	10,433	6,622	6,995	8,663
Seasonal estimates of boat trips among four geographic areas for boats seeking trout and salmon:											
West	24,694	18,562	14,258	14,715	12,671	13,674	12,092	11,350	11,061	10,412	12,156
West/Central	13,005	7,725	5,574	5,047	5,584	6,634	6,251	6,447	3,914	3,729	8,185
East/Central	28,400	19,173	16,740	15,137	13,596	15,259	15,852	13,937	13,830	12,613	15,856
East	29,153	16,568	13,487	14,649	14,208	11,954	15,239	14,408	9,972	9,111	11,642
Percent of total seasonal fishing effort by boats seeking trout and salmon:											
Fishing Boat Trips	75.0%	80.7%	80.6%	81.3%	82.0%	87.0%	84.4%	86.8%	83.7%	89.7%	87.5%
Boat Angler Trips	79.2%	85.5%	86.3%	86.2%	86.5%	90.9%	89.4%	90.9%	88.0%	92.9%	91.5%
Boat Angler Hours	86.8%	92.9%	93.1%	92.6%	92.5%	94.9%	93.6%	95.3%	93.4%	96.6%	95.3%

Table A2 (continued). Summary of effort statistics.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
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:											
Fishing Boat Trips	21,629	8,666	5,855	6,257	6,203	4,273	6,878	4,868	5,295	2,294	4,135
Boat Angler Trips	49,520	18,885	12,106	13,758	13,505	9,082	14,223	9,900	11,944	4,868	8,698
Boat Angler Hours	165,838	48,847	32,603	42,718	41,972	31,569	51,006	28,115	37,167	13,917	27,676
Anglers/Boat Trip	2.29	2.18	2.07	2.20	2.18	2.13	2.07	2.03	2.26	2.12	2.10
Hours/ Boat Trip	3.35	2.59	2.69	3.10	3.11	3.48	3.59	2.84	3.11	2.86	3.18
Monthly estimates of boat trips for boats seeking smallmouth bass during the traditional open season:											
April & May		-	-	-	-	-	-	-	-	-	-
June	3,833	1,284	634	935	1,525	637	1,900	543	904	281	730
July	7,650	2,517	2,212	2,704	2,303	1,403	1,786	2,376	1,498	822	1,544
August	6,744	2,878	2,139	1,724	1,646	959	2,312	1,148	1,931	522	1,027
September	3,402	1,987	870	894	728	1,275	880	801	962	669	833
Seasonal estimates of boat trips among four geographic areas for boats seeking smallmouth bass during the traditional open season:											
West	2,426	1,370	1,051	815	984	352	1,101	793	263	104	217
West/Central	3,568	1,453	642	784	1,006	564	609	370	138	257	237
East/Central	10,054	3,638	2,768	2,809	2,289	1,174	1,801	2,233	2,800	928	2,288
East	5,581	2,204	1,394	1,849	1,924	2,183	3,367	1,473	2,094	1,005	1,394
Percent of total seasonal fishing effort by boats seeking smallmouth bass during the traditional open season:											
Fishing Boat Trips	20.0%	11.3%	9.4%	10.3%	11.0%	7.8%	11.7%	9.2%	11.4%	5.7%	7.6%
Boat Angler Trips	16.7%	8.5%	6.9%	8.0%	8.4%	5.6%	8.2%	6.3%	8.6%	4.0%	5.2%
Boat Angler Hours	10.6%	4.0%	3.6%	4.8%	4.9%	3.4%	5.2%	3.2%	4.7%	2.0%	3.0%
Part F: Other species sought.											
Seasonal estimates of fishing boat trips by species sought for boats not seeking trout and salmon, or smallmouth bass during the traditional open season:											
Northern Pike	93	0	78	46	29	78	22	0	49	36	49
SMB pre-opener	237	644	292	239	521	191	295	164	356	198	221
Largemouth Bass	26	0	0	13	13	197	62	29	0	13	0
Yellow Perch	938	1,800	1,901	1,794	1,556	779	712	623	422	477	595
Walleye	479	270	470	384	233	249	137	348	368	176	234
All Other	3,832	3,863	3,449	2,662	1,568	1,319	1,015	980	1,073	905	1,591
% Northern Pike	0.08%	0.00%	0.13%	0.08%	0.05%	0.14%	0.04%	0.00%	0.11%	0.09%	0.09%
% SMB pre-opener	0.25%	0.84%	0.47%	0.39%	0.93%	0.35%	0.50%	0.31%	0.77%	0.50%	0.40%
% Largemouth Bass	0.02%	0.00%	0.00%	0.02%	0.02%	0.36%	0.11%	0.05%	0.00%	0.03%	0.00%
% Yellow Perch	0.82%	2.34%	3.06%	2.94%	2.77%	1.43%	1.22%	1.17%	0.91%	1.19%	1.09%
% Walleye	0.50%	0.35%	0.76%	0.63%	0.41%	0.46%	0.23%	0.65%	0.79%	0.44%	0.43%
% All Other	3.33%	5.03%	5.55%	4.37%	2.79%	2.42%	1.73%	1.84%	2.32%	2.26%	2.91%
Part G: Charter fishing boats.											
Seasonal (5½-month) estimates of fishing effort for charter boats:											
Fishing Boat Trips	12,923	9,885	8,612	8,332	7,632	9,343	9,718	9,831	8,653	7,102	11,683
Boat Angler Trips	65,247	50,142	44,773	43,124	38,880	48,694	51,351	51,311	45,496	36,558	62,651
Boat Angler Hours	476,464	347,188	288,231	275,652	256,420	338,688	345,925	334,663	314,553	242,992	388,651
Anglers/Boat Trip	5.02	5.07	5.20	5.18	5.09	5.21	5.28	5.22	5.26	5.15	5.36
Hours/ Boat Trip	7.24	6.92	6.44	6.39	6.60	6.96	6.74	6.52	6.91	6.65	6.20
Monthly estimates of boat trips for charter boats:											
April	766	331	428	300	599	426	281	353	607	285	326
May	2,223	1,712	1,425	1,119	733	1,607	1,401	1,941	954	915	1,359
June	1,444	974	657	873	648	965	1,028	707	981	615	1,167
July	2,054	1,917	2,112	2,174	1,826	2,252	2,141	1,724	2,431	1,846	2,209
August	4,244	2,949	3,259	2,513	2,622	3,060	3,620	3,407	1,946	2,154	4,666
September	2,194	2,002	731	1,353	1,203	1,032	1,247	1,700	1,735	1,287	1,956
Seasonal estimates of boat trips among four geographic areas for charter boats:											
West	3,418	2,624	2,837	2,658	2,060	2,572	2,234	2,401	2,426	2,139	2,310
West/Central	1,410	1,056	933	842	813	1,120	1,321	1,283	922	586	2,811
East/Central	4,668	4,235	3,512	3,263	2,879	3,935	4,254	3,732	3,411	2,912	4,207
East	3,428	1,971	1,329	1,570	1,880	1,715	1,910	2,415	1,894	1,464	2,355
Percent of total seasonal fishing effort by charter boats:											
Fishing Boat Trips	11.00%	12.9%	13.9%	13.7%	13.6%	17.1%	16.6%	18.5%	18.7%	17.8%	21.4%
Boat Angler Trips	20.12%	22.6%	25.5%	25.1%	24.2%	30.1%	29.5%	32.7%	32.9%	30.2%	37.3%
Boat Angler Hours	27.62%	28.2%	31.8%	30.7%	30.2%	36.1%	35.3%	38.0%	39.9%	34.2%	42.1%

Table A3. Estimated numbers of fish other than coho salmon, Chinook salmon, rainbow trout, Atlantic salmon, brown trout, lake trout, smallmouth bass, yellow perch, walleye, or sea or silver lamprey, that were harvested and caught April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5.5 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	28	0	365	0	14	72	0	20	53	12	12
Gizzard Shad	3	0	0	0	0	0	0	0	0	0	0
Cisco	22	0	76	187	247	221	270	48	15	14	58
Lake Whitefish	0	0	11	13	0	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	78	0	0	14	132	0	35	0	84	0	0
Chain Pickerel	0	0	0	0	0	67	0	0	0	0	343
Common carp	4	0	0	0	45	0	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	95	0	0	0	0	0	53	0	30	20	0
Channel Catfish	58	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	1,525	0	20	0	0	0	115	0	0	0	0
White Bass	269	0	0	0	0	0	22	0	0	0	0
Rock Bass	2,762	526	131	135	688	134	478	12	25	70	1,119
Pumpkinseed	446	29	20	0	0	0	0	0	0	0	0
Bluegill	112	87	140	329	0	0	368	13	0	12	292
Largemouth Bass	101	88	32	0	132	22	26	0	0	61	50
Black Crappie	80	0	0	0	26	0	151	0	0	0	0
Freshwater Drum	425	0	0	0	0	0	151	0	0	0	0
Round Goby	4,385	36,003	13,138	12,770	9,182	7,546	4,222	4,683	5,015	3,986	2,517
Seasonal (5.5 month) estimates of fish caught:											
Unidentified Fish	43	213	0	19	24	23	0	41	0	0	0
Lake Sturgeon	2	0	0	0	27	0	0	0	0	0	0
Longnose Gar	2	72	0	0	0	0	0	0	0	0	0
Bowfin	19	0	0	0	0	0	0	24	0	0	0
American Eel	74	0	0	0	0	0	0	0	0	0	0
Alewife	365	43	736	220	27	403	163	127	223	36	50
Gizzard Shad	10	0	0	0	14	0	0	13	0	0	0
Cisco	31	0	181	229	375	221	297	120	84	70	164
Lake Whitefish	0	0	11	13	0	0	0	0	0	0	0
Pink salmon	4	0	0	0	0	0	0	0	0	0	0
Unidentified Salmonine	280	14	106	113	0	0	0	60	26	0	44
Rainbow Smelt	9	0	0	0	0	0	0	0	0	0	0
Northern Pike	400	1,370	900	62	204	130	255	36	84	44	291
Muskellunge	2	0	0	0	0	0	0	0	0	0	0
Chain Pickerel	29	422	32	0	0	290	0	0	0	216	539
Common Carp	90	38	62	26	72	70	0	0	0	0	0
White Sucker	25	0	36	13	0	0	26	0	0	0	0
Unidentified Redhorse	12	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	129	0	0	0	0	25	53	0	30	20	0
Channel Catfish	143	0	15	0	19	0	0	0	0	0	0
Threespine Stickleback	3	0	0	0	0	0	0	0	0	0	0
White perch	4,047	0	83	101	0	12	115	0	40	180	0
White Bass	1,203	257	20	25	2,533	0	49	0	0	0	0
Rock Bass	13,933	2,546	991	818	1,840	1,088	5,371	596	555	199	2,380
Pumpkinseed	1,642	577	222	28	36	322	436	0	267	0	0
Bluegill	330	146	349	1,257	77	225	869	25	0	12	955
Largemouth Bass	606	594	190	227	516	456	106	425	160	247	259
Black Crappie	125	0	0	0	26	0	0	0	0	0	105
Freshwater Drum	7,150	266	701	240	525	256	388	163	393	12	59
Round Goby	8,304	58,310	21,033	25,290	13,484	12,659	6,704	6,297	12,982	5,817	5,383

Table A4. Residency for boat anglers interviewed April 15 – September 30, 1985-2018. Shown are percent contributions of the most common states or provinces, and for the most common counties among New York resident anglers.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
State or Province of Residence											
Connecticut	2.0	1.7	1.6	1.3	1.5	1.3	0.8	1.2	0.9	1.5	1.3
Florida	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.3	0.7
Maine	0.8	0.9	0.8	0.7	0.7	1.0	0.5	0.7	1.3	1.3	1.2
Maryland	0.3	0.1	0.2	0.2	0.3	0.8	0.4	0.5	0.8	0.3	0.4
Massachusetts	3.8	3.3	3.0	2.7	2.6	2.6	2.8	2.5	3.3	2.4	2.7
Michigan	0.4	0.3	0.4	0.6	0.2	0.6	0.5	0.3	0.4	0.6	0.3
New Hampshire	1.2	1.2	1.1	0.8	0.9	1.0	1.3	0.9	1.4	1.0	0.6
New Jersey	4.3	3.8	3.0	3.0	2.6	2.2	2.9	3.5	2.7	2.6	2.5
New York	61.5	60.8	61.8	61.3	60.6	59.8	60.9	60.3	58.9	56.4	62.9
Ohio	4.2	3.5	2.6	4.0	3.9	4.7	3.6	4.6	4.3	5.2	4.8
Pennsylvania	16.9	18.9	20.4	20.4	21.9	20.8	21.0	20.6	21.2	22.7	18.3
Province of Ontario	0.2	0.4	0.3	0.3	0.1	0.2	0.2	0.1	0.3	0.3	0.2
Province of Quebec	0.2	0.1	0.1	0.1	0.0	0.1	0.3	0.2	0.3	0.4	0.2
Vermont	2.2	2.8	2.3	2.1	2.5	2.2	2.3	2.1	1.5	2.6	1.8
Virginia	0.2	0.2	0.2	0.2	0.1	0.3	0.1	0.3	0.4	0.3	0.2
West Virginia	0.4	0.4	0.3	0.4	0.5	0.4	0.3	0.4	0.3	0.4	0.3
Total of all Listed States & Provinces:	98.9	98.7	98.4	98.4	98.9	98.5	98.4	98.7	98.5	98.4	98.5
County of Residence Among NY Anglers											
County Bordering Lake Ontario:											
Cayuga	2.5	3.0	3.3	2.6	2.2	2.2	2.6	3.1	4.4	3.2	2.5
Jefferson	2.5	2.2	1.6	1.5	3.2	3.6	3.3	2.5	2.7	2.2	2.1
Monroe	24.2	20.0	18.7	16.5	16.2	16.5	15.7	15.7	16.0	14.3	20.2
Niagara	8.6	7.3	7.8	10.9	9.4	9.7	8.6	9.1	6.5	8.5	7.2
Orleans	3.7	3.8	4.9	4.2	4.1	4.8	5.3	4.7	5.2	6.1	4.0
Oswego	10.7	13.0	13.1	13.6	12.5	12.8	12.8	13.1	12.8	14.1	12.9
Wayne	10.9	9.5	9.5	9.6	10.3	8.7	7.7	9.4	9.5	6.6	9.1
Border Co. Total	63.1	58.8	58.8	59.0	57.9	58.4	56.0	57.7	57.1	55.2	58.1
Other NY Counties:											
Albany	1.3	1.0	1.1	1.0	1.0	0.8	1.9	1.2	1.4	1.9	1.3
Broome	1.9	2.1	2.5	1.9	1.8	1.5	1.8	1.8	2.0	1.3	1.4
Dutchess	0.9	0.6	0.6	0.3	0.3	0.7	0.7	0.8	0.7	0.8	0.9
Erie	4.2	3.4	3.8	5.8	5.2	4.9	4.1	4.0	4.7	5.2	5.0
Genesee	1.5	1.9	2.1	1.6	2.5	1.8	2.3	0.9	1.5	1.4	1.4
Livingston	0.8	0.7	0.6	0.6	1.0	0.7	0.8	0.7	0.7	0.5	0.6
Oneida	2.0	1.8	1.8	2.2	1.4	2.0	2.0	2.2	2.1	1.8	1.8
Onondaga	5.8	5.4	6.0	6.4	6.4	5.7	5.9	5.9	6.0	7.3	6.0
Ontario	1.5	1.5	1.7	1.6	1.7	2.0	1.8	1.7	1.5	1.6	1.6
Orange	0.9	1.3	1.2	0.5	0.8	0.9	1.2	1.4	1.3	1.3	0.9
Saratoga	0.9	1.0	0.8	0.7	0.6	0.9	0.9	1.1	1.4	1.3	0.7
Ulster	0.8	1.4	1.4	1.0	1.3	0.9	0.9	0.9	1.2	1.8	2.0
Total of all Listed Counties:	85.7	80.9	82.2	82.6	81.9	81.2	80.3	80.3	81.8	81.4	81.5

Table A5a. Trout and salmon catch and harvest data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	144,964	120,477	89,092	110,196	107,456	100,047	106,880	77,887	79,334	93,524	142,447
Catch	227,673	223,316	167,405	221,977	196,625	168,837	200,763	154,411	138,231	162,341	252,976
% Harvested	63.0	53.9	53.2	49.6	54.7	59.3	53.2	50.4	57.4	57.6	56.3
Monthly estimates of harvest for all fishing boats:											
April	15,739	6,635	5,939	5,050	10,045	4,580	6,329	4,151	7,502	5,203	4,928
May	30,852	29,432	11,638	16,139	16,015	22,142	20,118	20,314	12,618	8,274	25,831
June	15,800	5,050	8,025	10,387	10,135	11,467	11,777	6,361	7,968	5,697	13,020
July	23,099	24,171	21,904	36,207	22,706	21,311	22,955	13,148	24,090	22,618	29,878
August	40,658	32,685	34,636	29,189	34,770	33,670	33,092	23,111	16,992	38,957	44,177
September	18,817	22,504	6,950	13,225	13,785	6,878	12,609	10,800	10,165	12,774	24,614
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	48,549	49,310	37,266	33,864	32,631	34,524	31,103	24,548	28,763	32,234	41,753
West/Central	15,733	8,174	6,523	8,356	9,216	11,694	13,696	9,191	7,982	7,568	20,604
East/Central	43,794	40,795	29,674	39,819	31,076	34,445	37,861	25,431	26,296	36,444	50,386
East	36,888	22,197	15,629	28,157	34,535	19,382	24,217	18,715	16,295	17,278	29,704
Monthly estimates of catch for all fishing boats:											
April	24,581	11,261	8,804	12,236	19,347	7,328	19,368	10,395	16,341	7,373	8,623
May	49,245	76,635	20,573	35,558	37,204	36,786	46,026	57,178	25,076	16,652	53,171
June	28,276	11,836	18,745	22,222	24,230	20,076	28,848	13,203	15,382	9,176	29,627
July	41,424	35,487	46,270	82,252	42,491	41,130	33,587	23,984	41,384	42,959	52,583
August	60,047	55,836	62,916	50,484	55,996	53,802	56,224	34,527	26,494	67,495	75,382
September	24,100	32,261	10,096	19,225	17,357	9,715	16,710	15,123	13,553	18,687	33,589
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	81,553	103,965	72,072	93,566	73,727	67,993	66,682	70,100	57,104	62,329	83,337
West/Central	30,497	30,121	22,128	22,100	26,231	26,378	35,306	18,565	15,641	20,996	48,182
East/Central	63,388	62,190	51,736	67,426	49,058	49,025	60,635	39,116	43,077	57,252	80,764
East	52,234	27,040	21,471	38,885	47,609	25,440	38,141	26,630	22,408	21,766	40,695
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.5	99.9	99.8	99.9	100.0	100.0	99.9	100.0	100.0	100.0	99.9
% Catch	99.4	99.8	99.6	99.8	99.7	99.9	99.9	100.0	100.0	100.0	99.8
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	47.5	50.5	50.3	47.3	47.5	59.4	56.0	60.2	61.8	49.4	56.7
% Catch	39.1	35.5	39.9	34.8	33.3	46.0	39.2	40.1	47.6	37.4	43.4

Table A5b. Trout and salmon catch and harvest rate data collected April 15 – September 30, 1985-2018. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.504	1.940	1.776	2.222	2.332	2.104	2.159	1.688	2.046	2.607	2.973
Catch/Boat Trip	2.397	3.593	3.329	4.473	4.258	3.549	4.056	3.345	3.563	4.526	5.278
Harv/Angler Trip	0.518	0.634	0.586	0.745	0.774	0.681	0.686	0.545	0.651	0.831	0.925
Catch/Angler Trip	0.825	1.174	1.098	1.500	1.414	1.148	1.288	1.081	1.134	1.443	1.642
Harv/Angler Hour	0.089	0.105	0.105	0.132	0.137	0.112	0.116	0.093	0.108	0.136	0.162
Catch/Angler Hr.	0.142	0.195	0.198	0.266	0.250	0.190	0.219	0.184	0.188	0.237	0.287
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.754	1.838	2.275	2.006	4.246	1.779	3.296	1.844	2.346	2.611	3.234
May	1.727	1.998	1.238	2.005	1.909	2.799	2.390	2.347	1.864	2.187	3.421
June	1.581	0.949	2.052	2.396	1.973	1.811	2.131	1.472	2.105	1.921	2.433
July	1.657	2.765	2.363	3.321	2.448	2.203	2.595	1.614	2.867	2.901	2.758
August	1.555	2.150	1.971	2.065	2.693	2.116	1.956	1.873	1.700	3.157	3.167
September	1.003	1.546	1.006	1.372	1.723	1.338	1.603	1.035	1.535	1.826	2.828
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	2.023	2.657	2.614	2.300	2.575	2.523	2.572	2.163	2.600	3.096	3.435
West/Central	1.191	1.059	1.170	1.656	1.650	1.763	2.191	1.426	2.039	2.029	2.517
East/Central	1.541	2.128	1.765	2.631	2.282	2.256	2.385	1.825	1.901	2.888	3.171
East	1.206	1.331	1.154	1.919	2.431	1.621	1.584	1.298	1.634	1.896	2.544
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	2.953	3.119	3.373	4.859	8.177	2.837	10.088	4.618	5.110	3.699	5.658
May	2.856	5.201	2.188	4.400	4.435	4.650	5.458	6.606	3.702	4.402	7.041
June	2.836	2.227	4.809	5.117	4.644	3.166	5.241	3.044	4.064	3.097	5.512
July	2.941	4.059	4.948	7.544	4.581	4.252	3.799	2.945	4.925	5.510	4.854
August	2.325	3.668	3.480	3.569	4.335	3.382	3.322	2.798	2.645	5.470	5.406
September	1.317	2.210	1.464	1.994	2.169	1.885	2.123	1.450	2.047	2.671	3.857
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	3.485	5.601	5.055	6.344	5.818	4.967	5.506	6.176	5.163	5.986	6.855
West/Central	2.543	3.898	3.969	4.379	4.697	3.976	5.644	2.880	3.996	5.630	5.882
East/Central	2.250	3.227	3.051	4.448	3.587	3.208	3.822	2.803	3.111	4.538	5.082
East	1.686	1.624	1.586	2.650	3.337	2.126	2.498	1.847	2.246	2.389	3.474
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	4.948	6.170	5.245	6.319	6.690	6.417	6.162	4.792	5.742	6.566	6.972
Catch/Boat Trip	6.445	8.044	7.826	9.359	8.583	8.385	8.115	6.321	7.719	8.626	9.476
Harv/Angler Trip	0.988	1.216	1.006	1.211	1.313	1.233	1.167	0.919	1.093	1.273	1.302
Catch/Angler Trip	1.284	1.585	1.500	1.794	1.685	1.611	1.536	1.212	1.469	1.672	1.770
Harv/Angler Hour	0.137	0.175	0.156	0.190	0.198	0.178	0.173	0.141	0.158	0.191	0.211
Catch/Angler Hr.	0.178	0.229	0.233	0.282	0.254	0.232	0.228	0.186	0.212	0.251	0.286
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.922	1.140	1.062	1.404	1.466	1.060	1.182	0.852	1.003	1.641	1.697
Catch/Boat Trip	1.705	2.750	2.404	3.497	3.399	2.378	3.064	2.544	2.391	3.525	3.938
Harv/Angler Trip	0.362	0.426	0.411	0.554	0.565	0.411	0.450	0.338	0.394	0.621	0.670
Catch/Angler Trip	0.670	1.027	0.931	1.379	1.309	0.922	1.166	1.008	0.939	1.334	1.555
Harv/Angler Hour	0.068	0.075	0.079	0.104	0.107	0.073	0.082	0.061	0.071	0.107	0.124
Catch/Angler Hr.	0.126	0.180	0.179	0.259	0.247	0.164	0.213	0.183	0.170	0.229	0.288

Table A6. Parameters used to assess angling quality among boats interviewed April 15 – September 30, 1985-2018. 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 creel 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 creel limits are presented only for 2007-2018.

	Year Surveyed											
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
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%	39.4%
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%	39.4%
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%	18.3%
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%	17.9%
Percent boats harvesting the daily bag limit - 3 lake trout per angler in 1998-2006, 2 lake trout per angler in 2007-present:												
Charters-Party Only	1.1%	2.1%	3.1%	1.2%	2.6%	5.3%	11.8%	8.5%	11.1%	13.5%	5.9%	1.6%
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%	0.4%
Noncharter Boats	0.1%	0.1%	0.0%	0.0%	0.5%	0.0%	0.4%	0.0%	0.2%	0.3%	0.4%	0.2%
Percent boats harvesting the daily bag limit of 3 coho salmon, Chinook salmon, rainbow trout, or brown trout, in aggregate, per angler.												
Charters-Party Only	21.8%	12.1%	24.2%	19.5%	21.4%	22.1%	14.3%	11.5%	5.8%	9.5%	21.2%	27.6%
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%	3.9%
Noncharter Boats	2.7%	0.9%	1.4%	1.9%	3.0%	3.7%	1.3%	1.5%	0.8%	1.3%	3.7%	6.0%
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%	89.7%
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%	84.0%
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%	48.7%
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%	40.7%
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%	1.2%

Table A7a. Coho salmon harvest and catch data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	9,797	12,931	9,223	7,380	8,259	4,871	5,653	2,078	2,173	8,291	4,761
Catch	13,127	21,376	12,908	11,915	12,494	7,704	8,442	4,260	3,219	10,630	8,232
% Harvested	74.9	60.5	71.5	61.9	66.1	63.2	67.0	48.8	67.5	78.0	57.8
Monthly estimates of harvest for all fishing boats:											
April	2,541	1,446	1,178	968	392	266	349	12	108	1,024	39
May	2,241	3,087	1,353	946	1,787	1,646	2,101	94	272	831	1,200
June	585	441	918	653	163	454	369	37	87	441	538
July	379	476	1,864	2,362	503	235	238	121	348	420	138
August	2,260	1,816	2,860	853	3,437	1,170	691	417	800	2,486	922
September	1,791	5,666	1,049	1,599	1,978	1,100	1,906	1,397	557	3,092	1,924
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	4,255	5,692	5,269	3,635	3,001	2,365	2,541	458	834	3,709	1,726
West/Central	1,582	566	772	765	411	201	310	0	51	216	293
East/Central	2,367	2,727	1,537	1,546	1,968	1,594	1,566	959	891	2,331	1,112
East	1,593	3,945	1,645	1,434	2,880	711	1,235	661	398	2,035	1,630
Monthly estimates of catch for all fishing boats:											
April	3,518	2,183	1,543	2,324	686	332	1,209	440	108	1,534	128
May	3,374	9,559	2,164	1,926	4,047	3,145	3,537	1,412	851	1,463	3,225
June	954	685	1,542	1,277	734	986	547	61	160	619	925
July	581	686	2,734	3,357	830	627	286	261	526	793	509
August	2,662	2,096	3,652	1,190	3,888	1,434	897	584	1,016	2,842	1,198
September	2,039	6,167	1,272	1,840	2,308	1,179	1,965	1,502	557	3,380	2,246
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	6,137	12,152	7,285	6,476	5,875	4,642	4,450	2,119	1,518	5,538	3,841
West/Central	2,432	1,354	1,636	1,837	1,072	592	801	238	236	284	848
East/Central	2,824	3,388	2,050	1,922	2,350	1,728	1,955	1,194	1,016	2,596	1,551
East	1,734	4,482	1,937	1,679	3,197	742	1,237	709	450	2,212	1,992
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	99.4	100.0	100.0	99.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	41.9	39.8	56.9	42.1	40.6	45.6	39.2	55.0	44.2	37.8	50.7
% Catch	34.8	26.2	44.2	28.2	28.5	31.5	30.9	35.0	29.8	34.9	36.7

Table A7b. Coho salmon harvest and catch rate data collected April 15 – September 30, 1985-2018. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.107	0.208	0.184	0.149	0.179	0.103	0.114	0.045	0.056	0.231	0.100
Catch/Boat Trip	0.145	0.345	0.258	0.239	0.271	0.162	0.171	0.092	0.083	0.296	0.172
Harv/Angler Trip	0.037	0.068	0.061	0.050	0.060	0.033	0.036	0.015	0.018	0.074	0.031
Catch/Angler Trip	0.050	0.113	0.085	0.080	0.090	0.052	0.054	0.030	0.026	0.094	0.054
Harv/Angler Hour	0.006	0.011	0.011	0.009	0.011	0.005	0.006	0.002	0.003	0.012	0.005
Catch/Angler Hr.	0.009	0.019	0.015	0.014	0.016	0.009	0.009	0.005	0.004	0.015	0.009
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.289	0.401	0.451	0.384	0.166	0.103	0.182	0.005	0.034	0.514	0.026
May	0.149	0.210	0.144	0.118	0.213	0.208	0.250	0.011	0.040	0.220	0.159
June	0.068	0.085	0.237	0.151	0.032	0.072	0.067	0.009	0.023	0.149	0.101
July	0.030	0.054	0.202	0.217	0.054	0.024	0.027	0.015	0.041	0.054	0.013
August	0.088	0.120	0.158	0.060	0.266	0.074	0.041	0.034	0.080	0.201	0.066
September	0.095	0.389	0.153	0.166	0.247	0.214	0.242	0.134	0.084	0.442	0.222
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.178	0.307	0.370	0.247	0.237	0.173	0.210	0.040	0.075	0.356	0.142
West/Central	0.102	0.073	0.139	0.152	0.074	0.030	0.050	0.000	0.013	0.058	0.036
East/Central	0.090	0.142	0.092	0.102	0.145	0.104	0.099	0.069	0.064	0.185	0.070
East	0.062	0.238	0.122	0.098	0.203	0.059	0.081	0.046	0.040	0.223	0.140
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.394	0.605	0.591	0.923	0.290	0.129	0.630	0.195	0.034	0.770	0.084
May	0.231	0.649	0.230	0.232	0.482	0.398	0.420	0.163	0.126	0.387	0.427
June	0.119	0.132	0.398	0.296	0.143	0.156	0.100	0.014	0.042	0.209	0.174
July	0.044	0.078	0.296	0.308	0.090	0.065	0.032	0.032	0.063	0.102	0.047
August	0.104	0.138	0.202	0.084	0.301	0.090	0.053	0.047	0.102	0.230	0.086
September	0.110	0.424	0.185	0.191	0.288	0.229	0.250	0.144	0.084	0.483	0.259
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.268	0.655	0.511	0.436	0.464	0.339	0.368	0.187	0.137	0.532	0.316
West/Central	0.164	0.175	0.294	0.364	0.192	0.089	0.128	0.037	0.060	0.076	0.104
East/Central	0.109	0.177	0.122	0.127	0.173	0.113	0.123	0.086	0.073	0.206	0.098
East	0.067	0.271	0.144	0.115	0.225	0.062	0.081	0.049	0.045	0.243	0.171
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.310	0.522	0.614	0.377	0.440	0.240	0.228	0.117	0.113	0.446	0.208
Catch/Boat Trip	0.351	0.569	0.668	0.407	0.467	0.261	0.269	0.152	0.113	0.526	0.261
Harv/Angler Trip	0.062	0.103	0.118	0.072	0.086	0.046	0.043	0.022	0.021	0.086	0.039
Catch/Angler Trip	0.070	0.112	0.128	0.078	0.092	0.050	0.051	0.029	0.021	0.102	0.049
Harv/Angler Hour	0.009	0.015	0.018	0.011	0.013	0.007	0.006	0.003	0.003	0.013	0.006
Catch/Angler Hr.	0.010	0.016	0.020	0.012	0.014	0.007	0.008	0.004	0.003	0.015	0.008
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.071	0.149	0.096	0.103	0.128	0.069	0.086	0.026	0.040	0.179	0.065
Catch/Boat Trip	0.108	0.302	0.174	0.206	0.232	0.138	0.147	0.076	0.075	0.240	0.144
Harv/Angler Trip	0.028	0.056	0.037	0.041	0.049	0.027	0.033	0.010	0.016	0.068	0.026
Catch/Angler Trip	0.043	0.113	0.067	0.081	0.089	0.054	0.056	0.030	0.029	0.091	0.057
Harv/Angler Hour	0.005	0.010	0.007	0.008	0.009	0.005	0.006	0.002	0.003	0.012	0.005
Catch/Angler Hr.	0.008	0.020	0.013	0.015	0.017	0.010	0.010	0.005	0.005	0.016	0.010

Table A8. Total length (inches), weight (lbs), and age statistics for coho salmon sampled April 15 - September 30 during the 1985-2018 NYSDEC Lake Ontario fishing boat surveys.

	Year Sampled											
	1985-08 Avg	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Mean length and weight data for coho salmon sampled April - September:												
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	24.4
Mean Weight (lbs)	-	8.09	6.30	7.15	6.27	8.29	6.70	6.37	6.55	7.70	7.62	6.49
Estimated weight (lbs) for standard length coho salmon sampled April - September:												
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	1.71
20.0 inches	-	2.92	2.82	2.75	2.79	2.92	2.84	2.76	3.06	2.67	2.55	2.63
22.0 inches	-	4.16	4.04	3.96	4.01	4.11	3.95	4.00	4.52	3.87	3.76	3.87
24.0 inches	-	5.75	5.61	5.52	5.57	5.60	5.35	5.60	6.45	5.42	5.35	5.52
26.0 inches	-	7.75	7.59	7.50	7.54	7.45	7.07	7.64	8.94	7.39	7.41	7.64
28.0 inches	-	10.15	9.98	9.90	9.92	9.66	9.10	10.13	12.02	9.79	9.95	10.28
30.0 inches	-	13.18	13.00	12.96	12.95	12.41	11.61	13.30	16.01	12.86	13.24	13.68
Percent length composition of coho salmon sampled April - September:												
<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%	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%	1.4%
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%	1.4%
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%	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%	7.1%
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%	0.0%
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%	4.3%
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%	8.6%
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%	7.1%
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%	2.9%
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%	11.4%
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%	15.7%
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%	20.0%
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%	11.4%
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%	7.1%
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%	1.4%
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%	0.0%
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%	0.0%
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%	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%	0.0%
Percent age composition of coho salmon sampled April -September:												
Age-1	4.4%	0.0%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	1.3%
Age-2	94.6%	93.3%	99.6%	99.9%	99.3%	98.0%	100.0%	97.2%	100.0%	100.0%	98.1%	98.7%
Age-3	1.0%	6.7%	0.0%	0.1%	0.7%	2.0%	0.0%	2.8%	0.0%	0.0%	0.8%	0.0%
Length data (inches) for age-2 coho salmon sampled April - September:												
April Mean	20.6	18.7	18.5	21.4	19.4	21.0	20.5	18.3	-	18.9	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	25.9
Avg Monthly Gain	1.6	1.89	1.97	1.72	1.93	1.59	1.68	1.90	-	1.94	1.56	1.68

Table A9a. Chinook salmon harvest and catch data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	52,453	54,964	31,676	46,333	55,137	38,292	47,935	34,951	34,405	53,871	101,192
Catch	74,069	101,427	61,960	97,899	88,851	62,570	76,626	58,870	60,435	96,226	173,691
% Harvested	70.7	54.2	51.1	47.3	62.1	61.2	62.6	59.4	56.9	56.0	58.3
Monthly estimates of harvest for all fishing boats:											
April	1,650	200	156	86	2,180	115	0	145	70	80	27
May	7,192	12,978	3,932	1,594	5,358	4,102	8,067	9,138	3,235	1,088	15,094
June	2,239	887	3,804	2,166	4,858	2,277	3,133	955	2,454	2,124	8,319
July	7,230	16,984	5,282	17,509	11,004	8,560	11,074	6,857	14,596	14,699	21,384
August	21,215	13,086	13,909	16,885	21,746	20,670	16,908	12,030	7,850	27,749	35,495
September	12,928	10,829	4,592	8,093	9,991	2,568	8,754	5,826	6,201	8,132	20,873
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	21,793	23,605	10,927	14,042	17459	17,417	13,314	14,349	16,444	17,526	34,440
West/Central	5,374	2,957	1,750	2,047	3277	2,223	2,458	3,593	872	2,867	15,716
East/Central	12,260	18,057	12,160	17,550	16097	13,258	20,796	10,808	12,269	23,284	30,705
East	13,027	10,345	6,839	12,694	18305	5,394	11,367	6,200	4,820	10,195	20,330
Monthly estimates of catch for all fishing boats:											
April	2,348	448	156	267	3,781	164	232	261	70	221	27
May	11,790	40,831	5,866	4,511	11,827	6,948	13,020	18,854	7,318	2,867	29,421
June	5,120	3,537	10,250	8,483	10,058	5,200	7,829	3,594	6,366	3,830	20,934
July	11,352	23,944	16,280	42,582	19,848	15,682	14,608	10,525	25,456	28,274	38,278
August	27,929	19,623	23,084	31,239	31,097	30,649	29,562	17,823	13,432	49,700	57,889
September	15,530	13,043	6,307	10,817	12,239	3,926	11,375	7,813	7,793	11,334	27,142
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	34,766	53,358	23,577	43,599	34,937	32,474	25,615	28,640	30,833	36,955	66,017
West/Central	9,137	9,887	9,774	7,038	9,223	6,622	10,001	6,896	2,676	8,630	33,813
East/Central	15,460	26,077	20,061	30,606	22,321	16,963	27,082	15,710	20,206	37,409	47,130
East	14,706	12,105	8,548	16,657	22,370	6,511	13,928	7,624	6,720	13,232	26,731
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	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	42.0	41.6	42.8	40.2	42.7	47.1	51.5	50.9	53.0	46.9	54.4
% Catch	36.1	27.8	35.8	32.3	32.3	38.3	38.9	39.4	45.5	35.5	41.3

Table A9b. Chinook salmon harvest and catch rate data collected April 15 – September 30, 1985-2018. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.573	0.886	0.633	0.935	1.197	0.806	0.970	0.757	0.887	1.502	2.115
Catch/Boat Trip	0.838	1.635	1.238	1.975	1.928	1.316	1.550	1.276	1.559	2.683	3.631
Harv/Angler Trip	0.197	0.290	0.209	0.314	0.398	0.261	0.308	0.245	0.282	0.479	0.658
Catch/Angler Trip	0.288	0.534	0.408	0.662	0.640	0.426	0.492	0.412	0.496	0.855	1.130
Harv/Angler Hour	0.034	0.048	0.038	0.056	0.070	0.043	0.052	0.042	0.047	0.079	0.115
Catch/Angler Hr.	0.050	0.089	0.073	0.118	0.113	0.070	0.083	0.070	0.082	0.140	0.197
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.108	0.055	0.060	0.034	0.921	0.045	0.000	0.064	0.022	0.040	0.018
May	0.407	0.881	0.418	0.198	0.639	0.519	0.958	1.056	0.478	0.288	1.999
June	0.227	0.171	0.981	0.502	0.946	0.360	0.571	0.221	0.648	0.718	1.560
July	0.567	1.943	0.572	1.606	1.189	0.886	1.255	0.842	1.737	1.885	1.974
August	0.836	0.860	0.769	1.196	1.684	1.299	0.999	0.975	0.785	2.249	2.547
September	0.679	0.744	0.670	0.839	1.249	0.500	1.113	0.558	0.936	1.163	2.409
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.881	1.272	0.766	0.954	1.378	1.274	1.101	1.264	1.487	1.683	2.833
West/Central	0.371	0.383	0.314	0.406	0.587	0.335	0.393	0.557	0.223	0.769	1.920
East/Central	0.471	0.941	0.726	1.159	1.184	0.868	1.312	0.775	0.887	1.846	1.936
East	0.483	0.624	0.507	0.867	1.288	0.451	0.746	0.430	0.483	1.119	1.746
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.168	0.124	0.060	0.106	1.598	0.064	0.121	0.116	0.022	0.111	0.018
May	0.700	2.772	0.624	0.560	1.410	0.878	1.547	2.178	1.081	0.758	3.897
June	0.534	0.680	2.643	1.967	1.958	0.821	1.426	0.832	1.682	1.282	3.927
July	0.940	2.739	1.763	3.906	2.145	1.624	1.655	1.293	3.029	3.626	3.533
August	1.137	1.291	1.278	2.208	2.407	1.926	1.746	1.444	1.344	4.028	4.154
September	0.843	0.896	0.920	1.122	1.529	0.764	1.446	0.749	1.177	1.620	3.133
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.496	2.875	1.654	2.959	2.757	2.375	2.118	2.523	2.788	3.549	5.431
West/Central	0.712	1.280	1.753	1.394	1.652	0.998	1.596	1.070	0.684	2.314	4.131
East/Central	0.615	1.359	1.198	2.022	1.640	1.111	1.708	1.127	1.461	2.966	2.972
East	0.559	0.731	0.634	1.137	1.575	0.545	0.914	0.529	0.674	1.452	2.296
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.681	2.319	1.588	2.260	3.087	1.946	2.542	1.820	2.138	3.587	4.758
Catch/Boat Trip	2.077	2.859	2.596	3.838	3.765	2.588	3.069	2.370	3.226	4.860	6.191
Harv/Angler Trip	0.334	0.457	0.304	0.433	0.606	0.374	0.481	0.349	0.407	0.695	0.889
Catch/Angler Trip	0.413	0.563	0.498	0.736	0.739	0.497	0.581	0.454	0.614	0.942	1.157
Harv/Angler Hour	0.047	0.066	0.047	0.068	0.092	0.054	0.071	0.054	0.059	0.104	0.144
Catch/Angler Hr.	0.058	0.081	0.077	0.116	0.112	0.072	0.086	0.070	0.089	0.141	0.187
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.382	0.615	0.436	0.670	0.822	0.529	0.586	0.472	0.534	0.993	1.272
Catch/Boat Trip	0.624	1.403	0.958	1.603	1.564	1.009	1.178	0.982	1.088	2.151	2.814
Harv/Angler Trip	0.150	0.230	0.169	0.264	0.316	0.205	0.223	0.187	0.210	0.376	0.502
Catch/Angler Trip	0.246	0.524	0.371	0.632	0.602	0.391	0.448	0.389	0.427	0.814	1.111
Harv/Angler Hour	0.028	0.040	0.033	0.050	0.060	0.036	0.041	0.034	0.038	0.065	0.093
Catch/Angler Hr.	0.047	0.092	0.072	0.119	0.114	0.070	0.082	0.071	0.077	0.140	0.206

Table A10. Total length (inches), weight (lbs), and age statistics for Chinook salmon sampled April 15 - September 30 during the 1985-2018 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-2008 avg.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Mean length and weight data for chinook salmon sampled April -September:											
Mean Length (in)	32.0	31.6	29.7	29.6	31.4	32.6	31.1	31.1	30.1	29.5	30.6
Mean Weight (lbs)	15.9	14.47	13.42	12.81	14.14	15.64	13.51	13.63	13.48	12.18	12.40
Estimated weight (lbs) for standard length chinook salmon sampled July & August:											
Standard Length:											
16.0 inches	1.4	1.31	1.47	1.36	1.34	1.47	1.38	1.34	1.41	1.40	1.32
20.0 inches	3.0	2.79	3.06	2.91	2.84	3.00	2.87	2.85	2.97	2.94	2.76
24.0 inches	5.4	5.16	5.57	5.41	5.25	5.36	5.20	5.28	5.48	5.40	5.05
28.0 inches	8.9	8.70	9.23	9.14	8.81	8.77	8.60	8.89	9.18	9.04	8.39
32.0 inches	13.8	13.66	14.31	14.40	13.81	13.42	13.29	13.97	14.36	14.10	13.04
36.0 inches	20.3	20.35	21.07	21.49	20.53	19.55	19.52	20.82	21.31	20.89	19.23
40.0 inches	28.6	29.07	29.79	30.75	29.27	27.36	27.53	29.74	30.33	29.68	27.22
Percent length composition of chinook salmon sampled April - September:											
<16.0 in	1.2%	0.3%	0.2%	0.9%	0.5%	0.5%	0.9%	1.2%	1.9%	0.6%	0.3%
16.0-17.9 in	2.6%	1.3%	2.4%	3.5%	0.8%	1.7%	1.9%	0.8%	2.5%	2.5%	1.5%
18.0-19.9 in	3.2%	3.1%	9.1%	7.8%	1.6%	2.8%	1.9%	1.6%	4.3%	5.6%	2.3%
20.0-21.9 in	3.1%	2.1%	8.9%	5.7%	3.5%	2.8%	3.0%	1.0%	5.0%	6.2%	2.0%
22.0-23.9 in	3.4%	3.0%	8.7%	3.9%	3.0%	2.8%	2.6%	2.5%	7.9%	4.5%	3.4%
24.0-25.9 in	4.5%	5.6%	5.5%	4.3%	5.3%	2.6%	4.4%	7.9%	6.8%	6.6%	6.3%
26.0-27.9 in	6.3%	6.4%	5.9%	5.8%	6.8%	4.9%	10.4%	8.3%	5.4%	8.1%	8.0%
28.0-29.9 in	7.3%	7.9%	5.7%	6.7%	12.8%	9.2%	10.3%	11.8%	9.3%	9.6%	15.9%
30.0-31.9 in	8.6%	12.6%	6.3%	13.7%	14.0%	9.9%	16.4%	15.9%	9.3%	16.0%	16.1%
32.0-33.9 in	11.3%	17.5%	10.2%	21.2%	17.7%	14.4%	15.0%	18.6%	12.4%	17.0%	17.2%
34.0-35.9 in	14.7%	19.9%	12.9%	16.2%	15.9%	15.5%	13.6%	16.9%	12.8%	13.8%	15.2%
36.0-37.9 in	17.6%	14.7%	12.6%	7.5%	9.6%	16.2%	11.6%	9.5%	14.7%	6.9%	9.4%
38.0-39.9 in	11.6%	4.7%	7.0%	1.9%	6.1%	12.3%	7.1%	3.3%	6.6%	2.2%	2.2%
40.0-41.9 in	4.0%	0.8%	4.3%	0.8%	2.2%	3.8%	1.1%	0.8%	1.2%	0.5%	0.1%
42.0-43.9 in	0.5%	0.1%	0.4%	0.0%	0.1%	0.5%	0.0%	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 - September:											
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	10.8%	4.8%	33.7%	22.2%	5.0%	10.7%	8.3%	3.7%	9.1%	18.4%	6.1%
Age-2	36.2%	29.5%	24.9%	68.9%	70.8%	37.0%	52.7%	46.5%	43.0%	47.9%	60.0%
Age-3	49.4%	64.8%	38.6%	8.6%	24.1%	52.0%	36.5%	49.1%	46.9%	33.0%	32.2%
Age-4	3.6%	0.9%	2.8%	0.2%	0.2%	0.3%	2.5%	0.7%	1.0%	0.7%	1.5%
Age-5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Ages 3-5	53.0%	65.7%	41.4%	8.8%	24.2%	52.3%	39.0%	49.8%	47.9%	33.7%	33.9%

Table A11. Mean length at age data (total length in inches) for Chinook salmon sampled July-September during the 1991-2018 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)
	2018	18.23	(14)	19.19	(28)	20.31	(8)
	91-'18 avg	19.27	(496)	19.79	(789)	21.67	(376)
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)
	2018	29.09	(133)	29.95	(156)	32.20	(155)
	91-'18 avg	29.01	(1873)	30.47	(2767)	31.89	(1447)

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)
	2018	34.89	(88)	35.44	(74)	35.75	(107)
	91-'18 avg	35.45	(1470)	36.63	(3279)	36.69	(2215)
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)
	2018	35.80	(3)	35.03	(3)	37.33	(8)
	91-'18 avg	38.00	(62)	38.53	(211)	38.96	(107)

Table A12. Chinook salmon relative harvest (age-specific harvest per 50,000 boat trips) by year class and year sampled, from the 1985-2018 NYSDEC Lake Ontario fishing boat surveys.

		Chinook Salmon Harvested Per 50,000 Boat Trips				
Year Class	Fing Equiv Stocked	Age-1	Age-2	Age-3	Age-4	Total
1981	862,840				531	
1982	1,175,354			7,510	392	
1983	2,544,180		5,837	9,043	1,267	
1984	2,957,230	5,022	8,347	15,102	1,185	29,665
1985	3,252,830	3,990	10,715	13,297	2,478	30,481
1986	2,810,771	4,026	8,038	21,317	1,112	34,494
1987	3,368,296	3,148	11,346	13,699	1,904	30,110
1988	3,104,104	3,017	7,040	13,759	784	24,630
1989	3,018,754	1,161	7,423	9,109	1,238	18,931
1990	2,964,722	1,779	6,428	11,901	1,217	21,325
1991	3,129,453	3,471	8,902	18,263	1,155	31,790
1992	3,004,329	3,334	12,489	11,690	2,645	30,212
1993	1,846,892	822	4,168	8,955	1,057	15,002
1994	1,221,491	357	1,976	4,135	364	6,832
1995	1,364,090	5,357	17,531	13,108	795	36,790
1996	1,495,138	3,334	6,754	14,007	0	24,096
1997	1,911,040	1,821	6,189	9,800	151	17,961
1998	1,903,929	3,616	7,016	7,159	209	18,000
1999	1,767,524	2,907	9,847	7,405	64	20,224
2000	1,906,543	2,716	8,562	19,445	326	31,048
2001	1,893,686	1,774	11,839	15,862	440	29,953
2002	1,908,002	1,751	25,606	38,454	1,758	67,570
2003	1,700,374	3,020	18,954	23,849	1,262	47,085
2004	1,962,565	2,103	11,925	22,083	812	36,923
2005	2,075,169	3,710	21,455	16,162	399	41,727
2006	1,898,083	1,483	16,602	28,719	873	47,677
2007	2,055,075	1,090	13,076	12,225	81	26,472
2008	1,038,844	2,113	7,877	4,041	99	14,129
2009	1,981,055	10,663	32,236	14,404	116	57,418
2010	1,911,756	10,398	42,386	20,939	1,207	74,929
2011	2,060,874	2,966	14,922	17,690	284	35,862
2012	1,816,778	4,314	25,569	18,581	453	48,917
2013	2,010,290	4,019	17,609	20,797	498	43,111
2014	2,229,494	1,400	19,079	24,797	1,577	46,874 *
2015	1,939,992	4,036	35,994	34,091		
2016	2,149,062	13,816	63,487			
2017	1,598,223	6,466				

* Total does not include any age-5 fish that might be harvested in the coming year.

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

		Chinook Salmon Harvested Per 50,000 Boat Trips				
Year Sampled	Salmonid 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
2018	47,839	6,466	63,487	34,091	1,577	105,763

Table A13. Number of fingerling equivalents and average size (grams) of Chinook salmon stocked into Lake Ontario from 1982-2017 (1981-2017 year-classes) by NYSDEC, Ontario Ministry of Natural Resources and pen-rearing cooperators. various cooperators. Fingerling equivalents use corrections for expected survival differences among Chinook salmon stocked at different sizes and assume most OMNR stocked fingerlings contribute half as much to harvest by New York anglers. Calculations previously described in Eckert (2007).

	DEC Stocked Fish						OMNR Stocked Fish				Total Lake Ontario	
	Salmon River		Caledonia		Pen Reared		Hatchery		Pen Reared		Chinook Salmon	
Year Class	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size	Number Stocked	Avg Size
1981	379,941	1.8	479,300	3.1			3,599	2.3			862,840	2.4
1982	888,400	2.1	184,000	3.7			102,954	2.5			1,175,354	2.3
1983	2,064,260	3.8	455,000	4.2			24,920	1.8			2,544,180	3.8
1984	2,609,750	3.5	195,000	2.0			152,480	2.0			2,957,230	3.1
1985	2,957,800	4.8					295,030	4.4			3,252,830	4.7
1986	1,848,800	4.2	663,200	4.5			298,771	4.9			2,810,771	4.4
1987	2,495,000	4.9	616,330	4.6			256,966	4.2			3,368,296	4.8
1988	2,305,000	4.5	543,000	4.5			256,104	5.1			3,104,104	4.6
1989	2,212,200	4.5	540,000	4.9			266,554	4.4			3,018,754	4.6
1990	2,180,000	5.3	540,000	4.5			244,722	4.1			2,964,722	5.0
1991	2,794,000	5.1			41,000	4.1	294,453	4.8			3,129,453	5.1
1992	2,655,691	4.6			46,260	3.9	302,378	5.0			3,004,329	4.7
1993	1,557,300	4.5			40,000	3.8	249,592	5.1			1,846,892	4.6
1994	944,000	5.0			40,000	3.9	237,491	4.5			1,221,491	4.8
1995	1,136,666	4.6					227,424	4.3			1,364,090	4.5
1996	1,300,000	4.6					195,138	3.8			1,495,138	4.4
1997	1,604,980	5.1					306,060	4.6			1,911,040	4.9
1998	1,546,000	5.0			49,763	7.6	308,166	4.6			1,903,929	4.9
1999	1,183,000	4.7	90,000	4.5	315,000	4.5	179,524	4.3			1,767,524	4.6
2000	1,252,300	4.7	90,000	4.1	300,000	4.8	264,243	4.1			1,906,543	4.5
2001	1,202,800	4.9	118,610	3.9	300,000	5.0	272,276	4.0			1,893,686	4.6
2002	1,211,000	5.3	123,000	4.3	299,496	5.4	274,506	4.4			1,908,002	5.0
2003	1,167,240	4.7	110,400	3.5	189,356	4.5	223,233	3.9	10,145	5.4	1,700,374	4.4
2004	928,160	4.7	451,030	3.9	322,269	5.3	251,103	4.1	10,004	5.2	1,962,565	4.5
2005	994,660	5.3	421,280	4.1	386,599	5.3	262,621	4.7	10,010	6.0	2,075,169	5.0
2006	1,035,680	3.9	342,200	3.5	313,100	6.1	197,107	3.9	9,997	5.7	1,898,083	4.1
2007	1,477,670	5.1			313,100	6.7	254,307	4.7	9,998	5.7	2,055,075	5.2
2008	559,524	6.0			224,702	5.9	241,875	4.1	12,743	6.6	1,038,844	5.3
2009	1,411,957	4.9			313,600	7.2	233,820	4.5	21,678	4.4	1,981,055	5.1
2010	1,024,046	5.6			506,560	6.4	341,390	4.9	39,820	8.9	1,911,756	5.7
2011	1,260,584	5.3			508,670	6.4	249,079	4.3	42,541	7.7	2,060,874	5.4
2012	1,013,110	6.6			497,970	6.3	245,758	6.5	59,940	10.7	1,816,778	6.7
2013	1,212,907	4.7			443,566	5.5	294,324	5.6	59,494	8.4	2,010,290	5.2
2014	1,394,560	4.9			505,990	6.0	246,124	5.6	82,820	8.1	2,229,494	5.5
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
2017	1,046,960	5.1			303,420	6.8	130,253	7.2	117,590	9.4	1,598,223	6.2

Table A14a. Rainbow trout harvest and catch data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	23,278	24,060	23,856	16,131	12,617	17,203	16,729	9,212	9,487	12,015	8,411
Catch	33,590	54,501	46,249	36,533	32,975	34,611	37,462	17,509	16,639	22,556	18,047
% Harvested	68.3	44.1	51.6	44.2	38.3	49.7	44.7	52.6	57.0	53.3	46.6
Monthly estimates of harvest for all fishing boats:											
April	1,125	473	463	56	199	76	101	127	65	0	0
May	5,089	1,698	1,548	410	939	2,099	2,315	1,773	451	330	437
June	3,295	813	2,406	1,095	2,156	965	5,102	614	1,228	539	962
July	3,091	5,816	4,831	7,299	4,301	5,488	2,461	1,750	4,097	3,377	2,250
August	7,989	10,096	13,568	4,587	4,381	7,567	5,670	3,876	3,531	6,768	4,152
September	2,688	5,164	1,040	2,684	640	1,009	1,080	1,072	113	1,001	610
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	14,005	19,388	18,973	11,637	8,622	11,437	9,225	6,143	7,764	9,049	2,977
West/Central	2,615	1,728	1,447	2,023	1,245	2,333	1,871	1,057	485	651	2,763
East/Central	5,507	2,221	3,065	2,340	1,852	3,036	4,800	1,442	1,016	1,920	2,204
East	1,152	722	370	131	898	397	833	570	222	395	467
Monthly estimates of catch for all fishing boats:											
April	1,910	1,197	867	305	442	379	649	387	214	151	71
May	7,741	7,418	2,724	2,060	3,100	4,824	6,341	3,816	1,191	629	1,435
June	4,875	2,676	4,828	1,813	6,515	2,077	13,747	2,384	2,245	932	2,379
July	4,393	9,053	8,856	18,448	11,100	11,489	4,050	3,560	7,005	6,401	4,757
August	10,878	22,335	27,121	9,037	10,858	14,198	11,072	5,701	5,689	11,752	7,803
September	3,793	11,822	1,851	4,869	960	1,644	1,603	1,661	296	2,692	1,603
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	19,944	35,347	36,512	26,897	22,064	23,021	16,603	9,899	12,792	15,151	7,376
West/Central	4,613	12,065	3,891	3,377	5,355	5,055	7,394	2,949	1,207	3,396	5,201
East/Central	7,595	5,824	5,166	5,164	4,195	5,957	10,976	3,456	2,099	3,462	4,509
East	1,438	1,266	681	1,096	1,361	578	2,489	1,204	541	547	961
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	99.8	100.0	100.0	99.7	100.0	100.0	99.9	100.0
% Catch	99.6	99.8	99.9	99.9	100.0	99.9	99.9	100.0	100.0	99.9	99.9
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	51.2	50.7	49.8	50.2	45.9	54.3	56.5	50.3	63.3	46.8	60.4
% Catch	40.7	34.7	35.5	33.5	27.1	39.0	38.7	36.8	44.1	30.4	39.2

Table A14b. Rainbow trout harvest and catch rate data collected April 15 – September 30, 1985-2018. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.253	0.388	0.477	0.325	0.274	0.362	0.337	0.200	0.245	0.335	0.176
Catch/Boat Trip	0.371	0.877	0.923	0.737	0.716	0.728	0.757	0.379	0.429	0.629	0.377
Harv/Angler Trip	0.087	0.127	0.157	0.109	0.091	0.117	0.107	0.065	0.078	0.107	0.055
Catch/Angler Trip	0.127	0.287	0.305	0.247	0.238	0.235	0.240	0.123	0.137	0.200	0.117
Harv/Angler Hour	0.015	0.021	0.028	0.019	0.016	0.019	0.018	0.011	0.013	0.018	0.010
Catch/Angler Hr.	0.022	0.048	0.055	0.044	0.042	0.039	0.041	0.021	0.023	0.033	0.020
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.109	0.131	0.177	0.022	0.084	0.030	0.053	0.056	0.020	0.000	0.000
May	0.290	0.115	0.165	0.051	0.112	0.265	0.275	0.205	0.067	0.087	0.058
June	0.338	0.156	0.620	0.254	0.420	0.152	0.920	0.142	0.324	0.178	0.180
July	0.234	0.665	0.523	0.669	0.465	0.569	0.279	0.215	0.488	0.433	0.208
August	0.307	0.665	0.750	0.323	0.339	0.476	0.335	0.314	0.353	0.549	0.298
September	0.156	0.355	0.152	0.278	0.080	0.196	0.137	0.103	0.017	0.143	0.070
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.670	1.044	1.331	0.789	0.680	0.836	0.763	0.541	0.702	0.869	0.245
West/Central	0.169	0.224	0.260	0.401	0.223	0.352	0.299	0.164	0.124	0.175	0.338
East/Central	0.184	0.116	0.183	0.155	0.136	0.199	0.303	0.103	0.073	0.151	0.139
East	0.033	0.044	0.027	0.009	0.063	0.033	0.052	0.040	0.022	0.043	0.040
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.197	0.332	0.332	0.121	0.187	0.147	0.338	0.172	0.067	0.076	0.047
May	0.467	0.504	0.290	0.256	0.370	0.610	0.753	0.441	0.176	0.166	0.188
June	0.515	0.515	1.238	0.417	1.268	0.328	2.495	0.552	0.593	0.311	0.446
July	0.329	1.035	0.959	1.692	1.199	1.188	0.459	0.437	0.834	0.821	0.439
August	0.420	1.465	1.500	0.638	0.841	0.892	0.654	0.462	0.569	0.953	0.560
September	0.219	0.811	0.270	0.505	0.120	0.320	0.204	0.159	0.045	0.385	0.183
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.956	1.904	2.561	1.826	1.741	1.682	1.373	0.872	1.156	1.455	0.607
West/Central	0.325	1.559	0.698	0.669	0.959	0.762	1.183	0.457	0.308	0.911	0.635
East/Central	0.264	0.300	0.307	0.340	0.309	0.390	0.692	0.248	0.152	0.273	0.283
East	0.042	0.076	0.050	0.075	0.096	0.048	0.160	0.084	0.054	0.060	0.083
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.891	1.236	1.391	0.981	0.759	1.008	0.973	0.474	0.704	0.799	0.439
Catch/Boat Trip	1.042	1.919	1.925	1.484	1.169	1.455	1.494	0.659	0.860	0.973	0.612
Harv/Angler Trip	0.177	0.244	0.267	0.188	0.149	0.194	0.184	0.091	0.134	0.155	0.082
Catch/Angler Trip	0.206	0.378	0.369	0.284	0.230	0.280	0.283	0.126	0.164	0.189	0.114
Harv/Angler Hour	0.024	0.035	0.041	0.030	0.023	0.028	0.027	0.014	0.019	0.023	0.013
Catch/Angler Hr.	0.028	0.055	0.057	0.045	0.035	0.040	0.042	0.019	0.024	0.028	0.018
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.141	0.227	0.289	0.194	0.178	0.206	0.182	0.126	0.115	0.221	0.092
Catch/Boat Trip	0.253	0.680	0.717	0.587	0.626	0.552	0.577	0.304	0.308	0.544	0.302
Harv/Angler Trip	0.055	0.085	0.112	0.077	0.068	0.080	0.069	0.050	0.045	0.084	0.036
Catch/Angler Trip	0.099	0.254	0.278	0.232	0.241	0.214	0.220	0.120	0.121	0.206	0.119
Harv/Angler Hour	0.010	0.015	0.022	0.014	0.013	0.014	0.013	0.009	0.008	0.014	0.007
Catch/Angler Hr.	0.019	0.045	0.054	0.044	0.046	0.038	0.040	0.022	0.022	0.035	0.022

Table A15. Length (total length in inches) and weight (lbs) statistics for rainbow trout sampled April 15 – September 30 during the 1985-2018 NYSDEC Lake Ontario fishing boat surveys. Note: Clip data includes any fin which was missing at last 50% of its normal structure. Some clips are likely due to fin erosion of hatchery stocked fish since agency clipping studies were not occurring in all years.

	Year Surveyed										
	1985-08 avg.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Mean length and weight data for rainbow trout sampled April - September:											
Mean Length (in)	24.4	25.0	25.3	24.7	24.9	24.5	24.6	25.3	24.6	24.8	25.2
Mean Weight (lbs)	-	6.02	6.76	6.11	5.86	6.00	5.87	6.10	5.93	6.34	6.24
Estimated weight (lbs) for standard length rainbow trout sampled April - September:											
Standard Length:											
18.0 inches	-	2.10	2.40	2.09	2.05	2.21	2.31	2.17	2.37	2.51	2.35
20.0 inches	-	2.89	3.26	2.92	2.83	3.04	3.10	2.94	3.16	3.36	3.14
22.0 inches	-	3.85	4.30	3.95	3.80	4.06	4.05	3.87	4.10	4.37	4.08
24.0 inches	-	5.00	5.53	5.21	4.97	5.28	5.17	4.97	5.19	5.56	5.18
26.0 inches	-	6.36	6.97	6.71	6.35	6.73	6.46	6.25	6.46	6.93	6.46
28.0 inches	-	7.92	8.60	8.46	7.94	8.39	7.91	7.70	7.87	8.47	7.88
30.0 inches	-	9.75	10.51	10.53	9.82	10.34	9.60	9.39	9.49	10.24	9.52
32.0 inches	-	11.84	12.67	12.92	11.98	12.58	11.50	11.30	11.32	12.24	11.36
Percent length composition of rainbow trout sampled April - September:											
<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	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%
16.0-16.9 in	0.9%	0.2%	0.0%	0.0%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%
17.0-17.9 in	2.0%	1.5%	0.3%	1.3%	0.5%	0.5%	2.3%	0.0%	0.0%	0.0%	0.0%
18.0-18.9 in	4.4%	1.2%	1.1%	1.3%	0.5%	0.5%	3.6%	2.0%	0.0%	0.0%	1.0%
19.0-19.9 in	6.3%	3.2%	1.6%	3.3%	1.6%	1.1%	4.5%	2.0%	3.0%	1.0%	3.8%
20.0-20.9 in	8.0%	5.4%	4.1%	4.6%	5.3%	8.1%	1.8%	2.9%	10.1%	1.9%	4.8%
21.0-21.9 in	9.0%	8.2%	8.5%	12.8%	7.4%	9.7%	7.7%	5.9%	6.1%	5.7%	7.7%
22.0-22.9 in	9.1%	9.2%	11.8%	12.1%	10.1%	14.1%	7.7%	9.8%	15.2%	15.2%	9.6%
23.0-23.9 in	9.2%	9.9%	11.5%	10.8%	16.0%	15.1%	7.7%	9.8%	15.2%	22.9%	9.6%
24.0-24.9 in	7.9%	7.7%	10.4%	7.5%	12.2%	9.2%	14.4%	13.7%	9.1%	13.3%	5.8%
25.0-25.9 in	7.0%	12.6%	8.5%	7.9%	11.2%	10.8%	13.5%	10.8%	15.2%	12.4%	11.5%
26.0-26.9 in	6.5%	10.1%	11.8%	11.1%	7.4%	8.1%	10.8%	11.8%	5.1%	6.7%	13.5%
27.0-27.9 in	7.2%	9.4%	9.0%	8.2%	12.8%	7.6%	7.7%	8.8%	4.0%	8.6%	15.4%
28.0-28.9 in	6.2%	9.9%	7.4%	9.5%	5.3%	5.4%	9.5%	6.9%	5.1%	5.7%	7.7%
29.0-29.9 in	5.2%	5.0%	4.9%	4.3%	3.7%	5.9%	4.5%	7.8%	4.0%	1.9%	2.9%
30.0-30.9 in	4.1%	4.0%	4.9%	3.6%	3.2%	1.1%	1.4%	3.9%	5.1%	1.0%	3.8%
31.0-31.9 in	3.0%	1.7%	1.4%	1.3%	1.1%	0.5%	2.3%	2.0%	2.0%	2.9%	1.9%
32.0-32.9 in	1.7%	0.7%	1.9%	0.0%	0.5%	0.5%	0.0%	1.0%	0.0%	0.0%	1.0%
33.0-33.9 in	0.9%	0.0%	0.5%	0.3%	1.1%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%
>33.9 in	0.7%	0.0%	0.3%	0.0%	0.0%	1.1%	0.0%	0.0%	1.0%	1.0%	0.0%
Percent fin clip composition of rainbow trout sampled April - September:											
No Clip	76.9%	84.9%	87.8%	94.4%	94.1%	94.1%	92.3%	93.1%	94.3%	93.3%	89.4%
Ad	1.9%	1.2%	2.0%	0.3%	1.6%	0.5%	1.8%	1.0%	0.8%	1.9%	2.9%
LV	7.5%	2.0%	0.6%	0.7%	0.5%	2.2%	0.9%	2.9%	1.6%	0.0%	1.0%
LV-Ad	1.2%	0.2%	0.7%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LP	1.8%	1.7%	0.7%	0.3%	0.5%	0.0%	0.5%	2.0%	1.6%	3.8%	0.0%
LP-Ad	3.7%	2.0%	2.2%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RV	1.8%	1.5%	1.3%	0.3%	2.1%	0.5%	0.9%	0.0%	0.8%	0.0%	1.0%
RV-Ad	0.4%	1.2%	0.4%	0.7%	1.1%	1.1%	0.9%	0.0%	0.0%	0.0%	0.0%
RP	2.6%	2.2%	1.8%	0.7%	0.0%	0.5%	1.4%	1.0%	0.8%	1.0%	1.0%
RP-Ad	0.2%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Misc.	1.9%	2.5%	2.4%	2.0%	0.0%	1.1%	1.4%	0.0%	0.0%	0.0%	4.8%

Table A16. Atlantic salmon harvest and catch data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	300	532	624	398	310	200	66	275	236	151	150
Catch	1,122	1,273	1,826	1,519	592	599	639	638	704	394	994
% Harvested	24.9	41.8	34.2	26.2	52.4	33.4	10.3	43.1	33.5	38.3	15.1
Monthly estimates of harvest for all fishing boats:											
April	56	105	98	128	29	0	28	24	15	61	24
May	129	222	79	95	183	175	25	24	54	38	14
June	44	15	24	54	46	0	0	12	27	0	35
July	26	66	301	76	51	25	14	169	140	41	0
August	38	124	108	25	0	0	0	25	0	12	54
September	7	0	15	21	0	0	0	20	0	0	23
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	76	226	205	236	126	51	39	0	41	48	59
West/Central	50	161	182	0	0	44	0	0	0	51	26
East/Central	85	74	204	106	93	105	0	136	102	15	26
East	90	71	33	56	91	0	27	139	93	37	40
Monthly estimates of catch for all fishing boats:											
April	203	201	273	296	56	48	180	132	62	61	127
May	361	430	223	439	387	251	215	194	66	120	243
June	152	66	231	171	46	77	0	37	87	0	166
July	185	211	648	212	90	165	162	209	397	65	99
August	157	365	372	340	13	58	82	25	92	69	323
September	64	0	79	62	0	0	0	41	0	80	37
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	266	363	560	526	242	186	121	26	112	112	144
West/Central	199	337	397	366	46	77	112	0	0	49	119
East/Central	338	509	650	339	211	255	209	368	445	171	609
East	320	63	219	287	93	81	197	244	147	63	122
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	94.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	96.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Seasonal rates of harvest and catch per 100 trips for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.249	0.858	1.247	0.803	0.673	0.421	0.134	0.596	0.609	0.421	0.314
Catch/Boat Trip	0.932	2.052	3.648	3.066	1.285	1.261	1.293	1.383	1.816	1.099	2.078
Harv/Angler Trip	0.086	0.280	0.411	0.269	0.224	0.136	0.042	0.193	0.194	0.134	0.098
Catch/Angler Trip	0.324	0.671	1.203	1.028	0.427	0.408	0.411	0.447	0.578	0.350	0.646
Harv/Angler Hour	0.015	0.047	0.074	0.048	0.039	0.022	0.007	0.033	0.032	0.022	0.017
Catch/Angler Hr.	0.056	0.111	0.217	0.183	0.075	0.067	0.070	0.076	0.096	0.057	0.113

Table A17a. Brown trout harvest and catch data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	30,227	23,148	18,311	32,937	23,305	18,969	20,626	12,590	14,608	10,604	22,985
Catch	43,218	33,484	32,604	49,661	39,507	27,793	44,487	20,780	20,871	17,092	39,763
% Harvested	69.4	69.1	56.2	66.3	59.0	68.3	46.4	60.6	70.0	62.0	57.8
Monthly estimates of harvest for all fishing boats:											
April	7,807	4,023	3,855	3,558	5,802	2,730	5,094	3,247	5,180	3,221	4,223
May	10,626	11,256	2,266	12,255	5,436	7,810	5,404	3,138	3,377	3,893	7,695
June	4,207	2,393	611	4,941	1,456	3,315	612	3,591	339	796	2,336
July	3,865	576	7,782	6,695	5,631	2,656	5,202	1,188	1,957	1,536	5,427
August	3,178	4,538	3,543	4,968	4,307	2,197	3,593	1,045	2,775	942	2,351
September	543	362	255	519	672	259	721	380	980	216	953
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	2,448	209	1,153	2,563	2,006	1,649	4,267	560	1,010	898	1,687
West/Central	2,920	1,744	1,487	2,163	2,792	1,566	2,958	503	2,534	1,429	1,100
East/Central	16,511	17,399	11,156	16,327	8,932	9,850	8,199	7,903	6,545	5,830	14,150
East	8,348	3,796	4,515	11,883	9,575	5,903	5,202	3,624	4,519	2,447	6,047
Monthly estimates of catch for all fishing boats:											
April	10,761	5,997	5,501	8,160	10,558	4,450	13,369	6,962	7,802	4,136	7,221
May	14,639	15,838	3,913	17,584	9,446	9,329	15,497	4,657	3,957	6,541	14,420
June	5,612	3,463	1,342	6,658	3,345	3,918	913	4,516	446	1,008	3,271
July	6,074	888	14,421	10,026	7,751	5,169	8,331	1,876	3,053	3,022	7,414
August	5,295	6,720	6,993	6,193	7,236	4,284	5,048	1,498	3,672	1,678	5,841
September	838	579	434	1,041	1,171	643	1,330	1,271	1,940	706	1,596
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	3,834	344	2,043	4,760	4,122	2,451	12,153	1,249	1,494	1,279	2,749
West/Central	5,931	3,182	3,005	5,710	6,836	4,933	6,544	1,785	4,364	3,085	5,096
East/Central	22,610	25,272	20,730	22,945	13,860	12,722	15,761	12,243	9,579	9,465	22,889
East	10,843	4,686	6,826	16,246	14,689	7,687	10,028	5,504	5,434	3,263	9,030
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.8	99.4	98.9	99.8	99.8	99.8	99.6	99.9	100.0	100.0	99.3
% Catch	98.5	98.9	97.8	99.8	98.8	99.5	99.8	99.8	99.8	100.0	99.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	46.3	70.3	54.7	53.3	55.6	72.9	57.9	62.6	61.1	52.4	63.4
% Catch	38.7	59.6	49.8	43.4	42.3	58.7	36.4	47.4	50.4	45.3	54.7

Table A17b. Brown trout harvest and catch rate data collected April 15 – September 30, 1985-2018. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.328	0.371	0.362	0.664	0.505	0.398	0.416	0.273	0.377	0.296	0.477
Catch/Boat Trip	0.480	0.534	0.637	1.000	0.848	0.582	0.898	0.450	0.537	0.477	0.823
Harv/Angler Trip	0.113	0.121	0.119	0.223	0.168	0.129	0.132	0.088	0.120	0.094	0.148
Catch/Angler Trip	0.165	0.175	0.210	0.335	0.282	0.188	0.285	0.145	0.171	0.152	0.256
Harv/Angler Hour	0.019	0.020	0.021	0.040	0.030	0.021	0.022	0.015	0.020	0.015	0.026
Catch/Angler Hr.	0.029	0.029	0.038	0.060	0.050	0.031	0.048	0.025	0.028	0.025	0.045
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.024	1.114	1.477	1.413	2.452	1.060	2.653	1.442	1.620	1.616	2.771
May	0.633	0.764	0.241	1.522	0.648	0.987	0.642	0.363	0.499	1.029	1.019
June	0.483	0.438	0.140	1.134	0.283	0.523	0.106	0.831	0.090	0.269	0.429
July	0.308	0.066	0.834	0.614	0.603	0.272	0.583	0.144	0.233	0.197	0.501
August	0.127	0.298	0.196	0.352	0.334	0.138	0.212	0.085	0.278	0.076	0.169
September	0.029	0.025	0.029	0.054	0.084	0.050	0.092	0.036	0.148	0.031	0.097
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.109	0.011	0.081	0.174	0.158	0.119	0.353	0.049	0.091	0.086	0.139
West/Central	0.265	0.226	0.267	0.429	0.500	0.236	0.473	0.078	0.647	0.383	0.134
East/Central	0.593	0.908	0.658	1.079	0.653	0.645	0.514	0.567	0.473	0.462	0.886
East	0.283	0.220	0.330	0.808	0.674	0.494	0.339	0.251	0.453	0.269	0.515
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.472	1.661	2.108	3.241	4.462	1.719	6.963	3.093	2.440	2.075	4.738
May	0.897	1.074	0.416	2.184	1.126	1.179	1.841	0.538	0.584	1.729	1.910
June	0.645	0.617	0.329	1.518	0.579	0.615	0.161	1.039	0.118	0.341	0.568
July	0.481	0.102	1.498	0.920	0.827	0.529	0.938	0.229	0.363	0.388	0.684
August	0.221	0.441	0.387	0.439	0.560	0.269	0.298	0.121	0.362	0.136	0.419
September	0.048	0.035	0.056	0.108	0.146	0.120	0.167	0.122	0.293	0.101	0.166
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.172	0.019	0.143	0.323	0.325	0.176	1.004	0.110	0.135	0.123	0.226
West/Central	0.571	0.413	0.539	1.131	1.224	0.744	1.047	0.277	1.115	0.827	0.619
East/Central	0.829	1.306	1.201	1.513	1.000	0.830	0.991	0.877	0.689	0.750	1.434
East	0.372	0.274	0.501	1.105	1.020	0.641	0.656	0.381	0.545	0.358	0.757
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.062	1.650	1.174	2.128	1.698	1.492	1.231	0.805	1.047	0.790	1.258
Catch/Boat Trip	1.298	2.022	1.903	2.611	2.187	1.760	1.667	1.008	1.234	1.101	1.880
Harv/Angler Trip	0.211	0.325	0.225	0.408	0.333	0.287	0.233	0.154	0.199	0.153	0.235
Catch/Angler Trip	0.259	0.398	0.365	0.500	0.429	0.338	0.316	0.193	0.235	0.213	0.351
Harv/Angler Hour	0.029	0.047	0.035	0.064	0.050	0.041	0.035	0.024	0.029	0.023	0.038
Catch/Angler Hr.	0.036	0.057	0.057	0.079	0.065	0.049	0.047	0.030	0.034	0.032	0.057
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.199	0.129	0.195	0.371	0.268	0.134	0.216	0.129	0.188	0.175	0.228
Catch/Boat Trip	0.334	0.253	0.377	0.678	0.582	0.297	0.710	0.299	0.340	0.324	0.485
Harv/Angler Trip	0.078	0.048	0.075	0.146	0.103	0.052	0.082	0.051	0.074	0.066	0.090
Catch/Angler Trip	0.132	0.094	0.146	0.267	0.224	0.115	0.270	0.119	0.134	0.123	0.192
Harv/Angler Hour	0.015	0.008	0.015	0.027	0.020	0.009	0.015	0.009	0.013	0.011	0.017
Catch/Angler Hr.	0.025	0.017	0.028	0.050	0.042	0.020	0.049	0.022	0.024	0.021	0.035

Table A18. Length (inches), weight (lbs), age, and fin clip statistics for brown trout sampled April 15 – September 30 during the 1985-2018 NYSDEC Lake Ontario fishing boat surveys. Note: Clip data includes any fin which was missing at last 50% of its normal structure. Some clips are likely due to fin erosion of hatchery stocked fish since agency clipping studies were not occurring in all years.

	Year Surveyed										
	1985-08 avg.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Mean length and weight data for brown trout sampled April - September:											
Mean Length (in)	20.1	19.0	20.8	20.7	20.4	21.1	20.2	20.0	19.7	20.4	20.3
Mean Weight (lbs)	-	3.70	5.39	5.30	4.92	5.87	4.48	4.21	4.25	5.20	4.44
Estimated weight (lbs) for standard length brown trout sampled April - September:											
16.0 inches	-	1.99	2.32	2.16	1.96	2.32	1.89	1.71	1.86	2.38	1.96
18.0 inches	-	2.88	3.30	3.15	2.89	3.30	2.76	2.55	2.75	3.36	2.82
20.0 inches	-	4.05	4.54	4.44	4.13	4.56	3.90	3.69	3.94	4.60	3.95
22.0 inches	-	5.50	6.06	6.06	5.70	6.10	5.33	5.14	5.43	6.11	5.34
24.0 inches	-	7.27	7.89	8.04	7.64	7.96	7.08	6.97	7.30	7.91	7.03
26.0 inches	-	9.41	10.06	10.44	10.00	10.16	9.21	9.21	9.56	10.05	9.06
28.0 inches	-	11.89	12.54	13.23	12.78	12.69	11.68	11.87	12.23	12.48	11.40
Percent length composition of brown trout sampled April - September:											
<15.0 in	1.3%	0.4%	0.2%	0.1%	0.0%	0.3%	1.2%	0.3%	0.3%	0.4%	0.0%
15.0-15.9 in	1.8%	3.3%	0.2%	0.1%	1.7%	1.7%	3.5%	6.3%	4.7%	0.4%	0.5%
16.0-16.9 in	6.0%	16.7%	3.1%	1.6%	4.8%	3.5%	8.9%	12.9%	16.2%	3.1%	5.8%
17.0-17.9 in	12.2%	21.1%	8.3%	7.0%	17.4%	8.7%	16.1%	17.4%	17.8%	9.7%	13.7%
18.0-18.9 in	18.1%	20.7%	14.0%	16.6%	15.7%	16.7%	13.2%	10.8%	13.1%	19.0%	17.7%
19.0-19.9 in	16.1%	10.3%	14.0%	19.3%	14.8%	14.2%	9.3%	6.3%	9.1%	19.5%	14.1%
20.0-20.9 in	12.6%	8.6%	18.8%	16.9%	10.2%	10.4%	9.3%	6.3%	8.8%	16.8%	14.6%
21.0-21.9 in	9.4%	4.4%	13.3%	11.4%	7.6%	7.6%	9.5%	9.1%	5.4%	6.2%	10.1%
22.0-22.9 in	7.0%	4.2%	10.2%	10.1%	5.7%	6.3%	8.8%	8.4%	5.7%	8.0%	6.0%
23.0-23.9 in	4.8%	3.9%	7.1%	6.9%	6.3%	9.0%	6.0%	8.0%	6.4%	4.4%	6.1%
24.0-24.9 in	3.7%	3.3%	2.4%	3.9%	5.9%	6.9%	5.6%	4.9%	3.7%	3.5%	4.5%
25.0-25.9 in	2.8%	1.7%	2.6%	2.0%	3.9%	5.6%	2.9%	5.2%	3.4%	5.3%	3.3%
26.0-26.9 in	2.1%	0.9%	3.8%	2.0%	1.7%	4.5%	2.3%	2.8%	1.7%	2.7%	1.4%
27.0-27.9 in	0.9%	0.4%	1.0%	1.0%	2.0%	2.8%	1.6%	1.0%	1.0%	0.0%	1.1%
28.0-28.9 in	0.6%	0.0%	0.7%	0.6%	1.5%	0.7%	1.0%	0.3%	1.7%	0.4%	0.4%
>28.9 in	0.5%	0.2%	0.2%	0.4%	0.7%	1.0%	0.6%	0.0%	1.0%	0.4%	0.5%
Percent fin clip composition of brown trout sampled April - September:											
No Clip	75.8%	81.4%	87.6%	88.7%	92.4%	91.0%	88.1%	91.3%	89.0%	84.5%	91.0%
Ad	2.1%	3.0%	2.9%	1.2%	0.4%	1.0%	0.4%	0.7%	0.3%	0.4%	0.9%
LV	4.0%	6.1%	2.6%	0.6%	1.7%	1.0%	1.9%	1.4%	0.3%	0.9%	0.2%
LV-Ad	2.7%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LP	4.0%	1.1%	2.6%	4.3%	2.2%	2.1%	1.2%	2.8%	6.2%	4.4%	3.3%
LP-Ad	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.2%
RV	3.9%	4.4%	2.1%	0.6%	0.7%	3.5%	6.2%	2.1%	2.1%	4.4%	1.1%
RV-Ad	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%
RP	4.0%	2.6%	1.0%	2.6%	1.5%	1.0%	1.4%	0.3%	1.4%	1.3%	2.9%
RP-Ad	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%
Misc.	1.2%	0.9%	1.2%	1.9%	1.1%	0.3%	0.4%	1.4%	0.7%	4.0%	0.4%
Percent age composition of brown trout sampled April - September:											
Age-1	0.5%	0.2%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Age-2	77.3%	80.0%	80.6%	78.7%	74.6%	60.0%	62.6%	58.3%	73.8%	79.7%	76.5%
Age-3	18.6%	17.2%	15.2%	17.2%	21.3%	34.6%	28.8%	30.9%	19.2%	16.7%	19.9%
Age-4	2.9%	2.4%	3.4%	3.9%	3.3%	2.7%	7.8%	9.2%	5.8%	3.3%	2.6%
Age-5+	0.6%	0.2%	0.4%	0.3%	0.7%	2.6%	0.8%	1.6%	1.2%	0.3%	1.0%
Mean length (inches) of aged brown trout sampled in April:											
Age-2	18.1	17.4	18.2	18.6	17.9	18.0	17.4	17.0	17.3	18.5	17.8
Age-3	22.8	21.8	23.1	22.8	23.1	23.3	21.7	21.6	22.1	23.8	22.8

Table A19a. Lake trout harvest and catch data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	28,893	4,842	5,403	7,017	7,829	20,511	15,870	18,780	18,426	8,592	4,949
Catch	62,263	11,241	11,753	24,336	22,206	35,533	33,108	52,294	36,336	15,444	12,205
% Harvested	41.2	43.1	46.0	28.8	35.3	57.7	47.9	35.9	50.7	55.6	40.5
Monthly estimates of harvest for all fishing boats:											
April	2,555	388	188	255	1,442	1,393	757	596	2,063	817	616
May	5,574	190	2,461	840	2,311	6,311	2,207	6,148	5,228	2,095	1,391
June	5,430	501	262	1,478	1,456	4,455	2,561	1,151	3,833	1,797	829
July	8,507	254	1,845	2,266	1,216	4,346	3,967	3,062	2,951	2,546	678
August	5,968	3,026	648	1,871	899	2,066	6,230	5,718	2,036	1,004	1,203
September	859	483	0	308	505	1,941	148	2,105	2,314	333	232
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	5,966	190	739	1,751	1,417	1,605	1,717	3,038	2,670	1,004	864
West/Central	3,193	1,018	885	1,358	1,491	5,327	6,099	4,038	4,040	2,354	706
East/Central	7,055	317	1,552	1,950	2,134	6,602	2,500	4,183	5,473	3,064	2,189
East	12,679	3,318	2,227	1,959	2,786	6,977	5,553	7,521	6,243	2,169	1,190
Monthly estimates of catch for all fishing boats:											
April	5,797	1,235	464	885	3,823	1,955	3,728	2,214	8,084	1,271	1,050
May	11,238	2,558	5,660	8,956	8,397	12,288	7,417	28,246	11,692	5,032	4,383
June	11,533	1,395	552	3,789	3,533	7,818	5,812	2,611	6,078	2,787	1,952
July	18,815	705	3,247	7,626	2,871	7,971	6,150	7,553	4,920	4,404	1,526
August	13,063	4,699	1,678	2,484	2,903	3,178	9,563	8,836	2,594	1,455	2,329
September	1,817	649	151	596	679	2,323	438	2,834	2,968	496	966
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	16,493	2,387	2,095	11,226	6,487	5,219	7,740	28,107	10,329	3,294	3,210
West/Central	8,126	3,296	3,346	3,772	3,699	9,099	10,454	6,697	7,158	5,552	3,105
East/Central	14,507	1,120	3,079	6,419	6,121	11,400	4,652	6,145	9,732	4,149	4,032
East	23,137	4,438	3,233	2,920	5,899	9,815	10,262	11,345	9,116	2,449	1,859
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.1
% Catch	99.5	100.0	100.0	100.0	100.0	100.0	99.7	100.0	100.0	100.0	99.6
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	62.6	88.7	69.6	64.9	67.2	77.9	72.5	82.0	80.0	76.4	70.3
% Catch	42.7	55.0	48.1	33.1	33.5	60.2	46.8	39.5	53.1	52.1	47.0

Table A19b. Lake trout harvest and catch rate data collected April 15 – September 30, 1985-2018. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.241	0.078	0.108	0.142	0.170	0.432	0.321	0.407	0.475	0.240	0.103
Catch/Boat Trip	0.551	0.181	0.235	0.491	0.482	0.748	0.668	1.133	0.937	0.431	0.254
Harv/Angler Trip	0.084	0.026	0.036	0.047	0.056	0.140	0.102	0.131	0.151	0.076	0.032
Catch/Angler Trip	0.191	0.059	0.077	0.165	0.160	0.242	0.212	0.366	0.298	0.137	0.079
Harv/Angler Hour	0.014	0.004	0.006	0.008	0.010	0.023	0.017	0.022	0.025	0.013	0.006
Catch/Angler Hr.	0.033	0.010	0.014	0.029	0.028	0.040	0.036	0.062	0.049	0.023	0.014
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.217	0.107	0.072	0.101	0.609	0.541	0.394	0.265	0.645	0.410	0.404
May	0.243	0.013	0.262	0.104	0.276	0.798	0.262	0.710	0.772	0.554	0.184
June	0.461	0.096	0.068	0.343	0.283	0.703	0.467	0.266	1.013	0.607	0.156
July	0.516	0.029	0.200	0.208	0.131	0.450	0.449	0.376	0.351	0.327	0.063
August	0.195	0.199	0.036	0.132	0.070	0.130	0.368	0.463	0.204	0.081	0.083
September	0.044	0.033	0.000	0.032	0.063	0.378	0.019	0.202	0.349	0.048	0.027
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.182	0.010	0.052	0.119	0.112	0.117	0.142	0.268	0.241	0.096	0.071
West/Central	0.280	0.132	0.159	0.269	0.267	0.803	0.976	0.626	1.032	0.631	0.086
East/Central	0.200	0.017	0.093	0.129	0.157	0.433	0.158	0.300	0.396	0.243	0.138
East	0.343	0.200	0.165	0.134	0.196	0.584	0.364	0.522	0.626	0.238	0.099
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.698	0.342	0.178	0.351	1.616	0.759	1.942	0.984	2.528	0.638	0.689
May	0.541	0.174	0.602	1.113	1.001	1.553	0.871	3.263	1.725	1.330	0.581
June	1.009	0.268	0.142	0.879	0.688	1.234	1.059	0.599	1.606	0.942	0.366
July	1.134	0.081	0.352	0.699	0.310	0.826	0.697	0.928	0.586	0.565	0.141
August	0.435	0.309	0.093	0.176	0.225	0.200	0.565	0.716	0.259	0.118	0.164
September	0.094	0.045	0.022	0.062	0.085	0.452	0.056	0.272	0.448	0.071	0.112
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.580	0.129	0.147	0.763	0.512	0.382	0.633	2.476	0.934	0.316	0.264
West/Central	0.752	0.427	0.600	0.747	0.662	1.372	1.673	1.039	1.829	1.489	0.379
East/Central	0.421	0.058	0.184	0.424	0.450	0.747	0.293	0.439	0.704	0.329	0.254
East	0.635	0.268	0.240	0.199	0.415	0.821	0.673	0.787	0.913	0.269	0.157
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.998	0.435	0.440	0.552	0.690	1.724	1.185	1.574	1.727	0.933	0.301
Catch/Boat Trip	1.656	0.626	0.662	0.976	0.975	2.309	1.596	2.111	2.262	1.144	0.495
Harv/Angler Trip	0.203	0.086	0.084	0.106	0.135	0.331	0.224	0.302	0.329	0.181	0.056
Catch/Angler Trip	0.332	0.123	0.127	0.187	0.191	0.444	0.302	0.405	0.431	0.222	0.093
Harv/Angler Hour	0.028	0.012	0.013	0.017	0.020	0.048	0.033	0.046	0.048	0.027	0.009
Catch/Angler Hr.	0.045	0.018	0.020	0.029	0.029	0.064	0.045	0.062	0.062	0.033	0.015
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.127	0.010	0.040	0.060	0.067	0.119	0.110	0.093	0.122	0.070	0.039
Catch/Boat Trip	0.375	0.097	0.147	0.394	0.384	0.370	0.441	0.870	0.563	0.257	0.177
Harv/Angler Trip	0.050	0.004	0.015	0.024	0.026	0.046	0.042	0.037	0.048	0.027	0.016
Catch/Angler Trip	0.146	0.036	0.057	0.155	0.148	0.143	0.168	0.344	0.221	0.097	0.070
Harv/Angler Hour	0.009	0.001	0.003	0.004	0.005	0.008	0.008	0.007	0.009	0.005	0.003
Catch/Angler Hr.	0.027	0.006	0.011	0.029	0.028	0.025	0.031	0.062	0.040	0.017	0.013

Table A20. Length and weight statistics for lake trout sampled April 15 - September 30 during the 1985-2018 NYSDEC Lake Ontario fishing boat surveys.

	Year Surveyed										
	1985-2008 avg.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Mean length and weight of lake trout sampled April - September:											
Mean Length (in)	25.2	25.1	23.4	25.5	26.3	25.9	27.2	27.5	27.5	26.9	26.7
Mean weight (lbs)	-	6.81	5.71	7.37	8.00	7.41	8.46	8.82	8.76	8.71	8.10
Percent length composition of lake trout sampled April - September:											
<15.0 inches	0.1%	0.0%	0.8%	0.0%	0.0%	0.0%	0.5%	0.0%	0.3%	0.0%	0.0%
15-15.9 inches	0.1%	0.0%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%
16-16.9 inches	0.4%	1.3%	1.6%	0.0%	0.0%	0.4%	0.0%	1.7%	0.0%	0.0%	0.0%
17-17.9 inches	1.1%	0.0%	4.1%	0.8%	0.9%	2.5%	0.0%	2.6%	1.2%	0.0%	1.3%
18-18.9 inches	1.6%	3.8%	7.3%	2.5%	3.4%	2.9%	0.0%	2.6%	1.8%	3.6%	5.1%
19-19.9 inches	3.8%	10.1%	2.4%	4.2%	1.7%	2.5%	1.8%	0.9%	2.1%	4.8%	0.0%
20-20.9 inches	4.8%	7.6%	10.6%	4.2%	2.6%	3.6%	0.9%	0.0%	2.6%	2.4%	3.8%
21-21.9 inches	8.0%	3.8%	13.0%	6.7%	6.8%	4.7%	1.4%	0.0%	5.3%	3.6%	5.1%
22-22.9 inches	10.4%	3.8%	9.8%	7.5%	4.3%	4.3%	5.1%	3.0%	5.6%	4.8%	6.4%
23-23.9 inches	13.1%	3.8%	14.6%	10.8%	3.4%	6.1%	4.1%	3.0%	2.9%	3.6%	6.4%
24-24.9 inches	13.4%	10.1%	4.9%	8.3%	6.8%	8.7%	8.8%	5.7%	1.8%	10.7%	3.8%
25-25.9 inches	9.5%	11.4%	3.3%	15.0%	14.5%	10.5%	11.5%	8.7%	5.9%	8.3%	7.7%
26-26.9 inches	5.7%	5.1%	5.7%	7.5%	11.1%	8.7%	13.8%	9.6%	7.6%	2.4%	7.7%
27-27.9 inches	3.3%	17.7%	1.6%	11.7%	15.4%	15.5%	10.6%	13.5%	13.2%	7.1%	7.7%
28-28.9 inches	3.0%	8.9%	7.3%	1.7%	5.1%	10.8%	12.9%	9.6%	9.7%	16.7%	9.0%
29-29.9 inches	4.0%	1.3%	4.1%	2.5%	4.3%	7.9%	11.1%	14.3%	10.0%	6.0%	14.1%
30-30.9 inches	6.0%	3.8%	4.1%	4.2%	7.7%	4.7%	7.8%	9.1%	11.1%	8.3%	7.7%
31-31.9 inches	4.8%	2.5%	1.6%	3.3%	7.7%	1.8%	3.7%	6.5%	5.3%	6.0%	3.8%
32-32.9 inches	2.6%	3.8%	2.4%	5.0%	0.9%	2.2%	1.4%	2.2%	4.4%	4.8%	5.1%
33-33.9 inches	2.1%	1.3%	0.0%	1.7%	0.0%	1.1%	2.8%	3.9%	3.2%	6.0%	2.6%
34-34.9 inches	1.3%	0.0%	0.0%	1.7%	2.6%	1.1%	1.4%	0.9%	4.1%	1.2%	1.3%
>34.9 inches	0.8%	0.0%	0.0%	0.8%	0.9%	0.0%	0.5%	2.2%	1.8%	0.0%	1.3%
30.0+ inches	17.6%	11.4%	8.1%	16.7%	19.7%	10.8%	17.5%	24.8%	29.9%	26.2%	21.8%
25.0-29.9 inches	25.5%	44.3%	22.0%	38.3%	50.4%	53.4%	59.9%	55.7%	46.3%	40.5%	46.2%

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, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	45,768	6,833	4,892	6,442	5,683	7,536	12,538	2,942	3,701	2,305	3,111
Catch	232,504	30,494	18,048	25,795	24,032	21,446	31,807	16,821	26,719	12,079	26,875
% Harvested	21.0	22.4	27.1	25.0	23.6	35.1	39.4	17.5	13.9	19.1	11.6
Monthly estimates of harvest for all fishing boats:											
April	3	2	0	0	0	0	0	0	0	0	0
May	50	0	0	0	0	0	0	0	0	0	0
June	7,717	1,565	1,258	268	1,178	1,073	6,740	0	520	157	846
July	13,544	647	1,643	668	2,702	3,846	2,520	1,306	1,164	677	571
August	15,954	1,695	1,727	3,331	1,377	853	2,928	738	797	389	1,079
September	8,500	2,923	265	2,176	426	1,764	350	899	1,220	1,082	615
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	3,364	163	182	254	800	556	208	118	0	0	0
West/Central	3,084	108	43	261	36	48	176	0	0	0	0
East/Central	23,273	3,250	1,785	700	1,940	1,214	589	1,078	978	744	461
East	16,048	3,312	2,882	5,227	2,907	5,718	11,566	1,746	2,723	1,561	2,650
Monthly estimates of catch for all fishing boats:											
April	535	240	136	22	82	438	480	60	781	121	144
May	5,877	1,264	483	1,299	1,558	350	364	1,564	1,470	667	1,185
June	30,843	5,734	2,159	1,604	4,987	2,859	12,380	2,296	6,792	1,645	2,066
July	73,342	3,983	4,437	8,026	9,561	10,239	7,057	4,831	4,720	3,795	9,644
August	83,304	11,115	8,571	10,407	5,611	2,732	8,957	5,187	7,691	2,369	4,889
September	38,603	8,159	2,263	4,437	2,234	4,829	2,570	2,884	5,266	3,482	8,948
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	21,453	1,610	2,565	2,459	5,768	3,009	4,818	3,059	2,744	105	2,102
West/Central	33,687	2,143	384	799	1,048	634	672	1,013	253	298	762
East/Central	117,300	15,862	9,462	5,830	6,648	5,916	4,088	7,265	12,720	5,790	8,924
East	60,063	10,878	5,638	16,706	10,567	11,888	22,229	5,484	11,002	5,886	15,086
Percent of seasonal harvest and catch made by boats seeking smallmouth bass during the traditional open season:											
% Harvest	92.3	69.0	83.8	96.4	88.5	94.5	98.4	99.2	96.7	97.2	90.4
% Catch	86.9	58.2	62.6	78.1	85.9	86.4	91.8	82.4	78.6	77.3	88.6
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	-	422	28	0	196	0	0	1,116	1,293	449	711
June	-	24	55	502	24	146	195	48	1,571	952	0
Total	-	446	83	502	220	146	195	1,164	2,864	1,401	711
Percent of seasonal catch made by boats seeking smallmouth bass during the catch and release season:											
% Catch	-	1.5%	0.5%	1.9%	0.9%	0.7%	0.6%	6.9%	10.7%	11.6%	2.6%

Table A21b. Smallmouth bass harvest and catch rate data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal rates of harvest and catch for boats seeking smallmouth bass during the **traditional open season**:											
Harv/Boat Trip	1.896	0.544	0.700	0.992	0.811	1.667	1.794	0.599	0.676	0.976	0.680
Catch/Boat Trip	8.916	2.047	1.928	3.219	3.327	4.337	4.244	2.847	3.969	4.072	5.757
Harv/Angler Trip	0.824	0.250	0.339	0.451	0.372	0.784	0.868	0.295	0.300	0.460	0.323
Catch/Angler Trip	3.897	0.939	0.933	1.464	1.528	2.040	2.052	1.400	1.759	1.919	2.737
Harv/Angler Hour	0.245	0.097	0.126	0.145	0.120	0.226	0.242	0.104	0.096	0.161	0.102
Catch/Angler Hr.	1.165	0.363	0.346	0.471	0.492	0.587	0.572	0.493	0.565	0.671	0.860
Monthly harvest rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	1.761	0.877	1.948	0.259	0.701	1.188	3.514	0.000	0.548	0.559	1.125
July	1.614	0.125	0.694	0.225	0.943	2.716	1.355	0.550	0.748	0.824	0.295
August	2.144	0.399	0.498	1.886	0.829	0.823	1.256	0.621	0.385	0.621	0.895
September	2.116	1.070	0.305	2.353	0.585	1.384	0.384	1.122	1.268	1.617	0.738
Seasonal harvest rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	1.134	0.118	0.169	0.312	0.605	1.577	0.126	0.150	0.000	0.000	0.000
West/Central	0.786	0.074	0.065	0.333	0.000	0.085	0.289	0.000	0.000	0.000	0.000
East/Central	1.990	0.584	0.388	0.209	0.720	0.991	0.280	0.472	0.330	0.726	0.172
East	2.644	1.053	2.013	2.761	1.449	2.454	3.421	1.186	1.267	1.558	1.735
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	5.911	2.796	2.907	0.612	2.940	2.256	6.299	3.368	5.489	1.754	1.871
July	8.462	0.932	1.581	2.871	3.766	7.177	3.292	2.017	3.095	4.409	5.751
August	10.722	2.236	2.058	4.803	3.210	2.326	3.808	3.958	3.397	4.209	4.517
September	9.225	2.701	1.779	3.944	3.016	3.759	2.881	3.360	5.048	4.525	10.709
Seasonal catch rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	6.393	0.796	1.605	1.450	5.397	6.534	3.585	3.227	0.897	0.231	9.415
West/Central	7.435	1.031	0.514	0.739	0.534	1.043	0.775	0.122	1.833	1.144	0.000
East/Central	9.562	2.499	1.545	1.103	2.086	4.285	1.661	2.807	4.119	4.956	3.569
East	9.331	2.748	3.585	8.264	5.204	4.862	6.468	3.384	4.294	4.402	9.753
Seasonal catch rates for boats seeking smallmouth bass during the catch and release season:											
Catch/Boat Trip	-	0.693	0.284	2.100	0.422	0.764	0.661	7.098	8.045	7.076	3.217
Catch/Angler Trip	-	0.417	0.153	1.887	0.170	0.327	0.293	3.660	3.788	2.895	2.294
Catch/Angler Hr.	-	0.181	0.099	1.035	0.072	0.188	0.124	1.257	0.867	0.802	1.491
Monthly catch rates per boat trip for boats seeking smallmouth bass during the catch and release season:											
April	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
May	-	1.323	0.118	0.000	0.590	0.000	0.000	10.731	13.061	5.684	3.217
June	-	0.074	1.000	2.523	0.127	1.390	0.878	0.800	6.113	9.520	0.000

Table A22. Yellow perch harvest and catch data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	10,494	51,653	18,405	31,830	16,701	6,572	6,066	6,960	10,483	5,204	4,541
Catch	24,060	102,442	61,816	65,394	35,836	15,345	17,966	17,384	18,176	19,459	11,782
% Harvested	51.9	50.4	29.8	48.7	46.6	42.8	33.8	40.0	57.7	26.7	38.5
Monthly estimates of harvest for all fishing boats:											
April	9	0	1,198	0	2,653	972	0	0	0	840	0
May	998	0	7,656	112	4,203	2,016	0	0	25	88	0
June	2,303	34,963	3,665	2,194	6,116	973	0	24	1,150	56	2,108
July	2,166	2,810	1,906	5,637	1,913	304	2,453	6,042	7,062	1,848	1,008
August	1,957	7,816	3,648	16,979	1,755	2,040	3,535	12	40	1,041	1,010
September	3,061	6,064	332	6,908	61	267	78	882	2,205	1,332	415
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	1,856	0	468	0	14	0	0	0	0	1,188	0
West/Central	1,013	1,035	1,080	30	2,816	1,136	0	759	2,014	0	0
East/Central	6,060	19,372	9,762	22,363	7,814	4,227	3,050	6,104	8,411	2,810	3,898
East	1,565	31,246	7,094	9,438	6,057	1,209	3,016	97	58	1,205	643
Monthly estimates of catch for all fishing boats:											
April	52	143	1,962	0	5,293	2,172	0	0	0	1,120	0
May	1,973	95	37,864	112	10,211	4,420	0	0	476	88	170
June	5,775	52,025	5,287	5,055	13,440	1,921	1,800	264	2,115	80	3,315
July	4,970	10,792	4,371	14,419	2,508	923	7,691	13,740	9,766	3,086	2,708
August	4,721	23,739	11,735	29,676	4,298	5,642	8,241	781	511	6,440	4,032
September	6,570	15,648	596	16,132	86	267	234	2,599	5,307	8,646	1,557
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	2,609	2,444	906	0	49	0	0	0	0	1,601	0
West/Central	2,164	1,749	2,026	193	4,384	3,890	45	2,411	5,399	332	386
East/Central	15,699	58,517	40,091	50,878	20,510	9,527	10,439	14,131	12,303	10,187	10,131
East	3,589	39,732	18,793	14,323	10,893	1,928	7,482	842	474	7,339	1,265

Table A23. Walleye harvest and catch data collected April 15 – September 30, 1985-2018.

	Year Surveyed										
	1985-08 avg	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	659	123	106	458	130	318	182	350	349	152	0
Catch	922	147	301	531	130	388	421	446	671	208	0
% Harvested	72.3	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	96	14	0	16	50	0	50	26	63	88	0
June	98	0	0	26	0	23	12	0	0	0	0
July	49	0	0	88	80	0	0	0	0	0	0
August	323	109	44	160	0	27	120	252	286	0	0
September	93	0	62	168	0	267	0	72	0	64	0
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	61	44	106	86	84	0	92	246	247	0	0
West/Central	5	0	0	0	22	21	0	0	0	0	0
East/Central	55	14	0	0	0	0	40	0	12	17	0
East	538	66	0	372	24	297	50	104	91	135	0
Monthly estimates of catch for all fishing boats:											
April	12	10	0	15	0	0	0	12	0	0	0
May	121	28	0	16	50	0	50	26	63	132	0
June	226	0	0	26	0	23	12	0	0	0	0
July	82	0	0	147	80	70	0	0	0	12	0
August	374	109	213	160	0	27	338	336	608	0	0
September	107	0	87	168	0	267	22	72	0	64	0
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	111	47	180	142	84	59	163	327	572	49	0
West/Central	7	0	0	0	22	22	165	0	0	0	0
East/Central	83	29	0	20	0	0	41	0	11	31	0
East	722	71	121	369	24	306	51	119	88	128	0

Table A24. Estimates of sea and silver lampreys observed by boat anglers April 15 – September 30, 1986-2018.

	Year Surveyed										
	1986-08 avg.	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Monthly and seasonal estimates of lampreys observed:											
April	226	218	429	558	575	68	100	118	199	260	59
May	706	1,769	551	1,618	1,266	835	595	775	363	505	1,134
June	362	150	372	769	294	353	384	212	92	102	367
July	472	1,358	486	1,155	460	789	567	460	730	589	1,067
August	680	1,142	697	842	707	829	951	767	199	685	2,035
September	209	526	64	184	138	53	401	63	97	237	666
Total	2,655	5,164	2,599	5,125	3,441	2,927	2,998	2,375	1,680	2,380	5,327
Seasonal estimates of lampreys observed among four geographic areas:											
West	1,043	2,026	946	1,163	1,147	969	894	1,251	766	634	1,649
West/Central	304	540	338	565	609	396	308	267	49	405	953
East/Central	756	2,126	799	1,812	1,007	1,242	976	510	728	1,027	1,750
East	552	472	516	1,585	678	320	819	347	137	314	975
Percentage of lampreys observed that were attached to angler caught trout and salmon:											
Percent	99.0%	97.0%	98.9%	96.8%	97.9%	98.4%	98.3%	99.1%	96.6%	100.0%	97.8%
Monthly and seasonal estimates of lampreys attached to angler caught trout & salmon, per 1000 trout & salmon caught:											
April	12.76	19.36	48.73	45.60	29.72	9.28	5.16	11.35	12.18	35.26	6.84
May	15.91	23.08	26.78	45.50	34.03	22.70	12.93	13.55	14.48	30.33	21.33
June	15.77	12.67	19.85	34.61	12.13	17.58	13.31	16.06	5.98	11.12	12.39
July	15.22	38.27	10.50	14.04	10.83	19.18	16.88	19.18	17.64	13.71	20.29
August	13.38	20.45	11.08	16.68	12.63	15.41	16.91	22.21	7.51	10.15	27.00
September	10.30	16.30	6.34	9.57	7.95	5.46	24.00	4.17	7.16	12.68	19.83
Total	14.34	23.12	15.53	23.09	17.50	17.34	14.93	15.38	12.15	14.66	21.06
Seasonal estimates of lampreys attached to angler caught trout & salmon by geographic area, per 1000 trout & salmon caught:											
West	14.84	19.49	13.13	12.43	15.56	14.25	13.41	17.85	13.41	10.17	19.79
West/Central	12.70	17.93	15.27	25.57	23.22	15.01	8.72	14.38	3.13	19.29	19.78
East/Central	14.57	34.19	15.44	26.87	20.53	25.33	16.10	13.04	16.90	17.94	21.67
East	14.40	17.46	24.03	40.76	14.24	12.58	21.47	13.03	6.11	14.43	23.96
Seasonal percent distribution of host species to which the lampreys were attached:											
Coho Salmon	2.6%	2.6%	3.2%	3.4%	2.9%	1.6%	2.6%	0.0%	0.0%	2.0%	2.2%
Chinook Salmon	41.7%	73.1%	51.6%	37.4%	60.0%	68.8%	58.1%	64.8%	60.7%	51.0%	71.7%
Rainbow Trout	7.2%	10.9%	14.0%	5.6%	8.6%	5.6%	18.8%	10.2%	7.1%	8.2%	3.1%
Atlantic Salmon	0.6%	0.0%	3.2%	0.0%	2.1%	0.0%	0.0%	0.0%	1.2%	1.0%	0.0%
Brown Trout	17.7%	13.5%	26.9%	47.5%	22.1%	13.6%	17.9%	12.0%	19.0%	35.7%	22.1%
Lake Trout	30.3%	0.0%	1.1%	6.1%	4.3%	10.4%	2.6%	13.0%	11.9%	2.0%	0.9%
Seasonal estimated total number of lampreys observed attached to specific hosts											
Coho Salmon	64	126	83	166	96	46	74	0	0	49	115
Chinook Salmon	1,219	3,590	1,327	1,856	2,021	1,967	1,685	1,511	963	1,214	3,720
Rainbow Trout	181	535	359	277	289	160	545	238	113	194	161
Atlantic Salmon	11	0	83	0	72	0	0	0	19	24	0
Brown Trout	519	661	691	2,355	746	389	520	281	302	850	1,148
Lake Trout	661	0	28	305	144	297	74	302	189	49	46
Seasonal percentage of total host-specific angler catch with attached lampreys:											
Coho Salmon	0.67%	0.59%	0.64%	1.40%	0.77%	0.59%	0.88%	0.00%	0.00%	0.46%	1.39%
Chinook Salmon	1.77%	3.54%	2.14%	1.90%	2.27%	3.14%	2.20%	2.57%	1.59%	1.26%	2.14%
Rainbow Trout	0.80%	0.98%	0.78%	0.76%	0.88%	0.46%	1.46%	1.36%	0.68%	0.86%	0.89%
Atlantic Salmon	4.32%	0.00%	4.54%	0.00%	12.19%	0.00%	0.00%	0.00%	2.68%	6.16%	0.00%
Brown Trout	1.44%	1.97%	2.12%	4.74%	1.89%	1.40%	1.17%	1.35%	1.45%	4.97%	2.89%
Lake Trout	1.14%	0.00%	0.24%	1.25%	0.65%	0.84%	0.22%	0.58%	0.52%	0.31%	0.38%

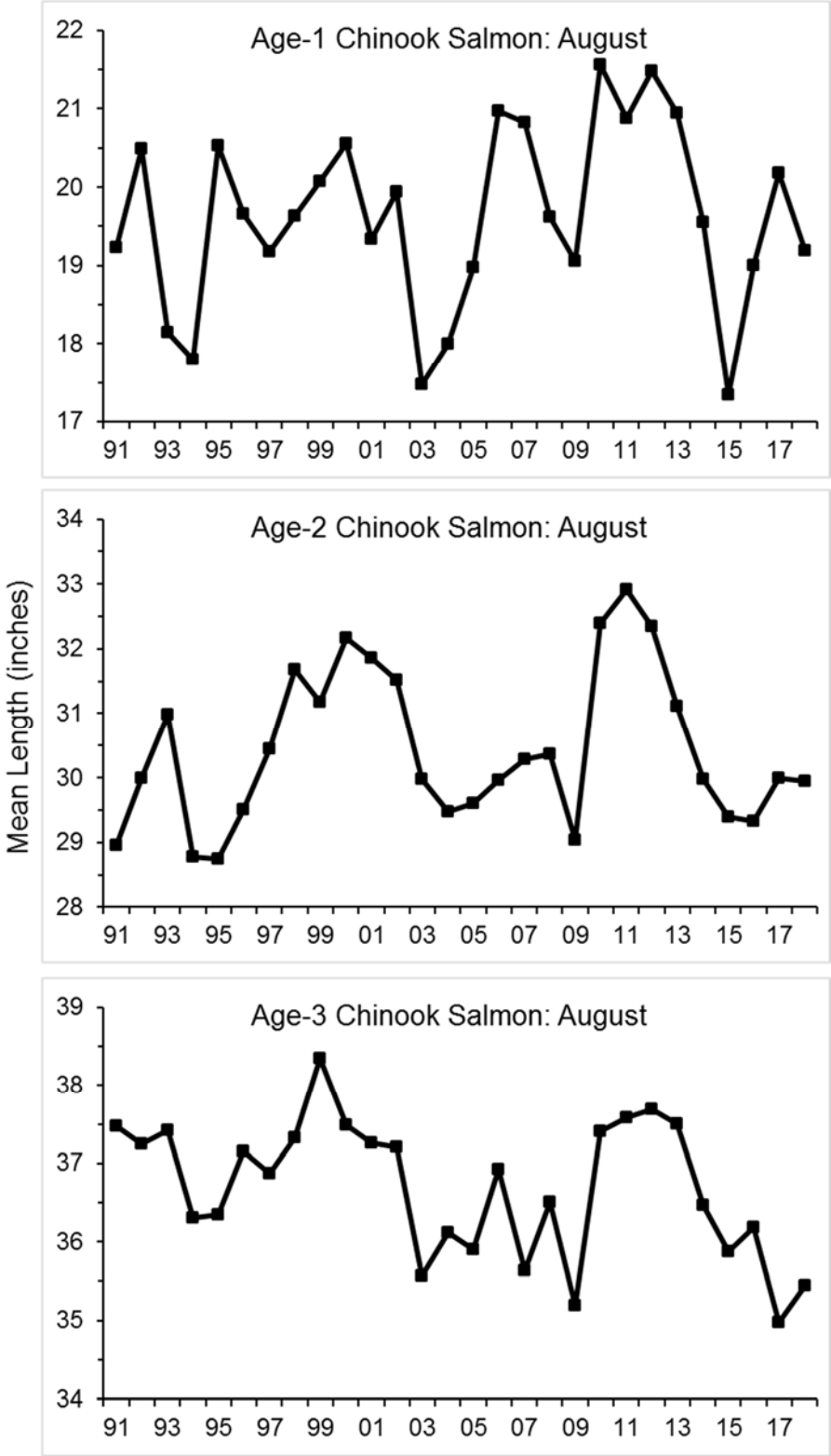

Figure A1. Mean length (total length in inches) of age-1, age-2, and age-3 Chinook salmon sampled in August during the 1991-2018 NYSDEC Lake Ontario fishing boat surveys.

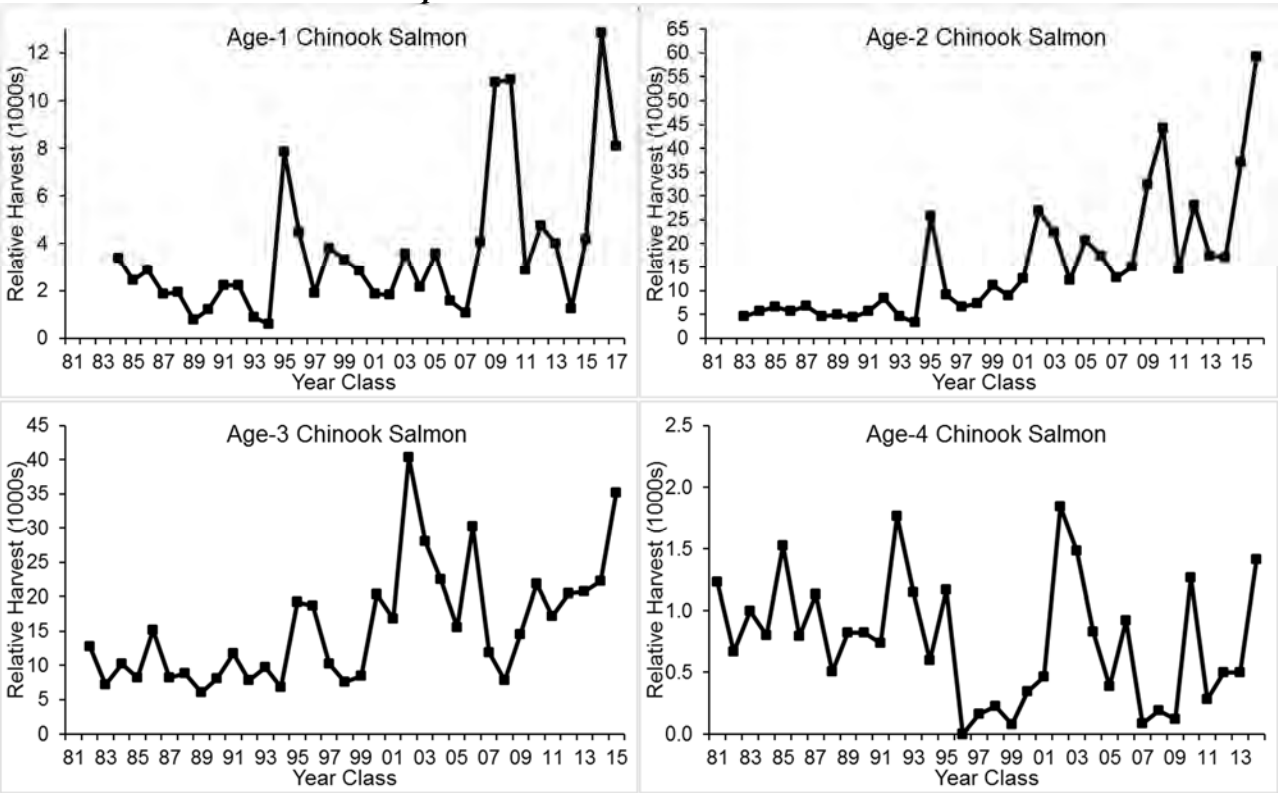

Figure A2. Relative harvest (age-specific harvest per 50,000 fishing boat trips, per 2,000,000 fingerling equivalents stocked), by year class, of age-1, age-2, age-3, and age-4 Chinook salmon from the 1985-2018 NYSDEC Lake Ontario fishing boat surveys.

2018 Status of the Lake Ontario Lower Trophic Levels[1]

Kristen T. Holeck, Lars G. Rudstam, and Christopher Hotaling
Cornell University Biological Field Station

Dave Lemon, Web Pearsall, Jana Lantry, Mike Connerton, Chris Legard, and Steve LaPan
New York State Department of Environmental Conservation

Zy Biesinger
United States Fish and Wildlife Service

Brian Lantry and Brian Weidel
U.S. Geological Survey – Lake Ontario Biological Station

Significant Findings for Year 2018:

1) Offshore spring total phosphorus (TP) in 2018 was 7.0 µg/L; values have remained stable since 2001. Offshore soluble reactive phosphorus (SRP) remained low (1.3 µg/L) in 2018; Apr/May – Oct mean values have been stable in nearshore and offshore habitats since 1998 (range, 0.4 – 3.3 µg/L). Apr/May – Oct mean TP concentrations were low at both nearshore and offshore locations (range, 3.9 – 7.8 µg/L). TP and SRP concentrations were not significantly different between nearshore and offshore habitats.
2) Chlorophyll-*a* and Secchi depth values are indicative of oligotrophic conditions in nearshore and offshore habitats. Offshore summer chlorophyll-*a* was stable 2000 – 2018. Nearshore chlorophyll-*a* increased 1995 - 2004 and then stabilized 2005 – 2018; values were below the long-term mean in 2018. In 2018, epilimnetic chlorophyll-*a* averaged between 0.9 and 1.8 µg/L across sites, and offshore and nearshore Apr/May – Oct concentrations were not significantly different. Summer Secchi depth increased significantly in the offshore 2000 – 2018 and in the nearshore 1995 – 2004. Apr/May – Oct Secchi depth ranged from 4.7 m to 13.5 m (15 ft to 44 ft) at individual sites and was not significantly different between offshore (8.6 m; 28 ft) and nearshore (6.3 m; 21 ft) locations.
3) In 2018, nearshore summer zooplankton biomass increased slightly to 10.7 mg/m^3 after an all-time low (10.3 mg/m^3) in 2017. Apr/May – Oct epilimnetic zooplankton density was significantly higher in the offshore than the nearshore, but zooplankton size and biomass were not different. Cyclopoid copepods were primarily responsible for the higher density in the offshore.
4) Peak (July) epilimnetic biomass of *Cercopagis* was 1.3 mg/m^3 in the nearshore and 1.9 mg/m^3 in the offshore. Peak (September-October) epilimnetic biomass of *Bythotrephes* was 0.4 mg/m^3 in the nearshore and 0.6 mg/m^3 in the offshore. *Bythotrephes* biomass has increased significantly in the nearshore, 1995 – 2018.
5) Summer nearshore zooplankton density and biomass declined significantly 1995 – 2004 and then remained stable 2005 – 2018. The decline was due mainly to reductions in cyclopoids copepods.
6) Summer epilimnetic daytime offshore zooplankton density and biomass decreased significantly 2000 – 2018, but density increased marginally since 2005. Density was 16000/m^3 in 2018, three times the levels seen 2015 – 2017. Offshore summer epilimnetic zooplankton biomass in 2018 was 11 mg/m^3—well below the mean from 2005 – 2017 (20 mg/m^3).
7) Most offshore zooplankton biomass was found in the metalimnion in July and early-September, and in the hypolimnion in late-September and October. Cyclopoids dominated the metalimnion in July while daphnids and cyclopoids comprised most of the biomass in September. Daphnids dominated the October hypolimnion.

[1]Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Introduction

This report presents data on the status of lower trophic levels of the Lake Ontario ecosystem (zooplankton, phytoplankton, nutrients) in 2018 collected by the US Biological Monitoring Program (BMP). Trophic level indicators for 2018 are compared with data collected by this program since 1995 and with similar long-term data from other sources. Production at lower trophic levels determines the lake's ability to support the prey fish upon which both wild and stocked salmonids depend. The maintenance of current alewife production in the offshore of the Great Lakes is uncertain due to declines in lower trophic level parameters and the general correlation found between lower trophic level production and prey fish abundance (Bunnell et al. 2014). A decline in offshore lower trophic level productivity is considered a main cause for the collapse of the alewife population and decline in Chinook salmon fishery in Lake Huron after 2003 by some authors (e.g. Barbiero et al. 2011, Bunnell et al. 2012), although others point at the importance of predation and winter severity as the causative mechanisms (Dunlop and Riley 2013, He et al. 2015) making the most likely cause a combination of these factors (Riley et al. 2008, Kao et al. 2016). The similarities in the development of lower trophic level indicators in Lake Michigan and Huron (Barbiero et al. 2018) and concern of a similar alewife decline in Lake Michigan as in Lake Huron (Bunnell et al. 2018) led to a decision to decrease Chinook salmon stocking rates in Lake Michigan by some states. Despite declines in offshore productivity, high nutrient levels close to shore are contributing to excessive growth of attached algae (e.g., *Cladophora*) at several shoreline and beach areas (Makarewicz and Howell 2012). The connection between nutrient loading and fish production remains an important research topic in the Great Lakes (Stewart et al. 2018).

From 1995-2018 we conducted a research program (hereafter referred to as the biomonitoring program, BMP) in Lake Ontario with the primary objective of evaluating temporal and spatial patterns in a number of ecological indicators: total phosphorus (TP), soluble reactive phosphorus (SRP), chlorophyll *a* (chl-*a*), Secchi depth (SD), and crustacean zooplankton (density, biomass, species composition, and size structure). Samples were collected from late April through October. These indicators are assessed from spring through fall because each indicator has a particular importance at a specific time of the year. Springtime (Apr-May) represents a time of peak nutrient levels in many systems, and these nutrients drive biological activity during the entire year. Therefore, spring TP is an important indicator. The summer stratified period characterizes the peak production period for phytoplankton and many zooplankton species; therefore, summer (Jul-Aug) chl-*a* and summer zooplankton biomass were chosen as indicators. The Sep-Oct period is useful to track species such as *Bythotrephes* whose biomass typically peaks later in the year. The BMP is a collaborative project that, in 2018, included the New York State Department of Environmental Conservation (NYSDEC) Lake Ontario Unit and Regions 6, 7, and 8 at Watertown, Cortland, and Avon (Lake Ontario regions); the U.S. Fish & Wildlife Service Lower Great Lakes Fishery Resources Office (USFWS); the U.S. Geological Survey–Lake Ontario Biological Station (USGS); and Cornell University.

In the "State of Lake Ontario" in 2014, Rudstam et al. (2017) summarized data from various sources including the BMP and analyzed trends through 2013. Total phosphorus and chlorophyll-*a* declined and Secchi depth increased from 1980-1995 but all remained stable thereafter. However, Dove and Chapra (2015) reported a continued decline in spring TP into the 2000s based on data from Environment & Climate Change Canada's Surveillance program. Therefore, we are especially interested in any evidence of further decreases in lower trophic level indicators as we incorporate the 2014 to 2018 years in our trend analyses in both the nearshore and offshore areas of the lake. Zooplankton populations have been more variable, likely due to the interplay between vertebrate and invertebrate predators, increased water clarity, lower epilimnetic production, and increased deep chlorophyll layers (Rudstam et al. 2015, Barbiero et al. 2014, 2019).

Report Objectives

Using data from 1995 to 2018, we address the following questions:

(1) What is the status of Lake Ontario's lower trophic levels in 2018, and what differences exist between nearshore and offshore sites this year?
(2) How does the year 2018 compare to the same indicators in 1995-2017 (using BMP data and other long-term data)?
(3) What is the status of the two, non-native predatory cladocerans, *Bythotrephes* and *Cercopagis*?
(4) Are there changes in zooplankton community structure (biomass, size, species composition) that could be indicative of changes in alewife or invertebrate predation, or lake productivity?
(5) Is the vertical distribution of different zooplankton groups changing, possibly a result of more phytoplankton production in deeper water?

Methods

Sampling

We measured total phosphorus (TP), soluble reactive phosphorus (SRP), chlorophyll-*a* (chl-*a*), Secchi depth (SD), and zooplankton density, size, and biomass by species at offshore and nearshore sites in Lake Ontario (Figure 1). Samples were collected from seven nearshore sites biweekly from May through October 2018 (12 potential sampling weeks). Inclement weather precluded sampling during one week at Niagara West (NWL), two weeks at Sodus (SOL), and four weeks at Sandy Pond (SPL), Chaumont (CBL), and Galloo Island (GIL). Offshore samples were collected during April through early May, July, and September by the R/V Seth Green, and in April, September, and October by the R/V Kaho. In addition, six stations were sampled at night in July during the hydroacoustic survey conducted by the R/V Seth Green (NYSDEC). Nearshore sites had depths ranging from 9.3 m to 15.2 m (31 to 50 ft), and offshore sites ranged from 16 m to 208 m (52 to 682 ft). Nearshore sampling totaled 69 samples taken from seven sites. Offshore sampling totaled 19 daytime samples taken from seven sites and six nighttime samples from six sites.

Water Chemistry

Water samples were collected for analysis of chl-*a*, TP, and SRP. Each sample was obtained by using an integrated water sampler (1.9 cm inside diameter Nalgene tubing) lowered to a depth of 10 m (33 ft) or bottom minus 1 m (3 ft) where site depth was 10 m or less. The tube was then closed off at the surface end and the column of water transferred to 2 L Nalgene containers. From each sample, a 100 mL unfiltered aliquot was frozen for later analysis of TP (APHA 1998; SM 4500-P). We also filtered 1-2 L of water through a Whatman 934-AH glass fiber filter that was frozen for later analysis of chl-*a* using acetone extraction followed by fluorometry (EPA 2013). A 100 mL aliquot of filtered water was frozen for later analysis of SRP (APHA 1998 SM 4500-P). TP and SRP samples were analyzed at the Upstate Freshwater Institute (UFI). Chl-*a* was analyzed at the Cornell Biological Field Station (CBFS) using a calibrated Turner 10-AU benchtop fluorometer and the EPA standard operating procedure SOP LG 405 (Revision 9, March 2013). Approximately 2 L of water was filtered for each chl-*a* sample.

Quality Control and Variability

To measure analytical precision at nearshore sites we processed replicate samples for TP and SRP. In July, six aliquots of water were taken from the same sample at four of the seven nearshore sites (no replicates provided from CBL, GIL, and SPL). We also collected triplicate samples once in August at nearshore sites (again, no replicates provided from CBL, GIL, and SPL) to determine within-site variability of TP, SRP, and chl-*a*. From each of the three samples, one aliquot was taken for TP, one for SRP, and one for chl-*a* analysis. At offshore locations, duplicate samples for TP, SRP, and chl-*a* were collected throughout the year. Mean values from those duplicates were used in the analyses.

Zooplankton

Zooplankton samples were collected with a standard 0.5 m diameter, 153-µm mesh, nylon net equipped with a calibrated flowmeter. At nearshore sites, tow depths ranged 9-10 m (30-33 ft). At offshore sites, epilimnetic tow depths ranged 3-20 m (10-66 ft; from the thermocline

when stratification was present). At offshore sites less than 75 m (246 ft) bottom depth (four daytime sites and three nighttime sites) a total water column sample (from 2 m above the bottom to the surface) was collected in addition to the epilimnetic sample when stratification was present. At sites greater than 75 m (246 ft) bottom depth (three daytime sites and two nighttime sites), one metalimnetic tow (50 m [164 ft] to the surface) and one hypolimnetic tow (90-100 m [295-328 ft] to the surface) were obtained in addition to the standard epilimnetic sample. Zooplankton were anesthetized with antacid tablets and then preserved in the field with 95% ethanol to obtain a final concentration of 70%. At nearshore sites, single samples were collected on a biweekly basis from May to October from 1–2 m (3-7 ft) above the bottom to the surface, depending on weather conditions.

At CBFS, each sample was strained through a 1.02 mm mesh cup to separate *Cercopagis* and other larger organisms (>1 mm in length) from smaller zooplankton (<1 mm). This was done because *Cercopagis* and *Bythotrephes* form clumps in the sample, making the usual random sub-sampling of 1 mL samples inappropriate. For each sample that contained clumps of *Cercopagis* or *Bythotrephes*, two analyses were performed - one on the smaller zooplankton and one on the larger zooplankton (including *Cercopagis* and *Bythotrephes*) that were caught in the 1.02 mm mesh strainer. At least 100 larger zooplankton (or the whole sample) were measured and enumerated by sub-sampling organisms from a gridded, numbered Petri dish in which the sample had been homogeneously separated. In some cases, different subsamples were used for *Bythotrephes* and *Cercopagis*. To calculate the total number of large crustaceans and *Cercopagis* in the clumped part of the sample, we used a ratio of wet weights of the sub-sample to wet weights of the total sample.

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

Data Analyses

We compared April/May to October mean TP, SRP, chl-*a*, SD, zooplankton density, size, and biomass, and zooplankton group biomass between the nearshore sites and the offshore epilimnion by first obtaining monthly means for each site and then fitting a general linear model with month and habitat as categorical predictor variables. Data for zooplankton density, biomass, and group biomass were log10-transformed prior to analysis. Offshore data collected in late April was analyzed with May nearshore data because of the proximity of nearshore to offshore sampling dates for those months. Data from June and August were omitted from this analysis because the offshore was not sampled during those months. We divided zooplankton into the following six groups: daphnids (*Daphnia mendotae*, *D. pulicaria*, *D. retrocurva*, *D. longiremis*, *D. schodleri*); bosminids (*Bosmina longirostris*, *Eubosmina coregoni*); calanoid copepods (*Leptodiaptomus minutus*, *Skistodiaptomus oregonensis*, *Leptodiaptomus sicilis*, *Leptodiaptomus ashlandi*, *Epischura lacustris*, *Eurytemora affinis*); cyclopoid copepods (*Acanthocyclops vernalis*, *Diacyclops thomasi*, *Mesocyclops edax*, *Tropocyclops prasinus*); other cladocera (*Alona sp.*, *Ceriodaphnia quadrangula*, *Chydorus sphaericus*, *Diaphanosoma sp.*, *Polyphemus pediculus*, *Leptodora kindtii*, *Camptocercus sp.*, *Scapholeberis sp.*, *Ilyocryptus sp.*); and nauplii. Four species were analyzed separately from the groups. Those species are: *Bythotrephes longimanus*; *Cercopagis pengoi*, *Holopedium gibberum*, and *Limnocalanus macrurus*. Differences were considered significant at $p<0.05$.

Change point analyses (Taylor Enterprises, Inc. 2003) were performed separately on nearshore

and offshore data using the entire data series (1995 – 2018 for nearshore and 2000 – 2018 for offshore) to test for breaks in the data. SRP data were available for 1998 – 2018 in both habitats. Analyses were performed on spring TP, Apr/May – Oct SRP, summer chl-*a*, summer epilimnetic zooplankton density and biomass, and zooplankton group biomass. Change point analysis uses cumulative deviations from the mean to detect changes in time trends and to estimate when those changes occurred. This is done by resampling the data series 1000 times to construct confidence intervals based on the inherent variability in the data series, and testing if and when the observed data series differ significantly from these confidence intervals. Regression analyses for time trends (JMP Pro v12.0.1, SAS Institute Inc. 2015) were performed on two time stanzas (1995 – 2018 and 2005 – 2018) for the offshore and three time stanzas (1995 – 2018, 1995 – 2004, and 2005 – 2018) for the nearshore using spring TP, summer chl-*a*, summer epilimnetic zooplankton density and biomass, and zooplankton group biomass. Zooplankton group biomass could not be normalized and Spearman rank correlation was used on those data. Nighttime zooplankton data are not included in time trend analyses. Zooplankton migrate up in the water column at night causing an increase in density and biomass in the epilimnion; therefore, results from day and night are not comparable.

Results

Quality Control and Variability

To estimate analytical precision (i.e. within sample variability), we analyzed 24 TP and 24 SRP samples (4 sites x 6 samples per site). Coefficients of variation (CV=SD/mean) ranged from 3 to 12% (mean of 8%) for TP and from 6 to 54% (mean of 35%) for SRP. Values from replicated sampling occasions were averaged for all analyses. Variation for SRP is larger because the concentrations are lower. These values were similar to previous years.

The analysis of August nearshore TP and SRP triplicate samples showed that the CV for TP ranged from 15 to 32% (mean of 25%), and the CV for SRP ranged from 6 to 25% (mean of 16%). Within site variability for TP and SRP represent typical variation observed in previous years. Values were averaged for later analyses.

2018 Water Quality

May through October mean chl-*a*, TP, SRP, and SD were similar across nearshore sites in 2018 (Table 1). Chl-*a* was lowest at Sodus Lake (SOL; 0.9 µg/L) and highest at Chaumont Lake and Sandy Pond Lake (CBL and SPL; 1.7 µg/L) (Table 1). TP was highest at Niagara West Lake (NWL; 7.0 µg/L) and lowest at Sandy Pond Lake (SPL; 3.9 µg/L). Despite having the lowest TP, Sandy Pond Lake had the highest SRP (1.8 µg/L). The lowest SRP occurred at Chaumont Lake and Galloo Island (CBL and GIL; 0.8 µg/L). SD was lowest at the site east of the Niagara River (NEL; 4.7 m [15 ft]) and highest at SOL (8.2 m [27 ft]). With the exception of SD, measurements of the same parameters at offshore locations also showed low variability. Chl-*a* ranged from 1.1 µg/L (Oak Orchard-O) – 1.8 µg/L (Smoky Point-O), TP ranged from 4.2 µg/L (Mid Lake and Tibbetts Point) – 7.8 µg/L (Oak Orchard-N), SRP ranged from 0.7 µg/L (Oak Orchard-O, Smoky Point-O and Mid Lake) – 3.7 µg/L (Oak Orchard-N), and SD ranged from 5.3 m (17 ft; Oak Orchard-N) – 13.5 m (44 ft; Oak Orchard-O) (Table 1). Apr/May – October comparisons of TP, SRP, chl-*a*, and SD showed no differences between nearshore and offshore locations (Table 2).

Seasonal trends were also observed for most variables. Nearshore SD was stable (5–7 m [16-23 ft]) Apr/May to October, while offshore SD was highest (13 m [43 ft]) in Apr/May and lowest (6 m [20 ft]) in September (Figure 2a). Nearshore chl-*a* concentrations were lowest in Apr/May (0.8 µg/L) and increased to a peak of 1.8 µg/L in August. Offshore concentrations were also lowest in Apr/May (0.6 µg/L) but did not peak until October (2.2 µg/L; Figure 3a). Nearshore total phosphorus was highest in June (7.6 µg/L) and then declined to a low of 3.8 µg/L in September. Offshore TP was high in Apr/May (7.0 µg/L) decreased to 3.5 µg/L in September, and then increased to 7.1 µg/L in October (Figure 4a). SRP concentrations were low (<1.7 µg/L) in both habitats for the entire season (Figure 5a).

Water Quality Trends Since 1995

Comparisons with data collected since 1995 show that 2018 had lower (6.0 m [20 ft]) than average SD in the nearshore and above (8.7 m [29 ft]) average SD in the offshore (Figure 2b). Summer chl-*a* concentrations decreased in both the nearshore and offshore (1.5 µg/L and 1.4 µg/L, respectively) and were lower than the long-term averages (Figure 3b). Spring TP and Apr/May – Oct SRP remained stable in both nearshore and offshore habitats (Figure 4b, 5b; Table 3).

2018 Zooplankton

In 2018, mean Apr/May-Oct zooplankton size did not differ significantly between nearshore and offshore sites (Table 2). However, zooplankton density was significantly higher in the offshore (7904 ind/m^3) than in the nearshore (4749 ind/m^3). Biomass was higher offshore (21.2 mg dw/m^3) than nearshore (11.9 mg dw/m^3), a difference that was marginally significant (p=0.08; Table 2). Biomass of cyclopoid copepods was significantly higher offshore, and biomass of bosminids, other cladocerans, and *Limnocalanus* were significantly higher in the nearshore (Table 2). Offshore zooplankton density was highest during early-July and biomass was highest in early-October (Figure 6); this coincided with peak biomass of bosminids in early-July and calanoids and *Bythotrephes* in early-October (Figure 7). Nearshore density and biomass were highest in June (Figure 6) and this was associated with peaks in bosminids, cyclopoids, and nauplii (Figure 7). Nearshore biomass was also high in early-September but density was not; this was due to the presence of large zooplankton (daphnids, calanoids, and *Bythotrephes*; Figures 6 and 7).

In 2018, *Cercopagis* and *Bythotrephes* were detected in samples from both habitats (Figure 7; Table 2). *Cercopagis* was first detected in late-May in the nearshore and in early-July in the offshore. *Cercopagis* peaked during early-July through early-August in the nearshore and in early-July in the offshore (Figure 7). *Bythotrephes* first appeared in late-August in the nearshore and in early-September in the offshore. *Bythotrephes* biomass was highest in the nearshore in early-September and in the offshore in late-September to early-October (Figure 7). During peak biomass, *Cercopagis* accounted for 22% of the total zooplankton biomass in the offshore and 14% in the nearshore, and *Bythotrephes* accounted for 3% of the nearshore biomass and 4% of the offshore biomass.

Comparison of epi-, meta-, and hypolimnetic daytime zooplankton tows showed that most zooplankton were present in the metalimnion at the one deep site (Mid Lake) sampled during the July stratified period (Figure 8). Toward the end of the stratified period (mid-September), the biomass was more evenly distributed between the meta- and hypolimnion. As the season progressed into late-September and October, the greatest biomass was present in the hypolimnion. From April-October, the epilimnion accounted for an average of just 10% of the total zooplankton biomass.

The species composition of zooplankton in the epi-, meta-, and hypolimnetic tows also changed seasonally. In the epilimnion, daphnids and bosminids represented the greatest biomass in July. In September calanoids (other than *Limnocalanus*) and daphnids accounted for the most biomass, and by October calanoids (other than *Limnocalanus*) dominated. The metalimnion had a high biomass of cyclopoids in July, daphnids dominated in September, and calanoid (other than *Limnocalanus*) biomass was greatest in October. The hypolimnion was dominated by *Limnocalanus* in July and September and by daphnids in October (Figure 9).

Zooplankton Trends Since 1995

Nearshore summer total zooplankton density and biomass declined significantly 1995 – 2018 (Figure 10; Table 3). These declines were driven by significant declines from 1995 – 2004 after which density and biomass stabilized (Table 3, regression results). Change point analysis showed that a negative break occurred in nearshore total zooplankton density and biomass in 1998 and in zooplankton density in 2005 (Figure 10; Table 3). In the offshore, there was a significant decline in summer epilimnetic zooplankton density and biomass from 2000 – 2018; however, density (but not biomass) increased marginally from 2005 – 2018 (Figure

10; Table 3). Change point analysis indicated a negative break in density and biomass in 2005 (Table 3).

Several trends were noted in nearshore summer zooplankton group biomass (Figure 11, Table 3). From 1995 – 2018, significant declines occurred in bosminid, cyclopoid, and daphnid biomass. At the same time, *Bythotrephes* and *Holopedium* biomass increased significantly (Table 3). Cyclopoid copepods declined 1995 – 2004 but then remained stable thereafter. *Holopedium* and *Cercopagis* biomass increased 1995 – 2004 and remained stable thereafter. Calanoid copepod biomass (other than *Limnocalanus*) was stable 1995-2004 and then declined thereafter.

In the offshore, no trends were evident in zooplankton group biomass, 2000 – 2018. Daphnids increased, 2005 – 2018 while *Cercopagis* biomass declined (Figure 12, Table 3). *Cercopagis* and *Bythotrephes* biomasses were low compared to overall zooplankton biomass. Therefore, we plotted them separately to better depict patterns in their biomass (Figure 13). The nearshore showed a negative change point in *Bythotrephes* biomass (2002) and a positive change point in 2006 (Table 3) while *Cercopagis* biomass showed no breaks. In the offshore, *Bythotrephes* and *Cercopagis* showed no breaks. Change points in the nearshore were also evident in bosminids (negative, 2005; positive, 2011), calanoid copepods (positive, 2007; negative 2012), and cyclopoid copepods (negative, 1998 and 2005; positive, 2013; Table 3). In the offshore, change points occurred in bosminids (negative, 2004) and cyclopoids (negative, 2005; positive, 2013; Table 3).

July daytime whole water column zooplankton biomass increased from 2017 to 2018, but remained below the average since 2010 (Figure 14). In 2017, *Bythotrephes* biomass was the highest recorded since 2010 in July whole water column samples, but *Bythotrephes* was absent in 2018. However, peak *Bythotrephes* biomass was similar in 2018 to the two previous years (Figure 13).

Discussion

Secchi depth, chl-*a*, and TP are indicators of lake trophic status (Carlson 1977). In 2018, average April-October values for all sites ranged from 4.7 to 13.5 m SD, 0.9 to 1.8 µg/L chl-*a*, 3.9 to 7.8 µg/L TP, and 0.7 to 3.7 µg/L SRP. These values are similar to other years in this decade and within the range for oligotrophic (low productivity) systems (0.3-3.0 µg/L chl-*a*, 1-10 µg/L TP; Wetzel 2001).

Spring TP is a good predictor of summer phytoplankton production (Dillon and Rigler 1975). Spring TP declined from 20 – 25 µg/L in the 1970s to 3 – 7 µg/L in the 2000s in the offshore and to 5 – 11 µg/L in the nearshore (Figure 4b). These values are consistent with data from the Canadian Surveillance Program (Dove and Chapra 2015) and EPA's lower trophic level assessments in the intensive field years of 2003, 2008, and 2013 (Holeck et al. 2008, 2015; Rudstam et al. 2017). EPA-GLNPO's offshore assessment of spring TP in April at 8 sites ranged between 7.1 and 3.7 µg/L between 1996 and 2016 (GLENDA). Spring TP has been mostly below or only slightly above the goal of 10 µg/L at both offshore and nearshore sites since the BMP started in 1995 (Figure 4b). Although we did observe low spring TP in 2014 and 2015 that at the time indicated a continued downward trend in spring TP comparable to observation of Dove and Chapra (2015, data up to 2013), the relatively high spring TP in 2016 and 2018 suggest little change in both offshore and nearshore spring TP through the 2000s. There is also no significant trend in the EPA-GLNPO spring TP data between 2000 and 2016 ($P=0.14$).

Summer chl-*a* in 2018 was slightly higher in both habitats than observations from 2011 – 2015 but lower than 2016 and 2017 (Figure 3b). There was no longer a significant time trend in summer chl-*a* in either habitat for the whole data series (from 1995 – 2018 in the nearshore and from 2000 – 2018 in the offshore), but chl-*a* in the nearshore increased during 1995 – 2004. Change points were detected in 2010 (a decline) and 2016 (an increase) in the nearshore indicating lower values in the early 2010s than in both 2000s and late 2010s. The data suggest relatively low summer chlorophyll in both habitats from 2011 to 2015 and a return to values seen through the early 2000s in 2016 – 2018.

Mean summer Secchi depth has not changed significantly since 1995 in the nearshore but has increased significantly in the offshore areas. A positive trend since 1997 is also evident in the EPA April and August data for the offshore. Thus, SD is the only commonly used trophic level indicator that shows significant continuing oligotrophication of offshore Lake Ontario.

Summer epilimnetic zooplankton density and biomass decreased significantly in the offshore 2000 – 2018 and in the nearshore 1995 – 2018 (Table 3). Biomass declined to below 20 mg/m^3 for the first time in 2005 in the offshore (Figure 12) and in 1999 in the nearshore (Figure 11), declines that have been attributed to increased *Bythotrephes* abundance in the offshore and *Cercopagis* in the nearshore (Warner et al. 2006, Barbiero et al. 2014, Rudstam et al. 2015). These trends are consistent with observed effects of these predatory zooplankton elsewhere (Lehman and Caceres 1993, Yan et al. 2001, Pangle et al. 2007). There is also a negative correlation between *Bythotrephes* and *Cercopagis* abundance, which is also observed in the EPA-GLNPO data (Barbiero et al. 2019). *Bythotrephes* abundance rebounded in 2016 and 2017 after two years of very low abundance (2014 and 2015) but may have declined some in 2018. As anticipated, we observed a zooplankton community in 2014 – 2015 with a higher proportion of bosminids, cyclopoids and *Cercopagis* similar to the community present pre-2005 and a return to lower cyclopoid and bosminid biomass in 2016 - 2017. Bosminids returned in 2018 but not cyclopoids, perhaps an intermediate response to intermediate *Bythotrephes* abundances in 2018.

Generally, *Bythotrephes* abundance is negatively correlated with Alewife abundance due to predation (Johannsson and O'Gorman 1991, Barbiero et al. 2014). In our Lake Ontario samples, offshore *Bythotrephes* biomass was low 1995 – 2003 and again in 2014 – 2015. However, this is not consistent with measures of adult Alewife abundance (Weidel et al. 2018). Adult Alewife abundance was relatively stable 1997 – 2017 with the exception of 2006, 2010 and 2016 when abundance was very low (Weidel et al. 2018). Note that Alewife abundance is estimated in spring while *Bythotrephes* peak biomass estimates are from fall (September – October). Therefore, changes that occur over the course of the summer may also contribute to the lack of consistency between Alewife abundance and *Bythotrephes* biomass. In any case, these inconsistencies suggest the interaction between Alewife and *Bythotrephes* is more complicated than suggested by Barbiero et al. (2014) and Rudstam et al. (2015).

The deep chlorophyll layer and associated zooplankton are not part of the long-term data set collected by the BMP. However, we have given this more attention since 2010 and are now collecting whole water column (100 m or bottom minus 2 m to the surface) zooplankton tows, as does the EPA-GLNPO program. EPA data show little decline in the offshore zooplankton biomass from 1998 to 2016 (Barbiero et al. 2019), and whole water column data from the BMP (2010 – 2018) support this observation (Figure 14). However, there are community changes, with more cyclopoid copepods in 2013 – 2015 and again in 2018 and more calanoids and daphnids in 2010 – 2012 and 2016; 2017 is an intermediate year with more cyclopoids and fewer calanoids and daphnids than in 2016, but not yet similar to 2014 – 2015. *Limnocalanus* remained a dominant species throughout 2010 – 2018 but declined some in 2018. The lower daphnid biomass and higher cyclopoid biomass observed in 2014 – 2015 in July may be in part due to an altered seasonal pattern. Cyclopoids usually peak in spring and daphnids in summer. In 2014 – 2015 cyclopoid biomass peaked in summer and daphnid biomass peaked in fall. In 2016 to 2018, both groups returned to the typical seasonal pattern. Note that the community changes may also be due to biological factors such as predation by *Bythotrephes* or Alewife. A decline in calanoid copepod and daphnids and an increase in cyclopoid copepods and bosminids is typical of high Alewife years in smaller New York lakes (Wang et al. 2010).

The BMP data indicate stable lower trophic conditions in Lake Ontario since 2000 and are consistent with Rudstam et al. (2017) analysis of data up to 2013. From 1980-2000, the offshore of Lake Ontario became more oligotrophic, but the years 2014–2018 do not indicate any further oligotrophication of the offshore. Nearshore

stations are similar to offshore stations with only slightly higher nutrient concentrations in some areas, in particular at the Niagara River sites. Our 10 m sites are in the open lake and have considerable exchange with the offshore waters, which certainly contributes to the similarity with the offshore sites. In the shoreside, wadeable depths, nutrient concentrations can be substantially higher with associated eutrophication problems and *Cladophora* blooms (Makarewicz and Howell 2012).

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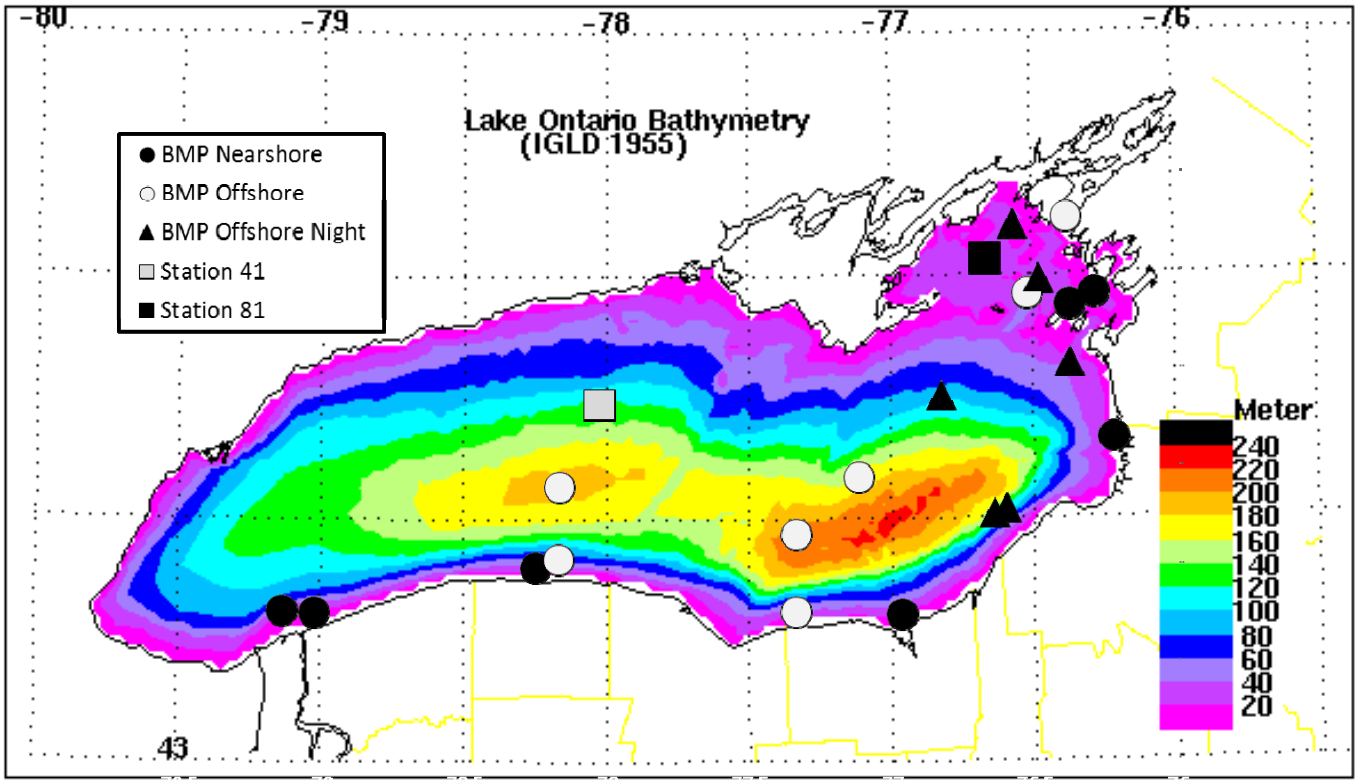


Figure 1. Map of Biomonitoring Program sites, 2018. Station 41 and station 81 are locations sampled by the Department of Fisheries and Oceans Canada's Bioindex Program (1981 – 1995) and are included here as reference for long-term data included in subsequent figures. Offshore stations are deeper than 16 m (52 ft). Nearshore stations are 10-15 m (33-49 ft) deep.

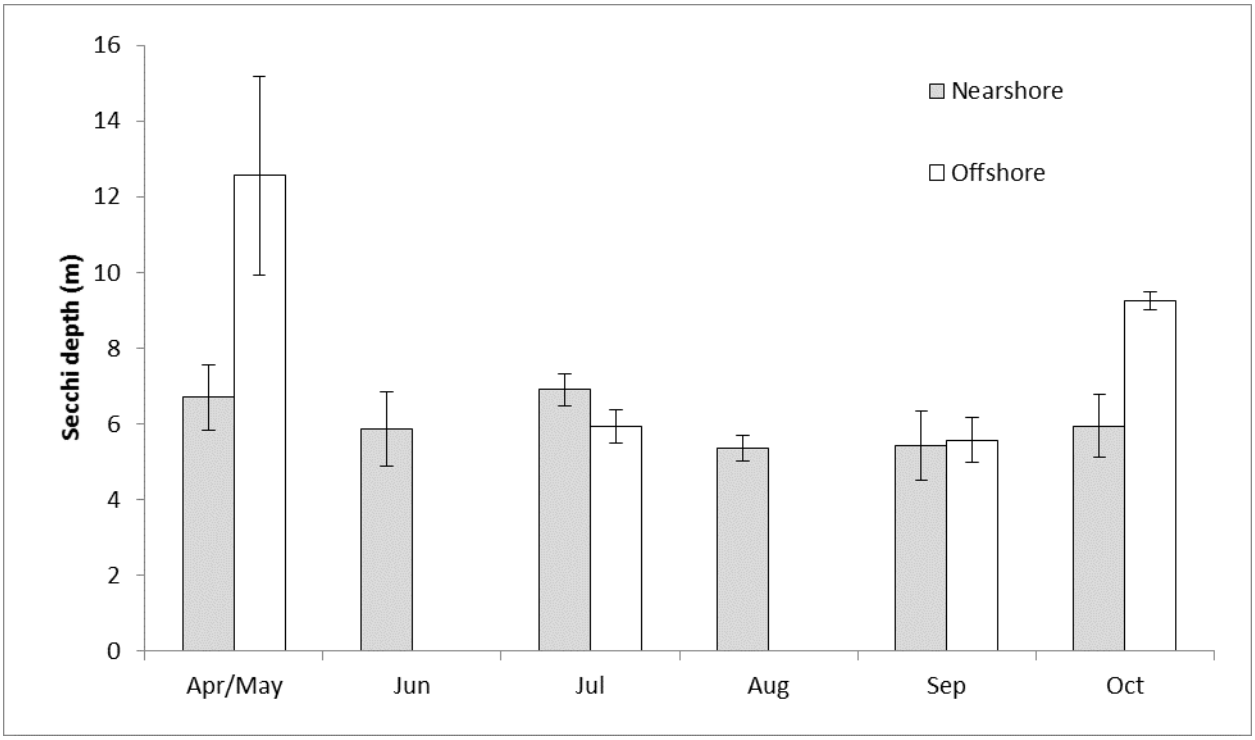


Figure 2a. Mean monthly Secchi depth (meters) for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2018. Error bars are ± 1SE.

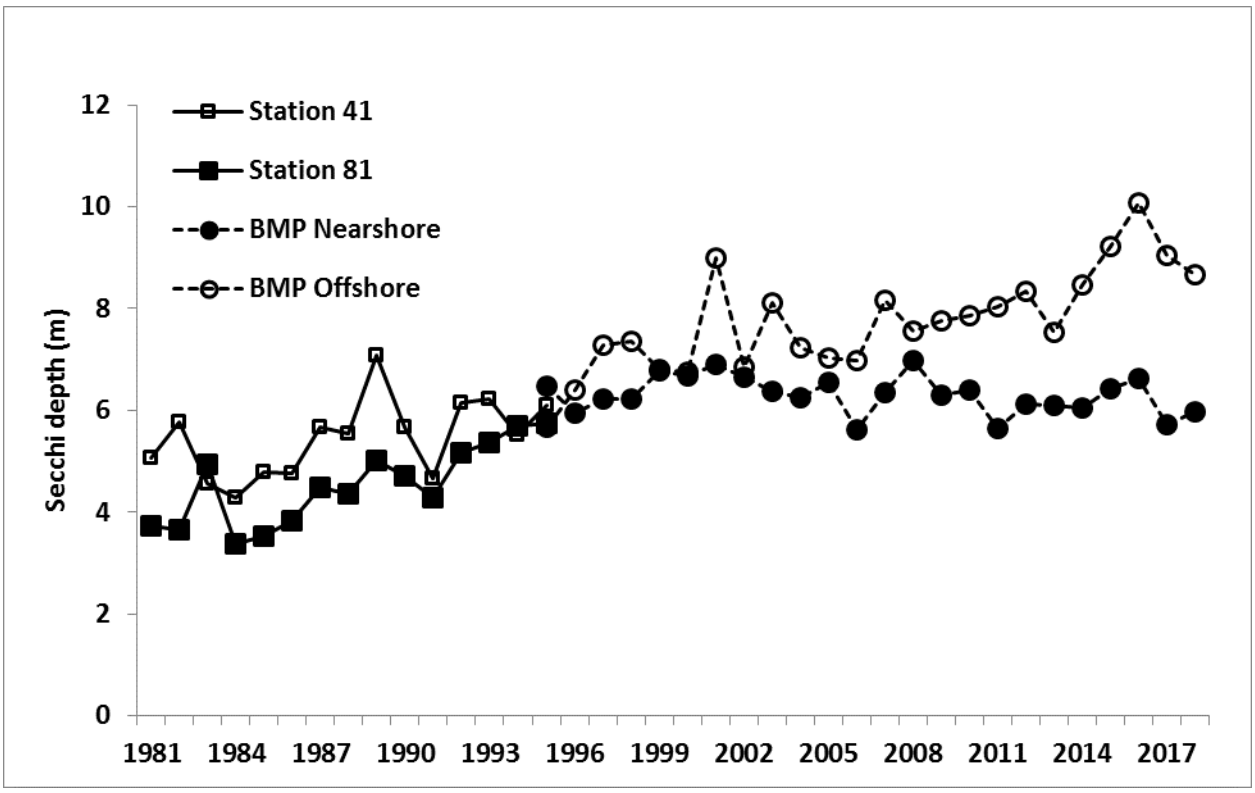


Figure 2b. Long-term mean Apr/May – Oct Secchi depth (meters) in Lake Ontario, 1981 – 2018. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2018 are from the US Biomonitoring Program (BMP).

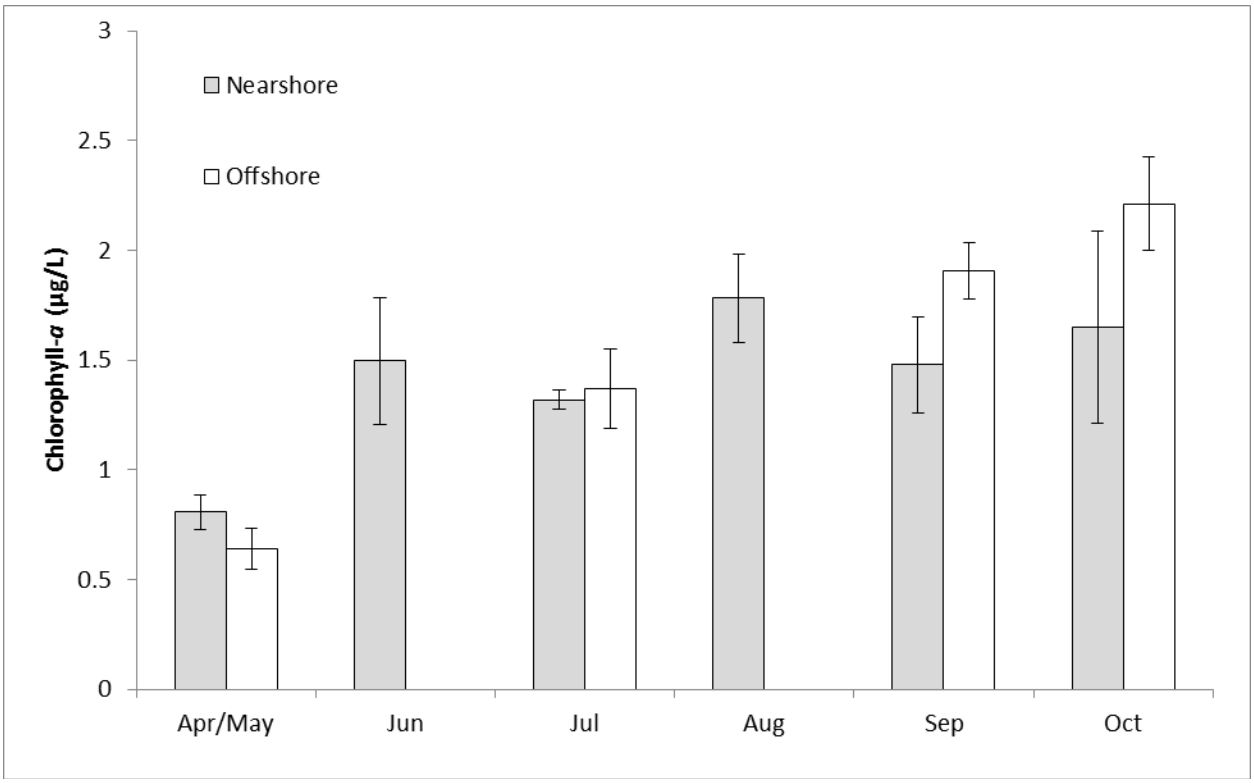


Figure 3a. Mean monthly epilimnetic chlorophyll-a concentrations for nearshore and offshore habitats in Lake Ontario, Apr/ May - October, 2018. Error bars are ± 1SE.

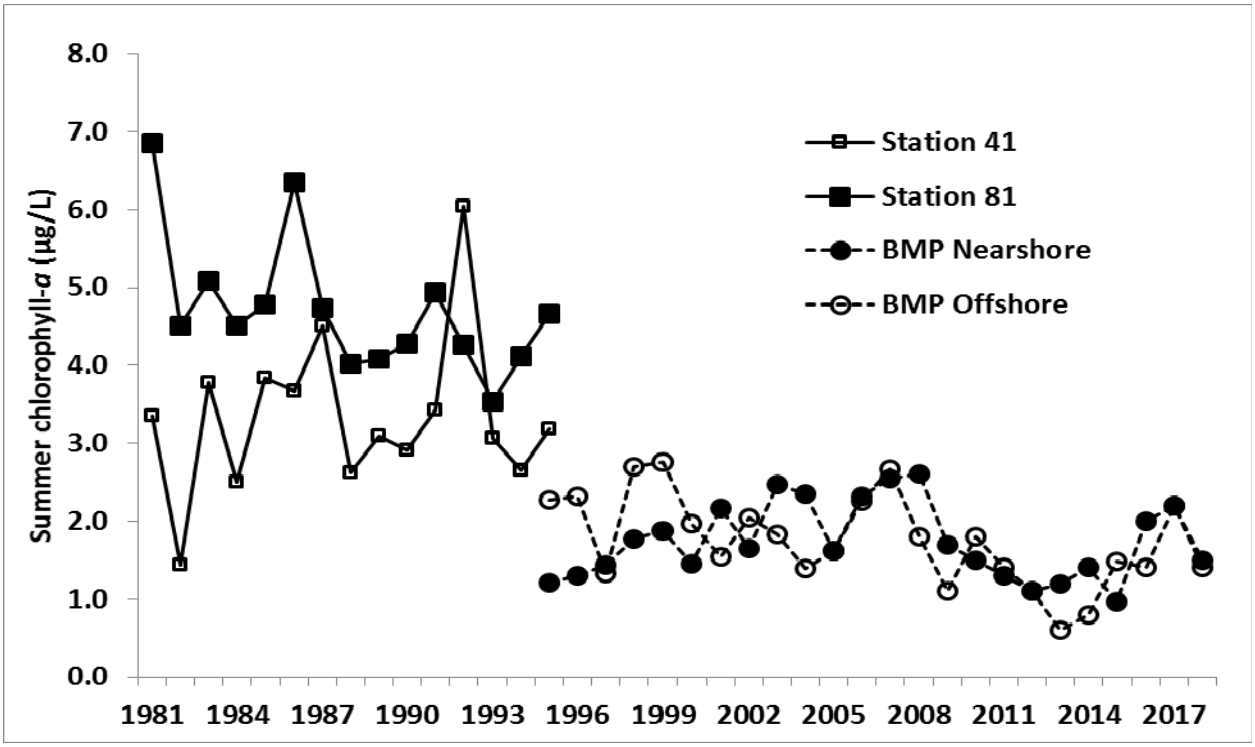


Figure 3b. Long-term summer (Jul – Aug) epilimnetic chlorophyll-a concentrations in Lake Ontario, 1981 - 2018. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2018 are from the US Biomonitoring Program.

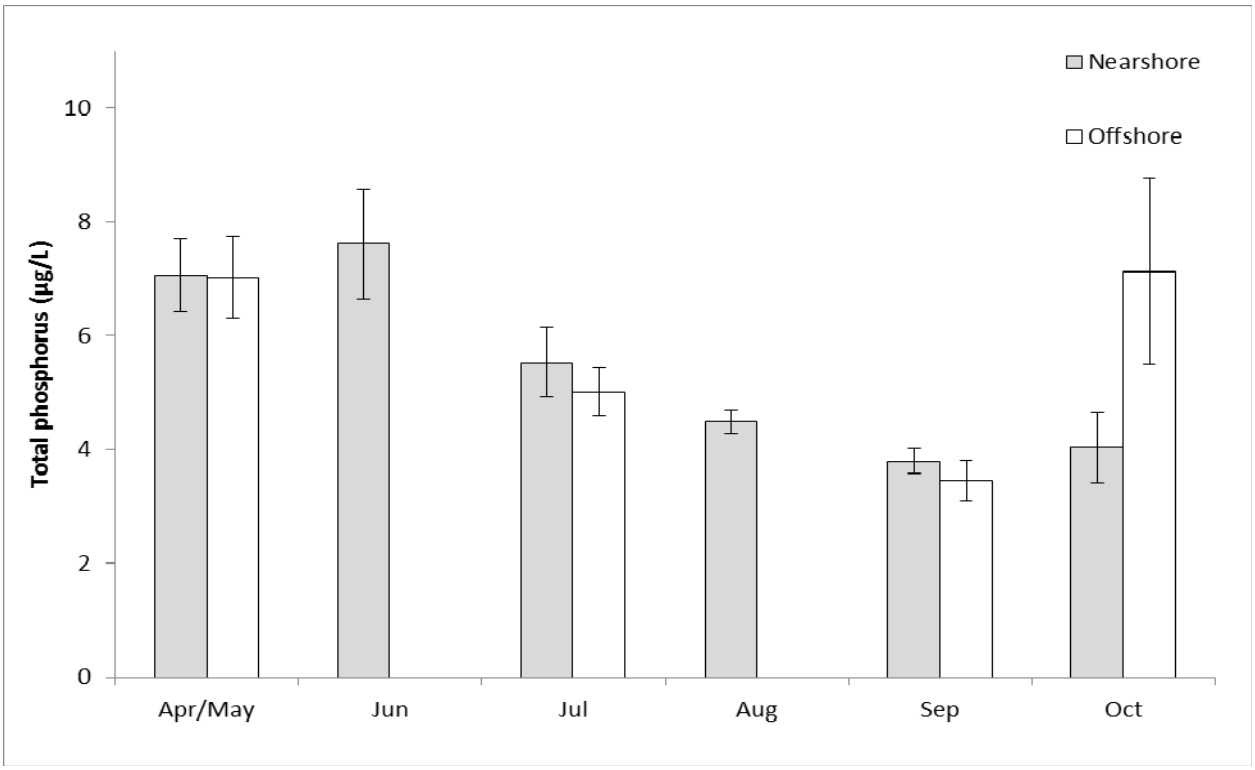


Figure 4a. Mean monthly total phosphorus concentrations for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2018. Error bars are ± 1SE.

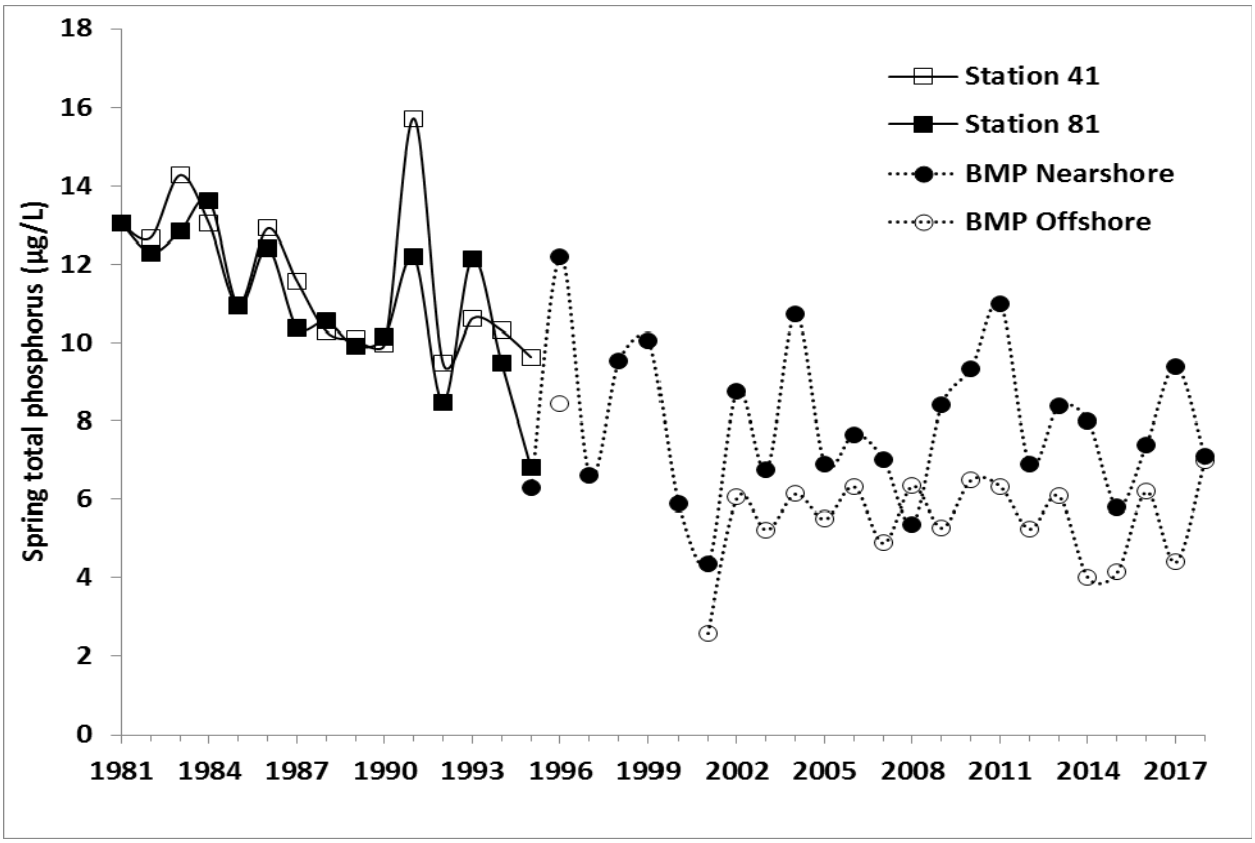


Figure 4b. Long-term spring (Apr – May) epilimnetic total phosphorus concentrations in Lake Ontario, 1981 - 2018. Data from 1981 – 1995 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1995 – 2018 are from the US Biomonitoring Program.

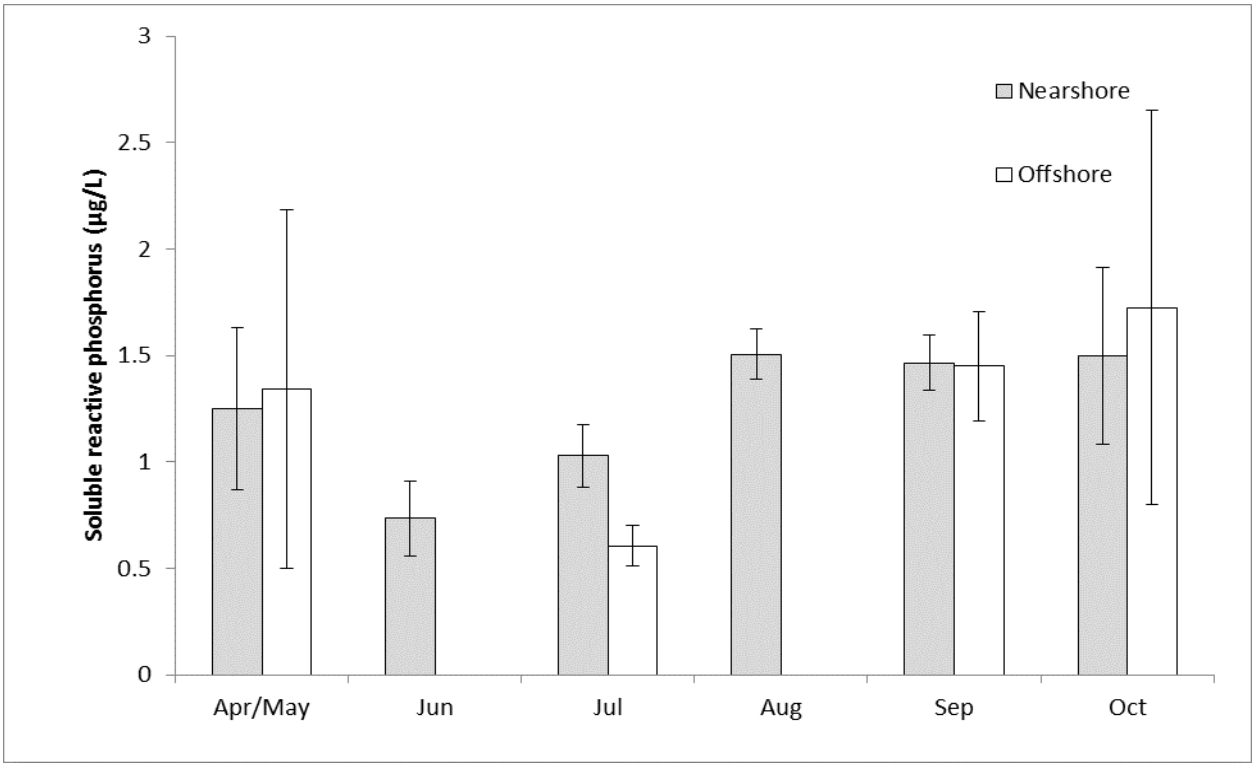


Figure 5a. Mean monthly soluble reactive phosphorus concentrations for nearshore and offshore habitats in Lake Ontario, Apr/May - October, 2018. Error bars are ± 1SE.

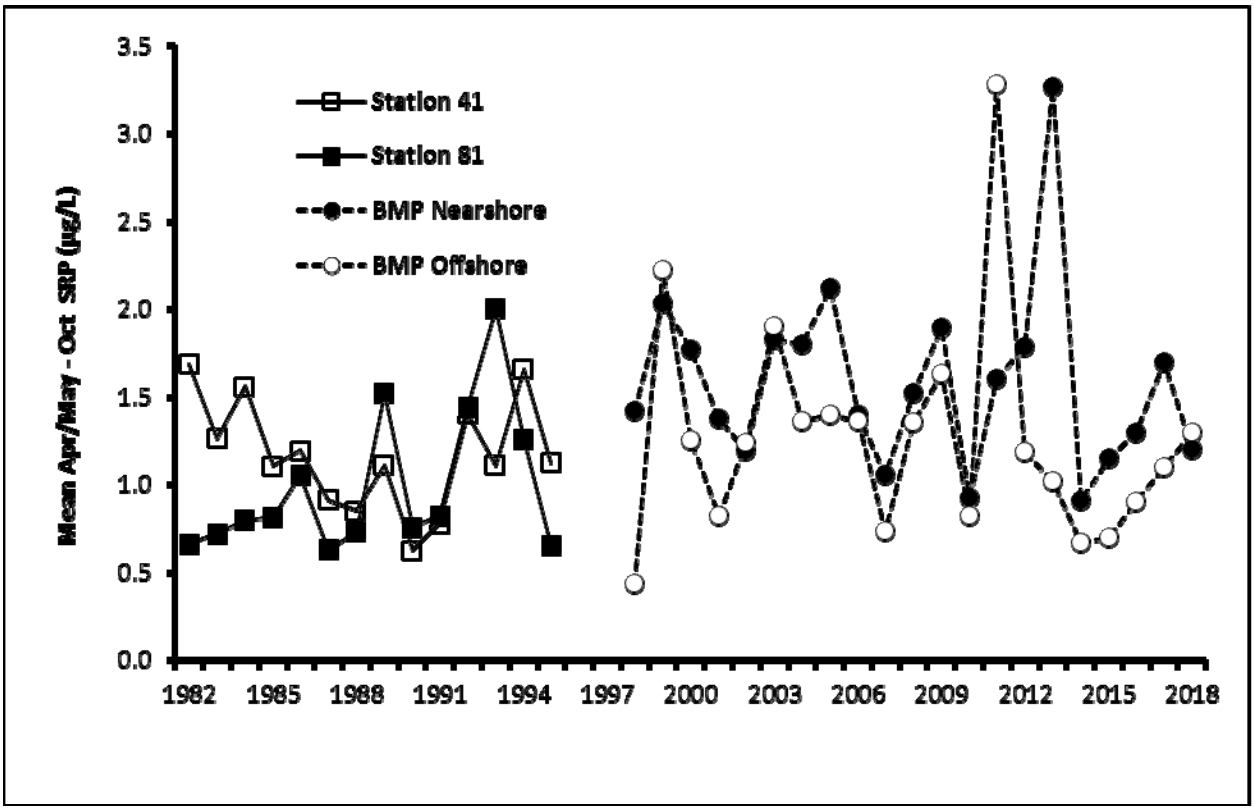


Figure 5b. Long-term mean Apr/May – Oct soluble reactive phosphorus concentrations in Lake Ontario, 1982 – 2018. Station 41 and Station 81 are from the Department of Fisheries and Oceans Canada's Bioindex Program. Data from 1998 – 2018 are from the US Biomonitoring Program.

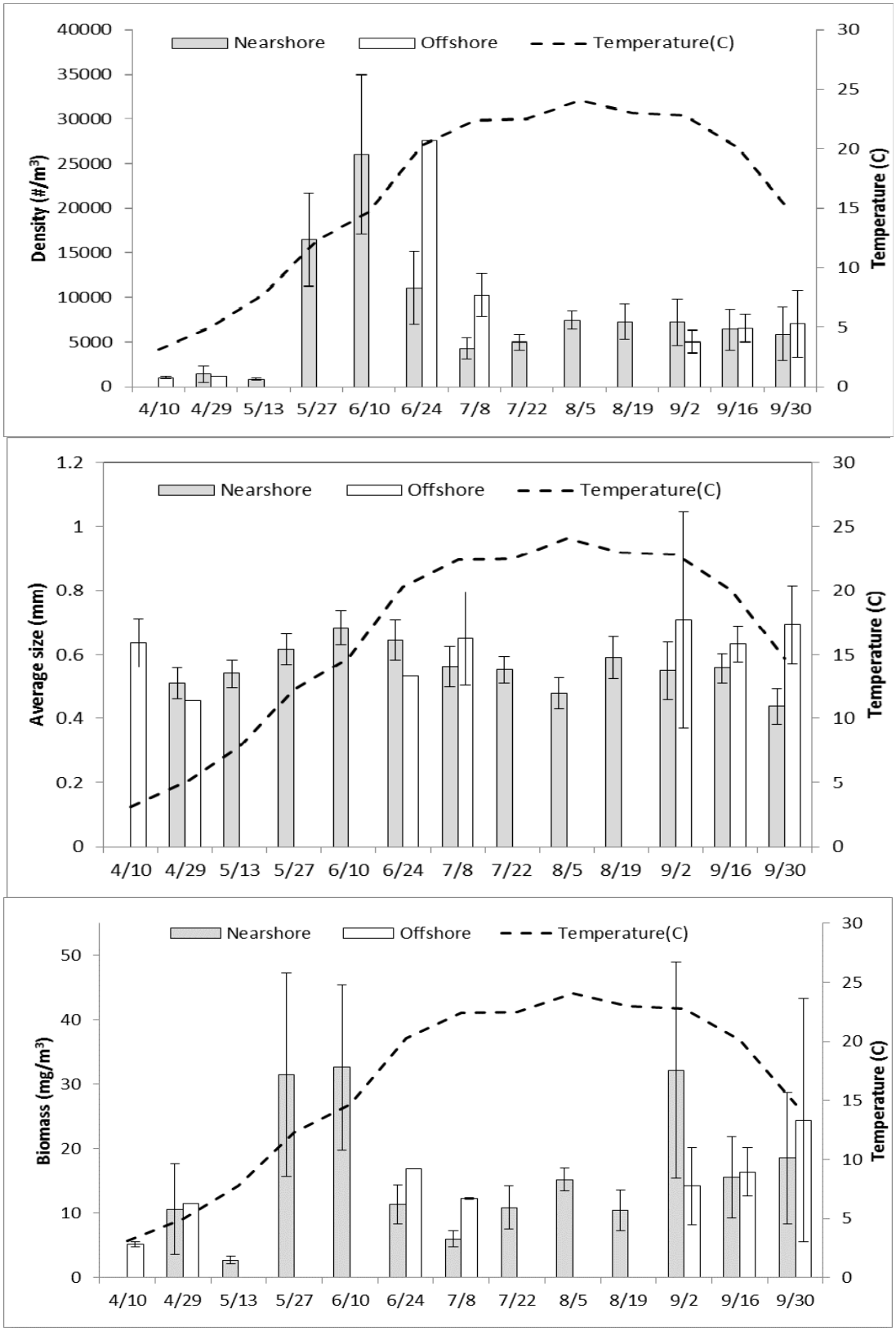


Figure 6. Biweekly mean (± 1 SE) daytime epilimnetic zooplankton density, size, and dry biomass for April through October 2018 at nearshore and offshore sites on Lake Ontario. On the x-axis, biweeks are designated by the date beginning each biweek. When no error bar is present, only one sample was taken that biweek. Lake surface temperatures (secondary y-axis) are from NOAA Coastwatch web site (https://coastwatch.glerl.noaa.gov/ftp/glsea/avgtemps/2018/glsea-temps2018_1024.dat).

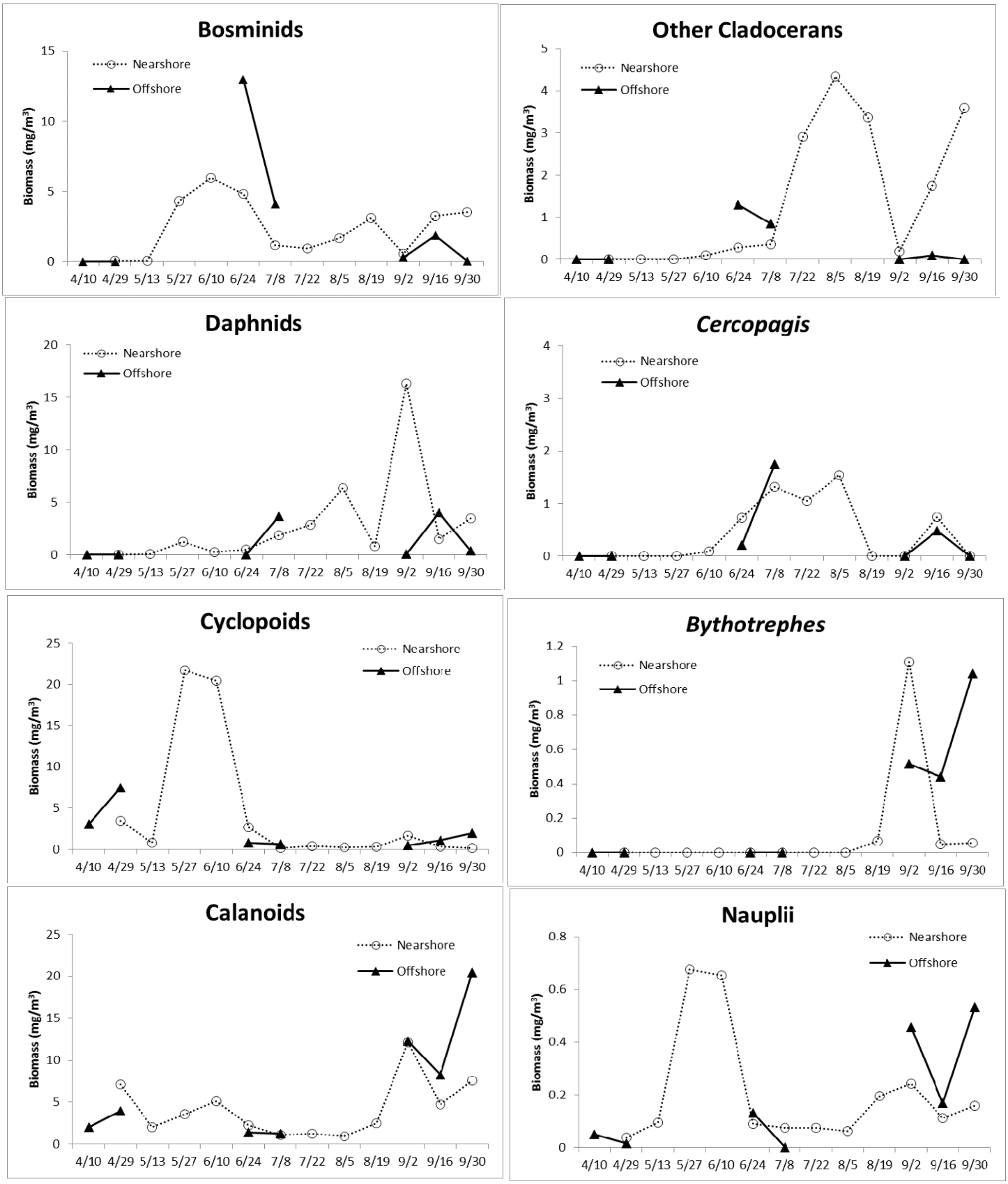


Figure 7. Daytime epilimnetic dry biomass of zooplankton community groups for nearshore and offshore areas of Lake Ontario, April - October 2018. Note different y-axis scales. On the x-axis, biweeks are designated by the date beginning each biweek.

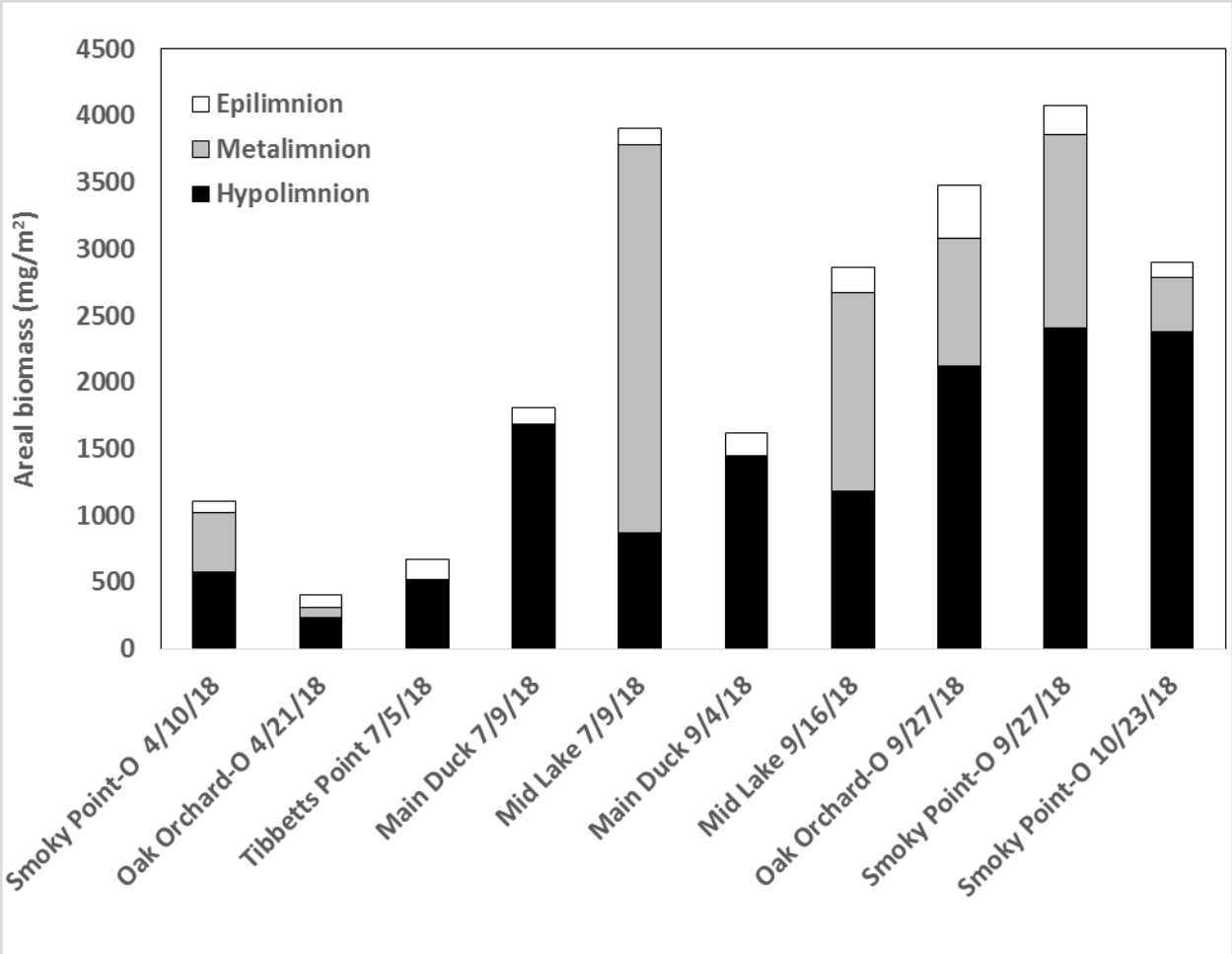


Figure 8. Daytime epilimnetic, metalimnetic, and hypolimnetic zooplankton dry biomass (areal) in Lake Ontario's offshore, 2018. Epilimnetic values determined directly from the epilimnetic tow. Metalimnetic values determined by subtracting epilimnetic tow values from the metalimnetic tow. Hypolimnetic values determined by subtracting metalimnetic tow values from the hypolimnetic tow. Stations without metalimnetic values are shallower stations where only two tows were performed (Tibbetts Point 7/5 and Main Duck 7/9 and 9/4).

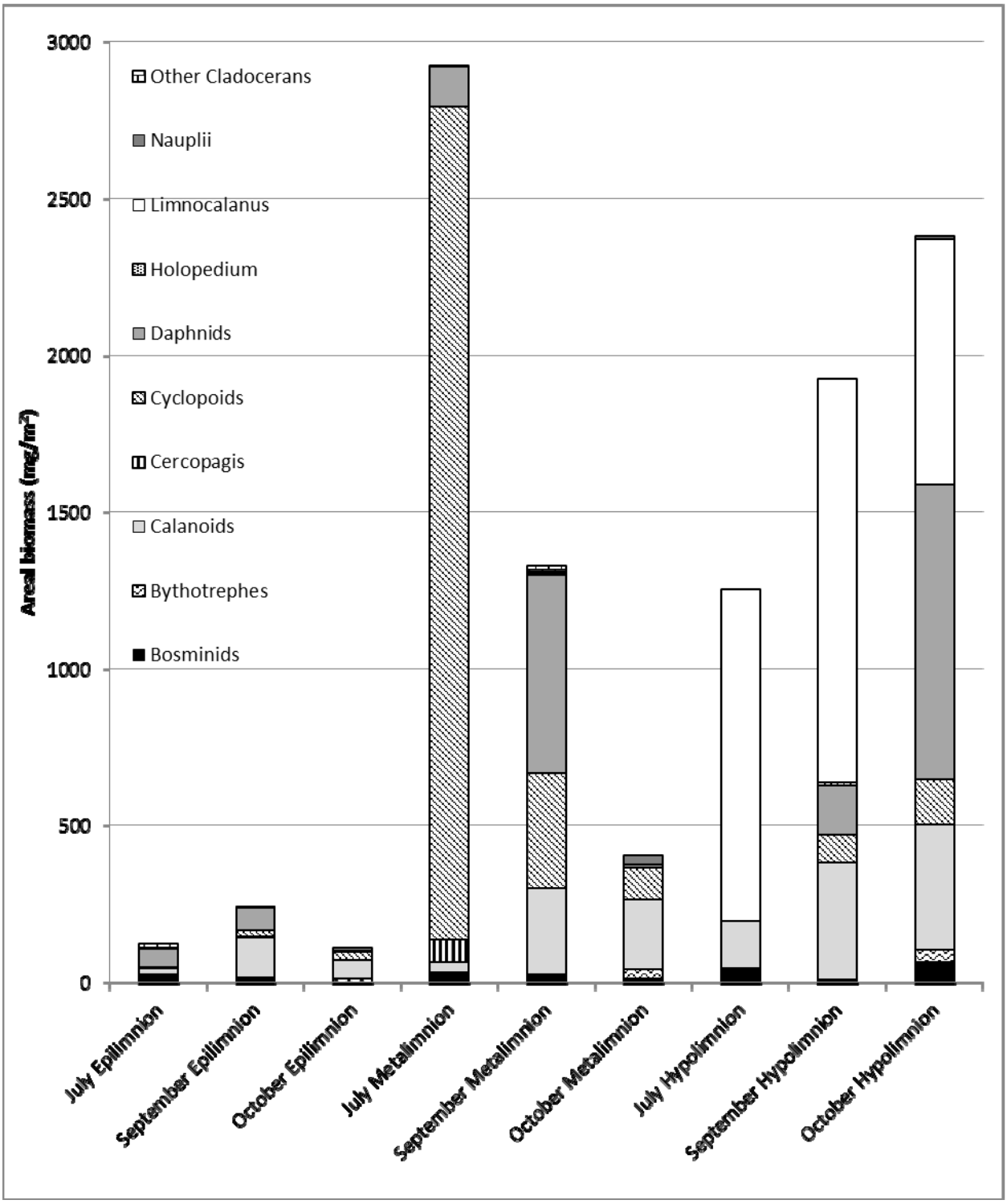
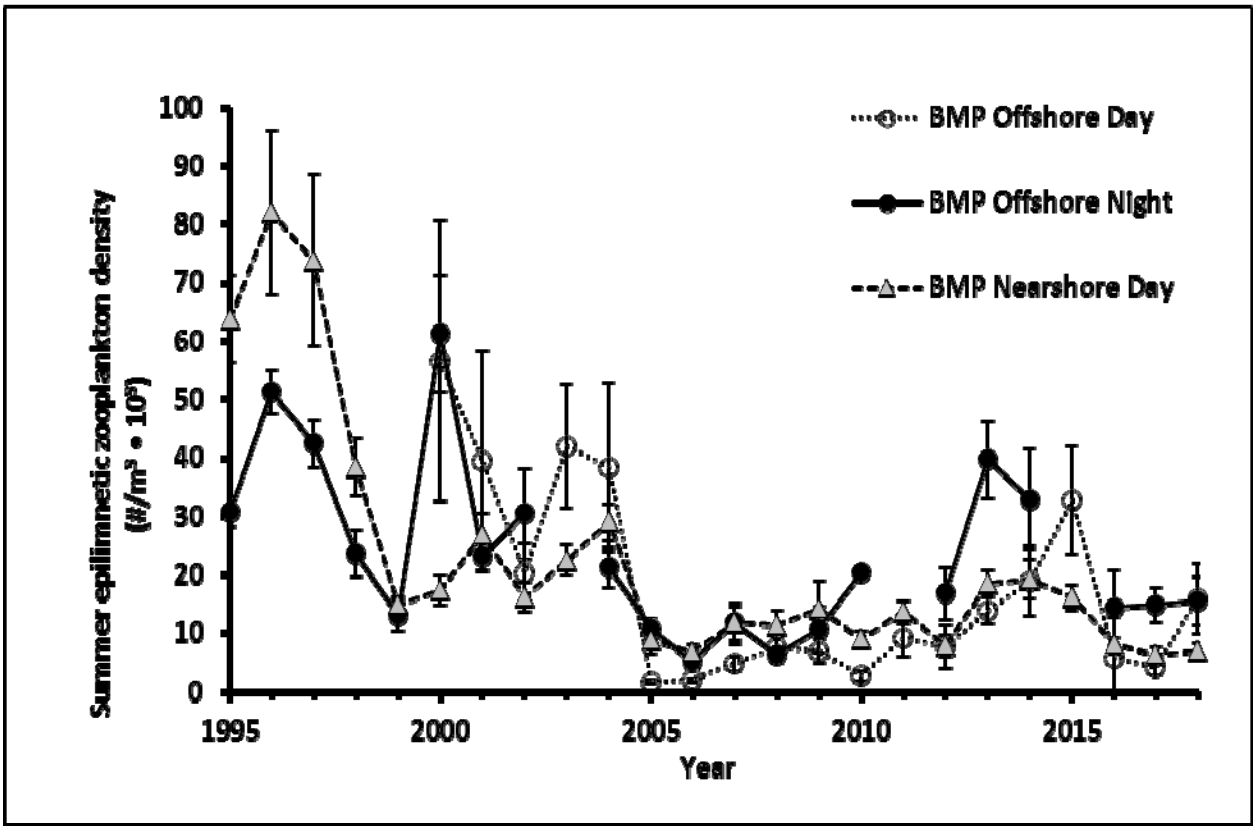


Figure 9. Comparison of mean daytime zooplankton biomass (dry) in epilimnetic, metalimnetic, and hypolimnetic samples taken from deep (>100m) sites in Lake Ontario's offshore, July, September, and October 2018. The epilimnetic strata includes zooplankton from the top of the metalimnion (10 – 20 m) up to the surface, the metalimnetic strata includes zooplankton from 50 m up to the top of the metalimnion, and the hypolimnetic strata contains zooplankton from 100 m up to the bottom of the metalimnion. A value of zero was assigned when values were negative due to variation in catch of zooplankton between epilimnetic and metalimnetic tows or between metalimnetic and hypolimnetic tows.



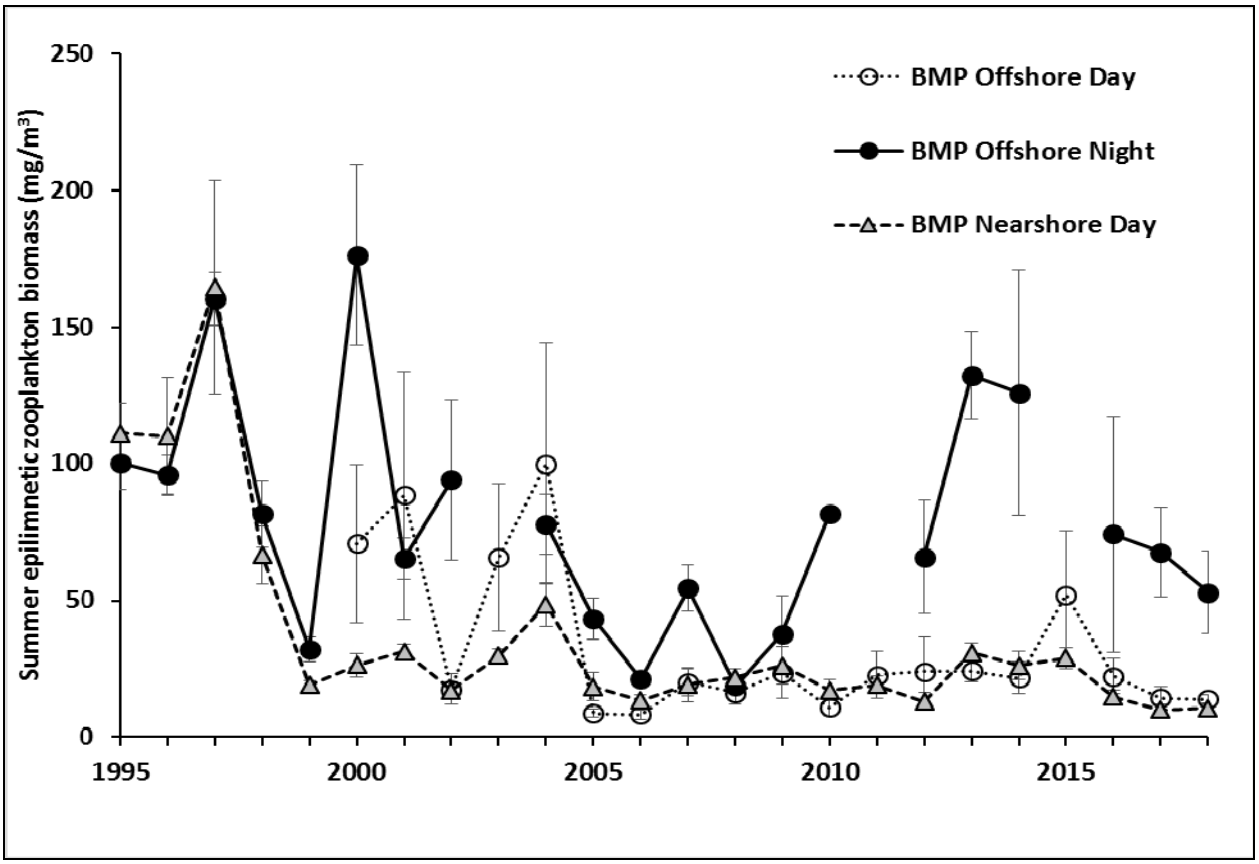


Figure 10. Mean summer (Jul-Aug) epilimnetic zooplankton density (top panel) and biomass (bottom panel) in nearshore and offshore habitats in Lake Ontario, 1995 – 2018. Error bars are ± 1 SE.

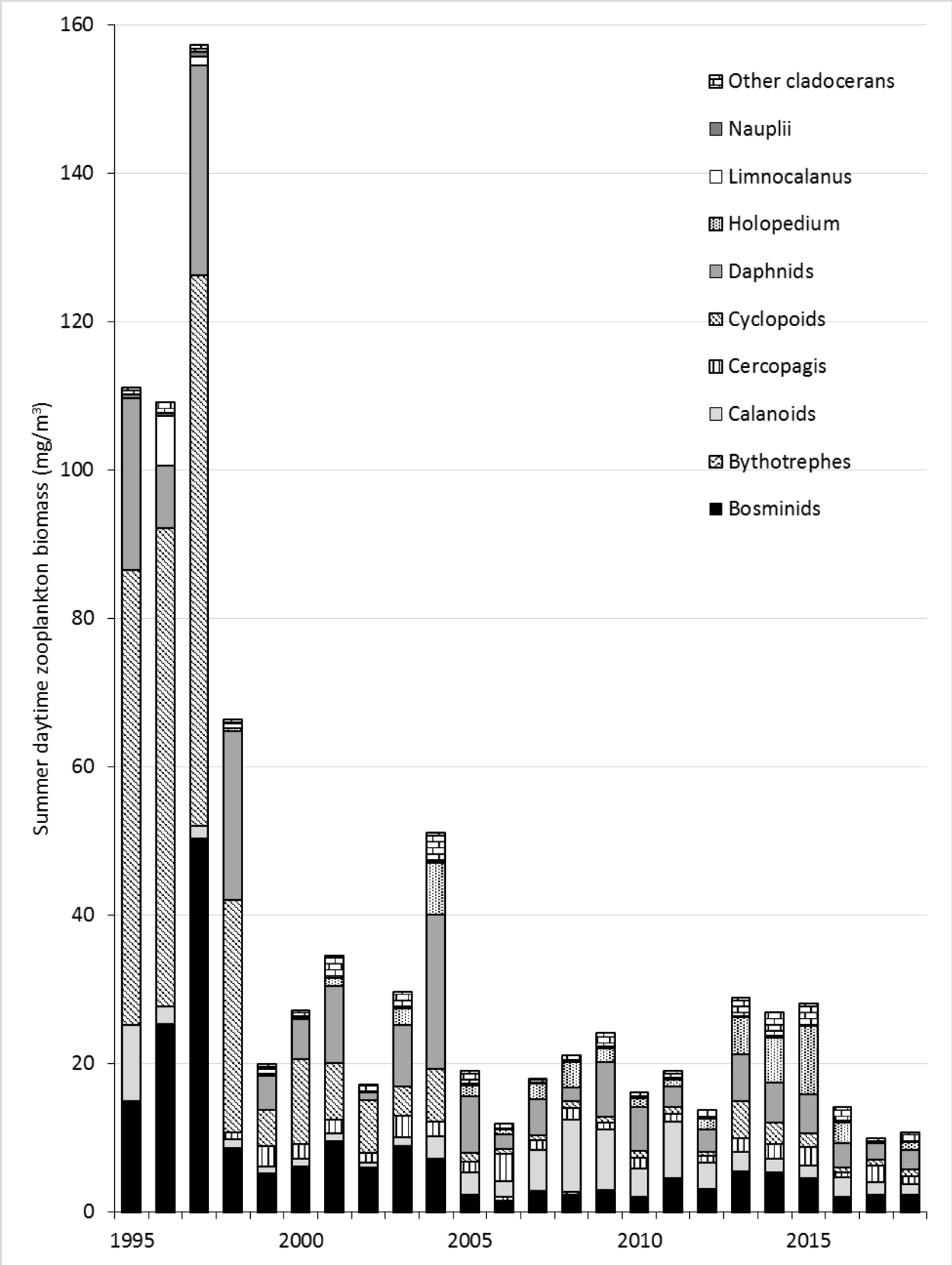


Figure 11. Mean summer (Jul – Aug) daytime nearshore zooplankton group biomass in Lake Ontario, 1995 – 2018.

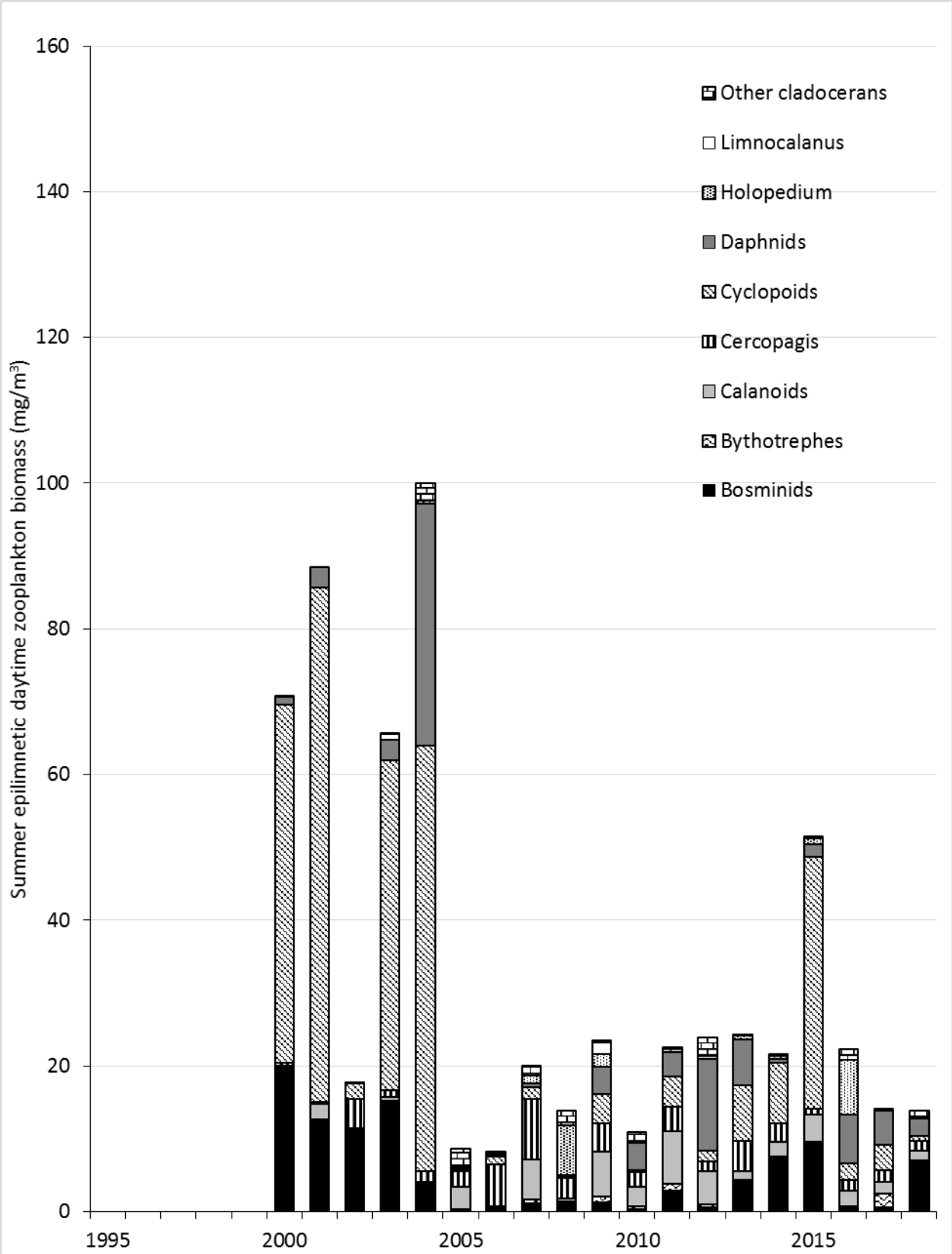


Figure 12. Mean summer (Jul – Aug) daytime epilimnetic offshore zooplankton group biomass in Lake Ontario, 2000 – 2018.

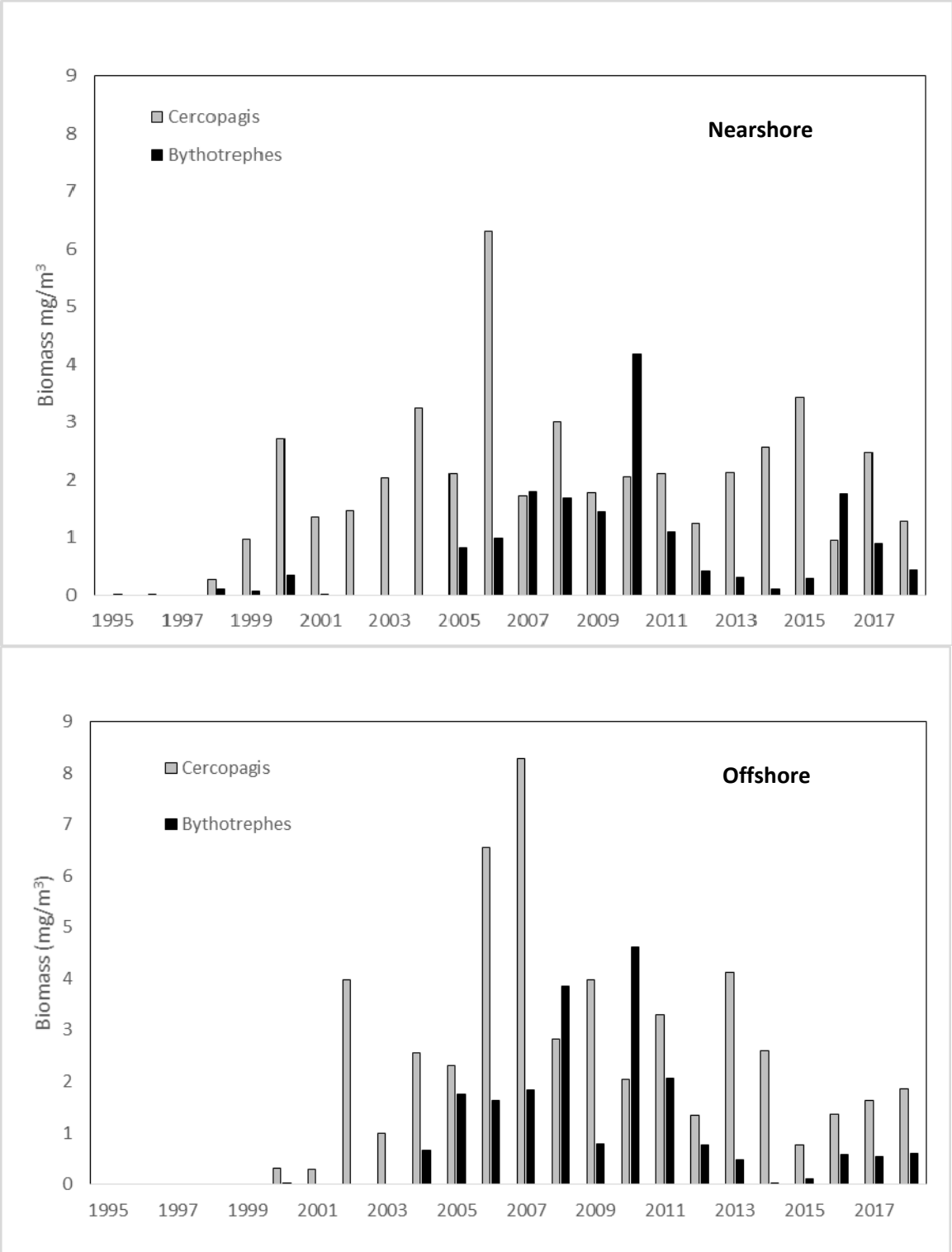


Figure 13. Daytime epilimnetic nearshore and offshore fall (September and October) **Bythotrephes** ***and summer (July)*** **Cercopagis** ***biomass in Lake Ontario, 1995 – 2018. Months were selected based on timing of peak biomass for each species.***

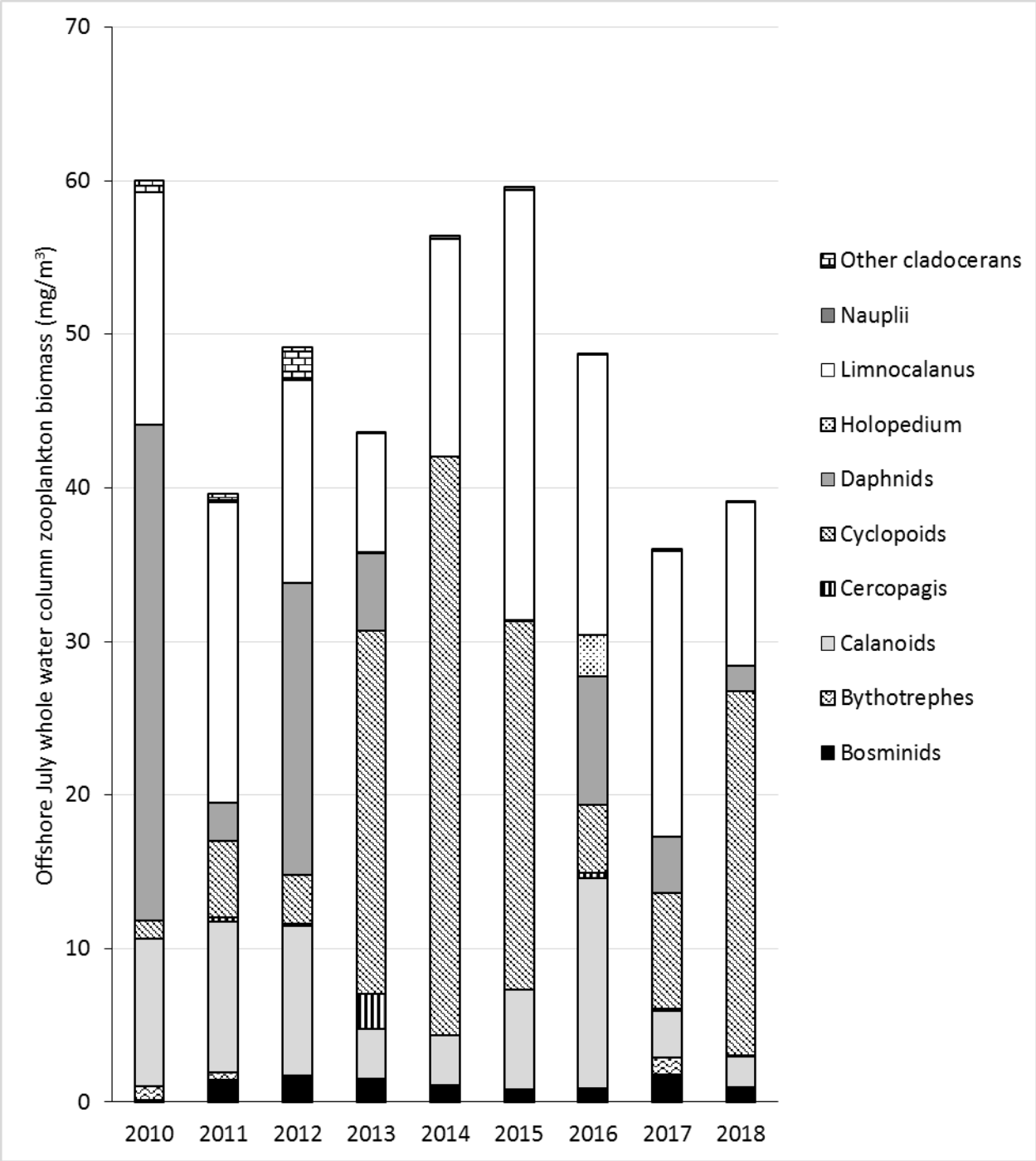


Figure 14. Mean July whole water column offshore zooplankton group biomass in Lake Ontario, 2010 – 2018.

Table 1. Mean chl a, TP, SRP and Secchi depth (± 1 SE) for nearshore and offshore sites, April – October 2018.

	Mean ± 1 SE			
Sites	Chlorophyll-*a* (µg/L)	Total phosphorus (µg/L)	Soluble reactive phosphorus (µg/L)	Secchi depth (m)
Nearshore				
Chaumont Lake (CBL)	1.7± 0.2 (n=8)	5.2± 0.4 (n=8)	0.8± 0.2 (n=7)	6.3± 0.6 (n=9)
Galloo Island (GIL)	1.4± 0.1 (n=8)	5.9± 0.8 (n=8)	0.8± 0.2 (n=8)	7.0± 0.7 (n=9)
Oak Orchard (OOL)	1.4± 0.1 (n=12)	5.6± 0.6 (n=12)	1.2± 0.2 (n=12)	6.4± 0.5 (n=12)
Sodus Lake (SOL)	0.9± 0.1 (n=10)	4.9± 0.7 (n=9)	1.2± 0.2 (n=10)	8.2± 0.8 (n=10)
Sandy Pond Lake (SPL)	1.7± 0.2 (n=8)	3.9± 0.3 (n=7)	1.8± 0.2 (n=8)	5.6± 0.7 (n=9)
Niagara East Lake (NEL)	1.3± 0.1 (n=12)	6.2± 0.6 (n=12)	1.0± 0.2 (n=12)	4.7± 0.3 (n=12)
Niagara West Lake (NWL)	1.3± 0.3 (n=11)	7.0± 1.1 (n=11)	1.5± 0.2 (n=11)	5.0± 0.4 (n=11)
Offshore				
Kaho				
Oak Orchard-N	1.4± 0.8 (n=2)	7.8± 2.8 (n=2)	3.7± 2.7 (n=2)	5.3± 1.8 (n=2)
Oak Orchard-O	1.1± 0.5 (n=2)	5.2± 2.7 (n=2)	0.7± 0.4 (n=2)	13.5± 7.5 (n=2)
Smoky Point-N	1.5± 0.4 (n=3)	6.8± 1.3 (n=3)	1.8± 0.5 (n=3)	7.5± 0.8 (n=3)
Smoky Point-O	1.8± 0.4 (n=3)	5.2± 0.9 (n=3)	0.7± 0.2 (n=3)	12.7± 4.5 (n=3)
Seth Green				
Main Duck	1.2± 0.5 (n=3)	4.5± 1.2 (n=3)	1.2± 0.8 (n=3)	7.1± 2.4 (n=3)
Mid Lake	1.2± 0.2 (n=3)	4.2± 0.8 (n=3)	0.7± 0.2 (n=3)	8.7± 3.1 (n=3)
Tibbetts Point	1.2± 0.6 (n=3)	4.2± 0.4 (n=3)	0.9± 0.3 (n=3)	5.9± 1.5 (n=3)

Table 2. Comparison of nearshore and offshore sites Apr/May-October, 2018 by fitting a general linear model with month and habitat as the effects on log-transformed (TP, SRP, SD, zooplankton density and biomass) or untransformed (chl-a and zooplankton size) Apr/May – Oct mean values. Zooplankton group biomass could not be normalized and the Wilcoxon test was used for those comparisons. Reported p-values are for the significance of habitat, not month. Values shown are arithmetic means summarized by site and then across months 4/5, 7, 9, and 10. Months 6 and 8 were removed from the analysis because the offshore was not sampled during those months. All offshore data are for the epilimnion (zooplankton) or the top 10 m (water chemistry).

Parameter		Mean		p-value
		Nearshore	Offshore	
	Total phosphorus (µg/L)	5.3	5.3	1
	Soluble reactive phosphorus (µg/L)	1.3	1.1	0.11
	Chlorophyll *a* (µg/L)	1.3	1.4	0.23
	Secchi depth (m)	6.3	8.6	0.08
Total zooplankton:				
	Density (#/m^3)	4749	7904	**0.049**
	Size (mm)	0.64	0.68	0.21
	Biomass (mg dw/m^3)	11.9	21.2	0.08
Group biomass (mg dw/m^3):				
	Bosminids	1.8	1.4	**0.035**
	Daphnids	2.4	3.3	0.90
	Calanoid copepods (excluding *Limnocalanus*)	4.1	5.5	0.62
	Cyclopoid copepods	1.0	8.7	**0.002**
	Other cladocerans (excluding *Holopedium*)	0.4	0.2	**0.007**
	Cercopagis pengoi	0.5	1.6	0.86
	Bythotrephes longimanus	0.2	0.3	0.26
	Holopedium gibberum	1.0	0.1	0.15
	Limnocalanus macrurus	0.4	0.2	**0.023**

Table 3. Results of regression analyses performed on data from two time stanzas in Lake Ontario's offshore (2000 – 2018 and 2005 – 2018) and for three time stanzas in Lake Ontario's nearshore (1995 – 2018, 1995 – 2004, and 2005 – 2018). Paucity of data precluded analysis of the offshore 1995 – 1999 time period. SRP data were available from 1998 – 2018 in both habitats. TP data were available from 2001 – 2018 and Secchi depth from 1995 – 2018 in the offshore. Trends are indicated by (+) or (-). Significant p-values (p=<0.05) are indicated in bold. Marginal p-values (p<0.10) are indicated in italics. ns=not significant. Change is the slope of the linear regression (units of change match the units of each parameter). Zooplankton group biomass could not be normalized; Spearman rank correlation was used on those data, but change reported is the slope of the linear regression. Change point analyses were performed on 2000 -2018 in the offshore and 1995 – 2018 in the nearshore. **change point performed on ranks due to outliers.

	Regression						Change Point Analysis
Offshore	2000 – 2018	Change			2005 – 2018	Change	2000 - 2018
April/May – Oct SRP (µg/L) (1998 – 2018)	ns				ns		no breaks
Spring TP (µg/L) (2001 – 2018)	ns				ns		no breaks
Summer Secchi Depth (m) (1995 – 2018)	**(+) p=0.016**	**0.1**			*(+) p=0.06*	*0.2*	no breaks
Summer chlorophyll *a* (µg/L)	ns				ns		no breaks
Summer epilimnetic zooplankton density (#/L)	**(-) p=0.029**	**1463**			*(+) p=0.0529*	*1068*	(-) 2005
Summer epilimnetic zooplankton biomass (µg/L)	**(-) p=0.028**	**2.5**			ns		(-) 2005
Summer epilimnetic zooplankton group biomass							
Bosminids	ns				ns		(-) 2004
Bythotrephes longimanus	ns				ns		no breaks
Calanoid copepods	ns				ns		no breaks
Cercopagis pengoi	ns				**(-) p=0.013**	**0.3**	no breaks
Cyclopoid copepods	ns				ns		(-) 2005, (+) 2013
Daphnids	ns				**(+) p=0.047**	**0.3**	**no breaks
Other Cladocerans	ns				ns		no breaks
Limnocalanus	ns				ns		**no breaks
Holopedium	ns				ns		**no breaks

	Regression						Change Point Analysis
Nearshore	1995 - 2018	Change	1995 - 2004	Change	2005 – 2018	Change	1995 -2018
April/May – Oct SRP (µg/L) (1998 – 2018)	ns		ns		ns		no breaks
Spring TP (µg/L)	ns		ns		ns		no breaks
Summer Secchi Depth (m)	ns		**(+) p=0.0009**	**0.1**	ns		no breaks
Summer chlorophyll *a* (µg/L)	ns		**(+) p=0.003**	**0.1**	ns		(-) 2010, (+) 2016
Summer epilimnetic zooplankton density (#/L)	**(-) p=0.0001**	**2076**	**(-) p=0.0102**	**6103**	ns		(-) 1998, (-)2005
Summer epilimnetic zooplankton biomass (µg/L)	**(-) p=0.0006**	**3.5**	**(-) p=0.0191**	**11.9**	ns		(-) 1998
Summer epilimnetic zooplankton group biomass							
Bosminids	**(-) p<0.0001**	**0.8**	ns		ns		**(-) 2005, (+) 2011
Bythotrephes longimanus	**(+) p=0.026**	**0.004**	ns		ns		**(-) 2002, (+) 2006
Calanoid copepods	ns		ns		**(-) p=0.009**	**0.3**	(+) 2007, (-) 2012
Cercopagis pengoi	ns		**(+) p=0.014**	**0.3**	ns		no breaks
Cyclopoid copepods	**(-) p<0.0001**	**2.1**	**(-) p=0.005**	**8.0**	ns		(-) 1998, (-) 2005, (+) 2013
Daphnids	**(-) p=0.003**	**0.7**	ns		ns		no breaks
Other Cladocerans	ns		**(-) p=.009**	**0.1**	ns		no breaks
Limnocalanus	ns		ns		ns		**no breaks
Holopedium	**(+) p=0.003**	**0.2**	**(+) p=0.005**	**0.5**	ns		no breaks

Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1976-2018

M.J. Connerton and C.D. Legard

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

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 2018 abundance indices as they relate to previous years.

Methods

A standardized, stratified random design gillnetting assessment was conducted annually from 1976 through 2018 in the New York waters of Lake Ontario's eastern basin to assess the warmwater fish community. Sampling was initiated as early as July 29 and completed as late as August 25, typically occurring during the first two weeks of August. Since 1980, standardized net gangs (nine 50 ft panels, 8 ft deep, and stretch-mesh sizes ranging from 2-6 in by ½ in increments) were set overnight, on bottom and parallel to depth contours at predetermined, randomly selected sample locations. Detailed assessment methods and corrections for 1980, 1989, and 1993 survey and gear design changes were described previously (Eckert 1986, 1998, and 2006). A net set was deemed biased when there was any indication of net fouling or tampering and data from that set were excluded from analyses. In 1993, gear changed from multifilament to monofilament gill nets and correction factors were determined, applied to multifilament catch data, and "monofilament equivalents" were calculated (Eckert 1998). The random survey design was stratified by three depth strata (Stratum 1: 12-30 ft; Stratum 2: 31-50 ft; Stratum 3: 51-100 ft) and five area strata (Grenadier Island, Chaumont Bay, Black River Bay, Henderson Bay, and Stony Island 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 2018, 29 randomly chosen netting locations were determined prior to initiation of the assessment on July 30 (Figure 1). From July 31 to August 9 we completed 27 unbiased net sets; two net sets were biased and not re-set. One net was not set because it was too cold and catch was assumed to be zero. 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 all 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 2003-2018, 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). Age interpretations have not yet been completed for 2017 and 2018 collections.

Results and Discussion

2018 Water Temperature

In 2018, bottom temperatures for all nets set in depth strata 1 (12-30 ft) and 2 (31-50 ft) ranged from 71.6°F to 77.1°F and 69.4°F to 76.6°F, respectively. In stratum 3 (51-100 ft), bottom temperatures at net set locations ranged from 50.0°F to 75.0°F. One planned set in stratum 3 was not set because temperature was 47.3°F. One unbiased net set in depth stratum 3 may have experienced some periods of water temperatures <50°F, given that six coldwater fish (lake trout) were captured in that net.

Species Richness and Composition

Since 1976, 44 fish species (33 warm/cool and cold water species) were captured during the eastern basin gillnetting assessment (Table 1). In 2018, 1,081 fish were captured in unbiased net sets, representing 16 warm and cool water species (1,063 fish) and five cold water species (18 fish). The greatest warm and coolwater species richness and CPUE (15 species; CPUE=76.0) occurred in depth stratum 1, followed by depth strata 2 (13 species; CPUE=40.7) and 3 (4 species; CPUE=8.9). The lowest warm and cool water species richness and catch typically occurs in depth stratum 3 (Eckert 2006). In 2018, five coldwater species were also captured in stratum 3.

Dominant species in the catch has changed over time (Figure 2). 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 (2018) most commonly caught species over the last five years, primarily due to changing catches of other species (Figure 2). Each year since 1986, smallmouth bass was the most or second most commonly caught species. In 2018, yellow perch was the most commonly caught species (34.1% of total catch) and smallmouth bass was the second most commonly caught species (24.1% 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 (see Weidel et al 2019 for index). 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 2000-2018. 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 2014-2017, 71.7% - 78.9% of non-empty bass stomachs contained goby. In 2018, 41.4% of the 111 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 1995-2018, at least one sturgeon was collected in 18 of the 24 years (nine captured in 2018), suggesting improved population status. Improved status is likely attributable to restoration efforts (e.g., stocking and habitat improvement; Klindt and Gordon 2019).

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; Connerton and Eckert 2019). 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 2-6). By 1984-1986, catch of these species declined nearly 80% (Table 1, Figures 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 3). Mean stratified CPUE for total warmwater fish remained at a low and variable

level through the mid-2000s (Table 1, Figure 3). 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 (Lantry 2018). Below average eastern basin water temperatures during those years may have influenced fish distribution and production, contributing to reduced catches. In 2018, the mean stratified CPUE of 28.9 was a 19% increase from the previous 5-year average.

Other species that influenced fish community trends in the eastern basin were alewife (*Alosa pseudoharengus*), walleye, and smallmouth bass (Figure 2). Alewife was relatively common in the assessment and varied without trend through 1988 before declining to low levels (Table 1, Figure 8). Walleye catches increased from low levels observed prior to the mid-1980s (Figure 9). 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 10). 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 11-17).

White Perch Index of Abundance

The most notable declines in species abundance between the late 1970s and mid 1980s occurred with white perch and gizzard shad, the two most abundant species in 1977 and 1978. White perch declined 83% from the 1976-1979 to 1984-1986 time periods (Table 1, Figure 4). 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 2018, white perch CPUE was 4.9, similar to the previous ten-year average.

Yellow Perch Index of Abundance and Size

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 5). 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 (Lantry 2018). 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 2018, yellow perch CPUE declined 35% compared with 2017 to 9.9 fish per net night, which is similar to (-3.5%) the previous 10-year average.

Variability of yellow perch catch in gill nets is relatively high (long-term average RSE=37.4%) when compared to smallmouth bass (long-term average RSE=20.8%), and is likely attributable to the schooling nature of perch. In 2018, yellow perch RSE (27.7%) was 26% lower than the long-term average.

In 2018, yellow perch total length ranged between 6.9 in (175 mm) and 12.9 in (325 mm), and averaged 8.7 in (221 mm). Approximately 32.7% of perch captured were $\geq$ 9 in ($\geq$ 228.6 mm; Figure 18). Weight of yellow perch captured in 2018 ranged from 2.5 oz (70.0 g) to 1.1 lb (489.0 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 6). 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 relatively lower, with CPUEs of zero or <1 in 23 of the 26 years from 1987-2012 (Table 1), representing less than an average of 0.5% of the catch (Figure 2). 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 (Lantry 2018). From 2013-2017, gizzard shad CPUE averaged 1.4 fish per net night and represented an average of 5.5% of the total CPUE of warm water species. In 2018, gizzard shad CPUE was 25.9% above the previous 5-year average (CPUE=1.78), and was the fourth most commonly caught species representing 6.1% of the total CPUE (Figure 2).

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 was relatively stable since 2011 (Figure 7). In 2018, rock bass CPUE (0.5) declined and was 57.2% below the previous 5-year average.

Alewife Index of Abundance

Alewife CPUE varied without trend through 1988, averaging 9.0 (Figure 8). CPUE then declined and was ≤1 each year 1993-2008. In 2009, alewife CPUE (1.2) was the highest observed since 1992, but well below levels observed through the 1970s and 1980s. Catch of alewife has been consistently low since the mid-1990s (2018 CPUE = 0.0 fish per net night).

Walleye Index of Abundance and Size

Walleye is the only relatively common species that increased in abundance since the assessment was initiated in 1976 (Figure 9). 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 9). The 2018 CPUE of 1.2 was 16.5% below the previous 5-year average. Variability of gill net catches was highest when CPUE was low (Figure 9) with RSE averaging 44.6% during 1980-1989. RSE fluctuated at a lower level without trend from 1990-2018 (average RSE=26.7%).

Walleye total length ranged between 12.7 in (323 mm) and 29.5 in (750 mm) and averaged 22.9 in (582 mm; Figure 18). Walleye weight ranged from 10.8 oz (307 g) to 10.1 lb (4945 g) and averaged 5.4 lb (2,429 g).

Age interpretations of samples collected in 2017-2018 have not been completed; however 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 based on previous otolith interpretations (Lantry 2018). Fall bottom trawling in the Bay of Quinte indicated that strong year classes were also produced there in 2011, 2014, 2015, and 2018 (OMNRF 2019).

Smallmouth Bass Index of Abundance

Smallmouth bass have provided an important sport fishery in Lake Ontario's eastern basin for decades (Jolliff and LeTendre 1967, Panek 1981, NYDEC 1989, McCullough and Einhouse 1999, McCullough and Einhouse 2004). 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 and remained near record-low levels during 2000-2004 (2000-2004 mean CPUE=4.2; Figure 10). DCC management was initiated in 1999 and management plan objectives were met by 2006 (McCullough and Mazzocchi 2016).

The index of abundance for Lake Ontario's eastern basin smallmouth bass population improved during 2005-2013 compared to the 2000-2004 record

lows; however, those levels were lower than expected following achievement of DCC population management objectives (Lantry 2018). 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 (Lantry 2018). The production of poor to weak year classes since 2005 resulted in the low CPUEs observed 2014 through 2016 (Lantry 2018). CPUE in 2017 (CPUE = 6.8) was only 18.4% higher than the 2000-2004 time period. Smallmouth bass CPUE in 2018 (7.4 fish per net night) improved 51.6% compared to the 2014-2016 time period but remained 15.3% below the 2005-2013 time period.

A number of other factors can impact bass recruitment including water temperature, 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 disease outbreaks (Lantry 2018). For example, below average summer water temperatures in 2014 and 2015 likely resulted in two recent years of poor reproduction (Lantry 2018). Increased Cladophora growth in nearshore areas may impact the condition of spawning habitat and consequently bass recruitment; however, these 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 anomola* (bloody red shrimp; first documented in 2006). Additional stressors including Type-E Botulism (early to mid-2000s), and Viral Hemorrhagic Septicemia virus (VHSv; 2005 with a major NY outbreak effecting bass in 2006) have caused bass die-offs in Lake Ontario's main basin and eastern basin and in the St. Lawrence River. 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.

Factors confounding comparisons of recent data to historic data include increased smallmouth bass growth resulting in accelerated recruitment to assessment gear, and earlier maturation that may be affecting bass longevity, as discussed in detail by Lantry (2018). Lake Ontario's eastern basin bass population experienced changes in growth rates from 1976-2018 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). Bass are not fully vulnerable to assessment nets until approximately 12 in TL. Prior to the mid-1990s, smallmouth 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 10; Lantry 2018). By the mid to late 1990s age-specific annual mean TLs were generally above age-specific long-term means for all ages (Lantry 2018). Mean length-at-age continued to increase following establishment of round goby in the system and in smallmouth bass diets. By the mid-2000s, gill nets could effectively sample many age-2 and age-3 bass, and likely all age-4 bass. 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 (Lantry 2018). Correcting gill net catch data for the change in selectivity by age in future analyses may lead to a better understanding of eastern basin smallmouth bass population dynamics. 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).

Smallmouth Bass Size and Condition

In 2018, smallmouth bass total length ranged between 7.2 in (184 mm) and 20.9 in (532 mm) and averaged 13.1 in (334 mm; Figure 18). Smallmouth bass weight ranged from 2.9 oz (81 g) to 6.5 lb (2933 g) and averaged 1.8 lb (801 g).

Condition of smallmouth bass in the eastern basin began increasing in the mid-2000s (Figure 19). This coincided with a shift from a diet dominated by crayfish, 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 19). Condition of bass in 2018 remained good and within the range of values observed in recent years (Figure 19). 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 suggests that bass are not currently limited by prey availability.

Mean relative weight, another indicator of condition, 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 20). Each year beginning in 2006, mean relative weight exceeded 105 (2006-2017 average=107.7; Figure 20) 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 21). Prior to 1991, no smallmouth bass > 4 lbs were caught. The first smallmouth bass ≥ 4 lbs was caught in 1992 (0.2% of total [n=483] catch). Beginning in 1998, smallmouth bass ≥ 4 lbs were caught with increasing regularity. In 2017, 22.4% of smallmouth bass caught weighed ≥ 4 lbs which was the highest percentage on record (n=245; Figure 21). In 2018, 12.0% of smallmouth bass caught weighed ≥ 4 lbs (n=283). Smallmouth bass weighing ≥ 5 lbs were first caught in 1999 and have been caught each year since 2005. After increasing in 2017 to the highest recorded (7.8% of all bass caught), the percentage of bass weighing > 5 lbs in 2018 dropped to 3.9%. smallmouth bass ≥ 6 lbs were first caught in the 2005 survey (0.2% of total smallmouth bass caught) and then again in 2011. Each year from 2011-2017, 0.3-1.2% of smallmouth bass caught weighed more than 6 lbs (1.1% in 2018). These increases are most likely attributed to good growth and condition and not increased abundance of older aged bass (Lantry 2018).

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Table 1. Stratified mean catch per unit effort data from the 1976-2018 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 1976-2018 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 1976-2018 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	2018
Lake Sturgeon	0.04	0.02	0.02	0.09	0.10	0.00	0.00	0.08	0.02	0.00	0.02	0.00	0.06	0.05	0.09	0.20
Longnose Gar	0.00	0.06	0.17	0.12	0.08	0.10	0.21	0.75	0.62	0.02	0.23	0.44	0.67	0.00	0.00	0.26
Bowfin	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
American Eel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alewife	0.08	0.00	0.00	0.07	0.14	0.19	1.19	0.00	0.16	0.46	0.00	0.31	0.47	0.02	0.09	0.00
Gizzard Shad	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.12	0.19	2.08	0.32	1.09	0.70	2.83	1.77
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	0.00	0.00
Chain Pickerel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
Muskellunge	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Goldfish X Carp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Carp	0.02	0.15	0.14	0.11	0.02	0.05	0.10	0.02	0.02	0.00	0.15	0.11	0.05	0.08	0.07	0.12
Golden Shiner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Spottail Shiner	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Quillback	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.02	0.02	0.03	0.02	0.03
Longnose Sucker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
White Sucker	1.66	0.41	1.03	0.72	0.57	0.65	1.31	0.48	0.25	2.35	0.19	0.16	0.57	0.22	1.17	0.44
Silver Redhorse	0.10	0.42	0.33	0.02	0.02	0.08	0.07	0.04	0.00	0.06	0.06	0.00	0.00	0.05	0.05	0.00
Shorthead Redhorse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.52
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	0.03
Stonecat	0.00	0.00	0.06	0.02	0.00	0.00	0.00	0.04	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Trout-perch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	4.89
White Bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	0.56
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	0.41
Bluegill	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
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	7.25
Largemouth Bass	0.00	0.02	0.02	0.02	0.00	0.00	0.03	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
Black Crappie	0.00	0.02	0.06	0.00	0.04	0.05	0.03	0.04	0.04	0.02	0.06	0.02	0.00	0.00	0.23	0.00
Yellow Perch	9.82	6.74	8.93	9.13	13.95	16.91	7.37	16.31	15.29	14.99	10.32	1.70	0.82	3.15	15.21	9.85
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	1.19
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	1.30
Round Goby	0.00	0.00	0.04	0.10	0.26	0.42	0.95	0.36	0.08	0.07	0.02	0.00	0.00	0.06	0.07	0.02
Total	22.92	19.10	31.36	28.16	25.60	44.36	31.44	37.84	30.73	32.02	33.09	20.62	14.92	16.52	36.08	28.68

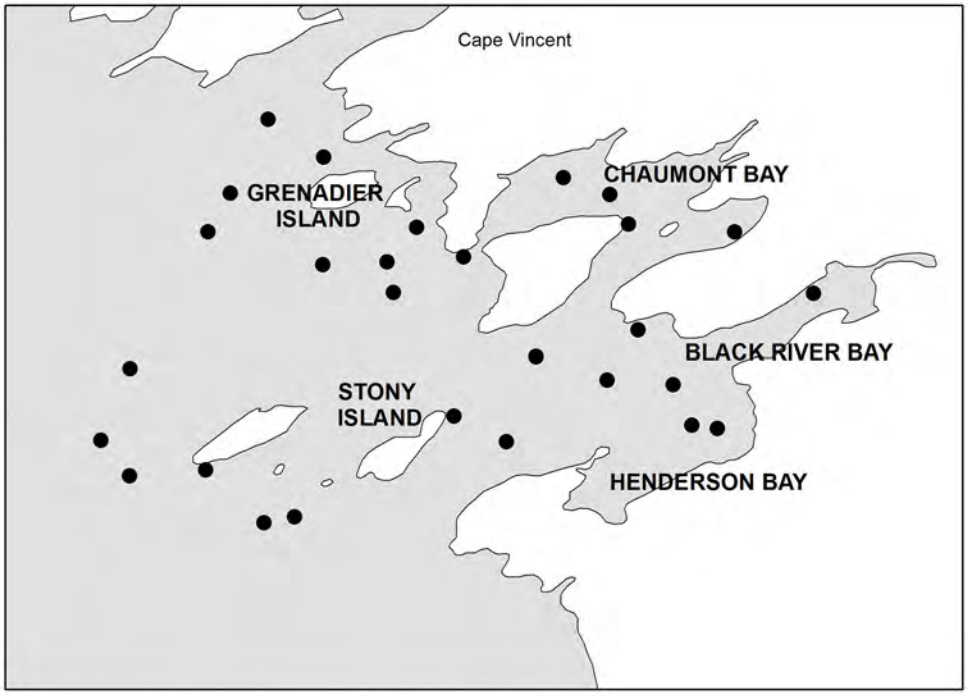

Figure 1. Map of New York waters of Lake Ontario's eastern basin showing five area strata used in the 1980-2018 warmwater assessment, and locations (black dots) of nets set in 2018.

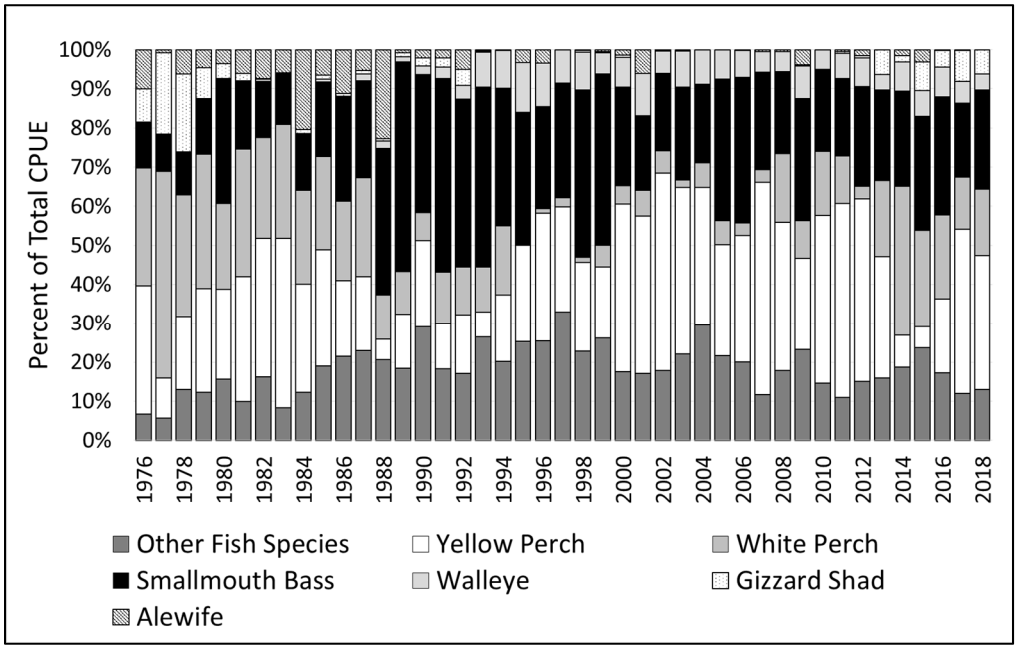

Figure 2. Species composition of warmwater species caught from 1976-2018 in the Lake Ontario eastern basin warmwater assessment.

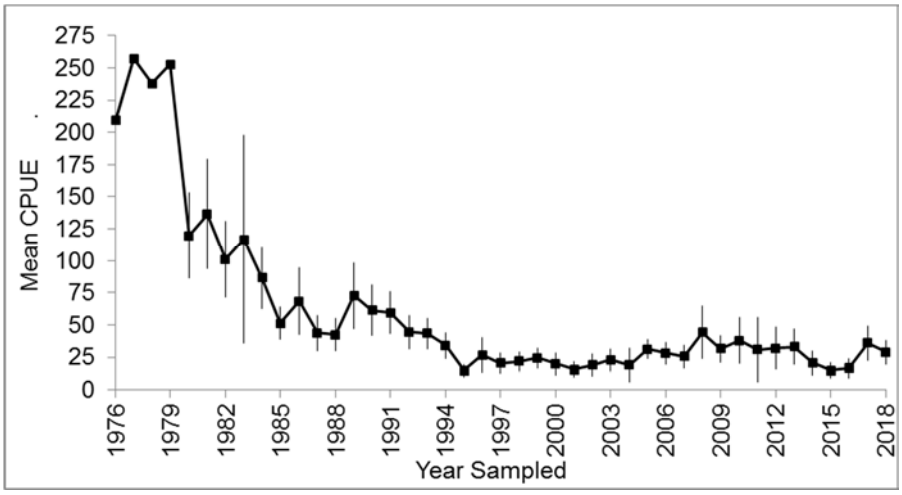

Figure 3. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for all warmwater fish, 1976-2018.

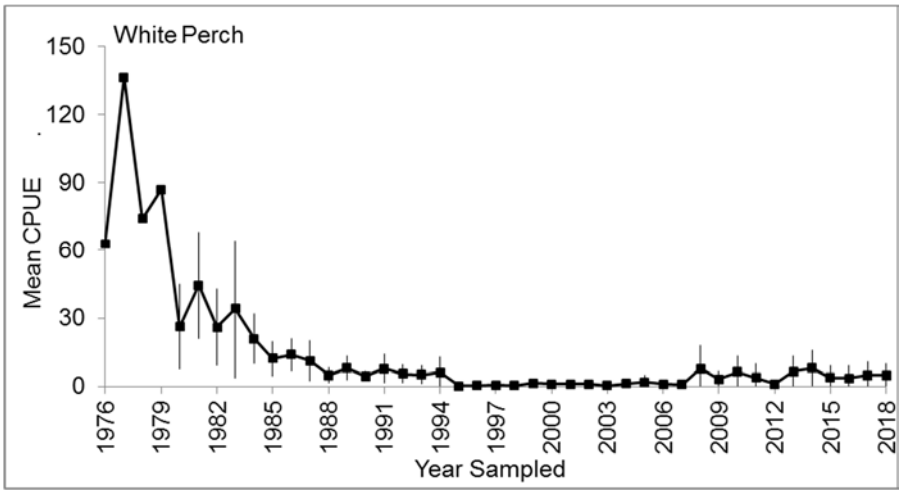

Figure 4. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for white perch, 1976-2018.

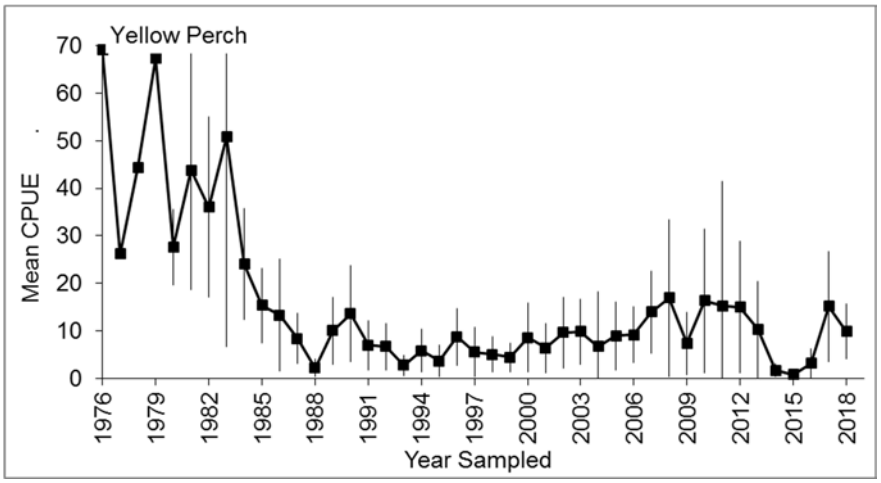

Figure 5. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for yellow perch, 1976-2018.

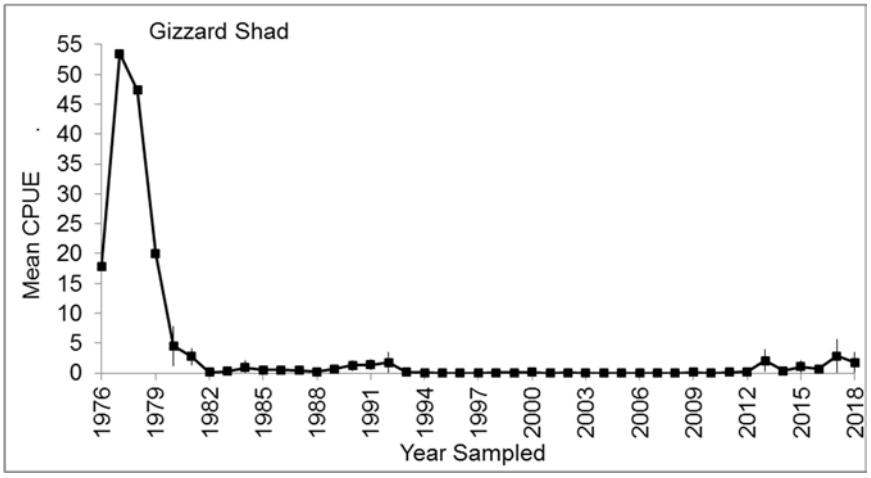

Figure 6. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for gizzard shad, 1976-2018.

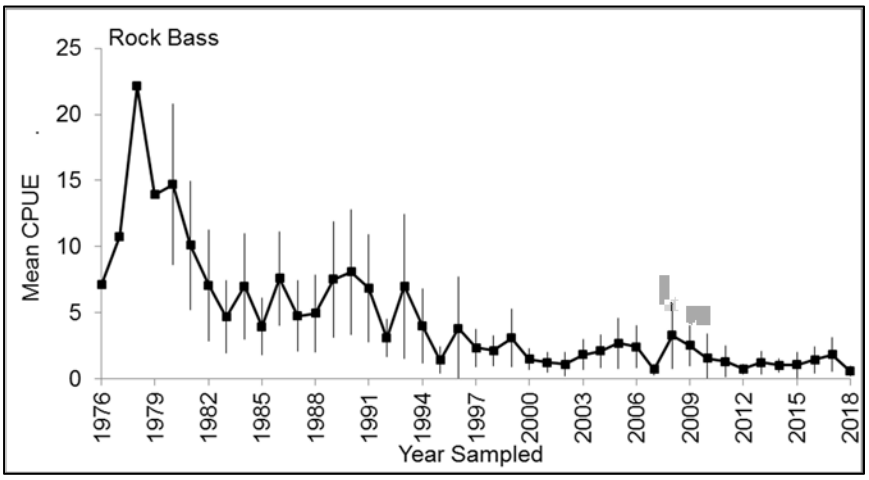

Figure 7. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for rock bass, 1976-2018.

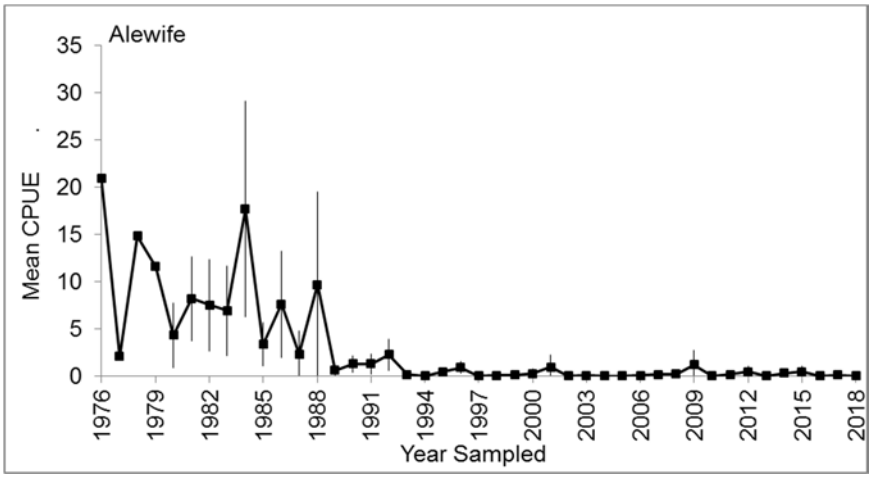

Figure 8. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for alewife, 1976-2018.

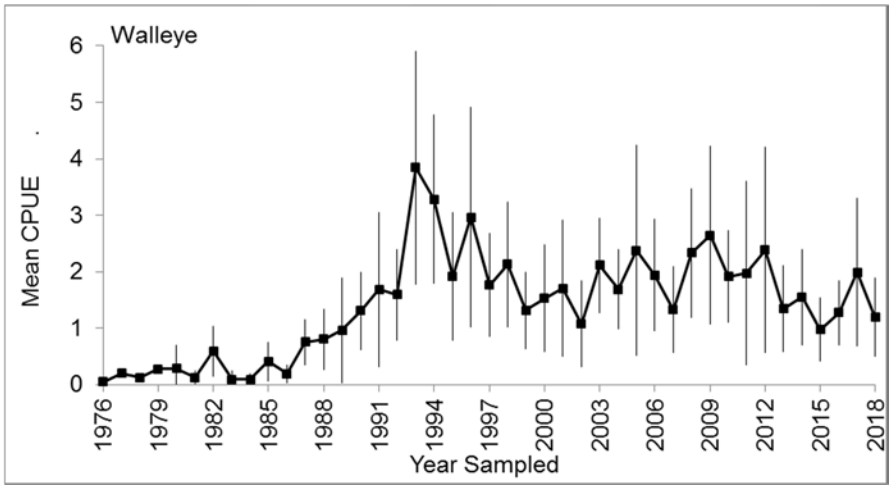

Figure 9. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for walleye, 1976-2018.

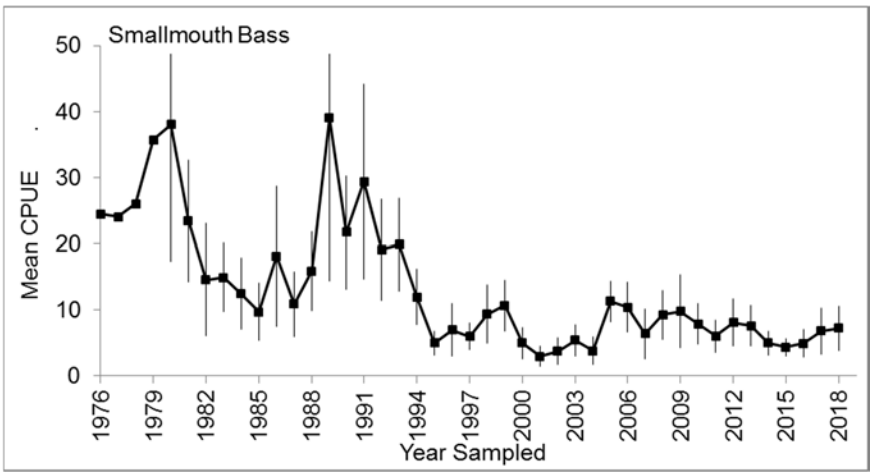

Figure 10. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for smallmouth bass, 1976-2018.

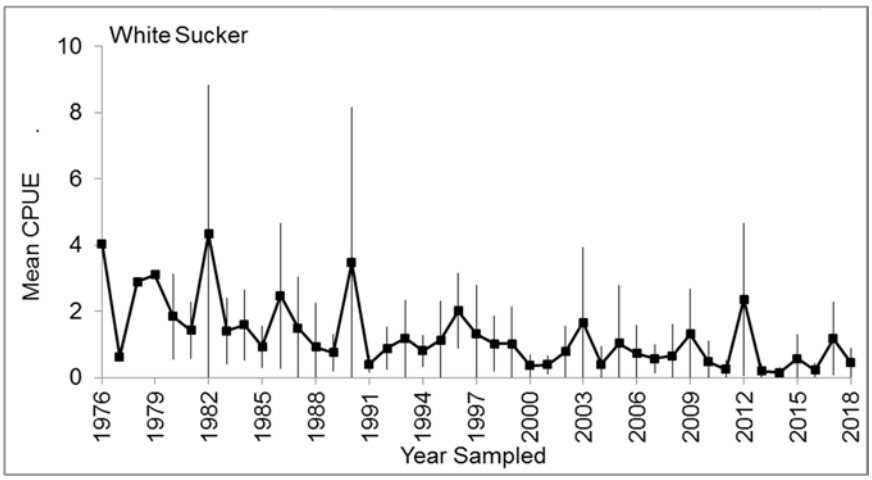

Figure 11. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for white sucker, 1976-2018.

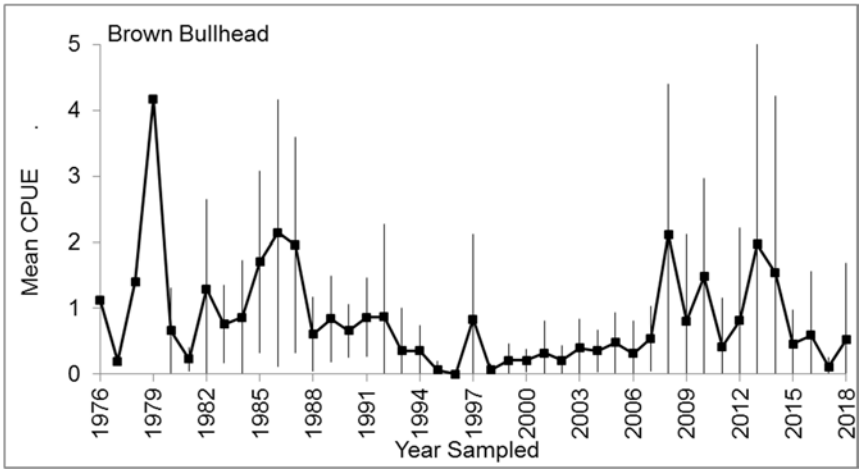

Figure 12. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for brown bullhead, 1976-2018.

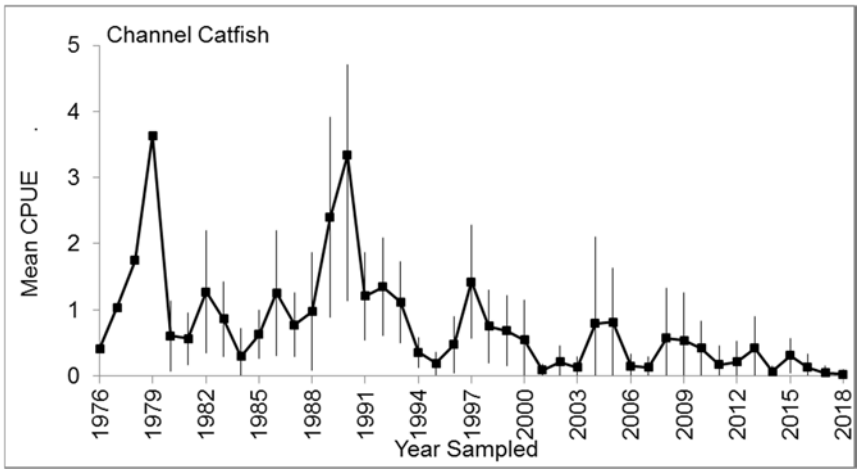

Figure 13. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for channel catfish, 1976-2018.

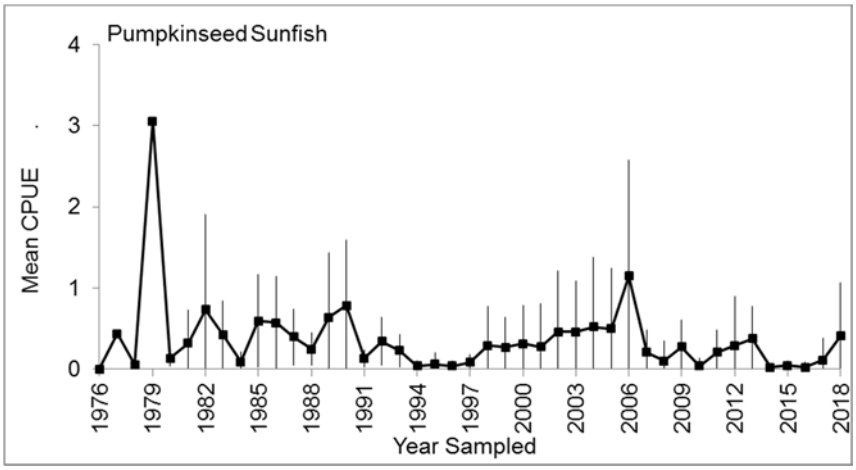

Figure 14. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for pumpkinseed sunfish, 1976-2018.

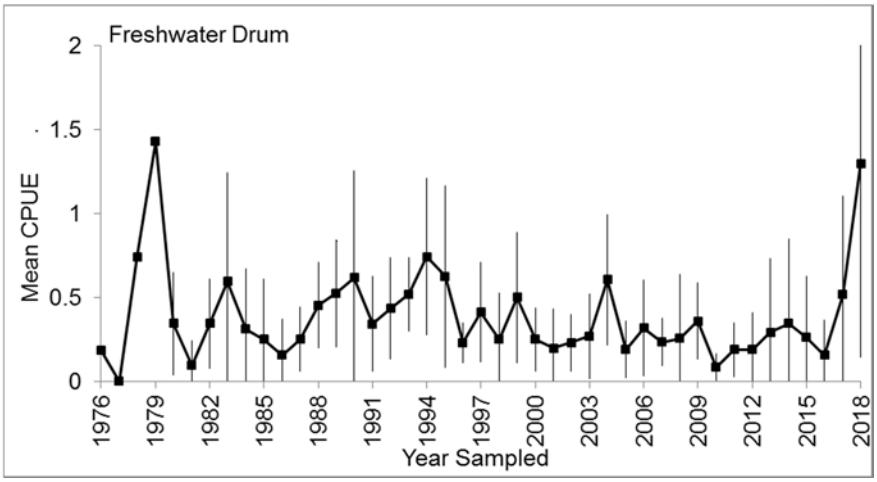

Figure 15. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for freshwater drum, 1976-2018.

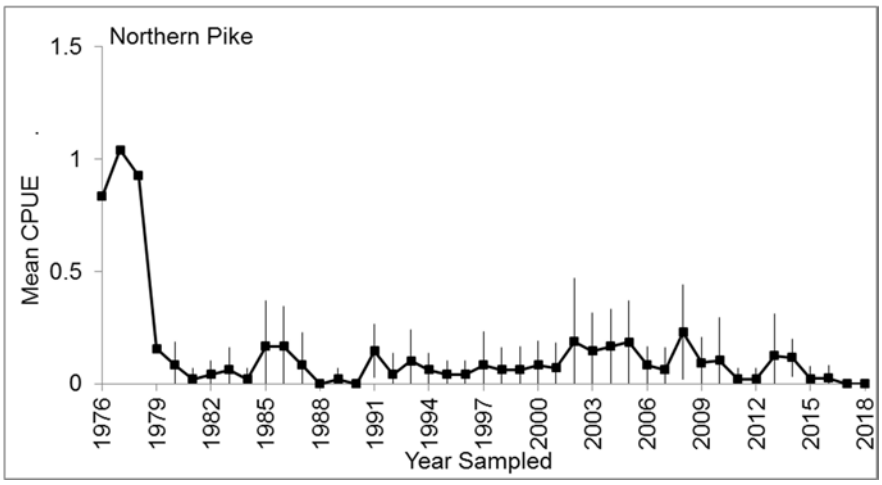

Figure 16. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for northern pike, 1976-2018.

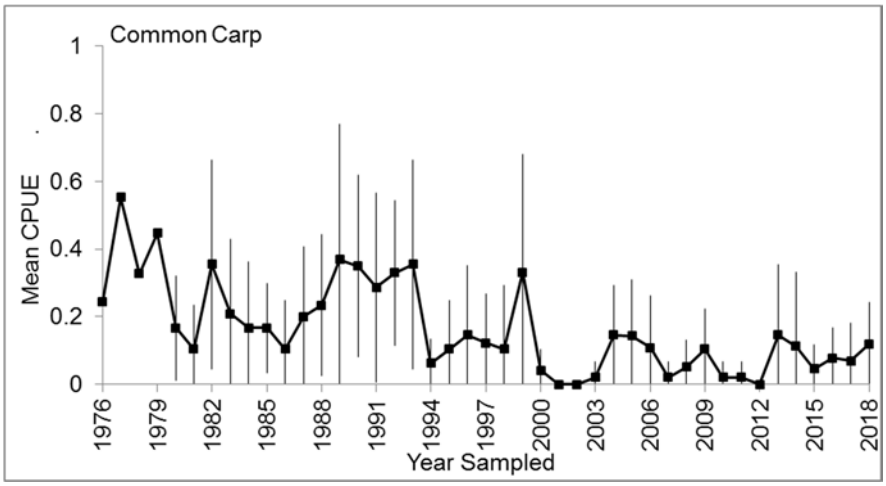

Figure 17. Stratified mean catch per 450 ft gill net gang (CPUE) and 95% confidence intervals for common carp, 1976-2018.

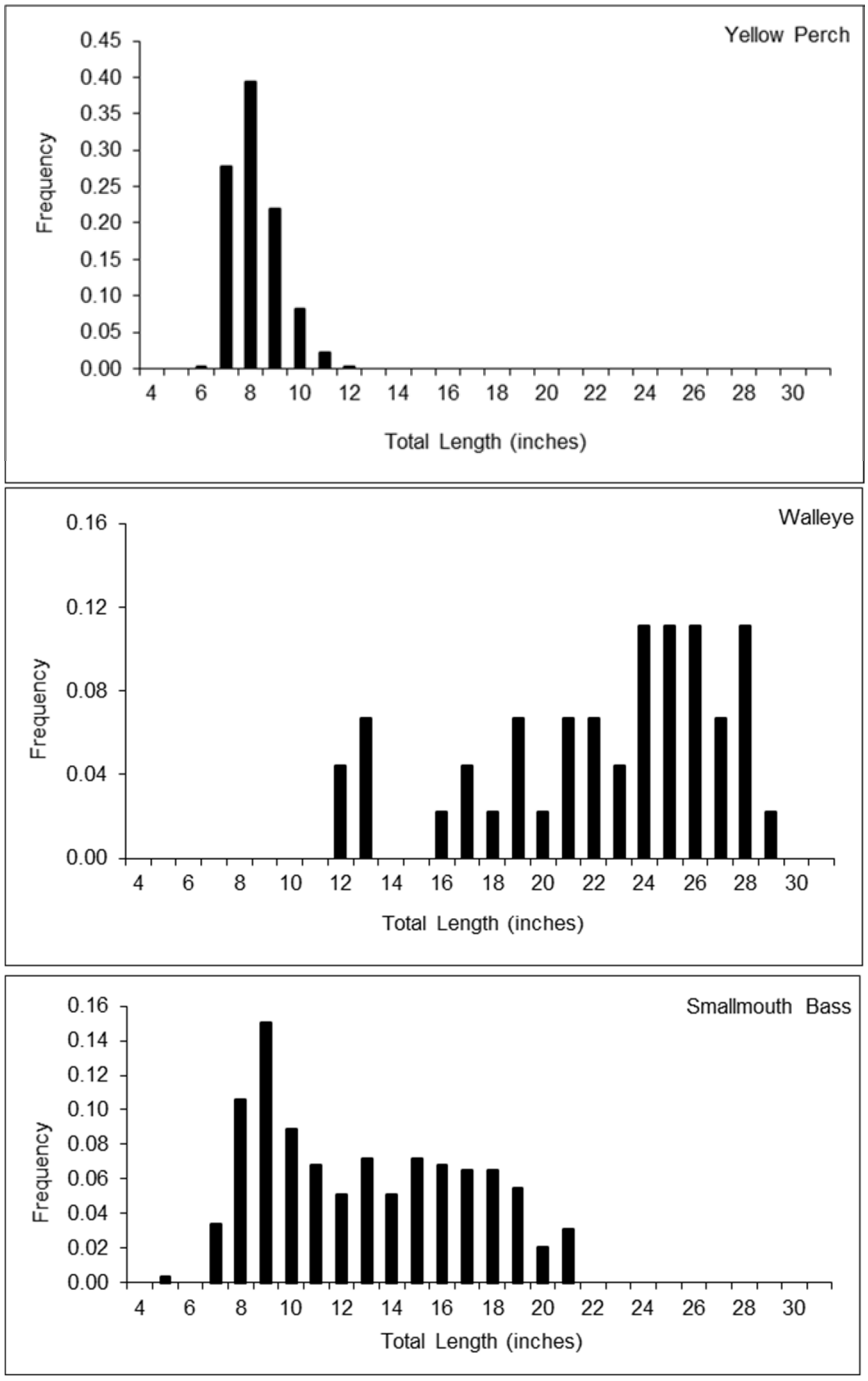

Figure 18. Length frequency distribution of yellow perch, walleye, and smallmouth bass collected during the eastern basin warmwater assessment in 2018.

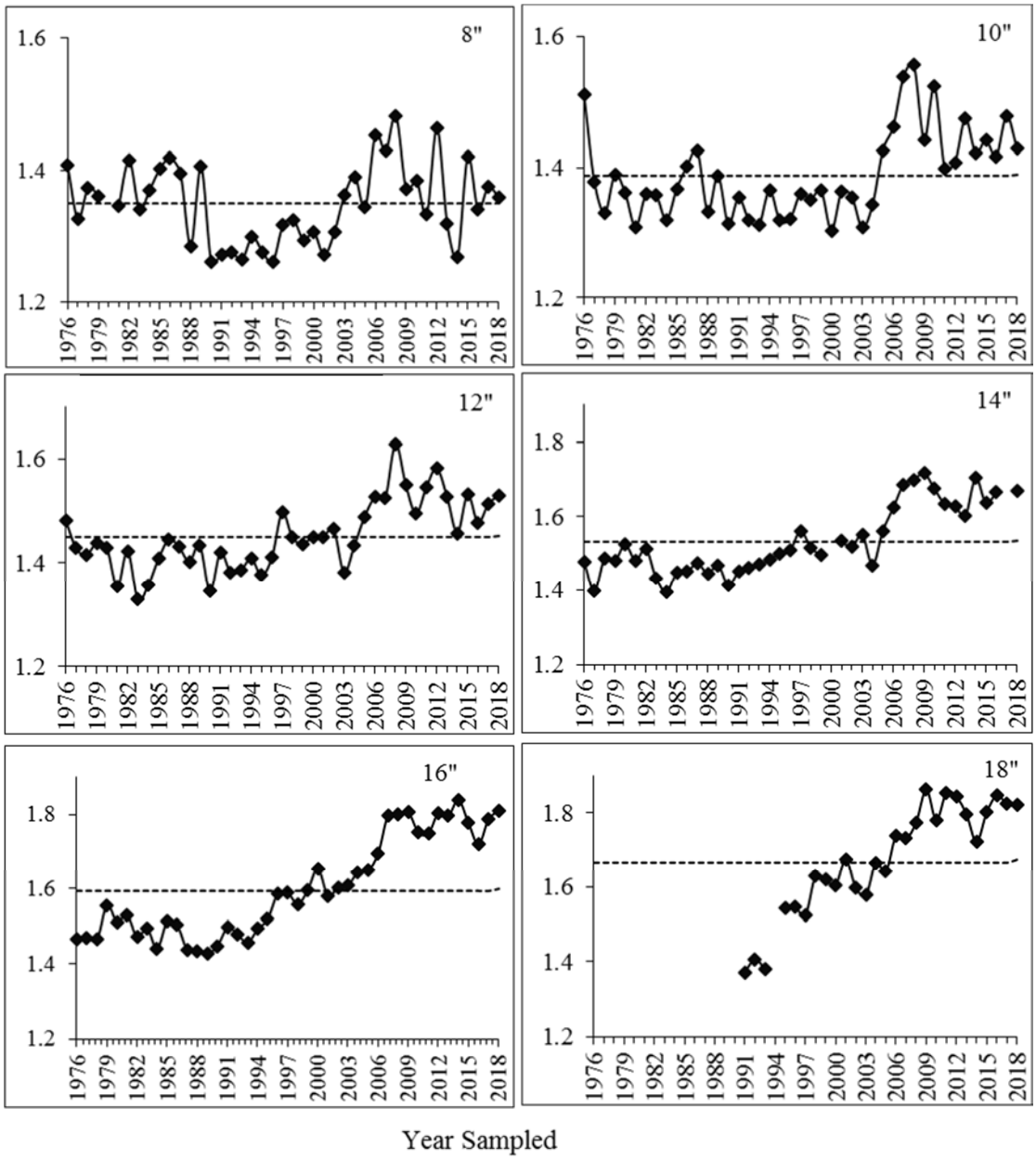

Figure 19. Mean condition (8-18 inches in 2-inch increments) by year sampled (1976-2018) for smallmouth bass collected during the eastern basin warmwater assessment. Dashed line represents the long-term mean condition for the respective length increment.

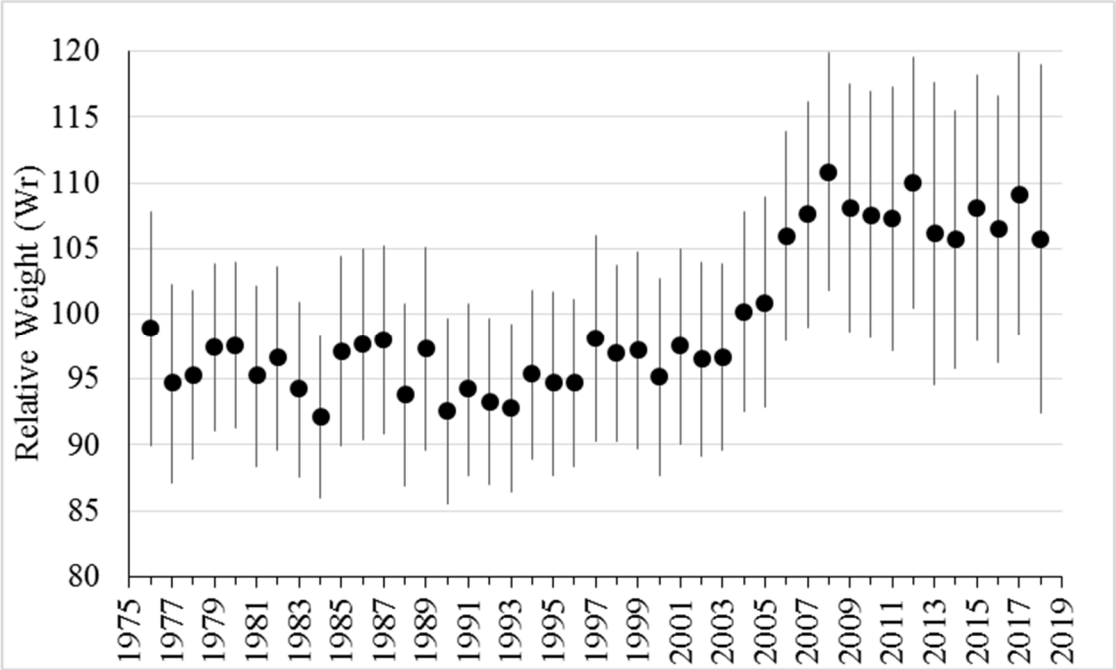

Figure 20. Mean relative weight of smallmouth bass caught in the eastern basin warmwater assessment (1976-2018) (± 1 standard deviation).

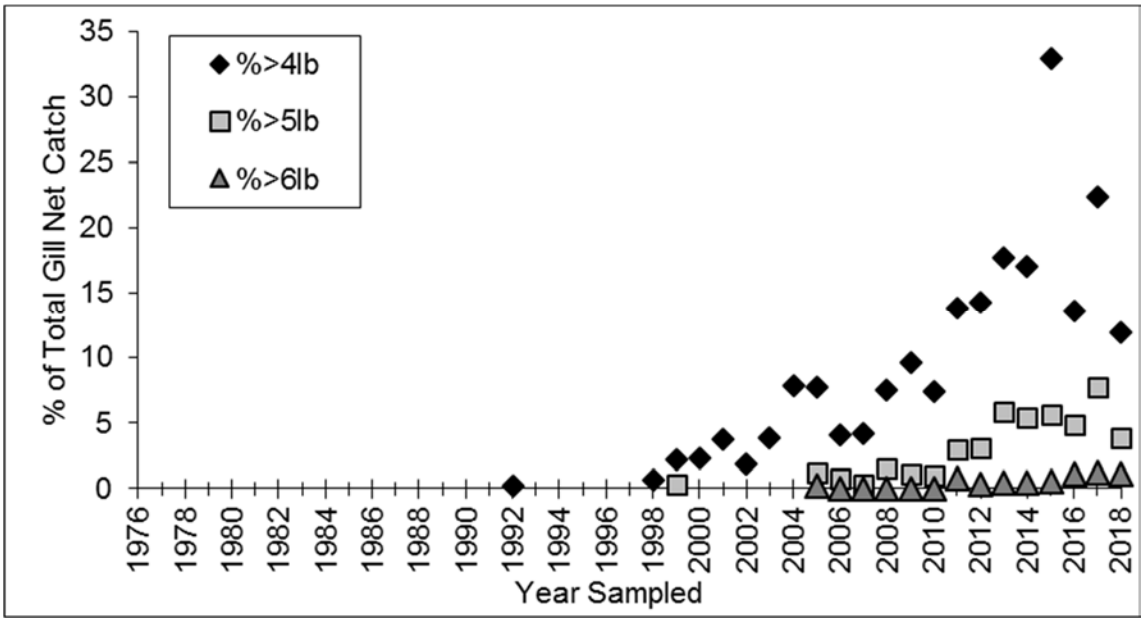

Figure 21. Percentage of total smallmouth bass catch during the eastern basin warmwater assessment (1976-2018 catches) that were ≥4lb, ≥5lb, and ≥6lb.

Lake Trout Rehabilitation in Lake Ontario, 2018

B. F. Lantry, S. L. Furgal
U.S. GEOLOGICAL SURVEY (USGS)
Oswego, NY 13126

M. J. Connerton
NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION (NYSDEC)
Cape Vincent, NY 13618

Dimitry Gorsky
U.S. FISH AND WILDLIFE SERVICE(USFWS)
Basom NY, 14013

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 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 2018 adult abundance increased by 51% over the 2017 value. The 2018 rate of wounding by sea lamprey (Petromyzon marinus) on lake trout caught in gill nets (0.61 A1 wounds (fresh wound) per 100 lake trout) was below target (2 wounds per 100 lake trout). Estimates from the NYSDEC fishing boat survey indicated angler catch rate of lake trout was low in 2018 and among the lowest recorded for the time series. 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 1983-2018 time series. 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 in 2017 from low values observed during 2015-2016 and remained relatively high in 2018. Reproductive potential for the adult stock indexed from the CPUE of mature females ≥ 4000g was again above the target in 2018 continuing a trend observed in nine of the last ten years. The 2018 catch of young native lake trout marked the 24th observation in the last 25 years, however the low numbers of native adults observed during that time period continues to indicate substantial restoration impediments still exist.

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. This report documents progress towards restoration by reporting on management plan targets and measures through 2018.

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 2018 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 1983-2018, 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 2018, NYSDEC R/V Seth Green fished standard monofilament gill nets for adult lake trout at 7 of the 14 geographic locations From Rochester to Cape Vincent along the U.S. shore in Lake Ontario. The USGS R/V Kaho was unavailable for most of the survey due to mechanical breakdowns, but was able to fish one location near Olcott, N.Y. at the western end of the U.S. shoreline. 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 six 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 three nets were fished between 26 m and 42 m (85.3 – 437.8 ft); and in the St. Lawrence Channel three nets were fished between 32 to 51 m (105.0 – 167.3 ft).

For all lake trout captured, total lengths and weights were measured, body cavities were opened, and prey items were removed from stomachs, identified, 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 linear 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, six year-classes of the Klondike (SKW) strain lake trout (2008, 2013-2017) 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. Thus, we included SKW in the population calculation of age-6 Fulton's K. No age-6 SKW were in the lake in 2018.

In past reports, 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 using length-fecundity relationships, and by accounting for observed differences in mortality rates among strains (Lantry et al. 2018). CPUE of mature females >3999g and egg indices were generally very well correlated from 1983-2017 (Figure 10, Lantry et al. 2018). In this year's report we used Pearson correlation to examine the correspondence between the two trends and only present female CPUE >3999 g to index reproductive potential.

Creel Survey

Catch and harvest by anglers fishing from boats on Lake Ontario 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 Harbor in the eastern basin (Connerton and Eckert 2019). 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, 1985-2018.

Juvenile Trawl Survey

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 - 2017. In 2018, the R/V Kaho was unavailable and the R/V Seth Green only conducted trawling at 3 locations in the eastern portion of the lake during July 2 - 11. In this year's report, because of the greatly reduced survey effort, we report only on juvenile condition and the catch of naturally reproduced lake trout. For full description of survey design and changes see Lantry et al. (2018).

Data collection from trawl-captured lake trout was the same as that described above for fish captured with gill nets. 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 for 1981 – 2017 survey catches, we used the predicted weight of a 400-mm (15.8 in) fish caught in July bottom trawl surveys. 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. During 2018 only one age-2 lake trout was captured in the trawl survey. To index condition for 2018 juvenile lake trout, data from 54 fish 250-500mm TL caught in the September gillnet survey were used.

Results and Discussion

Stocking

From 1973 to 1977 lake trout stocked in Lake Ontario were raised at several NYSDEC and USFWS (Michigan and Pennsylvania) hatcheries with annual releases ranging from 0.07 million for the 1973 year-class to 0.28 million for the 1975 year-class (Figure 1). By 1978 (1977 year-class) the USFWS Alleghany National Fish Hatchery (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. stocking 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 26 years during 1993-2018 (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 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.

Production targets for the 2017 year-class were met by stocking a combination of four strains of yearling lake trout in 2018 including 40,405 LCD produced at ENFH, and 119,227 SEN, 118,729 SKW, and 79,439 HPW from ANFH (Figure 1). Barge stocking was planned in 2018 at five sites, but bad weather forced shore stocking at Sodus and Olcott (Connerton 2019).

Abundance of Age-3 and Older Lake Trout

A total of 507 lake trout were captured in 30 nets during the September 2018 gill net survey, resulting in a total CPUE of mature adults of 13.83 (Figure 2). 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 9.2% and 10.7% respectively, for the entire data series (Figure 3). The RSE for immature lake trout, however, rose by 115% between 2017 and 2018 due to the reduced numbers of nets fished, a higher mean CPUE, and an expanded range in catch totals that included the largest single catch of immature lake trout in one net (n = 32) since 1992. 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 coincided with a nearly two-fold increase in the rate of wounding by sea lampreys on lake trout (Figure 6) and were similar to the 1983-1984 CPUEs which pre-dated effective sea lamprey control. The CPUE of mature lake trout increased each year during 2008-2014, but then declined during 2015-2017. Adult abundance in 2017 was 35% below the 2014 peak and 17% below 1999-2004 average. Results from the reduced effort deployed in the 2018 survey indicated adult abundance rose by 51% over 2017 values and was nearly equivalent to the prior peak observed in 2014. To examine whether the increase observed in 2018 was an artifact of fishing at only eight of the normal fourteen survey locations, we examined CPUEs calculated using data from only those eight sites (reduced design) for the 2011 to 2018 surveys. Comparisons indicated CPUE values and patterns were similar between the reduced and full survey datasets and the increased CPUE in 2018 was not solely due to decreased effort (Figure 2).

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. Similar to adult values, the 2018 CPUE for immature fish from the reduced 2018 survey increased by 1.7-fold over the 2017 full survey value. Comparisons between the reduced and full survey results for 2011-2018 again indicated that the CPUE values and patterns for both effort levels were similar.

Schneider et al. (1997) established a target gillnet CPUE of 2.0 for sexually mature female lake trout ≥ 4,000 g reflecting the level of abundance at which successful reproduction became detectable in the early 1990s. Building off observations in last year's report that the trends in the mature female CPUE and the egg deposition index were similar (Lantry et al. 2018), we ran Pearson correlations for the two time series and found strong positive correlation (Pearson r = 0.741). In this report, we only present the CPUE of mature females to index population reproductive potential. The CPUE for mature females reached the target value in 1989 and fluctuated about that value until 1992 (Figure 4). 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 2010-2018, 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 (Lantry and Eckert 2018). Since 1988, managers instituted a slot size limit 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 5) 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 reaching the lowest levels in the NYSDEC Fishing Boat Survey data series in 2007. Harvest at that time was more than 97% below the 1991 estimate. This low point in harvest coincided with lower adult abundance in the index gillnetting survey (Figure 2). Good fishing quality for other salmonids (i.e., anglers targeted other salmonids more frequently) may also have led to lower catch and harvest of lake trout during this period (Lantry and Eckert 2018). After 2007, however, catch and harvest rates and total catch and harvest increased for six consecutive years, then

were relatively stable 2013-2016. Increases from 2007 through 2016 followed the October 2006 regulation change and coincided with an increase in lake trout abundance and anecdotal reports of anglers targeting lake trout more frequently during 2013-2016. Catch and harvest rates declined in 2017 and declined further in 2018 to 0.25 and 0.10 fish per boat trip, respectively resulting in lower total catch (12,205) and harvest (4,949) in 2018. Total harvest in 2018 was well below NY target harvest levels (i.e., <10,000 per year) set forth in the management strategy to maintain adequate adult survival (Lantry et al 2014). While catch and harvest totals have been low recently, relative to the late 1980s, catch and harvest rates increased to relatively high levels in 2015 and 2016 (e.g., catch rates were over 7.5 times higher than the 2007 record low). Catch rate in 2018 declined 73% from 2016; and was among the lowest recorded (7th lowest on record); however, it was still about 2 times higher than the lows observed in 2007 (Connerton and Eckert 2019). The 2017-2018 declines in lake trout catch, harvest, and catch and harvest rates coincided with good to excellent fishing quality for other trout and salmon species (especially Chinook salmon) which may have reduced fishing effort directed at lake trout in those years.

Sea Lamprey Predation

Percentage of A1 sea lamprey marks on lake trout (fresh wounds where the sea lamprey has recently detached) has remained low since the mid-1980s, however, wounding rates (Figure 6) 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 again thereafter and the 2017 and 2018 wounding rates (0.50 and 0.61, respectively) were 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 1980-1990 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 2003-2009 cohorts as all fish stocked during those periods 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. Population survival of the 2003-2008 were all above target and survival for the 2009 year-class was at target (0.60). 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 (2006-2009 year-classes) continued to be high (≥74%) and survival for 2008 year-class of LCDs (73%, ages 7 to 10) resembled their mostly SEN origins. Only one year-class of LCWs was stocked (2009) and seems to be experiencing lower survival (47%, age7-9) than the LCDs. Survival rates could not be calculated for the first large stocking of STWs (225K of the 2006 year-class) which disappeared from survey catches after age 8. Survival for the 2007 (36%, ages7-11) and

the 2008 (45%, ages 7-10) year classes of STWs appear low and similar to the early values for SUPs. Survival rates for SAW (53%, 2008 year-class, age 7-9 only) strains were also low and no SAWs were caught in 2018. The first stocking of Klondikes (SKW) occurred in 2009 with the release of the 2008 year-class which reached age-10 in 2018. SKW survival increased substantially from 64% (age 7-9) in 2017 to 72 % (ages 7-10) in 2018. Similarly, survival of SENs from the 2007 and 2008 year-classes increased from 81% and 76% in 2017 to 91 and 92% in 2018. Catches across most ages of SKWs and SENs increased substantially from 2017 to 2018 which seems to indicate there may have been a change in catchability rather than population abundance. This trend makes the survival increases for SKWs and SENs suspect with upcoming 2019 survey results needed to help explain these changes.

Growth and Condition

The predicted weight of a 700-mm lake trout (from length-weight regressions) decreased during 1983 to 1986 but increased irregularly from 1986 to 1996 and remained relatively constant through 1999 (Figure 7). 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 2016-2018 mean (3814.9 g, 8.4 lb) was at the highest level for the data series. The trend of improving condition through 1996 and from 2007 to 2018 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 whether age was the primary driver of recent condition changes we calculated annual means for Fulton's K for age-6 mature male lake trout which removed the effects of age and sex, (Figure 7). Values of K for age-6 males, however, followed a similar trend as predicted weights and indicated that age alone was not the sole 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. The 2018 K value exceeded the 2016 value and now was the second highest for the data series.

Similar trends occurred for the predicted weight of 400-mm lake trout and Fulton's K for an age-2 lake trout (Figure 8). The 1999 -2018 mean values for both were below the 1978-1998 means. Both also experienced a decline in the means after 1999 and the 1999-2008 pattern seemed to coincide with changes in the foodweb. The mean for 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. Predicted weight 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 values were relatively high in 2014 (620.0 g, 1.4 lb), 2017 (617.5 g, 1.4 lb) and 2018 (600.3 g, 1.3 lb).

Natural Reproduction

Evidence of survival of naturally produced lake trout past the fall fingerling stage occurred in each year during 1993-2018 (Figure 9) except 2008, representing production of 24 year-classes. Numbers reported in previous reports represented the total capture of age-0 to age-2 unclipped and untagged lake trout from the entire annual bottom trawl catch from four surveys occurring during April-October (for a description of the surveys see O'Gorman et al. 2000 and Owens et al. 2003). Catch was not corrected for effort due to the low catch in most years and a relatively constant level of effort expended within the depth range (20m -100m) where age-0 to age-2 naturally reproduced lake trout are most often encountered in Lake Ontario. Changes in recent annual survey design necessitated a change in the way we report the catch. In 2013 effort in the July juvenile lake trout survey was reduced and only 9 of 14 trawling locations were fished because no yearling lake trout were stocked in 2012. Effort returned to normal for the July survey during 2014-2017, but was once again reduced in 2018 due to the RV Kaho not being available for the survey. In 2015, the June bottom trawl

survey was discontinued, and the annual April survey was broadened which resulted in a net decrease in annual trawling effort in U.S. waters of approximately 60 tows (Weidel et al. 2016). In the current report we converted total catch to catch-per-unit-effort (CPUE) to account for recent changes in effort. We present the data for five lake regions along the southern shore from the Niagara River in the west to the mouth of the St Lawrence River in the eastern basin, grouping them by geographic location and patterns in catch through the years that we suspect is related to the proximity to suitable spawning habitat. The regions from west to east were two sites near the mouth of the Niagara River (region 1), four sites located between Olcott and Rochester (region 2), four sites between Smoky Point and Fair Haven (region 3), three sites between Oswego and Southwick (region 4), and two sites in the eastern outlet basin (region 5).

The distribution of catches of wild fish suggests that lake trout are reproducing throughout New York waters of Lake Ontario with the greatest concentrations near the mouth of the Niagara River (region 1) and in the eastern portion of the lake (regions 4 and 5; Figure 9). 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 relatively low catch (3 age-1 and 3 age-2) near the Niagara River in 2018 is, in part, due to the two sites there not being fished during July when most wild lake trout were encountered in the past. The small age-0 lake trout (<100 mm, 3.9 in) observed early in the time series disappeared from catches by the early 2000s and may have been due, in part, to a change in our trawl gear that was necessary to avoid abundant dreissenid mussels. The wild yearlings captured in 2010-2018 were the first wild yearlings caught since 2005.

Catches from at least 24 cohorts of wild lake trout since 1994 and survival of those year-classes to older ages implies feasibility of lake trout rehabilitation in Lake Ontario (Schneider et al. 1997). The recent large catches of wild lake trout off the mouth of the Niagara River are encouraging, but those occurred in only one portion of the lake. Achieving the goal of a self-sustaining population requires consistent production of relatively large wild year-classes across the range of spawning habitat and survival of those fish to reproductive ages. Lack of a similar trend of expanding production of wild lake trout near the reputed spawning habitat in the eastern basin indicates that drivers of local spawning success (e.g., spawning habitat) need to be further explored.

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Appendix 1.

Strain Descriptions

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

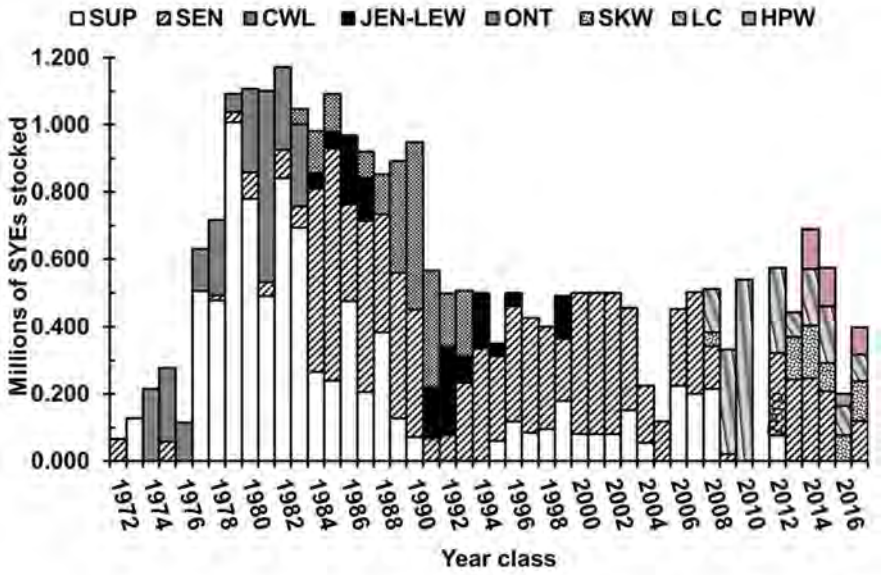

Figure 1. Total spring yearling equivalents (SYE) for lake trout strains (strain descriptions for ONT, JEN-LEW, CWL, SEN, LC, SUP, SKW, HPW appear in Appendix 1) stocked in U.S. waters of Lake Ontario for the 1972 – 2017 year-classes. For year-classes beginning in 2006, SUP refers to Lake Superior lean 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.

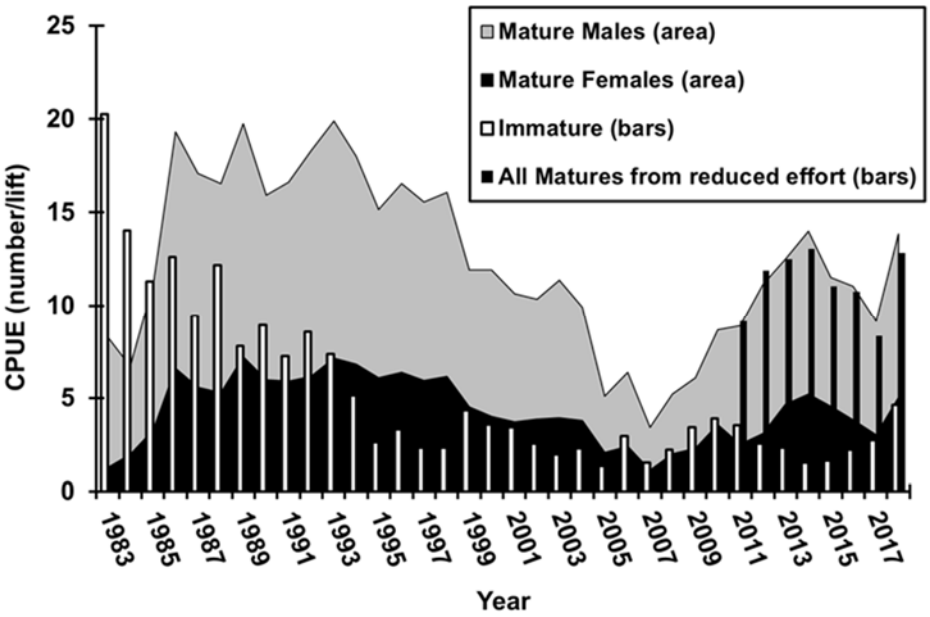

Figure 2. Abundance of mature (generally males ≥ age 5 and females ≥ age 6) and immature (sexes combined) lake trout calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2018. CPUE (number/lift) was calculated based on four strata representing net position in relation to depth of the sets.

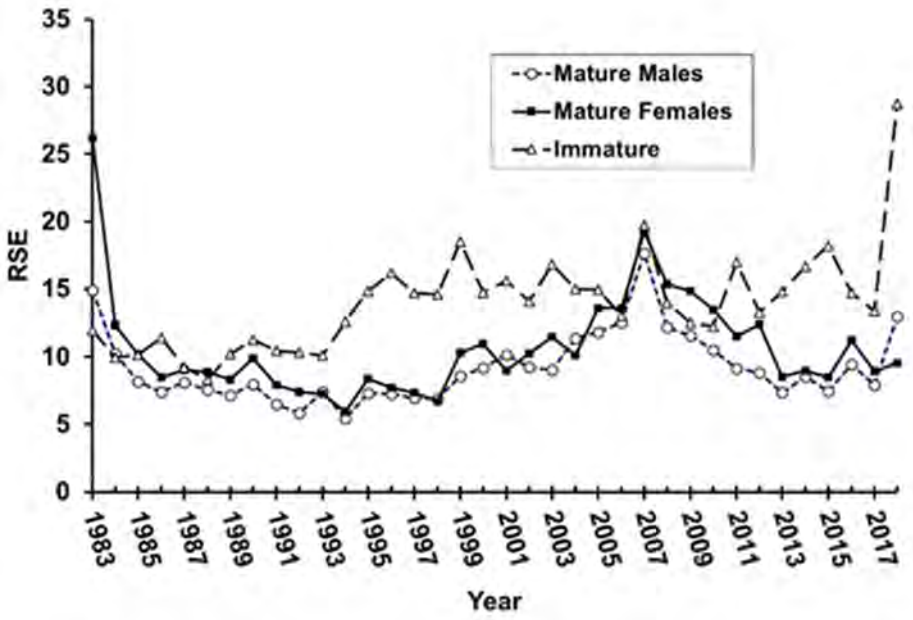

*Figure 3. Relative standard error (RSE = {SE / Mean}*100) of the annual CPUE for mature males, mature females and immature (sexes combined) lake trout caught with gill nets set in U.S. waters of Lake Ontario, during September 1983-2018. RSE increases after 1993 are in part due to an effort reduction with the number of sites sampled declining from 17 to 14 in 1994. In 2018 there were only 8 sites sampled with a total of 30 nets fished compared to an average of 53 nets (range 42-58) fished for the 14 sites sampled during 1994-2017. The reduced effort in 2018 contributed to the increases in RSE for the 2018 CPUEs.*

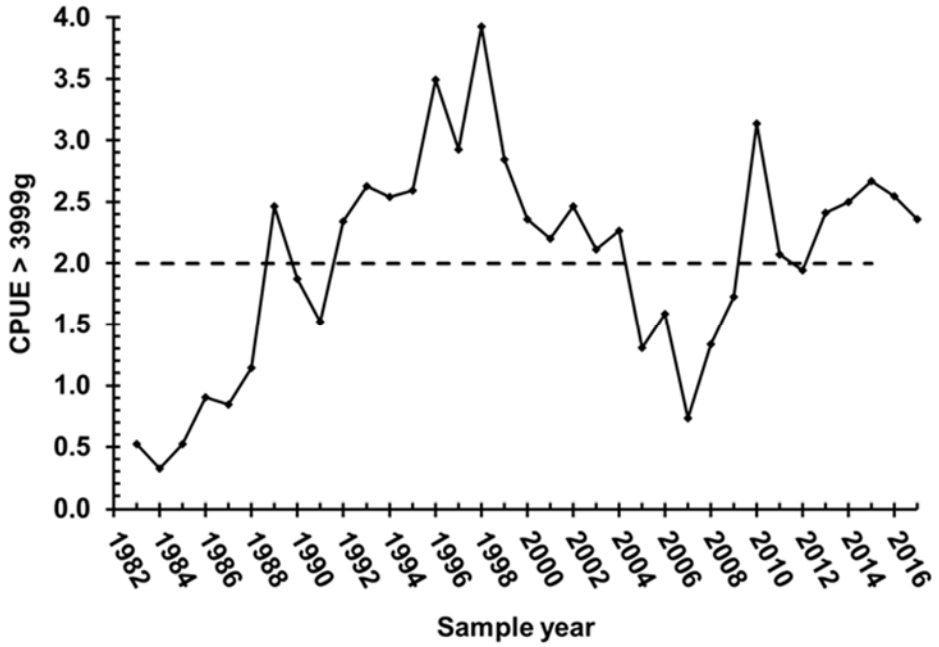

Figure 4. Abundance of mature female lake trout ≥4000g calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2018. The dashed line represents the target CPUE from Schneider et al. (1997) and Lantry et al. (2014).

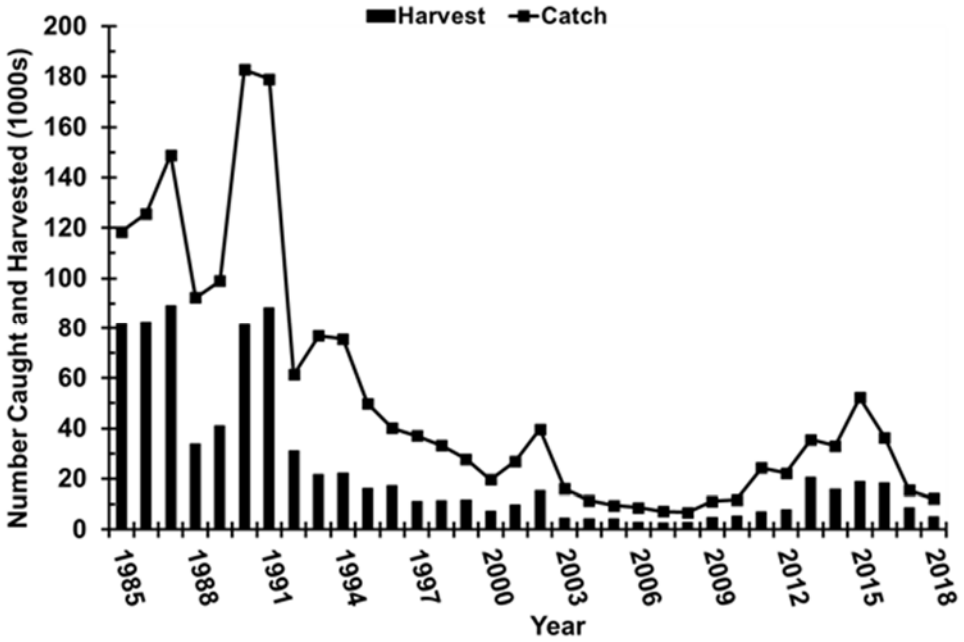

Figure 5. Estimated numbers of lake trout caught and harvested by boat anglers from U.S. waters of Lake Ontario, during April 15 – September 30, 1985-2018 (Connerton and Eckert 2019). Beginning with the 2012 report, all values have been reported reflecting a 5.5-month sampling interval. Prior reports were based on a 6-month sampling interval (April 1 – September 30).

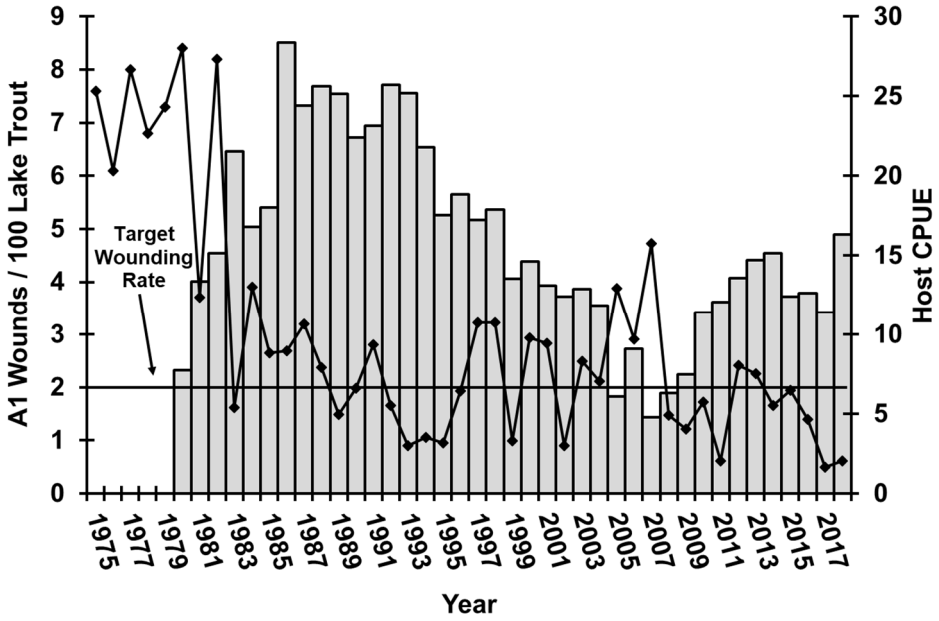

Figure 6. Wounding rates (A1 wounds per 100 lake trout, line) inflicted by sea lamprey on lake trout ≥ 433 mm (17.1 in) TL and the gill net CPUE of lake trout hosts (≥ 433 mm TL, bars) collected from Lake Ontario in fall, 1975-2018.

Table 1. Annual survival of various strains (strain descriptions appear in Appendix 1) of lake trout, sampled from U.S. waters of Lake Ontario, 1985-2018. 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. Values for ALL in some years are influenced by strains not included in the table because they only appeared in the lake for a short while (e.g., the 1991-1993 cohorts of OXS) or because they only occurred before successful sea lamprey control was established (1974-1983 cohorts of CWL).

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	7-11	-	-	-	-	-	0.36	0.91	-	-	0.84
2008	7-10	-	-	-	-	0.53	0.45	0.92	0.73	0.72	0.73
2009	7-9							0.58	0.66		0.60

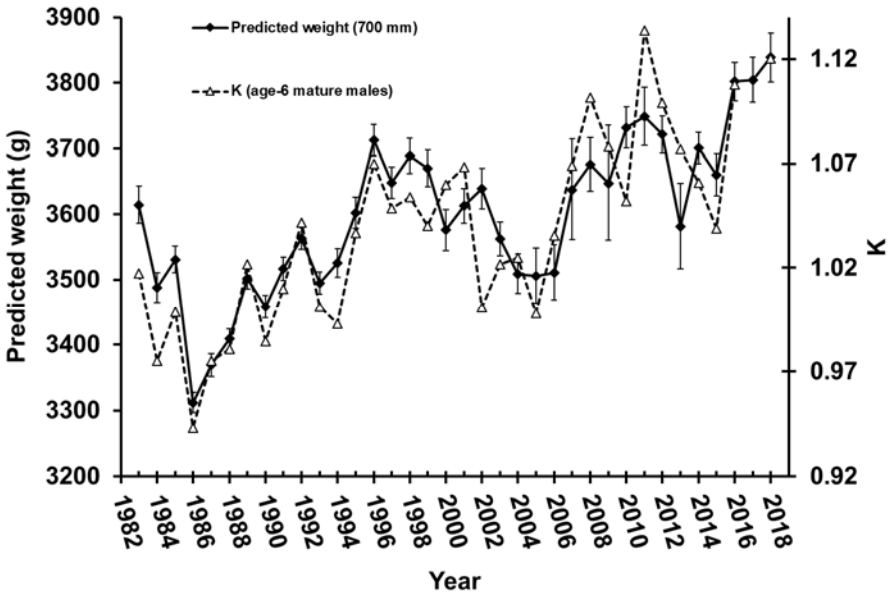

Figure 7. Lake Ontario lake trout condition (K) for age-6 mature males and predicted weight at 700-mm (27.6 in) TL from weight-length regressions calculated from all fish collected during each annual gill net survey, September 1983 – 2018. There were no fish stocked from the 2011 year-class in 2012 so age-6 K is not available in 2017. Error bars represent the regression confidence limits for each annual value.

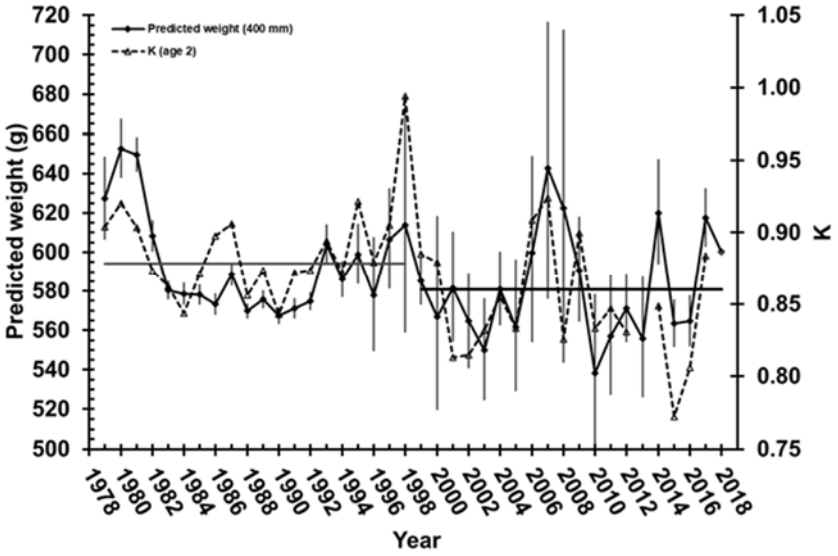

Figure 8. Lake Ontario lake trout condition (K) for age-2 coded wire tagged fish and predicted weight at 400-mm (15.8 in) TL from annual weight-length regressions calculated from fish 250 mm-500 mm (9.8 to 19.7 in). All lake trout were sampled from bottom trawls, July-August 1978-2017. The horizontal 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. The value for predicted weight in 2018 came from age-2 lake trout caught in gillnets during the September survey. Error bars represent the regression confidence limits for each annual value.

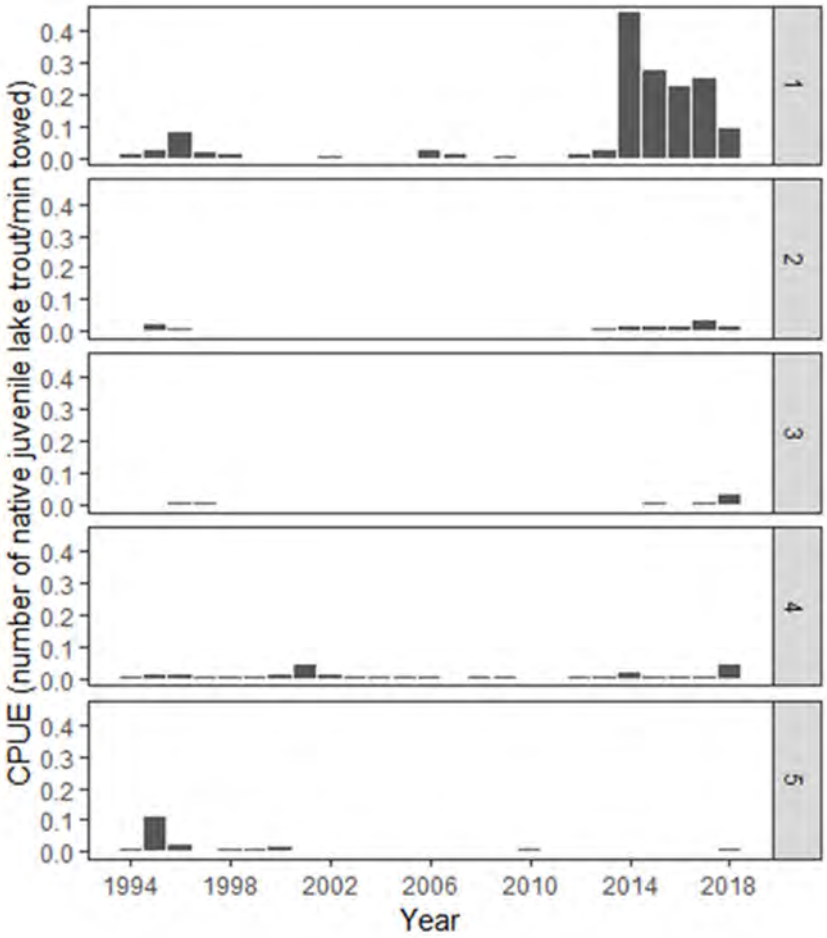

Figure 9. CPUE of naturally produced (wild) age-0 to age-2 lake trout captured with bottom trawls in Lake Ontario by NYSDEC and USGS, 1994-2018. Numbered panels represent regional groupings of bottom trawl locations proceeding from west to east: two sites near the mouth of the Niagara River (region 1), four sites located between Olcott and Rochester (region 2), four sites between Smoky Point and Fair Haven (region 3), three sites between Oswego and Southwick (region 4), and two sites in the eastern outlet basin (region 5).

Thousand Islands Warmwater Fisheries Assessment

Leslie B. Resseguie and David J. Gordon

NYSDEC Region 6 Fisheries Unit
Watertown, New York 13601

Annual warmwater fisheries 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 long-term data set provides standardized indices of abundance for major gamefish and panfish, information on year class strength, as well as 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). Although the term warmwater fisheries assessment is applied to this project, in keeping with NYSDEC Bureau of Fisheries administrative structure, 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 between the third week of July through the first week of August each year. Sampling effort consists of 32 overnight gill net sets (16 sets 1977 - 1982) at standard sites. Sampling is confined to the mid-depths of the river, from 10 to 60 ft (3 to 18.3 m), with standard net sites divided equally into two depth strata, 10 to 30 ft (3 to 9.1 m; n = 16) and 33 to 60 ft (10.1 to 18.3 m; n = 16). Nets are set on the bottom, typically parallel to shore and current. The nets are 200 ft (61 m) long by 8 ft (2.4 m) deep and contain eight 25 ft (7.6 m) panels with stretch measure mesh increasing in sizes from 1.5 to 6 in (38 to 152 mm) with ½ inch increments from 1.5 to 4 in and one inch increments from 4 to 6 in.

From 1977 to 2003, multifilament nylon nets were used; while monofilament nets were used beginning in 2004. Based on a 24 paired net comparison, catch per unit effort (CUE) of rock bass (*Ambloplites rupestris*) and yellow perch (*Perca flavescens*) in the two net types were significantly different (α = .05). Monofilament CUE of rock bass and yellow perch were converted to the multifilament standard by multiplying by 1.7 and 0.74, respectively (McCullough and Gordon 2018). Beginning this reporting year, monofilament net CUE (2004-2018) is reported and multifilament net CUE is converted to the monofilament standard (1990-2003; inverse of 0.588 for rock bass and 1.35 for yellow perch).

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

Results and Discussion

Environmental Conditions

The mid-summer sampling period was chosen to minimize intra- and inter-annual variation in environmental conditions, chiefly water temperature. Average surface water temperatures varied from a low of 65°F (18.3°C; 1982) to a high of 78°F (25.6°C; 1979). Surface temperature in 2018 was similar to recent years (72.5°F, 22.5°C; Table 1). Prior to colonization by dreissenid mussels, summer water transparency (measured by Secchi depth) ranged to about 10 ft (3 m) water depth (S. LaPan, NYSDEC, pers. communication), and was not considered a significant influence on catchability. By 1995, it was apparent that transparency had increased. Secchi depths were recorded during fish sampling beginning in 1996. Secchi depths during the sampling period have ranged from 14 ft (4.3 m) in 1997 to 55 ft (16.8

m) in 1999. In 2018, the Secchi depth was 23 ft (7.0 m). Secchi depths are quite variable annually, yet the three-year moving average appears stable around 30 ft (9.1 m; Figure 1).

Species composition

In 2018, a sample of 1210 fish comprising 18 species was collected. A total of 37 species were represented in Thousand Islands gill net sampling between 1977 and 2018 (Table 2). Small-bodied species such as cyprinids are poorly represented and are rarely captured as they are not vulnerable to the gear. Historically, more than 90% of the catch consisted of: northern pike, rock bass, pumpkinseed sunfish (*Lepomis gibbosus*), smallmouth bass *(Micropterus dolomieui*), yellow perch, and members of the catfish family, predominately brown bullhead (*Ameiurus nebulosus*). In more recent years, abundance indices of pumpkinseed sunfish and brown bullhead have declined. In 2018, yellow perch made up 49% of the catch, while rock bass, pumpkinseed sunfish, smallmouth bass, and northern pike represented 39% of the catch (Figure 2).

Primary Recreational Fishery Targets

Smallmouth Bass. Smallmouth bass are the most sought-after sport fish in the New York Thousand Islands fishery (McCullough 1987, Klindt 2011). The abundance index 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, smallmouth bass abundance index generally declined and was low from 1996 through 2004 (Figure 3). The catch increased in 2005 and varied at relatively higher level through 2018. In 2018, CUE was the fourth highest on record, indicating, that the low 2015 value was likely a sampling anomaly. The recent trends in the smallmouth bass index is complicated by a disproportionate representation of younger fish. In recent years smallmouth bass growth has increased (Figure 4). With fish reaching a larger size at a younger age they are, therefore, more effectively caught at a younger age. Historically, the index of abundance of age-5 and older fish represented the majority of the catch and catch of smallmouth bass ages 1-4 was low (Figure 5). Since 2006, CUE of smallmouth bass ages 1-4 increased and CUE of smallmouth bass ages 5 and older was lower relative to earlier years. This may indicate increased abundance of young fish, but more likely reflects an increased catchability of young smallmouth bass due to increased growth rates. In 2018, 71% of the catch was fish ages 2–6, representing the 2013-2016 year classes (Figure 6).

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. Since 2005 cormorant predation pressure was lower due to decreased cormorant numbers and a cormorant diet shift to predominantly round goby (*Neogobius melanostomus)* at St. Lawrence River cormorant colonies (Johnson et al. 2008). More recently and since a May 2016 federal court decision to vacate the Public Resource Depredation Order, cormorant management was limited and the trend in cormorant feeding days (i.e., predation pressure) has increased (Resseguie and Mazzacchi 2019).

Smallmouth bass growth changed little between 1977 and 2004 (regression slope = 0.04, R^2 = 0.35, Figure 7); thereafter, growth has increased. A possible density dependent effect (McCullough 2012), along with the establishment of round goby, have likely contributed to the increasing trend in mean length of age-5 bass. Bass are now generally reaching legal size (i.e., 12 inches, 305 mm), before age 5. Since round goby establishment in 2005, mean total length at age 5 increased (regression slope = 0.27, R^2 = 0.85; Figure 7). In 2018, age-5 bass averaged 15.3 inches (389 mm) while age-3 bass averaged just under the legal size limit at 11.8 inches (300 mm). Smallmouth bass growth also increased in Lake Ontario's Eastern Basin (Lantry 2018), Lake St. Lawrence (Klindt and Gordon 2018 and Lake Erie (Einhouse et al. 2014). For all of these areas, the most recent increase in growth is likely related to increased use of round goby as prey.

Smallmouth bass condition, reported as relative weight (Wr), follows a pattern similar to growth. Condition increased after 2002 and remained relatively high for over a decade (Figure 8). As with growth, this may be explained by a potential density dependent effect followed by an increased abundance of round goby.

Northern Pike. Northern pike are an important part of the recreational fishery in New York (Klindt 2011)

and have been the most sought-after fish in the Province of Ontario Thousand Islands recreational fishery (Bendig 1995). Their abundance index peaked in 1981, generally declined through 1996, and varied without trend through 2001 (Figure 9). From 2001 through 2005 abundance index again generally declined and tended to vary without trend until 2013, then declined from 2014 – 2018. 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 impairing northern pike recruitment (Connerton 2003). Sample size for northern pike has declined to the point that determination of year class strength is not possible.

Northern pike growth varied over the data series with a relatively high mean total length of age-4 fish occurring prior to 1983 and length was lowest in 1994 (Figure 10). There was no apparent change in growth since the establishment of round goby. However, mean lengths of age-4 northern pike in 2017 and 2018 were among the highest in the data series (Figure 10).

Condition (Wr) of northern pike was relatively stable through the late 1990s, then increased beginning in 2000. Unlike smallmouth bass, condition of northern pike did not continue to increase after 2005 except for a peak in 2009-2011 which coincided with relatively high alewife (*Alosa pseudoharengus)* abundance (Figure 11).

Yellow Perch. Due to the schooling nature of yellow perch, their abundance index is highly variable across the time series. Index of abundance peaked in the late 1970s then went into an irregular decline through 1992. From 1992 through 1999, the index tended to increase, but to only a fraction of its previous level. After 1999, although variable, yellow perch catches have generally declined. CUE of yellow perch has remained low since 2012 until a slight increase in 2018. (Figure 12).

The majority of perch sampled in recent years were ages 3-4. In 2018, the 2015 and 2014 year classes dominated the catch as age-3 (43% of catch) and age-4 (31% of catch) fish. Age-2 fish (2016 year class), made up 12% of the catch, a 56% increase from the 10-year average for that age (Figure 13). This may indicate a strong year class may be present.

Growth rates of yellow perch were relatively similar from the 1980's through the 2000's. Growth rate generally increased from 2010 to present (Figure 14). Growth of age-4 yellow perch was relatively stable from 1977-2004 (linear regression slope=0.01, R^2=0.08) and then increased from 2005-2018 (linear regression slope=0.14, R^2=0.63, Figure 15). Increased growth after 2005 may be attributable to the availability of round goby as forage. Total length of age-4 yellow perch reached a record high of 8.6 inches in 2013. In 2018 mean length of age-4 fish was 8.2 inches, remaining among the highest in the data series. Although growth appears to have increased, condition (Wr), was highly variable and showed no appreciable trend (Figure 16).

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 remained at relatively higher levels since (Figure 17). 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 2018).

<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 were 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 were caught since 1999. Lake sturgeon were stocked in St. Lawrence River tributaries in the 1990s (Grasse River 1993, Oswegatchie River 1993-1999) and in the St. Lawrence River at Ogdensburg in the 1990s and 2010s (1996-2000, 2013-2015). Natural spawning has been observed in the upper St. Lawrence River (LaPan et al. 1997) and is thought to be a major source of recruitment to this population.

Herrings. Alewives were frequently captured during the 1970s and 1980s and were detected at very low levels from 1989 through 2006. Catches since 2006 were highly variable. The 2009 CUE was the highest recorded, declined close to the background level by 2014, increased substantially in 2015-16 then

declined to near background level in 2018 (Figure 18). Many of the alewives in the river probably strayed from Lake Ontario. Additionally, this species is not effectively sampled in this assessment, contributing to relatively high variability of catches. Gizzard shad (*Dorosoma cepedianum)* were also collected sporadically from 1978 through 1999.

Salmon and Trout. Salmonids are not targeted in this assessment but are collected incidentally. Coho salmon (*Oncorhyncus kisutch*), brown trout (*Salmo trutta*) and lake trout (*Salvelinus namaycush*) were captured occasionally. These species are likely strays from Lake Ontario.

Pikes. Like northern pike, muskellunge (*Esox masquinongy*) is an important sport fish in the St. Lawrence River. This species is thought to occur at low density. Historically, approximately 50% of muskellunge tagged in the Thousand Islands migrated to eastern Lake Ontario in summer (LaPan et al. 1995). Only 11 muskellunge were 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). Grass pickerel (*Esox americanus)* are present in the St. Lawrence River, but abundance is thought to have declined (Klindt and Gordon 2016). No grass pickerel have been sampled in this assessment as the gear is most likely set too deep for this species.

Carp and Minnows. Common carp (*Cyprinus carpio*) were caught regularly since 1982. They are caught in low numbers, usually one to six individuals per year. Other minnows are usually not vulnerable to this sampling gear, but a few, such as fallfish (*Semotilus corporalis*) and golden shiner (*Notemigonus crysoleucas*), are caught occasionally. A single rudd (*Scardinius erythropthalmus*) was caught in 2000.

Suckers. White sucker (*Catostomus commersoni*) were caught in substantial numbers (30 or more individuals) most years since 1977; however, the index of abundance generally declined since 1990 (Figure 19). Silver (*Moxostoma anisurum*) and greater redhorse (*M. valenciennessi*) were 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. The brown bullhead index of abundance has varied over the data series (Figure 20). The highest indices occurred during the 1970s-1980s and 2000s, and the lowest occurred through the mid-1990s and since the late 2000s. The brown bullhead index remained at a relatively low level in 2018. Channel catfish (*Ictalurus punctatus*) have been sampled regularly throughout the survey. The abundance index of channel catfish rose slightly in 2009 and 2010, but quickly dropped to low levels similar to catches in the 1990's (Figure 20). Yellow bullhead (*Ameiurus natalis*) and stonecat (*Noturus flavus*) were caught twice during this project.

Centrarchids. Rock bass and pumpkinseed sunfish were the most common sunfishes caught in Thousand Island gillnet sampling. From 1977 through 1990, abundance indices for rock bass and pumpkinseed varied at similar levels (Figure 21). Rock bass index of abundance generally increased except for a slight decline in 2011 - 2015 but increased again in 2018. Pumpkinseed index of abundance declined since 1990, reaching a record low level in 2014 and remained near record low levels in 2018.

Both bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) are captured regularly but in very low numbers. Sample nets are likely set too deep to effectively sample these species in most years. Black crappie (*Pomoxis nigromaculatus*) were found in low numbers through 2003; none were caught since.

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Table 1. Average water temperature and Secchi depth in the St. Lawrence River Thousand Islands Warmwater Fisheries Assessment 1977 - 2018.

Sample Year	Average Temp °F (°C)	Secchi Depth ft (m)	Sample Year	Average Temp °F (°C)	Secchi Depth ft (m)
1977	72.5 (22.5)		1998	73.5 (23.1)	27 (8.2)
1978	71 (21.7)		1999	75 (23.9)	55 (16.8)
1979	78 (25.6)		2000	70.5 (21.4)	44 (13.4)
1980	70 (21.1)		2001	71.5 (21.9)	20 (6.1)
1981	70 (21.1)		2002	71.5 (21.9)	24 (7.3)
1982	65 (18.3)		2003	72.5 (22.5)	21 (6.4)
1983	72.5 (22.5)		2004	70 (21.1)	26.5 (8.1)
1984	68 (20)		2005	73.5 (23.1)	36 (11)
1985	69 (20.6)		2006	73.5 (23.1)	29 (8.8)
1986	68 (20)		2007	70.5 (21.4)	22.5 (6.9)
1987	68 (20)		2008	71.5 (21.9)	34 (10.4)
1988	73.5 (23.1)		2009	71 (21.7)	31 (9.4)
1989	69 (20.6)		2010	75.5 (24.2)	20 (6.1)
1990	73.5 (23.1)		2011	75 (23.9)	29 (8.8)
1991	73 (22.8)		2012	74 (23.3)	30.5 (9.3)
1992	65 (18.3)		2013	74 (23.3)	21 (6.4)
1993	72.5 (22.5)		2014	69.5 (20.8)	39.5 (12)
1994	72.5 (22.5)		2015	70 (21.1)	26 (7.9)
1995	73.5 (23.1)		2016	74 (23.3)	50 (15.2)
1996	70 (21.1)	29 (8.8)	2017	69.5 (20.8)	19.5 (5.9)
1997	70 (21.1)	14 (4.3)	2018	72.5 (22.5)	23 (7.0)

Table 2. Abundance index (CUE = catch/net night) by species in the St. Lawrence River Thousand Islands Area 1977 – 2018. a = multifilament CUE adjusted to monofilament standard

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
Longnose Gar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bowfin	0	0	0	0	0	0.06	0	0	0.03	0	0	0.03	0	0.09
Alewife	1.5	1.1	2.3	2.6	5	0	2	1.5	1	6.5	2.2	1.5	0.3	0.28
Gizzard Shad	0	6	0	0.06	0	0	0	0	0	0	0	0	0	0
Coho Salmon	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0
Brown Trout	0	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	0.16	0
Rainbow Smelt	0	0.18	0	0	0	0	0	0	0	0	0	0	0	0
Northern Pike	3.2	2.3	2.5	4.1	7.3	4.9	4.5	3.9	4.8	3.7	3.63	4.03	5.31	4.38
Muskellunge	0	0	0	0	0	0	0	0	0	0	0.03	0	0.03	0
Common Carp	0	0	0	0	0	0.2	0.1	0.1	0.03	0	0.19	0.09	0.16	0.31
Rudd	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Golden Shiner	0	0	0	0	0	0	0	0	0	0	0	0.03	0.03	0
Fallfish	0	0	0	0	0.12	0	0	0	0	0	0	0	0	0.03
Longnose Sucker	0	0	0	0	0	0.39	0	0.13	0	0	0	0	0	0
White Sucker	2.4	3.6	2.4	2	1.8	0.8	1.4	1.3	2.1	1.7	1.81	2.5	3.03	3.06
Silver Redhorse	0.1	0.1	0.2	0	0.2	0.1	0.1	0.1	0.3	0	0.16	1. 0	0.09	0.16
Shorthead Redhorse	-	-	-	-	-	-	-	-	-	-	0	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	0.1	1	0	0.2	0	0.2	0.4	0.8	4.8	1.4	0.41	1.31	0.16	0.97
Stonecat	0	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	0.1	0.8	0.1	0	0.1	0.1	0.1	0	0.1	0	0.03	0.13	0.16	0.03
White Bass	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0.09
Rock Bass	6	10.1	9	7.4	6.1	6.2	5.5	5.5	5.6	6.5	6.88	11.3	5.59	2.81a
Pumpkinseed	6.3	5.2	8.3	4.5	11.5	9.3	12.3	7.8	5.7	6.4	10.3	10.2	9.66	11.8
Bluegill	0.9	1.1	0	0.6	2.8	0.3	12.4	0.6	0.6	0.6	0.59	0.09	0.59	0.78
Smallmouth Bass	6.2	7.4	6.6	5.1	2.9	3.5	5.2	4.6	5.9	5.9	7.66	9.84	5.69	6.66
Largemouth Bass	0	0.1	0	0	0.1	0	0.5	0.1	0	0.1	0.28	0.22	0.09	0.09
Black Crappie	0.4	0.2	0.1	0.1	0.2	0.1	0	0	0.1	0	0.13	0.09	0.06	0.03
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	15.5a
Walleye	0	0	0	0	0	0.1	0.1	0.1	0.1	0.3	0.03	0.31	0.09	0.34
Freshwater Drum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Round Goby	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Abundance index (CUE = catch/net night) by species in the St. Lawrence River Thousand Islands Area 1977 – 2018. a = multifilament CUE adjusted to monofilament standard.

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	0.03	0.03	0.06	0	0	0
Longnose Gar	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0
Bowfin	0.03	0	0.03	0.03	0	0.03	0	0.03	0	0	0.03	0	0	0
Alewife	0.91	0.19	0.07	0.38	0	0.63	0.22	0	0.09	0.03	0.18	0.09	0	0.03
Gizzard Shad	0.06	0.03	0	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	0.03	0	0	0	0	0	0	0	0	0	0	0	0
Lake Trout	0	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	0.03	0.03	0.03	0	0.03	0	0	0	0.06	0.03
Common Carp	0	0.06	0.2	0.09	0.06	0.16	0.06	0.06	0.03	0.03	0.03	0.03	0.06	0.03
Rudd	0	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	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	0.09	0.03	0.03	0	0.06	0.13	0	0.03	0.03	0.03	0	0	0.06	0
Shorthead Redhorse	0	0	0	0	0	0	0.06	0.03	0	0	0	0	0	0
Greater Redhorse	0.03	0.03	0	0.03	0	0	0	0.03	0	0.03	0	0.06	0	0
Brown Bullhead	3.09	3.97	1.43	1.06	1	0.44	0.69	1.47	2.5	1.59	2.84	2.53	4.66	1.22
Yellow Bullhead	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0
Channel Catfish	0.19	0.13	0.63	0.22	0.3	0.13	0.19	0.31	0.13	0.06	0.06	0.03	0.22	0.22
Stonecat	0	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	0.09	0.03	0	0	0	0	0	0	0	0.03	0	0.03	0.03	0
White Bass	0	0	0	0	0	0	0	0.03	0.03	0	0	0	0	0
Rock Bass	2.94a	1.84a	2.89a	4.41a	3.73a	5.28a	3.71a	3.18a	4.58a	4.93a	3.35a	3.25a	4.39a	6.47
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	0.72	1. 03	0.2	0.34	0.5	0.16	0.06	0.12	0.3	0	0.06	0.09	0.03	0
Smallmouth Bass	6. 91	2. 47	5. 33	4. 53	5. 50	2. 94	2. 34	2. 91	3.3	1.84	3.06	2.16	2.78	3.13
Largemouth Bass	0.16	0.09	0.1	0.09	0	0.03	0.03	0.06	0.06	0.03	0.15	0.06	0.03	0.06
Black Crappie	0.09	0	0	0	0	0.03	0.03	0	0.03	0	0.06	0	0.03	0
Yellow Perch	13.4a	10.4a	18.6a	13.4a	17.1a	21.2a	22.8a	19.5a	27.9a	15.8a	13.3a	18.8a	18.1a	14.3
Walleye	0.25	0.09	0.23	0.13	0.3	0.25	0.09	0.06	0.13	0.19	0.31	0.5	0.34	0.28
Freshwater Drum	0	0	0	0	0	0.03	0	0	0	0	0	0	0.03	0.06
Round Goby	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2. Abundance index (CUE = catch/net night) by species in the St. Lawrence River Thousand Islands Area 1977 – 2018.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Lake Sturgeon	0.03	0	0	0	0.03	0	0	0	0	0	0	0.09	0	0
Longnose Gar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bowfin	0.03	0	0	0	0	0.03	0	0.03	0.03	0.03	0	0.03	0.06	0.03
Alewife	0.09	0.03	2.25	0.59	8.78	2.13	2.56	0.5	0.41	0.13	3.59	2.47	0.97	0.75
Gizzard Shad	0	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	0
Brown Trout	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Trout	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0
Rainbow Smelt	0	0	0.06	0	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	1.53	1.13	0.94	1.16	1.5
Muskellunge	0	0	0	0	0	0	0	0	0	0	0.03	0.03	0	0
Common Carp	0.12	0.19	0.16	0.19	0.09	0.06	0.16	0.16	0.22	0.03	0.06	0.06	0.06	0.06
Rudd	0	0	0	0	0	0	0	0.22	0	0	0	0	0	0
Golden Shiner	0	0	0.03	0	0.03	0.03	0.03	0	0	0	0	0.13	0	0
Fallfish	0	0	0	0	0	0	0	0.03	0.06	1	0	0.09	0	0.06
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	1.1	1.16	0.88	0.81	0.63	0.34	0.69	0.53	0.78	0.31	0.31	0.44	0.44	0.75
Silver Redhorse	0.03	0.06	0.03	0.03	0.03	0.19	0.03	0.03	0.03	0.41	0	0.03	0.03	0.25
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Redhorse	0	0	0	0	0.16	0	0	0	0.03	0.03	0	0	0.03	0.06
Brown Bullhead	1.53	2.47	1.22	0.81	1.56	0.72	0.75	0.97	0.5	0.19	0.09	1.34	0.38	1.09
Yellow Bullhead	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0
Channel Catfish	0.38	0.44	0.25	0.31	0.84	1.06	0.03	0.31	0.34	0.31	0.13	0.22	0.13	0.19
Stonecat	0	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	0
White Perch	0	0.03	0	0	0	0	0	0	0.13	0	0	0	0	0
White Bass	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0
Rock Bass	4.84	6.66	5.31	5.22	5.16	6.16	6.84	3.13	6.44	3.78	4.13	3	4.22	5.38
Pumpkinseed	1.88	2.41	0.97	0.88	0.81	0.72	0.69	0.47	0.94	0.09	0.09	0.25	0.34	0.36
Bluegill	0.06	0.03	0.13	0.06	0	0.06	0.09	0.25	0.09	0.03	0	0.06	0	0.06
Smallmouth Bass	4.75	7.84	5.13	6.69	4.19	7.5	5	8.91	6.41	4.59	1.88	5.25	5.91	7.56
Largemouth Bass	0	0	0.19	0	0	0.03	0	0.31	0.06	0	0	0.13	0.09	0
Black Crappie	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow Perch	9.2	17.6	22.2	20.8	10.4	12.8	17.4	7.7	11.3	10.5	11.1	10.8	13.2	18.4
Walleye	0.75	0.81	1.34	0.84	1.03	0.84	1.06	0.47	0.81	1.22	1.22	0.69	0.94	0.78
Freshwater Drum	0.06	0	0.13	0	0	0	0.09	0.06	0.03	0	0	0	0	0.06
Round Goby	0	0	0.09	0.53	0.19	0.16	0.75	0.06	0	0.37	0.13	0.16	0.81	0.34

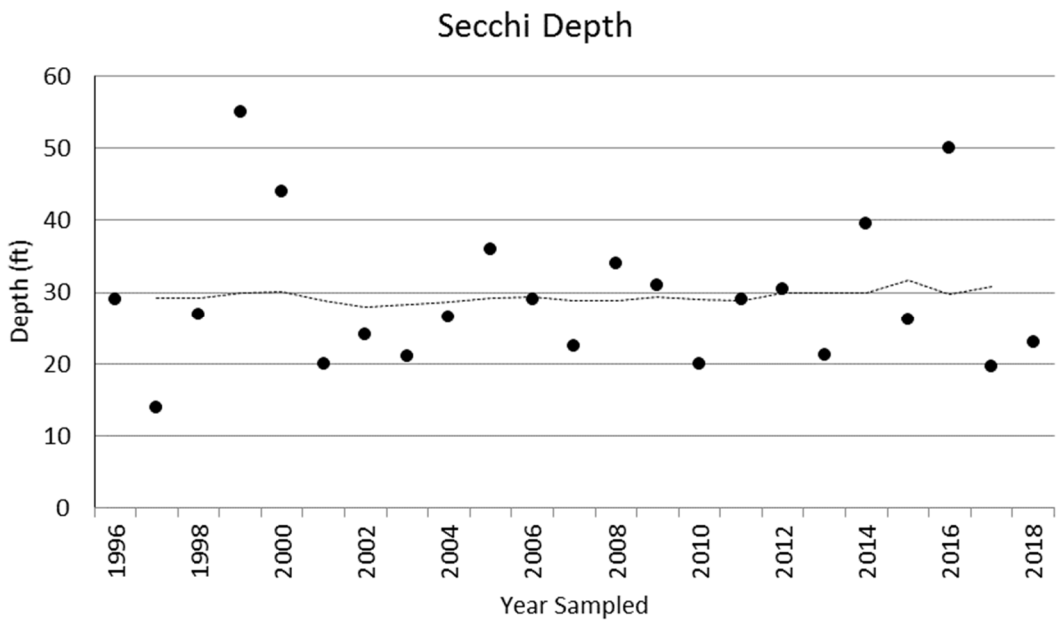

Figure 1. Mean secchi depth (ft) of the St. Lawrence River Thousand Islands area with a 3-year moving average recorded during warmwater fisheries assessment.

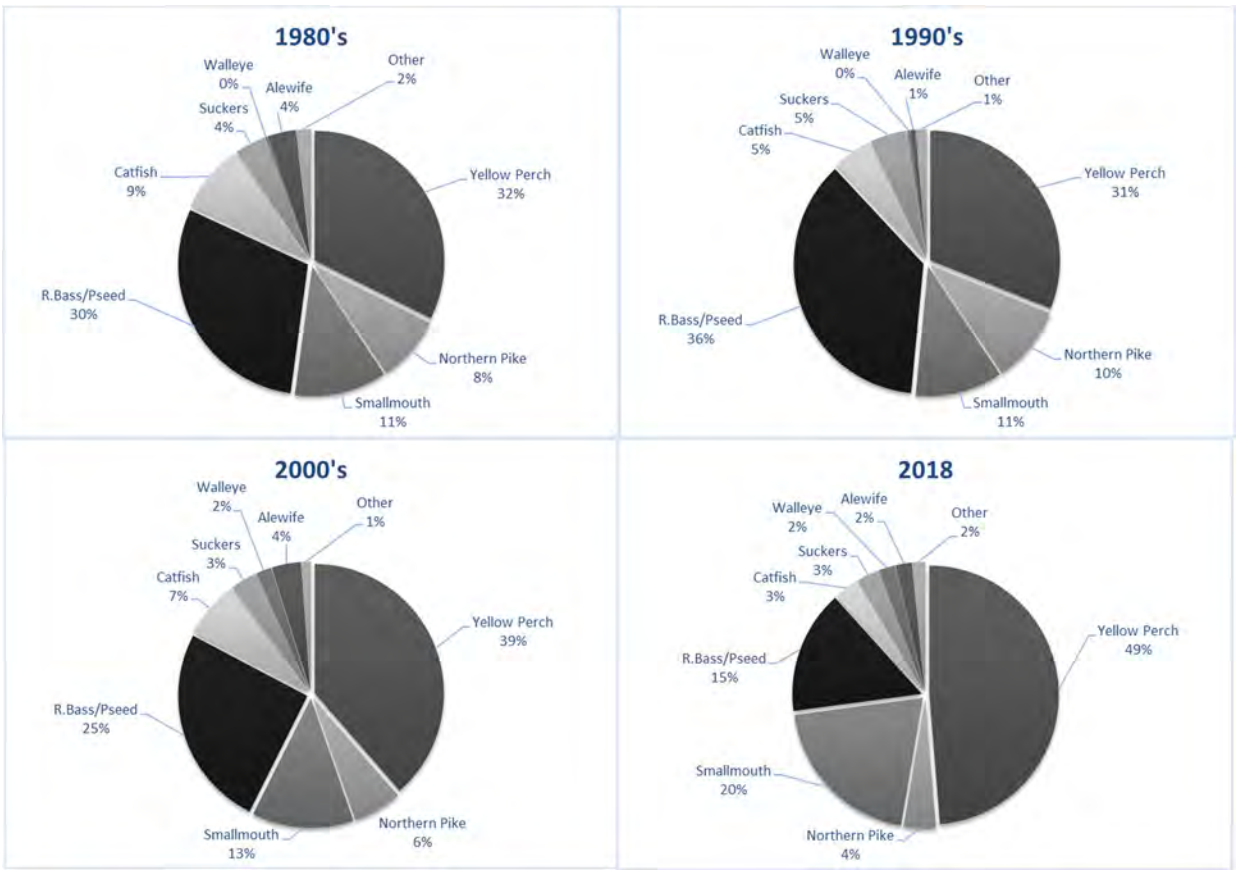

Figure 2. Catch composition of the warmwater fisheries assessment of the St. Lawrence River Thousand Islands area.

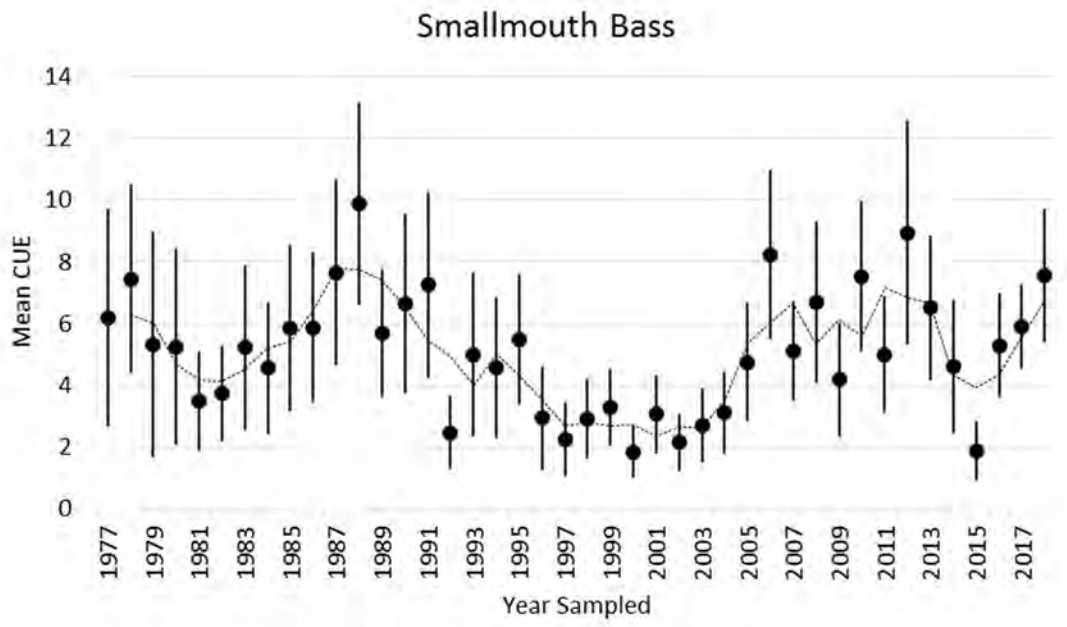

Figure 3. Smallmouth bass abundance index in the St. Lawrence River Thousand Islands area. Catch per unit effort (CUE) with 95% confidence intervals and 3-year moving average.

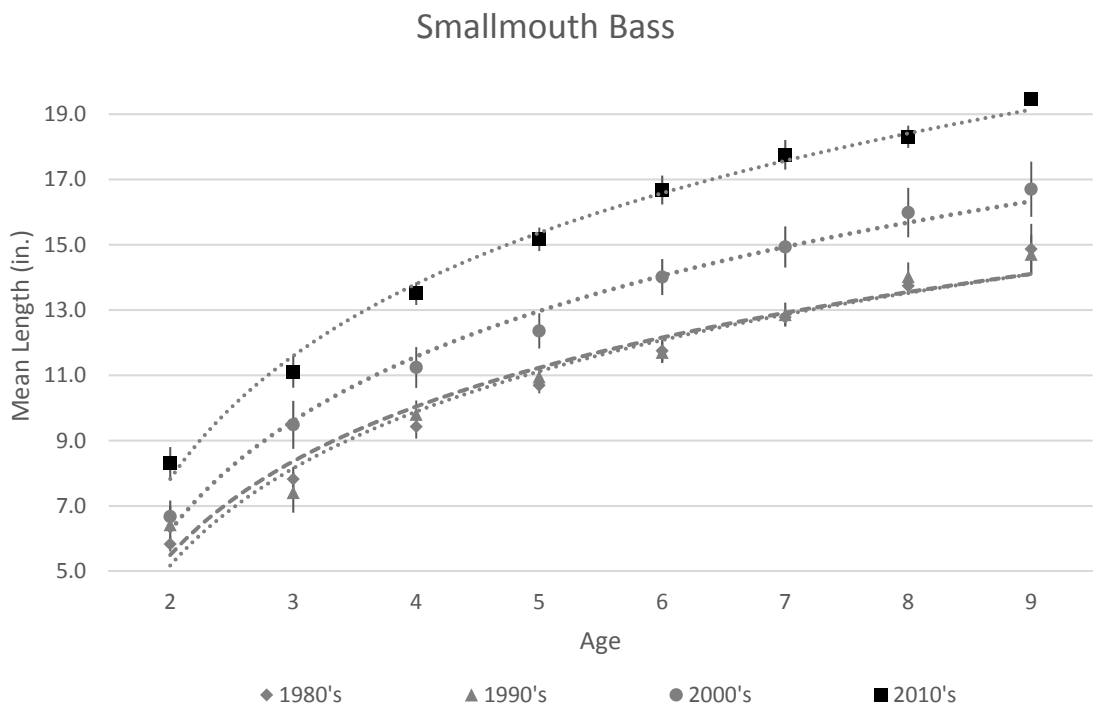

Figure 4. Decadal mean length at age of smallmouth bass caught in the Thousand Islands Warmwater Fisheries Assessment. Note: mean length was used when n ≥ 4.

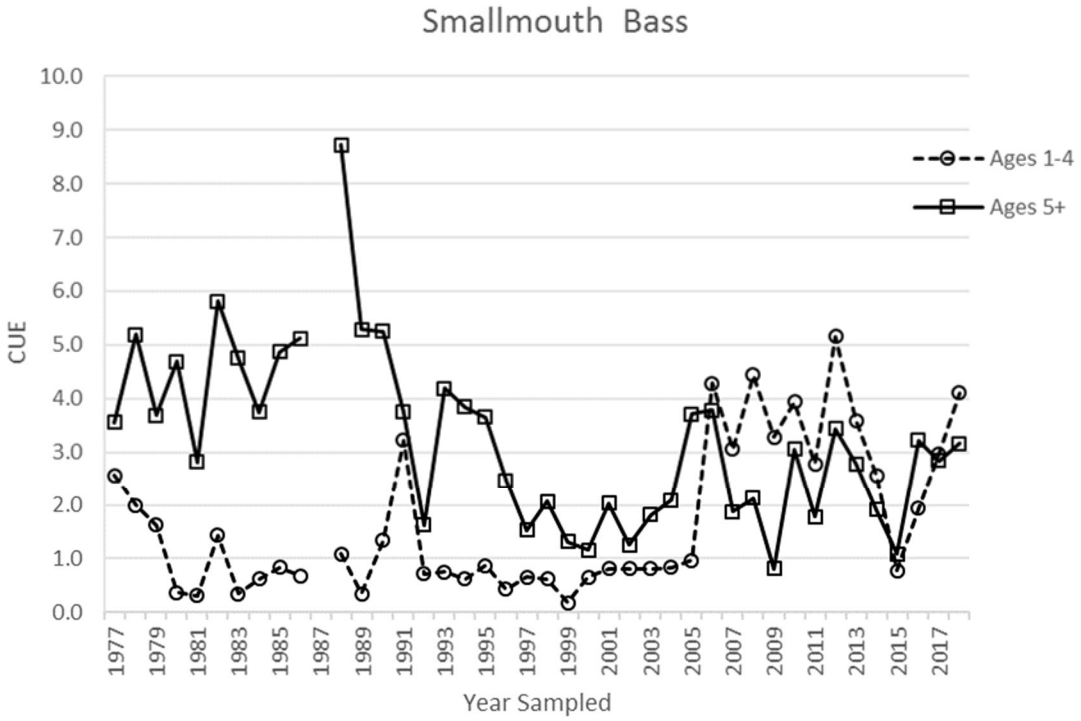

Figure 5. Mean CUE of smallmouth bass ages ≤ 4 and ages ≥ 5, 1977 – 2018. Increased growth beginning in the 2000s may have increased catchability of younger ages.

Figure 6. Age composition of smallmouth bass in the 2018 Thousand Islands Warmwater Fisheries Assessment compared with the average from 1977-1999 and 2000-2017.

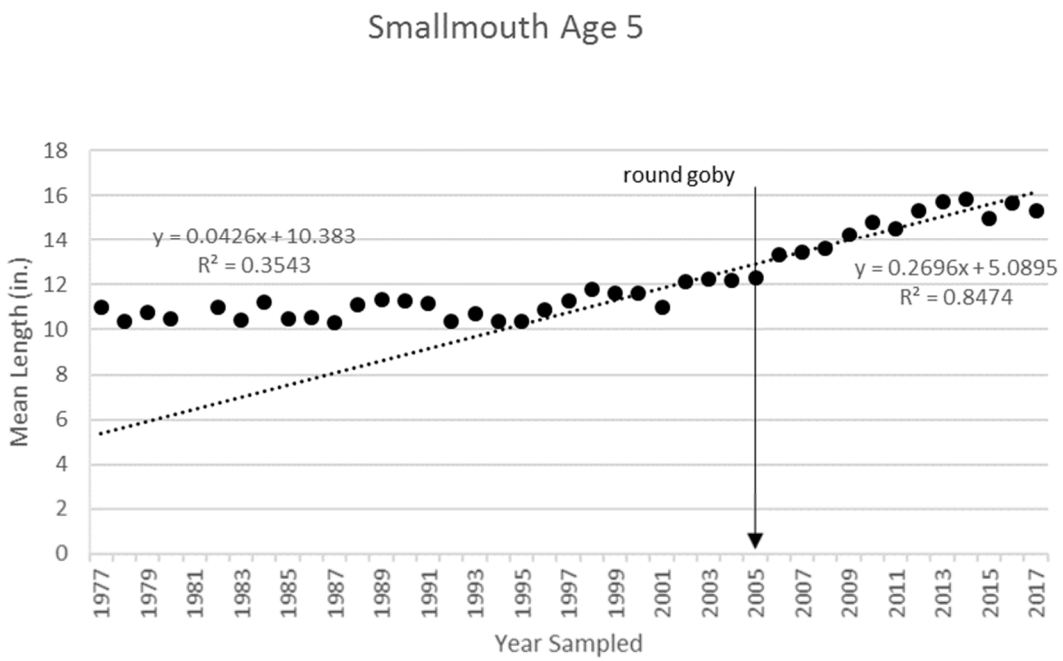

Figure 7. Mean total length of age 5 smallmouth bass in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Vertical line indicates establishment of abundant round goby-2005.

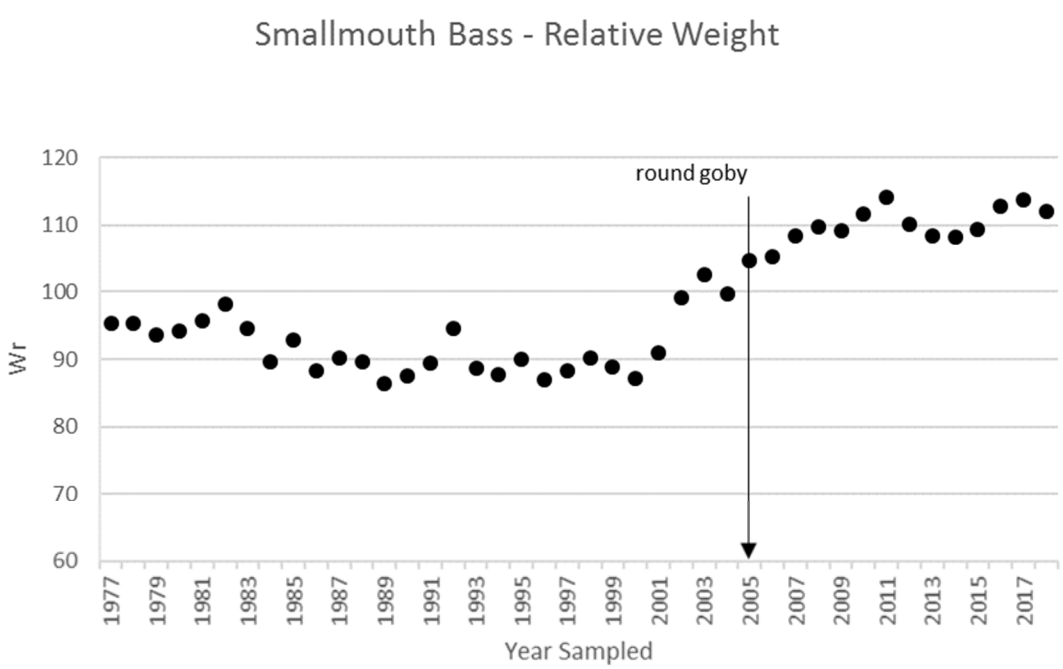

Figure 8. Condition (relative weight, Wr) of smallmouth bass in the Thousand Islands Warmwater Fisheries Assessment1977-2018. Vertical line indicates establishment of abundant round goby-2005.

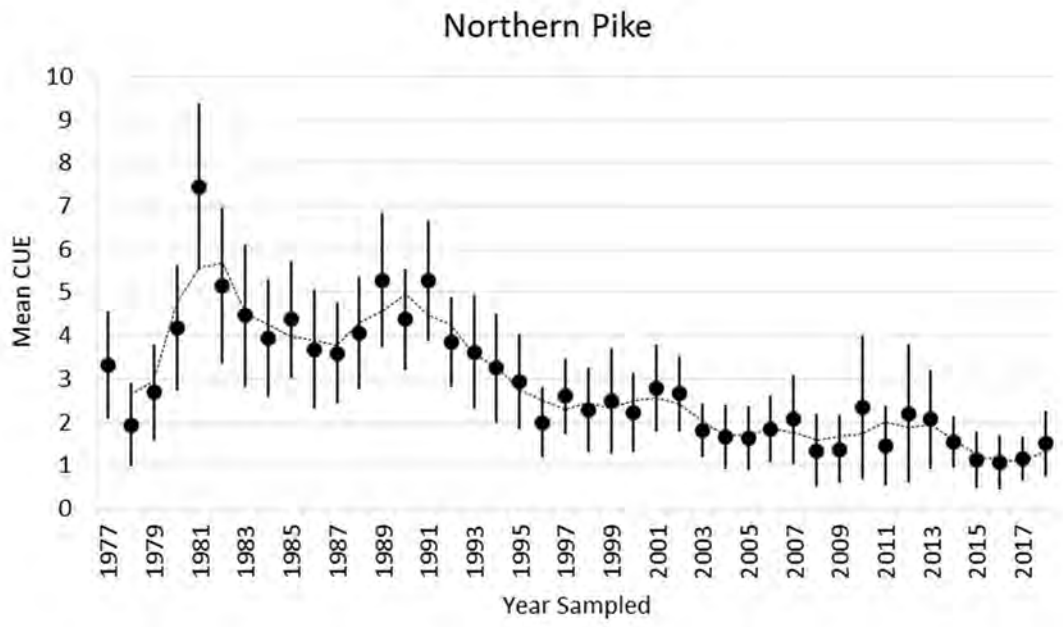

Figure 9. Northern pike abundance index in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Catch per unit effort (CUE) with 95% confidence and 3-year moving average.

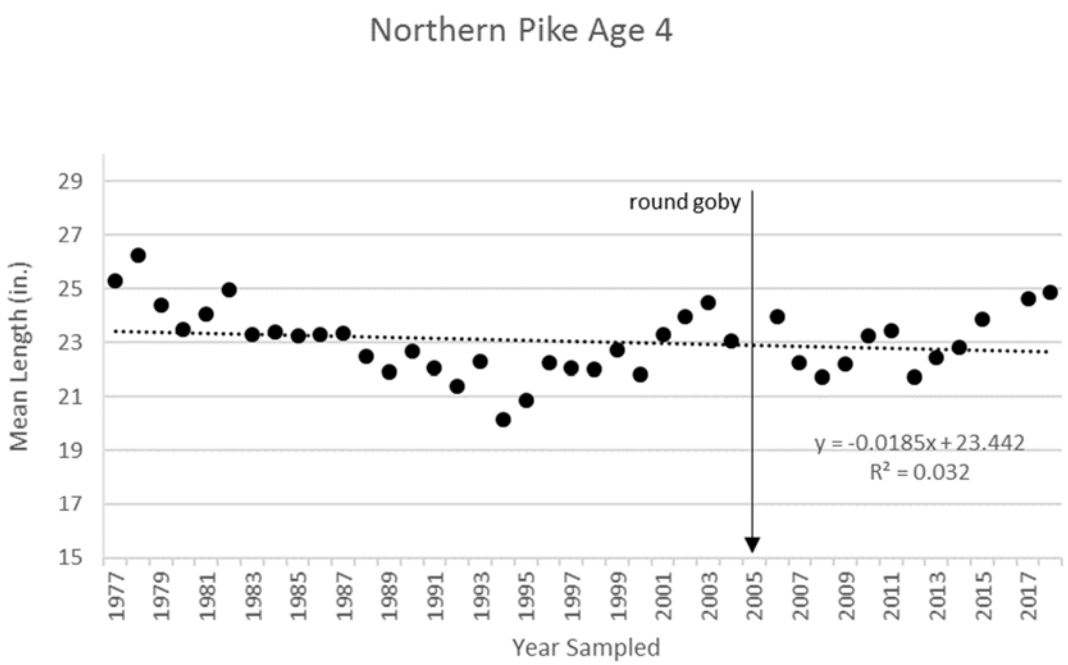

Figure 10. Mean total length of age 4 northern pike in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Vertical line indicates establishment of abundant round goby-2005.

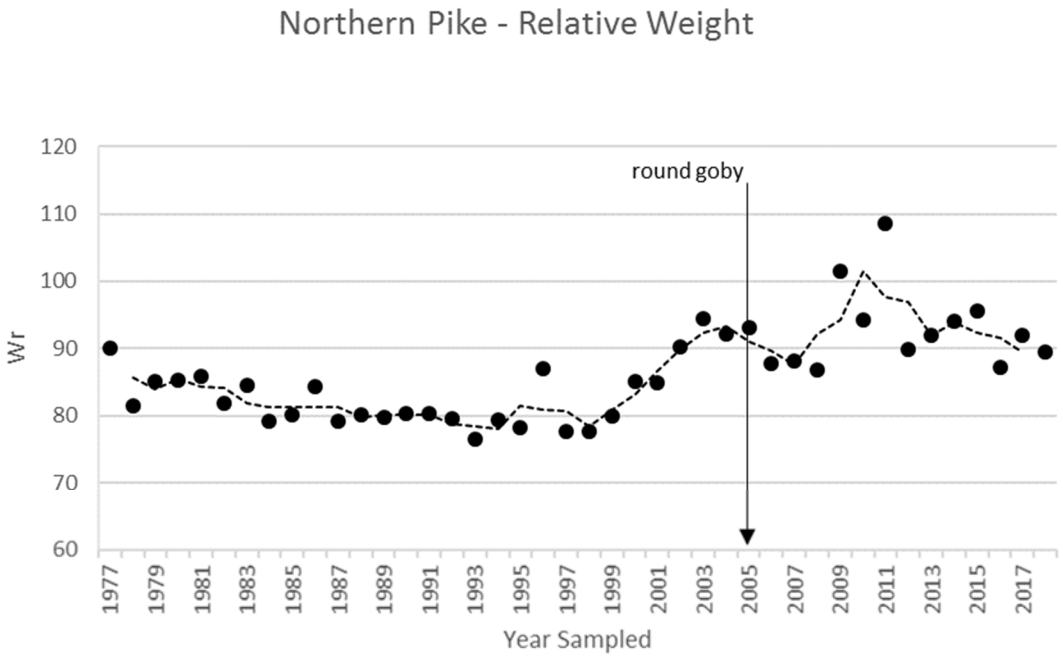

Figure 11. Condition (relative weight, Wr) of northern pike in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Vertical line indicates establishment of abundant round goby-2005.

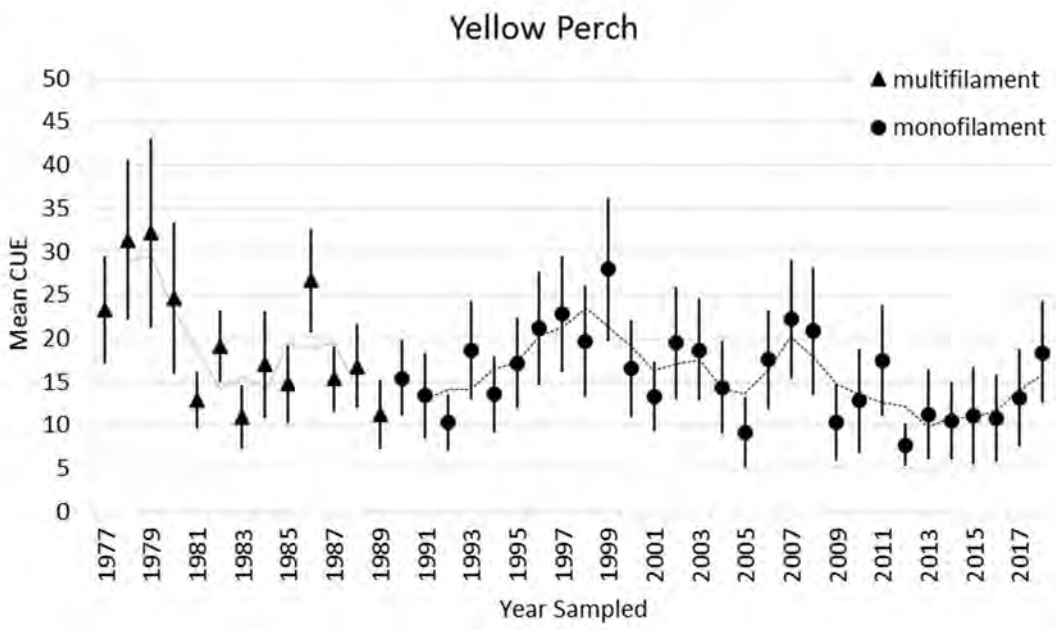

Figure 12. Yellow perch abundance index in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Catch per unit effort (CUE) with 95% confidence intervals and a 3-year moving average. Multifilament CUE from 1990 – 2003 adjusted to monofilament standard.

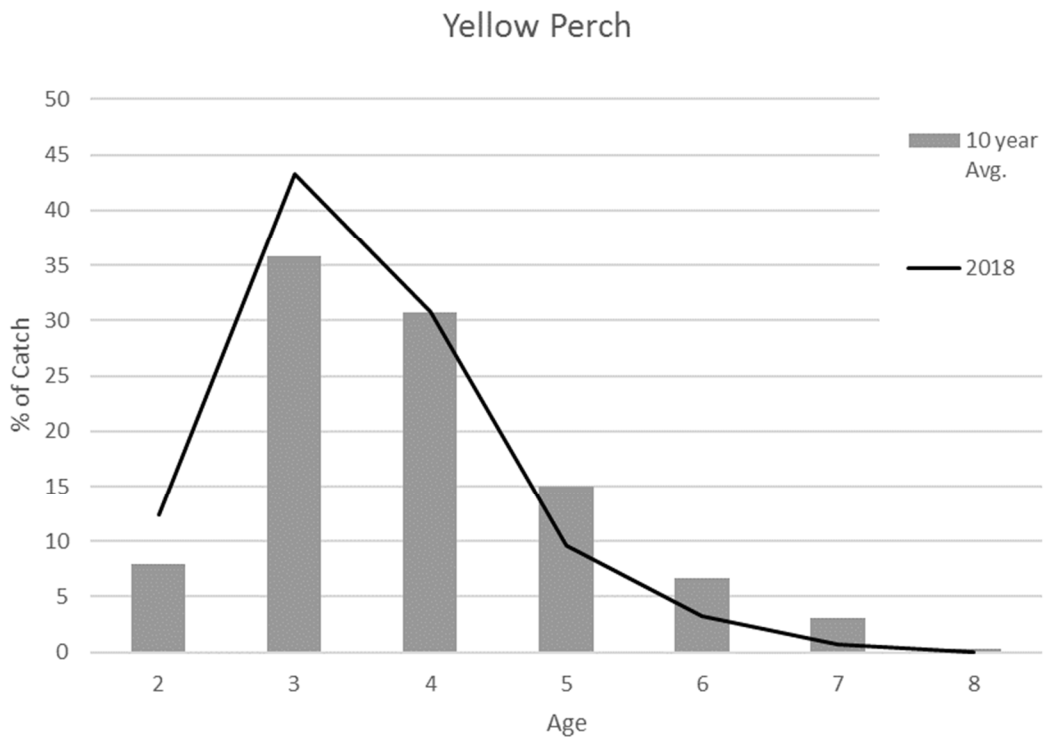

Figure 13. Age composition of yellow perch in the 2018 Thousand Islands Warmwater Fisheries Assessment compared to the previous ten year average.

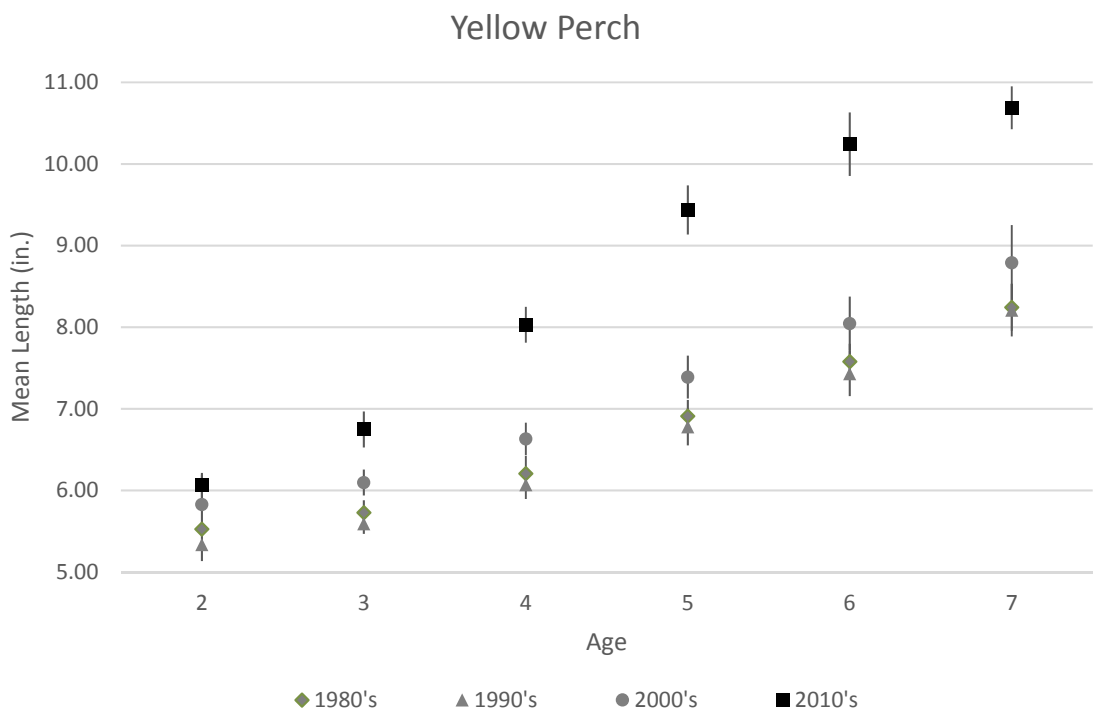

Figure 14. Decadal mean length at age of yellow perch caught in the Thousand Islands Warmwater Fisheries Assessment. Note: mean length was used when n ≥ 4.

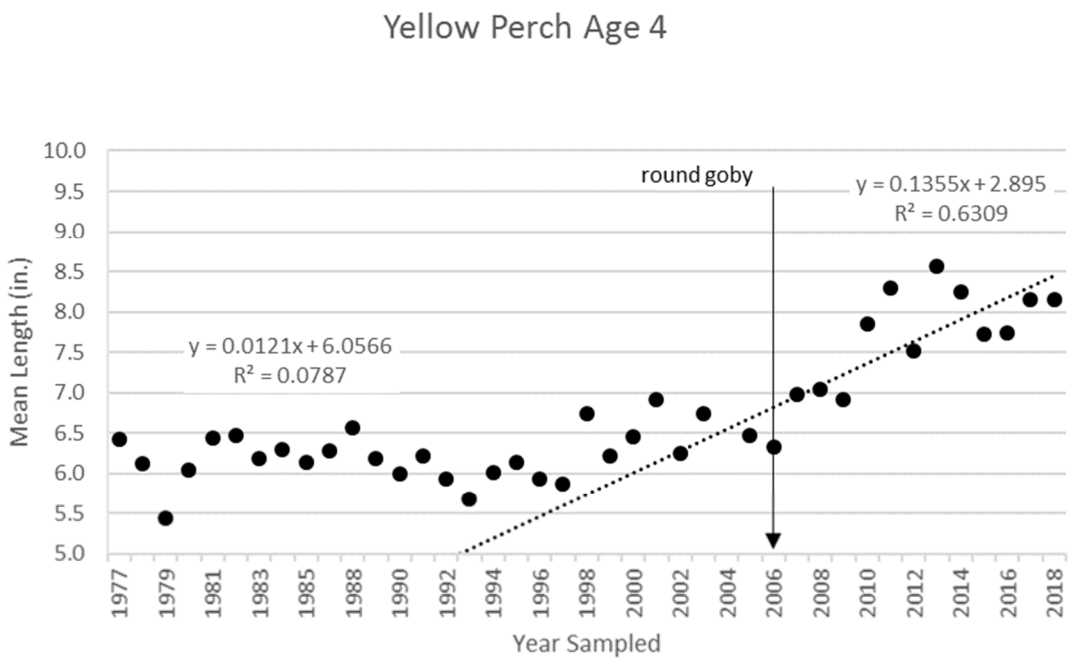

Figure 15. Mean total length of age 4 for yellow perch in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Vertical line indicates establishment of abundant round goby-2005.

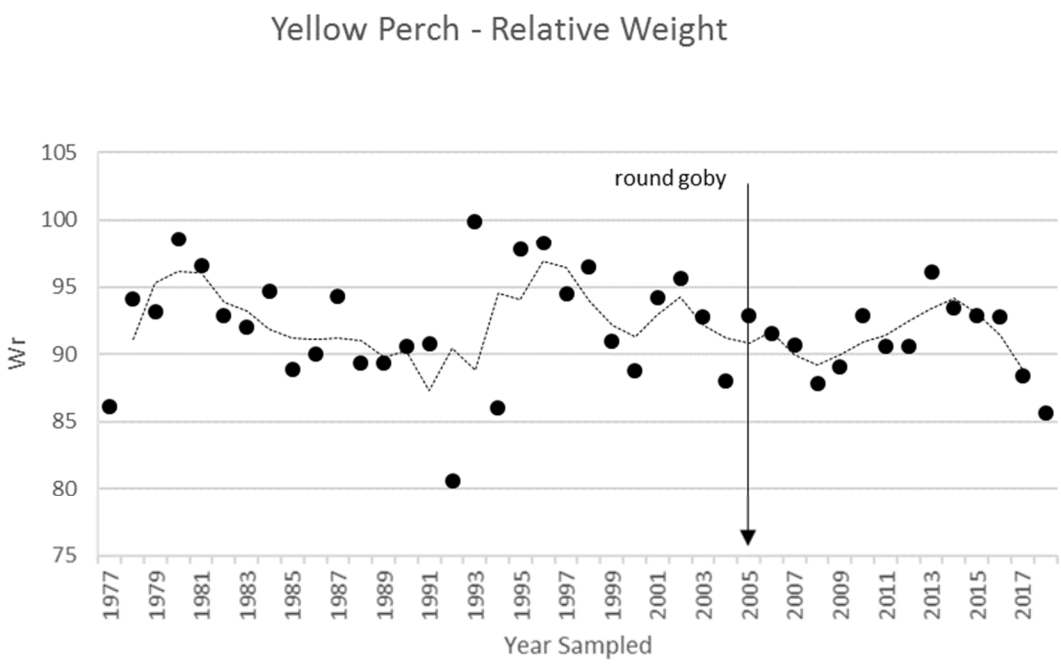

Figure 16. Condition (relative weight, Wr) of yellow perch in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Vertical line indicates establishment of abundant round goby-2005.

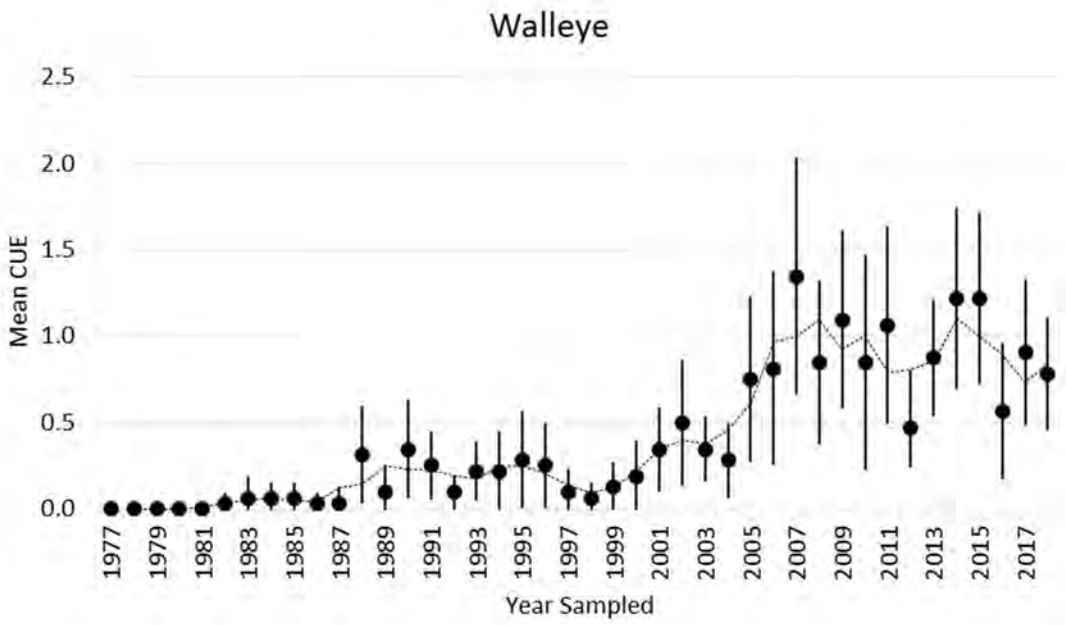

Figure 17. Walleye abundance index in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Catch per unit effort (CUE) with 95% confidence intervals and 3-year moving average.

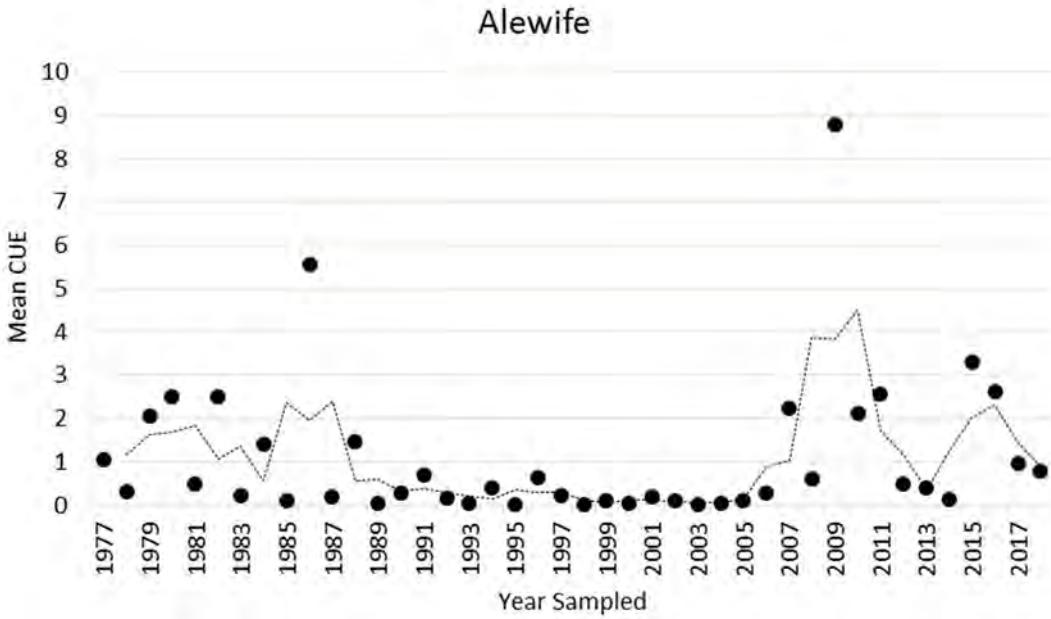

Figure 18. Abundance index for alewife in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Catch per unit effort (CUE) with 3-year moving average.

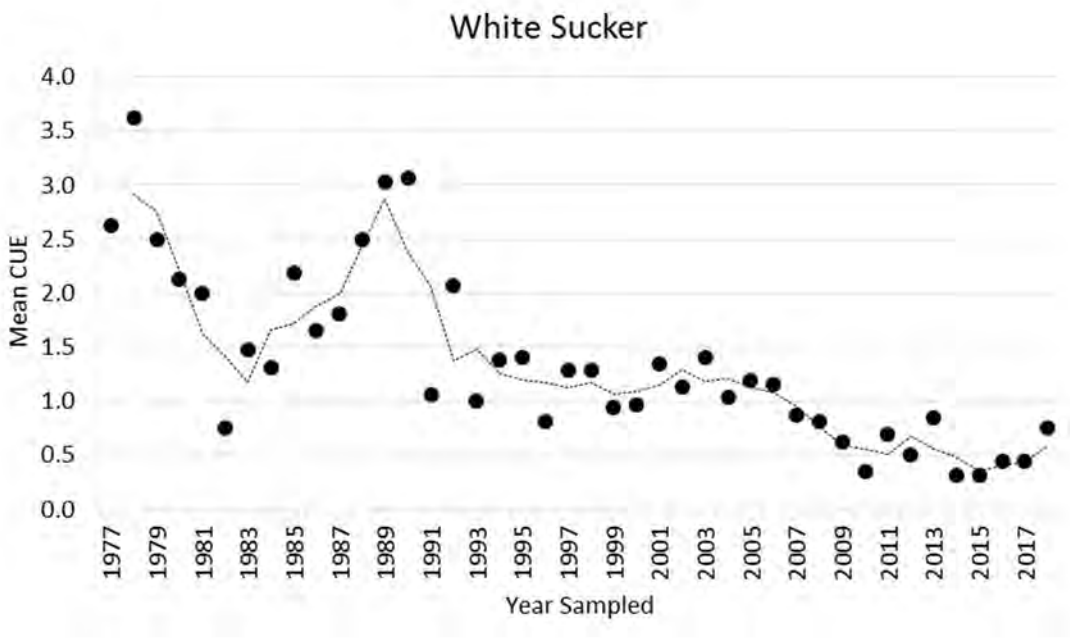

Figure 19. Abundance index for white sucker in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Catch per unit effort (CUE) with 3-yr moving average.

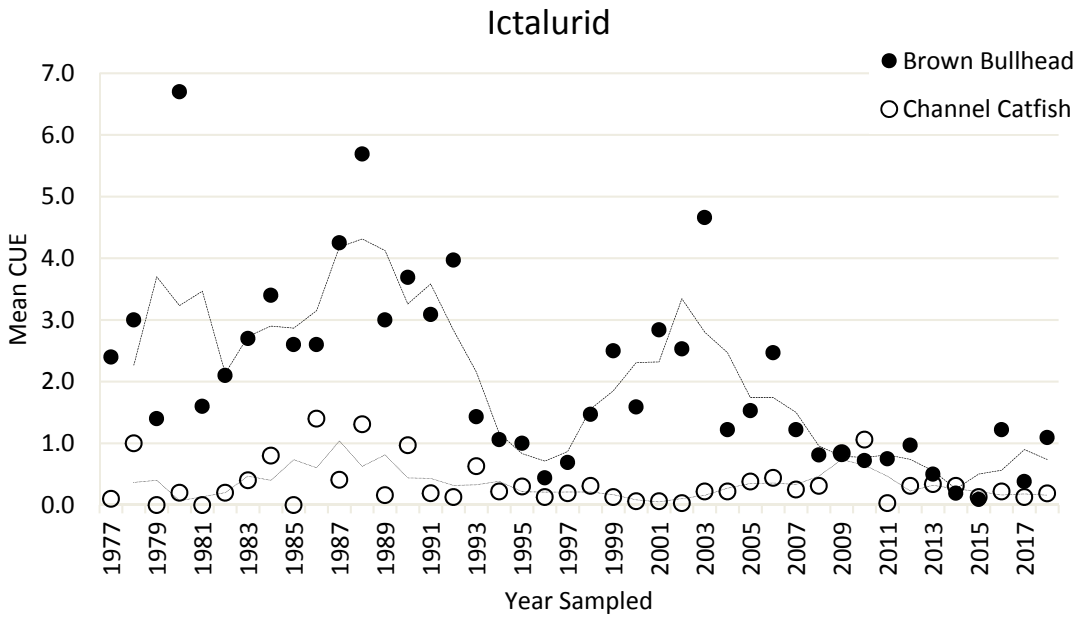

Figure 20. Abundance index for brown bullhead and channel catfish in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Catch per unit effort (CUE) with 3-yr moving average.

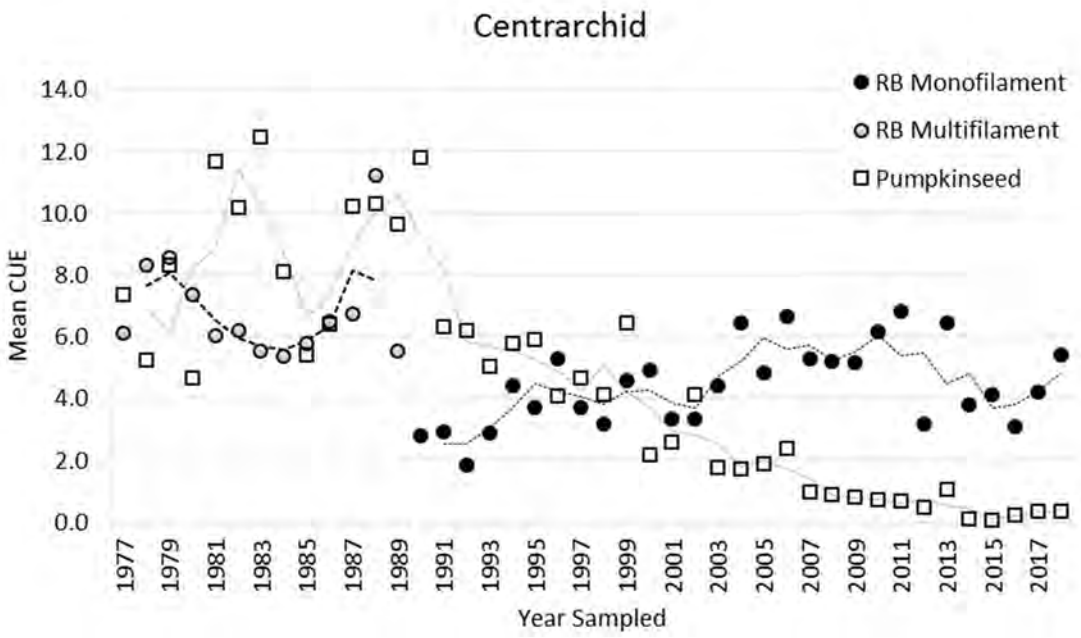

Figure 21. Abundance index for rock bass and pumpkinseed sunfish in the Thousand Islands Warmwater Fisheries Assessment 1977-2018. Catch per unit effort (CUE) with 3-year moving averages. The 1990 – 2003 multifilament catches of rock bass are adjusted to monofilament standard.

2018 Lake St. Lawrence Warmwater Fisheries Assessment

Rodger M. Klindt and David J. Gordon
New York State Department of Environmental Conservation
Watertown, New York 13601

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 17.9 hours (SE=0.08) 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 2018 Lake St. Lawrence warmwater fisheries assessment was conducted from 17 to 20 September. Surface water temperature ranged from 67-70°F (19.4-21.1^{o}C). A sample of 784 fish comprising 19 species was collected (Table 1). The catch was dominated by yellow perch (50.5%), rock bass (19.3%) and white perch (7.9%).

While overall diversity of the fish community in Lake St. Lawrence remained 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. A single Chinook salmon was collected in 2018, marking the second occurrence of this species in the survey.

Total CUE increased by 14.5% from 21.4 fish/net night in 2017 to 24.5 in 2018, and was the 4th highest since 1986 (Figure 2). The average CUE, for data collected by NYSDEC, for this period is 19.33 ± 1.05 (SE). Total CUE is generally driven by fluctuations in yellow perch catch.

Yellow perch CUE increased by 36% from 9.1 in 2017 to 12.4 in 2018, and was the third highest in the data series (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 in. with no fish <5.5 in. and a high proportion of fish >9 in. (17.5%; Figure 4). From 2006 to 2018, yellow perch >9 in. have comprised 17.5-33.9% of the catch. Age-3 yellow perch dominated the catch in 2018 (Figure 5), and were above the previous 10 year average. Yellow perch tend to be absent from the catch by age-7.

Growth rates of yellow perch were determined by year classes of 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 =0.53), an increasing growth rate trend remains apparent for the entire data series. A more recent, short-term trend (2000-2013 year classes) implies that growth rate is stabilizing. Round goby have become a forage source for most piscivorous species in the St. Lawrence River, and it is probable that increased growth rates seen since the expansion of round goby (circa 2000) are a result of yellow perch exploiting round 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 (1.53) was below the long-term average of 2.2 in 2018 (Figure 7). The length frequency distribution showed two distinct peaks at 11-13 inches and from 16-19 inches (Figure 8). The proportion of smallmouth bass <12 inches was approximately 31%. From 1996-2018 the proportion of fish >15 inches has ranged from 31-81% (mean 51%). Age-1&2 smallmouth bass numbers were similar to the previous 10-year average (Figure 9). High catch of the 2016 & 2017 year classes did not follow through to the 2018 catch. The 2011-year class, which had been performing well, has not recruited well past age-4. Both the 2013 & 2014 year classes were consistent with the 10-year average, while all of the older classes had catches below the 10-year average.

Growth rates of smallmouth bass were determined by year class for fish ages 3-7. 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) decreased 6% in 2018 and remains below the long-term average of 1.4 fish/net night (Figure 11). Walleye abundance has been in decline since 2009, however, it appears to have stabilized since 2015. The length-frequency distribution of walleye has one distinct peak at the 8-10 inch range which may indicate a potentially strong year class (Figure 12). Catch was dominated by age-0 fish in 2018 (Figure 13). Walleye representing ages 1-5 were present, but at low levels compared to the 10-year average. 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 (0.38) in 2018 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 8.3-36.4 in (Figure 15). Fish age-1, 2, 6, and 7 were represented in the catch (Figure 16).

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Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of primary species collected in the Lake St. Lawrence warmwater fisheries assessment, 1983-2018.

	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 Lake St. Lawrence warmwater fisheries assessment, 1983-2018.

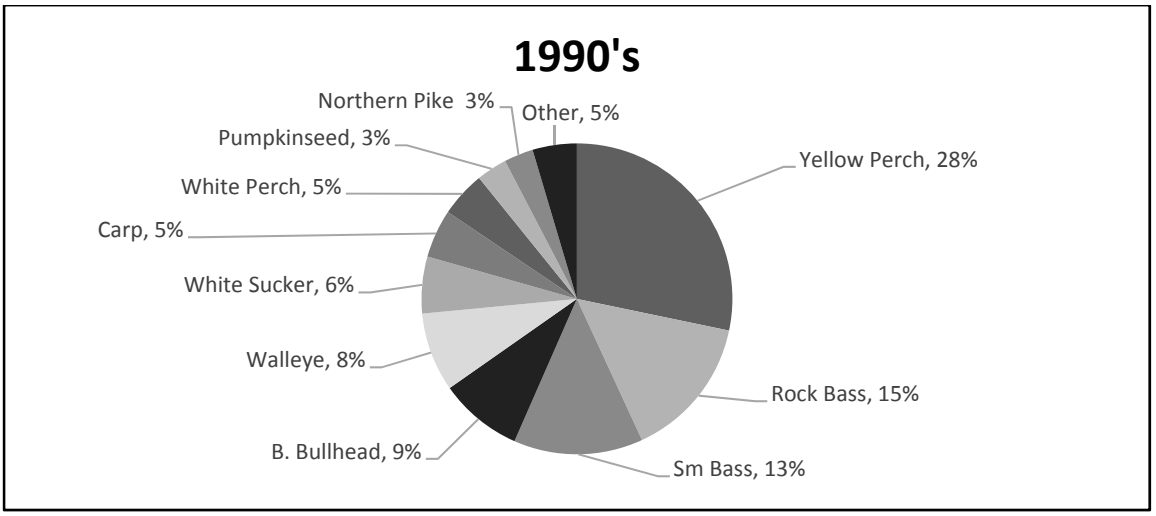
	Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg
Species	**# Nets**	32	47	32	47	32	47	32	32	32	32	
Lake Sturgeon		0	0	0	0	0.03	0	0	0.09	0	0	0.01
Bowfin		0	0	0	0	0	0	0	0	0	0	0.00
Alewife		0.34	0.04	0.66	0.02	0.28	0.43	0	0	0	0	0.18
Gizzard Shad		0.13	0.21	0	0.32	0	0	0.09	0	0	0.13	0.09
Rainbow 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

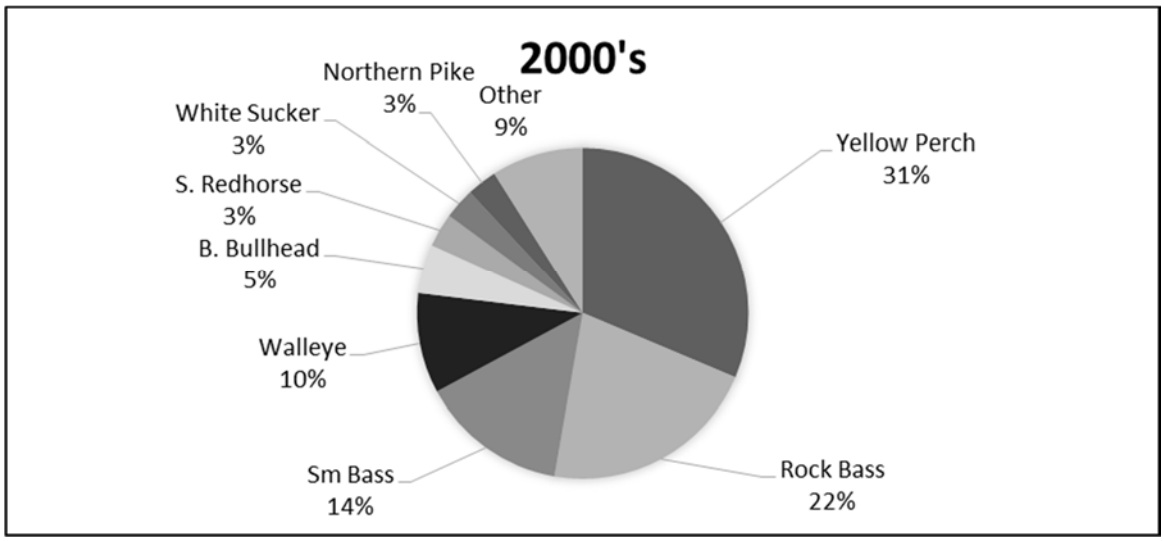
Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of primary species collected in the Lake St. Lawrence warmwater fisheries assessment, 1983-2018.

	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 Lake St. Lawrence warmwater fisheries assessment, 1983-2018.

	Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg
Species	**# Nets**	32	32	32	32	32	32	32	32	32		
Lake Sturgeon		0.06	0.03	0	0	0	0	0	0	0	x	0.01
Bowfin		0.03	0	0	0.03	0	0.03	0	0	0	x	0.01
Alewife		0	0.03	0.09	0	0.03	0	0.31	0.16	0.19	x	0.09
Gizzard Shad		0.06	0.03	0.63	0.44	0	0.03	0.56	0	0	x	0.19
Rainbow Trout		0	0	0	0	0	0	0	0	0	x	0.00
Brown Trout		0	0	0	0	0	0	0	0	0	x	0.00
Lake Trout		0	0	0	0	0	0	0	0	0	x	0.00
Rainbow Smelt		0	0	0	0	0	0	0	0	0	x	0.00
Northern Pike		0.28	0.31	0.19	0.28	0.09	0.13	0.28	0.22	0.38	x	0.24
Muskellunge		0	0.03	0	0	0	0	0	0	0	x	0.00
Lake Chub		0	0	0	0	0	0	0	0	0	x	0.00
Carp		0.19	0.16	0.41	0.25	0.09	0.25	0.13	0.19	0.25	x	0.21
Golden Shiner		0	0	0.03	0	0	0	0	0.16	0.03	x	0.02
Fallfish		0.19	0.19	0.16	0.47	0.16	0.25	0.22	0.69	0.47	x	0.31
White Sucker		0.44	0.53	1.22	0.72	0.59	0.41	0.88	0.88	0.44	x	0.68
Silver Redhorse		0.19	0.63	0.44	0.38	0.25	0.31	0.22	0	0.28	x	0.30
Shorthead Redhorse		0	0	0	0.03	0	0.03	0	0	0	x	0.01
Greater Redhorse		0.06	0.03	0	0.03	0.03	0	0.03	0	0	x	0.02
Yellow Bullhead		0	0	0	0	0	0	0	0	0	x	0.00
Brown Bullhead		0.16	0.22	0.66	0.31	0.78	0.25	0.34	0.25	0.31	x	0.36
Channel Catfish		0.03	0.09	0.09	0.09	0.06	0.06	0	0.03	0.06	x	0.06
White Perch		0.41	1.03	1.75	2.16	3.41	1.59	1.25	1.97	1.94	x	1.72
White Bass		0	0	0	0	0	0	0	0	0	x	0.00
Rock Bass		8.03	3.41	5.16	3.97	5.22	3.5	3.78	3.41	4.72	x	4.60
Pumpkinseed		0.19	0.09	0.16	0.38	0.16	0.56	0.22	0.34	0.34	x	0.27
Bluegill		0	0	0	0	0	0.09	0.09	0.03	0	x	0.02
Smallmouth Bass		2.22	1.34	2.66	3.09	1.97	2.25	1.81	2.06	1.53	x	2.10
Largemouth Bass		0.22	0.22	0.69	0.09	0.03	0.44	1.18	0.75	0.13	x	0.42
Black Crappie		0	0	0	0.03	0	0.03	0.13	0.09	0.03	x	0.03
Yellow Perch		18.78	9.03	16.69	7.94	7.5	8.88	7.28	9.06	12.38	x	10.84
Walleye		2.75	1.81	2.09	2.06	1.38	0.84	0.91	1.03	0.97	x	1.54
Freshwater Drum		0.03	0	0.03	0.03	0	0.03	0.03	0.03	0	x	0.02
TOTAL CATCH		34.25	19.34	33.16	22.93	21.78	19.97	19.66	21.37	24.50	x	24.17





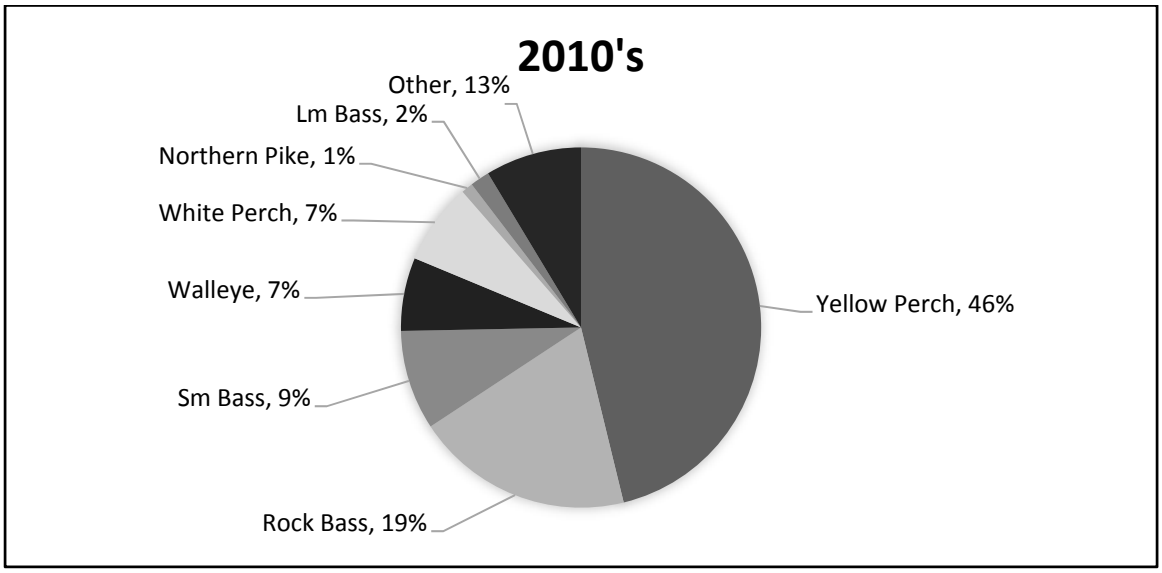


Figure 1. Composition of the fish community sampled in the Lake St. Lawrence warmwater fisheries assessment presented by decade.

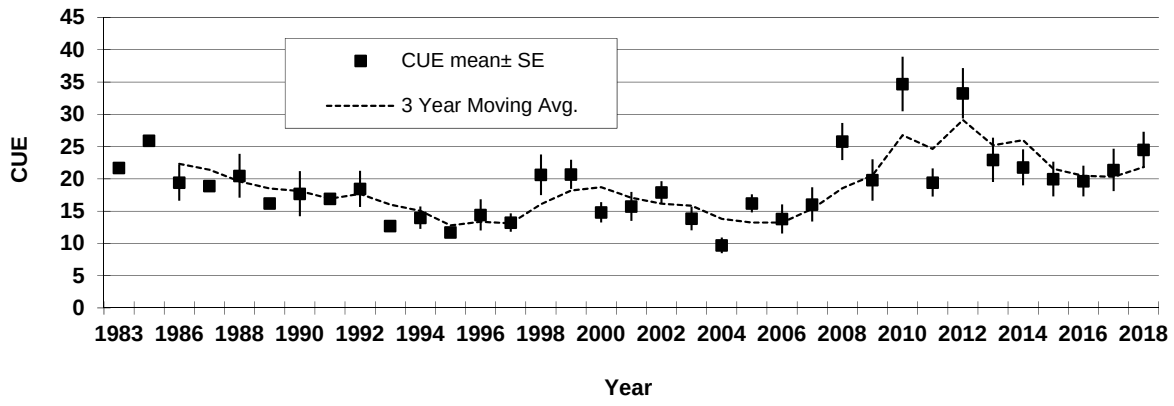


Figure 2. Total catch per gill net night (CUE) for the Lake St. Lawrence warmwater fisheries assessment, 1983-2018.

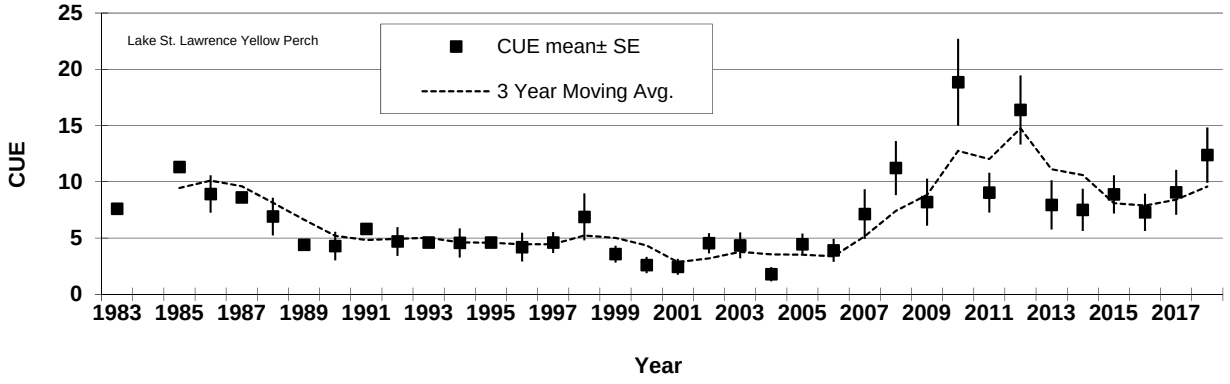


Figure 3. Yellow perch total catch per gill net night (CUE) for the Lake St. Lawrence warmwater fisheries assessment, 1983-2018.

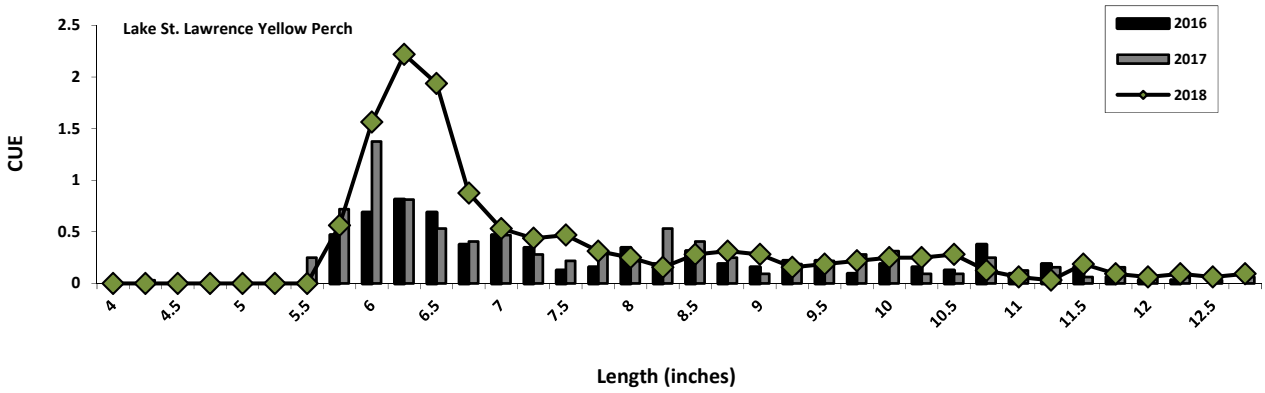


Figure 4. Yellow perch length-frequency distribution for the Lake St. Lawrence warmwater fisheries assessment, 2016-2018.

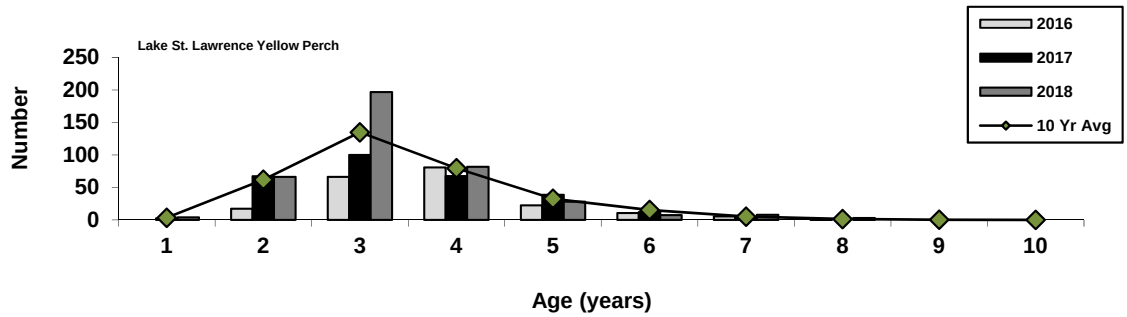


Figure 5. Yellow perch age-frequency distribution for the Lake St. Lawrence warmwater fisheries assessment, 2016-2018 and 10-year average .

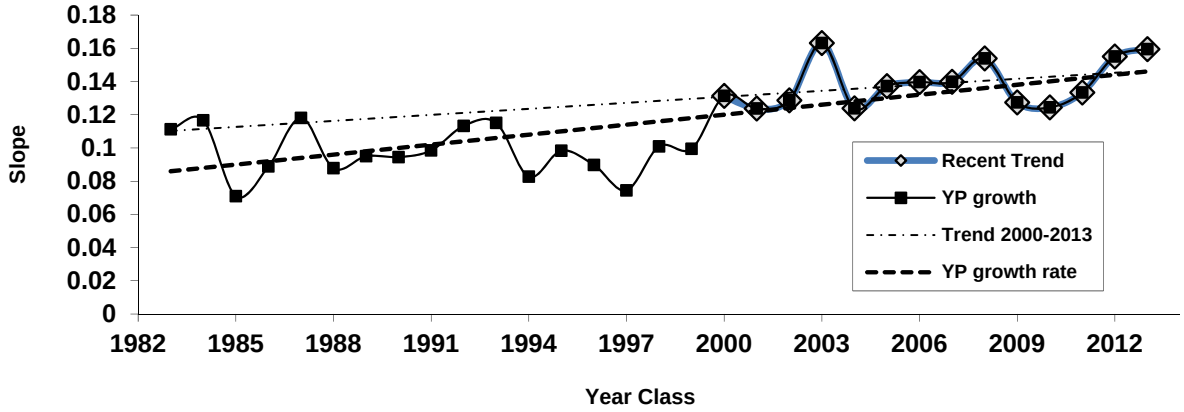


Figure 6. Yellow perch growth rates by year class using fish ages 2-6 for the Lake St. Lawrence warmwater fisheries assessment, 1982-2013 year classes.

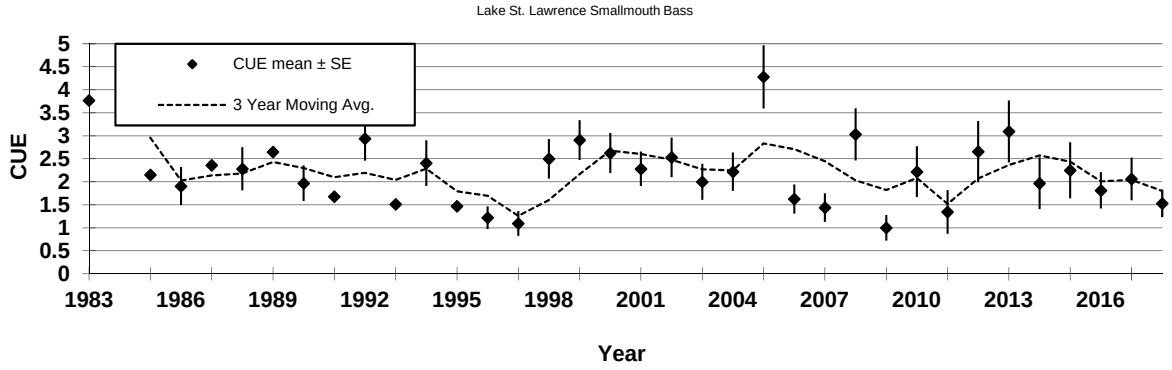


Figure 7. Total catch per gill net night (CUE) for smallmouth bass in the Lake St. Lawrence warmwater fisheries assessment, 1983-2018.

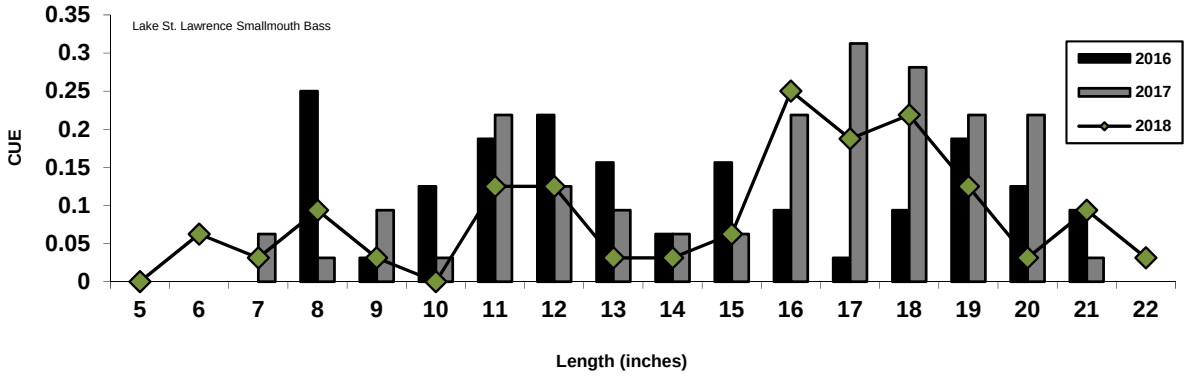


Figure 8. Smallmouth bass length-frequency distribution for the Lake St. Lawrence warmwater fisheries assessment, 2016-2018.

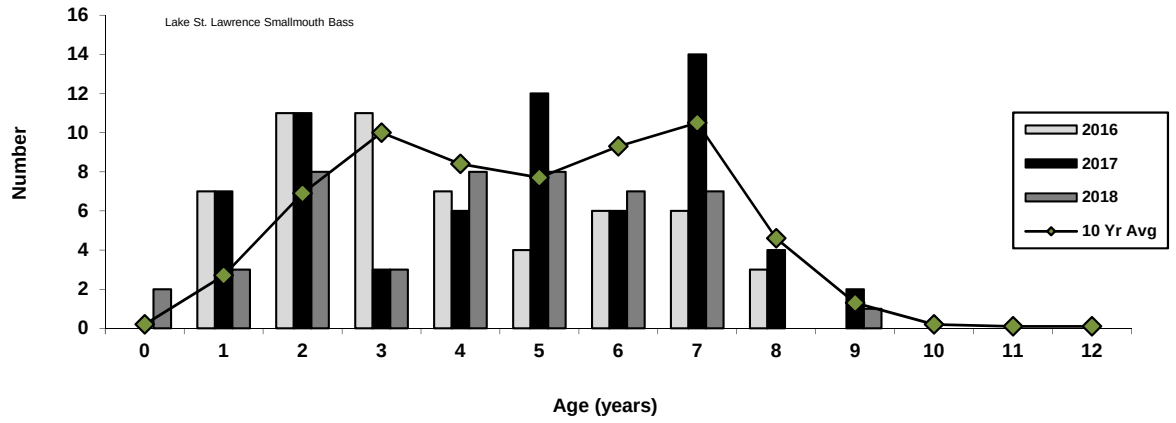


Figure 9. Smallmouth bass age-frequency distribution for the Lake St. Lawrence warmwater fisheries assessment, 2016-2018 and the 10-year average.

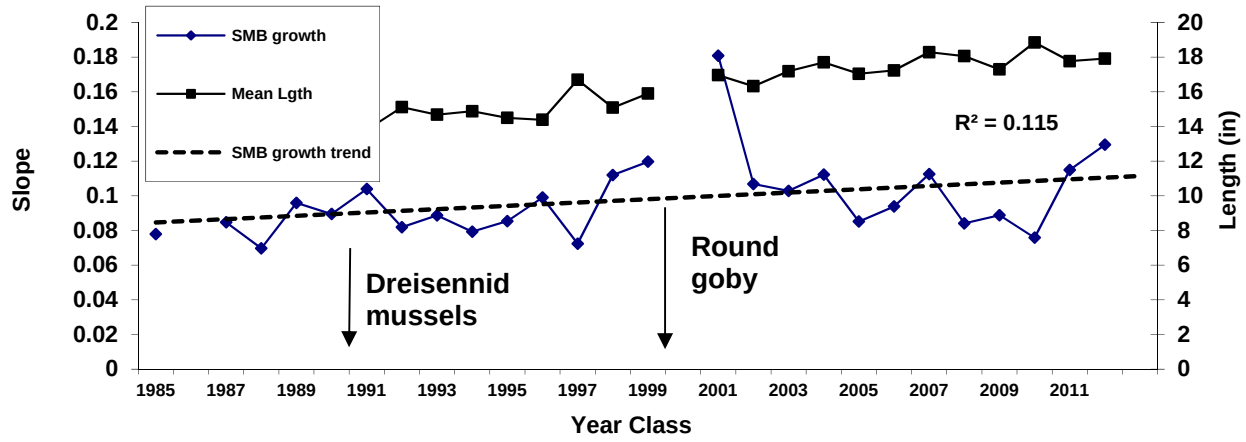


Figure 10. Smallmouth bass growth by year class described using two methods: growth rate (slope) using fish ages 3-7 and mean length (in) at age-6 for the Lake St. Lawrence warmwater fisheries assessment, 1985-2012 year classes.

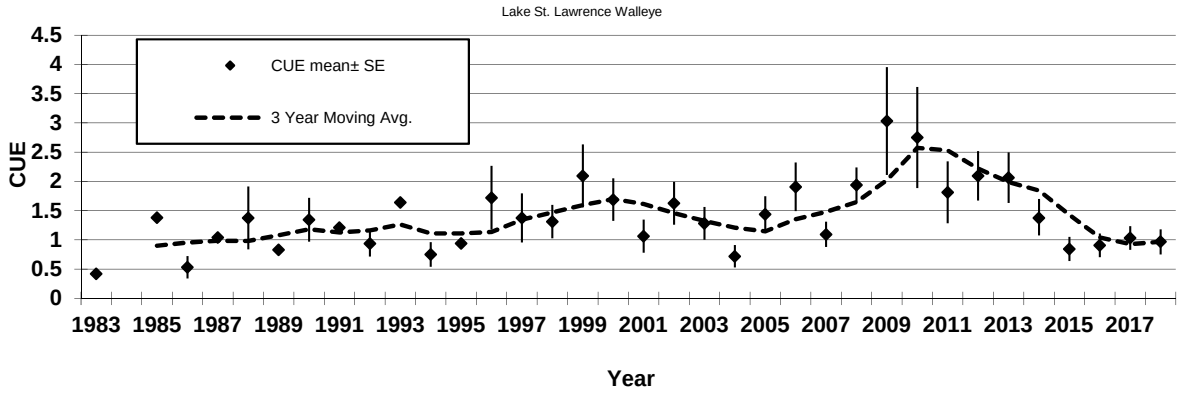


Figure 11. Total catch per gill net night (CUE) for walleye in the Lake St. Lawrence warmwater fisheries assessment, 1983-2018.

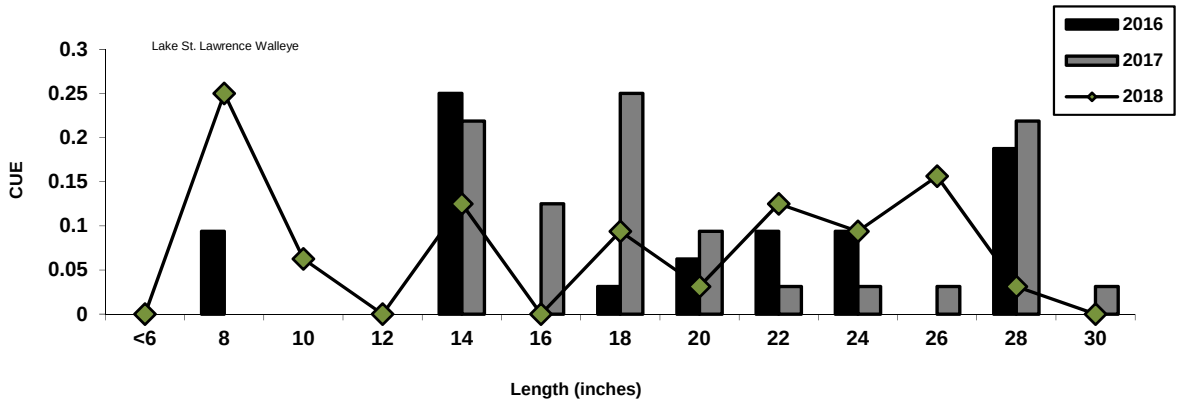


Figure 12. Walleye length-frequency distribution for the Lake St. Lawrence warmwater fisheries assessment, 2016-2018.

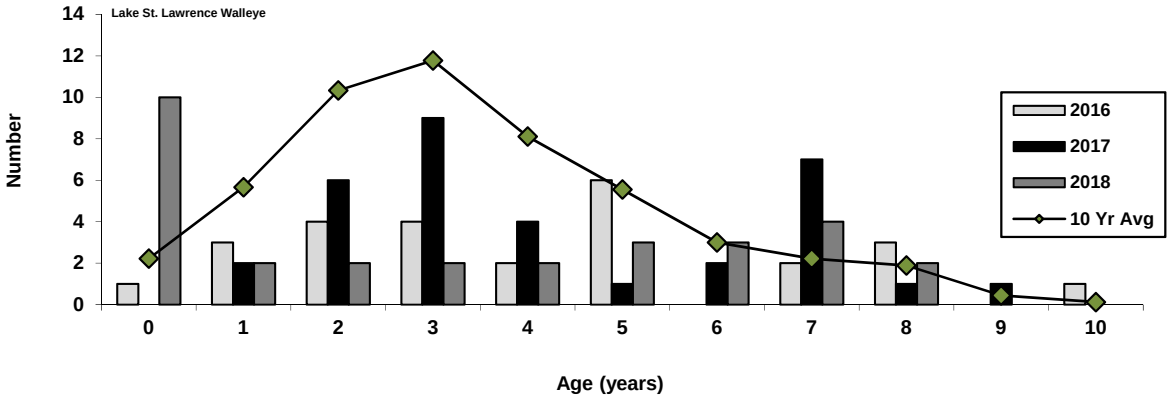


Figure 13. Walleye age-frequency distribution for the Lake St. Lawrence warmwater fisheries assessment, 2016-2018 and 10-year average.

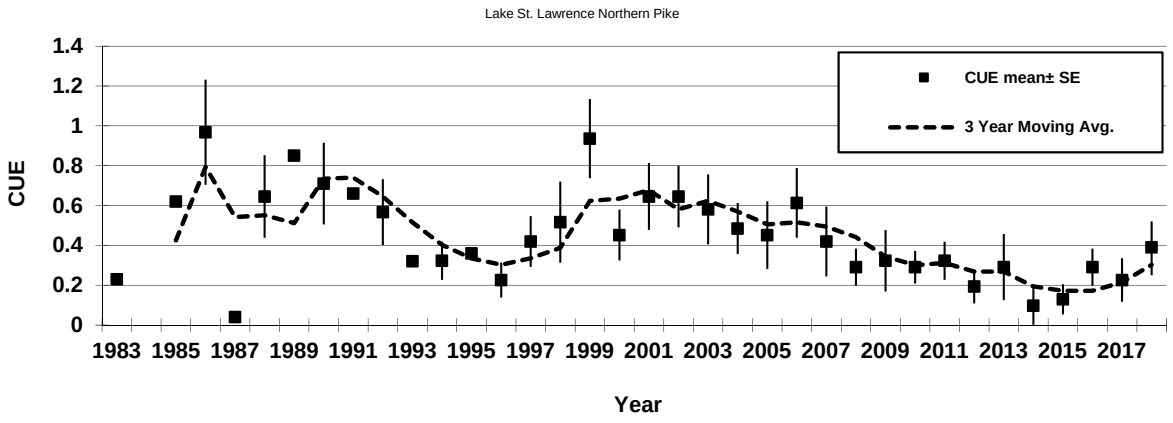


Figure 14. Total catch per gill net night (CUE) for northern pike in the Lake St. Lawrence warmwater fisheries assessment, 1983-2018.

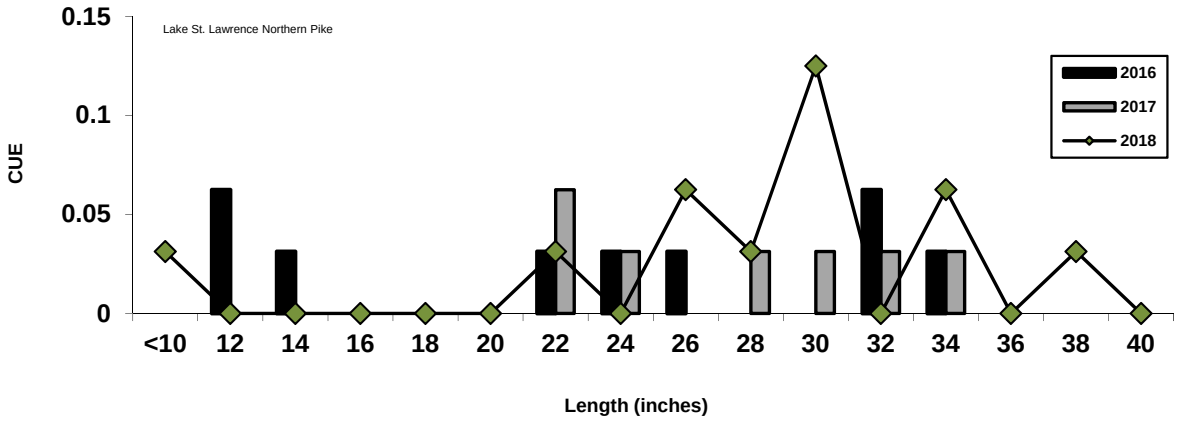


Figure 15. Northern pike length-frequency distribution for the Lake St. Lawrence warmwater fisheries assessment, 2016-2018.

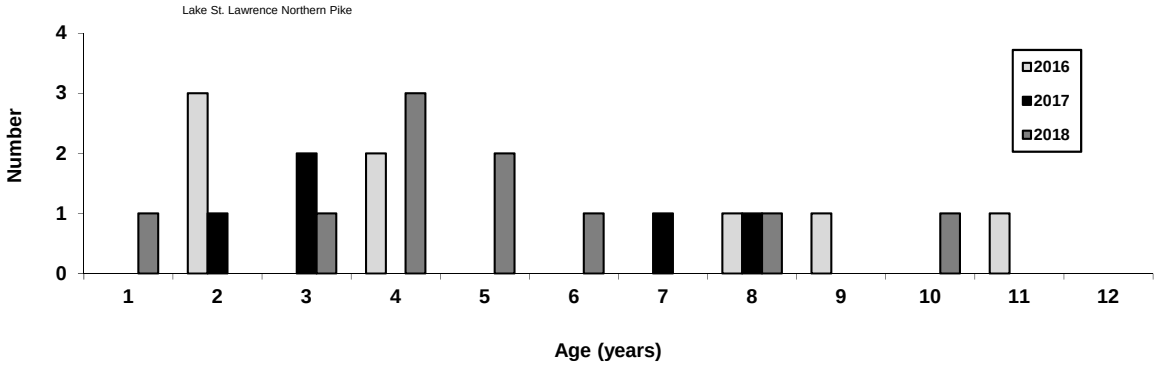


Figure 16. Northern pike age-frequency distribution for the Lake St. Lawrence warmwater fisheries assessment, 2016-2018.

2018 Salmon River Wild Young-of-Year Chinook Salmon Seining Program

D. L. Bishop and S. E. Prindle
New York State Department of Environmental Conservation
Cortland NY 13045

F. J. Verdoliva
New York State Department of Environmental Conservation
Altmar NY 13302

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 salmon caught per seine 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.

We used correlation and regression analyses to study the effects of flow and air temperature on Chinook salmon production (SAS rel. 9.3, Cary NC). The flow data used were mean daily discharges to the Salmon River from the Lighthouse Hill Reservoir available at: https://www.safewaters.com/facility/42. The temperature data used were mean daily air temperatures from October through May for Pulaski NY available at: http://www.weatherdatadepot.com/?gclid=CLumudWty80CFYMehgod_JwLGQ.

Results and Discussion

The mean peak YOY Chinook salmon catch in 2018 was 49 fish/haul tying the 2008 catches for the second lowest year of production in the study period (Figure 2). The three weeks used to calculate the mean peak catch were the fourth week of May through the second week of June (Figure 3). We used our 30 May sampling date to represent the first week in June in 2018. The largest haul for a single site was 147 which occurred at Pineville on 30 May (Figure 4) and the highest catches for all sites combined also occurred on 30 May.

We have previously reported on the importance of adequate flows during the spawning period (October 1 – 21) which provide fish access to the upper river, and the negative effects of high flow events during the incubation period (October 22 through May 31) which have the potential to move bed load and disturb redds. However, the correlation between the spawning flows and

subsequent Chinook salmon production (r=0.04, r=0.88) has deteriorated to the point where the spawning flows are no longer a useful predictor of production. Flows below 200 cfs in the falls of 2002 and 2007 resulted in very poor production in the springs of 2003 and 2008. Production has varied widely in years with spawning flows above 200 cfs with the strongest (2016) and one of the weakest (2018) years of production occurring with spawning flows at or near the prescribed baseflow of 385 cfs.

Maximum incubation flows from October 22 through the end of May are the most highly correlated predictor that we have for Chinook salmon production ($r = -0.64$, $p < 0.01$) and account for 53% of the variability in production in a second order polynomial regression model (i.e., includes an x^2 term to account of the non-linear relationship; Figure 5).

We also explored the use of mean daily air temperatures for Pulaski, NY from October 1 through May 31 as an additional predictor to account for thermal effects throughout the spawning and incubation periods. There was moderate correlation between temperatures during spawning and incubation period and the subsequent mean peak mean catches ($r = 0.44$, $p = 0.07$) revealing higher production occurring in warmer years (Figure 5). Additionally, the maximum incubation flows and temperature data were not correlated with each other ($r = -0.04$, $p = 0.88$) which has the advantage of the predictors accounting for different portions of the variability in the mean peak catches.

We developed a regression model that included both predictors and their squared terms and used Akaike's Information Criteria to select the "best" model. This resulted in selecting the square of the incubation flow, the mean spawning and incubation temperature, and its squared term. The model explained 70% of the variability in the mean peak catches ($r^2 = 0.70$, $p < 0.001$) and provides the following regression equation:

$$y = -0.00001086\, x^2 + 34.05967\, z^2 - 2602.04565\, z + 50155$$

Where y = mean peak catch, x = maximum incubation flow (cfs) and z = mean spawning and incubation temperature (F°). The regression model output is presented in Appendix 1.

Observed and predicted mean peak catches are depicted in Figure 6. The model badly over predicted the 2018 year class. We had near baseflow spawning flows and relatively low maximum incubation flow; both of which suggested that we would see more production in 2018. Figure 3 suggests that the peak week of abundance in 2018 was the first week of June, which is later than average.

The relative lateness of the hatch in 2018 prompted us to take a closer look at the relationship between temperature and production, a potential explanation for low catches observed in 2018 is that while the overall spawning and incubation temperatures were only slightly colder than average, the mean temperature in April 2018 (39 F°) was the coldest during the 18-year study period. This may have impaired development and subsequent hatching. Interestingly, the 2016 year class, which is the largest year class that we have observed, experienced the second coldest April (42 F°) but experienced above average temperatures over the entire spawning and incubation period. (Figure 7).

Other year classes that the model missed by over 100% were 2003, 2008, and 2009; all of which were relatively weak year classes that were over-estimated. The estimates for 2003 and 2008 can be explained by the sub-200 cfs flows which occurred during the spawning period. Recall that we no longer include the spawning flows in the model and that flows less than 200 cfs during the spawning period resulted in very low production in both of those years. It is also worth noting that, while the model did overestimate theses year classes, the number of fish/haul that the model predicted was still quite low.

The average flow during May could influence how fast fish move out of the system and/or our ability to sample them. The daily mean flow in May 2009 was 803 cfs which was above average (mean = 589 cfs) but perhaps more important was that flows

ranged from 1,121-2,030 cfs from 17-20 May which is generally near the peak of abundance. The only years with similar flows during May were 2002 and 2003; both of which also produced weak year classes but the catches were better explained by the incubation flows and spawning and incubation temperatures in the model.

Overall, the fact that the model explains 70% of the variability in the mean peak catches is remarkable considering the numbers of factors which could influence annual production. Maximum flow events during the incubation period appear to be the most important factor but air temperatures also play an important role in annual 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 salmon 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

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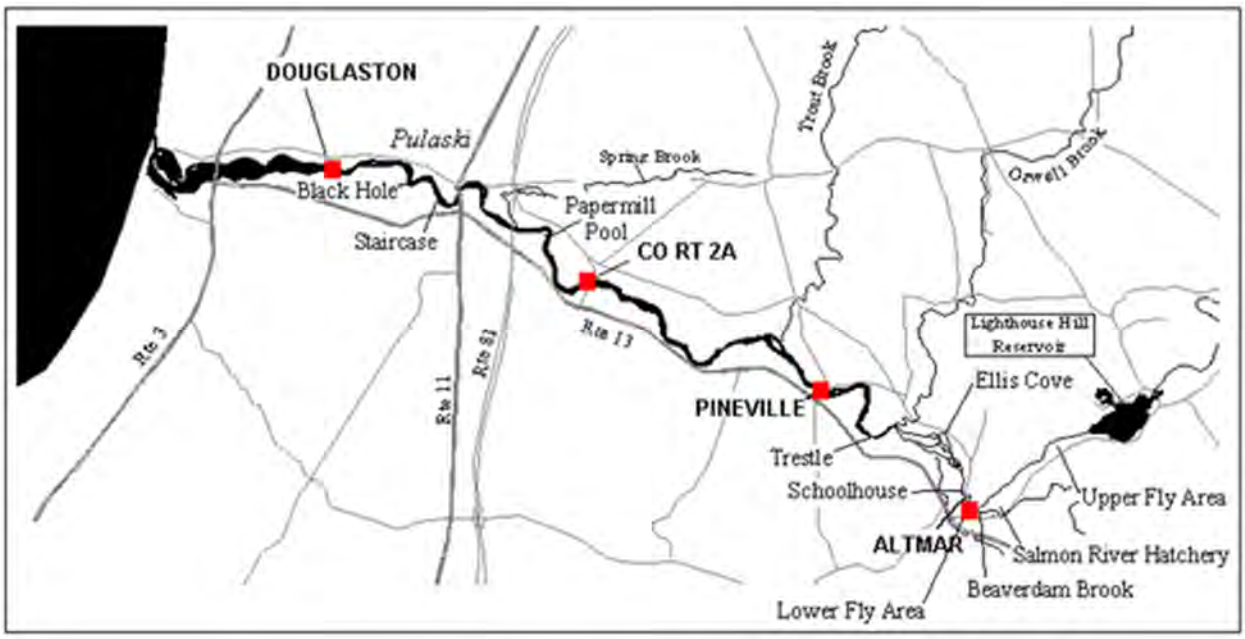


Figure 1. Sampling sites for the NYSDEC Salmon River seining program.

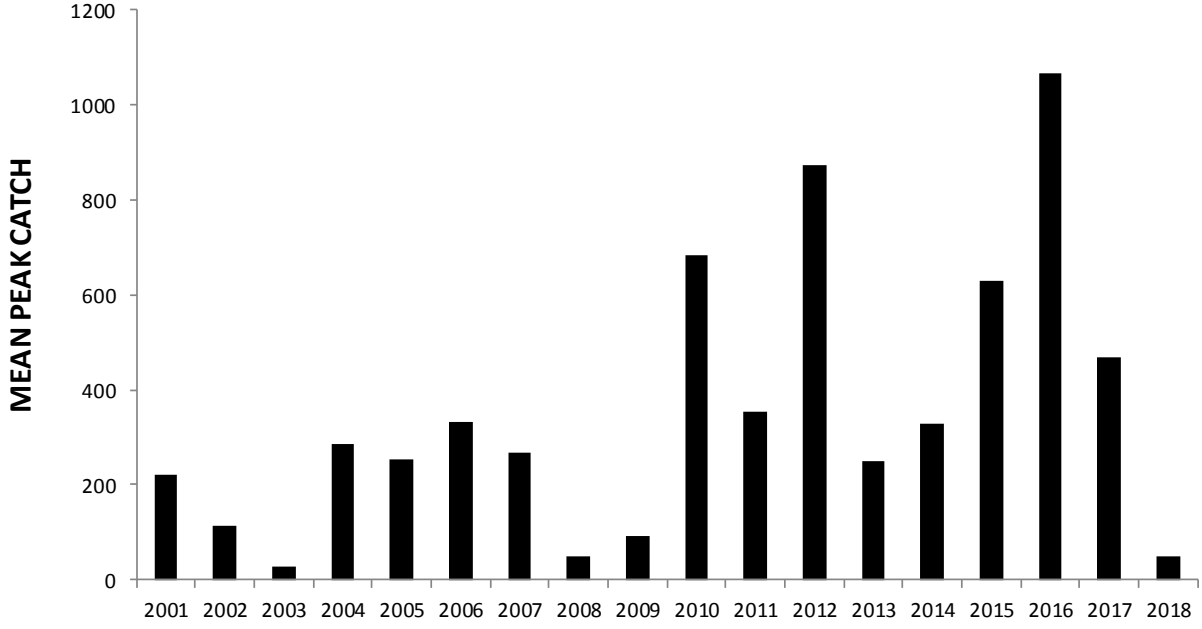


Figure 2. Mean peak catches of YOY Chinook salmon (mean number per seine haul) captured in the three consecutive weeks with the highest catches from the NYSDEC Salmon River seining program 2001-2018.

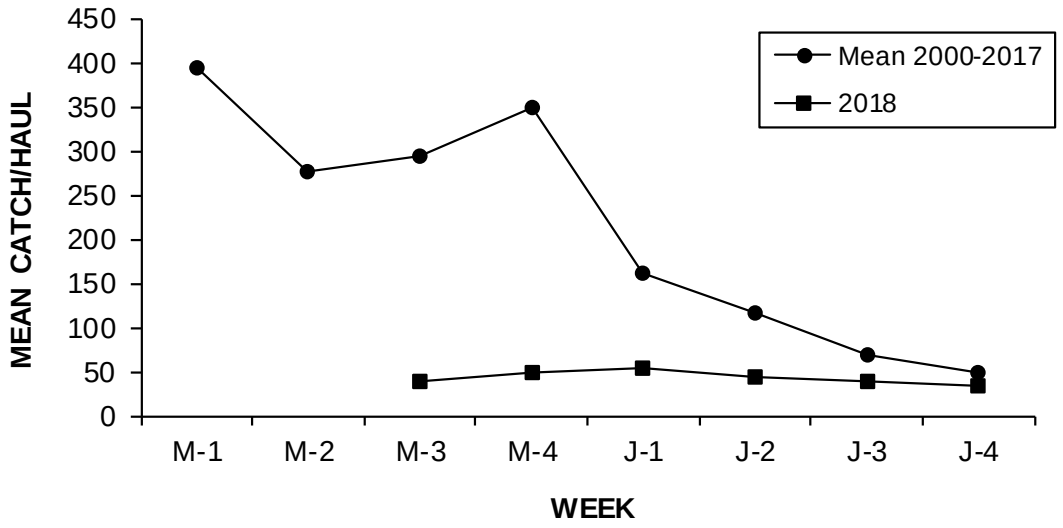


Figure 3. Mean numbers of YOY Chinook salmon captured per seine haul by week in the NYSDEC Salmon River seining program for 2001-2017 and 2018 (M=May, J=June).

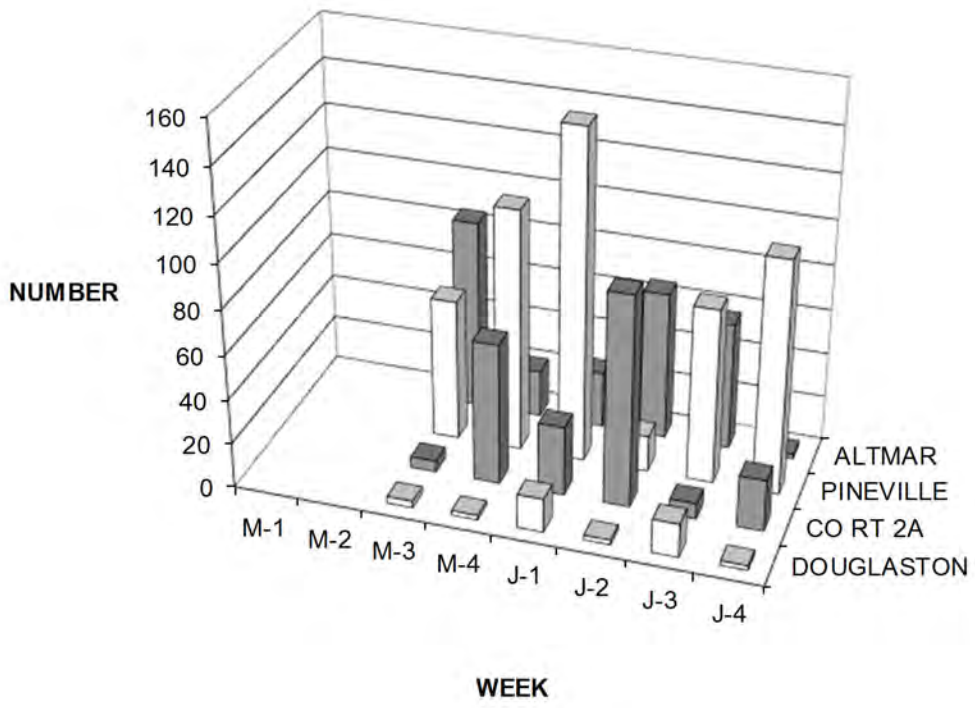
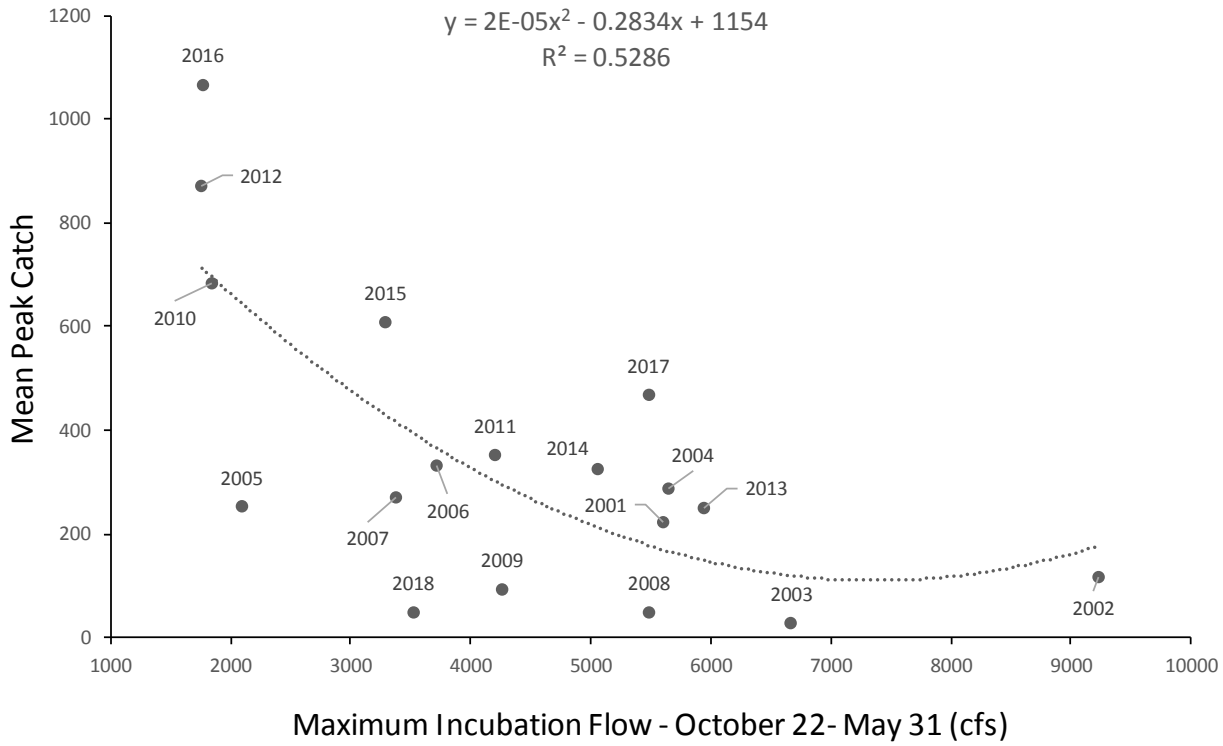


Figure 4. Numbers of YOY Chinook salmon caught by week and site from the NYSDEC Salmon River seining program 2018.



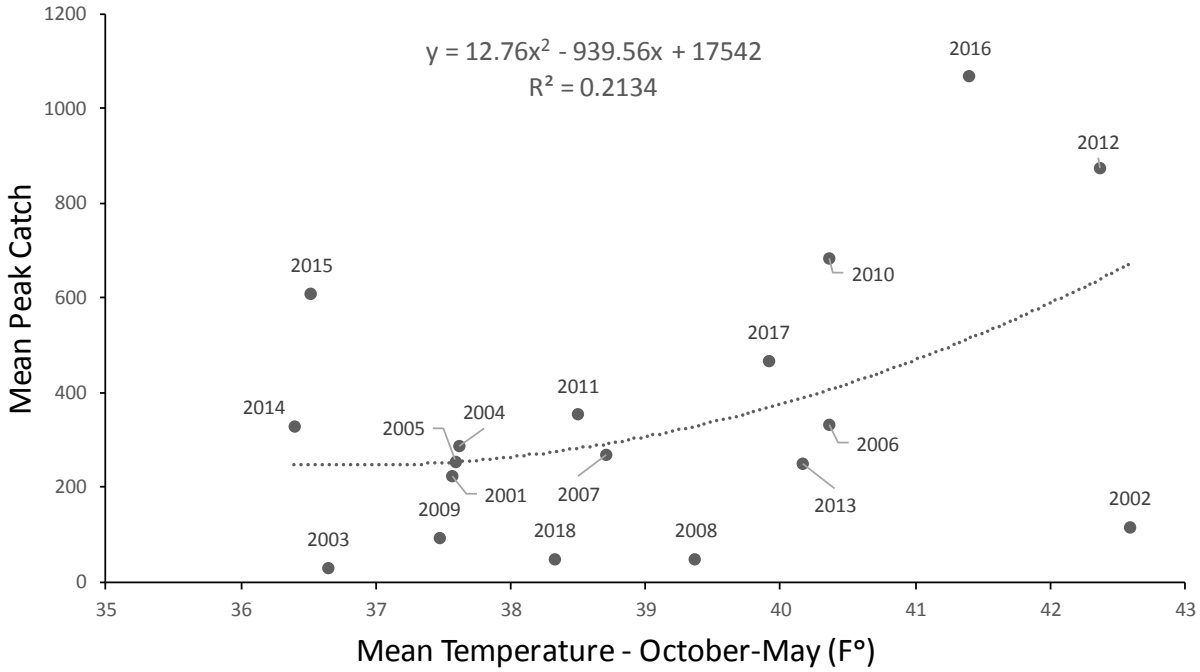


Figure* 5. *Maximum incubation flows (top graph) and mean spawning and incubation daily air temperatures (bottom graph) predicting mean peak catches of YOY Chinook salmon from the NYSDEC Salmon River seining program 2001-2018.

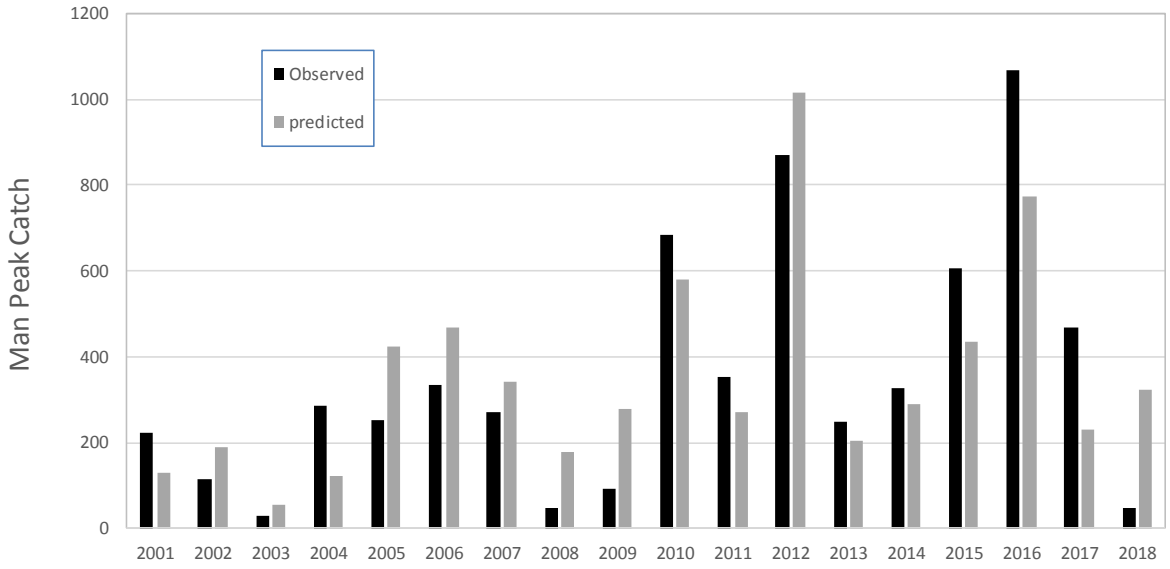


Figure 6. Observed and predicted mean peak catches of YOY Chinook salmon from the NYSDEC Salmon River seining program 2001-2018.

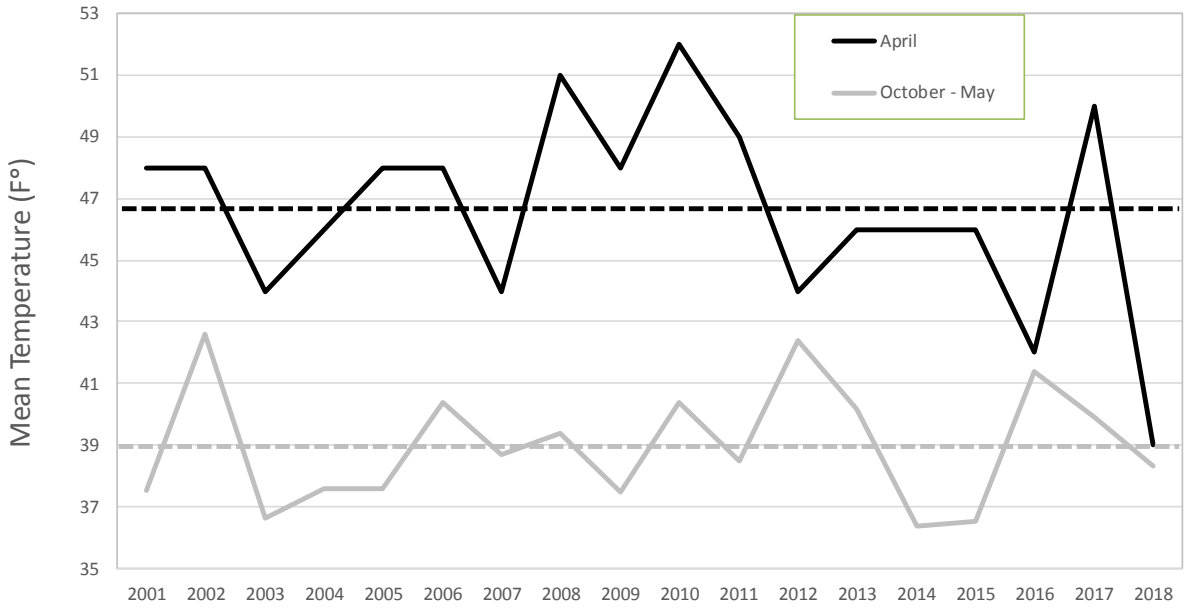


Figure 7. Mean October through May and April air temperatures (measured at Pulaski, NY) for the NYSDEC Salmon River seining program 2001-2018.

Appendix 1. Regression results for maximum incubation flows (October 22through May) and mean temperatures during the spawning and incubation period (October through May) predicting mean peak catches of young of year Chinook Salmon for the NYSDEC Salmon River seining program 2001-2018.

Dependent Variable: mean_peak_catch					
Analysis of Variance					
Source	**DF**	**Sum of Squares**	**Mean Square**	**F Value**	**Pr > F**
Model	3	996564	332188	10.72	0.0006
Error	14	433898	30993		
Corrected Total	17	1430463			
Root MSE	176.04749	**R-Square**	0.6967		
Dependent Mean	351.5	**Adj R-Sq**	0.6317		
Coeff Var	50.08463				
Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	**1**	50155	20091	2.5	0.0256
max_oct22tomay31_flow_sq	**1**	-0.00001086	2.3E-06	-4.72	0.0003
meantemp	**1**	-2602.04565	1022.301	-2.55	0.0233
meantemp_sq	**1**	34.05967	12.99167	2.62	0.0201

Population Characteristics of Pacific Salmonines Collected at the Salmon River Hatchery 2018

S.E. Prindle and D.L. Bishop
New York State Department of Environmental Conservation
Cortland NY 13045

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

Methods

Hatchery Sampling

Staff at the Salmon River Hatchery processed 2,069 steelhead during spring 2018 spawning operations (Nelson 2018a). Adult Washington strain (Chamber's Creek) winter run fish comprised 96% (1,985) of the returns. Marked Skamania strain fish (adipose fin) accounted for the remaining 4% (84).

A total of 2.1 million Washington strain steelhead eggs were taken from 651 females. The Skamania egg total was 76,615 from 28 females. Biological data were collected from 231 steelhead.

Returns of Pacific salmon in the fall included 6,372 Chinook salmon and 2,904 coho salmon. Biological data were collected at the hatchery from 786 Chinook salmon and 414 coho salmon. The egg totals were 3.7 million Chinook salmon from 828 females and 2.2 million coho salmon from 755 females (Nelson 2018b).

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 salmon males (jacks) sampled in 2018 was 4.4 pounds, the 24th highest value in the 1986-2018-time series (Figure 1) and not weighing significantly more than any other year. Age 2 males were 13.4 pounds, 0.5 pounds below the long-term average with seven years being significantly heavier. Age 2 females were 12.6 pounds, 2.0 pounds below the long-term average, with no other year being significantly lighter (Figure 2). Age 3 males were 15.8 pounds (same as 2017), over 3.0 pounds below average, and significantly lighter than weights observed in 21 of 32 years compared. Age 3 females were 15.3 pounds, 3.5 pounds below the long-term average, and the lowest value in the time series, but not significantly different from five of the 32 years (Figure 2). Mean lengths and weights at age for all species sampled in 2018 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 15.8 pounds in 2018, 0.8 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 second year of below average condition following nine consecutive years of at or near average condition (Figure 3).

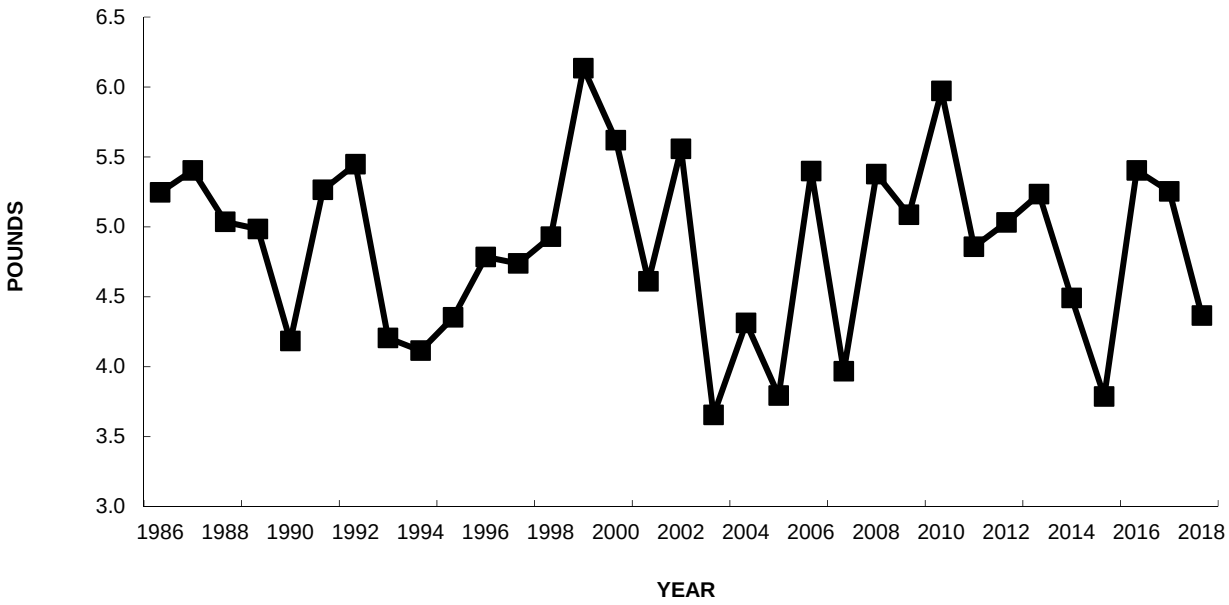


Figure 1. Mean weights of Chinook salmon jacks at Salmon River Hatchery, 1986-2018.

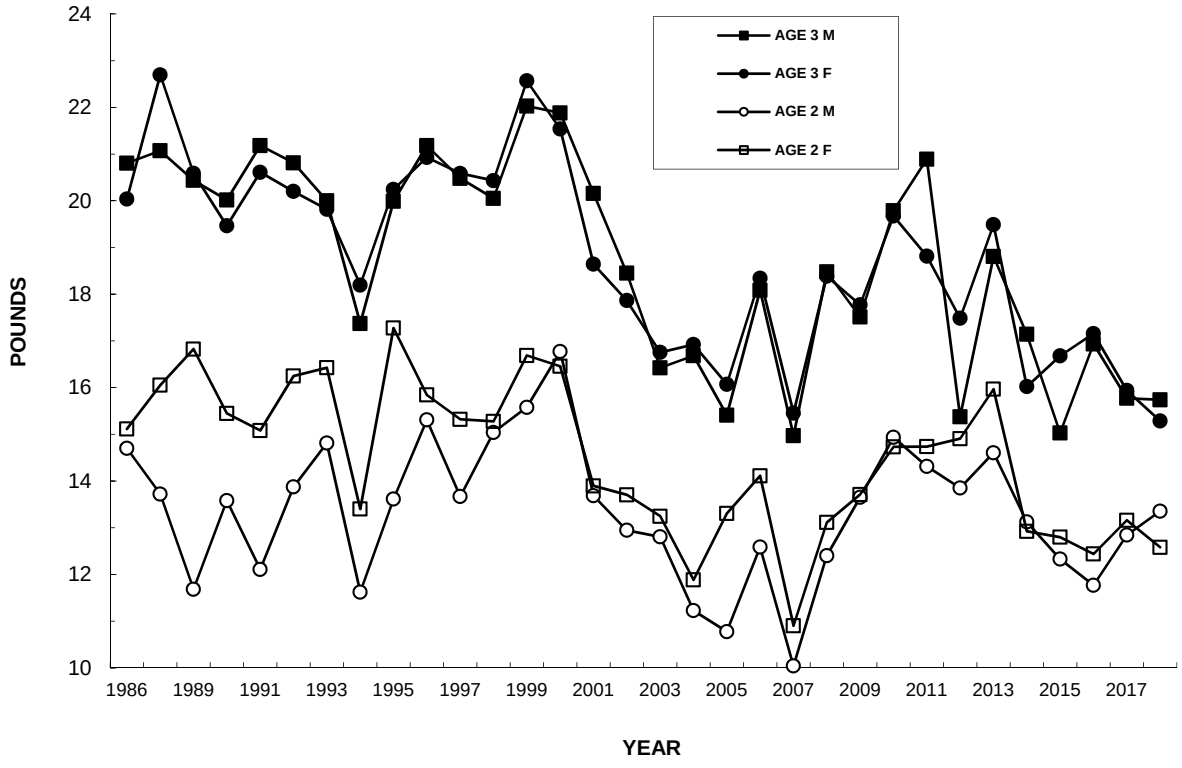


Figure 2. Mean weights of age 2 and 3 Chinook salmon at Salmon River Hatchery, 1986-2018.

Table 1. Mean lengths and weights of Chinook salmon, coho salmon and Washington steelhead sampled at Salmon River Hatchery 2018 (STD= standard deviation).

AGE	SEX	N	MEAN LENGTH (in)	STD	MEAN WEIGHT (lbs)	STD
			CHINOOK SALMON			
1	M	13	22.9	1.1	4.4	0.8
2	M	235	34.0	2.0	13.4	2.4
2	F	172	32.7	1.5	12.6	1.8
3	M	121	36.4	2.0	15.8	2.7
3	F	222	35.0	2.3	15.3	2.8
			COHO SALMON			
1	M	2	17.5	0.08	1.5	0.04
2	M	219	26.8	2.0	5.8	1.5
2	F	193	25.8	1.7	5.9	1.3
			WASHINGTON STEELHEAD			
3	M	65	26.1	1.7	5.7	1.1
3	F	55	25.2	1.7	5.7	1.4
4	M	35	26.2	1.5	5.8	1.0
4	F	43	25.7	2.2	6.0	1.8
5	M	4	26.2	1.1	5.8	0.6
5	F	18	27.0	2.8	6.8	2.3

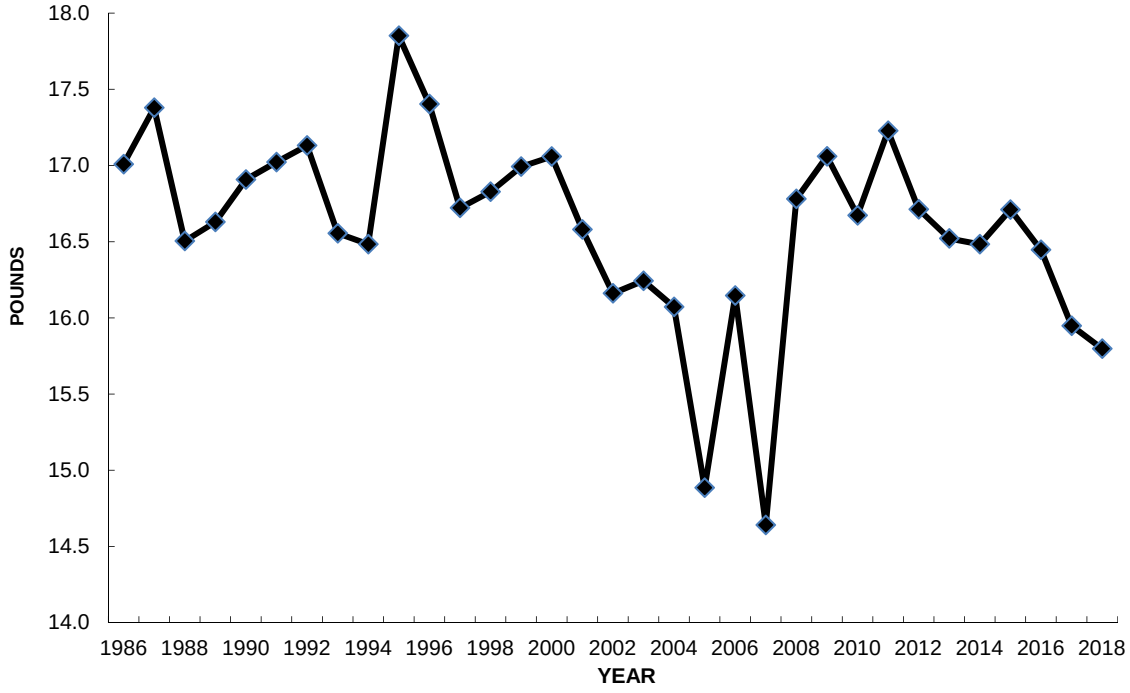


Figure 3. Estimated weights of a 36-inch Chinook salmon from the Salmon River Hatchery fall (October) collections 1986-2018.

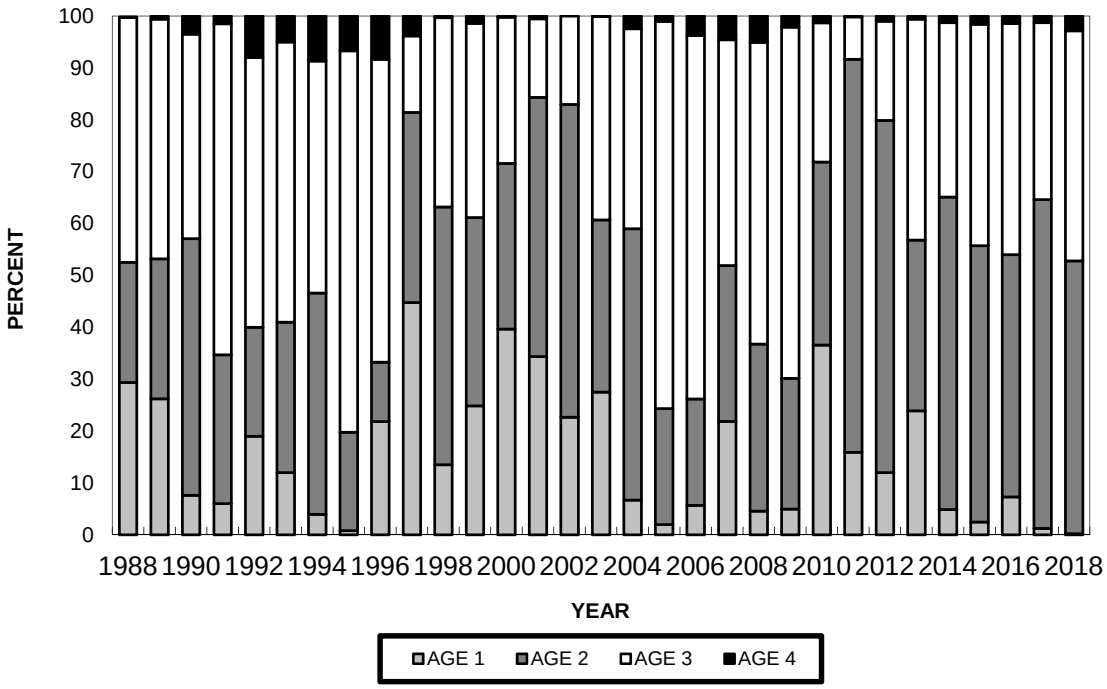


Figure 4. Estimated age structures of Chinook salmon sampled at Salmon River Hatchery 1989-2018.

Age Structure

The estimated age structure of the 2017 Chinook salmon run to the Salmon River Hatchery was 0.2% age-1, 53% age-2, 44% age-3, and 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 2018 was 5.9 pounds, approximately 2.4 pounds less than the long-term average (8.3 pounds, Figure 5). Age-2 males weighed 6.0 pounds, 2.1 pounds less than the long-term average (8.0 lbs., Figure 5). The 2018 males were the second lowest value in the time-series and weighed significantly less than twenty-six other years. Only the 2015 males weighed less, although not significantly so. Female coho weights were at a record low in 2018, and significantly lighter than fish sampled in 29 of 34 years sampled.

Washington Steelhead

Growth

Steelhead are sampled in the spring and, unlike Chinook and coho salmon, do not reflect growth during the 2018 growing season. Weights reported here reflect conditions prior to and including 2017. The mean weights of age-3 males and females were 5.7 and 5.6 pounds, respectively. The males and females were 0.2 and 0.7 pounds lighter than their respective long-term averages (Figure 6). The mean weights of age-4 males and females were 5.6 and 6.0 pounds, respectively, with males 2.8 and females 3.1 pounds lighter than their long-term averages (Figure 6). Age-3 females in 2018 (5.6 lbs.) were the eighth lightest in the time series and not significantly heavier than any other year. Age 3 males were near the middle of observed weights, and weighed significantly less than only six of those observations. The age-3 and -4 fish weight from both sexes all converged between 5.5 and 6.0 pounds (Figure 6).

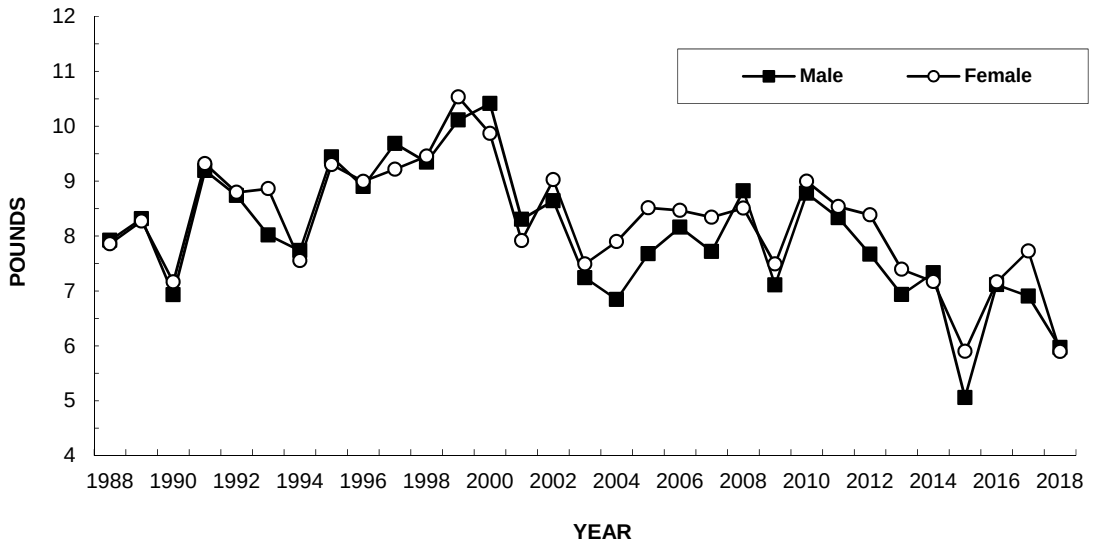


Figure 5. Mean weights of age-2 coho salmon at Salmon River Hatchery, 1988-2018.

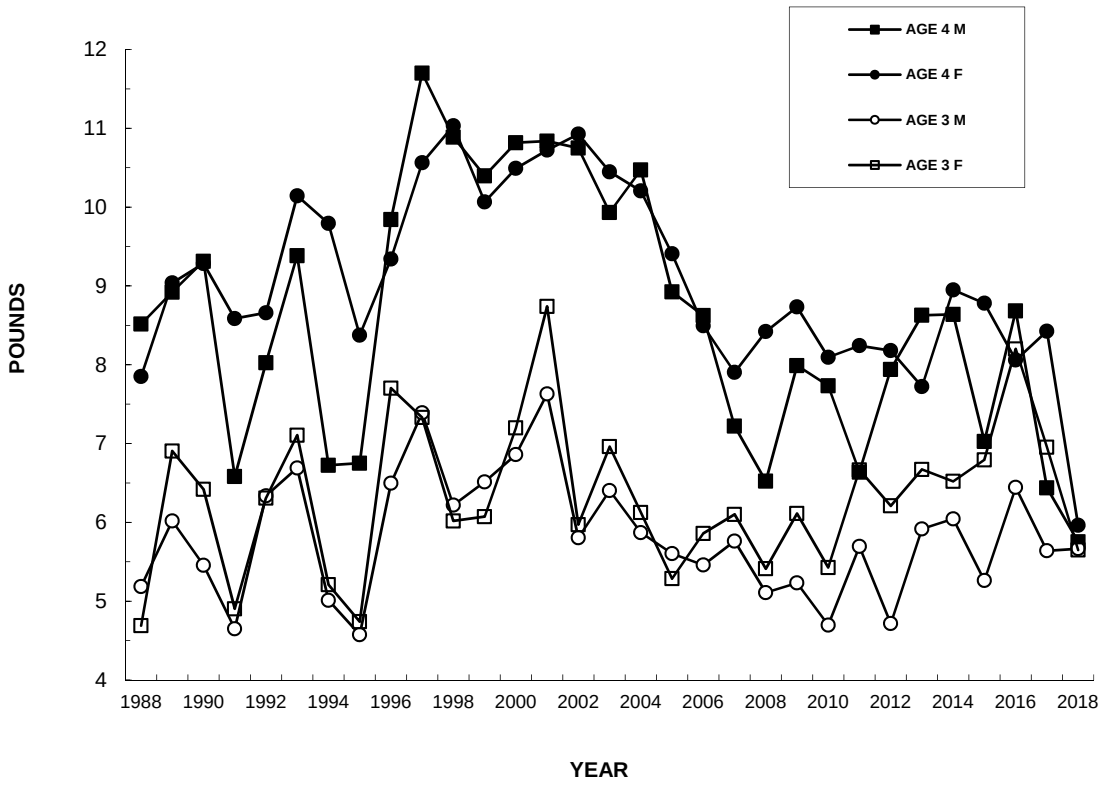


Figure 6. Mean weights of ages 3 and 4 Washington steelhead at Salmon River Hatchery, 1988-2018.

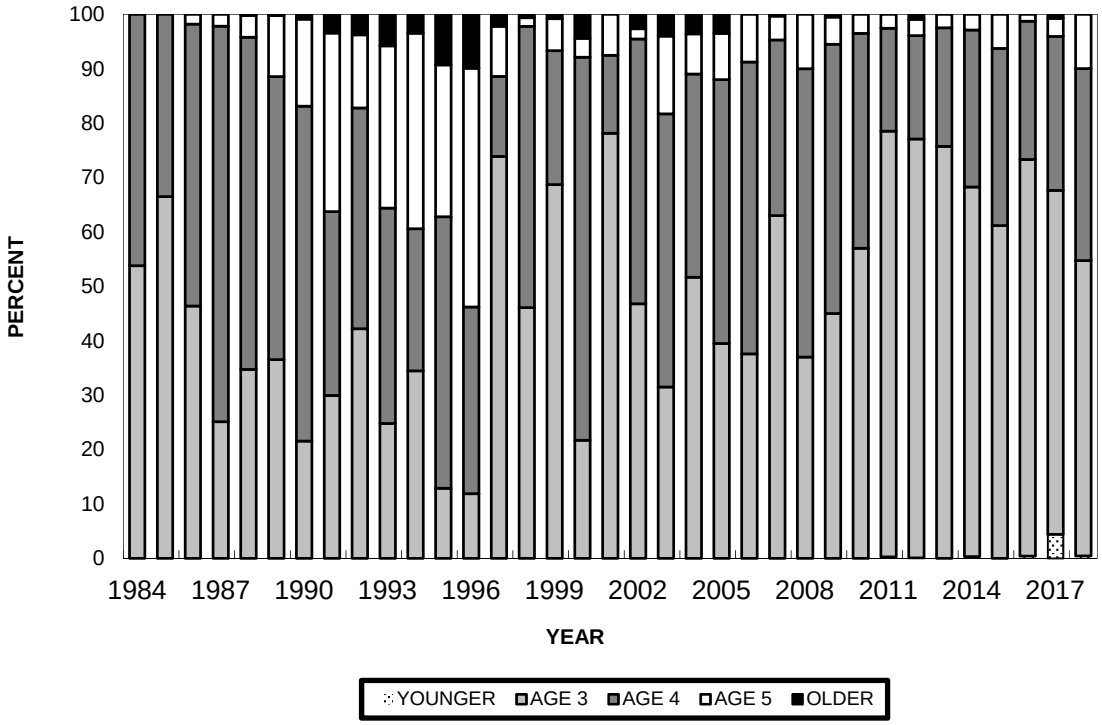


Figure 7. Age structures of Washington steelhead sampled at Salmon River Hatchery, 1984-2018.

Age 4 males weighed the least in the time series that dates to 1988 (5.8 pounds), breaking the previous low value from 2017 (6.4 pounds). The age 4 males weighed significantly less than 18 years in the series. Age 4 female average weight was also the lowest value, and was significant lower than every other year in the time series.

Age Structure

Similar to age structures observed in recent years, age-3 and age-4 steelhead dominated the run again in 2018 (Figure 7). As in the previous seven years, age-3 fish comprised a noticeably higher proportion of the run. The age structure of the fish sampled was 0.45% younger than age-3, 54% age-3, 35% age-4, 10% age-5.

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2018 New York Cooperative Trout and Salmon Pen-Rearing Projects

M.J. Sanderson
New York State Department of Environmental Conservation
6274 East Avon-Lima Road
Avon, New York 14414

M.T. Todd
New York State Department of Environmental Conservation
270 Michigan Avenue
Buffalo, New York 14203

S.E. Prindle
New York State Department of Environmental Conservation
1285 Fisher Avenue
Cortland, New York 13045

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 Eighteen mile Creek, and steelhead were added there in 2006. In 2006, a steelhead pen-rearing project was initiated at Wilson Harbor on East Branch Twelve Mile 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. 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, and 2015-2018.

This report summarizes pen-rearing activities and results for 2018, the twenty first year of pen-rearing projects along the New York shoreline of Lake Ontario.

Methods

Pen-rearing was conducted at ten sites along New York's coastline of Lake Ontario in 2018. 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 pen-reared salmon and trout were developed and refined by the NYS Department of Environmental Conservation (DEC; Wilkinson 1999, Sanderson 2006, Legard 2018). 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 2018 is provided in Table 2. Prior to 2018, pen fish were fed food provided by the NYSDEC contracted supplier. In 2018, Chinook salmon were fed a premium food provided by NYSDEC.

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.

The relative performance of pen-reared and direct-stocked Chinook salmon was assessed through a three-year study during 2010, 2011, and 2013. This study found that, on average, pen-reared Chinook salmon provided a 2:1 return to the open lake fishery (Connerton et al. 2016).

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

Results and Discussion

A total of 48,680 Washington strain steelhead were raised at seven pen-rearing sites, comprising 9.2% of NYSDEC's Lake Ontario Washington strain steelhead stocking allotment in 2018 (Table 3). Observed mortalities were relatively low at all steelhead pen sites, ranging from 0 to 0.30%. Results for all steelhead pen projects are summarized in Table 3.

Nine pen-rearing sites raised a total of 570,230 Chinook salmon fingerlings, representing 44.3% of NYSDEC's 2018 Chinook salmon stocking allotment. Observed mortalities were also low ranging from 0.01 to 0.33%. Results for all Chinook salmon pen projects are provided in Table 3.

The Little Salmon River, Oswego, Little Sodus Bay, Sodus Bay, Sandy Creek, Oak Orchard, Olcott Harbor, and Wilson Harbor pen projects are now all using automated feeders on all their pens and they have worked well. The growth rates are comparable to hand feeding. The projects further benefit by not having to schedule five volunteers per day to feed the fish, which has been a huge relief for the pen project coordinators. Only one person is needed to load the feed hopper and wind the spring in the morning, and feeders slowly dispense feed for a 12-hour period.

Little Salmon River

Washington strain steelhead were placed in the pen on 11 April at 30 fish per lb. The steelhead were released 31 days later on 12 May at a weight of 13 fish per lb. The pen was towed to the river mouth for release. Only 1 mortality was reported by the coordinator.

Oswego Harbor

Chinook salmon were delivered to the pen site on 16 April, weighing 124 fish per lb. Chinook salmon were released after 22 days on 8 May at a weight of 80 fish per lb. Thirty mortalities were observed.

Little Sodus Bay

Steelhead weighing 28 fish per lb. were delivered to the pen site on 12 April. Steelhead were released after 30 days on 12 May, weighing 12 fish per lb. No mortalities were reported by the coordinator.

Chinook salmon were also delivered to the pen site on 12 April. Chinook salmon weighed 128 fish per lb. when delivered and weighed 87 fish per lb. when released 30 days later, on 12 May. Fish were towed to the lake for release. Eight mortalities were reported by the coordinator.

Sodus Bay

Chinook salmon were placed into pens on 13 April at 127.6 fish per lb. They were held for 22 days and released on 5 May at 108.6 fish per lb., and were 3.1 inches long on average. Sixteen mortalities were reported.

Genesee River

Steelhead weighing 31 fish per lb. were delivered to the pen site on 6 April. Steelhead were released after 27 days on 3 May, weighing 22 fish per lb. Eighteen mortalities were reported by the coordinator.

Chinook salmon were also delivered to the pen site on 6 April. Chinook salmon weighed 133 fish per lb. when delivered and weighed 98.8 fish per lb. when released 27 days later on 3 May. Fish were released at the site. One hundred thirty mortalities were reported by the coordinator.

Sandy Creek

Washington strain steelhead were placed in a pen on 4 April at 31 fish per lb. The steelhead were

released 21 days later on 25 April at a weight of 26 fish per lb. The pen was towed to the river mouth for fish release. Twenty-two mortalities were recorded by the coordinator.

Chinook salmon were delivered to the pen site on 4 April, weighing 126.6 fish per lb. Chinook salmon were released after 25 days on 29 April at a weight of 105.6 per lb. Two hundred thirty-five mortalities were recorded.

Oak Orchard Creek

Chinook salmon were delivered at a weight of 132.2 per lb. on 5 April. They were held for 32 days and released on 7 May, weighing 88 fish per lb. Chinook salmon were released at the pen site at dusk. One hundred forty two mortalities were recorded.

Olcott Harbor

Steelhead were delivered at a weight of 31 fish per lb. on 9 April. They were held for 27 days and released on 6 May, weighing 24.7 fish per lb. The steelhead pen was towed to harbor outlet for release. Eight mortalities were reported.

Chinook salmon were delivered at a weight of 134.2 fish per lb. on 9 April. They were held for 28 days and released on 7 May, weighing 84.6 fish per lb. Chinook salmon were released at pen site at dusk. Sixty-six mortalities were reported.

Wilson Harbor

Steelhead were delivered at a weight of 30 fish per lb. on 10 April. They were held for 27 days and released on 7 May, weighing 16.4 fish per lb. Five mortalities were reported.

Chinook salmon were delivered at a weight of 134 fish per lb. on 10 April. They were held for 28 days and released on 8 May, weighing 84.3 fish per lb. One mortality was reported.

Lower Niagara River

The lower Niagara River pen site is typically the last site to receive fish due to slowly warming water temperatures. Steelhead were delivered at a weight of 33 fish per lb. on 25 April. They were held for 30 days and released on 25 May, weighing 20.9 fish per lb. No mortalities were reported.

Chinook salmon were delivered at a weight of 112 fish per lb. on 25 April. They were held for 28 days and released on 23 May, weighing 67.5 fish per lb. Twelve mortalities were reported.

Conclusions

Of the seven locations where steelhead were penned, target weights (12-15 fish per lb.) were reached at only two sites in 2018. Results at other sites were below target, ranging from 16-26 fish per lb.

Chinook salmon target weights (90 fish per lb.) were exceeded at six out of nine pen sites. Results at the other sites ranged from 99-109 fish per pound. 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.

Although premium food was fed to pen fish in 2018, cool weather conditions and resultant cold water temperatures during the pen rearing period likely played a strong role in fish growth. Also, several, but not all, pen sites were supplied with extra food to raise the fish in pens for a longer period of time. This likely explains the wide variation in the size of the fish at release. The twenty first year of pen-rearing steelhead and Chinook salmon along the New York shoreline of Lake Ontario was moderately successful due to low fish mortality, most measured Chinook salmon and some 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.

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Table 1. Description of 2018 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	Krenzer Marina	Krenzer 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 Guides Association Niagara River Anglers Association Village of Youngstown Fox Fence Company

Table 2. Methods used at 2018 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	2 times	Pen towed to river mouth for fish release.
Oswego Harbor	Hydraulic transfer	Automated	1	2 times	Pen towed to river mouth for fish release.
Little Sodus Bay	Hydraulic transfer	Automated	1	1 time	Pen towed to bay mouth for fish release.
Sodus Bay	Hydraulic transfer	Automated	1	Weekly	Pens towed to lake for fish release, pens inverted.
Genesee River	Hydraulic transfer	5	5	Weekly	Fish released at pen site.
Sandy Creek	Hydraulic transfer	Automated	1	Weekly	Fish released at pen site.
Oak Orchard Creek	Hydraulic transfer	Automated	5	Weekly	Fish released at pen site.
Olcott Harbor	Hydraulic transfer	Automated	1	Weekly	Chinook salmon released at pen site. Steelhead towed to harbor mouth.
Lower Niagara River	Hydraulic transfer	5	3	Weekly	Fish released at pen site.
Wilson	Hydraulic transfer	Automated	3	Weekly	Fish released at pen site

Table 3. Results of 2018 Lake Ontario trout and salmon pen-rearing projects.

Pen Site	Species	Number Stocked (into pens)	Number of pens	Date Stocked	Size at Stocking (#/ lb.)	Date Released (Days Held)	Size at Release (#/ lb.)	Mortality (# Fish)	Mortality (%)
Genesee	Chinook	85,250	4	6 Apr	133	3 May (27)	98.8	130	0.15
Little Sodus	Chinook	47,500	2	12 Apr	128	12 May (30)	87	8	0.02
Lower Niagara	Chinook	75,000	1	25 Apr	112	23 May (28)	67.5	12	0.02
Oak Orchard	Chinook	106,560	5	5 Apr	132.2	7 May (32)	88	142	0.13
Olcott	Chinook	67,100	3	9 Apr	134.2	7 May (28)	84.6	66	0.10
Oswego	Chinook	64,390	5	16 Apr	124	8 May (22)	80	30	0.05
Sandy Creek	Chinook	64,430	3	4 Apr	126.6	29 Apr (25)	105.6	235	0.36
Sodus	Chinook	50,000	2	13 Apr	127.6	5 May (22)	108.6	16	0.03
Wilson	Chinook	10,000	1	10 Apr	134	8 May (28)	84.3	1	0.01
Genesee	steelhead	10,000	2	6 Apr	31	3 May (27)	22.2	18	0.18
Little Salmon	steelhead	4,380	1	11 Apr	30	12 May (31)	13	1	0.02
Little Sodus	steelhead	6,000	1	12 Apr	28	12 May (30)	12	0	0.0
Lower Niagara	steelhead	10,000	1	25 Apr	33	25 May (30)	20.9	0	0.0
Olcott	steelhead	3,500	1	9 Apr	31	6 May (27)	24.7	8	0.23
Sandy Creek	steelhead	7,300	1	4 Apr	31	25 Apr (21)	26	22	0.30
Wilson	steelhead	7,500	2	10 Apr	30	7 May (27)	16.4	5	0.07

Sea Lamprey Control in Lake Ontario 2018

Jessica Barber
U.S. Fish and Wildlife Service
Marquette, Michigan 49855

Mike Steeves
Fisheries and Oceans Canada
Sault Ste. Marie, Ontario P6A 2E5

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 2018. 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 host fish. Approximately 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 adult Sea Lamprey. 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 15,502 Sea Lampreys was calculated from the average index estimated for the 5-year period, 1993-1997, when marking rates were closest to 2 marks per 100 Lake Trout >431 mm (1.6 A1 marks per fish >431 mm). During 2018, the index of adult abundance in Lake Ontario was estimated to be 11,666 (95% CI; 9,921 – 13,412), which is less 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 2018, the target and range were revised using A1 marks exclusively, which have been more consistently recorded on Lake Ontario. Also, the marking rate target 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 2018 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 2009-2018. Twenty-nine tributaries (15 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 2018 are found in Table 1 and Figure 1.

- Lampricide applications were conducted in 16 streams (6 Canada, 10 U.S.) and 1 lentic area (0 Canada, 1 U.S.).

- Salmon River and Lindsey Creek were treated in 2018 due to the presence of residual Sea Lamprey from the 2017 treatments.

- The Salmon River was treated from the Lighthouse Hill Dam in Altmar, New York for the first time since 1978 because Sea Lamprey larvae were collected immediately downstream of the Salmon River Fish Hatchery application site in 2017. In addition, lampricide was applied to large backwater areas harboring numerous residual Sea lampreys.

- Little Sandy and Lindsey creeks were rescheduled from late spring to October due to low discharge.

Table 1. Details on the application of lampricides to tributaries of Lake Ontario during 2018 (letter in parentheses corresponds to location of stream in Figure 1).

Tributary	Date	Discharge (m^3/s)	Distance Treated (km)	Liquid TFM (kg)[1]	Solid TFM (kg)[1]	Wettable Powder Bayluscide (kg)[1]	Emulsifiable Concentrate Bayluscide (kg)[1]	Granular Bayluscide (kg)[1]
Canada								
Credit R. (A)	May-27	7.0	40.3	1,556.4	3.1	---	18.2	0.2
Duffins Cr. (B)	Jun-05	2.4	38.9	723.7	---	---	---	0.1
Oshawa Cr. (C)	Jun-03	1.1	21.7	296.5	---	---	---	0.1
Wilmot Cr. (D)	Jun-01	0.8	17.4	292.4	---	---	---	0.0
Salem Cr. (E)	Apr-29	0.4	2.2	97.5	---	---	---	0.1
Proctors Cr. (F)	Apr-29	0.8	4.1	173.8	---	---	---	0.1
Total (Canada)		**12.5**	**124.6**	**3,140.3**	**3.1**	**0.0**	**18.2**	**0.6**
United States								
Black R. (G)	Aug-10	43.1	9.3	2,703.5	---	12.7	19.2	---
Lentic	Aug-11	---	---	---	---	---	---	106.6
Lindsey Cr. (H)	Oct-19	0.2	14.2	49.6	4.2	---	---	0.1
Little Sandy Cr. (I)	Oct-21	0.5	16.7	79.4	0.8	---	---	0.1
Salmon R. (J)	May-25	28.9	52.0	1,904.7	5.1	---	---	0.5
Grindstone Cr. (K)	Apr-23	2.1	44.0	270.3	1.5	---	---	0.3
Snake Cr. (L)	Apr-20	0.3	13.6	109.4	---	---	---	---
Catfish Cr. (M)	Apr-20	2.8	1.2	187.6	---	---	---	---
Eightmile Cr. (N)	Apr-26	0.6	4.5	85.0	---	---	---	0.1
Sterling Cr. (O)	May-28	0.9	28.0	394.3	4.8	---	---	0.2
Red Cr. (P)	Apr-27	1.1	11.1	247.3	1.7	---	---	0.0
Total (United States)		**80.5**	**194.6**	**6,031.1**	**18.1**	**12.7**	**19.2**	**107.9**
Total for Lake		**93.0**	**319.2**	**9,171.4**	**21.2**	**12.7**	**37.4**	**108.5**

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

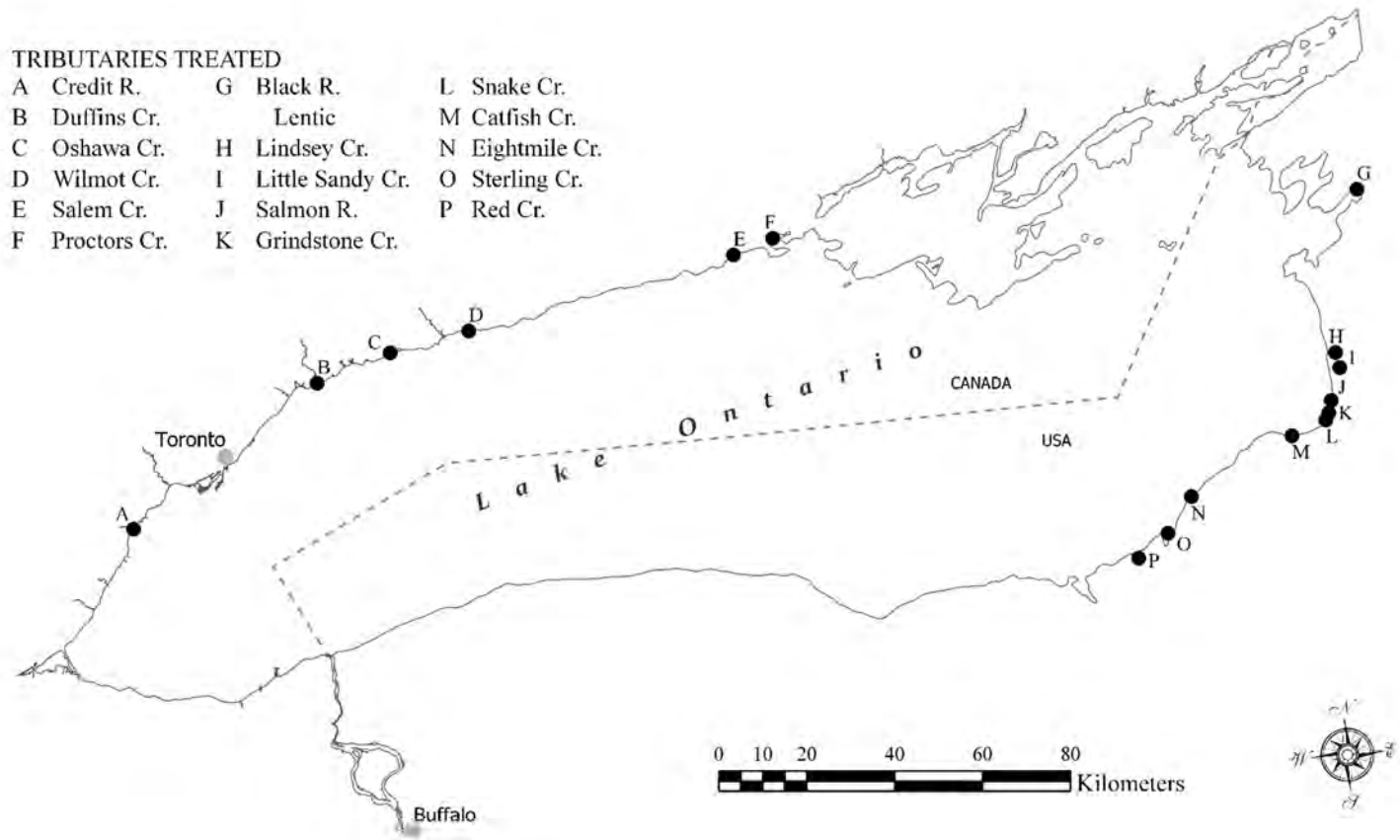

Figure 1. Location of Lake Ontario tributaries treated with lampricides (corresponding letters in Table 1) during 2018.

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 2018, 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) identify 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

- Field crews did not visit any structures located on tributaries to Lake Ontario to assess Sea Lamprey blocking potential and to improve the information in the BIPSS database.

Operation and Maintenance

- Routine maintenance, spring start-up, and safety inspections were performed on 13 barriers (10 Canada, 3 U.S.).

- Fish community assessment surveys were conducted on the Salmon River (15), tributary to Orwell Brook, to monitor the condition of the fish community.

Ensure Blockage to Sea Lamprey Migration

- No consultations to ensure blockage were conducted with partner agencies during 2018.

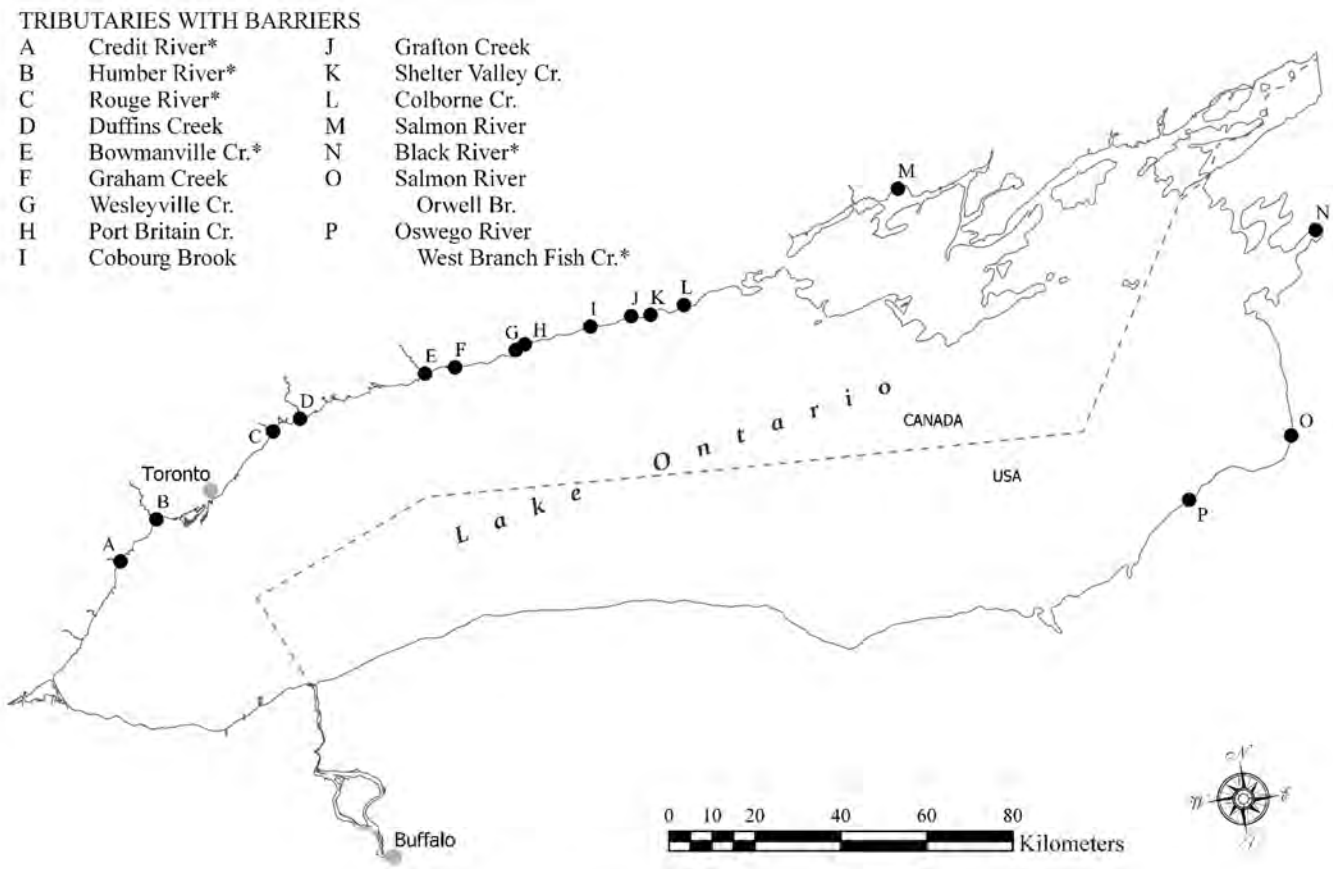

Figure 2. Location of Lake Ontario tributaries with Sea Lamprey barriers. Structures that were not constructed by the Commission, but have been modified to prevent the upstream migration of Sea Lampreys are indicated by an asterisk (*).

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 2019 were assessed during 2018 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 treatment and barrier effectiveness, and to establish the sites for lampricide application.

- Larval assessments were conducted on 58 tributaries (32 Canada, 26 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 (6 Canada, 4 U.S.).

- Surveys to detect the presence of new larval Sea Lamprey populations were conducted in 10 tributaries (7 Canada, 3 U.S.). No new Sea Lamprey infestations were detected.

- Post-treatment assessments were conducted in 13 tributaries (6 Canada, 7 U.S.) to determine the effectiveness of lampricide treatments conducted during 2017 and 2018. Surveys on the Salmon River (NY) found many residuals, resulting in the retreatment of some back-water areas during 2018.

- Surveys to evaluate barrier effectiveness were conducted in 28 tributaries (25 Canada, 3 U.S.). Due to high spring lake levels in 2017, several dams were inundated enabling sea lampreys to migrate further upstream. Graham Creek is scheduled for treatment upstream of the purpose built barrier during 2019.

- Larval assessment surveys were conducted in non-wadable lentic and lotic areas using 10.4 kg active ingredient of 3.2% gB (0 kg Canada, 10.4 kg U.S.; Table 5).

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 2018.

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-18	---	No	---	---	Unknown
Bronte Cr.	Apr-16	Jun-18	Yes	Yes	---	---	2019[1]
Sixteen Mile Cr.	Jun-82	Jun-18	---	No	---	---	Unknown
Credit R.	May-18	Jun-18	No	No	---	---	***2020***
Humber R.	Never	Jun-17	---	No	---	---	Unknown
Rouge R.	Jun-11	Jun-18	---	No	---	---	Unknown
Little Rouge. R.	Jun-15	Jun-18	---	No	---	---	Unknown
Petticoat Cr.	Sep-04	Jun-18	---	No	---	---	Unknown
Duffins Cr.	Jun-18	Jul-18	No	No	---	---	***2021[1]***
Carruthers Cr.	Sep-76	Jun-18	---	No	---	---	Unknown
Lynde Cr.	Jun-15	Jun-18	Yes	No	---	---	Unknown
Oshawa Cr.	Jun-18	Jun-18	No	No	---	---	***2021[1]***
Farewell Cr.	Jun-15	Jun-18	No	Yes	---	---	Unknown
Bowmanville Cr.	May-17	Jun-18	Yes	Yes	---	---	2020[1]
Wilmot Cr.	Jun-18	Jun-18	No	No	---	---	***2021[1]***
Graham Cr.	May-96	Jun-18	---	Yes	42,839	329	2019
Wesleyville Cr.	Oct-02	Jun-18	---	No	---	---	Unknown
Port Britain Cr.	Apr-16	Jun-18	No	Yes	238	119	2019
Gage Cr.	May-71	Jun-16	---	No	---	---	Unknown
Cobourg Br.	Oct-96	Jul-18	---	Yes	---	---	Unknown
Covert Cr.	Apr-16	Jul-18	Yes	Yes	3,119	1,637	2019
Grafton Cr.	Jun-17	Ju1-18	No	No	---	---	Unknown
Shelter Valley Cr.	Apr-16	Jul-18	No	Yes	316,578	---	2020
Colborne Cr.	Jun-17	Jul-18	No	Yes	178	25	2019
Salem Cr.	Apr-18	Jul-18	No	No	---	---	***2021[1]***
Proctor Cr.	Apr-18	Jul-18	No	No	---	---	Unknown
Smithfield Cr.	Sep-86	Jul-17	---	No	---	---	Unknown
Trent R. (Canal System)	Sep-11	Jul-17	---	No	---	---	Unknown
Mayhew Cr.	Jun-15	Jul-18	No	Yes	1,205	295	2019
Moira R.	Jun-15	Jul-17	Yes	No	---	---	Unknown
Salmon R.	Jun-16	Jul-18	No	---	---	---	Unknown
Napanee R.	Never	Jul-17	---	No	---	---	Unknown
United States							
Black R.	Aug-15	Aug-18	Yes	Yes	---	---	***2021[1]***
Stony Cr.	Sep-82	Aug-17	---	No	---	---	Unknown
Sandy Cr.	Never	Aug-18	---	No	---	---	Unknown
South Sandy Cr.	Jun-17	Aug-18	Yes	No	---	---	2020[1]

Table 3. *continued.*

Tributary	Last Treated	Last Surveyed	Status of Larval Lamprey Population (surveys since last treatment) Residuals Present	Recruitment Evident	Estimate of Overall Larval Population	Abundance Estimate of Larvae >100mm	Expected Year of Next Treatment
Skinner Cr.	Apr-05	Aug-17	---	No	---	---	Unknown
Lindsey Cr.	Oct-18	Aug-18	---	---			***2021***
Blind Cr.	May-76	Aug-17	---	No	---	---	Unknown
Little Sandy Cr.	Oct-18	Aug-17	---	---	---	---	2022
Deer Cr.	Apr-04	Aug-18	---	No	---	---	Unknown
Salmon R.	Jun-18	Aug-18	Yes	Yes	---	---	***2021***
Orwell Brook	May-17	Aug-17	No	No	---	---	Unknown
Trout Brook	Jun-18	Aug-18	Yes	Yes	---	---	***2021***
Altmar Cr.	Jun-18	Aug-18	No	No	---	---	***2021***
Grindstone Cr.	Apr-18	Aug-18	Yes	No	---	---	2021[1]
Snake Cr.	Apr-18	Aug-18	No	No	---	---	***2021[1]***
Sage Cr.	May-78	Jul-16	---	No	---	---	Unknown
Little Salmon R.	May-17	Aug-18	No	Yes	---	---	2020[1]
Butterfly Cr.	May-72	Jul-16	---	No	---	---	Unknown
Catfish Cr.	Apr-18	Aug-18	No	No	---	---	***2021[1]***
Oswego R.							
Black Cr.	May-81	Aug-17	---	No	---	---	Unknown
Big Bay Cr.	Sep-93	Aug-15	---	No	---	---	Unknown
Scriba Cr.	Jun-10	Aug-18	---	Yes	641	42	2019
Fish Cr.	May-16	Aug-18	No	Yes	---	---	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	Aug-18	No	Yes	3,489	1,480	2019
Rice Cr.	May-72	Aug-18	---	No	---	---	Unknown
Eight Mile Cr.	Apr-18	Aug-18	No	No	---	---	Unknown
Nine Mile Cr.	May-17	Aug-17	No	No	---	---	Unknown
Sterling Cr.	May-18	Aug-18	Yes	No	---	---	***2019***
Unnamed Cr.	May-18	Aug-18	Yes	No	823	323	***2019***
Blind Sodus Cr.	May-78	Aug-16	---	No	---	---	Unknown
Red Cr.	Apr-18	Jul-18	No	No	---	---	Unknown
Wolcott Cr.	May-79	Aug-17	---	No	---	---	Unknown
Sodus Cr.	Apr-15	Aug-17	No	No	---	---	Unknown
Forest Lawn Cr.	Never	Jul-18	---	Yes	728	48	Unknown
Irondequoit Cr.	Never	Jul-18	---	No	---	---	Unknown
Larkin Cr.	Never	Jul-18	---	No	---	---	Unknown
Northrup Cr.	Never	Jul-18	---	No	---	---	Unknown
Salmon Cr.	Apr-05	Aug-17	---	Yes	---	---	Unknown
Sandy Cr.	Apr-14	Aug-17	---	No	---	---	Unknown
Oak Orchard Cr.							
Marsh Cr.	Apr-14	Jul-18	---	No	---	---	Unknown
Johnson Cr.	Apr-10	Jul-18	---	No	---	---	Unknown
Third Cr.	May-72	Aug-17	---	No	---	---	Unknown
First Cr.	May-95	Jul-18	---	No	---	---	Unknown

[1]Stream is being treated based on stream-specific knowledge of sea lamprey recruitment and growth .

Table 4. Status of larval Sea Lampreys in historically infested lentic areas of Lake Ontario during 2018.

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-18	Aug-18	Aug-18

[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 2018.

Tributary	Bayluscide (kg)[1]	Area Surveyed (ha)
United States		
Black R. (lentic)	2.0	0.36
Black R. (lotic)	1.68	0.3
South Sandy Cr. (lentic)	1.12	0.20
South Sandy Cr. (lotic)	0.56	0.1
Lindsey Cr. (lentic)	1.12	0.20
Little Sandy Cr. (lentic)	1.12	0.2
Salmon R. (lentic)	1.68	0.3
Catfish Cr. (lentic)	0.56	0.1
Catfish Cr. (lotic)	0.56	0.1
Total (United States)	**10.4**	**1.86**
Total for Lake	**10.4**	**1.86**

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

Juvenile Assessment

The effects of 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, and are updated when basin-wide data becomes 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, Ontario Ministry of Natural Resources and Forestry, and the New York State Department of Environmental Conservation and analyzed by the Service's GBFWCO.

- The number of A1 marks per 100 Lake Trout >431 mm from standardized fall assessments during 2018 were submitted in February 2019 and have yet to be analyzed.

- Based on standardized fall assessment data, the marking rate during 2017 was 0.005 A1 marks per 100 Lake Trout >431 mm which is less than the target of 2 A1 marks per 100 Lake Trout (Figure 3).

- Marking rates on Steelhead and Chinook salmon have been increasing and are a concern.

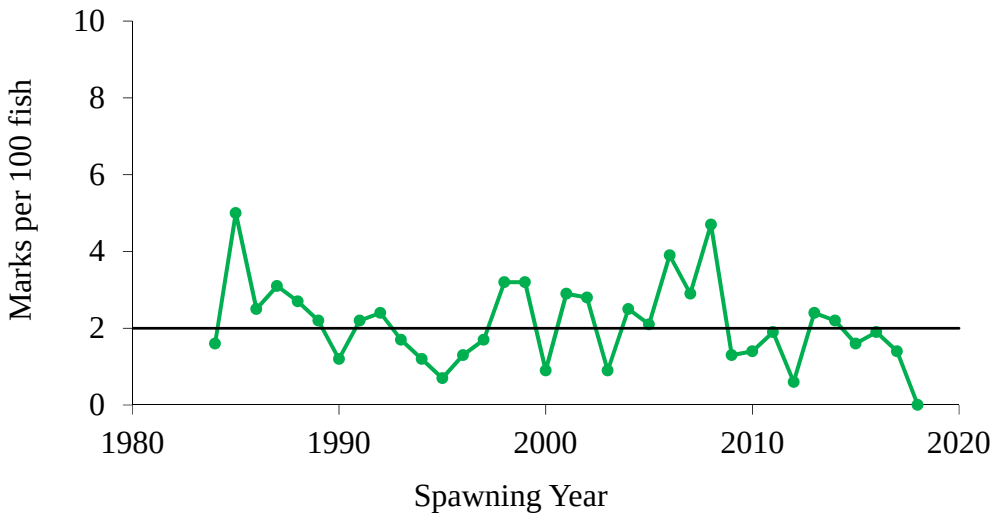

Figure 3. Number of A1 marks per 100 Lake Trout >431 mm from standardized fall assessments in Lake Ontario. The horizontal line represents the target of 2 A1 marks per 100 Lake Trout. The spawning year is used rather than the survey year (shifted by one year) to provide a comparison with the adult index.

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 target is 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. During 2018, the SLCP discontinued use of the Schaefer method in favor of the simpler Petersen method to calculate population estimates from mark-recapture data. The estimates were updated for all index streams from 1980 to 2018.

- A total of 5,428 Sea Lampreys were trapped in 8 tributaries during 2018, 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 11,666 (95% CI; 9,921 – 13,412), which is less than the target of 15,502 (Figures 5-6).

Table 6. Information regarding adult Sea Lampreys captured in assessment traps or nets in tributaries of Lake Ontario during 2018 (letter in parentheses corresponds to stream in Figure 4).

Tributary	Number Caught	Adult Estimate	Trap Efficiency (%)	Number Sampled[1]	Percent Males[2]	Mean Length (mm)		Mean Weight (g)	
						Males	Females	Males	Females
Canada									
Humber R. (A)	3,230	4,702	68	221	59	501	501	280	286
Duffins Cr. (B)	346	1,041	32	22	54	512	498	302	317
Bowmanville Cr. (C)	290	765	38	92	66	500	518	279	312
Cobourg Cr.[3] (D)	273	458	59	154	54	480	483	243	251
Salmon R.[3] (E)	4	---	---	---	---	---	---	---	---
Total or Mean (Canada)	**4,143**	---	---	**489**	**59**	**495**	**497**	**270**	**279**
United States									
Black R. (F)	993	2,291	18	131	68	503	490	282	281
Salmon R.(G)									
Orwell Br.[3]	31	331	9	2	0	---	490	---	293
Sterling Cr. (H)	261	2,868	21	16	69	459	429	314	288
Total or Mean (U.S.)	**1,285**	---	---	**149**	**67**	**498**	**484**	**285**	**282**
Total or Mean (for lake)	**5,428**	---	---	**638**	**61**	**496**	**495**	**274**	**280**

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

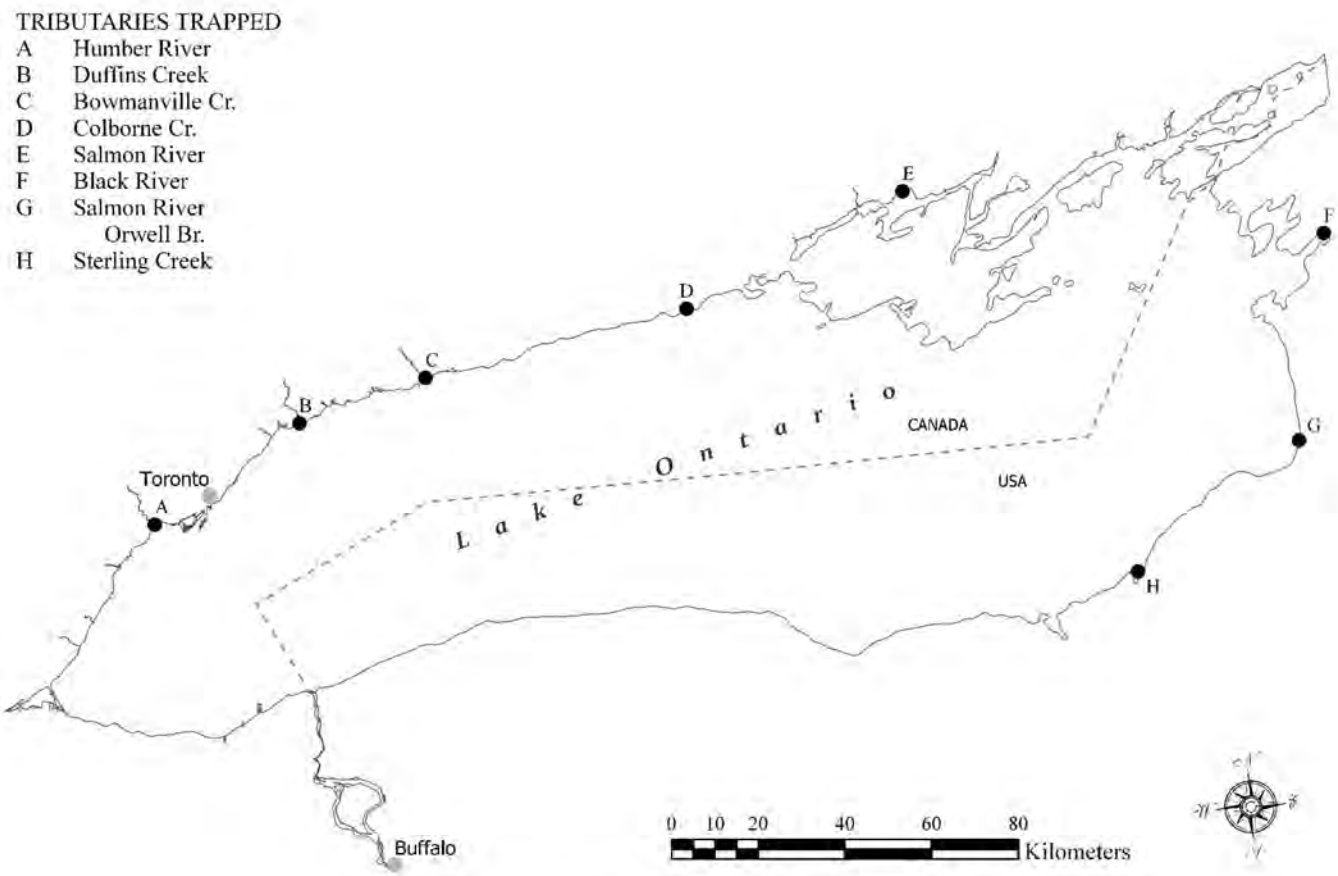

Figure 4. Location of Lake Ontario tributaries where assessment traps were operated (corresponding letters in Table 5) during 2018.

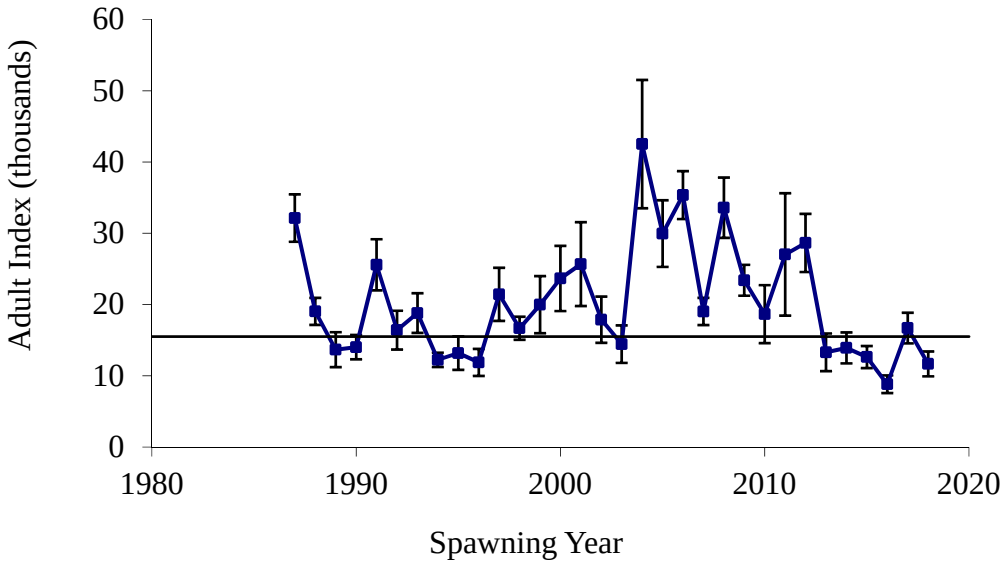

Figure 5. Index estimates with 95% confidence intervals (vertical bars) of adult Sea Lampreys. The adult index in 2018 was 11,666 (95% confidence interval 9,921 – 13,412). The point estimate is less than the target of 15,502 (black horizontal line). The index target was estimated as the mean of indices during a period with acceptable marking rates (1993-1997).

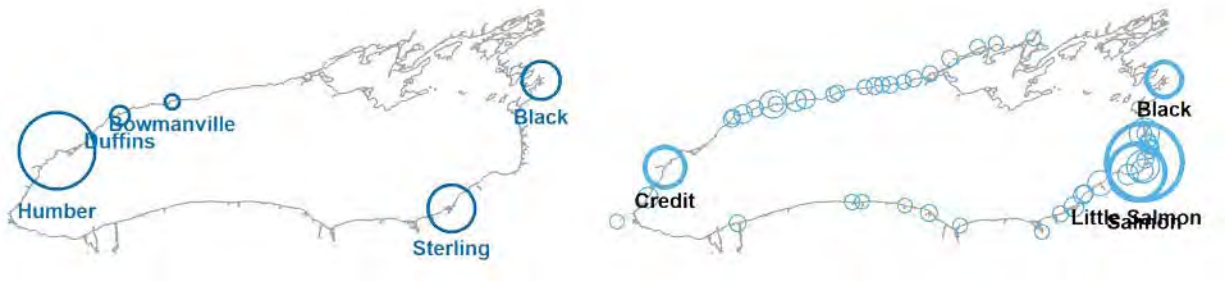

Figure 6. LEFT: Estimated index of adult Sea Lampreys during the spring spawning migration 2018. Circle size corresponds to estimated number of adults from mark-recapture studies. RIGHT: Maximum estimated number of larval Sea Lampreys in each stream surveyed during 1995-2012. Tributaries composing over half of the lake-wide larval population estimate are identified (Salmon 1,400,000; Little Salmon 970,000; Credit 590,000; Black 470,000).

Bottom trawl assessment of Lake Ontario prey fishes

Brian C. Weidel
U.S. Geological Survey, Great Lakes Science Center
Lake Ontario Biological Station, Oswego, New York 13126

Michael J. Connerton
New York State Department of Environmental Conservation
Lake Ontario Research Unit, Cape Vincent, New York 13618

Jeremy P. Holden
Ontario Ministry of Natural Resources and Forestry
Lake Ontario Management Unit, Picton, Ontario, Canada, K0K 2T0

Abstract

Collaborative Lake Ontario bottom trawl surveys, led by the United States Geological Survey (USGS), provide science and management information for evaluating Fish Community Objectives including predator-prey balance and prey fish community diversity. In 2018, the New York State Department of Environmental Conservation (NYSDEC), Ontario Ministry of Natural Resources and Forestry (OMNR), and the (USGS) completed an April bottom trawl survey (n = 208 tows) and an October survey (n = 118 tows), at depths 6-228 m, and captured 384,651 fish from 31 species. Alewife were 80% of the total catch by number and round goby, deepwater sculpin, and rainbow smelt comprised 12, 4, and 3% of the catch, respectively. The adult alewife abundance index for U.S. waters decreased in 2018 relative to 2017, while the index in Canadian waters increased. While lake wide density increased, biomass indices for Age-2 alewife decreased. Alewife condition indices were below the 10-year average for both the April and October indices. The 2018 Age-1 alewife abundance index, which measures reproductive success the previous year, was the third lowest observed in U.S. waters over the past 22 years. The Canadian Age-1 index 2018 value was four-times larger than the U.S. value. Within-year differences between Canadian and U.S. alewife abundance indices, highlight the importance of assessing Lake Ontario fishes at a whole-lake scale. Abundance indices for rainbow smelt, threespine stickleback and emerald shiner were similar to 2017. New experimental trawl sites in embayment habitats generally captured more species, a higher proportion of native species, and higher densities relative to similar depth sites in the main lake and regions adjacent to embayments. Pelagic prey fish diversity continues to be low because a single species, alewife, dominates the catch. Deepwater sculpin and round goby were the most abundant demersal (bottom-oriented) prey fishes in 2018. Slimy sculpin and native nearshore demersal prey fishes, which were historically more abundant in trawl catches, are rare and restricted to specific habitats, since round goby proliferation. Despite declines in some species, demersal prey fish community diversity continues to increase as deepwater sculpin and round goby comprise more even portions of the community in contrast to when a single species, slimy sculpin, dominated the community. Five bloater were captured in the 2018 surveys which is the largest number captured in Lake Ontario since restoration stocking began in 2012.

Introduction

Lake Ontario Fish Community Objectives (FCOs) call for maintaining predator-prey balance and for maintaining and restoring pelagic and benthic or demersal (bottom–oriented) prey fish diversity (Stewart et al. 2017). Collaboratively-conducted bottom trawl surveys have continually measured Lake Ontario prey fish community status and trends since 1978 to provide information for management decisions relative to these objectives.

Alewife are the most abundant fish in Lake Ontario and, as prey, support most of the lake's piscivores (Mills et al. 2003; Stewart and Sprules 2011; Weidel et al. 2018). Accordingly, their abundance and population abundance trajectories are critical to maintaining FCOs

and sport fishing quality. Recent bottom trawl prey fish surveys have documented lower-than-average alewife reproduction in 2013 and 2014 resulting in reduced adult abundances (Weidel et al. 2018). Concerns over maintaining alewife in balance with the lake's predators has resulted in management agencies reducing the number of sport fish stocked in 2016 - 2018 (Lake Ontario Committee 2016; New York State Department of Environmental Conservation 2018; OMNRF 2018).

In addition to providing information for managing sport fisheries, prey fish surveys also quantify the status of native species and prey fish communities, providing information for other FCOs and basin-wide prey fish status assessments (Environment and Climate Change Canada and U.S. Environmental Protection Agency 2017). Recently, surveys documented the natural recovery of native deepwater sculpin, a bottom-oriented prey fish once thought to be extirpated from the lake (Weidel et al. 2017). Bottom trawl surveys also measure the progress of bloater restoration. Bloater, a native, species that inhabits deep, offshore habitats was last caught by trawl surveys in 1983, indicating this species was also likely extirpated from the lake (Owens et al. 2003). Lake Ontario bloater restoration began in 2012 by stocking fish collected from Lake Michigan (Connerton 2018). Surveys also provide extensive, lake-wide surveillance for nonnative species and their effects such as round goby and its apparent negative effect on other demersal fishes (Weidel et al. 2018). In addition to sampling standardized annual trawl sites, surveys also conduct targeted research to better interpret historic bottom trawl data and design more-efficient sampling strategies. For instance, video cameras attached to the bottom trawls determined how long trawls were in contact with the lake bottom and found the area swept by deep trawls was three times what had been previously estimated based on recorded tow times (Weidel and Walsh 2013). Identifying where different surveys produced generally-duplicative results has allowed effort to be reallocated, expanding the spatial extent of the April and October surveys (Weidel et al. 2015). Expanding surveys to a whole-lake scale has provided new and critical insights, such as demonstrating the highest April alewife densities annually vary between the U.S. and Canadian waters of Lake Ontario (Weidel et al. 2018). Within this report we also document these value-added research projects to improve our interpretations of long-term survey data.

This report describes the status of Lake Ontario prey fishes with emphasis on information addressing the bi-national (OMNRF, NYSDEC) Lake Ontario Committee's FCOs (Stewart et al. 2017). This research is also guided by the U.S. Geological Survey (USGS) Ecosystems Mission Area science strategy whose goals seek to understand how ecosystems function and provide services, what drives ecosystems, and to develop science and tools that inform decision making related to ecosystem management, conservation and restoration (Williams et al. 2013).

Methods

April survey

The Lake Ontario April bottom trawl survey has been collaboratively conducted by NYSDEC and USGS during April and early-May since 1978. The survey collects many species but targets alewife at a time when their winter behaviors place them near the lake bottom which maximizes their susceptibility to bottom trawls (Wells 1968). Daytime trawling is conducted at fixed sites located along transects extending from shallow (~6m) to deep (228m) habitats. Although random sampling is preferable for trawl-based 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 sampled from 8-150m (26-495 ft) in U.S. waters at 12 transects. Changes in fish depth distribution and the need for lake-wide information have resulted in survey expansion. For instance, nutrient reductions and dreissenid mussel filtration increased water clarity in the mid 1990s (O'Gorman et al. 2000). Subsequently, the depth distributions of alewife and other prey fish shifted deeper and in 2004, trawling was expanded to 170m (557 ft) in U.S. waters (O'Gorman et al. 2000). In 2016, the survey was further expanded to a whole-lake extent and the OMNRF research vessel joined the survey. Since 2016, trawls have been collected from 6-225m (20-743 ft), with sites organized in 20-23 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 large catches of

dreissenid mussels in the 1990s required changing to a "3N1" trawl, with an 18-m (59 ft) headrope and slotted, metal, cambered V-doors. This trawl was configured such that the trawls footrope was not in contact with the lake bottom to reduce mussel catches. The survey adopted this trawl design in 1997 and for consistency, the time series statistics for the April bottom trawl survey are illustrated in this report's figures, from 1997 to present.

Bottom trawl catches are separated to species, counted, and weighed in aggregate. Subsamples of all species are also measured for individual length and weight, and stomachs, muscle tissue, and various aging structures are 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 m (66 ft) depth intervals and the proportional area of those depth intervals within the U.S. and Canadian portions of the lake (Table 1). The maximum depth sampled has increased as alewife distribution has increased. This survey expansion complicates analyses because the proportions of lake area within each 20m-strata change as more strata are included (Table 1). To estimate abundance based on a consistent area of the lake, stratified means for all years are calculated using all depth strata, assuming alewife catch was zero in those years when deep strata were not sampled. Separate abundance indices are calculated for U.S. and Canadian trawl catches. Mean and standard error calculations are from Cochrane (1977). Statistics reported for trawl catches in Canadian waters follow a similar analysis, however the area within 20m strata in Canadian waters differ from U.S. waters (Table 1). We also report a lake-wide alewife biomass index expressed in kilograms per hectare combining biomass estimates from U.S. and Canadian portions of the lake (48% lake area in U.S., 52% in Canada). Area-weighted biomass means based on 20 m strata are calculated similarly to number per 10 minute tow indices describe above; however, these calculations account for the area swept by the trawl, which changes with fishing depth (Weidel and Walsh 2013). Reporting in these units provides data in a more readily useable form to address ecosystem-scale management questions and facilitates comparisons across lakes. Condition indices are estimated using a linear model that predicts fish weight based on fish length, and are displayed as the average weight of a 165-mm (6.5 inch) alewife in the April and October surveys. Statistics for community diversity calculations were based on the most commonly captured pelagic species and those species identified FCOs (Table 2). The Shannon index was used to describe pelagic and demersal community diversity based on the overall trawl catch (Shannon and Weaver 1949).

In 2018, additional experimental trawling was conducted during the April survey to determine how embayment habitats differed from main lake habitats and understand how trawling effort influenced the chances of catching recently stocked bloater. Relative to the main lake, Lake Ontario embayments provide unique habitats and often contain different fish species, however these habitats have not historically been included in the April bottom trawl survey, except for sporadic sampling within Chaumont and Black River bays. For this study, trawls were conducted in the Bay of Quinte and northeastern embayments and catches were compared to trawls in habitat immediately adjacent to embayments and main lake trawl catches. Additional trawls were also collected near the bloater stocking site in U.S. waters (~100 m depth, near Oswego, NY) to determine if increased sampling effort was needed to capture bloater stocked the previous fall.

October survey

From 1978-2011, the October bottom trawl survey sampled six transects along the southern shore of Lake Ontario from Olcott to Oswego, NY, and targeted 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 using doors described above. Abundant dreissenid mussel catches led to the survey abandoning the standard trawl and experimenting with a variety of alternate polypropylene bottom trawls and metal trawl doors (2004-2010). Comparison towing indicated alternate trawls caught few demersal 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 doors but has reduced tow times to reduce mussel catches. Experimental sampling at new transects and in deeper habitats began in 2012. More notably, in 2015, the survey spatial extent was doubled to include Canadian waters. At that time the NYSDEC and OMNRF research vessels joined the survey, which greatly expanded the spatial extent and diversity of habitats surveyed. Demersal prey fish time series are illustrated in this report from 1978 to present and no adjustments are available for data when the alternative trawls were used. Trawl catch processing is as described for the April survey. Trawl results are expressed as biomass (kilograms of fish per hectare) and account for depth-

based differences in the lake area swept by the trawl (Weidel and Walsh 2013). Reporting in these units provides data in a more readily useable form to address ecosystem-scale management questions and facilitates comparisons across lakes. Time series are still regarded as biomass indices because we lack estimates of trawl catchability (proportion of the true density within a surveyed area captured by the trawl).

The total number of tows and spatial extent of the 2018 fall prey fish survey was reduced relative to the past three years. The USGS RV Kaho was delayed in starting the survey by approximately three weeks due to scheduling complications during routine maintenance. Additional weather-related delays reduced the transects sampled by the RV Kaho, especially in Canadian waters. In addition, scheduling conflicts and mechanical issues reduced the number of tows conducted by the OMNRF RV Ontario Explorer during the 2018 October survey.

Results and Discussion

Alewife – The adult alewife (Age-2 and older) abundance index (number per 10-minute tow) for U.S. waters decreased in 2018 (993) relative to 2017 (2,519) and was below the 10-year average (10-yr average =1,712; Figure 2). In contrast to the U.S. index, Figure 2 illustrates the adult alewife index for trawls in Canadian waters increased in 2018 (2,922) relative to 2017 (754). Figure 4 illustrates the spatial variability in alewife density. The U.S. and Canadian indices have trended in opposite directions in each of three years since the April survey was expanded into Canadian waters (Figure 2). Given the alternating trend in alewife distributions between the U.S. and Canadian waters, it is important to consider both when interpreting the Lake Ontario alewife population trends. The whole lake alewife density increased because the 2016 alewife year class was age-2 and counted towards the adult index, however the whole lake biomass declined (Table 3). Because density or number per 10-minute tow indices can not account for changes in alewife size we recommend using biomass indices to describe future changes in the Lake Ontario alewife population

In 2018, the adult alewife population was primarily Age-2, Age-3, and Age-6 fish (Figure 5) with relatively few fish from the 2013 and 2014 year-classes (Figure 5). As predicted, the large 2016 alewife year class (which was Age-2 in 2018 and counted towards the adult index) increased the overall adult alewife biomass, however at the time of sampling in April 2018, much of the adult population was in Canadian waters (Table 3; Figure 4). This apparent strong spatial variability in alewife habitat use in April further supports the need for whole-lake approaches to Lake Ontario fish sampling. The mechanisms contributing to the different spatial distribution across years are currently unknown.

The 2018, Age-1 alewife abundance index (number of fish per 10 minute trawl) for U.S. waters (102) was substantially smaller than 2017 (2945) which was among the highest values observed in U.S. waters since in 1997 (Figure 3). The 2018 U.S. waters Age-1 index value was the third lowest observed since 1997 with only 2015 (14) and 1997 (42) having lower values (Figure 3). The index value in Canadian waters was also lower in 2018 (911) relative to 2017 (1,012) but was higher than the U.S. index (Figure 3). The relatively cool 2017 spring and cold winter likely contributed to the lower than average 2017 year class since both spring and winter temperature has been shown to influence alewife reproduction success (O'Gorman et al. 2004; Madenjian et al. 2005). Adult alewife condition, assessed by the predicted weight of a 165 mm fish (6.5 inches) declined in April of 2018 relative to 2017, and followed a declining trend since 2016, however the October 2018 value indicated alewife condition increased during the 2018 year (Figure 6).

Other Pelagic Fishes – Bottom trawl abundance indices for other pelagic species noted in the FCOs (threespined stickleback, rainbow smelt, emerald shiner) either declined or remained at low levels in 2018 (Figure 7). Cisco catch per unit effort (CPUE) appeared to increase in 2018, however that value was driven predominantly by catches in experimental trawl sites within the Bay of Quinte that had not been sampled in previous years. Of the 21 cisco captured in the April survey, 20 were caught in the Bay of Quinte. If cisco predominantly inhabit embayments habitats in April, future survey efforts may consider additional sampling in these regions to better survey this native species. Alewife dominance relative to other pelagic fishes in Lake Ontario trawl catches is likely related to alewife predation on larval stages of other pelagic species (Crowder 1980; Brandt et al. 1987). The

habitat distribution of pelagic larvae, such as rainbow smelt, overlaps with adult alewife during the summer (Simonin et al. 2016) and in the spring for species like yellow perch (Brandt et al. 1987).

Bloater – Bloater are a pelagic species native to Lake Ontario that historically inhabited deep, offshore habitats. While records are sparse, commercial fishery catches suggest the species was historically abundant in Lake Ontario, but by the 1970s, was rare (Christie 1973). Restoration in Lake Ontario began in 2012 by stocking bloater raised from eggs collected from Lake Michigan. From 2012 – 2017, two bloater were captured in the April bottom trawl survey, one in U.S. waters and one in Canadian waters (Table 4). In 2018, three bloater were captured in the April survey and two bloater were captured in the October survey (Table 4). Bloater stocked in U.S. waters are batch marked with calcein, a nonantibiotic compound that produces a visible mark on fish scales and bones (Chalupnicki et al. 2016). Initial examinations suggest that most of the bloater captured in U.S. waters (2015:1; 2018: 3 April survey) were raised at the USGS Tunison Laboratory (personal communication, Marc Chalupnicki, USGS, July 2018) and stocked near Oswego, NY. The three Bloater captured in the 2018 April survey were 4 - 6 g and of similar size to the 5 g fish stocked in the fall of 2017 (Connerton 2018). The calcein mark and size of these fish suggest they were from the 2017 stocking near Oswego, NY. This means these fish moved at least 114 and 203 kilometers (71 and 126 miles) from the stocking site in fall of 2017 to their capture locations in April 2018 (Table 4; Figure 8). In 2018 additional trawling effort was conducted near the stocking location off Oswego NY, but none of the 72 trawls captured bloater, suggesting stocked fish move from the stocking site (Figure 8). The bloater captured in the October 2018 survey was a female (gonad weight 1.49g). Interestingly, the capture location of this female fish was on the same transect and similar depth as the only bloater captured in historic surveys (Table 4). Multiple catches in this same region may identify an important lake habitat for this native species.

Given the relatively large number of bloaters captured in 2018 relative to previous years we wondered if it these catches were unusual given the size of Lake Ontario and the number of if fish stocked. We used our understanding of how many rainbow smelt and alewife we caught relative to their population estimates to better understand our bloater catches. Since 1997, bottom trawls in U.S. waters captured on average 0.016 % of the alewife and rainbow smelt estimated in the U.S. portion of the lake (Figure 9). If we conservatively assume 10% of bloater survived from the fall when they are stocked to the following spring, and 58% survive each year thereafter (Brown et al. 1985), we can estimate the number of bloater in U.S. waters in April (Table 5). Using the trawl catch proportion from alewife and rainbow smelt (mean = 0.016%) and the estimated number of bloater in the lake we can estimated expected bloater trawl catches. Our observed April trawl catches were similar to the predicted catch (Table 5). This suggests the current trawl surveys may be able to track restoration success at the current bloater stocking levels. This analysis is simple and requires a number of assumptions, but it serves as a starting point from which to improve our understanding of Lake Ontario bloater restoration and assessment.

Slimy Sculpin – Slimy sculpin abundance indices in 2018 were among the lowest observed for the entire time series (Figure 10). Once the dominant demersal prey fish in Lake Ontario, slimy sculpin declines in the 1990s were attributed to the collapse of their preferred prey, the amphipod *Diporeia* (Owens and Dittman 2003). The declines of slimy sculpin 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% (Weidel et al. 2018). These data suggest round goby are limiting slimy sculpin reproduction or possibly recruitment of juvenile slimy sculpin to adult stages.

Deepwater Sculpin - In 2018, deepwater sculpin were among the most abundant demersal prey fishes in Lake Ontario, however, their biomass estimates declined slightly from 2017 (Figure 10). Interestingly, 9 of the 37 (24%) trawls that captured deepwater sculpin in the October survey also contained dead deepwater sculpin. The 54 dead individuals ranged in length from 100 to 170 mm. Deepwater sculpin condition has been declining as their abundance has increased over time (Figure 11), suggesting that the deepwater sculpin population may be nearing its carrying capacity in Lake Ontario and we might expect density and biomass to stabilize or decline slightly.

Round Goby – Round goby density increased in 2018 relative to 2017 for both the U.S. abundance index and the whole lake index based on data from the October survey (Figure 10). Estimating round goby abundance

using bottom trawls can be complicated by the fish's preference for rocky substrate and seasonal changes in depth distribution (Ray and Corkum 2001; Walsh et al. 2007). Round goby were captured during the April trawl survey as early as 2002, however that survey's trawl is likely less effective at capturing round goby since the foot rope is elevated off the lake bottom.

Prey fish diversity - Lake Ontario FCOs call for increased prey fish diversity (Stewart et al. 2017). Based on bottom trawl catches, the pelagic prey fish community diversity remains low because a single species, alewife, dominates the catch (Figure 12). Actions to improve pelagic community diversity are currently underway in Lake Ontario, including bloater restoration and cisco rehabilitation (Connerton 2018). Despite slimy sculpin declines, demersal prey fish community diversity has generally increased during recent decades. In the 1970s – 1990s, a single species, slimy sculpin, dominated the catch, resulting in lower diversity values. More recently, deepwater sculpin and round goby comprise similar proportions of the trawl catch, increasing diversity relative to when only slimy sculpin dominated the catches (Figure 12).

Embayment Catches – Trawl catches at embayment sites (Bay of Quinte, Chaumont Bay and Black River Bay) differed from trawl catches at similar depths in the main lake and at Eastern Basin sites immediately adjacent to the embayments (Figure 13, Table 6). Trawls in 2018 suggested embayment sites generally had more species, a higher proportion of native species, and higher fish densities relative to adjacent and similar main lake habitats (Figure 13). Historically, the April trawl survey focused solely on estimating alewife abundance; therefore, areas where alewife were rare or in low abundance, such as embayments, received little sampling effort. More recently, the April survey has provided more information on species other than alewife. For instance, cisco and lake whitefish are species mentioned in FCOs that may be more readily sampled with trawls in embayments as 100% of the cisco and 82% of the lake whitefish were caught in these habitats. The addition of embayment trawl sites in future surveys could more thoroughly address Lake Ontario FCOs by providing consistent sampling methods across different lake habitats.

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Table 1. Lake Ontario area in square kilometers within different depth strata in U.S. and Canadian (CA) waters. The proportional area columns illustrate how the area-weighting of stratified abundance mean indices changes as additional depths have been added to the survey over time.

Range	Area U.S	Area CA	Proportional Area U.S.			Proportional Area CA
(m)	. (km^2)	(km^2)	0-160m	0-180m	0-244m	0-160m
0-20	1155	1749	0.19	0.15	0.12	0.18
20-40	905	1616	0.15	0.12	0.10	0.16
40-60	680	1248	0.11	0.09	0.08	0.13
60-80	514	1426	0.08	0.07	0.06	0.14
80-100	441	1198	0.07	0.06	0.05	0.12
100-120	527	1293	0.09	0.07	0.06	0.13
120-140	822	964	0.13	0.11	0.09	0.10
140-160	1112	353	0.18	0.14	0.12	0.04
160-180	1598	0		0.21	0.18	NA
180-200	737	0			0.09	NA
200-220	448	0			0.05	NA
220-240	79	0			0.01	NA
240-260	<1	0			>.01	NA

Table 2. Number of fish captured in all of Lake Ontario during the 2018 April and October prey fish bottom trawl surveys. Figures 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 demersal prey fish community diversity calculations.

Species	April	October	total	percent	classification
Alewife	289706	16258	305964	80	pelagic
Round goby	5465	39603	45068	12	demersal
Deepwater sculpin	10245	5886	16131	4	demersal
Rainbow smelt	8418	1763	10181	3	pelagic
Yellow perch	1573	1107	2680	1	demersal
Trout-perch	1184	841	2025	1	demersal
White perch	319	279	598	< 1	pelagic
Slimy sculpin	238	352	590	< 1	demersal
Spottail shiner	262	201	463	< 1	demersal
Gizzard shad	0	308	308	< 1	
Lake trout	89	97	186	< 1	
White sucker	28	67	95	< 1	
Emerald shiner	79	8	87	< 1	pelagic
Brown bullhead	1	47	48	< 1	
White bass	5	35	40	< 1	
Threespine stickleback	26	2	28	< 1	pelagic
Walleye	25	2	27	< 1	
Cisco	21	1	22	< 1	pelagic
Logperch	0	20	20	< 1	demersal
Pumpkinseed	19	1	20	< 1	
Freshwater drum	4	15	19	< 1	
Lake whitefish	17	0	17	< 1	
Rockbass	12	1	13	< 1	
Johnny darter	0	8	8	< 1	demersal
Bloater	3	1	4	< 1	pelagic
Carp	0	3	3	< 1	
Chinook salmon	0	2	2	< 1	
American eel	1	0	1	< 1	
Bluntnose minnow	0	1	1	< 1	
Lake sturgeon	1	0	1	< 1	
Northern pike	1	0	1	< 1	
		total=	384651		
Dreissena mussel weight(kg)	79	3947	4026		

Table 3. Lake Ontario area-weighted stratified mean alewife density (numbers per hectare) and biomass (kilograms per hectare) based on the April bottom trawl survey (2016-2018). Whole lake figures are based on 52% of the lake area in Canada and 48% in U.S. waters.

Year	Density			Biomass		
	U.S. (n/ha)	Canada (n/ha)	Whole Lake (n/ha)	U.S. (kg/ha)	Canada (kg/ha)	Whole Lake (kg/ha)
2016	708	1649	1197	26	58	43
2017	2503	848	1642	75	27	50
2018	907	2929	1958	22	57	40

Table 4. Sampling and fish data for all bloater captured in Lake Ontario bottom trawls. The capture from Rocky Point in 2017 was from the OMNRF Community Index program (OMNRF 2018). Bloater can be difficult to distinguish from other coregonines such that additional meristic and genetic evaluations are ongoing to confirm the species identification.

Date	Transect	Fishing Depth (m)	Fishing Temp. (°C)	Length (mm)	Weight (g)	Distance from stock (km)
28-Apr-1983	Smoky Pt.	110	3.6	272	182	
8-May-2015	Oswego	95	3.5	125	10.2	3
5-Jul-2017	Rocky Point	90		130	14	39
22-Apr-2018	Youngstown	60	2.7	108	6	203
22-Apr-2018	Youngstown	75	2.7	102	4	203
25-Apr-2018	Hamlin	95	2.6	96	5	114
14-Oct-2018	30-Mile Pt	75	4.1	117		unknown
23-Oct-2018	Smoky Pt.	78	9.8	240	122	unknown

Table 5. Expected and observed number of bloater caught in U.S. waters of Lake Ontario during the April bottom trawl survey. Estimated abundance assumes bloater survival of 10% from when they are stocked in the fall to the following spring and 58% annual survival for all years after that (Brown et al. 1985). Expected catch is based on the mean percentage of alewife and rainbow smelt caught in trawls relative to their estimated abundance since 1997 in U.S. waters of Lake Ontario (Figure 9; 0.016 %).

Year Stocked (fall)	Number Stocked	Survey Year (spring)	Estimated Spring Abundance	Estimated Trawl Catch	Observed Trawl Catch
2012	1000	2013	100	0	0
2013	7000	2014	758	0.1	0
2014	20000	2015	2440	0.4	1
2015	62000	2016	7615	1.2	0
2016	149000	2017	19317	3.1	0
2017	94000	2018	20604	3.3	3

Table 6. Species captured in bottom trawls fished in specific embayment habitats, shallow main lake habitats (trawl depth < = 20m) and the deeper habitats within the Eastern Basin not within an embayment, in the 2018 Lake Ontario April prey fish survey.

Species	Bay of Quinte	Chaumont Bay & Black Riv. bay	Main lake <20m	Eastern Basin
Alewife	0	5	0	1
American Eel	1	0	0	0
Brown Bullhead	1	0	0	0
Cisco	20	1	0	0
Emerald Shiner	0	54	14	0
Freshwater Drum	4	0	0	0
Lake Trout	0	0	4	0
Lake Whitefish	14	0	0	1
Northern Pike	1	0	0	0
Pumpkinseed	18	1	0	0
Rainbow Smelt	65	126	102	345
Rockbass	12	0	0	0
Round Goby	3	1	9	6
Slimy Sculpin	0	0	1	0
Spottail Shiner	24	230	8	0
Threespine Stickleback	0	0	2	0
Trout-perch	210	974	0	0
Walleye	12	13	0	0
White Bass	1	4	0	0
White Perch	77	242	0	0
White Sucker	8	15	5	0
Yellow Perch	1440	103	2	0

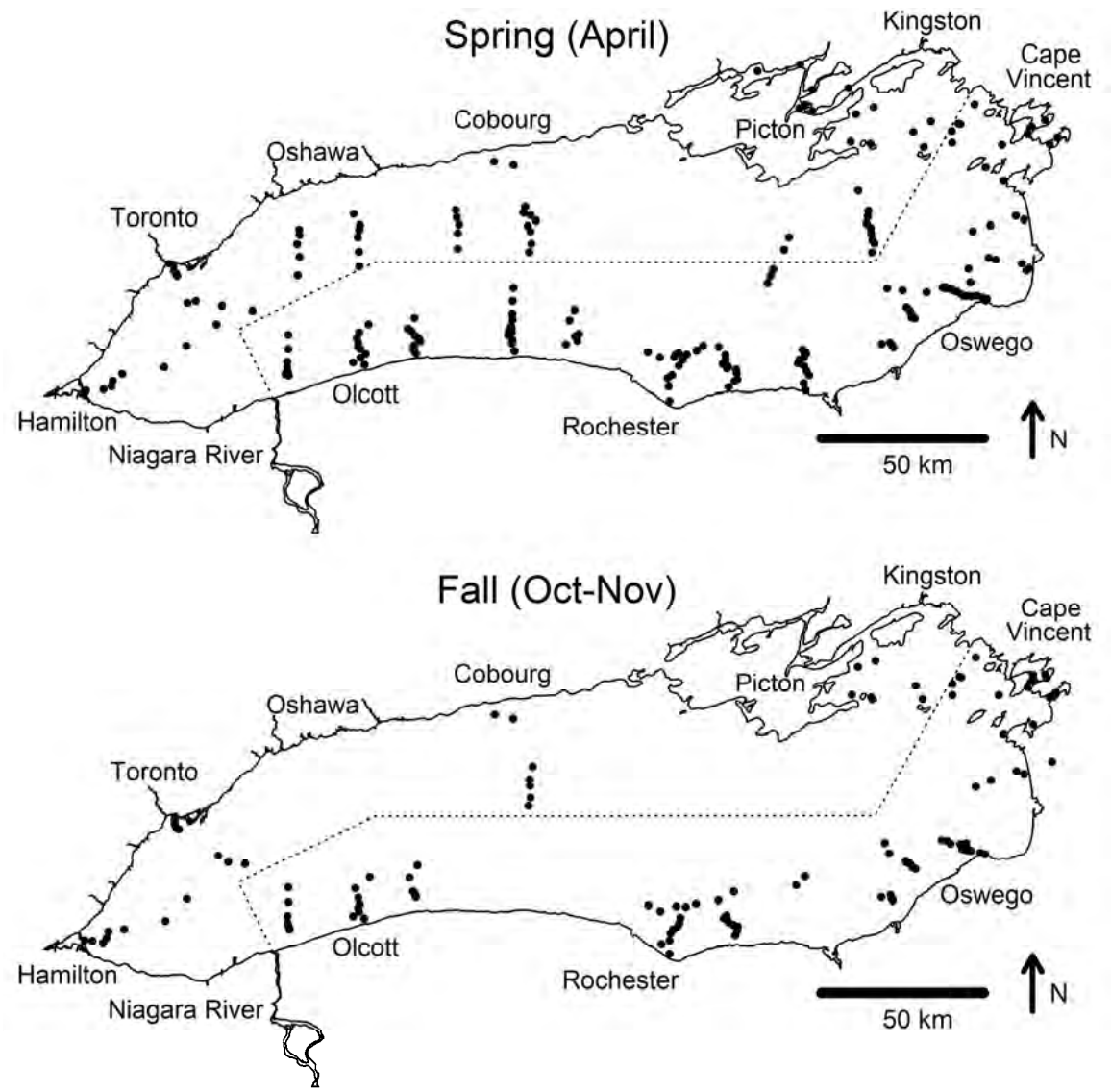

Figure 1. Lake Ontario bottom trawl sites from the 2018 April and October surveys. The April survey targets alewife and other pelagic prey fishes and the October survey targets demersal or benthic prey fishes. A total of 208 trawls were conducted in April and 118 trawls were conducted in the fall. Sample size and spatial sampling extent of the October survey were reduced due to mechanical, scheduling and weather complications.

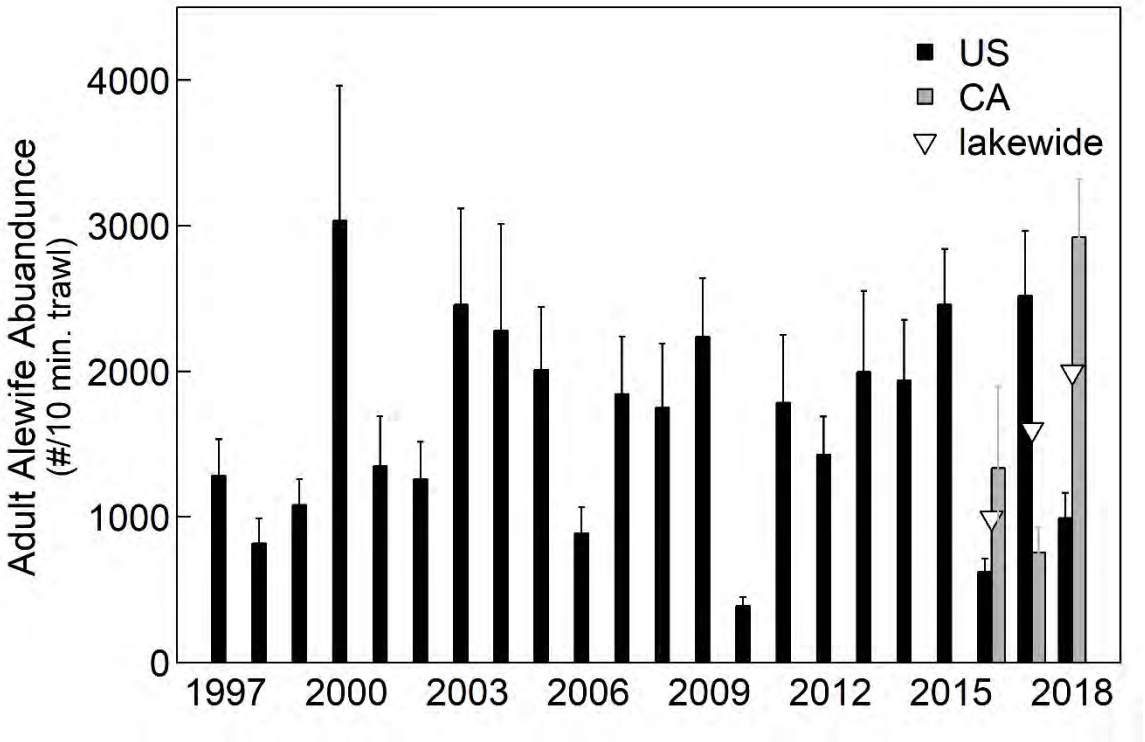

Figure 2. Lake Ontario April bottom trawl-based abundance indices for adult alewife. Values represent a stratified, area-weighted mean number of alewife in a 10-minute bottom trawl. Error bars represent one standard error of the mean. Trawling in Canadian waters began in 2016, but to maintain consistent comparisons through time, separate indices are illustrated for Canadian and U.S. waters. For reference the area of the lake in Canada is approximately 52% and in the U.S. is 48%. The values for 1997-2015 in this figure are slightly lower than reported in previous reports because those historic calculations did not include the portion of U.S. water greater than 180m in the area-stratified calculations. Alewife are rarely captured at depths greater than 180m and for those years when deep strata were not sampled we assumed alewife catch in those strata was zero. The above figure represents the index value calculated using a consistent lake area for all years (U.S. = 0-244m, Canada = 0-175m, Whole lake = 0-244m).

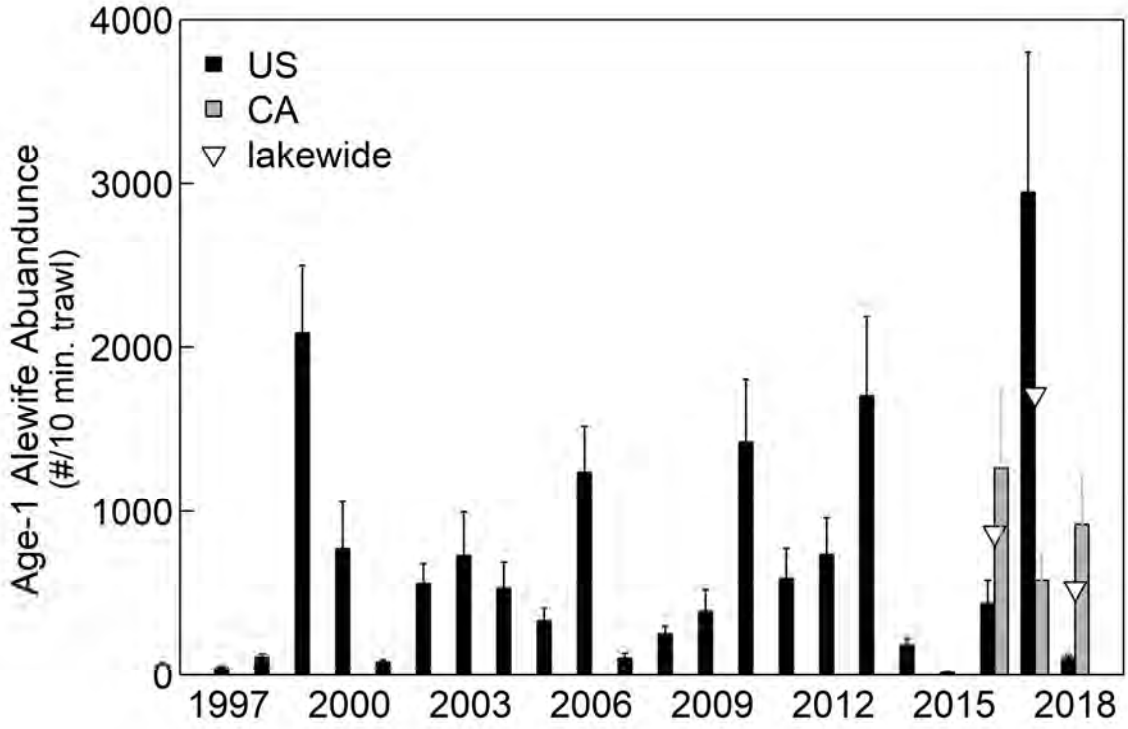

Figure 3. Lake Ontario April bottom trawl-based abundance indices for yearling or Age-1 alewife . Values represent a stratified, area-weighted mean number of alewife in a 10-minute bottom trawl. Error bars represent one standard error of the mean. Trawling in Canadian waters began in 2016, but to maintain consistent comparisons through time, separate indices are illustrated for Canadian and U.S. waters. For reference the area of the lake in Canada is approximately 52% and in the U.S. is 48%. The values for 1997-2015 in this figure are slightly lower than reported in previous reports because those historic calculations did not include the portion of U.S. water greater than 180m in the area-stratified calculations. Alewife are rarely captured at depths greater than 180m and for those years when deep strata were not sampled we assumed alewife catch in those strata was zero. The above figure represents the index value calculated using a consistent lake area for all years (U.S. = 0-244m, Canada = 0-175m, Whole lake = 0-244m).

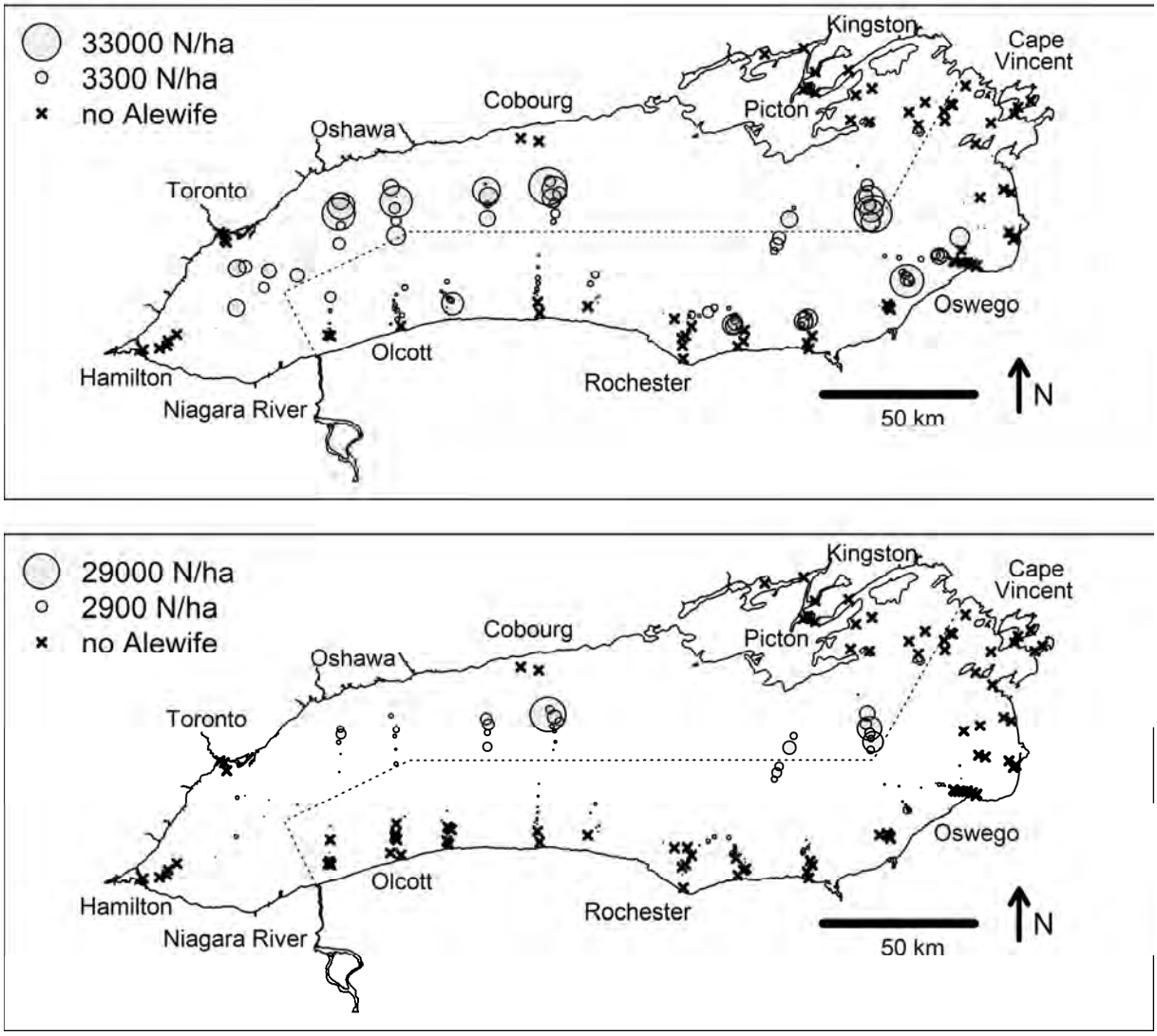

Figure 4. Density of adult (top panel) and Age-1 alewife (bottom panel) caught in the 2018 Lake Ontario April bottom trawl survey conducted collaboratively by USGS, NYSDEC, and OMNRF. The size of the gray circles represents the relative density in number per hectare of alewife captured while an "x" signifies a location where no alewife were captured.

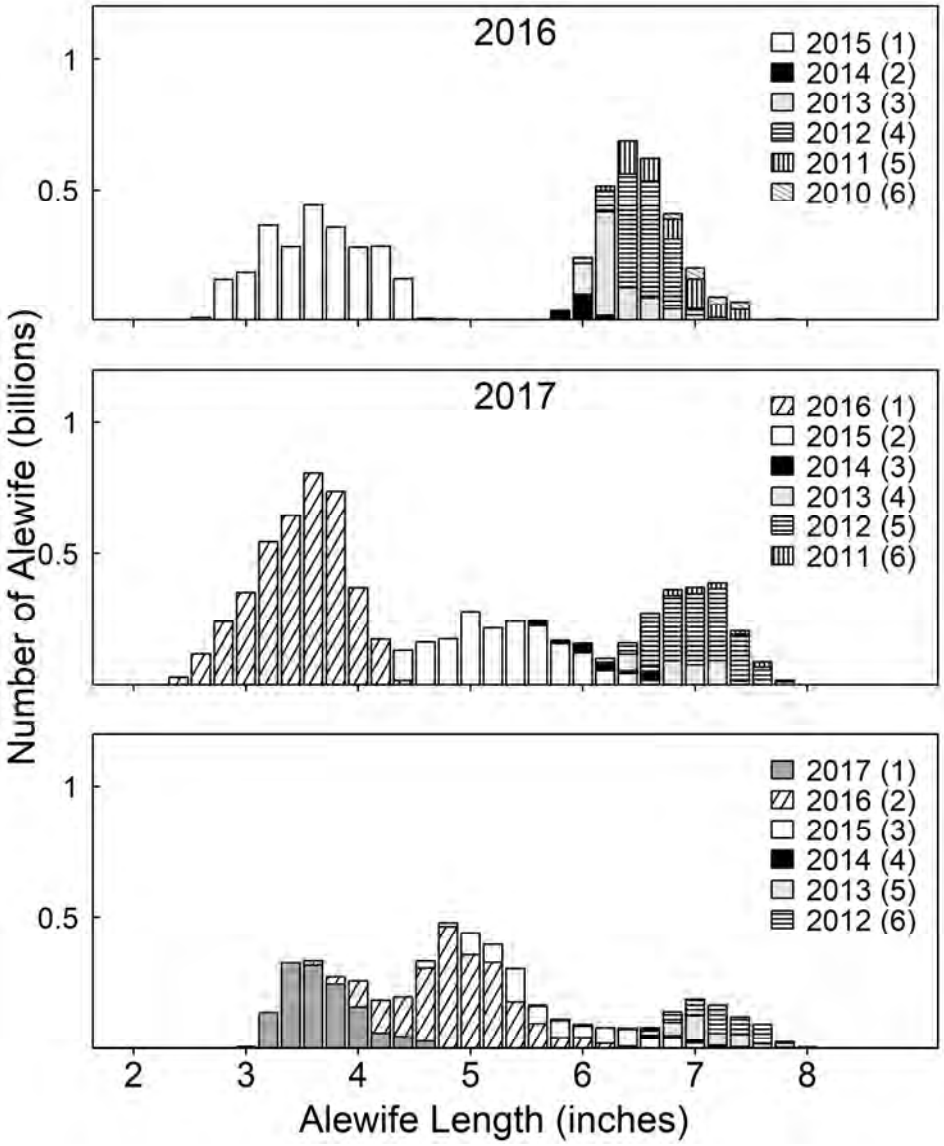

Figure 5. Alewife size and age distributions from April bottom trawl surveys conducted in Lake Ontario, 2016-2018. The height of each bar represents the number of alewife estimated in the lake within that size category (1/5 of inch). Each alewife year class (all the fish born in a given year) are represented by a consistent shading pattern across the different panels. All plots include the combined U.S. and Canadian observations. For instance, the relatively large 2012 alewife year class is illustrated by boxess filled with horizontal lines, whereas the relatively small 2014 year class is illustrated with black filled boxes.

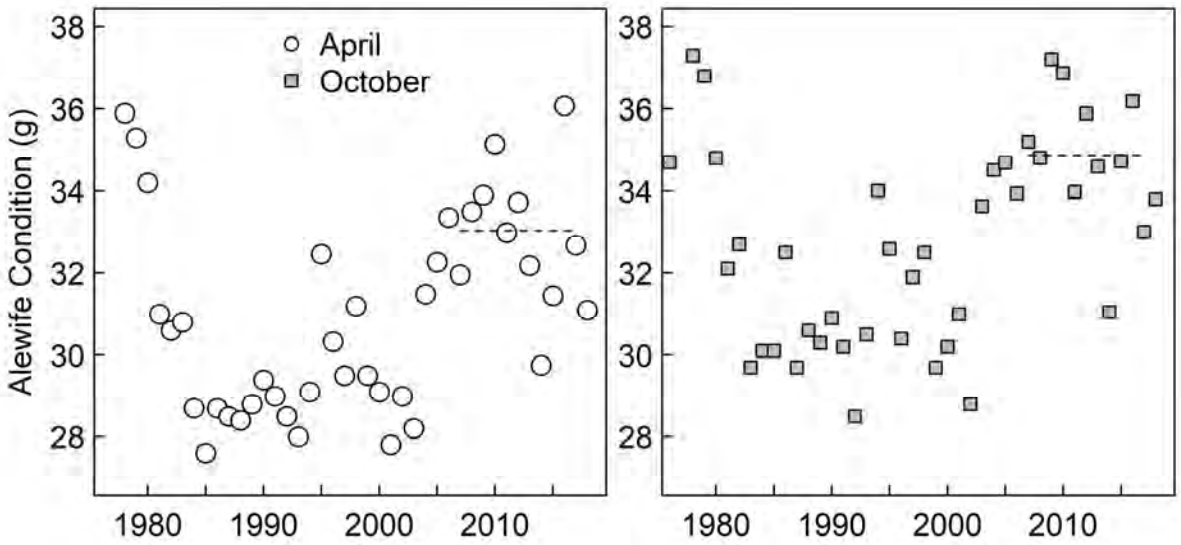

Figure 6. Lake Ontario alewife condition (fatness) represented as the predicted weight of a 165mm (6.5 inch) fish from the April (left panel) and October (right panel) bottom trawl surveys. Dashed lines represent the mean condition over the previous 10 years. Data from 1978-2015 represent trawls in U.S. waters while data from 2016-2019 also include observations from Canadian waters.

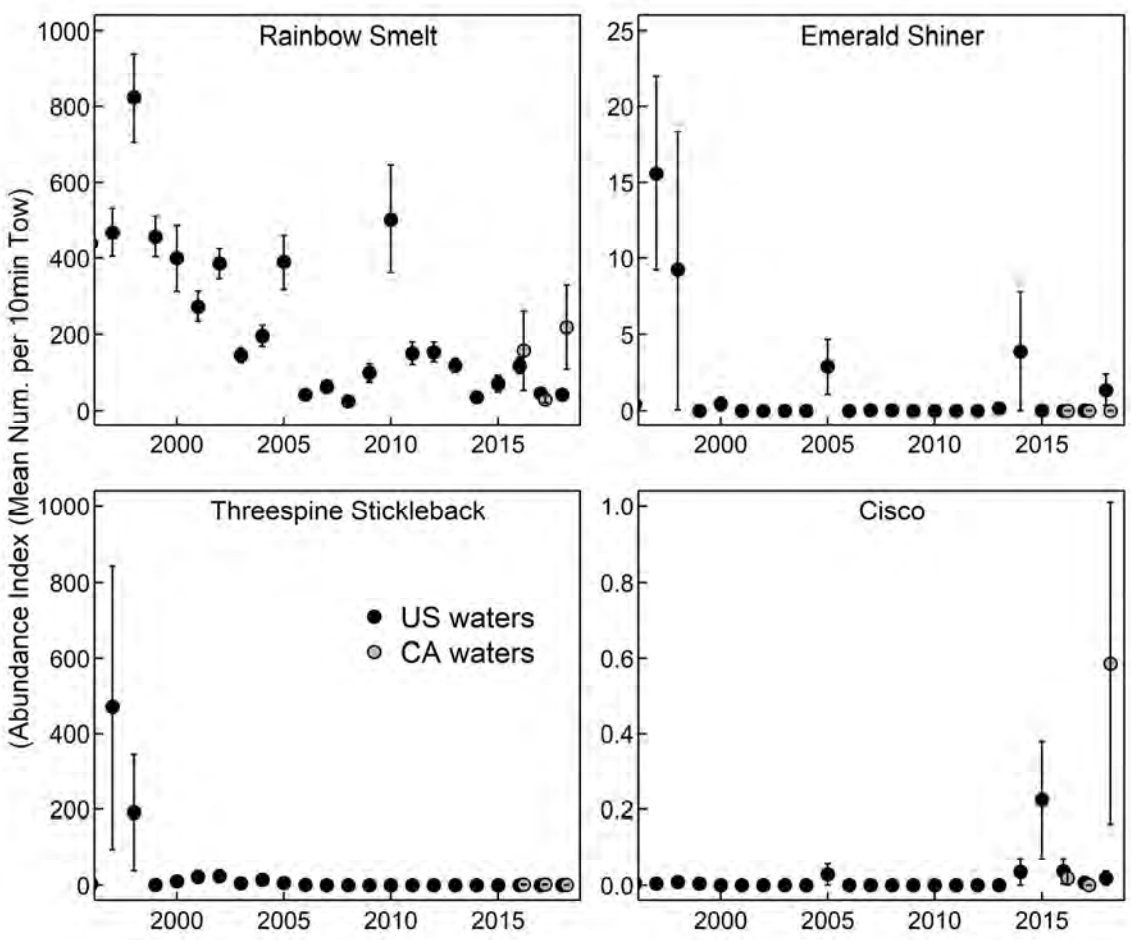

Figure 7. Abundance indices for other Lake Ontario pelagic prey fishes based on bottom trawls in U.S. and Canadian waters, 1997-2018. Error bars represent one standard error of the area-weighted stratified mean. The elevated point for 2018 cisco in Canadian waters was due to the addition of Bay of Quinte trawl sites that were not sampled in other years and where 20 of the 21 total cisco captured during the survey were caught.

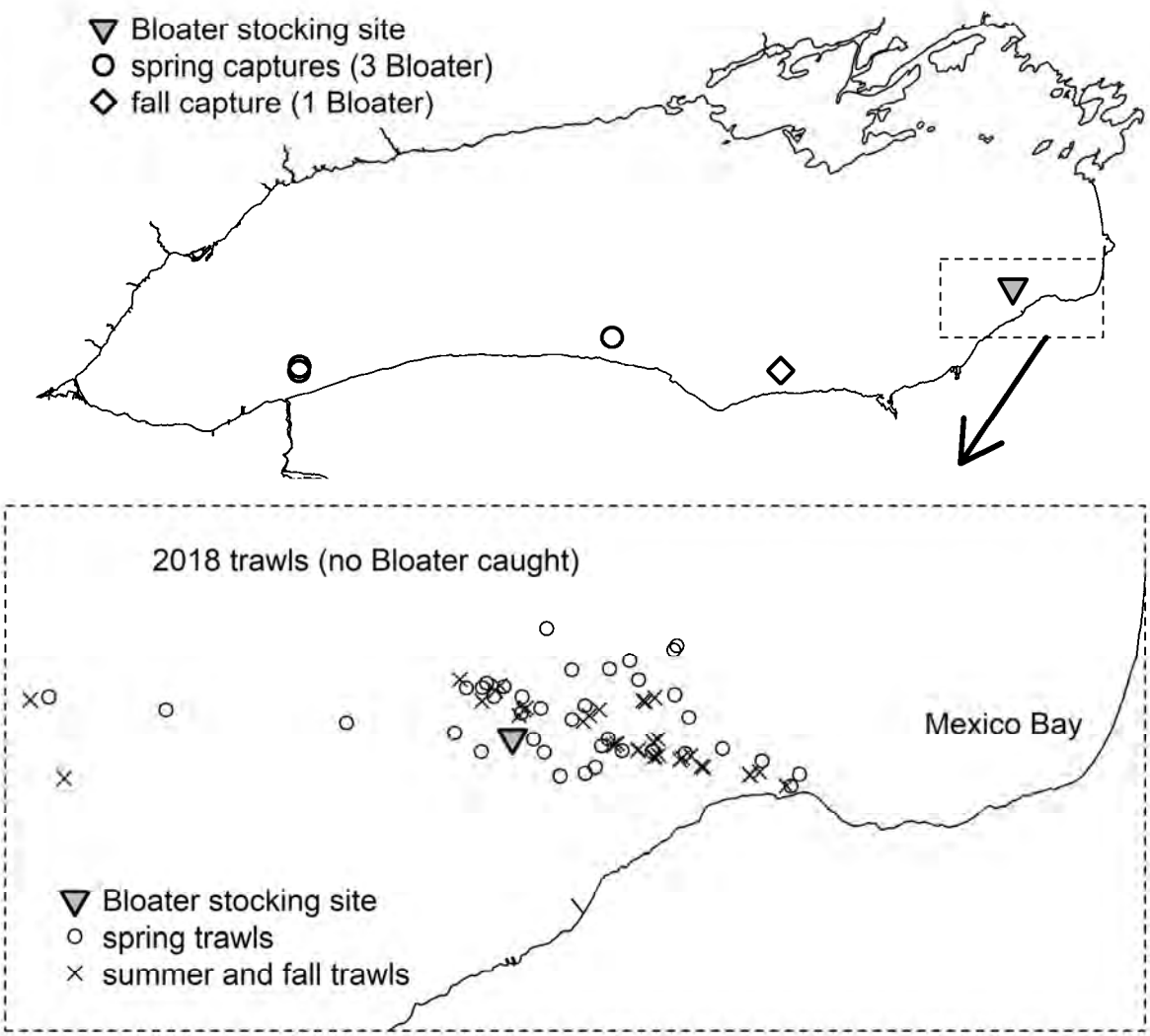

Figure 8. Top panel: bloater stocking location in the U.S. waters and the locations where bloater were captured in April and October bottom trawl surveys. Bottom panel: Additional bottom trawls were conducted near the stocking site but failed to capture any bloater.

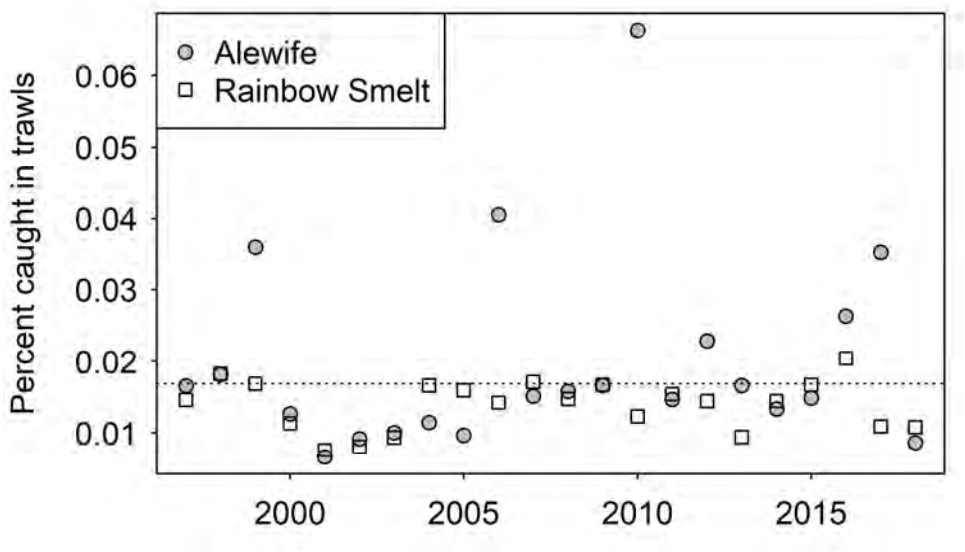

Figure 9. Percent of alewife and rainbow smelt captured in April bottom trawls in U.S. waters each year since 1997. Estimates are based on the total number of that species captured in trawls divided by the total number of that species estimated for all U.S. waters. The dashed line represents the average value of all estimates (0.016%).

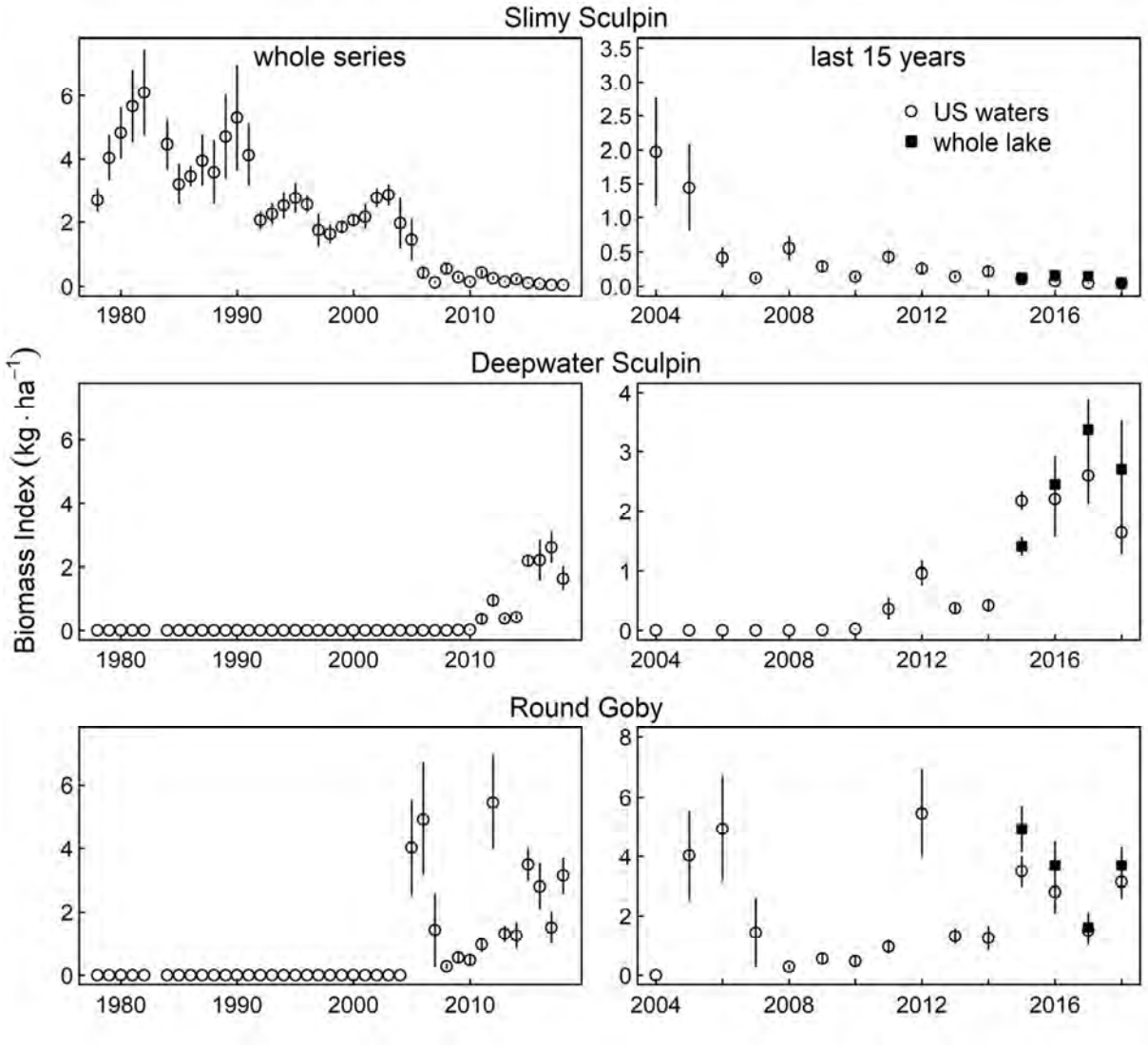

Figure 10. Lake Ontario biomass indices for demersal (bottom-oriented) prey fishes from 1978-2018 (left panels) and 2004-2018 (right panels). Note the different scales in the left and right panels. The survey is conducted in late-September and October. Error bars represent one standard error of the area-weighted stratified mean. Sampling in Canadian waters began in 2015 and values from the whole lake are shown in the right panels as filled squares. Separate means are calculated separately for tows in U.S. waters to maintain comparability across the U.S. time series.

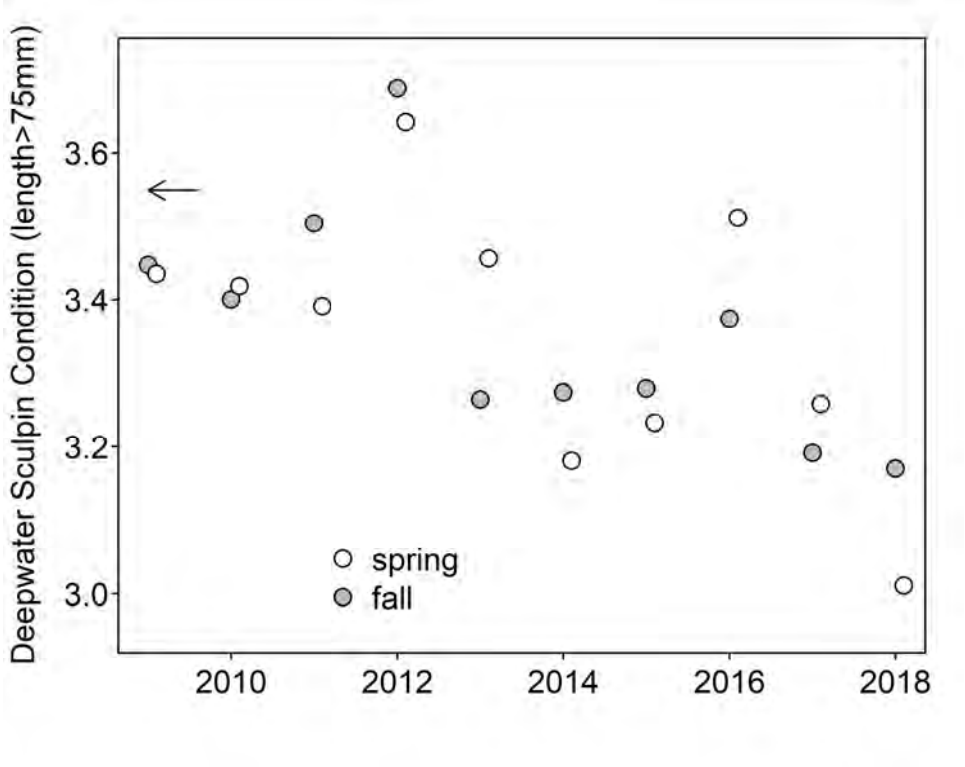

Figure 11. Deepwater sculpin 'condition' as measured by the slope of the relationship between log total length (mm) and log weight (g). When fish are heavier at a given length the y-axis value is higher, when fish are lighter at a given length the value is lower. For reference the arrow represents a value from Lake Superior deepwater sculpin from 1970 (Selgeby 1988).

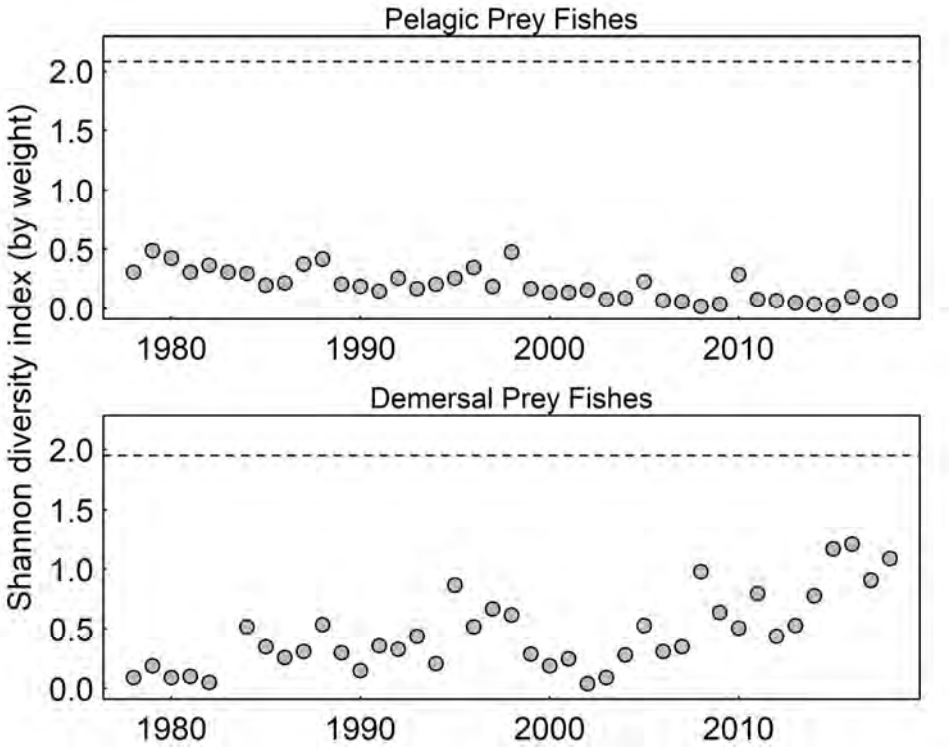

Figure 12. Lake Ontario prey fish diversity indices for pelagic and demersal prey fish communities based on bottom trawl catch weights 1978-2018. Species used for calculations are identified in Table 2. Diversity is represented with the Shannon index (Shannon and Weaver 1949) using commonly encountered species in the April (pelagic) and October (demersal) 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).

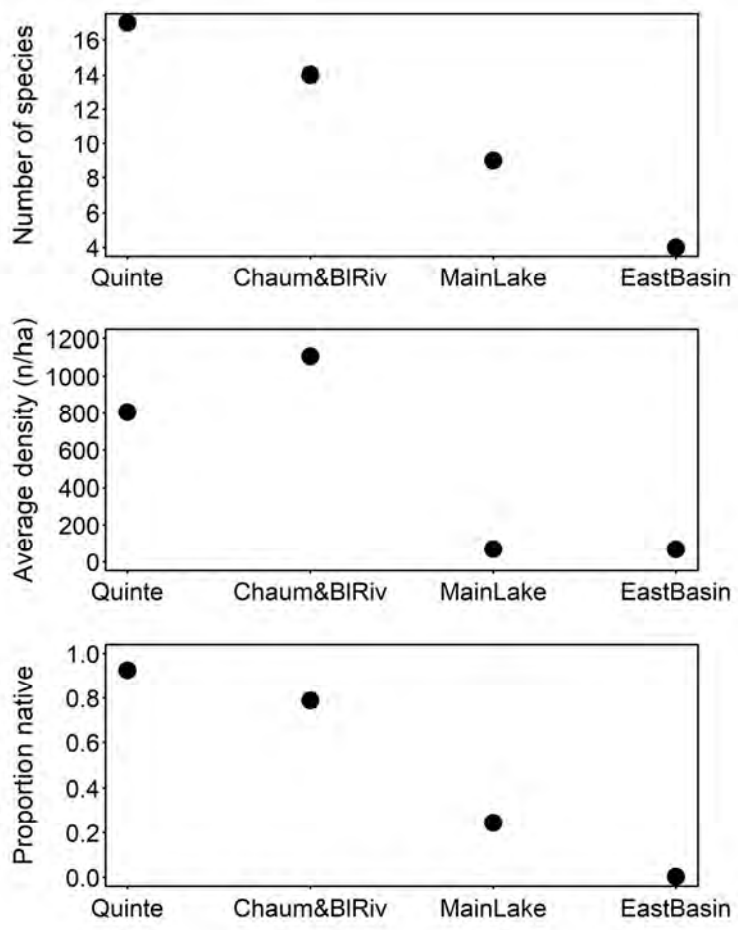

Figure 13. Lake Ontario April prey fish trawl catches differed among embayment (Quinte, Chaumont and Black River bays), shallow Main Lake (< 20m) and deeper East Basin (20 - 55m) habitats.

Cormorant Management Activities in Lake Ontario's Eastern Basin

Leslie B. Resseguie[1] and Irene M. Mazzocchi[2]
[1]*Bureau of Fisheries,* [2]*Bureau of Wildlife*
New York State Department of Environmental Conservation
Watertown, New York 13601

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 1996, there was an estimated 10,895 breeding pairs of cormorants in Lake Ontario's eastern basin; counted on five active Canadian and four American sites; Little Galloo Island (LGI), Bass, Gull, and Calf islands.

LGI, in the eastern basin of Lake Ontario, was first colonized by cormorants in 1974. Peak abundance at LGI reached over 8,400 nests in 1996. Concerns about the impacts cormorants have on fish populations, other colonial waterbird species, private property, and other ecological values followed this population expansion. LGI 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 of 1,500 breeding pairs and 780,000 feeding days, which includes feeding by chicks and non-breeding birds, in the eastern basin of Lake Ontario. 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).

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 LGI cormorant population to a target level described as a population associated with 1,500 nesting pairs and a target of zero production on the other eastern basin islands. 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 the NYSDEC to manage cormorants 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 2016 which resulted in a much reduced, and less effective management effort that year. No cormorant population control efforts were undertaken in 2017. In 2018, NYSDEC applied for a USFWS depredation permit under Priority 3 of the permitting application (to alleviate management and conservation concerns associated with threatened, endangered and species of high conservation concern). NYSDEC was granted an annual permit authorizing the culling of up to 965 birds and destroying up to 4,980 nests statewide.

Methods

Cormorant management in the New York waters of Lake Ontario's eastern basin has focused on LGI, Bass, Calf, and Gull Islands. These islands are located in Jefferson County, New York. Gull and LGI are owned by New York State and managed by NYSDEC. Bass and Calf islands are privately owned. These islands historically contained several colonial waterbird colonies (Table 1), and most were monitored annually. Management and monitoring activities were carried out by NYSDEC Region 6 staff, sometimes with assistance of U.S. Department of Agriculture Wildlife Services personnel. Cormorant management activities have included nest removal, egg oiling, and culling. Though no cormorant management activities were conducted in 2017, nest counts were conducted on islands in the St. Lawrence River and the Eastern basin of Lake Ontario. In 2018, limited cormorant management activities resumed (Table 2).

Nest removal efforts began on Gull and Bass islands in 1994. Calf Island was included following observation of cormorant nests 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 egg oil treatment of accessible cormorant nests on LGI began in early spring using methods similar to 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 before treatments ceased due to the federal court decision. In 2018, limited treatment resumed, and oil was applied to nests with greater than 3 eggs on four occasions. 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 can effectively oil 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 2018 NYSDEC depredation permit, nests that contained no eggs could be removed and would not be counted against the destruction quota. This practice was implemented on LGI and Gull Island on every visit in 2018.

Under the Depredation Order, limited culling of cormorants was conducted in 2004 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 and continued through 2014. No culling has been conducted on eastern basin islands from 2015 – 2018. The limited culling quota given under the 2018 permit was administered at other sensitive areas within the state. 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 LGI 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 LGI 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 cormorant 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 1,272 nests in 2004 (Table 1). 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. Due to historic flooding of the St. Lawrence River and Lake Ontario 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, overall cormorant nest counts were about the same as 2016 as many islands that are usually vacant were utilized in 2017 (primarily in the St. Lawrence River). On LGI, the 2018 peak nest count was made on May 30th, and totaled 2,778 nests, a 39% increase from 2017.

We estimated that the LGI colony generated 1,018,459 feeding-days in 2018, substantially higher than the target of 780,000 (Figure 1). There were approximately 78,384 feeding days attributed to chicks in 2018, a 78% decrease from 2017 (367,816). Despite the decrease in chick consumption, total feeding days remained high due to the increase in adult and sub-adult birds observed on the island. Cormorant feeding days at LGI remained within 10% of target most years from 2006 to 2015. However, in the years 2016, 2017 and 2018 (i.e., since the Depredation Order was rescinded), feeding days exceeded the target by 20%, 34%, and 31% respectively.

Nest counts for other colonial waterbirds (except ring-billed gulls) are conducted each year on eastern basin islands. Caspian terns continued to maintain a stable colony on LGI with 2018 yielding the highest nest count on record, estimating 2,700 breeding pairs. Great black-backed gulls (*Larus marinus*) have not been detected on any of the islands since 2008. Common terns (*Sterna hirundo*), which are listed as a threatened species in New York, were first observed on LGI in 2013 and successfully nested in 2014 with 34 nests counted. Numbers have since declined with 15 nests counted in 2016, 3 in 2017, and only 2 in 2018 (Table 1).

Black-crowned night herons (*Nycticorax nycticorax*), a species of special concern, were predominantly found nesting on Gull and Bass islands, and in low numbers on LGI. There have be no night heron nests observed on Bass Island since 2006, and LGI since 2008. Gull Island, the last known eastern basin night heron breeding site, has been without nests since 2016. This is likely due to competition with cormorants for nesting habitat. Due to the lack of a depredation order in 2016 and 2017, cormorant nests on Gull Island were not removed as in previous years. The 2018 June count on Gull Island totaled a record high of 673 cormorant nests, a 108% increase from 2016, along with a record high herring gull count of 123 nests. This is the second year in a row, since counting began in 1995, that there has been zero night heron nests observed on Gull Island (Table 1).

Discussion

Reduced cormorant population levels at LGI, 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. The cormorant population had reached the feeding-day target in 2006, and the management effort was operated at a maintenance level from 2007-2015 (Figure 1). The

production of numerous chicks in 2016 and 2017 resulted in an immediate increase in feeding days. Chick feeding day estimates were lower in 2018, however, total feeding day estimates are similar to 2017 most likely due to increased recruitment of breeding adults. With limited management intervention, cormorant numbers can be expected to increase 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 LGI (Johnson et al. 2006). However, the continuation of this trend is uncertain.

Cormorant management activities do not appear to negatively effect and may 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 LGI in 2013 and have continued to nest on the island, however, their numbers are decreasing. In 2018, caspian terns and herring gulls reached record high nest counts. In the absence of effective cormorant management in 2016 and 2017, nests of black-crowned night herons on Gull Island have once again not been observed (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, cormorant management in New York has successfully met objectives for limiting production of cormorants on New York's Lake Ontario eastern basin islands (i.e., 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.

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Table 1. Estimated breeding pair numbers for colonial waterbirds on eastern basin Lake Ontario islands. Note: Numbers for cormorants are reported using peak nest counts and may not match Bureau of Wildlife trend numbers which are taken in mid-June. *Dash indicates not checked for the given species.*

Species	Island	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
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	1,999	2,778
	Gull I.	478	21	77	486	188	0	110	152	292	261	275	0	391	276	235	276	323	530	673
	Bass I.	757	0	279	147	348	602	175	117	0	0	0	0	0	0	0	0	0	0	0
	Calf I.					736				170	76									
Ring-billed Gull	LGI	-	-	-	60,000	-	-	-	-	37,500	-	-	-	43,324	-	-	-	-	-	-
	Gull I.	-	-	-	0	-	-	-	-	0	-	0	-	0	0	0	0	0	0	0
	Bass I.	-	-	-	2,500	-	-	-	-	0	-	-	-	0	0	0	0	0	-	0
Herring Gull	LGI	-	-	-	313	-	-	367	0	375	356	364	459	512	645	979	784	971	579	1,156
	Gull I.	-	-	-	42	-	-	40	67	58	42	89	91	52	89	109	-	29	55	123
	Bass I.	-	-	-	10	-	-	10	16	0	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	0
	Gull I.	-	1	1	0	-	-	0	0	9	0	0	0	0	0	0	0	0	0	0
	Bass I.	-	0	0	0	-	-	0	0	9	0	-	-	0	0	0	0	0	0	0
Black-crowned Night Heron	LGI	1	1	1	3	3	4	0	0	1	0	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	0
	Bass I.	36	13	36	47	17	46	32	0	0	0	0	0	0	0	0	0	0	0	0
	Calf I.	-	0	-	-	0	-	-	-	-	13	0	0	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	2,700
Common Tern	LGI	0	0	0	0	0	0	0	0	0	0	0	0	0	20	34	30	15	3	2

Table 2. Cormorant management activities taken by Bureau of Wildlife in Lake Ontario's Eastern Basin. x-management unnecessary due to landowner activity; u - unknown

Island	Totals	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
LGI	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	1,049
	Nests w/ 0 eggs destroyed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,353
	DCCO culled	-	-	-	-	18	686	620	709	382	798	145	569	362	366	150	0	0	0	0
Bass I.	Total Nests Removed (peak one day)	793 (446)	0 (0)	986 (279)	260 (117)	959 (348)	935 (452)	477 (120)	470 (42)	x	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	x
Gull I.	Total Nests Removed (peak one day)	574 (368)	21 (21)	157 (77)	1,427 (480)	485 (188)	0 (0)	113 (90)	273 (95)	671 (266)	741 (261)	604 (270)	659 (302)	711 (u)	1,072 (u)	603 (u)	769 (u)	152 (u)	0 (0)	1,804 (673)
	DCCO culled	-	-	-	-	3	0	0	20	2	0	0	0	29	0	0	0	0	0	0
Calf I.	Total Nests removed (peak one day)	0	0	0	0	0	415 (539)	0	0	0	161 (111)	55 (52)	0	0	0	0	0	0	0	0
	DCCO culled	-	-	-	-	37	0	0	0	6	2	0	0	0	0	0	0	0	0	0

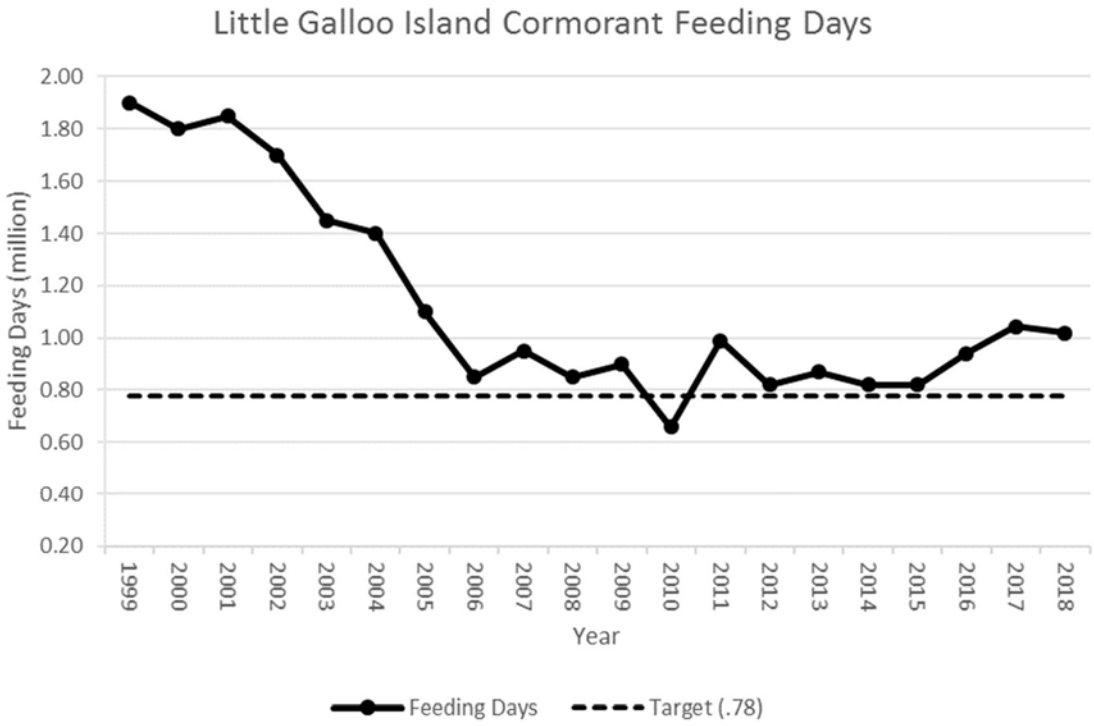

Figure 1. Trend in cormorant feeding days for the Little Galloo Island colony.

Salmon River Angler Survey
2017-2018

Scott E. Prindle, Daniel L. Bishop, and Rosemarie Greulich
Region 7 Fisheries
New York State Department of Environmental Conservation
Cortland, NY 13045

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 was conducted from September 2017 through mid-May 2018. It is intended that the Salmon River Angler Survey will be conducted on an annual basis complemented by periodic comprehensive tributary surveys.

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.

The Salmon River survey results presented here cover the period 1 September 2017 through 15 May 2018.

Methods

Data Collection

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 the 2017-2018 survey period on the Salmon River was 733,753 hours (Table 1). This was the second highest estimated effort of the surveys completed since 2005, with 2011 having 1,077,316 hours (Table 1). The estimated number of angler trips (127,166 trips) was the second highest for recent surveys; again, second only to 2011 (158,219 trips; Table 1).

As in previous surveys, the conventional regulation sections of the river had by far the highest estimated effort at 627,579 hours (81 % of the total; Table 1). The special regulations fly fishing-only zones were a very distant second place accounting for just 7.8% of the estimated effort.

October remained the most intensively fished month on the Salmon River accounting for 305,512 angler hours in 2017, and 39% of the total estimated effort (Table 2). The October 2017 effort estimate was the second highest for any month amongst recent surveys, only surpassed by October 2011 with an estimated 339,017 hours (Table 2).

The highest single day effort estimate occurred on 7 October 2017, when the morning car count 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 Chinook and coho salmon 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, targeting trout and salmon, was estimated at 685,818 angler hours (Lantry and Eckert 2018). The 2017-2018 Salmon River effort estimate was 11% higher than 2017 open lake boat fishing effort estimate. The 2017-2018 Salmon River fishery accounted for an estimated 127,166 trips (Tables 1 and 3) while the estimated open lake boat trips, targeting trout and salmon, in 2017 was 112,503 (Lantry and Eckert 2018).

Table 1. Estimated effort by fishing type/area from the Salmon River angler surveys by year.

	2005-2006			2006-2007			2011-2012			2015-2016			2017-2018		
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.)	449,520	6.0	74,966	436,096	6.8	64,607	842,074	6.5	129,351	579,036	6.0	97,125	627,579	6.3	99,001
Drift boat	42,598	7.7	5,520	35,213	7.7	4,549	88,720	7.4	11,973	56,674	7.2	7,898	58,906	7.0	8,366
Special regs. Fly	66,476	6.2	10,819	57,300	6.5	8,788	96,665	6.6	14,646	73,096	6.2	11,745	60,959	6.0	10,152
Estuary boat	9,368	4.6	2,032	10,407	6.3	1,657	16,503	5.9	2,778	9,731	4.7	2,066	8,242	5.1	1,601
Tributaries	37,809	5.8	6,551	56,251	6.5	8,614	33,354	4.9	6,779	16,865	4.4	3,843	18,065	5.9	3,068
Total	605,772	6.1	98,959	595,267	6.8	87,539	1,077,316	6.8	158,219	735,402	5.7	129,204	773,753	6.1	127,166

Table 2. Estimated angler hours by month and year for the Salmon River

	Year				
Month	2005-2006	2006-2007	2011-2012	2015-2016	2017-2018
September	183,019	171,265	261,838	176,480	247,212
October	212,213	251,031	339,017	276,779	305,512
November	61,418	44,752	145,522	104,347	56,729
December	23,220	36,783	59,603	31,453	34,478
January	19,682	18,598	38,760	22,981	14,145
February	12,158	7,399	52,498	21,701	18,698
March	38,385	25,461	85,184	38,035	41,207
April	51,564	24,230	87,777	58,854	41,681
May	4,114	15,747	7,118	4,772	14,091
Total	605,772	595,267	1,077,316	735,402	773,753

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 2,477 interviews were obtained during the 2017-2018 survey, down from previous studies (Table 4). However, during the 2017-2018 survey the anglers were asked a series of additional questions which diminished the time available to obtain interviews.

Fifty-seven percent of Salmon River anglers interviewed during 2017-2018 were non-New York State residents (Table 4), similar to previous surveys.

Catch and Harvest
Chinook Salmon
The estimated catch of Chinook salmon from the Salmon River in 2017 was 98,125 fish (Figure 1; Table 3), by far the highest catch since the 1980's. It also surpassed the estimated 2017 open water boat angler catch of 96,226 fish (Lantry and Eckert 2018). By comparison, the estimated 2015 Salmon River catch was only 23,940 Chinook salmon (Table 3).

The 2017 Chinook salmon harvest estimate was 27,850 fish (Figure 1; Table 3), This translates to a 72% 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 (66,977 or 68% of total), followed by September (30,162 or 31% of total; Figure 2).

As in past Salmon River surveys, the conventional regulations section yielded by far the highest number of Chinook salmon caught (84,403 fish; Table 5). The special regulations fly-only zone was the only other area that totaled more than 10,000 fish caught (10,614 fish; Table 5).

Coho Salmon
Coho salmon were a smaller component of the fishery in 2017, totaling only 15,453 fish caught (Figure 1; Table 5). While this result was roughly twice the estimated catch of 5,738 coho during the fall of 2015, it is still less than half of the 2011 estimated catch (Table 5). The 2017 release rate was 67%, with 5,150 fish harvested (Table 5).

Unlike Chinook salmon, September and October vary as to which has the highest monthly catch of coho. Coho catch was considerably higher in September 2017 (n=8,390 fish) compared to October (n=6,801 fish; Figure 2).

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 2017-2018 was 39,744 the second highest catch among recent surveys (Figure 1; Tables 3 and 5). The estimated number of steelhead harvested in 2017-2018 was 5,076, which equates to an 87% release rate (Tables 3 and 5). 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 caught with 23,564 (Table 5). Drift boats came in second, catching an estimated 14,525 steelhead during 2017-2018 (Table 5).

Table 3. Summary statistics for creel surveys conducted on the Salmon River since 1984

Year	Dates	Angler trips	Chinook salmon		Steelhead	
			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	84,213	24,477	20,593	2,258
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	88,566	30,750	21,480	2,748
2011	Sept 1 to Nov 30	112,109	85,106	31,516	39,697	3,657
2011-2012	Sept 1 to May 15	158,214	75,965	26,968	105,530	10,237
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	22,579	11,594	20,840	2,163
2017	Sept 1 to Nov 30	95,121	100,882	27,682	17,164	2,344
2017-2018	Sept 1 to May 15	127,166	98,125	27,850	39,744	6,159

Table 4. The number of interviews and percent of New York State residents from the Salmon River Angler Survey by year.

Year	Number of interviews	% non NYS residents
2005-2006	3,050	60
2006-2007	2,717	60
2011-2012	4,412	60
2015-2016	4,044	59
2017-2018	2,477	57

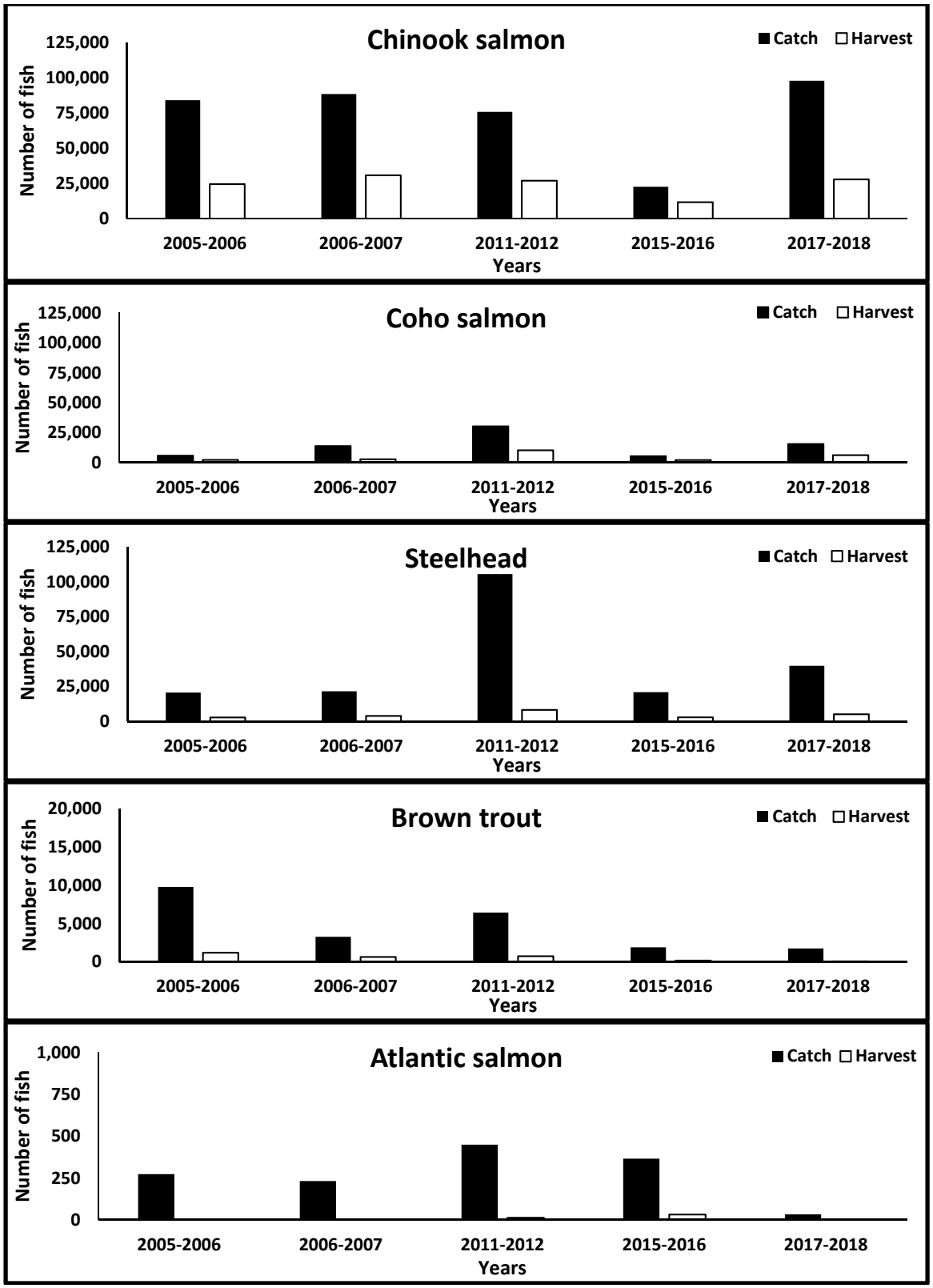

Figure 1. Estimated Salmon River catch and harvest by species and year.

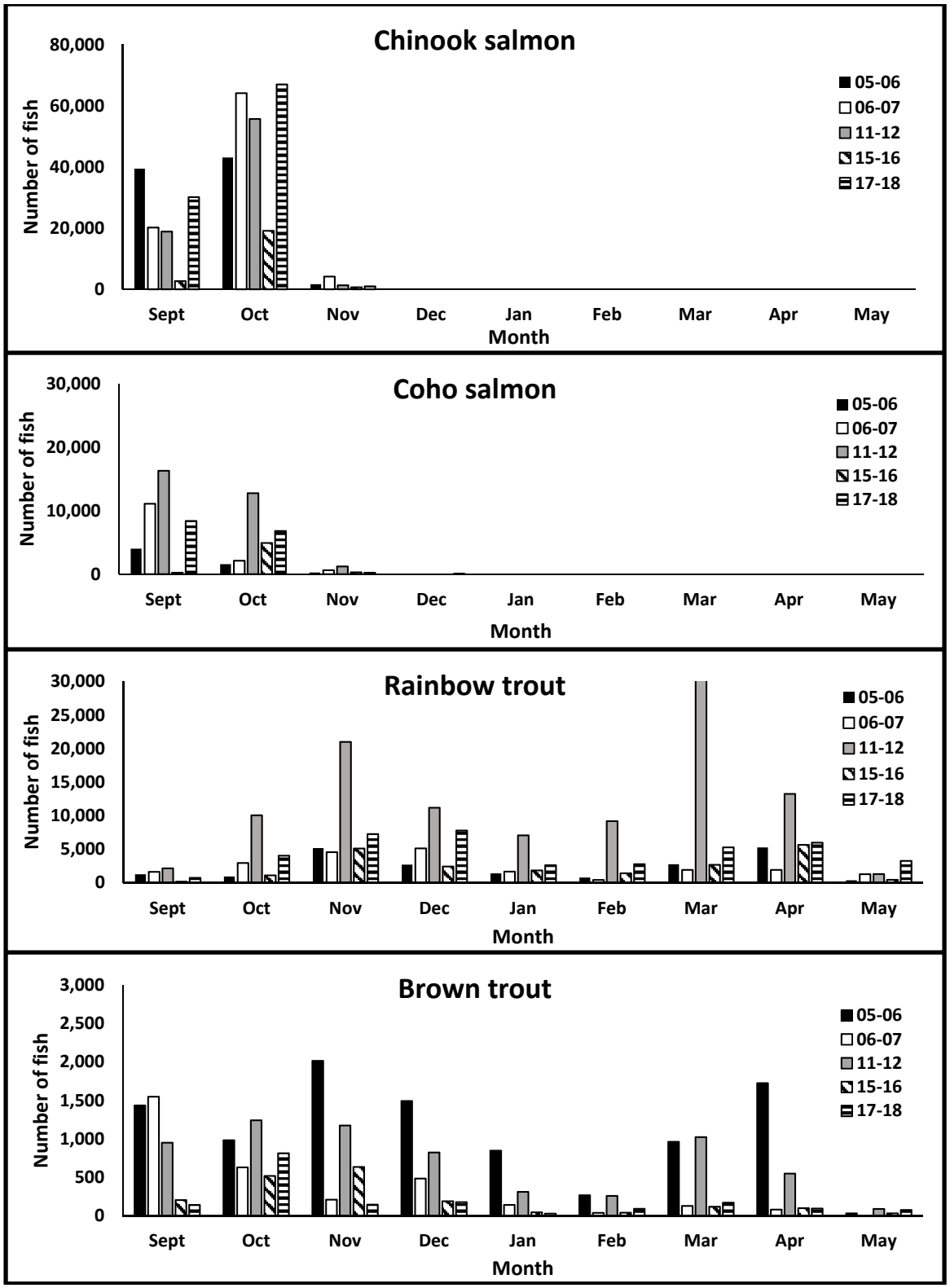

Figure 2. Estimated catch on the Salmon River by species, month, and year.

Table 5. Estimated catch and harvest by fishing type and year from the Salmon River creel surveys.

		2005-2006				2006-2007				2011-2012			
Species	Fishing type	Est. catch rate*	Est. catch	Est. harvest rate*	Est. harvest	Est. catch rate*	Est. catch	Est. harvest rate*	Est. harvest	Est. catch rate*	Est. catch	Est. harvest rate*	Est. harvest
Chinook salmon	Shore access-conv. regs	0.137	61,584	0.038	17,082	0.107	46,662	0.034	14,827	0.119	99,811	0.043	36,100
	Drift boat	0.096	4,089	0.027	1,150	0.042	1,479	0.021	739	0.057	5,014	0.026	2,275
	Special regs. Fly	0.076	5,052	0.000	0	0.049	2,808	0.000	0	0.099	9,595	0.000	0
	Estuary boat	0.008	75	0.007	66	0.455	4,735	0.117	1,218	0.058	964	0.043	710
	Tributaries	0.286	10,813	0.107	4,046	0.427	24,019	0.145	8,156	0.144	4,807	0.121	4,036
	All types[1]	0.139	84,213	0.040	24,477	0.150	88,566	0.052	30,750	0.115	75,965	0.042	26,968
Steelhead	Shore access-conv. regs	0.024	10,643	0.003	1,337	0.028	12,167	0.005	2,019	0.071	60,099	0.007	6,215
	Drift boat	0.098	4,193	0.025	1,064	0.155	5,448	0.045	1,578	0.196	17,378	0.025	2,216
	Special regs. Fly	0.075	5,018	0.000	4	0.051	2,905	0.002	122	0.147	14,224	0.000	14
	Estuary boat	0.000	0	0.000	0	0.072	746	0.000	0	0.055	908	0.002	28
	Tributaries	0.017	651	0.006	231	0.008	473	0.003	185	0.033	1,099	0.004	133
	All types[1]	0.034	20,593	0.004	2,757	0.036	21,480	0.007	3,870	0.089	105,530	0.008	8,219
Brown trout	All types	0.016	9,757	0.002	1,166	0.005	3,255	0.001	622	0.006	6,412	0.001	716
Coho salmon	All types	0.010	5,805	0.004	2,258	0.023	13,793	0.005	2,748	0.039	30,298	0.014	10,237
Atlantic salmon	All types	0.000	273	0.000	0	0.000	232	0.000	0	0.001	449	0.000	13

1 – The difference in the total catches and harvests and the sum of the fishing types are because we are dealing with stratum specific rate calculations which don't necessarily equal the total value using the entire survey data.

* = Rates are the number of fish caught or harvested per angler hour

Table 5. Estimated catch and harvest by fishing type and year from the Salmon River creel surveys. Continued.

		2015-2016				2017-2018			
Species	Fishing type	Est. catch rate*	Est. catch	Est. harvest rate*	Est. harvest	Est. catch rate*	Est. catch	Est. harvest rate*	Est. harvest
Chinook salmon	Shore access-conv. regs	0.036	21,060	0.019	11,117	0.134	84,403	0.040	24,884
	Drift boat	0.043	2,436	0.027	1,547	0.053	3,098	0.032	1,878
	Special regs. Fly	0.061	4,442	0.002	145	0.174	10,614	0.000	0
	Estuary boat	0.045	436	0.045	436	0.093	769	0.064	529
	Tributaries	0.089	1,507	0.086	1,443	0.230	4,148	0.028	497
	All types[1]	0.041	22,579	0.021	11,594	0.130	98,125	0.036	27,850
Steelhead	Shore access-conv. regs	0.024	13,793	0.003	1,882	0.038	23,564	0.005	2,936
	Drift boat	0.127	7,175	0.026	1,485	0.247	14,525	0.042	2,462
	Special regs. Fly	0.057	4,142	0.000	0	0.089	5,438	0.000	0
	Estuary boat	0.003	25	0.003	25	0.000	0	0.000	0
	Tributaries	0.000	0	0.000	0	0.002	43	0.000	0
	All types[1]	0.034	20,840	0.005	2,869	0.058	39,744	0.007	5,076
Brown trout	All types	0.003	1,875	0.000	154	0.002	1,728	0.000	43
Coho salmon	All types	0.010	5,380	0.004	2,163	0.018	15,453	0.007	6,159
Atlantic salmon	All types	0.000	366	0.000	32	0.000	33	0.000	0

1 – The difference in the total catches and harvests and the sum of the fishing types are because we are dealing with stratum specific rate calculations which don't necessarily equal the total value using the entire survey data

* = Rates are the number of fish caught or harvested per angler hour

Atlantic Salmon

An estimated 33 Atlantic salmon were caught in the Salmon River during 2017-2018 (Table 5). This is a dramatic reduction from the 2015-2016 estimate of 366 Atlantics caught in the same period (Table 5). However, the abundance of Chinook salmon may have altered the Atlantic salmon behavior and distribution in 2017-2018. Based on numerous anecdotal reports from summer anglers, Atlantic salmon were present in above average numbers before the Pacific salmon moved into the river.

The estimated catches from the 2005, 2006, and 2011 surveys were 273, 232, and 449 fish, respectively (Table 5). No Atlantic salmon were reported as harvested during the angler interviews in 2017-2018, so there was a 100% release rate (Table 5). Only the 2011-2012 and 2015-2016 surveys had less than 100% release, with 97% and 91%, respectively.

Brown Trout

An estimated 1,728 brown trout were caught in 2017-2018 (Table 5). This was the lowest estimated catch of the recent surveys and is consistent with lower catches in the open lake boat fishery (Lantry and Eckert 2018). The highest estimated catch occurred in 2005-2006 with 9,757 brown trout caught (Table 5). The 2017-2018 estimated harvest was 43 fish; therefore, the release rate was 98% (Table 5). Release rates in recent surveys varied from 81% in 2006-2007 to 92% in 2015-2016.

There was no monthly pattern of brown trout catches across the surveys. In 2017-2018, October had the highest estimated catch with 813 fish, followed by November and September with 144 and 141 fish caught, respectively (Figure 2).

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 6.

Anglers' overall opinion of the fishery was generally favorable, with 58% being "very satisfied" and only a combined 1% in the two "unsatisfied" categories (Table 6). The level of very satisfied anglers dropped from 62% in the fall (Sept, Oct, Nov) to 52% in the winter/spring (Table 6).

The level of law enforcement on the Salmon River question indicated 63% of the respondents were of neutral opinion (Table 6). Only 1% thought there was "too much" enforcement and 35% "not enough.". As with the level of overall satisfaction the level of law enforcement opinion varied by season. The percent of interviewed anglers in the fall that thought there was not enough law enforcement was 31% (Table 6). However, for the winter/spring steelhead anglers nearly half (43%) believed there was not enough law enforcement (Table 6).

The availability of fish in the Salmon River during 2017-2018 appeared to be adequate, as indicated by the 90% "good" rating (Table 6), which likely contributed to the high angler satisfaction results. The 90% "good" rating was consistent for the fall, winter/spring, and overall (Table 6).

Other noteworthy highlights summarized in Table 6 were that the Salmon River angling regulations were not too complicated or numerous, but 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. There was a noticeable jump in the number of repeat anglers during the winter/spring versus the fall. Seventy-two percent of the interviewed in the fall made multiple trips to the river, while 91% of the winter/spring anglers interviewed fished more than once (Table 6)..

Acknowledgments

Pat Sullivan of Cornell University deserves recognition for his very helpful statistical guidance.

Table 6. Summary tables of the additional 2017-2018 Salmon River Anger Survey questions

Opinion of fishery rating						
Rating	Fall #	Fall %	Winter/Spring #	Winter/Spring %	Total #	Total %
Very Satisfied	393	62	239	52	632	58
Somewhat satisfied	160	25	184	40	344	32
Neutral	70	11	35	8	105	10
Somewhat unsatisfied	3	0	3	1	6	1
Very unsatisfied	3	0	1	0	4	0
Opinion of law enforcement						
Rating	Fall #	Fall %	Winter/Spring #	Winter/Spring %	Total #	Total %
Neutral	400	68	264	57	732	63
Too much	9	2	3	1	14	1
Not enough	180	31	198	43	409	35
Angling opportunity						
Rating	Fall #	Fall %	Winter/Spring #	Winter/Spring %	Total #	Total %
Good	551	90	410	90	961	90
Poor	60	10	45	10	105	10

Table 6. Summary tables of the additional 2017-2018 Salmon River Anger Survey questions. Continued.

Question	Fall Yes	Fall % Yes	Fall No	Fall % No	Fall Sometimes*	Fall % Sometimes
Too many regulations ?	35	6	588	94		
Regs too complicated ?	58	9	565	91		
River too crowded ?	263	42	238	38	127	20
Need more regulations ?	74	12	551	88		
Fished the Salmon R. past years ?	578	92	50	8		
Fish the SR more than once per year ?	431	72	166	28		
Also fish Lake Ontario ?	265	42	364	58		
Question	Win./Spr. Yes	Win./Spr. % Yes	Win./Spr. No	Win./Spr. % No	Win./Spr. Sometimes*	Win./Spr. % Sometimes *
Too many regulations ?	17	4	447	96		
Regs too complicated ?	26	6	438	94		
River too crowded ?	217	47	156	34	92	20
Need more regulations ?	113	24	352	76		
Fished the Salmon R. past years ?	449	96	17	4		
Fish the SR more than once per year ?	424	91	42	9		
Also fish Lake Ontario ?	178	38	288	62		
Question	Total Yes	Total % Yes	Total No	Total % No	Total Sometimes*	Total % Sometimes*
Too many regulations ?	52	5	1035	95		
Regs too complicated ?	84	8	1003	92		
River too crowded ?	480	44	394	36	219	20
Need more regulations ?	187	17	903	83		
Fished the Salmon R. past years ?	1027	94	67	6		
Fish the SR more than once per year ?	855	80	208	20		
Also fish Lake Ontario ?	443	40	652	60		

*= not given as an option

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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:

$$V(\hat{R}) = \sum_{h=1}^{L} \left(\frac{N_h}{N} \right)^2 V(\hat{R}_h)$$

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Hydroacoustic and Midwater Trawl Assessment of Pelagic Planktivores, 2018

J.P. Holden
Ontario Ministry of Natural Resources and Forestry
R.R. #4, Picton, Ontario K0K 2T0

M.J. Connerton
New York State Department of Environmental Conservation
Cape Vincent, New York 13618

B.C. Weidel
U.S. Geological Survey
Lake Ontario Biological Station, Oswego, NY

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 rainbow smelt (Christie 1973). Bloater were extirpated from Lake Ontario during the mid-20th century; however, from 2012-2018, this species has been stocked by Canadian and U.S. agencies to reestablish a population.

Hydroacoustic surveys use scientific echosounders based on the same technology as recreational fishing sonars (a.k.a. depth finders) to assess fish populations. Scientific echosounders collect, store and allow users to process the data to obtain fisheries population estimates. 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); the New York State Department of Environmental Conservation (NYSDEC) and since 2016, the US Geological Survey (USGS). Results from the hydroacoustic survey complement population indices of alewife and rainbow smelt obtained in spring bottom trawling surveys (Weidel et al. 2019) and provide insights into the midsummer distribution of these species. The recent addition of midwater trawling since 2016 has provided an enhanced tool for monitoring cisco distribution. We present results from the 2018 survey in this report.

Methods

Before 2005, surveys followed established transects with only minor yearly deviations. This was a practical approach dictated by harbor locations, running time, and limited periods of darkness during the summer. In 2005, the survey was modified from 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. Within each corridor, transects were selected at random. A single east-west offset is 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. In addition to the 5 cross-lake transects, a U-shaped transect is surveyed each year in the Kingston Basin (also often referred to as the East Basin; Figure 1); however, no offset is applied to this transect.

The 2018 hydroacoustic survey was conducted from July 16th to 27th with an additional, reduced survey conducted between September 10th to 20th. Acoustic data were collected using a BioSonics 120 kHz split-beam echosounder and followed procedures described by Parker-Stetter et al. (2009). 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. Additional nearshore transects paired with midwater trawls have also been conducted since 2016 to inform the spatial distribution of cisco

and bloater (Figure 2). The trawl data is used to inform species composition, however, alewife and rainbow smelt population indices derived from hydroacoustic data are based only on the traditional survey transects. In 2018, there were 57 tows in July, 20 tows in September plus an additional six tows in the lower Bay of Quinte during September. The midwater trawl gear description is included in Table 1.

Historical midwater trawling data (2000 to 2004) showed a thermal separation between the primary species of interest, alewife and rainbow smelt. Midwater tows in depths where water temperatures were 9°C (48°F) 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%). The thermal separation of these dominant species coupled with target strengths thresholded to ranges consistent with prey fish species has been used as a means of species apportionment throughout the period when mid-water trawling wasn't conducted.

The data were processed with Echoview software (Myriax Inc. version 9.0). 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 (seven zones: North West [NW], South West [SW], Central East [CE], Central East [CE], South East [SE], North East [NE] and Kingston Basin [EB]; Figure 3). Whole-lake abundance estimates were calculated as the area-weighted average of these zones. Targets in the lower layer were assumed to be rainbow smelt, and targets in the upper layer were assumed to be alewife.

Previous surveys (Holden et al. 2018) computed an index of age-1 and older alewife from hydroacoustic data that used a -50 dB minimum target strength threshold. The -50 dB threshold was based on the theoretical relationship between the length of the fish and it's resulting target strength (Warner et al. 2002). This threshold intended to exclude age-0 fish from the population estimate. A comparison between alewife target strength distributions in July and September suggest an age-0 peak below -60 dB in July that has shifted above -60 dB by September (Figure 4) when age-0 alewife are caught in midwater trawls (Figure 5). In addition, an analysis of alewife behavior using a stationary, submerged surface looking transducer determined that a single fish could exhibit a wide range of target strength depending on whether the fish was oriented horizontally compared to a diving position (Elliott 2018). Fish behavior was also analyzed by looking at fish tracks (multiple pings on a single fish) from the mobile survey data, which indicated a diving response of fish near the surface that would result in a fish having a lower target strength than the fish length would predict (Elliot 2018). These combined results supported re-analyzing historical data with a lower minimum threshold (-60 dB) than previously applied (-50 dB for alewife, -52 for rainbow smelt) and are similar to thresholds used in other Great Lakes surveys (Warner et al. 2016, Parker-Stetter et al. 2009).

Results and Discussion

A total of 18 species were captured in the midwater trawls (Table 2) in 2018, eight of which were captured only in the Bay of Quinte. Main lake catches were numerically dominated by alewife and rainbow smelt in both seasons. When ranked per biomass (kg), cisco were the second highest species in the main lake in July (after alewife) and the highest in both the main lake and the Bay of Quinte in September although trawl effort focused on the eastern half of the lake where cisco catches are more common. Tows in the western portion of the lake in July did not catch any cisco (Figure 6). Also, four juvenile Chinook salmon (1 in July, 3 in September) were caught in tows near Cobourg, Ontario.

Midwater trawl catches in July 2018 (Figure 7) showed a strong relationship with temperature (r^2 = 0.5729, p = 0.0001) and supported the use of 10 (50 °F) as a means of classifying acoustic targets as either alewife or rainbow smelt. Alewife catches increased with increasing temperatures and declined to low numbers below 10 . Rainbow smelt catches generally occurred in temperatures below 10 . In contrast, September midwater trawl catches exhibited greater mixing of the two species as alewife tended to be more dispersed throughout the water column (Figure 7). It is noteworthy that as the thermocline becomes sharper (greater change in temperature over a smaller depth gradient), towing the midwater trawl through a target temperature becomes difficult due to the 6m (19.7ft) height of the trawl. Differences of over 10 between the footrope and headline temperature were regularly observed (Figure 8) Coldwater trawl catches can also be contaminated as the net passes through the warmwater layer upon retrieval.

Alewife

The lower target strength threshold applied to the time series did not change the general trend of abundance although overall abundance estimates were higher compared to the previous method (Figure 9). In some years (i.e., 2001, 2004, 2012, and 2016), there were notable increases in the percent change from one year to the next (e.g., 2000-2001, 2003-2004, 2011-2012, 2015-2016). It's possible that age-0 fish experienced early hatching and faster growth to reach the minimum target strength threshold by July in those years; however, this hypothesis requires further investigation.

The age-1 and older Alewife index for 2018 is 1.97 billion fish down from 4.48 billion fish in 2017. Midwater trawl catches indicate a large proportion of Age-2 fish (120 to 150mm; Figure 5). At the time the survey was conducted there was a significant upwelling event along the southeast shore. Lower density of alewife was observed in these areas, and few alewife were caught in midwater trawls in these areas at that time (Figure 10).

In years where midwater trawling was conducted concurrently with the hydroacoustic transects, the whole lake numeric index was converted to a biomass estimate (Table 3) using mean alewife weight obtained from the trawls to provide a comparable index to bottom trawl surveys (Weidel et al. 2019) and other lakes.

Rainbow Smelt

The index of rainbow smelt abundance increased in 2018 to 99.7 million fish but remained well below population levels observed in the 1990s (Figure 11). The areas of highest rainbow smelt density occurred in the eastern portion of the Lake. The size range of rainbow smelt was greater in July than September (Figure 12) despite fewer being caught and only a small difference in the mean length (July = 123mm [4.8 in], Sept = 112mm [4.4 in]).

Cisco

Midwater trawl catches support previous conclusions of Owens et al. (2003) who proposed that cisco are mainly restricted to eastern portions of the lake (Figure 6). The mean size of cisco (Figure 13; July = 340mm [13.4 in], Sept = 331mm [13.0 in]) caught in midwater trawls indicates a clear size difference from alewife and rainbow smelt which only infrequently reach sizes greater than 200mm [7.9 in], suggesting that target strength thresholds coupled with midwater trawl data are likely a suitable means of providing cisco abundance estimates from hydroacoustic data.

Midwater trawls paired with hydroacoustic technology have greatly increased the number of cisco observed in annual assessment surveys (Figure 14) and may also prove useful in assessing success of ongoing efforts to re-establish bloater in Lake Ontario. Although the Lake Ontario offshore pelagic fish community is still dominated by alewife and rainbow smelt, cisco may be a larger portion of the fish community than previously indicated by bottom trawl surveys.

Acknowledgements

We would like to thank the vessel staff of the Ontario Explorer (OMNRF), Seth Green (NYSDEC) and Lake Whitefish (USGS) for their expertise and efforts throughout the surveys. We would like to thank the technical staff at the USGS Lake Ontario Biological Station for managing the trawl catch data. Thank you to Colin Lake (OMNRF) for providing GIS support. 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 2018 publicly available from the GLSC website later in 2019. 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.

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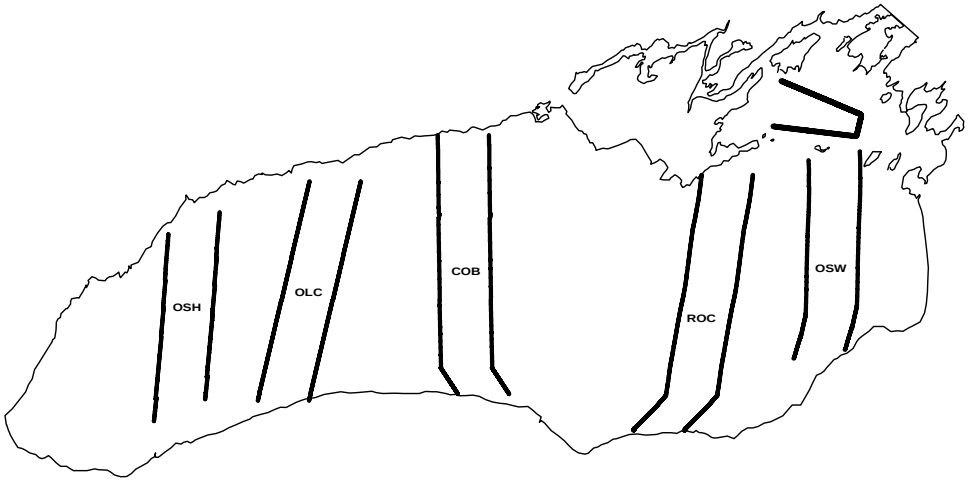

Figure 1. The Lake Ontario lake-wide prey fish survey uses cross-lake hydroacoustic transects based on a systematic random start approach where transects are randomly selected from within five cross-lake corridors. An additional U-shaped transect is conducted through the Kingston Basin.

Figure 2. Spatial coverage of the hydroacoustic data collected in July 2018 by OMNRF, NYSDEC and USGS. Cross-lake transects are supplemented with additional nearshore transects that include midwater trawls (indicated by solid dot).

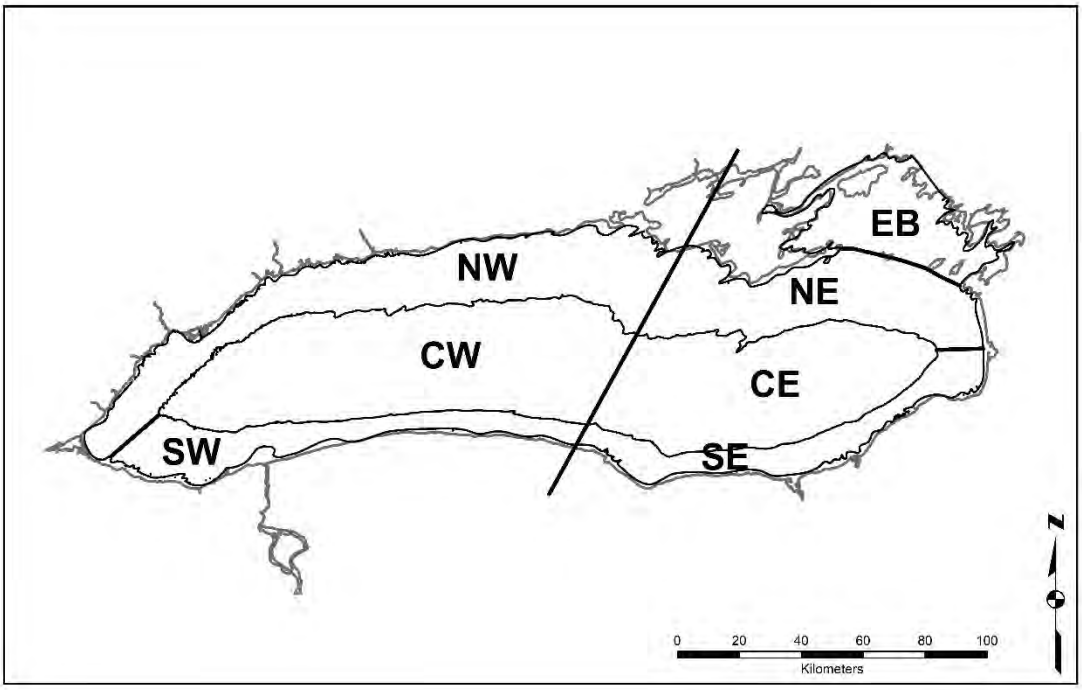

Figure 3. Hydroacoustic transects are binned in to seven geographical zones (North West (NW), South West (SW), Central West (CW), Central East (CE), South East (SE), North East (NE) and Kingston Basin (EB)) and whole-lake abundance estimates were calculated as the area-weighted average of these zones.

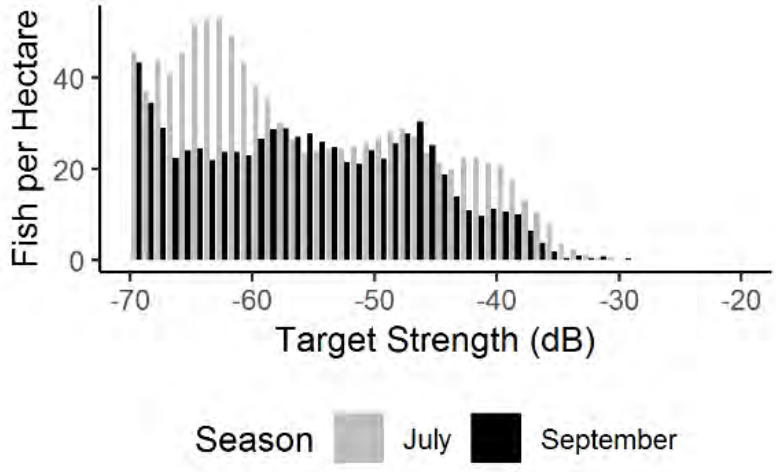

Figure 4. Target strength (dB) distribution in the epilimnion (temperature > = 10 [50 ºF]) across two seasons (July and September) in 2018 from hydroacoustic survey transects.

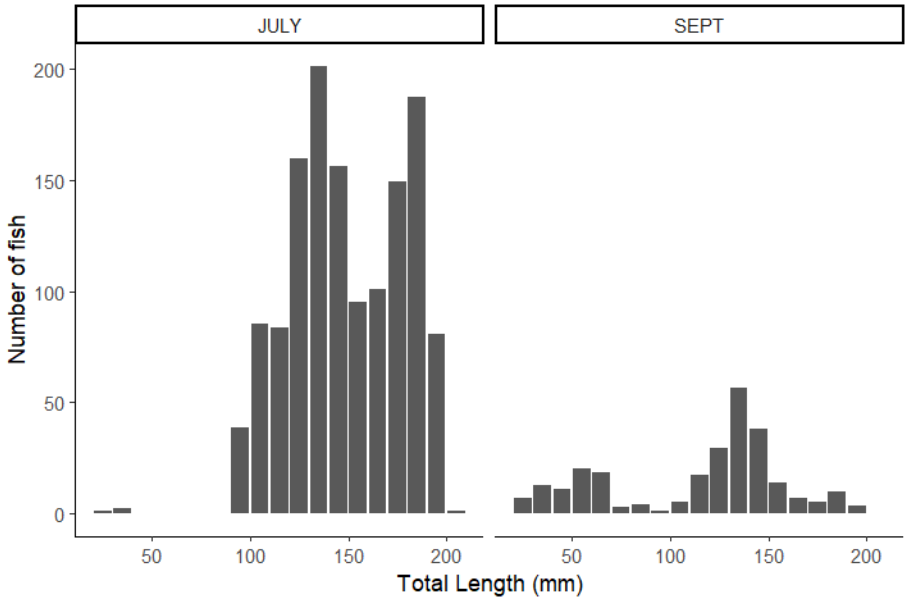

Figure 5. Length distribution of Alewife caught in midwater trawls conducted during the hydroacoustic surveys in July and September. Fish smaller than 100mm (3.9 inches total length) are assumed to be age-0.

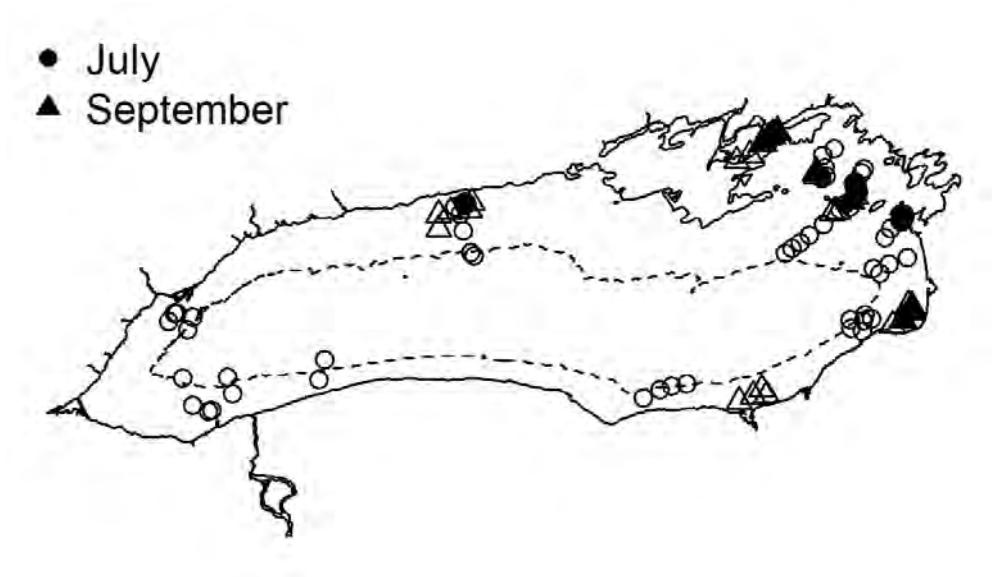

Figure 6. Distribution of cisco caught during midwater trawling in July (circles) and September (triangles), 2018. Open symbols are trawl locations where no cisco were caught and filled symbols are locations where cisco were caught. The 100m (328 ft) depth contour (dotted line) is included for context.

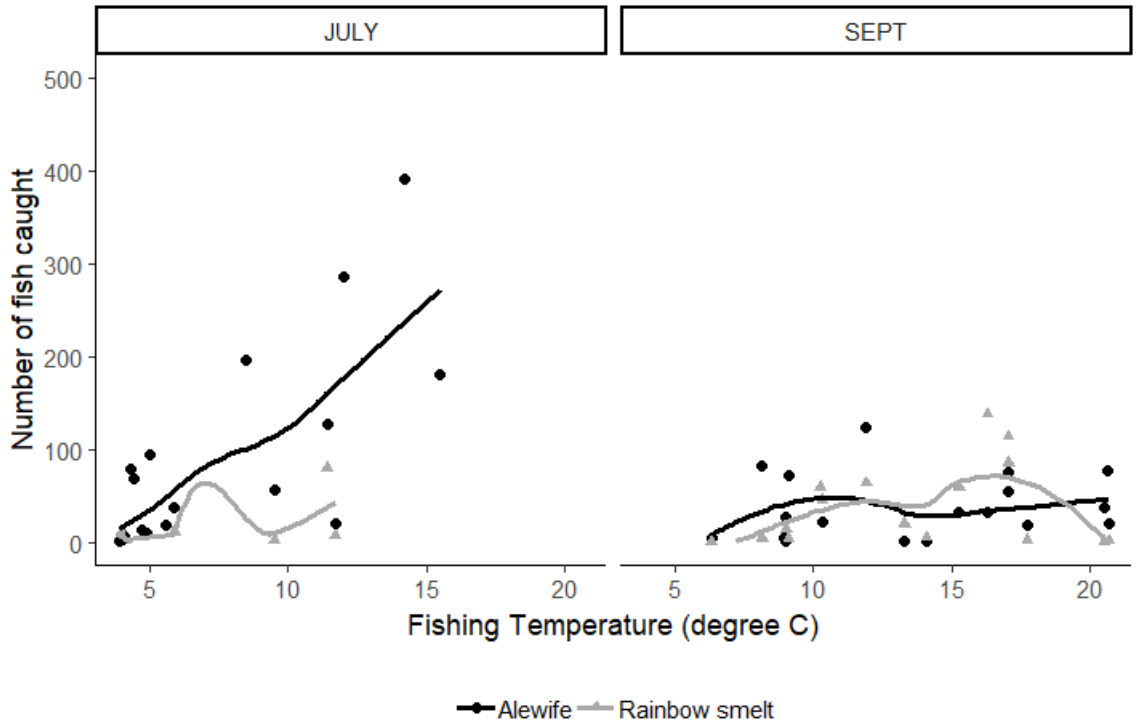

Figure 7. Temperature effect on midwater trawl catches of alewife and rainbow smelt in July and September 2018. Trend line is a locally estimated scatterplot smoothing (LOESS) fit.

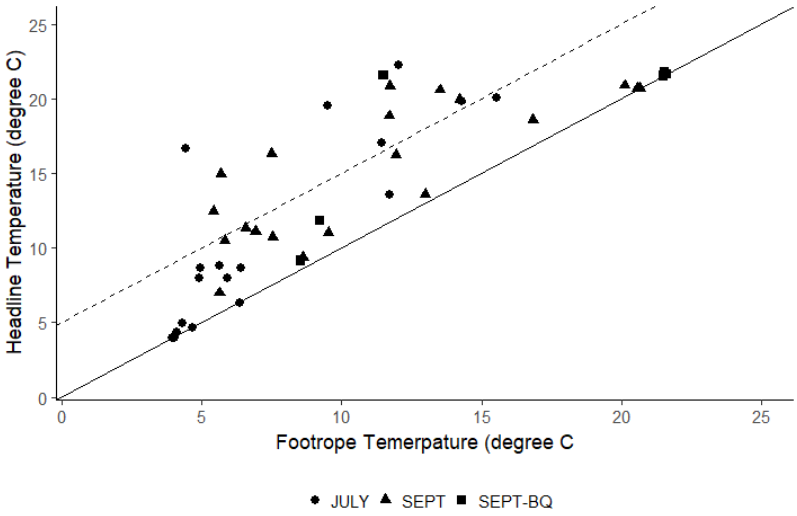

Figure 8. Relationship between headline and footrope temperatures. Solid line indicates the 1:1 line. Dotted line indicates a headline temperature 5 (41 ºF) greater than the footrope temperature.

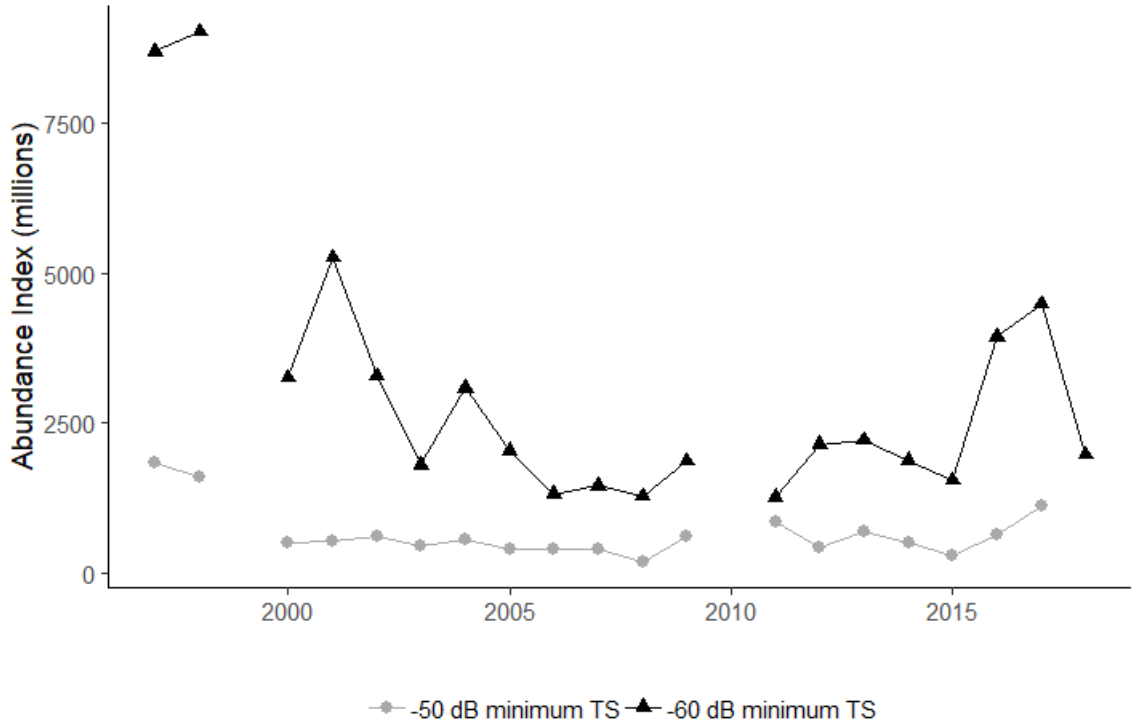

Figure 9. Abundance (in millions of fish) of yearling-and-older alewife in Lake Ontario from 1997-2018 based on hydroacoustic survey transects using a -60 dB minimum target strength (triangle markers). Previous estimates based on a -50 dB minimum target strength threshold are included (circles) from 1997 to 2017. No hydroacoustic survey was conducted in 1999 and 2010.

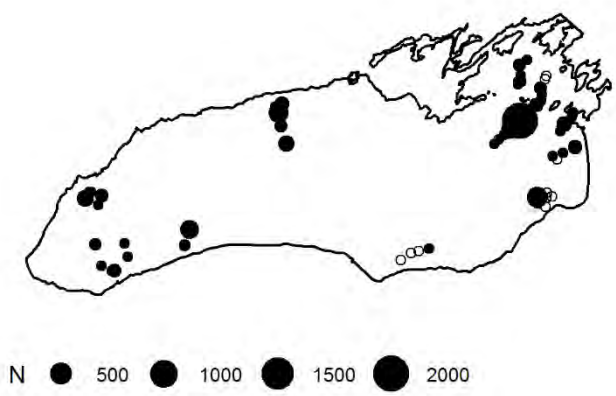

Figure 10. Midwater trawl catches of alewife. Open circles are trawls that did not capture alewife. Filled circles are scaled to catch.

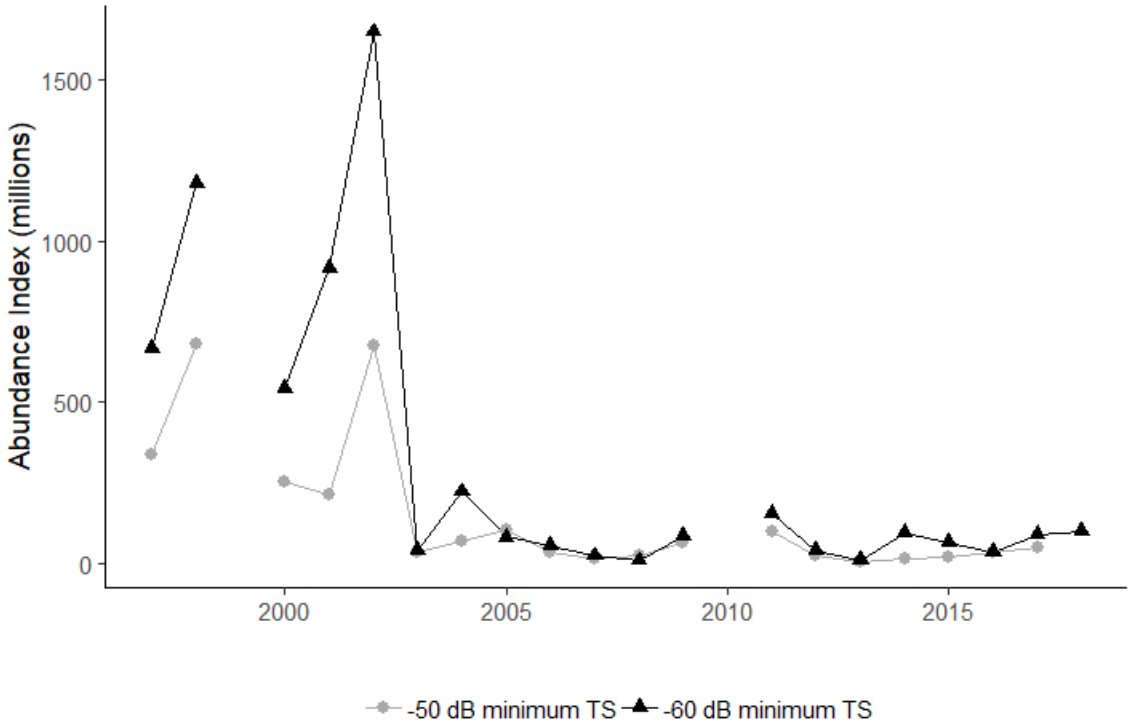

Figure 11. Abundance (in millions of fish) of yearling-and-older rainbow smelt in Lake Ontario from 1997-2017. No acoustic survey was conducted in 1999 and 2010.

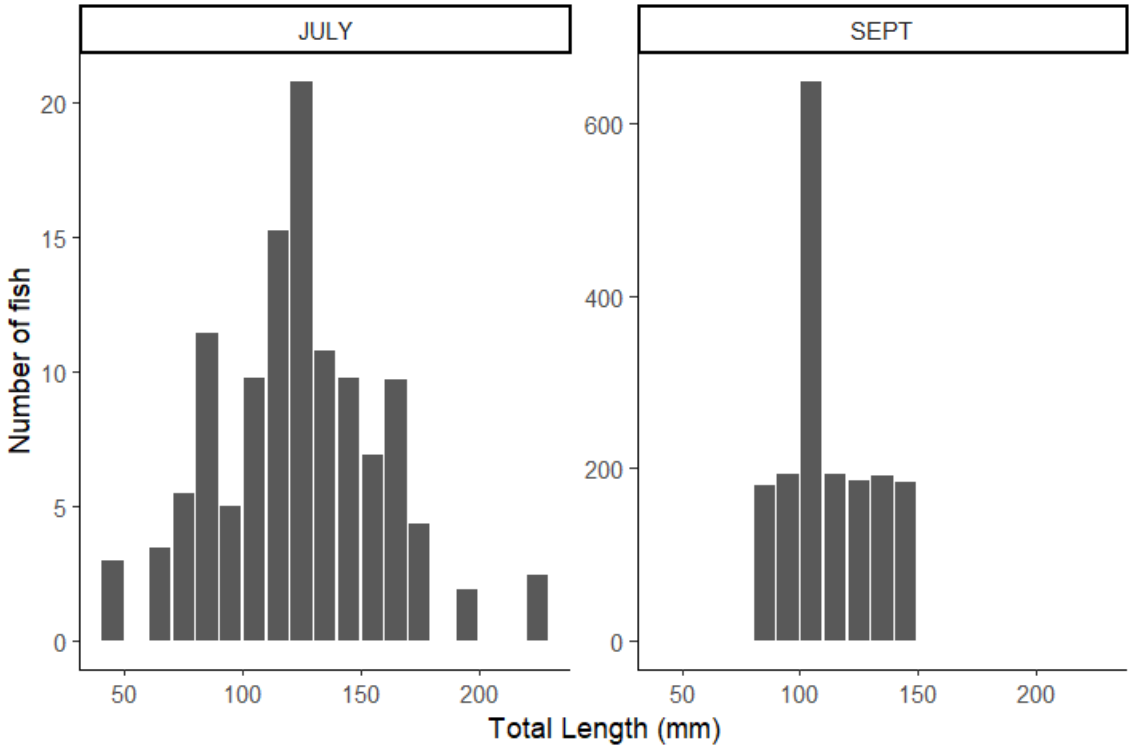

Figure 12. Size distribution of rainbow smelt captured in midwater trawls in July and September 2018. Note that y-axis scale ranges differ.

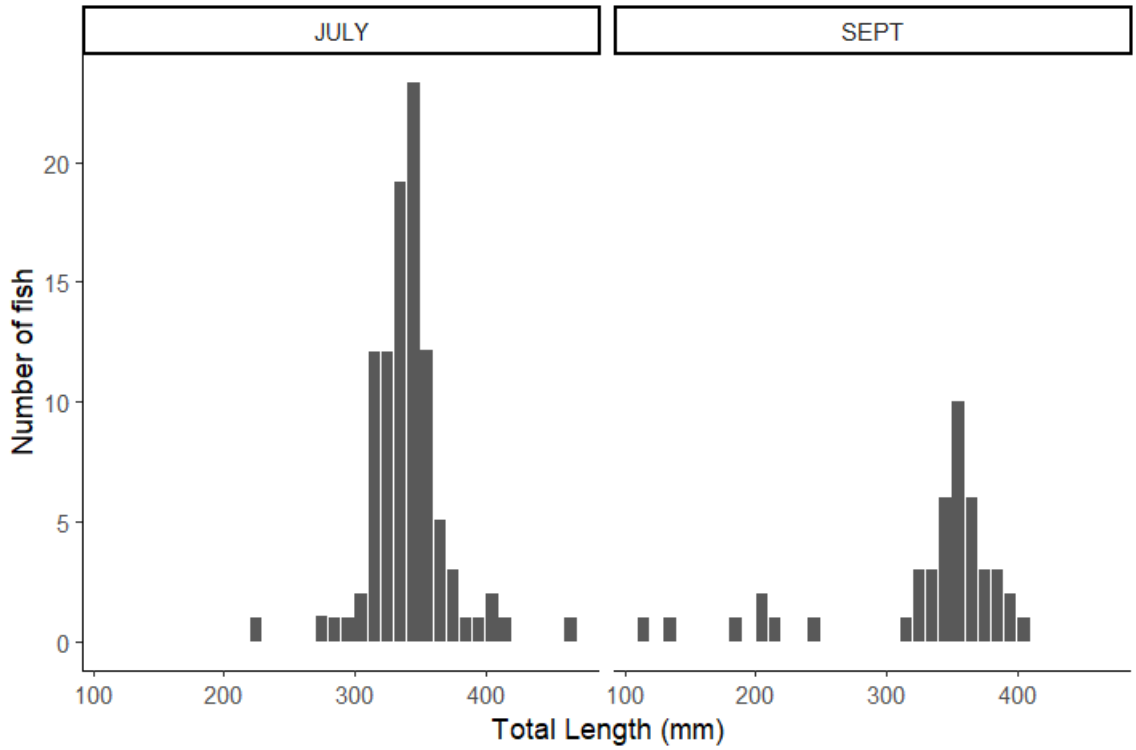

Figure 13. Size distribution of cisco captured in July and September midwater trawls.

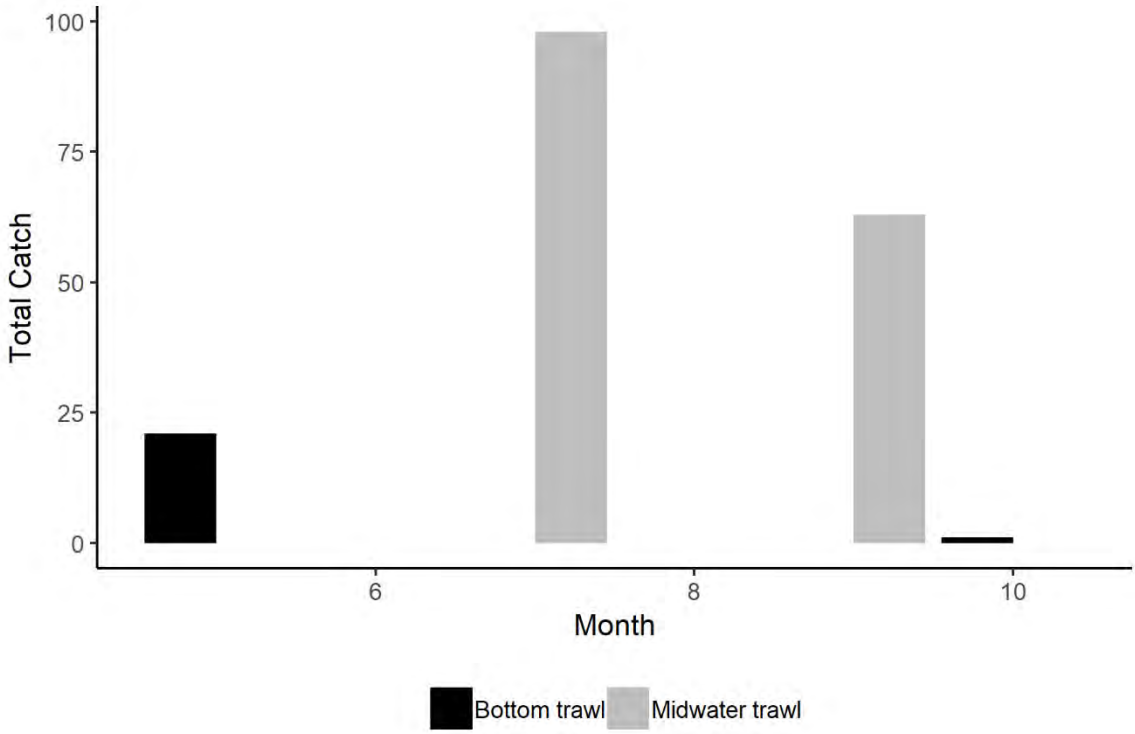

Figure 14. Number of cisco captured in spring and fall bottom trawls (N tows = 208; N tows = 118; respectively) and midwater trawls in July and September (N tows = 56, N tows = 26, respectively).

Table 1. Description of the midwater trawl configuration used during the 2018 pelagic fish survey.

Component	Description
Vessel Tow Speed	3 - 3.5 kts
Headrope length	18.3m
Footrope length	18.3m
Front Mesh	101 mm
Cod End	12.7 mm
Wing Spread	7 m
Net Height	6 m
Door Area	1.25 m^2
Note	22.5 kg of weight were hung from each wing to spread the trawl

Table 2. Summary of catch data for all species captured in midwater trawls.

Species	Number Caught			Biomass (kg) Caught		
	July	September	Sept - BQ	July	September	Sept - BQ
Alewife	4906	691	562	121.09	9.56	3.04
American eel	0	0	2	0.00	0.00	1.39
Bluegill	0	0	1	0.00	0.00	0.00
Chinook salmon	1	4	0	0.06	9.39	0.00
Cisco	99	48	15	32.78	19.24	6.13
Common shiner	0	0	1	0.00	0.00	0.01
Deepwater sculpin	1	0	0	0.00	0.00	0.00
Gizzard shad	0	0	259	0.00	0.00	6.16
Lake trout	0	1	3	0.00	8.35	2.80
Lake whitefish	1	0	0	1.29	0.00	0.00
Rainbow smelt	218	2349	314	2.14	15.50	2.69
Round goby	2	1	16	0.00	0.00	0.02
Slimy sculpin	2	0	0	0.02	0.00	0.00
Threespine stickleback	0	2	0	0.00	0.00	0.00
Trout-perch	0	0	109	0.00	0.00	1.37
Walleye	0	0	5	0.00	0.00	4.01
White perch	0	0	3	0.00	0.00	0.12
Yellow perch	0	0	8	0.00	0.00	0.07

Table 3. Hydroacoustic and midwater trawl survey estimates of alewife biomass in July 2016-2018.

Year	Biomass (kg/ha)
2016	45.1
2017	47.7
2018	26.6

Lake Sturgeon Tagging Study and Egg Take 2018

Rodger M. Klindt and David J. Gordon
New York State Department of Environmental Conservation
Watertown, New York 13601

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. All stocked fish have been Coded Wire Tagged (CWT) since 2013 to identify them as being of hatchery origin.

Methods

Geographic Area

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

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

Collection

Lake sturgeon (sturgeon) were collected from April-August in 2018. Collections included netting targeting sturgeon, and existing annual gill net surveys to assess warmwater fish populations which occasionally capture sturgeon.

Pre-spawn and spawning sturgeon were sampled in Lake Ontario (Black River Bay), and in the St. Lawrence River immediately downstream of the Moses Power Dam (Dam). Existing, long term index gill netting programs include two on the St.

Lawrence River (Thousand Islands and Lake St. Lawrence) and one in the Eastern Basin of Lake Ontario. Netting sites for 2018 are shown in Figure 1.

All fish were collected with monofilament gill nets fished from 16.8 – 25.0 hours in waters from 13-60 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. Fish < 39.5 inches were scanned for CWT's to determine whether they were of hatchery origin. 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.

Overall 2018 Results

DEC personnel captured a total of 155 sturgeon throughout the sampling area in 2018. PIT tags were applied to 120 sturgeon (86% St. Lawrence River; 14% Lake Ontario), ranging in length from 26.1-67.3 inches and weighing up to 84.6 pounds. Length-weight relationships were constructed using data from all sturgeon collected (where lengths and weights were available) from 2010-2018 (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 33 recaptures were recorded in 2018. The majority of recaptured fish came from the general area of initial tagging. Three recaptures originated from outside the sampling area and are described below.

Males (N=20) accounted for 13.9% of the catch while females (N=9) constituted 5.8%. The remaining fish were either immature or of undetermined sex (N=126, 81.3%). 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.

Black River

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.

Discharge in the Black River was at or above the maximum effective netting limit of 6000 cfs from 4/15 – 5/15/2018 (USGS gage 04260500, Watertown). No netting was attempted in the river during the 2018 spawning period.

Lake Ontario (Black River Bay & Eastern Basin)

A total of 29 sturgeon were captured in Black River Bay from April 19- May 10, 2018. Surface water temperature warmed through the period ranging from 36-62 ^{o}F. A total effort of 622.04 net-hrs was expended resulting in a catch per unit effort (CUE) of 0.05 fish/hr (Table 2). Sturgeon ranged in length from 33.5-67.3 inches, and weight from 9.9-84.6 pounds. Sex could not be determined for most fish. However, four fish were determined to be ripe males and four other fish, while not confirmed by internal examination, presented the body form of gravid females.

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.

Thirteen fish were recaptures having been tagged from 2008-2016 in either Black River Bay or the Black River. Three other recaptured fish were tagged a significant distance from the bay having been originally tagged in the Genesee River, Oswego River and one from an unknown location in the Oswego River System, as evidenced by broken Carlin Tag wires (Table 4). This fish was likely tagged by either Cornell University or SUNY ESF.

The annual index gill net survey conducted by the DEC's Lake Ontario Unit in the Eastern Basin collected eight juvenile sturgeon ranging from 26.1-35.0 inches in 2018. One adult fish, a recapture last collected in 2016 at Black River Bay, was 53.9 inches. Nets were fished at 28 sites with a total effort of 523.7 net-hrs (Table 2). Recent stockings of sturgeon have had Coded Wire Tag (CWT) implants. Five juveniles had CWT's detected verifying them as hatchery origin fish. Three remaining juveniles had no CWT detection implying that they were of wild origin.

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 117 sturgeon were collected from May 24-June 12, 2018 at eight net sites with an effort of 704 net-hrs (Table 2). Water temperature in the South Channel ranged from 53-59°F during the sampling period. Catch rate in 2018 (CUE= 0.16 fish/hr) fell below the range of previous years (CUE range 2009-2017; 0.24-0.59 fish/hr). Control gates at the Long Sault Dam were opened during to netting period releasing from 9,800-66,390 cubic feet/second. Copious amounts of filamentous algae were liberated which fouled nets. Decreased CUE is likely a direct result of high flow and algae.

Ripe males (N=14) represented 11.9% of the catch whereas ripe females (N=3) represented 2.5%. Five hard females with eggs in stages 2-3 of development were identified as well as one spent female. Sex could not be determined for the remainder of the catch (N=94, 80.3%). High flow rates through the South Channel may have influenced spawning sturgeon distribution possibly accounting for the lack of ripe males and the high number of hard females in our sample.

Sturgeon collected in 2018 ranged in length from 38.2-63.4 inches and in weight from 9.6-55.2 pounds. Fish used for the 2018 egg take

(females N=3, males N=8) were taken from this group.

Eighteen fish were recaptured from previous tagging events from 2009-2017 for a recapture rate of 15.4% (Figure 4). Most recaptures were fish collected previously in the South Channel. One recapture had been PIT and Acoustic tagged above the dam in 2013 (John Casselman, Queens University, personal communication).

The annual egg take took place on June 15, 2018. Prior to the egg take fish were collected and evaluated for gamete maturation. Fish selected (F=3, M=8) were treated with Carp Pituitary Hormone to induce ovulation and spermiation (Klindt 2014). Approximately 60,000 fertilized eggs were distributed between culture facilities in New York and Wisconsin. Fertilization rates were generally high, averaging 81.4% for all lots taken.

In October of 2018 approximately 13,500 CWT tagged fingerlings were stocked into various waters of NYS (Table 5). CWTs were inserted behind the head near the first dorsal scute, and are intended to simply identify hatchery vs. wild origin. Current stocking rates are intended to continue through 2024. 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.

St. Lawrence River Above Moses Power Dam

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 2018 have occurred in the Thousand Islands (N=9) and Lake St. Lawrence (N=14) index gill net surveys (DEC region 6 Warm Water Assessment database). However, no sturgeon were collected as part of these surveys in 2018, despite a combined effort of 1192.6 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 2010-2018 a total of 1494 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, eighteen sturgeon collected through this project are known to have made long movements from initial capture sites. Twelve 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 2009-2018 the recapture rate has averaged 11.6% 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 the Eastern Basin of Lake Ontario and the Coles Creek area of the St. Lawrence River 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 Morristown, Ogdensburg, and Coles Creek.

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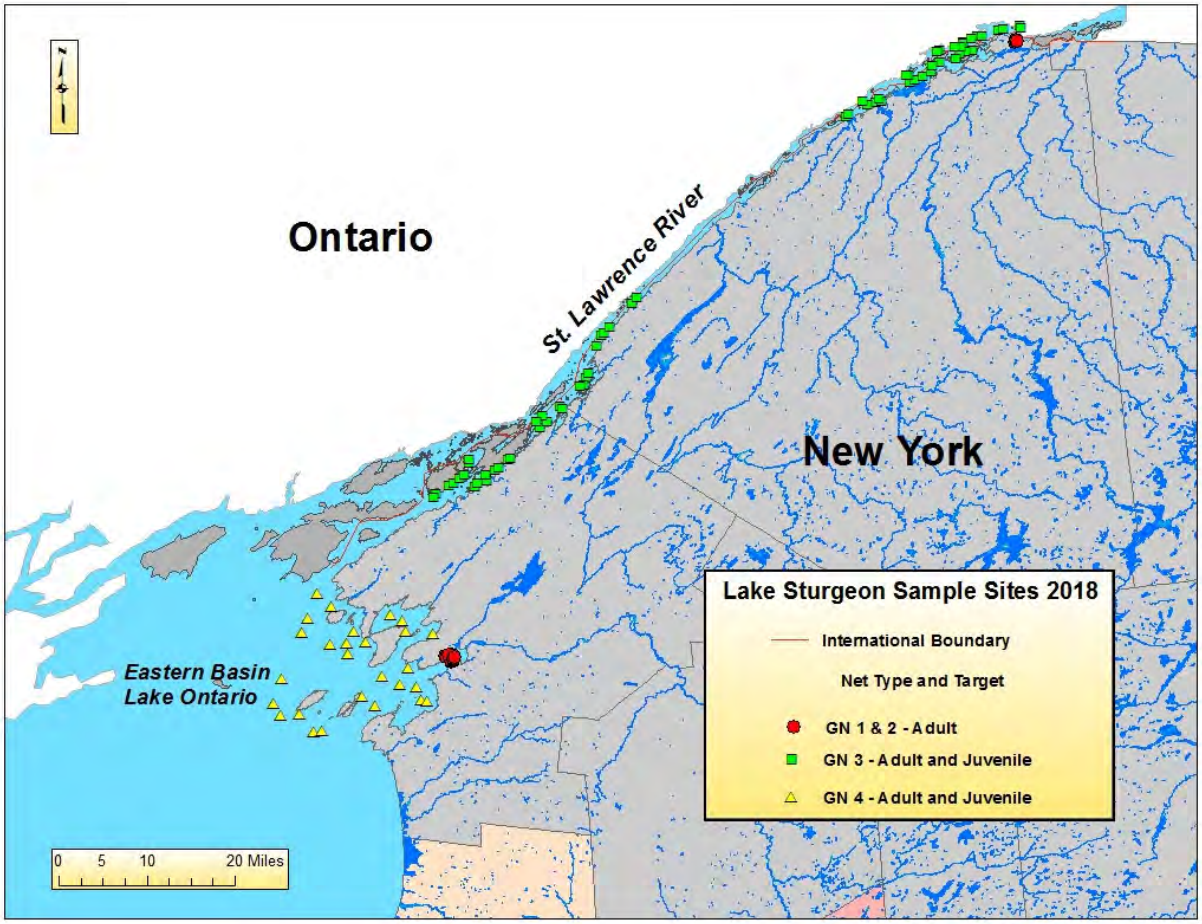

Figure 1. Lake sturgeon sampling locations and targets for 2018. Adults were targeted with large mesh gill nets only (GN1 & 2). Existing index projects in the Thousand Islands, Lake St. Lawrence, and Lake Ontario potentially targeted both juveniles and adults, utilizing experimental gill nets (GN3 & 4).

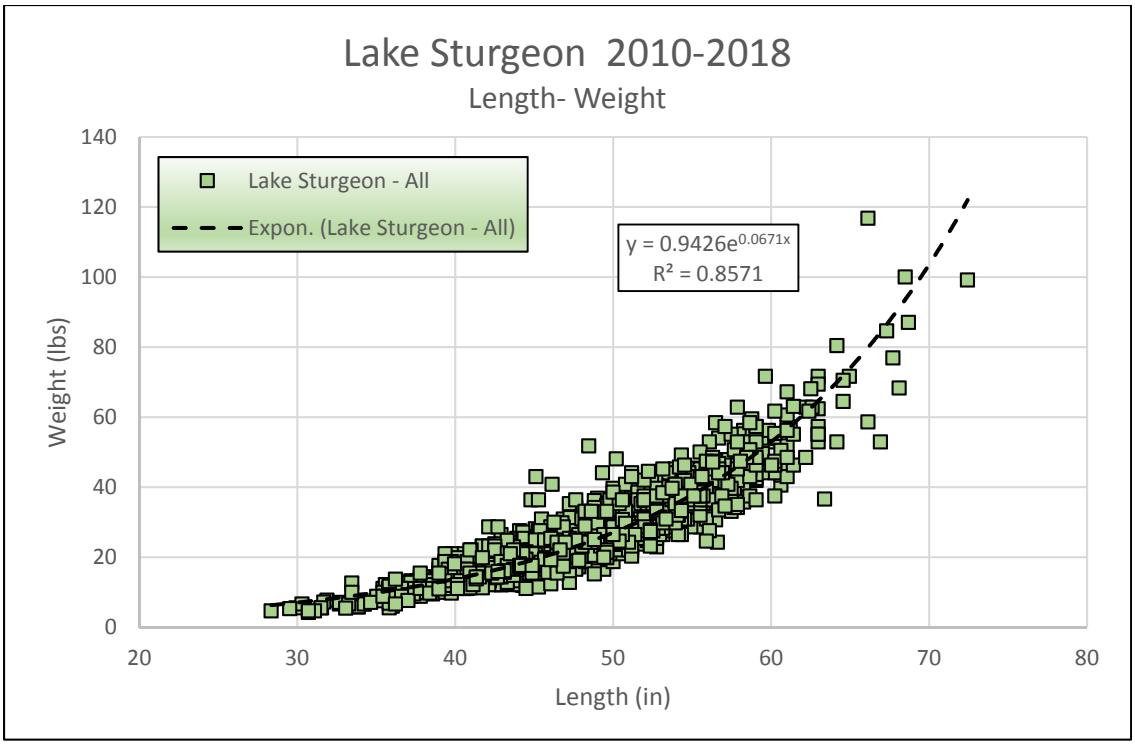

Figure 2. Length-weight relationship for lake sturgeon collected by DEC from 2010-2018. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined with no differentiation to sex.

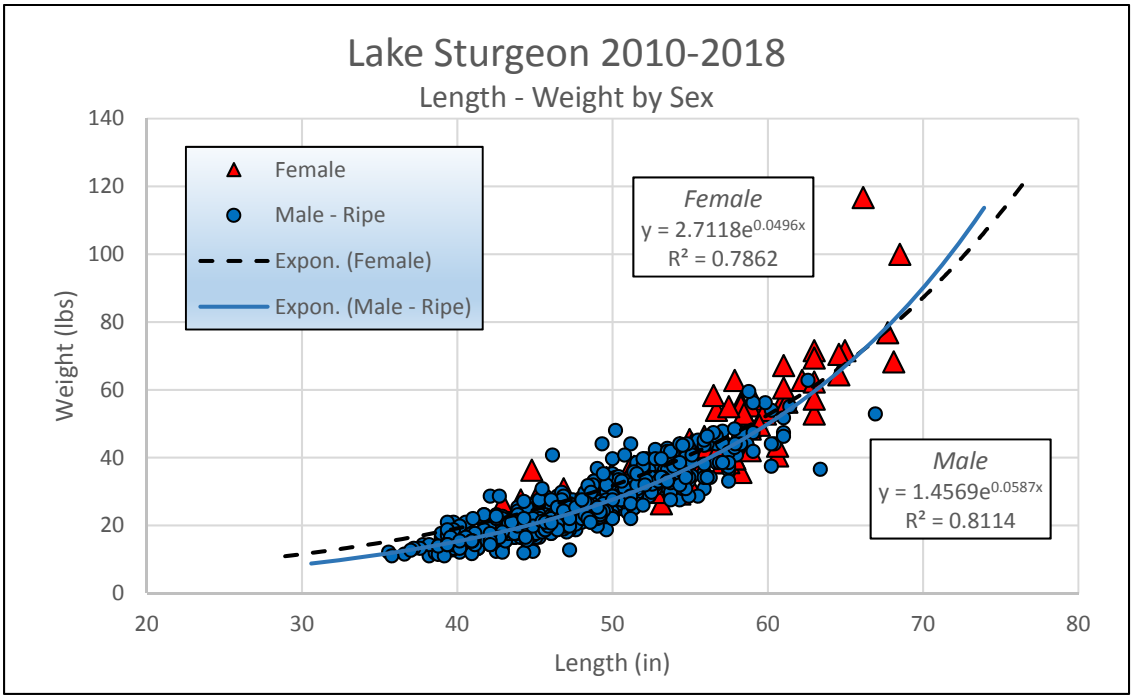

Figure 3. Length-weight relationship for lake sturgeon collected by DEC from 2010-2018 separated by sex. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined. Only female and ripe male sturgeon are presented.

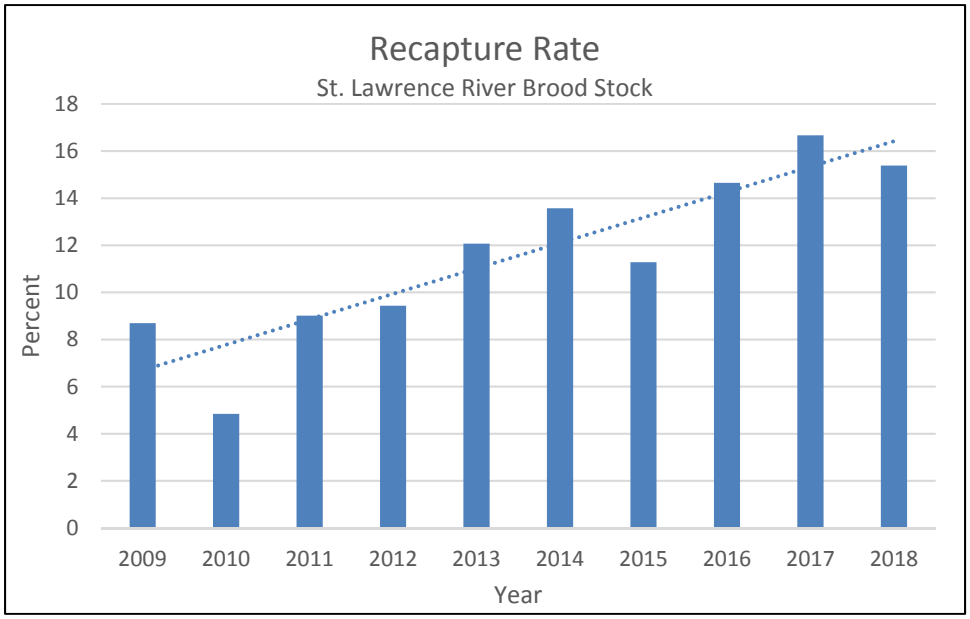

Figure 4. Lake sturgeon recapture rates from 2009-2018 during broodstock collection on the St. Lawrence River at the South Channel, Massena NY.

Table 1. Specifications of nets used for collecting lake sturgeon in 2018. 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 2018. 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	4/19-5/10/2018	16	A	GN1 & GN2	622.04	29	0.05
Black River	-	-	-	-	-	-	-
SLR@ South Channel	5/24-6/12/2018	8	A	GN1 & GN2	703.8	117	0.17
Existing projects							
SLR- TI	7/23-27/2018	32	B	GN3	617.96	0	0.00
LO Gill Net	7/30-8/9/2018	28	B	GN4	523.72	9	0.02
SLR- LSL	9/17-20/2018	32	B	GN3	574.62	0	0.00

Table 3. Total number of uniquely PIT tagged lake sturgeon from 2010-2018. 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	721	48.2
Female	85	5.7
Unknown	688	46.1

Table 4. Tagging and recapture locations for 18 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
Unknown	Black River Bay (2018)	?	?	Carlin
Genesee River (2010,2012)	Black River Bay (2018)	N	100	PIT
Oswego River (2009)	Black River Bay (2018)	Y	65	PIT
SLR, Jones Creek (Ontario) near Chippewa Pt. (2013)	SLR, South Channel (2018)	Y	62	PIT

Table 5. Lake sturgeon stocking for New York in 2018. All fish stocked received a coded wire tag (CWT) behind the head near the first dorsal scute for the purpose of identifying their origin (hatchery vs. wild).

Water	Number	Avg. Length at Stocking (in)	Date	Mark
Lake Ontario (Chaumont Bay)	2250	7.0	10/10/18	CWT
Black Lake	1000	7.0	10/10/18	CWT
Cayuga Lake	2500	7.0	10/10/18	CWT
Genessee River	1000	7.0	10/10/18	PIT
Oneida Lake	500	7.0	10/10/18	CWT
Oswegatchie River (Oxbow, Elmdale)	1000	7.0	10/10/18	CWT
Raquette River	1000	7.0	10/10/18	CWT
Salmon River (Franklin Co.)	1000	7.0	10/10/18	CWT
St Regis River	1000	7.0	10/10/18	CWT
St. Lawrence River (Ogdensburg)	2000	7.0	10/10/18	CWT
St. Lawrence River (Massena, blw dam)	500	7.0	10/10/18	CWT

Northern Pike Research, Monitoring and Management in the Thousand Islands Section of the St. Lawrence River

J. M. Farrell and N.A. Satre
State University of New York
College of Environmental Science and Forestry
1 Forestry Drive
Syracuse, NY 13210

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 levels and spawning habitat changes can promote deep-water pike spawning (over ~5 meters) and 4-6 week delays in the egg deposition period when habitat condition are poor (Farrell 2001). Deep water spawning occurs late in spring (May-June) and is believed to be maladaptive creating a significant reproductive sink. Nearshore pike spawning is affected by water level regulation by limiting spawner access to wetland spawning habitats. 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 wetlands by the US Fish and Wildlife Service (USFWS) and Ducks Unlimited through the Fish Habitat Conservation Strategy (Farrell et al. 2017). Studies at several of these projects have documented consistent use by northern pike for reproduction and success also is related to springtime water level conditions (Neveldine et al. in press).

Northern pike YOY have been monitored in eleven seining survey sites (also used to index muskellunge), in larger bays, and in tributaries. Overall YOY production has declined significantly from historic levels. Continued monitoring is necessary to track northern pike reproductive success, to evaluate responses to 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

Spawning run trapnet survey

Monitoring of adult northern pike during spring spawning occurred in five tributaries (four index and one exploratory) and one managed spawning marsh. Tributaries included French Creek, Cranberry Creek extension, Little Cranberry Creek, Chippewa Creek and Otter Creek (exploratory). 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 northern 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 sites with nets targeting spawning muskellunge (Farrell et al. 2018).

Water levels are typically held ~0.6 m or about 2 feet above main river level at Carpenters Branch and Delaney Marsh. Delaney Marsh was not included in the spring spawning survey because of its remote island location, but was surveyed for emigrating YOY pike. The water level management strategy for marshes is intended to prevent the fall drawdown (Farrell et al. 2010) experienced under IJC water level regulation.

Emigration of YOY northern pike at managed marshes and excavated spawning pools

During a related study funded by the USFWS, 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 northern 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 65 traps deployed. 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.

Summer seining surveys

Standardized seining for YOY northern pike was conducted in conjunction with YOY muskellunge monitoring. A total of 11 sites were sampled during July with a fine-mesh, 9.1 m (30 ft) long seine (90 hauls) and during August with a large-mesh, 18.3 m (60 ft) long seine (90 hauls); for methods details see Murry and Farrell (2007). In addition, 36 sites were sampled (181 hauls) in an exploratory series with a fine-mesh seine. Additional exploratory series were conducted in Lake St. Lawrence (2 sites, 10 hauls) and Eastern Lake Ontario (3 sites, 16 hauls). The 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 69 northern pike were captured at four index tributary sites from March 29 to April 26, 2018. No pike were captured at the exploratory site. An effort of 137 net nights resulted in a CPUE (catch per unit effort) of 0.50 fish/night (Table 1). The catch of spawning northern pike at index sites remains low since a significant peak in 2008 (CPUE = 4.20; Figure 2). Newly excavated spawning pools and channels were created by the USFWS at Otter Creek early in 2018 (post-sampling) and at Cranberry Creek in 2017, an attempt to increase local YOY pike production. Future habitat enhancement projects by USFWS are planned in Chippewa Bay, St. Lawrence County and in Barnett Marsh off Wellesley Island as a partnership with the Thousand Islands Land Trust.

Current and past trapnet catches continue to indicate a significant dominance of female northern pike in the early spawning run at the managed marsh sites. For 667 northern pike of known sex captured at Carpenters Branch since 2003, 465 were female or 2.30 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 unaltered reference habitats, constructed spawning areas, and managed marshes from June 6 to July 3 (Table 2). Overall sites, 483 YOY northern pike (overall CPUE = 0.37) were captured leaving nursery areas (Table 2). This catch is notably less than observations from 2017 (n = 68 sites; total catch = 2305; overall CPUE = 2.26) but similar to observations from 2016 (n = 18 sites; total catch = 154; overall CPUE = 0.33). Habitat restoration sites had higher catch rates for three consecutive years than the other site types. Analysis of YOY outmigration over time at excavation sites show a positive relationship to spring water level conditions, in addition to increased overall plant diversity and habitat conditions relative to unaltered reference sites in French Creek (Neveldine et al. online first).

Summer seining surveys

The YOY seining survey at eleven index sites produced a catch of 8 YOY northern pike during the 30' fine-mesh seine series in 90 hauls (standardized CPUE = 0.09 fish/haul, Table 3) and 3 in the 60' large-mesh seine series in 90 hauls (standardized CPUE = 0.03 fish/haul). Thirty-six additional upper St. Lawrence River bays were sampled by seining and 52 YOY pike were captured (n = 181 hauls; CPUE = 0.29). CPUE in Lake St. Lawrence and Eastern Lake Ontario were 0.20 and 0.13, respectively. Seine hauls at Delaney Bay (n = 10) resulted in the capture of 15 YOY pike (Table 3). Trends in YOY northern pike abundance are beginning to show slight improvement and have sequentially increased since 2013, with the exception of 2018 (Figure 3).

Conclusions and Recommendations

SUNY-ESF will continue monitoring northern pike juvenile and adult populations in concert with the DEC Region 6 Warmwater Assessment to provide data to inform management. Recent sportfish regulation adjustments include a reduction in the creel limit from five to three fish per day. The monitoring and population demographic data will help inform trends and assessment of regulation changes. This information will also inform population contributions from the potentially strong 2017 northern pike year-class. These fish will become fully recruited to WWA gillnetting as age-3 fish in 2020.

It is recommended that DEC, the USFWS and Ducks Unlimited continue to enhance critical spawning and nursery habitat in the region.

Acknowledgements

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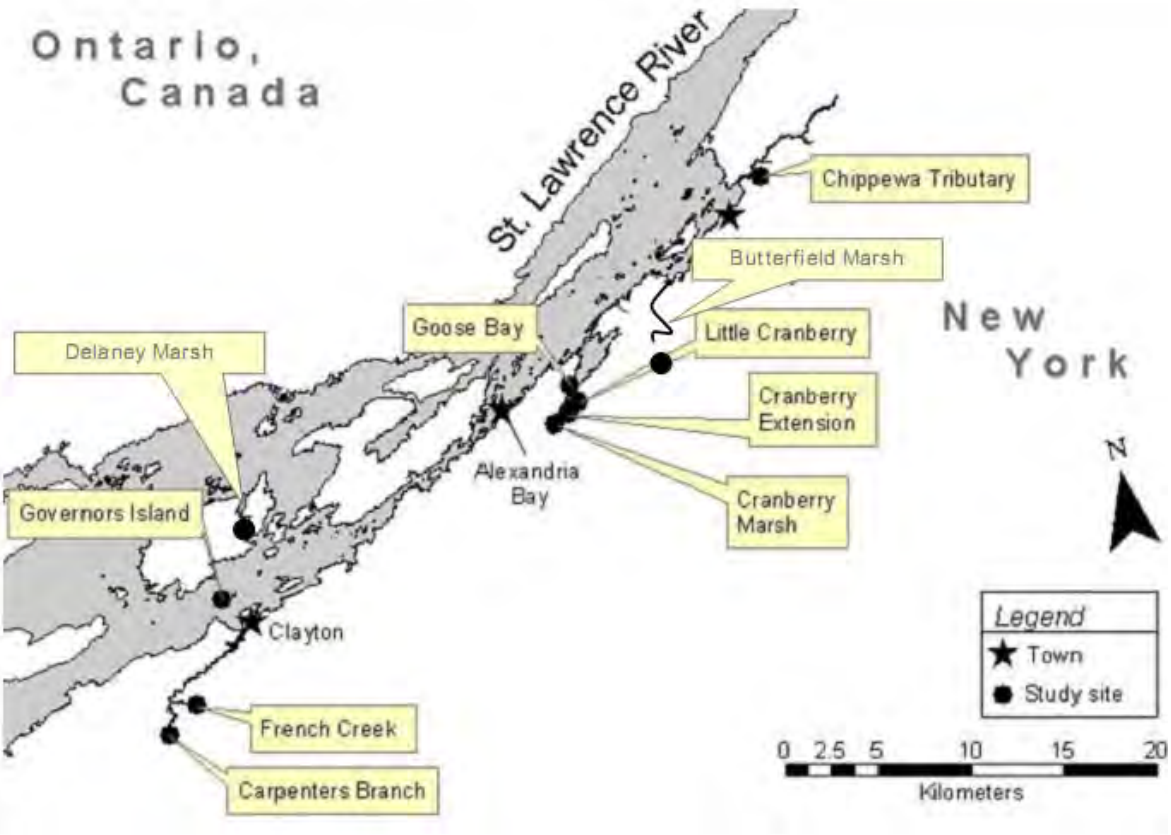

Figure 1. Study sites in the Thousand Islands Region of the upper St. Lawrence River in Clayton and Alexandria Bay, New York, including spawning marshes at Carpenters Branch (French Creek Wildlife Management Area) and Delaney Marsh (Grindstone Island) and sampling index locations at French Creek, Little Cranberry Creek, Cranberry Extension and Chippewa Creek Tributary. Governors Island is the location of the Thousand Islands Biological Station. Additional seining locations (not shown) are index YOY muskellunge monitoring sites and other regional embayments.

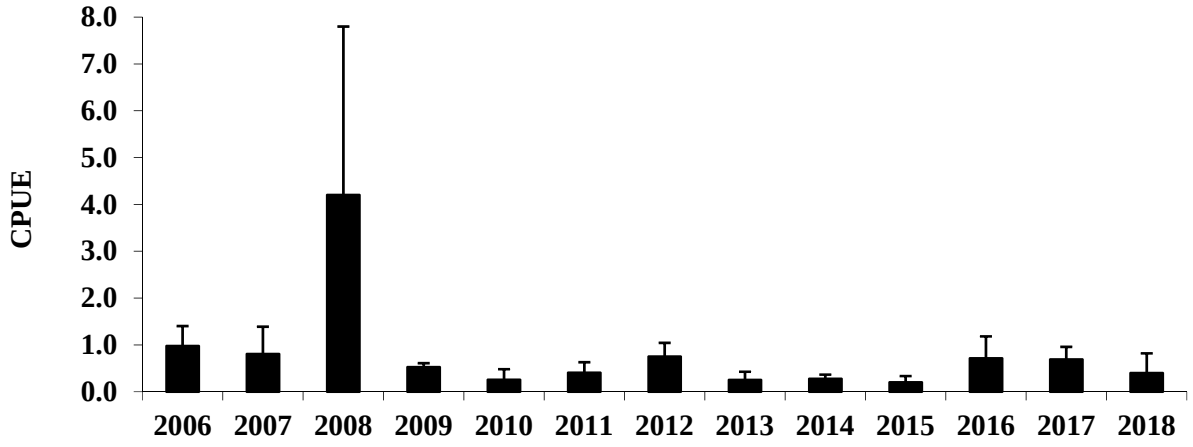

Figure 2. Average catch per net-night of adult northern pike in four spring spawning index trapnetting locations from 2006 to 2018 with 90% confidence limits.

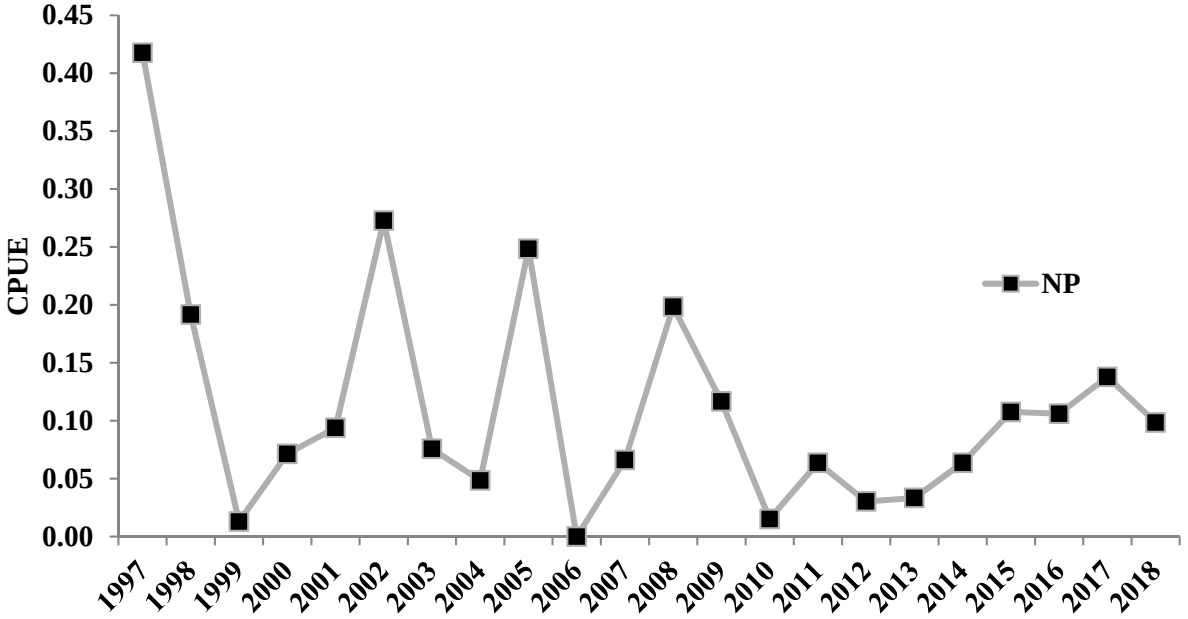

Figure 3. Catch per seine haul of YOY northern pike sampled during July from 1997-2018 with a fine-mesh, 9.1 m (30') long seine at Thousand Islands index sites.

Table 1. 2018 upper St. Lawrence River northern pike spawning survey effort and results by site from March 29 to April 26. Effort is defined as the total number of net-nights fished. F/M ratio is the ratio of female to male northern pike.

2018 NP Spawning				
Site	Effort	NP	CPUE	F/M ratio
Bevins (French Creek)	27	42	1.556	1.100
Carpenters (French Creek)	28	20	0.714	2.333
Chippewa	13	5	0.385	0.250
Cranberry Extension	25	2	0.080	0.000
Little Cranberry	25	0	0.000	0.000
Otter Creek	19	0	0.000	0.000
Total	**137**	**69**	**0.504**	**1.156**

Table 2. Summary of catch per unit effort for YOY northern pike captured during emigration netting. Site types include unaltered reference locations, habitat enhanced sites, and managed marshes. Effort is defined as the total number of net-nights fished.

2018 NP Emigration				
Locations	# Nets	Effort	NP	CPUE
REFERENCE				
French Creek	9	196	49	0.250
Point Vivian Marsh	2	36	3	0.083
Cranberry	3	65	8	0.123
Club Island	1	16	0	0.000
Swan Bay	2	32	0	0.000
Subtotal	**17**	**345**	**60**	**0.174**
SPAWNING POOLS AND CHANNELS				
French Creek	16	368	263	0.661
Point Vivian Marsh	7	123	28	0.228
Ferguson Cove	2	34	1	0.029
Blind/Chippewa Bays	7	111	1	0.009
Cranberry	9	239	125	0.523
Club Island	3	51	3	0.059
Subtotal	**44**	**926**	**421**	**0.455**
MANAGED MARSHES				
Carpenters Branch	1	17	0	0.000
Delaney Marsh	3	31	2	0.065
Subtotal	**4**	**48**	**2**	**0.042**
Total	**65**	**1319**	**483**	**0.366**

Table 3. Seining catch summary for 2018 at index and exploratory sites using a fine-mesh 30' bag seine and a large-mesh 60' bag seine targeting esocids.

2018 30' Index Seining							
Site	Hauls	MKY	NP	GP	MKY CPUE	NP CPUE	GP CPUE
Affluence Bay	6	5	1	0	0.83	0.17	0.00
Boscobel Bay	6	0	1	0	0.00	0.17	0.00
Cobb Shoal	12	0	0	0	0.00	0.00	0.00
Deer Island	6	0	0	0	0.00	0.00	0.00
Frink's Bay	10	0	0	0	0.00	0.00	0.00
Garlock Bay	10	1	0	0	0.10	0.00	0.00
Lindley Bay	6	0	1	0	0.00	0.17	0.00
Millens Bay	12	0	3	1	0.00	0.25	0.08
Peos Bay	6	0	1	0	0.00	0.17	0.00
Rose Bay	10	0	0	0	0.00	0.00	0.00
Salisbury Bay	6	0	1	0	0.00	0.17	0.00
Total	**90**	**6**	**8**	**1**	**0.07**	**0.09**	**0.01**

2018 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	1	0	0	0.17	0.00	0.00
Cobb Shoal	12	0	0	0	0.00	0.00	0.00
Deer Island	6	0	0	2	0.00	0.00	0.33
Frink's Bay	10	0	0	0	0.00	0.00	0.00
Garlock Bay	10	0	0	0	0.00	0.00	0.00
Lindley Bay	6	0	1	0	0.00	0.17	0.00
Millens Bay	12	0	1	0	0.00	0.08	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	1	0	0.00	0.17	0.00
Total	**90**	**1**	**3**	**2**	**0.01**	**0.03**	**0.02**

Table 3. Continued

2018 30' Exploratory Seining Upper St. Lawrence River							
Site	Hauls	MKY	NP	GP	MKY CPUE	NP CPUE	GP CPUE
A1	2	0	0	0	0.00	0.00	0.00
A2	2	1	0	0	0.50	0.00	0.00
A3	3	1	0	0	0.33	0.00	0.00
A4	1	0	0	0	0.00	0.00	0.00
Aunt Janes	1	0	0	0	0.00	0.00	0.00
Bartlett	2	0	0	0	0.00	0.00	0.00
Blind	10	0	4	0	0.00	0.40	0.00
Brown	4	0	0	0	0.00	0.00	0.00
Buck	6	0	0	0	0.00	0.00	0.00
Carrier	6	0	0	0	0.00	0.00	0.00
Delaney	10	0	15	0	0.00	1.50	0.00
Densmore	10	0	0	0	0.00	0.00	0.00
Eel	10	1	1	0	0.10	0.10	0.00
Escanaba	1	0	0	1	0.00	0.00	1.00
Ferguson Cove	3	0	0	0	0.00	0.00	0.00
Flynn	17	2	2	0	0.12	0.12	0.00
French	5	0	3	1	0.00	0.60	0.20
Goose	4	0	2	0	0.00	0.50	0.00
Grass Point	13	5	4	0	0.38	0.31	0.00
Jacques Cartier	2	0	0	0	0.00	0.00	0.00
Jolly Island	4	2	0	0	0.50	0.00	0.00
Long Point	4	0	9	1	0.00	2.25	0.25
Near Red Barn	2	0	0	0	0.00	0.00	0.00
Oak Point	2	0	0	0	0.00	0.00	0.00
Point Marguerite	4	0	0	0	0.00	0.00	0.00
Point Vivian	5	0	3	0	0.00	0.60	0.00
Red Barn	6	0	0	0	0.00	0.00	0.00
Roods Point	2	0	0	0	0.00	0.00	0.00
South Bay	5	0	3	0	0.00	0.60	0.00
South of Ferguson	3	1	0	0	0.33	0.00	0.00
Swan	10	3	0	0	0.30	0.00	0.00
Thurso	5	0	0	0	0.00	0.00	0.00
Webster Point	2	0	0	0	0.00	0.00	0.00
Whitehouse	6	0	0	0	0.00	0.00	0.00
Whitehouse (Waddington)	5	1	1	0	0.20	0.20	0.00
Windsong	4	2	5	0	0.50	1.25	0.00
Total	**181**	**19**	**52**	**3**	**0.10**	**0.29**	**0.02**

Table 3. Continued

2018 30' Exploratory Seining
Lake St. Lawrence

Site	Hauls	MKY	NP	GP	MKY CPUE	NP CPUE	GP CPUE
Waddington Beach	4	2	1	0	0.50	0.25	0.00
Waddington West	6	0	1	0	0.00	0.17	0.00
Total	**10**	**2**	**2**	**0**	**0.20**	**0.20**	**0.00**

2018 30' Exploratory Seining
Eastern Lake Ontario

Site	Hauls	MKY	NP	GP	MKY CPUE	NP CPUE	GP CPUE
Association	4	0	0	0	0.00	0.00	0.00
Muskellunge	8	0	2	0	0.00	0.25	0.00
Snowshoe	4	0	0	0	0.00	0.00	0.00
Total	**16**	**0**	**2**	**0**	**0.00**	**0.13**	**0.00**

Research, Monitoring, and Management of St. Lawrence River Muskellunge

J. M. Farrell and N.A. Satre
State University of New York
College of Environmental Science and Forestry
1 Forestry Drive
Syracuse, NY 13210

The 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). The focus now is on population recovery following significant mortality due to an outbreak of invasive viral hemorrhagic septicemia virus (VHSV) 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 (Casselman et al. 2017), which had recently been introduced to the Great Lakes (Elsayed et al. 2006). Since the adult muskellunge mortality events, a substantial and persistent decline has been observed in adult catch rate in the spring spawning survey, YOY abundance on the nursery grounds later in the summer, and is also reflected in reduce catch rates in the fishery (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 round goby, (*Neogobius melanostomus*) has invaded littoral nursery habitats of muskellunge (Farrell et al. 2010). Miano et al. (2019) 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 juvenile fish 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 18 years (1997-2000, 2003, and annually since 2006). In 2018, sixteen nets, including 3' and 4' hoop nets and 6' Oneida trapnets, were fished near shore in eleven muskellunge spawning bays between May 4 and June 10. An additional three sites (French Bay, Buck Bay and Grass Point) were surveyed using roving net placement in an attempt to increase catch of spawning muskellunge. An additional eight sites were fished with trapnets in Lake St. Lawrence in a collaborative muskellunge assessment effort with the US Fish and Wildlife Service Ecological Services Office in Cortland NY.

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.

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, standardized monitoring of 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). Recent research using these samples contributed to the current understanding of population and genetic structure of muskellunge in the St. Lawrence River (Kapuscinski et al 2013). More recently samples contribute to an examination of population structure in the upper and lower St. Lawrence including several lakes and tributaries to test for effects of the past stocking legacy in Quebec and the potential for introgression of those genes into the river's muskellunge genome (Rougemont et al. 2019).

Angler diary program

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.

Muskellunge catch and release program

A partnership with a local environmental advocacy group, Save The River, continued through 2018 sponsoring the Muskellunge Catch and Release Program. This program aims to both educate and involve the angling community in the conservation of the local adult muskellunge population by rewarding anglers who release a legal-size (54 inch) muskellunge with a limited edition, signed muskellunge print by St. Lawrence River artist Michael Ringer. Data are collected on each participant's total muskellunge catch and effort expended in hours, as well as information for the specific released fish submitted for the reward. Those details include location caught, water depth, weather conditions, date, time of day, weight of line used, bait or lure type, and total length of the muskellunge.

Results and Discussion

Spring trapnetting survey

A total of 2 spawning adult muskellunge were captured (catch rate = 0.004 fish/net night) in upper St. Lawrence River index sites in 2018 (Table 1 and 2; Figure 1). One sub-adult muskellunge was captured, but is not included in catch rate. At roving locations, zero adult muskellunge were captured in 75 net-nights. The mean number of muskellunge caught in the spring trapnetting survey before the VHSV outbreak (2005) was 0.063 muskellunge per net-night (SD = 0.032), but a mean of 0.019 (SD = 0.013) muskellunge per net-night have been captured in subsequent years (a 3.5 fold decline). The 2018 catch rate of 0.004 was a decrease from the 2017 catch rate of 0.016 muskellunge per net-night. The 2018 catch rate was the lowest in the time series, however, it was similar to 2016 (0.005) and comparable to the post-VHSV average (Figure 1).

Effort was again put forth in 2018 to capture spawning adult muskellunge in Lake St. Lawrence in cooperation with the US Fish and Wildlife Service Cortland Ecological Services Office. In total 7 adult muskellunge were captured (catch rate = 0.043 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.

Summer seining surveys

The annual standardized YOY muskellunge seining index resulted in continued low Catch per unit effort (CPUE) in 2018. 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 5). In August, a 60' large-mesh seine was employed in the same 11 bays, and 1 YOY muskellunge was captured in 90 seine hauls (Figure 2; Table 5). In addition to annual index seining, exploratory seining using a 30' seine was conducted from July 24 to August 16 in known nursery sites from Cape Vincent to the Moses Saunders power dam. This survey lead to a catch of 19 muskellunge (CPUE 0.10) across 36 exploratory sites (Table 6). The greatest CPUE for age-0 muskellunge was at Affluence Bay (index site) with 0.83 fish per haul, and at A2, Jolly Island, and Windsong Bay (exploratory sites) with 0.50 fish per haul.

Angler diary program

In 2018, 5 anglers (including guides) from the angler diary program fished 356.25 hours of effort for 26 muskellunge angled (0.073 fish / hour; Figure 3). The catch rate was an increase from 2017 where 17 muskellunge were captured in 691.25 hours of effort (0.025 fish / hour), and an increase from 2016 where 9 muskellunge were captured in 665 hours of effort (0.014 fish /

hour). It should be noted a substantial decrease in effort was recorded for 2018 compared to recent years. However, catch rates have increased consecutively for the past three years. Catch rates remain below the management goal of 0.1 fish per hour.

Muskellunge catch and release program

In 2018, only one angler participated in the Muskellunge Catch and Release program with TIBS and Save The River. The angler submitted a single muskellunge release award affidavit for a fish of 56 inches and estimated their 2018 angling effort of 3.5 hours. Discussions to improve angler participation are planned for 2019.

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Table 1. Locations, trapnet effort (net nights), muskellunge catch, and CPUE for index and roving bays in the upper St. Lawrence River, 2018. * Sub-adult muskellunge not include in CPUE.

Bay	Type	Effort	Muskellunge	CPUE
Blind	Index	33	0	0.000
Cobb	Index	32	0	0.000
Densmore	Index	24	0	0.000
Flynn	Index	143	2	0.014
Frink's	Index	33	0	0.000
Garlock	Index	25	0	0.000
Lindley	Index	33	1*	0.000
Millen's	Index	60	0	0.000
Peos	Index	30	0	0.000
Rose	Index	60	0	0.000
Swan	Index	28	0	0.000
Buck	Roving	33	0	0.000
French	Roving	11	0	0.000
Grass Point	Roving	31	0	0.000
Sub-total	Index	501	2	0.004
Sub-total	Roving	75	0	0.000
Total		**576**	**2**	**0.003**

Table 2. Summary of location of catch, total length (TL-mm), girth (mm), sex, reproductive stage, tag number and recapture history of spawning adult muskellunge caught and released from trapnets in upper St. Lawrence River bays, 2018. The tag entry number is for PIT type tags.

Date	Location	Sex	Stage	TL(mm)	Girth (mm)	Recap	Tag No.
5/6/18	Flynn	F	Ripe	1250	550	Y	900118001355001
5/10/18	Lindley	M	Immature	560	174	N	900118001347076
6/3/18	Flynn	M	Ripe	981	363	N	900118001105449

Table 3. Locations, trapnet effort (net nights), muskellunge catch, and CPUE for roving bays in Lake St. Lawrence, 2018.

Bay	Type	Effort	Muskellunge	CPUE
Leishman Point	Roving	23	2	0.087
Ogdensburg	Roving	17	0	0.000
Waddington Beach	Roving	23	0	0.000
Whitehouse	Roving	38	2	0.053
Windsong	Roving	39	0	0.000
Brandy Brook	Roving	12	1	0.083
Hawkins Point Bay	Roving	6	2	0.333
Robinson Bay	Roving	3	0	0.000
Total		**161**	7	**0.043**

Table 4. Summary of location of catch, total length (TL-mm), girth (mm), sex, reproductive stage, tag number and recapture history of spawning adult muskellunge caught and released from trapnets in Lake St. Lawrence bays, 2018. The tag entry number is for PIT type tags.

Date	Location	Sex	Stage	TL(mm)	Girth (mm)	Recap	Tag No.
5/18/18	Leishman Point	M	Ripe	1233	433	N	900118001105329
5/18/18	Leishman Point	F	Ripe	1091	481	N	900118001104969
5/23/18	Brandy Brook	M	Ripe	1012	379	N	900118001358881
6/1/18	Hawkins Point Bay	M	Ripe	1117	431	N	900118001345648
6/1/18	Hawkins Point Bay	F	Ripe	1320	508	N	900118001344847
6/2/18	Whitehouse	F	Ripe	1350	553	N	900118001347938
6/2/18	Whitehouse	M	Ripe	1233	481	Y	900118001105329

Table 5. Seining catch summary for 2018 sampling using a fine-mesh 30' bag seine (top) and a large-mesh 60' bag seine (bottom). Data for northern pike captures are also shown.

Index Seining (30')					
Site	Hauls	MKY	NP	MKY CPUE	NP CPUE
Affluence Bay	6	5	1	0.83	0.17
Boscobel Bay	6	0	1	0.00	0.17
Cobb Shoal	12	0	0	0.00	0.00
Deer Island	6	0	0	0.00	0.00
Frink's Bay	10	0	0	0.00	0.00
Garlock Bay	10	1	0	0.10	0.00
Lindley Bay	6	0	1	0.00	0.17
Millens Bay	12	0	3	0.00	0.25
Peos Bay	6	0	1	0.00	0.17
Rose Bay	10	0	0	0.00	0.00
Salisbury Bay	6	0	1	0.00	0.17
Total	**90**	**6**	**8**	**0.07**	**0.09**

Index Seining (60')					
Site	Hauls	MKY	NP	MKY CPUE	NP CPUE
Affluence Bay	6	0	0	0.00	0.00
Boscobel Bay	6	1	0	0.17	0.00
Cobb Shoal	12	0	0	0.00	0.00
Deer Island	6	0	0	0.00	0.00
Frink's Bay	10	0	0	0.00	0.00
Garlock Bay	10	0	0	0.00	0.00
Lindley Bay	6	0	1	0.00	0.17
Millens Bay	12	0	1	0.00	0.08
Peos Bay	6	0	0	0.00	0.00
Rose Bay	10	0	0	0.00	0.00
Salisbury Bay	6	0	1	0.00	0.17
Total	**90**	**1**	**3**	**0.01**	**0.03**

Table 6. Summary of 30' exploratory seining by bay from July 24 to August 16, 2018. Effort is defined as the total number of hauls completed per site. Data for northern pike captures are also shown.

Exploratory Seining (30') Upper St. Lawrence River					
Site	Hauls	MKY	NP	MKY CPUE	NP CPUE
A1	2	0	0	0.00	0.00
A2	2	1	0	0.50	0.00
A3	3	1	0	0.33	0.00
A4	1	0	0	0.00	0.00
Aunt Janes	1	0	0	0.00	0.00
Bartlett	2	0	0	0.00	0.00
Blind	10	0	4	0.00	0.40
Brown	4	0	0	0.00	0.00
Buck	6	0	0	0.00	0.00
Carrier	6	0	0	0.00	0.00
Delaney	10	0	15	0.00	1.50
Densmore	10	0	0	0.00	0.00
Eel	10	1	1	0.10	0.10
Escanaba	1	0	0	0.00	0.00
Ferguson Cove	3	0	0	0.00	0.00
Flynn	17	2	2	0.12	0.12
French	5	0	3	0.00	0.60
Goose	4	0	2	0.00	0.50
Grass Point	13	5	4	0.38	0.31
Jacques Cartier	2	0	0	0.00	0.00
Jolly Island	4	2	0	0.50	0.00
Long Point	4	0	9	0.00	2.25
Near Red Barn	2	0	0	0.00	0.00
Oak Point	2	0	0	0.00	0.00
Point Marguerite	4	0	0	0.00	0.00
Point Vivian	5	0	3	0.00	0.60
Red Barn	6	0	0	0.00	0.00
Roods Point	2	0	0	0.00	0.00
South Bay	5	0	3	0.00	0.60
Oak Point, Reeds Cove	3	1	0	0.33	0.00
Swan	10	3	0	0.30	0.00
Thurso	5	0	0	0.00	0.00
Webster Point	2	0	0	0.00	0.00
Whitehouse	6	0	0	0.00	0.00
Whitehouse (Waddington)	5	1	1	0.20	0.20
Windsong	4	2	5	0.50	1.25
Total	**181**	**19**	**52**	**0.10**	**0.29**

Table 6. Continued

Exploratory Seining (30') Lake St. Lawrence					
Site	Hauls	MKY	NP	MKY CPUE	NP CPUE
Waddington Beach	4	2	1	0.50	0.25
Waddington West	6	0	1	0.00	0.17
Total	**10**	**2**	**2**	**0.20**	**0.20**

Exploratory Seining (30') Eastern Lake Ontario					
Site	Hauls	MKY	NP	MKY CPUE	NP CPUE
Association	4	0	0	0.00	0.00
Muskellunge	8	0	2	0.00	0.25
Snowshoe	4	0	0	0.00	0.00
Total	**16**	**0**	**2**	**0.00**	**0.13**

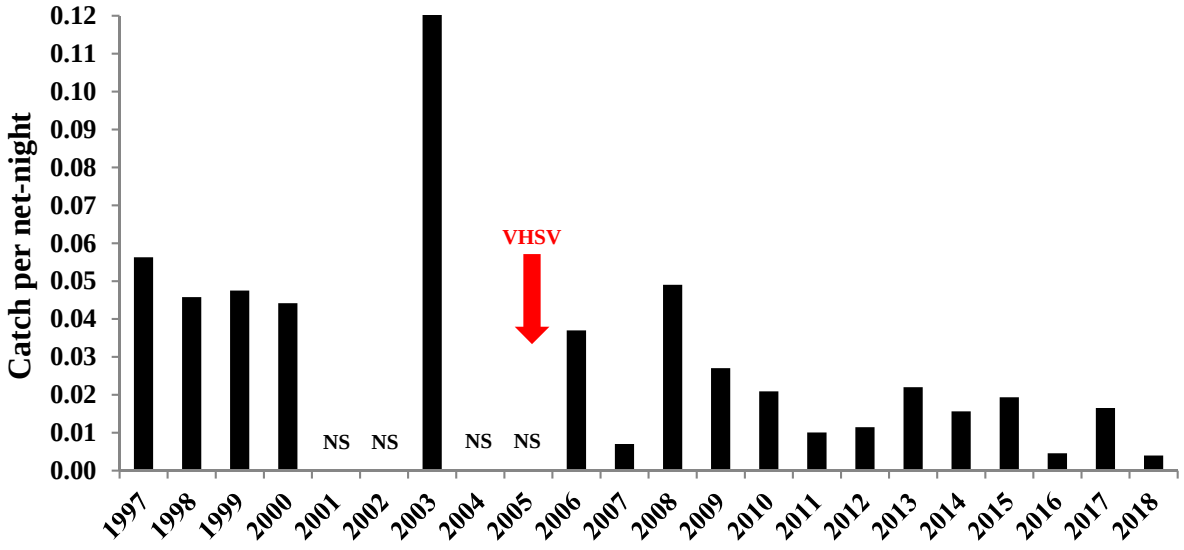

Figure 1. Total catch per net-night of muskellunge during spring trapnet sampling from 1997-2018 in the upper St. Lawrence River. Samples were not collected in 2001-02 and 2004-05 (NS) because of a decision of the Esocid Working Group to monitor muskellunge every third year. Following VHSV outbreak it was decided to resume annual monitoring.

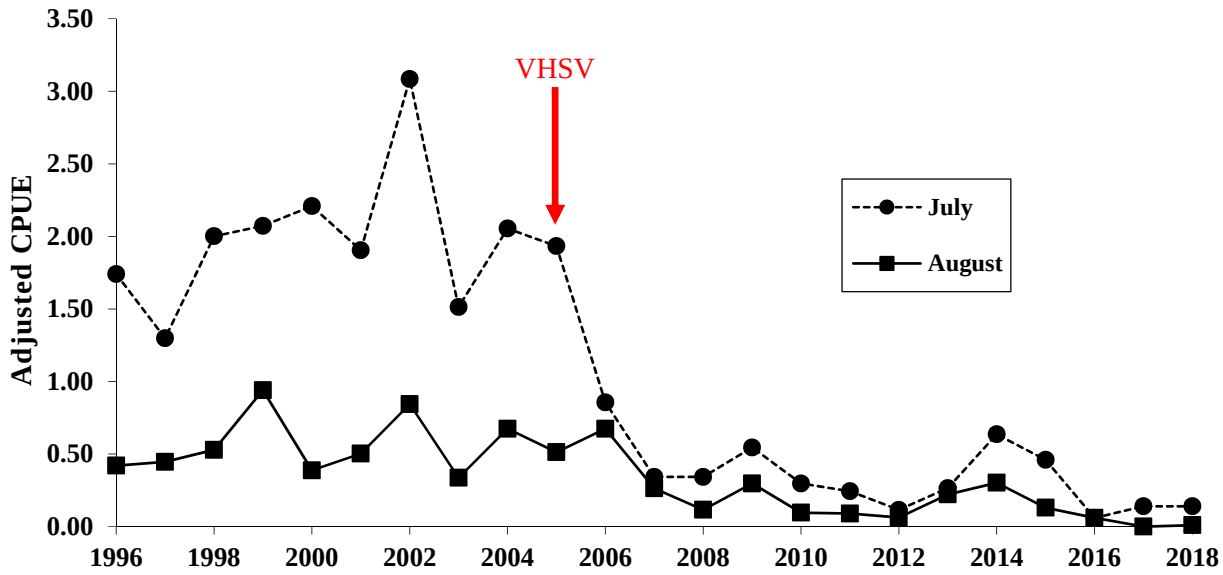

Figure 2. Catch per unit effort of YOY muskellunge captured in standardized seine hauls in eleven upper St. Lawrence River nursery sites from 1996 to 2018. A 9.14 m (30') fine-mesh seine was used during the month of July and an 18.3 m (60') large-mesh seine was used during the month of August. The fine-mesh 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.

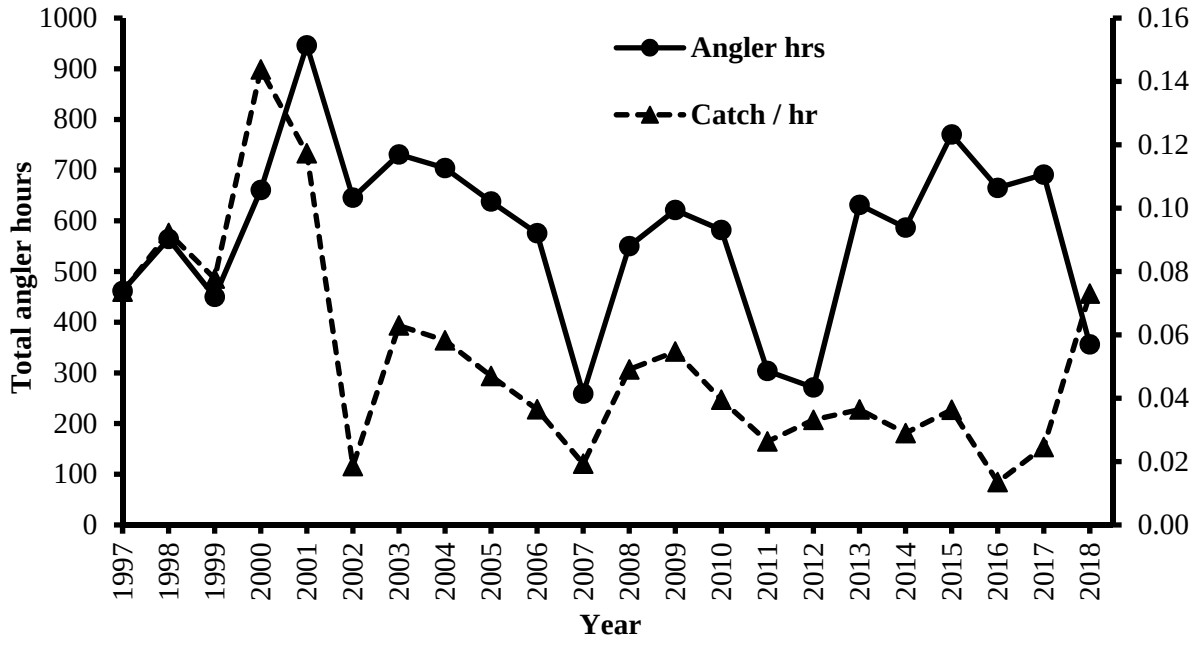

Figure 3. Thousand Islands Region Muskellunge Angler Diary Program data showing angler hours compared to average catch per angler hour. The management target goal is 0.1 fish per angler hour or 1 muskellunge per 10 hours fished. Note relationship between catch and effort over time, however, relatively high effort since 2012 has not produced large increases in catch of muskellunge.

Lake Ontario Commercial Fishery Summary, 2000 – 2018

Christopher D. Legard and Steven R. LaPan
New York State Department of Environmental Conservation
Cape Vincent Fisheries Station
Cape Vincent, New York 13618

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 2018. Commercial harvest generally targets yellow perch (*Perca flavescens*), however, harvest of cisco (*Coregonus artedii*) was also reported in 2018 (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 2018 (Table 2). Data from 1991-1999 are reported by LaPan (2005).

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Table 1. Approximate reported value ($US) of the 2018 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	38,987	$1.82	$71,133.50
White Perch	150	$0.50	$75.00
Brown Bullhead	30	$0.50	$15.00

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
2018	2	38,987	30	150	-	-	-	-	201

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

Lake trout spawning and habitat assessment at Stony Island Reef

S.L. Furgal, B.F. Lantry, and B.C. Weidel
U.S. Geological Survey, Great Lakes Science Center
Lake Ontario Biological Station, Oswego, New York 13126

J.M. Farrell
State University of New York
College of Environmental Science and Forestry
Syracuse, New York 13210

D. Gorsky and Z. Biesinger
U.S. Fish and Wildlife Service, Lower Great Lakes Fish and Wildlife Conservation Office
Basom, New York 14013

Abstract
Lake trout stocking began in the 1970s as part of a binational effort to restore a self-sustaining population of lake trout in Lake Ontario. Despite 48 years of restoration stocking, lake trout in Lake Ontario have not reestablished a self-sustaining population. Spawning surveys done at Stony Island Reef (SIR) in eastern Lake Ontario in 1987 and 1989 documented lake trout egg deposition and swim-up fry. Bottom trawls in the early 1990s found naturally-reproduced juvenile lake trout in this region of the lake. More recently, naturally-reproduced juveniles have been found in western Lake Ontario, but few have been found near SIR in the eastern basin. In 2017 and 2018, we examined SIR spawning habitat and lake trout egg deposition rates and compared them to historical values. The average interstitial depth observed in 2018 was less than 4 cm, and the maximum depth observed was 15 cm. These interstitial depths are greatly reduced from depths up to 45 cm reported in the 1980s. Only one egg was captured in 95 egg nets deployed during the spawning period, which resulted in a CPUE of 0.00035 eggs/net/day, markedly lower than the egg densities measured at SIR in 1987 and 1989 of (1.27 eggs/net/day and 0.27 eggs/net/day respectively). Observations of the cobble spawning habitat suggested interstitial spaces were more infilled relative to conditions observed in the 1980s. Infill material was heavily comprised of dreissenid mussels shells and shell fragments. These findings indicate that changes in lake trout spawning habitat may be inhibiting lake trout reproduction at SIR.

Introduction

Lake trout were functionally extirpated from Lake Ontario by the 1950s as a result of the impacts from overharvest and sea lamprey predation (Schneider et al. 1996). In the 1970s, restoration efforts began, which included stocking hatchery raised fish and the implementation of a sea lamprey control program (Elrod et al. 1995; Schneider et al. 1996). The fish community objectives for Lake Ontario detail a goal of restoring self-sustaining populations of lake trout (Stewart 2017). Historical accounts from commercial fisheries described catches of lake trout in the eastern basin of Lake Ontario during spawning season, indicating the possibility of nearby spawning habitat (Christie 1973).

Marsden and Krueger (1991) located high functioning lake trout spawning habitat in the eastern basin of Lake Ontario during the 1980s and 1990s in an area off the northeastern tip of Stony Island, referred to as Stony Island Reef (SIR; Figure 1). The area was characterized by cobble substrate, interstitial spaces exceeding 45 cm, close proximity to a sloped bank leading down to depths of 20 m, and close proximity to deep, cold, nursery habitat; which is important as lake trout fry are not strong swimmers (Humphrey 2011). Adult lake trout were observed by divers on the reef at spawning time in the 1980s, and substantial lake trout egg deposition was recorded, with a peak egg deposition rate of 1.27 eggs/net/day in 1987 (Marsden et al. 1988; Marsden and Krueger 1991; Fitzsimons 1995; Schneider 1985). Survival past the fry stage was first observed in Lake Ontario in 1994, when juvenile lake trout were captured in bottom trawls near SIR (Lantry et al. 2018; Schneider et al. 1997). Since that time, annual bottom trawls and gillnet collections have indicated that the abundance of adult stocked lake trout near the reef has declined, and few naturally reproduced juveniles have been collected in the surrounding sites. In recent years, the majority of naturally reproduced juvenile lake trout have been observed in the western end of the lake near the mouth of the Niagara River region (Figure 1) (Lantry et. al 2018).

Habitat and lake trout egg deposition at SIR was last evaluated in the 1980s. Since then, Lake Ontario has undergone changes that could influence lake trout spawning success including improved sea lamprey control (Lantry et al. 2018), decreased contaminant concentrations (Mills et al. 2003), more diverse lake trout diet (Dietrich et al. 2006), higher levels of thiamine in spawning adults (Jacques Rinchard, State University of New York College at Brockport, personal communication), a decrease in alewife abundance (Weidel et al. 2018), and dreissenid mussel and round goby invasions (Mills et al. 2003). Considering these recent ecosystem shifts, and large catches of young naturally reproduced lake trout from western basin of Lake Ontario, there is growing interest amongst fisheries managers and scientists to better understand lake trout spawning proximate to SIR and to assess the current quality of habitat at this location. In response to a request from the Great Lakes Fishery Commission, Lake Ontario Technical Committee to reexamine lake trout spawning habitat at Stony Island Reef, this study sought to: (1) quantify current egg deposition occurring on SIR, (2) assess habitat conditions on and around SIR, and (3) compare results to previous measurements and observations.

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 2018 is publicly available from the GLSC website (http://doi.org/10.5066/F75M63X0) and the data from the current study will be served in that database. 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

Egg Deposition

To measure current egg deposition rates and contrast those with previous observations, we deployed the same egg nets on SIR that were used by Marsden and Krueger (1991). Egg nets were constructed of a PVC ring measuring 8 in in diameter and 1.6 in in height, which were covered with a rigid plastic screen with 1 0.39 in openings and attached to the PVC ring with cable ties. Wrapped around the PVC ring was a 23.6 in long nylon net with 0.12 in mesh, which was secured with cable ties. Approximately 5.3 oz of lead weight was tied into the bottom to keep the egg nets upright during deployment and retrieval. (Horns et. al 1989; Marsden and Krueger 1991). Over the period of November 1-30, 2017, 95 egg nets in total were used to sample lake trout eggs deposited on SIR. Ten egg nets were strung together on a nylon rope approximately 6 ft apart to form one string. Five of these strings were deployed on the reef, anchored at both ends with anchors and marked with on the water surface with buoys tethered to the anchors. The strings were deployed for the first time November 1-13, then again a second time from November 13-30.

Spawning Habitat

On November 14, 2017 a crew from USGS and University of Vermont (UVM) scientists used the R/V Kaho to deploy a remotely operated vehicle (ROV) with live stream and video recording capabilities for 4 hours of observation on SIR. Video and still images of the habitat and fish species on the reef were taken with the intent to visually document the presence of spawning lake trout.

On June 25-26, 2018, USGS and USFWS scientists and divers surveyed four 100 m long transects on and around SIR. Transects were defined by anchoring a metered line, marked at 1-meter increments, at both ends with a buoy attached to a single end. Transects were generally oriented in an east-west direction with transect B being the most northernly, and transect D the most southerly. Transects spanned across contours at depths ranging from 4-10 m (Figure 2). On each transect, divers recorded approximately 5 interstitial depth measurements at 10 evenly spaced locations and recorded observations of infilling.

Results and Discussion

Egg Deposition

A total of 95 egg nets deployed over the course of the sampling period yielded only one egg, which resulted in a CPUE of 0.00035 eggs/net/day. The single egg captured measured 5 mm in diameter and was preserved in 95% ethanol. Based on size, location, and season (i.e. prior to the coregonine spawning period), the collected egg was assumed to be a lake trout egg (George et al. 2017; Lantry et al. 2008). Egg densities measured at SIR in 1987 and 1989 (1.27 eggs/net/day and 0.27 eggs/net/day respectively) were four orders of magnitude higher than what we observed in 2017 (0.00035 eggs/ net/day) (Marsden and Krueger 1991). A t-test confirmed significant difference between the 2017 and 1987/1989 egg densities.

Spawning Habitat

ROV video observation took place on SIR during the expected peak period for lake trout spawning, however, after 4 hours of observation, only a single pair of lake trout was observed, and no spawning was witnessed. Instead, we were able to

document a serious degradation in the quality of lake trout spawning habitat on SIR by comparing the ROV images with a photo taken on SIR during 1987-1988 (J.E. Marsden, University of Vermont, Personal Communication; Figure 3). While the images cannot be georeferenced to know the precise location on the reef, we are confident that they were taken in similar areas on SIR.

Dreissenid mussel shells, shell fragments, and fine sediments were observed by divers at every sampling point along all four transects sampled in 2017. The average interstitial space depth for all transects was less than 4 cm and the maximum observed was 15 cm (Figure 4). This is considerably less than previous studies of SIR, which reported interstitial space depths up to 45 cm (Marsden and Kruger 1991). Lake trout eggs require interstitial spaces for survival, as they provide protection from predators as well as protection from displacement by wave or current energy (Marsden at al. 1995). The lack of available interstitial space, as measured during this recent assessment, could result in lake trout eggs being damaged, dislodged, or consumed by egg predators and may have acted as a behavioral deterrent to lake trout spawning there.

Additionally, the physical presence of dreissenid mussel alters the substrate, and shell fragments have the potential, as seen in this study, to alter the interstices. Much of the substrate in Lake Ontario now has a high coverage of dreissenid mussel patches, with hard substrates such as bedrock and cobble having the highest coverage (Wilson 2006). As lake trout are known to preferentially spawn on clean cobble with deep interstitial spaces, dreissenid mussel colonization on this substrate type could have negative impacts on lake trout spawning success in Lake Ontario.

With lake trout known to be highly selective when choosing spawning sites (Marsden et al. 1995), there is a likelihood that the degraded conditions observed at SIR are deterring egg deposition, as few lake trout were observed spawning there. Further study of lake trout spawning habitat quality in Lake Ontario is needed to determine if habitat is limiting natural reproduction of lake trout. However, increased catches of wild juvenile lake trout near the Niagara River suggest that conditions fostering in-lake reproduction for lake trout may be favorable if good spawning habitat is available.

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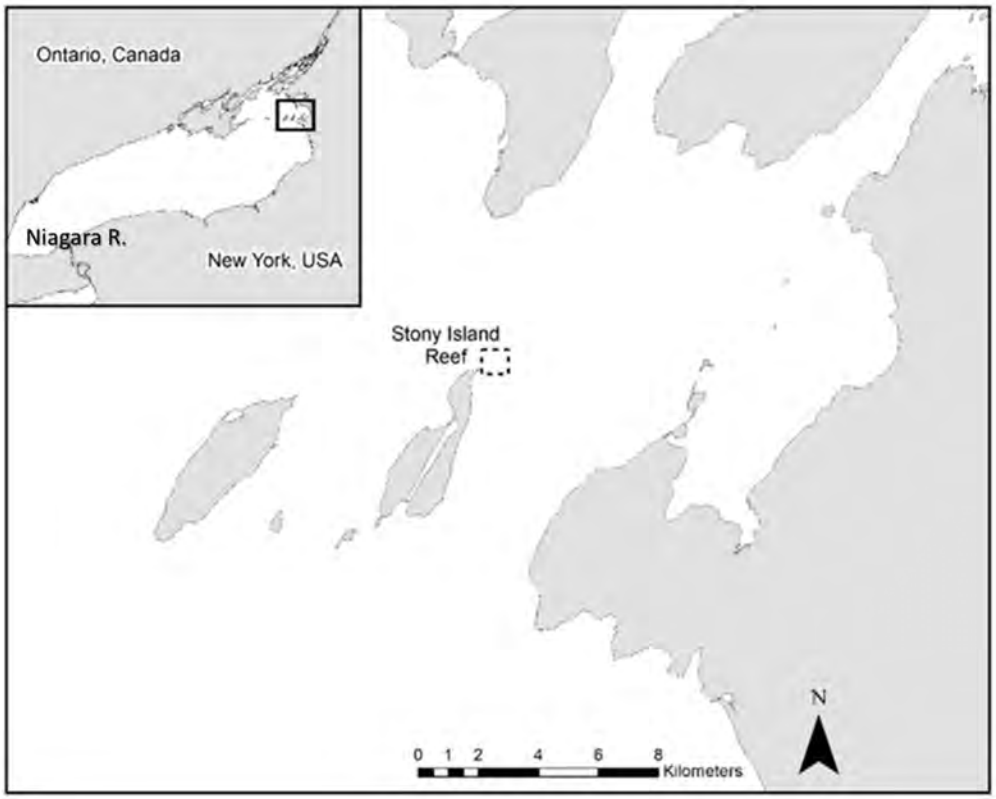

Figure 1. Lake trout egg deposition and spawning habitat study site, Stony Island Reef, off the northeastern top of Stony Island in the eastern basin of Lake Ontario, NY.

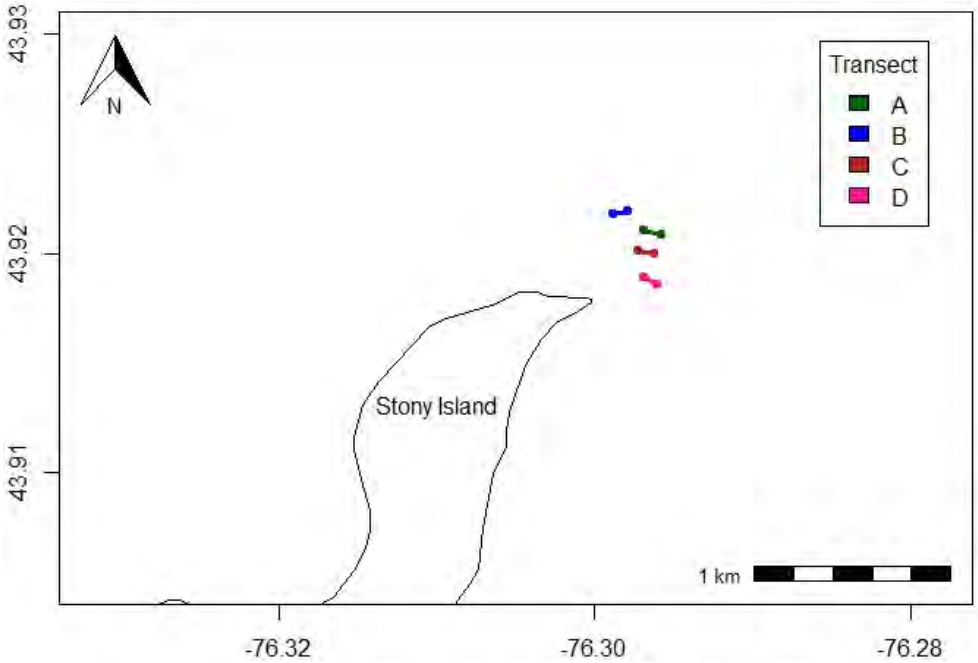

Figure 2. Locations of dive transects A-D, beginning on the reef (western end) and ending off the reef, down a slope in approximately 10m of water.

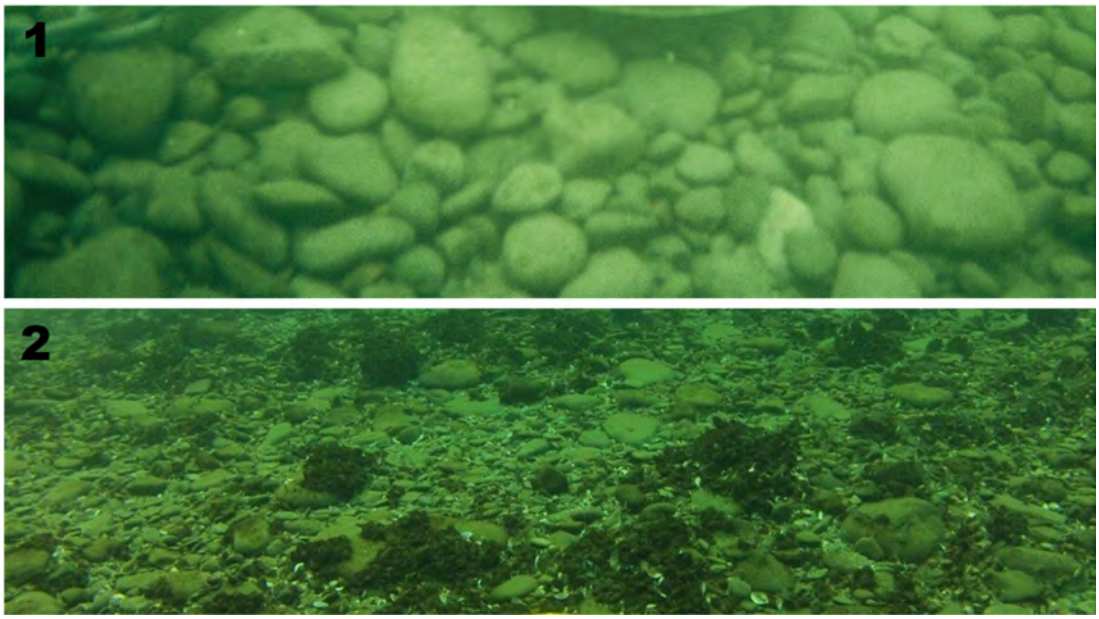

Figure 3. Image 1 (taken by J.E. Marsden) shows the substrate on Stony Island Reef during 1987-88. Image 2 (taken with an ROV) shows the condition of the substrate in 2017.

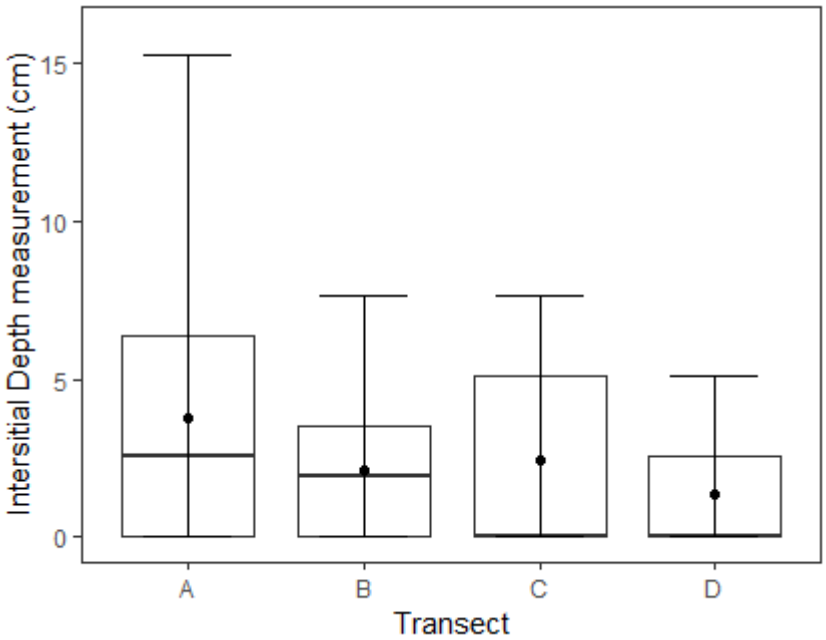

Figure 4. Box plot of interstitial depth measurements across the four transects sampled by divers on Stony Island Reef during June 2017. The bottom of the box represents the minimum value, the thicker black line represents the median which divides the first and third quartiles. Means are shown with a black dot.

2018 Administrative Program Summary Report for the Sportfishing Restoration & Spending Plan for the Lake Ontario System

Steven R. LaPan and Christopher Balk[1]
New York State Department of Environmental Conservation
Cape Vincent, New York 13618
[1]*Watertown, New York 13601*

Background

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

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

Natural Resources Damages Assessment

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

Funds recovered as a result of a NRD claim are to be used to restore/enhance either the injured natural resources themselves, or the services provided by the lost or injured natural resources. In general, the use of NRD funds to restore injured resources is preferred, followed by "replacement." If neither of these approaches is possible or practical, then equivalent resources could be acquired.

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

Settlement damages were calculated by measuring the difference between the value to anglers for fishing for contaminated fish in the Lake Ontario system, and what the value would have been if the fish had not been contaminated. This $12 million NRD settlement is one of the largest in the nation based on lost recreational fishing use. The $12 million settlement was apportioned to include $10.8 million for projects and $1.2 million for fund

administration. Administrative funds were exhausted in 2015.

Restoration Planning and Public Outreach

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

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

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

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

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

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

DEC conducted a series of 5 public meetings across the geographic area covered by the settlement to solicit potential project ideas. Project ideas were also solicited from other government agencies (state, federal and local), tribal entities, and non-government agencies. A committee of Department personnel consisting of the Chiefs of the Bureaus of Fisheries and Habitat, Great Lakes Fisheries Section Head, Regional Fisheries Managers from DEC Regions 6 through 9, Lake Ontario Unit Leader, Natural Resources Damage Unit Leader, and Lake Ontario Natural Resource Damages Coordinator developed project review criteria, and scored/ranked project proposals.

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

Status of Projects and Project Fund Accounts

Of the $10.8 million allocated to project implementation approximately $6.31 million has been expended to date on completed and ongoing projects (Tables 1 and 2). An additional $4 million is currently obligated toward ongoing projects.

As anticipated in the *Plan*, issues relating to engineering, availability of other funding sources, land acquisition, contract bidding, project planning and development, and other practical concerns hindered efforts to implement all projects in priority order, and prevented implementation of some projects altogether. As provided by the *Plan*, funds from cancelled and/or modified projects are being used for implementation of other, higher-ranking projects:

- $1.4 million from cancelled project #19 Cape Vincent hatchery improvements, transferred to #1 Salmon River Hatchery capital improvements.
- $353,000 re-allocated from #38 Port Bay West access to #7 Golden's Marina renovation.
- $9,410 re-allocated from #38 Port Bay West access to #10 Sandy Creek fishing access site.
- $100,000 transferred from cancelled project #42 Construct walkways on existing piers ($500,000) to #5 Salmon

River streambank stabilization and trails; also $100,000 transferred to #29 Pen rearing program assistance.

- Consolidation of project #s 16, 23 and 40 into renamed project #16 "St. Lawrence River wetland enhancements" ($295,000).

Enhancing the Value of this Settlement

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

Completed Projects

Completed projects described below are listed with their project priority number from the *Plan*. A summary of expenditures to date is presented in Table 1.

3. **Lindsey and Stony Creeks Angler Parking Areas, Jefferson Co. -** The five-car Stony Creek angler parking area on Jefferson County Rt. 152 and the six-car Lindsey Creek angler parking area on Jefferson County Rt. 87 were completed by DEC Region 6 Operations staff. These projects required $11,687 of the $20,000 allocation.

4. **OPRHP Lower Niagara River Access Trails at Artpark –** A Memorandum of Understanding with OPRHP was used to plan, administer and execute four angler access projects in the Niagara region (also project #s 11, 20 & 32). LONRD funding for these projects totaled $425,000, with additional funds and in-kind services exceeding $1.5 million (OPRHP capital funding and design, engineering and administrative work, as well as the New York Power Authority Greenway Fund). LONRD funds totaling $25,000 were used to install concrete piers for a new stairway in Artpark constructed by OPRHP. LONRD project costs totaled $25,000. In addition, the Service provided funds to install a gangway and floating fishing dock opposite Artpark's main stage.

6. **Village of Lewiston Boat Launch, Niagara Co. -** This $74,551 project was completed through a state assistance contract with the Village of Lewiston resulting in the replacement of the existing two-lane boat launch and docks, and improvements to the fish cleaning station and restroom facilities. Additional services and funds included BOF-funded design and administrative oversight from the Village of Lewiston.

7. **Golden's Marina Renovation, Jefferson Co. –** This $648,486 project is located on Jefferson County Rt. 57 at "the Isthmus," and included construction of a new two-lane concrete boat launch, parking for 25 cars and trailers, and ten additional parking spaces. New dockage was installed, and a universally accessible fishing site was created. The marina was purchased with EPF, and the site was designed with BOF-funded engineering. Construction was executed through a competitive bidding process.

8. **Boat Launch/Ice-fishing Access on Sandy Pond, Oswego Co. –** This project required acquisition of the former Groman Shores property on Sandy Pond. Design and construction were completed by DEC Operations staff. The parking lot was completed in October 2015, with the 20 foot wide concrete launch installed in May of

2016. In September 2017 the Town of Sandy Creek entered into a formal agreement with DEC for snow plowing the access road and parking lot. The Town took ownership of the road leading to the launch from Route 3 (Stanley Drive) in March 2018. The new parking lot has a capacity of 20 truck/trailer vehicles as well as 24 single vehicles. Project costs totaled $348,683.

10. **Sandy Creek Fishing Access Site, Monroe Co. -** This 50 car and trailer launch site was re-surfaced as described in the *Plan.* This project required $34,410 in LONRD project funds, necessitating the transfer of an additional $9,410 from the defunct Port Bay West Project (#38).

11. **OPRHP Trails at Schoelkopf Ruins site –** The goal for this site was to provide safe angler access to the water's edge at two locations, one each north and south of the Maid of the Mist Landing. The northerly site required construction of steps down 25 vertical feet of steep slope, while the southerly site required construction of an at-grade trail across areas of rubble. LONRD project costs totaled $78,200; OPRHP contributions included design work and project administration.

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

14. **Maxwell Creek Fishing Access Site, Wayne Co. –** Paving this 40 car gravel/dirt parking lot was completed as described in the *Plan*. This project required $53,115, requiring an additional $3,114 in funds from the defunct Port Bay West project (#38).

17. **Town of Wilson Boat Launch, Niagara Co. –** This project was completed through a state assistance contract with the Town of Wilson, resulting in the replacement of a single lane boat launch and installation of new floating dockage and erosion armoring. The new floating docks have improved overall use and enhanced universal accessibility. This project used $29,952 in NRD funds and approximately $14,205 of additional funding from the Town of Wilson. BOF-funded engineering/design work provided additional in-kind services.

18. **Boat Launch at Mud Bay, Jefferson Co. –** This new fishing access site was completed by Region 6 Operations staff and features two gravel parking lots and a 20' wide car-top boat launch. The upper parking lot (240' x 50') accommodates approximately fourteen cars and trailers. The lower lot (100' x 200') accommodates approximately ten cars and trailers. This site also provides public access to a popular walleye ice fishery in Mud Bay. LONRD project costs totaled $50,010.

20. **OPRHP Fort Niagara Boat Launches –** OPRHP designed, planned, largely funded and executed this project including two new boat launch slabs, installation of seasonal floating docks, an ADA floating boarding pier (north launch) and an ADA floating fishing dock (south launch), as well as removal of concrete shoreline protection and replacement with stacked quarried stone blocks. Total project cost was $979,106, with $308,800 in LONRD funds used.

21. **Slater Creek Fishing Access Site, Monroe Co.** – The parking area at this site was reduced in size to better reflect typical site use, and the un-used parking area was reclaimed to provide picnic/recreation space. Following project completion by Region 8

Operations staff, DEC transferred site operation and maintenance responsibilities to the Town of Greece. This site now features a newly paved 40 car parking area and accessible fishing platform enhancements. This project used $42,703 of its $75,000 allocation.

22. **Lake Ontario Watershed Display at the Niagara Falls Aquarium, Niagara Co. –** This $288,403 project was planned and executed by Aquarium staff and contractors, with additional funding from the Aquarium of Niagara and in-kind services. The project created a Great Lakes Gallery, including three new living exhibits: a 10,000 gallon Lake Ontario/Lower Niagara River, fish community tank, a 200 gallon tank housing juvenile lake sturgeon to highlight restoration/conservation efforts, and an 800 gallon invasive species tank used to educate the public on the ecological perils of nuisance aquatic invasive species (NAIS) and how to help stop the spread of NAIS.

25. **Irondequoit Creek Streambank Stabilization, Monroe Co. –** This project was executed through a state assistance contract with the County of Monroe, with assistance from the Service. The project enhanced 15 sites; 13 in Power Mills Park, and two in Ellison Park. Aquatic habitat restoration primarily entailed installing toe-wood structures in areas where bank erosion contributed to deteriorated aquatic habitat. Other restoration techniques included creation of rock v-weirs. Additionally, 1,000 native trees, shrubs, and perennials were planted to control erosion and provide shading. Project costs totaled $117,609, with additional funds and in-kind services from the County of Monroe (property acquisition and staff time) and the Service (engineering and staff time).

26. **Deepwater Cisco Reintroduction in Lake Ontario** – DEC, in partnership with the Great Lakes Fishery Commission (GLFC), the Ontario Ministry of Natural Resources and Forestry (OMNRF), USGS and the Service implemented this project. A $50,000 technical service contract was established with the GLFC, and all funds were expended on contracts with Lake Michigan commercial fishers to collect spawning bloaters for egg collections. Those egg collections enabled extensive research leading to development of the first techniques for culturing deepwater coregonines, the establishment of the first captive bloater brood stock, and the stocking of several hundred thousand juvenile bloater. Additional funds and in-kind services are provided by the OMNRF, DEC, GLFC, Service, USGS and $305,000 in Great Lakes Fish and Wildlife Restoration Act funding.

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

30. **Salmon River Hatchery Aquaria/ Interpretive Displays, Oswego Co. –** The Salmon River Hatchery hosts more public visitors annually than any other DEC facility. Defunct aquaria in the hatchery lobby have been replaced with a state of the art aquarium system serving as the center piece of public displays at this facility. The entire $100,000 LONRD fund allocation was used for this project, with an additional $40,485 in BOF funding. In-kind services were provided through BOF-funded engineering and design work and Salmon River Hatchery staff time. An additional $500,000 in funding was recently announced that will significantly enhance sportfishing outreach at this important facility.

32. **OPRHP Fourmile Creek State Park –** This project involved the construction of a 5 space parking lot and an angler trail. Total project costs were $24,000, using $13,000 in LONRD funds. Additional OPRHP contributions included design work and project administration.

33. **Multi-frequency Acoustic Analysis for Estimating Alewife Abundance in Lake Ontario -** A $47,431 Biosonics echo sounder (sonar device) used to estimate preyfish abundance in Lake Ontario has been acquired by the DEC Lake Ontario Fisheries Unit. This equipment employs state of the art technology that has improved the accuracy of Lake Ontario hydroacoustic preyfish surveys.

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

37. **Locate Areas Where Lake Trout Spawn in the Lower Niagara River** – This research study partnership between DEC and the Service required the purchase of acoustic telemetry tags and receivers to track the location of spawning lake trout. This $48,221 project has been augmented through substantial Service funds and staff time.

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

Table 1. Provisional summary of expenditures to date for completed projects (Total with funds reallocated from other projects**).***

Project Rank	Project Title	Allocation*	Expenditures	Remaining
3	Lindsey and Stony Creek Angler Parking Areas	$ 20,000	$11,687	$8,313
4	OPRHP Lower Niagara River Access Trails in Artpark	$ 150,000	$25,000	$125,000
6	Village of Lewiston Boat Launch Improvements	$ 75,000	$74,551	$449
7	Golden's Marina Renovation	**$ 648,486**	$648,486	$0
8	Boat Launch/Ice-fishing Access on Sandy Pond	$ 500,000	$498,563	$1,437
10	Sandy Creek Fishing Access Site	**$ 34,411**	$34,411	$0
11	OPRHP Trails; Schoelkopf/ Whirlpool/ Devil's Hole	$ 150,000	$78,200	$71,800
13	Enhance Fish Island Access Site at Dexter	$ 45,000	$45,000	$0
14	Maxwell Creek Fishing Access Site	**$ 53,115**	$53,115	$0
17	Town of Wilson Boat Launch improvements	$ 30,000	$29,952	$48
18	Boat Launch at Mud Bay	$ 100,000	$50,010	$49,990
20	OPRHP Fort Niagara Boat Launch	$ 50,000	$308,800	-$258,800
21	Slater Creek Fishing Access Site	$ 75,000	$42,703	$32,297
22	Lk. Ont. Watershed Display at the Niagara Falls Aquarium	$ 300,000	$288,403	$11,597
25	Irondequoit Creek Stream bank Stabilization	$ 250,500	$117,609	$132,891
26	Deepwater Cisco Reintroduction in Lake Ontario	$ 50,000	$50,000	$0
27	Public Access Improvements, Village of Morristown	$ 50,000	$50,000	$0
30	Salmon River Hatchery Aquaria/ Interpretive Displays	$ 100,000	$100,160	-$160
32	OPRHP Four Mile Creek State Park, Niagara Co.	$ 75,000	$13,000	$62,000
33	Multifrequency Acoustic Analysis for Estimating Alewife Abundance in Lake Ontario.	$ 55,000	$47,431	$7,569
34	Olcott Pier Access Improvement	$ 100,000	$53,803	$46,197
37	Locate Lake Trout Spawning areas in the Lower Niagara	$ 50,000	$48,221	$1,779
39	Sea Lamprey Control Barrier Fund	$ 60,000	$60,000	$0
	Totals		**$2,729,103.80**	**$292,408.20**

Ongoing Projects

Projects described in this section are in various stages of development and implementation. A summary of current and anticipated expenditures is presented in Table 2.

1. **Improvements to the Salmon River Hatchery –** In addition to an ongoing contract investigating and designing a partial water re-use system, the following projects have been completed:
   - Hydrogeological resistivity study to locate ground water resources
   - Drilling of additional test wells
   - Reservoir pipeline cleaning
   - Well rehabilitation (will be a recurring need in the future).
   - Purchase/installation of new well pumps and monitoring equipment.

   Approximately $1.39 million has been expended to date, with $2.2 million remaining.

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

knowledge of Lake Ontario fisheries that was previously impracticable.

To date, $1,447,857 of the $1.5 million allocated to this project has been expended. With new marking and tagging projects in development, the remaining funds will be used by the end of fiscal year (FY) '19.

5. **Salmon River Streambank Stabilization and Trail Project** - Project #5 was delayed awaiting the Department's acquisition of approximately 1,700 acres adjacent to the Lower Salmon River in a settlement agreement with National Grid. Upon acquisition, the Department developed a Lower Salmon River Restoration and Recreation Plan (River plan; http://www.dec.ny.gov/outdoor/113223.html) to guide restoration and management activities. A phased approach to River restoration and trail enhancement/development outlined in the River plan was in part based on the recognition that the initial $500,000 Plan allocation would be insufficient to complete all required work. In partnership with Service staff, the Department developed plans for several additional River restoration structures. Phase 1 of the work is focused on the construction of 4 rock "in-stream" habitat restoration structures (3 W-weirs and one vane) and the installation of toewood bank stabilization/habitat improvement structures and secondary channel blocks in the Lighthouse Hill Reservoir and Ellis Cove areas. The rock structures were built in summer 2018 at an expense of $304,894. An additional $100,00 has been transferred from cancelled project #42 for ongoing work in 2019.

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

12. **Fisheries Promotion Assistance -** This project entailed a collaboration with the Lake Ontario Sport Fishing Promotion Council to re-design a new Great Lakes Fishing brochure ($39,000). To cover ineligible costs related to promotion of Lake Erie and Upper Niagara River fisheries in the brochure, $10,000 of Federal Aid in Sport Fish Restoration funds were used for the project. Additional in-kind services were provided by DEC Office of Communication Services staff, Central Office BOF staff, and regional BOF staff. Additional project ideas are under consideration.

15. **Port Bay (East) Fishing Access Site, Wayne Co. –**This project is on hold due to ongoing issues with a breach in the barrier bar and plans to potentially re-build the barrier, requiring the proposed parking area to be used as a construction staging area.

16. **Northern Pike Spawning Marsh Rehabilitation –** Project #s 16, 23 and 40 have been consolidated into renamed project #16, **"St. Lawrence River wetland enhancements"** ($295,000). These funds will contribute to ongoing efforts of the Service, SUNY College of Environmental Science and Forestry, and Ducks Unlimited to enhance fish spawning and nursery habitat through the creation of spawning pools and access channels in cattail (*Typha)* mats in the Upper St. Lawrence River.

24. **Upgrade Hatchery Pond Complex at Lisbon, NY –** Since the mid-1980s, the St. Lawrence Valley Sportsman's Club (Club) has used a former DEC hatchery currently

owned by OPRHP to raise walleye fingerlings for stocking into the St. Lawrence River. The project entails the rehabilitation and clay-lining of two additional one-acre ponds to increase existing walleye production. OPRHP and DEC staff have worked with the Club on plans to improve the ponds, however, a series of logistic and administrative hurdles have delayed implementation while the condition of the ponds has deteriorated.

Given that walleye numbers in the lower Oswegatchie River spawning run have grown dramatically, and the New York Power Authority and the Service have enhanced walleye spawning habitat in Brandy Brook and Little Sucker Brook, respectively, DEC is considering cancelling this project and transferring the $100,000 in funds to a future walleye spawning habitat enhancement project. DEC staff will consult with stakeholders on this issue in 2019.

28. Sodus Bay boat launch, Wayne Co. – DEC Region 8 BOF staff continue to pursue potential properties for sale that would allow this project to advance.

29. Pen Rearing Program Assistance – Extensive studies made possible under Plan project #2 (Mass marking/tagging trailer) have documented that Chinook salmon reared in net pens by cooperating sportsmen survive approximately 2X better than traditional, direct-stocked fish. Additionally, evidence suggests that survival of steelhead reared in net pens may be increased over 7X that of traditionally stocked fish. For these reasons, DEC has transferred an additional $100,000 to this project from cancelled project #42. Increasing funding to project #29 will allow DEC to encourage and support additional net pen rearing projects, thereby enhancing Chinook salmon and steelhead sportfishing quality. Sportsmen's groups have contributed substantial funding and volunteer time in pen construction and maintenance.

31. Walleye Spawning Habitat Enhancement Fund – DEC Region 6 and Lake Ontario Unit staff, and USGS staff have identified several areas of the Black River at Dexter suitable for enhancing walleye spawning habitat. Necessary planning and permitting activities are underway. Additional funds and in-kind services for this project will come from BOF, USGS and Service staff time. The Service's FEMRF could also contribute to this project, as well as future projects in other tributaries.

35. Improvements to Cape Vincent Aquaria/Interpretive Displays – To date, new fish display placards highlighting life history descriptions for each of the fish species on display at the aquarium have been developed, printed and installed. New static displays are currently being developed, including fish mounts, and two new computers have been purchased that will serve as interactive exhibits at the visitor center. Staff time from DEC's Office of Communication Services for display design and development provided in-kind services for this project. The facility also received extensive renovations totaling over $75,000 in capital funding due to flooding in 2017.

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

Table 2. Provisional summary of expenditures to date and anticipated expenditures for "ongoing projects." Ongoing projects include those in various stages of development and implementation. (*Total with funds reallocated from other projects).

Project Rank	Project Title	Allocation*	Expenditures	Remaining	Status
1	Improvements to the NYSDEC Salmon River Fish Hatchery	$ 3,600,000	$1,386,285	$2,213,715	ongoing
2	Mass marking/tagging trailer	$ 1,500,000	$1,447,857	$52,143	ongoing
5	Salmon River Streambank Stabilization/Trail Project	$ 600,000	$304,894	$295,106	ongoing
9	Chaumont Bay Boat Launch Sites and Ice-fishing Access	$ 500,000	$270,174	$229,826	ongoing
12	Fisheries Promotion Assistance	$ 100,000	$39,000	$61,000	ongoing
15	Port Bay (East) Fishing Access Site	$ 2,000	$0	$2,000	ongoing
16	St. Lawrence River Wetlands Enhancements	$ 295,000	$0	$295,000	ongoing
24	Upgrade Hatchery Pond Complex at Lisbon, NY	$ 100,000	$0	$100,000	ongoing
28	Sodus Bay boat launch, Wayne Co.	$ 500,000	$0	$500,000	ongoing
29	Pen Rearing Program Assistance	$ 120,000	$15,000	$105,000	ongoing
31	Walleye Spawning Habitat Enhancement Fund	$ 200,000	$0	$200,000	ongoing
35	Improvements to Cape Vincent Aquaria/Interpretive Displays	$ 40,000	$2,742	$37,258	ongoing
36	Add. ice-fishing access on Sodus and Blind Sodus Bays,	$ 50,000	$0	$50,000	ongoing
	Totals		**$3,465,952.14**	**$4,141,047.86**	

Table 3. Summary of cancelled projects and disposition of funds.

	CANCELLED PROJECTS	Allocation*	Expenditures	Remaining	NOTES
19	Hatchery Improvements at Cape Vincent Fisheries Station	$ 1,400,000		$0	Re-Allocated to #1. Salmon River Hatchery Improvements
23	Repair Cranberry Creek Marsh Water Control Structure	$ 50,000		$0	Re-Allocated to #16. St. Lawrence R. Wetlands
38	Port Bay West access road project	$ 500,000		$0	Re-Allocated to project #s 7, 10, & 14
40	Experimental Techniques to Enhance Submergent Vegetation Growth and Efficacy of Artificial Spawning Habitat	$ 45,000		$0	Re-Allocated to #16. St. Lawrence R. Wetlands
41	Reconfigure the Waterport Dam tail races on the Oak	$ 50,000		$0	
42	Construct walkways on any existing piers or breakwalls	$ 500,000		$300,000	Re-Allocated to #16. St. Lawrence R. Wetlands
	TOTAL			$300,000	

Cancelled Projects - Several projects are no longer under consideration for implementation due to a number of issues (Table 3):

19. **Hatchery Improvements at Cape Vincent Fisheries Station –** Proposed capital improvements to the defunct hatchery infrastructure at the Cape Vincent Fisheries Station were deemed unnecessary and impracticable for a host of reasons. Walleye populations in Eastern Lake Ontario and the St. Lawrence River are relatively high and stable, and currently provide quality fisheries. Walleye spawning habitat enhancements (project #31) can be much more successful and cost-effective, including a recent project completed on Kents Creek (Lake Ontario tributary in Jefferson County) using FEMRF funds. Rearing other species at this facility would require additional human and fiscal resources from the BOF in an era when meeting the needs of the existing, 12 hatchery system is challenging. Lastly, repairs required at the facility were underestimated and would likely require funds exceeding the project allocation. Considering the above, the $1.4 million appropriated to this project will be reallocated to augment funding for improvements at the Salmon River Hatchery (SRH). The SRH improvement project is the highest ranked project and will require

funding beyond its original allocation. The SRH rears the majority of trout and salmon stocked into Lake Ontario, and stakeholders continue to express concerns that improvements to SRH have not been completed.

23. Repair Cranberry Creek Marsh Water Control Structure – The goal of this project was to provide quality spawning habitat for northern pike in the Thousand Islands region. Given unfavorable evaluations of juvenile pike production in managed spawning marshes, the $50,000 allocated for this project has been re-allocated to project #16.

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

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

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

42. Construct walkways on any existing piers or breakwalls – Since no viable project proposals have been advanced, DEC has cancelled this project. To date, funds from this project have been re-allocated to projects #5 ($100,000) and #29 ($100,000).

Pugnose shiner range expansion in New York's St Lawrence River, 1931-2018

Doug Carlson, Rodger Klindt and Jeff Maharan

NYSDEC Region 6 Fisheries Unit

Watertown, New York 13601

Pugnose shiner (*Notropis anogenus*) is an Endangered Species in New York State. Its range in the St. Lawrence River is monitored to provide habitat protection and to document changes in population range. Several survey programs, from 1976 to 2018, provide an update and summary of known occurrences on the New York waters of the St. Lawrence River. The distribution of pugnose shiner in the St. Lawrence River has increased dramatically in the last 25 years. Survey efforts have registered them as more widespread and have provided different perspectives on the status of this species.

A widespread sampling program in the St. Lawrence River in 1976 (357 sites) recognized pugnose shiner as occurring only in a in a few small bays in the upper Thousands Island area, river kilometer (rkm) 146-150, which was similar to their reported distribution in 1931 (Carlson 1997).

The next sampling effort spanned a similar area but included fewer sites (50). This study found pugnose shiner occurring in three areas in 1993-94 as far downstream as rkm 119 (Carlson 1997).

In 2002, NYSDEC began an annual sampling program began for juvenile sportfishes in vegetated areas of the Thousand Islands area downstream to Chippewa Bay (Klindt and Gordon 2016). After five years, it was extended downstream to Lake St. Lawrence to cover a larger area (rkm 122-32, Figure 1) and averaged 12 seining sites per year. There was a pattern of occasional catches of pugnose shiner of approximately one every other year for the first 10 years. In 2012 fish were caught for the first time as far downstream as rkm 55 (Figure 2). From 2012-18 there were more consistent catches of pugnose shiner at 2-4 locations each year. To date the farthest downstream record is Wilson Hill (rkm 32), which occurred in 2017.

In 2009-10 there was another widespread seining effort targeting nearshore river habitats (McKenna and David 2017), which offered a comparison to the most thorough study conducted in 1976 (Carlson and McKenna 2014). Pugnose shiner were reported at five locations, including sites within the previously documented upstream range, as well as sites located as far downstream as Jacques Cartier State Park (rkm 102).

A more intensive study of pugnose shiner in 2016 (Haynes et al. 2019) was focused on two bays in the Thousand Islands region, Chippewa and Goose bays, which provided 25 records and a total of 174 specimens. This study relied most consistently on boat electrofishing and also related pugnose shiner occupancy to a number of habitat variables including submerged aquatic

plants, fish community, and limnological variables.

Each time period after 1994 (Figure 2, Table 1) showed pugnose shiner occurring at new sites. A similar pattern was reported in the Ontario waters of the St. Lawrence River, showing numerous favorable habitats in the Thousand Islands reach and a similar downstream expansion into Lake St. Lawrence (COSEWIC 2013). By 2018, catches of pugnose shiner in the New York waters of the St. Lawrence River were known from 25 areas of the Thousand Island region from rkm 153-102, and from five areas downstream in Lake St. Lawrence (rkm 58-32) that are widely separated and represent patches of suitable habitat (Figure 2).

Pugnose shiner is currently a candidate to be down-classified as no longer threatened or endangered in New York State.

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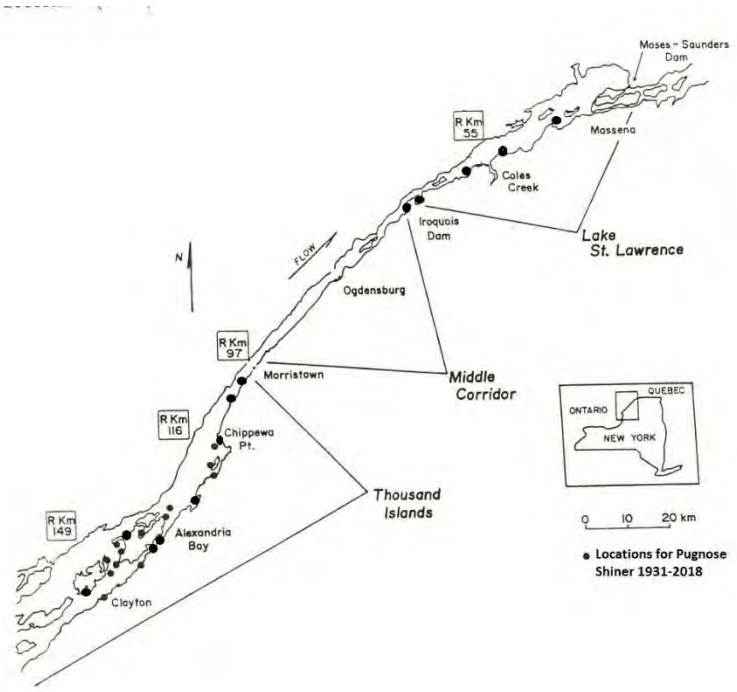

Figure 1. St. Lawrence River including locations of pugnose shiner records in the Thousand Islands area and Lake St. Lawrence, 1931-2018.

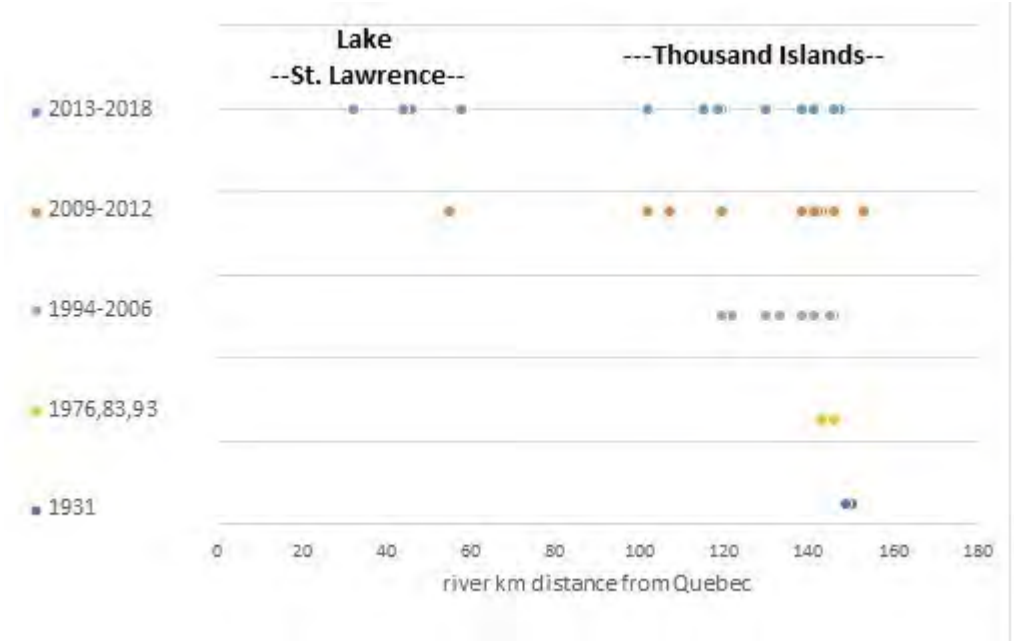

Figure 2. Locations of pugnose shiner records in the St. Lawrence River, 1931-2018, shown as river kilometer distance from Quebec border extending to Clayton.

Table 1. Records for pugnose shiner in the St. Lawrence River in New York, 1931-2018.

	no. records	no. locations	no. new locations	no. individuals
1931	4	2	2	39
1974, 83 & 93	3	2	2	13
1994-2006	31	10	9	216
2009-11	19	14	11	86
2012-18	60	18	10	461
Total	**117**	**46**	**34**	**815**