NYS DEC LAKE ERIE
2017 ANNUAL REPORT

to the Lake Erie Committee
and the Great Lakes Fishery Commission

March 2018

New York State Department of Environmental Conservation
625 Broadway, Albany, New York 12233-4753

Andrew M. Cuomo, *Governor*

MOST OF THE WORK REPORTED IN THIS DOCUMENT IS SUPPORTED BY THE FEDERAL AID IN SPORT FISH RESTORATION PROGRAM

Full Report Citation:

NYSDEC 2018. Lake Erie 2017 Annual Report. New York State Department of Environmental Conservation, Albany, New York, USA

Example Report Section Citation:

Markham, J.L. 2018. Coldwater gill net assessment. Section F in NYSDEC 2018, Lake Erie 2017 Annual Report. New York State Department of Environmental Conservation, Albany, New York, USA

NYS DEC LAKE ERIE 2017 ANNUAL REPORT
to the
Great Lakes Fishery Commission's
Lake Erie Committee

NYSDEC Lake Erie Fisheries Research Unit
e-mail: fwfishle@dec.ny.gov

Donald Einhouse, *Lake Erie Unit Leader*
James Markham, *Aquatic Biologist*
Jason Robinson, *Aquatic Biologist*
Douglas Zeller, *Research Vessel Captain*
Brian Beckwith, *Fisheries Technician*
Richard Zimar, *Fisheries Technician*
MariEllen (Ginger) Szwejbka, *Secretary*

Steven LaPan, *Great Lakes Fisheries Section Head*
Steven Hurst, *Chief, Bureau of Fisheries*

Acknowledgments

The Lake Erie Fisheries Unit recognizes the contributions of seasonal staff essential to completing an ambitious field schedule. During the 2017 field year these individuals included Fish and Wildlife Technicians Carrie Babcock, Jonathon Draves, Kevin Smith and Emilly Nolan. We also acknowledge contributions of DEC's Region 9 Fisheries Office, Buffalo State College's Great Lakes Center and the USFWS Northeast Fisheries Center in support of various Lake Erie field activities.

March 2018

New York State Department of Environmental Conservation
625 Broadway, Albany, New York 12233-4753

Preface

The Lake Erie Annual Report is prepared by New York State Department of Environmental Conservation as a compilation of ongoing Lake Erie investigations mostly supported by Federal Aid in Sportfish Restoration. This annual report is intended as a resource document for other member agencies of the Great Lakes Fishery Commission's Lake Erie Committee, as well as information for Lake Erie's angling community and other interested stakeholders. Many initiatives reported under this cover are long term monitoring efforts which are updated each year. Other efforts may not always be updated annually if there were no new activities since the previous report.

The summaries contained in this report are provisional although every effort has been made to insure their accuracy. We strongly encourage researchers to contact NYS DEC Lake Erie Unit before using or citing any specific data summary contained in this report.

TABLE OF CONTENTS

Lake Erie 2017 Annual Report
New York State Department of Environmental Conservation

Presented at the Lake Erie Committee Meeting
Markham, Ontario, CA
March 28, 2018

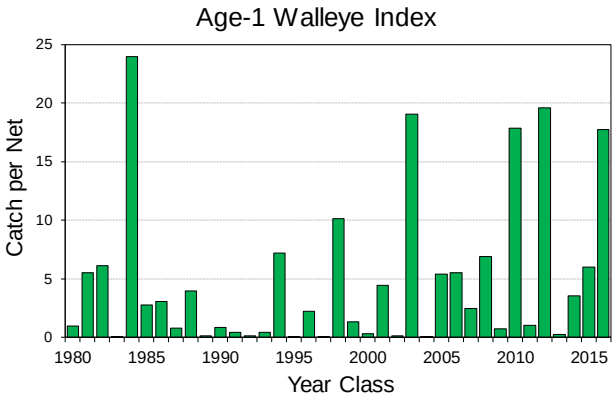
SECTION	TITLE
A	EXECUTIVE SUMMARY
B	RESEARCH PARTNERSHIPS *(D. W. Einhouse, J. L. Markham, J.M. Robinson)*
C	FORAGE AND JUVENILE YELLOW PERCH SURVEY *(J. L. Markham and J.M. Robinson)*
D	WARMWATER GILL NET ASSESSMENT *(J. M. Robinson)*
E	COMMERCIAL FISHERY ASSESSMENT *(J. M. Robinson)*
F	COLDWATER GILL NET ASSESSMENT *(J. L. Markham)*
G	SEA LAMPREY ASSESSMENT *(J. L. Markham)*
H	SALMONID STOCKING SUMMARY *(J. L. Markham and M. T. Todd)*
I	WALLEYE MOVEMENT STUDY *(J. M. Robinson)*
J	OPEN LAKE SPORT FISHING SURVEY *(J. M. Robinson)*
K	LOWER TROPHIC LEVEL MONITORING PROGRAM *(J. L. Markham and K. T. Holeck)*
L	LAKE STURGEON STUDY *(R. Neuenhoff, L. Davis, J. Withers, N. Markley and J. Sweka)*
M	2016 ANGLER SURVEY OF THE UPPER AND LOWER NIAGARA RIVER *(C. D. Legard)*
APPENDIX I	COMMON AND SCIENTIFIC NAMES OF FISH

NYSDEC Lake Erie Fisheries Research Unit
2017 Program Highlights

The New York State Department of Environmental Conservation's Lake Erie Fisheries Research Unit is responsible for research, assessment and fisheries management activities for one of New York's largest and most diverse freshwater fishery resources. A variety of annual monitoring programs are designed to improve our understanding of the Lake Erie fish community, guide fisheries management, and safeguard this valuable resource for current and future generations. This document shares just a few of the highlights from the 2017 program year. Our complete annual report is available on DEC's website at *http://www.dec.ny.gov/outdoor/32286.html*, or by contacting DEC's Lake Erie Unit office (contact information below).

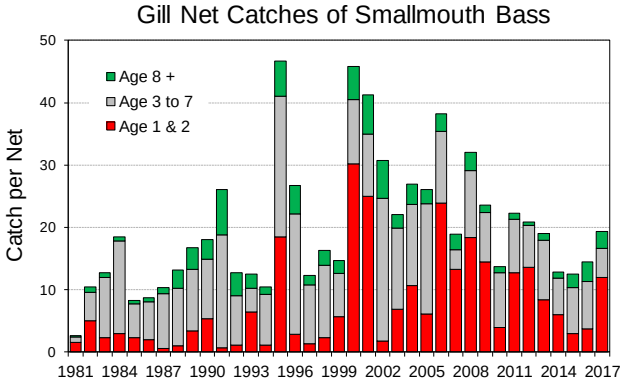
Walleye

Lake Erie's eastern basin walleye resource is composed of local spawning stocks as well as substantial contributions from summertime movements of west basin spawning stocks. Walleye fishing quality in recent years has generally been very good and largely attributable to excellent spawning success observed in 2003, 2010, 2012, 2014, & 2015. Measures of walleye fishing quality in 2017 were the highest recorded in the 30-year survey. New York's most recent juvenile walleye survey indicates an exceptional spawning year in 2016. Overall good recruitment through recent years, especially in 2010, 2012, and 2016, suggests adult walleye abundance in the east basin will remain satisfactory for the next several years. The west basin of Lake Erie experienced a record high walleye recruitment event in 2015, which should also help support New York's walleye fishery for years to come. Preliminary results from a new research initiative that began in 2015 using acoustic telemetry indicate that western basin migrants make a substantial contribution to the New York walleye fishery. A $100 reward is associated with the return of each tagged fish along with the internal acoustic tag.



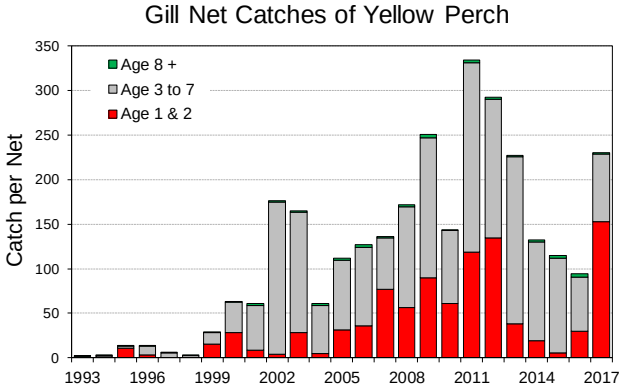
Smallmouth Bass

Lake Erie supports New York's, and perhaps the country's, finest smallmouth bass fishery. Bass fishing quality in 2017 was below the 30-year average for the first time in eight years, with the peak observed in 2013. Generally stable spawning success, coupled with very high growth rates and acceptable survival, produce relatively high angler catch rates and frequent encounters with trophy-sized fish. Recent data indicate a very gradual decline in abundance to near long term average measures. Juvenile abundance measures suggest 2016 was a below average smallmouth bass year class.



Yellow Perch

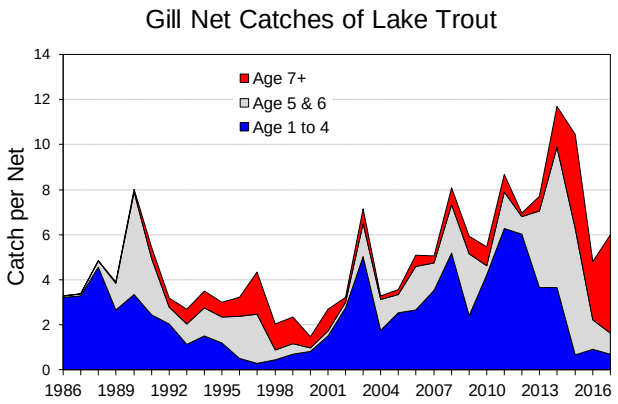
Lake Erie yellow perch populations have experienced wide oscillations in abundance over the last 30 years, from extreme lows in the mid-1990's to an extended recovery that has now lasted well over a decade. Poor recruitment in 2011-2013 resulted in a declining adult population and more recently a decline in angler catch rates. However, perch fishing quality began to increase 2017 and is now above the long-term average. Strong year classes observed in 2014, 2015, & 2016 should result in continued improvements in fishing quality in upcoming years.



Lake Erie Fisheries Research Unit
178 Point Drive North
Dunkirk, NY 14048-1031
(716) 366-0228

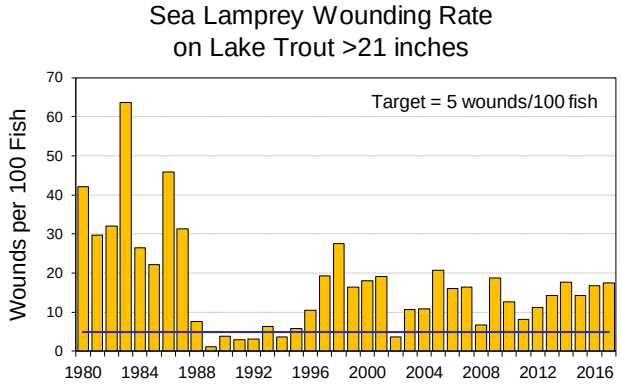
Lake Trout Restoration

Re-establishing a self-sustaining lake trout population in Lake Erie continues to be a major goal of Lake Erie's coldwater program. Lake trout have been stocked since 1978 and annual assessments monitor progress towards restoration objectives. A revised lake trout rehabilitation plan was completed in 2008 and guides current recovery efforts. The overall index of abundance of lake trout in the New York waters of Lake Erie increased 30% in 2017. Overall abundance has met or exceeded the Plan objective of 8.0 fish/lift in five of the past ten years. Adult lake trout (age 5+) measures slightly increased in 2017, remaining high relative to the entire time series; older fish (age 10+) remain scarce. Basinwide estimates of adult abundance remain below targets for the second time in the past five years. Adult survival for some lake trout strains remains low, mainly due to high sea lamprey predation. Natural reproduction has not yet been detected in Lake Erie. Significant stocking and sea lamprey control efforts must be continued to build and maintain the levels of adult population necessary to support natural reproduction. An acoustic telemetry study began in 2016 to determine spawning locations and habitats used by stocked lake trout.



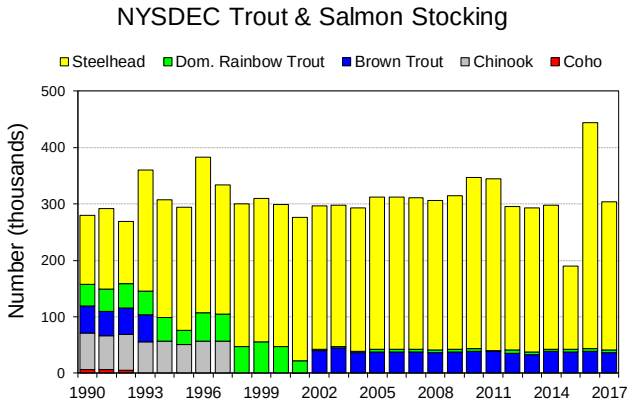
Sea Lamprey

Sea lamprey invaded Lake Erie and the Upper Great Lakes in the 1920s and have played an integral role in the demise of many native coldwater fish populations. Great Lakes Fishery Commission (GLFC) coordinated sea lamprey control in Lake Erie began in 1986 in support of lake trout rehabilitation efforts, and regular treatments are conducted to reduce sea lamprey populations. Annual monitoring undertaken by NYSDEC includes observations of sea lamprey wounds on lake trout and other fish species, and lamprey nest counts on selected stream sections. Wounding rates on lake trout have been steady over the past five years but remain well above targets. Inspections of sportfish species documented sea lamprey wounding on warmwater species as well. GLFC surveys conducted in recent years indicate the largest source of Lake Erie's sea lamprey production may be the St. Clair River rather than traditionally monitored and treated Lake Erie streams.



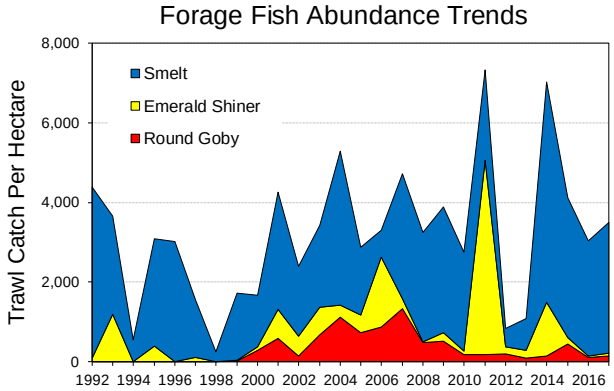
Salmonid Management

New York annually stocks approximately 255,000 steelhead and 35,000 brown trout into Lake Erie and its tributaries to provide recreational opportunities for anglers. Wild reproduction of steelhead also occurs in some tributaries but remains a minor contributor to the overall fishery. Steelhead stocking was above the target in 2017 due to a surplus of fish at the Salmon River Hatchery. A tributary angler survey conducted in 2014-15 found steelhead catch rates were 0.32 fish/hour, which represents some of the highest fishing quality in the country. A new angler survey is now being conducted in 2017-18. A study examining two different stocking sizes of steelhead and two different stocking strategies began in 2015, and will to continue through 2018. This research will provide guidance on the role of stocking size and location on adult returns with the goal of improving fishing quality.



Prey Fish

The Lake Erie Unit conducts a number of surveys to assess forage fishes and components of the lake's lower trophic levels that further our understanding of factors shaping the fish community. Current surveys include trawling, predator diet studies, and lower food web monitoring. A variety of prey fish surveys that began 20+ years ago identified rainbow smelt as the dominant component of the open lake forage fish community. Beginning in 2000, there was a notable increase in prey species diversity accompanied by slightly lower smelt abundance, and in some year's high abundances of round gobies and emerald shiners. In recent years overall prey fish abundance has become highly variable with a notable decline of goby abundance in trawl surveys. Overall abundance of soft-rayed forage fishes slightly increased in 2017 but stayed at average levels compared to the previous decade. Young-of-the-year (YOY) rainbow smelt were the most abundant soft-rayed prey species for the fourth consecutive year. YOY alewife were also abundant in 2017. Trawl catches of round gobies indicate low but stable abundance, and many sources of information suggest emerald shiners were scarce again in 2017. Lower trophic monitoring indicates near shore waters are within the mesotrophic productivity zone typically favored by yellow perch and walleye.



Lake Erie Fisheries Research Unit
178 Point Drive North
Dunkirk, NY 14048-1031
(716) 366-0228

B. RESEARCH PARTNERSHIPS

NYSDEC as signatory to the Great Lakes Fishery Commission's (GLFC) "Strategic Plan for Management of Great Lakes" is obliged to participate in joint management of shared fishery resources. The Lake Erie Unit's routine fishery management and research collaborators include the Pennsylvania Fish and Boat Commission, the Ohio Division of Wildlife, the Michigan Department of Natural Resources, the Ontario Ministry of Natural Resources and Forestry, the United States Geological Survey and the United States Fish and Wildlife Service.

The Lake Erie Unit also collaborates with investigators from various government and academic institutions in pursuit of a broad array of initiatives and Table B.1 lists active collaboration with various studies in 2017. New York's Lake Erie Unit remains willing to pursue additional partnerships to the extent such collaborations are consistent with our mission, and practical for integrating any additional efforts with our ongoing programs.

TABLE B.1. 2017 list of active research partnerships on Lake Erie with NYSDEC.

Principal Collaborator	Project Description
Buffalo State College	Eastern Lake Erie lower trophic monitoring program
USFWS	Long term pathogen surveillance of Lake Erie fishes
DFO - Canada	Long term contaminant monitoring of Lake Erie lake trout
USGS	Grass carp demographics in Lake Erie
Many State, Federal and Provincial Collaborators	Multiple eastern Lake Erie GLATOS Projects, particularly walleye, lake trout, lake sturgeon, and muskellunge
Ohio State University	Identify contribution of west and east basin walleye to NY gillnet indices using otolith microchemistry
Ohio State University	Identify contribution of west and east basin walleye to recreational and commercial fisheries in Lake Erie using genetics
USGS	Lake Erie GAP Analysis
EPA	US EPA GLNPO Great Lakes Fish Monitoring Program
USFWS	Lake Sturgeon demographics in vicinity of Buffalo Harbor and U. Niagara River

C. Forage and Juvenile Yellow Perch Survey

James L. Markham and Jason M. Robinson

Introduction

The Lake Erie Unit's annual bottom trawling program has been conducted since 1992 and replaced the Juvenile Percid Assessment conducted from 1986 to 1991 (Culligan et al. 1992). The principal objectives of the program are assessing trends in abundance of juvenile yellow perch and monitoring the status of the forage fish community. Data from this program are merged with those from other jurisdictions to generate lake wide estimates of juvenile yellow perch and forage fish populations, and are reported by the Lake Erie Committee's inter-agency Forage Task Group (Forage Task Group 2017) and Yellow Perch Task Group (Yellow Perch Task Group 2017).

Methods

This annual trawling program is conducted during October at selected locations with trawlable substrate between the 50- and 100-ft depth contours in New York's portion of Lake Erie. Standard tow duration is 10 minutes. Survey procedures generally follow those performed for an inter-agency, western basin Lake Erie assessment that is reported annually in Lake Erie's Forage Task Group Report (Forage Task Group 2017).

The standard gear for this trawling program is a 4-seam bottom trawl with the following characteristics:

Headrope length:	26.3 ft
Footrope length:	33.3 ft
Ground wire to doors:	50.0 ft
Trawl webbing:	2.0 inches
Twine diameter:	21 thread
Cod-end webbing:	0.4 inches

Reported measures conform to a lake wide standard measurement of trawl densities as mean number per hectare (Forage Task Group 1998). A hectare is 2.471 acres. The area density is computed from known trawl fishing dimensions measured from trawl mensuration equipment (NETMIND) used between 2004-2016 and individual tow distances estimated from navigation equipment. An analysis completed in 2016 from the trawl mensuration equipment revealed a trawl wingspread (13.8 ft) that was slightly different than the previous value (14.2 ft) estimated from a more limited trawl calibration exercise conducted in the late 1990's. Area density estimates were corrected beginning in 2016 for our now improved estimates of fishing dimensions and are slightly different than values reported prior to 2016.

An analysis was conducted in 2015 using a generalized linear modeling approach quantifying the effect of bottom temperature – as a proxy for fall turnover – on trawl catches of seven commonly encountered species and life stages (Markham and Robinson 2016). The results of this analysis indicated that the effect of fall turnover (bottom temperature) on catches of warm- and cool-water benthic species and life stages, including yellow perch, round goby, and young-of-the-year (YOY) rainbow smelt, is relatively modest compared to the effect of temperature on catches of pelagic species such as emerald shiner, and species with cooler temperature preferences such as yearling-and-older (YAO) rainbow smelt. Varying bottom temperatures over the course of the survey period do not seem to be a significant impediment to characterizing relative year class strength for benthic warm water species. As such, this trawl survey likely provides a better annual abundance index for benthic warmer water species and life stages compared to cooler water (e.g. YAO rainbow smelt) and pelagic species (e.g. emerald shiner), especially for temperatures at which the survey usually operates (57.2 – 64.4 °F (14-18°C).

Results

A total of 34 usable trawl tows were completed in the New York waters of Lake Erie in 2017 (Figure C.1). Due to a hydraulic failure on the R/V Argo and associated repair, the 2017 survey was not completed

FIGURE C.1. Locations of 34 individual 10 minute trawls between the 50 to 100 ft. depth contours used to assess the abundance of age-0 yellow perch and forage fish species in the New York waters of Lake Erie, November, 2017.

until November, one full month past the normal sampling period. Despite the delay, survey sampling temperatures (50.5 – 56.1ºF (10.3 – 13.4ºC)) remained within the typical temperature range of the program (>50ºF or 10ºC). Sampling was completed on three days between November 7 – 15, 2017. Overall, standard daytime trawling effort totaled 340 minutes (5.67 hours).

Time series trends of relative abundance for selected species of interest are presented in Figure C.2. YOY rainbow smelt were the most abundant species sampled in 2017, ranking as the third highest index in the 26-year survey. The abundance of YOY rainbow smelt has been high for four consecutive years. However, high YOY abundance has not translated into comparatively higher abundance of YAO rainbow smelt. Relative abundance estimates were also high for YOY alewife in 2017, ranking as the second highest in the time series. Abundance indices for round goby, YOY white perch, and YOY gizzard shad remained similar over the previous five years, but all other commonly encountered species were low in 2017 trawl samples. It is also notable that YOY walleye and YOY lake whitefish were encountered in 2017 trawl samples, which usually only occurs when especially large year classes are produced.

Juvenile Yellow Perch Assessment

The 2017 mean density estimate for age-0 (YOY) yellow perch (247.0/ha) was slightly above average and ranked 8th (69th percentile) in the time series (Table C.1; Figure C.2). Throughout the history of this survey, a relatively weak relationship has existed between age-0 yellow perch abundance and subsequent age-1 abundance (r^2 = 0.45). However, high abundance indices at age-0 rarely translate to weak year classes measured at age-1, so the prospects are favorable for the 2017 year class to be an average or above cohort of yellow perch. The age-1 yellow perch (2016 year class) density estimate was 129.5/ha in 2017, ranking as the second highest in the time series (Table C.1; Figure C.2). This is the third consecutive strong cohort of age-1 yellow perch. Adult (age 2+) relative abundance decreased for the third consecutive year and was at its lowest relative abundance since 2003 (Table C.1). The majority of the adult trawl catches (age 2+) in 2017 were comprised of the strong age-2 (2015 year class) and age-3 (2014 year class) cohorts.

TABLE C.1. Density (number per hectare) of yellow perch collected with a bottom trawl in the New York waters of Lake Erie, October - November, 1992 - 2017.

Year	Age-0	Age-1	Age-2+
1992	10.7	2.4	9.5
1993	113.0	3.1	6.1
1994	49.0	8.6	1.0
1995	5.9	13.6	14.6
1996	105.8	0.3	7.0
1997	0.2	5.7	2.7
1998	1.3	0.4	0.3
1999	35.9	33.3	11.1
2000	23.9	7.0	28.4
2001	100.4	11.7	23.5
2002	9.5	16.0	37.9
2003	484.8	2.0	22.0
2004	1.5	29.4	62.2
2005	59.3	5.6	34.5
2006	290.6	40.9	29.8
2007	412.0	42.3	87.2
2008	1116.7	45.5	56.4
2009	11.9	64.1	44.1
2010	197.7	4.2	39.9
2011	89.5	141.8	25.7
2012	280.0	16.7	62.6
2013	4.4	24.4	40.6
2014	274.2	2.9	105.4
2015	68.6	57.3	79.5
2016	2178.2	53.0	45.5
2017	247.0	129.5	28.6
Average	237.4	29.3	34.8

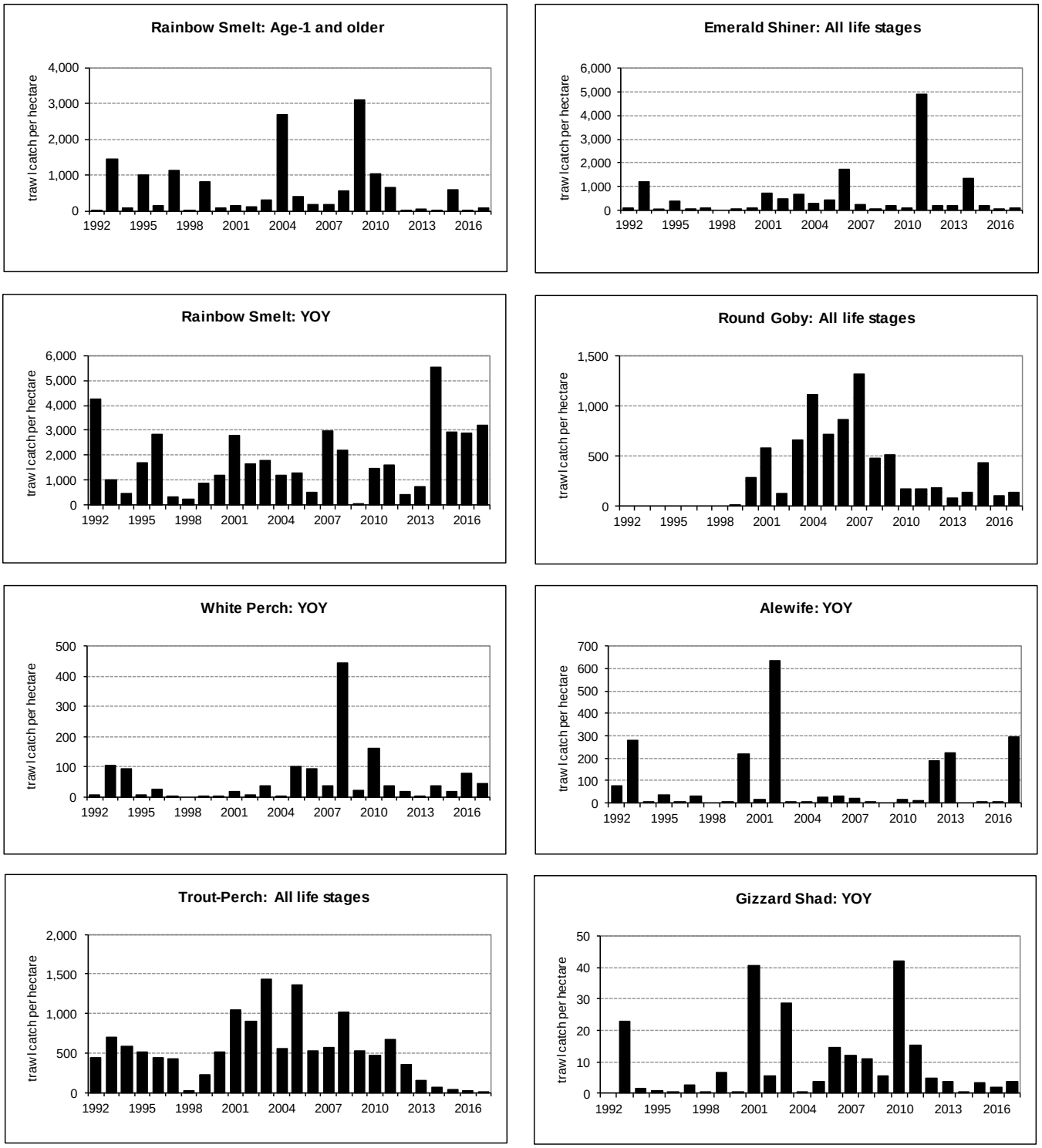


FIGURE C.2. Catch per hectare (2.471 acres) of selected species collected with a bottom trawl in the New York waters of Lake Erie, October - November, 1992 – 2017.

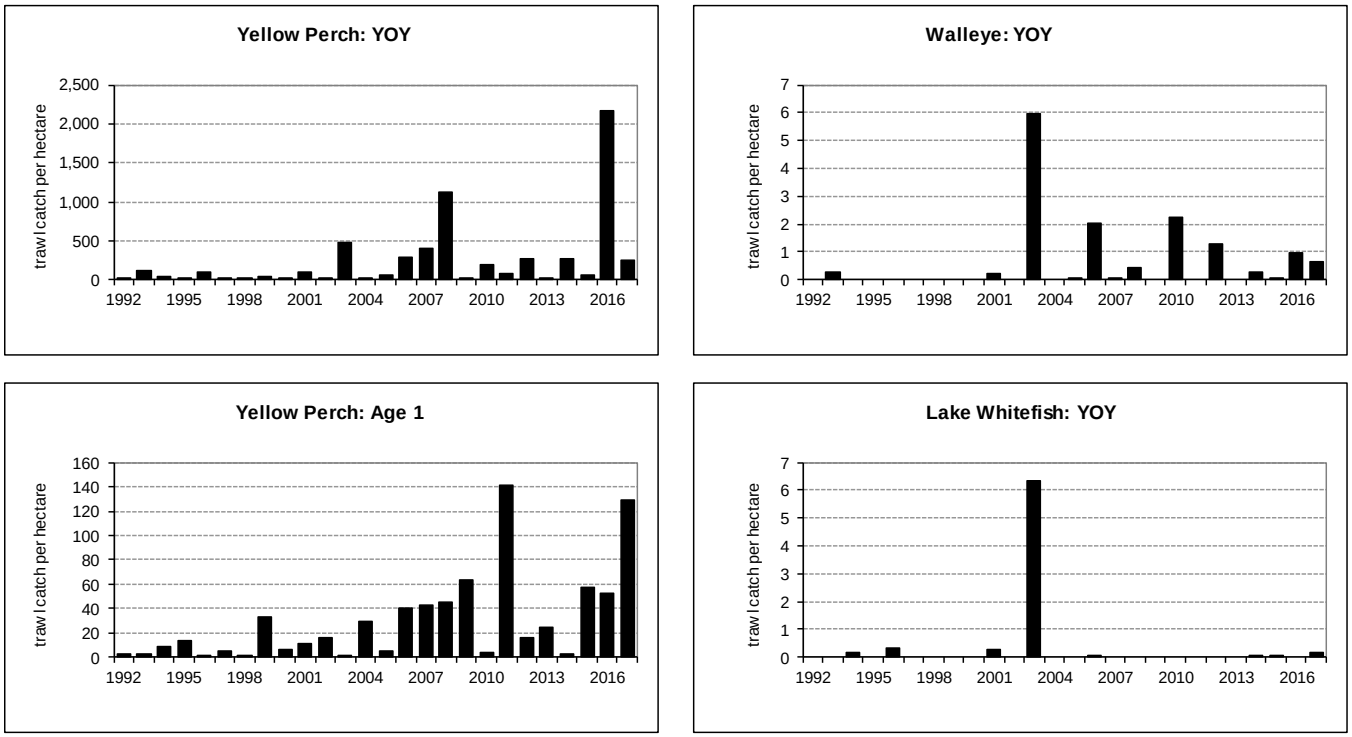


FIGURE C.2 (Continued). Catch per hectare (2.471 acres) of selected species collected with a bottom trawl in the New York waters of Lake Erie, October - November, 1992 – 2017.

Trends in juvenile yellow perch length-at-age indicate relative stability for both age-0 and age-1 age groups over the past decade (Figure C.3). The mean total length for age-0 yellow perch was 3.0 inches in 2017, slightly below the time series average of 3.1 inches. Age-1 yellow perch averaged 6.1 inches, well above the time series average (5.5 in) and tied for the third highest age-1 mean length in the time series.

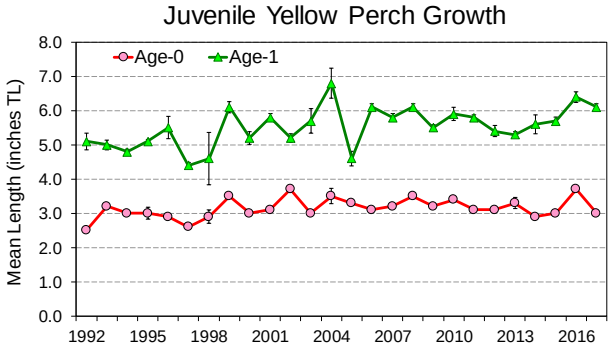


FIGURE C.3. Mean total length of age-0 and age-1 yellow perch collected by bottom trawl in New York waters of Lake Erie, October – November, 1992 - 2017. Error Bars are 95 % confidence intervals. During 1997 only one age-0 yellow perch was collected and error bars could not be computed.

Status of Forage Fish

Soft-rayed forage fishes dominated trawl catches (numerically) in the New York waters of Lake Erie each year (Figure C.4). This group includes rainbow smelt, emerald shiners, spottail shiners, trout-perch and round goby. Spiny-rayed forage fishes (YOY yellow perch, YOY white perch, and YOY white bass) have increased in general abundance since the early-2000s, and were especially abundant in 2016 due to very high abundance of YOY yellow perch. Clupeids (YOY gizzard shad, YOY alewife) have remained relatively minor contributors to this forage fish assessment since its inception. Estimated relative abundance of forage-sized fish was 4,099 fish/ha in 2017, a slight decrease from 2016 but near the time series average (4,128 fish/ha).

Rainbow smelt are typically the most numerically abundant species within the soft-rayed forage group, and this trend continued in 2017 (Figure C.5). In recent years, including 2017, smelt catches were dominated by YOY fish; abundance of YAO smelt has been generally low since 2012 (Figure C.2). In

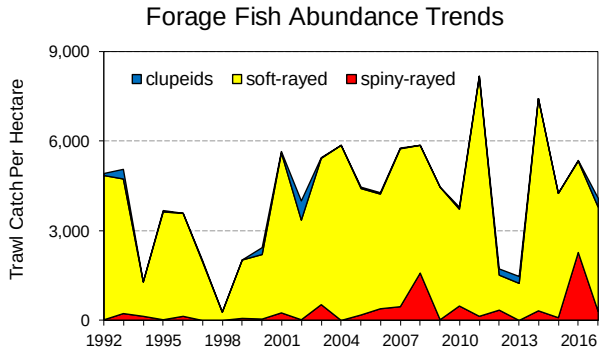


FIGURE C.4. Catch-per-hectare (2.471 acres) of functional groups of forage fishes collected with a bottom trawl in the New York waters of Lake Erie, October - November, 1992 - 2017.

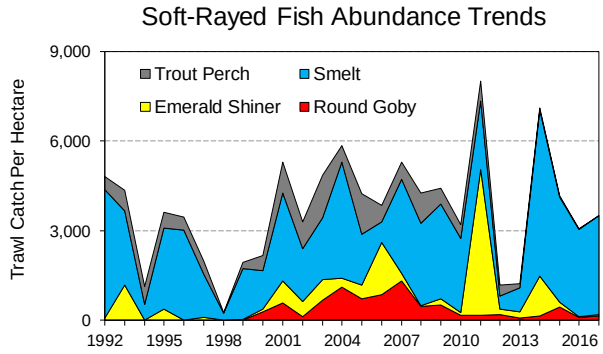


FIGURE C.5. Catch-per-hectare (2.471 acres) of common soft-rayed forage fishes (all ages combined) collected with a bottom trawl in the New York waters of Lake Erie, October - November, 1992 - 2017.

contrast, four of the six highest abundance indices of YOY rainbow smelt occurred in the past four years, including the highest abundance index in 2014 and third highest in 2017.

Beginning in 1999, species other than rainbow smelt also began to make significant contributions to the soft-rayed segment of the forage fish community, including emerald shiners, trout-perch and round goby (Figures C.2 and C.5). Round goby were first collected in the late 1990's and generally increased in abundance, peaking in 2007. Round goby abundance declined thereafter and has generally remained at a stable and lower abundance through 2017. Trout-perch were a stable component of the forage fish community through 2011, but have declined since and were at their lowest abundance in the time series in 2017.

Since 2001 emerald shiners have often contributed measurably to total forage biomass and abundance (Figures C.2 and C.5). Emerald shiner abundance declined notably between 2007 through 2010, then increased sharply to a time-series high in 2011 when they were the most abundant forage species caught. However, much of this abundance peak was attributable to a single trawl tow. Since the 2011 peak catch, only the 2014 catch is noteworthy. The estimated abundance of emerald shiners in 2017 was the seventh lowest in the time-series.

The estimated biomass of forage-sized fish was 7,873 grams/ha in 2017 (Figure C.6). This was a large decrease compared to 2016 and well below the time series average (13,266 grams/ha). The decline from 2016 was mainly due to the decline in spiny-rayed prey species; soft-rayed species and clupeids both increased in comparison. YOY rainbow smelt and YOY clupeids (specifically alewife) were the dominant species by weight, comprising 42% and 32%, respectively, of the 2017 overall forage biomass estimate (Figure C.7). YOY yellow perch were the only other species that made a significant biomass contribution in 2017 (14%).

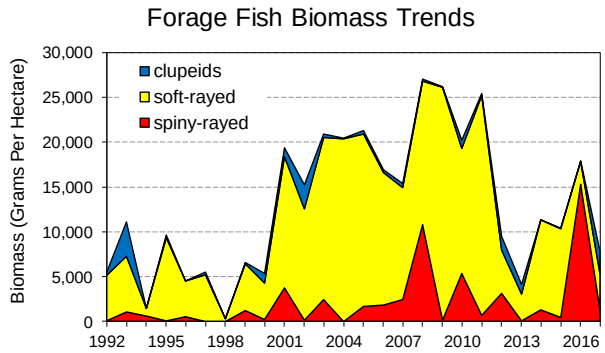


FIGURE C.6. Biomass (grams-per-hectare (2.471 acres)) of functional groups of forage fishes collected with a bottom trawl in the New York waters of Lake Erie, October - November, 1992 - 2017.

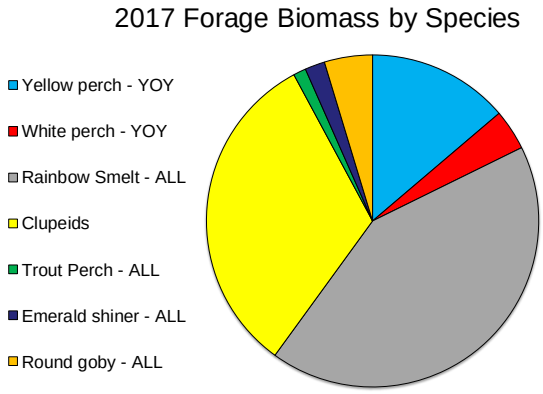


FIGURE C.7. Biomass (grams-per-hectare (2.471 acres)) of forage fishes by life stage collected with a bottom trawl in the New York waters of Lake Erie, November, 2017.

Discussion

This longstanding October trawling program was conducted during November in 2017 due to an untimely mechanical breakdown. Because of this, the entire survey was completed after fall turnover and at water temperatures that were on average colder than encountered during typical surveys. Nonetheless, an analysis conducted in 2015 has given us confidence that water temperature is not a significant bias for characterizing abundance of benthic species such as YOY yellow perch and round goby. Other species, such as emerald shiners and YAO rainbow smelt, are typically caught in higher abundances following fall turnover, and the fact that 2017 indices were low for both these species is perhaps an indication that their abundance is indeed low.

This trawling program continues to indicate a period of sustained yellow perch recruitment success and overall elevated abundance since 2003. Average or better age-1 yellow perch indices have been recorded in nine of the last 14 years, including 2015, 2016, and 2017, and above average YOY yellow perch catches occurred in 2017, holding promise for this cohort. The abundance of adult yellow perch (age-2+), which has been declining in recent years, should begin to improve as the strong 2014-16 year classes recruit to the fishery. Age-1 yellow perch measures correlate very well with subsequent age-2 abundance measures in this trawl survey as well as those observed in the annual Warmwater Gill Net Assessment (see Section D).

Bottom trawl estimates suggest average abundance of forage-sized fishes in the New York waters of Lake Erie in 2017. Overall abundance ranked 15th in the 26-year time series. Although species diversity generally remained high in 2017, YOY rainbow smelt, and to a lesser extent YOY alewife and YOY yellow perch, dominated the trawl catches; most other species were caught in relatively low abundance. YOY rainbow smelt density ranked as the 3rd highest in the series in 2017, and marked the fourth consecutive year of high YOY rainbow smelt abundance. In contrast, YAO rainbow smelt have been observed at low levels of abundance during five of the past six years. Emerald shiner abundance continues to be highly variable, and recent density estimates suggest very low abundance again in 2017. Trout-perch abundance declined for the sixth consecutive year to a record-low level in 2017. Trout-perch are rarely observed in the diets of the predator fishes in the eastern basin of Lake Erie (see Sections F and L). YOY alewife abundance was above average in 2017 with at the second highest measure observed in the time-series. Alewife typically increase in abundance following consecutive mild winters.

Overall biomass estimates declined sharply in 2017 compared to 2016, but remained at levels comparable to 2014 and 2015. Similar to 2012-2015, YOY rainbow smelt comprised the majority of the forage fish abundance in 2017, but are small in size and hence do not accrue a large biomass despite high abundance. Larger-bodied species such as emerald shiners (all life stages), trout perch, and many YOY spiny-rayed fishes were encountered in low densities and did not contribute notably to overall biomass measures. Round gobies, first detected in this survey in 1999, were mostly responsible for higher biomass estimates observed in the mid-2000s. However, smaller YOY round gobies made up the majority of their abundance in recent years and did not contribute measurably to overall biomass. The combination of scarce large round gobies, YAO rainbow smelt, emerald shiner, and trout-perch resulted in lower overall forage biomass estimates in recent years that remain similar to biomass estimates observed prior to the invasion of round gobies. These species remained scarce in 2017, and biomass estimates would have

been markedly lower without the unusually high abundance of YOY alewife.

Despite apparent wide oscillations in abundance and biomass of prominent forage fish species over the last 26 years, other survey efforts that monitor predator fish growth continue to describe generally high and stable growth rates for walleye, smallmouth bass (see Section D) and lake trout (see Section F) through this same time period. We conclude that although forage fish abundance, biomass and species composition has been highly variable over the past two decades, we find no evidence that eastern Lake Erie's forage fish community has been limiting for predator fishes.

References

Culligan, W. J., F. C. Cornelius, D. W. Einhouse, D. L. Zeller, and R. C. Zimar. 1992. 1992 Annual Report to the Lake Erie Committee. New York State Department of Environmental Conservation, Albany, USA.

Forage Task Group 1998. Report of the Lake Erie Forage Task Group, March 1999. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission. Ann Arbor, Michigan, USA.

Forage Task Group 2017. Report of the Lake Erie Forage Task Group, March 2018. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission. Ann Arbor, Michigan, USA.

Markham, J.L. and J.M. Robinson. 2016. Forage and juvenile yellow perch survey. Section C in NYSDEC 2016, Lake Erie 2015 Annual Report. New York State Department of Environmental Conservation, Albany, USA.

Yellow Perch Task Group 2017. Report of the Lake Erie Yellow Perch Task Group, March 2018. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission. Ann Arbor, Michigan, USA.

D. WARMWATER GILL NET ASSESSMENT

Jason M. Robinson

Introduction

The annual warmwater fish community gill net assessment has been performed by New York's Lake Erie Fisheries Research Unit since 1981. The principal objective of this September assessment is to produce standardized indices of relative abundance, age composition, and growth of walleye, smallmouth bass and yellow perch in New York's portion of Lake Erie. Walleye and yellow perch relative abundance and age composition data are also contributed to the Lake Erie Committee's (LEC) interagency Walleye and Yellow Perch Task Groups for annual lake wide assessment. A secondary objective is to monitor abundance trends for other commonly encountered warmwater fish species.

Methods

This annual assessment began in 1981, and methods were significantly altered after 1992 to adopt a standard interagency approach to fish community assessment. A detailed description of current survey methods can be found in Ryan et al. 1993. Several fixed sampling stations from New York's former (< 1993) gill netting assessment on Lake Erie were retained to maintain continuity of a long-term data series for nearshore (<50 ft) waters. Long-term catch rates presented in this report focus principally on the nearshore stratum, where a standard sampling strategy has been performed since 1981. All nearshore catch rates obtained by the former (<1993) standard gill net were calibrated to the current standard as described by Culligan et al. 1994. An offshore stratum (>50 ft) was added in 1993, primarily to assess yellow perch status.

This assessment utilizes a stratified, random approach with stations selected from a grid system. Both bottom and limnetic warmwater habitats were sampled with 700 ft. monofilament gill nets from 1993 through 1995. Beginning in 1996, only bottom habitat has been sampled and all measures reported for this survey are from bottom-set gill nets. Each net

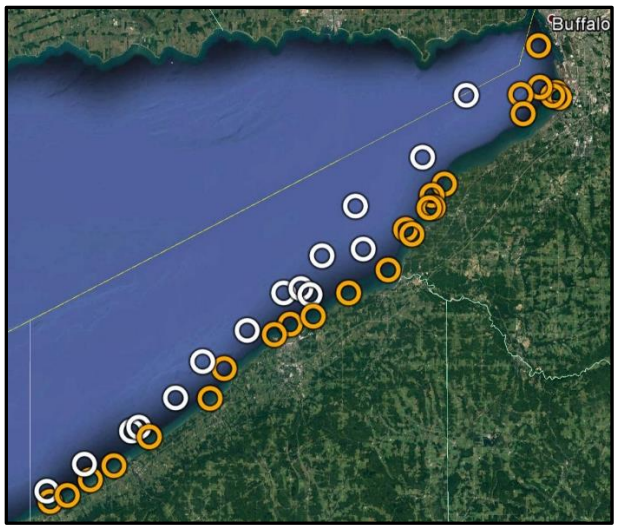


Figure D.1. Warmwater gill net sampling sites for 2017. Orange circles represent nearshore sites (<50 ft) and white circles represent offshore sites (>50 ft).

was made up of 14 individual gill net panels (50 ft long x 6 ft high) with stretch mesh sizes ranging from 1.25 to 6 inches. An examination of gill net catches from 1993 to 2004 found the 6-inch panel contributed miniscule catches for all commonly encountered species, but otherwise experienced excessive net damage. Excessive damage to the 6-inch netting occurred because our interagency standard monofilament twine diameter is often too weak to retain species large enough to be entangled in this panel. Beginning in 2005, New York's new standard gill net became a 650 ft gang consisting of 13 panels ranging from 1.25 to 5.5 inches. Previous summary statistics were not re-analyzed with the deletion of 6.0-inch panel catches because separate evaluations confirmed the presence/absence of the 6.0-inch panel did not measurably change overall catch rates for all commonly encountered species.

The warmwater gill net sampling period extends from September 1 until the target number of net sets is achieved or the bottom water temperature in the sampling area reaches 59°F (15°C). Target sampling effort is 40 overnight gill net sites, with four to six nets set each sample day. Effort is distributed between 25 nearshore and 15 offshore sites. The 40-net target was achieved in 2017 (Figure D1) and most other

survey years. Nets are set between 12:00 PM and sunset and retrieved between sunrise and 12:00PM the following day. Data from gill nets that sampled for more than 24 hours or from nets that became badly damaged, tangled, or fouled by filamentous algae or other debris are omitted from analyses.

Catches from overnight sets are completely enumerated by species. Walleye, yellow perch, and smallmouth bass are measured, weighed, sexed, and scales, spines or otoliths are removed for age determination. Large catches of walleye, smallmouth bass, and yellow perch, are sub-sampled as needed to process samples in a timely manner.

Results

Walleye

The relative walleye abundance index in 2017 was 23.8 fish per net (Figure D.2), well above the long-term average of 13.4 fish per net and the 9th highest observed in the survey.

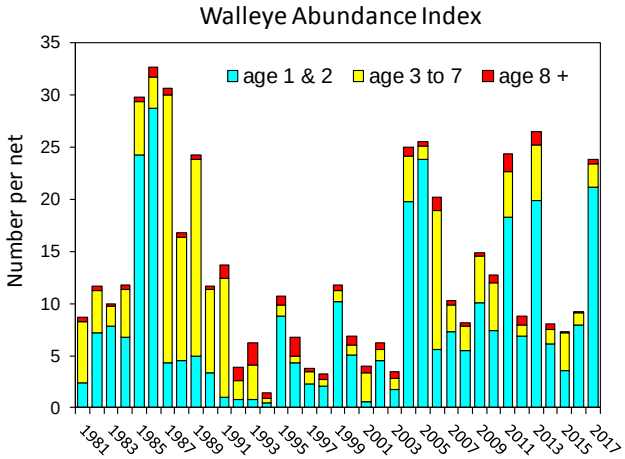


Figure D.2. Walleye catch by age category per gill net set from nearshore stations (< 50 ft) in New York waters of Lake Erie, September-October 1981–2017.

Fourteen walleye age groups were represented in the 2017 sample (nearshore and offshore). Age-1 walleye dominated the catch (2016 year class; 65%), followed by age-2 fish (2015 year class; 24%) (Figure D.3). Age-1 and age-2 walleye have typically comprised a large fraction of the overall walleye sample each year in nearshore gill nets (Figures D.2 and D.3). Juvenile walleye are not typically caught at offshore sites, and

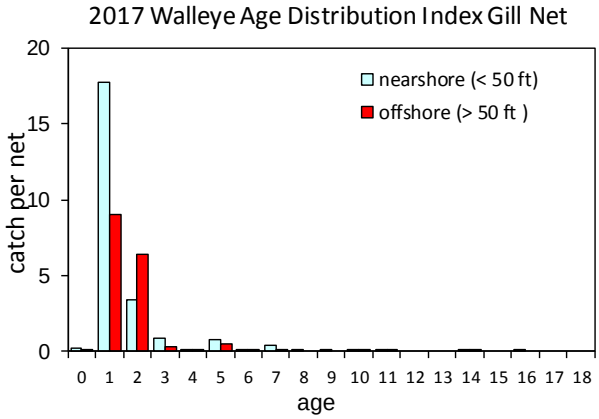


Figure D.3. Age composition of walleye collected from the New York waters of Lake Erie, September 2017

and adult walleye have proven difficult to sample effectively in this survey. Measures of mature walleye abundance from this assessment remain highly variable and are not thought to provide a sensitive index of adult abundance.

Consecutive weak walleye year classes have not been observed since the early 1990's, and four of the five exceptional year classes have been observed in the last 14 years. Yearling walleye catch rates in 2017 ranked the 2016 year class as the 5th largest recorded at 18.0 age-1 walleye per net, falling within our established threshold for an "exceptional" year class. In the last 14 years, four exceptional year classes have been observed, compared to only 2 weak year classes (Figure D.4). Length of age-1 and age-2 walleyes were at the long-term average in 2017 (Figure D.5).

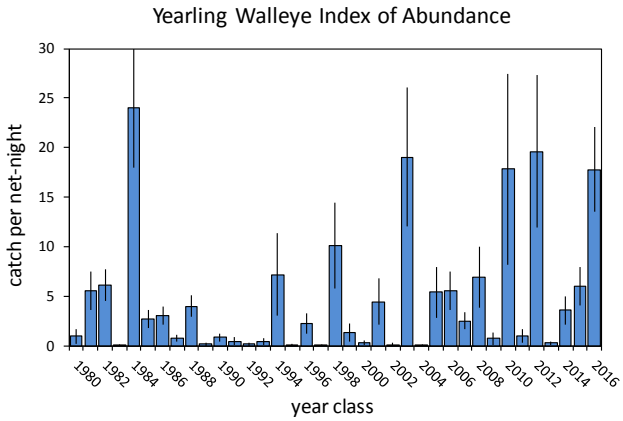


Figure D.4. Relative abundance of age-1 walleye from the New York waters of Lake Erie, September-October 1981-2017.

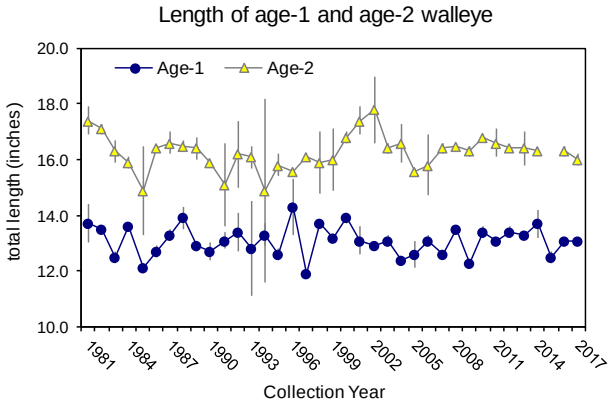


Figure D.5. Mean total length of age-1 & age-2 walleye collected from variable mesh gill nets in the New York waters of Lake Erie, September 1981-2017. Error bars are 2 standard errors.

Smallmouth Bass

Smallmouth bass relative abundance in 2017 (19.4 fish per night) was just below the time series average (20.0 fish per net; Figure D.6). Age-1 smallmouth bass dominated the 2017 nearshore sample (57%), which included 16 age groups from age-0 to age-18 (Figure D.7). Offshore gill nets caught notably fewer sub-adult smallmouth bass, and fewer smallmouth bass overall than companion nearshore gill nets, which is typical.

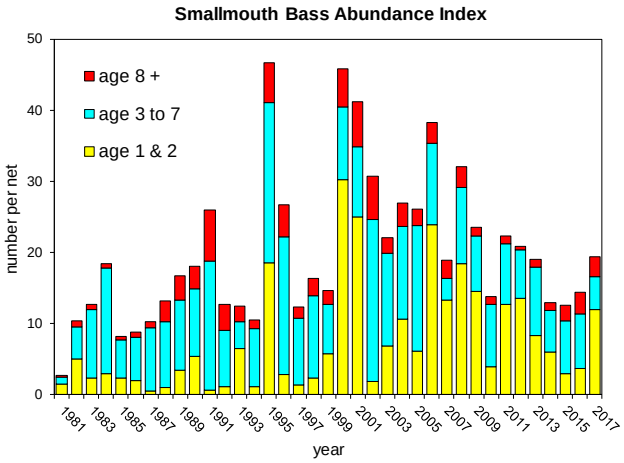


Figure D.6. Smallmouth bass catch rates by age category from nearshore stations (< 50 ft) in New York waters of Lake Erie, September 1981-2017.

Smallmouth bass abundance in gill nets has remained generally stable for most of the last 11 years (Figure D.6). In general, older cohorts of smallmouth (Age-10+) are less frequently encountered than they were in the early to mid-2000's (Figure D.8). However,

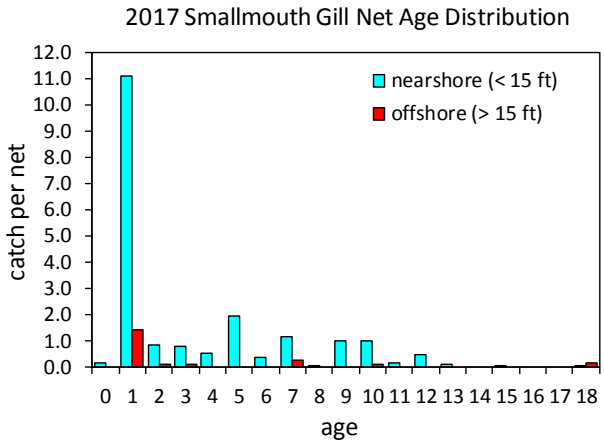


Figure D.7. Age composition of smallmouth bass collected from the New York waters of Lake Erie, September 2017.

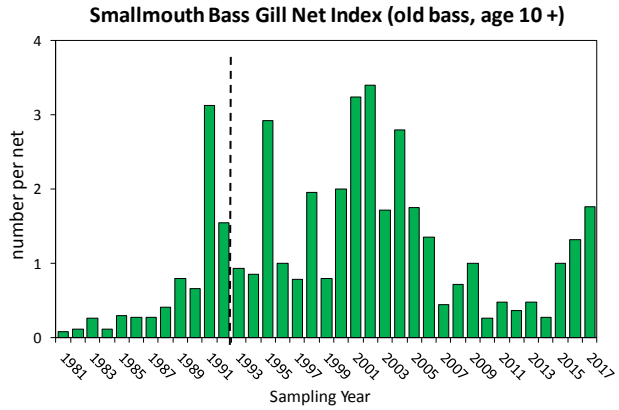


Figure D.8. Age-10 and older smallmouth bass catch rates from nearshore stations (< 50 ft) in New York waters of Lake Erie, September 1981-2017. The dashed line represents the time at which the aging structure for large bass (>17 in) was changed from scales to otoliths.

numbers of age-10+ smallmouth bass encountered in gillnets has been increasing for the past three years.

The recruitment index for age-2 smallmouth bass in 2017 (0.8 fish per net) fell below the time series average of 4.2 fish per net (Figure D.9). Age-2 and age-3 smallmouth bass cohorts averaged 12.2 in and 14.1 in total length, respectively (Figure D.10), which is well above the long-term average of 10.8 and 12.8 inches, and represents a time series high for both ages. In general, bass growth over the past decade has been the highest ever observed in this assessment.

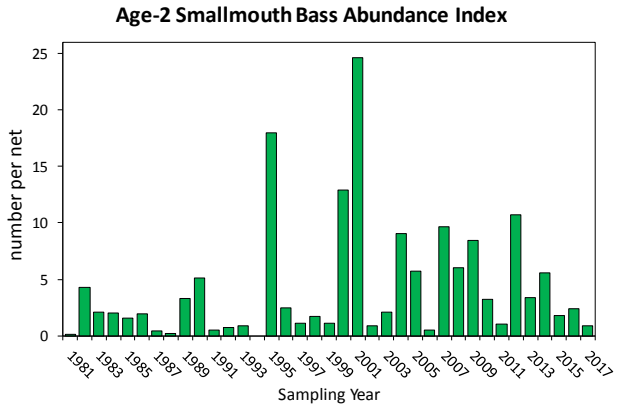


Figure D.9. Relative abundance of age-2 smallmouth bass collected from the New York waters of Lake Erie, September 1981-2017.

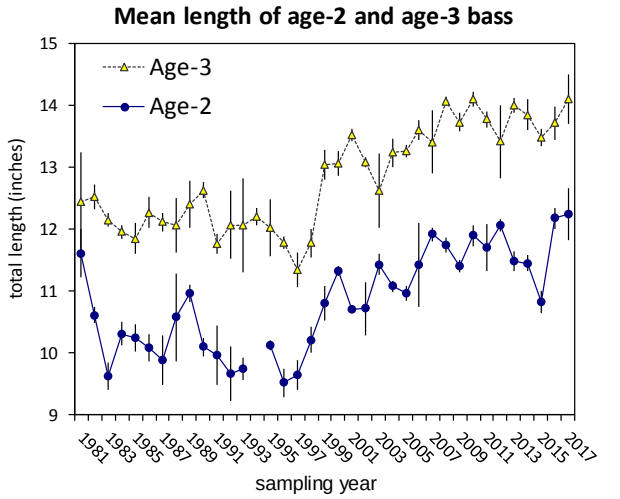


Figure D.10. Mean total length of age-2 and age-3 smallmouth bass collected from gill nets in the New York waters of Lake Erie, September 1981-2017. Error bars are 95% confidence limits.

Figure D.11 illustrates the estimated survival rate of adult smallmouth bass in the New York waters of Lake Erie. Ages 3-10 were used to calculate annual survival estimates for each year class from 1978-2007 using catch curve analysis. Year classes that lived their entire life without goby, those that lived a portion of their life with goby, and those that lived their entire life with goby are separated in the figure to examine the potential role that goby introduction played in the observed changes in survival. There has been a substantial decrease in annual survival rates from approximately 84% for late 1970's cohorts to approximately 64% for early 2000's cohorts. However, there has been an observed increase in estimated bass survival for mid-2000's cohorts.

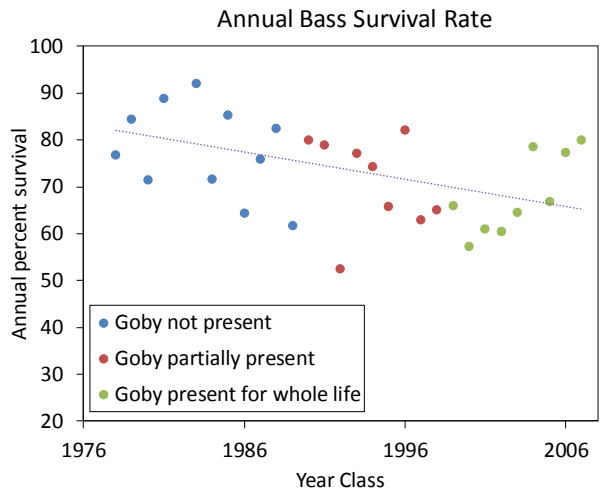


Figure D.11. Estimated survival of age 3-10 smallmouth bass in the New York waters of Lake Erie. Each point represents the survival rate estimate for a cohort.

Yellow Perch

Yellow perch are not encountered in high densities in the shallower, nearshore (0 to 50 ft.) long-term gill net locations. Therefore, the offshore gill net locations (Figure D.1, 50 to 100 ft.) are used to index yellow perch abundance. This deeper stratum has been sampled since the interagency index fishing protocol was implemented in New York, starting in 1993.

Yellow perch relative abundance was 230.4 fish per net in 2017, well above the time series average of 118.5 fish per net, and the 4th highest index observed (Figure D.12). The yellow perch index had been declining from 2011–2016 which was mostly attributable to a declining contribution by younger cohorts (age-1 and age-2). Age-1 and 2 yellow perch (2015 and 2016 year classes) dominated the catch in 2017, accounting for over 66% of the yellow perch captured (Figure D.13).

Other Fish Species

Relative abundance measures (catch per gill net) for the 15 species most commonly encountered in the 37-year gill net series are reported in Figure D.14a and D.14b. All species were encountered well within observed, historic ranges of abundance.

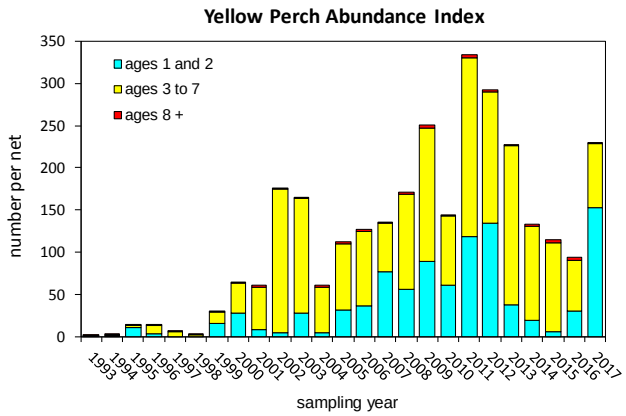


Figure D.12. Yellow perch gill net catch rates by age category from sampling locations between 50 and 100 ft. in New York waters of Lake Erie, September-October 1993–2017.

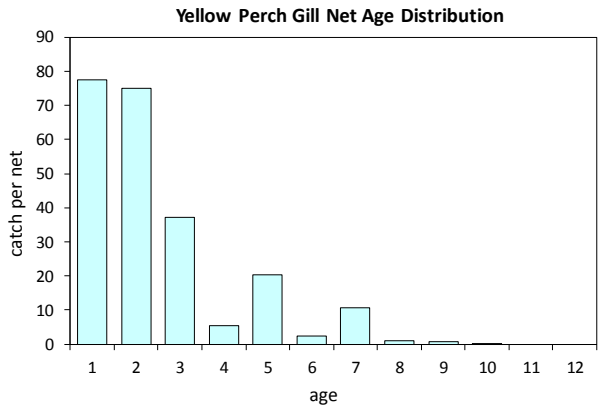


Figure D.13. Age composition of yellow perch collected in offshore, gill nets from the New York waters of Lake Erie, September 2017.

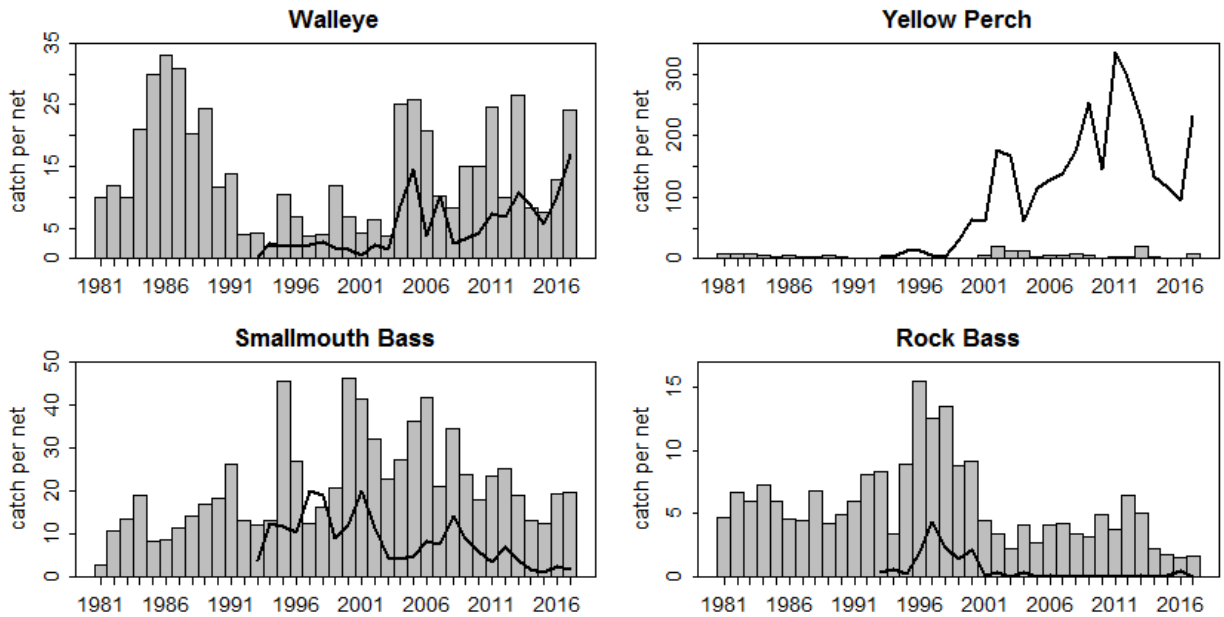


Figure D.14a. Bar plots represent gillnet catch rates for 15 selected fish species collected in the nearshore (< 50 ft) stations in New York waters of Lake Erie, September-October 1981-2017. The solid line represents gillnet catch rates in the offshore (> 50 ft) stations from September-October 1993-2017).

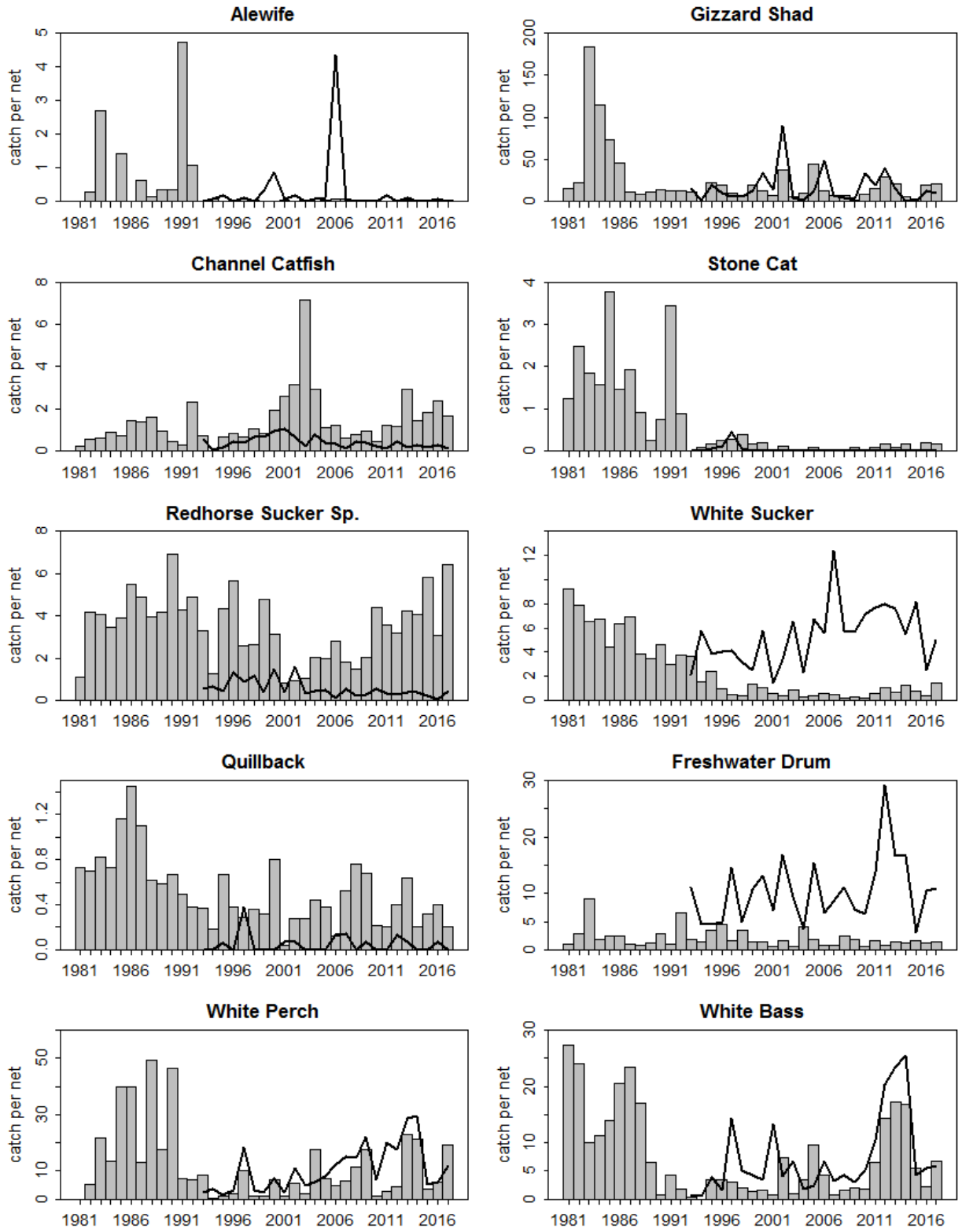


Figure D14b. Bar plots represent gillnet catch rates for ten selected fish species collected in the nearshore (< 50 ft) stations in New York waters of Lake Erie, September-October 1981-2017. The solid line represents gillnet catch rates in the offshore (> 50 ft) stations from September-October 1993-2017).

Discussion

Overall walleye relative abundance in 2017 was well above the long-term average, with age-1 fish dominating the catch. Juvenile walleye are typically more abundant than adult walleye in most sampling years because the gill netting survey is mostly focused in shallow, nearshore areas. The 2017 index for yearling walleye (2016 year class) was exceptional, signifying that this year class should be an important contributor to the fishery in the coming years. Three exceptional local walleye years classes have occurred since 2010 which should contribute to excellent walleye fishing for several years (see Section N).

Smallmouth bass abundance in 2016 was just below the long-term average, with age-1 fish dominating the catch. Standard recruitment measures suggest 2015 produced a below average smallmouth bass year class. This remains consistent with the observation that mean summer water temperatures are positively related to bass year class strength (Einhouse et al. 2002). Water temperatures during the summer of 2015 were about 3.2°F below average and produced a below average 2015 year class.

One of the most conspicuous long-term trends from our smallmouth bass data series is the measure of length-at-age for age-2 and age-3 smallmouth bass. Smallmouth bass showed significantly elevated growth rates that roughly correspond to the invasion of eastern Lake Erie by round goby in the late 1990's (see Section C). This observed increased growth by piscivores following the invasion of round goby has recently been more rigorously examined using this data series (Crane et al. 2016). They found that diet composition shifted from crayfish and a diversity of prey fish species to predominantly goby after the invasion. Increases in size at age and overall growth rate were observed. They attributed these changes to round goby invasion and the accompanying shift to goby as the major prey item of smallmouth bass.

Presently, the observed mean length of Lake Erie smallmouth bass exceeds measures for New York's other fast-growing populations (Green et al. 1986). Increases in growth rates are known to cause decreases in age at maturity and increases in mortality rate in fish. This is sometimes known as the "grow fast die young phenomenon" (Metcalfe and Monaghan 2003). One of the consequences of increased mortality are fewer older individuals in the population. The number of older (age 10+) bass has generally declined in recent years. Bass survival has also been declining over time which may be a consequence of increased growth and early maturity, or other potential recent stressors to the black bass population. However, over the past three years the number of age-10+ bass has started to increase and there is some evidence that bass survival is also increasing. The dynamics of smallmouth bass as they relate to goby introduction and abundance, disease, angling pressure, and other factors are still relatively poorly understood in the New York waters of Lake Erie. As such, Lake Erie smallmouth bass remain an excellent candidate for a more comprehensive study of bass bioenergetics, mortality rates, and population/fish community dynamics.

For more than a decade yellow perch status has been considerably improved relative to an earlier period of low abundance through the 1990's. Excellent juvenile recruitment during several recent years, coupled with a conservative harvest strategy by eastern basin jurisdictions (YPTG 2016), seem to have fostered improved status of yellow perch in Lake Erie's eastern basin, the lake's least biologically productive zone. More recently, yellow perch abundance had declined from 2011-2016 due largely to poor recruitment. This decrease did not initially influence yellow perch angler catch rates, which reached the highest observed level in 2014. However, angler catch rates for yellow perch declined substantially in 2015 and 2016 indicating that decreases in abundance began to influence fishery performance (see Section N). In 2017 the relative abundance of yellow perch increased substantially largely due to the success of the 2015 and 2016 year classes.

Long-term index netting remains invaluable as a tool to quantify and understand the relationships between fishing mortality, age structure, and year class strength. This information is imperative for informed management to ensure the continued sustainability of Lake Erie sport fish populations.

References

Crane, Derek P., and D. W. Einhouse. 2016. Changes in growth and diet of smallmouth bass following invasion of Lake Erie by the round goby. Journal of Great Lakes Research. 42:2 405-412.

Culligan, W.J., F.C. Cornelius, D.W. Einhouse, D.L. Zeller, R.C. Zimar, B.J. Beckwith, and M.A. Wilkinson. 1994. 1994 Annual Report of the Lake Erie Unit to the Lake Erie Committee and the Great Lakes Fishery Commission. New York State Department of Environmental Conservation, Bureau of Fisheries report. April 1994.

Einhouse, D. W., W. J. Culligan, and J. Prey. 2002. Changes in the smallmouth bass fishery of New York's portion of Lake Erie with Initiation of a spring black bass season. American Fisheries Society Symposium. 31:603-614.

Green, D. M., B. L. Schonhoff, and W. D. Youngs. The New York State Bass Study 1977-1980, Use of angler Collected Data to Determine Population Dynamics. New York State Department of Environmental Conservation, Bureau of Fisheries report. April, 1986.

Metcalfe, N. B., and P. Monaghan. 2003. Growth versus lifespan: perspectives from evolutionary ecology. Experimental Gerontology. 38: 935–940.

Ryan, P., S. Orsatti, D. Einhouse, D. Davies, R. Knight, M. Rawson, M. Turner, J. Murphy, and S. Nepszy. 1993. Interagency Protocol for Index Fishing with Gill Nets in Lake Erie. Report to the Standing Technical Committee and the Great Lakes Fishery Commission. September, 1993.

YPTG 2016. Report of the Lake Erie Yellow Perch Task Group. Presented to the Standing Technical Committee, Lake Erie Committee, and Great Lakes Fishery Commission.

E. Commercial Fishery Assessment

Jason M. Robinson

Introduction

Following 1986 legislation that prohibited the use of gill nets in New York waters of Lake Erie, a small commercial trap and hoop net fishery targeting yellow perch emerged and has remained for the last 32 years.

Methods

Commercial fishermen are required to submit monthly reports summarizing daily fishing effort and catches. The standard unit of effort is the number of net lifts that occurred during a day, irrespective of the amount of time the gear may have fished. Catches are reported as pounds harvested. Non-target species returned to the lake are not always reported. Due to increased fishing activity since 2005 we resumed annual collections of yellow perch ageing structures (anal spines) to assess the age distribution of the commercial harvest. These data, along with harvest and effort totals are reported to the Lake Erie Committee's Yellow Perch Task Group (YPTG) annually to produce a basin-wide summary of yellow perch status in the eastern basin of Lake Erie (Yellow Perch Task Group 2017).

Results

Four fishermen were issued licenses and two reported commercial fishing activity in 2017. The four fishermen licensed a combined total of 74 fyke nets and trap nets, which was the most gear licensed in the time series (Figure E.1).

Commercial catch reported by fishermen in 2017 totaled 12,366 lbs. (~30,200 fish) of yellow perch in 208 net lifts (Figure E.2). Yellow perch was the only species harvested or sold in 2017. Fishermen also caught 1,140 lbs. of burbot, 284 lbs. of white perch, 178 lbs. of catfish, 78 lbs. of suckers, 50 lbs. of freshwater drum, 19 lbs. of white bass, 9 lbs. of carp, 9 lbs. of rock bass, and 14 walleye (not harvested or salable). The 2017 commercial yellow perch harvest was the 10th highest in this 32-year time series. Trap netting effort was the 21st highest in this series. Seasonal fishing activity extended from April through October, with the greatest yellow perch harvest in May (Table E.1).

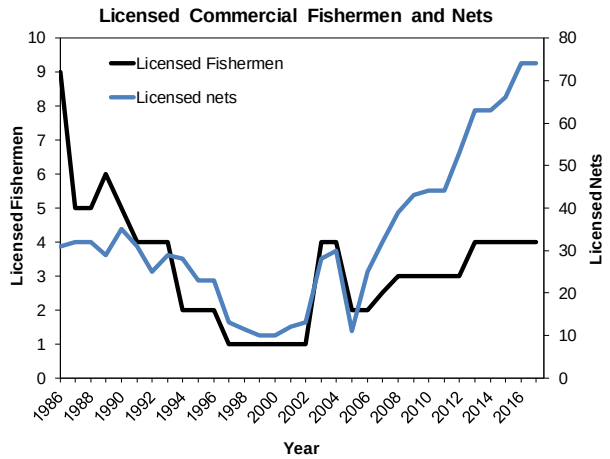


Figure E.1. Number of licensed commercial fishermen and combined licensed fyke and trap nets in the New York waters of Lake Erie form 1986–2017. Missing license and net data in 1998 and 2007 was interpolated for the purposes of this figure.

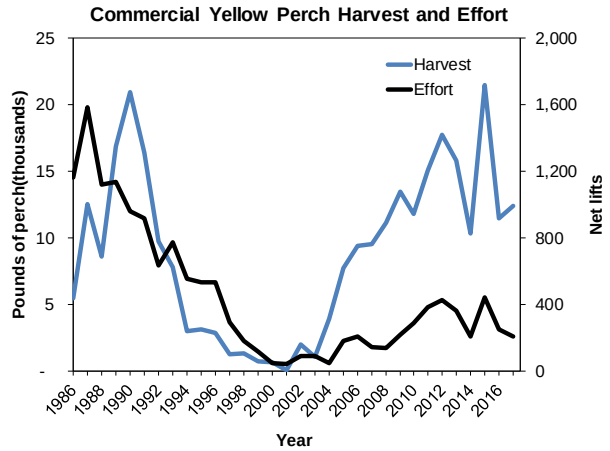


Figure E.2. Total commercial yield of yellow perch, and trap net lifts, reported by commercial fisherman operating in New York's portion of Lake Erie, 1986 to 2017.

Table E.1. The distribution of catch and effort of the five most reported species in New York's 2017 Lake Erie commercial fishery.

	Comercial catch of prominent species (lbs)					Effort
Month	Y. Perch	Burbot	W. Perch	Catfish	Suckers	(# of lifts)
Mar						
Apr	1,266	235	18	82		28
May	6,059	465	38	82	3	54
Jun	2,574	355	15	9		64
Jul	462	30	67			16
Aug	867	8	100	3	43	22
Sep	924	12	36	2	27	19
Oct	214	35	10		5	5
Nov						
Dec						
Total	12,366	1,140	284	178	78	208

We sampled commercially harvested yellow perch on three occasions during periods of high commercial fishing activity in May and June to characterize age distribution of the 2017 commercial harvest. Age determination from 150 yellow perch anal fin samples identified 11 cohorts that ranged from age-3 to age-14. Age-5 was the dominant cohort, comprising 53% of the sample (Figure E.3). The mean length and weight of yellow perch from this sample was 10.0 inches and 0.41 lbs. Sex ratio was skewed towards mature males; 87% of the yellow perch examined were males expressing gametes.

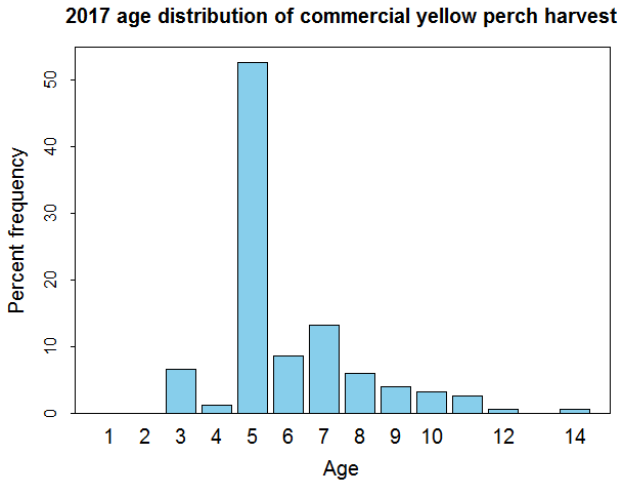


Figure E.3. Percent frequency age distribution of 150 yellow perch sampled from the commercial harvest in New York's portion of Lake Erie, May and June 2017.

Discussion

A small trap net fishery targeting yellow perch in the vicinity of Barcelona Harbor has continued since 1986 in New York's portion of Lake Erie. Commercial fishing activity has been somewhat elevated during the most recent 12-year period (2006 to 2017), generally corresponding to a period of increased yellow perch abundance in Lake Erie's eastern basin. While the number of commercial fishermen has remained relatively constant recently, the amount of gear licensed has continued to increase. Increases in reported effort have not kept pace with increases in the amount of gear licensed.

Commercial fishery harvest has not declined to the same extent as the recreational harvest over the past three years (See Section J). In 2017 the commercial fishery harvest accounted for an estimated 41% of the total measured harvest (commercial and recreational combined by number of fish). The commercial and recreational yellow perch fisheries are spatially segregated, as very little recreational effort is expended near Barcelona Harbor. Nevertheless, significant expansion of the commercial fishery is not recommended, as it could become difficult to maintain New York's long-term yellow perch harvest within annual internationally established total allowable harvest recommendations.

References

Yellow Perch Task Group. 2017. Report of the Lake Erie Yellow Perch Task Group, March 2018. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission. Ann Arbor, Michigan, USA.

F. COLDWATER GILL NET ASSESSMENT

James L. Markham

Rehabilitation of a self-sustaining lake trout population in the eastern basin of Lake Erie continues to be a major element of New York's Great Lakes coldwater fisheries management programs, in cooperation with member agencies of the Great Lakes Fishery Commission's Lake Erie Committee (LEC), the U.S. Fish and Wildlife Service (USFWS), and the US Geological Survey's Lake Erie Biological Station at Sandusky, Ohio. A lake trout management plan (Markham et al. 2008) was approved by the LEC in 2008 and serves as a guide for ongoing rehabilitation efforts.

New York's 2017 annual coldwater assessment program consisted of: (1) standardized deepwater gill netting in August, and (2) monitoring sea lamprey wounding on lake trout (see Section G). Additional netting in November to sample the lake trout spawning population has not been conducted since 2013, mainly due to unfavorable autumn sampling conditions. Beginning in 2016 those fall netting surveys were replaced by a new acoustic telemetry study that relies on remote sensing of tagged adult lake trout to identify areas used for spawning.

Methods

A standardized, random transect design gill net sampling protocol has been employed to assess the lake trout population in the New York waters of Lake Erie since 1986. Sampling is conducted in August each year, following lake stratification. LORAN-C lines of position having a relative North/South orientation are used to establish 13 equidistant candidate transects in each of two areas from Dunkirk west to the New York/Pennsylvania boundary. This zone delineates summertime lake trout habitat in the New York waters of Lake Erie. Six randomly selected transects in each of the two areas are sampled each survey year. Five net gangs are fished per sampling night on each transect, yielding 60 lifts annually. However, if bias is encountered (i.e., major thermocline shift overnight), the biased lifts are deleted from abundance calculations but otherwise used for age, growth, and wounding statistics.

Standard survey gear and fishing protocol were initially adopted in 1986, as follows: On any given transect, the first net gang (#1) is fished parallel with shore (on contour), at or below the 50ºF isotherm. Each of the next four successive net gangs are set on bottom along contours at increments of 5.0 feet greater depth or 0.5 miles distance from the previous gang, whichever occurs first, along the transect in a northerly (deeper) direction. Each net gang consists of 10 randomly placed, 8 ft deep by 50 ft long panels of monofilament mesh (500 feet total length), ranging from 1.5 to 6.0 inch by 0.5 inch increments (standard mesh sizes).

Modest changes to the initial standard sampling gear and protocol occurred in 1995 and 1996. In 1995, placement of the fifth gang was set 50 feet deeper than the shallowest gang (#1) or 1.0 mile distant from the fourth gang, whichever occurred first. This modification was made with hopes of intercepting lake trout that may have moved deeper in response to greater light penetration first experienced during the 1990's (Culligan et al. 1997). Prior to 1996, 6 ft deep by 50 ft long multifilament panels were used as the standard net. In 1996 this survey also adopted a new standard monofilament net and this change was accompanied by two years of comparison netting which found no significant difference in the catchability of lake trout between these two gill net webbing materials with differing panel depths (Culligan et al. 1998). Also beginning in 1996, a 50 foot long panel of both 7.0 and 8.0 inch mesh were added to each net gang in an attempt to improve catches of larger and older-aged lake trout (Culligan et al. 1997). In 2016, an analysis was conducted to determine if the addition of the 7.0 and 8.0 inch mesh panels collect a larger size component of the lake trout population compared to the standard mesh sizes (1.5 – 6.0 inch). Results of this analysis demonstrated that the 7.0 and 8.0 inch mesh sizes did not capture larger fish (Figure F.1). As such, these largest meshes were dropped from the net gang beginning in 2017.

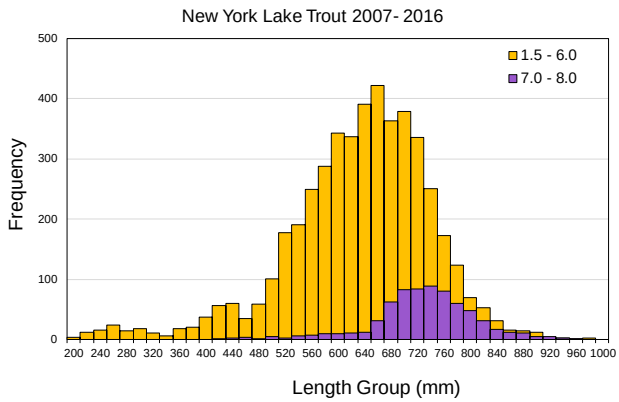


FIGURE F.1. Length frequency distribution of lake trout captured in standard (1.5 – 6.0 inch) and large (7.0, 8.0) mesh sizes during a coldwater gill net survey in the New York waters of Lake Erie, August, 2007-2016.

Lake trout captured in 7.0 and 8.0 inch mesh panels from 1996 through 2016 have never been included in abundance estimates to maintain comparable indices throughout the assessment time series.

Beginning in 2014, additional gill net sites were selected further offshore from our standard sites to improve our understanding of the distribution of coldwater fish species and assess potential differences in lake trout demographics in the large area outside of our standard assessment netting program. Three years of offshore sampling demonstrated that sufficient differences in lake trout abundance and sea lamprey wounding rates did occur in this previously unsampled area to warrant inclusion of the offshore net sites in the standard assessment program (Markham 2017). However, data from these sites are not included in long term abundance index calculations. In 2017, a total of 10 of the 60 gill net gangs set were switched to offshore locations, and consequently two fewer transects were sampled in the standard assessment area (Figure F.2). The offshore sampling locations were randomly selected from a grid system.

Data gathered from lake trout include total length, weight, sex, maturity, stomach contents, fin clips, and sea lamprey wounds. Snouts are retained from all tagged lake trout for coded-wire tag (CWT) retrieval. Otoliths are also collected from any lake trout without a clip and CWT. Secondary targets (i.e. burbot, whitefish, and other salmonids) are examined using the same protocol. Otoliths and/or scales are

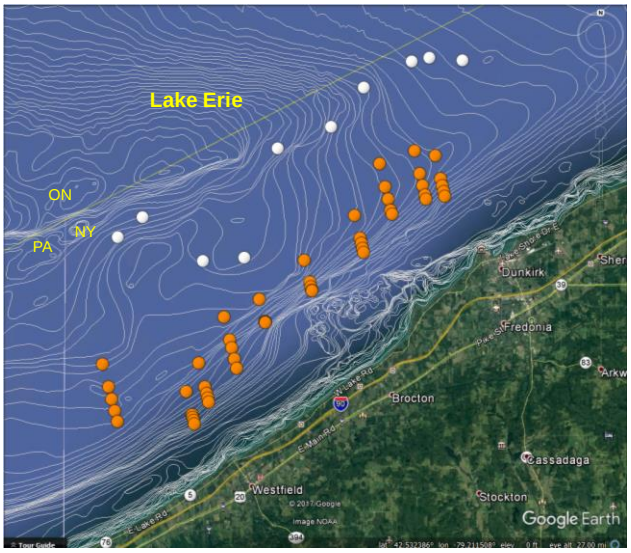


FIGURE F.2. Gill net locations for assessment of coldwater species in the NY waters of Lake Erie, Aug. 2017. White circles indicate locations of ten randomly selected offshore nets set outside of the long term standard sampling protocol.

collected from all secondary targets as needed.

Klondike strain lake trout are an offshore form from Lake Superior and are thought to behave differently than commonly stocked "Lean" strain lake trout. Klondikes were first stocked in Lake Erie in 2004 and are separated in most analyses to examine differences with all Lean strain lake trout. Lean strain lake trout comprise all other stocked strains, including Finger Lakes, Lake Champlain, Slate Island, and Lewis Lake. It should be noted that Klondike strain have not been stocked in Lake Erie since 2010, and their abundance (i.e. sample sizes) in this coldwater survey has dwindled in recent years.

Results

A total of 60 lifts were completed between 1-29 August in the 2017 assessment (Figure F.2). Ten of these lifts sampled a new offshore stratum in 2017 and two other lifts were considered biased due to a temperature shift; data from these twelve lifts were excluded from standard long term abundance estimates. The range of depths sampled at traditional net sites ranged from 85 to 146 feet as compared to 93 to 165 feet at offshore sites. Target coldwater species caught during the survey (all nets, all mesh sizes) included 361 lake trout, 99 lake whitefish, 32 burbot, 2 steelhead, 1 Chinook salmon, and 1 brown

trout. This was the first Chinook salmon caught in this survey since 2000. Other species caught included 26 yellow perch, 14 white bass, 18 white perch, 33 walleye, and 2 freshwater drum.

Natural Reproduction of Lake Trout

There were two potentially wild lake trout (missing fin clips and CWT) sampled in 2017, representing less than 1% of the fish captured (Table F.1). Altogether, 59 potentially wild fish have been caught since 2000, representing 2.2% or less of the annual lake trout sample. This rate is similar to measures of unclipped/untagged fish after marking in the hatchery. Otoliths from these potentially wild lake trout were removed and saved, and may be used in future studies to determine if these fish were of wild or hatchery origin.

TABLE F.1. Number of potentially wild lake trout and percentage of total sample of lake trout caught in coldwater assessment gill nets in the New York waters of Lake Erie, 2000-2017. A potentially wild fish has no fin clips and no coded-wire tag (CWT).

Year	Number of Fish without Tags/Clips	Number of Lake Trout Sampled	Percent without Tags/Clips
2000	3	134	2.2
2001	5	249	2.0
2002	2	226	0.9
2003	11	550	2.0
2004	2	248	0.8
2005	1	281	0.4
2006	1	353	0.3
2007	1	355	0.3
2008	5	603	0.8
2009	3	466	0.6
2010	6	365	1.6
2011	5	659	0.8
2012	3	498	0.6
2013	2	528	0.4
2014	2	837	0.2
2015	5	782	0.6
2016	0	363	0.0
2017	2	361	0.6

Lake Trout Age Structure

Nineteen age classes, ranging from age 1 to 31, were in the sample of 314 known-age fish as determined by CWT or fin clip examination (Tables F.2 and F.3). Ages 5, 7, 8, and 9 were the most abundant cohorts, representing 73% of the total catch. Age 10-and-older fish remain in relatively low abundance. Particularly noteworthy in the sample were a 31 year-old female, one of the oldest lake trout captured in this survey, and a 26 year-old male nearly 40 inches in length and weighing nearly 30 pounds. This was the largest lake trout ever sampled in this survey.

Lake Trout Growth and Maturity

Mean length-at-age and weight-at-age remain consistent with length and weight regressions from the previous ten years (2007-2016) for both Lean strain and Klondike strain lake trout (Figures F.3 and F.4). Klondike strain statistics are based on a sample size of only seven fish. Small variations in both mean length and weight compared to the ten-year regression occur at older ages and are likely an artifact of low sample sizes. Consistent with past results, mean length and weight of Klondike strain lake trout were lower than Lean strain lake trout at similar ages. In general, Klondike strain lake trout are smaller in both length and weight by age-3 compared to Lean strain fish.

Lean strain male lake trout are 100% mature by age-4, and females nearly 100% mature by age-5 (Table F.2). Despite differences in growth, Klondike and Lean strain lake trout have similar maturity schedules in Lake Erie. Given cessation of Klondike strain stocking in 2011, data are limited to older ages in Table F.3.

TABLE F.2. Number, mean total length (inches TL), mean weight (lbs.), and percent maturity of known age and sex lake trout (**Lean strain**) by age class collected in gill nets (all mesh sizes) from New York waters of Lake Erie, August 2017.

AGE	SEX	NUMBER	MEAN LENGTH (inches TL)	MEAN WEIGHT (pounds)	PERCENT MATURE
1	Male	1	7.8	0.3	0
	Female	0	-----	-----	-----
2	Male	12	16.6	1.8	0
	Female	8	16.1	1.7	0
3	Male	5	22.2	4.9	100
	Female	4	21.8	4.2	0
4	Male	6	24.5	6.7	100
	Female	2	25.5	7.4	50
5	Male	25	26.4	7.8	100
	Female	27	27.4	9.4	96
7	Male	47	29.4	11.7	100
	Female	24	28.8	11.3	100
8	Male	42	29.9	12.5	100
	Female	24	29.5	11.7	100
9	Male	17	30.3	12.6	100
	Female	19	30.6	13.3	100
10	Male	14	31.2	13.1	100
	Female	7	30.4	13.0	100
11	Male	3	31.1	13.7	100
	Female	5	32.4	15.2	100
12	Male	0	-----	-----	-----
	Female	1	32.2	12.5	100
14	Male	3	32.2	15.5	100
	Female	2	35.1	21.0	100
15	Male	0	-----	-----	-----
	Female	3	32.7	16.3	100
17	Male	0	-----	-----	-----
	Female	1	34.4	18.0	100
18	Male	1	34.3	14.6	100
	Female	0	-----	-----	-----
21	Male	0	-----	-----	-----
	Female	1	34.3	19.0	100
26	Male	1	39.5	29.7	100
	Female	0	-----	-----	-----
29	Male	1	37.1	18.1	100
	Female	0	-----	-----	-----
31	Male	0	-----	-----	-----
	Female	1	35.0	21.4	100

TABLE F.3. Number, mean total length (inches TL), mean weight (lbs.), and percent maturity of known age and sex lake trout (**Klondike strain**) by age class collected in gill nets (all mesh sizes) from New York waters of Lake Erie, August 2017.

AGE	SEX	NUMBER	MEAN LENGTH (inches TL)	MEAN WEIGHT (pounds)	PERCENT MATURE
9	Male	4	28.2	11.7	100
	Female	1	29.7	10.0	100
10	Male	0	-----	-----	-----
	Female	1	29.4	12.7	100
11	Male	0	-----	-----	-----
	Female	1	26.6	9.6	100

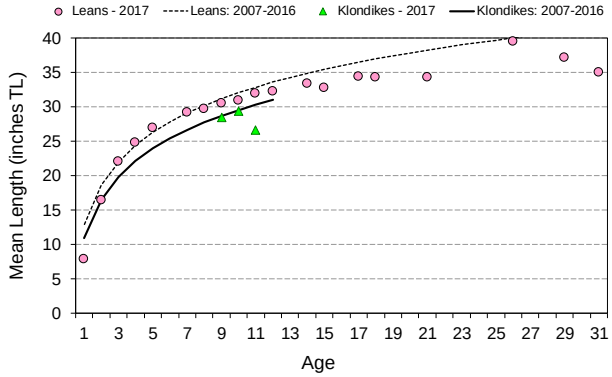


FIGURE F.3. Mean length-at-age of Lean strain and Klondike strain lake trout collected in gill nets from New York waters of Lake Erie, August 2017, and the 10-year (2007-2016) length-at-age regression for current growth rate comparison.

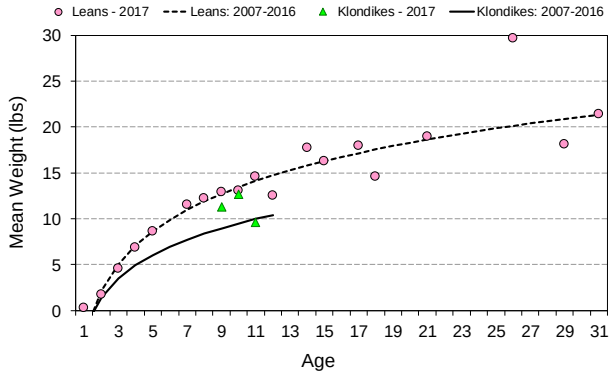


FIGURE F.4. Mean weight-at-age of Lean strain and Klondike strain lake trout collected in gill nets from New York waters of Lake Erie, August 2017, and the 10-year (2007-2016) weight-at-age regression for current growth rate comparison.

Lake Trout Abundance

The overall relative abundance of lake trout (immature and mature combined) caught in 2017 was 6.9 lake trout/lift (Figure F.5), a 30% increase compared to 2016 (5.3 fish/lift). Overall abundance in the New York waters of Lake Erie has met or exceeded the basinwide lake trout management plan objective of 8.0 fish/lift for five of the ten years since the Plan was adopted (Markham et al. 2008). Immature lake trout (generally ≤ age 4) abundance increased slightly in 2017 following five consecutive years of decline (Figure F.5). Age 2 lake trout were the most abundant immature cohort sampled during 2017 (Figure F.6). Lake trout are not fully recruited to the gill nets until age-4, so abundance measures of cohorts less than age-4 typically increase at older ages. Converse to immature fish, the overall abundance of mature adult lake trout (generally ≥ age

5) had been increasing in recent years, but sharply declined in 2016 to levels comparable to the late 2000s (Figure F.5). A slight increase in adult abundance occurred in 2017. The relative abundance by age in 2017 shows mature lake trout ages 5, 7, 8, and 9 were the most prevalent cohorts caught in the survey (Figure F.6). Age-10 lake trout were also more abundant compared to recent years; lake trout older than age-10 were relatively scarce. Klondike strain lake trout continue to decline in abundance with only three age classes (ages 9, 10 and 11) found in the 2017 survey (Figure F.6).

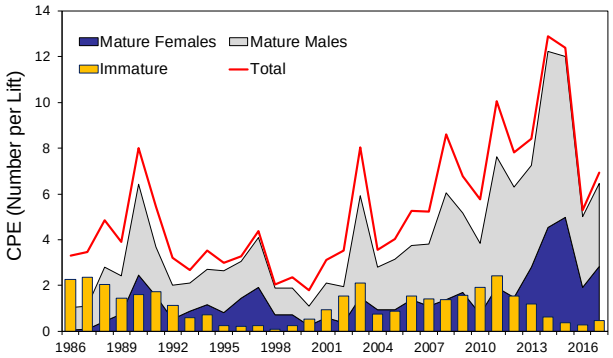


FIGURE F.5. Catch per lift of immature, mature (by sex), and total lake trout caught in standard assessment gill nets (mesh sizes 1.5 – 6.0 in) from NY waters of Lake Erie, August, 1986-2017.

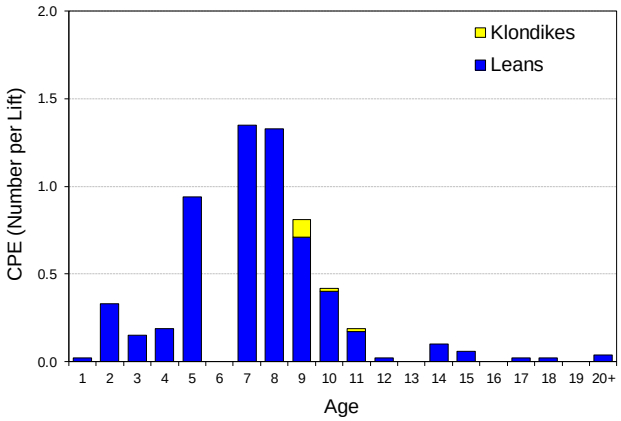


FIGURE F.6. Relative abundance by age of Lean strain and Klondike strain lake trout collected from standard assessment gill nets fished in New York waters of Lake Erie, August 2017.

A total of 23 lake trout were caught in the ten offshore nets in 2017 (see Figure F.2). Sampled depths ranged from 93 to 165 feet, and similar to the previous three years, fewer lake trout were caught in offshore nets compared to standard net locations despite some overlap in depth sampled (Figure F.7). Lake trout catch per lift in 2017 in offshore nets was 2.3 lake trout per lift, as compared to 6.9 fish/lift at standard assessment netting locations. With the exception of 2016, lake trout catch rates in the offshore sites remain approximately 1/3 of that at standard net locations. Both offshore and standard sites show similar patterns of declining abundance over the past four years. The age distribution and strain composition of lake trout from the offshore nets remain similar to the lake trout caught in the standard net locations.

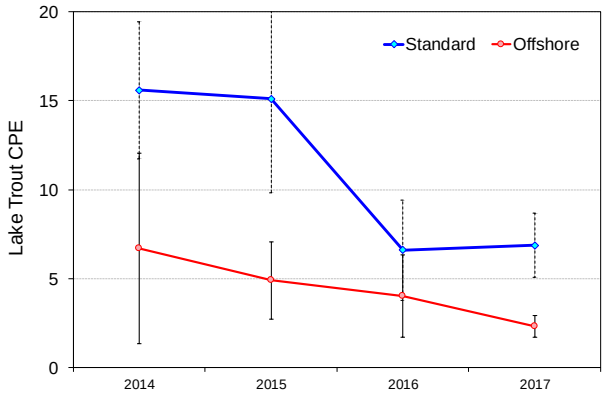


FIGURE F.7. Catch per lift with 95% confidence limits of lake trout caught in standard assessment and offshore gill nets (all mesh sizes) from the New York waters of Lake Erie, August, 2014-2017.

Lake Trout Survival

Point estimates of annual survival (S) for individual cohorts of lake trout were calculated by strain and year class using a 3-year running average of catch per unit effort (CPE) with ages 4 through 11. A running average was used due to the high year-to-year variability in catches, particularly in the Finger Lakes strain. The Superior and Finger Lakes strains have been the most consistently stocked lake trout strains in Lake Erie and provide the best timeline of changes in lake trout survival during restoration efforts. Survival estimates for both of these strains were near or below the target survival rate of 60% or higher (Lake Trout Task Group 1985; Markham et al. 2008) prior to 1986 due to excessive mortality from a large, untreated sea lamprey population (Table F.4). Substantial increases in survival occurred following the initial treatments of sea lamprey in Lake Erie in 1986. While survival estimates generally remained above targets for the Finger Lakes strain since this time, the Superior strain experienced very low

survival for the 1997-2001 cohorts, presumably due to increased sea lamprey predation (see Section G). Estimates of the 2003, 2004, and 2006 year classes of Klondike strain fish indicate very low survival rates comparable to Superior strain lake trout from the 1997-2001 year classes. Partial age estimates were also calculated for Lake Champlain strain lake trout to determine if their survival was comparable to Finger Lakes or Superior strain lake trout. Initial results indicate survival rates above the target rate for the 2008 and 2009 cohorts.

TABLE F.4. Cohort analysis estimates of annual survival (S) by strain and year class for lake trout caught in standard assessment nets in the New York waters of Lake Erie, 1985–2017. Three-year running averages of CPE from ages 4–11 were used due to year-to-year variability in catches. Cells in red indicate survival estimates that fall below the 0.60 target rate. Asterisk (*) indicates years where only partial ages were available.

	STRAIN				
Year Class	**LC**	**SUP**	**FL**	**KL**	**ALL**
1983		0.687			0.454
1984		0.619	0.502		0.533
1985		0.543	0.594		0.578
1986		0.678			0.634
1987		0.712	0.928		0.655
1988		0.726	0.818		0.679
1989		0.914	0.945		0.766
1990		0.789	0.634		0.709
1991					0.615
1992					0.599
1993			0.850		0.646
1994					0.649
1995					0.489
1996			0.780		0.667
1997		0.404	0.850		0.549
1998		0.414			0.364
1999		0.323	0.76		0.431
2000		0.438	0.769		0.655
2001		0.225	0.696		0.522
2002			0.693		0.633
2003			0.667	0.242	0.585
2004				0.485	0.420
2005			0.450		0.629
2006			0.827	0.58	0.770
2007*			0.818	0.589	0.801
2008*	0.665		0.828	0.489	0.756
2009*	0.688				0.801
MEAN	**0.677**	**0.575**	**0.745**	**0.477**	**0.614**

Lake Trout Strains

Seven lake trout strains were collected among the 316 fish caught with hatchery-implanted CWT's or fin-clips (Table F.5). Lake Champlain, Finger Lakes, and Slate Island have been the most commonly stocked lake trout strains in Lake Erie over the past nine years (see Section H, Figure H.2). Lake Champlain and Finger Lakes strains were the most numerous strains caught in Lake Erie in 2017. Catches of the Klondike strain have declined to the point that they were scarcely detected in our most recent survey. Despite being stocked in the Ontario waters of Lake Erie since 2005, the Slate Island strain are not commonly sampled in the New York assessment survey. The Finger Lakes strain remains the most common lake trout strain caught at older ages; all but 2 (96%) lake trout age-10-and-older were FL strain fish.

TABLE F.5. Number of lake trout per stocking strain by age collected in gill nets from New York waters of Lake Erie, August 2017. Stocking strain codes are: FL = Finger Lakes, KL = Klondike, SI = Slate Island, LC = Lake Champlain, and AI = Apostle Island. Finger Lakes include Finger Lakes, Finger Lakes/Superior cross, and Lake Ontario strains. Shaded cells indicate years' strain was stocked in Lake Erie.

AGE	FL	KL	SI	LC	AI
1				1	
2	18		2	1	
3	9				
4	2			7	
5	17			35	
6					
7				71	
8				66	
9	28	5		7	1
10	21	1			
11	8	1			
12	1				
13					
14	5				
15	3				
16					
17	1				
18	1				
19					
20					
21	1				
22					
23					
24					
25					
26	1				
27					
28					
29	1				
30					
31	1				
32					
TOTAL	**118**	**7**	**2**	**188**	**1**

Lake Trout Diet

Stomach analysis of lake trout and burbot revealed diets entirely comprised of fish (Figure F.8). Rainbow smelt have been the long-term main prey item for lake trout, but round gobies have become a

common prey item since they invaded the eastern basin of Lake Erie in the late 1990s. Klondike strain lake trout have typically shown a higher incidence of round gobies in stomach contents compared to lean lake trout strains (Markham 2010).

In 2017, rainbow smelt remained the dominant diet item for Lean strain lake trout, occurring in 88% of the non-empty stomachs; round goby was the second most common prey item (11%). Rainbow smelt were the only prey found in the four Klondike strain lake trout stomachs examined in 2017. Yellow perch were the only other identifiable species found in lake trout stomachs in 2017.

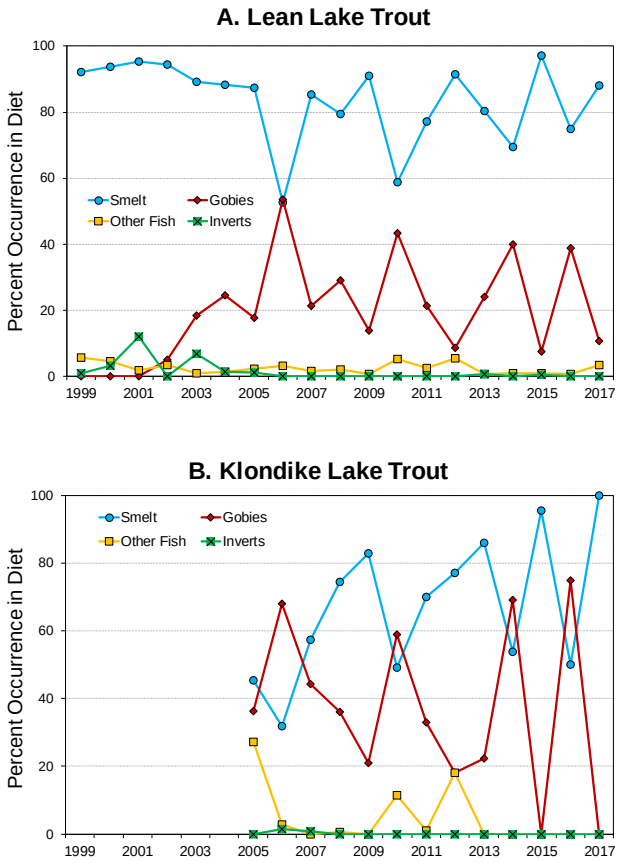


FIGURE F.8. Percent occurrence in diet of rainbow smelt, round gobies, all other fish species, and invertebrates from non-empty stomachs of: A) Lean strain lake trout, and B) Klondike strain lake trout collected in gill nets from New York waters of Lake Erie, August, 1999-2017.

Burbot Abundance

The burbot abundance index in 2017 was 0.5 fish/lift, slightly lower than 2016 and the third lowest observed (Figure F.9). Burbot abundance has declined 87% from a peak in 2004, but has remained relatively stable over the past five years. In offshore netting, the burbot abundance index has remained relatively stable and similar to that of standard netting locations (Figure F.10).

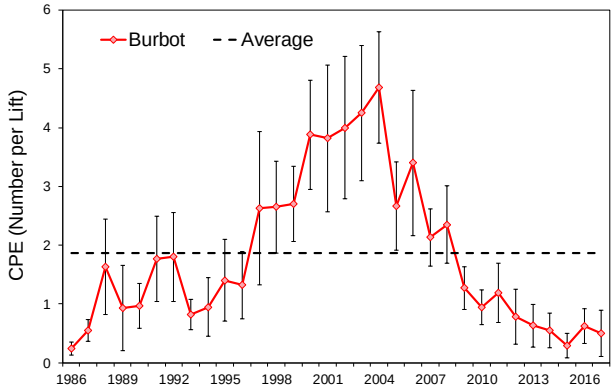


FIGURE F.9. Catch per effort (number fish/lift) and confidence limits (approximated as 2 SE's) of burbot caught in standard assessment gill nets (mesh sizes 1.5 – 6.0 in) from New York waters of Lake Erie, August 1986-2017. Dashed line indicates time series average.

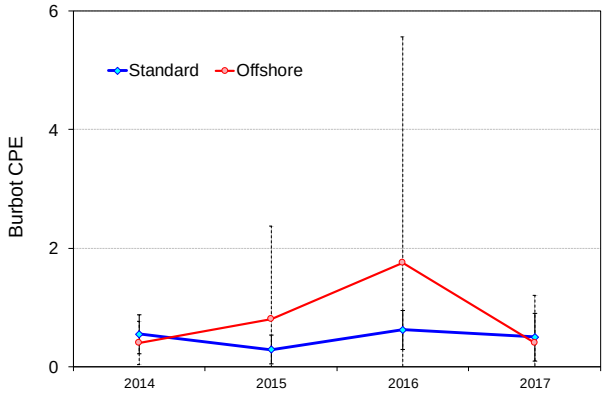


FIGURE F.10. Catch per lift with 95% confidence limits of burbot caught in standard assessment and offshore gill nets (all mesh sizes) from the New York waters of Lake Erie, August, 2014-2017.

Burbot Diet

Round goby have become the dominant prey item for burbot, surpassing rainbow smelt in occurrence in most years since 2003 (Figure F.11). The occurrence of invertebrates has also decreased in burbot diets since the round goby invasion. Round gobies remained the dominant prey species for burbot in 2017, occurring in 70% of burbot stomachs. Rainbow smelt were only found in 2 of the 10 burbot (20%)

with non-empty stomachs. Yellow perch and gizzard shad were the only other identifiable prey species found in burbot during 2017.

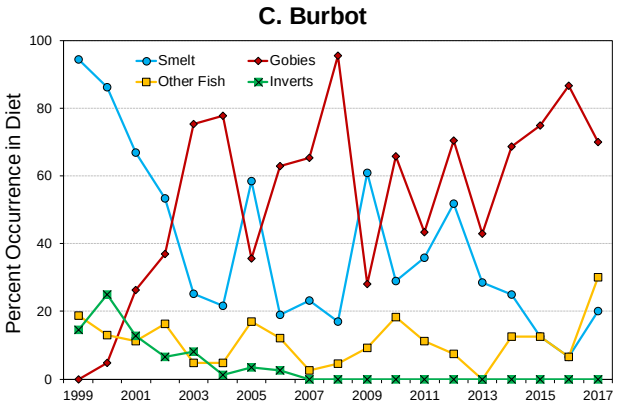


FIGURE F.11. Percent occurrence in diet of rainbow smelt, round gobies, all other fish species, and invertebrates from non-empty stomachs of burbot collected in gill nets from New York waters of Lake Erie, August, 1999-2017.

Lake Whitefish Abundance

Lake whitefish have characteristically exhibited highly variable catches in this survey (as depicted by large confidence limits), both between and within years. A total of 57 lake whitefish were caught at standard assessment netsites in 2017 (1.2 fish/lift; Figure F.12), the second consecutive increase in abundance but well below the average of 2.6 fish/lift. Whitefish abundance has declined over 90% since a peak observed in 2007.

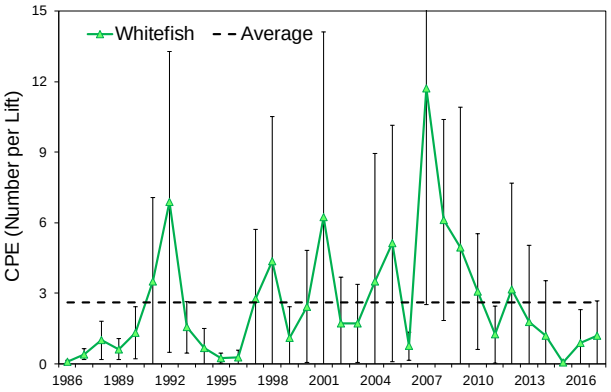


FIGURE F.12. Catch per lift and conf. limits (2 SE's) of lake whitefish caught in standard assessment gill nets (mesh sizes 1.5 – 6.0 in) in NY waters of Lake Erie, Aug 1986-2017.

Discussion

Overall lake trout abundance in the New York waters of Lake Erie in 2017 remained similar to 2016 estimates and signifies a substantial decline in overall abundance following the time series highs observed in 2014 and 2015. Despite the decline, lake trout abundance remains above average, and more importantly the abundance of mature lake trout changed little from 2016.

While sea lampreys continue to be a major factor influencing adult lake trout abundance and age structure of the population, the current strains being stocked in Lake Erie (Finger Lakes and Lake Champlain) appear to avoid or survive sea lamprey attacks better (see Section G, this report), exhibit higher overall survival, and hence are producing a more stable adult population than in the past. In contrast, survival estimates of the Superior strains of lake trout (mainly Superior and Klondike strains) were much lower, mainly due to a higher susceptibility to sea lamprey attacks, and failed to produce sufficient numbers of adults. These wounding observations relative to lake trout strain are consistent with previous research conducted in Lake Ontario by Schneider et al. (1996). The Lake Erie lake trout rehabilitation plan recommends a diversity of lake trout strains for re-establishment of lake trout stocks (Markham et al. 2008). However, with Lake Erie's continuing sea lamprey issues, the best strategy to produce a large adult lake trout population that provides the best opportunity for restoration is to eliminate stocking those strains which exhibit poor survival (i.e. Superior strains) and concentrate on strains that consistently have survival rates above the 60% target rate (i.e. Finger Lakes, and possibly Lake Champlain, strains).

Klondike strain lake trout were originally stocked in Lake Erie as an alternative deepwater form to utilize any offshore spawning habitat that may be available in Lake Erie. Modest numbers of these fish were stocked between 2004 and 2009, and while juvenile survival appeared to be high, adult survival was low, presumably due to sea lamprey mortality. Because Klondikes were a different form (humper) of lake trout compared to the normally stocked fish (lean form), they have been separated in many analyses

over the past decade. However, declining numbers of this strain have now reached the point where further reporting on this strain is unwarranted.

A relatively new offshore netting stratum has now become an ongoing component of our overall coldwater survey. This new stratum should prove useful for furthering our understanding of the dynamics of coldwater fish community beyond our standard assessment netting area. Thus far, the offshore stratum found lake trout occur at much lower densities than the standard long term locations. Lake trout relative abundance estimates in the offshore nets were generally one third of the estimates measured at standard survey locations. In contrast, burbot densities remained similar regardless of location and depth. Since most of Lake Erie's coldwater habitat extends well beyond the depth ranges sampled by our long-term standard assessment methods, obtaining additional knowledge of trends in offshore densities of lake trout and other species that inhabit a much larger but historically unmonitored area may reveal a more complete perspective of the status of coldwater species.

References

Culligan, W. J., F. C. Cornelius, D. W. Einhouse, D. L. Zeller, R. C. Zimar, B. J. Beckwith, and M. A. Wilkinson. 1997. NYSDEC Lake Erie 1997 Annual Report to the Lake Erie Committee. New York Department of Environmental Conservation, Albany.

Culligan, W. J., F. C. Cornelius, D. W. Einhouse, D. L. Zeller, R. C. Zimar, B. J. Beckwith, and M. A. Wilkinson. 1998. NYSDEC Lake Erie 1998 Annual Report to the Lake Erie Committee. New York Department of Environmental Conservation, Albany.

Lake Trout Task Group. 1985. A Strategic Plan for the Rehabilitation of Lake Trout in Eastern Lake Erie. Report to the Great Lakes Fishery Commission's Lake Erie Committee, Ann Arbor, Michigan, USA.

Markham, J.L. 2010. Coldwater gill net assessment. Section F *in* NYSDEC 2010, Lake Erie 2009 Annual Report. New York State Department of Environmental Conservation, Albany, New York, USA.

Markham, J.L. 2017. Coldwater gill net assessment. Section F *in* NYSDEC 2017, Lake Erie 2016 Annual Report. New York State Department of Environmental Conservation, Albany, New York, USA.

Markham, J., A. Cook, T. MacDougall, L. Witzel, K. Kayle, C. Murray, M. Fodale, E. Trometer, F. Neave, J. Fitzsimons, J. Francis, and M. Stapanian. 2008. A strategic plan for the rehabilitation of lake trout in Lake Erie, 2008-2020. Lake Erie Committee, Great Lakes Fisheries Commission, Ann Arbor, MI. Available at http://www.glfc.org/lakecom/lec/LEC_docs/other_docs/manplan2008.pdf [accessed 14 January 2008]

Schneider, C.P., R.W. Owens, R.A. Bergstedt, and R. O'Gorman. 1996. Predation by sea lamprey (*Petromyzon marinus*) on lake trout (*Salvelinus namaycush*) in southern Lake Ontario, 1982-1992. Canadian Journal of Fisheries and Aquatic Sciences 53(9):1921-1932.

G. SEA LAMPREY ASSESSMENT

James L. Markham

Sea lamprey invaded Lake Erie and the upper Great Lakes in the 1920's with the opening of the Welland Canal connecting lakes Erie and Ontario. While not the exclusive cause, sea lamprey predation undoubtedly played an integral part in the eventual demise of Lake Erie's lake trout population. The initial Strategic Plan for Lake Trout Restoration in Eastern Lake Erie (Lake Trout Task Group 1985) pointed to the lack of lamprey control as a bottleneck for re-establishing lake trout. The Sea Lamprey Management Plan for Lake Erie (Lake Trout Task Group 1985a) followed with a set of goals to achieve sea lamprey control. Since 1986, Great Lakes Fisheries Commission agents conducted regular lampricide treatments of key Lake Erie tributaries to control sea lamprey populations and mitigate damage inflicted on the lake's coldwater fish community.

This report outlines sea lamprey assessment efforts undertaken by the New York State Department of Environmental Conservation's (DEC) Lake Erie Fisheries Unit. Two types of DEC assessments monitor adult sea lamprey abundance: 1) a long term wounding rate index on lake trout and other species, and 2) an index of sea lamprey nest counts on standard stream sections. Other lake wide adult and larval sea lamprey assessments, and all Lake Erie sea lamprey control efforts, are performed by the United States Fish and Wildlife Service (Service) and the Department of Fisheries and Oceans Canada as agents of the Great Lakes Fishery Commission. A report covering these activities can be found in the Lake Erie Coldwater Task Group Report (Coldwater Task Group 2017).

Methods

Wounding Rate Assessment

Lake trout are the only Lake Erie salmonine used for sea lamprey wounding assessments due to their availability throughout the Great Lakes and vulnerability to sea lamprey attacks. More recently, sea lamprey wounds on burbot have also been reported due to observed population declines. Samples are obtained from gill net assessments targeting lake trout, burbot and other coldwater species during August in New York's portion of Lake Erie from Dunkirk westward to the New York/Pennsylvania boundary.

Sea lamprey wounds on lake trout are classified as A1-A4 for evidence of active feeding, and as B1-B4 wounds for non-active feeding, according to King and Edsall (1979). Standard wounding rates on lake trout are reported as the number of fresh (A1-A3) wounds per 100 fish > 21 in. A1 and A4 wounds, specifically, are also reported as evidence of the current and previous year's wounding, respectively. Data are tabulated using lake trout total length (TL) categories: 17-21 inches, 21-25 inches, 25-29 inches, and >29 inches. Burbot wounding rates are reported for fresh (A1-A3) and healed (A4) wounds on all individuals.

Beginning in 2013, angler survey technicians began recording wounds (fresh or healed) observed on harvested fish examined during the Open Lake Sport Fishing Survey (see Section J). These additional observations identify the broader list of sport fish species attacked by sea lamprey, and perhaps over time will also generate useful information to establish a wounding index for other components of the fish community.

Sea Lamprey Nest Assessment

Sea lamprey nest counts are conducted annually between June 1 and June 15 on standard sections of four streams: Delaware Creek, Clear Creek, North Branch of Clear Creek, and Canadaway Creek. Each year nest counts begin following peak adult lamprey catches in portable assessment traps operated by Service contractors on Cattaraugus Creek at the base of Springville Dam and at Spooner Creek, a tributary to Cattaraugus Creek. All Clear Creek count sites are located on Seneca Nation of Indian (SNI) Territory, and those counts are achieved with permission of the SNI.

Results

Wounding Rate Assessment

Lake trout collected in coldwater assessment netting (Section F) had a total of 59 A1-A3 wounds observed on 337 lake trout greater than 21 inches TL in 2017, resulting in a wounding rate of 17.5 wounds per 100 fish (Table G.1; Figure G.1). A1-A3 wounding rates on lake trout have remained high and stable for the past five years, and all annual measures since 2003 have been above the target rate of 5.0 A1-A3 wounds per 100 fish (Lake Trout Task Group 1985a, Markham et al. 2008). Typically wounding rates increase with increasing lake trout size. In 2017, lake trout examined from the 25-29 inch size class and the >29 inch size class had similar A1-A3 wounding rates (18.2 and 18.3 wounds/100 fish, respectively) (Table G.1). Lake trout <21 inches rarely show signs of sea lamprey attacks, and no wounds were evident on this size class in 2017.

TABLE G.1. Frequency of sea lamprey wounds and wounding rates observed on standard length groups of lake trout collected from gill nets in New York waters of Lake Erie, August 2017.

Size Class Total Length (inches)	Sample Size	Wound Classification				No. A1-A3 Wounds Per 100 Fish	No. A4 Wounds Per 100 Fish
		A1	A2	A3	A4		
17-21	7	0	0	0	0	0.0	0.0
21-25	19	0	1	0	3	5.3	15.8
25-29	121	0	8	14	65	18.2	53.7
>29	197	1	12	23	197	18.3	100.0
>21	337	1	21	37	265	17.5	78.6

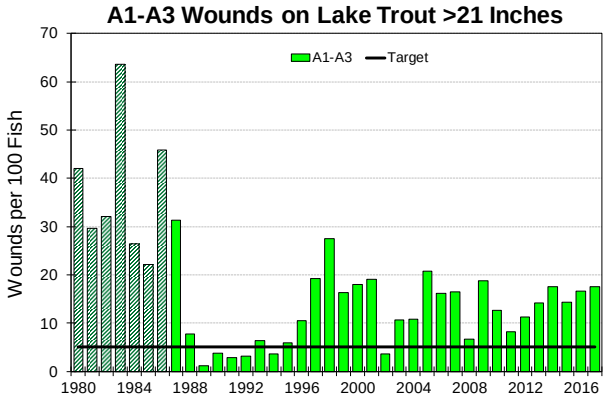


FIGURE G.1. Number of fresh (A1-A3) sea lamprey wounds per 100 adult lake trout greater than 21 inches sampled in gill nets from New York waters of Lake Erie, August, 1980-2017. The target wounding rate is ≤5% (5 wounds per 100 lake trout). Patterned bars indicate the pre-treatment period.

Fresh A1 wounds are considered indicators of the attack rate for the current year at the time of sampling (August). Only one A1 wound was found across all size categories >21 inches in 2017, generating an A1 wounding rate of 0.3 wounds/100 lake trout greater than 21 inches (Table G.1; Figure G.2). This was the lowest A1 wounding rate since 2002 and below the post-treatment series average of 2.1 wounds/100 fish for the fourth consecutive year.

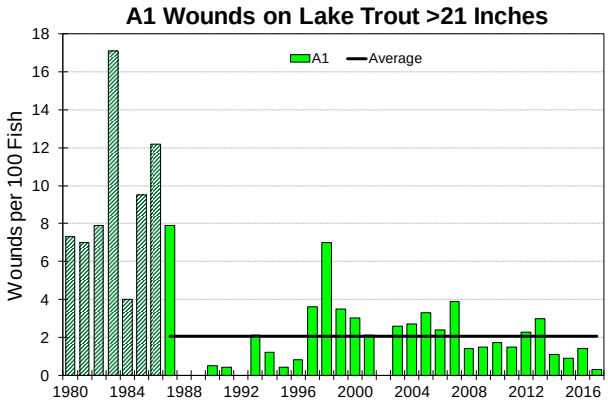


FIGURE G.2. Number of A1 sea lamprey wounds per 100 adult lake trout greater than 21 inches sampled in gill nets from New York waters of Lake Erie, August, 1980-2017. The post-treatment average includes 1987 through 2016. Patterned bars indicate the pre-treatment period.

Cumulative attacks from previous years are indicated by A4 wounds. Altogether 265 A4 wounds were found on 337 lake trout >21 inches in 2017, resulting in an A4 wounding rate of 78.6 wounds/100 fish (Table G.1). This was the second highest A4 wounding rate in the time series and above the series average (35.6 wounds/100 fish) for the 12th time in the past 13 years (Figure G.3). Similar to past surveys, the highest A4 wounding rates were found on lake trout greater than 25 inches TL (Table G.1). A4 wounding rates on lake trout >29 inches TL remain very high (100.0 wounds/100 fish) with many fish possessing multiple healed wounds.

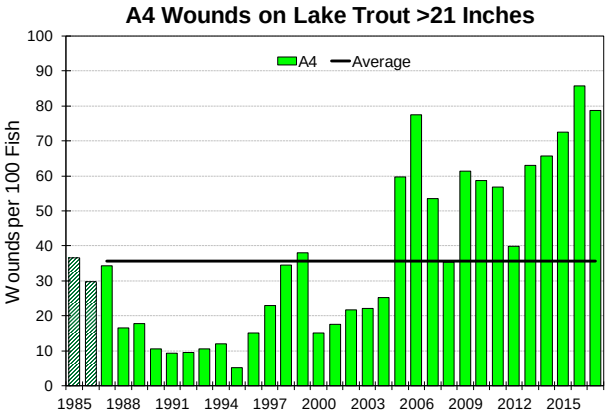


FIGURE G.3. Number of healed (A4) sea lamprey wounds observed per 100 adult lake trout greater than 21 inches sampled in gill nets from New York waters of Lake Erie, August, 1985-2017. The post-treatment average includes 1987 through 2016. Patterned bars indicate the pre-treatment period.

Lake Champlain and Finger Lakes were the most prevalent lake trout strains sampled in 2017 (Table G.2). A1-A3 wounding rates were similar between these two strains in 2017. The Finger Lakes strain lake trout had the highest A4 wounding rate of all the strains compared, mainly due to their longer stocking history and older age groups present in the population. A1-A3 wounding rates were higher on Klondike strain lake trout compared to the other two strains, but the sample size (7 fish) of this strain was very low. Previous surveys have indicated higher wounding rates on Klondike strain lake trout compared to Finger Lakes strain fish.

TABLE G.2. Frequency of sea lamprey wounds observed on lake trout >21 inches, by strain, in New York waters of Lake Erie, August 2017.

Lake Trout Strain	Sample Size	Wound Classification A1	A2	A3	A4	No. A1-A3 Wounds Per 100 Fish	No. A4 Wounds Per 100 Fish
Finger Lakes	96	0	6	10	93	16.7	96.9
Klondike	7	0	0	2	6	28.6	85.7
Lake Champlain	185	1	10	18	122	15.7	65.9

Burbot, once the most abundant coldwater predator observed in eastern basin coldwater assessments, have declined since 2004 and are now at low abundance (See Section F). Coincidentally, both A1-A3 and A4 wounding rates on burbot have generally increased since 2004 in the New York waters of Lake Erie. In 2017, there were no A1-A3 or A4 sea lamprey wounds observed on burbot (Figure G.4). It

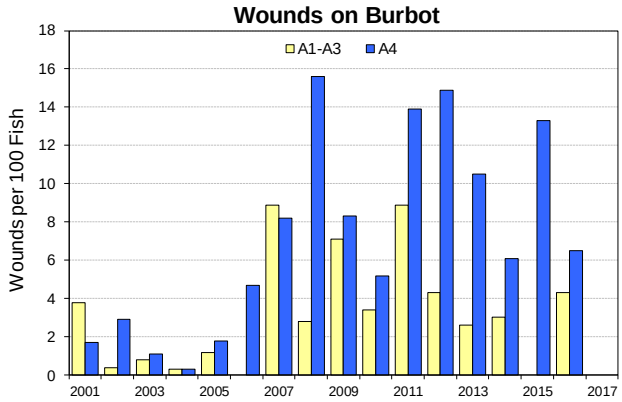


FIGURE G.4. Number of A1-A3 and A4 sea lamprey wounds per 100 burbot (all sizes) sampled in gill nets from New York waters of Lake Erie, August, 2001-2017.

should be noted that sample sizes used to develop indices of burbot wounding have been particularly low (N < 40) since 2013; the sample size in 2017 was 29 fish, of which only 18 were greater than 21 inches.

A total of two fresh and four healed sea lamprey wounds were observed by creel survey technicians examining 1,259 sport fish during the 2017 Open Lake Sport Fishing Survey (Table G.3). Angler harvested walleye were the most examined species, and two fresh and one healed wounds were observed. Sea lamprey wounds were also observed on lake trout in 2017, but no other species.

TABLE G.3. Number of recorded wounds (fresh or healed) on fish examined during the Open Lake Sport Fishing Survey, May – October 2017.

Species	Wounds Observed Fresh	Healed	Number of Fish Examined
Steelhead	0	0	24
Brown Trout	0	0	2
Lake Trout	0	3	4
Smallmouth Bass	0	0	32
Yellow Perch	0	0	234
Walleye	2	1	963

Sea Lamprey Nest Assessment

Sea lamprey nest counts were completed in four standard streams on two survey days (8 and 13 June 2017). Sampling conditions for the survey were ideal for counting nests. The overall sea lamprey nesting index was 31.6 nests/mile in 2017, the highest nest count index since 2012 (Figure G.5). As usual, the

most sea lamprey nests were counted in Clear Creek (156 nests; 39.0 nests/mile) (Table G.4). Higher than average nest densities were also found in N. Branch Clear Creek (29 nests; 58.0 nests/mile) and Canadaway Creek (8 nests; 10.0 nests/mile) in 2017. No nests were found on Delaware Creek for the second consecutive year. Despite the increase in 2017, the five year mean nesting rates (2013-2017) were below the 1981-2012 average on all streams sampled (Table G.4).

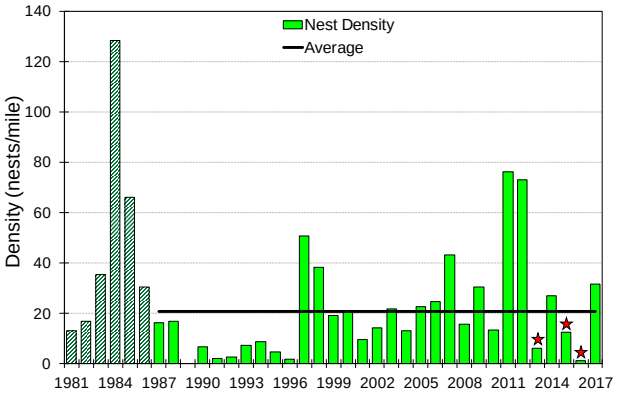


FIGURE G.5. Sea lamprey nest density (nests/mile) from standard stream sections on New York tributaries of Lake Erie, 1981-2017. No sampling was conducted in 1989. ★ Sea lamprey trapping occurred in Clear Creek in 2013, 2015 and 2016 that may have affected overall nest density estimates. The post-treatment average includes 1987 through 2016. Patterned bars indicate pre-treatment period.

Discussion

Despite ongoing efforts to control sea lamprey in Lake Erie, wounding rates on lake trout and lake-wide estimates of adult sea lamprey (see Coldwater Task Group 2017) continue to indicate the presence of a large sea lamprey population. Larval assessments conducted from 2011-14 revealed that sea lamprey recruitment in Lake Erie is most likely emanating from Lake St. Clair and the St. Clair River in addition to the traditional spawning tributaries located mainly in the lake's eastern basin (Coldwater Task Group 2017). Because the St. Clair system is very large and larval sea lamprey populations are dispersed, traditional treatment methods such as lampricide or granular Baylucide are unlikely to be effective. Other treatment methods, such as the sterile male program or pheromone treatments, are being considered as alternative treatment options.

Although only a few Lake Superior strain (Klondike, Apostle Island, Slate Island) lake trout were captured in this survey in 2017, previous data indicate that wounding rates, and hence mortality rates (see Section F, this report), are higher compared to Finger Lakes strain lake trout. Finger Lakes strain lake trout may have co-evolved with sea lamprey and appear to not only avoid sea lamprey attacks but survive attacks better than other lake trout strains (Schneider et al. 1996). These observations are supported in Lake Erie; large lake trout >29 inches are mainly Finger Lakes strain and exhibit a high rate of healed (A4) wounds (indicative of survival from an attack). The Lake Champlain strain, which has only been stocked in Lake Erie since 2009, is genetically very similar to the Finger Lakes strain with small influences of Superior and Clearwater Lake strains (T. Copeland, USFWS, personal communication). This strain appears to possess a level of sea lamprey avoidance more similar to the Finger Lakes strain than Lake Superior strains. Despite continued efforts, sea lamprey control in Lake Erie continues to fall short of

TABLE G.4. Minimum, maximum, and mean indices from 1981-2012, and individual year and 5-year mean indices from 2013-2017, of sea lamprey nest density (nests/mile) from standard stream sections on New York tributaries of Lake Erie. Sea lamprey trapping in Clear Creek in 2013, 2015 and 2016 may have affected overall nest density estimates in Clear Creek and N. Br. Clear Creek.

		1981 - 2012			2013 - 2017					
STD. STREAM SECTION	**Mile**	**Minimum**	**Maximum**	**Mean**	**2013**	**2014**	**2015**	**2016**	**2017**	**5- Year Mean**
Delaware Creek	0.8	0.0	148.8	8.8	0.0	0.0	5.0	0.0	0.0	1.0
Clear Creek	4.0	1.8	148.5	33.5	9.3	34.8	17.5	1.8	39.0	20.5
N. Br. Clear Creek	0.5	0.0	196.0	23.4	2.0	44.0	6.0	0.0	58.0	22.0
Canadaway Creek	0.8	0.0	30.0	7.8	0.0	5.0	0.0	0.0	10.0	3.0
OVERALL	**6.1**	**1.8**	**128.4**	**27.2**	**6.2**	**27.0**	**12.6**	**1.1**	**31.6**	**15.7**

benchmarks recommended by the Lake Erie Lake Trout Rehabilitation Plan (Markham et al. 2008), and selection of strains better able to survive sea lamprey attacks, such as the Finger Lakes and Lake Champlain strains, should be used exclusively to achieve rehabilitation goals.

Wounding observations on harvested fish from the Open Lake Sport Fishing Survey documented that sea lamprey do not exclusively target coldwater species. Observations from this survey over the past five years have shown that sea lamprey wounds occur on warm and cool-water species such as smallmouth bass, walleye, yellow perch, and northern pike. A lake sturgeon assessment also recorded wounding on sturgeon examined in the vicinity of Buffalo Harbor, and we are also aware that sea lamprey attack Lake Erie and Niagara River muskellunge (through observations shared via angler photos). Taken together, these observations confirm that sea lamprey have the potential to affect mortality rates of many other species and are a concern for Lake Erie's entire fish community.

References

Coldwater Task Group. 2017. Report of the Lake Erie Coldwater Task Group, March 2017. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission. Ann Arbor, Michigan, USA.

King, L.E., Jr. and T.A. Edsall. 1979. Illustrated Field Guide for the Classification of Sea Lamprey Attack Marks on Great Lakes Lake Trout. Great Lakes Fishery Commission, Special Publication 79-1, Ann Arbor, Michigan. 41 pp.

Lake Trout Task Group. 1985. A Strategic Plan for the Rehabilitation of Lake Trout in Eastern Lake Erie. Report to the Great Lakes Fishery Commission's Lake Erie Committee, Ann Arbor, Michigan, USA.

Lake Trout Task Group. 1985a. A Sea Lamprey Management Plan for Lake Erie. Report to the Great Lakes Fishery Commission's Lake Erie Committee, Ann Arbor, Michigan, USA.

Markham, J., A. Cook, T. MacDougall, L. Witzel, K. Kayle, C. Murray, M. Fodale, E. Trometer, F. Neave, J. Fitzsimons, J. Francis, and M. Stapanian. 2008. A strategic plan for the rehabilitation of lake trout in Lake Erie, 2008-2020. Lake Erie Committee, Great Lakes Fisheries Commission, Ann Arbor, MI. Available at http://www.glfc.org/lakecom/lec/LEC_docs/other_docs/manplan2008.pdf [accessed 14 January 2013].

Schneider, C.P., R.W. Owens, R.A. Bergstedt, and R. O'Gorman. 1996. Predation by sea lamprey (*Petromyzon marinus*) on lake trout (*Salvelinus namaycush*) in southern Lake Ontario, 1982-1992. Canadian Journal of Fisheries and Aquatic Sciences 53(9):1921-1932.

H. Salmonid Stocking Summary

James L. Markham and Michael T. Todd

New York has maintained a robust annual stocking program of salmonids (trout and salmon) into Lake Erie and tributaries at least since 1968 when the first coho salmon were introduced. Initial introductions were made to create a recreational fishery and to utilize the lake's sparsely inhabited hypolimnion. One exception is lake trout, which have been stocked by the US Fish and Wildlife Service (USFWS) since the mid-1970's to re-establish this native species. Coho and Chinook salmon are no longer stocked into Lake Erie by any jurisdiction and the majority of the lake wide stocking effort focuses on steelhead and lake trout.

Results and Discussion

A total of 575,936 salmonids were stocked into the New York waters of Lake Erie in 2017 (Table H.1). The majority (372,936; 65%) were stocked as yearlings with the remainder being fall fingerlings. Stocking targets were exceeded for steelhead and obtained for domestic rainbow trout, but were below target for both lake trout and brown trout. The overall combined stocking of salmonids in 2017 was near average compared to the previous 30 years of the time-series (Figure H.1).

Steelhead

Steelhead were the most numerous salmonid species stocked in NY's portion of Lake Erie in 2017 (Tables H.1 and H.2; Figure H.1). A total of 255,000 yearlings were stocked into the Lake Erie tributaries from the Salmon River State Fish Hatchery (SRSFH), which equaled the stocking target. In addition, a large number of surplus fall fingerlings (203,000) became available in November and were stocked into Cattaraugus Creek. This was the second consecutive year surplus steelhead were stocked into Cattaraugus Creek.

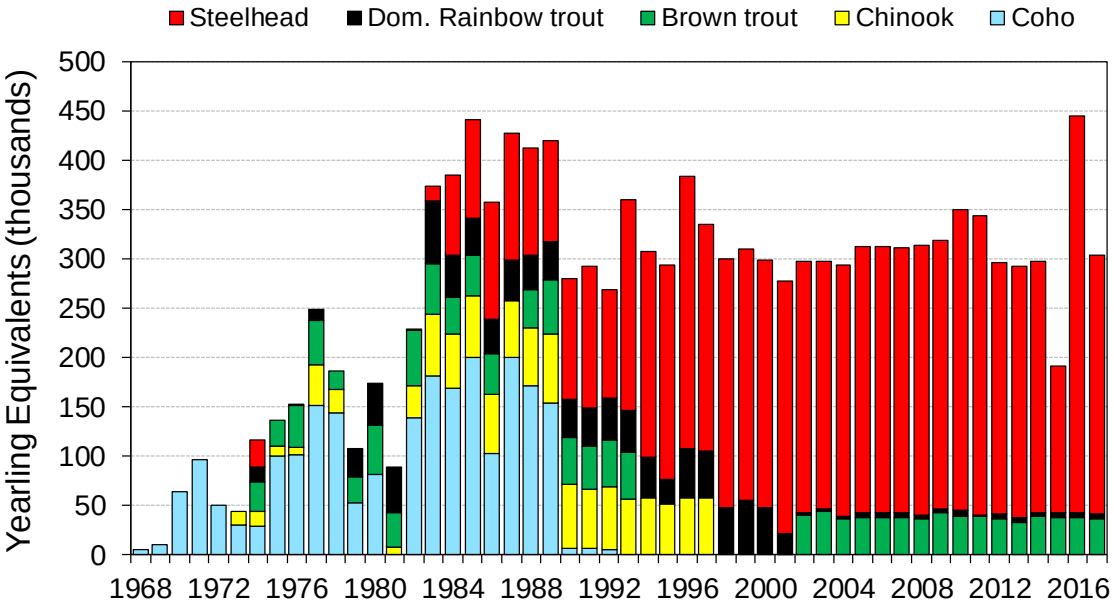


FIGURE H.1. Number (in yearling equivalent units) of coho and Chinook salmon, brown trout, and rainbow trout (domestic and steelhead) stocked in New York waters of Lake Erie, 1968-2017. 1 fall fingerling = 0.035 yearling equivalents.

In addition to the steelhead strain rainbow trout, a small number of domestic rainbow trout yearlings (5,000) were stocked at the Erie Basin Marina located near the mouth of the Buffalo River.

Lake Trout

A total of 76,456 yearling lake trout were stocked in New York's portion of Lake Erie on 16-17 May 2017 (Table H.1). The lake trout were stocked offshore of Dunkirk via the *R/V* Argo in 70 feet of water. All of these lake trout were Lake Champlain strain. Additional lake trout were also stocked into the Ontario (50,982) waters of Lake Erie in 2017. These fish were Slate Island (Superior) strain and were stocked on Nanticoke Shoal in the eastern basin. Altogether, a combined total of 127,438 yearlings were stocked in 2017, which was below Lake Erie's Lake Trout Management Plan annual stocking target of 200,000 yearlings. The shortage was mainly due to a large-scale mortality event that occurred at the Allegheny National Fish Hatchery during Fall 2016, and this was only the second time in the past ten years that lake trout stocking targets were not met (Figure H.2).

In addition to the yearlings, fall fingerling lake trout were stocked in the Ontario waters of Lake Erie in 2017. A total of 17,043 surplus fall fingerlings Finger Lakes strain lake trout were stocked on Nanticoke Shoal in early November. This was the second consecutive year that Ontario stocked fall fingerling lake trout.

Brown Trout

A total of 36,480 yearling brown trout were distributed in Lake Erie between Barcelona Harbor, Dunkirk Harbor, the lower reach of Cattaraugus Creek, and Eighteen Mile Creek in 2017 (Table H.1). This stocked total was 81% of the annual stocking target of 45,000 fish due to modest shortages in statewide hatchery inventory. After 2017, NYSDEC expects to terminate brown trout stocking in Lake Erie for the foreseeable future (see Stocking Policy Changes below).

Cooperative Net Pen Project

A cooperative pen-rearing project pursued in partnership with the Bison City Rod and Gun Club in the lower Buffalo River continued in 2017. A total of 10,000 unmarked yearling steelhead were stocked

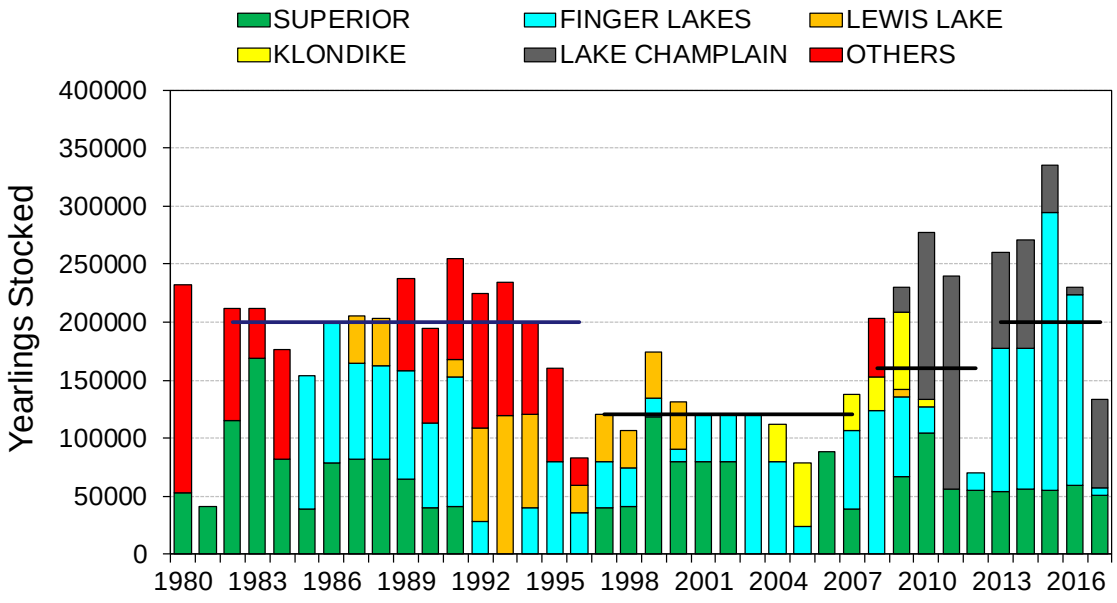


FIGURE H.2. Yearling and fall fingerling (in yearling equivalents) lake trout stocked by all jurisdictions in Lake Erie, 1980-2017, by strain. Stocking goals through time are shown by black lines; the current stocking goal is 200,000 yearlings per year. "Superior" includes Superior, Apostle Island, Traverse Island, Michipicoten, and Slate Island strains; "Others" include Clearwater Lake, Lake Ontario, Lake Erie, and Lake Manitou strains. 1 fall fingerling = 0.40 yearling equivalents.

into two floating pens on 26 April and released on 16 May. Steelhead weights during the 20-day pen period increased from 31.3 fish/lb to 21.3 fish/lb, a 32% increase. The release weight of 21.3 fish/lb was less than the target release weight of 15.0 fish/lb, due mainly to lower water temperatures, high turbidity, and the small initial size at delivery. Water temperature at release was 59 °F. Club members reported that fish mortality in the pens was negligible (28 fish). This was the 13th consecutive year of the project, which is scheduled to continue in 2018.

Stocking Policy Changes

Several changes to the Lake Erie salmonid stocking policy occurred in 2017, or are scheduled to occur beginning in 2018. Brown trout stocking will be terminated, mainly because the most recent 16 year trial with brown trout failed to produce a reliable lake, harbor or tributary fishery. Instead, fall fingerling domestic rainbow trout will replace the brown trout component in our trout stocking mix, and these fish will be distributed among New York's four largest Lake Erie tributaries (Chautauqua, Canadaway, Cattaraugus, and Eighteen Mile Creeks) in hopes that they will improve September and October trout fishing in these streams. In addition, the 5,000 domestic rainbow trout that in the past have been stocked into the Buffalo River will be moved to Eighteen Mile Creek.

Overall steelhead stocking numbers will remain unchanged, however Cazenovia Creek stocking will be terminated due to poor returns and accompanying lack of evidence of tributary fishery benefits. The 10,000 steelhead that have been stocked in Cazenovia Creek since 2003 were diverted from a portion of the Chautauqua Creek policy, and these fish will again contribute to the Chautauqua Creek policy beginning in spring 2018. Stocking totals beginning in 2018 include 50,000 yearling steelhead for Chautauqua Creek and 35,000 yearling steelhead for the Buffalo River system (15,000 Buffalo Creek, 10,000 Cayuga Creek, 10,000 Bison City net pens).

Steelhead stocking locations changed in 2017 based on emerging results of an ongoing study being conducted in Chautauqua Creek to examine alternative stocking locations and sizes for stocked steelhead, and based on perceived improvement in the steelhead fishery in Eighteen Mile Creek following a previously adopted stocking location change. Past long-term stocking practices used stocking sites located high in watersheds to provide the steelhead with ample time to imprint before out-migration. However, current research indicates that many newly stocked steelhead do not migrate downstream, but rather sometimes move further upstream, mainly due to their smaller sizes. The new stocking strategy moves the stocking locations in all streams somewhat further downstream with the hopes that stocked fish will have a better supply of forage that allow them to grow to large enough sizes to emigrate to the lake.

TABLE H.1. Summary of trout stocking in New York waters of Lake Erie in 2017.

Species	Location	Date Stk	YC	Hatchery	Strain	Mos	Stage	#/lb.	Clip/Mark	Num Stk.	Proposed 2018
Lake Trout	Dunkirk	5/16/2017	2016	ANFH	Lake Champlain	16	Ylg	14.3	640739	40,108	
Lake Trout	Dunkirk	5/17/2017	2016	ANFH	Lake Champlain	16	Ylg	13.4	640740	36,348	
Lake Trout Totals											
	Lake Trout Yearlings									**76,456**	**80,000**
Brown Trout	Eighteen Mile Creek	4/24/2017	2016	CSFH	Domestic	16	Ylg	3.6	None	4,130	0
Brown Trout	Cattaraugus Creek	4/24/2017	2016	RSFH	Domestic	16	Ylg	4.2	None	8,090	0
Brown Trout	Barcelona Harbor	4/19/2017	2016	RSFH	Domestic	16	Ylg	4.0	None	8,090	0
Brown Trout	Dunkirk Harbor	4/28/2017	2016	RSFH	Domestic	16	Ylg	3.8	None	16,170	0
Brown Trout Totals											
	Brown Trout Yearlings									**36,480**	**0**
Rainbow Trout	Silver Creek	4/12/2017	2016	SRSFH	Washington	12	Ylg	32	None	10,000	10,000
Rainbow Trout	Walnut Creek	4/12/2017	2016	SRSFH	Washington	12	Ylg	32	None	10,000	10,000
Rainbow Trout	Canadaway Creek	4/12/2017	2016	SRSFH	Washington	12	Ylg	32	None	20,000	20,000
Rainbow Trout	Eighteen Mile Creek	4/20/2017	2016	SRSFH	Washington	12	Ylg	30	None	40,000	40,000
Rainbow Trout	Chautauqua Creek	4/13/2017	2016	SRSFH	Washington	12	Ylg	42	None	40,000	50,000
Rainbow Trout	Buffalo River	4/26/2017	2016	SRSFH	Washington	12	Ylg	30	None	35,000	25,000
Rainbow Trout	Cattaraugus Creek	4/28/2017	2016	SRSFH	Washington	12	Ylg	33	None	90,000	90,000
Rainbow Trout	Cattaraugus Creek	11/2/2017	2017	SRSFH	Washington	8	FF	90	None	203,000	
Rainbow Trout	Buffalo River Net Pens	5/6/2017	2016	SRSFH	Washington	13	Ylg	15.7	None	10,000	10,000
Rainbow Trout	Bison City R&G Club	4/26/2017	2016	CSFH	Domestic	16	Ylg	3.1	None	5,000	50,000
Rainbow Trout Totals											
	Steelhead Yearlings (Washington Strain)									**255,000**	**255,000**
	Steelhead Fall Fingerlings (Washington Strain)									**203,000**	
	Domestic Rainbow Trout Yearlings (Randolph Strain)									**5,000**	**50,000**
TOTAL ALL SPECIES			**Yearlings**							**372,936**	**385,000**
			Fall Fingerlings							**203,000**	

Hatchery Codes: RSFH - Randolph State Fish Hatchery; CSFH - Caledonia State Fish Hatchery; SRSFH - Salmon River State Fish Hatchery
ANFH - Allegheny National Fishery Hatchery;

TABLE H.2. Approximate numbers (x 1000) of salmon and trout planted in New York waters of Lake Erie from 1970 through 2017. Lake trout numbers include those stocked in Pennsylvania, Ontario, and Ohio waters. Totals do not include spring fingerling or fry stockings.

	YEAR																							
Species/ Type	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Coho Y	64	96	50	30	29	100	87	149	144	50	81	0	139	181	169	200	102	200	169	148	0	0	0	0
Coho F	0	0	0	0	0	0	390	50	0	50	0	0	0	0	0	0	0	0	38	180	163	161	76	0
Coho f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	0	0	0	200	0
Chin f	0	0	0	125	125	85	65	362	206	0	0	71	280	550	478	547	529	500	520	620	574	525	565	497
Lake Y	0	0	0	0	0	0	0	0	236	201	41	41	196	205	176	154	199	205	203	213	195	206	225	217
Lake F	0	0	0	0	0	150	186	125	0	508	474	0	39	17	0	0	0	0	0	60	0	127	0	42
Lake fry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	150	0	0	150
Lake adt	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0
Brown Y	0	0	0	0	28	0	42	42	0	26	50	34	53	50	38	42	40	0	38	53	47	44	47	47
Brown F	0	0	0	0	60	26	25	81	0	0	0	0	85	50	0	0	50	0	22	42	37	0	0	0
Brown f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0
Rbow Y	0	0	0	0	15	0	0	12	19	29	43	46	0	61	39	34	32	41	34	38	37	39	43	43
Rbow F	0	0	0	0	0	0	25	0	0	0	0	40	0	50	28	32	49	0	22	25	38	0	0	0
Rbow f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	110	120	148	0	0	0	0	0	0	0
Sthd Y	0	0	0	0	28	0	0	0	0	0	0	0	0	15	81	100	118	270	107	103	121	143	105	214
Sthd F	0	0	0	0	0	0	0	0	0	0	0	0	37	0	38	0	0	0	0	13	48	0	130	0
TOTAL	**64**	**96**	**50**	**155**	**285**	**361**	**820**	**821**	**605.1**	**864**	**689**	**232**	**829**	**1179**	**1157**	**1229**	**1267**	**1216**	**1253**	**1495**	**1260**	**1245**	**1391**	**1060**

	YEAR																							
Species/ Type	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Coho Y	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coho F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coho f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chin f	500	500	500	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Y	200	160	82.9	120	107	158	128	120	120	120	111.6	54.2	88	137.6	202.8	223.3	277.7	234.3	55.3	260	230.1	246.6	218.7	126.7
Lake F	0	82	0	0	0	40.5	7	0	0	0	0	58.4	0	0	0	0	0	0	123.7	0	99.1	81.7	26.9	17
Lake fry	200	0	0	301	81	0	262.7	130.2	283.5	109.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake adt	0	2.7	1	0	0	1	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Y	0	0	0	0	0	0	0	0	38.7	43.4	36	37.4	37.5	37.9	36	37.6	37.5	38.1	35.5	32.6	38.5	37.8	38.1	36.5
Brown F	0	0	0	0	0	0	0	0	33.6	39.5	0	0	0	0	0	25	0	7.4	0	0	5	0	0	0
Brown f	0	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	40	0	0	0	0	0	0	0
Rbow Y	42	2.5	42.5	46.9	47	55.3	47.5	21.3	2.2	2.5	2.4	5	5	4.5	5	4.7	4.9	1	5	5	4	5	5	5
Rbow F	0	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	46	15	0	0	0	0	0	0
Rbow f	0	0	90.6	84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rbow adt	1	0	0	0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sthd Y	208	218	274.8	228	253	255	250.8	255	255	251.3	255	270	270	268	265	272	303.7	304.3	255	255	255	147.5	401.2	255
Sthd F	0	0	20	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	25	203
TOTAL	**951**	**986.2**	**1012**	**1019**	**407**	**509.8**	**433.5**	**431.3**	**449.5**	**456.7**	**405**	**425**	**400.5**	**448**	**508.8**	**562.6**	**709.8**	**600.1**	**474.5**	**552.6**	**631.7**	**548.6**	**714.9**	**643.2**

Legend: Y=Standard stocked yearling; F=Fall fingerling; adt=Surplus broodstock

I. WALLEYE MOVEMENT STUDY

Jason M. Robinson

Introduction

Walleye in the Great Lakes are known to move across large geographic areas through multiple management jurisdictions. Understanding fish movement dynamics and how they relate to fishing activity is essential when managing a complex, valuable, multijurisdictional fishery such as the Lake Erie walleye fishery. Adult walleye originating in the west basin are known to migrate into the east basin during the summer months and then return to the west basin (Figure I.1). This influx of walleye into the east basin supplements the walleye harvest in the east.

Walleye inhabiting the west and central basins of Lake Erie are currently managed using a binational quota system whereby a cohort-based statistical catch-at-age model is used to assess abundance and inform annual total allowable catch limits for each management jurisdiction. Existing uncertainties surrounding walleye dynamics and life history in the east basin have prevented inclusion of the east basin resource in the quota management zone of the west and central basins, or the development of a separate assessment and management framework for the east basin walleye resource.

East basin walleye indices are not explicitly included in the west and central basin management approach for two reasons; 1) Catch-at-age information in the east basin is collected from a mixture of west basin migrants and east basin resident walleye, and 2) there is a large amount of uncertainty and variability surrounding the annual age and size structure of the west basin migrants. These uncertainties suggest that managers may be unable to use catch-at-age information to track cohorts of west basin walleye in the east basin. Additionally, since the proportion of west basin walleye, and the origin of individual walleye in the east basin is unknown, the ability to track east basin cohorts is also compromised.

Zhao et al. (2011) suggested an alternative approach to walleye assessment in the east basin whereby an annual population estimate would be produced for east basin resident walleye using traditional mark-recapture techniques, and the contribution of the west basin migrants would be estimated as a function of the west basin population estimate. The east basin population estimate would rely on producing individual population estimates for the major walleye spawning populations (i.e. Van Buren Bay, and Grand River), then using the proportional contribution of those populations to produce a basin-scale estimate of adult walleye. The Van Buren Bay and Grand River populations are thought to constitute approximately 90% of the entire east basin spawning stock (Zhao et al. 2011). However, Zhao et al. (2011) acknowledge that further assessment of other spawning locations in the east basin is necessary prior to implementing this approach. Identifying discrete spawning stocks, quantifying the proportional contribution of individual spawning stocks, and describing spawning site fidelity of those stocks is necessary to apply the approach of Zhao et al. (2011) with confidence.

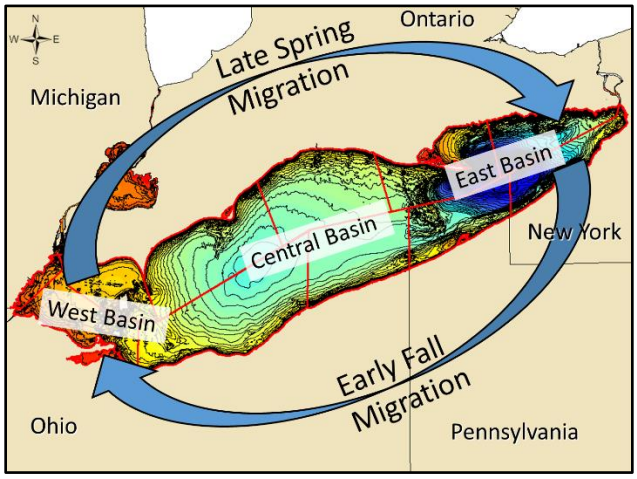


FIGURE I.1. Depth contour map of Lake Erie with jurisdictions and major basins labeled. Blue arrows represent hypothesized major seasonal directional migrations of adult west basin walleye. Walleye Quota Management area includes the west and central basins only.

We employed several tagging techniques to address the knowledge gaps illustrated above. These include state-of-the-art methods like acoustic telemetry, traditional methods like jaw tagging, and natural tags such as genetic markers and otolith microchemistry.

Acoustic Telemetry Technology

Acoustic telemetry technology allows passive collection of fish location information. At its simplest this technology can be thought of as conveying information from one place to another using sound waves. Tags are surgically implanted, and transmit an underwater signal of identification information about the tagged fish to arrays of stationary acoustic receivers (Figure I.2). Acoustic receivers can detect tagged fish that swim through their sphere of detection. Data associated with each tag detection is stored on the receiver until retrieval. This technology allows tracking of fish movements any time a tagged fish is near a receiver, offering major advantages over traditional tagging studies in which the location of tagged fish can only be detected through sampling, fishing, or active tracking (e.g. radio telemetry).

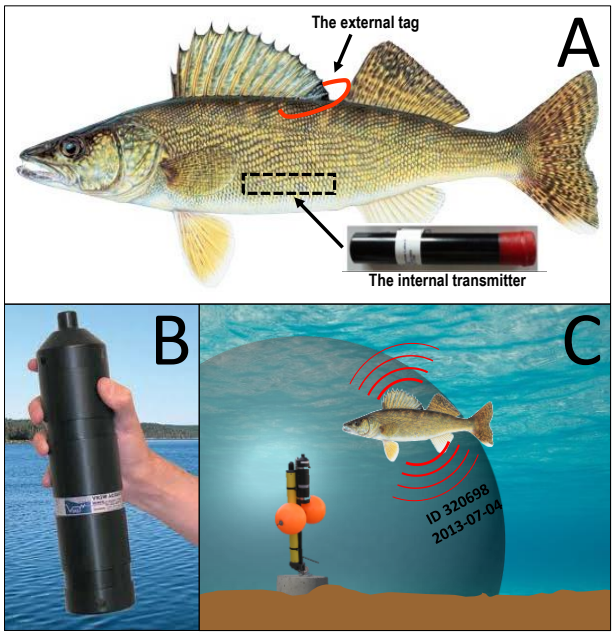


FIGURE I.2. A) Close-up of an acoustic tag and surgical implant location, with secondary loop tag location, B) close-up of acoustic receiver, and C) diagram of acoustic receiver deployed on the lake bottom with a tagged walleye entering the sphere of detection.

East Basin Telemetry Project

In the spring of 2015, the Lake Erie Fisheries Research Unit began a collaborative walleye movement study as part of the Great Lakes Acoustic Telemetry Observation System (GLATOS). This study monitors the timing, magnitude, demographics, and spatial extent of the west basin migrants tagged on west basin spawning areas by Ohio DNR. Additionally, spawning site fidelity and movement patterns of east basin spawning aggregations will be estimated. The relative contribution of east basin origin walleye to the mixed-origin fisheries in the east basin will be assessed by applying acoustic tags to walleye in the summer mixed fishery, then tracking their movements to determine spawning stock origin. The specific objectives of this project are to:

1. Determine the contribution of west and east basin walleye stocks to the east basin fishery.
2. Determine the timing, magnitude, demographics, extent, and consistency of the west basin migrants' movement to the east.
3. Determine the spawning site fidelity of individual east basin walleye spawning stocks.
4. Determine the extent of movements of east basin spawning stocks out of the east basin.

This study complements the ongoing efforts of a multi-agency walleye investigation being led by west basin investigators by improving their ability to detect west basin tagged fish in east basin waters. In turn, existing acoustic arrays in the west and central basin allow us to detect westward movement of walleye tagged as part of this east basin study. Individuals catching or finding a walleye with an internal or external tag are encouraged to report this information by calling NYS DEC's Lake Erie Fisheries Research Unit (716-366-0228). Reward and reporting information is clearly marked on tags.

Knowledge gained during this study will improve understanding of walleye life history and movement dynamics in the east basin of Lake Erie, as well as assist in addressing knowledge gaps for the lake wide walleye resource. Ultimately this work will provide information useful for advancing walleye stock assessment and management activities throughout Lake Erie. Acoustic arrays installed as part of this project extend the geographic scope of the acoustic network currently in place throughout the Great Lakes, and benefit other acoustic telemetry studies (Goulette et al. 2014) already in progress including the walleye movement studies of west basin investigators, sea lamprey investigations in the Huron Erie Corridor, sturgeon assessment based in Buffalo Harbor and the upper Niagara River, lake trout spawning studies throughout the lake.

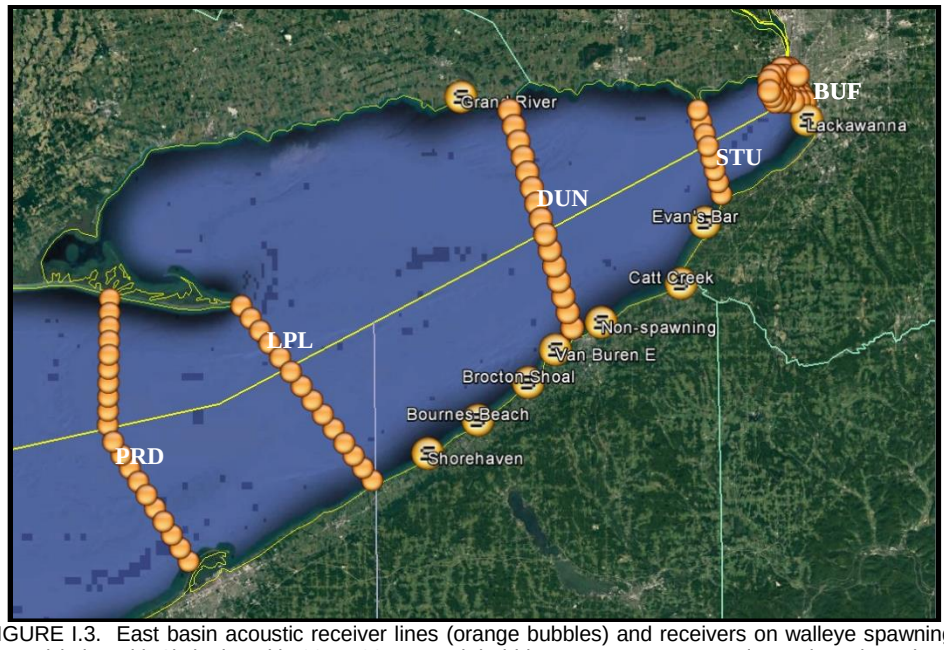


FIGURE I.3. East basin acoustic receiver lines (orange bubbles) and receivers on walleye spawning areas (circles with S) deployed in 2014–2017. Each bubble represents an acoustic receiver site. Three Letter abbreviations are associated with each acoustic line. Not all lines were deployed in all years.

Jaw tagging

Obtaining contemporary estimates of population size for east basin stocks is essential to understanding how dynamics of west and east basin walleye stocks influence walleye fisheries in the east. In addition to the acoustic telemetry study, Lake Erie Unit staff resumed annual jaw tagging effort to obtain estimates of population size for individual spawning aggregations in 2015 and beyond.

Informing Movement through Genetics

One of the major objectives of the acoustic telemetry study was to determine the relative contribution of west and east basin walleye stocks to the east basin fishery. Attempts to tag walleye that were representative of those harvested during summer in the mixed east basin fishery were largely unsuccessful due to a combination of high water temperatures and barotrauma. Genetic markers offer another approach to estimating west basin walleye stock contributions to east basin fisheries. In 2016 and 2017 genetics samples were collected from walleye implanted with acoustic tags, from the Canadian commercial gillnet fishery, and from the sport fishery in New York. Genetics samples will be used to assign origin (west or east basin) to each fish, allowing the proportional contribution of west basin walleye to the east basin fishery to be determined. Genetic markers may offer some advantages compared to the jaw tag or even the acoustic telemetry approach in that we should be able to obtain a more representative sample of fish contributing to sport and commercial fisheries in the east basin. The genetics portion of this work is being conducted in cooperation with researchers at Ohio State University

Otolith Microchemistry

We have recently begun a study in cooperation with Ohio State University to assess the contributions of west basin walleye to New York's annual gillnet survey. This study will analyze the chemical composition of archived otoliths to determine if walleye captured in September gillnets (Section D) are of west or east basin origin. Improved knowledge of what stocks New York's gillnet program are indexing will be essential for understanding how to incorporate east basin walleye assessments into the lake-wide management structure.

Tagging Methods

Acoustic Receiver Deployment

Spawning area receivers were deployed during spring 2017 at Shorehaven, Bournes Beach, Brocton Shoal, Van Buren Bay, Cattaraugus Creek, Evans Bar, the Lackawanna Shore (i.e., Smokes Creek), and the

Grand River spawning locations (Figure I.3). Four in-lake acoustic lines were deployed from May to November 2016 (Figure I.3). The Pennsylvania Ridge Line was not deployed in 2017.

Walleye Collection and Tagging Procedures

Spawning walleye were collected in 2017 using a combination of trap netting and pulsed DC electrofishing at Shorehaven, Van Buren Bay, Cattaraugus Creek, and Smokes Creek Shore spawning areas respectively (Fig. I.3). Jaw tags and acoustic tags were applied at Shorehaven, Van Buren, and Cattaraugus Creek, and Acoustic Tags were implanted at Smokes Creek.

Results and Discussion

East basin tagged walleye

In 2017 acoustic tags were surgically implanted in 70 spawning-phase walleye at Shorehaven, 28 at Van Buren Bay, 13 at Cattaraugus Creek, and 24 at Smokes Creek (Table I.1). Each acoustic-tagged walleye also received a loop tag with reward information ($100). Jaw tags were applied to 33 spawning-phase walleye at Shorehaven, 123 at Van Buren Bay, and 1 at Cattaraugus Creek.

TABLE I.1. Numbers of walleye tagged with acoustic and jaw tags in the NY waters of Lake Erie 2015–2017.

Stock	Year	Jaw Tag	Acoustic Tag
Van Buren Bay	2015	732	70
Van Buren Bay	2016	878	-
Van Buren Bay	2017	123	28
Bournes Beach	2015	53	-
Mixed Fishery	2016	-	52
Smokes Creek	2016	-	36
Smokes Creek	2017	-	24
Shorehaven	2017	33	70
Cattaraugus Ck.	2017	1	13
	Total:	1820	293

From 2015–2017 acoustic and jaw tagged walleye were returned from four of the five Lake Erie Jurisdictions (NY, ON, PA, and OH). Approximately 50% of the acoustic tag returns were from outside New York waters. In Contrast, only 34% of jaw tagged walleye were returned from outside NY waters. This discrepancy may indicate an unwillingness by some of fishers outside NY, to return NY tags that do not have a reward associated with them. Interestingly, only walleye tagged on the Van Buren Bay spawning area were returned from areas outside Lake Erie's eastern basin (i.e., west of the Pennsylvania Ridge) from 2015–2017. Acoustic detections indicated that the majority of walleye tagged in the east basin remain in the east basin. In 2015 and 2016 only 17% of walleye tagged in the east basin were detected in the central basin, 5% of were detected west of Fairport, OH, and none were detected in the western basin.

West basin tagged walleye

Total annual occupancy of the east basin by acoustically tagged west basin spawning stocks is higher than occupancy measured in any single month. Overall, approximately 10% of the western basin tagged walleye occupy the east basin (From Long Point to Buffalo) at some point during the year. Considering occupancy on a basin-wide and annual scale can be misleading when trying to understand movement dynamics driving local fisheries. Recreational walleye harvest in NY is typically concentrated during the summer months near major population centers, although this can vary annually. For example, in 2016 walleye harvest was highest in June near Buffalo Harbor, while in 2017 harvest was highest in September, adjacent to Cattaraugus Creek access locations. As such, it is important to consider the occupancy of west basin walleye in the east in areas and at times of highest fishing effort.

Acoustic detections of west basin spawning stocks in New York's east basin were combined from 2013–2017 to estimate average occupancy of the east basin by month and area. Percent occupancy was defined as the fraction of the tagged western basin population detected in the east basin. A consistent decline in east basin occupancy was observed from west to east regardless of the time of year considered (Figure I.4). In other words, at any given time there will be more west basin walleye in the western portion of the east basin than there is in the eastern portion of the east basin. However, the magnitude of observed occupancy varied greatly by location and season.

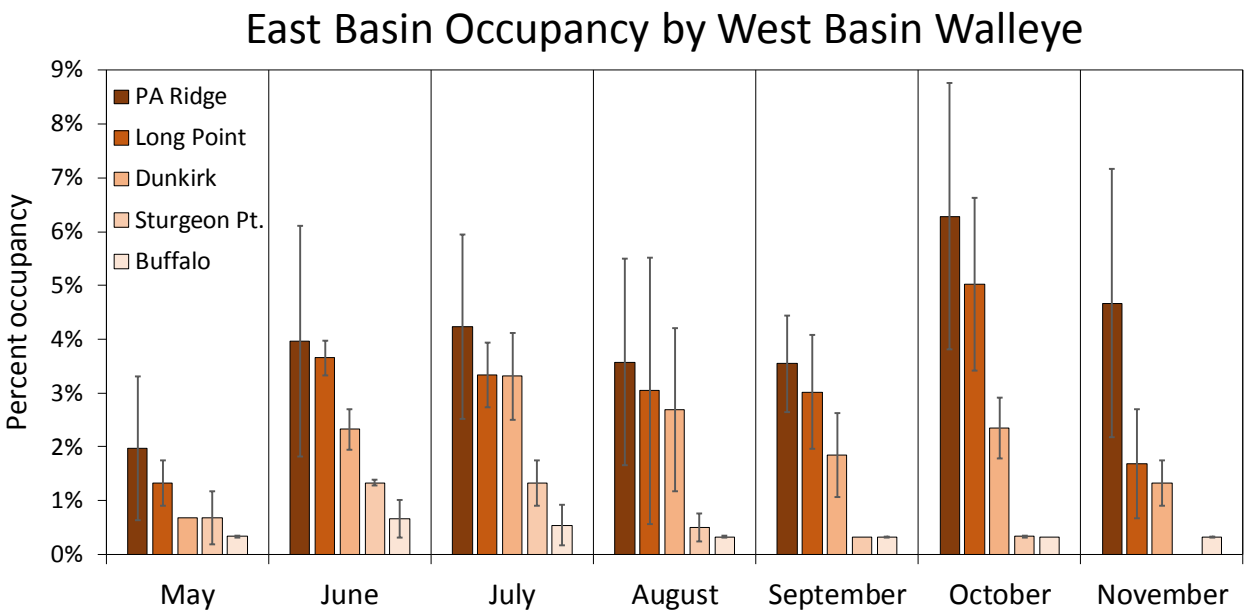


FIGURE I.4. Average percent occupancy of west basin origin walleye in the east basin from May–November at five locations from the Pennsylvania Ridge east to Buffalo. Error bars represent 95% confidence intervals.

Three general patterns of seasonal occupancy were observed in the east basin from May–November.

1. Near the Pennsylvania ridge and the Long Point Line, occupancy by west basin migrants was relatively low in May, increased and remained consistent from June–September and began to decline again in October and November.
2. Near the Dunkirk line, occupancy increased steadily from May–July, peaked in July and August, then began a generally steady decrease from August–November.
3. Near the Sturgeon Point line and Buffalo Harbor array, occupancy peaked in June and July, but remained relatively low during the other months considered.

Occupancy of the east basin by west basin walleye spawning stocks seems relatively low when considered spatially and seasonally. In the areas and times when the New York fishery is at its peak the occupancy can range from roughly 3% near Dunkirk to less than 1% near Buffalo. In 2017 the population estimate for walleye age-3-and-older in the Quota Management Area was approximately 20 million. A 3% occupancy rate would translate to approximately 600,000 age-3 and older walleye near Dunkirk in 2017. Near Buffalo, 0.5% occupancy would translate to approximately 100,000 age-3 and older walleye. This estimate does not incorporate possible sex, stock, or size specific migrations rates for west basin walleye, but it is likely that the order of magnitude of the estimate is correct. Additionally, linkages between occupancy and availability or vulnerability to east basin fisheries remain unknown. Given the apparent magnitude of the west basin population occupying the east basin relative to the size of our east basin stocks, it is still reasonable to conclude that western basin walleye contribute significantly to our New York walleye fishery in Lake Erie.

References

Goulette, G. S., J. P. Hawkes, J. F. Kocik, J. P. Manning, P. A. Music, J. P. Wallinga, and G. B. Zydlewski. 2014. Opportunistic acoustic telemetry platforms: benefits of collaboration in the Gulf of Maine. 39:441–450.

Zhao Y., D. W. Einhouse, T. M. MacDougall. 2011. Resolving some of the complexity of a mixed-origin Walleye population in the east basin of Lake Erie using a mark–recapture study. North American Journal of Fisheries Management. 31:379–389

J. OPEN LAKE SPORT FISHING SURVEY

Jason M. Robinson

Introduction

Since 1988, a direct contact sport fishing survey has been conducted to monitor boat fishing activity. This has been a standard, annual program that extends from May through October along the entire New York portion of Lake Erie. From 1993 to 1997 this survey was augmented by a spring angler survey of the nighttime walleye fishery, and those results were reported annually in earlier editions of this report (Einhouse et al. 2005). This nighttime survey component was suspended from 1998 to 2005, and then resumed during 2006 to update the status of this fishery. This nighttime survey may be conducted intermittently in future years as determined by available resources and program needs.

From 1988 to 2001, standard angler survey methodology included an aerial boat count component to measure fishing effort. Since 2002, fishing effort has been measured from the five major harbors bordering New York's portion of Lake Erie. A limited number of aerial boat counts were conducted from 2002 to 2004 to evaluate whether the change in survey methodology affected absolute measures of fishing effort and harvest. This investigation found that previous and current survey procedures produced very similar results, but the current methodology was more administratively efficient and remained statistically robust (Einhouse 2005).

Methods

Survey Procedures

Standard survey methods from 1988 to 2001 were patterned after a study by Schmidt (1975), collecting effort and catch information as independent samples with two collection schedules of stratified random sampling. Aerial counts of fishing boats were conducted to measure daytime fishing effort. Catch and harvest data were obtained by roving between five to six representative fishing access sites to conduct interviews of boat anglers who had just completed their fishing trip. Angler interviews were conducted between 0900 EDT and 1 hour after sunset.

During 1991, and for all surveys after 2001, fishing effort has been estimated using an "access approach" described by Pollock et al. (1994). The specific application of this method to the New York waters of Lake Erie is described in Einhouse (2005).

Assessment of the daytime open lake sport fishery occurs from May through October each year. Our current methodology employs stratification by day type (weekday-weekend day), harbor, and month. Although survey procedures changed in 2002, some independent measures of fishing and boating activity (annual paid launch totals at municipal ramps) suggest our results remain directly comparable for the entire 1988 to 2017 time series (Einhouse 2005).

Data Analysis

Daytime angler survey estimates for fishing effort, harvest, and catch rates, with associated precision (standard error or SE) measures, were calculated for each stratum using the formulae described in Einhouse (2005) based on methods described in Pollock et al. (1994).

Survey Results

Estimated overall 2017 open water sport fishing effort in New York waters of Lake Erie was 350,991 angler-hours, similar to 2016 (-3%). Peak fishing activity occurred during July and the most frequently used site was the Buffalo Harbor (Safe Harbor Marina, formerly Buffalo Small Boat Harbor), which accounted for approximately 37% of estimated boat fishing effort in 2017 (Table J.1).

TABLE J.1. The distribution of 2017 open water boat fishing effort (angler-hours) in New York's portion of Lake Erie.

Harbor	May	Jun	Jul	Aug	Sep	Oct	Total
Barcelona	1,524	8,959	20,095	5,078	7,179	1,328	44,163
Dunkirk	6,319	5,953	19,056	12,496	8,981	5,284	58,089
Cattaragus	2,724	16,153	14,344	7,866	25,448	6,476	73,012
Sturgeon Pt.	1,403	7,809	16,543	10,850	7,786	2,244	46,636
Buffalo	11,557	29,524	31,030	21,124	30,822	5,035	129,092
Grand Total	23,527	68,399	101,068	57,415	80,216	20,367	350,991

Overall fishing effort had generally increased from 2009-2014, but has stabilized more recently (Figure J.1). Effort targeting walleye was the largest component of the sport fishery, accounting for 61% of overall angling effort (Figure J.2). Smallmouth bass and yellow perch angling effort accounted for 21% and 7% of the total effort, respectively.

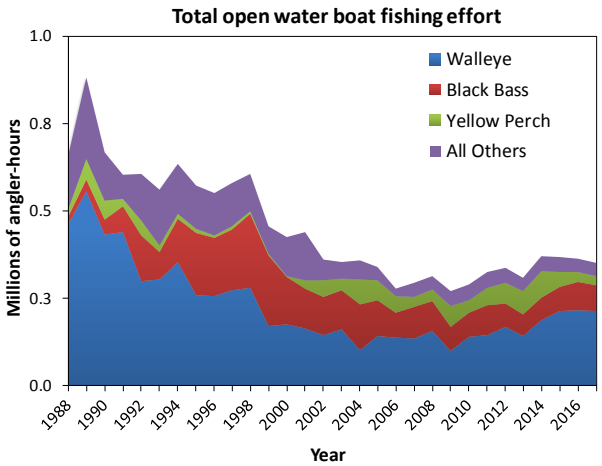


FIGURE J.1. Open water sport fishing effort in New York waters of Lake Erie by walleye anglers, bass anglers, perch anglers and all others, May-October, 1988-2017.

A total of 27 species were encountered by surveyed boat anglers in 2017, resulting in an estimated total catch of 311,347 individual fish (Table J.2). Fourteen species were harvested resulting in a total harvest of 117,267 fish. Walleye and yellow perch accounted for approximately 96% of the harvest, but only 57% of the fish caught.

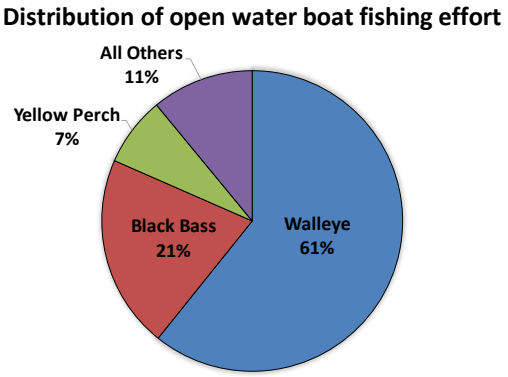


FIGURE J.2. Distribution of directed sport fishing effort by boat anglers in New York waters of Lake Erie, May-October, 2017.

Walleye

Estimated 2017 walleye fishing effort was 213,257 angler-hours, a 2% decrease from 2016 and but still among the highest annual effort estimates measured since 1998 (Figure J.3).

Estimated 2017 total daytime walleye harvest was 70,010 fish (Table J.2), a 37% increase from 2016. The 2014–2017 period produced the four highest walleye harvests of the past two decades. The 2017 walleye harvest estimate was the third highest measured in this 30-year time series (Figure J.3).

Walleye catch and harvest peaked during September, and the June through September period accounted for 95% of the total estimated catch and harvest (Table J.3). Walleye harvest typically peaks in June. The Barcelona, Dunkirk, and Cattaraugus survey locations were all strong contributors to the walleye catch and harvest in 2017.

TABLE J.2. Harvest, catch, and two standard errors (2SE) of selected species by boat anglers fishing on the New York waters of Lake Erie, May-October, 2017.

Species	Harvested	2SE	Caught	2SE
Walleye	70,010	13,110	119,944	21,412
Yellow Perch	42,890	12,922	57,895	15,847
Smallmouth Bass	1,896	950	56,477	16,073
White Bass	924	665	21,485	5,467
Steelhead	516	239	978	398
Sheepshead	276	534	29,466	6,994
*21 other species	755	525	25,103	6,451
Total	117,267	18,461	311,347	32,993

* 65 % of catch of other species were Round Goby

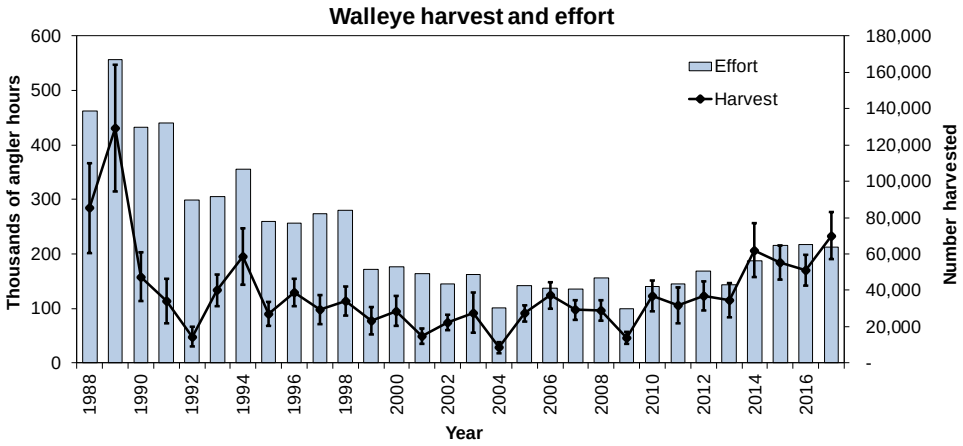


FIGURE J.3. Annual trends in walleye sport fishing effort (angler-hours) and number harvested from May-October, 1988–2017.

TABLE J.3. Distribution of daytime walleye catch and harvest totals in the New York waters of Lake Erie during 2017.

		May	Jun	Jul	Aug	Sep	Oct	Total
Barcelona	Catch	14	3,398	12,906	4,196	6,233	419	27,167
	Harvest	14	2,113	6,068	2,477	4,053	346	15,070
Dunkirk	Catch	79	196	9,617	11,101	8,306	1,987	31,286
	Harvest	69	196	6,185	5,864	4,738	1,528	18,580
Cattaraugus	Catch	20	1,236	3,465	3,820	15,963	1,556	26,059
	Harvest	20	985	2,047	2,211	11,978	1,131	18,372
Sturgeon	Catch	44	598	3,051	5,655	5,858	109	15,315
	Harvest	44	467	1,997	3,328	3,951	42	9,829
Buffalo	Catch	898	5,203	6,204	2,052	5,245	512	20,116
	Harvest	582	2,480	3,893	257	845	102	8,159
Total	Catch	1,055	10,631	35,244	26,825	41,605	4,583	119,944
	Harvest	729	6,242	20,189	14,136	25,565	3,149	70,010

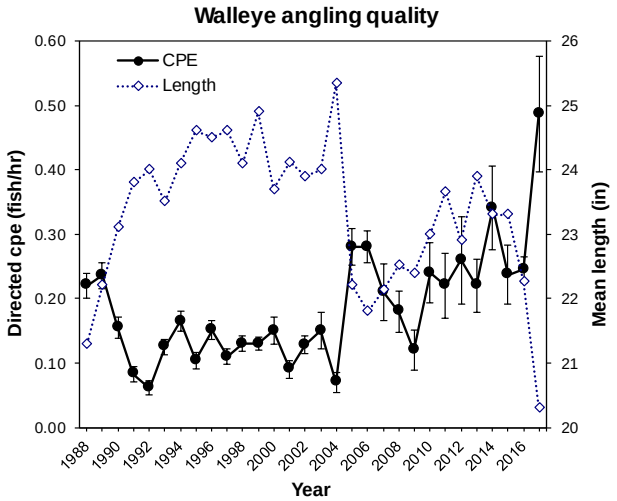


FIGURE J.4. Annual trends in Walleye sport fishing quality as measured by mean length harvested (inches) and catch rate (number per hour or CPE) from 1988 to 2017. CPE calculations are weighted by the amount of walleye effort estimated at each harbor.

Walleye was the most frequently caught species by boat anglers in 2017 (Table J.2). Walleye catch rates have been relatively high over the past decade and were exceptional in 2017. The overall 2017 targeted walleye catch rate was 0.49 fish per hour, the highest recorded (Figure J.4). The average total length of harvested walleye in 2017 was 20.3 inches; a decrease of two inches from 2016 and the lowest observation in survey history (Figure J.4).

Measures of walleye angler success can also be expressed as frequency of boat limit catches and frequency of zero catches for targeted walleye fishing trips. Table J.4 shows that boat limit catches of walleye remain an uncommon occurrence across all years, while complete lack of success (zero harvest) occurs more frequently. During 2017, approximately 10% of walleye fishing boats achieved a party limit, while nearly 32% failed to harvest any walleyes. In general, walleye condition has been trending down over the past five years. In 2017 the average weight of a 24- and 28-inch harvested walleye was 4.5 and 7.3 lbs., respectively, compared to long-term averages of 4.8 and 7.6 lbs. (Figure J.5).

TABLE J.4. Walleye boat fishing quality metrics, including harvest (HPE) and catch rates, harvest and catch per boat, percentage of boats achieving their daily limit, and percentage of boats that harvested no walleyes from 1988 to 2017.

Year	Walleye/ang-hr		Walleye/boat trip		Walleye boat		Daily limit
	HPE	CPE	harvest	catch	% Limit	% Zero	regulation
1988	0.19	0.22	2.6	3.0	4	41	5
1989	0.21	0.23	3.2	3.5	5	39	5
1990	0.13	0.15	2.0	2.3	1	42	5
1991	0.08	0.08	1.1	1.2	1	59	5
1992	0.06	0.06	0.8	0.9	1	71	5
1993	0.12	0.12	1.7	1.8	2	48	5
1994	0.15	0.16	2.1	2.2	3	45	5
1995	0.10	0.10	1.3	1.4	1	55	5
1996	0.14	0.15	1.8	2.0	3	47	5
1997	0.11	0.11	1.5	1.5	1	50	5
1998	0.12	0.13	1.7	1.8	1	47	5
1999	0.13	0.13	1.8	1.9	3	52	5
2000	0.14	0.15	2.1	2.2	5	49	5
2001	0.08	0.09	1.2	1.3	1	60	5
2002	0.11	0.12	1.4	1.6	2	52	5
2003	0.14	0.15	2.1	2.3	4	39	4
2004	0.06	0.06	0.7	0.8	0	65	4
2005	0.17	0.27	2.2	3.6	8	44	4
2006	0.24	0.29	3.1	3.8	12	32	4
2007	0.19	0.21	2.6	2.9	4	36	5
2008	0.16	0.17	2.1	2.3	2	42	5
2009	0.12	0.13	1.5	1.7	2	50	5
2010	0.21	0.24	2.9	3.3	5	36	5
2011	0.18	0.21	2.7	3.1	5	37	5
2012	0.18	0.24	2.8	3.6	5	37	5
2013	0.19	0.21	2.7	3.1	3	39	6
2014	0.27	0.32	3.7	4.4	6	28	6
2015	0.24	0.25	3.3	3.4	4	30	6
2016	0.21	0.24	2.7	3.1	4	36	6
2017	0.31	0.52	3.9	6.5	10	32	6

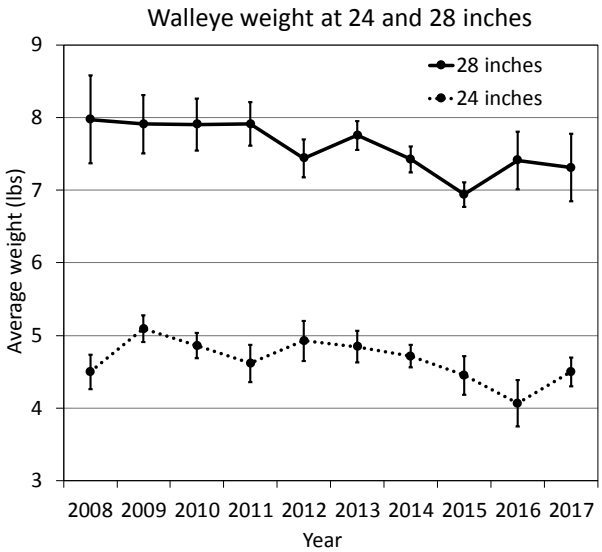


Figure J.5. Average body weight (lbs.) of angler-caught walleye in the New York waters of Lake Erie at 24 and 28 inches. Error bars represent 95 % confidence intervals.

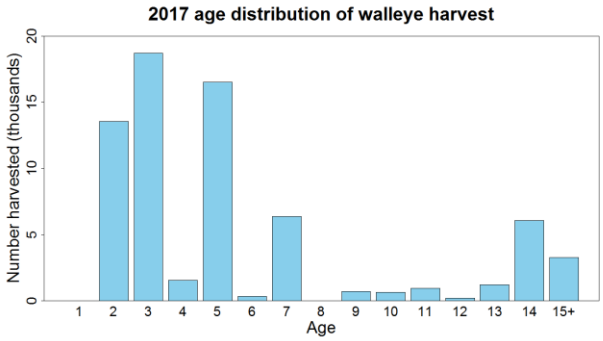


FIGURE J.6. Age distribution of the 2017 walleye harvest estimated by expanding the age distribution of samples at fish cleaning stations by the 2017 walleye harvest estimate

The age distribution of the walleye harvest was determined from otolith samples taken at fish cleaning stations, and was extrapolated to estimate number harvested by age (Figure J.6). Walleye harvest was dominated by the 2012, 2014, and 2015 year classes (ages 5, 3 & 2, respectively) making up approximately 70% of the total harvest. Diets of angler-caught walleye were dominated by round goby, gizzard shad, and smelt.

Smallmouth Bass

Smallmouth bass harvest was estimated at 1,896 fish in 2017, only 3% of the total bass catch, 56,447 (Table J.2). Approximately 67% of the catch and 78% of the harvest was reported from the Buffalo Harbor survey location in 2017. Estimated 2017 smallmouth bass harvest was the lowest observed. Targeted smallmouth bass effort has been very stable over the past decade (Figure J.7). The overall catch rate by bass anglers was 0.88 bass per hour, the twelfth lowest in the time series. Mean length of harvested smallmouth bass was 16.4 inches (N=45, Figure J.8).

TABLE J.5. Distribution of smallmouth bass catch and harvest totals in the New York waters of Lake Erie during 2017.

		May	Jun	Jul	Aug	Sep	Oct	Total
Barcelona	Catch	1,054	410	356	231	18	105	2,173
	Harvest	-	101	127	-	-	10	238
Dunkirk	Catch	5,449	6,287	306	1,374	338	108	13,862
	Harvest	-	19	23	-	-	-	41
Cattaraugus	Catch	191	317	321	89	47	48	1,014
	Harvest	-	-	37	-	-	-	37
Sturgeon	Catch	76	196	532	277	106	292	1,480
	Harvest	-	9	61	-	-	33	104
Buffalo	Catch	9,996	13,577	2,686	1,828	9,245	615	37,947
	Harvest	-	354	102	353	667	-	1,476
Total	Catch	16,766	20,788	4,201	3,800	9,754	1,168	56,477
	Harvest	-	483	350	353	667	44	1,896

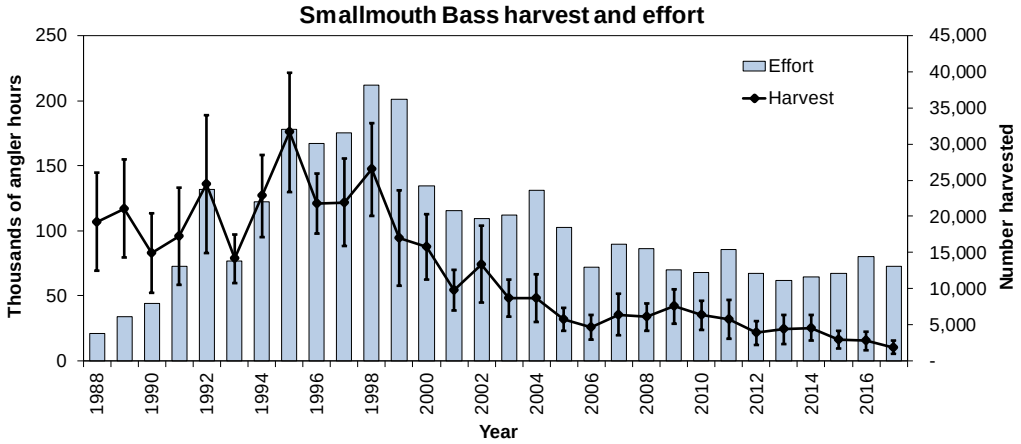


FIGURE J.7. Annual trends in smallmouth bass sport fishing effort (angler-hours) and number harvested from May through October 1988 to 2017.

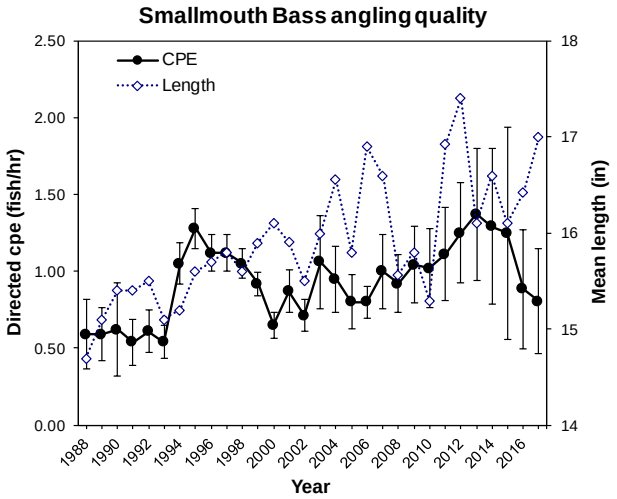


FIGURE J.8. Annual trends in smallmouth bass sport fishing quality as measured by mean length harvested (inches) and catch rate (number per hour or CPE) from 1988 to 2017.

Measures of bass angler success can also be expressed as catch per boat and frequency of zero catches for targeted bass fishing trips. Table J.6 shows that the catch per boat is below the time series average (11.5 bass per trip) and the number of boats that caught no bass is above the time series average (17.6). During 2017, approximately 23% of bass fishing boats failed to catch a bass.

TABLE J.6. Bass boat fishing quality metrics, including harvest and catch rates, harvest and catch per boat, and percentage of boats that caught no smallmouth bass from 1988 to 2017.

Year	Bass/ang-hr		Bass/boat trip		Boat
	HPE	CPE	harvest	catch	% Zero
1988	0.22	0.59	2.7	7.1	23
1989	0.18	0.59	2.0	6.5	22
1990	0.18	0.69	2.1	7.9	12
1991	0.17	0.54	2.1	6.7	22
1992	0.14	0.61	1.8	7.7	26
1993	0.09	0.54	1.0	5.8	23
1994	0.09	1.05	1.1	12.8	14
1995	0.11	1.27	1.3	14.6	11
1996	0.08	1.12	0.9	13.7	12
1997	0.09	1.12	1.1	14.3	12
1998	0.09	1.05	1.1	12.8	14
1999	0.06	0.91	0.8	10.6	17
2000	0.07	0.65	0.9	8.1	17
2001	0.07	0.87	0.9	11.7	13
2002	0.06	0.79	0.7	9.2	20
2003	0.06	1.03	0.7	11.5	17
2004	0.06	0.98	0.6	10.9	17
2005	0.04	0.82	0.4	9.9	23
2006	0.05	0.79	0.5	8.7	22
2007	0.05	1.01	0.6	12.7	16
2008	0.05	0.94	0.6	10.5	21
2009	0.06	1.06	0.7	12.4	19
2010	0.07	1.04	0.8	11.4	20
2011	0.05	1.19	0.6	13.8	18
2012	0.03	1.44	0.4	18.1	14
2013	0.04	1.50	0.6	18.5	15
2014	0.05	1.40	0.6	16.9	15
2015	0.04	1.40	0.5	17.5	14
2016	0.03	0.97	0.3	11.8	17
2017	0.02	0.83	0.2	9.4	23

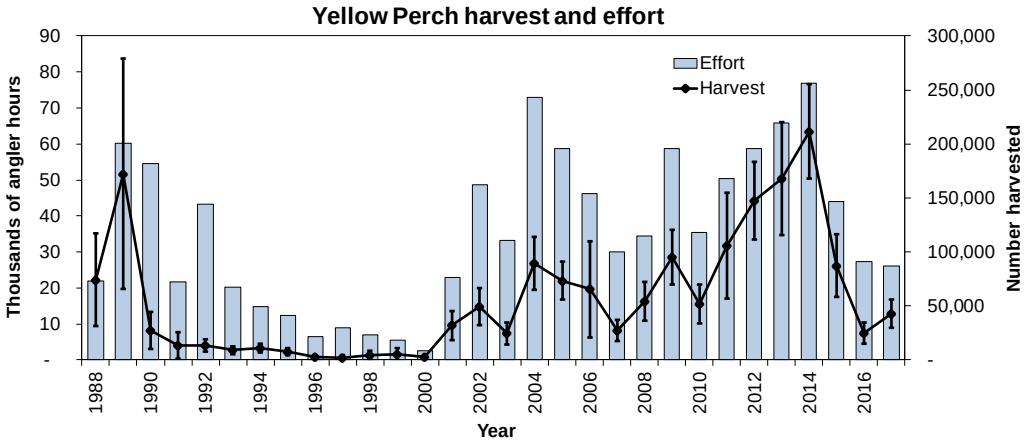


FIGURE J.9. Annual trends in yellow perch sport fishing effort (angler-hours) and number harvested from May through October 1988 to 2017.

Yellow Perch

Yellow Perch was the third most caught species by boat anglers in 2017 (Table J.2). Estimated 2017 targeted yellow perch effort (26,154 angler-hours) was down 66% from the time series high observed in 2014 (Figure J.9). Estimated 2017 Yellow perch harvest (42,890 fish) declined 80% from the time series high in 2014, and was below the long-term average (57,000 fish; Figure J.9). Boats fishing out of Cattaraugus Creek Harbor experienced the highest catch and harvest of yellow perch in 2017, followed by Sturgeon Point Harbor (Table J.7). The highest monthly yellow perch harvest occurred in September (36% of the total).

TABLE J.7. Distribution of yellow perch catch and harvest totals in the New York waters of Lake Erie during 2017.

		May	Jun	Jul	Aug	Sep	Oct	Total
Barcelona	Catch	14	62	127	26	35	21	285
	Harvest	-	54	42	-	18	10	125
Dunkirk	Catch	59	354	306	657	1,204	539	3,119
	Harvest	-	149	261	580	923	171	2,083
Cattaraugus	Catch	2,156	6,764	703	4,088	12,690	2,793	29,194
	Harvest	2,110	5,628	530	3,663	9,867	2,339	24,138
Sturgeon	Catch	180	1,374	236	5,065	3,771	5,634	16,259
	Harvest	163	1,262	184	4,064	3,093	4,841	13,608
Buffalo	Catch	177	914	1,190	2,149	3,378	1,230	9,037
	Harvest	152	261	612	513	1,245	154	2,936
Total	Catch	2,587	9,468	2,561	11,983	21,079	10,218	57,895
	Harvest	2,425	7,354	1,629	8,820	15,145	7,515	42,890

The 2017 overall yellow perch catch rate was 1.62 perch per hour (Figure J.10), a nearly two fish-per-hour decline from the time series high in 2014, but remained above the time-series average of 1.43 fish per hour. The mean length of harvested yellow perch was 11.0 inches in 2017, among the highest in the time series (Figure J.10).

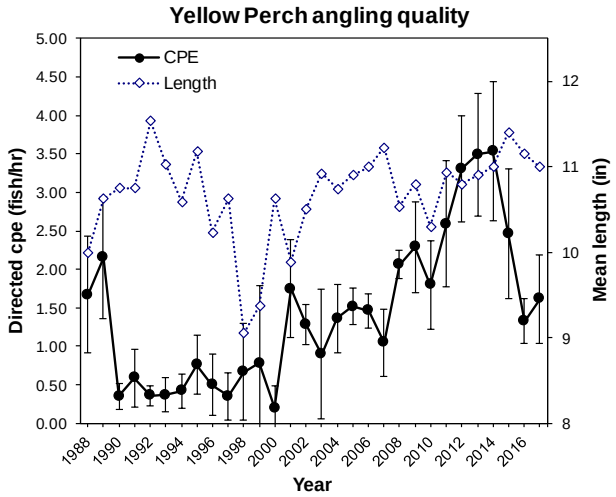


FIGURE J.10. Annual trends in yellow perch sport fishing quality as measured by mean length harvested (inches) and catch rate (number per hour or cpe) from 1988 to 2017.

The age distribution of the yellow perch harvest was determined from anal spine samples, and was extrapolated to estimate total number of fish caught by age class. Yellow perch harvest was dominated by the 2014, 2012, and 2010 year classes (ages 3, 5 & 7, respectively) making up approximately 64% of the total harvest. (Figure J.11).

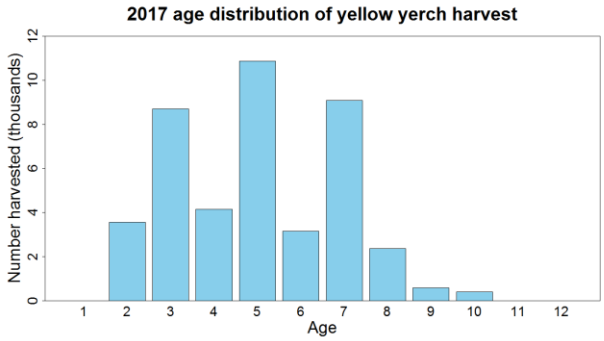


FIGURE J.11. Age distribution of the 2017 yellow perch harvest estimated by expanding the age distribution of samples collected during the angler survey with the 2017 harvest estimate.

Measures of yellow perch angler success can also be expressed as frequency of boat limit catches and frequency of zero catches for targeted yellow perch fishing trips. Table J.8 shows that boat limit catches of yellow perch remain a rare occurrence across all years, while complete lack of success (zero harvest) occurs more commonly. During 2017, approximately 2% of yellow perch fishing boats achieved a party limit, while nearly 26% failed to harvest any perch.

Other Species

Sport catch and harvest estimates for other prominent species are presented in Table J.2. White bass and sheepshead were caught routinely by anglers in 2017, making up over 16% of the total catch. Round goby also remained a commonly encountered nuisance species. Rainbow trout, brown trout, and lake trout were the salmonids identified among harvested species in 2017. Rainbow trout was the most commonly caught (978 fish) and harvested (516 fish) of these three salmonid species.

Discussion

A major declining trend in boat fishing effort extended through the 1990's and 2000's to a low point in 2009. Since 2009 effort has been generally increasing. Lake Erie's major decline in boat fishing effort from the late 1980's through the 1990's remains consistent with broad trends observed in other waters and is likely attributable to factors independent of fishing quality including high fuel prices, aging of the boat angler population, and regional population decline.

TABLE J.8. Yellow Perch boat fishing quality metrics, including harvest and catch rates, harvest and catch per boat, percentage of boats achieving their daily limit, and percentage of boats that harvested no yellow perch from 1988 to 2017.

Year	Perch/ang-hr		Perch/boat trip		Perch boat trips		Daily limit
	HPE	CPE	harvest	catch	% Limit	% Zero	regulation
1988	1.65	1.67	17.4	17.7	0	40	none
1989	2.04	2.17	24.2	25.7	0	36	none
1990	0.66	0.70	7.3	7.7	0	43	none
1991	0.56	0.59	6.0	6.3	0	46	none
1992	0.34	0.36	3.5	3.7	0	58	none
1993	0.31	0.37	3.2	3.8	0	68	none
1994	0.33	0.42	3.9	5.0	0	45	none
1995	0.53	0.76	4.4	6.4	0	38	none
1996	0.30	0.51	3.3	5.5	0	63	none
1997	0.27	0.35	2.2	2.9	0	71	50
1998	0.46	0.67	4.4	6.4	0	75	50
1999	0.44	0.78	5.7	10.2	0	70	50
2000	0.20	0.20	2.1	2.1	0	56	50
2001	1.64	1.75	18.4	19.7	2	24	50
2002	1.03	1.17	8.9	10.1	1	39	50
2003	0.79	0.97	8.2	10.1	0	45	50
2004	1.17	1.38	13.0	15.3	0	38	50
2005	1.11	1.36	11.9	14.7	0	40	50
2006	1.35	1.46	14.1	15.2	2	31	50
2007	0.99	1.08	9.7	10.6	0	43	50
2008	1.79	2.18	18.3	22.2	3	28	50
2009	1.72	2.23	18.4	23.9	3	24	50
2010	1.43	1.98	15.3	21.2	1	35	50
2011	2.00	2.59	23.1	30.0	3	27	50
2012	2.24	3.40	26.8	40.5	5	20	50
2013	2.64	3.56	30.2	40.7	6	18	50
2014	2.73	3.45	33.3	42.0	7	14	50
2015	2.15	2.67	26.1	32.3	3	27	50
2016	0.95	1.15	10.7	12.9	1	39	50
2017	1.50	1.78	17.2	20.3	2	26	50

In recent years, walleye fishing quality has been well above the long-term average. The dominant 2003 walleye year class supported excellent quality fishing through 2016. The relatively strong 2010, 2012, 2014, and 2015 year classes are currently supporting excellent fishing quality, which should persist for several more years. There is also strong evidence for an exceptional 2016 walleye year class (See Section D). Walleye born in 2016 should begin contributing to the harvest at age-2 in 2018, and should become a large component of the harvest at age-3 in in 2019.

In the past, large decreases in the average size of harvested walleye have been a precursor to excellent fishing, as they are an indication of large pulses of young walleye entering the fishery. Over the past two years the average size of harvested walleye decreased by three inches to an unprecedented 20.3 inches. This decrease is a result of the strong 2014 and 2015 year classes entering the fishery and should be interpreted as an indicator of excellent fishing quality expected in the coming years.

Targeted walleye effort increased in response to excellent fishing quality over the last decade. However, over the past three years walleye effort appears to have plateaued even though the quality of walleye fishing in the New York waters of Lake Erie has been well publicized and is at a 30-year high. Leveling off of walleye effort in the face of extremely high catch rates may indicate that there is limited capacity for increased walleye effort in the NY waters of Lake Erie by the current angling population. Moreover, the annual synthesis of lake wide walleye population status suggests exploitation in New York's portion of Lake Erie is very modest in scale (Walleye Task Group 2017). As such, efforts to further publicize the unprecedented walleye fishing quality that presently exists are justified.

Another well-known factor contributing to walleye fishing quality in the east basin of Lake Erie is summertime movements of walleye from Lake Erie into the central and eastern basins. The segment of the west basin walleye population largely responsible for this seasonal movement is generally larger and older walleye. The magnitude of this migration varies between years and may be attributable to walleye population densities in western Lake Erie as well as other factors independent of walleye densities (Einhouse and MacDougall 2010, Zhao et al. 2011). Beginning in 2015 the Lake Erie Unit began a study which uses acoustic telemetry technology to quantify this annual walleye migration and its importance to the eastern basin fishery (see Section I of this report for more information).

Bass angling quality has declined over the past two years as measured by angler catch rates. Nevertheless, Lake Erie's bass angling quality can still be characterized as excellent, especially relative to other bass populations. A more long-term decline in smallmouth bass harvest rates has been underway since this survey began in the 1980's. This notable trend of increasing catch-and-release fishing practices has caused catch rates by anglers targeting smallmouth bass to diverge from overall harvest totals. In recent years, smallmouth bass harvest totals are the lowest observed in the time series. In addition, anglers targeting species other than smallmouth bass can account for as much as 70% of the total smallmouth bass harvest in a given year. As such, overall smallmouth harvest estimates do not necessarily reflect targeted catch or harvest rates by bass specialists, who primarily release black bass. The excellent quality walleye fishing observed most recently also may provide a more appealing alternative for anglers interested in consuming their day's catch.

Beginning in 2001, excellent yellow perch fishing quality returned after a full decade of poor fishing. Improvements in yellow perch fishing quality are consistent with other population indicators (Sections C and D) indicating improved status from the low, 1990's levels. In 2014, yellow perch fishing effort and harvest were the highest observed. The exceptional 2014 fishing year was supported by the two strongest perch year classes observed in our surveys up to that point (2008 & 2010). These two strong year classes were followed by three consecutive years of relatively weak recruitment in 2011-2013. As the 2008 and 2010 year classes have aged and exited the population, fishing quality has declined as evidenced by the relatively low observed catch rates in 2016 and 2017. Strong year classes of yellow perch were observed in 2014, 2015, and 2016, but these cohorts will not reach a desirable size for anglers until age-3 in 2017, 2018, and 2019, respectively. Two of these three year classes will be concurrently abundant in the harvestable population starting in 2018, which should notably improve yellow perch angling quality. Yellow perch fishing quality should continue to improve for the next three years as all three of these age classes enter the fishable population.

Perch fisheries in New York's portion of Lake Erie typically operate in deeper water (> 40 ft) and some anglers tend to release smaller, but otherwise harvestable-sized yellow perch. Yellow perch that are caught are released into relatively deep water are known to experience high mortality due to barotrauma. As a result, we suspect that yellow perch mortality attributable to angling likely includes most of the fish released. Ongoing outreach efforts are conveying this message to the angling community.

References

Einhouse, D. W. 2005. Angler Survey Methods for Lake Erie's Open Water Sport Fishery. New York State Department of Environmental Conservation, Albany, New York. 68 pp.

Einhouse, D. W. and T. M. MacDougall. 2010. An emerging view of stock contributions to Lake Erie's eastern basin walleye resource. In Status of walleye in the Great Lakes: proceedings of the 2006 Symposium. Great Lakes Fish. Comm. Tech. Rep. 69. pp 151 -164.

Pollock, K. H. 1994. Angler survey methods and their application in fisheries management. American Fisheries Society Special Publication 25. American Fisheries Society, Bethesda, Maryland.

Schmidt, B. R. 1975. Results and Evaluation of an Aerial Creel Survey Technique on Lake Sharpe, South Dakota. Master's Thesis, South Dakota State U., Brookings, SD, USA.

Walleye Task Group. 2017. Report of the Lake Erie Walleye Task Group, March 2018. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission. Ann Arbor, Michigan, USA.

Zhao, Y., D. W. Einhouse, and T. M. MacDougall. 2011. Resolving some of the complexity of a mixed-origin walleye population in the east basin of Lake Erie using a mark–recapture study. North American Journal of Fisheries Management. 31: 371–381.

K. Lower Trophic Level Monitoring Program

James L. Markham and Kristen T. Holeck (Cornell University)

In 1983, the Lake Erie Fisheries Unit began a lower trophic level monitoring program as part of a broader statewide effort. Three nearshore sites were initially sampled (Barcelona, Dunkirk, and Buffalo) once a month from May through September for water transparency (Secchi depth), water temperature, and zooplankton. In 1988, sampling efforts shifted to two sites off Dunkirk; one shallow (11 m or 36 feet), and one deep (21.3 m or 70 feet), with sampling frequency increased to two week intervals from May through September (Figure K.1).

In 1999, a lakewide lower trophic level assessment program was initiated (FTG 2017). A total of 18 stations in Lake Erie, three offshore and three inshore in each of three basins, were established to gain an understanding of lakewide ecosystem trends and monitor lake productivity. Standard measurements included water temperature, dissolved oxygen, water transparency, total phosphorus, chlorophyll *a*, and zooplankton size and density. Results from New York's stations are merged with those from other jurisdictions and reported within the inter-agency Forage Task Group annual report (FTG 2017).

Lake Erie's bi-national fish community goals and objectives for the eastern basin fish community target maintaining a stable cool-water percid (walleye and yellow perch) community in nearshore waters that favor mesotrophic conditions (Ryan et al. 2003). Within this trophic state, summer water transparencies should range between 3-6 m (10-20 feet), total phosphorus between 9 and 18 µg/L, and chlorophyll *a* between 2.5 and 5.0 µg/L (Leach et al. 1977). Fish community objectives for the offshore waters of the eastern basin desire a stable salmonid fish community consistent with maintaining oligotrophic conditions (transparency > 6 m (20 feet); total phosphorus < 9 µg/L; chlorophyll *a* < 2.5 µg/L). Our ongoing measures of transparency, total phosphorus and chlorophyll *a* in nearshore and offshore habitats assess whether these key trophic state indicators remain consistent with Lake Erie's favored fish communities.

FIGURE K.1. Location of nearshore (36 ft) and offshore (70 ft) lower trophic sampling sites monitored by the NYSDEC's Lake Erie Unit between May and September annually.

Methods

Samples are collected at fixed shallow (11 m or 36 ft) and deep (21.3 m or 70 ft) sites adjacent to Dunkirk every two weeks from May through September, totaling 11 to 12 sampling periods annually. During each site visit, water depth, date, and time of day are recorded along with some environmental conditions during sampling such as cloud cover and wind speed. Water transparency to the nearest 0.5 meter (1.6 ft) is determined using a Secchi disk. A HydroLab meter is used to measure temperature and dissolved oxygen at one meter depth increments and to determine the thermocline depth. Composite water samples are collected above the thermocline for chlorophyll *a* and phosphorus samples. A 0.5 m (1.6 ft), 64 µm conical plankton net is retrieved vertically from one meter (3.3 ft) off the bottom, or above the thermocline (epilimnion), to the surface to obtain a zooplankton sample. Zooplankton, chlorophyll *a*, and phosphorus samples are outsourced for processing.

A trophic state index (TSI) (Carlson 1977) was developed to produce a metric which merges three independent variables to report a single broader measure of trophic conditions. This index uses algal biomass as the basis for trophic state classification, independently estimated using measures of chlorophyll *a*, transparency, and total phosphorus.

Each independent measure is combined and the average of the three indices reflects a trophic state value for that site and sampling event. The median value of the combined daily indices is used to determine an annual index for each site. Because the number generated is only a relative measure of the trophic conditions and does not define trophic status, this index was calibrated to accepted Lake Erie ranges for values of total phosphorus, chlorophyll *a*, and transparency (Leach et al. 1977) that have long been used to assess trophic conditions. In these terms, oligotrophic was determined to have a TSI < 36.5, mesotrophic between 36.5 and 45.5, eutrophic between 45.5 and 59.2, and hyper-eutrophic >59.2.

Results

A total of 11 scheduled sampling dates were completed at both shallow and deep sites between 1 May and 18 September 2017.

Surface Water Temperature

The average summer (June – August) surface water temperature, weighted by month, was calculated for the offshore station by year (Figure K.2). Summer water temperature should provide an index of relative system production and growth rate potential for fishes, assuming prey resources are not limiting. Average summer surface water temperatures ranged from 19.4 ºC (66.9 ºF) in 2000 to 22.7 ºC (72.8 ºF) in 2010. The average summer surface water temperature in 2017 was 21.7 ºC (71.0 ºF), the fifth highest temperature in the data series (1999 to 2017) and above the series average of 20.9 ºC (69.6 ºF).

More robust long-term measures of water temperature are also available for the east basin of Lake Erie. Average daily water temperatures have been recorded at the Buffalo Water Treatment Plant (BWTP) since 1927 (NOAA 2017). Water temperatures at this site are taken at the entrance to the upper Niagara River at 9.1 m (30 ft) depths. An archived water temperature series is also available from the Dunkirk Water Treatment Plant (DWTP) since 1980. Water temperatures from this site are taken from Lake Erie at 8.8 m (29 ft) depths. At both locations, daily water temperatures are the average of four separate measurements over a 24-hour period.

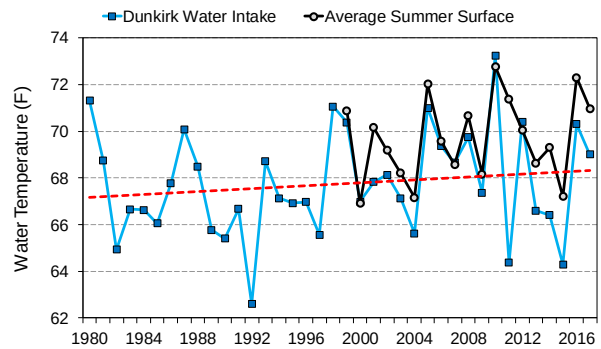


FIGURE K.2. Average summer (June – August) Lake Erie surface water temperature (ºF), weighted by month, at an offshore (70 ft) site at Dunkirk, NY, 1999-2017, and at an intake pipe (29 ft) for the Dunkirk Water Treatment Plant, 1980-2017. The time series trend for the Dunkirk Water Intake is also shown (dashed red line).

In 2017, the mean summer water temperature (June – August) at the DWTP was 20.6 ºC (69.0 ºF), ranking it as the 11th highest (71st percentile) in the 38-year time series (Figure K.2). With a few exceptions, water temperatures and general trends are similar between NYSDEC surface temperature observations and near bottom temperature measurements taken at the DWTP between 1999 and 2016. Long term trends show gradually increasing summertime water temperatures at the DWTP intake (Figure K.2). At the BWTP intake, the mean summer water temperature in 2017 was 21.9 ºC (71.4 ºF), which was the fifth highest average (95th percentile) summer temperature in the 91-year series and well above the series summertime average of 20.2 ºC (68.3 ºF) (Figure K.3). Long term trends at the BWTP also show gradually increasing summertime water temperatures.

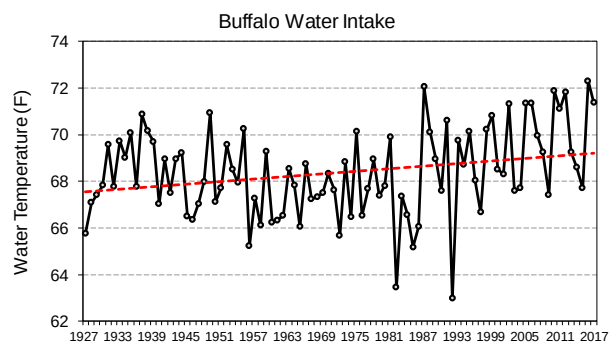


FIGURE K.3. Average summer (June – August) water temperature (ºF) recorded at the Buffalo Water Treatment Plant, 1927 – 2017. The intake pipe is located at a depth of 30 feet at the entrance to the Upper Niagara River. The time series trend is also shown (dashed red line).

Bottom Dissolved Oxygen

Dissolved oxygen (DO) levels less than 2 mg/L are considered stressful to fish and other aquatic biota (Craig 2012, Eby and Crowder 2002). Hypolimnetic DO can become low when the water column becomes stratified, which can begin as early as June and continue through September in the eastern basin. However, hypolimnetic DO is rarely limiting in Lake Erie's eastern basin due to a deep hypolimnion layer, lower productivity, and cooler water temperatures (FTG 2017).

DO measurements have only been collected since 2007 at the Dunkirk site and some of those years have few or no observations due to equipment malfunctions (Figure K.4). Bottom summertime measurements taken in 2017 ranged from 6.3 – 8.8 mg/L oxygen, well above the 2.0 mg/L threshold (Figure K.4). DO measures have never been below the 2.0 mg/L level at New York's offshore sampling site during the seven previous sampling years. The lowest DO measure recorded was 4.3 mg/L in 2009.

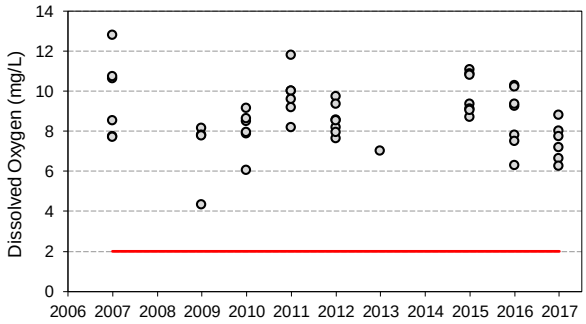


FIGURE K.4. Summer (June – August) Lake Erie bottom dissolved oxygen (mg/L) readings at an offshore (21.3 m or 70 ft) site at Dunkirk, NY, 2006-2017. 2.0 mg/L line represents the level at which oxygen becomes limiting for many temperate fishes. No readings were taken in 2008 or 2014.

Phosphorus

Total phosphorus (TP) levels throughout Lake Erie have generally increased over the past two decades, most notably in the west basin (FTG 2017). Modest increases have been evident at New York's nearshore and offshore sites (Figure K.5). Total phosphorus at the nearshore site exhibited a gradually increasing trend through 2010, stable values through 2014, and decreased levels in 2015 and 2016. A similar pattern occurred at the offshore site. In 2017, mean nearshore and offshore TP levels increased to 12.5 and 12.1

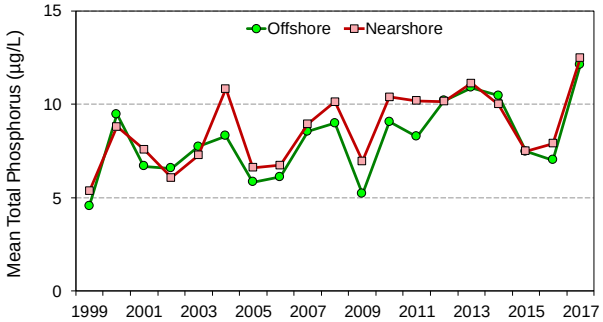


FIGURE K.5. Mean total phosphorus (µg/L), weighted by month, at nearshore (11 m or 36 ft) and offshore (21.3 m or 70 ft) Lake Erie sites at Dunkirk, NY, 1999-2017.

µg/L, respectively, the highest values observed at both sites.

Water Transparency

Transparency has been measured annually since the first 1983 survey in nearshore waters, and since 1988 in offshore waters. This long-term data series documents changes in water transparency that accompanied the invasion of dreissenid mussels into eastern Lake Erie in 1990. By 1992, summer water transparency increased in both nearshore and offshore sites to over 25 feet (Figure K.6). Transparency in the nearshore waters began to decrease by the late-1990s, perhaps in part in response to the invasion of round goby into eastern Lake Erie, a prolific consumer of dreissenids, and to increases in phosphorus (i.e. productivity). Water transparency has exhibited a gradual decrease in nearshore waters since this time, but has remained higher and more consistent in the offshore waters.

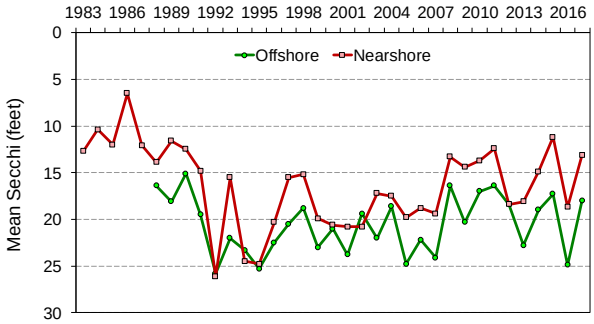


FIGURE K.6. Mean summer (June – August) Lake Erie transparency (feet), weighted by month, at nearshore (11m or 36 ft) and offshore (21.3 m or 70 ft) sites at Dunkirk, NY, 1983-2017. Note that the shallowest depths are at the top of the y-axis and deepest at the bottom.

Chlorophyll *a*

Chlorophyll *a* concentrations are an indicator of phytoplankton biomass, ultimately representing primary production. Trends in chlorophyll *a* have been similar between nearshore and offshore waters through this time series (Figure K.7). Chlorophyll *a* concentrations decreased in 2007 and exhibited an increasing trend beginning in 2013. Measures in 2017 were the highest in the time series at both sites.

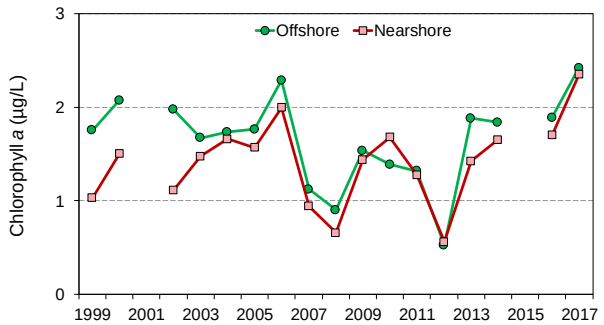


FIGURE K.7. Mean chlorophyll *a* (µg/L), weighted by month, at nearshore (11 m or 36 ft) and offshore (21.3 m or 70 ft) Lake Erie sites at Dunkirk, NY, 1999-2016. Shaded areas represent trophic state targets. Measures are not available in 2001 and 2015.

Trophic State Index (TSI)

A box and whisker plot was used to describe the trophic state index (TSI) at New York's nearshore and offshore sites in Lake Erie (Figure K.8). Trends in the nearshore waters indicate median TSI values and ranges mostly below the targeted mesotrophic range in the early years of the time series, but have generally increased into the targeted mesotrophic zone since the late-2000s. The median nearshore TSI value in 2017 was 38.7, the highest value in the time series and indicative of mesotrophic conditions. At the offshore site, TSI values have generally remained more consistent throughout the time series compared to the nearshore site and remained within the targeted oligotrophic range. The one exception was 2017, which was also the highest index in the time series and slightly above the targeted oligotrophic range (TSI = 37.7).

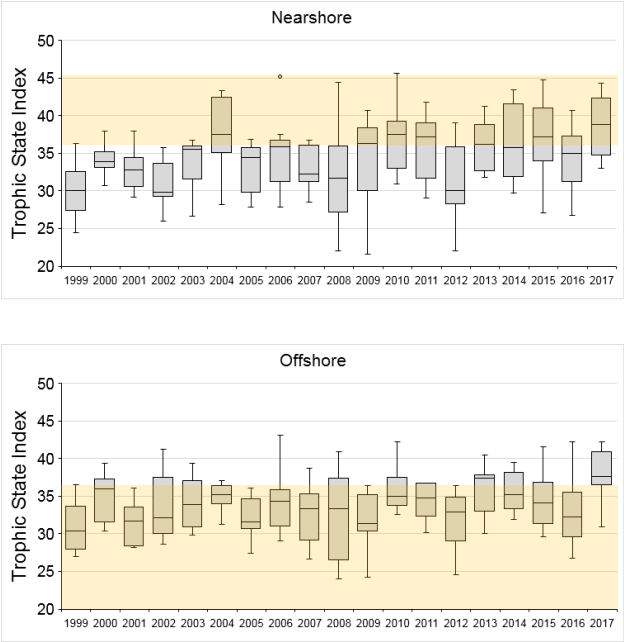
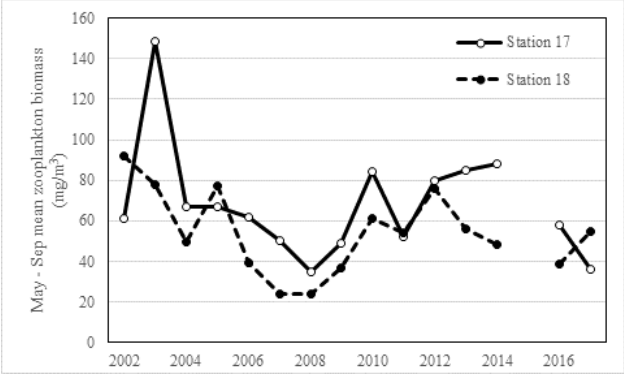


FIGURE K.8. Box and whisker plot of trophic state indices (TSI) at nearshore (11 m or 36 ft) and offshore (21.3 m or 70 ft) Lake Erie sites at Dunkirk, NY, 1999-2017. Boxes indicate 25th and 75th quartiles of the values with the median value as the horizontal line. Vertical lines show the range of values. Outlier values are shown as single data points; one outlier (2004 Nearshore) falls outside the upper scale. Shaded area represents trophic state target.

Zooplankton Density and Biomass

In 2017, May – September zooplankton density was 21,400 ind/m^3 at the nearshore site, slightly below the long-term mean (Figure K.9). At the offshore site, density was 31,700 ind/m^3, well above the long-term mean. Biomass at the nearshore site in 2017 was below average (36 mg/m^3) and about average at the offshore site (55 mg/m^3).



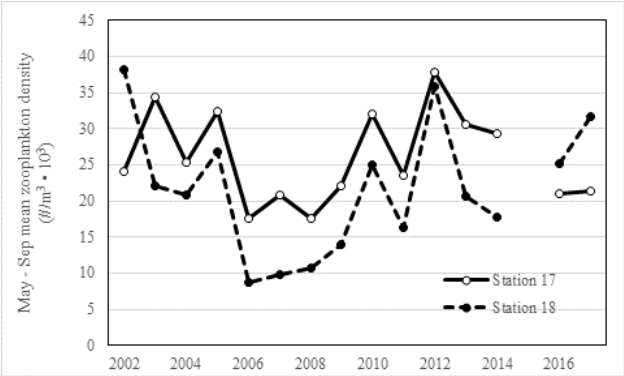


FIGURE K.9. May – September mean zooplankton density (top panel) and biomass (bottom panel) in the epilimnion at nearshore (Station 17) and offshore (Station 18) Lake Erie sites at Dunkirk, NY, 2002-2017. 2015 data are not yet available.

Discussion

Results from nineteen survey years have shown general stability in the eastern basin of Lake Erie lower trophic level indicators. With a few exceptions, average summer water temperatures have ranged within a few degrees over the time series, but with an overall gradually increasing trend, and dissolved oxygen is not limiting as fish habitat. The TSI at both nearshore and offshore sites indicates a pattern of slowly increasing productivity, mainly due to increases in phosphorus. As such, the TSI at the nearshore sites is within the targeted mesotrophic state while the offshore site is slightly more productive than the targeted oligotrophic state. Nevertheless, these east basin sites describe more stable trophic conditions relative to measures for the other basins of Lake Erie (FTG 2017).

A gradual increase in productivity in the eastern basin, especially in the nearshore waters, has occurred over the past nearly two decades. Oligotrophic conditions that were present nearshore in the 1990s and early 2000s have gradually shifted toward targeted mesotrophic conditions, and an apparent increase in lower trophic productivity is perhaps achieving a response in the eastern basin percid community. Yellow perch and walleye status have both improved from their low ebbs observed in the 1990s. Recent offshore lower trophic measures also indicate a gradual increase in productivity. However, these recent trends have not yet compromised thermal or DO habitat requirements for salmonid species.

References

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography **22**(2): 361-369.

Craig, J.K. 2012. Aggregation on the edge: effects of hypoxia avoidance on the spatial distribution of brown shrimp and demersal fishes in the Northern Gulf of Mexico. Marine Ecology Progress Series 445: 75-95.

Eby, L.A., and L.B. Crowder. 2002. Hypoxia-based habitat compression in the Neuse River Estuary: context-dependent shifts in behavioral avoidance thresholds. Can. J. Fish. Aquat. Sci. 59:952-965.

FTG. 2017. Report of the Lake Erie Forage Task Group, March 2016. Presented to the Standing Technical Committee, Lake Erie Committee of the Great Lakes Fishery Commission. Ann Arbor, Michigan, USA.

Leach, J.H., M.G. Johnson, J.R.M. Kelso, J. Hartman, W. Numan, and B. Ents. 1977. Responses of percid fishes and their habitats to eutrophication. J. Fish. Res. Board. Can. 34:1964-1971.

NOAA. 2017. Historical Lake Erie water temperatures. Online 7 March 2017 at: http://www.erh.noaa.gov/buf/laketemps/laketemps.php.

Ryan, P.A., R. Knight, R. MacGregor, G. Towns, R. Hoopes, and W. Culligan. 2003. Fish-community goals and objectives for Lake Erie. Great Lakes Fish. Comm. Spec. Publ. 03-02. 56 p.

L. Lake Sturgeon catch and abundance proximate to Buffalo Harbor, NY USA

Rachel Neuenhoff, Lori Davis, Jonah Withers, Nicholas Markley, John Sweka
United States Fish and Wildlife Service, Northeast Fisheries Center

Introduction

Lake sturgeon life history in eastern Lake Erie is generally characterized by a lack of stock specific information with a handful of exceptions (Koelz 1925; Legard 2015; USFWS 1999; Welsh et al. 2008). Furthermore, information on habitat preferences, early-life history, and residence patterns of lake sturgeon is limited mostly to the western basin (Baker and Borgeson 1999; Boase et al. 2011; Bruch and Binkowski 2002; Bur et al. 2007; Li and Jiao 2011; Roseman et al. 2011). While data from the western basin could potentially be used to inform research efforts and hypotheses, basic questions remain about the range and behavior of the unit stock, residency patterns, estimates of stock size, annual reproductive output, and location and characteristics of spawning site(s) in eastern Lake Erie.

Given the aforementioned, our objectives were to 1) capture adult lake sturgeon to summarize morphometric, age, and growth data, 2) evaluate distribution, range, and habitat use and 3) identify spawning areas in the vicinity of the Niagara River headwaters during the 2017 spring spawning. These metrics help quantify residency and usage patterns, and inform future stock assessments for lake sturgeon in the headwaters of the upper Niagara River.

Methods

Adult Sturgeon Assessment

We used gill nets to capture adult lake sturgeon in the area known as the North Gap in 2017 (Figure L.1). Two types of gill nets were used. One was a 300 ft. experimental monofilament net, 6 ft. deep with a 60 lb leadcore line and 0.5 inch foam core float line. This net was equipped with mesh sizes of 8.0, 10.0, and 12.0 inches alternating in 50 ft panels. The other net consisted of a 300 ft experimental monofilament and multifilament net, 6 ft deep with individual leads and floats. This net was equipped with mesh sizes of 10.0, 12.0, and 14.0 inches alternating in 50 ft panels. Gillnets were set for two to four hours during daylight hours, typically during the hours of 0800 and 1200. The unit of effort for catch rate calculations was number of fish per gill net hour, regardless of type of experimental gill net fished.

Lake sturgeon were captured from May 9 to June 13. Morphometric data were collected for each fish, and a passive integrated transponder (PIT) and anchor FLOY tag were applied at the time of capture unless already equipped with one from previous years capture. A subsample of lake sturgeon was also equipped with an internal acoustic transmitter (Vemco V16, Amirix, New Bedford, Nova Scotia). During acoustic transmitter implantation, we used external and internal assessment techniques to sex captured lake sturgeon that were not externally expressing gametes. A small section of the left leading pectoral fin spine was removed from each lake sturgeon for age estimation and oxytetracyline hydrochloride was administered intraperitoneally for partial age validation. Acoustic data were collected from telemetered lake sturgeon at large using both Vemco VR2W and VR2Tx acoustic receivers (Amirix, New Bedford, NS Canada) deployed in a grid style array near the headwaters of the Niagara River.

Spawning Area Assessment

We sampled three sites in the headwaters of the Niagara River with egg traps. Site selection was based on published accounts of lake sturgeon spawning habitat preferences and vicinity to adult

capture location. Criteria are outlined by Johnson et al. (2006): shallow in depth with gravel

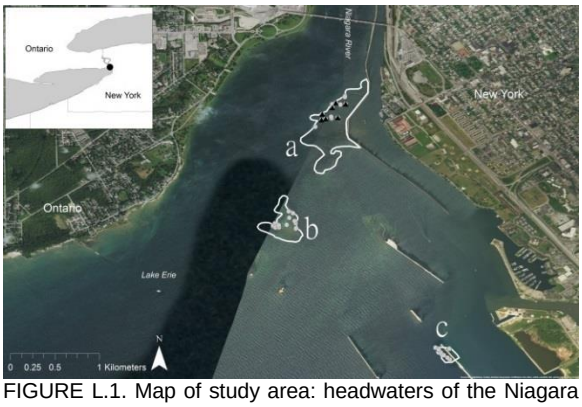


FIGURE L.1. Map of study area: headwaters of the Niagara River. Three egg trap strata outlined in gray were chosen based on habitat characteristics consistent with lake sturgeon spawning preferences (strata: a & b) and proximity to spring adult lake sturgeon capture site from 2012-2017 (strata: c). Locations from north to south: Bird Island Reef (a), Middle Reef (b), and the North Gap break wall area (c) at the south end of the North Gap region. Gray circles indicate the location of egg trap sets and the black triangles indicate locations where egg traps collected lake sturgeon eggs.

substrate in areas of high flow. We used ArcMap 10.4.1 for Desktop (ESRI 2015) to generate polygons of our three sites using a bathymetry raster (NOAA RNC: 14833). These polygons corresponded to: Bird Island Reef (221745.93 m^2), Middle Reef (84904.98 m^2) and the North Gap break wall area; 11815.21 m^2 (Figure L.1).

Egg traps were constructed using standard furnace filter (HD Supply 20’ x 360’) materials secured to welded steel frames per the design of Nichols et al. (2003). We deployed our traps in groups of three connected by a polypropylene line, (i.e., a “gang”), with each downstream end of the gang attached to a buoy (~ 13 lb buoyancy) by a stainless steel cable (30 – 50 ft long depending on water depth) and the upstream end attached to a 10 lb claw anchor. We deployed gangs when water temperature at depth reached 50°F. This was just prior to when mature individuals are typically captured at the North Gap area in May. We sampled with egg traps for six weeks. Upon retrieval, we examined the furnace filter material for the presence of eggs. All observed eggs were removed with forceps and placed in 15 ml falcon tubes with 95% non-denatured ethanol. Lake sturgeon eggs were identified based on morphological traits (Wang et al. 1985; Eckes et al. 2015). Of the traps that held presumed lake sturgeon eggs, one to two eggs per trap were selected for genetic species identification to validate morphological identification.

Results

Adult Sturgeon Assessment

Table L.1 summarizes annual catch-per-unit effort (CPUE, number of sturgeon per net hour). Overall effort varied from year to year. Male CPUE was high relative to female CPUE in all years, and female CPUE, although consistently low was less variable than either the male or overall CPUE. Most fish were sexually mature and expressing or near to expressing gametes. In 2017, the vast majority of the fish caught were sexually mature males (n=32). Four females and five males were equipped with acoustic transmitters. On 17 May, 2017, the first captured female was sexually mature and releasing eggs. Three black egg females were captured at the end of May and early June, two of which were releasing eggs. Between 2014 and 2017, 114 males, 10 females, and 15 lake sturgeon whose sex could not be identified were captured for a total of 139 across all four years.

Table L.2 summarizes the size bins for captured lake sturgeon. Males ranged in size from 49.8-71.7 inches total length, and 26.0-89.5 lb total weight. Females ranged in size from 51.6-70.9 inches total length and 45.4-108.5 lb total weight. Captured lake sturgeon were released at points of capture following tagging and surgery. Acoustic telemetry findings remain under evaluation.

TABLE L1. Number of gillnet net sets and CPUE (number per net hour) of lake sturgeon near Buffalo Harbor.

Year	Gillnet Sets	CPUE Female	CPUE Male	CPUE Total
2014	22	0.05	0.68	0.73
2015	39	0.02	0.17	0.19
2016	52	0.01	0.29	0.29
2017	32	0.03	0.23	0.26
Grand Total	145			

However, preliminary results suggest a high degree of site fidelity for some individuals to the Buffalo Harbor area across years. Additional results on behavior including range and habitat selectivity will be provided in upcoming USFWS reports. Table L.3 describes the number of recaptures encountered from 2014 to 2017. The proportion of recaptured fish has shown a generally increasing trend with the exception of 2015 when only one fish had been previously captured.

TABLE L.2. Weight frequency of lake sturgeon captured near the North Gap of Buffalo Harbor North Gap, 2017.

Weight (lbs)	Number
25-29.9	1
30-34.9	1
35-39.9	5
40-44.9	2
45-49.9	6
50-54.9	6
55-59.9	6
60-64.9	2
65-69.9	3
70-74.9	1
80-84.9	1
85-89.9	1
90+	1
Grand Total	**36**

TABLE L.3. Number of gill net recaptures, total caught and the proportion of recaptures in annual sample of lake sturgeon collected near Buffalo Harbor.

Year	Recaptures	Total	Proportion
2014	3	44	0.06
2015	1	22	0.05
2016	7	37	0.19
2017	8	36	0.22

Spawning Area Assessment

The combined sampled strata area of Bird Island Reef, Middle Reef, and the North Gap break wall was 318,465.19 m^2. Sixty-seven gangs of egg traps were deployed between May 5 and June 13, 2017. Twenty-seven were set at Bird Island Reef, 28 at Middle Reef and 12 near the North Gap break wall. In total, 2,728 eggs were collected from furnace filter materials. Eighty-six eggs were identified as lake sturgeon eggs, all originating from 12 gangs collected at the Bird Island Reef site. Lake sturgeon eggs collected at Bird Island Reef on June 1 produced emerging larvae after immersion in the ethanol preservative, indicating that these eggs had been fertilized and were viable at the time of capture. A total of 11 presumed lake sturgeon eggs were selected for genetic species identification, which spanned 11 different egg traps. All sequences matched to *Acipenser fulvescens*.

Collection trends of eggs from all species indicate that there were fewer eggs overall at the North Gap break wall than either Middle Reef or Bird Island Reef. Bird Island Reef had the greatest number of eggs deposited and was also the largest area surveyed but the difference in egg deposition between Bird Island Reef and Middle Reef was not significant. Across all sampling sites, lake sturgeon eggs were only identified at the Bird Island Reef site. Total lake sturgeon egg deposition at Bird Island Reef was low, though varied dramatically by sampling week. Figure L.2 shows two distinct peaks of lake sturgeon egg frequencies at sampling week three and five, which corresponded with water temperatures of 55.4-60.8 °F.

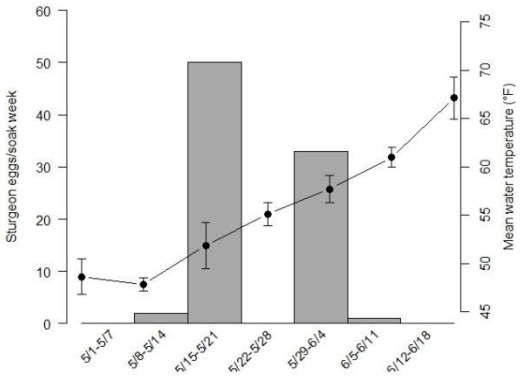


FIGURE L.2. A summary of the total number of lake sturgeon eggs collected using egg traps over six sampling weeks in May and June of 2017 from Bird Island Reef. The mean temperature (°F) in each week is given by the secondary axis. No lake sturgeon eggs were collected from either the Middle Reef or the North Gap break wall sites.

Discussion

Lake sturgeon captures in all years represent male-skewed data. Most females were captured in 2014 and 2017. The single 2016 female was also the second largest captured in any sampling year (73.8 in, 79.62 lb) and was extruding black eggs. The largest 2017 female was slightly shorter (71 in), but had a more robust body condition than the 2016 female. The low and variable collections of females in all years could reflect cohort specific differences in spawning periodicity and overall plasticity in life history strategies. It is unclear how these numbers reflect overall fecundity, egg deposition and production.

Conclusions about sex and stage determination must be considered with the caveat that correct assignment of males and females is more straightforward during later stages of gonadal development, particularly when clear indicators, such as external expression of milt and eggs, are evident. In the headwaters of the Niagara River, most captured fish are expressing gametes, reducing the need for more invasive techniques and improving the likelihood of correct sex determination. Only one male captured in 2017 was not expressing. However, this individual was captured in 2016 and was expressing milt.

We confirmed lake sturgeon egg deposition at Bird Island Reef. This discovery is the first of its kind for eastern Lake Erie lake sturgeon in the history of contemporary fishery statistics. We expect this finding will be important to habitat remediation planning, early-life history survey designs, and ultimately, recovery, management, and enhancement efforts for a state listed species.

Similar to other years, our sampling efforts were limited to the months of May and June when we anticipate spawning aggregations to occur. Catches after the second week in June decreased dramatically. This pattern in catch occurs in other outlet spawning populations of lake sturgeon (Chiotti personal comm.). Given the number of sexually mature individuals captured near the North Gap and its proximity to Bird Island Reef, this area may serve as both a staging and refuge/resting area during the spawning season. While Bird Island Reef provides high water velocities and bathymetry needed to support survival of eggs, this environment is also high in its energetic demands. The North Gap area provides vastly different conditions and is the area most proximate to Bird Island Reef to be characterized as such. Therefore, during spawning bouts lake sturgeon may seek the refuge of this area and increase their vulnerability to capture by our survey during this time. Furthermore, males typically arrive on the spawning grounds first and leave last as they await multiple female arrivals (Bruch and Binkowski 2002). This may explain why incidences of male captures are higher in all years over female due to the increased probability of capture related to time spent near the spawning area.

This spawning and early-life history information provides information for informing restoration initiatives. Complete life history data is particularly important if access to habitat becomes limited or lack of connectivity following the egg and larval drift periods reduces production. To detect these population signals, future research should include index surveys targeting several life history stages: eggs, larvae, juveniles and adults along with habitat

assessment of possible rearing and nursery areas. Continued annual efforts will contribute information critical to assessing stock status and formulating sound advice to advance recovery efforts of this threatened species in New York State.

References

Baker, E. A., and D. J. Borgeson. 1999. Lake sturgeon abundance and harvest in Black Lake, Michigan, 1975-1999. North American Journal of Fisheries Management 19:1080-1088.

Boase, J., J. Diana, M. Thomas, and J. Chiotti. 2011. Movements and distribution of adult lake sturgeon from their spawning site in the St. Clair River, Michigan. Journal of Applied Ichthyology 27(s2):58-65.

Bruch, R. M., and F. P. Binkowski. 2002. Spawning bahavior of lake sturgeon (*Acipenser fulvescens*). Journal of Applied Ichthyology 18:570-579.

Bur, M. T., W. H. Edwards, M. J. Porta, M. A. Stapanian, and P. M. Kocovsky. 2007. Surveillance and status of fish stocks in western Lake Erie, 2007. US Geological Survey, Niagara Falls, Ontario.

Eckes O.T., D.B. Aloisi, and M.B. Sandheinrich. 2015. Egg and larval development index for Lake Sturgeon. North American Journal of Aquaculture 77: 211-216.

ESRI. 2015. ArcGIS Desktop: Release 10. Redlands, CA: Environmental Systems Research Institute.

Johnson J.H., S.R. LaPan, R.M. Klindt, and A. Schiavone. 2006. Lake Sturgeon spawning on artificial habitat in the St Lawrence River. Journal of Applied Ichthyology 22: 465–470.

Koelz, W. 1925. Fishing industry of the Great Lakes: Appendix XI to the report of the U.S. commissioner of fisheries for 1925. Department of Commerce, Report 1001, Washington D.C.

Legard, C.D. 2015. Lake sturgeon monitoring in Buffalo Harbor. Section M in NYSDEC 2015, Lake Erie 2014 Annual Report. New York State Department of Environmental Conservation, Albany, NY, USA.

Li, Y., and Y. Jiao. 2011. Influences of gillnet fishing on lake sturgeon bycatch in Lake Erie and implications for conservation. Endangered Species Research 13:253-261.

Nichols, S.J., G. Kennedy, E. Crawford, J. Allen, J. French III, G. Black, M. Blouin, J. Hickey, S. Chernyák, R. Haas, M. Thomas. 2003. Assessment of lake sturgeon (*Acipenser fulvescens*) spawning effots in the lower St. Clair River, Michigan. Journal of Great Lakes Research 29:383-391.

Roseman, E. F., B. Manny, J. Boase, M. Child, G. Kennedy, J. Craig, K. Soper, and R. Drouin. 2011. Lake sturgeon response to a spawning reef constructed in the Detroit River. Journal of Applied Ichthyology 27(s2):66-76.

USFWS 1999. 1998 summary report of Niagara River and Oswegatchie River research projects. Great Lakes Native Fish Restoration Lake Sturgeon 99-01:1-11.

Wang Y.L., F.P Binkowski, and S.I. Doroshov, 1985. Effect of temperature on early development of white and Lake Sturgeon, Acipenser transmontanus and A. fulvescens. Environmental Biology of Fishes 14: 43-50.

Welsh, A., T. Hill, H. Quinlan, C. Robinson, and B. May. 2008. Genetic assessment of lake sturgeon population structure in the Laurentian Great Lakes. North American Journal of Fisheries Management; North American Journal of Fisheries Management 28:572-591.

M. 2016 Angler Survey of the Upper and Lower Niagara River

Christopher D. Legard

The Niagara River is a Great Lakes connecting channel forming the international boundary between New York State and the Province of Ontario. The Niagara River flows northward from Lake Erie to Lake Ontario for a distance of approximately 37 miles (59.5 km). The elevation difference between the two Great Lakes is approximately 328 feet (100 m), with slightly more than half of this height difference occurring at Niagara Falls. Niagara Falls divides the river into two distinct areas based on river basin morphometry and the fact that the Falls constitute an impressive natural barrier to upstream migration of fishes.

The upper Niagara River is best known for its warmwater fishery focused on smallmouth bass and muskellunge, while the lower Niagara River is best known for its coldwater fishery focused on migratory salmonids from Lake Ontario.

Assessment of the Niagara River sport fishery has been sporadic, with long periods of time between surveys. The most recent binational angler survey of the Niagara River occurred in 1999 (Einhouse et al. 2002), however, this survey only covered the upper Niagara River. A survey of New York anglers took place on both the upper and lower Niagara River during 2003 (NYPA 2005a and NYPA 2005b). Other angler surveys of the Niagara River were done by New York in 1984 (NYSDEC 1989) and Ontario in 1973, 1974 and 1980 (Craig 1976, Lewis and Dimond 1982)

This report summarizes the results of a binational angler survey conducted on the upper and lower Niagara River during 2016.

Methods

Boat fishery

This survey primarily targeted the Niagara River boat fishery, and ran from May 16 through October 16, 2016. We employed four creel agents (two in Ontario and two in New York) that worked three weekdays and two weekend days per week. The survey used a modified aerial-access design that was patterned after Einhouse et al. (2002). The survey was broken into three seasonal strata. The spring season ran from May 16 to June 17, the summer season ran from June 18 to September 5, and the fall season ran from September 6 to October 16, 2016.

We used instantaneous boat counts to estimate angler effort and performed completed trip interviews at representative sites along the New York and Ontario shoreline to estimate catch and harvest (Figures M.1 and M.2). We estimated daily angler effort using the instantaneous boat counts multiplied by the number of hours in the sampling period and the probability that the period was included in the sample. The daily effort estimates were calculated for both weekdays and weekend days, then expanded to spring, summer, and fall season estimates and summed to calculate the total fishing effort (Pollack et al. 1994).

Boat counts

Einhouse et al. (2002) used aerial boat counts via fixed wing aircraft. However, we were unable to employ an aircraft for the survey in 2016. Instead we used a combination of boat counts both from vantage points and by driving a vehicle along roads following the river. The boat count route took approximately two hours for the upper river and an additional two hours to complete the lower river. As such, the counts were not instantaneous. However, we believe the vehicle based boat counts represent a near instantaneous count, and assumed such for data analysis. Boat counts were conducted on one week day and one weekend day per week. Boat counts were randomly assigned to AM or PM shifts, and to either the first half of the shift or the last half of the shift. Only boats actively engaged in fishing were counted. On two occasions the accuracy of the vehicle based boat count method was checked by conducting a boat based count concurrent with the vehicle based count on the upper Niagara River. The

comparison was not done on the lower river because the vantage points used here allowed for better viewing of fishing boats than those on the upper river.

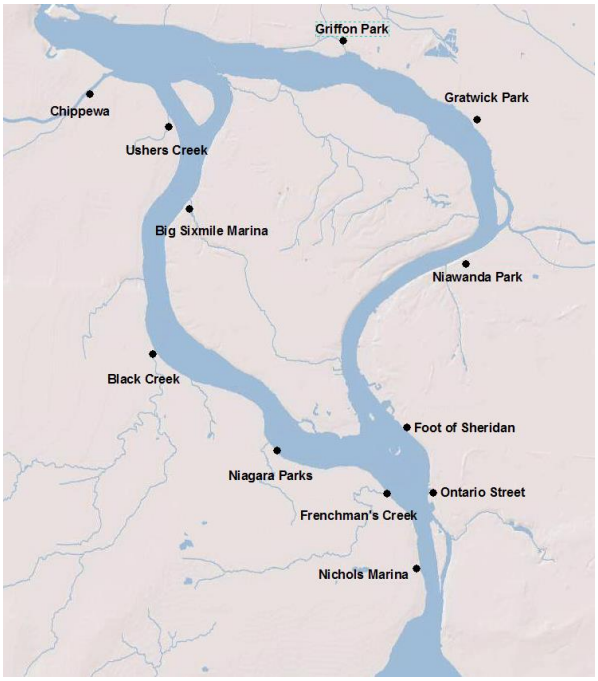


FIGURE M.1. Locations where angler interviews were conducted on the upper Niagara River in 2016

FIGURE M.2. Locations where angler interviews were conducted on the lower Niagara River in 2016

Interviews

On the upper river, interviews were conducted at six locations each in New York and Ontario (Figure M.1). On the lower river, interviews were conducted at three locations in New York and one location in Ontario (Figure M.2). Creel agents were randomly assigned three locations per day to conduct interviews at each location for two hours. If no boat trailers were present at the assigned location, they would move to the next location on the list.

Shore fishery

This survey was primarily focused on the boat fishery, however, we did sample the shore fishery on an opportunistic basis. Shore fishing effort was estimated using instantaneous counts of shore anglers present at interview locations when the creel agent first arrived. Incomplete trip interviews were used to estimate catch and harvest. All of the interview locations were boat launches that also offered some form of shore fishing. The lone exception was the New York Power Authority (NYPA) fishing platform on the lower river, which only allowed shore fishing.

Calculations

Estimates of fishing effort, mean catch and harvest rates, and catch and harvest of fish by species were estimated for each survey stratum, along with associated standard errors, according to the following formulae reported in Pollack et al. 1994 and Einhouse et al. 2002:

Fishing Effort

$$E = \sum \left(\frac{e_i}{\pi_i}\right)$$

$$S_i^2 = \left(\frac{1}{n-1}\right) \sum (e_i - \overline{e_i})^2$$

$$Var(\overline{e_i}) = \frac{S_i^2}{n_i}$$

$$Var\ (E) = N_i^2\ (Var(\overline{e_i}))$$

$$SE\ (E) = \sqrt{Var(E)}$$

Where:
E = Total fishing effort
e_i = Daily fishing effort in the ith day
π_i = The probability of the sampling period being included in the sample
S_i^2 = Standard error square of the mean daily fishing effort

Catch Rate and Harvest

$$CR = \frac{\left\{\left(\frac{\sum F_i}{n}\right)\right\}}{\left\{\left(\frac{\sum H_i}{n}\right)\right\}} = \frac{\sum F_i}{\sum H_i}$$

$$Y = P * (CR)$$

Where:

CR = mean catch rate in fish harvested per angler-hour
H_i = number of angler-hours expended by i-th party
F_i = number of fish caught by i-th party
n = number of parties interviewed
P = fishing effort in angler-hours
Y = harvest in number for particular species

$$S_{CR^2} = CR^2 * [\left(\frac{S_{F^2}}{F^2}\right) + \left(\frac{S_{H^2}}{H^2}\right) - \left(\frac{\{2COV(F * H)\}}{(F * H)}\right)]$$

$$S_{Y^2} = \left(S_{p^2} * CR^2\right) + (S_{CR^2} * P^2)$$

$$S_{F^2} = \left\{\frac{1}{n(n-1)}\right\} * [\sum F_i^2 - \left\{\frac{(\sum F_i)^2}{n}\right\}]$$

$$S_{H^2} = \left\{\frac{1}{n(n-1)}\right\} * [\sum H_i^2 - \left\{\frac{(\sum H_i)^2}{n}\right\}]$$

$$COV\ (F * H) = \left\{\frac{1}{n(n-1)}\right\} * \left\{\sum F_i H_i - \left[\frac{\{\sum F_i * \sum H_i\}}{n}\right]\right\}$$

Where:

S_{CR}^2 = standard error square of the mean catch rate
S_Y^2 = standard error square of estimated harvest
S_F^2 = standard error square of the mean number of fish
S_H^2 = standard error square of mean hours
S_p^2 = standard error square of estimated fishing effort
Cov (F x H) = covariance of fish and hours
F = mean number of fish per party
H = mean number of angler-hours per party

Results and Discussion

Boat fishery

Upper Niagara River angler effort

A total of 754 boats actively engaged in fishing were counted during 45 boat counts on the upper Niagara River (9 counts during the spring season; 24 counts during the summer season; and 12 counts during the fall season). On two occasions we compared the vehicle based boat counts; to a count conducted by running a boat down the river. The difference between the boat and vehicle counts on the first run was two boats (total n = 26), and the difference on the second run was one boat (total n = 5). Based on these results we believe that the vehicle based boat counts were an accurate method that had the added benefits of being much cheaper than aerial counts, and were less likely to be cancelled due to weather or scheduling issues.

The total estimated boat fishing effort on the upper Niagara River was 61,965 angler hours (Table M.1). This is a considerable increase in angler effort from the 1999 survey, which reported 39,350 angler hours (Einhouse et al. 2002), but is similar to the 65,050 angler hours reported by NYPA (2005a) for the 2003 season. The average length of boat trips on the upper river was 3.2 hours and the average number of anglers per boat was 1.93. The summer season contained the bulk of the boat fishing effort, which is not

surprising given that it covered a much larger period of time.

Boat anglers on the upper Niagara River primarily targeted smallmouth bass during all seasons, followed by anglers targeting "anything," muskellunge and walleye (Figure M.3). Anglers in New York and Ontario both targeted similar species (Table M.2).

TABLE M.1. Estimated fishing effort expended in the upper Niagara River during 2016 (SE= standard error).

Season	Total fishing effort (angler hours)	SE
Spring (05/16/16 – 06/17/16)	9,294	3,290
Summer (6/18/16 – 09/05/16)	45,748	6,507
Fall (09/06/16 – 10/16/16)	6,923	1,738
Total (05/16/16 – 10/16/16)	61,965	7,496

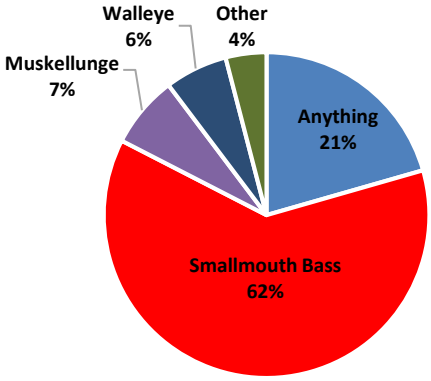


FIGURE M.3. Percent of total fishing effort directed towards each species in the upper Niagara River (NY and Ontario data combined) during 2016

TABLE M.2. Percent of total fishing effort directed towards each species by New York and Ontario anglers in the upper Niagara River during 2016

Species	New York effort
Smallmouth bass	65%
Anything	22%
Muskellunge	5%
Walleye	4%
Other species	5%

Species	Ontario effort
Smallmouth bass	59%
Anything	19%
Muskellunge	10%
Walleye	9%
Other species	3%

Upper Niagara River catch and harvest

Interviews of boat anglers identified 13 species caught and 7 species harvested in the upper Niagara River during 2016.

Boat anglers on the upper Niagara River caught an estimated 25,228 fish and harvested an estimated 3,472 fish for an overall catch and harvest rate of 0.4 fish per hour and 0.06 fish per hour, respectively. The catch was dominated by smallmouth bass, followed by yellow perch, freshwater drum, largemouth bass, walleye and muskellunge (Table M.3).

Anglers targeting smallmouth bass had a catch rate of 0.42 bass per hour for the entire survey. Catch rates were highest in spring and lowest in the fall. Ontario anglers experienced higher bass catch rates than New York anglers during all seasons (Table M.4). The catch rate of smallmouth bass on the upper Niagara River in 2016 was considerably lower than the catch rates of 0.84 fish per hour reported by NYPA (2005a) and 0.8 fish per hour reported by Einhouse et al. (2002). The total estimated catch of smallmouth bass was slightly less than half of the estimate in 2003 (NYPA 2005a), but similar to the number caught in 1999 (Einhouse et al. 2002).

Reasons for the decline in the catch rate of smallmouth bass in the upper Niagara River are unknown. The lack of fishery assessment

information for the upper Niagara River makes it difficult to infer population trends based on this survey alone. There were drought conditions across the region during 2016 and it is possible that the low catch rates experienced this year were due to poor fishing conditions and not related to a decrease in the smallmouth bass population. The catch rate of smallmouth bass in Lake Erie also declined in 2016 (Robinson 2017), which provides some evidence for the decline being related to poor fishing conditions.

Average length of smallmouth bass harvested in the upper Niagara River was 15.7 in (399 mm), which is approximately one inch larger than the average length in 1999 (Einhouse et al. 2002). The largest smallmouth bass identified in the interviews was 20 in (508 mm).

Anglers targeting muskellunge in the upper Niagara River were restricted to fishing only during the summer and fall seasons due to the muskellunge fishing season being closed during the spring portion of the survey. All muskellunge catches reported in the interviews occurred during the summer season. Muskellunge anglers were interviewed during the fall season but no catches were reported.

Muskellunge anglers had an overall catch rate of 0.07 fish per hour for the entire survey period. During the summer season New York anglers had a catch rate of 0.19 fish per hour and Ontario anglers had a catch rate of 0.02 fish per hour. The combined summer season catch rate for all muskellunge anglers was 0.11 fish per hour (Table M.5).

Muskellunge catch rates in the upper Niagara River indicate a high quality muskellunge fishery, and are similar to the catch rates of 0.06 and 0.07 fish per hour reported in 1999 and 2003, respectively (Einhouse et al. 2002 and NYPA 2005a). The estimated catch rate in 2016 is also very similar to the catch rate of 0.08 fish per hour reported through an angler diary study done by the Niagara Musky Association in 2016 (Tony Scime, Niagara Musky Association, personal communication).

The sustained high quality muskellunge catch rate in the upper Niagara River is truly remarkable and presents a unique opportunity to experience excellent muskellunge fishing in an urban setting.

TABLE M.3. Total estimated catch and harvest by boat anglers in the upper Niagara River during 2016 (SE=standard error).

Species	Number caught	SE	Number harvested	SE
Smallmouth bass	17,497	2,158	1,058	479
Yellow perch	1,926	234	705	86
Freshwater drum	1,492	181	---	---
Largemouth bass	868	105	---	---
Walleye	352	43	217	30
Muskellunge	272	59	---	---
Other species*	2,577	313	1,492	200
Total	25,228		3,472	

* Other species include bluegill, *Catostomidae spp.* (suckers), common carp, northern pike, pumpkinseed, rock bass, round goby and white bass

TABLE M.4. Catch rates (fish/hr) by anglers targeting smallmouth bass in the upper Niagara River during 2016

Season	New York anglers	Ontario anglers	All anglers
Spring	0.73	1.15	0.92
Summer	0.29	0.39	0.33
Fall	0.19	0.33	0.27
Total	0.36	0.5	0.42

TABLE M.5. Catch rates (fish/hr) by anglers targeting muskellunge in the upper Niagara River during 2016

Season	New York anglers	Ontario anglers	All anglers
Summer	0.19	0.02	0.11
Fall	0.00	0.00	0.00
Total	0.14	0.01	0.07

Lower Niagara River angler effort

We conducted a total of 43 boat counts on the lower Niagara River and counted 242 boats actively engaged in fishing (8 counts during the spring season; 23 counts during the summer season; and 12 counts during the fall season). The average length of boat trips on the lower river was 4.1 hours and the average number of anglers per boat was 2.1.

The total estimated boat fishing effort on the lower Niagara River was 21,963 angler hours (Table M.6). This is a considerable decrease in angler effort from the New York Power Authority survey that was conducted in 2002-2003, which reported 138,154 angler hours (NYPA 2005b). These two surveys are not directly comparable because the NYPA survey covered an entire year (spring 2002 to spring 2003). However, they reported 58,009 angler hours during the summer season alone.

The reason for the dramatic decline in warmwater angler effort on the lower Niagara River is unknown, but could be related to the quality of smallmouth bass fishing. Smallmouth bass anglers had extremely high catch rates (2.46/hr) in the lower Niagara River during 2002 (NYPA 2005b). This time period also corresponds to the highest catch rate of smallmouth bass ever recorded in Lake Ontario (2/hr). The catch rate of smallmouth bass has dramatically declined in Lake Ontario since that time (Lantry and Eckert, 2016). It is possible that the NYPA (2005b) survey occurred during a period of unusually high angler activity on the lower Niagara River that was driven by record high catches of smallmouth bass.

In 2016, boat anglers on the lower Niagara River primarily targeted smallmouth bass, followed by salmonids, “anything” and walleye (Figure M.4). Smallmouth bass were the most targeted species during spring and summer, and salmonids were the most targeted during the fall. New York and Ontario anglers targeted similar species, but New York anglers directed more effort toward salmonids and Ontario anglers directed more effort toward “other species” (Table M.7).

TABLE M.6. Estimated fishing effort expended in the lower Niagara River during 2016 (SE=standard error).

Season	**Total fishing effort (angler hours)**	**SE**
Spring (05/16/16 – 06/17/16)	3,840	1,654
Summer (6/18/16 – 09/05/16)	7,019	1,422
Fall (09/06/16 – 10/16/16)	11,104	2,791
Total (05/16/16 – 10/16/16)	21,963	3,542

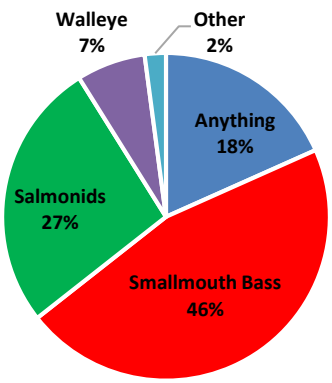


FIGURE M.4. Percent of total fishing effort directed towards each species in the lower Niagara River during 2016

TABLE M.7. Percent of total fishing effort directed towards each species by New York and Ontario anglers in the lower Niagara River during 2016

Species	New York effort
Smallmouth bass	45%
Salmonids	30%
Anything	18%
Walleye	7%
Other species	1%

Species	Ontario effort
Smallmouth bass	56%
Anything	15%
Salmonids	11%
Walleye	7%
Other species	11%

* Other species include muskellunge, longnose gar, and yellow perch

Lower Niagara River catch and harvest

Interviews of boat anglers identified 18 species caught and 10 species harvested in the lower Niagara River during 2016.

Boat anglers on the lower Niagara River caught an estimated 15,170 fish and harvested an estimated 3,315 fish for an overall catch and harvest rate of 0.69 fish per hour and 0.15 fish per hour, respectively. The catch was dominated by smallmouth bass, followed by yellow perch, Chinook salmon, white bass, freshwater drum, walleye, steelhead and lake trout (Table M.8).

Anglers targeting smallmouth bass had a catch rate of 0.59 bass per hour for the entire survey. Catch rates were highest in summer and lowest in the spring. New York anglers had higher bass catch rates than Ontario anglers during all seasons (Table M.9). The targeted catch rates for bass anglers in the lower Niagara River were higher than in the upper river. However, the overall catch rate was still lower than the catch rate of 0.8 fish per hour reported in 1999 for the upper river (Einhouse et al. 2002) and is dramatically lower than the catch rate of 2.46 fish per hour reported for the lower river in 2003 (NYPA 2005b).

Smallmouth bass catch rates in the lower Niagara River appear to have mirrored those in Lake Ontario. Catch rates were at record high levels in Lake Ontario during the late 1990s and early 2000s, with a peak catch rate in 2002. Since then the smallmouth bass catch rate in Lake Ontario has dramatically declined and was 0.49 fish per hour in 2015 (Lantry and Eckert 2016). Reasons for the decline are unknown but may be related to invasive species, Viral Hemorrhagic Septicemia virus (VHSv) and/or environmental changes.

The average length of smallmouth bass harvested from the lower Niagara River was 15 in (381 mm), similar to the length reported for the upper river in 1999 (Einhouse et al. 2002). The largest smallmouth bass reported in the interviews was 18 in (457 mm).

Boat anglers targeting Chinook salmon experienced a catch rate of 0.18 fish per hour during the fall season. This catch rate is driven almost entirely by New York anglers as only one fishing party targeting Chinook salmon was interviewed in Ontario during the fall season. In contrast, 41 parties that targeted Chinook salmon were interviewed in New York. The 2016 catch rate was considerably higher than the 0.04 fish per angler hour and 0.035 fish per angler hour reported for all New York anglers (boat and shore) on the lower Niagara River in 2015 (Prindle and Bishop 2016) and in 2011 (Prindle and Bishop 2012), respectively. The difference in the catch rate in 2016 is likely due to boat anglers having higher catch rates than combined boat and

shore anglers for Chinook salmon in the lower Niagara River.

Catch rates of steelhead and lake trout were generally low, due to the timing of the survey. The steelhead and lake trout fishery occurs mostly within the winter season. This survey ran from spring through fall and, as a result, only covered the very beginning and end of this fishery.

TABLE M.8. Total estimated catch and harvest by boat anglers in the lower Niagara River during 2016 (SE=standard error).

Species	Number caught	SE	Number harvested	SE
Smallmouth bass	6,334	1,027	555	547
Yellow perch	3,377	545	727	117
Chinook	1,454	235	1,393	225
White bass	1,171	189	234	38
Freshwater drum	850	137	12	2
Largemouth bass	382	62	--	--
Walleye	333	54	160	29
Steelhead	148	24	---	---
Lake trout	86	14	---	---
Other species*	986	160	234	43
Total	15,170		3,315	

* Other species include brown trout, channel catfish, *Catostomidae spp.* (suckers), coho salmon, common carp, pumkinseed, rock bass, round goby, and white perch.

TABLE M.9. Catch rates (fish/hr) by anglers targeting smallmouth bass in the lower Niagara River during 2016

Season	New York anglers	Ontario anglers	All anglers
Spring	0.33	---	0.33
Summer	0.75	0.31	0.68
Fall	0.5	0.47	0.48
Total	0.63	0.35	0.59

Shore fishery

Estimating the fishing effort, catch and harvest of the shore fishery on the Niagara River was a secondary component of this survey. Shore anglers were counted and interviewed as they were encountered during the boat fishing survey but there was not a dedicated effort to sample the entire shore fishery. The results presented here should be taken as an observation of a portion of the Niagara River shore fishery and not as an estimate of the entire fishery.

Upper Niagara River

The estimated shore fishing effort at the 12 interview sites on the upper Niagara River was 3,696 angler hours (*SE* = 615) for the entire survey period. The actual shore fishing effort for the upper river is likely much higher. The 12 sites that were used for boat interviews all allow some type of shore fishing. However, they represent only a small fraction of the shore fishing locations available on the upper Niagara River, and do not include many of the most popular locations. In comparison, NYPA (2005a) sampled a large portion of the shore fishery of the upper Niagara River and reported a shore fishing effort estimate of 91,530 angler hours.

Upper Niagara River shore anglers that were interviewed during this survey primarily targeted “anything,” followed by smallmouth bass, walleye and yellow perch.

The total estimated catch and harvest by shore anglers at the 12 interview locations on the upper Niagara River appears in Table M.11.

Lower Niagara River

The estimated shore fishing effort on the lower Niagara River was 10,492 angler hours (*SE* = 1,260) for the entire survey period. The shore fishing effort estimate for the lower river is likely more accurate than that for the upper river. The lower Niagara River has fewer shore fishing access locations than the upper river, and the NYPA fishing platform, one of the most popular shore access sites, was included in the survey. However, there were still many popular shore fishing locations that were not covered, and, as a result, our effort estimate still likely underestimates the total shore fishing effort.

Lower Niagara River shore anglers primarily targeted "anything," followed by smallmouth bass, salmonids, walleye and white bass.

The estimated catch and harvest by shore anglers at four locations on the lower Niagara River appears in Table M.12.

It is difficult to draw meaningful conclusions about trends in the Niagara River fishery when there are long periods of time between surveys. In this case it has been 17 years since the last bi-national angler survey and 11 years since the last survey of New York anglers in the Niagara River. There were large differences in catch rates and angler effort in 2016, compared to the earlier surveys. Many ecological changes have occurred over the last 17 years and without angler or fish population survey data for these years it is virtually impossible to identify potential causes for decreases in angler effort or angling quality.

TABLE M.11. Total estimated catch and harvest by shore anglers at 12 sites on the upper Niagara River during 2016 (SE=standard error).

Species	**Number caught**	**SE**	**Number harvested**	**SE**
Smallmouth bass	557	93	24	4
Yellow perch	4,383	729	1,187	197
Other species*	3,148	2,746	2,349	2,576
Total	8,088		3,560	

* Other species include *Catostomidae spp.* (suckers), channel catfish, freshwater drum, pumpkinseed sunfish, white bass and white perch

TABLE M.12. Total estimated catch and harvest by shore anglers at 4 sites on the lower Niagara River during 2016

Species	**Number caught**	**SE**	**Number harvested**	**SE**
Smallmouth Bass	2,081	362	779	584
Yellow Perch	413	50	365	43
Chinook	268	32	207	26
White Bass	1,461	182	1265	156
Steelhead	122	21	37	4
Lake Trout	85	10	12	2
Other species*	1,789	288	742	119
Total	6,220		3,407	

* Other species include brown trout, common carp, channel catfish, gizzard shad, rock bass, round goby, freshwater drum, *Catostomidae spp.* (suckers), white perch and walleye

References

Craig, R. E. 1976. The Niagara River Smallmouth Bass (*Micropterus dolomieui*) 1973-74. Ontario Ministry of Natural Resources.

Einhouse, D. W., J. Haws, J. Knight, L. Sztramko and M. W. Wilkinson. 2002. 1999 Angler Survey of the Upper Niagara River. Federal aid in sportfish restoration, job completion report, Job 120: Upper Niagara River Creel Survey Grant Number: F-48-R.

Lewis, R. W. and P. E. Dimond. 1982. Selected creel census in Niagara south – Niagara District. Ontario Ministry of Natural Resources, summer, 1980.

Lantry, J.L. and T.H. Eckert. 2016. 2015 Lake Ontario Fishing Boat Census. Section 2 *in* 2015 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

New York Power Authority. 2005a. A recreational fishing survey of the upper Niagara River. New York Power Authority.

New York Power Authority. 2005b. A recreational fishing survey of the lower Niagara River in 2002 and 2003. New York Power Authority.

NYSDEC. 1989. 1984 New York State Great Lakes Angler Survey. New York State Department of Environmental Conservation, Bureau of Fisheries Report.

Pollock, K. H., C. M. Jones, and T. L. Brown. 1994. Angler survey methods and their application in fisheries management. Special Publication 25, American Fisheries Society, Bethesda, Maryland.

Prindle, S. E. and D. L. Bishop. 2012. Fall 2011 Lake Ontario Tributary Angler Survey. Section 11 *in* 2011 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Prindle, S. E. and D. L. Bishop. 2016. Fall 2015 Lake Ontario Tributary Angler Survey. Section 14 *in* 2015 NYSDEC Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commission's Lake Ontario Committee.

Robinson, J. M. 2017. Open lake sport fishing survey. Section L *in* NYSDEC 2016 Lake Erie Annual Report to the Lake Erie Committee and the Great Lakes Fishery Commission.

APPENDIX I

Common and scientific names of fish potentially mentioned in text, tables, and/or figures.

Common Name	Scientific name
Alewife	*Alosa pseudoharengus*
Banded Killifish	*Fundulus diapphanus*
Blacknose Shiner	*Notropis heterolepis*
Bluntnose Minnow	*Pimephalesnotatus*
Bridle Shiner	*Notropis bifrenatus*
Brook Silverside	*Labidesthes sicculus*
Brown Trout	*Salmo trutta*
Bullheads	*Ictaluridae spp.*
Burbot	*Lota lota*
Common Carp	*Cyprinus carpio*
Channel Cat	*Ictalurus punctatus*
Chinook Salmon	*Oncorhynchus tshawytscha*
Coho Salmon	*Oncorhynchus kisutch*
Darter spp.	*Percidae spp.*
Emerald Shiner	*Notropis atherinoides*
Freshwater Drum	*Aplodinotus grunniens*
Gizzard Shad	*Dorosoma cepedianum*
Goldfish	*Carassius auratus*
Lake Sturgeon	*Acipenser fulvescens*
Lake Trout	*Salvelinus namaycush*
Lake Whitefish	*Coregonus clupeaformis*
Largemouth Bass	*Micropterus salmoides*
Muskellunge	*Esox masquinongy*
Northern Hog Sucker	*Hypentelium nigricans*
Northern Pike	*Esox lucius*
Quillback	*Carpiodes cyprinus*
Rainbow Smelt	*Osmerus mordax*
Rainbow Trout/Steelhead	*Oncorhynchus mykiss*
Redhorse Sucker spp.	*Moxostoma spp.*
Rock Bass	*Ambloplites rupestris*
Round Goby	*Neogobius melanostomus*
Sand Shiner	*Notropis stramineus*
Sea Lamprey	*Petromyzon marinus*
Smallmouth Bass	*Micropterus dolomieui*
Spottail Shiner	*Notropis hudsonius*
Sticklebacks	*Gasterosteidae spp.*
Stonecat	*Noturus flavus*
Trout-perch	*Percopsis omiscomaycus*
Walleye	*Sander vitreus*
White Bass	*Morone chrysops*
White Perch	*Morone americana*
White Sucker	*Catastomus commersoni*
Yellow Perch	*Perca flavescens*