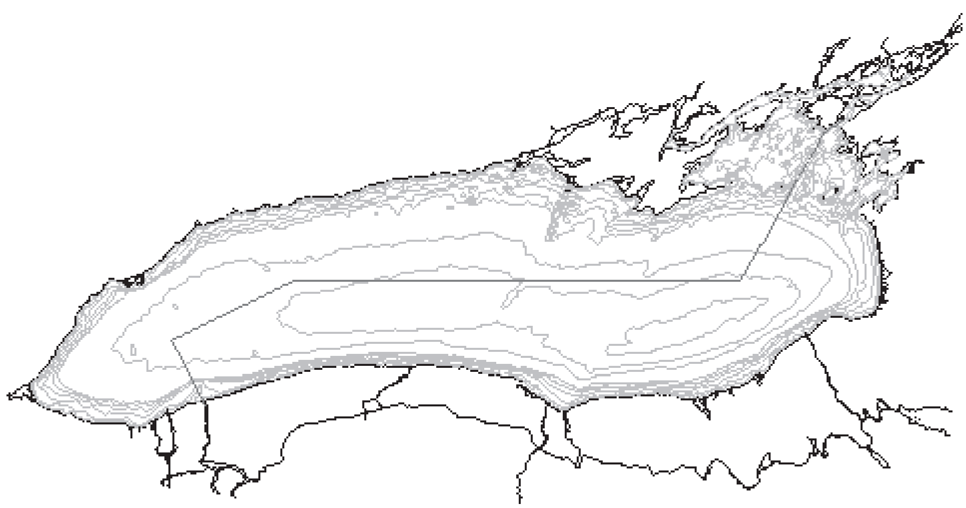
Department of Environmental Conservation

2021 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 State Department of Environmental Conservation
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THE FOLLOWING STUDIES REPORTED IN THIS DOCUMENT ARE SUPPORTED IN WHOLE OR IN PART BY THE FEDERAL AID IN SPORT FISH RESTORATION PROGRAM

SECTIONS 1, 2, 3, 4, 5, 8, 9, 10, 12, 13 and 15

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

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2	**2021 Lake Ontario Fishing Boat Survey** *(Connerton)*	NYSDEC
3	**The Relative Survival of Stocked Fall Fingerling vs Spring Yearling Coho Salmon and the Proportions of Wild and Hatchery Coho Salmon in Lake Ontario** *(Connerton, Prindle, Moore, Lake, Yuille)*	NYSDEC OMNRF
4	**Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1993-2021** *(Goretzke)*	NYSDEC
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New York Lake Ontario and Upper St. Lawrence River Stocking Program 2021

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The New York stocking report is prepared annually to summarize information on fish stocked in the most recent calendar year. This report includes all fish stocked into New York waters of Lake Ontario and its tributaries, and the St. Lawrence River upstream of Alexandria Bay. Fish stocked into tributaries of Lake Ontario which are not expected to contribute to the Lake Ontario open water or associated tributary fisheries (e.g., brook trout, domestic rainbow trout, and brown trout stocked above barriers or in headwaters) are not reported here. Additional information on fish stocked in all New York waters can be found on the Internet at: www.dec.ny.gov/outdoor/7739.html

The report consists of three tables, and a description of stocking terminology and abbreviations. Table 1 provides totals for fish stocked in 2021 by species, strain, and life stage, and compares those totals with the 2021 New York Department of Environmental Conservation (NYSDEC) stocking policy. Table 2 provides totals by species and life stage, summarizing the New York stocking history from 1991-2021. New York stocking history from 1968-1990 is reported in Eckert (2000). Table 3 provides specific information for each group of fish stocked in 2021. If needed, more detailed information on fish stocked can be obtained from the agencies and/or hatcheries which conducted the work.

TERMINOLOGY AND ABBREVIATIONS

Species: Names follow those in the American Fisheries Society's seventh edition of *Common and Scientific Names of Fishes from the United States, Canada, and Mexico* (Page et al. 2013).

Location and **GD/KY** (Grid/Key): Location information for fish stocked in New York waters. Fish stocked in tributaries of Lake Ontario are designated using the name of the water in the location column, and the official NY stream key in the GD/KY column (key = capital O, period, 2 or 3 digit number, plus in some cases, a dash followed by a pond/embayment designation and one or more tributary numbers). Stream keys which are too long to fit within the GD/KY column are completed in the Remarks column. More specific information about stream stocking sites is not included in Table 3 but is part of the NYSDEC stocking database. Fish stocked directly into Lake Ontario, Lower Niagara and the St. Lawrence Rivers are designated using a shore area description in the location column, and a 3-digit grid number in the GD/KY column (standard grids based primarily on 10-minute blocks of longitude and latitude).

Htch (Hatchery): Last hatchery at which the fish were raised for a significant period of time. Hatcheries in Table 3 are designated using the abbreviations shown below.

Abbreviations for NYSDEC hatcheries:

AD	Adirondack
BA	Bath
CA	Catskill
CD	Caledonia
CQ	Chautauqua
CH	Chateaugay
CS	Cedar Springs
ON	Oneida
RA	Randolph
RM	Rome
SR	Salmon River
SO	South Otselic
VH	Van Hornesville

Abbreviations for other county, state or federal hatcheries, and sportsmen clubs:

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

U.S. Fish and Wildlife Service Hatcheries:

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

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

YCL (Year-class): Year-class of the fish stocked. Year-class is defined as the first year spawned for a group of fish, or the first year in which they grew significantly. For spring or summer spawning fish, year-class and year spawned will be the same. For fall spawning fish, year-class will be one year later than the year spawned (e.g., Coho Salmon from eggs spawned in October 2015 are 2016 year-class).

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

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

HPW (Huron Parry Sound Wild): "Lean"-type lake trout strain originated from a remnant population on the Canadian side of Georgian Bay in Lake Huron. A captive HPW broodstock is maintained at SC and is the source of eggs for HPW reared at AL for stocking into Lake Ontario. Fall fingerling HPW were stocked in 2014 and 2015 by AL. HPW yearlings were stocked in 2015-2021 by AL.

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

LCH (Lake Champlain strain): Lake trout descended from a feral population in Lake Champlain. The broodstock (Lake Champlain Domestic; LCH-D) is maintained at the Vermont State Salisbury Fish Hatchery and is supplemented with eggs collected from feral Lake Champlain fish. Broodstock eggs were supplied to WR for rearing of the 2008-2010 year-classes stocked into Lake Ontario as spring yearlings in 2009-2011, and as fall fingerlings in October 2010 (2010 year-class). A portion of the 2009 year-class was reared at WR from eggs taken directly from feral Lake Champlain fish (Lake Champlain Wild; LCH-W). In 2011, flooding from Hurricane Irene inundated WR, severely damaging the hatchery and potentially contaminating the raceways with *Dydimo*, an invasive alga. USFWS determined that lake trout slated to be stocked in 2012 (2011 year-class) could not be stocked without posing a risk of spreading *Dydimo* to other waters so these fish were destroyed. Production at AL resumed in 2011, and the hatchery produced surplus fall fingerling LCH-D lake trout (2012 year-class; eggs from Salisbury Fish Culture Station, VT) which were stocked in October 2012. LCH-D yearlings were reared and stocked by AL in 2013 and 2021, and by EI in 2013-2020. LCH-D fall fingerlings were stocked by EI in 2015. This strain has been abbreviated as FL-HYB and LC in the NYSDEC stocking database; LCD and SLWVT in the USFWS stocking database; and as LCH and SNVT in the NYSDEC Lake Ontario Unit annual reports.

LM (Lake Michigan): Wild, self-sustaining population of bloater from Lake Michigan. In each year from 2012-2017, eggs were collected from wild fish in Lake Michigan near Dorr County, WI or Milwaukee, WI and were incubated and reared at TUN and stocked into Lake Ontario as FF from 2012-2017. Beginning in 2012, wild eggs were also shipped to OMNRF White Lake Fish Culture Station (WLFCS) to produce fish for stocking in Canadian waters. Some portion of those fish were also held to develop captive broodstock because obtaining wild caught bloater eggs during winter required considerable effort, making it difficult to achieve annual stocking targets. In 2018, TUN received eyed eggs from WLFCS broodstock and produced FF Bloater for stocking in 2018 and then retained a portion for stocking as yearlings in spring, 2019. In 2019-2020, TUN received eyed eggs from WLFCS broodstock and produced yearlings stocked in 2020-2021. In 2020, TUN also received a small number of eggs from LM wild caught Bloater and produced yearlings stocked in 2021. AL received Bloater fingerlings in December 2016 from TUN for experimental rearing, and they stocked these fish in spring 2018 as age-2 adults, retaining 85 Bloater. AL received eggs directly from WLFCS broodstock in 2018-2020 and stocked these year-classes as yearlings in 2019-2021. LAM also stocked yearlings in 2021 produced from eggs from WLFCS broodstock in 2020.

LO (Lake Ontario): Wild, self-sustaining populations from Lake Ontario used to describe both cisco and walleye strains. Cisco eggs were collected in Chaumont Bay, Jefferson County and reared at TUN from 2011-2020, and at LAM in 2019-2020. Walleye eggs were collected from adults netted in Mud Bay, Jefferson County, NY and incubated and reared at the NYSDEC Cape Vincent Fisheries Station in partnership with the Lake Ontario Fisheries Coalition and the Village of Cape Vincent from 2005-2008. From 2009-present, however no walleye production occurred.

MEP (Lake Mephromagog): A naturalized freshwater strain of landlocked Atlantic salmon originally derived from the West Grand Lake, ME strain, an outlet spawner. Fry stocked by State University of New York College of Environmental Science and Forestry in 2014 were produced from a captive broodstock held at BH. In 2019, MEP were stocked at Oak Orchard Creek by AD (eggs from BH) to make up for shortfall of NSB.

NSB- (New York Sebago): Landlocked SEB strain of Atlantic salmon maintained in Little Clear Lake and at AD hatchery as broodstock. Beginning in 2007, Adirondack Hatchery began to transition both feral LC (held in the lake) and broodstock LC to Sebago strain only (see SEB below). That transition was complete with the 2015 egg collection (2016 year-class), which were stocked in Lake Ontario in 2017-2021 as yearlings. New York Sebago were derived from SEB eggs taken from Casco Hatchery in Maine.

ONL (Oneida Lake): Wild, self-sustaining, population of walleye from Oneida Lake, NY.

RA (Randolph): A fall spawning strain of domestic rainbow trout maintained at the NYSDEC Randolph Hatchery.

RL (Rome Lab): Domesticated, furunculosis resistant, strain of brown trout originated and maintained at the NYSDEC Rome Hatchery with production broodstocks at Randolph and Catskill Hatcheries.

SAL (Salmon River): Lake Ontario populations of coho salmon and Chinook salmon which return to Salmon River to spawn. These populations were originally derived from eggs obtained mainly from Lake Michigan sources through 1983 for coho salmon, and through 1986 for Chinook salmon. The spawning runs consist of feral fish from Salmon River Hatchery stockings but may contain some strays from Ontario hatcheries or wild fish. The state of Michigan originally obtained its Chinook eggs mainly from the Green River, WA (Weeder 1997) and its coho eggs initially from the Cascade River, Oregon and Toutle River, WA, and later from the Platte River, WA (Keller et al. 1990).

SEB (Sebago): Landlocked strain of Atlantic salmon derived from Maine. SEB were stocked in 2011-2015 by TUN from eggs originating from Ed Weed Fish Culture Station, VT (2011-2015), Casco Fish Hatchery, ME (2013), Bald Hill Fish Culture Station (2015) and from NYSDEC Adirondack Hatchery (2014-2021). In 2015, TUN stocked fry from BH, fall fingerlings from AD, and yearlings from EW. In 2016, TUN stocked fall fingerling and yearling SEB from AD and BH sources. In 2017-2021 TUN stocked fall fingerlings and yearlings from AD. All SEB stocked by TUN from AD (2014-2021) were eggs taken from SEB broodstock held at AD. Note that AD transitioned from LC to SEB strain, and this was completed in 2015 (2016 year-class). AD designated these SEB as New York Sebago (NSB) and were stocked as yearlings in 2017-2021.

SEN (Seneca Lake strain): Lake trout descended from a native population that coexisted with sea lamprey in Seneca Lake, NY. Until 2005, a captive broodstock was maintained at the U.S. Fish and Wildlife Service (USFWS) Allegheny Hatchery (AL), which began rearing lake trout for stocking in Lakes Erie and Ontario beginning with the 1978 year-class. Through 1997, eggs were collected from fish in Seneca Lake and used to supplement broodstocks held at the AL and the SC. Beginning in 1998, SEN strain broodstock was supplemented using eggs collected from both Seneca and Cayuga Lakes. Since 2003, eggs were collected exclusively from Cayuga Lake. After the 2005 stocking of the 2004 year-class, an outbreak of Infectious Pancreatic Necrosis (IPN) required that all fish be destroyed, and AL was closed for disinfection and renovation. The 2005 year-class originated from eggs collected from Cayuga Lake and fish were reared at the NYSDEC Bath Fish Hatchery. The 2006 year-class originated from both the NYSDEC Bath Hatchery egg take in Cayuga Lake and broodstock held at SC, and these fish were raised at WR and EI hatcheries. Concerns over potential viral hemorrhagic septicemia virus introduction to WR prevented transfer of eggs from Cayuga Lake to WR following the fall 2005 egg take. SC provided eggs for the 2007 and 2008 year-classes stocked in 2008 (reared at WR and EI) and 2009 (reared at WR only). The 2009 year-class originated from the fall 2008 Cayuga Lake egg take and was reared at the BA hatchery. Production of SEN strain at AL resumed with the 2012 year-class, and AL stocked yearlings in 2013-2021 and fall fingerlings in 2015. This strain has been abbreviated as FL and FLW in the NYSDEC stocking database; SLW in the USFWS stocking database; and as SEN and SLW in the

NYSDEC Lake Ontario Unit annual reports.

SKA (Skamania): Summer run, anadromous strain of rainbow (steelhead) trout derived from eggs imported from Lake Michigan to New York. Feral Lake Ontario broodstock maintained since 1996 by collection of eggs from spawning runs of fin-clipped adults at SRH. This strain was discontinued at SRH after stocking in 2021.

SKW (Klondike Reef): This strain originated from a native, deep spawning "humper" morphotype of Lake Superior lake trout that are intermediate in fat content to lean and fat (Siscowet) morphotypes. Eggs for the 2008 year-class raised at WR were obtained from the broodstock held at SC. Disease concerns prevented transfer of eggs from SC to WR in fall 2008 (2009 year-class). Stocking of SKW resumed in 2014 with fall fingerlings produced at AL (eggs from broodstock at IR). Stocking of SKW by AL also occurred in 2015 as fall fingerlings and in 2015-2020 as yearlings. In 2017, 304 SKW broodstock adults were available from BK and stocked in December. This strain has been referred to as Klondike in the NYSDEC stocking database, and abbreviated SKW in the USFWS stocking database and in the NYSDEC Lake Ontario Unit annual reports.

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

SR- Atlantic salmon collected from Salmon River, NY during summer or fall in 2016-2020. Adults were collected from the river and held until spawning at TUN. These adults were presumably a mix of LC, SEB, and NSB strains, resulting from either natural reproduction or from feral fish stocked by TUN or AD at an earlier life stage.

SUP (Lake Superior strains): Captive lake trout broodstock initially developed at the USFWS Marquette Hatchery and derived from "lean" Lake Superior lake trout. Broodstock for the Lake Ontario stockings of the Marquette strain was maintained at AL until 2005. After the 2005 stocking of the 2004 year-class, an outbreak of Infectious Pancreatic Necrosis (IPN) at AL required that all fish, including broodstock, be destroyed and the hatchery was closed for disinfection and renovation. The Superior – Marquette strain was no longer available for Lake Ontario stockings. Lake Ontario stockings of "lean" strains of Superior lake trout resumed in 2007 with Traverse Island strain fish (SUP-STW; 2006-2008 year-classes) and Apostle Island strain fish (SUP-SAW; 2008 year-class). The SUP-STW broodstock was phased out of production at IR and is no longer available as a source of eggs for future Great Lakes stockings. The Apostle Island strain broodstock was maintained at IR until after the fall 2011 egg take when production ceased. Disease concerns prevented transfer of eggs from IR to WR in fall 2008. These strains have been referred to as Trav Isl and Apostle Isl in the NYSDEC stocking database; and abbreviated as SAW, and STW in the USFWS stocking database; and as SUP, STW and SAW in the NYSDEC Lake Ontario Unit reports.

WAS (Washington): Winter run, anadromous, strain of rainbow (steelhead) trout derived from eggs imported from Washington State (Chambers Crk. strain) to New York through 1980. Feral Lake Ontario broodstock was maintained through collection of eggs from spawning runs of fin-clipped adults at Salmon River from 1981-2006. Spawning of only fin-clipped Washington strain was discontinued in 2007 and since then, both clipped and unclipped steelhead are spawned, but adipose clipping and selection of fin-clipped Skamania strain was continued to maintain separate steelhead strains.

W (Wild): Broodstock which spends a significant amount of time and achieves most growth in a lake or river, including both fish from natural reproduction as well as feral fish stocked at an earlier life stage. Adult fish may be held in captivity for several weeks or months until eggs are ready to be stripped.

D (Domestic): A captive broodstock which reaches maturity in a hatchery, regardless of the source of the eggs from which were derived.

Mos (Months): Age of the fish to the nearest half month from the time the fish initiated feeding to the time they were stocked.

Stage: Life stage at which the fish was stocked, based on the convention that the birth date of fish from any particular year-class is assumed to be January 1. Fingerlings (fing) are fish in their first year of life (age 0 or young-of-year), and year stocked will equal year-class. The terms fry, spring fingerlings (SF, stocked prior to mid-June), advanced fingerlings (AF, stocked between mid-June and September), and fall fingerlings (FF, stocked between September and December), are simply additional designations for portions of the fingerling life stage. The term pond fingerling (PF) is used for fingerling walleye reared outside in ponds, usually without any supplemental food. The term 50-day fingerling (FDF) is used for pond fingerlings held for at least 50 days. Yearlings (Ylg) are fish in their second year of life (age 1), and year stocked will be one more than year-class. Yearling fish are most often stocked in the spring, and the term spring yearling is applied to such fish. The term adult (Ad) is applied to fish stocked in their third or later year of life (age 2 or more), even though these fish have often not reached sexual maturity.

Wt (g) [Weight]: Average weight of the fish in grams. For pen reared fish, refers to their size at the time they were released from their rearing pen.

Mark: Fin clips, tags, or other identifying marks applied to all members of a group before stocking. If more than one mark is applied (i.e. two clips or a clip plus a tag), all will be listed. Standard abbreviations for the various marks and tags are listed below. Tag colors, and numbers or codes, are included under "Remarks" in Table 3. Some marks or tags are not visible without specialized equipment including:

ALZ	alizarin chemical mark
ACC	acoustic tag
CAL	calcein chemical mark
CWT	coded wire tag
DOTC	double oxytetracycline mark on two different dates
OTC	oxytetracycline – 6-hour immersion
PIT	passive integrated transponder tag

Visible marks and tags include:

AD	adipose fin clip
FLOY	plastic external tag with number and contact data
JAW	jaw tag
LV	left ventral fin clip
LP	left pectoral fin clip
RV	Right ventral fin clip
RP	Right pectoral fin clip
SCU	Scute clip (sturgeon)
VIE	visible implant elastomer

Number (stocked): Number of fish stocked at the particular site.

Remarks: Significant comments and additional information relating to the rearing, marking, or stocking of the fish. If left blank, it can be assumed that the group of fish was released in a direct shore-line or stream-side stocking during daylight hours, without incident or undue mortality. Further descriptions for some of the comments listed in Table 3 are given below.

Barge: Fish transferred to a barge, ship, or other watercraft, and transported some distance offshore before being released (LCM=military landing craft).

Boat Stocked: Fish transferred to a smaller boat or watercraft and stocked nearshore.

CWT (2- or 6-digit number): Number for the coded wire tag used with each lot of Chinook salmon (2- or 6-digit), lake trout or rainbow trout (both 6-digit).

Pen Reared (date, size): Fish held and reared in a pen for a period, usually one to four weeks. The date the fish were placed in their pen, and their average size at that time, are shown in the Comments.

PMP release pond: Outdoor raceway at Powder Mill Park Hatchery (owned by Monroe County) which drains directly into a tributary of Irondequoit Creek. This hatchery raised WAS strain steelhead/rainbow trout until 2005, when concerns about spreading viral hemorrhagic septicemia (VHS) prevented transfer of WAS strain from Salmon River Hatchery. Since then, Bath Hatchery supplied PMP with rainbow trout from a wild Finger Lakes strain (in 2007, 2009, and 2011, 2012-2017, 2019-21), or a Randolph (RA) domestic/wild Finger Lakes hybrid (in 2008 and 2010).

Smolt Release Pond (date): Fish released through the smolt release pond at the NYSDEC Salmon River Hatchery. Up until 2016, only coho salmon were stocked using this method. In fall 2017 and 2018, and March 2019 Atlantic salmon from TUN were experimentally marked and stocked into the smolt release pond. The fish were transferred to the pond in the fall, and regularly monitored and fed. Downstream gates on the pond were removed, allowing the fish to voluntarily migrate into Beaverdam Brook at any time. The use of the smolt release pond was discontinued in 2019. Coho salmon are now held in outdoor ponds at SRH from fall until they are released as yearlings in spring.

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Table 1. Summary of stocking in New York waters of Lake Ontario, the lower Niagara River, and the upper St. Lawrence River during 2021, and comparisons with the NYSDEC 2021 stocking policy.

Species	Stage		Strain	DEC Stocking Policy	Actual Number Stocked
Atlantic Salmon Total	Ylg	1	NSB	140,000	124,469
Bloater Total	Ylg	2	LM	-	313,221
Brown Trout Total	Ylg	3	RL-D	480,001	489,487
Chinook Salmon	SF		SAL-W	845,568	860,560
Coho Salmon Total	Ylg	4	SAL-W	135,000	150,953
Lake Sturgeon Total	FF		SLR	-	2,000
Lake Trout	Ylg	5,6	HPW	160,000	99,900
	Ylg	6	LCH-D	80,000	80,200
	Ylg	6	SEN-W	80,000	80.,600
Lake Trout Total		5,6		320,000	260,700
Rainbow Trout	Ylg		FL-W	7,500	7,300
	Ylg		SKA-W	43,000	51,700
	Ylg		WAS-W	497,700	510,559
	fry	7	WAS-W	-	89,687
Rainbow Trout Total (including fry)					659,246
Rainbow Trout Yearling Total		2		548,200	569,559
Walleye	PF		ONL-W	59,200	59,600
Salmon and Trout Total (excluding fry)				2,468,769	2,455,728
Salmon and Trout Total (including fry)					2,545,415
All Species Total				2,527,969	2,920,236

Notes: See Table 3 for details.

1 Atlantic salmon stocking policy was changed in 2021 to add stocking sites at South Sandy Creek and Sandy Creek (Monroe County), and to increase stocking at Salmon River.
2 US Fish and Wildlife Service and US Geological Survey stocked bloater for restoration project.
3 Barge stocking of brown trout occurred at Stony Point, Oswego, and Fairhaven. Water level was too low for the barge to load at launch near Selkirk, so these fish were shore stocked.
4 Coho salmon stocking policy was changed in 2021 to discontinue fall fingerling stocking and convert to stocking only yearlings based on the results of a study showing higher relative survival by yearlings in Lake Ontario. Currently, the capacity of Salmon River Hatchery is limited to producing 135,000 coho salmon yearlings.
5 Lower than normal survival at AL in 2020 led to 2021 stocking shortfall.
6 Barge stocking of lake trout occurred at Stony Point, Oswego, Oak Orchard, Sodus and Olcott.
7 surplus stocking

Table 2. Approximate numbers (1000s) of trout, salmon, and other species stocked in New York waters of Lake Ontario, the lower Niagara River, and the upper St. Lawrence River from 1991 to 2021. Numbers stocked from 1968-1990 can be found in Eckert (2000).

Species & Stage	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
AS Ad	0	0	0	0	2	2	1	4	6	1	0	0	0	1	0
AS AF	0	0	0	0	0	0	0	0	0	0	0	12	2	5	0
AS FF	0	0	30	38	34	34	25	25	25	25	25	0	0	0	0
AS f	0	0	0	0	0	171	56	0	0	65	49	2	28	0	0
AS SF	0	0	0	0	60	0	17	0	156	20	13	4	3	0	0
AS Ylg	178	169	135	151	130	97	77	73	84	78	75	75	50	51	50
BT Ad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BT AF	0	0	0	0	0	0	0	0	0	0	114	0	0	0	10
BT FF	0	0	0	0	0	0	0	0	25	0	0	136	39	0	66
BT SF	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0
BT Ylg	382	415	445	402	382	361	426	426	429	421	405	382	414	367	391
Ck SF	2835	2798	1603	1000	1150	1300	1605	1596	1596	1654	1629	1633	1622	1836	1809
Co FF	132	155	100	223	172	196	155	155	137	155	155	155	155	155	155
Co SF	0	290	0	0	0	0	0	0	0	0	0	4	7	0	0
Co Ylg	97	94	96	92	119	98	95	90	90	99	101	105	95	95	99
LT Ad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LT FF	160	0	0	5	0	0	0	0	0	0	0	0	0	0	0
LT Ylg	818	508	501	507	500	350	500	426	476	490	500	500	500	457	224
ST f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RT AF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RT FF	29	0	0	0	0	0	0	14	0	0	20	10	0	0	0
RT SF	82	0	0	0	0	0	0	0	0	0	0	14	40	0	0
RT Ylg	40	85	278	164	46	106	93	92	97	75	60	71	75	64	75
ST f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sthd FF	0	0	0	0	50	60	110	0	107	0	0	15	0	0	0
Sthd f	175	0	0	0	0	0	0	0	0	0	0	1	6	0	0
Sthd Ylg	551	515	264	415	513	507	555	528	521	533	583	535	560	558	570
Bloater Ad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bloater FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bloater Ylg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cisco AF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cisco FF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cisco SF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stur AF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stur FF	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Stur Ylg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wal AF	121	51	202	100	97	0	0	0	0	0	0	10	211	30	0
Wal FDF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wal FF	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Wal f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wal PF	0	1	0	0	0	0	0	0	0	0	0	0	0	41	104
Wal SF	0	0	0	0	7	264	250	194	155	129	10	0	0	0	0
Sal Subtotal	5478	5029	3453	2996	3158	3282	3715	3430	3874	3615	3729	3655	3594	3619	3450
TOTAL	5600	5081	3655	3095	3262	3546	3964	3623	4029	3745	3739	3665	3807	3691	3555

Abbreviations:

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

Table 2. Approximate numbers (1000s) of trout, salmon, and other species stocked in New York waters of Lake Ontario, the lower Niagara River, and the upper St. Lawrence River from 1991 to 2021. Numbers stocked from 1968-1990 can be found in Eckert (2000).

Species & Stage	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
AS Ad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS AF	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0
AS FF	0	0	0	24	37	66	73	61	71	74	74	51	73	89	48	0
AS f	0	0	0	0	0	0	0	0	6	8	0	0	0	0	0	0
AS SF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AS Ylg	29	52	49	50	50	50	60	67	65	70	82	77	126	30	81	125
ST SF	0	0	0	54	0	0	0	0	0	0	0	0	0	0	0	0
BT Ad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
BT AF	0	0	50	6	116	0	0	0	41	0	0	0	0	36	0	0
BT FF	0	0	0	70	57	6	0	0	27	0	31	0	0	8	0	0
BT SF	0	0	0	46	0	0	0	0	0	0	0	0	0	0	0	0
BT Ylg	376	385	370	418	409	424	419	331	397	449	464	412	434	484	609	490
Ck SF	1827	1813	799	1757	1531	1769	1511	1772	1970	1762	1883	1350	1287	1018	907	861
Co FF	155	155	104	155	155	155	0	155	0	141	158	139	73	170	114	0
Co SF	0	0	0	0	0	0	0	0	0	0	59	0	0	0	52	0
Co Ylg	110	90	124	95	114	141	120	69	130	90	99	93	85	85	92	151
LT Ad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LT FF	0	0	0	0	122	0	123	0	528	455	0	0	0	0	0	0
LT Ylg	118	453	501	511	332	488	0	523	443	521	384	201	398	401	302	261
RT AF	0	0	0	0	0	30	0	0	0	0	0	0	0	0	0	0
RT FF	0	0	0	15	0	27	0	0	0	0	0	0	0	0	0	0
RT SF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RT Ylg	72	68	74	78	80	82	82	83	42	76	82	79	49	83	7	7
ST f	0	0	0	54	0	0	0	0	0	0	0	0	0	0	0	0
Sthd FF	0	0	0	80	188	0	337	0	0	149	0	0	0	0	0	0
Sthd f	0	0	0	0	0	0	0	0	0	0	0	0	0	928	641	89
Sthd Ylg	572	537	570	561	702	615	554	546	521	382	583	578	572	521	580	562
Bloater Ad	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Bloater FF	0	0	0	0	0	0	1	7	20	62	149	94	88	0	0	0
Bloater Ylg	0	0	0	0	0	0	0	0	0	0	0	0	19	21	11	313
Cisco AF	0	0	0	0	0	0	0	0	0	0	0	79	0	0	0	0
Cisco FF	0	0	0	0	0	0	9	9	145	100	22	88	521	248	239	0
Cisco SF	0	0	0	0	0	0	0	0	0	0	0	243	0	0	0	0
Stur AF	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0
Stur FF	0	0	0	0	0	0	0	1	9	9	1	3	3	3	3	2
Stur Ylg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wal AF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wal FDF	0	0	0	0	0	0	0	0	0	0	0	10	39	0	0	0
Wal FF	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Wal f	0	0	0	0	0	30	0	0	40	0	0	0	0	0	0	0
Wal PF	123	29	50	118	12	118	23	149	98	70	68	160	69	112	93	60
Wal SF	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sal subtotal	3259	3553	2641	3920	3892	3853	3293	3606	4239	4177	3900	2979	3098	3852	3435	2545
TOTAL	3382	3582	2696	4037	3904	4002	3327	3773	4551	4417	4140	3655	3837	4244	3781	2920

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

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2021.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Atlantic Salmon	South Sandy Creek	O.45	3/29/21	AD	2020	NSB	13.3	Ylg	47.0	NONE	20,000	
Atlantic Salmon	Sandy Creek	O.130	4/28/21	AD	2020	NSB	14.2	Ylg	48.1	NONE	10,000	
Atlantic Salmon	Salmon River	O.53	5/13/21	AD	2020	NSB	14.7	Ylg	50.0	AD LV	17,290	stocked into pens, pens released without measuring
Atlantic Salmon	Salmon River	O.53	5/17/21	AD	2020	NSB	14.8	Ylg	51.5	LV	17,900	direct stocked
Atlantic Salmon	Salmon River	O.53	4/9/21	TUN	2020	NSB	13.6	Ylg	81.6	AD RV	14,220	Tunison direct stocked April
Atlantic Salmon	Salmon River	O.53	5/26/21	TUN	2020	NSB	15.1	Ylg	75.6	RV	15,059	Tunison direct stocked May
Atlantic Salmon	Sandy Creek	O.130	5/10/21	AD	2020	NSB	14.6	Ylg	55.3	NONE	20,000	Oak Orchard fish stocked at Sandy Creek due to cormorants
Atlantic Salmon	Sandy Creek	O.130	4/26/21	AD	2020	NSB	14.2	Ylg	48.1	NONE	10,000	
Atlantic Salmon	**Total**					**NSB**		**Ylg**	**57.0**		**124,469**	
Bloater	Stony Point	422	5/18/21	AL	2020	LM	12.0	Ylg	10.3	OTC	24,700	Stocked by barge, White Lake Captive broodstock origin
Bloater	Stony Point	422	5/19/21	AL	2020	LM	12.1	Ylg	11.2	OTC	80,000	Stocked by barge, White Lake Captive broodstock origin
Bloater	Stony Point	422	5/19/21	LAM	2020	LM	12.4	Ylg	9.2	OTC	20,566	Stocked by barge, White Lake Captive broodstock origin
Bloater	Oswego	621	5/20/21	TUN	2020	LM	12.8	Ylg	5.0	OTC	8,367	Stocked by barge, Lake Michigan Wild origin
Bloater	Oswego	621	5/21/21	TUN	2020	LM	12.8	Ylg	5.0	OTC	138,283	Stocked by barge, White Lake Captive broodstock origin
Bloater	Oswego	621	5/21/21	LAM	2020	LM	12.8	Ylg	9.5	OTC	20,764	Stocked by barge, White Lake Captive broodstock origin
Bloater	Olcott	708	5/26/21	LAM	2020	LM	13.0	Ylg	9.2	OTC	20,541	Stocked by barge, White Lake Captive broodstock origin
Bloater	**Total**					**LM**		**Ylg**	**7.8**		**313,221**	
Brown Trout	Stony Point	423	5/19/21	SR	2020	RL-D	18.2	Ylg	79.7	NONE	68,834	Barge/LCM
Brown Trout	Stony Point	O.45	5/19/21	RM	2020	RL-D	18.2	Ylg	109.3	NONE	10,000	Barge/LCM. Fish slated for South Sandy Creek
Brown Trout	Selkirk	623	5/10/21	RM	2020	RL-D	17.9	Ylg	95.9	NONE	45,917	Shore stocked at Selkirk
Brown Trout	Selkirk	623	6/2/21	SR	2020	RL-D	18.7	Ylg	79.6	NONE	1,650	Shore stocked at Selkirk
Brown Trout	Oswego	622	5/21/21	SR	2020	RL-D	18.3	Ylg	76.6	NONE	19,700	
Brown Trout	Oswego	622	5/21/21	RM	2020	RL-D	18.3	Ylg	77.5	NONE	15,300	
Brown Trout	Fair Haven	720	5/21/21	RM	2020	RL-D	18.3	Ylg	81.2	NONE	30,996	Barge/LCM off Oswego
Brown Trout	Sodus	O.84-P96	5/13/21	RM	2020	RL-D	18.0	Ylg	90.0	NONE	12,810	
Brown Trout	Sodus	O.84-P96	5/18/21	RM	2020	RL-D	18.2	Ylg	76.6	NONE	12,810	
Brown Trout	Sodus	O.84-P96	6/3/21	SR	2020	RL-D	18.7	Ylg	79.7	NONE	14,250	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2021.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Brown Trout	Pultneyville	818	4/30/21	RM	2020	RL-D	17.6	Ylg	86.6	NONE	13,000	
Brown Trout	Pultneyville	818	5/25/21	RM	2020	RL-D	18.4	Ylg	86.5	NONE	6,220	
Brown Trout	Irondequoit Bay	O.108-P113	5/6/21	RM	2020	RL-D	17.8	Ylg	86.1	NONE	15,000	
Brown Trout	Irondequoit Bay	O.108-P113	5/14/21	RM	2020	RL-D	18.1	Ylg	92.8	NONE	6,620	
Brown Trout	Webster	816	5/7/21	RM	2020	RL-D	17.8	Ylg	95.5	NONE	15,000	
Brown Trout	Webster	816	5/25/21	RM	2020	RL-D	18.4	Ylg	86.4	NONE	6,620	
Brown Trout	Braddocks Bay	815	4/28/21	RM	2020	RL-D	17.5	Ylg	86.9	NONE	16,275	
Brown Trout	Braddocks Bay	815	5/14/21	RM	2020	RL-D	18.1	Ylg	92.8	NONE	5,345	
Brown Trout	Rochester	815	5/12/21	RM	2020	RL-D	18.0	Ylg	92.2	NONE	21,620	
Brown Trout	Hamlin	713	4/27/21	RM	2020	RL-D	17.5	Ylg	81.8	NONE	15,000	Lake rough / Fish stocked in Sandy Creek
Brown Trout	Hamlin	713	5/17/21	RM	2020	RL-D	18.2	Ylg	80.6	NONE	17,550	
Brown Trout	Hamlin	713	6/7/21	RM	2020	RL-D	18.8	Ylg	97.7	NONE	11,380	
Brown Trout	Point Breeze	711	5/3/21	RM	2020	RL-D	17.7	Ylg	80.7	NONE	16,275	
Brown Trout	Point Breeze	711	5/27/21	RM	2020	RL-D	18.5	Ylg	85.1	NONE	16,275	
Brown Trout	Olcott	708	5/10/21	RM	2020	RL-D	17.9	Ylg	95.5	NONE	20,020	
Brown Trout	Wilson	707	4/26/21	RM	2020	RL-D	17.5	Ylg	108.2	NONE	16,020	
Brown Trout	Wilson	707	4/26/21	RM	2020	RL-D	17.5	Ylg	108.3	NONE	4,000	held for 48 hours in pens and released at dusk
Brown Trout	Niagara River	806	4/8/21	RM	2020	RL-D	16.9	Ylg	85.0	NONE	17,500	
Brown Trout	Niagara River	806	4/22/21	RM	2020	RL-D	17.4	Ylg	81.3	NONE	17,500	
Brown Trout	**Total**					**RL-D**		**Ylg**	**86.9**		**489,487**	
Chinook Salmon	Black River Bay	424	5/6/21	SR	2021	SAL-W	3.6	SF	6.1	NONE	50,000	Stocked into pens on 4/13/21 at 140 fish/lb
Chinook Salmon	Oswego River	O.66	5/5/21	SR	2021	SAL-W	3.5	SF	8.0	NONE	111,390	Stocked into pens on 4/13/21 at 127 fish/lb
Chinook Salmon	Salmon River	O.53	6/4/21	SR	2021	SAL-W	4.5	SF	5.9	NONE	300,000	Stocked on 6/2, and 6/4/21
Chinook Salmon	Genesee River	O.117	5/6/21	SR	2021	SAL-W	3.6	SF	4.6	NONE	111,390	No pens in 2021; water too low
Chinook Salmon	Genesee River	O.117	6/3/21	SR	2021	SAL-W	4.5	SF	5.9	NONE	15,000	Surplus
Chinook Salmon	Oak Orchard Creek	O.138	4/27/21	SR	2021	SAL-W	3.3	SF	6.3	NONE	111,390	Stocked into pens 4/5/21 at 132 fish/lb
Chinook Salmon	Eighteenmile Creek	O.148	4/28/21	SR	2021	SAL-W	3.3	SF	6.3	NONE	111,390	Stocked into pens 4/6/21 at 126 fish/lb
Chinook Salmon	Niagara River	O.158	5/17/21	SR	2021	SAL-W	3.9	SF	6.1	NONE	50,000	Stocked into pens 4/14 at 131 fish/lb
Chinook Salmon	**Total**					**SAL-W**		**SF**	**6.1**		**860,560**	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2021.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Coho Salmon	Beaverdam Brook	O.53-8	4/9/21	SR	2020	SAL-W	14.0	Ylg	24.6	NONE	105,953	
Coho Salmon	Oak Orchard Creek	O.138	3/23/21	SR	2020	SAL-W	13.4	Ylg	26.3	NONE	22,500	
Coho Salmon	Eighteenmile Creek	O.148	3/24/21	SR	2020	SAL-W	13.5	Ylg	26.3	NONE	22,500	
Coho Salmon	**Total**					**SAL-W**		**Ylg**	**25.1**		**150,953**	
Lake Sturgeon	Chaumont Bay	324	9/24/21	ON	2021	SLR-W	3.2	FF	15.0	CWT	1,000	Agency 43 & #05-04-87
Lake Sturgeon	Genesee River	O.117	10/6/21	ON	2021	SLR-W	3.5	FF	22.7	CWT-PIT	1,000	Agency 43 & #05-04-87, Back of head, 1st scute
Lake Sturgeon	**Total**					**SLR-W**		**FF**	**18.9**		**2,000**	
Lake Trout	Stony Point	422	5/18/21	AL	2020	HPW	15.8	Ylg	30.9	AD-CWT	28,800	Barge/LCM, CWT#640864
Lake Trout	Stony Point	422	5/18/21	AL	2020	LCH-D	15.6	Ylg	33.9	AD-CWT	39,800	Barge/LCM, CWT#640979
Lake Trout	Oswego	721	5/20/21	AL	2020	SEN-W	15.9	Ylg	33.2	AD-CWT	40,700	Barge/LCM, CWT#640982
Lake Trout	Oswego	721	5/20/21	AL	2020	HPW	15.9	Ylg	30.7	AD-CWT	20,000	Barge/LCM, CWT#690945
Lake Trout	Sodus	819	5/24/21	AL	2020	LCH-D	15.8	Ylg	36.4	AD-CWT	40,400	Barge/LCM, CWT#640981
Lake Trout	Sodus	819	5/24/21	AL	2020	HPW	16.0	Ylg	30.3	AD-CWT	22,900	Barge/LCM, CWT#640946
Lake Trout	Olcott	708	5/26/21	AL	2020	HPW	16.1	Ylg	28.6	AD-CWT	28,200	Barge/LCM, CWT#640863
Lake Trout	Olcott	708	5/26/21	AL	2020	SEN-W	16.1	Ylg	30.8	AD-CWT	39,900	Barge/LCM, CWT#640985
Lake Trout	**Total**							**Ylg**	**32.2**		**260,700**	
Rainbow Trout	Black River Bay	424	4/13/21	SR	2020	WAS	9.7	Ylg	22.0	NONE	25,000	
Rainbow Trout	Black River Bay	424	5/6/21	SR	2020	WAS	10.5	Ylg	22.0	NONE	10,000	stocked in pens at 4/13/2021 at 23.4 fish/lb
Rainbow Trout	North Sandy Creek	O.44	4/15/21	SR	2020	WAS	9.8	Ylg	19.4	NONE	21,250	
Rainbow Trout	South Sandy Creek	O.45	4/15/21	SR	2020	WAS	9.8	Ylg	19.4	NONE	21,250	
Rainbow Trout	Stony Creek	O.40	4/12/21	SR	2020	WAS	9.7	Ylg	19.5	NONE	4,250	
Rainbow Trout	Beaverdam Brook	O.53-8	4/7/21	SR	2020	SKA	9.5	Ylg	15.7	AD	51,700	
Rainbow Trout	Beaverdam Brook	O.53-8	4/28/21	SR	2020	WAS	10.2	Ylg	32.2	NONE	157,450	Stocked on 4/27 and 4/28/21
Rainbow Trout	Beaverdam Brook	O.53-8	6/7/21	SR	2021	WAS	11.5	Fry	0.2	NONE	89,687	Excess fry stocked near river pump
Rainbow Trout	Oswego River	O.66	4/21/21	SR	2020	WAS	10.0	Ylg	16.1	NONE	35,000	

Table 3. Trout, salmon and other species stocked in New York waters of Lake Ontario and the Upper St. Lawrence River in 2021.

SPECIES	LOCATION	GD/KY	STK_DATE	HTCH	YCL	STRAIN	MOS	STAGE	WT(g)	MARK	NUMBERS	REMARKS
Rainbow Trout	Irondequoit Creek	O.108	4/16/21	SR	2020	WAS	14.7	Ylg	16.0	NONE	18,000	
Rainbow Trout	Irondequoit Creek	O.108	4/13/21	PMP	2020	FL-W	11.0	Ylg	37.9	NONE	7,300	
Rainbow Trout	Genesee River	O.117	4/12/21	SR	2020	WAS	9.7	Ylg	19.4	NONE	35,000	
Rainbow Trout	Sandy Creek	O.130	4/16/21	SR	2020	WAS	9.8	Ylg	16.0	NONE	17,000	
Rainbow Trout	Johnson Creek	O.139	4/19/21	SR	2020	WAS	9.9	Ylg	16.0	NONE	6,380	
Rainbow Trout	Oak Orchard Creek	O.138	5/4/21	SR	2020	WAS	10.4	Ylg	29.1	NONE	10,000	Fish in pens on 4/5/21 at 24.2 fish/lb
Rainbow Trout	Oak Orchard Creek	O.138	4/19/21	SR	2020	WAS	9.9	Ylg	16.0	NONE	25,000	
Rainbow Trout	Maxwell Creek	O.85	4/20/21	SR	2020	WAS	10.0	Ylg	16.0	NONE	12,750	
Rainbow Trout	Eighteenmile Creek	O.148	4/26/21	SR	2020	WAS	10.2	Ylg	28.4	NONE	10,000	Fish into pens on 4/6/21 at 24.2 fish/lb
Rainbow Trout	Eighteenmile Creek	O.148	4/26/21	SR	2020	WAS	10.2	Ylg	28.4	NONE	7,000	Fish went into pens instead of direct 4/6/21 at 24.2 fish/lb
Rainbow Trout	East Branch Twelvemile Creek	O.152	4/25/21	SR	2020	WAS	10.1	Ylg	26.1	NONE	6,380	Fish into pens on 4/7/21 at 24.2 fish/lb
Rainbow Trout	Twelvemile Creek	O.152A	4/7/21	SR	2020	WAS	9.5	Ylg	18.8	NONE	4,250	Fish were direct stocked into 12-Mile East due to low water
Rainbow Trout	Niagara River	O.158	4/26/21	SR	2020	WAS	10.2	Ylg	16.1	NONE	53,380	
Rainbow Trout	Niagara River	O.158	5/4/21	SR	2020	WAS	10.4	Ylg	14.6	NONE	19,219	
Rainbow Trout	Niagara River	O.158	5/13/21	SR	2020	WAS	10.7	Ylg	24.7	NONE	12,000	Fish into pens 4/14/21 at 23.4 fish/lb
Rainbow trout	**Subtotal**					**SKA**		**Ylg**	**15.7**		**51,700**	
Rainbow trout	**Subtotal**					**WAS**		**Fry**	**0.2**		**89,687**	
Rainbow trout	**Subtotal**					**WAS**		**Ylg**	**22.9**		**510,559**	
Rainbow Trout	**Subtotal**					**FL-W**		**Ylg**	**37.9**		**7,300**	
Rainbow trout	**Total**								**19.2**		**659,246**	
Walleye	Irondequoit Bay	O.108-P113	6/4/21	CQ	2021	ONL-W	1.2	PF	0.3	NONE	36,000	Shore stocked
Walleye	Niagara River	EN-P0000	6/4/21	CQ	2021	ONL-W	1.2	PF	0.3	NONE	23,600	includes 400 surplus fish
Walleye	**Total**					**ONL-W**		**PF**	**0.3**		**59,600**	
Total All Salmon and Trout											**2,545,415**	
Total All Fish Stocked											**2,920,236**	

Lake Ontario Fishing Boat Survey 1985-2021

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Lake Ontario provides anglers with a diverse world-class trout and salmon fishery and ample fishing opportunities for a variety of warm- and cool-water species (e.g., smallmouth bass, walleye, yellow perch). Each year from 1985-2021 the New York State Department of Environmental Conservation (NYSDEC) surveyed boats operating in New York waters of Lake Ontario's main basin, except the survey was not conducted in 2020 due to Coronavirus pandemic health and safety restrictions. The data collected from boat counts and interviews of fishing boats are used for management of New York's Lake Ontario trout and salmon fishery and provide valuable information on other fish species (e.g., Eckert 1999). Each year from 1985-2009 the planned start of the survey was April 1 and the survey ended on September 30. Six-month estimates of creel survey results (1985-2009) were reported in previous annual reports (e.g., Eckert 1999, Eckert 2007, Lantry and Eckert 2010). The planned initiation of the survey was permanently changed to April 15 beginning with the 2010 season. Data presented and discussed in this report are 5½ month estimates for each survey year (1985-2019, and 2021). This report focuses on 2021 results and on comparisons of 2021 with data collected during previous years. Appended tables and figures provide additional data (e.g., annual estimates of effort, catch, harvest and biological data) collected each year 2010-2019 and 2021 and a 26-year average for 1985-2010.

Methods

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

Methods and procedures have changed little throughout the 35 years surveyed. For 20 of the 36 years the fishing boat survey covered the entire six-month period, April 1 to September 30. For 1995, 2002, 2003, 2008, and 2009 delays in hiring prevented an April 1 start, and sampling was initiated between April 8 and April 26. Beginning with 2010, the scheduled start of the survey was changed to April 15. This angler survey does not include fishing activity from shore, in embayments and tributaries, in the eastern outlet basin (except for those which terminated their trip by returning through the Association Island Cut), boats fishing anywhere in Lake Ontario from October through April 14, or boats returning from the lake between one-half hour after sunset to two hours after sunrise (1.5 hours after sunrise during April and September only).

Boating access to Lake Ontario is limited and occurs mainly through channels associated with embayments and tributaries. Two crews of two agents each were used to survey access channels along approximately 190 shoreline miles from the Niagara River to the Association Island Cut near Henderson (Figure 1). The number of access channels surveyed varied between years from 28 to 30 (29 channels in 2021). Channels were divided each year into three or four sample strata based on estimates of expected fishing boat use (low-, medium-, high-, or super-use) and days were divided into two strata (low- and high-use). A stratified random design was used to proportionately allocate sampling effort among day and channel types for each month. Both crews were scheduled to work all of the designated high-use days (weekend days and holidays) and half of the crew/day combinations were scheduled on low-use week days.

During each time period surveyed, creel agents counted all boats returning from Lake Ontario and interviewed a random sample by anchoring and/or motoring small (18-20 ft) boats at the channel mouth. Time periods surveyed varied in length according to changes in sunrise and sunset, with each crew surveying opposite halves of the time period from two hours after sunrise (1.5 hours after sunrise during April and September only) and

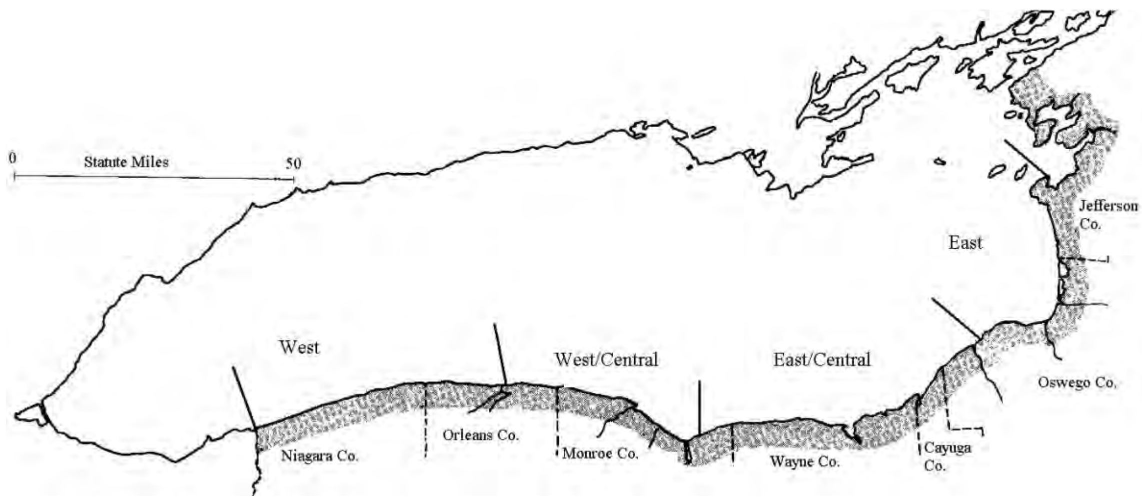


Figure 1. Lake Ontario's New York shoreline (shaded in gray), the seven New York counties that border the lake, and the four geographic areas used in analysis of the survey data.

one-half hour after sunset. Interviews were conducted only among boat anglers who had completed their fishing trip, and all data and estimates presented in this report, unless clearly stated otherwise, are from completed fishing boat trips. A fishing boat trip was classified as completed if the anglers were not planning on returning to Lake Ontario within 1.5 hours or if some or all of the fish or fishermen were left onshore before returning to the lake. Under these criteria, any completed fishing boat trip could have consisted of more than one excursion to and from Lake Ontario, and the same boat or anglers could have participated in more than one completed fishing boat trip per day. The term harvest is used throughout this report for fish that were actually kept by the anglers, as well as any fish that were intentionally killed and discarded (e.g., round goby). The term catch is used for the sum of fish harvested plus fish intentionally released (intentionally unhooked and returned to the water alive).

Data Analysis

Estimated Effort, Catch and Harvest

Estimates of fishing boat effort, catch and harvest were calculated for each channel and day surveyed by utilizing data from the sample of interviewed boats expanded by the total count of boats returning from the lake. These individual daily estimates were then multiplied by two to account for the "half day" census periods, and expanded by month using standard formulas for stratified random samples (Cochran 1977) to obtain monthly and 5.5-month estimates of effort, catch, harvest, and their respective variances. Variance estimates are conservative; therefore, the 95% confidence intervals are broad. To evaluate angling quality between years, species, areas, etc., we adjusted catch and harvest data per unit of fishing effort (e.g., catch and harvest per fishing boat trip). The basic unit sampled was an individual boat; therefore, effort is presented as estimated boat trips, and harvest rates and catch rates are presented per fishing boat trip. Effort in terms of angler trips and angler hours, and harvest and catch per angler trip and angler hour were also determined. Estimates of many variables such as angler residence and characteristics of fish harvested (e.g., length, age) were calculated directly from the interviewed boats assuming they were a random sample of the population. Data were also summarized for charter and noncharter boat trips.

Beginning in 2010, the initiation of the Lake Ontario Fishing Boat Survey (hereafter "survey") was April 15 rather than April 1 as was scheduled from 1985-2009 (Lantry and Eckert 2010). To allow for between year comparisons, we reanalyzed 1985-2009 April data to determine half-month (April 15-30) estimates (see Lantry and Eckert 2013 for detailed methods).

Geographic Area Comparisons

Regional comparisons were made by dividing the New York shoreline into four approximately equal areas (Table A1; Figure 1), and combining the daily estimates for access channels within each area for the entire season (i.e., months were eliminated as a strata classification). Boundaries of the four geographic areas and their designated names used throughout this report are: west area - Niagara River to Point Breeze;

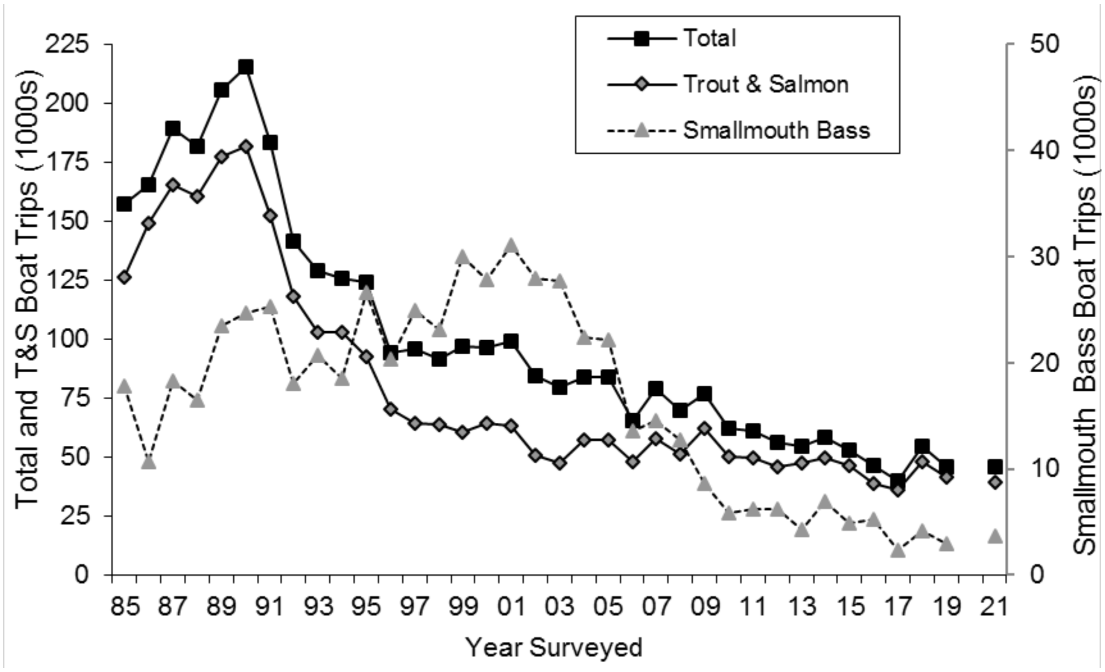


Figure 2. Estimated number of total fishing boat trips, trips targeting trout and salmon (T&S; April 15-September 30), and trips targeting smallmouth bass during the traditional open season (3rd Saturday in June-September 30 when the survey ended), 1985-2019, and 2021 (No survey was conducted in 2020).

west/central area - Bald Eagle Creek to Irondequoit Bay; east/central area - Bear Creek to Oswego Marina; and east area - Sunset Bay (Nine Mile Point) to Association Island Cut (Table A1). In this report, annual estimates of catch, harvest or catch and harvest rates or biological variables are compared with long-term averages except in cases where long-term trends have changed values considerably. In these cases, annual estimates are compared with shorter, previous 10-year average values.

Results and Discussion

Fishing and Boating Effort

The estimated number of all fishing boat trips increased from 1985-1990, then decreased through 1996 (Figure 2). The largest declines in fishing effort occurred shortly after the peak (215,405 trips), with declines of 31,751 trips between 1990 and 1991, 42,112 trips between 1991 and 1992, and 12,740 trips between 1995 and 1996. Effort remained relatively stable until the early 2000s when a declining trend in total fishing effort was apparent. Until recently, the declining trend was mostly attributed to a decline in effort targeting smallmouth bass (see *Smallmouth Bass Targeted Effort* in this section). Fishing effort targeting trout and salmon was relatively stable from the early 2000s through 2015, then declined in 2016 and 2017. The drop in effort in 2016 was likely due to unfavorable weather patterns and reduced fishing quality for some salmonid species (Lantry and Eckert 2018). In 2017 effort declined to a new low (39,964 boat trips) due to high water levels affecting boat launch access and boat navigability. After rebounding in 2018 to 54,663 boat trips, total fishing effort in 2019 dropped again to an estimated 46,099 boat trips due to high-water levels affecting boat access (Connerton et al. 2020). In 2021, fishing effort (45,617 boat trips) remained relatively stable compared to 2019, however, the estimate was still 14% below the previous 10-year average. The average number of anglers per boat trip ranged from 2.5 (1985) to 3.3 (2021 was highest in data series) and averaged 3.0 during the last 10 years with an increasing trend since 2003 (Table A2). The 2021 average trip length of 5.7 hours per boat trip was similar (+3%) to the previous 10-year average.

The greater proportion of annual of fishing effort (Table A2) typically occurs during the second half of the open lake fishing season (2010-2019 10-year averages: April 15-30: 4.2%, May: 15.5%, June: 11.6%, July: 21.8%, August: 30.1%, and September: 16.8%). In 2021, total fishing effort estimates were below 10-year averages for May (-27%), August (15%) and September. September effort (5,046 boat trips) was 44% below average, and the lowest recorded in the time series.

Geographic Area Fishing Effort

For all 36 years surveyed, the lowest fishing effort occurred in the west/central area, and this was true again in 2021 (Table A2). Effort in this region (6,385 boat trips, 14% of total) was very near the previous 10-year average and was more than double the effort observed in 2019 when this area was particularly affected by launch closures from high water levels. For 29 of the last 36 years, the most fishing boat effort occurred in the east/central area (14,882 boat trips in 2021, 33% of fishing effort; Table A2). In 2021, effort was below the 10-year average for all areas (ranging from -0.5% in the west/central to -23.5% below average in the east area)

Power Boat and Sailboat Excursions

This survey was specifically designed to count and interview fishing boat anglers; however, all recreational boats returning from Lake Ontario were also documented. In general, all power boats followed a similar trend: peaking between 1988-1990, followed by sharp declines until about 1993, then levelling off or declining slightly since then. When the survey began, power boaters who spent at least a portion of their time fishing on Lake Ontario equaled or exceeded the number of non-fishing power boats. Beginning in 2009 until present, non-fishing power boats outnumbered fishing boats and the numbers of excursions stabilized while fishing boat excursions declined slightly. In 2021 power fishing boats accounted for 45,727 vessel excursions and 35% of the total vessel traffic (Table A2). Non-fishing power boats (i.e., recreational boaters) were estimated at 72,978 excursions in 2021 and 56% of the total vessel traffic. Both categories were below previous 10-year averages by 14.9% and 6%, respectively. Sailboats, the smallest component of vessel traffic, showed a downward trend through much of the time series. In 2021, sailboats accounted for 10,640 excursions (3rd lowest recorded) and represented 8% of vessel traffic, down 36.5% compared to the previous ten-year average (Table A2).

Trout and Salmon Targeted Effort

Trout and salmon were the primary target of boat anglers interviewed each year since 1985 averaging 78.3% of total boat trips (1985-2021 range: 59.7% [2003] to 90.0% [1986]; Table A2; Figure 2). There was no significant trend in effort directed at trout and salmon from 2001-2015 (Lantry and Eckert 2018); however, effort declined in 2016 and again in 2017 to a record low level (Table A2). After rebounding to about 5% above the previous 10-year average in 2018, effort in 2019 (41,722 boat trips) and 2021 (39,273 boat trips) dropped to 12% and 13% below the 10-year averages respectively. In contrast, the number of angler trips (137,365) and angler hours (816,603) spent targeting trout and salmon in 2021 were closer to their respective averages, primarily because the number of anglers per boat has climbed from 3.0 in 2010 to 3.5 in 2021 (mean=3.1) Trout and salmon anglers accounted for 86.1% of total fishing boat trips (10th highest), 90.9% of angler trips (5th highest), and 94.6% of total angler hours (7th highest, Table A2). Estimated monthly fishing effort targeting trout and salmon in 2019 was below previous 10-year averages during May, August and September (down 29.7%, 11.5%, and 40.6%, respectively; Table A2) with September effort at a record low. Effort in April, June and July were above average by 3.6, 7.0, and 6.1% respectively. During 2021, 46.2% of interviewed salmonine anglers were specifically targeting Chinook salmon, 43.8% were targeting a mix of two or more species, 7.2% were specifically targeting brown trout, 2.5% were targeting lake trout and less than 1% were targeting other species (i.e., coho salmon, rainbow trout and Atlantic salmon).

Smallmouth Bass Targeted Effort

<u>Pre-Season Catch and Release Period:</u>

An October 1, 2006 regulation change established a catch and release bass season from December 1 through the Friday preceding the third Saturday in June (except in Jefferson County waters of Lake Ontario's eastern basin). Prior to this regulation change some anglers admitted to targeting smallmouth bass before the traditional season opening (third Saturday in June) and, except for 2006, accounted for nearly 1% of the April 15 - September 30 total smallmouth bass fishing effort (Table A2). In 2006, prior to the new pre-season catch and release regulation taking effect, 3.5% of total effort occurred pre-season (an estimated 500 boat trips). Since the regulation change, effort targeting bass during the pre-season catch and release period remained low (range: 164 boat trips [2015] – 644 trips [2009]) and a minor component of total bass fishing effort occurring from April 15 - September 30 (range: 2.8% [2008] to 7.9% [2017]). Pre-season effort targeting smallmouth bass in 2021 was an estimated 495 boat trips (12.0% of total bass effort; Table A2); this was the highest percentage of the total seasonal bass effort observed since the regulation change.

Traditional Open Season:

The traditional open season for bass begins the third Saturday of June. Each year since 1985, smallmouth bass was the primary species targeted by Lake Ontario anglers not seeking trout or salmon (Table A2; Figure 2). Among all fishing boat trips (April 15 - September 30) on Lake Ontario, the percent contribution of smallmouth bass trips during the traditional season varied and ranged from a low of 5.7% of all fishing boat trips in 2017 (a record low) to a high of 34.8% in 2003. In 2021, smallmouth bass anglers fishing during the traditional open season accounted for 8.0% of boat trips, 5.4% of angler trips, and 3.4% of angler hours. All were among the 5th lowest percent contributions on record.

From 1985-2001 effort targeting smallmouth bass increased significantly (P=0.0004), averaging a gain of 797 boat trips per year. During 2001-2010, however, smallmouth bass effort declined significantly (P <0.05, Lantry and Eckert 2011; Table A2; Figure 2). These trends in fishing effort coincided with a similar declining trend in fishing quality through 2010 (see section "Smallmouth Bass *Fishing Quality*" of this report). From 2010 through 2016, effort remained at a lower and relatively stable level that was about 82% lower than the 2001 peak (2001: 31,035 boat trips; 2010-2016 average = 5,661 boat trips, Lantry and Eckert 2017). In 2017, however, smallmouth bass fishing effort declined 59.5% from the 2010-2016 level to a record low (Table A2; Figure 2). This reduced effort was partly attributed to high water levels negatively impacting access to the lake and boating activity (Lantry and Eckert 2018). After rebounding in 2018, the total number of boat trips targeting smallmouth bass on Lake Ontario in 2019 dropped 29.4% to the 2nd lowest level in 35 years, attributed again to high water levels preventing access at launches (Connerton et al. 2020). In 2021, effort increased 24.2% from 2019 to 3,627 boat trips, however bass effort was still 25.9% below the previous 10-year average. Effort has trended significantly downward from 2010-2021 (p=0.0107) averaging a loss of 309 boat trips per year.

Fishing effort for smallmouth bass in June 2021 was relatively high, at 37.7% above the 10-year average, but in other months, effort was lower than recent ten-year averages (range: -19.1% [July] to -67.0% [September]). Effort in 2021 was also well below recent averages in most areas surveyed (west: -70.1%, west/central: -89.4%, east central: -42.5%, Table A2) except in the east area where effort was 0.6% above the 10-year average). The mean number of anglers per bass boat trip was 2.2 anglers and the numbers of hours per bass boat trip was 3.6 hours.

Effort Targeting Other Species

Yellow perch and walleye were the third and fourth most commonly targeted species among open lake boat anglers in 2021 (preceded by salmonines and smallmouth bass), however, trips targeting these species only represented 1.1% and 1.3% respectively of the total fishing boat trips on Lake Ontario (Table A2). The "all others" category, which represented 2.2% of 2021 fishing boat trips, was primarily composed of anglers who stated that they were fishing for "anything" (Table A2).

Charter Boat Fishing Effort

Charter boats are an important, highly visible component of the Lake Ontario open lake fishery. Charter boats differ from noncharter boats in that charter boats have more anglers onboard (captain and mate included), fish for a longer period of time, are more likely to target trout and salmon, have higher catch rates per boat trip (but not always per angler hour), and harvest a higher percentage of the catch. In 2021, charter boats accounted for 25.6% of all fishing boat trips (Figure 3). With more anglers on board (mean: 5.5 anglers per trip) and longer trips (mean: 6.6 hours), charter boats accounted for 42.4%

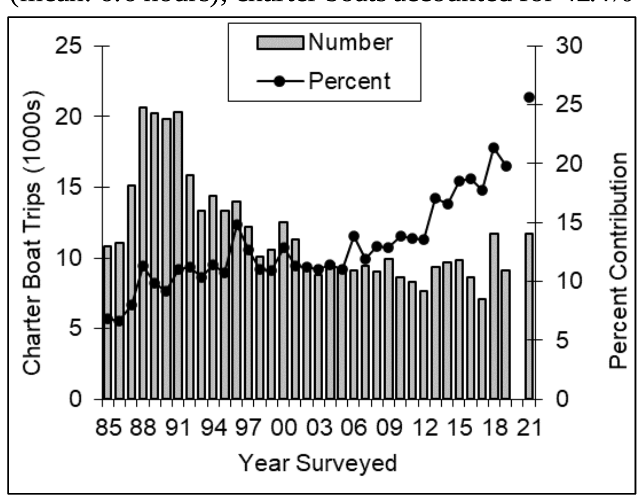


Figure 3. Estimated number of charter fishing boat trips and their percent contribution to total fishing boat trips, April 15- September 30, 1985-2019, and 2021. No survey was conducted in 2020.

and 47.7% of the angler trips and angler hours respectively (captains and mates counted as anglers; Table A2), the highest percentages in the 36-year series. Although charter boats accounted for only 25.6% of total fishing boat trips, they accounted for 49.1% of the total salmonine catch in 2021.

The highest charter fishing effort occurred 1988-1991, then declined and has remained relatively stable for the last nineteen years (Table A2; Figure 3). The 2021 estimated charter boat effort was 11,689 (±23.5% CI) trips, 29.8% above the previous 10-year average and the highest value observed since 2000. Estimated monthly charter fishing effort in 2021 was well above the previous 10-year averages in April (+60.9%), June (+81.4%), July (+72.4%) and August (+29.8%, Table A2). however, charter effort in May (-22.9%) and September (-28.8%) was below the previous 10-year averages. The percent contribution of charter boats to total fishing boat effort has increased over the last 10 years (Figure 3) and in 2021 was the highest in the time series. This increase is the result of declining noncharter effort over this period.

<u>Angler Residency</u>

Lake Ontario's world-class sport fishery has attracted anglers from all 50 states (40 in 2021) and many different countries (1 in 2021) over the last 36 years. Residency of anglers fishing Lake Ontario changed little over the time series with New York State (NYS) anglers consistently dominating the open lake boat fishery (Table A4; Figure 4). The most notable change in angler residency occurred during the first few years of the survey. In 1985 and 1986, NYS residents comprised 79.8% and 75.7% of all anglers interviewed, respectively (Figure 4). Over the last 34 years, there was no trend in the percentage of anglers residing in NYS. Over the last 10 years, an average of 60.4% of Lake Ontario anglers resided in NYS (60.2% in 2021; Table A4).

Contribution of nonresident anglers increased after 1985 when 20.2% of Lake Ontario open lake anglers were not NYS residents. This increase was likely due to increasing awareness of the Lake Ontario trout and salmon sport fishery. Since the early 1990s the percentage of anglers who reside outside of NYS

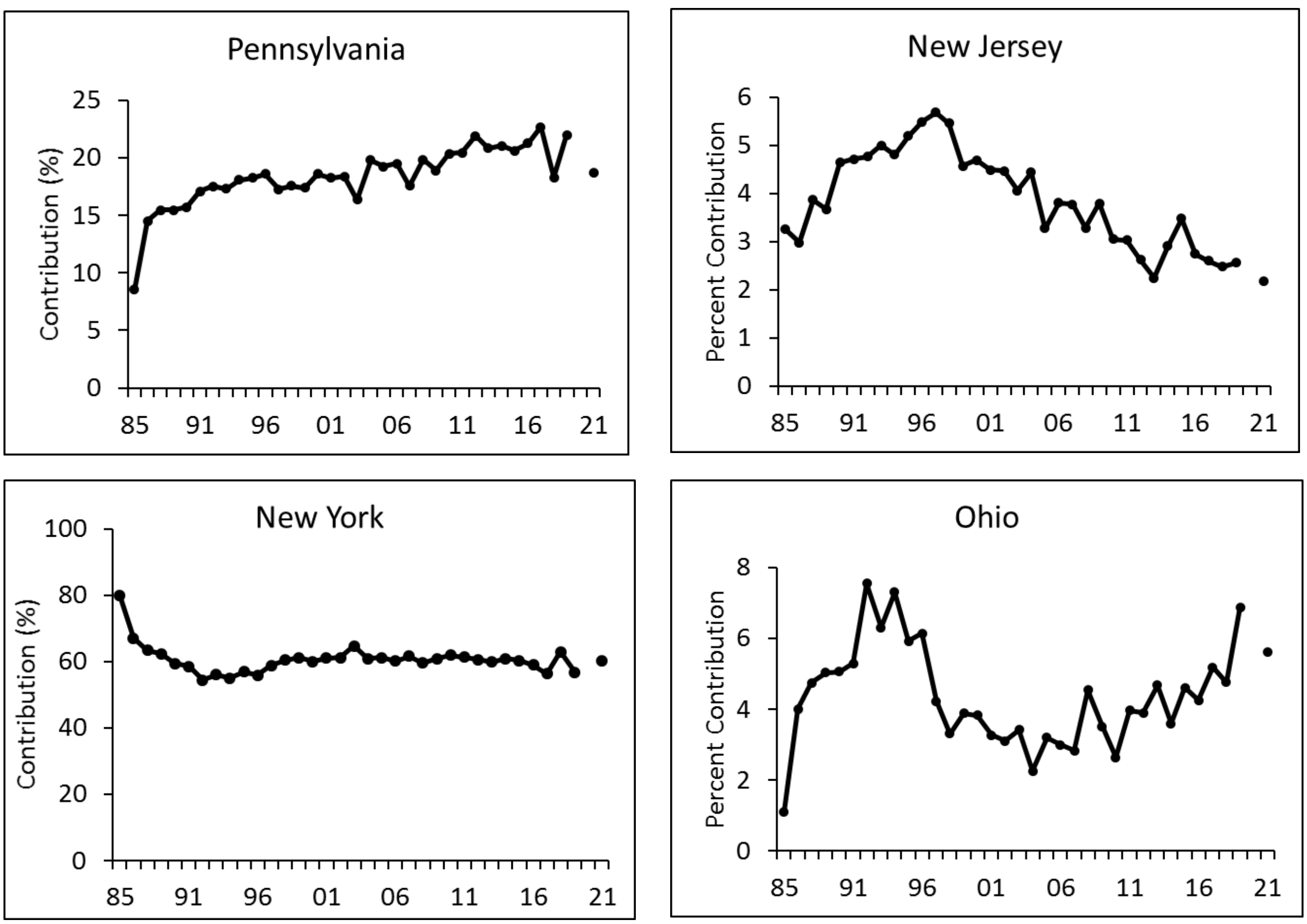


Figure 4. Percent contribution of anglers from New York, Pennsylvania, Ohio and New Jersey to the Lake Ontario Boat Fishery 1985-2019, and 2021. No survey was conducted in 2020.

ranged from 35.2% (2003) to 45.6% (1992). In 2021, non-NYS residents comprised 39.8% of the boat anglers interviewed, a slight decrease compared to the previous 10-year average (Tables A2, A4; Figure 4). Pennsylvania represented the largest component of nonresident anglers for each of the 36 years surveyed (18.7% in 2021, Figure 4) and the percentage has generally increased over time. The highest percentage of Pennsylvania anglers occurred in 2017 (22.7%) and the lowest (8.5%) occurred in 1985 (Table A4). Other main sources of non-NYS anglers in 2021 were Ohio (5.6%, Figure 4), New Jersey (2.2%, Figure 4), Vermont (2.2%), Massachusetts (2.7%), Connecticut (1.3%), and Maine (1.4%, Table A4).

Throughout the 35-year survey period, the majority of NYS anglers resided in the seven counties bordering Lake Ontario (Jefferson, Oswego, Cayuga, Wayne, Monroe, Orleans and Niagara counties; peaked at 66.9% in 2003; Table A4). The percentage of NYS residents residing in the border counties declined in recent years, with the lowest levels recorded 2014-2017 (60.6% in 2021). Monroe County was the most important source of residents in the boat fishery for 35 out of 36 years surveyed (1985-2019 average=22.1%). Other counties representing important components of the open lake boat fishery in 2019 were Oswego (14.5%), Niagara (8.1%), Onondaga (4.0%) Wayne (10.4%), Orleans (5.7%), and Erie (4.2%; Table A4).

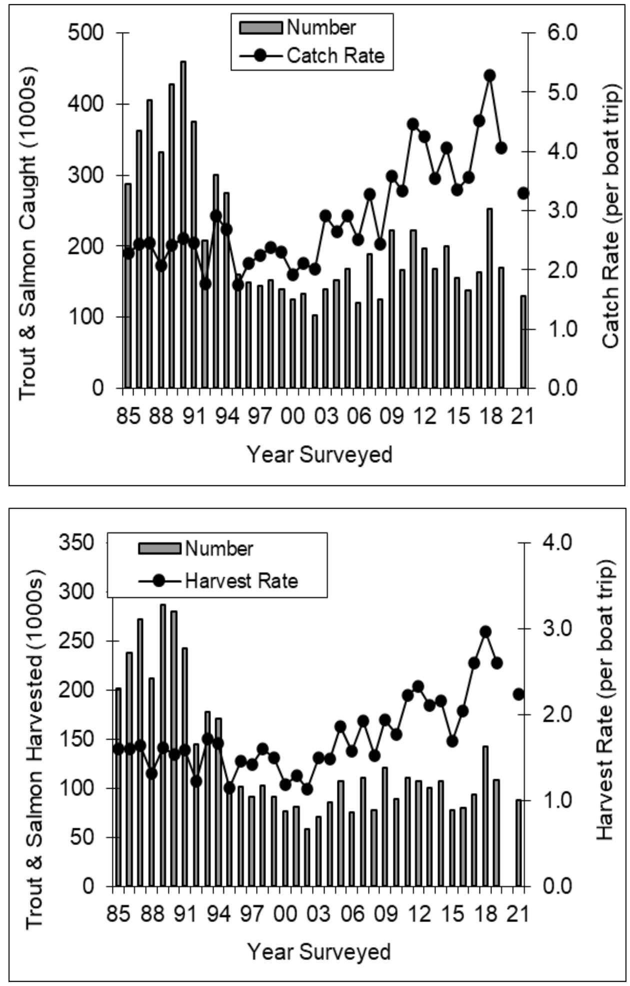


Figure 5. Total trout and salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985 – 2019 and 2021).

<u>Total Salmonine Catch, Harvest and Fishing Quality</u>

Catch and Harvest

Trout and salmon are the most sought-after fish in Lake Ontario. The six salmonine species provide anglers with a diverse trout and salmon fishery throughout the open lake season and along the entire NY shoreline. This variety gives anglers the opportunity to target another species when their preferred target is not available. Total catch of all trout and salmon species was estimated at 129,582 fish a 23.8% decrease from 2019 and 29.3% below the previous 10-year average (Tables 1, A5a; Figure 5). In 2021, anglers harvested 68.1% of the salmonine catch totaling 88,300 fish, which is 13.9% below the previous 10-year average (Tables 1, A5a; Figure 5).

Each year since 2003, Chinook salmon dominated the trout and salmon fishery representing 48.8% of the catch and 50.6% of the harvest on average (Table 1). In 2021 Chinook salmon represented 46.9% of the catch and 49.9% of the harvest. Brown trout or rainbow trout have often been the second most caught and harvested species. In 2021, rainbow trout was the second most caught and harvested species representing 16.0% and 16.4% of catch and harvest, respectively, followed by lake trout (14.6% of catch, 13.2% of harvest). Brown trout represented 11.8% of angler catch and 8.3% of harvest in 2021 due to lower than normal fishing quality for this species (See section on brown trout). On the other hand, anglers experienced higher than normal catch rates for Coho salmon in 2021 and this species represented 12.4% and 10.6% of the total trout and salmon catch and harvest respectively, which is about double the previous 10-year mean. Atlantic salmon were a small component of the fishery in 2021 representing less than 0.2% of the total catch.

Fishing Quality

Each year trout and salmon catch rates vary by month and region and similar trends tend to occur each year. Fishing quality is influenced by many factors including, angler experience (e.g., best lure, fishing depths), water temperature patterns, recent wind patterns, distance from shore, fish distribution, and species targeted. Quality also varies with when (e.g., specific day, week, month, year) and where anglers are fishing (e.g., west, west/central, east/central, east). With the variety of trout and salmon species present in Lake Ontario, anglers can target another species when catch rates for their preferred target are lower than desired.

The quality of trout and salmon fishing in Lake Ontario, as measured by catch rate of all species combined, was variable but relatively stable from 1985-2002; however, catch rate increased substantially in 2003 and remained at a higher, variable level since then (Figure 5). Anglers experienced eleven consecutive years (2009-2019) of exceptional or record high trout and salmon catch rates. Fourteen of the highest catch rates observed in the survey occurred between 2003 and 2021. During this period anglers experienced relatively high species-specific catch rates for Chinook salmon (2003-2019), coho salmon (2006-2007, 2009-2012, 2017, 2021); rainbow trout (2008-2014, 2017), brown trout (2007, 2011, 2012, 2014, and 2018), and lake trout (2013-2016). In 2021, the catch per boat trip dropped to 3.3 fish caught per boat trip, was the 12th highest in the survey and was 18.6% below the previous 10-year average (Table A5b; Figure 5). The 2021 total trout and salmon harvest rate for all boats targeting trout and salmon was 2.2 fish per boat trip, the 5th highest in the data series, and similar (-0.5%) to the 2010-2019 average harvest rate (Table A5b; Figure 5).

Catch rate data (fish per boat trip) were also evaluated by month. In 2021, catch rates were below respective previous 10-year averages in all months (range: -61.5% [May] to +11.4% [June]) except in July which was similar to the 10-year average (+0.5%; Table A5b). In 2021, charter boats targeting trout and salmon accounted for 53% and 64% of all salmonines caught and harvested, respectively, but represented only 29.7% of trout and salmon fishing boat effort, 46.5% of angler trips and 49.5% of angler hours directed at trout and salmon. The percent contribution of charter boats to total trout and salmon fishing effort has increased every year since 2012 and was the highest among the data series in 2021 (Figure 3). Charter boat total trout and salmon catch rate (5.9 fish per boat trip) and harvest rate (4.8 fish per boat trip, 0.17 per angler hour) in 2021 decreased from the record highs observed in 2018 and 2019, ranking 29th and 24th in the 36-year survey respectively, and 28.3% and 21.1% below the respective 10-year averages (Table A5b).

Noncharter fishing boat total trout and salmon catch and harvest rates in 2021 also declined from the record highs observed in 2018 and 2019. Noncharters caught an average of 2.2 salmonines per boat trip (0.15 fish caught per angler hour), about 27% lower

Table 1. Harvest and catch estimates and 95% confidence intervals for April 15 – September 30, 2021 from the NYSDEC Lake Ontario fishing boat survey.

	Harvested	95% CI	Caught	95% CI
Coho salmon	10,969	4,154	13,679	4,799
Chinook salmon	44,064	12,453	60,754	15,728
Rainbow trout	14,215	4,747	20,683	6,347
Atlantic salmon	97	114	200	153
Brown trout	7,307	10,417	15,293	12,620
Lake trout	11,649	4,226	18,959	5,525
Total Trout and Salmon	88,300	19,993	129,582	25,820
Smallmouth bass (includes pre-season)	2,863	4,746	18,318	12,289
Yellow perch	7,334	7,901	14,386	13,084
Walleye	503	960	667	972
Round goby	3,022	5,224	5,013	5,091

than the previous 10-year average (Table A5b). The 2021 lake-wide harvest rate was 1.2 salmonines per noncharter boat trip (0.08 fish per angler hour, Table A5b) which is lower than the charter rate, however noncharter boats usually have smaller parties and tend to release more fish than charters.

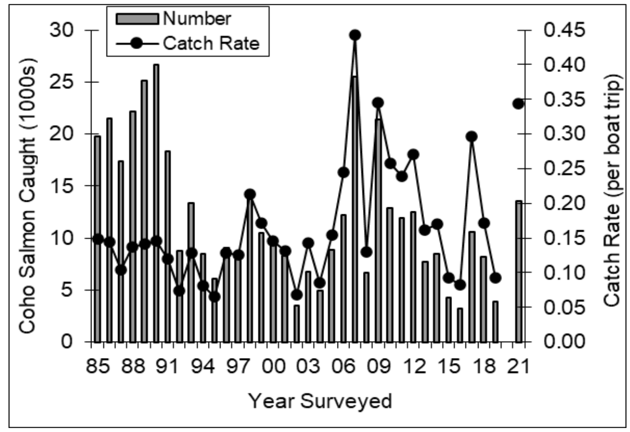
Coho Salmon

Catch and Harvest

In 2021, coho salmon was the fourth most caught and harvested salmonine in the trout and salmon boat fishery representing 12.4% and 10.6% of total catch and harvest, respectively (Tables 1, A6a). Estimated coho salmon catch (13,679 fish) in 2021 was about double the 10-year average (Figure 6). Approximately 80% of coho salmon caught were harvested which is higher than the previous 10-year average (64.4%). Coho salmon harvest was an estimated 10,969 fish, which ranked as the 11th highest in the 36-year survey (Table A7a; Figure 6). During 2021, estimated monthly catches of coho salmon were above the previous 10-year averages in all months (range: 10.2% in April to 814% in June) except September (-15.7%).

Fishing Quality

Coho salmon catch rates and harvest rates were generally at, or near record levels from 2006-2012 (Table A6b; Figures 6, 6b). Rates declined to near record lows in 2015 and 2016, then rebounded in 2017 to the fourth highest in the series, then dropped again in 2019 to levels observed during 2015-2016. Catch rates in 2021 increased and were 126% above the previous 10-year average, ranking 3rd among the 36-year survey. Both charter and noncharter boats experienced above average catch rates for coho in 2021 (0.016 and 0.017 fish per angler hour, respectively, Table A6b). Charter boats targeting trout and salmon caught 47.0% of all coho salmon. Coho salmon catch and harvest rates are typically highest during April and May and in the western portion of the lake (Lantry and Eckert 2011; Table A6b; A1). In 2021, this was not the case, as catch rates were unusually high in June and July, with both months exhibiting record highs for those months (708.9% and 263% above recent 10-year averages). In May and September, anglers also experienced excellent Coho salmon fishing (3rd highest catch rates for both months, 113% and 28.7% above respective averages). For the past 22 years, the west area experienced the highest coho salmon catch rate among all areas, and this was again the case in 2021,



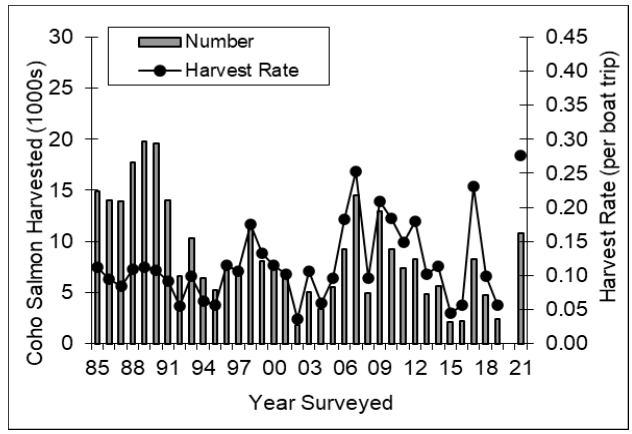


Figure 6. Total coho salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2019 and 2021.

setting a record high catch rate for that region (0.57 per boat trip). Catch rates in all regions surveyed in 2021 were above 10-year averages (Table A6b).

Biological Data

Biological data analysis presented below includes fish processed during April 15 - September 30 (length: 1985-2019, 2021, weight: 1988-2019 and 2021, scale samples for age determination: 2000-2019 and 2021). Coho salmon scale samples for aging were not collected regularly until 2000. To determine percent contribution by age for 1985-1999, we assigned age to fish of unknown ages (i.e., fish processed 1985-1999) using monthly length frequency distributions from fish of unknown age, and age and length data from fish of known age (i.e., those sampled after 1999). Ages of coho salmon for which no scale samples were collected during 2000-2019 and 2021 were determined using monthly length frequency distributions, and age and length data derived from fish aged by scales in the respective year.

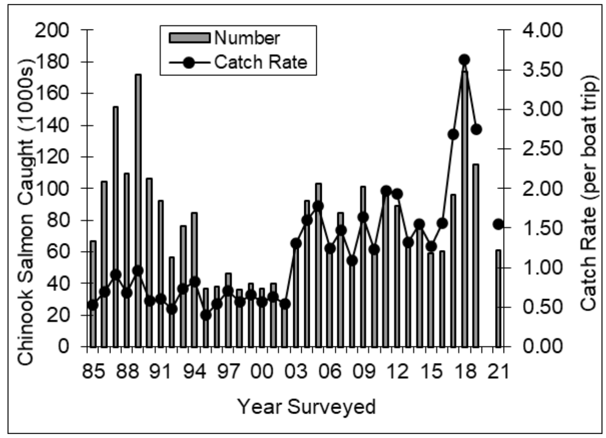
Each year, the majority (>73.8%) of coho salmon harvested in the open lake were age 2 (35-year average = 95.9% of those harvested were age 2; Table A7). Harvest of age 1 coho salmon is influenced by harvest regulations (i.e., 15-inch minimum harvestable size and angler desire to release small coho salmon). Most anglers prefer to release the smaller age-1 fish even when they are longer than 15 inches, so age-1 fish are underrepresented in the harvest sample. The contribution of age-3 coho salmon in angler harvest is small and represented ≤2.0% of harvest for 29 out of 35 years surveyed. In 2021, 0.6% of coho salmon sampled were age-1, 99.4% were age-2, and 0% were age-3.

Condition indices for coho salmon in 2021, as determined from predicted weights of standard-length fish, were below previous 32-year (1988-2019) averages for the smallest inch groups evaluated from 18 in to 24 in (range: -27.5% [18-in] to -3.6% [24-in]). For the largest inch groups evaluated, predicted weights were equal to or slightly above average (+0.1% [28-in] and +4.5% [30-in]; Table A7). Generally, the longer coho salmon are sampled later in the season when condition often improves. The mean length of age-2 coho salmon in September 2021 (27.6 in) was similar to the long-term average (i.e., 27.8 in, Table A7).

Chinook Salmon

Catch and Harvest

Chinook salmon dominated the catch and harvest of trout and salmon in New York's Lake Ontario boat fishery annually since 2003 and was the most caught salmonine in 25 of the 36 years surveyed. From 1985-2002 Chinook salmon represented an average of 28.3% of the total salmonine catch among boats targeting trout and salmon. From 2003-2019, 47.6% of all salmonines caught (and 48.1% harvested) were Chinook salmon. In 2021, Chinook salmon catch was an estimated 60,754 fish representing 49.9% of the total salmonine catch (Tables 1, A8a; Figure 7). This was the 23rd highest catch on record in the 36-year survey (2018 was highest), 23.3% below the long-term average, and 31.9% below the previous 10-year average. Harvest in 2021 was estimated at 44,064 Chinook salmon, making up 49.9% of the total salmonine harvest, which was similar to the recent 10-year average for the percent composition. (Tables 1, A8a; Figure 7).



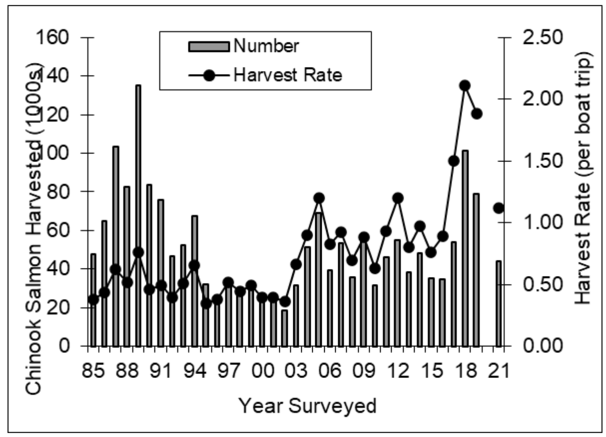


Figure 7. Total Chinook Salmon catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2019 and 2021.

Of all Chinook salmon caught in 2021, 72.5% were harvested (Table A8a) which is the highest level of harvest since 1999 and higher than the previous 10-year average of 56.9%. The highest percent harvest occurred in 1995 when 87.3% of all Chinook salmon caught were harvested. Since 2003, anglers on Lake Ontario have experienced the best Chinook salmon fishing quality in its history and the percentage of Chinook salmon harvested (2003-2019 average percent harvest=58.3%) was lower than during the 1985-2002 period (average = 73.9%). The decline in percent harvest was likely attributable to both improved catch rates (i.e., with increased catch rates the anglers can be more selective with the fish harvested and still harvest their limit of fish) and increasing numbers of anglers practicing catch and release (Lantry and Eckert 2018). In 2021, the higher percent harvest may be attributed to relatively lower catch rates (i.e., catch per trip was 22% below the

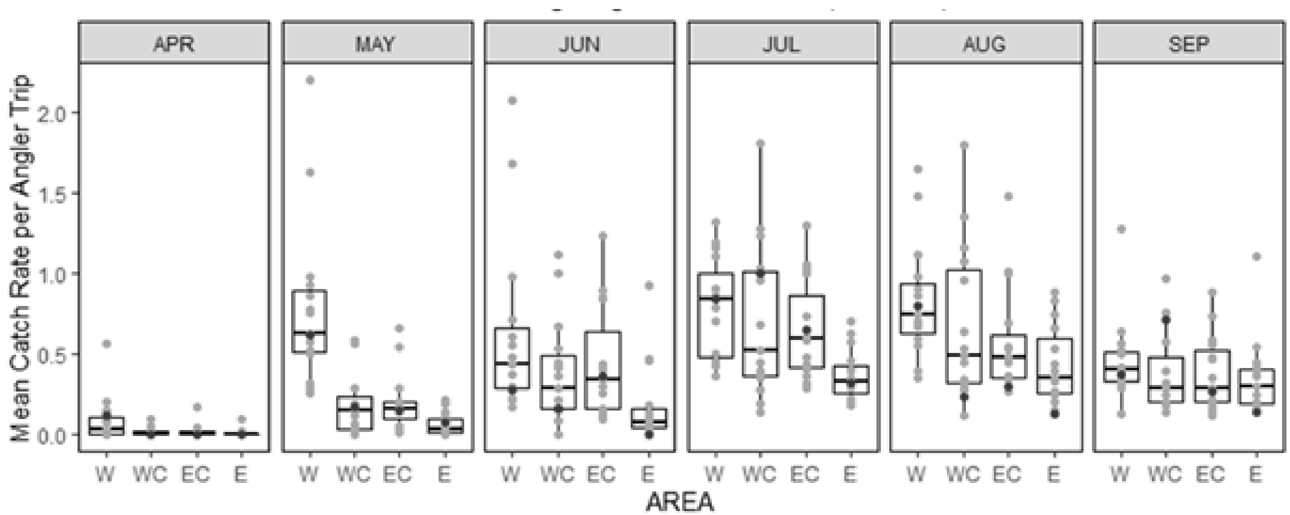


Figure 8. Chinook salmon mean catch rate per anlger trip by month in the west (W), west/central (WC), east/central (EC) and east (E) areas estimated in 2021 (black circles) compared with mean catch rates estimated from 2006-2019 (grey circles). The box encompasses between 25% and 75% of the observed values, and the dark line represents the median of the values.

recent 10-year average) and a higher percent contribution of charter boats in 2021, i.e., charter boats tend to harvest a higher proportion of their catch.

Typically, the majority of the Chinook salmon catch, and harvest occurs during August (28 of 35 years 1985-2019, Table A8a). In 2021, catch and harvest estimates were highest in July, representing 45% and 42% of all Chinook salmon caught and harvested, respectively. Estimated July catch was the fourth highest in the 36 years surveyed (1989 was the highest), and 78% above the long-term average. Catch estimates were below respective long-term averages in April (-76.0%), May (-83.2%), August (-29.9%) and September (-71.6%) and slightly above average in June (+6.1%). The highest regional contribution of Chinook salmon catch typically occurs in the west area (30 of 35 years). In 2021, estimated catch was again highest in the west area (29.363 fish, 48% of all Chinook salmon caught). Catch was slightly above average in the east/central area (+6.1%), and below long-term averages in the west (-18.5%) west/central (-23.4%), and east (-72.2%, Table A9a).

Fishing Quality

The highest Chinook salmon fishing quality occurred from 2003-2021 with 2018 marking best year on record (Table A8b; Figure 7). From 1985-2002 catch rate of Chinook salmon per boat trip for all trout and salmon boats was variable and without trend, however beginning in 2003 lake-wide catch rates averaged more than 2.4-fold higher than those observed in years prior to 2003. In 2021, the average Chinook salmon catch rate was 1.5 Chinook salmon per boat trip, a 43.9% drop from 2019, but still the 11th highest catch rate in 36 years of the survey and 30% above the long-term average. Compared to the previous 10-year average, however, catch rate was 22.3% lower, and anglers experienced relatively poorer fishing (Table A9b).

As with other salmonines, Chinook salmon catch rates vary by region and month. Typically, April-June catch rates of Chinook salmon in the western half of the lake are relatively higher than those toward the eastern half (Lantry and Eckert 2011; Figure 8). In all areas, Chinook salmon catch rates are typically highest in summer, lasting into early September in some years. In 2021, the seasonal average catch rate was negatively influenced by relatively poorer fishing quality in most months, but catch rates depended on the month and the area anglers were fishing (Figure 8). For example, in June, catch rates were relatively lower in all areas, except in the east/central area, resulting in a below average catch rate for that month (i.e., June: -32% below 10-year average). Catch rates in July were relatively good in the west and west/central areas and more average in the eastern areas resulting in above average mean catch rates for July (+9%). In August, catch rates were relatively lower for all areas except in the west, and the mean for the month was 30.1% below average. On a whole season level in 2021 and stratified by area, catch rates were below 10-year previous averages in the west/central (-32.2%) and east (-53.1%) and slightly above average for the west (+13.3%) and east central area (+3.4%, Table A8b).

In 2021, charter boats targeting trout and salmon caught 49.1% of the Chinook salmon caught by all trout and salmon anglers. Among charter boats, the 2021 Chinook salmon average catch rate was 2.6 fish per boat trip, a 31.1% decrease compared to the previous 10-year average and the 18th highest in 36 years surveyed (Table A8b). Charter boat catch per angler hour of Chinook salmon (0.07 in 2021) was the 16th highest on record and 27.9% below the 2003-2018 average (Figure 7b). Among noncharter boats, the 2021 average catch rates were 1.1 Chinook salmon per boat trip and 0.07 per angler hour, both the 2nd highest on record, and both below previous 10-year averages (-28.5% and -32.3%, respectively; Table A8b).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2021, weight: 1988-2021, scale samples for age determination: 1991-2021). In 2020, the fishing boat survey was not conducted due to Coronavirus health and safety restrictions, however some sampling of angler caught Chinook was done at cleaning stations in August. Chinook salmon scale samples for aging were not collected regularly until 1991. To determine percent contribution by age for fish processed 1985-1990, age was assigned to fish of unknown age (i.e., Chinook salmon processed 1985-1990) using monthly length frequency distributions from fish of unknown age, and age and length data from fish of known age (i.e., those sampled in the early 1990s). Ages of Chinook salmon for which no scale samples were collected during 1991-2018, were determined using monthly length frequency distributions, and age and length data derived from fish aged by scales collected in the respective year.

Each year, age composition of Chinook salmon harvested is influenced by several factors, including catchability, year-class strength (Table 12), growth rates, and fishing quality for all salmonines. For 32 of the 36 years surveyed, Chinook salmon sampled from the angler harvest were dominated by age-2 and

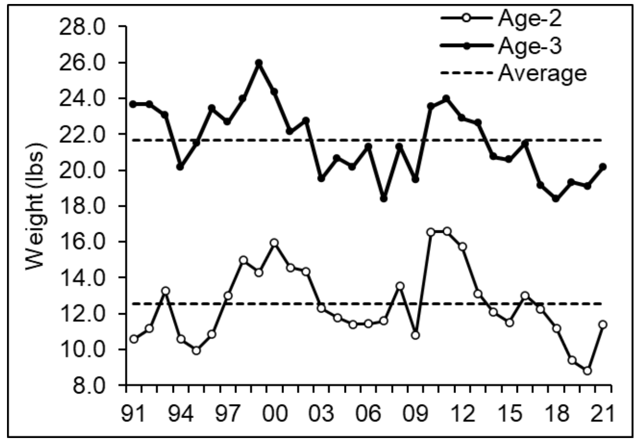


Figure 9. Average weight of age-2 and age-3 Chinook salmon measured in August each year from angler harvested fish, 1991-2021.

age-3 fish (1985-2019 averages: age 2 = 39.6%, age 3 = 46.6% of fish sampled; Table A9). In 2021, angler harvest consisted of 45.7% age-2 fish and 35.6% age-3 fish. Ages 1 and 4 typically represent small components of the harvest. In 2021, 14.0% of Chinook salmon processed were age-1 which is above the long-term average of 11%, and Age-4 Chinook salmon represented 4.5% of all Chinooks processed which is also above the long-term average of 2.8% (Table A9).

To evaluate Chinook salmon growth, we determined mean length-at-age by month for samples collected July through September (data collected from 1991-2021; Figure A1) and compared August means of each year with the long-term averages. In 2021, August mean length of age-1 fish was 20.1 inches, 0.5 inches above the long-term average (19.6 in). The mean length of age-2 Chinook in August was 29.7 inches which is 0.6 inches below the long-term average and approximately 3 inches shorter than the peak average lengths observed from 2010-2012. Mean length of age-3 Chinook salmon in August was 35.8 inches, 0.8 inches below the long-term average and 1.9 inches below the recent peak in 2012.

As another index of growth, we track the average weight of age 2 and age 3 Chinook salmon in August and compare that with long-term average values to assess trends from 1991-2021 (Figure 9, Table A10). Average weight of age-2 Chinook salmon in August 2021 was 11.4 lb which is 1.1 lb below the long-term average. Mean weight of age-3 Chinook salmon in August was 20.2 lb, which is 1.5 lb below average and 1.8 lbs above the Fish Community Objective threshold (i.e., (weight>18.4 lb, Stewart et al. 2017). Weight at age-3 in August has been maintained or increased for three consecutive years after falling to 18.4 lbs in 2018.

As an indicator of Chinook salmon condition, we also evaluated predicted weights of seven standard lengths (16-in to 40-in length fish by 4-in size increments). The predicted weights were calculated from length-weight regressions of fish harvested in July and August 1988-2019 (Table A9) and showed no statistically significant trends over the 30-year survey period (Connerton et al. 2020). Predicted weights of Chinook salmon in 2021 were slightly below respective long-term averages in all seven categories (16 in: -0.05 lbs; 20 in: -0.09 lbs; 24 in: -0.24 lbs; 28 in: -0.21 lbs; 32 in: -29 lbs; 36:in: -0.38 lbs; 40 in: -0.49 lbs; Table A9).

Overall, mean length, weight at age, and predicted weight indicated improved growth and condition of Chinook salmon in 2021 compared to 2018 and 2019. This may be partly attributable to lower predator biomass relative to prey biomass. From 2017-2019, stocking levels of Chinook salmon and lake trout were reduced to maintain predator prey balance after concern among fishery managers about a declining prey population after poor alewife recruitment in 2014 and 2015 (Weidel et al. 2020).

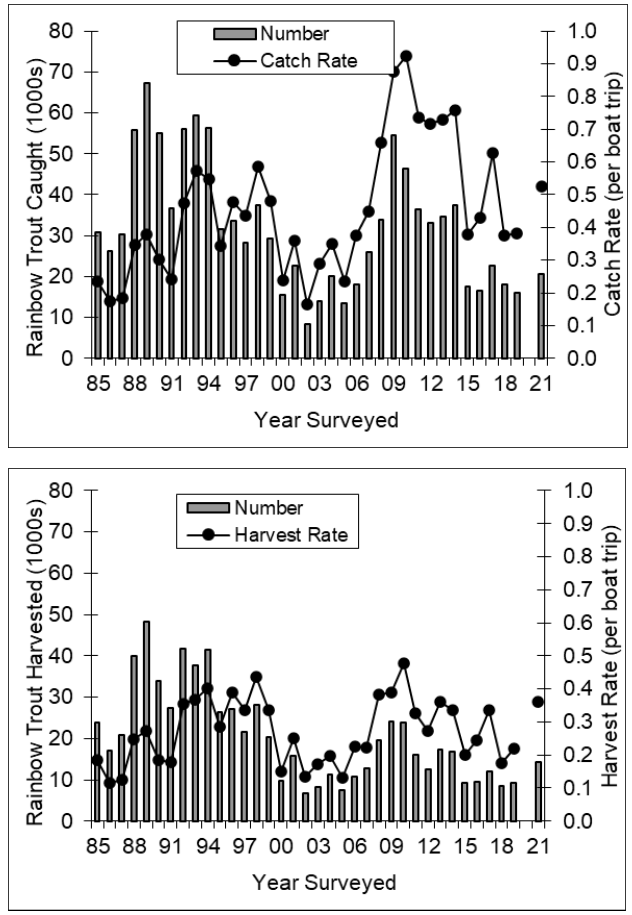


Figure 10. Total Rainbow trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 - September 30, 1985-2019 and 2021.

<u>Rainbow Trout</u>

Catch and Harvest

Estimates of total catch and harvest of rainbow trout peaked in 1989, declined to the lowest levels in the early 2000s, then improved from 2008-2014 to reach the highest catch rates on record (Figure 9). Catch and catch rates of rainbow trout dropped in 2015-2016, partly attributable to reduced population size after a prolonged rainbow trout mortality event related to thiamine deficiency in the Salmon River, NY from fall 2014 through winter 2015 (Lantry and Eckert 2018). The size of the spawning run at the Ganaraska River Fishway, an index of population size in Ontario was also markedly lower during 2014-2016. During spring of 2017 and 2018, however, the rainbow trout run at the Ganaraska River increased compared to the 2016 run indicating a higher population level in 2017 and 2018 (OMNRF 2019). Rainbow trout catch in New York waters of Lake Ontario, however, have remained lower since 2015. There have been no substantial reports of die-offs since 2014-2015, so reasons for the reduced catch are unclear. Stocking of yearling rainbow trout in 2015 was 23% below target which may have impacted population abundance in 2018 but would not have much effect thereafter since steelhead older than age 5 represent a relatively small proportion of the population (10% in 2018; Prindle and Bishop 2020). It is also possible that rainbow trout were targeted less by anglers from 2017-2019 due to record high catch rates for Chinook salmon. Anglers will often target rainbow trout by going further offshore during periods when Chinook salmon are not available.

In 2021, rainbow trout was the second most caught and harvested salmonine and represented 16.0% and 16.1% of the total trout and salmon catch and harvest, respectively (Tables 1, A11a; Figure 9). Rainbow trout catch in 2021 was an estimated 20,683 fish, 25.7% lower than the 10-year average but an increase compared with 2019, and 14% above the 2015-2019 average. Anglers harvested 14,215 rainbow trout, which was 5.5% higher than the 10-year average. Since 2003, anglers released an average of 52% of the steelhead they caught, but in 2021, 68.7% of steelhead caught were harvested. These levels of percent harvest have not been observed since the 1985-2002 period when anglers harvested an average of 72% of the rainbow trout they caught. Chinook salmon fishing quality declined in 2021, which may have influenced angler behavior and increased the targeting, catch, and percent harvest of rainbow trout.

For 36 consecutive years (1986-2021), most rainbow trout were caught and harvested in the west area (Table 11a). In 2021, 64.3%% of all rainbow trout caught and 62.4% of those harvested were from the west area, which is similar to the long-term averages (62.3% and 64.6% respectively). Most rainbow trout catch (37.8%) and harvest (40.8%) occurred during August (Table A11a). There have been significant downward trends ($p<0.001$) in the April/May percent contribution to harvest with April/May 2021 ranking 34th out of 36 years; along with corresponding significant increases in percent contribution to total harvest in the other months, especially June/July ($p=0.0235$, Connerton and Eckert 2019).

Fishing Quality

For seven consecutive years from 2008 to 2014, anglers experienced the highest rainbow trout catch per boat trip in the history of the survey (average=0.77 fish per boat trip; Table A11b; Figure 8). However, the 2015 and 2016 catch rates (0.38 and 0.43 fish per boat trip, respectively), declined to the lowest levels since 2006. After catch rates temporarily improved in 2017, they declined to 0.38 fish per boat trip in 2018 and 2019, 16.2% below the long-term average and 41.8% below the previous 10-year average, likely for reasons discussed above. Catch rates per boat trip in 2021 increased and ranked 12th out of 36 years. Catch rate per boat trip was 16.4% above the long-term average but 13% below the 10-year average which included those record high years from 2010-2014. In 2021, charter boats caught 49.1% of all rainbow trout caught by trout and salmon boats which is the 6th highest on record. Charter boats caught 0.87 rainbow trout per boat trip, 23.2% lower than the 10-year average. Charter boat catch per angler hour (0.03 fish per hour) was also below (-17.3%) the long-term average, but still higher than 12 out of 35 years. Anglers fishing onboard noncharter boats caught 0.38 rainbow trout per boat trip and 0.03 fish per angler hour (Table A11b) which was 15.6% above the long-term average. The 2021 lake-wide harvest rates among charter and non-charter boats showed similar trends to lake-wide catch rates (Table A11b).

Rainbow trout monthly and geographical catch rate and harvest rate trends for most years showed monthly rates highest during the summer (June and July) in the western end of the lake and lowest in the east area (Lantry and Eckert 2018; Table A11b). This was again the case in 2021. Compared to the long-term averages, the 2021 rainbow trout monthly catch rates per boat trip were above average in June (1.3, +111.9%) and July (0.7, +41.8%), and below average in April (0.05, -72.2%), May (0.13, -70.5%), August (0.48, -11.3%), and September (0.16, -33.9%, Table A14b). The west area catch rate was 1.1 per boat trip, about three times higher than the west/central (0.32) and east central areas (0.38), and fourteen times higher than the east area (0.07). Catch rates were below average in the west/central by 30.7%, and at (west) or above average in the east/central (+33.1%) and east areas (+47%).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2019 and 2021, weight: 1988-2019 and 2021). Scale samples were collected from rainbow trout processed for biological data each year 1996-2019 and 2021; however, they are not yet aged. Lengths of rainbow trout sampled from the open lake boat fishery were dependent on several factors including age and strain composition, stage of maturity, and fishing regulations (i.e. minimum size limit). The 2021 open lake season was the 15th year affected by the increased minimum harvestable length of rainbow trout from 15 to 21 in. The average percent contribution of fish <21.0 in for the twelve years since the regulation (2007-2021) was 9.5%, and significantly lower than the twelve years prior to the increased minimum size limit (1996-2006) when 20.2% of rainbow trout processed were <21.0 inches (Connerton and Eckert 2019). During 2021, 3.5% of harvested rainbow trout were shorter than the legal 21 in minimum harvestable size. The percentages of fish harvested in the four size categories from 25.0-28.9 inches were notably higher in 2021 representing 16.2%, 16.2%, 12.0%, 9.9% of the harvested fish, respectively, in 2021 The percent of fish over 25 inches was the 2nd highest of all years surveyed (highest in 2019).

Higher proportions of larger fish may be related to age structure in the population (i.e., relatively higher numbers of older fish or larger average size of age-4 rainbow trout as measured in the hatchery in spring 2021 (Prindle and Bishop 2022). In 2020, new regulations were established for rainbow trout which included a reduction of in the harvest limit of Rainbow trout on the lake from 3 to 2, and an increase in the minimum size from 21” to 25” in the tributaries, but it may be too early to see a measurable effect in the Lake fishery from that regulation change.

Weight data were collected each year from 1988-2019 and rainbow trout condition was calculated as predicted weights of standard-length fish (Table A12). For each standard-length group (18- to 32-in lengths, by 2-in size increments), predicted weights were variable but showed increasing trends from 1988 to about 2002-2003 (trends similar to those observed with Chinook and coho salmon), then generally declined to record and near record lows by 2006. Since then condition of rainbow trout has varied at a lower level resulting in significant downward trends among all 30 years (Connerton and Eckert 2019). In 2021, predicted weight (condition) was below average for all inch groups >26 inches relative to long-term averages. Predicted weights of the largest groups (30 and 32 inches) were the lowest and 2nd lowest recorded in the 33-year series. On a positive note, predicted weights of fish less than 25 inches were above average (Table A12).

Atlantic Salmon

In 1990, New York's Lake Ontario Atlantic salmon program changed from a small-scale experimental project with an annual stocking target of 50,000 yearlings, to a larger put-grow-take program for trophy fish (>25 in) with an annual stocking target of 200,000 yearlings and fall fingerlings. These stocking increases began in 1991 (1990 year-class) with annual stockings ≥160,000 fish for most years up to 1996 (Eckert 2000). Given this increased stocking level, Atlantic salmon catch in the open lake was expected to increase beginning in 1992, however, both catch and harvest declined after 1994 (Eckert 1998; Table A13; Figure 11). In 1996, the objective of a put-grow-take program for trophy fish was maintained but the annual stocking target was reduced to 100,000 yearlings and fall fingerlings. Stocking policy was further reduced to an annual target of 50,000 yearlings effective with the 2002 year-class (stocked in 2003) because of continued poor returns, and a decision to replace the Atlantic salmon stockings in the Black River with an equivalent number of brown trout. Each year from 2009-2021, the USGS Tunison Laboratory of Aquatic Sciences reared and conducted experimental stockings of Atlantic salmon in addition to the NYSDEC stockings (Connerton 2020).

Each year from 2003 through 2008, few Atlantic salmon were reported in angler catch or harvest, and <1 was observed in the boat fishery by creel agents, resulting in harvest estimates of less than 80 fish per year and catch estimates of less than 250 fish per year (Lantry and Eckert 2018; Table A16; Figure 11). Beginning in 2009, anglers began catching Atlantic salmon in greater frequency than in the previous decade. For three consecutive years (2009-2011), estimated lake-wide catch and harvest were the

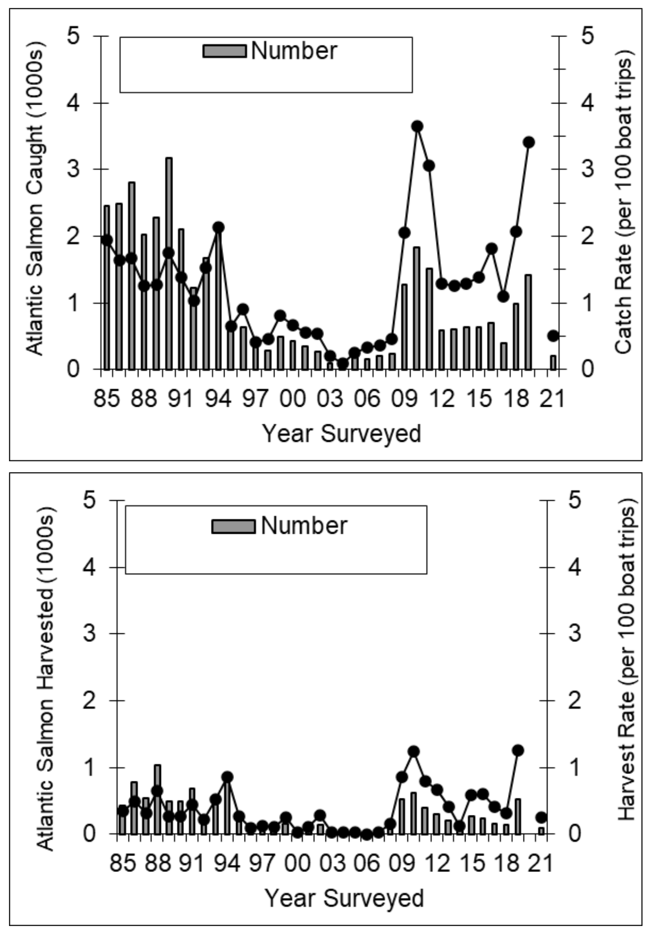


Figure 11. Total Atlantic salmon catch and catch rate, and harvest and harvest rate per 100 boat trips for boats seeking trout and salmon, April 15 – September 30, 1985-2019, and 2021. Note the difference in scale (100 boat trips) compared with other species.

highest since 1994 (Table A13; Figure 11). Since then, fewer Atlantic salmon were caught and harvested, however, estimates remained well above 1995-2008 levels. During 2019, estimated catch and catch rate 79.5% and 80.1% higher than the previous 10-year average (Tables 1, A13; Figure 11) and more than 7-fold higher than the 1995-2008 average rate (average = 0.48 per 100 boat trips). Unfortunately, in 2021, catch (200± 153) and catch rates (0.5 per 100 boat trips) declined again to levels observed during 2003-2008. This decline may be attributed to below normal stocking levels of yearlings in 2019 (14,140 yearlings vs 50,000 normal) due to a power failure at NYSDEC Adirondack Hatchery in 2018. This year-class was age-3 in 2021, which typically makeup some proportion of the catch in Lake Ontario. While natural reproduction of Atlantic salmon has been detected in the Salmon River (J, Johnson, USGS, pers. comm.) levels are very low, therefore this species presence in the fishery is currently supported mostly by hatchery stocking. Although USGS has experimentally stocked an average of 81,244 Atlantic salmon since 2009, these releases consisted mostly of fall fingerlings (75% of total USGS stocking). These fish were marked with fin clips, elastomer tags, and/or coded wire tags. About 7% of Atlantic salmon measured by the fishing boat survey since 2011 were clipped, indicating relatively lower survival than expected according to the number stocked; however, sample size is low (n=55) for this species throughout that period.

Additionally, efforts by OMNRF to restore self-sustaining populations of Atlantic salmon in several Lake Ontario tributaries included increased stocking levels beginning in 2006. To date, the contribution of the enhanced stocking by OMNRF to the sport fishery is unknown. Genetic analysis of tissue samples collected from New York angler caught salmon from 2009-2016 indicated that 86.5% were from NYSDEC stockings, 4.3% were from OMNRF stockings and 9.2% were undetermined (Lantry and Eckert 2018).

Brown Trout

Catch and Harvest

Brown trout catch and harvest declined from the mid-1980s to the mid-1990s and varied without trend since 1995 (Table A14a; Figure 12). Brown trout was the 4th most caught and 5th most harvested salmonine in 2021, accounting for 11.8% and 8.3% of the total catch and harvest, respectively (Tables 1, A14a). Estimated catch (15,293) and harvest (7,307) in 2021 was 50.7 and 60.6% respectively lower than the previous ten-year averages (Tables 1, A14a; Figure 12). Both harvest and catch in 2021 were the lowest in the time series. In 2021, 47.8% of brown trout caught were harvested. Typically, the majority of brown trout are caught during April and May (mean=54%) when this species is especially targeted by anglers, but this was not the case in 2021 when only 32.9% were caught in these months, mostly due to the record low catch in May. (Table A14a). Brown trout are also especially targeted in the east/central area for a longer period each fishing boat season and this area typically represented a majority (mean=50.3%) of the catch compared to other areas. In 2021, the east central represented 39%of the catch.

Fishing Quality

Brown trout catch rates (lake-wide, charter and

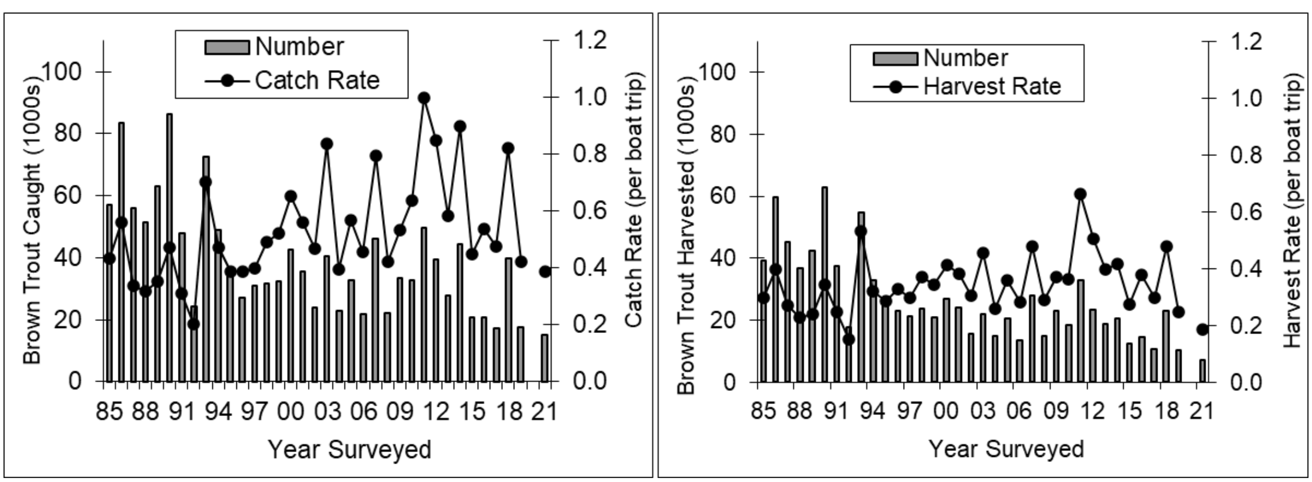


Figure 12. Total brown trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 September 30, 1985-2019 and 2021.

noncharter) were variable over the survey's history with no trend (Table A14b; Figure 12). In 2021, among trout and salmon fishing boats, brown trout catch rate (0.39 fish per boat trip) was 27.5% lower than long-term average and 41.9% lower than the previous 10-year average. Brown trout monthly catch and harvest rate trends for most years showed catch rates highest in April and May, when anglers especially target brown trout, and lower and/or declining through September when they switch to other species (Lantry and Eckert 2011; Table A14b). In 2021, estimated catch rate in April (1.6 per boat trip) was 54% lower than the 10- year average, and the catch rates in May (0.26 fish per boat trip) and June were 2nd and 3rd lowest observed for those months, which negatively impacted the average catch rate for the whole season. In July and August, brown trout catch rates improved, and were above average for those months. Higher catch rates in August may be partly attributable to poorer Chinook salmon fishing quality in three lake areas (i.e., west/central, east/central, and east; Figure 8) because anglers will often switch to other species when Chinook are not available. Nonetheless, anglers in 2021 reported a general lack of the typical 2-4 lb (age 2) brown trout that usually makeup the majority of the catch, and this negatively influenced brown trout catch rates throughout the season.

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-2019, and 2021, weight: 1988-2019, and 2021). Scales were collected from nearly all brown trout processed by creel agents during 1993-2019, and 2021 (i.e., 27 years). Each year very few brown trout sampled are age-1 (0.0%-3.3%) due to their small size (i.e., mostly shorter than the 15-inch minimum size limit) and angling strategies (e.g., species targeted, lure type). Each year 2011-2019, none of the brown trout sampled were age-1 (Table A15); the majority were age 2. During 1993-2012, 66.0% (2004) to 88.8% (1993) of all brown trout harvested were age-2 fish. Each year 2013-2015, age-2 brown trout dominated angler harvest, however, contributions of age 2s were the lowest recorded (range: 58.3% - 62.6%) and contributions of age 3s were the highest recorded (range: 28.8%-34.6%). From 2016-2018, contributions of age 2s were more like historical levels (average 75.4%). In 2019, 49.2% of brown trout harvested were age 2, about 34% below average. Conversely 28.7% of the harvested brown trout were age-3 fish. For most years, <4% of brown trout harvested were age-4 fish. The highest contributions of age-4 brown trout occurred in 2014, 2015, 2019 (7.8%, 9.2% and 7.2% of harvest, respectively), and in 2021 when 14.9% were age-4. From 1993-2019, age-5 or older brown trout comprised an average of 0.7% (4.5% in 2021; Table A15). Few brown trout age-6 or older were observed, and in the 26 years that scale samples were aged, only sixteen age-6 and two age-7 brown trout were observed (none in 2021).

Higher proportions of age-3 and older brown trout harvested by anglers in 2021 is the result of lower availability of age-2 fish that typically makeup the majority of the harvest and catch each year. The reasons for low catches of age-2 brown trout in 2021 is unclear. Hatcheries released the target number (472,000) of brown trout yearlings at twenty sites in 2020 and stocked an additional 128,906 surplus yearlings at seven of those sites (Connerton 2021). Some sites were stocked earlier than normal (in late March vs early or mid-April) due to coronavirus health and safety restrictions in 2020, and this may have impacted brown trout survival, however, brown trout stocked by barge off Stony Point, Little Salmon River, Oswego, and Fairhaven were released at normal time in May. Even so, anglers experienced low catches of age-2 brown trout at these sites in 2021, so the poor survival of the 2020 stocking seemed to be a lake wide issue.

Each year the mean length of brown trout sampled April 15-30 is determined. From 2014 to 2016, lengths of age-2 brown trout were among the lowest levels recorded. Growth rates of those fish were likely negatively impacted by two consecutive long and cold winters followed by below average summer temperatures. Milder weather and a relatively strong 2016 year-class of alewife may have contributed to improved growth observed in 2017 (Lantry and Eckert 2018). Conversely, brown trout size in 2018 and 2019 was below average. In 2021, growth rebounded, and average length of an age-2 brown trout measured in April was 18.7 in, 4.1% above the long-term average (18.0 in, Table A15). Mean length of age-3 brown trout measured in April was 22.3 inches, only 2% below the long-term average (22.7 in). Mean weight of age-2 and age-3 in 2021 were both 0.8 lbs above the long-term averages (3.0 and 6.1 lb respectively).

Brown trout condition was also evaluated by determining predicted weights of seven standard length groups (16-28 in, by 2-in length increments; Table A15). Each year 2014 to 2016, brown trout condition was at or near record low values for all sizes examined. After temporarily improving in 2017, condition of brown trout in 2018 declined again to among the lowest levels observed for the time series. Predicted weights of all sizes examined were still mostly below long-term averages in 2019 (Table A15). In 2021, condition generally improved, and predicted weights of all size groups were above average. Growth and condition of brown trout was likely positively influenced by warmer weather conditions and increased prey availability in 2021 (Weidel et al. 2022).

Lake Trout

Catch and Harvest

Lake trout fishing regulations for New York waters of Lake Ontario differ from the other salmonines and affect harvest. Since 1988, lake trout harvest was limited by a slot size limit designed to increase the number and ages of spawning adults. In 1993, the slot limit was set at 25-30 inches total length. Until fall 2006, Lake Ontario anglers could harvest three lake trout outside of the 25 to 30-inch slot limit. Effective October 1, 2006, the lake trout creel limit was reduced to two fish per day per angler, one of which could be within the 25 to 30-inch slot. Although regulations affect harvest and harvest rates, declines in lake trout catch observed from 1990-2000 were mostly attributable to declining fishing effort among trout and salmon boats during this period. Lake trout abundance remained relatively steady in lake trout gillnetting surveys from 1992-2000 (Lantry and Lantry 2018) as did angler catch rates (Figure 13). Relatively lower catch and catch rates of lake trout through much of the 2000s were attributed, in part, to both the excellent fishing quality for other salmonine species (i.e., possibly less effort specifically directed at lake trout) and relatively low lake trout abundance during the mid-2000s (Lantry and Eckert 2018). Increased lake trout catch and catch rates, which began in 2011, were attributed to increased lake trout abundance (Lantry and Lantry 2018). Additionally, some anglers reported specifically targeting lake trout when fishing quality for other species (e.g., brown trout) was considered low during 2013-2017. In 2018 and 2019, lower catch and harvest of lake trout may have been partly due to record high Chinook catch rates rather than abundance of lake trout, which was relatively high according to the adult lake trout gillnet survey conducted in these years (Lantry et al 2021).

In 2021, lake trout was the third most caught and harvested trout or salmon species in the creel survey, contributing 14.6% and 13.2% of the total salmonine catch and harvest, respectively (Tables 1, A16a). Estimated lake trout catch (18,959) and harvest (11,649) were 27.0% lower and 0.3% higher than the previous 10-year averages, respectively (Tables 1, A16a; Figure 13). Lake trout harvest in 2021 may once again have been affected by Chinook salmon and brown trout fishing quality. In this case, relatively lower fishing quality for these species may have influenced angler behavior. For example, the proportion lake trout harvested (61.4%) was higher than observed recently (10-year average=37.9%) and

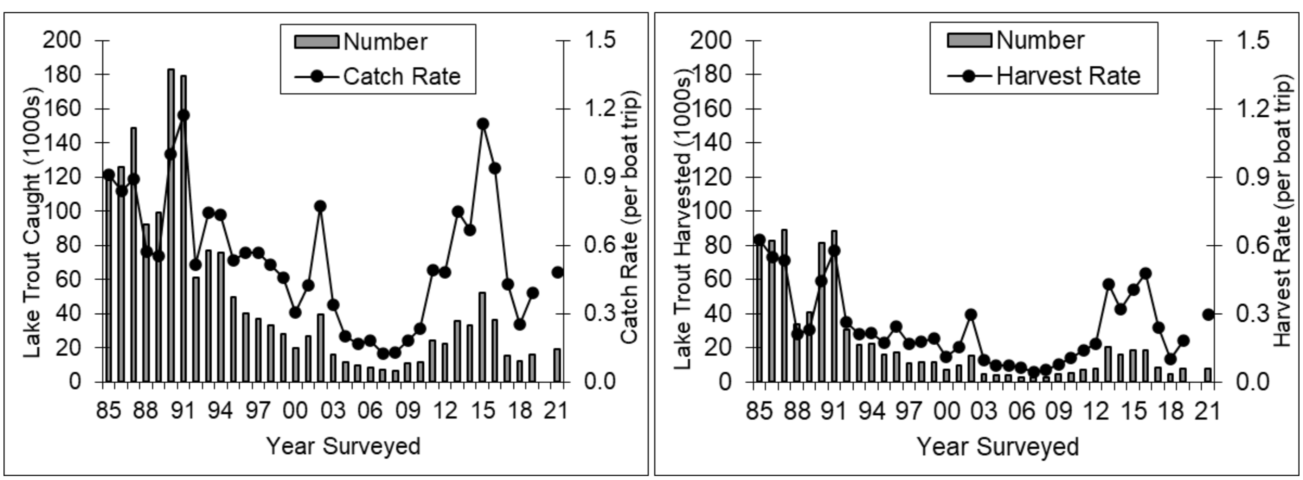


Figure 13. Total lake trout catch and catch rate, and harvest and harvest rate per boat trip for boats seeking trout and salmon, April 15 – September 30, 1985-2019 and 2021.

charters accounted for 61.6% of the catch, which was also higher than usual compared to the recent 10-year average (45.6%), suggesting a shift towards targeting lake trout by charters and more anglers deciding to harvest lake trout they caught.

Prior to 2001, the east area accounted for the highest proportion of lake trout catch and harvest for nearly every survey year (Lantry and Eckert 2011; Table A16a). Since 2000, most lake trout were caught in the west or west/central areas (15 of the 18 years 2001-2019). In 2021, the majority (51.0%) were caught in the east area (6,115 fish, Table A16a).

Fishing Quality

Low lake trout abundance during the mid-2000s (Lantry and Lantry 2018) and excellent fishing quality for other salmonine species beginning in 2003 contributed to declining lake trout catch and harvest rates from 2003 to 2007 (2003-2007 average catch rate = 0.2 per boat trip; Table A16b; Figures 13, 13b). From 2008-2016, catch rates increased reaching 1.1 per boat trip in 2015 (second highest on record) and remained high in 2016 (0.9 per boat trip, fourth highest on record; Table A16b; Figure 13). This increase coincided with an increased population of adult lake trout in recent years as well as a likely increase in angler effort targeting lake trout during periods of relatively lower catch rates for other species (2014-2016). In 2018 and 2019, lake trout catch rates declined and coincided with good to excellent fishing quality for other, more preferred trout and salmon species (e.g., Chinook salmon) and likely reduced effort specifically targeting lake trout. In 2021, seasonal catch rate of lake trout increased to 0.48 fish per boat trip but was still about 16% below the 10-year average. Comparisons by month showed that catch rates were below their respective long-term averages for four months (range: -65.3% [September] to -39.0% [July]); Table A16b), however they were above average in April (+84.9%) and August (+68.9%). Estimated catch rate in April (1.95 per boat trip) was exceptionally high, ranking 3rd in the 36-year survey (Table A16b). Higher catch rates in these months may be due in part to anglers switching to targeting lake trout when brown trout fishing quality was relatively poor in April and when Chinook fishing was relatively poor in August.

For nearly all years since 1997, the west/central area experienced the highest lake trout catch rates (Table A16b). In 2021, anglers fishing the east area experienced the highest catch rate of 0.70 lake trout per boat trip, 48.8% higher than the 10-year average for that area. Catch rates in the other areas surveyed were below average (range: -56.8% [west] to -14.6% [west central]).

Biological Data

Biological data analysis presented here includes fish processed during April 15 - September 30 (length: 1985-20121, weight: 1988-20121). The 2021 fishing season was the 14th season affected by the October 2006 regulation change permitting each angler to keep two lake trout per day with no more than one between 25 and 30 inches. From 1993-2006, 9.8% (1998) to 26.6% (1993; 1993-2006 average = 17.0%) of the lake trout harvested were within the 25-30 inch slot, due in part to measurement errors and location of capture (fish harvested in Ontario waters are exempt from New York regulations; Table A17). Given the regulation change we expected to see increased harvest of slot limit sized fish. As expected, during the first five years after the regulation change (2007-2011) the percentage of harvested lake trout within the 25 to 30-inch slot increased to an average of 37.2% (Table A17). From 2012 through 2019, an average of 48.3% of lake trout harvested were within the slot limit. In 2019, 48.5% of all lake trout harvested were within the 25 to 30-inch slot, 17.2% of lake trout harvested were shorter than, and 37.4% harvested were greater than the slot.

Smallmouth Bass

Catch and Harvest

Prior to October 1, 2006, NYSDEC fishing regulations established the smallmouth bass open season in Lake Ontario from the third Saturday in June through November 30 and allowed anglers to harvest a daily limit of five smallmouth bass with a minimum length of 12 inches. A regulation change effective October 1, 2006 established a pre-season catch and release period for smallmouth bass from December 1 through the Friday preceding the third Saturday in June (excluding Jefferson County's Lake Ontario waters). In 2021, there were an estimated 495 fishing boat trips targeting smallmouth bass during the catch and release season, representing 12% of the total fishing effort targeting smallmouth bass from April 15-September 30 (Table A18), which was the highest value since catch and release season was established in 2007.

Among all fish species, smallmouth bass was the

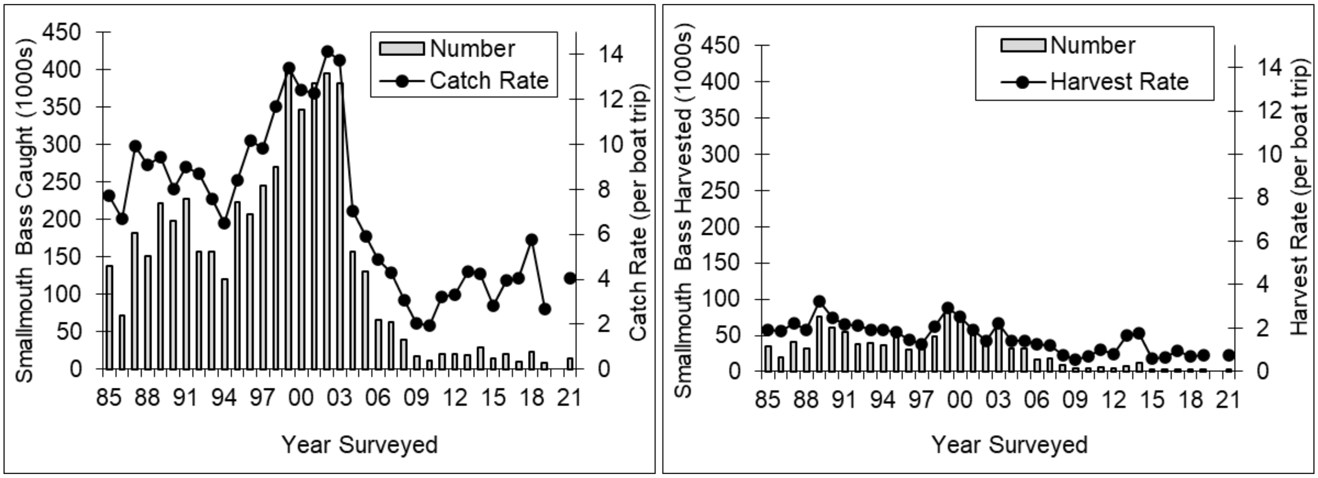


Figure 14. Total smallmouth bass catch and catch rate, and harvest and harvest rate per boat trip for boats seeking smallmouth bass during the traditional open season, 1985-2019 and 2021.

most caught species each year 1985 and 1987-2006. In 2007, smallmouth bass became the third most commonly caught species in the open lake boat fishery, preceded by yellow perch and Chinook salmon (Lantry and Eckert 2018). From 2009-2021, catch of smallmouth bass remained relatively low and was the fourth most caught species in 2021. Estimated catch and harvest of smallmouth bass April 15 – September 30, 2021, was 18,318 and 2,863 fish, respectively (Tables 1, A18a). During the traditional open fishing season, 14,723 smallmouth bass were caught and 18.1% of those were harvested (2,659) fish; Table A18a; Figure 14). From 2007-2019, the number of smallmouth bass caught during the catch and release season represented a relatively small percentage (average=4.9%) of all smallmouth caught from April 15-September 30. Total catch of smallmouth bass during the catch and release season in 2021 was 1,761 fish, which represented 9.6% of total smallmouth bass caught during the survey season (Table A18a).

Fishing Quality

Fishing quality was relatively stable from 1985 through the early 1990s (1985-1994 average catch per boat trip = 8.3 bass; average catch per angler hour = 1.0 bass). Catch rate increased to the highest level in 2002 (14.1 per boat trip and 2.02 per angler hour; Eckert 2005; Table A18b; Figure 14), then declined to the lowest level recorded in 2010 (1.9 per boat trip and 0.35 per angler hour). A Lake Ontario bass angler diary program conducted 2010-2013 surveyed bass anglers fishing Lake Ontario and its embayments and tributaries in NYSDEC Region 8. Catch rates experienced by diarists (0.39-0.63 bass per angler hour) were similar to rates reported in this survey for the same time period (0.35-0.59 bass per angler hour; Sanderson and Lantry 2014; Table A18b). The angler diary program was discontinued following the 2013 season due to low participation (Sanderson and Lantry 2014).

Smallmouth bass catch rates steadily improved from 2011 until 2018 when anglers targeting smallmouth bass averaged 5.80 per boat trip (0.86 per angler hour). Bass catch rates in 2018 were similar to rates experienced in Lake Erie and Oneida Lake, which are considered acceptable catch rates. Smallmouth bass catch per angler hour in 2019, however decreased to 0.4 per angler hour (2.8 per boat trip), the 3rd lowest in the survey (Table A21b; Figure 14b). In 2021, bass catch rates improved to 4.0 bass per boat trip (0.5 per angler hour), 11% above the recent 10-year average but 43% below the long-term average.

In 2021, 54% of boats specifically targeting smallmouth bass during the traditional open season failed to catch any bass, which is higher than most recent years, but well above levels observed prior to 2006 (1985-2005 mean=24.7%), indicating continued relatively poor fishing quality. Each year, a relatively low percentage of bass boats harvested the daily creel limit of five bass per angler (1985-2003 average=6.3%). Since catch rates began decreasing after 2003, an even lower percentage of bass boats harvested their limit of bass (2004-2019 average=2.3%). In 2021, 1.4% of the boats specifically targeting bass harvested the daily creel limit of five bass per angler (Table A6). This metric can be influenced by sizes of bass caught and a change in angler attitude toward catch and release (i.e., more anglers may favor release rather than harvest).

Smallmouth bass fishing quality along Lake Ontario's south shore since the mid-2000s may have been influenced by several negative factors including round goby, Viral Hemorrhagic Septicemia virus (VHSv), *Hemimysis*, *Cladaphora* (commonly called "witch's hair"), and nutrient and water clarity changes. Many of these factors also affect bass populations in Lake Ontario's Eastern Outlet Basin, the St. Lawrence River and Lake Erie. Unlike the southern shore, however, these regions have generally continued to provide acceptable bass catch rates (Lantry and Eckert 2018).

Yellow Perch

Yellow perch catch and harvest estimates are highly variable in this survey because few anglers with perch in their creel are interviewed, perch anglers targeting yellow perch in the lake can have very low to very high catches, and the probability of interviewing perch anglers is low. The 2021 estimated catch (14,386 fish) and harvest (7,334 fish) increased compared to 2019 and were below long-term (1985-2019) averages (-46.8% and -37.8%, respectively, Tables 1, A19). Yellow perch are distributed along much of the Lake Ontario shoreline, however, each year 1996-2019 the greatest proportion of catch occurred in the east/central area by relatively few fishing boats targeting perch (average 72% of total catch). In 2021, catch was highest in the east area, representing 51% of the catch and 2nd highest in the east/central area (40% of the catch).

Walleye

Walleye have always been a minor component of the open lake boat survey, although angler interest in this species is high and, as part of management programs, fingerling stocking has occurred in many Lake Ontario embayments (e.g., Eckert 2005, Connerton 2020). Catch and harvest estimates for walleye are highly variable which is partly attributed to catch and harvest being greatest in locations and at times not included in, or poorly covered by, this survey (i.e., harvest in embayments or the eastern basin, and at night). Additionally, as with yellow perch, walleye catch and harvest estimates are influenced by only a few boats encountered by the survey specifically targeting walleye and the probability of interviewing those boats is low. In 2021, there were an estimated 667 and 503 walleye caught and harvested, respectively, in Lake Ontario (Table A20). Assessment data (Goretzke and Connerton 2020) and anecdotal angler reports suggest that walleye populations and fisheries are greatly underestimated by this survey.

Lamprey Observations

Since 1986, all boat anglers were specifically asked if they observed lampreys attached to any of the fish they caught. Follow-up questions confirmed that the anglers observed an actual parasitic phase lamprey (as opposed to a lamprey mark) and determined what species of fish the lamprey was attached to. When saved by anglers, the lampreys were examined and a length measurement taken.

In 2021, there were an estimated 2,982 lampreys observed in this survey, 4.5% higher than the long-term average, and 65% lower than the 2007 record high (Table A21; Figure 15). The number of lampreys observed by anglers per 1,000 trout and salmon caught (hereafter referred to as attack rate) was relatively stable during 1986-1995 and averaged 5.9. After 1995, the attack rate increased, reaching a peak in 2007 when an average of 44.4 lampreys were observed per 1,000 trout and salmon caught. This increase coincided with a decline in abundance of lake trout >17 in, the preferred prey of sea lamprey (Lantry and Lantry 2018). Lamprey attack rates decreased from the 2007 peak and in 2021, there were an estimated 23.0 lamprey per 1,000 trout or salmon caught (Table A21; Figure 15). This rate was 51.8 % above the long-term average.

For 17 of the last 20 years (2001-2021) the majority of lamprey observations occurred on Chinook salmon (2001-2019 average=60.1%), which was due, in part, to the large number of Chinook salmon caught by anglers (e.g., 2001-2021 average=46.6% of total trout and salmon catch; 46.9% in 2021; Tables A5a, A8a). In 2021, 72.4% of lamprey observed by anglers were on Chinook salmon which is the 5th highest on record (Tables A5a, A21). Other host salmonines in 2021 were brown trout (15.5% of observations), rainbow trout (4.3%), coho salmon (2.6%), lake trout (5.2%), and Atlantic salmon (0%; Table A21). Among the 35 years of lamprey observation data, there were a total of 45 lampreys reported on fishing gear out of 3,265 total observations. No lampreys were observed on fishing gear in 2021.

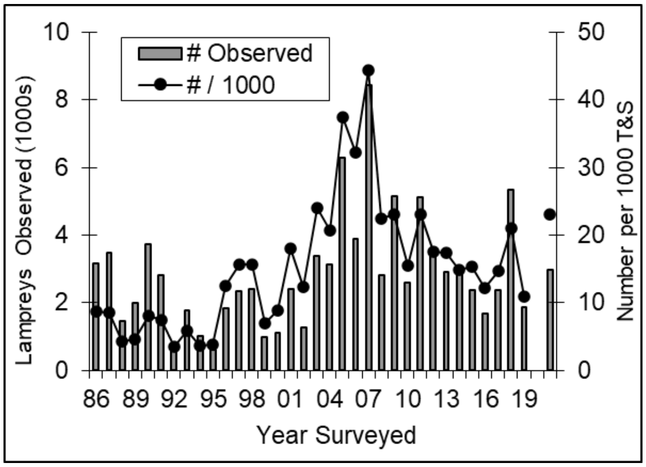


Figure 15. Total lamprey observed, and lampreys observed per 1,000 trout and salmon caught, April 15-September 30, 1985-2019, and 2021.

Host-specific attack rate on Lake Ontario's trout and salmon (e.g., the proportion of brown trout caught by anglers with a lamprey attached; Table A24) was determined each year. Prior to 1996, lamprey attack rate on "other" salmonines (i.e., excluding lake trout) was low and, on average, fewer than 1% of each species caught by anglers was observed with a lamprey attached (range of 1986-1995 averages: 0.08% [coho salmon] – 0.74% [Chinook salmon]). By 1996, the percentage of angler-caught salmonines with an attached lamprey increased for the "other" salmonines. On average, during 1996-2021, lampreys were observed on a higher percentage of angler catch (range: 0.9% [coho salmon] to 5.3% [Atlantic salmon]). The increase in attack rate on these salmonine species coincided with a decrease in abundance of the preferred lamprey prey (i.e., lake trout ≥17 inches; Lantry and Lantry 2018). The lower attack rates since 2007 (Figure 17) coincided with a reduced lake trout wounding rate as determined from September gillnetting, fewer lampreys observed attached to lake trout in the creel survey, and an increased lake trout population (Lantry and Lantry 2018).

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2021 Lake Ontario Fishing Boat Survey

Appendix Tables and Figures

Table A1. The four geographic areas (Roman numerals) used in analysis of the 1985-2019 and 2021 NYSDEC Lake Ontario fishing boat survey data.

I. West geographic area: Niagara River to Point Breeze. Access locations include Williams Marina, Fort Niagara State Park launch ramps (Youngstown), Roosevelt Beach, Wilson, Olcott, Green Harbor Marina, Golden Hills State Park, Johnson Creek, and Point Breeze.

II. West/Central geographic area: Bald Eagle Creek Marina, Sandy Creek, Braddock Bay, Long Pond outlet, Genesee River, Irondequoit Bay.

III. East/Central geographic area: Bear Creek, Pultneyville, Hughes Marina, Sodus Bay, East Bay, Port Bay, Blind Sodus Bay, Little Sodus Bay (Fair Haven), Sterling Creek, Wrights Landing at Oswego, Oswego Marina.

IV. East geographic area: Sunset Bay, Catfish Creek, Dowie Dale Marina, Little Salmon River, Salmon River, Sandy Pond, Lakeview (North and South Sandy), Stony Creek, Association Island Cut.

Table A2. Effort and use statistics collected April 15 - September 30 during the 1985-2019, and 2021 NYSDEC fishing boat surveys. No survey was conducted in 2020.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Part A: Effort for all fishing boats.											
Seasonal (5½ -month) estimates of fishing effort for all fishing boats:											
Fishing Boat Trips	118,438	60,943	56,182	54,605	58,554	53,154	46,339	39,964	54,663	46,099	45,617
Boat Angler Trips	327,470	171,519	160,363	161,620	174,079	157,151	138,434	121,041	168,084	144,561	151,114
Boat Angler Hours	1,764,776	898,339	848,905	937,822	980,409	879,681	787,588	709,638	922,527	820,695	863,456
Anglers/Boat Trip	2.76	2.81	2.85	2.96	2.97	2.96	2.99	3.03	3.07	3.14	3.31
Hours/ Boat Trip	5.30	5.24	5.29	5.80	5.63	5.60	5.69	5.86	5.49	5.68	5.71
Monthly estimates of boat trips for all fishing boats:											
April	9,693	2,529	2,409	2,672	1,935	2,251	3,257	2,032	1,524	1,283	2,346
May	17,943	8,605	9,540	8,368	8,652	9,147	7,299	4,269	8,151	7,245	6,011
June	14,243	6,183	8,128	7,608	8,002	5,190	5,231	3,585	6,814	5,408	7,007
July	21,611	15,024	12,024	11,950	11,234	10,904	10,305	8,907	12,813	10,191	11,650
August	33,153	17,315	15,096	17,404	19,666	14,085	12,284	13,035	15,564	14,090	13,558
September	21,795	11,286	8,986	6,603	9,061	11,577	7,963	8,136	9,798	7,883	5,046
Seasonal estimates of boat trips among four geographic areas for all fishing boats:											
West	27,728	16,248	14,145	14,602	13,674	12,543	11,649	10,848	12,938	15,209	12,662
West/Central	17,141	6,890	7,412	7,648	7,210	7,407	4,561	4,051	9,052	2,921	6,385
East/Central	38,973	19,926	17,410	17,368	18,455	16,964	17,508	14,145	18,803	14,575	14,882
East	34,596	17,879	17215	14,988	19,215	16,240	12,622	10,920	13,869	13,393	11,688
Part B: Seasonal estimates of total boat excursions (traffic).											
Power Boats:											
Fishing Boats	121,792	61,383	56,979	55,116	59,149	53,812	46,747	40,156	55,063	46,180	45,727
Nonfishing Boats	107,085	69,943	71,318	89,530	70,311	97,066	96,268	52,445	89,221	55,827	72,978
Sail Boats	27,526	23,782	20,703	21,432	19,104	13,905	12,789	10,013	13,105	8,948	10,640
Part C: Seasonal estimates of boat angler trips by residence.											
NY Resident	202,428	105,145	97,153	96,610	106,088	94,785	81,559	68,245	105,780	81,786	90,985
Nonresident	125,042	66,374	63,210	65,010	67,991	62,366	56,875	52,796	62,304	62,775	60,128
% NY Resident	61.5%	61.3%	60.6%	59.8%	60.9%	60.3%	58.9%	56.4%	62.9%	56.6%	60.2%
Part D: Effort for boats seeking trout and salmon.											
Seasonal (5½-month) estimates of fishing effort for boats seeking trout and salmon:											
Fishing Boat Trips	92,236	49,548	46,059	47,520	49,434	46,142	38,776	35,865	47,839	41,722	39,273
Boat Angler Trips	267,730	147,775	138,687	146,900	155,656	142,816	121,828	112,503	153,774	135,583	137,365
Boat Angler Hours	1,566,249	831,675	785,271	889,719	917,662	838,730	735,716	685,818	879,499	791,564	816,603
Anglers/Boat Trip	2.92	2.98	3.01	3.09	3.15	3.10	3.14	3.14	3.21	3.25	3.50
Hours/ Boat Trip	5.82	5.63	5.66	6.06	5.90	5.87	6.04	6.10	5.72	5.84	5.94
Monthly estimates of boat trips for boats seeking trout and salmon:											
April	9,577	2,518	2,366	2,575	1,920	2,251	3,198	1,993	1,524	1,283	2,303
May	17,040	8,050	8,388	7,911	8,417	8,656	6,770	3,783	7,550	6,949	5,330
June	8,949	4,313	5,138	6,333	5,489	4,322	3,785	2,959	5,331	4,712	4,951
July	13,045	10,903	9,255	9,651	8,827	8,140	8,403	7,797	10,833	8,910	9,752
August	25,736	14,123	12,910	15,910	16,917	12,340	9,997	12,338	13,937	13,269	12,376
September	17,890	9,642	8,002	5,141	7,864	10,433	6,622	6,995	8,663	6,599	4,560
Seasonal estimates of boat trips among four geographic areas for boats seeking trout and salmon:											
West	24,057	14,715	12,671	13,674	12,092	11,350	11,061	10,412	12,156	14,308	12,002
West/Central	12,516	5,047	5,584	6,634	6,251	6,447	3,914	3,729	8,185	2,696	5,644
East/Central	27,597	15,137	13,596	15,259	15,852	13,937	13,830	12,613	15,856	12,896	12,938
East	28,066	14,649	14,208	11,954	15,239	14,408	9,972	9,111	11,642	11,822	8,689
Percent of total seasonal fishing effort by boats seeking trout and salmon:											
Fishing Boat Trips	75.4%	81.3%	82.0%	87.0%	84.4%	86.8%	83.7%	89.7%	87.5%	90.5%	86.1%
Boat Angler Trips	79.7%	86.2%	86.5%	90.9%	89.4%	90.9%	88.0%	92.9%	91.5%	93.8%	90.9%
Boat Angler Hours	87.2%	92.6%	92.5%	94.9%	93.6%	95.3%	93.4%	96.6%	95.3%	96.5%	94.6%

Table A2 (continued). Summary of effort statistics.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Part E: Boats seeking smallmouth bass during the open season.											
Seasonal estimates of fishing effort for boats seeking smallmouth bass during the traditional open season:											
Fishing Boat Trips	20,524	6,257	6,203	4,273	6,878	4,868	5,295	2,294	4,135	2,919	3,627
Boat Angler Trips	46,903	13,758	13,505	9,082	14,223	9,900	11,944	4,868	8,698	5,994	8,227
Boat Angler Hours	156,214	42,718	41,972	31,569	51,006	28,115	37,167	13,917	27,676	19,699	29,172
Anglers/Boat Trip	2.28	2.20	2.18	2.13	2.07	2.03	2.26	2.12	2.10	2.05	2.27
Hours/ Boat Trip	3.29	3.10	3.11	3.48	3.59	2.84	3.11	2.86	3.18	3.29	3.55
Monthly estimates of boat trips for boats seeking smallmouth bass during the traditional open season:											
April & May		-	-	-	-	-	-	-	-	-	
June	3,612	935	1,525	637	1,900	543	904	281	730	315	1,166
July	7,243	2,704	2,303	1,403	1,786	2,376	1,498	822	1,544	1,005	1,428
August	6,418	1,724	1,646	959	2,312	1,148	1,931	522	1,027	461	735
September	3,250	894	728	1,275	880	801	962	669	833	1,138	299
Seasonal estimates of boat trips among four geographic areas for boats seeking smallmouth bass during the traditional open season:											
West	2,332	815	984	352	1,101	793	263	104	217	211	271
West/Central	3,374	784	1,006	564	609	370	138	257	237	64	177
East/Central	9,527	2,809	2,289	1,174	1,801	2,233	2,800	928	2,288	1,307	1,367
East	5,290	1,849	1,924	2,183	3,367	1,473	2,094	1,005	1,394	1,338	1,812
Percent of total seasonal fishing effort by boats seeking smallmouth bass during the traditional open season:											
Fishing Boat Trips	19.7%	10.3%	11.0%	7.8%	11.7%	9.2%	11.4%	5.7%	7.6%	6.3%	8.0%
Boat Angler Trips	16.3%	8.0%	8.4%	5.6%	8.2%	6.3%	8.6%	4.0%	5.2%	4.1%	5.4%
Boat Angler Hours	10.4%	4.8%	4.9%	3.4%	5.2%	3.2%	4.7%	2.0%	3.0%	2.4%	3.4%
Part F: Other species sought.											
Seasonal estimates of fishing boat trips by species sought for boats not seeking trout and salmon, or smallmouth bass during the traditional open season:											
Northern Pike	89	46	29	78	22	0	49	36	49	107	88
SMB pre-opener	254	239	521	191	295	164	356	198	221	230	495
Largemouth Bass	24	13	13	197	62	29	0	13	0	0	0
Yellow Perch	1,008	1,794	1,556	779	712	623	422	477	595	215	609
Walleye	471	384	233	249	137	348	368	176	234	360	510
All Other	3,819	2,662	1,568	1,319	1,015	980	1,073	905	1,591	544	1,016
SMB Pre-opener % of total SMB		3.7%	7.7%	4.3%	4.1%	3.3%	6.3%	7.9%	5.1%	7.3%	12.0%
% Northern Pike	0.08%	0.08%	0.05%	0.14%	0.04%	0.00%	0.11%	0.09%	0.09%	0.23%	0.19%
% SMB pre-opener	0.28%	0.39%	0.93%	0.35%	0.50%	0.31%	0.77%	0.50%	0.40%	0.50%	1.08%
% Largemouth Bass	0.02%	0.02%	0.02%	0.36%	0.11%	0.05%	0.00%	0.03%	0.00%	0.00%	0.00%
% Yellow Perch	0.97%	2.94%	2.77%	1.43%	1.22%	1.17%	0.91%	1.19%	1.09%	0.47%	1.33%
% Walleye	0.50%	0.63%	0.41%	0.46%	0.23%	0.65%	0.79%	0.44%	0.43%	0.78%	1.12%
% All Other	3.48%	4.37%	2.79%	2.42%	1.73%	1.84%	2.32%	2.26%	2.91%	1.18%	2.23%
Part G: Charter fishing boats.											
Seasonal (5½-month) estimates of fishing effort for charter boats:											
Fishing Boat Trips	12,641	8,332	7,632	9,343	9,718	9,831	8,653	7,102	11,683	9,132	11,689
Boat Angler Trips	63,878	43,124	38,880	48,694	51,351	51,311	45,496	36,558	62,651	48,851	64,027
Boat Angler Hours	464,252	275,652	256,420	338,688	345,925	334,663	314,553	242,992	388,651	318,529	405,812
Anglers/Boat Trip	5.03	5.18	5.09	5.21	5.28	5.22	5.26	5.15	5.36	5.35	5.48
Hours/ Boat Trip	7.20	6.39	6.60	6.96	6.74	6.52	6.91	6.65	6.20	6.52	6.34
Monthly estimates of boat trips for charter boats:											
April	736	300	599	426	281	353	607	285	326	300	628
May	2,173	1,119	733	1,607	1,401	1,941	954	915	1,359	1,183	974
June	1,395	873	648	965	1,028	707	981	615	1,167	1,248	1,613
July	2,051	2,174	1,826	2,252	2,141	1,724	2,431	1,846	2,209	1,953	3,564
August	4,156	2,513	2,622	3,060	3,620	3,407	1,946	2,154	4,666	3,234	3,957
September	2,130	1,353	1,203	1,032	1,247	1,700	1,735	1,287	1,956	1,143	953
Seasonal estimates of boat trips among four geographic areas for charter boats:											
West	3,365	2,658	2,060	2,572	2,234	2,401	2,426	2,139	2,310	2,805	3,229
West/Central	1,378	842	813	1,120	1,321	1,283	922	586	2,811	907	1,287
East/Central	4,607	3,263	2,879	3,935	4,254	3,732	3,411	2,912	4,207	3,353	4,973
East	3,291	1,570	1,880	1,715	1,910	2,415	1,894	1,464	2,355	2,066	2,200
Percent of total seasonal fishing effort by charter boats:											
Fishing Boat Trips	11.2%	13.7%	13.6%	17.1%	16.6%	18.5%	18.7%	17.8%	21.4%	19.8%	25.6%
Boat Angler Trips	20.4%	25.1%	24.2%	30.1%	29.5%	32.7%	32.9%	30.2%	37.3%	33.8%	42.4%
Boat Angler Hours	27.8%	30.7%	30.2%	36.1%	35.3%	38.0%	39.9%	34.2%	42.1%	38.8%	47.0%

Table A3. Estimated numbers of fish other than coho salmon, Chinook salmon, rainbow trout, Atlantic salmon, brown trout, lake trout, smallmouth bass, yellow perch, walleye, or sea or silver lamprey, that were harvested and caught April 15 – September 30, 1985-2019 and 2021.

	1985-10	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5.5 month) estimates of fish harvested:											
Unidentified Fish	4	0	0	0	0	0	0	0	0	0	0
Bowfin	1	0	0	0	0	0	0	0	0	0	0
American Eel	5	0	0	0	0	0	0	0	0	0	0
Alewife	40	0	14	72	0	20	53	12	12	53	0
Gizzard Shad	3	0	0	0	0	0	0	0	0	0	0
Cisco	23	187	247	221	270	48	15	14	58	0	118
Lake Whitefish	0	13	0	0	0	0	0	0	0	0	59
Pink Salmon	3	0	0	0	0	0	0	0	0	0	0
Unidentified Salmonine	11	0	0	0	0	0	0	0	0	15	0
Northern Pike	72	14	132	0	35	0	84	0	0	0	27
Chain Pickerel	0	0	0	67	0	0	0	0	343	84	0
Common carp	4	0	45	0	0	0	0	0	0	0	0
Unidentified Redhorse	1	0	0	0	0	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	88	0	0	0	53	0	30	20	0	0	0
Channel Catfish	53	0	0	0	0	0	0	0	0	0	0
Threespine Stickleback	1	0	0	0	0	0	0	0	0	0	0
White Perch	1,408	0	0	0	115	0	0	0	0	0	0
White Bass	248	0	0	0	22	0	0	0	0	0	0
Rock Bass	2,575	135	688	134	478	12	25	70	1,119	48	0
Pumpkinseed	413	0	0	0	0	0	0	0	0	50	0
Bluegill	112	329	0	0	368	13	0	12	292	0	0
Largemouth Bass	98	0	132	22	26	0	0	61	50	126	13
Black Crappie	74	0	26	0	151	0	0	0	0	0	0
Freshwater Drum	393	0	0	0	151	0	0	0	0	15	0
Round Goby	5,938	12,770	9,182	7,546	4,222	4,683	5,015	3,986	2,517	284	3,022
Seasonal (5.5 month) estimates of fish caught:											
Unidentified Fish	48	19	24	23	0	41	0	0	0	864	26
Lake Sturgeon	2	0	27	0	0	0	0	0	0	0	0
Longnose Gar	4	0	0	0	0	0	0	0	0	0	0
Bowfin	18	0	0	0	0	24	0	0	0	0	93
American Eel	68	0	0	0	0	0	0	0	0	0	0
Alewife	366	220	27	403	163	127	223	36	50	53	11
Gizzard Shad	9	0	14	0	0	13	0	0	0	0	0
Cisco	35	229	375	221	297	120	84	70	164	88	261
Lake Whitefish	0	13	0	0	0	0	0	0	0	73	59
Pink salmon	3	0	0	0	0	0	0	0	0	0	0
Unidentified Salmonine	263	113	0	0	0	60	26	0	44	94	0
Rainbow Smelt	8	0	0	0	0	0	0	0	0	0	0
Northern Pike	456	62	204	130	255	36	84	44	291	84	314
Muskellunge	2	0	0	0	0	0	0	0	0	0	0
Chain Pickerel	44	0	0	290	0	0	0	216	539	84	115
Common Carp	87	26	72	70	0	0	0	0	0	0	27
White Sucker	25	13	0	0	26	0	0	0	0	13	0
Unidentified Redhorse	11	0	0	0	0	0	0	0	0	0	0
Yellow Bullhead	1	0	0	0	0	0	0	0	0	0	0
Brown Bullhead	119	0	0	25	53	0	30	20	0	0	0
Channel Catfish	133	0	19	0	0	0	0	0	0	0	0
Threespine Stickleback	3	0	0	0	0	0	0	0	0	0	0
White perch	3,739	101	0	12	115	0	40	180	0	0	0
White Bass	1,121	25	2,533	0	49	0	0	0	0	0	0
Rock Bass	12,997	818	1,840	1,088	5,371	596	555	199	2,380	396	266
Pumpkinseed	1,547	28	36	322	436	0	267	0	0	50	86
Bluegill	324	1,257	77	225	869	25	0	12	955	0	0
Largemouth Bass	590	227	516	456	106	425	160	247	259	307	442
Black Crappie	115	0	26	0	0	0	0	0	105	0	0
Freshwater Drum	6,637	240	525	256	388	163	393	12	59	224	112
Round Goby	10,717	25,290	13,484	12,659	6,704	6,297	12,982	5,817	5,383	2,889	5,013

Table A4. Residency for boat anglers interviewed April 15 – September 30, 1985-2019 and 2021. Shown are percent contributions of the most common states or provinces, and for the most common counties among New York resident anglers.

	1985-10 avg	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
State or Province of Residence												
Connecticut	2.0	1.6	1.3	1.5	1.3	0.8	1.2	0.9	1.5	1.3	1.1	1.3
Florida	0.3	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.3	0.7	0.5	0.5
Maine	0.8	0.8	0.7	0.7	1.0	0.5	0.7	1.3	1.3	1.2	1.5	1.4
Maryland	0.3	0.2	0.2	0.3	0.8	0.4	0.5	0.8	0.3	0.4	0.4	0.5
Massachusetts	3.8	3.0	2.7	2.6	2.6	2.8	2.5	3.3	2.4	2.7	1.3	2.7
Michigan	0.4	0.4	0.6	0.2	0.6	0.5	0.3	0.4	0.6	0.3	0.8	0.5
New Hampshire	1.2	1.1	0.8	0.9	1.0	1.3	0.9	1.4	1.0	0.6	1.1	1.0
New Jersey	4.2	3.0	3.0	2.6	2.2	2.9	3.5	2.7	2.6	2.5	2.6	2.2
New York	61.5	61.8	61.3	60.6	59.8	60.9	60.3	58.9	56.4	62.9	56.7	60.2
Ohio	4.1	2.6	4.0	3.9	4.7	3.6	4.6	4.3	5.2	4.8	6.9	5.6
Pennsylvania	17.1	20.4	20.4	21.9	20.8	21.0	20.6	21.2	22.7	18.3	22.0	18.7
Province of Ontario	0.2	0.3	0.3	0.1	0.2	0.2	0.1	0.3	0.3	0.2	0.1	0.0
Province of Quebec	0.2	0.1	0.1	0.0	0.1	0.3	0.2	0.3	0.4	0.2	0.2	0.0
Vermont	2.2	2.3	2.1	2.5	2.2	2.3	2.1	1.5	2.6	1.8	1.9	2.2
Virginia	0.2	0.2	0.2	0.1	0.3	0.1	0.3	0.4	0.3	0.2	0.4	0.6
West Virginia	0.4	0.3	0.4	0.5	0.4	0.3	0.4	0.3	0.4	0.3	0.9	0.6
Total of all Listed States & Provinces:	98.9	98.4	98.4	98.9	98.5	98.4	98.7	98.5	98.4	98.5	98.5	98.1
County of Residence Among NY Anglers												
County Bordering Lake Ontario:												
Cayuga	2.5	3.3	2.6	2.2	2.2	2.6	3.1	4.4	3.2	2.5	2.3	2.1
Jefferson	2.4	1.6	1.5	3.2	3.6	3.3	2.5	2.7	2.2	2.1	2.3	4.1
Monroe	23.8	18.7	16.5	16.2	16.5	15.7	15.7	16.0	14.3	20.2	10.0	15.7
Niagara	8.5	7.8	10.9	9.4	9.7	8.6	9.1	6.5	8.5	7.2	9.8	8.1
Orleans	3.7	4.9	4.2	4.1	4.8	5.3	4.7	5.2	6.1	4.0	6.2	5.7
Oswego	10.9	13.1	13.6	12.5	12.8	12.8	13.1	12.8	14.1	12.9	21.0	14.5
Wayne	10.8	9.5	9.6	10.3	8.7	7.7	9.4	9.5	6.6	9.1	9.0	10.4
Border Co. Total	62.7	58.8	59.0	57.9	58.4	56.0	57.7	57.1	55.2	58.1	60.6	60.6
Other NY Counties:												
Albany	1.3	1.1	1.0	1.0	0.8	1.9	1.2	1.4	1.9	1.3	2.0	1.1
Broome	1.9	2.5	1.9	1.8	1.5	1.8	1.8	2.0	1.3	1.4	1.0	1.0
Dutchess	0.9	0.6	0.3	0.3	0.7	0.7	0.8	0.7	0.8	0.9	0.5	0.7
Erie	4.1	3.8	5.8	5.2	4.9	4.1	4.0	4.7	5.2	5.0	6.8	4.2
Genesee	1.5	2.1	1.6	2.5	1.8	2.3	0.9	1.5	1.4	1.4	1.5	1.5
Livingston	0.8	0.6	0.6	1.0	0.7	0.8	0.7	0.7	0.5	0.6	1.0	0.9
Oneida	2.0	1.8	2.2	1.4	2.0	2.0	2.2	2.1	1.8	1.8	1.7	2.8
Onondaga	5.8	6.0	6.4	6.4	5.7	5.9	5.9	6.0	7.3	6.0	3.7	4.0
Ontario	1.5	1.7	1.6	1.7	2.0	1.8	1.7	1.5	1.6	1.6	1.4	2.2
Orange	0.9	1.2	0.5	0.8	0.9	1.2	1.4	1.3	1.3	0.9	0.8	0.3
Saratoga	0.9	0.8	0.7	0.6	0.9	0.9	1.1	1.4	1.3	0.7	1.0	1.6
Ulster	0.9	1.4	1.0	1.3	0.9	0.9	0.9	1.2	1.8	2.0	0.8	0.7
Total of all Listed Counties:	85.3	82.2	82.6	81.9	81.2	80.3	80.3	81.8	81.4	81.5	82.9	81.6

Table A5a. Trout and salmon catch and harvest data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	141,873	110,196	107,456	100,047	106,880	77,887	79,334	93,524	142,447	108,798	88,300
Catch	225,188	221,977	196,625	168,837	200,763	154,411	138,231	162,341	252,976	170,106	129,582
% Harvested	62.3	49.6	54.7	59.3	53.2	50.4	57.4	57.6	56.3	64.0	68.1
Monthly estimates of harvest for all fishing boats:											
April	15,011	5,050	10,045	4,580	6,329	4,151	7,502	5,203	4,928	4,252	4,975
May	30,058	16,139	16,015	22,142	20,118	20,314	12,618	8,274	25,831	17,448	6,588
June	15,088	10,387	10,135	11,467	11,777	6,361	7,968	5,697	13,020	12,433	14,267
July	23,094	36,207	22,706	21,311	22,955	13,148	24,090	22,618	29,878	26,117	29,113
August	40,120	29,189	34,770	33,670	33,092	23,111	16,992	38,957	44,177	35,871	28,559
September	18,502	13,225	13,785	6,878	12,609	10,800	10,165	12,774	24,614	12,677	4,799
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	48,144	33,864	32,631	34,524	31,103	24,548	28,763	32,234	41,753	39,702	37,026
West/Central	15,088	8,356	9,216	11,694	13,696	9,191	7,982	7,568	20,604	8,451	8,844
East/Central	43,135	39,819	31,076	34,445	37,861	25,431	26,296	36,444	50,386	38,796	29,355
East	35,506	28,157	34,535	19,382	24,217	18,715	16,295	17,278	29,704	21,849	13,076
Monthly estimates of catch for all fishing boats:											
April	23,462	12,236	19,347	7,328	19,368	10,395	16,341	7,373	8,623	7,409	9,348
May	49,196	35,558	37,204	36,786	46,026	57,178	25,076	16,652	53,171	37,111	9,891
June	27,277	22,222	24,230	20,076	28,848	13,203	15,382	9,176	29,627	21,388	18,995
July	41,382	82,252	42,491	41,130	33,587	23,984	41,384	42,959	52,583	37,174	46,618
August	59,995	50,484	55,996	53,802	56,224	34,527	26,494	67,495	75,382	50,398	37,958
September	23,876	19,225	17,357	9,715	16,710	15,123	13,553	18,687	33,589	16,627	6,771
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	82,051	93,566	73,727	67,993	66,682	70,100	57,104	62,329	83,337	71,629	55,306
West/Central	30,161	22,100	26,231	26,378	35,306	18,565	15,641	20,996	48,182	15,425	20,884
East/Central	62,894	67,426	49,058	49,025	60,635	39,116	43,077	57,252	80,764	55,765	37,427
East	50,082	38,885	47,609	25,440	38,141	26,630	22,408	21,766	40,695	27,287	15,964
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.5	99.9	100.0	100.0	99.9	100.0	100.0	100.0	99.9	100.0	99.7
% Catch	99.4	99.8	99.7	99.9	99.9	100.0	100.0	100.0	99.8	100.0	99.8
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	47.7	47.3	47.5	59.4	56.0	60.2	61.8	49.4	56.7	51.7	63.7
% Catch	39.0	34.8	33.3	46.0	39.2	40.1	47.6	37.4	43.4	39.9	52.8

Table A5b. Trout and salmon catch and harvest rate data collected April 15 – September 30, 1985-2019 and 2021. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.531	2.222	2.332	2.104	2.159	1.688	2.046	2.607	2.973	2.607	2.241
Catch/Boat Trip	2.479	4.473	4.258	3.549	4.056	3.345	3.563	4.526	5.278	4.077	3.292
Harv/Angler Trip	0.525	0.745	0.774	0.681	0.686	0.545	0.651	0.831	0.925	0.802	0.641
Catch/Angler Trip	0.849	1.500	1.414	1.148	1.288	1.081	1.134	1.443	1.642	1.255	0.941
Harv/Angler Hour	0.091	0.132	0.137	0.112	0.116	0.093	0.108	0.136	0.162	0.137	0.108
Catch/Angler Hr.	0.147	0.266	0.250	0.190	0.219	0.184	0.188	0.237	0.287	0.215	0.158
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.777	2.006	4.246	1.779	3.296	1.844	2.346	2.611	3.234	3.315	2.160
May	1.719	2.005	1.909	2.799	2.390	2.347	1.864	2.187	3.421	2.511	1.236
June	1.575	2.396	1.973	1.811	2.131	1.472	2.105	1.921	2.433	2.639	2.875
July	1.727	3.321	2.448	2.203	2.595	1.614	2.867	2.901	2.758	2.931	2.982
August	1.594	2.065	2.693	2.116	1.956	1.873	1.700	3.157	3.167	2.702	2.304
September	1.024	1.372	1.723	1.338	1.603	1.035	1.535	1.826	2.828	1.921	1.011
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	2.070	2.300	2.575	2.523	2.572	2.163	2.600	3.096	3.435	2.765	3.079
West/Central	1.185	1.656	1.650	1.763	2.191	1.426	2.039	2.029	2.517	3.125	1.566
East/Central	1.572	2.631	2.282	2.256	2.385	1.825	1.901	2.888	3.171	3.027	2.266
East	1.209	1.919	2.431	1.621	1.584	1.298	1.634	1.896	2.544	1.843	1.484
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	2.976	4.859	8.177	2.837	10.088	4.618	5.110	3.699	5.658	5.777	4.050
May	2.921	4.400	4.435	4.650	5.458	6.606	3.702	4.402	7.041	5.340	1.856
June	2.888	5.117	4.644	3.166	5.241	3.044	4.064	3.097	5.512	4.539	3.830
July	3.061	7.544	4.581	4.252	3.799	2.945	4.925	5.510	4.854	4.172	4.777
August	2.421	3.569	4.335	3.382	3.322	2.798	2.645	5.470	5.406	3.798	3.064
September	1.357	1.994	2.169	1.885	2.123	1.450	2.047	2.671	3.857	2.520	1.444
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	3.627	6.344	5.818	4.967	5.506	6.176	5.163	5.986	6.855	4.992	4.607
West/Central	2.650	4.379	4.697	3.976	5.644	2.880	3.996	5.630	5.882	5.705	3.696
East/Central	2.318	4.448	3.587	3.208	3.822	2.803	3.111	4.538	5.082	4.352	2.887
East	1.679	2.650	3.337	2.126	2.498	1.847	2.246	2.389	3.474	2.302	1.814
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	5.007	6.319	6.690	6.417	6.162	4.792	5.742	6.566	6.972	6.211	4.825
Catch/Boat Trip	6.560	9.359	8.583	8.385	8.115	6.321	7.719	8.626	9.476	7.487	5.872
Harv/Angler Trip	0.997	1.211	1.313	1.233	1.167	0.919	1.093	1.273	1.302	1.152	0.881
Catch/Angler Trip	1.304	1.794	1.685	1.611	1.536	1.212	1.469	1.672	1.770	1.389	1.072
Harv/Angler Hour	0.139	0.190	0.198	0.178	0.173	0.141	0.158	0.191	0.211	0.177	0.139
Catch/Angler Hr.	0.182	0.282	0.254	0.232	0.228	0.186	0.212	0.251	0.286	0.214	0.169
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.936	1.404	1.466	1.060	1.182	0.852	1.003	1.641	1.697	1.607	1.150
Catch/Boat Trip	1.772	3.497	3.399	2.378	3.064	2.544	2.391	3.525	3.938	3.129	2.202
Harv/Angler Trip	0.366	0.554	0.565	0.411	0.450	0.338	0.394	0.621	0.670	0.604	0.432
Catch/Angler Trip	0.694	1.379	1.309	0.922	1.166	1.008	0.939	1.334	1.555	1.175	0.827
Harv/Angler Hour	0.069	0.104	0.107	0.073	0.082	0.061	0.071	0.107	0.124	0.111	0.077
Catch/Angler Hr.	0.130	0.259	0.247	0.164	0.213	0.183	0.170	0.229	0.288	0.216	0.148

Table A6a. Coho salmon harvest and catch data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	9,895	7,380	8,259	4,871	5,653	2,078	2,173	8,291	4,761	2,384	10,969
Catch	13,436	11,915	12,494	7,704	8,442	4,260	3,219	10,630	8,232	3,852	13,679
% Harvested	74.2	61.9	66.1	63.2	67.0	48.8	67.5	78.0	57.8	61.9	80.2
Monthly estimates of harvest for all fishing boats:											
April	2,447	968	392	266	349	12	108	1,024	39	255	506
May	2,239	946	1,787	1,646	2,101	94	272	831	1,200	190	1,578
June	592	653	163	454	369	37	87	441	538	309	3,628
July	440	2,362	503	235	238	121	348	420	138	108	2,337
August	2,266	853	3,437	1,170	691	417	800	2,486	922	238	1,581
September	1,911	1,599	1,978	1,100	1,906	1,397	557	3,092	1,924	1,284	1,339
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	4,313	3,635	3,001	2,365	2,541	458	834	3,709	1,726	567	6,925
West/Central	1,541	765	411	201	310	0	51	216	293	0	420
East/Central	2,382	1,546	1,968	1,594	1,566	959	891	2,331	1,112	987	2,141
East	1,687	1,434	2,880	711	1,235	661	398	2,035	1,630	830	1,484
Monthly estimates of catch for all fishing boats:											
April	3,390	2,324	686	332	1,209	440	108	1,534	128	344	547
May	3,565	1,926	4,047	3,145	3,537	1,412	851	1,463	3,225	996	2,017
June	966	1,277	734	986	547	61	160	619	925	481	4,145
July	668	3,357	830	627	286	261	526	793	509	145	3,690
August	2,678	1,190	3,888	1,434	897	584	1,016	2,842	1,198	302	1,903
September	2,169	1,840	2,308	1,179	1,965	1,502	557	3,380	2,246	1,583	1,377
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	6,413	6,476	5,875	4,642	4,450	2,119	1,518	5,538	3,841	1,275	8,953
West/Central	2,360	1,837	1,072	592	801	238	236	284	848	0	909
East/Central	2,816	1,922	2,350	1,728	1,955	1,194	1,016	2,596	1,551	1,598	2,288
East	1,848	1,679	3,197	742	1,237	709	450	2,212	1,992	979	1,528
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.6
% Catch	99.4	99.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.9
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	42.4	42.1	40.6	45.6	39.2	55.0	44.2	37.8	50.7	37.9	55.2
% Catch	34.8	28.2	28.5	31.5	30.9	35.0	29.8	34.9	36.7	34.4	47.0

Table A6b. Coho salmon harvest and catch rate data collected April 15 – September 30, 1985-2019 and 2021. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.114	0.149	0.179	0.103	0.114	0.045	0.056	0.231	0.100	0.057	0.275
Catch/Boat Trip	0.157	0.239	0.271	0.162	0.171	0.092	0.083	0.296	0.172	0.092	0.345
Harv/Angler Trip	0.039	0.050	0.060	0.033	0.036	0.015	0.018	0.074	0.031	0.018	0.079
Catch/Angler Trip	0.054	0.080	0.090	0.052	0.054	0.030	0.026	0.094	0.054	0.028	0.098
Harv/Angler Hour	0.007	0.009	0.011	0.005	0.006	0.002	0.003	0.012	0.005	0.003	0.013
Catch/Angler Hr.	0.009	0.014	0.016	0.009	0.009	0.005	0.004	0.015	0.009	0.005	0.017
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.299	0.384	0.166	0.103	0.182	0.005	0.034	0.514	0.026	0.199	0.220
May	0.151	0.118	0.213	0.208	0.250	0.011	0.040	0.220	0.159	0.027	0.296
June	0.075	0.151	0.032	0.072	0.067	0.009	0.023	0.149	0.101	0.066	0.733
July	0.037	0.217	0.054	0.024	0.027	0.015	0.041	0.054	0.013	0.012	0.240
August	0.092	0.060	0.266	0.074	0.041	0.034	0.080	0.201	0.066	0.018	0.124
September	0.108	0.166	0.247	0.214	0.242	0.134	0.084	0.442	0.222	0.195	0.270
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.190	0.247	0.237	0.173	0.210	0.040	0.075	0.356	0.142	0.040	0.572
West/Central	0.102	0.152	0.074	0.030	0.050	0.000	0.013	0.058	0.036	0.000	0.074
East/Central	0.092	0.102	0.145	0.104	0.099	0.069	0.064	0.185	0.070	0.077	0.165
East	0.071	0.098	0.203	0.059	0.081	0.046	0.040	0.223	0.140	0.070	0.161
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.410	0.923	0.290	0.129	0.630	0.195	0.034	0.770	0.084	0.269	0.237
May	0.247	0.232	0.482	0.398	0.420	0.163	0.126	0.387	0.427	0.143	0.378
June	0.130	0.296	0.143	0.156	0.100	0.014	0.042	0.209	0.174	0.102	0.837
July	0.055	0.308	0.090	0.065	0.032	0.032	0.063	0.102	0.047	0.016	0.378
August	0.109	0.084	0.301	0.090	0.053	0.047	0.102	0.230	0.086	0.023	0.150
September	0.125	0.191	0.288	0.229	0.250	0.144	0.084	0.483	0.259	0.240	0.278
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.292	0.436	0.464	0.339	0.368	0.187	0.137	0.532	0.316	0.089	0.741
West/Central	0.169	0.364	0.192	0.089	0.128	0.037	0.060	0.076	0.104	0.000	0.161
East/Central	0.112	0.127	0.173	0.113	0.123	0.086	0.073	0.206	0.098	0.125	0.177
East	0.078	0.115	0.225	0.062	0.081	0.049	0.045	0.243	0.171	0.083	0.166
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.330	0.377	0.440	0.240	0.228	0.117	0.113	0.446	0.208	0.100	0.519
Catch/Boat Trip	0.371	0.407	0.467	0.261	0.269	0.152	0.113	0.526	0.261	0.146	0.551
Harv/Angler Trip	0.066	0.072	0.086	0.046	0.043	0.022	0.021	0.086	0.039	0.019	0.095
Catch/Angler Trip	0.074	0.078	0.092	0.050	0.051	0.029	0.021	0.102	0.049	0.027	0.101
Harv/Angler Hour	0.009	0.011	0.013	0.007	0.006	0.003	0.003	0.013	0.006	0.003	0.015
Catch/Angler Hr.	0.010	0.012	0.014	0.007	0.008	0.004	0.003	0.015	0.008	0.004	0.016
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.075	0.103	0.128	0.069	0.086	0.026	0.040	0.179	0.065	0.045	0.173
Catch/Boat Trip	0.118	0.206	0.232	0.138	0.147	0.076	0.075	0.240	0.144	0.077	0.257
Harv/Angler Trip	0.029	0.041	0.049	0.027	0.033	0.010	0.016	0.068	0.026	0.017	0.065
Catch/Angler Trip	0.046	0.081	0.089	0.054	0.056	0.030	0.029	0.091	0.057	0.029	0.097
Harv/Angler Hour	0.005	0.008	0.009	0.005	0.006	0.002	0.003	0.012	0.005	0.003	0.012
Catch/Angler Hr.	0.009	0.015	0.017	0.010	0.010	0.005	0.005	0.016	0.010	0.005	0.017

Table A7. Total length (inches), weight (lbs), and age statistics for coho salmon sampled April 15 - September 30 during the 1985-2019 and 2021 NYSDEC Lake Ontario fishing boat surveys.

	1985-2010 Avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Mean length and weight data for coho salmon sampled April - September:											
Mean Length (in)	24.1	24.0	26.1	25.0	23.8	23.7	25.6	25.5	24.4	24.2	24.7
Mean Weight (lbs)	6.6	6.27	8.29	6.70	6.37	6.55	7.70	7.62	6.49	6.34	6.53
Estimated weight (lbs) for standard length coho salmon sampled April - September:											
Standard Length											
18.0 inches	2.0	1.87	2.01	1.97	1.84	1.99	1.78	1.66	1.71	1.86	1.41
20.0 inches	2.9	2.79	2.92	2.84	2.76	3.06	2.67	2.55	2.63	2.79	2.26
22.0 inches	4.1	4.01	4.11	3.95	4.00	4.52	3.87	3.76	3.87	4.03	3.46
24.0 inches	5.6	5.57	5.60	5.35	5.60	6.45	5.42	5.35	5.52	5.63	5.10
26.0 inches	7.5	7.54	7.45	7.07	7.64	8.94	7.39	7.41	7.64	7.65	7.30
28.0 inches	9.8	9.92	9.66	9.10	10.13	12.02	9.79	9.95	10.28	10.12	10.10
30.0 inches	12.7	12.95	12.41	11.61	13.30	16.01	12.86	13.24	13.68	13.26	13.83
Percent length composition of coho salmon sampled April - September:											
<15.0 in	0.4%	0.0%	0.0%	0.0%	0.0%	2.6%	0.0%	0.0%	0.0%	0.0%	0.0%
15.0-15.9 in	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.4%	0.0%	0.0%
16.0-16.9 in	0.6%	0.0%	0.0%	0.0%	3.8%	0.0%	0.0%	0.0%	1.4%	5.3%	0.0%
17.0-17.9 in	2.1%	1.4%	0.0%	0.0%	7.7%	0.0%	1.9%	0.0%	0.0%	0.0%	0.0%
18.0-18.9 in	3.5%	7.7%	0.8%	2.4%	10.3%	2.6%	1.9%	0.4%	7.1%	0.0%	1.8%
19.0-19.9 in	6.3%	6.3%	3.1%	4.9%	5.1%	2.6%	3.8%	5.2%	0.0%	5.3%	2.4%
20.0-20.9 in	9.3%	10.6%	7.7%	4.9%	5.1%	2.6%	7.5%	6.9%	4.3%	13.2%	6.6%
21.0-21.9 in	11.7%	9.6%	7.7%	8.5%	3.8%	5.3%	3.8%	7.8%	8.6%	0.0%	6.0%
22.0-22.9 in	9.8%	5.3%	7.7%	13.4%	2.6%	21.1%	5.7%	6.9%	7.1%	5.3%	12.6%
23.0-23.9 in	8.0%	6.7%	4.6%	8.5%	3.8%	7.9%	3.8%	6.9%	2.9%	13.2%	14.4%
24.0-24.9 in	6.5%	9.6%	3.8%	9.8%	7.7%	23.7%	3.8%	5.6%	11.4%	7.9%	12.0%
25.0-25.9 in	6.0%	11.1%	5.4%	8.5%	5.1%	18.4%	9.4%	6.9%	15.7%	21.1%	13.2%
26.0-26.9 in	6.8%	5.8%	6.2%	6.1%	16.7%	5.3%	9.4%	12.1%	20.0%	5.3%	4.8%
27.0-27.9 in	8.2%	8.7%	14.6%	11.0%	15.4%	5.3%	22.6%	9.9%	11.4%	13.2%	6.6%
28.0-28.9 in	7.9%	9.1%	16.9%	4.9%	7.7%	0.0%	11.3%	14.2%	7.1%	5.3%	9.6%
29.0-29.9 in	5.8%	4.8%	9.2%	11.0%	2.6%	2.6%	9.4%	12.1%	1.4%	5.3%	7.2%
30.0-30.9 in	3.7%	2.4%	8.5%	1.2%	1.3%	0.0%	5.7%	3.4%	0.0%	0.0%	1.8%
31.0-31.9 in	1.6%	0.5%	3.1%	2.4%	0.0%	0.0%	0.0%	1.7%	0.0%	0.0%	1.2%
32.0-32.9 in	0.9%	0.0%	0.0%	2.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
>32.9 in	0.3%	0.5%	0.8%	0.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Percent age composition of coho salmon sampled April -September:											
Age-1	3.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	1.3%	0.0%	0.6%
Age-2	95.0%	99.3%	98.0%	100.0%	97.2%	100.0%	100.0%	98.1%	98.7%	97.7%	99.4%
Age-3	1.1%	0.7%	2.0%	0.0%	2.8%	0.0%	0.0%	0.8%	0.0%	2.3%	0.0%
Length data (inches) for age-2 coho salmon sampled April - September:											
April Mean	20.5	19.4	21.0	20.5	18.3	-	18.9	21.0	-	-	20.5
September Mean	28.1	28.2	28.2	28.1	26.3	24.1	27.6	27.9	25.9	25.3	27.6
Avg Monthly Gain	1.7	1.93	1.59	1.68	1.90	-	1.94	1.56	1.68	-	1.61

Table A8a. Chinook salmon harvest and catch data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	51,751	46,333	55,137	38,292	47,935	34,951	34,405	53,871	101,192	78,677	44,064
Catch	74,656	97,899	88,851	62,570	76,626	58,870	60,435	96,226	173,691	114,861	60,754
% Harvested	69.3	47.3	62.1	61.2	62.6	59.4	56.9	56.0	58.3	68.5	72.5
Monthly estimates of harvest for all fishing boats:											
April	1,537	86	2,180	115	0	145	70	80	27	285	321
May	7,289	1,594	5,358	4,102	8,067	9,138	3,235	1,088	15,094	11,897	1,282
June	2,247	2,166	4,858	2,277	3,133	955	2,454	2,124	8,319	9,804	5,280
July	7,530	17,509	11,004	8,560	11,074	6,857	14,596	14,699	21,384	19,105	18,323
August	20,622	16,885	21,746	20,670	16,908	12,030	7,850	27,749	35,495	29,038	16,206
September	12,526	8,093	9,991	2,568	8,754	5,826	6,201	8,132	20,873	8,547	2,653
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	21,445	14,042	17459	17,417	13,314	14,349	16,444	17,526	34,440	30,448	20,219
West/Central	5,142	2,047	3277	2,223	2,458	3,593	872	2,867	15,716	6,521	3,031
East/Central	12,479	17,550	16097	13,258	20,796	10,808	12,269	23,284	30,705	28,839	17,147
East	12,686	12,694	18305	5,394	11,367	6,200	4,820	10,195	20,330	14,869	3,667
Monthly estimates of catch for all fishing boats:											
April	2,191	267	3,781	164	232	261	70	221	27	315	428
May	12,679	4,511	11,827	6,948	13,020	18,854	7,318	2,867	29,421	22,428	2,143
June	5,256	8,483	10,058	5,200	7,829	3,594	6,366	3,830	20,934	16,456	6,651
July	12,026	42,582	19,848	15,682	14,608	10,525	25,456	28,274	38,278	26,001	27,209
August	27,423	31,239	31,097	30,649	29,562	17,823	13,432	49,700	57,889	38,828	20,306
September	15,080	10,817	12,239	3,926	11,375	7,813	7,793	11,334	27,142	10,833	4,018
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	35,051	43,599	34,937	32,474	25,615	28,640	30,833	36,955	66,017	51,323	29,363
West/Central	9,190	7,038	9,223	6,622	10,001	6,896	2,676	8,630	33,813	11,812	7,347
East/Central	16,046	30,606	22,321	16,963	27,082	15,710	20,206	37,409	47,130	33,797	20,034
East	14,369	16,657	22,370	6,511	13,928	7,624	6,720	13,232	26,731	17,929	4,010
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8
% Catch	99.8	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	42.0	40.2	42.7	47.1	51.5	50.9	53.0	46.9	54.4	48.8	59.0
% Catch	35.8	32.3	32.3	38.3	38.9	39.4	45.5	35.5	41.3	38.0	49.4

Table A8b. Chinook salmon harvest and catch rate data collected April 15 – September 30, 1985-2019 and 2021. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.587	0.935	1.197	0.806	0.970	0.757	0.887	1.502	2.115	1.885	1.120
Catch/Boat Trip	0.884	1.975	1.928	1.316	1.550	1.276	1.559	2.683	3.631	2.753	1.545
Harv/Angler Trip	0.201	0.314	0.398	0.261	0.308	0.245	0.282	0.479	0.658	0.580	0.320
Catch/Angler Trip	0.302	0.662	0.640	0.426	0.492	0.412	0.496	0.855	1.130	0.847	0.442
Harv/Angler Hour	0.035	0.056	0.070	0.043	0.052	0.042	0.047	0.079	0.115	0.0994	0.0539
Catch/Angler Hr.	0.053	0.118	0.113	0.070	0.083	0.070	0.082	0.140	0.197	0.1451	0.0743
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.104	0.034	0.921	0.045	0.000	0.064	0.022	0.040	0.018	0.223	0.139
May	0.425	0.198	0.639	0.519	0.958	1.056	0.478	0.288	1.999	1.712	0.210
June	0.254	0.502	0.946	0.360	0.571	0.221	0.648	0.718	1.560	2.081	1.067
July	0.620	1.606	1.189	0.886	1.255	0.842	1.737	1.885	1.974	2.144	1.876
August	0.834	1.196	1.684	1.299	0.999	0.975	0.785	2.249	2.547	2.187	1.309
September	0.681	0.839	1.249	0.500	1.113	0.558	0.936	1.163	2.409	1.295	0.570
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.892	0.954	1.378	1.274	1.101	1.264	1.487	1.683	2.833	2.120	1.684
West/Central	0.369	0.406	0.587	0.335	0.393	0.557	0.223	0.769	1.920	2.412	0.537
East/Central	0.499	1.159	1.184	0.868	1.312	0.775	0.887	1.846	1.936	2.094	1.323
East	0.489	0.867	1.288	0.451	0.746	0.430	0.483	1.119	1.746	1.254	0.417
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.162	0.106	1.598	0.064	0.121	0.116	0.022	0.111	0.018	0.246	0.186
May	0.777	0.560	1.410	0.878	1.547	2.178	1.081	0.758	3.897	3.228	0.337
June	0.621	1.967	1.958	0.821	1.426	0.832	1.682	1.282	3.927	3.492	1.343
July	1.041	3.906	2.145	1.624	1.655	1.293	3.029	3.626	3.533	2.918	2.787
August	1.148	2.208	2.407	1.926	1.746	1.444	1.344	4.028	4.154	2.926	1.641
September	0.848	1.122	1.529	0.764	1.446	0.749	1.177	1.620	3.133	1.642	0.869
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.555	2.959	2.757	2.375	2.118	2.523	2.788	3.549	5.431	3.577	2.446
West/Central	0.774	1.394	1.652	0.998	1.596	1.070	0.684	2.314	4.131	4.368	1.302
East/Central	0.666	2.022	1.640	1.111	1.708	1.127	1.461	2.966	2.972	2.637	1.546
East	0.569	1.137	1.575	0.545	0.914	0.529	0.674	1.452	2.296	1.512	0.456
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.702	2.260	3.087	1.946	2.542	1.820	2.138	3.587	4.758	4.241	2.231
Catch/Boat Trip	2.127	3.838	3.765	2.588	3.069	2.370	3.226	4.860	6.191	4.822	2.573
Harv/Angler Trip	0.337	0.433	0.606	0.374	0.481	0.349	0.407	0.695	0.889	0.787	0.407
Catch/Angler Trip	0.422	0.736	0.739	0.497	0.581	0.454	0.614	0.942	1.157	0.894	0.470
Harv/Angler Hour	0.047	0.068	0.092	0.054	0.071	0.054	0.059	0.104	0.144	0.121	0.064
Catch/Angler Hr.	0.059	0.116	0.112	0.072	0.086	0.070	0.089	0.141	0.187	0.138	0.074
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.393	0.670	0.822	0.529	0.586	0.472	0.534	0.993	1.272	1.232	0.651
Catch/Boat Trip	0.667	1.603	1.564	1.009	1.178	0.982	1.088	2.151	2.814	2.178	1.111
Harv/Angler Trip	0.154	0.264	0.316	0.205	0.223	0.187	0.210	0.376	0.502	0.463	0.244
Catch/Angler Trip	0.262	0.632	0.602	0.391	0.448	0.389	0.427	0.814	1.111	0.818	0.417
Harv/Angler Hour	0.029	0.050	0.060	0.036	0.041	0.034	0.038	0.065	0.093	0.085	0.044
Catch/Angler Hr.	0.050	0.119	0.114	0.070	0.082	0.071	0.077	0.140	0.206	0.150	0.074

Table A9. Total length (inches), weight (lbs), and age statistics for Chinook salmon sampled April 15 - September 30 during the 1985-2019 and 2021 NYSDEC Lake Ontario fishing boat surveys.

	1985-10 avg.	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Mean length and weight data for chinook salmon sampled April -September:											
Mean Length (in)	31.9	29.6	31.4	32.6	31.1	31.1	30.1	29.5	30.6	31.8	30.8
Mean Weight (lbs)	15.7	12.81	14.14	15.64	13.51	13.63	13.48	12.18	12.40	13.94	13.50
Estimated weight (lbs) for standard length chinook salmon sampled July & August:											
Standard Length:											
16.0 inches	1.4	1.36	1.34	1.47	1.38	1.34	1.41	1.40	1.32	1.33	1.36
20.0 inches	2.9	2.91	2.84	3.00	2.87	2.85	2.97	2.94	2.76	2.78	2.84
24.0 inches	5.4	5.41	5.25	5.36	5.20	5.28	5.48	5.40	5.05	5.08	5.20
28.0 inches	8.9	9.14	8.81	8.77	8.60	8.89	9.18	9.04	8.39	8.44	8.67
32.0 inches	13.8	14.40	13.81	13.42	13.29	13.97	14.36	14.10	13.04	13.12	13.49
36.0 inches	20.3	21.49	20.53	19.55	19.52	20.82	21.31	20.89	19.23	19.36	19.93
40.0 inches	28.7	30.75	29.27	27.36	27.53	29.74	30.33	29.68	27.22	27.41	28.25
Percent length composition of chinook salmon sampled April - September:											
<16.0 in	1.1%	0.9%	0.5%	0.5%	0.9%	1.2%	1.9%	0.6%	0.3%	0.4%	0.0%
16.0-17.9 in	2.6%	3.5%	0.8%	1.7%	1.9%	0.8%	2.5%	2.5%	1.5%	0.4%	3.0%
18.0-19.9 in	3.5%	7.8%	1.6%	2.8%	1.9%	1.6%	4.3%	5.6%	2.3%	0.9%	3.0%
20.0-21.9 in	3.3%	5.7%	3.5%	2.8%	3.0%	1.0%	5.0%	6.2%	2.0%	3.2%	4.1%
22.0-23.9 in	3.6%	3.9%	3.0%	2.8%	2.6%	2.5%	7.9%	4.5%	3.4%	3.2%	3.9%
24.0-25.9 in	4.6%	4.3%	5.3%	2.6%	4.4%	7.9%	6.8%	6.6%	6.3%	6.5%	5.0%
26.0-27.9 in	6.3%	5.8%	6.8%	4.9%	10.4%	8.3%	5.4%	8.1%	8.0%	6.4%	7.8%
28.0-29.9 in	7.2%	6.7%	12.8%	9.2%	10.3%	11.8%	9.3%	9.6%	15.9%	8.1%	9.9%
30.0-31.9 in	8.6%	13.7%	14.0%	9.9%	16.4%	15.9%	9.3%	16.0%	16.1%	13.0%	13.2%
32.0-33.9 in	11.5%	21.2%	17.7%	14.4%	15.0%	18.6%	12.4%	17.0%	17.2%	17.7%	15.6%
34.0-35.9 in	14.8%	16.2%	15.9%	15.5%	13.6%	16.9%	12.8%	13.8%	15.2%	21.0%	16.0%
36.0-37.9 in	17.3%	7.5%	9.6%	16.2%	11.6%	9.5%	14.7%	6.9%	9.4%	14.5%	11.9%
38.0-39.9 in	11.2%	1.9%	6.1%	12.3%	7.1%	3.3%	6.6%	2.2%	2.2%	4.4%	5.6%
40.0-41.9 in	3.9%	0.8%	2.2%	3.8%	1.1%	0.8%	1.2%	0.5%	0.1%	0.1%	1.1%
42.0-43.9 in	0.5%	0.0%	0.1%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
>43.9 in	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Percent > 30""	68.4%	61.4%	65.7%	72.7%	64.8%	64.9%	57.0%	56.5%	60.3%	70.8%	63.3%
Percent age composition of chinook salmon sampled April - September:											
Age-0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
Age-1	11.4%	22.2%	5.0%	10.7%	8.3%	3.7%	9.1%	18.4%	6.1%	2.8%	14.0%
Age-2	35.5%	68.9%	70.8%	37.0%	52.7%	46.5%	43.0%	47.9%	60.0%	35.7%	45.7%
Age-3	49.6%	8.6%	24.1%	52.0%	36.5%	49.1%	46.9%	33.0%	32.2%	61.2%	35.6%
Age-4	3.5%	0.2%	0.2%	0.3%	2.5%	0.7%	1.0%	0.7%	1.5%	0.4%	4.5%
Age-5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
Ages 3-5	53.1%	8.8%	24.2%	52.3%	39.0%	49.8%	47.9%	33.7%	33.9%	61.5%	40.1%

Table A10. Mean weight at age data (weight in pounds) for Chinook salmon sampled July-September during the 1991-2021 NYSDEC Lake Ontario fishing boat survey

		July		August		September	
AGE	YR	Mean	N	Mean	N	Mean	N
Age 1	1991	2.4	8	2.9	20	5.1	9
	1992	2.6	35	3.7	46	4.7	27
	1993	2.8	7	2.4	59	3.2	29
	1994	1.4	1	2.3	9	2.6	12
	1995	2.4	6	3.6	4	.	.
	1996	2.9	14	3.1	68	4.8	21
	1997	2.3	7	2.7	45	3.6	22
	1998	3.5	10	3.2	21	3.8	3
	1999	3.7	16	3.5	21	6.0	12
	2000	3.8	23	4.1	17	6.2	9
	2001	2.7	23	3.3	20	5.0	9
	2002	2.2	7	3.0	8	4.4	6
	2003	2.7	3	2.1	8	4.8	6
	2004	2.0	4	2.2	32	3.7	16
	2005	2.1	25	2.8	14	3.5	3
	2006	3.0	38	3.6	37	5.6	9
	2007	2.7	6	3.7	9	4.8	14
	2008	2.5	8	3.1	6	4.4	1
	2009	2.5	13	2.6	24	5.3	1
	2010	3.5	55	4.5	65	6.3	27
	2011	2.7	75	3.9	49	5.1	19
	2012	2.6	11	4.3	12	5.9	1
	2013	3.0	14	3.7	25	7.3	5
	2014	2.0	13	3.0	24	3.7	11
	2015	2.0	3	2.2	10	2.3	3
	2016	2.5	21	2.8	9	5.5	3
	2017	3.0	16	3.2	60	5.5	59
	2018	2.1	14	2.7	28	3.4	8
	2019	.	.	2.6	6	3.7	10
	2020	4.0	18	3.2	41	.	.
	2021	3.6	17	3.0	20	5.9	2
	91-21 Avg	2.9	511	3.2	817	4.7	357

		July		August		September	
AGE	YR	Mean	N	Mean	N	Mean	N
Age 2	1991	8.0	27	10.6	68	14.2	21
	1992	9.5	28	11.2	112	14.9	43
	1993	10.9	20	13.3	119	14.1	40
	1994	8.6	54	10.6	77	10.4	98
	1995	9.3	41	10.0	47	15.9	7
	1996	13.0	2	10.8	27	12.5	11
	1997	12.0	55	13.0	226	14.9	52
	1998	12.4	30	15.0	73	17.3	15
	1999	11.4	11	14.3	37	16.2	39
	2000	12.2	28	15.9	46	17.5	17
	2001	11.8	59	14.6	67	14.6	32
	2002	10.7	4	14.4	54	15.3	34
	2003	9.9	54	12.3	32	14.8	26
	2004	9.6	117	11.8	178	13.1	104
	2005	9.5	94	11.4	115	14.7	68
	2006	10.4	73	11.4	101	12.5	30
	2007	10.8	131	11.6	163	13.6	91
	2008	9.1	68	13.5	91	15.3	78
	2009	8.4	80	10.8	65	14.0	31
	2010	11.4	36	16.6	35	18.1	20
	2011	13.1	183	16.6	172	18.0	78
	2012	12.0	118	15.7	154	17.5	76
	2013	12.4	41	13.1	73	15.6	18
	2014	10.2	83	12.1	94	14.9	54
	2015	9.0	81	11.5	76	13.8	49
	2016	7.5	78	13.0	29	12.9	36
	2017	10.0	75	12.3	158	13.7	67
	2018	9.9	130	11.2	156	15.1	146
	2019	8.6	41	9.4	55	12.2	63
	2020	9.5	36	8.7	59	13.2	5
	2021	11.0	63	11.3	53	15.7	24
	91-21 Avg	10.4	1941	12.6	2812	14.5	1473

Table A10 (continued). Mean weight at age data (weight in pounds) for Chinook salmon.

		July		August		September	
AGE	YR	Mean	N	Mean	N	Mean	N
Age 3	1991	22.8	42	23.7	99	24.5	131
	1992	22.1	37	23.7	114	23.4	125
	1993	23.4	19	23.0	205	21.5	104
	1994	19.6	84	20.2	199	19.6	104
	1995	21.2	71	21.5	130	23.3	112
	1996	21.9	9	23.4	95	24.0	73
	1997	20.3	7	22.7	53	22.1	18
	1998	23.4	39	24.0	185	22.5	31
	1999	23.1	11	26.0	108	25.0	84
	2000	21.2	23	24.3	105	24.4	35
	2001	19.6	41	22.1	50	23.2	20
	2002	23.0	1	22.8	49	21.4	40
	2003	18.3	27	19.5	64	18.9	112
	2004	17.6	51	20.7	149	19.4	68
	2005	17.7	106	20.2	264	19.4	162
	2006	19.1	106	21.3	218	19.9	116
	2007	17.6	127	18.4	163	18.6	126
	2008	19.3	43	21.3	130	21.5	83
	2009	17.6	137	19.5	145	19.7	139
	2010	20.3	23	23.5	79	23.1	27
	2011	20.3	26	24.0	17	26.3	12
	2012	21.4	35	22.9	70	23.3	21
	2013	20.7	58	22.6	115	21.4	27
	2014	18.7	48	20.7	53	21.0	78
	2015	18.4	60	20.6	65	18.6	44
	2016	19.2	55	21.5	48	21.3	73
	2017	17.1	44	19.2	109	18.8	76
	2018	17.3	88	18.4	74	19.2	105
	2019	17.8	82	19.3	100	20.1	50
	2020	17.3	73	18.9	104	19.0	41
	2021	19.0	54	20.2	42	20.9	22
	91-21 Avg	19.0	1627	21.5	3401	21.5	2259

		July		August		September	
AGE	YR	Mean	N	Mean	N	Mean	N
Age 4	1991	25.9	6	26.0	21	24.5	7
	1992	29.5	4	28.2	9	26.6	12
	1993	23.4	3	22.5	17	24.5	7
	1994	23.0	5	23.7	15	24.1	4
	1995	25.3	9	23.4	15	22.8	5
	1996	22.5	2	26.2	29	28.1	23
	1997	.	.	26.4	18	26.3	4
	1998	.	.	24.1	6	.	.
	1999	.	.	28.8	6	27.1	5
	2000						
	2001	20.4	2	.	.	23.3	1
	2002	.	.	21.3	2	33.0	1
	2003	.	.	.	.	20.7	1
	2004	21.7	1	21.8	5	20.9	1
	2005	16.9	2	20.8	4	17.6	1
	2006	22.6	7	24.9	20	19.9	2
	2007	19.7	3	18.2	11	21.0	8
	2008	21.4	3	21.7	9	22.5	2
	2009	25.8	1	20.1	4	.	.
	2010	20.8	2	22.9	4	25.8	2
	2011	19.2	1	.	.	.	.
	2012	.	.	29.0	1	.	.
	2013	32.0	1	.	.	.	.
	2014	18.9	3	20.8	3	22.5	7
	2015	.	.	24.9	1	.	.
	2016	19.2	2	23.0	1	22.0	1
	2017	24.3	2	21.0	1	18.6	1
	2018	16.7	3	19.0	3	20.1	8
	2019	18.2	1	.	.	22.7	1
	2020	20.8	2	23.8	6	.	.
	2021	22.9	6	24.1	7	22.6	2
	91-21 Avg	22.8	71	24.2	215	24.6	106

Table A11a. Rainbow trout harvest and catch data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	23,330	16,131	12,617	17,203	16,729	9,212	9,487	12,015	8,411	9,131	14,215
Catch	34,881	36,533	32,975	34,611	37,462	17,509	16,639	22,556	18,047	15,896	20,683
% Harvested	66.8	44.2	38.3	49.7	44.7	52.6	57.0	53.3	46.6	57.4	68.7
Monthly estimates of harvest for all fishing boats:											
April	1,075	56	199	76	101	127	65	0	0	170	29
May	4,822	410	939	2,099	2,315	1,773	451	330	437	322	430
June	3,165	1,095	2,156	965	5,102	614	1,228	539	962	850	4,298
July	3,263	7,299	4,301	5,488	2,461	1,750	4,097	3,377	2,250	2,571	4,717
August	8,285	4,587	4,381	7,567	5,670	3,876	3,531	6,768	4,152	3,730	4,369
September	2,720	2,684	640	1,009	1,080	1,072	113	1,001	610	1,488	373
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	14,403	11,637	8,622	11,437	9,225	6,143	7,764	9,049	2,977	6,368	8,871
West/Central	2,536	2,023	1,245	2,333	1,871	1,057	485	651	2,763	274	1,019
East/Central	5,286	2,340	1,852	3,036	4,800	1,442	1,016	1,920	2,204	1,967	3,731
East	1,105	131	898	397	833	570	222	395	467	523	594
Monthly estimates of catch for all fishing boats:											
April	1,843	305	442	379	649	387	214	151	71	338	125
May	7,536	2,060	3,100	4,824	6,341	3,816	1,191	629	1,435	909	679
June	4,788	1,813	6,515	2,077	13,747	2,384	2,245	932	2,379	1,502	6,249
July	4,743	18,448	11,100	11,489	4,050	3,560	7,005	6,401	4,757	4,940	6,915
August	11,943	9,037	10,858	14,198	11,072	5,701	5,689	11,752	7,803	6,013	5,976
September	4,027	4,869	960	1,644	1,603	1,661	296	2,692	1,603	2,194	740
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	21,173	26,897	22,064	23,021	16,603	9,899	12,792	15,151	7,376	10,338	13,296
West/Central	4,872	3,377	5,355	5,055	7,394	2,949	1,207	3,396	5,201	767	1,814
East/Central	7,434	5,164	4,195	5,957	10,976	3,456	2,099	3,462	4,509	4,049	4,898
East	1,402	1,096	1,361	578	2,489	1,204	541	547	961	741	676
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.8	99.8	100.0	100.0	99.7	100.0	100.0	99.9	100.0	100.0	100.0
% Catch	99.6	99.9	100.0	99.9	99.9	100.0	100.0	99.9	99.9	100.0	100.0
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	51.2	50.2	45.9	54.3	56.5	50.3	63.3	46.8	60.4	53.2	64.7
% Catch	40.2	33.5	27.1	39.0	38.7	36.8	44.1	30.4	39.2	40.2	49.1

Table A11b. Rainbow trout harvest and catch rate data collected April 15 – September 30, 1985-2019 and 2021. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.267	0.325	0.274	0.362	0.337	0.200	0.245	0.335	0.176	0.219	0.362
Catch/Boat Trip	0.412	0.737	0.716	0.728	0.757	0.379	0.429	0.629	0.377	0.381	0.527
Harv/Angler Trip	0.091	0.109	0.091	0.117	0.107	0.065	0.078	0.107	0.055	0.067	0.103
Catch/Angler Trip	0.140	0.247	0.238	0.235	0.240	0.123	0.137	0.200	0.117	0.117	0.151
Harv/Angler Hour	0.016	0.019	0.016	0.019	0.018	0.011	0.013	0.018	0.010	0.012	0.023
Catch/Angler Hr.	0.024	0.044	0.042	0.039	0.041	0.021	0.023	0.033	0.020	0.020	0.025
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.113	0.022	0.084	0.030	0.053	0.056	0.020	0.000	0.000	0.133	0.01243
May	0.278	0.051	0.112	0.265	0.275	0.205	0.067	0.087	0.058	0.046	0.08065
June	0.342	0.254	0.420	0.152	0.920	0.142	0.324	0.178	0.180	0.180	0.8681
July	0.262	0.669	0.465	0.569	0.279	0.215	0.488	0.433	0.208	0.289	0.48368
August	0.338	0.323	0.339	0.476	0.335	0.314	0.353	0.549	0.298	0.258	0.35298
September	0.163	0.278	0.080	0.196	0.137	0.103	0.017	0.143	0.070	0.225	0.0818
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.710	0.789	0.680	0.836	0.763	0.541	0.702	0.869	0.245	0.444	0.739
West/Central	0.174	0.401	0.223	0.352	0.299	0.164	0.124	0.175	0.338	0.101	0.181
East/Central	0.181	0.155	0.136	0.199	0.303	0.103	0.073	0.151	0.139	0.153	0.288
East	0.033	0.009	0.063	0.033	0.052	0.040	0.022	0.043	0.040	0.044	0.068
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.208	0.121	0.187	0.147	0.338	0.172	0.067	0.076	0.047	0.263	0.054
May	0.461	0.256	0.370	0.610	0.753	0.441	0.176	0.166	0.188	0.131	0.127
June	0.543	0.417	1.268	0.328	2.495	0.552	0.593	0.311	0.446	0.319	1.262
July	0.380	1.692	1.199	1.188	0.459	0.437	0.834	0.821	0.439	0.554	0.709
August	0.502	0.638	0.841	0.892	0.654	0.462	0.569	0.953	0.560	0.453	0.483
September	0.244	0.505	0.120	0.320	0.204	0.159	0.045	0.385	0.183	0.332	0.162
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	1.054	1.826	1.741	1.682	1.373	0.872	1.156	1.455	0.607	0.720	1.108
West/Central	0.387	0.669	0.959	0.762	1.183	0.457	0.308	0.911	0.635	0.284	0.321
East/Central	0.267	0.340	0.309	0.390	0.692	0.248	0.152	0.273	0.283	0.316	0.379
East	0.043	0.075	0.096	0.048	0.160	0.084	0.054	0.060	0.083	0.063	0.078
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.924	0.981	0.759	1.008	0.973	0.474	0.704	0.799	0.439	0.536	0.788
Catch/Boat Trip	1.109	1.484	1.169	1.455	1.494	0.659	0.860	0.973	0.612	0.706	0.871
Harv/Angler Trip	0.183	0.188	0.149	0.194	0.184	0.091	0.134	0.155	0.082	0.099	0.144
Catch/Angler Trip	0.219	0.284	0.230	0.280	0.283	0.126	0.164	0.189	0.114	0.131	0.159
Harv/Angler Hour	0.025	0.030	0.023	0.028	0.027	0.014	0.019	0.023	0.013	0.015	0.023
Catch/Angler Hr.	0.030	0.045	0.035	0.040	0.042	0.019	0.024	0.028	0.018	0.020	0.025
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.150	0.194	0.178	0.206	0.182	0.126	0.115	0.221	0.092	0.131	0.182
Catch/Boat Trip	0.287	0.587	0.626	0.552	0.577	0.304	0.308	0.544	0.302	0.291	0.381
Harv/Angler Trip	0.059	0.077	0.068	0.080	0.069	0.050	0.045	0.084	0.036	0.049	0.068
Catch/Angler Trip	0.112	0.232	0.241	0.214	0.220	0.120	0.121	0.206	0.119	0.109	0.143
Harv/Angler Hour	0.011	0.014	0.013	0.014	0.013	0.009	0.008	0.014	0.007	0.009	0.012
Catch/Angler Hr.	0.021	0.044	0.046	0.038	0.040	0.022	0.022	0.035	0.022	0.020	0.026

Table A12. Length (total length in inches) and weight (lbs) statistics for rainbow trout sampled April 15 – September 30 during the 1985-2019 and 2021 NYSDEC Lake Ontario fishing boat surveys. Note: Clip data includes any fin which was missing at last 50% of its normal structure. Some clips are likely due to fin erosion of hatchery stocked fish since agency clipping studies were not occurring in all years.

	Avg 1985-2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Mean length and weight data for rainbow trout sampled April - September:											
Mean Length	24.5	24.7	24.9	24.5	24.6	25.3	24.6	24.8	25.2	25.6	25.7
Mean Weight	6.4	6.11	5.86	6.00	5.87	6.10	5.93	6.34	6.24	6.63	6.71
Estimated weight (lbs) for standard length rainbow trout sampled April - September:											
Standard Length:											
18.0 inches	2.3	2.09	2.05	2.21	2.31	2.17	2.37	2.51	2.35	2.28	2.90
20.0 inches	3.2	2.92	2.83	3.04	3.10	2.94	3.16	3.36	3.14	3.09	3.70
22.0 inches	4.2	3.95	3.80	4.06	4.05	3.87	4.10	4.37	4.08	4.07	4.62
24.0 inches	5.5	5.21	4.97	5.28	5.17	4.97	5.19	5.56	5.18	5.22	5.65
26.0 inches	6.9	6.71	6.35	6.73	6.46	6.25	6.46	6.93	6.46	6.58	6.79
28.0 inches	8.6	8.46	7.94	8.39	7.91	7.70	7.87	8.47	7.88	8.11	8.04
30.0 inches	10.5	10.53	9.82	10.34	9.60	9.39	9.49	10.24	9.52	9.89	9.43
32.0 inches	12.7	12.92	11.98	12.58	11.50	11.30	11.32	12.24	11.36	11.91	10.95
Percent length composition of rainbow trout sampled April - September:											
<15.0 in	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
15.0-15.9 in	0.2%	0.0%	0.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%	0.0%
16.0-16.9 in	0.9%	0.0%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
17.0-17.9 in	1.9%	1.3%	0.5%	0.5%	2.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
18.0-18.9 in	4.2%	1.3%	0.5%	0.5%	3.6%	2.0%	0.0%	0.0%	1.0%	0.0%	0.7%
19.0-19.9 in	6.0%	3.3%	1.6%	1.1%	4.5%	2.0%	3.0%	1.0%	3.8%	2.7%	0.0%
20.0-20.9 in	7.8%	4.6%	5.3%	8.1%	1.8%	2.9%	10.1%	1.9%	4.8%	1.4%	2.8%
21.0-21.9 in	9.0%	12.8%	7.4%	9.7%	7.7%	5.9%	6.1%	5.7%	7.7%	6.8%	3.5%
22.0-22.9 in	9.2%	12.1%	10.1%	14.1%	7.7%	9.8%	15.2%	15.2%	9.6%	4.1%	11.3%
23.0-23.9 in	9.3%	10.8%	16.0%	15.1%	7.7%	9.8%	15.2%	22.9%	9.6%	9.6%	9.2%
24.0-24.9 in	8.0%	7.5%	12.2%	9.2%	14.4%	13.7%	9.1%	13.3%	5.8%	11.0%	8.5%
25.0-25.9 in	7.2%	7.9%	11.2%	10.8%	13.5%	10.8%	15.2%	12.4%	11.5%	16.4%	16.2%
26.0-26.9 in	6.8%	11.1%	7.4%	8.1%	10.8%	11.8%	5.1%	6.7%	13.5%	15.1%	16.2%
27.0-27.9 in	7.4%	8.2%	12.8%	7.6%	7.7%	8.8%	4.0%	8.6%	15.4%	13.7%	12.0%
28.0-28.9 in	6.4%	9.5%	5.3%	5.4%	9.5%	6.9%	5.1%	5.7%	7.7%	11.0%	9.9%
29.0-29.9 in	5.2%	4.3%	3.7%	5.9%	4.5%	7.8%	4.0%	1.9%	2.9%	6.8%	4.9%
30.0-30.9 in	4.2%	3.6%	3.2%	1.1%	1.4%	3.9%	5.1%	1.0%	3.8%	0.0%	3.5%
31.0-31.9 in	2.9%	1.3%	1.1%	0.5%	2.3%	2.0%	2.0%	2.9%	1.9%	0.0%	0.7%
32.0-32.9 in	1.7%	0.0%	0.5%	0.5%	0.0%	1.0%	0.0%	0.0%	1.0%	1.4%	0.7%
33.0-33.9 in	0.9%	0.3%	1.1%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
>33.9 in	0.7%	0.0%	0.0%	1.1%	0.0%	0.0%	1.0%	1.0%	0.0%	0.0%	0.0%
Percent fin clip composition of rainbow trout sampled April - September:											
No Clip	77.7%	94.4%	94.1%	94.1%	92.3%	93.1%	94.3%	93.3%	89.4%	98.6%	98.6%
Ad	1.9%	0.3%	1.6%	0.5%	1.8%	1.0%	0.8%	1.9%	2.9%	1.4%	0.7%
LV	7.0%	0.7%	0.5%	2.2%	0.9%	2.9%	1.6%	0.0%	1.0%	0.0%	0.0%
LV-Ad	1.1%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LP	1.8%	0.3%	0.5%	0.0%	0.5%	2.0%	1.6%	3.8%	0.0%	0.0%	0.0%
LP-Ad	3.6%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RV	1.8%	0.3%	2.1%	0.5%	0.9%	0.0%	0.8%	0.0%	1.0%	0.0%	0.0%
RV-Ad	0.5%	0.7%	1.1%	1.1%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RP	2.5%	0.7%	0.0%	0.5%	1.4%	1.0%	0.8%	1.0%	1.0%	0.0%	0.0%
RP-Ad	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Misc.	1.9%	2.0%	0.0%	1.1%	1.4%	0.0%	0.0%	0.0%	4.8%	0.0%	0.7%

Table A13. Atlantic salmon harvest and catch data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	321	398	310	200	66	275	236	151	150	528	97
Catch	1155	1,519	592	599	639	638	704	394	994	1,426	200
% Harvested	26	26.2	52.4	33.4	10.3	43.1	33.5	38.3	15.1	37.0	48.4
Monthly estimates of harvest for all fishing boats:											
April	60	128	29	0	28	24	15	61	24	66	55
May	131	95	183	175	25	24	54	38	14	80	0
June	42	54	46	0	0	12	27	0	35	110	0
July	38	76	51	25	14	169	140	41	0	67	13
August	44	25	0	0	0	25	0	12	54	204	29
September	7	21	0	0	0	20	0	0	23	0	0
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	87	236	126	51	39	0	41	48	59	331	26
West/Central	59	0	0	44	0	0	0	51	26	0	44
East/Central	89	106	93	105	0	136	102	15	26	162	13
East	87	56	91	0	27	139	93	37	40	36	14
Monthly estimates of catch for all fishing boats:											
April	206	296	56	48	180	132	62	61	127	128	79
May	359	439	387	251	215	194	66	120	243	534	0
June	151	171	46	77	0	37	87	0	166	175	0
July	204	212	90	165	162	209	397	65	99	228	80
August	173	340	13	58	82	25	92	69	323	300	29
September	62	62	0	0	0	41	0	80	37	61	13
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	281	526	242	186	121	26	112	112	144	756	54
West/Central	212	366	46	77	112	0	0	49	119	0	76
East/Central	356	339	211	255	209	368	445	171	609	543	55
East	306	287	93	81	197	244	147	63	122	127	15
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	95	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% Catch	97	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Seasonal rates of harvest and catch **per 100 trips** for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.3104	0.803	0.673	0.421	0.134	0.596	0.609	0.421	0.314	1.266	0.246
Catch/Boat Trip	1.0793	3.066	1.285	1.261	1.293	1.383	1.816	1.099	2.078	3.417	0.509
Harv/Angler Trip	0.1061	0.269	0.224	0.136	0.042	0.193	0.194	0.134	0.098	0.389	0.070
Catch/Angler Trip	0.3713	1.028	0.427	0.408	0.411	0.447	0.578	0.350	0.646	1.052	0.146
Harv/Angler Hour	0.0182	0.048	0.039	0.022	0.007	0.033	0.032	0.022	0.017	0.067	0.012
Catch/Angler Hr.	0.0639	0.183	0.075	0.067	0.070	0.076	0.096	0.057	0.113	0.180	0.024

Table A14a. Brown trout harvest and catch data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	29,497	32,937	23,305	18,969	20,626	12,590	14,608	10,604	22,985	10,391	7,307
Catch	42,436	49,661	39,507	27,793	44,487	20,780	20,871	17,092	39,763	17,625	15,293
% Harvested	68.8	66.3	59.0	68.3	46.4	60.6	70.0	62.0	57.8	59.0	47.8
Monthly estimates of harvest for all fishing boats:											
April	7,510	3,558	5,802	2,730	5,094	3,247	5,180	3,221	4,223	3,200	2,512
May	10,329	12,255	5,436	7,810	5,404	3,138	3,377	3,893	7,695	2,414	657
June	3,999	4,941	1,456	3,315	612	3,591	339	796	2,336	85	307
July	3,889	6,695	5,631	2,656	5,202	1,188	1,957	1,536	5,427	2,310	1,924
August	3,245	4,968	4,307	2,197	3,593	1,045	2,775	942	2,351	1,675	1,730
September	525	519	672	259	721	380	980	216	953	707	177
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	2,312	2,563	2,006	1,649	4,267	560	1,010	898	1,687	660	149
West/Central	2,819	2,163	2,792	1,566	2,958	503	2,534	1,429	1,100	536	1,333
East/Central	16,339	16,327	8,932	9,850	8,199	7,903	6,545	5,830	14,150	6,022	3,885
East	8,026	11,883	9,575	5,903	5,202	3,624	4,519	2,447	6,047	3,174	1,939
										0.58	0.53
Monthly estimates of catch for all fishing boats:											
April	10,375	8,160	10,558	4,450	13,369	6,962	7,802	4,136	7,221	5,212	3,658
May	14,273	17,584	9,446	9,329	15,497	4,657	3,957	6,541	14,420	5,761	1,372
June	5,365	6,658	3,345	3,918	913	4,516	446	1,008	3,271	129	317
July	6,195	10,026	7,751	5,169	8,331	1,876	3,053	3,022	7,414	3,001	5,496
August	5,415	6,193	7,236	4,284	5,048	1,498	3,672	1,678	5,841	2,409	4,095
September	812	1,041	1,171	643	1,330	1,271	1,940	706	1,596	1,113	354
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	3,631	4,760	4,122	2,451	12,153	1,249	1,494	1,279	2,749	2,149	578
West/Central	5,712	5,710	6,836	4,933	6,544	1,785	4,364	3,085	5,096	900	5,387
East/Central	22,640	22,945	13,860	12,722	15,761	12,243	9,579	9,465	22,889	10,363	5,969
East	10,452	16,246	14,689	7,687	10,028	5,504	5,434	3,263	9,030	4,213	3,358
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	98.9	99.8	99.8	99.8	99.6	99.9	100.0	100.0	99.3	100.0	99.2
% Catch	98.5	99.8	98.8	99.5	99.8	99.8	99.8	100.0	99.0	99.9	99.6
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	47.5	53.3	55.6	72.9	57.9	62.6	61.1	52.4	63.4	64.0	78.5
% Catch	39.9	43.4	42.3	58.7	36.4	47.4	50.4	45.3	54.7	51.0	66.9

Table A14b. Brown trout harvest and catch rate data collected April 15 – September 30, 1985-2019 and 2021. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.331	0.664	0.505	0.398	0.416	0.273	0.377	0.296	0.477	0.249	0.185
Catch/Boat Trip	0.488	1.000	0.848	0.582	0.898	0.450	0.537	0.477	0.823	0.422	0.388
Harv/Angler Trip	0.113	0.223	0.168	0.129	0.132	0.088	0.120	0.094	0.148	0.077	0.053
Catch/Angler Trip	0.167	0.335	0.282	0.188	0.285	0.145	0.171	0.152	0.256	0.130	0.111
Harv/Angler Hour	0.020	0.040	0.030	0.021	0.022	0.015	0.020	0.015	0.026	0.013	0.009
Catch/Angler Hr.	0.029	0.060	0.050	0.031	0.048	0.025	0.028	0.025	0.045	0.022	0.019
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.045	1.413	2.452	1.060	2.653	1.442	1.620	1.616	2.771	2.495	1.090
May	0.623	1.522	0.648	0.987	0.642	0.363	0.499	1.029	1.019	0.347	0.123
June	0.469	1.134	0.283	0.523	0.106	0.831	0.090	0.269	0.429	0.018	0.055
July	0.319	0.614	0.603	0.272	0.583	0.144	0.233	0.197	0.501	0.259	0.197
August	0.136	0.352	0.334	0.138	0.212	0.085	0.278	0.076	0.169	0.126	0.140
September	0.029	0.054	0.084	0.050	0.092	0.036	0.148	0.031	0.097	0.107	0.033
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.104	0.174	0.158	0.119	0.353	0.049	0.091	0.086	0.139	0.046	0.046
West/Central	0.264	0.429	0.500	0.236	0.473	0.078	0.647	0.383	0.134	0.198	0.198
East/Central	0.607	1.079	0.653	0.645	0.514	0.567	0.473	0.462	0.886	0.470	0.470
East	0.283	0.808	0.674	0.494	0.339	0.251	0.453	0.269	0.515	0.268	0.268
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	1.504	3.241	4.462	1.719	6.963	3.093	2.440	2.075	4.738	4.063	1.588
May	0.885	2.184	1.126	1.179	1.841	0.538	0.584	1.729	1.910	0.829	0.257
June	0.631	1.518	0.579	0.615	0.161	1.039	0.118	0.341	0.568	0.023	0.057
July	0.505	0.920	0.827	0.529	0.938	0.229	0.363	0.388	0.684	0.337	0.564
August	0.236	0.439	0.560	0.269	0.298	0.121	0.362	0.136	0.419	0.182	0.331
September	0.048	0.108	0.146	0.120	0.167	0.122	0.293	0.101	0.166	0.169	0.072
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.165	0.323	0.325	0.176	1.004	0.110	0.135	0.123	0.226	0.149	0.048
West/Central	0.564	1.131	1.224	0.744	1.047	0.277	1.115	0.827	0.619	0.333	0.954
East/Central	0.862	1.513	1.000	0.830	0.991	0.877	0.689	0.750	1.434	0.810	0.461
East	0.373	1.105	1.020	0.641	0.656	0.381	0.545	0.358	0.757	0.353	0.381
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	1.089	2.128	1.698	1.492	1.231	0.805	1.047	0.790	1.258	0.734	0.492
Catch/Boat Trip	1.349	2.611	2.187	1.760	1.667	1.008	1.234	1.101	1.880	0.991	0.877
Harv/Angler Trip	0.216	0.408	0.333	0.287	0.233	0.154	0.199	0.153	0.235	0.136	0.090
Catch/Angler Trip	0.268	0.500	0.429	0.338	0.316	0.193	0.235	0.213	0.351	0.184	0.160
Harv/Angler Hour	0.030	0.064	0.050	0.041	0.035	0.024	0.029	0.023	0.038	0.021	0.014
Catch/Angler Hr.	0.038	0.079	0.065	0.049	0.047	0.030	0.034	0.032	0.057	0.028	0.025
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.196	0.371	0.268	0.134	0.216	0.129	0.188	0.175	0.228	0.114	0.055
Catch/Boat Trip	0.333	0.678	0.582	0.297	0.710	0.299	0.340	0.324	0.485	0.264	0.181
Harv/Angler Trip	0.077	0.146	0.103	0.052	0.082	0.051	0.074	0.066	0.090	0.043	0.021
Catch/Angler Trip	0.131	0.267	0.224	0.115	0.270	0.119	0.134	0.123	0.192	0.099	0.068
Harv/Angler Hour	0.014	0.027	0.020	0.009	0.015	0.009	0.013	0.011	0.017	0.008	0.004
Catch/Angler Hr.	0.025	0.050	0.042	0.020	0.049	0.022	0.024	0.021	0.035	0.018	0.018

Table A15. Length (inches), weight (lbs), age, and fin clip statistics for brown trout sampled April 15 – September 30 during the 1985-2019 and 2021 NYSDEC Lake Ontario fishing boat surveys. Note: Clip data includes any fin which was missing at last 50% of its normal structure. Some clips are likely due to fin erosion of hatchery stocked fish since agency clipping studies were not occurring in all years.

	1985-10 avg.	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Mean length and weight data for brown trout sampled April - September:											
Mean Length (in)	20.1	20.7	20.4	21.1	20.2	20.0	19.7	20.4	20.3	20.7	22.5
Mean Weight (lbs)	4.9	5.30	4.92	5.87	4.48	4.21	4.25	5.20	4.44	4.94	7.32
Estimated weight (lbs) for standard length brown trout sampled April - September:											
16.0 inches	2.1	2.16	1.96	2.32	1.89	1.71	1.86	2.38	1.96	2.09	2.11
18.0 inches	3.1	3.15	2.89	3.30	2.76	2.55	2.75	3.36	2.82	2.97	3.13
20.0 inches	4.4	4.44	4.13	4.56	3.90	3.69	3.94	4.60	3.95	4.09	4.48
22.0 inches	6.0	6.06	5.70	6.10	5.33	5.14	5.43	6.11	5.34	5.47	6.19
24.0 inches	8.0	8.04	7.64	7.96	7.08	6.97	7.30	7.91	7.03	7.13	8.33
26.0 inches	10.4	10.44	10.00	10.16	9.21	9.21	9.56	10.05	9.06	9.09	10.94
28.0 inches	13.2	13.23	12.78	12.69	11.68	11.87	12.23	12.48	11.40	11.34	14.01
Percent length composition of brown trout sampled April - September:											
<15.0 in	1.2%	0.1%	0.0%	0.3%	1.2%	0.3%	0.3%	0.4%	0.0%	1.3%	0.0%
15.0-15.9 in	1.8%	0.1%	1.7%	1.7%	3.5%	6.3%	4.7%	0.4%	0.5%	2.6%	1.3%
16.0-16.9 in	6.3%	1.6%	4.8%	3.5%	8.9%	12.9%	16.2%	3.1%	5.8%	11.0%	1.3%
17.0-17.9 in	12.4%	7.0%	17.4%	8.7%	16.1%	17.4%	17.8%	9.7%	13.7%	9.7%	1.3%
18.0-18.9 in	18.1%	16.6%	15.7%	16.7%	13.2%	10.8%	13.1%	19.0%	17.7%	9.0%	3.9%
19.0-19.9 in	15.8%	19.3%	14.8%	14.2%	9.3%	6.3%	9.1%	19.5%	14.1%	12.9%	7.9%
20.0-20.9 in	12.7%	16.9%	10.2%	10.4%	9.3%	6.3%	8.8%	16.8%	14.6%	8.4%	17.1%
21.0-21.9 in	9.4%	11.4%	7.6%	7.6%	9.5%	9.1%	5.4%	6.2%	10.1%	5.2%	18.4%
22.0-22.9 in	7.0%	10.1%	5.7%	6.3%	8.8%	8.4%	5.7%	8.0%	6.0%	12.3%	11.8%
23.0-23.9 in	4.9%	6.9%	6.3%	9.0%	6.0%	8.0%	6.4%	4.4%	6.1%	9.7%	6.6%
24.0-24.9 in	3.6%	3.9%	5.9%	6.9%	5.6%	4.9%	3.7%	3.5%	4.5%	8.4%	5.3%
25.0-25.9 in	2.8%	2.0%	3.9%	5.6%	2.9%	5.2%	3.4%	5.3%	3.3%	3.2%	9.2%
26.0-26.9 in	2.1%	2.0%	1.7%	4.5%	2.3%	2.8%	1.7%	2.7%	1.4%	3.2%	5.3%
27.0-27.9 in	0.9%	1.0%	2.0%	2.8%	1.6%	1.0%	1.0%	0.0%	1.1%	2.6%	6.6%
28.0-28.9 in	0.6%	0.6%	1.5%	0.7%	1.0%	0.3%	1.7%	0.4%	0.4%	0.0%	2.6%
>28.9 in	0.5%	0.4%	0.7%	1.0%	0.6%	0.0%	1.0%	0.4%	0.5%	0.6%	1.3%
Percent fin clip composition of brown trout sampled April - September:											
No Clip	76.5%	88.7%	92.4%	91.0%	88.1%	91.3%	89.0%	84.5%	91.0%	94.2%	98.7%
Ad	2.2%	1.2%	0.4%	1.0%	0.4%	0.7%	0.3%	0.4%	0.9%	1.3%	0.0%
LV	4.1%	0.6%	1.7%	1.0%	1.9%	1.4%	0.3%	0.9%	0.2%	0.0%	0.0%
LV-Ad	2.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
LP	3.9%	4.3%	2.2%	2.1%	1.2%	2.8%	6.2%	4.4%	3.3%	1.9%	1.3%
LP-Ad	1.6%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%
RV	3.8%	0.6%	0.7%	3.5%	6.2%	2.1%	2.1%	4.4%	1.1%	0.6%	0.0%
RV-Ad	0.4%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RP	3.9%	2.6%	1.5%	1.0%	1.4%	0.3%	1.4%	1.3%	2.9%	1.9%	0.0%
RP-Ad	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%
Misc.	1.2%	1.9%	1.1%	0.3%	0.4%	1.4%	0.7%	4.0%	0.4%	0.0%	0.0%
Percent age composition of brown trout sampled April - September:											
Age-1	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.4%
Age-2	77.6%	78.7%	74.6%	60.0%	62.6%	58.3%	73.8%	79.7%	76.5%	64.2%	49.2%
Age-3	18.4%	17.2%	21.3%	34.6%	28.8%	30.9%	19.2%	16.7%	19.9%	27.1%	28.7%
Age-4	2.9%	3.9%	3.3%	2.7%	7.8%	9.2%	5.8%	3.3%	2.6%	7.2%	14.9%
Age-5+	0.6%	0.3%	0.7%	2.6%	0.8%	1.6%	1.2%	0.3%	1.0%	1.5%	4.8%
Mean length (inches) of aged brown trout sampled in April:											
Age-2	18.1	18.6	17.9	18.0	17.4	17.0	17.3	18.5	17.8	17.1	18.7
Age-3	22.8	22.8	23.1	23.3	21.7	21.6	22.1	23.8	22.8	22.7	22.3
Mean weight (lbs) of aged brown trout sampled in April											
Age-2	3.1	3.4	2.8	3.3	2.4	2.0	2.5	3.7	2.6	2.4	3.8
Age-3	6.1	6.0	6.4	7.2	4.7	4.5	5.7	7.6	5.6	6.1	6.9

Table A16a. Lake trout harvest and catch data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	27,065	7,017	7,829	20,511	15,870	18,780	18,426	8,592	4,949	7,672	11,649
Catch	58,358	24,336	22,206	35,533	33,108	52,294	36,336	15,444	12,205	16,354	18,959
% Harvested	41.5	28.8	35.3	57.7	47.9	35.9	50.7	55.6	40.5	46.9	61.4
Monthly estimates of harvest for all fishing boats:											
April	2,380	255	1,442	1,393	757	596	2,063	817	616	275	1,552
May	5,247	840	2,311	6,311	2,207	6,148	5,228	2,095	1,391	2,545	2,641
June	5,042	1,478	1,456	4,455	2,561	1,151	3,833	1,797	829	1,274	754
July	7,934	2,266	1,216	4,346	3,967	3,062	2,951	2,546	678	1,956	1,799
August	5,651	1,871	899	2,066	6,230	5,718	2,036	1,004	1,203	987	4,645
September	811	308	505	1,941	148	2,105	2,314	333	232	636	257
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	5,543	1,751	1,417	1,605	1,717	3,038	2,670	1,004	864	1,630	1,128
West/Central	3,021	1,358	1,491	5,327	6,099	4,038	4,040	2,354	706	1,180	2,947
East/Central	6,584	1,950	2,134	6,602	2,500	4,183	5,473	3,064	2,189	2,560	2,278
East	11,917	1,959	2,786	6,977	5,553	7,521	6,243	2,169	1,190	2,301	5,297
Monthly estimates of catch for all fishing boats:											
April	5,416	885	3,823	1,955	3,728	2,214	8,084	1,271	1,050	1,072	4,499
May	10,690	8,956	8,397	12,288	7,417	28,246	11,692	5,032	4,383	6,482	3,681
June	10,721	3,789	3,533	7,818	5,812	2,611	6,078	2,787	1,952	2,645	1,632
July	17,519	7,626	2,871	7,971	6,150	7,553	4,920	4,404	1,526	2,859	3,229
August	12,304	2,484	2,903	3,178	9,563	8,836	2,594	1,455	2,329	2,467	5,649
September	1,708	596	679	2,323	438	2,834	2,968	496	966	828	270
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	15,397	11,226	6,487	5,219	7,740	28,107	10,329	3,294	3,210	6,528	3,597
West/Central	7,757	3,772	3,699	9,099	10,454	6,697	7,158	5,552	3,105	2,126	5,094
East/Central	13,552	6,419	6,121	11,400	4,652	6,145	9,732	4,149	4,032	4,606	4,156
East	21,652	2,920	5,899	9,815	10,262	11,345	9,116	2,449	1,859	3,094	6,113
Percent of seasonal harvest and catch made by boats seeking any or all species of trout and salmon:											
% Harvest	99.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.1	100.0	100.0
% Catch	99.6	100.0	100.0	100.0	99.7	100.0	100.0	100.0	99.6	100.0	99.9
Percent of seasonal harvest and catch made by charter boats seeking any or all species of trout and salmon:											
% Harvest	63.8	64.9	67.2	77.9	72.5	82.0	80.0	76.4	70.3	68.9	79.6
% Catch	43.4	33.1	33.5	60.2	46.8	39.5	53.1	52.1	47.0	42.5	61.6

Table A16b. Lake trout harvest and catch rate data collected April 15 – September 30, 1985-2019 and 2021. Table includes estimates for all boats targeting trout and salmon, and charter and non-charter boats targeting trout and salmon.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal rates of harvest and catch for boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.230	0.142	0.170	0.432	0.321	0.407	0.475	0.240	0.103	0.184	0.297
Catch/Boat Trip	0.525	0.491	0.482	0.748	0.668	1.133	0.937	0.431	0.254	0.392	0.482
Harv/Angler Trip	0.080	0.047	0.056	0.140	0.102	0.131	0.151	0.076	0.032	0.057	0.085
Catch/Angler Trip	0.181	0.165	0.160	0.242	0.212	0.366	0.298	0.137	0.079	0.121	0.138
Harv/Angler Hour	0.014	0.008	0.010	0.023	0.017	0.022	0.025	0.013	0.006	0.010	0.014
Catch/Angler Hr.	0.031	0.029	0.028	0.040	0.036	0.062	0.049	0.023	0.014	0.021	0.023
Monthly harvest rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.207	0.101	0.609	0.541	0.394	0.265	0.645	0.410	0.404	0.214	0.674
May	0.235	0.104	0.276	0.798	0.262	0.710	0.772	0.554	0.184	0.366	0.495
June	0.432	0.343	0.283	0.703	0.467	0.266	1.013	0.607	0.156	0.270	0.152
July	0.486	0.208	0.131	0.450	0.449	0.376	0.351	0.327	0.063	0.219	0.184
August	0.189	0.132	0.070	0.130	0.368	0.463	0.204	0.081	0.083	0.074	0.375
September	0.042	0.032	0.063	0.378	0.019	0.202	0.349	0.048	0.027	0.096	0.056
Seasonal harvest rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.170	0.119	0.112	0.117	0.142	0.268	0.241	0.096	0.071	0.114	0.094
West/Central	0.270	0.269	0.267	0.803	0.976	0.626	1.032	0.631	0.086	0.436	0.522
East/Central	0.189	0.129	0.157	0.433	0.158	0.300	0.396	0.243	0.138	0.200	0.176
East	0.330	0.134	0.196	0.584	0.364	0.522	0.626	0.238	0.099	0.194	0.610
Monthly catch rates per boat trip for boats seeking any or all species of trout and salmon:											
April	0.664	0.351	1.616	0.759	1.942	0.984	2.528	0.638	0.689	0.836	1.945
May	0.529	1.113	1.001	1.553	0.871	3.263	1.725	1.330	0.581	0.933	0.691
June	0.947	0.879	0.688	1.234	1.059	0.599	1.606	0.942	0.366	0.561	0.330
July	1.064	0.699	0.310	0.826	0.697	0.928	0.586	0.565	0.141	0.321	0.331
August	0.417	0.176	0.225	0.200	0.565	0.716	0.259	0.118	0.164	0.186	0.456
September	0.089	0.062	0.085	0.452	0.056	0.272	0.448	0.071	0.112	0.125	0.059
Seasonal catch rates per boat trip among geographic areas for boats seeking any or all species of trout and salmon:											
West	0.546	0.763	0.512	0.382	0.633	2.476	0.934	0.316	0.264	0.455	0.298
West/Central	0.734	0.747	0.662	1.372	1.673	1.039	1.829	1.489	0.379	0.786	0.903
East/Central	0.398	0.424	0.450	0.747	0.293	0.439	0.704	0.329	0.254	0.359	0.321
East	0.606	0.199	0.415	0.821	0.673	0.787	0.913	0.269	0.157	0.261	0.704
Seasonal rates of harvest and catch for charter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.955	0.552	0.690	1.724	1.185	1.574	1.727	0.933	0.301	0.583	0.795
Catch/Boat Trip	1.578	0.976	0.975	2.309	1.596	2.111	2.262	1.144	0.495	0.767	1.001
Harv/Angler Trip	0.194	0.106	0.135	0.331	0.224	0.302	0.329	0.181	0.056	0.108	0.145
Catch/Angler Trip	0.316	0.187	0.191	0.444	0.302	0.405	0.431	0.222	0.093	0.142	0.183
Harv/Angler Hour	0.027	0.017	0.020	0.048	0.033	0.046	0.048	0.027	0.009	0.017	0.023
Catch/Angler Hr.	0.043	0.029	0.029	0.064	0.045	0.062	0.062	0.033	0.015	0.022	0.029
Seasonal rates of harvest and catch for noncharter boats seeking any or all species of trout and salmon:											
Harv/Boat Trip	0.119	0.060	0.067	0.119	0.110	0.093	0.122	0.070	0.039	0.073	0.086
Catch/Boat Trip	0.355	0.394	0.384	0.370	0.441	0.870	0.563	0.257	0.177	0.288	0.263
Harv/Angler Trip	0.046	0.024	0.026	0.046	0.042	0.037	0.048	0.027	0.016	0.027	0.032
Catch/Angler Trip	0.139	0.155	0.148	0.143	0.168	0.344	0.221	0.097	0.070	0.108	0.099
Harv/Angler Hour	0.009	0.004	0.005	0.008	0.008	0.007	0.009	0.005	0.003	0.005	0.006
Catch/Angler Hr.	0.026	0.029	0.028	0.025	0.031	0.062	0.040	0.017	0.013	0.020	0.018

Table A17. Length and weight statistics for lake trout sampled April 15 - September 30 during the 1985-2019 and 2021 NYSDEC Lake Ontario fishing boat surveys.

	1985-10 avg.	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Mean length and weight of lake trout sampled April - September:												
Mean Length (in)	25.1	23.4	25.5	26.3	25.9	27.2	27.5	27.5	26.9	26.7	26.3	28.5
Mean weight (lbs)	6.8	5.71	7.37	8.00	7.41	8.46	8.82	8.76	8.71	8.10	8.58	10.64
Percent length composition of lake trout sampled April - September:												
<15.0 inches	0.1%	0.8%	0.0%	0.0%	0.0%	0.5%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
15-15.9 inches	0.1%	0.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%
16-16.9 inches	0.4%	1.6%	0.0%	0.0%	0.4%	0.0%	1.7%	0.0%	0.0%	0.0%	2.5%	0.0%
17-17.9 inches	1.2%	4.1%	0.8%	0.9%	2.5%	0.0%	2.6%	1.2%	0.0%	1.3%	3.8%	0.0%
18-18.9 inches	1.9%	7.3%	2.5%	3.4%	2.9%	0.0%	2.6%	1.8%	3.6%	5.1%	3.8%	2.0%
19-19.9 inches	4.0%	2.4%	4.2%	1.7%	2.5%	1.8%	0.9%	2.1%	4.8%	0.0%	0.0%	0.0%
20-20.9 inches	5.2%	10.6%	4.2%	2.6%	3.6%	0.9%	0.0%	2.6%	2.4%	3.8%	3.8%	2.0%
21-21.9 inches	8.1%	13.0%	6.7%	6.8%	4.7%	1.4%	0.0%	5.3%	3.6%	5.1%	3.8%	3.0%
22-22.9 inches	10.1%	9.8%	7.5%	4.3%	4.3%	5.1%	3.0%	5.6%	4.8%	6.4%	3.8%	3.0%
23-23.9 inches	12.8%	14.6%	10.8%	3.4%	6.1%	4.1%	3.0%	2.9%	3.6%	6.4%	7.5%	5.1%
24-24.9 inches	12.9%	4.9%	8.3%	6.8%	8.7%	8.8%	5.7%	1.8%	10.7%	3.8%	11.3%	2.0%
25-25.9 inches	9.3%	3.3%	15.0%	14.5%	10.5%	11.5%	8.7%	5.9%	8.3%	7.7%	8.8%	8.1%
26-26.9 inches	5.7%	5.7%	7.5%	11.1%	8.7%	13.8%	9.6%	7.6%	2.4%	7.7%	6.3%	5.1%
27-27.9 inches	3.8%	1.6%	11.7%	15.4%	15.5%	10.6%	13.5%	13.2%	7.1%	7.7%	3.8%	6.1%
28-28.9 inches	3.4%	7.3%	1.7%	5.1%	10.8%	12.9%	9.6%	9.7%	16.7%	9.0%	8.8%	14.1%
29-29.9 inches	3.9%	4.1%	2.5%	4.3%	7.9%	11.1%	14.3%	10.0%	6.0%	14.1%	6.3%	12.1%
30-30.9 inches	5.8%	4.1%	4.2%	7.7%	4.7%	7.8%	9.1%	11.1%	8.3%	7.7%	8.8%	13.1%
31-31.9 inches	4.6%	1.6%	3.3%	7.7%	1.8%	3.7%	6.5%	5.3%	6.0%	3.8%	5.0%	4.0%
32-32.9 inches	2.7%	2.4%	5.0%	0.9%	2.2%	1.4%	2.2%	4.4%	4.8%	5.1%	3.8%	5.1%
33-33.9 inches	2.0%	0.0%	1.7%	0.0%	1.1%	2.8%	3.9%	3.2%	6.0%	2.6%	5.0%	10.1%
34-34.9 inches	1.2%	0.0%	1.7%	2.6%	1.1%	1.4%	0.9%	4.1%	1.2%	1.3%	1.3%	2.0%
>34.9 inches	0.7%	0.0%	0.8%	0.9%	0.0%	0.5%	2.2%	1.8%	0.0%	1.3%	2.5%	3.0%
30.0+ inches	17.0%	8.1%	16.7%	19.7%	10.8%	17.5%	24.8%	29.9%	26.2%	21.8%	26.3%	37.4%
25.0-29.9 inches	25.5%	22.0%	38.3%	50.4%	53.4%	59.9%	55.7%	46.3%	40.5%	46.2%	33.8%	45.5%

- Note: From 1985-1992 a variety of size limits were in effect in New York waters. In 1985-1987, there was only a small minimum size limit in effect. In 1988, and the first half of the 1989 fishing season, a 25 to <30 inch slot limit was in effect. During the second half of the 1989 fishing season, and from 1990-1992, there was a 27 to <30 inch slot limit. From 1993-2006, the 25 to <30 inch slot limit was reinstated. In October 2006, the lake trout creel limit was reduced from three fish per angler per day to two fish, while allowing one of the two fish per angler to be between 25 to <30 inches.

Table A18a. Smallmouth bass harvest and catch data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	42,698	6,442	5,683	7,536	12,538	2,942	3,701	2,305	3,111	2,248	2,863
Catch	216,486	25,795	24,032	21,446	31,807	16,821	26,719	12,079	26,875	10,524	18,318
% Harvested	21.3	25.0	23.6	35.1	39.4	17.5	13.9	19.1	11.6	21.4	15.6
Monthly estimates of harvest for all fishing boats:											
April	2	0	0	0	0	0	0	0	0	0	0
May	47	0	0	0	0	0	0	0	0	0	0
June	7,232	268	1,178	1,073	6,740	0	520	157	846	184	1,846
July	12,590	668	2,702	3,846	2,520	1,306	1,164	677	571	607	416
August	14,858	3,331	1,377	853	2,928	738	797	389	1,079	162	451
September	7,969	2,176	426	1,764	350	899	1,220	1,082	615	1,295	150
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	3,118	254	800	556	208	118	0	0	0	56	0
West/Central	2,852	261	36	48	176	0	0	0	0	0	0
East/Central	21,676	700	1,940	1,214	589	1,078	978	744	461	608	483
East	15,052	5,227	2,907	5,718	11,566	1,746	2,723	1,561	2,650	1,585	2,380
Monthly estimates of catch for all fishing boats:											
April	508	22	82	438	480	60	781	121	144	172	1,149
May	5,492	1,299	1,558	350	364	1,564	1,470	667	1,185	1,099	180
June	28,774	1,604	4,987	2,859	12,380	2,296	6,792	1,645	2,066	1,794	5,304
July	68,024	8,026	9,561	10,239	7,057	4,831	4,720	3,795	9,644	3,454	6,229
August	77,653	10,407	5,611	2,732	8,957	5,187	7,691	2,369	4,889	1,719	3,422
September	36,034	4,437	2,234	4,829	2,570	2,884	5,266	3,482	8,948	2,286	2,033
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	19,963	2,459	5,768	3,009	4,818	3,059	2,744	105	2,102	1,413	1,408
West/Central	31,193	799	1,048	634	672	1,013	253	298	762	126	206
East/Central	109,251	5,830	6,648	5,916	4,088	7,265	12,720	5,790	8,924	2,649	7,307
East	56,078	16,706	10,567	11,888	22,229	5,484	11,002	5,886	15,086	6,336	9,397
Percent of seasonal harvest and catch made by boats seeking smallmouth bass during the traditional open season:											
% Harvest	91.1	96.4	88.5	94.5	98.4	99.2	96.7	97.2	90.4	99.0	92.9
% Catch	84.9	78.1	85.9	86.4	91.8	82.4	78.6	77.3	88.6	75.0	80.4
Estimates of catch by boats seeking smallmouth bass during the catch and release season:											
April	-	0	0	0	0	0	0	0	0	0	1,100
May	-	0	196	0	0	1,116	1,293	449	711	1,071	102
June	-	502	24	146	195	48	1,571	952	0	1,049	559
Total	-	502	220	146	195	1,164	2,864	1,401	711	2,120	1,761
Percent of seasonal catch made by boats seeking smallmouth bass during the catch and release season:											
% Catch	-	1.9%	0.9%	0.7%	0.6%	6.9%	10.7%	11.6%	2.6%	20.1%	9.6%

Note: A regulation change effective October 1, 2006 established a pre-season catch and release period for smallmouth bass from December 1 through the Friday preceding the third Saturday in June (excluding Jefferson County's Lake Ontario waters).

Table A18b. Smallmouth bass harvest and catch rate data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal rates of harvest and catch for boats seeking smallmouth bass during the **traditional open season**:											
Harv/Boat Trip	1.80	0.992	0.811	1.667	1.794	0.599	0.676	0.976	0.680	0.762	0.733
Catch/Boat Trip	8.38	3.219	3.327	4.337	4.244	2.847	3.969	4.072	5.757	2.704	4.059
Harv/Angler Trip	0.78	0.451	0.372	0.784	0.868	0.295	0.300	0.460	0.323	0.371	0.323
Catch/Angler Trip	3.67	1.464	1.528	2.040	2.052	1.400	1.759	1.919	2.737	1.317	1.789
Harv/Angler Hour	0.24	0.145	0.120	0.226	0.242	0.104	0.096	0.161	0.102	0.113	0.091
Catch/Angler Hr.	1.10	0.471	0.492	0.587	0.572	0.493	0.565	0.671	0.860	0.401	0.505
Monthly harvest rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	1.73	0.259	0.701	1.188	3.514	0.000	0.548	0.559	1.125	0.583	1.584
July	1.52	0.225	0.943	2.716	1.355	0.550	0.748	0.824	0.295	0.604	0.216
August	2.01	1.886	0.829	0.823	1.256	0.621	0.385	0.621	0.895	0.352	0.483
September	2.01	2.353	0.585	1.384	0.384	1.122	1.268	1.617	0.738	1.119	0.503
Seasonal harvest rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	1.06	0.312	0.605	1.577	0.126	0.150	0.000	0.000	0.000	0.132	0.000
West/Central	0.73	0.333	0.000	0.085	0.289	0.000	0.000	0.000	0.000	0.000	0.000
East/Central	1.87	0.209	0.720	0.991	0.280	0.472	0.330	0.726	0.172	0.461	0.313
East	2.56	2.761	1.449	2.454	3.421	1.186	1.267	1.558	1.735	1.193	1.232
Monthly catch rates per boat trip for boats seeking smallmouth bass during the **traditional open season**:											
April & May	-	-	-	-	-	-	-	-	-	-	-
June	5.68	0.612	2.940	2.256	6.299	3.368	5.489	1.754	1.871	2.229	3.470
July	7.91	2.871	3.766	7.177	3.292	2.017	3.095	4.409	5.751	3.439	4.094
August	10.06	4.803	3.210	2.326	3.808	3.958	3.397	4.209	4.517	3.262	4.245
September	8.69	3.944	3.016	3.759	2.881	3.360	5.048	4.525	10.709	1.964	5.735
Seasonal catch rates per boat trip among geographic areas for boats seeking smallmouth bass during the **traditional open season**:											
West	5.99	1.450	5.397	6.534	3.585	3.227	0.897	0.231	9.415	0.626	1.108
West/Central	6.92	0.739	0.534	1.043	0.775	0.122	1.833	1.144	0.000	1.922	0.458
East/Central	8.98	1.103	2.086	4.285	1.661	2.807	4.119	4.956	3.569	1.448	4.669
East	8.86	8.264	5.204	4.862	6.468	3.384	4.294	4.402	9.753	4.297	4.392
Seasonal catch rates for boats seeking smallmouth bass during the catch and release season:											
Catch/Boat Trip	-	2.100	0.422	0.764	0.661	7.098	8.045	7.076	3.217	9.231	3.558
Catch/Angler Trip	-	1.887	0.170	0.327	0.293	3.660	3.788	2.895	2.294	4.380	1.988
Catch/Angler Hr.	-	1.035	0.072	0.188	0.124	1.257	0.867	0.802	1.491	0.927	0.648
Monthly catch rates per boat trip for boats seeking smallmouth bass during the catch and release season:											
April	-	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	25.781
May	-	0.000	0.590	0.000	0.000	10.731	13.061	5.684	3.217	6.754	0.449
June	-	2.523	0.127	1.390	0.878	0.800	6.113	9.520	0.000	14.755	2.492

Table A19. Yellow perch harvest and catch data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:											
Harvest	12,382	31,830	16,701	6,572	6,066	6,960	10,483	5,204	4,541	2,722	7,334
Catch	28,527	65,394	35,836	15,345	17,966	17,384	18,176	19,459	11,782	3,046	14,386
% Harvested	51.0	48.7	46.6	42.8	33.8	40.0	57.7	26.7	38.5	89.4	51.0
Monthly estimates of harvest for all fishing boats:											
April	55	0	2,653	972	0	0	0	840	0	0	0
May	1,216	112	4,203	2,016	0	0	25	88	0	0	0
June	3,611	2,194	6,116	973	0	24	1,150	56	2,108	126	2,227
July	2,181	5,637	1,913	304	2,453	6,042	7,062	1,848	1,008	2,345	488
August	2,248	16,979	1,755	2,040	3,535	12	40	1,041	1,010	14	4,521
September	3,071	6,908	61	267	78	882	2,205	1,332	415	237	98
Seasonal estimates of harvest among geographic areas for all fishing boats:											
West	1,731	0	14	0	0	0	0	1,188	0	0	0
West/Central	1,017	30	2,816	1,136	0	759	2,014	0	0	0	0
East/Central	6,714	22,363	7,814	4,227	3,050	6,104	8,411	2,810	3,898	2,532	483
East	2,919	9,438	6,057	1,209	3,016	97	58	1,205	643	190	2,380
Monthly estimates of catch for all fishing boats:											
April	129	0	5,293	2,172	0	0	0	1,120	0	0	1,149
May	3,281	112	10,211	4,420	0	0	476	88	170	0	180
June	7,535	5,055	13,440	1,921	1,800	264	2,115	80	3,315	126	5,304
July	5,170	14,419	2,508	923	7,691	13,740	9,766	3,086	2,708	2,466	6,229
August	5,722	29,676	4,298	5,642	8,241	781	511	6,440	4,032	217	3,422
September	6,689	16,132	86	267	234	2,599	5,307	8,646	1,557	237	2,033
Seasonal estimates of catch among geographic areas for all fishing boats:											
West	2,537	0	49	0	0	0	0	1,601	0	0	1,408
West/Central	2,142	193	4,384	3,890	45	2,411	5,399	332	386	0	206
East/Central	18,284	50,878	20,510	9,527	10,439	14,131	12,303	10,187	10,131	2,860	7,307
East	5,564	14,323	10,893	1,928	7,482	842	474	7,339	1,265	185	9,397

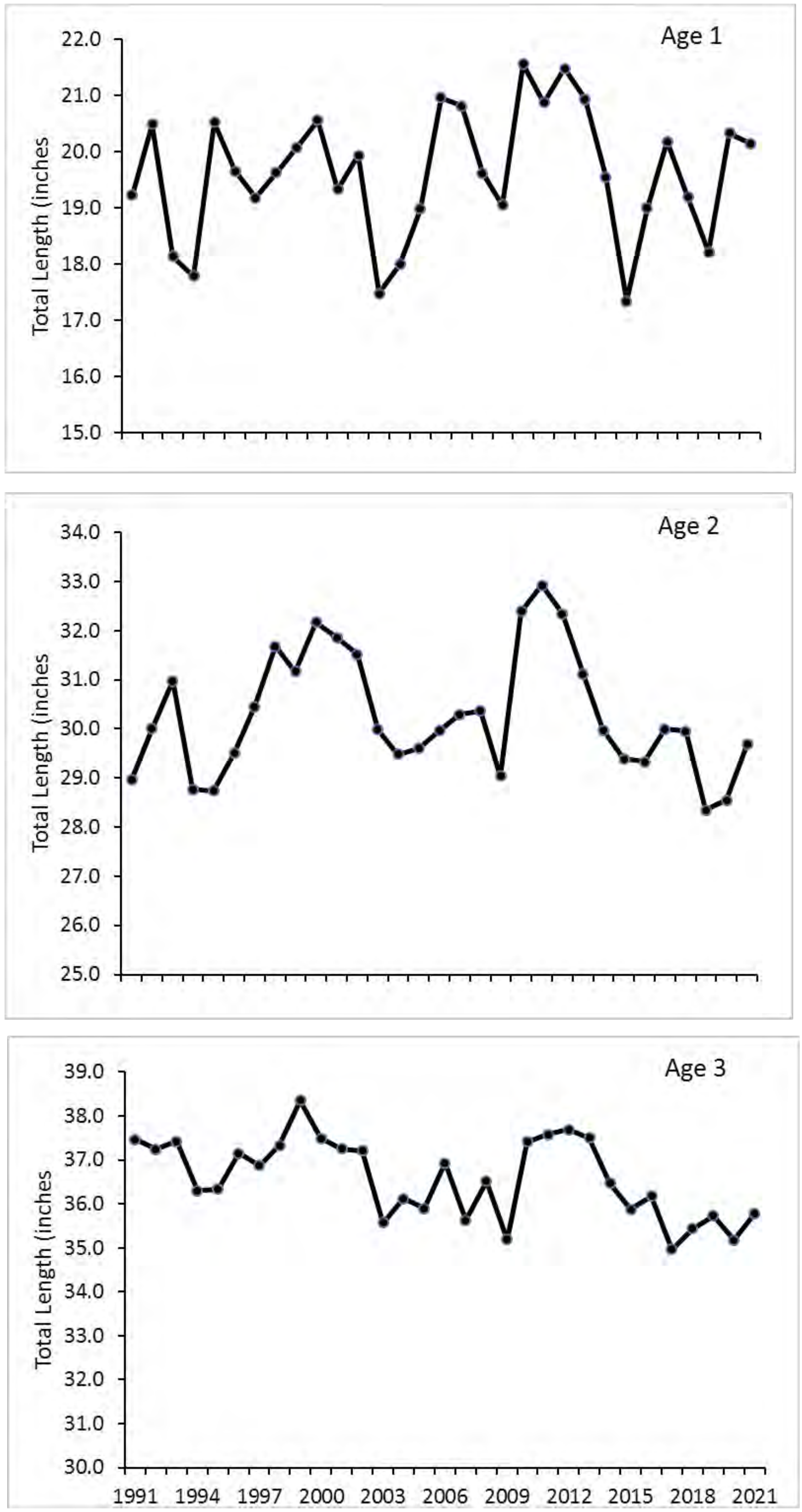
Table A20. Walleye harvest and catch data collected April 15 – September 30, 1985-2019 and 2021.

	1985-10 avg	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Seasonal (5½-month) estimates of harvest and catch for all fishing boats:												
Harvest	637	106	458	130	318	182	350	349	152	0	144	503
Catch	891	301	531	130	388	421	446	671	208	0	919	667
% Harvested	72.8	35.2	86.3	100.0	82.0	43.2	78.5	52.0	73.1		15.7	75.4
Monthly estimates of harvest for all fishing boats:												
April	0	0	0	0	0	0	0	0	0	0	0	0
May	92	0	16	50	0	50	26	63	88	0	56	0
June	94	0	26	0	23	12	0	0	0	0	21	0
July	47	0	88	80	0	0	0	0	0	0	0	0
August	314	44	160	0	27	120	252	286	0	0	67	503
September	89	62	168	0	267	0	72	0	64	0	0	0
Seasonal estimates of harvest among geographic areas for all fishing boats:												
West	61	106	86	84	0	92	246	247	0	0	54	448
West/Central	5	0	0	22	21	0	0	0	0	0	0	0
East/Central	53	0	0	0	0	40	0	12	17	0	61	9
East	519	0	372	24	297	50	104	91	135	0	29	46
Monthly estimates of catch for all fishing boats:												
April	12	0	15	0	0	0	12	0	0	0	0	24
May	117	0	16	50	0	50	26	63	132	0	56	0
June	217	0	26	0	23	12	0	0	0	0	42	0
July	79	0	147	80	70	0	0	0	12	0	0	42
August	363	213	160	0	27	338	336	608	0	0	821	503
September	102	87	168	0	267	22	72	0	64	0	0	98
Seasonal estimates of catch among geographic areas for all fishing boats:												
West	108	180	142	84	59	163	327	572	49	0	588	591
West/Central	7	0	0	22	22	165	0	0	0	0	0	0
East/Central	80	0	20	0	0	41	0	11	31	0	67	9
East	696	121	369	24	306	51	119	88	128	0	264	67

Table A21. Estimates of sea and silver lampreys observed by boat anglers April 15 – September 30, 1986-2019 and 2021.

	1986-10 avg.	2011	2012	2013	2014	2015	2016	2017	2018	2019	2021
Monthly and seasonal estimates of lampreys observed:											
April	234	558	575	68	100	118	199	260	59	15	512
May	743	1,618	1,266	835	595	775	363	505	1,134	157	208
June	354	769	294	353	384	212	92	102	367	227	449
July	508	1,155	460	789	567	460	730	589	1,067	649	1,233
August	699	842	707	829	951	767	199	685	2,035	664	550
September	216	184	138	53	401	63	97	237	666	151	38
Total	2,753	5,125	3,441	2,927	2,998	2,375	1,680	2,380	5,327	1,863	2,982
Seasonal estimates of lampreys observed among four geographic areas:											
West	1,078	1,163	1,147	969	894	1,251	766	634	1,649	708	1,086
West/Central	315	565	609	396	308	267	49	405	953	228	237
East/Central	812	1,812	1,007	1,242	976	510	728	1,027	1,750	636	1,441
East	548	1,585	678	320	819	347	137	314	975	291	218
Percentage of lampreys observed that were attached to angler caught trout and salmon:											
Percent	98.9%	96.8%	97.9%	98.4%	98.3%	99.1%	96.6%	100.0%	97.8%	99.0%	100.0%
Monthly and seasonal estimates of lampreys attached to angler caught trout & salmon, per 1000 trout & salmon caught:											
April	14.46	45.60	29.72	9.28	5.16	11.35	12.18	35.26	6.84	2.02	54.77
May	16.63	45.50	34.03	22.70	12.93	13.55	14.48	30.33	21.33	4.23	21.03
June	15.81	34.61	12.13	17.58	13.31	16.06	5.98	11.12	12.39	10.61	23.62
July	15.95	14.04	10.83	19.18	16.88	19.18	17.64	13.71	20.29	17.46	26.44
August	13.57	16.68	12.63	15.41	16.91	22.21	7.51	10.15	27.00	13.18	14.50
September	10.38	9.57	7.95	5.46	24.00	4.17	7.16	12.68	19.83	9.08	5.55
Total	14.74	23.09	17.50	17.34	14.93	15.38	12.15	14.66	21.06	10.95	23.01
Seasonal estimates of lampreys attached to angler caught trout & salmon by geographic area, per 1000 trout & salmon caught:											
West	14.96	12.43	15.56	14.25	13.41	17.85	13.41	10.17	19.79	9.88	19.63
West/Central	13.01	25.57	23.22	15.01	8.72	14.38	3.13	19.29	19.78	14.78	11.33
East/Central	15.39	26.87	20.53	25.33	16.10	13.04	16.90	17.94	21.67	11.41	38.51
East	14.91	40.76	14.24	12.58	21.47	13.03	6.11	14.43	23.96	10.66	13.68
Seasonal percent distribution of host species to which the lampreys were attached:											
Coho Salmon	2.6%	3.4%	2.9%	1.6%	2.6%	0.0%	0.0%	2.0%	2.2%	1.1%	2.6%
Chinook Salmon	43.3%	37.4%	60.0%	68.8%	58.1%	64.8%	60.7%	51.0%	71.7%	89.1%	72.4%
Rainbow Trout	7.6%	5.6%	8.6%	5.6%	18.8%	10.2%	7.1%	8.2%	3.1%	2.2%	4.3%
Atlantic Salmon	0.7%	0.0%	2.1%	0.0%	0.0%	0.0%	1.2%	1.0%	0.0%	2.2%	0.0%
Brown Trout	17.9%	47.5%	22.1%	13.6%	17.9%	12.0%	19.0%	35.7%	22.1%	5.4%	15.5%
Lake Trout	27.9%	6.1%	4.3%	10.4%	2.6%	13.0%	11.9%	2.0%	0.9%	0.0%	5.2%
Seasonal estimated total number of lampreys observed attached to specific hosts											
Coho Salmon	67	166	96	46	74	0	0	49	115	19	77
Chinook Salmon	1,318	1,856	2,021	1,967	1,685	1,511	963	1,214	3,720	1,575	2,159
Rainbow Trout	203	277	289	160	545	238	113	194	161	38	129
Atlantic Salmon	14	0	72	0	0	0	19	24	0	38	0
Brown Trout	531	2,355	746	389	520	281	302	850	1,148	96	463
Lake Trout	609	305	144	297	74	302	189	49	46	0	154
Seasonal percentage of total host-specific angler catch with attached lampreys:											
Coho Salmon	0.67%	1.40%	0.77%	0.59%	0.88%	0.00%	0.00%	0.46%	1.39%	0.50%	0.6%
Chinook Salmon	1.85%	1.90%	2.27%	3.14%	2.20%	2.57%	1.59%	1.26%	2.14%	1.37%	3.6%
Rainbow Trout	0.81%	0.76%	0.88%	0.46%	1.46%	1.36%	0.68%	0.86%	0.89%	0.24%	0.6%
Atlantic Salmon	4.16%	0.00%	12.19%	0.00%	0.00%	0.00%	2.68%	6.16%	0.00%	2.69%	0.0%
Brown Trout	1.49%	4.74%	1.89%	1.40%	1.17%	1.35%	1.45%	4.97%	2.89%	0.54%	3.0%
Lake Trout	1.06%	1.25%	0.65%	0.84%	0.22%	0.58%	0.52%	0.31%	0.38%	0.00%	0.8%

Figure A1. Mean length (total length in inches) of age-1, age-2, and age-3 Chinook salmon sampled in August during the 1991-2019 and 2021 NYSDEC Lake Ontario fishing boat surveys.



The Relative Survival of Stocked Fall Fingerling vs Spring Yearling Coho Salmon and the Proportions of Wild and Hatchery Coho Salmon in Lake Ontario

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Coho Salmon were first introduced to Lake Ontario in 1968 to provide a sport fishery and help control overabundant invasive Alewife after the extirpation of native Atlantic Salmon and Lake Trout. Coho Salmon were derived from eggs obtained mainly from Lake Michigan sources which originally obtained eggs from the Cascade River, Oregon and Toutle River, WA, and later from the Platte River, WA (Keller et al. 1990). New York State Department of Environmental Conservation (NYSDEC) currently maintains its stocking program by collecting eggs from mature Coho Salmon returning to the Salmon River and ascending a fish ladder at Salmon River Hatchery in Altmar, NY. Ontario Ministry of Natural Resources and Forestry (OMNRF) collects eggs from mature Coho Salmon returning to Credit River, Ontario each fall and a cooperator group produces the fish at Ringwood Hatchery in Stouffville, Ontario. Although stocking levels fluctuated from 2001-2019, NYSDEC annually targeted releases of approximately 90,000 yearlings at Salmon River (Altmar, New York), and 155,000 fall fingerlings at six sites in New York (Figure 1). The Province of Ontario targeted average annual releases of 80,0000 fall fingerling Coho Salmon at the Credit River (Toronto, Ontario) during this period. Fall fingerlings are held in hatcheries until they are released at tributaries in the fall (age~10 months), whereas yearlings are released the following spring (age ~15 months).

Coho Salmon are a relatively minor component of the Lake Ontario salmon and trout fishery in New York, ranking 5th among the most frequently caught of six trout and salmon species available. Coho catch rates are typically an order of magnitude lower than other more commonly caught Chinook Salmon, Brown Trout, Lake Trout, and Rainbow Trout, and Coho represented about 2% of the total estimated trout and salmon catch in 2019 (Connerton et al. 2019). Total estimated catches of Coho Salmon at six tributaries at which fall fingerlings are stocked in New York are also relatively low, ranging from 459 to 2,244 fish caught annually based on periodic surveys conducted between 2012-2020 (Prindle and Bishop 2021). In contrast, in those same years, the majority of Coho Salmon were caught at Salmon River where yearlings are stocked, with estimated total catches of 5,738 to 29,295 Coho Salmon annually. These results can be explained by several alternative hypotheses including 1) lower survival of stocked fall fingerlings relative to yearlings, leading to lower catches of adults in the tributaries and overall lower catches per number stocked in the lake; 2) high straying of fall fingerlings to the Salmon River where they are produced; and/or 3) higher levels of Coho Salmon natural reproduction in Salmon River relative to the other stocked tributaries or 4) a combination of these hypotheses. Previous studies by Johnson and Ringler (1981), Bishop et al. (2021), and Bowlby and Yuille (OMNRF) have documented wild Coho Salmon parr and smolts in Lake Ontario tributaries but the relative contribution of wild and hatchery Coho Salmon to the Lake Ontario fishery was unknown.

The objectives of this study were to 1) estimate the relative contribution of wild and hatchery Coho Salmon to the Lake Ontario fishery; 2) to compare the relative performance (survival) of fall fingerling vs spring yearling Coho Salmon, and 3) to determine the straying rate of Coho Salmon fall fingerlings to the Salmon River hatchery.

Methods

Mass Marking

To determine the relative contribution of wild Coho Salmon to the Lake Ontario fishery, four year-classes of hatchery Coho Salmon were marked with an adipose clip in each spring of 2016-2019 (Table 1) when the fish were parr (mean length=84mm). In Ontario, Coho Salmon were clipped by hand and in NY, marking and tagging was completed with the AutoFish system (Northwest Marine Technology Inc.), which is contained in a 45 ft portable trailer. This automated tagging and fin clipping system has been used extensively in the Pacific Northwest (Nandor et al. 2010) and more recently in the Great Lakes (Bronte et al. 2012, Connerton et al 2022) and is capable of clipping the adipose (AD) fin and/or applying coded-wire-tags (CWTs) (hereafter AD-CWT) to salmonids automatically at a high rate of speed and accuracy.

To compare the relative performance (i.e., smolt to adult survival) of fall fingerling vs. spring yearling stocking, Coho Salmon in NY were marked and tagged with an AD-CWT in each spring of 2016, 2017 and 2019 (Table 1) when the fish were parr (mean length: 63-125 mm). Tagging was planned for 2018, but poor survival of eggs at the Salmon River hatchery resulted in a production shortfall that year, therefore tagging was postponed until 2019. Each stocking year-class, site and treatment (FF and SY) received a unique code to identify its stocking origin. Ontario FF were not tagged or included in this part of the study.

According to longstanding stocking policies in NY, spring yearlings were released at Salmon River, and fall fingerlings were released at six other NY tributaries (Figure 1), which prevented paired comparisons of treatments within sites during the original study design. For the 2016 year-class, releases of approximately 155,000 fall fingerlings at six sites in 2016 and 90,000 yearlings at Salmon River in 2017 occurred as planned (Table 1). For the 2017 year-class, Coho Salmon with AD-CWT originally slated for yearling release were moved to an outdoor pond, and soon after began experiencing higher than normal mortality due to unusually high water-temperatures. Mortalities were counted and the remaining fish were pushed out of the pond into the Salmon River in October 2017 to avoid further loss. To ensure adequate returns of adults for future egg collections, hatchery and fishery managers cancelled the planned fall fingerling releases in 2017 at Niagara, Sandy Creek, Genesee River, and Sodus, and instead, these fish were held at Salmon River hatchery overwinter and released as AD-CWT yearlings in 2018 (Table 1). This effectively resulted in an unplanned paired release of tagged fall fingerlings and spring yearlings at Salmon River for that year-class. The 2018 year-class had a significant production shortfall so only approximately 85,000 fall fingerlings could be released; therefore, the study was postponed, and all Coho Salmon were AD clipped but not tagged. For the 2019 year-class, fish stocked at Sodus were not tagged; otherwise all other clipping, tagging and releases occurred as planned.

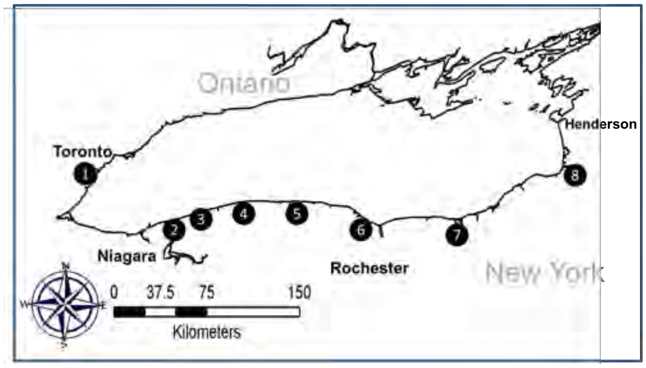

Figure 1. Map of Lake Ontario showing NY and ON stocking sites including fall fingerlings released at: 1) Credit River, 2) Niagara River, 3) Eighteen Mile Creek 4) Oak Orchard, 5) Sandy Creek, 6) Genesee River, and 7) Sodus; and spring yearlings released at: 8) Salmon River Hatchery where all NY Coho Salmon are raised before stocking.

To estimate CWT retention for this study and to check clip quality each year, samples of Coho Salmon were checked for an AD clip and a CWT 4-5 months post-tagging and prior to stocking using a portable CWT detector (Hand et al. 2010). Salmon were sampled at the hatchery (n=200 per site for fall fingerlings, n=600 for yearlings) prior to release. For each treatment and year class, we estimated the proportions of tagged fish as $\hat{p} = x/n$, where x is the number of fish containing a CWT, and n is the sample size (Agresti and Coull 1998).

Field Sampling

To compare the relative survival of stocking treatments and to estimate the relative contribution of hatchery and wild Coho Salmon to the Lake Ontario fishery, salmon were sampled from angler caught fish during the Lake Ontario open lake creel survey (Connerton et al. 2020) conducted from April-September at 29 NY fishing ports in 2017-2019, and in 2021. The creel survey was not conducted in 2020 due to Coronavirus health and safety restrictions. A salmonid diet study conducted by US Geological Survey provided some samples in 2020. From 2017-2021, we also supplemented collections by soliciting help from individual angler cooperators to collect length and clip data, and to deposit Coho Salmon head samples in freezers at six locations along the lake. During the fall tributary fishery, technicians were stationed at fish cleaning stations at Salmon River, Niagara River, Eighteen Mile Creek, and Oak Orchard/Sandy Creek to sample from angler catches. More limited collection efforts were attempted at Genesee River from individual anglers but as noted above, Coho Salmon returns in most tributaries are low, so collections there were unsuccessful.

Table 1. Numbers of Coho Salmon released at New York and Ontario sites in Lake Ontario from 2016-2019 including estimated percent clipped and tagged and estimated number of clipped and tagged based on quality control checks prior to stocking.

Stocking Location	Year-class	Stage	Total	Tagged (%)	Clipped (%)	Mean Weight (g)	Mean Length (mm)	Number Clipped	Number Tagged
Salmon River	2016	SY	93,000	92.4	99.8	28.4	140	92,814	85,932
Eighteen Mile Creek	2016	FF	30,697	97.5	99.5	14.4	113	30,544	29,930
Genesee River	2016	FF	22,770	97.5	99	21.2	124	22,542	22,201
Niagara River	2016	FF	25,640	98.9	99.5	18.4	120	25,512	25,358
Oak Orchard Creek	2016	FF	25,640	97	98.5	17.9	121	25,255	24,871
Sandy Creek	2016	FF	31,069	96.5	98	16.5	117	30,448	29,982
Sodus Bay	2016	FF	25,390	95.5	100	17.8	119	25,390	24,247
Credit River (ON)	2016	FF	50,000	0	100*	30.0	146	50,000	0
Salmon River	2017	SY	68,180	74.7	97.6	32.9	142	66,544	50,930
Salmon River	2017	FF	90,020	72	98	15.2	114	88,220	64,814
Eighteen Mile Creek	2017	FF	26,665	72.2	95.5	18.6	123	25,465	19,252
Oak Orchard Creek	2017	FF	21,800	85	95	21.5	130	20,710	18,530
Credit River (ON)	2017	FF	40,110	0	100*	22.1	132	40,110	0
Salmon River	2018	SY	84,900	0	96.3	30.2	140	81,759	0
Eighteen Mile Creek	2018	FF	14,100	0	96.3	23.2	127	13,578	0
Genesee River	2018	FF	10,340	0	96.3	22.8	127	9,957	0
Niagara River	2018	FF	11,750	0	96.3	22.7	127	11,315	0
Oak Orchard Creek	2018	FF	12,220	0	96.3	21.4	127	11,768	0
Sandy Creek	2018	FF	12,200	0	96.3	23.2	127	11,749	0
Sodus	2018	FF	12,200	0	96.3	23.2	127	11,749	0
Credit River (ON)	2018	FF	36,000	0	100*	30.0	146	36,000	0
Salmon River	2019	SY	91,950	87.5	97.3	31.1	141	89,467	80,456
Eighteen Mile Creek	2019	FF	35,310	71	99	19.7	121	34,957	25,070
Genesee River	2019	FF	21,585	95.5	98	20.1	120	21,153	20,614
Niagara River	2019	FF	24,062	98.5	98.5	18.5	118	23,701	23,701
Oak Orchard Creek	2019	FF	22,581	95.5	98	18.3	118	22,129	21,565
Sandy Creek	2019	FF	21,795	79.5	98.5	16.3	114	21,468	17,327
Sodus Bay	2019	FF	26,000	0	100	14.6	111	26,000	0
Credit River (ON)	2019	FF	40,000	0	100*	45.0	167	40,000	0

* All fish stocked in Ontario were clipped by hand, however quality control data were not available and clip efficiency was assumed to be 100%.

To determine the proportion of wild and hatchery Coho Salmon returning to the Credit River, ON during the fall spawning run, Coho Salmon were counted and checked for presence of adipose fin clips as fish travelled through the weir at Streetsville using a camera and imaging system (OMNRF 2022).

To estimate the degree of straying by fall fingerlings to the Salmon River and Salmon River hatchery, Coho Salmon were sampled at cleaning stations from angler caught fish, and during egg collection operations at the hatchery from 2017-2021. These collections also provided estimates of the proportions of wild and hatchery salmon at Salmon River.

Throughout the study, Coho Salmon were measured and weighed, a scale sample or otolith was collected, and the snout was taken if the fish contained a CWT. All hatchery Coho Salmon released by NY and ON from 2016-2019 were clipped but not all were tagged; therefore, untagged salmon sampled from 2017-2021 were aged using scale impressions or otoliths. The majority (98.6%) of Coho Salmon in the Lake Ontario harvest and returning to tributaries are age 2 (Connerton et al., 2020, Prindle and Bishop 2021), thus analysis focused on this age class only.

Data Analysis

To estimate the proportions of wild and hatchery salmon in the Lake Ontario fishery, we stratified harvest samples by lake and tributaries, and further stratified tributary samples by region (west, east, Salmon River) because we hypothesized that different tributary regions would have different natural reproduction potential based on previous habitat quality data and previous results by Connerton (2016) showing regional differences for Chinook salmon natural reproduction. In the lake we pooled all samples for each year class and assumed that the distribution of Coho Salmon from April-August is mixed (i.e., unbiased towards any site).

We estimated the proportions of wild and hatchery adults in each strata as $\hat{p} = x/n$, where x is the number of fish sampled in each category and n is the total sample size; the standard error was estimated using the Agresti-Coull bionomial proportion confidence interval (Agresti and Coull 1998). As described above, adult returns of Coho Salmon to most tributaries is usually low except at the Salmon River (Prindle and Bishop 2020); and sample size was also low in west and east tributaries during the study; therefore, samples in these regions were pooled for all year classes (west n=108, east n=62). At Salmon River, samples sizes were higher (n= 234, 70, 98, 118 respectively for the 2016-2019 year-classes) so proportions were calculated for each year class.

To compare the relative recoveries of fall fingerling and yearling Coho Salmon in the lake fishery (as an index of relative survival) we used methods similar to Connerton et al. (2022). CWTs recovered from salmon from 2017-2021 were grouped by unique codes that identified the fish's stocking origin (i.e., year-class (y), site (s), and stocking treatment (t): yearling (SY) or fall fingerling (FF)).

Expected lake recoveries (r) of a treatment t (FF or SY) for a given year-class (y), and stocking site (s) was:

$$E(r_{sty}) = N_{sty} * T_{sty} * S_{sty} * f_y * P_y$$

where the expected recoveries are a function of the number released (N), the probability of a fish being tagged (T), the probability of a fish surviving to the harvest (S), the probability of a fish being captured in the harvest (harvest effort, f), and the probability of a fish being sampled in the harvest (sampling effort, P). The probability of a fish being tagged was included because different numbers of fish were tagged at the sites and not all fish were tagged. Accounting for f and P may be necessary in cases when some stocking sites' fish could be recovered more than others because of their proximity to ports and the effort at ports, which may bias recoveries in cases; however, we assumed that fish of each treatment were equally likely to be harvested or sampled in the lake prior to the staging period when fish were assumed mixed, conditional on survival to harvest, so these effects were not included in the general linear model. We also assumed there is no angler selection bias. Angler selection bias might be caused by noticeable size differences between treatments, where an angler would choose to harvest one treatment type over another (e.g., because of size or regulation). Age was not considered a factor because all recoveries were aged-2. The expected lake recoveries were modelled with a Poisson general linear model with a log link function of the form:

$$\log(r) = \beta_0 + \beta_1 s + \beta_2 y + \beta_3 t + offset\ (\log(N * T)$$

where s is the stocking location, y is year-class, t is stocking treatment (SY or FF), N is number tagged, and T is the probability of a fish being tagged based on tag retention estimates. Poisson or quasi-Poisson regression models, using a log-link function with N as an offset and a single overdispersion parameter, have been used for recoveries of tagged salmon by others (Cormack and Skalski 1992; Newman and Rice 2002, Connerton et al. 2022). We modelled all variables as factors and considered possible first order interactions between factors. The most parsimonious model was selected based on Akaike's Information Criteria (AIC). We performed analysis of deviance to test the significance of the variables, and we tested for overdispersion using a dispersion test (Cameron and Trivedi 2013) available in the R package *countreg* (Zeileis and Klieber 2020). For each year-class and treatment, specific recovery rates (Rty: R_{SY}, R_{FF}), recovery rate ratios (R_{YR}/R_{FF}), and standard errors were estimated from the model using the *emmeans* package (Lenth 2021) in R statistical software. Recovery rates (R_{ty}, fish* 10000 tagged^{-1} *year^{-1}) were calculated by back transforming modelled recoveries. Logically, recovery rate ratios of pen- and direct-stocked salmon (R_{YR}/R_{FF}) should equal 1 if no differences in survival from smolt to the lake harvest existed between the stocking treatments, which was our null hypothesis.

To evaluate straying to the Salmon River Hatchery by fall fingerlings stocked at the six sites, we compared recovery rates in the hatchery of fall fingerling and yearlings for each year-class (2016-17, 2019). To estimate recovery rates of each treatment in the hatchery while accounting for differences in smolt to adult survival in the lake for each treatment, we used methods similar to those detailed in Connerton et al. (2022) and used Rty as an index of a year-class relative lake survival. In this study, however, we did not include the effects of site and age. Site was not identified as a significant factor in the lake analysis, and total strays recovered at the hatchery were low and only from two sites; thus, we used the pooled value of Rty as our index of relative survival. All tagged Coho Salmon recovered during the study were aged-2, thus, we did not consider age as a factor. We used the general linear model:

$$\log(r) = \beta_0 + \beta_1 y + \beta_2 t + offset\ (\log(N * T * Rty)$$

where y is year-class, t is treatment, N is number tagged, T is the probability of a fish being tagged based on tag retention estimates, and Rty is index of relative lake survival for each year-class and treatment based on estimated lake recoveries.

Results and Discussion

Marking Quality

Results of clip quality showed average clip percentages of 99%, 97%, 96%, and 99% for the 2016-2019 year-classes respsectively (Table 1). Tag retention varied by site and year-class, ranging from 92-99% in 2016 (mean=96.5%), from 72-85% in 2017 (mean=76%), and from 71%-99% in 2019 (mean=88%). Tag retention and clip quality were accounted for in subsequent data analyses.

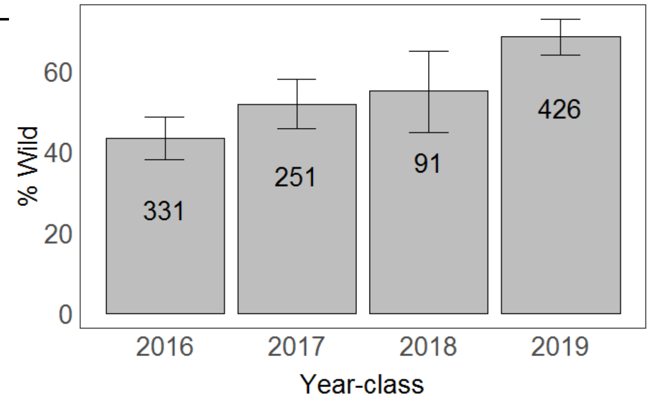

Figure 2. Percent wild Coho Salmon in the Lake Ontario harvest for the 2016-2019 year-classes. Error bars represent 95% confidence intervals. Sample sizes are provided for each corresponding year-class.

Proportions of Wild Coho in Lake Ontario and Streams

The proportions of wild Coho Salmon in the Lake Ontario NY angler harvest varied by year class, making up 43%, 52%, 55%, and 69% of the Coho Salmon from the 2016-2019 year-classes respectively (Figure 2). Sample size for the 2018 year-class (n=91) was limited by COVID health and safety precautions which restricted field activities in 2020, but for other year-classes, sample sizes in the lake were n=331, 251, and 426 for the 2016, 2017, and 2019 year-classes respectively.

In Lake Ontario tributaries, samples were collected during the fall spawning runs from the Salmon River including the main stem and Orwell and Trout Brooks (n=234, 50, 97, and 125 respectively from 2018-2021); from western region tributaries (n=108 all years) including the Niagara River (n=2), Twelve Mile Creek (n=1), Eighteen Mile Creek (n=36), Johnson Creek (n=9), Oak Orchard Creek (n=14), Marsh Creek (n=9), Sandy Creek (n=17), Genesee River (n=1), Mill Creek (n=1), and Shipbuilders Creek (n=18); and from eastern region tributaries including the Black River (n=19), Mill Creek (n=2), North Sandy Creek (n=9), South Sandy Creek (n=26), Grindstone Creek (n=1), Little Salmon River (n=1), and the Oswego River (n=3).

Percentages of wild Coho Salmon estimated in tributaries during the spawning runs varied by region (Figure 3). The Salmon River contained substantially

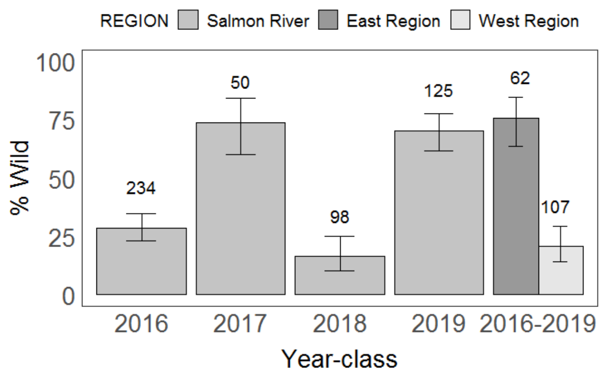

Figure 3. Percent wild Coho Salmon in Lake Ontario tributaries by Region for the 2016-2019 year-classes. Error bars represent 95% confidence intervals. Sample sizes are provided for each corresponding year-class above each bar for Salmon River and combined for all year classes for the east and west regions.

higher percentages of wild Coho Salmon (29%, 74%, 16%, and 70% wild for 2016-2019 year-classes respectively) than western tributaries (20%, all years combined). Sample sizes in west tributaries were low despite considerable effort, possibly as a result of low survival of fall fingerlings in combination with lower habitat quality in western streams. The percentage of wild Coho Salmon estimated in eastern region tributaries (76%, all years combined) was also significantly higher than the west region. Although most Coho sampled in eastern tributaries were wild, the total number of recoveries was relatively low compared to Salmon River perhaps suggesting a lower abundance of wild fish overall. Eastern tributaries are not stocked; however, they contained strays from the Salmon River found at Black River (n=11), Mill Creek (n=1), and South Sandy Creek (n=1) leading to some proportion of hatchery fish in that region.

Results at Salmon River Hatchery during the spawning run from 2017-2021 showed lower proportions of wild salmon entering the hatchery than we estimated in the river harvest, with wild fish making up only 0.2%, 0.5%, 1%, and 13% of the 2016-2019 year-classes respectively (n= 418, 451, 446, and 199). Few wild Coho Salmon evidently strayed to the hatchery despite relatively high percentages of wild Coho Salmon in the River. Connerton et al. (2016) found similar results for Chinook salmon in the Salmon River from 2010-2016, and Nack et al (2010) found a pattern of decreasing proportions of wild Chinook as they sampled further away from the Salmon River hatchery.

At Credit River, Ontario, the percentage of wild fish returning through the weir from 2018-2021 was 7%, 5%, 8% and 54% for the 2016-2019 year-classes respectively (Table 2).

Table 2. Percent Wild of Coho Salmon counted at Credit River, Ontario from 2018-2021

Year class	N	% Wild	SE
2016	253	6.7	1.6
2017	190	4.9	1.6
2018	130	8.2	2.4
2019	25	53.8	9.3

Relative Survival of Fall Fingerlings vs Yearlings

From 2018-2021, a total of 1,347 Coho Salmon were recovered from the April-September Lake Ontario harvest including: n=957 fish from angler cooperators who individually collected and deposited Coho Salmon heads at six freezers along the lake; n=278 from the Lake Ontario fishing boat survey; and n=112 from directed sampling activities (e.g., diet study, cleaning stations or tournaments). Of those lake samples, 361 fish contained CWTs.

To estimate recovery rates, a Poisson model fit the lake recovery reasonably well (McFadden's pseudo-R^2=0.80). A dispersion test (Kleiber and Zeileis 2008) did not indicate overdispersion (z = 0.22142, *p-value* = 0.4124). The most parsimonious model based on the lowest AIC included the factors: year-class, stocking treatment, stocking location and an interaction between stocking treatment and year-class.

The estimated recovery rate (Figure 4) for spring yearlings was 13.9 (standard error [SE]=7.4), 9.2 [5.0], and 5.9 [3.2] fish per 10,000 released for the 2016, 2017 and 2019 year-classes respectively compared to estimated recovery rates of 3.2 [0.58], 0.9 [0.4], and 0.9 [0.3] fish per 10,000 released for those same year-classes. The relative survival of spring yearlings per number stocked was significantly higher than fall fingerlings, with smolt to adult recovery ratios of 4.2 [SE=2.6], 10.1 [4.0] and 7.0 [4.7] spring yearlings to fall fingerlings for the 2016, 2017, and 2019 year-classes respectively. Spring yearlings and fall fingerlings from the 2017 year-class were both stocked at Salmon River which allowed one paired comparison at the same site in the same year-class: in this case, the ratio of SY/FF recoveries per 10,000 fish stocked in the lake was 10.1. When we only included the other sites stocked from the 2017 year-class (i.e., Eighteen mile and Oak Orchard creeks) the SY/FF ratio was 8.3.

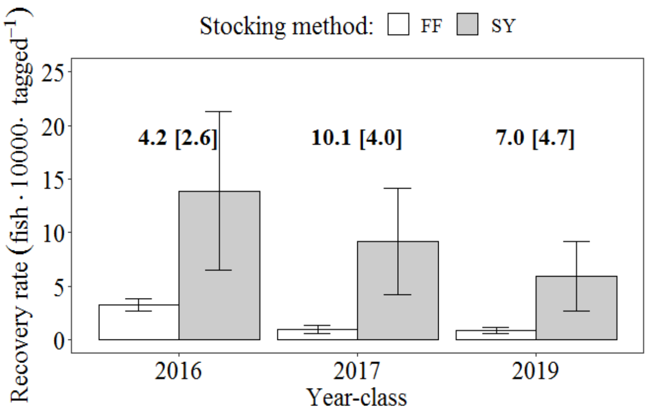

Figure 4. Recovery rates of spring yearling (R_{SY}) and fall fingerlings (R_{FF}) from three year-classes stocked into Lake Ontario. Error bars represent 95% confidence intervals. Numbers in bold above each year-class are ratios of R_{SY}/R_{FF} and estimated standard errors [SE].

Straying to Salmon River Hatchery

To determine the degree of straying to Salmon River Hatchery, a total of 2,392 Coho Salmon were checked for the presence of fin clips and CWT during egg collection activities at Salmon River Hatchery from 2018-2021, including n=853, 889, 452, and 199 for the 2016-2019 year-classes respectively. Of those samples, a portion contained coded wire tags including, n=721, 569, 0, and 137 for those year classes, of which n=666, 569, 0, and 137 had tags extracted and read to determine their stocking origin.

To estimate recovery rates, a Poisson model which accounted for differential lake survival and numbers tagged, and included both factors, year-class and stage, fit the data well (McFadden Pseudo-R^2= 0.96). Both factors were significant (stage: p=0.002, year-class: p=0.002)

The estimated recovery rate per number tagged of SY was 5.5, 7.9 and 2.7 fish per 10000 tagged, and for FF was 0.05, 0.32. and 0.10 fish per 10,000 tagged for the 2016, 2017 and 2019 year-classes respectively. For each year-class, a very small percentage of the tagged fish in the Hatchery were strays from other sites. When expressed as a ratio of the total (FF/(FF+SY)), the percentage of strays was 1.1%, 3.9% and 3.5% of the returns, indicating low straying rates of FF to the Salmon River Hatchery.

Some straying occurred from the Salmon River as well. Salmon River strays were found in western tributaries at Mill Creek (n=1), Shipbuilders Creek (n=1), Eighteen Mile Creek (n=1), and Oak Orchard Creek (n=1) out of a total n=148 Coho Salmon sampled in western tributaries from 2018-2021. Strays from the Salmon River were also found in eastern tributaries at Black River (n=11), Mill Creek (n=1), and South Sandy Creek (n=1) out of a total n=73 samples.

Returns of Fall Fingerlings to Stocked Tributaries

As stated above, recoveries of Coho Salmon from stocked tributaries was low except at Salmon River; therefore, not much can be concluded regarding imprinting of fall fingerlings. Generally, results suggested that tagged fish recovered in tributaries were either stocked at those tributaries or stocked at nearby tributaries (Table 3, Figure 1). For example, Coho stocked in Genesee River were recovered in two adjacent streams (i.e., Shipbuilders or Mill Creek); tagged Coho stocked at Niagara River were captured in Twelve Mile and Eighteen Mile Creeks, and the majority of Coho sampled in Eighteen Mile Creek were stocked there. Coho stocked at Eighteen Mile Creek strayed to Johnson and Oak Orchard; Coho Salmon stocked at Oak Orchard strayed to Sandy; and Coho stocked at Sandy Creek strayed mostly to Johnson Creek.

Table 3. Recoveries of tagged Coho Salmon in tributaries from 2018-2021.

Stocking Location	Capture Location	N
Eighteen Mile Creek	Eighteen Mile Creek	24
	Johnson Creek	1
	Oak Orchard Creek	1
Genesee River	Ship Builders Creek	1
	Mill Creek	1
Niagara River	Eighteen Mile Creek	3
	Twelve Mile Creek	1
Oak Orchard Creek	Oak Orchard Creek	15
	Sandy Creek	6
	Eighteen Mile Creek	7
	Johnson Creek	2
Sandy Creek	Sandy Creek	6
	Johnson Creek	5
	Eighteen Mile Creek	1
	Oak Orchard	1

Summary and Management Implications

- The proportion of wild Coho Salmon in the Lake Ontario angler harvest varied, making up 43%, 52%, 55%, and 68% of the Coho Salmon sampled from 2016-2019 year-classes respectively.
- The Salmon River contained substantially higher percentages of wild adult salmon in the harvest (29%, 74%, 16%, and 70% wild for 2016-2019 year-classes respectively) than western tributaries (20%, n=107 all years) where fall fingerlings are stocked.
- Eastern tributaries (not including the Salmon River), are not stocked, and these streams also contained higher percentages of wild salmon (76%, n=62 all years) than the west region; but lower overall numbers of wild fish compared with the Salmon River.
- The relative survival of spring yearlings per number stocked was significantly higher than fall fingerlings, with smolt to adult recovery ratios of 4.2, 10.1 and 7.0. (SY/FF).
- Straying by fall fingerlings to the Salmon River Hatchery was very low. Less than 1% of the salmon sampled in the hatchery during fall egg take were strays from other tributaries. After accounting for differential survival of FF and SY, and numbers tagged, the estimated percentage of strays was 1-4% of the total.

Based on results of this study, wild Coho Salmon contribute a significant proportion to the Lake Ontario Coho Salmon fishery. In the lake, an average of 54% of the Coho were wild, and both the Salmon River and eastern NY region tributaries contained high percentages of wild fish in the harvest. In contrast, western NY region tributaries and the Credit River, ON mostly contained low proportions of wild fish and low numbers of Coho salmon. Previous research also suggests that some other Ontario tributaries produce wild Coho smolts (OMNRF 2017); the relative contribution to the adult population is unknown. Considering the results of our study which suggest relatively low survival of fall fingerlings, and the fact that only 90,000 yearlings are stocked annually into Lake Ontario, it would not take many wild Coho salmon adults to equal or exceed the numbers of hatchery fish surviving to the adult population.

Prior to conducting the study, we proposed three alternative hypotheses for explaining low catches of Coho Salmon in western NY tributaries compared to the Salmon River: (1) relatively poor survival of FF; (2) high straying to Salmon River, or (3) relatively high wild Coho Salmon reproduction at Salmon River. Our results support hypothesis 1 and 3 but not 2. Straying to the Salmon River by FF was very low. Most Coho Salmon stocked by NY and Ontario are fall fingerlings, and results of this study suggested that stocking yearlings yielded an average of 7:1 returns compared to fall fingerlings. If fishery objectives include increasing catch rates (returns) of Coho Salmon in the lake and tributaries, fisheries managers may consider shifting more production to stocking yearlings in order to increase survival of stocked fish. If so, more research is needed to understand the imprinting of Coho Salmon in Lake Ontario. For example, a better understanding about the best timing of smolt release is needed to ensure imprinting of spring yearlings at release sites while also optimizing survival. Otherwise managers may achieve their objective of higher survival and higher overall catch rates of Coho Salmon in the lake fishery by stocking more yearlings; but they may simultaneously increase straying to the rearing hatchery, which would fail to increase catch rates in tributary fisheries except at the Salmon River.

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Eastern Basin of Lake Ontario Warmwater Fisheries Assessment, 1993-2021

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Each year the New York State Department of Environmental Conservation (NYSDEC) assesses the warmwater fish community in the New York waters of Lake Ontario's eastern basin. This long-term assessment program was initiated in 1976 to establish abundance indices for warmwater fishes, with emphasis on smallmouth bass (*Micropterus dolomieu*), walleye (*Sander vitreus*), yellow perch (*Perca flavescens*), and white perch (*Morone americana*). Data collected allow for evaluations of other population parameters including growth, age structure, year class strength, survival rates, and diet composition for some of the target species. This long-term dataset also proved valuable for examining impacts of double-crested cormorant (*Phalacrocorax auritus*; DCC) predation on smallmouth bass and yellow perch populations in the eastern basin (e.g., O'Gorman and Burnett 2001, Lantry et al. 2002), and evaluating changes in body condition after the invasion of round goby (*Neogobius melanostomus*; Crane et al. 2015). This report focuses on 2020 abundance indices as they relate to previous years, as well as a summary of age and growth trends for smallmouth bass, age structure for walleye and size structure of yellow perch caught between 2016-2021.

Methods

A standardized stratified random design gillnetting assessment was conducted annually from 1976 through 2021 in the New York waters of Lake Ontario's eastern basin to evaluate the warmwater fish community. Sampling was initiated as early as July 26 and completed as late as August 25, but typically occurred during the first two weeks of August. Since 1980, standardized net gangs (nine 50 ft panels, 8 ft deep, and stretch-mesh sizes ranging from 2 to 6 in by ½ in increments) were set overnight, on bottom and parallel to depth contours at predetermined, randomly selected sample locations. Detailed assessment methods and corrections for 1980, 1989, and 1993 survey and gear design changes were described previously (Eckert 1986, 1998, and 2006). A net set was deemed biased when there was any indication of net fouling or tampering and data from that net set were excluded from analyses. In 1993, gear changed from multifilament to monofilament gill nets and previous reports used correction factors that were applied to multifilament catch data, and "monofilament equivalents" were calculated and reported (Eckert 1998).

Beginning with the 2019 report, we present data from 1993 forward. This represents a more contemporary period in Lake Ontario with lower nutrient levels and increased water clarity compared to the previous years. This period also reports data covering a period of consistent survey design and fishing gear that eliminates the need to correct previous years' data. Analysis covering trends from 1976-1992 may be found in the 2018 version of this report (Connerton and Legard, 2019). The random survey design was stratified by three depth strata (Stratum 1: 12-30 ft; Stratum 2: 31-50 ft; Stratum 3: 51-100 ft) and five area strata (Grenadier Island, Chaumont Bay, Black River Bay, Henderson Bay, and Stony Island areas; Figure 1). Area strata were used primarily to ensure that all major geographic areas within depth strata 1 and 2 were sampled each year in proportion to their surface areas. Each year 10 net sets were scheduled for depth stratum 3, with two nets set per 10ft change in depth.

Prior to 1996, a net set was canceled and the catch of warmwater fish was assumed to be zero when the scheduled set location had stable water temperatures below 50°F. Experience had shown that catches of warmwater fish were consistently zero in areas inundated by cold hypolimnetic water (Eckert 2006). From 1996-2005, all scheduled net sets were completed regardless of temperature, given the potential for a shift in fish depth distribution related to increased water clarity resulting from dreissenid mussel colonization. Similar shifts were observed with alewife (*Alosa pseudoharengus*), rainbow smelt (*Osmerus mordax*), and lake trout (*Salvelinus namaycush*; e.g., O'Gorman et al. 2000). During that time period, 18 nets were set and pulled at temperatures <50°F. 16 out of 18 nets captured coldwater fish species (mean=10.5 coldwater fish per net, most of which were lake trout), and only seven nets captured warmwater species (mean=3.7 warmwater fish per net). Two of the 18 nets captured no fish. Beginning again in 2006, a net set was canceled and catch of warmwater fish was assumed to be zero when scheduled at a location with stable water temperatures below 50°F for at least 9 ft off bottom.

In 2021, 24 randomly chosen netting locations were determined prior to initiation of the assessment on July 26 (Figure 1). From July 26 to August 6, we completed 23 unbiased net sets. One net was not set because water temperatures were below 50°F and catch of warmwater fish was assumed to be zero for this net. Typically, 29 netting locations are planned, but in 2021 five nets were not set in depth stratum 3 due to maintenance of the R/V Seth Green and other survey commitments. As a result, one net was dropped across each 10ft substrata in this stratum. Mean stratified catch-per-unit-effort (CPUE = fish per overnight net set) was calculated for each fish species captured and for the total warmwater fish catch. The 95% confidence intervals were also determined for each mean stratified CPUE estimate. Relative standard error ($RSE = 100 * [\frac{\text{standard error}}{\text{mean}}]$) was calculated to examine variability in CPUE between years.

For all fish collected, we determined species, total length (TL) and weight, and, when possible, sex and maturity (with the exception of longnose gar [*Lepisosteus osseus*] and lake sturgeon [*Acipenser fulvescens*]). Stomach contents of gamefish (i.e., smallmouth bass, walleye, northern pike [*Esox lucius*], and muskellunge [*Esox masquinongy*]) were identified each year beginning in 2000. For each assessment year, scales were collected from all species with the exception of ictalurids, longnose gar, and lake sturgeon. We removed cleithra from all esocids and pectoral spines from all ictalurids. From 2003-2021, in addition to scales, we collected otoliths from smallmouth bass >13.8 in, yellow perch >8.7 in, all walleye, and freshwater drum (*Aplodinotus grunniens*).

Species composition, depth-stratum-specific species richness and CPUE, and trends in abundance indices were described. Additional data analyses completed for smallmouth bass include: 1) scales (1993-2021) and otoliths (2004-2021) were aged to determine age composition, age-specific CPUE and mean length-at-age; 2) relative weight (Wr) was determined for each fish.

($Wr = 100 * \frac{\text{actual weight}}{\text{standard weight } [Ws]}$; where:

$log_{10}[Ws] = -5.329 + 3.20[log_{10} TL]$;

Kolander et al. 1993, Anderson and Neumann 1996); 3) condition (Fulton's K) was calculated for two inch increments (8-18 in); and 4) average percent maturity was determined for male and female bass ages 1-7 (1993-2021).

Results and Discussion

<u>2021 Water Temperature</u>

In 2021, bottom temperatures for nets set in depth strata 1 (12-30 ft) and 2 (31-50 ft) ranged from 68.4°F to 73.0°F and 67.2°F to 71.5°F, respectively. In stratum 3 (51-100 ft), bottom temperatures at net set locations ranged from 57.9°F to 69.1°F. One planned net set in stratum 3 was not set because water temperature was below 50°F. Three unbiased net sets in depth stratum 3 and one net set in depth stratum 2 may have experienced some periods of water temperatures <50°F, given that 20 coldwater fish (ten cisco, two lake trout, and eight brown trout) were captured in those nets.

<u>Species Richness and Composition</u>

Since 1993, 38 fish species (28 warm and cool water species) were captured during the eastern basin gillnetting assessment (Table 1). In 2021, 973 fish were captured in unbiased net sets, representing 18 warm and cool water species (953 fish) and three cold water species (20 fish). The greatest warm and coolwater species richness and CPUE (17 species; CPUE=53.2) occurred in depth stratum 1, followed by depth strata 2 (13 species; CPUE=35.0) and 3 (four species; CPUE=21.2). The lowest warm and cool water species richness and catch typically occurs in depth stratum 3 (Eckert 2006). In 2021, three coldwater species were captured in stratum 3.

The dominant species represented in the catch has changed over time (Figure 2). From 1976-1979 white perch, yellow perch and gizzard shad (*Dorosoma cepedianum*) were the most commonly caught species and represented an average of 37.2%, 22.1% and 14.3% of the total catch, respectively (Lantry 2018). Through the 1980s, smallmouth bass (mean=25.2%), yellow perch (mean=25.0%) and white perch (mean=22.5%) were most prevalent in gill net catches (Lantry 2018).

The five most frequently caught species from 1993-2021 were yellow perch (mean=32.3%), smallmouth bass (mean=27.3%), white perch (mean=10.9%), walleye (mean=7.4%), and rock bass ([*Ambloplites rupestris*]; mean=7.3%). The dominant species varied year-to-year, but each year since 1993, smallmouth bass was the most or second most commonly caught species, while yellow perch was one of the three most frequently caught species for 27 of the 29 years in the reporting period. In 2021, yellow perch was the dominant species (50.2% of the total stratified catch), smallmouth bass was second most commonly caught species (15.1% of total catch), followed by white perch (12.2% of total catch) gizzard shad (6.4%), and walleye (4.9%).

Index of Abundance: Total Warmwater Catch

The abundance index for warmwater fish in New York waters of Lake Ontario's eastern basin was highest during the early years of the assessment (1976 - 1992; range: 42.42 [1988] - 252.8 [1979]; Connerton and Legard, 2019).The mean stratified CPUE for all warmwater species reached the lowest recorded in 1995 when CPUE was 14.9 (Table 1 and Figure 3) and was 93% lower than the 1976-1992 average (Connerton and Legard, 2019). Mean stratified CPUE for total warmwater fish catch remained low and variable through the mid-2000s (Table 1, Figure 3). Between 2008-2013, and 2017-2021, CPUE improved (mean CPUE = 33.0) to levels similar to those in the early 1990s (1993-1994 mean CPUE = 38.7). A decrease during 2014-2016 (mean CPUE = 17.4) was attributed to reduced catches of yellow perch, smallmouth bass and white perch (Lantry 2018). Below average eastern basin water temperatures during those years may have influenced fish distribution and production, contributing to reduced catches. In 2021, the mean stratified CPUE of 30.5 was similar to the previous 10-year average (mean CPUE = 27.1).

Index of Abundance: White Perch

The most notable declines in species abundance between the inception of the survey and the mid-1980s occurred with white perch and yellow perch, the two most abundant species in the first five years of sampling (Connerton and Legard 2019). The white perch index continued to decline through the early 1990s, reaching a low CPUE of 0.06 in 1995, and remained low through 2007 (Table 1, Figure 4). In 2008, white perch CPUE was 7.7, the highest level observed since 1991 (Lantry 2018). CPUE has remained variable at about the same level since then (2008-2021 average CPUE = 4.7). In 2021, white perch CPUE was 3.7, lower than the ten-year average (mean CPUE = 4.6). Variability of white perch catch in gill nets is higher than that of other relatively abundant species (long term average [1993-2021] RSE = 57.9%). In 2021, white perch RSE (41.0%) was 29.2% lower than the long-term average.

Index of Abundance: Yellow Perch

Yellow perch were commonly caught since the assessment began in 1976; however, abundance declined significantly through the late 1980s, from a mean CPUE of 36.5 (1980-1984) to a low CPUE of 2.2 in 1988 (Lantry 2018). Subsequently, CPUE varied without trend and averaged 6.7 from 1993-2006 (range: 2.8 [1993] - 9.9 [1990]; Table 1, Figure 5). Yellow perch CPUE began to increase in 2007 and in 2008 reached the highest level (CPUE=16.9) since 1984, remaining near that level through 2013. From 2014-2016, catches declined to among the lowest levels recorded in over two decades (CPUE range: 0.8 - 3.1 fish per net night; Table 1, Figure 5). Reduced population size and/or changes in distribution were likely contributing factors to the diminished 2014-2016 catches. Two consecutive long, cold winters (2013/2014 and 2014/2015) followed by below-average summer temperatures may have influenced abundance and distribution (Lantry 2018). We do not attribute the reduced catches in 2014-2016 to DCC predation because effective cormorant management and a DCC dietary shift to round goby reduced predation pressure on yellow perch (Johnson et al. 2014, McCullough and Mazzocchi 2016). In 2021, yellow perch CPUE increased 118.6% compared to 2020 (CPUE = 7.0) to 15.3 fish per net night, which is 68.1% higher than the 10-year average (mean CPUE = 9.1).

Variability of yellow perch catch in gill nets is relatively high (long-term [1993-2021] average RSE=41.8%) when compared to smallmouth bass (long-term average RSE=20.6%) and is likely attributable to the schooling nature of perch. In 2021, yellow perch RSE (37.0%) was 11.5% lower than the long-term average.

In 2021, yellow perch total length ranged between 6.4 in (162 mm) and 11.9 in (303 mm) and averaged 8.0 in (204 mm). Approximately 14.1% of perch captured were > 9 in (> 228.6 mm; Figure 6). Weight of yellow perch captured in 2020 ranged from 1.8 oz (50 g) to 14.4 oz (409 g) and averaged 4.2 oz (119 g).

Index of Abundance: Gizzard Shad

Gizzard shad was one of the most abundant species at the start of the warmwater assessment program. Since the mid-1980s, gizzard shad abundance has remained relatively low, with CPUEs of zero or <1 for 20 consecutive years from 1993-2012 (Connerton and Legard 2019; Table 1, Figure 7), representing an average of less than 0.17% of the catch (Figure 2). In 2013, gizzard shad CPUE (2.1) increased to the highest level since 1981 (CPUE=2.8). From 2013-2018, gizzard shad CPUE averaged 1.5 fish per net night and represented an average of 5.6% of the total CPUE of warmwater species. In 2021, gizzard shad CPUE (1.9) was similar to the 10-year average (CPUE=1.4) and was the fourth most commonly caught species, representing 6.4% of the total CPUE (Figure 2).

Index of Abundance: Walleye

Walleye is the only relatively common species that has increased in abundance since the assessment was initiated in 1976. Catches were lowest through the 1980s (mean CPUE 1980-1989=0.4) and increased through the early 1990s (Connerton and Legard, 2019). Walleye CPUE peaked in 1993 (CPUE=3.8; Table 1). Subsequently, CPUE declined through the late 1990s, but has remained relatively stable since (Figure 8). The 2021 CPUE of 1.5 was 6.3% below the 10-year average (mean CPUE = 1.6). RSE fluctuated at a low level without trend from 1993-2021 (average RSE=26.3%). 2021 RSE for walleye (28.1%) was 6.8% higher than the long-term average.

In 2021, walleye total length ranged between 14.7 in (373 mm) and 29.8 in (758 mm) and averaged 24.9 in (632 mm; Figure 6). Walleye weight ranged from 18.6 oz (526 g) to 11.8 lb (5372g) and averaged 6.8 lb (3087 g).

Walleye ages, interpreted from otoliths, indicated that strong year classes were produced in 2003, 2005, 2008, 2011, 2014, and 2015 (Figure 9; Lantry 2018). The 2003 year class was first captured at age 1 in 2004, when they represented 25.9% of the catch (n=21 age-1 fish; a record-high; Eckert 2005). Prior to 2004, age-1 walleye were rare in this assessment (n=17 during 1976-2003; Lantry 2018). Assessments in Ontario waters of Lake Ontario and New York waters of Lake Erie also identified a strong 2003 walleye year class (Einhouse et al. 2010, OMNR 2011a and 2011b). By 2016, the 2003 year class represented only 2.0% of total catch and CPUE was only 0.02 indicating that few fish from that year class remained. Good to strong 2005 and 2008 year classes were produced in Ontario waters (OMNR 2009, 2011a) and were well represented in this assessment through recent years.

Fall bottom trawling in the Bay of Quinte indicated that strong 2014, 2015, and 2018 year classes were produced there (OMNRF 2015, OMNRF 2016, OMNRF 2019). The 2014 and 2015 year classes of walleye have shown up in consistently higher numbers than other year classes over the last 5 years (2017-2021; Figure 10). Good production of the 2014 year class in New York waters was first evident in 2015 when 10.5% of the walleye catch in this assessment were age-1 (i.e., 2014 year class fish). This trend continued over the next few years, with relative contribution of this year class ranging from 10% (2018) - 25% (2016) of the total walleye catch between 2016-2021 (mean = 16.3%). The 2015 year class had similar representation over this six year period as well, with relative contributions to the total walleye catch ranging from 5%, as age-1 fish in 2016, to 18% in 2020 (mean =12.6%). In 2021, no age-1 walleye (2020 year class) were captured in the warmwater assessment. In 2021, the average length of age-2 walleye (2019 year class) was 16.0 inches (n=3), and in 2022, this year class will be age 3 and will likely be just over the legally harvestable length of 18 inches.

Index of Abundance: Smallmouth Bass

Smallmouth bass have provided an important sport fishery in Lake Ontario's eastern basin for decades (Jolliff and LeTendre 1967, Panek 1981, NYDEC 1989, McCullough and Einhouse 1999, McCullough and Einhouse 2004). By the early 2000s, the eastern basin fish community was impacted by many perturbations including reduced lake productivity, dreissenid mussel mediated ecosystem changes (e.g., increased water clarity), increased abundance of DCC, and a variety of invasive species (e.g. *Bythotrephes*, *Cercopagis*, round goby). Studies demonstrated that the DCC population was contributing to reduced populations of smallmouth bass and yellow perch at that time (e.g., Adams et al. 1999, NYSDEC 1999, NYSDEC 2001, O'Gorman and Burnett 2001, Lantry et al. 2002), but direct impacts of other system stressors were not well understood. Angler surveys reported reduced smallmouth bass fishing quality in the eastern basin (Eckert 1999, McCullough and Einhouse 1999). By 2001, the smallmouth bass population declined to the lowest level observed and remained near record-low levels during 2000-2004 (2000-2004 mean CPUE=4.2; Figure 10). DCC management was initiated in 1999 and management plan objectives were met from 2006-2015, but DCC feeding days have been above target since 2016 (Resseguie and Bleau 2022).

The index of abundance for Lake Ontario's eastern basin smallmouth bass population improved from 2005-2013, compared to the 2000-2004 record lows; however, those levels were lower than expected following achievement of DCC population management objectives (Lantry 2018). Smallmouth bass have not produced strong year classes relative to those produced in the 1980s (Figure 11; Lantry 2018). Recently, year classes that appeared to have improved compared to other recent year classes did not persist. The production of poor to weak year classes since 2005 resulted in the lower CPUEs observed 2014 through 2016 (Figures 10, 11). CPUE improved somewhat in 2017 and 2018, declined slightly in 2019 and 2021 (2021 CPUE = 4.6 fish per net night), after an increase in 2020 (CPUE = 7.7). CPUE in 2021 was only 9.5% higher than the record lows of the 2000-2004 time period and was 25.8% below the 10-year average (mean CPUE=6.2; Figure 10). Variability of smallmouth bass catch in gill nets was consistently lower than that of other commonly caught species, with a long-term average RSE of 20.6% (1980-2021). In 2020, the RSE (32.9%) of smallmouth bass was 59.7% higher than the long-term average.

A number of other factors can impact bass recruitment, including water temperature, condition of spawning habitat, water clarity, predation on bass eggs or fry by round goby or other predators, prey availability for young-of-year bass, and disease outbreaks (Lantry 2018). For example, below average summer water temperatures in 2014 and 2015 likely resulted in two years of poor reproduction (Lantry 2018). Increased *Cladophora* growth in nearshore areas may impact the condition of spawning habitat and consequently bass recruitment; however, these impacts are unknown, as are potential impacts of round goby predation. Prey availability for bass from fry to age-1 is unknown and may be impacted through competition for prey with the invasive macroinvertebrate *Hemimysis anomola* (bloody red shrimp; first documented in 2006). Additional stressors including Type-E Botulism (early to mid-2000s), and Viral Hemorrhagic Septicemia virus (VHSv; 2005 with a major NY outbreak affecting bass in 2006) have caused bass die-offs in Lake Ontario's main and eastern basins and in the St. Lawrence River. It is unclear if VHSv mortality events have occurred since, will occur in the future, or if VHSv is currently hindering bass reproductive success.

Smallmouth Bass Growth, Condition, Maturity, and Age Structure

Lake Ontario's eastern basin bass population experienced changes in growth rates over the 1976 to 2021 time period which confound comparisons of "historic" (prior to mid-1990s) data with more recent data, including age-specific

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

Smallmouth bass > 12 in TL are both fully vulnerable to assessment nets across the entire survey time series and are harvestable in the sport fishery (i.e., minimum harvestable size is 12 in TL). Age structure of bass > 12 in TL changed such that for years prior to the mid-1990s, 98.0% (1980-1996 mean) of bass > 12 in were age 5 and older (Figure 13; Lantry 2018). The increased growth rate since the mid-1990s resulted in some bass reaching 12 in TL at a younger age (Figure 21). During 1997-2021, between 50.5% (2009) and 94.2% (2004) of the bass > 12 in TL were age 5 and older (1997-2005 average=82.2%; 2006-2021 average=73.9%). The contribution of younger bass (i.e., ages 2-4) that were 12 in TL increased from an average of 1.9% prior to 1997 to 23.2% since 1997 (1997-2005 average=17.9%; 2006-2021 average=26.1%; Figure 13).

Mean length-at-age continued to increase following establishment of round goby in the system and in bass diets. Unlike early years of this survey, gill nets could effectively sample many age-2 and age-3 bass, and likely all age-4 bass by the mid-2000s (Figures 12, 13; Lantry 2018). By 2010, a portion of bass sampled reached 12 in TL by age 2 (Figure 13), and average length of age-3 bass was over 12 in TL in 2010, 2012, 2014, and 2019 (Figures 12a, 12b). From the mid-2000s through 2021, mean length-at-age remained at or near record high for all ages 2-10 (Figures 12a, 12b).

In 2021, smallmouth bass total length ranged between 7.7 in (196 mm) and 20.3 in (515 mm) and averaged 15.1 in (383 mm; Figure 6). Smallmouth bass weight ranged from 3.2 oz (92 g) to 6.0 lb (2736 g) and averaged 2.6 lb (1180 g).

Condition of smallmouth bass in the eastern basin began increasing in the mid-2000s (Figure 14). This coincided with a shift from a diet dominated by crayfish to one dominated by round goby with very low occurrence of crayfish. Smallmouth bass condition varied about the long-term mean from 1993-2005, then increased for all length groups by 2006 (Figure 14). Condition of bass in 2021 remained within the range of values observed in recent years, with slight decreases for fish 12 inches and under (Figure 14). Crane et al. (2015) found a significant increase in smallmouth bass condition following invasion of round goby into lakes Ontario and Erie. Increased condition of bass > age 2 suggests that bass are not currently limited by prey availability.

Mean relative weight, another indicator of condition, varied without trend 1993-2005 and averaged 96.7 (range: 92.8 [1993] - 100.8 [2005]) suggesting that during that time period the bass population was likely in balance with the food supply (Flickinger and Bulow 1993; Figure 15). Each year beginning in 2006, mean relative weight exceeded 105 (2006-2021 average=108.2; Figure 15) indicating that the system could support more fish (Flickinger and Bulow 1993). The mean relative weight of bass in 2021 was 110.6 and was the second highest value in the time series, exceeded only by the 2008 value of 110.9.

In addition to increased growth and condition, an increasing contribution of large smallmouth bass (i.e., > 4 lb, 5 lb, and 6 lb) in assessment nets was documented (Figure 16). Prior to the 1990s, no smallmouth bass > 4 lbs were caught. The first smallmouth bass > 4 lbs was caught in 1992 (0.2% of total [N=483] catch). Beginning in 1998, smallmouth bass > 4 lbs were caught with increasing regularity. In 2017, 22.4% of smallmouth bass caught weighed > 4 lbs which was the highest percentage on record (N=245; Figure 16). In 2021, 13.9% of smallmouth bass caught weighed > 4 lbs (N=158). Smallmouth bass weighing > 5 lbs were first caught in 1999 and have been caught each year since 2005. In 2021, 8.9% of all bass were > 5 lbs. Smallmouth bass > 6 lbs were first caught in the 2005 survey (0.2% of total smallmouth bass caught) and then again in 2011. Each year from 2011-2021, 0.3-1.3% of smallmouth bass caught weighed more than 6 lbs (1.3% in 2021). These increases are most likely attributed to good growth and condition rather than increased abundance of older aged bass.

Fish populations with increased growth rates tend to mature at earlier ages (e.g., Carlander 1969, 1977, 1997; Heibo et al. 2005). Analysis of percent maturity of male and female bass ages 1-7 sampled prior to (1976-1995) and after (1996-2016) the observed increased growth rates indicated that a higher percentage of bass matured at younger ages in recent years (Figure 26). This began as early as age 2 for both males and females. For example, an average of 28.9% of age-4 females were identified as mature during 1976-1995 (Lantry 2018) compared to 86.5% mature during 1996-2021 (Figure 18). For both time periods and sexes, >99.3% of the smallmouth bass sampled were mature by age 7. Across the time series, a higher percentage of male bass were mature at age 2-5 than female bass (Figure 17).

Life span is generally shorter where growth is faster (e.g., Carlander 1969, 1977, 1997; Heibo et al. 2005), further confounding population structure evaluations. CPUE of older bass was evaluated to determine if abundance of older bass declined following increased growth rates. During 1980-1995, mean CPUE of age 10+ smallmouth bass was 1.6 (range: 0.4-3.6; Figure 18). Since then (1996-2021), mean CPUE was 64.8% lower (mean CPUE=0.57; range: 0.1-1.1; Figure 18). Increasing growth of older bass (ages 8+) was observed as early as about 1990 (Figures 12a, 12b) and may have influenced bass life span; however, this also coincides with a period of reduced survival rates that were attributed to DCC predation (Chrisman and Eckert 1999; Lantry et al. 2002). The year classes that reached age 10+ in recent years were impacted by DCC predation, improved growth (Figures 12a, 12b), and mostly poor year class production (Figure 11), all of which can contribute to continued relatively low CPUE of bass ages 10+ (Figure 18).

Age composition of the smallmouth bass catch is influenced by several factors including assessment net mesh size, size-selective predation by DCC, and year class strength. Through 1994, bass catches were dominated by age-5+ bass (1980-1994 mean CPUE=14.8, representing 73.0% of total bass catch; Lantry 2018; Figure 18). Catches of bass ≤ age 4 were substantially lower (1980-1994 mean CPUE=5.1 representing an average of 27.0% of total bass catch; Lantry 2018; Figure 18). Through the 1990s and early 2000s, ecosystem changes, increasing DCC predation and accelerated bass growth rate influenced age-specific CPUE and age composition of bass caught in nets. Since 1995, CPUE of age-5+ bass varied at a lower level than the previous time period, averaging 3.1 and representing 48.1% of the total bass catch (38.3% [CPUE] and 34.1% [total bass catch] decreases, respectively). Year class-specific CPUEs often peak before age 5 and trends in higher CPUE for strong year classes have not persisted at ages 5+ since the 1983 year class (Lantry 2018). CPUE of younger bass (ages ≤ 4) also decreased during 1995-2021 (mean CPUE=3.6) relative to 1980-1994 (mean CPUE=5.2; Figure 18), despite increased vulnerability to capture due to increased growth.

Despite a reduction in DCC predation pressure through the mid-2010s, CPUE of bass ≤ age 4 was 31.5% below the earlier time period (1980-1994), when bass were less vulnerable to gill nets due to slower growth rates. In 2021, the CPUE of bass ≤ age 4 declined to 2.0 bass per net night, 44.4% below the long term average.

Index of Abundance: Rock Bass

Rock bass CPUE peaked in 1980 at 14.7, declined through the early 1980s, and varied without trend through the early 1990s. Abundance subsequently declined through the 1990s, and has remained relatively stable since (Figure 19). In 2021, rock bass CPUE (0.5) decreased and was 50.0% below the previous 10-year average (CPUE = 1.0).

Occurrence of Round Goby

Round goby is an invasive species first reported in southwestern Lake Ontario in 1998 and in the Bay of Quinte in 1999 (Mills et al. 2005). By 2006, they were abundant, distributed across the entire New York shoreline, and captured from the nearshore zone to depths of at least 150m (Walsh et al. 2007). Round goby did not appear in this assessment until 2005, when two were captured. Since then, they have appeared in low numbers (Table 1). This assessment will not provide an index of goby abundance due to their relatively small size and the size-selective nature of the assessment gill nets. We are, however, able to gain insight into the importance of round goby in predator diets during early August from examination of predator stomachs.

Stomach contents from all predators captured were identified from 2000-2020. We first observed round goby in predator diets in 2005 (i.e., a total of 16 round goby observed in smallmouth bass stomachs). Their occurrence in smallmouth bass stomachs increased each year through 2013 when 80.9% of the non-empty bass stomachs contained goby. From 2014-2017, 72.8-76.7% of non-empty bass stomachs contained goby (Figure 20). In 2021, 62.5% of the 104 non-empty bass stomachs contained goby, an increase from the lower frequency (49.7%) observed in 2020 (Figure 20). Round goby were present in walleye diets each year from 2006-2010 and 2012-2016. Round goby have also been observed in the diets of northern pike, brown trout (*Salmo trutta*), lake trout, lake whitefish (*Coregonus clupeaformis*), rock bass, yellow perch, and white perch over the course of this assessment. DCC in the eastern basin have also historically consumed round goby. Round goby first appeared in DCC diets at the Snake and Pigeon Island colonies in 2002 (Ross et al. 2003) and at the Little Galloo Island colony in 2004 (Johnson et al. 2005), and were documented in DCC diets each year through 2013 (i.e., the most recent year of cormorant diet analysis; Johnson et al. 2010, Johnson et al. 2012, Johnson et al. 2013, Johnson et al. 2014). Round goby dominated DCC diets by 2004 at the Snake and Pigeon Island colonies, and by 2005 at the Little Galloo Island colony (Ross et al. 2005, Johnson et al. 2006).

Occurrence of Lake Sturgeon

Lake sturgeon is designated as a threatened species in New York State. Prior to 1995, this species was extremely rare in this assessment with only one lake sturgeon captured in 19 years (1976-1994; Table 1, Figure 21). From 1995-2021, at least one lake sturgeon was collected in 21 of the 27 years (10 captured in 2021), suggesting improved population status. Improved status is likely attributable to restoration efforts (e.g., stocking and habitat improvement; Klindt and Gordon 2019).

Occurrence of Chain Pickerel

Chain pickerel (*Esox niger*) presence in Ontario waters was confirmed in 2008 (Hoyle and Lake 2011). This species was first captured in this assessment in 2013 when three were caught in two nets (each set in 15 ft water depth). No chain pickerel were caught in 2021. Chain pickerel capture in this assessment is rare because nets are distributed at water depths 12-100 ft, beyond preferred chain pickerel habitat. Chain pickerel have also been reported in angler catches during the Lake Ontario Fishing Boat Survey each year 2008-2010, 2013 and 2017 (Table 1; Connerton and Eckert 2019). Occurrence of chain pickerel in recent years is attributed to range expansion (Hoyle and Lake 2011).

Other Species

Catches of other species (i.e., alewife, white sucker [*Catostomus commersonii*], brown bullhead [*Ameiurus nebulosus*], channel catfish [*Ictalurus punctatus*], pumpkinseed sunfish [*Lepomis gibbosus*], freshwater drum, northern pike, and common carp [*Cyprinus carpio*]) were low and variable across the entire data series (Table 1).

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Table 1. Stratified mean catch per unit effort data from the 1993-2021 warmwater assessment netting conducted late July through mid-August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang									
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Alewife	0.18	0.00	0.48	0.92	0.00	0.06	0.13	0.26	0.95	0.02
American Eel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black Crappie	0.04	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.06
Brown Bullhead	0.35	0.35	0.06	0.00	0.83	0.06	0.22	0.21	0.32	0.21
Chain Pickerel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Channel Catfish	1.12	0.35	0.19	0.47	1.42	0.75	0.61	0.54	0.09	0.21
Common Carp	0.35	0.06	0.10	0.15	0.12	0.10	0.18	0.04	0.00	0.00
Freshwater Drum	0.52	0.74	0.63	0.23	0.41	0.25	0.41	0.25	0.20	0.23
Gizzard Shad	0.12	0.06	0.00	0.00	0.00	0.08	0.07	0.13	0.00	0.06
Lake Sturgeon	0.00	0.00	0.02	0.00	0.02	0.06	0.03	0.10	0.02	0.00
Largemouth Bass	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
Longnose Gar	0.48	0.35	0.00	0.00	0.02	0.02	0.05	0.00	0.02	0.00
Longnose Sucker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Muskellunge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Pike	0.10	0.06	0.04	0.04	0.08	0.06	0.07	0.08	0.07	0.19
Pumpkinseed	0.23	0.04	0.06	0.04	0.08	0.29	0.22	0.31	0.28	0.46
Quillback	0.04	0.00	0.00	0.04	0.00	0.04	0.00	0.00	0.00	0.00
Rock Bass	6.99	3.99	1.41	3.79	2.33	2.13	3.18	1.47	1.22	1.10
Round Goby	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shorthead Redhorse	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.00	0.02	0.00
Silver Redhorse	0.00	0.08	0.12	0.02	0.13	0.12	0.07	0.12	0.05	0.17
Smallmouth Bass	19.91	11.99	5.01	6.98	6.03	9.36	9.44	5.01	2.99	3.76
Stonecat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Walleye	3.84	3.29	1.91	2.97	1.76	2.13	1.38	1.53	1.70	1.08
White Bass	0.02	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
White Perch	5.04	6.01	0.06	0.31	0.48	0.29	1.04	0.92	1.04	1.09
White Sucker	1.18	0.81	1.13	2.01	1.31	1.02	0.89	0.35	0.38	0.78
Yellow Perch	2.78	5.87	3.68	8.76	5.53	5.01	4.26	8.58	6.37	9.65
Total	43.32	34.08	14.91	26.73	20.58	21.94	22.25	19.92	15.73	19.06

Table 1 (continued). Stratified mean catch per unit effort data from the 1993-2021 warmwater assessment netting conducted late July through mid-August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang									
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Alewife	0.08	0.00	0.00	0.07	0.14	0.19	1.19	0.00	0.16	0.46
American Eel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Black Crappie	0.00	0.02	0.06	0.00	0.04	0.05	0.03	0.04	0.04	0.02
Brown Bullhead	0.40	0.35	0.48	0.31	0.54	2.12	0.81	1.48	0.42	0.82
Chain Pickerel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Channel Catfish	0.12	0.79	0.81	0.15	0.12	0.57	0.54	0.42	0.17	0.21
Common Carp	0.02	0.15	0.14	0.11	0.02	0.05	0.10	0.02	0.02	0.00
Freshwater Drum	0.27	0.60	0.19	0.32	0.23	0.26	0.36	0.08	0.19	0.19
Gizzard Shad	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.12	0.19
Lake Sturgeon	0.04	0.02	0.02	0.09	0.10	0.00	0.00	0.08	0.02	0.00
Largemouth Bass	0.00	0.02	0.02	0.02	0.00	0.00	0.03	0.02	0.00	0.00
Longnose Gar	0.00	0.06	0.17	0.12	0.08	0.10	0.21	0.75	0.62	0.02
Longnose Sucker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Muskellunge	0.00	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Pike	0.15	0.17	0.19	0.08	0.06	0.23	0.09	0.10	0.02	0.02
Pumpkinseed	0.46	0.52	0.50	1.15	0.21	0.10	0.28	0.04	0.21	0.29
Quillback	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rock Bass	1.84	2.09	2.70	2.43	0.70	3.27	2.52	1.54	1.31	0.75
Round Goby	0.00	0.00	0.04	0.10	0.26	0.42	0.95	0.36	0.08	0.07
Shorthead Redhorse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Silver Redhorse	0.10	0.42	0.33	0.02	0.02	0.08	0.07	0.04	0.00	0.06
Smallmouth Bass	5.43	3.84	11.33	10.45	6.39	9.27	9.81	7.90	6.09	8.12
Stonecat	0.00	0.00	0.06	0.02	0.00	0.00	0.00	0.04	0.02	0.02
Walleye	2.12	1.69	2.38	1.94	1.33	2.33	2.65	1.91	1.97	2.38
White Bass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
White Perch	0.42	1.18	1.94	0.92	0.81	7.75	3.02	6.22	3.72	1.04
White Sucker	1.66	0.41	1.03	0.72	0.57	0.65	1.31	0.48	0.25	2.35
Yellow Perch	9.82	6.74	8.93	9.13	13.95	16.91	7.37	16.31	15.29	14.99
Total	22.92	19.10	31.36	28.16	25.60	44.36	31.44	37.84	30.73	32.02

Table 1 (continued). Stratified mean catch per unit effort data from the 1993-2021 warmwater assessment netting conducted late July through mid-August in New York waters of Lake Ontario's eastern basin.

	Stratified Mean Catch per 450 ft Monofilament Gill Net Gang								
	2013	2014	2015	2016	2017	2018	2019	2020	2021
Alewife	0.00	0.31	0.47	0.02	0.09	0.00	0.16	0.04	0.13
American Eel	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00
Black Crappie	0.06	0.02	0.00	0.00	0.23	0.00	0.02	0.00	0.00
Brown Bullhead	1.97	1.54	0.46	0.60	0.12	0.52	0.30	0.61	0.27
Chain Pickerel	0.06	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
Channel Catfish	0.42	0.07	0.31	0.13	0.05	0.03	0.05	0.04	0.06
Common Carp	0.15	0.11	0.05	0.08	0.07	0.12	0.07	0.19	0.02
Freshwater Drum	0.29	0.34	0.26	0.16	0.52	1.30	0.68	0.87	0.38
Gizzard Shad	2.08	0.32	1.09	0.70	2.83	1.77	0.98	1.94	1.94
Lake Sturgeon	0.02	0.00	0.06	0.05	0.09	0.20	0.07	0.48	0.21
Largemouth Bass	0.02	0.00	0.00	0.00	0.00	0.00	0.07	0.02	0.00
Longnose Gar	0.23	0.44	0.67	0.00	0.00	0.26	0.39	0.35	0.02
Longnose Sucker	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
Muskellunge	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Northern Pike	0.12	0.12	0.02	0.02	0.00	0.00	0.08	0.02	0.08
Pumpkinseed	0.38	0.02	0.04	0.03	0.12	0.41	0.25	0.96	0.27
Quillback	0.08	0.02	0.02	0.03	0.02	0.03	0.07	0.00	0.00
Rock Bass	1.21	1.00	1.06	1.43	1.82	0.56	1.37	0.46	0.50
Round Goby	0.02	0.00	0.00	0.06	0.07	0.02	0.00	0.06	0.02
Shorthead Redhorse	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Silver Redhorse	0.06	0.00	0.00	0.05	0.05	0.00	0.00	0.04	0.04
Smallmouth Bass	7.65	5.01	4.36	4.98	6.83	7.46	5.30	7.67	4.61
Stonecat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Walleye	1.34	1.55	0.97	1.28	1.99	1.19	2.30	1.22	1.48
White Bass	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.00
White Perch	6.41	7.87	3.69	3.55	4.80	4.89	2.82	6.80	3.73
White Sucker	0.19	0.16	0.57	0.22	1.17	0.44	0.73	0.38	1.41
Yellow Perch	10.32	1.70	0.82	3.15	15.21	9.85	12.84	7.04	15.29
Total	33.09	20.62	14.92	16.52	36.08	29.07	28.68	29.23	30.47

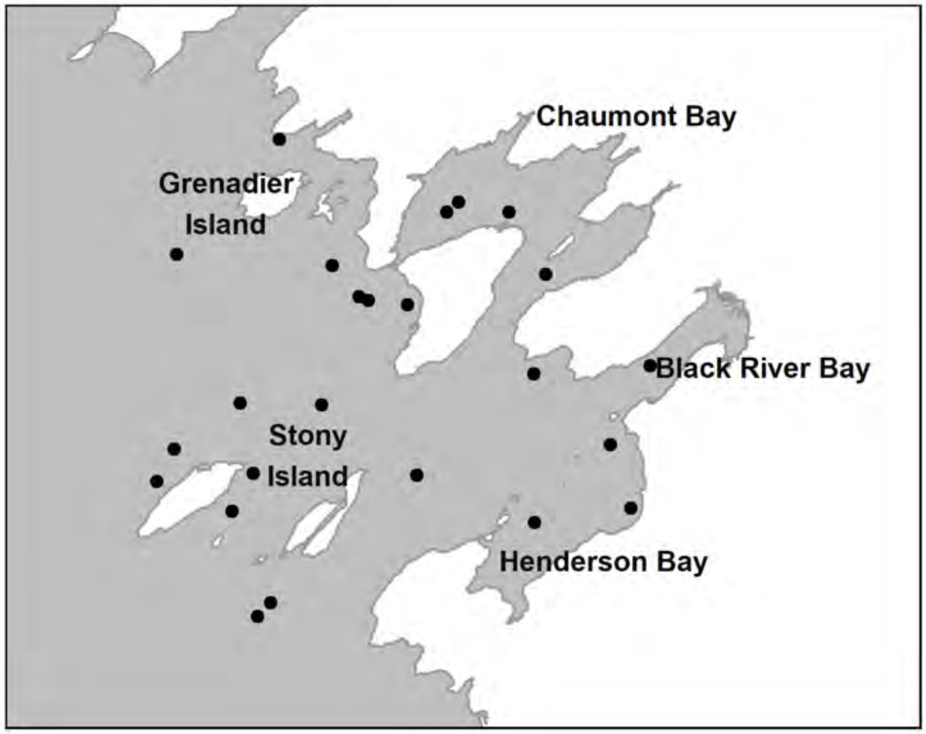

Figure 1. Map of New York waters of Lake Ontario's eastern basin showing the five area strata used in the 1993-2021 warmwater assessment and locations (black dots) of nets set in 2021.

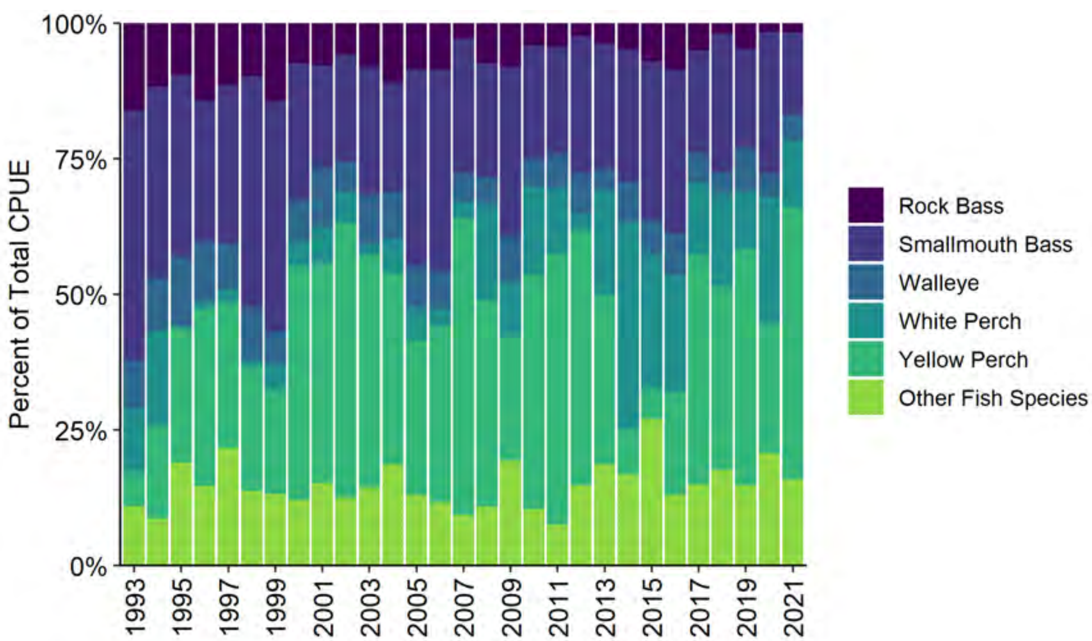

Figure 2. Species composition of warmwater species caught from 1993-2021 in the Lake Ontario eastern basin warmwater assessment.

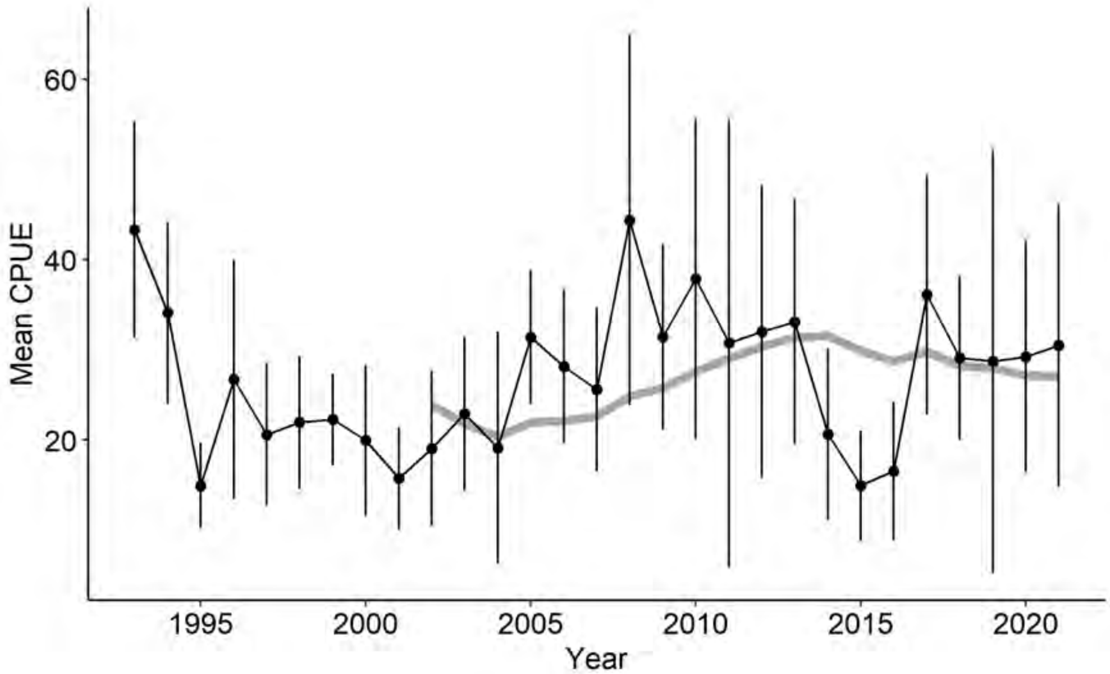

Figure 3. Stratified mean catch per 450 ft gill net gang (CPUE), 95% confidence intervals, and ten-year moving average (solid grey line) for all warmwater fish, 1993-2021.

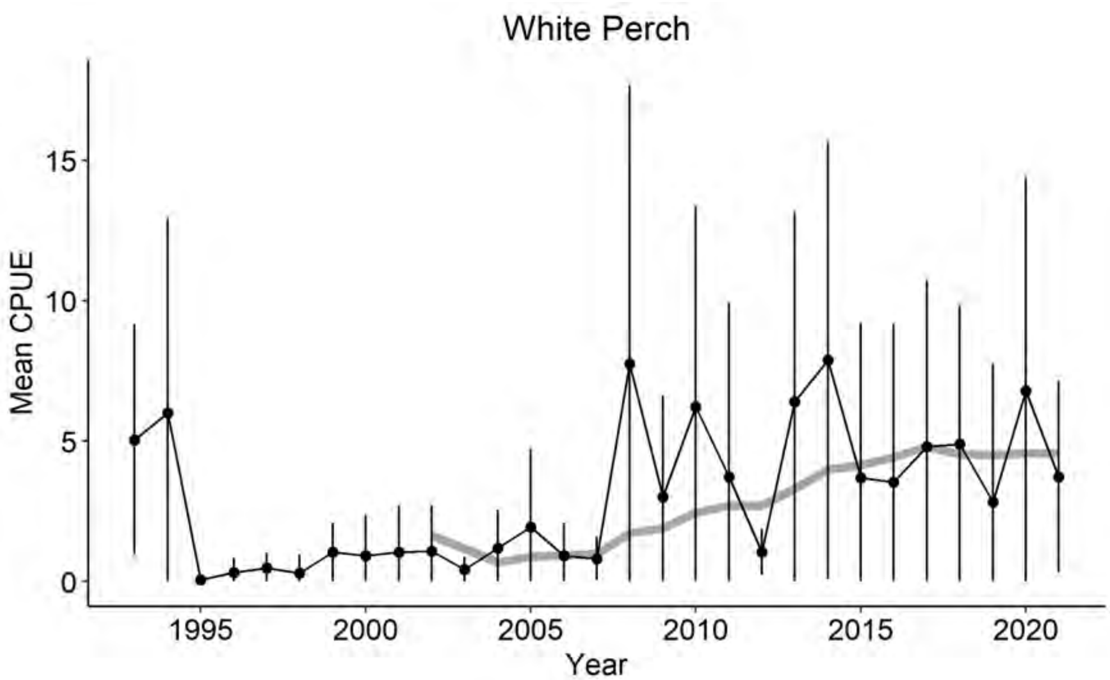

Figure 4. Stratified mean catch per 450 ft gill net gang (CPUE), 95% confidence intervals, and ten-year moving average (solid grey line) for white perch, 1993-2021.

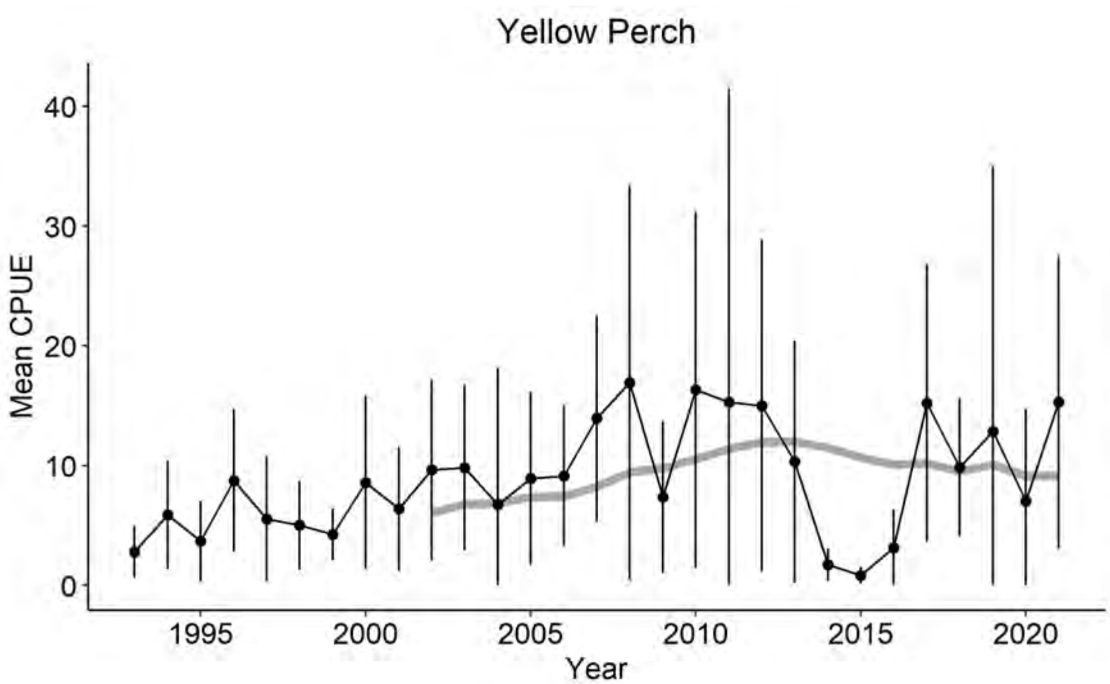

Figure 5. Stratified mean catch per 450 ft gill net gang (CPUE), 95% confidence intervals, and ten-year moving average (solid grey line) for yellow perch, 1993-2021.

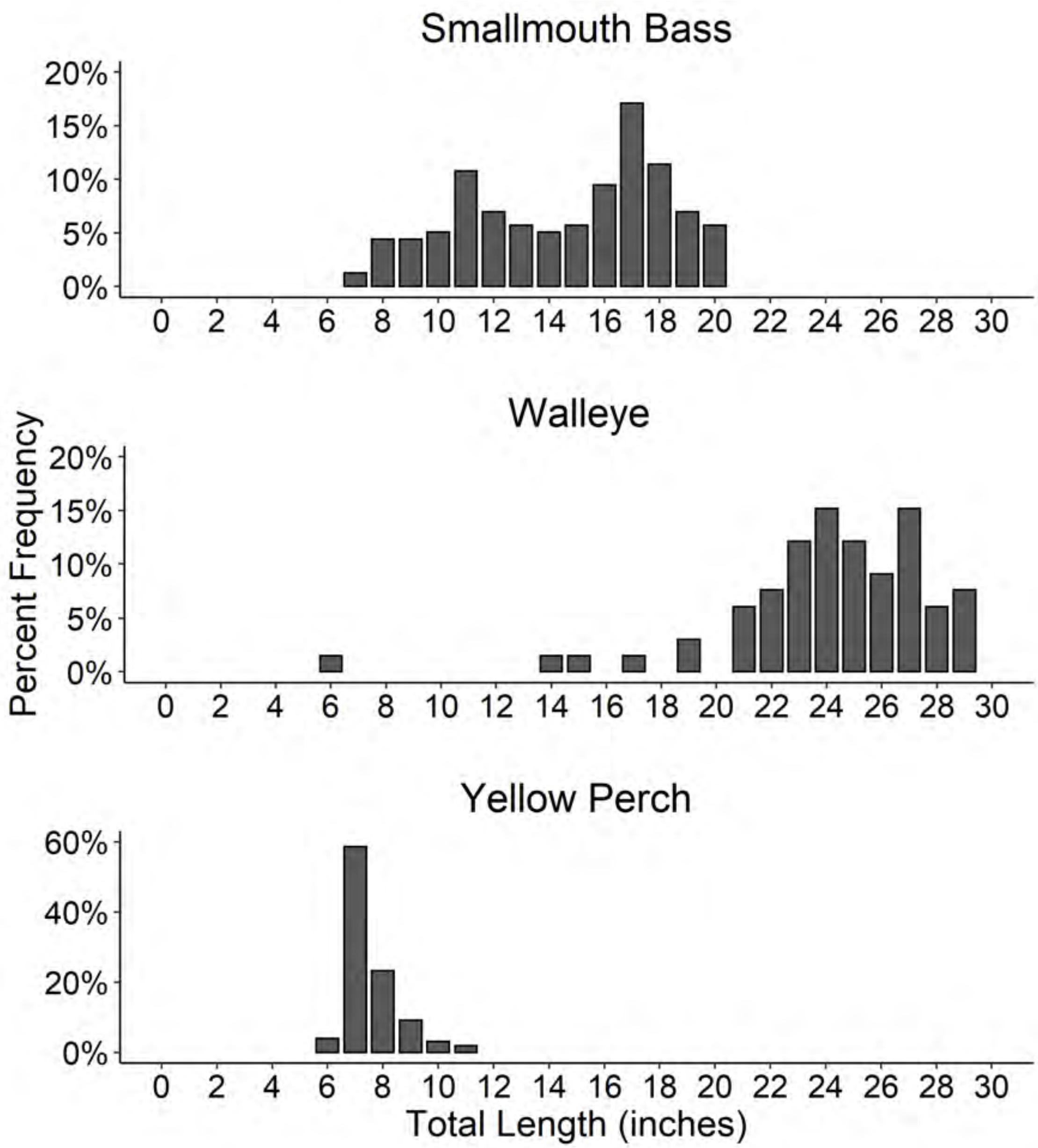

Figure 6. ***Length frequency distribution of smallmouth bass, walleye, and yellow perch collected during the eastern basin warmwater assessment in 2021.***

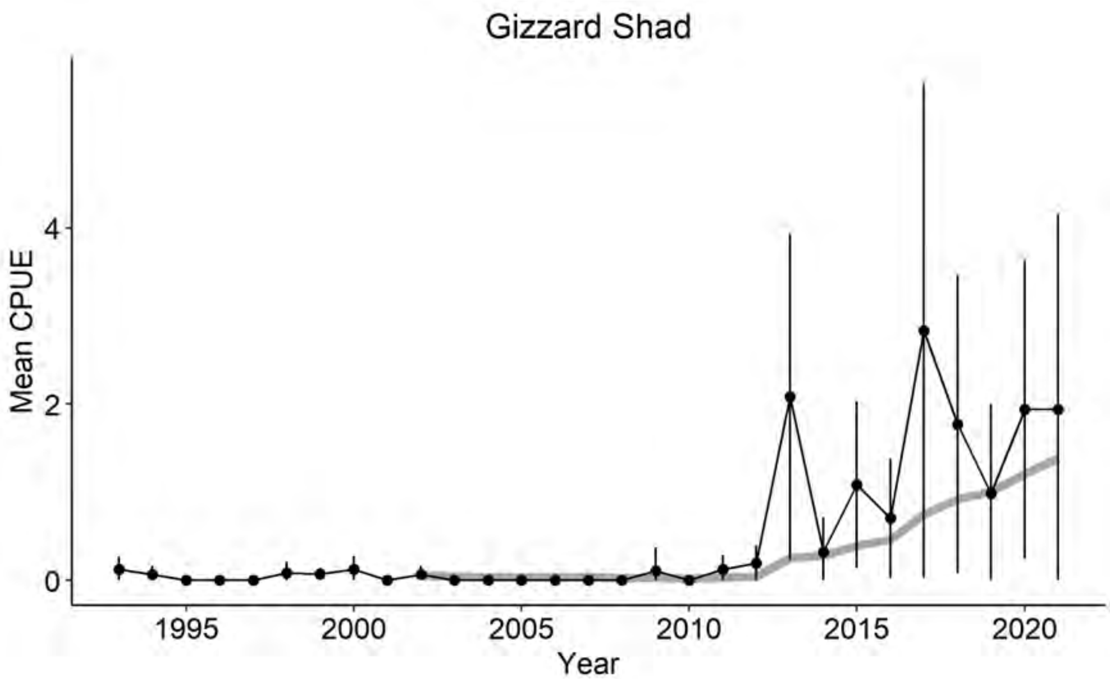

Figure 7. Stratified mean catch per 450 ft gill net gang (CPUE), 95% confidence intervals, and ten-year moving average (solid grey line) for gizzard shad, 1993-2021.

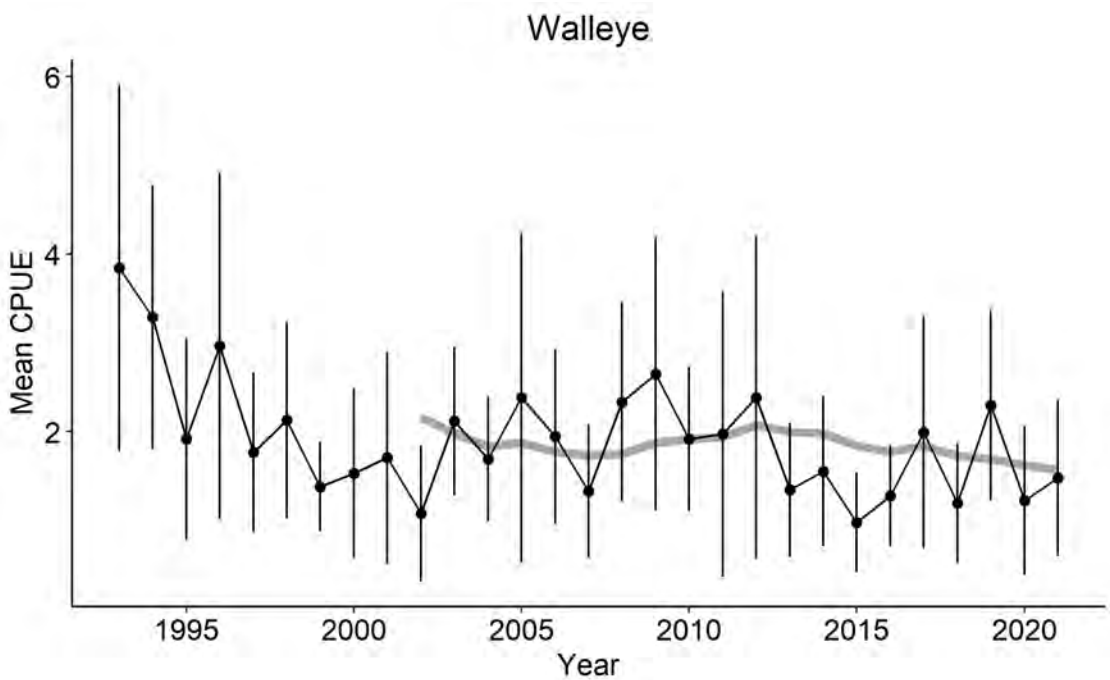

Figure 8. Stratified mean catch per 450 ft gill net gang (CPUE), 95% confidence intervals, and ten-year moving average (solid grey line) for walleye, 1993-2021.

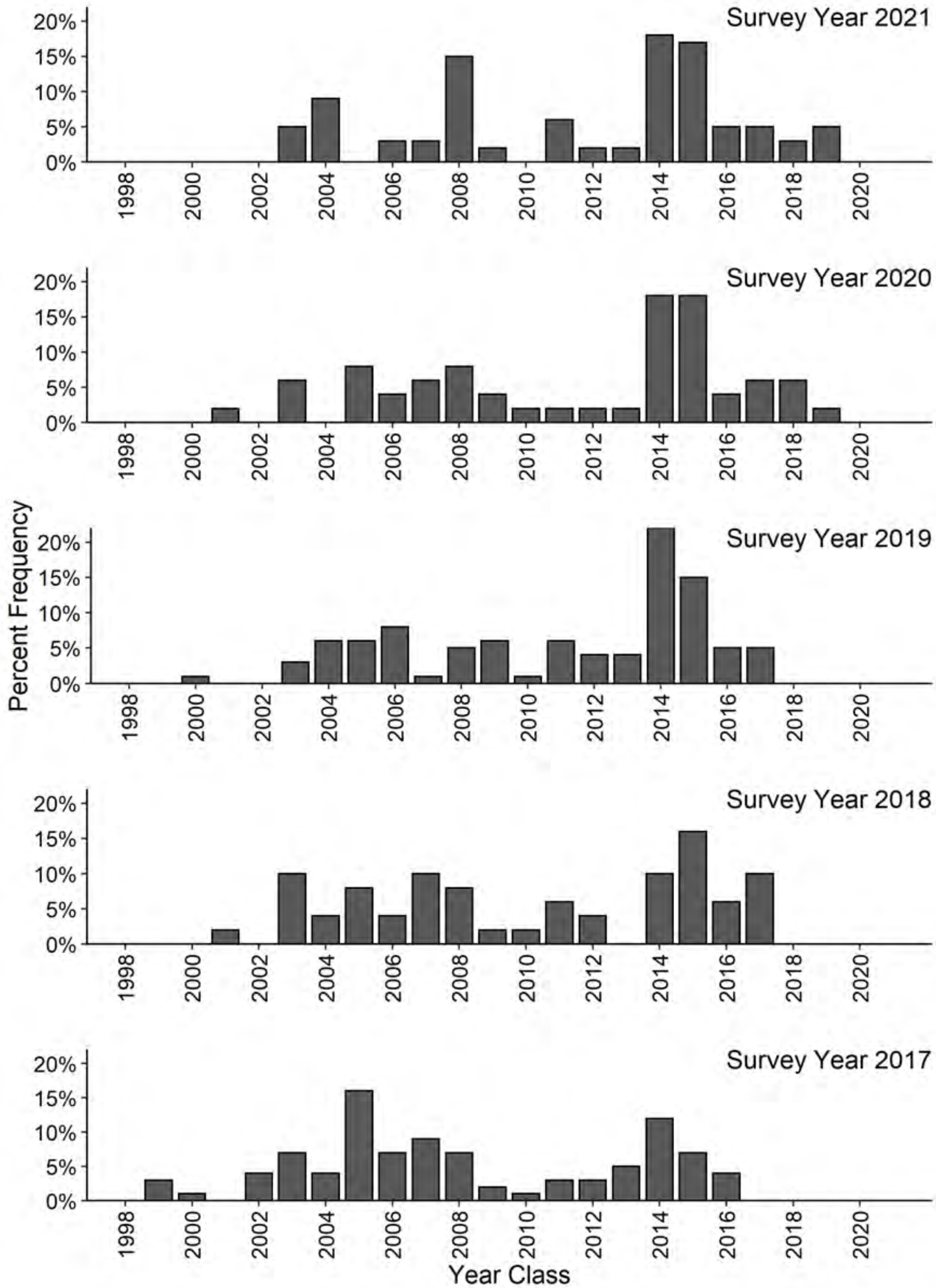

Figure 9. Year class frequency distributions of walleye collected during the warmwater assessment from 2017-2021.

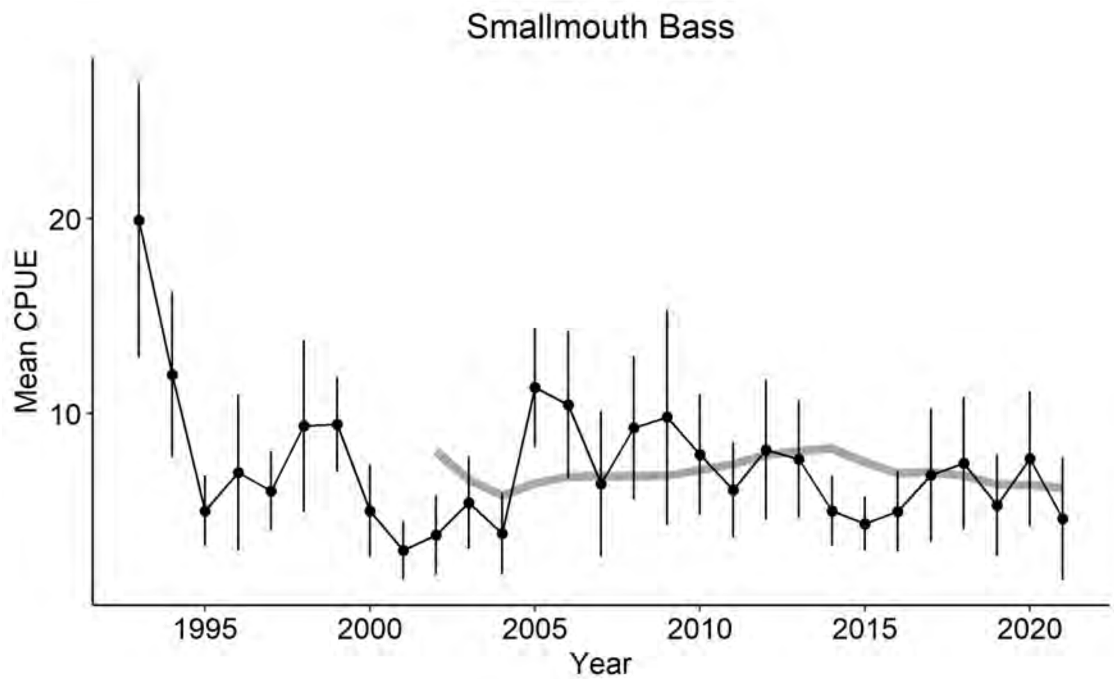

Figure 10. Stratified mean catch per 450 ft gill net gang (CPUE), 95% confidence intervals, and ten-year moving average (solid grey line) for smallmouth bass, 1993-2021.

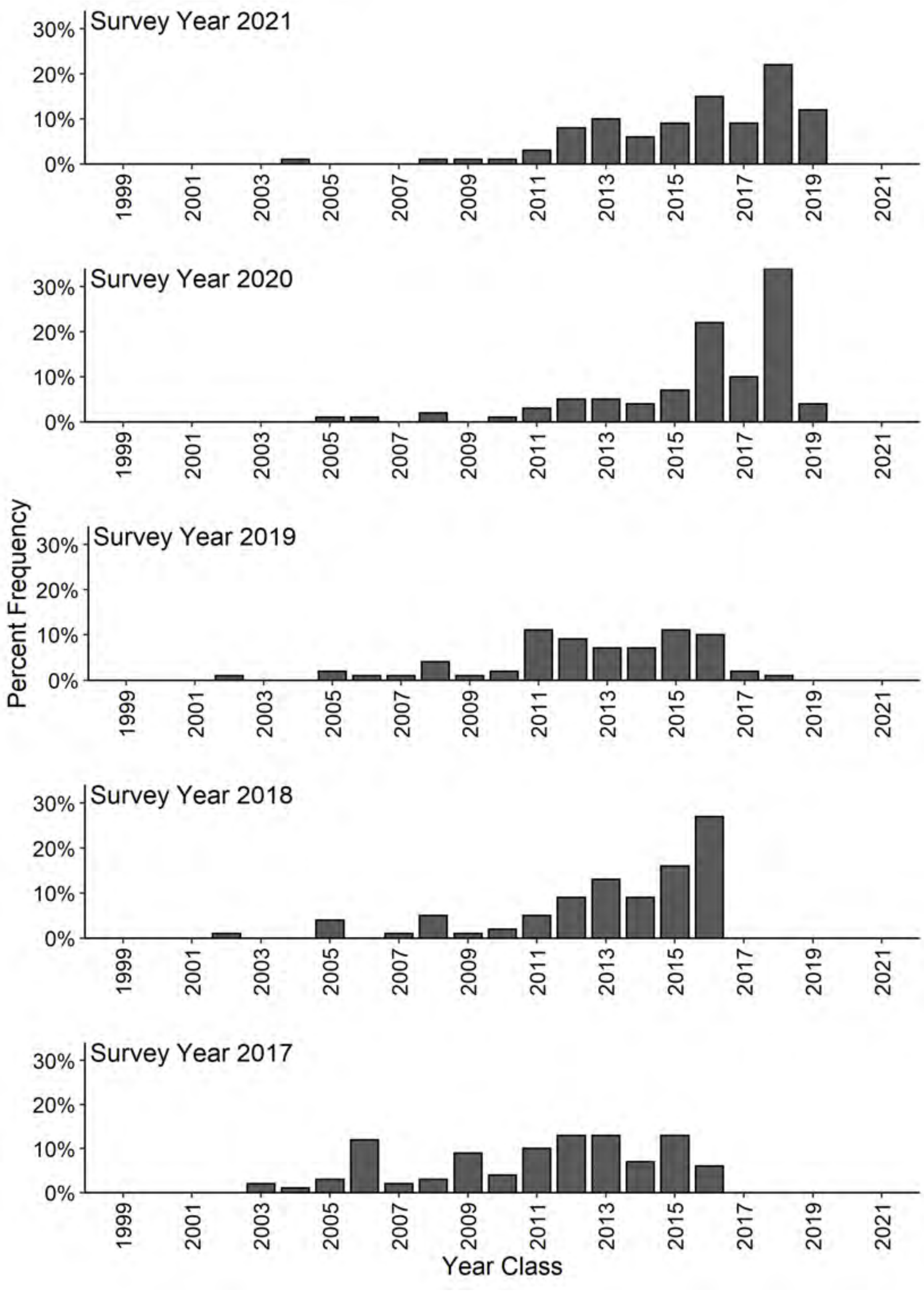

Figure 11. Year class frequency distributions of smallmouth bass collected during the warmwater assessment from 2017-2021.

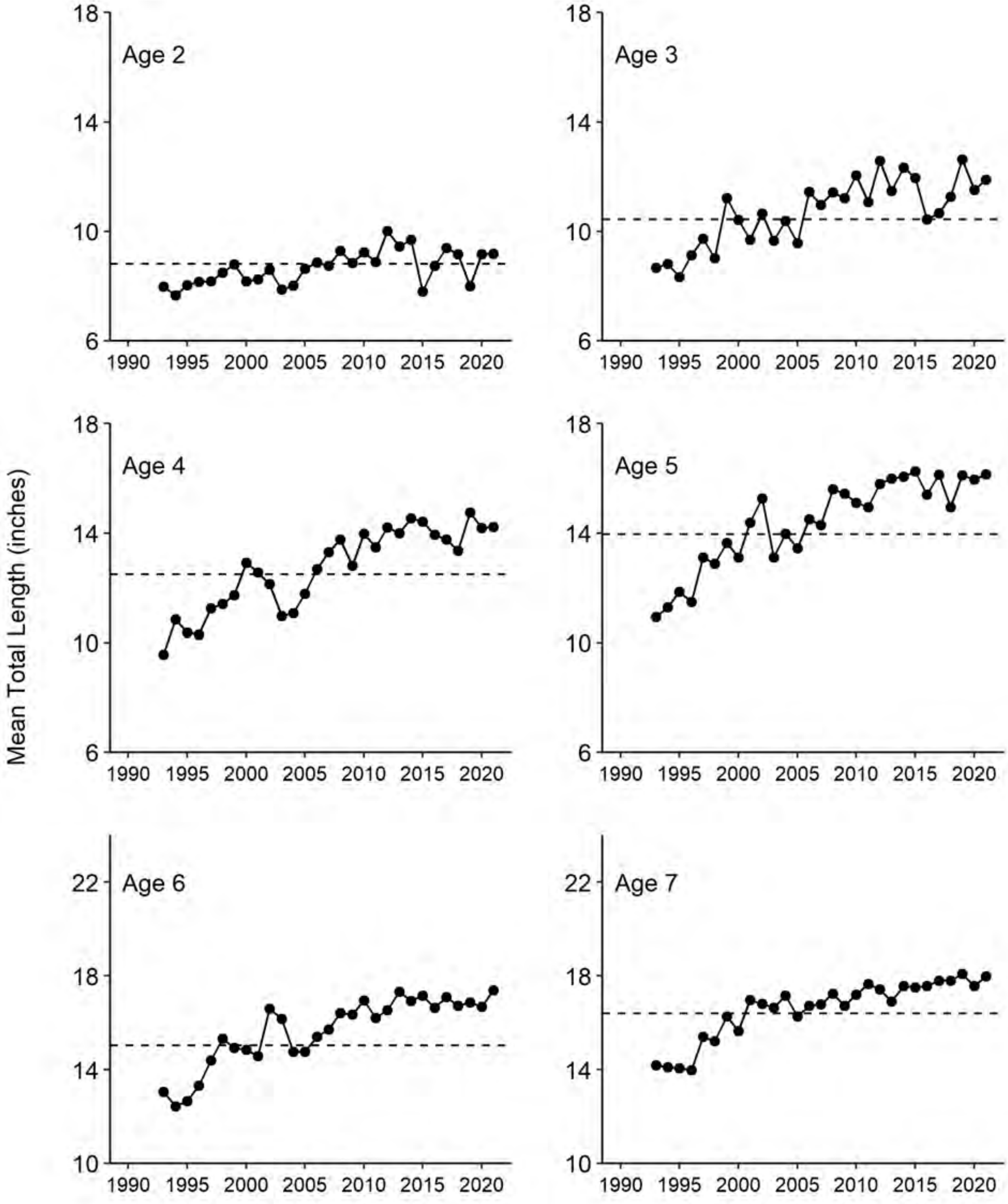

Figure 12a. Mean length at age (ages 2-7) by year sampled (1993-2021) for smallmouth bass collected during the eastern basin warmwater assessment. Dashed lines represent longterm mean lengths for each age group.

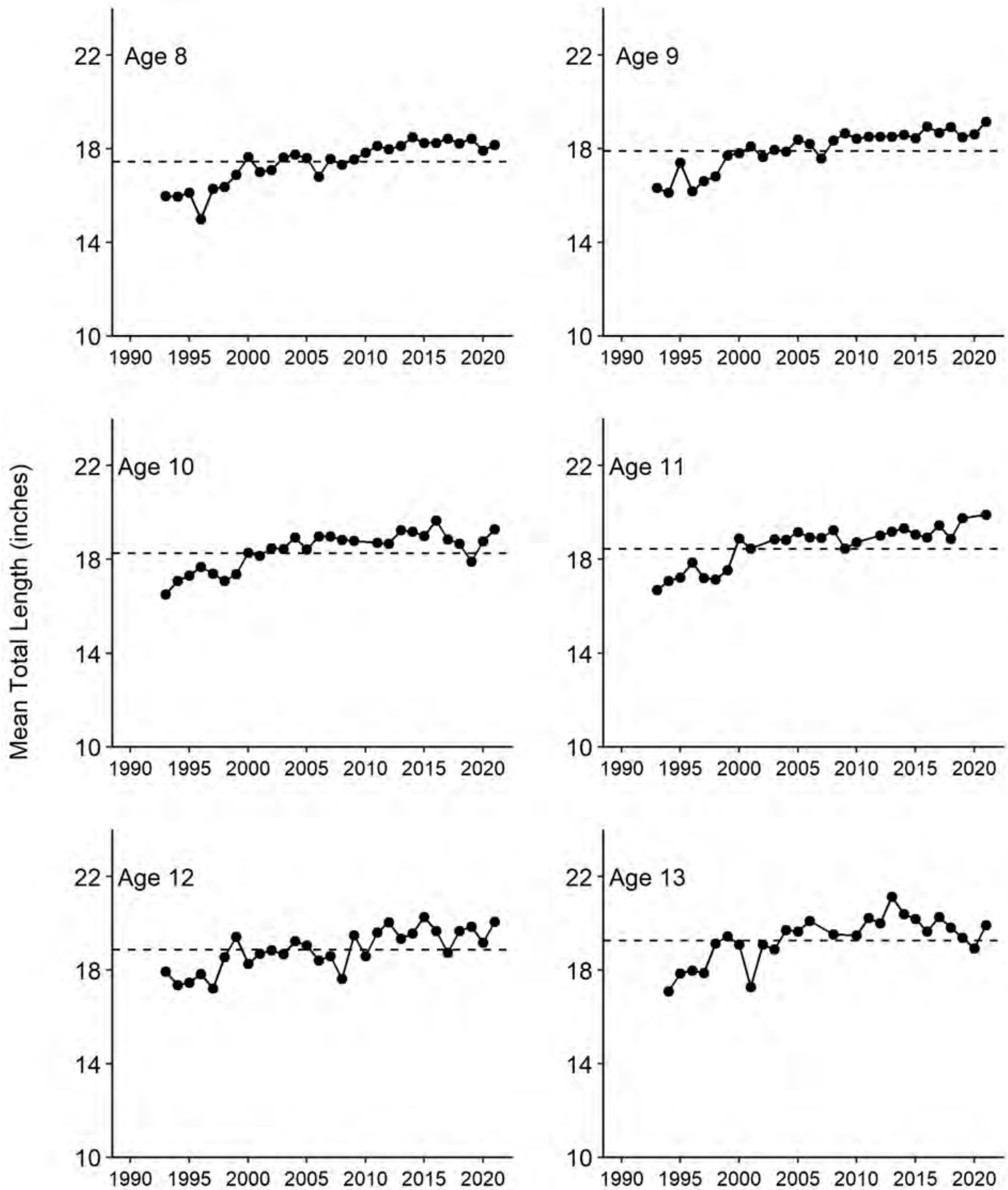

Figure 12b. Mean length at age (ages 8-13) by year sampled (1993-2021) for smallmouth bass collected during the eastern basin warmwater assessment. Dashed lines represent longterm mean lengths for each age group.

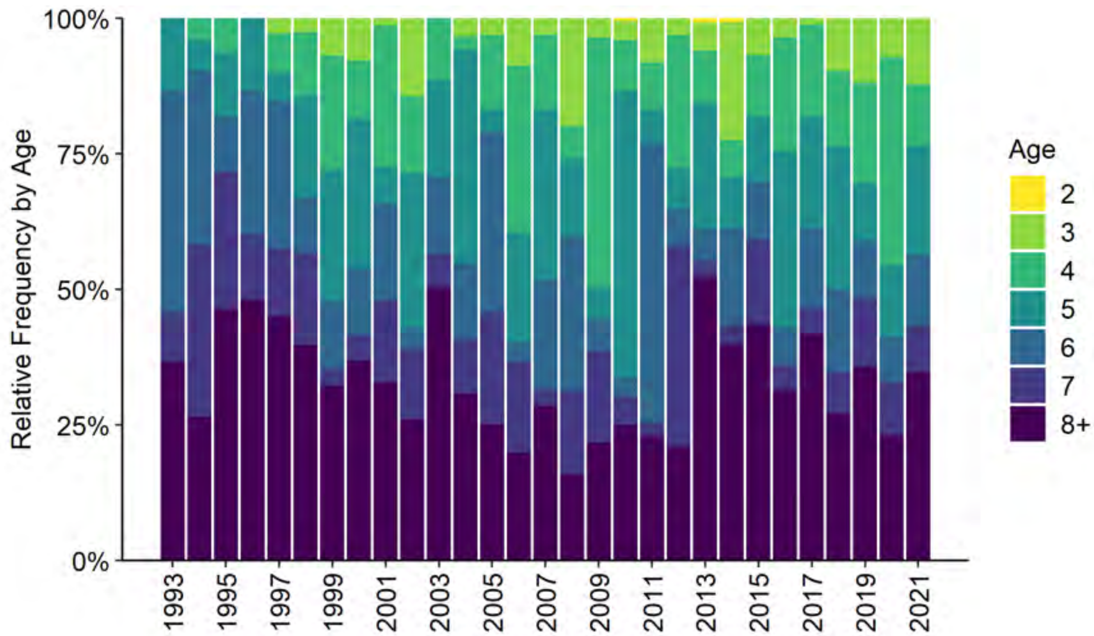

Figure 13. Age structure of smallmouth bass ≥ 12 inches total length in the eastern basin warmwater assessment (1993-2021).

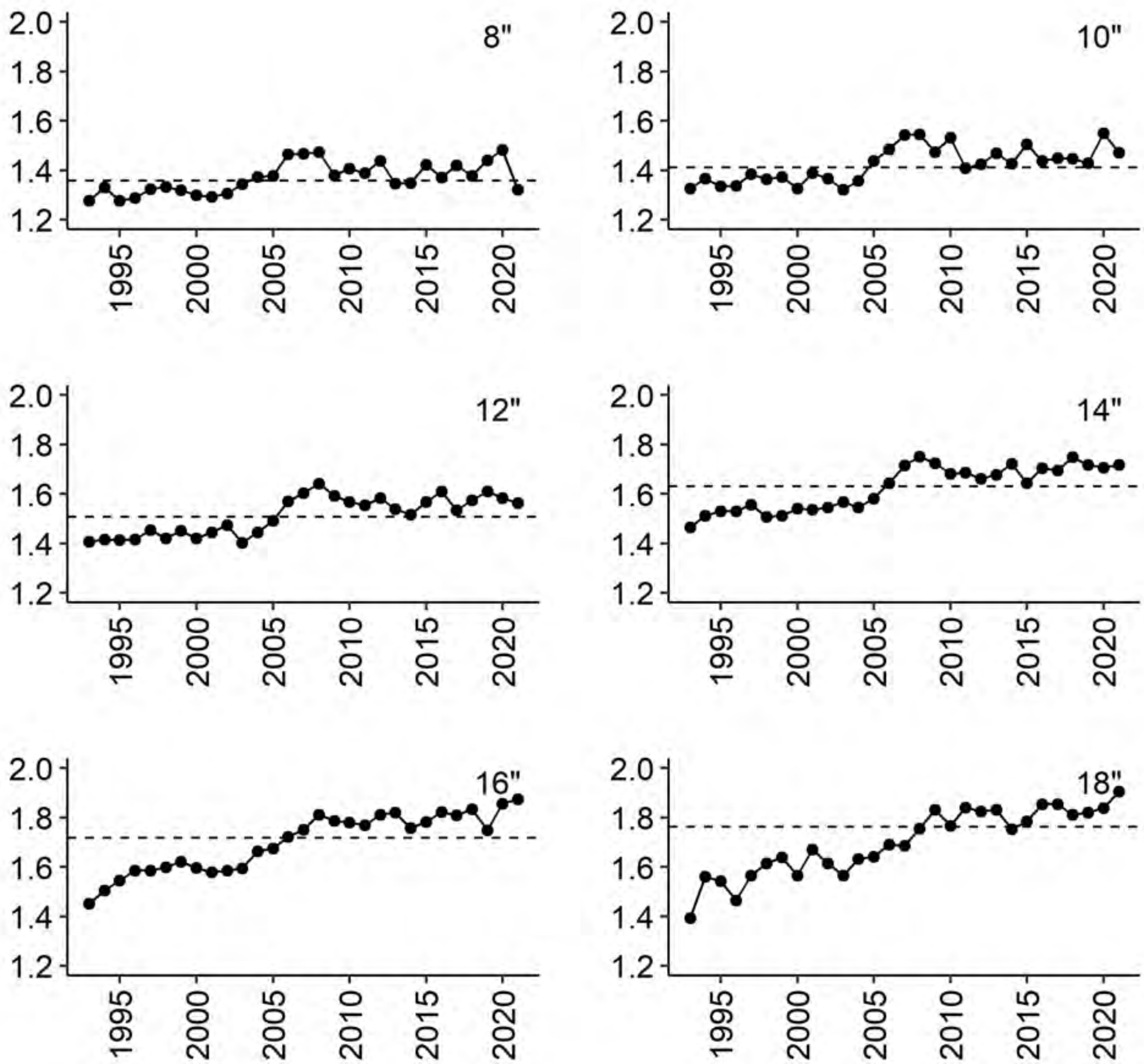

Figure 14. Mean condition by length (8-18 inches in 2-inch increments) and year sampled (1993-2021) for smallmouth bass collected during the eastern basin warmwater assessment. Dashed line represents the long-term mean condition for the respective length increment.

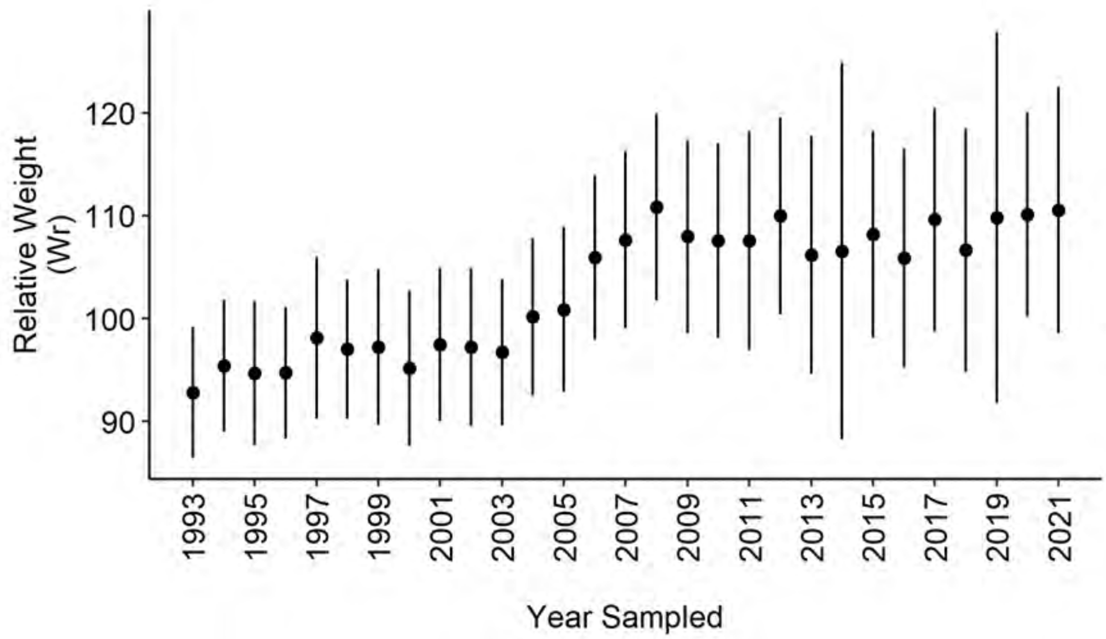

Figure 15. Mean relative weight of smallmouth bass caught in the eastern basin warmwater assessment (1993-2021; ± 1 standard deviation).

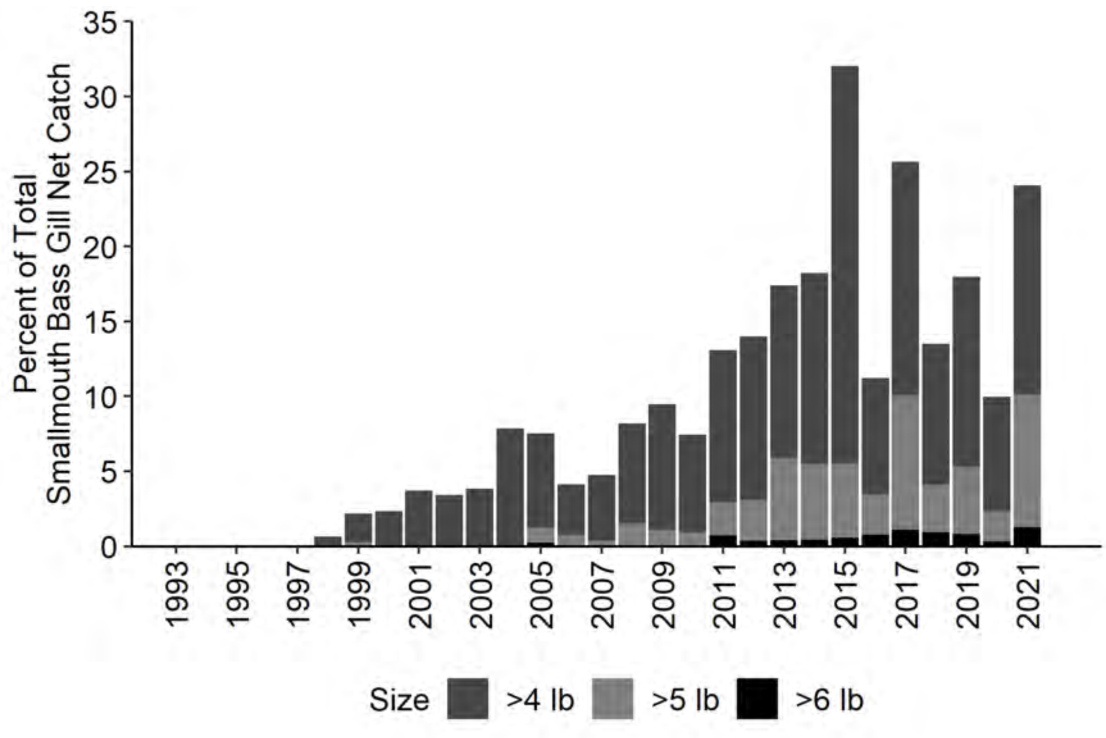

Figure 16. Percentage of total smallmouth bass catch during the eastern basin warmwater assessment (1993-2021 catches) that were >4lb, >5lb, and >6lb.

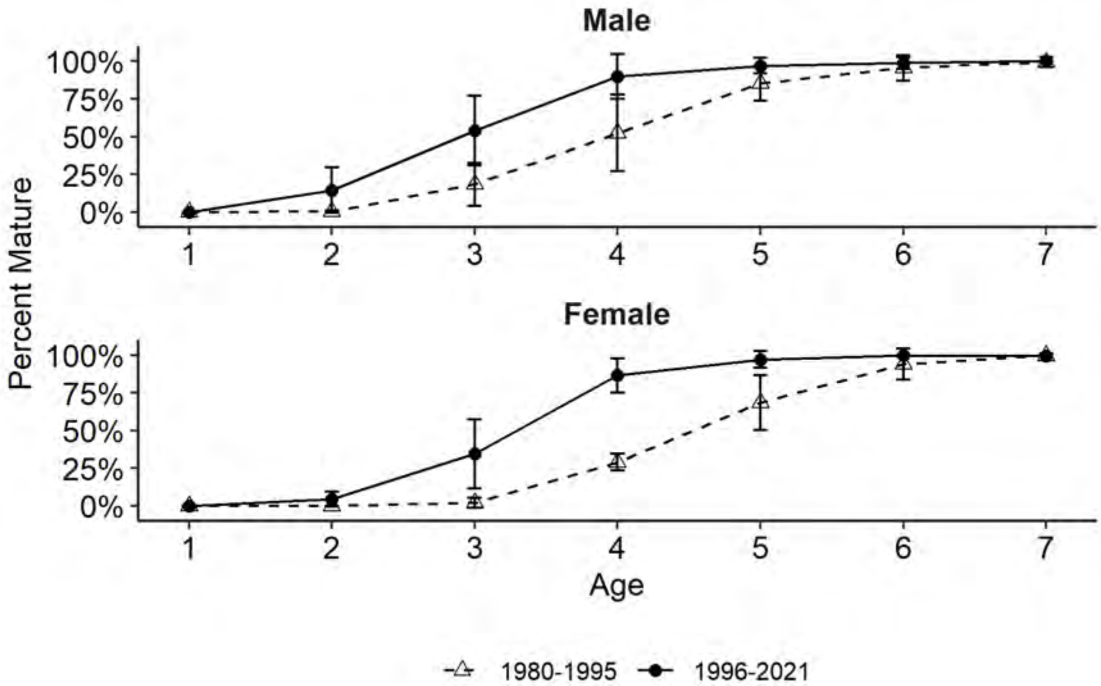

Figure 17. ***Mean (± 1 standard deviation) percent maturity of age-1 to age-7 male and female smallmouth bass sampled during survey years 1980-1995 and 1996-2021.***

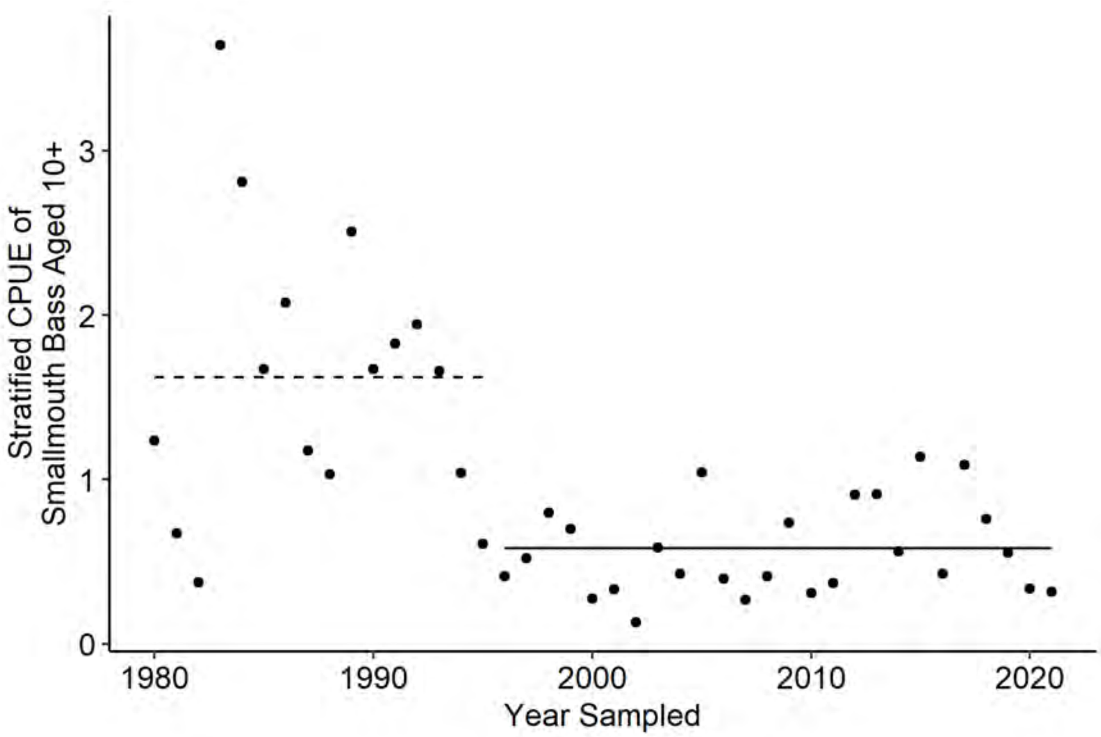

Figure 18. ***CPUE of smallmouth bass ages 10+ sampled during survey years 1980-1995 (long term mean denoted by dashed line) and 1996-2021 (long term mean denoted by solid line).***

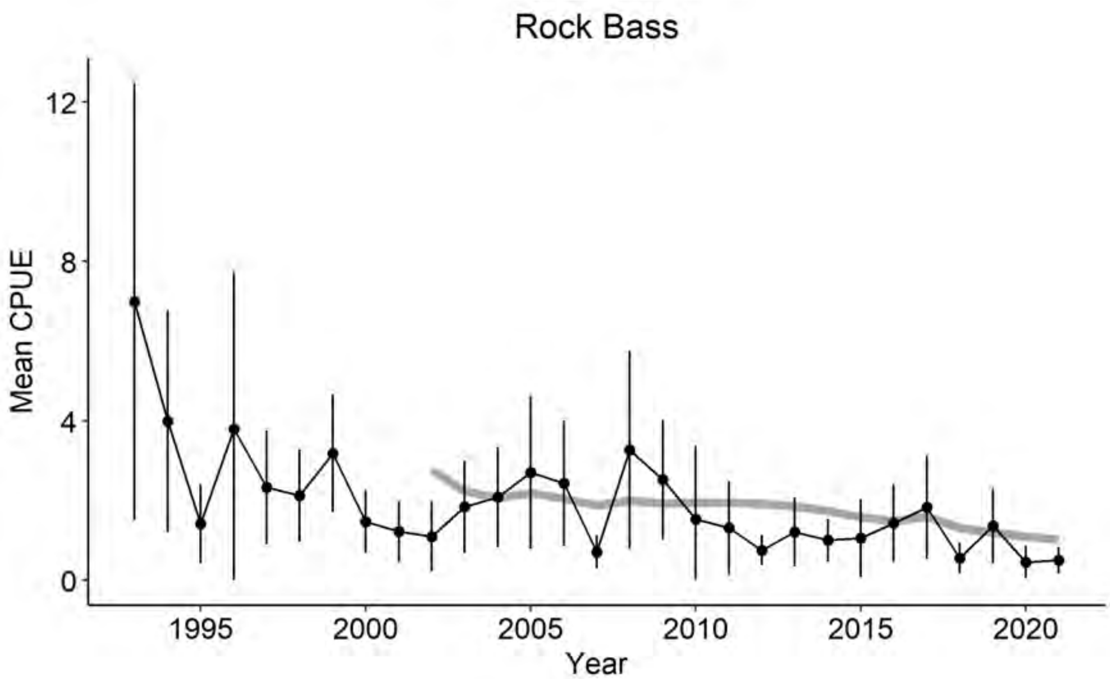

Figure 19. Stratified mean catch per 450 ft gill net gang (CPUE), 95% confidence intervals, and ten-year moving average (solid grey line) for rock bass, 1993-2021.

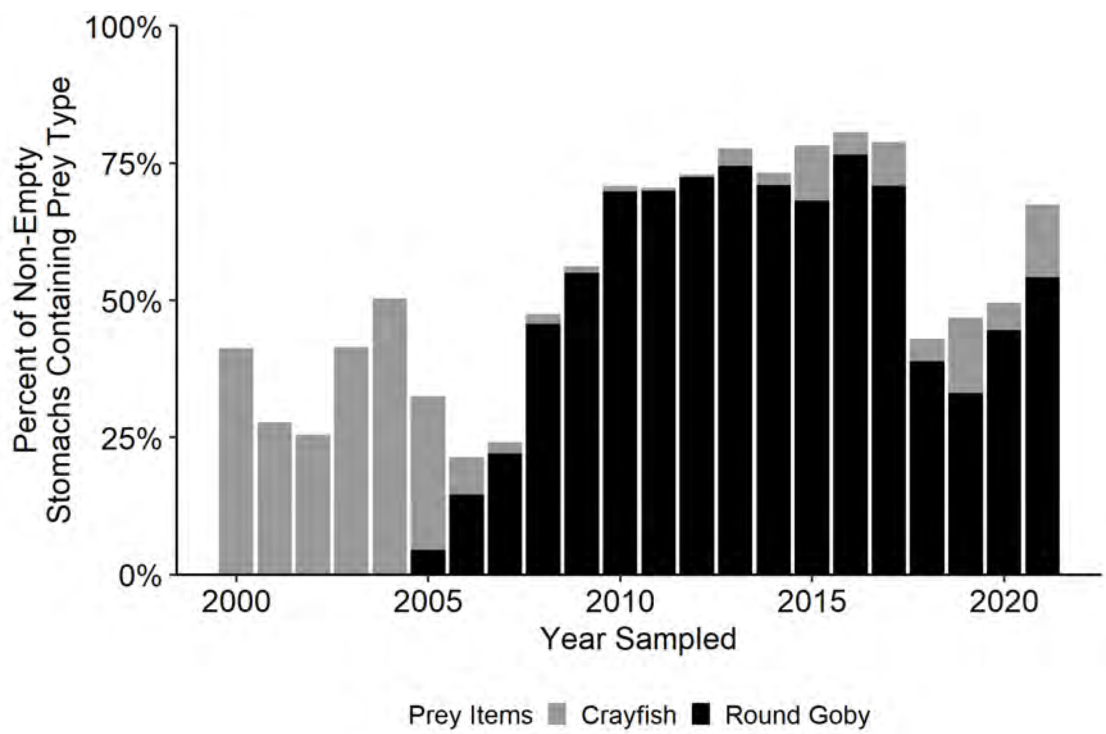

Figure 20. Percent of non-empty smallmouth bass stomachs containing crayfish and/or round goby during survey years 2000-2021.

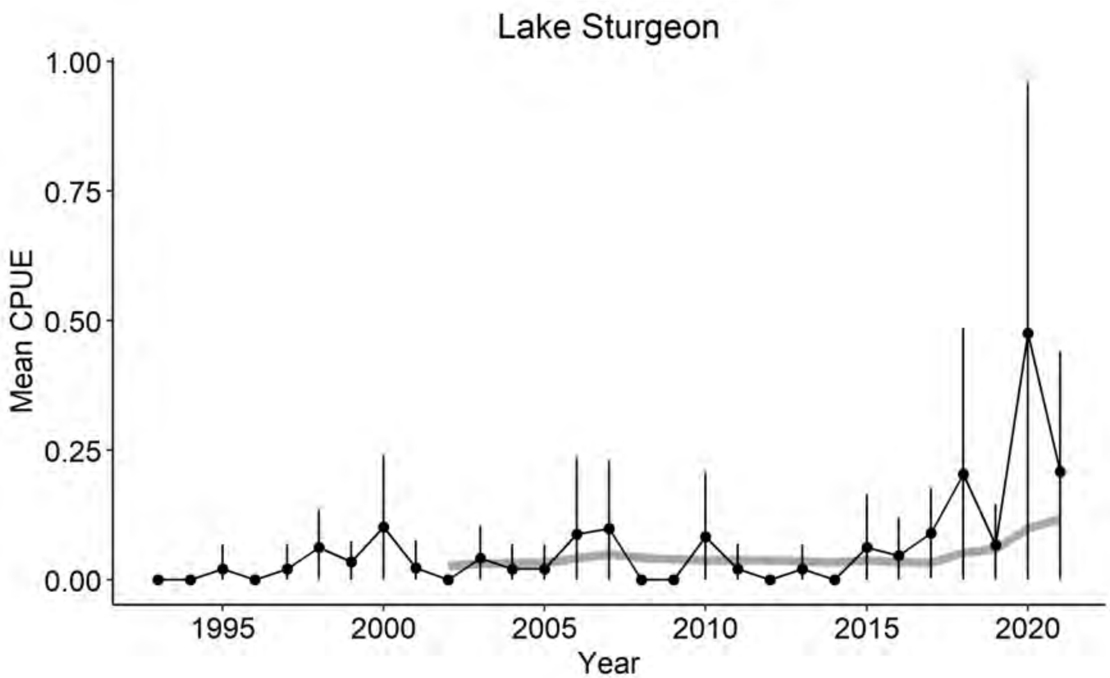

Figure 21. Stratified mean catch per 450 ft gill net gang (CPUE), 95% confidence intervals, and ten-year moving average (solid grey line) for lake sturgeon, 1993-2021.

Lake Trout (*Salvelinus namaycush*) Rehabilitation in Lake Ontario, 2021

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Abstract

*Each year we report on the progress toward rehabilitation of the Lake Ontario lake trout (*Salvelinus namaycush*) population, including the results of stocking, annual assessment surveys, creel surveys, and evidence of natural reproduction observed from standard surveys performed by U.S. Geological Survey (USGS) and New York State Department of Environmental Conservation (NYSDEC). The catch per unit effort (CPUE) of adult lake trout in gill nets increased each year from 2008-2014, recovering from historic lows recorded during 2005-2007. Adult abundances declined each year from 2015 to 2017; and in 2017 were about 35% below the 2014 peak and 17% below the 1999-2004 mean. Adult abundance increased in 2018 by 51% over the 2017 value and remained nearly stable between 2018 and 2021. The 2021 rate of wounding by sea lamprey (*Petromyzon marinus*) on lake trout caught in gill nets was 1.68 A1 wounds (fresh wound) per 100 lake trout and was near target (2 wounds per 100 lake trout). Condition values for adult lake trout, indexed in September from the predicted weight for a 700 mm lake trout from annual length-weight regressions and Fulton's K for age-6 males, were among the highest levels observed for the 1983-2021 time series. Reproductive potential for the adult stock indexed from the CPUE of mature females ≥ 4000 g was again above the target in 2021, continuing the trend observed since 2010. The 2021 catch of young wild lake trout marked the 27th cohort observed in the last 28 years and the recent large catches observed off the mouth of the Niagara River persisted in 2021.*

Introduction

Restoration of a naturally reproducing population of lake trout (*Salvelinus namaycush*) is the focus of a major international effort in Lake Ontario. Coordinated through the Lake Ontario Committee of the Great Lakes Fishery Commission, representatives from cooperating agencies (New York State Department of Environmental Conservation [NYSDEC], U.S. Geological Survey [USGS], U.S. Fish and Wildlife Service [USFWS], and Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry [NDMNRF]) developed the Joint Plan for Rehabilitation of Lake Trout in Lake Ontario (Schneider et al. 1983, 1997), which guided restoration efforts and evaluation through 2014. A revised document, *A Management Strategy for the Restoration of Lake Trout in Lake Ontario, 2014 Update* (Lantry et al. 2014), guides current efforts. This report documents progress towards restoration by reporting on management plan targets and measures through 2021.

The data associated with this report are currently under review and will be publicly available in 2022 when all USGS research vessel data collected between 1930 and 2021 are released. Refer to U.S. Geological Survey, Great Lakes

Science Center, 2022, Great Lakes Research Vessel Catch (RVCAT) Database: U.S. Geological Survey data release, https://doi.org/10.5066/P9XVOLR1. Please direct questions to our Data Management Librarian, Sofia Dabrowski, at sdabrowski@usgs.gov. All USGS sampling and handling of fish during research are carried out in accordance with guidelines for the care and use of fishes by the American Fisheries Society (http://fisheries.org/docs/wp/Guidelines-for-Use-of-Fishes.pdf). Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Methods

Gill Net Survey

In September of most years during 1983-2021, adult lake trout were collected with gill nets at random transects within each of 17 (1983-1993) and 14 (1994-2021) geographic areas distributed uniformly within U.S. waters of Lake Ontario. Due to vessel availability in 2018 and to concerns over the COVID-19 pandemic in 2020, abbreviated surveys were conducted at 7 of the 14 geographic locations From Rochester to Cape Vincent along the U.S. shore in Lake Ontario. Survey design (size of geographic areas) and gill net construction (multi- vs. mono-filament netting) have changed through the years. For a description of survey history, including gear changes and corrections, see Elrod et al. (1995) and Owens et al. (2003).

During September 2021, the NYSDEC R/V Seth Green and the USGS R/V Kaho fished standard monofilament gill nets for adult lake trout at the 14 standard geographic locations from the Niagara River to Cape Vincent along the U.S. shore in Lake Ontario (Figure 1). Survey gill nets consisted of nine 15.2 x 2.4 m (50 x 8 ft) panels of 51 to 151 mm (2- to 6-in stretched measure) mesh in 12.5 mm (0.5 in) increments. At the 12 sites in the lake's main basin and two sites in the eastern basin, four survey nets were fished along randomly chosen transects parallel to depth contours beginning at the 10ºC (50ºF) isotherm and proceeding deeper in 10-m (32.8-ft) increments.

For all lake trout captured, total lengths and weights were measured, body cavities were opened, and prey items were removed from stomachs, identified, and enumerated. Presence and types of fin clips were recorded, and when present, coded wire tags (CWTs) were removed and decoded to retrieve information on age and strain (see Appendix 1 for strain descriptions). Sex and maturity of lake trout were determined by visual inspection of gonads. Sea lamprey (*Petromyzon marinus*) wounds on lake trout were counted and graded according to King and Edsall (1979) and Ebener et al. (2006).

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

In past reports, population reproductive potential was estimated by calculating annual egg deposition indices (O'Gorman et al. 1998) from catches of mature females in September gill nets using length-fecundity relationships, and by accounting for observed differences in mortality rates among strains (Lantry et al. 2019). CPUE of mature females $\geq$ 4000 g and egg indices were generally very well correlated from 1983-2017 (Figure 10 in Lantry et al. 2019). Beginning with the 2018 report (Lantry et al. 2019) and continuing forward, we use the CPUE for females $\geq$ 4000 g to index population reproductive potential.

Adult condition was indexed from both the predicted weights of a 700-mm (27.6 in) fish calculated from annual length-weight regressions based on all lake trout caught that did not have deformed spines, and from Fulton's K (Ricker 1975, Nash et al. 2006) for age-6 males:

$$K = (WT/\ TL^3) * 100{,}000;$$

where WT is weight (g) and TL is total length (mm). Condition was grouped across strains because Elrod et al. (1996) found no difference between strains in the slopes or intercepts of annual length-weight regressions in 172 of 176 comparisons for the 1978 through 1993 surveys. Lake trout in those comparisons were of the lean morphotype, the only morphotype stocked into Lake Ontario until 2009. Since 2009, eight year-classes of the Klondike (SKW) strain lake trout (2008, 2013-2019) were stocked into Lake Ontario. The SKW strain originated from a native, deep spawning "humper" morphotype of Lake Superior lake trout that are intermediate in fat content to lean and fat (siscowet) morphotypes with the potential to have a higher condition factor than the leans. Fulton's K value of SKWs at age-6, the 2008 and the 2013-2015 year-classes (1.07, 1.12, 1.12, and 1.11), were similar to Seneca Lake strain (SEN; 1.08, 1.13, 1.12, and 1.07), one of the most prominent strains in the population. Thus, SKW was included in the population calculation of age-6 Fulton's K.

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

Creel Survey

Catch and harvest by anglers fishing from boats on Lake Ontario is measured by a direct-contact creel survey, which covers the open-lake fishery from the Niagara River in the western end of the lake to Association Island near Henderson Harbor in the eastern basin (Connerton et al. 2020). The survey uses boat trips as the primary unit of effort. Boat counts are made at boat access locations and interviews are based on trips completed during April 15 - September 30, 1985-2019. Due to concerns over the COVID-19 pandemic, the creel survey was not completed in 2020, but was resumed in 2021 (Connerton et al. 2022).

Indices of Natural Reproduction

In previous reports, indices of natural reproduction were based on either the total catch (reports through 2017) or the CPUE (2018-2020) of juvenile unclipped and untagged ages-0 to -2 lake trout captured during April, June, July, and October USGS and NYSDEC bottom trawl surveys (for a description of the surveys see O'Gorman et al. 2000; Owens et al. 2003). Only ages 0 to 2 were used because we had the most confidence in assigning them to natal origin (hatchery or in-lake reproduction) based on absence of clips and tags, color, shape, fin quality, and size (Schaner et al. 2007).

Catch was not corrected for effort in the earlier reports due to the low catch in most years and a relatively constant level of effort expended within the depth range (20 m - 100 m) where age-0 to age-2 naturally reproduced lake trout were most often encountered in Lake Ontario. Changes in recent annual survey design and effort necessitated changing to CPUE (the number caught per 10 minutes of tow time) to correct for varying levels of effort. For survey results for wild juveniles based on total catch and on CPUE, see the 2017 and 2020 reports (Lantry et al. 2018 and 2021).

During 2021 the Lake Ontario Technical Committee, Lake Trout Working Group recommended discontinuing the July bottom trawl survey focused on juvenile lake trout. As a result, July bottom trawling in 2021 aimed at assessment of wild juvenile lake trout and was only performed by USGS at the two sites off the mouth of the Niagara River, West Niagara and East Niagara, to examine the persistence of the uniquely large catches experienced there since 2014. In the current report we focus on comparisons of catch at these two sites during 2014-2019 and 2021. For comparisons, we used age-1 to age-2 sized fish based on monthly length and weight distributions of putative wild lake trout caught in survey bottom trawls (85mm to 313mm TL). We dropped age-0 lake trout from these analyses due to low catches during 2014-2021 relative to catches prior to a trawl gear change in 1997.

Trawling effort was split over two days at each site in 2021 with the depth range covering the area between where the bottom of the thermocline intersected the lake bottom (20m at West Niagara and 30m at East Niagara) and the 75m contour. Trawls were fished along contour proceeding deeper at 10m increments (e.g., 20m, 30m, 40m, 50m, 60m, and 70m fished on one day and the 25m, 35m, 45m, 55m, 65m, and 75m on the other day). Depths fished were altered within sites between days by 5m to minimize the probability of diminished catches due to localized disturbance. Tow duration was 10 minutes for all but one tow which was 5 mins in duration. For each site, day was considered the treatment and depth fished the replicate. ANOVA was used to examine differences in the catch within sites and between days with tow depth being a fixed effect and day and the interaction between day and tow depth as random effects. To accommodate small differences in effort between days, the catch for each trawl tow was expressed as the sqrt(catch/tow time).

For indices of natural reproduction based on adult lake trout catches, from the September gill net assessments were used to examine trends in the proportion of unclipped to untagged mature lake trout in annual catches (see above for survey methods).

Results and Discussion

Stocking

Stocking information was derived from annual correspondence with the managers of the USFWS Alleghany National Fish Hatchery (ANFH, Pennsylvania), USFWS Eisenhower National Fish Hatchery (ENFH, Vermont), the White River National Fish Hatchery (WRNFH, Vermont), and the NYSDEC Bath Fish Hatchery; and from summaries presented in Elrod et al. (1995), Eckert (2001) and Connerton (2022). For a more thorough description of stocking during 1973-2020, see Lantry et al. (2021).

From 1973 to 1977, lake trout stocked in Lake Ontario were raised at several NYSDEC and USFWS (Michigan and Pennsylvania) hatcheries with annual releases ranging from 0.07 to 0.28 million (Figure 2). By 1978 (1977 year-class), the USFWS was raising nearly all lake trout stocked in U.S. waters of Lake Ontario and annual releases exceeded 0.60 million fish. An annual U.S. stocking target of 1.25 million yearlings was established in 1983 with the release of the first rehabilitation plan (Schneider et al. 1983). Stockings approached the target during 1979-1987 (about 1.07 million stocked annually), but numbers declined by about 22% between 1981 and 1989. Stocking again declined by 47% in 1992 and in 1993 the stocking target was reduced to 500,000 yearlings (Lantry et al. 2014). Annual stockings were near the revised target in 18 of 26 years during 1993-2016 (Figure 2). Hatchery infrastructure issues and disease outbreaks caused stocking shortfalls in 2005, 2006, 2012, and 2014. In 2014, the stocking target was increased to

800,000 spring yearling equivalents (Lantry et al. 2014) which was met through combinations of fall fingerlings and spring yearling stockings for the 2014 and 2015 year-classes. In fall 2016, fisheries managers reduced the stocking target to 400,000 spring yearlings which was met for the 2018 and 2019 stockings but not the 2017 stocking. The 2020 stocking target was further reduced to 320,000 yearlings, which was nearly met during the May 2020 stocking in which four of the five stocking sites (Olcott, Oak Orchard, Sodus, Stony) received fish.

In 2021, production shortfalls at ANFH lead to a stocking total of 260,700 spring yearlings which were released at four of the five stocking sites (Olcott, Sodus, Oswego, Stony) with the Oak Orchard site not receiving any lake trout (Connerton 2022). All stockings occurred offshore. Strain totals included 99,900 Huron Parry Sound (HPW), 80,200 Lake Champlain Domestic (LCD), and 80,600 SEN.

Abundance Indices

A total of 959 lake trout were captured in 56 nets set at 14 sites during the September 2021 gill net survey, resulting in a total mature adult CPUE of 13.77 (Figure 3). Catches of lake trout among sample locations were similar within years with the RSE for the CPUE of adult males and females (generally ≥ age 5) averaging only about 9.3% and 10.7% respectively, for the entire data series (Figure 4). The CPUE of mature lake trout had remained relatively stable from 1986 to 1998, but then declined by 31% between 1998 and 1999. Declines in adult numbers after 1998 were likely due to poor survival of hatchery fish in their first year post-stocking and lower numbers of fish stocked since the early 1990s. After the 1998-1999 decline, the CPUE for mature lake trout remained relatively stable during 1999-2004 (mean = 11.1), but then abundance declined by 54% between 2004 and 2005. The 2005-2007 CPUEs of mature lake trout coincided with a nearly two-fold increase in the rate of wounding by sea lamprey on lake trout (See Figure 7 and the sea lamprey section on page 6) and were similar to the 1983-1984 CPUEs, which pre-dated effective sea lamprey control. Appearing to respond to enhanced sea lamprey control, the CPUE of mature lake trout increased each year during 2008-2014, but then declined during 2015-2017. Adult abundance in 2017 was 35% below the 2014 peak and 17% below 1999-2004 average. Abundance was similar during 2018-2021, measuring 55% greater than the 2017 value, and was similar to the value in 2014 before the declines between 2015 and 2017. Those abundance declines were in-part driven by the absence of fish from the missing 2011 stocked year-class, which would have been ages 4, 5, and 6 in years 2015, 2016, and 2017, respectively.

Schneider et al. (1997) established a target gill net CPUE of 2.0 for sexually mature female lake trout ≥ 4,000 g reflecting the level of abundance at which successful reproduction became detectable in the early 1990s. Building off observations in the 2017 report that the trends in the mature female CPUE and the egg deposition index were similar (see Figure 10 in Lantry et al. 2018), we only present the CPUE of mature females to index population reproductive potential. The CPUE for mature females reached the target value in 1989 and fluctuated about that value until 1992 (Figure 5). From 1992 until 2004, the CPUE exceeded the target, but fell below target during 2005 to 2009, coincident with the decline of the entire adult population. As the adult population abundance increased during 2008-2014, the CPUE of mature females ≥ 4,000 g also increased. During 2010-2021, CPUEs of mature females remained near or above target.

Growth and Condition

The predicted weight of a 700-mm lake trout (from length-weight regressions) decreased during 1983 to 1986 but increased irregularly from 1986 to 1996 and remained relatively constant through 1999 (Figure 6). Predicted weight declined by 158.8 g (5.6 oz) between 1999 and 2006 but increased again in 2007 and remained high through 2015. Predicted weight rose sharply after 2015 so that 2016-2021 mean (3828.6 g, 8.4 lb) was at the highest level for the data series. The trend of improving condition through 1996 and from 2007 to 2021 corresponded to periods when the age and size composition of the population was shifting to higher levels. Our data suggested that for lake trout of similar length, older fish were heavier. To examine whether age was the primary driver of condition changes, we calculated annual means for Fulton's K for age-6 mature male lake trout, which removed the effects of age and sex (Figure 6). However, values of K for age-6 males followed a similar trend as predicted weights and indicated that age alone was not the sole determinant of condition for this population.

Sea Lamprey Predation

Percentage of A1 sea lamprey marks on lake trout (fresh wounds where the sea lamprey has recently detached) was low in most years since the mid-1980s. However, wounding rates (Figure 7) in 9 out of 11 years between 1997 and 2007 were above the target level of 2 wounds per 100 fish ≥433 mm (17.1 in). Wounding rate rose well above target in 2005, reaching a maximum of 4.7 wounds in 2007, which was 2.35 times the target level. Wounding rates fell below target again in 2008 (1.47) and remained there through 2011 (0.62). While the rate was slightly above target again in 2012 (2.41) and 2013 (2.26), it fell below target during 2014-2019 and the 2017 through 2019 wounding rates (0.50, 0.61, and 0.53, respectively) were the lowest for the data series. Wounding measured from the 2020 abbreviated survey (2.27) was above but near target, however, interpreting the increased level should be exercised with caution since sample size (n = 441) of host-sized lake trout was 53% lower than that in 2019. Wounding in 2021 once again fell below target at 1.68 A1 wounds per 100 lake trout ≥433 mm.

Angler Catch and Harvest

The NYSDEC fishing boat survey has been conducted each year from 1985 to 2019, but was not conducted in 2020 because of the COVID-19 pandemic. The survey resumed in 2021 and herein we report on lake trout catch and harvest trends during 1985-2021.

Fishing regulations, lake trout population size, and availability of other trout and salmon species influenced angler harvest through time (Connerton et al. 2022). During 1988-1992, managers instituted and adjusted a slot size limit to decrease harvest of mature lake trout and increase the number and ages of spawning adults in the population (Elrod et. al. 1995). The slot limit from 1992 persisted through 2006, permitting a limit of three lake trout harvested outside of the protected length interval of 635 to 762 mm (25 to 30 in). Effective October 1, 2006, the lake trout creel limit was reduced to two fish per day per angler, one of which could be within the 635 to 762 mm slot.

Annual catch and harvest of lake trout from U.S. waters of Lake Ontario (Figure 8) declined over 84% from 1991 to the early-2000s (Connerton et al. 2020). Catch and harvest declined further from the early to the mid-2000s, reaching the lowest levels in the NYSDEC Fishing Boat Survey data series in 2007. Harvest at that time was more than 97% below the 1991 estimate. This low point in harvest coincided with lower adult abundance in the index gill netting survey (Figure 3). Good fishing quality for other salmonids (i.e., anglers targeted other salmonids more frequently) may also have led to lower catch and harvest of lake trout during this period (Connerton et al. 2020). After 2007, however, catch and harvest and catch rate and harvest rate increased for six consecutive years, then were relatively stable during 2013-2016. Increases from 2007 through 2016 followed the October 2006 regulation change and coincided with an increase in lake trout abundance and anecdotal reports of anglers targeting lake trout more frequently during 2013-2016. While catch and harvest totals have been low recently relative to the late 1980s, harvest during 2013-2016 exceeded the U.S. 10,000 lake trout target for restoration (Lantry et al 2014). Catch rates of lake trout declined between 2016 and 2019, trending from 0.94 to 0.39 fish per boat trip, as did total catch, dropping from 36,336 in 2016 to 16,354 in 2019 (Connerton et al. 2020). The 2017-2019 declines in lake trout catch, harvest, and catch and harvest rates coincided with good to excellent fishing quality for other trout and salmon species (especially Chinook salmon *Oncorhynchus tshawytscha*), which may have reduced fishing effort directed at lake trout in those years. In 2021, catch rates of lake trout increased to 0.56 per boat trip, as did lake trout catch (22,398, Figure 8) and harvest (11,368), once again exceeding restoration targets. These increases coincided with lower catch rates of both Chinook salmon and brown trout *Salmo trutta* in the fishery in 2021 (Connerton et al 2022).

Adult Survival

Survival of SEN strain lake trout (ages 7 to 11) was consistently greater (20-51%) than that of the Lake Superior (SUP) strain for the 1980-2003 year-classes (Table 1). Lower survival of SUP strain lake trout was likely due to higher mortality from sea lamprey (Schneider et al. 1996). Survival of both Jenny (JEN) and Lewis Lake (LEW) strains (1984-1995 year-classes) were similar to the SUP strain, suggesting that those strains may also be highly vulnerable to sea lamprey. Lake Ontario strain (ONT) were developed from collections of eggs from feral adults at a time when the composition of survey catches was predominantly SUP, SEN and Clear Water Lake (CWL) strains (Appendix 1; Elrod et al. 1995; Schneider et al. 1996); and the survival of the 1983-1991 year-classes was intermediate to that SENs and SUPs.

Population survival was based on catches for all strains combined for the 1983-1995 and 2003-2012 cohorts, as all fish stocked during those periods received coded wire tags. Population survival exceeded the restoration plan target value of 0.60 beginning with the 1984 year-class and remained above the target for most year-classes thereafter.

The SUP strain was no longer available in 2006 and Traverse Island strain (STW) and Apostle Island strain (SAW), also both of Lake Superior origins, replaced SUPs in stockings from 2007-2009 and in 2009 and 2013, respectively. Strains from Seneca Lake origins included feral and domestic Lake Champlain strains (LCW and LCD, respectively) beginning with the 2009 stockings. Survival for LCD 2008-2010 and 2012 year-classes (71-87%) resembled their mostly SEN origins. Only one year-class of LCWs (not shown in Table 1) was stocked (2009) and its survival for ages 7-10 (73%) also was similar to SENs. Survival rates could not be calculated for the first large stocking of STWs (225K of the 2006 year-class) as they disappeared from survey catches after age-8. Survival for the 2007 (36%, ages 7-11) and the 2008 (41%, ages 7-11) year classes of STWs was low and similar to the early values for SUPs. Survival rates for SAW (53%, 2008 year-class, age 7-9 only) strains were also low and no 2008 SAWs were caught in 2018 or 2019. There were no SAWs stocked 2010 through 2012 (2009-2011 year-classes), but the 2012 year-class of SAWs (2013 stockings) observed in survey catches at ages 7-9 during 2019-2021 also experienced low survival (0.61%).

The first stocking of Klondikes (SKW) occurred in 2009 with the release of the 2008 year-class which reached age-11 in 2019. SKW survival for the 2008 year-class was 82 % (ages 7-11) in 2019 and similar to survival for SENs from the 2007 and 2008 year-classes, which were 91% and 96% in 2019. Further stockings of SKWs occurred during 2014-2018 (2013-2017 year-classes) with the 2013 year-class reaching age-7 in 2020, the first survival estimates for those year-classes will be available in 2022.

Natural Reproduction
Evidence of survival of naturally spawned lake trout past the fall fingerling stage occurred only once during bottom trawl surveys during 1980-1993 with the catch of one age-1 lake trout in July 1990 (1989 year-class; Owens et al. 2003). Following that early catch, evidence of natural reproduction occurred each year during 1994-2021 representing production of 27 year-classes.

The distribution of catches of age-1 and 2 sized wild fish suggests that lake trout are reproducing throughout New York waters of Lake Ontario with the greatest concentrations near the mouth of the Niagara River (see Figure 11, Lantry et 2021). Catches from at least 27 cohorts of wild lake trout and survival of those year-classes to older ages implies feasibility of lake trout rehabilitation in Lake Ontario (Schneider et al. 1997). The recent large catches of wild lake trout off the mouth of the Niagara River are encouraging, but those occurred in only one portion of the lake and abundance appeared to decline there between 2014 and 2019 (July data was not available in 2020). While the full July survey was discontinued after 2019, July trawling was conducted by USGS over four days (July 13-16, 2021) at the West Niagara and East Niagara sites to find out whether the large catches observed there in previous years were persisting.

During repetitive sampling at the two sites off the mouth of the Niagara River, ANOVA indicated that depth and the day by depth interactions were not significant and that catches between days were not significantly different within either site ($p = 0.213$ and $p = 0.259$ for the west and east sites, respectively). Despite combining catches over both days at each site, differences between sites also were not detectable ($p = 0.253$). Peak catches occurred at 4 adjacent trawl depths within the 40 to 75m contours at the West Niagara site. At the East Niagara site there were two catch peaks, one at 65 to 75m, similar to catches from West Niagara, and another concentrated near the thermocline at 30 to 35m (Figure 9).

From 2014-2021, during the period of high catches off the Niagara Bar, catches on the west side of the bar were generally deeper than those from the east side (Figure 10). Peak catches from the West Niagara site occurred between 45 and 75m, whereas peak catches from the East Niagara site occurred over 25 to 65m. Within years, the catch was generally concentrated on one side of the bar shifting from high catches at East Niagara during 2014-2015 to high catches at West Niagara during 2016-2021 (Figure 11). The large catches from the bar in 2021 indicated that reproduction is persisting in that area.

Achieving the goal of a self-sustaining population requires consistent production of relatively large wild year-classes across the range of spawning habitat and survival of those fish to reproductive ages. During the same time period (1993-2021) that young naturally reproduced lake trout were being caught in bottom trawls, an annual average of eight (range 0-17) unclipped and untagged mature lake trout were observed in September gill net catches (Figure 12). That low number of unclipped and untagged individuals represented a mean of 1.64% of all mature lake trout sampled with a range of 0 - 5.98%. Increases in catches of mature wild lake trout following the relatively large catches of juveniles beginning in 2014 would have been expected to show up in gill net catches by now, however, reduced survey effort in 2018 and 2020 likely influenced our ability to detect those changes. Survey effort returned to normal in 2021, however, the proportion of the catch of mature adults that were not clipped and not tagged remained low at 2.08%.

Acknowledgements

The long histories of survey data we present herein depended on the efforts of the vessel crews of the RV Kaho and RV Seth Green whose professionalism and willingness to adapt to challenging working conditions make the data collection possible. Recent vessel operations were run by Captain Lewchanin and MMR Strang on the RV Kaho (USGS), and by Captain Fairbanks on the RV Seth Green (NYSDEC). We also thank the numerous biologists and technicians from USGS, NYSDEC and USFWS who have assisted in sample collection and data analysis and provided insight and edits for the report. For the 2021 reporting we thank from USGS: Brian O'Malley, Scott Minihkeim and Thomas Sanfilippo; and from NYSDEC: Russell Moore, Nicholas Farese, and Julie Beck. We especially thank the retired biologists, Cliff Schneider and Thomas Eckert from NYSDEC, and Joseph Elrod, Robert O'Gorman and Randall Owens from USGS (formerly USFWS), who shaped the early surveys and guided the initial reporting.

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Appendix 1.

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

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

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

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

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

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

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

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

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

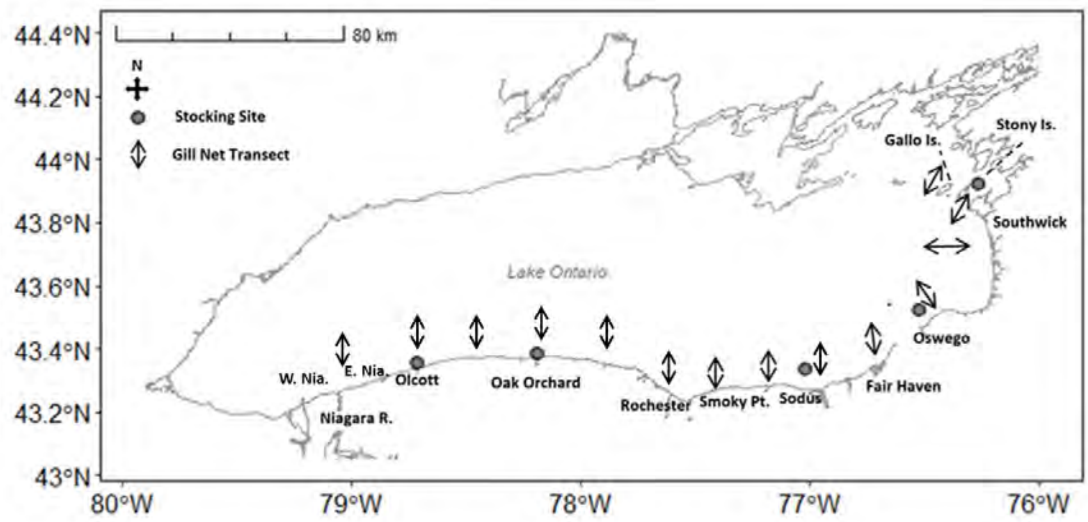

Figure 1. Lake Ontario map displaying 2021 locations for the NYSDEC May lake trout stockings (circles), the USGS July bottom trawling at W. Nia. (West Niagara) and E. Nia. (East Niagara), and the USGS-NYSDEC September gill netting survey (arrows).

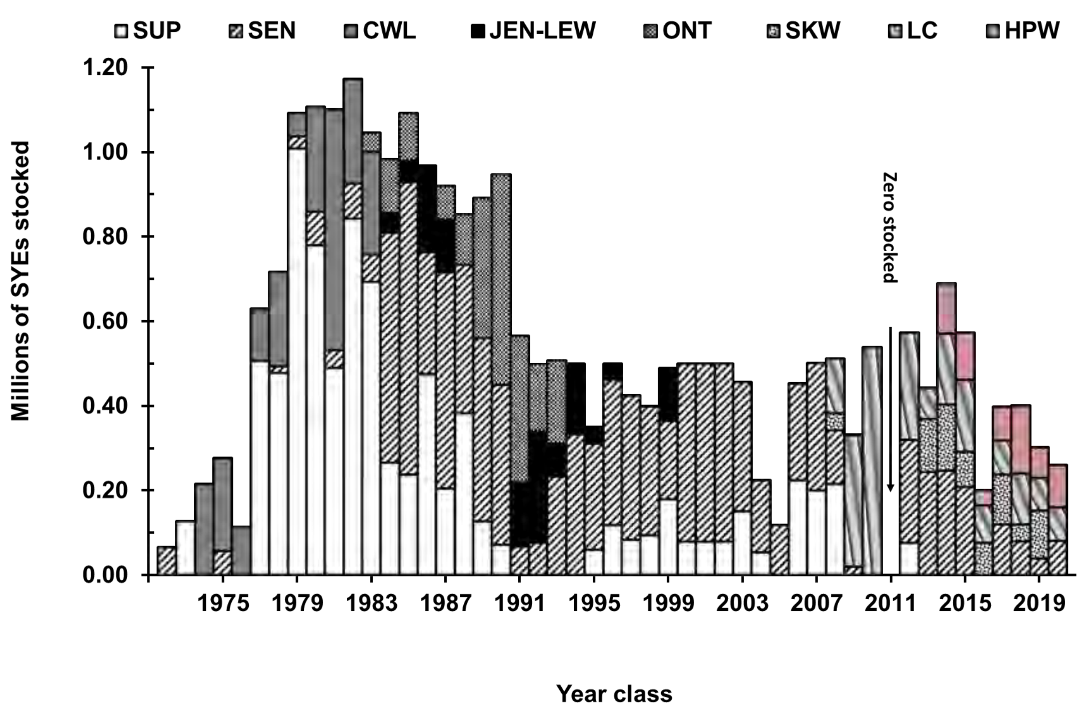

Figure 2. Total spring yearling equivalents (SYE) for lake trout strains stocked in U.S. waters of Lake Ontario for the 1972 – 2020 year-classes. Strain descriptions for ONT (Lake Ontario), JEN-LEW (Jenny-Lewis Lakes), CWL (Clearwater Lake), SEN (Seneca Lake), LC (Lake Champlain), SUP (Lake Superior), SKW (Lake Superior Klondikes), HPW (Lake Huron-Parry Sound) appear in Appendix 1. For year-classes beginning in 2006, SUP refers to Lake Superior the lean strains SAW (Lake Superior, Apostle Islands) and STW (Lake Superior, Traverse Islands) other than the Superior Marquette Domestics stocked prior to that time. SYE = 1 spring yearling or 2.4 fall fingerlings (Elrod et al. 1988). No lake trout from the 2011 year-class were stocked in 2012.

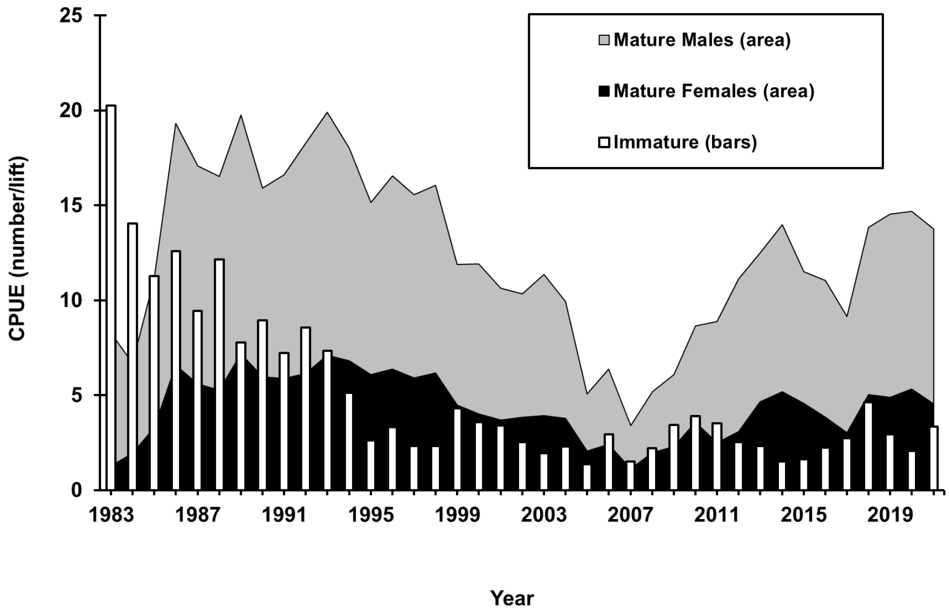

Figure 3. Abundance of mature (generally males ≥ age 5 and females ≥ age 6) and immature (sexes combined) lake trout calculated from catches made with USGS-NYSDEC gill nets set in U.S. waters of Lake Ontario during September 1983-2021. CPUE (number/lift) was calculated based on four strata representing net position in relation to depth of the sets. Abbreviated surveys occurred in 2018 and 2020 in which approximately half of the sites were fished and most effort occurred east of Rochester, NY.

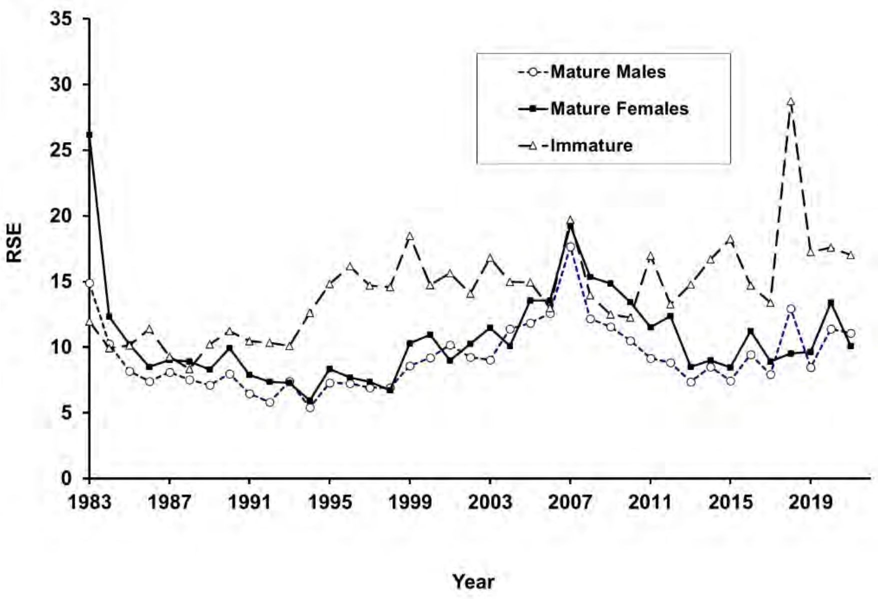

Figure 4. Relative standard error (RSE = {SE / Mean}*100) of the annual CPUE (number/lift) for mature male, mature female and immature (sexes combined) lake trout caught with USGS-NYSDEC gill nets set in U.S. waters of Lake Ontario during September 1983-2021. RSE increases after 1993 are in part due a reduction in the number of sites sampled declining from 17 to 14 in 1994. Reduced effort in 2018 and 2020 (only 8 sites fished in each year) contributed to the in RSE for those years.

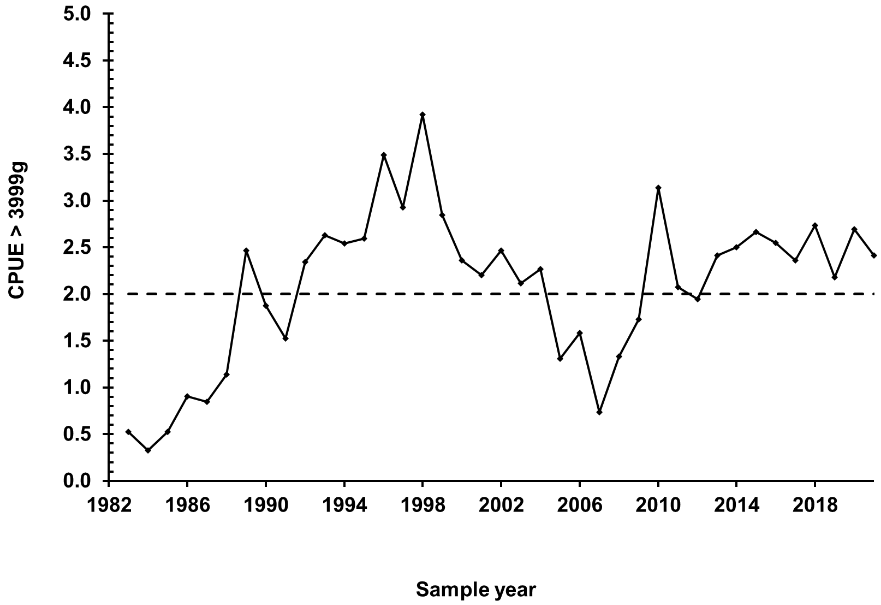

Figure 5. Abundance of mature female lake trout ≥ 4000 g calculated from catches made with USGS-NYSDEC gill nets set in U.S. waters of Lake Ontario during fall 1983-2021. The dashed line represents the target CPUE (number/lift) from Schneider et al. (1997) and Lantry et al. (2014).

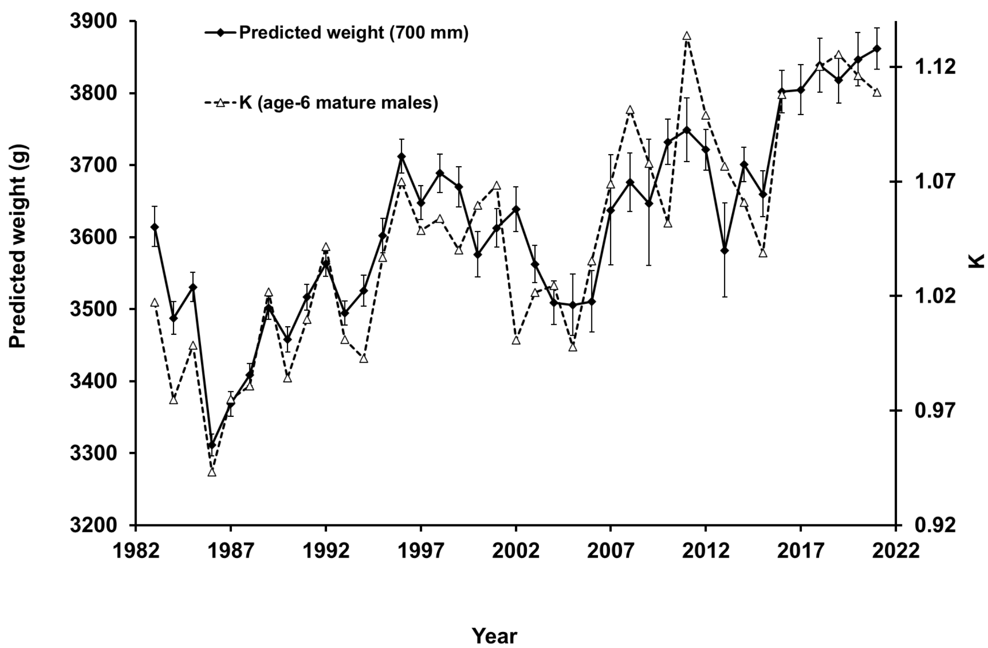

Figure 6. Lake Ontario lake trout condition (K) for age-6 mature males and predicted weight at 700-mm TL (27.6 in) from weight-length regressions calculated from all fish collected during each annual USGS-NYSDEC gill net survey during fall 1983–2021. There were no fish stocked from the 2011 year-class in 2012 so age-6 K was not available in 2017. Error bars represent the regression confidence limits for each annual value.

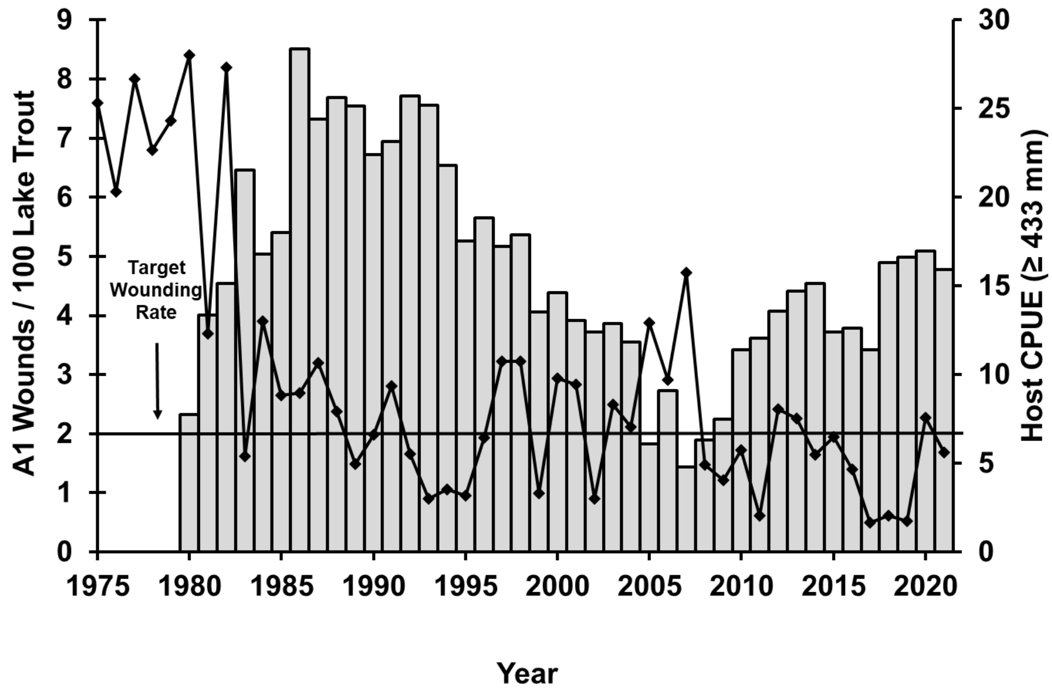

Figure 7. Wounding rates (A1 wounds per 100 lake trout, line) inflicted by sea lamprey on lake trout ≥ 433 mm (17.1 in) TL and the USGS-NYSDEC gill net CPUE (number/lift) of lake trout hosts (≥ 433 mm TL, bars) collected from Lake Ontario during fall 1975-2021.

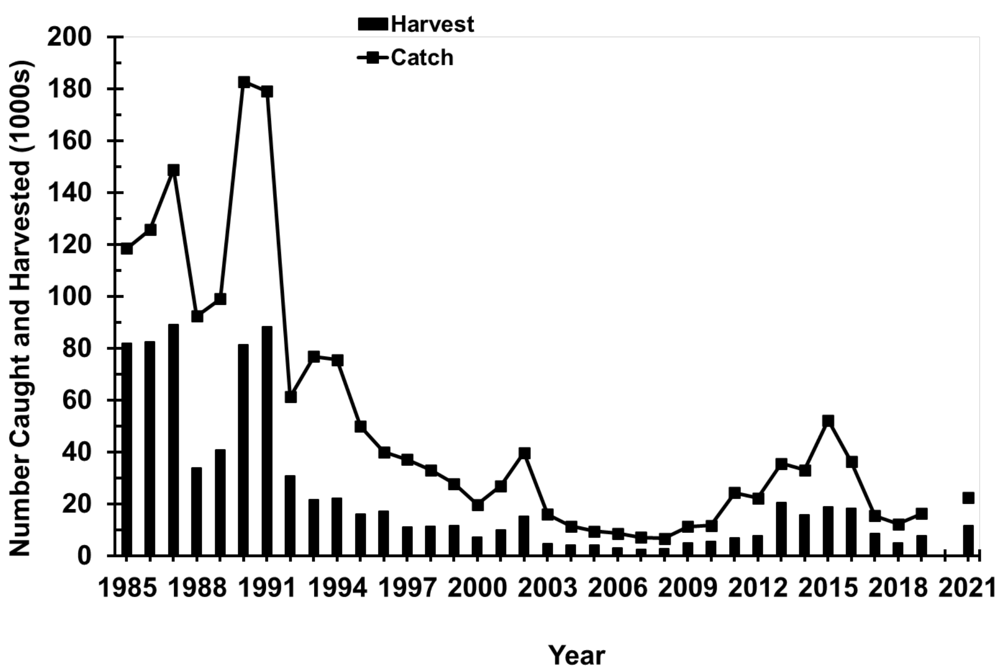

Figure 8. Estimated numbers of lake trout caught and harvested by boat anglers from U.S. waters of Lake Ontario, during April 15 – September 30, 1985-2021 (Connerton et al. 2022). Beginning with the 2012 report, all values have been reported reflecting a 5.5-month sampling interval. Prior reports were based on a 6-month sampling interval (April 1 – September 30).

Table 1. Annual survival of various strains of lake trout sampled from U.S. waters of Lake Ontario during the USGS-NYSDEC fall gill net surveys, 1985-2021. Strain descriptions for JEN (Jenny Lake), LEW (Lewis Lake), ONT (Lake Ontario), SUP (Lake Superior), SAW (Lake Superior, Apostle Islands), STW (Lake Superior, Traverse Island), SEN (Seneca Lake), LCD (Lake Champlain Domestic), SKW (Lake Superior Klondikes), OXS (Lake Ontario backcross with Seneca Lake), LCW (Lake Champlain Wild) and CWL (Clearwater Lake) appear in Appendix 1. Dashes represent missing values due to no or low numbers of tagged lake trout stocked for the strain, or when the strain was not in the US federal hatchery system. ALL is population survival of all strains combined using only coded wire tagged fish. Values for ALL in some years are influenced by strains not included in the table because they only appeared in the lake for a short while (e.g., the 1991-1993 cohorts of OXS; the 2009 cohort of LCW) or because they only occurred before successful sea lamprey control was established (1974-1983 cohorts of CWL). Missing survival values for 1997, 1998 and 2002 year-classes were caused by low tagged proportions of total stockings and there were no lake trout stocked from the 2011 year-class. Reduced survey effort in 2020 contributed to missing values for the 2009 year-class of SENs at age 11.

YEAR		STRAIN									
CLASS	AGES	JEN	LEW	ONT	SUP	SAW	STW	SEN	LCD	SKW	ALL
1978	7-10	-	-	-	0.40	-	-	-	-	-	-
1979	7-11	-	-	-	0.52	-	-	-	-	-	-
1980	7-11	-	-	-	0.54	-	-	0.85	-	-	-
1981	7-11	-	-	-	0.45	-	-	0.92	-	-	-
1982	7-11	-	-	-	0.44	-	-	0.82	-	-	-
1983	7-11	-	-	0.61	0.54	-	-	0.90	-	-	0.57
1984	7-11	0.39	-	0.61	0.48	-	-	0.70	-	-	0.65
1985	7-11	-	-	0.80	0.47	-	-	0.77	-	-	0.73
1986	7-11	0.57	-	-	0.43	-	-	0.81	-	-	0.62
1987	7-11	0.50	-	-	0.50	-	-	0.80	-	-	0.73
1988	7-11	-	-	0.77	0.61	-	-	0.73	-	-	0.68
1989	7-11	-	-	0.78	0.59	-	-	0.86	-	-	0.81
1990	7-11	-	-	0.64	0.60	-	-	0.75	-	-	0.68
1991	7-11	-	0.56	0.62	-	-	-	0.70	-	-	0.70
1992	7-11	-	0.51	-	-	-	-	0.81	-	-	0.60
1993	7-11	-	0.64	-	-	-	-	0.72	-	-	0.71
1994	7-11	-	0.73	-	-	-	-	0.45	-	-	0.56
1995	7-11	-	0.50	-	-	-	-	0.76	-	-	0.72
1996	7-10	-	-	-	0.43	-	-	-	-	-	-
1999	7-11	-	-	-	-	-	-	0.84	-	-	-
2000	7-11	-	-	-	-	-	-	0.90	-	-	-
2001	7-11	-	-	-	-	-	-	0.73	-	-	-
2003	7-11	-	-	-	0.53	-	-	0.72	-	-	0.68
2004	7-11	-	-	-	-	-	-	0.78	-	-	0.78
2005	7-11	-	-	-	-	-	-	0.85	-	-	0.85
2006	7-11	-	-	-	-	-	-	0.74	-	-	0.72
2007	7-11	-	-	-	-	-	0.36	0.91	-	-	0.84
2008	7-11	-	-	-	-	0.53	0.41	0.96	0.76	0.82	0.79
2009	7-11	-	-	-	-	-	-	0.74	0.71	-	0.66
2010	7-11	-	-	-	-	-	-	-	0.75		0.75
2012	7-9		-	-	-	0.60	-	0.93	0.89	-	0.87

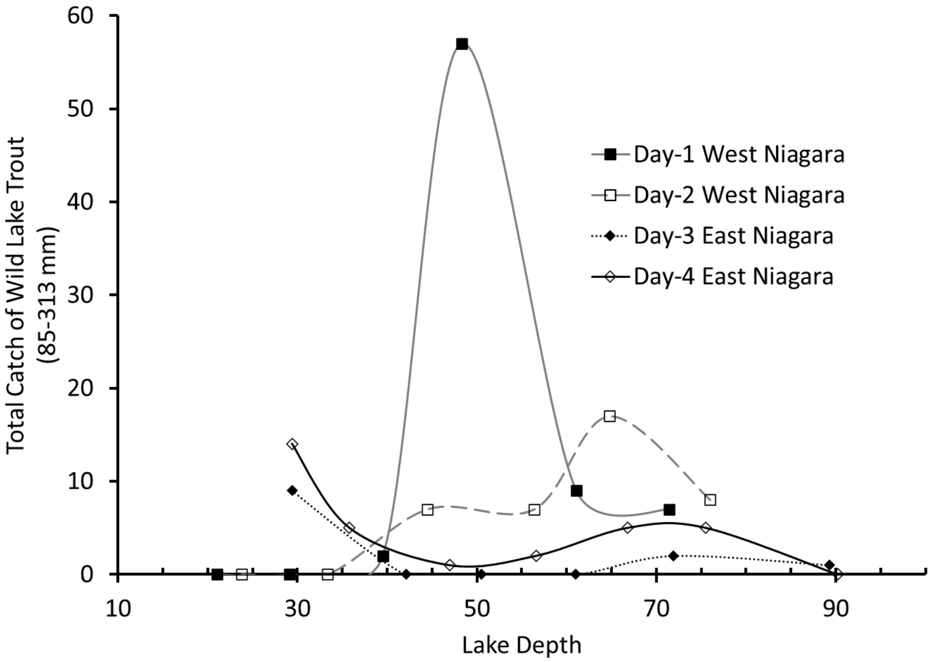

Figure 9. Total catch of naturally produced (wild) lake trout (85-300 mm TL) captured in USGS bottom trawls towed for 10 mins on consecutive days at two sites off the mouth of the Niagara River during July 2021.

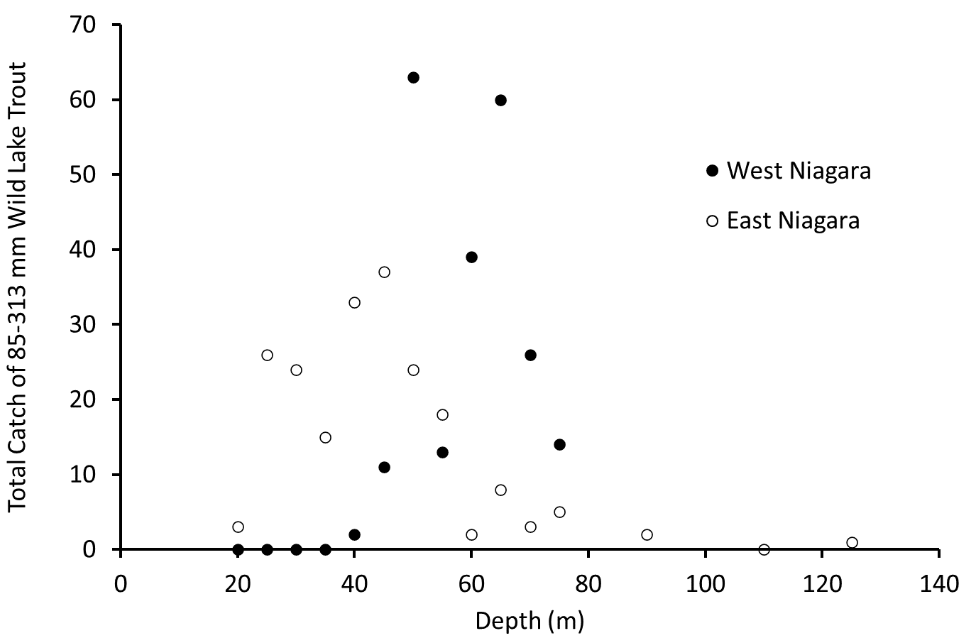

Figure 10. Total catch versus depth of naturally produced (wild) lake trout (85-300 mm TL) captured at two sites off the mouth of the Niagara River in annual USGS-NYSDEC July bottom trawl surveys during 2014-2021 (no data were available in 2018 or 2020). During this period consistent effort was expended at depths between 30 and 75m, fewer tows were conducted at shallower and deeper depths.

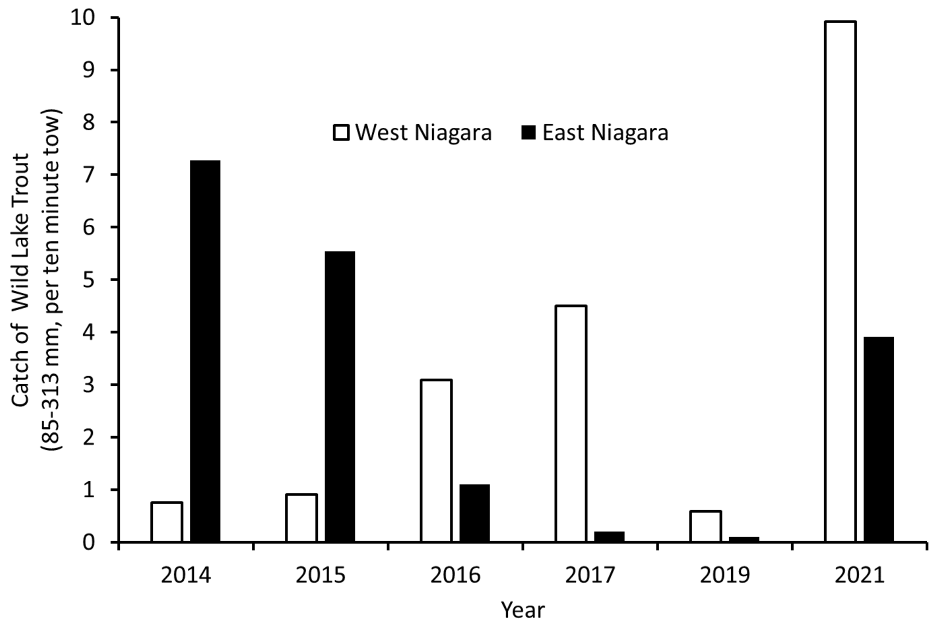

Figure 11. CPUE of naturally produced (wild) lake trout (85-300 mm TL) captured in annual USGS-NYSDEC July bottom trawl surveys in Lake Ontario during 2014-2021 (no data were available in 2018 or 2020). The two sites represented were both near the mouth of the Niagara River.

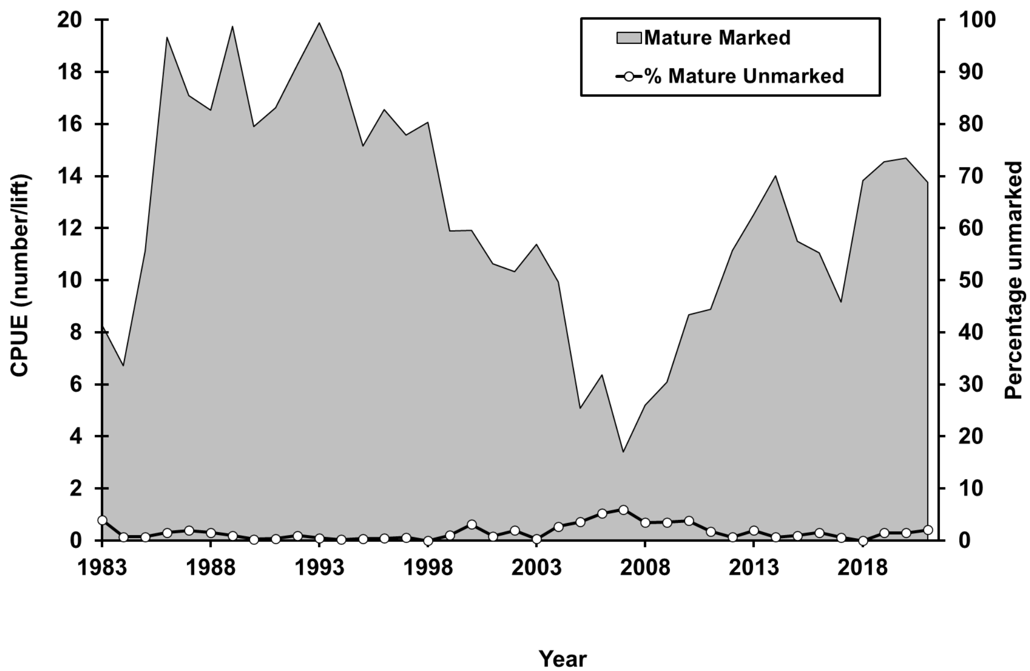

Figure 12. Percentage of unmarked (no clips or tags) sexually mature lake trout captured in annual USGS-NYSDEC September gill net surveys in Lake Ontario during 1983-2021 (black line with white markers). The percentage of unmarked fish is presented against the backdrop of the CPUE (number/lift) of all mature lake trout caught per year (gray shaded area) and for the period from 1993-2021 represents on average 1.64% of the CPUE (range 0 to 5.98%).

Thousand Islands Warmwater Fisheries Assessment

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Annual warmwater fisheries assessment on the St. Lawrence River began in 1977 as an outgrowth of environmental assessment projects related to proposed St. Lawrence Seaway navigation season extension. This long-term data set provides standardized indices of abundance for major gamefish and panfish, information on year class strength, as well as age and growth relationships. Information obtained is used to evaluate and, if necessary, modify existing fishing regulations. It also provides baseline information for evaluation of environmental disturbances.

Methods

Warmwater fisheries assessment in New York waters of the Thousand Islands is conducted from the upstream end of Grindstone Island (near Clayton, New York) downstream to the Morristown area (opposite Brockville, Ontario), covering a water surface area of approximately 43,000 acres (17,400 ha). Although the term warmwater fisheries assessment is applied to this project, in keeping with NYSDEC Bureau of Fisheries administrative structure, many of the species of interest would normally be considered coolwater fishes (e.g., northern pike [*Esox lucius*], walleye [*Sander vitreus*]; Eaton et al. 1995). Sampling was conducted between the third week of July through the first week of August each year. Sampling effort consists of 32 overnight gill net sets (16 sets 1977 - 1982) at standard sites. Sampling is confined to the mid-depths of the river, from 10 to 60 ft (3 to 18.3 m), with fixed net sites divided equally into two depth strata, 10 to 33 ft (3 to 10.1 m; n = 16) and >33 to 60 ft (>10.1 to 18.3 m; n = 16). Nets are set on the bottom, typically parallel to shore and current. The nets are 200 ft (61 m) long by 8 ft (2.4 m) deep and contain eight 25 ft (7.6 m) panels with stretch measure mesh increasing in sizes from 1.5 to 6 in (38 to 152 mm) with ½ inch increments from 1.5 to 4 in and one-inch increments from 4 to 6 in.

From 1977 to 2003, multifilament nylon nets were used; while monofilament nets were used beginning in 2004. Based on a 24 paired net comparison, catch per unit effort (CUE; also referred to as abundance index) of rock bass (*Ambloplites rupestris*) and yellow perch (*Perca flavescens*) in the two net types were significantly different (α = .05). From 2004 through 2017, monofilament CUEs of rock bass and yellow perch were converted to the multifilament standard by multiplying by 1.7 and 0.74, respectively (McCullough and Gordon 2018). With the 2018 reporting year, we began reporting monofilament net CUEs with multifilament net CUEs converted to the monofilament standard (1977-2003; inverse of 0.588 for rock bass and 1.35 for yellow perch; Resseguie and Gordon 2019).

All fish collected were identified to species, weighed, measured for total length, and examined for sex and maturity. Structures used for age determination were removed from all game fish and sub-samples of panfish (Ketchen 1949). Cleithrum were removed from all esocids, and beginning in 2020 otoliths were collected from smallmouth bass >13.8 inches (scales from bass <13.8 inches) and all walleyes. Ages were determined from projections of scale impressions or from direct examination of cleithra and transverse sectioning of otoliths.

Results and Discussion

<u>Environmental Conditions</u>
The mid-summer sampling period was chosen to minimize intra- and inter-annual variation in environmental conditions, chiefly water temperature. Average surface water temperatures varied from a low of 65°F (18.3°C; 1982) to a high of 78°F (25.6°C; 1979). Average surface temperature in 2021 was slightly cooler than recent years (range: 69.6°F - 20.9°C; Table 1). Prior to colonization by dreissenid mussels, summer water transparency (i.e., Secchi depth, measured by Secchi disc) ranged to about 10 ft (3 m) water depth (S. LaPan, NYSDEC, pers. communication), and was not considered a significant influence on catchability. By 1995, it was apparent

that transparency had increased. Secchi depths were recorded during fish sampling beginning in 1996. Secchi depths during the sampling period have ranged from 14 ft (4.3 m) in 1997 to 55 ft (16.8 m) in 1999. In 2021, the Secchi depth was 29.5 ft (9 m). Secchi depths are variable annually (Figure 1).

Species composition

In 2021, we collected 780 fish comprising 18 species. A total of 37 species are represented in Thousand Islands gill net sampling between 1977 and 2021 (Table 2). All species mean CUE generally declined across the time series in response to a changing ecosystem (Figure 2). In 2021, all species mean CUE was 24.4 fish/net-night which is the second lowest value of the timeseries. A three-year moving average shows a slight increasing trend since 2015 (lowest CUE on record) but again drops with the addition of 2021 data (Table 1). Small-bodied species, such as cyprinids, are poorly represented and are rarely captured as they are not vulnerable to the gear. Historically, more than 60% of the catch consisted of rock bass, pumpkinseed sunfish (*Lepomis gibbosus*), and yellow perch. In more recent years, abundance indices of pumpkinseed sunfish dramatically declined and smallmouth bass *(Micropterus dolomieu*) represent a greater percentage of the catch (Figure 3). In 2021, yellow perch dominated the total catch (52%) and smallmouth bass represented a slightly lower percentage (18%) than the previous 10-year average (21%).

Primary Recreational Fishery Targets

Smallmouth Bass. Smallmouth bass are the most sought-after sportfish in the New York Thousand Islands fishery (McCullough 1987, Klindt 2011). The abundance index of smallmouth bass was relatively high in the late 1970's, declined through 1982, then increased to its highest recorded level in 1988 (9.9 fish/net-night). After 1988, smallmouth bass abundance index generally declined and was low from 1996 through 2004. The catch increased in 2005 and varied at relatively higher levels through 2021 (Figure 4). The low 2015 value was likely a sampling anomaly as abundance indices in subsequent years were similar to those prior to 2015. The recent smallmouth bass trend is impacted by increased catchability of younger fish attributed to increased growth rate (Figure 5; i.e., young fish are more effectively caught now because they are bigger). Historically, the catch was dominated by fish that were age-5 and older fish (Figure 6). Since 2006, and coinciding with increased growth, CUE of smallmouth bass ages 1-4 increased and CUE of smallmouth bass ages 5 and older was lower relative to earlier years. This likely reflects the increased catchability of young smallmouth bass due to increased growth rates and not an increase in their abundance. In 2021, catch of smallmouth bass was dominated by fish from the 2016, 2017, and 2018 year classes (ages 3, 4 and 5; Figure 7). Year-class specific catch curves show moderate (2017, 2018) to strong (2016) year classes (Figure 8).

Increased growth of smallmouth bass in the St. Lawrence River in recent years is similar to trends observed elsewhere. Smallmouth bass growth also increased in Lake Ontario's Eastern Basin (Lantry 2018), Lake St. Lawrence (Klindt and Gordon 2018) and Lake Erie (Robinson 2019). In the St. Lawrence River, smallmouth bass growth changed little between 1977 and 2004 with an average length of age-5 bass of 11 inches (Figure 9). Thereafter growth increased, likely due to a density dependent effect (McCullough 2012), along with the establishment of round goby (*Neogobius melanostomus*). Bass now reach legal size (i.e., 12 inches, 305 mm) between age 3 and 4 (Figure 5). Since round goby establishment in 2005, mean total length at age 5 increased quickly, but may be reaching an asymptote around 15 inches (Figure 9). In 2021, age-5 bass averaged 15.4 inches (391.3 mm) while age-3 bass averaged just under the legally harvestable size limit at 11.2 inches (284.7 mm). For the St. Lawrence River and the other systems, the most recent increase in growth is likely related to increased consumption of round goby as prey.

Northern Pike. Northern pike provide an important recreational fishery in New York (Klindt 2011). Their abundance index peaked in 1981, generally declined through 1996, and varied without trend through 2001 (Figure 10). From 2001 through 2005, the abundance index generally declined and varied without trend until 2013, then was variable at the lowest levels in the data series from 2014 – 2021. Reduced abundance index is largely attributed to a decline in spawning habitat (i.e., impairing recruitment) as a result of water level regulation (Farrell 2001, Farrell et al. 2006, Smith et al. 2007). Cormorant predation on young fish has also been implicated as a factor impairing northern pike recruitment (Connerton 2003). The number of northern pike captured in this assessment has declined to the level that does not permit determination of year class strength.

Northern pike growth varied over the data series with a relatively high mean total length of age-4 fish occurring prior to 1983 and length was lowest in 1994 (Figure 11). There was no apparent change in growth since the establishment of round goby, however, mean lengths of age-4 northern pike in 2017 through 2020 were among the highest in the data series (range 24-26 inches). In 2021, the mean length of age-4 northern pike was 23.1 inches (588.6 mm).

Yellow Perch. Due to the schooling nature of yellow perch, their abundance index is highly variable across the time series. After 1999, yellow perch catches were variable and generally declined. Since 2012, CUE of yellow perch remained among the lowest in the data series. (Figure 12).

The majority of perch sampled in recent years were ages 3-4. In 2021, the bulk of the catch was comprised of the 2018 and 2017 year-classes (age 3 and 4, Figure 13). Age structure of the 2021 catch is consistent with recent trends. Year-class specific catch rates also remain comparable (Figure 14).

Growth rates of yellow perch were relatively similar from the 1980's through the 2000's, then generally increased in the most recent decade (Figure 15). Growth of age-4 yellow perch was relatively stable from 1977-2004 and then increased beginning in 2005 to a record high in 2019 of 8.7 inches (221 mm; Figure 16). This increase may be attributable to the availability of round goby as forage. In 2021, the length of an age-4 yellow perch was 7.9 inches, slightly below the current 5-year average (8.2 inches).

Walleye. Walleye were first captured in 1982 and were caught regularly in low numbers throughout the 1980s and 1990s. Abundance increased in the early 2000s and remained at relatively higher levels, although variable since (Figure 17). As in Lake Ontario's eastern basin, walleye is the only sportfish species that has generally increased in abundance since this assessment began (Lantry 2018).

<u>Other species of interest</u>

Lake Sturgeon. Lake sturgeon is listed as a threatened species by New York State. Sturgeon were first captured in this survey in 1999 (Table 1). They generally survive gillnetting and all sturgeon captured during this project were released alive. Each fish was implanted with a passive integrated transponder (PIT) tag, and their information was entered into a regional and basinwide sturgeon database. Lake sturgeon were stocked in St. Lawrence River and tributaries beginning in the 1990s; Grass River (1993), Oswegatchie River (1993-1999, 2004, 2014-2021) and in the St. Lawrence River at Ogdensburg (1996-2000, 2013-2015, 2017-2021) and Massena (1996-2000, 2003, 2004, 2013-2021). Natural spawning has been observed in the upper St. Lawrence River (LaPan et al. 1997) and is thought to be a major source of recruitment to this population. No lake sturgeon were captured in this survey in 2021.

Herrings. Alewives were frequently captured during the 1970s and 1980s and were detected at very low levels from 1989 through 2006. Alewife CUE from 2007-2021 was highly variable with the 2009 CUE being the highest recorded (Figure 18). Relatively high variability of catches is likely due to alewife straying from Lake Ontario to the river and because they are not effectively captured in gillnets used for this survey. Gizzard shad (*Dorosoma cepedianum)* were also collected sporadically from 1978 through 1999 (Table 1).

Salmon and Trout. Salmonines are collected incidentally. Coho salmon (*Oncorhyncus kisutch*), brown trout (*Salmo trutta*) and lake trout (*Salvelinus namaycush*) were captured occasionally (Table 1). These species are likely strays from Lake Ontario. One brown trout was captured in 2021.

Pikes. Like northern pike, muskellunge (*Esox masquinongy*) is an important sportfish in the St. Lawrence River. This species occurs at low density. Historically, approximately 50% of muskellunge tagged in the Thousand Islands migrated to eastern Lake Ontario in summer (LaPan et al. 1995). Only 11 muskellunge were caught in this survey since 1977, including one in 2015 and one in 2016 (Table 1). A possible chain pickerel (*Esox niger*) was caught in 2010 and the presence of chain pickerel in the Thousand Islands has been confirmed by other investigators (J. Farrell, personal communication). Grass pickerel (*Esox americanus)* are present in the St. Lawrence River, but abundance is thought to have declined (Klindt and Gordon 2016). No grass pickerel have ever been sampled in this assessment as the gear likely set too deep for this species.

Carp and Minnows. Common carp (*Cyprinus carpio*) were caught regularly since 1982 (Table 1). They are caught in low numbers, usually one to six individuals per year. Other minnows are usually not vulnerable to this sampling gear, but a few are caught occasionally, such as fallfish (*Semotilus corporalis*) and golden shiner (*Notemigonus crysoleucas*). A single rudd (*Scardinius erythropthalmus*) was caught in 2000 (Table 1).

Suckers. White suckers (*Catostomus commersoni*) were caught in substantial numbers most years since 1977; however, the index of abundance generally declined since 1990 (Figure 19). Silver (*Moxostoma anisurum*) and greater redhorse (*M. valenciennessi*) were detected at low levels sporadically since they were first identified to the species level in this assessment in 1987. Shorthead redhorse (*M. macrolepidotum*) were caught in 1989, 1997 and 1998, and longnose sucker (*Catostomus catostomus*) were caught in 1982 and 1984 (Table 1).

Catfishes. The brown bullhead index of abundance has varied over the data series. The highest indices occurred during the 1970s-1980s and 2000s, and the lowest occurred through the mid-1990s and since the late 2000s. The brown bullhead index reached a record low in 2015 has been variable since (Figure 20). Channel catfish (*Ictalurus punctatus*) were sampled regularly throughout the survey. The abundance index of channel catfish rose slightly in 2009 and 2010, then returned to low levels similar to catches in the 1990's (Figure 20). Yellow bullhead (*Ameiurus natalis*) and stonecat (*Noturus flavus*) were caught twice during this assessment (Table 1).

Centrarchids. Rock bass and pumpkinseed sunfish were the most common sunfishes caught in Thousand Island gillnet sampling. From 1977 through 1990, abundance indices for rock bass and pumpkinseed varied at similar levels (Figure 21). The rock bass index of abundance generally increased from the early 1990s to the early 2010s (high CUE of 6.8 in 2011; Table 2), then declined to a lower level. CUE of rock bass in 2021 was the second lowest of the time series (2.47 fish/net-night). Pumpkinseed index of abundance declined drastically since 1990, reaching a record low level in 2015 and remained near record low levels continuous through 2021.

Bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) were captured regularly but in very low numbers (Table 1). Nets are likely set too deep to effectively sample these species in most years. Black crappie (*Pomoxis nigromaculatus*) were captured in low numbers through 2003; none were caught since.

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Table 1. Average water temperature and Secchi depth in the St. Lawrence River Thousand Islands Warmwater Fisheries Assessment 1977 - 2021.

Sample Year	Average Temp °F (°C)	Secchi Depth ft (m)	Sample Year	Average Temp °F (°C)	Secchi Depth ft (m)
1977	72.5 (22.5)		2000	70.5 (21.4)	44 (13.4)
1978	71 (21.7)		2001	71.5 (21.9)	20 (6.1)
1979	78 (25.6)		2002	71.5 (21.9)	24 (7.3)
1980	70 (21.1)		2003	72.5 (22.5)	21 (6.4)
1981	70 (21.1)		2004	70 (21.1)	26.5 (8.1)
1982	65 (18.3)		2005	73.5 (23.1)	36 (11)
1983	72.5 (22.5)		2006	73.5 (23.1)	29 (8.8)
1984	68 (20)		2007	70.5 (21.4)	22.5 (6.9)
1985	69 (20.6)		2008	71.5 (21.9)	34 (10.4)
1986	68 (20)		2009	71 (21.7)	31 (9.4)
1987	68 (20)		2010	75.5 (24.2)	20 (6.1)
1988	73.5 (23.1)		2011	75 (23.9)	29 (8.8)
1989	69 (20.6)		2012	74 (23.3)	30.5 (9.3)
1990	73.5 (23.1)		2013	74 (23.3)	21 (6.4)
1991	73 (22.8)		2014	69.5 (20.8)	39.5 (12)
1992	65 (18.3)		2015	70 (21.1)	26 (7.9)
1993	72.5 (22.5)		2016	74 (23.3)	50 (15.2)
1994	72.5 (22.5)		2017	69.5 (20.8)	19.5 (5.9)
1995	73.5 (23.1)		2018	72.5 (22.5)	23 (7.0)
1996	70 (21.1)	29 (8.8)	2019	72.8 (22.7)	19.7 (6)
1997	70 (21.1)	14 (4.3)	2020	75.6 (24.3)	24.6 (7.5)
1998	73.5 (23.1)	27 (8.2)	2021	69.6 (20.9)	29.5 (9)
1999	75 (23.9)	55 (16.8)			

Table 2. Abundance index (CUE = catch/net night) by species in the St. Lawrence River Thousand Islands Area 1977 – 2021. * Yellow perch and rock bass multifilament CUE adjusted to monofilament standard.

Species	1977*	1978*	1979*	1980*	1981*	1982*	1983*	1984*	1985*	1986*	1987*	1988*	1989*	1990*
Lake Sturgeon	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Longnose Gar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bowfin	0	0	0	0	0	0.06	0	0	0.03	0	0	0.03	0	0.09
Alewife	1.06	1.1	2.3	2.6	5	0	2	1.5	1	6.5	2.2	1.5	0.3	0.28
Gizzard Shad	0	6	0	0.06	0	0	0	0	0	0	0	0	0	0
Coho Salmon	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0
Brown Trout	0	0	0	0	0	0.06	0	0	0	0	0	0	0	0
Lake Trout	0	0	0	0	0	0	0	0	0	0	0	0	0.16	0
Rainbow Smelt	0	0.18	0	0	0	0	0	0	0	0	0	0	0	0
Northern Pike	3.31	2.3	2.5	4.1	7.3	4.9	4.5	3.9	4.8	3.7	3.63	4.03	5.31	4.38
Muskellunge	0	0	0	0	0	0	0	0	0	0	0.03	0	0.03	0
Common Carp	0	0	0	0	0	0.2	0.1	0.1	0.03	0	0.19	0.09	0.16	0.31
Rudd	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Golden Shiner	0	0	0	0	0	0	0	0	0	0	0	0.03	0.03	0
Fallfish	0	0	0	0	0.12	0	0	0	0	0	0	0	0	0.03
Longnose Sucker	0	0	0	0	0	0.39	0	0.13	0	0	0	0	0	0
White Sucker	2.6	3.6	2.4	2	1.8	0.8	1.4	1.3	2.1	1.7	1.81	2.5	3.03	3.06
Silver Redhorse	0.1	0.1	0.2	0	0.2	0.1	0.1	0.1	0.3	0	0.16	1. 0	0.09	0.16
Shorthead Redhorse	-	-	-	-	-	-	-	-	-	-	0	0.03	0	0
Greater Redhorse	-	-	-	-	-	-	-	-	-	-	0	0	0	0
Brown Bullhead	2.25	3	1.4	6.7	1.6	2.1	2.7	3.4	2.6	2.6	4.25	5.69	3	3.69
Yellow Bullhead	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Channel Catfish	0.1	1	0	0.2	0	0.2	0.4	0.8	4.8	1.4	0.41	1.31	0.16	0.97
Stonecat	0	0	0	0	0	0	0	0.13	0	0	0	0	0	0
Burbot	0	0	0	0	0	0	.0 3	0	0	0	0	0	0	0
White Perch	0.1	0.8	0.1	0	0.1	0.1	0.1	0	0.1	0	0.03	0.13	0.16	0.03
White Bass	0	0	0	0	0	0	0	0	0.06	0	0	0	0	0.09
Rock Bass	3.6	4.9	5.1	4.3	3.6	3.7	3.3	3.2	3.4	3.8	3.97	6.6	3.7	2.81
Pumpkinseed	7.4	5.2	8.3	4.5	11.5	9.3	12.3	7.8	5.7	6.4	10.3	10.2	9.66	11.8
Bluegill	0.9	1.1	0	0.6	2.8	0.3	12.4	0.6	0.6	0.6	0.59	0.09	0.59	0.78
Smallmouth Bass	6.2	7.4	6.6	5.1	2.9	3.5	5.2	4.6	5.9	5.9	7.66	9.84	5.69	6.66
Largemouth Bass	0	0.1	0	0	0.1	0	0.5	0.1	0	0.1	0.28	0.22	0.09	0.09
Black Crappie	0.4	0.2	0.1	0.1	0.2	0.1	0	0	0.1	0	0.13	0.09	0.06	0.03
Yellow Perch	31.5	42.3	43.4	33.3	17.4	25.7	14.7	22.9	19.9	36.1	20.7	22.6	15.2	15.5
Walleye	0	0	0	0	0	0.1	0.1	0.1	0.1	0.3	0.03	0.31	0.09	0.34
Freshwater Drum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Round Goby	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	59.52	79.25	72.35	63.58	54.59	51.59	62.81	50.68	51.53	69.08	56.36	65.33	47.04	51.1

Table 2. Abundance index (CUE = catch/net night) by species in the St. Lawrence River Thousand Islands Area 1977 – 2021. * yellow perch and rock bass multifilament CUE adjusted to monofilament standard.

Species	1991*	1992*	1993*	1994*	1995*	1996*	1997*	1998*	1999*	2000*	2001*	2002*	2003*	2004
Lake Sturgeon	0	0	0	0	0	0	0	0	0.03	0.03	0.06	0	0	0
Longnose Gar	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0
Bowfin	0.03	0	0.03	0.03	0	0.03	0	0.03	0	0	0.03	0	0	0
Alewife	0.91	0.19	0.07	0.38	0	0.63	0.22	0	0.09	0.03	0.18	0.09	0	0.03
Gizzard Shad	0.06	0.03	0	0	0	0	0	0	0.03	0	0	0	0	0
Coho Salmon	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Trout	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0
Lake Trout	0	0.06	0	0	0	0	0	0	0	0	0	0	0	0
Rainbow Smelt	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Pike	5.28	3.84	3.87	3.22	2.9	2	2.53	2.28	2.5	2.21	2.78	3.22	1.94	1.69
Muskellunge	0	0	0	0	0.03	0.03	0.03	0	0.03	0	0	0	0.06	0.03
Common Carp	0	0.06	0.2	0.09	0.06	0.16	0.06	0.06	0.03	0.03	0.03	0.03	0.06	0.03
Rudd	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0
Golden Shiner	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fallfish	0	0	0	0	0	0	0	0	0	0	0.03	0	0	0
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	1.16	2.06	1.07	1.28	1.5	0.81	1.3	1.28	1	0.97	1.34	1.13	1.41	1.03
Silver Redhorse	0.09	0.03	0.03	0	0.06	0.13	0	0.03	0.03	0.03	0	0	0.06	0
Shorthead Redhorse	0	0	0	0	0	0	0.06	0.03	0	0	0	0	0	0
Greater Redhorse	0.03	0.03	0	0.03	0	0	0	0.03	0	0.03	0	0.06	0	0
Brown Bullhead	3.09	3.97	1.43	1.06	1	0.44	0.69	1.47	2.5	1.59	2.84	2.53	4.66	1.22
Yellow Bullhead	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0
Channel Catfish	0.19	0.13	0.63	0.22	0.3	0.13	0.19	0.31	0.13	0.06	0.06	0.03	0.22	0.22
Stonecat	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0
Burbot	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Perch	0.09	0.03	0	0	0	0	0	0	0	0.03	0	0.03	0.03	0
White Bass	0	0	0	0	0	0	0	0.03	0.03	0	0	0	0	0
Rock Bass	2.94	1.84	2.89	4.41	3.73	5.28	3.71	3.18	4.58	4.93	3.35	3.25	4.39	6.47
Pumpkinseed	6.94	6.28	5.43	5.81	6.2	4.1	4.65	4.13	6.8	2.19	2.59	4.13	1.91	1.72
Bluegill	0.75	1.03	0.2	0.34	0.5	0.16	0.06	0.12	0.3	0	0.06	0.09	0.03	0
Smallmouth Bass	6.91	2.47	5.33	4.53	5.5	2.94	2.34	2.91	3.3	1.84	3.06	2.16	2.78	3.13
Largemouth Bass	0.16	0.09	0.1	0.09	0	0.03	0.03	0.06	0.06	0.03	0.15	0.06	0.03	0.06
Black Crappie	0.09	0	0	0	0	0.03	0.03	0	0.03	0	0.06	0	0.03	0
Yellow Perch	13.4	10.4	18.6	13.4	17.1	21.2	22.8	19.5	27.9	15.8	13.3	18.8	18.1	14.3
Walleye	0.25	0.09	0.23	0.13	0.3	0.25	0.09	0.06	0.13	0.19	0.31	0.5	0.34	0.28
Freshwater Drum	0	0	0	0	0	0.03	0	0	0	0	0	0	0.03	0.06
Round Goby	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	42.37	32.66	40.11	35.05	39.18	38.38	38.79	35.51	49.50	30.05	30.23	36.11	36.11	30.27

Table 2. Abundance index (CUE = catch/net night) by species in the St. Lawrence River Thousand Islands Area 1977 – 2021.

Species	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Lake Sturgeon	0.03	0	0	0	0.03	0	0	0	0	0	0	0.09	0	0
Longnose Gar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bowfin	0.03	0	0	0	0	0.03	0	0.03	0.03	0.03	0	0.03	0.06	0.03
Alewife	0.09	0.03	2.25	0.59	8.78	2.13	2.56	0.5	0.41	0.13	3.59	2.47	0.97	0.75
Gizzard Shad	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coho Salmon	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brown Trout	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lake Trout	0	0	0	0	0	0	0	0	0	0.03	0	0	0	0
Rainbow Smelt	0	0	0.06	0	0	0	0	0	0	0	0	0	0	0
Northern Pike	1.63	1.84	2.06	1.34	1.38	2.34	1.44	2.19	2	1.53	1.13	0.94	1.16	1.5
Muskellunge	0	0	0	0	0	0	0	0	0	0	0.03	0.03	0	0
Common Carp	0.12	0.19	0.16	0.19	0.09	0.06	0.16	0.16	0.22	0.03	0.06	0.06	0.06	0.06
Rudd	0	0	0	0	0	0	0	0.22	0	0	0	0	0	0
Golden Shiner	0	0	0.03	0	0.03	0.03	0.03	0	0	0	0	0.13	0	0
Fallfish	0	0	0	0	0	0	0	0.03	0.06	1	0	0.09	0	0.06
Longnose Sucker	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Sucker	1.1	1.16	0.88	0.81	0.63	0.34	0.69	0.53	0.78	0.31	0.31	0.44	0.44	0.75
Silver Redhorse	0.03	0.06	0.03	0.03	0.03	0.19	0.03	0.03	0.03	0.41	0	0.03	0.03	0.25
Shorthead Redhorse	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greater Redhorse	0	0	0	0	0.16	0	0	0	0.03	0.03	0	0	0.03	0.06
Brown Bullhead	1.53	2.47	1.22	0.81	1.56	0.72	0.75	0.97	0.5	0.19	0.09	1.34	0.38	1.09
Yellow Bullhead	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0
Channel Catfish	0.38	0.44	0.25	0.31	0.84	1.06	0.03	0.31	0.34	0.31	0.13	0.22	0.13	0.19
Stonecat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Burbot	0	0	0	0	0	0	0	0	0	0	0	0	0	0
White Perch	0	0.03	0	0	0	0	0	0	0.13	0	0	0	0	0
White Bass	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0
Rock Bass	4.84	6.66	5.31	5.22	5.16	6.16	6.84	3.13	6.44	3.78	4.13	3	4.22	5.38
Pumpkinseed	1.88	2.41	0.97	0.88	0.81	0.72	0.69	0.47	0.94	0.09	0.09	0.25	0.34	0.36
Bluegill	0.06	0.03	0.13	0.06	0	0.06	0.09	0.25	0.09	0.03	0	0.06	0	0.06
Smallmouth Bass	4.75	7.84	5.13	6.69	4.19	7.5	5	8.91	6.41	4.59	1.88	5.25	5.91	7.56
Largemouth Bass	0	0	0.19	0	0	0.03	0	0.31	0.06	0	0	0.13	0.09	0
Black Crappie	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow Perch	9.2	17.6	22.2	20.8	10.4	12.8	17.4	7.7	11.3	10.5	11.1	10.8	13.2	18.4
Walleye	0.75	0.81	1.34	0.84	1.03	0.84	1.06	0.47	0.81	1.22	1.22	0.69	0.94	0.78
Freshwater Drum	0.06	0	0.13	0	0	0	0.09	0.06	0.03	0	0	0	0	0.06
Round Goby	0	0	0.09	0.53	0.19	0.16	0.75	0.06	0	0.37	0.13	0.16	0.81	0.34
Total	26.48	41.6	42.43	39.1	35.31	35.17	37.61	26.36	30.61	24.58	23.89	26.21	28.77	37.68

Table 2. Abundance index (CUE = catch/net night) by species in the St. Lawrence River Thousand Islands Area 1977 – 2021.

Species	2019	2020	2021
Lake Sturgeon	0.06	0.03	0
Longnose Gar	0	0	0
Bowfin	0	0	.06
Alewife	1.75	0.63	1.31
Gizzard Shad	0	0	0
Coho Salmon	0	0	0
Brown Trout	0	0	0.03
Lake Trout	0	0	0
Rainbow Smelt	0	0	0
Northern Pike	1.18	0.75	1.06
Muskellunge	0	0	0
Common Carp	0.19	0.03	0.19
Rudd	0	0	0
Golden Shiner	0	0	0.06
Fallfish	0.03	0.28	0.09
Longnose Sucker	0	0	0
White Sucker	0.13	0.59	0.41
Silver Redhorse	0	0.13	0
Shorthead Redhorse	0	0	0
Greater Redhorse	0.22	0	0
Brown Bullhead	0.38	1.16	0.28
Yellow Bullhead	0	0	0
Channel Catfish	0.09	0	0
Stonecat	0	0	0
Burbot	0	0	0
White Perch	0.03	0	0
White Bass	0	0	0
Rock Bass	4.28	4.06	2.47
Pumpkinseed	0.22	0.22	0.06
Bluegill	0	0.06	0.06
Smallmouth Bass	5.25	9.13	4.41
Largemouth Bass	0	0.03	0.06
Black Crappie	0	0	0
Yellow Perch	12.25	13.19	12.56
Walleye	1.06	0.53	1.0
Freshwater Drum	0	0	0.06
Round Goby	0.34	0.28	0.19
Total	27.46	31.09	24.38

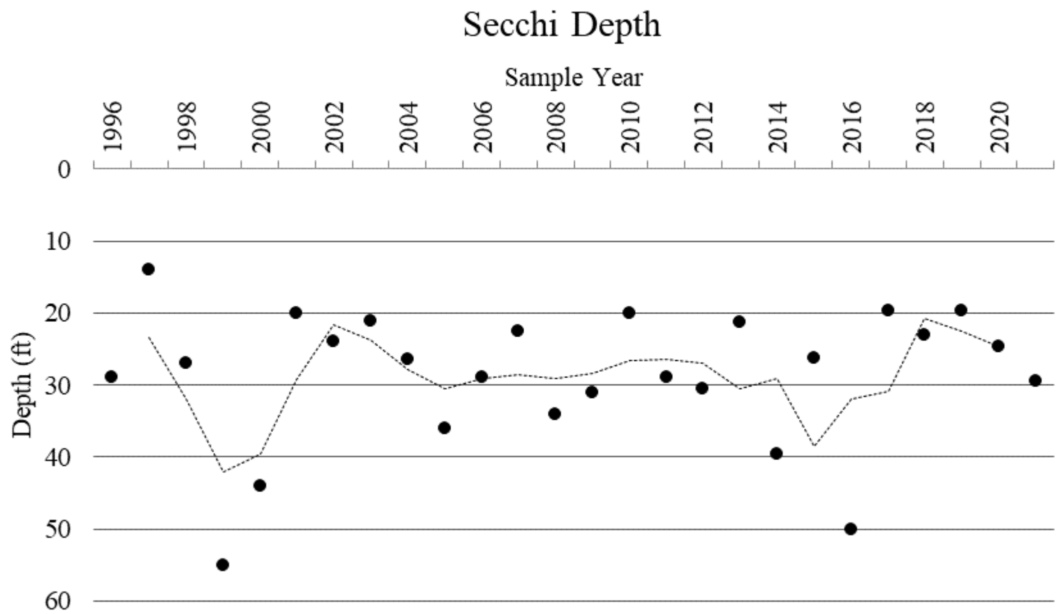

Figure 1. Mean Secchi depth (ft) of the St. Lawrence River Thousand Islands area during the Warmwater Fisheries Assessment. Line is the 3-year moving average.

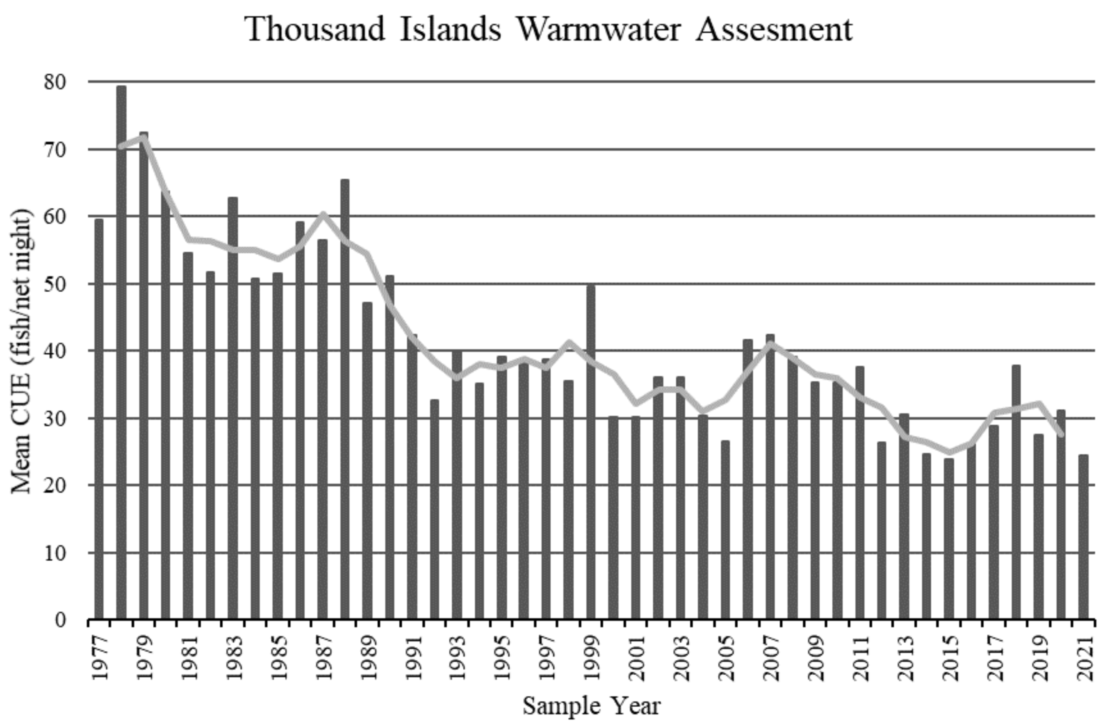

Figure 2. Mean catch per gill net night (CUE, fish/net-night) of all species for the St. Lawrence River Thousand Islands Warmwater Assessment 1977-2021. Line is the 3-year moving average.

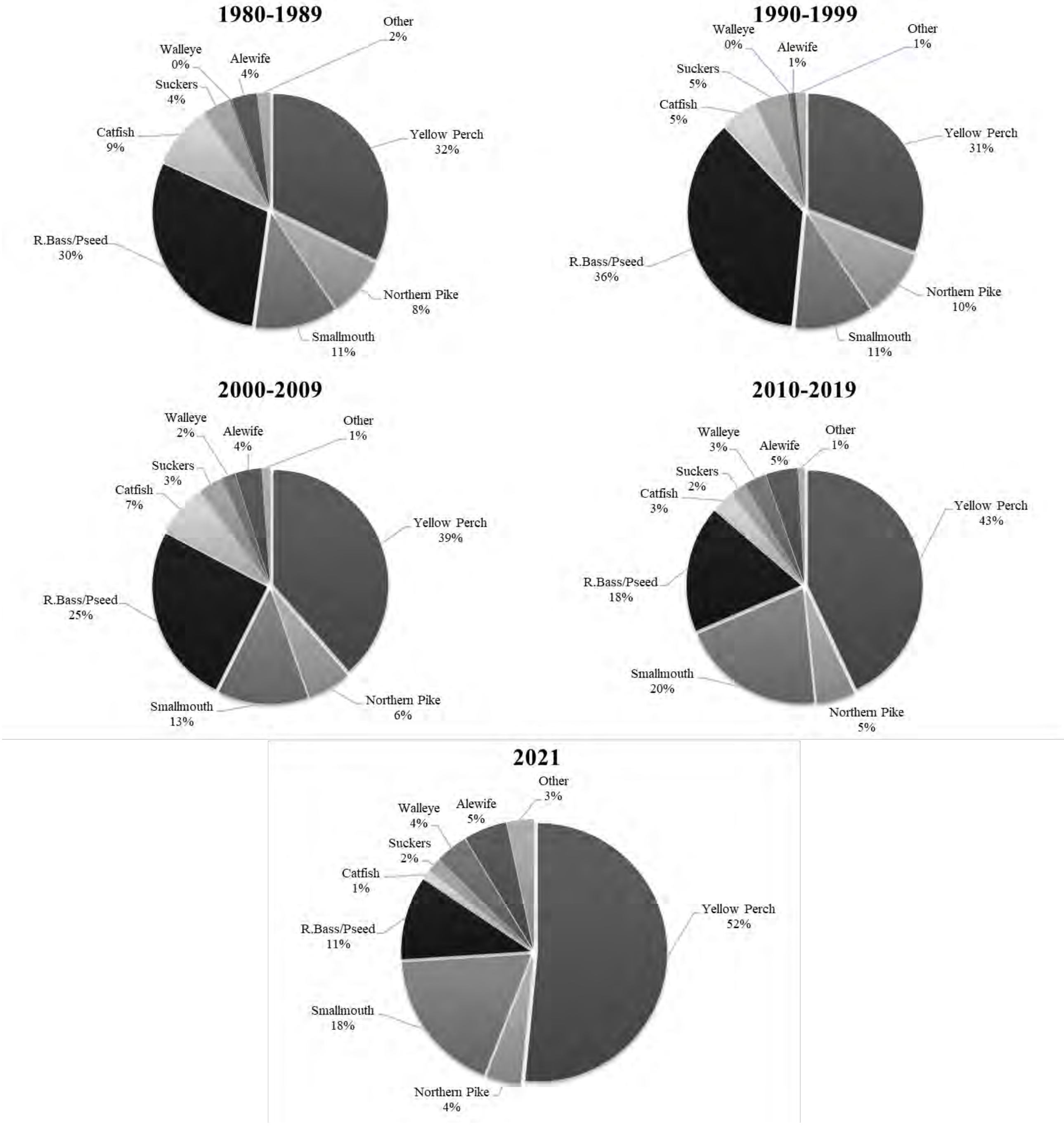

Figure 3. Catch composition of the St. Lawrence River Thousand Islands Warmwater Fisheries Assessment in the 1980's, 1990's, 2000's, 2010's, and sample year 2021.

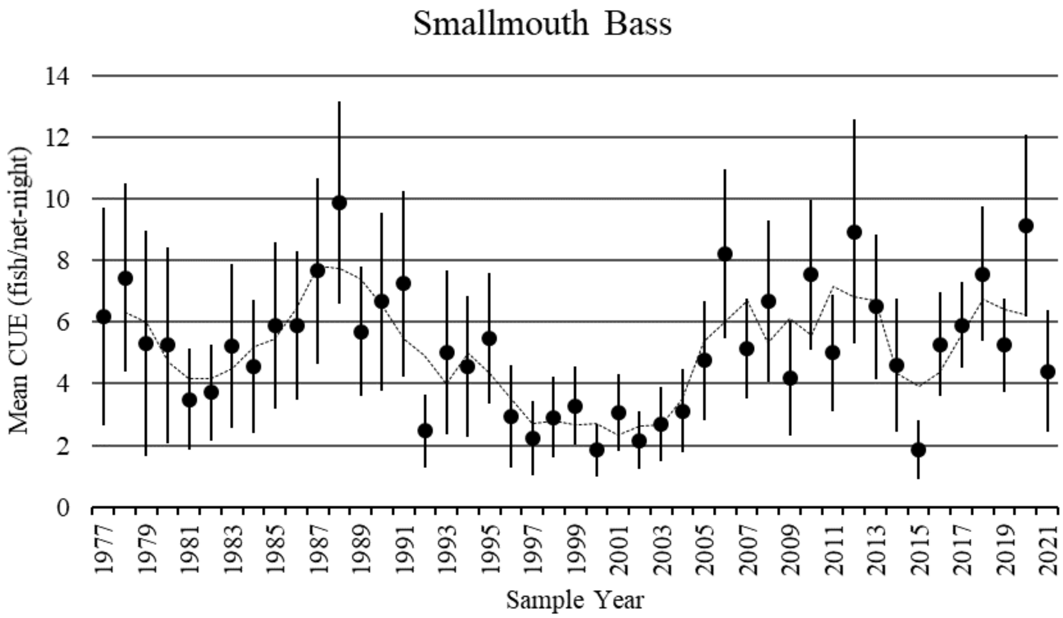

Figure 4. Smallmouth bass CUE of the St. Lawrence River Thousand Islands area 1977-2021. Mean catch per unit effort (CUE) with 95% confidence intervals and 3-year moving average.

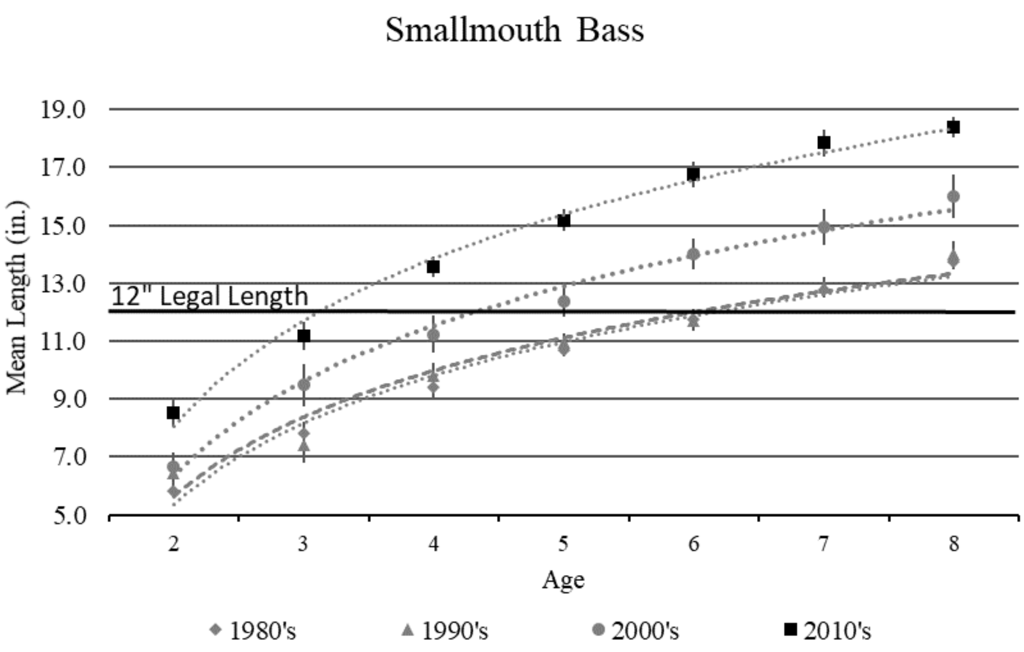

Figure 5. Decadal mean length at age of smallmouth bass caught in the Thousand Islands Warmwater Fisheries Assessment.

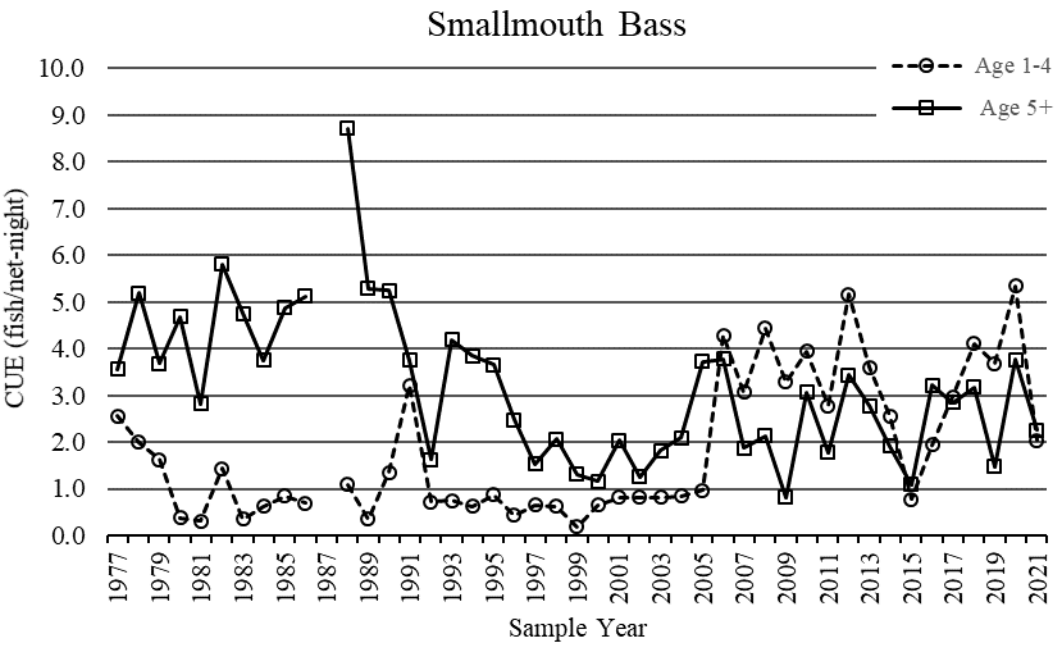

Figure 6. Mean CUE of smallmouth bass ages ≤ 4 and ages ≥ 5 in the Thousand Islands Warmwater Fisheries Assessment 1977 – 2021.

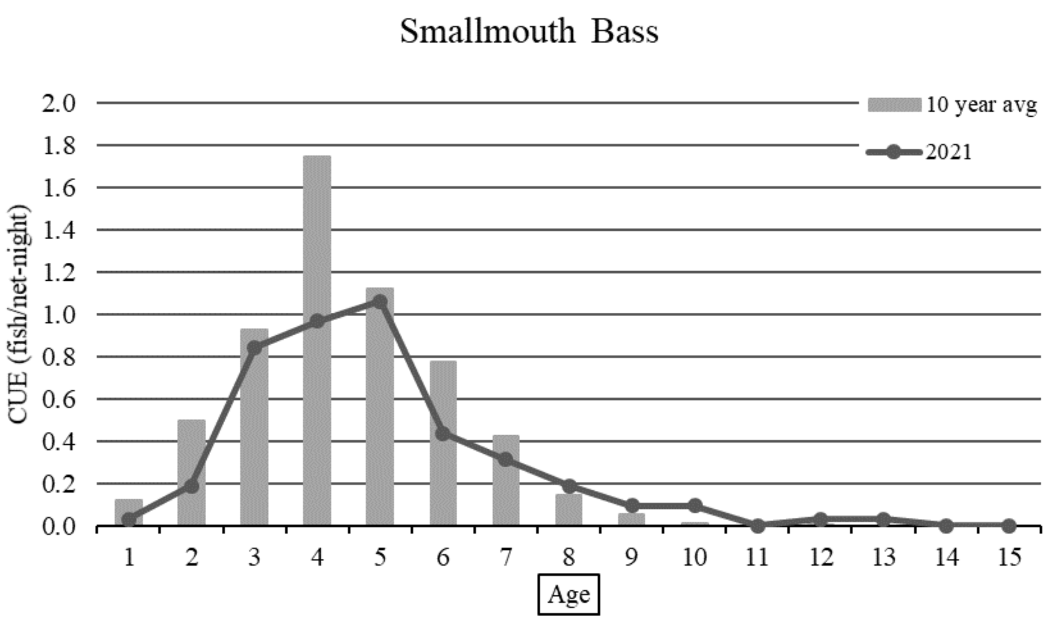

Figure 7. Age-specific CUE of smallmouth bass in the 2021 Thousand Islands Warmwater Fisheries Assessment and the previous ten-year average.

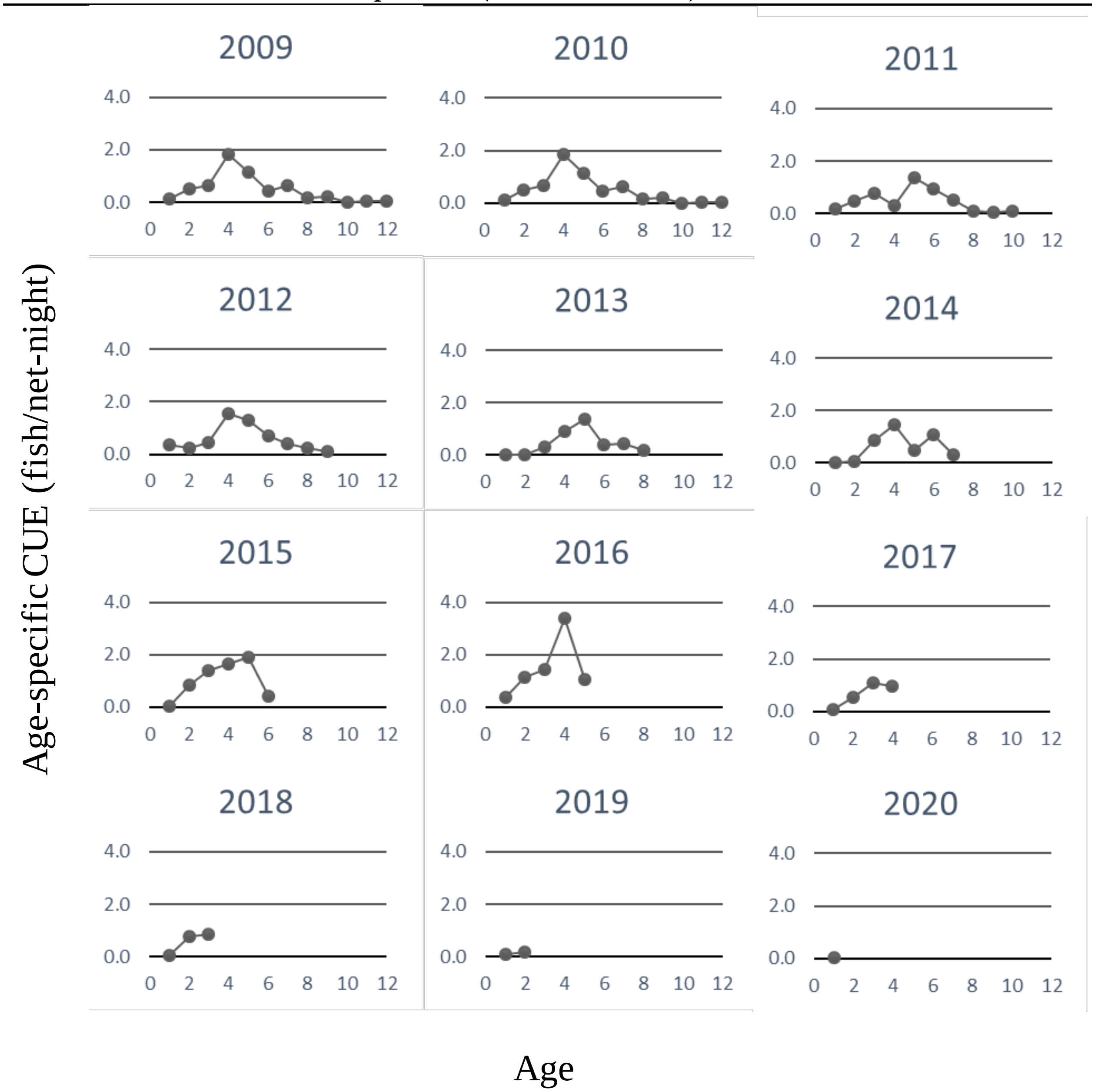

Figure 8. Year-class specific catch curves of smallmouth bass for the Thousand Island Region of the St. Lawrence River.

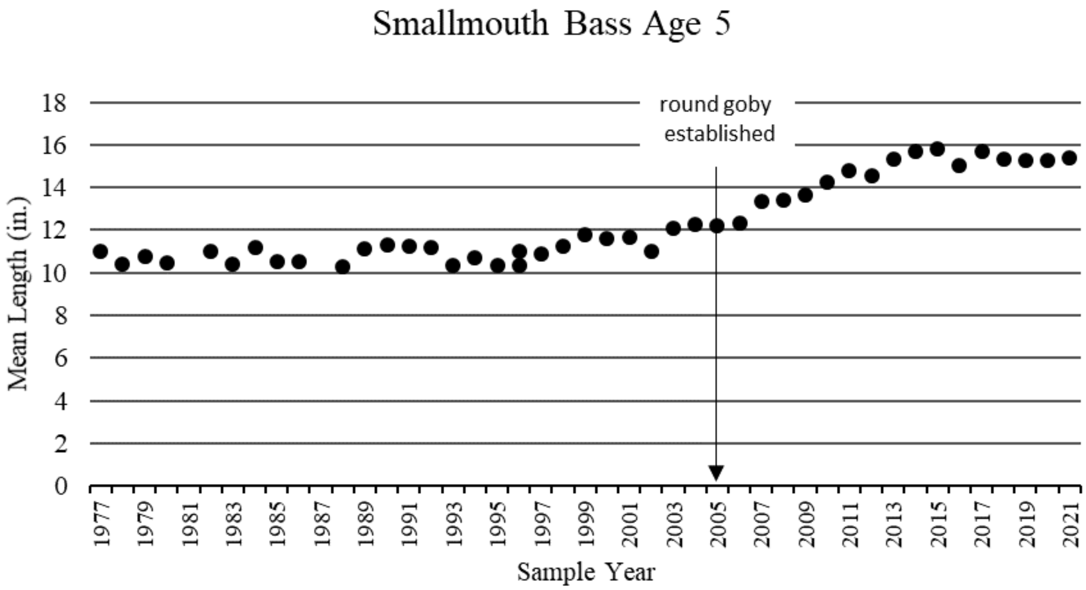

Figure 9. Mean total length of age-5 smallmouth bass in the Thousand Islands Warmwater Fisheries Assessment 1977-2021. Vertical line indicates establishment of abundant round goby in 2005.

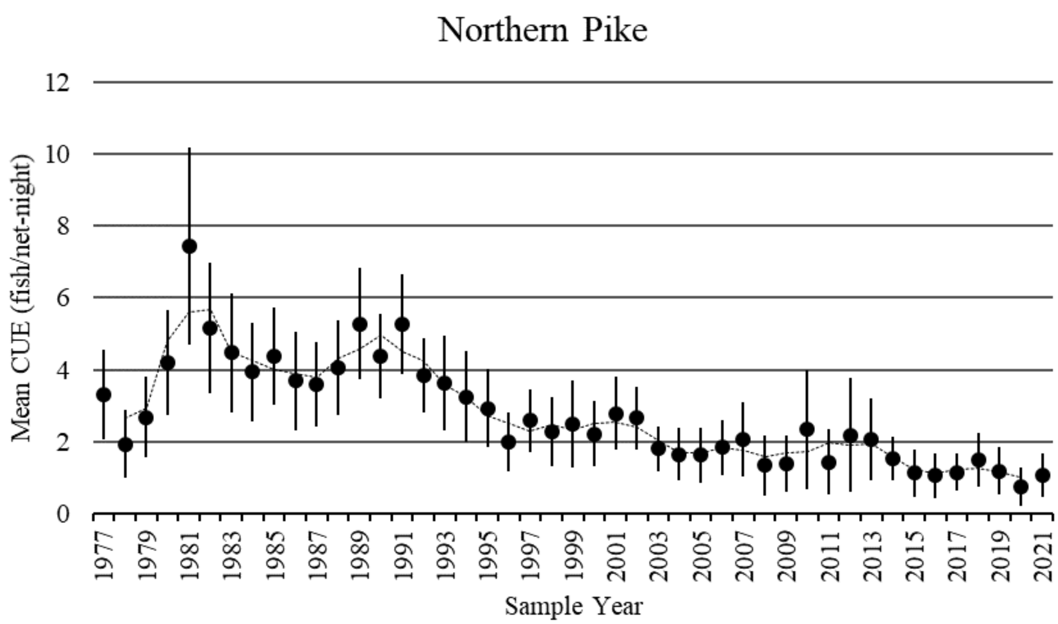

Figure 10. Northern pike CUE of the Thousand Islands Warmwater Fisheries Assessment 1977-2021. Mean catch per unit effort (CUE) with 95% confidence and 3-year moving average.

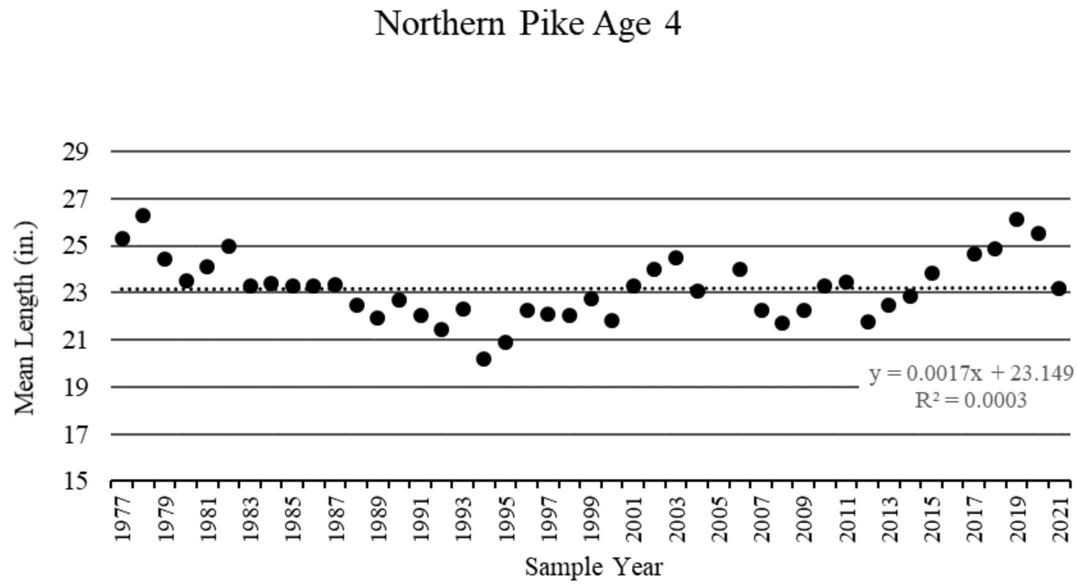

Figure 11. Mean total length of age-4 northern pike in the Thousand Islands Warmwater Fisheries Assessment 1977-2021.

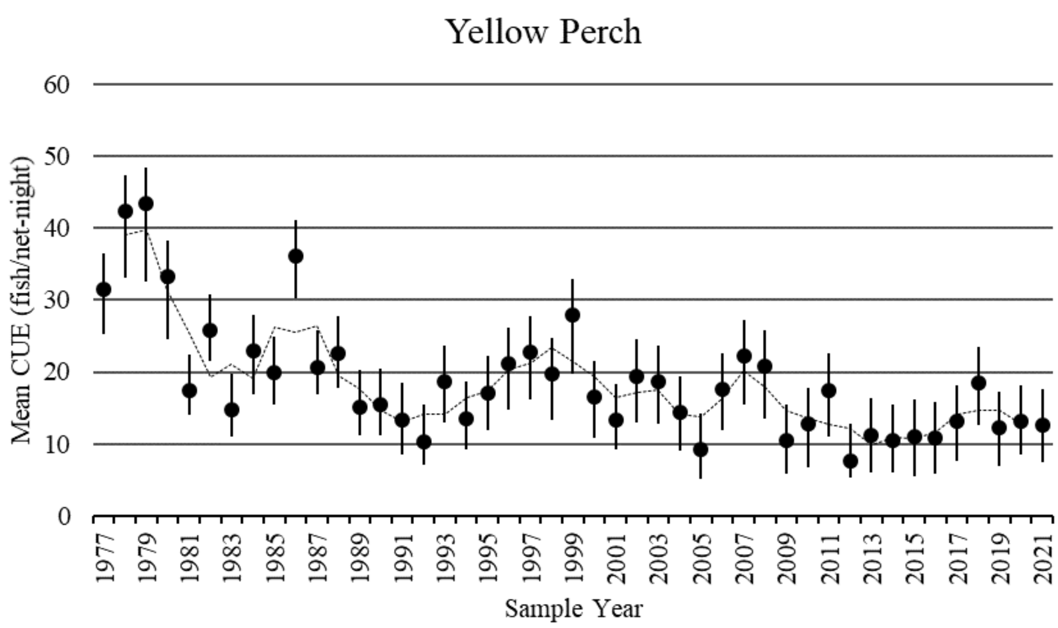

Figure 12. Yellow perch CUE of the Thousand Islands Warmwater Fisheries Assessment 1977-2021. Mean catch per unit effort (CUE) with 95% confidence intervals and 3-year moving average. Multifilament CUE from 1977 – 2003 adjusted to monofilament standard.

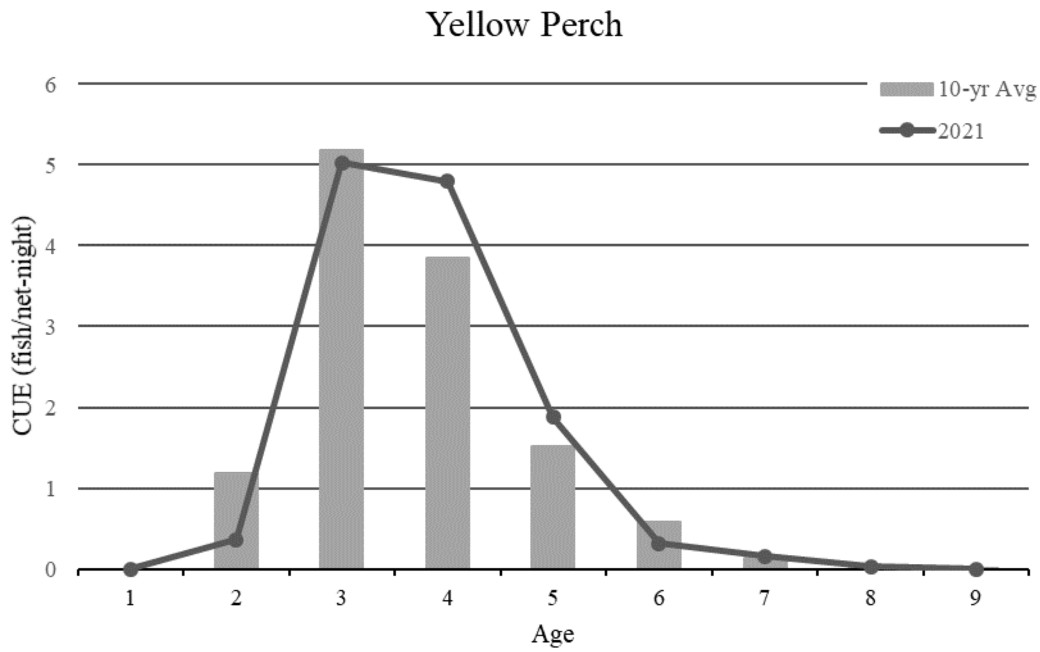

Figure 13. Age-specific CUE of yellow perch catch in the 2021 Thousand Islands Warmwater Fisheries Assessment compared to the previous ten-year average.

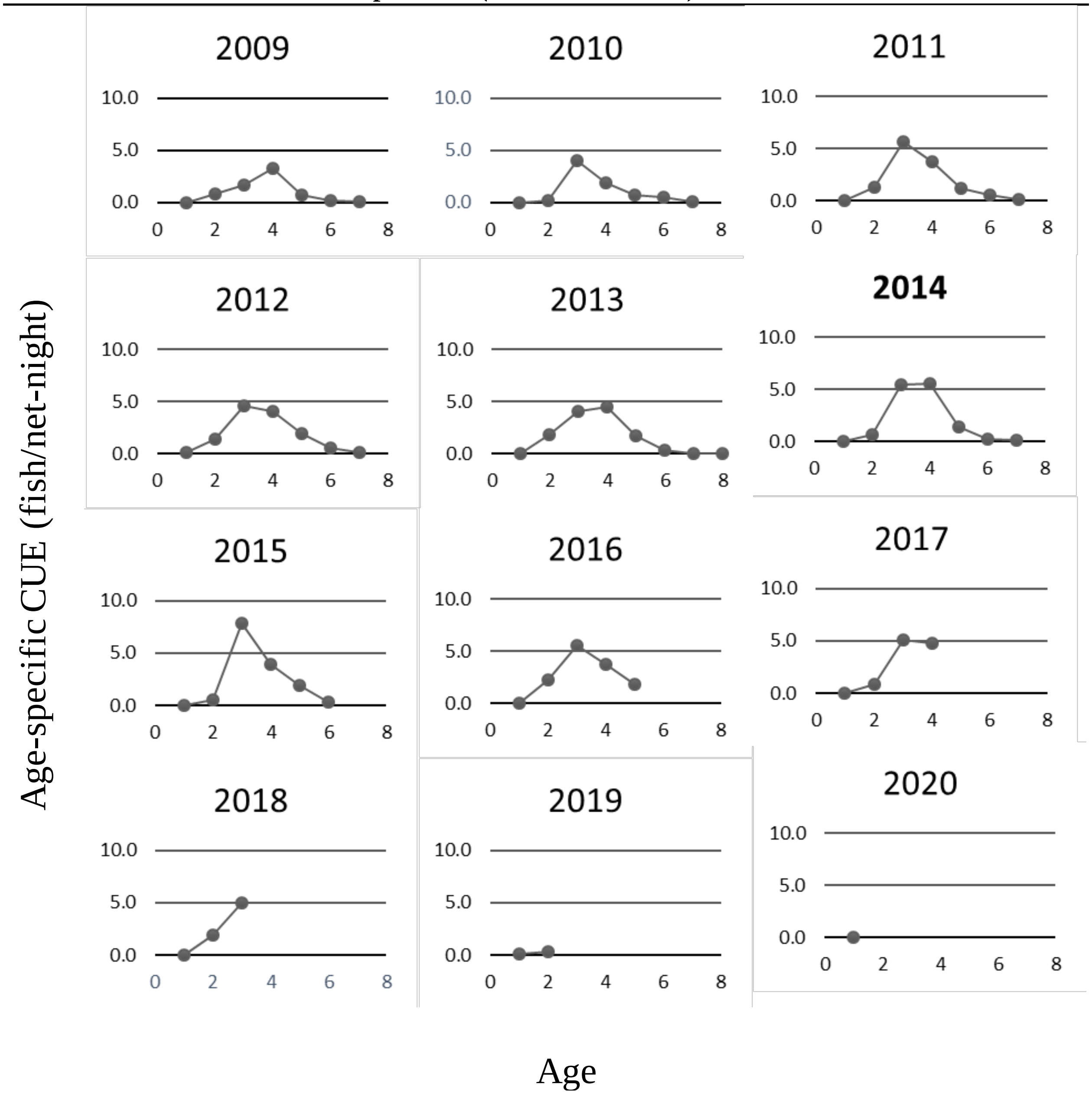

Figure 14. Year-class specific catch curves of yellow perch for the Thousand Islands region of the St. Lawrence River.

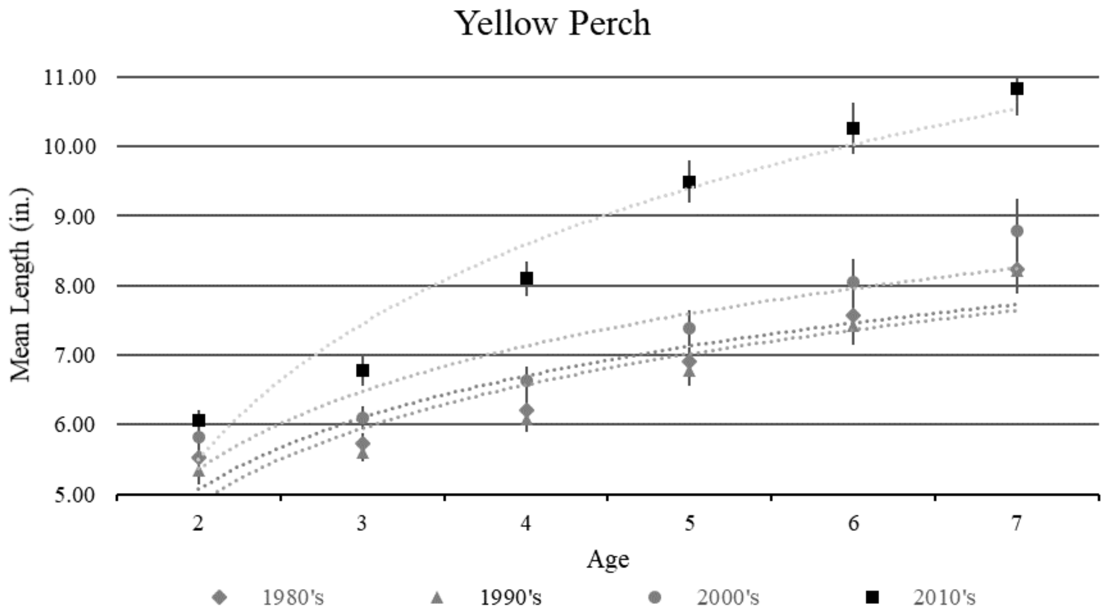

Figure 15. Decadal mean length at age of yellow perch caught in the Thousand Islands Warmwater Fisheries Assessment.

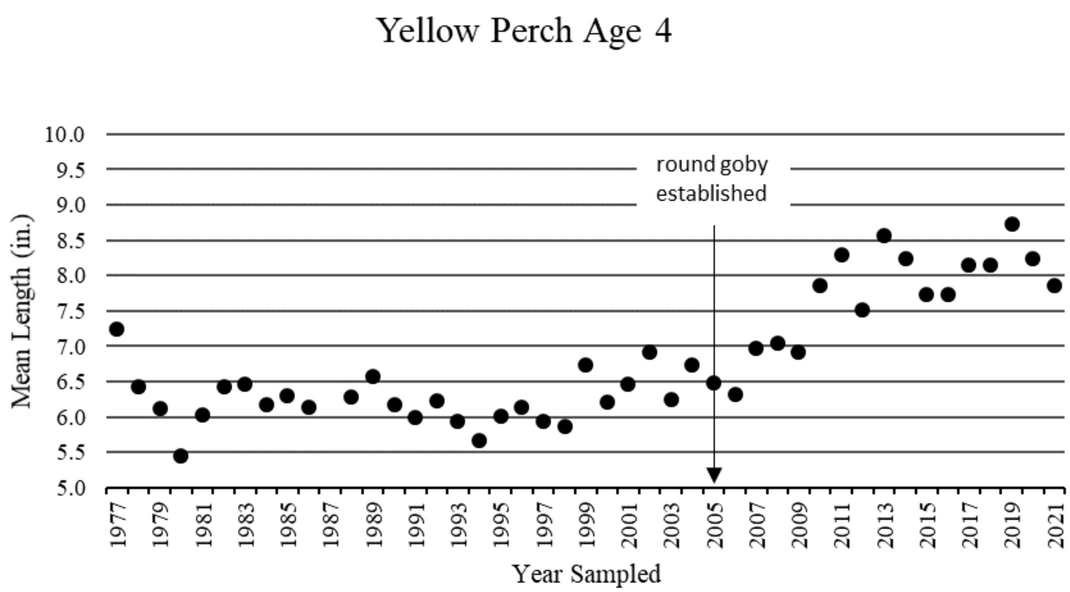

Figure 16. Mean total length of age-4 yellow perch of the Thousand Islands Warmwater Fisheries Assessment 1977-2021. Vertical line indicates establishment of abundant round goby in 2005.

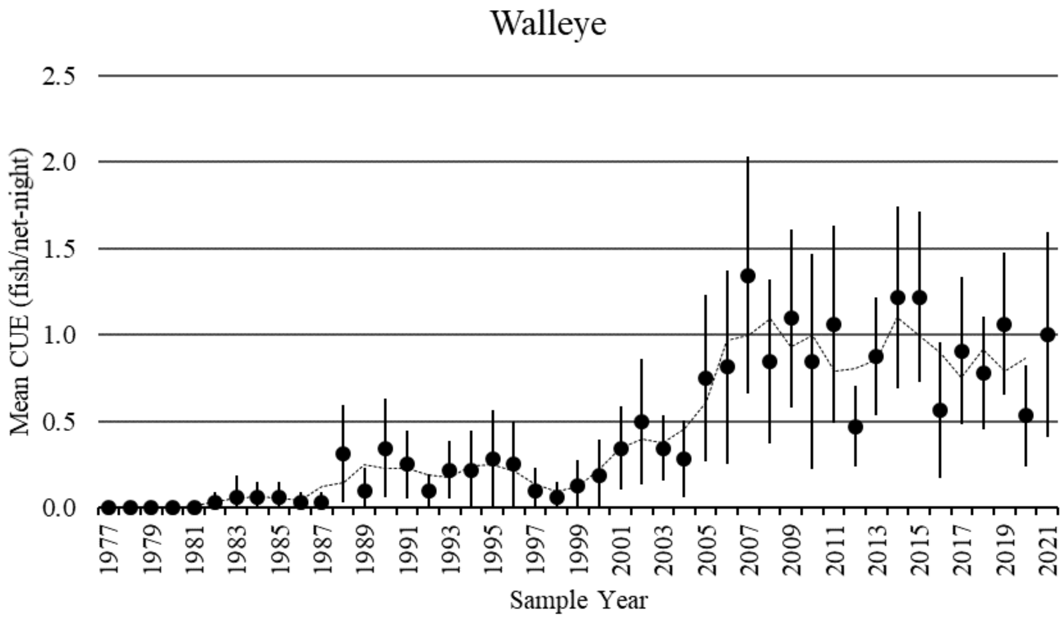

Figure 17. Walleye CUE of the Thousand Islands Warmwater Fisheries Assessment 1977-2021. Mean catch per unit effort (CUE) with 95% confidence intervals and 3-year moving average.

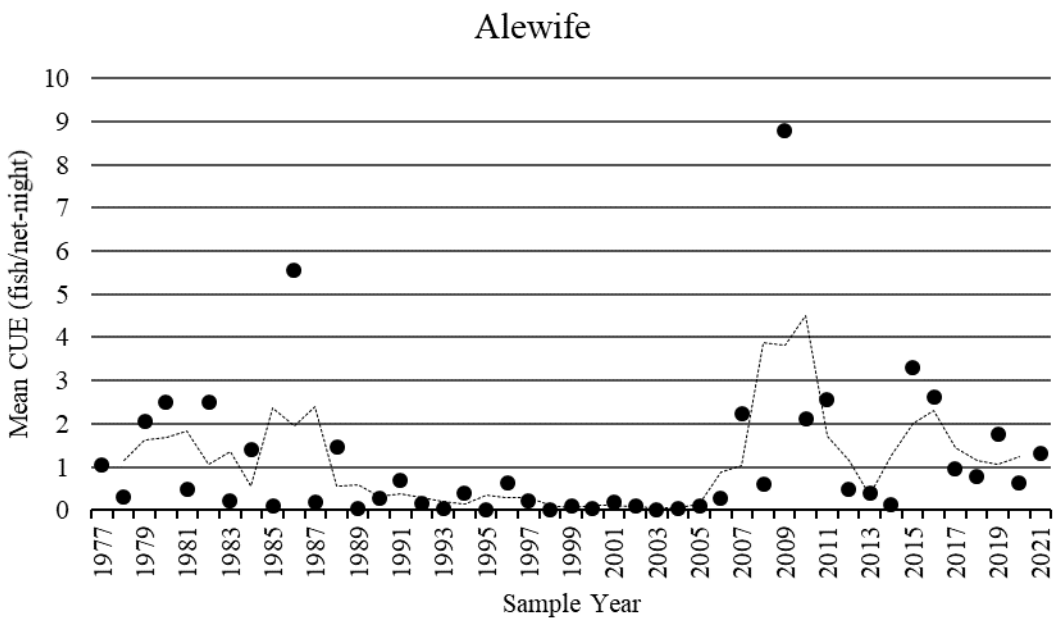

Figure 18. Alewife CUE of the Thousand Islands Warmwater Fisheries Assessment 1977-2021. Mean catch per unit effort (CUE) with 3-year moving average.

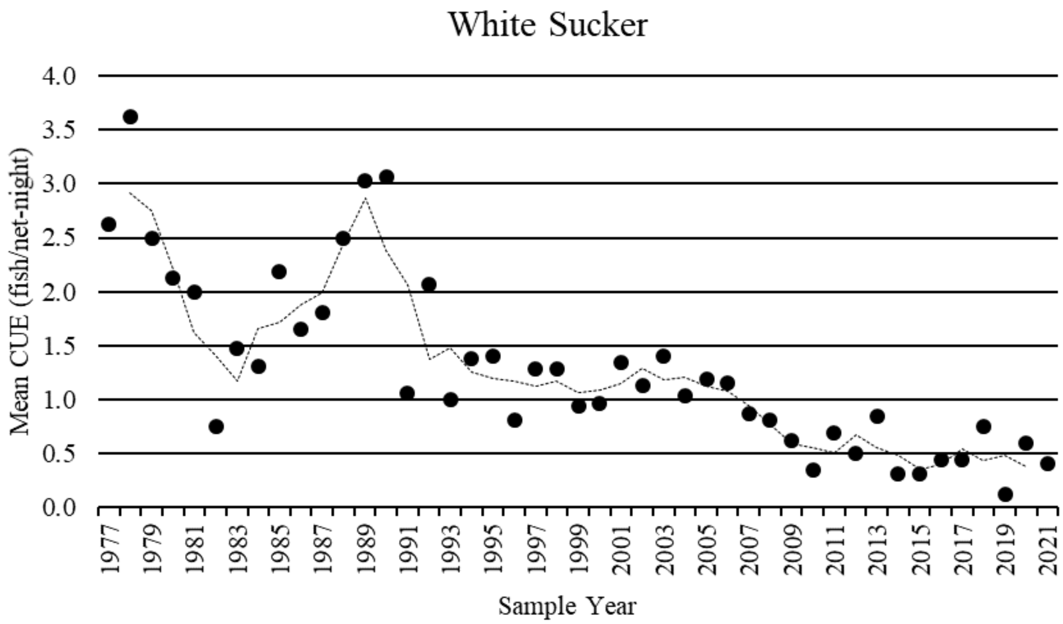

***Figure 19.** White sucker CUE of the Thousand Islands Warmwater Fisheries Assessment 1977-2021. Mean catch per unit effort (CUE) with 3-yr moving average.*

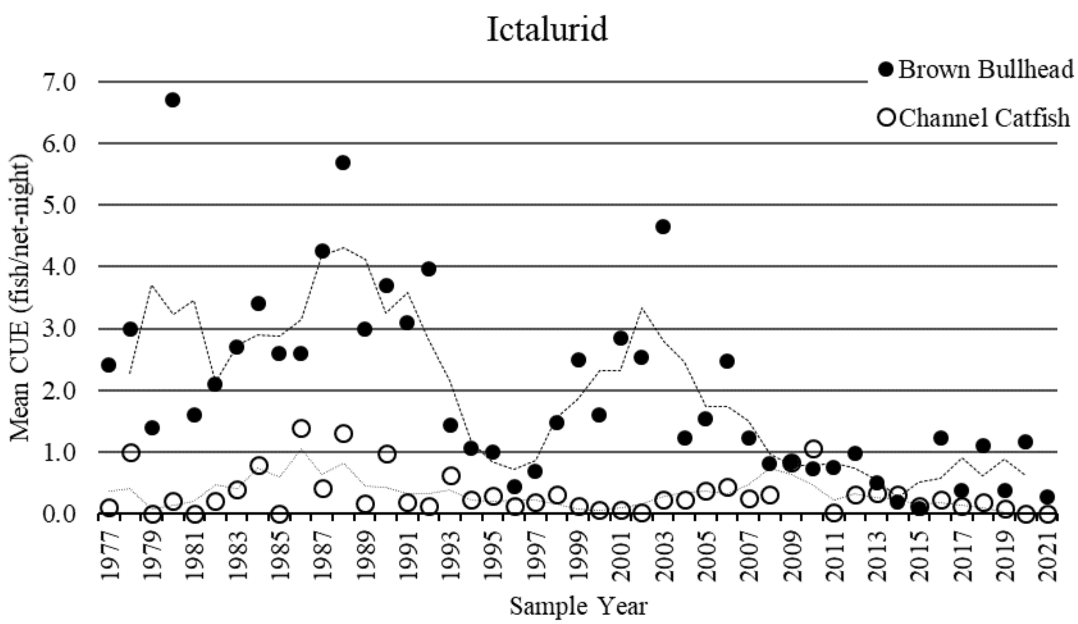

***Figure 20.** Brown bullhead and channel catfish CUE of the Thousand Islands Warmwater Fisheries Assessment 1977-2021. Mean catch per unit effort (CUE) with 3-yr moving average.*

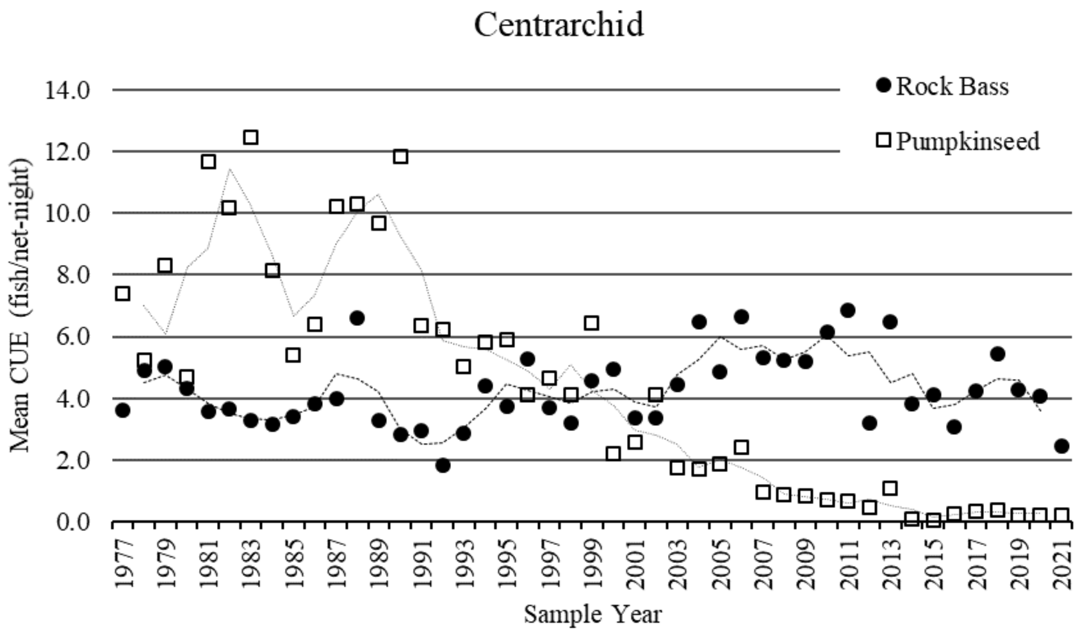

***Figure 21.** Rock bass and pumpkinseed sunfish CUE of the Thousand Islands Warmwater Fisheries Assessment 1977-2021. Mean catch per unit effort (CUE) with 3-year moving averages. The 1977 – 2003 multifilament catches of rock bass are adjusted to monofilament standard.*

Lake St. Lawrence Warmwater Fisheries Assessment

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

Methods

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

In 2021, gill nets were set overnight and fished an average of 17.2 hours (SE=0.17) at standard New York (n=16) and Ontario (n=16) sites described by Klindt and Town (2002). Net sites were stratified in equal number by depth as shallow and deep (12-25 ft and 30-50 ft, respectively).

Data collected from fish included total length, weight, sex, and stage of maturity. Scale samples were taken from percids and centrarchids for age analysis. Cleithra were removed from northern pike and, beginning in 2020, otoliths were collected from all walleye and black bass over 350 mm for more accurate age determination. Data were entered into the NYSDEC Statewide Fisheries Database.

Total and species-specific catch per unit effort (CUE; catch per gill-net-night) and standard error (SE) were calculated. Other metrics calculated include length-frequency and age-frequency.

Results and Discussion

The 2021 Lake St. Lawrence warmwater fisheries assessment was conducted from 9/13 - 9/17 and surface water temperature averaged 67.9 °F (19.9°C). A sample of 897 fish comprising 22 species was collected (Table 1). The catch was dominated by yellow perch (45%), rock bass (17%) and smallmouth bass (11%; Figure 1).

While overall diversity of the fish community in Lake St. Lawrence remained relatively stable, the contribution of individual species changed over time (Figure 1). Over time the yellow perch contribution increased (28% of catch in 1990's compared to 45% of catch in 2021), while other common species such as rock bass, smallmouth bass and walleye remained relatively stable. Species poorly represented in earlier surveys (e.g., brown bullhead and pumpkinseed) now make up smaller proportions of the overall catch (74 - 84% decrease in the 2020's compared to the 1990's, respectively).

Average CUE of all species increased by 5% from 26.6 fish/net night in 2020 to 28.0 ± 3.1 (SE) in 2021 and was the 3rd highest since 1986 (Table 1; Figure 2). The long-term average CUE for this assessment is 19.3 ± 0.94 (SE). Mean CUE is generally driven by variable yellow perch catch.

The 2021 yellow perch mean CUE decreased by 4% to 12.6 from 13.1 in 2020 but was still the 4th highest in the data series (Figure 3). From 2008-2012 annual perch catch was highly variable. From 2013-2017 the population was relatively stable (CUE average = 8.1) at a lower level. CUE 2018-2021 was higher, with a current 3-year average of 12.3 fish/net-night. Predation from double-crested cormorant (*Phalacrocorax auritus*; DCC) influenced yellow perch numbers in Lake St. Lawrence in the past (Klindt and Gordon 2013).

DCC diet data are no longer available for Lake St. Lawrence, however, cormorant nesting colonies will continue to play a role in altering the fishery as they have in the Thousand Islands (McCullough and Gordon 2013) and Lake Ontario (Lantry et al. 1999). The increase in overall perch numbers in recent years may indicate a diet shift of DCC towards round goby (Johnson et al. 2015) allowing for strong recruitment of the recent year classes.

The majority of yellow perch collected ranged from 5.5-7.0 inches with no fish <5.5 inches (Figure 4). Age-3 yellow perch dominated the catch in 2021 (2018 year class, Figure 5). Yellow perch tend to be absent from the catch by age 7. Year class specific catch rates indicated that stronger year classes were produced 2015-2018 compared to the previous 5 years (2010-2014; Figure 6).

Yellow perch growth increased throughout the time series (Figure 7, 1990-2019). Round goby (*Neogobiuos melanostomus*) are a source of forage for most piscivorous species in the St. Lawrence River, and it is probable that increased growth rates seen since their expansion (circa 2000) are at least partly attributed to yellow perch exploiting round goby as forage. The length of an age-4 yellow perch averaged 6.8 inches prior to the expansion and noticeably increased beginning in 2005 (Figure 8) once gobies had become established. The current ten-year average length of and age-4 yellow perch is 8.5 inches.

Smallmouth bass CUE was relatively stable from 1998-2004, variable from 2005-2013, and remained relatively stable from 2014 to 2018 (Figure 9). In 2021, smallmouth bass CUE (3.1) was similar to 2020 (3.2) and has contributed to an increasing trend in CUE 2019-present. The length frequency distribution in 2021 showed three distinct peaks at 7-8 inches, 11-14 inches and from 16-19 inches (Figure 10). In 2021, 61.6% of smallmouth bass sampled were longer than the current legal harvestable length of 12 inches. CUEs of age-1 & -3 smallmouth bass were higher than the previous 10-year average (Figure 11). This year the CUE of age-1 smallmouth bass (.75; 2020 year class) was the highest of the time series. The 2018 year class (age –3 in 2021) was again represented well in the catch with a CUE (.75) two times greater than the previous 10-year average (0.37). Year class specific catch curves also indicated strong year classes were produced in 2018 and 2020 (Figure 12). CUE's of the fish older than age-8 were also above ten year averages, but this may due to the change in aging structures used. All bass prior to 2020 were aged with scales, which result in less accurate age interpretations for older fish. We recommend continued use of otoliths for aging bass > 350mm.

Like yellow perch, smallmouth bass growth has increased across the time series (Figure 13). In previous years, smallmouth typically reached the current legal harvestable length of 12 inches during year four, whereas currently legal length is reached between two and three years old. The length of age-5 smallmouth bass steadily increased since 1986 but appears to have reached an asymptote around 16.4 inches (current 10-year average, Figure 14). In 2021, the length of age-5 bass was lower, 15.4 inches (n=3).

In 2021, walleye CUE (1.9) increased 42% from 2020 (1.0) and is above the long-term average of 1.4 fish/net night (Figure 15). Walleye abundance was relatively stable 1986-2007, rose to series high in 2009 then declined. CUE was relatively stable 2014-2020 then increased in 2021. The length-frequency distribution of walleye has one distinct peak at the 10-14 inch range which may indicate a potentially strong year class (Figure 16). Catch was dominated by age-1 (2020 year-class, 46%) followed by age-2 (2019 year class, 26%; Figure 17). A strong 2020 year class was also noted in Ontario Ministry of Natural Resources Bay of Quinte bottom trawling (Brown *in press* 2022) and NYSDEC warmwater assessment of Lake Erie (Wilkins 2022). High catches of young-of-year, or age-1 fish, often occur but do not always persist in the catch through time. Walleye captured during this assessment are predominately younger fish (i.e., ≤ age 3) with older fish being poorly represented. It is unclear if older walleye leave the Lake St. Lawrence area or utilize habitat that is not sampled. All walleye prior to 2020 were aged using scales, which may result in less accurate age interpretations for older fish. We recommend continued use of otoliths for interpreting walleye ages in the future.

Netting strata were not designed to take advantage of limited littoral zone habitat in Lake St. Lawrence; therefore, northern pike are poorly represented in this assessment. Northern pike CUE (0.38) in 2021 remained low but shows an increasing trend from the low of 0.09 observed in 2014 (Figure 18). Total length of northern pike ranged from 18.-34 inches (Figure 19). Fish ages 2-3 and 5-7 were represented in the catch (Figure 20).

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Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of species collected in the Lake St. Lawrence warmwater fisheries assessment, 1986-2021.

	Year	1986	1987	1988	1989	1980s Avg
Species	**# Nets**	32	47	32	46	
Lake Sturgeon		0	0	0	0	0
Bowfin		0	0	0.03	0	0.007
Alewife		1.50	0.11	0.06	0.06	0.43
Gizzard Shad		0	0.26	0.09	0.33	0.43
Rainbow Trout		0.03	0	0	0	0.07
Brown Trout		0.09	0.02	0	0	0.02
Lake Trout		0	0	0	0.06	.02
Rainbow Smelt		0	0	0	0	0
Northern Pike		0.94	0.04	0.63	0.85	0.62
Muskellunge		0	0.02	0	0.02	0.01
Lake Chub		0	0.02	0	0	0.005
Carp		1.94	1.06	0.66	0.72	1.1
Golden Shiner		0	0	0	0	0
Fallfish		0.25	0.32	0.19	0.15	0.23
White Sucker		0.91	1.04	1.41	1.43	1.2
Silver Redhorse		0.06	0.23	0.44	0.15	0.22
Shorthead Redhorse		0	0	0	0	0
Greater Redhorse		0.03	0	0	0	0.008
Yellow Bullhead		0	0	0	0	0.0
Brown Bullhead		0.63	0.79	0.97	1.61	1.0
Channel Catfish		0	0	0.09	0.02	0.03
White Perch		0.38	0.96	3.00	0.87	1.3
White Bass		0	0.02	0	0.04	0.02
Rock Bass		2.41	1.36	1.84	1.02	1.66
Pumpkinseed		0.13	0.26	0.28	0.74	0.35
Bluegill		0	0	0	0	0
Smallmouth Bass		2.03	2.36	2.28	2.65	2.33
Largemouth Bass		0	0	0	0.02	0.005
Black Crappie		0	0.02	0.16	0.13	0.08
Yellow Perch		9.63	8.61	6.94	4.41	7.4
Walleye		0.53	1.04	1.38	0.83	0.95
Freshwater Drum		0	0	0	0.06	0.02
TOTAL CATCH		21.5	18.9	20.4	16.2	19.25

Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of species collected in the Lake St. Lawrence warmwater fisheries assessment, 1986-2021.

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

Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of species collected in the Lake St. Lawrence warmwater fisheries assessment, 1986-2021.

	Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2000s Avg
Species	**# Nets**	32	32	32	32	32	32	32	32	32	32	
Lake Sturgeon		0	0	0	0.06	0.03	0	0	0.06	0	0	0.02
Longnose Gar		0	0	0	0	0	0	0.03	0	0	0	0.003
Bowfin		0.03	0.03	0.06	0	0.03	0	0	0	0.06	0	0.02
Alewife		0.03	0	0.06	0	0	0	0	0	0	0	0.01
Gizzard Shad		0.03	0	0.03	0	0.06	0.06	0.06	0	0.53	0.06	0.08
Rainbow Trout		0	0	0	0	0	0	0	0	0	0	0
Brown Trout		0	0	0	0	0	0	0.03	0	0	0	0
Lake Trout		0	0	0	0	0	0	0	0	0	0	0
Rainbow Smelt		0	0	0	0	0	0	0	0	0	0	0
Northern Pike		0.44	0.59	0.63	0.56	0.47	0.44	0.59	0.41	0.28	0.31	0.47
Muskellunge		0	0	0	0	0	0	0	0	0	0	0
Lake Chub		0	0	0	0	0	0	0	0	0	0	0
Carp		0.38	0.47	0.91	0.41	0.19	0.5	0.25	0.31	0.41	0.06	0.39
Golden Shiner		0	0	0	0	0	0	0	0	0	0	0
Fallfish		0.09	0.06	0.03	0	0	0	0.06	0.16	0	0.25	0.07
White Sucker		0.69	0.66	0.66	0.25	0.16	0.25	0.31	0.44	0.81	0.59	0.48
Silver Redhorse		1.06	0.94	0.88	0.28	0.53	0.53	0.25	0.25	0.28	0.31	0.53
Shorthead Redhorse		0.03	0.13	0.06	0.03	0.03	0.06	0	0.09	0	0	0.04
Greater Redhorse		0.03	0	0	0	0	0	0	0	0.03	0.03	0.01
Yellow Bullhead		0	0	0	0	0	0	0	0	0	0	0
Brown Bullhead		0.56	2.94	2.47	0.56	0.44	0.22	0.22	0.19	0.06	0.09	0.78
Channel Catfish		0.06	0.41	0.06	0.09	0.16	0.03	0.03	0.09	0.09	0.09	0.11
White Perch		0.28	0.03	0.09	0	0.19	0	1.75	0	0.25	1.22	0.38
White Bass		0.13	0	0	0	0	0.06	0	0.06	0	0.09	0.03
Rock Bass		3.38	2.72	2.59	2.63	2.5	3.38	2.5	4.03	6.38	4.19	3.43
Pumpkinseed		0.56	0.75	0.56	1.41	0.09	0.03	0.16	0.16	0.16	0.13	0.40
Bluegill		0	0.03	0	0.03	0	0	0	0	0	0	0.01
Smallmouth Bass		2.56	2.31	2.53	2.06	2.22	4.28	1.63	1.44	3.03	1	2.31
Largemouth Bass		0.03	0	0.06	0	0.03	0.28	0.13	0	0.13	0.03	0.07
Black Crappie		0.03	0	0.03	0	0	0	0	0	0.06	0.03	0.02
Yellow Perch		2.59	2.44	4.53	4.34	1.78	4.44	3.78	7.13	11.22	8.16	5.04
Walleye		1.69	1.06	1.75	1.28	0.72	1.44	1.91	1.09	1.94	3.03	1.59
Freshwater Drum		0	0	0	0	0	0.13	0.06	0.06	0	0.03	0.03
TOTAL CATCH		14.7	15.6	17.9	14	9.69	16.19	13.75	15.96	25.75	19.67	16.32

Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of pecies collected in the Lake St. Lawrence warmwater fisheries assessment, 1986-2021.

	Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2010s Avg
Species	**# Nets**	32	32	32	32	32	32	32	32	32	32	
Lake Sturgeon		0.06	0.03	0	0	0	0	0	0	0	0	0.01
Longnose Gar		0.06	0	0	0.03	0	0	0	0	0	0	0.009
Bowfin		0.03	0	0	0.03	0	0.03	0	0	0	0	0.01
Alewife		0	0.03	0.09	0	0.03	0	0.31	0.16	0.19	0.09	0.09
Gizzard Shad		0.06	0.03	0.63	0.44	0	0.03	0.56	0	0	0	0.17
Rainbow Trout		0	0	0	0	0	0	0	0	0	0	0
Brown Trout		0	0	0	0	0	0	0	0	0	0	0
Lake Trout		0	0	0	0	0	0	0	0	0	0	0
Rainbow Smelt		0	0	0	0	0	0	0	0	0	0	0
Northern Pike		0.28	0.31	0.19	0.28	0.09	0.13	0.28	0.22	0.38	0.34	0.25
Muskellunge		0	0.03	0	0	0	0	0	0	0	0	0
Lake Chub		0	0	0	0	0	0	0	0	0	0	0
Carp		0.19	0.16	0.41	0.25	0.09	0.25	0.13	0.19	0.25	0.13	0.20
Golden Shiner		0	0	0.03	0	0	0	0	0.16	0.03	0	0.02
Fallfish		0.19	0.19	0.16	0.47	0.16	0.25	0.22	0.69	0.47	0.31	0.31
White Sucker		0.44	0.53	1.22	0.72	0.59	0.41	0.88	0.88	0.44	0.88	0.70
Silver Redhorse		0.19	0.63	0.44	0.38	0.25	0.31	0.22	0	0.28	0.31	0.30
Shorthead Redhorse		0	0	0	0.03	0	0.03	0	0	0	0	0.01
Greater Redhorse		0.06	0.03	0	0.03	0.03	0	0.03	0	0	0	0.02
Yellow Bullhead		0	0	0	0	0	0	0	0	0	0	0
Brown Bullhead		0.16	0.22	0.66	0.31	0.78	0.25	0.34	0.25	0.31	0.29	0.35
Channel Catfish		0.03	0.09	0.09	0.09	0.06	0.06	0	0.03	0.06	0.06	0.06
White Perch		0.41	1.03	1.75	2.16	3.41	1.59	1.25	1.97	1.94	1.13	1.66
White Bass		0	0	0	0	0	0	0	0	0	0	0
Rock Bass		8.03	3.41	5.16	3.97	5.22	3.5	3.78	3.41	4.72	3.16	4.44
Pumpkinseed		0.19	0.09	0.16	0.38	0.16	0.56	0.22	0.34	0.34	0.13	0.26
Bluegill		0	0	0	0	0	0.09	0.09	0.03	0	0.03	0.02
Smallmouth Bass		2.22	1.34	2.66	3.09	1.97	2.25	1.81	2.06	1.53	2.44	2.14
Largemouth Bass		0.22	0.22	0.69	0.09	0.03	0.44	1.18	0.75	0.13	0.41	0.42
Black Crappie		0	0	0	0.03	0	0.03	0.13	0.09	0.03	0	0.03
Yellow Perch		18.78	9.03	16.69	7.94	7.5	8.88	7.28	9.06	12.38	11.28	10.88
Walleye		2.75	1.81	2.09	2.06	1.38	0.84	0.91	1.03	0.97	1.72	1.56
Freshwater Drum		0.03	0	0.03	0.03	0	0.03	0.03	0.03	0	0.03	0.02
TOTAL CATCH		34.37	19.34	33.16	22.93	21.78	19.97	19.66	21.37	24.50	22.69	24.17

Table 1. Relative abundance (number of fish per net night) and decadal average (Avg.) of species collected in the Lake St. Lawrence warmwater fisheries assessment, 1986-2021

	Year	2020	2021
Species	**# Nets**	32	32
Lake Sturgeon		0.03	0
Longnose Gar		0	.06
Bowfin		0	0
Alewife		0	0.31
Gizzard Shad		0.03	0.53
Rainbow Trout		0	0
Brown Trout		0	0
Lake Trout		0	0
Rainbow Smelt		0	0
Northern Pike		0.31	0.38
Muskellunge		0	0
Lake Chub		0	0
Carp		0	0.19
Golden Shiner		0	0.03
Fallfish		0.63	0.63
White Sucker		0.78	1.19
Silver Redhorse		0.06	0.06
Shorthead Redhorse		0.03	0.06
Greater Redhorse		0	0.03
Yellow Bullhead		0	0
Brown Bullhead		0.66	0.53
Channel Catfish		0	0.06
White Perch		1.25	1.41
White Bass		0	0
Rock Bass		5.09	4.63
Pumpkinseed		0.16	0.13
Bluegill		0.03	0
Smallmouth Bass		3.19	3.09
Largemouth Bass		0.25	0.09
Black Crappie		0	0.03
Yellow Perch		13.13	12.59
Walleye		1	1.94
Freshwater Drum		0	0.03
TOTAL CATCH		26.63	28.03

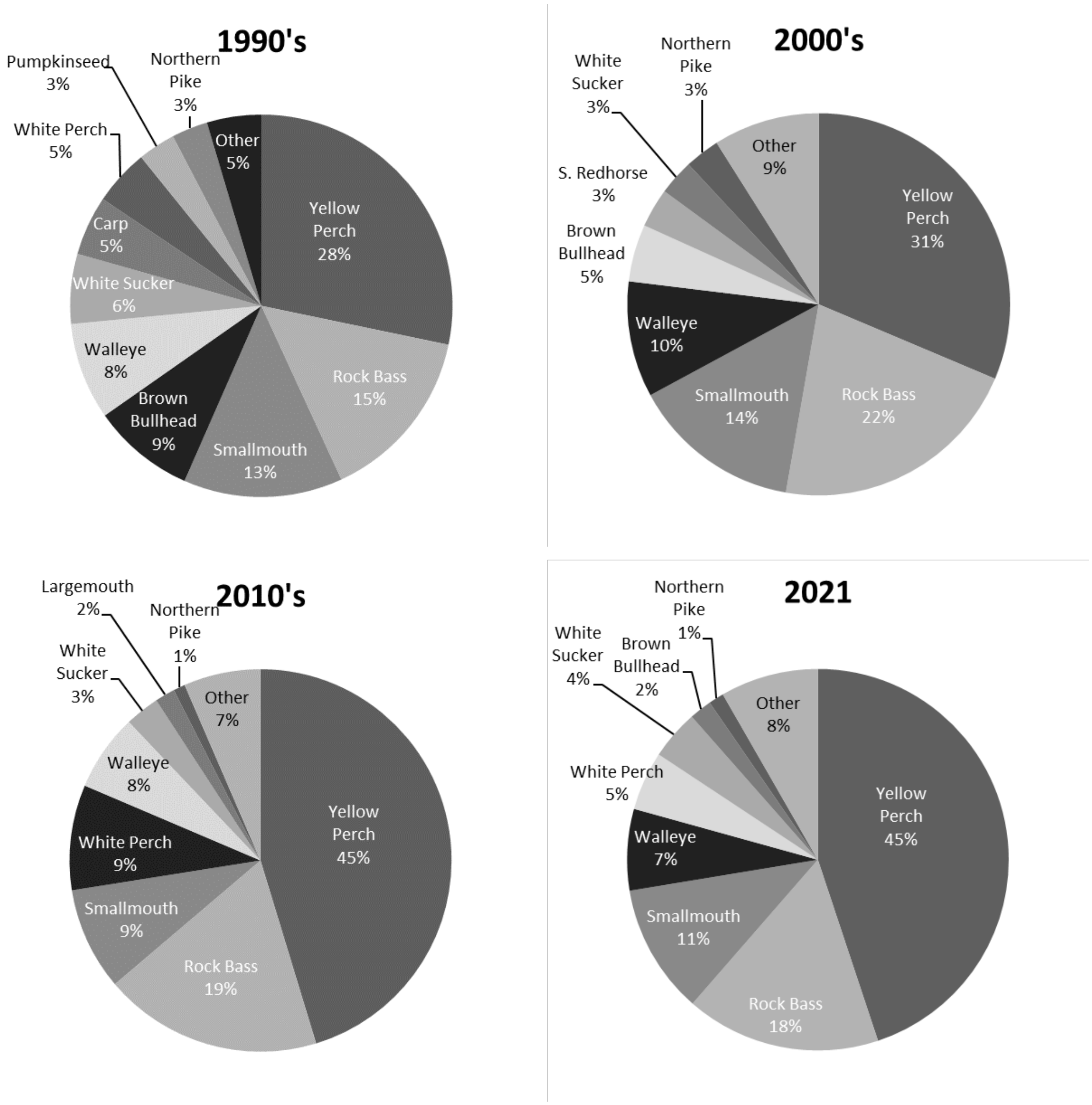

Figure 1. Composition of fish sampled in the Lake St. Lawrence warmwater fisheries assessment presented by decade and the 2021 sample year.

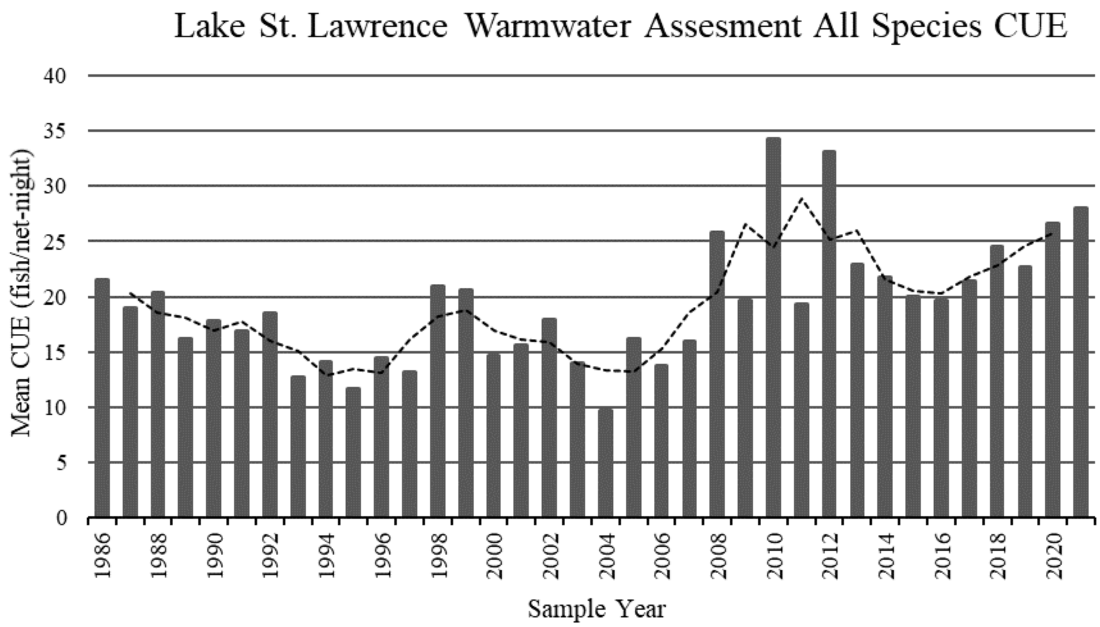

Figure 2. Mean catch per gill net night (CUE, fish/net-night) of all species for the Lake St. Lawrence warmwater fisheries assessment, 1986-2021. Line is a 3-year moving average.

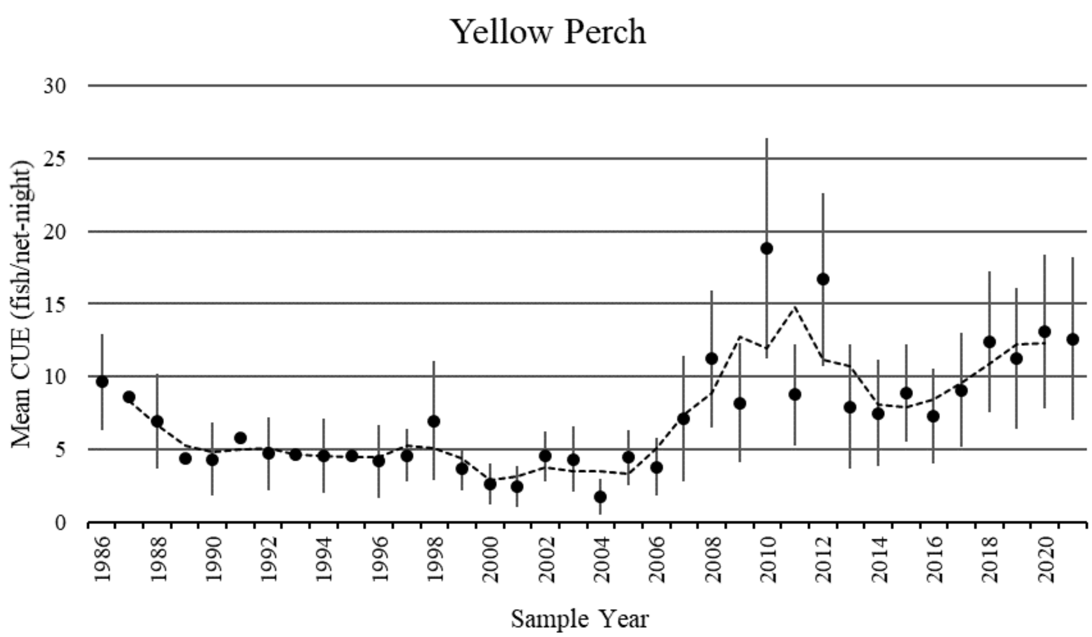

Figure 3. Yellow perch CUE of the Lake St. Lawrence warmwater fisheries assessment, 1986-2021. Mean catch per unit effort (CUE) with 95% confidence intervals and 3-year moving average (dashed line).

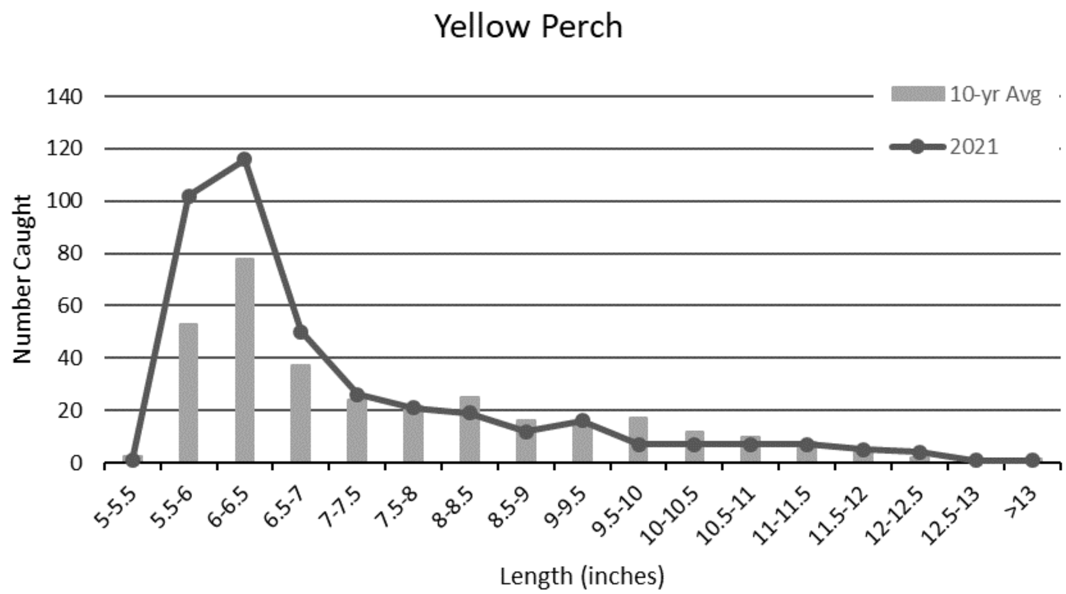

Figure 4. Yellow perch length-frequency distribution of the Lake St. Lawrence warmwater fisheries assessment in 2021 and the previous ten year average.

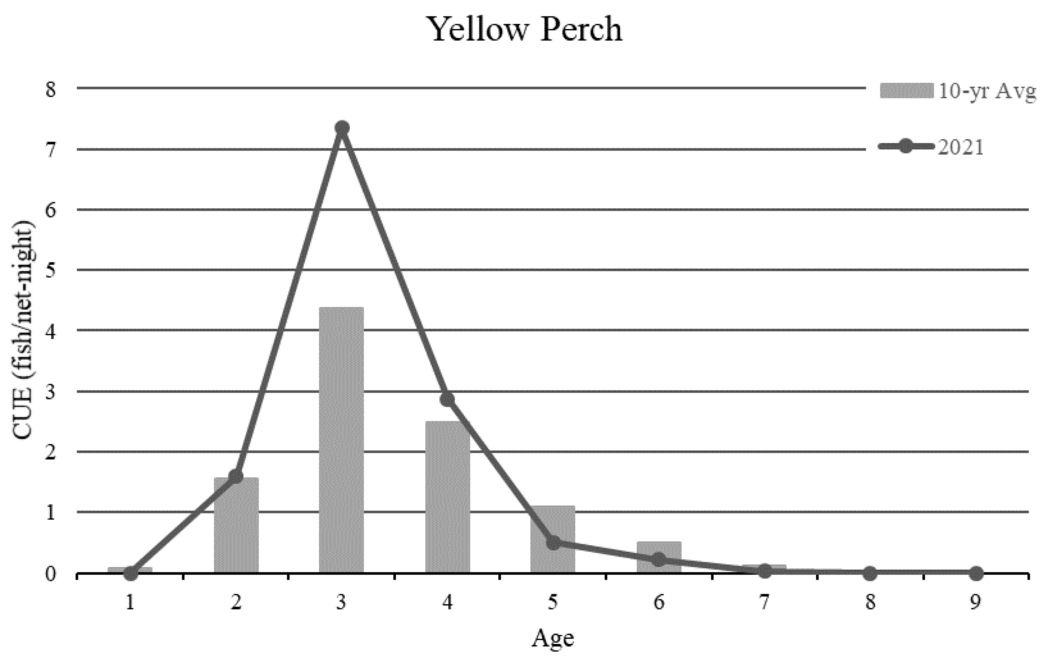

Figure 5. Yellow perch age-specific CUE of the 2021 Lake St. Lawrence warmwater fisheries assessment and the previous ten year average.

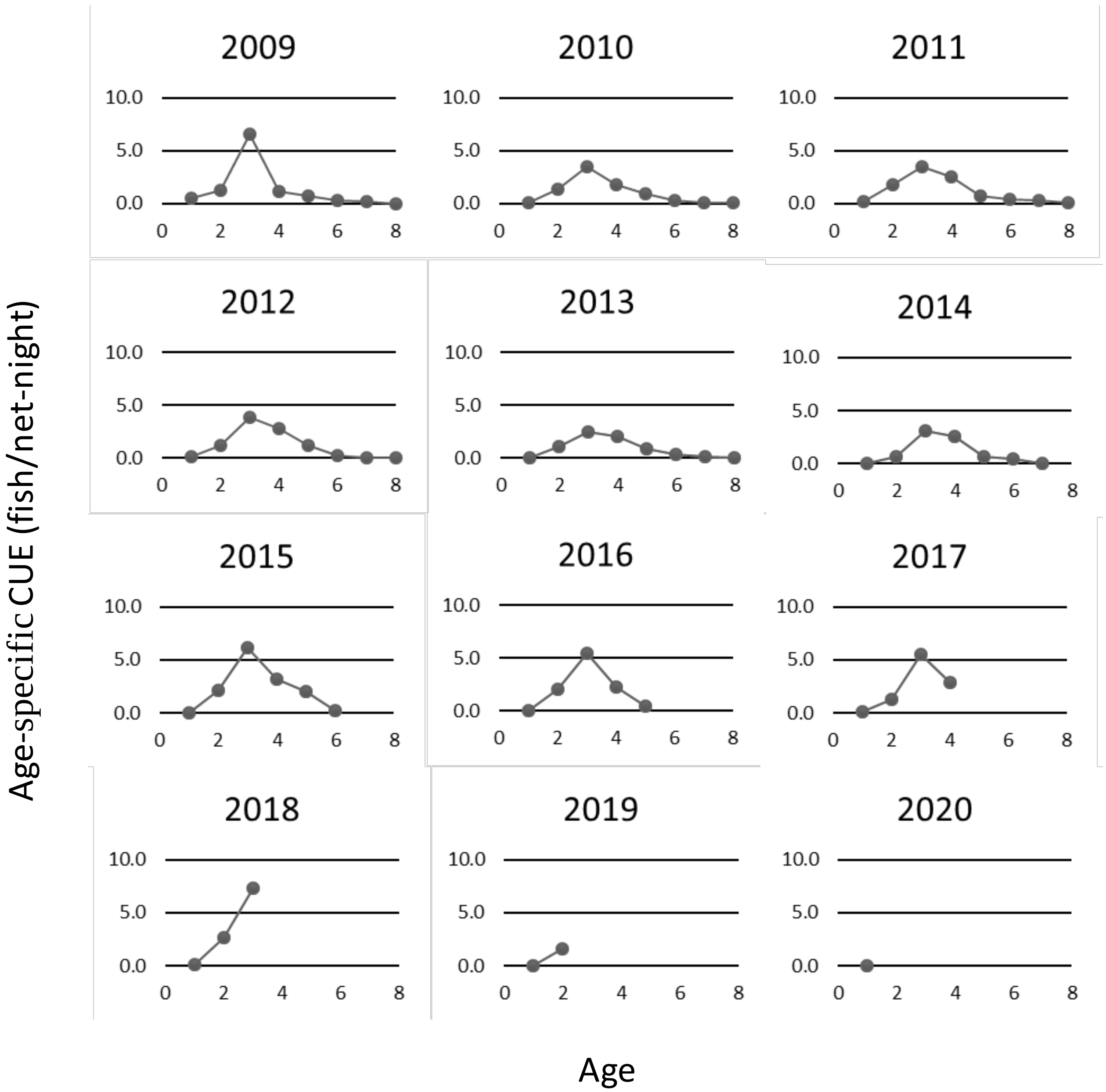

Figure 6. Year-class specific catch curves of yellow perch for the Lake St. Lawrence warmwater fisheries assessment.

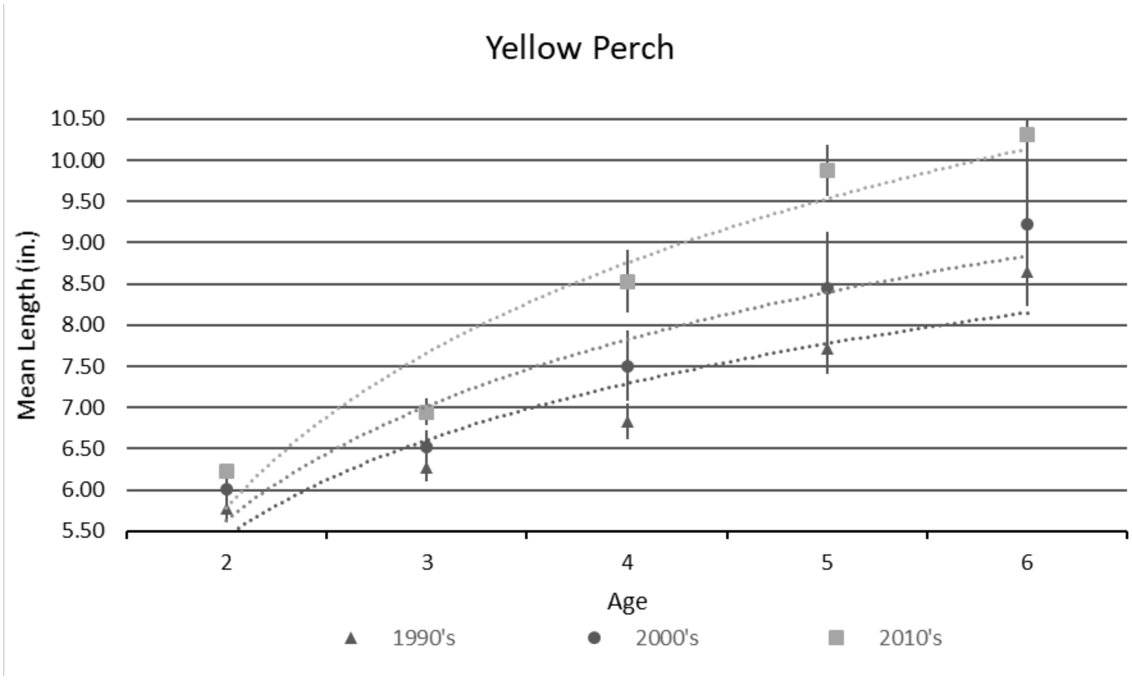

Figure 7. Decadal yellow perch growth using mean length at age (n ≥ 3) for the Lake St. Lawrence warmwater fisheries assessment. Dashed lines represent a logarithmic trend.

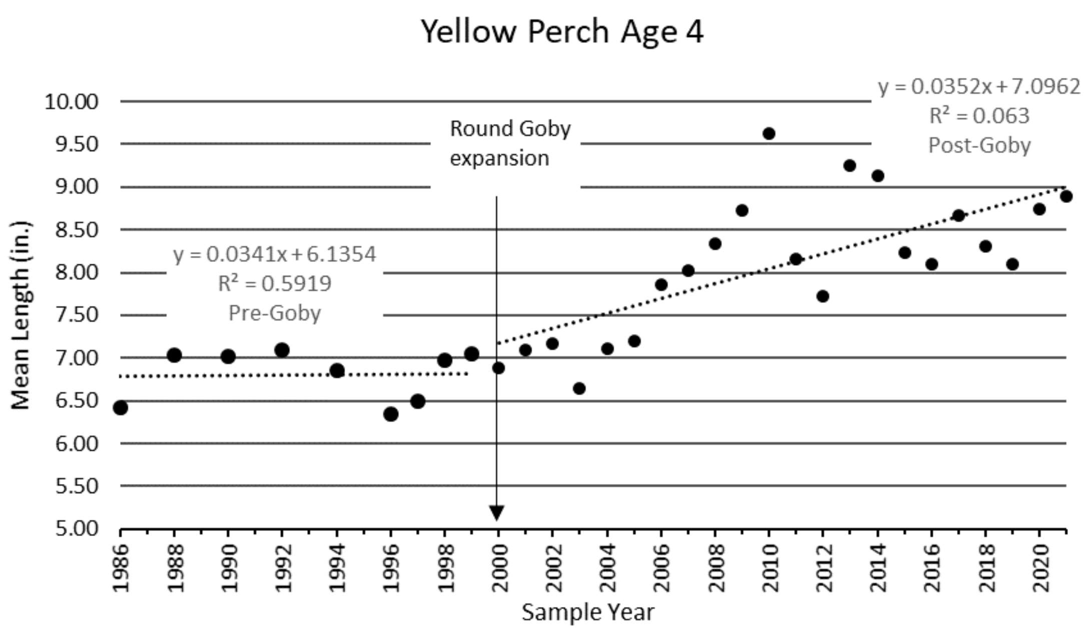

Figure 8. Mean length of age-4 yellow perch for the Lake St. Lawrence warmwater fisheries assessment 1986-2021.

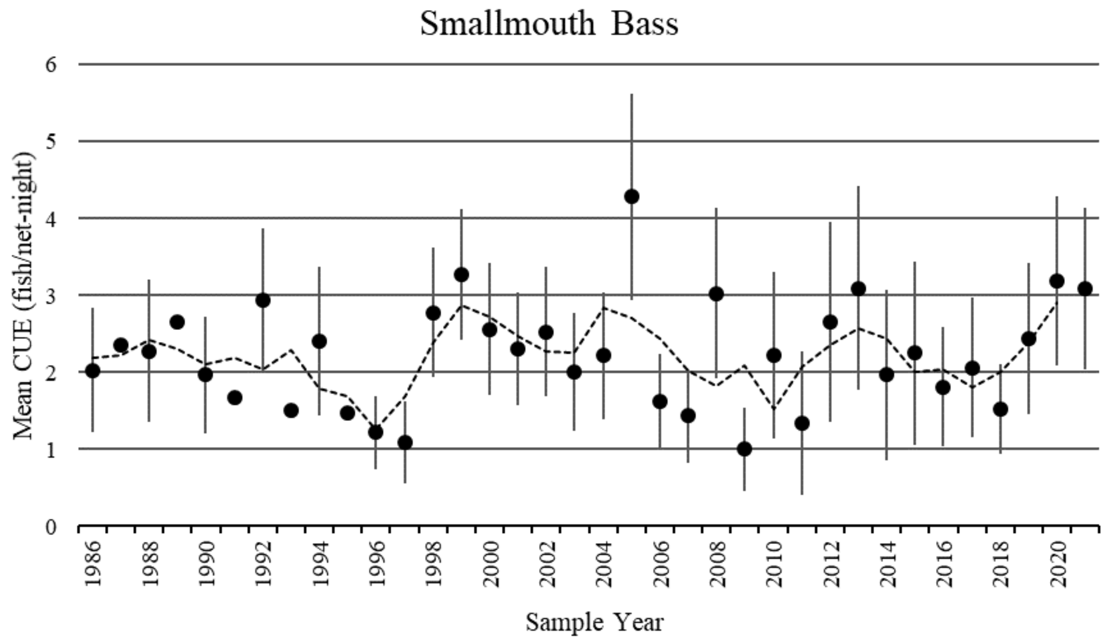

Figure 9. Smallmouth bass CUE of the Lake St. Lawrence warmwater fisheries assessment, 1986-2021. Mean catch per unit effort (CUE) with 95% confidence intervals and 3-year moving average (dashed line).

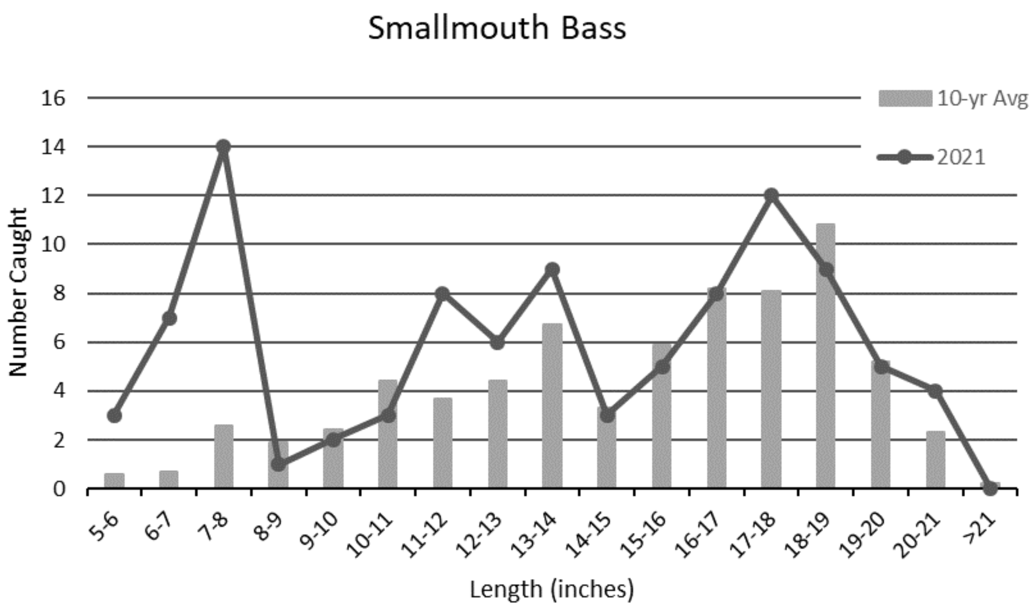

Figure 10. Smallmouth bass length-frequency distribution for the 2021 Lake St. Lawrence warmwater fisheries assessment and the previous ten year average.

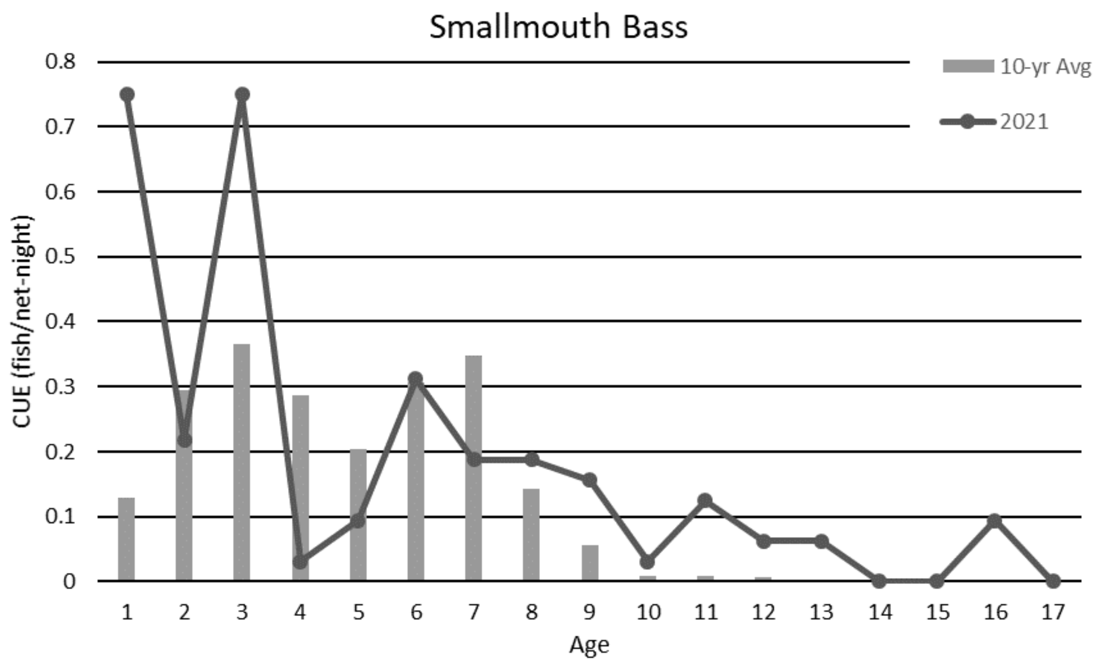

Figure 11. Smallmouth bass age-specific CUE for the 2021 Lake St. Lawrence warmwater fisheries assessment along with the previous ten year average.

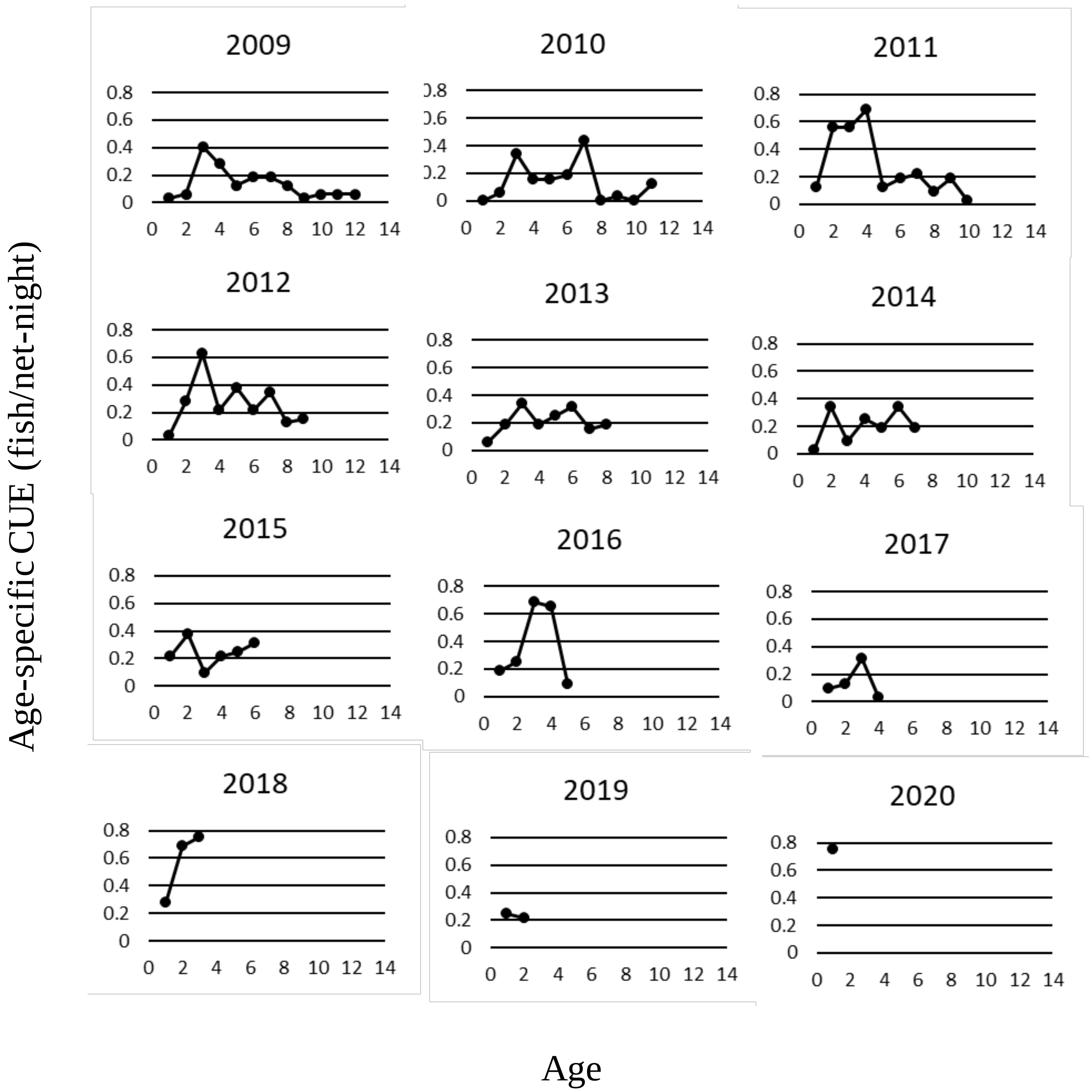

Figure 12. Year class specific catch curves for smallmouth bass in the Lake St. Lawrence warmwater fisheries assessment.

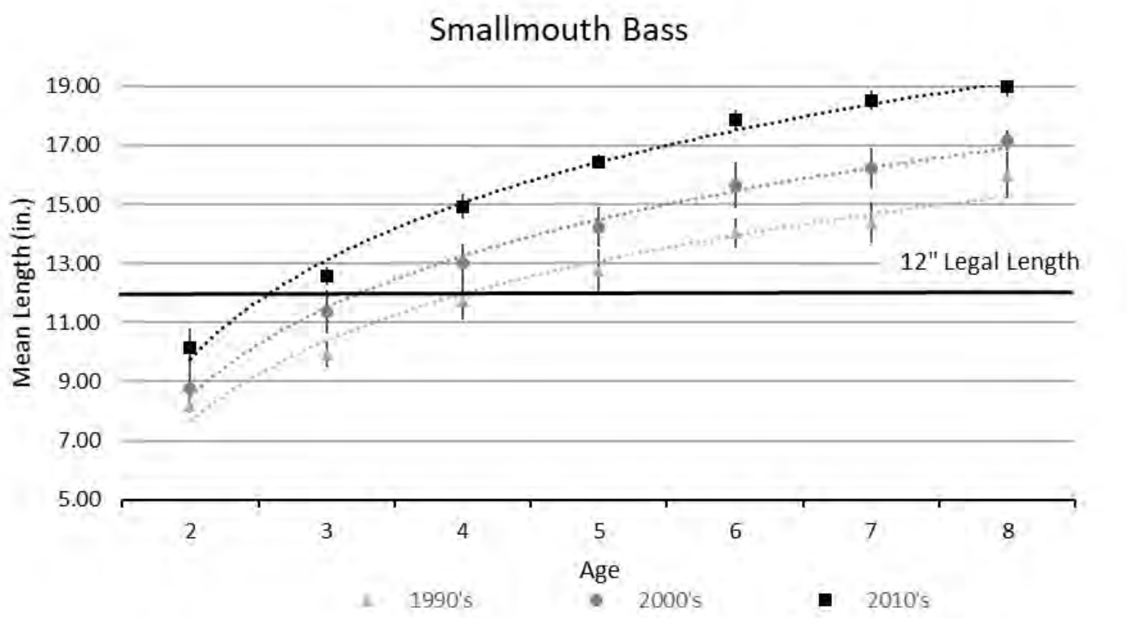

Figure 13. Decadal smallmouth bass growth using mean length at age (n≥3) for the Lake St. Lawrence warmwater fisheries assessment. Dashed lines represent a logarithmic trend.

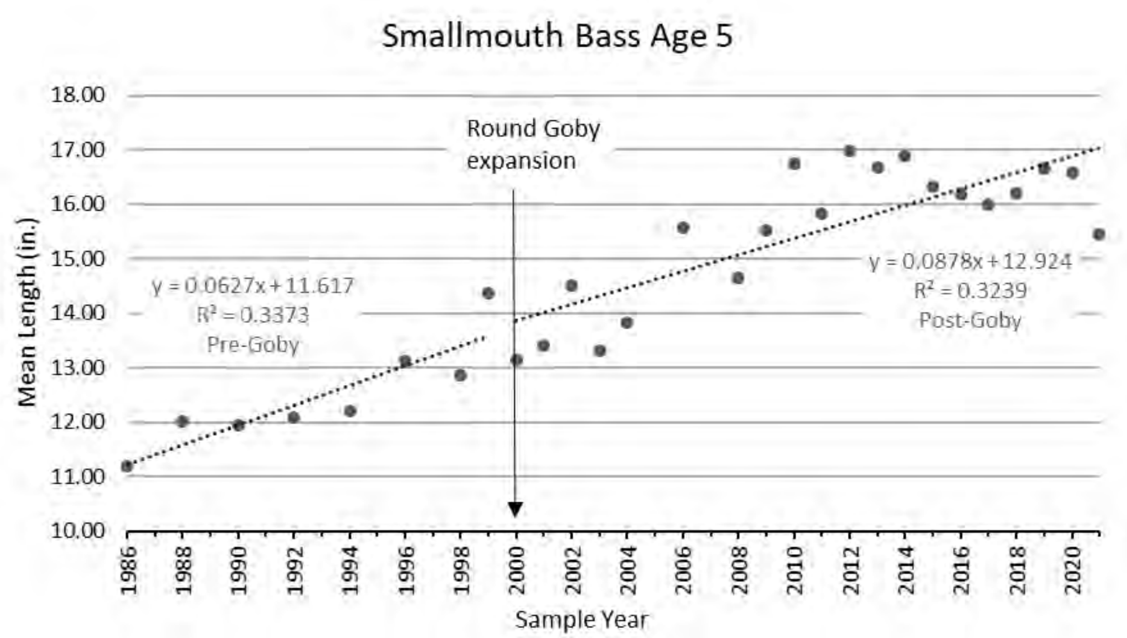

Figure 14. Mean length of age-5 smallmouth bass in the Lake St. Lawrence warmwater fisheries assessment 1986-2021.

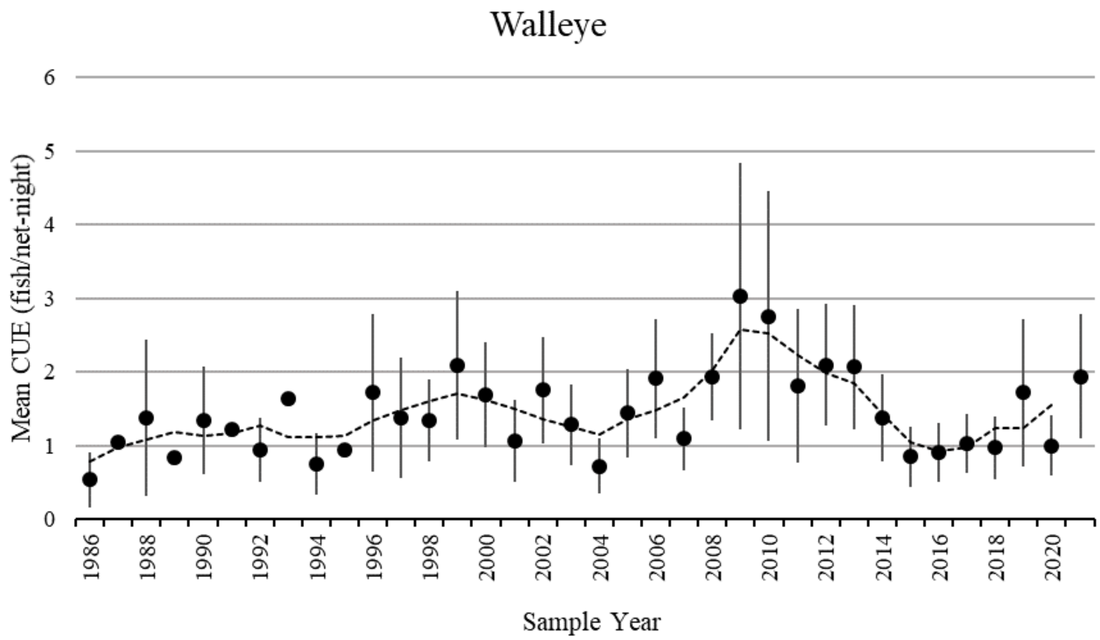

Figure 15. ***Walleye CUE of the Lake St. Lawrence warmwater fisheries assessment, 1986-2021. Mean catch per unit effort (CUE) with 95% confidence intervals and 3-year moving average (dashed line).***

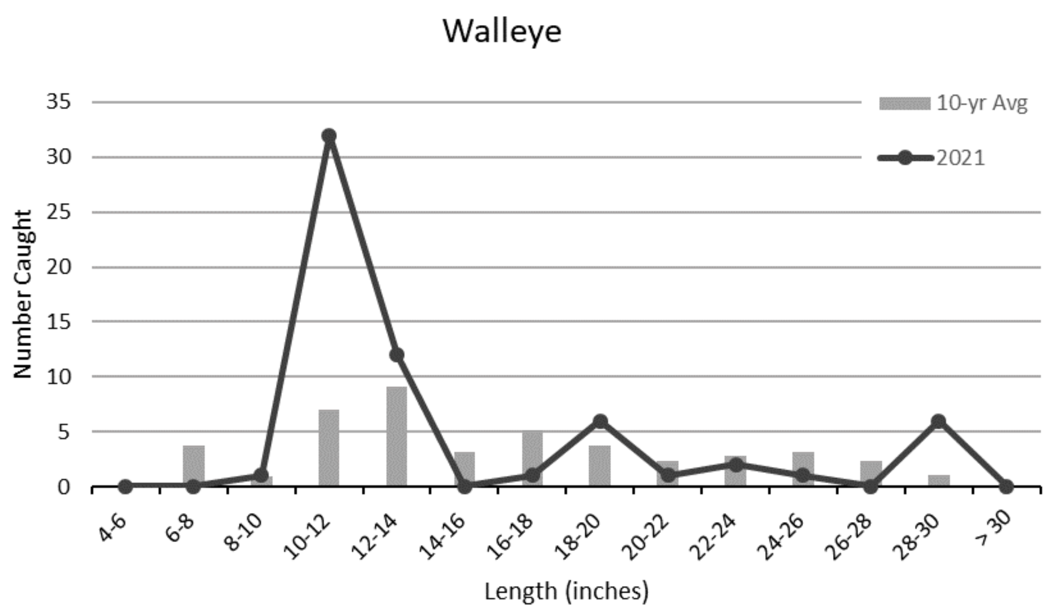

Figure 16. ***Walleye length-frequency distribution for the 2021 Lake St. Lawrence warmwater fisheries assessment, and the previous ten year average.***

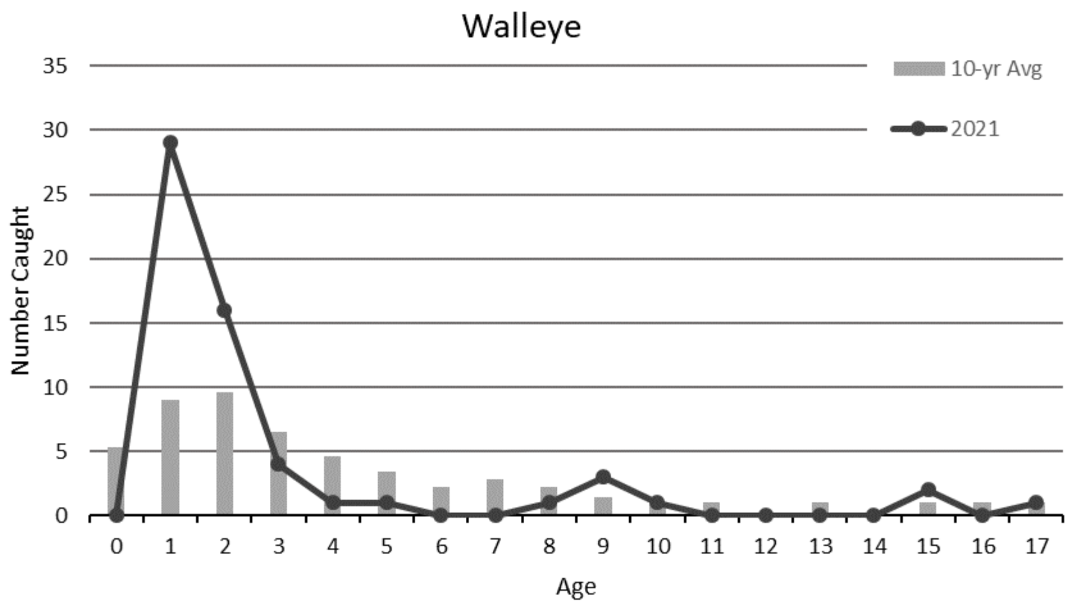

Figure 17. Walleye age-frequency distribution for the 2021 Lake St. Lawrence warmwater fisheries assessment, and previous ten year average.

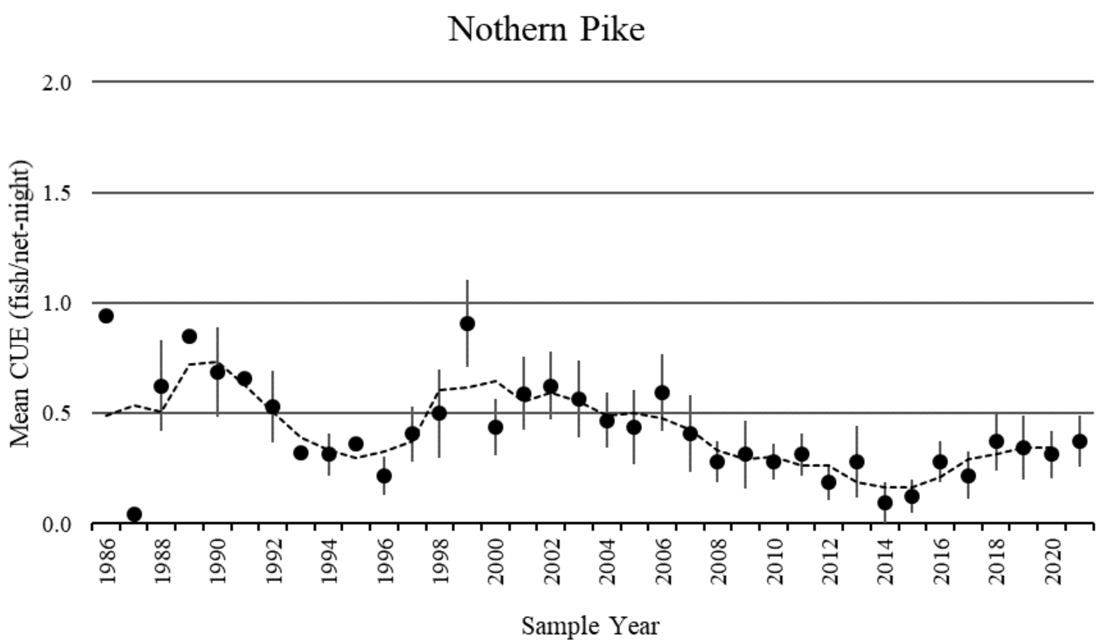

Figure 18. Northern pike CUE of the Lake St. Lawrence warmwater fisheries assessment, 1986-2021. Mean catch per unit effort (CUE) with 95% confidence intervals and 3-year moving average (dashed line).

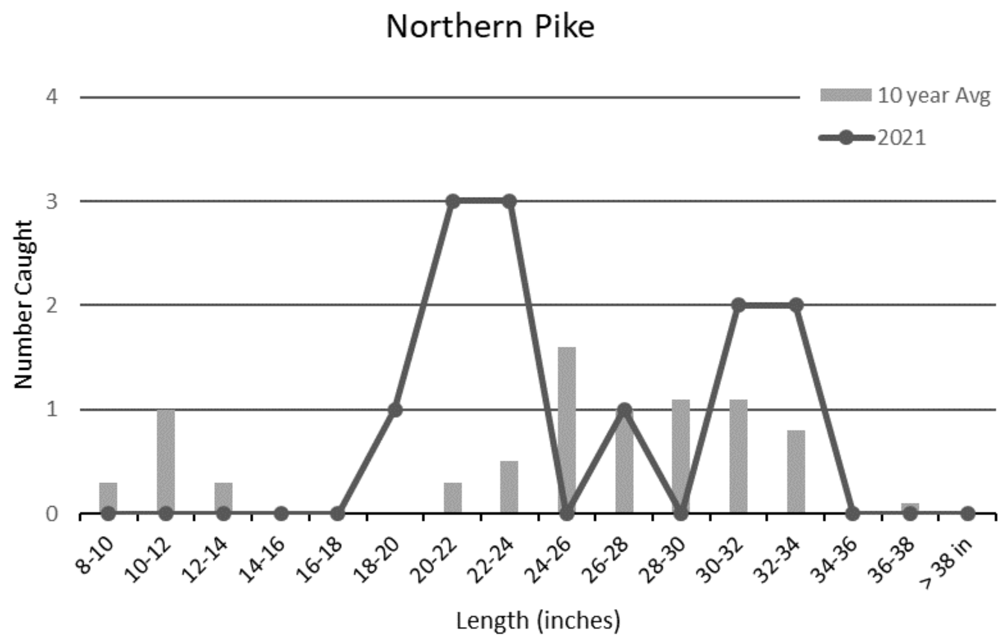

Figure 19. Northern pike length-frequency distribution for the 2021 Lake St. Lawrence warmwater fisheries assessment, and previous ten year average.

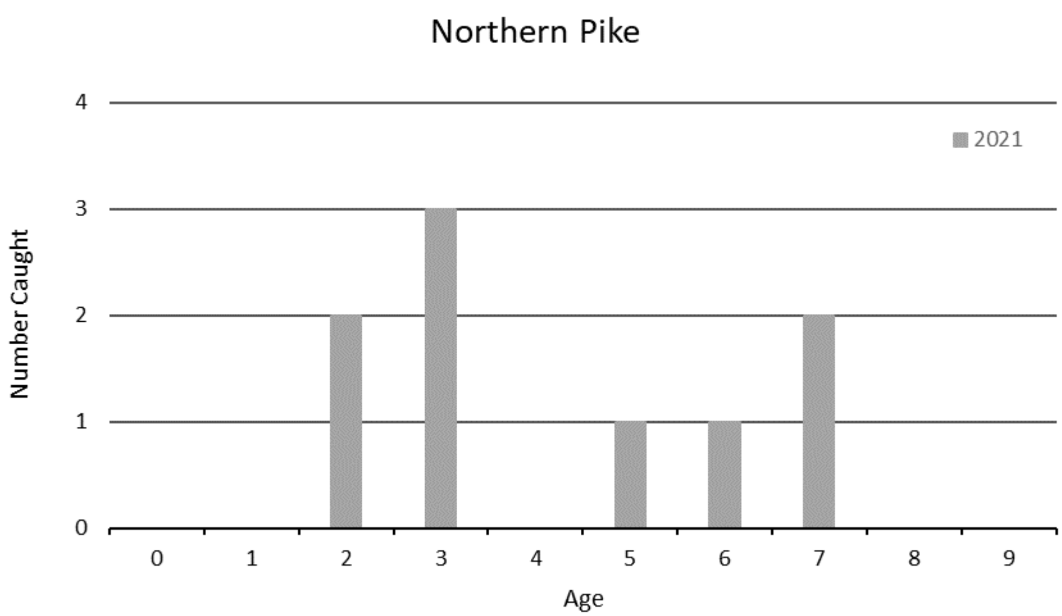

Figure 20. Northern pike age-frequency distribution for the 2021 Lake St. Lawrence warmwater fisheries assessment.

2021 Salmon River Wild Young-of-Year Chinook Salmon Seining Program

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

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

Methods

The survey design calls for weekly seine hauls during May and June at 4 sites: Altmar, Pineville, County Rt. 2A, and Douglaston (Figure 1). The bag seine was 20 feet wide by 6 feet deep with 1/8th inch bar mesh. Hauls were made by stretching the seine perpendicular to the current and sweeping toward one bank to a suitable landing area. A sample consisted of one seine haul per site. Obstacles on the river bottom and differences in the lengths of the hauls prevented the use of catches per unit of effort as precise density estimates but the range of numbers captured between sites and dates do provide an estimate of relative abundance. All species captured were counted and a sub-sample of up to 30 Chinook salmon were measured (total length) for each haul.

We calculated “mean peak catches” for each year from 2001 to the present to provide an index of relative abundance. We used the average number of YOY Chinook salmon caught per seine haul for the three consecutive weeks with the highest catches in each year. High flows prevented sampling the third week of May in 2011, which was likely the peak week, so we used the average of the second and fourth weeks in May to generate the likely conservative mean peak catch estimate. Catches likely peaked in the fourth week of May 2013, and we were unable to sample the first week of June. We therefore used the mean from the second through fourth weeks of May to estimate mean peak catch. In 2019, high flows the third week of May prevented sampling the Douglaston site, so we assigned a catch of 200 based upon numbers observed in previous years with similar catches. Various weeks were also missed in other years which did not influence the mean peak catch estimates.

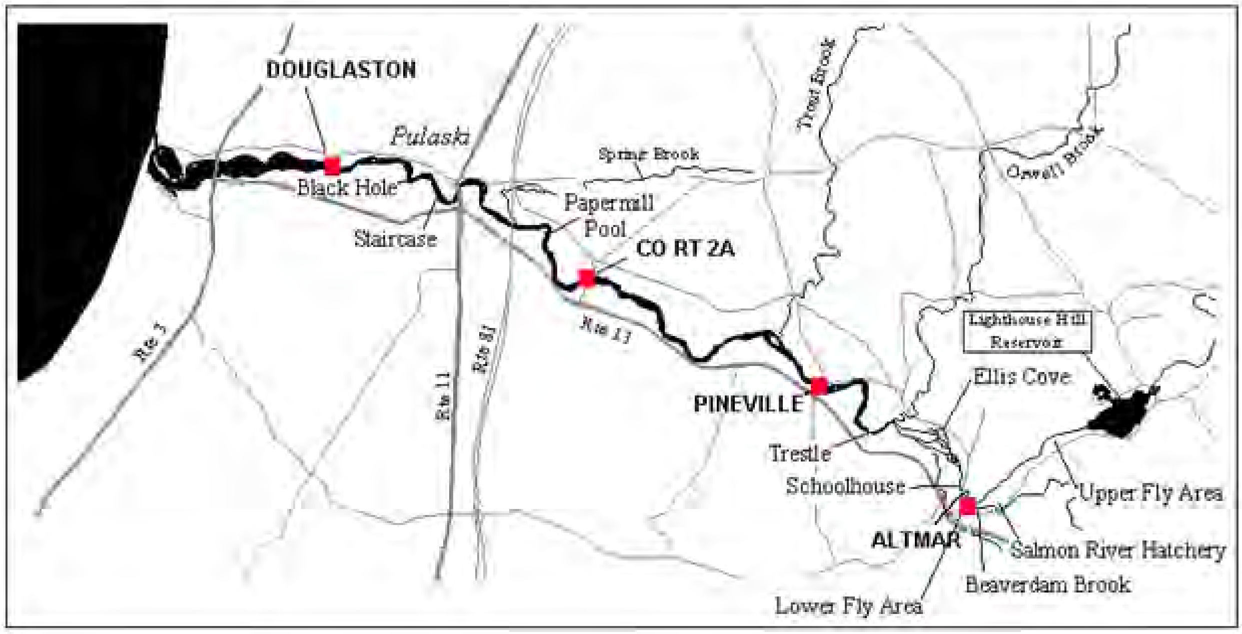

Figure 1. Sampling sites for the NYSDEC Salmon River seining program.

Prior reports have included efforts to explain the variability in the catches using various aspects of flow and temperature effects. However, these predictors were overly simple and are not presented here. Unexpectedly high production in 2019, and that we now have over 20 years of data on Chinook salmon reproduction in the Salmon River have led us to explore additional factors that also likely influence production. In addition to temperature during the incubation period, we found that the condition and abundance of the spawning fish were also important factors influencing production, and the results of these efforts will be reported in a separate publication.

Results and Discussion

The mean peak YOY Chinook salmon catch in 2021 was 350 fish/haul which is slightly below the average catch rate (mean=377 fish/haul) in the study period (Figure 2). The three weeks used to calculate the mean peak catch were the third week of May through the first week of June and abundance dropped sharply by the second week of June (Figure 3). The largest haul for a single site was 997 which occurred the first week of June (the 6th) at Altmar (Figure 4) and the highest catches for all sites combined (1,570) also occurred the same week.

The size distribution of the fish sampled was typical of those seen in past years. Generally, the fish grew larger as the survey progressed (Figure 5).

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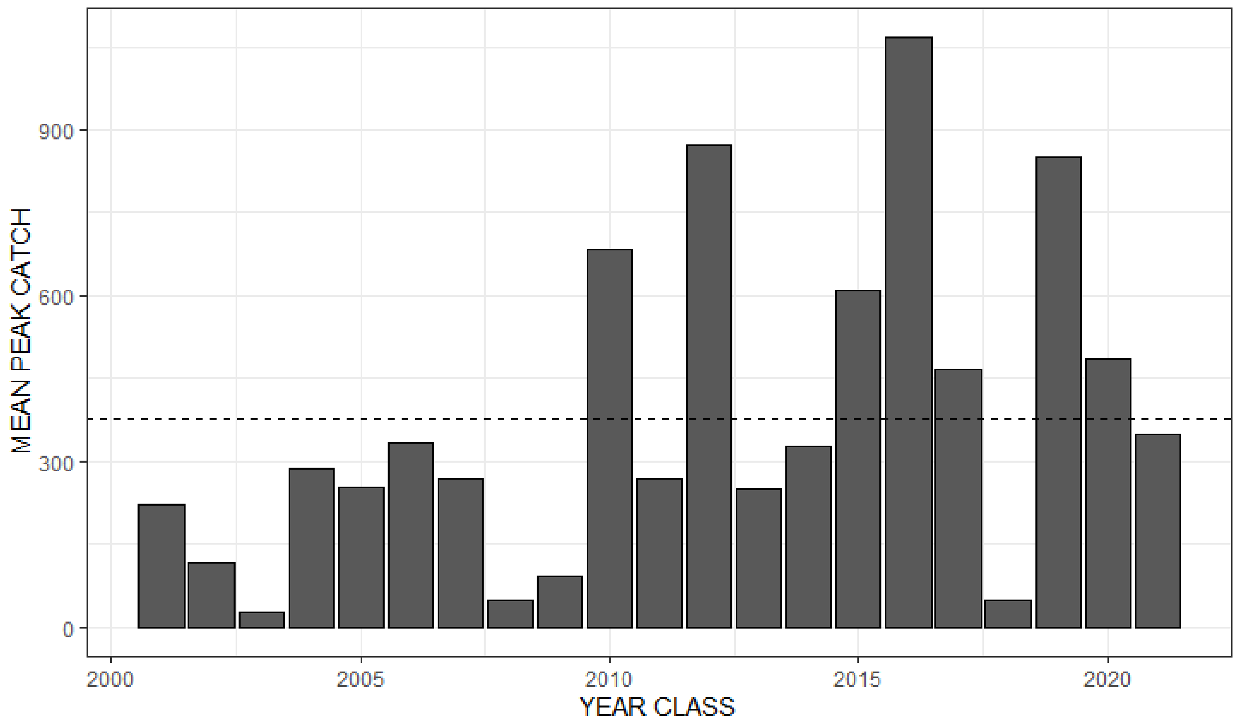

Figure 2. Mean peak catches of YOY Chinook salmon (mean number per seine haul) captured in the three consecutive weeks with the highest catches from the NYSDEC Salmon River seining program 2001-2021. The mean peak catch for all years sampled (the dashed line) is 377.

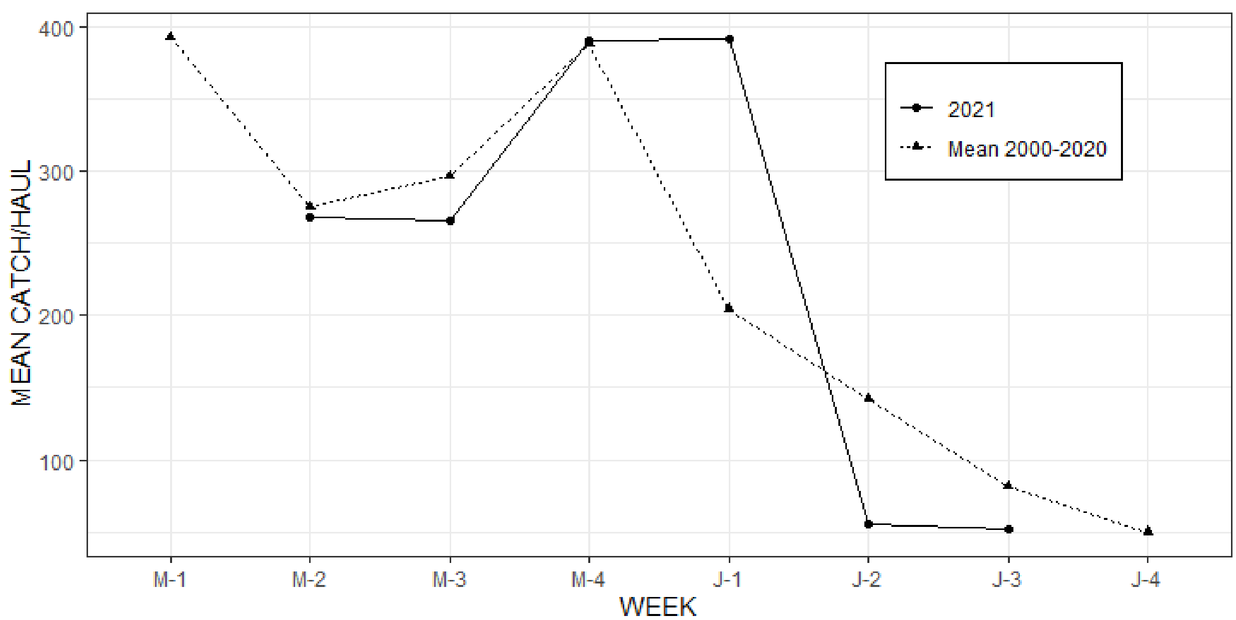

Figure 3. Mean numbers of YOY Chinook salmon captured per seine haul by week in the NYSDEC Salmon River seining program for 2001-2020 and 2021 (M=May, J=June).

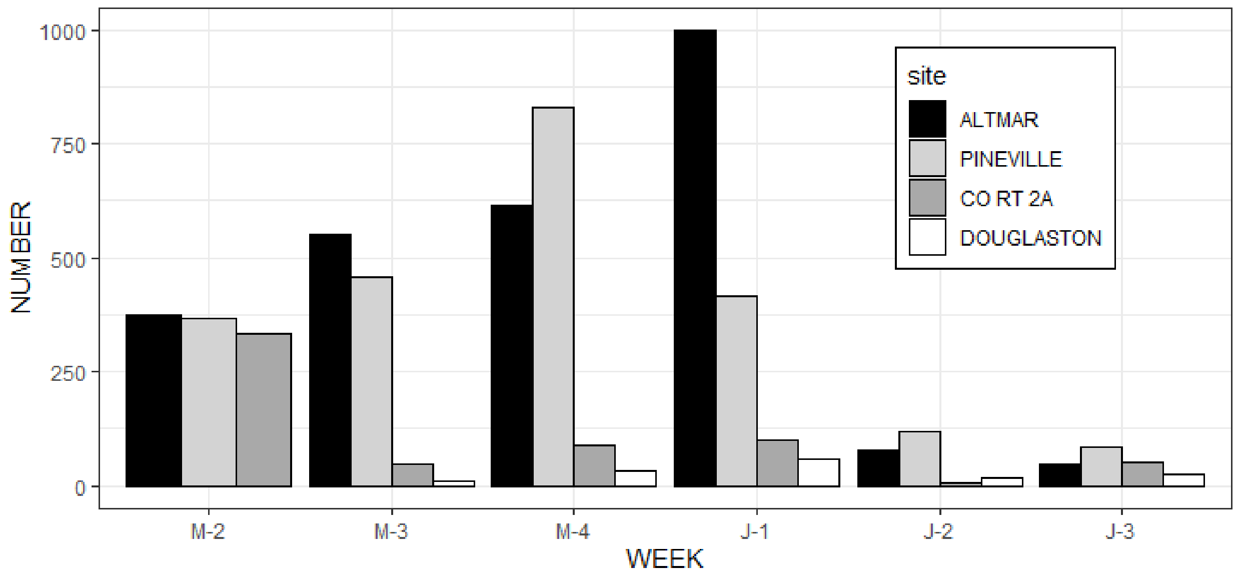

Figure 4. Numbers of YOY Chinook salmon caught by week and site from the NYSDEC Salmon River seining program 2021.

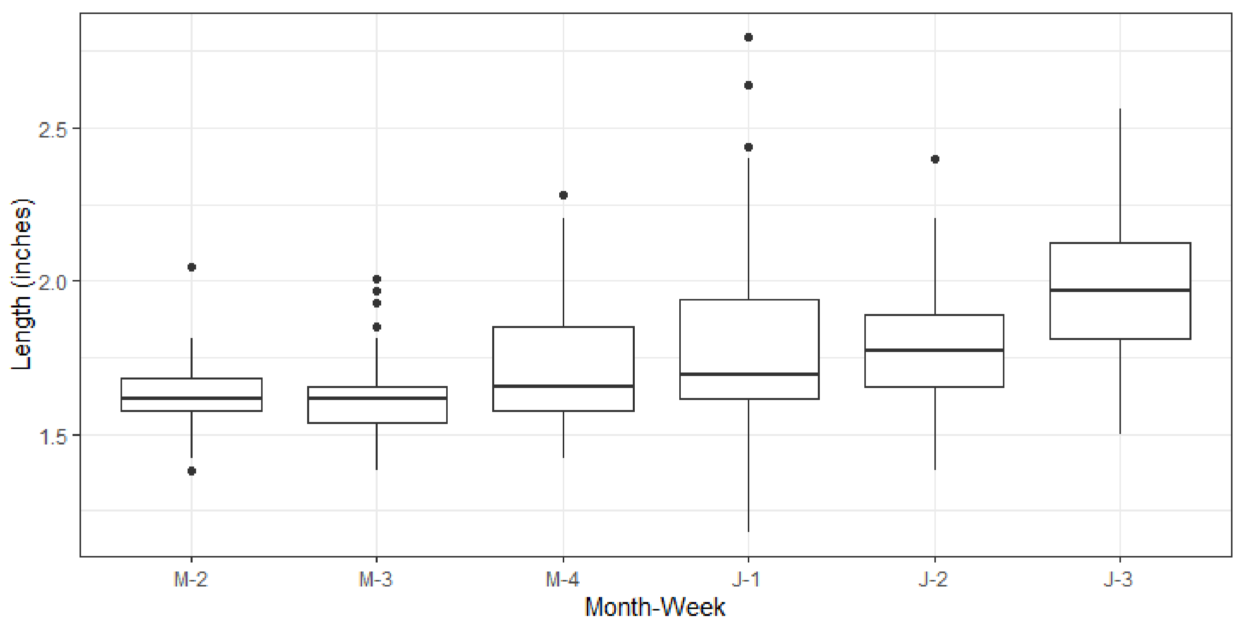

Figure 5. Weekly size distributions of catches of YOY Chinook Salmon for the NYSDEC Salmon River seining program 2021. Twenty five percent of the fish measured each week lied below the bottom of the boxes, 50% lied below the heavy horizontal lines in the boxes (i.e., the medians) and 75% lied below the tops of the boxes. The range of measurements lied between the tops and bottoms of the vertical lines except for the individual dots which represent outliers.

Population Characteristics of Pacific Salmonines Collected at the Salmon River Hatchery 2021

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

Methods

Hatchery Sampling

Staff at the Salmon River Hatchery processed 1,350 steelhead during spring 2021 spawning operations (Kinney 2021a). Adult Washington strain (Chamber's Creek) winter run fish comprised 100% of the returns. No marked Skamania strain fish (adipose fin) entered the hatchery.

A total of 1.5 million Washington strain steelhead eggs were taken from 445 females. There were no Skamania eggs collected due to a lack of fish and that we are no longer maintaining that strain of steelhead.

Returns of Pacific salmon in the fall included 2,478 Chinook salmon and 508 coho salmon. Biological data were collected at the hatchery from 671 Chinook salmon and 199 coho salmon. The egg totals were 2.6 million Chinook salmon from 556 females and 495,000 coho salmon from 163 females (Kinney 2021b).

All statistical analyses were done with R statistics software package (RStudio version 1.1.463 2018). ANOVAs of all weight at age comparisons over a series of years were done with the Tukey's Studentized Range test multiple comparison procedure with the type I experiment-wise error rate set at $\alpha = 0.05$.

Results and Discussion

Chinook Salmon

Growth

The mean weight of age-1 Chinook salmon males (jacks) sampled in 2021 was 5.3 pounds, which is approximately 0.5 lbs. above average in the 1986-2021-time series (Figure 1) and weighing significantly less than 22 of the years measured. However, their weight was not significantly different than any year since 2014. Age-2 males were 11.9 pounds, 1.3 pounds below the long-term average and significantly different than 26 of 35 years measured. Age-2 females were 12.6 pounds, 1.7 pounds below the long-term average, but 2 pounds heavier than 2020 (Figure 2). Age-3 males were 15.1 pounds, which is 3.3 pounds below average, and significantly lighter than weights observed in 22 of 35 years compared. Age-3 females were 15.9 pounds, 2.7 pounds below the long-term average, and lighter than 24 of the 35 years in the time series, but not significantly different from 10 of the 35 years (Figure 2). Mean lengths and weights at age for all species sampled in 2021 are provided in Table 1.

Wet weight condition of Chinook salmon was measured by predicting the weight of a 36-inch fish from linear regressions on natural log transformed lengths and weights. The predicted weight was 15.8 pounds in 2021, 0.8 pounds below the long-term average. This is a slight reduction in condition after two years of an uptick in estimates, although still below average (Figure 3). The hatchery egg-take and associated biological data collection described here was delayed by a week in 2021 due to warm water temperatures. That additional week of residing in the river and not eating likely impacted the fish weight and condition. The warmer temperatures also may have kept their metabolism higher thus dropping their weight more than during a typical year.

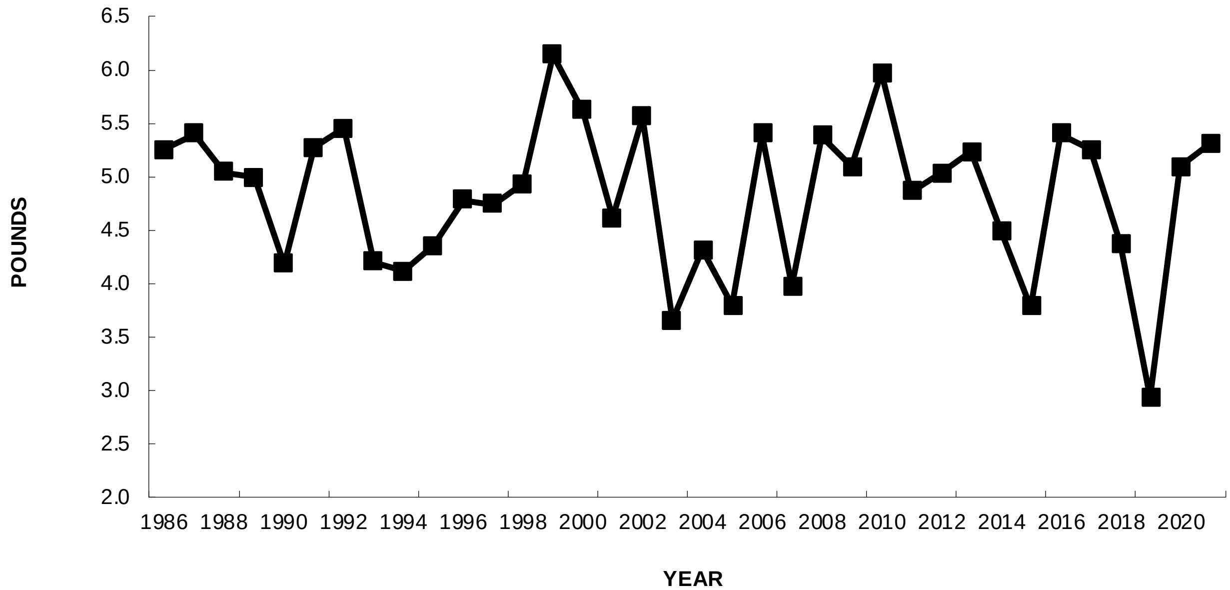

Figure 1. Mean weights of Chinook salmon jacks at Salmon River Hatchery, 1986-2021.

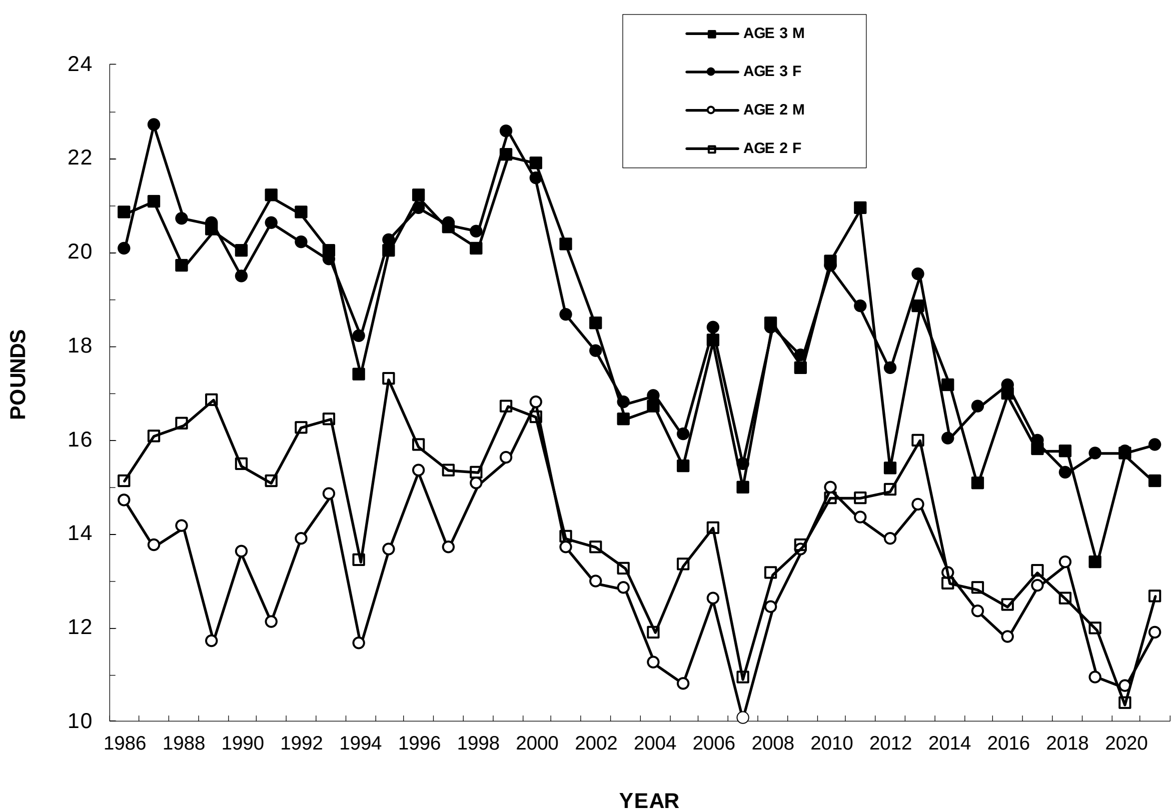

Figure 2. Mean weights of age 2 and 3 Chinook salmon at Salmon River Hatchery, 1986-2021.

Table 1. Mean lengths and weights of Chinook salmon, coho salmon, and steelhead sampled at Salmon River Hatchery 2021 (STD= standard deviation).

AGE	SEX	N	MEAN LENGTH (in)	STD	MEAN WEIGHT (lbs)	STD
			CHINOOK SALMON			
1	M	27	24.7	1.0	5.3	0.7
2	M	245	32.9	2.0	11.9	2.4
2	F	110	32.5	1.6	12.6	2.0
3	M	59	36.3	2.2	15.1	3.1
3	F	200	35.6	2.0	15.9	2.7
			COHO SALMON			
1	M	4	17.1	1.2	1.6	0.3
2	M	90	28.4	2.3	7.1	2.0
2	F	102	28.1	1.4	7.9	1.4
			WASHINGTON STEELHEAD			
3	M	62	25.8	2.9	5.6	2.0
3	F	57	27.9	1.6	7.5	1.3
4	M	19	29.8	2.9	8.5	2.3
4	F	72	29.0	1.7	8.6	1.6
5	M	1	30.2		8.3	
5	F	5	29.1	0.83	8.2	0.97

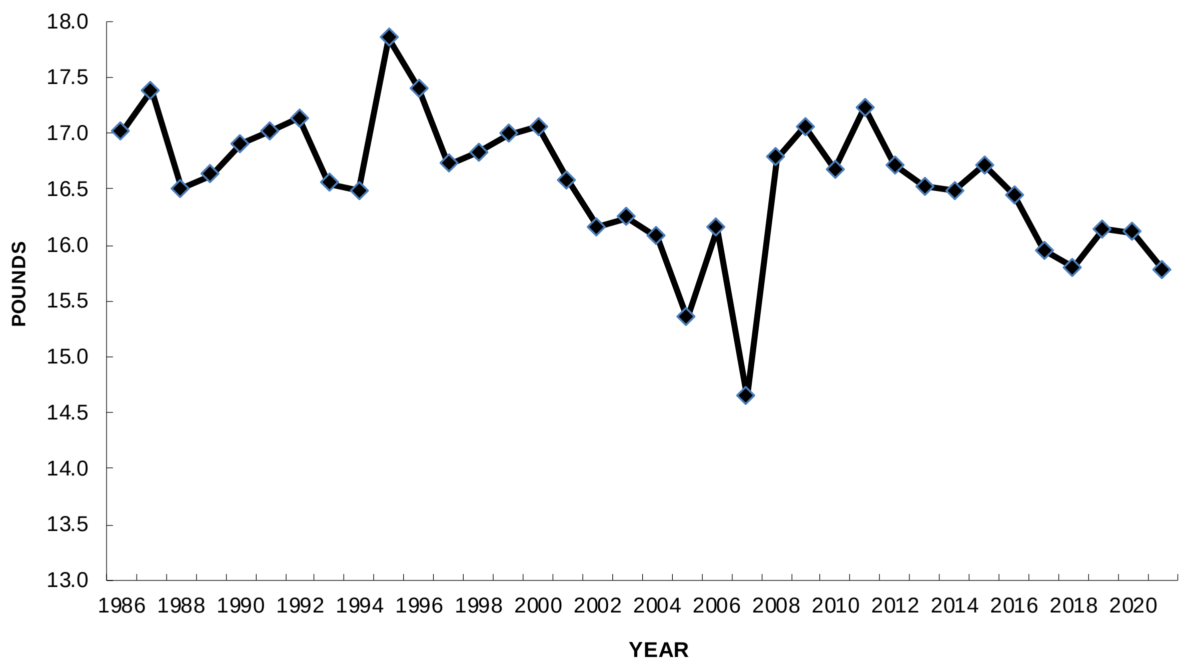

Figure 3. Estimated weights of a 36-inch Chinook salmon from the Salmon River Hatchery fall (October) collections 1986-2021.

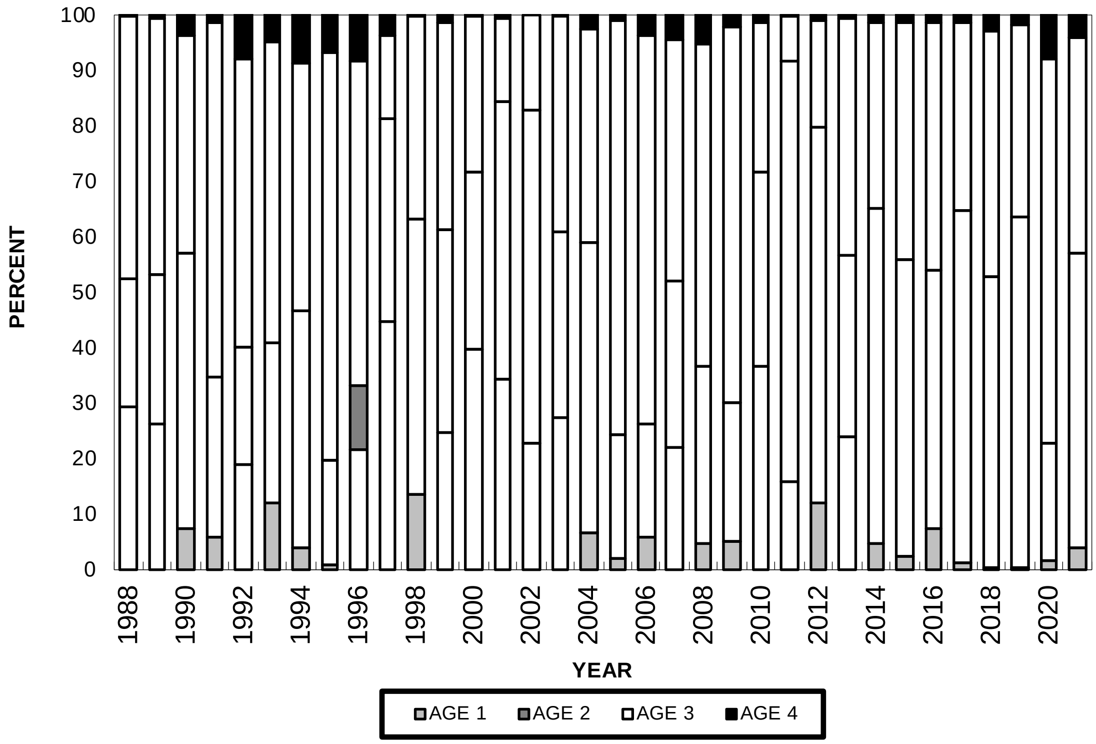

Figure 4. Estimated age structures of Chinook salmon sampled at Salmon River Hatchery 1988-2021.

<u>Age Structure</u>

The estimated age structure of the 2021 Chinook salmon run to the Salmon River Hatchery was 4% age-1, 53% age-2, 39% age-3, and 4% age-4 (Figure 4). Changes in the dominant age represented in the run are likely influenced strongly by relative Chinook salmon year class strength. Age-2 Chinooks rebounded from a relatively low percentage of the hatchery run in 2020 when they were at the lowest level since 2006.

Coho Salmon

<u>Growth</u>

The average weight of age-2 female coho salmon in 2021 was 7.9 pounds, over 2 pounds more than in 2020. They were 0.2 pounds lighter than the long-term average (8.1 pounds, Figure 5). Age-2 males weighed 7.1 pounds, 0.8 pounds less than the long-term average (7.9 lbs., Figure 5). The 2021 males were near average in the time-series but weighed significantly less than 16 other years. Female coho weights were near average in 2021 but were significantly lighter than fish sampled in 13 of 35 years.

Washington Steelhead

<u>Growth</u>

Steelhead are sampled in the spring and, unlike Chinook and coho salmon weights, their weights do not represent growth during the 2021 growing season. Weights reported here reflect growing conditions prior to and including 2020. The mean weights of age-3 males and females were 4.7 and 5.8 pounds, respectively. The males and females were 0.5 and 2.5 pounds lighter than their respective long-term averages (Figure 6). The mean weights of age-4 males and females were 6.0 and 7.8 pounds, respectively, with males 2.5 and females 1.2 pounds lighter than their long-term averages (Figure 6). Age-3 females in 2021 (5.8 lbs.) were in the near average range for the time series and significantly lighter than six of the 32 years. Age-3 males were among the lowest observed weights and weighed significantly less than 23 of the 32 observations.

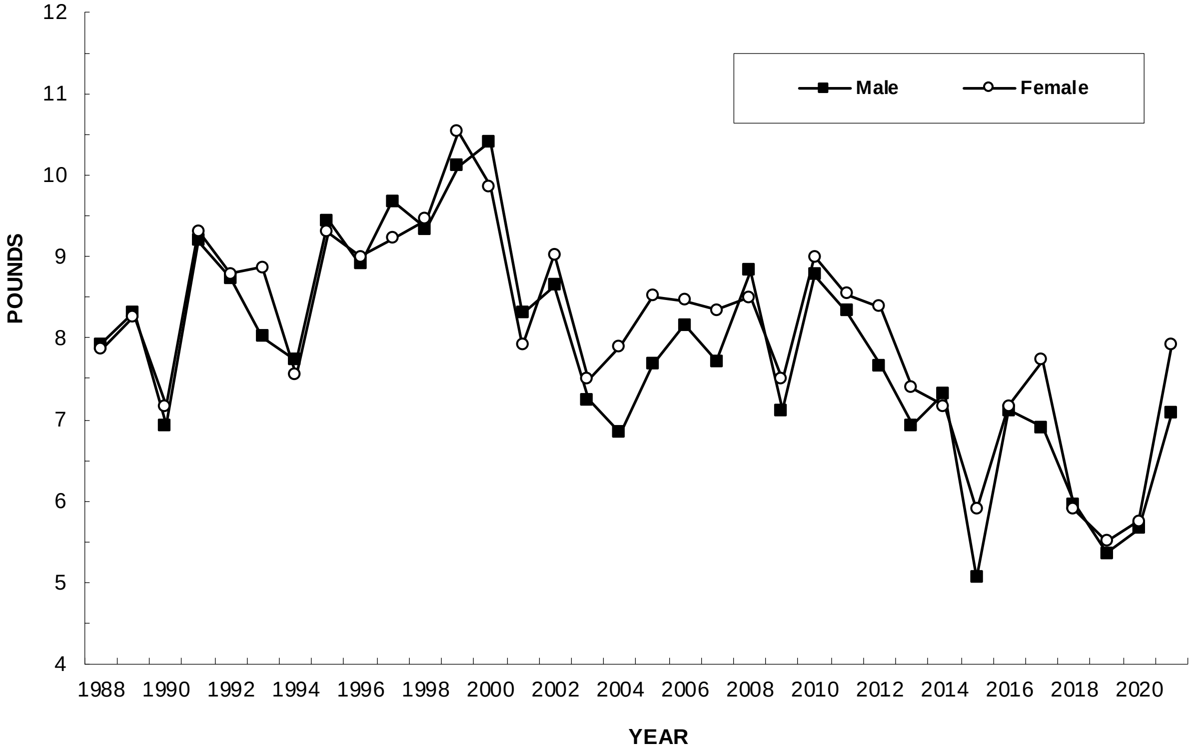

Figure 5. Mean weights of age-2 coho salmon at Salmon River Hatchery, 1988-2021.

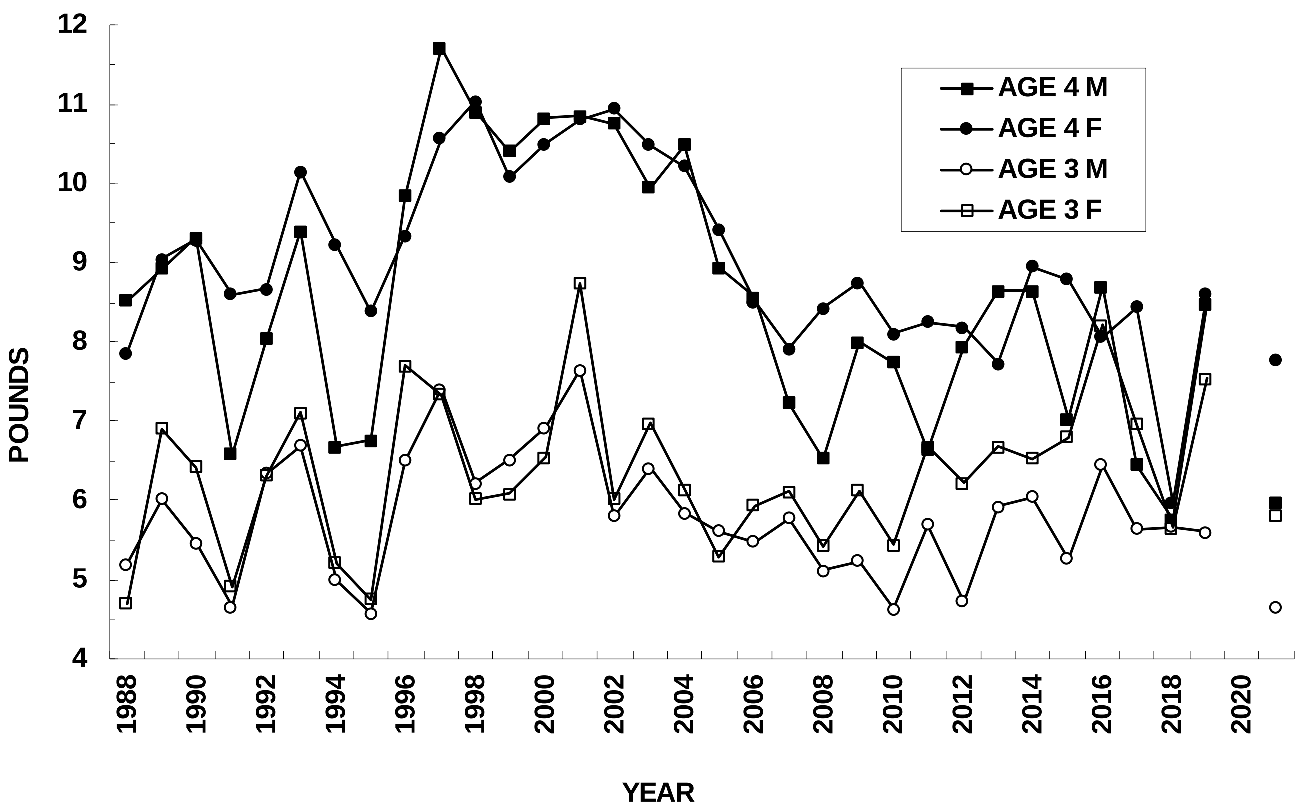

Figure 6. Mean weights of ages 3 and 4 Washington steelhead at Salmon River Hatchery, 1988-2021.

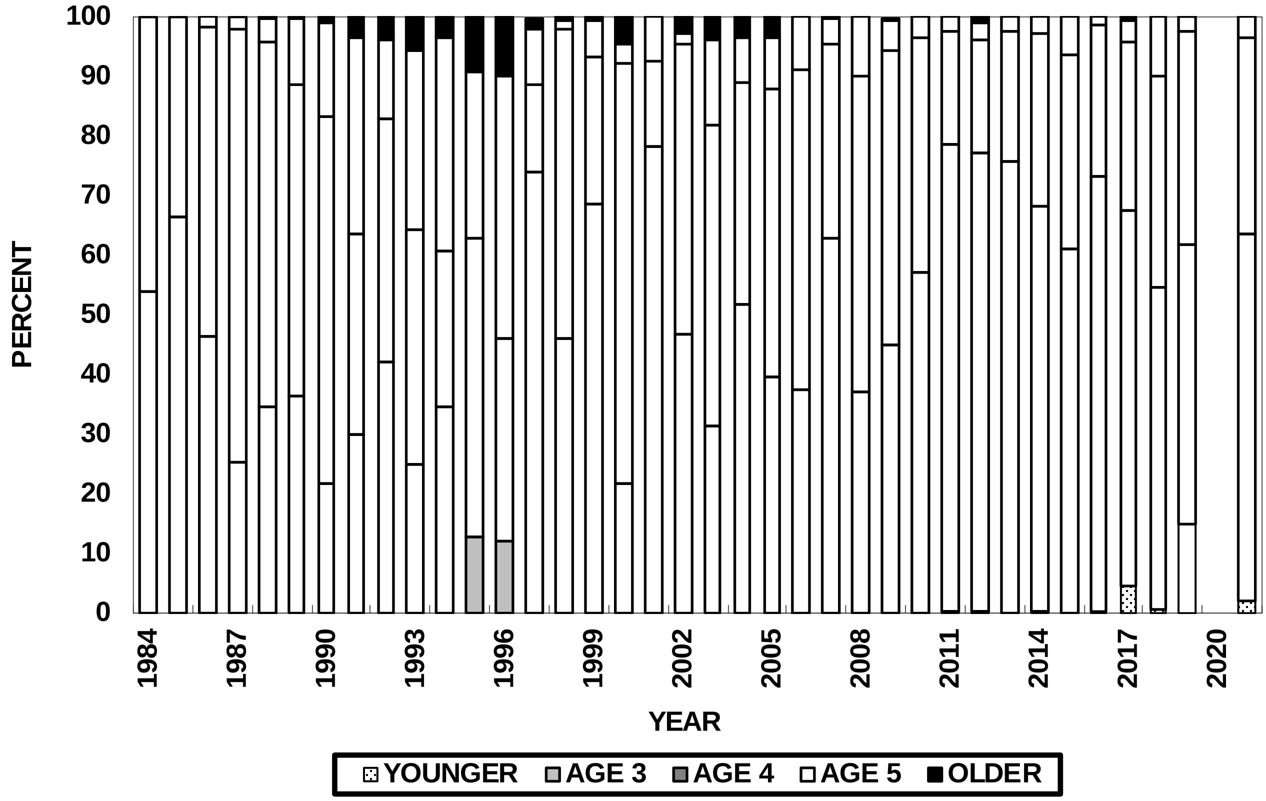

Figure 7. Age structures of Washington steelhead sampled at Salmon River Hatchery, 1984-2021.

Age-4 male weights (6.0 pounds) were close to the record low 2018 value (5.8 pounds) of the time series that dates to 1988 and noticeably lower than the 8.5 pounds in 2019. The age-4 males weighed significantly less than the results from 17 years in the series. Age-4 female average weight was near the series mean value, but down a bit from 2019 (Figure 6) and significantly lighter than 17 years in the series.

Age Structure

Like age structures observed in recent years, age-3 and age-4 steelhead dominated the run again in 2021 (Figure 7). Age-2 fish returned to their normal relatively low contribution to the run in 2021 from a noticeably higher proportion in 2019.

The age structure of the fish sampled was 2% younger than age-3, 62% age-3, 33% age-4, 4% age-5, and 0% older than age-5.

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RStudio Version 1.1.463. 2018. Free Software Foundation, Inc. 51 Franklin Street, Fifth Floor, Boston, MA 02110-1301 USA

2021 New York Cooperative Trout and Salmon Pen-Rearing Projects

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In 1998, concerns over post-stocking survival and imprinting of steelhead (*Onchorynchus mykiss*) and Chinook salmon (*O. tshawytscha*) to stocking sites led to the formation of several cooperative sportsmen's groups interested in pen-rearing (Bishop and Pearsall 1999). Concerns from the eastern basin of Lake Ontario centered on predation of stocked steelhead by cormorants. Western basin concerns included the apparent lack of imprinting and subsequent impaired homing of Chinook salmon and steelhead to the stocking streams.

After the successful completion of pen-rearing projects at Oswego Harbor and Oak Orchard Creek in 1998, a number of other sportsmen's groups expressed interest in pen-rearing. New sites were added in 1999 including the Lower Niagara River, Sandy Creek, Genesee River and Sodus Bay. In 2005, a pen-rearing project was established at Olcott Harbor on Eighteenmile Creek. In 2006, a pen-rearing project was initiated at Wilson Harbor on East Branch Twelvemile Creek. In 2009, a new pen-rearing site was added at Little Sodus Bay. In 2019, a second, separate pen project was initiated at Oak Orchard Creek to rear steelhead.

Due to changes in the DEC's Lake Ontario salmon and trout stocking strategy, pen projects were discontinued at Sandy Creek, Sodus Bay and Little Sodus Bay, while a new pen project was established in the Black River in 2020. Pen-rearing at Genesee River was temporarily paused in 2021 but is planned to resume pen-rearing in 2022.

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

This report summarizes pen-rearing activities and results for 2021, the twenty-fourth year of pen-rearing projects along the New York shoreline of Lake Ontario.

Methods

Pen-rearing was conducted at six sites along New York's coastline of Lake Ontario in 2021. The project sites, along with a description of site locations and project sponsors, are listed from east to west in Table 1.

All sites used similar pen materials, design and netting as described for the 1998 Oak Orchard Creek Project in Bishop and Pearsall (1999).

Standard operating procedures for stocking, maintaining, feeding, and releasing pen-reared salmon and trout were developed and refined by the NYS Department of Environmental Conservation (DEC; Wilkinson 1999, Sanderson 2006, Legard 2018). Rearing methods have remained very similar at most sites from year to year, with the exception of the lower Niagara River where in 2004 conventional floating pens were switched to two larger, fixed pens located within a bulkheaded boat slip (Wilkinson et al. 2005). Additional information about methods used at pen sites in 2021 is provided in Table 2. Prior to 2018, pen fish were fed food provided by the NYSDEC contracted supplier. From 2018-2021, pen fish were fed a premium food provided by NYSDEC.

Water temperature was monitored primarily using hand-held and digital thermometers, with manual recording of observations. Frequency of temperature measurements is provided in Table 2.

Prior to release, samples from each pen are weighed and counted to determine the average number of fish per pound. The subsampled fish are also measured for length. Observed mortalities for all projects were based on the number of dead fish collected from the pens during captivity and from the bottom of the pens after release. Both sources of mortality were noted by cooperators, except where listed otherwise. Mortality does not include fish lost to cannibalism or from predators that may have gained access to pens.

Results and Discussion

A total of 55,375 Washington strain steelhead yearlings were raised at five pen-rearing sites, comprising 10.8% of NYSDEC's Lake Ontario Washington strain steelhead yearling stocking allotment in 2021 (Table 3). Observed mortalities were low at all steelhead pen sites, ranging from 0.44 to 1.71%. Results for all steelhead pen projects are summarized in Table 3.

Five pen-rearing sites raised a total of 434,170 Chinook salmon fingerlings, representing 50.5% of NYSDEC's 2021 Chinook salmon stocking allotment. Observed mortalities were low, ranging from 0 to 0.16%. Results for all Chinook salmon pen projects are provided in Table 3.

All pen-rearing projects are now using automated feeders and they have worked well. The growth rates are comparable to hand feeding. The projects further benefit by not having to schedule five volunteers per day to feed the fish, which has been a huge relief for the pen project coordinators. Only one person is needed to pull back conveyor belts and load the feed in the morning, and feeders slowly dispense feed over a 12-hour period.

<u>Black River</u>
Steelhead were delivered at a weight of 24 fish per lb. on 14 April. They were held for 22 days and released on 6 May, weighing 15 fish per lb. The water temperature was 56 F at release. One-hundred-seventy-one mortalities were reported

Chinook salmon were delivered at a weight of 140 fish per lb. on 14 April. They were held for 22 days and released on 6 May, weighing 77 fish per lb. The water temperature was 56 F at release. Seventy-nine mortalities were observed.

<u>Oswego Harbor</u>
Chinook salmon were delivered at a weight of 127 fish per lb. on 13 April. They were held for 22 days and released on 5 May, weighing 57 fish per lb. The water temperature was 51 F at release. Eight mortalities were reported.

<u>Oak Orchard Creek</u>
Steelhead were delivered at a weight of 24.2 fish per lb. on 5 April. They were held for 29 days and released on 4 May, weighing 15.6 fish per lb. The water temperature was 53 F at release. One-hundred-fifty-two mortalities were reported.

Chinook salmon were delivered at a weight of 132 fish per lb. on 5 April. They were held for 23 days and released on 28 April, weighing 72.5 fish per lb. The water temperature was 53 F at release. No mortalities were recorded, as the pen coordinator was unable to count any mortalities left in bottom of nets due to removal logistics.

<u>Olcott Harbor</u>
Steelhead were delivered at a weight of 24.2 fish per lb. on 6 April. They were held for 20 days and released on 26 April, weighing 16 fish per lb. The water temperature was 49 F at release. One-hundred-seventy-six mortalities were reported.

Chinook salmon were delivered at a weight of 126 fish per lb. on 6 April. They were held for 22 days and released on 28 April, weighing 71.7 fish per lb. The water temperature was 49 F at release. Thirty-five mortalities were reported.

Wilson Harbor

Steelhead were delivered at a weight of 24.2 fish per lb. on 7 April. They were held for 18 days and released on 25 April, weighing 17.4 fish per lb. The water temperature was 46 F at release. Eighty-five mortalities were reported.

Lower Niagara River

The lower Niagara River pen site is typically the last site to receive fish due to slowly warming water temperatures. Steelhead were delivered at a weight of 23.4 fish per lb. on 14 April. They were held for 29 days and released on 13 May, weighing 18.4 fish per lb. The water temperature was 49 F at release. Fifty-three mortalities were reported.

Chinook salmon were delivered at a weight of 131 fish per lb. on 14 April. They were held for 33 days and released on 17 May, weighing 74.4 fish per lb. The water temperature was 54 F at release. One mortality was reported.

Conclusions

Of the five locations where steelhead were penned, target weight (12-15 fish per lb.) was reached at one site in 2021. Results at the other four sites were below target, ranging from 15.6-18.4 fish per lb.

Chinook salmon target weights (90 fish per lb.) were exceeded at all five pen sites, ranging from 57-77 fish per lb. It is likely that a large percentage of the penned salmon imprinted to their respective pen sites, increasing the likelihood that salmon will return as spawning adults.

The twenty-fourth year of pen-rearing steelhead and Chinook salmon along the New York shoreline of Lake Ontario was successful due to low fish mortality, all Chinook salmon exceeding target weights, and the goodwill generated through partnerships in the projects.

Acknowledgments

We wish to express our very sincere appreciation to the many individuals, businesses, municipalities and organizations that made these pen projects possible. Their dedicated efforts demonstrate a deep commitment to the Lake Ontario sport fishery and provide a management technique that would not be available without their valuable help.

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Table 1. Description of 2021 Lake Ontario pen project locations and sponsors.

Pen Site	Location	Project Sponsors
Black River	Navy Point Marina	NYSDEC Region 6 Staff Henderson Harbor Guides Association
Oswego Harbor	Oswego Marina and Independence Marina	Oswego Harbor Charter Captains Oswego Marina City of Oswego
Oak Orchard Creek (Chinook salmon)	Lake Breeze Marina	Lake Breeze Marina (Chinook salmon and steelhead) Oak Orchard Pen-Rearing Association Orleans County Department of Tourism
Oak Orchard Creek (steelhead)	Lake Breeze Marina	Lake Ontario Trout and Salmon Association Orleans Outdoors Seth Greene Chapter of Trout Unlimited
Olcott Harbor	Town of Newfane Marina	Lake Ontario Trout and Salmon Association Town of Newfane (including Town Marina) Local charter captains
Wilson Harbor	Bootlegger's Cove Marina	Lake Ontario Trout and Salmon Association Bootlegger's Cove Marina
Lower Niagara River	Constitution Park, Youngstown	Wet Net Charters Destination Niagara Village of Youngstown Fox Fence Company Niagara River charter captains

Table 2. Methods used at 2021 Lake Ontario pen project sites.

Pen Site	Pen Stocking Method	Feeding Frequency (times per day)	Water Temperature Measurement (times per day)	Pen Cleaning Frequency	Fish Release Method
Black River	Hydraulic transfer	Automated	1	Daily	Pen towed to harbor mouth in evening for fish release
Oswego Harbor	Hydraulic transfer	Automated	1	Once	Fish released at pen site.
Oak Orchard Creek (Chinook salmon)	Hydraulic transfer	Automated	5	Weekly	Fish released at pen site.
Oak Orchard Creek (steelhead)	Hydraulic transfer	Automated	1	Weekly	Pen towed to harbor mouth in evening for fish release
Olcott Harbor	Hydraulic transfer	Automated	1	Weekly	Fish released at pen site.
Lower Niagara River	Hydraulic transfer	Automated	1	Weekly	Fish released at pen site.
Wilson	Hydraulic transfer	Automated	1	Weekly	Fish released at pen site

Table 3. Results of 2021 Lake Ontario trout and salmon pen-rearing projects.

Pen Site	Species	Number Stocked (into pens)	Number of pens	Date Stocked	Size at Stocking (#/ lb.)	Date Released (Days Held)	Average Size at Release (#/ lb.)	Mortality (# Fish)	Mortality (%)
Black River	Chinook	50,000	2	14 Apr	140	6 May (22)	77	79	0.16
Lower Niagara	Chinook	50,000	1	14 Apr	131	17 May (33)	74.4	1	0.0
Oak Orchard	Chinook	111,390	5	5 Apr	132	28 Apr (23)	72.5	0	0.0
Olcott	Chinook	111,390	5	6 Apr	126	28 Apr (22)	71.7	35	0.03
Oswego	Chinook	111,390	5	13 Apr	127	5 May (22)	57	8	0.01
Black River	Steelhead	10,000	2	14 Apr	24	6 May (22)	15	171	1.71
Lower Niagara	Steelhead	12,000	1	14 Apr	23.4	13 May (29)	18.4	53	0.44
Oak Orchard	Steelhead	10,000	2	5 Apr	24.2	4 May (29)	15.6	152	1.52
Olcott	Steelhead	17,000	4	6 Apr	24.2	26 Apr (20)	16	176	1.04
Wilson	Steelhead	6,735	2	7 Apr	24.2	25 Apr (18)	17.4	85	1.33

Double-crested Cormorant Management Activities in Lake Ontario's Eastern Basin

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Double-crested cormorants (*Phalacrocorax auritus*) on the Great Lakes have undergone large population changes in the past half century (Hatch 1995). The Great Lakes population had declined throughout the 1960s and early 1970s, from about 900 nests in 1950 to 114 in 1973 (Weseloh and Collier 1995, Weseloh et al. 1995, Weseloh and Pekanik 1999). This decline, along with that of other fish-eating birds, was associated with high levels of toxic contaminants, particularly DDE and PCBs, found in the Great Lakes ecosystem (Miller 1998). Due to pollution control programs, contaminant levels were reduced, and cormorant numbers made a remarkable recovery in the Great Lakes and elsewhere (Price and Weseloh 1986). In 1996, there was an estimated 10,895 breeding pairs of cormorants in Lake Ontario's eastern basin; counted on five Canadian and four American sites (Little Galloo Island [LGI], Bass, Gull, and Calf islands).

LGI was first colonized by cormorants in 1974. Peak nest abundance was reached in 1996 at over 8,400 breeding pairs as determined by nest counts. Concerns about the impact cormorants have on fish populations, other colonial waterbird species, private property, and other ecological values followed this population expansion. LGI currently supports the largest cormorant, ring-billed gull *(Larus delawarensis),* and Caspian tern (*Sterna caspia*) colonies in New York State.

The New York State Department of Environmental Conservation (NYSDEC) and the U.S. Fish and Wildlife Service (USFWS) began to examine the impacts of cormorants in 1992. In 1998, analyses by the NYSDEC and the United States Geological Survey (USGS) identified a connection between cormorant numbers and increased mortality of young smallmouth bass (*Micropterus dolomieui*) (Adams et al. 1999, Lantry et al. 2002).

Implementation of a cormorant management plan for U.S. waters of the eastern basin of Lake Ontario began in 1999. The goal of this management plan was to improve the benefits people derive from the eastern basin ecosystem; primarily by reducing the negative impacts of abundant cormorants on the structure and function of the warmwater fish community, on other bird nesting habitats, and on other colonial waterbird species.

The plan's major objective required reaching and maintaining a target cormorant population of 1,500 breeding pairs and 780,000 feeding days, which includes feeding by chicks and non-breeding birds. This was the maximum cormorant population level prior to the observed increase in mortality of young bass. It is important to note that this objective does not focus on numbers of nesting birds, but on reducing the total number of cormorant feeding days, a measure by which fish consumption is assessed (Weseloh and Casselman, unpublished 1992).

In April 2000, NYSDEC accepted a Final Environmental Impact Statement ([EIS], NYSDEC 2000) regarding eastern Lake Ontario cormorant management. The statement outlined a process of reducing the LGI cormorant population to a target level described as a population associated with 1,500 nesting pairs on LGI and a target of zero production on the other eastern basin islands. This target population would produce approximately 780,000 feeding days, including contributions of sub-adults and young-of-the-year.

Through 2003, NYSDEC cormorant management was conducted under individual USFWS permits for each colony. Using techniques available during that period, population objectives were not reached within the five years projected.

The USFWS 2003 Federal Public Resource Depredation Order (PRDO; USFWS 2003) allowed the NYSDEC to manage cormorants without applying for and receiving individual permits. Beginning in 2004, non-lethal management actions were continued and some lethal control (culling), which was permitted under the PRDO, was used to reduce cormorant numbers more rapidly. This control resulted in a population such that the number of feeding days was near target most years 2006-2015 (McCullough and Mazzocchi 2016).

In May 2016, a federal court decision vacated an extension of the PRDO. As a result, all cormorant management activities were terminated in May 2016 which resulted in a much reduced, and less effective management effort that year. No cormorant population control efforts were undertaken in 2017. Beginning in 2018, NYSDEC received a USFWS depredation permit under Priority 3 of the permitting application, specifically, to alleviate management and conservation concerns associated with threatened, endangered and species of high conservation concern. In 2021, NYSDEC was granted an annual permit authorizing the take of up to 965 adult birds and up to 4980 active nests statewide. NYSDEC was also granted a permit under Priority 5 (i.e., to alleviate conflicts with wild and stocked fish managed by state agencies and with state operated fish hatcheries) authorizing the additional take of up to 1,115 birds statewide.

Methods

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

Nest removal efforts began on Gull and Bass islands in 1994. Calf Island was included following observation of cormorant nests in 1997. Nest removal teams included two to four people. Ground nests were removed by hand while tree nests were removed with a telescoping pole or shotgun. Each nest removed was scattered as much as possible to discourage rebuilding. Cormorants that nested too high in trees for nest removal or repeatedly rebuilt nests were culled (Table 2).

When the PRDO was in effect, annual egg oil treatment of accessible cormorant nests on LGI began in early spring using methods similar to Shonk (1998). Corn oil was applied from a backpack sprayer unit in sufficient volume to cover the exposed surface of each egg, approximately 0.2 oz (6 ml)/egg. A sub colony of ground nests are not treated each year which serve as a control group, usually 200-300 nests. From 1999 through 2015 oil was applied to accessible nests outside the control sub colony three to five times per season, at roughly two-week intervals. Oiling at two-week intervals ensured that most nests would be treated at least twice during the incubation period. Each nest or group of nests treated was marked with spray paint to minimize missed or repeat treatment. Two or three teams of two to three persons each, complete the oiling in three hours or less (not including travel time). Each team can effectively oil 500 to 700 nests per hour, depending on nest density. Oiling teams recorded the number of nests treated, the number of eggs in each nest, the number of chicks observed, and the number of nests not treated (tree or control nests). Beginning in 2019, the NYSDEC depredation permit allowed removal of nests containing no eggs and they were not counted against the destruction quota. This practice was implemented on LGI and Gull Island on every visit 2019 - 2021.

Under the 2003 PRDO, limited culling of cormorants was conducted in 2004 to determine the effectiveness of the technique, assess non-target species disturbance, and add to the effect of non-lethal removal efforts. Beginning in 2005, culling was used as a full-scale management technique and continued through 2014. No culling was conducted on eastern basin islands from 2015 – 2018. The limited culling quota given under the 2018 permit was administered at other sensitive areas within the state. Beginning in 2019, culling resumed on eastern basin islands (Table 2). Most culling, when conducted, was done using .22 or .17 caliber rimfire rifles. Culling teams consist of at least two people and carcasses are disposed of by burial or composting on site.

The NYSDEC conducted cormorant diet studies from 1992 through 2013 by collecting regurgitated pellet samples at LGI from mid-April through mid-October. All samples were analyzed by the USGS Great Lakes Science Center (Johnson et al. 2014). Beginning in 2019, NYSDEC Fish and Wildlife staff collected and archived a total of 450 pellets across the pre-chick (5/1-5/17), chick (5/18-7/16) and post-chick (7/17-8/23) feeding periods described by Johnson et. al (2014; 150 pellets/period). Pellets were collected and archived again in 2020 and 2021.

Colony feeding days for LGI cormorants were calculated according to the Casselman-Weseloh model (unpublished, 1992) modified for culling where:

Colony Feeding Days = (N Adults x 158) + (N Subadults x 112) + (N Chicks x 92)

and:

N Adults = (peak nest count x 2) - (N birds culled/2)
N Subadults = peak nest count/5
N Chicks = untreated nests x nest productivity rate

Unless otherwise indicated, the productivity rate for unoiled nests was assumed to be 2.0 chicks fledged per nest (Sullivan et al. 2006). No correction was made for in-season bird movements or natural mortality**.**

Results

Since the cormorant nest removal program began on Gull, Bass and Calf islands in 1994, nesting attempts (including re-nests) on these islands have varied from year to year with a peak of 1,272 nests in 2004 (Table 1). From 2007 - 2018, increased landowner activity on Bass Island has prevented significant waterbird production and made active cormorant management unnecessary. Cormorants were observed nesting on Bass Island again in 2019-2021 but no management action was taken (Table 1) due to private ownership. Cormorants have not attempted to nest on Calf Island since 2009. A record high peak nest count occurred on Gull Island in 2019 totaling 718 nests. Peak nest count decreased to 202 nests in 2020, then increased slightly to 220 nests in 2021. Gull Island is managed for zero reproduction; therefore, all cormorant nests are destroyed during every visit.

On LGI, the 2021 peak nest count totaled 4,164 nests, a 42.6% increase from 2020. We estimated that the LGI colony generated 1,847,706 feeding-days in 2021, which is the third highest estimate since 1999 and 137% above the target of 780,000 (Figure 1). There were approximately 465,152 feeding days attributed to chicks in 2021, a 300% increase from 2020 (116,288), due to large numbers of untreated nests. This reporting year, an error was discovered in the calculation of the number of untreated nests from 2018 – 2020 (Resseguie and Mazzocchi 2019, 2020, 2021) which changes the reported chick feeding days slightly. Cormorant feeding days at LGI remained within 10% of target most years from 2006 to 2015. However, in the years 2016-2021 (i.e., since the PRDO was rescinded), feeding days exceeded the target by 21% to 137%.

Double crested cormorants were observed nesting on Little Grenadier Island in 2018 with 40 nests counted and peaked in 2019 (150 nests, Table 1). The colony continues to exist with 142 nests counted in 2021. No management can occur by NYSDEC due to private ownership.

Nest counts for other colonial waterbirds (except ring-billed gulls) were conducted each year on eastern basin islands. Caspian terns on LGI were observed to have a 7.8% increase in colony size in 2021 (2,458 breeding pairs) compared to 2020 (2280 breeding pairs). Great black-backed gulls (*Larus marinus*) have not been detected on any of the islands since 2008. Common terns (*Sterna hirundo*), a threatened species in New York, were first observed on LGI in 2013 and successfully nested in 2014 with 34 nests counted. Numbers then declined to zero nests observed in 2019 (Table 1). In 2020 and 2021, common terns were observed again (10 and 11 nests respectively). Nesting success rate of common terns on LGI is unknown. Record numbers of herring gull (*Larus argentatus*) nests were observed on LGI and Gull Island in 2020 (1,247 and 138 nests, respectively). In 2021, herring gull nests decreased slightly (1,210 nests) and increased slightly on Gull Island (150 nests, Table 1).

Black-crowned night herons (*Nycticorax nycticorax*), a species of special concern, were historically (before 2007) predominantly found nesting on Gull and Bass islands and in low numbers on LGI (Table 1). From 2007 through 2015, they were predominantly on Gull Island. Numbers dropped significantly after 2016. In 2021, one black-crowned night heron nest was found on LGI (the first since 2005) and nine were found on Gull Island (the first since 2016, Table 1).

Discussion

Reduced cormorant population levels at LGI, believed to be related to egg oiling, became noticeable in 2002. Johnson et al. (2004) reported a substantial decline in fish consumption at this colony due to lack of consumption by chicks, and lower numbers of feeding adults. The cormorant population had reached the feeding-day target in 2006, and the management effort was operated at a maintenance level from 2007-2015. The production of numerous chicks beginning in 2016 resulted in an immediate increase in feeding days. Colony feeding days dropped in 2020 from the 2019 level, but increased by 300% in 2021 due to a large number of nests left untreated. Despite management intervention, the 2021 cormorant feeding days (1,847,706) are well above the target of 780,000. A colony of this size is likely to impact other aquatic and avian species; therefore, increased cormorant management is recommended.

Changes in cormorant management and the fish community have occurred over the last 20 years. From the mid-2000s and through 2015, cormorant population management combined with a dietary shift to predominantly round goby (*Neogobius melanostomus*), helped to work towards meeting the objectives of the EIS in reducing negative impacts to the warmwater fish community. The reduced level of cormorant management since 2015 and changes in the fish community would result in increased predation pressure on the eastern basin fishes and a potentially greater impact to smallmouth bass, yellow perch, and other species desired by recreational anglers. Resumption of cormorant diet analyses and return to the targeted number of feeding days is recommended.

Cormorant management activities reduce the number of nesting cormorants, and thus reduces the nesting habitat competition with other colonial waterbirds such as Caspian terns, common terns, herring gulls and black-crowned night herons. Common terns were first observed nesting on LGI in 2013 and continued to nest in low numbers each year on the island. In 2019, no nests were observed on LGI likely due to the lack of cormorant management and high lake levels reducing nest site availability. Low numbers of common tern nests were observed on LGI in 2020 and again in 2021, but the nesting success rate is unknown.

Site-specific management is a labor-intensive undertaking, although not particularly expensive in comparison to other predation management efforts, such as sea lamprey (*Petromyzon marinus*) management (Schiavone and Adams 1995). These management actions can be effectively implemented to resolve conflicts on the local scale. When given sufficient latitude, cormorant management can successfully limit production of cormorants on Lake Ontario's eastern basin islands (i.e., reducing predation on important fisheries and protecting other waterbird populations) as demonstrated by the many years of maintaining near feeding day targets (2006-2015). Feeding day estimates post-2016 show how rapidly this species can rebound in the absence of effective management actions and can persist despite renewed (albeit it limited) management intervention.

Cormorant management, whether implemented locally, regionally, or range-wide, should be considered in a broad, long term context to ensure that management actions remain sound, integrated and effective.

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

Species	Island	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Double-crested Cormorant	LGI	3,967	3,401	2,692	2,959	2,492	2,751	1,758	2,831	2,227	2,387	2,283	2,264	2,161	1,999	2,778	3563	2920	4164
	Gull I.	188	0	110	152	292	261	275	0	391	276	235	276	323	530	673	718	202	220
	Bass I.	348	602	175	117	0	0	0	0	0	0	0	0	0	0	0	340	100	75
	Calf I.	736	-	-	-	170	76	0	0	0	0	0	0	0	0	0	0	0	0
	Little Grenadier	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	150	90	142
Ring-billed Gull	LGI	-	-	-	-	37,500	-	-	-	43,324	-	-	-	-	-	-	-	-	-
	Gull I.	-	-	-	-	0	-	0	-	0	0	0	0	0	0	0	0	0	0
	Bass I.	-	-	-	-	0	-	-	-	0	0	0	0	0	-	0	0	0	0
Herring Gull	LGI	-	-	367	0	375	356	364	459	512	645	979	784	971	579	1,156	996	1,247	1210
	Gull I.	-	-	40	67	58	42	89	91	52	89	109	-	29	55	123	89	138	150
	Bass I.	-	-	10	16	0	0	0	0	0	0	0	0	0	-	0	0	0	0
Great Black-backed Gull	LGI	-	-	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gull I.	-	-	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0
	Bass I.	-	-	0	0	9	0	-	-	0	0	0	0	0	0	0	0	0	0
Black-crowned Night Heron	LGI	3	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	Gull I.	78	81	77	127	78	78	105	151	44	56	79	106	39	0	0	0	0	9
	Bass I.	17	46	32	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0
	Calf I.	0	-	-	-	-	13	0	0	0	0	0	0	0	0	0	0	0	-
Caspian Tern	LGI	1,560	1,788	1,589	1,580	1,376	1,499	1,472	1,934	2,332	1,848	2,436	2,084	2,354	2,511	2,700	1,715	2,280	2458
Common Tern	LGI	0	0	0	0	0	0	0	0	0	20	34	30	15	3	2	0	10	11

Table 2. Cormorant management activities taken by Bureau of Wildlife in Lake Ontario's Eastern Basin. *x-management unnecessary due to landowner activity; u – unknown; Dash indicates not checked for the given species.*

Island	Totals	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
LGI	Peak nests oiled	3,389	3,359	2,896	2,275	2,502	1,804	2,166	1,104	2,000	1,600	1,456	1,625	1,546	914	0	1,049	323	2,063	1336
	Nests w/ 0 eggs destroyed	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,353	877	1,478	631
	DCCO culled	-	18	686	620	709	382	798	145	569	362	366	150	0	0	0	0	205	256	336
Bass I.	Total Nests Removed (peak one day)	260 (117)	959 (348)	935 (452)	477 (120)	470 (42)	x	x	x	x	x	x	x	x	x	x	x	0	0	0
	DCCO culled	-	167	281	200	124	x	x	x	x	x	x	x	x	x	x	x	0	0	0
Gull I.	Total Nests Removed (peak one day)	1,427 (480)	485 (188)	0 (0)	113 (90)	273 (95)	671 (266)	741 (261)	604 (270)	659 (302)	711 (u)	1,072 (u)	603 (u)	769 (u)	152 (u)	0 (0)	1,804 (673)	5,788 (718)	1,696 (202)	770 (220)
	DCCO culled	-	3	0	0	20	2	0	0	0	29	0	0	0	0	0	0	90	59	26
Calf I.	Total Nests removed (peak one day)	0	0	415 (539)	0	0	0	161 (111)	55 (52)	0	0	0	0	0	0	0	0	0	0	0
	DCCO culled	-	37	0	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0

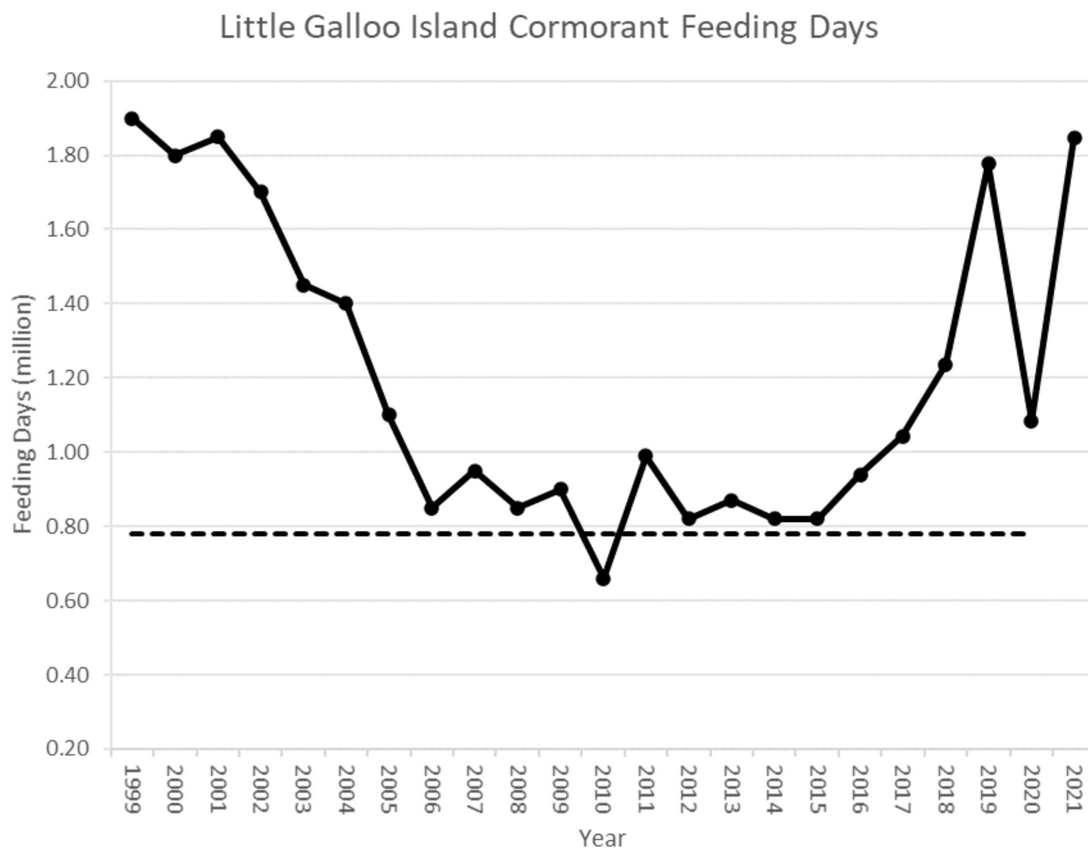

Figure 1. Trend in cormorant feeding days for the Little Galloo Island colony 1999-2021. Dashed line represents the target of 0.78 million feeding days.

Salmon River Angler Survey
2020-2021

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Introduction

Angler surveys of all the major tributaries to Lake Ontario in New York were conducted in 2005-2006 and 2006-2007 (Prindle and Bishop 2007). The purpose of these surveys was to provide baseline information for a longer-term data set consisting of periodic surveys to monitor trends in the Lake Ontario tributary fishery. The most recent comprehensive tributary survey was conducted in 2019-2020.

A Salmon River only angler survey was conducted from September 2020 through mid-May 2021. It is intended that the Salmon River Angler Survey will be conducted on an annual basis complemented by periodic comprehensive tributary surveys.

Prior to the 2005 survey, the last comprehensive tributary survey was the 1984 New York State Great Lakes Angler Survey (NYSDEC 1984). Creel surveys of varying duration and purpose were also conducted on the Salmon River in 1989 (Connelly et al. 1989), 1992 (Bishop 1993), and 1997 through 2004 (Bishop 1998-2004, Bishop and Penney-Sabia 2005). The 1989 survey covered the fall fishery, through the salmon and early steelhead runs. The 1992 survey captured the salmon run, but ended on November 1st, missing most of the fall steelhead fishery. The 1997-2003 surveys were conducted from mid-October through the last weekend in November to examine the fall steelhead angling seasons. The 2004 survey ran from the day after Labor Day through the last weekend in November, to cover the fall salmon and steelhead fisheries.

The Salmon River survey results presented here cover the period September 9, 2020 through May 11, 2021.

Methods

Data Collection

We used an instantaneous access site survey design on the Salmon River employed since 2004. Counts (numbers of anglers, vehicles and/or boats) and interviews were conducted from the estuary upstream to the Upper Fly Zone.

We estimated effort (numbers of angler hours and angler trips), catch and harvest (total numbers), and catch and harvest rates (fish per angler hour) for each fishing type (conventional regulations shore access, drift boat, special regulations catch and release fly fishing, tributary, and estuary boat) on the Salmon River. For interviews, we recorded site, date, interview time, residency, angler party size, start time, time taken for breaks, trip status (complete versus incomplete), species targeted, fish kept and released, weather effects, and any relevant comments made by the angler or survey agent. A set of angler satisfaction questions were also posed to the anglers. The proportion of non-NYS resident anglers was also calculated.

A detailed description of the statistical analyses used in this report is provided in Appendix 1. All statistical analyses were done with R Statistical software package version 4.0.2 (R Core Team 2020).

The survey agent sampled three randomly selected weekdays and one weekend day each week. We used a staggered shift to cover the morning counts and interviews; the afternoon shift continued until ½ hour after sunset. Twenty-five sites were sampled for vehicle, angler, and boat (or boat trailer) counts, and angler interviews

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

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

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

Time not spent conducting instantaneous counts during a shift was used to interview anglers. Interviews from anglers who had been fishing for at least ½ hour were used in the analyses. (Appendix 1).

Results and Discussion

Angler Effort

The estimated angler effort during the 2020-2021 survey period on the Salmon River was 808,795 angler hours (Table 1). This was the fourth highest estimated effort of the surveys completed since 2005, with 2011 having the high value of 1,077,316 hours (Table 1). The estimated number of angler trips (135,788 trips) was also the fourth highest for recent surveys, with 2019-2020 being the highest (170,264 trips; Table 1).

As in previous surveys, the conventional regulation sections of the river had by far the highest estimated effort at 674,199 hours (83 % of the total; Table 1). The special regulations flyfishing only areas were a very distant second place accounting for just 6% of the estimated effort, but up well above the estimates from previous surveys. The tributary fishery (Trout and Orwell brooks) had uncharacteristically low effort in 2020-2021. The dry conditions and low flows likely impacted fish migration into those streams during the fall when the majority of the effort occurs.

October remained the most intensively fished month on the Salmon River accounting for 351,397 angler hours in 2020, and 43% of the total estimated effort (Table 2). The October 2020 effort estimate was the third highest for any month amongst recent surveys (Table 2).

The highest single day effort estimate in the present survey occurred on October 3 2020, when the morning car count yielded 1,340 vehicles at the access locations. Each year the effort increases during September with a peak in either the first or second week in October. By the fourth week in October the effort drops substantially as Chinook and coho salmon spawning activities diminish. The long-term trend in fishing effort for the Salmon River appears similar to that observed in the open lake boat fishery (Connerton 2021), with a peak in the late 1980s and early 1990s (Table 3). Observed declines from peak effort were of similar magnitude (approximately 50%) for both the tributary and open lake fisheries. However, Salmon River angler effort returned to historic levels beginning in 2010 (Table 3).

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

Year	2005-2006	2006-2007	2011-2012	2015-2016	2017-2018	2018-2019	2019-2020	2020-2021
Fishing type	Effort (angler hrs)	Effort (angler hrs)	Effort (angler hrs)	Effort (angler hrs)	Effort (angler hrs)	Effort (angler hrs)	Effort (angler hrs)	Effort (angler hrs)
Shore access (conv. regs.)	449,520	436,096	842,074	579,036	627,579	632,236	772,689	674,199
Drift boat	42,598	35,213	88,720	56,674	58,906	62,655	48,605	46,377
Special regs. Fly	66,476	57,300	96,665	73,096	60,959	40,581	55,039	51,197
Estuary boat	9,368	10,407	16,503	9,731	8,242	5,241	15,677	28,092
Tributaries	37,809	56,251	33,354	16,865	18,065	99,544	25,608	8,931
Total hours	605,772	595,267	1,077,316	735,402	773,753	840,258	917,618	808,795
Total trips	98,959	87,539	158,219	129,204	127,166	135,788	170,264	129,657

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

	Year							
Month	2005-2006	2006-2007	2011-2012	2015-2016	2017-2018	2018-2019	2019-2020	2020-2021
September	183,019	171,265	261,838	176,480	247,212	181,055	288,005	160,000
October	212,213	251,031	339,017	276,779	305,512	396,011	386,272	351,397
November	61,418	44,752	145,522	104,347	56,729	73,026	64,732	85,064
December	23,220	36,783	59,603	31,453	34,478	46,933	34,361	38,683
January	19,682	18,598	38,760	22,981	14,145	17,672	26,216	32,748
February	12,158	7,399	52,498	21,701	18,698	18,008	29,828	27,881
March	38,385	25,461	85,184	38,035	41,207	48,078	32,774	40,502
April	51,564	24,230	87,777	58,854	41,681	44,397	45,780	56,580
May	4,114	15,747	7,118	4,772	14,091	15,078	9,647	15,940
Total	605,772	595,267	1,077,316	735,402	773,753	840,258	917,615	808,795

Interviews and Residency
A total of 2,816 interviews were obtained during the 2020-2021 survey (Table 4). Interviews were from anglers residing in 37 states.

Forty-eight percent of Salmon River anglers interviewed during 2020-2021 were non-New York State residents (Table 4), similar to previous surveys. It was the lowest number of non-residents, but the results were likely impacted by Covid-19 travel restrictions and advisories.

Catch and Harvest

Chinook Salmon
The estimated catch of Chinook salmon from the Salmon River in 2020 was 76,671 fish (Figure 1; Table 3), which is similar to past results.

The 2020 Chinook salmon harvest estimate was 36,626 fish (Figure 1; Table 3), This translates to a 52% release rate for a species that dies after spawning. In 2015, when the catch was markedly lower, the release rate was lower but was still relatively high at 49%.

Chinook salmon catch by month in 2020 continued historic patterns, with the highest number of Chinook salmon caught in October (55,421 or 72% of total), followed by September (20,541 or 27% of total; Figure 2).

Coho Salmon
Coho salmon were a smaller component of the fishery in 2020, totaling only 6,641 fish caught (Figure 1; Table 5). This result was nearly equal to the estimated catch of 6,171 coho during the fall of 2019 and far below the peak of 30,298 estimated to have been caught in 2011 (Table 5). The 2020 release rate was 64%, with 2,393 fish harvested (Table 5).

Unlike Chinook salmon, September and October vary as to which has the highest monthly catch of coho. Coho estimated catch was 1,500 fish higher in October 2020 (n= 3,875 fish) compared to September (n= 2,306 fish; Figure 2).

Steelhead
Steelhead is the primary species sought by post-salmon run Salmon River anglers. This fishery gains momentum in mid-October as fish enter the river and the salmon run begins to decline and extends into mid-May with the “drop-back” fishery. Thus, steelhead are the most important species in the late fall through early spring fishery.

The estimated steelhead catch from 2020-2021 was 30,106 which is approximately average among recent surveys (Figure 1; Tables 3 and 5). The estimated number of steelhead harvested in 2020-2021 was 2,679, which equates to an 91% release rate (Tables 3 and 5). The release rate typically increases as the salmon season wanes.

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

			Chinook salmon		Steelhead	
Year	Dates	Angler trips	Catch	Harvest	Catch	Harvest
1984	Sept-Nov	107,306	143,244	83,784	15,529	8,359
1984	Jan 1 to Dec 31	140,911	143,244	83,784	36,925	20,699
1989	Aug 17 to Dec 4	180,400	150,100	69,200	8,150	4,350
1992	Sept 3 to Nov 1	103,900	80,300	55,900		
1997	Oct 20 to Nov 30	7,061	----	----	1,543	554
1998	Oct 19 to Nov 29	7,009	----	----	2,830	523
1999	Oct 18 to Nov 28	11,372	----	----	4,751	1,010
2000	Oct 16 to Nov 26	11,231	----	----	2,870	806
2001	Oct 15 to Nov 25	12,563	----	----	3,660	746
2002	Oct 21 to Dec 1	9,381	----	----	2,743	555
2003	Oct 20 to Nov 30	6,183	----	----	1,960	357
2004	Sept 7 to Nov 28	90,825	85,251	24,360	6,924	1,314
2005	Sept 6 to Nov 30	75,985	89,448	25,998	7,738	1,441
2005-2006	Sept 6 to May 15	98,959	89,448	25,998	20,705	2,713
2006	Sept 9 to Nov 26	83,409	96,088	33,530	9,509	2,002
2006-2007	Sept 9 to May 16	87,539	96,088	33,530	21,489	3,869
2011	Sept 1 to Nov 27	112,109	85,106	31,516	39,697	3,657
2011-2012	Sept t to May 15	158,214	85,106	31,516	96,398	8,608
2015	Sept 1 to Nov 29	101,465	23,940	12,305	11,334	1,401
2015-2016	Sept 1 to May 15	129,018	23,940	12,305	25,335	3,427
2017	Sept 1 to Nov 30	95,121	100,882	27,682	17,164	2,344
2017-2018	Sept 1 to May 15	127,166	98,125	27,850	34,638	5,076
2018	Sept 1 to Nov 30	103,189	83,481	35,082	10,581	1,753
2018-2019	Sept 1 to May 15	135,788	83,481	34,123	41,582	5,043
2019	Sept 1 to Nov 30	140,144	76,417	32,705	7,827	1,441
2019-2020	Sept 1 to May 13	158,128	76,417	32,705	44,484	4,855
2020	Sept 9 to Nov 30	92,732	76,671	36,626	12,495	930
2020-2021	Sept 9 to May 11	129,657	76,671	36,626	31,177	2,755

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

Year	Number of interviews	% non NYS resident
2005-2006	3,050	60
2006-2007	2,717	60
2011-2012	4,412	60
2015-2016	4,044	59
2017-2018	2,477	57
2018-2019	3,605	56
2019-2020	3,276	51
2020-2021	2,816	48

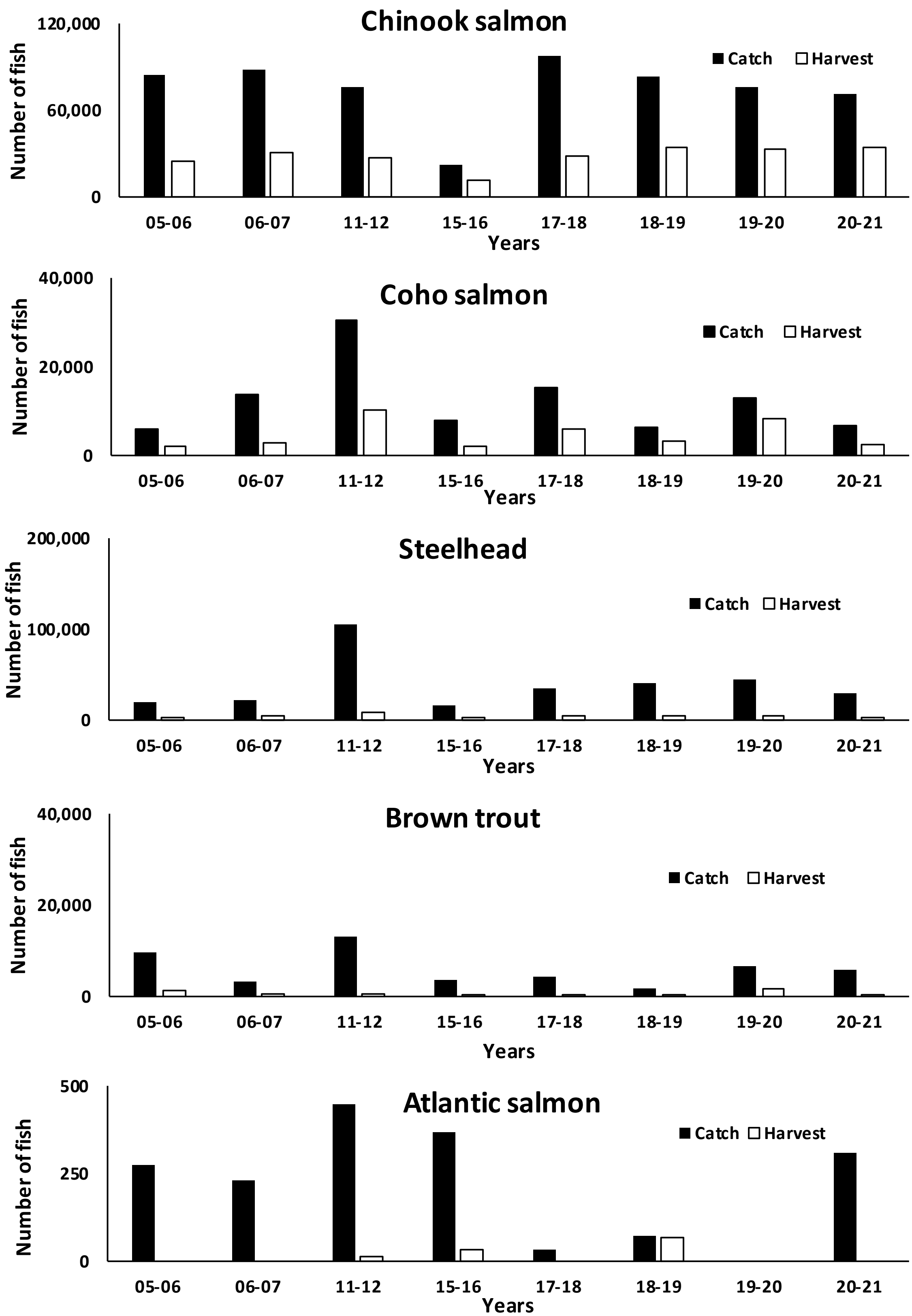

Figure 1. Estimated Salmon River catch and harvest by species and year.

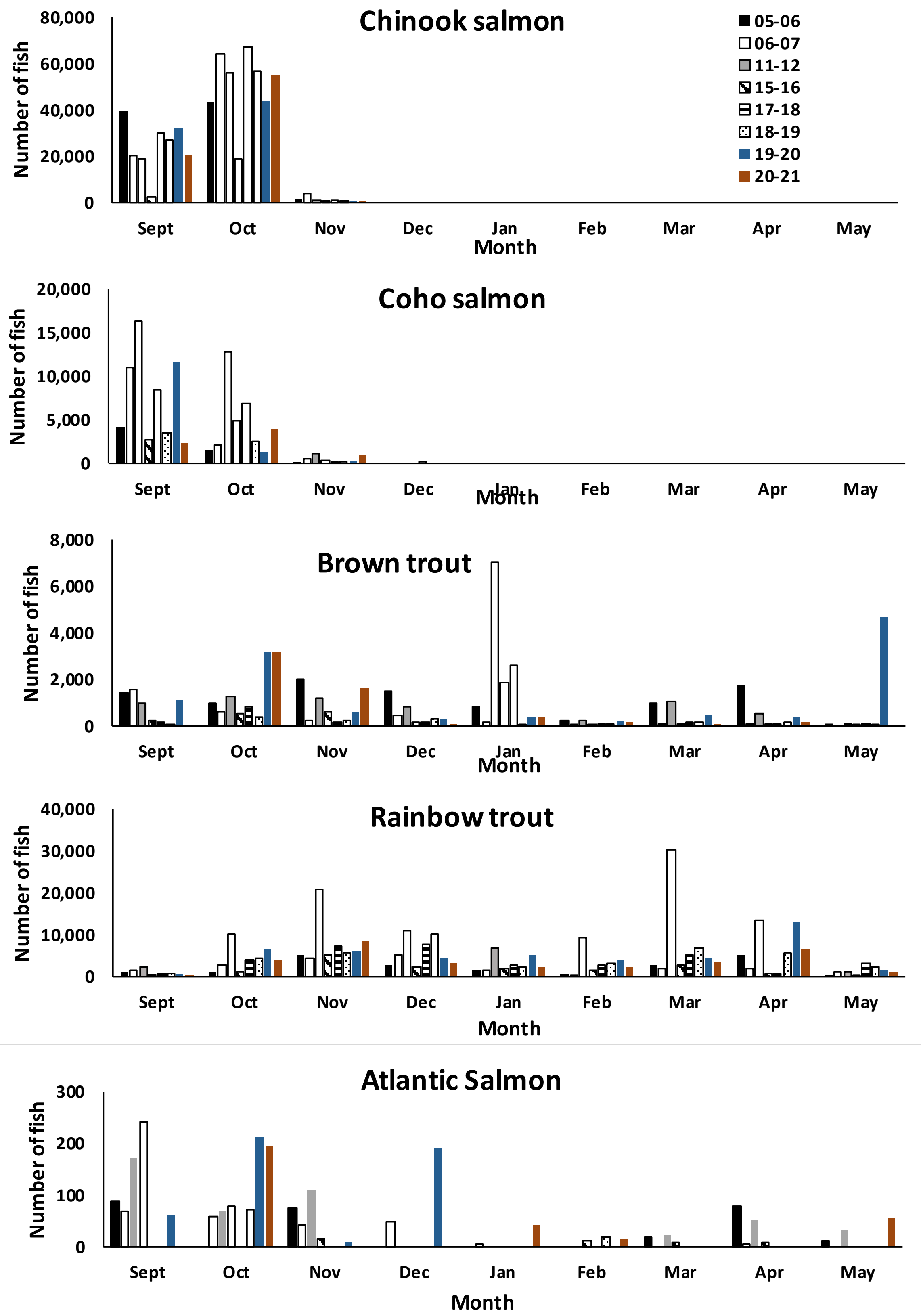

Figure 2. Estimated catch on the Salmon River by species, month, and year.

Atlantic Salmon
An estimated 309 Atlantic salmon were caught in the Salmon River during 2020-2021 (Figure 1). This is the highest estimated catch since 2015-2016 (366 fish), but well above the 71 estimated to have been caught in 2019-2020 (Figure 1).

Atlantic salmon typically get released nearly 100% of the time based on past results and was also the case in 2020-2021 (Figure 1). Only the 2011-2012 and 2015-2016 surveys had less than 100% release, with 97% and 91%, respectively.

Brown Trout
An estimated 5,723 brown trout were caught in 2020-2021 (Figure 1). This was an approximately average catch of the recent surveys, but a 1,000 fish below the 2019-2020 estimate. The highest estimated catch occurred in 2011-2012 with 13,161 brown trout caught (Table 5). The 2020-2021 estimated harvest was 185 fish (Figure 1). Release rates varied from 81% in 2006-2007 to 97% in 2020-2021.

There was no monthly pattern of brown trout catches across the surveys. In 2020-2021, October had the highest estimated catch with 3,175 fish, followed by November and January with 1,631 and 370 fish caught, respectively (Figure 2).

Acknowledgments

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Appendix 1. Calculations and Formulas

Effort estimates for the <u>Salmon River</u>

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

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

where:

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

A_t = the number of anglers counted in Pulaski

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

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

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

V_t = the number of vehicles counted at the tributary access points

D_b = the number of drift boat trailers counted. Note: the (Vsr + Vuf + Vt - Db) term accounts for one pickup vehicle per drift boat being left in a downstream parking area

P_{sh} = the mean size of shore access parties (anglers/vehicle)

P_{db} = the mean size of drift boat parties

B_e = the number of boats counted in the estuary

P_{be} = the mean party size (anglers/boat) for boat access fishermen in the estuary

$daylength_j$ = the number of hours from ½ hour before sunrise to ½ hour after sunset on day *j*.

The estimator for mean angler hours for all days sampled in stratum h is:

$$\hat{H}_h = \frac{\sum_{j=1}^{n_h} \hat{H}_{j,h}}{n_h}$$

n_h = the number of days sampled in stratum *h*

and the stratum variance is:

$$s_h^2 = \frac{\sum_{j=1}^{n_h} (\hat{H}_{j,h} - \hat{H}_h)^2}{n_h - 1}$$

and the variance of $\hat{H}_h$ is:

$$V(\hat{H}_h) = \frac{s_h^2}{n_h}\left(\frac{N_h - n_h}{N_h}\right)$$

where N_h is the total number of days in the stratum h and $\left(\frac{N_h - n_h}{N_h}\right)$ is the finite population correction factor, and the standard error of $\hat{H}_h$ is:

$$SE(\hat{H}_h) = \sqrt{V(\hat{H}_h)}$$

The estimated total for all angler hours is:

$$T_H = \sum_{h=1}^{L} N_h(\hat{H}_h)$$ where L is the total number of stratum and the variance of the total is:

$$V(T_H) = \sum_{h=1}^{L} N_h^2 V(\hat{H}_h)$$

and the standard error of the total is:

$$SE(T_H) = \sqrt{V(T_h)}$$

The effort estimates were partitioned by fishing type into boat fishing in the estuary, shore access and drift boat fishing in the normal regulations portion of the main stem, fishing in the tributaries, and fishing in the special regulations catch and release fly fishing only areas. This was done to provide appropriate weighting factors for stratification of the catch data.

Drift boat effort was calculated by taking the number of drift boat trailers counted and multiplying by the mean size of drift boat party (from the interview forms). Special regulations fly fishing effort was estimated by multiplying the number of vehicles in the upper fly fishing parking area by the mean size of shore fishing parties (again, from the interview forms) and adding the number of anglers counted in the lower fly fishing area in Altmar. Note that the overall estimate of angler effort accounts for special regulations area fly fishermen with vehicle counts only. We had to count the anglers in the lower fly fishing area for the estimate of effort for the special regulations fly fishing areas, however, because there was no way to know whether vehicles parked in Altmar belonged to anglers fishing the fly fishing area or the conventional regulations area of the river. We also had to count anglers in Pulaski and in the estuary because they did not all park in designated lots. Similar partitions of the data allowed us to estimate boat effort in the estuary and effort in the tributaries. Angler trips were estimated by dividing the estimates for angler hours by the mean lengths of completed trips for each fishing type and for the overall estimate.

Catch and Harvest

These parameters were stratified for the Salmon River the same as the effort data (by week for Sept. through Nov. and month for Dec. through May) and additionally by five fishing types: shore access (conventional regulations section of the river), special regulations fly fishing, drift boat fishing, boat fishing in the estuary, and tributary fishing.

Mean catch rates were calculated as follows with the ratio of means estimator being used for the Salmon River survey. The ratio of means estimator is appropriate for access site creel surveys and the calculations followed Lockwood *et al*. 1999.

Ratio of Means Stratified Catch Rate Estimator for all Salmon River interviews

y = fish caught or harvested, *x* = hours fished by angler *i* in stratum *h* and *L* is the total number of strata.

$\hat{R}_h = \frac{\bar{y}_h}{\bar{x}_h}$ is the rate in stratum *h* and $\hat{R} = \frac{\bar{y}_{st}}{\bar{x}_{st}}$ is the overall estimator

where:

$$\bar{y}_{st} = \frac{\sum_{h=1}^{L} N_h \bar{y}_h}{N} \quad \text{And} \quad \bar{x}_{st} = \frac{\sum_{h=1}^{L} N_h \bar{x}_h}{N}$$

and the variance of $\hat{R}_h$ is:

$$V(\hat{R}_h) = \left(\frac{N_h - n_h}{N_h} \right) \frac{\sum_{i=1}^{n_h} \left(y_{i,h} - \hat{R}_h x_{i,h} \right)^2}{n_h (n_h - 1) \bar{x}_h^2}$$

and the variance of $\hat{R}$ is:

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

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Bottom trawl assessment of Lake Ontario's benthic preyfish community, 2021

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Abstract
Since 1978, the Lake Ontario preyfish community survey has provided information on the status and trends of the benthic preyfish community related to Fish Community Objectives that includes understanding preyfish population dynamics and community diversity. Beginning in 2015, the benthic preyfish survey expanded from US-only to incorporate lake-wide sampling sites which increased the survey's spatial coverage, and resumed sampling in eastern US embayments (Black River, Chaumont, Guffin, and Henderson Bays) that were historically sampled during a September bottom trawl survey to index yellow perch from 1978 to 2007. In 2021, the collaborative benthic preyfish survey completed 195 bottom trawl tows across main lake and embayments at depths from 5 to 226 m. New embayment sites at Bay of Quinte, Sodus, and Little Sodus Bay were added to the survey in 2021 to compare fish communities across nearshore sites. In total, the 2021 survey sampled 107,110 fish from 35 species. Round goby (Neogobius melanostomus) was the most numerically abundant species comprising 44% of the total catch, followed by deepwater sculpin (Myoxocephalus thompsonii), and alewife (Alosa pseudoharengus) at 17% and 12%, respectively. Deepwater sculpin accounted for most (402 kg) of the fish biomass sampled during the 2021 survey (total=1,963 kg), followed by common carp (252 kg, Cyprinus carpio), white perch (248 kg), and round goby (237 kg). Slimy sculpin (Cottus cognatus) biomass was higher in 2021 than in 2020, when spatial coverage was reduced. Deepwater sculpin biomass remained high in 2021 and similar to observations since 2019. White perch biomass (Morone americana) in Black River Bay has increased compared to observations from historical surveys. Yellow perch (Perca flavescens) accounted for most of the benthic preyfish biomass across the embayments surveyed in 2021 except for the Bay of Quinte and Black River Bay, where white perch accounted for a greater proportion of the fish community biomass.

Introduction

Lake Ontario Fish Community Objectives (herein FCOs) call for maintaining predator-prey balance and for maintaining and restoring pelagic and benthic (bottom–oriented, demersal) preyfish diversity (Stewart et al., 2017). Collaborative bottom trawl surveys have annually assessed Lake Ontario preyfish community status and trends since 1978 to provide information for decision-making relative to those objectives. Here, we summarize recent findings from the fall 2021 Lake Ontario benthic preyfish survey.

During the 1970–1980s, the benthic preyfish community was dominated by slimy sculpin (*Cottus cognatus*), with lesser amounts of trout-perch (*Percopsis omiscomaycus*), johnny darter (*Etheostoma nigrum*), and spottail shiner (*Notropis hudsonius*). Recent bottom trawl surveys have documented a decline in slimy sculpin abundance and an increase in non-native round goby (*Neogobius melanostomus*) beginning in 2005, as well as a resurgence in native deepwater sculpin (*Myoxocephalus thompsonii*), once considered extirpated (O'Malley et al. 2021; Weidel et al. 2017). These large changes in benthic preyfish composition exemplify the importance of monitoring populations and improving survey design to provide the best information possible to track population changes through time. Moreover, Lake Ontario spring and fall preyfish surveys have routinely sampled the same lake areas across different seasons from April to October over multiple years, which allows for quantifying seasonal migrations of fish populations to better understand ecosystem structure and function and how habitats are coupled by different species (Ives et al. 2019; Pennuto et al. 2021).

Bottom trawl surveys also measure the progress of native species restoration. In Lake Ontario, bloater (*Coregonus hoyi*), a native coregonine species that inhabits deep, offshore habitats, was considered extirpated from the lake by the 1980s (Weidel et al. 2022). Since 2012, bloater have been reintroduced through stocking, and bottom trawl recaptures allow for tracking the progress of the restoration program (Holey et al. 2021; Weidel et al. 2022). Beginning in 2015, bloater have been captured in bottom trawl surveys, marking the first time this species has been sampled in Lake Ontario since 1983 (Weidel et al. 2022). Additionally, using similar gear types and trawling at similar times of year to other surveys conducted throughout the Laurentian Great Lakes allows managers to interpret Lake Ontario preyfish dynamics at a basin-wide scale, as well as across different habitats (main lake vs. embayments) and depth strata.

This report describes the status of the Lake Ontario benthic preyfish community, with an emphasis on information addressing the bi-national (Ontario Ministry of Northern Development, Mines, Natural Resources and Forestry [NDMNRF], and New York State Department of Environmental Conservation [NYSDEC]) Lake Ontario Committee's FCOs (Stewart et al. 2017). This research is also guided by U.S. Geological Survey (USGS) Ecosystems Mission Area science strategy that seeks to understand how ecosystems function and provide services, as well as what drives them, and to develop science and tools that inform decision making related to ecosystem management, conservation and restoration (Williams et al., 2013). In addition to presenting long term results from the benthic preyfish survey, we also leverage bottom trawl data from a survey that sampled northeastern Lake Ontario embayments from 1978 to 2007 to describe community changes in these habitats that were added to the benthic preyfish survey in 2015.

Methods

Benthic preyfish survey

From 1978 to 2011, the benthic preyfish survey sampled six to ten transects along the southern shore of Lake Ontario from Olcott to Oswego, NY. Daytime trawls were typically 10 minutes and sampled depths from 8–150 m (26–495 ft). The original survey gear was a Yankee bottom trawl with an 11.8-m (39 ft) headrope and was spread with flat, rectangular, wooden trawl doors (2.1 m x 1 m). The survey typically occurred during October but also included sampling from September to November (Figure 1). Abundant dreissenid (*Dreissena* spp.) mussel catches in the early 2000s led to the survey abandoning the standard trawl and experimenting with a variety of alternate polypropylene bottom trawls and metal trawl doors (2004-2010). Comparison towing indicated that alternate trawls caught fewer demersal fishes and the alternative trawl doors influenced net morphometry (Weidel and Walsh, 2013). Since 2011, the survey has used the historically standard Yankee trawl and doors, but has reduced tow times to reduce mussel catches. Typical trawl tows in recent years have been 5 minutes, and in nearshore areas or those where mussel catches are high as indicated by the preceding trawl tow, tow times have been reduced to 2.5-4 minutes. Experimental sampling at new transects and in deeper habitats began in 2012. More notably, in 2015, the survey spatial extent was doubled to include Canadian waters and embayment sites in the eastern basin. At that time, the NYSDEC and NDMNRF research vessels joined the survey, which greatly expanded the spatial extent and diversity of habitats surveyed. Time series generated from the benthic preyfish survey from 1978 to present are illustrated in this report. No adjustments are available for data when the alternative trawls were used.

In 2021, a record high number of 195 trawl tows were completed between three research vessels from September 13 to October 15 (Figure 2). Trawl catches were sorted by species, counted, and weighed. Dreissenid mussels were weighed but not counted or identified to species. Subsamples of species in each trawl tow were measured for individual length and weight. Additional samples for growth, diet, reproduction, and genetic analysis were collected for some species.

Trawl effort was historically based on tow time, and abundance indices were reported as number or weight per 10-minute trawl. Area-swept estimates calculated using trawl mensuration sensors and video cameras indicated that trawl effort expressed as area swept differed substantially from tow-time based effort. Trawl results are expressed as biomass densities (kg/ha, kilograms of fish per hectare) and account for depth-based differences in the lake area swept by the trawl (Weidel and Walsh, 2013). Time series are still regarded as biomass indices, rather than absolute densities, because we lack estimates of trawl catchability (proportion of the true density within a surveyed area captured by the trawl). Trawl tows were assigned to a country based on the mid-point of start-end trawl coordinates. Historical trawl tows without coordinates were assigned to a country based on the nearest port (only U.S. waters). Annual area-weighted biomass indices expressed as kg/ha were calculated for U.S waters (1978–2021) and lake-wide (2015–2021) using thirteen 20 m strata (66 ft) within U.S. and Canadian waters (Table 1). Strata not sampled in a given survey year were assumed to be zeroes for each species. The lake-wide index was calculated assuming 52% and 48% area for Canadian and US waters, respectively. Mean and standard error calculations are from Cochrane (1977).

Perch Survey

From 1978 to 2007, fish communities in northeastern embayments of Lake Ontario (Chaumont, Guffin, Black River, and Henderson Bays) were sampled during late September through early October (Figure 1) in an effort to assess yellow perch (*Perca flavescens*) and white perch (*Morone americana*) populations and document long term trends in the fish community of these habitats (O'Gorman and Burnett, 2001). We refer to this dataset as the perch survey for convenience. In our analysis, we pooled observations from Guffin and Chaumount Bay, and simply refer to these as Chaumont Bay given their close proximity to each other in Lake Ontario. Catch protocols were similar to those described above where species were sorted, counted, weighed, and subsamples were measured for length frequency. From 1978 to 1997, sampling was conducted by the USGS R/V Kaho with a 7.9-m headrope bottom trawl, with a 13-mm stretch nylon mesh cod end. Trawl tows occurred during the day and typically lasted for 5 minutes. Site depths were between 6 to 20 m, and approximately 15 sites were sampled each year. In 1996, problems with fouling from large catches of dreissenid mussels led to the adoption of mud rollers in 1997 to reduce fouling. From 1998-2007, the NYSDEC R/V Seth Green continued the sampling using an 18-m, 3N1 bottom trawl at the same locations. For detailed descriptions of trawl gear used in Lake Ontario surveys, see Lantry et al. (2007). In 2015, the R/V Seth Green resumed sampling these sites annually in early October as part of the benthic preyfish survey using a Yankee bottom trawl. The recent expansion of our annual benthic preyfish survey into these historically sampled habitats has created an opportunity to assess long term trends for fall benthic preyfish communities from these embayments.

In addition to the benthic preyfish survey data, we used data from the perch survey to illustrate long term trends in the benthic fish populations of embayments by combining both datasets. In contrast to lake-wide trends which use an area weighted mean, we report mean biomass density for yellow and white perch for the embayments (1978–2021) without weighting by depth strata. We calculated the biomass proportion of benthic preyfish species for each year using the total weight across all trawl sites per embayment. Additionally, we compared 2021 catches among the eastern embayments to new trawl sites that were added to the benthic preyfish survey in 2021 at Little Sodus, Sodus Bay, and Bay of Quinte. These new sites have also been sampled in the spring preyfish bottom trawl survey that uses a 3N1 trawl (Weidel et al. 2021). Because of issues with fouling from sediments in the Bay of Quinte, a 3N1 trawl was used for these sites during the 2021 benthic preyfish survey instead of a Yankee trawl and tow times were reduced to 2.5 minutes.

Results and Discussion

Bloater – Bloater are a benthopelagic species native to Lake Ontario that historically inhabited deep, offshore habitats. While records are sparse, commercial fishery catches suggest the species was historically abundant in Lake Ontario but rare by the 1970s (Christie, 1973). Catches have been sporadically low since restoration stocking began in 2012 but are reasonable based on our power to detect species at low abundance (Weidel et al., 2022). In 2021, no bloater were captured during the benthic preyfish survey, marking the third consecutive year where bloater were absent in fall bottom trawls.

Slimy Sculpin – Slimy sculpin biomass in 2021 continued to be low compared to historical values but was slightly higher on a lake-wide scale than in 2020, when limited sampling occurred (Figure 3). Once the dominant demersal preyfish in Lake Ontario, slimy sculpin declines in the 1990s were attributed to the collapse of their preferred prey, the amphipod *Diporeia* (Owens and Dittman, 2003). The further declines of slimy sculpin that occurred in the mid-2000s appear to be related to round goby. Recent increases in deepwater sculpin may also have negative impacts on slimy sculpin at the deep edge of their depth distribution where the two species overlap (Volkel et al. 2021). Slimy sculpin distribution appears to vary spatially across suitable Lake Ontario depth strata. Trawl sites in Canadian waters, notably at sites south of Pickering and Oshawa, had the highest biomass density among all trawl tows (Figure 4). Slimy sculpin biomass peaks by depth strata were higher at shallower depths (< 120 m) in Canadian waters, whereas higher biomass density in U.S. waters occurred at depths > 120 m (Figure 5).

Deepwater Sculpin – Deepwater sculpin were the second most abundant preyfish in trawl catches during the benthic preyfish survey in 2021 (Table 2). Deepwater sculpin biomass has generally increased from 2010 to 2017 and has been relatively stable since 2019 (Figure 3; 2019–2021 mean lake wide biomass = 2.98 ± 0.28 SD kg/ha).

Round Goby – Round goby was the most abundant preyfish in trawl catches during the 2021 survey (Table 2), although biomass was lower in 2021 compared to 2020 (Figure 2). Estimating round goby abundance using bottom trawls can be complicated by the fish's preference for rocky substrate and seasonal changes in depth distribution (Ray and Corkum, 2001; Pennuto et al., 2021). Round goby are typically concentrated at shallower depths during the survey (Figure 4).

Embayment Catches – Trawl catches at embayment sites sampled in 2021 (Chaumont Bay, Black River Bay, Henderson Bay, Bay of Quinte, Sodus and Little Sodus Bay) continued to represent species that are not common in main lake catches. Since 2015, these habitats, especially Black River Bay, are the only sites where trawls routinely capture trout-perch, darters, and spottail shiner, native species that were once common in main-lake portion of Lake Ontario in the 1970–1990s (Figure 6). Yellow perch accounted for most of the benthic preyfish biomass across the embayments surveyed in 2021 (Figure 6), except for in Black River Bay and Bay of Quinte where white perch constituted a greater proportion of the catch. Time series constructed from combining the yellow perch survey and benthic preyfish survey indicate increases in white perch biomass in Black River Bay (Figure 7).

Acknowledgements

We thank all the administrative, vessel, biological, and support staff for their effort and flexibility conducting the 2021 Lake Ontario benthic preyfish survey. Funding for U.S. Geological Survey sampling and analysis is from the Ecosystems Mission Area and the Fisheries and Status and Trends programs. Provincial funding to implement NDMNRF sampling was from the Canada-Ontario Agreement on Great Lakes Water Quality and Ecosystem Health and Ontario's Great Lakes Strategy. NYSDEC funding was from the Federal Aid in Sport Fish Restoration Program. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government. The data associated with this report can be found in the following data release: U.S. Geological Survey, Great Lakes Science Center, 2022, Great Lakes Research Vessel Catch (RVCAT) Database: U.S. Geological Survey data release, https://doi.org/10.5066/P9XVOLR1. All USGS sampling and handling of fish during research are carried out in accordance with guidelines for the care and use of fishes by the American Fisheries Society (http://fisheries.org/docs/wp/Guidelines-for-Use-of-Fishes.pdf).

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Table 1. Proportions of Lake Ontario surface area by 20m depth strata that fall within Canadian and U.S. waters. Blank values indicate depths that are not represented in Canadian waters.

Depth bin (m)	Proportional area in Canadian waters	Proportional area in U.S. waters
0-20	0.176	0.128
20-40	0.163	0.100
40-60	0.126	0.075
60-80	0.143	0.057
80-100	0.120	0.049
100-120	0.130	0.058
120-140	0.097	0.091
140-160	0.036	0.123
160-180		0.177
180-200		0.082
200-220		0.050
220-240		0.009
240-243		<0.001

Table 2. Number of fish caught in the fall 2021 benthic preyfish survey. Dreissenid mussel catch (**Dreissena*** ***spp.) is represented by weight in kilograms. Values include all Lake Ontario sampling sites, including Canadian waters.***

Common name	Scientific name	Number caught
Round goby	*Neogobius melanostomus*	47,148
Deepwater sculpin	*Myoxocephalus thompsonii*	17,684
Alewife	*Alosa pseudoharengus*	12,356
Rainbow smelt	*Osmerus mordax*	8,170
Emerald shiner	*Notropis atherinoides*	4,363
White perch	*Morone americana*	4,204
Yellow perch	*Perca flavescens*	4,079
Threespine stickleback	*Gasterosteus aculeatus*	3,753
Gizzard shad	*Dorosoma cepedianum*	2,283
Trout-perch	*Percopsis omiscomaycus*	723
Brown bullhead	*Ameiurus nebulosus*	709
Spottail shiner	*Notropis hudsonius*	564
Pumpkinseed	*Lepomis gibbosus*	409
Slimy sculpin	*Cottus cognatus*	357
White sucker	*Catostomus commersonii*	92
Lake trout	*Salvelinus namaycush*	75
Freshwater drum	*Aplodinotus grunniens*	69
Carp	*Cyprinus carpio*	35
Walleye	*Sander vitreus*	27
Quillback	*Carpiodes cyprinus*	23
Logperch	*Percina caprodes*	14
Darters	*Etheostoma* spp.	13
Largemouth bass	*Micropterus salmoides*	10
Bluntnose minnow	*Pimephales notatus*	9
Black crappie	*Pomoxis nigromaculatus*	7
White bass	*Morone chrysops*	6
Cisco	*Coregonus artedi*	5
Bluegill	*Lepomis macrochirus*	5
Smallmouth bass	*Micropterus dolomieu*	5
Lake whitefish	*Coregonus clupeaformis*	4
Rockbass	*Ambloplites rupestris*	4
Lake sturgeon	*Acipenser fulvescens*	2
Northern pike	*Esox lucius*	1
Channel catfish	*Ictalurus punctatus*	1
Brown trout	*Salmo trutta*	1
Dreissenid mussel (kg)	*Dreissena* spp.	4,983

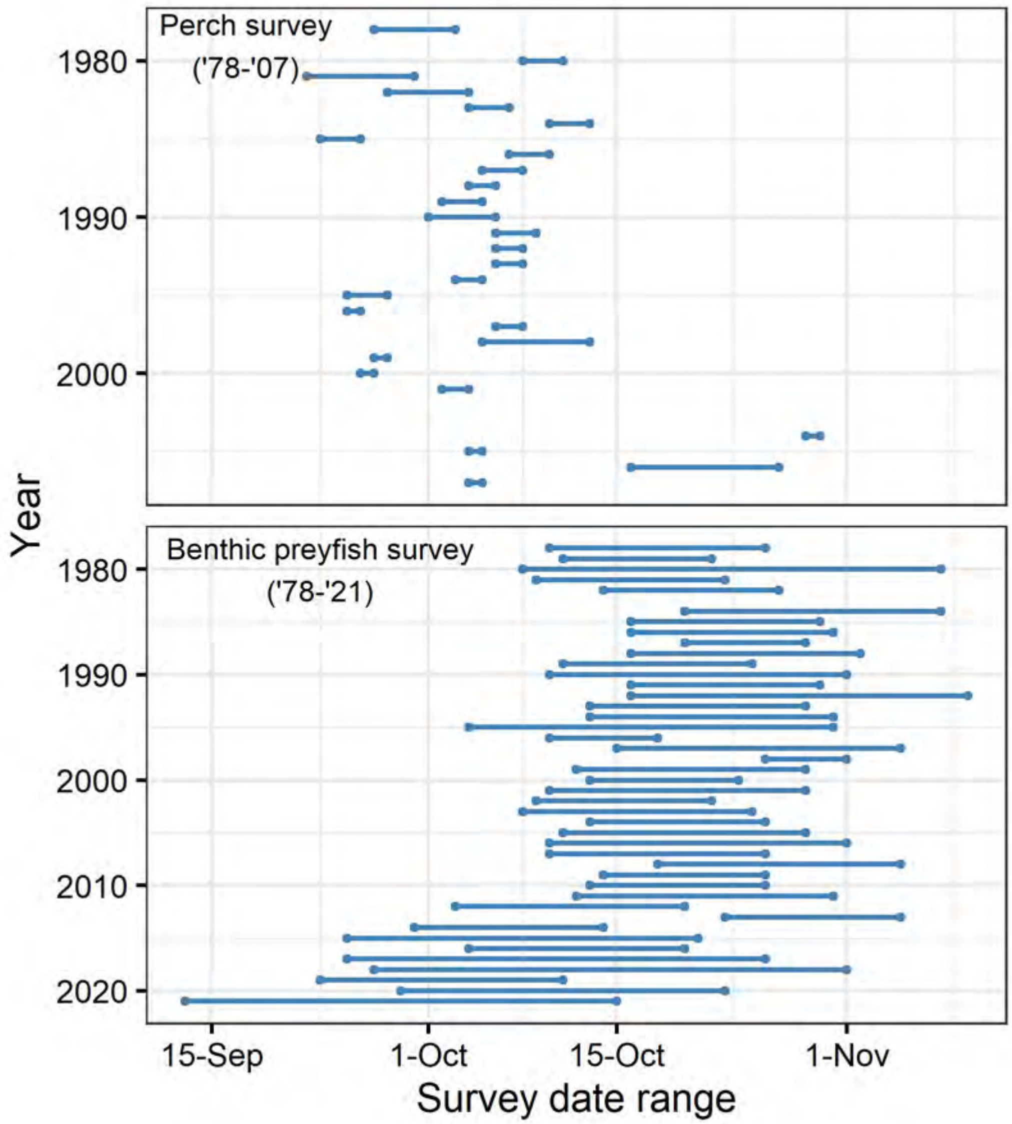

Figure 1. Calendar date range for bottom trawl tows conducted during the yellow perch survey (top panel; 1978–2007) and the benthic preyfish survey (1978–2021).

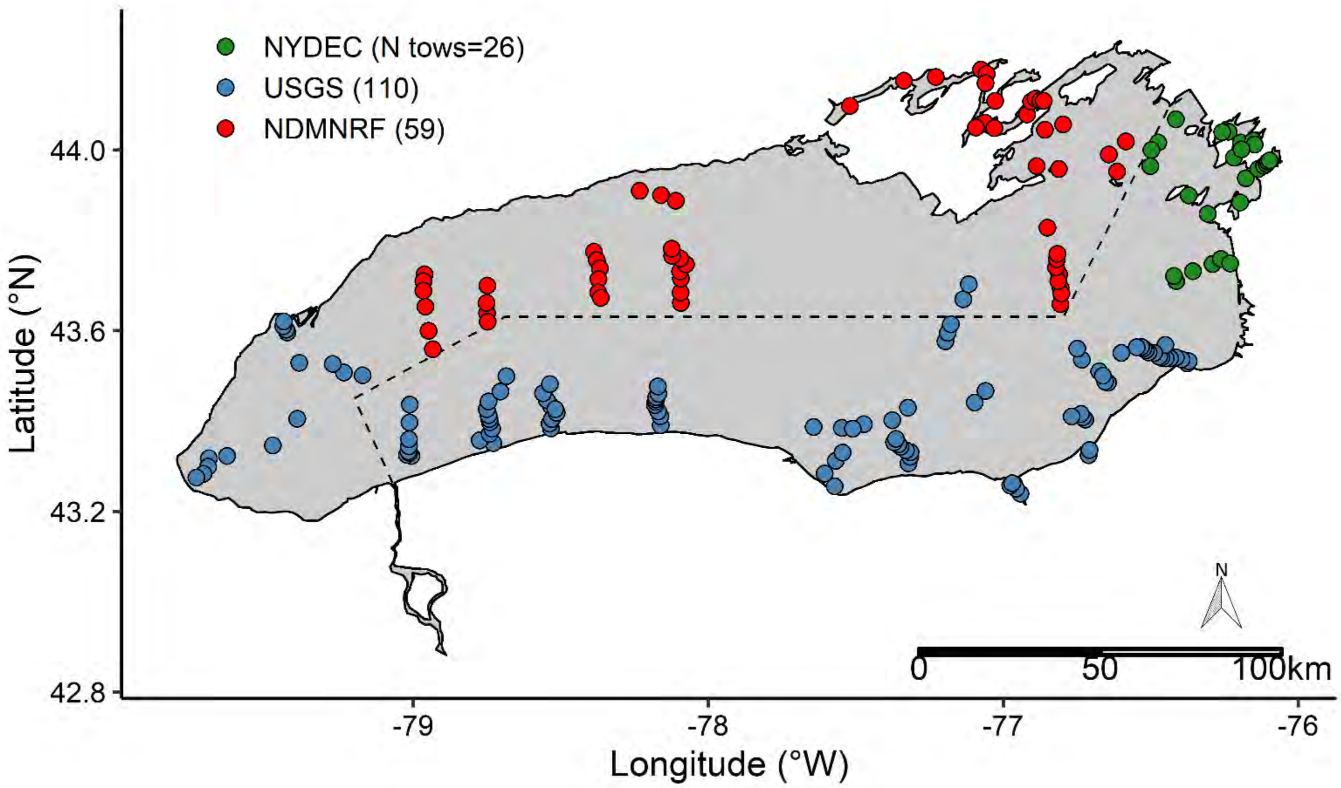

Figure 2. Lake Ontario bottom trawl sites sampled during the 2021 benthic preyfish survey. 195 bottom trawls tows were collectively sampled by the New York Department of Environmental Conservation (NYSDEC) R/V Seth Green, U.S. Geological Survey (USGS) R/V Kaho, and Ontario Ministry of Northern Mines, Natural Resources, and Forestry (NDMNRF) R/V Ontario Explorer during September 13 - October 15. Dashed line represents the U.S.-Canada international boundary.

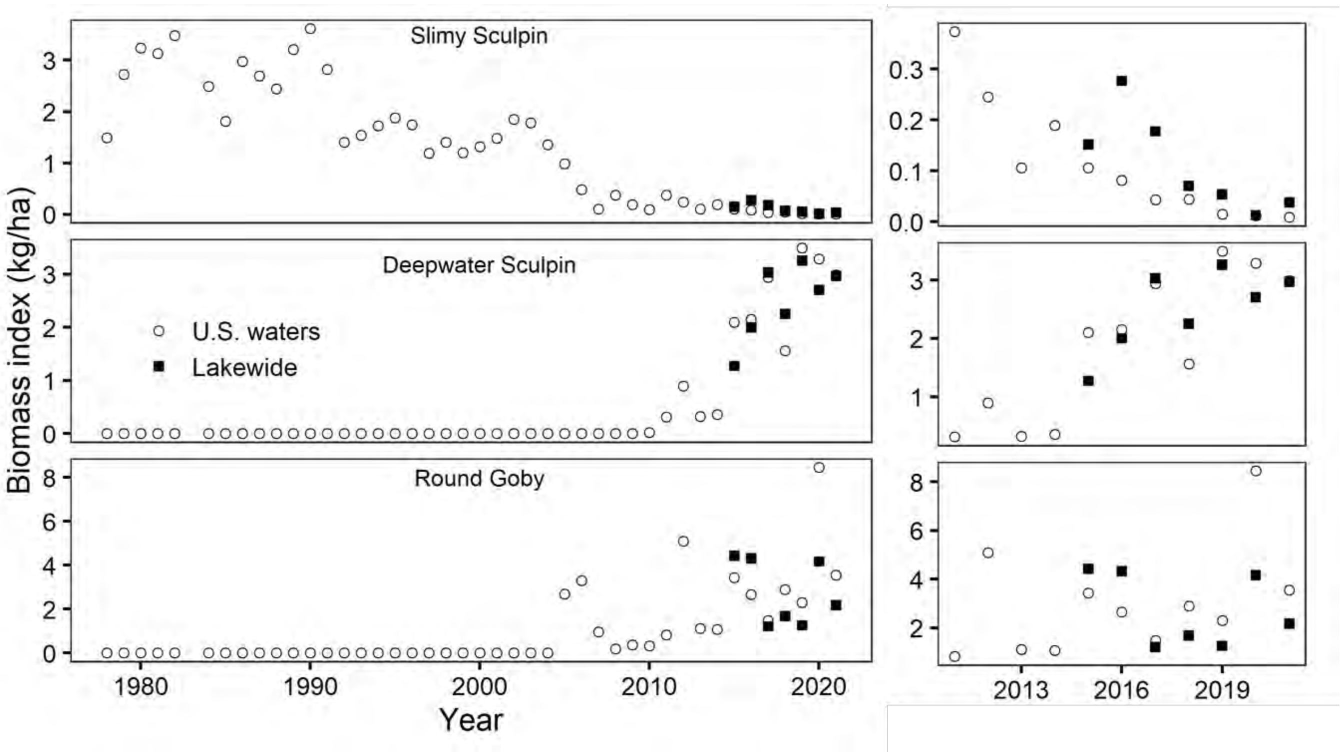

Figure 3. (Left) Area-stratified biomass density (kilograms per hectare) for slimy sculpin, deepwater sculpin, and round goby in the benthic preyfish survey, 1978–2021. Open symbols represent the index for U.S. waters only, and closed squares represent lake-wide values that include trawls from both U.S. and Canadian waters. (Right) A subset of the time series representing only 2011–2021 to illustrate recent trends over the past ten years that may not be apparent when viewing the entire time series. Note the difference in scale for slimy sculpin biomass between the two time periods.

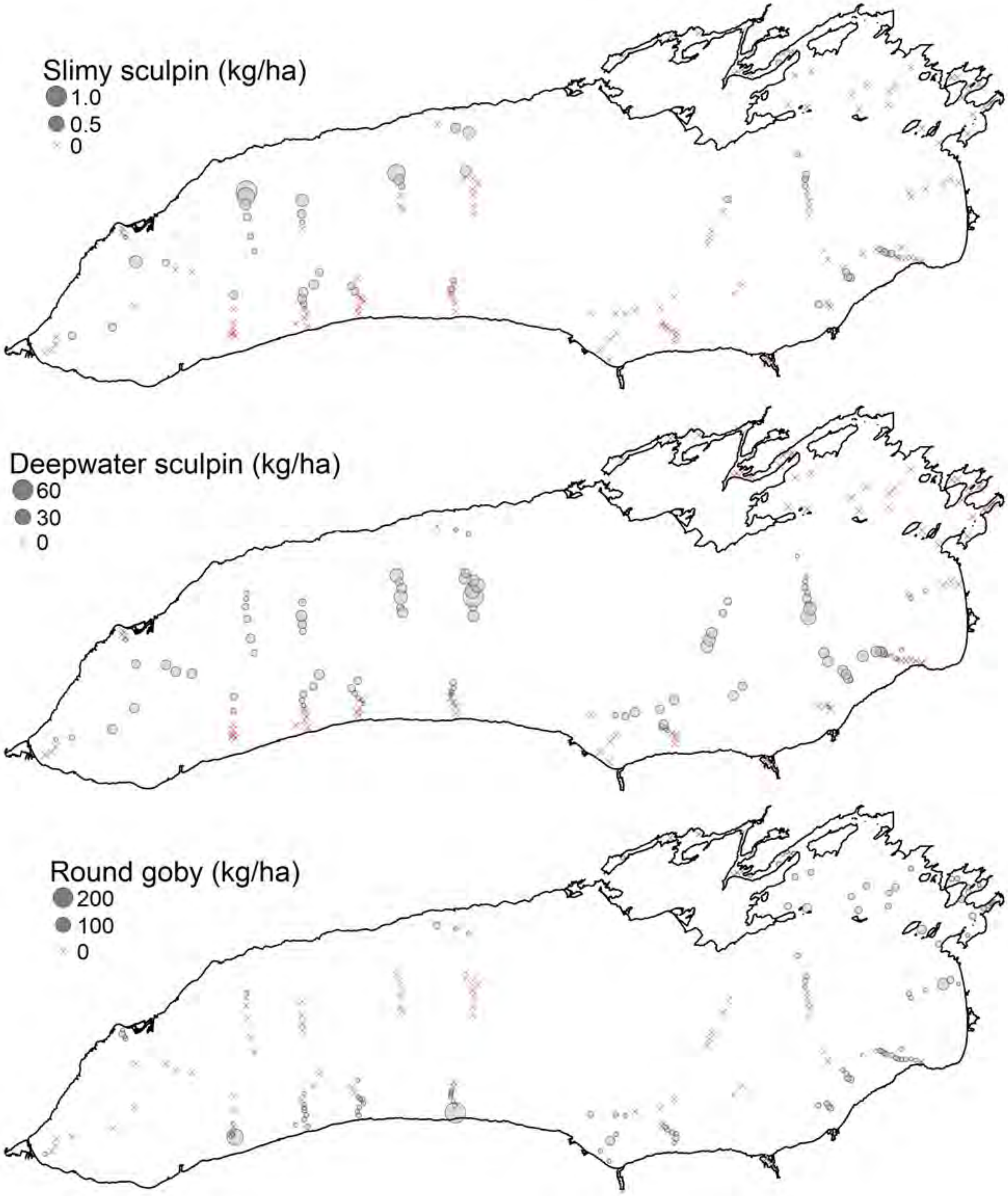

Figure 4. Spatial distribution of biomass density (kg/ha) from individual trawl tows for slimy sculpin, deepwater sculpin, and round goby in Lake Ontario, 2021. Note the difference in biomass scales among maps.

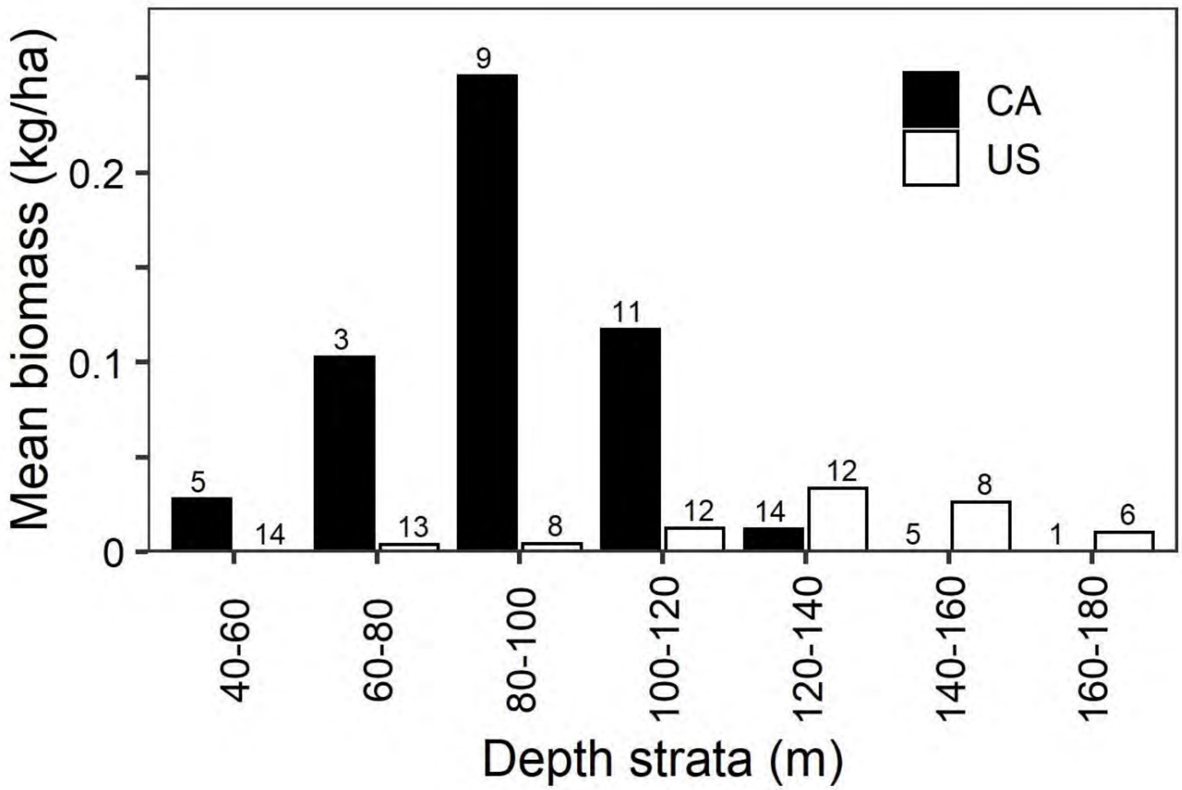

Figure 5. Mean slimy sculpin biomass estimated from bottom trawl tows by depth strata in Canadian (CA) and U.S. (US) waters of Lake Ontario during the 2021 benthic preyfish survey. Numbers above each bar represent the number of trawl tows.

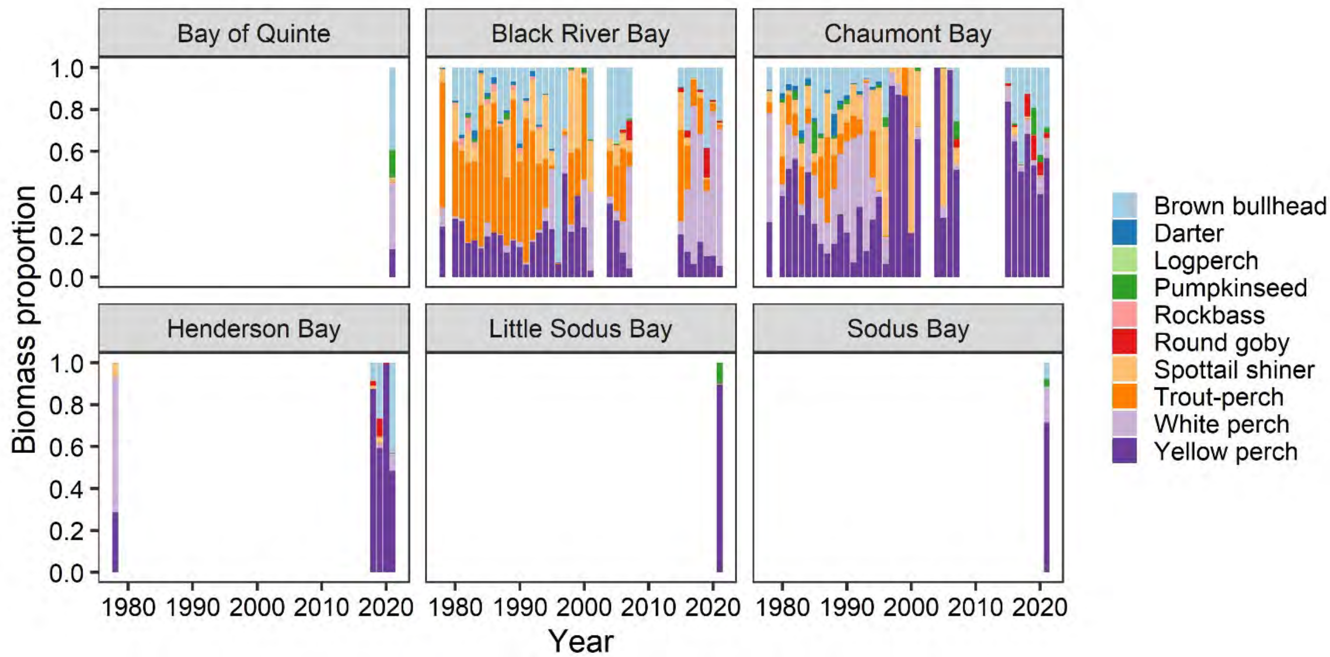

Figure 6. Community composition of benthic preyfish in Lake Ontario embayment catches from the yellow perch survey 1978–2007 (O'Gorman and Burnett 2001), and the benthic preyfish survey 2015–2021.

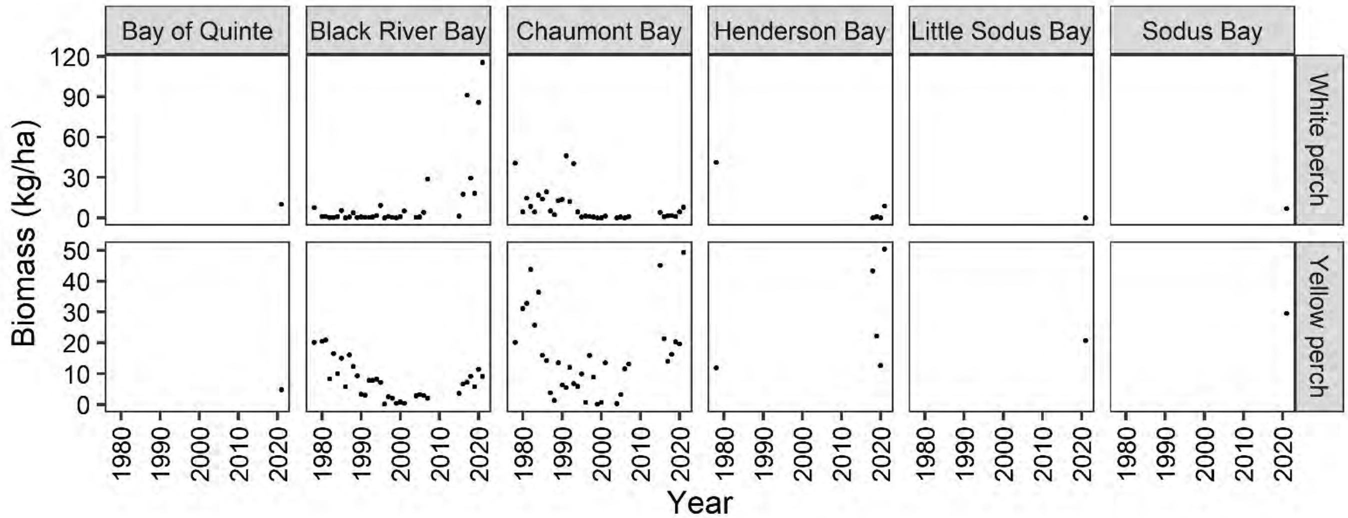

Figure 7. Mean biomass density (kg/ha) of yellow perch and white perch from trawl tows in embayments during the yellow perch survey 1978–2007 (O'Gorman and Burnett 2001), and during the benthic preyfish survey 2015–2021. Note that trawl sites in Chaumont, Black River, and Henderson Bays were added to the benthic preyfish survey beginning in 2015, and Bay of Quinte, Sodus, and Little Sodus Bays were added in 2021.

Lake Sturgeon Tagging Study and Egg Take 2021

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Lake sturgeon (*Acipenser fulvescens*) were historically an abundant and widely distributed species in New York State (NYS). Overharvest, habitat degradation, and migratory impediments (i.e., dams) resulted in drastic decline of the species by the early 1900s. Due to severely depleted stocks, the lake sturgeon fishery was closed by the NYS Department of Environmental Conservation (DEC) in 1976. Lake sturgeon were listed as a threatened species by NYSDEC in 1986, with lost, sparse or declining populations in six of the nine watersheds where they historically occurred.

Restoration efforts, including stocking and habitat enhancement, benefit from a tagging methodology that allows for long-term fish identification, especially when considering broodstock genetics and spawning site fidelity. This project is a continuation of one funded by the U.S. Fish and Wildlife Service's (USFWS) Fish Enhancement, Mitigation and Research Fund (FEMRF) to tag lake sturgeon with permanent individual markers. Lake sturgeon were collected annually at various sites in the St. Lawrence River and Eastern Basin of Lake Ontario since 2010. Fish were evaluated for basic biological information and then scanned for Passive Integrated Transponder (PIT) tags to determine if they had been previously tagged. A PIT tag was applied to untagged fish for permanent individual identification. The goal is to create a long-term database of individual fish to support ongoing species rehabilitation.

Restoration of lake sturgeon has been ongoing in NYS since 1993 through propagation, stocking, and spawning site creation. Wild broodstock are collected annually downstream of the Moses Power Project (Massena, NY) adjacent to the South Channel. Gametes are collected, fertilized, and then cultured at the Oneida Fish Culture Station (Constantia, NY) and the USFWS Genoa National Fish Hatchery (Wisconsin). Progeny are stocked into the St. Lawrence River, the Eastern Basin of Lake Ontario and various NYS Lake Ontario and St. Lawrence River tributaries. Most stocked fish have received Coded Wire Tags (CWT) since 2013 to identify them as being of hatchery origin.

Methods

<u>Geographic Area</u>
Project boundaries encompass the U.S. waters of the St. Lawrence River and the Eastern Basin of Lake Ontario. U.S. waters of the St. Lawrence River is approximately 84 mi^2, of which a very small portion is both suitable for netting activity and overlaps with suitable sturgeon habitat.

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

<u>Collection</u>
Lake sturgeon (sturgeon) were collected from April - August in 2021. Collections included netting that targeted sturgeon along with existing annual gill net surveys that assess warmwater fish populations which frequently catch sturgeon.

Pre-spawn and spawning adult sturgeon were targeted in Lake Ontario (Black River Bay), Black River, and in the St. Lawrence River immediately downstream of the Moses Power Dam (hereafter Dam). Existing long-term index gill netting programs include two on the St. Lawrence River (Thousand Islands and Lake St. Lawrence) and one in the Eastern Basin of Lake Ontario which capture both adult and juvenile sturgeon. Most fish were collected with monofilament gill nets fished in waters from 13-60 feet in depth. Set lines, fished in the same manner as gill nets, were examined as a potential alternative to gill nets to be used under certain environmental conditions in 2019 (Klindt and Gordon 2020). Gear configurations and relative effort used in 2021 to target sturgeon are described in Tables 1 and 2 respectively.

Captured sturgeon were measured to the nearest millimeter total length (TL), weighed, examined/scanned for existing Floy® or PIT tags, and were scanned for CWTs to determine whether they were of hatchery origin. Sex could only be verified in fish captured during the spawning period through extrusion of gametes. Some fish captured for potential egg-take were examined internally with a hypodermic extractor (Candrl et al. 2010) for confirmation that they were late stage, gravid females.

PIT tags were applied to fish captured for a first time or fish that were previously only Floy® tagged. Tags were placed under the fourth dorsal scute, the standard location for the DEC, Ontario Ministry of Natural Resources and Forestry (OMNRF), and U.S. Geological Survey (USGS). All fish, with the exception of those held for egg and milt collections, were released immediately after tagging within 0.1 miles of their capture location. PIT tag data were shared with the USFWS Great Lakes Lake Sturgeon Database which will allow researchers to acquire information related to individual sturgeon they may encounter.

Results and Discussion

Beginning in the early 1990s, DEC has sampled St. Lawrence River sturgeon below the Dam. Collections initially focused on documenting presence of sturgeon and acquiring basic biological information. Beginning in 1996, sturgeon were collected for use as broodstock in restoration efforts. As restoration efforts intensified and genetic investigations revealed distinct spawning stocks of sturgeon (Welsh et al. 2008), the need for reliable and permanent identification of individual fish became clear.

Use of PIT tags began in 2008 and continues to be the primary method of uniquely marking sturgeon. In 2010, a FEMRF grant provided tags and related equipment for large-scale tagging of sturgeon in the St. Lawrence River and Eastern Basin of Lake Ontario.

<u>2021 Results – All Surveys Combined</u>

DEC personnel captured a total of 115 sturgeon throughout the sampling area in 2021, ranging in length from 14.7-67.8 inches and weighing up to 83.8 pounds. Capture locations and gear type for 2021 are shown in Figure 1. PIT tags were applied to 79 sturgeon (63% St. Lawrence River; 37% Lake Ontario). A total of 35 recaptures were recorded in 2021 across the study area. Most recaptured fish came from the general area of initial tagging, although two fish were recorded to have traveled a significant distance from initial tagging and one fish was reported to be recaptured by DEC in two different Lake Sturgeon Restoration Management Units this year (Table 3; NYSDEC 2018). Length-weight relationships were constructed using data from all sturgeon collected (where lengths and weights were available) from 2010-2021 (Figure 2), and for adult fish separated by sex (Figure 3). Sturgeon body form can be quite variable as demonstrated by the relationships.

In 2021, males (n=28) accounted for 24% of the catch while females (n=9) represented 8%. The remaining fish were either immature or of undetermined sex (n=78, 68%). Few juvenile sturgeon were represented in the catch (< 30”, n=12), due to the large mesh size of gill nets used in targeted surveys. The index gill net surveys use smaller mesh sizes, however, may not cover areas of preferred juvenile habitat.

<u>Black River Sampling</u>

Lake Sturgeon spawning in the Black River was first documented in 2005 (Klindt and Adams 2006). Sampling since 2005 was to acquire biological information and apply Floy® or PIT tags and targeted spawning fish either in the Black River or Black River Bay, depending on environmental conditions. This sampling also informs status of lake sturgeon within the Eastern Lake Ontario Management Unit outlined in the Lake Sturgeon Recovery Plan (NYSDEC 2018). Sampling did not occur in 2020 due to COVID-19 protocols.

In 2021, the majority of the targeted adult sampling effort was concentrated in Black River Bay where 42 sturgeon were collected with a CUE of 0.09 fish per hour (Table 2, Figure 4). Of fish collected, 57.1% were recaptures (n=24), two of which were originally tagged outside the study area (Table 3). Of particular note, one fish (PIT tag #: 985121024823231) was first caught in Black River Bay in 2015 and recaptured again on April 27, 2021. Three weeks later, on May 18, 2021, Region 7 DEC staff caught the same fish (PIT tag #: 985121024823231) in the mouth of the Oswego River approximately 45 miles away.

Low water conditions in the Black River prevented the use of gill nets; therefore, only set lines were used to target sturgeon in 2021. No fish were collected using this method.

Lake Ontario (Eastern Basin) Sampling

The annual Eastern Basin Lake Ontario index gill net survey conducted by the DEC's Lake Ontario Unit (LOU) collected 10 sturgeon in 2021 (Goretzke 2022) ranging from 16.8 – 25.2 inches. CWT reader malfunction prevented scanning of five fish, but of the remaining, two fish were confirmed CWT positive (hatchery stock) and three CWT negative (wild stock). Each fish received PIT tags and were released alive. Nets were fished at 28 sites with a lake sturgeon catch per unit effort (CUE) of 0.36 fish per net-night (Table 2).

Two sturgeon were captured during LOU's fall prey fish trawling survey (O'Malley et. al 2022). One fish was reported as a mortality while the other received a PIT tag and was released alive.

St. Lawrence River Sampling Above Moses Power Dam

In contrast to the Dam netting site, targeted sturgeon sampling upstream of the Dam has been limited. In 2014, a targeted effort at the mouth of the Oswegatchie River identified a spawning concentration with both ripe male and female fish occupying the area (Klindt and Gordon 2015). Occasional catches have occurred in the Thousand Islands (n=12) and Lake St. Lawrence (n=15) index gill net surveys prior to 2021 (Resseguie and Gordon 2022). In 2021, no sturgeon were collected above the Dam in the St. Lawrence River Assessments.

St. Lawrence River Sampling and Egg-Take Below Moses Power Dam

The confluence of the bypassed reach of the Dam or "South Channel" and the main stem of the St. Lawrence River has been used as a sturgeon broodstock source for the DEC since 1996 (LaPan et al. 1999). This area is considered a staging area for sturgeon spawning in the vicinity of the Dam. Net sites used for this collection typically produce large numbers of fish, accounting for the bulk of the annual sturgeon catch, including both potential spawners and resident fish.

A total of 61 sturgeon were collected from May 24-27, 2021 at fifteen sites with a CUE of 0.17 fish per hour (Table 2). Increased flows through the South Channel reduced gear efficiency two of the four netting days in 2021. Water temperature in the South Channel ranged from 55.7-58.5°F during the sampling period.

Sturgeon collected in 2021 ranged in length from 39.2-60.8 inches and in weight from 13.6-61.6 pounds. Fish used for the 2021 egg take (females n=6, males n=21) were taken from this group.

Eleven fish were recaptured in 2021 from previous tagging events from 2009-2020 for a recapture rate of 18% (Figure 5). Recapture rate, for our purposes, is the number of tagged fish divided by the total number of fish collected in a given year. All recaptured fish collected in 2021 were originally tagged in the South Channel.

Prior to egg collection, female fish were evaluated to verify that eggs are in the final stage of maturation and will likely respond to hormone injections (Chapman 2019). Fish selected as gamete donors (F=6, M=21) were treated with Carp Pituitary Hormone to induce ovulation and spermiation (Klindt 2014). The annual egg take took place on June 2, 2021, where approximately 155,500 fertilized eggs were collected and distributed between culture facilities in New York (77,500) and Wisconsin (77,500).

2021 Lake Sturgeon Stocking

Approximately 45,164 fingerlings were stocked into various waters of NYS as a result of the 2021 egg-take in the St. Lawrence River below the Dam (Table 4). A total of 19,000 fingerlings were stocked at standard stocking sites. Fish stocked at standard sites above the Dam received CWT's to assist in evaluations of wild recruitment within management units. Approximately 26,164 surplus fish ranging from 3.2-6.1 inches were stocked between August 10 and September 24, 2021. One thousand of the surplus fish were tagged with CWTs and stocked into Chaumont Bay. The remaining surplus were stocked with no tags into the St. Lawrence River below the Dam. In 2021, CWTs were inserted behind the head near the 1st dorsal scute at the NYSDEC Oneida Fish Culture Station to allow for identification of hatchery vs. wild origin (Table 5). CWTs inserted by USFWS Genoa National Fish Hatchery followed the 2020 tag schedule of behind the 3rd lateral scute right side. Current stocking rates are intended to continue through 2024. The purpose of stocking is to enhance the genetic diversity of new and rehabilitated populations for future spawning success. Use of PIT tags below the Dam is particularly critical to effective management of broodstock genetics (i.e. not using an individual that was previously used in an egg take), as well as to provide insight into sturgeon biology, including spawning periodicity, growth rate, and population mixing.

Summary

The intent of this program was to collect biological data and PIT tag sturgeon across a broad geographic area and create a long-term database of individual fish that will be used to support ongoing species rehabilitation. Due to the unique life history of this species, collecting these data is a long-term commitment.

From 2005-2021 a total of 1,666 unique sturgeon have been PIT tagged in the St. Lawrence River, Lake Ontario, and Black River by NYSDEC. Male fish, and those classified as unknown, are similar in percent occurrence (Table 6). Total female fish handled is approximately 6% of the sample, which is characteristic of spawning populations (Dr. Molly Webb, USFWS, personal communication).

To date, recapture information indicate that most fish remain within a distinct population unit. However, 25 sturgeon collected through this project are known to have made long movements from initial capture sites. Fifteen fish traveled substantial distances to a different spawning population, which included movement over, around, or through (entrained) a hydroelectric facility (Table 3). Three sturgeon were recaptured for which the original tagging location is unknown. In 2021, two juvenile sturgeon were of unknown origin (i.e., had no CWT).

With the preceding exceptions, spawning site fidelity appears to be high, with little documented movement between known spawning sites. Recapture rate was calculated for the broodstock collection at the South Channel (Figure 5). From 2009-2021 the recapture rate has ranged from 4.9-24.2% (average 13.7%). Recapture rate in 2021 was above the average at 20.8%.

Several spawning congregations both in the St. Lawrence River and Lake Ontario have been identified, and continually attract fish for reproduction. Past studies of age and growth (Jolliff and Eckert 1971, Johnson et al. 1998) would indicate that most sturgeon collected in this project range in age from 10-30 years.

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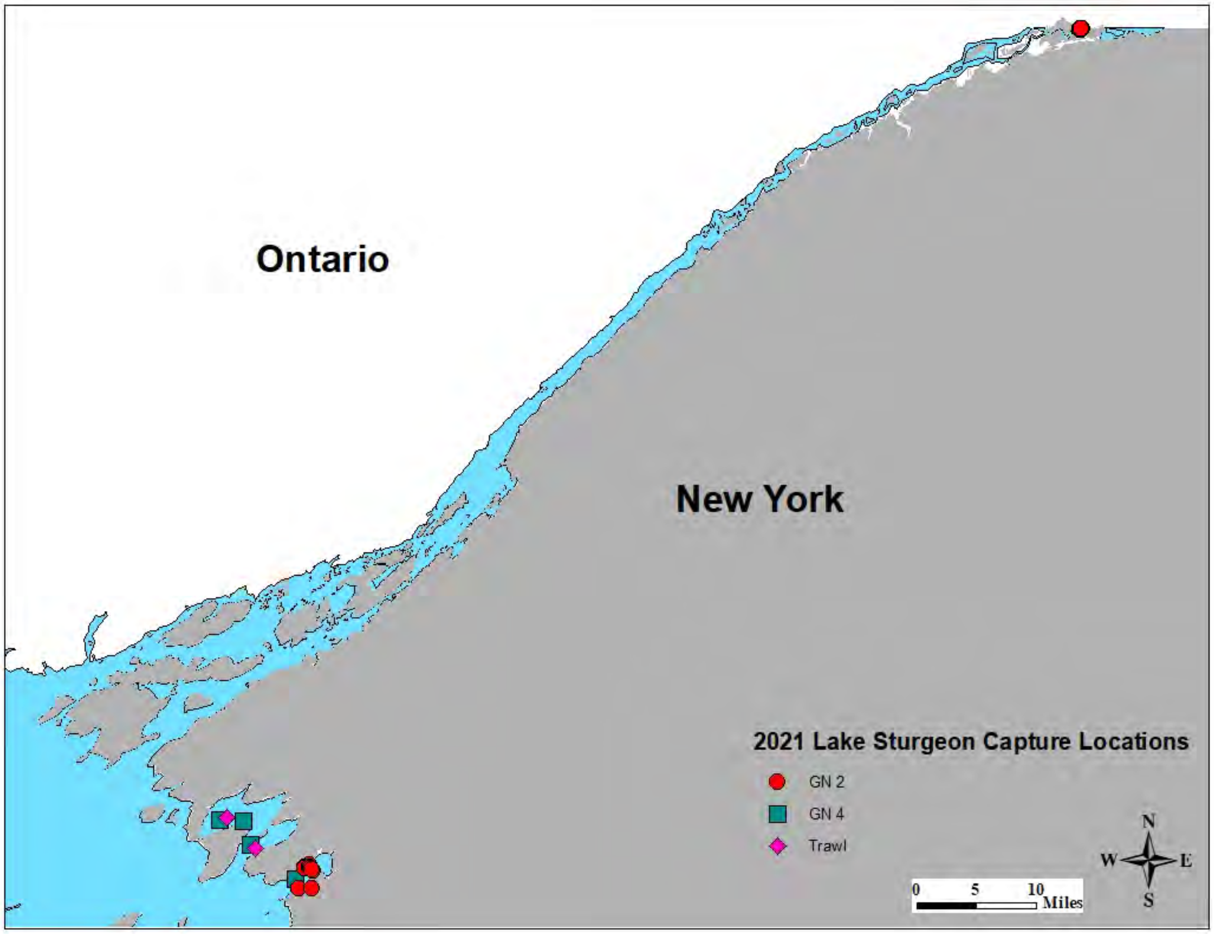

Figure 1. Lake sturgeon capture locations for 2021. Adults were targeted with large mesh gill nets only (GN 2). Existing index projects, utilizing experimental gill nets, in the St. Lawrence River (GN3) and Lake Ontario (GN4) potentially targeted both juveniles and adults. Two fish were captured during prey-fish trawling by NYSDEC Lake Ontario Unit.

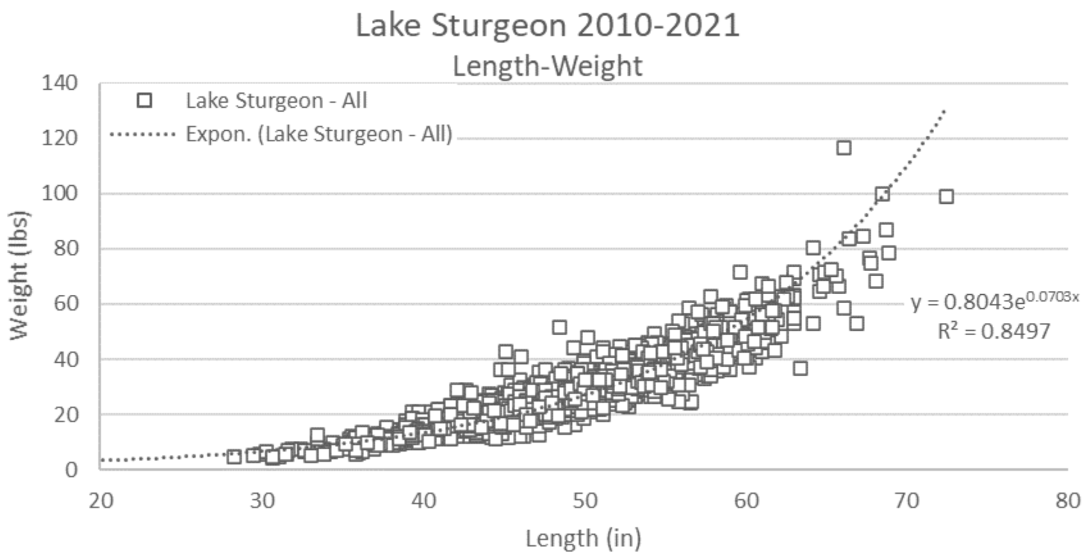

Figure 2. Length-weight relationship for lake sturgeon collected by DEC from 2010-2021. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined with no differentiation to sex.

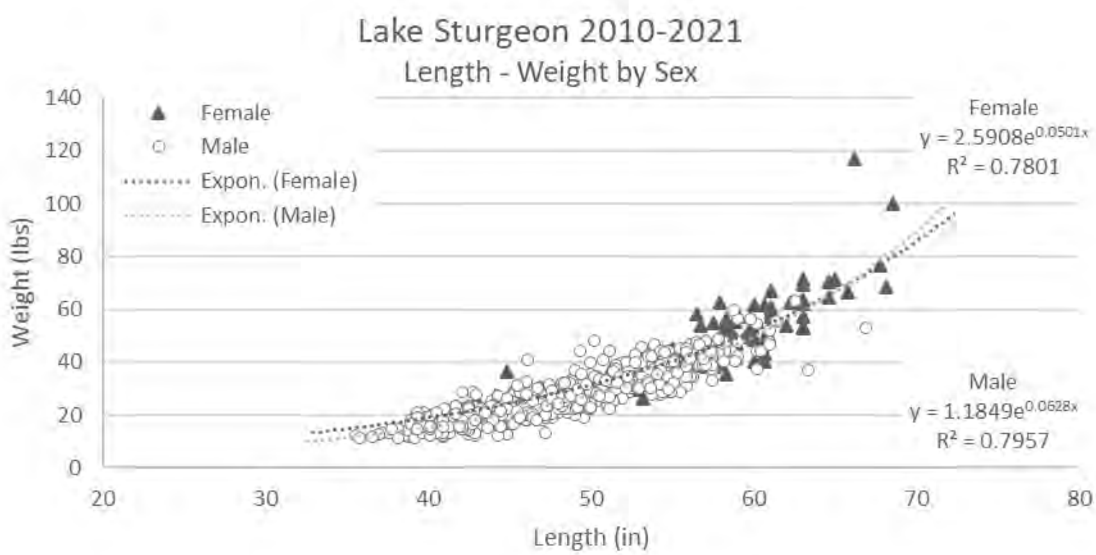

Figure 3. Length-weight relationship for lake sturgeon collected by DEC from 2010-2021 separated by sex. Fish from the St. Lawrence River, Lake Ontario, and the Black River were combined. Only female and ripe male sturgeon are presented.

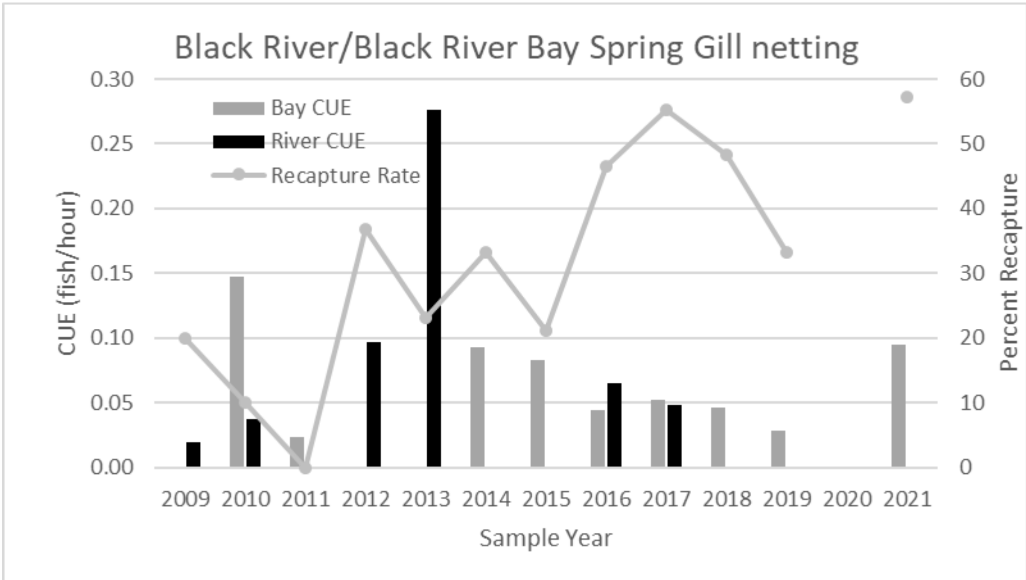

Figure 4. Lake sturgeon catch per unit effort (CUE) and recapture rates from 2009-2021 in Black River and Black River Bay. COVID 19 prevented any sampling in 2020.

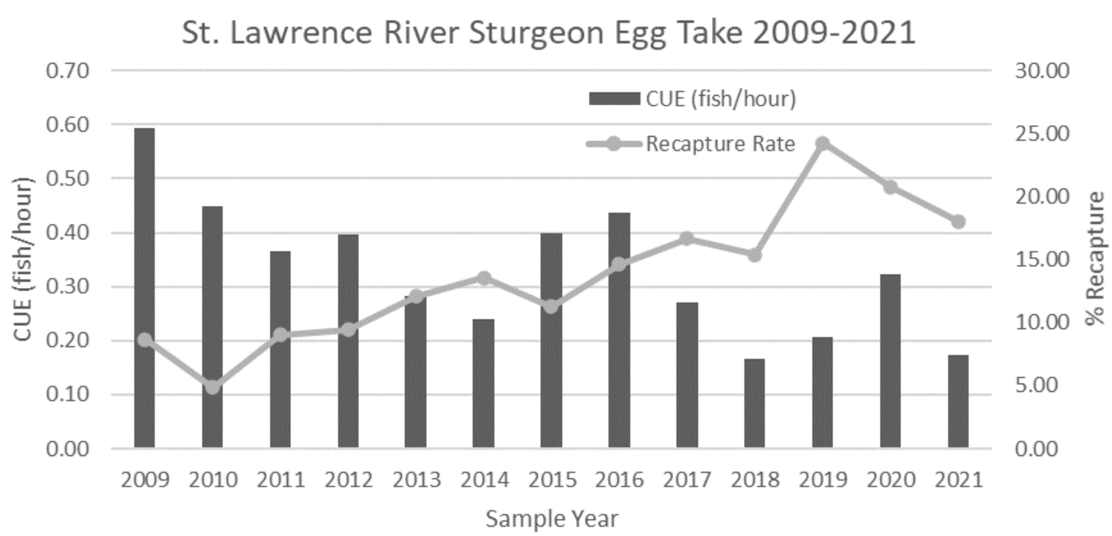

Figure 5. Lake sturgeon catch per unit effort (CUE) and recapture rates from 2009-2021 during broodstock collection on the St. Lawrence River at the South Channel, Massena NY. High flow events in 2017-2018 may have influenced catch rates.

Table 1. Specifications of gear used for targeting lake sturgeon in 2021. Target refers to the general size of sturgeon anticipated to be collected: A=adult or B=both adult and juvenile.

Name	Target	Code	Length(ft)	Depth (ft)	Stretch Mesh (in)	Material
R6 Sturgeon Nets	A	GN2	300	8	12	Monofilament
St. Lawrence Nets	B	GN3	200	8	1.5-6 (8 panel)	Monofilament
Lake Ontario Nets	B	GN4	400	8	2-6 (9 panel)	Monofilament
R6 Sturgeon Set Lines	B	SL	100			9 Hooks

Table 2. Relative effort and success rate of lake sturgeon collection attempts on the St. Lawrence River, Lake Ontario in 2021. Targeted surveys specifically attempted to collect sturgeon. Existing project surveys targeted the major fish assemblage with sturgeon as a possible component (A=adult or B=both adult and juvenile).

Location	Dates	# Sites	Target	Net Code	Catch	Hours Fished	CUE (fish/net night)
Targeted							
SLR@ South Channel	5/25 - 6/2/2021	15	A	GN2	61	350	4.0 (0.17 fish/hour)
Black River Bay	4/15- 5/4/2021	21	A	GN2	42	445	2.0 (0.09 fish/hour)
Black River	4/27- 4/28/2021	1	B	SL	0	43.25	0
Existing projects							
SLR- TI	7/26 - 7/30/2021	32	B	GN3	0	-	0
LO Gill Net	7/26- 8/6/2021	28	B	GN4	10	-	0.36
SLR- LSL	9/13 - 9/16/2021	32	B	GN3	0	-	0

Table 3. Tagging and recapture locations for 25 study fish that relocated substantial distances from initial capture. The "Dam" column indicates whether the fish had an interaction with a hydroelectric dam to reach its recapture point. Distance is the approximate straight-line water distance (miles) from initial tagging to the recapture point. Tag type indicates the tag used to identify the fish.

Initial Tagging Location (year)	Recapture Point (year)	Dam	Distance (mi) from Tag Location	Tag Type
Black River (2006)	SLR, Mth Oswegatchie River (2010)	N	85	Floy
SLR, Coles Creek (2008)	SLR, South Channel (2011)	Y	18.5	PIT
SLR, Mth Oswegatchie River (2009)	SLR, South Channel (2011)	Y	43	PIT
St. Regis River stocking at Brasher Falls (2003)	SLR, South Channel (2013)	Y	30	Floy
Oneida Lake (2005)	Black River Bay (2014)	Y	92	PIT
Oswegatchie River blw Eel Weir (2009)	SLR, South Channel (2014)	Y	45	PIT
SLR, Mth Oswegatchie River (2010)	SLR, South Channel (2015)	Y	43	Floy
Oneida Lake (2004, stocking)	Black River Bay (2016)	Y	92	Carlin
Genesee River (2004, stocking)	Black River Bay (2016)	N	100	PIT
Cayuga Lake Outlet (2008)	Black River Bay (2016)	Y	114	PIT
Onondaga Lake Outlet (2016)	Black River Bay (2017)	Y	74	Carlin
Oneida Lake (?)	Black River Bay (2017)	Y	92	Carlin
Genesee River (2013)	Black River Bay (2017)	N	100	PIT
Unknown	Black River Bay (2017)	?	?	Carlin
Unknown	Black River Bay (2018)	?	?	Carlin
Genesee River (2010,2012)	Black River Bay (2018)	N	100	PIT
Oswego River (2009)	Black River Bay (2018)	Y	65	PIT
SLR, Jones Creek (Ontario) near Chippewa Pt. (2013)	SLR, South Channel (2018)	Y	62	PIT
Geneseee River (2017)	Chaumont Bay (2020)	N	100	PIT
SLR, Mth Oswegatchie River (2010)	SLR, South Channel (2020)	Y	43	PIT
Genesee River (2014)	SLR, South Channel (2020)	Y	100	Floy
Unknown	SLR, South Channel (2020)	?	?	PIT
Genesee River (2015)	Black River Bay (2021)	N	100	PIT
Onondaga Lake (2006)	Black River Bay (2021)	Y	90	Floy
Black River Bay (2015, 2021)	Oswego River (2021)	N	45	PIT

Table 4. Lake sturgeon stocking for New York in 2021. Coded wire tag (CWT) were placed for the purpose of identifying their origin (hatchery vs. wild). CWT's were placed at the back of the head by the 1st scute in the Genesee River, Oneida Lake and Cayuga Lake. All other CWT's were placed behind the third lateral scute on the right side (*). Passive integrated transponder (PIT) tags were implanted by Cornell University (Oneida Lake) and USGS (Genesee River) for ongoing population research.

Water	No. Fish	Size (inches)	Date	Mark	Type
St. Lawrence R - Massena	6,160	3.2	8/10/2021	No Tag	Surplus
St. Lawrence R - Massena	14,890	3.7	8/19/2021	No Tag	Surplus
St. Lawrence R - Massena	4,114	5.1	9/8/2021	No Tag	Surplus
Chaumont Bay	1,000	6.1	9/24/2021	CWT*	Surplus
Total Surplus	**26,164**				
Cayuga L	2,500	6.9	10/8/2021	CWT	Regular
Oneida L	500	6.9	10/7/2021	CWT/PIT	Regular
Genesee R	1,000	6.8	10/6/2021	CWT/PIT	Regular
Black L	1,400	7.5	10/13/2021	CWT*	Regular
Oswegatchie R	1,400	7.5	10/13/2021	CWT*	Regular
Raquette R	1,400	7.5	10/13/2021	CWT*	Regular
St. Regis R	1,400	7.5	10/13/2021	CWT*	Regular
Salmon R (Franklin Co)	1,400	7.5	10/13/2021	CWT*	Regular
St. Lawrence R - Ogdensburg	8,000	6.7	9/29/2021	CWT*	Regular
Total Regular	**19,000**				
NYS 2020 Total	**45,164**				

Table 5. Roving tag location schedule of coded wire tags (CWT) for sturgeon tagged in the hatcheries.

Year	St. Lawrence River
2012	PIT Tagged left dorsal
2013	1st Scute, Left side
2014	3rd Scute, right side
2015	Right Rostrum
2016	1st Scute, Right Side
2017	3rd Scute, Left Side
2018	Back of head near 1st Scute
2019	1st Scute, Left Side
2020	3rd Scute, Right Side
2021	Back of head near 1st Scute
2022	1st Scute, Right Side

Table 6. Total number of uniquely PIT tagged lake sturgeon from 2005-2021 in the St. Lawrence River, Lake Ontario Eastern Basin, and Black River by Region 6 Fisheries. Fish listed as Male or Female were confirmed via direct evidence of gametes. Fish that did not produce gametes through palpation or direct examination were listed as Unknown.

Sex	Number	Percentage
Male	765	46
Female	99	6
Unknown	802	48

2021 Status of the Lake Ontario Lower Trophic Levels[1]

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Significant Findings for Year 2021:

1) Average 2021 total phosphorus (TP) was 4.2 µg/L (offshore) and 4.7 µg/L (nearshore, 10 m depth), lower than the long-term (1995 – 2020) average (6.5 µg/L, offshore; 7.8 µg/L, nearshore). In 2021, TP concentrations were not significantly different between the offshore and the nearshore.
2) Average 2021 (spring, summer, fall) epilimnetic chlorophyll-*a* was similar at offshore (1.5 µg/L) and nearshore (1.7 µg/L) sites. These values were similar to the average for 1995 – 2020 (1.7 µg/L, offshore; 1.5 µg/L, nearshore).
3) Average 2021 (spring, summer, fall) Secchi depth was significantly higher in the offshore (9.3 m; 31 ft) than in the nearshore (6.7 m; 22 ft). The difference between offshore and nearshore is due to high Secchi depth in April in the offshore, a month that nearshore sites are not sampled. Offshore values were higher than the 1995-2020 average of 7.3 m and nearshore values were similar to the 1995-2020 average of 6.2 m.
4) TP, chlorophyll-*a* and Secchi depth in 2021 are indicative of oligotrophic conditions in both the nearshore and the offshore of Lake Ontario.
5) Average 2021 nearshore summer (Jul-Aug) zooplankton biomass was 8.0 µg/L, the lowest since monitoring began in 1995. Offshore epilimnetic summer zooplankton biomass was 16.2 µg/L which is also low, but not the lowest on record. Note though, that over 90% of the offshore zooplankton biomass occurs in the meta and hypolimnion during the day.
6) In 2021, peak epilimnetic biomass of *Cercopagis* was 0.8 µg/L in the nearshore and 0.3 µg/L in the offshore. Peak epilimnetic biomass of *Bythotrephes* was 0.3 µg/L in the nearshore and 2.2 µg/L in the offshore. Peak *Cercopagis* abundance occurred in mid-July and peak *Bythotrephes* abundance occurred in June. In past years, peak abundance of *Bythotrephes* occurred in September-October.
7) Summer nearshore and offshore epilimnetic zooplankton density and biomass declined significantly 1995 – 2021. The declines were due mainly to reductions in cyclopoid copepods and bosminids in both habitats. Calanoid copepods increased in the offshore during the same time period. *Daphnia* spp. decreased in the nearshore but not in the offshore.
8) Whole water column (surface to 100 m) zooplankton biomass in July (3.9 g/m^2 in 2021) shows no time trend since the beginning of whole water column sampling in 2010 (average 2010-2019: 3.7 g/m^2, no samples in 2020). Whole water column zooplankton were dominated by large calanoid copepods in 2021.

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

Introduction

This report presents data on the status of lower trophic levels of the Lake Ontario ecosystem (zooplankton, phytoplankton, nutrients) in 2021 collected by the US Biological Monitoring Program (BMP). The BMP is a collaborative project that includes the New York State Department of Environmental Conservation (NYSDEC) Lake Ontario Unit and Regions 6, 7, and 8 at Watertown, Cortland, and Avon; the U.S. Fish & Wildlife Service (USFWS) Lower Great Lakes Fish and Wildlife Conservation Office; the U.S. Geological Survey (USGS) Lake Ontario Biological Station; and Cornell University.

The BMP has collected data on several ecological indicators since 1995 in both the offshore and nearshore of Lake Ontario. These indicators include total phosphorus (TP), soluble reactive phosphorus (SRP), chlorophyll-*a* (chl-*a*), Secchi depth (Secchi), and crustacean zooplankton (density, biomass, species composition, and size structure). In 2021, samples were collected from April, July, September, and October in the offshore) and biweekly from May to October at most nearshore sites (Table 1).

Trophic level indicators for 2021 are compared with data collected by this program since 1995 and with data from other sources. Production at lower trophic levels determines Lake Ontario's ability to support prey fish populations upon which both wild and stocked salmonids depend. Alewife appear to be sensitive to declines in lower trophic level resources (Kao et al. 2016). Such declines are considered a main cause for the 2003 collapse of the Alewife population in Lake Huron and the subsequent decline in the Chinook Salmon fishery (Barbiero et al. 2011, Rudstam et al. 2020), although increased predation and winter severity may also have contributed to Alewife declines in that lake (Dunlop and Riley 2013, He et al. 2015). Similarly, declines in zooplankton in Lake Michigan (Barbiero et al. 2019) are correlated with lower Alewife abundance in that lake. The connection between nutrient loading and fish production remains an important research topic in the Great Lakes (Stewart et al. 2016, Bunnell et al. 2018) and central to current discussions of future phosphorus loading targets in Lake Ontario under Annex 4 of the Great Lakes Water Quality Agreement.

Report Objectives

Using data from 1995 to 2021, the following questions are addressed in this report:

(1) What is the status of Lake Ontario's lower trophic levels in 2021, and what differences exist between nearshore and offshore sites this year?

(2) How does the year 2021 compare to the same indicators measured in 1995-2020?

(3) What is the status of the two non-native predatory cladocerans *Bythotrephes longimanus* (spiny waterflea) and *Cercopagis pengoi* (fish-hook waterflea).

(4) Are there changes in zooplankton community structure (biomass, size, species composition) that could be indicative of changes in fish predation, invertebrate predation, or lake productivity?

Methods

Sampling

Total phosphorus (TP), soluble reactive phosphorus (SRP), chlorophyll-*a* (chl-*a*), Secchi depth (Secchi), and zooplankton density, size, and biomass by species were measured at offshore and nearshore sites in Lake Ontario (Figure 1). Samples were collected from seven nearshore sites biweekly, although only three stations were sampled in all 12 sampling weeks from May through early October 2021 (Table 1). Two stations were sampled in 11 of the 12 weeks, one station was sampled in 10 of the 12 weeks and one station (NWL) was sampled in 5 of the 12 weeks. Nearshore sites had depths ranging from 9.5 to 14.6 m (31 to 48 ft), and offshore site depths ranged from 21 to 209 m (69 to 686 ft).

Water Chemistry

Water samples were collected for analysis of chl-*a*, TP and SRP. Each sample was obtained by using an integrated water sampler (1.9 cm inside diameter Nalgene tubing) lowered to a depth of 10 m (33 ft) or bottom minus 1 m (3 ft) where site depth was 10 m or less. The tube was then closed off at the surface end and the column of water transferred to 2 L Nalgene containers. From each sample, a 100 mL unfiltered aliquot was frozen for later analysis of TP (APHA 1998; SM 4500-P). Two liters of water were filtered through a

Whatman 934-AH glass fiber filter that was frozen for later analysis of chl-*a* using acetone extraction followed by fluorometry (USEPA 2013). A 100 mL aliquot of filtered water was frozen for later analysis of SRP (APHA 1998 SM 4500-P). TP and SRP samples were analyzed at the Upstate Freshwater Institute (UFI), an ELAP certified laboratory. Limits of detection for TP and SRP were 1.5 µg/L and 0.6 µg/L, respectively. If a value was below the limit of detection, it was replaced by the limit of detection. This occurred in 5 of 158 of TP measurements and in 84 of 152 SRP measurements. Chl-*a* was analyzed at the Cornell Biological Field Station (CBFS) using a calibrated Turner Trilogy benchtop fluorometer and the USEPA standard operating procedure (USEPA 2013). Approximately 2 L of water was filtered for each chl-*a* sample.

Quality Control and Variability

To measure analytical variability, replicate aliquots for TP and SRP were saved from the same water sample. In July nearshore sites, 6 aliquots were saved from each of the sites CBL, GIL, SOL and 3 aliquots from NEL and OOL.

To evaluate variability within a site, three separate water samples were collected on one date in August at each of the seven nearshore sites and once in April at three offshore sites. These triplicate samples were analyzed separately for TP, SRP and chl-*a*. At offshore locations (other than the three in April), duplicate samples for TP, SRP, and chl-*a* were collected and analyzed separately.

Variability was assessed as the coefficient of variation (CV; standard deviation/mean) for samples with 3 or more replicates and as the relative difference (RPD; difference/mean) for samples with two replicates. Both CV and RPD are expressed in percent.

Zooplankton

Zooplankton samples were collected with standard 0.5 m diameter, 153-µm mesh, nylon nets equipped with calibrated flowmeters. At nearshore sites, tow depths ranged 8.5-11 m (28-36 ft). Tows started 1–3 m (3-10 ft) above the bottom depending on weather conditions. At offshore sites, epilimnetic tows were taken from above the thermocline (10 to 36 m (37-118 ft) depending on location of the thermocline) to the surface. At offshore sites greater than 100 m (328 ft) bottom depth, one additional tow was collected from 50 m (164 ft) to the surface (“metalimnetic”) and one from 100 m (328 ft) to the surface (“hypolimnetic”). During unstratified conditions a tow was taken from bottom minus 2 m or to 50 m. Zooplankton were anesthetized with antacid tablets and then preserved in the field with 95% ethanol to obtain a final concentration of 70%.

In the laboratory, each sample was strained through a 1-mm mesh cup to separate *Cercopagis* and *Bythotrephes* from other zooplankton. These two species form clumps in the sample, making the usual random sub-sampling of 1 mL samples impossible. For each sample that contained *Cercopagis* or *Bythotrephes*, two analyses were performed – one on the *Cercopagis* and *Bythotrephes* that were caught in the 1.0 mm mesh cup and one on the other zooplankton (see below). A subsample was sometimes used, and the total number of animals were calculated from the ratio of wet weights of the subsample to wet weights of the total sample (following USEPA 2017).

For smaller-sized zooplankton, at least 100 organisms were counted and measured from one or more 1 mL subsamples. The subsample was examined through a compound microscope at 10-40X magnification. Images from the sample were projected onto a digitizing tablet interfaced with a computer for measurements. Zooplankton were identified to species (except for nauplii and small copepodites) using Pennak (1978) and Balcer et al. (1984). Length:dry-weight regression equations were used to estimate zooplankton biomass. Note that we used the standard EPA equations in this year’s report (USEPA 2017) to provide better comparisons with other monitoring programs and other Great Lakes. All historic data were recalculated with the EPA equations. Note that zooplankton biomass values in this report may be different from past reports due to the switch in L-W regressions.

Data Analyses

April/May to October mean TP, SRP, chl-*a*, and Secchi were compared between the nearshore and the offshore sites. To account for the different sampling efforts in the two habitats, we first calculated the average values for all measurements within each season (Apr-

Jun=spring; Jul-Aug=summer; Sep-Oct=fall) and then averaged these three seasons. For statistical comparison, we used a mixed model ANOVA with habitat and season as the fixed effects (including interactions) and site as a random effect. For zooplankton biomass and density, we used a square-root transformation to reduce heteroscedasticity.

Zooplankton were analyzed by groups. Since 1995, a total of 28 species or species groups have been identified; 16 of these were found in 2021 (plus calanoid and cyclopoid copepodites and nauplii). Zooplankton were divided into the following six groups (names of the species found in 2021 in parenthesis): *Daphnia* spp. (*Daphnia mendotae, D. retrocurva*); bosminids (*Bosmina longirostris, Eubosmina coregoni*); calanoid copepods (*Leptodiaptomus minutus, L. sicilis, Skistodiaptomus oregonensis, Epischura lacustris, Eurytemora affinis*); cyclopoid copepods (*Diacyclops thomasi, Mesocyclops edax, Tropocyclops prasinus*); other cladocera (*Alona sp., Ceriodaphnia sp Chydorus sphaericus, Diaphanosoma sp., Polyphemus pediculus, Leptodora kindtii, Camptocercus sp.)* and nauplii. Four species were analyzed separately: the two invasive predatory cladocerans *Bythotrephes longimanus* and *Cercopagis pengoi*, the cladoceran *Holopedium gibberum*, and the large calanoid copepod *Limnocalanus macrurus.* Time trends for epilimnetic zooplankton do not include night collections. Zooplankton in Lake Ontario migrate towards the surface at dusk, causing an increase in density and biomass in the epilimnion at night (Watkins et al. 2017); therefore, epilimnetic results from day and night are not comparable.

Regression analyses for time trends (JMP Pro v16, SAS Institute Inc. 2021) were performed for the offshore and nearshore separately. TP, Secchi, chl-*a* were averaged over the whole sampling season. Summer epilimnetic zooplankton density and biomass and group biomass were averaged over July and August

To detect change points in the time series, we used change point analysis (Taylor Enterprises, Inc. 2003) on nearshore and offshore data. Change point analysis uses cumulative deviations from the mean to detect significant changes in time trends and to estimate when those changes occurred. This is done by resampling the data series 1000 times to construct confidence intervals based on the inherent variability in the data series and testing if and when the observed data series differ significantly from these confidence intervals.

The BMP data for chlorophyll, TP and Secchi depth were also compared with data sent to us from Environment and Climate Change Canada (ECCC) office in Burlington, Ontario (Heather Niblock and Alice Dove). These data were collected during the surveillance survey between August 24 and 30. Averages of offshore values were added to our seasonal graphs.

Results

Quality Control and Variability

To estimate analytical precision, we analyzed 24 TP and 24 SRP samples (3 sites with 6 samples per site plus 2 sites with 3 samples per site). Coefficients of variation ranged from 6 to 37% (mean of 21%) for TP and from 0 to 15% (mean of 6%) for SRP. Values from replicates were averaged for each station-date for all further analyses. Variation for SRP is smaller because many samples had concentrations below the detection limit of 0.6 µg/L. In those cases, the sample was assigned the detection limit. This level of precision in the laboratory analyses was similar to previous years.

The analysis of August nearshore TP, SRP, and chl-*a* triplicate samples showed that the CV for TP ranged from 2 to 128% (mean of 28%), the CV for SRP ranged from 0 to 39% (mean of 17%), and the CV for chl-*a* ranged from 2 to 10% (mean of 6%). One value of 14.5 µg/L TP from Tibbetts Point was the reason for the 128% variability in TP. Values for the other two replicates at that site were both below the detection limit and assigned 1.5 µg/L. Variability was also high in the TP at Tibbetts Point in September (2.8 and 16.5 µg/L for the two duplicate samples). This station is located at the outlet and high variability in TP between samples has been found by others sampling in the Thousand Island Region (John Farrell, pers. comm). We do not know the reason for high variability in that region of the lake but suspect that high water flow results in different waters being sampled during one sampling occasion. For other areas of the lake, variability was typical of previous years. Note that the variability among replicate samples in the field and variability resulting from laboratory procedures are similar suggesting that field samples do not vary more than expected from analytical precision alone at most locations. Values were averaged for later analyses.

Offshore duplicates were compared using RPD values. The average RPD was 16% for TP (range 1 to 38%, excluding a high value of 142% from Tibbetts Point and a value of 90% from OOO in April), 10% for SRP (range 0-45%), and 20% for chl-*a* (range 0-92%), similar to the analysis of the triplicate samples. Values of duplicates were averaged for each site visit for later analyses.

2021 Water Quality

Annual average (May – Oct) chl-*a*, TP, SRP, and Secchi were similar across nearshore sites in 2021 (Table 1). Chl-*a* was lowest at Oak Orchard (1.1 µg/L) and highest at Niagara East (2.5 µg/L) (Table 1). TP was highest at Niagara East (6.2 µg/L) and lowest at Galloo Island (3.4 µg/L). Niagara East also had the highest SRP (2.8 µg/L). Secchi was lowest at Niagara East (4.5 m [15 ft]) and highest at Sodus (8.6 m [28 ft]). In the offshore, chl-*a* ranged from 1.1 µg/L (Mid Lake) to 2.0 µg/L (Smoky Point-O), TP ranged from 2.2 µg/L (Tibbetts Point) to 4.9 µg/L (Oak Orchard-N), SRP ranged from 0.6 µg/L (Tibbetts Point) to 1.4 µg/L (Smoky Point-N), and Secchi ranged from 6.5 m (21 ft; Oak Orchard-N) to 12.5 m (41 ft; Main Duck and Mid Lake) (Table 1). Average May – October values for SRP, chl-*a*, and TP showed no significant differences between nearshore and offshore locations. Secchi was significantly higher ($p=0.002$) in the offshore (10.2 m [33 ft]) than the nearshore (6.6 m [22 ft]) (Table 2).

Seasonal trends occurred for most variables. The seasonal Secchi pattern was similar between nearshore and offshore locations; Secchi was 6-8 m (20-26 ft) in the nearshore and slightly lower (5-6 m; 16-20 ft) in the offshore except for April offshore where Secchi was much higher (17.5 m; 57 ft) (Figure 2a). Nearshore sites are not sampled in April and the Secchi is higher in the offshore only when April data are included. Nearshore chl-*a* values were lowest in May (1.1 µg/L) and highest in October (2.5 µg/L; Figure 3a). Offshore concentrations were lowest in April (0.4 µg/L) and highest in October (2.2 µg/L; Figure 3a). Nearshore TP was lowest in June (3.2 µg/L) and highest in October (5.6 µg/L) (Figure 4a). Offshore TP was highest in September (5.0 µg/L) and lowest in October (2.9 µg/L) (Figure 4a). SRP concentrations were low (<2.0 µg/L) in both habitats for the entire season (Figure 5). SRP values are not very informative due to the high number of measurements below the detection limit and will not be collected in future years

Water Quality Trends Since 1995

Comparisons with data collected since 1995 show that 2021 had near average Secchi (6.6 m [22 ft]) in the nearshore and higher than average Secchi (10.2 m [33 ft]) in the offshore (Figure 2b, Table 3). Chl-*a* concentration in both the nearshore and offshore was close to the long-term mean of 1.5 µg/L in the nearshore and 1.7 µg/L in the offshore (Figure 3b). There is a strong correlation between nearshore and offshore chl-*a* since year 2005 (Figure 3b) (Pearson correlation $R^2=0.67$, $p<0.001$, $n=17$) suggesting a stronger coupling between the nearshore and offshore in the last 17 years. This relationship is not present in the first 10 years of the data series (1995-2004, $R^2=0.30$ $p=0.10$, $n=10$). The 2021 average April – Oct TP concentrations were lower than the 1995-2020 averages in both habitats (nearshore 4.6 µg/L; offshore 4.3 µg/L, Table 3, Figure 4b).

Over the time period 1995 to 2021, Secchi increased and chl-*a* decreased in the offshore, but there were no significant time trends in the nearshore (Table 3). TP trends were not significant in the offshore, but when the questionable data point from 2020 is removed (see Holeck et al. 2021 for discussion of TP data from the 2020 covid year) the decline in TP concentrations is highly significant (Table 3). There were no significant time trends in the nearshore water quality variables.

Consistent with non-significant overall time trends in the nearshore, change point analysis detected no change points in TP or Secchi in the nearshore (Table 3). However, this analysis detected several significant change points for chl-*a:* an increase in 2003 (from 1.4 µg/L to 1.8 µg/L), a decrease in 2009 (from 1.8 µg/L to 1.2 µg/L) and an increase in 2016 (from 1.2 µg/L to 1.8 µg/L). In the offshore, no change points were detected for TP and a decrease in chl-*a* was detected in 2009. Secchi increased continuously through the time series resulting in a dependent error structure that violates the assumptions of change point analyses (Table 3).

The BMP program is not sampling offshore sites in August. However, Environment Canada does in some years, including 2021. The values from the Canadian program are comparable to the values obtained by the BMP program (Figure 2, 3 and 4) when sites deeper than 20 m were selected from the Canadian database.

2021 Zooplankton

Nearshore zooplankton density was highest in late September (Figure 6) and peak biomass occurred in mid-July (13.7 µg/L) and in late September (13.0 µg/L). Offshore zooplankton density and biomass were highest in late September (Figure 6). Zooplankton average length was highest in early May in the nearshore and in April in the offshore (Figure 6).

Nearshore bosminid biomass was highest in June, July, and late September – Oct but biomass was low overall (<5 µg/L). Offshore biomass followed a similar pattern (Figure 7). Nearshore daphnid biomass remained low throughout the season but increased to a peak of 3.0 µg/L in late September. In the offshore, daphnid biomass was high in July (10.7 µg/L) but otherwise mirrored the pattern of the nearshore. Cyclopoid biomass was highest in May (2.3 µg/L) in the nearshore and in April (1.8 µg/L) in the offshore and then declined and remained low for the remainder of the sampling season in both habitats. Calanoid biomass (including *Limnocalanus*) peaked in mid-July (9.6 µg/L) in the nearshore and in September (14.7 µg/L) in the offshore. *Cercopagis* was first detected in early-June in the nearshore and peaked during mid-July (0.8 µg/L) while *Bythotrephes* first appeared in early May, peaked in late June (1.9 µg/L), and was present at low levels through October. In the offshore, *Cercopagis* and *Bythotrephes* were present in mid-July when both species were more abundant than in the fall sampling. In Jul-Aug, *Cercopagis* accounted for 5.7% of the total zooplankton biomass in the nearshore and 3.5% of the epilimnetic offshore biomass whereas *Bythotrephes* accounted for 1.5% of the nearshore biomass and 13% of the epilimnetic offshore biomass.

Zooplankton Trends Since 1995

Summer total zooplankton density and biomass declined significantly from 1995 to 2021 (Figure 8; Table 3) in both the nearshore and offshore. Summer epilimnetic density in the nearshore (4.6/L) was lower in 2021 than in any year 1995 – 2020 (Figure 8). Offshore epilimnetic density (7.0/L) was also low and was less than half that of the long-term mean (19.8/L) Summer epilimnetic biomass in the nearshore (8.0 µg/L) was also a record low while offshore epilimnetic biomass was below average at 16.2 µg/L.

Change point analysis showed decreases in nearshore total zooplankton density in 1998, 2005, and 2016 (Figure 8; Table 3); density declined from an average of 70/L to 24/L and then to 7/L. A decline in biomass occurred in 1999 when biomass decreased from 68 µg/L to 19 µg/L. In the offshore, there was decrease in both density and biomass in 2005 and another decrease in biomass in 2017 (Figure 8; Table 3). Density declined from 37/L to 9/L and biomass declined from 47 µg/L to 17 µg/L in 2005 and from 17 µg/L to 13 µg/L in 2017 (Figure 8, Table 3). The 2021 values remain at the low levels observed most years since 2005 (Figure 8).

We noted several trends in summer zooplankton group biomass (Figure 9 and 10, Table 3). From 1995 – 2021, there was a significant decline in bosminid and cyclopoid biomass (nearshore and offshore), in *Limnocalanus* biomass (offshore only) and in daphnid biomass (nearshore only). At the same time, biomass of *Bythotrephes* increased significantly (nearshore and offshore) (Table 3).

Change point analysis in the nearshore showed breaks for bosminids (negative, 1998, 2005, and 2020), *Bythotrephes* (positive 2006, negative 2007), calanoids (positive 2007; negative 2012, positive 2019), cyclopoids (negative 1997 and 1999), daphnids (negative 2006) and *Holopedium* (positive 2003) (Table 3). In the offshore, change points occurred in bosminids (negative, 2004), *Bythotrephes* (positive 2006), calanoid copepods (positive, 2005), *Cercopagis* (negative 2010), cyclopoids (negative, 2005 and 2018), *Limnocalanus* (negative, 1996) and *Holopedium* (positive 2001) (Table 3). A more detailed analysis of these changes is being prepared for journal publication (Figary et al. MS).

Cercopagis and *Bythotrephes* biomasses were plotted separately to better show time trends (Figure 11). Here we used Jul-Aug for *Cercopagis* and Sep-Oct for *Bythotrephes*, time periods representing typical peak abundance months for the two species. *Cercopagis* first appeared in nearshore and offshore samples in 1998. It reached an average biomass of 1.2 µg/L in the nearshore (2006) and 2.5 µg/L in the offshore (2003). *Bythotrephes* reached a biomass of 3.4 µg/L in the nearshore (2010) and a biomass of 5.0 µg/L in the offshore (2010). Note that peak *Bythotrephes* biomass in 2021 was measured in July and was then higher than at any previous July data (Table 3).

Since 2010, the BMP program is also collecting samples from 100 m and 50 m at the deeper sites. Comparisons of these samples with the epilimnetic samples show that the majority of the zooplankton biomass is in the metalimnion and hypolimnion during the day (Figure 12). The proportion of the total areal zooplankton biomass in the epilimnion was 27 and 38% in April, as low as 2% at both stations in July, and 8 - 15% in September and October. Zooplankton biomass in metalimnion and hypolimnion are dominated by large calanoids (*Limnocalanus macrurus* and *Leptodiaptomus sicilis*, but high biomass of *Daphnia mendotae* and cyclopoids copepods can also be found in the metalimnion (Figure 12).

Due to the importance of deep zooplankton, we present the July whole water column biomass from the three deep sites (OOO, SPO, and MID). Those values are compared with the EPA GLNPO data from eight sites sampled in August. Even though the two sampling events are separated by a month and are conducted at different locations in the lake, the correspondence is reasonable (Figure 13). During this time period, both programs show dominance of calanoid copepods, especially *Limnocalanus*, and years with more daphnids (e.g., 2012, 16, 18) and more cyclopoid copepods (e.g., 2013, 14, 18). In 2021, the total areal biomass was 4.0 g dw/m^2 in the BMP whole water column July samples and 2.7 g dw/m^2 in the EPA-GLNPO samples (Watkins and Rudstam unpubl.). Zooplankton biomass is higher in the BMP than in the EPA data for 9 of the 11 years with comparable data, indicating as consistent seasonal pattern of higher biomass in July than in August. Note that this areal biomass does not include mysids that can contribute up to 30% of the total zooplankton biomass in Lake Ontario (Holda et al. 2019).

Discussion

Secchi depth, chl-*a*, and TP are indicators of lake trophic status (Carlson 1977). In 2021, average April-October values from individual sites ranged from 4.5 to 12.5 m Secchi, 1.1 to 2.5 µg/L chl-*a*, and 2.2 to 6.2 µg/L TP. These values are similar to other years in this decade and within the range for oligotrophic (low productivity) systems (0.3-3.0 µg/L chl-*a*, 1-10 µg/L TP; Wetzel 2001).

In 2021, April–October average TP concentrations were below the long-term (1995 – 2020) average in both the nearshore and offshore, consistent with continued oligotrophication of both areas. However, TP showed only a marginally significant decline in the offshore for 1995 – 2021 due to the relatively high values from 2020. Given the issues with high sampling variability and limited field samples due to covid in 2020 (Holeck et al. 2021), we also looked at trends without the 2020 values and found a highly significant decreasing trend in offshore TP. Thus, the offshore TP trends in BMP is consistent with the declining offshore TP observed by Environment Canada (Dove and Chapra, 2015). A continuing decline in offshore TP after 1995 was not apparent in the data analysis of spring TP of Holeck et al. (2015, also Rudstam et al. 2017), but the data they used was limited to 1995 - 2013. Interestingly, there was no time trend in nearshore TP.

Nearshore chl-*a* was slightly above the long-term mean and offshore chl-*a* was slightly below the long-term mean. Chl-*a* decreased significantly in the offshore 1995 – 2021 but not in the nearshore (Table 3). Even so, chlorophyll concentrations in the offshore and nearshore have been highly correlated since 2005. The lack of a decline in the nearshore is due to low levels in that habitat in the early years of the BMP program, an effect attributed to high nearshore zebra mussel abundances by Hall et al. (2003). It is possible that mussel populations have declined in the shallower nearshore, as has been observed in smaller lakes after round goby arrival (Rudstam and Gandino 2020, Brooking et al. 2022). However, mussels have not declined in waters ~20 to 90m bottom depth and are increasing in water deeper than 90 m (sampled by EPA biomonitoring program, Karatayev et al. 2022).

Nearshore Secchi was slightly above the long-term mean, and offshore Secchi was well above the long-term mean. April – Oct Secchi increased significantly in the offshore but showed no trend in the nearshore (Table 3). This is mainly due to the high water clarity in the April sampling in the offshore as Secchi during the rest of the year is similar in the two habitats. Similar high water clarity was also observed in the EPA April sampling (Bunnell et al. 2021). Higher water clarity is likely to affect fish distributions and feeding (reviewed in Bunnell et al. 2021) as well as distribution of zooplankton, extent of diel vertical migrations and importance of the deep chlorophyll layer (Scofield et al. 2020a). Note that the low water clarity for 2020 is because the offshore was not sampled in April that year.

Summer epilimnetic zooplankton density and biomass decreased significantly in the offshore and in the nearshore from 1995 – 2021 (Table 3). Many groups had negative change points around 2005, declines that have been attributed to increased *Bythotrephes* abundance (Barbiero et al. 2014, Rudstam et al. 2015). Similar, changes in the nearshore in 1999 correlated with the increase in *Cercopagis* (Warner et al. 2006). In addition to predatory effects of *Bythotrephes* on zooplankton described from both Lake Michigan and smaller lakes (Lehman and Caceres 1993, Yan et al. 2001), daphnids like *Daphnia mendotae* and several copepods avoid epilimnetic waters during the day when *Bythotrephes* is present (Pangle et al. 2007, Bourdeau et al. 2011, 2015). In an analysis of offshore zooplankton 1997 – 2016, Barbiero et al. (2019) observed the appearance of *Daphnia mendotae* around the time *Bythotrephes* became abundant (~2004-05). *Daphnia mendotae* has remained the dominant *Daphnia* in Lake Ontario through 2021, perhaps because this species is more likely to migrate vertically to avoid *Bythotrephes* predation.

It is possible that *Bythotrephes* increased due to lower Alewife abundance in Lake Ontario. Generally, *Bythotrephes* abundance is negatively correlated with Alewife abundance (Johannsson and O'Gorman 1991, Barbiero et al. 2014) as Alewife select for *Bythotrephes*. Interestingly, Alewife also appeared to grow better after *Bythotrephes* became abundant in Lake Ontario (Weidel et al. 2020), which is contrary to our expectations based on studies showing young fish avoiding this species (Barnhisel and Harvey 1995, Barnhisel and Kerfoot 2004) and speculations of lower growth rates of fish feeding on this zooplankton species (Parker et al. 2001, Storch et al. 2007). Our data indicate that *Bythotrephes* biomass was low 1995 – 2003, increased in 2004 to 2012, was again low in 2013 and 2014, and then increased in 2019 to 2021. This pattern does not directly mirror spring Alewife abundance (Weidel et al. 2020) suggesting that the interaction between Alewife and *Bythotrephes* may be less direct than suggested by the earlier analyses.

Although the decline in zooplankton abundance in the epilimnion may be detrimental for young-of-year fish, some species like coregonids and Rainbow Smelt can also feed on zooplankton in deeper water and at least larger Alewife migrate deeper during the day to feed on zooplankton in the metalimnion (Riha et al. 2017). In addition, several zooplankton species migrate from deeper waters to the epilimnion at night (Watkins et al. 2017, Scofield et al. 2020b). Much of the zooplankton biomass resides in the metalimnion and hypolimnion during the day perhaps due to avoidance of the visual predator *Bythotrephes* and increased water clarity (Rudstam et al. 2015, Bunnell et al. 2021). We cannot understand the changes in zooplankton in Lake Ontario's offshore from epilimnetic samples alone. Continued sampling of the whole water column at offshore sites is an important complement to the epilimnetic samples. With only 2 % of the offshore zooplankton biomass in the epilimnion during the day in the summer, it is important to monitor diel distribution of zooplankton and how fish adapt to these changes. We need to understand if young Alewife in particular will use deeper zooplankton during the day or have to rely on less efficient nighttime feeding of migrating zooplankton.

The 2021 comparison of offshore whole water column data from two programs, the BMP and the EPA-GLNPO, continues to show similar overall biomass and species composition. July BMP biomass was in general higher than the EPA-GLNPO August biomass; differences that we attribute to seasonality. We are encouraged by the similarity in species composition and annual patterns in the two programs which lend support to observed species shifts in both time series. We are exploring the differences between the BMP and the EPA-GLNPO data in more detail in an upcoming paper as part of Stephanie Figary's PhD thesis (Figary et al. MS).

BMP data from 2021 and our comparisons with the longer-term data indicate relatively stable lower trophic level indicators in the nearshore but declining values in the offshore. The data show a significant increase in Secchi, as well as decreases in summer chl-*a* and epilimnetic zooplankton density and biomass in the offshore. A decline in whole water column zooplankton biomass since 1997 is also present in the GLNPO summer offshore data (Barbiero et al. 2019, USEPA 2011). Declines in the nearshore are primarily in zooplankton density and biomass, not in water quality indicators TP, chl-*a* and Secchi. Other similar data collected by Environment Canada and EPA are comparable lending further support to the trends detected by the BMP.

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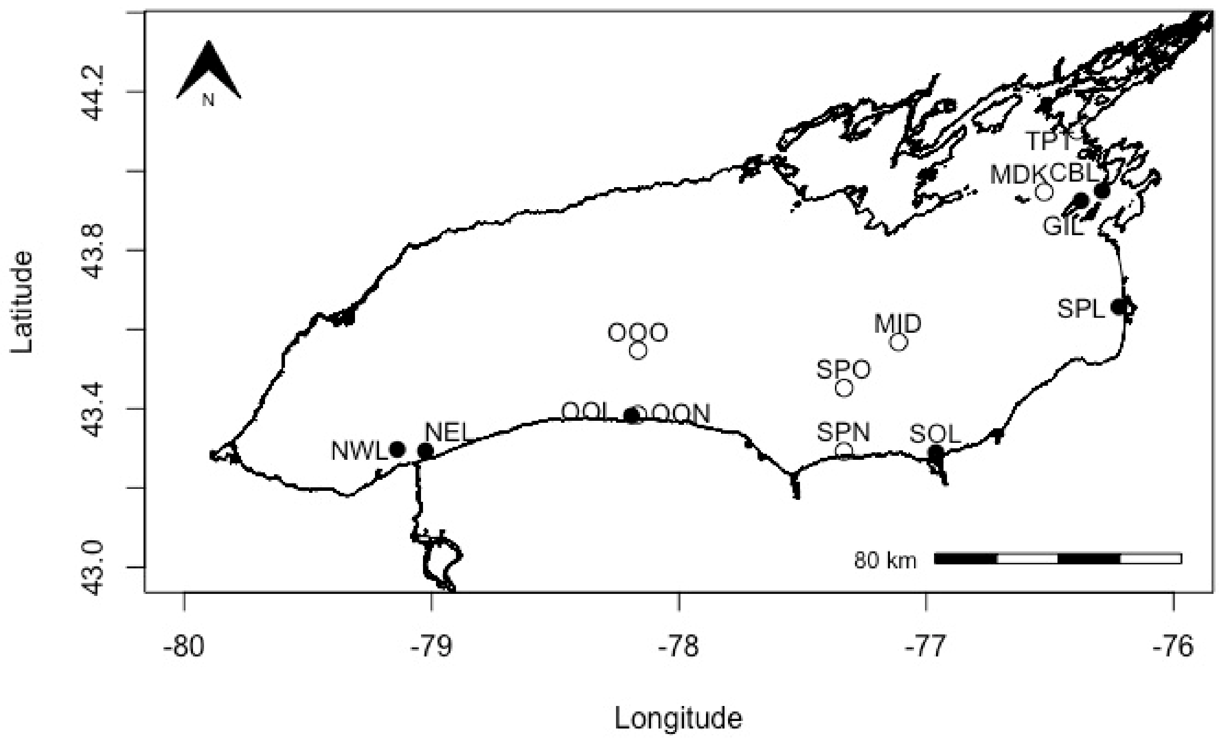

Figure 1. Map of Biomonitoring Program sites, 2021. Offshore stations (open squares) are deeper than 20 m (66 ft). Nearshore stations (closed squares) are 10-15 m (33-49 ft) deep.

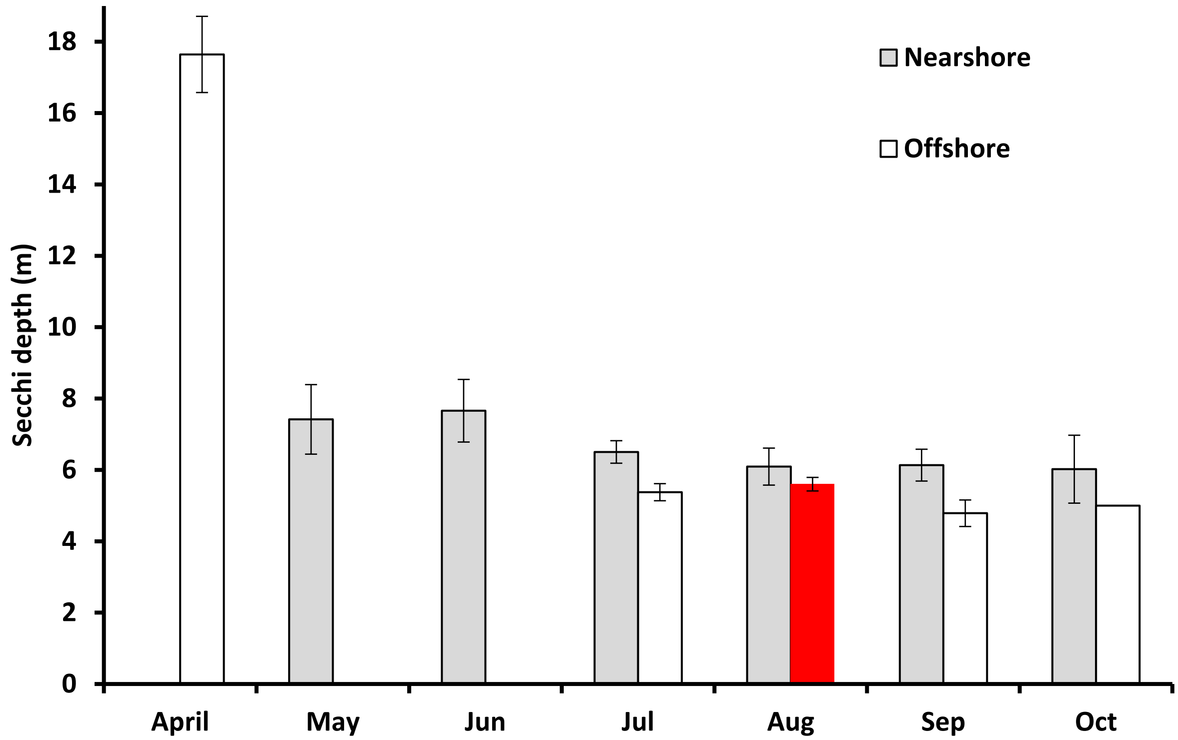

Figure 2a. Mean monthly Secchi depth (meters) for nearshore and offshore sites in Lake Ontario, April – October, 2021. Error bars are ± 1 SE. August (red bar) offshore Secchi from ECCC Surveillance averaged 5.6 m (35 stations >20m sampled end of August).

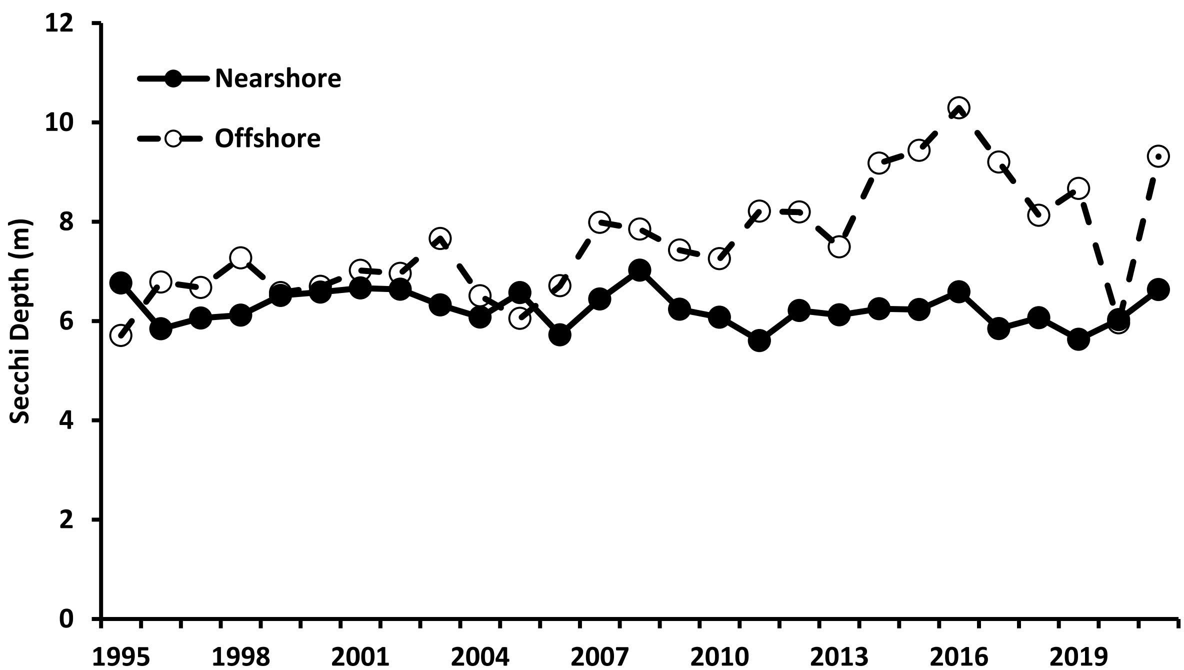

Figure 2b. Long-term mean Secchi depth (meters) in Lake Ontario, 1995 – 2021. Values are means equally weighted by site, then by month, and then by season (spring=April-June; summer=July-August; fall=September-October). 2020 offshore Secchi does not include April samples.

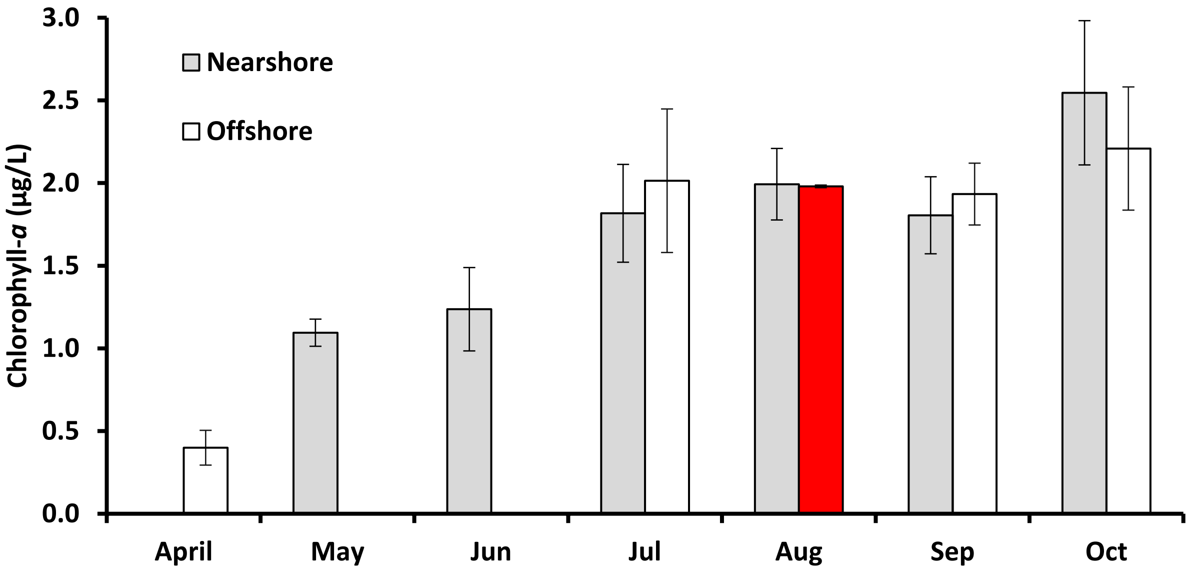

Figure 3a. Mean monthly epilimnetic chlorophyll-a concentrations for nearshore and offshore sites in Lake Ontario, April - October, 2021. Error bars are ± 1 SE. August (red bar) offshore integrated corrected chlorophyll from ECCC Surveillance averaged 2.0 ug/L (68 stations >20m sampled end of August and excluding Hamilton Harbor data).

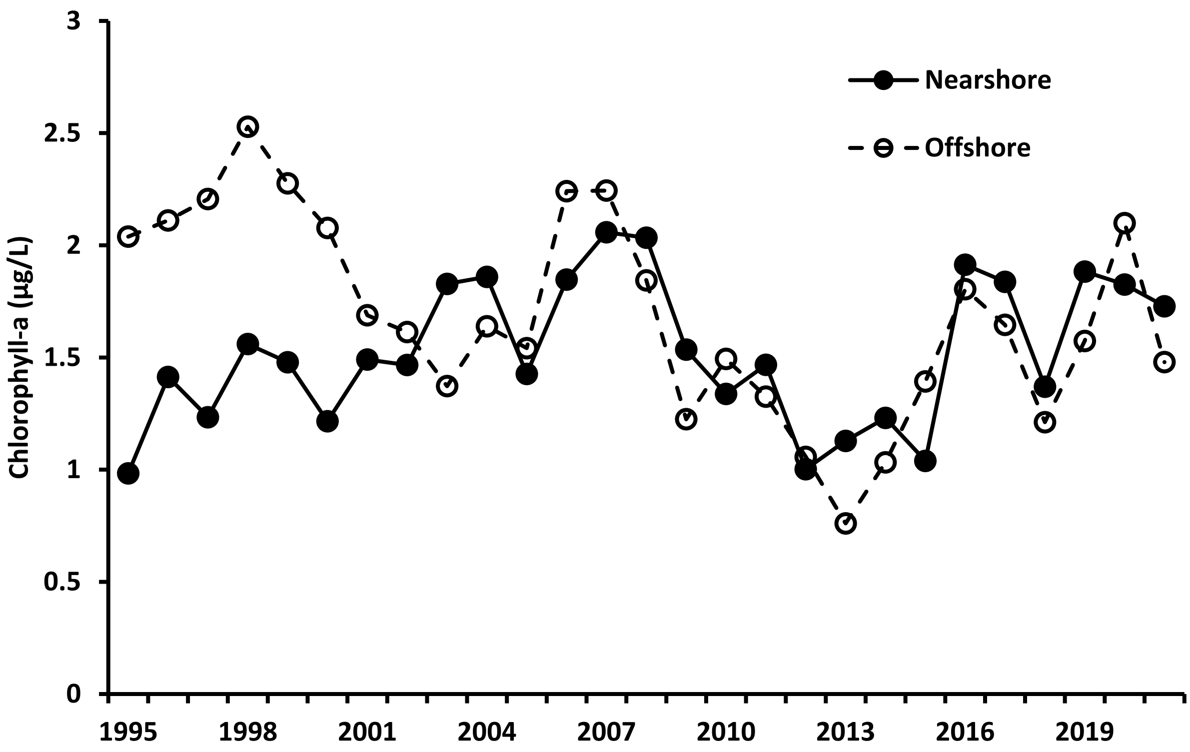

Figure 3b. Long-term mean chlorophyll-a in Lake Ontario, 1995 – 2021. Values are means equally weighted by site, then by month, and then by season (spring=April-June; summer=July-August; fall=September-October).

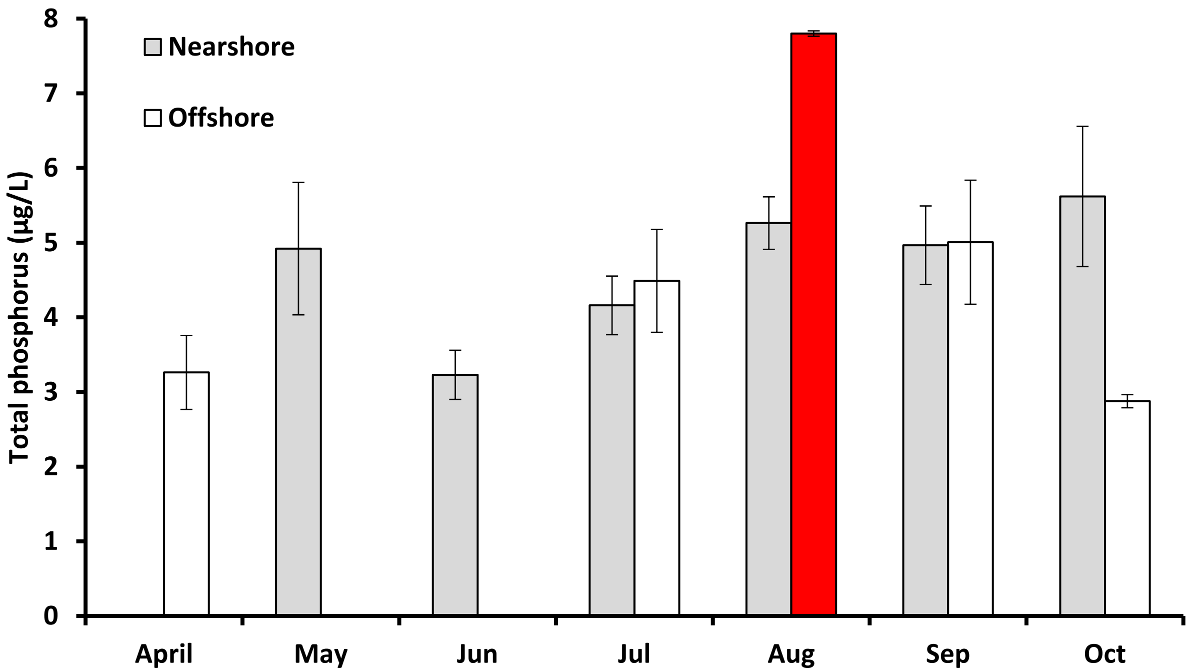

Figure 4a. Mean monthly total phosphorus concentrations for nearshore and offshore habitats in Lake Ontario, April - October, 2021. Error bars are ± 1 SE. August (red bar) offshore TP from ECCC Surveillance averaged 6.3 ug/L (69 stations deeper than 20m sampled end of August).

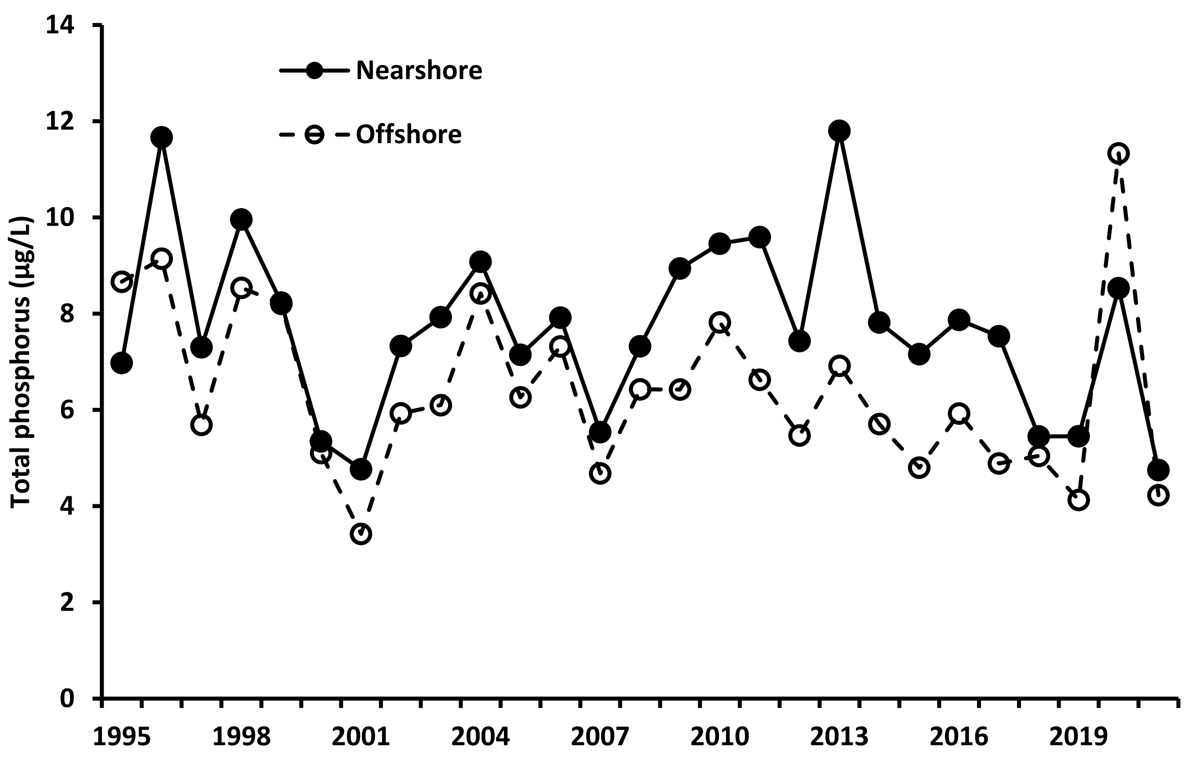

Figure 4b. Long-term mean epilimnetic total phosphorus concentrations in Lake Ontario, 1995 - 2021. Values are means equally weighted by site, then by month, and then by season (spring=April-June; summer=July-August; fall=September-October).

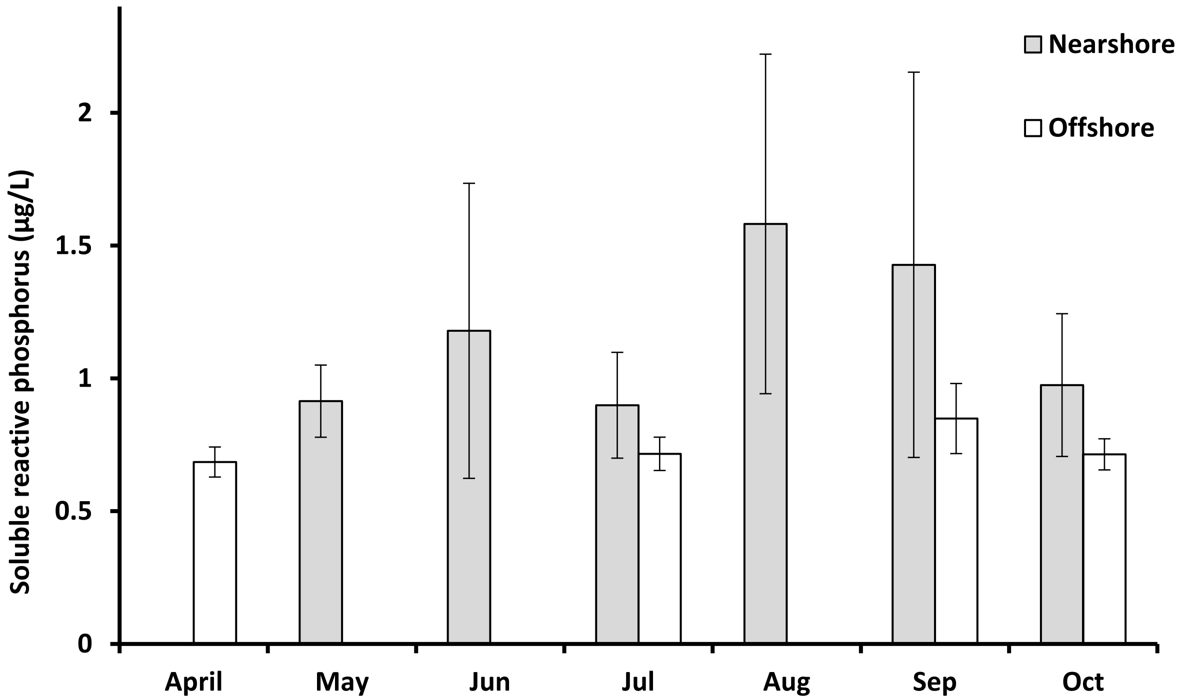

Figure 5. Mean monthly soluble reactive phosphorus concentrations for nearshore and offshore sites in Lake Ontario, April - October, 2021. Error bars are ± 1 SE.

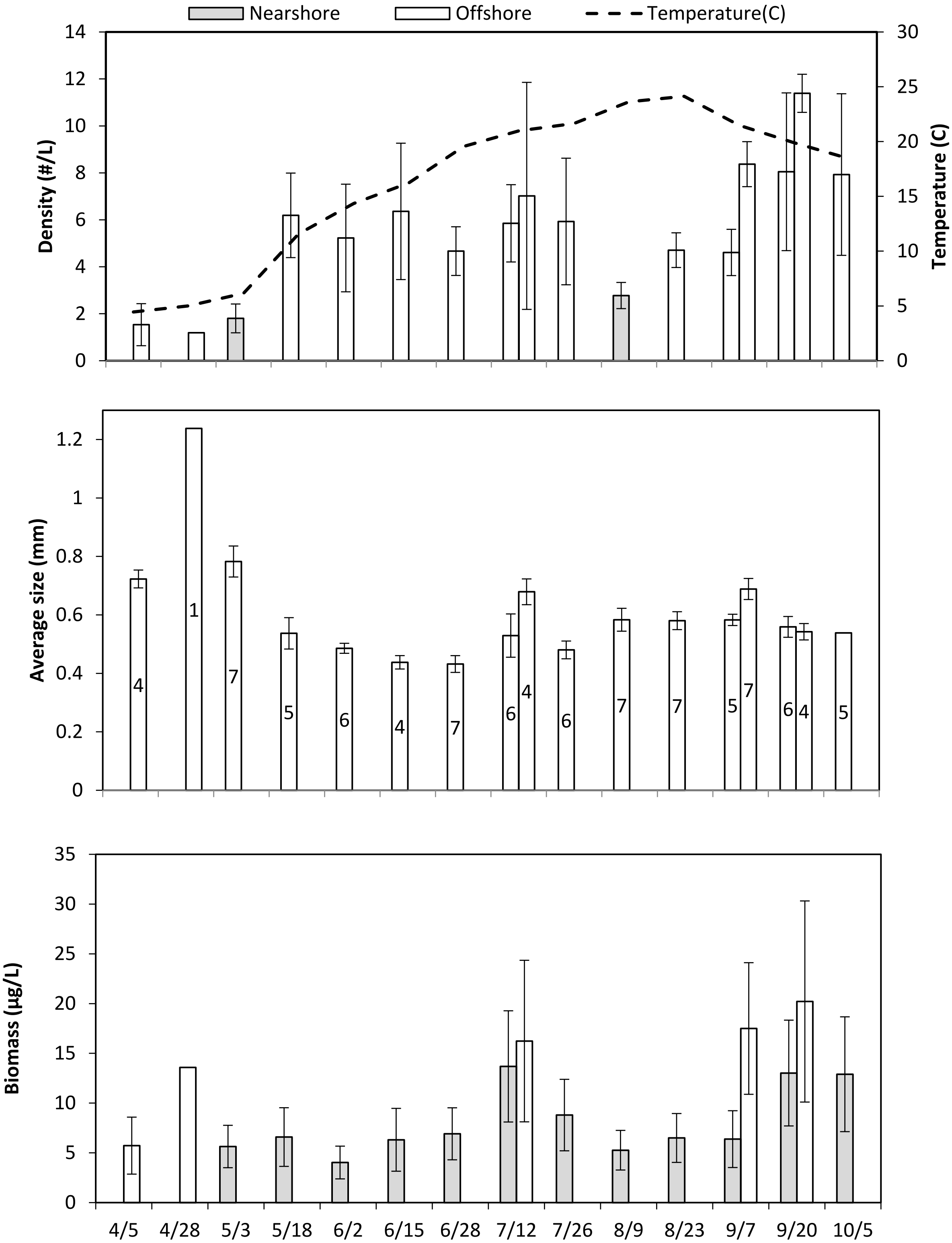

Figure 6. Biweekly mean (± 1 SE) daytime epilimnetic zooplankton density, size, and dry biomass for April - October 2021 at nearshore and offshore sites on Lake Ontario. On the x-axis, biweeks are designated by the date beginning each biweek. Numbers on bars in the middle panel indicate the number of samples taken. Lake surface temperatures (secondary y-axis; top panel) are from NOAA Coastwatch web site (https://coastwatch.glerl.noaa.gov/ftp/glsea/avgtemps/2021/glsea-temps2021_1024.dat).

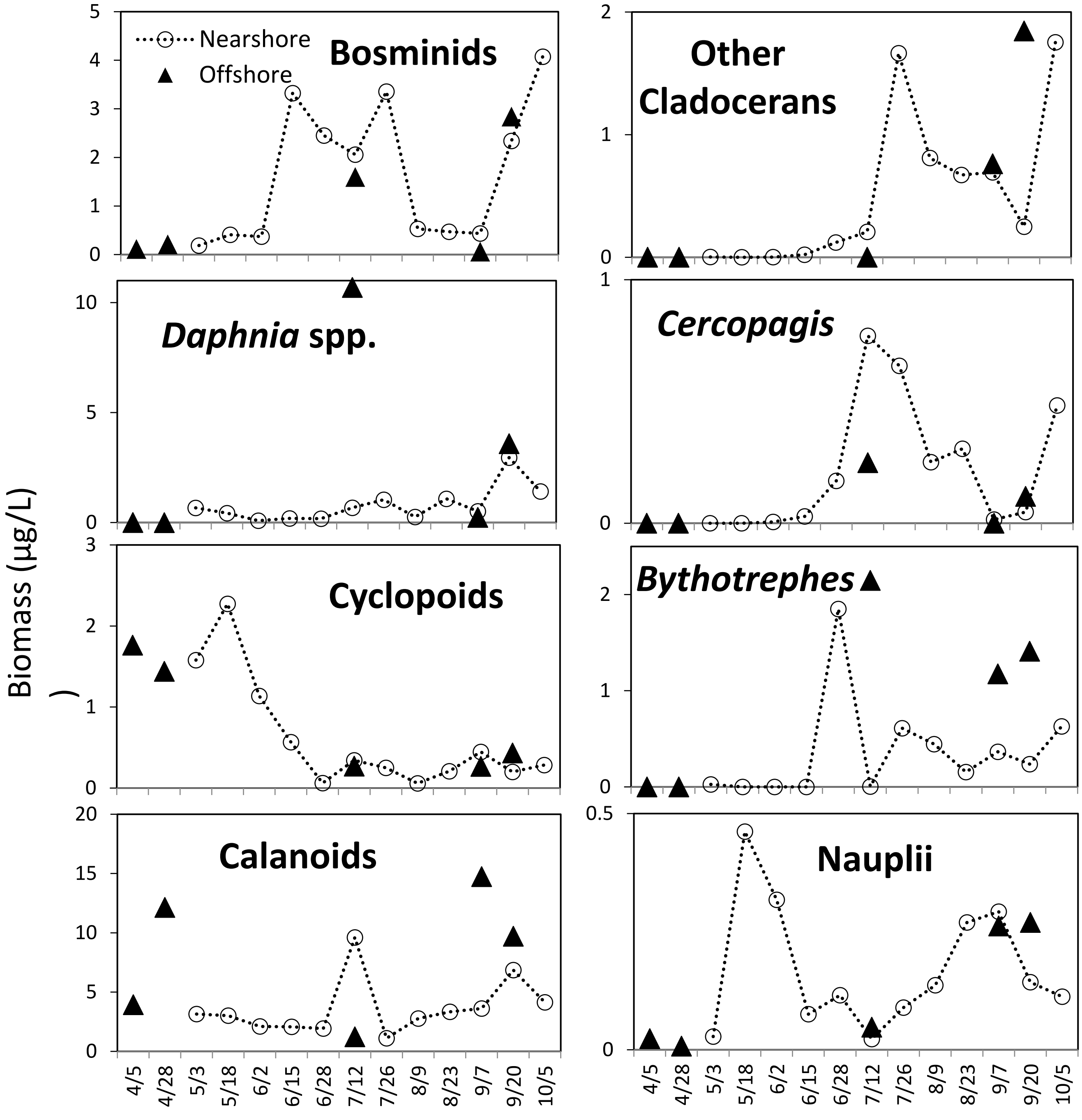

Figure 7. Daytime epilimnetic dry biomass of zooplankton community groups for nearshore and offshore areas of Lake Ontario, April - October 2021. Note different y-axis scales. On the x-axis, biweeks are designated by the date beginning each biweek.

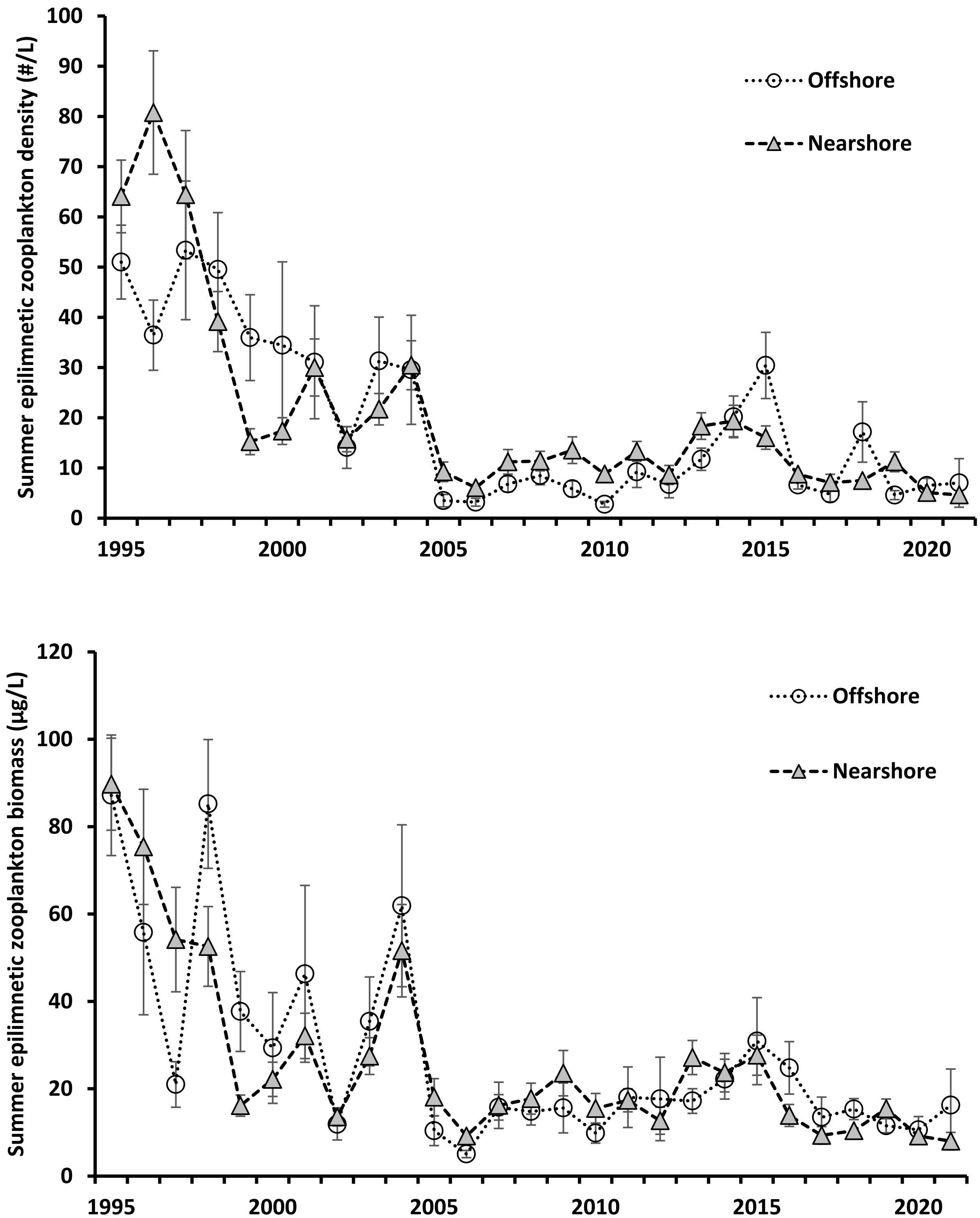

Figure 8. Mean summer (Jul-Aug) epilimnetic zooplankton density (top panel) and dry biomass (bottom panel) in nearshore and offshore habitats in Lake Ontario, 1995 – 2021. Error bars are ± 1 SE.

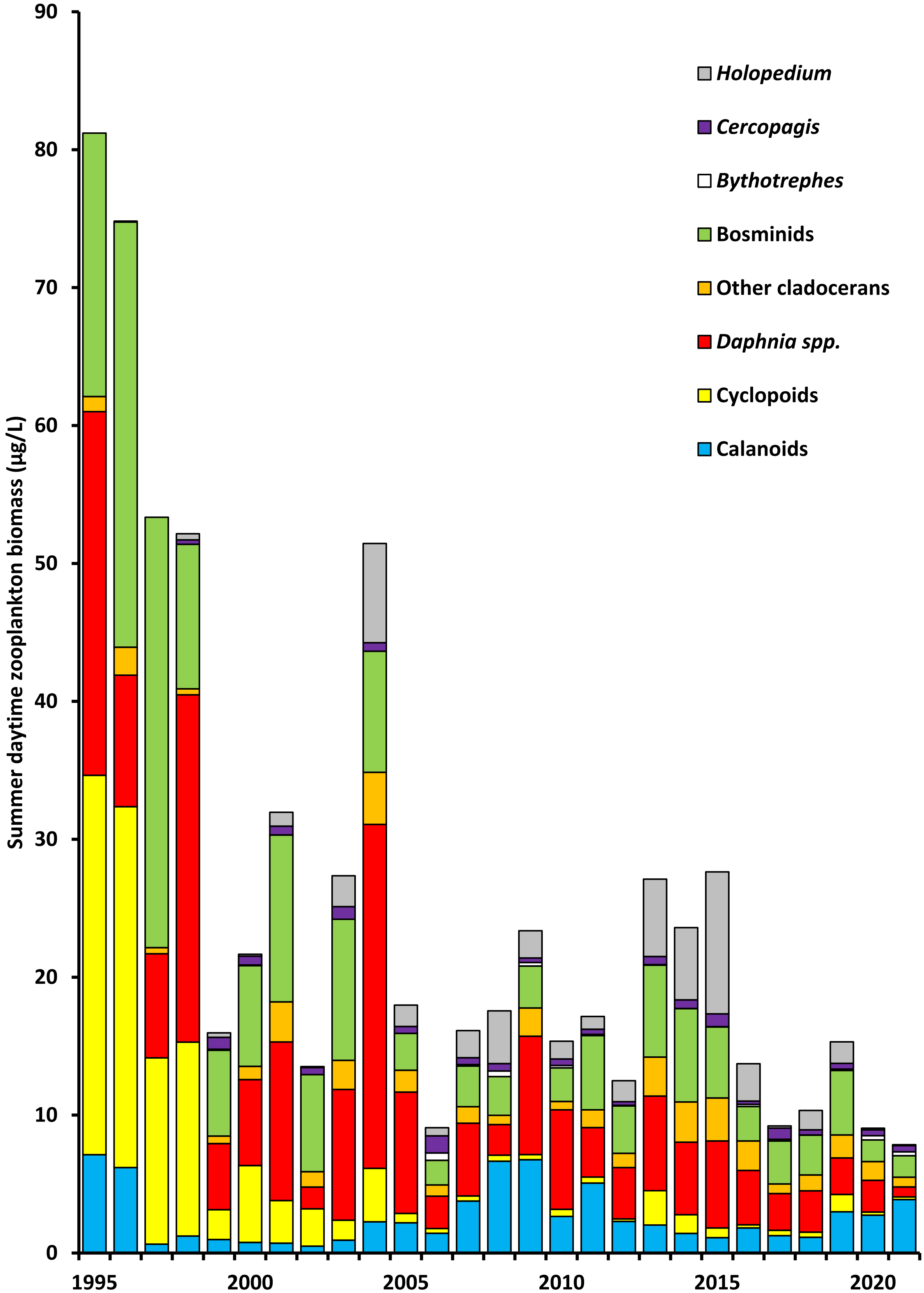

Figure 9. Mean summer (Jul – Aug) daytime biomass of nearshore zooplankton in Lake Ontario, 1995 – 2021.

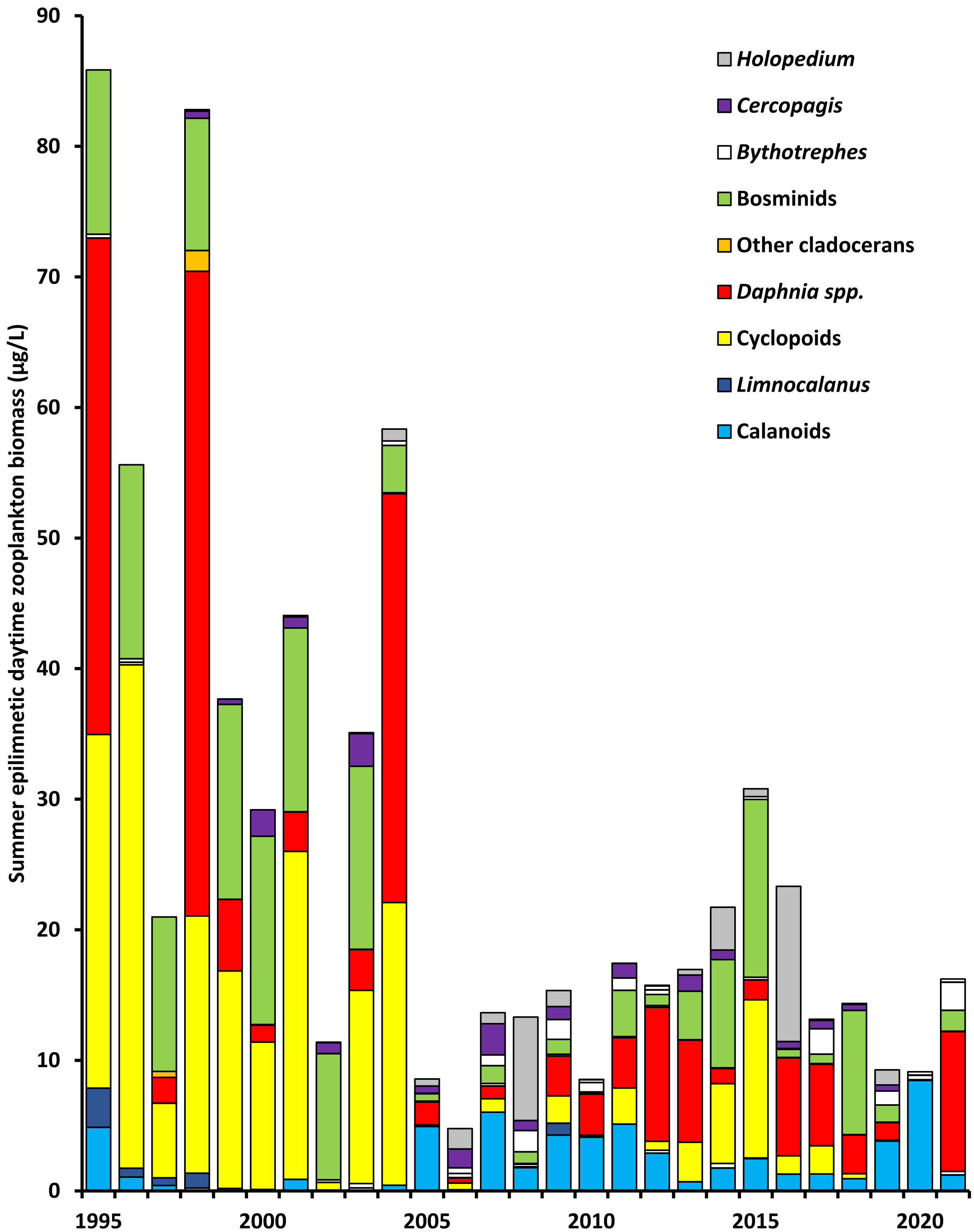

Figure 10. Mean summer (Jul – Aug) daytime biomass of epilimnetic offshore zooplankton in Lake Ontario, 1995 – 2021.

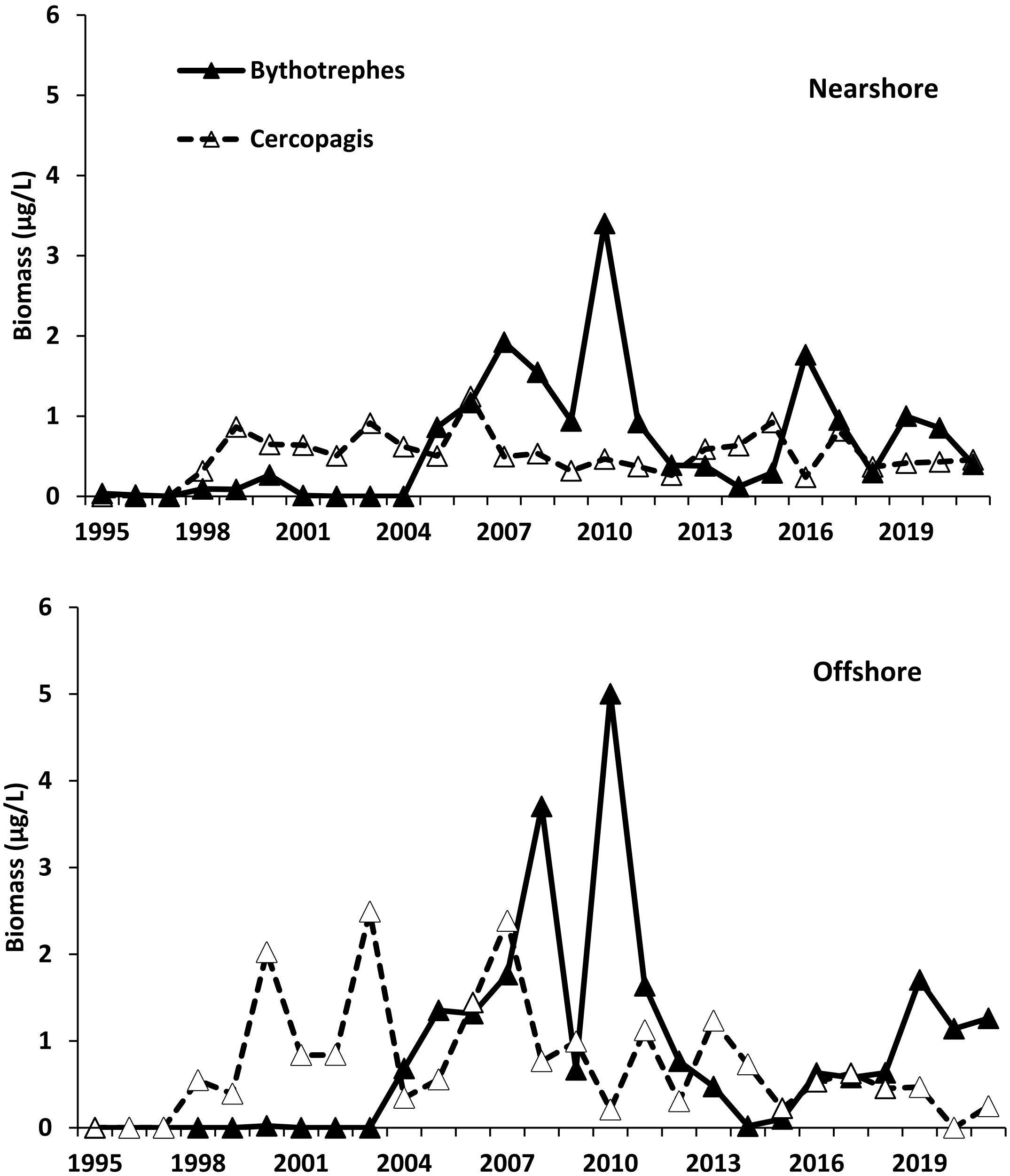

Figure 11. Daytime epilimnetic nearshore and offshore fall (September-October)* Bythotrephes *and summer (July-August)* Cercopagis *dry biomass in Lake Ontario, 1995 – 2021.

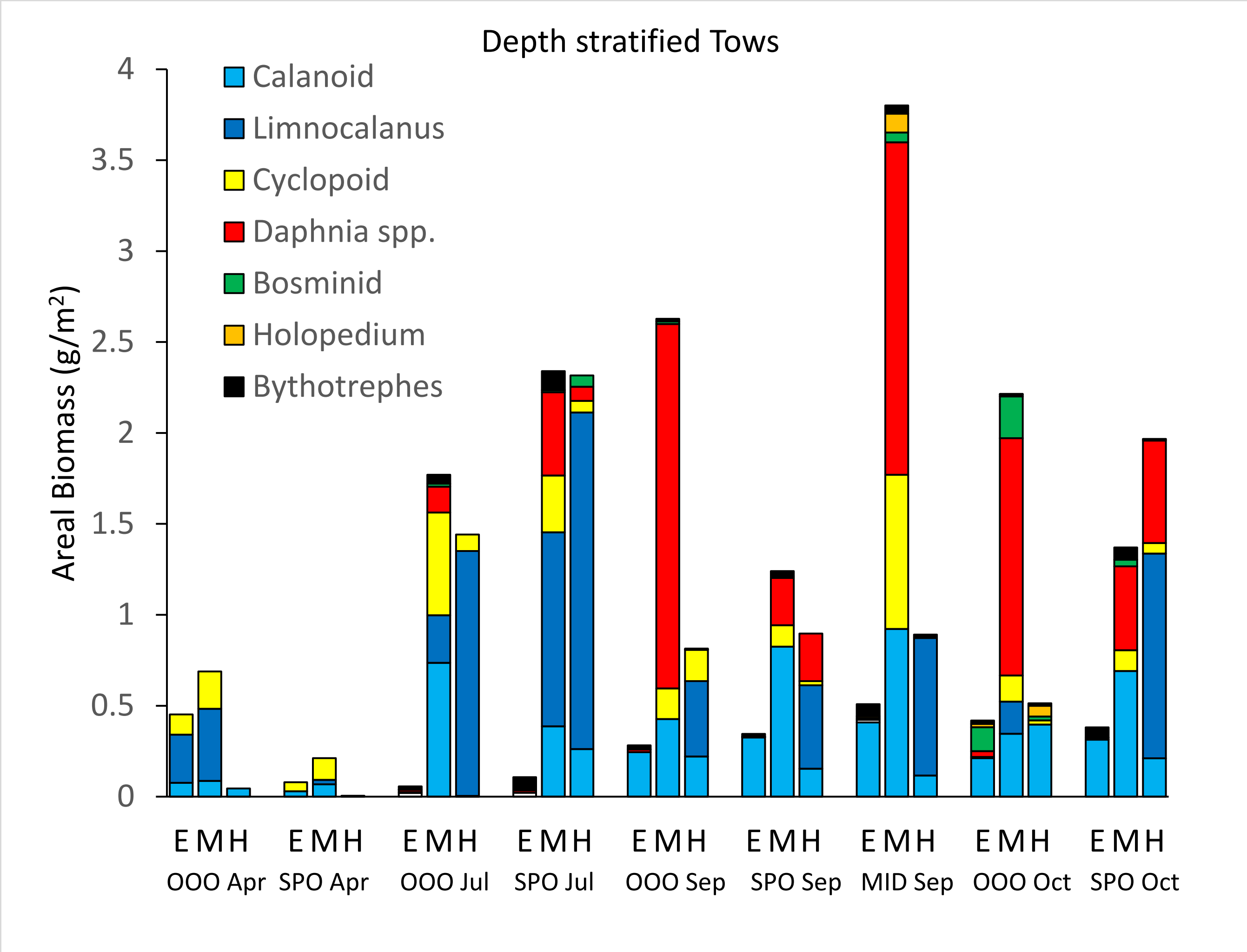

Figure 12. Comparison of mean daytime zooplankton dry biomass in the epilimnion (E), metalimnion (M) and hypolimnion (H)at deep (>100m) sites in Lake Ontario's offshore, April, July, September, and October 2021. The epilimnetic strata includes zooplankton from above the thermocline (from ~11-12m to surface in July, from ~20-25m to the surface other months), the metalimnetic samples are from 50 m, and the hypolimnetic are from 100 m depth. Values in the graphs are obtained by subtracting the shallower depth biomass from the deeper depth biomass. A value of zero was assigned if the upper strata sample contained more animals than the lower strata (can happen due to patchiness). Site codes in Table 1.

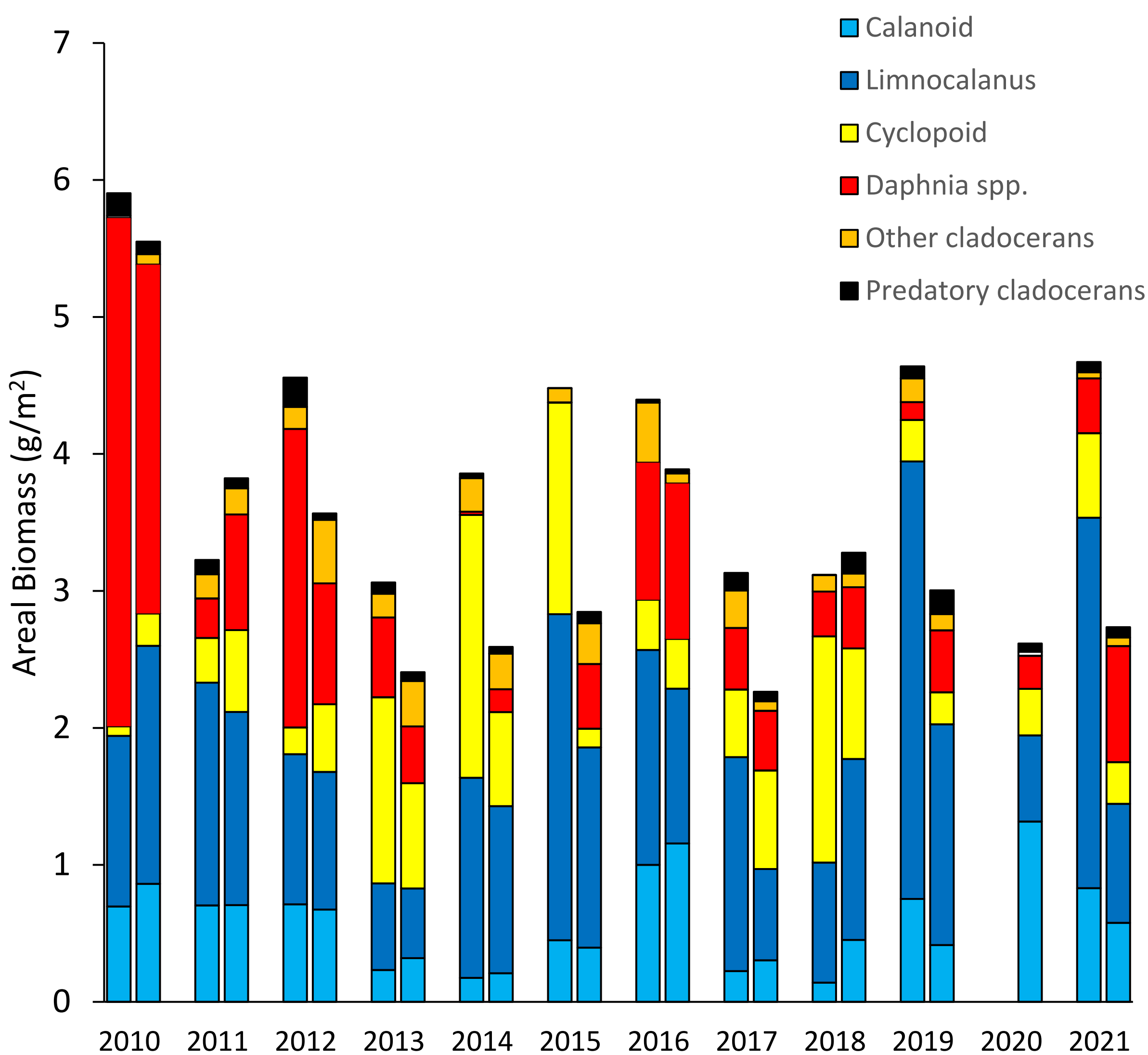

***Figure 13.** Mean whole water column offshore zooplankton group dry biomass in Lake Ontario, 2010 – 2021. First bar for each year is BMP July data. Second bar for each year is USEPA-GLNPO August data. Groups are calanoid copepods (except for Limnocalanus); Limnocalanus macrurus, cyclopoid copepods, Daphnia* **spp.**, *other non-daphnid cladocerans (including Holopedium and bosminids), and predatory cladocerans (Bythotrephes, Cercopagis, Leptodora, Polyphemus).*

Table 1. Mean chl a, TP, SRP and Secchi depth (± 1 SE) for nearshore and offshore sites, April/May Oct 2021. Site code refer to Figure 1. Number after site code refer to bottom depth.
****=sampled once in early September and once in late September.***

Sites	Chlorophyll-*a* (μg/L)	Total phosphorus (μg/L)	Soluble reactive phosphorus (μg/L)	Secchi depth (m)	Months sampled
Nearshore					
Chaumont Lake (CBL, 10.4m)	1.8± 0.2 (n=12)	3.9± 0.3 (n=12)	1.1± 0.4 (n=12)	6.3± 0.3 (n=12)	5, 6, 7, 8, 9, 10
Galloo Island (GIL, 10.3m)	1.5± 0.2 (n=12)	3.4± 0.4 (n=12)	0.7± 0.1 (n=12)	7.9± 0.5 (n=12)	5, 6, 7, 8, 9, 10
Oak Orchard (OOL, 13.6m)	1.1± 0.1 (n=12)	4.6± 0.3 (n=12)	0.9± 0.1 (n=12)	6.3± 0.3 (n=12)	5 ,6, 7, 8, 9, 10
Sodus Lake (SOL, 12.4m)	1.5± 0.2 (n=11)	4.0± 0.4 (n=11)	0.6± 0.02 (n=11)	8.6± 0.7 (n=11)	5, 6, 7, 8, 9, 10
Sandy Pond Lake (SPL, 10m)	1.7± 0.3 (n=10)	6.0± 0.7 (n=10)	0.6± 0.0 (n=10)	7.9± 0.4 (n=10)	5, 6, 7, 8. 9
Niagara East Lake (NEL, 11.3m)	2.5± 0.5 (n=10)	6.2± 0.6 (n=11)	2.8± 0.6 (n=10)	4.5± 0.3 (n=11)	5, 6, 7, 8, 9, 10
Niagara West Lake (NWL, 11.5m)	1.5± 0.3 (n=5)	4.6± 1.0 (n=5)	1.9± 0.2 (n=5)	5.7± 0.7 (n=5)	5, 7, 8
Offshore					
Oak Orchard-N (OON, 25.1m)	1.5± 0.5 (n=4)	4.9± 0.5 (n=4)	0.9± 0.1 (n=4)	6.5± 2.4 (n=4)	4, 7, 9*
Oak Orchard-O (OOO, 193m)	1.9± 0.5 (n=4)	3.0± 0.2 (n=4)	1.1± 0.3 (n=4)	8.9± 4.0 (n=4)	4, 7, 9, 10
Smoky Point-N (SPN, 21.4m)	2.0± 0.4 (n=4)	4.2± 0.6 (n=4)	1.4± 0.8 (n=4)	8.4± 3.5 (n=4)	4, 7, 9*
Smoky Point-O (SPO, 207m)	1.2± 0.3 (n=4)	3.2± 0.2 (n=4)	0.9± 0.2 (n=4)	8.1± 3.1 (n=4)	4, 7, 9, 10
Main Duck (MDK, 47m)	1.2± 0.8 (n=2)	3.6± 1.9 (n=2)	0.7± 0.1 (n=2)	12.5± 6.5 (n=2)	4, 9
Mid Lake (MID, 162m)	1.1± 0.6 (n=2)	3.6± 0.3 (n=2)	0.8± 0.2 (n=2)	12.5± 7.5 (n=2)	4, 9
Tibbetts Point (TPT, 23.5m)	1.2± 1.1 (n=2)	2.2± 0.7 (n=2)	0.6± 0.0 (n=2)	10.0± 4.0 (n=2)	4, 9

Table 2. Comparison of variables in nearshore and offshore habitats. The analyses are based on all collected data for each variable and categorized by habitat (offshore and nearshore) and season (April-June=spring, July-August=summer, September-October=fall). The mean value represents the mean of the seasonal averages for each habitat. The Effect tests p values are based on a mixed model ANOVA with season, habitat, and their interaction as fixed effect, and site as a random effect using all observations (71 in nearshore, 22 in offshore, 7 stations in each habitat). For the statistical analysis we used untransformed values for total phosphorus, soluble reactive phosphorus, chlorophyll, secchi depth and zooplankton average size and square root transformed values for the other variables. Calanoid copepods exclude **Limnocalanus** ***and other cladocerans exclude*** **Holopedium, Cercopagis** ***and*** **Bythotrephes.**

	Mean		Effect tests		
Parameter	Nearshore	Offshore	Habitat	Season	Habitat x season
Water quality					
Total phosphorus (µg/L)	4.7	4.2	0.51	**0.0041**	0.61
Soluble reactive phosphorus (µg/L)	1.1	0.7	0.24	0.42	0.85
Chlorophyll *a* (µg/L)	1.7	1.5	0.33	**<.0001**	0.15
Secchi depth (m)	6.7	9.3	**0.0022**	**<.0001**	**<.0001**
Total zooplankton:					
Density (#/L)	5.3	6.0	0.95	**<.0001**	**0.0141**
Average Length (mm)	0.55	0.74	**<.0001**	**0.0051**	**0.0054**
Biomass (µg dw/L)	8.3	14.6	**0.0021**	**0.0016**	0.35
Group biomass (mg dw/m^3):					
Bosminids	1.57	0.82	0.082	0.14	0.45
Daphnia spp.	0.89	3.97	0.071	**<.0001**	**<.0001**
Calanoid copepods	3.77	6.21	0.126	**<.0001**	**0.0082**
Cyclopoid copepods	0.60	0.70	0.26	**<.0001**	0.76
Nauplii	0.17	0.12	0.29	**0.0020**	**0.0296**
Other cladocerans	0.32	0.14	0.17	**0.0090**	**0.0132**
Cercopagis pengoi	0.22	0.09	0.40	**0.0098**	0.98
Bythotrephes longimanus	0.38	1.15	**0.022**	**<.0001**	**0.0041**
Holopedium gibberum	0.21	0.19	0.83	**0.0005**	0.62
Limnocalanus macrurus	0.17	1.24	**.048**	**<.0001**	**<.0001**

Table 3. Results of regression analyses performed on data from Lake Ontario's offshore and nearshore. Significant p-values ($p \leq 0.05$) are indicated in bold. Slope is from the linear regression and represents the annual change in each parameter (units of change match the units of each parameter) and indicates direction of the change over time. Slopes are only given when $p<0.10$. Slope reported is the slope of the linear regression. Change point analyses were performed on 1995 – 2021 data in both the offshore and nearshore. *change point performed on ranks due to outliers. Values for 2021 in Table 2 and 3 differ slightly due to differences in averaging.

	Regression		Change Point Analysis	2021	1995 – 2020
Offshore	p value	Slope	1995 - 2021	mean	mean (range)
TP (µg/L) all years	0.096	-0.07	No change points	4.3	6.5 (4.0-10.4)
TP (µg/L) excluding 2020	**0.0042**	**-0.11**	No change points		6.4 (4.0-9.5)
Secchi Depth (m)	**<0.0001**	**0.14**	Violates assumptions	10.2	7.3 (5.0-10.3)
Secchi (m) excluding 2020	**<0.0001**	**0.17**	Violates assumptions		7.3 (5.0-10.3)
Chlorophyll *a* (µg/L)	**0.0061**	**-0.03**	(-) 2009	1.4	1.7 (0.8-2.5)
Summer epilimnetic zooplankton density (#/L)	**<0.0001**	**-1.5**	(-) 1999 (-) 2005	7.0	19.8 (2.8-53.3)
Summer epilimnetic zooplankton biomass (µg/L)	**0.0006**	**-1.7**	(-) 2005, (-) 2007	16.2	27.9 (5.1-87.2)
BMP July total areal zoopl. biomass (g/m^2)[a]	0.33		Series too short	3.9	3.7 (3.1-5.9)
GLNPO August total areal zoopl. biomass (g/m^2)[b]	0.052	-0.14	Series too short	2.7	3.0 (2.2-5.5)
Summer epilimnetic biomass (µg/L)					
Bosminids	**0.0006**	**-0.46**	(-) 2004	1.6	6.4 (0.02-14.9)
Bythotrephes longimanus	**0.0113**	**0.04**	(+) 2006	2.2	0.38 (0-1.94)
Calanoid copepods	0.108	0.09	(+) 2005	1.2	2.24 (0.06-8.5)
Cercopagis pengoi [c]	0.57		(-) 2010	0.3	0.75 (0-2.5)
Cyclopoid copepods	**0.0001**	**-0.90**	(-) 2005, (-) 2018	0.3	8.2 (0-38.5)
Daphnia spp.	0.098	-0.50	No change points	10.7	7.16 (0.04-49.4)
Other cladocerans	0.099	-0.01	No change points	0.05	0.16 (0-1.6)
Limnocalanus	**0.0108**	**-0.04**	(-) 1996	0	0.28 (0-3.0)
Holopedium	0.25		(+) 2001 *	0	1.19 (0-11.9)
Nearshore					
TP (µg/L) all years	0.35		No change points	4.6	7.8 (4.7-11.6)
TP (µg/L) excluding 2020	0.25				7.8 (4.7-11.6)
Secchi Depth (m)	0.56		No change points	6.6	6.2 (5.6-6.9)
Chlorophyll *a* (µg/L)	0.19		(+) 03, (-) 10, (+) 16	1.7	1.5 (1.0-2.1)
Summer epilimnetic zooplankton density (#/L)	**<0.0001**	**-1.76**	(-) 98, (-) 05, (-) 16	4.6	21.3 (5.1-80.7)
Summer epilimnetic zooplankton biomass (µg/L)	**<0.0001**	**-1.79**	(-) 1999	8.0	27.0 (9.2-89.7)
Summer epilimnetic biomass (µg/L)					
Bosminids	**<0.0001**	**-0.67**	(-) 98, (-) 05, (-)20	1.6	7.7 (1.6-31.2)
Bythotrephes longimanus	**0.0106**	**0.006**	(+) 2006, (-) 2007	0.28	0.10 (0-0.53)
Calanoid copepods	0.58		(+) 07, (-) 12, (+) 19	3.9	2.32 (0.36-7.13)
Cercopagis pengoi [c]	0.40		No change points	0.46	0.57 (0.24-1.24)
Cyclopoid copepods	**<0.0001**	**-0.63**	(-) 1997, (-) 1999	0.19	4.24 (0.18-27.5)
Daphnia spp.	**0.0014**	**-0.52**	(-) 2006	0.72	7.76 (1.58-26.4)
Other cladocerans	0.55		No change points	0.71	1.56 (0.44-3.78)
Holopedium	0.18		(+) 2003	0.06	2.0 (0-10.3)

(a) Only available from 2010 to 2021, excluding 2020
(b) Data available from 1997 for time trends but data presented here calculated for 2010-2021 to allow direct comparisons with the BMP program
(c) Cercopagis analyzed from 1998 when they were first encountered in Lake Ontario.

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

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Northern pike abundance in the NYS Department of Environmental Conservation's (DEC) Thousand Islands Warmwater Fisheries Assessment (Resseguie and Gordon 2020) continues to indicate low population levels. Smith et al. (2007) demonstrated an overall dampening in the strength of Thousand Islands northern pike year classes beginning in the 1990s and seining indices show a corresponding low abundance for young of the year (hereafter YOY). Models of YOY northern pike production developed as part of the International Joint Commission (IJC) St. Lawrence River Water Levels Study indicated a negative relationship of water level regulation on northern pike reproduction (Farrell et al. 2006). Water levels and spawning habitat changes can promote deep-water pike spawning (over ~5 meters) and 4-to-6-week delays in the egg deposition period when habitat condition are poor (Farrell 2001). Deep water spawning occurs late in spring (May-June) and is maladaptive creating a significant reproductive sink. Nearshore pike spawning is affected by water level regulation by limiting spawner access to wetland spawning habitats. A related effect is the expansion of hybrid cattail (*Typha* x *glauca*) into shallow riparian wet meadow habitats that northern pike prefer for spawning (Farrell et al. 2010).

To provide improved spawning habitat conditions habitat improvements via water level-controlled marshes and through excavation of spawning channels and pools have been employed to increase connectivity in coastal wetlands by the US Fish and Wildlife Service (USFWS) and Ducks Unlimited through the Fish Habitat Conservation Strategy (Farrell et al. 2017). Studies at several enhanced sites have documented consistent use by northern pike for reproduction and success also is related to springtime water level conditions (Neveldine et al. 2019). Comparisons of years with high spring levels (including floods of 2017 and 2019) show significantly higher outmigration rates compared to years with lower levels. There are additional needs to better understand the effects of low oxygen levels outmigration of young pike.

Northern pike YOY are monitored in eleven seining survey sites (also used to index muskellunge), in larger bays, and in tributaries. Overall YOY production has declined significantly from historic levels. Continued monitoring is necessary to track northern pike reproductive success, to evaluate responses to habitat management activities, and as a baseline to assess effects of IJC water level management Plan 2014 enacted in January 2017. Other needs fulfilled by the project include a better understanding of early life history processes for northern pike in drowned river mouth tributary systems and coastal bays. Research regarding habitat restoration efforts, in addition to providing options for northern pike management (Crane et al. 2015), will be critical to maintaining future populations.

Our objective is to provide an update of current research and monitoring activities related to northern pike management.

Methods

<u>Spawning run trapnet survey</u>

Monitoring of adult northern pike during spring spawning occurred in four index tributaries, one exploratory tributary, and one managed spawning marsh. Index tributaries included Chippewa Creek, Cranberry Creek extension, French Creek, and Little Cranberry Creek, while Bonnie Castle was sampled as an exploratory site. In addition, the managed marsh sampled was Carpenters Branch of French Creek (Figure 1).

Northern pike were captured in trapnets and assessed for sex/spawning condition (pre-spawn, ripe, and spent), examined for fin-clips or tags, measured for total length (TL), and tagged with a Monel metal jaw tag with an unique alphanumeric code and "RTN TO NYSDEC WAT NY 13601" in the left maxillary of fish greater than 500 mm TL (19.7 inches). Recaptured fish yielded information on distribution, individual growth, and spawning site fidelity. A scale sample was retained from each fish and notes on any physical abnormalities were recorded. Captured northern pike were transferred upstream of each net following processing. The sex ratio (females to each male) was compared for each site. Additional data is collected for late spawning northern pike (during May and June) in embayment sites with nets targeting spawning muskellunge (Farrell and Weber 2020).

Water levels are typically held ~0.6 m (2 feet) above main river level at Carpenters Branch and Delaney Marsh in partnership with the Thousand Islands Land Trust. Delaney Marsh was not included in the spring spawning or emigration surveys because of its remote island location. The water level management strategy for marshes is intended to prevent the fall drawdown (Farrell et al. 2010) experienced under IJC water level regulation.

<u>Emigration of YOY northern pike at managed marshes and excavated spawning pools</u>

During a related study funded by the USFWS, northern pike have been monitored and managed at habitat enhancement areas in the DEC French Creek Wildlife Management Area and provide a useful comparison to the spawning marsh monitoring program. Excavated marsh spawning pools were created by Ducks Unlimited, and the US Fish and Wildlife Service Partners for Fish and Wildlife Program restored channels connecting French Creek to remnant wet meadow habitats. Spawning pool and connecting channel sites are created to increase YOY pike production through improved habitat and access for spawners (Farrell et al. 2017).

In early summer, YOY northern pike emigrating from marshes were captured in fine-mesh mini-hoopnets (i.e., emigration traps). This survey provides an index of emigration from nursery areas and can be used as a metric of marsh productivity. Emigration traps are set in French Creek and include reference sites and restored spawning pool complexes. Emigration traps were also set at Cranberry Creek and Point Vivian Marsh, for a total of 24 nets deployed. All fish captured were identified and enumerated. Northern pike were measured for total length (mm), and a pelvic fin for all fish greater than 80 mm (2.3 in.) was removed to evaluate the presence of marsh-origin fish during subsequent summer seining surveys and future spring adult trapnetting surveys. Traps were emptied and reset daily. In addition to northern pike and other fish catches, abundances of macroinvertebrates and amphibians were recorded. Environmental data collected included water temperature, dissolved oxygen, and water level.

<u>Summer seining surveys</u>

Standardized seining for YOY northern pike was conducted in conjunction with YOY muskellunge monitoring. A total of 11 index sites were sampled during July with a fine-mesh, 9.1 m (30 ft) long seine (90 hauls) and during August with a large-mesh, 18.3 m (60 ft) long seine (90 hauls); for methodology details see Murry and Farrell (2007). In addition, 36 sites were sampled (177 hauls) in an exploratory series with a fine-mesh seine, while 15 exploratory sites were sampled from August-October with a large mesh seine (148 hauls). Additional exploratory seining was conducted in Lake St. Lawrence (4 sites, 12 hauls) and Eastern Lake Ontario (3 sites, 12 hauls). The exploratory series is used to compare to the long-term index seining results.

Results and Discussion

<u>Spawning run trapnet survey</u>

A total of 13 northern pike were captured across four index tributary sites from March 30th to April 9th, 2021. One pike was captured at Bonnie Castle, while 19 individuals were collected at Carpenters Branch. An effort of 88 net nights resulted in a mean catch per unit effort (hereafter CPUE) of 0.38 fish/night (Table 1). Of the 33 pike captured, the majority were collected in Carpenters Branch of French Creek (n=19, CPUE=1.73) while the next best site was Bevins Upper (n=6, CPUE=0.55). The catch of spawning northern pike at index sites in 2021 was lower than in 2020 (n=57, CPUE=0.86) and remains low since a significant peak in 2008 (CPUE = 4.20; Figure 2).

However, CPUE in 2020 was greater than any year since 2008, potentially due to the strong year-class produced in 2017. The CPUE in 2020 was bolstered by one large catch at Little Cranberry; otherwise, catch was low among other sampling sites. Newly excavated spawning pools and channels were created by the USFWS contractors in upper French Creek in 2020 and completed in late winter 2021.

Current and past trapnet catches continue to indicate a significant dominance of female northern pike in the early spawning run at the managed marsh sites. Of the 736 northern pike of known sex captured at Carpenters Branch since 2003, 494 were female, corresponding to 2 females for each male captured. The causative factors for this imbalance or its potential influence on pike populations are not understood. It is now known that the sex-determining gene (SDG) complex in northern pike east of the continental divide has been lost due to founder effects and genetic drift (Johnson et al. 2020). Sex determination is therefore likely a result of an unknown mechanism that may be influenced directly by environmental conditions.

Emigration of northern pike at managed marshes and excavated spawning pools

Emigration traps were used to capture YOY northern pike leaving spawning and nursery areas in unaltered reference habitats, constructed spawning areas, and managed marshes from June 14th to June 25th (Table 2). Across all sites, 65 YOY northern pike (overall CPUE = 0.27) were captured leaving nursery areas (Table 2). The majority of pike were collected at Point Vivian (n=58) while catches were minimal at Cranberry Creek (n=3) and French Creek (n=4). Total catch in 2021 was much lower than the flood year of 2017 (total catch = 2,305 pike: overall CPUE = 2.26) and the flood year of 2019 (total catch = 464 pike, CPUE = 0.54). Habitat restoration sites did have higher catch rates for three consecutive years than the other site types. Analysis of YOY outmigration over time at excavation sites show a positive relationship to spring water level conditions relative to unaltered reference sites in French Creek (Neveldine et al. 2019). A related study of northern pike fry survival detailed in Massa and Farrell (2020) indicate an influence of environmental parameters including DO and water temperature on survival.

Summer seining surveys

The YOY seining survey at eleven index sites produced a catch of 2 YOY northern pike in 90 hauls with the 30’ fine-mesh seine (CPUE = 0.02 fish/haul, Table 3) while two pike were captured in the 60’ large-mesh seine in 90 hauls (CPUE = 0.02 fish/haul). Additionally, 35 exploratory upper St. Lawrence River bays were sampled with a 30’ seine and 30 YOY pike were captured (n = 177 hauls: CPUE = 0.17). Exploratory bays were also sampled with a 60’ seine from August-October, resulting in 12 YOY pike captured during 148 hauls (CPUE = 0.08 fish/haul). CPUE in Lake St. Lawrence was higher at 0.33 (4 pike, 12 hauls) while seining in eastern Lake Ontario resulted in no YOY pike caught (12 hauls). Trends in YOY northern pike abundance were showing slight improvement from 2013-2020 but declined in 2021, potentially due to low spring water levels limiting access to wetland spawning habitat (Figure 3).

Conclusions and Recommendations

SUNY-ESF will continue monitoring northern pike juvenile and adult populations in concert with the DEC Region 6 Warmwater Assessment to provide data to inform management. Recent sportfish regulation adjustments include a reduction in the creel limit from five to three fish per day. The monitoring and population demographic data will help inform trends and assessment of regulation changes. This information will also inform population contributions from the potentially strong 2017 northern pike year-class. These fish should have recruited to WWA gillnetting as age-3 and age-4 individuals, but catches were exceptionally low in the WWA. Research is examining the potential effect of double-crested cormorant predation on northern pike as an influence on recruitment. Restoration projects are contributing to numbers emigrating from coastal wetland habitats. Future work with habitat restoration is recommended to continue through the Fish Habitat Conservation Strategy with its partners including DEC, FWS, DU, and the Thousand Islands Land Trust and others.

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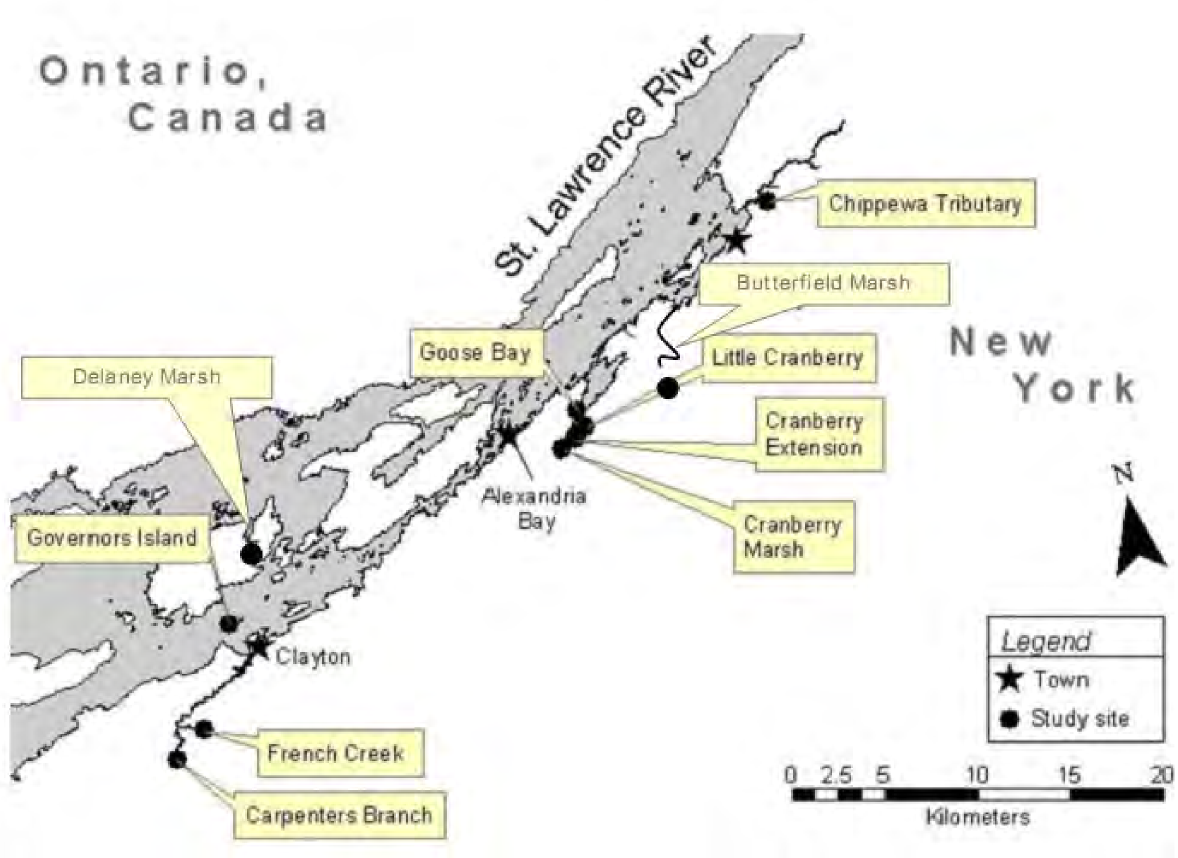

Figure 1. Study sites in the Thousand Islands Region of the upper St. Lawrence River, New York, including spawning marshes at Carpenters Branch (French Creek Wildlife Management Area) and Delaney Marsh (Grindstone Island) and sampling index locations at French Creek, Little Cranberry Creek, Cranberry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

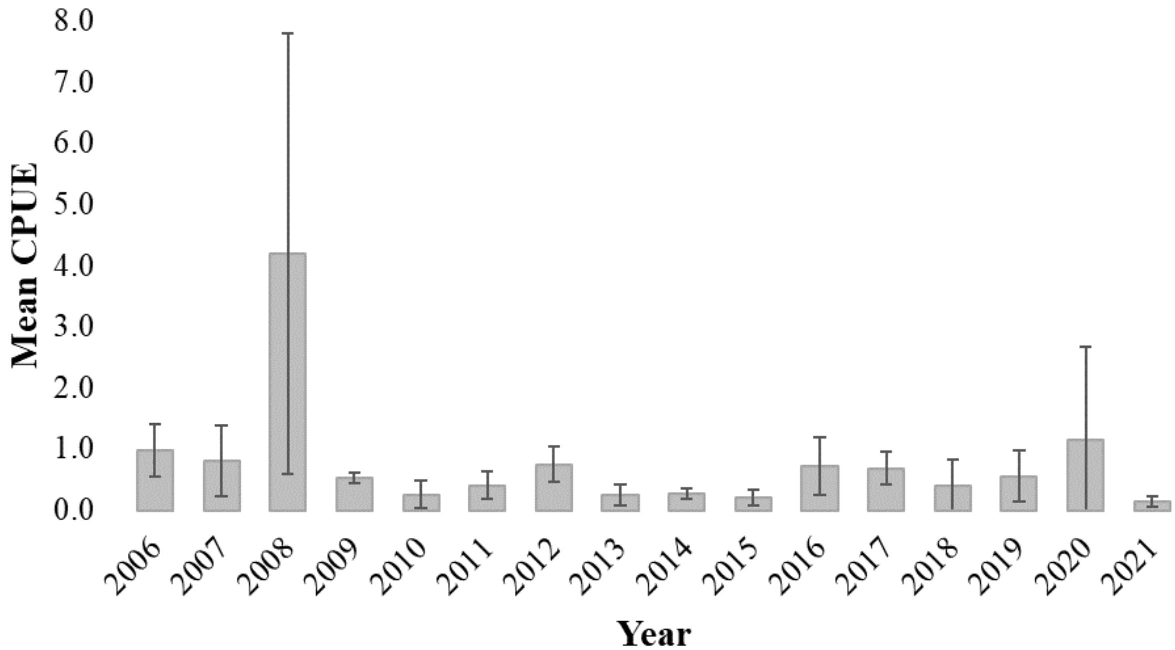

Figure 2. Mean catch per net-night of adult northern pike in four spring spawning index trapnetting locations from 2006 to 2021. Error bars represent 90% confidence intervals.

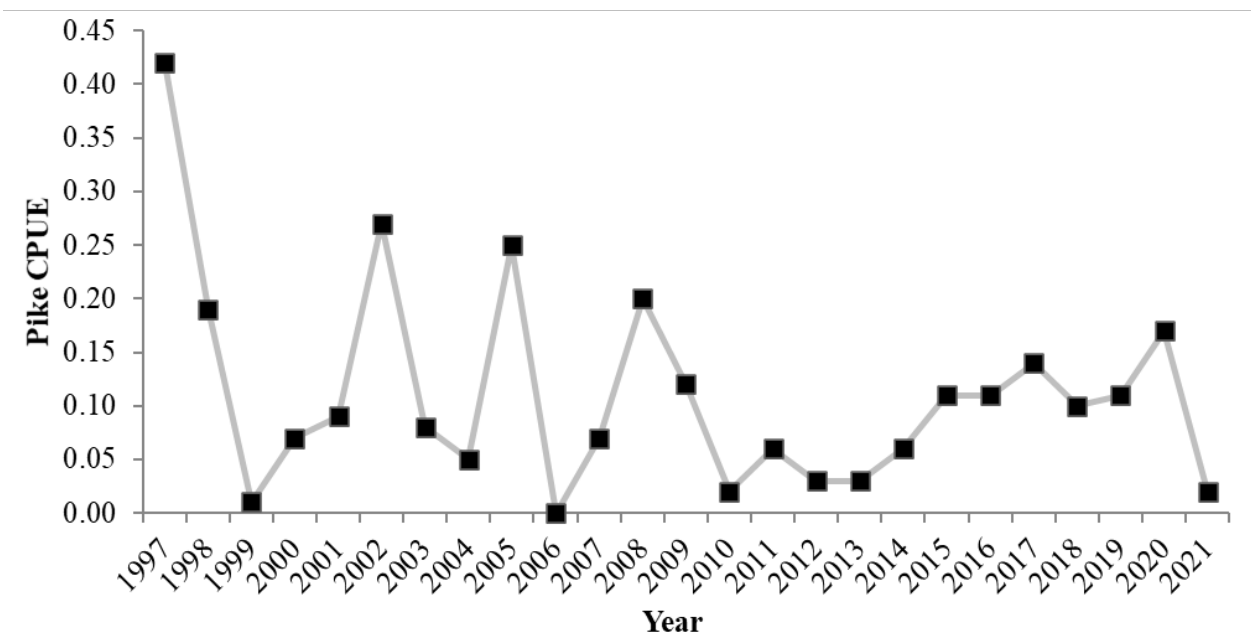

Figure 3. Catch per seine haul of YOY northern pike sampled during July from 1997-2021 with a fine-mesh, 9.1 m (30’) long seine at Thousand Islands index sites.

Table 1. 2021 upper St. Lawrence River northern pike spawning survey effort and results by site from March 30th to April 10th. Effort is defined as the total number of net-nights fished. F/M ratio is the ratio of female to male northern pike.

2021 NP Spawning				
Location	Effort	NP	CPUE	F/M ratio
Bevins (French Creek)	11	4	0.36	3.00
Bevins Upper (French Creek)	11	6	0.55	5.00
Bonnie Castle	11	1	0.09	N/A
Carpenters (French Creek)	11	19	1.73	5.00
Chippewa Extension	11	1	0.09	N/A
Cranberry Extension	11	1	0.09	N/A
Deferno (French Creek)	11	0	0.00	N/A
Little Cranberry	11	1	0.09	N/A
Total	**88**	**33**	**0.38**	**3.13**

Table 2. Summary of catch per unit effort for YOY northern pike captured during 2021 emigration netting. Site types include unaltered reference locations, habitat enhanced sites, and managed marshes. Effort is defined as the total number of net-nights fished.

2021 NP Emigration				
Location	Nets	Effort	NP	CPUE
REFERENCE				
Cranberry Creek	2	20	3	0.15
French Creek	4	43	4	0.09
Point Vivian Marsh	2	18	14	0.78
Subtotal	**8**	**81**	**21**	**0.26**
SPAWNING POOLS AND CHANNELS				
Cranberry Creek	2	20	0	0.00
French Creek	9	99	0	0.00
Point Vivian Marsh	5	45	44	0.98
Subtotal	**16**	**164**	**44**	**0.27**
Total	**24**	**245**	**65**	**0.27**

Table 3. Summary of 2021 index seining muskellunge and northern pike catch data using a fine-mesh 30' bag seine (top) and a large-mesh 60' bag seine (bottom).

Location	Hauls	# Age-0 MKY	# Age-0 NP	Age-0 MKY CPUE	Age-0 NP CPUE
Affluence Bay	6	2	0	0.33	0.00
Boscobel Bay	6	0	0	0.00	0.00
Cobb Shoal	12	3	0	0.25	0.00
Deer Island	6	0	0	0.00	0.00
Frinks Bay	10	13	0	1.30	0.00
Garlock Bay	10	26	0	2.60	0.00
Lindley Bay	6	0	0	0.00	0.00
Millens Bay	12	0	2	0.00	0.17
Peos Bay	6	13	0	2.17	0.00
Rose Bay	10	1	0	0.10	0.00
Salisbury Bay	6	2	0	0.33	0.00
Total	**90**	**60**	**2**	**0.67**	**0.02**
Location	**Hauls**	**# Age-0 MKY**	**# Age-0 NP**	**Age-0 MKY CPUE**	**Age-0 NP CPUE**
Affluence Bay	6	2	0	0.33	0.00
Boscobel Bay	6	0	0	0.00	0.00
Cobb Shoal	12	1	0	0.08	0.00
Deer Island	6	0	0	0.00	0.00
Frinks Bay	10	2	0	0.20	0.00
Garlock Bay	10	8	0	0.80	0.00
Lindley Bay	6	0	0	0.00	0.00
Millens Bay	12	0	2	0.00	0.17
Peos Bay	6	0	0	0.00	0.00
Rose Bay	10	0	0	0.00	0.00
Salisbury Bay	6	0	0	0.00	0.00
Total	**90**	**15**	**2**	**0.17**	**0.02**

Table 4. Summary of exploratory seining catch data using a fine-mesh 30’ bag seine (top) and a large-mesh 60’ bag seine (bottom). Data for muskellunge and northern pike captures.

Location	Hauls	# Age-0 MKY	# Age-0 NP	Age-0 MKY CPUE	Age-0 NP CPUE
A1	2	0	0	0.00	0.00
A3	2	2	0	1.00	0.00
A4	2	0	0	0.00	0.00
Aunt Jane's Bay	4	5	0	1.25	0.00
Birch Island	1	0	0	0.00	0.00
Blind Bay	11	3	1	0.27	0.09
Brush Island	3	0	0	0.00	0.00
Buck Bay	6	8	1	1.33	0.17
Delaney Bay	8	0	1	0.00	0.13
Densmore Bay	10	2	3	0.20	0.30
Eel Bay	8	0	0	0.00	0.00
Flynn Bay	26	6	3	0.23	0.12
Fox Creek	3	2	0	0.66	0.00
Fox Island	6	11	0	1.83	0.00
Grass Bay	3	0	0	0.00	0.00
Grass Point	11	3	7	0.27	0.64
Jolly Island	4	3	0	0.75	0.00
Kring Point	2	0	0	0.00	0.00
Leishman Point	2	0	0	0.00	0.00
Long Point	6	0	10	0.00	1.67
Mead Island	3	0	0	0.00	0.00
Mud Bay	3	1	0	0.33	0.00
Number 9 Island	3	0	0	0.00	0.00
Oak Point	7	2	0	0.29	0.00
Point Marguerite Marsh	3	0	0	0.00	0.00
Point Vivian	6	3	0	0.50	0.00
Red Barn Bay	2	0	0	0.00	0.00
Roods Cove	2	0	0	0.00	0.00
Sheepshead Point	5	0	0	0.00	0.00
Swan Bay	6	0	0	0.00	0.00
Thurso Bay	5	6	0	1.20	0.00
Waddington Beach	2	1	1	0.50	0.50
Whitehouse Bay	2	3	0	1.50	0.00
Whitehouse Bay (LSL)	6	0	1	0.00	0.17
Windsong Bay	2	0	2	0.00	1.00
Total	**177**	**61**	**30**	**0.34**	**0.17**
Location	**Hauls**	**# Age-0 MKY**	**# Age-0 NP**	**Age-0 MKY CPUE**	**Age-0 NP CPUE**
A3	6	6	0	1.00	0.00
Aunt Jane's Bay	6	1	0	0.17	0.00
Blind Bay	9	0	0	0.00	0.00
Buck Bay	6	1	1	0.17	0.17
Densmore Bay	8	0	1	0.00	0.13
Eel Bay	3	0	0	0.00	0.00
Flynn Bay	29	3	0	0.10	0.00
Fox Creek	2	0	0	0.00	0.00
Fox Island	6	2	0	0.33	0.00

Table 4. Continued

Grass Point	38	11	9	0.29	0.24
Jolly Island	4	0	0	0.00	0.00
Mud Bay	2	0	1	0.00	0.50
Oak Point	6	1	0	0.17	0.00
Point Vivian	6	1	0	0.17	0.00
Thurso Bay	17	14	0	0.82	0.00
Total	**148**	**40**	**12**	**0.27**	**0.08**

Research, Monitoring, and Management of St. Lawrence River Muskellunge

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The St. Lawrence River is well known for its world-class Great Lakes strain muskellunge (*Esox masquinongy*, Mitchell) fishery. The fishery is managed through efforts of an international St. Lawrence River Esocid Working Group (EWG) guided by muskellunge management plans (Panek 1980, LaPan and Penney 1991, Farrell et al. 2003). The goal for management is: "To perpetuate the muskellunge as a viable, self-sustaining component of the fish community in the St. Lawrence River and to provide a quality trophy fishery" (with a catch rate of 0.1 muskellunge per hour fished). The EWG is composed of resource managers from the US and Canada and meets periodically to discuss recently completed studies, research needs, and potential management actions. Attention to muskellunge management and research needs has served as a long-term management model (Farrell et al. 2007). The focus now is on population recovery following significant mortality due to an outbreak of invasive viral hemorrhagic septicemia virus (VHSV) in the mid-2000s (Farrell et al. 2017).

As recommended by the management plan, monitoring of adult and young-of-year (hereafter YOY) muskellunge has been ongoing since 1990 and recent population changes were detected using this data series. The first was an apparent positive response to the improved management strategies of the late 1990s and early 2000s with increased numbers of YOY on nursery grounds and higher adult catch rates. From 2005 through 2008, however, widespread mortality of adult muskellunge was observed and attributed to VHSV (Casselman et al. 2017, Farrell et al. 2017), which had recently been introduced to the Great Lakes (Elsayed et al. 2006). Since the adult muskellunge mortality events, a substantial and persistent decline has been observed in adult catch rate in the spring spawning survey and in YOY abundance on the nursery grounds, in addition to reduced catch rates in the fishery (Farrell et al. 2017). Monitoring is important to understand the population's response to perturbations such as disease-induced mortality and changes to habitat or fish community structure. For example, the nonnative round goby, (*Neogobius melanostomus*) has invaded littoral nursery habitats of muskellunge (Farrell et al. 2010). Miano et al. (2019) demonstrated in experimental treatments of northern pike and muskellunge habitats that round goby have the potential to be significant egg predators of esocids, a broadcast spawning species. Round goby are also known as reservoirs and vectors for VHSV (Groocock et al. 2007). Further, the St. Lawrence River esocid seining index has detected changes in the nearshore fish assemblage associated with the dominance of round goby that potentially impacts esocid prey availability.

Because of these stressors, maintenance of productive spawning and rearing habitats is imperative to ensure sustained natural muskellunge reproduction (Dombeck et al. 1986). To address these needs, monitoring and research targeting factors influencing population status and reproductive success continue to be of high importance. Significant progress has been made in these areas in previous work (summarized in Farrell et al. 2007), including studies of spawning ecology (LaPan et al. 1995, Farrell et al. 1996, Cooper 2000, Farrell 2001), nursery habitat requirements (Werner et al. 1990, Clapsadl 1993, Jonckheere 1994, Farrell and Werner 1999, Murry and Farrell 2007, Woodside

2008), dietary characteristics of YOY (Kapuscinski et al. 2012), YOY response to invasions by non-native prey fish (Kapuscinski and Farrell 2014), and fall juvenile fish movements and overwintering (Farrell et al. 2014, Gallagher et al. 2017, Walton et a. 2020). The information obtained in these studies is being used to develop a more comprehensive understanding of muskellunge as part of the food web, habitat, and population dynamics to guide enhancement strategies. Our objective here is to report current research and monitoring efforts with annual updates pertinent to muskellunge management.

Methods

Spring trapnetting survey

Trapnet surveys have been used to monitor spring spawning adult muskellunge populations at a set of Thousand Islands region index bays for 19 years (1997-2000, 2003, and annually since 2006). In 2021, twenty-one nets, including 4’ hoop nets as well as 4’ and 6’ Oneida trapnets, were fished near shore in eleven muskellunge spawning bays between May 10th and June 11th. An additional two sites (total of three nets) were surveyed to increase catch of spawning muskellunge. Trapnets were also set at downstream sites in Lake St. Lawrence in a collaborative muskellunge assessment effort with the US Fish and Wildlife Service Ecological Services Office in Cortland NY.

Data collected from captured muskellunge included total length (TL), sex, and spawning condition. All adult muskellunge were tagged with Passive Integrated Transponder (PIT) tags. Catch data are reported as an index to monitor trends in relative abundance, size distribution, and sex ratios of spawning muskellunge. Data on muskellunge recaptured in this survey and by angler collaborators are used to examine fish movements, particularly as it pertains to spawning site fidelity. In addition to collecting muskellunge-specific data, all other fishes are identified and enumerated to characterize fish assemblages present at muskellunge spawning sites and this information will be summarized elsewhere.

Culturing and stocking

In collaboration with DEC and USFWS, a muskellunge advanced fry (~25 mm) and fingerling stocking research plan. This experimental muskellunge population recovery program aims to examine the ability of the nursery habitat to sustain muskellunge in comparison to previous survival studies (Farrell and Werner 1999, Farrell 2001, Farrell et al. 2017) to enhance the overall abundance and spawning potential of the SLR muskellunge population. In spring 2021, broodstock muskellunge were captured in sufficient numbers in both the Thousand Islands region and in Lake St. Lawrence sections of the River. A total of 38,300 advanced fry were released in 46 locations from Eastern Lake Ontario downstream to Lake St. Lawrence near Waddington, NY.

Summer seining surveys

In 1990, a standardized seining procedure was initiated at six sites to monitor YOY muskellunge in the upper St. Lawrence River. Since 1997, standardized monitoring of the relative abundance of YOY muskellunge during the nursery period has occurred, with two surveys per year at each of eleven sites between Cape Vincent and Alexandria Bay, NY. Survey procedures are further detailed in Farrell and Werner (1999). Habitat data collected include geographic coordinates, depth, temperature, vegetation type, and coverage and substrate. Juvenile esocid data collected comprises relative abundance, distribution, and total length (mm). Seining survey data are used to monitor trends in abundance and growth between periods, and to monitor fish assemblage/habitat relationships at muskellunge nursery locations. Diet information for YOY muskellunge was obtained from selected juveniles >80 mm TL by gastric lavage (Farrell 1998, Kapuscinski et al. 2012).

A fin tissue sample was retained in 95% non-denatured ETOH for genetic analysis of all muskellunge sampled (both YOY and adults). Recent research using these samples contributed to the current understanding of population and genetic structure of muskellunge in the St. Lawrence River (Kapuscinski et al 2013). Genetic samples also contribute to an examination of population structure in the upper and lower St. Lawrence including several lakes and tributaries to evaluate for effects of the past stocking legacy in Quebec and the potential for introgression of those genes into the river's muskellunge genome (Rougemont et al. 2019). We plan to use genetic tools to compare YOY to adults used in broodstock collection to verify stocked vs. wild origin of seine-captured juveniles as part of the population recovery study. Standardized seining also occurs in an additional set of sites (exploratory) to ensure the seining index is representative of the system as a whole and supply more biological data at a diversity of sites. Additional seine hauls occurred at sites (including index sites) that were successful for capture of YOY muskellunge to monitor growth at those locations.

<u>Angler diary program</u>

We continue to maintain an angler diary program (since 1997) with participants ranging in angling frequency from casual to dedicated muskellunge anglers, including several professional guides. Cooperators are selected based on the quality of information volunteered in previous diary projects and responses to requests for program assistance. New program participants are encouraged to participate. Anglers are asked to record data on daily effort (rod hours, where trolling vessels typically use two rods independent of the number of participants onboard), catch and harvest rates, total lengths, and approximate location of muskellunge capture. In 2021, anglers had the option to report angling trips including the number of rods, and catch information via electronic submission in cooperation with NY Chapter 69 Muskies Inc., https://nymusky.com/dec-tibs-muskellunge-angler-diary-program/

<u>Muskellunge catch and release program</u>

A partnership with a local environmental advocacy group, Save The River sponsors the Muskellunge Catch and Release Program. This program aims to educate and involve the angling community in the conservation of the local adult muskellunge population by rewarding anglers who release a legal-size (54 inch) muskellunge with a limited edition, signed muskellunge print by St. Lawrence River artist Michael Ringer. Data are collected on each participant's total muskellunge catch and effort expended in hours, as well as information for the specific released fish submitted for the reward. Those details include location caught, water depth, weather conditions, date, time of day, weight of line used, bait or lure type, and total length of the muskellunge.

Results and Discussion

<u>Spring trapnetting survey</u>

A total of 8 muskellunge were captured (catch rate = 0.014 fish/net night) in upper St. Lawrence River index sites in 2021 (Table 1 and 2; Figure 1). All eight muskellunge captured were spawning adults; five of these fish were males, while the other three were females. At the two supplementary locations, zero adult muskellunge were captured in 45 net-nights. The mean number of muskellunge caught in the spring trapnetting survey before the VHSV outbreak (2005) was 0.063 muskellunge per net-night (SD = 0.032), but a mean of 0.017 (SD = 0.012) muskellunge per net-night have been captured in subsequent years, representing a near fourfold decrease. The catch rate in 2021 was greater than in 2020 (0.004 fish/net night) but comparable to rates in 2019 (0.014 fish/net night) (Figure 1). In Lake St. Lawrence, a total of 128 net-nights of effort resulted in the capture of seven adult muskellunge (Table 3 and 4).

<u>Summer seining surveys</u>

The annual standardized YOY muskellunge seining index resulted in a much higher catch per unit effort (CPUE) relative to 2020. Eleven bays were sampled during July with a 30' fine-mesh seine. Sixty YOY muskellunge were captured in 90 hauls in the July index survey (CPUE = 0.67 fish/haul; Figure 2; Table 5). In August, a 60’ large-mesh seine was deployed in the same 11 bays, resulting in the capture of 15 YOY muskellunge in 90 seine hauls (CPUE = 0.17 fish/haul; Figure 2; Table 5). In addition to annual index seining, exploratory seining using a 30’ seine was conducted from July 19th to August 16th in known nursery sites from eastern Lake Ontario to the Robert Moses-Saunders power dam. This survey resulted in a catch of 61 muskellunge (CPUE = 0.34 fish/haul) across 35 exploratory sites (Table 6). Furthermore, exploratory seining was conducted with a 60’ seine from August 27th to October 20th to track the growth and survival of YOY muskellunge. This survey resulted in a catch of 40 muskellunge (CPUE = 0.27 fish/haul) across 15 exploratory sites (Table 6). The greatest CPUE for age-0 muskellunge at 30’ exploratory sites was 1.83 fish/haul at Fox Island followed by Whitehouse Bay (1.50 fish/haul) and Buck Bay (1.33 fish/haul). During 60’ exploratory, CPUE was greatest at A3 (1.00 fish/haul) followed by Thurso Bay (0.82 fish/haul) and Fox Island (0.33 fish/haul). Greater catches in 2021 seining surveys are due to fry stocking conducted by TIBS in late June, although a number of wild fry were collected at sites as well. Despite increased catches, production in these nursery sites remains much lower than it was historically. It appears that the stocking of advanced fry increased abundances within nursery areas in 2021. Continued muskellunge releases under the Muskellunge Recovery Program are recommended to attempt to rebuild populations.

<u>Angler diary program</u>
During fall 2021, participation in the angler diary program resulted in a total of 486.75 hours logged in the Thousand Islands region, resulting in a catch of 34 muskellunge (0.070 fish/hour; Figure 3). The catch per unit effort was a notable increase from previous years, despite fewer angler hours than in 2019 and 2020. This trend in musky catches is encouraging and will hopefully continue. Additionally, anglers in the diary program were successful fishing the Massena/Hawkins Point area of the St. Lawrence, with 161.25 hours of angling producing eleven muskellunge and a catch per unit effort of 0.068 fish/hr. Catch rates remain below the management goal of 0.1 fish per hour.

<u>Muskellunge catch and release program</u>
Save The River reported eight muskellunge catch and release awards for 2021; fish ranged from 42 to 56.5 inches in length and were caught from eastern Lake Ontario to Lake St. Francis. Of the eight muskellunge, six were caught in the TI region.

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Table 1. Locations, effort (net nights), muskellunge catch, and CPUE for index and roving bays in the upper St. Lawrence River 2021 trapnetting survey.

Site	Type	Effort	# Muskellunge	CPUE
Blind Bay	Index	58	0	0.000
Cobb Shoal	Index	62	0	0.000
Densmore Bay	Index	61	0	0.000
Flynn Bay	Index	77	5	0.065
Frinks Bay	Index	29	0	0.000
Garlock Bay	Index	62	0	0.000
Lindley Bay	Index	30	0	0.000
Millens Bay	Index	56	2	0.036
Peos Bay	Index	29	0	0.000
Rose Bay	Index	58	0	0.000
Swan Bay	Index	60	1	0.017
Grass Point	Roving	31	0	0.000
South Bay	Roving	14	0	0.000
Sub-total	Index	582	8	0.014
Sub-total	Roving	45	0	0.000
Total		**627**	**8**	**0.013**

Table 2. Catch location, total length (mm), girth (mm), sex, reproductive stage, PIT tag number and recapture history of spawning adult muskellunge caught and released from trapnets in upper St. Lawrence River bays during 2021.

Date	Location	Sex	Stage	TL (mm)	Girth (mm)	Recap	Tag #
5/17/21	Flynn Bay	M	Ripe	1207	490	N	900119001345167
5/17/21	Flynn Bay	M	Ripe	850	360	N	900118001351675
5/17/21	Flynn Bay	M	Ripe	1075	427	N	900118001345260
5/17/21	Flynn Bay	F	Ripe	1296	600	Y	900118001105015
5/19/21	Swan Bay	F	Ripe	1134	490	N	900118001344570
5/24/21	Flynn Bay	M	Spent	1252	518	N	900118001352464
6/7/21	Millens Bay	M	Ripe	1198	516	N	900118001345830
6/7/21	Millens Bay	F	Ripe	1334	602	N	900118001345107

Table 3. Locations, effort (net nights), muskellunge catch, and CPUE for roving bays in the Lake St. Lawrence 2021 trapnetting survey.

Location	Type	Effort	# MKY	CPUE
Barnhart Island	Roving	9	0	0.00
Hawkins Point	Roving	18	3	0.17
Leishman Point	Roving	21	4	0.19
Ogden Island	Roving	10	0	0.00
Robinson Bay	Roving	9	0	0.00
Waddington Beach	Roving	11	0	0.00
Whitehouse Bay	Roving	20	0	0.00
Windsong Bay	Roving	30	0	0.00
TOTAL		**128**	**7**	**0.055**

Table 4. Catch location, total length (mm), girth (mm), sex, reproductive stage, PIT tag number and recapture history of spawning adult muskellunge caught and released from trapnets in lower St. Lawrence River bays during 2021.

Date	Location	Sex	Stage	TL (mm)	Girth (mm)	Recap	Tag #
5/20/21	Hawkins Point	F	Ripe	1300	569	N	900118001104157
5/20/21	Leishman Point	F	N/A	1340	465	N	989001003974883
5/21/21	Leishman Point	M	Ripe	1230	500	N	900118001348250
5/21/21	Leishman Point	M	Ripe	1013	394	N	900118001344263
5/21/21	Leishman Point	F	Ripe	1202	510	N	900118001346865
5/22/21	Hawkins Point	M	Ripe	1162	460	N	900118001104549
5/24/21	Hawkins Point	N/A	N/A	1070	387	N	989001004340473

Table 5. Summary of 2021 index seining catch data using a fine-mesh 30' bag seine (top) and a large-mesh 60' bag seine (bottom). Data for muskellunge and northern pike captures are included.

Location	Hauls	# Age-0 MKY	# Age-0 NP	Age-0 MKY CPUE	Age-0 NP CPUE
Affluence Bay	6	2	0	0.33	0.00
Boscobel Bay	6	0	0	0.00	0.00
Cobb Shoal	12	3	0	0.25	0.00
Deer Island	6	0	0	0.00	0.00
Frinks Bay	10	13	0	1.30	0.00
Garlock Bay	10	26	0	2.60	0.00
Lindley Bay	6	0	0	0.00	0.00
Millens Bay	12	0	2	0.00	0.17
Peos Bay	6	13	0	2.17	0.00
Rose Bay	10	1	0	0.10	0.00
Salisbury Bay	6	2	0	0.33	0.00
Total	**90**	**60**	**2**	**0.67**	**0.02**
Location	**Hauls**	**# Age-0 MKY**	**# Age-0 NP**	**Age-0 MKY CPUE**	**Age-0 NP CPUE**

Table 5. Continued

Affluence Bay	6	2	0	0.33	0.00
Boscobel Bay	6	0	0	0.00	0.00
Cobb Shoal	12	1	0	0.08	0.00
Deer Island	6	0	0	0.00	0.00
Frinks Bay	10	2	0	0.20	0.00
Garlock Bay	10	8	0	0.80	0.00
Lindley Bay	6	0	0	0.00	0.00
Millens Bay	12	0	2	0.00	0.17
Peos Bay	6	0	0	0.00	0.00
Rose Bay	10	0	0	0.00	0.00
Salisbury Bay	6	0	0	0.00	0.00
Total	**90**	**15**	**2**	**0.17**	**0.02**

Table 6. Summary of 2021 exploratory seining catch data using a fine-mesh 30’ bag seine (top) and a large-mesh 60’ bag seine (bottom). Data for muskellunge and northern pike captures are included.

Location	Hauls	# Age-0 MKY	# Age-0 NP	Age-0 MKY CPUE	Age-0 NP CPUE
A1	2	0	0	0.00	0.00
A3	2	2	0	1.00	0.00
A4	2	0	0	0.00	0.00
Aunt Jane's Bay	4	5	0	1.25	0.00
Birch Island	1	0	0	0.00	0.00
Blind Bay	11	3	1	0.27	0.09
Brush Island	3	0	0	0.00	0.00
Buck Bay	6	8	1	1.33	0.17
Delaney Bay	8	0	1	0.00	0.13
Densmore Bay	10	2	3	0.20	0.30
Eel Bay	8	0	0	0.00	0.00
Flynn Bay	26	6	3	0.23	0.12
Fox Creek	3	2	0	0.66	0.00
Fox Island	6	11	0	1.83	0.00
Grass Bay	3	0	0	0.00	0.00
Grass Point	11	3	7	0.27	0.64
Jolly Island	4	3	0	0.75	0.00
Kring Point	2	0	0	0.00	0.00
Leishman Point	2	0	0	0.00	0.00
Long Point	6	0	10	0.00	1.67
Mead Island	3	0	0	0.00	0.00
Mud Bay	3	1	0	0.33	0.00
Number 9 Island	3	0	0	0.00	0.00
Oak Point	7	2	0	0.29	0.00
Point Marguerite Marsh	3	0	0	0.00	0.00
Point Vivian	6	3	0	0.50	0.00
Red Barn Bay	2	0	0	0.00	0.00
Roods Cove	2	0	0	0.00	0.00
Sheepshead Point	5	0	0	0.00	0.00
Swan Bay	6	0	0	0.00	0.00
Thurso Bay	5	6	0	1.20	0.00

Table 6. Continued

Waddington Beach	2	1	1	0.50	0.50
Whitehouse Bay	2	3	0	1.50	0.00
Whitehouse Bay (LSL)	6	0	1	0.00	0.17
Windsong Bay	2	0	2	0.00	1.00
Total	**177**	**61**	**30**	**0.34**	**0.17**
Location	**Hauls**	**# Age-0 MKY**	**# Age-0 NP**	**Age-0 MKY CPUE**	**Age-0 NP CPUE**
A3	6	6	0	1.00	0.00
Aunt Jane's Bay	6	1	0	0.17	0.00
Blind Bay	9	0	0	0.00	0.00
Buck Bay	6	1	1	0.17	0.17
Densmore Bay	8	0	1	0.00	0.13
Eel Bay	3	0	0	0.00	0.00
Flynn Bay	29	3	0	0.10	0.00
Fox Creek	2	0	0	0.00	0.00
Fox Island	6	2	0	0.33	0.00
Grass Point	38	11	9	0.29	0.24
Jolly Island	4	0	0	0.00	0.00
Mud Bay	2	0	1	0.00	0.50
Oak Point	6	1	0	0.17	0.00
Point Vivian	6	1	0	0.17	0.00
Thurso Bay	17	14	0	0.82	0.00
Total	**148**	**40**	**12**	**0.27**	**0.08**

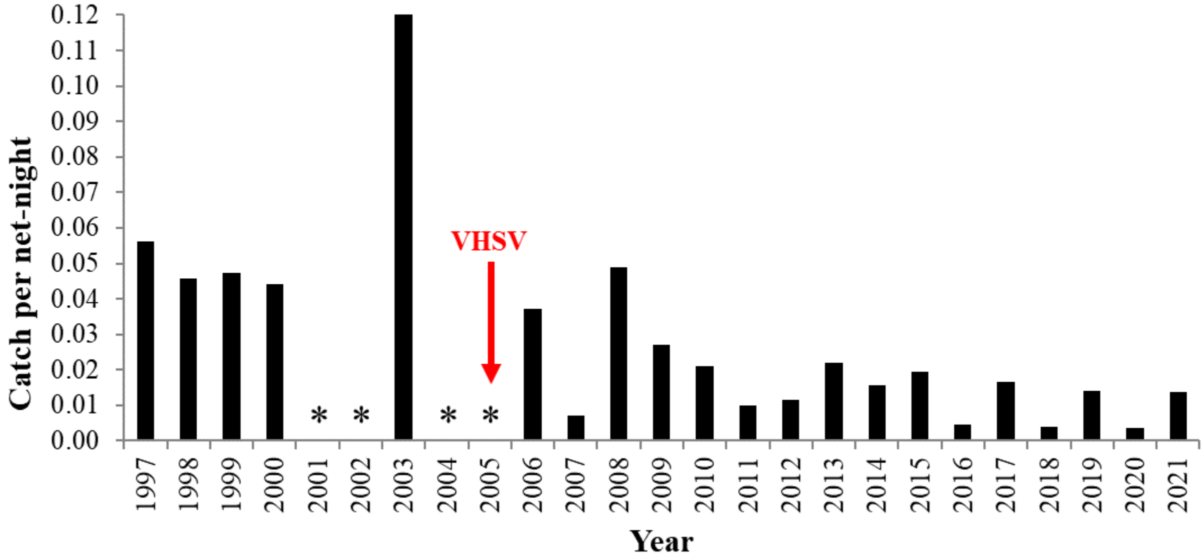

Figure 1. Total catch per net-night of muskellunge during spring trapnetting from 1997-2021 in the upper St. Lawrence River. Samples were not collected in 2001-02 and 2004-05 (indicated by "NS") due to a decision by the Esocid Working Group to monitor muskellunge every third year. Following the VHSV outbreak, sampling has been conducted annually.

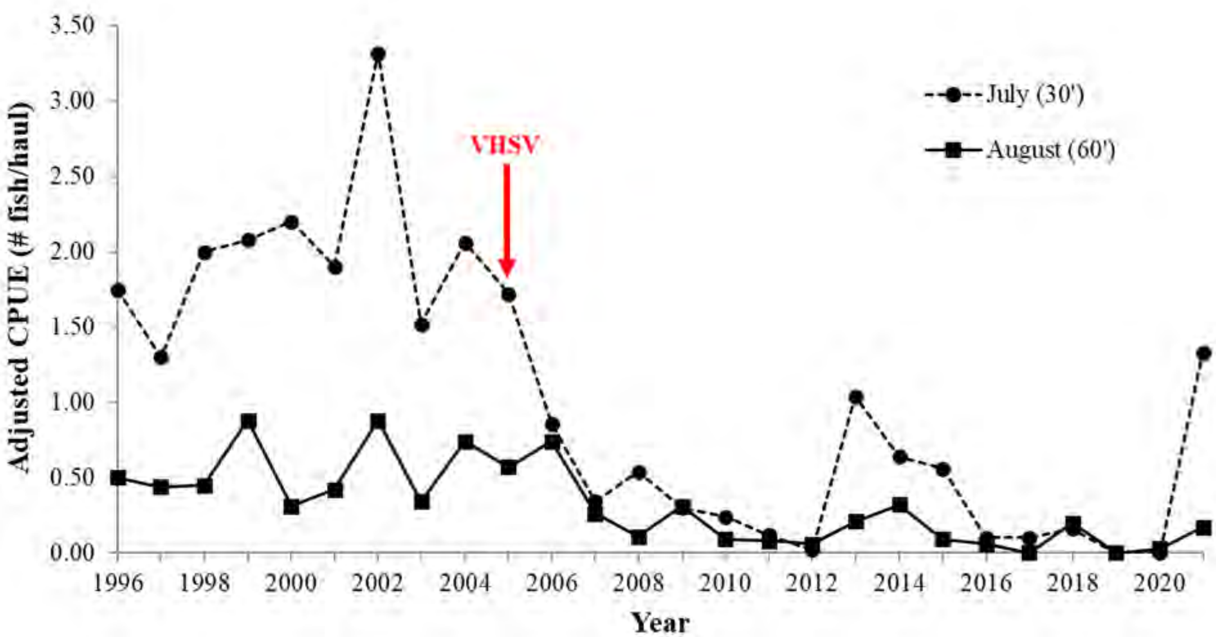

Figure 2. Catch per unit effort of YOY muskellunge captured in standardized seine hauls in eleven upper St. Lawrence River nursery sites from 1996 to 2021. A 9.14 m (30') fine-mesh seine was used during the month of July and an 18.3 m (60') large-mesh seine was used during the month of August. The fine-mesh seine CPUE was doubled to standardize the area sampled among the two gears. VHSV was detected in 2005 and widespread mortality of muskellunge continued through 2008 in the upper river.

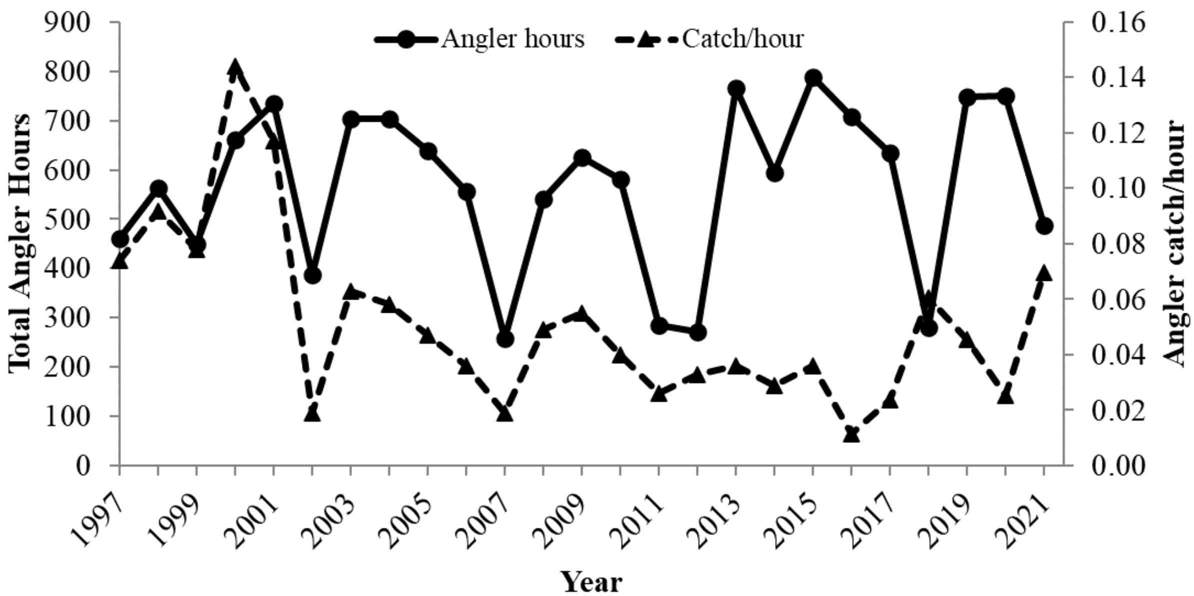

Figure 3. Thousand Islands Region Muskellunge Angler Diary Program data showing angler hours compared to average catch per angler hour. The management target goal is 0.1 fish per angler hour or 1 muskellunge per 10 hours fished. Note the relationship between catch and effort over time; however, high effort since 2012 has not produced large increases in catch of muskellunge.

Lake Ontario Commercial Fishery Summary, 2000 – 2020

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Commercial fishing activity in the New York waters of Lake Ontario is limited to the embayments and nearshore open waters of the eastern basin. Commercial fishing gear includes gill nets, trap nets, and fyke nets, however, only gill nets were actively fished in 2021. Commercial harvest generally targets yellow perch, however, harvest of white perch and cisco were also reported in 2021 (Tables 1 and 2). Of four licensed commercial fishermen, only two actively fished in 2021 (Table 2). Data from 1991-1999 are reported by LaPan (2005).

References

LaPan, S.R. 2005. Lake Ontario commercial fishing summary 1997-2004. Section 22 *in* NYSDEC 2004 Annual Report, Bureau of Fisheries Lake Ontario Unit and St. Lawrence River Unit to the Great Lakes Fishery Commissions Lake Ontario Committee.

Table 1. Approximate reported value ($US) of the 2021 commercial catch from the New York waters of Eastern Lake Ontario (*estimated, weighted mean value, as price fluctuates throughout the year).

SPECIES	TOTAL POUNDS	PRICE/POUND*	TOTAL VALUE
Yellow Perch	21,046	$2.95	$62,176.25
White Perch	268	$1.70	$465.35

Table 2. Reported* commercial fish catch in pounds from the New York waters of Eastern Lake Ontario, 2000-2021.

	# Lic.	YP	BBH	WP	RB	SF	CRP	WTF	CSCO
2000	7	59,928	5,709	383	280	3,571	308	-	-
2001	6	40,323	5,875	442	15	16	-	-	-
2002	6	37,223	4,435	-	-	-	-	-	-
2003	6	6,153	5,815	-	-	-	-	-	-
2004	3	37,066	1,200	-	-	-	-	-	-
2005	3	6,354	1,040	-	-	-	-	-	-
2006	3	4,274	500	-	-	-	-	-	-
2007	3	34,343	535	-	-	-	-	-	-
2008	3	14,428	735	-	-	-	-	-	-
2009	3	41,338	31	-	20	-	-	-	347**
2010	2	44,008	75	546	-	-	-	16	465
2011	3	77,238	105	3,736	-	-	-	-	613
2012	3	59,989	105	1,130	-	-	-	18	44
2013	3	20,589	-	1,820	-	-	-	-	12
2014	2	44,143	63	815	22	-	-	-	20
2015	2	46,473	-	859	-	-	-	11	52
2016	2	67,405	-	494	-	-	-	210	1,806
2017	2	67,435	-	-	-	-	-	-	509
2018	2	38,987	30	150	-	-	-	-	201
2019	2	54,553	-	490	-	-	-	-	5
2020	2	58,188	120	508	-	-	-	100	205
2021	2	21,046	-	268	-	-	-	-	245

YP = Yellow Perch
BBH = Brown Bullhead
WP = White Perch
RB = Rock Bass
SF = sunfish (Pumpkinseed, Bluegill)
CRP = Black Crappie
WTF = Whitefish
CSCO= Cisco

*does not include documented illegal and/or unreported harvest
**known harvest in previous years was not reported
Lic. = number of active fishers