Lake Ontario April prey fish survey results and Alewife assessment, 2023

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A report from the Lake Ontario Prey Fish Working Group to the Great Lakes Fishery Commission's Lake Ontario Committee

ABSTRACT

The April bottom trawl survey and Alewife *Alosa pseudoharengus* population assessment provides science to inform Lake Ontario fisheries management. The 2023 survey included 215 trawls in the main lake and embayments and sampled depths from 6.5 to 252 m (21 – 827 ft). The survey captured 1,012,178 fish from 32 species with a total weight of 12,136 kg (26,700 lbs.). Alewife were 92% of the catch by number while Rainbow Smelt *Osmerus mordax*, Deepwater Sculpin *Myoxocephalus thompsonii*, and Round Goby *Neogobius melanostomus*, comprised 3%, 3%, and 1% of the catch respectively. To improve the accuracy of prey fish biomass and density estimates we reanalyzed trawl sensor data from each of three participating survey vessels and created vessel-specific relationships predicting how bottom trawl bottom contact time, wing width, and area-swept varies with depth.

Total Alewife biomass increased in 2023 due to growth and survival of the abundant 2020 year class (now age-3) and an abundant 2022 year class (age-1). The 2023 mean Alewife biomass (81.1 kg·ha^{-1}) was the largest since whole lake sampling began in 2016 and was the ninth largest value observed in the modern time series (1997-2023, maximum value in 2000 = 91.8 kg·ha^{-1}). The 2023 Alewife density (6795 n·ha^{-1}) was the greatest density observed in the modern time series. These high biomass and density values are due to above average Alewife reproductive success in 2020 and 2022. Simulation modeling suggests the 2024 and 2025 Alewife biomass index may be substantially higher than the 2023 observations.

In 2023, the Rainbow Smelt biomass index increased relative to the 2022 index, as did the biomass index for Cisco, *Coregonus artedi*. In contrast, Emerald Shiner *Notropis atherinoides* and Threespine Stickleback *Gasterosteus aculeatus*, biomass values continue to be low (< 0.01 kg·ha^{-1}). Three Bloater *Coregonus hoyi*, were captured during the 2023 survey. Hydroacoustic sampling conducted during the bottom trawl survey estimated prey fish densities in pelagic habitats not sampled by the bottom trawl (3 m below the surface to 3 m above the lake bottom) and these densities were hundreds to thousands of times lower than bottom trawl-based densities. These results support the idea that, in April, when the warmest water is on the lake bottom, Alewife and most other pelagic prey fish are near the lake bottom and can be effectively sampled with bottom trawling.

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INTRODUCTION

Why study Lake Ontario prey fish?

Lake Ontario fisheries are important to Canadian and U.S. economies, with an estimated annual economic value of US$440 million in New York in 2017[1]. The salmon and trout fisheries are managed by altering salmonid stocking levels to stay in balance with lake productivity and prey fish availability. This management approach requires reliable information about prey fish populations like Alewife *Alosa pseudoharengus.* Alewife are native to the Atlantic Coast and likely gained access to Lake Ontario in the 1860's through canals[2]. Since annual prey fish surveys began in 1978, Alewife have been the most abundant fish in Lake Ontario and have supported most of the lake's predators[3–6]. Over time, food web productivity and prey fish abundance have declined and are likely driven by declines in mineral nutrient concentration (i.e., phosphorus)[7–9]. Concerns related to having sufficient prey fish abundance to support the lake's salmonids have resulted in the management agencies taking an adaptive approach and adjusting stocking numbers based on prey fish biomass, and other indicators. Multiple stocking adjustments (reductions and increases) have been made, first in the mid-1990s and again form 2016 - present[10,11]. In addition to Alewife population information, surveys also illustrate the status and spatial distribution of other prey fishes and native species of restoration or conservation interest[12,13].

This report presents the results from the multi-agency 2023 Lake Ontario April prey fish survey and Alewife assessment. Results are tailored to inform the Fish Community Objectives: 2.3 "Increase prey fish diversity—maintain and restore a diverse prey-fish community including Alewife, Cisco, Rainbow Smelt, Emerald Shiner, and Threespine Stickleback" and 2.4 "Maintain predator/prey balance—maintain abundance of top predators (stocked and wild) in balance with available prey fish" [14]. This research is also guided by the U.S. Geological Survey (USGS) Ecosystems Mission Area, Species Management Research Program to "provide science that is used by managers, policy makers, and others for decisions that protect, conserve, and enhance healthy fish and wildlife populations".

Why are bottom trawl surveys used to study Alewife and other prey fish?

Bottom trawl surveys conducted in April have been the most consistent method for quantifying the relative abundance of Lake Ontario Alewife and other pelagic prey fishes. For most of the year, Alewife inhabit pelagic or open water habitat[15], but in winter and early spring Alewife are near the lake bottom where the water is warmest[16,17]. This deep migration is because freezing winter surface water temperatures are well below Alewife's preferred temperature range (11 - 25°C, 52 - 77°F) and the warmest water (~ 4°C, 39°F) is on the lake bottom [16,18–20]. In a given year, similar bottom trawl surveys conducted in June, July and October capture fewer Alewife compared to the April survey because the fish are not near the lake bottom at those times of year[15]. Summer hydroacoustic surveys have also indexed Alewife abundance[2], but those estimates are also much lower than April bottom trawl estimates. When Alewife inhabit near surface waters in summer and early fall they are difficult to detect with acoustics and appear to avoid acoustic survey vessels, which results in lower biomass estimates[15,21].

Why is it important to estimate the area swept by each vessel's bottom trawls?

Since 2019, pelagic prey fish abundance indices have been reported relative to area (e.g., kilograms per hectare). For reference, a hectare is 10,000 m^2 or ~2.5 acres. Reporting in these standard ecological units facilitates comparisons among populations from different lakes and informs analyses that study multiple trophic levels. Trawl sensors measure the width between the trawl wings and how long the trawl is in contact with the lake bottom. The wing width, bottom contact time, and vessel speed are then multiplied to calculate area swept. Even though the intended time period of a trawl remains constant over depths, sensor data illustrate the wing widths and bottom contact times vary with depth. In general, the deeper the trawl, the more 'extra' time the trawl is in contact with the bottom and assumed to be fishing. Previous analyses incorporated area swept estimates that varied with depth, but assumed those relationships were the same among the different vessels used in the survey. This year specific relationships were developed for the USGS, New York State Department of Environmental Conservation (NYSDEC) and Ontario Ministry of Natural Resources and Forestry (OMNRF) vessels to more accurately estimate area swept. Accounting for the differences in bottom contact time between vessels depth provides a more accurate index of prey fish biomass and density.

METHODS

How is the bottom trawl survey conducted?

The April bottom trawl survey began in 1978 and was collaboratively conducted by the USGS and NYSDEC in U.S. waters of Lake Ontario. Daytime bottom trawling has been conducted at fixed sites because substrate variability at random sites prohibitively damages trawls[22]. The initial survey design included approximately 100 trawls at depths from 8 – 150 m (26 – 495 ft.) and used an 11.8 m (39 ft.) headrope nylon trawl. That trawl was replaced in 1997 with an 18.3-m (60 ft.) headrope polypropylene ‘3N1’ trawl due to large catches of dreissenid m6ussels. In 2016, the survey was expanded to include Canadian waters, a wider depth range, embayment sites, and support from the Province of Ontario’s research vessel (Fig. 1)[23]. Intended trawl times varied from 3 – 10 minutes, bottom contact times varied from 2 – 14 minutes, and trawl speed was 4.3 - 5.5 kph (2.7 – 3.4 mph). If trawl sensor observations were not available for a given sample then wing width and bottom contact time were estimated with established relationships based on sampling depth (Fig. 2)[24]. In 2002, an external expert review found the survey was ‘sufficiently robust to detect year to year variations in forage fish abundance”[22]. This report includes data from 1997 to present (2023) and have been collected with a single trawl type.

How are annual biomass and density estimates calculated?

Bottom trawl catches are expressed as the mean biomass (kilograms per hectare, $kg \cdot ha^{-1}$) or density (numbers per hectare, $N \cdot ha^{-1}$) and are calculated as annual, lake area-weighted, stratified means. Stratification is based on depth, where each strata is a 20-m (66-ft) depth interval (i.e., 0 – 20 m, 21 – 40 m). Weighting is based on the proportional area of those depth strata within U.S. and Canadian portions of the lake. Annual indices are calculated separately for U.S. and Canadian waters, and whole-lake indices are the weighted sum of these indices (52% lake area in Canada, 48% in U.S.). Biomass and density values are considered indices because we lack estimates of trawl catchability (proportion of the true biomass or density captured by the trawl)[25].

How are Alewife population age structure and year class abundance determined?

We annually interpret Alewife ages from sagittae otoliths (ear stones) to estimate the abundance of each Alewife year class (all the fish born in a particular year). Ages are interpreted for 500 to 1300 Alewife from multiple interpreters using compound microscopes, and reflected light[26]. Year class abundances were estimated using an age-length key developed from annual age interpretations and length frequency distributions[27]. Tracking the abundance of each year class through time allows us to estimate survival and growth and then predict how the Alewife population may change in the future.

How are future Alewife biomass values predicted?

We use a Monte Carlo simulation approach to predict how Alewife biomass is likely to change two years into the future[28]. Simulations begin with the most recent year’s density and biomass for each age. For a given age, survival and growth into the next year were randomly selected from previously observed distributions for those parameters, and the next year’s biomass was summed. The number and size of age-1 Alewife was randomly sampled from the previous years of age-1 observations. For each year we conducted 1,000 simulations as described above to predict a range of possible biomass levels. We plot predictions from previous years relative to the observed biomass and also the predicted biomass index in 2024 and 2025.

<u>How were hydroacoustic data collected and analyzed?</u>

Hydroacoustic data were collected using 120 kHz-split beam echosounder (BioSonics) following established standardized sampling procedures[21,29]. Acoustic data were collected during the day immediately preceding or following a bottom trawl sample, at depths from 5 to 237 m. Pelagic fish density was estimated for depths from 3 m from the surface to 3 m above the lake bottom. This range is not sampled by bottom trawls and hydroacoustic sampling can be effective in this range[21,29]. Fish density estimates were computed with hydroacoustic data processing software (Echoview version11.1), assuming a mean target strength of -43 decibels (dB). The hydroacoustic data alone do not provide species specific estimates but do provide a size distribution. The fish targets observed are consistent with prey sized fish are included in the analysis providing an aggregate estimate.

RESULTS AND DISCUSSION

Survey timing, extent, and catch

The 2023 April bottom trawl survey conducted 215 trawls in main lake and embayment sites (Fig.1), at depths from 6.5 to 252 m (21 – 827 ft). The survey captured 1,012,178 fish from 32 species with a total weight of 12,136 kg (26,700 lbs.) and 288 kg (634 lbs.) of dreissenid mussels (Table 1)[30]. Numerically, Alewife were 92% of the catch while Rainbow Smelt *Osmerus mordax*, Deepwater Sculpin *Myoxocephalus thompsonii*, and Round Goby *Neogobius melanostomus*, comprised 3%, 3%, and 1% of the catch respectively (Table 1).

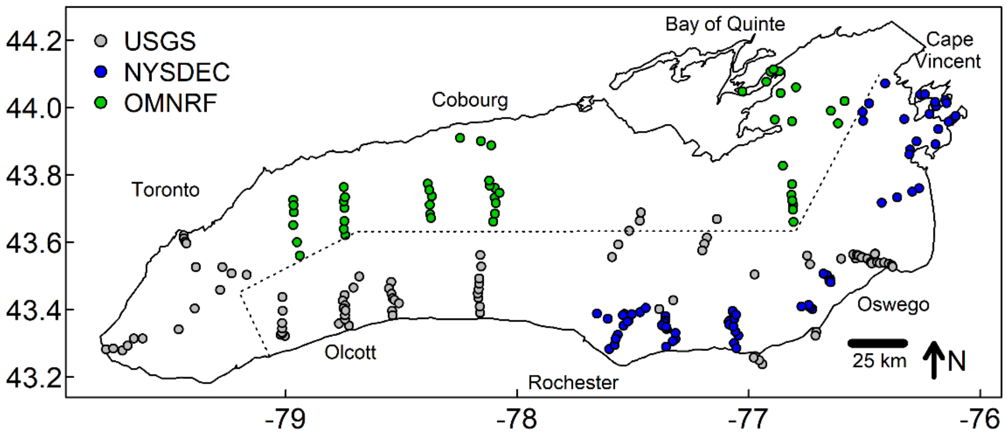

Figure 1. Lake Ontario bottom trawl sites from the 2023 multi-agency April prey fish survey[31]. The dotted line represents the U.S. – Canada border.

Variability in bottom trawl area swept

Previous year's calculations used consistent wing width and bottom contact depth models to calculate area swept for all three vessels (red lines, Fig. 2). New generalized additive models[31] that predicted wing width, bottom contact time, and area swept used fishing depth as a smoothed variable found these relationships varied substantially among the three vessels (Fig. 2). While all vessels used the same trawls, small differences in vessel speed, winch speed, and deployment procedures cause the observed variability. For example, given a 20 kg (44 lbs.) Alewife catch from a 150 m (495 ft.) site, the estimated biomass would range from 30 to 46 kg·ha^{-1} depending on the vessel. These more accurate, vessel-specific estimates of sampling effort were applied to the entire time series. This resulted in slight changes in biomass, density, and survival estimates relative to previous year's calculations[32]. We will continue to improve our understanding of bottom trawl dynamics and evaluate their influence on estimates of prey fish biomass and density.

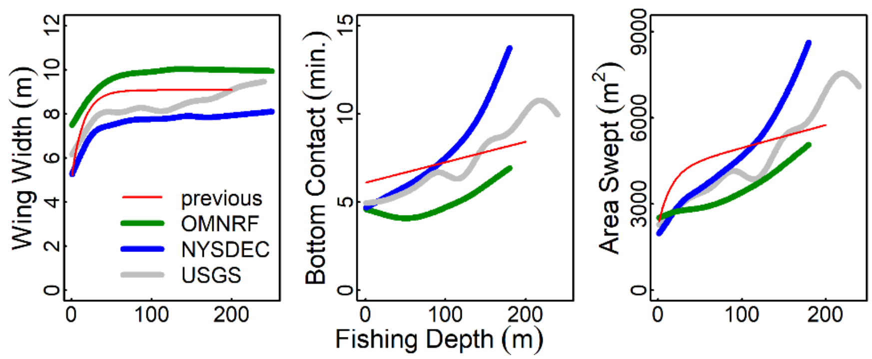

Figure 2. Bottom trawl dynamics for vessels that conduct Lake Ontario trawl surveys[31]. Lines represent the model predicted values for a five minute intended tow time. The greater variability in the gray line is likely because of computer controlled winches on that vessel which vary winch speeds more frequently than human controlled winches.

Alewife biomass, density, and condition indices

The 2023 Alewife biomass and density indices increased relative to 2022 and were among the highest values estimated in the modern time series, 1997 to 2023 (Fig. 3). While the adult biomass index was predicted to increase in 2023, the above average catches of age-1 Alewife (2022 year class) contributed to both the greater biomass and density increases observed in 2023 (Fig. 3). The biomass estimate for the 2022 year class (captured as age-1) was slightly below the high value observed for the 2020 year class (Fig. 4). We note that the adjustments to the vessel specific area swept estimates shifted some of the biomass and density values relative to previous year's figure. These shifts tended to increase these index values compared to estimates based on a single area swept relationship applied to all vessels. Alewife condition, measured as the predicted weight of a 165 mm fish (6.5 inches), declined in 2023 relative to 2022 which is expected given the observed increases in biomass and density (Fig. 5).

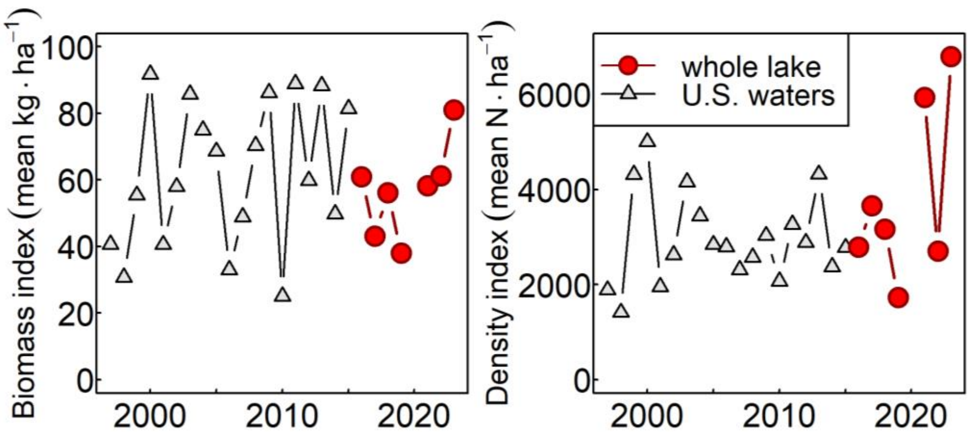

Figure 3. Total Alewife *Alosa pseudoharengus* biomass (left) and density (right) indices from the Lake Ontario April bottom trawl survey, 1997-2023[31]. No survey was conducted in 2020. Adjustments to the trawl area swept values caused a slight increase in these time series relative to previous reports.

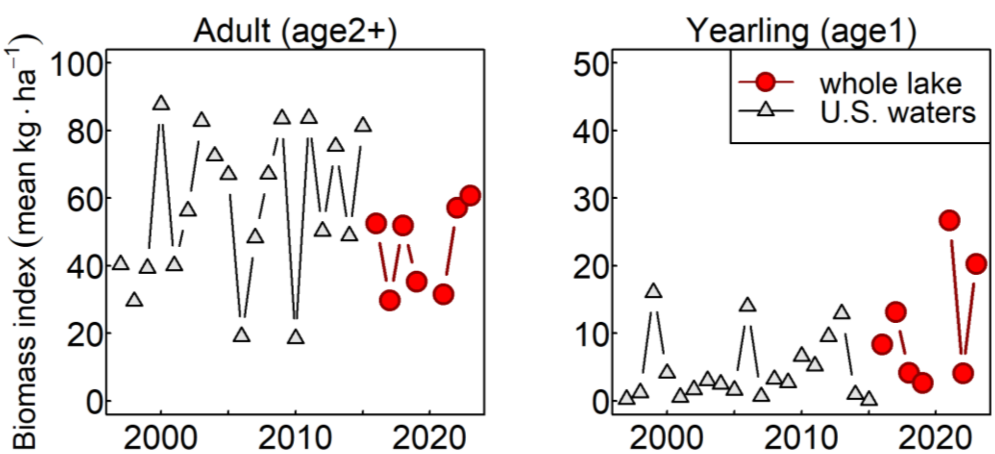

Figure 4. Alewife *Alosa pseudoharengus* biomass indices for adults age-2 and older (left) and yearlings or age-1 (right) from the April bottom trawl survey in Lake Ontario, 1997-2023[31]. No survey was conducted in 2020. Adjustments to the trawl area swept values caused a slight increase in these time series relative to previous reports.

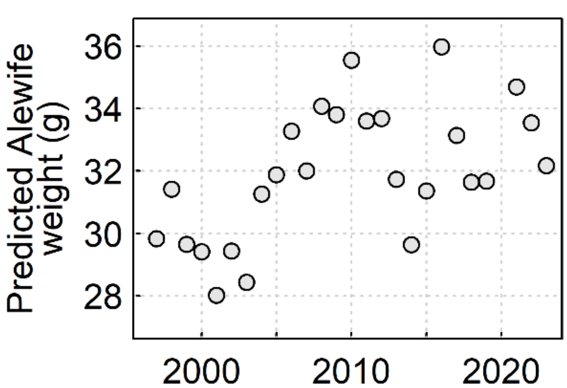

Figure 5. Predicted weight of a 165 mm Alewife (6.5 inches) in Lake Ontario from the April bottom trawl survey, 1997-2023[31]. No survey was conducted in 2020. Weight is predicted based on a linear natural log length – natural log weight relationship fit to observations collected from Alewife from 150 to 180 mm total length (5.9 – 7.1 inches).

Alewife spatial distribution

In 2023, mean Alewife biomass in Canadian and U.S. waters was similar (78.7, 83.6 kg·ha^{-1}, respectively; Fig. 6). Adult Alewife biomass in Canadian waters was higher than in U.S. waters (66.2, 54.8 kg·ha^{-1}, respectively) but conversely Age-1 biomass in Canadian waters was less than half the value estimated for U.S. waters (12.4, 28.8 kg·ha^{-1}, respectively). The spatial distribution of Alewife varied considerably between years which highlights the importance of a spatially extensive survey (Fig. 6). At this point it is not clear what factors influence the spatial distribution of Alewife in Lake Ontario during April.

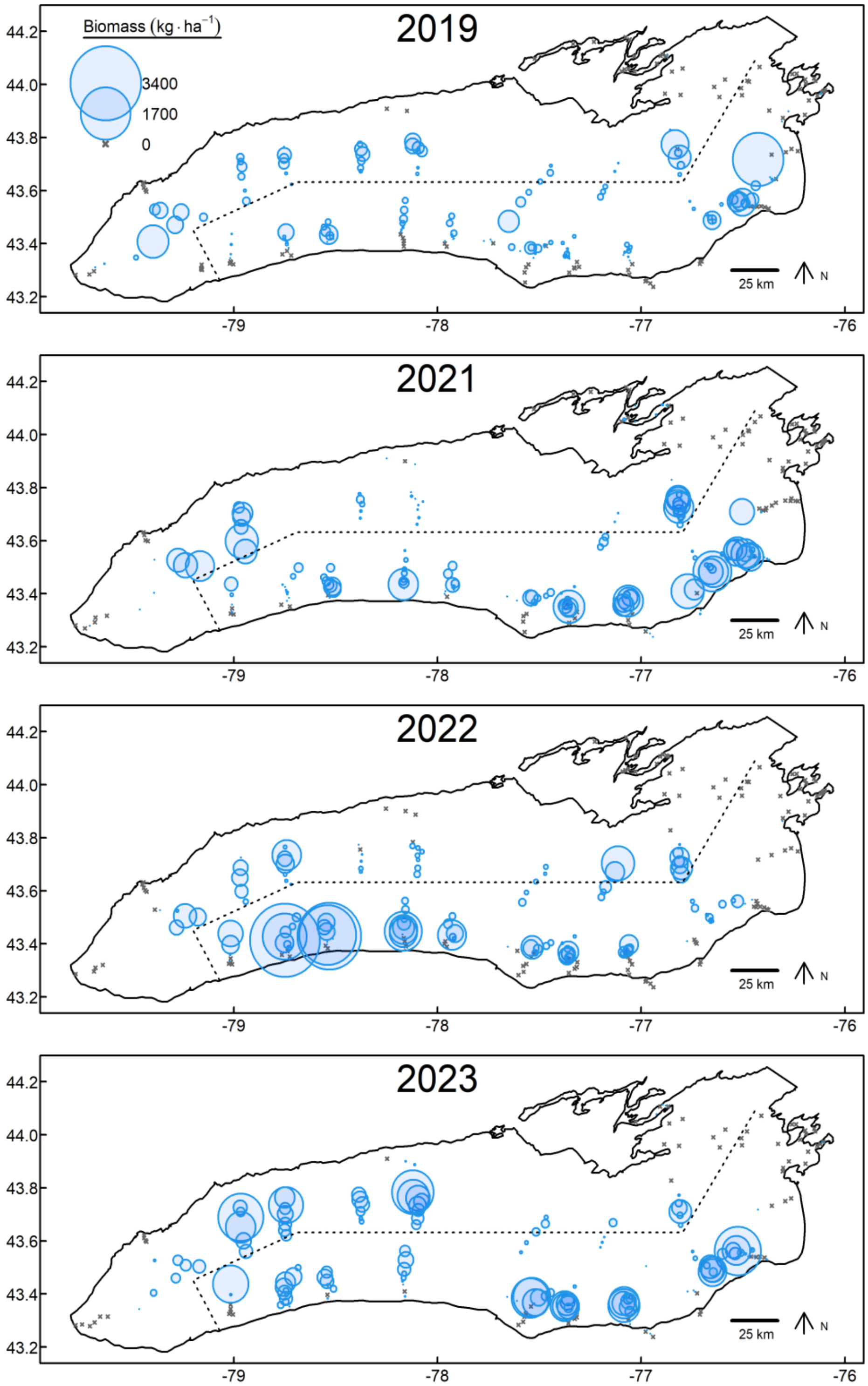

Figure 6. Biomass distribution of Alewife *Alosa pseudoharengus* (all ages) in Lake Ontario from the April bottom trawl survey, 2019 and 2021-2023[31]. The dotted line represents the U.S. – Canada border. No survey was conducted in 2020.

Alewife age structure, survival, growth

A total of 1,281 Alewife ages were interpreted from sagittae otoliths collected from fish that had a total length range from 57 to 224 mm (2.2 – 8.8 inches). The oldest interpretation was age-9 and was from the 2014 year class. The 2020, 2021, and 2022 year classes comprised 42, 13 and 25% of the Alewife biomass observed in 2023 (Fig. 7, bottom right panel).

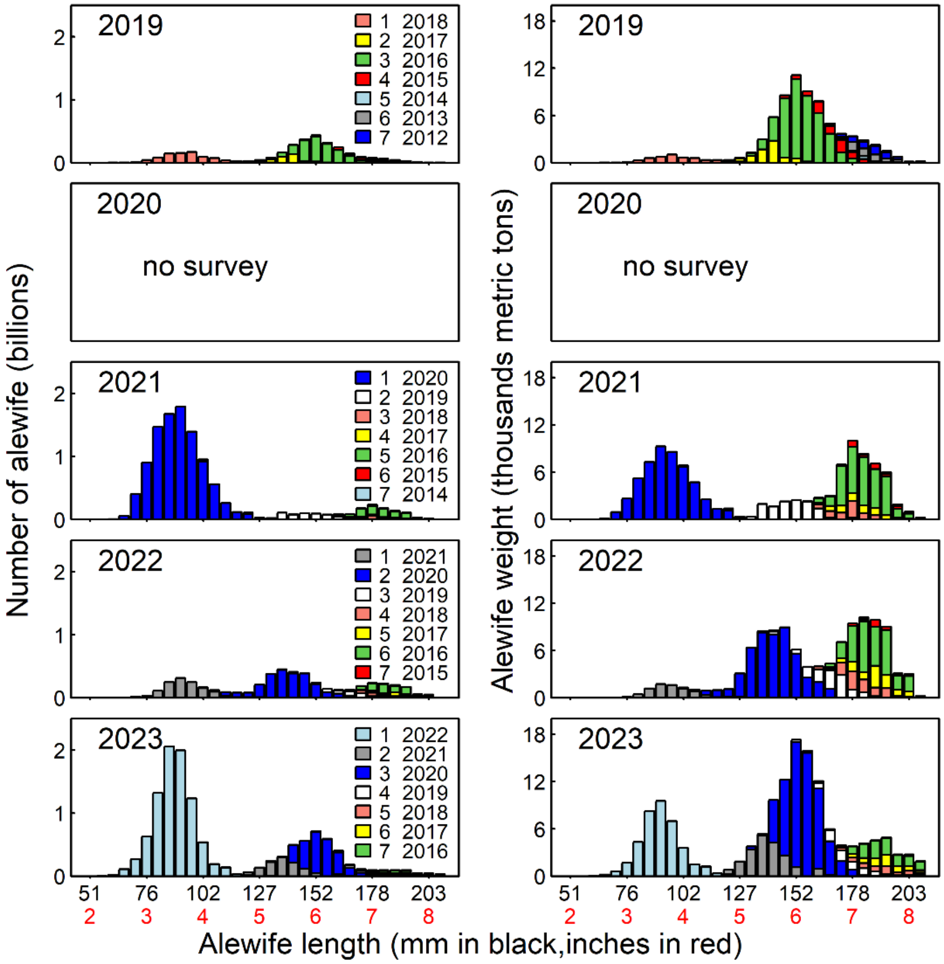

Figure 7. Alewife *Alosa pseudoharengus* size and age distribution in Lake Ontario from the April bottom trawl surveys, 2019 – 2023[31]. Bar height represents the number of Alewife (left panels) or weight (right panels) for each size bin (~1/5th inch or 5 mm). Bar colors represent distinct year class and are consistent across the panels. No survey was conducted in 2020.

Annual estimates of Alewife survival and growth are used to predict future biomass (Table 2). In 2023, Alewife survival estimates from age-4 and older fish were similar to previously observed values, but younger Alewife appeared to have experienced greater survival relative to previous observations (Fig. 8, top panel). Proportional survival values near or greater than one are not possible and likely reflect an underestimated abundance in a previous year's survey. For instance, in 2023, where survival from age 1-2 and age 2-3 were near or over one, the abundance estimates for age-1 and age-2 fish in 2022 were likely biased low. Age specific growth estimates (weight change) observed in 2023 were similar to previously observed values (Fig. 8, bottom panel).

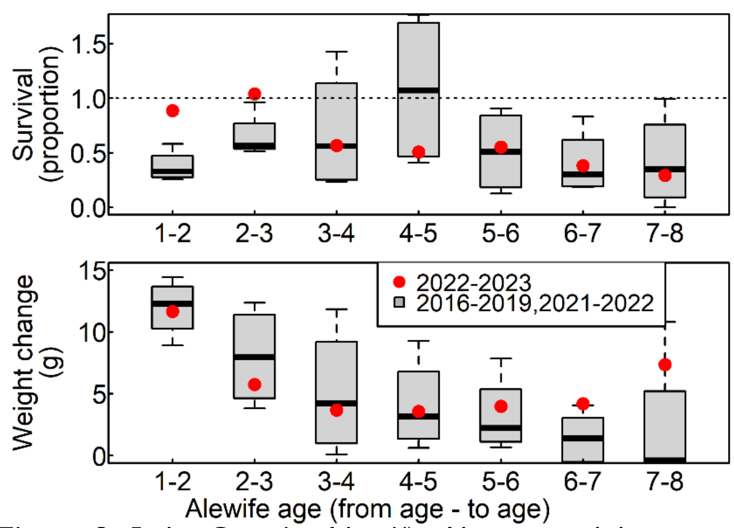

Figure 8. Lake Ontario Alewife *Alosa pseudoharengus* survival (top) and weight change (bottom)[31]. The gray boxes represent the 25th and 75th quartiles, black bars represent the median, and the whiskers represent the remaining range.

Alewife simulation results

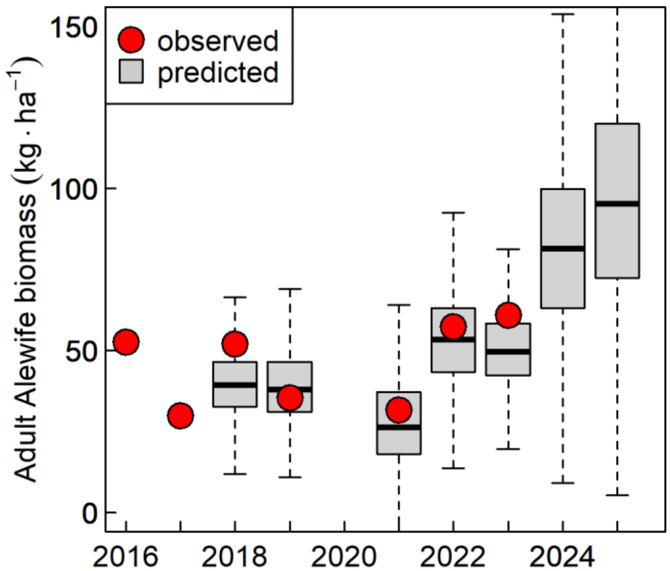

Figure 9. Simulated adult Alewife *Alosa pseudoharengus* (age-2+) biomass (boxplots) and observed values (red circle) in Lake Ontario, 2021 - 2025[31]. In the gray boxplots the thick black bars represent the median, the boxes represent the 25th and 75th quartiles, and the whiskers represent the remaining range. No survey was conducted in 2020 therefore 2021 predictions were based on two years of predictions from the 2019 observations.

Alewife simulation models predict future adult biomass based on previous year abundance, survival, and growth estimates. The future biomass estimates generally predict the direction of change in adult biomass relative to the observed biomass however the range of possible values is often large (Fig. 9). The large range of predicted values is due to the high variability in the estimates of survival and growth (Fig. 8, Table 2.). For instance, when the simulations randomly select both a high survival and growth value for an age class, the subsequent predicted biomass is much larger than most of the values in the simulation (Fig. 9). Similarly, when an abundant Alewife year classes (e.g., 2016, 2020, 2022) is first counted as in the adult population, extreme values of survival and growth result in more variable predictions. In Figure 9, the increase and wide range of predicted Alewife biomass in 2024 is due to the abundant 2022 year class being counted in the adult biomass that year. These modeling exercises help test our understanding of Alewife population dynamics and the validity of our survey design assumptions. As the number of survival and growth estimates increases with subsequent surveys we can better understand and adjust potentially biased estimates and improve the precision of predicted biomass estimates.

How many prey fish were above the bottom trawls?

Estimates of acoustic prey fish densities in waters above the trawl were hundreds to thousands of times lower than bottom trawls density estimates (Table 3, Fig. 10). Bottom trawl prey fish densities include Alewife and Rainbow Smelt catches. We do not know which species were sampled by acoustics, but their low target strength values indicated most were small fishes (Table 3). The low acoustic densities, relative to trawl densities indicate prey fishes in waters above the bottom trawl would have a minimal change on whole lake biomass or density estimates. Incorporating acoustic sampling, paired with bottom trawling, provides information of how prey fish habitat use varies and corroborates that most prey fishes are susceptible to the bottom trawl during the survey period.

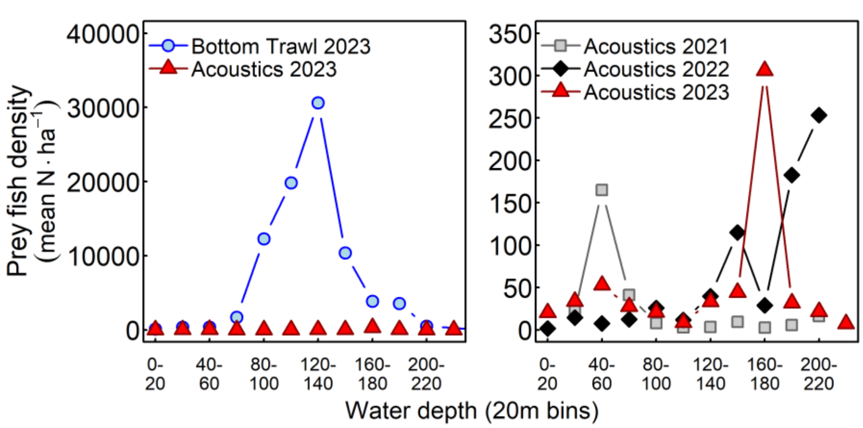

Figure 10. Mean prey fish density from bottom trawl and acoustics by 20-m depth bin in Lake Ontario, April 2023 (left panel)[31]. Trawl prey fish density represents the sum of Alewife *Alosa pseudoharengus* and Rainbow Smelt *Osmerus mordax*. Mean prey fish acoustic density from 2021-2023 (right panel). Note the vertical scales differ between the plots.

Pelagic fish biomass indices (non-Alewife)

The Rainbow Smelt biomass index increased relative to the 2022 index as did the biomass index for Cisco, *Coregonus artedi*. Emerald Shiner *Notropis atherinoides* and Threespine Stickleback *Gasterosteus aculeatus*, biomass estimates continue to be low (Fig. 11).

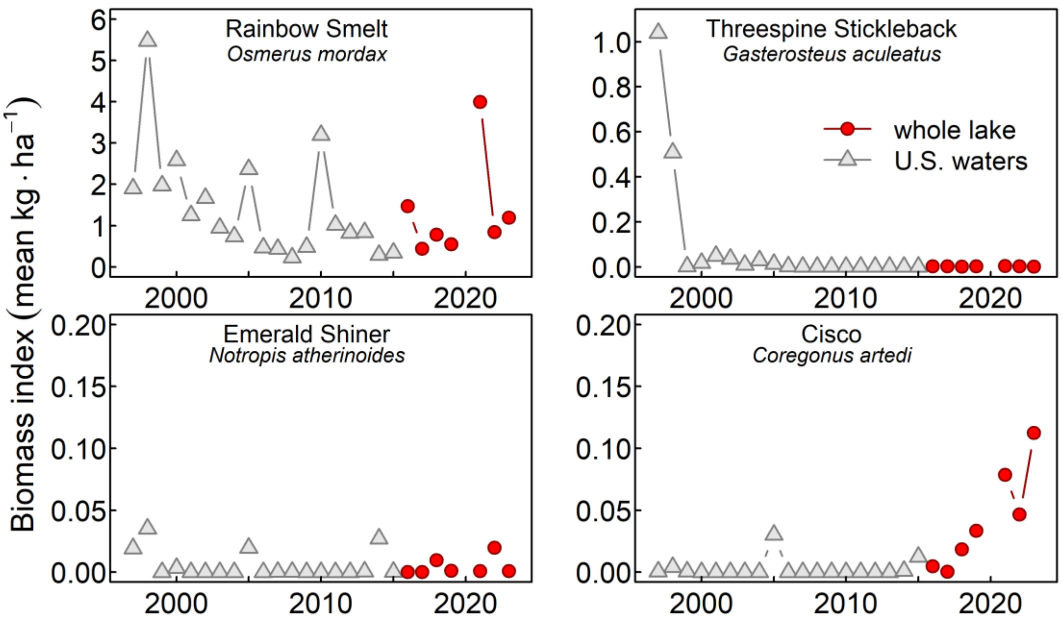

Figure 11. Biomass indices for Lake Ontario pelagic prey fishes from the April bottom trawl survey, 1997-2023[31]. No survey was conducted in 2020. Adjustments to the trawl area swept caused slight changes in these time series relative to previous reports. Note differing vertical scales on each of the panels.

Native species of interest - Bloater

Three Bloater *Coregonus hoyi* were captured during the 2023 April survey (Fig. 12, Fig.13). Bloater are a native pelagic prey fish that was extirpated from Lake Ontario and is currently being reintroduced[13]. This species closely resembles Cisco, therefore identification is confirmed using genetic analyses of fin tissue[33]. Nine of the fifteen Bloater recaptured since stocking began were caught in the April bottom trawl survey, highlighting this survey's value for tracking the restoration progress. Recaptured Bloater are most likely encountered within a relatively

Figure 12. Bloater *Coregonus hoyi* (total length 220 mm; 8.6 inches) captured near Olcott NY in Lake Ontario, April 2023. Photo: Brian W

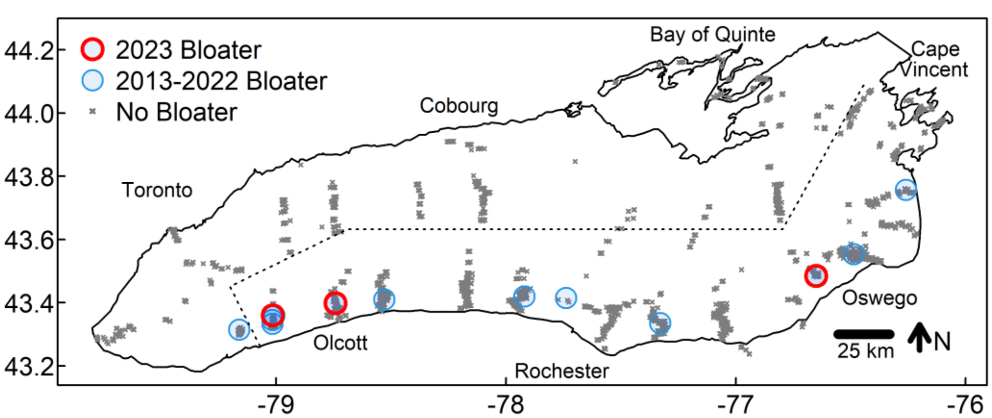

Figure 13. Bottom trawl sites in the Lake Ontario April and October prey fish surveys, 2013 – 2023, and sites where Bloater *Coregonus hoyi* were captured[31,14]. Each red and blue circle represents a single Bloater captured in a trawl. No survey was conducted in 2020. The dotted line represents the U.S. – Canada border.

narrow depth range from 75 – 95 m (247 – 314 ft.) along Lake Ontario's southern shore (Fig. 13).

Native species of interest - Lake Whitefish

Lake Whitefish *Coregonus clupeaformis* are native to Lake Ontario and once supported important commercial fisheries in both U.S. and Canadian waters[34]. The whole lake spatial coverage of the April bottom trawl survey provides a unique perspective for understanding Lake Whitefish distribution and population status. The species is rarely encountered in U.S. waters during the April survey but is more regularly captured in Canadian water near or within the Bay of Quinte (Fig. 14).

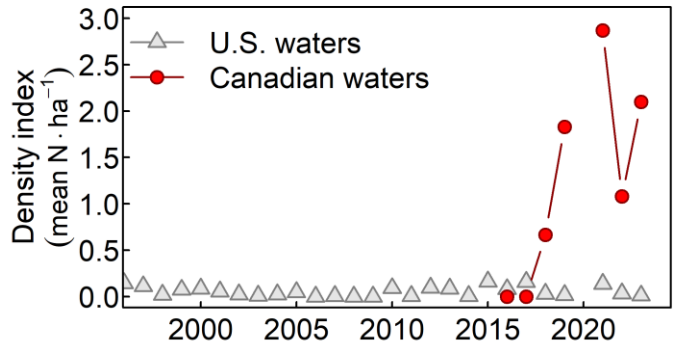

Figure 14. Density estimates for Lake Whitefish *Coregonus clupeaformis* in Lake Ontario from the April bottom trawl survey, 1997-2023[31]. No survey was conducted in 2020.

Native species of interest -naturally reproduced Lake Trout

Lake Trout *Salvelinus namaycush* restoration in Lake Ontario began in the 1970s[35] and the lake-wide coverage of the April trawl survey can inform the status of the restoration. Catches of naturally reproduced juvenile Lake Trout (total length < 500 mm) are generally rare, but these fish have been encountered more frequently in trawls near the Niagara River beginning in ~2012 (Fig. 15, Fig. 16) The large density observed in 2019 in Canadian catches (Fig. 15) resulted from sampling a transect that was not normally surveyed but is adjacent to the Niagara River in Canadian waters.

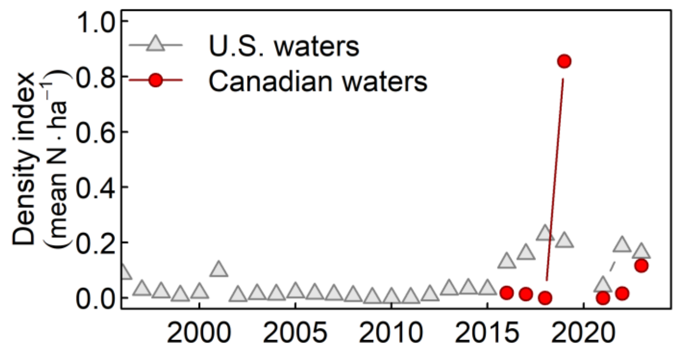

Figure 15. Density estimates for naturally reproduced Lake Trout *Salvelinus namaycush* in Lake Ontario from the April bottom trawl survey 1997-2023[31]. No survey was conducted in 2020.

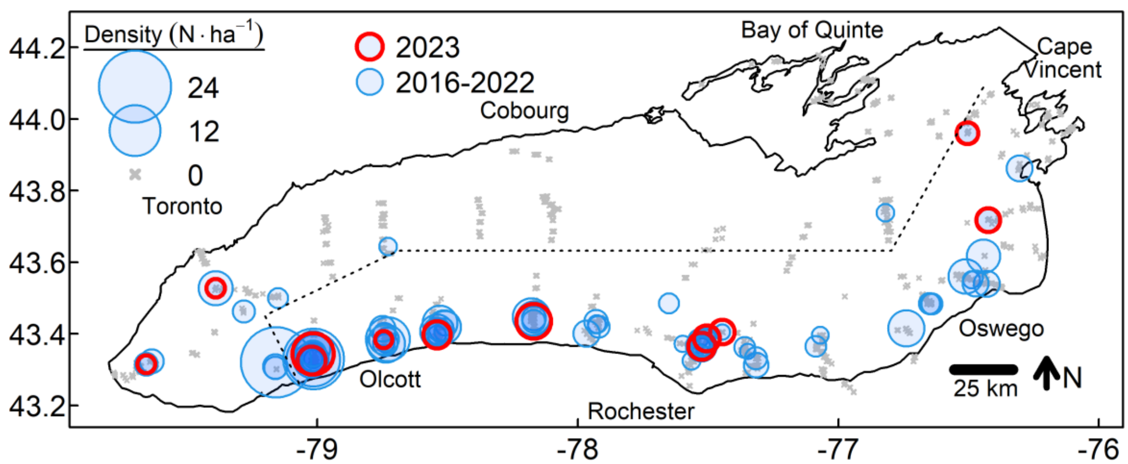

Figure 16. Density (number per hectare) and distribution of naturally reproduced juvenile (total length <500 mm) Lake Trout *Salvelinus namaycush* during the April bottom trawl survey in Lake Ontario from 2016-2023[31]. No survey was conducted in 2020. The size of the circles are proportional to the Lake Trout density. The dotted line represents the U.S. – Canada border.

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Table 1. Number of fish captured in Lake Ontario during the 2023 April bottom trawl survey. Individual dreissenid mussels are not counted; however, the total catch was 288 kilograms (634 lbs.). The density and biomass columns represent the lake wide, area-stratified mean value. The “NA” represents not available.

Species	Genus Species	Number	Proportion (number)	Density ($n \cdot ha^{-1}$)	Biomass ($kg \cdot ha^{-1}$)
Alewife	*Alosa pseudoharengus*	930029	0.92	6923.53	85.73
Rainbow Smelt	*Osmerus mordax*	28507	0.03	202.52	1.09
Deepwater Sculpin	*Myoxocephalus thompsonii*	28411	0.03	275.04	7.41
Round Goby	*Neogobius melanostomus*	13369	0.01	94.59	1.74
Yellow Perch	*Perca flavescens*	6427	0.01	58.18	0.46
Spottail Shiner	*Notropis hudsonius*	2443	0	18.54	0.16
Trout-perch	*Percopsis omiscomaycus*	2218	0	16.93	0.15
White Perch	*Morone americana*	326	0	3.54	0.30
Threespine Stickleback	*Gasterosteus aculeatus*	100	0	0.94	0.00
Lake Trout	*Salvelinus namaycush*	91	0	0.51	0.86
Pumpkinseed	*Lepomis gibbosus*	83	0	0.71	0.04
Slimy Sculpin	*Cottus cognatus*	41	0	0.70	0.00
Lake Whitefish	*Coregonus clupeaformis*	30	0	0.84	0.13
Rockbass	*Ambloplites rupestris*	20	0	0.21	0.00
White Sucker	*Catostomus commersonii*	17	0	0.16	0.07
Emerald Shiner	*Notropis atherinoides*	12	0	0.09	0.00
Freshwater Drum	*Aplodinotus grunniens*	10	0	0.51	0.86
Cisco	*Coregonus artedi*	9	0	0.46	0.08
Brown Bullhead	*Ameiurus nebulosus*	7	0	0.06	0.02
Common Carp	*Cyprinus carpio*	6	0	0.05	0.35
Walleye	*Sander vitreus*	5	0	0.07	0.01
Lake Sturgeon	*Acipenser fulvescens*	4	0	0.02	0.06
Bloater	*Coregonus hoyi*	3	0	0.01	0.00
Smallmouth Bass	*Micropterus dolomieu*	3	0	0.03	0.02
Black Crappie	*Pomoxis nigromaculatus*	1	0	0.01	0.00
Bluntnose Minnow	*Pimephales notatus*	1	0	NA	NA
Burbot	*Lota lota*	1	0	0.01	0.06
Grass Pickerel	*Esox americanus*	1	0	NA	NA
Largemouth Bass	*Micropterus salmonides*	1	0	NA	NA
Northern Pike	*Esox lucius*	1	0	NA	NA
Sea Lamprey	*Petromyzon marinus*	1	0	NA	NA

Table 2. Mean and standard deviations (s.d.) for Alewife *Alosa pseudoharengus* weight change (grams) and survival (proportion) by age for Lake Ontario population simulations. Weight change was calculated as the change in mean weight (in grams) for a given age class, from one age to the next. All the weight changes for that age transition create a distribution with a mean and a standard deviation (s.d.). Survival proportion is similarly calculated using the number of fish in a year class from one year to the next. These mean and s.d. values for the weight change and survival proportion are from at most years of observations, (2016-2019, 2021-2023). No age-9 through age-10 Alewife were captured in successive years, so neither weight change nor survival could be estimated. Values for survival and weight change for these ages were conservatively assumed to be zero. Values for survival greater than 0.90 were omitted from simulations.

Age	Weight change			Survival		
(from-to)	mean	s.d.	N	mean	s.d.	n
1 - 2	11.91	2.04	5	0.48	0.26	4
2 - 3	9.41	3.58	3	0.55	0.03	4
3 - 4	5.55	4.95	4	0.48	0.29	4
4 - 5	5.71	3.11	3	0.48	0.06	4
5 - 6	4.07	2.71	4	0.42	0.30	4
6 - 7	1.86	2.49	5	0.40	0.26	4
7 - 8	5.92	5.73	3	0.25	0.22	4
8 - 9	0.00	0.00	1	0.16	0.33	3
9 - 10	0.00	0.00	0	0.00	0.00	1
10 - 11	0.00	0.00	0	0.00	0.00	1

Table 3. Hydroacoustic density estimates, single target detections, and mean target strength from specific regions during the 2023 Lake Ontario April prey fish survey. Densities were estimated for depths from 3 m from the surface to 3 m above the lake bottom. Target strength is reported in decibels (dB). Geographic coordinates are in decimal degrees and represent the approximate center of that region of hydroacoustic observations.

Region	Latitude	Longitude	Mean density ($N \cdot ha^{-1}$)	S.D.	Sample size	Single targets (N)	Mean target strength (dB)
Hamilton	43.343	-79.561	7.1	18.7	14	287	-40.36
Little Sodus Bay	43.333	-76.706	11.7	19.7	7	0	NA
Oak Orchard	43.389	-78.192	39.2	79.7	21	1521	-38.85
Olcott	43.463	78.748	81.2	102.0	26	3245	-43.16
Oswego	43.542	-76.556	58.1	232.4	44	1684	-41.10
Point Petre	43.713	-77.199	11.6	10.0	14	1866	-45.22
Scotch Bonnet	43.705	-77.526	74.5	72.7	12	4686	-40.51
Sodus Bay	43.252	-76.958	27.0	51.1	13	0	NA
Smoky Point	43.391	-77.305	32.2	13.8	5	988	-42.57
Youngstown	43.368	-79.073	16.1	28.1	14	923	-45.88