Preliminary status of Lake Ontario Alewife based on the 2019 spring trawl survey

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

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Summary

- The 2019 spring prey fish trawl survey was the most extensive fish survey ever conducted on Lake Ontario with 252 bottom trawls collecting 214,569 fish from 39 species, in main-lake and embayment habitats, at depths ranging from 5 to 225 meters (16.5 – 742.5 feet).
- Alewife distribution was similar in U.S. (southern) and Canadian (northern) portions of the lake, which differs from the previous three years of whole-lake surveys when Alewife in April were more abundant in either U.S. (2017) or Canadian (2016, 2018) waters.
- The 2019 lake-wide average biomass index for adult Alewife (Age2+) declined 29% relative to 2018.
- The lake-wide biomass index for Age-1 Alewife in 2019 (2.2 kg/ha) declined relative to 2018 (2.6 kg/ha) and was the lowest Age-1 biomass observed since whole-lake sampling began in 2016.
- The current biomass, size structure, and age structure of the adult Alewife population reflect the lower-than-average Alewife reproductive success observed in the 2013- and 2014-year classes.
- Reproductive success was also lower than average in 2017 and 2018, suggesting the adult Alewife biomass may continue to decline.

Introduction

Alewife are the dominant prey species supporting Lake Ontario's multi-million dollar native and stocked salmonid fisheries. Management decisions depend on the status and trends of the Alewife population in concert with other indicators to balance predator stocking levels with available prey (Great Lakes Fishery Commission Lake Ontario Committee, 2016; New York State Department of Environmental Conservation, 2018; Ontario Ministry of Natural Resources and Forestry, 2019). This report informs stakeholders, the Great Lake's Fishery Commission's Lake Ontario Committee (LOC), regional fisheries managers and advisors on the preliminary status of Lake Ontario's Alewife population based on the 2019 spring prey fish trawl survey. Discussions on Lake Ontario fish populations occur among stakeholders, biologists, and managers throughout the year, requiring the most recent information be available as early as possible. Survey and analytical methods are described at the end of this report.

Results

The 2019 Lake Ontario Spring Prey Fish Survey collected 252 bottom trawls at depths from 5 to 225m from April 3 to May 3 (Figure 1). The survey captured 214,569 fish from 39 different species (Table 1).

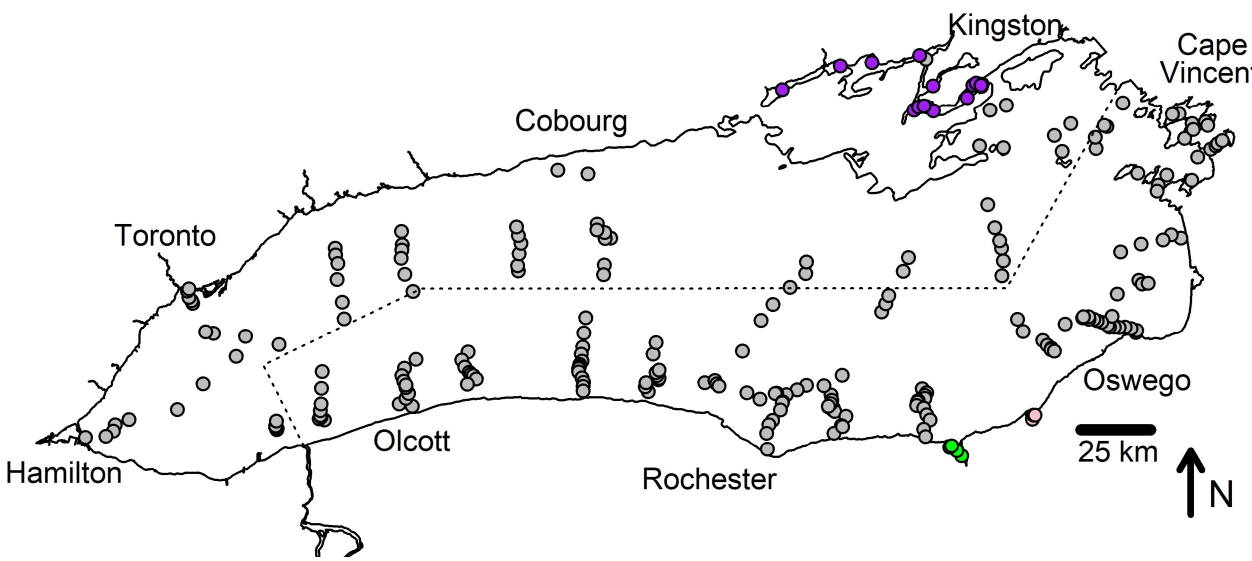

Figure 1. Lake Ontario bottom trawl locations (N=252) from the 2019 Spring Prey Fish Survey. Three vessels participated in the survey and new trawl sites sampled this year included the Bay of Quinte (purple), Sodus Bay (green) and Little Sodus Bay (pink). Sampling embayments with the same sampling gear as the main lake allows us to check for early inshore migrating Alewife and measure how different the fish communities are in these diverse habitats relative to the main lake.

<u>Alewife Distribution</u>

This survey historically sampled only U.S. waters of Lake Ontario from 1978-2015 but was expanded lake-wide in 2016. Four years of lake-wide surveys have dramatically changed our understanding of how the spatial distribution of Alewife can vary during the survey in April. This variability in lake-wide Alewife distribution influences how we interpret the previous survey results, since Alewife may have been aggregated in either the U.S. or Canadian portions of the lake in any given year (Figure 2).

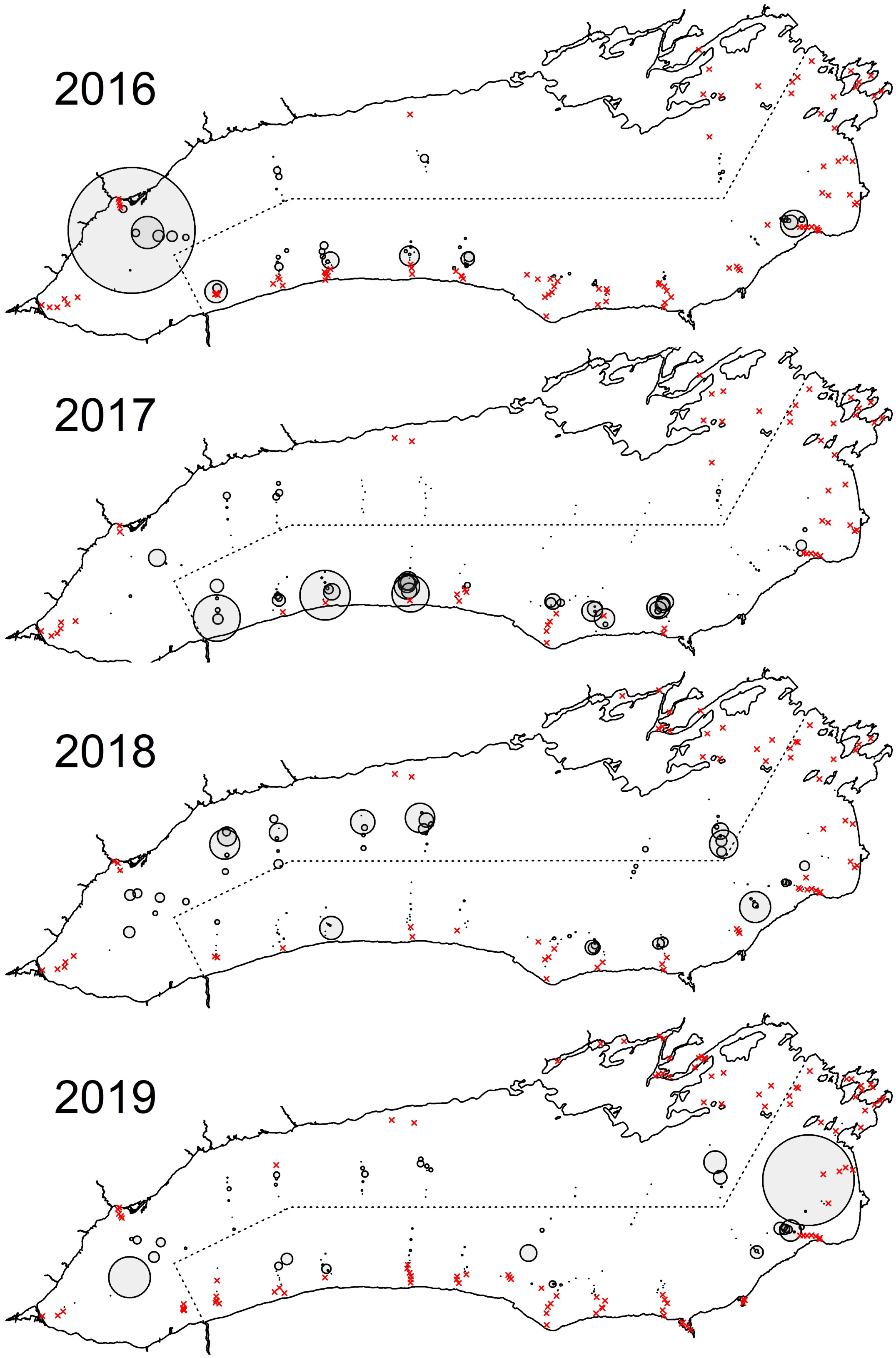

Figure 2. Spatial distribution of Lake Ontario Alewife biomass, 2016-2019. The area of a gray circle is proportional to the biomass caught (standard scale across all plots). Red 'x' symbols denote where trawls did not catch any Alewife. The largest catch (2016) represented a biomass of approximately 2100 kilograms per hectare (kg/ha). One kilogram (kg) is approximately equal to 2.2 pounds and a hectare (ha) is approximately 2.5 acres.

Alewife Population Status

Estimates for whole-lake adult (Age-2 and up) and Age-1 Alewife biomass declined in 2019 relative to 2018 (Figure 3). The 2019 estimate follows a general trend of declining biomass over the past five years and is likely among the lowest biomasses estimated in Lake Ontario over the past two decades. Observations from 2006 and 2010 were similarly low, but subsequent year's data illustrated those survey estimates were biased low. In those years a large proportion of the Alewife population was likely in Canadian waters, where the trawls did not sample.

We measure Alewife reproductive success in a year or the strength of an Alewife "year class" when the fish are Age-1. The current observed decline in adult Alewife biomass is the result of the lower than average year classes produced in 2013 and 2014, and likely higher than average predation on the remaining adult Alewife. Lower-than-average Alewife reproduction in both 2017 and 2018 (Figure 3, right side) suggests that adult biomass will continue to decline through 2019 and into 2020.

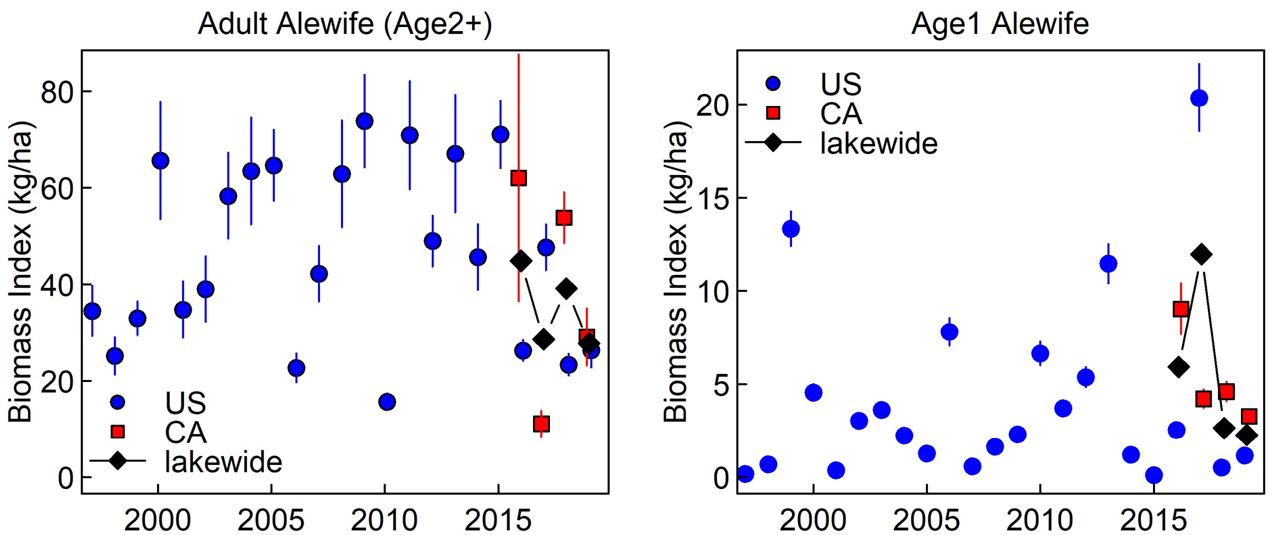

Figure 3. Lake Ontario average adult Alewife biomass index (above left in kilograms per hectare) and the average Age 1 Alewife biomass index (above right), 1997-2019. Error bars represent two standard errors. The term 'index' is used because trawl catchability is not accounted for in the estimates.

The reproductive success of Alewife in Lake Ontario and other Great Lakes has been shown to be influenced by the number of adults, climate, and predation (Collingsworth et al., 2014; Eck and Wells, 1987; Madenjian et al., 2005; O'Gorman et al., 2004). Alewife typically spawn in July, and warm conditions allow the spawn to occur earlier and provide more time for Alewife to grow before their first winter. In contrast, cold springs delay spawning and reduce growth of young fish, and colder than average winters can potentially reduce survival (O'Gorman and Stewart, 1999). Accurately predicting Alewife reproductive success is difficult, but the colder than average spring experienced in 2019 suggests the 2019 Lake Ontario Alewife reproductive success may be lower than average.

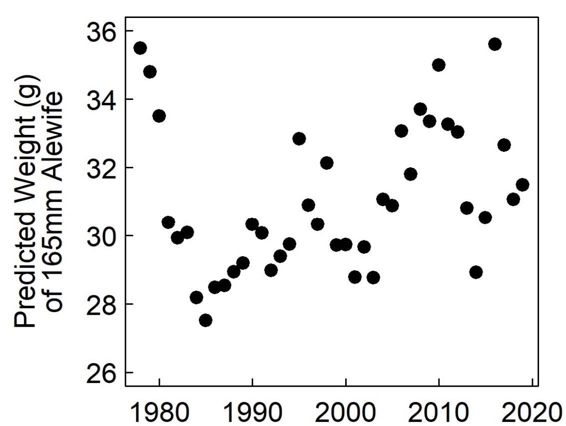

Figure 4. The predicted weight of a 165mm Lake Ontario Alewife (6.5"), 1978-2019.

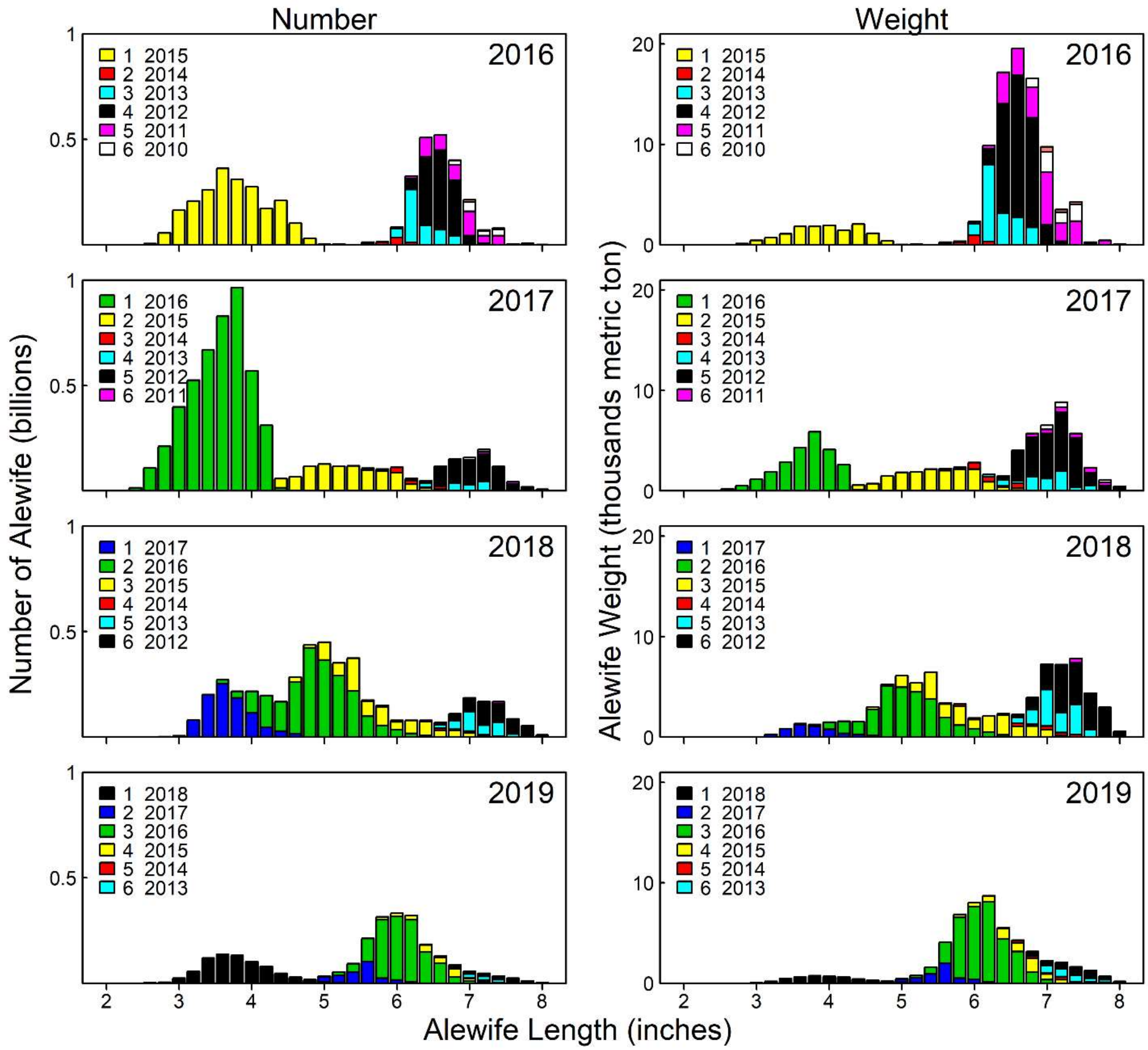

Figure 5. Lake Ontario Alewife size and age structure based on whole-lake survey results, 2016-2019. The horizontal position of a bar indicates Alewife length, while the bar height illustrates the number or weight. The year in which Alewife are born (year class) is depicted by the different colors and is the same across each panel.

Figure 5 illustrates how Alewife size and age structure have changed over the past four years. Small or non-existent red and turquoise bars in the 2019 panels (Figure 5 lower panels) reflect the lower the average reproduction observed in 2013 and 2014 (Figure 3). The substantial decline in large Alewife from 2018 to 2019 suggests predation presssure may have been higher than average in that time period. Additionally, we have observed the maximum age of Alewife has declined slightly in recent years (Figure 6). This also indicates predation on the oldest, largest Alewife may have increased.

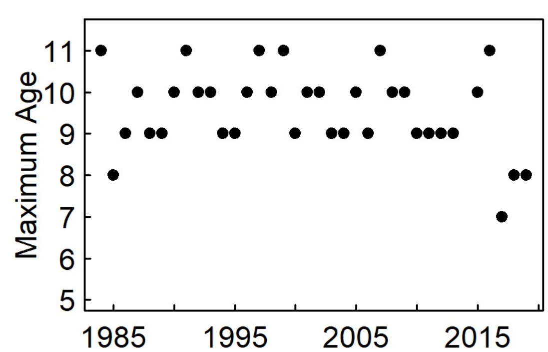

Figure 6. Maximum age of Lake Ontario Alewife based on whole saggitae otolith, 1984-2019.

Methods

The bottom trawl survey targets Alewife in April when they predominately remain in their winter habitat near the lake bottom, maximizing their susceptibility to bottom trawls (Wells, 1968). Daytime trawling is conducted at fixed sites. Catches are separated to species, counted, weighed in aggregate and samples from individual fish are collected. Alewife biomass (kilograms per hectare) and density (number per hectare) are calculated and reported as area-weighted, stratified means (Cochrane, 1977). Table 2 illustrates the depth strata specific values in U.S. and Canadian waters for 2019. Population metrics are calculated separately for U.S. and Canadian lake areas to maintain consistency with the longer U.S. time series (1978-2019) relative to the Canadian time series (2016-2019). Whole lake values are based on the proportion of the lake in Canada (0.52) and the U.S. (0.48). Biomass time series are reported here from 1997 when a consistent trawl gear was used.

Alewife ages (n = 800-2000 fish aged per year) are interpreted from whole saggitae otoliths (Figure 7). Age-length keys are calculated that estimate the proportion of Alewife ages within 5mm total length categories. Age-length keys are used to apportion ages or cohorts to observed Alewife length frequency and estimate abundance and biomass for Age-1 and adult (Age-2 and up). Additional methods information can be found in previous annual reports (Weidel et al., 2019).

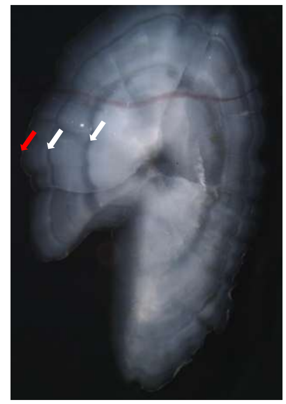

Figure 7. Alewife saggita otolith, collected in April from Lake Ontario. The age was interpreted as three based on the two annual marks (white arrow) and a third annual mark (red) arrow at the edge that is just forming.

Why use Alewife biomass as a population index?

As the Lake Ontario Alewife population changes it becomes increasingly important to understand how current abundance estimates relate to predator consumption levels, to historic values in the time series, and to other lakes where Alewife have experienced declines (Dunlop and Riley, 2013). Understanding how the Alewife population responded to previous declines may provide insight into how the population may respond in the future. Historic abundance indices reported total Alewife number or combined Alewife weight per 10-minute trawl. Herein, we report survey results using biomass (kilograms per hectare) and/or density (number of fish per hectare) units. These ‘per area’ metrics are more widely accepted and used in fisheries science, account for fish size changes, and account for differences in how much area the bottom trawl sweeps which is not consistent with depth (Weidel and Walsh, 2013).

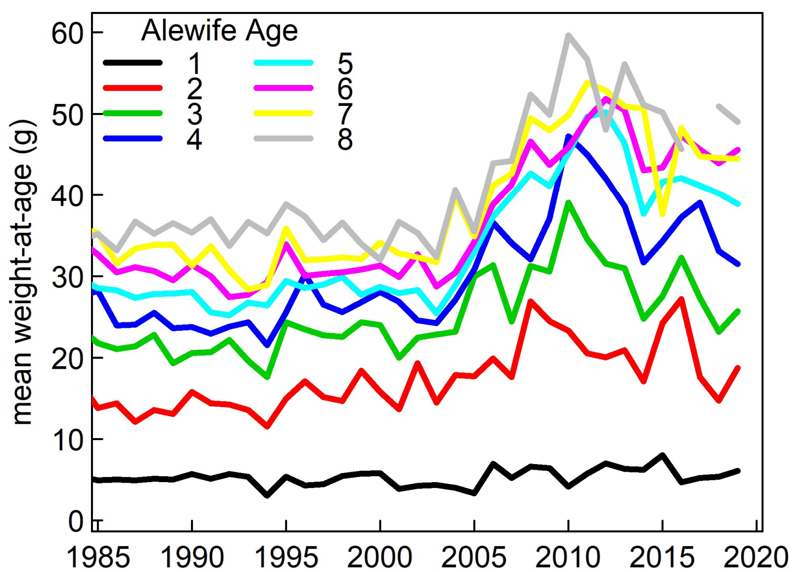

Figure 8. Lake Ontario Alewife weight at age, 1984-2019. Alewife age interpretations are from whole saggitae otoliths. For reference, a gram is approximately the weight of a small paper clip.

The importance of biomass metrics is further highlighted due to the dramatic changes in Lake Ontario Alewife growth and size at age over the past four decades (Figure 8). For example, Figure 8 illustrates how an Age 3 Alewife (green line) captured in 2010 weighed approximately 40 grams, as much as an Age 8 Alewife (grey line) did from 1985-2000. Initial analyses suggest that growth variability may be due to changes in the number of non-native predatory zooplankton (i.e. fish hook fleas). When these zooplankton are abundant they comprise a large portion of Alewife diets, especially in the fall (Walsh et al., 2008).

We feel biomass provides a more integrated description of Alewife population dynamics as it includes both measures of density and fish size. Adult Alewife size can vary substantially from year to year (Figures 5 and 8). Many small adult Alewife may not provide as much forage potential to predators as an Alewife population with fewer but larger individuals. Figure 9 illustrates how the density, average size, and biomass of adult Alewife has changed in Lake Ontario over the past four years. While density increased markedly from 2017-2018, the decrease in average weight from 2017-2018 meant that the biomass increased slightly, then declined.

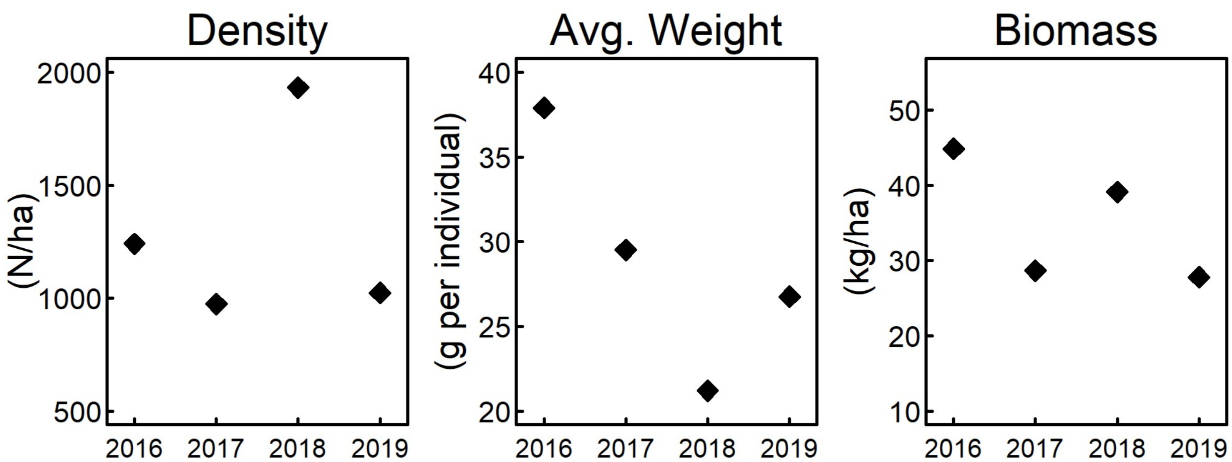

Figure 9. Lake Ontario adult Alewife density (number of fish per hectare), average weight (individual fish in grams) and biomass (total combined weight per hectare), 2016-2019. Biomass is the product of multiplying density with the average weight and is a more relevant metric to use when comparing Lake Ontario Alewife to other lakes and to understanding predator-prey balance.

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Table 1. Species, number and weight of fish captured in the 2019 Lake Ontario, Spring Bottom Trawl Survey.

Common Name	Number	Weight (g)
Alewife	177091	4048968
Deepwater Sculpin	16074	441767
Round Goby	6542	108310
Rainbow Smelt	6376	58932
Yellow Perch	4853	103272
Trout-perch	1543	19272
Spottail Shiner	876	8698
White Perch	333	6389
Slimy Sculpin	197	1643
Pumpkinseed	146	6946
Lake Trout	119	133166
Walleye	108	56489
Freshwater Drum	98	130044
Threespine Stickleback	82	112
Lake Whitefish	42	8111
White Sucker	13	3185
Emerald Shiner	12	90
Rockbass	9	633
White Bass	9	2989
Brown Bullhead	8	2221
Johnny Darter	5	6
Common Carp	4	44940
Cisco	4	1483
Lake Sturgeon	4	41760
Northern Pike	4	867
Logperch	3	17
Bluegill	2	63
American Eel	1	862
Black Crappie	1	424
Bloater	1	3
Brown Trout	1	261
Chain Pickerel	1	620
Common Mudpuppy	1	0
Largemouth Bass	1	784
Longnose Sucker	1	662
Sea Lamprey	1	142
Smallmouth Bass	1	842
Tubenose Goby	1	3
Unidentified Coregonine	1	15

Table 2. Lake Ontario Alewife sampling statistics, by 20-m strata, from the 2019 Spring Bottom Trawl Survey.

Strata	U.S. waters			Canadian waters		
Depth (m)	# trawls	Avg. biomass kg/ha	Strata Area %	# trawls	Avg. biomass kg/ha	Strata Area %
0-20	26	0	12.1	13	0	16.7
20-40	22	0	10.3	15	0	16.5
40-60	20	0	7.6	7	0.1	12.5
60-80	18	78.7	5.8	2	0.2	14.3
80-100	15	10.1	4.8	11	51.7	12.1
100-120	20	41.2	5.8	14	108.1	13.1
120-140	19	59.7	8.9	10	50.3	9.9
140-160	10	55.4	12.2	8	15.1	3.8
160-180	10	12.7	17.8	2	11.5	1
180-200	5	25.2	8.5			
200-220	2	5.8	5.1			
220-240	2	4.5	1			
240-260	0	0	0			