Inland Seas Angler
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Highlights of the Annual Lake Committee Meetings

Great Lakes Fishery Commission proceedings, Sault Ste. Marie, Ontario

This fourth of a series of annual special reports is a summary of Lakes Huron and Superior. These lake committee reports are from the annual Lake Committee meetings hosted by the Great Lakes Fishery Commission in March/April 2018. We encourage reproduction with the appropriate credit to the GLSFC and the agencies involved. Our thanks to Michigan DNR; Ontario Ministry of Natural Resources & Forestry; USFWS; the many other DNR biologists who make this all happen, and also thanks to the staffs of the GLFC and USGS for their contributions to these science documents. Thanks also to the Great Lakes Fishery Commission, its staff, Bob Lamb & Marc Gaden, for their efforts in again convening and hosting the Upper Lake Committee meetings in Sault Ste. Marie, Ontario.

Lake Huron

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Lake Superior

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Abbreviation	Expansion
CPH	Catch per hectare
CWT	Coded Wire Tag
DFO	Dept. of Fisheries and Oceans
KT	1,000 metric tons
MDNR	MI Dept. of Natural Resources
OMNR	ON Ministry Natural Resources
USFWS	U.S. Fish and Wildlife Service
WDNR	WI Dept. of Natural Resources
YAO	Age 1 and older
YOY	Young of the year (age 0)

Highlights

- Lake-wide biomass was 23% higher in 2017 as compared to 2016.
- The total lake-wide biomass of pelagic fish species, excluding cisco, was entirely of bloater and rainbow smelt.
- Age-0 rainbow smelt abundance increased from 155 fish/ha in 2016 to 598 fish/ha in 2017.
- Biomass of age-1 +rainbow smelt increased from 2.5 kg/ha in 2016 to 4.1 kg/ha in 2017.
- Age-0 bloater abundance increased from 94 fish/ha in 2016 to 342 fish/ha in 2017.
- Biomass of age-I+ bloater in 2017 (5.0 kg/ha) remained at levels similar to 2016 (5.2 kg/ha).
- Emerald shiner density decreased from 38.6 fish/ha in 2016 to 19.5 fish/ha in 2017.
- Cisco lake-wide biomass was estimated at 2.2 kg/ha and mean density was estimated at 5.1 fish/ha in 2017.
- Bloater and rainbow smelt will continue to be the primary pelagic species to offshore predators in coming years.
- The 2017 main basin prey fish biomass estimate for Lake Huron was 20.9 kilotonnes, a decrease of about 21 % from 2016.
- Lake Huron has 1,761 tributaries (1,334 Canada, 427 U.S.).
- 127 tributaries (59 Canada, 68 U.S.) have historical records of larval Sea Lamprey production.
- 84 tributaries (38 Canada, 47 U.S.) have been treated with lampricide at least once during 2008-2017.
- The Lake Trout marking rate of 5 per 100 Lake Trout has decreased to less than the target for the first time since 1983.

Status and Trends of Pelagic Prey Fish in Lake Huron, 2017(USGS)

Abstract

Scientists from the U.S. Geological Survey's Great Lakes Science Center conducted integrated acoustic and mid-water trawl surveys of Lake Huron in 1997 and annually from 2004-2017. The 2017 survey was conducted during September and included transects in Lake Huron's main basin, Georgian Bay, and North Channel. Mean lake-wide pelagic fish density was 1582 fish/ha and mean pelagic fish biomass was I 0.5 kg/ha in 2017, which represents 96% and 93% of the long-term mean respectively. Mean lake-wide biomass was 23% higher in 2017 as compared to 2016. The total estimated lake-wide standing stock biomass of pelagic fish species, excluding cisco, was ~49 kt(± 10.4 kt), consisting almost entirely of bloater (26.8 kt; 55%) and rainbow smelt (22 kt; 45%), with small contributions from sticklebacks (0.13 kt; 0.26 %), emerald shiner (0.09 kt; 0.18%), and alewife (0.004kt; <0.005%). Age-0 rainbow smelt abundance increased from 155 fish/ha in 2016 to 598 fish/ha in 2017. Biomass of age-1 +rainbow smelt increased from 2.5 kg/ha in 2016 to 4.1 kg/ha in 2017. Age-0 bloater abundance increased from 94 fish/ha in 2016 to 342 fish/ha in 2017. Biomass of age-I+ bloater in 2017 (5.0 kg/ha) remained at levels similar to 2016 (5.2 kg/ha). Emerald shiner density decreased from 38.6 fish/ha in 2016 to 19.5 fish/ha in 2017. Emerald shiner biomass remained at 0.02 kg/ha between 2016-2017 which represented 19% of the long-term mean. Cisco lake-wide mean biomass was estimated at 2.2 kg/ha and mean density was estimated at 5.1 fish/ha in 2017. Bloater and rainbow smelt will likely continue to be the primary pelagic species available to offshore predators in coming years.

The pelagic prey fish survey in Lake Huron is based on a stratified-random design with acoustic transects in five geographic strata: eastern main basin (ME), western main basin (MW), southern main basin (SB), Georgian Bay (GB), and the North Channel (NC) **(Fig 1).**

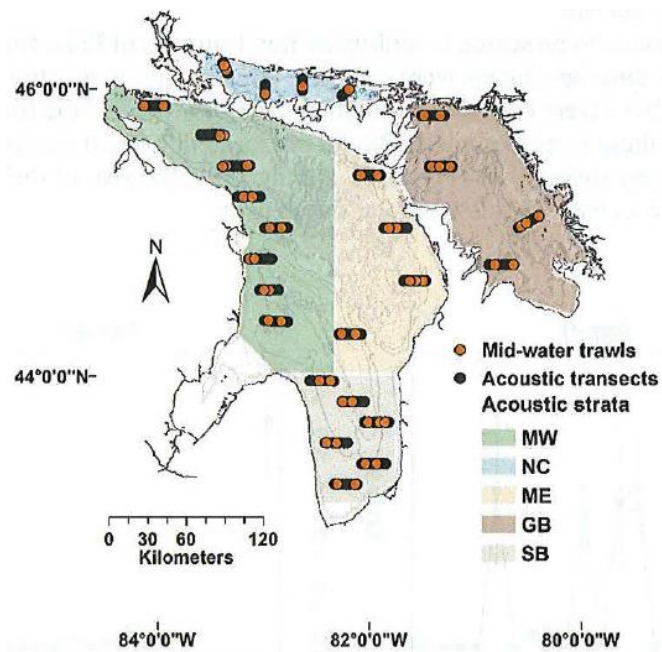


Fig 1-Location of acoustic transects and mid-water trawls within sampling strata in Lake Hurnn during 2017. Sampling strata correspond to geographic regions: eastern main basin (ME), western main basin (MW), southern main basin (SB), Georgian Bay (GB), and the North Channel (NC).

Density (fish/ha) of individual species was estimated for each transect as the product of acoustic fish density and the proportion of each species (by number) in the mid-water trawl catches at that location. Total density per species was subdivided into age-0 and age-1 + age-classes by multiplying total density by the numeric proportions of each age group. Biomass (kg/ha) of each species was estimated for each transect as the product of density and size-specific mean mass estimated from fish lengths in trawls, and length-weight relationships. The arithmetic mean and standard error are presented for total and species-specific density and biomass estimates for the survey area.

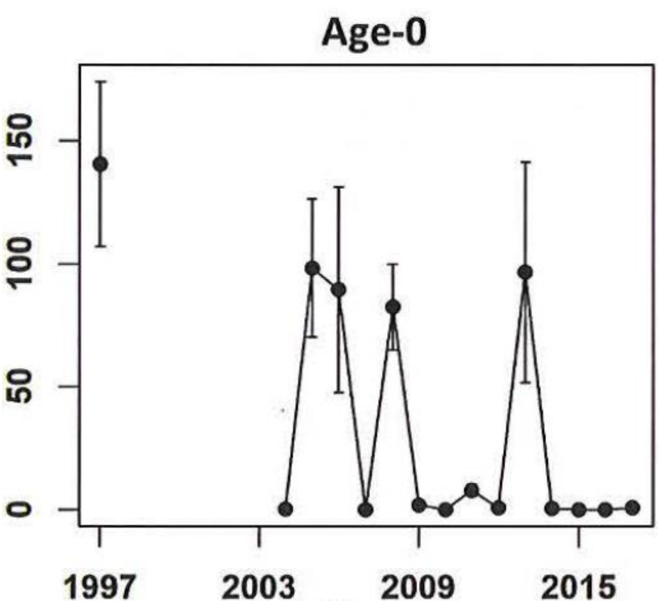
Mean, standard error, and confidence limits for density and biomass for the entire survey area (all three basins pooled) were estimated using stratified cluster analysis methods in SAS (SAS Institute Inc. 2007). Cluster sampling techniques are appropriate for acoustic data, which represent a continuous stream of autocorrelated data.

Results and Discussion

Density and biomass by species

Alewife

Alewife continue to be scarce in mid-water trawl surveys of Lake Huron, including during 2017 when only three specimens were captured. Alewife densities estimated in 1997, 2005-2006, 2008, and 2013 were considerably higher than other years in the time series. However, we note that these increases in density did not mean that age-0 alewives were especially abundant in any survey year **(Fig 2**). During 1997, the year of their highest abundance, age-0 alewives were only 2% of total fish density.



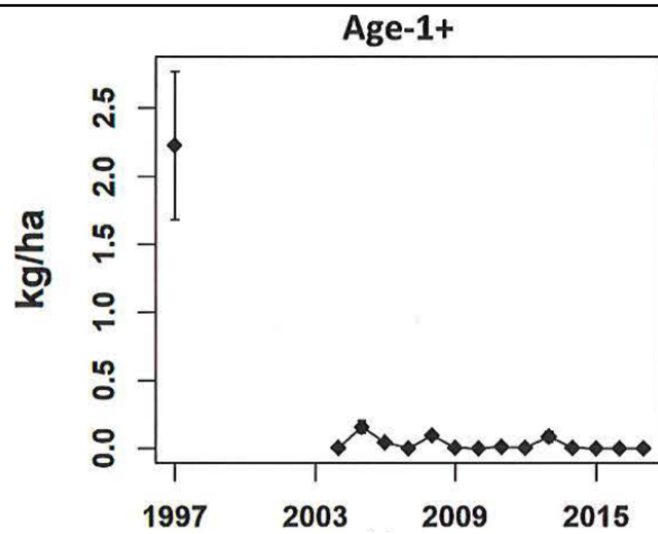


Fig 2-Acoustic and mid-water trawl estimates of alewife numeric density (fish/ha; upper panel) and biomass (kg/ha; lower panel) in Lake Huron, 1997-2017.

Acoustic estimates of age-1 + alewife biomass have remained low for the last decade despite fluctuations in age-0 densities during 2004-2013 **(Fig 2).** Temporal biomass differences were largely due to differences in size and age structure between 1997 and other years. Higher biomass in 1997 was due to higher abundance of age 1 + alewife and low biomass during 2004-2014 was the result of trawl catches dominated by age-0 fish (Figure 2). Since 2004, alewives have never comprised more than 2% of pelagic fish biomass. Although sporadic catches of alewife have continued, recruitment to older age classes appears to be limited based on evidence from both mid-water and bottom trawl surveys conducted by the GLSC.

Rainbow smelt

During 2017, age-0 rainbow smelt density increased from 2016 estimates by nearly a factor of 4 to 86% of the long-term mean **(Fig 3**). Age-0 rainbow smelt productionstill remains lower than 1997. There has been no clear trend in abundance since 2004. Age 1 +rainbow smelt biomass also increased in 2017 from 2.5 kg/ha in 2016 to 4.1 kg/ha in 2017. This is roughly 95% of the long-term mean of 4.3 kg/ha, but only 24% of the biomass estimated in1997 **(Fig 3).** Rainbow smelt biomass was spatially variable during 2017 and primarily distributed in the northern portions of the lake and some areas of the southern main basin **(Fig 4).**

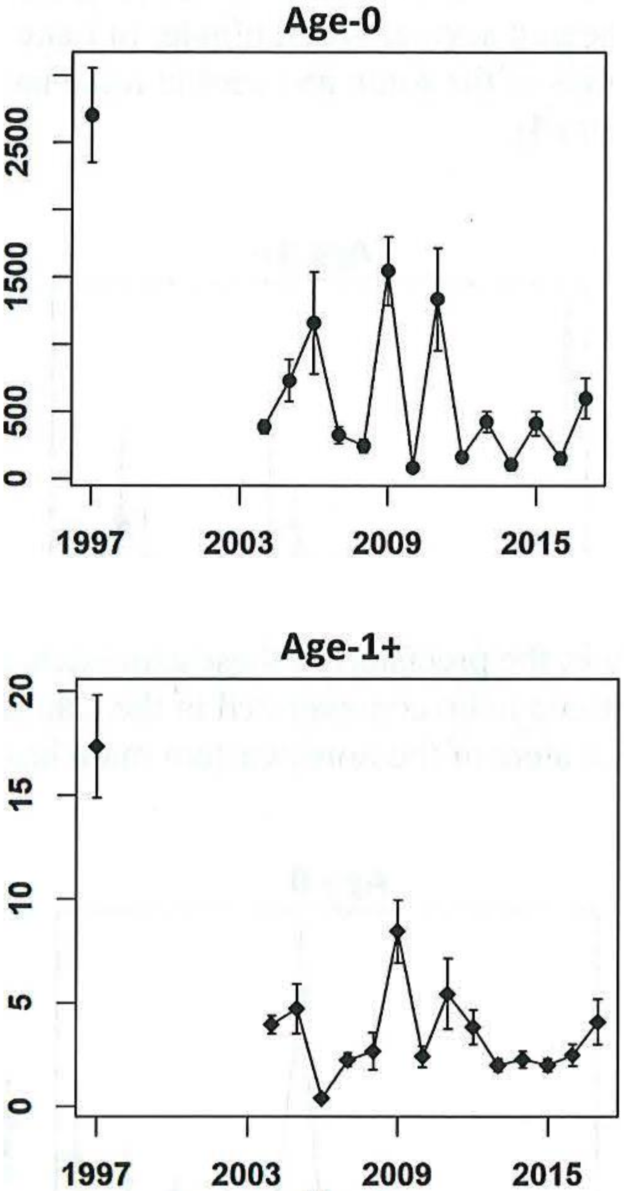


Fig 3-Acoustic and mid-water trawl estimates of rainbow smelt age-0 numeric density (fish/ha; upper panel) and age-1+ biomass (kg/ha; lower panel) in Lake Huron, 1997-2017. .

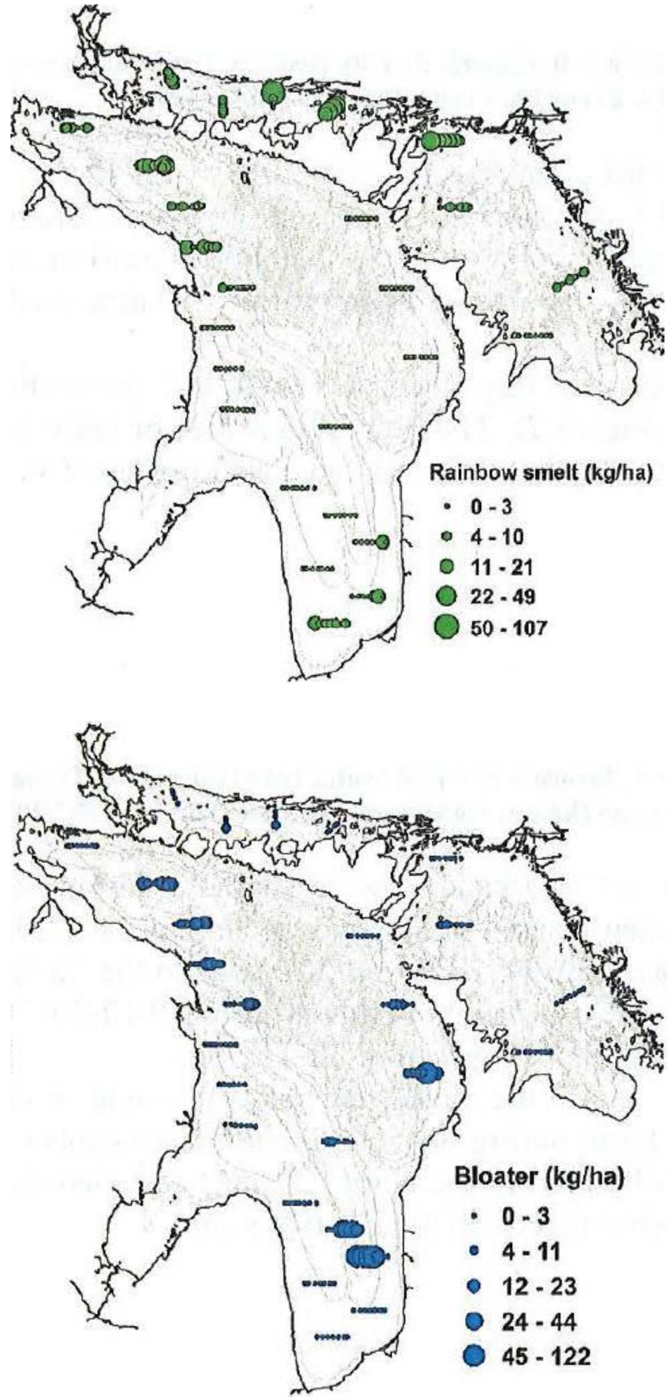


Fig 4-Geographic distribution of rainbow smelt (upper and bloater (lower) biomass summarized within elementary sampling units (dots) during 2017. Gray lines are 20 m depth intervals.

Bloater

Lake-wide mean age-0 bloater density in 2017 was 3.5-times that estimated in 2016 and was the second highest estimate for the time series **(Fig 5**). Mean biomass of age-1 + bloater decreased from 5.2 kg/ha in 2016 to 5.0 kg/ha in 2017 **(Fig 5).** Since 2014, age-1+ bloater biomass has remained at or above 5 kg/ha, but standard error around these estimates have been fairly large indicating lower precision. Similar to results from bottom trawl surveys, age-0 bloater density was variable, but increased during 2004-2015 (average density > 160 fish/ha). Biomass of age-1 + bloater indicated an increasing trend during 2004-2008, followed by a decrease from 2009-2010. Although we have estimated somewhat higher bloater biomass during the past four years, variable spatial distribution across the survey area has resulted in greater uncertainty in the precision of these estimates. As in the past several years, bloater in Lake Huron continue to be concentrated in the Canadian waters of the south and central main basin and in U.S waters of the northwestern main basin **(Fig 4**).

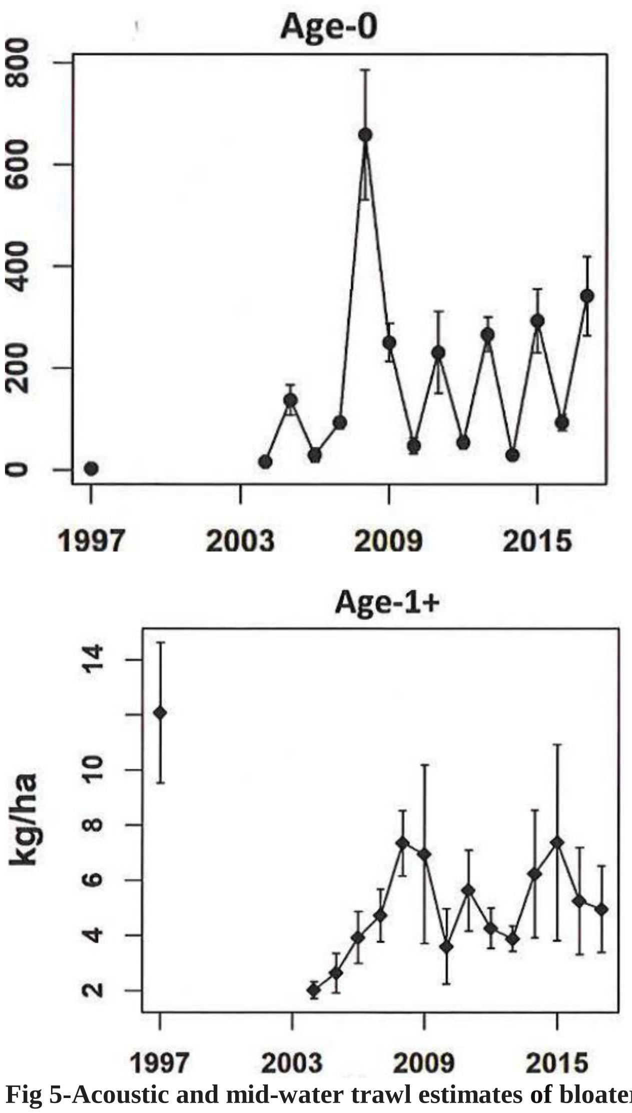


Fig 5-Acoustic and mid-water trawl estimates of bloater age-0 numeric density (fish/ha; upper panel) and age-1+ biomass (kg/ha; lower panel) in Lake Huron, 1997-2017.

Cisco

Cisco catches were sporadic during acoustic surveys in 2010-2013, with few (<10) specimens caught in most years. During 2014-2017, cisco catches increased **(Fig 6).** Biomass increased during 2016 and 2017 due to the increased number of larger fish (>300 mm) in trawl catches.

Cisco caught in trawls during 2010-2017 were mostly > 100 mm (mean 280 mm, median 295 mm) and ranged from 80-471 mm. Cisco are almost exclusively caught in Georgian Bay, North Channel, and the northern main basin during September and early October **(Fig 7).** The highest densities of cisco have been observed in the North Channel and Georgian Bay but densities have also increased in the northern main basin the last two years.

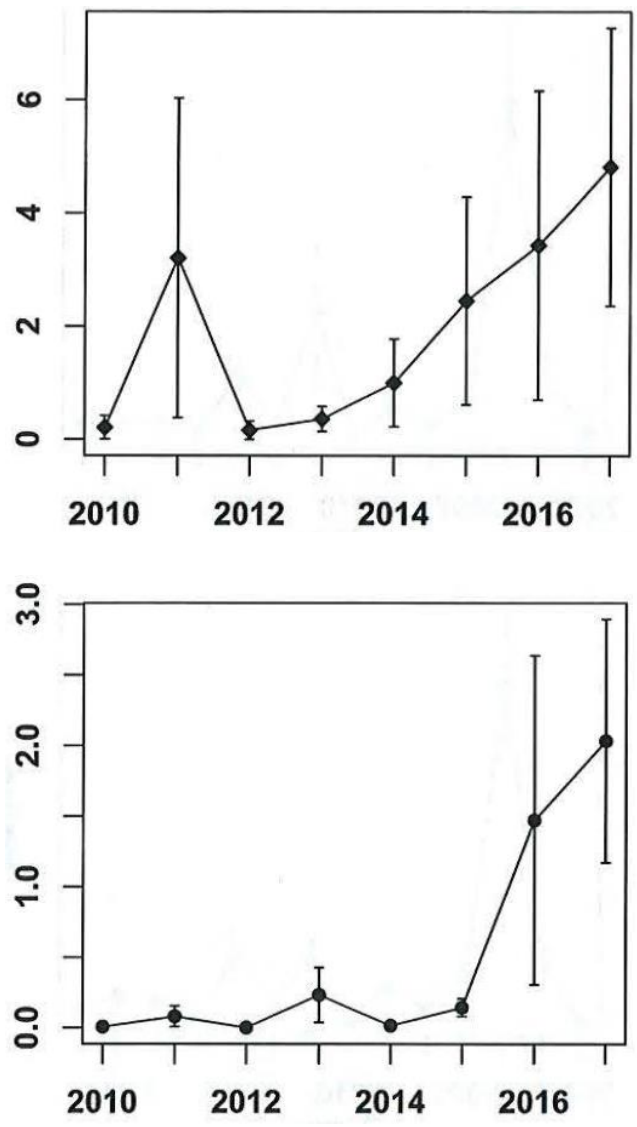


Fig 6-Acoustic and mid-water trawl estimates of cisco numeric density (fish/ha; upper panel) and biomass (kg/ha; lower panel) in Lake Huron, 2010-2017.

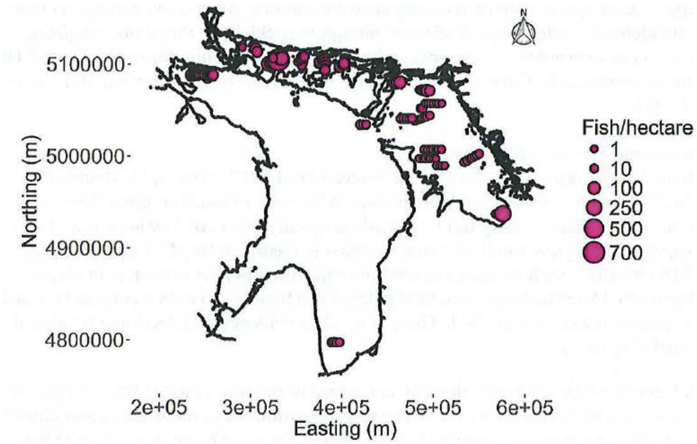


Fig 7-Geographic distribution of cisco numeric density (mean) estimated from acoustic surveys during 2010-2017. Points are elementary sampling units.

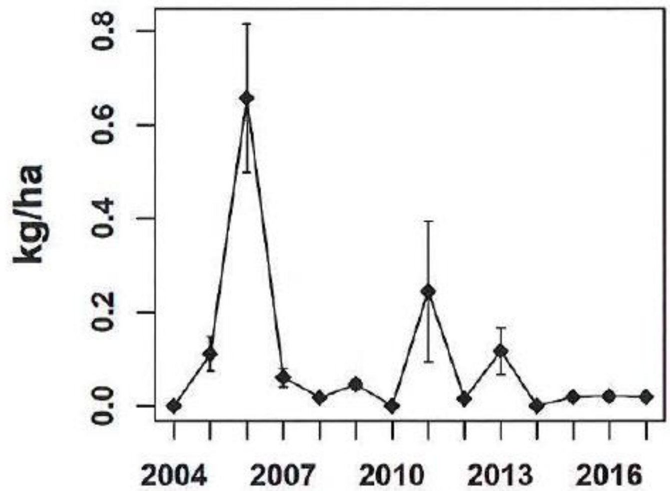
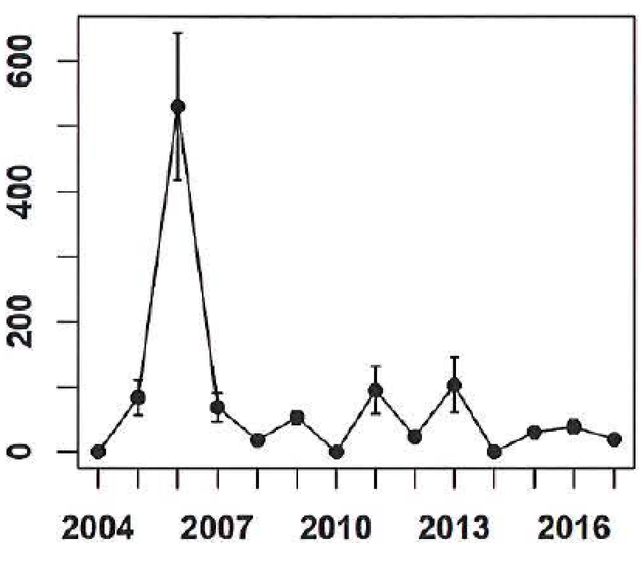


Fig 8-Acoustic and mid-water trawl estimates of emerald shiner numeric density (fish/ha; upper panel) and biomass (kg/ha; lower panel) in Lake Huron, 2004-2017.

Emerald shiner

Mean density of emerald shiner declined moderately in 2017 and was approximately 24% of the long-term mean. Emerald shiner biomass in 2017 was 0.02 kg/ha and remained unchanged relative to 2016 **(Fig 8)**. The 2017 biomass estimate was 20% of the long-term mean of 0.10 kg/ha. Emerald shiner biomass averaged 1.6% of total fish biomass during 2004-2014, but with the exception of 2006, rarely exceeded 1 % of total fish biomass in a given year.



Other species

Other species captured during acoustic and mid-water trawl surveys included threespine stickleback, ninespine stickleback, chinook salmon, lake whitefish, and lake trout. These species typically compose a small proportion of the midwater trawl catch.

Among-basin comparisons of fish biomass

Biomass in the North Channel (22.9 kg/ha) in September of2017 was roughly double that estimated in 2016 and was driven solely by increased biomass ofrainbow smelt (Figure 9). Biomass in the main basin (11.6 kg/ha) increased marginally from 2016 estimates, and was due to small increases in rainbow smelt biomass. Biomass in Georgian Bay (7.7 kg/ha) changed little between 2016 and 2017, with increases in rainbow smelt biomass but decreases in bloater biomass (Figure 9). Over the long-term, total pelagic fish biomass in both Georgian Bay and the main basin remains lower than in 1997. There is no clear evidence of a declining trend in the North Channel **(Fig 9).**

Biomass in Georgian Bay has been primarily composed of smelt (58% average), while biomass in the main basin has consisted of varying proportions of smelt and bloater. Since 2012, bloater has been the dominant contributor in the main basin, averaging 75% of pelagic fish biomass annually. In the North Channel, rainbow smelt have averaged 75% of annual biomass since 1997.

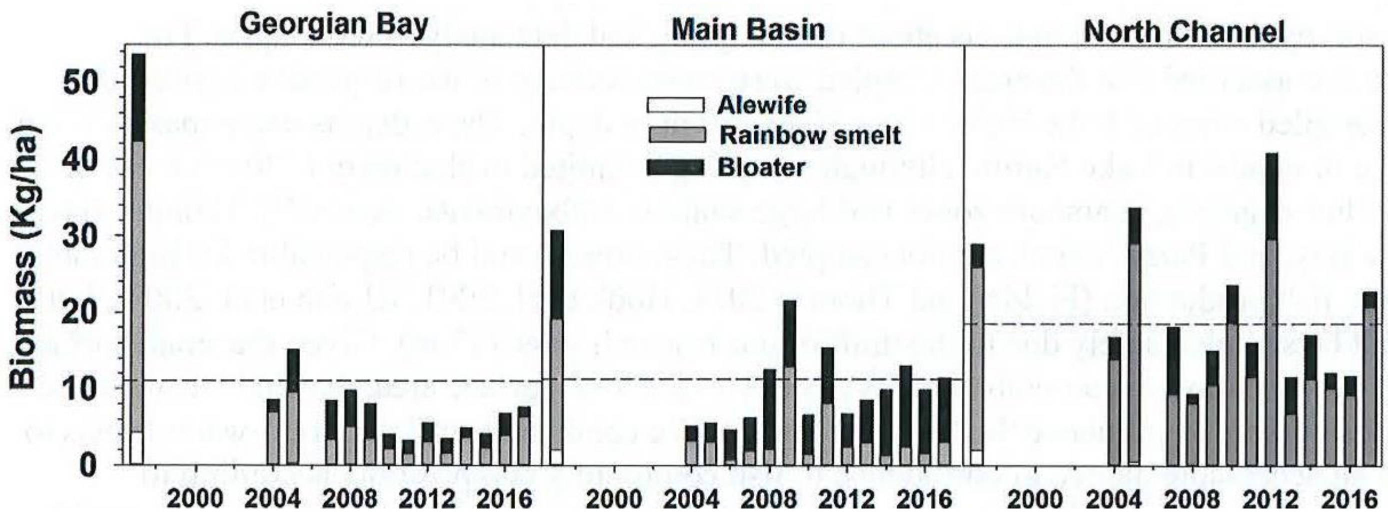
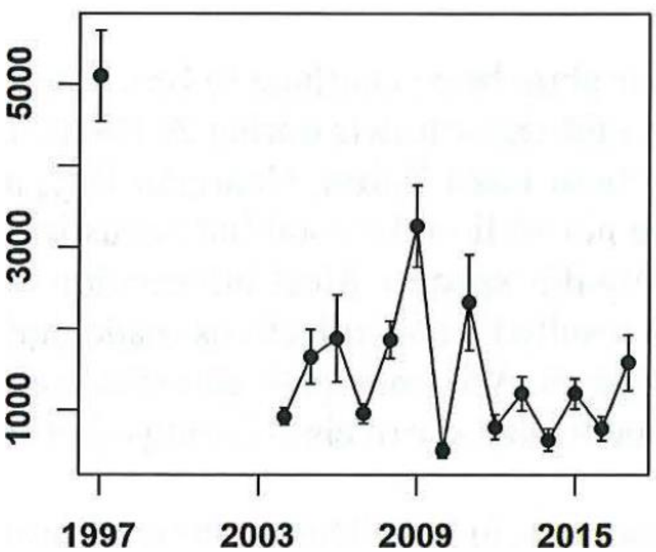


Fig 9-Biomass (kg/ha) of major pelagic fish species in Georgian Bay, main basin, and North Channel during 1997-2017. Horizontal lines denote 1997-2016 mean density.

Lake-wide fish density and biomass

Lake-wide mean pelagic fish density increased from 775 fish/ha in 2016 to 1582 fish/ha in 2017, representing roughly 60% of the long-term mean **(Fig 10).** The 2017 pelagic fish density estimate represented roughly 30% of the 1997 estimate. The 2017 lake-wide mean pelagic fish biomass estimate was 10.4 kg/ha, a 23% increase from 2016. Total standing stock biomass in 2017 was estimated at 49 kt (SE 10.4 kt) **(Fig 10).** The increase in standing stock biomass in 2017 was driven primarily by increased smelt biomass. In general, acoustic estimates of pelagic fish biomass in Lake Huron have been relatively stable between 2004 and 2017.



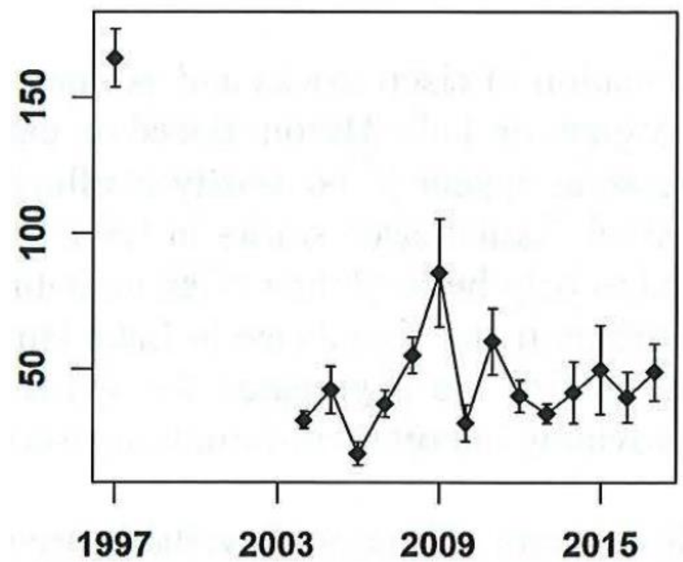


Fig 10-Acoustic and mid-water trawl estimates of lake-wide numeric density (fish/ha; upper panel) and standing stock biomass (kilotonnes; lower panel) in Lake Huron, 1997-2017. Error bars represent ±1 standard error.

Fish population estimates derived from the lake-wide acoustic survey, as with any other type of fishery survey, include assumptions about the sampling and data analysis techniques. For example, we assumed that the areas sampled were representative of the respective basins. This survey sampled areas of Lake Huron from 10 to 250 m in depth. These depths encompass 85% of the range of depths in Lake Huron, although sampling is limited in shallower (<20 m) areas of the lake. For example, nearshore zones and large shallow embayments, especially Thunder Bay, Saginaw Bay, and Parry Sound, are not sampled. These areas could be responsible for high rates of pelagic fish production, but could not be sampled safely due to the draft of our research vessel (3 m). Given the small surface areas of these shallow-water embayments relative to the total surface area, densities would need to be considerable to influence the lake-wide mean. We conducted sufficient mid-water trawls to achieve an acceptable degree of confidence in fish community composition, according to guidelines in Warner et al. (2012). An additional assumption was that fish size was a reasonable proxy for age-0 or age-1 + groupings. We used size to assign age and assumed no overlap in age among size classes. This assumption was likely violated, especially for rainbow smelt. While this might have slight effects on our estimates of age-0 versus age-I+ density and biomass, it would have no impact on our estimates of total density or biomass for a species.

Conclusions

Lake-wide biomass of common pelagic species in Lake Huron continues to consist of primarily bloater and rainbow smelt, with bloater making up more of the biomass in recent years. Distribution of preyfish biomass also continues to be patchy, with high areas of biomass in the North Channel (rainbow smelt) and the southern main basin (bloater). Since 2012, acoustic derived estimates of lake-wide prey fish biomass in Lake Huron have remained relatively stable, with biomass fluctuating by 1-2 kg/ha per year. At the basin level, annual biomass continues to show some variation, but this is mostly for the North Channel.

Better delineation of cisco stocks and estimates of their abundance continue to be a focus of the acoustic program on Lake Huron. Based on catches in mid-water trawls during 2010-2017, cisco in offshore areas appear to be mostly confined to northern Lake Huron, Georgian Bay, and the North Channel. Extant cisco stocks in Lake Huron are not well understood but acoustic surveys have served to help better define offshore habitat use by this species. Most information on cisco spatial distribution and abundance in Lake Huron has resulted from collections made during the late fall when fish are aggregated for spawning purposes. We anticipate acoustic surveys to continue providing important information on ecology and habitat use of cisco during other seasons.

To provide accurate estimates of available prey fish resources in Lake Huron, the continuation of acoustic surveys will be instrumental in assessing the pelagic component of the prey fish community, while complementing bottom trawl surveys that better estimate benthic prey resources. The info1mation gathered from acoustic surveys that sample areas where bottom trawling is not feasible will increase our understanding of variation in prey fish biomass across large temporal and spatial scales (i.e., all of Lake Huron's basins). As no single gear is best for assessing all species, life stages, or habitats, estimates of fish biomass from multiple gear types will lead to a better understanding of fish population dynamics. ✧

Status/Trends of Lake Huron Offshore Demersal Fish Community, 1976-2017 (USGS)

Abstract

The USGS Great Lakes Science Center has conducted trawl surveys to assess annual changes in the offshore demersal fish community of Lake Huron since 1973. Sample sites include five ports in U.S. waters with more recent sampling near Goderich, Ontario. The 2017 fall bottom trawl survey was carried out between 14 and 28 October at all standard ports. The 2017 main basin prey fish biomass estimate for Lake Huron was 20.9 kilotonnes, a decrease of about 21 percent from 2016. This estimate is the third lowest in the time series, and is approximately 6 percent of the maximum estimate observed in 1987. Adult alewife abundance increased over 2016, but remained relatively low. YOY alewife biomass decreased from 2016 and was the fifth-lowest estimate in the time series, although catches varied substantially among ports. The estimated biomass of yearling-and-older rainbow smelt in 2017 was the lowest observed in the time series. YOY rainbow smelt abundance and biomass increased over that observed in 2016 but remained relatively low. Estimated adult bloater biomass was slightly less than the 2016 estimate, while the abundance and biomass estimates for YOY bloater were among the highest of the time series. Biomass estimates for deepwater and slimy sculpins, trout-perch, and ninespine stickleback remained very low compared to historic estimates. The 2017 abundance and biomass estimates for round goby were relatively low and similar to those from 2016.

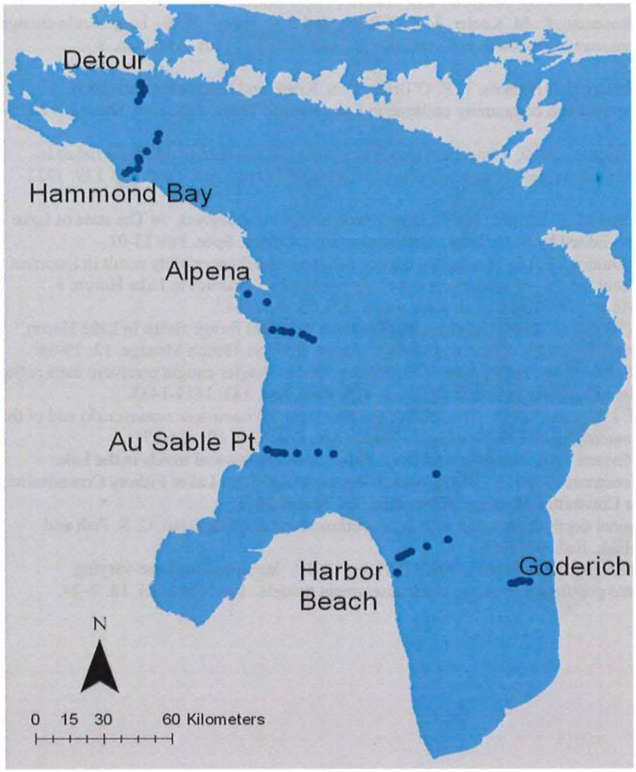


Fig 1-Bottom trawl sampling locations in Lake Huron.

The 2017 Lake Huron fall bottom trawl survey was carried out during 14-28 October. Fortyseven trawl tows were completed and all standard ports were sampled. One standard transect (46 m transect at Detour) was not sampled this year due to the presence of commercial fishing gear in the trawl path. Fifteen fish species were captured in the 2017 survey: rainbow smelt, alewife, bloater, slimy sculpin, deepwater sculpin, trout-perch, Lake whitefish, threespine stickleback, ninespine stickleback, lake trout, round goby, yellow *perch,* round whitefish, white sucker and walleye.

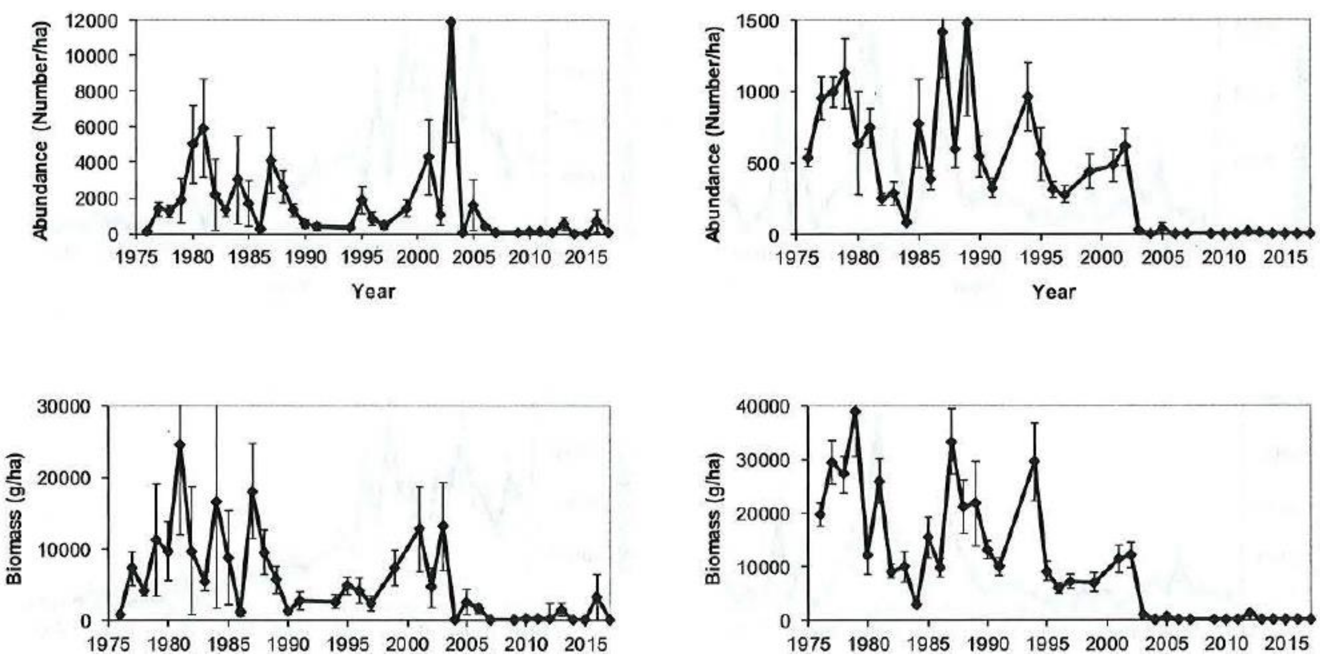


Fig 2-Density of young-of-the-year (YOY: left panels) and adult (YAO: right panels) alewives as number (top panels) and biomass (bottom panels) 6f f~sh per hectare in Lake Huron, 1976-2017.

Alewife abundance in Lake Huron remained relatively low in 2017. The abundance and biomass estimates for yearling and older (YAO) alewife were among the lowest observed in the history of the survey **(Fig. 2).** Age-0 alewife density and biomass during 2017 were much reduced from 2016 and remained low compared to historic estimates (Fig. 2). As in 2016, YOY alewife catches varied spatially, with the majority of the fish captured at the northern port of Hammond Bay, with a few captured at Detour (**Fig. 3).**

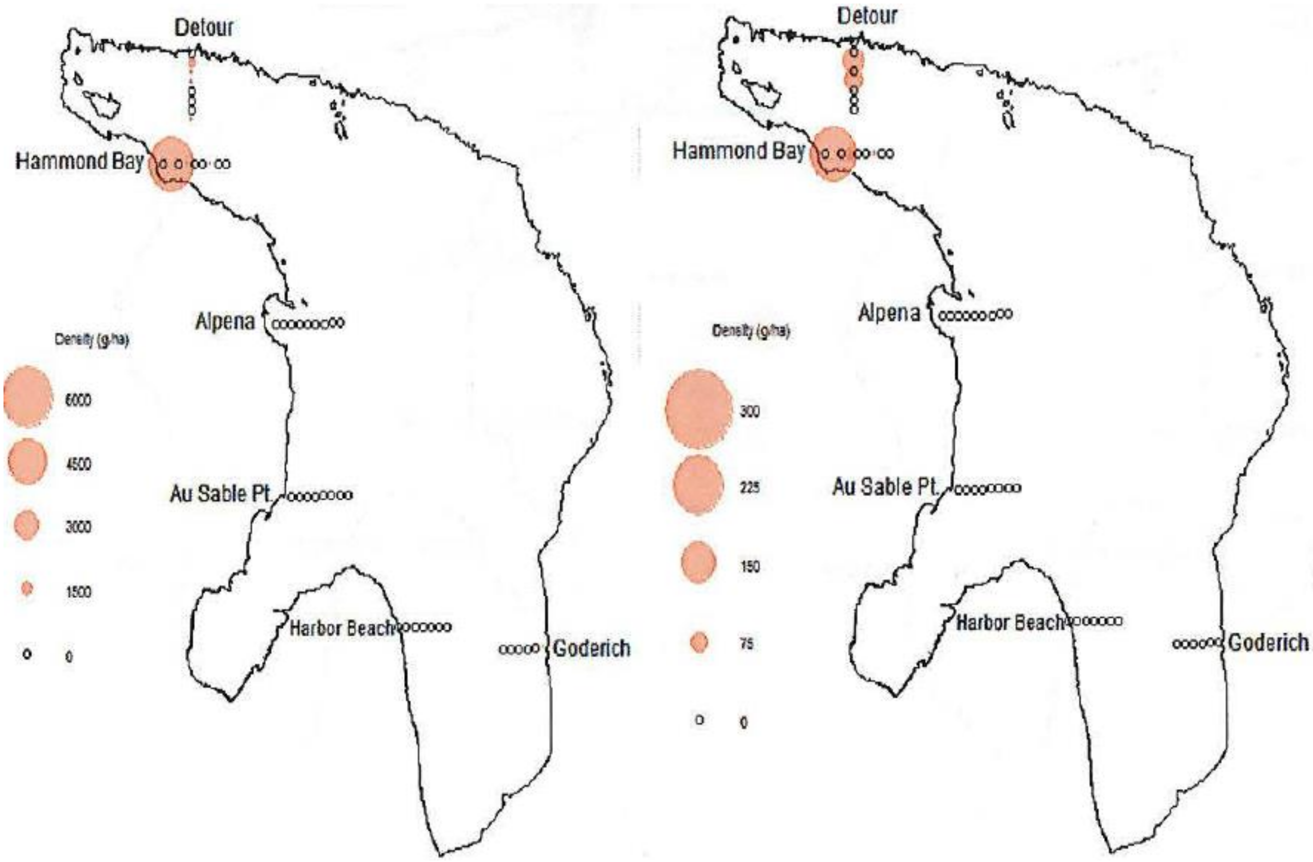


Fig 3-Distribution of catches of young-of-the-year (YOY: left) and adult (YAO: right) alewife in Lake Huron in 201 7.

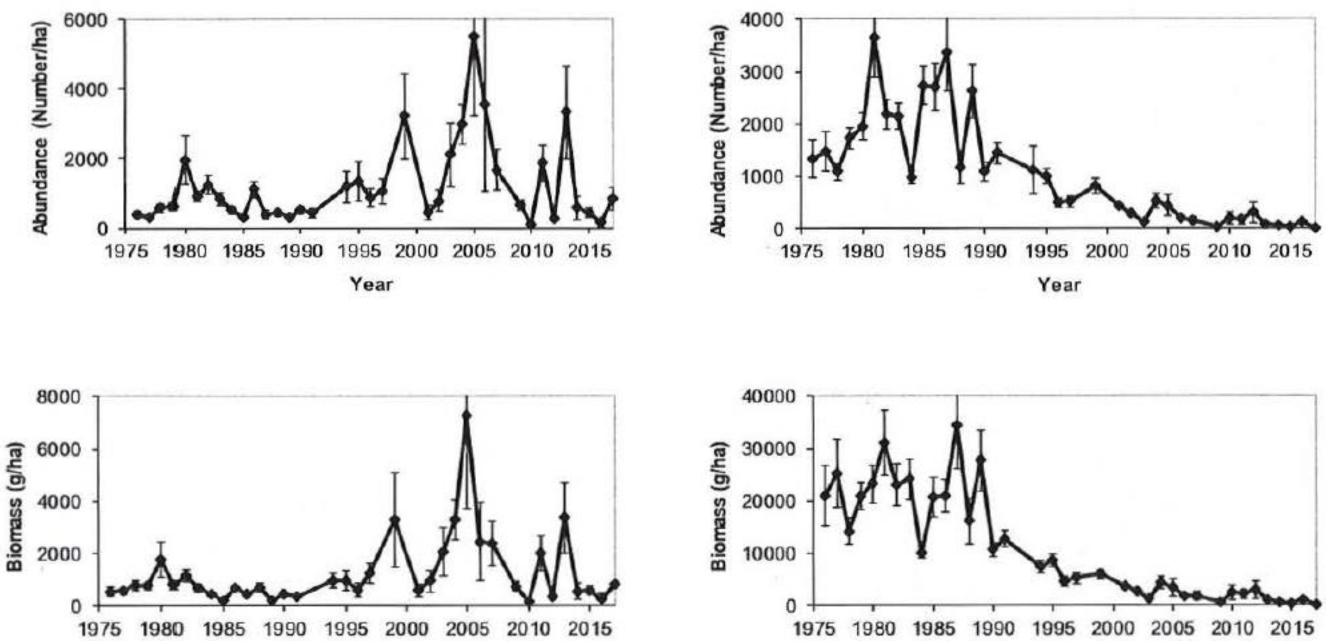


Fig 4-Density of young-of-the-year (YOY: left panels) and adult (YAO: right panels) rainbow smelt as number (top panels) and biomass (bottom panels) of fish per hectare in Lake Huron, 1976-20 17. 1976- 1991 estimates for YAO were c01Tected using fishing power corrections developed by Adams et al. (2009); YOY data are uncorrected. Error bars are 95% confidence intervals.

YAO rainbow smelt abundance and biomass estimates in 2017 were the lowest observed in the time series **(Fig. 4).** YOY rainbow smelt abundance and biomass estimates increased over 2016, but remained relatively low. Both age classes of smelt were most abundant at northern ports (**Fig. 5**). YOY bloater abundance and biomass estimates have been highly variable since 2005, and the 2017 estimates were among the highest in the time series **(Fig. 6)**. YAO bloater abundance and biomass reached peaks in 2012 and have declined steadily since; 20 17 estimates were the lowest observed since 2007 **(Fig. 6).** Most YOY bloater were captured at Hammond Bay, while YAO fish were most abundant at Goderich and Harbor Beach (**Fig. 7)**.

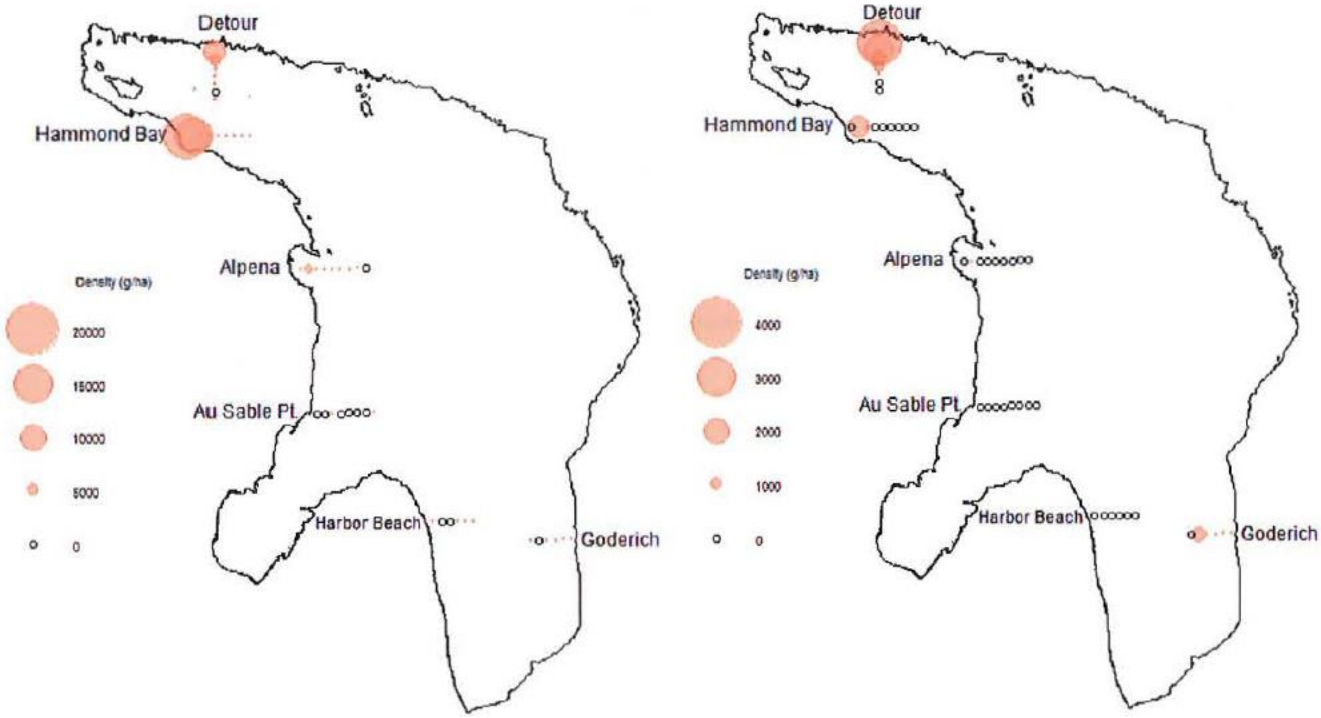


Fig 5-Distribution of catches of young-of-the-year (YOY: left) and adult (YAO: right) rainbow smelt in Lake Huron in 2017.

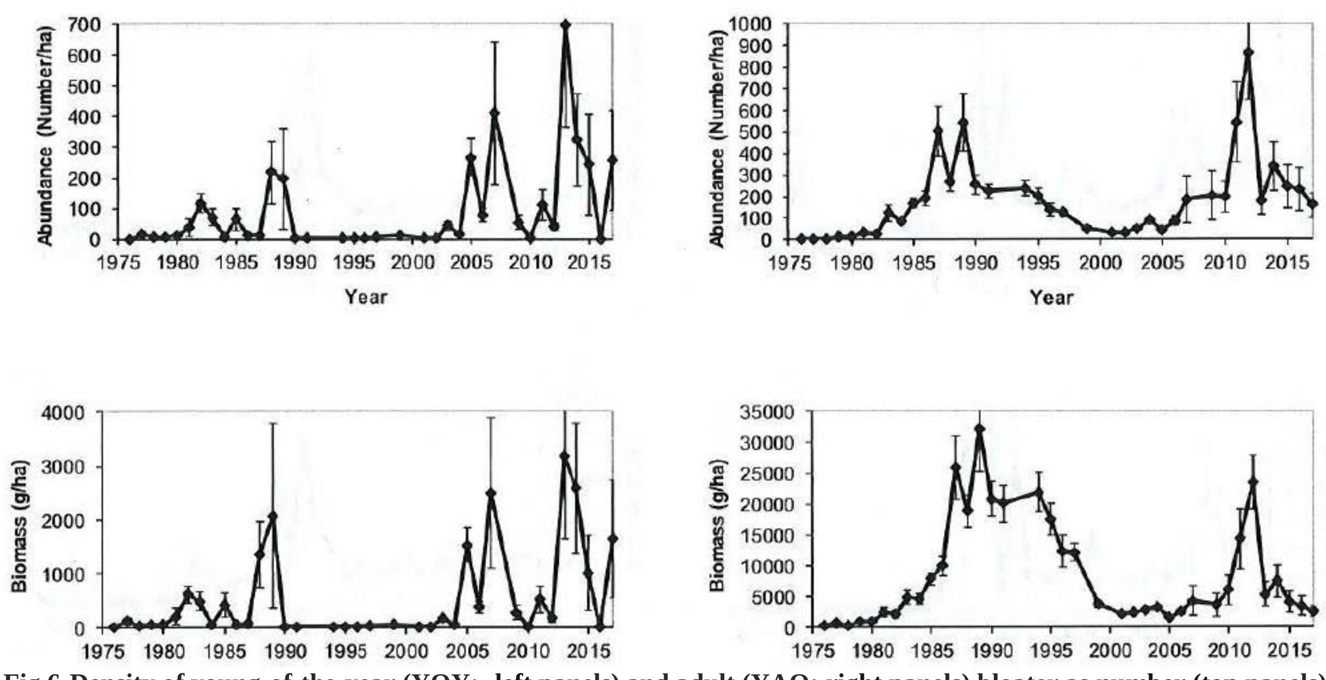


Fig 6-Density of young-of-the-year (YOY: -left panels) and adult (YAO: right panels) bloater as number (top panels) and biomass (bottom panels) _of fish per hectare in Lake Huron, 1976-2017.

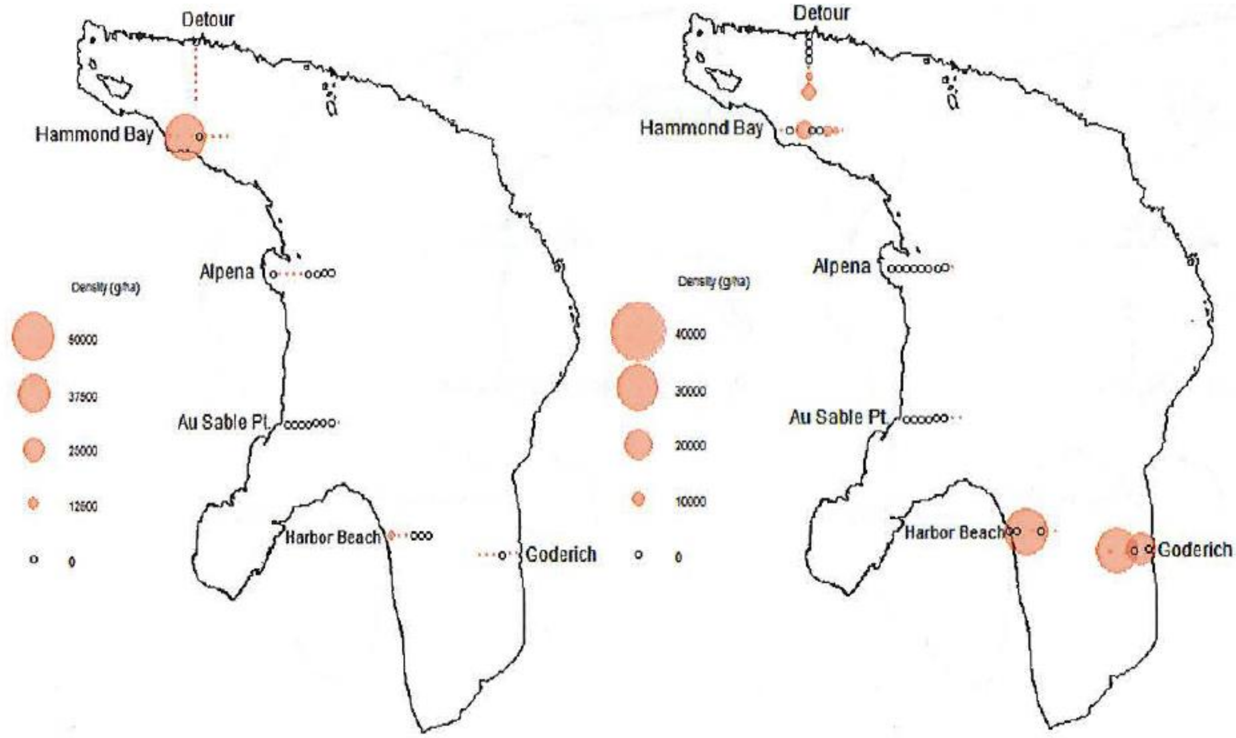


Fig 7-Distribution of catches of young-of-the-year (YOY: left) and adult (YAO: right) bloater in Lake Huron in 2017.

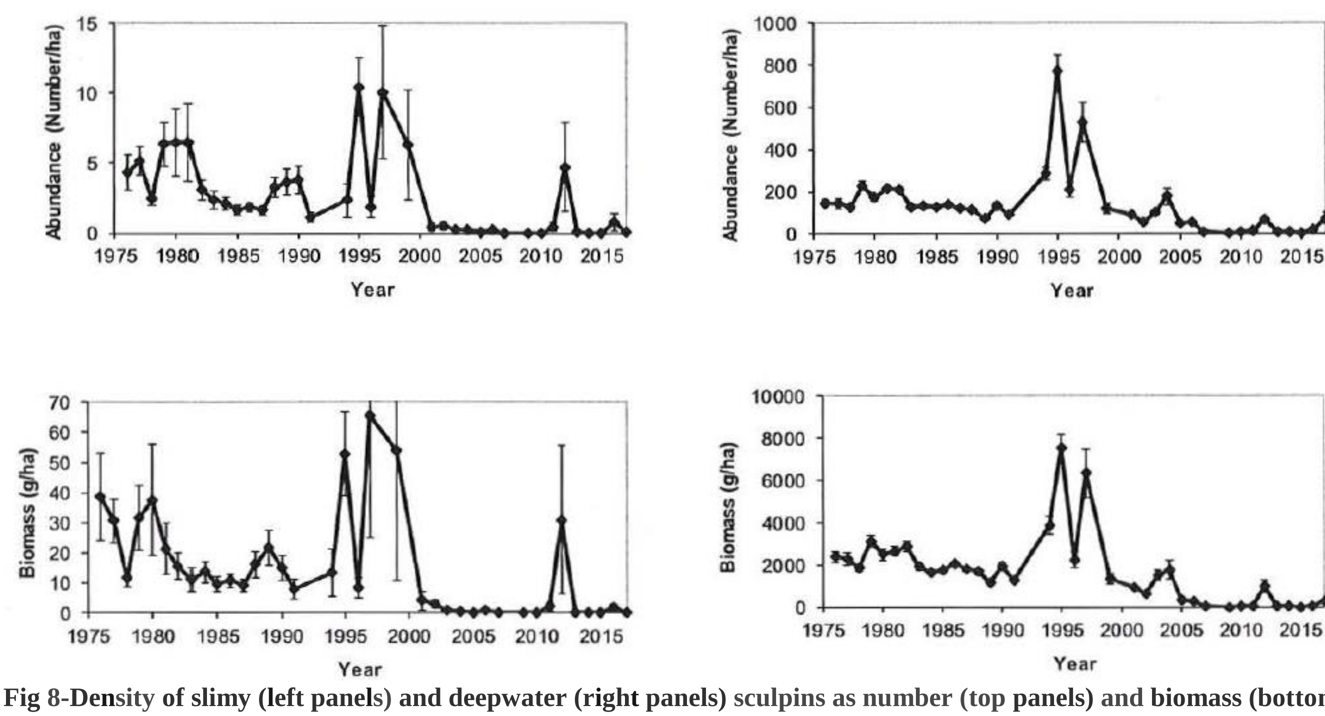


Fig 8-Density of slimy (left panels) and deepwater (right panels) sculpins as number (top panels) and biomass (bottom panels) of fish per hectare in Lake Huron, 1976-2017. 1976- 1991 estimates were corrected using fishing power corrections developed by Adams et al. (2009).

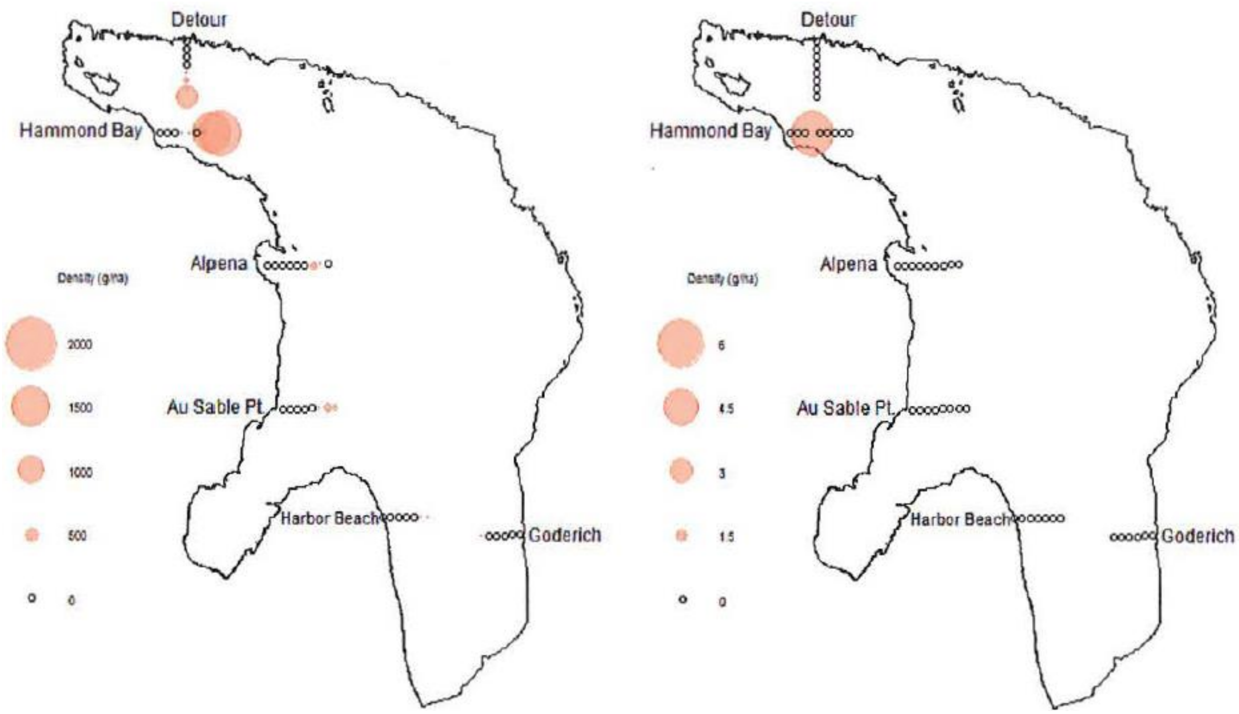


Fig 9-Distribution of catches of deepwater sculpin (left) and slimy sculpin (right) in Lake Huron in 20 17.

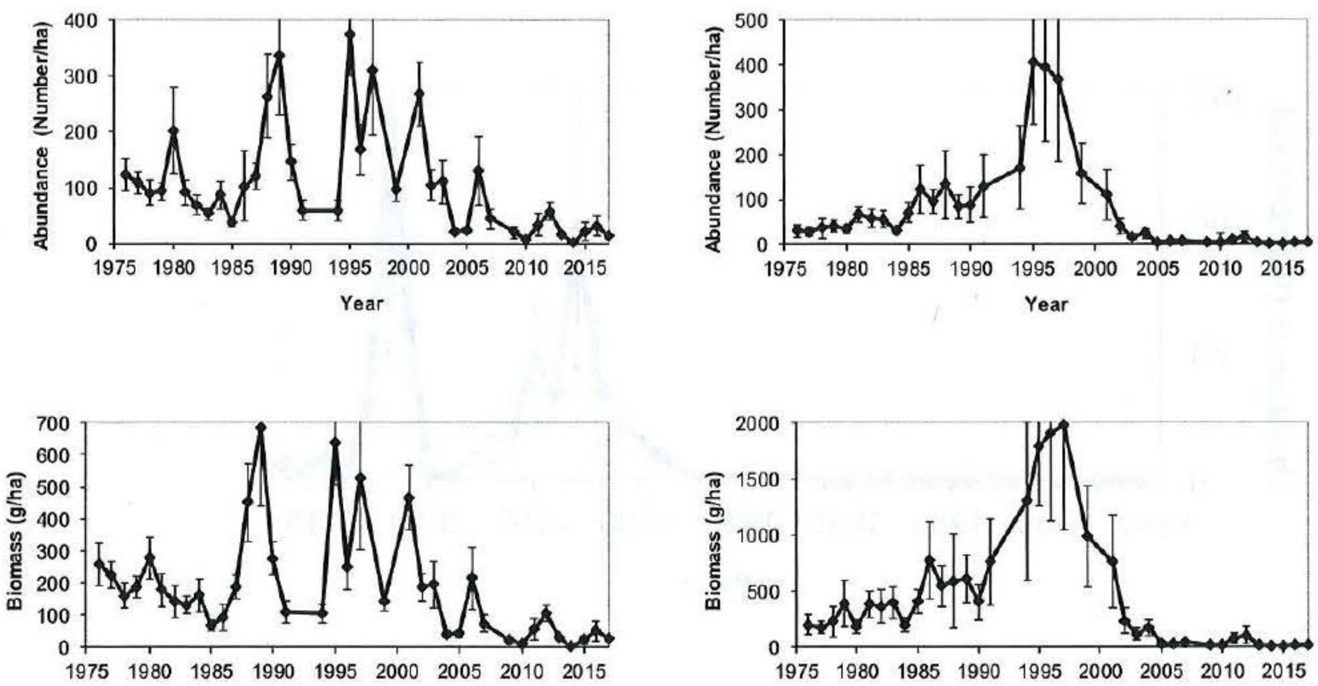


Fig 10-Density of ninespine stickleback (left panels) and trout-perch (right panels) as number (top panels) and biomass (bottom panels) of fish per hectare in Lake Huron, 1976-2017..

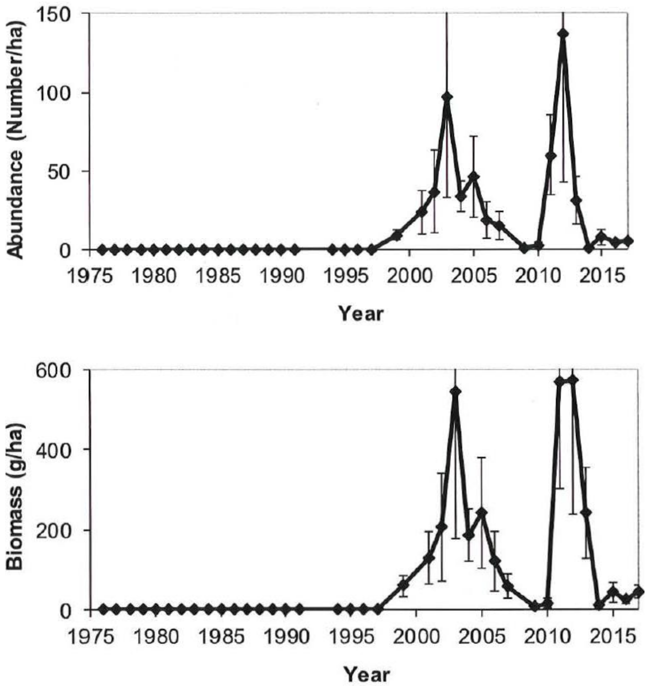


Fig 11-Density of round goby as number (top panel) and biomass (bottom panel) of fish per hectare in Lake Huron, 1976-20 17.

Slimy sculpin abundance and biomass estimates in 2017 decreased from the 2016 estimates and remained relatively low compared to historic estimates **(Fig. 8**). The abundance estimate for deepwater sculpin in 2017 was the highest observed since 2004, while the biomass estimate was the highest since 2012 (**Fig. 8**). Deepwater sculpins were most abundant at deep transects at Hammond Bay and Detour, while slimy sculpins were captured only at Hammond Bay (**Fig. 9).** The 2017 abundance and biomass estimates for ninespine stickleback and trout-perch decreased slightly from previous years (**Fig. 10).** Round go by abundance and biomass estimates for 2017 increased slightly over 2015 levels and remained among the lowest estimates in the time series **(Fig. 11).**

The total main basin prey biomass estimate (5 - 114 m) in 2017 was 20.9 kilotonnes, a decrease of about 21 percent from the 2016 estimate **(Fig. 12).** This estimate is the third-lowest in the time series, similar to the extreme low estimates that occurred during 2009-2010, and represents approximately 6 percent of the maximum lake-wide biomass estimate observed in 1987. Approximately 40 percent of the 2017 biomass estimate was composed of YAO bloater.

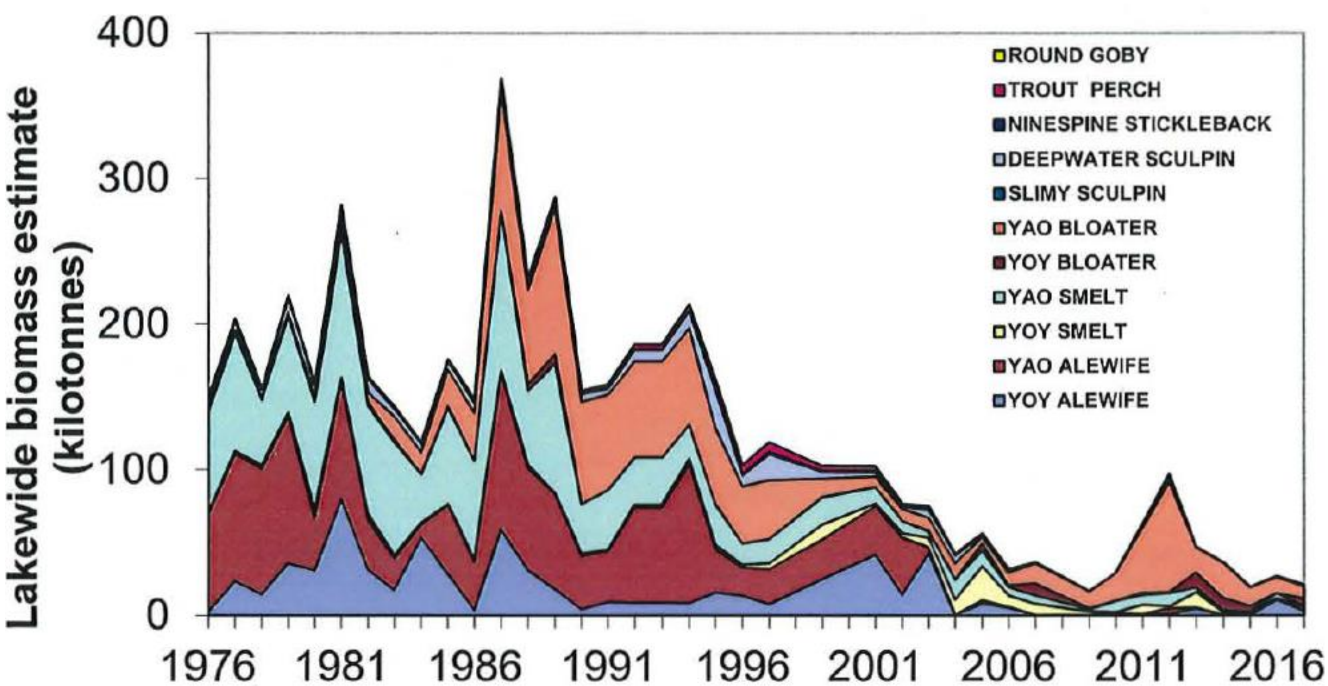


Fig 12-Offshore demersal fish community biomass in the main basin of Lake Huron, 1976-2017.Valid data were not collected in 1992, 1993, 1998, 2000, and 2008; biomass estimates for those years represent interpolated values.

The abundance of prey fish in Lake Huron has remained at low levels since the collapse of the offshore demersal fish community in 2004, although survey catches in 2012 suggested that several species were beginning to increase in abundance. The estimated lake-wide biomass of prey fish in 2012 was the highest observed since 2001, but has declined since and remains among the lowest observed. Biomass estimates for YAO rainbow smelt and alewife in 2017 were also among the lowest observed in the history of the survey. The collapse of alewife in the lake may have been precipitated by an extremely cold winter, but was likely ultimately caused by bottom-up controls due to reduced production at all trophic levels, which may have been related to the invasion of dreissenid mussels, and also by predators such as lake trout and Chinook salmon (Kao et al. 2016). The persistence of low abundance estimates for exotic alewife and rainbow smelt is consistent with fish community objectives for Lake Huron (DesJardine et al. 1995), but does not bode well for Chinook salmon populations in the lake (Roseman and Riley 2009), which rely heavily on these species as prey.

YAO bloater showed a consistent positive trend in biomass for 2009-2012, but the 2013 estimate was much reduced from 2012, and while 2014 showed a modest increase over the 2013 levels, biomass has continued to decline since and remains relatively low. The abundance of this native species is currently at a moderate level, higher than the extreme low estimates observed in 2001-2006. YAO bloater biomass, however, is currently at low levels comparable to estimates observed during 2001-2006. Decreases in body condition of bloater may be associated with declines in abundance of lipid-rich prey, including *Diporeia* spp., in the lake.

Deepwater and slimy sculpins, ninespine sticklebacks, and trout-perch are typically minor components of lake trout diets in the Great Lakes, but were probably more important before the invasion of the lakes by alewife, rainbow smelt and round goby. In 2017, biomass estimates for all of these species remained very low compared to historical estimates. Round goby have become a significant part of lake trout diets in some areas of the Great Lakes, including Lake Huron. Round goby were first captured in the Lake Huron trawl survey in 1997, reached a peak in abundance in 2003, and declined in abundance until increasing again in 2011-2012. Our results suggest that they are currently at a moderate to low level of abundance in the offshore waters of Lake Huron, although sharp fluctuations in the time series indicate that abundance estimates for this species may be particularly sensitive to various environmental factors. Moreover, round gobies primarily inhabit nearshore areas and tend to be most common on rocky substrates, and the Lake Huron bottom trawl survey may not provide a robust estimate of their relative abundance or biomass in the lake.

The estimated lake-wide biomass of common offshore prey species in Lake Huron increased from 2009 - 2012, but has generally decreased through 2017, and lake-wide biomass is currently very low and similar to the lowest estimates that occurred in 2006-2009. The peak estimated biomass of prey fish in Lake Huron occurred in the late 1980s, and has declined steadily since then; a similar decline has occurred in Lake Michigan and Lake Ontario. It is possible that these declines are associated with the invasion of the lakes by several exotic species, including the spiny water flea *(Bythotrephes)*, zebra mussels, quagga mussels, and round gobies, all of which have been introduced since the mid-1980s. However, similar declines in some species (particularly coregonines) have occurred in Lake Superior, which has been less impacted by invasive species.

Fish abundance estimates reported here are likely to be negatively biased, primarily due to variability in the catchability of fish by the trawl, which may reflect the vulnerability of fish to the gear and/or the distribution of fish off the bottom. Many individuals of some demersal species may be pelagic at certain times and not available to our trawls, particularly young-of-the-year alewife, rainbow smelt, and bloater. Results reported here should therefore not be interpreted as absolute abundance ~stimates for any species (see Riley and Dunlop 2016).

Some of the fluctuations in the estimated abundance of individual species may be a result of changes in catchability caus<?d by altered fish distributions. For example, catchability of a given species might differ from year to year due to changes in temperature or food distribution, and observed changes in abundance might result from fish becoming less vulnerable to bottom trawls in recent years. Time varying catchability is common in survey gear, and understanding how bottom-trawl catchability changes through time may provide insight Into our estimates of prey fish biomass. The invasion of Lake Huron by dreissenid mussels may also have affected the efficiency of the traw1, as has been observed in Lake Ontario. Data reported here were collected at a restricted range of depths in areas that were free of obstructions with sandy or gravel substrates, and it is therefore possible that USGS trawl data do not fully characterize the offshore demersal fish community. There are no other published long-term data on offshore demersal fish abundance in Lake Huron that would allow us to investigate the representativeness of the trawl data. Despite the foregoing constraints, however, these data are currently the best available to assess trends in the Lake Huron offshore fish community. ✧

Sea Lamprey Control in Lake Huron 2017(USFWS)

Introduction

This report summarizes Sea Lamprey control activities conducted by Fisheries and Oceans Canada (Department) and the United States Fish and Wildlife Service (Service) as agents of the Great Lakes Fishery Commission (Commission) in Lake Michigan during 2017. The Sea Lamprey is a destructive invasive species in the Great Lakes that contributed to the collapse of Lake Trout and other native species in the mid-20th century and continues to affect efforts to restore and rehabilitate the fish-community. Sea Lampreys subsist on the blood and body fluids of large-bodied fish. It is estimated that about half of Sea Lamprey attacks result in the death of their prey and up to 18 kg (40 lbs) of fish are killed by every Sea Lamprey that reaches adulthood. The Sea Lamprey Control Program (SLCP) is a critical component of fisheries management in the Great Lakes because it facilitates the rehabilitation of important fish stocks by significantly reducing Sea Lamprey-induced mortality.

Lake Huron has 1,761 tributaries (1,334 Canada, 427 U.S.). One hundred twenty-seven tributaries (59 Canada, 68 U.S.) have historical records of larval Sea Lamprey production. Of these, 84 tributaries (38 Canada, 47 U.S.) have been treated with lampricide at least once during 2008-2017. Forty-five tributaries (22 Canada, 24 U.S.) are treated every 3-5 years. Details on lampricide applications to Lake Huron tributaries and lentic areas during 2017 are found in **Fig 1**.

• Lampricide applications were completed in 16 tributaries (9 Canada, 7 U.S.), 1 lentic areas (0 Canada, 1 U.S.) and 346 ha of the St. Marys River (see Table 1). Two St. Marys River plots were re-ranked based on a 75% reduction during the first treatment and were re-treated to remove residual Sea Lamprey larvae.

• Sand Creek, on Cockburn Island, was treated during 2017 due to the presence of residual Sea Lamprey larvae.

• Treatments of the Garden and Mississagi rivers were deferred to 2018.

• The Still River was treated for the first time in 21 years and many Sea Lampreys were observed during treatment.

• Silver Creek was re-treated in 2017 due to the presence of residual Sea Lamprey from the 2016 treatment.

• Myers Creek (Cheboygan River) was treated for the first time since 1999.

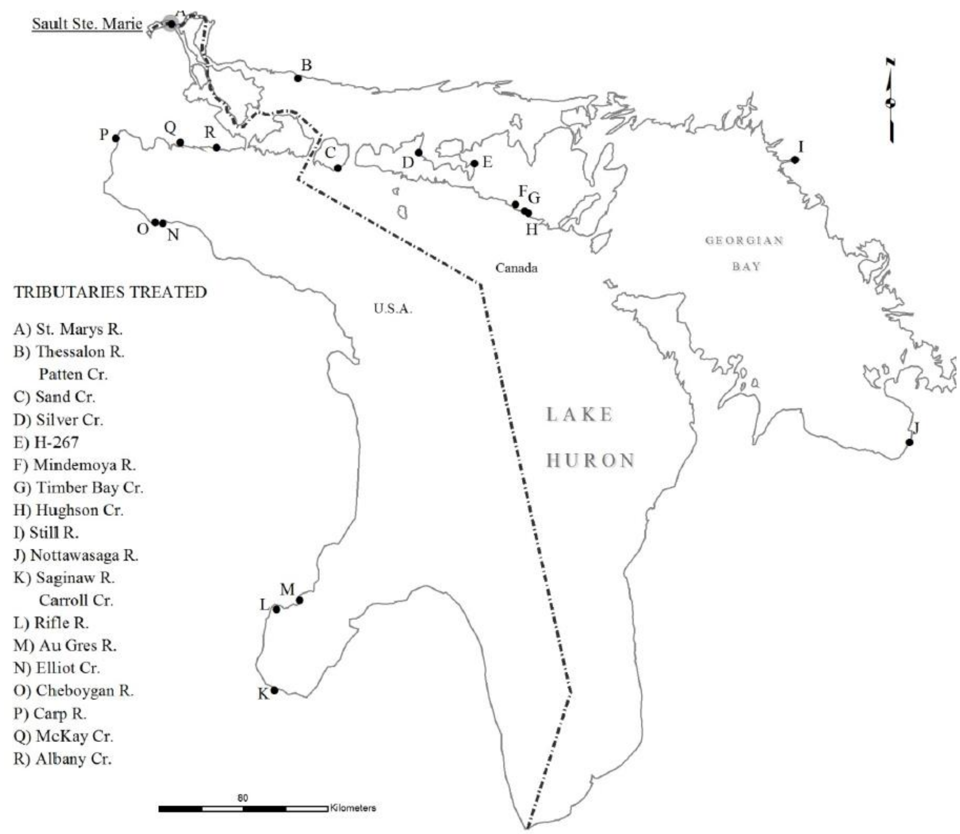


Fig 1- Location of Lake Huron tributaries treated with lampricides during 2017.

Barriers

The Sea Lamprey barrier program priorities are to:

1) Operate and maintain existing Sea Lamprey barriers that were built or modified by the SLCP.

2) Ensure Sea Lamprey migration is blocked at important non-SLCP barrier sites.

3) Construct new structures in streams where they:

a. provide a cost effective alternative to lampricide control;

b. provide control where other options are impossible, excessively expensive, or ineffective;

c. improve cost effective control in conjunction with attractant and repellent based control, trapping, and lampricide treatments; and

d. are compatible with a system's watershed plan.

The Commission has invested in 17 barriers on Lake Huron **(Fig 2).** Of these, 13 were purpose built as Sea Lamprey barriers and 4 were constructed for other purposes, but have been modified to block Sea Lamprey migrations. Data gathered during field visits to assess the status of other dams and structures were recorded in the SLCP's Barrier Inventory and Project Selection System (BIPSS) and may be used to: 1) select barrier projects; 2) monitor inspection frequency; 3) schedule upstream larval assessments; 4) assess the effects of barrier removal or modifications on Sea Lamprey populations, or; 5) identify structures that are important in controlling Sea Lampreys.

• Field crews visited 12 structures on tributaries to Lake Huron to assess Sea Lamprey blocking potential and to improve the information in the BIPSS database.

• Routine maintenance, spring start-up, and safety inspections were performed on 11 barriers (5 Canada, 6 U.S.).

• Repairs or improvements were conducted on one Canadian barrier:

• Echo River – Replacement of the existing sea lamprey trap to improve function and safety is underway at the Echo River barrier. Construction is expected to be completed by September 30, 2018.

• The electrical field of the combination low-head/electrical barrier in the Ocqueoc River was active from March 25 until August 27. The barrier was electrified for most of March and April when water levels inundated the low-head barrier.

• Fish community assessment surveys were conducted in the upper Nottawasaga watershed. This work was conducted as a monitoring component of the Nicolston Dam Rehabilitation Project.

➢Cheboygan River – Plans to block adult Sea Lampreys at the Cheboygan lock and dam complex and to eradicate lampreys from the upper river included:

▪ Control and research agents continued discussion with the U.S. Army Corps of Engineers (USACE) and the Michigan Department of Natural Resources (MIDNR) regarding alternatives for preventing Sea Lamprey passage at the Cheboygan River lock. The MIDNR is pursuing a refurbishment of the aging structure and the federal partners are interested in making the lock "lamprey proof" using Great Lakes Fishery and Ecosystem Restoration (GLFER) funding through the USACE.

▪ A total of 3,680 sterilized male Sea Lampreys were released upstream of the Cheboygan Dam during 2017 as part of a research project testing an eradication hypothesis using Sterile Male Release Technique.

▪ Fyke nets were deployed in the Pigeon, Sturgeon, and Maple rivers during 2017. Two unmarked lamprey were captured in the Pigeon, one in the Sturgeon, and zero in the Maple. Fin clipped sterile males were also released in these rivers: 1,425 in the Pigeon, 1,425 in the Sturgeon, and 830 in the Maple. Fyke nets recaptured sterile males at the following rates in these rivers: 29% in the Pigeon, 28% in the Sturgeon, and 60% in the Maple. Results are consistent with previous netting efforts between 2013-2016 suggesting the abundance of adult sea lamprey in the streams is very low (less than 50). Some of the sterile males in the Pigeon River were recaptured in a trap integrated with resistance weir panels (n=25), but nets were generally more efficient. A modified trap and resistance weir panel will be installed during 2018. The sterile male evaluation study is expected to take place during 2017-2020.

➢ Saugeen River – The Saugeen Ojibway Nation (SON) and Commission entered into an agreement to rehabilitate Denny's Dam to maintain its Sea Lamprey control function. Reconstruction began during 2017 and will be completed in 2018. DFO-SLCC is providing funding through the Federal Infrastructure Initiative for this project.

➢ Nottawasaga River – Reconstruction of Nicolston dam began during 2017 under Canada's Federal Infrastructure Initiative. The work, including rehabilitation of the auxiliary and main spillways, abutments, and headwalls, will be completed in 2018.

➢ Consultations to ensure blockage at barriers were completed with partner agencies for 24 sites in 8 streams during 2017.

New Construction

• Pine River (Nottawasaga River tributary) – An engineering consulting firm was contracted under Canadian Federal Infrastructure Initiative funding to prepare detailed design, specifications and construction drawings for a Sea Lamprey Barrier proposed within the boundaries of Canadian Forces Base Borden, near Angus, Ontario. The design phase will be completed in 2018, however; there are no immediate plans for construction.

Experimental barriers

• A next generation low voltage electrical fish barrier was deployed seasonally (March –August) near the mouth of Black Mallard Creek (near Hammond Bay, MI) during 2016 and 2017 to block adult Sea Lampreys and eliminate the need for the next scheduled treatment during 2019. Although no adult Sea Lamprey were captured or observed above the barrier during 2016 and 2017, assessment crews from the Service found sea lamprey larvae in the river from the 2015, 2016, and 2017 year classes. The electrical barrier with modified design will be tested again during 2018, but the stream will likely require lampricide treatment on a normal schedule.

Larval Assessment

Tributaries considered for lampricide treatment during 2018 were assessed during 2017 to define the distribution and estimate the abundance and size structure of larval Sea Lamprey populations. Assessments were conducted with backpack electrofishers in waters <0.8 m deep, while waters ≥0.8 m in depth were surveyed with gB or by deep-water electrofishing (DWEF). Additional surveys are used to define the distribution of Sea Lampreys within a stream, detect new populations, evaluate lampricide treatments, evaluate barrier effectiveness, and to establish the sites for lampricide application.

• Larval assessments were conducted on 113 tributaries (57 Canada, 56 U.S.) and 20 lentic areas (14 Canada, 6 U.S.).

• Surveys to estimate abundance of larval Sea Lampreys were conducted in 22 tributaries (12 Canada, 10 U.S.) and 6 lentic areas (5 Canada; 1 U.S.).

• Surveys to detect the presence of new larval Sea Lamprey populations were conducted in 30 tributaries (16 Canada; 14 U.S.). No new infestations were identified.

• Post-treatment assessments were conducted in 26 tributaries (13 Canada; 13 U.S.) and in 1 lentic area (0 Canada; 1 U.S.) to determine the effectiveness of lampricide treatments during 2016 and 2017. The Carp River and McKay Creek are scheduled for treatment during 2018 based on the presence of residual Sea Lampreys.

• Surveys to evaluate barrier effectiveness in 7 tributaries (2 Canada; 5 U.S.) revealed no evidence of escapement.

• Monitoring of larval Sea Lampreys in the St. Marys River continued during 2017. With the use of deepwater electrofishers, 921 geo-referenced sites were sampled. Surveys were conducted according to a stratified, systematic sampling design. The larval Sea Lamprey population in the St. Marys River was estimated to be 2,320,000 (95% CI; 1,300,000 – 3,300,00).

• Larval assessments were conducted in non-wadable lentic and lotic areas using 42.83 kg active ingredient of gB (28.0 kg Canada; 14.83 U.S.; **Table 1).**

Tributary	Bayluscide (kg)1	Area Surveyed
Canada		
Echo R.	0.84	0.15
Bar R.	0.56	0.1
Koshkawong R.	0.84	0.15
Thessalon R.	1.4	0.25
Lauzon R.	0.28	0.05
Marcellus Cr.	0.28	0.05
Serpent R.	0.56	0.1
Spanish R.	2.8	0.5
Whitefish R.	0.84	0.15
Blue Jay Cr.	2.24	0.4
French R.	2.24	0.4
Key R.	2.24	0.4
Magnetawan R.	1.96	0.35
Shebeshekong R.	0.84	0.15
Seguin R.	0.56	0.1
Boyne R.	1.4	0.25
Squirrel Cr.	0.28	0.05
Moon R.	1.12	0.2
Musquash R.	1.12	0.2
Simcoe/Severn Waterway	1.68	0.3
Nottawasaga R.	1.12	0.2
Bighead R.	1.68	0.3
Saugeen R.	1.12	0.2
Total (Canada)	**28.0**	**5.0**
United States		
Charlotte River	1.51	0.27
Caribou Creek	2.32	0.41
Pine River	2.32	.41
Cheboygan R.	3.36	0.60
HBBS Cr.	1.68	0.30
Black River	0.84	0.15
Ausable River	1.12	0.20
Saginaw R.	1.68	0.30
Total (United States)	**14.83**	**2.64**
Total for Lake	**42.83**	**7.64**

Table 1- Applications of granular Bayluscide to tributaries and lentic areas of Lake Huron for larval assessment purposes during 2017.

Juvenile Assessment

• Lake Trout marking data for Lake Huron are provided by the Michigan Department of Natural Resources, Chippewa-Ottawa Resource Authority, U.S. Geological Survey, and OMNRF. The data was analyzed by the Service's GBFWCO.

• The number of A1-A3 marks on Lake Trout from spring assessments in 2017 were submitted in February 2018 and have yet to be analyzed.

• Based on standardized spring assessment data, the marking rate during 2016 was 4.0 A1-A3 marks per 100 Lake Trout >532 mm. The marking rate had been greater than the target of 5 per 100 Lake Trout since 1983 but has decreased to less than the target for the first time in the time series.

• Marking rates on Lake Whitefish and ciscoes have been increasing and these species may be important initial hosts for juvenile Sea Lampreys.

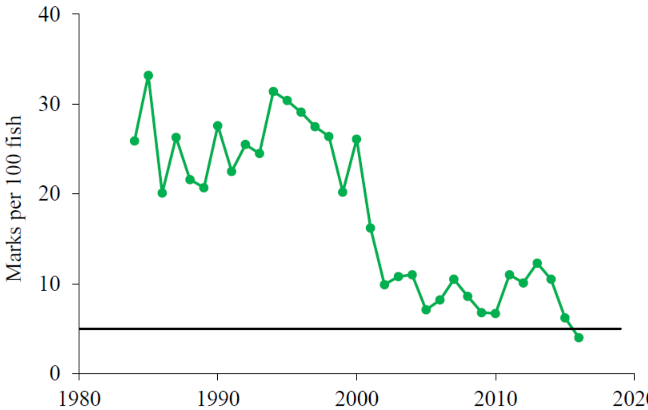


Fig 2- Northern Lake Huron commercial fisheries index showing CPUE (number of parasitic juvenile Sea Lampreys per km of gillnet per night) for 1984-2016.

Adult Assessment

• A total of 22,215 Sea Lampreys were trapped in six tributaries, all of which are index locations. Adult population estimates based on mark-recapture were obtained from all six tributaries.

• The index of adult Sea Lamprey abundance was 36,269 (95% CI; 31,928 – 40,609), which is higher than the index target of 24,113**.** The index target was estimated as 0.25 times the mean of indices between 1989 and 1993.

• A total of 2,861 adult Sea Lampreys were captured in traps operated in the St. Marys River at the Clergue Generating Station in Canada, and the USACE and Cloverland Electric plants and compensating gates in the U.S. The estimated population in the river was 7,803 adult Sea Lampreys and trapping efficiency was 37%.

• The USACE continued planning for trap improvement projects at the St. Marys, Au Sable, and East Au Gres rivers under GLFER.

• The SLCP assisted Michigan State University with EPA-funded Sea Lamprey alarm substance field trials on the Ocqueoc River. The team tested whether the natural Sea Lamprey alarm cue (a repellent) may be combined with the partial pheromone 3kPZS (an attractant) in a Push-Pull configuration to guide migrants into a trap in a free-flowing river channel (i.e., a trap not associated with a barrier). The work will continue in 2017.

• The SLCP assisted University of Guelph researchers with a project aimed at understanding adult Sea Lamprey behaviour near traps on the St. Marys River. Two hypotheses are being tested to explain why many Sea Lampreys that encounter traps do not enter them. Entrance rates may be influenced by: a) the local hydrodynamic conditions at the traps when Sea Lampreys encounter them or b) differences in behaviour among individual Sea Lampreys. Researchers are first screening Sea Lampreys for "behavioural type", tagging and releasing them, monitoring their behavior near traps with PIT tagging equipment, and measuring water flows.

• The SLCP assisted United States Geological Survey researchers in Hammond Bay, Michigan with the first year of a study to test the sterile male release technique in the upper Cheboygan River tributaries (Pigeon, Sturgeon and Maple). The overall goal is to delay or eliminate the need to treat these tributaries with lampricides. In May and June 2017, over 2,500 male sea lamprey captured in traps were sterilized and released into these three tributaries. Similar numbers will be sterilized and released in 2018 and 2019, and the larval assessment will occur in 2019 to determine if treatment is required in 2020.

Tributary	Number Caught	Adult Estimate	Trap Efficiency (%)	Number Sampled[1]	Percent Males[2]	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
Canada									
St. Marys R. (A)	2,861	7,803	37	57	65	493	493	263	275
Echo R. (B)	3,035	7,213	42	85	65	499	491	261	261
Thessalon R. (C)									
Bridgeland Cr.	1,668	2,042	82	---	---	---	---	---	---
Total or Mean (Canada)	**7,564**	---	---	**142**	**65**	**496**	**492**	**262**	**267**
United States									
East Au Gres R. (D)	424	1,542	27	30	60	497	460	261	223
Ocqueoc R. (E)	1,782	2,539	70	114	51	476	479	240	241
Cheboygan R. (F)	12,445	15,130	82	633	54	490	495	242	258
St. Marys R. (A)	See Canada	30	60	495	497	300	279		
Total or Mean (U.S.)	**14.651**	---	---	**810**	**54**	**488**	**491**	**245**	**255**
Total or Mean (for Lake)	**22,215**	---	---	**952**	**56**	**490**	**491**	**248**	**256**

Table 2- Information regarding adult Sea Lampreys captured in assessment traps or nets in tributaries of Lake Huron during 2017.✧

Lake Superior

Highlights

- Whitefish, Smelt, Bloater, Longnose Sucker, and lean Lake Trout were the species with the highest lakewide average biomass.
- Nearshore average larval *Coregonus* densities in 2017 were greater than observed in any previous year.
- Offshore larval *Coregonus* densities were much less than observed in previous years.
- Nearshore water temperatures in 2017 were near the long-term average.
- Lakewide nearshore biomass of Cisco was similar to that observed the past two years.
- Lakewide nearshore biomass for Bloater was 0.5 kg/ha, below the long-term average of 1.6 kg/ha.
- Lakewide nearshore biomass for Lake Whitefish was 1.1 kg/ha,less than the long-term average of 2.1 kg/ha.
- Lakewide nearshore biomass for Rainbow Smelt was 0.9 kg/ha, similar to the long-term average of 1.2 kg/ha.
- Lakewide nearshore biomass for Sculpin was 0.01 kg/ha, below the long-term average of 0.06 kg/ha.
- Lean Lake Trout biomass was 0.2 kg/ha, less than the long-term average and median of 0.3 kg/ha.
- Siscowet Lake Trout nearshore biomass was 0.1 kg/ha, similar to the long-term average and median of 0.1 kg/ha.
- Offshore water temperatures were cooler than average (2011-2017) and warmer than observed in 2014 and 2015.
- Lakewide offshore biomass in 2017 (3.7 kg/ha) for siscowet Lake Trout was greater than the long-term mean (3.0 kg/ha).
- Lakewide average biomass of Deepwater Sculpin in 2017 (2.0 kg/ha) was similar to the long-term average (2.0 kg/ha.
- Lake Superior has 1,566 tributaries (833 Canada, 733 U.S.).
- One hundred sixty-five tributaries (58 Canada, 107 U.S.) have historical records of larval Sea Lamprey production.
- Fifty-one tributaries (17 Canada, 34 U.S.) are treated every 4-6 years.

✧

Status and Trends in the Lake Superior Fish Community, 2017 (USGS)

Abstract

In 2017, the Lake Superior fish community was sampled with daytime bottom trawls at 76 nearshore and 36 offshore stations. Spring nearshore and summer offshore water temperatures in 2017 were similar to slightly cooler than the 1991-2017 average. In the nearshore zone, a total of 28,902 individual fish from 27 species or morphotypes were collected. The number of species collected at each station ranged from 0 to 13, with a mean of 5.5 and median of 5. Lakewide nearshore mean biomass was 3.8 kg/ha which was below the long-term average of 8.7 kg/ha and the median lakewide biomass was 1.8 kg/ha. which was similar to the long-term average median value of 1.9 kg/ha. Lake Whitefish, Rainbow Smelt, Bloater, Longnose Sucker, and lean Lake Trout were the species with the highest lakewide average biomass. In the offshore zone, a total of 16,674 individuals from 13 species were collected lakewide. The average and median observed species richness at each station was 3.8 and 4 species, respectively, and ranged from 2 to 6 species. Deepwater Sculpin, Kiyi, and siscowet Lake Trout made up 99% of the total number of individuals and biomass collected in offshore waters. Mean and median lakewide biomass for all species in 2017 was 6.8 kg/ha and 6.6 kg/ha, respectively. This was similar to the long-term mean of 6.9 kg/ha and greater than that observed in 2014-2016. Nearshore average larval *Coregonus* densities in 2017 were greater than observed in any previous year; whereas offshore larval *Coregonus* densities were much less than observed in previous years.

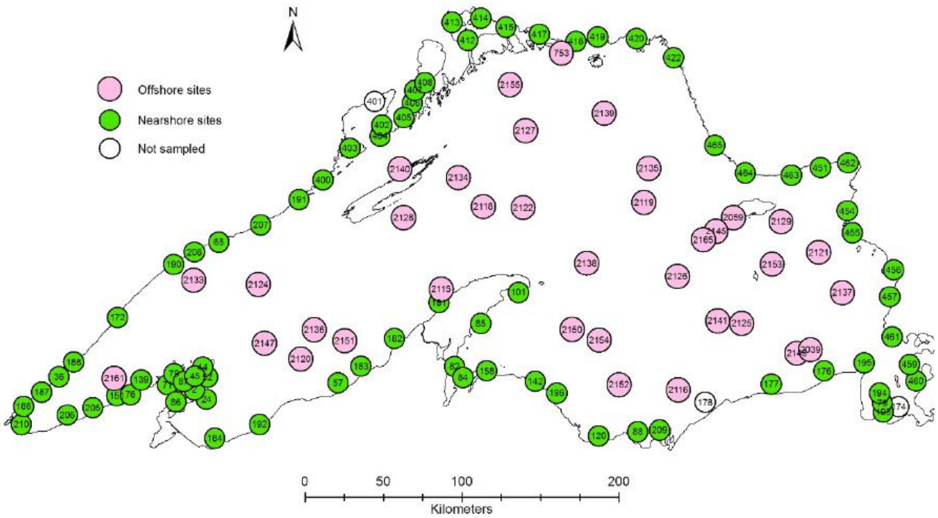


Fig 1-Location of 76 nearshore (green circles) and 36 offshore (pink circles) stations sampled May-July 2017. Samples collected at each location included bottom trawls for demersal fish, surface trawls for larval fish, epilimnetic (30 m) and whole water column (100 m) zooplankton collections, and an water profile that electronically collected data on depth, temperature, specific conductance, pH, dissolved oxygen, Chlorophyll a, photosynthetic active radiation, and beam transmission.

Nearshore water temperatures in 2017 were near the long-term average (**Fig 2a**). Nearshore temperatures in June averaged 5.7 °C (range = 3.8-15.2 °C) at the surface and 4.0 °C (range = 3.3-3.9 °C) at 100 m. The long-term average (1991-2017) water temperatures for these same locations and dates is 6.3 °C at the surface and 3.5 °C at 100 m.

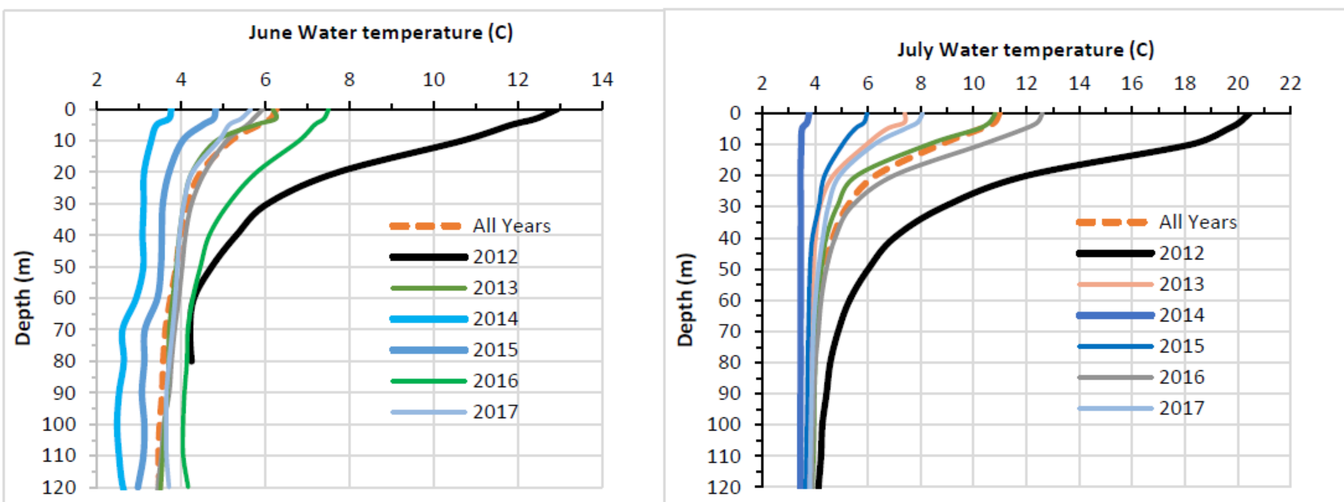


Fig 2a) Average nearshore water temperature profiles collected in June. B) Average offshore water temperatures collected in July. All years is the average of temperatures collected from 1991-2017.

A total of 28,902 individual fish from 27 species or morphotypes were collected. The number of species collected at each station ranged from 0 to 13, with a mean of 5.5 and median of 5. Lakewide mean biomass was 3.8 kg/ha, which was below the long-term average of 8.7 kg/ha (**Fig 3**). Lakewide median biomass was 1.8 kg/ha, which was similar to the long-term average median value of 1.9 kg/ha **(Fig 3**).

Individual station biomass was non-normally distributed and left-skewed (**Fig 4).** The skewness of the distribution of individual station biomass estimates in 2017 was 2.0, which was one of the lower values in the time series **(Fig 4**). Individual stations with the highest biomass were site 183-14 Mile Point north of Ontonagon, Michigan, and sites 2-Stockton Island, 205-Port Wing, and 86-Basswood Island which are in or near the Apostle Islands, Wisconsin.

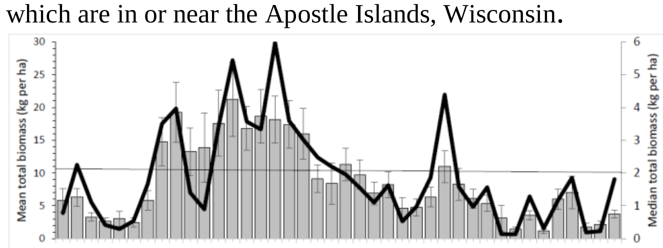


Fig 3-Annual mean + SE (bars, left y-axis) and median (line, right y-axis) lakewide nearshore biomass estimates for all fish species collected in bottom trawls from 1978-2017. The horizontal line is the long-term average mean and median values.

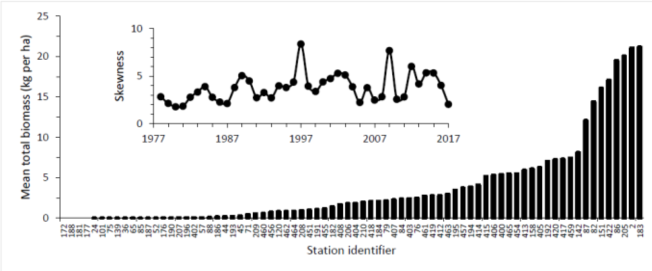


Fig 4-Estimated biomass at individual nearshore sampling stations in 2017. Station locations are shown in Fig 1. The in set plot shows the annual skewness in the distribution of individual station biomass estimates. Higher skewness values indicate greater differences in fish biomass among sampling locations.

Cisco
Lakewide mean nearshore biomass of Cisco was 0.2 kg/ha in 2017. This was similar to that observed the past two years and below the long-term average of 2.3 kg/ha and median annual average of 1.1 kg/ha**.** Density of age-1 Cisco was 1.4 fish/ha in 2017, which indicated a small, but measureable recruitment year. The long-term median annual average density of age-1 Cisco is 3.3 fish/ha. Over the 40-year history of the nearshore survey, densities of age-1 Cisco <1.4 fish/ha have been observed in 17 of the 40 years. The age-1 cisco density was 14.3 and 5.0 fish/ha in 2014 and 2015.

Bloater
Lakewide mean nearshore biomass for Bloater was 0.5 kg/ha in 2017. This was below the long-term average of 1.6 kg/ha and median annual average of 0.9 kg/ha**.** Age-1 Bloater density was 5.8 fish/ha in 2017. This was below the long-term average of 9.3 fish/ha and greater than the median annual average of 0.8 fish/ha**.**

Lake Whitefish
Lakewide mean nearshore biomass for Lake Whitefish was 1.1 kg/ha in 2017. This was less than the long-term average of 2.1 kg/ha and median annual average of 1.9 kg/ha. Age-1 Lake Whitefish density was 1.4 fish/ha in 2017, which was below the long-term average of 7.0 fish/ha and less than the long-term median annual average of 5.5 fish/ha.

Rainbow Smelt
Lakewide mean nearshore biomass for Rainbow Smelt was 0.9 kg/ha in 2017. This was similar to the long-term average of 1.2 kg/ha and median of 1.0 kg/ha. This year was the first year since 2008 that Rainbow Smelt biomass was near 1 kg/ha (Table 2). Age-1 Rainbow Smelt density was 147 fish/ha in 2017, which was a bit less than the long long-term average of 159 fish/ ha and similar to the long-term median annual average of 150 fish/ha.

Sculpin
Lakewide mean nearshore biomass for Sculpin was 0.01 kg/ha in 2017. This was below the long-term average of 0.06 kg/ha and median of 0.05 kg/ha. Sculpin biomass has not exceeded 0.06 kg/ha since 1998.

Other forage fish species
The combined mean nearshore lakewide biomass for all other forage fish species was 0.7 kg/ha in 2017. This was similar to the long-term mean and median of 0.7 kg/ha. Miscellaneous species included Ninespine Stickleback, Trout-perch, Kiyi, Shortjaw Cisco, Pygmy Whitefish, Round Whitefish, and Longnose Sucker. The highest biomass of these fishes were Long-nose Sucker (0.5 kg/ha), followed by Trout-Perch (0.1 kg/ha), and Pygmy Whitefish (0.04 kg/ha).

Burbot
Lakewide mean nearshore biomass for Burbot was 0.03 kg/ha. Burbot biomass has not exceeded the long-term average of 0.12 kg/ha or the long-term median of 0.1 since 2008**.**

Lake Trout
Eleven hatchery Lake Trout were collected during the 2017 nearshore survey. Hatchery Lake Trout biomass has been near zero since 2002, with the exception of 2005 **(Fig 5).** Lean Lake Trout biomass was 0.2 kg/ha. This was less than the long-term average and median of 0.3 kg/ha. Siscowet Lake Trout nearshore biomass was 0.1 kg/ha, which was similar to the long-term average and median of 0.1 kg/ha. Densities of age-3 and younger lean and siscowet Lake Trout were 0.4 and 0.01 fish/ha in 2017, respectively. Young lean Lake Trout densities were greater than the long-term average of 0.3 fish/ha, while young siscowet Lake Trout densities were less than the long-term average of 0.03 fish/ha**.**

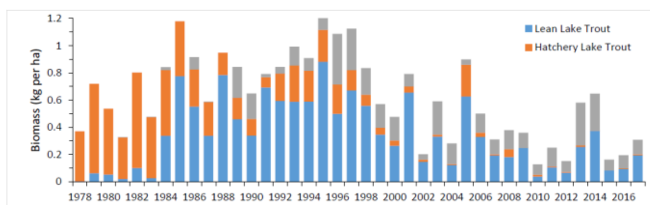


Fig 5-Mean annual lakewide biomass estimates for hatchery, lean, and siscowet Lake Trout estimated from bottom trawls in nearshore locations from 1978-2017.

Offshore survey
Offshore water temperatures were cooler than average (2011-2017) and warmer than observed in 2014 and 2015. Offshore water temperatures in July averaged 8.1 °C (range = 3.9-15.7 °C) at the surface and 3.8 °C (range = 3.6-3.9 °C) at 100 m (**Fig 2).**

A total of 16,674 individuals from 13 species were collected lakewide at 36 offshore sites. The average and median observed species richness at each station was 3.8 and 4 species, respectively, and ranged from 2 to 6 species. Deepwater Sculpin, Kiyi, and siscowet Lake Trout made up 99% of the total number of individuals and biomass collected in offshore waters **.** Ninespine Stickleback, Pygmy Whitefish, Spoonhead Sculpin, and Slimy Sculpin were the most common other species collected, but these species were generally limited to depths <100 m. Variation in biomass estimates across offshore sites was low. The standard error in biomass estimates across sites was 0.5 kg/ha for total biomass, 0.4 kg/ha for siscowet Lake Trout, 0.2 kg/ha for Kiyi, and 0.3 kg/ha for Deepwater Sculpin.

Mean and median lakewide biomass for all species in 2017 was 6.8 kg/ha and 6.6 kg/ha, respectively. This was similar to the long-term mean of 6.9 kg/ha and greater than that observed in 2014-2016 (**Fig 6).**

Siscowet Lake Trout

Lakewide average biomass in 2017 (3.7 kg/ha) for siscowet Lake Trout was greater than the long-term mean (3.0 kg/ha) and higher than any previous year other than 2011 (3.7 kg/ha, **Fig 6).**

Kiyi

Lakewide average biomass of Kiyi in 2017 (1.0 kg/ha) was less than the long-term (1.6 kg/ha) average, but slightly greater than that observed in 2016 (0.7 kg/ha, **Fig 6).**

Deepwater Sculpin

Lakewide average biomass of Deepwater Sculpin in 2017 (2.0 kg/ha) was similar to the long-term average (2.0 kg/ha) and greater than that observed in 2016 (0.9 kg/ha, **Fig 6).**

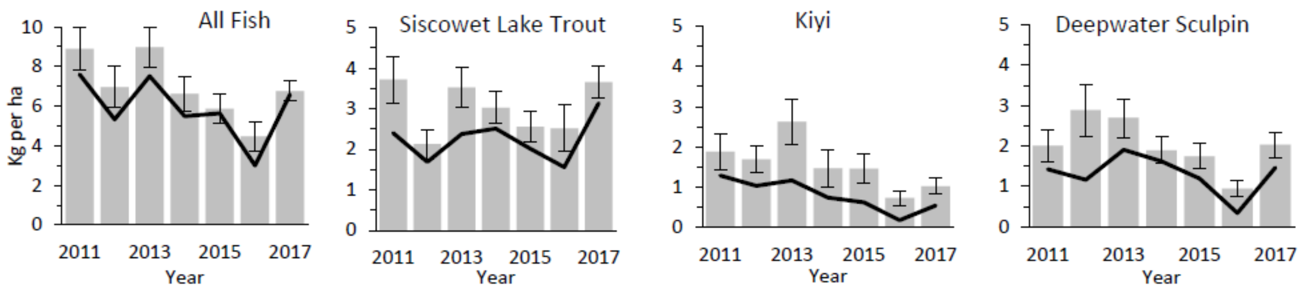


Fig 6-Annual mean + SE (bars) and median (line) lakewide offshore biomass estimates for all species, siscowet Lake Trout, Kiyi and Deepwater Sculpin collected in bottom trawls from 2011-2017.

Larval Coregonus collections

A total of 21,019 larval *Coregonus* individuals were collected from May-July 2017. The lakewide nearshore mean larval *Coregonus* density was 1,934 fish/ha (range 0-73,130 fish/ha) and the median density was 88 fish/ha. Average densities in 2017 were greater than observed in any previous year; whereas the median value was less than observed in 2015 and 2016 **(Fig 7).** Offshore larval *Coregonus* densities were much less than observed in previous years. Average densities in 2017 were 46 fish/ha (range 0-473 fish/ha) as compared to >200 fish/ha in previous years **(Fig 8**). Larval *Coregonus* were first collected the week of 15 May 2017 and averaged >11 mm in length. This suggests a hatch date around mid-April based on previous year's collections and the length at hatch observed for Cisco raised in the laboratory (~9 mm, Oyadomari and Auer 2008, CJFAS 65:1447-1358). Estimated hatch dates were early-May in 2016, mid-May in 2015 and the end of May in 2014. Growth of nearshore larval fish in 2017, as determined by the change in total length over time, was less than that observed in previous years (**Fig 8).**

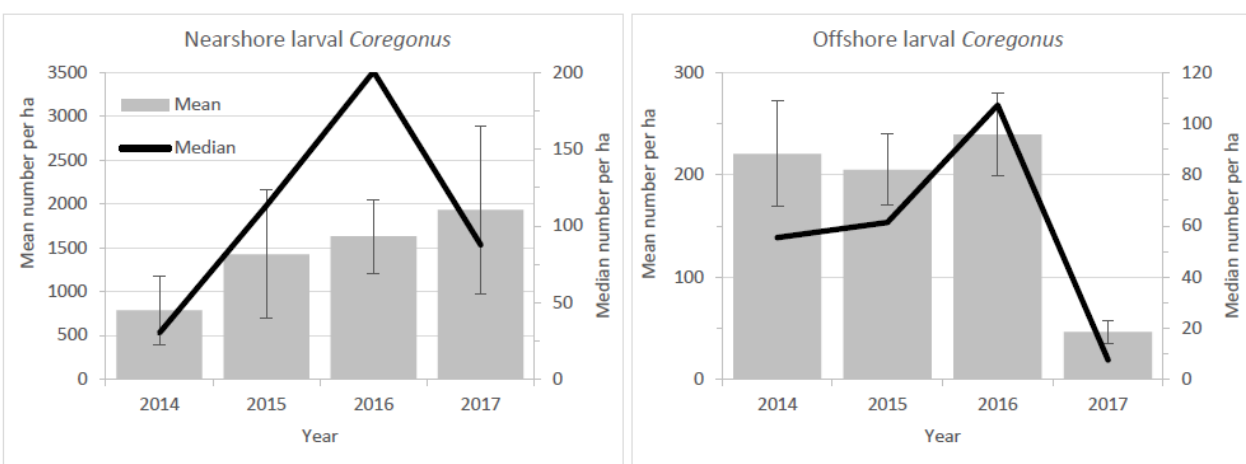


Fig 7-Annual mean + SE (bars) and median (line) lakewide nearshore and offshore larval Coregonus abundance from 2014-2017.

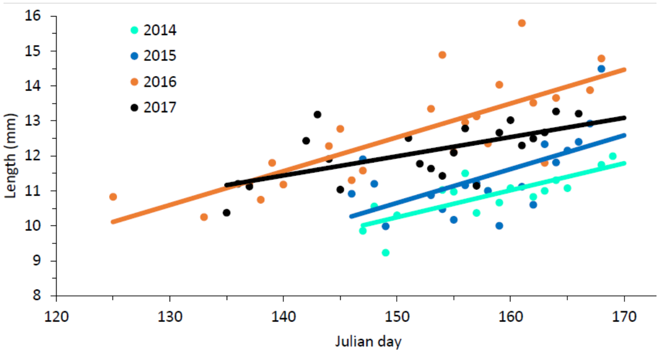


Fig 8-Average nearshore larval Coregonus total length over time for the years 2014-2017. Annual growth rates are described by the slope of the regression line in mm per day. Growth was 0.08 mm per day in 2014, 0.1 mm per day in 2015, 0.1 mm per day in 2016, 0.05 mm per day in 2017

Summary

Over the 40-year history of the Lake Superior nearshore survey, estimated total biomass of demersal fish species has been dependent on recruitment and survival of age-1+ Bloater, Cisco, and Lake Whitefish populations as well as survival of Rainbow Smelt to age-3 or older. The lack of significant recruitment (survival to age-1) in *Coregonus* species in recent years, particularly of Cisco, has caused low prey fish biomass. This is of concern to fishery managers. Factors underlying low recruitment are not known, but are being actively studied. Offshore demersal fish biomass estimates have exceeded nearshore demersal fish biomass estimates over the years (2011-2017) this survey has been conducted. Offshore demersal fish biomass was higher in 2017 than observed in 2016; which reversed a 4-5 year decline in Deepwater Sculpin, Kiyi, and siscowet Lake Trout biomass. It will be interesting to see what the estimated offshore biomass levels will be in 2018.

After four years of collection, larval *Coregonus* population dynamics remain a mystery with respect to their ability to forecast *Coregonus* survival to age-1. Larval *Coregonus* abundance estimates and growth rates were lower in 2014 than estimated in 2015 and 2016, yet survival of age-1 *Coregonus* was higher for the 2014 year class than the 2015 and 2016 year classes. In 2017, lakewide nearshore mean larval *Coregonus* densities were higher and growth rates were lower than the previous 3 years; how this will translate to age-1 survival will be a key finding of our sampling in 2018.

The combination of our near- and offshore bottom and surface trawl surveys provide a lakewide picture of the status and trends of the Lake Superior fish community susceptible to bottom trawls particularly with respect to describing recruitment dynamics for *Coregonus* species and lake trout morphotypes. Our plan is to continue these surveys into the future and adapt them as needed to address emerging issues. ✧

Sea Lamprey Control in Lake Superior 2017

Introduction

This report summarizes Sea Lamprey control activities conducted by Fisheries and Oceans Canada (Department) and the United States Fish and Wildlife Service (Service) as agents of the Great Lakes Fishery Commission (Commission) in Lake Michigan during 2017. The Sea Lamprey is a destructive invasive species in the Great Lakes that contributed to the collapse of Lake Trout and other native species in the mid-20th century and continues to affect efforts to restore and rehabilitate the fish-community. Sea Lampreys subsist on the blood and body fluids of large-bodied fish. It is estimated that about half of Sea Lamprey attacks result in the death of their prey and up to 18 kg (40 lbs) of fish are killed by every Sea Lamprey that reaches adulthood. The Sea Lamprey Control Program (SLCP) is a critical component of fisheries management in the Great Lakes because it facilitates the rehabilitation of important fish stocks by significantly reducing Sea Lamprey-induced mortality.

Lake Superior has 1,566 tributaries (833 Canada, 733 U.S.). One hundred sixty-five tributaries (58 Canada, 107 U.S.) have historical records of larval Sea Lamprey production. Of these, One hundred sixty-five tributaries (58 Canada, 107 U.S.) have historical records of larval Sea Lamprey production. Fifty-one tributaries (17 Canada, 34 U.S.) are treated every 4-6 years. Details on lampricide applications to Lake Superior tributaries and lentic areas during 2017 are found in **Table 1 and Figure 1**.

• Lampricide treatments were completed in 23 tributaries (6 Canada, 17 U.S.) and in 5 lentic areas (3 Canada, 2 U.S.).

• The lentic areas of the Jackpine River and D’Arcy Creek were treated for the first time.

• A lentic area of the Chippewa River was treated due to the presence of large sea lamprey larvae.

• The Jarvis River was treated for the first time. Fish community assessment surveys were completed pre- and post-treatment. Non-target surveys following lampricide application covered 3.3% of the treated area; 1 white sucker was identified from this effort.

• Larval distribution in the Neebing River was further upstream than previous treatments.

• The Flintsteel River was treated for the first time and high densities of Sea Lamprey larvae were observed.

• Treatment of the mainstream Bad River, including the White River (Bad River tributary), was postponed from September due to high stream discharge and treated in late October.

• The Middle, Silver, and Falls rivers were treated under unusually high discharge conditions.

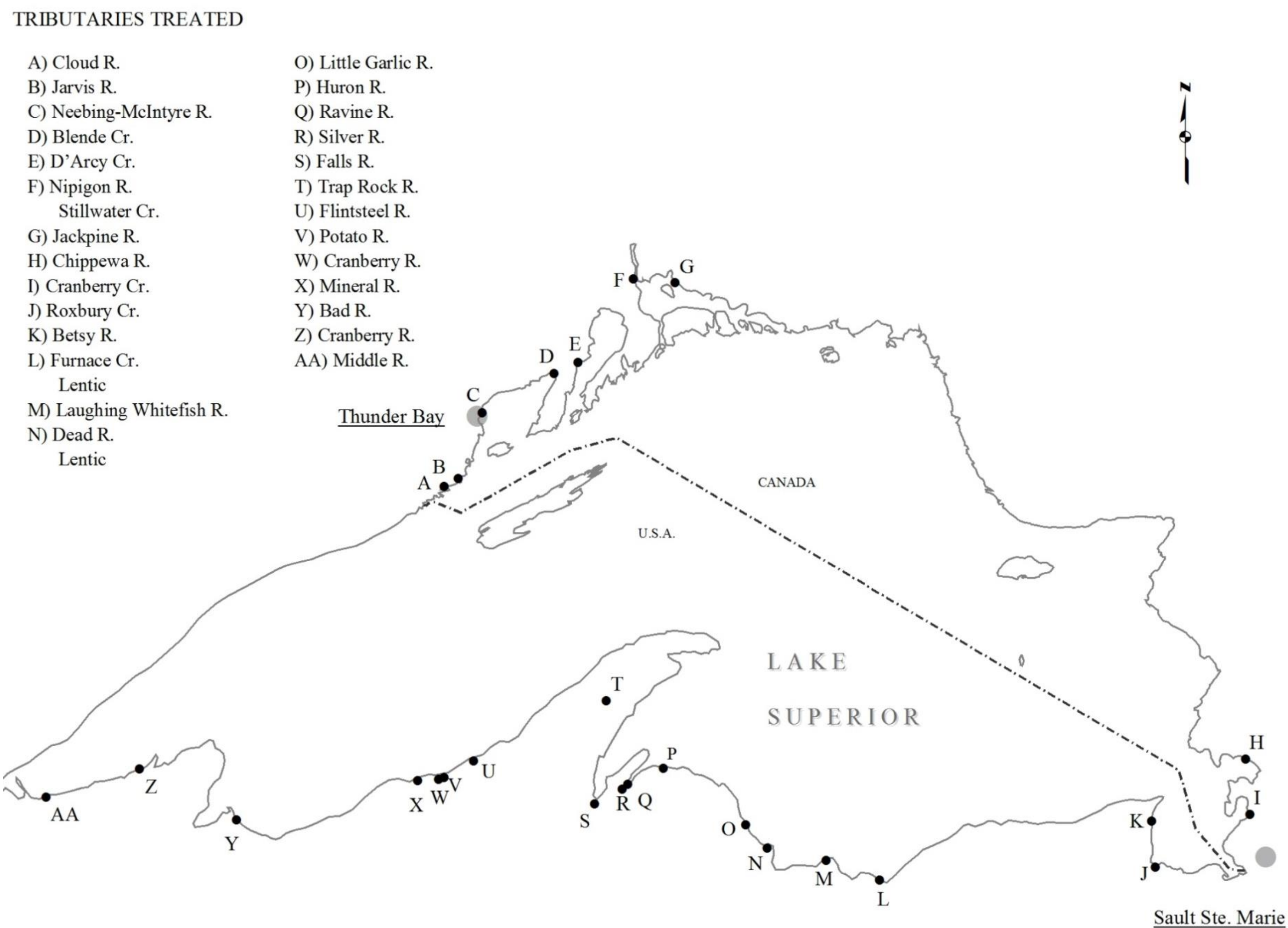


Fig 1- Location of Lake Superior tributaries treated with lampricides (corresponding letters in Table 1) during 2017.

Barriers

The Sea Lamprey Barrier Program priorities are to:

1) Operate and maintain existing Sea Lamprey barriers that were built or modified by the SLCP.

2) Ensure Sea Lamprey migration is blocked at important non-SLCP barrier sites.

3) Construct new structures in streams where they: a. provide

a cost-effective alternative to lampricide control;

b. provide control where other options are impossible, excessively expensive, or ineffective;

c. improve cost-effective control in conjunction with attractant and repellent based control, trapping, and lampricide treatments; and

d. are compatible with a system's watershed plan.

The Commission has invested in 18 barriers on Lake Superior **(Fig 2**). Of these, 11 were purpose-built as Sea Lamprey barriers and 7 were constructed for other purposes but have been modified to block Sea Lamprey migrations. Data gathered during field visits to assess the status of other dams and structures were recorded in the SLCP's Barrier Inventory and Project Selection System (BIPSS) and may be used to: 1) select barrier projects; 2) monitor inspection frequency; 3) schedule upstream larval assessments; 4) assess the effects of barrier removal or modifications on Sea Lamprey populations, or; 5) identify structures that are important in controlling Sea Lampreys.

• Field crews visited one structure on a tributary to Lake Superior to assess Sea Lamprey blocking potential and to improve the information in the BIPSS database.

• Routine maintenance, spring start-up, and safety inspections were performed on 17 barriers (6 Canada, 11 U.S.).

• Repairs or improvements were conducted on one Canadian barrier.

• Stokely Creek – Sediment upstream of the barrier was impeding flow, posing a risk that the stream would bypass the barrier. The accumulated sediment was flushed out to the original riverbed profile in October 2017.

• Fish community assessment surveys (42) were conducted in the Black Sturgeon watershed upstream of the Black Sturgeon Dam (Camp 43) to the Camp 1 Site at the outlet of Eskwanonwatin Lake to evaluate the fish community within this reach. In addition to electrofishing surveys, 3 lakes (Black Mountain, Shillabeer, and Driftsone) were also sampled using trap nets.

• Black Sturgeon River – The Ontario Ministry of Natural Resources and Forestry (OMNRF) initiated an Environmental Assessment (EA) during 2012 of a proposal to decommission the Camp 43 dam and construct a new Sea Lamprey barrier 50 km upstream. A draft Environmental Study Report was released for public and management agency comment in March 2017. Preparation of the final report is in process.

• Middle River – Larval and habitat surveys were conducted upstream from the Middle River Sea Lamprey barrier during July 2017 to determine the production potential for sea lampreys upstream of the dam.

• Consultations to ensure blockage at barriers at 16 sites in 9 streams were conducted with partner agencies during 2017.

New Construction

• Bad River – The USACE is the lead agency administering a project to construct a Sea Lamprey barrier in the Bad River under the Great Lakes Fishery Ecosystem Restoration program. The USACE completed the feasibility study to site a new barrier and trap downstream from the Potato River junction (the location supported by the Bad River Tribe). The study indicated that the topography at this location would require a structure much larger than anticipated to block Sea Lampreys and would result in potential backwater effects. Personnel from the Service, the Natural Resources Department of the Bad River Band of Lake Superior Chippewa Indians (NRD), and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) met to discuss alternate locations. The NRD is supportive of investigating the feasibility of barrier construction on the smaller high production tributaries to the Bad River. Permission to survey potential barrier locations in the Marengo River was requested during 2016.

• Ontonagon River – The Service is working with the US Forest Service to investigate construction of an adjustable-crest, seasonal barrier several miles downstream of the Lower Dam on the East Branch Ontonagon River, which would be removed as part of the project. Site visits were conducted during fall 2017 and water surface elevation loggers were installed at one of the locations.

Larval Assessment

Tributaries considered for lampricide treatment during 2018 were assessed during 2017 to define the distribution and estimate the abundance and size structure of larval Sea Lamprey populations. Assessments were conducted with backpack electrofishers in waters <0.8 m deep, while waters ≥0.8 m in depth were surveyed with gB or by deep-water electrofishing (DWEF). Additional surveys are used to define the distribution of Sea Lampreys within a stream, detect new populations, evaluate lampricide treatments, evaluate barrier effectiveness, and to establish the sites for lampricide application.

• Larval assessments were conducted on 160 tributaries (73 Canada, 87 U.S.) and 35 lentic areas (18 Canada, 17 U.S.).

• Surveys to estimate larval abundance were conducted in 36 tributaries (19 Canada, 17 U.S.) and in lentic areas offshore of 13 tributaries (9 Canada, 4 U.S.).

• Surveys to detect the presence of new larval Sea Lamprey populations were conducted in 46 tributaries (32 Canada, 14 U.S.). No new populations were discovered during 2017.

• Post-treatment assessments were conducted in 39 tributaries (19 Canada, 20 U.S.) and 10 lentic areas (7 Canada, 3 U.S.) to determine the effectiveness of lampricide treatments conducted during 2016 and 2017. The Cranberry River (Ontonagon Co.), Whitman Creek (Goulais River tributary), Batchawana River, Michipicoten River and the lentic areas of Ankodosh Creek (Chippewa Co.) and Black River (Gogebic Co.) are scheduled for treatment in 2018 based on the presence of residual Sea Lampreys.

• Surveys to evaluate barrier effectiveness were conducted in 4 tributaries (1 Canada, 3 U.S.). All barriers remain effective in limiting sea lamprey infestations.

• Biological collections for research or training purposes were conducted in two U.S. tributaries. A total of 576 Sea

Lamprey larvae were collected for research purposes from Harlow Creek and Middle River.

• Larval assessment surveys were conducted in non-wadable lentic and lotic areas using 104.53 kg active ingredient of gB (38.36 kg Canada, 66.17 kg U.S.; **Table 1).**

Tributary	Bayluscide (kg)1	Area Surveyed
Canada		
Haviland Cr.	0.84	0.15
Stokely Cr.	0.84	0.15
Harmony R.	0.84	0.15
Chippewa R.	1.68	0.3
Batchawana R.	2.52	0.45
Carp R.	1.68	0.3
Agawa R.	1.68	0.3
Sand R.	0.56	0.1
Michipicoten R.	1.12	0.2
Dog R. (lotic)	0.56	0.1
White R. (lotic)	1.68	0.3
Little Pic R. (lotic)	1.68	0.3
Gravel R. (Lentic)	1.96	0.35
L. Gravel R. (Lentic)	0.56	0.1
Jackfish R. (Lotic)	0.84	0.15
Nipigon R. (Lentic/Lotic)	6.44	1.15
Black Sturgeon R. (Lotic)	0.84	0.15
Pearl R. (Lotic)	0.84	0.15
D'Arcy Cr. (Lentic)	0.84	0.15
MacKenzie R. (Lentic)	1.68	0.3
Current R.	2.24	0.4
Kaministiquia R.	5.6	1
Pigeon R.	0.84	0.15
Total (Canada)	**38.36**	**6.85**

Tributary	Bayluscide (kg)1	Area Surveyed
United States		
Pendills Creek (Lentic)	2.32	0.41
Grants Creek (Lentic)	2.32	0.41
Ankodosh Creek (Lentic)	2.32	0.41
Tahquamenon R. (Lentic)	3.48	0.62
Beaver Lake Creek (Lentic)	4.06	0.73
Anna River (Lentic)	2.32	0.41
Furnace Creek (Lentic)	4.94	0.88
AuTrain River (Lotic)	2.34	0.42
Carp River (Lentic)	2.32	0.41
Dead River (Lotic/Lentic)	5.81	1.04
Harlow Creek (Lentic)	1.16	0.21
Little Garlic River (Lentic)	1.74	0.31
Garlic River (Lentic)	1.74	0.31
Ravine River (Lentic)	2.32	0.41
Silver River (Lentic)	3.48	0.62
Falls River (Lentic)	2.32	0.41
Pilgrim River (Lotic)	1.74	0.31
Flintsteel River (Lotic)	1.16	0.21
Ontonagon River (Lotic)	1.02	0.18
Black River (Lotic/Lentic)	3.48	0.62
Iron River (Bayfield (Lotic)	1.74	0.31
Nemadji River (Lotic)	1.89	0.34
St. Louis River (Lotic)	6.97	1.18
Arrowhead River (Lotic)	3.18	0.57
Total (United States)	**66.17**	**11.73**
Total for Lake	**104.53**	**18.58**

Table 1 Applications of granular Bayluscide to tributaries and lentic areas of Lake Superior for larval assessment purposes during 2017.

Juvenile Assessment

• Lake Trout marking data for Lake Superior are provided by the MIDNR, Minnesota DNR, WDNR, GLIFWC, Chippewa-Ottawa Resource Authority (CORA), Keweenaw Bay Indian Community, Grand Portage Band of Lake Superior Chippewa Indians, and the OMNRF, and analyzed by the Service's GBFWCO.

• The number of A1-A3 marks on Lake Trout from spring assessments in 2017 were submitted in February 2018 and have yet to be analyzed.

• Based on standardized spring assessment data, the marking rate during 2016 was 7.5 A1-A3 marks per 100 Lake Trout >532mm (Figure 3). The marking rate is greater than the target of 5 marks per 100 fish **(Fig 2).**

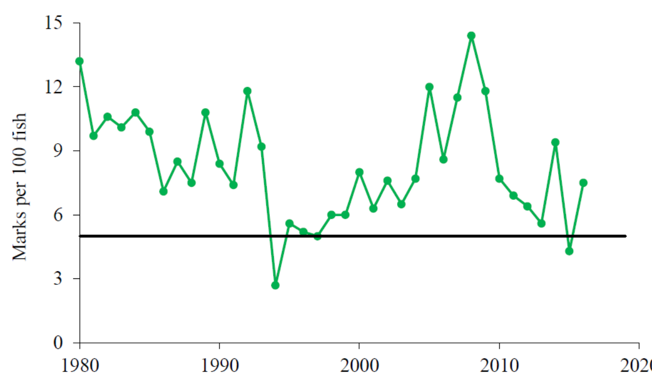


Fig 2-Average number of A1-A3 marks per 100 Lake Trout >532 mm from standardized spring assessments in Lake Superior. The horizontal line represents the target of 5 A1-A3 marks per 100 Lake Trout.

Adult Assessment

•A total of 8,387 Sea Lampreys were captured in 10 tributaries, 7 of which are index locations. Adult population estimates based on mark-recapture were obtained for each index location **(Table 2**).

•The index of adult Sea Lamprey abundance was 48,636 (95% CI; 36,197 – 61,074), which was higher than the target of 9,664 (Figures 5-6). The index target was estimated as the mean of indices during a period with acceptable marking rates (1994-1998).

• Adult Sea Lamprey migrations were monitored in the Middle, Bad, Misery, and Silver rivers through cooperative agreements with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) and in the Brule River with the Wisconsin Department of Natural Resources.

• The access road to the Bad River trap site was repaired prior to the start of the 2017 trapping season. Service staff worked with the Natural Resources Department and GLIFWC to make the necessary improvements.

• The configuration of the Brule River fishway downstream from the lamprey trap was modified to enhance trapping of Sea Lampreys and facilitate improved fish passage. The fish ladder was operated as a vertical slot fishway instead of a pool and weir fishway up to the lamprey trap jumping pool. This change allowed for easier passage up to the lamprey trap for both fish and lampreys. In addition, two sorting weirs were placed within two rungs of the lower fish ladder to test their ability to sort lampreys from finfish. The system was monitored using underwater cameras and trap catch observations of marked fishes.

• Service staff are evaluating if the accuracy and precision of mark-recapture abundance estimates differ when using weekly batch marks or unique individual marks as part of a 2-year Technical Assistance Program study on the Brule and Middle rivers.

Tributary	Number Caught	Adult Estimate	Trap Efficiency (%)	Number Sampled[1]	Percent Males[2]	Mean Length (mm) Males	Mean Length (mm) Females	Mean Weight (g) Males	Mean Weight (g) Females
Canada									
Neebing R. (A)	468	1,893	25	58	52	474	440	259	205
Big Carp R.[3] (B)	15	---	---	10	70	454	488	277	264
Total or Mean (Canada)	**483**	---	---	**68**	**54**	**471**	**445**	**263**	**211**
United States									
Tahquamenon R. (C)	2,374	10,549	23	101	72	470	464	237	240
Betsy R. (D)	591	3,778	16	54	69	468	453	246	230
Rock R. (E)	401	994	40	81	60	465	456	234	232
Silver R.[3] (F)	2	---	---	---	---	---	---	---	---
Misery R.[3] (G)	24	---	---	2	50	590	447	309	238
Bad R. (H)	731	5,878	12	12	33	433	466	171	272
Brule R. (I)	3,309	21,024	16	59	64	468	465	233	246
Middle R. (J)	481	4,519	11	14	57	500	485	277	283
Total or Mean (U.S.)	**7,913**	---	---	**323**	**65**	**469**	**462**	**238**	**242**
Total or Mean (for lake)	**8,396**	---	---	**391**	**63**	**470**	**458**	**242**	**235**

Table 2. Information regarding adult Sea Lampreys captured in assessment traps or nets in tributaries of Lake Superior during 2017 (letter in parentheses corresponds to streams in Fig 4).

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