Inland Seas Angler

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Highlights of the Annual Lake Committee Meetings

Great Lakes Fishery Commission proceedings, Milwaukee, WI

This second 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 2016. 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; Dale Hanson, Charles Bronte, Jessica Barber and Mark Holey, 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 Milwaukee.

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
WDNR	WI Dept. of Natural Resources
OMNR	ON Ministry Natural Resources
USFWS	U.S. Fish and Wildlife Service
YAO	Age 1 and older
YOY	Young of the year (age 0)

Status and Trends of Pelagic Prey Fish in Lake Huron, 2015

Abstract

The USGS Great Lakes Science Center has conducted integrated acoustic and mid-water trawl surveys of Lake Huron during 1997 and annually from 2004-2015. The 2015 survey was conducted during September and included transects in Lake Huron's main basin, Georgian Bay, and North Channel **(Fig 1)**. Mean lake-wide total pelagic fish density was 1,313 fish/ha and mean total pelagic fish biomass was 10.7 kg/h in 2015, which represents 77% and 92%, respectively of the long-term mean. Mean lake-wide biomass was 13% higher in 2015 as compared to 2014. The total estimated lake-wide standing stock biomass of pelagic fish species was -50 kt, consisting almost entirely of bloater (36.8 kt; 74%) and rainbow smelt (12.5 kt; 25%). No alewives were captured during the 2015 survey. Age-O rainbow smelt abundance increased from 129 fish/ha in 2014 to 475 fish/ha in 2015. Biomass of age-l + rainbow smelt decreased from 2.8 kg/ha in 2014 to 2.2 kg/ha in 2015. Age-O bloater abundance increased from 35 fish/ha in 2014 to 315 fish/ha in 2015. Biomass of age-1+ bloater increased from 6.2 kg/ha in 2014 to 7.1 kg/ha in 2015. Emerald shiner density increased from 0.1 fish/ha in 2014 to 37 fish/ha in 2015 and biomass increased from < 0.001 kg/ha in 2014 to 0.02 kg/ha in 2015. Bloater and rainbow smelt will continue to be the primary pelagic species available to offshore predators in coming years, with reduced numbers of rainbow smelt if recruitment to older ages remains poor. Pelagic fish biomass in Lake Huron is greater than that observed in recent lake-wide acoustic surveys of Lake Michigan and Lake Superior, but species composition differs among the three lakes. Of the three upper Great Lakes, Lake Superior had the greatest pelagic prey fish diversity and occurrence of native species, while Lake Michigan had the lowest species diversity and lowest native fish prevalence, whereas Lake Huron was intermediate in regards to both.

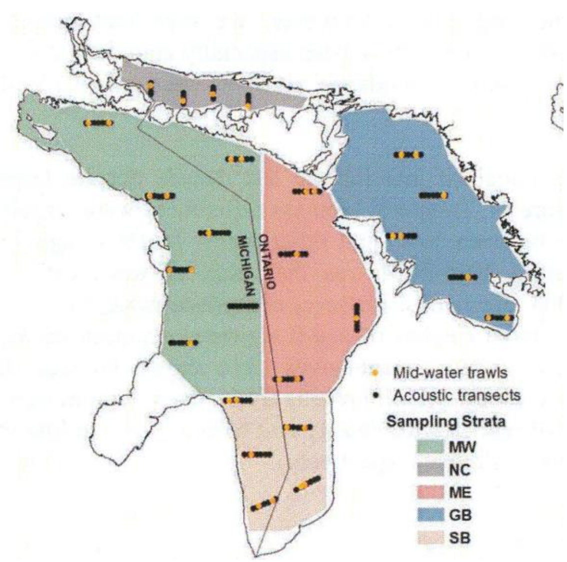

Fig 1- Location of acoustic transects and mid-water trawls, and delineation of sampling strata in Lake Huron during 2015.

Density and biomass by species

Alewife

During 2015, no alewives were caught in mid-water trawls that sampled a broad range of depths in Lake Huron. Alewife densities estimated in 1997, 2005-2006, 2008, and 2013 were considerably higher than other years in the time series. However, we note that density differences, though substantial, did not mean that alewives have been especially abundant in any survey year (**Fig 2**). During 1997, the year of highest abundance, alewives were only 3.1% of total fish density.

Acoustic estimates of alewife biomass have remained low for the last decade despite large fluctuations in density during 2004-2013 **(Fig 2).** Temporal biomass differences were largely due to differences in size and age structure between 1997 and other years. In 1997, age 1+ alewife was captured, but low biomass during 2004-2014 was the result of trawl catches dominated by age-O fish (**Fig 2).** Since 2004, alewives have never comprised more than 2 % of pelagic fish biomass. Although mid-water trawl catches of age-O alewives occurred during some acoustic surveys, recruitment has been limited and alewives have shown no sign of returning to higher abundance. Our findings are consistent with results from annual bottom trawl surveys, which indicated that alewife density and biomass remain low in the open waters of Lake Huron.

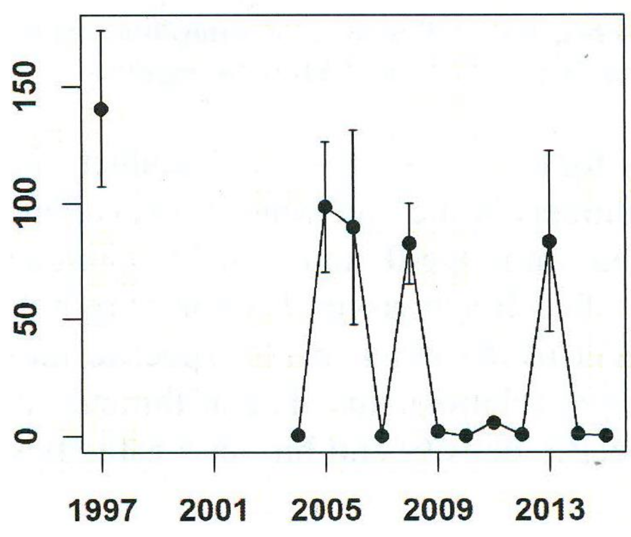

Fig 2-Acoustic and mid-water trawl estimates of alewife numeric density in Lake Huron, 1997-2015.

Rainbow smelt

During 2015, age-O rainbow smelt density increased from 2014 estimates to 66% of the long-term mean **(Fig 3).** Age-O rainbow smelt populations are considerably less than the high observed in 1997, but there has been no clear trend in abundance since 2004. Age

1+ rainbow smelt biomass decreased from 2.8 kg/ha in 2014 to 2.2 kg/ha in 2015, This was roughly 50% of the long-term mean of 4.4 kg/ha (**Fig 3)** and substantially less than that observed in 1997.

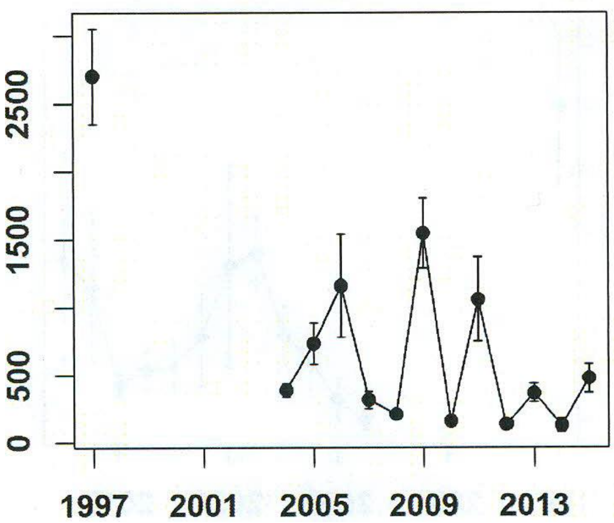

Fig 3- Acoustic and mid-water trawl estimates of rainbow smelt age-O numeric density in Lake Huron, 1997-2015.

Bloater

Estimates of age-O bloater numeric density showed a nine-fold increase between 2014 and 2015 (**Fig 4**). Estimated biomass of age-l+ bloater increased from 6.2 kg/ha in 2014 to 7.1 kg/ha in 2015 (Figure 4) however, the standard error around this estimate was large, indicating lower precision. Acoustic estimates of age-O bloater were low during 1997 (4 fish/ha, **Fig 4).** Similar to results from bottom trawl surveys, age-O bloater density was variable but increased during 2004-2014 (average density> 160 fish/ha). Biomass of age-1+ bloater showed an increasing trend from 2004-2008, followed by a decrease from 2009-2010. Abundance of age-1+ bloater remained relatively unchanged during 2011-2013. Although we have seen increased bloater biomass during the past two years, relative standard error for these estimates ranged from 40-50% indicating low equitability in distribution of biomass throughout Lake Huron. Much of the biomass is driven by bloater aggregations in the southern main basin.

Emerald shiner

In 2015, emerald shiner biomass increased from 2014 estimates and was 24% of the long-term mean of 0.10 kg/ha **(Fig 5**). Mean biomass of emerald shiner was estimated to be < 0.01 % of total pelagic fish biomass in 2014, but increased to 0.22 % of total biomass in 2015. 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.

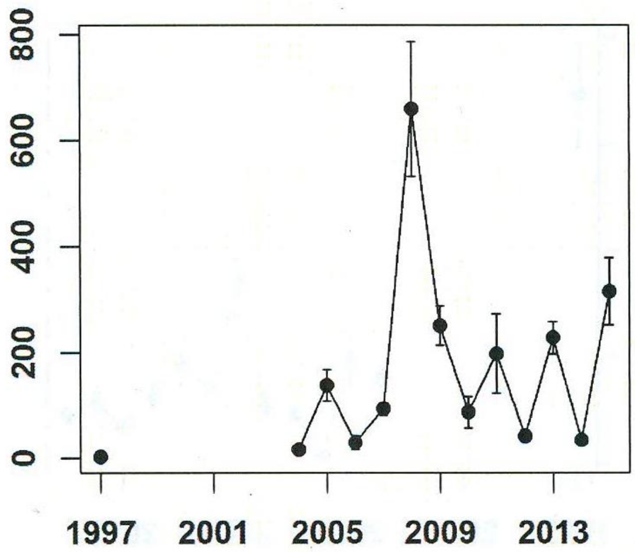

Fig 4-Acoustic and mid-water trawl estimates of bloater age-Onumeric density in Lake Huron, 1997-2015.

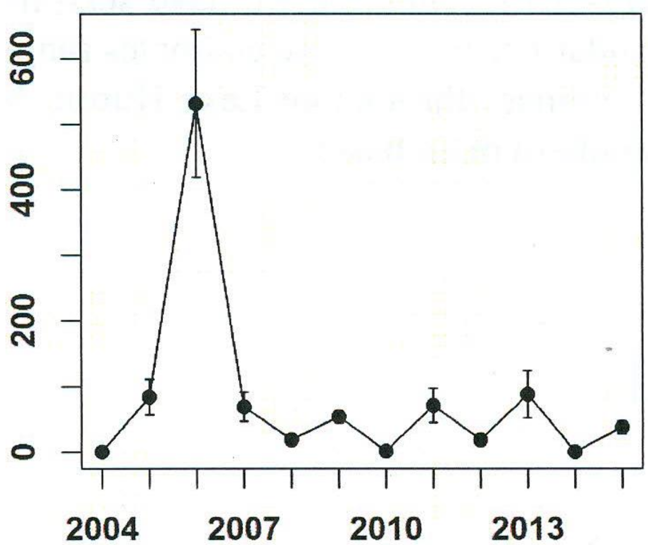

Fig 5-Acoustic and mid-water trawl estimates of emerald shiner numeric density in Lake Huron, 2004-2014.

Other species

Other species captured during acoustic and mid-water trawl surveys included threespine stickleback, lake whitefish, lake trout, and cisco. These species compose a small proportion of the mid-water trawl catch. In the case of cisco, catches have occurred in most years during acoustic surveys but their density remains low in open waters of the lake during September and October. During October in northern Lake Huron, cisco are primarily distributed in shallow, near shore areas. Our acoustic and mid-water trawl surveys primarily operate in deeper waters (> 15 m) during the fall, and therefore do not effectively sample cisco that are likely more concentrated in nearshore areas. Cisco are occasionally caught in mid-water trawls but catches are too sporadic to be able to use trawl proportions to apportion acoustic densities.

During 2015, several small cisco « 200 mm TL) were caught in the North Channel and two larger cisco (441 mm and 376 mm TL) were caught offshore in Georgian Bay. During 2004-2014, catches of cisco were similarly low during acoustic surveys.

Among-basin comparisons of fish biomass

In 2015, pelagic fish biomass increased in the main basin and decreased in both the North Channel and Georgian Bay. Biomass in the North Channel (12.1 kg/ha) was roughly 63% of the long-term mean and decreases were driven by lower biomass of both age-l + rainbow smelt and bloater **(Fig 6.)**. Main basin biomass (12.9 kg/ha) showed a 28% increase from 2014 due to increases in age-l + bloater and a slight increase in age-O rainbow smelt. Biomass in Georgian Bay (4.1 kg/ha) declined to 37% of the long-term mean due to decreases in age-l + rainbow smelt. Bloater biomass increased slightly in Georgian Bay during 2015. In addition to differences in fish biomass, the three basins have had different temporal trends in biomass and community composition. In both Georgian Bay and the main basin, fish biomass has declined relative to 1997, but there is no evidence of a declining trend in the North Channel.

Community composition differences are predominantly the result of variation in the proportion of biomass comprised by rainbow smelt and bloater. Most biomass in Georgian Bay has been in the form of rainbow smelt (54% average), while biomass in the main basin has consisted of varying proportions of rainbow smelt and bloater. Since 2012, bloater has been the dominant contributor in the main basin, averaging 72% of pelagic fish biomass. In the North Channel rainbow smelt have comprised 73% of biomass on average.

Lake-wide fish density and biomass

Lake-wide mean pelagic fish density increased from 729 fish/ha in 2014 to 1,313 fish/ha in 2015, representing 77% of the long-term mean (**Fig 6).** The 2015 pelagic fish density estimate represented 26% of that observed in 1997. The 2015 lake-wide mean pelagic fish biomass estimate was 10.6 kg/ha, a 12.5% increase from 2014. Total standing stock biomass in 2015 was estimated at 50 kt (SE 16.3 kt) (**Fig 6**). This was slightly greater than that observed in 2014 **(Fig 6**) and was driven by higher biomass of age-l + bloater in the main basin. In general, acoustic estimates of pelagic fish biomass in Lake Huron have shown no consistent trend between 2004 and 2015. However, biomass has been considerably lower than in 1997 when rainbow smelt and bloater were more abundant in Georgian Bay and the main basin, and alewife was more abundant throughout the lake.

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. This depth range encompasses about 85% of the total surface area of Lake Huron. However, 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. An additional assumption was that fish size was a reasonable proxy for age-O 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-O versus age-l + density and biomass, it would have no impact on our estimates of total density or biomass for a species.

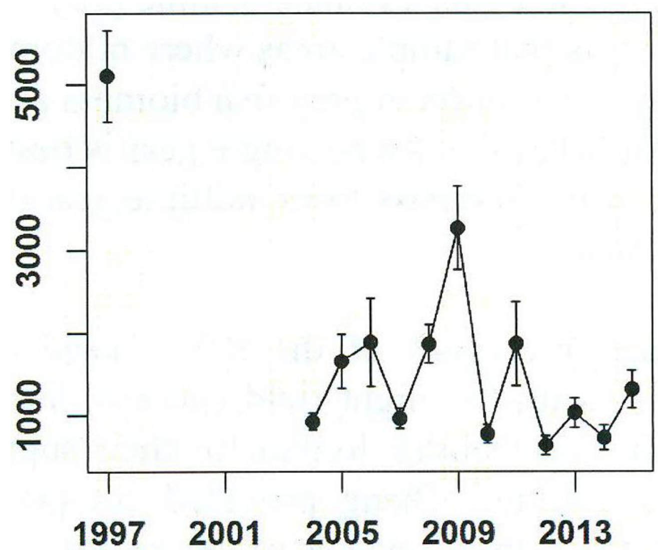

Fig 6- Acoustic and mid-water trawl estimates of lake-wide numeric density in Lake Huron, 1997-2015

Conclusions

Higher age-O production and adult biomass during 2015 indicate bloater will continue to be the most available pelagic prey species in the offshore zone of Lake Huron. Although lake-wide preyfish biomass increased in 2015, we note that biomass was only 30% of the 1997 estimate. This decline is primarily due to reduced biomass of rainbow smelt, which in 2015 was only 13% of the 1997 estimate of 21 kg/ha. Biomass of rainbow smelt in the main basin will likely remain low during 2016 given recent declining trends in recruitment for this species (0'Brien et at. 2014) and lower adult biomass in 2015. During 2016, pelagic prey available to piscivores will likely be similar to that seen in recent years, although offshore predators such as lake trout will have increased numbers of adult bloater available as forage.

Lake-wide pelagic biomass in Lake Huron during 2015 was higher than that estimated for Lake Michigan during 2015 and Lake Superior during 2011. In addition to differences in lake-wide biomass in recent years, pelagic fish community composition differs considerably between the three lakes. In Lake Michigan, alewife is still prevalent and comprises about 70% of the pelagic biomass, while in lakes Huron and Superior, the biomass of this species is negligible. Additionally, native coregonines and other species are at historic low levels in Lake Michigan. Native species constitute much higher proportions of total biomass in lakes Huron and Superior. In the case of Lake Superior, kiyi are numerically dominant at depths> 100 m, while cisco are most of the biomass. In Lake Huron, rainbow smelt are numerically more abundant, while rainbow smelt and bloater have been alternating roles as the dominant contributor to total biomass, with bloater contributing more in recent years. Additionally, there have been relatively consistent (but low) catches of emerald shiner and cisco in Lake Huron mid-water trawling. In the case of emerald shiner, it is likely that their reappearance was the result of a release from predation on fry following the collapse of alewife.

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 information 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 ecosystem dynamics. ✧

Status and Trends of the Lake Huron Offshore Demersal Fish Community, 1976-2015

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 less frequent sampling near Goderich, Ontario **(Fig 1).** The 2015 fall bottom trawl survey was carried out between 14 and 28 October and included all U.S. ports, as well as Goderich, ON. The 2015 main basin prey fish biomass estimate for Lake Huron was 19.4 kilotonnes, a decline of about 50 percent from 2014. This estimate is the second lowest in the time series, and is approximately 5 percent of the maximum estimate in the time series observed in 1987. No adult alewife were collected in 2015 and YOY alewife was the second lowest in the time series, up slightly from the record low in 2014. The estimated biomass of yearling and older rainbow smelt also decreased and was the lowest observed in the time series. Estimated adult bloater biomass in Lake Huron declined to about half of the 2014 estimate. YOY alewife, rainbow smelt, and bloater abundance and biomass decreased over 2014. Biomass estimates for deepwater sculpins declined while trout-perch and ninespine stickleback increased over 2014 values, but all remained low compared to historic estimates. The 2014 biomass estimate for round goby increased from 2014 but remains at only 7 percent of the maximum observed in 2003. Wild juvenile lake trout were captured again in 2015, suggesting that natural reproduction by lake trout continues to occur.

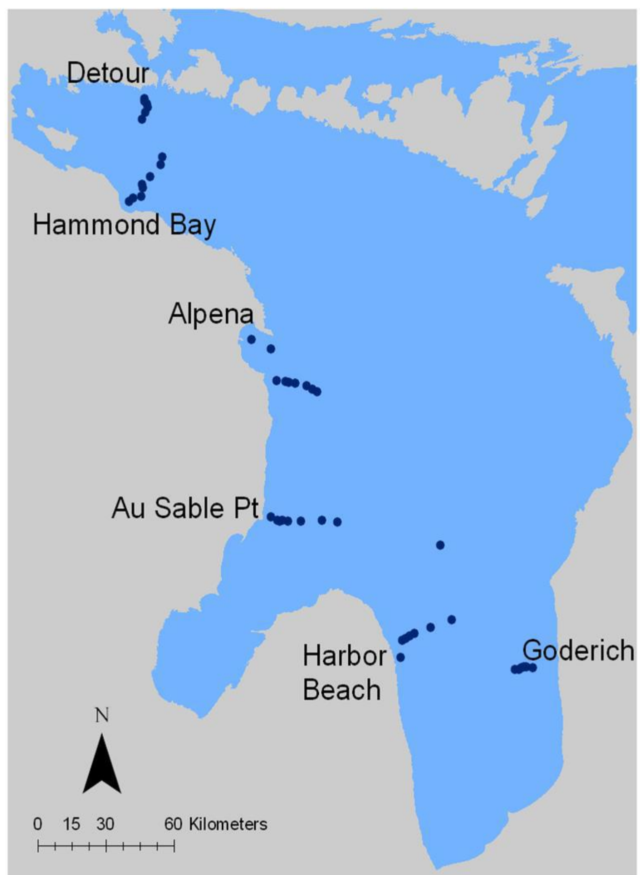

Fig 1-Bottom trawl sampling locations in Lake Huron.

Introduction

Lake Huron supports valuable recreational and commercial fisheries that may be at risk due to recent widespread ecological changes in the lake. Recent major ecosystem changes in Lake Huron include the invasion of dreissenid mussels and drastic declines in the abundance of the native amphipod *Diporeia*, decreases in lake whitefish Chinook salmon catches, significant changes in the abundance and species composition of the zooplankton community, the invasion of the round goby, and the collapse of the offshore demersal fish community.

Results

The 2015 Lake Huron fall bottom trawl survey was conducted between 14 and 28 October. Forty-three trawl tows were completed and all standard ports were sampled, including Goderich, Ontario. Seventeen fish species were captured in the 2015 survey: rainbow smelt, alewife, bloater, deepwater sculpin, trout-perch, lake whitefish, round whitefish, ninespine stickleback, three-spine stickleback, lake trout, round goby, yellow perch, walleye, white bass, Gizzard shad, sea lamprey, and common carp.

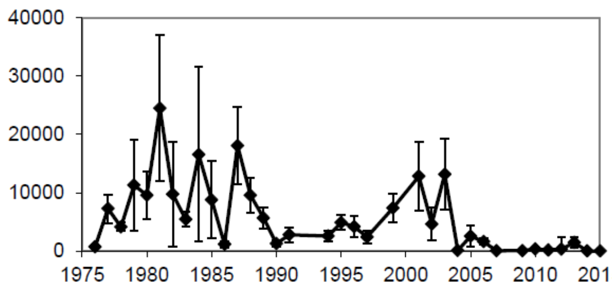

Fig 2- Biomass of young-of-the-year alewives as number of fish per hectare in Lake Huron, 1976-2015

Alewife abundance in Lake Huron remained low in 2015. YAO alewife were not collected in 2015 for the first time in the history of the survey **(Fig. 2)**. YOY alewife density and biomass during 2015 were the second lowest in the time series (**Fig. 2).** YAO rainbow smelt density in Lake Huron in 2015 was the lowest observed in the time series **(Fig. 3).** Young-of-the-year rainbow smelt abundance and biomass were similar to 2014 values. YAO bloater density and biomass decreased in 2015 **(Fig. 4).**

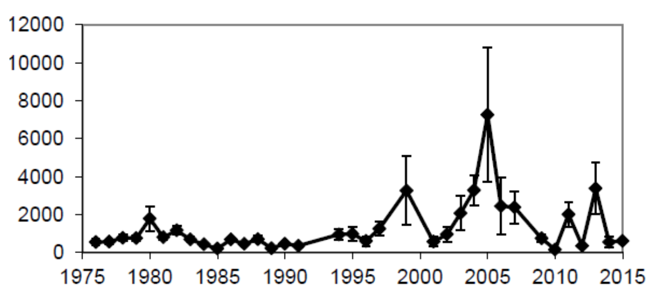

Fig 3- Biomass of young-of-the-year rainbow smelt as number of fish per hectare in Lake Huron, 1976-2015

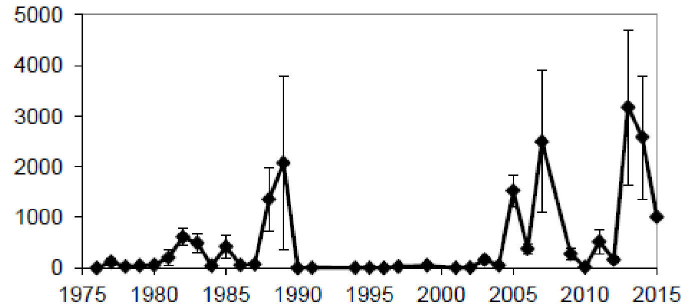

Fig 4- Biomass of young-of-the-year bloater as number of fish per hectare in Lake Huron, 1976-2015

Abundance and biomass estimates for deepwater sculpins in Lake Huron in 2015 were also lower than the previous four years and remained relatively low compared to historic estimates (**Fig. 5).** The 2015 abundance and biomass estimates for ninespine stickleback and trout-perch increased slightly from previous years **(Fig. 6).** Round goby abundance and biomass estimates for 2015 increased over 2014 levels but was well below levels observed during 2001-06 and 2011-13 **(Fig. 7).**

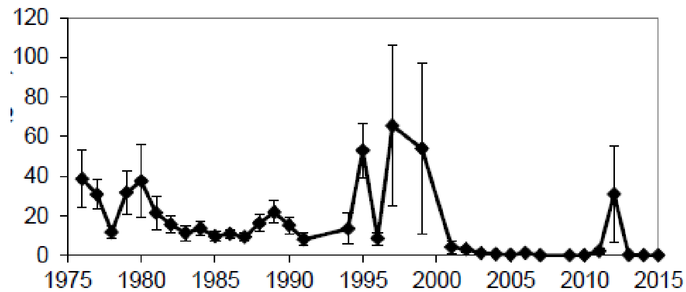

Fig 5- Biomass of slimy sculpin as number of fish per hectare in Lake Huron, 1976-2015

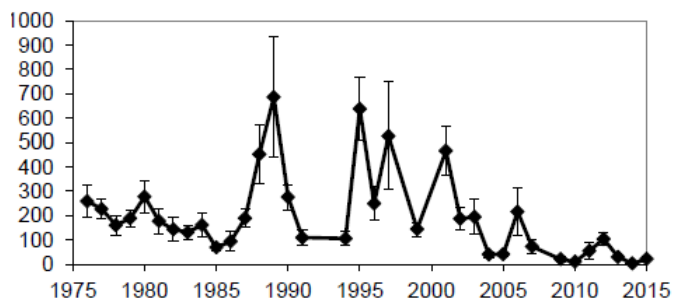

Fig 6- Biomass of ninespine stickleback as number of fish per hectare in Lake Huron, 1976-2015

The total main basin prey biomass estimate (5 - 114 m) in 2015 was 19.4 kilotonnes, a decrease of about 50% from the 2014 estimate **(Fig. 8).** This estimate is the second lowest observed in the time series and is similar to the extreme low estimates that occurred during 2009 and represents approximately 5 percent of the maximum lakewide biomass estimate observed in 1987. Approximately two-thirds of the 2015 biomass estimate was composed of YAO bloater.

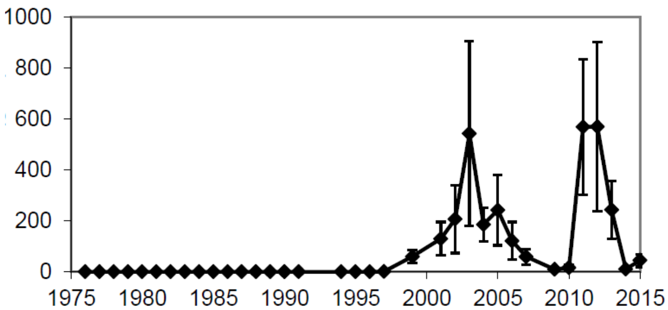

Fig 7- Biomass of round goby as number of fish per hectare in Lake Huron, 1976-2015

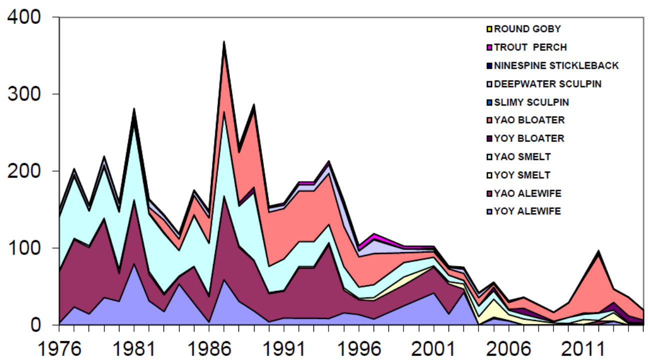

Fig 8- Offshore demersal fish community biomass in the main basin of Lake Huron, 1976-2015

Discussion

Despite collecting 6 more fish species than in 2014, overall abundances were still low. The abundance of prey fish in Lake Huron has remained at very 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 lakewide biomass of prey fish in 2012 was the highest observed since 2001, while the 2013 estimate was approximately half as high as 2012; 2014 and 2015 were even lower. The estimated biomass of YAO rainbow smelt and alewife in 2015 were lower than in 2014 and remained low compared to earlier data. The reduction in the abundance of these exotic species is consistent with fish community objectives for Lake Huron, but does not bode well for Chinook salmon populations in the lake, which rely almost solely 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. In 2014, a modest increase over the 2013 levels occurred, but then declined again in 2015. The abundance of this native species is currently at a moderate level, higher than the extreme low estimates observed in 2001-2006. Bloater are one of the only species that has increased in abundance in recent years and continued monitoring of this species will determine whether conditions in the lake are conducive to the survival and recruitment of native coregonines.

Prior to the invasion of alewife and rainbow smelt, deepwater sculpins, slimy sculpins, and trout-perch were likely an important diet of lake trout in the Great Lakes, however in recent years have become only a minor component of lake trout diets. As the prey fish community continues to change, including a reduction in numbers of alewife and rainbow smelt in the system and proliferation of round goby, monitoring these species continues to be important to understand food availability to lake trout. In 2015, biomass estimates for deepwater sculpins, sticklebacks, and trout-perch were lower than in recent years and remained relatively low compared to historical peak 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 peak abundance in 2003, and declined in abundance until 2011. 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. Additionally, because our survey samples on smooth bottom areas of the lake, and because round goby are known to prefer rocky substrates with interstitial spaces, our bottom trawl estimates of abundance and distribution likely do not reflect true round goby population demographics. New research is being proposed by USGS GLSC and partner agencies in 2017 to address these deficiencies.

The estimated lakewide biomass of common offshore prey species in Lake Huron increased from 2009 - 2012, but then decreased in 2013, 2014, and 2015. 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. These declines are possibly associated with the invasion of the lakes by several exotic species, including the spiny water flea, 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 a lessened impact from 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 estimates for any species.

Some of the fluctuations in the estimated abundance of individual species may be a result of changes in catchability caused 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. The invasion of Lake Huron by dreissenid mussels may also have affected the efficiency of the trawl, as has been observed in Lake Ontario (O'Gorman et al. 2005). Data reported here were collected at a restricted range of depths in areas that were free of obstructions and were characterized by 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 demersal fish community.

The results of this survey demonstrate that there has been great variability in the abundance or biomass of a number of fish species (YOY benthopelagic planktivores, round goby) over the last decade. Low levels of prey fish abundance have persisted since approximately 2006, although the 2012-2015 surveys provided evidence that the abundance of some species (e.g. YAO bloater) may be starting to rebound. These results, along with other analyses (Riley and Adams 2010), may indicate that the offshore demersal fish community in Lake Huron is currently in an unstable state. This survey provides the Great Lakes scientific community with the opportunity to monitor and help explain the changes occurring in the Lake Huron food web. ✧

Sea Lamprey Control in Lake Huron 2015

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, 83 tributaries (38 Canada, 45 U.S.) have been treated with lampricide at least once during 2006 - 2015. Forty-five tributaries (22 Canada, 23 U.S.) are treated every 3-5 years. Details on lampricide applications to Lake Huron tributaries and lentic areas during 2015 are found in **Fig 1**.

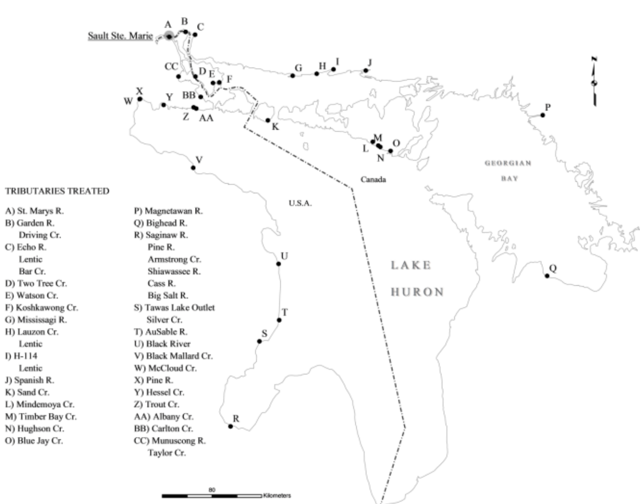

Fig 1- Location of Lake Huron tributaries treated with lampricides during 2015

● Lampricide applications were completed in 28 tributaries (15 Canada, 13 U.S.), 5 lentic area (4 Canada, 1 U.S.) and 304 ha of the St. Marys River.Six St. Marys River plots were re-ranked based on a 75% reduction and were treated twice to remove residual larval Sea Lampreys from the first treatment.

● The Garden River's main branch was deferred due to sub-optimal flows and temperatures during the time scheduled for treatment. Only one tributary, Driving Creek, was treated.

● This was the second year of an expanded large-scale treatment strategy that targeted consecutive year treatments to remove residual Sea Lampreys in large producing streams in lakes Michigan and Huron. The Spanish River and Driving Creek (Garden River tributary) in Canada and the Pine (Mackinac County), Au Sable, and Shiawassee (Saginaw River tributary) rivers and Silver Creek (Tawas Lake Outlet tributary) were treated as part of this effort.

● Five separate tributaries to the Saginaw River (Big Salt, Cass, Pine, and Shiawassee rivers and Armstrong Creek) were treated.

● The North Branch of the Big Salt River (Saginaw River tributary) was treated further upstream than any previous treatment and required increased effort.

Armstrong Creek (Saginaw River tributary) was treated for the first time.

● The South Branch of the Black River was treated further upstream than any previous treatment. Increased distribution is attributed to the replacement of a perched culvert that had previously limited access to spawning adults.

● The Au Sable River lentic area was treated for the first time.

Alternative Control

Sterile Male Release Technique
The Commission discontinued the Sterile Male Release Technique (SMRT) in the St. Marys River beginning in 2012. Long-term monitoring of egg viability and larval populations are used to assess changes that may be attributable to termination of the SMRT.

● In 2015, the mean egg viability from 15 nests was 62%. The mean post-SMRT (2012-2015) egg viabilities (67%) are significantly higher than mean viabilities (32%) when SMRT was applied (1993-2011).

● The annual proportion of age-1 larvae (≤47mm) captured in the St. Marys River by deepwater electrofishing may provide an indication of recruitment. The proportion in 2015 was 60%. The mean proportion during post-SMRT years (74%) was higher than the mean proportion during SMRT years (42%). The proportion of age-1 larvae captured was highest in 2013 (85%), which was the cohort from the 2012 spawning year, and the first year SMRT was not applied.

Barriers

The Commission has invested in 17 barriers on Lake Huron. 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.

Barrier Inventory and Project Selection System (BIPSS)
● Field crews visited 139 structures on tributaries to Lake Huron to assess Sea Lamprey blocking potential and to improve the information in the BIPSS database.

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

Repairs or improvements were conducted on two Canadian barriers:

● Still River – To avoid stop logs lifting during high flow and reduce the risk of Sea Lamprey escapement, a locking mechanism was installed in fall 2015.

● Echo River – Handrails were replaced in spring 2015.

● The electrical field of the combination low-head/electrical barrier in the Ocqueoc River was active from March 10 until October 21. The barrier was electrified for 14 total days during 4 separate events when water levels inundated the low-head barrier.

Ensure Blockage to Sea Lamprey Migration
● Cheboygan River – Plans to block adult Sea Lampreys at the Cheboygan lock and dam complex and to eradicate lampreys from the upper river continued:

● Control and research agents continued discussion with the U.S. Army Corps of Engineers and the Michigan DNR 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 study continued in the Upper Cheboygan River to seek evidence of a landlocked Sea Lamprey population and to inform lock refurbishment plans. Fyke nets were used to determine run timing and obtain morphology and statolith microchemistry data on adult lampreys in the upper river. Adult Sea Lamprey abundance in the upper river was estimated by weekly fin clipping (marking) male Sea Lampreys captured in the lower river (Lake Huron source) and released in the upper river (Schaefer mark-recapture model). Results indicated evidence that a small population of adult Sea Lampreys (n < 200) completed their life cycle in the upper Cheboygan River during 2013- 2015. There was no evidence of persistent upstream escapement of Sea Lampreys through the lock and dam complex. Adult Sea Lamprey assessment in the Cheboygan River will continue during 2016 as described above to determine if abundance is still very low.

●Saugeen River – In the fall, GLFC and Saugeen Ojibway Nation (SON) met in Ann Arbor, MI to formally discuss the Denny's Dam project. The result of this meeting was a new agreement formed between the GLFC and SON to work together in a collaborative partnership in an attempt to resolve the Denny's Dam issue with specific respect to Sea Lamprey control. In December 2015, representatives from GLFC and SON (including engineers) met onsite to discuss project impacts and review previous construction plans.

● Nottawasaga River – Structural deterioration is evident at the Nicolston Dam near Alliston, Ontario, posing a risk of Sea Lamprey escapement. DFO Engineering staff visited the site to conduct a topographical survey and to install data loggers to monitor hydraulic conditions at the dam in September 2015. Design drawings of the existing structure, including the fishway, were provided by Ontario Ministry of Natural Resources and Forestry (OMNRF).

● Consultations to ensure blockage at barriers in five tributaries were completed with partner agencies for nine sites in three streams during 2015.

Assessment of Candidate Streams

● Bighead River– Construction of a Sea Lamprey barrier has been proposed for Bighead River and a potential site has been identified on private land near Meaford, Ontario. New barrier construction requires authorization by the OMNRF under the Federal-Provincial Agreement on Sea Lamprey Barrier Dams (1983). Previously, the province authorized new construction under the Lakes and Rivers Improvement Act, but this legislation is not binding to federal agencies. Because of uncertainty regarding authorization, the Canada-Ontario Fisheries Advisory Board has recommended a DFO-OMNRF workshop to review and revise, as necessary, the existing federal/provincial agreement, and address other issues related to structures that serve a Sea Lamprey control function in Ontario. New barrier construction in Ontario streams will be pending until completion of this process.

● Pine River (Nottawasaga River) – Construction of a new barrier has been proposed for the Pine River. A potential site has been identified within Canadian Forces Base Borden, near Angus, Ontario. Construction is pending completion of the aforementioned process.

Larval Assessment

Tributaries being considered for lampricide treatment during 2016 were assessed during 2015 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 deepwater electrofishers. Infested areas were ranked for treatment during 2016 based on the most cost-effective kill of larval Sea Lampreys ≥100 mm, based on estimates of abundance and average treatment costs. Additional surveys are used to define the distribution of Sea Lampreys within a stream, detect new populations, evaluate lampricide treatments, and to establish the sites for lampricide application.

●Larval assessment surveys were conducted on 100 tributaries (39 Canada, 61 U.S.) and 14 lentic areas (5 Canada, 9 U.S.).

● Surveys to estimate abundance of larval Sea Lampreys were conducted in 25 tributaries (10 Canada, 15 U.S.) and 2 lentic areas (1 Canada; 1 U.S.).

● Surveys to detect the presence of new larval Sea Lamprey populations were conducted in 20 tributaries (2 Canada; 18 U.S.). A new population of sea lampreys was found in the Gogomain River.

● Post-treatment assessments were conducted in 26 tributaries (11 Canada; 15 U.S.) to determine the effectiveness of lampricide treatments during 2014 and 2015.

● Surveys to evaluate barrier effectiveness in 9 tributaries (2 Canada; 7 U.S.) revealed no evidence of escapement.

● Monitoring of larval Sea Lampreys in the St. Marys River continued during 2015. Eight hundred ninety six geo-referenced sites were sampled using deepwater electrofishers. Surveys were conducted according to a stratified, systematic sampling design. The larval Sea Lamprey population in the St. Marys River was estimated to be 0.7 million (95% confidence limits 0.1-1.3 million).

● More than 6,800 Sea Lamprey larvae were collected for research purposes from the Black and Cass rivers.

Larval assessment surveys were conducted in non-wadable lentic and lotic areas using 33.2 kg (active ingredient) of gB.

Juvenile Assessment

● Lake Trout marking data for Lake Huron provided by the MIDNR, Chippewa-Ottawa Resource Authority, U.S. Geological Survey, and OMNRF, are analyzed by the Service's GBFWCO.

● The number of A1-A3 marks on Lake Trout from spring assessments in 2015 were submitted in February 2016 and have yet to be analyzed.

● Based on standardized spring assessment data, the marking rate during 2014 was 12 A1-A3 marks per 100 Lake Trout >532 mm. The marking rate has been greater than the target of 5 per 100 Lake Trout since 1983 (Figure 3), but has decreased dramatically since the early 2000's.

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

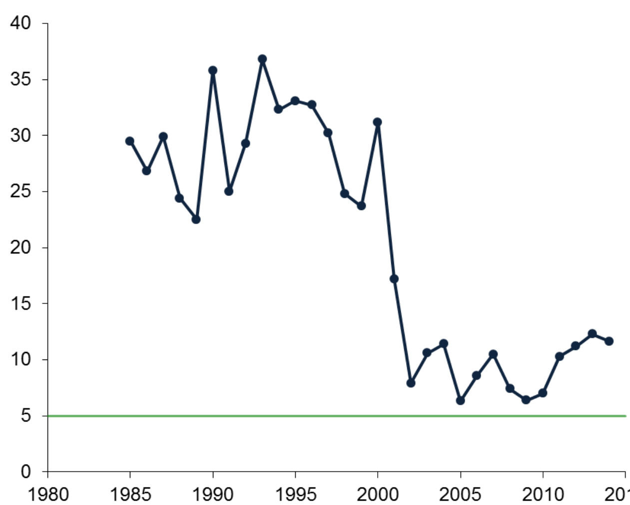

Fig 2- Average number of A1-A3 marks per 100 Lake Trout >532 mm caught in U.S. waters during spring assessments in Lake Huron. The horizontal line represents the target of 5 A1-A3 marks per 100 Lake Trout.

● Canadian commercial fisheries in northern Lake Huron continued to provide parasitic juvenile Sea Lampreys in

2015, along with associated catch information including date, location and host species. The total number of Sea Lampreys captured each year, along with effort data provided by the OMNRF, is used as an index of juvenile Sea Lamprey abundance in northern Lake Huron. Although the data for 2015 is not yet available, the CPUE value for 2014 was the lowest in nearly 30 years **(Fig 3).**

● Since 1998, standardized trapping for out-migrating juveniles has been conducted in the St. Marys River as an index of Sea Lamprey production in this system. Eleven floating fyke nets are deployed each October and November in the Munuscong, Sailor's Encampment, and Middle Neebish channels. In 2015, fyke nets were fished for a total of 545 net days, capturing 27 out-migrating juveniles (0.05 juveniles per net day;

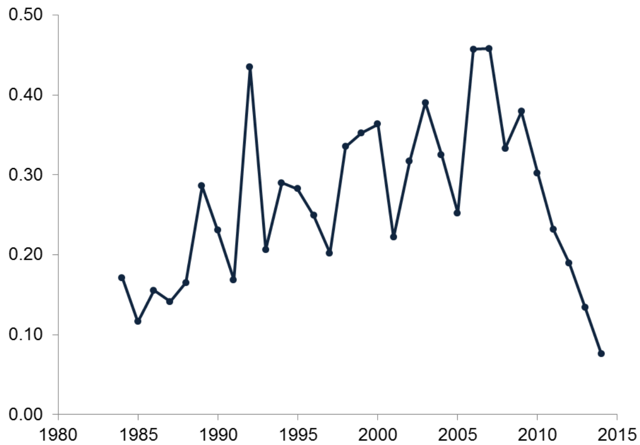

Fig 3- Northern Lake Huron commercial fisheries index showing CPUE (number of parasitic juvenile Sea Lampreys per km of gillnet per night) for 1984-2014.

Fig 4- CPUE (number of out-migrating juvenile Sea Lampreys per net day) of fall fyke netting in the St. Marys River during 1996-2015

Adult Assessment

● A total of 13,551 Sea Lampreys were trapped in 6 tributaries, all of which are index locations. Adult population estimates based on mark-recapture were obtained from all 6 tributaries.

● The index of adult Sea Lamprey abundance was 23,968 (jackknifed range; 21,842-25,482), which was less than the target of 24,113 **(Fig 5).**

● A total of 2,100 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 6,092 Sea Lampreys and trapping efficiency was 34%.

● The USACE continued planning for trap improvement projects at the St. Marys, Au Sable, and East Au Gres rivers using GLFER program funding.

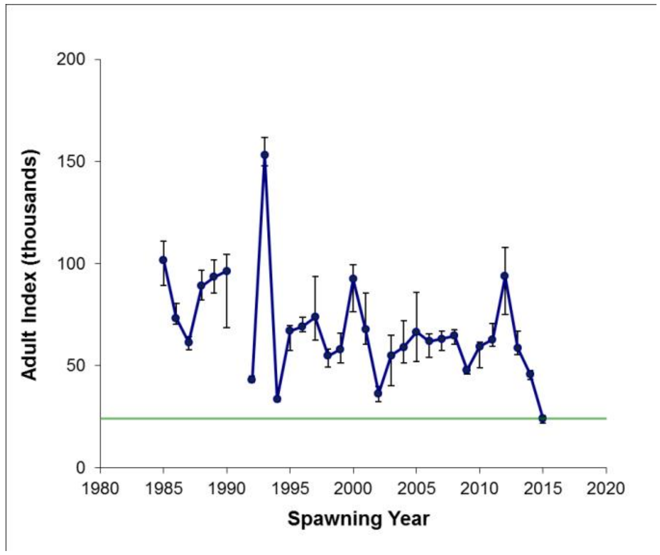

***Fig 5- Index estimates with jackknifed ranges (vertical bars) of adult Sea Lampreys. The adult index in 2015 was 24,113 with jackknifed range (21,842*-25,482). The point estimate was slightly above the target of 24,000 (green horizontal line).**

● The results of a 2-year collaboration between the SLCP and Eastern Michigan University in the Ocqueoc and Cheboygan rivers indicate that increasing ramp angle, water velocity on the ramp, and the amount of attractant water for the trap, increases capture of Sea Lampreys entering Eel Ladder-Style Traps (ELST). Analysis to determine optimal water velocities and ramp angles is in progress. A synthesized male sex pheromone (3kPZS) was also applied to the ELST entrance at the Cheboygan River to evaluate changes in trap entrance and capture rates. The results of this investigation were inconclusive. Results from this study will improve our ability to passively sort Sea Lampreys from teleost fishes at Sea Lamprey trap sites, and improve fish passage.

● 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 2016.

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● The SLCP assisted the USGS with deployment of an experimental trap with a pulsed direct current lead in Bridgeland Creek (tributary to Thessalon River) during 2014-2015. The electric lead was activated every night to determine the cost and effectiveness of using this type of trap on streams with no physical barrier. The portable trap with electric lead was similar in cost and effectiveness to a physical barrier and trap located 50 m upstream. ✧

2015 Lakes Erie/Huron Lake Sturgeon Working Group Report

The 2015 Lakes Erie/Huron Lake Sturgeon Working Group Reports, comprised of fisheries biologists from USFWS (multiple offices), U.S. Army Corp of Engineers, the Great Lakes Center at SUNY Buffalo State, New York Department of Environmental Conservation, USGS Great Lakes Science Center, Ontario Ministry of Natural Resources and Forestry (OMNRF, U of Windsor, U of Toledo, Michigan DNR, Ohio DNR and West Virginia U are collectively collaborating in twelve ongoing projects to collect life history and population demographics for the lake sturgeon population in and about Lakes Erie, Huron & St. Clair; and the Maumee, St. Clair, Detroit and Niagara Rivers

Some sample projects:

●Researchers are collecting life history and population demographics for the lake sturgeon population in and about Buffalo Harbor.

●Researchers equipped 9 fish with archival satellite transmitters and surgically implanted acoustic transmitters into 19 fish to analyze coarse- and fine-scale temporo-spatial movement, behavior and habitat use within Buffalo Harbor.

●Researchers are collecting information on age, growth, sex, health and spawning contribution of adult and sub-adult lake sturgeon caught in annual surveys conducted in the Buffalo Harbor and upper Niagara River.

●Two remnant groups of sturgeon are being studied: one in the Detroit River and the other in the upper Niagara River, in order to gain a better understanding of these existing groups of sturgeon as they relate to historical populations and identify other historically important areas that supported the largest commercial fishery of lake sturgeon in the Great Lakes.

●Genetic analysis of the lake sturgeon sampled in the Niagara River and eastern Lake Erie will improve the understanding of the genetic relationship between lake sturgeon from both the upper and lower Niagara River, as well as in comparison to other populations throughout the Great Lakes.

●In order to determine if current habitat quantity and quality are sufficient to support reintroduction, researchers are constructing a spatially explicit habitat suitability index model for spawning adult and age-0 lake sturgeon for the lower Maumee River.

●The Michigan DNR Lake St. Clair Fisheries Research Station (LSCFRS) has been conducting lake sturgeon assessment surveys since 1996 to capture lake sturgeon in the open waters of Lake St. Clair. All sturgeon captured are scanned for PIT tags and untagged fish are PIT tagged prior to release, with data used to obtain growth, genetics, distribution, spawning site, and population demographic information.

●The North Channel of the St. Clair River supports a unique recreational fishery for lake sturgeon. The objectives of this project are to better understand the human dimensions of sturgeon fishing, and to gather firsthand observations of the effect of recreational angling on lake sturgeon caught with conventional fishing equipment.

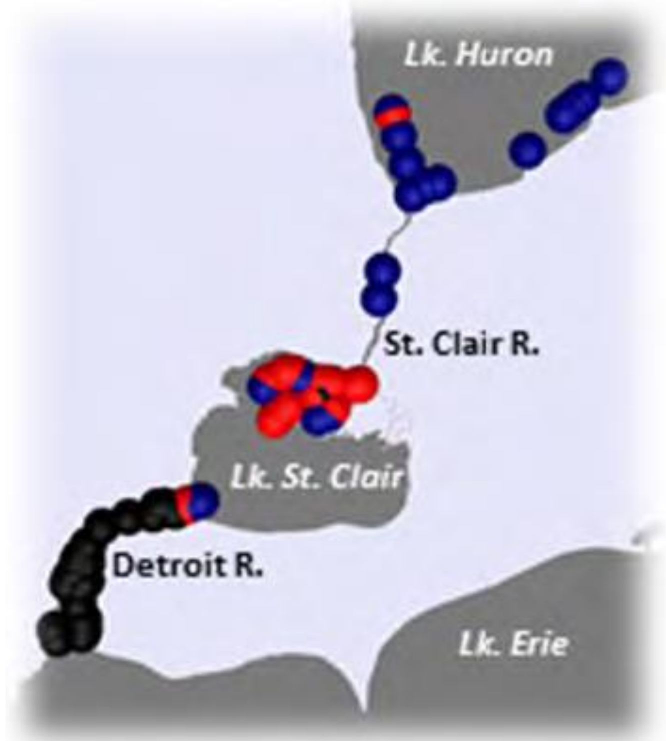
●Since 2011, a total of 268 adult lake sturgeon have been captured in the Detroit and St. Clair rivers, implanted with highpower acoustic tags with a battery life of 10 years, and then released near the capture site.

●A current study evaluated the use of a portable ultrasound unit to determine sex of lake sturgeon in the St. Clair-Detroit River System. The sex and maturity of 41 female and 107 male lake sturgeon was determined by visually inspecting gametes through a small incision.

●Raw imagery was collected in 2015 and the categorical map will be completed in 2016. Additionally, biometric, age, blood and genetic data for each individual will be used to describe population demographics and health.

●Annually since 2002, researchers have been using setline assessments to obtain information on adult and subadult lake sturgeon, specifically to obtain growth information, genetics, distribution, potential spawning sites, and population demographic information. To date, the Service has tagged 374 lake sturgeon in the Detroit River.

●In an effort to gain a better understanding of lake sturgeon presence and abundance in western Lake Erie, the Ohio DNR and USFWS Alpena FWCO are working with commercial fisherman in Ohio waters of Lake Erie to collect lake sturgeon information.



●The Ontario Ministry of Natural Resources and Forestry (OMNRF) does not conduct annual targeted survey for lake sturgeon on Lake Erie, but does rely on indirect sources of information in order to track lake sturgeon presence and absence over time across the Ontario waters of Lake Erie. This program monitors the abundance, age structure, size, and species composition throughout Lake Erie.

●Understanding how invasive species alter the food web structure in Lake Sturgeon Isotopic signatures in the Huron-Erie Corridor is an effort of USFWS, OMNRF and U of Windsor. The research questions Is there an ontogenetic shift in lake
sturgeon trophic position and how have/are invasive species affecting the trophic position of juvenile and adult lake sturgeon?

●Researchers want to determine whether the lake sturgeon of the St. Clair system and Southern Lake Huron differ morphometrically due to variation in migratory phenotypes, 2) determine if individuals with different migratory phenotypes are reproductively isolated, and 3) determine if migratory and river resident individuals are differentially methylated, indicating epigenetic differences between the two phenotypes. ✧

2016 Lake Huron Implementation Plan

Introduction

Aquatic invasive species pose a serious threat to Lake Huron with at least 70 non-native aquatic species already present (NOAA 2014). Ecological degradation in Lake Huron has been extensive from invasive species such as Sea Lamprey, Zebra and Quagga Mussels, and Round Gobies. The Sea Lamprey contributed to depletion or localized extirpations of Lake Trout populations in Lake Huron. Zebra and Quagga Mussels have caused dramatic changes to the Lake Huron ecosystem, shifting energy from pelagic to benthic sources and leading to reductions in fish production and growth rates, among other impacts.

Resource agencies and managers around the Great Lakes have identified the need to monitor existing aquatic invasive species as well as detect the arrival of new species (Great Lakes Water Quality Agreement 2012; Great Lakes Restoration Initiative 2014; USEPA 2008). The Lake Huron Binational Partnership Action Plan outlined objectives to 1) prevent the introduction of any non-indigenous aquatic species that are not currently established in Lake Huron, 2) prevent or delay the spread of non-indigenous nuisance species, where feasible, and 3) eliminate or reduce populations of non-indigenous nuisance species, where feasible. Invasive species prevention plans recognize that preventative measures are the best actions for deterring the establishment of new invasive species. However, subsequent actions should include monitoring for new species arrivals so that the spread of a new species may be controlled when their abundance is low and spatial distribution restricted.

This Lake Huron specific implementation plan elaborates on the strategic framework outlined in the proposed *Strategic Framework for the Early Detection of Non-native Fishes and Select Benthic Macroinvertebrates in the Great Lakes* (USFWS 2014) by defining how the USFWS will carry out non-native species early detection in Lake Huron and its connecting channels **(Fig 1).** The USFWS, Alpena Fish and Wildlife Conservation Office (FWCO) identified the risk associated with specific vectors at locations across the station's area of responsibility on Lake Huron and western Lake Erie. Locations were prioritized based on vector risk such that locations with the highest risk of introduction were considered for sampling to maximize the likelihood of detecting a new non-native species, should it arrive.

Based on the risk characterization across all areas of responsibility for the Alpena FWCO and required time/staff to implement early detection efforts, one high risk location in the Lake Huron basin will be sampled in 2016 **(Fig 1).**

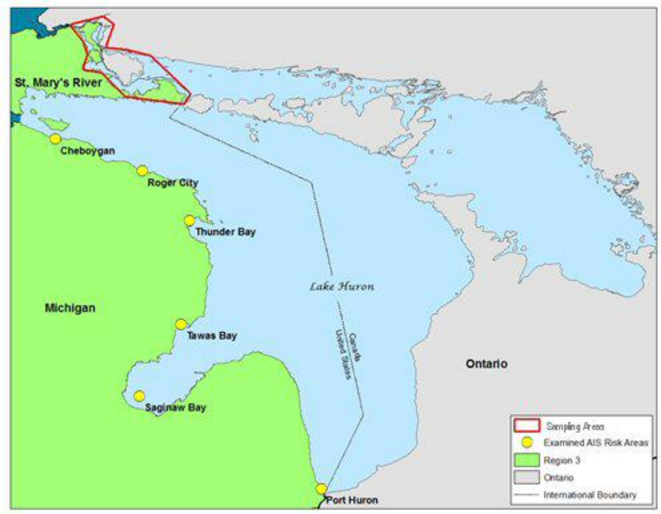


Fig 1- The Lake Huron Implementation Plan addresses Lake Huron and its connecting channels.

Species of Greatest Concern/Risk

Several risk assessments have been conducted to predict likelihood of introduction of non-native organisms to the Great Lakes. Species highlighted as being of particular concern for this Lake Huron implementation plan (**Table 1**) are based on assessments conducted by the Great Lakes Mississippi River Interbasin Study, and the current Great Lakes Aquatic Nonindigenous Species Information System watchlist.

Table 1- Non-native species of particular focus for USFWS early detection monitoring activities in the Lake Erie and Lake Huron watersheds for 2016. Refer to key below table for code definitions. The "*" denotes presence in the Great Lakes system; the "+" denotes presence in the Mississippi River system; and the "!" denotes it has been found in the Lake Erie or Lake Huron systems.

Type	Common name	Scientific name	Vector(s)	Donor region	Reproduction & larval temp. (C)	Habitat	Potential effective gear
A	Amphipod	*Dikerogammarus haemobaphes*	M	PC	10 - 25.6[1]		A, B, C, D
A	Amphipod	*Echinogammarus warpechowski*	M	PC			A, B, C, D
A	Amphipod	*Pontogammarus aralensis*	M	PC			A, B, C, D
A	Amphipod	*Pontogammarus robustoides*	M	PC	7.5 - 24.2[4]	S, V, G, H	A, B, C, D
A	Caspian Mud Shrimp	*Corophium curvispinum*	M	PC	12 - 26.5[8]	S, V, H, Z	A, B, C, D
A	Killer Shrimp	*Dikerogammarus villosus*	M	PC	13 - 30[7]	G, H	A, B, C, D
B	Basket (European) Shell	*Corbula gibba*	M	E	Unknown[13]	S, Z	C, D, P
B	Golden Mussel	*Limnoperna fortunei*	M	A	16 - 28[12]	H, LO, LE	C, D, P
B	Mussel	*Hypanis (Monodacna) colorata*	M	PC			C, D, P
F	Bighead Carp +!	*Hypophthalmichthys nobilis*	C, F, I, O	A	18 - 30[5]		E, G, L, P
F	Bitterling	*Rhodeus sericeus*	O[28]	E, A[28]	18-21[28]	LE,S	F, E, G, L, P
F	Black Carp +	*Mylopharyngodon piceus*	C, F	A	26- 30[6]		E, G, L, P
F	Black Sea Silverside	*Atherina boyeri*	F, O	PC	10- 30[25,26]		E, F, L, P, S
F	Bleak	*Alburnus alburnus*	F, O	PC	>15[14]	S, G	L, P
F	Blotched Snakehead	*Channa maculata*	F, A, O[30]	A[29]		LE, LO, S, V[29]	E, F, G, L, P, S
F	Blue Catfish +	*Ictalurus furcatus*	F, I	NA	21 - 24[23]		L, P
F	Blueback Herring *	*Alosa aestivalis*	C, F, M	NA	14 - 273		E, G, L, P
F	Bullhead	*Cottus gobio*	F, O	E	7.5 - 13.5[15]	G	L, P
F	Bullseye Snakehead	*Channa marulius*	I, F, O[31]	A[31]		G, LE, LO, S, V[31]	E, F, G, L, P, S
F	Caucasian Goby	*Knipowitschia caucasica*	M	PC		V, G, Z	L, P
F	Eastern Mosquitofish*	*Gambusia holbrooki*	A, F[44]	NA[44]	>16[46]	LE, V[44]	E, F, L, M, P, S
F	Eurasian Dace	*Leuciscus leuciscus*	F, O	PC	5 - 10[20]	G, LO	L, P
F	Eurasian Minnow	*Phoxinus phoxinus*	F, O	PC	>11.4[24]	G, LO	E, L, P, S
F	European Perch	*Perca fluviatilis*	F, O	PC	7 - 20[27]		E, G, L, P, S

Type	Common name	Scientific name	Vector(s)	Donor region	Reproduction & larval temp. (C)	Habitat	Potential effective gear
F	European Whitefish (Vendace)	*Coregonus albula*	F	E	2-7[18]	S, G	G, L, P
F	Giant Snakehead	*Channa micropeltes*	O[32]	A[32]		LE, LO, V[33]	E, F, G, L, P, S
F	Grass Carp *!	*Ctenopharyngodon idella*	F, I, O	A	15 - 30[2]	V	E, G, L, P, S
F	Ide	*Leuciscus idus*	A, F[34]	E[34]	8-23[35]	LE, LO, G, V[34]	E, F, G, L, P,
F	Monkey Goby	*Neogobius fluviatilis*	M	A, E	>13[22]	V, G, Z	E, T, L, P, S
F	Northern Snakehead +	*Channa argus*	O[37]	A, PC[37]	25-31[37]	LO, S, V[37]	E, F, G, L, P, S
F	Oriental Weatherfish *	*Misgurnus anguillicaudatus*	O[36]	A[36]		LE, S[36]	F, L, M, P, S, T
F	Roach	*Rutilus rutilus*	F	PC	8 - 14[14]	V, LE	E, F, L, P
F	Rudd *!	*Scardinius erythrophthalmus*	F[38]	A, E, PC[38]	>18[38]	LE, LO, V[38]	E, G, L, P
F	Ruffe *!	*Gymnocephalus cernua*	C, F, M	PC	10 - 20[11]		L, P
F	Sand Goby	*Pomatoschistus minutus*	F, O	PC	8 - 15[17]	S, Z	E, L, P, S
F	Silver Carp +	*Hypophthalmichthys molitrix*	C, F, I, O	A	18 - 26[5]	LE	E, G, L, P
F	Stone Moroko	*Pseudorasbora parva*	F[39]	A[39]	20[40]	LE, V[39]	E, F, L, M, P, S
F	Sunbleak	*Leucaspius delineatus*	C	PC	16 - 20.4[16]	V, LE	L, P
F	Tench	*Tinca tinca*	C, F	PC	20 - 31.6[9]	S, V, LE	E, L, P
F	Toothed Carp	*Aphanius fasciatus*	C	PC	21 - 33[10]	LE	L, P
F	Tyulka/Caspian Kilka	*Clupeonella cultriventris/caspia*	M	PC	10 - 25[19]		E, G, L, P
F	Walking Catfish	*Clarias batrachus*	F, O, I[41]	A[41]		LE, LO, S, V[41]	F, G, L, P
F	Wels Catfish	*Silurus glanis*	F, O[42]	E, A[42]	18-22[42]	LE, LO, V, B[42]	G, L, P
F	Western Mosquitofish *!	*Gambusia affinis*	A, F[45]	NA[45]	>16[46]	LE, V[45]	E, F, L, M, P, S
F	Western Tubenose Goby *!	*Proterorhinus semilunaris*	M[43]	PC[43]		H, V[43]	E, T, L, P, S
F	Zander	*Sander lucioperca*	C, F	PC	8 - 15[21]	G, LE	G, L, P

Key for codes listed in Table 1:

Organism Type
A= amphipod
B= bivalve
F= fish

Vectors of introduction
A= agency activities
C= canals/diversions
F= fishing/aquaculture
I= illegal activities
M= maritime commerce
O= organisms in trade
T= tourism and development

Donor Region
A= Asia
E= Europe
NA= North America
PC= Ponto-Caspian

Habitat
H=boulder/hard
LE= lentic
LO= lotic
S= silt/mud/sand
V= vegetation
Z= dreissenid beds

Effective Gears
A= amphipod trap
B= benthic sled
C= colonization sampler
D= dredge (e.g. Ponar/Ekman)
E= electrofishing
F= fyke/trap netting
G= gillnet
L= quatrefoil light trap
M= minnow trap
P= plankton net
S= seine
T= bottom trawl

Vector Risk Assessment

Eight vectors were identified and detailed by which non-native species may be introduced to the Great Lakes and include: maritime commerce, agency activities, canals and water diversions, organisms in trade, fishing and aquaculture, water recreation, tourism and development, and illegal activities **(Fig 2).**

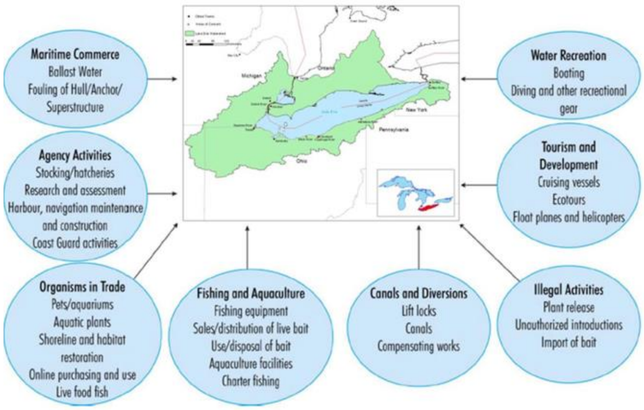


Fig 2- Vector and pathway concept map for Lake Huron

For past early detection planning, the Alpena FWCOs prioritized these vectors **(Fig 2)** based on pathways for historical non-native species introductions (**Table 2**). In 2016, prioritization was changed to now focus on pathways for species at risk for introduction into the Great Lakes **(Table 1**). The change is relevant because the importance of pathways changes with the economy, population and other factors. For example, the pathway for organisms in trade and the movement of non-native species to new locations through commerce has become a greater concern through time now that Internet trade has made a wide variety of species readily available to almost anywhere.

Therefore, using vector pathways for non-natives with high risk to become introduced to the Great Lakes **(Table 1**), the eight vector categories were prioritized from highest to lowest risk as follows (**Fig 3):** 1) fishing and aquaculture with an anticipated 34% of species introductions, 2) organisms in trade with an anticipated 23% of species introductions, 3) maritime commerce with an anticipated 19% of species introductions, 4) canals and diversions with an anticipated 11% of species introductions, 5) illegal activities with an anticipated 8% of species introductions, and 6) agency activities with an anticipated 5% of species introductions. Water recreation and tourism, and development were not readily identified as vector pathways for high risk species.

Fishing and Aquaculture

Fishing and aquaculture was identified as the most common vector for introduction of high risk non-native organisms found in **Table 1 (Fig 3),** anticipated to provide a vector for

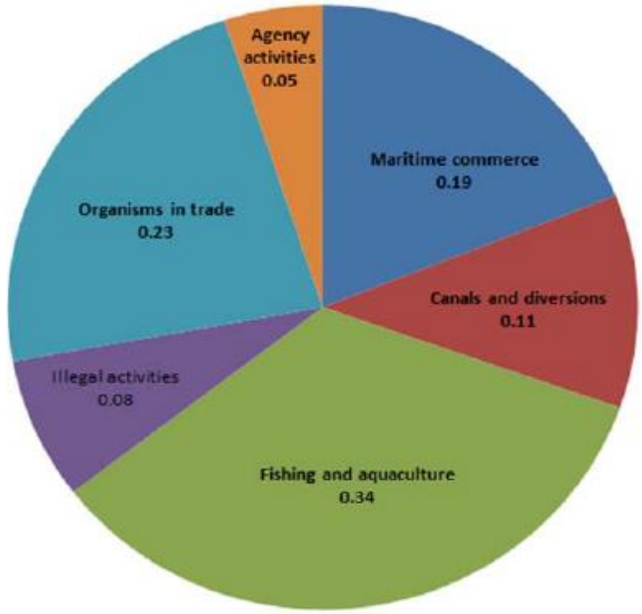


Fig 3- Vector pathways for high risk non-native fish, amphipod, and bivalves (Table 1) that are of concern to become introduced into the Great Lakes. Numbers are proportions by which at risk non-native species may become introduced.

34% of the species listed. Two non-native species were historically introduced to Lake Huron as a result of fishing or aquaculture operations (**Table 2).**

Some issues related to fishing and aquaculture risk for the introduction and spread of non-native species include the potential for recreational and charter anglers and commercial fishermen to move non-natives on their fishing equipment, boats, nets or other fishing gear; and the survival of live bait. Recreational and charter anglers and commercial fishermen have the potential to move nonnative species on their fishing gear. Some species can survive for long periods inside boat livewells. Even so, fishing equipment alone has not been identified as a source of former species introductions into Lake Huron.

Many Great Lakes anglers use live bait, and the sale and use of live bait is cause for concern as a vector for the introduction of non-native species. Juvenile Silver and Bighead Carp, for example, could be confused with other fishes commonly used as bait. Commercial harvesting of baitfish routinely occurs in Lake Huron and at other Great Lakes locations. These fish are distributed across the region, potentially moving live non-native species to new locations for use by angers. Each governmental jurisdiction in the Lake Huron basin addresses the sale and distribution of live bait through its own regulations. Illegal activities regarding the movement or illegal stocking of live bait is a concern for this vector category.

Table 2- Historical non-native fish, amphipod, and bivalve introductions to Lake Huron (USGS 2016). Vector codes are: M = maritime commerce, A = agency activities, C = canals and water diversions, F = fishing and aquaculture, O = organisms in trade, U = unknown.

Common Name	Scientific Name	Vector	USGS NAS pathway
Amphipod	*Gammarus tigrinus*	M	shipping ballast water
Freshwater Shrimp	*Gammarus fasciatus*	M	shipping-ballast water
Scud	*Echinogammarus ischnus*	M	shipping ballast water
Asian Clam	*Corbicula fluminea*		unknown
European Fingernail Clam	*Sphaerium corneum*	M	shipping
Greater European Peaclam	*Pisidium amnicum*	M	shipping solid ballast
Quagga Mussel	*Dreissena rostriformis bugensis*	M	shipping, shipping-ballast water
Zebra Mussel	*Dreissena polymorpha*	M	shipping, shipping-ballast water
Alewife	*Alosa pseudoharengus*	C, A	canal, stocked
American Eel	*Anguilla rostrata*	C	canal
American Shad	*Alosa sapidissima*	C	canal
Atlantic Salmon	*Salmo salar*	A	stocked for sport
Black Buffalo	*Ictiobus niger*	C	canal
Brown Trout	*Salmo trutta*	A	stocked for sport
Chinook Salmon	*Oncorhynchus tshawytscha*	A	stocked for sport
Coho Salmon	*Oncorhynchus kisutch*	A	stocked for sport
Common Carp	*Cyprinus carpio*	A	stocked
Cutthroat Trout	*Oncorhynchus clarkii*	A	stocked for sport
European Flounder	*Platichthys flesus*	M	shipping ballast water
Ghost Shiner	*Notropis buchanani*	F+A	bait release
Goldfish	*Carassius auratus*	O, A	aquarium release, stocked
Grass Carp	*Ctenopharyngodon idella*	A	stocked for biocontrol
Green Sunfish	*Lepomis cyanellus*	A	stocked for sport
Longear Sunfish	*Lepomis megalotis*	A	stocked for sport
Pink Salmon	*Oncorhynchus gorbuscha*	A	stocked for sport
Rainbow Smelt	*Osmerus mordax*	A	stocked
Rainbow Trout	*Oncorhynchus mykiss*	A	stocked for sport
Red-bellied Pacu	*Piaractus brachypomus*	O	aquarium release
Red Piranha	*Pygocentrus nattereri*	O	aquarium release
Round Goby	*Neogobius melanostomus*	M	shipping ballast water, dispersed
Ruffe	*Gymnocephalus cernua*	M	shipping ballast water, dispersed
Sea Lamprey	*Petromyzon marinus*	C	canal
Splake	*Salvelinus fontinalis x namaycush*	A	stocked for sport
Sockeye Salmon	*Oncorhynchus nerka*	A	stocked for sport
Striped Bass	*Morone saxatilis*	C	canal
Threespine Stickleback	*Gasterosteus aculeatus*	C, F+A	unknown (canal, bait release)
White Bass x White Perch hybrid	*Morone chrysops x M. americana*	C	canal
White Perch	*Morone americana*	C, M	canal, shipping ballast water
Yellow Bass	*Morone mississippiensis*	C	canal

Water Area	##	Proportion	Risk
Saginaw Bay	1,836	0.0521	Low
Cheboygan Cnty, MI	592	0.0168	Low
Northern Lake Huron	344	0.0097	Low
Southern Lake Huron	292	0.0083	Low
Presque Isle Cnty, MI	256	0.0072	Low
St Marys River	248	0.0070	Low
Thunder Bay	141	0.0040	Low
Alcona County, MI	98	0.0027	Low

Table 3- Boat harbor slips counted along the Lake Huron shoreline using Google Earth. Proportion is a fraction of the sum of boat harbor slips, where Lake Erie and Lake Huron locations were assessed cumulatively. Only Lake Huron locations are represented.

Water Area	##	Proportion	Risk
Saginaw Bay	40	0.1277	High
St Marys River	11	0.0351	Low
Cheboygan Cnty, MI	8	0.0255	Low
Northern Lake Huron	8	0.0255	Low
Presque Isle Cnty, MI	5	0.0159	Low
Thunder Bay	4	0.0127	Low
Alcona County, MI	3	0.0095	Low
Southern Lake Huron	3	0.0095	Low

Table 4- Boat access sites counted along the Lake Huron shoreline using Google Earth. Proportion is a fraction of the sum of boat access sites, where Lake Erie and Lake Huron locations were assessed cumulatively. Only Lake Huron locations are represented.

Target measures that were used to assess the risk of fishing and aquaculture at Lake Huron locations included: number of boat harbor slips **(Table 3)**, number of boat accesses **(Table 4)**, number of boat ramp parking spaces **(Table 5**), and number of bait shops per county bordering Lake Huron **(Table 6).** Other targeted measures for fishing and aquaculture were difficult to assess in an equal manner for all locations analyzed and therefore were not used to assess risk for this implementation plan.

They included angling effort, aquaculture, charter boat fishing, commercial fishing, and live bait usage.

The number of boat harbor slips (**Table 3),** boat accesses **(Table 4),** and boat ramp parking spaces **(Table 5)** were analyzed by examining the Lake Huron shoreline using a satellite image on Google Earth and counting the number of boat harbor slips, boat accesses, and boat ramp parking spaces present. The number of bait shops **(Table 6)** was counted per county based on a search of the Internet. The proportion provided is the number counted at any given location divided by the sum total for all locations. High risk was assigned to the top ⅓, medium risk was assigned to the middle ⅓, and low risk was assigned to the bottom ⅓.

Water Area	##	Proportion	Risk
Saginaw Bay	1,864	0.2118	High
Cheboygan Cnty, MI	264	0.0300	Low
Thunder Bay	245	0.0278	Low
Southern Lake Huron	232	0.0263	Low
Presque Isle Cnty, MI	188	0.0213	Low
Alcona County, MI	175	0.0198	Low
St Marys River	159	0.0180	Low
Northern Lake Huron	143	0.0162	Low

Table 5- Boat ramp parking spaces counted along the Lake Huron shoreline using Google Earth. Proportion is a fraction of the sum of boat ramp parking spaces, where Lake Erie and Lake Huron locations were assessed cumulatively. Only Lake Huron locations are represented.

Water Area	##	Proportion	Risk
Saginaw Bay	46	0.2044	High
St Marys River	15	0.0666	Low
Northern Lake Huron	10	0.0444	Low
Cheboygan Cnty, MI	10	0.0444	Low
Presque Isle Cnty, MI	8	0.0355	Low
Alcona County, MI	4	0.0177	Low
Thunder Bay	4	0.0177	Low
Southern Lake Huron	1	0.0044	Low

Table 6- Number of bait shops per county for counties bordering Lake Huron. Proportion is a fraction of the sum of bait shops, where Lake Erie and Lake Huron locations were assessed cumulatively. Only Lake Huron locations are represented.

Organisms in Trade

Most aquatic animals in pet stores, such as snails and fish, are not native to the Great Lakes and unwanted aquatic pets are often released into a nearby waterway because pet owners believe it is a humane effort as opposed to disposal, however this is not an ecologically sound way to dispose of pets because their survival could result in an infestation. Examples highlighting incidence of pet shop releases include a fancy Goldfish which was caught during a recent USFWS sampling effort in the River Raisin, and aquarium fish were found in a pet store bag floating on the Erie Canal.

Historically, three species have been identified as being introduced to Lake Huron via this vector category (**Table 3),** and this remains an important means for new non-native species introductions. Twenty-three percent of species with high risk to invade the Great Lakes are anticipated to arrive in the Great Lakes via this pathway (**Fig 3**).

Water Area	##	Proportion	Risk
Saginaw Bay	14	0.1007	Medium
Thunder Bay	1	0.0071	Low
St Marys River	1	0.0071	Low
Southern Lake Huron	1	0.0071	Low

Table 7- Number of aquarium and pond shops per county for counties bordering Lake Huron. Proportion is a fraction of the sum of aquarium and pond shops, where Lake Erie and Lake Huron locations were assessed cumulatively. Only Lake Huron locations are represented.

Water Area	Pop.	Proportion	Risk
Saginaw Bay	210,450.75	0.0179	Low
Southern Lake Huron	75,113.25	0.0063	Low
St Marys River	38,676.50	0.0032	Low
Central Lake Huron	36,272.75	0.0030	Low
Thunder Bay	29,322.75	0.0024	Low
Cheboygan Cnty, MI	25,915.75	0.0022	Low
Presque Isle Cnty, MI	13,185.75	0.0011	Low
Northern Lake Huron	11,090.00	0.0009	Low

Table 8- Population for U.S. counties bordering Lake Huron based on U.S. Census information. Proportion is a fraction of the total sum of population, where Lake Erie and Lake Huron locations were assessed cumulatively. Only Lake Huron locations are represented.

Target measures that were used to assess the risk of organisms in trade at Lake Huron locations included the number of aquarium and pond shops per county bordering Lake Huron **(Table 7)** and population size of counties bordering Lake Huron **(Table 8).** Population was used as a surrogate for pet shops because an assessment of pet shops was not conducted within the time needed to complete this plan. Another targeted measure for organisms in trade that was difficult to assess in an equal manner for all locations analyzed and therefore was not used to assess risk for this implementation plan was fish markets per area.

The number of aquarium and pond shops per county bordering Lake Huron (**Table 7)** was analyzed based on a search of the Internet. The U.S. population numbers for counties bordering Lake Huron were compiled using U.S. Census Bureau information (U.S. Census Bureau 2010). The proportion provided is the number counted or population at any given location divided by the sum total for all locations. High risk was assigned to the top ⅓, medium risk was assigned to the middle ⅓, and low risk was assigned to the bottom ⅓.

Historically, a number of non-native species were introduced to Lake Huron and the Great Lakes via maritime commerce. In an analysis of priority species poised to become introduced to the Great Lakes, maritime commerce continued to be a potential vector pathway for 19% of the species listed (**Fig 3, Table 1**).

Historically, ballast water from commercial ships was identified as the most important vector for introduction of non-native organisms to the Great Lakes, accounting for 65% of species invasions from 1960-2006. Ships entering the Great Lakes claiming NOBOB (No Ballast on Board) status can transport non-native species to the system, particularly invertebrates.

Ballast water from commercial ships that operate only in the Great Lakes can also be a vector that accelerates the spread of non-native species within the system. In addition, barge traffic enters the Great Lakes from the Mississippi River basin and potentially via the St. Lawrence Seaway or Erie Canal system and the movement of non-native species on infested barges can be a potential source of new species introduction.

No Lake Huron ports received known overseas ballast water from outside the Great Lakes **(Table 9),** however Lake Huron ports did receive large volumes of coastwise ballast water **(Table 9).** Coastwise ballast water transfer could move non-native species introduced outside of the basin to a port within Lake Huron.

Canals and Water Diversions

Canals and water diversions are pathways by which non-native species can enter the Great Lakes. Historically, canals and water diversions accounted for approximately 24% of non-native aquatic species introductions to Lake Huron. Many species were able to enter the upper Great Lakes when the Welland Canal was constructed, opening water access which allowed organisms to swim around Niagara Falls. This vector category includes canals, lift locks, water diversions, compensating works, and other hydrologic connections which may provide a pathway for non-native species to become introduced. Eleven percent of high risk species with potential to become introduced into the Great Lakes are anticipated to arrive via this vector pathway **(Fig 3).**

There are no canals or water diversions in U.S. waters of Lake Huron. We recognize that the Canadian Trent-Severn Waterway in Georgian Bay is a canal that connects Lake Huron and Lake Ontario, however we did not analyze risk for Canadian locations for this plan. The target measure that was used to assess the risk of this vector at other locations within the Great Lakes where canals were present (Lake Erie) was the number of canals, diversions, or connections associated with each location. Proportions were generated and high risk was assigned to the top ⅓, medium risk was assigned to the middle ⅓, and low risk was assigned to the bottom ⅓.

Sampling effort and gears

● Juvenile and adult fish sampling have been conducted in the lower St. Marys River annually from 2013 to 2015 and will continue in 2016.
● Juvenile and adult fish sampling: In 2016, 45 sites will be sampled during August-October. Effort will be distributed equally among three gear types: paired fyke net overnight sets at 15 sites, nighttime electrofishing 600 s transects at 15 sites, and daytime bottom trawling five minute tows at 15 sites.
● In addition to this effort on Lake Huron, prioritized sampling will also be conducted at four other high risk locations on Lake Erie by the USFWS Alpena FWCO and the USFWS Lower Great Lakes FWCO in 2016. Those locations include the Detroit River, Maumee Bay, Sandusky Bay, and Buffalo/upper Niagara River. ✧

Lake Huron Chinook Salmon Fishery Unlikely to Recover

U. of Michigan School of Natural Resources-led computer-modeling study

Lake Huron's Chinook salmon fishery will likely never return to its glory days because the lake can no longer support the predatory fish's main food source, alewife, according to a new Univ. of Michigan study.

The study's results suggest that Lake Huron managers should focus on restoration of native species such as lake trout, walleye, whitefish and herring. The findings also suggest that if current trends continue, Lake Michigan will likely experience an alewife collapse similar to Lake Huron's, followed by the crash of its Chinook salmon fishery there.

"These results serve as a reality check for those who continue to pressure the managers to stock Chinook salmon in Lake Huron," said study co-author Sara Adlerstein-Gonzalez, a fishery scientist at U-M's School of Natural Resources. "The findings are also good news for native fish species and for the restoration of the entire Lake Huron ecosystem. Maybe we should celebrate the improvements in the native fish populations and try to adapt to this new situation."

A paper summarizing the findings was published in the journal Ecosystems on March 14. The paper's first author is Yu-Chun Kao, who conducted the work for his doctoral dissertation at U-M under Adlerstein-Gonzalez. He is now a postdoctoral researcher at Michigan State University and works at the U.S. Geological Survey's Great Lakes Science Center in Ann Arbor.

The other author of the paper is Ed Rutherford of NOAA’s Great Lakes Environmental Research Laboratory in Ann Arbor.

Pacific salmon were introduced into the Great Lakes 50 years ago to establish a new recreational fishery and to help control alewives, a non-native species that entered the lakes in the late 1940s. Alewives soon became the main prey species for Chinook salmon and lake trout, which are staples of a fishery valued at more than $4 billion per year.

Lake Huron's alewife population collapsed in 2003, and a sharp Chinook salmon decline soon followed. Michigan and the province of Ontario stopped stocking Chinook salmon in southern Lake Huron in 2014 but continue to stock in the northern part of the lake. In Lake Michigan, where populations of both alewives and salmon are declining, stocking of Chinooks continues at significantly reduced levels.

The new study is the first attempt to use a food-web modeling approach to assess the various factors behind the 2003 collapse of Lake Huron alewives and the implications for future fish populations there. The total weight or "biomass" of alewives in Lake Huron plunged by more than 90% between 2002 and 2003, and the exact causes of the collapse are still debated by anglers and biologists.

Some researchers say the alewife collapse was mainly due to too much predation by Chinook salmon and native lake trout. Others say it likely resulted from a drop in food availability tied to the explosive spread of zebra and quagga mussels in the late 1980s.

The computer simulations in the new study show that the collapse was caused by a combination of predation and food limitation—and that predation alone would not have caused the crash. The spread of the non-native mussels, coupled with declining levels of the nutrient phosphorus entering the lake from rivers and streams, were essential factors, according to the new study.

The Lake Huron dominoes fell sequentially, according to the report. First came increased predation of alewives, due initially to heavier stocking of Chinook salmon and later the result of increased natural reproduction of salmon and a drop in sea-lamprey mortality. Predation of Lake Huron alewives likely peaked in the mid-1980s and then remained roughly constant until the alewife collapse, according to the new simulations.

Beginning in the 1990s, quagga mussels spread quickly at a time when the level of phosphorus flowing into the lake from rivers and streams was dropping in response to nutrient abatement programs initiated in the 1970s. Mussels in Lake Huron's Saginaw Bay compounded the problem by sucking up and storing nutrients near the shore, preventing them from making it into Lake Huron's main basin.

The loss of essential nutrients in the main basin reduced the amount of algae at the base of the Lake Huron food web, and zooplankton suffered.

At the time, alewives and rainbow smelt were the two most important prey species for Chinook salmon in Lake Huron. The new computer simulations show that rainbow smelt suffered significant declines before alewives did, dropping 78% by 2002. Deprived of a favorite food, Chinook salmon began to rely more heavily on alewives, and this increased predation hastened the alewife population collapse, according to the study. This sequence of events can be used to assess the likelihood of an alewife and Chinook salmon collapse in lakes Michigan and Ontario, the researchers said.

"We are seeing all the same warning signs in lakes Michigan and Ontario," Kao said. "We're seeing decreasing nutrient loads, a decrease in soft-bodied, bottom-dwelling invertebrates due to the mussels, a decrease in rainbow smelt and, as a result, Chinook salmon feeding almost solely on alewives."

With researchers from Michigan State and the USGS, Kao is working on a follow-up modeling study that focuses specifically on the Lake Michigan food web. ✧

Strategy for Reducing Lake Trout Stocking in Lake Huron

Executive Summary

The Lake Huron Technical Committee (LHTC) recommends that the Lake Huron Committee consider adopting an integrated set of criteria that could be used to evaluate when to reduce or discontinue stocking hatchery-reared lake trout into Lake Huron. The three criteria are relative survival of stocked year classes, recruitment of wild lake trout, and relative or absolute abundance of wild adult lake trout. Decisions to reduce or discontinue stocking should be made in each of six spatial areas in Lake Huron. Trends in the catch per unit effort at a given age per number stocked will be the first criteria to evaluate the necessity of stocking hatchery lake trout. One relative survival index will describe the relative abundance of year classes of stocked lake trout at age-7 per million stocked in the main basin of Lake Huron. A second index will describe relative abundance of year classes of stocked lake trout at ages 3-6 in the Cape Rich area of southern Georgian Bay. When the relative survival of stocked lake trout falls below a level judged to be effective for 3-5 years, managers should reduce or discontinue stocking. Declines in the relative survival of stocked fish should, however, be judged in light of the other two criteria. The recruitment criteria will consist of the catch per unit effort of age-0 lake trout in fall bottom-trawl surveys and the relative abundance of wild year classes represented in survey or commercial catches. These two indices will provide evidence of the scale of natural reproduction and recruitment. The LHTC further suggests that when stable or increasing levels of reproduction result in the contribution of multiple year classes of wild age-5 and older lake trout to survey gear and fisheries, stocking should be reduced or discontinued. The relative and/or absolute abundance of wild adult lake trout is the last criteria for evaluating future stocking levels. These indices will consist of the catch per unit effort of mature spawning wild lake trout at multiple spawning sites around Lake Huron and statistical catch-at-age estimates of spawning biomass of wild lake trout in each spatial area of the main basin. Catch-at-age estimates of spawning biomass levels observed during 2002-2004 should be viewed as sufficient for maintaining natural reproduction. Fishery management agencies in both the United States and Canada have been attempting to rehabilitate self-sustaining populations of indigenous lake trout the Great Lakes since the late 1950s and early 1960s, with varying degrees of success.

However, rehabilitation of lake trout in Lake Huron has advanced quickly since 2004 when populations of adult alewife collapsed and measurable numbers of age-0 wild lake trout were captured during fall bottom-trawl surveys throughout the lake. Age-0 wild lake trout have been captured nearly every year since 2004 and catches in 2012 were larger than in any year during 1973-2012. Fishery agencies have observed substantial recruitment of these wild fish into both the juvenile and adult portions of the lake trout population at both nearshore and offshore sites. Year class abundance of wild lake trout has been increasing through time and at least 10 year classes of wild lake trout are now present in the lake-wide population. Wild lake trout now compose about 50% of the lake trout population in the main basin of Lake Huron. Rehabilitation has not progressed to the same degree in the North Channel or Georgian Bay.

The Lake Huron Technical Committee believes that successful restoration of lake trout in Lake Huron is possible in the not-too-distant future and that now is the time to consider something unthinkable even ten years ago - that stocking may no longer be a viable tool for managing lake trout in Lake Huron.

Lake trout stocking was terminated in Parry Sound of Lake Huron because the criteria for successful restoration were achieved. Abundance of wild spawning lake trout in Parry Sound increased after 1988 due to successful sea lamprey control, high stocking rates, and control of exploitation. Average age of mature females, abundance of wild lake trout, and proportion of wild fish in the population were established as criteria for successful restoration of lake trout in Parry Sound and all these criteria were met by 1997. Consequently, the Province of Ontario ceased stocking lake trout in Parry Sound that same year. Anecdotal information suggests the wild lake trout population in Parry Sound remains stable and self-sustaining. Based partly on the experience in Parry Sound, the current draft rehabilitation plan for Ontario waters of Lake Huron states that the need for stocking should be reviewed once wild lake trout make up 25% of the population and that stocking should be terminated when 50% of the population is made up of wild fish (http://www.mnr.gov.on.ca/stdprodconsume/groups/lr/@mnr/@letsfish/documents/document/stdprod_086681.pdf).

Recruitment of Wild Fish

Recruitment of wild progeny to the spawning population is the true measure of success in lake trout rehabilitation. The U.S. Geological Survey's Great Lakes Science Center fall bottom trawl survey has regularly captured age-0 wild lake trout (1) throughout the main basin of Lake Huron since 2004 (**Fig 1**). During 2004-2011 the fall bottom trawl catch rate of age-0 wild lake trout has averaged roughly 0.3 fish per hectare, with annual catch rates varying from 0 to 0.7 fish per hectare. In 2012 density of age-0 wild lake trout increased eight-fold over the 2004-2011 average and indicates that recruitment to the adult population lake-wide should be substantial during 2017-2022.

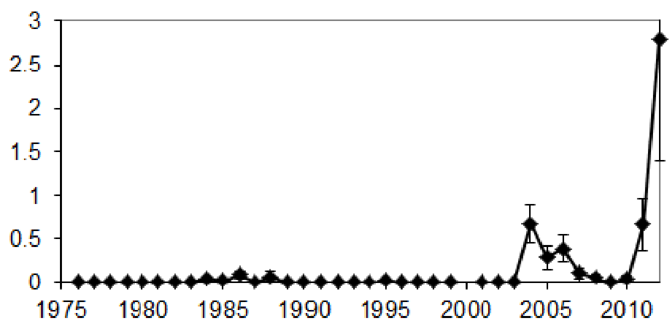


Fig 1- Density of wild juvenile (YOY, < 125 mm) lake trout collected in fall bottom trawls from Lake Huron 1976-2012.

Abundance of Wild Adults

Trends in population abundance of wild lake trout have to be considered when developing a stocking reduction strategy in order to prevent population collapses. In the Drummond Island Refuge of MH-1 densities of adult wild lake trout began to increase in 2002, increased substantially during 2009-2013, and in 2013 made up nearly 50% of all spawners in that year (**Fig 2**). Abundance of hatchery spawners in the Drummond Island Refuge has been stable or slightly increasing since 2002 and the abundance of mature lake trout in the Refuge was higher during 2009-2013 than any time previous.

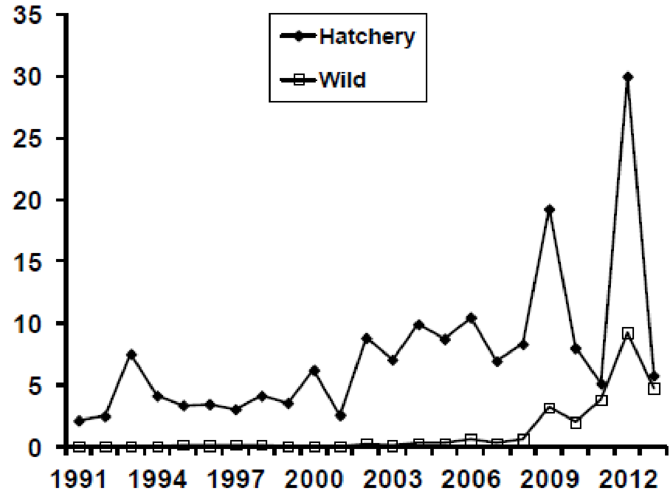


Fig 2- Relative abundance of sexually mature hatchery and wild lake trout captured on spawning reefs with graded mesh gill nets in the Drummond Island Refuge during October 1991-2013.

Abundance of wild lake trout varies considerably among the three basins in Ontario waters of Lake Huron based on monitoring of commercial fishery catches. In Ontario waters, abundance of wild lake trout during 2007-2012 was highest in the northern main basin (NMB) and southern main basin (SMB), followed by the North Channel, and Georgian Bay. Catch rate of wild lake trout by the commercial fishery in Ontario's main basin averaged 2 fish per 305 m during 2008-2012 and was highest at about 4 fish per 305 m of gill net in 2011 and 2012. The trends in catch rate of wild fish in the main basin of Ontario are very similar to catch rates in the Drummond Island Refuge. Catch rate in the North Channel was lower than in the main basin but still averaged 1 fish per 305 m during 2008-2012.

Management Areas

We recommend that the decision to reduce or discontinue lake trout stocking should be made individually for each of six spatial areas in Lake Huron; three in the main basin, two in Georgian Bay, and the North Channel (**Fig 3**). Stock assessment models that include information from both Michigan and Ontario waters have been developed for each of the three units in the main basin of Lake Huron. 2012). Boundaries of the three spatial units in the main basin roughly follow lake trout management unit and statistical district boundaries The stock assessment models provide estimates of year class relative survival, abundance, and biomass, all of which are important for evaluating the need to stock. Information with which to evaluate relative survival of stocked year classes is extremely "noisy" when viewed on smaller spatial scales in the main basin.

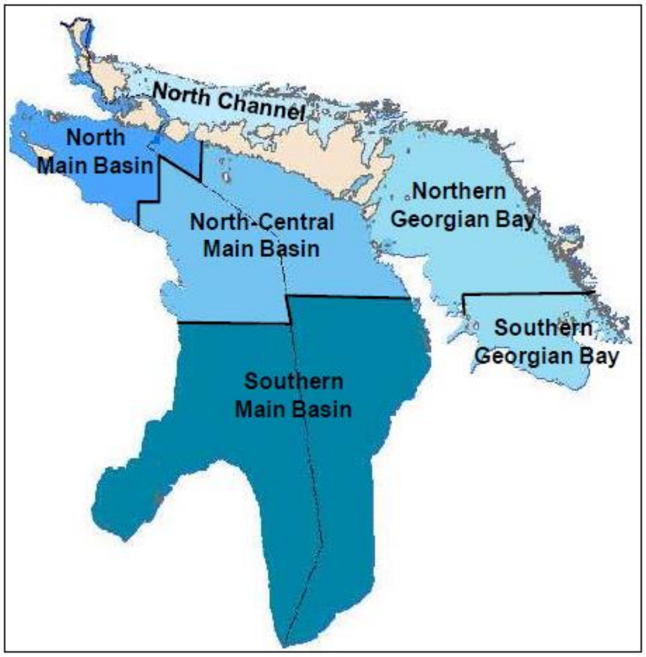


Fig 3- Spatial areas in Lake Huron where lake trout stocking cessation decisions should occur

The decision to reduce or discontinue stocking should be made with a consensus of managers based on a common set of criteria, and input from technical staff and constituents. No single criteria or reference point should be used to judge changes to existing stocking practices, rather the integrated set of criteria outlined in this document should be used to guide the decision-making process.

End Lake Huron Report

Trends in the CPUE at a given age per number stocked will be the first criterion used to evaluate the necessity of stocking hatchery lake trout. One index will describe the relative abundance of year classes of stocked lake trout at age-7 per million stocked in the main basin of Lake Huron. A second index will describe relative abundance of year classes of stocked lake trout at ages 3-6 in the Cape Rich area of southern Georgian Bay.

The recruitment criterion will consist of the catch per unit effort of age-0 lake trout in fall bottom-trawl surveys and the relative abundance of wild year classes represented in survey or commercial catches. These two indices will provide evidence of the scale of natural reproduction and the recruitment (integration of reproduction, survival, and growth) of these fish to the extant population.

Estimates of the relative and/or absolute abundance of wild adult lake trout is the final criterion we propose to evaluate the necessity of stocking. These indices will consist of the catch per unit effort of mature spawning wild lake trout at multiple spawning sites around Lake Huron and statistical catch-at-age estimates of spawning biomass of wild lake trout in each spatial area of the main basin. Spawning stock biomass must reach levels judged to be sufficient for achieving the rehabilitation goals and for sustaining natural reproduction. Catch-at-age estimates of spawning biomass that is at least at levels observed during 2002-2004 when a measurable number of age-0 lake trout were captured in bottom-trawls, and year classes were abundant enough to recruit to survey gear and fisheries, may be viewed as sufficient for maintaining natural reproduction.

Lake Superior

Lake trout recovery a highlight of Lake Superior management plan

Three public open houses to gather input and answer questions are scheduled

A healthy recovery staged by wild lake trout in Lake Superior means these fish no longer need to be stocked in the lake, according to an updated management plan that covers the Minnesota waters of Lake Superior. The public can comment on the plan starting today.

"The successful lake trout recovery is a highlight of the plan," said Cory Goldsworthy, Lake Superior fisheries supervisor with the Minnesota Department of Natural Resources. "Extensive public input informs this plan. It covers the years 2016 to 2025 and outlines management goals for sportfish populations, as well as steps to reach these goals."

Lake trout rehabilitation

The recovery of lake trout in Minnesota waters and beyond is historic, said Cory Goldsworthy, DNR Lake Superior Area fisheries supervisor. "It is a big deal. It's something agencies around Lake Superior have been working on for 60 years," he said. "It's unprecedented in the fisheries world to re-establish a top predator after they've been decimated like lake trout were. It took a lakewide effort." If not for sea lamprey control, he said, that rehabilitation wouldn't have been possible.

Under the plan's lake trout proposal, a new commercial fishing zone would be established in a portion of Lake Superior between the Knife River and the Encampment River with a quota of 500 lake trout.

Steelhead stocking

Under the proposed plan, steelhead fry stocking will be limited to streams south of the Split Rock River to the Lester River, where fishing pressure is higher and catch rates are lower, Goldsworthy said. Fry stocking of steelhead will be eliminated in the Cascade, Temperance, Cross, Baptism and Beaver rivers. A total of 400,000 fry would be stocked annually in rivers between the Lester and Split Rock.
"Catch rates on the upper-shore streams are quite a bit higher than down toward Duluth," Goldsworthy said. "We want to see whether these steelhead populations that have high catch rates will sustain themselves if we discontinue fry stocking."

Kamloops stocking

The plan calls for stocking some Kamloops rainbow trout directly in the Lester River, rather than at its mouth in Lake Superior as has been the practice in recent years. That would be accomplished by stocking Kamloops rainbows raised only at the Spire Valley Hatchery near Remer, thus avoiding the threat of viral hemorrhagic septicemia from Kamloops rainbows raised entirely or partially at the French River Hatchery, which uses Lake Superior water. VHS has been found in Lake Superior but not in inland waters of Minnesota.
Duluth's Ross Pearson, with Kamloops Advocates, is pleased that the plan calls for raising 35,000 other Kamloops rainbow trout to an expected 9 to 10 inches for stocking, rather than stocking them at a smaller size.

"We have to look favorably on that," Pearson said. "Predation is probably the number-one limiting factor, and the bigger size of any fish they might stock in Lake Superior counteracts that predation." Goldsworthy said input from the Lake Superior Advisory Group was important to the process of updating the plan.

"The amount of work they put in was something special for us in fisheries management to get," he said. "You're working with people's livelihoods or their passion, and we need to be respectful of that." The plan does not address the future of the DNR's French River Hatchery, which needs an estimated $8 million in repairs. The agency had said from the outset that the plan would address fisheries management and that any decisions about the hatchery would be made after management strategies were set.

Three public open houses to gather input and answer questions have already been held but comments can be submitted until Sunday, May 8, at www.mndnr.gov/lakesuperior or by contacting Goldsworthy at 218-302-3268 or cory.goldsworthy@state.mn.us.

Management actions recommended include:

- Discontinue lake trout stocking in Lake Superior waters near Duluth because wild fish populations have reached rehabilitation criteria recommended in the Lake Trout Restoration Plan for Lake Superior.
- Expand the zone where steelhead are maintained solely through natural reproduction and evaluate catch rates in the absence of supplemental stocking.
- Reconfigure kamloops stocking methods to employ direct stocking upstream in the Lester River.
- Increase commercial fishing opportunities for lake trout.

"The plan combines fisheries science with extensive public input from the 26-member Lake Superior Citizen's Advisory Group," Goldsworthy said. "The people who served on the group should be commended for their commitment to this project."
The advisory group included representatives from interested groups, commercial harvesters, tribal and watershed interests, and others. The process began with a public

conference in December 2014, and was followed by a series of seven advisory group meetings.
The plan, which will be finalized this summer, includes history and background on lake trout stocking and other items and is available on the DNR website at www.mndnr.gov/areas/fisheries/lakesuperior/index.html or by emailing cory.goldsworthy@state.mn.us. ✧

Status and Trends in the Lake Superior Fish Community, 2015

Abstract

In 2015, the Lake Superior fish community was sampled with daytime bottom trawls at 76 nearshore and 33 offshore stations. Spring and summer water temperatures in 2015 were colder than average, but warmer than 2014. In the nearshore zone, a total of 11,882 individuals from 22 species or morphotypes were collected. Nearshore lakewide mean biomass was 1.8 kg/ha, which was near the lowest biomass on record for this survey since it began in 1978. In the offshore zone, a total 12,433 individuals from 8 species or morphotypes were collected lakewide. Offshore lakewide mean biomass was 5.9 kg/ha. The mean of the four previous years was 7.1 kg/ha. The abundance of age-1 Cisco was 14.3 fish/ha which was similar to that measured in 2009. We collected larval *Coregonus* in surface trawls at 94 locations and estimated a nearshore lakewide average density of 1,459 fish/ha which was nearly twice that measured in 2014.

In 2015, 76 of the 82 long-term sampling locations were sampled between 18 May and 17 June 2015 **(Fig 1).** Six locations were not sampled due to commercial fishing operations or mechanical problems. At each location, a single bottom trawl tow was conducted with a 12-m Yankee bottom trawl. The median start and end depths for bottom trawl tows were 17 m (range 7-37 m) and 56 m (range 19-140 m), respectively. Biomass estimates are reported for all species combined and individually for Cisco, Bloater, Rainbow Smelt, Lake Whitefish, Sculpin species (Slimy Sculpin, Spoonhead Sculpin, and Deepwater Sculpin), and hatchery, lean, and siscowet Lake Trout.

Offshore sites are randomly located around the lake using a spatially-balanced, depth-weighted probabilistic sampling design that targets depths >100 m **(Fig 1).** In 2015, 33 of 35 established trawl locations were sampled during daylight hours between 7 and 22 July. Water temperatures in 2015 were cooler than average and warmer than that observed in 2014. A total of 11,882 individuals from 22 species or morphotypes were collected. The number of species collected at each station ranged from 0 to 15, with a mean of 4.3 and median of 4. Lakewide mean biomass was 1.8 kg/ha, which was one of the lowest values on record and well below the long term average of 9.0 kg/ha**.** The highest individual station biomass was estimated for station 76 near Cornucopia, Wisconsin and station 86 near Basswood Island in the Apostle Islands.

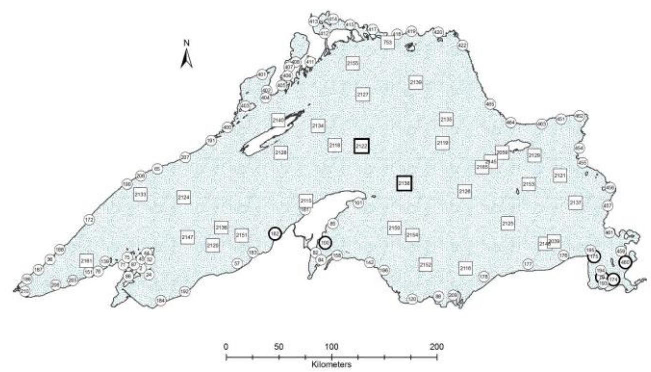


Fig 1- Location of 82 nearshore (circles) and 35 offshore (squares) bottom trawl stations for sampling the Lake Superior fish community. In 2015, 76 nearshore and 33 offshore sites were sampled. Numbers are station numbers.

Cisco

Lakewide mean nearshore biomass of Cisco was 0.23 kg/ha in 2015. This was below the long-term average of 2.45 kg/ha and similar to that observed since 2007. Density of age-1 fish was 14.31 fish/ha in 2015, which indicated a small, but measureable recruitment year. This estimate was similar to that observed in 2009. Over the period of record, densities of age-1 Cisco have exceeded 30 fish/ha 8 times and 175 fish/ha 5 times and have been measured as high as 750 fish/ha**.** A density of about 14 age-1 fish/ha (range=11.1-14.3) has been measured in 14 of the 38 years this survey has been conducted.

Bloater

Lakewide mean nearshore biomass for bloater was 0.40 kg/ha in 2015. This was below the long-term average of 1.69 kg/ha **(Table 1).** Density of age-1 fish was 8.57 fish/ha in 2015. This was the highest density observed since 2005. The highest observed densities of age-1 Bloater is >30 fish/ha.

Lake Whitefish

Lakewide mean nearshore biomass for Lake Whitefish was 0.54 kg/ha in 2015. This was less than the long-term average of 2.14 kg/ha **(Table 1).** Density of age-1 fish was 1.00 fish/ha in 2015. This was below the long-term average of 7.31 fish/ha**.**

Table 1- Spring bottom trawl estimated nearshore mean lakewide biomass (kg/ha) of common fishes in Lake Superior, 1978-2015. Sculpin includes Slimy, Spoonhead, and Deepwater sculpin. All species is the mean and median total biomass for all species. Other species includes Ninespine Stickleback, Trout-Perch, Kiyi, Shortjaw Cisco, Pygmy Whitefish, Round Whitefish, and Longnose Sucker.

Year	Sites	No fish sites	Number of Species	All species mean	All species median	Rainbow Smelt	Cisco	Lake Whitefish	Bloater	Hatchery Lake Trout	Lean Lake Trout	Siscowet Lake Trout	Burbot	Sculpin	Other. species
1978	43	0	17	5.88	0.78	4.07	0.01	0.70	0.13	0.37	0.00	0.00	0.17	0.14	0.29
1979	49	0	17	6.33	2.25	2.17	0.06	1.27	0.45	0.66	0.06	0.00	0.30	0.20	1.15
1980	48	0	16	3.28	1.11	0.87	0.28	0.58	0.28	0.48	0.05	0.00	0.19	0.19	0.35
1981	48	2	19	2.62	0.42	0.21	0.36	0.67	0.41	0.30	0.02	0.00	0.24	0.18	0.22
1982	32	0	18	3.06	0.29	0.25	0.35	0.85	0.43	0.70	0.10	0.00	0.06	0.03	0.29
1983	50	0	19	2.48	0.54	0.92	0.17	0.20	0.43	0.45	0.03	0.00	0.07	0.06	0.15
1984	53	0	21	5.84	1.67	0.80	0.65	1.30	1.75	0.48	0.34	0.02	0.20	0.06	0.25
1985	53	0	19	14.77	3.50	1.33	6.53	2.14	2.69	0.40	0.78	0.00	0.05	0.08	0.77
1986	53	2	19	19.28	3.97	2.84	8.65	2.65	3.79	0.27	0.55	0.09	0.18	0.07	0.19
1987	53	0	16	13.26	1.40	1.78	5.69	2.00	2.57	0.25	0.34	0.00	0.14	0.07	0.44
1988	53	0	19	13.89	0.90	1.18	3.10	2.40	5.97	0.16	0.78	0.00	0.08	0.04	0.17
1989	76	0	21	17.60	3.41	2.08	6.21	5.54	1.71	0.16	0.46	0.23	0.21	0.08	0.93
1990	81	0	22	21.28	5.44	1.95	10.12	2.36	4.85	0.12	0.34	0.19	0.11	0.08	1.17
1991	84	1	22	16.83	3.57	1.17	10.23	2.74	0.81	0.08	0.69	0.02	0.21	0.10	0.78
1992	85	0	24	18.65	3.33	1.02	3.40	3.70	8.39	0.20	0.59	0.05	0.17	0.07	1.06
1993	87	1	23	18.12	5.86	2.12	4.99	3.67	4.28	0.27	0.59	0.14	0.27	0.08	1.71
1994	87	0	23	17.39	3.59	1.89	7.24	5.42	0.42	0.23	0.59	0.09	0.11	0.08	1.32
1995	87	0	27	15.95	3.02	2.21	3.96	5.84	0.57	0.23	0.88	0.10	0.14	0.09	1.92
1996	87	0	26	9.13	2.48	1.28	1.04	1.63	3.09	0.22	0.50	0.37	0.19	0.11	0.69
1997	85	1	30	8.41	2.20	1.35	1.35	2.77	0.86	0.15	0.67	0.30	0.10	0.06	0.80
1998	87	0	22	11.29	1.95	1.47	1.09	2.26	4.37	0.08	0.56	0.19	0.07	0.07	1.12
1999	83	5	23	9.76	1.54	1.11	2.73	1.28	3.13	0.05	0.35	0.17	0.07	0.04	0.83
2000	85	4	25	6.92	1.10	0.83	2.42	1.60	0.93	0.04	0.27	0.17	0.02	0.04	0.59
2001	83	1	32	8.23	1.63	1.51	1.15	2.78	1.18	0.05	0.65	0.09	0.13	0.04	0.63
2002	84	2	26	4.68	0.53	0.18	1.48	1.69	0.57	0.02	0.15	0.04	0.10	0.02	0.44
2003	86	10	26	4.73	0.98	0.30	0.64	1.84	0.88	0.01	0.33	0.24	0.01	0.02	0.45
2004	75	1	25	6.31	1.87	0.32	1.80	1.88	1.15	0.01	0.12	0.15	0.20	0.03	0.65
2005	52	0	27	10.97	4.39	1.00	2.23	4.37	1.64	0.23	0.63	0.04	0.31	0.01	0.52
2006	55	2	24	8.29	1.57	0.95	2.25	1.70	1.79	0.03	0.33	0.14	0.08	0.02	0.99
2007	56	0	31	6.09	0.97	1.77	0.27	1.86	0.90	0.01	0.19	0.11	0.12	0.02	0.84
2008	59	3	23	5.40	1.57	0.94	0.38	2.37	0.17	0.06	0.18	0.14	0.29	0.02	0.86
2009	64	6	20	3.14	0.14	0.38	0.30	0.15	1.18	0.00	0.25	0.11	0.04	0.02	0.72
2010	76	11	24	1.46	0.13	0.22	0.31	0.27	0.23	0.01	0.04	0.08	0.03	0.05	0.23
2011	82	13	21	3.56	1.28	0.62	0.41	0.94	0.56	0.01	0.11	0.14	0.02	0.05	0.70
2012	72	16	25	1.14	0.31	0.16	0.02	0.15	0.35	0.01	0.07	0.08	0.02	0.03	0.26
2013	79	3	27	6.00	1.17	0.53	0.52	2.98	0.49	0.01	0.26	0.31	0.10	0.02	0.77
2014	73	3	27	6.91	1.66	0.43	0.35	4.31	0.50	0.00	0.37	0.27	0.08	0.02	0.59
2015	76	4	21	1.78	0.19	0.22	0.23	0.54	0.40	0.00	0.08	0.08	0.00	0.02	0.21
Mean	69	2	23	8.97	1.91	1.17	2.45	2.14	1.69	0.18	0.35	0.11	0.13	0.06	0.68

<u>Rainbow Smelt</u>

Lakewide mean nearshore biomass for Rainbow Smelt was 0.22 kg/ha in 2015. This was less than the long-term average of 1.17 kg/ha. This was among the lowest estimates on record for Rainbow Smelt **(Table 1).** Density of age-1 fish was 30.66 fish/ha in 2015, which is less than the long-term average of 159.01 fish/ **ha.**

Sculpin

Lakewide mean nearshore biomass for Sculpin was 0.02 kg/ha in 2015. This was below the long-term average of 0.06 kg/ha. Sculpin biomass has not exceeded 0.06 kg/ha since 1998 **(Table 1).**

Other species

The combined mean nearshore lakewide biomass for other species was 0.21 kg/ha in 2015. This was less than the long-term mean of 0.68 kg/ha. Other species include Ninespine Stickleback, Trout-perch, Kiyi, Shortjaw Cisco, Pygmy Whitefish, Round Whitefish, and Longnose Sucker.

Burbot

For the first time since the survey began in 1978, no Burbot were collected in our nearshore survey in 2015. Two Burbot were collected in our offshore survey. Burbot biomass has not exceeded the long-term average of 0.13 kg/ha since 2008 **(Table 1).**

Lake Trout

No hatchery Lake Trout were collected in our nearshore or offshore survey in 2015. Hatchery Lake Trout biomass has been near zero since 2002 **(Fig 2).** Lean Lake Trout biomass was 0.08 kg/ha. This was similar to that estimated in 2012. These estimates are the lowest estimates since the early 1980s **(Table 1).** Siscowet Lake Trout nearshore biomass was 0.08 kg/ha. This was similar to the long-term mean and similar to that observed in 2012, but well below that observed in 2014 **(Table 1).** Density of age-3 and younger lean and siscowet Lake Trout were 0.14 and 0.06 fish/ha in 2015, respectively. Young lean Lake Trout densities were less than the long-term average and siscowet Lake Trout densities were similar to the long-term average**.**

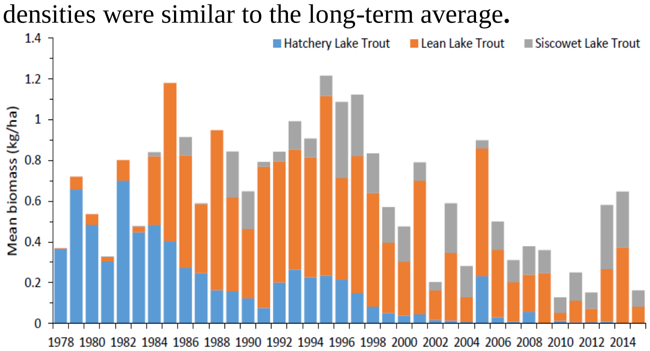


Fig 2- Annual lakewide biomass estimates for hatchery, lean, and Siscowet Lake Trout from bottom trawls in nearshore locations, 1978-2015.

Offshore survey

A total of 12,435 individuals from 9 species were collected lakewide at 33 offshore sites **(Table 1).** The average and median number of species collected at each station was 3.8 and 4, respectively, and ranged from 1-6. Deepwater Sculpin, Kiyi, and siscowet Lake Trout made up 98% of the total biomass collected in offshore waters at nearly every location **(Fig 3).** Mean and median lakewide biomass were 5.9 kg/ha and 5.6 kg/ha, respectively. This was less than observed in previous years.

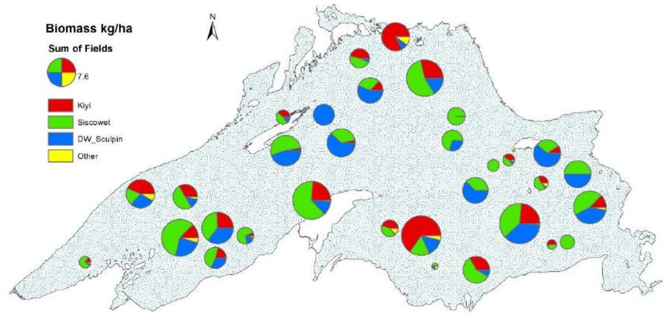


Fig 3- Lakewide biomass estimates for Kiyi, siscowet Lake Trout, Deepwater Sculpin, and other species estimated from bottom trawls in offshore locations in 2015. Pie diameter is proportional to the biomass collected at that site and ranged from 0.6-22.1 kg/ha. The pie in the legend is proportional to 7.6 kg/ha with the size of the pies on the map scaled accordingly.

Deepwater Sculpin

Lakewide offshore biomass of Deepwater Sculpin was 1.7 kg/ha. This was less than observed in previous years.

Kiyi – Lakewide offshore biomass of Kiyi was 1.4 kg/ha. This was less than observed in previous years.

Siscowet Lake Trout – Lakewide offshore biomass of siscowet Lake Trout was 2.6 kg/ha. This was less than observed in previous years.

Larval Coregonus collections

A total of 17,433 larval *Coregonus* were collected. The lakewide nearshore average density was 1,425 fish/ha and ranged from 0-56,747 fish/ha. The lakewide nearshore mean density in 2014 was 577 fish/ha **(Fig 4).** The total estimated number of larval *Coregonus* lakewide was 26.3 billion with a standard error of + 1.9 billion. Larval *Coregonus* collected at the start of the survey on 18 May 2015 were 8-10 mm in length. This suggests a hatch date around mid-May, as this is the length at hatch observed for Cisco raised in the laboratory (Oyadomari and Auer 2008, CJFAS 65:1447-1358). Fish were >20 mm in July. Growth of larval fish (as determined by changes in total length) in 2015 was higher than that observed in 2014 (0.15 mm/day in 2015 and 0.06 mm/day in 2014). We suspect this was related to warmer water in 2014 compared to 2015.

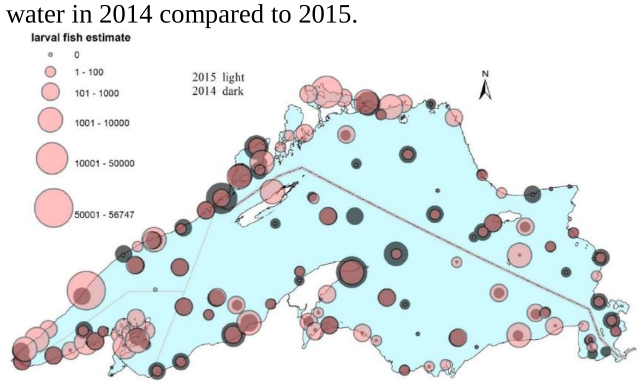


Fig 4- Estimated larval Coregonus abundances collected in 2014 and 2015 from surface trawling

Summary

Over the 38 year history of the nearshore survey, total reported biomass has been largely dependent on recruitment of age-1+ Bloater, Cisco, and Lake Whitefish and survival of Rainbow Smelt to age-3 or older. The lack of significant recruitment of these species in recent years, particularly of Cisco, is of concern to fishery managers. In 2015 we observed a measureable recruitment event of age-1 Cisco and Bloater. For Cisco, the population abundance of this year class was similar to that observed in 2009. For Bloater, it was the highest population recruitment index observed since 2005. Our second year of larval *Coregonus* collections indicated density estimates roughly twice that observed in 2014. Time will tell if this will translate in to a larger age-1 year class in 2016. We plan to continue annual sampling of larval *Coregonus*. 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 as well as insights into *Coregonus* recruitment dynamics.

Sea Lamprey Control in Lake Superior 2015

Lampricide Control

●Lampricide treatments were completed in 41 tributaries (8 Canada, 33 U.S.) and in 13 lentic areas (6 Canada, 7 U.S.).

●GB treatments of the lentic areas of the Wolf River and Haviland Creek were completed for the first time.

●The Graveraet River was treated for the first time since 1963 and contained high densities of Sea Lampreys throughout most of the infested length.

●The Slate River (Baraga County) lentic area was added to the treatment schedule after moderate populations of larval Sea Lampreys were found during assessment surveys.

●The Traverse and Little Carp rivers were treated under extremely low discharge conditions likely leading to low treatment efficacy. Both streams contained moderate to high densities of larval Sea Lampreys. Treatment evaluation surveys indicated high numbers of residuals from the Little Carp River, and both will be re-treated in 2016.

●Eliza Creek was treated with an interrupted lampricide bank, as opposed to the traditional 12-hour continuous bank. This study was done to evaluate the effectiveness of this type treatment and its potential to protect non-target species.

●Coordination and support was provided by several National Park Service (NPS) employees during the Lowney Creek (Beaver Lake Outlet) treatment in Pictured Rocks National Lakeshore.

●Several members of the Red Cliff Band of Chippewa Indians assisted in pre and post-treatment assessments during the Red Cliff Creek treatment, marking beaver dam locations via GPS and assisting with post-treatment collections.

●The Tahquamenon River was treated in October 2015 after being deferred in 2014 due to high water.

●The Carp River (Marquette County) lentic area was treated for the first time.

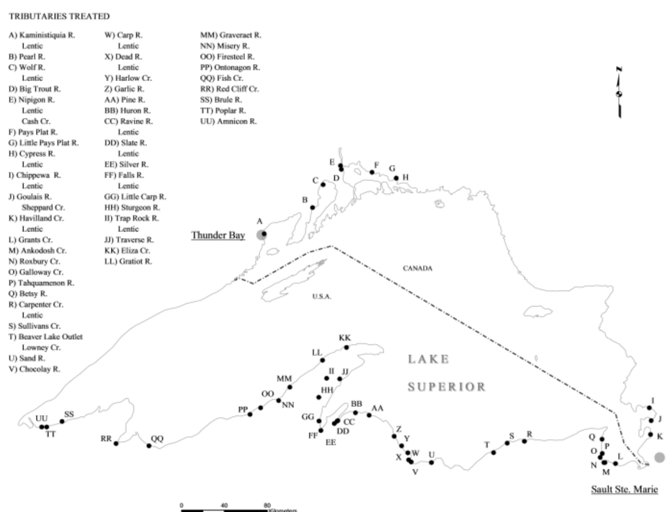


Fig 1- Location of Lake Superior tributaries treated with lampricides during 2015.

Barriers

Field crews visited 17 structures on tributaries to Lake Superior to assess Sea Lamprey blocking potential and to improve the information in the BIPSS database.

Operation and Maintenance

●Routine maintenance, spring start-up, and safety inspections were performed on 12 barriers (6 Canada, 6 U.S.).

●Repairs or improvements were conducted on one Canadian and one U.S. barrier.

●Gimlet Creek (Pancake River tributary) – Recent larval assessments indicate escapement of adult Sea Lamprey, resulting in the establishment of one age class of larvae in either 2010 or 2011. During the fall 2015, data loggers were installed to monitor flow at the barrier site.

●Middle River – The Wisconsin DNR installed a new steel lip on the crest of the Middle River Sea Lamprey barrier during the fall of 2015.

Ensure Blockage to Sea Lamprey Migration

●Black Sturgeon River – During 2012, the Ontario Ministry of Natural Resources and Forestry (OMNRF) initiated an Environmental Assessment (EA) of the proposed decommissioning of the Camp 43 dam and construction of a new Sea Lamprey barrier 50 km upstream. More recently, the OMNRF has contracted the class EA to the KGS Group, who is developing a draft Environmental Study Report (ESR). OMNRF will provide the draft ESR for public review once completed.

●Consultations to ensure blockage at barriers in six tributaries were completed with partner agencies.

Mainstream	Tributary	Lead Agency	Project	Position	Comments
Ontonagon R.	East Br. Ontonagon R.	USFS[1]	Lower Dam	Do not concur	First blocking
Bad R.	Trib. to Krause Cr.	NFWF[2]	Gilgen Rd. culvert	Pending	Ineffective barrier
Bad R.	Four Corners Store Cr.	NFWF[2]	Four Corners Rd. culvert	Pending	Ineffective barrier
Bad R.	Sec. 33 Trib to Marengo R.	NFWF[2]	Beckman Rd. culvert	Pending	Ineffective barrier
Bad R.	Marengo R.	NFWF[2]	Marengo Lake Rd. culvert	Pending	Ineffective barrier
Huron Lake Outlet		USFWS[3]	Waterfront Park Dam	Pending	First blocking

Table 1-Status of concurrence requests for barrier removals, replacements, or fish passage projects in Lake Superior tributaries

New Construction

●Bad River – The U.S. Army Corps of Engineers 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 Lamprey 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, and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) met to discuss alternate locations.

●Whitefish River – Hydraulic analysis of the proposed barrier site was completed in 2014. However, construction of barriers requires authorization from the OMNRF under the Federal-Provincial Agreement on Sea Lamprey Barrier Dams (1983). Previously, the province authorized new construction under the Lakes and Rivers Improvement Act, but this legislation is not binding to federal agencies. Because of uncertainty regarding authorization, the Canada-Ontario Fisheries Advisory Board has recommended a DFO-OMNRF workshop to review and revise, as necessary, the existing federal/provincial agreement and address other issues related to structures that serve a Sea Lamprey control function in Ontario. New barrier construction in Ontario streams will be pending until completion of this process.

Juvenile Trapping

●Trapping for out-migrating Sea Lamprey juveniles was conducted by the GLIFWC in the Bad River during September and October. Fyke nets were set at Elmhoist Bridge and eight out-migrating juveniles were captured.

Fish Community Assessment

●Fish community assessments were conducted on six tributaries to Lake Superior: Wolf, Carp, Big Carp and Little Carp rivers and Stokely and Gimlet (Pancake River tributary) creeks. The purpose of this work was to evaluate the condition of fish communities within streams where purpose built Sea Lamprey barriers exist.

Assessment

The Assessment Program has three components which are described as follows:

1. Larval Assessment determines the abundance and distribution of Sea Lamprey larvae in streams and lentic areas. These data are used to predict where larvae ≥100 mm total length will most likely be found by the end of the growing season during the year of sampling. These predictions are used to prioritize lampricide treatments for the following year.

2. Juvenile Assessment evaluates the lake-specific rate of Lake Trout marking inflicted by Sea Lamprey. These time series data are used in conjunction with Adult Assessment data to assess the effectiveness of the SLCP for each lake. In addition, several indices of relative abundance of feeding juveniles are used in some lakes to monitor Sea Lamprey populations over time.

3. Adult Assessment annually estimates an index of adult Sea Lamprey abundance in each lake. Because this life stage is comprised of individuals that have either survived or avoided exposure to lampricides, the time series of adult abundance indices is the primary metric used to evaluate the effectiveness of the SLCP.

Larval Assessment

Tributaries considered for lampricide treatment during 2016 were assessed during 2015 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. Infested areas were ranked for treatment during 2016 based on the most cost-effective kill of larval Sea Lampreys ≥100 mm, based on estimates of abundance and average treatment costs. Additional surveys are used to define the distribution of Sea Lampreys within a stream, detect new populations, evaluate lampricide treatments, and to establish the sites for lampricide application.

●Larval assessments were conducted on 125 tributaries (43 Canada, 82 U.S.) and 21 lentic areas (9 Canada, 12 U.S.).

●Surveys to estimate larval abundance were conducted in 30 tributaries (8 Canada, 22 U.S.) and in lentic areas offshore of 5 tributaries (4 Canada, 1 U.S.).

●Surveys to detect the presence of new larval Sea Lamprey populations were conducted in 10 tributaries (5 Canada, 5 U.S.). A new population was found in Jarvis Creek, near Thunder Bay, Ontario, and is scheduled for treatment in 2016.

●Post-treatment assessments were conducted in 39 tributaries (7 Canada, 32 U.S.) and 1 Canadian lentic area to determine the effectiveness of lampricide treatments conducted during 2014 and 2015.

●Surveys to evaluate barrier effectiveness were conducted in 13 tributaries (4 Canada, 9 U.S.).

●Biological collections for research or training purposes were conducted in eight U.S. tributaries.

●A special appropriation from the State of Wisconsin to enhance Sea Lamprey control in Wisconsin waters led to additional surveys being conducted in 20 streams. Detection surveys in 6 streams found no new infestations.

●Surveys to evaluate treatment effectiveness were conducted in 8 streams and surveys in 6 streams were conducted to evaluate larval abundance and growth, and to rank streams for future treatments.

●An evaluation of larval Sea Lamprey production potential was completed on the Sturgeon River (Baraga County) upstream from the barrier by assessing larval lamprey habitat and native lamprey abundance as a surrogate for Sea Lamprey production. Results from the study are pending.

●Larval assessment surveys were conducted in non-wadable lentic and lotic areas using 33.2 kg (active ingredient) of gB.

Juvenile Assessment

●Lake Trout marking data for Lake Superior are provided by the Michigan DNR, Minnesota DNR, and Wisconsin DNR, GLIFWC, Chippewa-Ottawa Resource Authority, 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 2015 were submitted in February 2016, and have yet to be analyzed.

●Based on spring assessment data, the marking rate during 2014 was 2.5 A1-A3 marks per 100 Lake Trout >532mm **(Fig 2)**. The marking rate has been declining and is below the target for the first time since 1995.

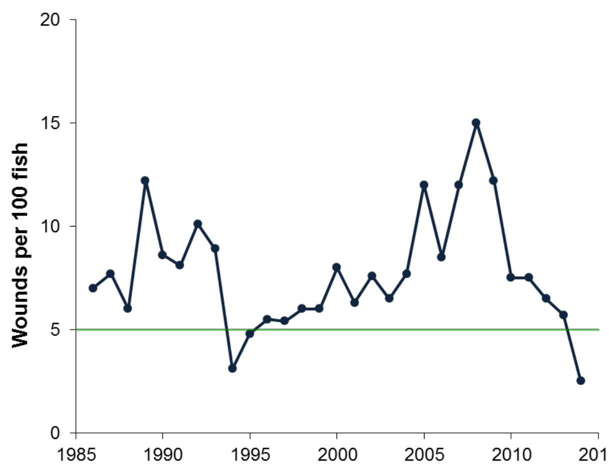


Fig 2-Average number of A1-A3 marks per 100 Lake Trout >532 mm caught during April-June assessments in Lake Superior. The horizontal line represents the target of 5 A1-A3 marks per 100 Lake Trout.

Adult Assessment

An annual index of adult Sea Lamprey abundance is derived by summing individual population estimates from traps operated in a specific suite of streams (index streams) during spring and early summer. Mark-recapture estimates are attempted in each index stream, however, in the absence of an estimate due to an insufficient number of marked or recaptured Sea Lampreys, abundance is estimated using the annual pattern of adult abundance observed in all streams and years, and adjusted to the stream-specific average abundance estimate in the time series.

●A total of 820 Sea Lampreys were captured in 10 tributaries, 7 of which are index locations. Adult population estimates based on mark-recapture were obtained from 4 of the 7 index locations; the other 3 (Bad, Brule and Middle rivers) were estimated using the relative annual pattern of abundance **(Fig 2).**

●The index of adult Sea Lamprey abundance was 20,224 (jackknifed range; 16,715-23,675), which was greater than the target of 9,664 **(Fig 3).**

●Adult Sea Lamprey migrations were monitored in the Middle, Bad, Misery, and Silver rivers through cooperative agreements with GLIFWC, and in the Brule River with the WIDNR.

●Several adult Sea Lampreys were observed spawning on September 9 just prior to the Huron River treatment. Overall, five adult Sea Lampreys were collected during post-treatment surveys.

●An eel-ladder style trap (ELST) was tested at the Brule River trapping site. This was the second year of a two year study to determine if passage success differs between ELST ramps and smooth ramps, and between Sea Lampreys and teleosts. Early observations indicated that ELST ramps passed only Sea Lampreys while smooth ramps passed mostly teleosts and a small number of Sea Lampreys.

●A resistance weir was installed in the Brunsweiler River (Bad River tributary) to field test its functionality. The weir was installed and operated as intended. Several fish were captured, but no Sea Lampreys due in part to low water velocity at the trap. Further testing is planned for 2016.

●The SLCP assisted the USGS with deployment of an experimental trap with a pulsed direct current lead in the Chocolay River during 2015. The electric lead was activated every other night to determine how many more Sea Lampreys were captured when the electric lead was on. The trap captured more Sea Lampreys during nights when the electric lead was on (n=83) versus when the electric lead was off (n=36). Additional analysis is ongoing.

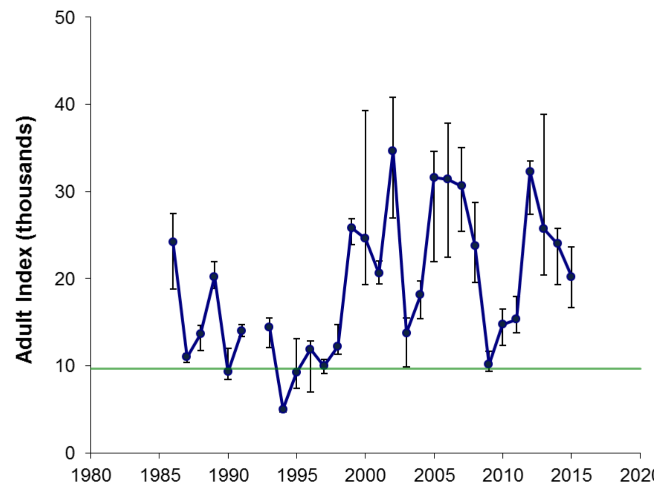


Fig 3-Index estimates with jackknifed ranges (vertical bars) of adult Sea Lampreys. The adult index in 2015 was 20,224 with jackknifed range (16,715-23,675). The point estimate was greater than the target of 9,700 (green horizontal line).

2015 Range of Ruffe in the Great Lakes

Range expansion was not detected during 2015.

Lake Superior: The Ruffe range spans locations along the south shore from the Duluth-Superior Harbor on the border of Minnesota/Wisconsin to Whitefish Bay, Michigan, and locations along the northwestern shore from the Duluth-Superior Harbor to Black Bay in Ontario, Canada.

St. Marys River: Ruffe remain undetected in the St. Marys River.

Lake Huron: Ruffe have been detected at locations in northwestern Lake Huron including Thunder Bay at Alpena, Michigan; the Trout River in Rogers City, Michigan; and the Cheboygan River in Cheboygan, Michigan.

Lake Michigan: The Ruffe range consists of Green Bay.

Lakes Erie and Ontario: Ruffe remain undetected in the Lower Great Lakes.

Inland lakes and streams: Ruffe remain undetected from inland lakes and streams within the Great Lakes Basin.
For detailed information about Ruffe sightings in the Great Lakes, visit the U.S. Geological Survey, Nonindigenous Aquatic Species Database at http://nas.er.usgs.gov/

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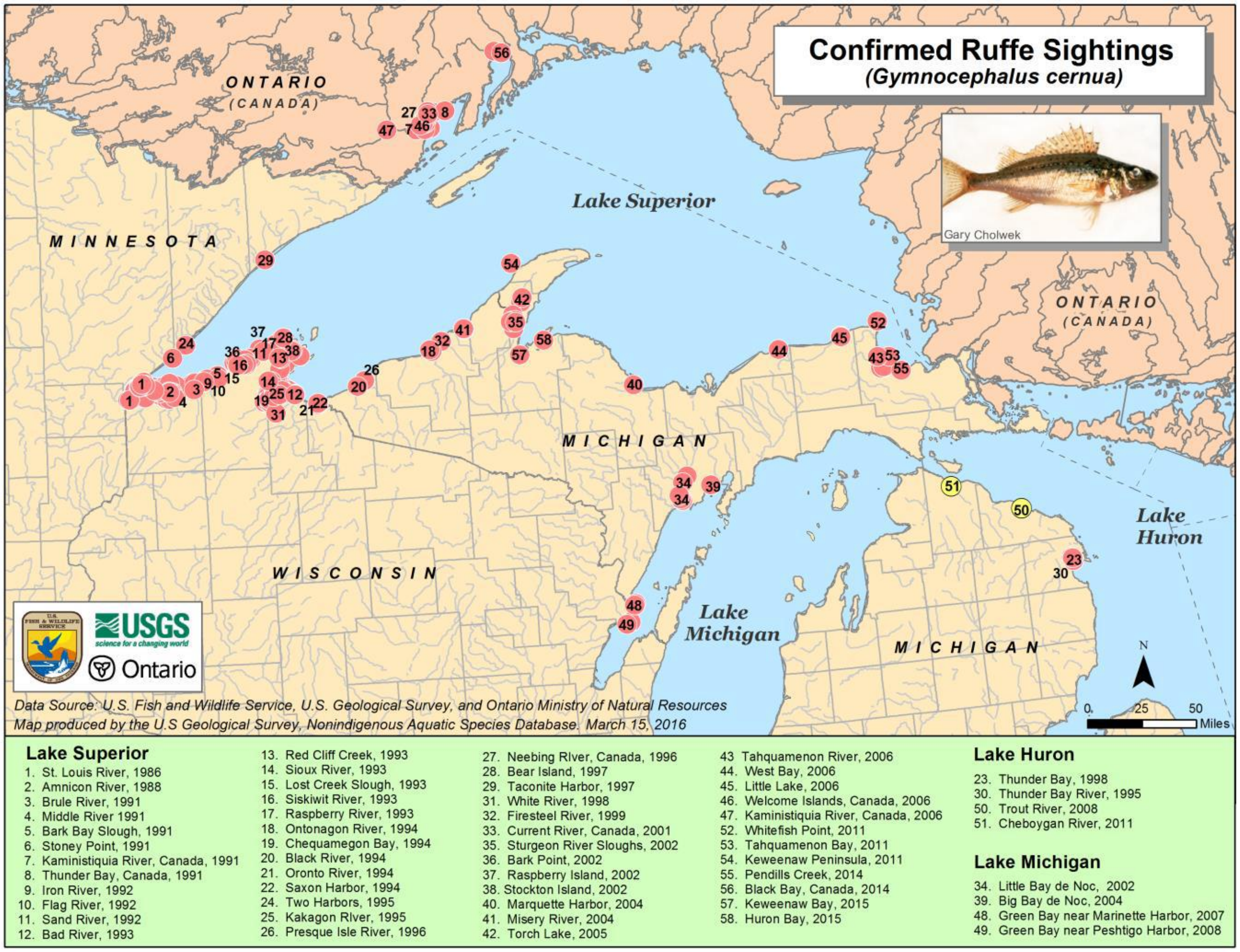

Status in the United States

"The Ruffe was first identified by Wisconsin DNR in specimens collected from the St. Louis River at the border of Minnesota and Wisconsin in 1987. Following that report, reexamination of archived samples revealed misidentified larval specimens of Ruffe had been collected from the same area in 1986. The Ruffe subsequently spread into Duluth Harbor in Lake Superior and several tributaries of the lake. It is found in the Amnicon, Flag, Iron, Middle, Raspberry, and Bad rivers, Chequamegon Bay, and Apostle Islands National Lakeshore in Wisconsin. In August 1994, it was found in Saxon Harbor, Wisconsin, and in the upper peninsula of Michigan at the mouths of the Black and Ontonagon rivers. In the lower Peninsula of Michigan along Lake Huron, the first three specimens were caught at the mouth of the Thunder Bay River in August 1995. This species has also been collected in Michigan in Lake Michigan, Lake Superior, Torch Lake, Little Bay de Noc in Escanaba, Big Bay de Noc, Misery River, Ontonagon River, Thunder Bay, and Sturgeon River Sloughs. The ruffe has been collected in Lake Superior at Thunder Bay Harbour, Ontario, Canada."

Means of Introductions in the United States

"The ruffe was probably introduced via ship ballast water discharged from a vessel arriving from a Eurasian port, possibly as early as 1982-1983. Within the Great Lakes, the species' spread may have been augmented by intra-lake shipping transport. Recent genetic research has indicated that the origin of ruffe introduced to the Great Lakes was southern Europe, not the Baltic Sea as previously believed."

Remarks

"The ruffe has already invaded Lake Superior and GARP modeling predicts it will find suitable habitat almost everywhere in all five Great lakes. GARP models are not able to make a prediction about some of the deeper waters of Lake Superior. It has been established in western portion of Lake Superior since about 1988 and expanded in an easterly direction. Ruffe has been reported from Lake Huron at Thunder Bay River, and in Thunder Bay, Lake Superior, Ontario, Canada. It has become the dominant species in the St. Louis River estuary and considered the most abundant of the 60 species found in Duluth Harbor. Based on bottom trawl samples, ruffe makes up an estimated 80% of fish abundances in the southwestern regions of Lake Superior. The population in Duluth Harbor was estimated at two million adult fish in 1991. In 2006 surveys of Lake Huron, no ruffe were collected from Thunder Bay River and St. Marys River. In fact, ruffe has not been collected in the Thunder Bay region of Lake Huron since 2003 despite sampling efforts nor has it been found elsewhere in the lake."

"The ruffe also has been collected in the Canadian waters of Lake Superior at Thunder Bay and in Kaministiquia River estuary, 290 kilometers northeast of Duluth. Seven fish were collected from the latter location in 1991. Busiahn (1993) indicated that the potential North American range of ruffe may well extend from the Great Plains to the eastern seaboard and north into Canada. However, early reports that the ruffe was established in Lake Michigan are considered erroneous. In March 1997, an international symposium was held in Ann Arbor, Michigan, to exchange information on the biology and management of ruffe. Ogle et al. (1996) found that certain native species preyed on introduced ruffe; however, their study indicated that predation is unlikely to effectively prevent ruffe from colonizing new areas in the Great Lakes." "Brazner et al. (1998) found that densely vegetated shoreline wetland habitats provide a refuge from intense competition with ruffe for indigenous fish."

Distribution outside the United States

"Ruffe are native to most European countries. They are not native to Spain, Portugal, western France, Norway, northern Finland, Ireland, Scotland, Italy, Greece, Croatia, Serbia, or Montenegro. They are native to most of the former USSR where they inhabit rivers, lakes and brackish sea coastal waters. In the north, the range extends nearly to the coast of the arctic sea and, south, to the Aral, Caspian, and Black seas. They occur throughout Siberia except they are not found in the Amur River, Lake Baikal, and Transcaucasia."

"In Europe they are now found in Loch Lomond, Scotland, Llyn Tegid, Wales, Bathenthwaite Lake, England, Lake Geneva, Switzerland and France, Lake Constance, on the borders of Austria, Germany and Switzerland, Lake Mildevatn, Norway, the Camargue region, France, and Italy." ✧

Progress Report on Great Lakes Fish Mass Marking Program, 2015 (USFWS)

Great Lakes Fish Tag and Recovery Laboratory, New Franken, Wis

Introduction

Fishery managers in the Great Lakes, along with the U.S. Fish and Wildlife Service, annually stock over 20 million salmonines to diversify sport fisheries, restore native fish populations, and control invasive fishes. However, information is required to determine how well these fish survive and contribute to fisheries and the levels of natural reproduction by all native and non-native salmonines. Fishery managers agreed in 2005 to develop a basin-wide program to tag and or fin- clip all stocked salmonines. This effort would provide greater insight into survival of stocked fish, the contribution of stocked lake trout to the restoration of this native fish, the ability to manage harvest away from wild fish, and the opportunity to evaluate and improve hatchery operations.

They requested the USFWS deliver a basin-wide mass marking program based on its successful delivery of the basin-wide sea lamprey control and lake trout restoration programs. To address this request, the Great Lakes Fish Tag and Recovery Lab was established at the Green Bay Fish and Wildlife Conservation Office in New Franken, WI. Pilot tagging and marking operations began in 2010 and recovery of tagged fish began in 2012.

In 2015, the Lab staff consisted of four AutoFish trailer operators, one data analyst/statistician, and one supervisory biologist. In addition, thirteen contracted seasonal technicians were hired to assist state agencies with recovery of coded wire tags and biological data from sport fisheries on lakes Michigan, Huron and Ontario. The program's tagging trailer fleet consists of four automated trailers and one manual tagging and marking trailer. In 2015, the lab staff used these trailers to coded wire tag and adipose fin clip 9,649,549 lake trout, Chinook salmon, Atlantic salmon, and brook trout at state and federal hatcheries. The Great Lakes Restoration Initiative, managed by the USEPA, provided annual operational funding of $0.8 million through a request made by the USFWS, Region 3.

Summary of Chinook Salmon Tagging Operations

This was the fifth year that all Chinook salmon stocked into Lake Michigan and the U.S. waters of Lake Huron received a coded wire tag and an adipose fin clip (ADCWT). Using two automated trailers, the lab tagged and clipped about 2.5 million Chinook salmon. Additionally, over 400,000 fish were adipose fin clipped only (AD only) and stocked into Lake Superior. These efforts required coordination and cooperation with seven state-administered hatcheries in Michigan, Wisconsin, Indiana, and Illinois.

Table 1- Total numbers of Chinook salmon processed and project completion dates by hatchery in 2015

Hatchery	Agency	Number tagged	Date completed
Jake Wolf	Illinois Department of Natural Resources	257,996	3/15/2015
Mixsawbah	Indiana Department of Natural Resources	203,123	3/21/2015
Kettle Moraine Springs	Wisconsin Department of Natural Resources	176,113	4/1/2015
Wild Rose	Wisconsin Department of Natural Resources	643,852	4/14/2015
Wolf Lake	Michigan Department of Natural Resources	248,961	3/27/2015
Platte River	Michigan Department of Natural Resources	973,758	4/30/2015
Thompson (ADCWT)	Michigan Department of Natural Resources	53,233	4/29/2015
Thompson (AD only)	Michigan Department of Natural Resources	411,761	5/4/2015
Total Chinook salmon processed:		2,968,797	

Chinook salmon tagging performance comparison 2010 - 2015

This year had continued high performance in efficiency and throughput that is attributable to consistent operator experience, and to hardware and software improvements. Average throughput was almost 9,000 fish/hour this year and has steadily risen from 6,800 fish/hour in 2010 **(Table 2).**

Table 2- Total numbers of Chinook salmon processed and average throughput for 2010 - 2015 tagging projects at all hatcheries combined.

Year	Number of fish processed	Number of machine run hours	Average throughput (fish/hour)
2010	1,104,166	162.0	6,794
2011	4,689,947	667.4	7,241
2012	4,320,884	518.9	8,460
2013	2,856,038	319.0	8,749
2014	2,953,814	321.6	8,736
2015	2,968,797	323.2	8,997

Summary of Lake Trout Tagging Operations

This is the sixth year that all lake trout (2010-2015) were coded wire tagged and adipose fin clipped at USFWS hatcheries in Region 3 (lakes Michigan and Huron), and the fourth year for USFWS hatcheries in Region 5 (lakes Erie and Ontario). In 2015, 4,814,092 fish were processed at the three Region 3 hatcheries, and 1,356,884 fish at the two Region 5 hatcheries **(Table 3).** An additional 218,849 lake trout were tagged and clipped at the Michigan Department of Natural Resources, Marquette State Fish Hatchery.

Table 3- Total numbers of lake trout processed and project completion dates by hatchery in 2015

Hatchery	Agency	Number tagged	Date completed
Marquette State Hatchery	Michigan Department of Natural Resources	218,849	7/12/2015
Jordan River National Fish Hatchery	US Fish and Wildlife Service – Region 3	2,393,846	9/26/2015
Pendill's Creek National Fish Hatchery	US Fish and Wildlife Service – Region 3	1,152,182	9/2/2015
Iron River National Fish Hatchery	US Fish and Wildlife Service – Region 3	1,268,064	10/5/2015
Allegheny National Fish Hatchery	US Fish and Wildlife Service – Region 5	1,111,754	9/13/2015
Eisenhower National Fish Hatchery	US Fish and Wildlife Service – Region 5	245,130	9/20/2015
Total lake trout processed:		6,389,825	

Lake Trout Strain Comparison

In 2015, Region 3 hatcheries raised four different strains of lake trout for restoration stocking into lakes Michigan and Huron: Seneca Lake, Lewis Lake, Superior Klondike, and Huron Parry Sound. Trailer efficiency is similar among strains with the exception of the Lewis Lake strain that has lower average throughputs than all other strains **(Fig 1**). The lower throughputs for the Lewis Lake Wild strain are likely due to morphological and behavioral differences that cause operational complications when tagging and clipping using the automated tagging trailers.

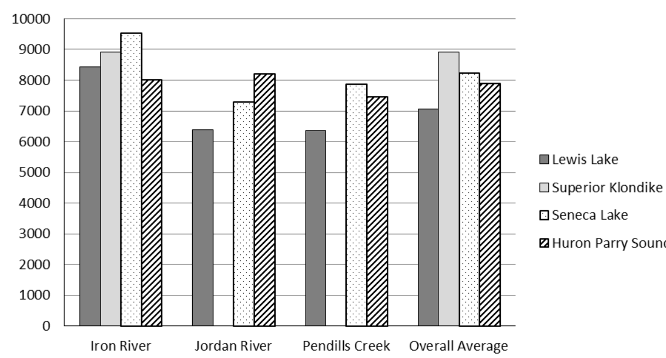

Fig 1- Total average throughput (fish/hour) for the four strains of lake trout tagged and marked at Region 3 USFWS hatcheries in 2015.

Tag recovery from fish captured in Lakes Michigan and Huron

During April 17 – October 18, eleven FWS technicians worked with Wisconsin, Michigan, Illinois and Indiana DNRs sampling sport-caught salmon and trout on lakes Michigan and Huron. Anglers were engaged at various ports and boat landings, with the technicians concentrating their collections at fish cleaning stations and fishing tournaments. Over 21,000 fish were examined throughout the season for biological data **(Table 4)** as well as collecting snouts from 4,715 fish that contained coded wire tags. In addition, scales, otoliths, or maxillae were collected from 6,342 fish to assist state agencies for year class estimation, while tissue specimens were collected from 2,007 fish for three research collaborations.

Muscle tissues, belly flaps and stomachs were collected for cooperative studies of Great Lakes food web dynamics and contaminant bioaccumulation, while fin clips were collected to assist in determining what genetic strains of lake trout contribute most to natural reproduction. Biological data collected included length, weight, fin clip lamprey wounding, sex, and aging structures. All hatchery reared lake trout and all 2011 – 2015 year class hatchery reared Chinook salmon have been fin clipped, therefore, all lake trout and any age 3 or younger Chinook salmon lacking a fin clip is presumed to be naturally reproduced (wild). The percent of wild Chinook salmon and Lake Trout (without a fin clip) was determined for each jurisdiction **(Table 5).** Fish snouts containing coded wire tags were sent to the Laboratory for tag extraction and reading.

Table 4- Number of fish by species examined by USFWS for tags from Lake Michigan and Lake Huron anglers during 2015.

State of Landing	Chinook Salmon	Lake Trout	Steelhead/ Rainbow	Coho Salmon	Atlantic Salmon	Brown Trout	Pink Salmon	Total
Wisconsin	5,946	1,729	2,290	886	2	455	1	11,310
Michigan – L. Huron	130	836	96	42	19	1	9	1,133
Michigan – L. Mich.	2,325	1,934	118	73	1	24	0	4,475
Illinois	277	246	61	345	0	5	0	934
Indiana	319	1,773	361	848	0	47	0	3,348
Total	8,997	6,517	2,926	2,194	22	532	10	21,200
Number of fish with no clip (wild)	5,177 (57.5%)	1,420 (21.8%)	N/A	N/A	N/A	N/A	N/A	N/A

Table 5- Percent of examined Chinook salmon and Lake Trout in each sampling jurisdiction that did not have any fin clips and presumed to be wild.

Sampling Jurisdiction	Wild Chinook salmon	Wild Lake Trout
Wisconsin - Lake Michigan	49.8%	20.6%
Michigan – Lake Huron	41.5%	53.2%
Michigan – Lake Michigan	76.1%	10.1%
Illinois	62.5%	43.5%
Indiana	68.7%	17.8%

Tag Recovery Assistance on Lake Ontario

During the summer and early fall of 2015, two FWS technicians assisted New York Department of Environmental Conservation (NYDEC) with recovering coded wire tagged Chinook salmon and lake trout from anglers on Lake Ontario. They engaged anglers at various ports between the Niagara River and Cape Vincent, New York, concentrating their collections at fish cleaning stations and fishing derbies. Over 5,600 fish were examined throughout the season for biological data and snouts were collected from 2,430 fish that contained coded wire tags. Biological data that included length, weight, fin clips and scales for aging were collected on each fish. Snouts that contained tags were collected and frozen for later tag extraction at the Great Lakes Fish Tag and Recovery Laboratory.

The main objectives of the study being conducted by NYDEC and the Ontario Ministry of Natural Resources, is to determine the relative proportion of wild and hatchery Chinook salmon and lake trout in the population, and to determine the relative return rates of truck stocked fish and pen-held released fish from stocking sites. By analyzing information on the proportion of tagged Salmonids captured in the sport fishery, managers can better understand how stocking methods and numbers can influence the fishery and rates of natural reproduction.

Appendix I *-Details of Chinook salmon and lake trout tagging and marking projects in 2015*

Hatchery	Agency	Species	Total number tagged	Number of tag groups	Number of tag codes	Start date	Complete date	Total machine run hours	Average machine processed fish/hour	Average hand processed fish/hour	Average fish/hour	Mean total length (mm)	Average Coefficient of Variation (CV)	Range of CV
Jake Wolf	Illinois Dept. of Natural Resources	Chinook salmon	257,996	3	3	3/11/15	3/15/15	31.2	7,422	853	8,275	96	8.5	8.2-8.6
Mixsawbah	Indiana Dept. of Natural Resources	Chinook salmon	203,123	3	3	3/18/15	3/21/15	23.2	8,171	594	8,764	83	11.2	9.8-12.3
Kettle Moraine	Wisconsin Dept. of Natural Resources	Chinook salmon	176,113	5	1	3/30/15	4/1/15	18.3	8,971	667	9,638	71	5.4	5.3-5.6
Wild Rose	Wisconsin Dept. of Natural Resources	Chinook salmon	643,852	7	7	4/7/15	4/14/15	66.8	8,286	894	9,180	76	6.1	5.7-6.8
Wolf Lake	Michigan Dept. of Natural Resources	Chinook salmon	248,961	12	2	3/23/15	3/27/15	29.0	7,899	625	8,523	84	7.8	7.4-8.5
Platte River	Michigan Dept. of Natural Resources	Chinook salmon	973,758	6	5	4/22/15	4/30/15	106.1	8,489	922	9,411	80	8.5	7.9-8.8
Thompson (ADCWT)	Michigan Dept. of Natural Resources	Chinook salmon	53,233	1	1	4/29/15	4/29/15	6.3	8,147	303	8,450	81	8.3	n/a
Thompson (AD only)	Michigan Dept. of Natural Resources	Chinook salmon	411,761	0	0	4/30/15	5/4/15	42.3	8,532	1,202	9,734	81	8.6	n/a
	Chinook salmon totals and means:		2,968,797	37	22	3/11/15	5/4/15	323.2	8,240	758	8,997	82	8.1	5.3-12.3
Marquette	Michigan Dept. of Natural Resources	lake trout	218,849	2	1	7/9/15	7/12/15	26.7	7,278	944	8,222	86	7.1	6.9-7.3
Jordan River	U.S. Fish and Wildlife Service	lake trout	2,393,846	38	27	8/5/15	9/26/15	339.1	6,535	697	7,232	88	10.0	8.7-12.7
Pendills Creek	U.S. Fish and Wildlife Service	lake trout	1,152,182	16	12	8/4/15	9/2/15	166.0	6,511	607	7,118	96	10.2	8.7-11.8
Iron River	U.S. Fish and Wildlife Service	lake trout	1,268,064	24	15	9/23/15	10/5/15	139.0	8,533	666	9,199	92	8.8	7.9-9.9
Allegheny	U.S. Fish and Wildlife Service	lake trout	1,111,754	27	27	8/19/15	9/13/15	136.8	7,380	831	8,211	87	9.8	8.2-12.8
Eisenhower	U.S. Fish and Wildlife Service	lake trout	245,130	6	6	9/16/15	9/20/15	32.9	6,708	849	7,557	98	8.8	8.2-10.4
	Lake trout totals and means:		6,389,825	113	88	7/9/15	10/5/15	840.5	7,158	766	7,923	91	9.1	6.9-12.8
	Chinook salmon and lake trout totals and means:		9,358,622	150	110	3/11/15	10/5/15	1,163.7	7,735	761	8,496	86	8.5	5.3-12.8

Appendix II*-Total fish processed for all tagging and marking projects 2010-2015*

	2010	2011	2012	2013	2014	2015	6 year Total
Chinook salmon	1,104,166	4,689,947	4,320,884	2,856,038	2,953,814	2,968,797	18,893,646
Lake trout	4,584,509	5,779,176	6,094,302	5,660,034	6,412,006	6,389,825	34,919,852
Atlantic salmon	0	0	97,804	133,706	154,188	190,170,	575,868
Brook Trout	0	0	0	0	0	100,757	100,757
Totals	5,688,675	10,469,123	10,512,990	8,649,778	9,520,008	9,649,649	54,490,123

End Lake Superior report