Inland Seas Angler
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Highlights of the Annual Lake Committee Meetings

Great Lakes Fishery Commission proceedings, Duluth, MN

This first of a series of annual special reports is a summary of Lakes Huron-Superior. These lake committee reports are from the annual Upper Lakes Committee meetings hosted by the Great Lakes Fishery Commission in March 2013. We encourage reproduction with the appropriate credit to the GLSFC and the agencies involved. Our thanks to Dave Clapp, Jim Johnson, MI DNR; Dale Hanson, Charles Bronte and Mark Holey, USFWS; the staffs of the GLFC, OMNR, and USGS for their contributions to these science documents. Thanks also to the Great Lakes Fishery Commission, its staff, Chris Goddard & Marc Gaden, for their efforts in again convening and hosting the Upper Lake Committees meetings in Duluth.

Lake Huron

Index of Reports

Lake Superior

Index of Reports

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

Status and Trends of Pelagic Prey Fishes in Lake Huron, 2012 (USGS)

Abstract

The 2012 acoustic/midwater trawl surveys were conducted during September and October, and included transects in Lake Huron's Main Basin, Georgian Bay, and North Channel. Pelagic fish density (638 fish/ha) was lower in 2012 compared to 2011, with density in 2012 only 34% of 2011. Total biomass in 2012 was 74% of the 2011 value. Alewife remained nearly absent, and only one cisco was captured. Rainbow smelt density was only 31% of the 2011 density. Bloater density was less than half the 2011 density, mostly as a result of lower density of small bloater. Density and biomass of large bloater in 2012 were similar to 2011 levels. During 2012 we observed significantly higher fish biomass in North Channel than in the Main Basin or Georgian Bay. Prey availability during 2013 will likely be similar to 2012. Lake Huron now has pelagic fish biomass similar to that observed in recent lakewide acoustic surveys of Lake Michigan and Lake Superior, but species composition differs in the three lakes. There is an increasing diversity and prevalence of native species gradient from Lake Michigan to Lake Superior, with Lake Huron being intermediate in the prevalence of native fish species like coregonines and emerald shiner.

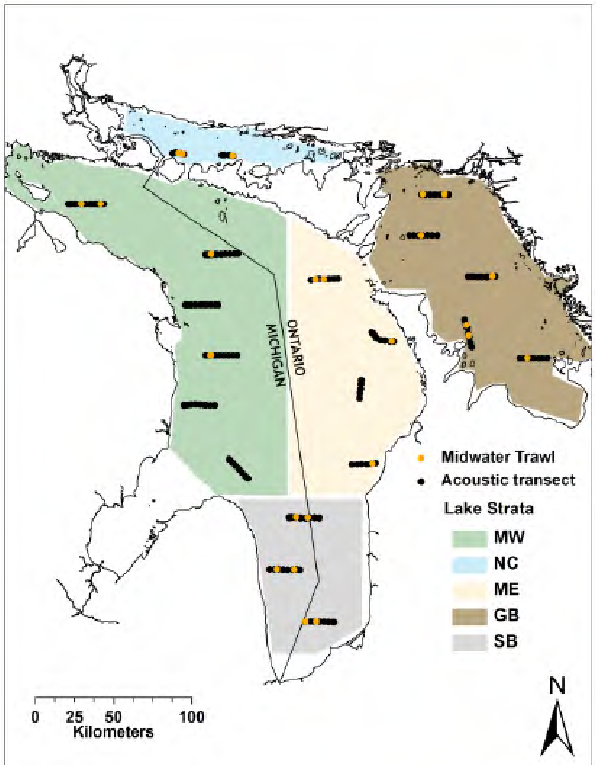


Fig 1-Hydroacoustic transects sampled during the 2012 lakewide acoustic& midwater trawl survey in Lake Huron

Alewife

Since 2004, we have captured very few alewife, and almost all have been age-0 fish. During 2012, both alewife density and biomass remained low and represented 1.5 and 1.8% of the long-term mean, respectively **(Fig 2**). Alewife density in 1997, 2005, 2006, and 2008 was higher than all other years in the time series. However, we note that density differences, though large, did not mean that alewife have been especially abundant in any survey year. During 1997, their year of highest abundance, they were only 3.1% of total fish density. Temporal biomass differences were due in part to differences in size/age structure between 1997 and other years. In 1997 Age 1+ alewife were captured, but only age-0 alewife were captured during 2004-2012. Age-0 alewife biomass remains low and since 2004 they have never comprised more than 2.5 % of pelagic fish biomass. Alewife have shown no sign of returning to higher abundance. During 2012, only 9 of the 3,187 fish we captured in the midwater trawl were alewife; all were age-0 and most catches were comprised of single scattered individuals in the North Channel and southern Georgian Bay. The largest catch was 7 individuals taken in southern Georgian Bay. These results are consistent with the results from the annual bottom trawl survey, which indicated that alewife abundance remains very low.

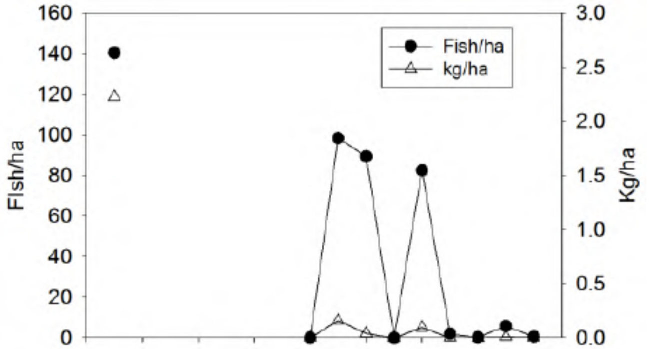


Fig 2 - Acoustic estimates of alewife density and biomass in Lake Huron, 1997-2012

Rainbow smelt

Rainbow smelt density and biomass decreased during 2012 compared to 2011 estimates. Age-0 rainbow smelt density decreased substantially and 2012 estimates were 13% of 2011 estimates, 16 % of the long-term mean, and the second lowest in the time series following 2010 **(Fig 3**). Abundance of age-0 rainbow smelt has been variable over the time series with the highest densities occurring during 1997, followed by 2006 and 2009.

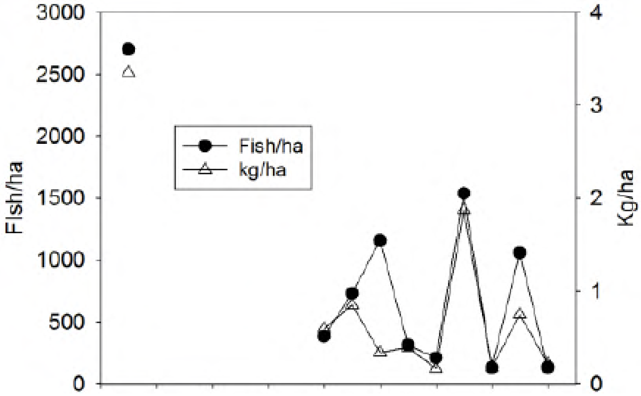


Fig 3-Acoustic estimates of age-0 (< 90 mm) rainbow smelt density and biomass in Lake Huron, 1997-2012

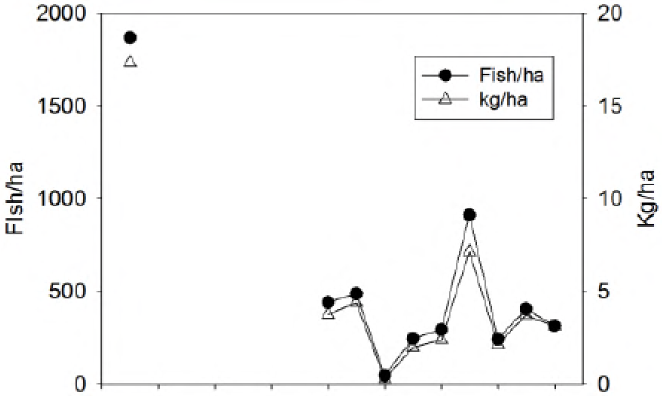


Fig 4-Acoustic estimates of age-1+ (> 90 mm) rainbow smelt density and biomass in Lake Huron, 1997-2012

Consistent with low densities observed in 2012, age-0 rainbow smelt biomass was low and 29% of 2011 estimates and 25% of the long-term mean. Only 2008 and 2010 had lower estimates of age-0 biomass. Age 1+ rainbow smelt biomass and density were similar in 2011 and 2012 **(Fig 4)**. Density of age-1+ rainbow smelt during 2012 was 78% of 2011 estimates and 60% of the long-term mean. Age-1+ rainbow smelt biomass in 2012 was 84% of 2011 estimates and 68% of the long term mean. Following the highest observed age-1+ abundance in 1997, estimates of rainbow smelt density and biomass were substantially lower during 2004-2012. Acoustic survey results indicate rainbow smelt density and biomass have shown no trend during 2004-2012. Density and biomass estimates from the bottom trawl survey in 2012 were similar to acoustic estimates.

Bloater

Age-0 bloater density in 2012 was 22% of the 2011 value (**Fig 5**) and 27% of the long-term mean. Density has been highly variable and has shown no trend. Similarly, age-0 bloater biomass showed no trend. The estimate in 2012 was 15% of the 2011 estimate and 17% of the long-term mean.

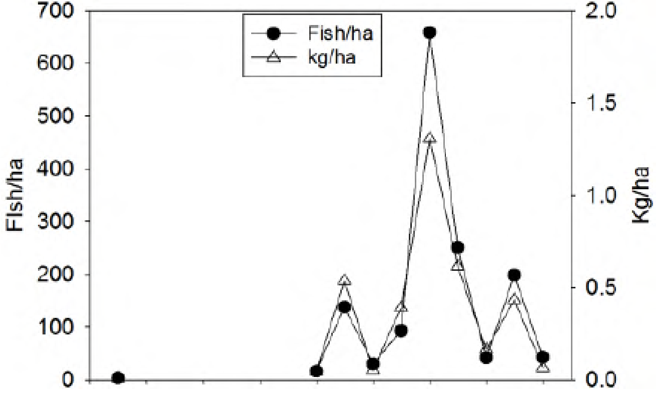


Fig 5-Acoustic estimates of age-0 (< 120 mm) bloater density and biomass in Lake Huron, 1997-2012

The density and biomass of large bloater has been somewhat less variable from year to year (**Fig 6).** Both density and biomass of large bloater showed an increasing trend from 2004-2008, followed by a decrease from 2009-2010 Density of large bloater in 2012 was similar to the estimates in 2010 and 2011 and was 60% of the long-term mean. Biomass of large bloater in 2012 was similar to biomass in 2011 and was 60% of the long-term mean. The acoustic estimate of large bloater biomass in 2012 was much lower than the bottom trawl estimate, but results from both surveys suggest an increasing trend in biomass of large bloater since 2004.

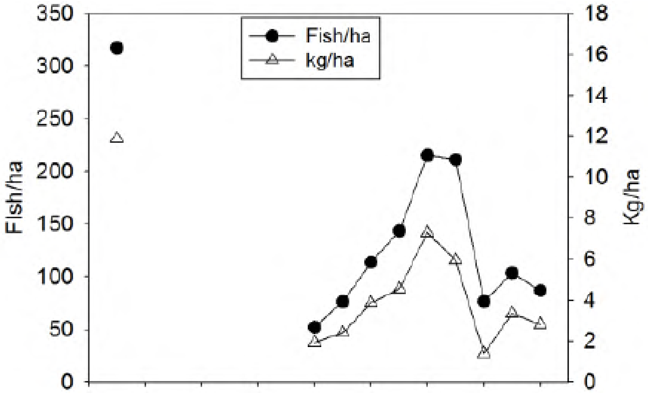


Fig 6-Acoustic estimates of age-1+ (> 120 mm) bloater density and biomass in Lake Huron, 1997-2012

Cisco

Cisco abundance has been very low in Lake Huron. Catches in midwater trawls are too sporadic to be able to use trawl proportions to apportion acoustic densities. For example, only one cisco was caught in 2012 and in six of the years from 2004-2012, zero or one cisco was captured during acoustic surveys. GLSC sampling (all types) has captured only 108 ciscos since 1980. There has been no evidence of a trend in the density of large adult cisco-sized targets in the period 2004-2012. Mean density of targets >-36 dB in Lake Huron varied between 0.7 and 2.6 fish/ha with no discernible trend. Furthermore, this analysis showed that density of large cisco-sized targets in Lake Huron has been much lower than during a lakewide acoustic survey of Lake Superior in 2011 (**Fig 7).**

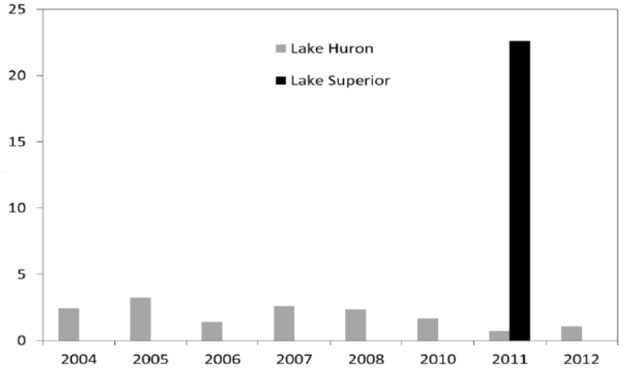


Fig 7-Density of large cisco-sized targets in Lake Huron during lakewide acoustic surveys in the years 2004-2012; the lakewide mean density from Lake Superior, estimated using the same methods, is shown for comparison

Emerald shiner

Emerald shiner density and biomass in 2012 were much lower than in 2011 (**Fig 8).** Lakewide mean density was 26% of the 2011 value, while biomass was 7% of the 2011 value. Emerald shiners were captured only in the western portion of the Main Basin and were not observed in Georgian Bay or the North Channel. They were a small proportion (<1%) of pelagic fish biomass during 2012.

Among-Basin Comparisons

One factor that makes Lake Huron unique among the Laurentian Great Lakes is the presence of four large, distinct basins that make up significant portions of the total lake area. For example, Georgian Bay makes up approximately 25% of the total Lake Huron area and is 77% of the area of Lake Ontario. These basins differ in mean depth and area, and in past years, fish biomass. In 2012, pelagic fish biomass varied significantly among basins, with biomass higher in the North Channel than in the Main Basin or Georgian Bay **(Fig 8).**

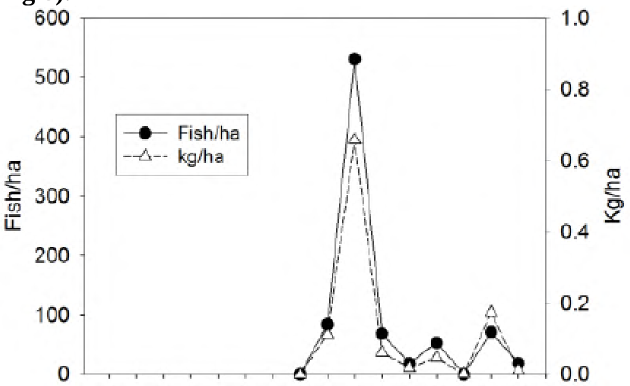


Fig 8-Acoustic estimates of emerald shiner density and biomass in Lake Huron, 1997-2012

In addition to differences in fish biomass, the three basins appear to have different temporal trends in biomass and they differ in community composition. In both Georgian Bay and the Main Basin, fish biomass has declined since 1997 **(Fig 9)** and remains low, while there is no evidence of a declining trend in North Channel. Community composition differences are predominantly the result of variation in the proportion of biomass made up by rainbow smelt and bloater. Most biomass in Georgian Bay has been in the form of rainbow smelt (53%), while most of the biomass in the Main Basin has been in the form of bloater (54%). North Channel, where rainbow smelt have made up 71% of biomass, has had even greater rainbow smelt dominance than Georgian Bay. To date, the only factor identified as having consistently influenced the biomass and community composition differences among these basins is bottom depth.

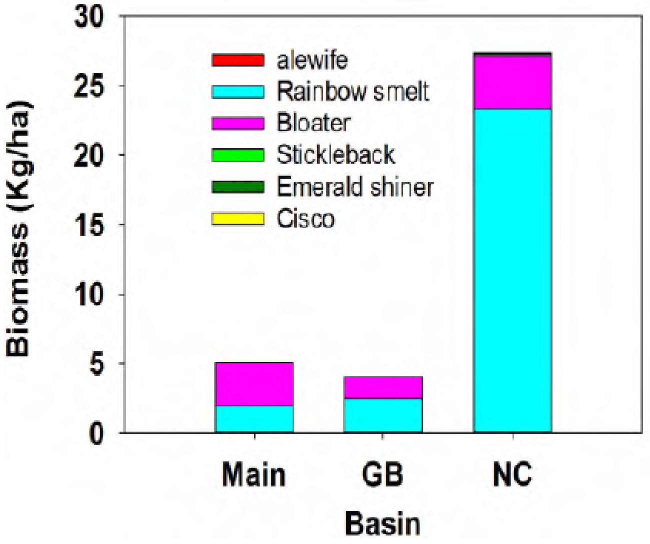


Fig 9-Acoustic estimates of total pelagic fish biomass among Lake Huron's three basins, 2012

Summary

Acoustic estimates of pelagic fish biomass in Lake Huron have shown no consistent trend between 2004 and 2012 (Figure 10). However, biomass remains much lower than in 1997. Most of this decrease in biomass is the result of decreased abundance of rainbow smelt and bloater.

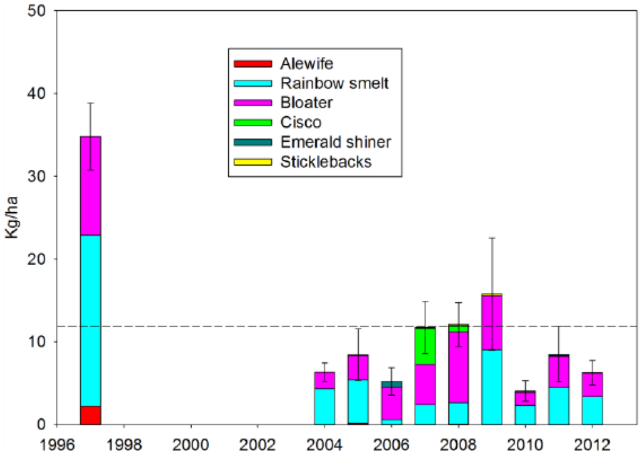


Fig 10-Lakewide pelagic fish biomass in Lake Huron, 1997-2012; the horizontal line denotes the 1997-2011 mean

During 2013, forage availability for piscivores will likely be similar to that seen in other recent years. Alewife remain rare, and there has been no trend in pelagic biomass since 2004. The Lake Huron forage base still remains low compared to previous decades when alewife, rainbow smelt, and bloater were likely more abundant. Lakewide pelagic biomass in Lake Huron in 2012 (6.3 kg/ha) was similar to biomass in Lake Michigan (6.4 kg/ha, Warner et al. 2013) as well as Lake Superior in 2011. There is, however, a key difference between the three lakes. In Lake Michigan, alewife are still prevalent in that they comprise about 77% of the pelagic biomass, while in the other two lakes, the biomass of this species is negligible. Additionally, native coregonines and other species are extremely rare or absent in Lake Michigan. Both Huron and Superior have much greater contribution to density and biomass from native species. In the case of Lake Superior, are numerically dominant, while cisco make up most of the biomass. In Lake Huron, rainbow smelt are numerically dominant, while rainbow smelt and bloater have been alternating roles as the dominant contributor to total biomass. Additionally, there have been relatively consistent (but low) catches of emerald shiner and cisco in Lake Huron midwater 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. The alewife collapse likely had a similar effect on lake trout, an important native species that appears to have an influence on rainbow smelt abundance through predation. While the results of this survey indicate clearly that cisco have not been restored to Lake Huron given the a) cisco-sized target densities have averaged <10% of densities in Lake Superior and b) midwater trawl catches remain limited to few fish, it is not clear why this species remains at such low densities nor is it clear what a reasonable density for Lake Huron might be.

Comparison of the acoustic and bottom trawl estimates of bloater biomass revealed a large difference in these estimates for 2012. While this difference may be disconcerting to some, a number of factors must be considered in interpreting this comparison.

First, it is important to reiterate that when considering data since 2004, both surveys indicate there is an increasing trend in large bloater biomass and both surveys suggest that this increase was a result of high biomass of small bloater between 2005 and 2009. This is in contrast to Lake Michigan, where large numbers of young produced in 2007-2009 have not resulted in increased abundance of large bloater.

Second, the bottom trawl estimate was driven in large part by relatively few tows with very high catches.

Third, a number of factors could have led to differences in the results of the acoustic and bottom trawl surveys. Differences in biomass may arise from differences in survey timing, locations sampled, and sample size. Differences in survey timing may be quite important, as there is significant temporal variability at very small temporal scales in fish density at a given site. For example, two replicate bottom tows at the same site in Lake Huron <45 minutes apart in July 2012 had bloater catches that varied 63-fold, and two replicate bottom tows in Lake Michigan in September 2010 had bloater catches that varied 135-fold. Furthermore, the tow with the highest catch can be the second tow. Given this variation in replicate bottom trawl catches, it is reasonable to expect differences in estimates that are generated from samples taken up to 30 days apart. Finally, as with acoustic sampling, there are many caveats to consider with bottom trawling. ✧

Status and Trends of the Lake Huron Offshore Demersal Fish Community, 1976-2012 (USGS)

Abstract

The USGS Great Lakes Science Center conducted trawl surveys at five ports in U.S. waters with less frequent sampling near Goderich, Ontario. The 2012 fall bottom trawl survey was carried out between 20 October – 5 November 2012, and included all U.S. ports as well as Goderich, ON. The 2012 main basin prey fish biomass estimate for Lake Huron was 97 kilotonnes, higher than the estimate in 2011 (63.2 Kt), approximately one third of the maximum estimate in the time series, and nearly 6 times higher than the minimum estimate in 2009. The biomass estimates for adult alewife in 2012 were higher than 2011, but remained much lower than observed before the crash in 2004, and populations were dominated by small fish. Estimated biomass of rainbow smelt also increased and was the highest observed since 2005. Estimated adult bloater biomass in Lake Huron has been increasing in recent years, and the 2012 biomass estimate was the third highest ever observed in the survey. Biomass estimates for trout-perch and ninespine stickleback were higher than in 2011 but still remained low compared to historic estimates. The estimated biomass of deepwater and slimy sculpins increased over 2011, and slimy sculpin in particular seem to be increasing in abundance. The 2012 biomass estimate for round goby was similar to that in 2011 and was the highest observed in the survey. Substantial numbers of wild juvenile lake trout were captured again in 2012, suggesting that natural reproduction by lake trout continues to occur. The 2012 Lake Huron bottom trawl survey results suggest that several species of offshore demersal fish are beginning to increase in abundance.

Fig 1-Bottom trawl sampling locations in Lake Huron, 2012

Recent major ecosystem changes in Lake Huron include the invasion of dreissenid mussels and drastic declines in the abundance of the native amphipod *Diporeia* sp, decreases in lake whitefish and Chinook salmon catches, significant changes in the abundance and species composition of the zooplankton community, the invasion of the round goby, and the restructuring of the offshore demersal fish community.

A total of 41 trawl tows were completed and all standard ports were sampled, including Goderich, Ontario. Twenty-four fish species were captured in the 2012 survey: rainbow smelt, alewife, bloater, deepwater sculpin, slimy sculpin, trout-perch, lake whitefish, ninespine stickleback, threespine stickleback, lake trout, walleye, spottail shiner, burbot, round goby, yellow perch, gizzard shad, white sucker, emerald shiner, freshwater drum, white bass, white perch, logperch, sea lamprey and common carp **(Fig 1).**

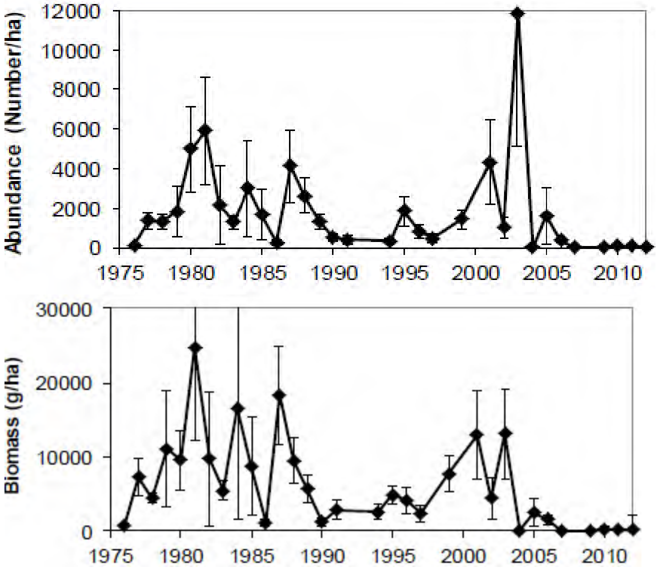


Fig 2-Density of young-of-the-year alewives as number (top panels) and biomass (bottom panels) of fish per hectare, 1976-2012

Alewife abundance in Lake Huron remained very low in 2012. Adult (YAO) alewife density and biomass estimates increased from 2011, but remained much below levels observed before the population crashed in 2004 **(Fig. 2**). Age-0 alewife density and biomass showed a decrease in 2012, and remained near the all-time low for the time series **(Fig. 2**).

Adult (YAO) rainbow smelt density in Lake Huron in 2012 increased compared to 2011, but remained relatively low (8.5% of the maximum; **Fig. 3**). YOY rainbow smelt abundance and biomass decreased compared to recent years. Adult (YAO) bloater density in Lake Huron has been increasing in recent years, and the 2012 abundance estimate was the highest observed in the time series. While the estimated bloater abundance was the highest observed since 1989, biomass, however, was only third-highest in the time series, due to the relative lack of larger fish compared to earlier years (**Fig. 4).** YOY bloater abundance was relatively low and lower than 2011 **(Fig. 4**).

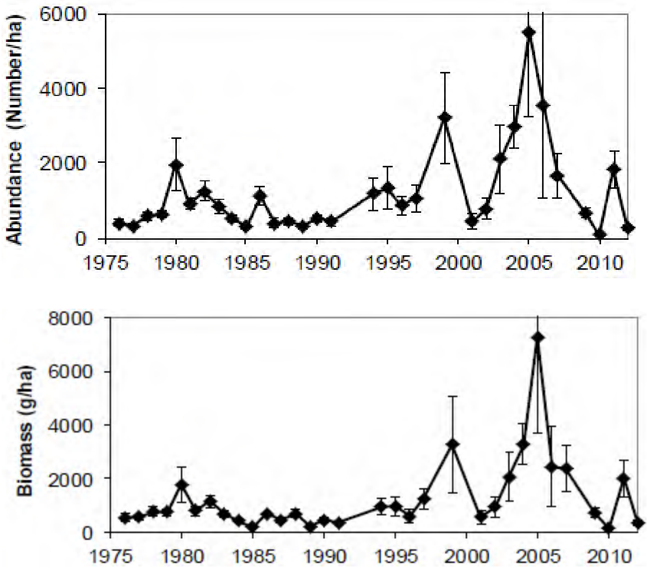


Fig 3-Density of young-of-the-year rainbow smelt as number (top panels) and biomass (bottom panels) of fish per hectare, 1976-2012

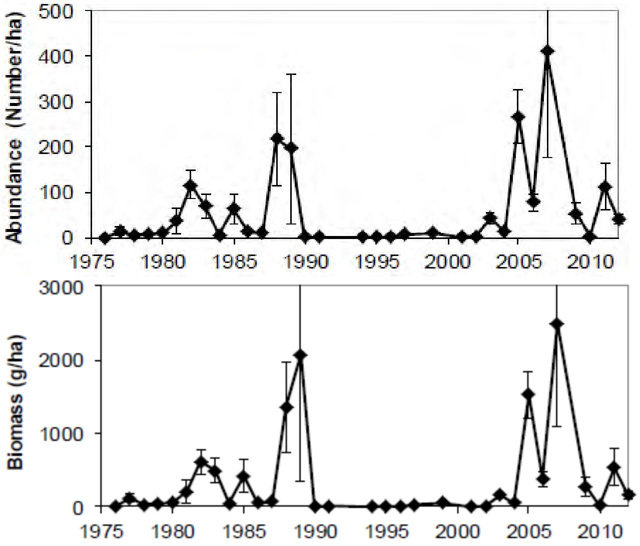


Fig 4-Density of young-of-the-year bloater as number (top panels) and biomass (bottom panels) of fish per hectare, 1976-2012

The 2011 survey was the first time that slimy sculpins were captured in the Lake Huron bottom trawl survey since 2006, and the estimated abundance of this species rebounded in 2012 to approximately 45% of the highest abundance observed in the time series **(Fig. 5).** Abundance and biomass estimates for deepwater sculpins in Lake Huron in 2012 were higher than 2011, but still remained relatively low compared to historic estimates **(Fig. 6)**. The 2012 abundance and biomass estimates for ninespine stickleback were higher than in 2011, but remain relatively low. Trout-perch abundance and biomass estimates increased from 2011, and the abundance estimate was the highest observed since 2004. Round goby abundance and biomass estimates for 2012 were similar to those in 2011 and were the highest observed since the species was first captured in the survey in 1997 **(Fig. 7).**

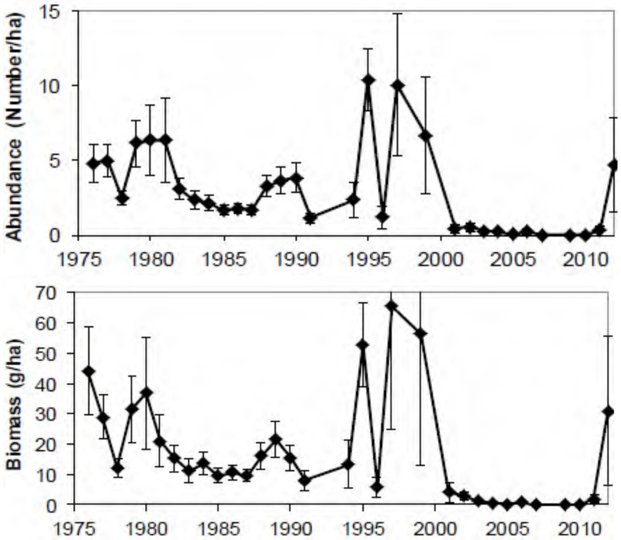


Fig 5-Density of young-of-the-year slimy sculpin as number (top panels) and biomass (bottom panels) of fish per hectare, 1976-2012

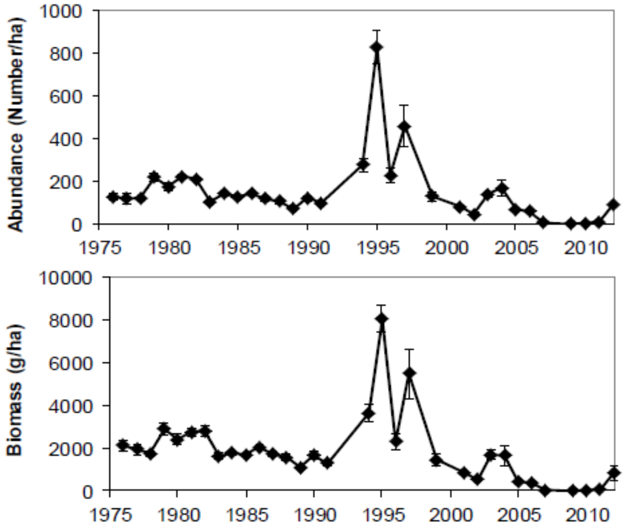


Fig6-Density of young-of-the-year deepwater sculpin as number (top panels) and biomass (bottom panels) of fish per hectare, 1976-2012

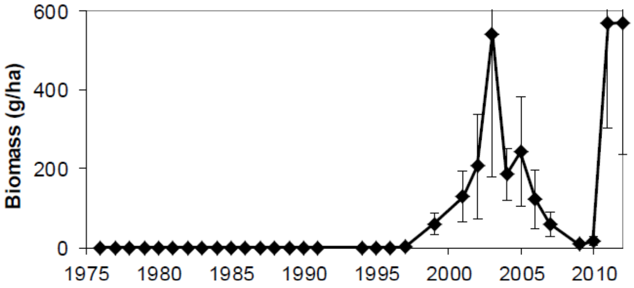


Fig 7-Density round goby as biomass of fish per hectare, 1976-2012

The total main basin prey biomass estimate (5 - 114 m) in 2012 was 97 kilotonnes, nearly six times the minimum estimate in 2009 **Fig. 8)**. This is the highest estimate since 2001, and represents 26 percent of the maximum lakewide biomass estimate observed in 1987. Approximately 78 % of the 2011 biomass estimate was made up of YAO bloater. Large numbers of wild juvenile lake trout were captured in the 2012 fall survey. The density of wild juvenile lake trout observed in 2012 was the highest observed since they first appeared in the catches in large numbers in 2004.

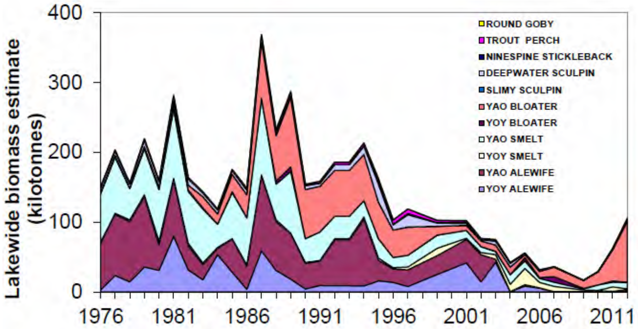


Fig 8-Offshore demersal fish community biomass in the main basin of Lake Huron, 1976-2012

Summary

The abundance of prey fish in Lake Huron has remained at very low levels since the collapse of the offshore demersal fish community, although survey catches in 2012 suggest that several species are beginning to increase in abundance. The estimated lakewide biomass of prey fish in 2012 was the highest reported since 2001, and is 27 percent of the maximum biomass estimated in 1987. The estimated biomass of YAO rainbow smelt in 2012 was higher than in 2011, but remained low compared to earlier data. Existing populations of alewife and rainbow smelt were dominated by small fish. 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 on these species as prey.

YAO bloater have shown a consistent positive trend in abundance in recent years based on the bottom trawl index. YAO bloater biomass has been increasing since approximately 2001, and the 2012 biomass estimate was the third-highest in the time series and the highest observed since the peak in 1989. The abundance of this native species has reached levels higher than those observed in the 1980s and 1990s, but biomass remains somewhat lower due to a relative lack of larger fish. Trends in bloater abundance based on acoustic surveys also show an increasing trend since 2004). The recent trend in bloater abundance is encouraging from a fishery management perspective, and may indicate that current conditions in the lake are conducive to the survival and recruitment of native coregonids including deepwater ciscoes.

Deepwater and slimy sculpins, ninespine sticklebacks, and trout-perch are currently minor components of lake trout diets in the Great Lakes, but were probably more important before the invasion of the lakes by alewife and rainbow smelt. In 2012, biomass estimates for deepwater sculpins, sticklebacks, and trout-perch were higher than in 2011, but nevertheless remained relatively low, while slimy sculpin biomass has increased dramatically. Recent increases in abundance of most of these species are encouraging.

Round gobies have recently become a significant part of the diet of lake trout in some areas of the Great Lakes, including Lake Huron. Round gobies 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 round goby are currently at high abundance in the offshore waters of Lake Huron, although the sharp fluctuation in abundance suggests that abundance estimates for this species may be subject to the effects of factors such as fish movement due to temperature or other factors.

The estimated lakewide biomass of common offshore prey species in Lake Huron has increased each year since 2009, but remains relatively low. 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. It is possible that these declines are 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. Similar declines in some species (particularly coregonids) have occurred in Lake Superior, however, where these exotic species have not invaded.

Naturally-produced juvenile lake trout were first captured in relatively large numbers by the Lake Huron fall survey in 2004, the year after the alewife population collapsed. Catches generally declined after 2004, but rebounded to high levels in 2011 and 2012. This suggests that the conditions that are conducive to natural reproduction of lake trout in Lake Huron may be sporadic but show signs of a recovering natural population. These wild juvenile lake trout are now recruiting to gill net surveys as adults, which is the first evidence of natural recruitment of wild adult lake trout in the main basin of Lake Huron since the 1950s, and is an important step towards lake trout rehabilitation in Lake Huron.

The results of this survey show that there has been great variability in the abundance or biomass of a number of fish species (YOY benthopelagic planktivores, round goby, wild juvenile lake trout) over the last decade. Low levels of prey fish abundance have persisted since approximately 2006, although the 2012 survey provides evidence that the abundance of some species may be starting to rebound. These results, along with evidence of shifts in depth distribution of prey (Riley and Adams 2010), may indicate that, while abundance of many important prey species in the offshore demersal fish community in Lake Huron remain depressed, some native fishes such as lake trout, bloater, and sculpins may be increasing in abundance. ✧

Life After Alewife Collapse:
Native Species Contributions to Lake Huron’s Recreational Fishery

Introduction

With the collapse of alewives in Lake Huron in 2003-2004 **(Fig 1**), there followed a well-documented decline in Lake Huron’s offshore fishery for Chinook salmon. Angler use fell nearly 75% after 2005 in Michigan’s Main Basin and to a lesser degree in Saginaw Bay. Prior to alewife collapse, several species were showing signs of reproductive impairment, lake trout and walleyes in particular. After the alewife collapse reproduction improved. The purpose of this report is to use trends in estimates of angler harvest, harvest rates, and effort to explore whether native species have benefited in the years following the alewife collapse.

Angler use has been estimated at 13 ports on the Main Basin and 7 sites on Saginaw Bay since 1986. For summarizing catch and effort trends from 1986-2012, we used the 17 ports with most consistent coverage (**Fig. 2**). For trends after 2000, we used 20 ports. Species were grouped as either “native” or “introduced” to look at trends in native species composition of the catch. Trends in angler hours were examined with respect to catch rates and catch composition to elucidate causes for recent sharp declines in effort.

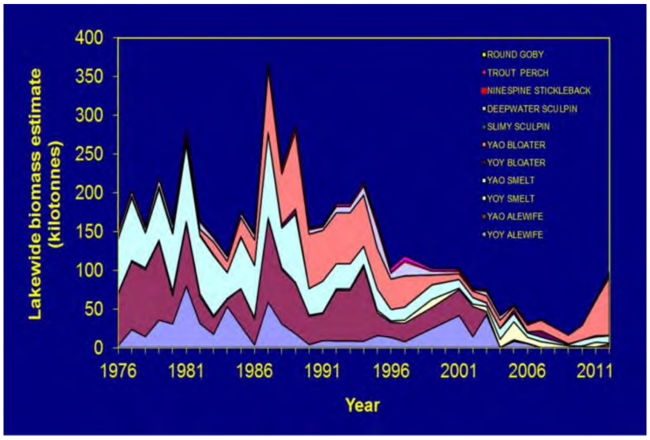


Fig. 1-Trends in bottom trawl prey assessment of the Main Basin, illustrating the collapse of alewives in 2003-04 and a recent rise in bloater biomass.

Results

Alewives collapsed during 2003-2004; most other prey species have remained in low numbers or also declined (**Fig 1**). With little compensation by other species for the alewife collapse, the pelagic prey community reached record low biomass levels after 2004. Alewives remained almost absent in prey assessments from 2005-2012 but the native bloater chub has increased in the trawl catch in recent years **(Fig 1**).

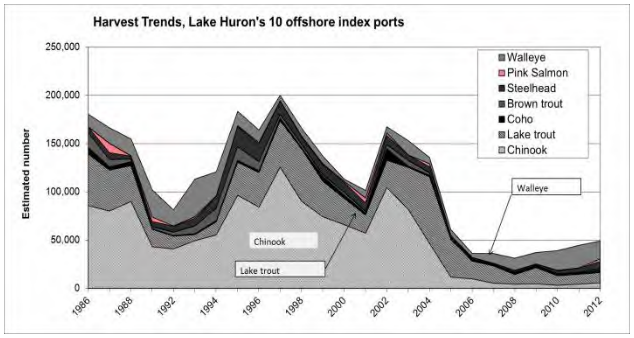


Fig. 2 - Chinook salmon harvest from the 10 index ports on the Main Basin, 1986-2012. Chinook catch declined precipitously after 2004, when alewives crashed.

In the Main Basin, Chinook salmon harvest and catch rates fell more than 90% and 66%, respectively, from their 1986-2004 averages during the 8 years following the alewife collapse. Angler effort followed, declining about 73% in the Main Basin. Catch and catch rates of other salmonids, such as lake trout and steelhead, did not change consistently and harvest and catch rates of walleyes rose. Catch rate of walleye nearly equaled the combined catch rates of salmonids in these 10 Main Basin, traditionally salmon fishing, ports after 2009 (**Fig 3).** Chinook catch rate (number harvested per angling hr) explained more of the variation in fishing effort than did total salmonid catch rates.

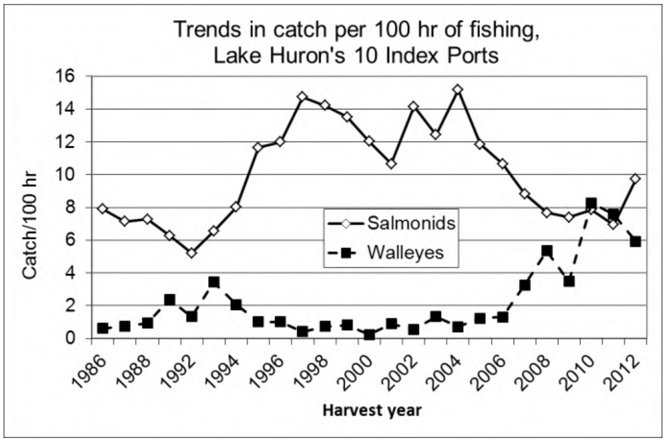


***Fig. 3 - Catch rates of walleye and the combined salmonids, 1986-2012. Walleye catch rates rose to near those of the combined salmonids by 2010. After 2009, total catch rate of walleyes and salmonids together recovered to near that prior to alewife collapse*.**

In Saginaw Bay, where Chinook salmon were always less important, effort and harvest also declined **(Figs 4, 5),** but less so than for the Main Basin. A mitigating factor was the rise in walleye (**Fig. 5),** fueled by a surge in natural reproduction that began in 2003.

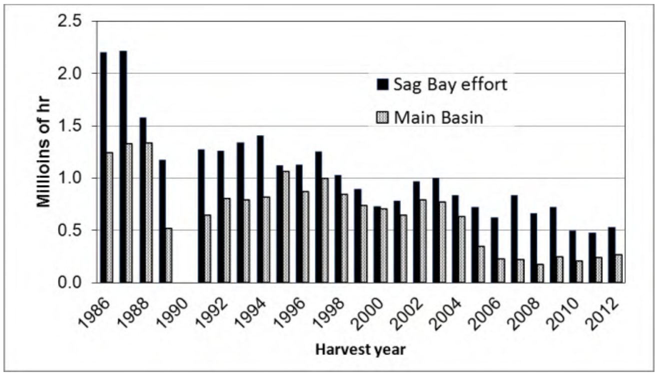


Fig. 4 - Trends in fishing effort (hrs), Main Basin and Saginaw Bay. Effort declined more sharply in the Main Basin than Saginaw Bay after alewife collapse. The decline in effort contributed to declines in harvest of all species.

Reproduction has continued to be strong in ensuing years and stocking of walleyes, which once ranged near 1 million spring fingerlings per year, has not taken place since 2006. Despite the rise in walleye, angler use declined by about 53% in the years following 2004, probably due to a long-term trend in declining yellow perch abundance. While yellow perch reproduction, measured as young-of-year in trawl catches, increased after the alewife collapse, recruitment to age-1 declined by more than 75%.

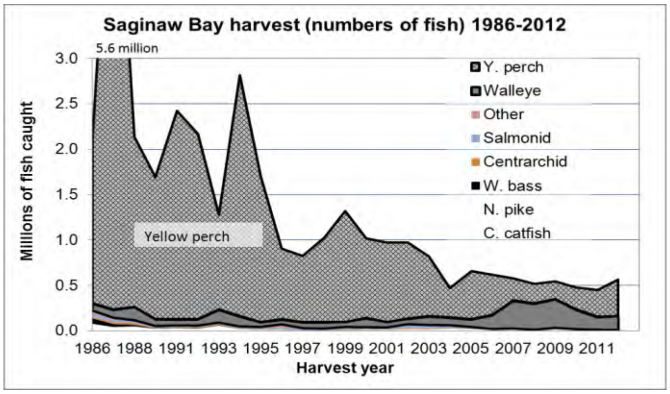


Fig. 5 - Trends in harvest, Saginaw Bay. The long-term decline in yellow perch harvest contributed to steady erosion in fishing effort in the Bay.

Beginning in 2003, yellow perch became prominent in Saginaw Bay walleye diets **(Fig. 6);** the near disappearance of alewives from the Bay probably increased exposure of yellow perch to predation. The rise in predation on yellow perch appears to explain the decline in recruitment to yearling and older ages and the failure of the perch population to recover. Yellow perch catch rates, which reached long-term low points after 2004, appear to be the leading cause of lower angler use of the Bay in recent years.

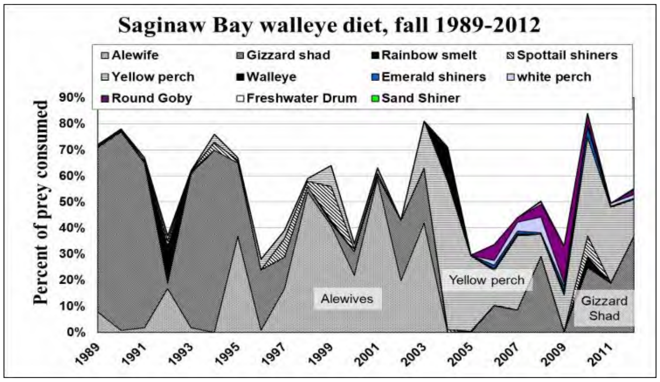


Fig. 6 - Walleye prey composition from annual fall assessments of Saginaw Bay. Yellow perch became prominent in walleye diets after alewives collapsed.

In the Main Basin, the contribution of native species to harvest rose from 39% prior to alewife collapse to 87% after, mostly because of declines in Chinook salmon catch. While the proportion of native species in the catch rose, there was no increase in native species yield in the Main Basin after alewife collapse, because effort dropped so sharply.

Yield, expressed as pounds of fish harvested per 100 hours of fishing effort (yield rate, lb/hr), is an abundance index less influenced by the effect of effort changes. Yield rate of native species more than doubled in the Main Basin, from an annual average of 48 lb/100 hr during 2001-2004 to 109 lb per 100 hr during 2005-2012. Introduced species yield rates declined from 100 to 37 lb per hour (**Fig. 7**). In Saginaw Bay, yield rate of natives increased from 52 to 93 lbs/100 hr across the same two periods, while the introduced species almost disappeared from the catch, dropping from 15 lb/100 hr to less than 1 lb/100 hr **(Fig. 8).**

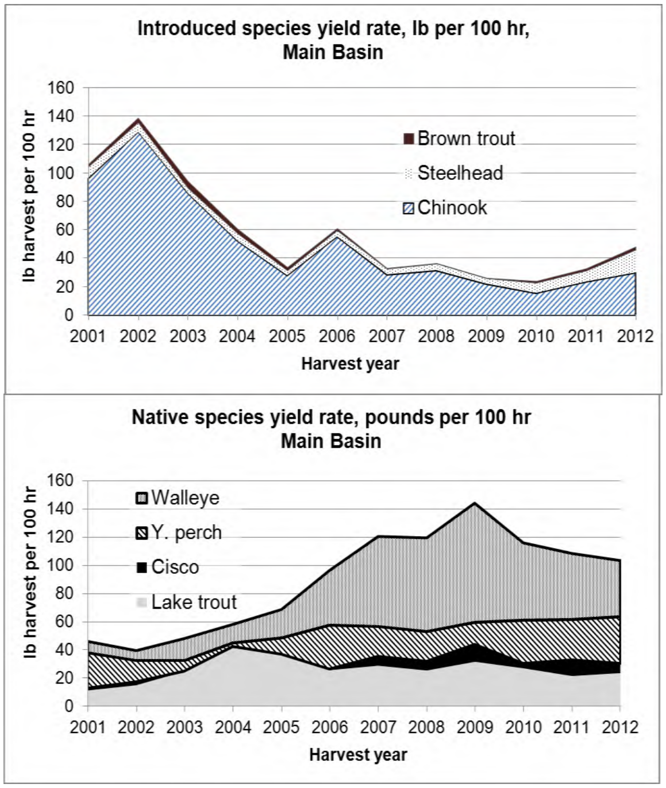


Fig. 7 - Trends in yield per 100 hr of recreational fishing, Main Basin, by species grouping. Yield rate is nearly the same in recent years as prior to the 2004 alewife collapse, but native species, led by walleyes, have sharply increased in contribution to the harvest.

The rising contribution of native species was led by walleye, especially in Saginaw Bay because the recovery of Lake Huron's walleye population was centered there. The Saginaw Bay walleye population migrates throughout Michigan waters of Lake Huron and contributed to rising native fish catches in both basins (**Figs. 7, 8).** For the Main Basin, total yield rates did not change between the two periods; native and introduced species combined, averaged 148 lb per hr during 2001-05 and 146 lb per hour after alewife collapse (during 2005-12). In Saginaw Bay, yield rate increased from 67 lb/100 hr in the four years prior to alewife collapse to 94 lb/100 hr from 2005-2012.

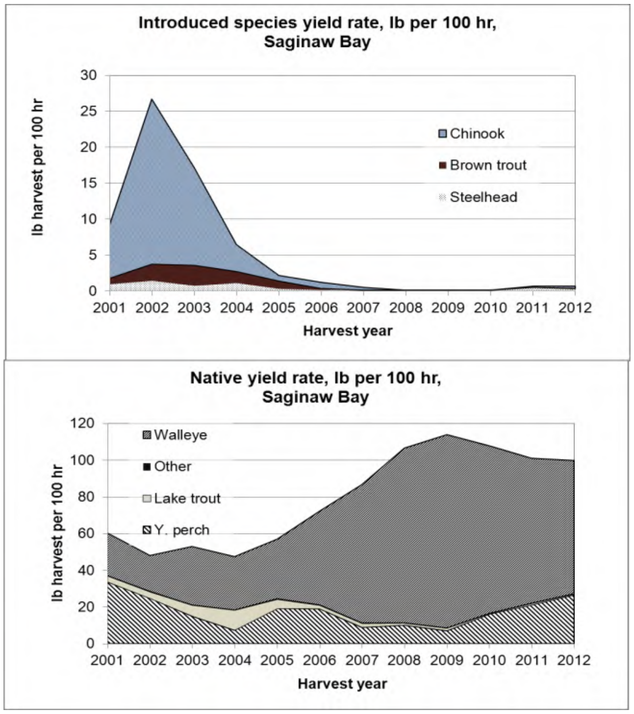


Fig. 8 - Trends in yield per 100 hr of recreational fishing, Saginaw Bay, by species grouping. Note differences in scaling of Y axes. Total yield rate is higher in recent years than prior to the 2004 alewife collapse, but the introduced species are virtually absent.

Discussion

The Lake Huron fish community reacted sharply to alewife collapse and does not yet appear to have reached a new equilibrium. Yellow perch reproduction rose in Saginaw Bay after 2002, but yellow perch also became a major prey species, having lost the predator buffering effect of a large alewife population. Recruitment of age-0 perch in the trawl to the next year's age-1 catch dropped from 74% prior to 2003 to just 9.9% during 2003-12. Were the prey community to further diversify, yellow perch might experience a degree of relief from predation. A recent rise in consumption of gizzard shad by walleye should give perch such relief, however, gizzard shad are sensitive to hard winters and their recent rise may be short lived.

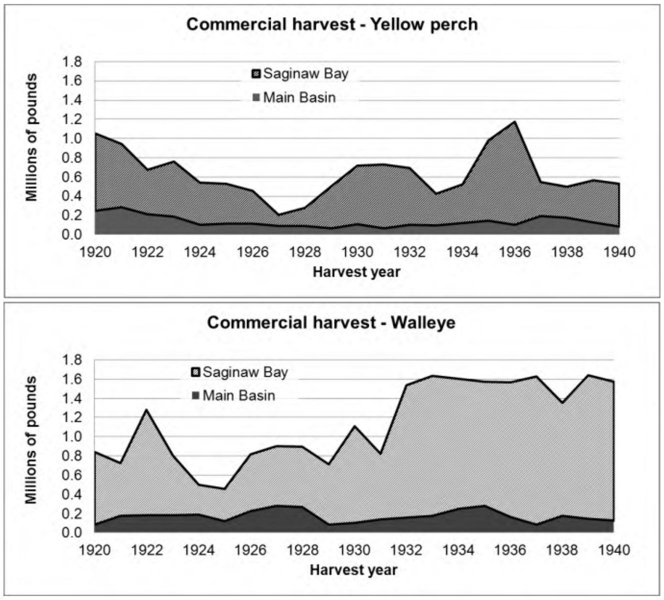


Fig. 10 - Commercial harvest of yellow perch and walleye from the Main Basin and Saginaw Bay, 1920-1940, Michigan waters of Lake Huron. Both species were simultaneously abundant enough to produce large commercial harvests during this period when ciscoes were also abundant.

The decline in alewives was followed by a rise in egg thiamine in lake trout and a related rise in reproduction. Lake trout are continuing to undergo change, transitioning from mostly hatchery-origin fish to increasingly wild. As naturalized spawning populations develop, lake trout numbers (and prey consumption) should rise.

Cisco (lake herring) populations and harvests are confined to Michigan's Upper Peninsula waters of Lake Huron. Ciscoes were once very abundant in the Main Basin and Saginaw Bay (**Fig. 9**) and they occurred at a time when commercial fisheries for both yellow perch and walleyes were at near record-high levels **(Fig. 10).** The abundance of ciscoes prior to about 1950 may have absorbed much of the predation of walleyes and lake trout, allowing the yellow perch population to thrive.

Yield rates are unchanged in the Main Basin and actually rose in Saginaw Bay after alewife collapse, yet angler use remains much below that of the alewife era. Low angler use is the principal reason harvest rates of both native and introduced species remain at near-record low levels in the Main Basin. In the Main Basin, the decline in effort was principally caused by low numbers of Chinook salmon. It is doubtful whether recoveries of both lake trout and walleye would be enough to stimulate the same level of angler use Chinook salmon did during the pre-alewife-collapse era. Angler use of Saginaw Bay appears to be very sensitive to yellow perch availability. ✧

Attributes of landlocked Atlantic Salmon in Relation to their Management in Lake Huron

Introduction

This document was prepared for the purpose of guiding planning efforts designed to test the stocking of landlocked Atlantic salmon in Lake Huron. It is not a thorough literature review, but instead focuses on attributes of landlocked Atlantic salmon that are relevant to their potential performance in Lake Huron and on Michigan's past evaluated Atlantic salmon introductions. The review of Michigan's experiences is limited to those instances for which there was continuous stocking of at least 3 years and for which there was at least a modicum of evaluation available.

What are Landlocked Atlantic Salmon?

Atlantic salmon are native to the northern Atlantic Ocean from the Iberian Peninsula to northern Russia and Scandinavia, and the British Isles to Iceland, the Canadian Maritime Provinces and New England. They evolved with and probably are more closely akin to sea-run brown trout than to the Pacific salmonids such as steelhead. Most Atlantic salmon populations are anadromous, migrating as smolts from freshwater tributary spawning and nursery habitats to salt water at ages of one or two years old. Some populations, known as landlocked salmon, remain in fresh water their entire life cycle, the smolts migrating to cold, freshwater lakes rather than the ocean. Like Pacific salmon, Atlantic salmon undergo smoltification, a physiological process that adapts them to the transition to a salt water environment. Importantly for the Great Lakes, coloration changes as they smolt to a color scheme that blends better with a lacustrine environment, and it camouflages them from predators and their prey. Smolting also stimulates downstream migration to lakes and a change in behavior from a territorial, benthic stream dweller to that of a pelagic, possibly shoaling lake or ocean fish.

Michigan Stocking History Since 1972

From 1972-1982 over 250,000 landlocked Atlantic salmon were stocked in Michigan in several large inland lakes and in rivers that are tributary to lakes Michigan and Huron. Several land-locked strains, Quebec, Gullspang (from Norway), Sebago and Penobscot (from Maine), and a Vermont strain were used in these introductions. Survival was generally below 1%, but there was better survival in two inland lakes, Gull Lake and Higgins Lake. Evaluation was hampered by lack of systematic creel surveys and was dependent principally upon reports from anglers and occasional confirmations of identity by biologists. Mature fish returning to Lake Michigan tributaries commonly were in poor health and egg quality was poor; most fry resulting from these eggs died shortly after hatching. Many locations were stocked with yearlings that were too small to smolt in the year of stocking and many stocked fish remained in the stocking tributaries during the ensuing summer. Many of the fish were stocked at too small a size to smolt, which compromised survival, and that stocking inland lakes gave better return-to-creel rates than stocking the smolts into the Great Lakes.

Atlantic salmon are vulnerable to thiamine deficiency, especially those individuals that feed heavily on alewives. In view of subsequent findings with Pacific salmon stocked in the Great Lakes, thiamine deficiency may have contributed to the lower performance of Great Lakes stockings of Atlantic salmon by causing low egg survival from returning fish and poor health and mortality of the adults.

Three stocking sites figure prominently in this Michigan stocking history: Gull Lake, Torch Lake, and the St. Marys River. Each was stocked in successive years for a period long enough to permit evaluation.

Gull Lake

Gull Lake, a 2,030 acre lake in southwest Michigan, was stocked with an average of 23,300 yearlings per year during the period 1986-1990 for a stocking rate of 10.6 fish per acre. Despite a lack of rainbow smelt, a preferred prey for landlocked Atlantic salmon, the stocking efforts were successful. In Gull Lake, Atlantic salmon diet was composed of a combination of mayfly nymphs, small bluegills and perch, and minnows based on a small number of fish examined. In 1987, the year after stocking began, 2,222 Atlantic salmon were harvested. This harvest rate was nearly 10% of the 25,356 fish stocked in 1986. Atlantic salmon proved to be very catchable through the ice during winter of 1987 but the season for harvest was closed. Unfortunately, there were no estimates of harvest after 1987.

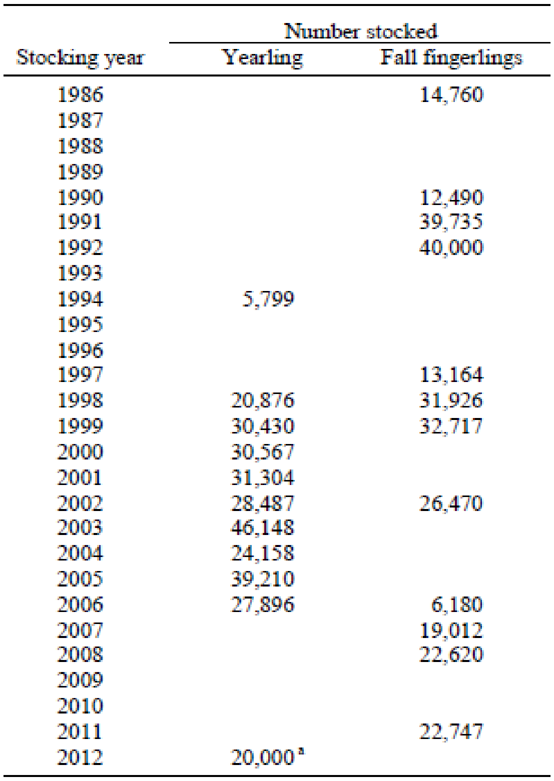
Stocking targeted a small tributary, Prairieville Creek, and broodstock fish were collected from the creek using a portable weir and trap nets placed near the creek mouth. Fish stocked in the vicinity of the small tributary produced similar or better returns of spawning-phase fish to the creek than fish stocked directly into the river. In three years of trapping, 130, 185, and 314 returning salmon were collected during spawn-taking operations in 1988, 1989, and 1990, respectively. Interestingly, more females then males were observed in each year. First spawning, or age at maturity, for most fish was age 2 and 3 at lengths of 450-575 mm (17.7-22.7 inches). Repeat spawning was not uncommon and some fish spawned in alternate years, skipping years between spawning events.

The 1986-1990 stockings established a population estimated to be 6-8 adult fish per acre by 1992, resulting in declining growth rates. This accumulation of adult fish was in spite of observations that the fish stocked were in poor health, having suffered fungal infections and bacterial gill disease immediately prior to release. The perception that the prey base had been adversely affected led to the abandonment of this apparently successful stocking program after 1990, although some fall fingerlings were stocked in Gull Lake in 1991 and 1992. The Gull Lake experience led to the recommendation that stocking rates for inland waters be 1-2 fish per acre for sport fisheries and 2-4 per acre for broodstock lakes.

Torch Lake

Torch Lake has been stocked intermittently with fall fingerlings and spring yearlings since 1986, but the years 1998-2006 were consistently stocked with a substantial numbers of yearlings (**Table 1**). Torch Lake is a deep, 18,770 acre oligotrophic lake with a rainbow smelt and cisco prey base. An average of 31,000 yearlings was stocked annually 1998-2006. The yearlings were rather large, averaging 199 mm (7.8 inches). The stocking rate during that period averaged 1.65 yearlings per surface acre, which is on the high end of rates recommended by the Maine Department of Inland Fisheries and Wildlife for stocking landlocked Atlantic salmon (Boucher and Warner 2006). However, there were no estimates of angler use or harvest during or subsequent to stocking the fish. The only information available on the fishing opportunity afforded by Atlantic salmon is from angler reports to managers. These reports suggest that stocking has established a popular fishery in Torch Lake.

Table 1.–Atlantic salmon stocking history of Torch Lake.



Stocking year	Number stocked Yearling	 Fall fingerlings
1986		14,760
1987		
1988		
1989		
1990		12,490
1991		39,735
1992		40,000
1993		
1994	5,799	
1995		
1996		
1997		13,164
1998	20,876	31,926
1999	30,430	32,717
2000	30,567	
2001	31,304	
2002	28,487	26,470
2003	46,148	
2004	24,158	
2005	39,210	
2006	27,896	6,180
2007		19,012
2008		22,620
2009		
2010		
2011		22,747
2012	20,000[a]	

Some anglers have recorded length-weight data and collected scale samples but the number of these samples is insufficient to determine age, growth rates, or other biological parameters of the Torch Lake population. Interestingly, following cessation of yearling stocking in 2006, cooperating anglers did not report a noticeable reduction in fishing quality, perhaps suggesting that fall fingerlings stocked in 2008 and 2009 may have contributed significantly to the fishery. The Atlantic salmon fishery at Torch Lake is regarded best during spring, when the fish are near shore and can be caught in 4-6 ft of water. Angling success declines during summer, but recovers as surface temperatures cool in fall. Anglers are increasingly recognizing that a good summer fishery exists for those equipped to fish the lake's deeper, offshore waters.

Little is known about whether the Torch Lake Atlantic salmon move to tributaries and attempt spawning. Adult Atlantic salmon are commonly observed in Torch River, the lake's outlet. They have also been reported in the Clam River, Torch Lake's principal tributary which drains from the "Chain of Lakes'. Some of these could be spawning-phase fish. However, neither the outlet nor the Clam River inlet have habitat suitable for salmonid spawning. Other streams flowing into Torch Lake are small, the largest of which is Spencer Creek, near the Alden Village stocking site.

St. Marys River

Lake Superior State University (LSSU), under a Memorandum of Agreement with the DNR, has stocked Atlantic salmon in the St. Marys River since 1986. The fish are raised at the LSSU Aquatic Research Laboratory (ARL). The LSSU ARL Laboratory is a cooperative venture with the Cloverland Electric Company and allows LSSU to raise the fish adjacent to the St. Marys River and use water from the river for their culture operations. From 1995–2008 LSSU has stocked an average of 36,771 spring yearlings annually that average 179 mm (approximately 7") in total length at stocking. Fish are stocked when the temperature of the upper St. Marys River approaches 8°C, which is usually near June 1. The return to creel from this program has been stable and relatively high, apparently unaffected by the alewife collapse in Lake Huron and even benefitting from the decline in Chinook salmon. In recent years the return to creel has been near 6% **(Fig 1).**

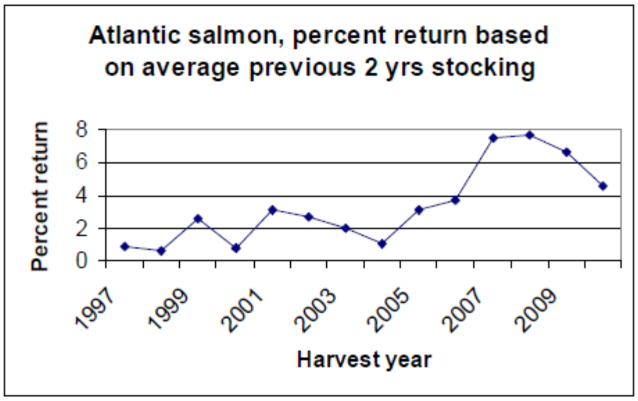


Fig 1–Return to creel estimated for Atlantic salmon stocked by LSSU at Sault Ste. Marie andcaught in the St. Marys River and Michigan waters of Lake Huron

Since 2003, the LSSU Atlantic salmon program has collected enough eggs from returning, spawning-phase adults, to supply egg needs for culture operations. Prior to 2004, however, several sources were used to establish the St. Marys River spawning population **(Table 2**). This mix of gametes founded what is now the "St. Marys River" broodstock.

Table 2–Number of eggs received by Lake Superior State University,
by source, for culture in the Aquatic Research Lab, 1985–2003

Strain	Number	Percent
Wolf Lake SFH Brood (West Grand Lake)	38,479	2.0
Gull Lake (West Grand Lake)	314,641	16.3
Minnesota (West Grand Lake)	31,000	1.6
Penobscot (Maine)	493,569	25.5
Sebago (Maine)	72,601	3.8
Torch (West Grand Lake)	9,228	0.5
West Grand Lake (Maine)	975,893	50.4

Gull Lake was established as a broodstock lake during the 1980s and thus was a major source of eggs for the establishment of the St. Marys River population. Most of the eggs used for stocking Gull Lake were, in turn, from West Grand Lake. Thus, approximately 74.5% of the eggs used to found the St. Marys River population were either West Grand Lake or Sebago strain and 25.5% were from the Penobscot strain. Few eggs were ever taken from Penobscot-strain brood fish returning to the upper St. Marys River and what few eggs were taken suffered almost complete mortality. The result is that the founding strain for the St. Marys River broodstock is almost entirely from Maine's West Grand Lake. In Maine, landlocked Atlantic salmon were native to four basins, including West Grand Lake in the St. Croix Basin of north-central Maine and Sebago Lake in the Presumscot River basin in southern Maine. These populations share a common, postglacial ancestry with sea-run Atlantic salmon. Grand Lake Stream, the outlet of West Grand Lake, provides excellent spawning habitat. Thus, much reproduction of West Grand Lake strain Atlantic salmon occurs in the lake's outlet. The LSSU experience has shown that West Grand Lake strain Atlantic salmon return to an upstream stocking site (upper St. Marys River) to spawn, despite their ancestry as an outlet spawner. There is the possibility that this strain is capable of taking advantage of either outlet or inlet spawning opportunities. Lake Huron's outlet, the St. Clair River, appears to offer a suitable habitat for an outlet-spawning-run fishery.

Life History Attributes of Landlocked Atlantic Salmon

Atlantic salmon stocked by LSSU have consistently provided a better catch per number of fish stocked (return to creel) than any other salmonid stocked in Lake Huron. Most importantly, returns to creel actually rose and have remained higher since the food web change, including alewife collapse that occurred in 2003-04. The rise may also indicate the altered food web is more favorable to Atlantic salmon survival than when alewives were the dominant prey. Return to creel averaged 5.5% after the 2004 alewife collapse **(Fig 1**), which is nearly 10 times the return to creel for steelhead during the same period. Changes in fish culture methods at LSSU ARL (lower rearing densities) that improved fish health at time of stocking may also have contributed to the apparent rise in survival since 2004.

These return-to-creel rates are higher than for other salmonids, such as steelhead, Chinook salmon, and brown trout, stocked in Lake Huron by the Michigan Department of Natural Resources (MDNR), however the high survival of Atlantic salmon stocked by LSSU in the St. Marys River does not logically lead to a firm conclusion that Atlantic salmon are uniquely well suited to Lake Huron.

There are several alternative explanations for the high return-to-creel rates experienced by the LSSU stockings, including:

1. LSSU's facility is different than any of MDNR's fish culture stations. It is located on the St. Marys River and uses St. Marys River water for its water supply. The fish are not transported before stocking but instead are released directly to the St. Marys River from their raceways. These conditions should significantly reduce the stress levels experienced by LSSU's Atlantic salmon at release, which could translate into much higher survival rates.

2. The St. Marys River may be an exceptionally well suited Atlantic salmon stocking site. There is an ample supply of larval rainbow smelt for prey and water temperatures are ideal at time of stocking. Stocking is in fact timed such that the fish are released when the St. Marys River reaches 8°C in late May or early June. This is the ideal temperature and time of year for smoltification to occur in yearling Atlantic salmon.

3. Nearly 80% of the documented catches of Atlantic salmon from the fish stocked by LSSU are from the St. Marys River, rather than Lake Huron. This may be a reflection of the imprinting to the river that LSSU fish receive by being cultured from egg to smolt in river water. Alternatively, there are reasons to believe that Atlantic salmon are indeed better suited to Lake Huron, as measured in terms of return to creel, than other salmonids typically stocked by the MDNR.

These include:

1. Smoltification triggers a strong tendency in Atlantic salmon to swim downstream and rapidly migrate through river mouths and estuaries to open water. Smolts often migrate downstream near the stream's surface; this may be an adaptation to take advantage of areas of highest downstream current speed or to avoid predators. Thus, unlike brown trout which do not smolt or move offshore, or Chinook salmon which smolt but only migrate to beach zones during spring, Atlantic salmon smolts migrate to offshore waters of lakes and oceans where predation rates on them may be lower. This offshore migration therefore may translate into higher post-stocking survival for Atlantic salmon stocked as smolts or pre-smolts than for species that do not migrate offshore after stocking.

2. Like brown trout, Atlantic salmon are tolerant of relatively high temperatures and may therefore be more available than other salmonids to anglers fishing closer to shore in mid-summer. This may be especially true for mature Atlantic salmon, which begin their spawning migrations in July. Atlantic salmon feed and grow at warmer temperatures than, for example, steelhead. Lethal and optimal growth temperatures are approximately 31°C (87.8°F) and 19°C (66.2°) F for Atlantic salmon and 27°C (80.6°F) and 17°C (62.6°F) for steelhead. In Lake Ontario tributaries with mean summer temperatures > 20.5°C (70°F), stocked Atlantic salmon survived and grew, whereas stocked rainbow trout failed and wild rainbow trout were absent. Thus, a combination of their summer migration to stocking/spawning sites and tolerance of warmer temperatures means Atlantic salmon may be capable of providing stream and nearshore fisheries at times of year other stocked salmonids cannot. Unlike brown trout, Atlantic salmon appear to be very catchable during spring and summer.

3. Atlantic salmon begin their upstream migrations during summer. There is no consensus as to why this early spawning migration occurs; it causes Atlantic salmon to forego growth opportunities in the lake available to other salmonids that migrate to streams in late summer or fall. Regardless of the reason, this migration, which for the LSSU population begins in late June and early July, brings Atlantic salmon into streams and nearshore waters of Lake Huron at times of peak angling pressure. This convergence of spawning migrations and angling pressure, combined with the relatively high vulnerability of Atlantic salmon to angling, renders Atlantic salmon more vulnerable to harvest than species that migrate in fall and winter.

Therefore, return to creel could be higher for Atlantic salmon even if post-stocking survival did not differ from that of other species.

4. Atlantic salmon appear to be opportunistic in their feeding behavior. For example, after the collapse of alewives in Lake Huron, round gobies became one of the most available prey species in Lake Huron. In 2009, after the alewife collapse, round gobies made up only 6% by weight of the diets of Chinook salmon while Atlantic salmon diets were composed of 25% gobies. Atlantic salmon also consumed a variety of other fish and invertebrates including rainbow smelt. Rainbow smelt are the preferred prey of landlocked Atlantic salmon in Maine and are also a leading offshore prey fish in Lake Huron (Riley et al. 2008).

5. Studies appear to be lacking that compare return to creel of Atlantic salmon with other stocked salmonids in the same

waters and stocking sites. There are, however, reasons to think that "stocking power" of Atlantic salmon, that is, the survival realized by a given number of fish stocked, is greater than for some other species. The Gull Lake stockings of 1986-1990 (10.6 yearlings per acre) produced a large enough population (6-8 adult fish per acre by 1992) to produce density-related limitations such as declining growth and diminished prey base. In Maine, where landlocked Atlantic salmon are stocked in 127 lakes, stocking rates have been reduced as managers realize that "overstocking, even to a minor extent, can result in depressed smelt abundance, followed by slow salmon growth and reduced fishing quality". Stocking rates in Maine presently do not exceed 1.5 yearlings per surface acre and average between 0.4 and 0.7 per acre. From 2000-2004 Maine annually stocked an average of 113,000 spring yearlings in its inland lakes at an average rate of 0.43 per acre. These fish averaged about 7 inches in length and 3 oz at time of stocking. Returns to creel for yearling Atlantic salmon stocked in 13 Maine lakes averaged 23% from 1988-1996. By comparison, returns to creel of steelhead in Lake Huron averaged 0.5% from 2005-2010.

The present (beginning in 2011) experimental stocking of Atlantic salmon raised in MDNR hatcheries and stocked at the same time and location as LSSU-raised fish will allow comparison of return to creel and allow us to tease out the degree to which two factors - culture and release practices versus ecological attributes of Atlantic salmon - have contributed to the high return-to-creel rates of LSSU fish. Additional research is needed to determine the potential to establish fisheries for Atlantic salmon elsewhere in Lake Huron.

Types of Fishing Opportunities Afforded by Landlocked Atlantic Salmon

There are some attributes to Atlantic salmon that translate into somewhat unique fishing opportunities. Some of these have been alluded to above, including the use of both inlet (St. Marys River) and outlet (West Grand Lake, Grand Lake Stream) spawning sites by the West Grand Lake strain, and their migration to spawning sites during early summer. Oceanic Atlantic salmon are best known for the stream fishing opportunities they offer during their spawning migrations in summer and fall but Maine's landlocked Atlantic salmon are "taken in the sport fishery by almost every means of legal angling". The open-water fishery is probably most popular during early spring until warmer water temperatures drive Atlantic salmon to deeper, cooler waters in summer, but trolling fisheries persist during that time of year, and ice fishing is gaining in popularity. Their early summer migration to spawning/stocking sites corresponds with months of peak recreational fishing at most Lake Huron ports, which will further increase their availability to angling. In Maine, the timing of landlocked salmon spawning runs often depends on flows and water temperatures. Stream fisheries can be delayed by warm water temperatures. The St. Marys River, on the other hand, is cool enough in most summers for the spawning run to commence in June and July. Most of Lake Huron's other large tributaries are impounded, which contributes to them being relatively warm in summer; presumably spawning runs to these rivers would be delayed until their temperatures declined to the upper temperature limits for Atlantic salmon, approximately 20°C-22 (68-73 °F). Possibly, maturing Atlantic salmon would stage off these river mouths during summer, offering nearshore boat fishing opportunities.

River fishing opportunities for landlocked Atlantic salmon begin with the staging of maturing fish off river mouths in early summer followed by the upstream migration which may continue through fall, but Atlantic salmon do not spawn until November. Many spent fish remain in rivers during winter, offering angling opportunities for these "kelts" until spring. ✧

Status of Lake Trout Stock and Fisheries in the Main Basin of Lake Huron, 2011

Introduction

One major fish-community objective for the main basin of Lake Huron is to restore a self sustaining lake trout population. The rehabilitation process can be marked by three milestones. The first has been achieved recently and our measure is that the reestablished spawning stock has produced pervasive wild recruitment over more than ten consecutive years. In the near future wild adults may exceed 50% of the spawning biomass, which is our measure of the second milestone that the stock starts to be self-sustaining.

In comparison with Lake Superior when that lake was experiencing a successful transition from a hatchery-stocked population to a wild fish population, the current spawning biomass in Lake Huron is still very low. If the abundance of top predators is below a minimum required level, the prey fish community always has a potential to reach the undesirable status that non-native prey species either heavily feed on lake trout egg and fry or even lead to unbalanced nutritional status of adult lake trout and reproduction failures. Our measure of the third milestone of the rehabilitation process is to have sufficient and sustained top-down influence on the dynamically changing food web by lake trout, together with walleye and other top predators to stabilize and diversify the preyfish community.

Toward those large goals for the main basin of Lake Huron, the purpose of lake trout stock assessment is to provide essential measures of the primary lake trout management strategies and thereby inform management decisions. In the near future these management decisions will include continuation or termination of lake trout stocking, protection of spawning stock and wild recruitment through fishery regulation and the control of sea lamprey abundance, and improvement of fishing opportunity for recreational anglers.

Stocking

By 2011, hatchery-stocked lake trout still dominated the lake trout population in the main basin of Lake Huron, and annual stocking of lake trout yearlings was continued. With all fall fingerlings converted to yearlings based on an average survival of 40%, the total annual stocking of yearling-equivalent lake trout has been stable in the main basin, ranging between 1.4 and1.8 million since 1991 **(Fig 1).** On average 0.28 million per year of the stocking was from the Ontario side of the main basin during 2005-2011. Canadian stocking has emphasized areas of Lake Huron other than the main basin, including average annual stocking of 1.5 million in Georgina Bay and average annual stocking of 0.36 million in North Channel. The annual stocking allocation among northern, north-central, and southern main basin of Lake Huron has been similar since 2003.

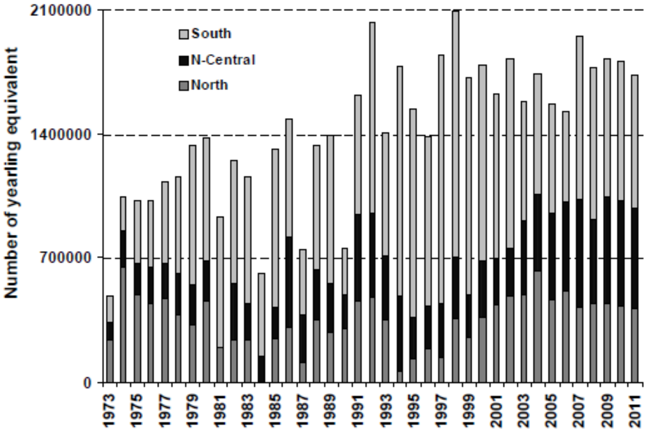


Fig 1 –Annual stocking of yearling-equivalent lake trout allocated among northern, north-central, and southern main basin of Lake Huron

Post Stocking Survival

Prior to 2005, stocking success was measured as age-5 lake trout caught per 1,000 ft of gillnet per million of yearling equivalents stocked. This measure of stocking success is called catch per effort per recruit. The age-5 CPE/R has decreased steadily from the highest value of 2.1 for the 1995 year class to almost zero recently. Meanwhile, for the 1990-2001 year classes, age-7 CPE/R remained relatively high and stable **(Fig 2**). The stable age-7 CPE/R and the decline in age-5 CPE/R indicates a delay in recruitment from age 5 to age 7. This delay in recruitment is also evident in the increases in age composition from recreational and commercial harvests. Both a decline in growth and changes in spatial distribution must be used to explain the delay, as our survey gillnets have always included smaller graded mesh sizes and are suitable to catch very small fish. For the last three year classes indexed by 2011, however, age-7 CPE/R also became very low, indicating that the post-stocking survival was poor. These three consecutive weak year classes made the peak in age composition unclear and thus the age at full recruitment more difficult to interpret.

The effectiveness of stocking should be questioned if the survival index continues to be at this low level. These last three year classes were stocked during 2003-2005, and corresponded in time with the dramatic food-web change and the collapse of alewives. The performance of more recent hatchery year classes after the event of alewife collapse will be one major focus of the near future assessments.

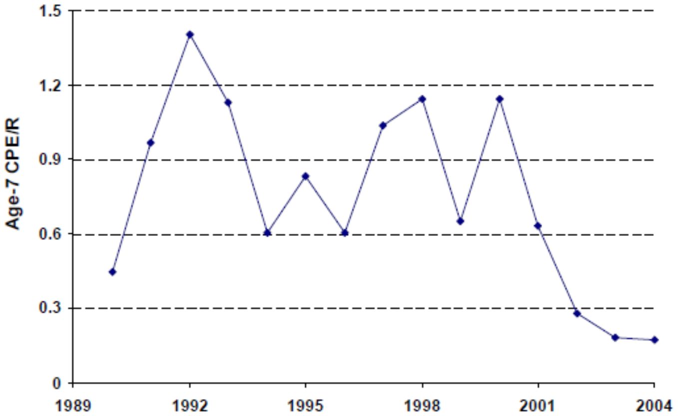


Fig 2.–Age-7 hatchery-stocked lake trout caught per 1,000 feet of gillnet per million lake trout stocked as yearling equivalents, based on annual lake-wide spring gillnetting survey in U.S. waters of Lake Huron

Year classes

Relative Abundance

Lake trout survey catch has changed substantially from being dominated by juveniles to being dominated by adults. The highest total catch per thousand feet (CPE) was 16 in 1996, but only about 4 in 2010. Since 1996, however, the CPE for lake trout longer than 21 inches has been stable, ranging between 4-8 fish per 1,000 ft, in comparison with 2-4 before 1996 (**Fig 3**).

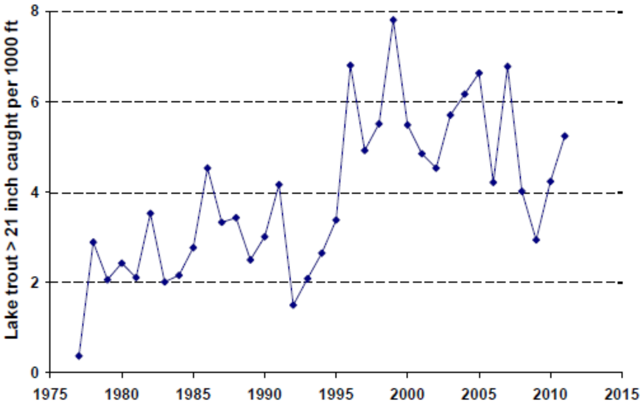


Fig 3.–Geometric gillnetting CPE for lake trout larger than 21", based on annual lake-wide spring gillnetting surveys in U.S. waters

The adult percentage in the total catch has increased from less than 30% in 1995 to more than 90% by 2010. For those age groups too small to be fully recruited to our nets (e.g., age 6 and younger lake trout), the life-history measurements of individual fish will be very important for understanding their pre-recruitment status and more informative than the unreliable estimation of their relative abundance.

Recruitment of Wild Lake Trout

The increase in wild recruitment started in the mid 1990s, and was correlated with the increases in relative abundance of adults. A more recent major increase was after 2001, and corresponded with the decline and collapse of alewives and the increase in thiamine concentration in lake trout eggs. By 2011, wild lake trout consistently made up 18% of lake trout sampled from annual spring gillnetting surveys.

Furthermore, wild lake trout are now an increasing component of the spawning stock and will be more effective than hatchery-stocked fish in using suitable spawning habitats and contributing to an even higher level of wild recruitment. Future development of the stock will include further expansion of older and mature age groups, and gradual replacement of hatchery stocked lake trout by wild lake trout. The assessment will closely monitor the increases in wild recruitment and wild adults, and cooperate with university and federal laboratories to identify the temporal and spatial patterns of the genetic makeup of wild lake trout.

Spawning Stock Biomass

Based on the catch-at-age statistics of the fishery-independent surveys and recreational and commercial harvests, and size at age and body condition of the fish, the estimated biomass of age-7 and older lake trout in the main basin has been remarkably stable between 1.2 and 1.4 million kg since 2004 (**Fig 4).** Biomass of age-10 and older has increased from 0.23 million kg in 2004 to 0.60 in 2011, while biomass of ages 7-9 has decreased from 1.0 million kg in 2004 to 0.66 in 2011. The increase in biomass of age-10 and older lake trout indicates that adult mortality is generally below the maximum limit of 40%.

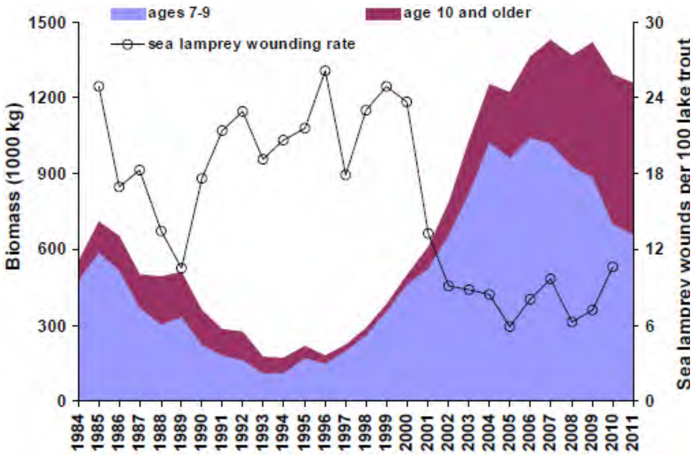


Fig 4–Biomass estimated for age-7 and older lake trout in the main basin, and sea lamprey wounding rate estimated as the year effect in additional to the effects of seasons, regions, and size groups.

Protection of spawning stock and wild recruitment will require sufficient consideration of the increased recruitment uncertainty which in part is related to the delay in recruitment to adult size and age and the annual variation to be expected in annual reproduction success as wild fish replace hatchery recruits which were stocked in nearly static numbers since 1990 **(Fig 1**).

Fishery Harvests

The reported total fishery harvest has been relatively stable since the mid 1990s **(Fig 5).** There was a sharp increase during 2000-2004, which is due to the rapid increase in the stock biomass (**Fig 4**). The total harvest has decreased from 0.58 million kg in 2004 to 0.26 million kg in 2011 and this decrease is largely due to the declines in Ontario commercial fishing effort targeting Whitefish and the recreational fishing efforts targeting Chinook salmon in the north-central and southern Michigan waters.

The current total fishery yield is similar to the late 1990s, but the harvest composition has changed. During the 1990s, both the recreational and commercial fisheries relied on strong and predictable recruitment from hatchery stocking, the overall harvest was dominated by ages 4 and 5 fish, and the age structure was truncated at age 6. Now the mean age of harvests is far above 6.5, which is the mean age at first maturity. Currently, pre-recruitment status of the stock is not reflected by the fishery harvest, and the total harvest is essentially a proportion of the established spawning stock. Commercial harvests have continued to dominate the total yield, on average making up more than 80% since 2005. As long as the total spawning stock is maintained or further increases, the circumstances that require the use of very restrictive recreational size limits should become rare.

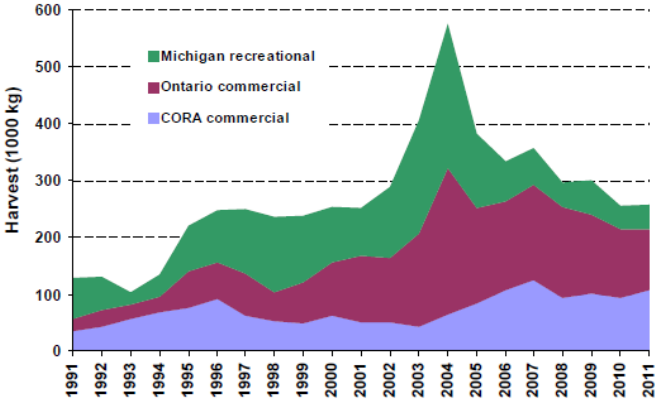


Fig 5–Total lake trout yield produced by all agencies

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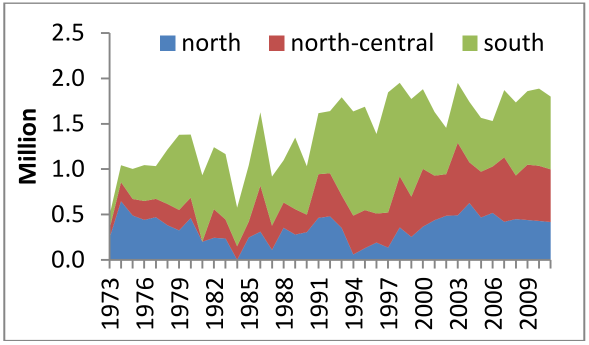
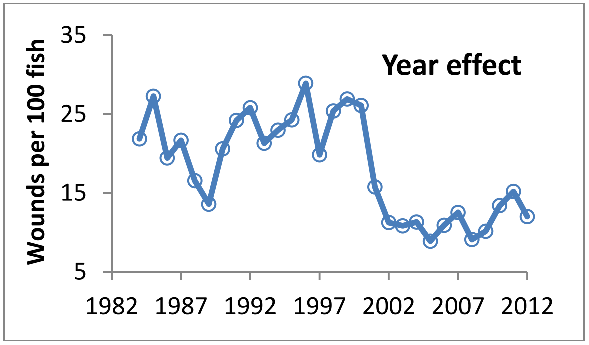
Lake Trout in the main basin of Lake Huron 2012

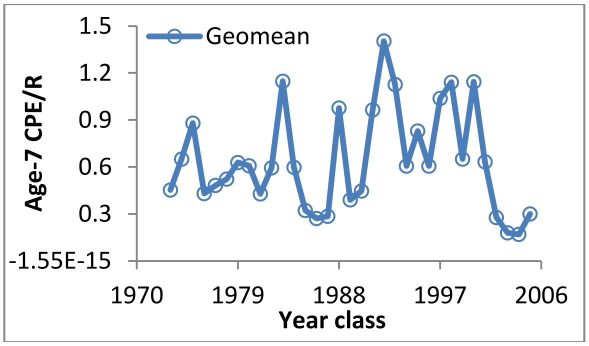
1. Yearling equivalent stocking:



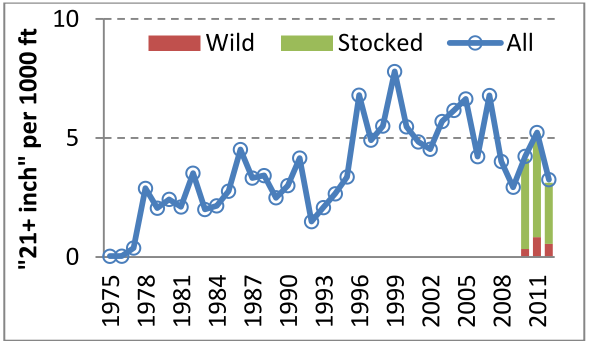
2. Sea lamprey wounding rate:



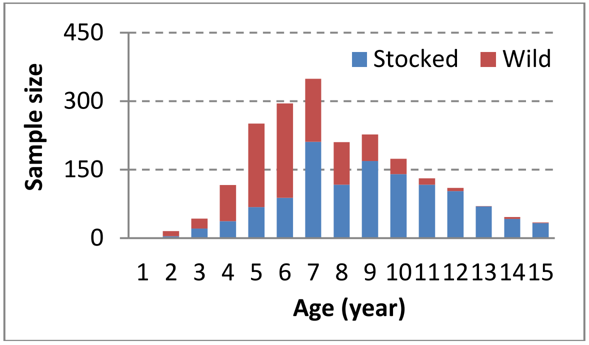
3. Relative survival index of stocked fish:



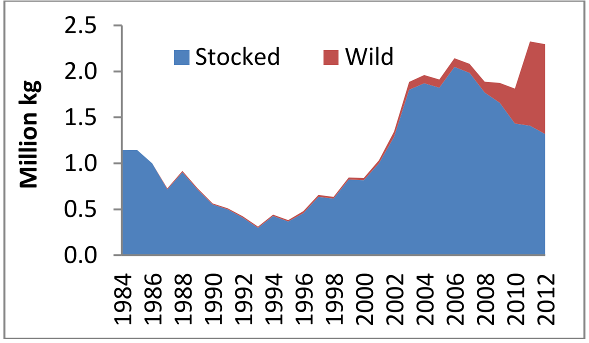
4. Relative adult abundance (spring surveys):



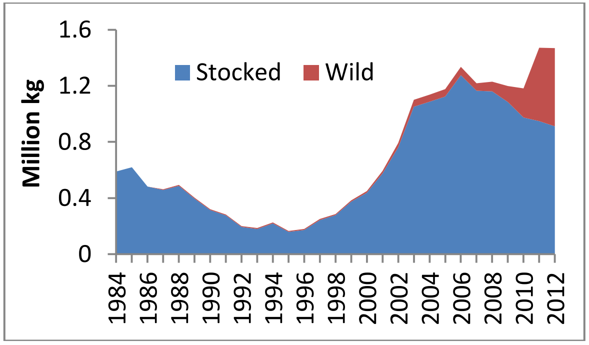
5. Bio-samples (2012: c-f, r-f, and surveys):



6. SCAA estimate of age 6 and older biomass:



7. SCAA estimate of spawning stock biomass:



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Pilot Cisco Egg Take and Culture Study

This report is on a pilot project to experimentally culture ciscoes (lake herring) on a small scale. The objectives of the pilot study were to: 1) Determine spawning date; 2) Collect broodstock and improve methods of broodstock collection; 3) Improve spawn-taking efficiency and determine the number of eggs that can be fertilized per day using a trailer; 4) Improve fertilization rates; 5) Develop and refine egg incubation methods and temperatures; 6) Determine appropriate rearing densities for production level culture; 7) Determine whether fingerling ciscoes can be OTC marked using Chinook salmon fingerling marking protocols; and 8) Determine optimal size and timing of stocking.

This document focuses on results from 2010–11 while providing recommendations based on the synthesis from previous results reported for 2006, 2007, and 2008.

In November, 2010, the final experimental production year, 773,000 eggs were taken from 60 pairings of live ripe cisco adults. Fertilization rate averaged 44% for eggs from the two collection dates combined. The eggs were incubated at 7.6°C at Thompson State Fish Hatchery and transferred to Wolf Lake State Fish hatchery shortly after they reached the eyed stage.

The eyed eggs were incubated at about 7.5°C at Wolf Lake where there were serious losses of eggs and hatching fry as well as a high incidence of fry deformities likely from incubating at water temperatures that were too high, caused by failure of a chiller. Only 9,495 fingerlings remained and these were successfully OTC marked and stocked on June 21 in Thunder Bay. Two OTC-marked cisco adults were sampled at the Thunder Bay stocking site in November 2011; both were mature females and were estimated to have originated with the 2008 and 2009 stocking events.

Our findings and recommendations are as follows:
- ► Egg availability is limited by the small size of the Upper St. Marys River population of ciscoes. Up to 1,000,000 eggs can be taken from this egg source.
- ► An alternate source of cisco eggs should be located to increase the number of eggs that could be collected while also providing redundancy that would better assure that production numbers of eggs were collected in any given year;
- ► Broodstock, unless running ripe, should be staged to ripeness in trap-net pots;
- ► Methods used for walleye egg incubation are appropriate for cisco eggs;
- ► High losses of eggs after the eye-up stage and fry deformities followed chiller breakdowns that led to incubation temperatures that were probably too warm for this species;
- ► After hatch, rearing methods and feeding are similar to those for Chinook salmon
- ► Cisco fry took the OTC-laced diet and a good to excellent OTC mark was administered in 2011.

Most of the initial small-scale objectives have been achieved. The remaining questions are those pertaining to scale and include:
- ► How can live-capture spawner collection (trapnetting, electrofishing) success be improved as live fish are essential to assure good egg quality?
- ► The current Baie de Wasai egg source is not sufficient to meet stocking goals of the reintroduction proposal. What other egg sources should be considered and should these potential alternative egg sources be explored? Which ones are acceptable from fish health and genetics perspectives?

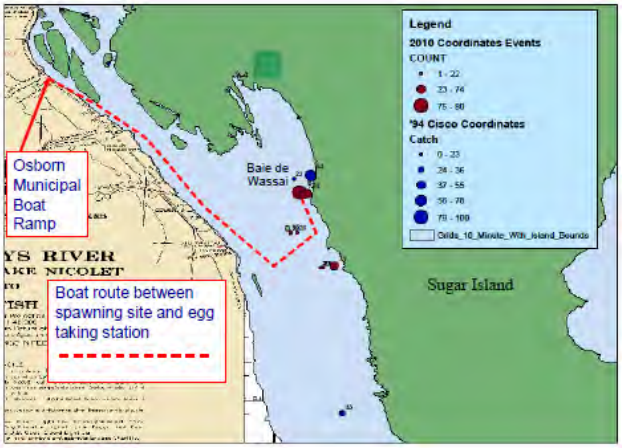


Fig 1.–Location of broodstock collection site at Baie de Wasai and the egg taking station at Osborn Access Site; the travel distance by boat between the two locations is 4.5 miles.

- ► Lower St. Marys River/Drummond Island;
- ► Lake Huron—Georgian Bay/North Channel, Ontario;
- ► Lake Superior—Apostle Island offshore source
- ► Can satisfactory fry survival be realized with a stable rearing temperature of approximately 7.5 degrees C?
- ► Is a colder regime desirable?
- ► What are appropriate rearing densities for optimal production of ciscoes
- ► What is required to rear ciscoes at production numbers

Recommendations

Weather conditions in 2010 were ideal for spawn taking. Winds were light (≤10 mph), which meant transport of broodstock by boat was done quickly with minimal stress to the fish. Locating the spawn-taking site closer to the broodstock source (Baie de Wasai) would speed the spawn-taking operation, thus increasing the number of eggs that can be taken per day and decreasing the amount of stress imposed on the broodstock during boat transport. Future work should include examining the availability of locations on the shore of Sugar Island at Baie de Wasai that could be used as a spawntaking base

Whether trap nets are efficient in taking cisco broodstock has yet to be determined because we were unable to orient the trap nets correctly in 2010. Relatively calm weather, rarely experienced this time of year, needs to be targeted for setting these nets. In 2010 we determined that ciscoes can be held and staged to ripeness for at least a week in trap nets with minimal escapement or mortality. Additional information is needed concerning other broodstock collection methods including nighttime electrofishing. However, electrofishing requires relatively calm weather and the DNR's electrofishing boats are not designed for working large, open waters in rough conditions.

During the pilot study years, we found only one specific site in Baie de Wassai where good numbers of ripe ciscoes could be sampled (Fig 1). Green ciscoes were collected in a variety of locations but this was the only site where fish were commonly in spawning condition during the egg take. This spawning site is only large enough to accommodate one or, at most, two trap nets. This indicates the Baie de Wasai population may be too small to supply more than about 1,000,000 eggs per year. We therefore suggest that alternative sources of eggs be evaluated as cisco rearing is scaled up to production levels, which will probably require more than 1,000,000 eggs per year. Potential broodstock sources for this evaluation could include other Lake Huron (Georgian Bay, Drummond Island) and Lake Superior populations (i.e. the Apostle Islands broodstock). ✧

2013 Lake Huron Fisheries Workshops

Michigan Sea Grant in partnership with other agencies and local fishery organizations hosted three evening regional workshops across Lake Huron's coastline.

Workshops were open to the public, and provided valuable information for anglers, charter captains, resource professionals, and other community members interested in attending. Workshops included information and status updates on Lake Huron low water levels and fish populations and angler catch data, resurgence of native species such as Lake Huron walleye, forage fish surveys and results from the Lake Huron predator diet study, updates of fisheries management activities, among other Lake Huron related topics of local interest.

In addition, discussions included expansion of Atlantic salmon stocking, important increases in natural reproduction of many species and several topics of interest locally. The workshops were free to participants however pre-registration was requested. Workshop details were available online: www.miseagrant.umich.edu/explore/fisheries/fishery-workshops/. ✧

LAKE SUPERIOR

Why it's called Lake Superior

Pretty amazing..... Did you realize how big this lake is?

©2004 Lake Superior Magazine

LAKE SUPERIOR FACTS

Lake Superior contains ten percent of all the fresh water on the planet Earth.

It covers 82,000 square kilometers or 31,700 square miles.

The average depth is 147 meters or 483 feet.

There have been about 350 shipwrecks recorded in Lake Superior

Lake Superior is, by surface area, the largest lake in the world.

A Jesuit priest in 1668 named it Lac Tracy, but that name was never officially adopted.

It contains as much water as all the other Great Lakes combined, plus three extra Lake Erie's!!

There is a small outflow from the lake at St. Mary's River (Sault Ste Marie) into Lake Huron, but it takes almost two centuries for the water to be completely replaced.

There is enough water in Lake Superior to cover all of North and South America with water one foot deep.

There are 78 different species of fish that call the big lake home.

The deepest point in the lake is 405 meters or 1,333 feet.

The maximum wave ever recorded on Lake Superior was 9.45 meters or 31 feet high.

If you stretched the shoreline of Lake Superior out to a straight line, it would reach from Duluth to the Bahamas.

Over 300 streams and rivers empty into Lake Superior with the largest source being the Nipigon River.

The average underwater visibility of Lake Superior is 27 feet, making it the cleanest and clearest of the Great Lakes. Underwater visibility in some spots reaches 30 meters.

In the summer, the sun sets 35 minutes later on the western shore of Lake Superior than at its southeastern edge.

Some of the world's oldest rocks, formed about 2.7 billion years ago, can be found on the Ontario shore of Lake Superior.

It very rarely freezes over completely, and then usually just for a few hours. Complete freezing occurred in 1962, 1979, 2003 and 2009. ✧

Status and Trends in the Fish Community of Lake Superior, 2012 USGS)

Abstract

The Great Lakes Science Center has conducted daytime nearshore bottom trawl surveys of Lake Superior (15-80 m bathymetric depth zone) each spring since 1978 and an offshore survey (>80 m) since 2011 to provide long-term trends of relative abundance and biomass of the fish community. In 2012, 72 nearshore and 34 offshore stations were sampled with a 12-m Yankee bottom trawl.

The 2012 estimate of lake-wide nearshore fish community biomass was 1.14 kg/ha, second lowest in the 35-year survey history, down from 3.63 kg/ha observed in the 2011 survey. Dominant species in the catch, in order of relative biomass, were bloater, rainbow smelt, lake whitefish, pygmy whitefish, and shortjaw cisco. Compared to 2011 levels, biomass of all species decreased. Year-class strengths for the 2011 cisco and bloater cohorts were well below average and ranked as the second weakest year-classes in the past 35 years. Year-class strength of rainbow smelt was the weakest in the survey record, continuing a decline that began in 2008. As in 2011, densities of hatchery lake trout remained near zero in 2012, while densities of wild (lean) lake trout and siscowet lake trout decreased. Proportions of total lake trout density in 2012 that were hatchery, wild, and siscowet were 5, 74, and 21%, respectively.

The 2012 estimate of lake-wide offshore fish community biomass was 6.9 kg/ha, down from 9.0 kg/ha in 2011. Deepwater sculpin, kiyi, and siscowet lake trout represented 98% of the fish caught in terms of both density and biomass. Community composition, number of species collected and densities and biomass for most species were similar to that observed in 2011.

Due to ship mechanical failures, nearshore sampling was delayed from mid-May to mid-June to mid-June to late August. The shift to summer sampling when the lake was stratified may have affected our estimates, thus our estimates of status and trends for the nearshore fish community in 2012 are tentative, pending results of future surveys. However, the results of the 2012 survey are comparable with those during 2009 and 2010 when lake-wide fish biomass declined to < 1.40 kg/ha. Declines in prey fish biomass since the late 1990s can be attributed to a combination of increased predation by recovered lake trout populations and infrequent and weak recruitment by the principal prey fishes, cisco and bloater. In turn declines in lake trout biomass since the mid-2000s are likely linked to declines in prey fish biomass. If lean and siscowet lake trout populations in nearshore waters continue to remain at current levels, predation mortality will likely maintain the relatively low prey fish biomass observed in recent years. Alternatively, if lake trout populations show a substantial decline in abundance in upcoming years, prey fish populations may rebound in a fashion reminiscent to what occurred in the late 1970s to mid-1980s. However, this scenario depends on substantial increases in harvest of lake trout, which seems unlikely given that levels of lake trout harvest have been flat or declining in many regions of Lake Superior since 2000.

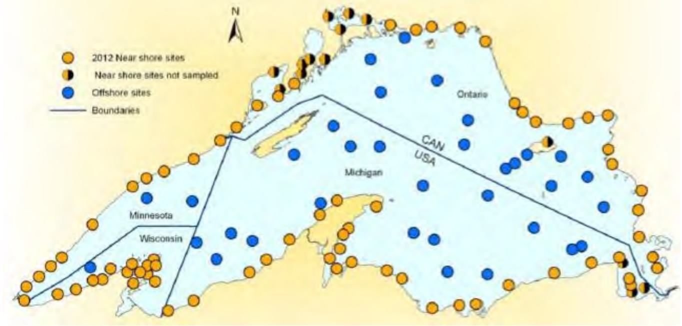


Fig 1- Locations of 86 nearshore and 34 offshore bottom trawl stations established for sampling the Lake Superior fish community. Of the 86 nearshore stations, 72 were sampled in 2012.

Cisco

Year-class strength for the 2011 cisco cohort was estimated at 0.03 fish/ha, the second weakest year-class observed over the 35-year survey **(Fig. 2)**. The 2011 cohort was 0.05% of the 35-year survey mean density of 65.48 fish/ha, and 1.9% of the survey median density of 1.71 fish/ha. Year-class strength for the 2011 cohort in U.S. waters was 0.05 fish/ha and 0.00 fish/ha in Canadian waters.

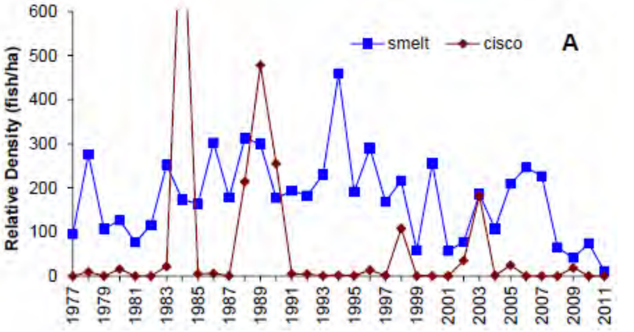


Fig 2-*Year-class strength (number of age-1 fish/ha) for cisco and rainbow smelt for all nearshore sampling stations in Lake Superior for cohorts produced from 1977 to 2011.*

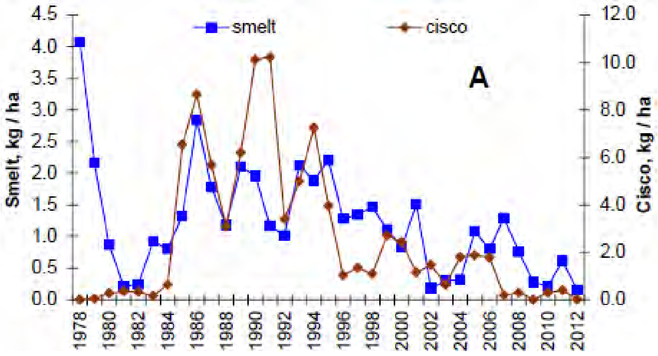


Fig 3-*Biomass (kg/ha) of age-1 and older cisco and rainbow smelt for all nearshore sampling stations in Lake Superior, 1978-2012.*

In 2012, cisco biomass was near zero in all jurisdictions (Fig. 4). The low biomass recorded in Minnesota, Michigan and Canadian waters continues a trend of low levels since 2007. The decline in biomass in Wisconsin waters from 1.67 kg/ha in 2011 to 0.05 kg/ha in 2012 ends a 4-year trend of higher biomass (1.20-1.68 kg/ha) sustained by recruitment from a weak 2009 year class (**Figs. 2, 4).** The 2012 relative biomass estimates as a percent of long-term means was very low in US jurisdictions (Wisconsin, 0.8%; Michigan, 0.1%; Minnesota, 0.2%) and low in Canadian jurisdictions (E. Ontario, 3.1%; W. Ontario, 1.9%). This pattern is consistent with low cisco recruitment since 2003.

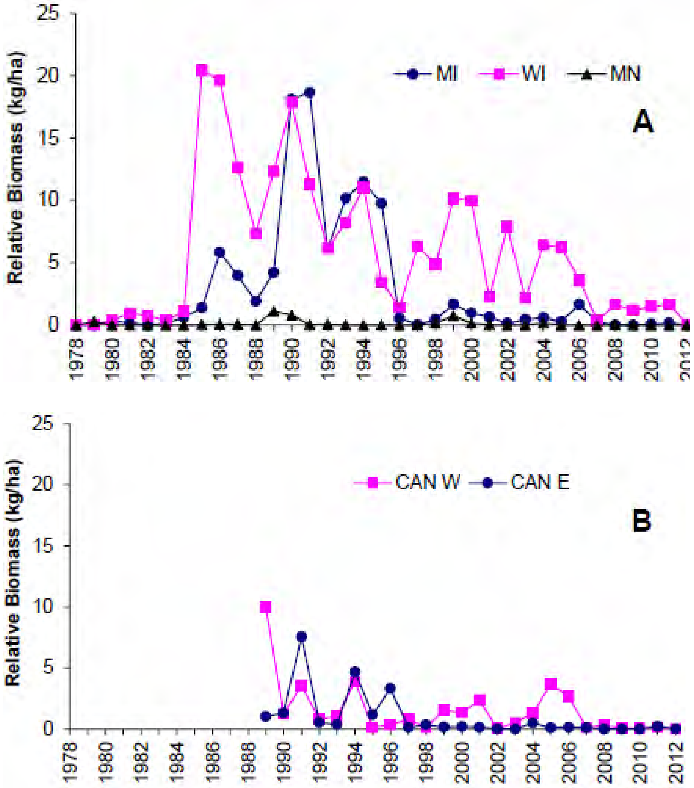


Fig 4-Biomass (kg/ha) of age-1 and older cisco in nearshore waters of Lake Superior: (A) Michigan (MI), Wisconsin (WI), and Minnesota (MN), 1978-2012. (B) Eastern and western Ontario, 1989-2012

Rainbow Smelt

Rainbow smelt year-class strength decreased to a record low 11.05 fish/ha in 2012, much lower than the previous a record low 41.03 fish/ha set in 2009 **(Fig. 2**). This decline continues a trend of weak year-classes following the 246.58 fish/ha peak set by the 2006 cohort (**Fig. 2**). The 2011 cohort was 6.2% of the 35-year survey mean density of 177.13 fish/ha, and 6.2% of the survey median density of 178.1 fish/ha.

Mean relative biomass for age-1 and older rainbow smelt declined to record low 0.16 kg/ha, continuing a declining trend following the most recent maximum of 1.29 kg/ha in 2007 **(Fig. 3).** The 2012 biomass estimate was 13% of the 35-year mean of 1.21 kg/ha. Compared to 2011, estimated biomass of rainbow smelt in 2012 declined sharply in Wisconsin and Ontario waters but increased slightly in Michigan and Minnesota waters (**Fig. 5).** Relative biomass was lower than the long-term average in all jurisdictions: 45.9%, 33.3%, 7.1%, 6.9%, and 3.5% in E. Ontario, Michigan, Wisconsin, Minnesota, and W. Ontario waters, respectively.

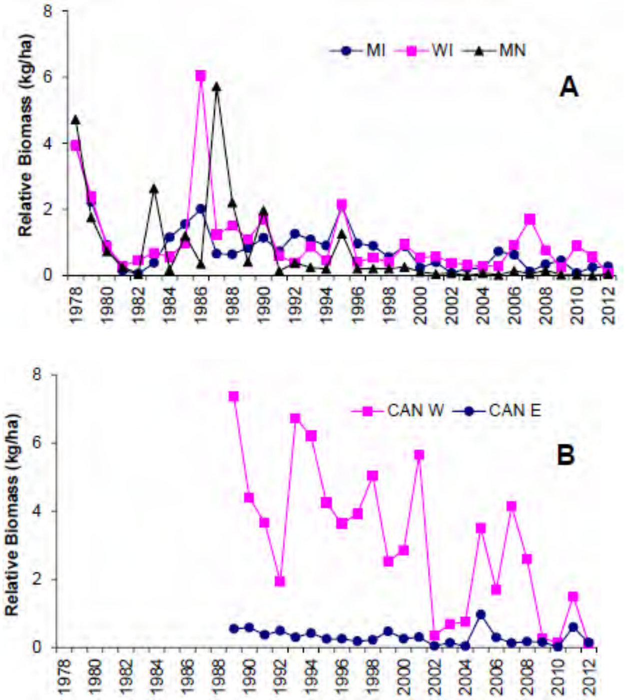


Fig 5- Biomass (kg/ha) of age-1 and older rainbow smelt in nearshore waters of Lake Superior: (A) Michigan, Wisconsin, and Minnesota, 1978-2012. (B) Eastern and western Ontario, 1989-2012.

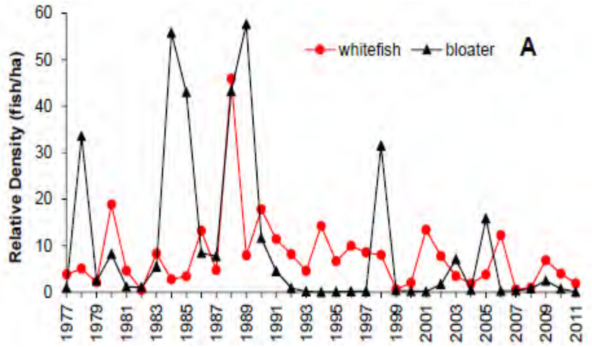


Fig 6-Year-class strength (number of age-1 fish/ha) for bloater and lake whitefish for all nearshore sampling station for cohorts produced1977 to 2011

Bloater

The 2011 bloater year-class strength **(Fig. 6)** was the second weakest on record (0.05 fish/ha), only surpassed by record of 0.00 fish/ha set in 1994, and that value was the result of incorrectly identifying yearling bloater as cisco in the annual survey. The 2011 year-class was 0.5% and 0.4% of the 35-year average and median densities of 9.95 and 1.18 fish/ha, respectively. Year-class strength was greater in US waters (0.42 fish/ha) compared to Canadian waters (0.12 fish/ha).

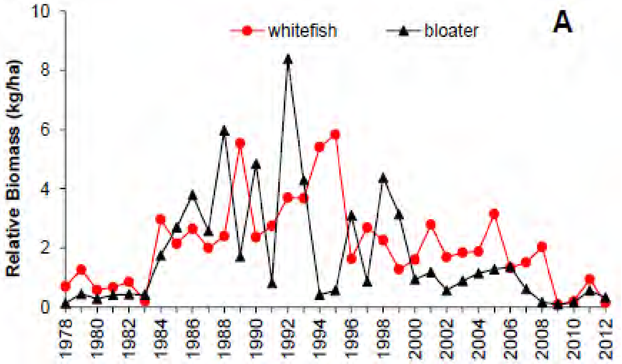


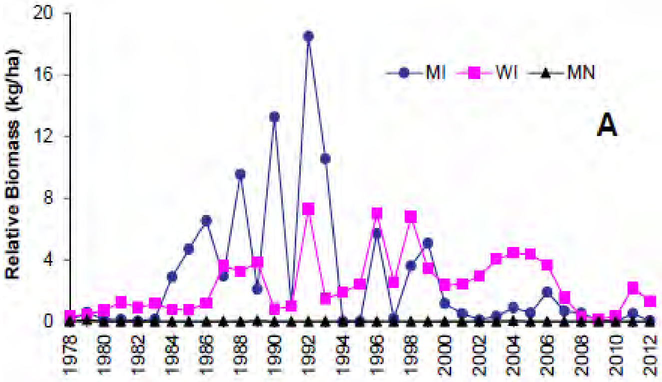
Fig 7-Biomass (kg/ha) of age-1 and older bloater and lake whitefish for all nearshore sampling stations in Lake Superior, 1978-2012

Lake-wide biomass of age-1 and older bloater decreased from 0.56 kg/ha in 2011 to 0.33 kg/ha in 2012, continuing a recent declining trend that began 2006 when lake-wide biomass was 1.36 kg/ha **(Fig. 7).**

In 2011, bloater biomass was well below the long-term average in all jurisdictions: 56% in Wisconsin, 13% 18% in E. Ontario, 3% in W. Ontario, 2% in Michigan, and 0% in Minnesota waters **(Fig. 8).**

Lake Whitefish

Lake whitefish year-class strength decreased from 3.98 fish/ha for the 2010 cohort to 1.90 fish/ha for the 2011 cohort (Fig. 6A). For comparison, the average and median lake-wide year-class strengths for the 35-year survey period were 7.72 and 5.05 fish/ha, respectively. RSE for lake whitefish year-class strength was 60%, slightly greater than the 35-year survey average of 57% (Fig. 6B). The 2011 year-class was stronger in U.S. (2.58 fish/ha) than in Canadian waters (0.33 fish/ha).



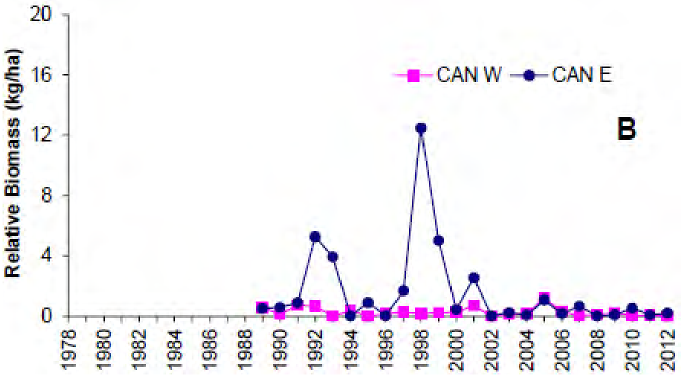


Fig 8-*Biomass (kg/ha) of age-1 and older bloater in nearshore waters of Lake Superior: (A) Michigan, Wisconsin, and Minnesota, 1978-2012. (B) Eastern and western Ontario, 1989-2012.*

Mean relative biomass for age-1 and older lake whitefish in all waters decreased from 0. 94 kg/ha in 2011 to 0.15 kg/ha in 2012, resuming a trend of decline that began after the last high of 2.04 kg/ha in 2008 (**Fig. 7).**

Whitefish biomass estimates decreased across all U.S. and Canadian jurisdictions with the exception of Minnesota where biomass estimates remained at zero (**Fig. 9**). The 2012 biomass estimates were a fraction of the long-term jurisdictional averages: 10% in Michigan, 9% in E. Ontario, 7% in Wisconsin, 0% in Minnesota, 0% in W. Ontario waters.

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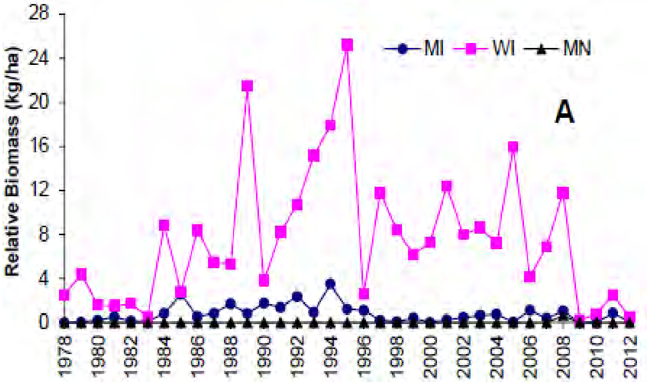

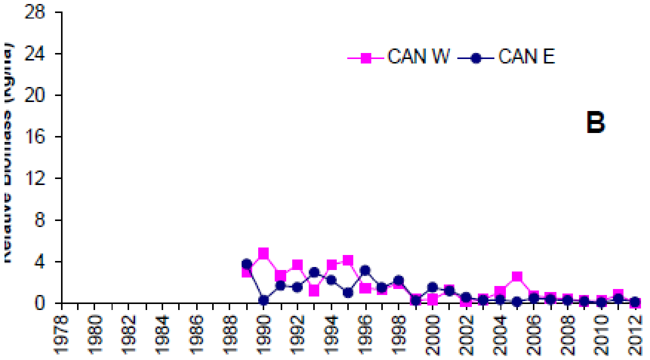

Fig 9-*Biomass (kg/ha) of age-1 and older lake whitefish in nearshore waters of Lake Superior: (A) Michigan, Wisconsin, and Minnesota, 1978-2012. (B) Eastern and western Ontario, 1989-2012.*

Other Species

Ninespine stickleback

The 2012 lake-wide estimate of mean relative biomass for ninespine stickleback declined to the lowest level in the survey record (0.01 kg/ha), only slightly lower than the previously lowest values recorded in 2009 and 2010. The record low 2012 estimate continues a trend of declining biomass since the late 1990s; biomass averaged 0.03 kg/ha for 2000-2012 compared to 0.14 kg/ha for 1978-1999 **(Fig. 10).**

Sculpins

Biomass for the three sculpin species (spoonhead *Cottus ricei*, slimy *C. cognatus*, and deepwater *Myoxocephalus thompsonii*) decreased in 2012, down to 0.03 kg/ha from 0.05 kg/ha in 2011 (**Fig. 10).** The 2012 decrease was caused by a decline in abundance of all sculpin species and continues a recent trend of decline after the recent peak of 0.07 kg/ha in 2010.

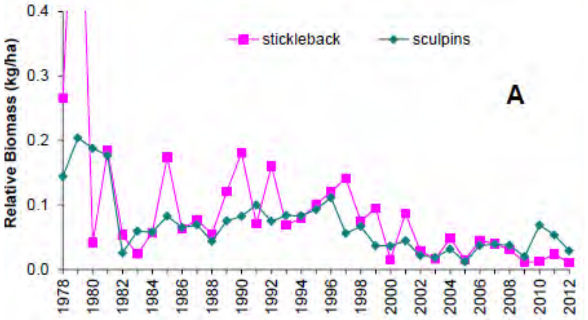

Fig 10-B*iomass (kg/ha) of age-1 and older ninespine stickleback and sculpins (slimy, spoonhead, and deepwater combined), for all nearshore sampling stations in Lake Superior, 1978-2012*

Lake Trout

Biomass of hatchery lake trout in 2012 remained unchanged from 2011 (0.01 kg/ha), slightly above the near-zero record observed in 2009 **(Fig. 10).** Between 2011 and 2012, biomass of wild (lean) lake trout decreased from 0.16 to 0.07 kg/ha, continuing a declining trend following the 2005 high of 0.62 kg/ha (Fig. 10B). Biomass of siscowet lake trout decreased from 0.10 kg/ha in 2011 to 0.08 kg/ha in 2012, continuing a declining trend that began after reaching 0.15 kg/ha in 2006 and 2007 (**Fig. 11).**

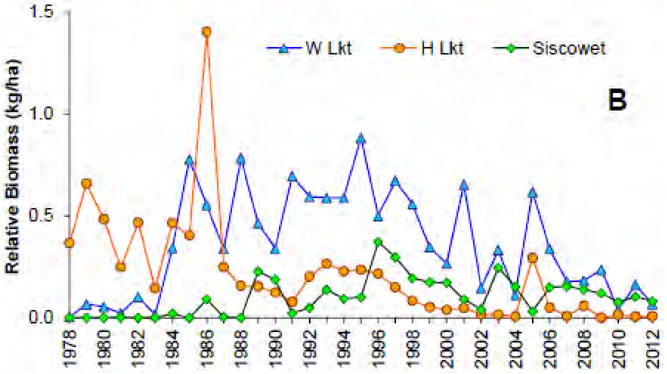

Fig 11-Biomass (kg/ha) of age-1 and older) lake trout (wild-lean, hatchery, and siscowet) for all nearshore sampling stations in Lake Superior, 1978-2012.

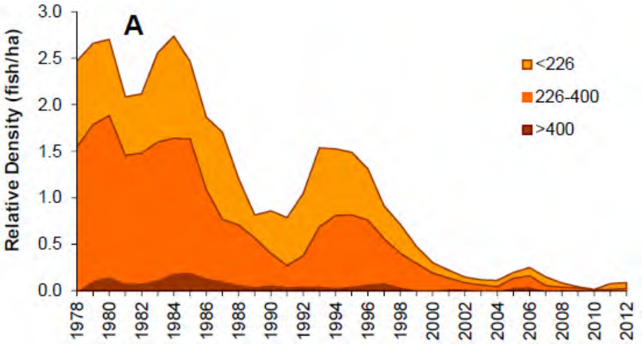

Fig 12-Density (fish/ha) of age-1 and older hatchery lake trout for all nearshore sampling stations in Lake Superior, 1978-2012. Densities are shown for three length bins: < 226 mm, 226-400 mm, and > 400 mm TL.

Densities of small, intermediate and large hatchery lake trout in Lake Superior remained very low in 2012 (**Fig. 12),** consistent with the decline beginning in the mid-1990s that followed a decline in stocking after 1995. Between 2010 and 2012, densities of small and intermediate wild (lean) lake trout increased from 0.05 and 0.07 fish/ha, to 0.42 and 0.23 fish/ha, respectively **(Fig. 13).** Density of large wild lake trout decreased from 0.10 fish/ha in 2010 to 0.04 fish/ha in 2012. The overall increase in wild lake trout density in 2011-2012 punctuates a declining trend that started in 1996-1998 **(Fig. 13**). Between 2010 and 2012, density of small and intermediate siscowet lake trout declined from 0.07 and 0.11 fish/ha to 0.05 and 0.07 fish/ha, respectively **(Fig. 14**). Density of large siscowet remained relatively constant at ~ 0.10 fish/ha between 2010 and 2012. Overall densities of siscowet lake trout have declined from peak levels in 1997-2000 to lower levels, and since 2008, densities have exhibited a declining trend **(Fig. 14).** In 2012, the proportions of total lake trout density that were hatchery, wild, and siscowet were 5, 74, and 21%, respectively.

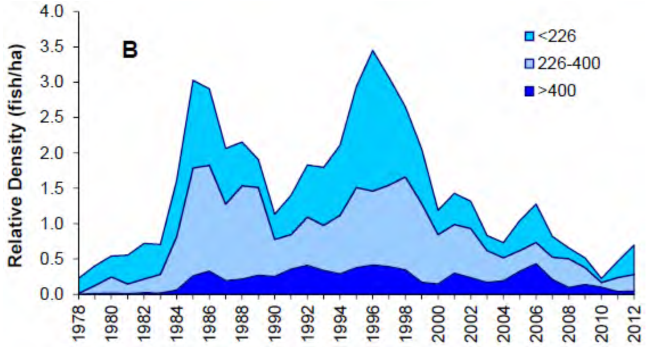

Fig 13- Density (fish/ha) of age-1 and older wild (lean) lake trout for all nearshore sampling stations in Lake Superior, 1978-2012. Densities are shown for three length bins: < 226 mm, 226-400 mm, and > 400 mm TL.

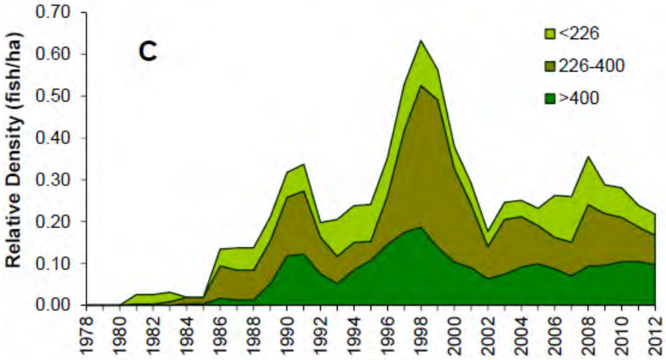

Fig 14- Density (fish/ha) of age-1 and older siscowet lake trout for all nearshore sampling stations in Lake Superior, 1978-2012. Densities are shown for three length bins: < 226 mm, 226-400 mm, and > 400 mm TL.

Summary and Discussion

Estimated mean biomass of all fish species caught during the spring bottom trawl survey decreased 69% from 3.63 kg/ha in 2011 to 1.14 kg/ha in 2012 and was 88% lower than long-term average of 9.20 kg/ha (**Fig. 15).** The decline in community biomass might be attributable, at least in part, to a delay in the bottom trawl survey from spring (mid-May to mid-June) to summer (mid-June to late August) as a result of ship mechanical failures. Thus our estimates of status and trends for the nearshore fish community in 2012 should be viewed with caution, pending results of future surveys. However, the low yields of the 2012 survey are comparable with the 2009 and 2010 surveys when lake-wide fish biomass declined to < 1.40 kg/ha, and are consistent with a declining trend that began in 2006. Moreover, the decline in biomass across jurisdictions reflects a common pattern of declining abundances of the key prey species, cisco, bloater, rainbow smelt, and lake whitefish. Declines in prey fish biomass since the mid-1990s can be attributed to a combination of increased predation by recovered lake trout populations and infrequent and weak recruitment by the principal prey fishes, cisco and bloater. In turn, declines in lake trout biomass and adult density since the mid-2000s are likely linked to declines in prey fish biomass. If lean and siscowet lake trout populations in nearshore waters continue to remain at current levels, high predation mortality will likely limit prey fish biomass to the low levels observed since 2009.

The decrease in total community biomass in 2012 was driven in large part to decreased biomass of rainbow smelt, cisco, bloater and lake whitefish, species which expressed biomass increases in 2010-2011 as a result of recruitment of weak to moderate 2009 year classes. Since the appearance of the 2009 year classes, cisco and bloater have not produced detectable year classes, and lake whitefish and rainbow smelt produced weak year classes in 2010 and 2011. Thus the 2012 survey results continue a trend of declining biomass since 2005 which was driven largely by declines in biomass of cisco, bloater, lake whitefish, and rainbow smelt. In 2012, principal species contributing to community biomass were: bloater (29%), rainbow smelt (14%), lake whitefish (13%), pygmy whitefish (9%), shortjaw cisco (8%), siscowet lake trout (7%), lean lake trout (6%), and longnose sucker(6%). Of the remaining 8%, cisco and burbot each contributed 2% and the remaining eight species each contributed < 1% to the total community biomass: slimy, spoonhead, and deepwater sculpins, hatchery lake trout, trout-perch, ninespine stickleback, kiyi *C. kiyi*, and round whitefish. The 2012 community contrasts with the long-term average community composition in which cisco represents the highest percentage of biomass for any species (28%), followed by bloater (19%), whitefish (23%), and smelt (13%).

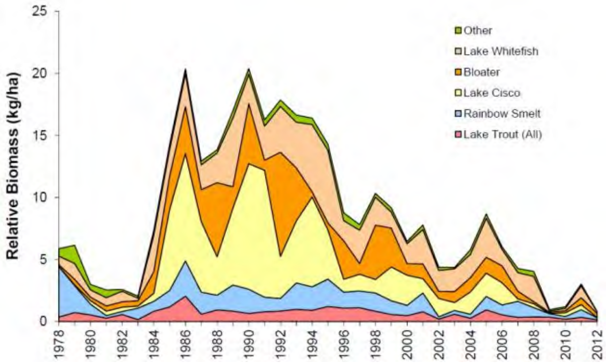

Fig 15-Biomass (kg/ha) of the fish community caught in bottom trawls at all nearshore sampling stations in Lake Superior, 1978-2012. Canadian waters were not sampled until 1989.

Changes in estimated community biomass over the 35-year time series have been largely the result of changes in abundance of major prey species (**Fig. 15).** Rainbow smelt was the dominant prey fish prior to 1981 and afterwards dominance shifted to native prey species; cisco, bloater, and lake whitefish. Principal factors associated with changes in the community have been recovery of lake trout, increased mortality of rainbow smelt, sustained recruitment of lake whitefish, and variable recruitment of large year-classes of cisco and bloater. Annual variation in community biomass since 1984 has been driven largely by recruitment variation in cisco, bloater and lake whitefish. Recruitment of large year-classes of cisco in 1984, 1988-1990, and 1998 resulted in subsequent short-term increases in prey fish biomass detectable with bottom trawls **(Fig. 15).** Recruitment of the most recent large cisco year-class in 2003 yielded smaller and less sustained increases in biomass than previous large year-classes. Growth of cisco from the relatively weak 2009 year-class resulted in a slight increase in community biomass in 2011 but did not carry through to 2012. Since 2006, densities of adult cisco (≥ 4 yrs) in our spring bottom trawl samples declined to levels at or below those observed prior to recovery of cisco before 1984. Thus, weak recruitment of cisco has contributed considerably to the decline in prey fish biomass since the mid-1990s and especially after the mid-2000s.

Recent declines in lake-wide biomass of cisco, bloater, and lake whitefish to levels near or below that observed prior to recovery of the Lake Superior fish community in the mid-1980s is consistent with a hypothesis of strong predation by recovered lake trout populations reducing prey fish populations, and in turn, resulting in food-limited lake trout populations. Total estimated community biomass reached the lowest levels in the time series in 2009 and 2012. The reduction of prey fish biomass, reduced frequency of large cisco and bloater year-classes, reduced mean sizes and younger age structure of rainbow smelt all support the hypothesis that strong predation pressure by lake trout is resulting in a reduction of prey fish stocks.

Shortjaw cisco, a species of special concern in the U.S. and Canada, was ranked fifth by biomass in 2012. Some of the increase in relative importance of shortjaw cisco is due to the sharp decline in densities of cisco and bloater, however, absolute density of shortjaw cisco has increased in some regions of Lake Superior. A resurgence of shortjaw cisco since 2005 has been most evident in E. Ontario waters, where shortjaw cisco has always persisted and in Wisconsin waters, primarily the Apostle Islands region, where a strong year-class recruited in 2003. The recent increases in abundance of shortjaw cisco relative to bloater may be indicative that lake trout are exerting strong predation pressure on other deepwater ciscoes in Lake Superior.

Although the abundance of small and intermediate-size lean (wild) lake trout increased in 2012 over the record low levels in 2010, they remained well below levels observed before 2007 and at levels comparable to those observed before 1984, a period when wild lake trout populations were recovering. The decline in abundance of small and intermediate lake trout after 2000 suggests that cannibalism of younger life stages by adult lake trout may be contributing to declining recruitment. Declines in lean lake trout lipid content are also consistent with declines in prey fish biomass and resulting reduced food availability in Lake Superior. Although the decline in abundance of lean lake trout we observed in our bottom trawl series since the late 1990s is consistent with a reduced prey base (this report) and slower growth, others have not detected a similar decline in abundance of lean lake trout based on the results of gill net surveys conducted during 2000-2005 (Sitar et al. 2010). In the future, prey fish biomass is likely to fluctuate as a result of recruitment variation. However, if lean and siscowet lake trout populations in nearshore waters continue to remain at current levels, strong predation pressure will likely dampen those fluctuations and maintain the relatively low prey fish biomass observed in recent years. Alternatively, if lake trout populations show a substantial decline in abundance in upcoming years, prey fish populations may rebound in a fashion reminiscent to what occurred in the late 1970s to mid-1980s. However, this scenario depends on substantial increases in harvest of lake trout, which seems unlikely given that levels of lake trout harvest have been flat or declining in many regions of Lake Superior since 2000.

Results

In 2012, sampling at 34 locations yielded 19,912 individuals of 13 species. Collectively, deepwater sculpin, kiyi, and siscowet lake trout, represented 98% of the fish caught in terms of both density and biomass. These results were similar to that observed in 2011 for the number of species, and both density and biomass for most species. In 2011, a total of 13 species and 15,365 individuals were collected. Lake-wide mean density and biomass estimates differed only slightly between years. Mean lake-wide density across all sites was 553.3 fish per ha in 2012 and 428.1 fish per ha in 2011. Mean lakewide biomass across all sites was 6.9 kg per ha in 2012 and 9.0 kg per hectare in 2011. Differences between years were due to more deepwater sculpin being collected in 2012 which increased mean density and fewer siscowet, kiyi, and pygmy whitefish being collected in 2012, which decreased mean biomass compared to that observed 2011. ✧

North Shore Stream Fishing Report

A creel survey has been conducted annually on 17 tributaries along the Minnesota shore of Lake Superior since 1992 and at the McQuade Safe Harbor since 2010. The spring creel survey provides estimates of fishing pressure, catch, and catch rates that aid in the management of the rainbow trout fishery in Lake Superior.

Three creel census clerks conduct angler interviews from April through late-May on the following rivers:

- Lower Shore: Lester, McQuade Harbor/Talmadge River, French, Sucker, and Knife
- Middle Shore: Stewart, Silver, Gooseberry, Split Rock, Beaver, and Baptism
- Upper Shore: Cross, Temperance, Poplar, Cascade, Devil Track, Kadunce, and Brule

Fishing reports are updated on the web Mondays and Fridays: http://mndnr.gov/areas/fisheries/lakesuperior/report.html or by calling our office at 218-525-0853 and selecting 1 for the updated fishing report

Update 04/05/13:

Tributaries have just started to flow but are still mainly ice. Anglers are regularly fishing near river mouths for Kamloops. There has been no smelt activity because rivers are still mostly frozen, and stream temperatures must be in the upper 40s for smelt runs to occur. Refer to the “Smelt on the North Shore” fact sheet at http://www.dnr.state.mn.us/areas/fisheries/lakesuperior/smelt.html for more information on smelt. An updated report will be posted when the ice goes out on North Shore streams. ✧

End ✧✧