Status and Trends of the Lake Huron Offshore Demersal Fish Community, 1976-2012[1]

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Abstract

The USGS Great Lakes Science Center has conducted trawl surveys to assess annual changes in the offshore demersal fish community of Lake Huron since 1973. Sample sites include five ports in U.S. waters with less frequent sampling near Goderich, Ontario. 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.

[1]Prepared for the Great Lakes Fishery Commission Lake Huron Committee Meeting, Duluth, MN, 21 March 2013.

Introduction

Lake Huron supports valuable recreational and commercial fisheries that may be at risk due to recent widespread ecological changes in the lake (Bence and Mohr 2008). 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. (McNickle et al. 2006; Nalepa et al. 2003, 2005, 2007), decreases in lake whitefish and Chinook salmon catches (Mohr and Ebener 2005; Bence and Mohr 2008), significant changes in the abundance and species composition of the zooplankton community (Barbiero et al. 2009), the invasion of the round goby, and the restructuring of the offshore demersal fish community (Riley et al. 2008).

The USGS Great Lakes Science Center (GLSC) began annual bottom trawl surveys on Lake Huron in 1973, and the first full survey with ports covering the Michigan waters of the lake was conducted in 1976. These surveys are used to examine relative abundance, size and age structure, and species composition of the offshore demersal fish community. The primary purpose of this report is to present estimates of the abundance and biomass of offshore demersal fish species that are important as prey to common predators in the lake (i.e., lake trout *Salvelinus namaycush* and Chinook salmon *Oncorhynchus tshawytscha*).

Methods

The GLSC has monitored fish abundance annually from 1973-2012 using 12 m headrope (1973-1991) and 21 m headrope (1992-2012) bottom trawls at fixed transects at up to eleven depths (9, 18, 27, 36, 46, 55, 64, 73, 82, 92, and 110 m) at five ports (Detour, Hammond Bay, Alpena, Au Sable Point, and Harbor Beach) in the Michigan waters of Lake Huron (Fig. 1). Both trawls used a 4.76 mm square mesh cod end. The same fixed transects were sampled each year from the USGS R/V *Kaho* during 1973-1977 and from the USGS R/V *Grayling* during 1978-2006; some transects were fished from the USGS R/V *Cisco* in 1990. The first year that all of the Michigan ports were sampled was 1976. Sampling has been intermittently conducted at Goderich (Ontario) from the R/V *Grayling* since 1998 using the same trawling protocols as U.S. ports; this port was sampled in 2012.

Single 10-min trawl tows were conducted during daylight at each transect each year. Tow duration was occasionally less than 10 min due to large catches or obstacles in the tow path; catches for these tows were corrected to be equivalent to 10-min tows (equation 1). Trawl catches were sorted by species, and each species was counted and weighed in aggregate. Large catches (> ca. 20 kg) were subsampled; a random sample was sorted, counted, and weighed, and the remainder of the catch was weighed for extrapolation of the sample.

We applied correction factors to standardize trawl data among depths, as the actual time on bottom for each trawl increased with depth (Fabrizio et al. 1997). Relative abundance was standardized to CPE (catch per 10 min on bottom) as

$$C_t = \frac{10N}{K_t T}, \qquad [1]$$

where C_t is the catch per 10 min (CPE) on bottom for trawl type t, N is the catch, T is tow time, and K_t is a correction factor that varies with fishing depth (D in m) and trawl type such that $K_{12} = 0.00400D + 0.8861$ for the 12-m trawl and $K_{21} = 0.00385D + 0.9149$ for the 21-m trawl. Catches were expressed in terms of density and biomass (number/ha and kg/ha) by dividing the CPE by the area swept by the trawl. The area swept was estimated as the product of the distance towed (speed multiplied by tow time) and the trawl width. Trawl width estimates were depth-specific and were based on trawl mensuration data collected from the R/V *Grayling* in 1991, 1998, and 2005 (USGS unpublished data). Catches were weighted by the area of the main basin of Lake Huron that occurred in each depth range. Lakewide biomass was estimated as the sum of the biomass of the common species sampled in the survey, and is not a true "lakewide" estimate, as sampling is conducted only to a depth of 110 m.

We partitioned the catches of alewife *Alosa pseudoharengus*, rainbow smelt *Osmerus mordax*, and bloater *Coregonus hoyi* into size-based age classes based on length-frequency data. Year-specific length cutoffs were determined from length-frequency data and used to apportion the catch into age-0 fish (young-of-the-year, or YOY) and those age-1 or older (yearling and older, or YAO). In earlier reports, a constant length cutoff was used in all years.

To make density estimates from the two trawls comparable, we multiplied density estimates from the 12-m trawl (1976-1991) by species-specific fishing power corrections (FPCs) developed from a comparative trawl experiment (Adams et al. 2009). We applied FPCs greater than 1.0 to the density and biomass of alewife, rainbow smelt (YAO only), bloater, and FPCs less than 1.0 to the density and biomass of slimy sculpin *Cottus cognatus* and deepwater sculpin *Myoxocephalus thompsonii*. Catches of trout-perch *Percopsis omiscomaycus* were not significantly different between the two trawls. Insufficient data were available to estimate FPCs for ninespine stickleback *Pungitius pungitius* and YOY rainbow smelt; density estimates were not corrected for these species.

Trawl surveys on Lake Huron are typically conducted between 3 October and 15 November. In 1992 and 1993, however, trawl surveys occurred in early- to mid-September, and these data were not used in this report because the distribution of many offshore species in the Great Lakes is seasonally variable (Dryer 1966; Wells 1968) and data collected in September may not be comparable to the rest of the time series. In 1998, sampling was conducted in a non-standard manner, and these data were also excluded. The fall survey was not conducted in 2000 and was not completed in 2008. We did not use data prior to 1976 because all ports and depths in Lake Huron were not consistently sampled until 1976.

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

Some of the fluctuations in abundance of individual species that we observed may be a result of changes in catchability caused by altered fish distributions. For example, catchability of a given species might differ from year to year due to changes in temperature or food distribution, and observed changes in abundance might result from fish becoming less catchable by bottom trawls in recent years. The invasion of Lake Huron by dreissenid mussels may also have affected the efficiency of the trawl, as has been observed in Lake Ontario (O'Gorman et al. 2005). Data reported here were collected at a restricted range of depths in areas that were free of obstructions and were characterized by sandy or gravel substrates, and it is therefore possible that USGS trawl data do not fully characterize the offshore demersal fish community. There are no other published long-term data on offshore demersal fish abundance in Lake Huron that would allow us to investigate the representativeness of the trawl data. Despite the foregoing constraints, however, these data are currently the best available to assess the Lake Huron offshore demersal fish community.

Results

The 2012 Lake Huron fall bottom trawl survey was carried out during 20 October – 5 November. 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 *Coregonus clupeaformis*, ninespine stickleback, threespine stickleback *Gasterosteus aculeatus*, lake trout, walleye *Sander vitreus*, spottail shiner *Notropis hudsonius*, burbot *Lota lota*, round goby *Neogobius melanostomus*, yellow perch *Perca flavescens*, gizzard shad *Dorosoma cepedianum*, white sucker *Catostomus commersoni*, emerald shiner *Notropis atherinoides*, freshwater drum *Aplodinotus grunniens*, white bass *Morone chrysops*, white perch *Morone americana*, logperch *Percina caprodes*, sea lamprey *Petromyzon marinus* and common carp *Cyprinus carpio*.

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).

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. 5). The 2012 abundance and biomass estimates for ninespine stickleback were higher than in 2011, but remain relatively low (Fig. 6). Trout-perch abundance and biomass estimates increased from 2011, and the abundance estimate was the highest observed since 2004 (Fig. 6). 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).

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 percent 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 (Fig. 9). 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.

Discussion

The abundance of prey fish in Lake Huron has remained at very low levels since the collapse of the offshore demersal fish community (Riley et al. 2008), 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 (DesJardine et al. 1995), but does not bode well for Chinook salmon populations in the lake (Roseman and Riley 2009), 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 (Warner et al. 2013). 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 (e.g., Van Oosten and Deason 1938). 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 (Dietrich et al. 2006), including Lake Huron (Ji He, MDNR Alpena, pers. comm., E. F. Roseman, USGS, unpublished data). 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 (Bunnell et al. 2009). It is possible that these declines are associated with the invasion of the lakes by several exotic species including the spiny water flea (*Bythotrephes*), zebra mussels, quagga mussels, and round gobies, all of which have been introduced since the mid-1980s. Similar declines in some species (particularly coregonids) have occurred in Lake Superior (Gorman and Bunnell 2009; Gorman et al. 2009), 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 (Riley et al. 2007). 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 (He et al. 2012), 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.

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Figures

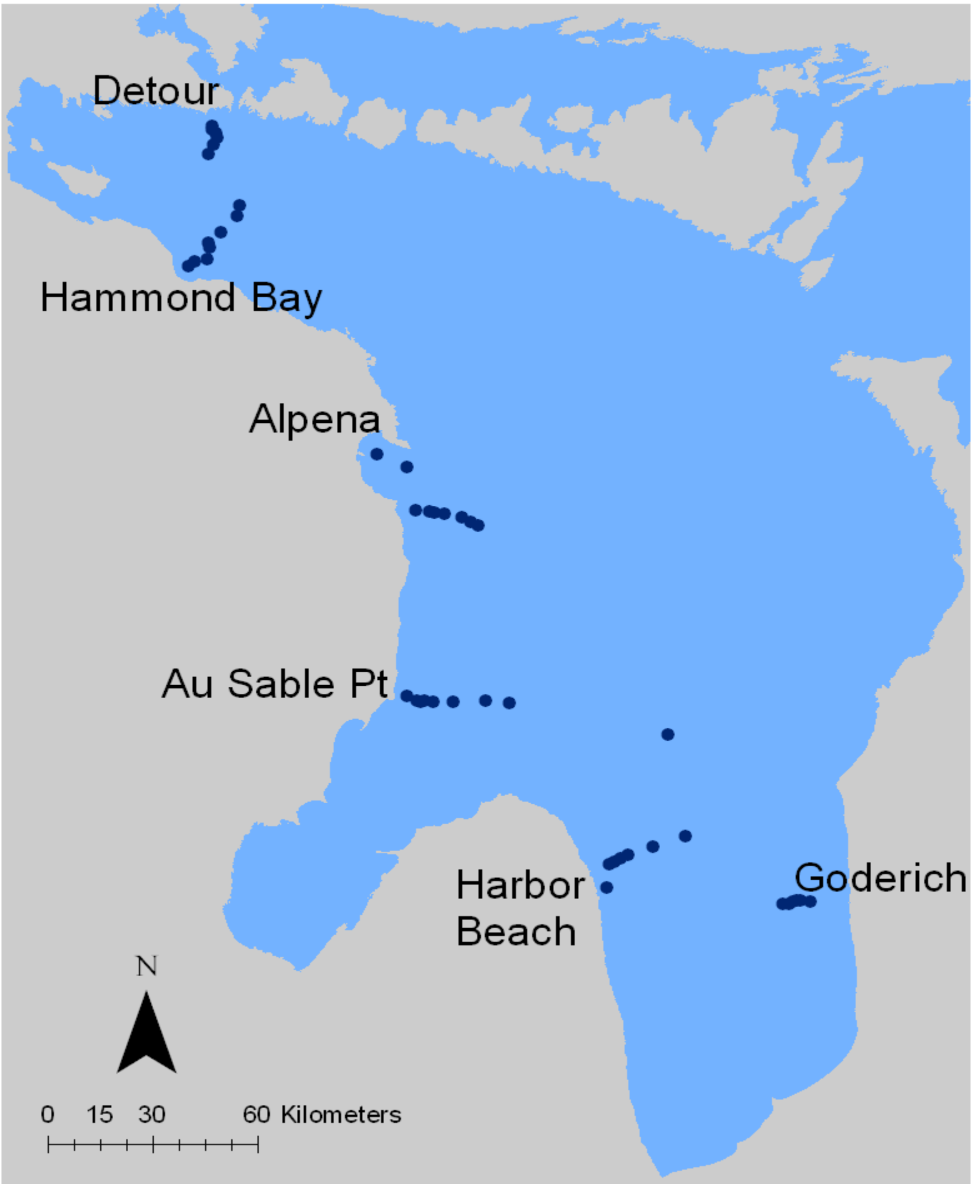

Figure 1. Bottom trawl sampling locations in Lake Huron, 2012.

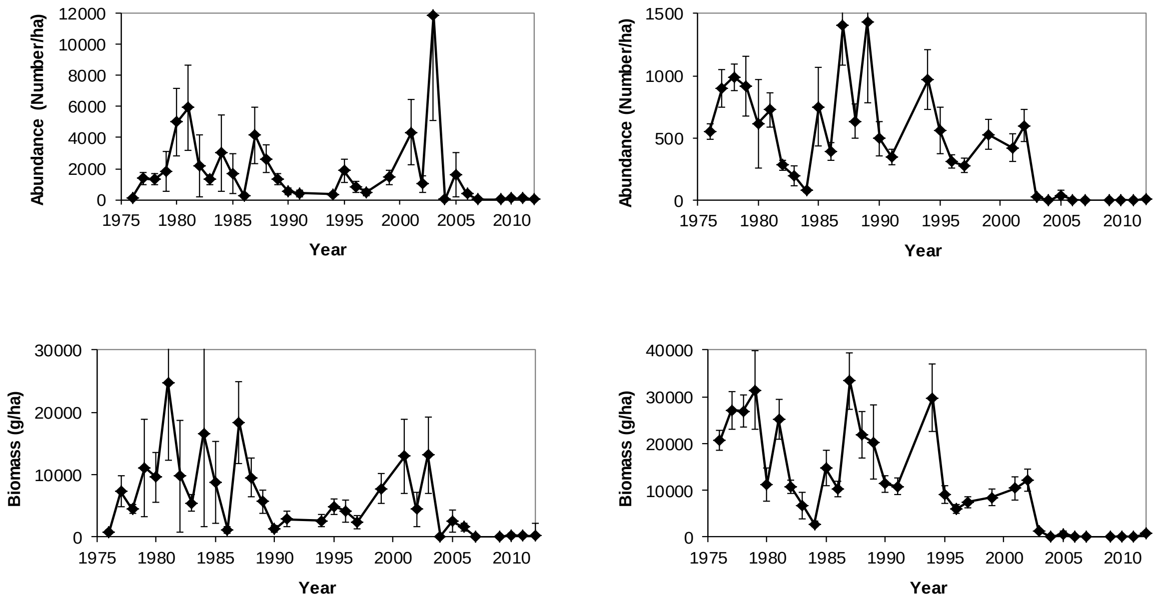

Figure 2. Density of young-of-the-year (YOY: left panels) and adult (YAO: right panels) alewives as number (top panels) and biomass (bottom panels) of fish per hectare in Lake Huron, 1976-2012. 1976-1991 estimates were corrected using fishing power corrections developed by Adams et al. (2009). Error bars are 95% confidence intervals.

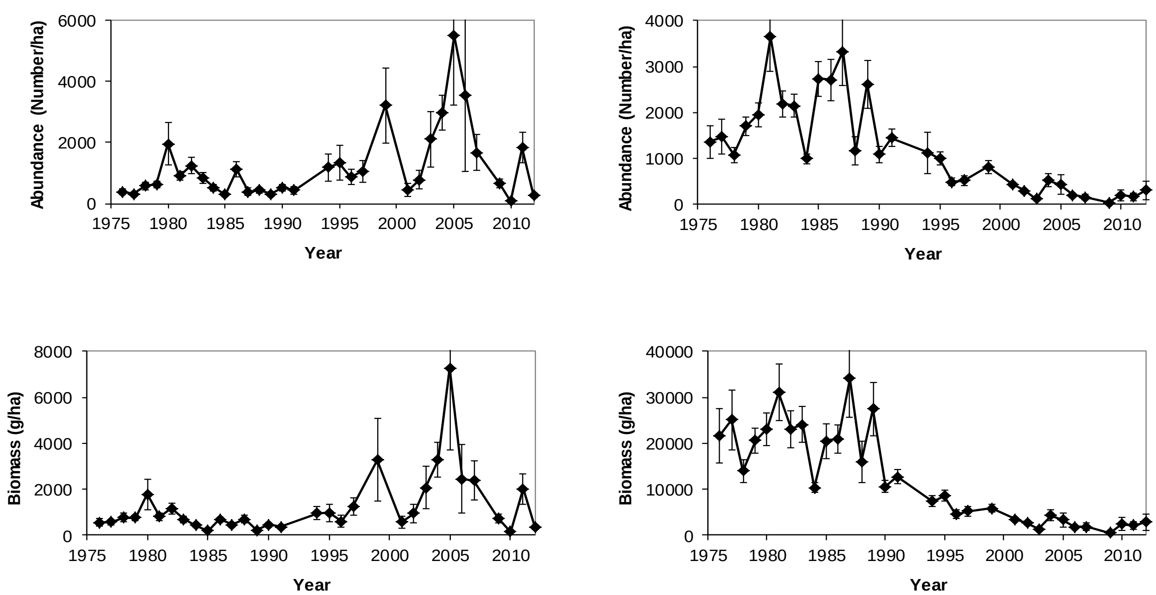

Figure 3. Density of young-of-the-year (YOY: left panels) and adult (YAO: right panels) rainbow smelt as number (top panels) and biomass (bottom panels) of fish per hectare in Lake Huron, 1976-2012. 1976-1991 estimates for YAO were corrected using fishing power corrections developed by Adams et al. (2009); YOY data are uncorrected. Error bars are 95% confidence intervals.

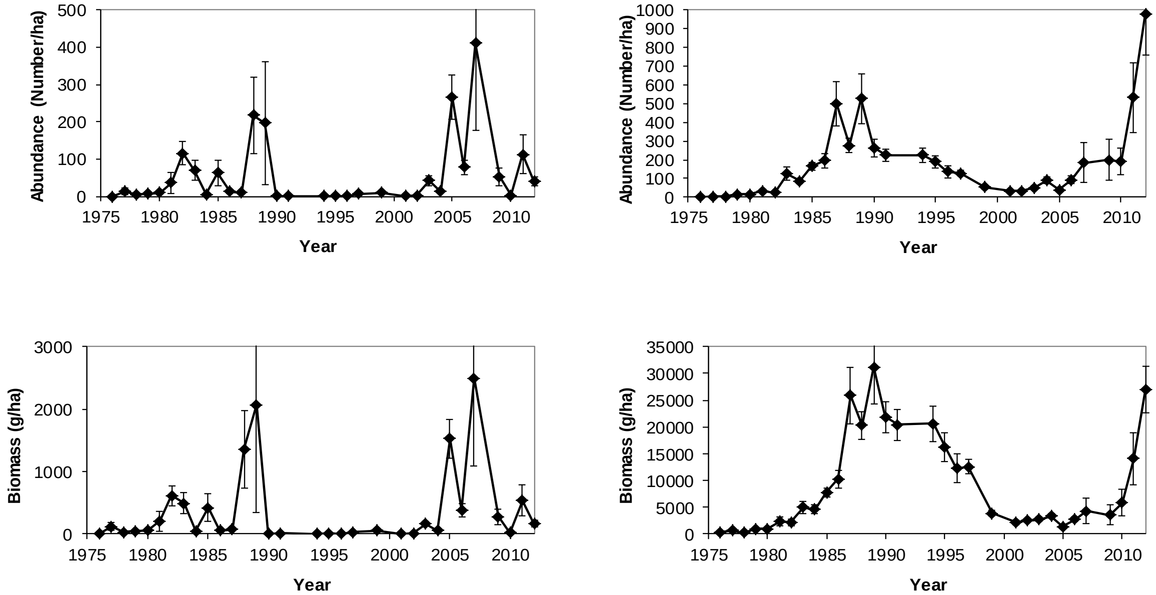

Figure 4. Density of young-of-the-year (YOY: left panels) and adult (YAO: right panels) bloater as number (top panels) and biomass (bottom panels) of fish per hectare in Lake Huron, 1976-2012. 1976-1991 estimates were corrected using fishing power corrections developed by Adams et al. (2009). Error bars are 95% confidence intervals.

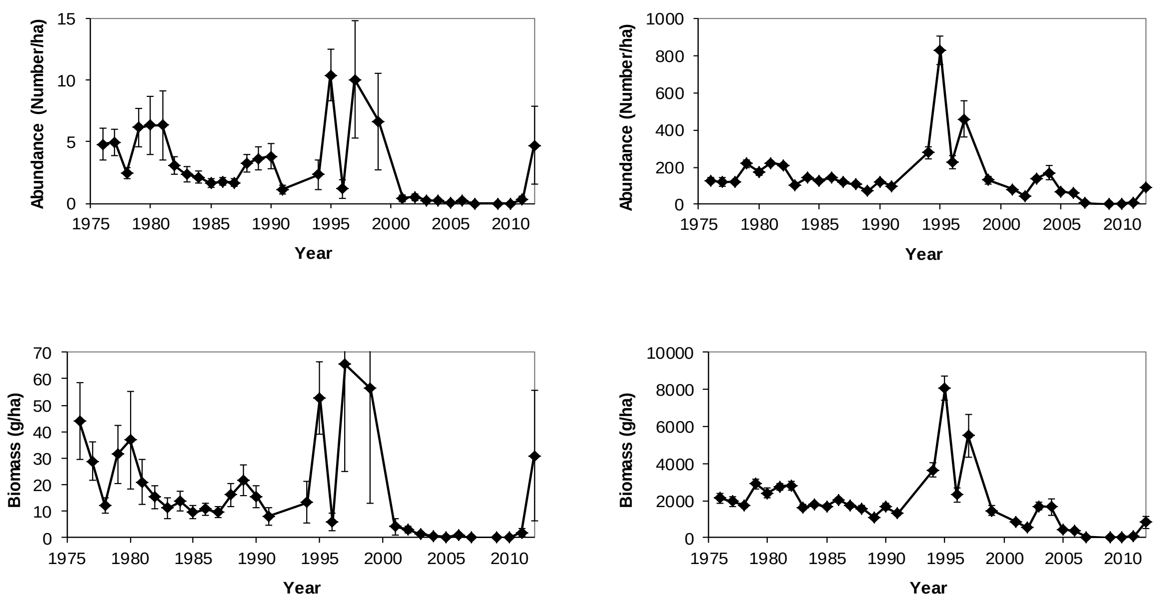

Figure 5. Density of slimy (left panels) and deepwater (right panels) sculpins as number (top panels) and biomass (bottom panels) of fish per hectare in Lake Huron, 1976-2012. 1976-1991 estimates were corrected using fishing power corrections developed by Adams et al. (2009). Error bars are 95% confidence intervals.

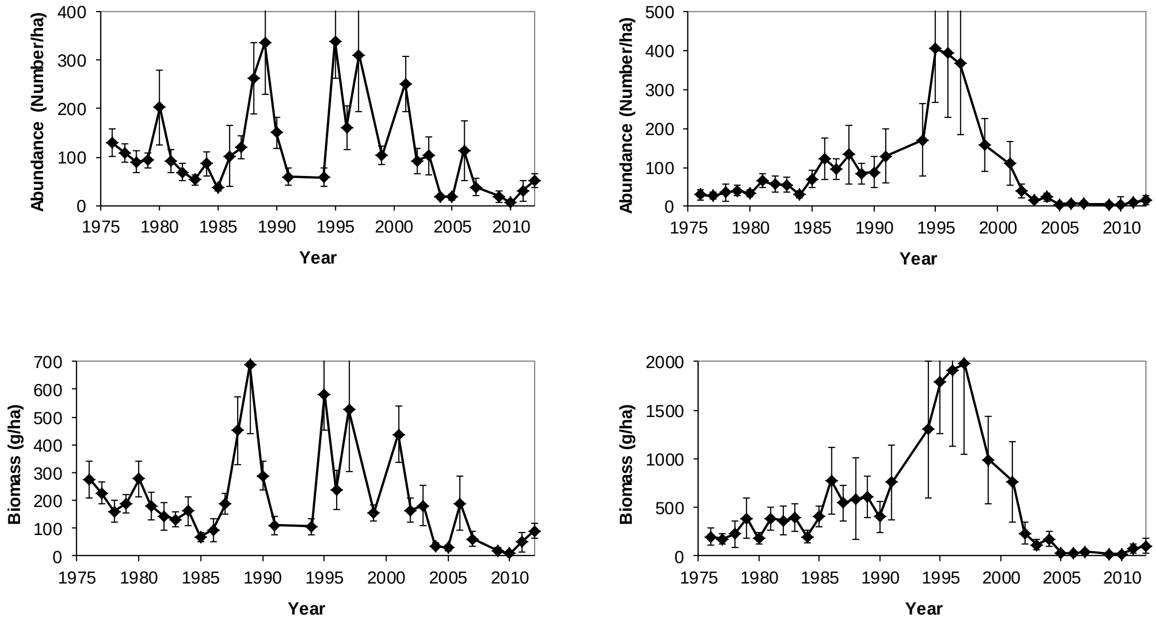

Figure 6. Density of ninespine stickleback (left panels) and trout-perch (right panels) as number (top panels) and biomass (bottom panels) of fish per hectare in Lake Huron, 1976-2012. Error bars are 95% confidence intervals.

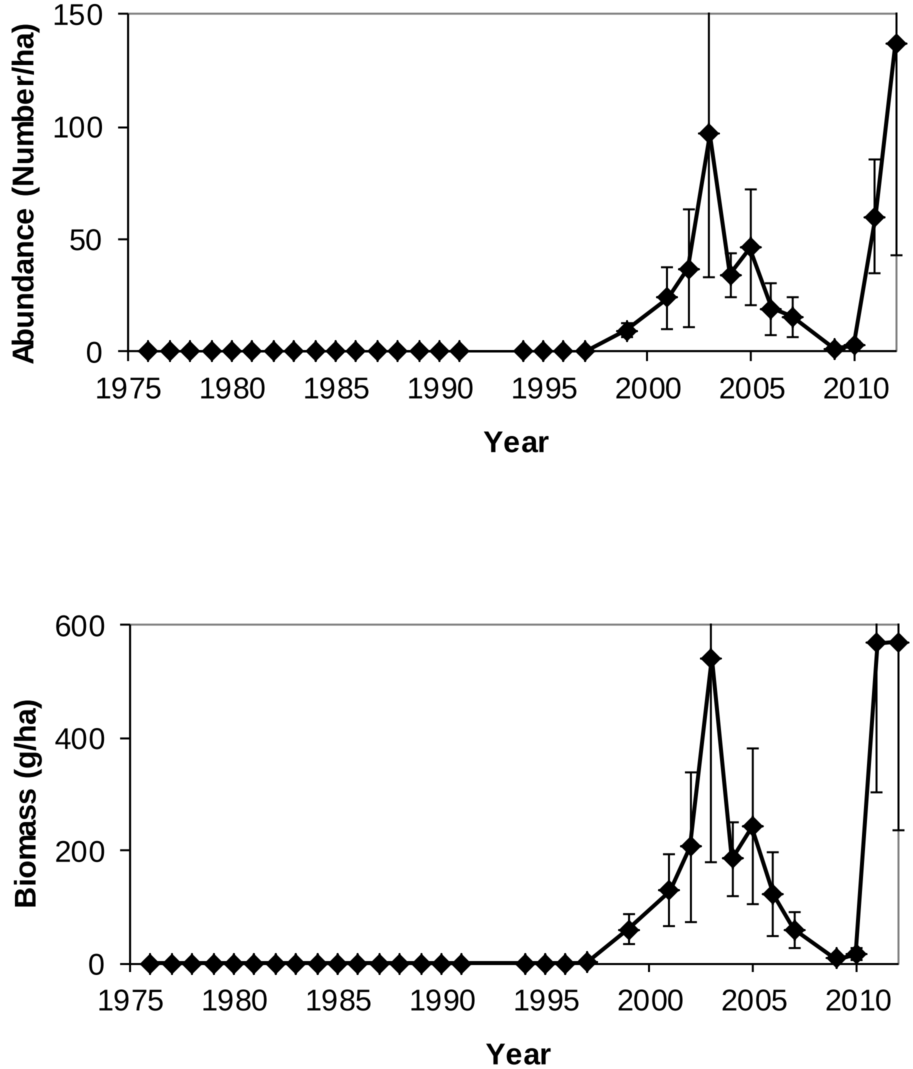

Figure 7. Density of round goby as number (top panel) and biomass (bottom panel) of fish per hectare in Lake Huron, 1976-2012.

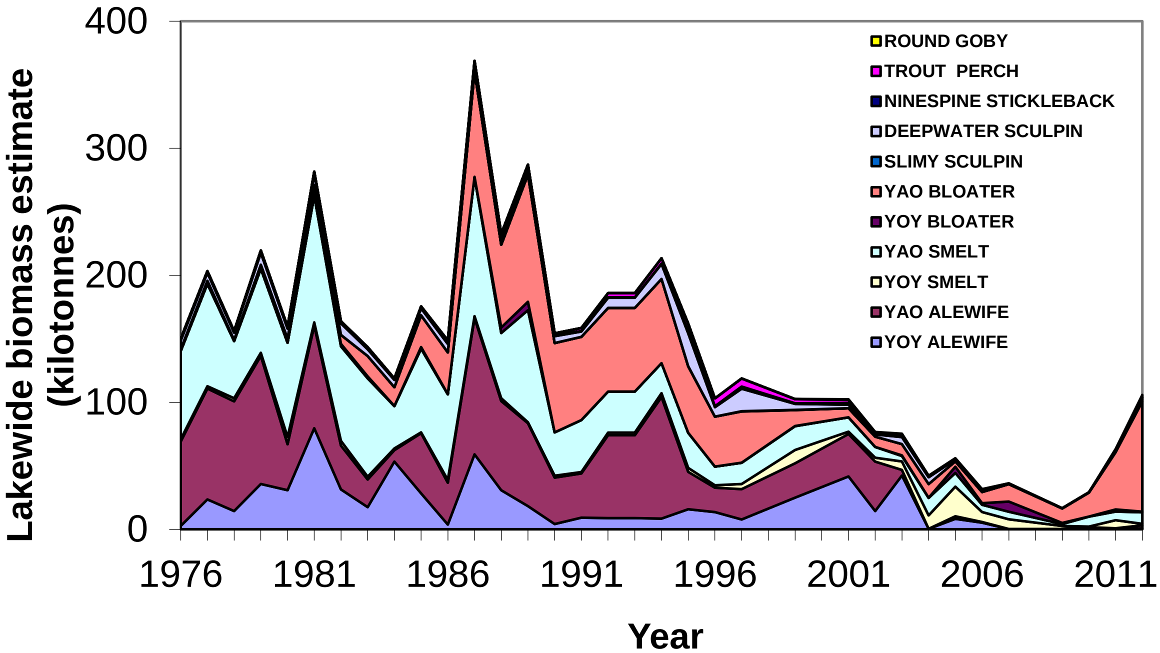

Figure 8. Offshore demersal fish community biomass in the main basin of Lake Huron, 1976-2012. Valid data were not collected in 1992, 1993, 1998, 2000, and 2008; biomass estimates for those years represent interpolated values.

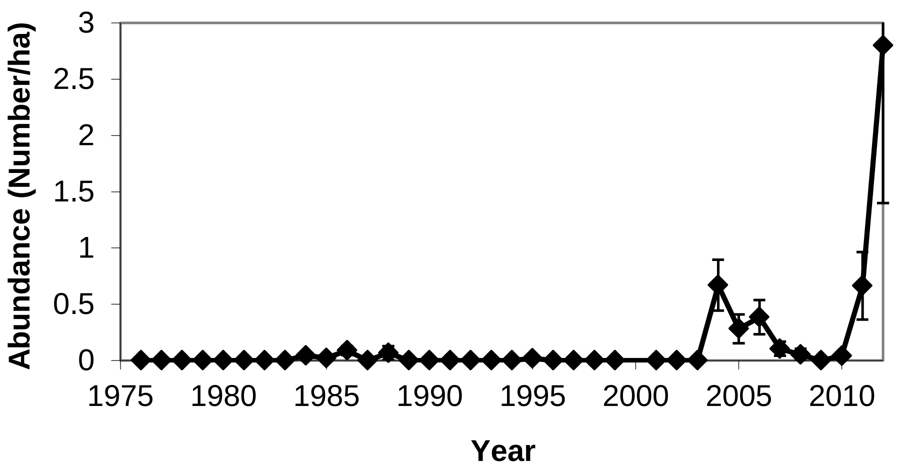

Figure 9. Density of wild juvenile (YOY, < 125 mm) lake trout collected in fall bottom trawls from Lake Huron 1976-2012. Error bars are 95% confidence intervals.