Status and Trends of the Lake Huron Deepwater Fish Community, 2004

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Abstract

The Great Lakes Science Center has conducted trawl surveys to assess annual changes in the fish community of Lake Huron since 1973. Since 1992, surveys have been carried out using a 21 m wing trawl towed on-contour at depths ranging from 9 to 110 m on fixed transects at five ports in U.S. waters with less frequent sampling near Goderich, Ontario. The 2004 fall prey fish survey was carried out during October and sampled all five US ports and Goderich, Ontario. The alewife population collapsed during 2004, due to three consecutive years of poor recruitment. Both adult and age-0 alewife density and biomass were at historical lows for the time series. Density and biomass of adult rainbow smelt abundance increased from 2003 levels due to strong year classes in both 2003 and 2004. Adult bloater abundance decreased slightly, but juvenile bloaters remained ubiquitous. Density of small bloaters increased during 2004 due to continued abundance of the exceptionally strong 2003 year class combined with substantial numbers of age-0 fish produced during 2004. Abundances for most other prey species were lower than 2003. We captured 22 wild age-0 lake trout in 2004; this represents the first time that substantial numbers of wild fish were captured in the survey. Prey biomass available to the trawl decreased by 65 % during 2001-2004; nearly all the decrease was due to reduced alewife biomass, and no other species has increased in abundance enough to compensate for their loss. The primary source of food for salmonids during 2005 will be small rainbow smelt. Predators in Lake Huron face potential prey shortages; estimates of predatory demand are now similar to estimates of prey biomass, and nearly all the remaining prey species are smaller than the adult alewives consumed traditionally.

Introduction

The Great Lakes Science Center (GLSC) has conducted annual bottom trawl surveys on Lake Huron since 1973. These surveys are used to examine relative abundance, size and age structure, and species composition of the prey fish community. Estimates of lake-wide prey fish biomass available to the trawl are also generated. Sampling was conducted with a 12 m bottom trawl during 1973-1991, but in 1992 the gear was changed to a 21 m wing trawl to improve biomass estimates of pelagic prey species and to reduce apparent size selectivity. This report focuses on data collected during 1992-2004 using the 21 m wing trawl. Sampling was conducted annually during this time period, except during 2000 when sampling did not occur due to vessel breakdown and poor weather.

The 2004 report format differs from previous lake reports, and has been changed to make calculations and presentation more consistent among lakes. The major changes in format are: 1) density (number·Ha^{-1}) and biomass (kg·Ha^{-1}) replace catch per tow (CPE) as measures of abundance, 2) line graphs replace stacked bar graphs, and 3) relative standard error is presented as a measure of data variability.

The most important change in our calculations is a revision of prey biomass. Swept area biomass estimates for Lakes Huron and Michigan (Madenjian et al. 2005) are now calculated in the same manner and lakewide biomass estimates are made only for those depth contours sampled by trawling. No biomass estimates are made for waters too deep to sample with the trawl. There, acoustic surveys were used to estimate biomass, and those estimates are detailed in a separate report (Warner et al. 2005).

Methods

Trawl sampling is performed annually at five ports in US waters: Detour, Hammond Bay, Alpena, Ausable Point (Tawas), and Harbor Beach (Figure 1). At each port, 10-minute on-contour trawl tows are made on approximate 9 m depth intervals at fixed transects from 9 to 110 m in depth. The 27, 36, 46, 55, 64, and 73 m depths are common to all ports, but the number of shallower and deeper tows varies among ports due to variation in bathymetry and bottom composition. Sampling also occurred at Goderich, Ontario during 1998, 1999, 2003, and 2004 using the same trawling regime as US ports (Figure 1).

Tow times and speeds were constant, but true time-on-bottom increases with depth, and catches C_i were standardized among tows using the formula:

$$C_i = N_i * \left(\frac{10}{t(0.004d + .8861)} \right)$$

where N_i is the number of fish of species i captured in a single tow, t is tow time (usually 10 minutes), and d is depth (m). Density (D_i) was calculated for each species by dividing C_i by area swept, expressed as number·ha^{-1}.

Annual abundance (A) was defined as mean number · ha^{-1} of each species:

$$A = \frac{\sum_{i=1}^{n} D_i}{n}$$

where D_i is the density of a species from each trawl tow, and n is total number of tows performed.

Variability associated with A was estimated using Relative Standard Error (RSE):

$$RSE = 100 \times \left(\frac{se}{A} \right)$$

Where *se* represents the standard error of A (mean density) weighted for areal differences among 10 m contours.

For analysis of recruitment trends, mean density was apportioned into age-0 and adult fish based on length frequency data from all tows where a species was captured. We used 100 mm TL as a demarcation between age-0 and older fish for alewife *Alosa pseudoharengus*, 90 mm for rainbow smelt *Osmerus mordax*, and 120 mm for bloater *Coregonus hoyi* based on archived historical age data. Age structure of alewives was calculated by collecting otoliths from a stratified random sample of 10 fish per 10 mm length group for each port.

Swept area biomass of each major prey fish species was calculated from trawl biomass per tow

$$B_t = \sum_{s=0}^{s=110} \frac{W_i a_s}{n}$$

where B_i is biomass of a species, W_i represents mean biomass (g · meter^{-2}) of each species within each depth stratum, a_s represents the weighted area (m^2) of individual strata, and n represents total number of tows. W_i was derived for each species by dividing mean weight (g) per tow within each depth stratum for that species, and converted to density (g · meter^{-2}) by dividing mean weight by area swept by the trawl. We then expanded mean density by the total area (m^2) within each stratum. We used 10 m intervals for depth strata to make calculations consistent with other lakes.

The 2004 Survey

The 2004 survey was carried out during October 8-21, 2004. Forty-six of the 48 planned tows were trawled; trawling could not be carried out at the 18 and 27 m transects at Detour due to commercial fishing gear. The lake remained stratified for all ports with a deep (30-40 m) thermocline present.

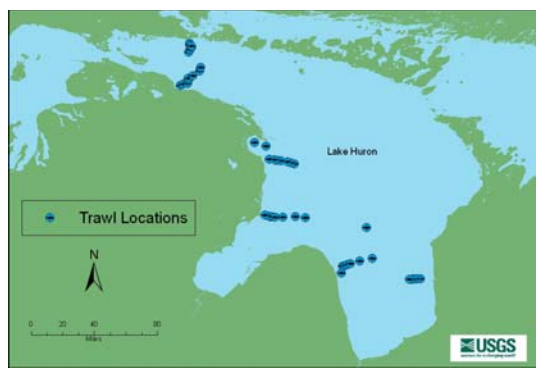

Figure 1. Sampling locations in Lake Huron, 2004.

Abundance, size, and age structure

Alewife- Adult alewife density and biomass were at an all time low for the time series (Figure 2). The RSE for alewife has traditionally ranged between 20 and 45%; however, during 2004 it increased to 75% because of extremely patchy alewife distribution (Figure 2). Alewives were caught in only 14 of the 46 tows, and only in low numbers.

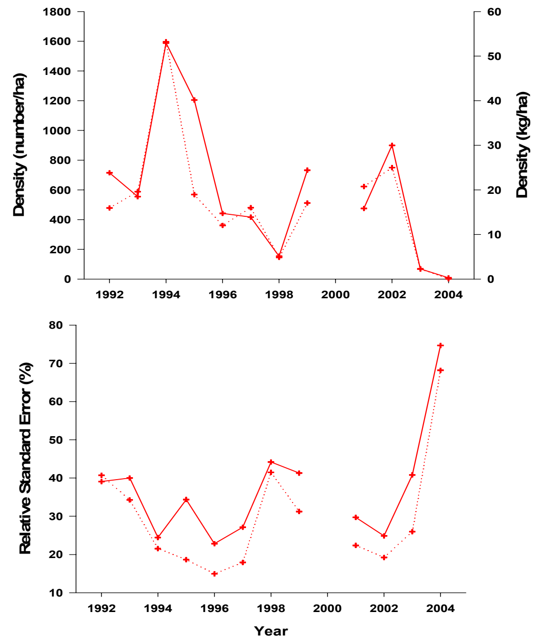

Figure 2. Density of adult alewives as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

The alewife population collapse occurred during 2002-2004 and resulted from three consecutive years of poor recruitment. During 2002, alewives of all sizes and ages were abundant due to a series of strong year classes that occurred in 1998, 1999, 2001, and 2002 (Figure 3). However, high mortality of all sizes during 2002-2003 caused almost complete mortality of the 2002 year class, and substantial reduction in abundance of older fish. During 2003, the few remaining adults produced the largest year class in the time series (Figure 3), but age-0 alewives experienced almost complete mortality during 2003-2004. The 2004 year class was the smallest in the time series.

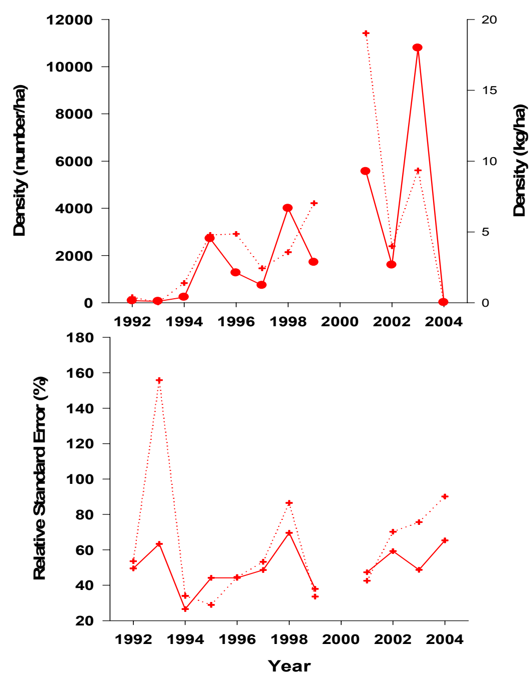

Figure 3. Density of age-0 alewives as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

Recent alewife size and age structure reflected these conditions. During 2002, all sizes of alewife were present, and age-1 through age-5 fish were abundant (Figures 4, 5). During 2003 and 2004, the catch was dominated by age-0 fish less than 100 mm in length. However these fish either failed to survive (2003) or were present at low densities (2004). Currently, only low numbers of small alewives are available to predators.

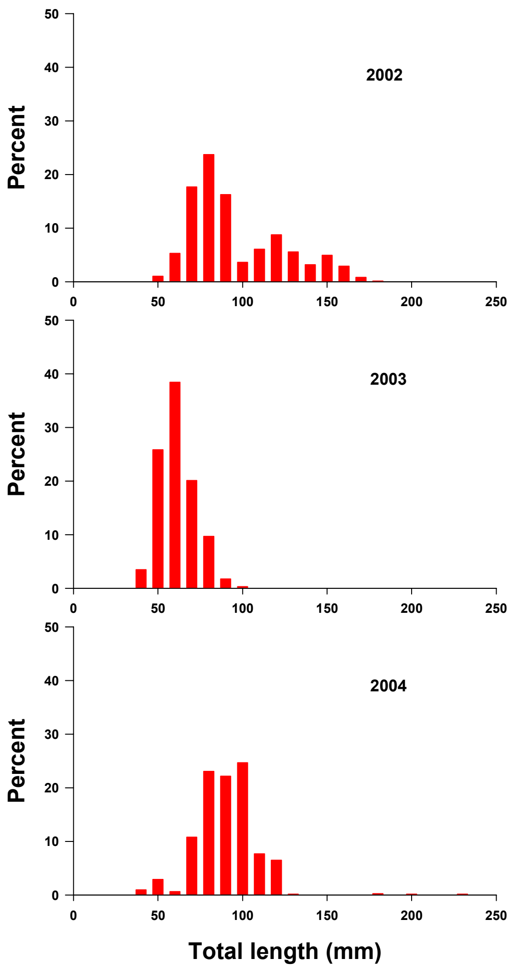

Figure 4. Size structure of Lake Huron alewives, 2002-2004. Percentages less than 1 % are not visible.

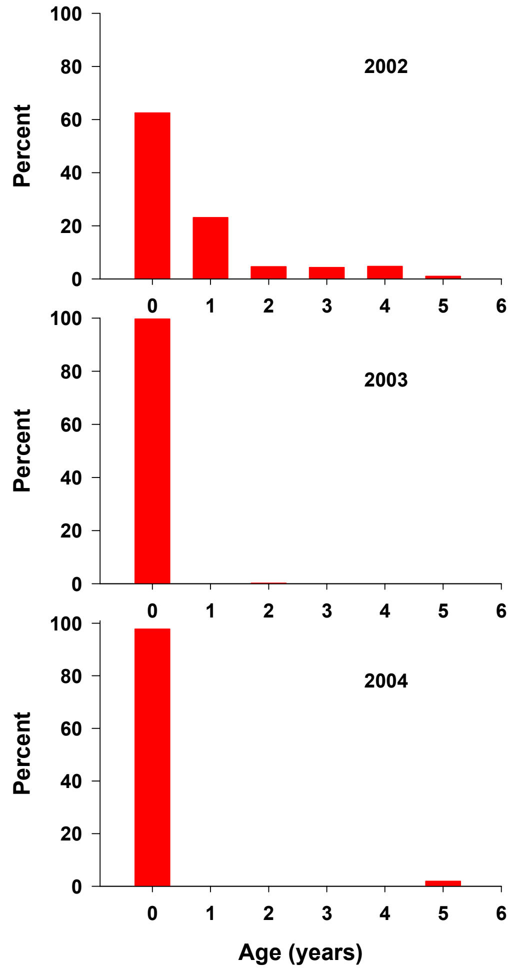

Figure 5. Age structure of Lake Huron alewives, 2002-2004. Percentages less than 1 % are not visible.

Rainbow smelt- Adult rainbow smelt density increased during 2004 (Figure 6) probably because the 2003 year class was the second strongest since 1992 (Figure 7). The 2004 year class was even larger (Figure 7). Consequently, abundance of age-0 rainbow smelt increased during 2004.

The RSE's for rainbow smelt in 2004 were about 32%, and were consistent with values from other years. This reflects the even spatial distribution of rainbow smelt, which tend to be ubiquitous in all tows in the survey.

Rainbow smelt biomass increased only slightly because the population was dominated by small fish and length frequency distribution was truncated beyond 150 mm (Figure 8).

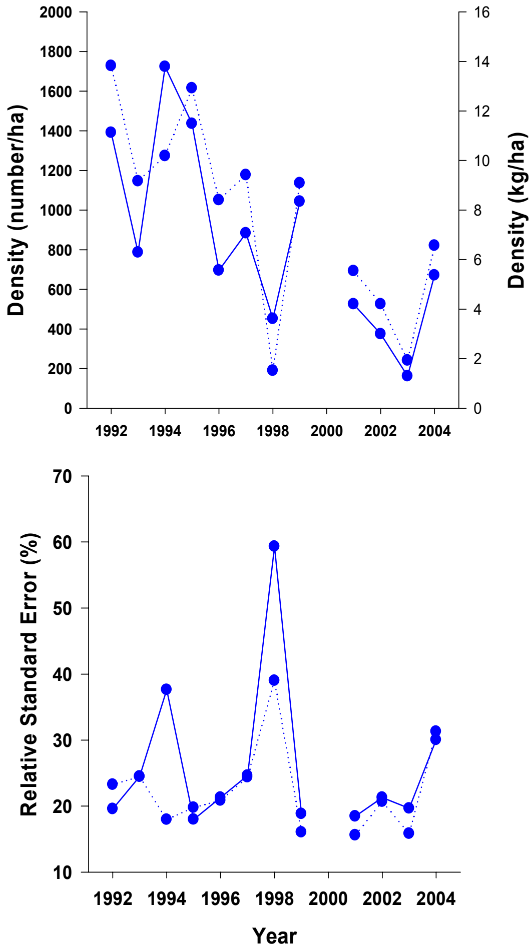

Figure 6. Density of adult rainbow smelt as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

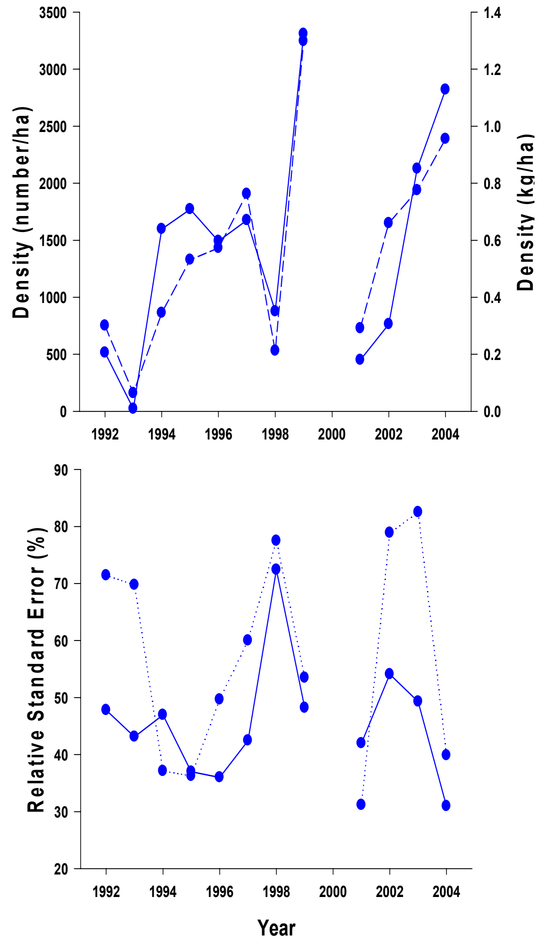

Figure 7. Density of age-0 rainbow smelt as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

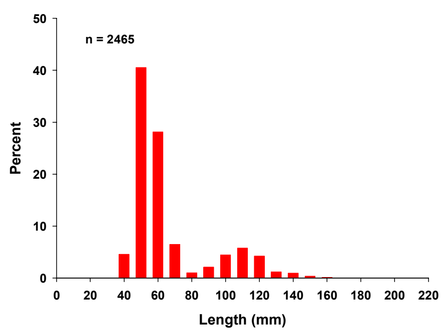

Figure 8. Rainbow smelt length frequency, Lake Huron, 2004.

Bloater- Adult bloater density and biomass in Lake Huron were slightly higher during 2004 compared with the previous year (Figure 9). In contrast, abundance of small bloaters decreased, but densities were higher than most years in the time series (Figure 10). Bloaters less than 120 mm TL captured during 2004 originated from two year classes: a strong 2003 year class that has persisted, and a second year class that occurred during 2004. Both year classes were identifiable through length frequency distributions (Figure 11).

Juvenile bloaters are pelagic and generally not susceptible to bottom trawls, so true year class strength may not be apparent until they become fully recruited to the trawl at age-3 or older (Wells 1968). High densities of juveniles observed during 2003 and 2004 may represent a conservative estimate of the strength of these year classes.

RSE values for both adult and juvenile bloaters typically fluctuate between 30 and 40 percent, and 2004 results were similar to most previous years. Although bloater catches vary, their distribution with depth varies little from year to year.

Juvenile bloater densities rarely exceeded 5 fish ha^{-1} during 1992-2002, but densities increased to approximately 60 fish ha^{-1} in 2003, and 28 fish ha^{-1} in 2004 (Figure 10). The overall increase in density of young fish suggests that adult bloater may be more abundant in the future.

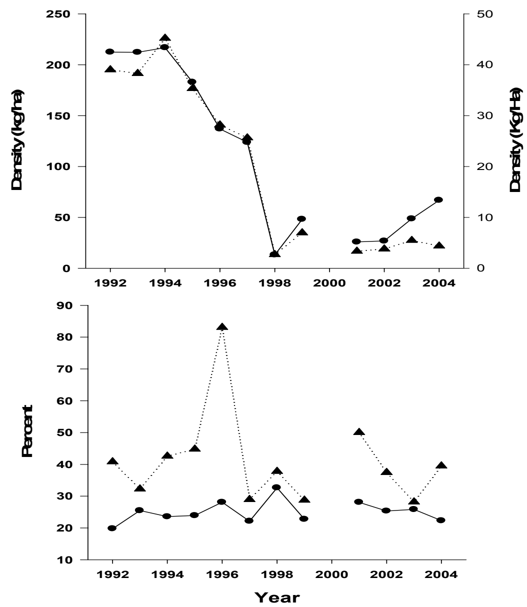

Figure 9. Density of adult bloaters as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

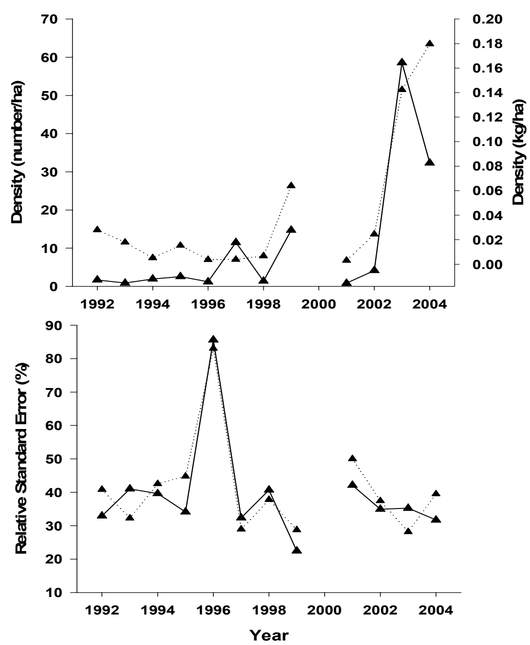

Figure 10. Density of juvenile bloaters as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

<u>Sculpins, sticklebacks, and troutperch-</u> Sculpin abundance in Lake Huron has been highly variable since 1992. Deepwater sculpins *Myoxocephalus thompsoni* comprise most of the total sculpin catch, while slimy sculpins *Cottus cognatus* are only a minor component of the fish community. Deepwater sculpin abundance increased during 2004 (Figure 12). RSE also increased because deepwater sculpin distributions have become patchier during recent surveys.

During 2004, we captured small (30-50 mm TL) deepwater sculpins (Figure 13). Small deepwater sculpins comprised only a small proportion of total sculpin catch (1.6%), but small deepwater sculpins are not often captured in our survey, and the proportion of fish less than 50 mm TL in the 2004 catch was the highest observed since 1992. This suggests that deepwater sculpin recruitment during 2004 was higher than in previous years.

Density and biomass of ninespine sticklebacks *Pungitius pungitius* were lower in 2004 compared with 2003 (Figure 14). Ninespine stickleback abundance has varied considerably since 1992 and similar low densities have been observed previously. However, the recent trend is downward, and indicates that sticklebacks will not be highly available as an alternative prey species.

Troutperch *Percopsis omiscomaycus* density and biomass increased slightly during 2004, but their overall abundance remained near historic lows for the time series (Figure 15). As with sticklebacks, troutperch will not be important as an alternative prey species in 2005.

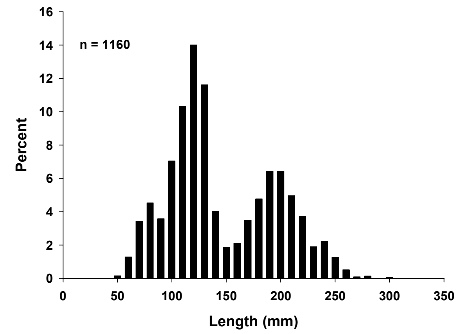

Figure 11. Bloater length frequency, Lake Huron, 2004.

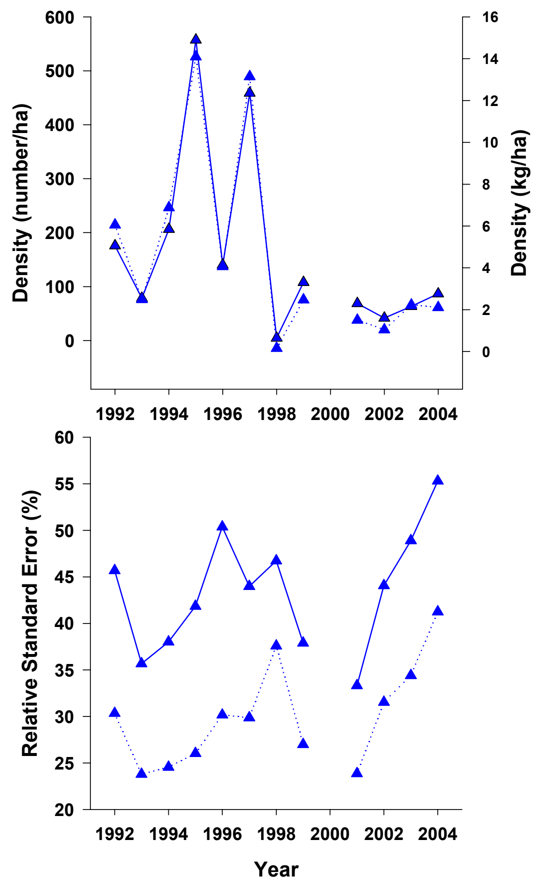

Figure 12. Density of deepwater sculpins as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

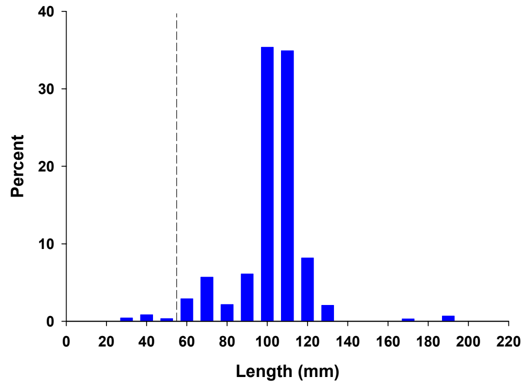

Figure 13. Length frequency of deepwater sculpins, Lake Huron, 2004.

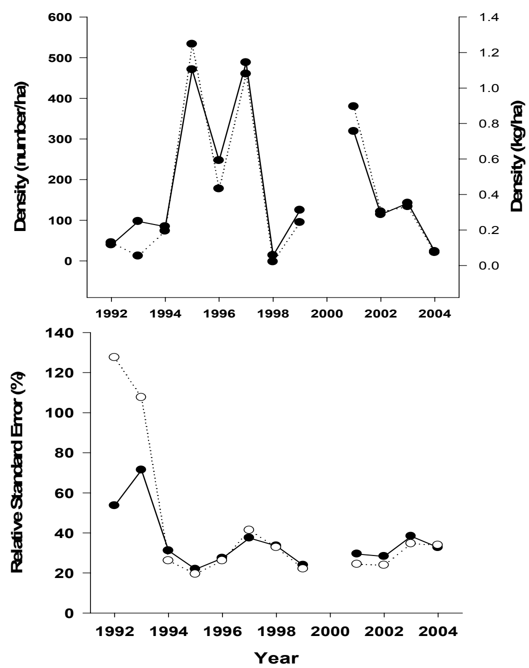

Figure 14. Density of ninespine sticklebacks as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

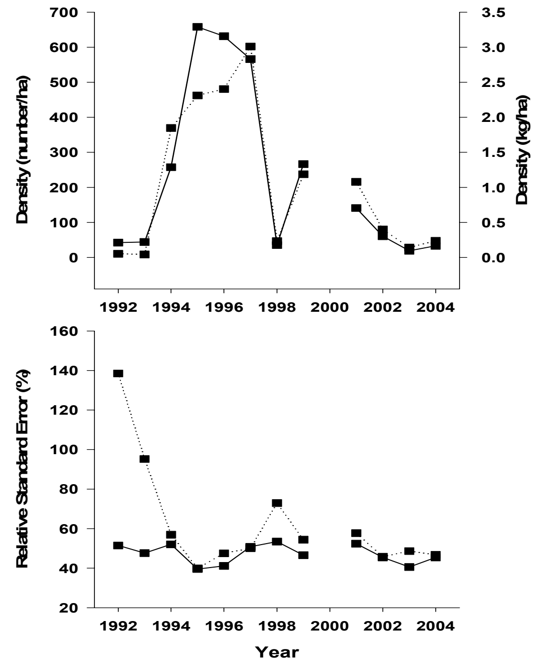

Figure 15. Density of troutperch as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

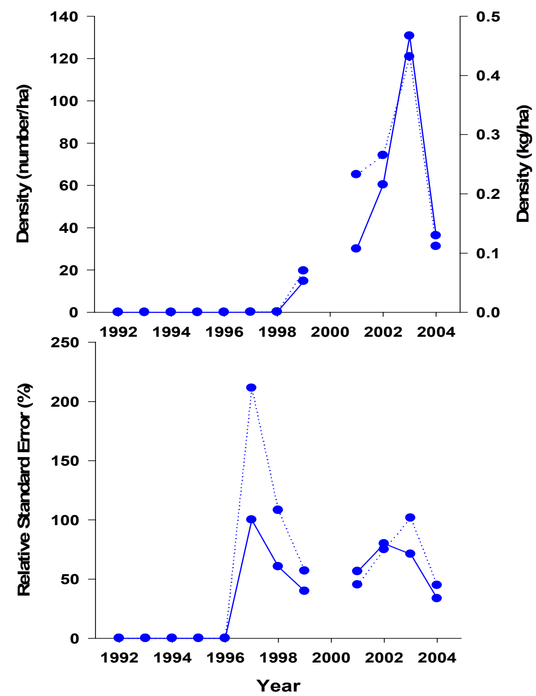

Figure 16. Density of round gobies as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2004.

<u>Round gobies</u>- Round gobies *Neogobius melanostomus* were first encountered in the trawl survey during 1997 and increased in abundance steadily until 2003; however, their abundance declined in 2004 (Figure 16).

The round goby range continues to expand. During 2004 we collected round gobies at Hammond Bay for the first time, and also at offshore stations near Alpena. In previous years, round gobies collected near Alpena had been found only within Thunder Bay. As in previous years, we collected round gobies at depths up to73 m, indicating that their distribution extends well offshore. Many exotics follow a pattern of initial proliferation followed by decline (Moyle and Light 1996). This may be the case with round gobies, but heavy predation by salmonids in the absence of alewife may also be responsible for this trend.

<u>Lake trout</u>- One of the most surprising events of the 2004 survey was the capture of 22 wild age-0 lake trout *Salvelinus namaycush*. These fish were identified as naturally spawned because they lacked fin clips and were far smaller during October than even the smallest hatchery lake trout that were stocked earlier that year. Wild lake trout were distributed widely and were captured at Detour, Hammond Bay, Alpena, and Ausable Point at an overall mean density of 0.85 fish $\cdot$ ha^{-1}.

Wild age-0 lake trout have been collected in mid-lake surveys of Six-Fathom Bank (Desorcie and Bowen 2003), but this is the first time that significant numbers of wild lake trout have been collected during this survey. Fish collected during 2004 represent the first time that widespread main basin natural reproduction has occurred since the beginning of the lake trout rehabilitation effort in the 1970's.

Biomass Estimates- Total main basin prey biomass for the area between 0 and 110 m declined from 125 kilotonnes in 2001 to 44 kilotonnes in 2004 (Figure 17). This represents a 65% decline over the three year period. Virtually all the decline resulted from the loss of alewife. Biomass of other principal species did not change appreciably or increased slightly, indicating that no species has begun to replace lost alewife production, at least in the offshore environment. The bulk of the remaining prey biomass is composed of rainbow smelt and bloaters.

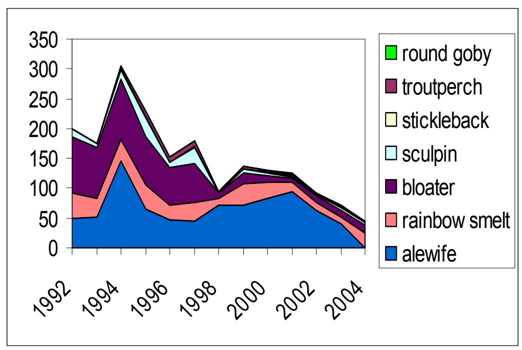

Figure 17. Prey fish community biomass (Kilotonnes) in main basin waters of Lake Huron, 1992-2004. No sampling occurred during 2000; biomass estimates for that year represent interpolated values.

Discussion- The Lake Huron prey fish community has undergone rapid change. For the first time in many years, the fish community has moved away from dominance by exotic species and toward a community comprised of native species. This occurred due to the collapse of alewives and reduction in round goby density, and recent recruitment by native bloaters, lake trout, and deepwater sculpins. These changes are consistent with fish community objectives for Lake Huron (DesJardine et al. 1995), but they raise important issues regarding prey availability, ecosystem stability, and sustainability of the Chinook salmon *Oncorhynchus tshawytscha* sport fishery.

Prey availability

Prey availability for piscivores will likely be low during 2005 because no species has replaced alewife in either numbers or biomass. While bloaters, lake trout, and deepwater sculpins all exhibited recruitment during 2004, these species normally are scarce numerically compared to alewife. Rainbow smelt density and biomass increased, but their biomass remains low and their length frequency distribution was truncated and most fish were less than 100 mm TL. Other potential prey species such as ninespine sticklebacks, trout-perch, and round gobies are declining in abundance.

The most recent estimate of predator consumption in Lake Huron occurred in 1998, when consumption by Chinook salmon, lake trout, walleyes *Sander vitreus*, and burbot *Lota lota* was estimated to be about 41 kilotonnes (Dobiesz and Bence 2003). That estimate does not take into account recent increases in abundance of wild Chinook salmon, better survival of stocked, pen-reared Chinook salmon, and strong walleye year classes during 2003 and 2004 that will likely translate into even higher predatory demands (David Fielder, Michigan Department of Natural Resources, personal communication).

A total predatory demand of 41 kilotonnes is very close to the lakewide prey biomass of 44 kilotonnes that we estimated for 2004. Our biomass estimate is conservative because the trawl does not sample the entire water column and pelagic individuals of any species are unlikely to be captured. Moreover, biomass estimates assume that each tow is a representative sample from that depth stratum. This assumption was probably violated because trawls can only be made in areas with smooth substrates up to 100 m deep. These factors would all contribute to underestimation of true prey fish biomass.

However, the trend toward convergence of predatory demand and prey biomass suggests that predators in Lake Huron face potential prey shortages during 2005. Rainbow smelt will be the only common pelagic prey. Rainbow smelt are a preferred prey of salmonids (Diana 1990), but there are likely to be low numbers of large-sized prey items needed to sustain growth of large salmonids, especially adult lake trout (Martin 1966, Madenjian et al. 1998). Managers and anglers should expect slow growth and low condition factors for salmonids during 2005.

Will alewife return?

Although the alewife population has apparently collapsed, alewives are not extinct in Lake Huron, and they are still present in moderate densities in Lake Michigan (Madenjian et al. 2005). Thus, alewives have at least the potential to regain their former abundance. Although the spawning stock is at an all time low, low adult densities can result in large year classes (O'Gorman and Schneider 1986). This may have occurred in Lake Huron during 1998 and 2003, when adult densities only slightly higher than those observed during 2004 produced exceptionally large year classes. However, no recent alewife year class has persisted. For adult alewives to become abundant by 2006, the 2005 year class would have to be at least moderately strong, and survival would have to be higher than in previous years.

The Role of Alewife

One of the most significant findings of the 2003 and 2004 surveys has been the resurgence in recruitment of native species during the near-absence of alewife. Bloaters produced strong year classes both years, and our data suggest recruitment of wild lake trout and deepwater sculpins in 2004. In Saginaw Bay, walleyes and yellow perch *Perca flavescens* produced strong year classes in both years (David Fielder, Michigan Department of Natural Resources, personal communication). Lake trout had not shown recruitment previously and the other species had not experienced strong recruitment for many years.

The native species showing strong potential recruitment represented four distinct fish families (salmonidae, coregonidae, cottidae, and percidae) with different ecologies, but all species shared a common trait of having pelagic larvae that are thought to be vulnerable to alewife predation (Smith 1970, Eck and Wells 1987). The ability of alewives to consume fish larvae has been well established (Krueger et al. 1995, Mason and Brandt 1996) and the temporal association between low alewife density and recruitment of native species supports the hypothesis that alewives play a major role as predators on early life stages of native species.

This raises a difficult issue: if alewife were the cause of poor recruitment of native species, fisheries managers trying to achieve fish community objectives may need almost total alewife suppression to maintain a diverse fish community supported by natural reproduction (DesJardine et al. 1995). To achieve alewife suppression, managers would have few options other than to maintain high predator populations, and accept slower predator growth and some risks to salmonid health (Holey et al. 1998).

Given that adult alewives are likely to remain scarce for at least one year, there is a strong and immediate need for better understanding of how salmonids respond both energetically and behaviorally to low prey availability. Alternatively, periods of low alewife abundance may provide opportunities to diversify fisheries and the fish community as a whole.

Acknowledgements

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