Status and Trends of the Lake Huron Deepwater Demersal Fish Community, 2005

Edward F. Roseman, Jeffrey S. Schaeffer, John R.P. French III, Timothy P. O'Brien, and Courtney S. Faul

U. S. Geological Survey
Great Lakes Science Center
1451 Green Rd.
Ann Arbor, MI 48105

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. Sample sites include five ports in U.S. waters with less frequent sampling near Goderich, Ontario. The 2005 fall prey fish survey was carried out between October 18 and November 7, 2005 and sampled all five US ports and Goderich, Ontario. The alewife population remained at low levels after collapsing in 2004 due to three consecutive years of poor recruitment. Adult alewife density and biomass remained near the historical low observed in 2004. Age-0 alewife showed a slight increase in abundance over 2004 estimates, but remain below the long-term mean for the time series. Density and biomass of adult rainbow smelt decreased from 2004 levels but juvenile rainbow smelt were at a record-high abundance in 2005. Adult bloater abundance decreased slightly, but juvenile bloaters remained ubiquitous with record high abundance for the time series. Abundances for most other prey species were lower than 2004. We captured 11 wild age-0 lake trout in 2005; this represents the second consecutive year that substantial numbers of wild fish were captured in the survey. Density of benthic macroinvertebrates was the lowest observed since collections began in 2001 due to declines in abundance of oligochaetes, *Diporeia* spp., and quagga mussels while sphaerid clams and chironomids increased slightly over 2004 levels. Prey biomass available to the trawl increased slightly over 2004 levels due to increases in age-0 alewife and rainbow smelt biomass. However, total prey biomass remains near the all-time low observed in 2004. The prey available to salmonids during 2006 will be small rainbow smelt and small bloaters. 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 traditionally consumed.

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 (i.e., between 5- and 114-m depth contours) 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 1992-2005 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.

Methods

Trawl sampling is performed annually at five ports in US waters: Detour, Hammond Bay, Alpena, Au Sable 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, 2004, and 2005 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:

$$C_i = N_i * \left(\frac{10}{t(0.004d + 0.8861)} \right)$$

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 density by number (A_i) 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 species *i* from each trawl tow, and *n* is total number of tows performed.

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

$$RSE_i = 100 \times \left(\frac{se}{A_i} \right)$$

where *se* represents the standard error of *A* (mean density).

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 estimates for Lakes Huron and Michigan (Madenjian et al. 2005) are now calculated in the same manner. In both lakes, they only consider those depth contours sampled by trawling (i.e., 5- to 114-m depth). The Lake Huron acoustic survey estimates lakewide biomass in deeper waters (see Schaeffer et al. 2006). In this report, lakewide biomass B_i of each major prey fish species $_i$ was calculated from trawl biomass per tow

$$B_i = \sum_{s=0}^{s=110} \frac{W_{is} a_s}{n}$$

where B_i is biomass of species i, W_{is} represents mean biomass (g · meter^{-2}) of each species within each depth stratum s, a_s represents the weighted area (m^2) of individual strata s, and n represents the number of depth strata. W_i was derived for each species i by calculating its total weight within each depth stratum and dividing by area swept by the trawl.

Benthic samples were collected at each port during 2001 through 2005. Three replicate grabs were made with a Ponar dredge (484 cm^2 mouth) at 27 m, 46 m, and 73 m depths. From 2001 through 2004, only the five U.S. ports were sampled. In addition to these ports, Goderich, ON was also sampled in 2005. Samples were washed onto 0.5 mm benthos sieves and preserved in 5% formalin. We calculated mean density of major invertebrate groups representing common prey types for fish.

The 2005 Survey

The 2005 survey was carried out during October 18-November 5, 2005. Forty-five of the forty-eight planned tows were completed; trawling could not be carried out at the 18 and 27 m transects at Detour and the 27 m transect at Thunder Bay due to commercial fishing gear. The lake remained stratified for all ports with a deep (30-40 m) thermocline present.

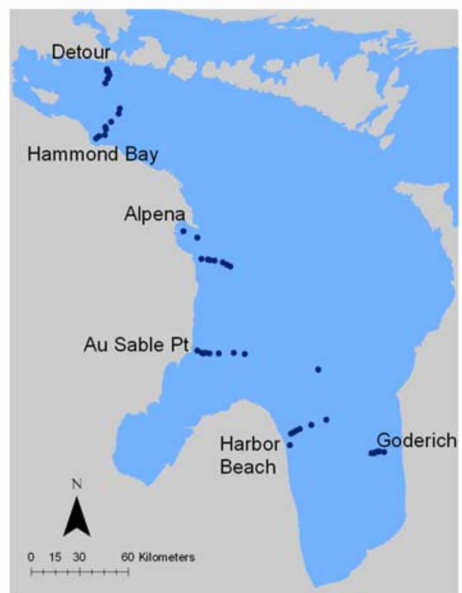

Figure 1. Sampling locations in Lake Huron, 2005.

Abundance, size, and age structure

__Alewife__- Adult alewife density and biomass increased only slightly from the all-time low observed in 2004 (Figure 2). The RSE for alewife has traditionally ranged between 20 and 45%; however, during 2004 it increased to 75% because of patchy alewife distribution and was even higher in 2005 at 85% (Figure 2).

Alewives were caught in thirty-five of the forty-five completed trawl tows in 2005. Distribution of adult alewife catches was variable with 89% of all adult alewives collected at Goderich, 9% from Alpena, and about 1% each at Hammond Bay, Detour, and Harbor Beach. Distribution of the age-0 alewife catch was also variable with approximately 88% of the total catch collected at Hammond Bay, 10% from Alpena, 1% at Tawas and Harbor Beach, and less than 1% from Detour and Goderich (Figure 3).

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 (Figures 2, 4, and 5). However, high mortality of all sizes during 2002-2004 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 4), but age-0 alewives experienced almost complete mortality resulting in record-low densities during 2004. The 2005 year-class rivals those produced in 1999 and 2002 with densities of about 4.0 kg or 2,000 fish · Ha^{-1} (Figure 4).

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 5, 6). During 2003, 2004, and 2005, 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 and 2005). Currently, only low numbers of small alewives are available to predators and the majority of these were found at the northern-most sites (Figure 3).

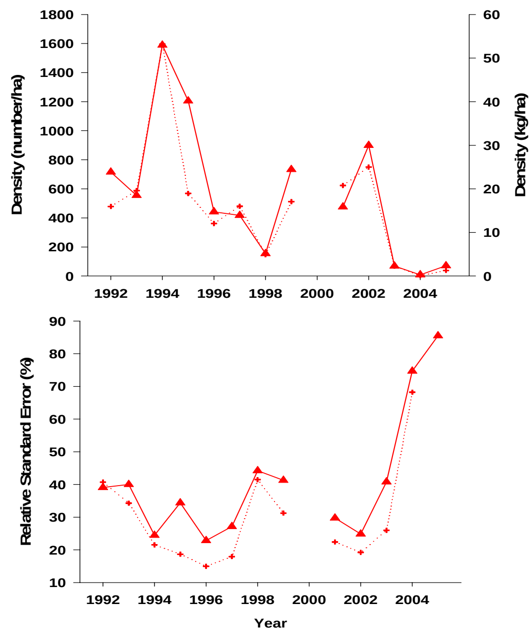

Figure 2. Density of adult alewives as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

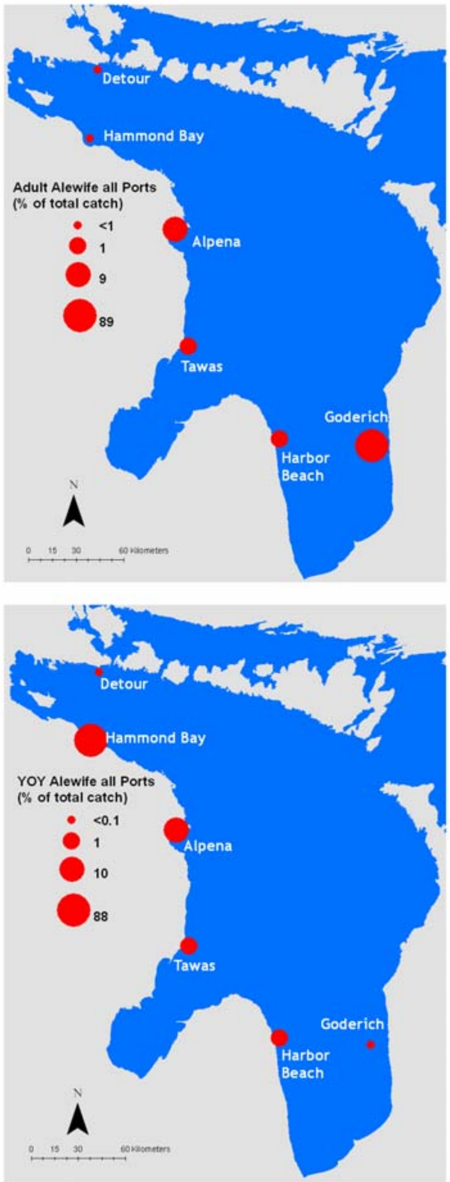

Figure 3. Distribution of catch (% of total number collected) for adult (top panel) and age-0 alewives collected with bottom trawls from sites in the main basin of Lake Huron, 2005.

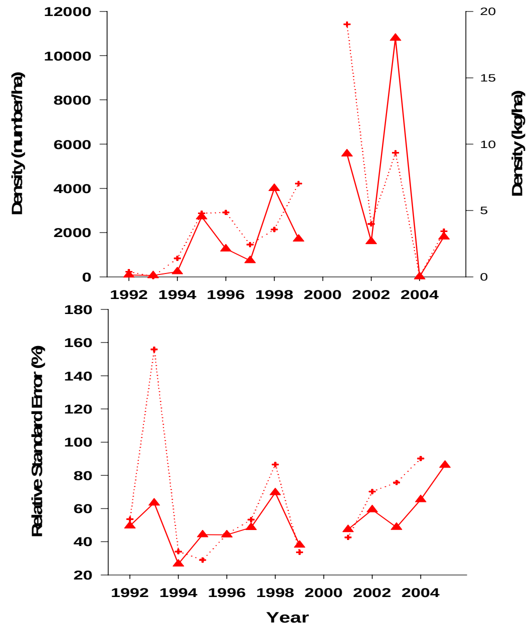

Figure 4. Density of age-0 alewives as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

Rainbow smelt- Adult rainbow smelt density decreased slightly between 2004 and 2005 (Figure 7) but age-0 densities were the highest on record since 1992 representing a doubling in density over 2004 estimates (Figure 8). The RSE's for rainbow smelt in 2005 were between 35 and 52%, higher than other recent years reflecting the moderately uneven spatial distribution of adult rainbow smelt observed in 2005 (Figure 7).

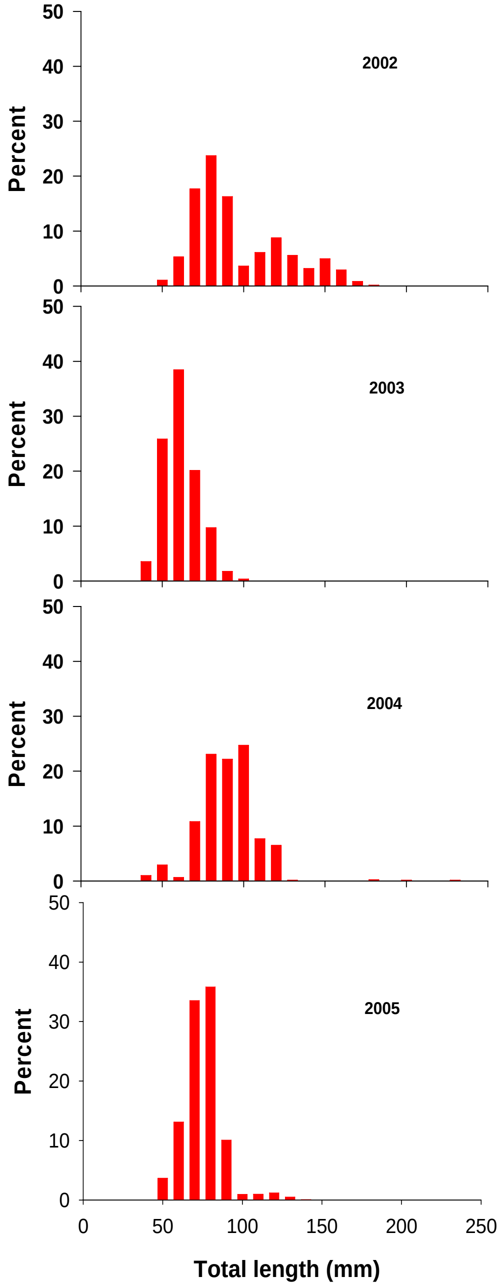

Figure 5. Size structure of Lake Huron alewives, 2002-2005. Percentages less than 1% are not visible.

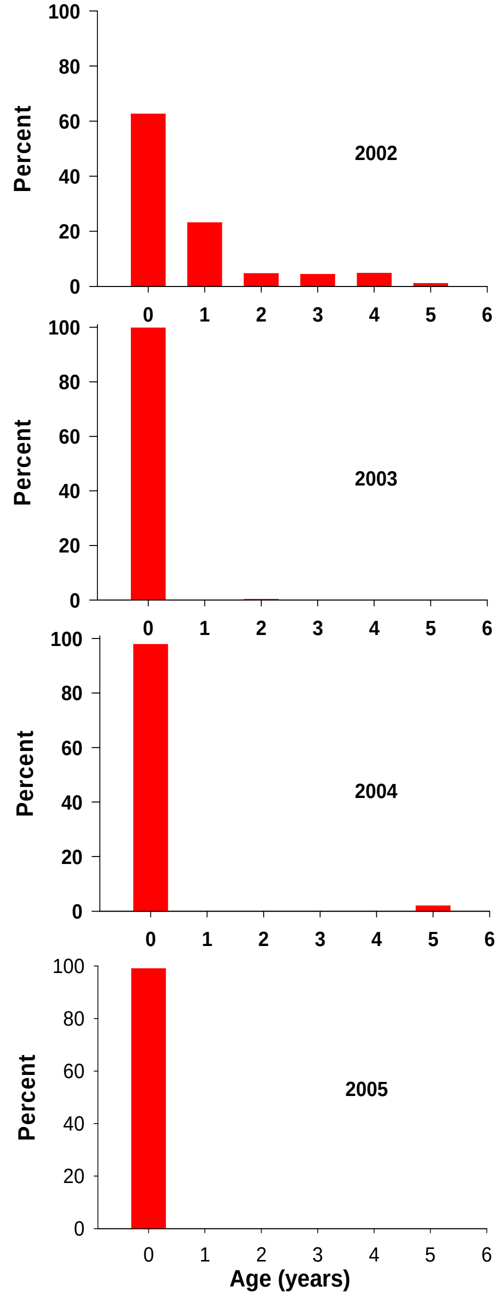

Figure 6. Age structure of Lake Huron alewives, 2002-2005. Percentages less than 1% are not visible.

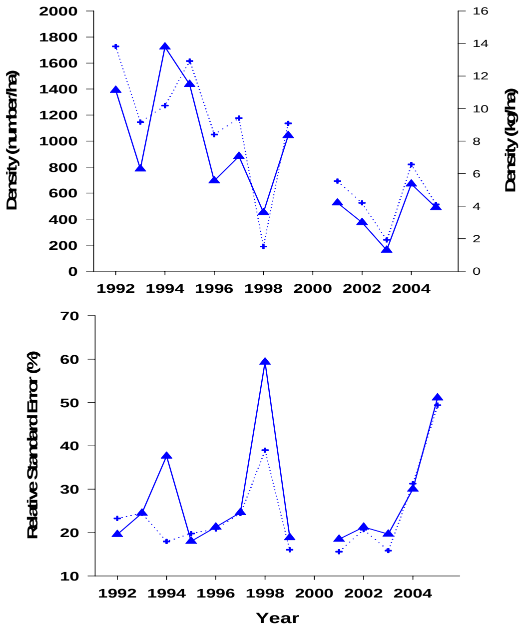

Figure 7. Density of adult rainbow smelt as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

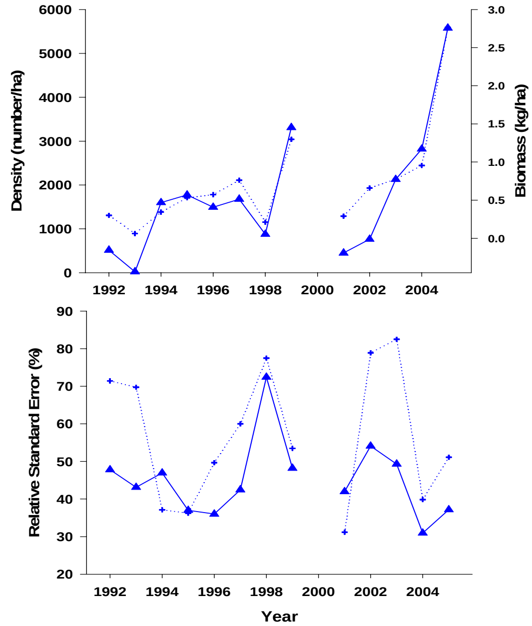

Figure 8. Density of age-0 rainbow smelt as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

The rainbow smelt population was dominated by age-0 fish in 2005 with less than 6% of the population larger than 100 mm (Figure 9). The combined biomass for all age classes of rainbow smelt increased only slightly from 2004 to 2005 despite the record-high density of age-0 fish.

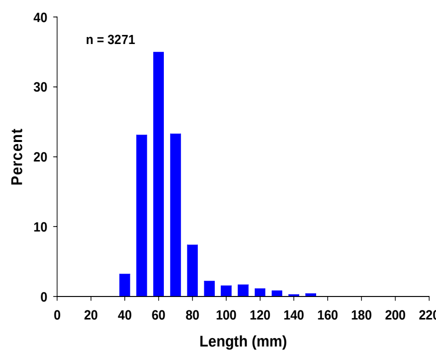

Figure 9. Length-frequency distribution of rainbow smelt length frequency collected in bottom trawls from Lake Huron during fall, 2005.

Bloater- Adult bloater density and biomass in Lake Huron were slightly lower during 2005 compared with the previous year (Figure 10). In contrast, abundance of small bloaters increased to an all-time high. Juvenile bloater were about six times more abundant and biomass about eight times that observed in 2004 (Figure 11).

Most bloaters captured during 2005 were less than 120 mm TL representing strong year-classes formed in 2005 and to a lesser extent, 2004 (Figure 12).

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 2003-2005 may represent a conservative estimate of the strength of these year classes. Nonetheless, juvenile bloater densities rarely exceeded 5 fish · Ha^{-1} during 1992-2002, but densities increased to approximately 60 fish · Ha^{-1} in 2003, 28 fish · Ha^{-1} in 2004, and 320 fish · Ha^{-1} in 2005 (Figure 10). The overall increase in density of young fish suggests that adult bloater may be more abundant in the future.

RSE values for both adult and juvenile bloaters typically fluctuate between 30 and 40 %, and 2005 results were similar to most previous years (Figures 10 and 11). Although bloater catches vary, their distribution with depth varies little from year to year.

<u>Sculpins, sticklebacks, and troutperch-</u> Sculpin abundance in Lake Huron has fluctuated widely since 1992 but has been depressed since 2001 (Figure 13). Deepwater sculpins *Myoxocephalus thompsonii* comprise most of the total sculpin catch, while slimy sculpins *Cottus cognatus* are only a minor component of the fish community and were not seen in trawls in 2005. Deepwater sculpin abundance decreased between 2004 and 2005. RSE also increased because deepwater sculpin distributions have become patchier during recent surveys.

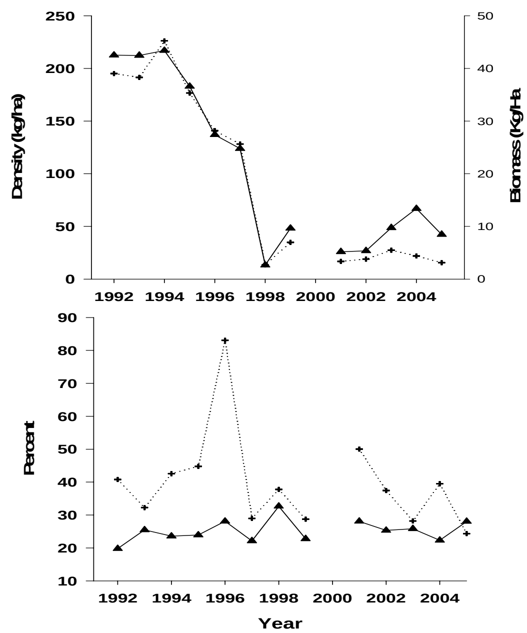

Figure 10. Density of adult bloaters as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

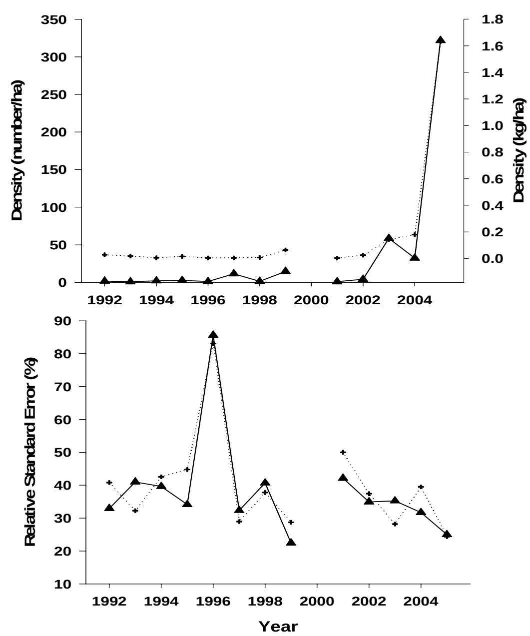

Figure 11. Density of juvenile bloaters as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

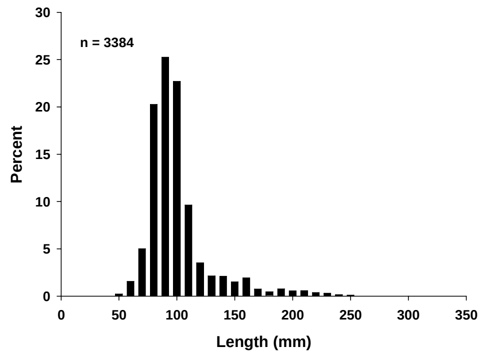

Figure 12. Length frequency distribution of bloaters collected in bottom trawls from Lake Huron, 2005.

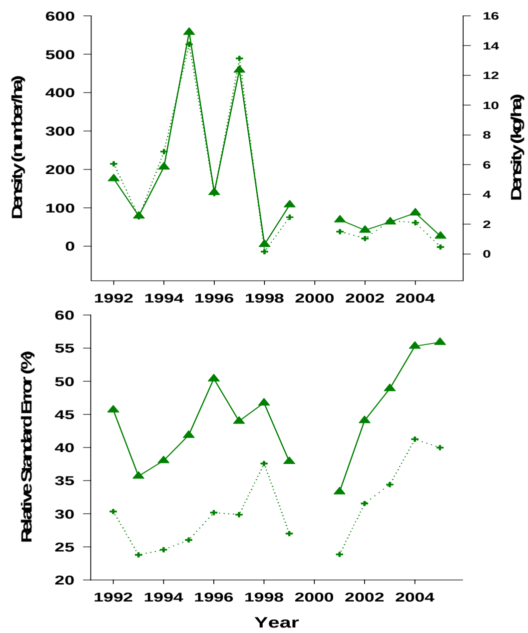

Figure 13. Density of deepwater sculpins as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

Deepwater sculpin lengths ranged between 50 and 130 mm TL in 2005 with over 90% of the catch between 70 and 110 mm TL (Figure 14).

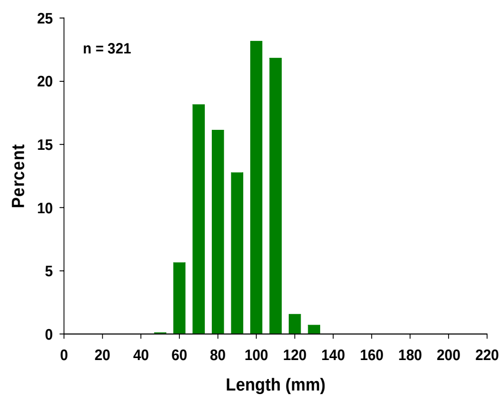

Figure 14. Length frequency distribution of deepwater sculpins collected in bottom trawls from Lake Huron, 2005.

Density and biomass of ninespine sticklebacks *Pungitius pungitius* continued their five-year decline in 2005 (Figure 15). 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 contribute to the fish community as an alternative prey species.

Troutperch *Percopsis omiscomaycus* density and biomass also continue a five-year overall decline. Their overall abundance remains low for the time series (Figure 16). As with sticklebacks, troutperch will not be an important alternative prey species in 2006.

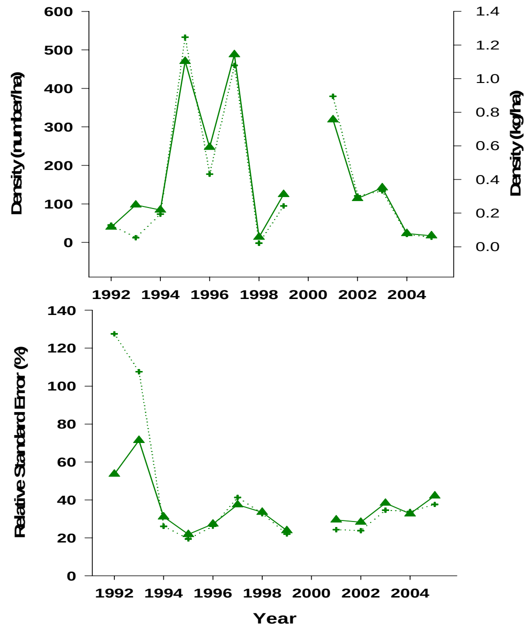

Figure 15. Density of ninespine sticklebacks as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

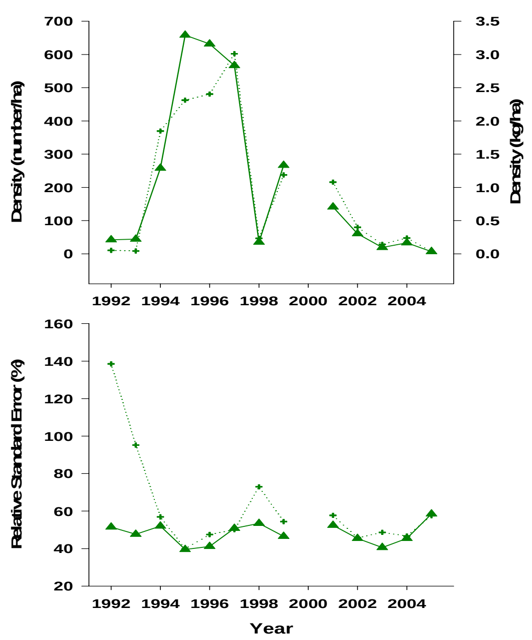

Figure 16. Density of troutperch as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

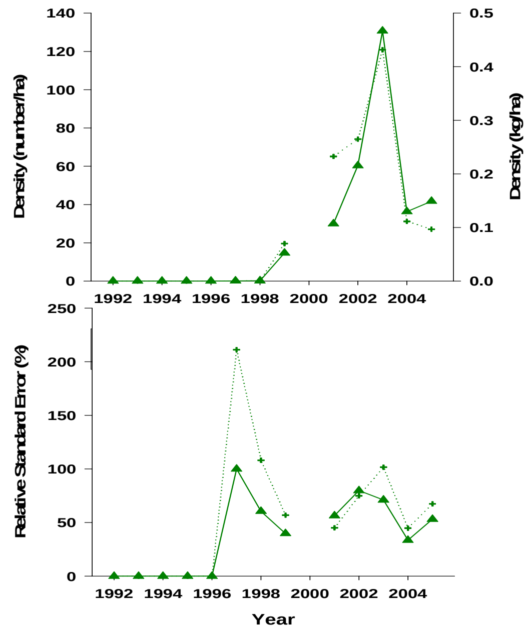

Figure 17. Density of round gobies as number (solid line) and weight (dotted line) of fish per hectare (top panel) and relative standard error (bottom panel) in Lake Huron, 1992-2005.

Round gobies- 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. Numbers of round gobies increased only slightly in 2005 but biomass continued to decline (Figure 17).

As in previous years, we collected round gobies at depths up to73 m, indicating that their distribution extends well offshore. Round gobies were collected at all ports except Detour where they remain absent from our samples.

Lake trout- Collection of wild age-0 lake trout *Salvelinus namaycush* continued in 2005. 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 collected at Detour and Alpena. Overall lake-wide mean density was 0.27 fish · Ha^{-1} in 2005.

Wild age-0 lake trout have been collected in mid-lake surveys of Six-Fathom Bank (Desorcie and Bowen 2003), and this is the second consecutive year that significant numbers of wild lake trout have been collected during this survey. Twenty-two fish were collected from four ports in 2004 with an overall density of 0.85 fish · Ha^{-1}. Collections of age-0 lake trout in recent years indicate that widespread reproduction is occurring in the main basin.

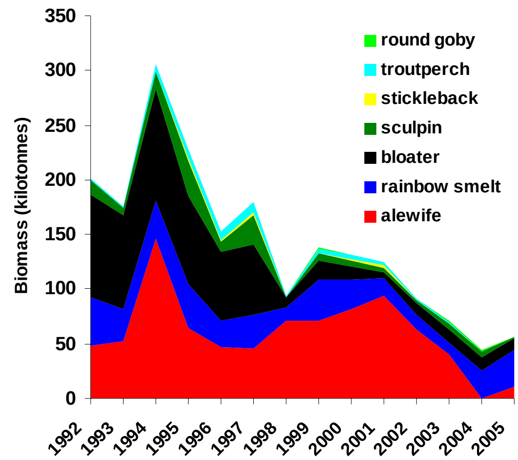

Figure 18. Prey fish community biomass (Kilotonnes) in main basin waters of Lake Huron, 1992-2005. No sampling occurred during 2000; biomass estimates for that year represent interpolated values.

Biomass Estimates- Total main basin prey biomass for the area between 5 and 114 m increased from 44 kilotonnes in 2004 to 56 kilotonnes in 2005 (Figure 18). This is the first increase in biomass since 2001 and likely since 1999 (no sampling occurred in 2000). The increase is due to increases in rainbow smelt and alewife biomass. Biomass of other species did not change appreciably or decreased slightly, indicating that no species other than rainbow smelt has begun to replace lost alewife production, at least in the offshore environment. The bulk of the remaining prey biomass is composed of bloaters which showed record-high juvenile abundance in 2005. These fish should contribute to an increase in overall biomass in future years as young fish grow.

Benthic Invertebrates- Density of benthic invertebrates was at an all-time low for the 5-year time series representing a 62 % decline in abundance since 2004 (Figure 19). Densities of oligochaetes, *Diporeia* spp., and quagga mussels *Dreissena bugensis*

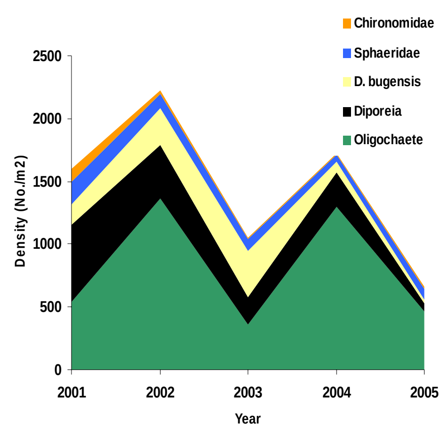

Figure 19. Mean density of benthic macroinvertebrates collected from five U.S. ports in western Lake Huron (2001 to 2004) and five U.S. ports plus Goderich, ON (2005). Data include all depths pooled.

declined while chironomids and sphaerid clams increased slightly. Density of *Diporeia* spp. has shown a continuing decline in abundance since sampling began in 2001 and densities in 2005 are the lowest observed, particularly at the 46 m depth stations (Figure 20). *Diporeia* spp. remained rare in samples collected at 27 m stations. Overall mean quagga mussel density showed a decline in abundance since reaching a peak density in 2002, although abundance at deeper stations is increasing (Figure 21).

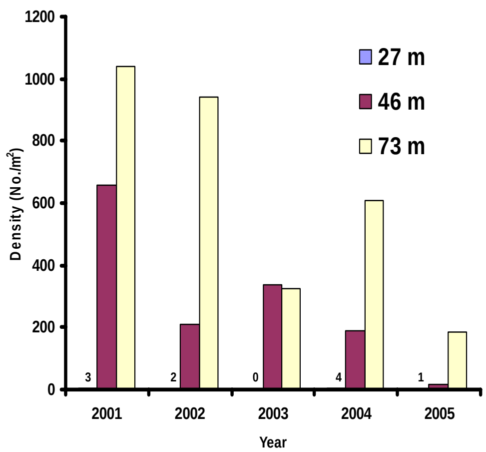

Figure 20. Mean density of *Diporeia* spp. at 27 m, 46 m, and 73 m depth strata determined from collections at five U.S. ports in western Lake Huron (2001 to 2004) and five U.S. ports plus Goderich, ON (2005).

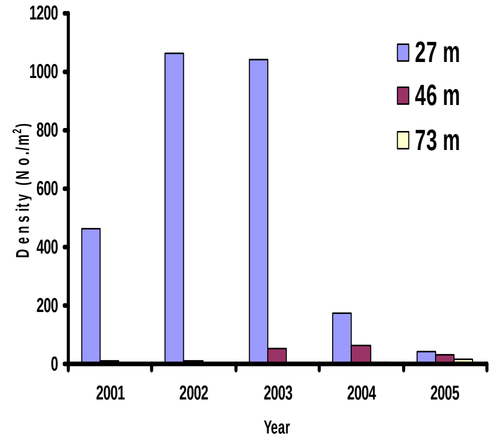

Figure 21. Mean density of quagga mussels *Dreissena bugensis* at three depth strata as determined from samples collected from five U.S. ports in western Lake Huron (2001 to 2004) and five U.S. ports plus Goderich, ON (2005).

Discussion

The Lake Huron prey fish community is showing some signs of recovery after reaching an all-time low in 2004. Collections made in 2005 showed an increase in total prey biomass largely constituted by increases in alewife and rainbow smelt density, although alewife density remains near the all-time low for the time series observed in 2004. Abundance of young bloater and juvenile rainbow smelt were at all-time highs for this survey, but contributed little to lakewide biomass estimates. While these changes are consistent with fish community objectives for Lake Huron (DesJardine et al. 1995), prey availability, ecosystem stability, and sustainability of the Chinook salmon *Oncorhynchus tshawytscha* sport fishery remain as concerns for fisheries managers.

Prey availability for piscivores will likely be low during 2006 because no species has replaced alewife in either numbers or biomass. While alewives, rainbow smelt, and bloaters increased in density between 2004 and 2005, this increase amounted to about a 30% increase over 2004 values but overall prey biomass remains low compared to previous years. The increase in age-0 alewives was due to atypical high catches at Hammond Bay, a northern port. These fish may have migrated into northern Lake Huron from Lake Michigan.

Rainbow smelt density and biomass increased showing the strongest year-class produced in the fourteen year time series. However, rainbow smelt biomass remains low due to their truncated length frequency distribution. Most rainbow smelt collected in 2005 were less than 100 mm TL.

Density of juvenile bloater was also at a record-high level in 2005 indicating formation of another consecutive strong year-class. Other potential prey species such as deepwater sculpins, ninespine sticklebacks, and trout-perch are declining in abundance whereas round gobies increased only slightly since 2004.

Despite the overall low biomass of the Lake Huron prey fish community, several features of the 2005 survey show promise for the future. Record-high catches of age-0 rainbow smelt and juvenile bloater should translate into increases in prey biomass as these fish recruit into their adult populations. However, with the recent high predatory demand of the salmonid-dominated piscivore community, these young year-classes may not persist. Further, the abundance of other prey species such as sticklebacks, sculpins, and round gobies are low and add little to prey fish biomass.

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, 2004, and again in 2005 that will likely translate into even higher predatory demands (David Fielder, Michigan Department of Natural Resources, personal communication).

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. However, acoustic estimates and mid-water trawl surveys show fish in the pelagia are typically small (Warner et al. 2005, Schaeffer et al. 2006) and would likely contribute little to biomass estimates. 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 110 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 2006. Rainbow smelt and juvenile bloaters will be the only common pelagic prey. Rainbow smelt and bloater are utilized as prey of salmonids (Diana 1990, Rybicki and Clapp 1996, Madenjian et al. 1998), 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 2006.

Acknowledgements

This report is dedicated to MMR William Boyle who retired in February 2006 after working his entire 30-year career aboard the R/V *Grayling*. We thank Captain Edward Perry and MMR William Boyle for their seamanship and dedication and T. DeSorcie and S. Riley for assistance with data collection. S. Nelson, L. Zhang, and D. Benes provided database and computer support. D. Bunnell, J. Savino, T. Todd, C. Vandergoot, and D. Warner provided many helpful insights and suggestions that greatly improved the quality of this report.

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