Status and Trends in the Lake Huron Deepwater Aquatic Community, 2003

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Abstract

The Great Lakes Science Center has conducted annual trawl surveys of the fish community in 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 2003 fall prey fish survey was carried out during October, and sampled all five US ports and Goderich, Ontario. The fish community during 2003 was very different from recent years. Adult alewife abundance during 2003 was extremely low, presumably due to a combination of over winter mortality during 2002-2003 and salmonid predation. However, age-0 alewives were more abundant than at any time since 1992 due to an exceptionally strong year class. Adult rainbow smelt abundance was the lowest observed since 1992, but age-0 rainbow smelt were more abundant than any year since 1998. Adult bloater abundance increased slightly, but age-0 bloaters were ubiquitous. The CPE of juvenile bloaters was the highest recorded since 1992, and the 2003 year class may be one of the largest since annual surveys began in 1973. Abundances for most other prey species were stable, but round gobies continued to increase at southern ports. Prey biomass available to the trawl increased during 2003 with alewives comprising the bulk of the biomass; However, unlike 2002, alewife biomass was composed almost entirely of age-0 fish rather than adults. Monitoring of benthic invertebrates suggested a sequential decline in nearly all benthic invertebrates, especially the deepwater amphipod *Diporeia*. *Diporeia* is now absent or declining at all sampling stations. These declines were associated with increases in quagga mussels *Dreissena bugensis*, but the mechanism is still unknown. Predators in Lake Huron face potential prey shortages. Although overall prey density was high, there were few adult alewives or rainbow smelt available. Predator feeding conditions during 2004 will depend on overwinter survival of age-0 alewife and the ability of large predators to subsist on small or non-traditional prey.

Introduction

The Great Lakes Science Center has conducted annual bottom trawl surveys on Lake Huron since 1973. These surveys are used to examine relative abundance, size and age structure, and community 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 1992-2003 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 bad weather.

Trawl samples are performed annually at five ports in US waters: Detour, Hammond Bay, Alpena, Ausable Point (Tawas), and Harbor Beach. 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 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, and 2003 using the same trawling regime as at US ports. Data from Goderich were included in this report.

True time-on-bottom increases with depth, thus, *CPE* was standardized using the formula:

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

where N_i is the number of each species captured in a single tow, t is measured tow time (usually 10 minutes), and d is depth (m).

Annual abundance (A)was defined as mean CPE of each species:

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

where CPE_i is the CPE of a species from each trawl tow, and n is total number of tows performed. Because abundance was calculated from a fixed-site survey, there was no measure of variability and mean CPE represents an index of abundance.

For analysis of recruitment trends, mean CPE 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, rainbow smelt, and bloaters based on archived historical data.

Age structure of adult alewives and bloaters was calculated by collecting scales or otoliths from a stratified random sample of 10 fish per 10 mm length group for each port. Alewives were aged exclusively from otoliths. Bloater have traditionally been aged from scales, but during 2003 we collected both scales and otoliths to determine if otoliths represent a more accurate way of ageing that species. A single experienced observer using a blinded design that provided no biological information about individual fish read both scales and otoliths.

Swept area biomass of each major prey fish species within U.S. waters was calculated from trawl catch per tow (CPE).

$$B_i = \sum_{A=20}^{A=80} W_i A_i$$

where B_i is biomass of a species, W_i represents mean biomass (g · meter^{-2})of a species in trawl catches within each depth stratum, A_i represents the area (m^2) of individual strata. 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. Strata biomass estimates were summed for a lakewide estimate. Strata areas and biomass calculations were revised in 2001 to take advantage of updated bathymetry data and make calculations more consistent between lakes Michigan and Huron (Schaeffer and Adams 2002).

We used 10 m intervals for calculating fish biomass for depth strata between 20 and 80 m because samples within this range were common to all ports, but biomass in shallower and deeper strata was calculated differently. Prey fish biomass from 0-20 m was calculated from mean biomass of all 9 m and 18 m tows while fish biomass from 80 to 110 m was calculated as mean biomass of all 82, 91, and 110 m tows. These classifications were arbitrary, but were supported in three ways: 1) in accounted for differences in the fish community with depth, 2) it reduced effects of sampling depth strata near the edge of a contour interval, and 3) it prevented biomass from being estimated using a single tow within some strata. Depths greater than 110 m were never sampled by our trawl; areal biomass there was assumed to be equal to areal biomass between 80 and 110 m.

Benthic samples were taken at each port during 2001, 2002, and 2003. Three replicate Ponar grabs were made at 27 m, 46 m, and 73 m; representing the shallow, middle, and deepest depths common to all ports in the trawl survey. 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.

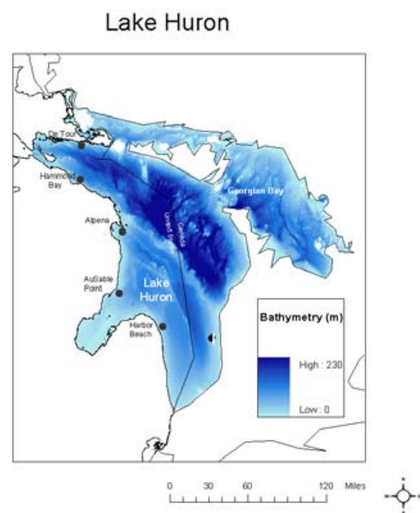

Figure 1. Ports sampled in Lake Huron, 2003.

The 2003 Survey

The 2003 survey was carried out during October 6-23 with six ports sampled (Figure 1). There were no mechanical problems or weather delays. Forty-six of the 48 transects were trawled; trawling could not be carried out at 27-m transects at Alpena and Detour due to commercial fishing gear. The lake remained stratified for all ports with a deep (30-40 m) thermocline present.

Abundance, size, and age structure

Alewife- Alewives *Alosa pseudoharengus* were abundant during 2003, but catches were dominated almost completely by age-0 fish (Figure 2). CPE of age-0 fish was higher than at any time since 1992 (Figure 2). Adult CPE was lower than at any time since 1992, and the 2003 index (49/tow) was less than half the previous lowest value of 112/tow in 1998. (Figure 2).

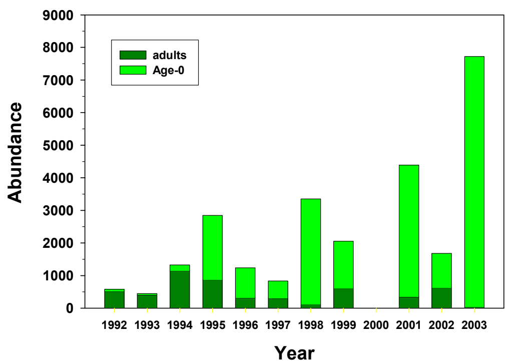

Figure 2. CPE of age-0 and adult alewife, Lake Huron, 1992-2003. Age assignments based on a 100 mm demarcation.

Alewife length distribution reflected high density of age-0 fish, and low numbers of adults (Figure 3). Low numbers of 100-130 mm alewives suggested that the 2002 year class experienced almost complete mortality.

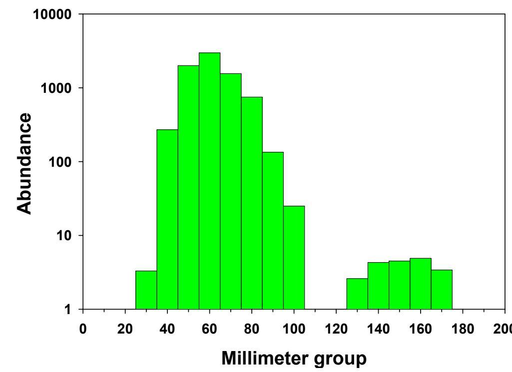

Figure 3. Alewife length frequency, Lake Huron, 2003 based on CPE and length data from all tows. Note $\log_{10}$ scale on Y-axis.

The alewife age structure changed dramatically between 2002 and 2003. During 2002, age-1 through age-5 fish comprised about half the catch. During 2003 trawl catches were dominated almost completely by age-0 fish from the 2003 year class (Figure 4). The loss of adults from previous year classes occurred presumably due to combined high over winter mortality and predation on all older age groups during 2002.

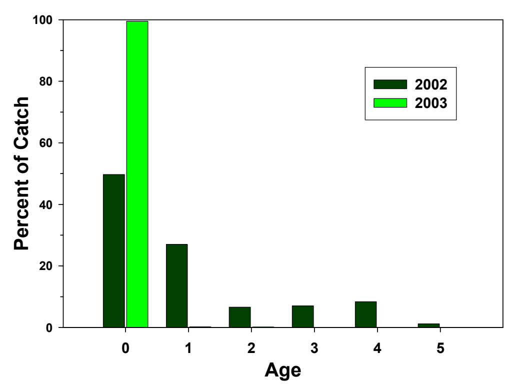

Figure 4. Alewife age structure, Lake Huron, 2003.

Rainbow smelt- Adult rainbow smelt *Osmerus mordax* were at the lowest level of recorded abundance since 1992 (Figure 5) and length frequency of rainbow smelt was truncated; fish greater than 150 mm TL were rare (Figure 6). Low adult abundance was probably a result of poor recruitment during 2001 and 2002 combined with high predation from stocked predators. Age-0 rainbow smelt were abundant; the 2003 year class was the second largest since 1992 (Figure 5). Adult rainbow smelt will continue to remain scarce. Although the 2003 year class appeared strong, the trend during 1998-2003 differs from 1992-1997, when even smaller year classes recruited much better in subsequent years (Figure 5).

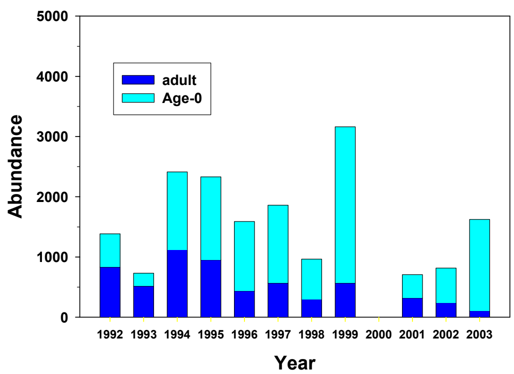

Figure 5. CPE of age-0 and adult rainbow smelt, Lake Huron, 2003. Age assignment based on a 110 mm demarcation.

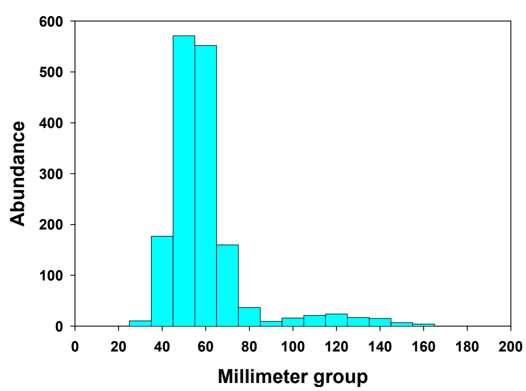

Figure 6. Length frequency distribution of rainbow smelt, Lake Huron, 2003.

<u>Bloater</u>- Adult bloater *Coregonus hoyi* abundance in Lake Huron increased during 2003 (Figure 7) Unusually high numbers of age-0 bloaters captured during 2003 may represent a dominant year class (Figure 7). Juvenile bloaters are pelagic and generally not susceptible to bottom trawls, so their abundance may not be a reliable index of year class strength (Wells 1968). However, age-0 bloaters were captured in every tow, and abundance was higher than any survey since 1992. Bloater length frequencies mirrored high CPE of age-0 fish (Figure 8).

Ageing of both otoliths and scales suggests that annual variation in bloater age structure may be due in part to under-ageing of fish using scales. Ages determined from otoliths tended to be older than those from scales, especially for fish older than age-6. (Figure 9). Otolith ages also suggest that bloaters are longer-lived than previously thought. The oldest individual scale age was age 11, but reading otoliths suggests that a substantial proportion of the population was from 12 to 17 years old (Figure 9).

Analysis of bloater age structure using data from scales suggested decreasing abundance of adults through age-11, while data from otoliths suggested that age-10 through 17 fish comprised a substantial proportion of adults (Figure 10). This study will be replicated by having additional readers perform blind readings during 2004.

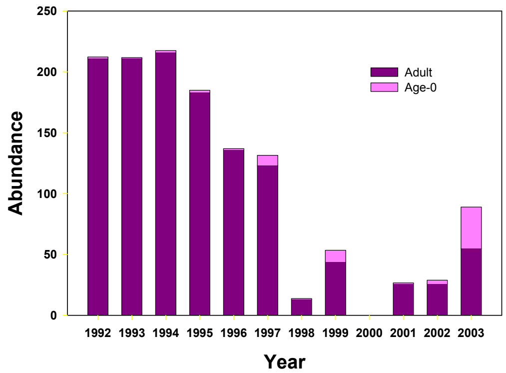

Figure 7. CPE of adult and age-0 bloater, Lake Huron, 1992-2003.

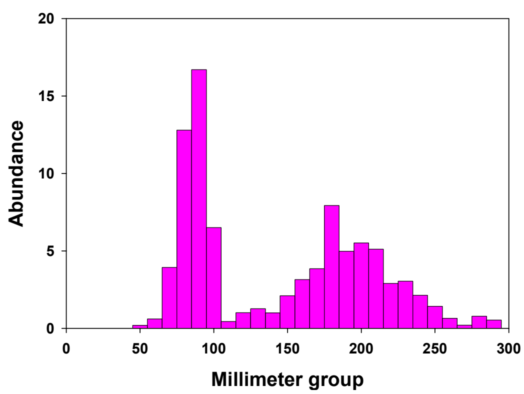

Figure 8. Bloater length frequency, Lake Huron, 2003.

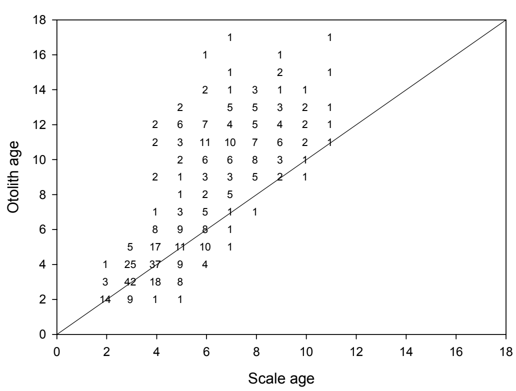

Figure 9. Otolith age versus scale age from 501 Lake Huron bloaters, 2003. Numbers refer to sample sizes of fish in which both structures were examined.

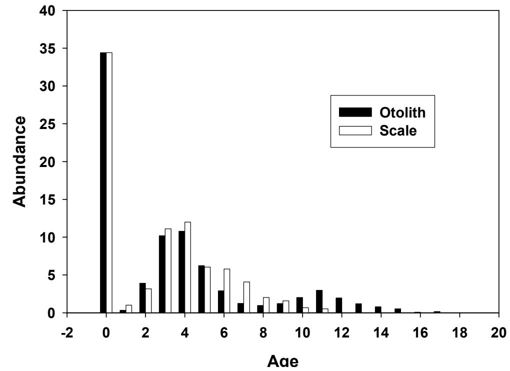

Figure 10. Bloater age structure based on scales and otoliths, Lake Huron, 2003.

Sculpins, sticklebacks, and trout-perch- Sculpin abundance in Lake Huron has been highly variable since 1992, but CPE during 2003 suggests that they have been stable recently at low levels. Deepwater sculpins *Myoxocephalus thompsoni* comprise most of the trawl catch, while slimy sculpins *Cottus cognatus* are only a minor component of the fish community (Figure 11). Overall sculpin abundance during 2003 was below the average value for the time period, and slimy sculpins were virtually absent from the catch.

Abundance of 9-spine sticklebacks *Pungitius pungitius* increased slightly this year (Figure 12), while trout-perch *Percopsis omiscomaycus* continue a steady decline that began in 1995 (Figure 13).

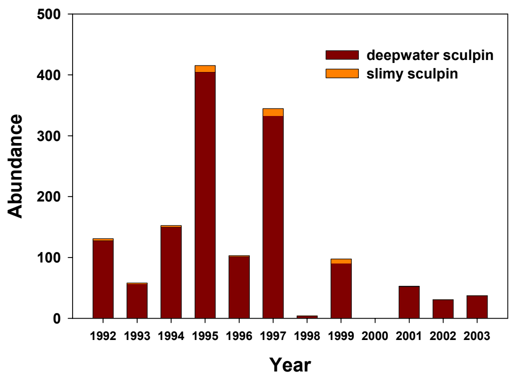

Figure 11. CPE of deepwater and slimy sculpins, Lake Huron, 1992-2003.

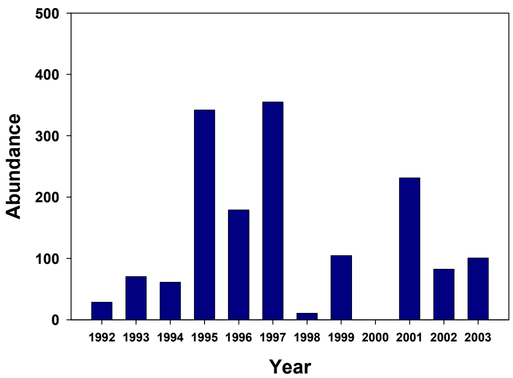

Figure 12. CPE of nine-spine sticklebacks, Lake Huron, 1992-2003.

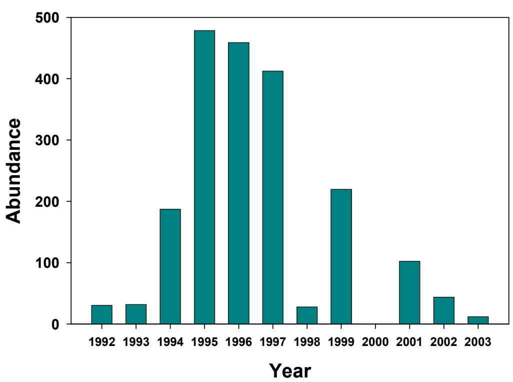

Figure 13. CPE of trout-perch, Lake Huron, 1992-2003.

Round gobies- Round gobies were first encountered in the trawl survey during 1997, and have increased in abundance each year since (Figure 14). Round gobies are now present at Goderich, Harbor Beach, Ausable Point (Tawas), and Alpena, but they have not been collected in the straits.

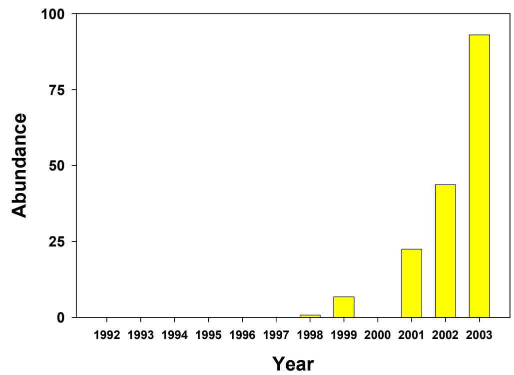

Figure 14. CPE of round gobies, Lake Huron, Fall 2003.

Lake whitefish- CPE of adult lake whitefish *Coregonus clupeaformis* has decreased since the mid-1990s, and this trend continued during 2003 (Figure 15). Assuming that all whitefish less than 200 mm TL were age-0, CPE of juvenile lake whitefish has been consistently low since 1997. Decreased abundance of adult lake whitefish is consistent with lower recruitment since 1997.

Lake trout- Lake trout CPE during fall, 2003 was below the average CPE of 2.3 for the time series, but 8.8 percent of lake trout were unclipped Figure 16). This was well above the expected rate of 4% that occurs due to failure of hatchery lake trout to receive clips, and suggests that at least some wild fish are being produced. Several unclipped individuals we captured were well below normal stocking size and were undoubtedly wild fish. These individuals were preserved for genetic analysis.

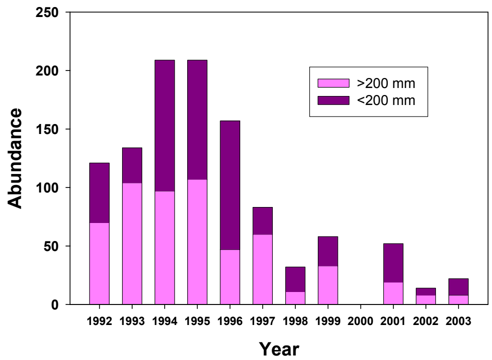

Figure 15. CPE of lake whitefish, Lake Huron, Fall 2003.

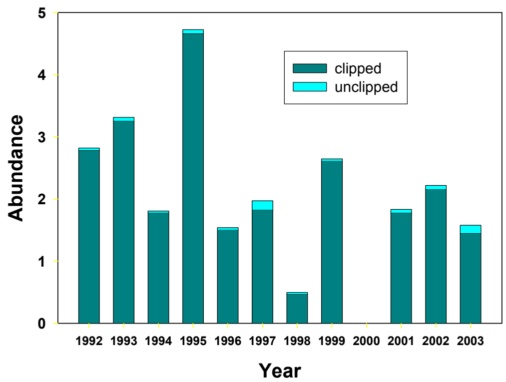

Figure 16. CPE of stocked and unclipped lake trout, Fall 2003.

Biomass Estimates- Biomass estimates for U.S. waters indicate that total prey biomass was higher in 2003 compared with 2002 (Figure 17). Biomass increased for all species but trout-perch, however, most of the increase between 2002 and 2003 was composed of age-0 alewife from the 2003 year class.

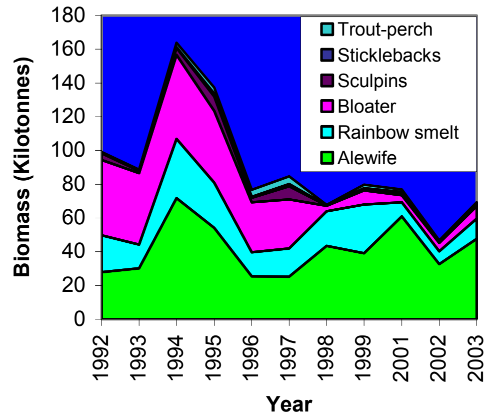

Figure 17. Prey fish community biomass (Kilotonnes), U.S. waters of Lake Huron, 1992-2003.

Benthic invertebrates- Oligochaetes (aquatic annelids), *Diporeia*, chironomids (midge larvae), sphaerid clams, and dreissenids (zebra and quagga mussels) were the most abundant groups (Figure 18). Between 2001 and 2003, abundance of all species except quagga mussels generally declined (Figure 18). But although quagga mussels increased, we still have not observed densities as great as those found in Lake Michigan (Fleischer et al. 2001),

Diporeia was absent at 27 m sites during 2001 through 2003 (Figure 19). At 46 m sites, *Diporeia* density decreased between 2001 and 2002, and increased slightly during 2003, but at 73 m sites there have been steady decreases in all three years (Figure 19).

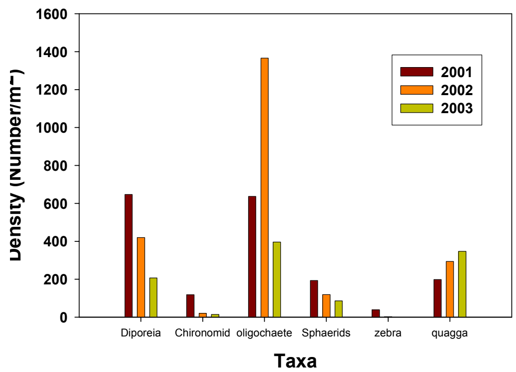

Figure 18. Benthic invertebrate densities, Lake Huron, 2001-2003. All depths pooled.

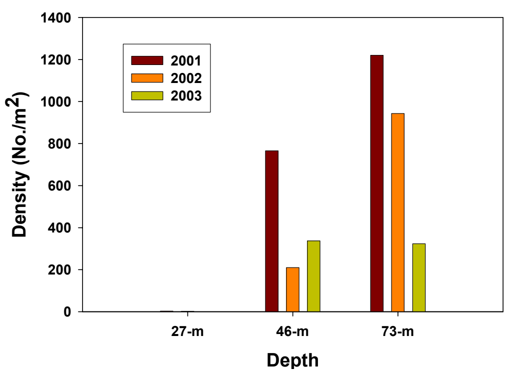

Figure 19. *Diporeia* densities at 27, 46, and 73-m stations, Lake Huron, 2001-2003.

Discussion- The major change in the Lake Huron prey fish community between 2002 and 2003 is the apparent loss of loss of large alewives from the 1998, 1999, and 2001 year classes that formerly dominated the prey fish community. Alewife biomass increased, but it was composed almost entirely of age-0 fish from the 2003 year class.

During 2003, we sampled at Goderich, Ontario and these data were included in the analyses. Inclusion of Goderich influenced results by increasing CPE of both alewife and round goby by about 10 %; this would not have changed our interpretation of abundance trends for either species.

Trawl biomass estimates should be interpreted as a conservative index that integrates growth and abundance. The trawl does not sample the entire water column and pelagic individuals of any species are unlikely to be captured. Catchability undoubtedly varies with size; small fish may not be fully recruited to the gear, while large individuals may be able to avoid the trawl. Furthermore, 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. These factors would all contribute to underestimation of true prey fish biomass.

Rainbow smelt and bloater both produced strong year classes, but most rainbow smelt will probably be too small to serve as prey for large salmonids, and juvenile bloaters are rare compared to other preferred prey. This may force salmonids to rely predominantly on small alewives during 2004, but individuals from this year class had the smallest mean length of any year class since 1992, and the winter of 2003-2004 was of above average severity. Consequently, we expect these individuals to suffer high over winter mortality, and heavy predation may reduce their survival even further (O'Gorman and Schneider 1986). If survival is poor, predators may face outright prey shortages, in addition to potential growth limitation imposed by small prey size. Fisheries managers should anticipate slower predator growth during 2004, even if alewife over winter survival is better than expected.

Our results suggest that *Diporeia* continued to decline sequentially from shallow to deeper depths. *Diporeia* formerly reached high abundance at 27 m (Shrivastava 1974); by the time our sampling began in 2001 it had disappeared at 27 m. *Diporeia* decline occurred at 46 m by 2002, and at 73 m during 2003. *Diporeia* appears to have been replaced by quagga mussels, but the mechanism responsible is not known. This suggests that changes in the benthic community observed in other Great Lakes (Mills et al. 1999) are now happening in lake Huron, and we should anticipate changes in diets, growth, or distribution of fishes as this process continues.

Changes in the prey fish community may be unprecedented in that there has never been a recent time when adult alewife were so scarce. The outcome of this situation will be determined by alewife over winter survival, and the ability of predators to forage on alternate or smaller prey during early 2004.

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