Acoustic Assessment of Pelagic Planktivores, 2007

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Alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*) are the most abundant pelagic planktivores in Lake Ontario, and the most important prey for salmon and trout. Alewife is also important prey for warm water predators, notably walleye, and for Double-crested cormorants. Abundance of alewife and smelt has declined over the past decade, likely due to reduced nutrient loading, proliferation of non-native dreissenid mussels, and the buildup of stocked salmon and trout. In years when alewife and smelt declined, threespine stickleback (*Gasterosteus aculeatus*) became more prominent. These recent observations signal a change in the pelagic fish community.

Concerns for declining numbers of prey fish were addressed by the Ontario Ministry of natural resources (OMNR) and the N.Y.S. Department of Environmental Conservation (NYSDEC) in 1993, when the number of salmonines stocked was reduced to a level that would cut the prey demand by approximately half. Since that time, following public consultation on both sides of the border, stocking levels were moderately increased in 1997. Furthermore since 1997, increased rates of natural reproduction of Chinook salmon have been observed (Bishop et al. 2007). Thus alewife and smelt populations continue to be under intense predatory pressure.

Sound management decisions regarding predator-prey balance require continued monitoring of prey fish populations. Starting in 1991, hydroacoustic surveys to estimate lake-wide abundance of pelagic prey fish have been conducted jointly by the OMNR and the NYSDEC. Information from the hydroacoustic surveys complements information obtained in bottom trawling surveys conducted jointly by NYSDEC and the U.S. Geological Survey (USGS) in the U.S. waters of the lake.

Methods

Before 2005, the surveys followed established transects with only minor yearly modifications due mostly to logistics. This was a practical approach dictated by harbor locations, running time, and limited periods of darkness in the summer. A statistically preferable random-transect design was deemed impractical. In 2005 we modified the fixed transect design to include a random element. Five fixed cross-lake corridors approximately 15 km wide were established (Fig. 1) based on logistical constraints, but within these corridors transects are selected at random. A single east-west offset is randomly chosen, determining the relative position of all transects within their respective corridors, and thus the survey is essentially a systematic survey with a random start. The randomly chosen offset in 2007 was 0.8, meaning that transects were offset 0.8 times the width of the corridors from the western boundaries.

In 2003, the Simrad EY500 120 kHz split beam echosounder was upgraded to a Biosonics DTX 120 kHz split beam. At the same time we switched to new analytical software. Comparisons between the two systems suggested that the new sonar/software combination yielded lower estimates than the previous system (by as much as 30%, but generally less). The potential bias of this magnitude does not substantially alter interpretation of population trends, and therefore the results from the two time periods have been reported without corrections (Schaner and LaPan 2006).

The 2007 hydroacoustic survey was conducted from August 14 to August 26, and consisted of 4 cross-lake transects and an Eastern Basin transect (Figure 1). The survey period began several weeks later than usual because the dark-moon phase in July conflicted with other surveys, and in August, bad weather (i.e., strong southwest winds) delayed the survey one week, forcing modification of one transect and elimination of another to complete the survey. Each night, sampling began approximately one hour after sunset at the 10 m depth contour on one side, and continued across the lake to the 10 m depth contour on the other side. Sampling was completed one hour before sunrise or earlier. Acoustic data were collected along transects using a Biosonics DTX 120 kHz split beam echosounder. A temperature profile was measured at several points along each transect.

Raw acoustic data were stratified based on thermal layer, bottom depth and geographical zone. The data were processed with Echoview software by Sonardata (version 4.2), using -64 dB volume backscattering strength and target strength thresholds. The resulting scaled integrated voltage estimates of total target abundance were split into 3 dB target strength (TS) bins according to results of single-target analysis. The abundances of yearling and older fish (YAO) were apportioned from the resulting target strength histograms by fitting binomial curves to the three modes of the histogram, and then calculating the proportions of each curve relative to the total target strength frequency distribution. In the upper layer (epilimnion plus metalimnion) the histograms were processed to identify the proportions of targets in the mode at or below -35 dB, which were assumed to be YAO alewife. In the lower layer (hypolimnion) all targets larger than -55 dB were assumed to be YAO smelt.

During the hydroacoustic survey, trawling is also done to assess biological attributes of fish. On four nights during the 2007 survey, six tows were made with a midwater trawl (613 ft^2, 57 m^2). Each tow sampled up to four depths obliquely ranging from 5 to 40 m over an average distance of 6 km per tow (20 minutes per depth at 3 kts trawl speed). Average masses of alewife and smelt were calculated based on trawl catches. To account for the differences in the proportion of yearlings and adults caught, all means are weighted by catch per unit effort.

Results and discussion

Alewife

The 2007 midsummer acoustic estimate of yearling and older (YAO) alewife was 62 million fish. Using catch per unit effort (CUE)-weighted average mass of alewife (26.5 g), total estimated biomass in Lake Ontario was 1,647 metric tons (Figure 2).

The 2007 abundance and biomass of YAO alewife declined from 2006, and the values are the lowest numbers on record for the acoustic survey time series. The abundance and biomass are 13% and 15% respectively of the 10-year averages, and 93% and 94% below the 10-year maximum values.

Similar to the results of the spring alewife survey (see O'Gorman et al. 2008), trawl catches during the acoustic survey were dominated by one size class (i.e. 2 year olds), and yearlings were relatively absent. The small yearling population may explain the apparent shift in the acoustic target strength distribution observed during our analyses. The mode of the target strength histogram shifted approximately +5dB from 2006 to 2007, indicating a change from a population dominated by small alewife to one dominated by larger fish. Unlike other years, young-of-the-year alewives were present in our trawl catches in 2007. This is because the survey was conducted in August rather than July when YOY alewife begin moving offshore, however, acoustic results did not include fish in this size class.

The large decline in YAO alewife can be attributed to a weak 2006 year class, and an adult population dominated by 2-year old fish. Unlike the strong 1998 year class which increased and sustained alewife numbers for four years, the relatively large 2005 year class was apparently not large enough to substantially increase adult alewife abundance in 2007.

Rainbow smelt

The 2007 midsummer acoustic estimate of YAO smelt in Lake Ontario was 146 million fish (Figure 3). Using CUE-weighted average mass of YAO smelt (9.85 grams), the total biomass estimate of smelt in Lake Ontario was 1,434 metric tons.

The abundance of YAO smelt was the 4th lowest value in the 11-year survey, only 15% higher than 2006, and 90% below the maximum value recorded in 1997 when the survey began. The average size of smelt captured in trawls declined from 12.3 to 9.9 grams. This value, however, is based only on 60 fish captured, so the YAO smelt biomass estimate should be viewed with some skepticism. Total YAO smelt biomass declined by 9% compared to 2006. Abundance and biomass were 34% and 48% below the long term averages, respectively.

Rainbow smelt abundance steadily declined from 1997-2004. It briefly increased in 2005 after a relatively good year class in 2003, and then continued declining in 2006. Although abundance in 2007 increased slightly, overall smelt biomass declined because there were fewer large fish present in the population. The average mass of a smelt caught in our trawls declined by 3 grams. The spring bottom trawling survey also reported a decline in large smelt (>150mm TL) which made up less than 2.5% of the population in 2006 and 2007 and reported a decline in the overall weight index (Walsh et al. 2008). The acoustic survey recorded low catches of yearling-sized smelt in trawls, suggesting a weak 2006 year class. Similarly, the spring index of Age-1 fish was very low.

There was one apparent contradiction between the results of the spring index and the summer acoustic survey. The spring abundance index declined from 2006-2007, whereas the acoustic abundance estimate increased by 15%. Given the error associated with each estimation technique, and the low abundance levels observed in each survey, 2006 values are not statistically different from 2007, however, it is still possible to conclude that the smelt population is at or near an all-time low. With several successive years of weak reproductive output, few large fish and low spawner abundance, the future of the smelt population in Lake Ontario remains uncertain.

Threespine stickleback

The abundance of threespine stickleback is monitored in midwater trawl catches during the acoustic survey every year. In 2007, the CUE of sticklebacks was a record low (0.007 fish per 100m) compared to the long-term mean of 5.6 fish per 100m (Figure 4). Stickleback were caught in only 26% of the trawls, when in most years at least 60% of the trawls contain these fish. Usually the catch includes two size classes (~30mm and 60mm), however, in 2006 we caught only fish in the larger size class, suggesting a weak year class of stickleback in 2005. Conversely in 2007, catches contained only stickleback in the smaller size category, and at very low levels. Apparently the weak 2005 year class produced very few adults and subsequently a weak 2006 year class. The low catches of ~30mm stickleback suggest that the stickleback population will remain low in 2008.

From 1993-2004, threespine stickleback populations appeared to be experiencing a rebound. The conventional thought was that stickleback populations were suppressed by high alewife and smelt populations, and in years when alewife and smelt declined, threespine stickleback became more prominent. Since 2004, however, stickleback CUE has declined in our catches, and the data indicate very low reproduction in the last 2 years. Yet, alewife and smelt populations remain very low.

Stickleback spawn in the nearshore during spring and exhibit very interesting nest-building behavior. Since 2003, the round goby (*Neogobius melanostoma*) population has expanded exponentially and are now found along the entire south shore of Lake Ontario (Walsh et al. 2008a). They occupy the profundal zone to depths of at least 140m from October-April and then move to shallower depths during spring. Round gobies are also nest builders, are very territorial and have been shown to interfere with other nest builders leading to recruitment failure (Jansen and Jude 2001). Perhaps the round goby is impacting stickleback reproduction as well. The disappearance of sticklebacks from our catches would coincide with increased catches of goby in other surveys (Walsh et al. 2008a).

Little is currently known about stickleback in Lake Ontario, and no survey is currently designed to effectively index this species. Trawling during the acoustic survey may provide a glimpse into the population dynamics of threespine stickleback, however, increased effort is required to provide reasonable error bounds around mean catches, especially for low populations with patchy distributions.

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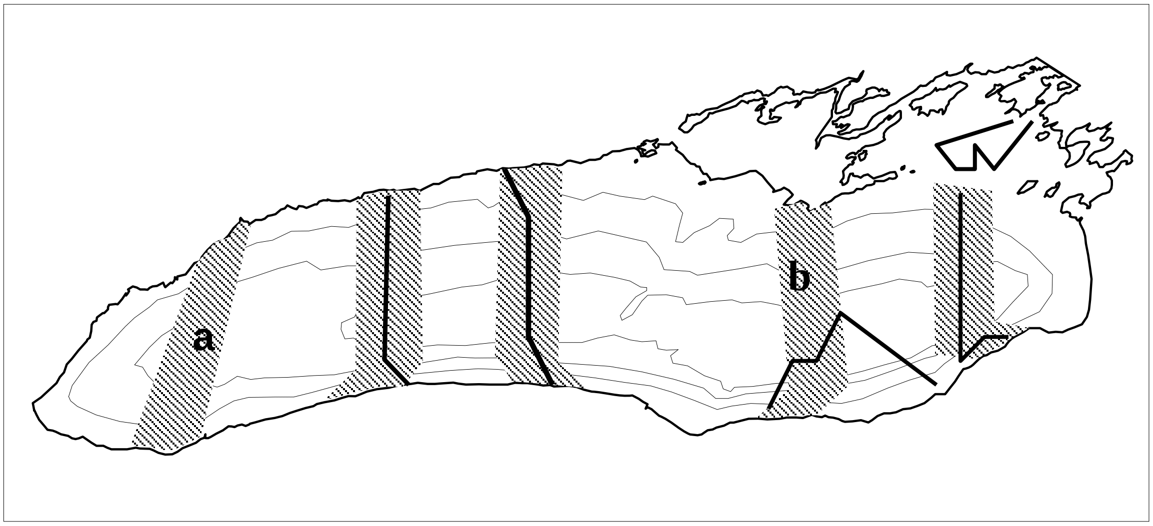

FIGURE 1. Transects surveyed in the 2007 hydroacoustic survey. Also shown are sampling corridors established in 2005, from which transects in the main lake are randomly chosen. Deviations from the corridors in 2007 had to be modified due to bad weather: one corridor (a) was not sampled and another transect (b) was modified.

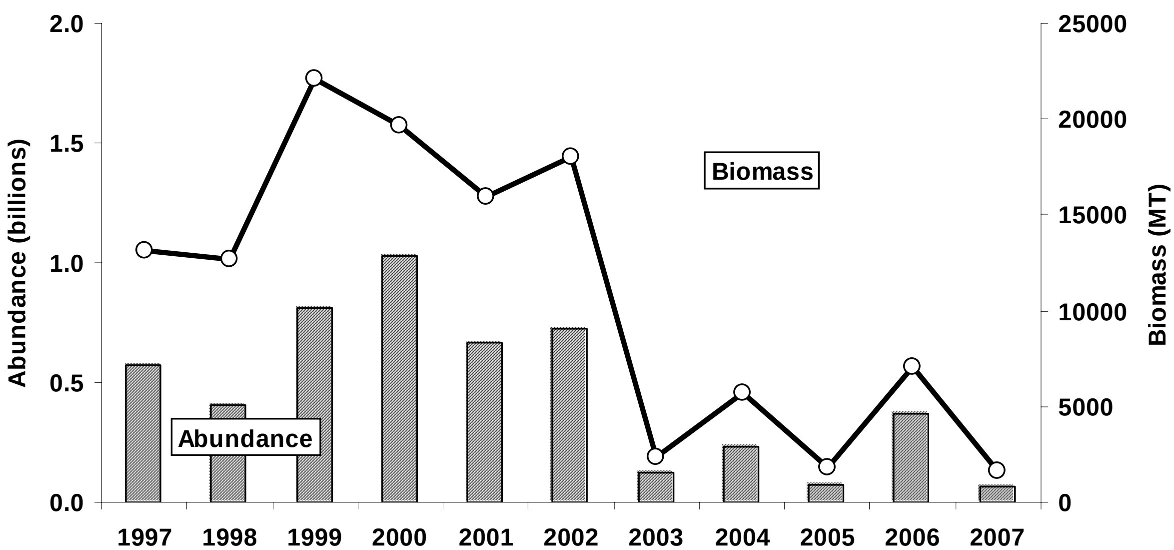

FIGURE 2. Abundance and biomass of yearling-and-older alewife from 1997-2007. Abundance estimates were obtained directly from hydroacoustic surveys, biomass estimates were obtained by applying average weights measured in midwater trawls to abundance estimates. Average weights used in biomass calculations in 2002, 2004 and 2005 were based on pooled data from other years. Note an error in the 2006 abundance and biomass estimate was also corrected (see Connerton and Schaner 2007).

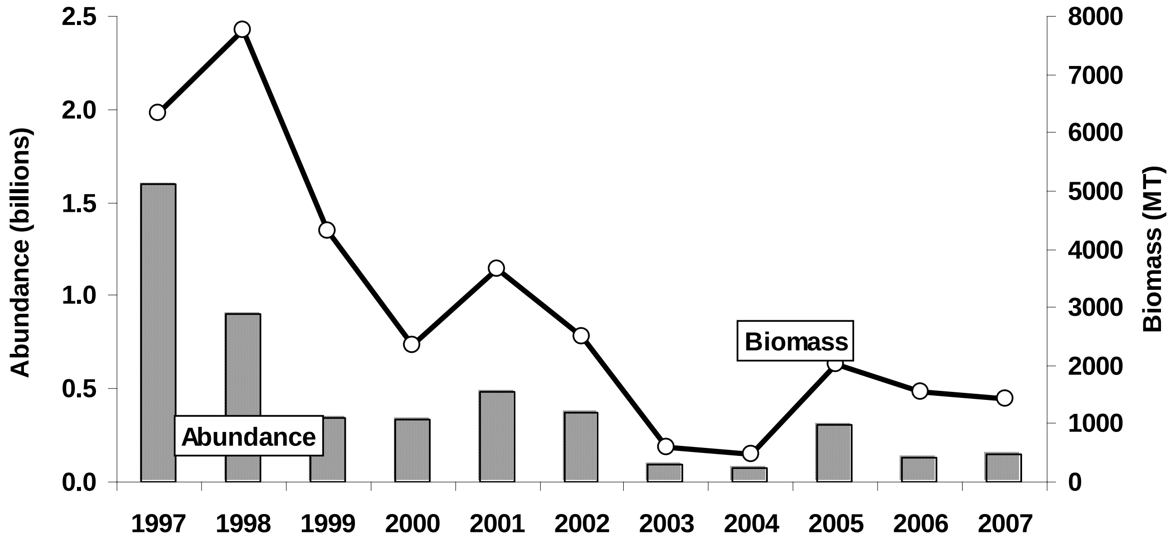

FIGURE 3. Abundance and biomass of yearling-and-older rainbow smelt from 1997-2007. Abundance estimates were obtained directly from hydroacoustic surveys, biomass estimates were obtained by applying average weights measured in midwater trawls to hydroacoustic abundance estimates. Average weights used in biomass calculations in 2002 through 2005 were based on pooled data from other years.

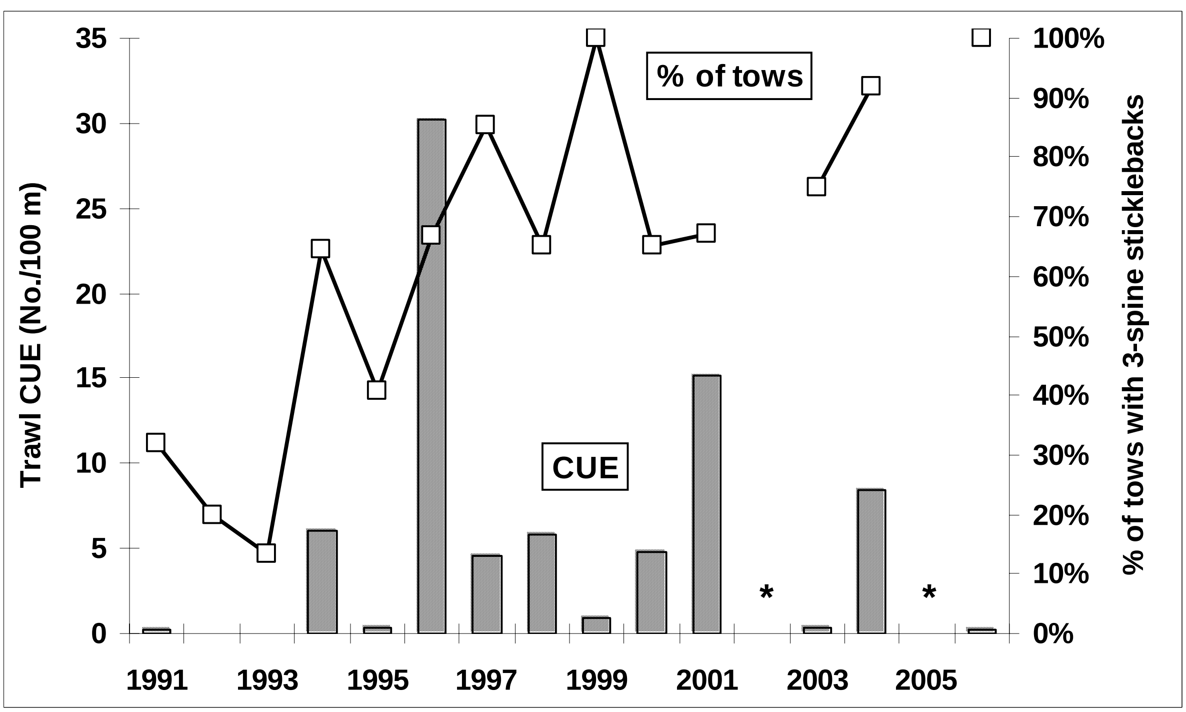

FIGURE 4. Catches of threespine sticklebacks in midwater trawls conducted during the summer of 1991-2007 hydroacoustic surveys. Bars represent yearly catch per unit effort; lines show proportion of tows containing sticklebacks. * No midwater trawls were done in 2002 and 2005.