STATUS OF MAJOR PREY FISH STOCKS IN THE U.S. WATERS OF LAKE ONTARIO, 2004

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Abstract

We began a comprehensive re-analysis of our bottom trawl assessments, conducted annually since 1978, with a re-evaluation of the alewife Alosa pseudoharengus *assessment. Although, the re-evaluation resulted in numerous changes to the calculation of alewife abundance, the new indices showed the same trends as the historical indices (Spearman rank correlation,* $P < 0.0001$, $r \geq 0.95$). *Numerical and weight abundance indices for adult (age-2 and older) alewives in U.S. waters of Lake Ontario during spring 2004 were similar to those in spring 2002-2003 and were well below the long-term averages. The numerical abundance index for yearling alewives (2003 year class) was about 25% smaller in 2004 than in 2002-2003 and was below the long-term average for the fourth consecutive year. Wet weight condition of adult alewife in fall 2004 was higher than in any year since 1980 suggesting that the alewife population was more in balance with the productive capacity of the lake in 2004 than in any of the previous 23 years. Numerical and weight abundance indices for age-1 and older rainbow smelt* Osmerus mordax *in 2004 were markedly higher than the record lows recorded in 2003. The increase was due entirely to a strong 2003 year class and not to a decrease in mortality rates of adult rainbow smelt -- age-2 and older smelt remain scarce. We have lost the ability to track abundance of slimy sculpin* Cottus cognatus *along the south shore -- dreissenid numbers now preclude towing the trawl gear historically used to assess sculpins, and trawling with other gear produced inconsistent results. One deepwater sculpin* Myoxocephalus thompsonii *was collected in spring 2004.*

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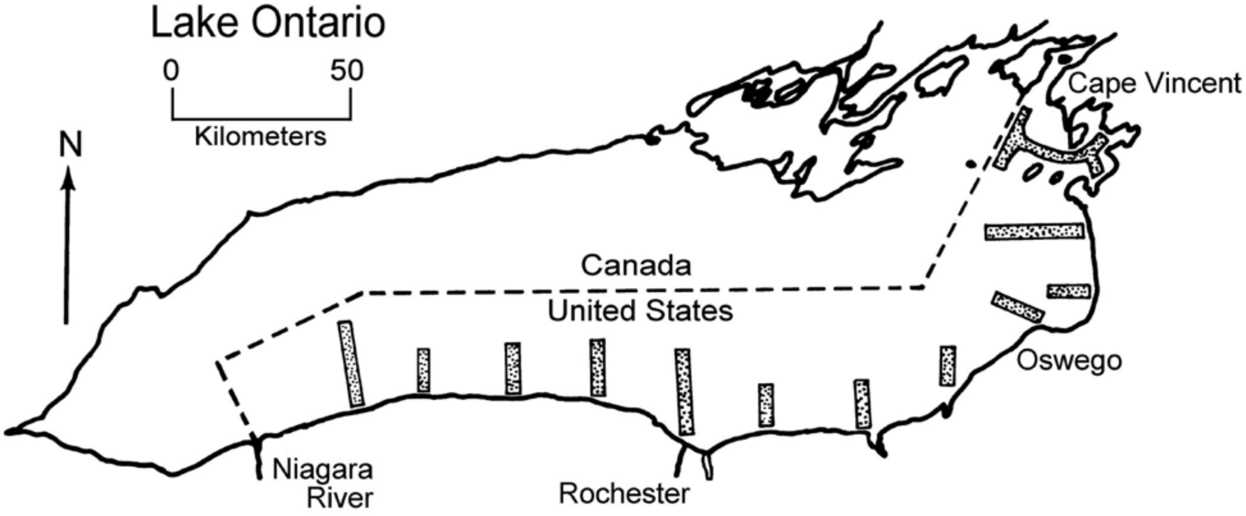

Figure 1. – Lake Ontario showing 12 areas sampled with bottom trawls.

Introduction

The U.S. Geological Survey (USGS) and New York State Department of Environmental Conservation (NYSDEC) have cooperatively assessed Lake Ontario prey fishes each year since 1978. Bottom trawling has been conducted during spring, summer, and fall to assess alewives *Alosa pseudoharengus,* rainbow smelt *Osmerus mordax*, and slimy sculpins *Cottus cognatus*. Timing of the surveys was selected to correspond with the season when bottom trawl catches of the target species peaked during May to October trawling conducted in 1972. Twelve transects were established at roughly 25-km intervals along the U.S. shoreline (Figure 1). Bottom trawling was generally conducted at all 12 transects in spring to assess alewives, at 11 transects in summer to assess rainbow smelt, and at 6 transects in fall to assess slimy sculpins. At each transect, trawl hauls were usually made at 10-m depth intervals through the range of depths occupied by the target species. Fixed station sampling designs, such as ours, are commonly used for assessing fish populations in the Great Lakes and in northern Europe (ICES 2004). The underlying assumption is that changes in relative abundance at the fixed stations are representative of changes in the whole population. Mean abundance from fixed station surveys will not be biased if the fish are randomly distributed. We have always assumed that the fish are randomly distributed in the geographic area in which a transect is located and, because we have numerous transects spaced at regular intervals around the shore, that our abundance indices are unbiased. However, not until 2004 did we initiate acoustic sampling to test the assumption of random distribution within geographic areas (see below). If the fish are not randomly distributed within geographic areas, mean abundance will be biased, although if the non-random pattern of fish distribution persists through time the differences in mean abundance between years will be unbiased (Warren in ICES 1992). Although random sampling is preferable for estimating precision, the systematic, fixed-station sampling that we employ in Lake Ontario will often be optimal for getting the most precise estimate of relative abundance even though the variance of the estimated relative abundance will be biased (ICES 2004).

Two vessels participated in prey fish surveys during 1978-1982, the 19.8-m, steel hull R/V *Kaho* (USGS) and the 12.8-m, fiberglass hull R/V *Seth Green* (NYSDEC). During 1983-1985, all assessment trawling was conducted by the *Kaho* (the fiberglass *Seth Green* was permanently retired in fall 1982). In 1985, the NYSDEC accepted delivery of a new R/V *Seth Green* and this 14-m, steel hull vessel participated with the *Kaho* in prey fish surveys during 1986-2002 and in 2004. Because of personnel shortages within the NYSDEC, only the *Kaho* was used to assess prey fish stocks in 2003. Intercalibration studies were conducted to determine if fishing power of the *Kaho* differed from that of either *Seth Green* (see below).

A 12-m (39-ft, headrope) bottom trawl and flat, rectangular trawl doors were used for assessment fishing until 1997 when fouling by dreissenids forced a change to a 3-in-1 trawl (18-m/59-ft headrope) and slotted, cambered V-doors. We made a series of paired tows to determine calibration factors for the two gears to allow comparison of alewife and rainbow smelt catches made by the new gear with those made by our traditional trawling gear. However, up until 2004, we continued to use the traditional trawling gear to assess slimy sculpins in those areas (mainly in deep water) where dreissenid density was sufficiently low to allow us to trawl unimpeded. In 2004, the 3-in-1 trawl was used to assess slimy sculpins because increased dreissenid density in deeper water had greatly reduced not only the number of depths where we could tow a trawl but also the amount of time we could tow at most depths.

In 2004, the number of trawl hauls made for assessment of alewives, rainbow smelt, and slimy sculpins totaled 243 – 118 during April 20-May 8, 93 during June 1-June 10, and 32 during October 8-25. The number of trawl tows made to assess alewives was the largest since 1993 despite the fact that the population can now be indexed more reliably with fewer trawl hauls than in the past because the geographic and bathymetric distribution of alewives narrowed after dreissenids colonized the lake in the early 1990s (O'Gorman et al. 2000). Alewives are no longer found off the eastern shore in spring and off the south shore, they now concentrate in a narrow depth range. Trawling effort during the rainbow smelt assessment was similar to that in recent years whereas effort during the slimy sculpin assessment was lower than that in most recent years.

Re-analysis of the Alewife Assessment

An independent peer review of the USGS-NYSDEC bottom trawling assessments of prey fishes (primarily alewife) conducted in fall 2003 found that the assessments provided reliable indices of trends in relative abundance and suggested a number of strategies for improving assessment design and data analysis (New York Sea Grant 2004). In response to this review, we began a re-analysis of the alewife assessment and plan on initiating similar re-analyses of other assessments in the near future. The reviewers also suggested using acoustics to examine fish distribution during the alewife assessment to test whether fish are concentrated near bottom and homogenously distributed in the areas between the transects. We initiated acoustic sampling during the 2004 alewife assessment. We also extended sampling to greater depths (170 m / 558 ft) but have not as yet incorporated catches made there into the index calculations.

We began our review of the alewife assessment by building, and verifying, an electronic file of all trawl catches made during the alewife assessments conducted during 1978-2004. A single electronic catch file for the survey was not previously available. Since the mid 1980s, yearly abundance indices were calculated by use of a spreadsheet and prior to that by use of hand calculators. Next we revisited the validity of using fishing power correction factors (FPC) to account for changes in survey vessels and gear, redrew the sampling frame and strata, and recast rules for adding zero catches (see below). Finally, we recalculated alewife abundance indices and compared the new indices to the old indices by use of the Spearman rank correlation.

Fishing Power Correction Factor for Vessel and Gear

A FPC has been applied to alewife catches made by the steel *Seth Green* based on the results of about 50 paired tows with the *Kaho* during 1985-1989 -- t-tests of the differences in log transformed catches indicated marginally significantly larger catches of yearling (P = 0.07) and adult alewives (P = 0.12) by the *Seth Green*.

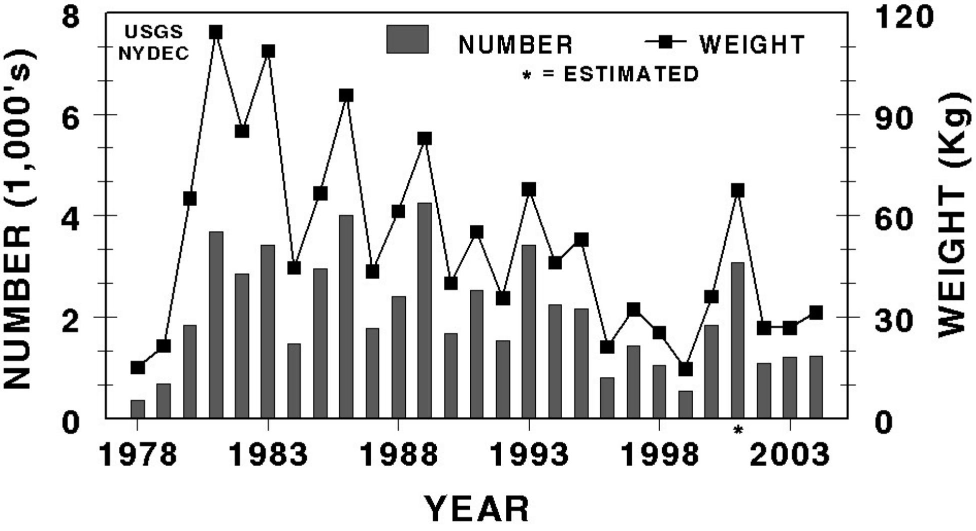

Figure 2. – Stratified mean catch of adult alewives (age-2 and older) with bottom trawls in U.S. waters of Lake Ontario shoreward of the 160-m (525 ft) bottom contour in late April-early May, 1978-2004. Mean catch in 2001 was estimated from bottom trawl catches in June 2001. For weight indices, 1kg =2.2 lb.

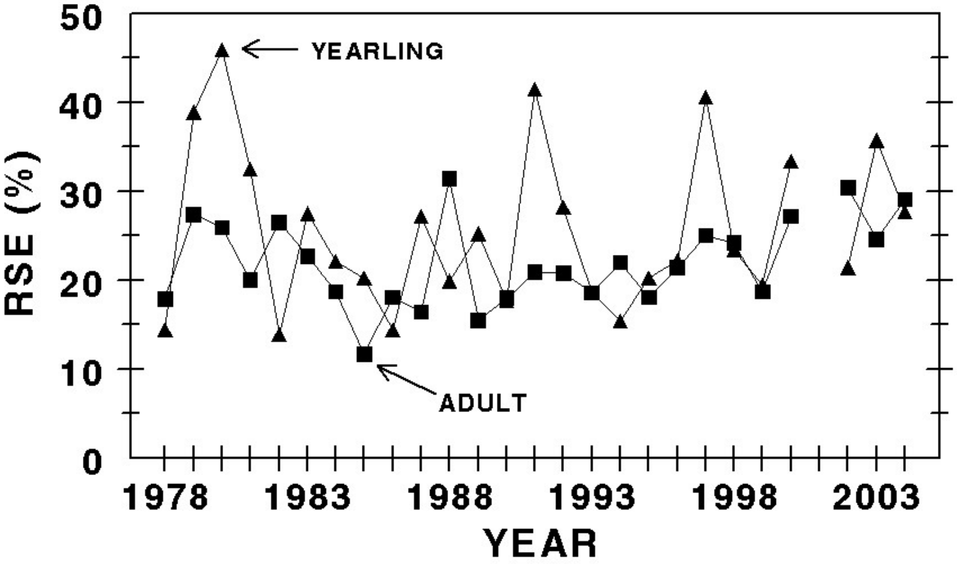

Figure 3. – Relative standard error (RSE) for yearling and adult alewife abundance indices in U.S. waters of Lake Ontario, 1978-2004. The RSE (RSE = 100%*{standard error of the index/the index})is a measure of variability in abundance indices.

Munro (1998) developed a decision rule for applying FPCs to trawl survey data. The objective was to balance the trade-off between the reduction in bias and the increase in variance that comes with applying correction factors. Recently, a new decision rule (Adams and O'Gorman, in prep.) was developed based on improvements made to the one proposed by Munro (1998). The new decision rule is based on the root mean square error (RMSE) of a change in catch rate (e.g., a change in abundance from one year to the next), which can be fixed in a simulation. The RMSEs of the estimated change are estimated separately for each of three options: (1) no correction factor applied to either vessel, (2) a correction factor applied to vessel A, and (3) a correction factor applied to the vessel B. If the RMSE of the estimated change in catch rate is smaller when a correction factor is applied regardless of vessel (2 and 3) than when no correction factor is applied (1), then, and only then, is a FPC recommended. The RMSEs are calculated from simulated data, based on observed distributions of catch in paired trawl hauls, over a wide range of fishing power differences. Using this method, we found that the FPC for alewife calculated from the side-by-side trawling fell within the range that would not reduce error in tracking catch rates over time and concluded that a FPC was not needed for the steel *Seth Green*.

A FPC was never applied to catches made by the fiberglass *Seth Green*, indeed, there was never a rigorous analysis of 17 paired tows conducted with the *Kaho* in 1980. We again used the Adams and O'Gorman (in prep.) modification of the Munro (1998) decision rule to evaluate if it would be appropriate to apply a FPC to alewife catches and found that a FPC was not needed for the fiberglass *Seth Green*.

To maintain continuity of our trawling data sets, we had applied a FPC to catches made with the 3-in-1 trawl during 1997-2003. Because there appeared to be a relation between the fishing power of the two gears and depth, the correction factor was based on a linear regression of the difference in log transformed catches with depth. Catch data were from paired tows conducted during 1995-1998 using two vessels, the *Kaho* and steel *Seth Green*. In the reanalysis, to keep the FPC model as simple as possible, we searched for a single depth cut off to be used for both life stages of alewife based on all possible pair-wise ratios of log transformed catches. To reduce the effects of extreme ratios (caused by occasional zero or very high catches), we minimized the median absolute deviation, $\text{median}|x_i - \text{median}(x_i)|$, of the ratio (rather than the sums of squares). The depth cut off that minimized the median absolute deviation was 91.5 m (300 ft).

Fishing power corrections for each gear were estimated for each alewife life stage and depth zone separately (<91.5 m and >91.5 m). Vessel effects were ignored in this analysis because previous analyses of the two vessels pulling the same 12-m trawl indicated that fishing power differed little between the two vessels. We used the Adams and O'Gorman (in prep.) modification of the Munro (1998) decision rule to determine whether the estimated FPCs for gear should be applied. Measurement variability of both yearling and adult alewives was high at depths <91.5 m (300 ft), contributing to the decision not to apply the FPC to alewife catches made at those depths. Measurement variability was much lower at depths >91.5 m (300 ft) and the decision rule indicated that a FPC should be applied to alewife catches at these depths.

Recalculation of Alewife Abundance Indices

Indices of alewife abundance are simply stratified, weighted mean catch per tow.

$$\sum \frac{\overline{Y}_h N_h}{N}$$

Where $\overline{Y_h}$ is the mean catch in either numbers or kg per 10-min tow in the *h*th stratum, N_h is the number of hectares in the *h*th stratum, and N is the total number of hectares in the sampling frame. Historically, the strata were depth intervals, six 20-m (66 ft) strata from shore to the 120-m (394 ft) contour (47% of U.S. waters) and one stratum encompassing the area in U.S. waters beyond the 120-m (394 ft) contour (53% of U.S. waters). About 33% of U.S. waters are >160 m (525 ft) deep and yet trawling was rarely conducted at depths >160 m. Therefore, when recalculating alewife abundance indices, we defined the outer limit of the sampling frame as the 160-m (525 ft) contour and divided the area between shore and that contour into eight, 20-m (66 ft) depth strata. Survey precision is reported as the relative standard error (RSE); 100%* standard error of the index / index.

In the early 1980s, as the alewife population rebounded from the 1976-1977 winter die-off, the time required to handle large trawl catches made fishing all possible depths at a transect problematic. In general, we adopted the practice of always fishing at mid-depths, where catches were consistently high, and at the shoreward end of the distribution, terminating fishing after a catch of 50 or fewer alewives, assuming a catch of zero at shallower depths that would have been fished if time allowed. When shallower depths occasionally were sampled after a catch of less than 50 to check this assumption, catches were small and contributed little to the total abundance estimate (O'Gorman and Schneider 1986). After the dreissenid mediated shift of alewives to deeper water in 1994 (O'Gorman et al. 2000), we reduced sampling effort at depths <40 m (131 ft) and abandoned the use of assuming a catch of zero at standard sampling depths that were not fished after a catch of 50 or fewer alewives.

In summary, when recalculating alewife abundance indices, we increased the number of strata from seven to eight, reduced the total area within the sampling frame by 33%, abandoned the zero catch assumption from 1994 onward, dropped the FPC for the steel *Seth Green*, did not include a FPC for the fiberglass *Seth Green*, and used a FPC to account for the 1997 gear change only for catches at depths >91.5 m (300 ft). The recalculated alewife abundance indices for numbers and weight mirrored the historical indices for yearlings (Spearman rank correlations; P's < 0.0001, r's = 0.98) and adults (Spearman rank correlations, P's < 0.0001, r's > 0.95).

Acoustic Evaluation of Fish Distribution in Spring

To evaluate the distribution of fish during the alewife assessment, hydroacoustic data were collected from the *Seth Green* along four parallel tracks running perpendicular to shore, to the 160-m (525 ft) bottom contour, off Rochester, NY on April 21, 2004 while the *Kaho* was bottom trawling. The area sampled with hydroacoustics corresponded to the area sampled with bottom trawls. Scheduled hydroacoustic evaluation of fish distribution between bottom trawling transects was thwarted by equipment malfunction. The acoustic data were collected with a Biosonics DT-X 120 kHz split-beam echosounder, and analyzed with SonarData Echoview software. Estimates of targets were stratified vertically along the path of the acoustic track into three layers – within 3 m (10 ft) of bottom, 3 to 10 m (10 to 33 ft) above bottom, and >10 m (33 ft) above bottom and <5 m (16 ft) from surface. Maximum vertical opening of our bottom trawl was 3.25 to 3.75 m (10 to 12 ft) at those depths where alewives were abundant.

Within 3 m (10 ft) of bottom at depths <80 m (262 ft), acoustic sampling showed a concentration of -55 to -45 dB targets, too small to be alewives, and few targets of alewife size. Bottom trawl catches at <80 m (262 ft) were dominated by threespine stickleback *Gasterosteus aculeatus*; rainbow smelt and alewives were rare. At depths >80 m (262 ft), acoustics detected a concentration of -50 to -35 dB targets some of which could be alewives. Bottom trawl catches were dominated by rainbow smelt at 85 m (279 ft) and alewives at 95 to 150 m (312 to 492 ft).

From 3 to 10 m (10 to 33 ft) above bottom, there were relatively few acoustic targets and no targets with a strength corresponding to that of alewife. In the large volume extending from 10 m (33 ft) above bottom to within 5 m (16 ft) of the surface, targets smaller than alewife were prominent above bottom depths of 20 to 40 m (66 to 131 ft) and decreased markedly beyond the 80-m (262 ft) bottom contour. In sum, acoustic sampling failed to detect large numbers of fish with target strengths corresponding to that of alewife above the zone sampled with the bottom trawl and where acoustics detected near bottom concentrations of fish with signal strengths similar to alewife, bottom trawl catches were dominated by rainbow smelt or alewives.

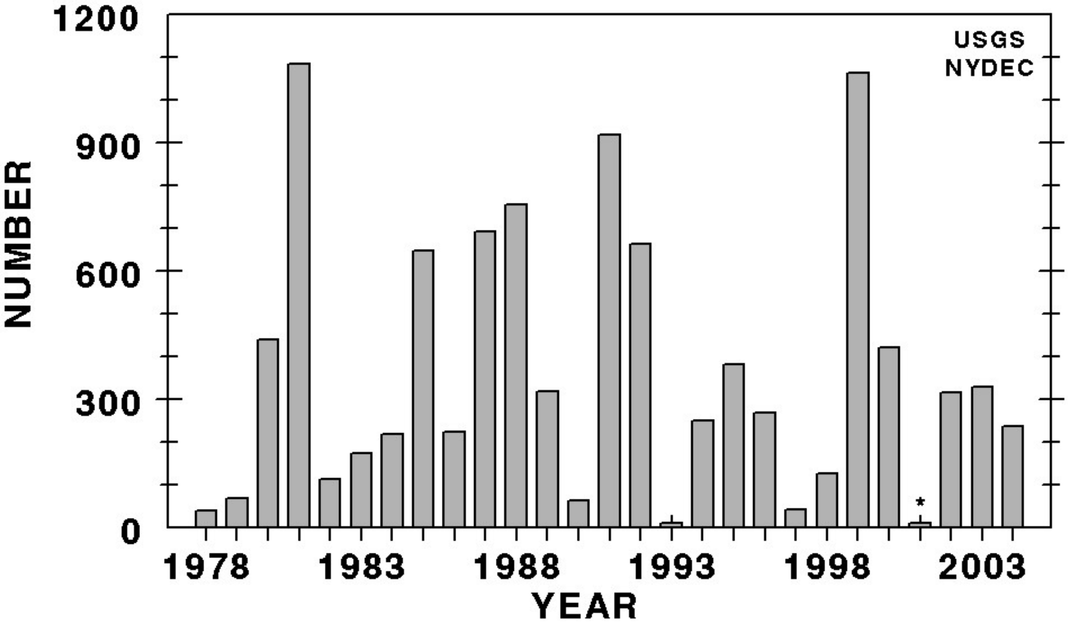

Figure 4. – Stratified mean catch of yearling alewives with bottom trawls in U.S. waters of Lake Ontario shoreward of the 160-m (525 ft) bottom contour in late April-early May, 1978-2004. Mean catch in 2001 (*) was estimated from bottom trawl catches in June 2001.

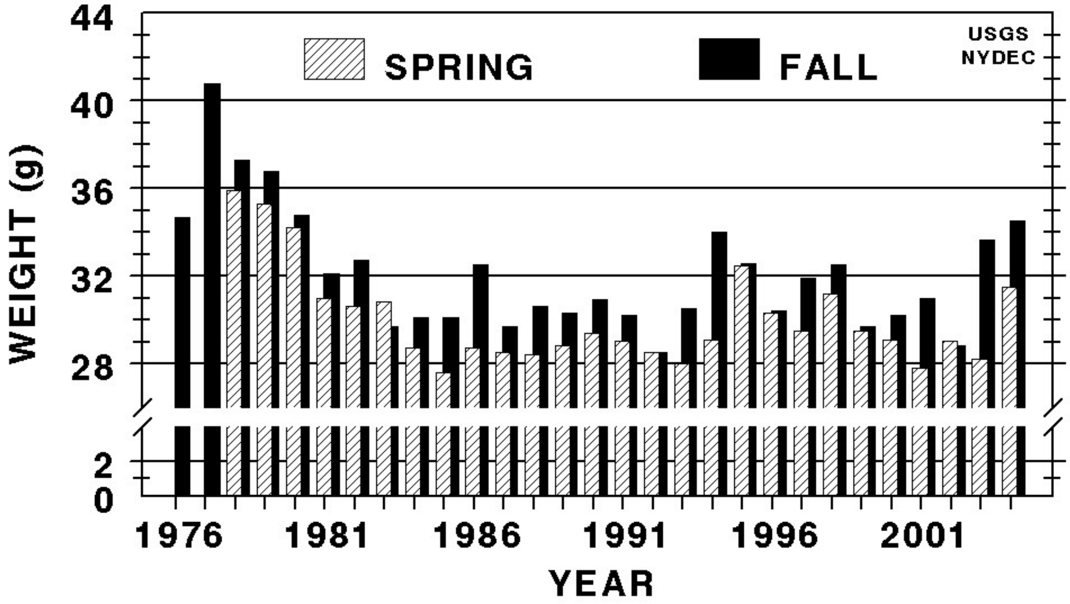

Figure 5. – Wet weight of a 165-mm (6.5 in) alewife (predicted from annual length-weight regressions) in spring and fall, Lake Ontario, 1976-2004. 1 gram = 0.035 ounce.

Alewife

The numerical index of abundance for adult alewives (age 2 and older) in U.S. waters of Lake Ontario in April-May 2004 was similar to that in 2003 whereas the weight index of abundance was 16% higher than that in 2003 (Figure 2). The 2004 weight index was about double the record low of 1999, about one quarter of the record high of 1981, and about 40% less than the long term mean. Relative standard error of the 2004 adult abundance indices was 29%, which was not only above average but also the third highest RSE on record (Figure 3). Age-3 fish made up 38% of the adult catch, age-5 fish made up 22%, and age-2 and age-6 fish (from the record 1998 year class) each made up 18% of the catch.

The numerical abundance index for age-1 alewives (2003 year class) in U.S. waters in spring 2004 was about 25% lower than numerical indices for the two previous years and about 35% below the long term average (Figure 4). Although yearling alewives are not fully recruited to our sampling gear, we consider the yearling abundance index a rough indicator of year class strength because the indices are correlated with the catch rates of the same year class at age 2 (Spearman rank correlation, $n = 26$, $r = 0.60$, $P = 0.001$). Relative standard error of the 2004 yearling abundance index was 28%, similar to the long term average (26%) (Figure 3). The moderately weak 2003 year class, 12th smallest out of 27 at age 1, apparently will not provide sufficient age-2 recruits to propel adult abundance above spring 2004 levels in 2005. Our index of adult alewife condition is the wet weight of a 165-mm (6.5-in) alewife predicted from annual length-weight regressions. The predicted weight in fall 2004 was higher than the predicted weight in fall 2003 suggesting that the alewife population was not expanding and depressing food resources (Figure 5). Indeed, condition of adults in fall 2004 was better than in any year since 1980 indicating that the alewife population was more in balance with Lake Ontario's productive capacity in 2004 than in any of the previous 23 years.

Size of alewife year classes at age 1 is positively linked to nearshore water temperatures during May-July and negatively linked to the number of days nearshore water is <4° C (39° F) during the first winter after hatch (an index of winter duration) (O'Gorman et al. 2004). Year class size is also influenced by the abundance of spawners in a curvilinear manner – weak year classes are produced by large and small spawning stocks whereas strong year classes are produced by intermediate spawning stocks. In spring 2004, the size of the spawning stock was intermediate. May-July water temperatures, however, were much colder than average (8th coldest out of 29 years) indicating unfavorable conditions for reproduction. Conversely, the duration of winter is apparently going to be shorter than average indicating favorable conditions for survival of juveniles. Nonetheless, unfavorable conditions for reproduction in May-July 2004 will likely outweigh favorable conditions for juvenile survival in winter 2004-2005 leading us to anticipate a weak 2004 year class.

The prognosis is poor for the Lake Ontario alewife population returning to the early 1990s intermediate levels of abundance. In recent years, the population was able to rebound to intermediate abundance levels in 2000-2001 only because of the unusually large 1998 year class. But with the population at an intermediate level, adult condition declined and the population quickly returned to a lower level. The process of food web disruption, mediated by exotic species, may well have eroded lower trophic level support for the Lake Ontario alewife population to below that of the early 1990s. With reproductive success average or below during 2000-2002, the population has been stable at a low level and adult condition has improved. With the carrying capacity of the lake reduced, the alewife population at a low level and made up of a high proportion of fish ≥age 5 (44%), and environmental conditions unfavorable for production of age-1 alewives, we expect the indices of adult alewife abundance to be at, or below, 2004 levels through 2006.

Rainbow Smelt

Indices of rainbow smelt abundance are, like indices for alewife, simply stratified, weighted mean catch per tow. Whereas the sampling frame for alewife extends from shore to the 160-m (525 ft) bottom contour in U.S. waters, the sampling frame for rainbow smelt extends from shore to the 140-m (459 ft) bottom contour in U.S. waters because historically few smelt were found at depths >140-m (459 ft). The rainbow smelt sampling frame was divided into six strata by depth and geographic area where catches were homogenous. Beginning in 2000, we modified our stratification scheme for calculating rainbow smelt abundance indices to account for the shift in distribution of smelt to deeper water (O'Gorman et al. 2000). During 1978-1999, because catches made at ≥70 m (230 ft) were uniformly low, the area between the 70-m and 140-m bottom contours was considered one stratum and few trawl tows were made there. After the distribution shift, however, catches at ≥70 m (230 ft) were neither low nor homogenous. Therefore, sampling effort at depths ≥70 m (230 ft) was increased, the single ≥70 m (230 ft) strata was divided into three strata in which catches were homogenous – 60 to 79 m (197 to 259 ft), 80 to 99 m (262 to 325 ft), and 100 to 139 m (328 to 456 ft). Characterization of survey precision awaits a reanalysis of the rainbow smelt database, similar to the ongoing reanalysis of the alewife database, which is scheduled to be completed in 2005.

Number and weight indices for yearling and older rainbow smelt in 2004 were the highest since 1997 and 1998 (Figure 6). Compared to the record low of 2003, indices in 2004 were higher by 17 fold (numerical) and 10 fold (weight). The spike in abundance was driven by a strong 2003 year class and not by increased survival of fish in earlier year classes -- abundance of age-2 and older rainbow smelt remained extremely low.

In the 1980s, rainbow smelt mortality rates declined when alewives produced large year classes, presumably because the young alewives buffered smelt from predation. However, despite strong alewife year classes in 1998 and 1999, smelt survival from age ≥2 to age ≥3 in recent years has remained uniformly low, averaging 11% during 1997-2003 compared with about 49% during 1979-1996. Chronically high rainbow smelt mortality rates followed an increase in water clarity and a shift of smelt to deeper water that began in the early 1990s (O'Gorman et al. 2000). Increased water clarity makes rainbow smelt more visible and thus more vulnerable to predation by all trout and salmon. The shift to deeper water probably resulted in the distribution of rainbow smelt overlapping more completely with that of lake trout *Salvelinus namaycush*.

Rainbow smelt year classes generally alternate between strong and weak in Lake Ontario apparently due to cannibalism, primarily by yearling smelt on young-of-year (Figure 7). The alternating pattern was interrupted by two successive weak year classes in 1982-1983 and again in 2001-2002. The catch of yearling rainbow smelt in 2004 (2003 year class), however, was the 5th largest during 1978-2004 and perhaps signals a resumption of the alternating pattern in year class strength that had been intact during 1984-2000. We had expected that abundance of yearling rainbow smelt would increase in 2004 because abundance of yearling smelt was very low in 2003. However, because the number of mature rainbow smelt in the population was at a record low in 2003, the magnitude of the 2003 cohort was unexpectedly large.

The mean weight of rainbow smelt caught during the June 2004 survey decreased to 2.4 g (0.08 oz) from 3.9 g (0.14oz) in June 2003, because yearling rainbow smelt (the youngest age group in the catch) dominated the catch in 2004 (Figure 7). The heaviest mean weight for rainbow smelt was 13.8 g (0.49 oz) in 1979.

The relative and absolute abundances of large rainbow smelt (≥150 mm or ≥5.9 in) remained low in 2004. Large rainbow smelt made up less than 3% of the population during 1989-2003 (range: 0.1 to 2.8%) and in 2004 they made up about 1% of the population. The stratified mean catch per tow of large rainbow smelt ranged from 1 to 14 during 1989-2003 and was only 1 in 2004. In contrast, during 1978-1983, large rainbow smelt were 10 to 26% of the population and mean catch per tow ranged from 55 to 205. The paucity of large rainbow smelt during 1989-2004 was most likely due to heavy predation and, more recently, several consecutive weak year classes.

We are forecasting that 2005 rainbow smelt abundance indices will be slightly higher for all age groups combined and much lower for yearlings. In all likelihood, any rise in rainbow smelt abundance will be short lived without a relaxation of predation pressure. Rainbow smelt have demonstrated considerable resiliency by rebounding from an extremely low level of spawner abundance which suggests that a prolonged population collapse is unlikely.

Sculpins

Slimy sculpin

In 1996, we lost our ability to index the sculpin population at depths <70 m (230 ft) along the south shore because dreissenid density had risen to a level that made sampling with our 12-m trawl problematic – quantities of dreissenids in the net were so large that they had the potential to alter the fishing power of the net, hindered catch sorting, and, sometimes, even precluded winching the cod end of the net onto the deck. We continued to use the 12-m trawl to assess sculpins at depths >70 m (230 ft) during 1997-2003 although tow times at depths <100 m (328 ft) were continually reduced as the dreissenid population expanded into ever deeper water. By 2003, in southwestern Lake Ontario, we were unable to trawl at depths <80 m (262 ft) and the standard 10-min tow time had to be reduced to 5 min or less at depths of 85 (279 ft) and 95 m (312 ft). Moreover, in southeastern Lake Ontario, we were, for the first time, forced to reduce tow time at two depths. Therefore, we attempted to use the 3-in-1bottom trawl to assess slimy sculpins in 2004.

In southwestern Lake Ontario, few slimy sculpins were captured in 2004, so few in fact that we suspect the net was in poor contact with the bottom, perhaps due to unusually strong currents in the aftermath of fall storms. In central Lake Ontario, catches were about 1% of previous years whereas in the southeast catches were about 50% of previous years. Overall, our general impression was that the net performed inconsistently but that with some modification it could be a useful tool for assessing sculpins and other small, demersal fishes on the dreissenid-infested bottom. Due to the problematic performance of the net, the low catches of slimy sculpins in 2004 are quite likely not an indication of a severe population decline. In 2003, slimy sculpin numbers were at intermediate levels along the south shore at depths >70 m (230 ft).

In summer 2005, we intend to explore various modifications to the 3-in-1 net that might make it a more consistent sampler of benthic fishes. If a suitable modification is found, we intend to develop a FPC factor (and use a decision rule to test whether it is worth applying) over the next few field seasons from paired tows with the 12-m net in fall. Calibration factors can differ among seasons (ICES 2004), so an appropriate calibration factor for slimy sculpins can only be developed from data collected in fall. This investigation of relative fishing power will be needed to allow comparison of slimy sculpin catches made in past years with the 12-m trawl to catches made in future years with the modified 3-in-1 trawl.

Deepwater sculpin

During the alewife assessment in April 2004, we caught (and released) one deepwater sculpin *Myoxocephalus thompsonii*, albeit at a depth deeper than those usually fished during the alewife assessment (170 m, 558 ft). This was the first deepwater sculpin we have caught since 2000. During 1998-2000, we caught five deepwater sculpins at depths of 110-150 m (361-492 ft), two while conducting long-term assessment trawling, and three while conducting short-term assessment trawling that targeted deepwater prey fishes in mid lake, along the international boundary. After 2000, we did not conduct targeted trawling for deepwater sculpins in mid lake. Prior to 1998, the last documented record of a deepwater sculpin being captured in U.S. waters of Lake Ontario was over 50 years ago.

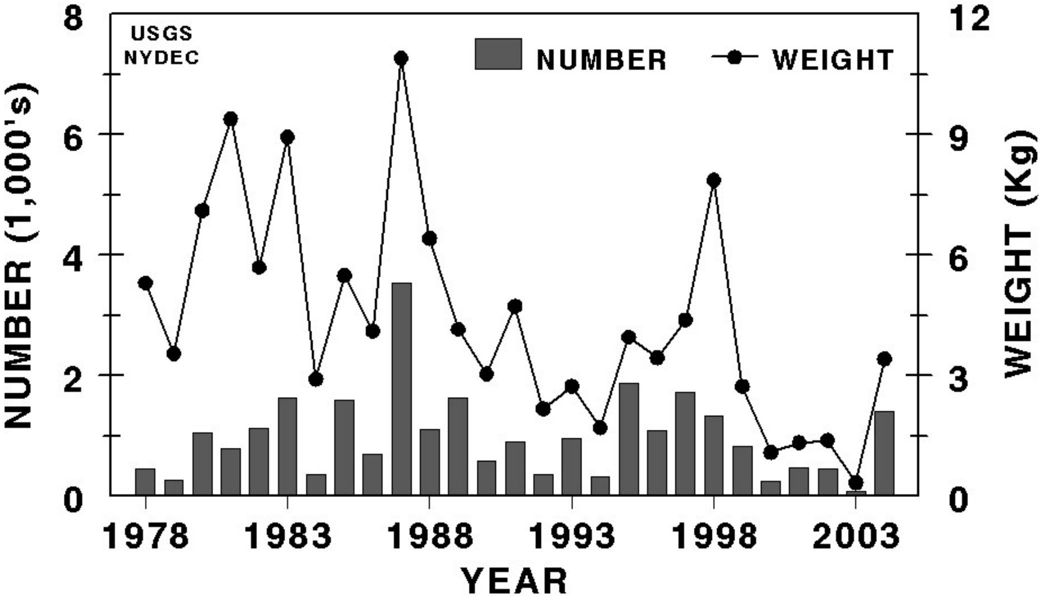

Figure 6. – Stratified mean catch (±1 SE) of rainbow smelt (age 1 and older) with bottom trawls in U.S. waters of Lake Ontario shoreward of the 140-m (459 ft) bottom contour in June, 1978-2004. For weight estimates, 1kg =2.2 lb.

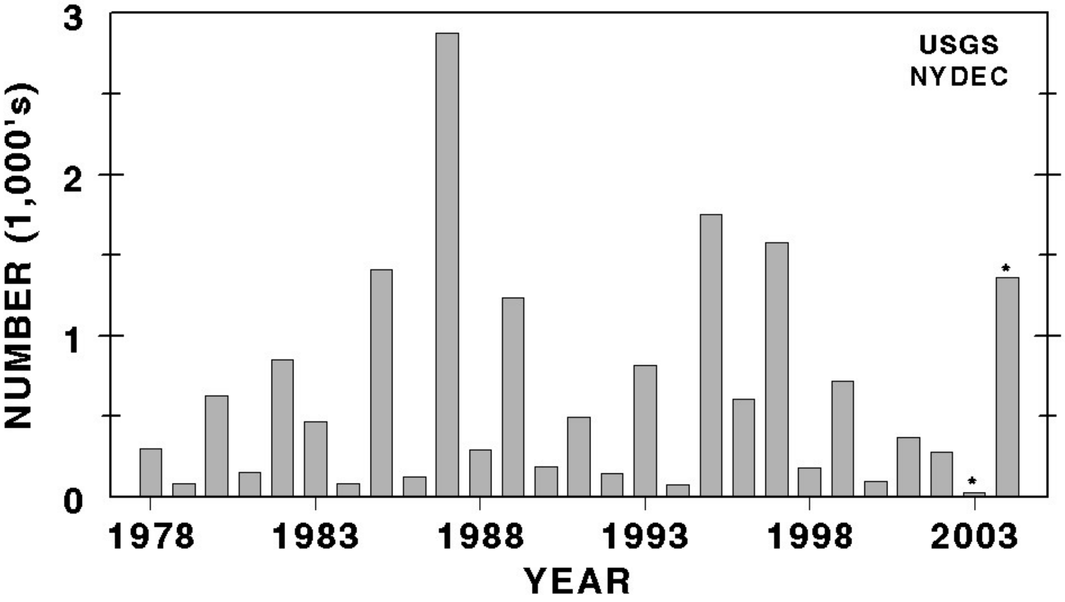

Figure 7. – Stratified mean catch of age-1 rainbow smelt with bottom trawls in U.S. waters of Lake Ontario shoreward of the 140-m (459 ft) bottom contour in June, 1978-2004. Asterisks denote length-frequency based estimates.

Acknowledgements

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References

Adams, J. V., and R. O'Gorman. in prep. A decision rule for applying fishing power corrections.

ICES. 1992. Report of the workshop on the analysis of trawl survey data. ICES CM 1992/D:6. 96 p.

ICES. 2004. Report of the workshop on survey design and data analysis (WKSAD). Fisheries Technology Committee. ICES CM 2004/B:07, Ref. D, G. 65 p.

Munro, P. T. (1998). A decision rule based on the mean square error for correcting relative fishing power differences in trawl survey data. Fishery Bulletin 96: 538-546.

New York Sea Grant. 2004. Coastlines. Volume 33/3:4-5.

O'Gorman R., and C. P. Schneider. 1986. Dynamics of alewives in Lake Ontario following a mass mortality. Transactions of the American Fisheries Society 115:1-14.

O'Gorman, R., J. H. Elrod, R. W. Owens, C. P. Schneider, T. H. Eckert, and B. F. Lantry. 2000. Shifts in depth distributions of alewives, rainbow smelt, and age-2 lake trout in southern Lake Ontario following establishment of dreissenids. Transactions of the American Fisheries Society 129:1096-1106.

O'Gorman, R., B. F. Lantry, and C. P. Schneider. 2004. Effect of stock size, climate, predation, and trophic status on recruitment of alewives in Lake Ontario, 1978-2000. Transactions of the American Fisheries Society 133: 855-867.