

Status of Important Prey Fishes

in the U.S. Waters of Lake Ontario, 2006

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 to assess alewife *Alosa pseudoharengus*, summer to assess rainbow smelt *Osmerus mordax*, and autumn to assess slimy sculpin *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 (Owens et al. 2003). Twelve transects were established at roughly 25-km (15.5 mile) intervals along the U.S. shoreline (Figure 1). Bottom trawling was generally conducted at all transects to assess alewife, at all transects except Fair Haven to assess rainbow smelt, and at six transects to assess slimy sculpin. Although each of the three surveys targets one species of fish, catches of non-target fishes are also tracked and they provide information on ecologically important changes in the fish community such as resurgence of once abundant native species like deepwater sculpin *Myoxocephalus thompsonii* (Lantry et al. 2007) or increasing abundance of recently introduced invasive species like round goby *Neogobius melanostomus* (Walsh et al. 2007).

The underlying principle of our original sampling plan was to concentrate sampling effort in the depth zone where the target species was most abundant by using our knowledge of each fish species' unique bathymetric distribution. At each transect, we usually made trawl hauls at 10-m

depth intervals through the range of depths occupied by the target species. In latter years, however, the number of depths fished at each transect, as well as the depth interval between tows, was modified in response to the invasion of zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*, respectively, hereafter referred to collectively as dreissenids) which changed fish distribution (O'Gorman et al. 2000) and resulted in bottom trawls clogged with shells. 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, we did not initiate acoustic sampling to test the assumption of random distribution within geographic areas until 2004 when we began a three-year acoustic evaluation of fish distribution during the alewife assessment (see Status of Alewife, 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).

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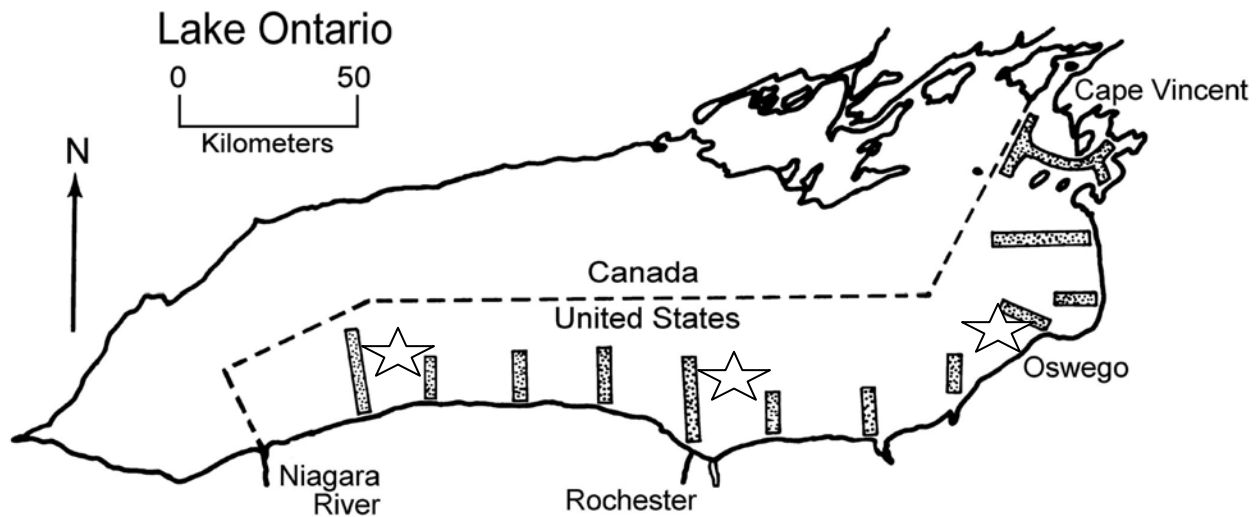


Figure 1. – Lake Ontario showing 12 transects sampled with bottom trawls. Transect names, from west to east, are: Olcott, Thirty Mile Pt., Oak Orchard, Hamlin, Rochester, Smoky Pt., Sodus, Fair Haven, Oswego, Mexico Bay, Southwick, and Cape Vincent. The six transects sampled during the slimy sculpin assessment are adjacent to the stars.

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 (65 ft), steel hull R/V *Kaho* (USGS) and the 12.8-m (42 ft), 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 (46 ft), steel hull vessel participated with the *Kaho* in prey fish surveys during 1986-2002 and in 2004-2006. Because of personnel shortages within the NYSDEC, only the *Kaho* was used to assess prey fish stocks in 2003. Intercalibration studies determined that, for alewife and rainbow smelt, the fishing power of the *Kaho* did not differ from that of either the fiberglass or steel *Seth Green*. Intercalibration studies were not conducted for slimy sculpin because the *Kaho* was the only vessel used to assess slimy sculpin each fall.

A bottom trawl with a 12-m (39 ft) headrope and flat, rectangular trawl doors were used to assess

alewife and rainbow smelt until 1997 when fouling by dreissenids forced a change to a 3-in-1 bottom trawl with an 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 sculpin in areas where dreissenid density was sufficiently low (mainly in deep water) to allow us to trawl unimpeded. In 2004, the 18-m (headrope) trawl was used to assess slimy sculpin because increased dreissenid density in deeper water had greatly reduced not only the number of depths at which we could tow a trawl but also the amount of time we could tow at most depths. Few slimy sculpin were caught in 2004, however, indicating that the 18-m (headrope) trawl, which makes minimal contact with the bottom, was not suitable for assessing benthic sculpin. In 2005 and 2006, to increase bottom contact, a tickler chain was added to the 18-m (headrope) trawl for the slimy sculpin assessment (see Status of Sculpins and Round Goby below).

In 2006, the number of trawl hauls made for assessment of alewife, rainbow smelt, and slimy sculpin totaled 250 – 91 during April 17 - May 5 (8 additional tows were made to assess round

goby), 104 during May 30 - June 10, and 55 during October 10 - November 1. The number of trawl tows made to assess alewife was about 12% below the long-term average due to adoption of informed allocation of sampling effort (see Status of Alewife below). Trawling effort during the rainbow smelt assessment was greater than in most recent years due to a revised stratification scheme and increased sampling effort designed to increase precision of abundance indices (see Status of Rainbow Smelt below). Effort (minutes towed) during the slimy sculpin assessment was similar to that in 2005 but about 60% greater than effort in 2003, the last year the 12-m bottom trawl was in use. Trawling effort increased in 2005-2006 because addition of the tickler chain to the 18-m trawl allowed us to increase tow duration and to trawl over a broader range of depths than was possible with the 12-m bottom trawl on dreissenid infested substrate.

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Status of Alewife in the U.S. Waters of Lake Ontario, 2006

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Abstract

*In 2006, we concluded our review of the alewife *Alosa pseudoharengus* assessment by implementing a new sampling plan, based on informed allocation of effort, which improved the precision of alewife abundance indices (standard errors reduced by 9% to 17%). We also concluded the last of three years of acoustic sampling during the alewife assessment. Geographical differences in fish abundance detected by acoustic sampling and bottom trawling were similar and acoustic sampling did not identify any potentially large sources of error. Abundance indices for adult alewife (age-2 and older) in 2006 were about 71% lower than in 2005 and 94% lower than their peaks in the 1980s. The numerical abundance index for age-1 alewife in 2006 was 5-fold the numerical index in spring 2005, about double the long term mean, and very similar to recruitment model predictions. In 2007, we expect strong recruitment of age-2 fish from the large 2005 year class to lift adult alewife abundance indices to 2002-2004 levels. Our alewife recruitment model suggests that, at age 1, the strength of the 2006 year class (i.e., the numerical abundance index for age-1 alewife in 2007) will be close to the long term mean.*

Progress on Review of Survey Analysis and Design

An independent peer review of the USGS-NYSDEC bottom trawling assessments of prey fishes (primarily alewife) conducted in fall 2003 concluded that the assessments provided reliable indices of trends in relative abundance and suggested a number of strategies for improving assessment data analysis and design (New York Sea Grant 2004, 2005). In response to this review, we began a re-analysis of the alewife assessment during 2004. The reviewers also suggested using acoustics to examine fish distribution during the alewife assessment to determine whether fish are concentrated near bottom and homogeneously distributed in the area between transects. We initiated acoustic sampling during the 2004 alewife assessment and continued

it in 2005 and 2006 (see below). We also extended sampling to greater depths (170 m or 558 ft) but have not, as yet, incorporated catches made there into the index calculations.

Data Analysis

In 2004, we began our review of the alewife assessment by examining all aspects of the data analysis. The review of the data analysis is described in O’Gorman et al. (2005) and is repeated briefly here. We began by building and verifying an electronic file of all trawl catches made during the alewife assessment since its 1978 inception. Next, we revisited the validity of using fishing power correction factors to account for changes in survey vessels and gear, redefined the sampling frame and strata, and revised rules

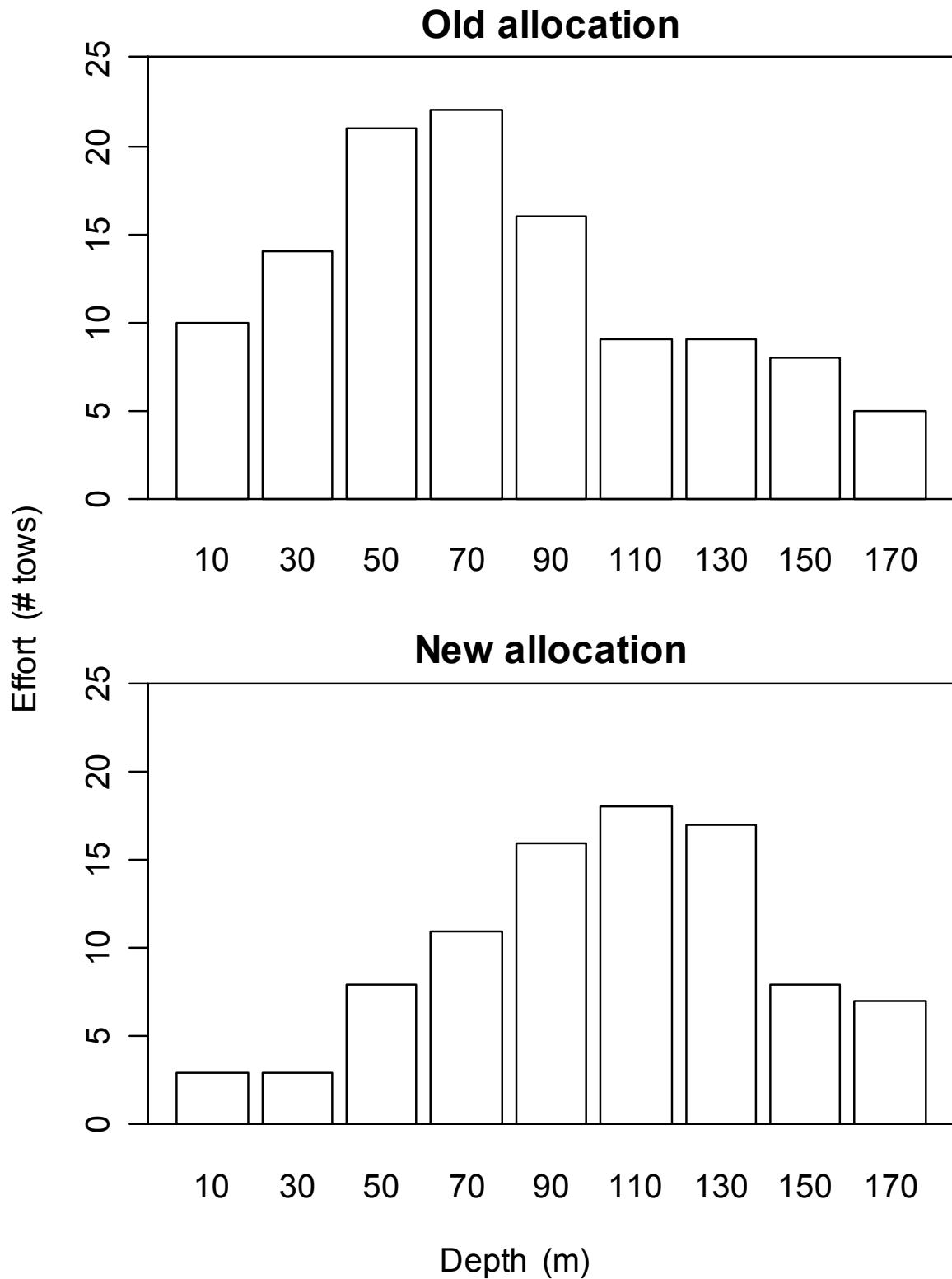


Figure 1. – Allocation of sampling effort during the Lake Ontario alewife assessment in 1980-2005 (old) and 2006 (new).

for adding structural zeroes (assumed catches of zero at depths that were not sampled and that were deeper or shallower than the depth at which an actual zero catch occurred). Finally, we recalculated alewife abundance indices and compared the record of relative abundance from the new indices to that of the old indices by use of the Spearman rank correlation. The historical record of relative abundance of alewife from the new abundance indices for numbers and weight mirrored that from the old indices for yearlings ($P < 0.0001$, $r = 0.98$) and adults ($P < 0.0001$, $r > 0.95$).

Survey Design

In 2005, we continued our review of the alewife assessment, concentrating on examining all aspects of the survey design. In considering what might be done to improve the design of the Lake Ontario alewife assessment, we examined three critical elements of survey design: 1) what sampling plan is used; 2) what estimation procedure is used; and 3) how the samples are allocated. We decided to continue conducting the Lake Ontario alewife assessment using a “fixed site” sampling plan; to continue calculating indices of mean alewife density with a stratified random estimator as if our fixed site design were in fact random; and to implement an informed allocation scheme for apportioning trawling effort among depth zones and geographic regions in 2006 (see O’Gorman et al. 2006 for details).

Sample Allocation

Analysis of catches made in Lake Ontario in 2003 suggested that shifting more trawling effort to deeper waters would yield a more precise estimate of alewife abundance (Adams and O’Gorman 2005). The spring distribution of alewives shifted deeper in the mid 1990’s (O’Gorman et al. 2000), reducing the performance of the sampling allocation initiated in 1980. During 2003-2004, the peak catch of both yearling and adult alewives occurred over an average bottom depth of 120 m, but sampling effort during that time was concentrated over depths from 60 to 80 m (Figure 1). We devised a dynamic sampling allocation plan, designed to adjust to the depth distribution of alewives. The sampling allocation for each year’s spring alewife survey is based on the optimal allocation from last year’s survey (with

some modifications to ensure broad spatial coverage).

The dynamic sampling allocation plan was first implemented in 2006 and resulted in a shift of sampling effort to deeper waters (Figure 1). The number of tows in the survey was reduced from, on average, 103 to 91 but the overall survey cost remains about the same because trawl tows in deep water cost more than trawl tows in shallow water (due to an increase in trawl deployment time). We used simulation (bootstrap resampling) to assess the effects of this change in sample allocation from the allocation initiated in 1980 to the new allocation initiated in 2006. The new allocation improved the precision of our survey, reducing the standard errors of the indices by 9% to 17%, based on 1,000 simulations.

Acoustic Evaluation of Fish Distribution in Spring

In 2004, we began an acoustic evaluation of fish distribution during the alewife assessment. Acoustic sampling was conducted from the R/V *Seth Green* during 2004-2006. In 2004, four closely spaced transects perpendicular to the shore and centered on a bottom trawling transect were sampled off Rochester. In 2005 and 2006, we ran zigzag courses parallel to the shore between the Hamlin-Rochester bottom trawling transects, and the Sodus-Oswego bottom trawling transects. Most of the effort was concentrated at bottom depths of 50-150m, although in all three years we extended some effort to waters shallower than 50 m, and in 2005 we also sampled beyond the 150-m contour. All sampling occurred in the second half of April.

Acoustic data were collected during daylight hours with a Biosonics DT-X 120 kHz split-beam echosounder, and analyzed with SonarData Echoview software. We examined detected single targets, and constructed a target density index based on weighting individual targets by a depth factor which compensated for variable volumes sampled by the conical acoustic beam. Targets in the -45 to -35 dB range were examined, corresponding to the expected range of alewife, based on previous experience in Lake Ontario and target strength studies by Warner et al. (2002). Target strengths of other fishes, notably

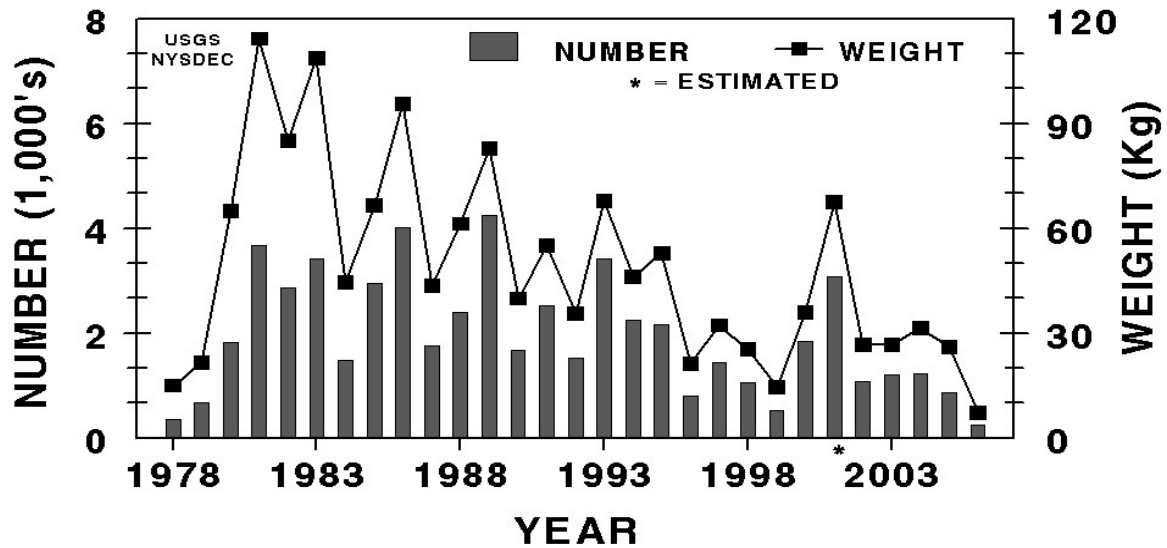


Figure 2. – Stratified mean catch of adult alewife (age-2 and older) with bottom trawls in U.S. waters of Lake Ontario shoreward of the 160-m (525 ft) bottom contour in late April - early May, 1978-2006. Mean catch in 2001 (*) was estimated from bottom trawl catches in June 2001. For weight indices, 1kg =2.2 lb.

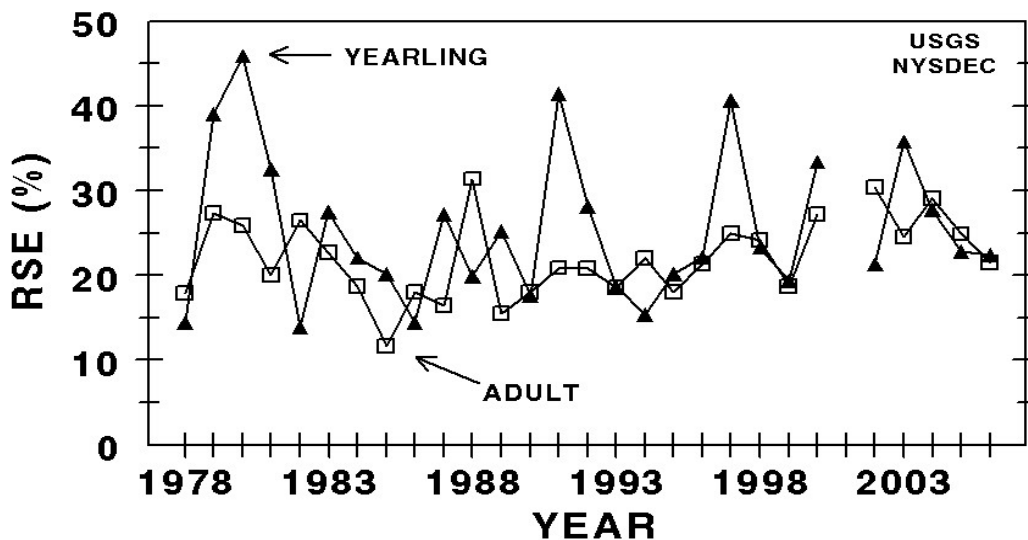


Figure 3. – Relative standard error (RSE) for yearling and adult alewife abundance indices in U.S. waters of Lake Ontario, 1978-2006. The RSE ($RSE = 100\% \times \{ \text{standard error of the index} / \text{the index} \}$) is a measure of variability in abundance indices

adult rainbow smelt (*Osmerus mordax*), overlap those of alewife and thus an unknown portion of the -45 to -35 dB targets are not alewife. All analyses were framed in terms of the targets' off-bottom distance (rather than the usual target depth) in order to examine availability of fish to the bottom trawl, which has a vertical opening of 3.25-3.75 m.

Detailed examination of near-bottom data from all three years found that there were high densities of alewife-size targets (-35 to -45 dB) very close to the bottom, generally within 2 m of it. The only exception to this occurred in the Hamlin-Rochester area in 2005. Furthermore, because target detection is impaired within approximately 1 m of bottom, due to bottom interference, the acoustic data probably under represents the actual near-bottom fish concentrations. These near-bottom concentrations were generally found at depths beyond 60 m in all three years, although they extended into shallower water in 2006 near Hamlin.

Alewife-size targets were also found off bottom in all three years, but the overall target size distribution was generally different than that found in the near-bottom aggregations. In 2004 and 2006, the midwater targets were generally smaller than the assumed range of alewife (-35 to -45 dB), although there was overlap. In 2005, larger targets were found midwater over bottom depths greater than 100 m, again with overlap. The differences in size spectra between near-bottom and midwater targets suggest a different fish assemblage, but a proper interpretation is not possible without supporting evidence from midwater trawls.

The abundance of acoustically detected near-bottom targets generally was positively correlated with trawl catches in corresponding areas. Alewife-size targets within 3 m of bottom were more abundant in the Sodus-Oswego area than in the Hamlin-Rochester area in 2005 and 2006, and bottom trawl catches of alewife were indeed larger in the Sodus-Oswego area in both years.

The zigzag track taken during collection of the acoustic data allowed us to collect data on along-shore variability of target density. These data could be used in formal geostatistical analysis to

evaluate the design of the trawl survey. Informal examination of the pattern of variability shows autocorrelation between successive segments, suggesting density trends on a scale larger than the distance between segments (roughly 5-7 km), and suggesting that the trawl transects are fairly representative of their respective general areas.

In summary, three years of acoustic sampling during the alewife assessment have not identified potential large sources of error. There were no dense concentrations of alewife-size targets found at shallow bottom depths where bottom trawls indicated that alewife were absent, and differences among lake areas in acoustically measured density of alewife-strength targets were reflected in density of alewife measured by bottom trawl. The presence of alewife-strength targets beyond the historical sampling frame suggests that recently implemented bottom trawling at depths > 160 m (525 ft) should be continued and we fully intend to do so.

Status of Alewife

In April-May 2006, the abundance of adult alewife (age-2 and older) in U.S. waters of Lake Ontario was the lowest recorded since annual assessments began in 1978 (Figure 2). Since the spring of 2005, adult alewife indices of abundance have declined about 71%. The 2006 weight index for adult alewife was equal to 15% of the long term mean, 6% of the record high of 1981, and about 50% of the previous record low set in 1999. The 2006 numerical index was equal to 12% of the long term mean, 6% of the record high of 1989, and 71% of the previous record low set in 1978. Age-2 fish (2004 year class) made up 34% of the adult alewife catch, age-5 fish made up 22%, age-3 fish made up 20%, and age-4 fish made up 13%. About 8% of the adults were age 7 and older.

We use the relative standard error (RSE; $RSE = 100\% * \{ \text{standard error of the index} / \text{the index} \}$) as a measure of variability in abundance indices. In 2006, the RSE of the adult abundance indices was 21%, which was the smallest since 1999 and similar to the long term mean (22%) (Figure 3). The RSE of the yearling abundance index was 22%, which was the smallest since 2002 and smaller than the long term mean (26%).

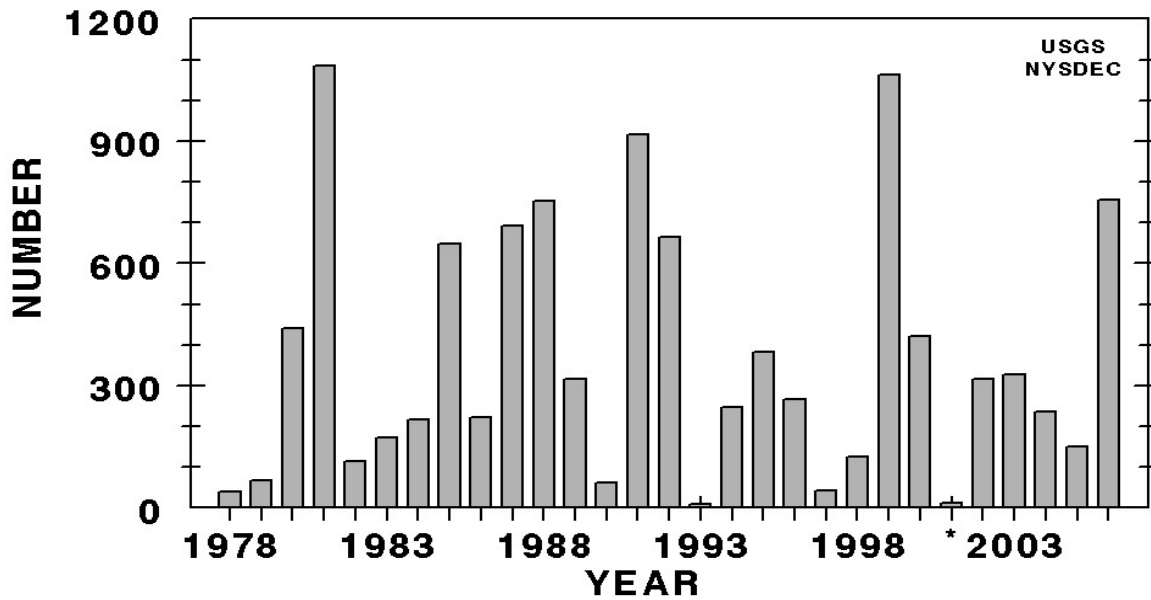


Figure 4. – Stratified mean catch of yearling alewife with bottom trawls in U.S. waters of Lake Ontario shoreward of the 160-m (525 ft) bottom contour in late April-early May, 1978-2006. Mean catch in 2001 (*) was estimated from bottom trawl catches in June 2001.

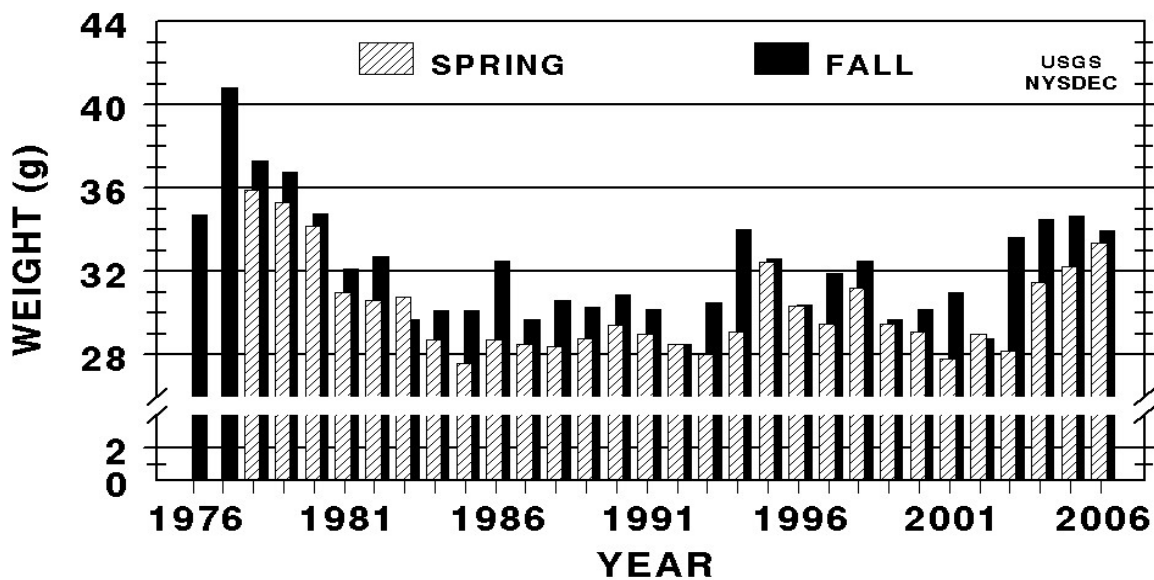


Figure 5. – Wet weight of a 165-mm (6.5 in) alewife (predicted from annual length-weight regressions) in spring and fall, Lake Ontario, 1976-2006. 1 gram = 0.035 ounce.

The numerical abundance index for age-1 alewife in 2006 (2005 year class) was 5-times the numerical index in spring 2005 and about double the long term mean (Figure 4). Observed abundance of age-1 alewife was only 9% lower than that predicted by our recruitment model (O’Gorman et al. 2004). Although yearling alewife are not fully recruited to our sampling gear, we consider the yearling abundance index a reliable 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, $n = 28$, $r = 0.61$, $P = 0.0005$) and age 3 (Spearman rank correlation, $n = 23$, $r = 0.74$, $P < 0.0001$). The strong 2005 year class, 4th largest out of 29 year classes measured at age 1, should provide sufficient age-2 recruits in 2007 to lift adult abundance back to the level recorded in spring 2002-2004.

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 2006 was similar to that in fall 2003-2005. During 2003-2006, condition in fall has been higher than in any four-year period since the late 1970’s (Figure 5). Elevated condition each fall during 2003-2006 suggests that the alewife population was not expanding to a level at which it would depress food resources, and that the relatively small alewife population in recent years was more in balance with Lake Ontario’s productive capacity than at any time during 1981-2002. The fact that sharply lower numbers of adults in spring 2006 did not result in a jump in condition in fall 2006 suggests that fish from the strong 2005 year class will provide a surge of age-2 recruits in 2007.

Strength 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 $< 4^{\circ} \text{C}$ (39°F) during the first winter after hatch (an index of winter duration) (O’Gorman et al. 2004). In 2006, May-July water temperatures were the 3rd warmest of the last 31 springs (1976-2006) indicating favorable conditions for reproduction. Moreover, the duration of winter 2006-2007 is apparently going to be shorter than average indicating favorable conditions for survival of juveniles. But year class strength is also influenced by the abundance of spawners in a

curvilinear manner – weak year classes are produced by extremely large and very small spawning stocks whereas strong year classes are produced by spawning stocks of intermediate size (O’Gorman et al. 2004). The effect of spring water temperatures, winter duration, and spawner numbers were combined in a model by O’Gorman et al. (2004) and, as previously mentioned, we used this model to accurately predict the magnitude of the 2005 year class. However, using the model to predict the magnitude of the 2006 year class is problematic because the spawning stock in spring 2006, was the smallest we have ever observed and thus we have no basis for predicting the influence of a spawning stock this small on reproductive success (i.e., we are using the model to extrapolate an outcome outside of the range of observations used to build the model). Thus, there is more uncertainty than usual about predictions of the magnitude of the 2006 year class. Model output indicates that, at age 1, the 2006 year class will be within 15% of the long term mean (i.e., the numerical abundance index for age-1 alewife in 2007 will be equal to the long term mean $\pm 15\%$).

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Status of Rainbow Smelt in the U. S. Waters of Lake Ontario, 2006

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Abstract

*We completed a re-analysis of our rainbow smelt *Osmerus mordax* bottom trawl assessments conducted annually since 1978. Based on analyses of 97 side-by-side comparison tows conducted in 1995-1998, we did not detect a difference in rainbow smelt catches between the 12-m (39 ft, headrope) trawl and the 18-m (59 ft, headrope) bottom trawl. Therefore, we conclude that no conversion factor is needed and the revised time series reflects unadjusted catch by both gears. The abundance index for age-1 and older rainbow smelt in 2006 was lower than that recorded in 2005, and is the second lowest population index in the 29-year time series. The number of age-1 rainbow smelt caught in 2006 (2005 year class) was an increase of more than 50% from the number caught in 2005 (2004 year class), but was still the third lowest age-1 smelt index since 1995. An unusually large 2003 year class followed by a relatively small 2004 year class appeared to signal a resumption of the alternating pattern in year class strength that had been intact during 1984-2000, but the two small year classes in succession in 2004 and 2005 indicate another breakdown in the pattern. Larger and older rainbow smelt remain scarce in Lake Ontario, but the population has demonstrated considerable resiliency in the past, which suggests that a prolonged population collapse is unlikely.*

Rainbow Smelt

Progress on Review of Survey Design and Analysis

Indices of rainbow smelt (*Osmerus mordax*) abundance are, like abundance indices for alewife (*Alosa pseudoharengus*), simply stratified, weighted mean catch-per-tow. Eleven of the twelve transects sampled on the alewife assessment are sampled on the rainbow smelt assessment (only Fair Haven is not sampled, see Figure 1 in the Introduction). The sampling framework for alewife extends from shore to the 160-m (525 ft) bottom contour in U.S. waters, whereas the sampling framework 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 framework 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 and re-allocated sampling effort to account for the shift in distribution of smelt to deeper water (O’Gorman et al. 2000). During 1978-1999, the area between the 70-m (230 ft) and 140-m (459 ft) bottom contours was considered one stratum and few trawl tows were made there because catches made at ≥ 70 -m (230 ft) were uniformly low. 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 and the single ≥ 70 -m (230 ft) stratum 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). This stratification scheme was expected to be more sensitive to future shifts in smelt distribution. We re-evaluated this post-2000 stratification in 2006 to assess ways to increase index precision.

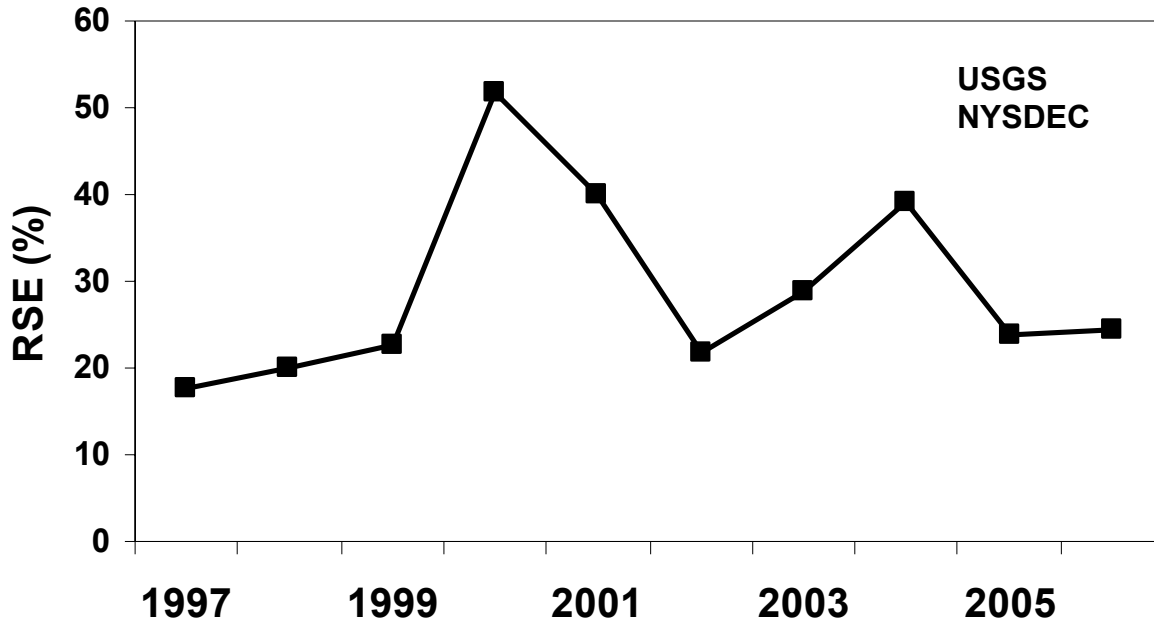


Figure 1. – Relative standard error (RSE) for age-1 and older rainbow smelt abundance indices in U.S. waters of Lake Ontario, 1997-2006. The RSE [$RSE = 100 * (\text{standard error of the index} / \text{the index})$] is a measure of variability in the abundance index.

Variability (expressed as relative standard error, $RSE = 100\% * \{\text{standard error of the index} / \text{the index}\}$) for the rainbow smelt population index has been relatively high, ranging from 20% to 52% between 1997-2005, the time period following the gear change to the 18-m (59 ft) trawl (Figure 1). The post-2000 stratification had some strata that encompassed a disproportionately large area, so for the 2006 assessment we kept the basic six strata, but further subdivided some strata such that no one area makes up more than 20% of the total sampling framework. An analysis of relative standard error (RSE) among years since 2000 showed that the proposed stratification did not affect the RSE. Therefore, we also looked at variability within strata to identify those strata where an increase in effort might lead to a reduction in the RSE. We identified the strata with the highest contribution to RSE among years, and in 2006 we increased the number of tows made in those strata when possible. Added effort in some strata was limited by the availability of smooth bottom suitable for trawling. We will continue evaluation of this revised sampling design in 2007. Also in 2006, we reconstructed and quality checked the entire 29-year rainbow smelt database. The process of correcting the database will continue into 2007.

An independent peer review of the USGS-New York State Department of Environmental Conservation (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 2005). In response to this review, we completed a thorough re-analysis of the alewife assessment in 2004-2005 (O’Gorman et al. 2005). We initiated a similar re-analysis of the rainbow smelt assessment in 2005 and determined that no conversion factor was necessary between the R/V Kaho and either the fiberglass-hulled R/V Seth Green (retired permanently in fall 1982) or the steel-hulled Seth Green currently in use by NYSDEC (Walsh et al. 2006). In 2006, we completed our re-analysis of the rainbow smelt assessment by evaluating differences in catch between the 12-m (39 ft, headrope) bottom trawl used on the smelt assessment until 1996, and the 18-m (59 ft, headrope) bottom trawl adopted on the smelt assessment in 1997 after biofouling by dreissenid mussels (*Dreissena* spp.) made use of the 12-m (39 ft) trawl impractical. Based on analyses conducted in 1998, rainbow smelt catches using

the 18-m (59 ft) trawl during 1997-2005 were converted to equivalent catches from the 12-m (39 ft) trawl using depth-specific correction factors (LOBS unpublished data).

To compare catches of rainbow smelt using the 12-m (39 ft) trawl with those using the 18-m (59 ft) trawl, we conducted 97 side-by-side comparison tows during April-June, 1995-1998 at depths ranging from 8 to 154 m (26 to 505 ft). Forty-nine paired tows were conducted with the 12-m (39 ft) trawl on the R/V *Kaho* and the 18-m (59 ft) trawl on the R/V *Seth Green*, and 48 tows were made with the opposite configuration of vessels and gears. Initially, we did not detect a difference in rainbow smelt catches between the two trawling gears based on paired *t*-tests of log-transformed catches ($P = 0.23$), indicating that we do not need to use a correction factor to account for the change in trawling gear (Walsh et al. 2006). However, graphical evaluation and stepwise regression showed some evidence that catch differences between the two gears became more pronounced at greater depths, which warranted further investigation (Walsh et al. 2006).

To evaluate the relationship between rainbow smelt catches and depth, we divided the data in two depth zones based on a depth threshold, and compared catches in each depth zone to see if a fishing power correction (FPC) was needed. For each gear, we selected the depth threshold that minimized the error around FPCs (one for each depth zone). We used median absolute deviation (MAD, Hampel 1974) rather than least squares as a minimization routine because it is more robust to the type of extreme values common with ratios such as FPC's (J. V. Adams, personal communication). For the 12-m (39 ft) trawl FPC, the depth threshold that minimized MAD was 68.5 m, and for the 18-m (59 ft) trawl FPC, the depth threshold that minimized MAD was 88.5 m. Using these depth cutoffs, we again conducted paired *t*-tests of log-transformed catches, grouping catches below and above the specified depth thresholds. We did not detect a difference in log-transformed rainbow smelt catches between the two gears for either depth threshold ($P \geq 0.1587$).

Re-analysis of the alewife assessment resulted in a fishing power correction factor being applied to alewife catches at depths >91.5 m to account for

the increased effectiveness of the 18-m (59 ft) trawl in that depth zone (O'Gorman et al. 2005). In contrast, based on the weight of evidence in our analyses of the comparison tow data for rainbow smelt, we conclude that no correction factor is needed to account for the change in trawling gears for smelt. As a result of our analyses, we will no longer be converting rainbow smelt catches from the 18-m (59 ft) bottom trawl currently in use to the 12-m (39 ft) trawl used prior to 1997. All data and figures in this report reflect the revised time series of unadjusted catch for both gears.

Status of Rainbow Smelt

Number and weight indices for rainbow smelt were lower in 2006 than in 2005, and were markedly lower than in 2004 when the abundance indices were the highest since 1998 (Figure 2). In 2006, the numerical index was over four times lower than in 2004, and the weight index was about two times lower than in 2004. The 2006 index values are the second lowest observed over the 29-year time series (Figure 2). Under the new sampling design, RSE for the number index was 24.3% in 2006, which is similar to that in 2005 and close to the lower end of the range of RSE's (Figure 1).

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 (Lantry and Stewart 2000; Figure 3). The alternating pattern was interrupted by two successive weak year classes in 1982-1983 and again in 2001-2002. However, an unusually large catch of yearling rainbow smelt in 2004 (2003 year class) followed by a relatively small catch of age-1 fish in 2005 (2004 year class) appeared to signal a resumption of the alternating pattern in year class strength that had been intact during 1984-2000. The age-1 rainbow smelt index in 2006 represents an increase from the index in 2005 (0.05 in 2005, 0.08 in 2006). However, it is still the third lowest age-1 rainbow smelt index since 1995, and is similar to the age-1 index in 1994 (Figure 3). Two small year classes in succession, 2004 and 2005, seem to represent another breakdown in the alternating pattern of year class success.

The relative and absolute abundance of large rainbow smelt (≥ 150 -mm or ≥ 5.9 in) remained low in 2006. Large rainbow smelt made up

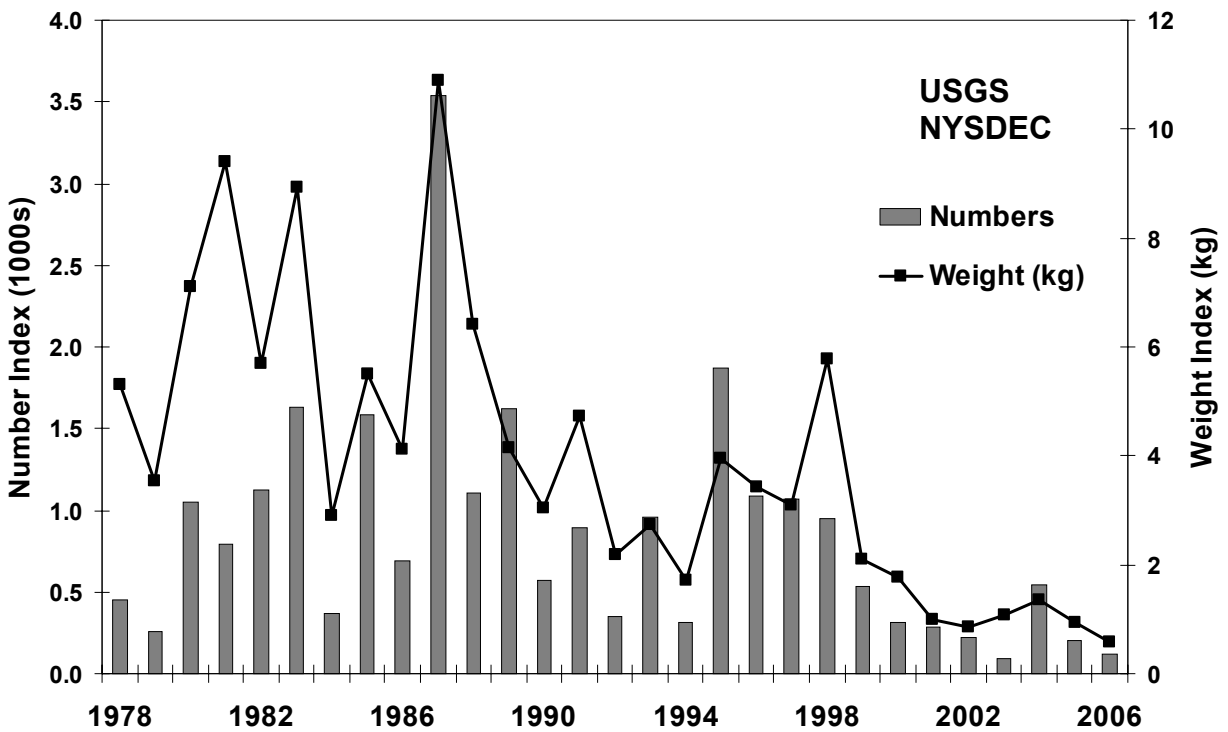


Figure 2. – Stratified mean catch of rainbow smelt (age-1 and older) with bottom trawls in U.S. waters of Lake Ontario shoreward of the 140-m (459 ft) bottom contour in late May-early June, 1978-2006. For the weight index, 1 kg = 2.2 lb.

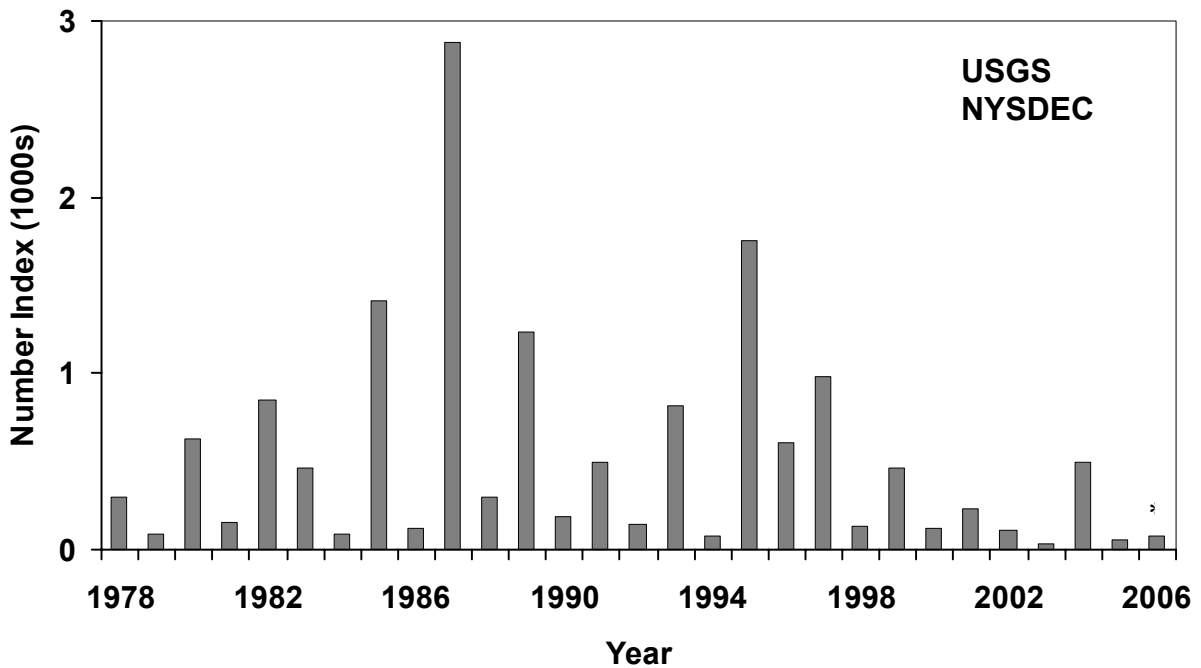


Figure 3. – Stratified mean catch of age-1 rainbow smelt with bottom trawls in U.S. waters of Lake Ontario shoreward of the 140-m (459 ft) bottom contour in late May-early June, 1978-2006. The 2006 estimate (*) is based on 2001-2005 age-length keys.

less than 3% of the population during 1989-2005 (range: 0.1 to 2.8%) and in 2006 they made up about 2.5% of the population (compared to 0.1% in 2005). The stratified mean catch per tow of large rainbow smelt ranged from 1 to 14 during 1989-2005 and was 3 in 2006. 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 1989-2006 was likely due to heavy predation and, more recently, weak year classes in 1999-2002.

We forecast that in 2007, rainbow smelt abundance indices will be higher for all age groups combined, and that after two successive years of weak year classes the number of age-1 smelt will increase. In all likelihood, however, 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 an immediate population collapse is unlikely.

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Status of Sculpins and Round Goby in the U.S. Waters of Lake Ontario, 2006

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Abstract

In 2004, after dreissenid mussels Dreissena spp. precluded towing the 12-m (39 ft, headrope) trawl historically used to assess slimy sculpin Cottus cognatus, we used the 18-m (59 ft, headrope) bottom trawl, but results were inconsistent. In 2005, we began use of a tickler chain modification to the 18-m (59 ft) trawl that allowed us to both add tows at shallower depths and tow for longer amounts of time at deeper depths without biofouling. In October 2006, we continued use of the tickler chain modification. Catches of slimy sculpins in 2006 were lower than in 2005 for all depths. During 2006 sampling, we caught 16 deepwater sculpin Myoxocephalus thompsonii [52 - 108 mm (2.0 – 4.3 in)], continuing the 2005 trend of increased catches of this species, once thought to be extirpated from Lake Ontario. The numerical abundance index for round goby in 2006 was similar to that in 2005, but the weight index continued to increase.

Sculpins

Slimy Sculpin

Slimy sculpins are the sole remaining native prey fish in the profundal zone of Lake Ontario. The slimy sculpin assessment is conducted at six transects, two in each of three lake areas (western, central, and eastern) in southern Lake Ontario (see Introduction Figure 1). In 1996, we lost our ability to index the slimy sculpin (*Cottus cognatus*) population at depths <70-m (230 ft) along the south shore of Lake Ontario because density of zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*; hereafter collectively referred to as dreissenids) had risen to a level that made sampling with our 12-m (39 ft) 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 catch in the cod end of the net onto the deck. We continued to use the 12-m (39 ft) 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 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). In 2004, we tried to assess slimy sculpin using the 18-m (59 ft) bottom trawl which catches few dreissenids and has been used successfully to assess alewife and rainbow smelt since 1997. Use of this gear to assess slimy sculpins was generally unsuccessful, with catches greatly decreased from previous years. Overall, our impression was that the 18-m (59 ft) trawl 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.

Based on 2005 analyses we decided to add a tickler chain [18-m (59 ft) length of 5/16 inch chain] to the 18-m (59 ft) trawl as a method to increase slimy sculpin catches (Walsh et al. 2006). A tickler chain is a common trawl modification used in commercial fisheries, and consists of a chain attached to the net in such a manner that it drags along bottom in front of the footrope, causing benthic animals to move up off of the sea floor so they can be more easily swept into the trawl net. We successfully implemented this gear

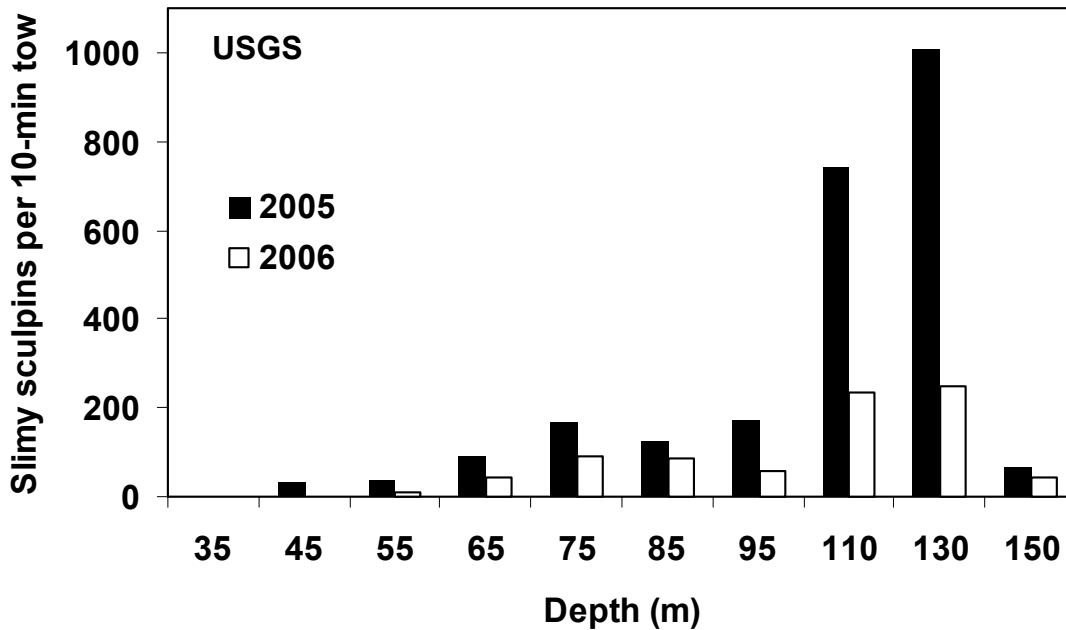


Figure 1. – Number of slimy sculpins caught per 10-min tow with an 18-m (59 ft, headrope) bottom trawl equipped with a tickler chain in southern U. S. waters of Lake Ontario during October 2005 and 2006. For depth, 1 m = 3.28 ft.

change in 2005, and substantially increased trawling effort from that in 2003 (the last year that the 12-m (39 ft) trawl was used), with most added effort at depths ≤ 85 m (279 ft, Walsh et al. 2006). We continued use of the tickler chain on the slimy sculpin assessment in 2006 and effort (55 tows, 512 min) was similar to that in 2005 (59 tows, 502 min).

Mean slimy sculpin catches were generally lower in 2005 than in 2003 (the last year that the 12-m (39 ft) trawl was used), which we surmised was likely due to the change in gear (i.e. the 18-m (59 ft) net with tickler chain is less effective at catching slimy sculpins than the 12-m trawl) and not to a sharp drop in the number of slimy sculpins (Walsh et al. 2006). Catches in 2005 were adequate to conduct a population assessment in an efficient, timely, and safe manner, which would not have been possible had we continued to use the 12-m (39 ft) trawl. In 2006, the second year that we used the 18-m (59 ft) trawl with the tickler chain modification, we saw decreased catches of slimy sculpins from 2005 across all depths sampled (Figure 1). The decrease in catch was most pronounced at 110 and 130 m (361 and 426 ft.; Figure 1).

Length-frequencies of slimy sculpins were generally similar between 2005 and 2006, with a slight shift toward larger individuals in 2006 (Figure 2). No individuals < 35 mm were collected in either year, whereas individuals 20-35 mm TL were collected when the 12-m (39 ft.) trawl was in use. The absence of small slimy sculpins in 2005 and 2006 may indicate poor sculpin recruitment in recent years, however, we caution that this pattern may be due, in whole or part, to the change in gear from the 12-m (39 ft) trawl to the 18-m (59 ft) trawl with tickler chain attachment. Additional assessment of the slimy sculpin population with the new trawl configuration is required before changes in catch rate or the length-frequency distribution can be reliably interpreted.

Deepwater Sculpin

Deepwater sculpin (*Myoxocephalus thompsonii*) were abundant in Lake Ontario in the 1920's and at least common into the 1940's. By the mid 1960's, they were rare and thereafter, some considered the population extirpated. A recent summary of deepwater sculpin records from literature, commercial fishing records, and fisheries surveys in Lake Ontario during 1960-

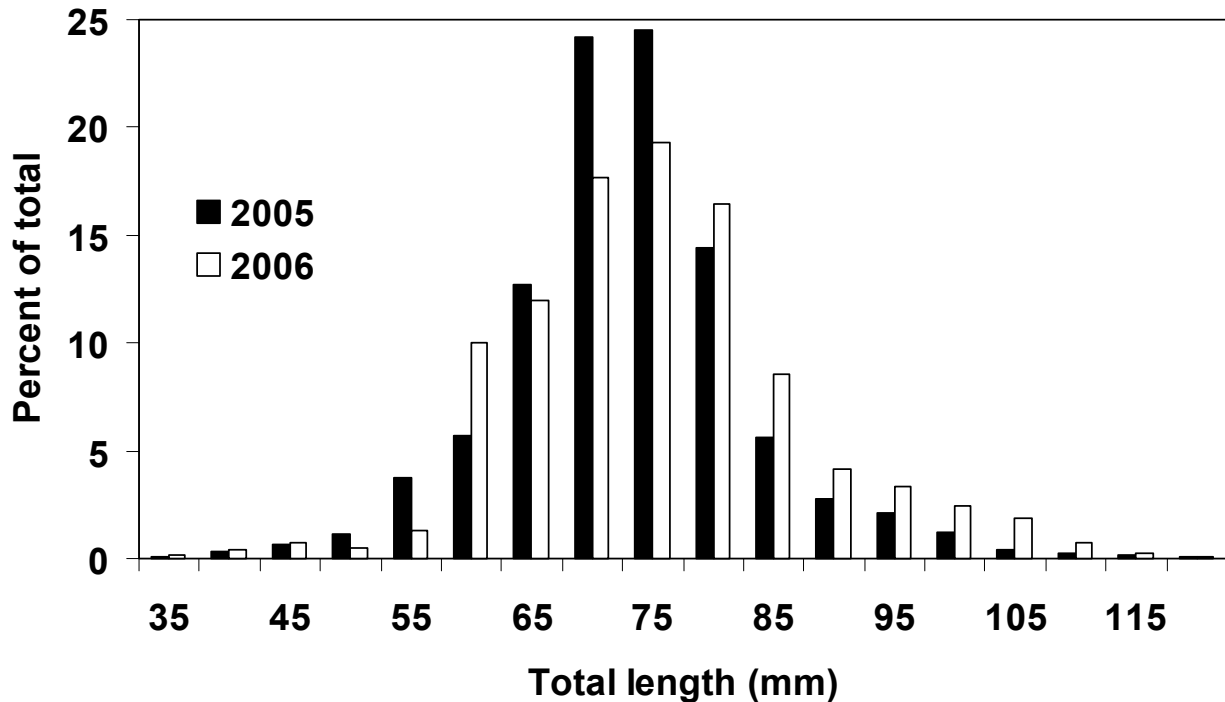


Figure 2. – Length-frequency distribution (as percent of expanded catch) of slimy sculpins caught with an 18-m (59 ft, headrope) bottom trawl equipped with a tickler chain in southern U. S. waters of Lake Ontario during October 2005 and 2006. For length, 25.4 mm = 1 in.

2005 documents sporadic captures of deepwater sculpin through 2004 (Lantry et al. in press). In 2005, 17 deepwater sculpin were caught in U.S. waters of Lake Ontario and two were caught in Canadian waters, and among these deepwater sculpin, young, small individuals were numerically dominant (Walsh et al. 2006; Lantry et al. in press).

Increased catches of deepwater sculpins and presence of small individuals continued in 2006 with a total catch of 18 deepwater sculpins in U.S. waters of Lake Ontario. Sixteen were collected during U.S. Geological Survey-New York State Department of Environmental Conservation annual assessments (range: 52-108 mm, mean: 75 mm; all lengths herein are total lengths) in U.S. waters of Lake Ontario: seven during standard assessment trawling, and nine during gear mensuration. Two additional deepwater sculpins (97 and 140 mm) were caught by Environment Canada during contaminant sampling near Oswego, New York (M. Keir, personal communication). Young fish could have originated from strong reproduction by the small in-lake population, from downstream drift of planktonic larvae from Lake Huron, or both

(Lantry et al. 2007). Nonetheless, the presence of juveniles in 2005-2006 is a clear sign that conditions for survival of young deepwater sculpin are favorable. This may be because of reduced abundance of alewife, which have been linked to depression of deepwater sculpin in Lake Michigan (Madenjian et al. 2005), and burbot (*Lota lota*) and lake trout (*Salvelinus namaycush*), benthic piscivores (Lantry et al. 2007).

Round Goby

Round gobies (*Neogobius melanostomus*) were first detected in the Great Lakes Basin in the St. Clair River between Lakes Huron and Erie in 1990, likely introduced with ballast water (Jude et al. 1992). Round gobies probably moved downstream into Lake Ontario through a navigation canal; they were first reported in southwestern Lake Ontario in 1998 near the entrance to the Welland Canal (Owens et al. 2003), and we first collected round gobies in our standard assessment trawling in 2002 (2 individuals). Since then, the round goby population has expanded substantially, and round gobies are now found along the entire south shore of Lake Ontario, with the highest population

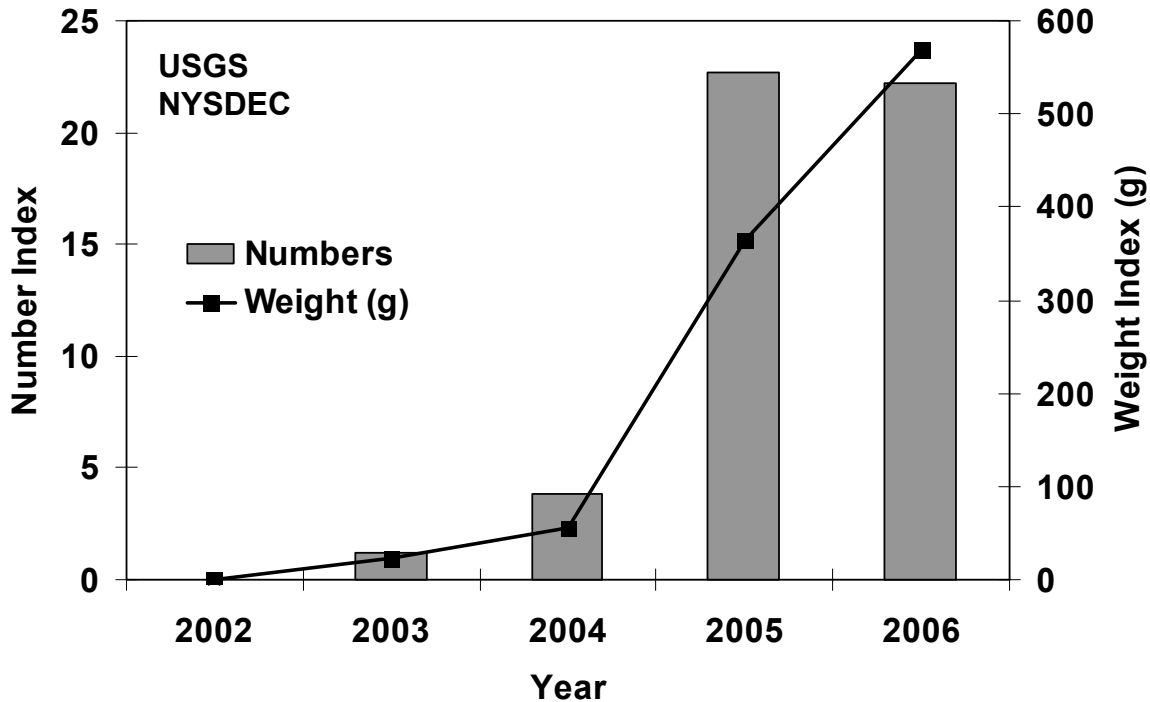


Figure 3. - Stratified mean catch of round goby with bottom trawls in U.S. waters of Lake Ontario shoreward of the 160-m (525 ft) bottom contour in late April - early May, 2002-2006 (no round gobies were caught prior to 2002). For weight index, 454 g = 1 lb.

densities in U.S. waters just east of the Niagara River mouth (Walsh et al. 2006). Based on our Ontario, it appears that round goby will inhabit profundal waters for at least six months of the year (October through April), and are capable of colonizing to depths of at least 150-m (492 ft, Walsh et al. 2006; Walsh et al. 2007).

Given the potential importance of the round goby as a member of offshore and nearshore fish communities in Lake Ontario, we developed abundance and weight indices (calculated in the same manner as those for alewife and rainbow smelt, as depth-stratified weighted means) to track the abundance of round goby in 2005 (Walsh et al. 2006). The round goby number and biomass indices show an exponential increase through 2005 (Figure 3). In 2006, the abundance index seemed to plateau, whereas the weight index continued to increase (Figure 3). Given the uneven spatial distribution of round goby along the southern shore of the lake, the relative standard error of the abundance was initially high, but has decreased through time to 26% in 2006. Due to uncertainties about the ultimate population dynamics of round gobies in Lake Ontario, we

observations on the seasonal and bathymetric distribution of round goby in southern Lake Ontario will continue to calculate these indices and evaluate better ways to monitor the round goby population in the future.

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