Lake Trout Rehabilitation in Lake Ontario, 2007

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Abstract

Each year we report on the progress toward rehabilitation of the Lake Ontario lake trout Salvelinus namaycush *population, including the results of stocking, annual assessment surveys, creel surveys, and evidence of natural reproduction observed from all standard surveys performed by USGS and NYSDEC. During 2007, the number of yearling lake trout stocked in May (453,156) was only 9.4% below the target level of 500,000. The adjusted catch of age-2 lake trout with bottom trawls during the juvenile lake trout survey remained low and was 87% below the mean for the 1983-1989 year classes. Adult lake trout catch per unit effort from the gill net survey was 80% below the 1986-1998 average. The rate of wounding by sea lamprey* Petromyzon marinus *on lake trout caught in gill nets was 2.4 times the target level, suggesting that host density was continuing to affect wounding rates. Estimates from the NYSDEC fishing boat census indicated that, for the third consecutive year, angler catch, harvest, and harvest rate of lake trout were record lows. The condition of adult lake trout, indexed from annual length–weight regressions, increased from the reduced levels observed during 2004-2006 and approached the high level observed during 1996-1999. The improved condition for juvenile lake trout observed in 2006 continued in 2007 and remained above the mean for the data series. Reproductive potential for the adult stock in 2007, determined from the annual egg deposition index, fell to a level 85% below the 1993-1998 mean. Three age-2 naturally produced lake trout were present in survey catches providing evidence of a 2005 year class, but age-1s were absent for the third consecutive year.*

Introduction

Restoration of a naturally reproducing population of lake trout (*Salvelinus namaycush*) is the focus of a major international effort in Lake Ontario. Coordinated through the Lake Ontario Committee of the Great Lakes Fishery Commission, representatives from cooperating agencies (New York State Department of Environmental Conservation [NYSDEC], United States Geological Survey [USGS], United States Fish and Wildlife Service [USFWS], and Ontario Ministry of Natural Resources [OMNR]) developed the Joint Plan for Rehabilitation of Lake Trout in Lake Ontario (Schneider et al. 1983, 1997), identifying a goal, interim objectives, and strategies. The present report documents progress towards restoration through 2007.

Methods

<u>Adult Gill Net Survey:</u>
During September 1983-2007, adult lake trout were sampled with gill nets at random transects within 14 to 17 geographic areas distributed uniformly within U. S. waters of Lake Ontario. Survey design (size of geographic areas) and gill net construction (multi vs. mono-filament netting) has changed through the years. For a complete description of survey history including gear changes and corrections see Elrod et al. (1995).

During September 2007, USGS R/V *Kaho* and NYSDEC R/V *Seth Green* fished standard gill nets for adult lake trout at 14 geographic locations encompassing the entire U.S. shore in Lake Ontario. Survey gill nets consisted of nine, 15.2- x 2.4-m (50 x 8 ft) panels of 51- to 151-

mm (2- to 6-in stretched measure) mesh in 12.5-mm (0.5-in) increments. At 12 sites in the main lake, four survey nets were fished along randomly chosen transects, parallel to contours beginning at the 10°C (50°F) isotherm and proceeding deeper in 10-m (32.8-ft) increments. At two sites in the eastern basin, a total of five nets were fished covering two or three sequentially deeper locations per site and ranging in depth from 20 to 50 m.

For all lake trout captured, total lengths and weights were measured, stomachs were emptied and prey items enumerated, fin clips were recorded, and, when present, coded wire tags (CWT's) were removed. Sex and maturity of lake trout were determined by visual inspection of gonads. Sea lamprey *Petromyzon marinus* wounds on lake trout were counted and graded according to King and Edsall (1979) and Ebener et al. (2006).

A stratified catch per unit effort (CPUE) was calculated using four strata based on net position from shallowest to deepest. Depth stratification was used because effort was not equal among years and catch per net decreased uniformly with increasing depth below the thermocline. To examine variability in CPUE between years, the relative standard error was calculated (RSE = 100% * {standard error / mean}).

Survival of various year classes and strains was estimated by taking the antilog of the slope of the regression of ln(CPUE) on age for fish that received coded wire tags of ages 7 to 11 (estimates for recent cohorts used data for ages 6 to 10). Catches of age-12 and older lake trout were not used in calculations because survival often seemed to greatly increase after age 11 and catch rates were too low to have confidence in estimates using those ages (Lantry et al. 2006).

Adult condition was indexed from both the predicted weights of a 700-mm fish calculated from annual length-weight regressions based on all lake trout caught that were not deformed, and from "Fulton's *K*" (Ricker 1975, Nash et al. 2006) for age-6 males:

$K = (WT/ TL^3)*100,000$;

where WT is weight (g) and TL is total length (mm). We grouped data across strains because Elrod et al. (1996) found no difference between strains in the slopes or intercepts of annual length-weight regressions in 172 of 176 comparisons for the 1978 through 1993 surveys.

Population reproductive potential was estimated by calculating annual egg deposition indices from catches of mature females in September gill nets, length/age-fecundity relationships, and observed differences in mortality rates among strains. Appropriate length-fecundity relationships were determined from the fecundity of individual lake trout collected with gill nets in September and early October each year during 1977-1981 and in September 1994 (O'Gorman et al. 1998). During 1977-1981, fecundity-length relationships were not different among fish of various ages but in 1994, age-5 and age-6 fish had fewer eggs per unit length ($P<0.003$) than age-7 fish, and age-7 fish had fewer eggs per unit length ($p<0.003$) than fish of ages 8, 9, or 10. This suggests that at some point between the early 1980s and the mid 1990s, age began to influence fecundity. The lake trout population in the earlier period was small with few mature fish whereas the population in the 1990s was relatively large with many mature fish (Elrod et al. 1995).

Elrod et al. (1996) demonstrated that the weight of a 700-mm mature female lake trout was much greater during 1978-1981 than during 1982-1993 and they attributed the better condition during 1978-1981 to a lack of competition for food or space at low population levels. Therefore, we used the fecundity-length regression for 1977-1981 to calculate indices of egg deposition during 1980-1981 and the fecundity-length regressions for 1994 to calculate indices of age and size related egg deposition during 1982-2002. To account for sea lamprey induced mortality that occurred between September gill net sampling and November spawning, we reduced catches of mature females, other than Seneca strain fish, by $1 - e^{[-(ZSEN-ZSUP)]}$. Where ZSEN = instantaneous rate of total mortality for Seneca Lake strain, and ZSUP = instantaneous rate of total mortality for Lake Superior strain. Elrod et al. (1995) reported that mature SUP lake trout had a higher annual mortality rate than mature SEN fish. The difference was most likely due to the large numbers of SUP fish killed each fall by sea lamprey. Because SUP fish were present in large numbers throughout the study period, they were our standard for judging mortality rates of those lake trout strains susceptible to sea lamprey induced mortality.

Creel Census:

Harvest by U.S. anglers fishing from boats is measured by a direct contact creel survey, which covers the open lake fishery from the Niagara River in the western end of the lake to Association Island near Henderson in the eastern basin. This survey is conducted during the months of April through September and measures about 85% of the total lake trout harvest (Eckert 2007). The survey uses boat trips as the primary unit of effort; boat counts are made at boat access locations and interviews are based on completed trips.

Juvenile Trawl Survey:

From mid-July to early-August 1980-2007, crews from USGS and NYSDEC used the R/V *Kaho* and the R/V *Seth Green* to capture juvenile lake trout (targeting age-2 fish) with bottom trawls. Trawling was conducted at 14 locations in U.S. waters distributed evenly along the southern shore and within the eastern basin and at one location in Canadian waters off the mouth of the Niagara River. A standard tow was 10 min long. From 1980 to 1996, trawling was conducted with a 12-m (39.4-ft, headrope) trawl at 5-m (16.4-ft) depth intervals, beginning at the metalimnion (15°C, 59°F isotherm) and progressing into deeper water until few or no lake trout were captured. Because of an abrupt shift in the depth distribution of juvenile lake trout to deeper waters in 1993 (O'Gorman et al. 2000) and fouling of the gear by dreissenid mussels in 1996, the sampling scheme and gear were changed. In 1997 the 12-m (39.4-ft) trawl was replaced with a 3-in-1 trawl (18-m or 59-ft headrope, 7.6-m or 24.9-ft spread) equipped with roller gear along the footrope. In addition, effort was decreased at depths < 55 m (180.4 ft) and increased at depths > 70 m (229.6 ft). For years after 1997, the sampling protocol was modified by alternating between odd and even depths (5-m or 16.4-ft increments) between adjacent sites and adjacent years. At four sites where depth did not exceed 60 m (196.8 ft), all 5-m (16.4-ft) contours at and below the 15°C (59°F) isotherm were fished. From July 23 to August 3, 2007, trawling was conducted at all 14 locations. Data collection from trawl captured lake trout was the same as that described above for gill net captured fish.

Trends were similar for the catch of age-2 lake trout caught in this survey and age-3 lake trout caught in the gill net survey. This indicated that recruitment of hatchery fish to the population was governed by survival during their first year in Lake Ontario. Therefore, survival indices were calculated from catches of age-2 lake trout that were stocked in U.S. waters and caught in the bottom trawl survey. For 1981 to 1996 (1979-1994 year classes), survival indices were calculated by adjusting CPUE for strain, stocking location, and to reflect a total of 500,000 spring yearlings stocked. Data obtained on the 1995 year class were not adjusted for strain or stocking location because of poor retention rates of CWT's. Among the age-2 lake trout caught in trawls in 1997, 36% of adipose-fin clipped individuals did not have tags. Data for year classes stocked since 1997 were not adjusted for strain or stocking location because from 36% to 84% of fish in those year-classes did not receive CWT's. Catches of the 1995 through 2005 year classes were, however, adjusted for numbers stocked. Most untagged fish stocked since 1997 received paired fin clips that facilitated year class identification through at least age 4. The ages of unmarked fish and fish with poor clips were estimated with age-length plots developed from CWT tagged fish.

To assess the condition of juvenile lake trout, we used the weight of a 400-mm (15.8 in) total length fish (range: 250 mm to 500 mm, 9.8 in to 19.7 in) predicted from annual length-weight regressions. A 400-mm fish would be age 2 or age 3. Juvenile condition was also indexed from "Fulton's *K*" (Ricker 1975, Nash et al. 2006) for age-2 individuals.

Results and Discussion

Stocking:

From 1973 to 1977 lake trout stocked in Lake Ontario were raised at several NYSDEC and USFWS (Michigan and Pennsylvania) hatcheries with annual releases ranging from 0.07 million for the 1973 year class to 0.28 million for the 1975 year class (Figure 1). By 1978 the USFWS Alleghany National Fish Hatchery (Pennsylvania) was raising all lake trout stocked in U.S. waters of Lake Ontario and annual releases exceeded 0.55 million fish. In

1983, the first official Lake Ontario lake trout rehabilitation plan (Schneider et al. 1983) was formalized and it called for a target of 1.25 million fish stocked annually in U.S. waters. The stockings of the 1979-1986 year classes approached that level averaging about 1.07 million annually. The number of yearling equivalents released declined by about 22% between the stockings of the 1981 and 1988 year classes. Stocking declined by 47% in 1992 (1991 year class) due to problems encountered at the hatchery. In 1993, because of a predator-prey imbalance in Lake Ontario, and following recommendations from an international panel of scientists and extensive public review, managers reduced the lake trout stocking target to the current level of 500,000 yearlings. In the 14 years since the stocking cuts (1992-2006 year classes), the annual stockings were at the target level in only seven years. The USFWS Alleghany National Fish Hatchery was closed in 2005 due to an outbreak of infectious pancreatic necrosis and will remain closed for fish production through at least 2010. Lake trout for 2007 stockings were raised at that the USFWS Pittsford and White River Hatcheries in Vermont.

A total of 453,156 yearling lake trout were stocked into Lake Ontario during May 8 to 18, 2007 (Figure 1). The strain composition was 50.3% Seneca Lake wild (SEN) and 49.7% Lake Superior (from Traverse Island broodstock). All fish were stocked from a landing craft, offshore at four sites Stony Point, Oswego, Sodus and Oak Orchard, over waters 55-m (180.4 ft) deep. Detailed stocking information appears in Connerton (2008), section 1 of this volume.

<u>Survival to age-2</u>

First-year survival was relatively high for the 1979-1982 year classes but then declined by about 32% and fluctuated without trend for the 1983-1989 year-classes (Figure 2). First-year survival declined further for the 1990 year class and continued to decline for the 1991-1996 year classes. The average survival of the 1994-1996 year classes at age 2 was only 6% of the average for the 1979-1982 year classes and only 9% of the average for the 1983-1989 year classes. The 2007 survival index, while not as low as the record low observed in 2006, was still quite low and about 87% below the average for the 1983-1989 year classes.

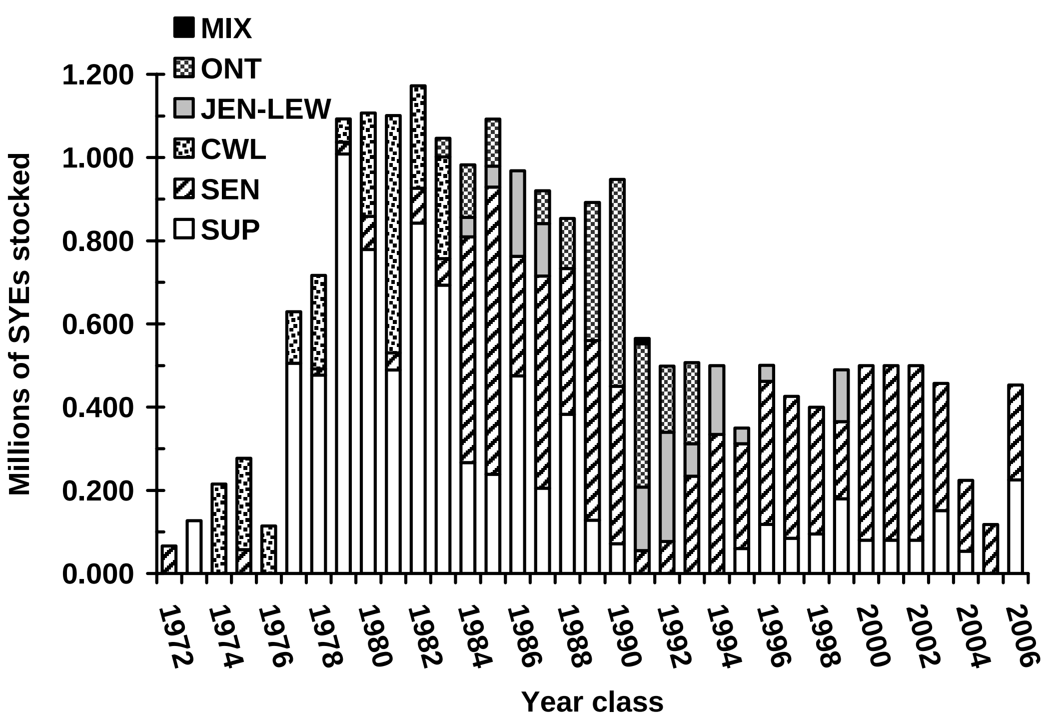

Figure 1. Total spring yearling equivalents (SYE) for lake trout strains (strain descriptions for ONT, JEN-LEW, CWL, SEN, and SUP appear in Appendix 1) stocked in U.S. waters of Lake Ontario for the 1972 – 2006 year classes. MIX were unknowns. SYE = 1 spring yearling or 2.4 fall fingerlings (Elrod et al. 1988). Fall fingerlings were not stocked after 1991.

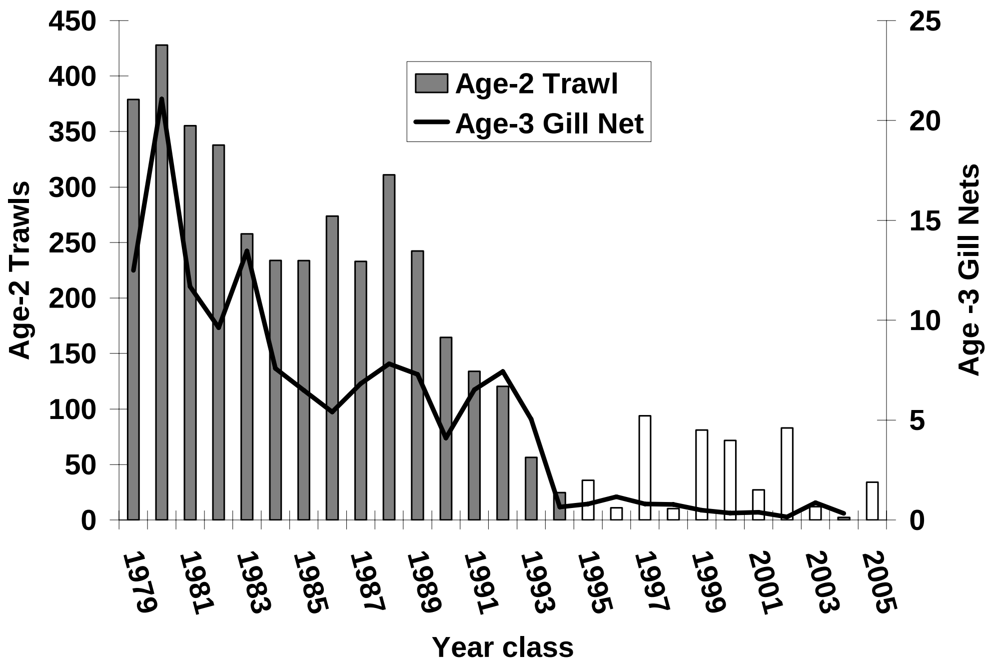

Figure 2. Survival indices for age-2 lake trout stocked as yearlings in U.S. waters of Lake Ontario in 1980 – 2006. Survival was indexed at age 2 as the total catch per 500,000 fish stocked from bottom trawls (BTR) fished in July-August (Note: White bars represent trawl data collected with the new trawl configuration which did not fish as hard on the lake bottom as the old trawl).

<u>Abundance of age-3 and older lake trout:</u>
A total of 266 lake trout were captured in the September 2007 gill net survey (Figure 3). Catches of lake trout among sample locations has been similar within years with the RSE for the CPUE of adult males and females (generally ages 5 and older) averaging only about 9.0 and 10.4%, respectively, for the entire data series (Figure 4). The CPUE of mature lake trout had remained relatively stable from 1986 to 1998, but then declined by 31% between 1998 and 1999 due to the poor recruitment of the weak 1993 year class. Declines in adult numbers after 1998 were likely due to poor survival of hatchery fish in their first year post-stocking and lower numbers of fish stocked since the early 1990's. After the 1998-1999 decline, the CPUE for mature lake trout remained relatively stable during 1999-2004 (mean = 11.0), but then declined by 54% in 2005. The 2007 mature CPUE (3.4) was 80% below the 1986-1998 mean and 69% below the 1999-2004 mean. The 2007 mature CPUE was similar to the 1982 and 1983 values which predated effective sea lamprey control and recruitment from the first large stockings in 1979. The CPUE for immature lake trout (generally ages 2 to 5) followed trends similar to the trawl catches of age-2 fish, but shifted ahead in time by three to four years (Figure 3). The average CPUE of immature lake trout dropped by 64% between the 1989-1993 interval (8.0) and the 1995-2004 interval (2.9). The CPUE in 2007 (1.52) was the second lowest observed and was 47% lower than the 1995-2004 mean.

Schneider et al. (1983, 1997) established a target CPUE of 2 for sexually mature female trout (≥ 4,000 g weight). The CPUE for mature females reached the target value (2) in 1989 and fluctuated about the value until 1992 (Figure 5). From 1992 until 2004, the CPUE exceeded the target, but fell below target during 2005 to 2007, coincident with the decline of the entire adult population.

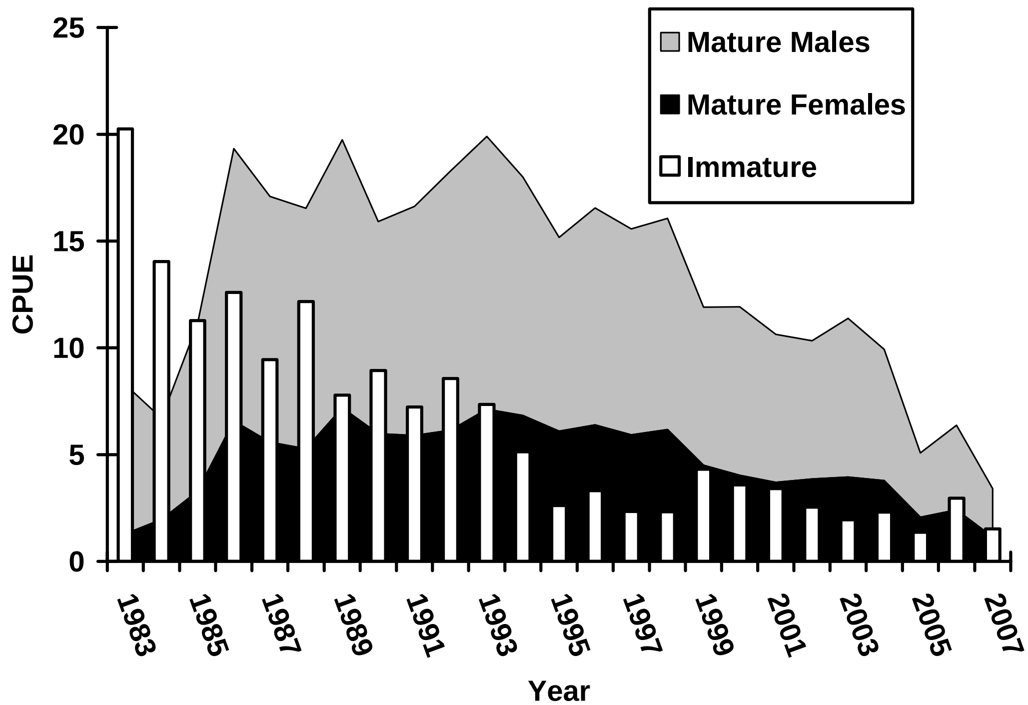

***Figure 3.** Abundance of mature and immature (sexes combined) lake trout calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2007. CPUE was calculated based on four strata representing net position in relation to depth of the sets.*

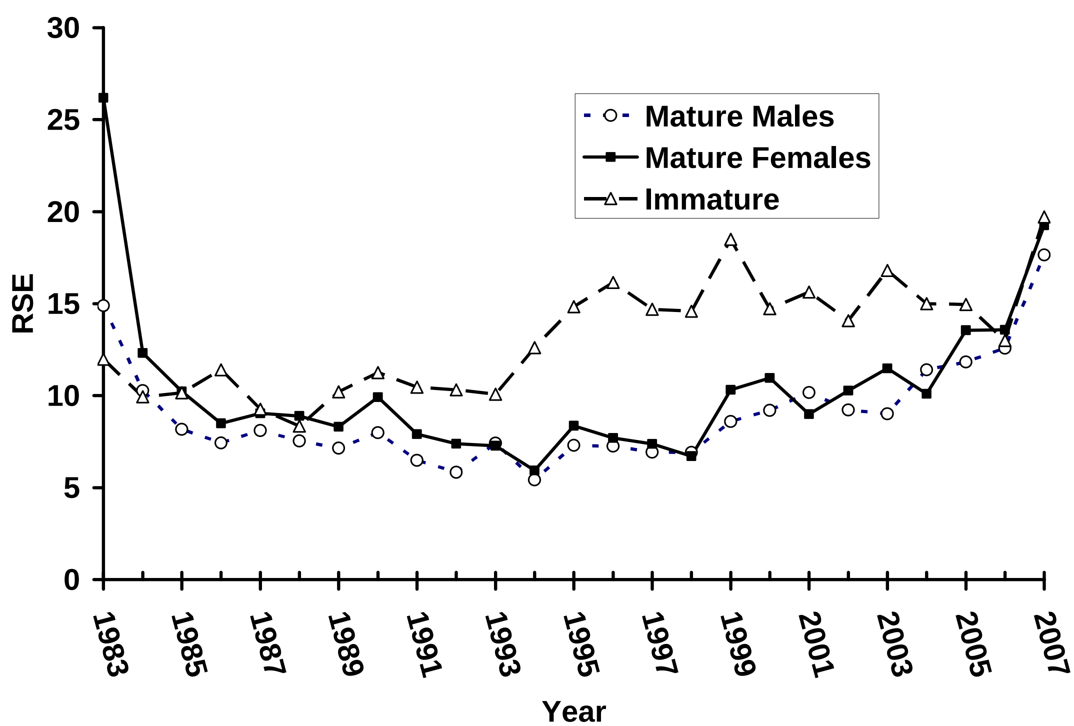

***Figure 4.** Relative standard error (RSE = {SE / Mean}*100%) of the annual CPUE for mature and immature (sexes combined) lake trout caught with gill nets set in U.S. waters of Lake Ontario, during September 1983 – 2007.*

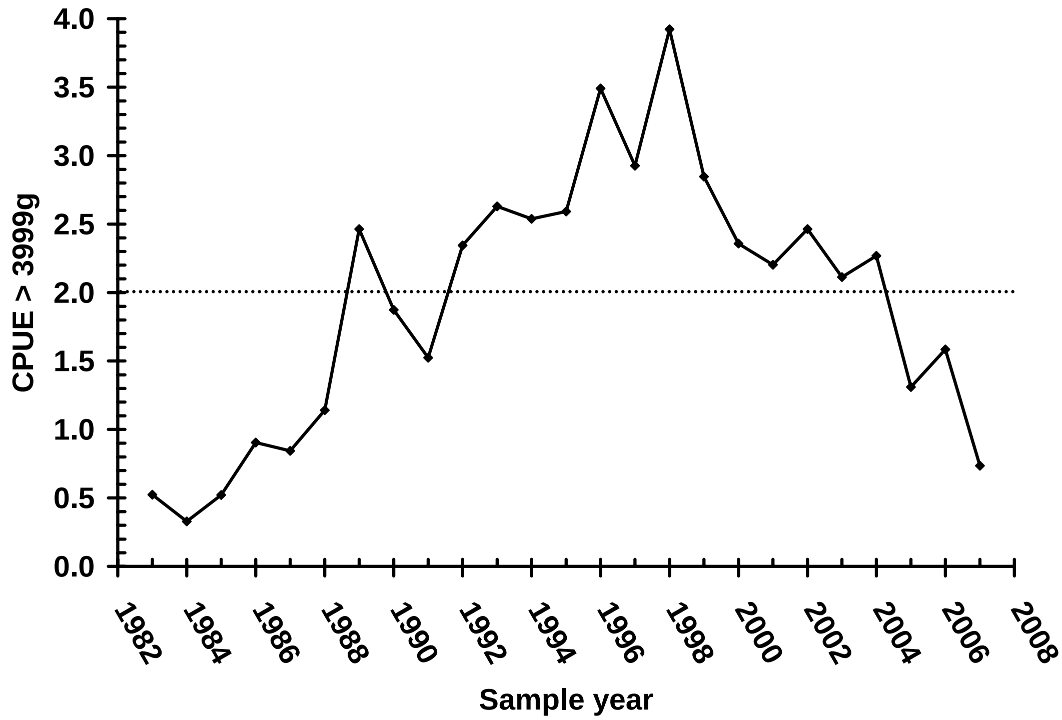

Figure 5 Abundance of mature female lake trout ≥ 4000g calculated from catches made with gill nets set in U.S. waters of Lake Ontario, during September 1983-2007.

Angler Harvest:
The annual harvest of lake trout from U.S. waters of Lake Ontario (Figure 6) declined over four fold since the protected slot limit was re-instated in 1992 compared to years without size limits (Lantry and Eckert 2008). The protected slot regulation was a limit of 3 lake trout harvested outside of the protected length interval of 635 to 762 mm, or 25 to 30 in. In October 2006, a regulation change reduced the creel limit to two fish per angler and allowed for one of those fish to be within the 25 to 30 in slot. Despite the new "relaxed" slot limit lake trout harvest (2570), catch (7147), and harvest rate in 2007 were the lowest on record. The relatively poor fishing for lake trout in 2007 was likely related to the declines in adult population size since 2004 and also to exceptional fishing for Chinook salmon (*Onochorynchus tshawytscha*) and the other stocked salmonids (Lantry and Eckert 2008). Although total harvest of lake trout fell with the development and institution of the slot limit (1988-1993), the portion of the harvest that was larger than the upper limit of the protected slot increased substantially. Previous to 1993, lake trout >762 mm (30 in) made up only 5% or less of the annual total harvest. During 1997-2005, these fish made up an average of 32% of the harvest. In 2006 the proportion >762 mm harvested dropped to 15.4%, the lowest level since 1996, but rebounded to 24.5% in 2007 (Lantry and Eckert 2008).

Although targeted fishing for large fish during 1997-2005 may have influenced size composition of the harvest, availability of large lake trout seems to also have had an effect. Catches from our September gill netting survey give an index of the size distribution of adult lake trout. Of fish caught in index gill nets during 1984 to 1994, less than 10% were >762 mm (30 in) whereas during 1997-2006 an average of 22% were >762 mm. In 2007 13.5% of lake trout caught in survey gill nets were >762 mm (30 in).

Sea Lamprey Predation:
Although percentage of fresh (A1) sea lamprey marks on lake trout has remained low since the mid 1980s, wounding rates (Figure 7) in eight out of eleven years between 1997 and 2007 were above the target level of 2 per 100 fish >433 mm (17.1 in). The 1999 and 2002 wounding rates

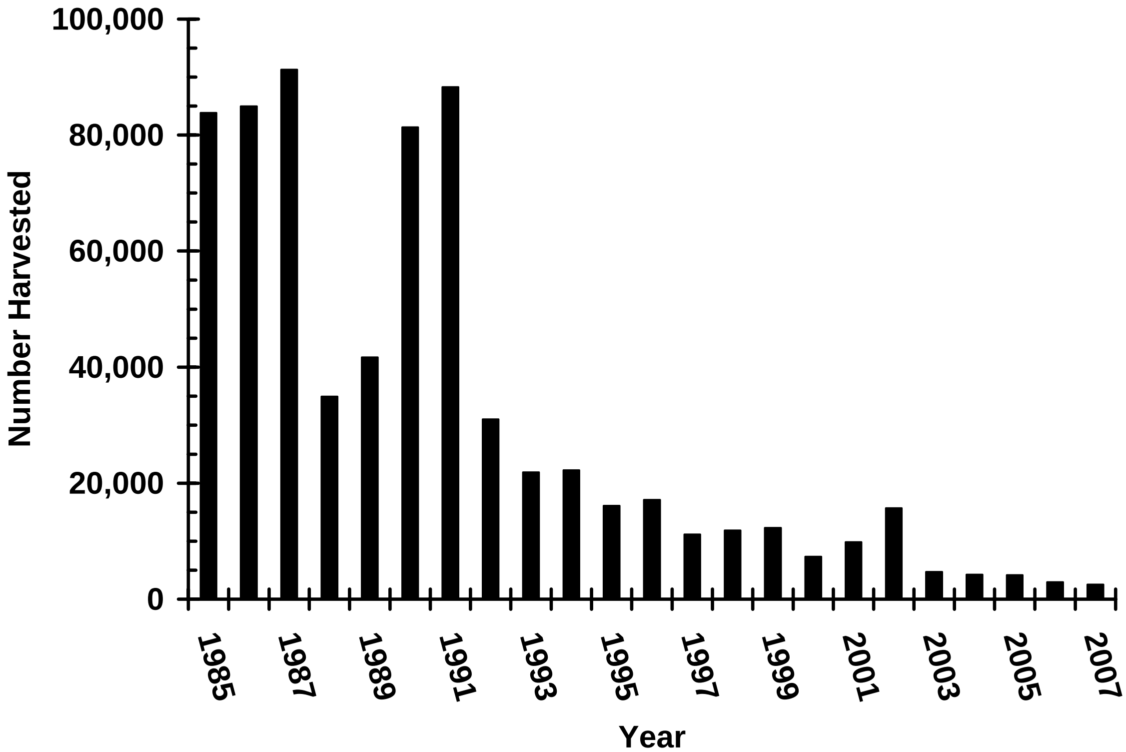

Figure 6. Estimated numbers of lake trout harvested by boat anglers from U.S. waters of Lake Ontario, 1985 – 2007 (Lantry and Eckert 2008).

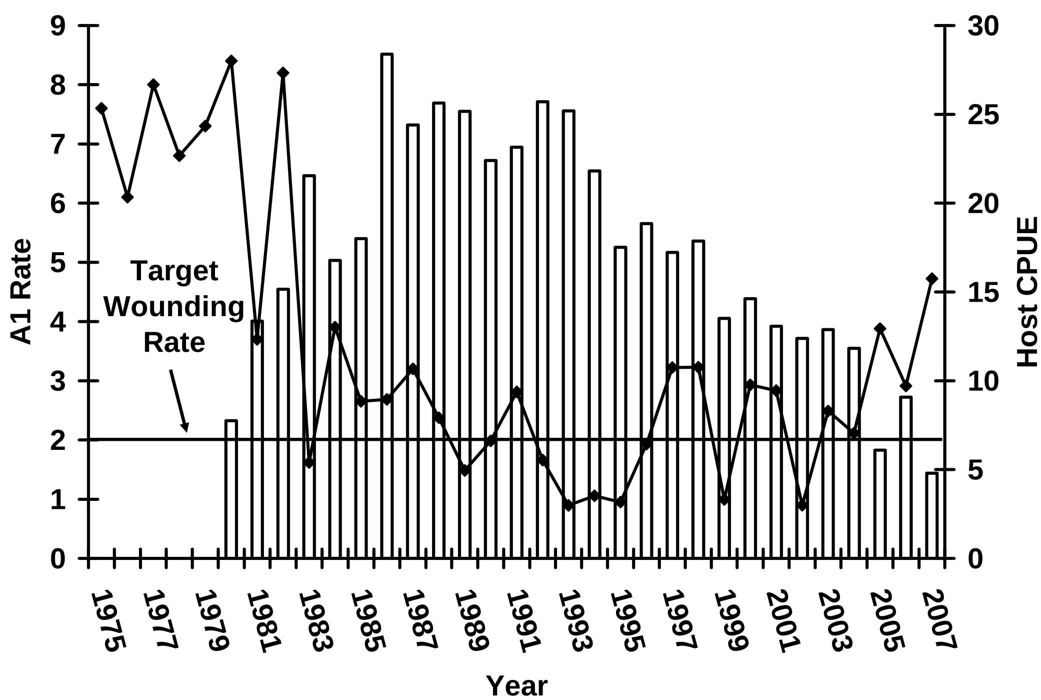

Figure 7. Wounding rates (A1 wounds per 100 lake trout, line) inflicted by sea lamprey on lake trout longer than 433 mm (17.1 in) TL and the CPUE of lake trout hosts (> 433 mm TL, bars) collected from Lake Ontario in fall, 1975 – 2007.

were below the target and similar to the 1992-1996 levels of about 1.0 wound per 100 fish. The 2007 A1 wounding rate of 4.7 wounds was 2.35 times the target level. The length of A1 marked fish in 2007 ranged from 528 to 800 mm (20.8 to 31.5 in, n = 12, mean = 671 mm or 26.4 in).

The effect of the current wounding rate on the lake trout population is difficult to assess without measures of lake trout carcass density. Dreissenid mussels have made trawling for carcasses impossible since 1996. Wounding rates may be related to sea lamprey abundance, host density, lake trout strain composition, or changes in sea lamprey search behavior. In the past, significant correlations between numbers of A1 wounds on Superior strain lake trout and carcass density (Schneider et al. 1996) provided a basis for relating A1 wounds to sea lamprey-induced mortality on lake trout and other salmonines. However, the current population is dominated by Seneca strain fish which are attacked by sea lamprey less frequently than Superior strain fish (Schneider et al. 1996). Additionally, poorly recruited lake trout year classes since 1990 were becoming vulnerable to attack by sea lampreys by 1995. Wounding rate increases during 1997-2007 occurred as host CPUE (lake trout >433 mm) declined (Figure 7). Hence, changes in A1 rates may be attributable to either increased sea lamprey abundance or decreased host density.

Survival of Adults:

Survival of Seneca strain lake trout (ages 7 to 11) has been consistently greater (20 to 51%) than that of the Superior strain for the 1980-1995 year classes (Table 1). Lower survival of Superior strain lake trout was likely due to higher mortality from sea lampreys (Schneider et al. 1996). Lewis and Jenny Lake strain lake trout share a common genetic origin that can be traced back to native Lake Michigan fish. Survival of both of those strains was similar to the Superior strain, suggesting that Jenny and Lewis Lakes fish are also highly vulnerable to sea lampreys. Ontario strain lake trout are progeny of Seneca and Superior strains and their survival has been intermediate to that of their parent strains. In recent years survival of the remaining Ontario strain fish has approached that of the Seneca strain indicating many of the members of these cohorts that were highly vulnerable to sea lamprey predation have been removed from the population. Population survival for all strains combined generally increased with successive cohorts up through 1985 year class, exceeded the restoration plan target value of 0.60 first with 1984 year class, and remained above the target for most year classes thereafter. Survival values the 1996-1998 cohorts could not be estimated for untagged SENs which made up 69-80% of those stockings. Survival values for those cohorts were for SUP strain fish only and are not representative of the true population values.

Table 1. Annual survival of various strains (strain descriptions appear in Appendix 1) of lake trout, U.S. waters of Lake Ontario, 1985-2007. Note: ALL is survival of all strains combined using only coded wire tagged fish.

YEAR		STRAIN					
CLASS	AGES	SEN	ONT	SUP	JEN	LEW	ALL
78	7-10	-	-	0.40	-	-	
79	7-11	-	-	0.52	-	-	0.52
80	7-11	0.85	-	0.54	-	-	0.58
81	7-11	0.92	-	0.45	-	-	0.48
82	7-11	0.82	-	0.44	0.39	-	0.50
83	7-11	0.90	0.61	0.54	-	-	0.57
84	7-11	0.70	0.61	0.48	-	-	0.65
85	7-11	0.77	0.80	0.47	-	-	0.73
86	7-11	0.81	-	0.43	0.57	-	0.62
87	7-11	0.80	-	0.50	0.50	-	0.73
88	7-11	0.73	0.77	0.61	-	-	0.68
89	7-11	0.86	0.78	0.59	-	-	0.81
90	7-11	0.75	0.64	0.60	-	-	0.68
91	7-11	0.70	0.62	-	-	0.56	0.70
92	7-11	0.81	-	-	-	0.51	0.60
93	7-11	0.72	-	-	-	0.64	0.71
94	7-11	0.45	-	-	-	0.73	0.56
95	7-11	0.76	-	-	-	0.50	0.72
96	7-10	-	-	0.43	-	-	0.43
98	7-08	-	-	0.56	-	-	

Growth and Condition:

The predicted weight of a 700-mm lake trout (from length-weight regressions) decreased from 1983 to 1986, but increased irregularly from 1986 to 1996 and remained relatively constant through 1999 (Figure 8). Mean weight declined by 158.8 g (5.6 oz) between 1999 and 2006, but increased again in 2007 (3637.2 g, 8.0 lb) and was only 42.4 g (0.09 lbs) below the 1996-1999 mean.

The past trend of improving condition through 1996 corresponded to increased abundance of older lake trout in the population. Our data suggest that for lake trout of similar length, older fish are heavier. However, recent declines in condition since 1999 may be indicative of resource limitation. To remove the effects of age and sex, we also calculated annual means for "Fulton's *K*" for age-6 mature male lake trout (Figure 8). The *K* for age-6 males followed a similar trend as the predicted weight, which was calculated using data from all fish captured. The correspondence of these two trends indicates that the relation between condition, age, and resource availability for lake trout in Lake Ontario was more complex than was thought in the past (Lantry et al. 2005). Further analysis has indicated that trends in predicted weight were related both inversely to the proportion of juveniles to adults and directly to the slope of the length-weight regressions used to predict weights. This indicates that it is likely that differences in growth trajectories between juveniles and adults confuse the relation between predicted weight and resource availability. The *K* for age-6 mature males may yield a better picture of condition and resource availability; however, *K* has the same trend as predicted weight and increasing condition with increasing abundance between 1984 and 1999 is counterintuitive. Understanding the trend of increasing condition from 1986 to 1996 for both indices will require further analysis.

Predicted weight (from length-weight regressions based on bottom trawl catches) for a 400-mm lake trout was highest for trout caught in 1980 (these were likely from the 1979 stocking of the 1978 year class) (Figure 9). That was the end of the early stockings (1973-1979) where numbers planted ranged from 66,000 to 728,240 yearling equivalents (Figure 1). Immature lake trout condition remained high through 1981. Stocking first exceeded 1,000,000 yearling equivalents in 1980 and between 1980 and 1981 the CPUE of immature lake trout from gill net catches doubled. From 1981 to 1983 predicted weight fell by 69 g (2.4 oz) and remained relatively constant (mean = 576 g, 1.3 lb) through 1992.

Predicted weights of 400-mm lake trout (Figure 9) were inversely related to both total numbers stocked and the CPUE of immature fish captured with gill nets in September (Figures 1 and 3). Stocking remained at a relatively high rate from 1980 to 1991 (846,260 to 1,165,530 fish) then declined to its' current level (500,000 fish) in 1992. It has remained there or below through 2007. Predicted weight rose in 1993 and the 1993-1998 mean was 22 g (0.8 oz) higher than the mean for 1983-1992. Increased condition of young lake trout from 1993 to 1998 was likely due to poor survival of stocked fish and not due

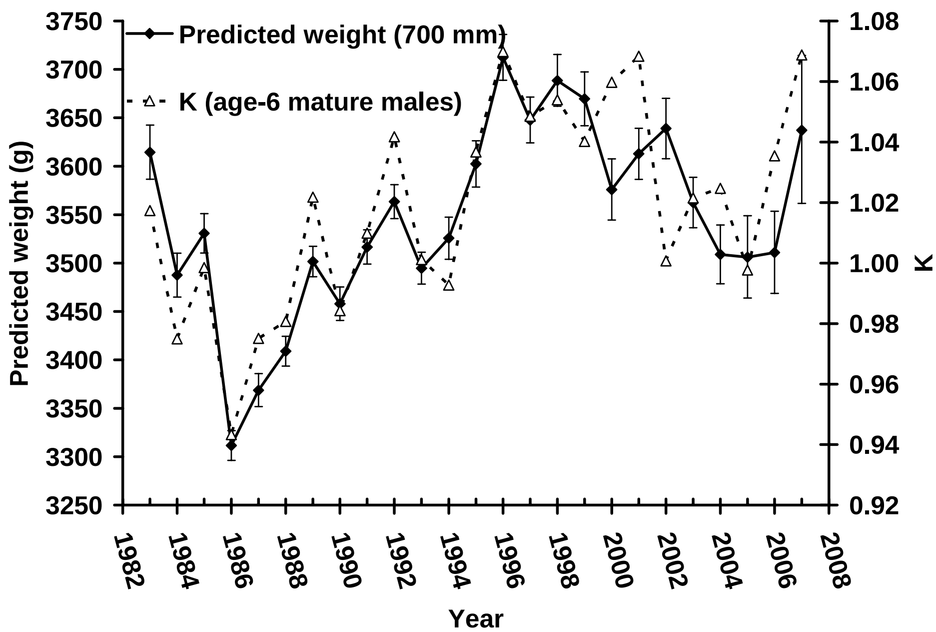

Figure 8. For Lake Ontario lake trout, condition (K) for age-6 mature males and predicted weight at 700-mm (27.6 in) TL from weight-length regressions calculated from all fish collected during each annual gill net survey, September 1983 – 2007. Error bars represent the regression confidence limits for each annual value.

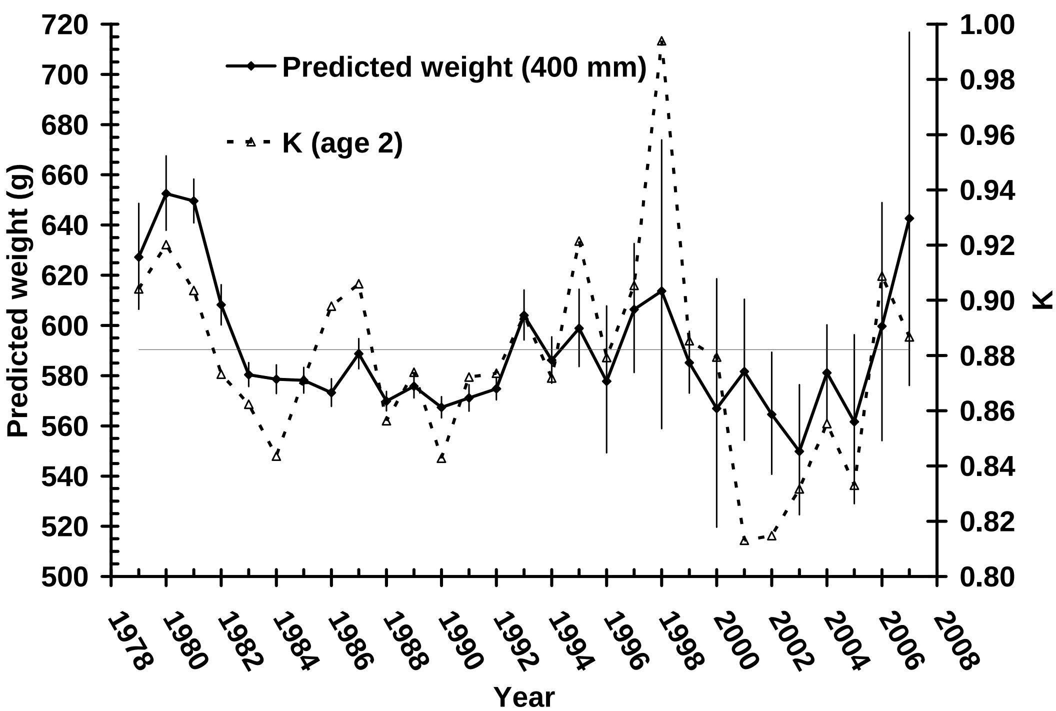

Figure 9. For Lake Ontario lake trout, condition (K) at age-2 and predicted weight at 400-mm (15.8 in) TL from annual weight-length regressions calculated from fish 250 mm-500 mm (9.8 to 19.7 in). All lake trout were sampled from bottom trawls, July -August 1978 – 2007. The horizontal line represents the mean of the predicted weight across all years. Sample sizes for K were ≥27 except for 1998, 2000, 2005, 2006 and 2007 (n = 9, 10, 8, 1, and 8, respectively) and for regressions were ≥ 39 except for 1997, 2000, 2005, 2006 and 2007 (n = 13, 15, 19, 11, and 14, respectively). Error bars represent the regression confidence limits for each annual value.

to resource limitation. During 1999-2005, condition declined to a level similar to the mid-1980's and may have reflected resource limitation. Both predicted weight and *K* increased during 2005-2007. Predicted weight may have been somewhat influenced by the larger mean size of yearling lake trout at stocking in 2006 and 2007, however *K* is only calculated from age-2 fish. Recent increases in *K* likely reflect better condition possibly due to increases in round goby (*Neogobius melanostomus)* abundance (Walsh et al. 2008) which are beginning to appear in lake trout diets.

Reproductive Potential:

Previously, we used the CPUE of mature females as a measure of reproductive potential of lake trout in Lake Ontario. However, the CPUE of mature females in September is not a precise measure of reproductive potential because fecundity changes with age and length (O'Gorman et al. 1998), both of which have increased through the years. Also, sea lampreys kill mature lake trout each fall, mostly between our September assessment and November spawning (Bergstedt and Schneider 1988, Elrod et al. 1995). Furthermore, the numbers of lake trout killed have varied through time, and not all strains of lake trout are equally vulnerable to attack by sea lampreys or are as likely to succumb to an attack. Compared with Superior strain fish, Seneca strain lake trout were 0.41 times as likely to be attacked and they were much less likely to die from an attack (Schneider et al. 1996). Thus, change in age and strain composition of mature females has to be considered when judging reproductive potential from September gill net catches. Since 1996, potential population egg deposition has been indexed from age and size related fecundities and strain specific survivorships (O'Gorman et al. 1998).

Temporal changes in lake trout reproductive potential measured by the egg deposition index (Figure 10) differed considerably from those measured by the CPUE of mature females (Figures 3 and 5). The CPUE of mature females suggests that reproductive potential quadrupled from 1983 to 1986 and then fluctuated around a high level through 1998. In contrast, the egg index suggests that reproductive potential quadrupled from 1985 to 1993 and then remained high through 1999. The CPUE of mature females declined by 31% between 1998 and 1999, yet a change in reproductive potential was delayed by one year dropping by 27% between 1999 and 2000. Strain composition of the eggs was mostly SUP during 1983-1990 and mostly SEN during 1991-2002. After 2002 it became increasingly difficult to assess strain specific contribution to the egg deposition index because many fish stocked since 1997 were not marked with coded wire tags. In most years during the recent period SEN strain dominated stockings and we assume that they continue to contribute the greatest proportion to the egg index. The first predominantly untagged cohort since 1983 was stocked as spring yearlings in 1997 and began to show up in substantial numbers as mature females at age 5 in 2001. For 2001 and later indices we calculated size and age-specific fecundities for untagged fish with paired fin clips that permitted aging. We then applied strain related mortality correction factors to those values by calculating the strain composition of untagged fish based on the strain composition for the specific cohorts at stocking. The egg deposition index changed little between 2001 and 2004 and the average for those years was 42% lower than the average for 1993 to 1999. In 2005, the index dropped to 40% below the 2001-2004 mean and was the lowest observed since 1985. The 2007 value was the lowest calculated for the data series and was 85.5% below the 1993-1999 mean.

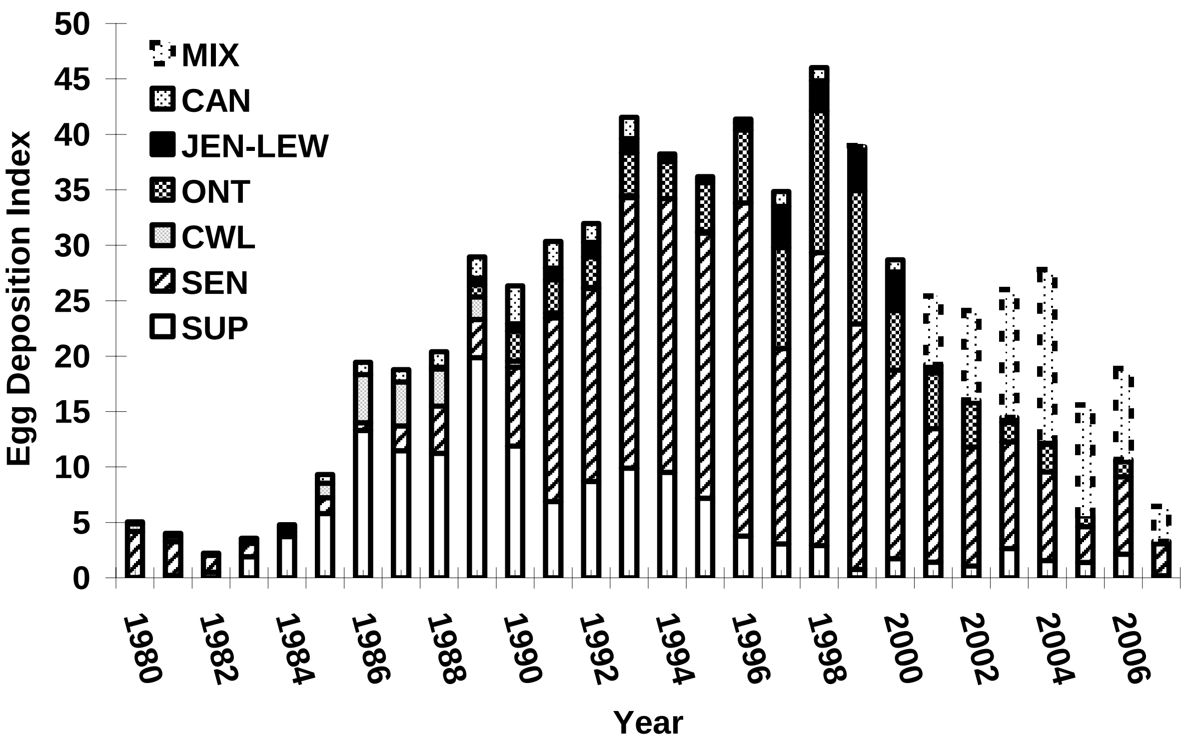

Figure 10. Egg deposition indices by strain (strain descriptions for ONT, JEN-LEW, CWL, SEN, and SUP appear in Appendix 1) for lake trout in U.S. waters of Lake Ontario during 1980-2007. CAN represents a mix of the strains stocked by OMNR and MIX represents values for untagged females stocked since 1997 for which strain could not be determined.

Natural Reproduction:

In 2007, five naturally produced (wild) age-2 (3) and age-3 (2) lake trout were caught with bottom trawls. They ranged in length from 204 to 393 mm (8.0 to 15.5 in). Survival of naturally produced lake trout to the fingerling stage in summer and fall occurred each year during 1993-2005 (Figure 11) representing production of 13 consecutive year classes. We caught no wild yearling lake trout during 2005-2007 and have no evidence of a naturally produced year class in 2006. Low numbers of small (<100 mm, 3.9 in), wild fish captured in recent years (1997-2007) may be due in part to a change in our trawl gear that was necessary to avoid abundant dreissenid mussels. Our new bottom trawls do not fish as hard on bottom as the old gear and are not as efficient at capturing small benthic fishes. We were encouraged by catches of age-1 wild fish near Oswego in 2001. However, low catches during 2002 to 2007 may have been related to increases in predation on young, changes in prey resources, and to declines in adult abundance.

The distribution of catches of wild fish suggests that lake trout are reproducing throughout New York waters (Figure 12). Catches from 13 consecutive cohorts of wild lake trout since 1994 and survival of those year classes to older ages, meets the plan objective to demonstrate the feasibility of lake trout rehabilitation in Lake Ontario (Schneider et. al. 1997). Although recent evidence of wild reproduction is encouraging, achieving the goal of a self-sustaining population requires improvement in production of wild lake trout. Surviving members of the 1993-1999 year classes would have begun to reach sexual maturity by the fall of 2000-2006 and greater catch rates of young, naturally reproduced lake trout would have been an encouraging sign of restoration. The absence of this snowball effect on abundance of natural recruits may indicate that naturally reproduced fish are experiencing system pressures similar to those that have had a negative impact on stocked fish survival and reproduction.

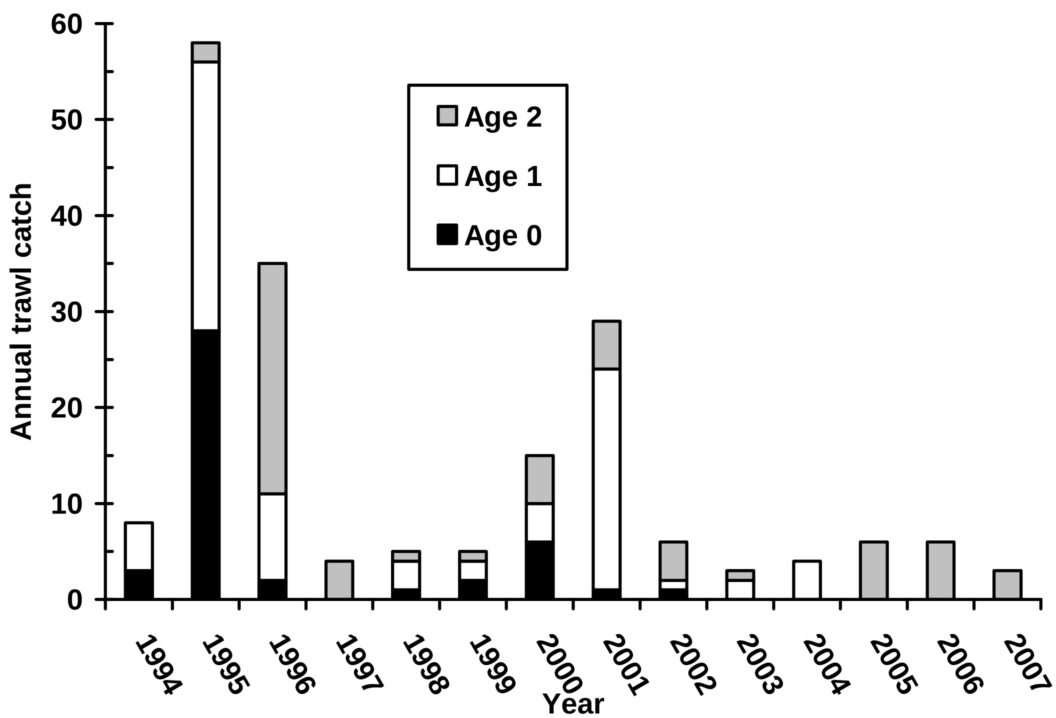

Figure 11. Numbers and ages of naturally produced (wild) lake trout captured with bottom trawls in Lake Ontario by NYSDEC and USGS, 1994-2007. During 1980-1993, only one naturally produced lake trout was captured with bottom trawls.

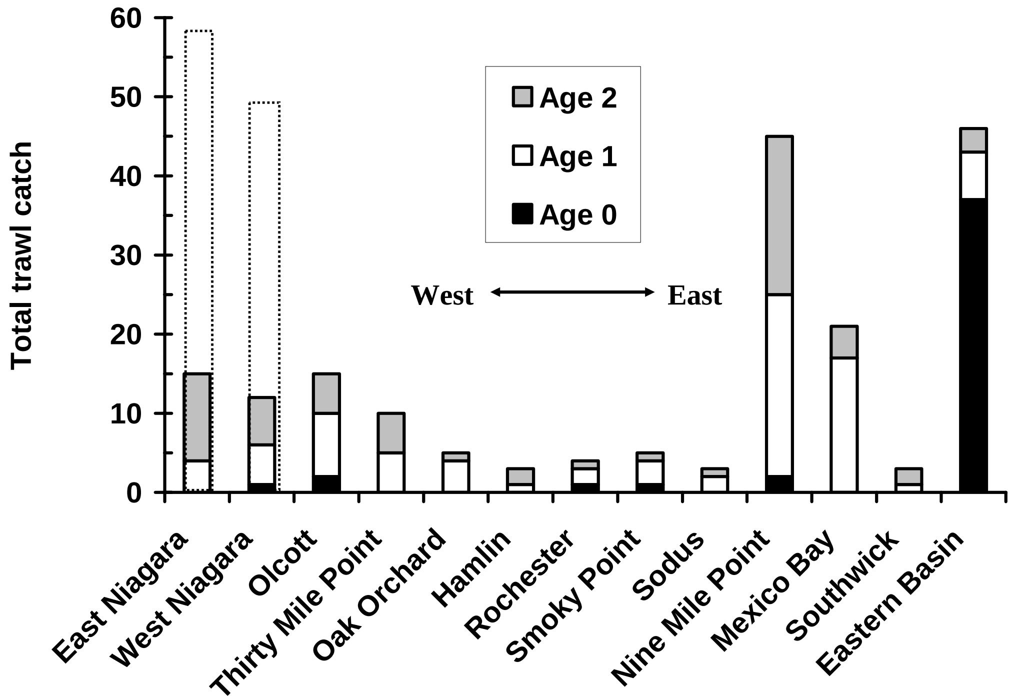

Figure 12. Numbers of wild lake trout (age 0 to 2) captured with bottom trawls at various locations in Lake Ontario by NYSDEC and USGS, 1994 – 2007. (Note: east and west Niagara are only sampled once per year whereas the other locations are usually sampled four times per year. Dashed lines show these catches adjusted for effort).

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Appendix 1.

<u>Strain Descriptions</u>
SEN – (Connerton 2008) Lake trout descended from a naturally sustained population that coexisted with sea lamprey in Seneca Lake, New York. In addition to eggs collected from the population in Seneca Lake, a captive broodstock has been maintained at the Alleghany National Fish Hatchery in Warren, Pennsylvania.

SUP – (Connerton 2008) Captive lake trout broodstock initially developed at the Marquette (Michigan) State Hatchery and derived from restored lean, Lake Superior lake trout. Broodstock for Lake Ontario stockings has also been maintained at the Alleghany National Fish Hatchery in Warren, Pennsylvania. The 2006 year class of this strain was derived from Traverse Island broodstock and raised at the USFWS Pittsford and White River Hatcheries in Vermont.

CWL – (Elrod et al. 1995) Eggs collected from lake trout in Clearwater Lake, Manitoba, Canada and raised to fall fingerling and spring yearling stage at the Alleghany National Fish Hatchery in Warren, Pennsylvania.

JEN-LEW Northern Lake Michigan origin stocked as fall fingerlings into Lewis Lake, Wyoming in 1890. Jenny Lake is connected to Lewis Lake. The 1984-1987 year classes were from brood stock at the Jackson (Wyoming) National Fish Hatchery and the 1991-1992 year classes were from broodstock at the Saratoga (Wyoming) National Fish Hatchery

ONT – (Elrod et al. 1995) from mixed strains stocked into and surviving to maturity in Lake Ontario. The 1983-1987 year classes were from eggs collected in the eastern basin of Lake Ontario. The 1988-1990 year classes were from broodstock developed from the 1983 egg collections from Lake Ontario. Portions of the 1991-1992 year classes were from ONT strain broodstock only and portions were developed from crosses of ONT strain broodstock females and SEN males.