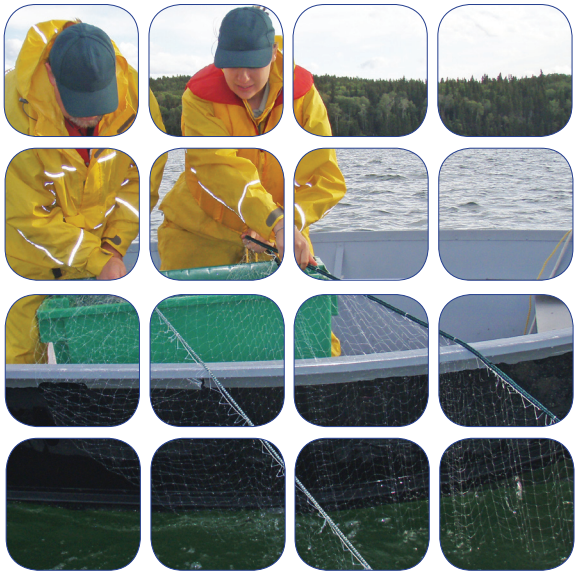
Science and Information Branch
Southern Science and Information

Aquatic Science Unit Report 2011–1

Status of Lake Trout (*Salvelinus namaycush*) in Lake Rosseau, Ontario

By Steve Sandstrom



Ministry of Natural Resources

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Abstract

Lake trout (*Salvelinus namaycush*) are an important fish species in southern Ontario not only from the perspective of being of considerable interest to anglers, but also given their specific habitat requirements, serving a role as an indicator of the health of coldwater ecosystems. Lake Rosseau is the third largest unstocked lake trout lake in southern Ontario, and supports an active winter fishery exhibiting around 22,000 angler hours of effort annually. The following report presents a summary of biological results collected by the Aquatic Science Unit about this population and its associated fishery. The abundance of lake trout was determined by use of a calibrated gillnet methodology (Summer Profundal Index Netting) and estimated currently at approximately 41,000 fish (range 29,000 to 53,000; 68% confidence interval). No statistically significant changes in population abundance were found from 2004 to 2009. The findings of this program will provide an important source of data and reference points for use by Southern Region Fisheries Management Zone Councils in support of the Ecological Framework for Fisheries Management, developed to improve the way provincial fishery resources are managed.

Keywords:

lake trout, density, fishing mortality rate, angler effort, growth, diet

Résumé

Le touladi (*Salvelinus namaycush*) est une espèce de poisson importante dans le Sud de l'Ontario – non seulement du point de vue de sa valeur pour les pêcheurs sportifs mais également pour ses exigences en matière d'habitat, qui jouent un rôle d'indicateur de la santé des écosystèmes d'eau froide. Le lac Rosseau est le troisième plus grand lac de touladi non ensemencé dans le Sud de l'Ontario et il supporte une pêche hivernale active comportant quelque 22 000 heures-pêcheur. Le rapport suivant donne un résumé des résultats biologiques recueillis par l'Unité des sciences aquatiques au sujet de cette population et de ses pêches connexes. L'abondance de touladis a été déterminée en utilisant une méthodologie faisant appel au filet maillant calibré (pêche indicatrice estivale au filet en eau profonde) et on estime présentement qu'il y a environ 41 000 poissons (entre 29 000 et 53 000; intervalle de confiance de 68 %). Aucun changement important du point de vue statistique n'a été observé dans l'abondance de la population entre 2004 et 2009. Les résultats de ce programme seront une source de données et des points de référence importants pour les conseils des zones de gestion des pêches de la région du Sud pour appuyer le Cadre stratégique pour la gestion écologique de la pêche sportive qui a été mis sur pied pour améliorer la façon dont les ressources de pêche provinciales sont gérées.

Mots-clés :

touladi, densité, taux de mortalité du poisson, efforts de pêche, croissance, alimentation

Acknowledgements

I would like to thank the various seasonal and permanent staff at the Bracebridge Area Office and the Aquatic Science Unit that assisted with this program over the years. In particular, I'd like to thank Michelle Craigen for her technical direction which was critical to the success of the program. I would also like to thank Steve Scholten, Tim Haxton, Jeff Amos, Dave Weider, Cam Willox, and Melissa Robillard for their review and comments which greatly improved the report, Melissa Payne for assistance with data entry, Susan Mann for age interpretation, Andrew Oshier for GIS support and Lyn Thompson for assistance with the final formatting and publishing.

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Overview

Lake trout (*Salvelinus namaycush*) are a key sport fish species in Fisheries Management Zone (FMZ) 15, found in approximately 390 lakes encompassing a combined area of 154,000 ha. Four large lakes in the District of Muskoka; Muskoka, Rosseau, and Joseph (collectively known as the Muskoka Lakes) and Lake of Bays constitute a major portion (28 % of surface area) of the overall FMZ 15 natural lake trout resource outside of Algonquin Park. A series of four reports are being prepared to present the current status and trend in these lakes. The following report will focus on Lake Rosseau.

Lake Rosseau is a large (6449 ha), deep (mean depth: 23 m) oligotrophic lake (total phosphorous = 5.7 µg/l, Secchi depth = 5.6 m; District Municipality of Muskoka data) located approximately 200 km north of Toronto in the Muskoka District of central Ontario. The area is a popular summer and winter recreational destination for residents of the Greater Toronto Area. Lake Rosseau's shoreline is heavily developed with recreational homes, with a current estimate of 1,882 shoreline accessible properties. Having a combined shoreline distance (including that of islands) of 212 km, this equates to a property on average every 113 m of shoreline. All land surrounding the lake is currently privately owned; but four-season public access is available at several locations.

Lake trout are native to Lake Rosseau, but were also stocked from the early 1940s up to and including 1990 after which time the practice was stopped when emerging science showed that supplemental stocking was potentially damaging to self sustaining natural lake trout populations (Evans and Willox 1991). A variety of life history stages have been stocked over the years ranging from fry in the 40s and 50s, to two years old in the mid-60s to mid-70s. Primarily yearlings were stocked in the last decade, at an average intensity of approximately 5000 each spring.

The current regulations in place to protect this population include the standard lake trout opening on January 1st and closure on October 1st. There are currently no restrictions on the size of lake trout that can be harvested, and the catch and possession limits are the same as the other lakes in Zone 15 (two lake trout for sport fishing licence and one lake trout for a conservation licence).

Long-term monitoring of Lake Rosseau by the Ministry of Natural Resources has occurred since the late-1980s. The following report will highlight and summarize some biological information for lake trout from Lake Rosseau collected between 2004 and 2009 by the Aquatic Science Unit [ASU] using the Summer Profundal Index Netting [SPIN] methodology. Since initial testing in 2003, the method has slowly been refined to where it is possible to derive estimates of lake trout abundance based on the average number of fish caught in a net. Developed as a low mortality, i.e., greater than 50% release rate, rapid approach to assessing lake trout, it is widely used across the distributional range of lake trout in Canada by a host of agencies and levels of government. In addition to the biological results, trends in winter angler success and overall angling effort will also be discussed, and observed fishing mortality compared to theoretically sustainable levels.

Methodology

Water quality

The lake was divided into four sectors to assist in sampling and monitoring (Figure 1). The surface area for each of these sectors, along with that for the whole lake, is presented for ten metre stratas (Table 1). Detailed bathymetric information for the lake was collected by the ASU between 2001 to 2003.

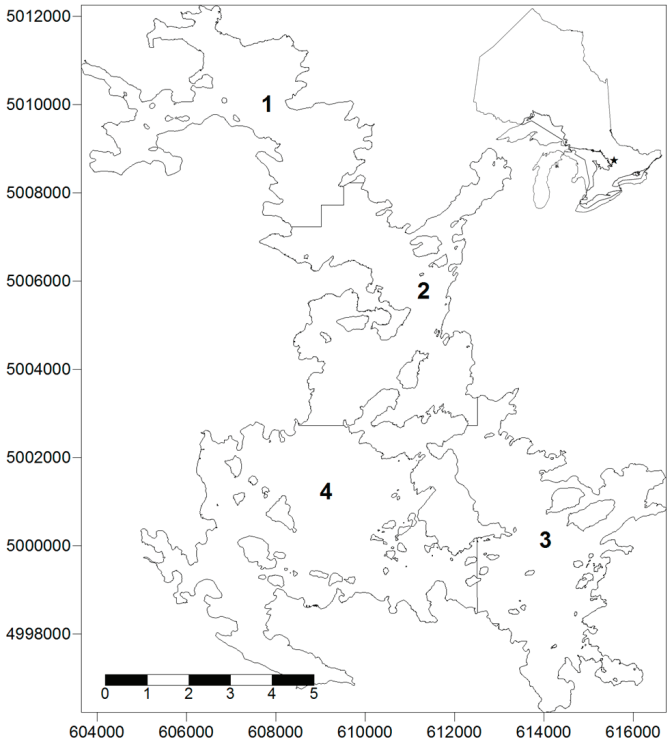


Figure 1. Lake Rosseau (6449 ha) located approximately 200 km north of Toronto. Numbers (1 to 4) represent represent sectors that the lake is divided into for sampling. Bathymetry and abundance will be presented for each of these. Scale is in km. Axes display Universal Transverse Mercator coordinates (UTM). Insert depicts location of Lake Rosseau in Ontario.

The mean volume weighted hypolimnetic dissolved oxygen [MVWHDO] concentration is a predictive measure of habitat quality for young lake trout survival. Using data collected by the District Municipality of Muskoka in 2007, MVWHDO was calculated by weighting the oxygen measures mgL^{-1} for each one metre depth strata in the hypolimnion (area below the thermocline) by the strata's habitat volume. Volumes were calculated based on the area as follows:

$$V_h = 1/3\ (A_h + A_i + (A_h \times A_i)^{.5})$$

Where:

V_h = volume of interval $_h$ ($m^3 x 10^4$)

A_h = area (ha) of upper stratum

A_i = area (ha) of lower adjoining stratum

Table 1. The surface area (ha) of each ten metre depth stratum in Lake Rosseau by Sector (see Figure 1) and for the whole lake combined.

	Sector Areas (ha)					
Strata (m)	1	2	3	4	Total	%
0-10	340	352	584	694	1969	31
10-20	193	311	344	510	1357	21
20-30	119	247	420	424	1210	19
30-40	73	164	154	288	679	11
40-50	83	197		249	528	8
50-60	167	101			268	4
60-70	32	29			61	1
70-80	36	37			73	1
80-90	200	102			303	5
Total	1243	1540	1502	2164	6449	
%	19	24	23	34		

Lake trout abundance

The lake trout population in Lake Rosseau was surveyed in mid-summer from 2004 to 2006 and again in 2009 using the SPIN methodology (Sandstrom and Lester 2009). Gillnets (8 mesh sizes x 8 panels, 8 m long; mesh sizes 38 mm to 127 mm individual stretch mesh panels) were set on the bottom below the thermocline (typically >10 m) during the summer. Nets were set for two hours and live fish released whenever possible after being sampled. Effort was stratified by depth into three ten metre wide stratas (10 m to 40 m). Sampling occurred between the hours of 09:00 and 17:00, and sets were equitably distributed between the morning and afternoon periods. For some surveys, multiple gangs (two nets joined together) were used to increase biological samples; but catch-per-unit-effort [CPUE] reported herein is presented for a standard 64 metre net, i.e., average of the two nets. In 2009, habitats deeper than 40 m was also surveyed.

Sites sampled were randomly chosen in the initial year of survey within each depth stratum. These sites were then subsequently re-used (i.e., fixed) in future years to provide more control of sampling variability. CPUE of lake trout in the nets were adjusted as outlined in Sandstrom and Lester (2009) to account for differences in vulnerability to the net due to body size of the fish. In addition, catch rates observed in the various depth strata were adjusted by the proportional area of each stratum to provide a representative estimate of density within the habitat surveyed. CPUE was converted to a density estimate (fish-per-ha) using the large body (piscivorous) calibration relationship provided in Sandstrom and Lester (2009). This includes a calculation of variance around the estimate, and incorporates an empirically derived measure of sampling error.

All sectors were sampled in each survey year, and within these, habitat between 10 to 40 m (72% of available optimal lake trout habitat, i.e., ≤ 13°C and ≥ 3 mgL^{-1} dissolved oxygen) was spatially surveyed. Hence, CPUE comparisons pertain only to this region of the lake. Whole lake estimates of abundance were calculated using the 2009 survey when all lake trout depth stratum (10 to 100 m) received full sampling.

The 2009 biomass estimate (abundance x mean weight of a lake trout) was generated using the length weight relationship observed for this population and the mean size of lake trout. Mean size of lake trout for the lake was derived by summing the average sector mean length x the proportion of the whole lake abundance attributed to that sector.

The 68% confidence interval (CL) is presented throughout the document, rather than the more typical 95%, as it provides a reasonable balance between the inherent high variability associated with measuring fish population metrics, and the relatively low precision requirement when considering estimates for recreational fisheries management.

Lake trout biological characteristics

Fork length (mm) was recorded from all lake trout captured and round weight (g), sex, maturity, stomach contents and ageing structures collected from all dead lake trout sampled. Fish were either aged using otoliths (mounted and sectioned), or assigned an age based on fork length using an age-length key (50 mm size bin) obtained from the actual age data. Estimates of von Bertalanffy growth parameters were calculated from the best fit non-linear regression equation of mean length at age for those ages with ten or more fish, using the software of Slipke and Maceina (2006). These parameters are useful in modelling and tracking changes in the growth characteristics of the population, where:

$$L_t = L\left(1 - e^{-k(t-t_o)}\right)$$

L_t = length at age t

L = maximum theoretical length

k = growth coefficient

t_o = year when length is zero

Catch curve analysis was used to estimate the annual survival rate of fish greater than 300 mm for those ages fully recruited to the gear, i.e., >6 years; all years combined. A weighted regression technique was followed (Steel and Torrie 1980), to moderate the influence of the older and rarer fish, using the software of Slipke and Maceina (2006).

Abundance of other species

Understanding the factors behind changes in lake trout abundance and/or their biological characteristics require that these be evaluated not only in relation to changes in habitat and fishing pressure, but also in conjunction with trends in other sympatric fish species.

Relative abundance of large bodied coldwater species was examined by comparing the proportional composition of

the SPIN catch by year and all years combined. In addition, lake trout stomachs were inspected to provide a measure of the primary forage species utilized during the summer in each survey year and all survey years combined.

Relative abundance of the primary i.e., most abundant small fish species (less than 250 mm) present in the lake was determined in 2008 using the Ontario broad-scale fisheries monitoring program's small-mesh sampling protocol (Sandstrom et. al. 2010). Straps, i.e., two gangs, of small-mesh (gang = five mesh sizes x five panels, 2.5 m long panels, 13 to 127 mm stretch mesh) were set for approximately 18 h at 21 random sites around the lake covering four depth strata spanning from 1 to 20 m. Catch was identified by species and measured for fork length. Individual species CPUE was depth stratified and calculated based on a single gang (as done for SPIN CPUE), but was not selectivity adjusted as the appropriate corrections have yet to be developed. A species specific area weighted CPUE of 0.25 was used as the minimum prevalence level to be classified as a primary species in this particular study.

Lake trout fishery

From 1988 to 2001 inclusive, the ASU has gathered information on winter angling catch rates and overall effort by way of intensive roving creels on Lake Rosseau. These surveys collected information on the number of anglers, the size of their catch and the associated success rate, i.e., fish-per-hour. As a result of fiscal constraints after 2001, the annual roving winter creel became more intermittent. The less expensive and less time consuming annual survey of maximum number of ice huts was maintained to the present (except in 1996 and 2002). Permanent ice huts were counted, either by way of on-ice roving survey, or through aerial observation during the peak period of fishing activity (late February to early March). Measures of winter effort on Lake Rosseau for years with only maximum hut count information was estimated by plotting effort (h/ha) and maximum hut count for years with both data sets available (1988 to 1995, 1997 to 2001, 2003, 2005). The resulting best fit relationship was then used to derive an estimate of total effort (h/ha) based on observed maximum hut count for those years with missing effort data (2004, 2006 to 2010).

Although some fishing also occurs during the summer months, assessment of this in the early-1990s revealed it to represent only a very small portion of the annual lake trout fishery, likely less than 1,000 lake trout. Given the high cost of conducting summer roving creels and the apparently relatively low contribution to this lake's annual harvest metrics, collection of data on the summer fishery has not occurred during the time period focused on in this report.

Results and discussion

Water quality

Mean volume weighted hypolimnetic dissolved oxygen of greater than 7 mgL^{-1} are considered to be conducive to recruitment (Evans 2005), and is the level presently used by the Ministry to guide allowable shoreline development.

The 2007 MVWHDO concentration for Lake Rosseau was 9.8 mg/l and is considered very high, indicating the deep waters of the lake are well-oxygenated and provide excellent juvenile habitat for lake trout production.

Lake trout abundance

Summary of the CPUE from each year of the survey is presented in Figure 2. The plot demonstrates that no trend is evident in CPUE (i.e., abundance), indicating that the population has remained relatively stable over this time period.

The 2009 estimate of lake trout abundance for fish greater than 300 mm was estimated at 41,000 fish (range 29,000 to 53,000; 68% [CL]) (Table 2). Using the observed relationship between the 2009 CPUE (10 to 40 m) and whole lake abundance (10 to 100 m), estimates of abundance can be approximated for 2004 to 2006 where only CPUE (10 to 40 m) measures were collected. The average abundance for Lake Rosseau for the period of 2004 to 2009 was estimated to be 36,000 lake trout (range 26,000 to 47,000) for fish greater than 300 mm.

The length weight relationship observed for this population is best described using a power function (weight = $1.36x10^{-06}$ x $length^{3.33}$; R^2 = 0.98), and the mean weight of lake trout determined to be 0.670 kg based on the calculated mean length (Table 2). Current biomass of lake trout was determined to be 6.09 kg/ha (4.38 to 7.91; 68% CL) for optimal habitat (>10 m) and 4.23 kg/ha (3.04 to 5.50; 68% CL) for the whole lake. The average biomass for the sample period of 2004 to 2009 was similarly calculated to be 5.44 kg/ha for the optimal habitat (3.91 to 7.07; 68% CL) and 3.78 kg/ha (2.71 to 4.91; 68% CL) for the whole lake.

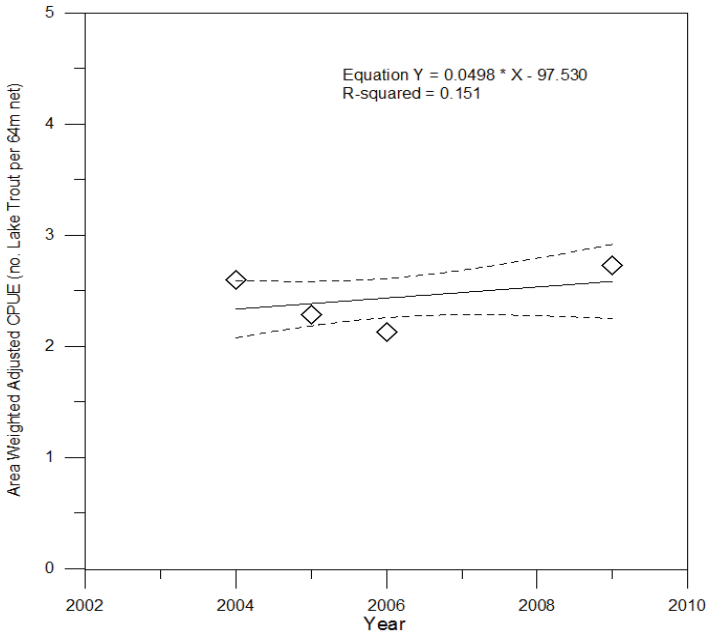


Figure 2. Catch-per-unit-effort of Lake Rosseau lake trout greater than 300 mm by year of survey with 68% confidence limits. Catch was standardized for spatial area, depth sampled and time of season, and catch was corrected for selectivity of the gear. No surveys were undertaken in 2007 and 2008.

Table 2. Summary of catch and associated abundance estimates by sector for the 2009 survey. CPUE is number of lake trout per 64 m net set for two hours. This is a selectivity-corrected depth-stratified estimate. Average values (CPUE, density) are weighted by the respective sector surface area proportions; average values for mean length were weighed by the sector abundances.

	Sector				
Variables	1	2	3	4	Avg/ Total
CPUE	2.09	2.03	2.47	2.12	2.16
Stdev of CPUE	1.58	1.46	1.62	1.80	
Density (no. per ha >10 m)	8.8	8.6	10.3	8.9	9.1
Mean Abundunce (>300 mm)	7,944	10,184	9,494	13,132	40,754
Min Abundundance (>300 mm)	5,654	7,196	7,022	9,383	29,255
Max Abundunce (>300 mm)	10,364	13,337	12,120	17,095	52,916
Mean Fork Length (mm)	351	403	389	452	406
Stdev of Fork Length (mm)	46	99	79	116	
Number of Sets	23	21	17	30	91
Number of Lake Trout	112	62	66	95	335
Area(ha) >10 m	903	1,188	918	1,471	4,480

Lake trout biological characteristics

A length frequency distribution of the combined index catches from all years is presented in Figure 3. The mean fork length (selectivity corrected) and associated variability has been consistent throughout the time series (Figure 4); indicating there have not been any large shifts in the size distribution of the population.

A change would be expected if the level of recruitment (juveniles reaching adulthood) was changing significantly, or, the effect of the fishery on the population was shifting, i.e., would expect fewer larger fish if the level of exploitation (proportion of population harvested) was escalating.

Sex ratios were also observed to remain relatively stable and balanced over the six year time period (Table 3). Males in this population appear to spawn for the first time (based on the youngest age observed) at 5 years of age and females at 6 years of age. Age at 50% maturity was determined to be approximately 11 and 13 years of age in males and females respectively (Table 4).

Mean size of spawning fish was calculated to be 519 mm (513 to 527; 68% CL), the distribution of spawner and non-spawner fork lengths by age is presented in Figure 5. Growth of males and females was found to be virtually the same (Figure 6), and size at age (i.e., growth) did not vary for any age between five and seven (those with sufficient data)

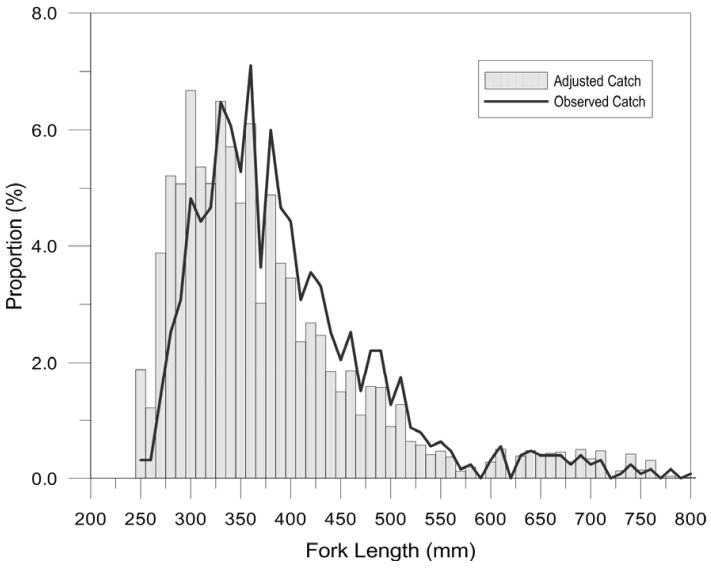


Figure 3. The selectivity-corrected length distribution (bars) of the Lake Rosseau lake trout population (>300 mm) as described by the index net catch (all survey years combined). The unadjusted length distribution is described by the line.

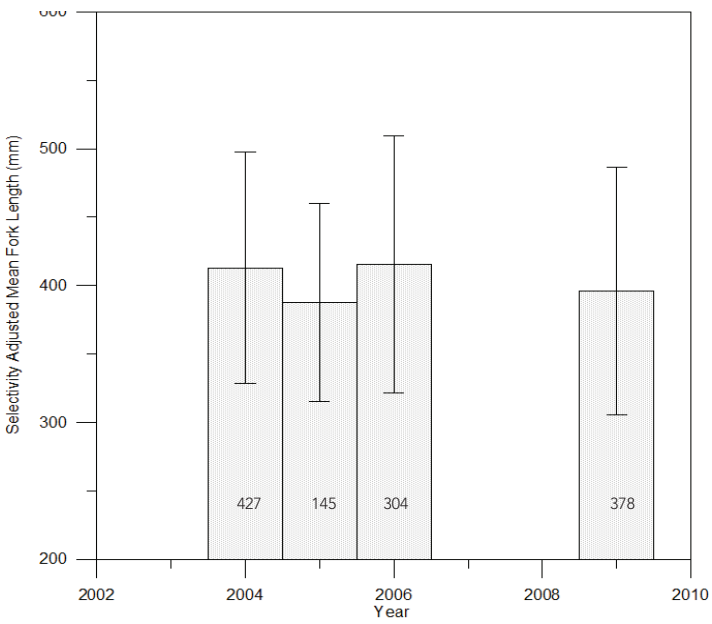


Figure 4. Mean selectivity corrected lake trout fork length (mm) of the catch by year of survey. Error bars represent one standard deviation. Sample sizes are indicated within the respective bar.

Table 3. The composition of the SPIN lake trout catches by sex and year.

Year	Male	Female
2004	50%	50%
2005	52%	48%
2006	45%	55%
2009	57%	43%
Avg	52%	48%

Table 4. Frequency of non-spawning to spawning lake trout by age group and sex. Grey dotted line indicates where approximately 50% of the sample for a particular age was found to be comprised of current year spawning individuals (i.e., age at 50% maturity). Non-Sp= non-spawner; Sp= spawner.

Male					Female				
Age	Non-Sp	Sp	% Sp	F lth	Age	Non-Sp	Sp	% Sp	F lth
4	14		0	309	4	14		0	287
5	80	1	1	323	5	56		0	323
6	136	6	4	362	6	128	3	2	358
7	65	8	11	386	7	71	4	5	387
8	35	9	20	421	8	51	5	9	419
9	18	8	31	429	9	28	6	18	459
10	14	11	44	446	10	15	7	32	465
11	7	6	46	472	11	9	6	40	515
12	1	10	91	525	12	9	6	40	510
13	4	3	43	483	13	5	8	62	501
14	3	4	57	530	14	3	6	67	527
15		3	100	582	15		3	100	604
16	1	2	67	588	16	2	3	60	532
17		1	100	560	17		2	100	758
18		1	100	725	18		3	100	543
19					19		2	100	590
20					20		1	100	550
21	24	1	4	550	21	1			473
24	1	1	50	775	24				
28		1	100	761	28				
29		1	100	671	29		1	100	850
Total	403	77	16		Total	392	66	14	

F lth = mean fork length (mm)

for the survey years of 2003 to 2006 (two way analysis of variance, P = 0.4541) (Figure 7).

The von Bertalanffy growth function parameters were estimated from all fish (actual plus age-length key assigned) as follows:

L - maximum theoretical length = 695 mm

k - growth coefficient = 0.10

t_o - year when length is zero = -1.175

Abundance of other species

Annual SPIN surveys can also provide information on the general trends in community composition and relative abundance of other large coldwater species (Table 5). Lake herring (*Coregonus artedi*) was the second most prevalent species captured (45% of catch on average) in all surveys, with lake whitefish (*Coregonus clupeaformis*) being the third, making up approximately 5% of the fish caught. Neither of these two species showed any noticeable change in their relative abundance over the time series suggesting, like lake

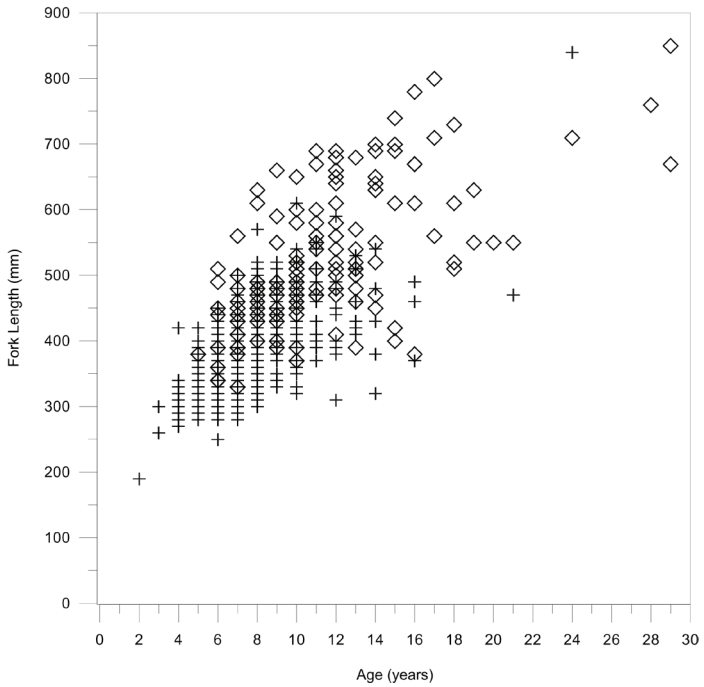


Figure 5. Fork length distribution of spawning (diamond) and non-spawning (plus) lake trout by age in Lake Rosseau.

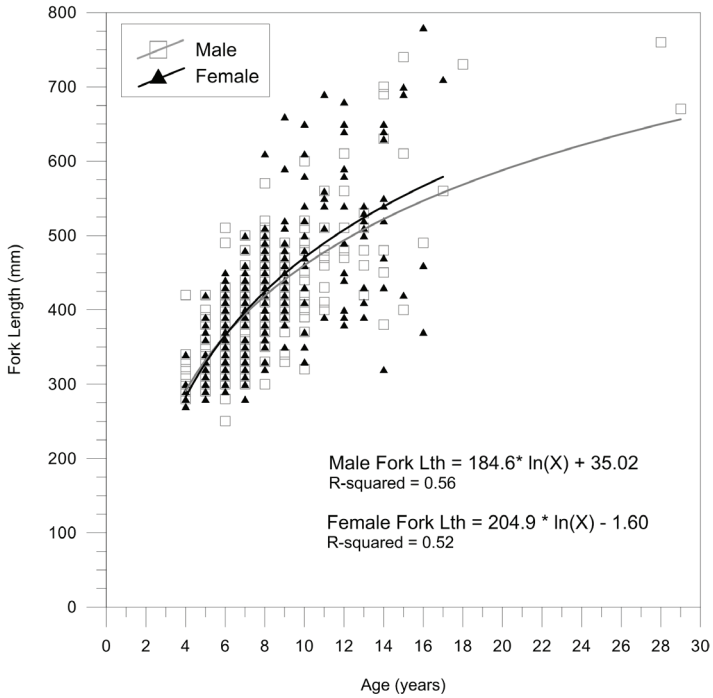


Figure 6. Fork length-at-age recorded for Lake Rosseau male and female lake trout and best fit line, all years combined.

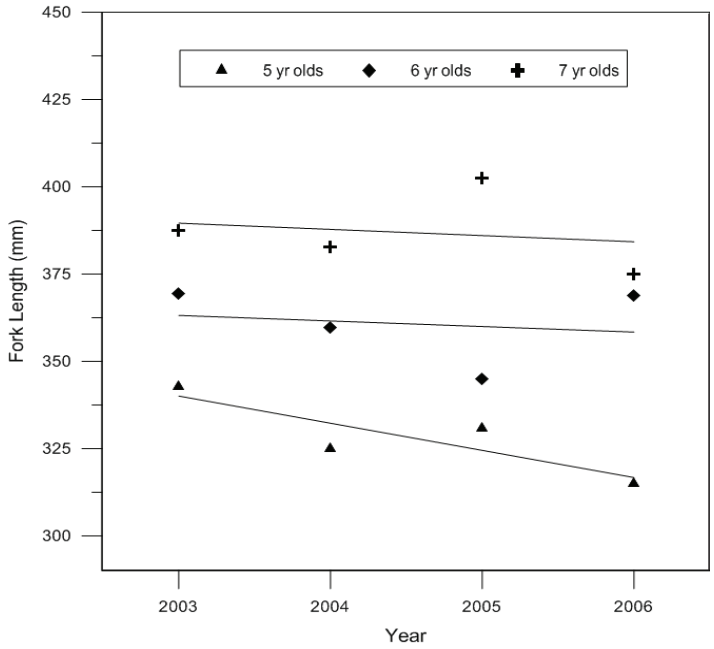


Figure 7. Mean fork length of lake trout recorded each year for ages 5 to 7 years. Increasing or decreasing trend was not detected in any age group examined (ANOVA P= 0.4541).

Table 5. The composition of large bodied coldwater species caught in the index nets by year.

Year	Trout	Whitefish	Herring
2004	49%	4%	47%
2005	44%	6%	50%
2006	43%	5%	51%
2009	63%	6%	31%
Avg	50%	5%	45%

trout, their abundance is presently relatively stable. There is negligible angling pressure on these species.

Stomach contents of lake trout revealed that Lake Rosseau lake trout are primarily piscivorous with rainbow smelt (*Osmerus mordax*) and lake herring representing the principal prey species identified (Table 6). The presence of ninespine stickleback (*Pungitius pungitius*) in the diet is likely because this particular species is known to occupy deepwater benthic habitat during the summer (Scott and Crossman 1973; Madenjian et. al. 2010).

A total of fourteen species were captured in the 2008 small-mesh survey of warm and coldwater species composition in Lake Rosseau, which found rock bass (*Ambloplites rupestris*), yellow perch (*Perca flavescens*) and lake herring, in that order, were the most abundant species detected by this methodology (Table 7).

Lake trout fishery

Winter angler effort has been highly variable over the complete time series (1988 to 2010); (Figure 8). Weather conditions among the years likely accounts for a large proportion of the variability observed. Warm winters typically result in poorer ice conditions, and hence, lower effort. However; angler effort (h/ha) was observed to increase noticeably during the early 1990s before leveling off and becoming highly variable. More recently, the average effort for the period of 2003 to 2010 was estimated to be 3.8 h/ha (Figure 8 and 9), and did not appear to be increasing or decreasing during this time.

The increase in effort at the beginning of the time series is likely a consequence of higher catch rates also witnessed in the early-1990s (Table 8). This has been speculated to be due to an increase in natural recruitment and/or survival once supplemental stocking ceased in 1990. Annual winter harvest and catch averaged 6,900 and 3,600 (58% of catch) fish respectively over the time series (Table 8). This equates to a sustainable average annual harvest of approximately 0.37 kg/ha whole lake or 0.54 kg/ha for optimal lake trout habitat (i.e., >10 m). The average observed success rate for years with data was determined to be 0.24 fish-per-hour (Table 8). This has also varied considerably and without trend.

Comparison of the length distribution from the winter creel in 2005 (the only year with a corresponding prior summer index survey) and that collected from the index is provided in Figure 10.

Table 6. The composition of lake trout stomachs as measured by presence-absence (for example: 5% of lake trout stomachs examined in 2009 were found to contain one or more smelt). All identifications were made at time of sampling and only represent a coarse measure.

Stomach	2009	2006	2005	2004	Avg
Empty	53.3%	41.1%	43.1%	27.7%	41.3%
Unidentifiable Fish	25.4%	28.4%	16.7%	24.1%	23.6%
Rainbow Smelt	5.2%	6.4%	16.7%	19.1%	11.9%
Lake Herring	6.4%	11.3%	12.5%	10.6%	10.2%
Invertebrates	6.9%	6.4%	4.2%	5.0%	5.6%
Ninepine Stickle-back	0.0%	0.7%	5.6%	11.0%	4.3%
Sculpin (spc unk) [1]	1.7%	2.8%	1.4%	2.5%	2.1%
Smallmouth Bass [2]	0.0%	2.1%	0.0%	0.0%	0.5%
Fish Hooks	1.1%	<1%	0.0%	0.0%	0.4%

[1] Family *Cottidae*

[2] *Micropterus dolomieu*

Table 7. The area weighted single gang CPUE of the most prevalent species caught in the broad-scale small-mesh survey in 2008. A total of 14 species were captured, but only the primary species are reported (i.e., CPUE greater than or equal to 0.25).

Species	CPUE
Rock Bass	10.90
Yellow Perch	1.68
Lake Herring	1.16
Spottail Shiner [1]	0.78
Rainbow Smelt	0.71
Pumpkinseed [2]	0.50
Lake Trout	0.28

[1] *Notropis hudsonius*

[2] *Lepomis gibbosus*

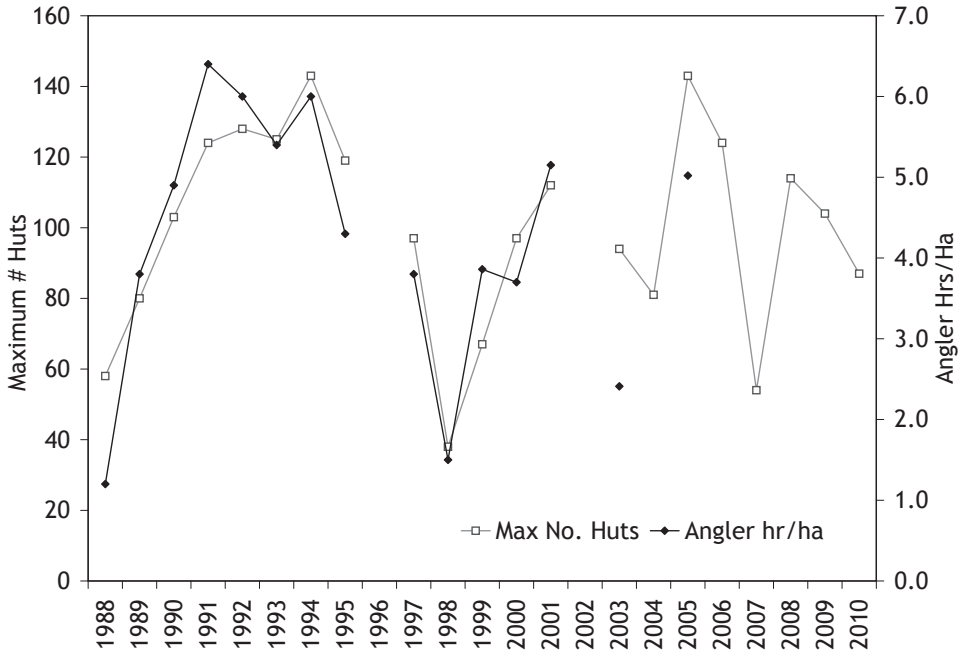
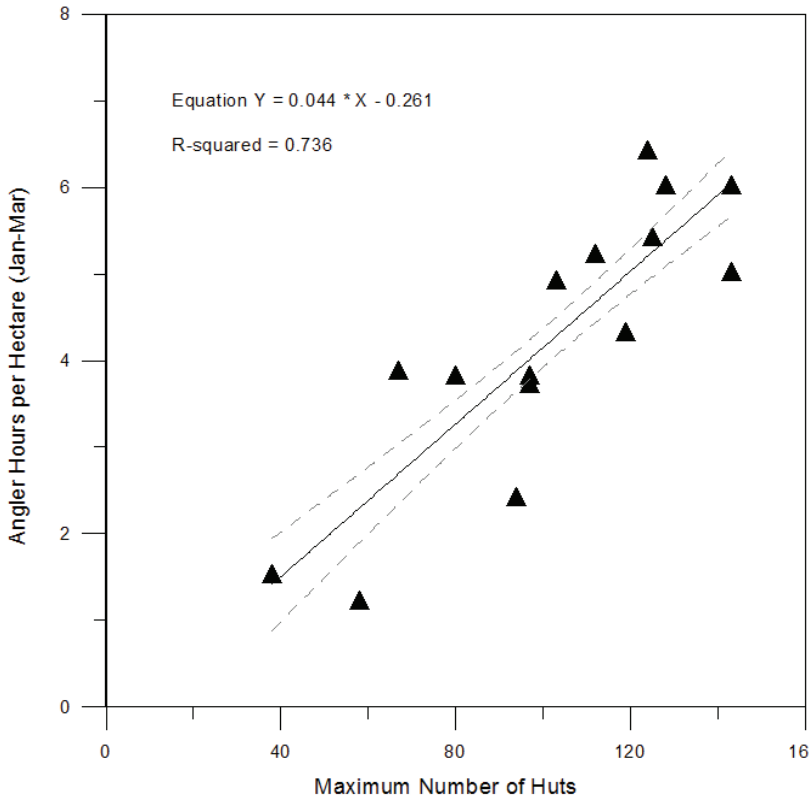


Figure 8. The relationship between maximum number of huts present on the lake at one time, and the calculated total angler hour-per-hectare for the winter fishery (January 1st to March 31st) for the years 1988 to 2010. For years with data, angler effort (h/ha) was derived by way of roving creel survey.



Year	No. Huts	Est h/ha
2003	94	2.4
2004	81	3.3
2005	143	5.0
2006	124	5.2
2007	54	2.1
2008	114	4.8
2009	104	4.3
2010	87	3.6
Avg	100	3.8

Figure 9. Relationship between winter effort (hours-per-hectare) and the observed maximum number of huts observed on the lake at one time (1988-2003, 2005). The equation for the best fit line was used to derive an estimate of angler effort for 2004 and 2007 to 2010 when only maximum hut counts were available (see table insert for summary). Dashed line are 68% confidence limits.

Table 8. Winter catch and harvest (number of lake trout), ratio of harvest to catch (%), and fish-per-hour for Lake Rosseau winter fishery estimated by roving creel survey.

Year	Winter Catch	Winter Harvest	Harvest Ratio	Catch per Hour
2005	6,131	3,729	61	0.19
2004				
2003				
2002				
2001	8,745	5,318	61	0.26
2000	7,769	4,421	57	0.30
1999	11,397	5,543	49	0.31
1998	5,256	1,542	29	0.57
1997	9,218	3,849	42	0.37
1996				
1995	5,928	1,515	26	0.20
1994	10,789	3,979	37	0.26
1993	8,449	3,762	45	0.21
1992	8,204	4,717	58	0.21
1991	6,480	4,621	71	0.15
1990	3,841	3,372	88	0.12
1989	3,551	3,247	91	0.11
1988	931	890	96	0.11
Avg	6,906	3,608	58	0.24

This figure demonstrates that the index provides a reasonable measure of the size distribution caught by anglers up to 600 mm (Kolmogorov-Smirnov maximum difference between the cumulative distributions = 0.171; P = 0.640, i.e., distributions not different). However, it would appear by the relative absence in the angler harvest, that lake trout greater than 600 mm may be less vulnerable than smaller fish to capture by hook and line. This observation could be due to an angler preference for smaller fish (for eating) with larger individuals being released. Newby et. al. (2000) demonstrated that older larger walleye (*Sander vitreus*)were less vulnerable to anglers than younger smaller walleye in Escabana Lake, Wisconsin. For the same lake, Serns and Kempinger (1981) concluded that this was likely due to baits typically used by anglers being below the preference size of larger walleye. This might also explain the relative absence of large (>600 mm) lake trout in Lake Rosseau angler catches where the predominant bait used in the winter is small (<120 mm) minnows. Larger lake trout were typically observed in the netting program with adult herring (avgerage length 230 mm) in their stomachs (Table 9), so, they may be less inclined to take the smaller prey items presented by anglers. Rainbow smelt and various sculpin species (both species generally <140 mm) comprised 90% of prey fish species identified in stomachs of lake trout less than 400 mm caught in the index nets.

Analysis of the catch curve for fish fully vulnerable to the index gear (ages 6^{+}; all years combined) provided an estimate of absolute annual mortality of 28%, i.e., annual survival of 72% (Figure 11).

If current harvest levels have remained consistent with those observed over the whole time series (1988 to 2005), speculation that is supported by the trend in effort, then level of exploitation (μ) would be 10.0% (range 8.0% to 14%; 68% CL; using 2004 to 2009 average whole lake abundance estimate).

Furthermore, as:

F - instantaneous fishing mortality

Z - instantaneous total mortality

A - absolute annual mortality

Instantaneous fishing mortality can be calculated by solving

$$\mu = \frac{F}{Z}(A)$$

the above formula for *F* and using the values of *Z* and *A* estimated from the catch curve (Figure 11), and the value of μ estimated using the average population estimate and average harvest for the time series (2004 to 2009). Fishing mortality rate was determined to be 0.10 (range 0.08 to 0.14; 68% CL) for this population.

Shuter et. al. (1998) put forward a life history based model for management of lake trout in Ontario which calculated fishing rates (F) at maximum equilibrium yield, for a lake of the size and productivity (total dissolved solids = 33 mgL^{-1}) of Lake Rosseau, would be in the order of 0.30. As the values found in the present study are considerably lower on average than predicted to be unsustainable, it would appear the current level of fishing is biologically acceptable.

Conclusions

The current estimate of lake trout abundance (>300 mm) in Lake Rosseau is 41,000 fish (range 29,000 to 53,000) with an optimal habitat biomass of 6.09 kg/ha. Average

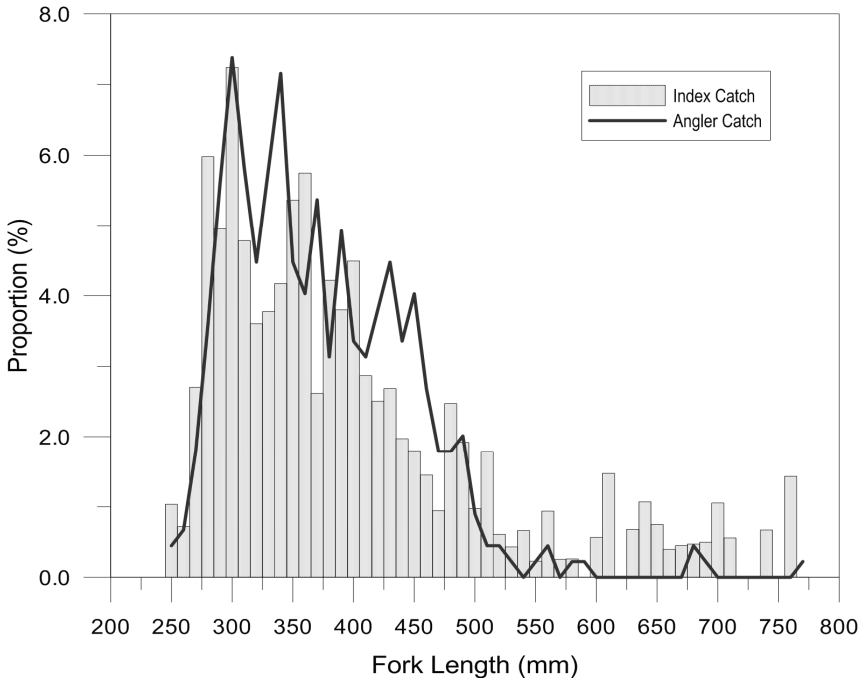


Figure 10. Distribution of fork lengths (mm) recorded during the winter creel survey in 2005 and the selectivity corrected index catch from the preceding summer (i.e., 2004). Statistical comparison only found them to be different for lengths greater than 600 mm (Kolmogorov-Smirnov for fish <600 mm P = 0.640).

Table 9. Fork lengths of whole herring observed in the stomach of Lake Rosseau lake trout greater than 550 mm fork length.

Lake Trout	Prey Fork Lth (mm)				Prey Predator
Fork Lth	Lth 1	Lth 2	Lth 3	Avg	Ratio
550	230			230	42%
600	220			220	37%
630	205			205	33%
670	200			200	30%
710	250	210		230	32%
740	285	260	250	265	36%
800	265			265	33%
			avg	231	35%

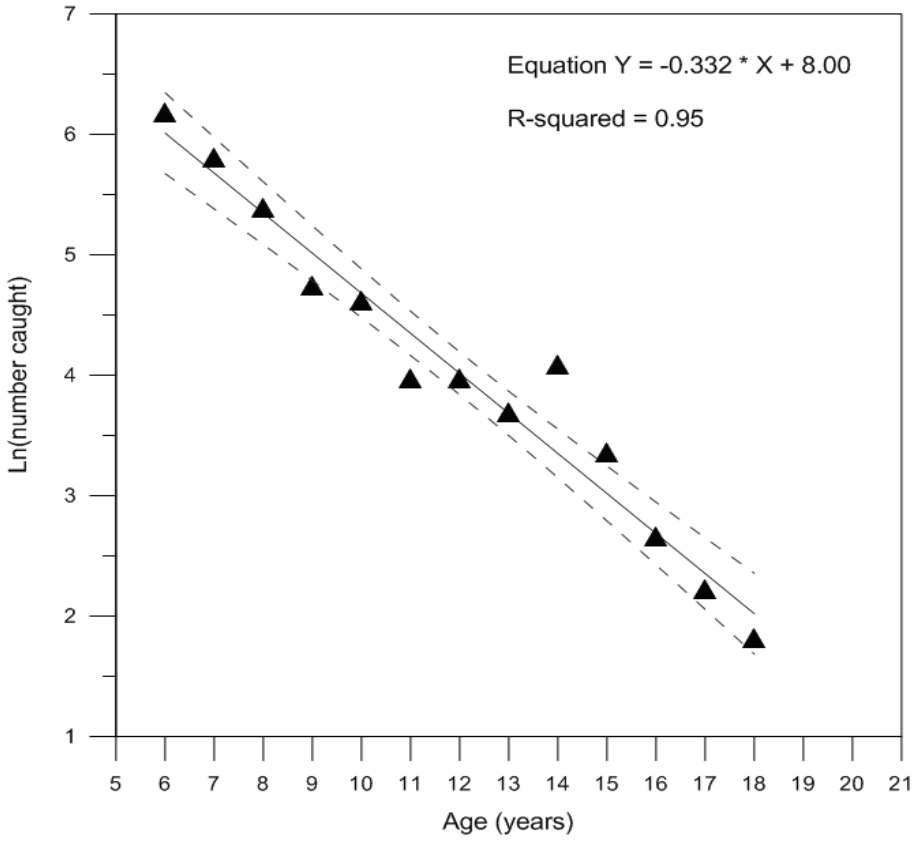


Figure 11. Weighted catch curve regression for fish six years of age and older. Slope of the regression equation (-0.332) is the estimate of the instantaneous annual rate of total mortality (Z). The inverse of this natural logarithm value is the annual survival rate, in this case 72%.

lake wide abundance estimated for the period of 2004 to 2009 was 36,000 fish (range 26,000 to 47,000). Trends in 2004 to 2009 index netting CPUE, mean length and species composition of catch, along with long-term (1988 to present) trends observed in winter angler effort, indicate that this population is likely stable at the present time. Annual survival of lake trout greater than 300 mm was estimated to be 72%, with approximately 10% of the lake trout (>300 mm) removed annually by the fishery (range 8% to 14%), which appears from analysis of catch curve information to be sustainable.

Current mean volume weighted hypolimnetic dissolved oxygen concentration indicates that the status and availability of critical habitat for lake trout is also not limiting.

The metrics produced by this program will function as useful reference points to evaluate trends in this population in the future. Ecological measures generated (i.e., fish/ha) will be directly comparable, and hence useable, in Ontario's new broad-scale fisheries monitoring program. Annual monitoring by index netting is unnecessary given the low degree of variability observed in CPUE, with assessments on a three or five year interval likely sufficient to adequately monitor the ongoing status of this population.

References

Evans, D.O. 2005. Effects of hypoxia on scope-for-activity of lake trout: defining a new dissolved oxygen criterion for protection of lake trout habitat. Tech. Rep. 2005-01 Habitat and Fisheries Unit, ARDS, ARDB, Peterborough. 18 p.

Evans, D.O. and C.C. Willox. 1991. Loss of exploited indigenous populations of lake trout, *Salvelinus namaycush*, by stocking of hatchery-reared, non-native stocks. Can. J. Fish. Aquat. Sci. 48 (Supplement 1):134-147.

Madenjian, C.P., D.B. Bunnell, and O.T. Gorman. 2010. Ninespine stickleback abundance in Lake Michigan increases after invasion of dreissenid mussels. Trans. Amer. Fish. Soc. 139:11-20.

Newby, J.R., M.J. Hansen, S.P. Newman, and C.J. Edwards. 2000. Catchability of walleye to angling in Escanaba Lake, Wisconsin, 1980-1995. North Amer. J. Fish. Manag. 20:873-881.

Sandstrom, S., M. Rawson, and N. Lester. 2010. Manual of Instructions for Broad-scale Fish Community Monitoring; using Large Mesh Gillnets and Small Mesh Gillnets. Ontario Ministry of Natural Resources. Peterborough, Ontario. Version 2010.2. 34 p. + appendices.

Sandstrom, S.J. and N. Lester. 2009. Summer Profundal Index Netting Protocol; a Lake Trout Assessment Tool. Ontario Ministry of Natural Resources. Peterborough, Ontario. Version 2009.1. 22 p. + appendices.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. 184:1-966.

Shuter, B.J., M.L. Jones, R.M. Korver, and N.P. Lester. 1998. A general life history base model for regional management of fish stocks: the inland lake trout (*Salvelinus namaycush*) fisheries of Ontario. Can. J. Fish. Aquat. Sci. 55:2162-2177.

Slipke, J.W. and M.J. Maceina. 2006. Fishery analysis and simulation tools (FAST), version 3.0. Auburn University, Auburn, Alabama.

Steel, R.G.D. and J.H. Torrie. 1980. Principles of statistics: a biometrical approach. 2nd edition. McGraw-Hill, New York.

Serns, S.L. and J.J. Kempinger. 1981. Relationship of angler exploitation to the size, age, and sex of walleyes in Escanaba Lake, Wisconsin. Trans. Amer. Fish. Soc. 110:216-220.

This report was prepared by the Aquatic Science Unit in conjunction with Regional Operations Division.

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Printed in Ontario, Canada

52687

ISBN 978-1-4435-5793-1(PDF)

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Cette publication hautement specialisée La situation du touladi (*Salvelinus namaycush*) dans le lac Rosseau, Ontario n'est disponible qu'en anglais en vertu du Règlement 411/97 qui en exempte l'application de la Loi sur les services en français. Pour obtenir de l'aide en français, veuillez communiquer avec Southern Science and Information Section au ministère des Richesses naturelles au 1-800-667-1840 ou informationssi@mnr.gov.on.ca.

This publication should be cited as:

Sandstrom, Steve. 2011. Status of Lake Trout (*Salvelinus namaycush*) in Lake Rosseau, Ontario. Ont. Min. Natur. Resour., Science and Information Branch, Southern Sci. and Info., SIB ASU Report 2011–1. 12 p.

MNR 52687
ISBN 978-1-4435-5793-1