Science and Information Branch
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Aquatic Science Unit Report 2010 –1

Status of Lake Trout (*Salvenlinus namaycush*) in Lake Joseph

By Steve Sandstrom



Ministry of Natural Resources

Ontario

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

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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 indicators of the health of coldwater ecosystems. Lake Joseph is the fourth largest unstocked lake trout lake in southern Ontario, and supports an active winter fishery exhibiting around 25,000 angler hours of effort. The following report presents a summary of biological results collected by the Southern Region Aquatic Science Unit (ASU) 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 28,000 fish (range 18,000–38,000; 68% confidence interval). No statistically significant changes in population abundance were found from 2003 to 2009. However, these findings stand in contrast to the visually discernable decline observed in the index catch rate. Future monitoring over the next several years will be key to properly addressing this discrepancy. 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 du sud de l'Ontario, non seulement en raison de son intérêt considérable pour les pêcheurs à la ligne, mais également compte tenu de ses exigences particulières en matière d'habitat, car il joue un rôle en tant qu'espèce indicatrice de la santé des écosystèmes des eaux froides. Le lac Joseph est le quatrième plus grand lac de truite non ensemencé du sud de l'Ontario, et il soutient une pêche hivernale active représentant un effort d'environ 25 000 heures pêcheurs. Le rapport suivant présente un sommaire des résultats biologiques recueillis par l'Unité des sciences aquatiques (USA) de la Section des sciences et de l'information du Sud (SSI) au sujet de la population et de la pêche qui y est associée. L'abondance du touladi a été déterminée par l'utilisation de la méthodologie calibrée au filet maillant (campagne de pêche indicatrice effectuée en profondeur l'été) et estimée présentement à environ 28 000 poissons (gamme de 18 000 à 38 000; intervalle de confiance de 68 %). Aucune modification importante de l'abondance de la population sur le plan statistique n'a été observée de 2003 à 2009. Cependant, ces conclusions s'opposent au déclin visuellement perceptible observé dans l'indice du taux de prise. La surveillance future au cours des prochaines années sera essentielle afin d'aborder cet écart. Les résultats de ce programme procureront une source importante de données et de points de référence pouvant être utilisés par les conseils de zones de gestion des pêches de la région du sud en appui au cadre stratégique pour la gestion écologique des pêches, élaboré en vue d'améliorer la manière dont les ressources provinciales des pêches sont gérées.

Mots-clés :

touladi, densité, taux de mortalité par pêche, effort du pêcheur, croissance, régime

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Contents

Abstract ii

Résumé iii

Acknowledgements iv

Contents v

List of tables vi

List of figures vi

Overview 1

Methodology 1
- Water quality 1
- Lake trout abundance 2
- Lake trout biological characteristics 2
- Abundance of other species 2
- Lake trout fishery 3

Results and Discussion 3
- Water quality 3
- Lake trout abundance 3
- Lake trout biological characteristics 4
- Abundance of other species 6
- Lake trout fishery 6

Conclusions 10

References 11

List of tables

Table 1. The surface area of each 10 metre depth stratum by sector..... 1

Table 2. Summary of catch and associated abundance estimates by sector, 2009. 4

Table 3. The composition of the SPIN lake trout catches by sex and year. .. 5

Table 4. Frequency of non-spawning to spawning lake trout by age group and sex. 5

Table 5. The composition of large bodied coldwater species caught in the index nets by year. 7

Table 6. The composition of lake trout stomachs as measured by presence absence 7

Table 7. CPUE of species caught in the Broad-scale Small mesh survey in 2008. 8

Table 8. Winter Harvest (number of lake trout) and catch-per-rod-hour..... 9

List of figures

Figure 1. Map and location of Lake Joseph. 1

Figure 2. Catch-per-unit-effort of lake trout by year of survey. 3

Figure 3. The selectivity-corrected length distribution from index nets..... 4

Figure 4. Mean selectivity corrected lake trout fork length (mm) by year of survey. 4

Figure 5. Fork length distribution of spawning and non-spawing lake trout by age in Lake Joseph 6

Figure 6. Fork length-at-age recorded for male and female lake trout. 7

Figure 7. Mean fork length recorded each year for ages 6 to 12 years. 7

Figure 8. Maximum number of ice huts and total angler hours per hectare by year. 8

Figure 9. Relationship between winter effort (hours-per-hectare) and the observed maximum number of huts. 8

Figure 10. Distribution of fork lengths (mm) from the winter creel and the index catch, 2005. 10

Figure 11. Weighted catch curve regression for fish nine years of age and older. 10

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 percent % 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 Joseph.

Lake Joseph is a large (5560 ha), deep (mean depth: 25 m) oligotrophic lake (Total Phosphorous = 4.9 per ug/l, Secchi depth = 6.5 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 Joseph's shoreline is heavily developed with recreational homes, with a current estimate of 1526 shoreline accessible properties. Having a combined shoreline distance (including that of islands) of 193 km, this equates to a property on average every 126 m of shoreline. All land surrounding the lake is currently privately owned; but four-season public access is available at several locations.

Widely recognized as the best of the four large lakes for lake trout fishing, Lake Joseph experiences the highest fishing effort per hectare. The current regulations in place to protect this population include the standard closure starting October 1, afforded the other populations, but is unique in having a late opening of February 15 (implemented in 1989) rather than January 1, to provide increased protection. There are currently no restrictions on the size of lake trout that can be harvested, and the catch limit and possession 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 Joseph by the Ministry of Natural Resources has occurred since the late-1980s. The following report will highlight and summarize biological information for lake trout from Lake Joseph collected between 2003 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., >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 be discussed, and observed fishing mortality compared to theoretically sustainable levels.

Methodology

Water quality

The lake was divided into three sectors to assist in sampling and monitoring (Figure 1). The surface area (ha) for each of these sectors, along with that for the whole lake, is presented for 10 metre depth intervals (Table 1). Detailed bathymetric information for the lake was collected by the ASU in 2003–04.

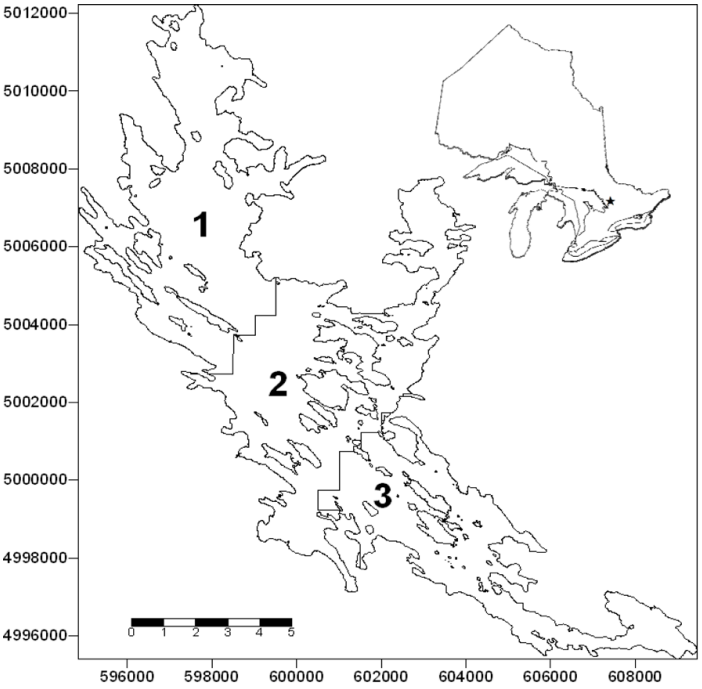


Figure 1. Lake Joseph (5560 ha) located approximately 200 km north of Toronto. Numbers (1–3) represent sectors that the lake is divided into for sampling purposes; bathymetry and abundance will be presented at this level. Scale in km. Axes display Universal Transverse Mercator coordinates (UTM). Insert depicts location of Lake Joseph in Ontario.

Table 1. The surface area (ha) of each 10 metre depth stratum in Lake Joseph by sector (see Figure 1) and for the whole lake combined.

		Sector Areas (ha)				
Strata	(m)	1	2	3	Total	%
	0-10	431	657	550	1637	29%
	10-20	401	410	526	1337	24%
	20-30	302	228	280	810	15%
	30-40	183	305	46	534	10%
	40-50	212	61		273	5%
	50-60	129	69		198	4%
	60-70	125	173		298	5%
	70-80	174	73		248	4%
	80-90	146	34		180	3%
	90-100	41			41	1%
	Total	2145	2009	1400	5555	
	%	39%	36%	25%		

The mean volume weighted hypolimnetic dissolved oxygen (MVWHDO) concentration is used in Ontario as a predictive measure of habitat quality for young lake trout survival.

Using data collected by the District Municipality of Muskoka in 2008, MVWHDO was calculated by weighting the oxygen measures mgL^{-1} at each one metre depth interval in the hypolimnion (area below the lower thermocline boundary) by the volume of habitat at each interval. 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

Lake trout abundance

The lake trout population in Lake Joseph was surveyed in mid-summer from 2003 to 2007 and again in 2009 using the SPIN methodology (Sandstrom and Lester, 2009). Gillnets (8 mesh sizes × 8 panels, 8 m long; mesh sizes 38–127 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 10 metre wide depth intervals (10 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, habitat deeper than 40 m was also surveyed.

Sampling sites 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.

Not all of the lake sectors were sampled in all years due to various operational constraints, thus, inter-annual CPUE comparisons were standardized by the spatial area sampled, i.e., same geographical region of the lake and same depth interval. In all surveys, sector 2 and 3 (61% of the lake's surface area) and depths 10–40 m were sampled, which constituted 82% of available optimal lake trout habitat, i.e., ≤ 13 °C and ≥ 3 mgL^{-1} dissolved oxygen, in these sectors. Hence, CPUE comparisons pertain only to this region of the lake. Whole lake estimates of abundance were calculated using the 2009 survey when all sectors and lake trout depth stratum (10–100 m) received full sampling.

The 2009 biomass (abundance × 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 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 of these 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 lake trout dead 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:

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

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., 9^+ years; all sample 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 cold-water 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 determine in 2008 using the Ontario Broad-scale Monitoring Program's Small-mesh sampling protocol (Sandstrom et al. 2009). Straps, i.e., two gangs, of Small-mesh gear (gang = five mesh sizes × five panels, 2.5 m long panels, 13–127 mm stretch mesh) were set for approximately 18 hours at 21 random sites around the lake covering four depth strata spanning from 1–20 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 Joseph. 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 intermittent. The less expensive and less time consuming annual survey of maximum number of ice huts was maintained to the present (except in 1996, 2002 and 2006). 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 Joseph for years with only maximum hut count information was estimated by plotting effort (hrs/ha) and maximum hut count for years with both data sets available (1988 to 2001, 2003, 2005). The resulting best fit relationship was then used to derive an estimate of total effort (hrs/ha) based on observed maximum hut count for those years with missing effort data (2004, 2007 to 09).

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

MVWHDO of greater than 7 mgL^{-1} are considered to be conducive to recruitment (Evans, 2005) and is the level presently used by the Ministry of Natural Resources to guide allowable shoreline development. The 2008 MVWHDO concentration for Lake Joseph was 10.9 mgL^{-1} 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 suggests a declining trend in CPUE, i.e., abundance, but this is not statistically significant (P= 0.18). The high degree of dispersion between 2006 and 2007, and missing data in 2008, clouds any statistically detectable trend, if one exists.

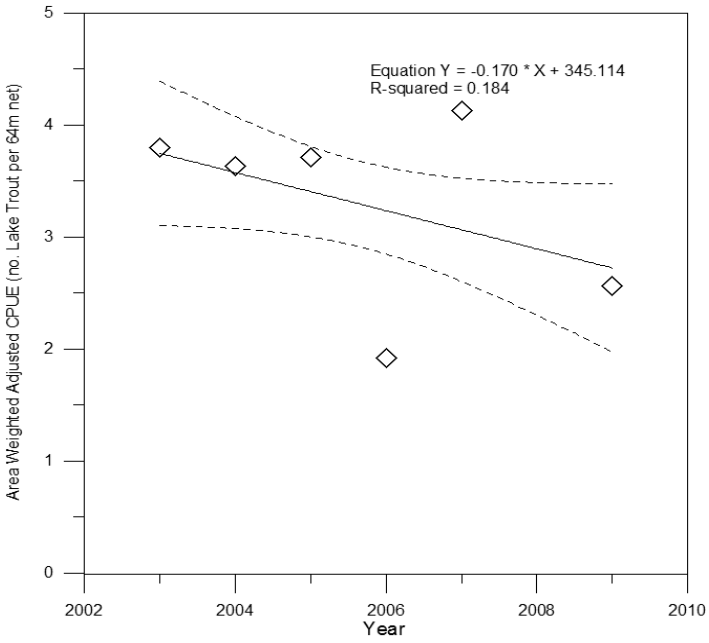


Figure 2. Catch-per-unit-effort of Lake Joseph lake trout greater than 300 mm by year of survey with 68% confidence limits. Catch was standardized for spatial area, depth sampled and time of season, and catch was corrected for selectivity of the gear. Although this apparently indicates a declining trend, it is not significant (P >0.05). No survey was undertaken in 2008.

The 2009 estimate of lake trout abundance for fish greater than 300 mm was estimated at 28,000 fish (range 19,000–38,000; 68% CL) (Table 2). Using the observed relationship between the 2009 CPUE in sector 2 and 3 combined (CPUE2_3) and the whole lake abundance determined in that year, estimates of abundance can be approximated for 2003 to 2007 where only CPUE2_3 measures were collected. The average abundance for Lake Joseph for the period of 2003 to 2009 was estimated to be 36,000 lake trout (range 24,000–49,000) for fish greater than 300 mm.

The length weight relationship observed for this population was best described using a power function (weight = 1x10-06 × length3.39; R^2=0.97), and the mean weight of lake trout determined to be 0.887 kg based on the calculated mean length (Table 2). Current biomass of lake trout was determined to be 6.34 kg/ha (4.30–8.60; 68% CL) for optimal habitat (>10m) and 4.47 kg/ha (3.03–6.07; 68% CL) for the whole lake. The average biomass for the sample period of 2003 to 2009 was similarly calculated to be 8.15 kg/ha for optimal (5.43–11.09; 68% CL) and 5.75 kg/ha (3.83–7.82; 68% CL) for the whole lake.

Table 2. Summary of catch and associated abundance estimates by sector for the 2009 survey. CPUE is number of lake trout per 64m 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	Avg/Total
CPUE	1.11	2.22	2.03	1.7
Stdev of CPUE	0.96	2.03	2.22	1.6
Density (no. per ha >10m)	4.9	9.3	8.6	7.2
Mean Abundunce(300+mm)	8,353	12,619	7,306	28,278
Min Abundunce(300+mm)	4,572	9,119	5,164	18,855
Max Abundunce(300+mm)	12,269	16,325	9,568	38,162
Mean Fork Length (mm)	449	425	444	440
Stdev of Fork Length (mm)	75	104	76	85
Number of Sets	20	27	14	61
Number of Lake Trout	22	62	27	111
Area(ha) >10m	1714	1353	851	3918

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 has not been any large shifts in 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 level of exploitation (proportion of population harvested) was escalating.

Sex ratios were also observed to remain relatively stable and balanced over the seven year time period (Table 3). Males in this population appear to spawn for the first time (based on the youngest age observed) at six years of age and females at eight years of age. Age at 50% maturity was determined to be approximately nine and 13 years of age in males and females respectively (Table 4). Mean size of spawning fish was calculated to be 511 mm (505-516; 68% CL), the distribution of spawner and non-spawner fork lengths by age is presented in Figure 5.

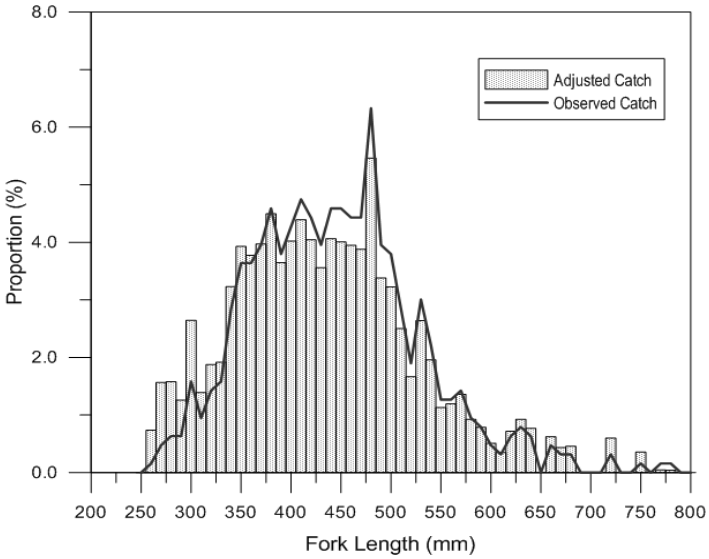


Figure 3. The selectivity-corrected length distribution (bars) of the Lake Joseph lake trout population (>300 mm) as described by the index net catch (all survey years combined). The unadjusted length distribution is described by the line.

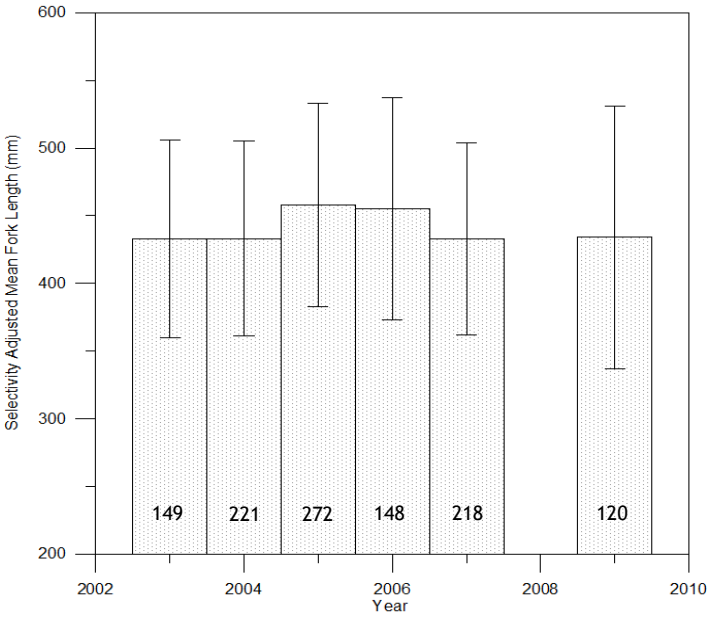


Figure 4. Mean selectivity corrected lake trout fork length (mm) of the catch by year of survey. Error bars represent one standard deviation. Sample sizes are indicated within the respective bar.

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

Year	Male	Female
2003	47%	53%
2004	43%	57%
2005	51%	49%
2006	53%	47%
2007	43%	57%
2009	43%	57%
Avg	46%	54%

Table 4. Frequency of non-spawning to spawning lake trout by age group and sex. Grey dotted line indicates where 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
3	1		0%	350		3	3			290
4	4		0%	318		4	6		0%	342
5	7		0%	360		5	15		0%	353
6	29	4	12%	397		6	40		0%	366
7	34	9	21%	412		7	56		0%	403
8	24	17	41%	437		8	54	6	10%	436
9	29	30	51%	459		9	41	11	21%	446
10	15	21	58%	479		10	28	8	22%	452
11	12	16	57%	476		11	14	8	36%	467
12	3	9	75%	525		12	12	6	33%	481
13	4	4	50%	496		13	4	4	50%	500
14	3	6	67%	523		14	3	3	50%	503
15		1	100%	460		15		1	100%	660
16	1	1	50%	490		16		1	100%	540
17		1	100%	630		17	1	2	67%	597
18		2	100%	625		18				
19						19		1	100%	680
20	1	1	50%	535		20				
21		1	100%	780		21				
22						22				
23						23				
24		2	100%	795		24				
Total	167	125	43%			Total	277	51	16%	

F lth = mean fork length (mm)

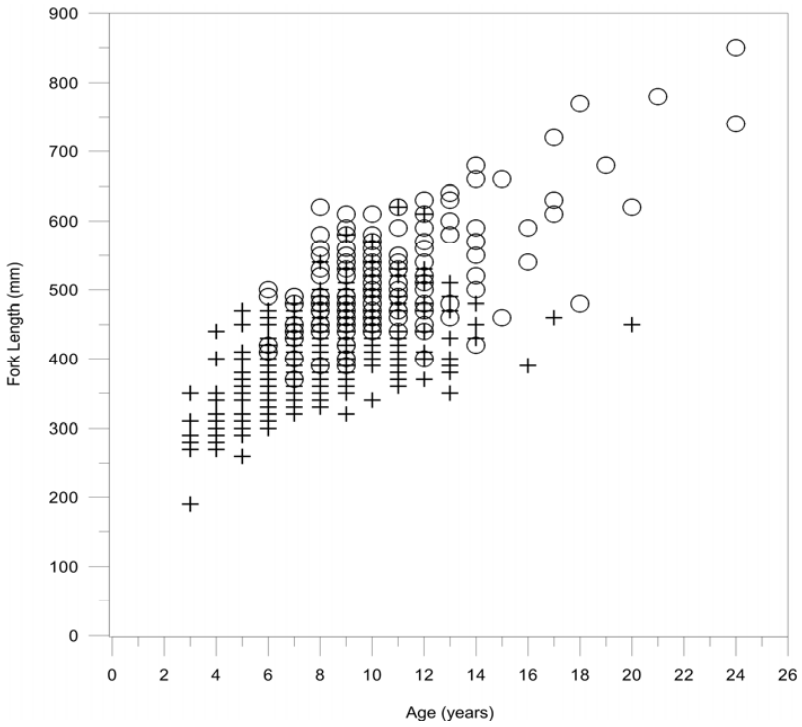


Figure 5. Fork length distribution of spawning (circle) and non-spawning (plus) lake trout by age in Lake Joseph.

Growth of males and females was found to be significantly different (ANCOVA P= 0.006; Figure 6), with males observed to be larger (by approximately 13 mm) than females of the same age.. Size at age, i.e., growth, did not vary for any age between six and 12 (those ages with sufficient data) for the survey years of 2003 to 2009 (two way analysis of variance, P = 0.5023) (Figure 7).

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

L - maximum theoretical length = 691mm

k - growth coefficient = 0.091

t_o - year when length is zero = -2.539

Abundance of other species

Annual SPIN surveys can also provide information on the general trends in fish community composition and relative abundance of other large coldwater species (Table 5). Lake herring (*Coregonus artedi*) was the second most prevalent species captured (30% on average) in all surveys, with lake whitefish (*Coregonus clupeaformis*) being the third, making up approximately 3% of the fish caught. Neither of these two species showed any noticeable change in their relative abundance over the time series suggesting, like lake trout, their abundance is relatively stable. There is negligible angling pressure on these species.

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

A total of thirteen species were captured in the 2008 small-mesh survey of warm and cold water species composition in Lake Joseph, which found rock bass (*Ambloplites rupestris*), rainbow smelt and lake herring, in that order, were the most abundance species detected by this methodology (Table 7).

Lake trout fishery

Winter angler effort has been highly variable over the complete time series (1988 to 2009) (Figure 8). Weather conditions among years likely accounts for a large proportion of the variability observed. Warm winters typically result in poorer ice conditions, and hence, lower effort.

No distinct trend was detected in the number of winter angler-hours-per-hectare, with the current (2003 to 2009) average effort estimated to be 4.8 hours-per-hectare (Figure 8 and 9).

Annual winter harvest and catch, also variable and without trend, averaged 9,100 and 5,600 (63% of catch) lake trout respectively over the time series (Table 8). This equates to an average annual harvest of approximately 0.89 kg/ha whole lake or 1.27 kg/ha for optimal lake trout habitat (i.e., >10m). The average observed success rate for years with data was determined to be 0.35 fish-per-hour (Table 8). This has also varied considerably and without trend.

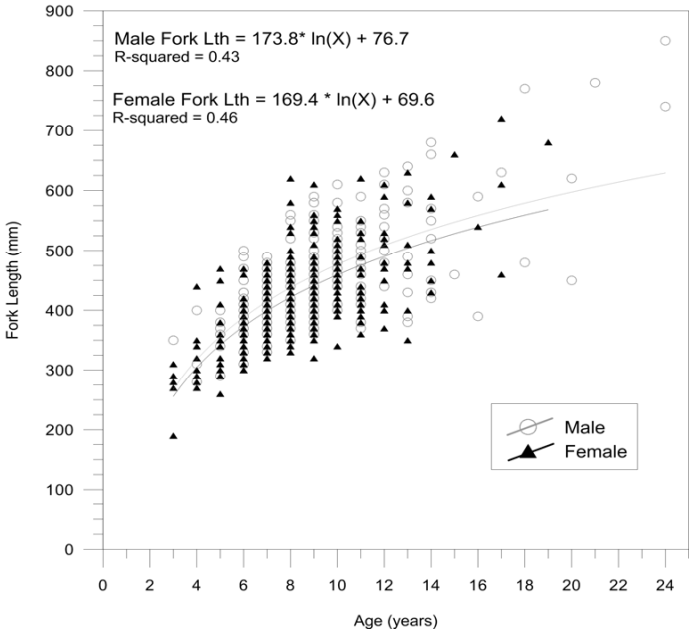


Figure 6. Fork length-at-age recorded for Lake Joseph male and female lake trout and best fit line, all years combined.

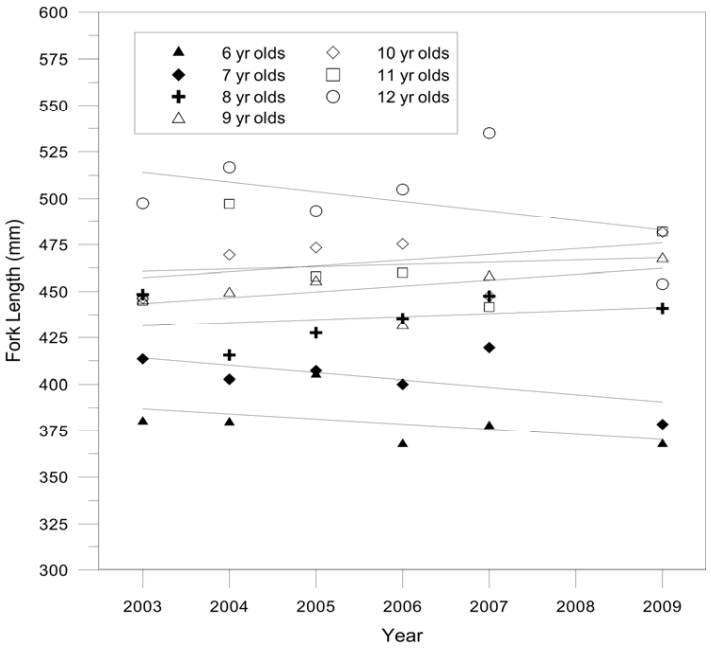


Figure 7. Mean fork length recorded each year for ages 6 to 12 years. Increasing or decreasing trend was not detected in any age group examined (ANOVA P = 0.5023).

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

Species	Trout	Whitefish	Herring
2003	75%	3%	23%
2004	62%	3%	35%
2005	69%	4%	28%
2006	63%	5%	32%
2007	71%	1%	28%
2009	67%	2%	31%
Avg	67%	3%	30%

Table 6. The composition of lake trout stomachs as measured by presence absence (for example: 13% 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	2007	2006	2005	2004	2003	Avg
Empty	40%	26%	24%	30%	18%	35%	29%
Unidentifiable Fish	19%	23%	18%	21%	22%	13%	19%
Smelt	13%	23%	7%	23%	9%	12%	15%
Invertebrates	13%	4%	33%	7%	16%	6%	13%
Lake Herring	10%	10%	14%	12%	12%	9%	11%
Stickleback		13%	2%	4%	21%	18%	10%
Sculpin	3%	1%	1%	1%	3%	4%	2%
Smallmouth Bass						1%	1%
Lake Trout	2%			1%		1%	1%
Fish Hooks	1%			1%		2%	1%
Burbot					1%		0.3%

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 13 species were captured, but only the primary species are reported (i.e., CPUE ≥0.25).

Species	CPUE
Rock Bass	11.72
Smelt	1.64
Herring	1.40
Smallmouth Bass	0.64
Lake Trout	0.39
Yellow Perch	0.27

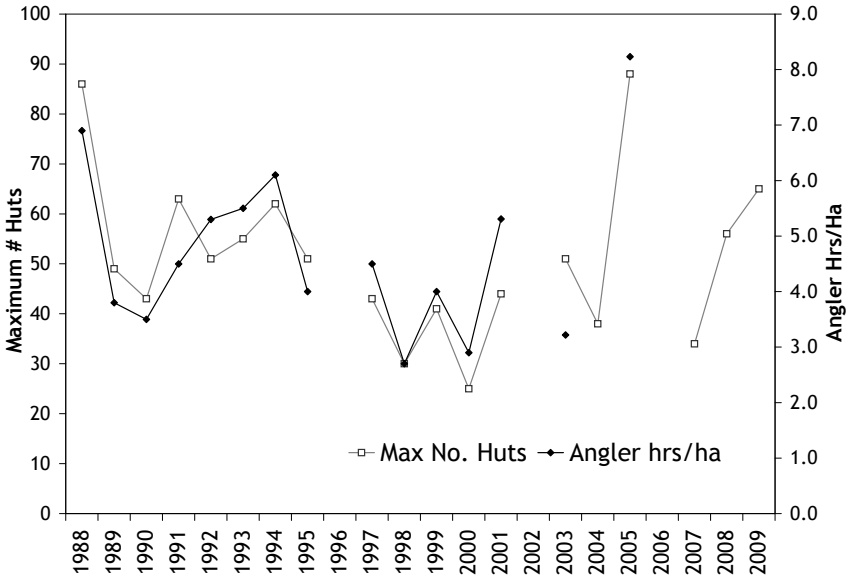
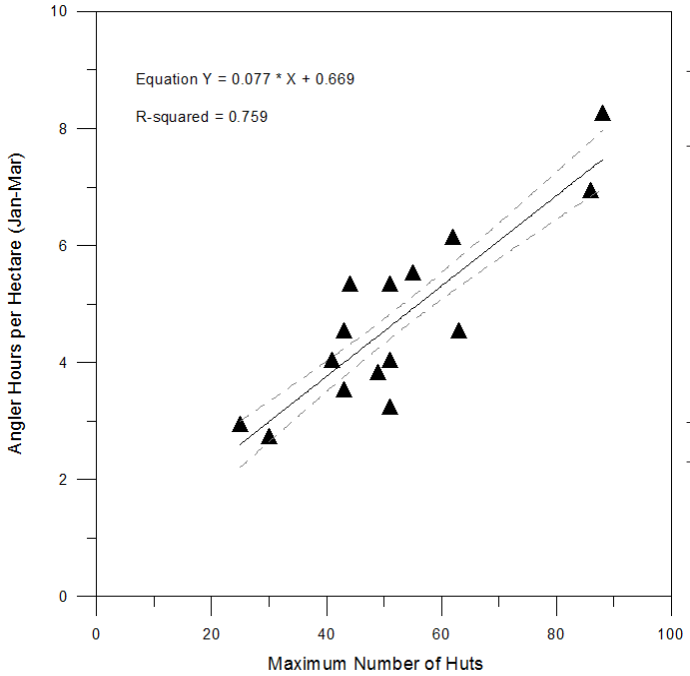


Figure 8. The relationship between maximum number of huts present on the lake at one time, and the calculated total angler hours per hectare for the winter fishery (February 15th to March 31st) for the years 1988 to 2009. For years with data, angler effort (hrs/ha) was derived by way of roving creel survey.



Year	No. Huts	Est hr/ha
2003	51	3.2
2004	38	3.5
2005	88	8.2
2006	na	na
2007	34	3.2
2008	56	4.9
2009	65	5.9
Avg	55	4.8

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 2009 when only max hut counts were available (see table insert for summary). Hut count data for 2006 was not available.

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

Year	Winter Catch	Winter Harvest	Harvest Ratio	Catch per Hour
2005	10,619	7,592	72	0.24
2004				
2003	5,405	3,590	66	0.28
2002				
2001	12,936	6,928	54	0.41
2000	8,618	3,617	47	0.55
1999	10,778	5,076	47	0.45
1998	8,973	3,972	44	0.61
1997	8,972	5,271	59	0.33
1996				
1995	6,058	3,466	57	0.27
1994	9,588	5,832	61	0.27
1993	9,911	5,843	59	0.29
1992	8,990	6,464	72	0.29
1991	7,023	5,050	72	0.26
1990	10,087	5,785	57	0.46
1989	8,088	5,769	71	0.36
1988	13,047	9,631	74	0.33
1985	7,243	6,412	89	0.18
Avg	9,146	5,644	63	0.35

Comparison of the length distribution from the winter creel in 2005 (the only year with a corresponding summer index survey) and that collected from the index survey is provided in Figure 10. This figure demonstrates that the index provides a reasonable measure of the length distribution of fish caught by anglers. Additionally, given the considerable difference in collection techniques, the similarity of the estimates (Kolmogorov-Smirnov maximum difference between the cumulative distributions = 0.0926; P = 0.986, i.e. distributions not different) suggests that the index also provides a fairly accurate description of the actual length distribution in Lake Joesph. However, it would appear that larger lake trout may be somewhat less vulnerable to anglers than smaller fish based on the proportional differences observed between the methods for larger (> 500 mm) and smaller (<400 mm) fish.

Analysis of the catch curve for fish fully vulnerable to the index gear (ages 9^{+}; all years combined) provides an estimate of absolute annual mortality of 32%, i.e., annual survival of 68% (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

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

level of exploitation (μ) would be 16% (range 11%–23%; 68% CL; using 2003 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 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 (2003 to 2009). Fishing mortality rate was determined to be 0.20 (range 0.14–0.29; 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 = 45 mgL^{-1}) of Lake Joseph, would be in the order of 0.30. The values derived in the present study are considerably lower on average than those predicted by Shuter et al. to be unsustainable suggesting the current level of fishing is perhaps biologically acceptable.

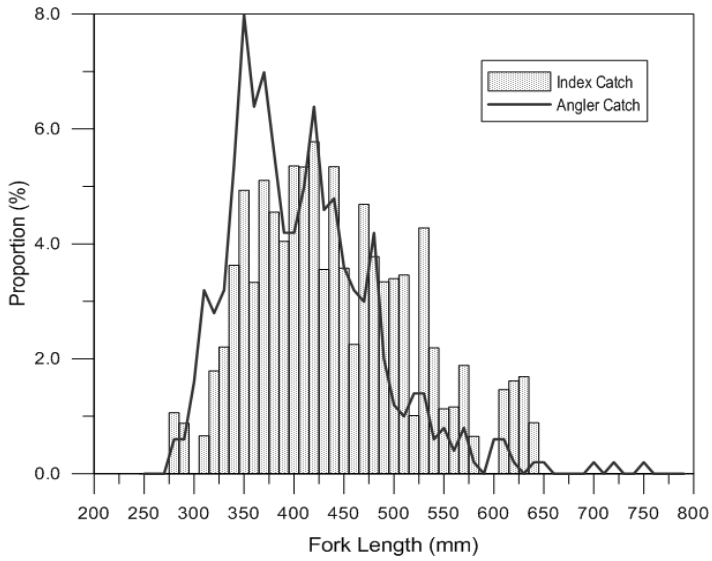


Figure 10. Distribution of fork lengths (mm) recorded during the winter creel survey in 2005 and the selectivity corrected index catch from the preceding summer (i.e., 2004). Statistical comparison of the distributions found them to not be different (Kolmogorov-Smirnov P = 0.968).

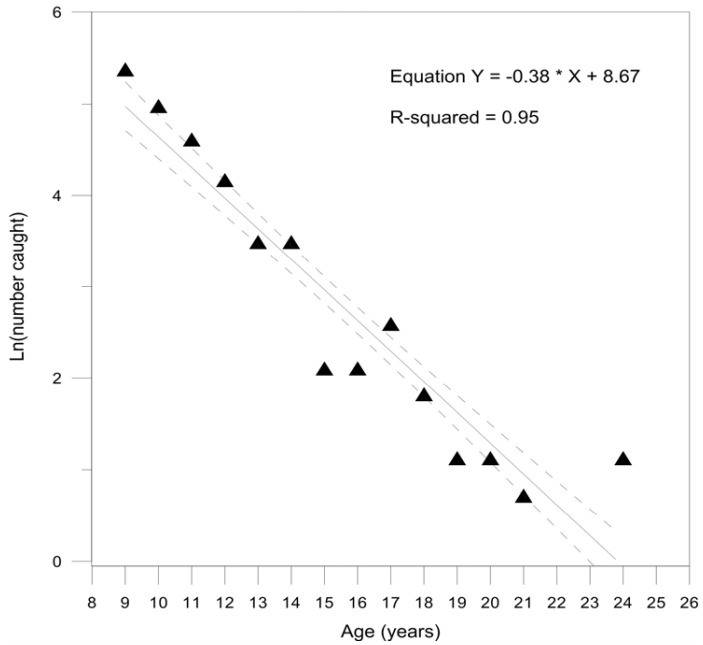


Figure 11. Weighted catch curve regression for fish nine years of age and older. Slope of the regression equation (0.38) is the estimate of the instantaneous annual rate of total mortality (Z). The inverse of this natural logarithm value is the annual survival rate, in this case 68%.

Conclusions

The current estimate of lake trout abundance (>300 mm) in Lake Joseph is 28,000 fish (range 18,000–38,000) with an optimal habitat biomass of 6.34 kg/ha. Average lake wide abundance estimated for the period of 2003 to 2009 was 36,000 fish (range 24,000–49,000). Trends in 2003 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 68%, with approximately 16% of the lake trout (>300 mm) removed annually by the fishery (range 11%–23%), which appears from analysis of catch curve information to be sustainable.

Current MVWHDO indicates the status and availability of critical habitat for lake trout is also not limiting.

The recent decline in the CPUE requires more monitoring over the next several consecutive years to confirm if a trend is occurring. If this is only an artifact of the sampling variability, then subsequent annual monitoring is likely unnecessary with assessments on a three or five year interval sufficient to adequately monitor the ongoing status of this population.

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