Lake Monitoring Program: Sturgeon Lake Stock Assessment, 2003

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Lake Monitoring Program: Sturgeon Lake Stock Assessment, 2003

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EXECUTIVE SUMMARY

In recent years, increased angling pressure on lakes with populations of walleye (*Sander vitreus*) and northern pike (*Esox lucius*) has raised concerns about the sustainability of fish populations. Strategies to maintain or recover walleye and northern pike populations have been implemented in 1995 and 1999, respectively by Alberta Sustainable Resource Development. These strategies prescribe regulatory measures, including angling regulations, which can be used to maintain or recover fisheries. Regular evaluation of the sport fishery and regulations are also necessary to ensure that fisheries management goals are being achieved.

The purpose of this stock assessment conducted from 9 to 12 June 2003 was to describe the size and age structure, as well as growth of walleye (*Sander vitreus*), northern pike (*Esox lucius*), lake whitefish (*Corregonus clupeaformis*) and yellow perch (*Perca flavescens*).

Results from this study showed that walleye accounted for 59% of the total catch. The total catch per unit effort (TCUE) was 16.5 fish/100m^2/24hrs. Of all walleye collected where sex could be determined, 47.1% (n=469) were female. Fork lengths of all walleye collected ranged from 170 to 510 mm (n=474, mean=391.2 mm). Ages ranged from two to 17 years (n=461, mean=8.4). By contrast, northern pike accounted for 11.0% of the total catch. The TCUE was 3.0 fish/100m^2/24hrs. Of all northern pike collected where sex could be determined, 64.3% (n=84) were female. Fork lengths of all northern pike collected ranged from 208 to 995 mm (n=85, mean=447.4 mm). Ages ranged from two to 12 years (n=75, mean=5.2). Lake whitefish accounted for 16.0% of the total catch. The TCUE was 4.4 fish/100m^2/24hrs. Of all lake whitefish collected where sex could be determined, 57.3% (n=124) were female. Fork lengths of all lake whitefish collected ranged from 171 to 582 mm (n=125, mean=484.9 mm). Ages ranged from two to 14 years (n=122, mean=8.2). Yellow perch accounted for only 4.0% of the total catch. The TCUE was 1.1 fish/100m^2/24hrs. Of all yellow perch collected where sex could be determined, 62.5% (n=32) were female. Fork lengths of all yellow perch collected ranged from 126 to 347 mm (n=32, mean=265.3 mm). Ages ranged from three to 12 years (n=26, mean=8.3).

ACKNOWLEDGEMENTS

This program is funded by Alberta anglers, whose contributions fund the Fisheries Management Enhancement Program. We would like to thank the following individuals and/or organizations for their in-kind and logistical support: Alberta Conservation Association employees: Cedar Chittenden, Mike Doran, Dave Jackson, Tyler Johns, and Al Wildeman. Thanks also to Don Schroeder (Alberta Sustainable Resource Development) for contributions to data collection.

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1.0 INTRODUCTION

The Northwest Boreal Lake Monitoring Program began in 1999–2000. The objective of this program is to provide pertinent trend data for various water bodies and fish species in order to augment regional population monitoring programs carried out by Alberta Sustainable Resource Development. Data collection techniques have been standardized, allowing comparisons between different lakes, over time, providing current information to fisheries managers.

In order to successfully manage local fisheries, it is essential to monitor sport-fish populations. This can be accomplished through repeated sampling to determine temporal changes in population structure attributed to management strategies and environmental effects (e.g., water level fluctuations and spawning success). Angler surveys provide information on harvest, effort, and abundance of sport-fish species. The results of this project will provide fisheries managers with current fisheries information and allow us to improve our current monitoring strategies.

2.0 STUDY AREA

Sturgeon Lake is located approximately 85 km northeast of Grande Prairie, Alberta. Test-netting was conducted from June 9 – 12, 2003. The lake supports natural populations of white sucker (*Catostomus commersoni*), lake whitefish (*Corregonus clupeaformis*), northern pike (Esox lucius), yellow perch (*Perca flavescens*), and walleye (*Sander vitreus*).

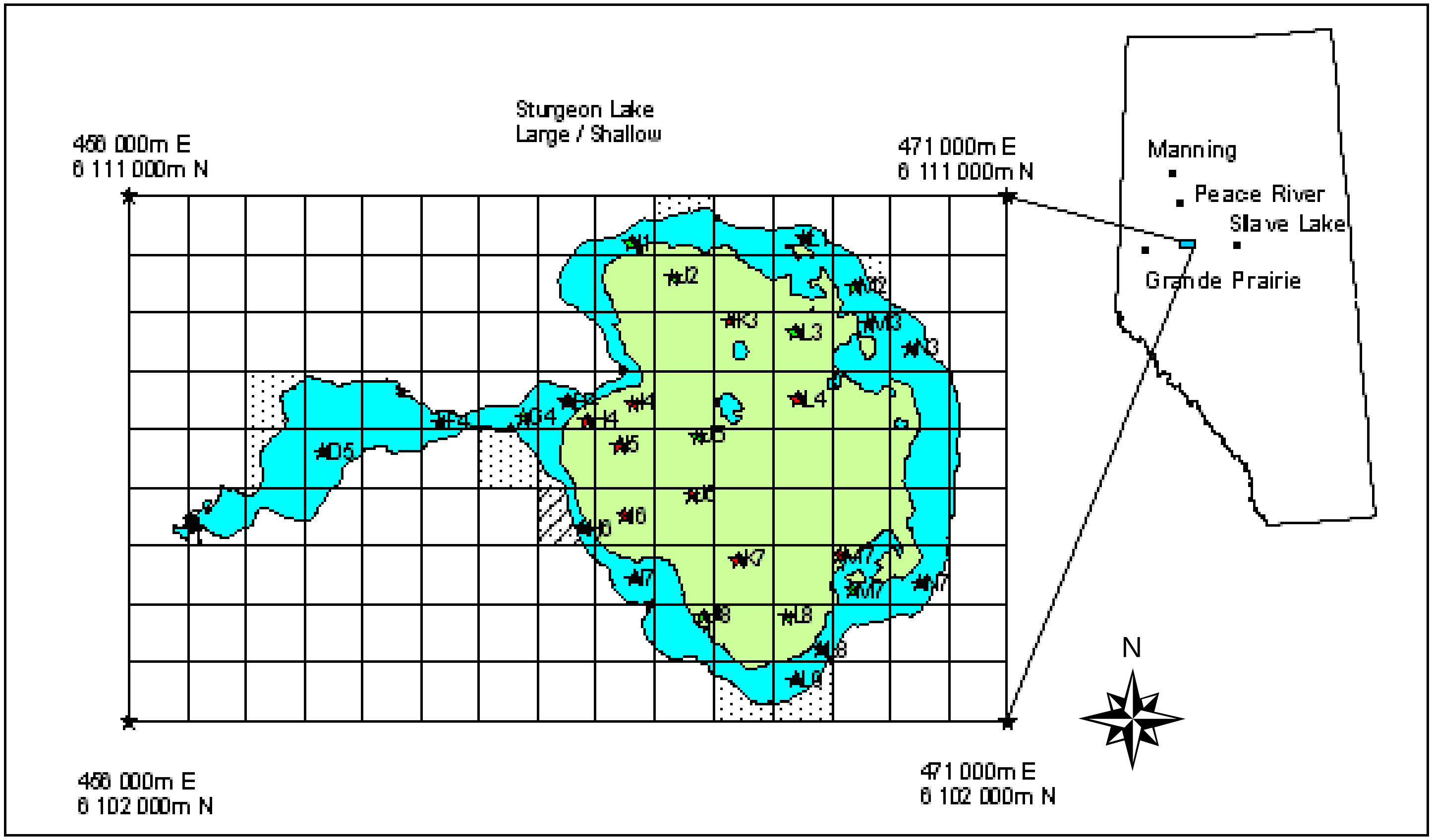

Figure **1**. Sturgeon Lake bathymetric map showing 0-5 m and >10 m intervals and test-netting sample sites for 2003. Stars indicate sample locations red and green color coding indicate alternate and primary site locations, respectively. A grid is overlaid with 1000 m spacing and tick marks shown are in Universal Transverse Mercator, NAD 83, and Zone 11.

Table 1. Test-net locations in Universal Transverse Mercator (UTM zone 11) for Sturgeon Lake, Alberta.

Shallow	**0-5 m**	**Deep**	**5-10 m**
UTM X	**UTM Y**	**UTM X**	**UTM Y**
459315	6106613	463833	6107160
461326	6107125	464631	6107449
463495	6107480	464387	6106739
463771	6105311	465628	6105875
464599	6110201	466249	6108867
464638	6104444	466382	6104767
467517	6110280	467401	6107515
467793	6103221	468148	6104838
468621	6108821		
469331	6108387		

3.0 MATERIALS AND METHODS

3.1 General sampling methods

Eighteen sample sites were randomly selected using Arc view 3.2 and a random point generator and stratified by depth following lake-monitoring protocol (Wilcox, 2000). Sites were sampled using multi-mesh (38, 63, 89, 114, and 140 mm) benthic gill nets set for approximately 24 hours as this time frame allowed for setting and retrieving several nets within the work day. Fork lengths (FL), weights, sex, maturity, ageing structures, and stomach contents were examined and recorded for each managed fish species (lake whitefish, northern pike, yellow perch, and walleye) and FL were obtained for all other species captured.

Ageing structures were collected from all sport fish. Lake whitefish were aged using scales collected below the dorsal fin region on the left side. Northern pike were aged using the left cleithrum. Yellow perch and walleye were aged using sections of the left pelvic fin rays (MacKay et al. 1990). In general ages were determined from fin rays by first cross sectioning the fin ray using a rotary saw. Cross-sections were then mounted on a clear slide using a non-toxic adhesive. The cross-sections were then aged using reflected light and a stereomicroscope by counting annuli following procedures outlined by Mackay et al. (1990). Cliethra were aged by counting annuli on the structure using reflected light with a dark background following (Mackay et al. 1990).

3.2 Statistical analyses

Fisheries biologists have long recognized the importance of several factors in the assessment of fish populations. Proportional stock density (PSD) and relative stock density (RSD) are indices widely used to assess size structure in freshwater sport fish populations (Anderson 1976, 1980; Reynolds and Babb 1978; Wege and Anderson 1978). Relative stock density allows for the comparison of stock classes within and among fish populations. It provides useful information about the relative contribution of size classes to the sampled population (Willis et al. 1993) and its application is detailed below.

Growth is another factor used to assess exploited fish populations. Growth rates are used by fisheries managers to determine the time it takes to grow harvestable size fish and as an indicator of exploitation. The von Bertalanffy growth function describes growth of fish using a non-linear equation. Another important factor considered by fisheries biologists in the assessment of a fishery are indices of condition and provide indication of health of the population. Relative weight as described below provides a convenient, comparable measure of the physiological condition of a fish population (Murphy et al. 1990).

Other metrics recognized for their importance in fisheries management include length-frequency and age-frequency histograms. These are among the oldest methods used to assess size structure in fish populations (Everhart and Youngs 1981). These distributions can help in understanding fish population dynamics and specific problems such as year class failures and excessive annual mortality. These simple metrics are not explained in detail but are provided in the results sections where sample size was not limiting.

3.2.1 Relative stock density

The five-cell model (stock, quality, preferred, memorable, and trophy) proposed by Gablehouse (1984) was used to identify predominant length classes of fish. A sub-stock category was added to the model in order to include smaller sized fish.

3.2.2 von Bertalanffy growth function

Age and length data were fitted for each sex to the von Bertalanffy growth function. The von Bertalanffy growth function is a non-linear equation that explains growth using three parameters. Length infinity (L_∞) represents the asymptote or the theoretical maximum length that can be achieved. The parameter representing rate of growth is K, which is defined as the rate at which the fish approaches L_∞. Higher values of K represent faster growth and are usually associated with a lower L_∞. The third parameter of the von Bertalanffy growth function is t_0, which is the theoretical age at length zero. In addition age at length zero has very little practical application in our case and was therefore fixed at zero. Comparisons of growth parameters were made between years and were based on common age classes.

3.2.3 Relative weight (W_r)

Relative weight (W_r) is a measure of condition calculated by applying an individual's weight and total length (TL) to a species-specific equation. Total lengths were estimated using linear regression equations determined from FL and TL collected during 2005 index netting at Sturgeon Lake. Total length was estimated from FL using the following equations.

$$\text{Walleye}: TL(mm) = 1.053(FL(mm)) + 3.327;\ R^2 = 0.999;\ n = 287$$
$$\text{Northern pike}: TL(mm) = 1.044(FL(mm)) + 10.292;\ R^2 = 0.995;\ n = 72$$

Wege and Anderson (1978) introduced relative weight as the following formula:

$$W_r = \left(\frac{W}{W_s}\right) * 100$$

where W is the measured weight of the fish and W_s is the standard weight of a fish of the same length. W_s is species-specific and determined by several different authors. Standard weight equations for northern pike and walleye were determined by D.W. Willis (1989) and Murphy et al. (1990).

W_r varies with such parameters as sex, length, time of year, and maturity (D.W. Willis 1989; Murphy et al. 1990). Reporting a total sample mean W_r is inappropriate without first checking for differences among size classes within that sample (Blackwell 2000). Variation in W_r associated with length was identified through visual inspection of 95% confidence intervals of mean W_r plotted against length.

4.0 RESULTS

The following results are provided and presented for each managed species found in Sturgeon Lake. These consist of lake whitefish, northern pike, yellow perch, and walleye. The results will be used to assist with management decisions.

4.1 Lake whitefish

Lake whitefish accounted for 16% of the total catch (n=27). They were captured at a rate of 4.4 fish/100m^2/24-hour.

The memorable class (480 – 609 mm FL) included 76.4% (n=97) of all lake whitefish caught and was the most predominant of all RSD classes. The PSD was 98.4% (i.e., 98.4% of lake whitefish were 300 mm or greater FL).

Females comprised 56% (n=72) of the sample, males 43% (n=55), and one sample was of undetermined sex. Ranges of FL were as follows: male FL= 317 – 555 mm (mean = 492 mm); female FL= 285 – 582 mm (mean = 482 mm). Figure 2 shows the FL distributions from 1999, 2001, and 2003.

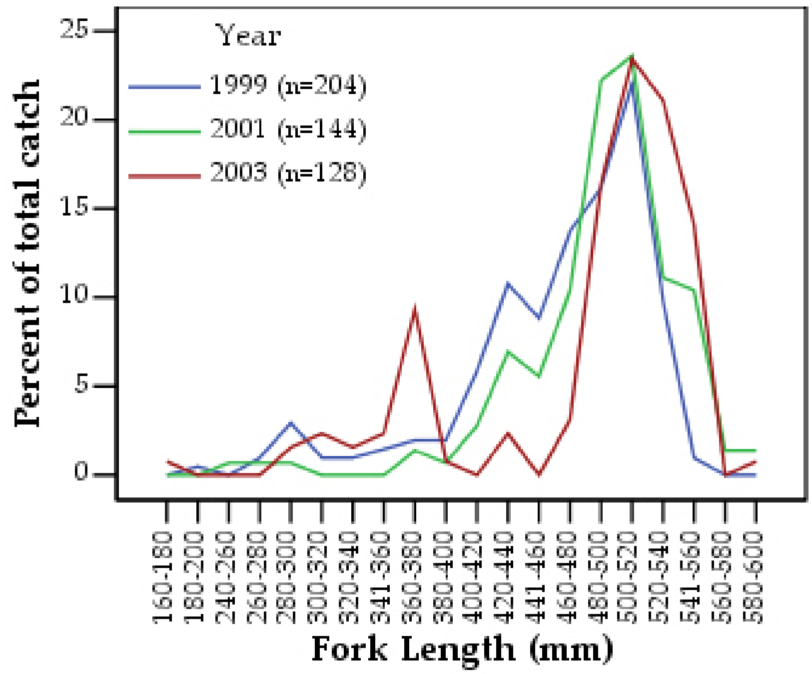

Figure 2. Fork length frequency distributions of lake whitefish from samples collected during 1999, 2001 and 2003 multi-mesh test-netting at Sturgeon Lake Alberta.

The most frequently occurring size class of lake whitefish was 500 – 520 mm. This size class was also predominant in 1999 and 2001 samples. Fish that are 420 mm to 440 mm were also found to be a strong size class. Fish 360 mm to 380 mm were well represented in the gear in 2003. Therefore, this likely represents a strong class of fish.

Examination of the age distributions further supported evidence of a strong class of 3-year old fish corresponding to the 360 mm to 380 mm size class. The strongest age class in 2003 was 8 years with a mean length of 509 mm (Figure 3).

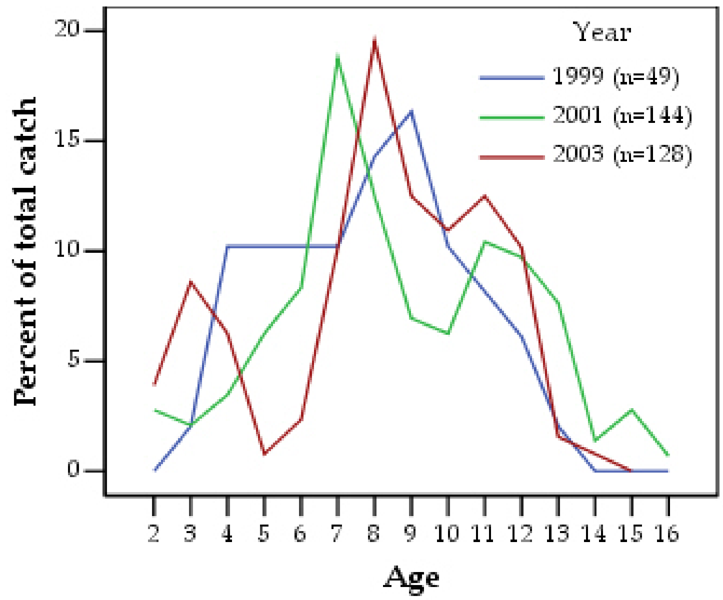

Figure 3. Age frequency distributions of lake whitefish from samples collected during 1999, 2001 and 2003 multi-mesh test-netting at Sturgeon Lake Alberta.

The von Bertalanffy growth function was used to assess growth of lake whitefish. Figures 4 and 5 show female and male data from three years fitted to the von Bertalanffy growth function.

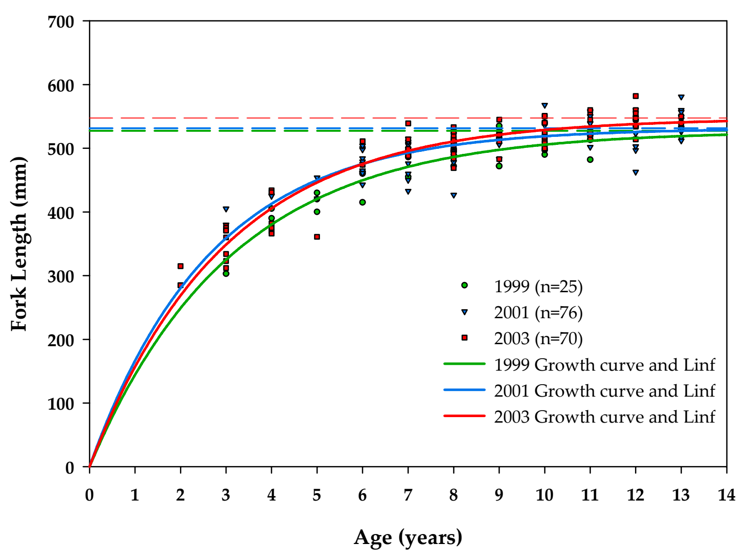

Figure 4. von Bertalanffy growth functions fitted to female lake whitefish samples collected during test-netting in 1999, 2001, and 2003 at Sturgeon Lake Alberta.

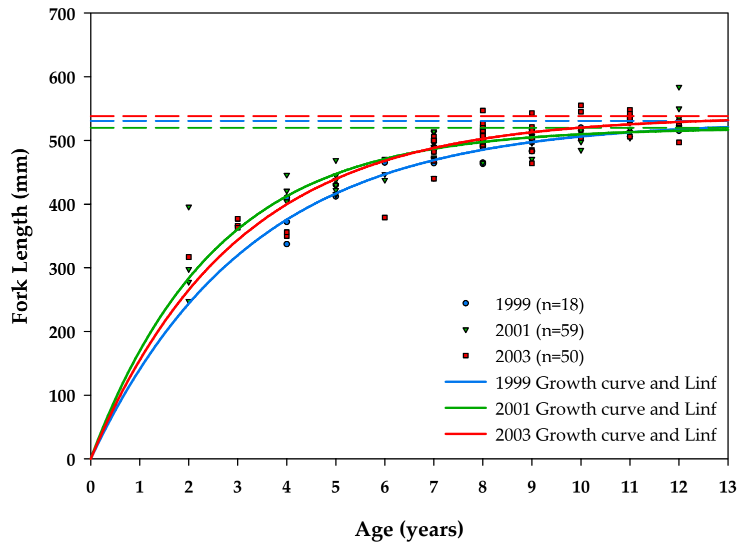

Figure 5. von Bertalanffy growth functions as fitted to male lake whitefish samples collected during test-netting in 1999, 2001, and 2003 at Sturgeon Lake Alberta.

We compared parameter estimates of the von Bertalanffy growth function from different years by evaluating confidence limits of the estimates (Table 2). If the 90% confidence intervals of two years do not overlap it is likely that they are actually different.

Table 2. Estimates and 90% confidence intervals of von Bertalanffy growth function parameters of lake whitefish from test-netting in 1999, 2001, 2003 at Sturgeon Lake Alberta.

Lake Whitefish		**Female**		**Male**	
Year	**90% CI**	**L∞ (mm)**	**K**	**L∞ (mm)**	**K**
1999	Lower CI	511.18	0.2825	512.05	0.2697
Male n=18	Estimate	527.30	0.3191	530.70	0.3074
Female n=25	Upper CI	543.42	0.3557	549.35	0.3451
2001	Lower CI	522.83	0.3405	510.04	0.3600
Male n=59	Estimate	531.40	0.3749	519.70	0.3944
Female n=76	Upper CI	539.97	0.4093	529.36	0.4288
2003	Lower CI	538.84	0.3162	525.92	0.3024
Male n=50	Estimate	547.40	0.3376	538.10	0.3394
Female n=70	Upper CI	555.96	0.3590	550.28	0.3764

Estimates of L_∞ for 1999 show a great deal of variation and overlap with all other years (Table 2 and Figure 6). There appears to be an increase in both male and female L_∞ from 2001 to 2003 but overlap of 90% confidence intervals remains.

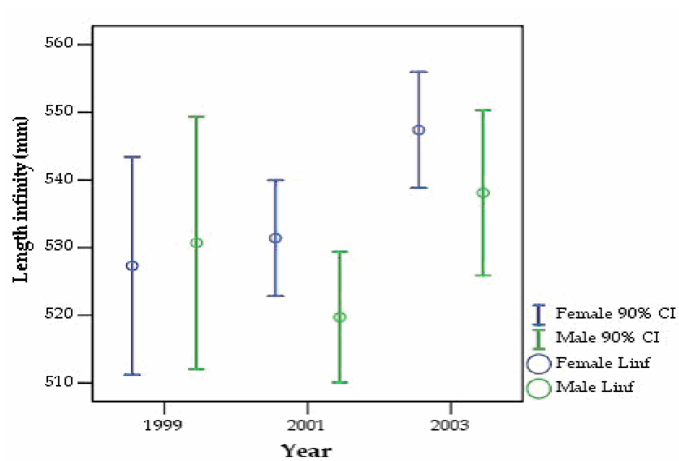

Figure 6. Mean male and female lake whitefish length at infinity (L_∞) from the von Bertalanffy growth function with 90% confidence intervals determined from samples collected during 1999, 2001 and 2003 multi-mesh test-netting, Sturgeon Lake Alberta.

Both male and female estimates of growth rate (K) show an increase from 1999 to 2001 followed by a marked reduction in 2003 (Figure 7). Confidence intervals (90%) do not overlap for male lake whitefish between 1999 and 2001 while those of females overlap through all years.

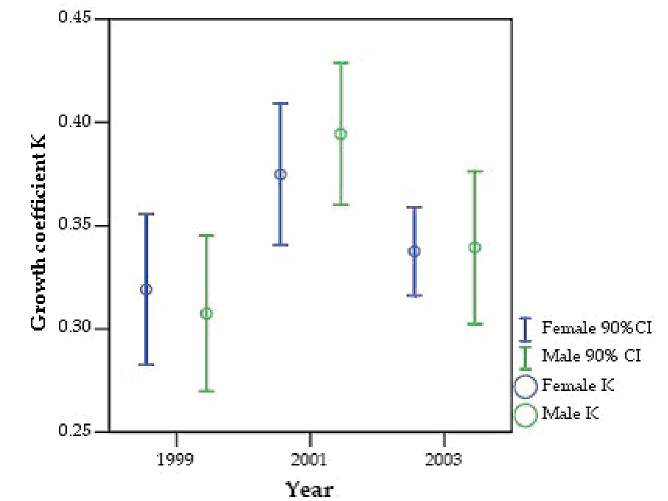

Figure 7. Mean male and female lake whitefish growth rate K from the von Bertalanffy growth function with 90% confidence intervals determined from samples collected during 1999, 2001 and 2003 multi-mesh test-netting, Sturgeon Lake Alberta. A significant increase in male growth rate is substantiated by non-overlapping confidence intervals between 1999-2001 while all other confidence intervals are overlapping making it unlikely that a significant difference between any other time periods occurred.

The estimates and 90% confidence limits of L_∞ and K were used to estimate length-at-age of fish 5, 10, and 15 years (Table 3).

Table 3. Length-at-age for lake whitefish was estimated by substitution of the parameter estimates and their confidence limits, determined from test-netting at Sturgeon Lake Alberta, into the von Bertalanffy equation (length = L∞ * (1 - e^(-K*Age)). Where L∞ is the theoretical maximum length and K is the rate of growth.

Lake whitefish		**Length-at-age (mm)** **Female**			**Male**		
Year	**90% CI**	**5 years**	**10 years**	**15 years**	**5 years**	**10 years**	**15 years**
1999	Lower CI	386.72	480.88	503.81	379.13	477.54	503.09
Male n=18	Estimate	**420.36**	**505.61**	**522.90**	**416.59**	**506.16**	**525.42**
Female n=25	Upper CI	451.62	527.91	540.80	451.51	531.93	546.25
2001	Lower CI	427.57	505.47	519.67	425.72	496.10	507.74
Male n=59	Estimate	**449.87**	**518.89**	**529.48**	**447.37**	**509.63**	**518.30**
Female n=76	Upper CI	470.20	530.95	538.80	467.33	522.09	528.51
2003	Lower CI	427.98	516.03	534.15	409.94	500.34	520.28
Male n=50	Estimate	**446.19**	**528.69**	**543.94**	**439.50**	**520.03**	**534.79**
Female n=70	Upper CI	463.58	540.61	553.41	466.50	537.53	548.34

Both male and female length estimates at age 10 and 15 show an increasing trend with the exception of 15-year old males being slightly smaller in 2001 than in 1999. All 90% CI of estimates for both male and female lake whitefish length-at-age overlapped between all three years therefore it is unlikely that the differences seen are significant.

Stomach contents information is located in the appendix.

Relative weight was not used to analyse lake whitefish due to an absence of a standard weight equation in literature.

4.2 Northern pike

Northern pike (n=87) accounted for 11% of the total catch. They were captured at a rate of 3.0 fish/100m^2/24-hours.

Sturgeon Lake angling regulations in 2003 allow for the harvest of two northern pike over 550 mm TL (approximately 517 mm FL). The Stock class (350 – 529 mm FL) included 75.3% of all northern pike caught and was predominant. The PSD was 24.7% (i.e., 24.7% of northern pike caught were greater than 529 mm FL).

Females consisted of 66% (n=56) of the sample, males 34% (n=29). Male FL ranged from 208 to 555 mm with a mean of 426 mm. Female FL ranged from 209 to 995 mm with a mean of 466 mm. Length distributions from 1999-2003 are shown in Figure 8.

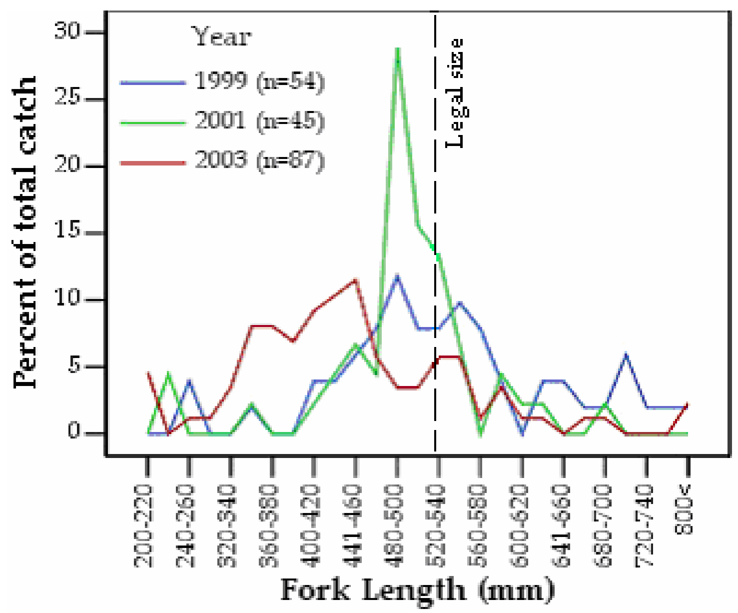

Figure 8. Fork length distributions of northern pike as determined from samples collected during 1999, 2001 and 2003 multi-mesh test-netting at Sturgeon Lake Alberta.

The most frequent size class of northern pike in 2003 was between 441 mm and 460 mm representing approximately 12% of the total catch (n=86). The most frequent size class in 1999 and 2001 samples was 480 – 500 mm. The length distributions suggest that a greater proportion of the population consists of fish under 470 mm in 2003 when compared to 1999.

Examination of the age distributions further supported evidence of a stronger class of fish 441 to 460 mm corresponding with strong classes of 3, 4, and 5-year old fish (Figure 9). The strongest age class in 2003 was 4 years with a mean length of 405 mm. Age distributions from 1999 and 2001 both show a very strong 5-year old age class. The 2001 5-year old class is visible in the 2003 sample as a peak in 7-year old fish.

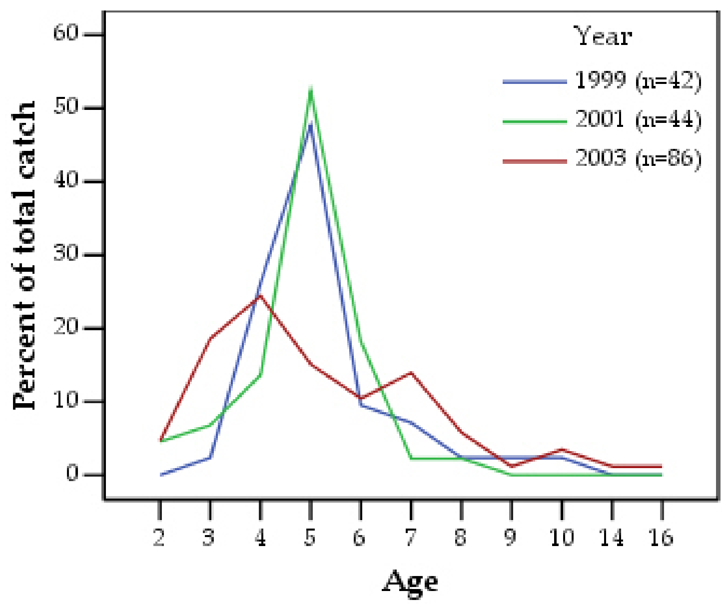

Figure 9. Age frequency distributions of northern pike from samples collected during 1999, 2001 and 2003 multi-mesh test-netting at Sturgeon Lake Alberta.

Highly variable estimates and curves occurred when length and age data were fitted to the von Bertalanffy growth function. This variation was likely due to small sample sizes, and therefore results of the von Bertalanffy growth function were not reported.

Northern pike data from 1999, 2001, and 2003 were combined and visually inspected by plotting relative weight (W_r) against FL in order to select a length range for analysis (Figure 10). Sizes showing excessive variability were omitted from analysis. The range was also selected in order to isolate any length-related trends in W_r.

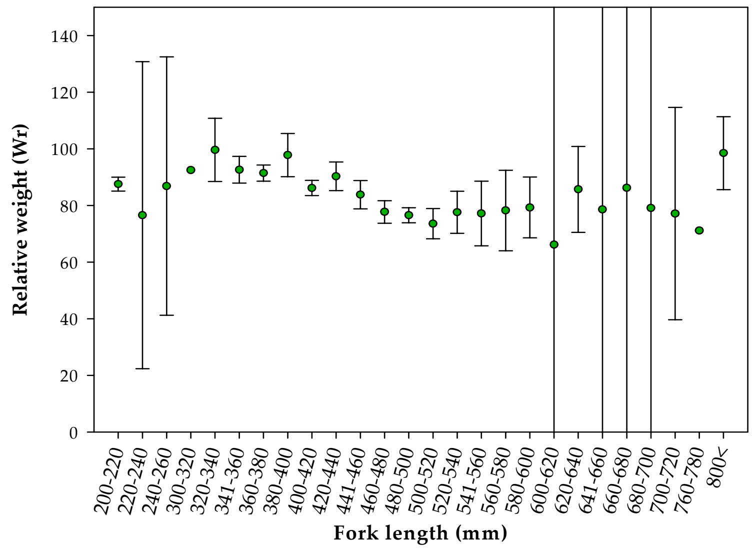

Figure 10. Mean relative weight (W_r) and 95% confidence intervals for 20 mm length classes of northern pike (n=167) from 1999, 2001, and 2003 test-netting, Sturgeon Lake Alberta.

Northern pike samples (n=78) from 460 to 600 mm FL were selected for analysis of W_r. Samples outside of this range showed greater variability in W_r values likely to be attributed to smaller sample sizes. No significant difference between male and female W_r was found in any of the three years (t-test; p>0.05). Therefore male and female relative weight data was pooled to increase sample size. The mean and range of W_r values is shown in Table 4 for females and males of the selected size range for each year. Figure 11 shows the mean W_r from three years.

Table 3. Mean and range of relative weight (Wr) values for male and female northern pike measuring 460-600 mm fork length, Sturgeon Lake Alberta.

	Females			**Males**		
Year	Mean Wr	Low	High	Mean Wr	Low	High
1999 (n: 4, males; 19, females)	77.56	71.02	81.99	76.62	69.05	88.31
2001 (n: 12, males; 21, females)	70.84	56.10	80.65	73.23	65.82	84.04
2003 (n: 7, males; 15, females)	86.35	71.81	98.33	89.32	69.10	110.01

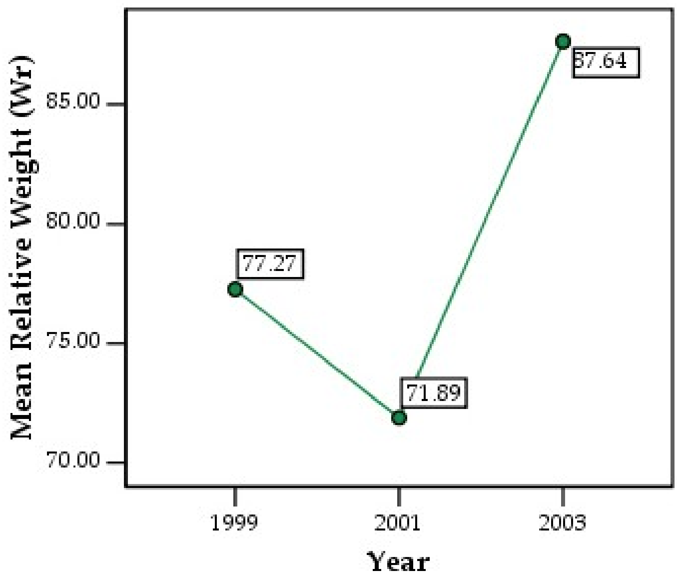

Figure 11. Mean relative weight of northern pike between 460 and 600 mm fork length, from test-netting in1999 (n=20), 2001 (n=34), and 2003 (n=13) Sturgeon Lake Alberta.

Using ANOVA, significant differences were found between the three years of sample mean W_r (α=0.05). Bonferonni post-hoc analysis showed significant differences between 1999 and 2003 (p<0.001) with the mean W_r being 10.37 higher in 2003. W_r in years 2001 and 2003 were also found to be significantly different (p<0.001) with 2003 15.76 higher. No significant difference was found between 1999 and 2001 W_r at a significance level of α=0.05 (p=0.086).

4.3 Yellow perch

Yellow perch (n=32) accounted for 4% of the total catch. Most of these (75% or 24 individuals) were caught in one set (Figure 1: D5). This set was located in a shallow (approximately 2 m depth) weed bed. Overall, they were captured at a rate of 1.1 fish/100m^2/24-hours. In set D5 they were captured at a rate of 13.3 fish/100m^2/24-hours.

The memorable class (300 – 379 mm FL) was the most predominant of all RSD classes. Of all yellow perch caught 48.8% fit in this length category. Proportional Stock Density was 80.65% therefore, 80.65% of yellow perch caught were 200 mm or greater FL. These ratios are very unlikely to be representative of the actual population as the sample size was small (n=32) and was obtained primarily in one location.

Females consisted of 62% of the sample and males 38%. Male FL ranged from 135 to 308 mm with a mean of 242 mm. Female FL ranged from 220 to 347 mm with a mean of 302 mm. The most frequent size of yellow perch was between 300 and 320 mm composing approximately 38% of the total catch. The most frequent size class in 1999 samples was 260 – 300 mm. Figure 12 shows the FL distribution for 1999 and 2003 samples. In 2001 only 1 yellow perch was captured.

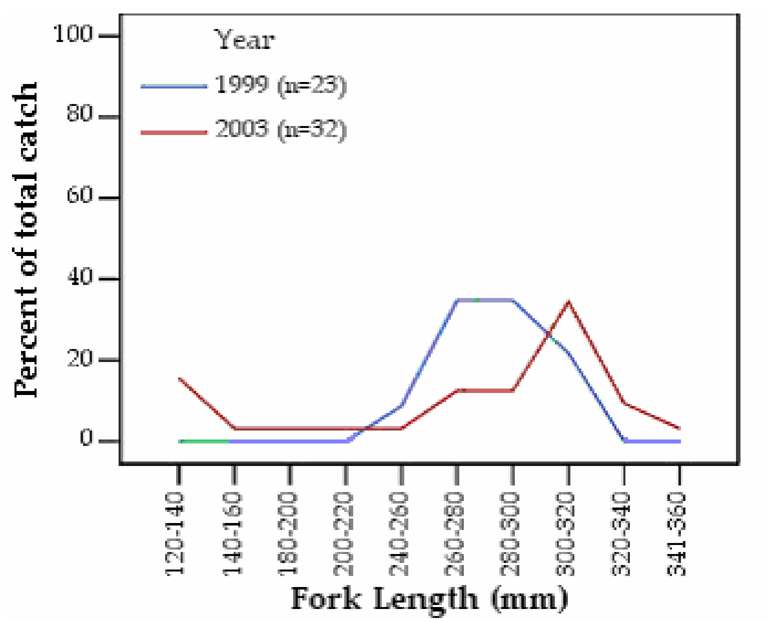

Figure 12. Fork length distributions of yellow perch as determined from samples collected during 1999 and 2003 multi-mesh test-netting at Sturgeon Lake Alberta. It must be noted that nearly the entire sample of yellow perch in 2003 were captured in one net set and is likely not representative of the population.

Highly variable estimates and curves occurred when length and age data were fitted to the von Bertalanffy growth function. This variation was due to small sample sizes, and therefore results of the von Bertalanffy growth function were not used. Furthermore, relative weight (W_r) was not calculated for yellow perch and stomach analysis was not performed as a result of small sample size.

4.4 Walleye

Walleye (n=474) accounted for 59% of the total catch. They were captured at a rate of 16.5 fish/100m^2/24-hours.

Sturgeon Lake angling regulations in 2003 allow for the harvest of two walleye over 430 mm TL (approximately 405 mm FL) except during the month of July where one may be under 430 mm and one may be over. The quality class (380 – 509 mm FL) was most predominant of all RSD classes. Of all walleye caught, 75.8% were in this length category. The PSD was 76.0% (i.e., 76.0% of walleye caught were greater than 379 mm FL).

Females (n=221) consisted of 47% of the sample, males (n=248) 52%, and remaining samples (n=3) were of undetermined sex. Male FL ranged from 176 to 510 mm with a mean of 385 mm. Female FL ranged from 170 to 461 mm with a mean of 402 mm. Fork lengths from all samples, including undetermined sex, ranged from 170 to 510 mm with a mean of 392 mm. Sizes of walleye that were most abundant were between 380 and 420 mm. While the most frequent size classes from 1999 and 2001 were 341-360 mm and 360-380 mm, respectively. Figure 13 shows the FL distribution for all three years. These strong length classes likely represent the succession of one cohort through time.

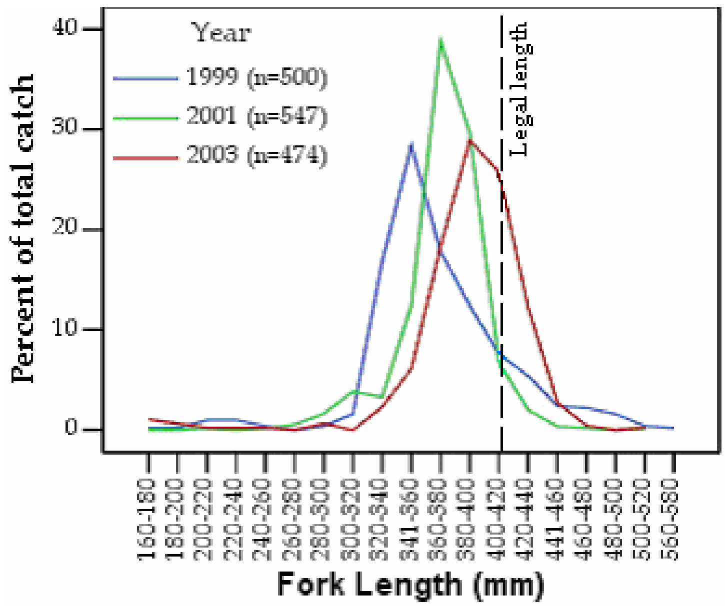

Figure 13. Fork length frequency distributions of walleye from samples collected during 1999, 2001 and 2003 multi-mesh test-netting at Sturgeon Lake Alberta.

Examination of the age distributions (Figure 14) further supports evidence of a strong cohort of fish over time with mean lengths of 351, 374, and 402m corresponding to ages 5, 7, and 9, from 1999, 2001 and 2003 samples, respectively.

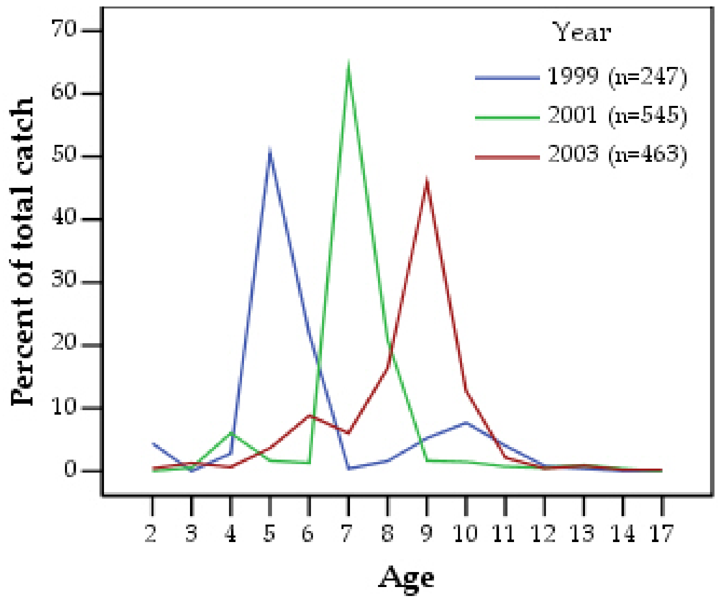

Figure 14 Age distributions of walleye from samples collected during 1999, 2001 and 2003 multi-mesh test-netting at Sturgeon Lake Alberta.

Figures 15 and 16 show female and male data fitted to the von Bertalanffy growth function. We can compare the parameter estimates of the von Bertalanffy growth function of different years by comparing the confidence limits of the estimates (Table 5). If the 90% confidence intervals of two years do not overlap there is strong evidence they are significantly different. The same comparison was made between predicted length-at-age estimates provided in Table 6.

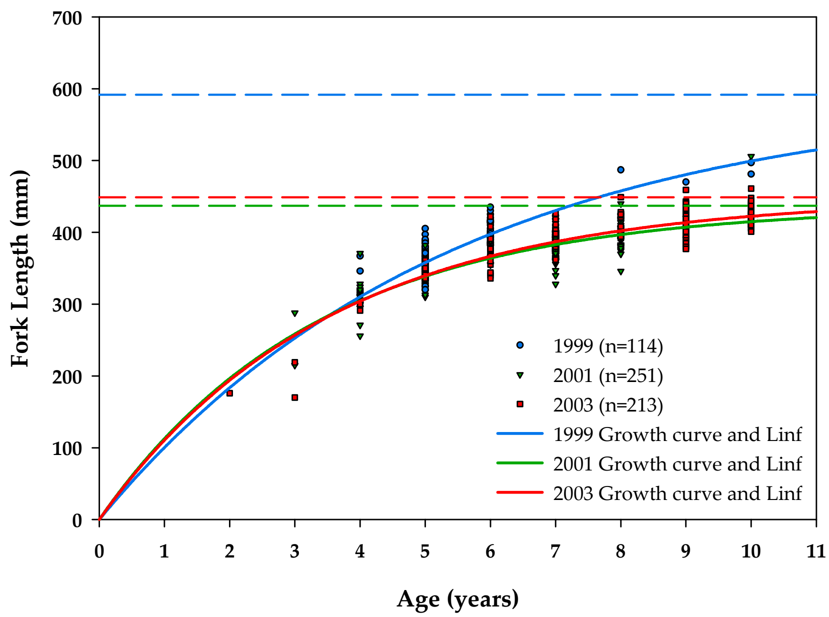

Figure 15. von Bertalanffy growth functions as fitted to female walleye samples collected during test-netting in 1999, 2001, and 2003 at Sturgeon Lake Alberta.

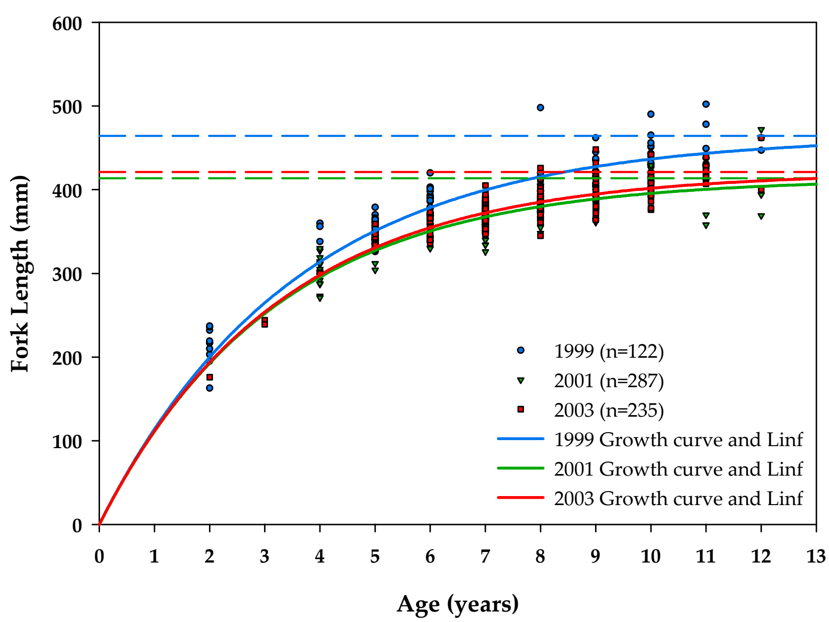

Figure 16. von Bertalanffy growth functions as fitted to male walleye samples collected during test-netting in 1999, 2001, and 2003 at Sturgeon Lake Alberta.

Table 4. Estimates and 90% confidence intervals of von Bertalanffy growth function parameters of walleye from test-netting in 1999, 2001, 2003 at Sturgeon Lake Alberta.

		Female		Male	
Year	**90% CI**	**L_∞ (mm)**	**K**	**L_∞ (mm)**	**K**
1999	Lower CI	546.59	0.1614	454.30	0.2647
Male n=122	Estimate	**591.50**	**0.1857**	**464.40**	**0.2815**
Female n=114	Upper CI	636.41	0.2100	474.50	0.2983
2001	Lower CI	426.83	0.2751	406.93	0.2946
Male n=287	Estimate	**436.90**	**0.2984**	**413.60**	**0.3133**
Female n=251	Upper CI	446.97	0.3217	420.27	0.3320
2003	Lower CI	441.37	0.2640	415.78	0.2907
Male n=235	Estimate	**448.80**	**0.2827**	**421.10**	**0.3078**
Female n=213	Upper CI	456.23	0.3014	426.42	0.3249

Confidence intervals for estimates of L_∞ (maximum theoretical length) for 1999 males and females are significantly different, confidence intervals do not overlap, when compared to male and female estimates of 2001 and 2003. When comparing estimates from 2001 and 2003 there appears to be a small increase in both male and female L_∞ (Figure 17) from 2001 (males=413.60 mm SE=4.0530; females=436.90 mm SE=6.1220) to 2003 (males=421.10 mm SE=3.2370; females=448.80 mm SE=4.5190) but the differences appear to remain insignificant.

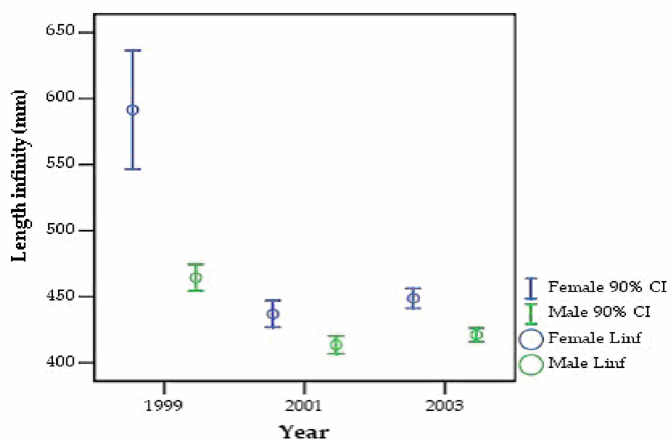

Figure 17. Male and female walleye length infinity (L_∞) from the von Bertalanffy growth function with 90% confidence intervals determined from samples collected during 1999, 2001 and 2003 multi-mesh test-netting, Sturgeon Lake Alberta.

As the **confidence intervals** of these estimates remain overlapping at the 90% level it can not be concluded that there has in fact been a change in L_∞ between 2001 and 2003 for male or female walleye. Both male and female estimates of growth rate K show a slight decrease from 2001 to 2003 (Table 5 and Figure 18) but the differences remain insignificant at a level of 90%, confidence intervals overlap.

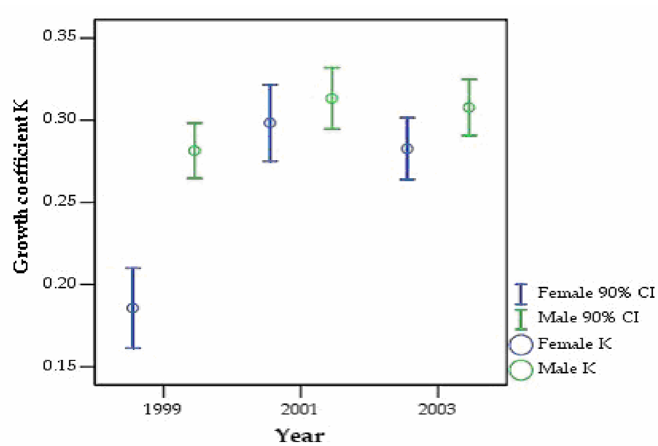

Figure 18. Male and female walleye growth rate K from the von Bertalanffy growth function with 90% confidence intervals determined from samples collected during 1999, 2001 and 2003 multi-mesh test-netting, Sturgeon Lake Alberta.

Length-at-age estimates based on the parameter estimates of the von Bertalanffy growth function and their 90% confidence intervals are displayed in Table 6. When the 1999 estimates are disregarded for the same reasons as for the von Bertalanffy growth function comparisons there is no evident trend. Differences seen in these estimates are very small and insignificant as confidence intervals overlap at a significance level of 90%.

Table 5. Length-at-age for walleye was estimated by substitution of the parameter estimates and their confidence limits, determined from test-netting at Sturgeon Lake Alberta, into the von Bertalanffy equation (length = L∞ * (1 - e^(-k*Age)). Where L∞ is the theoretical maximum length and k is the rate of growth.

		Length-at-age (mm-at-age) **Female**			**Male**		
Year	**90% CI**	**5 years**	**10 years**	**15 years**	**5 years**	**10 years**	**15 years**
1999	Lower CI	302.65	437.72	498.01	333.37	422.11	445.73
Male n=122	Estimate	**357.77**	**499.14**	**555.01**	**350.74**	**436.58**	**457.59**
Female n=114	Upper CI	413.75	558.51	609.15	367.72	450.47	469.10
2001	Lower CI	318.96	399.57	419.94	313.66	385.55	402.03
Male n=287	Estimate	**338.63**	**414.80**	**431.93**	**327.25**	**395.57**	**409.84**
Female n=251	Upper CI	357.50	429.06	443.38	340.35	405.07	417.38
2003	Lower CI	323.48	409.88	432.96	318.61	393.07	410.47
Male n=235	Estimate	**339.61**	**422.24**	**442.34**	**330.73**	**401.71**	**416.94**
Female n=213	Upper CI	355.13	433.83	451.27	342.40	409.87	423.16

Differences of the 1999 growth curve when compared to 2001 and 2003 curves may be due to ageing inconsistencies over time. Ages of 1999 walleye samples should be reassessed to ensure accuracy and provide further insight into changes in the age distribution and von Bertalanffy growth function parameters (L_∞, K, and length-at-age estimates).

Walleye data were visually inspected by plotting relative weight W_r by TL in order to select a length range for analysis (Figure 19). Sizes showing excessive variability were not selected. The range was also selected in order to isolate any length related trends in

W_r. Walleye samples from 300 mm to 450 mm FL were selected for analysis of W_r. Samples outside of this range showed greater variability in W_r values likely attributable to sample sizes.

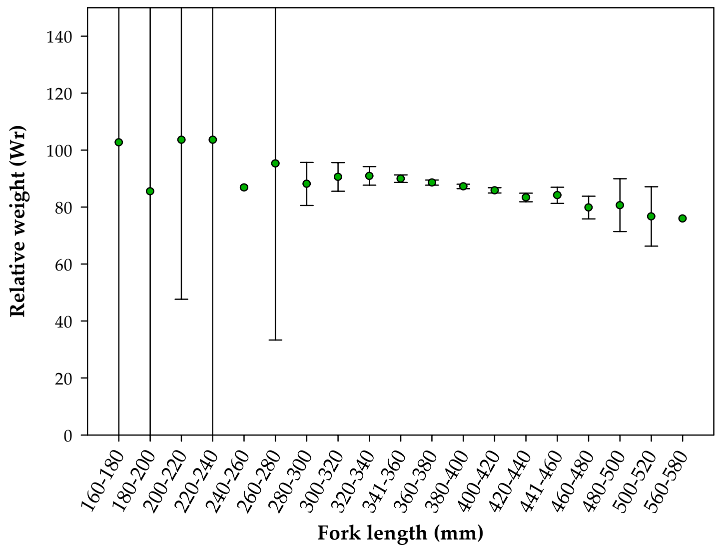

Figure 19. Mean relative weight (W_r) and 95% confidence intervals of 20 mm length classes of walleye (n=1348) from 1999, 2001, and 2003 test-netting, Sturgeon Lake Alberta.

A significant difference between male and female W_r was found in fish sampled in 2003 (t-test; df=452, $p<0.001$). Therefore, male and female relative weight data could not be pooled. The mean and range of W_r values is shown in Table 7 for females and males of the selected size range for each year. Figure 20 and 21 show the mean female and male W_r from all years.

Table 6. Mean relative weight (Wr) and confidence limits for walleye measuring 300-450 mm fork length, Sturgeon Lake Alberta.

	Females			**Males**		
Year	Mean W_r	Low	High	Mean W_r	Low	High
1999 (n: 102, males; 109, females)	88.03	78.56	98.50	88.09	72.35	107.33
2001 (n: 279, males; 244, females)	86.29	54.67	136.85	87.54	62.12	142.03
2003 (n: 232, males; 208, females)	85.77	72.28	110.76	89.26	76.37	103.99

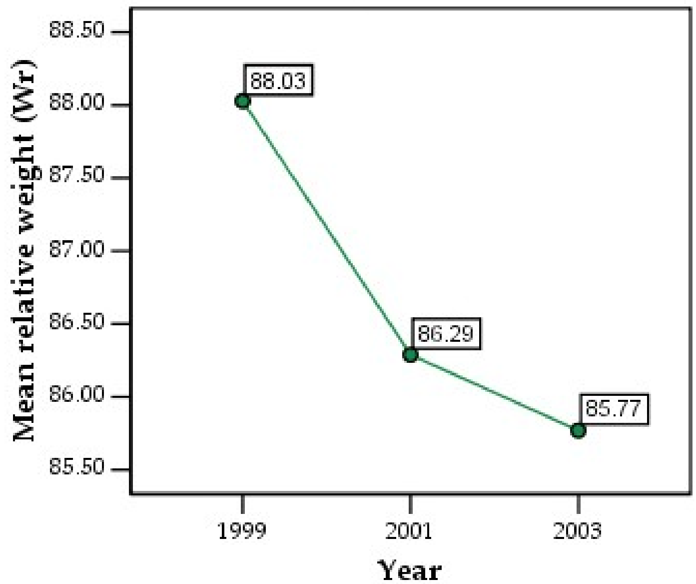

Figure 20. Mean relative weight of mature female walleye between 300 and 450 mm fork length, from test-netting in 1999 (n=128), 2001 (n=245), and 2003 (n=212) Sturgeon Lake Alberta.

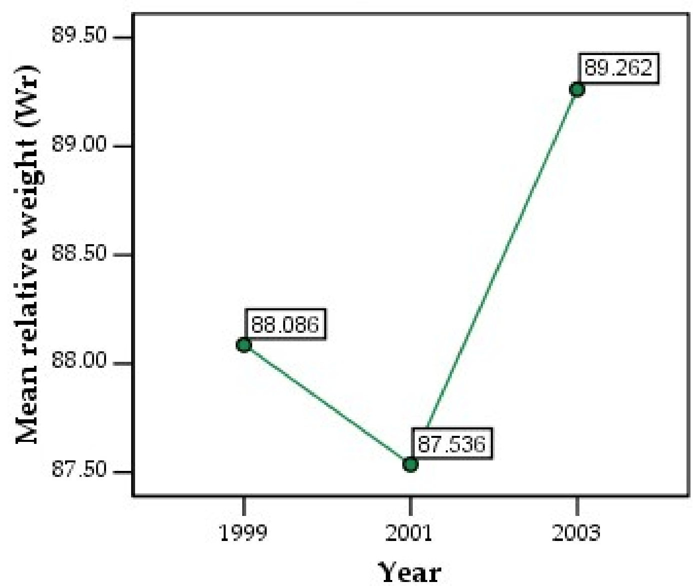

Figure 21. Mean relative weight of mature male walleye between 300 and 450 mm TL, from 1999 (n=124), 2001 (n=287), and 2003 (n=242) Sturgeon Lake Alberta.

Using ANOVA, no significant differences in mean female W_r were found between the three years ($p=0.278$). ANOVA revealed that there were significant differences in mean male W_r between the three years ($p=0.007$). Bonferroni post-hoc analysis showed that 2001 and 2003 showed a significant difference ($p=0.005$) with the mean W_r being 1.73 points higher in 2003.

4.5 Summary

Minimum size limits were implemented across Alberta for walleye and northern pike several years ago. At lakes where fishing pressure is relatively high the length distribution of walleye and northern pike tends to be truncated at or near the minimum size limit for harvest, as fish mortality tends to be greatest at or above the size limit. In Sturgeon Lake, the walleye length distribution from 2003 shows an increase in the relative abundance of fish larger than the minimum size limit (43 cm TL) when compared to the distributions from 1999 and 2001. It is, therefore, unlikely that walleye mortality is causing truncation of the length distribution.

Mortality of northern pike does not appear to be causing truncation of the length distribution in 2003. While relative abundance of northern pike larger than the minimum size limit (55 cm TL) is low, it is the result of higher abundance of smaller fish. The abundance of smaller northern pike and the wide range of age classes indicate stability of the population.

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6.0 APPENDIX

Stomach contents

Lake whitefish

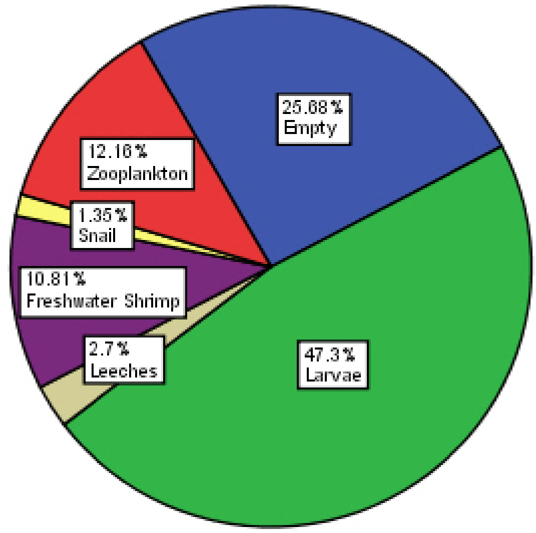

Figure 22. Stomach contents from all lake whitefish sampled in 2003 (n=75). Data are percent frequency of occurrence.

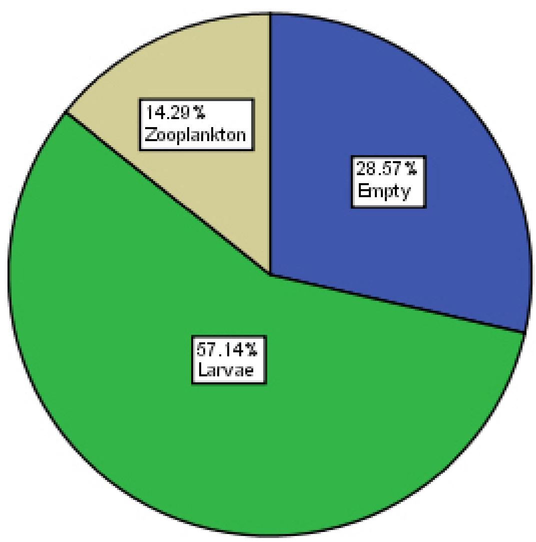

Figure 23. Stomach contents from 2003 Quality class (300mm - 409mm FL) lake whitefish (n=7).

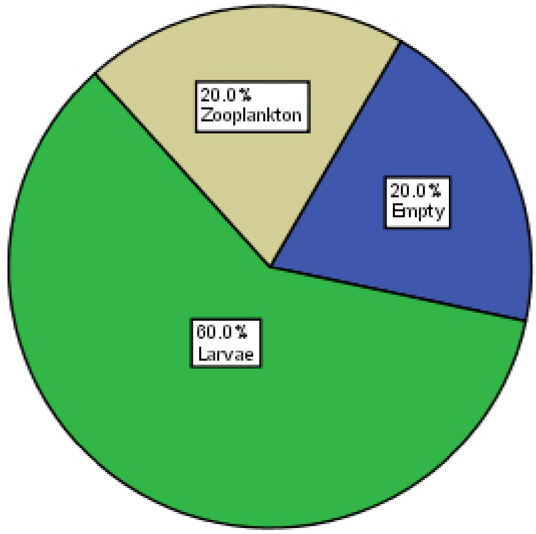

Figure 24. Stomach contents of 2003 Preferred class (350mm – 529mm FL) lake whitefish (n=5).

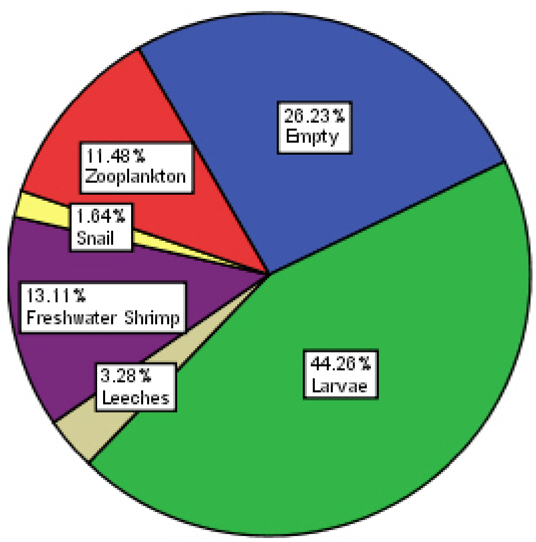

Figure 25. Stomach contents of 2003 Memorable class (480mm – 609mm FL) lake whitefish (n=62).

Northern pike

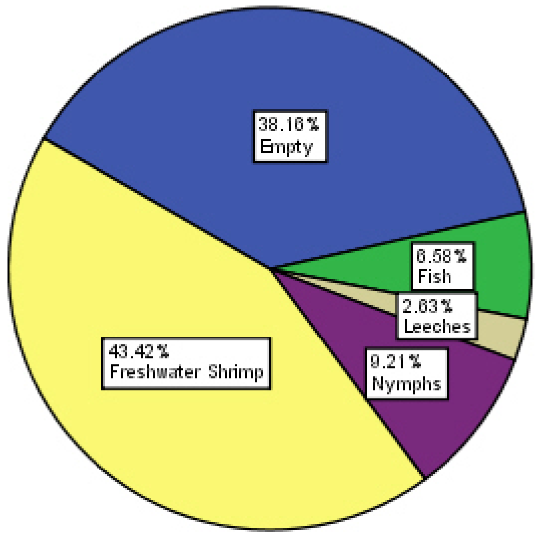

Figure 26. Stomach contents from all northern pike sampled in 2003 (n=77), Sturgeon Lake.

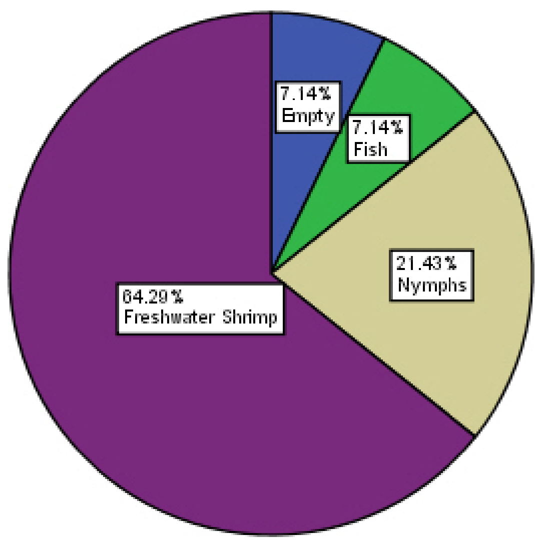

Figure 27. Stomach contents from 2003 Sub-stock class (<350mm FL) northern pike (n=14), Sturgeon Lake.

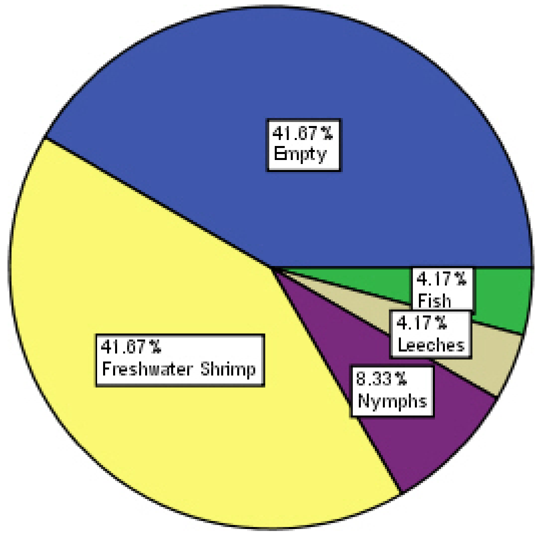

Figure 28. Stomach contents of 2003 Stock class (350mm – 529mm FL) northern pike (n=48), Sturgeon Lake.

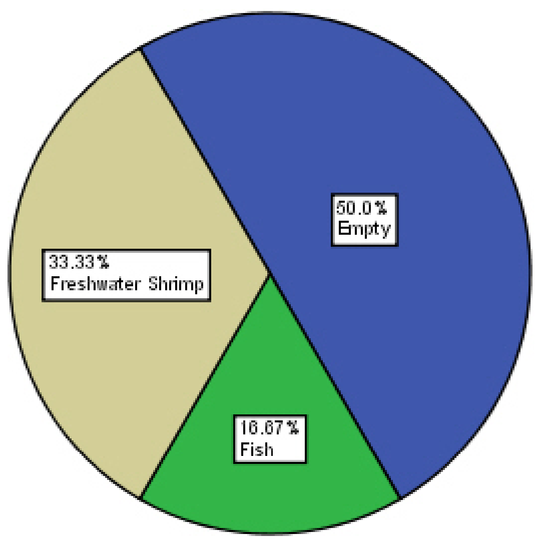

Figure 29. Stomach contents of 2003 Quality class (530mm – 709mm FL) northern pike (n=12), Sturgeon Lake.

Walleye

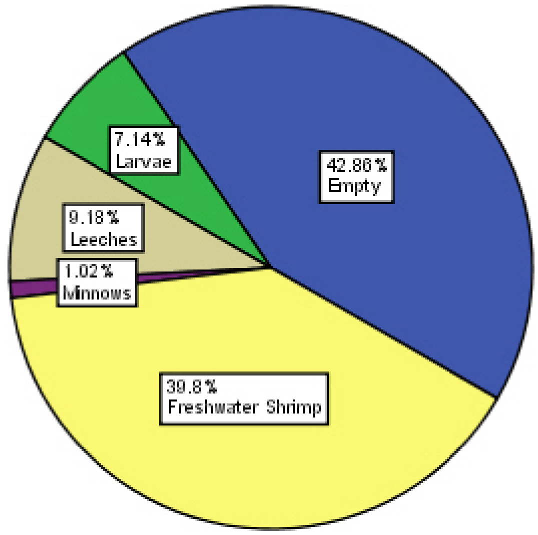

Figure 30. Stomach contents from all walleye sampled in 2003 (n=98), Sturgeon Lake.

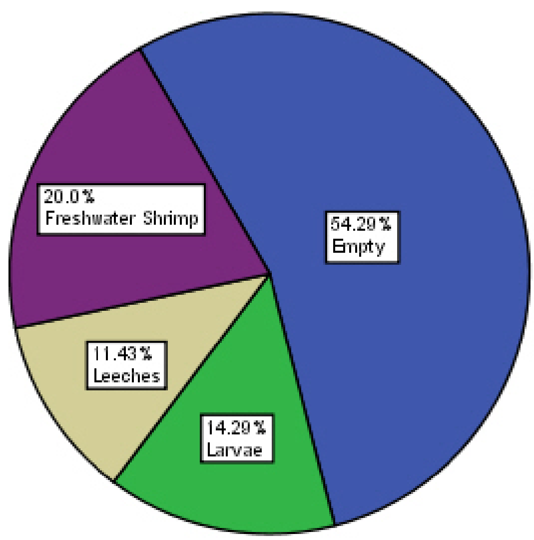

Figure 31. Stomach contents from 2003 Stock class (250mm - 379mm FL) walleye (n=35), Sturgeon Lake.

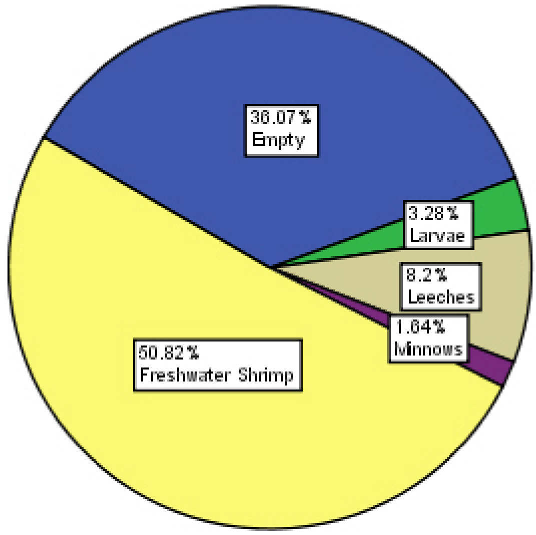

Figure 32. Stomach contents from 2003 Quality class (380mm - 509mm FL) walleye (n=61), Sturgeon Lake.

The Alberta Conservation Association acknowledges the following partner for their generous support of this project

Alberta

Alberta Conservation Association