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Biological characteristics and population assessment of walleye (*Sander vitreus)* from Tathlina Lake, Northwest Territories.

Caractéristiques biologiques et évaluation de la population du doré jaune (*Sander vitreus*) du lac Tathlina (Territoires du Nord-Ouest)

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ABSTRACT

The commercial walleye fishery in Tathlina Lake, Northwest Territories, collapsed in 2001 from a quota of 20,000 kg per year. The total catch of walleye has fluctuated multiple times since commercial fishing began in the 1950s and past quotas do not appear to have been sustainable. The interaction between harvest levels and the abiotic conditions of the lake is poorly understood and likely has an important effect on recruitment of walleye to the fishery as Tathlina Lake is large, shallow and turbid, with one documented case of winterkill in the 1940s. Biological and catch-per-unit-effort information from experimental gill netting conducted between 2001 and 2007 were used to assess the status of the walleye population. Additionally, commercial plant sampling data collected between 1990 and 1998 were examined. Between 2001 and 2007, the status of the stock appears to have improved although the extent of recovery was unknown. The mean fork length, weight, age and catch-per-unit-effort of walleye increased among years. Additionally, the proportion of walleye in the total catch increased. The growth rate of walleye between 2001 and 2007 did not demonstrate significant changes among sampling years. Compared to results from experimental gill netting in 1946 and 1979, walleye in Tathlina Lake appear to have increased in mean length, age and length-at-age. A recommendation was made to open the fishery with a conservative quota (≤5000 kg). Additional recommendations were made regarding approaches to monitoring the fishery and environmental conditions that likely influence walleye production.

RÉSUMÉ

La pêche commerciale du doré jaune dans le lac Tathlina (Territoires du Nord-Ouest) a chuté en 2001, partant d'un quota de pêche de 20 000 kg par année. La capture totale du doré jaune a fluctué plusieurs fois depuis le début de la pêche commerciale pendant les années 1950, et les anciens quotas ne semblent pas avoir été durables. On comprend mal l'interaction entre les niveaux de capture et les conditions abiotiques du lac, qui a probablement un effet important sur le recrutement du doré jaune pour la pêche, étant donné que le lac Tathlina est un grand lac, de faible profondeur, aux eaux turbides, et pour lequel on a relevé un cas prouvé de destruction par l'hiver au cours des années 1940. Les renseignements relatifs à la biologie et à la capture par unité d'effort d'une pêche expérimentale au filet maillant menée entre 2001 et 2007 ont été utilisés pour évaluer l'état de la population du doré jaune. De plus, les données sur l'échantillonnage aux usines de transformation recueillies entre 1990 et 1998 ont été examinées. Entre 2001 et 2007, l'état du stock semblait s'être amélioré, bien qu'on ne connaisse pas l'étendue du rétablissement. Les valeurs moyennes de longueur à la fourche, de poids, d'âge et de capture par unité d'effort du doré jaune ont augmenté au fil des années. De plus, la proportion du doré jaune dans le total des captures a augmentée. Le taux de croissance du doré jaune entre 2001 et 2007 ne démontrait pas d'écarts importants entre les années d'échantillonnage. Par comparaison aux résultats de la pêche expérimentale au filet maillant de 1946 et 1979, la longueur moyenne, l'âge et la longueur selon l'âge du doré jaune du lac Tathlina semblent avoir augmenté. On a recommandé d'ouvrir la pêche avec un quota prudent (≤ 5000 kg). D'autres recommandations ont été formulées concernant les approches de la surveillance de la pêche et des conditions ambiantes qui ont vraisemblablement une incidence sur la production de doré jaune.

INTRODUCTION

Commercial fishing of walleye (*Sander vitreus*) on Tathlina Lake, Northwest Territories, began in the winter of 1953/1954 and has provided important economic benefits for residents from the nearby community of Kakisa. The history of the fishery demonstrates multiple periods where harvest has fluctuated dramatically with periods of fishery collapse (Fig. 1). The fishery was not opened in 2001 after catches declined from a quota of 20,000 kg. An attempt to fish in 2003 (quota of 5,000 kg) produced negligible yields while a small quota (2,000 kg) in 2008 was not completely attained (620 kg) in part because fishers reported that the returns would not have been worth the effort. No commercial fishing has taken place since 2008. No angling occurs on Tathlina Lake due to its remote location.

Commercial harvest over the past 20 years occurred during the winter months in the western area of the lake while commercial harvest prior to the 1990s occurred in both the winter and summer months (Roberge et al. 1988). Initially, the commercial quota was set to 91,000 kg/year and while never achieved, was reduced to 30,900 kg/year in 1967. Assessment of the stock by Roberge et al. (1988) further reduced the quota to 20,000 kg/year (Fig. 1). The minimum mesh size used in the fishery prior to 1980 was 114 mm and was subsequently changed to 108 mm. Roberge et al. (1988) state that after 1980 both the 108 mm and 114 mm mesh size were used in the commercial fishery. The fishery in 2003 and 2008 was opened with a single gill net mesh size of 108 mm.

The number of fishers operating on the lake has varied, but over the decade prior to the last closure there has been as few as one and as many as four.

Prior sampling for assessment of the population occurred in 1946 (Kennedy 1962) and 1979 (Roberge et al. 1988). The walleye population is likely sensitive to environmental conditions of the lake due to its large size and shallow depths. Recruitment may be influenced by variable water levels, temperature and turbidity. A severe winterkill was observed in 1943 (Kennedy 1962) which is likely attributed in part to the morphology of the lake.

In order to monitor the population after the commercial fishery was not opened in 2001, an experimental gill netting program was conducted. Data were collected from 2001-2007 and also compared to historical data in order to evaluate the status of the stock. Additionally, biological data from commercial plant sampling of walleye between 1990 and 1998 were used to observe for trends prior to the collapse of the fishery in 2001. The information was used to determine whether the commercial fishery should be reopened and to establish a quota. Additionally, recommendations were made on data requirements for monitoring the fishery in order to improve future population assessments.

STUDY AREA

Tathlina Lake (N 60° 32'; W 117° 31') is a large (57,300 ha) shallow (greater depths ranging between 1.5 and 1.8 m) lake situated in southern Northwest Territories (Fig. 2) (Kennedy 1962). The number of growing degree days ≥5°C in the Tathlina Lake area is approximately 1,250. The lake is part of the Kakisa River which drains an area of 14,900 km^2 and is situated in a low lying area composed mainly of muskeg (Roberge et al. 1988). The western area of the lake where the Kakisa River enters is deeper than the rest of the lake. The substrate of Tathlina Lake has been described as soft black organic bottom (Kennedy 1962). The water in most of the lake is turbid likely due to wave action while the water is clearer in the western area of the lake (Kennedy 1962).

Other species inhabiting the lake include lake whitefish (*Coregonus clupeaformis*), northern pike (*Esox lucius*), longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commersoni*), burbot (*Lota lota*) and lake cisco (*Coregonus artedi*).

MATERIAL AND METHODS

COMMERCIAL PLANT SAMPLING

Walleye captured by commercial fishers were randomly selected for biological sampling by DFO employees at the fish plant in Hay River between 1975 and 1998. Results from plant sampling between 1975 and 1986 are presented and discussed in Roberge et al. (1988), while data from 1990, 1991 and 1994-1998 are presented in this assessment. The catch-per-unit-effort and mesh size of commercial landings were never recorded.

EXPERIMENTAL GILL NETTING

Experimental gill nets were 274.2 m long consisting of 45.7 m long and 0.6 m deep panels of 38, 64, 89, 108, 114, 140 mm mesh (stretched). Gill nets were set in 2001 and 2002, and 2005-2007, while no sampling was conducted in 2003 and 2004 (Table 1, Fig. 2). Experimental gill netting occurred during winter (November or December) in all years except for 2002 when sampling was conducted in spring (June). In the winter, gill nets were set using an articulated jigger and were left to soak for approximately 24 hours in locations where commercial fishing typically occurred. Gill nets were set in the western area of the lake in most years while in 2002 sites further north and east were also sampled.

BIOLOGICAL DATA

Commercial plant sampling

Between 1990 and 1995, fork length (± 1 mm) and round weight (± 5 g) were recorded (Table 2). In 1996, fork length and the headless dressed length, and headless dressed weight were recorded, while in 1997 and 1998 only headless dressed length and weight were recorded. Dorsal spines were collected in 1991 and 1994-1998 for ageing.

Experimental gill netting

Location, duration and catch among mesh sizes for each species were recorded for each experimental gill net set. The fork length (± 1 mm), weight (± 10 g), and sex and maturity were recorded for each walleye, although maturity was not recorded in 2001. The first two dorsal spines were taken for age determination. All other species were enumerated, measured and weighed.

Ageing

Walleye spines collected between 1991 and 2006 were sectioned 0.25-0.50 mm thick using an Isomet saw at low speed (~200 rotations per minute). Sections were mounted onto a glass slide and covered using Cytoseal. Annuli were enumerated under a dissecting microscope using transmitted light and a dark background. North/South Consultants aged samples collected between 1991 and 1996 while the record of who did the ageing of the 1997 sample was lost. The same age reader (L. Heuring) was used to prepare and age samples collected between

1998 and 2006, while a different reader (independent contractor) was used for the 2007 sample. Spines from the 2007 sample were sectioned approximately 1 mm thick and mounted onto glass slide but not covered using Cytoseal.

The age data from the 1997 and 2007 samples were questionable due to concerns that the age reading was inaccurate. The 1997 distribution was bimodal with peaks at ages 8 and 15 (mean= 10.9; mode= 8, n= 210). In the 2007 sample, significantly older ages (mean= 10.2; mode= 11 years, n= 825) were observed in the sample in proportions not observed in any other year using experimental gill nets. A sub-sample (n= 50 for 1997 and n= 60 for 2007) was taken and read by another age reader with >10 years experience ageing walleye spines and was trained by the same instructors as the original reader who aged samples from 1998-2006. The new ageing results from the 1997 and 2007 sub-samples were plotted against the original results to examine whether results were similar (Fig. 3). Precision was measured by using the mean coefficient of variation (CV):

$$CV = 100 \times \frac{1}{N} \sum_{j=1}^{N} \frac{\sqrt{\sum_{i=1}^{R} \frac{(X_{ij} - X_j)^2}{R - 1}}}{X_j}$$

where N is the number of fish aged, R is the number of times a fish was aged, X_{ij} is the i^{th} age estimate for the j^{th} fish, and X_j is the average age determined for the j^{th} fish (Chang 1982). A Mann-Whitney was also used to test whether the age readers were different.

The 1997 and 2007 sample had a percent agreement of 26.0% and 18.3%, respectively. In both instances the second reader generally obtained younger ages compared to the original reader. The CV was equal to 9.34% and 12.9% for the 1997 and 2007 samples, respectively, while the Mann-Whitney tests were significant for both years (1997: U= 961.5, p= 0.045; 2007: U= 1168.5, p= 0.001). Based on these results it was decided not to include the 1997 and 2007 age data for the assessment.

DATA ANALYSIS

<u>Length and age</u>

Length data from headless dressed samples from the commercial plant sampling was converted to fork length in order to standardize results among years using the equation by Roberge et al. (1988):

Fork length= 98.875 + 0.971 (headless length); r= 0.79.

Averages and standard deviations among years were calculated.

The mean and standard deviation of length and age was calculated for the total sample and separately for female and male walleye captured in experimental gill nets. Differences in mean length and age were tested separately for males and females among sampling years using analysis of variance (ANOVA) with a Bonferonni corrected post-hoc test. Length and age frequency distributions were generated for the total sample and separately for female and male walleye for each year. Because age data were not normally distributed, Kruskall-Wallis tests were conducted to determine if ages were significantly different between years.

Year class strength was examined by plotting the proportion (%) of each age class among sampling years using data from the 108 and 114 mm mesh from both experimental gill nets and the commercial fishery against the year the walleye hatched.

Weight and condition

The mean and standard deviation of weight and Fulton's condition factor was calculated for the total sample and separately for female and male walleye. Analysis of covariance (ANCOVA) was used to test for differences in weight ($\log_{10}$ transformed) between females and males and among study years using length ($\log_{10}$ transformed) as a covariate. The weight-length relationships were described by the equation:

$$\log_{10}W = a + b\ (\log_{10}L)$$

where W= weight in grams, L= fork length in millimetres, a= Y intercept and b= slope of the regression line. Fulton's condition factor was calculated:

$$K = \frac{W \times 10^5}{L^3}$$

where W= weight in grams and L= fork length in millimetres.

Growth

The mean length- and mean weight-at-age was plotted for female and male walleye captured in experimental gill net among sampling years. A scatterplot of length against age was generated to illustrate the variance in length among age classes for both sexes.

The von Bertalanffy growth function was used to model the length-at-age of walleye:

$$L_t = L_\infty\ [1-e^{-K(t-t0)}],$$

where $L_{(t)}$= estimated length at age, L_∞= maximum length, K= body growth coefficient, t_0= theoretical age at length zero, and t= age, and fit according to Ricker (1975). Analysis of residual sum of squares (Chen et al. 1992) was used to test for significant differences in growth in males and females, and between males and females collected in 2001 and 2006.

Maturity and sex ratio

Maturity was assessed based on the maturity codes in Appendix 1. The age and length at 50% maturity was calculated for female and male walleye. The female to male ratio was calculated among years to determine whether they were equal and to examine whether there were any trends among years. Differences in the ratio were evaluated by examining the confidence limits for binomial proportions that would indicate whether the observed they differed significantly from 0.5 (Rohlf and Sokal 1995).

Catch-at-age

Catch curves (natural log of age class frequency plotted against age) were generated for walleye captured using experimental gill nets. A least squares regression was fitted against the descending limb (modal age plus one year) of the catch curve. The instantaneous mortality (Z), annual survival (S) and annual mortality rate (A) were calculated as follows: Z= positive slope of the regression, S= e^{-z}, A= 1-S.

Catch-per-unit-effort

The catch per unit effort (CPUE) from the experimental gill netting was calculated as number of fish/91 m/ 24 hours using the formula:

CPUE= number of fish x (91 m/ net length) x (24 hours/ hours set)

in order to compare with experimental gill netting results from Roberge et al. (1988).

Catch among mesh sizes

The percent total catch of walleye by number and weight among mesh size was examined to determine which mesh size walleye from Tathlina Lake were most vulnerable. The mean length, weight, and age of walleye were also calculated for each mesh size among sampling years.

Historical comparisons

Historical experimental gill netting data were available from 1946 (Kennedy 1962) and 1979 (Roberge et al. 1988). It was impossible to compare some results from this study and Roberge et al (1988) to Kennedy (1962) due to the confounding effect of different experimental gill nets (Table 3). An extra mesh size (108 mm) was used in this study compared to Roberge et al. (1988) in order to obtain information using a mesh size similar to those used by commercial fishers. Comparisons should be treated cautiously between Roberge et al. 1988 and this study because the timing of sampling was different, with the exception of 2002. Any comparison of the CPUE between 1979 and 2002 has to consider that the depth of nets used in 1979 was 1.9 m compared to 0.6 m in 2002. Kennedy (1962) sampled Tathlina Lake between July 26 and August 9, while Roberge et al. (1988) sampled approximately in mid-June.

Kennedy (1962) and Roberge et al. (1988) used scales to age walleye. It is not known whether annuli counted from scales and spines of walleye from Tathlina Lake provide comparable results. Roberge et al. (1986) report that ages obtained from scales and spines of walleye from nearby Kakisa Lake were similar. Belanger and Hogler (1982) found that the results from spines were comparable to scales, although Kocovsky and Carline (2000) reports that scales were more accurate than spines while Erickson (1983) concluded that spines were more accurate than scales. Until a comparative ageing study is made between scales and dorsal spines of walleye from Tathlina Lake, it will be assumed that ages between both structures are similar.

RESULTS

COMMERCIAL PLANT SAMPLING

Length and age

Statistically significant differences in fork length were detected among sampling years ($F= 80.5$; $d.f.= 6, 1306$; $p< 0.001$). Post-hoc analyses demonstrated no differences between 1990 and 1994, which had significantly smaller lengths than 1995-1997, which were not significantly different from one another (Table 4) (Fig. 4). The post-hoc test also indicated that significantly larger sized walleye were observed in 1998 compared to other years between 1990 and 1997.

Significant differences in age were observed among 1991, 1994, 1995, 1996 and 1998 sampling years ($H(4)= 111.5$, $p< 0.0001$). No significant differences in age were detected between 1995 and 1996 (Table 5), while a higher proportion of younger ages (≤8 years) were detected in the 1998 sample compared to other years (Fig. 5).

<u>Catch-at-age</u>

Instantaneous mortality calculated from the plant samples indicate that mortality was relatively high in 1991 (1.73), 1994 (0.67) and 1996 (0.65) than in 1995 (0.56) although considerably lower in 1998 (0.20) (Table 6).

EXPERIMENTAL GILL NETTING

<u>Length and age</u>

The mean length of Tathlina Lake walleye generally increased among sampling years from a low of 362 mm in 2002 to 413 mm in 2007 (Table 7) ($F= 210.0$; d.f.= 4, 2979; $p< 0.001$). Fork length frequency distributions for the total sample among years are presented in Figure 6, and separately for females and males in Figure 7. Modal values of the total sample were similar for 2001-2002 (350-399 mm) and for 2005-2007 (400-449 m). Walleye 400-449 mm in length increased in proportion throughout the study, comprising 50.1% of the total sample in 2005, 53.6% in 2006 and 64.1% in 2007.

Statistically significant differences in length among study years were observed among females ($F= 193.3$; d.f.= 4, 1359; $p <0.0001$) and males ($F= 102.1$; d.f.= 4, 1415; $p <0.0001$). Bonferroni post-hoc tests revealed no significant differences in female lengths between 2006 and 2007, and no significant differences in male lengths between 2001 and 2002, and between 2005 and 2006. Females had higher mean lengths than males among years ($F= 28.2$; d.f.= 1, 2774; $p< 0.001$), although post-hoc testing showed no differences in 2002. Females captured in experimental gillnets during the winter were on average ~30 mm larger than males. Interestingly, no males >450 mm were captured in 2005. Size selectivity among gill net mesh sizes for males and females among sampling years is provided in Appendix 2.

The mean age of walleye captured among winter samples between 2001 and 2006 increased from 5.0 years to 7.3 years (Table 8). Statistically significant differences were observed between years except between 2005 and 2006 (Table 9). Females and males had similar mean ages yet were significantly different except between 2005 and 2006 (Table 10). Age frequency distributions of the total sample among study years demonstrated a strong age class of four-year-old walleye in 2001 that was detected in relatively high abundance as five-year-olds in 2002, eight-year-olds in 2005, and nine-year-olds in 2006 (Fig. 8).

Age frequency distributions demonstrate that in 2001, 58.2% of males were four-years-old while 79.4% of females were five and six years old (Fig. 9). In 2005, similar proportions of females and males were observed in ages three to eight although higher proportions of males lived to older ages (Fig. 9). Compared to males, higher numbers of females two to six years of age were observed in 2006.

Year class strength was high (i.e., accounting for at least ≥30% of year classes) in 1966-1968, 1971-1973, 1995-1998; and low (i.e., accounting for ≤15% of year classes) from ~1980-1984 and 1991-1994 (Fig. 10).

Mean length, weight, condition factor and percent mature among length and age classes for female, male and the total sample among sampling years are presented in Appendix 3.

Weight and condition

Mean weight of walleye from Tathlina Lake was significantly different among sampling years (Table 11) (F= 384.9; d.f.= 1, 4; p< 0.001). The mean weight generally increased from 601 g in 2001 and 507 g in 2002 up to 875 g in 2007, with females being typically heavier than males. Differences among years between females and males ranged between 16 g (2002) and 231 g (2006). ANCOVA indicated that weight between males and females captured during the winter were significantly different among winter sampling years, although it was similar in June 2002 (Table 12). Comparisons of weights by ANCOVA for females between years showed significant differences except for 2005 and 2006, 2005 and 2007, and 2006 and 2007 (Table 13). Between-year differences in weight for males were all significant except between 2005 and 2006 (Table 13). The parameters of the weight-length regression among years are presented in Table 14.

Mean condition among sampling years ranged between 1.03 (2002) and 1.24 (2005) (Table 15). The condition factor for females (F= 199.9; d.f.= 4, 1359; p< 0.001) and males (F= 244.3; d.f.= 4; 1415; p< 0.001) differed significantly among years. Post-hoc testing showed no difference in female condition between 2005 and 2006, 2005 and 2007, and 2006 and 2007, while no difference in male condition was observed between 2005 and 2006. Mean condition increased among age classes up to approximately age 6-7 (Appendix 3).

Growth

Length-at-age plots demonstrate that female walleye from Tathlina Lake have higher growth relative to males (Fig. 11), although differences were not statistically significant (2001 data F= 1.13; d.f.= 12,15; p= 0.38; 2006 data F= 1.26; d.f.= 12,15; p= 0.33), even when females attained greater maximum lengths (Table 16). No differences in length-at-age were detected between 2001 and 2006 for both females (F= 1.88; d.f.= 10,13; p= 0.20) and males (F= 2.64; d.f.= 14,17; p= 0.09). No differences in length-at-age were observed between males and females in June (F= 2.88; d.f.= 20,23; p= 0.06) (Fig. 12). Length among age classes can vary as some walleye >10 years were similar in size to six-year-olds. Scatterplots of length among age classes demonstrate the variability of up to 100 mm among some ages (Fig. 13).

Similar to length-at-age, the weight-at-age for female walleye was greater than males among sampling years (Fig. 14). Females and males had similar weight-at-age values up to age 4. Additionally, females captured during the winter demonstrated a dramatic increase in weight-at-age beginning at approximately age 8.

Maturity and sex ratio

The length- and age-at-maturity among sampling years were relatively consistent (Appendix 3). Significantly higher proportions of males were observed in 2001 and 2006, while other sampling years did not demonstrate any significant differences (Table 17). The majority of samples collected during the winter were maturing to spawn in the spring while samples collected in June 2002 were mainly spent although some were resting (Table 18). Age-at-maturity for females appeared to be between 4-6 years while the length at maturity, based on averaging mean length-at-age among study years, was approximately 381 mm. The majority of males were mature at age four; although two walleye from the 2006 sample were mature by ages 2 and 3. The length at maturity for males was approximately 359 mm. The majority of female to male ratios were nearly equal while the 2006 and 2001 samples were both depauperate of females with ratios equal to 0.81 and 0.54, respectively (Table 17).

Catch-at-age

Instantaneous mortality, survival and annual mortality of Tathlina Lake walleye varied among study years (Table 6). Comparing instantaneous mortality among years was not as reliable because the age ranges of the descending limb of the catch curves did not exactly overlap. Between 2001 and 2006, instantaneous mortality increased, ranging from 0.57 to 1.07, respectively.

Catch-per-unit-effort

The CPUE increased among sampling years from 11.8 walleye/91 m/ 24 hours in 2001 to 39.2 walleye/91 m/ 24 hours in 2007 (Figure 15). The only statistically significant difference between sampling year was 2001 against all other years, except 2006 (Table 19). The proportion of walleye among other species among winter sampling seasons increased from 36% in 2001 to 68% in 2007 (Table 20).

Catch among mesh sizes

The majority of walleye captured in experimental gill nets between 2001 and 2007 were caught using the 89 mm mesh size (Table 21). The 89 mm mesh typically captured 32-59% of all walleye by number and weight. Walleye captured in June 2002 were mainly collected in the 64 mm mesh (48% by number). The highest CPUE among mesh size was the 89 mm in all sampling years (Figure 16).

The female to male ratios among mesh sizes generally demonstrated that fewer females were susceptible to mesh sizes 38-89 mm while most males were consistently captured in the 89 mm mesh size (Table 22). The ratio was nearly equal in 2002, 2006 and 2007 for the 108 mm mesh size while females were three to five times more susceptible to the 114 mm mesh between 2002 and 2007.

Bycatch species

The most abundant species other than walleye captured in Tathlina Lake was lake whitefish (Figure 17). The mean CPUE of lake whitefish was fairly consistent among most winter months ranging between 16.5 and 23.9 fish/91m/24 hours from 2001 to 2006 then decreasing to 12.9 fish/91m/24 hours in 2007. Lake whitefish were most abundant in 2002 during the spring. Longnose sucker was also abundant in 2002 during the spring but not among winter sampling years. All other species were low (<5 fish/91 m/24 hours) in relative abundance compared to walleye and lake whitefish. Very few cisco (n= 1) and burbot (n= 23) were captured.

DISCUSSION

BIOLOGICAL CHARACTERISITCS

The results of the 2001-2007 experimental gillnetting program for walleye from Tathlina Lake may not be representative of the population as net sets were located in the western portion of the lake and not randomly distributed. Regardless, the location and timing (excluding 2002) were consistent among sampling years which permits evaluation of biological trends over time for the western area of the lake.

The average length, age and weight of walleye from Tathlina Lake appear to have increased during the closure of the fishery. Greater proportions of larger sizes and older ages were evident over the course of the sampling program. Concurrently, the relative abundance of walleye also increased. These results suggest an increase in total biomass of walleye in Tathlina Lake.

The higher average length and weight of adult females compared to males is consistent with results from other systems (Henderson et al. 2003). Although females captured near the mouth of the Kakisa River were heavier than males during the winter, no differences in size were observed in June. Length, weight, age and condition factor results from 2002 should be compared cautiously to other sampling years due to the confounding effects of season and differences in some sampling locations. The smallest average size was observed in 2002. This could be a result of larger-sized females having moved away from the area after spawning which may be reflected in the higher ratio of males, or, because sampling locations in June were more widely distributed compared to winter ones, may be due to sampling of habitat favoured by males. Interestingly the length-at-age of walleye ≤6 years of age in 2002 was lowest compared to other years and may possibly be a result of smaller-sized immature fish that congregate in the area that was sampled during early June.

Walleye from Tathlina Lake attain a mean length of 300 mm within 2-3 years of age while growth typically slows after age six. In all sampling years, females had higher mean length-at-age than males beginning at age four. Maximum length of female walleye from Tathlina Lake appears to be similar to the 1978 sample from Kakisa Lake (Roberge et al. 1986). Maximum length of female walleye from Kakisa Lake was 564 mm yet males had a similar value (530 mm) and a growth rate that did not appear to be different which is similar to the results from walleye from Tathlina Lake where males appear to have a similar growth rate (in length) to females. Interestingly, walleye from Tathlina Lake currently have a higher growth rate among ages 2-10 than walleye from Kakisa Lake in 1978. Walleye from Tathlina Lake have slower growth compared to southern walleye populations (Quist et al. 2003) partly due to the relatively limited productivity at northern latitudes.

The apparent increase in the relative abundance of walleye based on CPUE results and total catch composition did not appear to affect the growth rate and although speculative it may suggest a low influence of density dependence on the growth of walleye in Tathlina Lake. Sass et al. (2004) and Sass and Kitchell (2005) found that density dependence was a weak driver of walleye growth in northern Wisconsin yet observed differences in growth among lakes was possibly influenced by physical, chemical and biological characteristics of lakes. Alternatively, higher growth was observed in juvenile walleye from Lake Erie during a period of low abundance suggesting density dependence (Jones et al. 2006).

The similarity of length-weight relationships among winter sampling years suggests no change in the foraging success of walleye. Females have higher length-weight than males in part due to the increased mass from gonad development. The lower length-weight in June is mostly a result of decreased mass due to the release of eggs during spawning, seeing as most adult walleye in 2002 were post-spawners.

The strong 1997 year class that appear as four year-olds in 2001 was a very important contributor to the proportion among age classes for all sampling years. A relatively high proportion of four year-olds was not observed again in subsequent sampling years.

Poor year classes between ~1980-1984 and 1991-1994 correspond with a period of low productivity in the fishery (Fig. 1) suggesting that the harvest of walleye reduced the ability of the population to produce new recruits. Alternatively, strong year classes were observed during periods when the fishery was productive. However, until the information is evaluated, it is impossible to assess the effects of both environmental factors (e.g., weather) and the fishery on year class strength.

Although the fishery was not opened in 2001, instantaneous mortality among sampling years increased. The instantaneous mortality can be considered natural mortality because no fishing was taking place apart from a relatively small amount in 2003. Regardless, annual mortality values in some sampling years approximate what is considered as “low” for walleye in the Great Lakes area (40%) (Colby et al. 1994). Reasons for the increase in mortality can be an effect of the influence of shifting modal age, particularly from the 1997 cohort, which skews the frequency distributions towards the right in later sampling years. The survival (S) values of walleye from Tathlina Lake were lower than those of walleye from Bay of Quinte on Lake Erie which where survival was equal to 68.4% during a period of strong recovery (Stewart et al. 2002). Results from experimental gillnetting in nearby Kakisa Lake (which supports a sustainable walleye fishery) in 1978 indicated that annual mortality was equal to 0.55 (Roberge et al. 1986).

The female to male sex ratios were fairly consistently equal among sampling years, except in 2001, and suggest that sexes were not spatially segregated during the time of sampling.

No clear pattern was evident in the relationship between the CPUE of walleye and other species in Tathlina Lake. No conclusive evidence suggests that the increase in relative abundance of walleye resulted in changes in the large-size fish community of the lake.

HISTORICAL COMPARISONS

Comparison among the commercial plant sampling years indicates that walleye captured from 1995-1998 have increased in length and age compared to the 1970s. The lack of CPUE and mesh size data from the commercial catches limits the historical comparison of length and age. Mortality estimates demonstrated lower mortality in the 1990s compared to earlier years, although age ranges of the catch curve do not exactly overlap. The apparently higher survival in the 1990s did not provide any indication of the impending collapse of the fishery that occurred in 2000. Interestingly, the low mortality in 1998 is a result of a skewed distribution towards younger aged fish (Fig. 5) which may indicate a dearth in the number of older walleye available to the fishery in subsequent years and a reason why the fishery collapsed. The mortality in the 1990s is similar to 2001-2007 experimental gill netting results when no commercial fishing was occurring and the status population was likely improving. Additionally, having information on the composition of males and females in the commercial catch may have provided additional information useful for assessment. If larger-sized fish were being harvested, there may have been a greater proportion of females harvested which may have influenced future abundance.

Comparisons among experimental gill netting results from Roberge et al. (1988), Kennedy et al. (1962) and this study were done using data from 2002. Mean length, age and weight of Walleye in Tathlina Lake in 1979 were equal to 339 mm, 7.5 years and 421 g, respectively (Tables 7, 8 and 11). Compared to males, females were on average 12 mm longer and 60 g heavier in length and weight, respectively, in June 1979. Relative to 1979, walleye from Tathlina Lake were on average 23 mm longer and 86 g heavier in length and weight, respectively, in June 2002. The maximum length observed in walleye from Tathlina Lake was from a female equal to 439 mm in 1979 and 575 mm in 2002. Additionally, a greater range and number of age classes were observed in 2002 (n= 19) compared to 1979 (n= 7). Roberge et al. (1988) reported that no differences in the weight-length relationship were detected between males and females in 1979 which was also observed in 2002. The condition factor between 1979 and 2002 was similar.

The length-at-age appears to have increased among assessment years (Fig. 18). Among comparable ages (2-5 years), walleye from 2002 have increased between 29 and 57% in length compared to 1946. Growth has also increased between 1979 and 2002 as comparable age classes have increased in mean length between 1 and 19%.

No sexually mature fish were captured in 1946 (Kennedy 1962) while Roberge et al. (1988) reported that the approximate length and age where ≥50% of walleye were mature was 290 mm and 6 years. Length-at-maturity appears to have increased since 1979, while the age-at-maturity of males may be smaller while that of females may not have changed considerably. It should be noted that no walleye <6 years of age were captured in 1979 and that conclusive evaluation of trends in maturity was not possible as younger walleye may have been sexually mature. Unlike 2002, females significantly outnumbered males (1:1.6) in June 1979, and further suggest some degree of sexual segregation during this period of the year. In both 1979 and 2002, the 64 mm panel was the most efficient mesh size, accounting for 57.7% and 48%, respectively, of the catch (by number).

Annual mortality estimates from experimental gill nets in 1979 was equal to 0.80 (Roberge et al. 1988) (Table 6) and appears to have decreased relative to this study (0.43-0.66) suggesting that more walleye were allowed to reach older ages, which was also evident with the increase in older age classes in 2002 relative to 1979. Roberge et al. (1988) calculated the mortality of walleye from Tathlina Lake walleye captured in 1946 using data from Kennedy (1962). The calculated instantaneous mortality was 1.79 (survival= 0.17, annual mortality= 0.83) with an age range of only 4-5 years. The estimate is likely erroneous because it was not a representative sample of the population and the calculation was made using the modal age and not the descending limb which only constituted one age class with n= 1. It is more likely that the mortality of walleye from Tathlina Lake prior to the 1942 winterkill was similar to Kakisa Lake which had an instantaneous mortality equal to 0.91 in 1946 (survival= 0.40, annual mortality= 0.60) (age range 9-12 years).

Catch-per-unit-effort has also increased between 1979 (17.7 29.4 walleye/ 91 m/ 24 hours) and 2002 (29.4 walleye/ 91 m/ 24 hours) (Fig. 15). Unfortunately, no estimate of error was calculated for the 1979 data. Walleye constituted a greater proportion of the total catch among species in 1979 (55%) than in 2002 (29%) (Table 20).

HABITAT

Lester et al. (2004) examined the role of water clarity, climate, temperature, bathymetry and nutrients (total dissolved solids, TDS) to develop a yield model for walleye using data from walleye populations throughout Ontario. A measure of suitable habitat was determined, termed the “thermal-optical habitat area” (TOHA), which calculates the benthic area of a lake that supplies optimum light and temperature for walleye in thermally stratified lakes. Optimal habitat was affected by climatic and morphometric characters. The model predicts that in saucer shaped lakes, not unlike Tathlina Lake, decreased water clarity is optimal. Water from Tathlina Lake is not clear as Kennedy (1962) reported that secchi depth was equal to 0.1 m. Saucer shaped lakes provide less habitat for walleye compared to bowl shaped lakes. Interestingly, Ward et al. (2007) found that secchi depth and walleye fingerling production were negatively correlated in shallow (mean depth= 0.86-1.81 m) Minnesota lakes.

Water temperature in Tathlina Lake was recorded by Kennedy (1962) and in 2002 (Appendix 4). Late spring water surface temperatures appear to attain temperatures of approximately 20°C while deeper areas have been observed as low as 15°C. Lake nutrients has never been directly measured, however the TDS of the Kakisa River flowing out of Tathlina Lakes was 279 mg/L on June 14, 1972 (Lamoureux 1973).

Although speculative, lake temperature data and morphometry suggest walleye habitat throughout the lake. However, the shallow depth, in concert with the limited number of growing degree days, likely limits walleye productivity in the lake.

Fergusson (2005) hypothesized that warmer water temperatures caused by global warming will increase pre-maturation growth rate, decrease age-at-maturity, and increase maximum size, fecundity (inversely with lake productivity) and mortality (Fergusson 2005). Tathlina Lake is vulnerable to changes in temperature due to its shallow depths. If changes in climate alter life history parameters, it will be important to incorporate these in future assessments. Already possible effects of a warming environment may be evident as the pre-maturation growth rate and maximum length of walleye from Tathlina Lake has increased since the 1970s. Additional effects of global warming at northern latitudes may be a decrease in runoff which would affect lake volume. Jones et al. (2006) predicted that reduced lakes levels on walleye from Lake Erie would decrease recruitment.

Monitoring of environmental variables or habitat characteristics that have been shown to influence walleye abundance may provide useful information in evaluating influences in addition to harvest that will affect walleye production in Tathlina Lake.

POPULATION ASSESSMENT

Since the cessation of commercial fishing activity, results from experimental gill netting between 2001 and 2007 indicate that the status of the stock has improved based on:

1) increased CPUE among years,
2) increased proportion of walleye in the total catch,
3) increased proportion of larger sized (≥400 mm) walleye,
4) increased proportion of older (≥8 years) walleye,
5) presence of a strong year class (1997) detected among sampling years that has been very lightly harvested and left to reproduce multiple times since reaching maturity in ~2003.

The 2001-2007 results, compared to other study years, also suggest some degree of improvement in the condition of the stock. Roberge et al. (1988) examined the population during a period of low yields in the fishery. Compared to 1979, walleye captured in Tathlina Lake between 2001 and 2007 (more accurately in 2002) have increased in length-at-age, and mean length, weight and age. It is unknown whether environmental conditions have changed between the study years and what influence this may have on growth/biomass production. Although the population is demonstrating signs of improvement, the extent of the recovery is unknown.

The attempt to commercially fish in 2003, which did not produce any considerable catch, was preceded by experimental sampling a year earlier which had a mean CPUE of 29.4 walleye/ 91 m/ 24 hours. Although the average CPUE increased after 2002, the differences were not statistically significant. Therefore, any interpretation of recovery based on CPUE from experimental gill netting should be treated cautiously.

The stock is vulnerable to depletion due to the higher growth rate (in mass) demonstrated by females. Females are 3-5 times more susceptible than males to the 114 mm mesh size. Overharvest of females due to their susceptibility to the 114 mm mesh size may have been a contributing factor in past collapses of the fishery. The 108 mm mesh size has a more equal sex ratio and captured 17% of walleye ≤6 years of age (2006 data) which suggests that the immature component of the stock is generally protected by using this mesh size as a minimum.

Year class strength is variable, however the effects of the population decline (interpreted from the decline in commercial catches) appears to have an effect on recruitment. A ten year period of poor catches from the early 1980s to the 1990s suggests a long period of time is necessary for rebuilding the stock.

RECOMMENDATIONS

1. It is recommended that a conservative commercial quota of ≤5,000 kg be allocated. The quota is relatively low compared to the 20,000 kg/year quota established in 1990. Although the recommended quota is not established by using any modeling, a conservative approach is warranted due to the past cyclical nature of the harvest and the long period until signs of improvement after collapses/declines in the fishery.

2. Research will be required to establish parameters useful for modeling the response of walleye from Tathlina Lake to harvest which will be important for establishing quotas.

3. It is recommended that commercial fishers record the length of their nets, mesh size and soak time in order to allow for monitoring of CPUE.

4. Commercial plant sampling of walleye from Tathlina Lake should continue in order to monitor biological characteristics.

5. Monitoring the limnological conditions of the lake in order to determine if there is any relationship with yield or harvester's CPUE may provide an important means to help manage the fishery. The morphometry of the lake likely makes it susceptible to changes in temperature or turbidity which may affect habitat quality and success for recruitment. Important variables that could be recorded would include temperature, dissolved oxygen, dissolved solids, secchi depth, pH, and variables related to productivity such as chlorophyll *a*. Additionally, relating the results with meteorological information would strengthen environmental monitoring of Tathlina Lake.

6. Examining if there is a relationship between historical year class strength and weather data (e.g. air temperature) may provide an indication on the environmental influences on recruitment.

7. It is recommended to conduct future assessment during the winter (during the commercial fishery) in order to standardize with past sampling years. All the variables that were measured in earlier sampling years should be recorded in order to keep the data consistent. Additionally, experimental sampling should occur throughout the lake.

8. Reliable ages are necessary for management of the fishery. It is recommended to conduct an ageing study using multiple ageing structures to investigate whether there are any differences in ages among structures and to establish an ageing protocol.

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Table 1. Dates, number of locations and net lifts, and depth of gill nets among experimental sampling conducted between 2001 and 2007 in Tathlina Lake, NT.

Year	Sampling dates	Gill net sites	Total number of lifts	Depth (m)
2007	December 14-20	3	7	0.6-1.2
2006	December 7-11	3	4	0.9-1.2
2005	December 1-9	4	10	1.5
2002	June 13-20	3*	5	2.1
2001	November 21-30	3	13	1.5-1.8

*n= 4 but one net could not be sampled due to adverse weather conditions.

Table 2. Sample size of length, weight and age structures taken from commercial plant sampling of walleye from Tathlina Lake, NT.

Year	Month of sampling	Fork length	Round weight	Dressed weight	Length (headless dressed)	Weight (headless dressed)	Ages	Total number of samples
1998	November	0	0	0	210	210	210*	210
1997	November	0	0	0	210	210	210*[1]	210
1996	February	88	0	88	122	122	200*	200
1995	February	210	210	0	0	0	199*	210
1994	February	97	97	0	0	0	97*	97
1991	March	167	167	0	0	0	166*	167
1990	March	210	210	0	0	0	0	210
1986	April	209	209	0	0	0	195	209
1983	September	0	0	0	208	208	198	208
1982	February	215	215	0	0	0	204	215[a]
1981	April	136	136	0	0	0	124	136
1980	April and May	194	194	0	0	0	106	194
1979	June	0	0	0	50	50	44	50
1976	August and September	195	195	0	106	106	106	301
1975	October	0	0	0	98	98	94	98

* ageing structures were spines while scales were use in all other years.
[1] age data not used as results were questionable.
[a] n= 201 in Roberge et al. (1988)

Table 3. Summary of experimental gill net mesh and time of sampling from past surveys of Tathlina Lake.

Study	Mesh sizes	Date/ timing
2001-2007	38, 64, 89, 108, 114, 140 mm	November/ December; June (2002)
Roberge et al. (1988)	38, 64, 89, 114, 139[a] mm	June, 1979
Kennedy (1962)	38, 64, 121, 140 mm[b]	July 26-August 9, 1946

[a] same as 140 mm.
[b] One gang of nets consisted of 1 panel of 140 mm, 2 panels of 121 mm, 3 panels of 64 mm and 1 panel of 38 mm; while the second gang of nets consisted of 1 panel of 140 mm, 4 panels of 121 mm and 1 panel of 64. Three overnight sets were made with the first type of gang while one overnight set was made with the second type of gang.

Table 4. Mean ± SD length and age of walleye from Tathlina Lake, NT, sampled from the commercial fishery.

Year	Fork Length (mm)	Age (years)
1998	432 ± 20.8 [a]	9.3 ± 2.9 [c]
1997	410 ± 20.6 [a]	Data not used
1996	414 ± 18.4 [a]	10.9 ± 1.8 [c]
1995	411 ± 18.6	11.0 ± 1.7 [c]
1994	396 ± 18.1	10.3 ± 1.7 [c]
1991	403 ± 22.6	9.4 ± 1.1 [c]
1990	398 ± 20.6	n.a.
1986	415 ± 23.5	11.6 ± 1.7
1983	398 ± 14.2 [a]	10.5 ± 1.1
1982	410 ± 16.7	10.9 ± 0.9
1981	396 ± 17.7	9.4 ± 1.1
1980	369 ± 22.8	8.5 ± 0.9
1979	393 ± 18.0 [a]	8.2 ± 1.1
1976	398 ± 25.1 [b]	7.7 ± 1.3
1975	397 ± 20.3 [a]	8.4 ± 1.2

[a] obtained using conversion equation: fork length = 99.857 + 0.971x headless length.
[b] Conversion equation not used due to questionable headless length data, fork length data only.
[c] aged using spines, all other years were aged with scales
Note that the switch from a minimum mesh size of 114 mm to 108 mm occurred in 1980.

Table 5. U statistic and p value of Mann-Whitney tests to determine whether the age of walleye from Tathlina Lake, NT, differed between commercial plant sampling years.

	1991	1994	1995	1996	1998
1991	-				
1994	U= 5355.5, p< 0.0001	-			
1995	U= 7796.5, p< 0.0001	U= 7599.5, p= 0.003	-		
1996	U= 7779.0. p< 0.0001	U= 7614.0, p= 0.002	U= 19892.5, p= 0.99	-	
1998	U= 14096.5, p< 0.001	U= 689.5, p< 0.0001	U= 12041.0, p< 0.0001	12776.5, p< 0.0001	-

Table 6. Instantaneous mortality (Z), survival (S) and annual mortality (A) of walleye from Tathlina Lake captured using experimental gillnets in 2001-2007 and 1979, and from the commercial plant sampling 1975-1996.

	Year	Z	S	A	r^2	Range
Experimental gill netting	2006	1.07	0.34	0.66	0.88	9-15
	2005	0.90	0.41	0.59	0.85	8-13
	2002	0.61	0.54	0.46	0.88	6-21
	2001	0.57	0.57	0.43	0.71	5-14
	1979[a]	1.61	0.20	0.80	-	9-11
Commercial plant sampling	1998	0.20	0.82	0.18	0.73	9-18
	1996	0.65	0.52	0.48	0.61	12-15
	1995	0.56	0.57	0.43	0.86	11-15
	1994	0.67	0.51	0.49	1.0	11-16
	1991	1.73	0.18	0.82	1.0	11-13
	1986[a]	1.21	0.30	0.70	-	13-16
	1983[a]	1.48	0.23	0.77	-	12-13
	1982[a]	1.83	0.16	0.84	-	12-14
	1981[a]	1.28	0.28	0.72	-	10-12
	1980[a]	1.24	0.41	0.59	-	10-12
	1979[a]	0.90	0.41	0.59	-	9-11
	1976[a]	1.53	0.22	0.78	-	9-11
	1975[a]	1.11	0.33	0.67	-	9-12

[a] from Roberge et al. (1988).

Table 7. Sample size (n), mean (± SD), mode and range of length (mm) of female, male and total sample of walleye captured in experimental gill nets in Tathlina Lake, NT.

Year	Female					Male					Total sample				
	n	Mean	SD	Mode	Range	n	Mean	SD	Mode	Range	n	Mean	SD	Mode	Range
2007	414	431	26	422	271-542	382	402	26	422	260-470	828	413	37	422	260-542
2006	166	424	23	433	362-536	206	389	27	381	299-472	399	402	33	411	255-536
2005	375	412	25	410	282-538	332	385	24	370	305-445	738	398	29	370	218-538
2002	268	367	47		257-575	250	366	35		265-444	569	362	46		165-575
2001	141	398	31	400	295-500	250	361	32	345	273-445	450	369	37	345	261-500
1979	419	345			254-439*	258	333			266-426	696	339			254-439

* range of means

Table 8. Sample size (n), mean (± SD), mode and range of age (years) of female, male and total sample of walleye captured in experimental gill nets in Tathlina Lake, NT.

Year	Female					Male					Total sample				
	n	Mean	SD	Mode	Range	n	Mean	SD	Mode	Range	n	Mean	SD	Mode	Range
2006	165	7.9	1.1	8	5-12	205	7.0	1.8	8	2-15	397	7.3	1.7	8	1-15
2005	373	7.2	1.0	8	3-12	329	7.3	1.4	7	3-13	733	7.2	1.3	7	2-13
2002	268	5.8	1.7	5	3-21	251	6.4	2.0	5	3-17	569	5.9	2.0	5	3-21
2001	141	5.5	1.2	6	3-14	250	5.0	1.6	4	3-13	450	5.0	1.5	4	2-14
1979	282	7.6	0.7	8	6-11	143	7.4	0.9	8	5-10	437	7.5	0.8	8	5-11

Table 9. U statistic and p value of Mann-Whitney tests to determine whether the age of walleye from Tathlina Lake, NT, differed between experimental gill net sampling years.

	2001	2002	2005	2006
2001	-			
2002	U= 80771; p< 0.001	-		
2005	U= 39415; p< 0.001	U= 89699; p< 0.001	-	
2006	U= 28280; p< 0.001	U= 56298; p< 0.001	U= 13579; p= 0.06	-

Table 10. U statistic and p value of Mann-Whitney tests to determine differences in ages between male and female walleye from Tathlina Lake, NT, among sampling years.

2006	U= 11475; p< 0.001
2005	U= 60971; p= 0.88
2002	U= 28437; p< 0.001
2001	U= 11311; p< 0.001

Table 13. F statistic, degrees of freedom and p value from ANCOVA of weight, using length as a covariate, between sampling years for female (bottom diagonal) and male (top diagonal) walleye from Tathlina Lake. All data logarithmically transformed.

	2001	2002	2005	2006	2007
2001	-	F= 224.5; d.f.= 1, 497; p< 0.001	F= 125.1; d.f.= 1, 589; p< 0.001	F= 80.2; d.f.= 1, 453; p< 0.001	F= 62.6; d.f.= 1, 629; p< 0.001
2002	F= 214.8; d.f.= 1, 406; p< 0.001	-	F= 866.0; d.f.= 1, 579; p< 0.001	F= 559.3; d.f.= 1, 453; p< 0.001	F= 659.7; d.f.= 1, 629; p< 0.001
2005	F= 105.1; d.f.= 1, 513; p< 0.001	F= 741.5; d.f.= 1, 679; p< 0.001	-	F= 0.13; d.f.= 1, 535; p= 0.72	F= 14.0; d.f.= 1, 711; p< 0.001
2006	F= 60.6; d.f.= 1, 304; p< 0.001	F= 477.2; d.f.= 1, 413; P< 0.001	F= 0.08; d.f.= 1, 538; p= 0.77	-	F= 14.2; d.f.= 1, 585; P< 0.001
2007	F= 92.4; d.f.=1, 552; p< 0.001	F= 741.5; d.f.= 1, 679; p< 0.001	F= 0.44; d.f.= 1, 786; p= 0.51	F= 0.003; d.f.= 1, 577; p= 0.96	-

Table 14. Regression equation of logarithmically transformed weight-length data from female, male and total sample of walleye from Tathlina Lake, Northwest Territories, 2001-2007.

Year	Female			Male			Total sample		
	Slope	r^2	intercept	Slope	r^2	intercept	Slope	r^2	intercept
2007	2.70	0.87	-4.12	2.98	0.92	-4.87	3.13	0.96	-5.26
2006	2.90	0.89	-4.89	2.99	0.90	-4.89	3.01	0.94	-5.11
2005	2.55	0.80	-3.72	2.84	0.90	-4.50	2.82	0.88	-4.43
2002	2.77	0.95	-4.41	2.78	0.93	-4.43	2.86	0.95	-4.63
2001	3.10	0.94	-5.18	2.74	0.90	-4.27	2.96	0.95	-4.83
1979	-	-	-	-	-	-	2.83	-	-4.52

Table 15. Sample size (n), mean (± SD), mode and range of condition factor of female, male and total sample of walleye captured in experimental gill nets in Tathlina Lake, NT.

Year	Female					Male					Total sample				
	n	Mean	SD	Mode	Range	n	Mean	SD	Mode	Range	n	Mean	SD	Mode	Range
2007	414	1.24	0.11	1.21	1.05-3.16	382	1.19	0.06	1.10	0.07-1.43	828	1.21	0.10	1.21	0.98-3.16
2006	166	1.24	0.07	1.27	0.99-1.43	206	1.22	0.10	1.23	0.90-2.19	399	1.23	0.09	1.20	0.90-2.19
2005	376	1.25	0.15	1.26	0.12-3.05	332	1.22	0.08	1.24	0.99-1.73	739	1.24	0.13	1.26	0.12-3.05
2002	268	1.03	0.09		0.43-1.26	250	1.03	0.09		0.83-2.00	569	1.03	0.09		0.43-2.00
2001	141	1.17	0.07	1.21	0.88-1.50	250	1.15	0.08	1.14	0.55-1.61	450	1.16	0.08	1.15	0.55-1.66
1979	345	1.08			0.78-1.10	258	1.03			0.93-1.06	696	1.06			0.96-1.10

Table 16. Von Bertalanffy growth function parameters of walleye from Tathlina Lake, NT.

Year	Female				Male				Combined			
	K	t_0	L_∞ (mm)	Age range	K	t_0	L_∞ (mm)	Age range	K	t_0	L_∞ (mm)	Age range
2006	0.21	-0.37	536	5-12	0.13	-6.79	472	2-15	0.12	-5.12	536	1-15
2005	0.21	-0.62	538	3-12	0.20	-3.22	445	3-13	0.07	-10.39	538	2-13
2002	0.11	-3.39	575	3-21	0.11	-11.65	444	3-17	0.07	-7.60	575	1-21
2001	0.37	1.04	500	3-14	0.17	-5.37	445	3-13	0.11	-7.34	500	2-14
1979	0.25	1.33	439	6-10	0.24	0.83	425	5-9	0.24	0.90	439	5-10

Table 17. The female to male ratio (F:M), and total number of female, male and sex undetermined walleye from Tathlina Lake, Northwest Territories, captured in experimental gill nets from 2001-2007.

Year	F:M	Female	Male	Undetermined
2007	1.08	414	382	32
2006	0.81*	166	206	27
2005	1.13	376	332	31
2002	1.07	268	251	51
2001	0.56*	141	250	59
1979	1.62*	419	258	19

*significantly different from 1:1

Table 18. Number (percent in brackets) of walleye among maturity stages among sampling years of males and females from Tathlina Lake, NT.

Year	Female				Male				Unknown
	Immature	Resting	Spent	Mature	Immature	Resting	Spent	Mature	
2007	14 (3.4)	1 (0.2)	0	399 (96.4)	18 (4.7)	0	0	364 (95.3)	32
2006	3 (1.8)	0	0	163 (98.2)	11 (5.3)	0	0	195 (94.7)	27
2005	13 (3.5)	2 (0.5)	2 (0.5)	359 (95.5)	42 (12.7)	0	9 (2.7)	281 (84.0)	20
2002	125 (46.6)	50 (18.9)	93 (34.7)	0	61 (24.3)	0	190 (75.7)	0	51
1977	19 (4.1)	0	0	438 (95.9)	28 (10.8)	0	0	230 (89.2)	0

Mature= maturing to ripe
Immature and resting may have been confused in some years

Table 19. U statistic and p value of Mann-Whitney tests to determine differences in CPUE of walleye from Tathlina Lake, NT, between sampling years.

	2001	2002	2005	2006	2007
2001	-				
2002	U= 0.00; p < 0.001	-			
2005	U= 26.0; p= 0.02	U= 14.0; p= 0.21	-		
2006	U= 23.0; p= 0.79	U= 10.0; p= 1.0	U= 18.0; p= 0.84	-	
2007	U= 13.0; p= 0.008	U= 7.0; p= 0.11	U= 19.0; p= 0.13	U= 14.0; p= 1.0	-

Table 20. Percent composition of walleye captured in experimental gill nets in Tathlina Lake, NT.

Year	%
2007	68
2006	53
2005	49
2002	29
2001	36
1979	55

Table 21. Percent by number and biomass (total weight), sample size (n), mean length, weight and age of walleye captured among mesh sizes in experimental gill nets set in Tathlina Lake, NT, from 2001-2007.

Year	Mesh	Female									Male									Total sample								
	(mm)	% of	% of		Length		Weight		Age		% of	% of		Length		Weight		Age		% of	% of		Length		Weight		Age	
		catch	biomass	n	Mean	SD	Mean	SD	Mean	SD	catch	biomass	n	Mean	SD	Mean	SD	Mean	SD	catch	biomass	n	Mean	SD	Mean	SD	Mean	SD
2007	38	0.7	0.8	3	438	33	1042	195	n.a.		1	1.3	5	409	14	805	66	n.a.		1	1.0	8	420	25	894	168	n.a.	
	64	7.2	6.1	30	403	49	843	234	n.a.		15	14.0	59	388	34	712	177	n.a.		14	10.6	114	369	58	645	279	n.a.	
	89	23.4	22.6	97	427	22	963	153	n.a.		48	45.6	185	394	21	737	124	n.a.		35	32.2	287	405	27	812	174	n.a.	
	108	35.0	34.7	145	431	19	990	124	n.a.		29	31.7	110	416	18	861	89	n.a.		31	33.1	257	425	20	934	128	n.a.	
	114	32.6	34.4	135	439	19	1055	137	n.a.		6	7.4	23	430	19	958	109	n.a.		19	22.7	158	438	19	1041	138	n.a.	
	140	1.0	1.5	4	501	46	1563	484	n.a.		0	0	0	0	0	0	0	n.a.		1	0.9	4	501	46	1563	484	n.a.	
2006	38	1.2	1.2	2	416	4	918	103	8.5	0.7	3.9	3.3	8	373	27	620	152	5.5	1.5	2.5	2.1	10	382	30	680	187	6.1	1.9
	64	10.2	8.9	17	408	19	836	112	7.8	1.1	21.4	18.8	44	373	29	641	157	6.3	1.9	17.0	14.0	68	377	37	669	187	6.3	2.1
	89	28.3	26.9	47	418	20	909	126	7.7	1.0	41.7	40.0	86	384	22	696	120	7.0	1.7	37.6	35.1	150	395	26	763	160	7.0	1.6
	108	27.1	26.8	45	425	24	947	159	7.9	1.0	24.8	27.3	51	402	21	800	100	7.6	1.4	24.8	26.4	99	413	24	868	148	7.8	1.3
	114	31.9	34.3	53	433	19	1027	152	8.0	1.1	6.8	8.9	14	419	20	956	255	7.9	1.0	16.8	20.8	67	430	20	1012	178	8.0	1.1
	140	1.2	1.9	2	495	59	1478	555	10.0	2.8	1.5	1.7	3	409	57	825	404	9.7	4.6	1.3	1.7	5	443	68	1086	535	9.8	3.6
2005	38	4.0	3.7	15	395	42	7	218	6.6	1.2	9	8.5	30	377	137	137	137	7.0	1.4	6	5.5	45	383	179	179	179	6.9	1.4
	64	13.6	12.4	51	399	25	7	148	6.8	1.2	27	25.6	91	376	142	142	142	6.8	1.4	21	18.1	153	381	173	173	173	6.6	1.5
	89	27.9	26.8	105	406	20	7	125	7.1	0.9	43	42.0	142	384	108	108	108	7.4	1.4	35	33.5	260	393	138	138	138	7.3	1.2
	108	34.3	34.5	129	413	21	7	106	7.3	0.8	17	19.2	56	401	92	92	92	7.8	1.3	26	27.8	189	409	109	109	109	7.5	1.0
	114	19.7	21.8	74	427	19	8	106	7.7	0.8	4	4.7	13	409	118	118	118	7.8	1.4	12	14.6	90	424	123	123	123	7.7	0.9
	140	0.5	0.9	2	483	78	10	679	10.0	2.8	0	0	0	-	-	-	-	-	-	0	0.5	2	483	679	679	679	10.0	2.8
2002	38	8	5.8	21	328	50	391	177	5.1	1.4	8	7.0	19	354	43	473	164	5.7	1.6	10	6.9	54	320	59	371	185	4.8	1.8
	64	44	37.5	119	348	39	449	144	5.3	1.1	49	44.5	124	353	34	463	127	6.0	2.1	48	42.1	274	347	38	443	139	5.5	1.7
	89	35	40.8	94	392	28	619	121	6.3	1.1	33	37.4	82	386	24	596	100	7.0	1.8	32	37.6	180	389	26	607	112	6.6	1.5
	108	5	7.1	13	410	73	777	492	7.8	4.5	6	6.2	14	378	39	571	150	7.1	2.3	5	6.7	28	397	61	689	372	7.6	3.5
	114	6	7.2	16	395	48	643	274	6.6	3.1	1	1.3	3	382	34	557	85	8.0	3.5	4	4.3	20	390	46	617	252	6.8	3.1
	140	2	1.7	2	345	47	471	186	5.2	0.8	4	3.5	9	364	29	502	110	5.7	0.7	3	2.4	14	357	36	491	135	5.5	0.8
2001	38	0	0	0	-	-	-	-	-	-	0	0	1	339	-	470	-	4.0	-	0	0.2	1	339	-	470	-	4.0	-
	64	12.8	12.0	18	389	41	707	243	5.3	1.5	20	17.3	49	345	30	488	134	4.5	1.5	17.1	16.1	67	357	38	547	197	4.7	1.5
	89	45.4	40.7	64	385	26	673	138	5.1	0.8	67	63.8	168	356	25	524	102	4.7	1.2	59.3	54.8	232	364	28	565	128	4.8	1.1
	108	35.5	39.0	50	411	22	826	149	5.9	1.4	11	15.3	27	408	17	784	83	7.6	1.6	19.7	23.9	77	410	20	812	133	6.5	1.7
	114	6.4	8.3	9	434	27	973	180	6.7	1.4	2	3.2	5	419	12	887	68	8.2	1.5	3.6	5.1	14	429	24	942	175	7.2	1.6
	140	0	0	0	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-	0	0	0	-	-	-	-	-	-

2007: Sex and maturity could not be determined for 32 samples.
2006: Sex and maturity could not be determined for 27 samples.
2005: Sex and maturity could not be determined for 31 samples; one female from 114 mm mesh with length and weight outlier ommitted from biomass estimate.
2002: Sex and maturity could not be determined for 51 samples; one male from 89 mm mesh with length and weight outlier ommitted from biomass estimate.
2001: Sex and maturity could not be determined for 59 samples.

Table 22. F:M ratio of walleye from Tathlina Lake, NT, among mesh sizes (mm) among sampling year.

Year	Mesh					
	38	64	89	108	114	140
2007	0.60	0.51*	0.52*	1.32	5.87*	0
2006	0.25	0.39*	0.55*	0.88	3.79*	0.67[a]
2005	0.50*	0.56*	0.74*	2.30*	5.69*	0
2002	1.11	0.96	1.15	0.93	5.33*	0.22
2001	0	0.37*	0.38*	1.85*	1.80	-
1979	2.18*	1.15	2.92*	n.a.	2.33	3.67

* significantly different from 1:1.
[a] cannot test because n is too low.

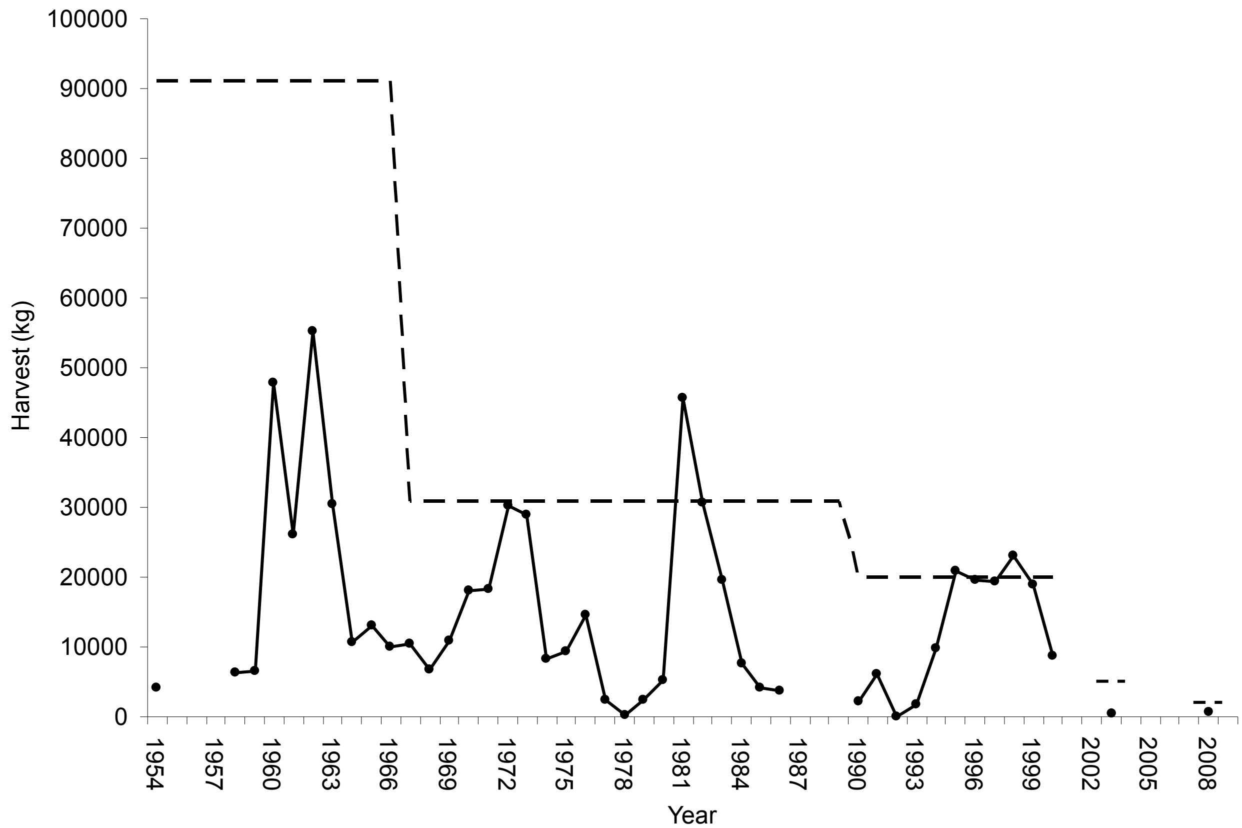


Figure 1. Total annual commercial production of walleye from Tathlina Lake, NT, 1954-2008. The dashed line is the quota for walleye. The fishery was not opened in 2001-2002 and 2004-2007.

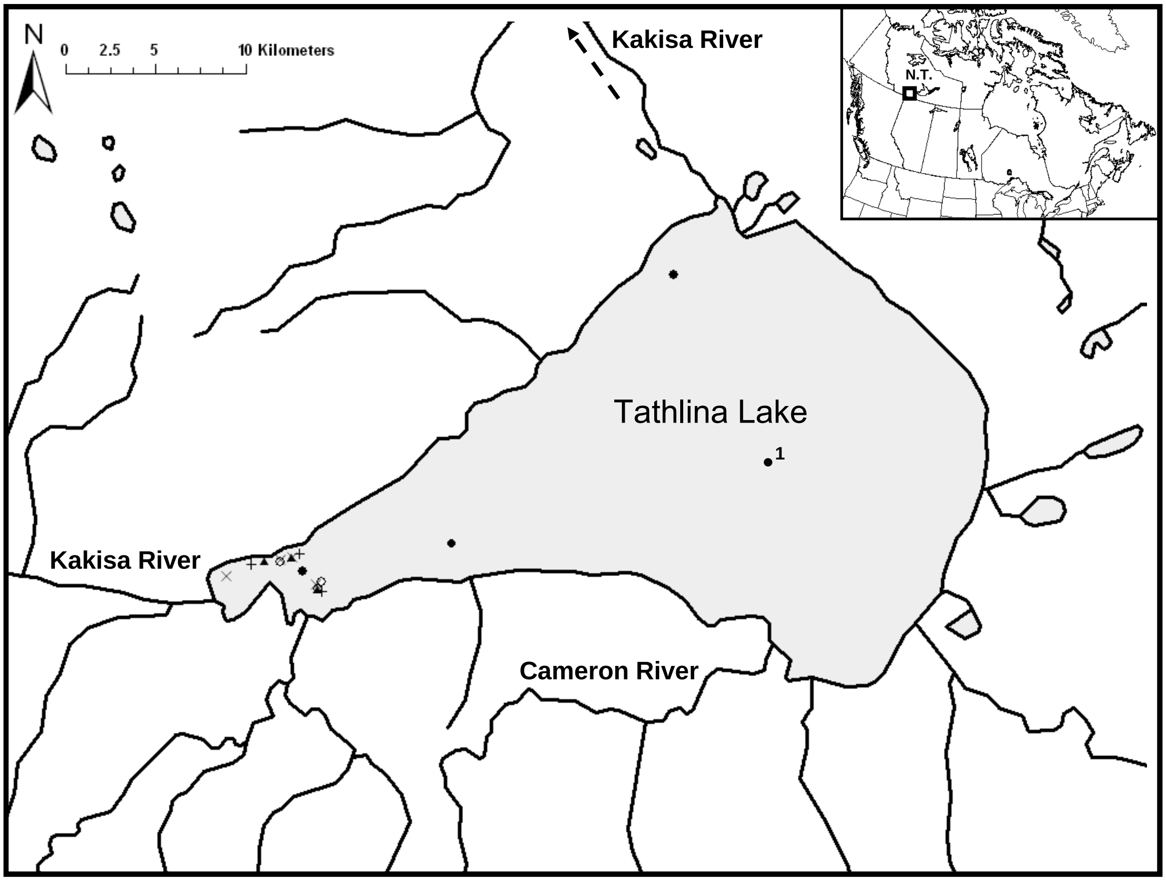


Figure 2. Locations of experimental gill nets set in Tathlina Lake, NT, in 2001 (○), 2002 (●), 2005 (x), 2006 (▲), and 2007 (+). [1] the fish in the net were not sampled because they remained in the net for too long due to adverse weather conditions. Dotted arrow shows direction of flow.

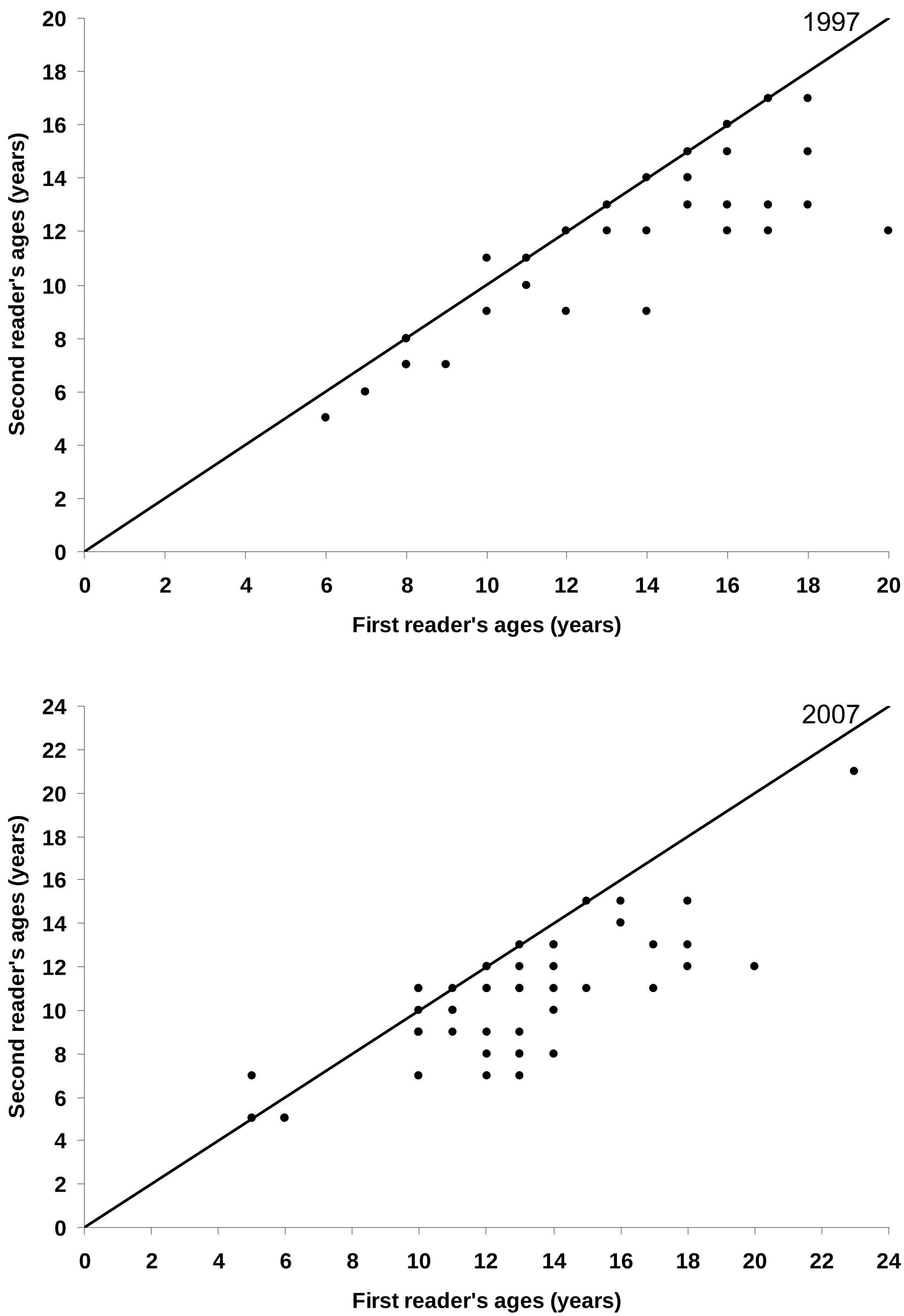


Figure 3. Age bias plot between readers of a sub-sample of walleye spines sampled in 1997 and 2007. The solid line represents agreement between readers.

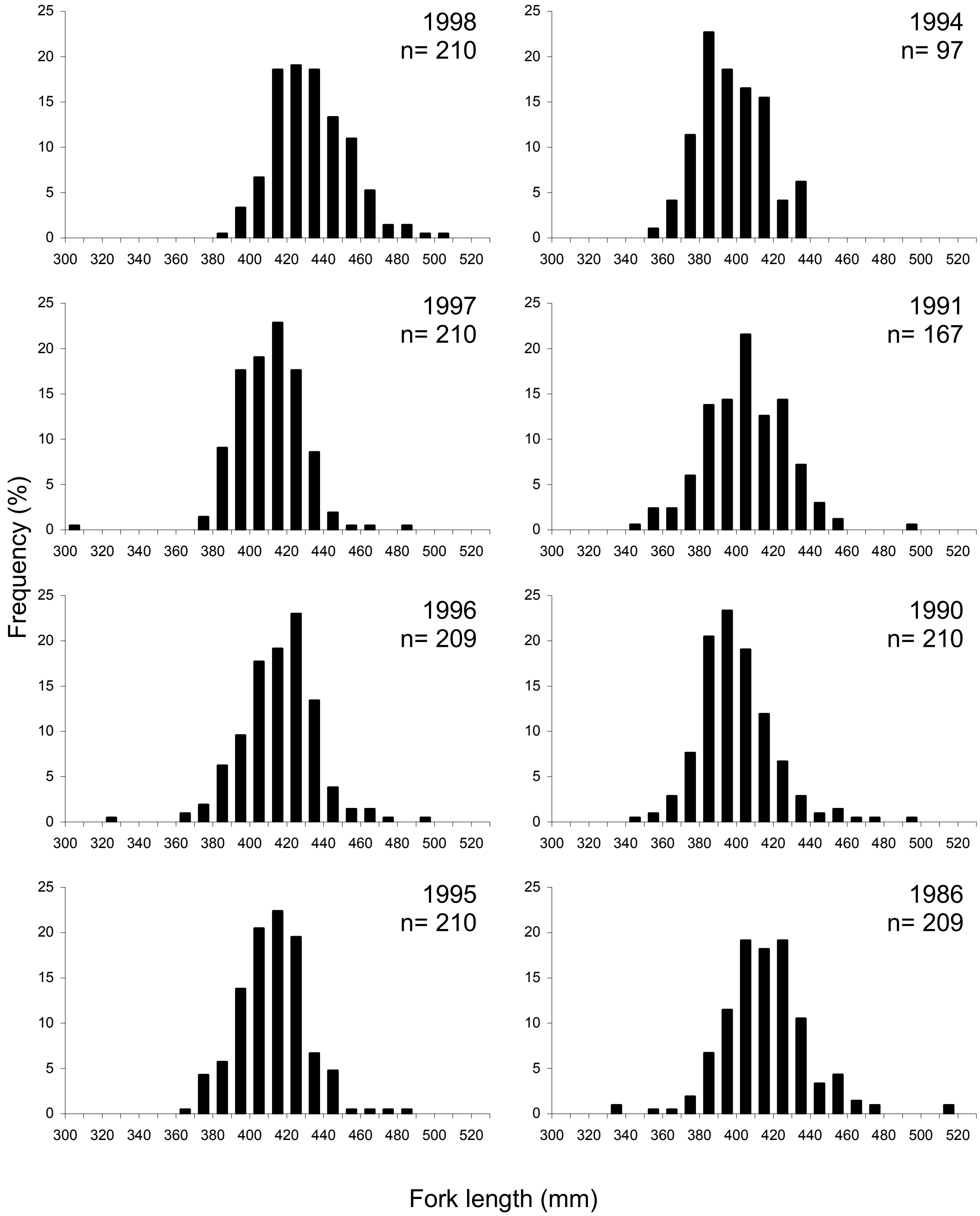


Figure 4. Length frequency distribution of walleye from Tathlina Lake, NT, sampled from the commercial catch from 1998-1979.

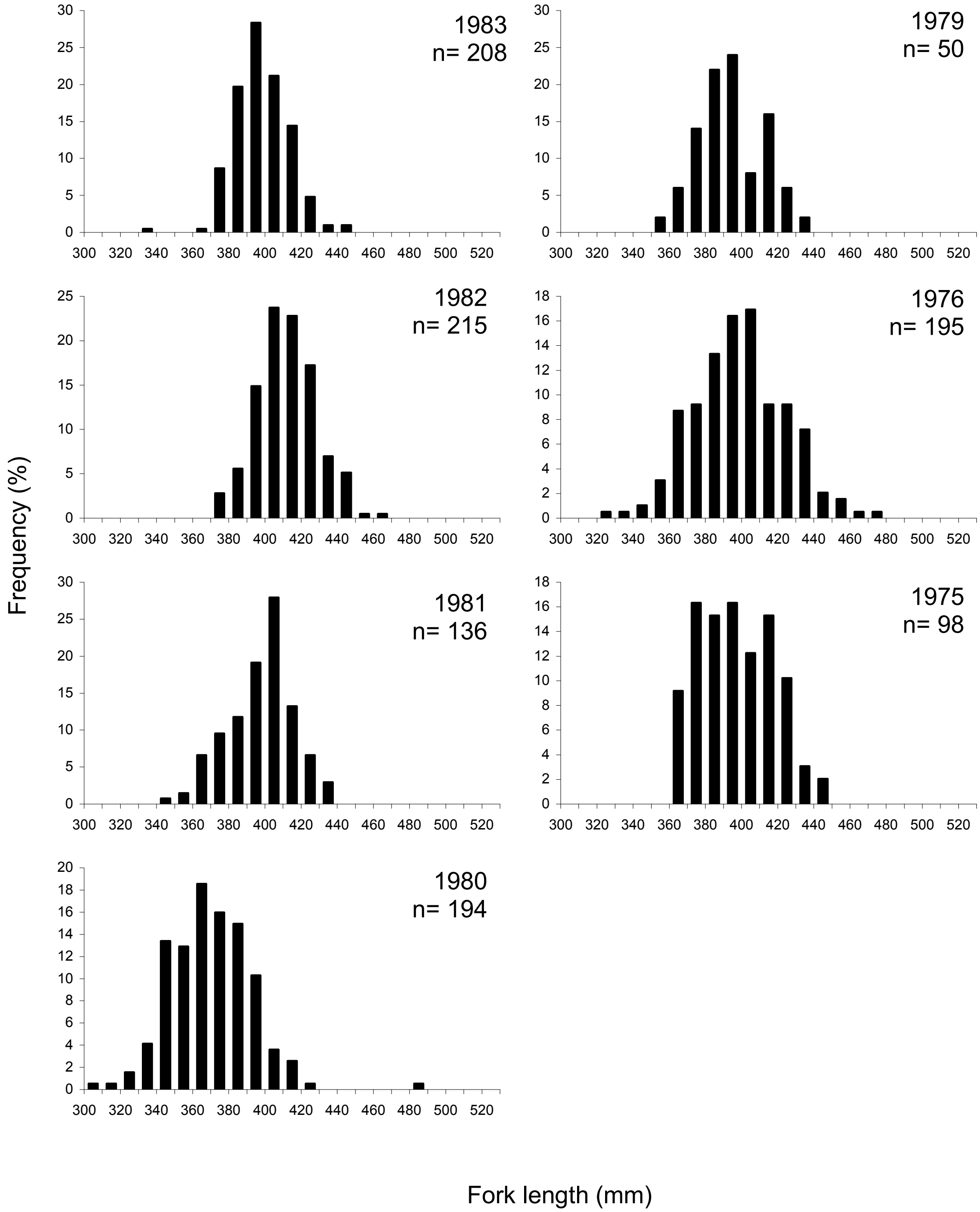


Figure 4. Continued.

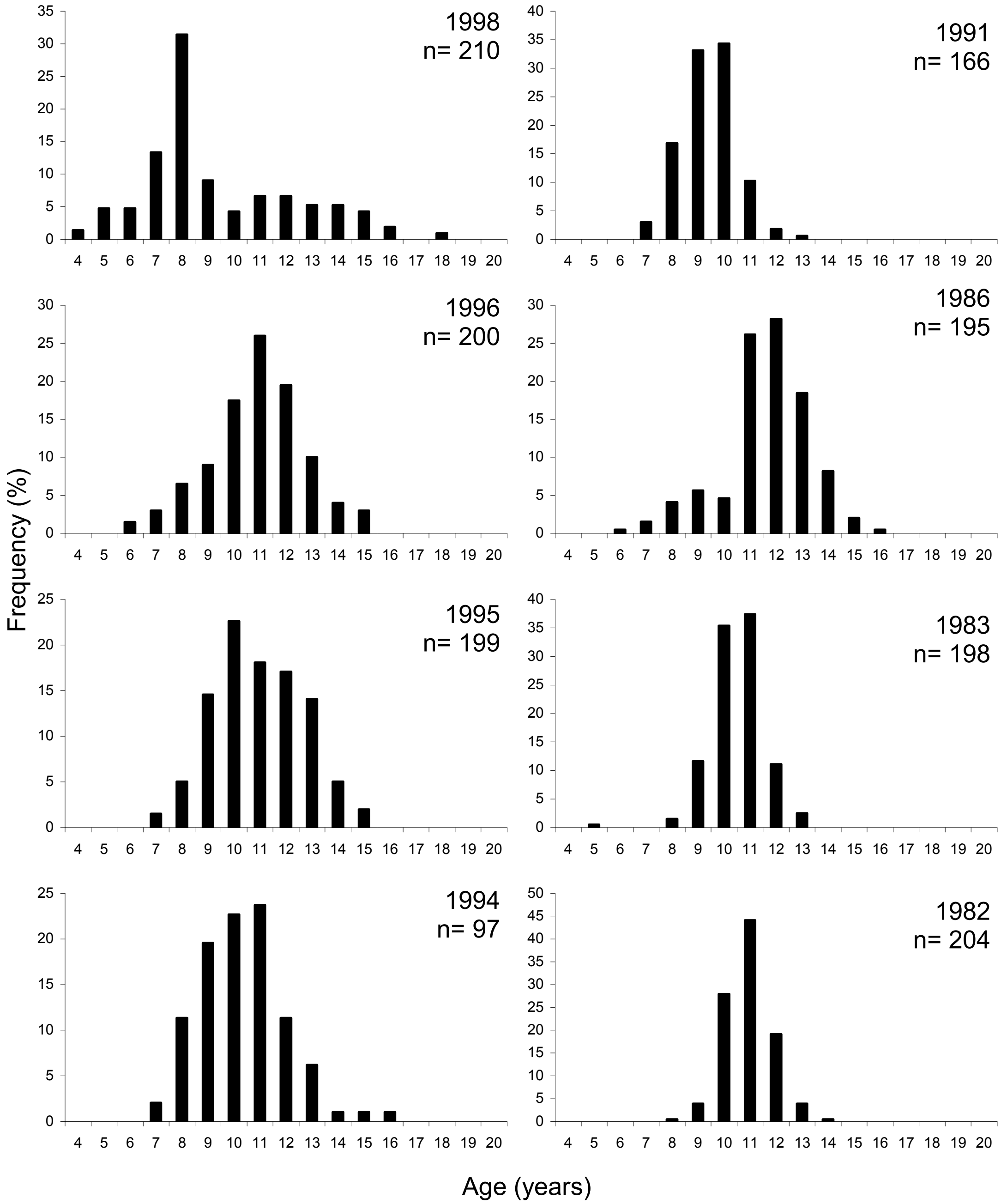


Figure 5. Age frequency distribution of walleye from Tathlina Lake, NT, sampled from the commercial catch from 1975-1998.

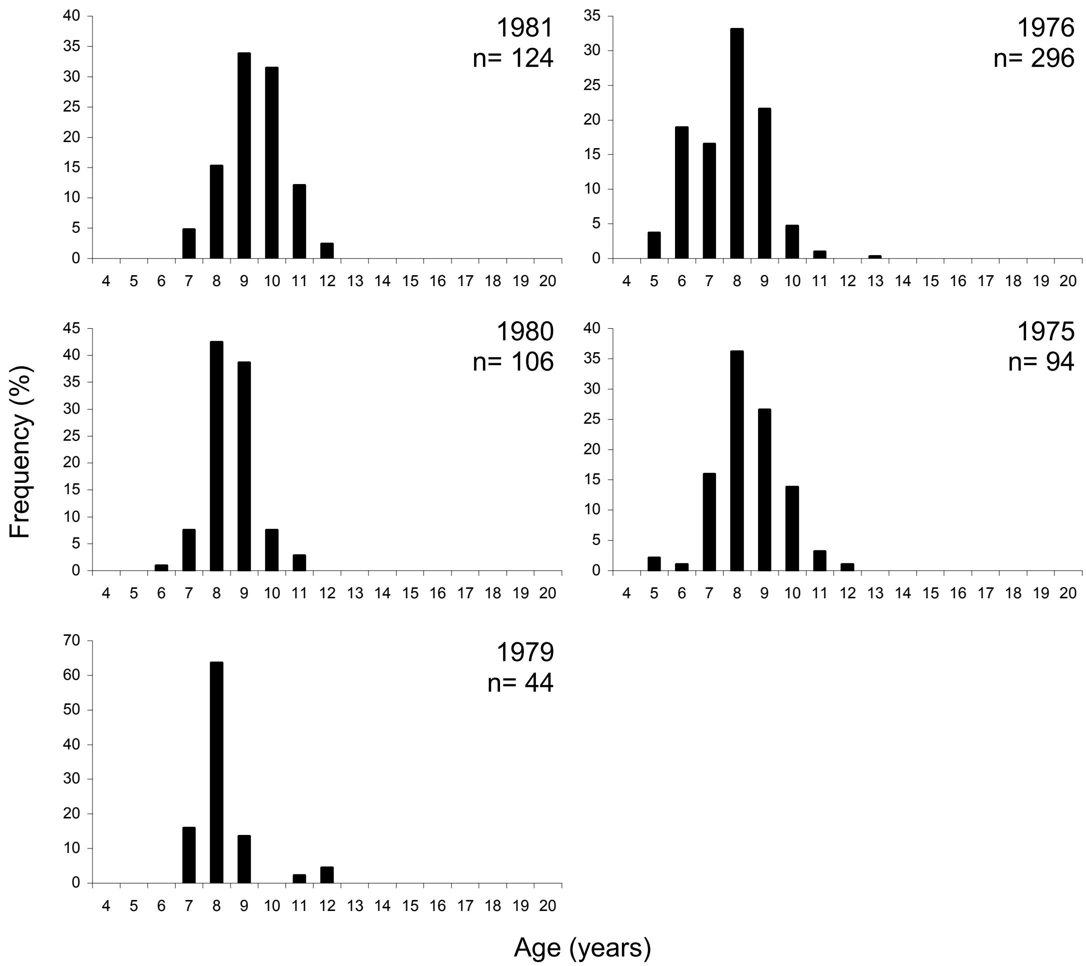


Figure 5. continued

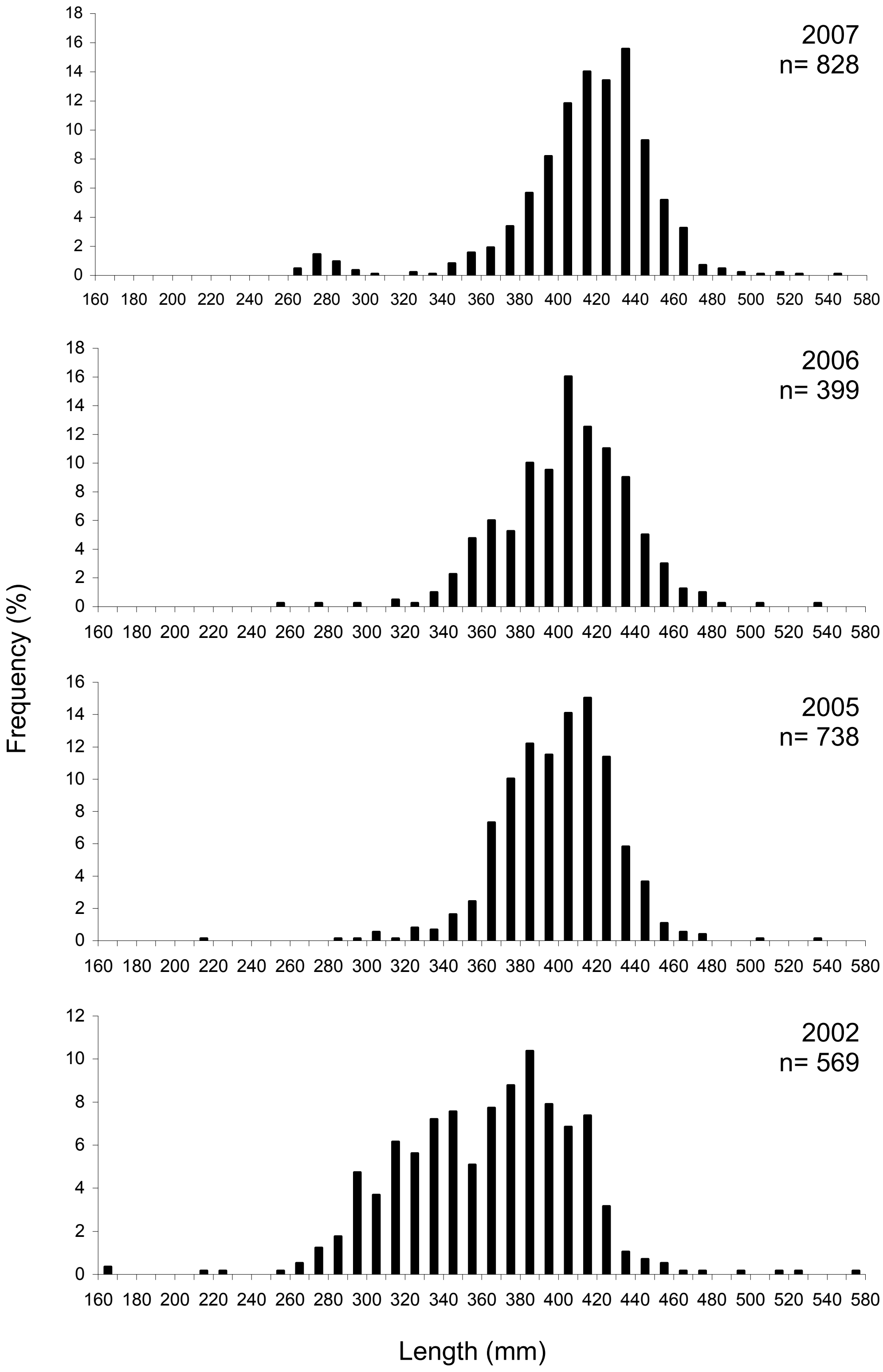


Figure 6. Length frequency distribution of walleye from Tathlina Lake, NT, captured in experimental gill nets in 2007-2005, 2002-2001 and 1979.

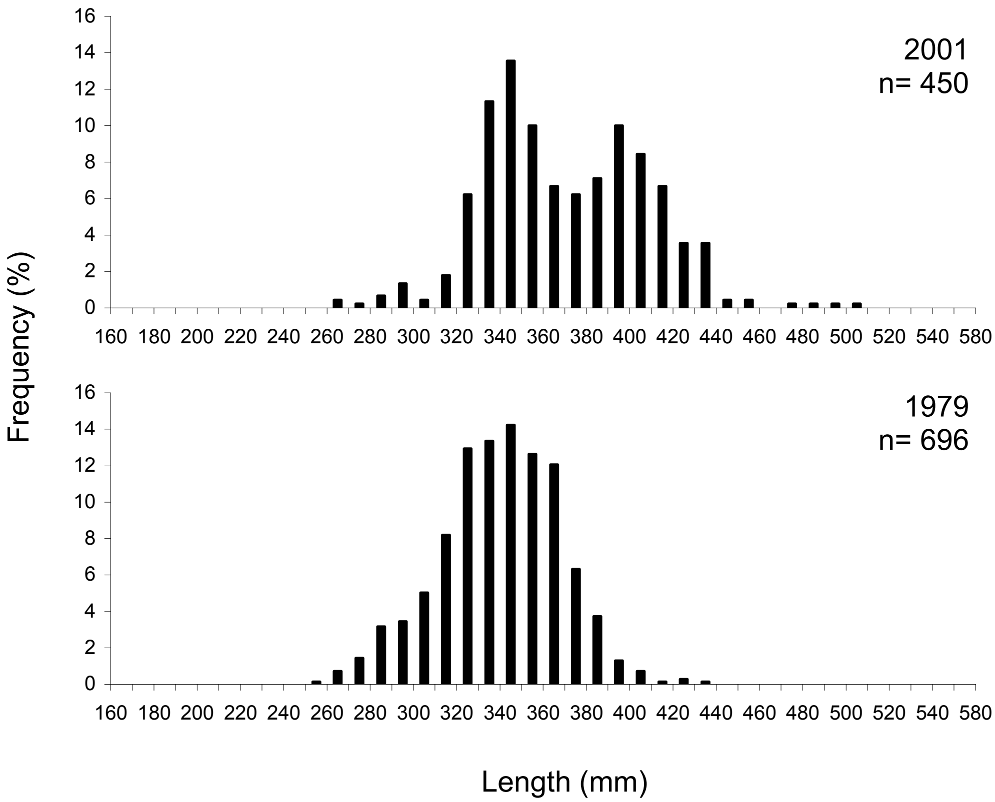


Figure 6. Continued.

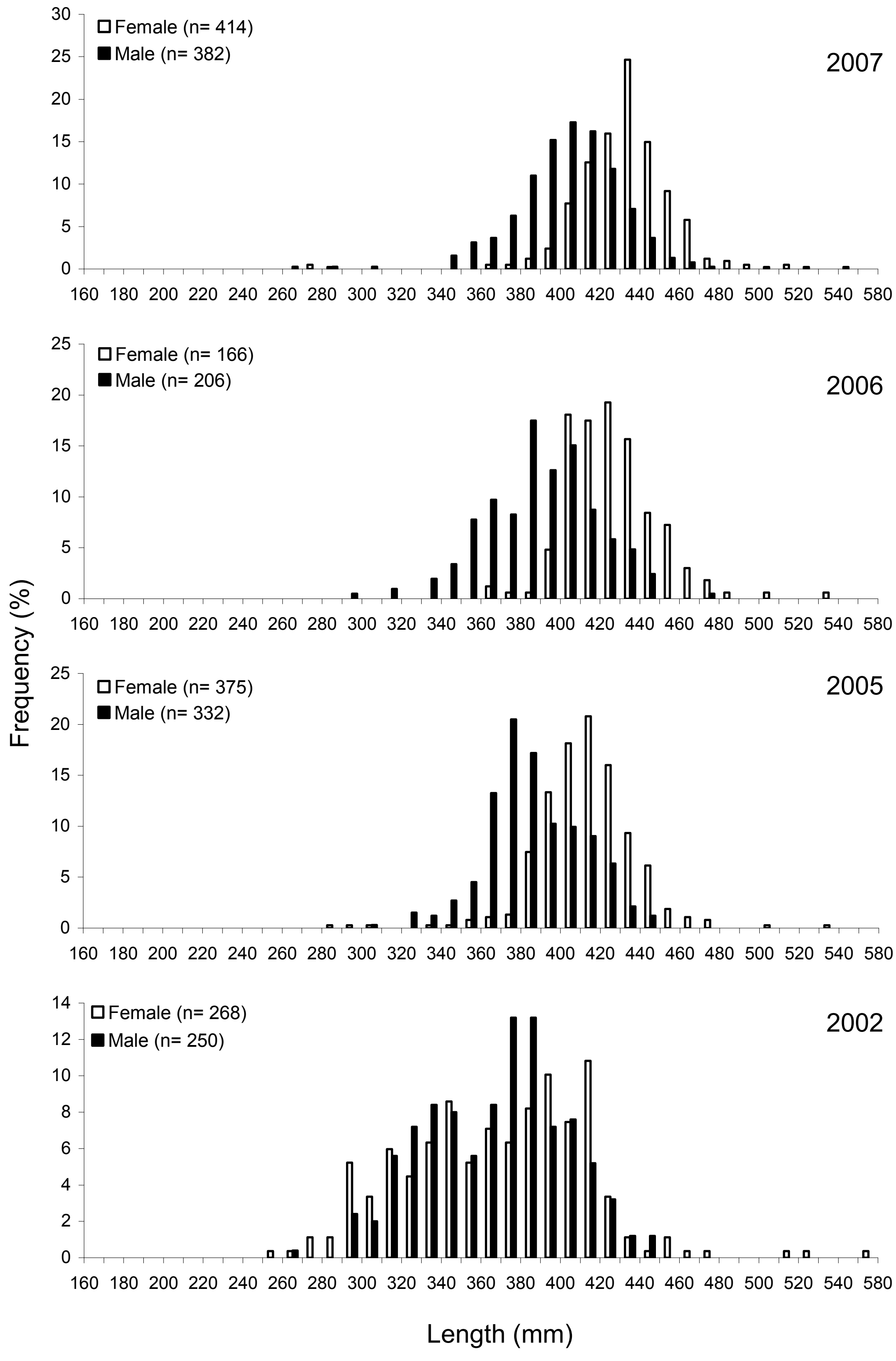


Figure 7. Length frequency of male and female walleye from Tathlina Lake, NT, captured using experimental gill nets in 2007-2005, 2002-2001 and 1979.

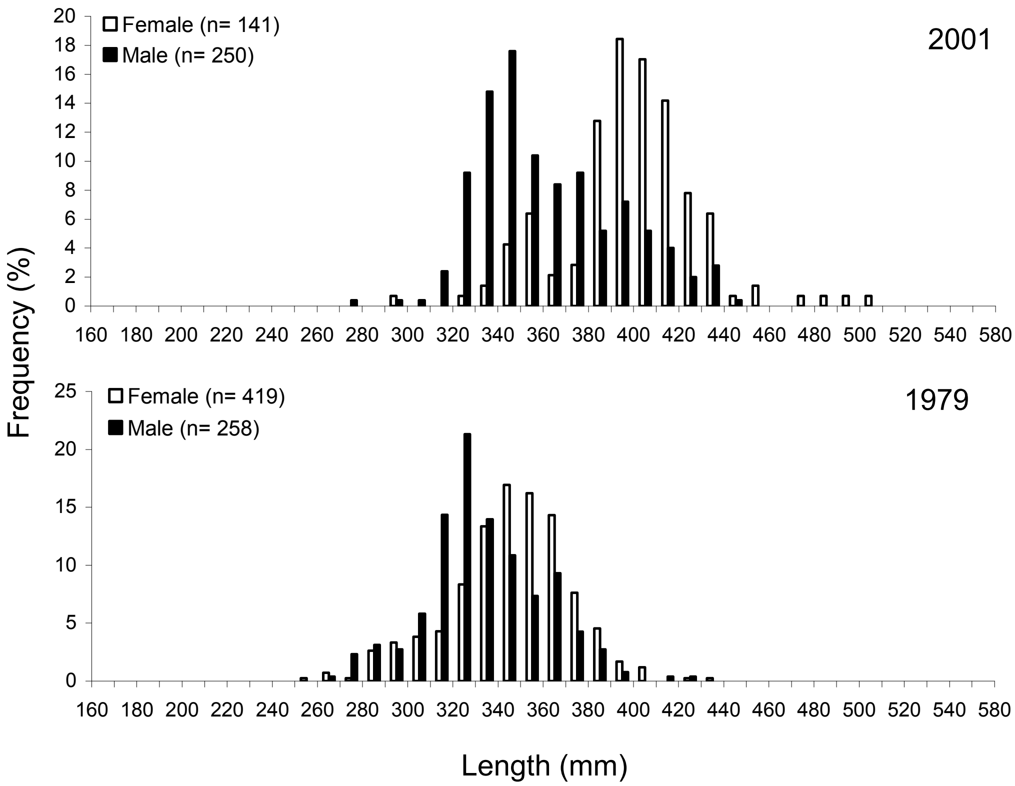


Figure 7. Continued.

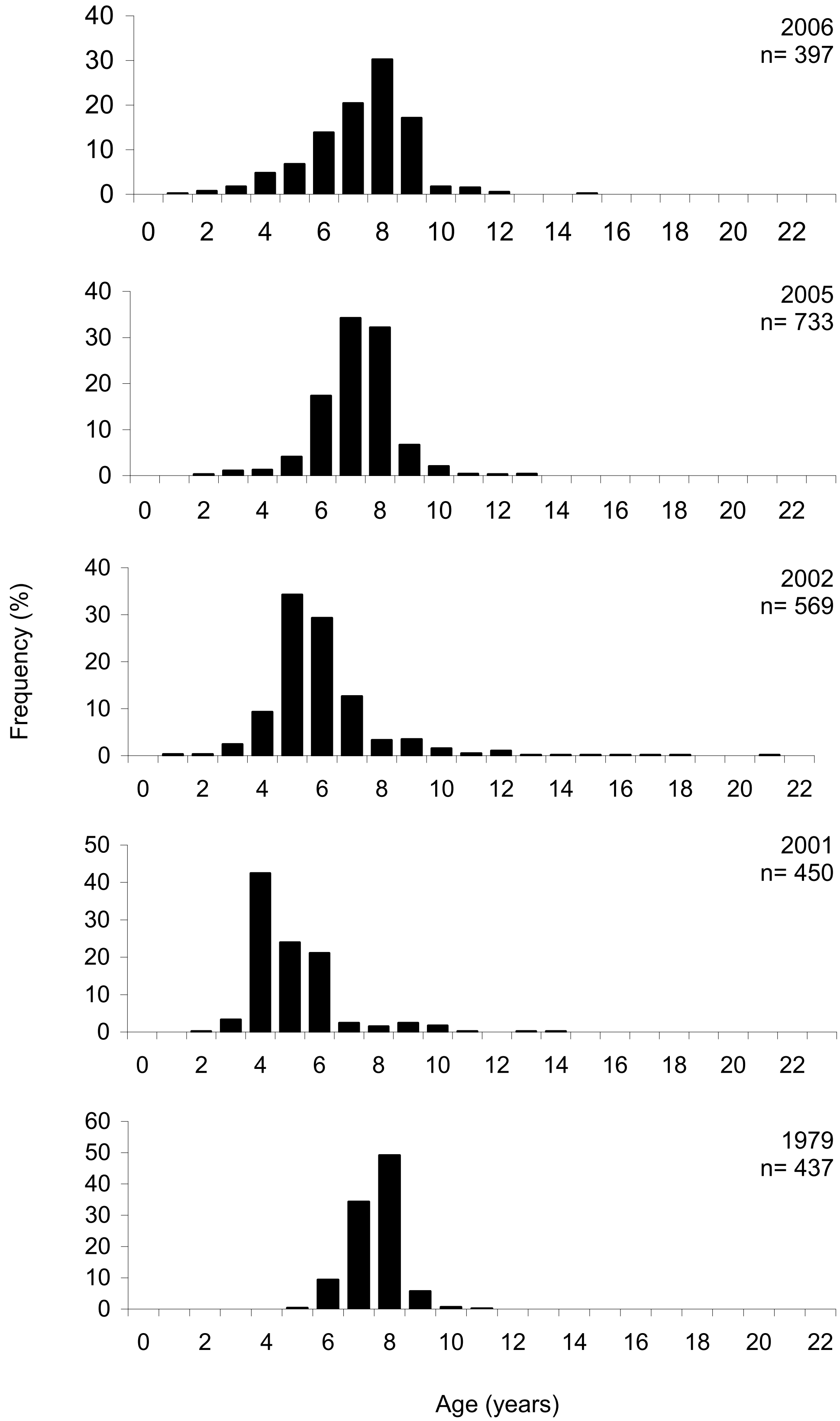


Figure 8. Age frequency distribution of walleye from Tathlina Lake, NT, captured using experimental gill nets in 2006-2005, 2002-2001 and 1979.

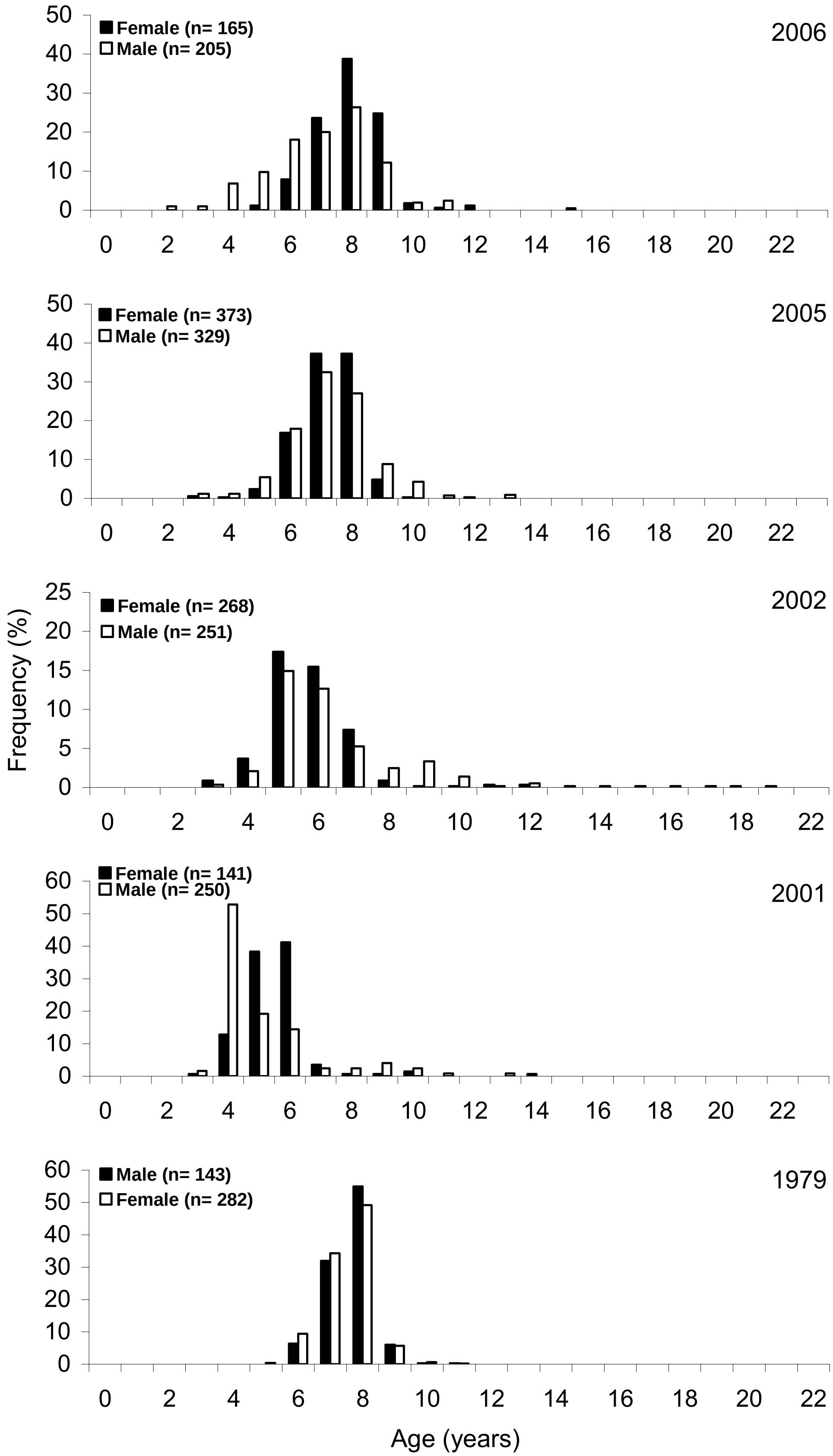


Figure 9. Age frequency distribution of female and male walleye from Tathlina Lake, NT, captured using experimental gill nets in 2006-2005, 2002-2001 and 1979.

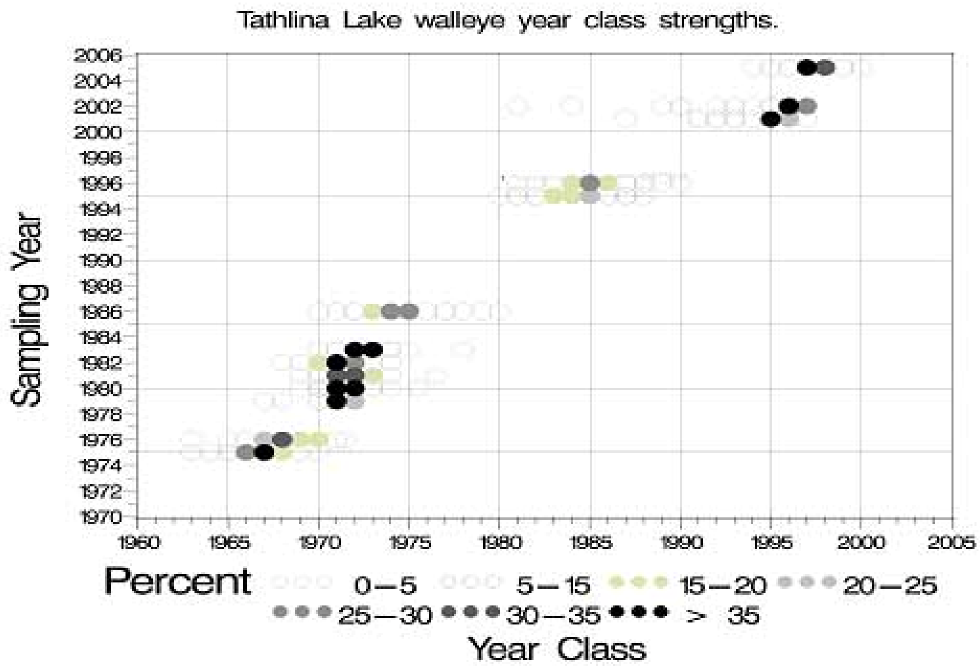


Figure 10. Year class strength of walleye from Tathlina Lake using age data from samples taken from the 108 and 114 mm mesh sizes from experimental and commercial gill nets.

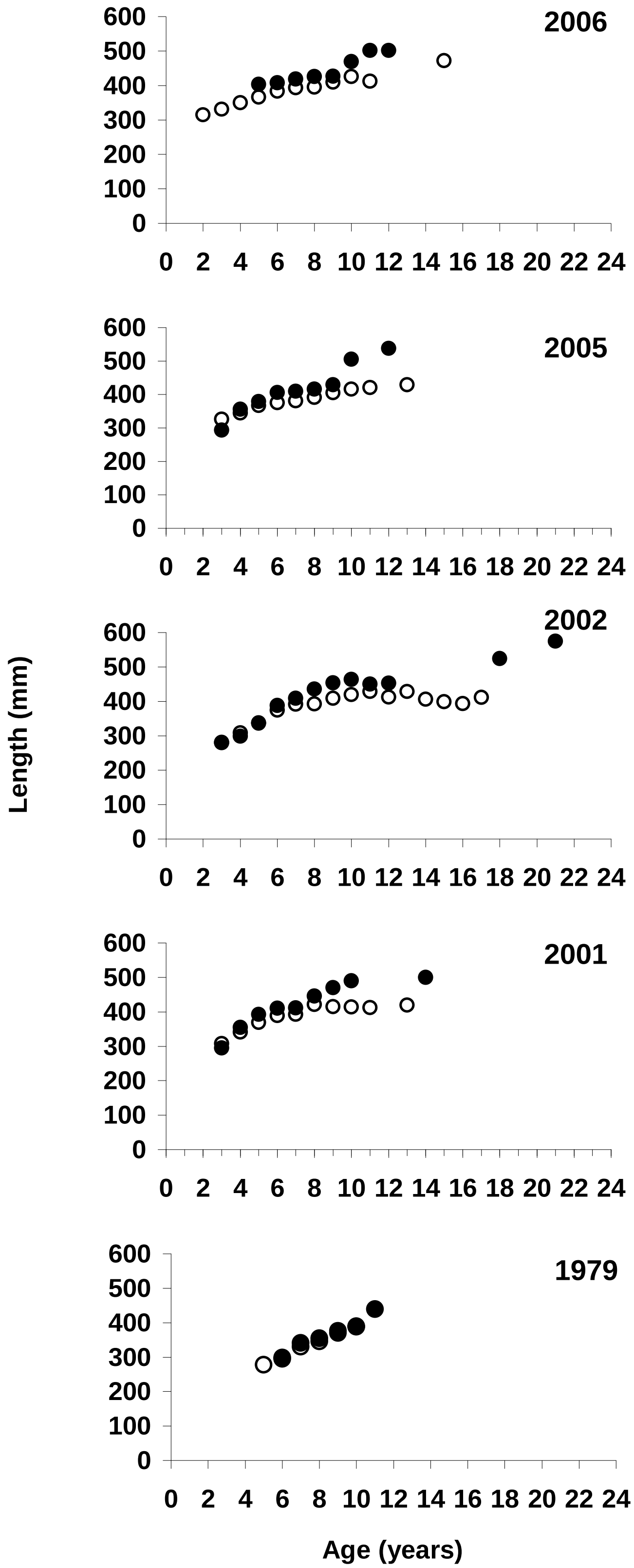


Figure 11. Mean length-at-age of female (●) and male (○) walleye from Tathlina Lake, NT, captured using experimental gill nets in 2001-2002, 2005-2007.

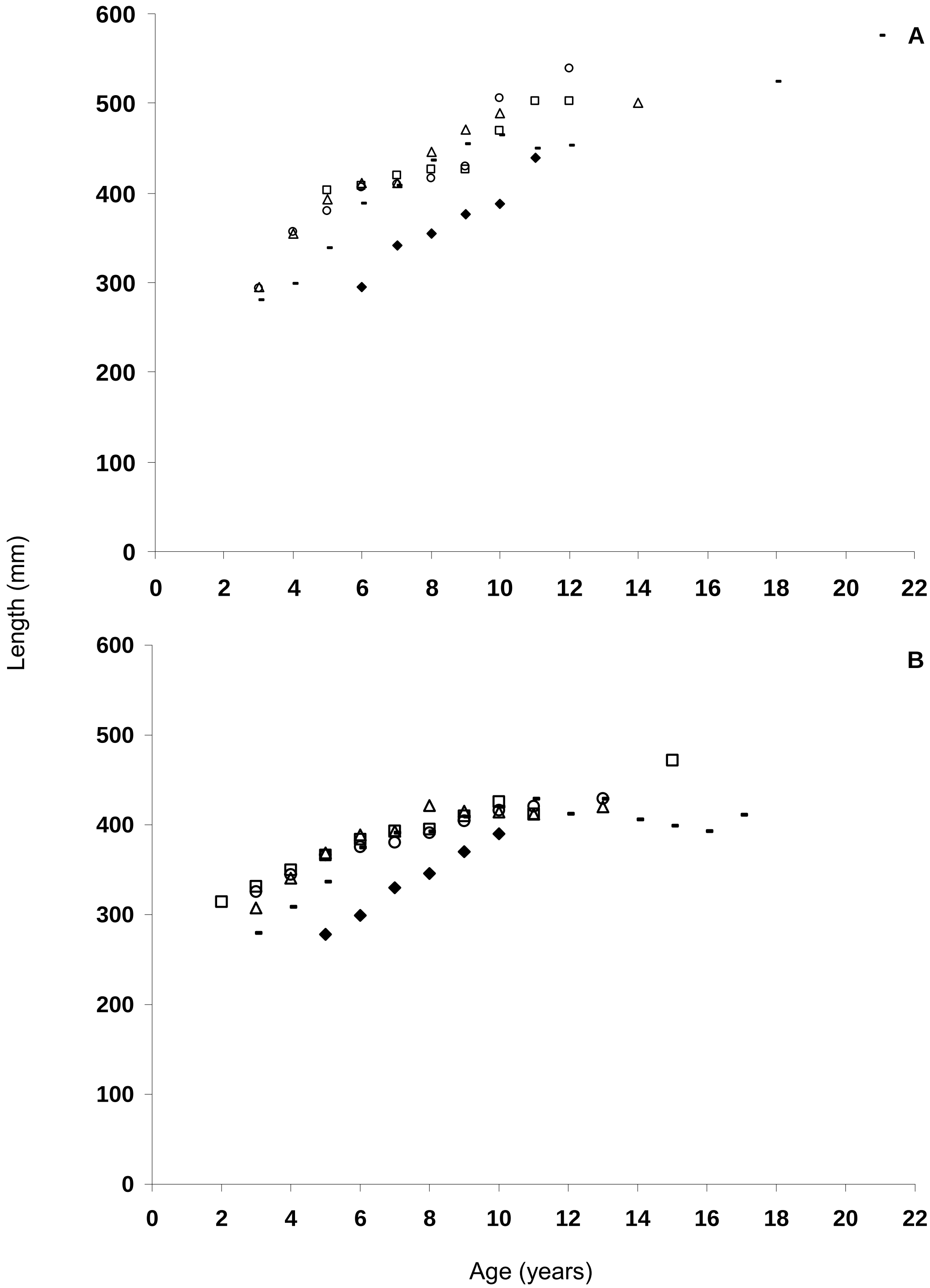


Figure 12. Length-at-age of female (A) and male (B) walleye from Tathlina Lake, NT, captured using experimental gill nets in 1979 (♦), 2001 (△), 2002 (−), 2005 (○) and 2006 (□).

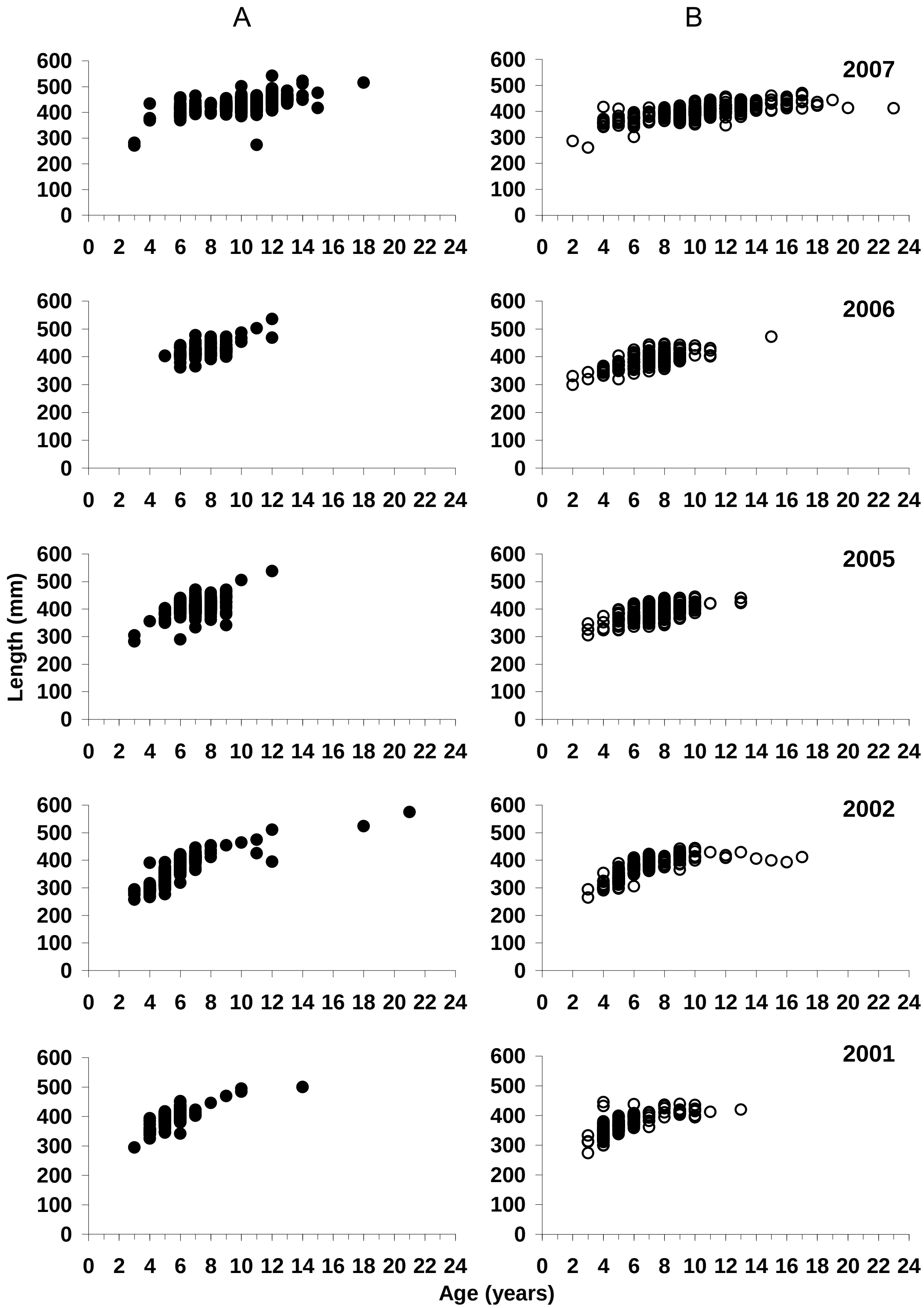


Figure 13. Length-at-age of female (A) and male (B) walleye from Tathlina Lake, NT, captured using experimental gill nets in 2001-2002, 2005-2007.

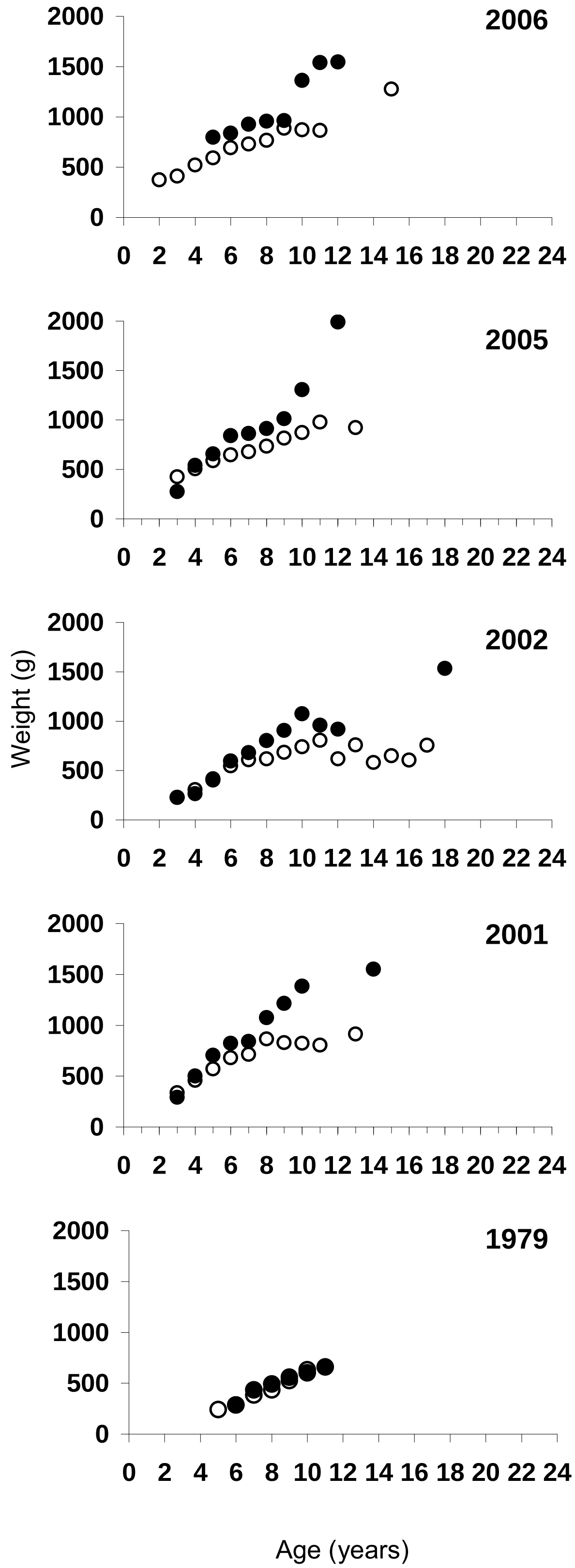


Figure 14. Weight-at-age of female (●) and male (○) walleye from Tathlina Lake, NT, captured using experimental gill nets in 2001-2002, 2005-2007.

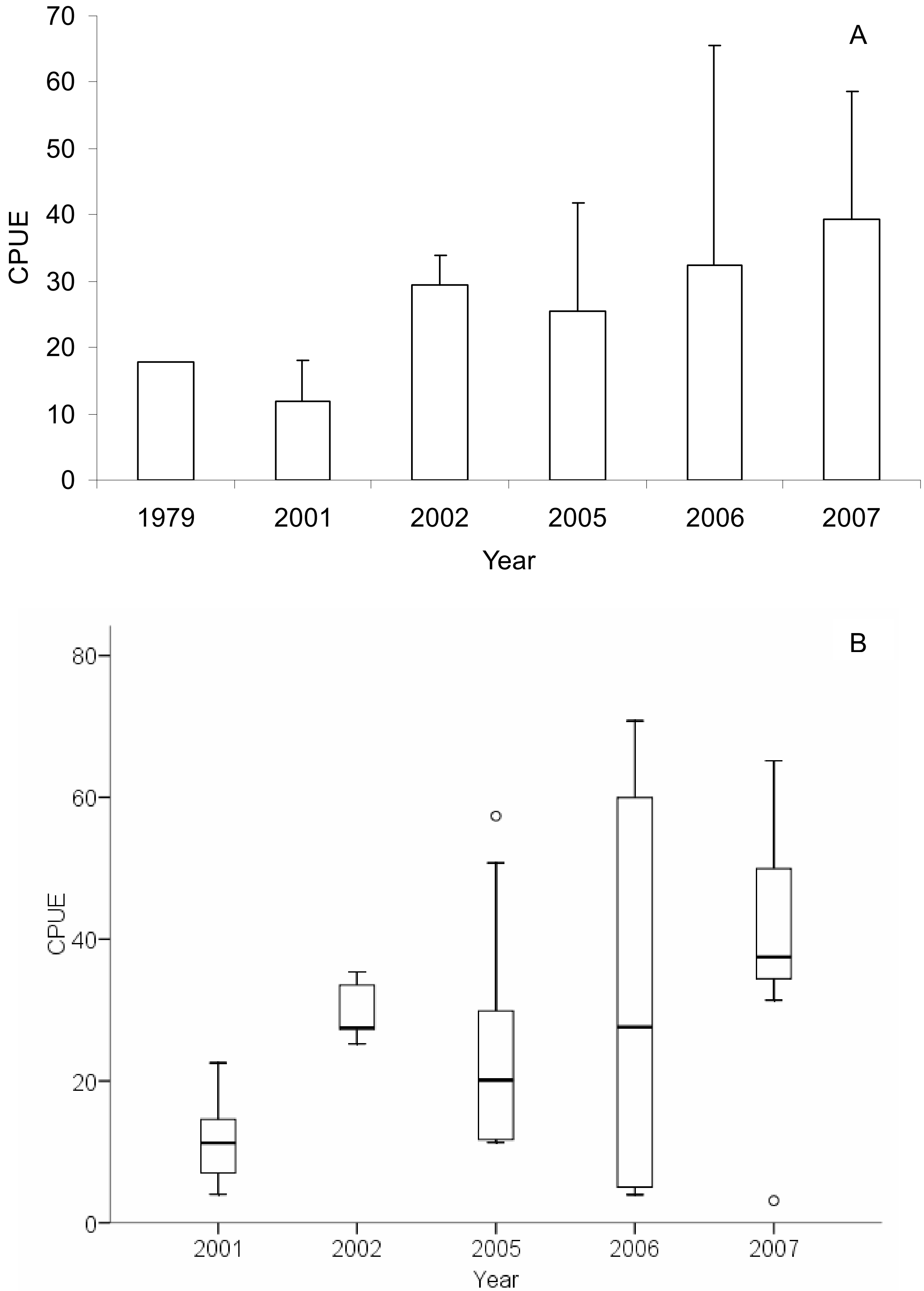


Figure 15. A) Mean and standard deviation of CPUE (# walleye/ 91 m/ 24 hours; 1979 and 2001-2007), and B) boxplot of CPUE of walleye from Tathlina Lake, NT, captured in experimental gill nets between 2001 and 2007. The standard deviation was not available for 1979.

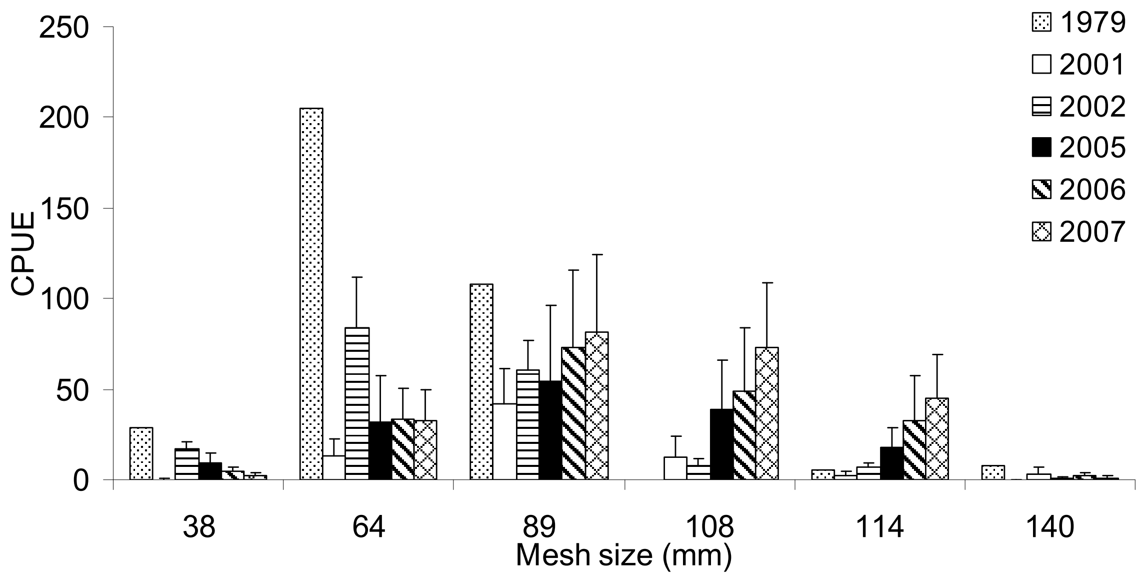


Figure 16. Mean and standard deviation of CPUE (# walleye/91 m/ 24 hours) of walleye from Tathlina Lake, NT, captured among mesh sizes from experimental gill nets set in 1979 (standard deviation was not available), 2001-2002, 2005-2007. The 108 mm mesh size was not used in 1979.

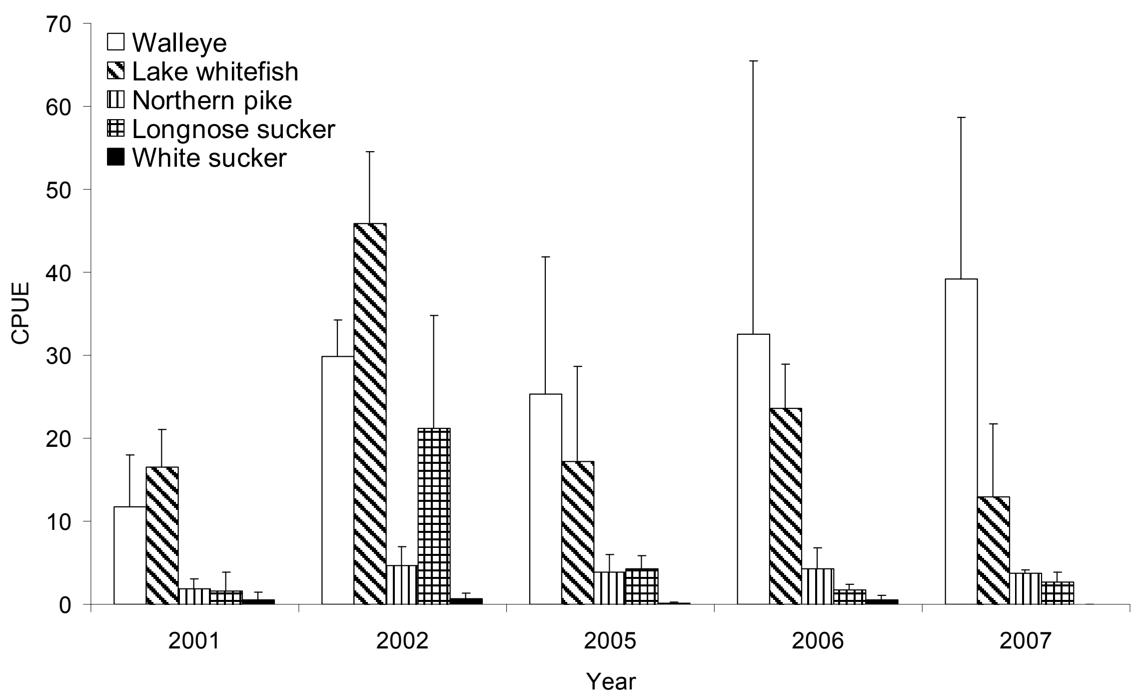


Figure 17. Mean and standard deviation of CPUE (# fish/ 91m/ 24 hours) of walleye, lake whitefish, northern pike, longnose sucker, and white sucker captured using experimental gill nets in Tathlina Lake, NT, between 2001 and 2007. Burbot and lake cisco were excluded because values were <0.5 fish/ 91 m/ 24 hours).

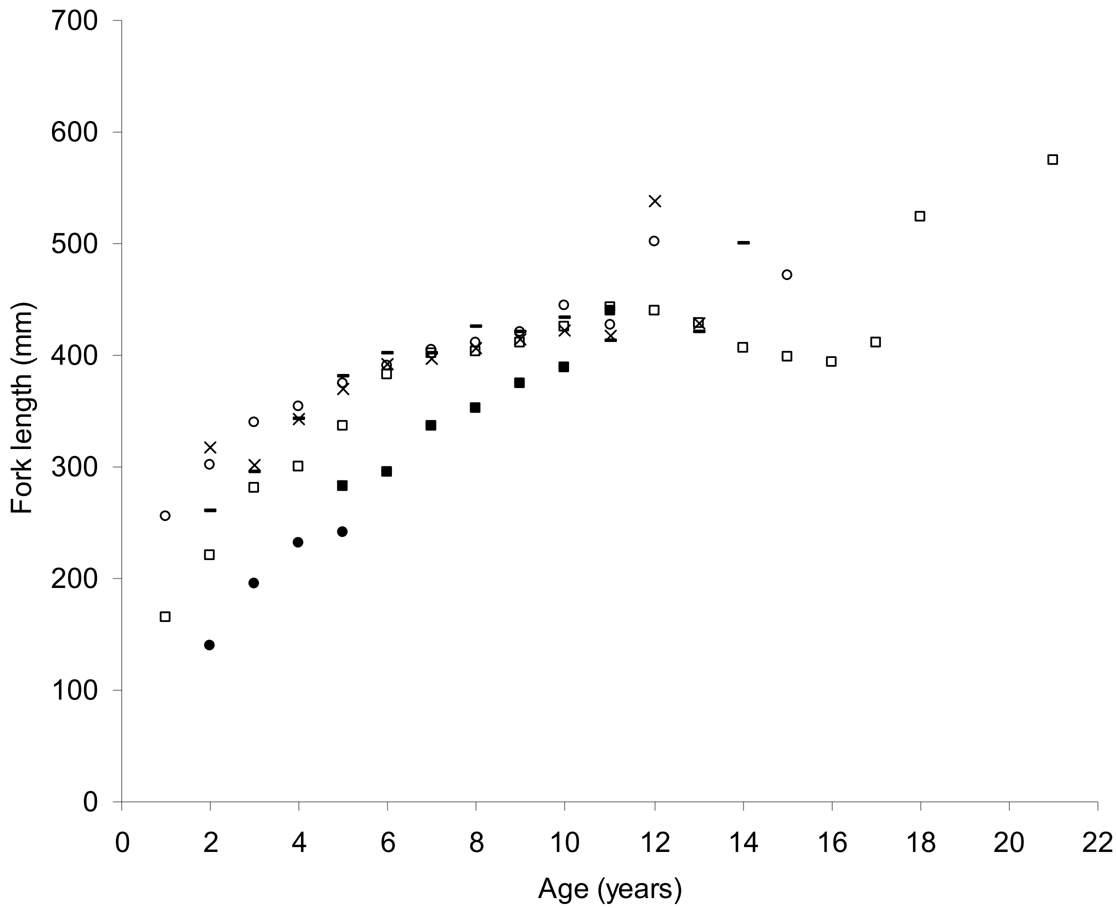
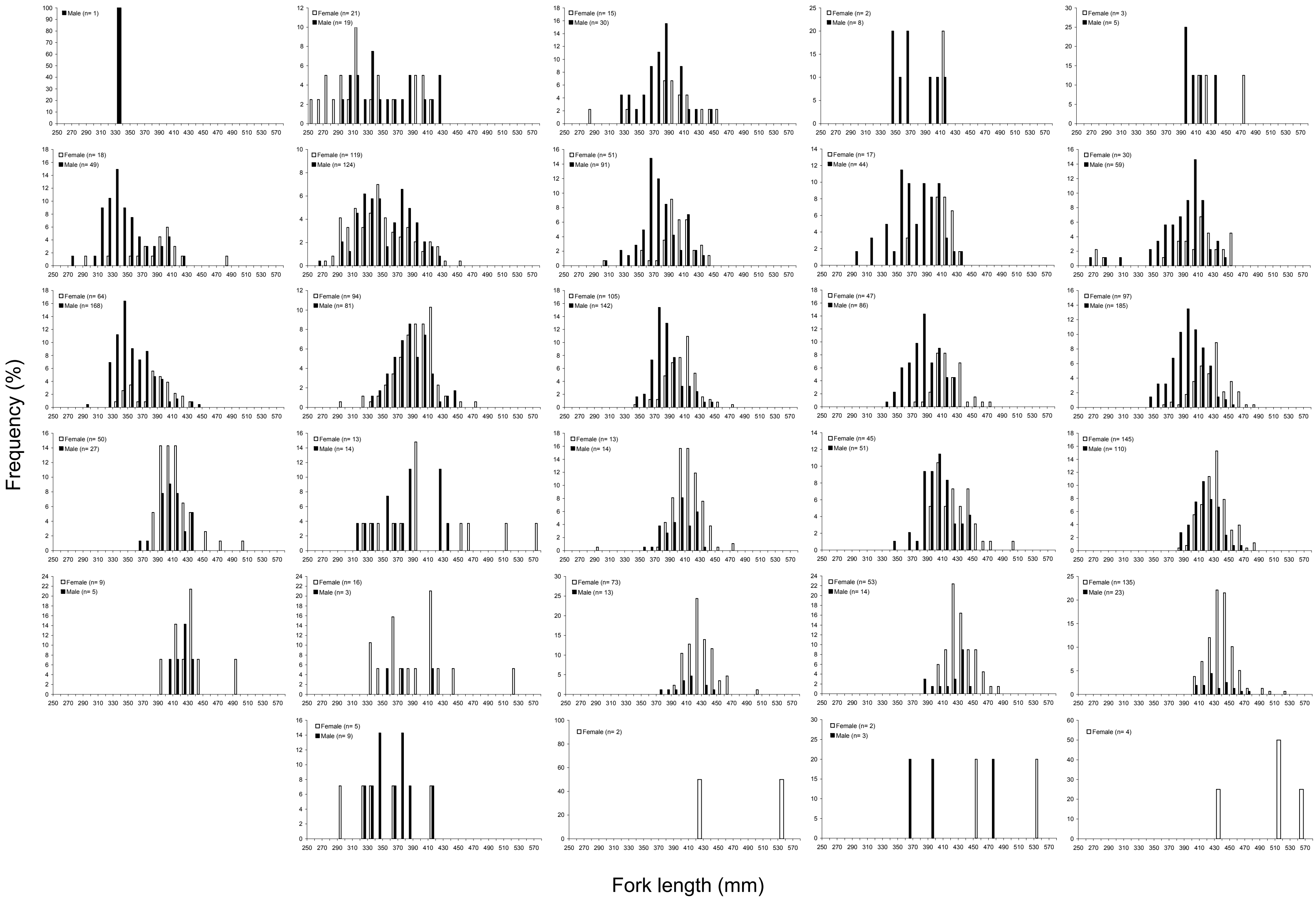


Figure 18. Mean length-at-age of walleye (sexes combined) from Tathlina Lake, NT, captured using experimental gill nets in 1946 (●), 1979 (■), 2001 (―), 2002 (□), 2005 (x) and 2006 (○).

APPENDIX 1. Numeric code for visual examination of gonads to determine sex and maturity status.

Maturity Code	Maturity Stage	Sex	Gonad Description
0	Unknown (Virgin)	Unknown	cannot be sexed, gonads long or short and thin, transparent or translucent.
1	Immature	Female	ovaries granular in texture, hard and triangular in shape, up to full length of body cavity, membrane firm, eggs distinguishable.
2	Mature	Female	current year spawner, ovary fills body cavity, eggs near full size but not loose, eggs not expelled by pressure.
3	Ripe	Female	ovaries greatly extended and fill body cavity, eggs full size and transparent, expelled by slight pressure.
4	Spent	Female	spawning complete, ovaries ruptured and flaccid, seed eggs visible, some retained eggs in body cavity.
5	Resting	Female	ovary fills 40 to 50% of body cavity, membrane thin, loose, semi-transparent, and healed from spawning, seed eggs apparent with few atritic eggs, some eggs may be retained in body cavity.
6	Immature	Male	testes long and thin, tubular and scalloped shaped, up to full body length, putty like firmness.
7	Mature	Male	current year spawner, testes large and lobate, white to purplish in colour, centers may contain fluid, milt not expelled by pressure.
8	Ripe	Male	testes full size, white and lobate, milt expelled by pressure.
9	Spent	Male	spawning complete, testes flaccid with some milt remaining, blood vessels obvious, testes violet-pink in colour.
10	Resting	Male	testes tubular, less lobate, healed from spawning, no fluid in center, usually full length of body cavity, mottled and purplish in colour.
11	Unknown (Non-Virgin)	Unknown	resting fish, has spawned but gonads have not regenerated, sexing not possible.

Appendix 2. Length frequency distribution of male and female walleye from Tathlina Lake, NT, captured among 38, 64, 89, 108, 114 and 140 mm mesh sizes from experimental gill nets set in 2001, 2002, 2005, 2006 and 2007.



Appendix 3. Mean length (mm), weight (g) and condition and percent mature among length intervals and age classes of female, male and the total sample of walleye captured in experimental gill nets in Tathlina Lake in 2001, 2002, 2005, 2006 and 2007.

2001*

	Female								Male								Total sample							
	Length			Weight			K	% Mat	Length			Weight			K	% Mat	Length			Weight			K	% Mat
	N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD		
250-299	1	295	0	1	290		1.13		2	286	18	2	330	141	1.37		12	285	12	12	274	61	1.17	
300-349	9	341	7	9	456	63	1.15		111	335	10	111	438	40	1.17		150	335	10	150	438	42	1.16	
350-399	60	383	15	60	655	87	1.16		101	372	15	101	593	78	1.15		180	374	16	180	608	88	1.15	
400-449	65	415	12	65	839	77	1.18		36	416	13	36	803	104	1.12		102	415	12	102	827	88	1.16	
450-500	6	475	21	6	1262	216	1.17										6	475	21	6	1262	216	1.17	
Total	141			141					250			250					450			450				
Mean		398	31		751	183	1.17			361	32		552	144	1.15			369	37		601	188	1.16	

	Female								Male								Total sample							
	Length			Weight			K	% Mat	Length			Weight			K	% Mat	Length			Weight			K	% Mat
	N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD		
2	0			0					0			0					1	261		1	195		1.10	
3	1	295		1	290		1.13		4	308	25	4	336	76	1.14		15	295	17	15	296	54	1.13	
4	18	354	17	18	501	75	1.12		132	341	18	132	458	56	1.16		191	342	17	191	463	57	1.15	
5	54	392	16	54	705	96	1.16		48	369	15	48	572	70	1.14		108	381	19	108	641	108	1.15	
6	58	411	20	58	822	100	1.18		36	389	16	36	681	82	1.16		95	402	21	95	767	115	1.17	
7	5	411	8	5	840	48	1.21		6	393	19	6	714	92	1.17		11	401	17	11	771	97	1.19	
8	1	446		1	1075		1.21		6	422	16	6	866	91	1.16		7	425	18	7	896	115	1.16	
9	1	470		1	1215		1.17		10	415	10	10	828	76	1.15		11	420	19	11	863	137	1.16	
10	2	490	8	2	1383	18	1.18		6	414	15	6	822	57	1.16		8	433	37	8	962	264	1.16	
11	0			0					1	412		1	805		1.15		1	412		1	805		1.15	
12	0			0					0			0					0			0				
13	0			0					1	420		1	915		1.24		1	420		1	915		1.24	
14	1	500		1	1550		1.24		0			0					1	500		1	1550		1.24	
Total	141			141					250			250					450			450				
Mean		398	31		751	183	1.17			361	32		552	144	1.15			369	37		601	188	1.16	

* maturity was not recorded in 2001

2002

	Female								Male								Total sample							
	Length			Weight			K	% Mat	Length			Weight			K	% Mat	Length			Weight			K	% Mat
	N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD		
150-199	0	-	-	0	-	-	-	-	0	-	-	0	-	-	-	-	2	165	0	2	42.5	4	0.95	0
200-249	0	-	-	0	-	-	-	-	0	-	-	0	-	-	-	-	2	221	5	2	102	3	0.95	0
250-299	22	287	11	22	246	25	1.05	4.5	7	291	11	7	256	30	1.04	0	48	287	10	48	246	24	1.04	2.1
300-349	77	328	14	77	381	55	1.07	18.2	78	329	13	78	376	55	1.05	50.0	172	327	14	172	373	56	1.06	30.8
350-399	99	377	14	99	556	74	1.04	61.6	119	376	13	119	550	59	1.03	88.2	227	376	13	227	553	65	1.04	73.1
400-449	62	414	10	62	691	68	0.98	95.2	46	414	12	46	704	68	0.99	97.8	109	414	11	109	697	68	0.98	95.4
450-499	5	460	10	5	979	125	1.01	100	0	-	-	0	-	-	0.00	-	6	466	18	6	1014	141	1.00	83.3
500-549	2	518	9	2	1395	198	1.00	100	0	-	-	0	-	-	0.00	-	2	518	9	2	1395	198	1.00	100
550-600	1	575	0	1	2175	0	1.14	100	0	-	-	0	-	-	0.00	-	1	575	0	1	2175	0	1.14	100
Total	268			268					250			250					569			569				
Mean		367	47		532	208	1.03			366	35		516	136	1.03			362	46		507	186	1.03	

	Female								Male								Total sample							
	Length			Weight			K	% Mat	Length			Weight			K	% Mat	Length			Weight			K	% Mat
	N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD		
1																	2	165	0	2	43	4	0.95	0
2																	2	221	4.9	2	102	3	0.95	0
3	5	281	15	5	229	28	1.03	0	2	280	21	2	228	0	1.03	0	14	281	11.5	14	229	26	1.03	0
4	21	299	24	21	265	33	1.01	9.5	12	309	18	12	307	0.8	1.04	16.7	53	300	19.8	53	278	43	1.03	7.5
5	99	338	21	99	415	76	1.07	24.2	85	337	18	85	402	18.0	1.05	52.9	195	337	19.7	195	408	74	1.06	35.4
6	88	388	19	88	598	77	1.02	72.7	72	375	16	72	548	26.0	1.04	90.3	167	382	19.1	167	576	77	1.03	77.2
7	42	408	16	42	683	81	1.00	95.2	30	391	15	30	609	11.6	1.01	96.7	72	401	17.4	72	652	83	1.01	95.8
8	5	435	18	5	803	132	0.97	100	14	393	14	14	620	5.6	1.02	100	19	404	24.3	19	668	119	1.01	100
9	1	454	0	1	905	0	0.97	100	18	409	21	18	683	6.8	0.99	94.4	19	411	22.6	19	695	108	0.99	94.7
10	1	464	0	1	1075	0	1.08	100	8	420	16	8	741	3.2	1.00	100	9	425	21.3	9	778	133	1.01	100
11	2	450	35	2	960	198	1.05	100	1	429	0	1	805	0.4	1.02	100	3	443	27.8	3	908	166	1.04	100
12	2	453	82	2	918	477	0.94	100	3	412	5	3	618	1.2	0.88	100	6	440	50.5	6	813	319	0.92	83.3
13									1	429	0	1	760	0.4	0.96	100	1	429	0	1	760	0	0.96	100
14									1	406	0	1	580	0.4	0.87	100	1	406	0	1	580	0	0.87	100
15									1	399	0	1	650	0.4	1.02	100	1	399	0	1	650	0	1.02	100
16									1	393	0	1	605	0.4	1.00	100	1	393	0	1	605	0	1.00	100
17									1	411	0	1	755	0.4	1.09	100	1	411	0	1	755	0	1.09	100
18	1	524	0	1	1535	0	1.07	100									1	524	0	1	1535	0	1.07	100
19																								
20																								
21	1	575	0	1	2175	0	1.14	100									1	575	0	1	2175	0	1.14	100
22																								
23																								
Total	268			268					250			250					568			568				
Mean		367	47		532	208	1.03			366	35		516	136	1.03			362	46		507	186	1.03	

2005

	Female								Male								Total sample							
	Length			Weight			K	% Mat	Length			Weight			K	% Mat	Length			Weight			K	% Mat
	N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD		
200-249	0	-	-	0	-	-	-	-	0	-	-	0	-	-	-	-	1	218	-	1	270	-	2.61	0
250-299	2	286	6	2	495	354	2.07	50.0	0	-	-	0	-	-	-	-	2	286	6	2	495	354	2.07	50.0
300-349	3	327	19	3	677	350	1.87	66.7	19	336	12	19	479	73	1.26	57.9	28	332	14	28	477	143	1.29	46.4
350-399	90	387	11	90	735	71	1.26	86.7	218	376	12	218	649	68	1.22	83.5	321	379	13	321	673	79	1.23	81.0
400-449	264	418	12	264	914	88	1.24	98.9	95	415	12	95	866	74	1.21	90.5	369	417	12	369	901	87	1.24	94.0
450-499	14	459	8	14	1182	73	1.22	100	0	-	-	0	-	-	-	-	15	458	8	15	1182	70	1.23	93.3
500-549	2	522	23	2	1648	484	1.15	100	0	-	-	0	-	-	-	-	2	522	23	2	1648	484	1.15	100
Total	375			375					332			332					738			738				
Mean		412	25		881	148	1.26	95.5		385	12		701	131	1.22	84.0		398	29		791	171	1.24	86.3

	Female								Male								Total sample							
	Length			Weight			K	% Mat	Length			Weight			K	% Mat	Length			Weight			K	% Mat
	N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD		
2	0	-	-	0	-	-		-	0	-	-	0	-	-	-	-	1	318	-	1	350	-	1.09	0
3	2	294	16	2	275	42	1.08	0	4	326	17	4	426	68	1.23	0	8	302	39	8	359	89	1.36	0
4	1	356	-	1	540	-	1.20	0	4	345	23	4	506	97	1.23	100	9	342	24	9	476	131	1.16	44.44
5	9	379	18	9	658	103	1.20	33.3	18	367	23	18	589	113	1.18	77.8	30	370	21	30	604	110	1.19	56.67
6	63	406	21	63	840	102	1.27	95.2	59	376	19	59	646	107	1.21	81.4	127	391	25	127	746	140	1.24	85.04
7	138	409	20	138	863	120	1.26	99.3	107	380	18	107	678	99	1.23	83.2	250	397	24	250	781	144	1.24	90.44
8	139	416	18	139	912	108	1.26	97.8	89	391	22	89	733	117	1.22	88.8	236	406	23	236	843	145	1.24	91.1
9	18	429	33	18	1012	181	1.28	94.4	29	405	20	29	816	102	1.23	93.1	49	414	28	49	887	166	1.24	89.8
10	1	505	-	1	1305	-	1.01	100	14	416	17	14	873	100	1.21	85.7	15	422	28	15	901	147	1.19	86.67
11	0	-	-	0	-	-	-	-	2	421	1	2	978	18	1.31	100	3	417	6	3	940	66	1.29	66.67
12	1	538		1	1990	-	1.28	100	0	-	-	0	-	-	-	-	1	538	-	1	1990	-	1.28	100
13	0	-	-	0	-	-	-	-	3	429	9	3	922	6	1.17	66.7	3	429	9	3	922	6	1.17	66.67
Total	372			372					329			329					732			732				
Mean		411	25		880	148	1.26	95.4		385	24		702	132	1.22	84.2		398	29		791	171	1.24	86.4

3 females were not aged
3 males were not aged

2006

	Female								Male								Total sample							
	Length			Weight			K	% Mat	Length			Weight			K	% Mat	Length			Weight			K	% Mat
	N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD		
250-299	0	-	-	0	-	-	-	-	1	299	-	1	325	-	1.22	0	3	276	22	3	250	69	1.17	0
300-349	0	-	-	0	-	-	-	-	13	337	10	13	470	61	1.23	69.2	16	337	10	16	467	61	1.21	56.25
350-399	12	387	12	12	727	103	1.25	83.3	115	377	13	115	656	81	1.22	95.7	142	378	14	142	660	87	1.22	84.51
400-449	131	421	13	131	928	96	1.24	99.2	76	415	13	76	874	133	1.22	98.7	214	418	13	214	907	114	1.23	95.79
450-499	21	460	10	21	1198	115	1.22	100	1	472	-	1	1275	-	1.21	100	22	461	10	22	1201	114	1.22	100
500-549	2	519	24	2	1705	233	1.22	100	0	-	-	0	-	-	-	-	2	519	24	2	1705	233	1.22	100
Total	166			166					206			206					399			399				
Mean		424	23		957	169	1.24	98.2		389	27		726	166	1.22	94.7		402	33		817	208	1.23	89.7

	Female								Male								Total sample							
	Length			Weight			K	% Mat	Length			Weight			K	% Mat	Length			Weight			K	% Mat
	N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD		
1	0	-	-	0	-	-	0	-	0	-	-	0	-	-	-		1	255	-	1	190	-	1.15	0
2	0	-	-	0	-	-	0	-	2	315	21.9	2	375	70.7	1.2	50	3	301	28.1	3	328	95	1.18	33.33
3	0	-	-	0	-	-	0	-	2	332	17.7	2	410	42.4	1.13	50	7	340	14.1	7	459	64.2	1.16	14.29
4	0	-	-	0	-	-	0	-	14	350	11.8	14	522	44.5	1.22	85.7	19	355	14.1	19	543	63.3	1.21	63.16
5	2	403	1.41	2	798	10.6	1.22	100	20	366	18.4	20	592	99.4	1.19	75	27	375	22	27	638	125	1.2	62.96
6	13	408	22	13	837	151	1.22	92.3	37	384	21.7	37	692	121	1.21	100	55	390	23.1	55	727	140	1.21	89.09
7	39	419	19.8	39	927	132	1.26	97.4	41	393	20.6	41	730	96.7	1.2	100	81	405	23.7	81	825	151	1.23	97.53
8	64	426	19.9	64	958	137	1.24	98.4	54	395	20.4	54	767	122	1.24	96.3	120	411	25	120	869	160	1.24	95.83
9	41	427	16	41	963	107	1.24	100	25	410	18.2	25	885	208	1.28	100	68	421	18.7	68	936	155	1.25	97.06
10	3	469	16.6	3	1363	139	1.32	100	4	426	14.8	4	871	112	1.13	100	7	444	27.3	7	1082	286	1.21	100
11	1	502	-	1	1540	-	1.22	100	5	412	13.5	5	865	99.9	1.23	100	6	427	38.6	6	978	290	1.23	100
12	2	502	48.1	2	1548	456	1.2	100	0	-	-	0	-	-	-	-	2	502	48.1	2	1548	456	1.2	100
13	0	-	-	0	-	-	-	-	0	-	-	0	-	-	-	-	0	-	-	0	-	-	-	-
14	0	-	-	0	-	-	-	-	0	-	-	0	-	-	-	-	0	-	-	0	-	-	-	-
15	0	-	-	0	-	-	-	-	1	472	-	1	1275	-	1.21	100	1	472	-	1	1275	-	1.21	100
Total	165			165					205			205					397			397				
Mean		425	23		958	168	1.24	98.2		389	27		726	167	1.22			403	33		817	208	1.23	89.7

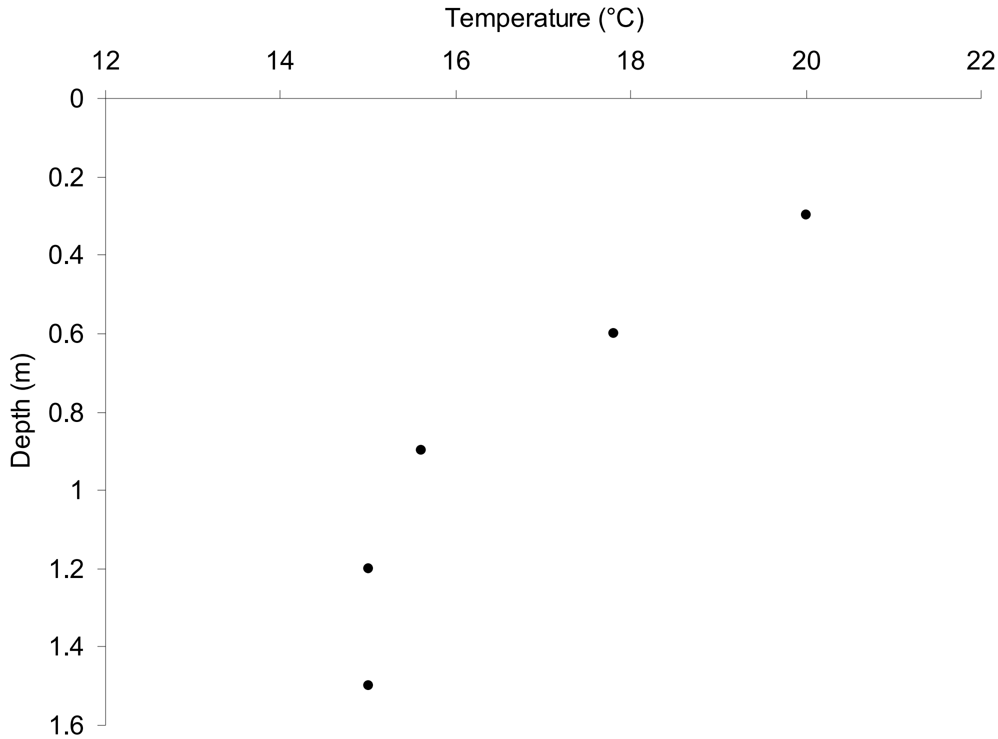
1 female was not aged
1 male was not aged

2007*

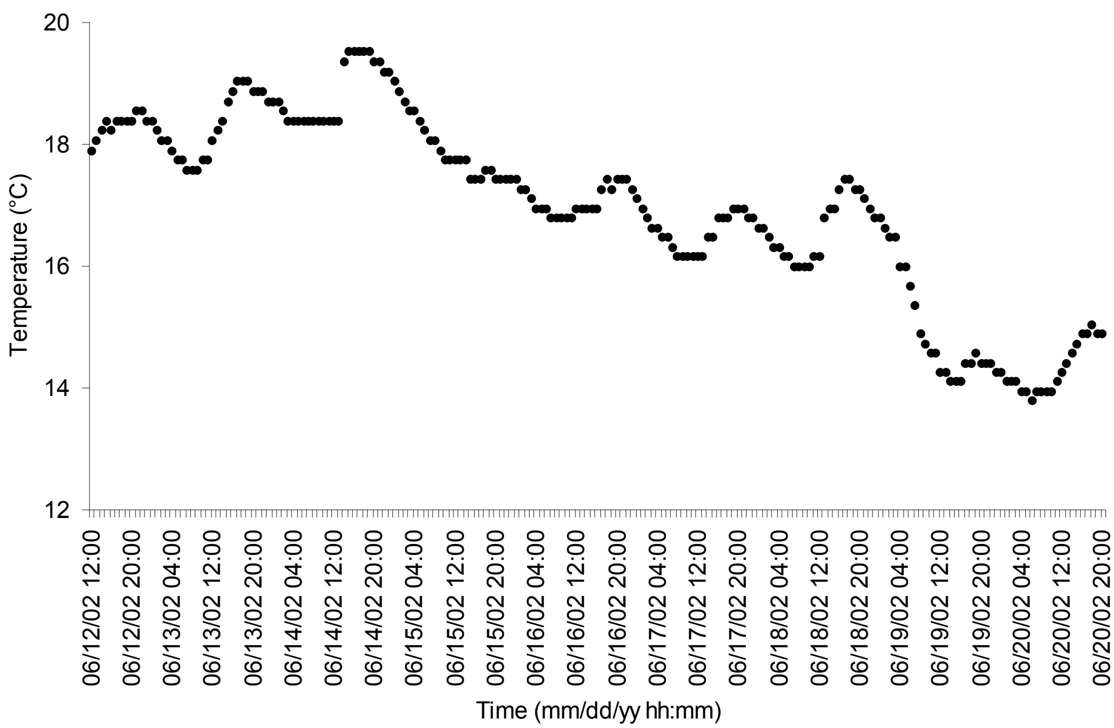
	Female								Male								Total sample							
	Length			Weight			K	% Mat	Length			Weight			K	% Mat	Length			Weight			K	% Mat
	N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD			N	Mean	SD	N	Mean	SD		
250-299	3	276	6	3	377	237	1.81	0	2	273	18	2	220	28	1.08	0	27	277	9	27	248	84	1.16	0
300-349	0	-	-	0	-	-	-	-	7	337	16	7	459	62	1.19	71.4	11	335	14	11	445	60	1.18	45.5
350-399	19	386	9	19	698	71	1.21	52.6	150	382	13	150	673	85	1.20	93.3	172	383	13	172	674	84	1.20	87.2
400-449	314	427	13	314	968	87	1.24	99.4	214	417	12	214	863	82	1.19	98.1	531	423	14	531	925	99	1.22	98.3
450-499	73	461	10	73	1188	83	1.21	98.6	9	458	7	9	1076	50	1.12	100	82	461	10	82	1176	87	1.20	98.8
500-549	5	518	15	5	1771	138	1.27	100	0	-	-	0	-	-	-	-	5	518	15	5	1771	138	1.27	100
Total	414			414					382			382					828			828				
Mean		431	26		1000	170	1.24	96.4		402	26		783	144	1.19			413	37		875	219	1.21	92.1

* age information was not available.

Appendix 4. Water temperature of Tathlina Lake taken in 1946 and 2001.



Temperature profile of Tathlina Lake taken between July 26 and August 9, 1946 (Kennedy 1962).



Water temperature recorded from a data logger placed in the western area of Tathlina Lake, NT, at 1.2 m from a location with a depth of 2.4 m between June 12 and 20, 2002.