Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2011

A Joint Effort of the 1854 Treaty Authority and the
Fond du Lac Resource Management Division

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Introduction

Under the Treaty of 30 September 1854, the Fond du Lac, Grand Portage, and Bois Forte Bands of Lake Superior Chippewa entered into an agreement with the United States of America. Under this agreement, these three Bands retained certain hunting, fishing, and gathering rights in the land ceded under this treaty.

Along with the right to utilize a resource comes the responsibility to manage and monitor the resource. Bands have assumed an increased responsibility to monitor fish populations and to develop long-term databases to set harvest quotas and to monitor the effects of tribal harvest. Fishery assessment surveys by Native American organizations have been performed for many years in both reservation and ceded territory waters of Wisconsin, Michigan, and Minnesota. Fond du Lac and the 1854 Treaty Authority have been actively involved with fish assessments since 1994 (Borkholder 1994a).

The 1854 Treaty Authority and Fond du Lac Resource Management Division work to protect and enhance the natural resources of the 1854 Ceded Territory for the three Bands. Cooperating with local Minnesota Department of Natural Resources (DNR) offices, the 1854 Treaty Authority and Fond du Lac identify priority natural resource projects for areas within the Ceded Territory. One goal is to assist with walleye assessments in the Ceded Territory. Walleye have always been a traditional subsistence resource for Fond du Lac and the Lake Superior Chippewa Bands. A 1994 survey conducted by Fond du Lac indicated that walleye were the primary game fish sought by Fond du Lac band members in the 1854 Ceded Territory (Borkholder 1994b).

Three techniques are typically utilized for the sampling of adult fish populations from within inland bodies of water; gill nets, trap (fyke) nets, and electrofishing gear. Gill nets are typically set for longer periods of time (10 - 18 hours), and can result in high fish mortality. Trap nets have been used for the sampling of adult walleye populations, but catch rates are low compared to electrofishing (Goyke et al. 1993 and 1994). Electrofishing is an effective and rapid method for sampling large areas, and has been used to sample walleye populations by other Native American agencies (Ngu and Kmiecik 1993; Goyke et al. 1993 and 1994) and within Northeastern Minnesota for many years (Borkholder 1994a and 1995). In order to maximize the number of fish handled and marked during the 2011 spawning season, Fond du Lac and the 1854 Treaty Authority chose once again to utilize electrofishing gear for these surveys.

Population estimates can be made using mark - recapture data (Ricker 1975). In this type of assessment, fish are collected, marked (fin clips, tags, etc.), and returned to the water. Population estimates are based upon the ratio of marked fish to unmarked fish within subsequent recapture samples. Accurate estimates are obtained when a large portion of the population is marked, usually 10% to 30% (Meyer 1993).

Surveying adult walleye populations using just electrofishing gear will usually result in conservative estimates of the adult stock. Walleye spawn in shallow water, where they are vulnerable to electrofishing gear. Male walleyes remain in the shallow water following spawning and have an extended spawning period, while females retreat to deeper water (Meyer 1993). Thus, females are only vulnerable to the sampling gear for a short period of time. Population estimates based solely upon spring electrofishing data alone will be conservative estimates, lower than the true population size. The Great Lakes Indian Fish and Wildlife Commission and the U.S. Fish and Wildlife Service utilize trap nets to aid in the sampling of walleye females, thus improving the accuracy of their population estimates.

The first objective of our assessments in 2011 was to obtain adult walleye population estimates (PE) during the spring spawning period using mark - recapture data. Our electrofishing PEs may be biased towards males in the populations, and thus, are presumed conservative estimates of population abundance. However, by cooperating with the MN DNR area offices, a second PE is obtained using the State's summer gill net data, with which to compare to the spring-only electrofishing PE. An additional benefit of the spring electrofishing surveys is that it allows biologists to identify and determine key and critical spawning sites, i.e. where catch rates are the highest.

The second objective of our 2011 walleye surveys targeted juvenile (age-1) and young-of-the-year (age-0) individuals in the fall. The purpose for assessing age-0 and age-1 individuals is to evaluate recruitment and year-class strength, and to continue developing long-term data sets using this data.

Methods

Spring Assessments

Lakes within the 1854 Ceded Territory of Minnesota were identified during meetings between MNDNR Area Managers and Tribal biologists. Lakes chosen for the 2011 spring survey were Cadotte Lake (Duluth Area), Fourmile Lake (Finland Area), and Tait Lake (Grand Marais Area). The objective was to obtain adult walleye (*Sander vitreus*) population estimates using mark-recapture methods and determine the age structure and growth rates of each respective walleye population. Fin clipped and colored floy-tagged walleye would then be available during the summer gill net assessments conducted by the MNDNR, thus providing a second population estimate.

Electrofishing was performed at night using boom-shocking boats equipped with Smith-Root Type VI-A electrofisher units and two Smith-Root umbrella anode arrays (Smith-Root, Vancouver, WA). Pulsed direct current was used to minimize injuries to the fish. Surface water temperature was taken prior to the beginning of each night's assessment activity. Ambient water conductivity measurements were taken using either a Hanna HI8733 conductivity or a Fisher Scientific Digital Conductivity Meter.

Electrofishing surveys were planned to begin soon after ice-out, and continue for as long as un-tagged walleye were abundant in the samples or when the percentage of recaptured individuals approached or exceeded 30%. Adult and juvenile walleye immobilized by the electrofishing gear were collected. Collected fish were placed into a 90-gallon tank equipped with an aerator and given time to recover. Walleye were measured to the nearest millimeter (mm), examined for fin clips and floy tags, and the sex determined (male, female, unknown) based upon visual identification of gametes. Walleye that had been floy-tagged during any previous nights' collections were counted as recaptured fish (Appendix 1). All individuals (> 254 mm) were marked using non-numbered red floy tags (Super Swiftachment Fasteners available from the Dennison Fastener Division, Framingham, Massachusetts). The reason for this was because of many years of clipping dorsal fin rays would make it impossible to differentiate 2011 marked fish from previously clipped individuals. A dorsal fin spine from five individuals per centimeter group and per sex was removed and placed in a labeled envelope for later aging in the lab. Following marking and spine collection, walleyes were released away from the shoreline.

Mark and recapture data were used to calculate adult walleye population estimates using both the Schumacher and Eschmeyer formula for multiple recapture surveys and the adjusted Petersen Method for single census (Ricker 1975). The Schumacher and Eschmeyer formula was used to take advantage of multiple evenings of recapture data. Walleye less than 254 mm (10 inches, "stock" size defined by Anderson 1976 and 1978) were excluded from population estimates.

Spines from adults were cleaned using bleach to remove the layer of skin on the bone. Spines were set in epoxy resin and sectioned (0.3 to 0.5 mm thick) using a Buehler Isomet™ low speed bone saw. Spines were examined using a microfiche reader. Annual rings were counted (McFarlane and Beamish 1987), and marked on overhead transparency sheets. Each spine's annuli were digitized into a computer using the DisBCal89 program (Frie 1982). DisBCal89 was used to back-calculate length-at-age estimates, using no transformation and a standard intercept of 27.9 mm.

Fall Assessments

Catch per unit effort (CPUE) for age-0 walleye has been found to be the highest in the fall when water temperatures are between 20.0°C and 10.0°C (Borkholder and Parsons, 2001). Fall assessments began in the Grand Marais area on 6 September 2011. Due to a warmer-than-normal autumn, the 20°C threshold was exceeded in four of the lakes (Table 10).

Presumed age-0 and age-1 walleye immobilized by the electrofishing gear were collected. Collected fish were placed into a 90-gallon tank of lake water and given time to recover. Walleye were measured to the nearest mm. Scales were taken for age analysis from five fish per cm group prior to release.

Sampling stations used were either those established during previous electrofishing surveys by the MN DNR or by Fond du Lac and the 1854 Treaty Authority (Borkholder 1996, 1997, and 1998; Borkholder and Edwards 1999, 2000, 2002, 2003, 2004, 2010, & 2011). Sampling stations were repeated from previous years' surveys.

Walleyes were aged by counting annuli on scales viewed under a microfiche reader (Borkholder 1996 and 1997). Walleye ages were used to estimate CPUE (number of walleye / hour of electrofishing) of juvenile (age-1) and young-of-the-year (age-0) individuals.

Results and Discussion

Spring Assessments

Cadotte Lake

Electrofishing activities were conducted on Cadotte Lake on 28, 29 and 30 April (Figure 1). Dates of electrofishing activities, water temperature, water conductivity, shocking time, the voltage and amps, the number of walleye collected, and the number caught per hour of electrofishing (CPUE) are presented in Table 1. CPUE ranged from 46.0 (EF3, 30 April) to 350.2 (EF5, 30 April) adult walleye per hour of sampling (Table 1, Figure 1). At an 80% confidence interval, mean CPUE for Cadotte Lake, determined using each sampling station, was 152.1 ± 33.2 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled is presented in Figure 2. Walleye as large as 681 mm (26.8 inches) were observed in the survey. Incidentally, 13 walleyes were observed to have the mark from the 2003 survey. Additional species observed included northern pike, white sucker, burbot, yellow perch, and bluegill.

Table 2 presents the population estimates based upon mark-recapture data. The electrofishing Schumacker and Eschmeyer population estimate is 1606 (Table 2). The electrofishing adjusted Petersen estimate is 1576 ± 458, with a 6.8% CV (Table 2). These estimates represent the population abundance of walleye using the sampled areas for spawning, and are not estimates of the walleye population within the entire lake. During summer 2011, the Minnesota Department of Natural Resources performed a standardized net assessment on Cadotte Lake (MN DNR, Duluth Area Fisheries). One hundred fifty (150) walleyes (> 264 mm) were sampled in the gill nets that would have been 254 mm during the April assessments. Twenty-two individuals were observed to have the clipped dorsal fin ray from the spring sampling. The adjusted Petersen estimate using both the summer and spring data is 5390 ± 3223, with an 18.8% CV (Table 2). The Schumacker and Eschmeyer population estimate from the net data is 2213 (Table 2). The estimates from our electrofishing survey are lower than those observed in 2003 (Borkholder and Edwards 2004), as were the estimates from the MNDNR gill net assessment (Table 2).

Table 3 presents the age data for the walleye collected from Cadotte Lake. Of the 822 unique fish sampled, 560 were assigned to ages 4 and 5. Total annual mortality (*A*) of the Cadotte Lake population was estimated at 48.8% (Figure 3). Table 4 presents back-calculated lengths-at-age for walleye collected from Cadotte Lake, as determined by aging dorsal fin rays.

Stock density indices are used to quantify the size structure of a population. Proportional stock density (PSD) was first proposed by Anderson (1976 and 1978), and is simply a measurement of the proportion of the fish observed larger than a predetermined “quality” length divided by the number of fish observed larger than a predetermined “stock” length. For walleye, “stock” length fish are those larger than 10.0 inches (254 mm), and “quality” length fish are those larger than 15.0 inches (381 mm). Gabelhouse (1984) proposed further separating “quality” fish into “preferred” (walleye > 20.0 inches / 508 mm), “memorable” (walleye > 25.0 inches / 635 mm), and “trophy” length fish (walleye > 30.0 inches / 762 mm), and calculating a relative stock density (RSD), or proportion, for each category. For example, RSD S-Q is the proportion of walleye in the sample between “stock” length (10.0 inches / 254 mm) and “quality” length (< 15.0 inches / 381 mm), divided by the total number of walleye sampled larger than 10.0 inches.

PSD and RSD values determined by our spring electrofishing sampling and summer gillnet survey are presented in Table 5. The electrofishing PSD of 36.7 ± 3.3 (Table 5) suggests a population characterized by fish smaller than 15.0 inches (Anderson and Weithman 1978). The summer gill net PSD (51.2 ± 7.7) was significantly different than the PSD estimate from the spring electrofishing survey

(χ^2=11.9, P>0.05, critical Chi-square value of 3.841. No significant differences were observed in any of the RSD metrics between the electrofishing and gill net assessments during 2011 assessments (Table 5).

PSD metrics calculated from the 2003 electrofishing assessments are included for comparison (Table 5) (Borkholder and Edwards 2004). Significant differences were observed between the 2011 PSD and the 2003 PSD (χ^2=62.1, P<0.05, critical Chi-square value of 3.841), and between the two estimated RSD Q-P and RSD Q-P metrics (χ^2=-7.9 and χ^2=-1.7, P<0.05, critical Chi-square value of -1.64). This is largely attributable to many more individuals observed in 2003 between 10.0 and 15.0 inches, than what was observed in our 2011 survey. Our fall assessment data indicates relatively strong year classes in 2005 (age 6) and in 2006 (age 5) (Figure 4). These 5 and 6-year old individuals may be influencing the PSD values more due to their relatively high abundance in the population (61.1% of surveyed individuals, Table 3). There appears to be a pulse of age-4 individuals that are currently "stock" sized (Table 3). Thus there does not seem to be a concern over lack of recruitment since 2006. Interestingly, these age-4 individuals were not observed in high numbers in our 2007 fall assessments (Figure 4).

The relationship between age-0 and age-1 fall electrofishing data and spring 2011 adult data is presented in Figure 5. The weak relationships observed between the adult CPE data and the age-0 and age-1 data may be due to the many years that have passed between the fall assessments, and the years of natural and angling mortality that have reduced adult walleye abundance by 2011. A second possibility may be that fall age-0 and age-1 CPE data is a poor predictor of adult abundance 3+ years later. The fall data were all collected between 2003 and 2010, and correspond to 2011 adult ages of 2 to 8 years old.

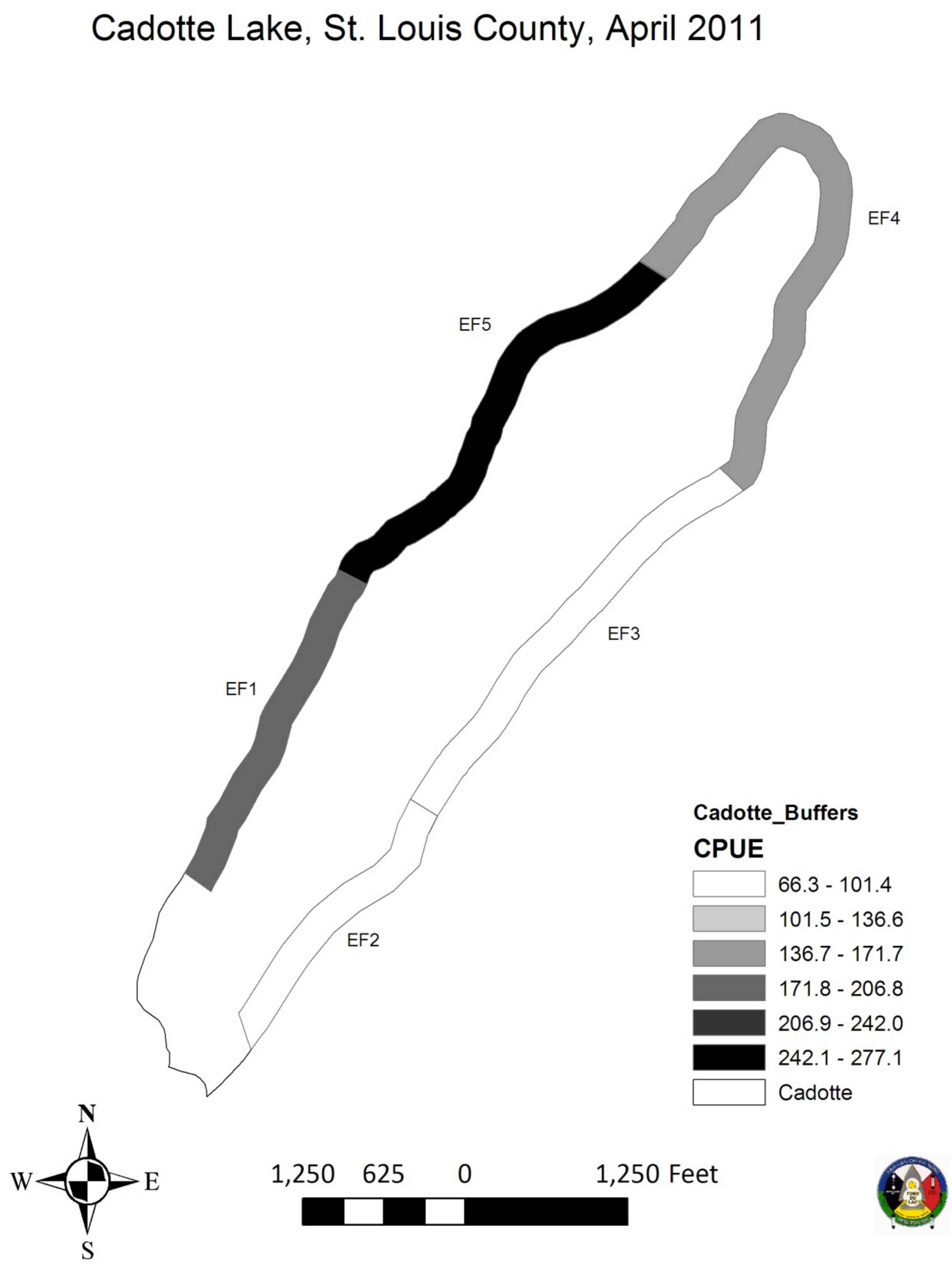

Figure 1. Catch per hour (CPE) of adult walleyes on Cadotte Lake, St. Louis County, during spring 2011 electrofishing surveys.

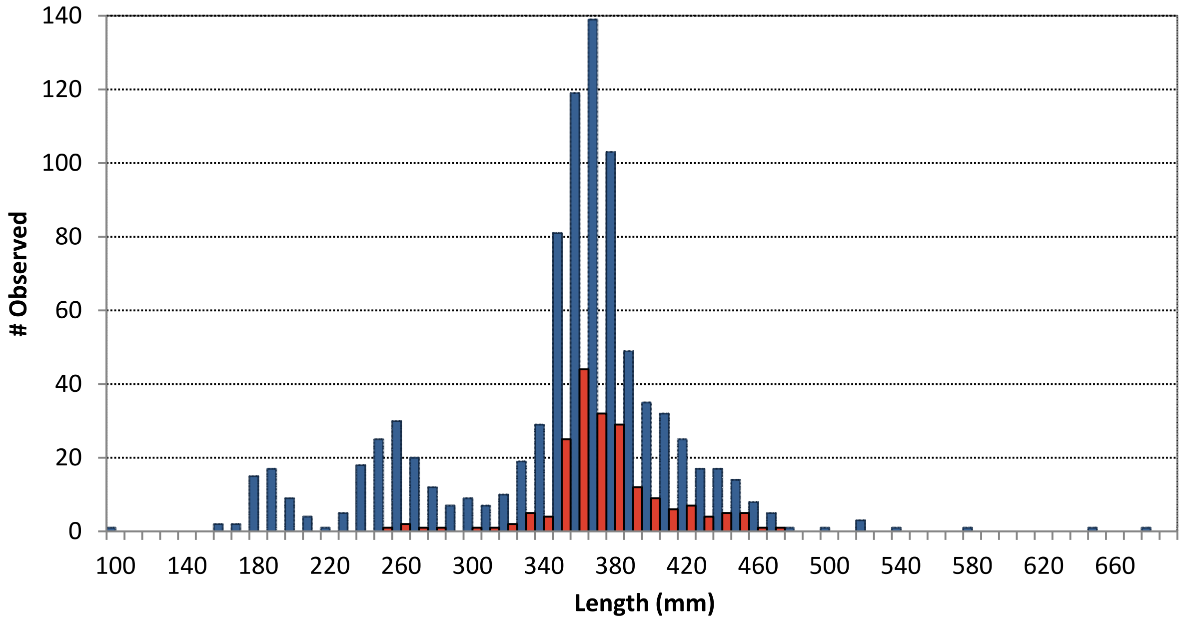

Figure 2. Length frequency distribution of walleye sampled from Cadotte Lake, St. Louis County, MN, during spring 2011 electrofishing assessments. Length frequency distribution of recaptured walleyes is shown in red bars.

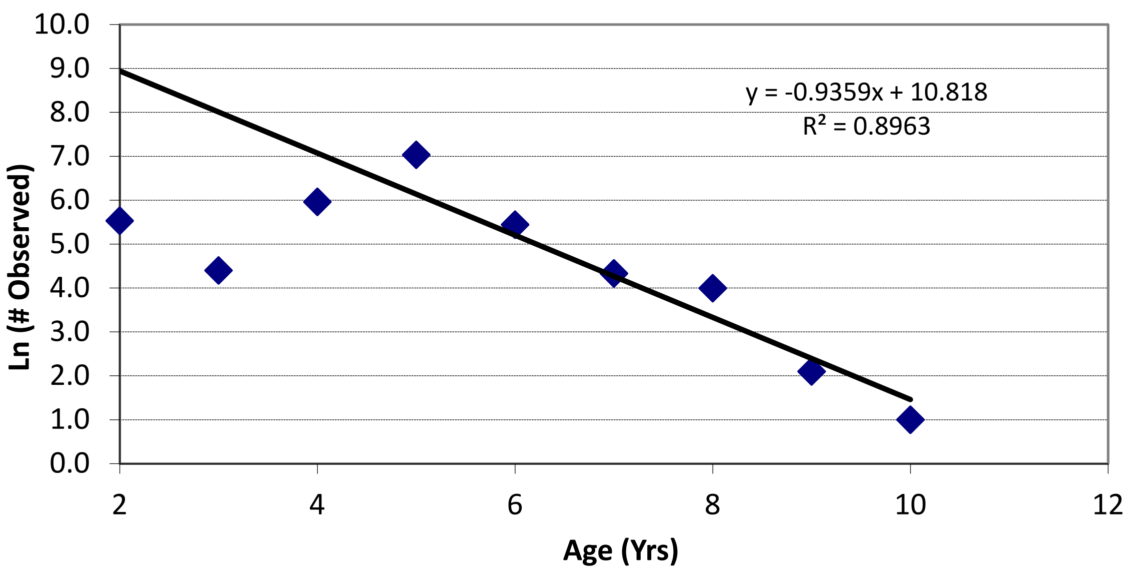

Figure 3. Instantaneous mortality (*Z*) of walleye from Cadotte Lake. Estimates are made from April 2011 electrofishing data.

Table 1. Summary of electrofishing activities on three lakes surveyed within the 1854 Ceded Territory, Minnesota, during Spring 2011.

ID #	County	Lake	Area (Acres)	Max Depth	Date	Water Temp (F)	Conductivity[1]	Shocking Time (sec)	Voltage (PDC)	Amps	# WAE[2]	CPUE WAE[3]
69-0114	St. Louis	Cadotte	325	18	4/28/2011	40	34.8	7413	High (45%)[4]	1.5	301	146.2
					4/29/2011	46	33.9	7176	High (45%)[4]	1.5	375	188.1
					4/30/2011	44	33.1	7273	High (45%)[4]	1.5	342	169.3
38-0024	Cook	Fourmile	272	18	5/6/2011	50	41.7	3939	1061 / High (60%)[4]	3.0	129	117.9
					5/7/2011	44	47.6	4014	1061 / High (60%)[4]	3.0	189	169.5
					5/8/2011	45	49.7	10194	High (60%)[4]	1.5	397	140.2
					5/9/2011	47	41.4	3389	High (60%)[4]	1.5	108	114.7
16-0384	Cook	Tait	338	15.0	5/10/2011	51	30.5	8680	1061 / High (60%)[4]	3.0/1.5	286	118.6
					5/11/2011	55	31.7	10672	1061 / High (60%)[4]	3.0/1.5	325	109.6
					5/12/2011	55	31.4	7689	1061 / High (60%)[4]	3.0/1.5	398	186.3

1 Water conductivity measured in microSiemens / cm.

2 WAE = walleye. Numbers in column represent the number of "stock" sized walleye (>254mm (10 inches)) collected. Includes marked and recaptured individuals.

3 CPUE = catch per unit effort, computed as per hour (3600 sec) of electrofishing. Numbers in column represent CPUE for "stock" sized walleye (>254mm (10 inches)).

4 The 1854 Treaty Authority began using a new Smith-Root controller in 2009, that does not indicate actual voltage, but rather HIGH or LOW, and a % Power, which is reported. Voltage reported would be that of the Fond du Lac vessel.

Table 2. Walleye population estimates for Cadotte, Fourmile, and Tait Lakes, Spring 2011. Estimates are for walleye larger than 254 mm (10.0 inches). EF denotes population estimates determined from spring electrofishing data. GN refers to population estimates determined from gill net samples collected in the summer following marking with the electrofishing surveys. Rows of shaded data indicate population estimates from previous surveys, and are presented for comparison purposes.

	Population	95% Confidence Limits			
Lake	Estimate[1]	Lower	Upper	Estimate[2]	C.V.[3]
Cadotte – EF_{2003}	4044	3809	4309	4016 ± 831	6.6 %
Cadotte – GN_{2003}	4487	3550	6097	8049 ± 3872	18.7 %
Cadotte – EF_{2011}	1606	1466	1776	1576 ± 458	6.8%
Cadotte – GN_{2011}	2213	1177	18453	5390 ± 3223	18.8%
Fourmile – EF_{2001}	873	631	1416	821 ± 106	6.6%
Fourmile – GN_{2001}	---	--	--	2758 ± 1405	26.0%
Fourmile – EF_{2006}	1448	1345	1568	1413 ± 180	4.0%
Fourmile – GN_{2006}	1638	1148	2857	5303 ± 3212	21.8%
Fourmile – EF_{2011}	1872	1419	2751	2129 ± 991	14.6%
Fourmile - GN_{2011}	2938	1546	29417	8190 ± 6029	26.5%
Tait – EF_{2009}	1593	1544	1645	1584 ± 416	6.4%
Tait – GN_{2009}	1720	1372	2303	2212 ± 983	14.0%
Tait – EF_{2011}	1216	1029	1488	1253 ± 386	7.2%
Tait – GN_{2011}	1325	961	2135	2226 ± 1581	22.3%

[1] Schumacher and Eschmeyer population estimate.
[2] Adjusted Petersen population estimate, with 95% confidence interval.
[3] Coefficient of variation for the Petersen estimate.
[4] Unable to calculate upper and lower confidence limits with one degree of freedom (1 *df*)

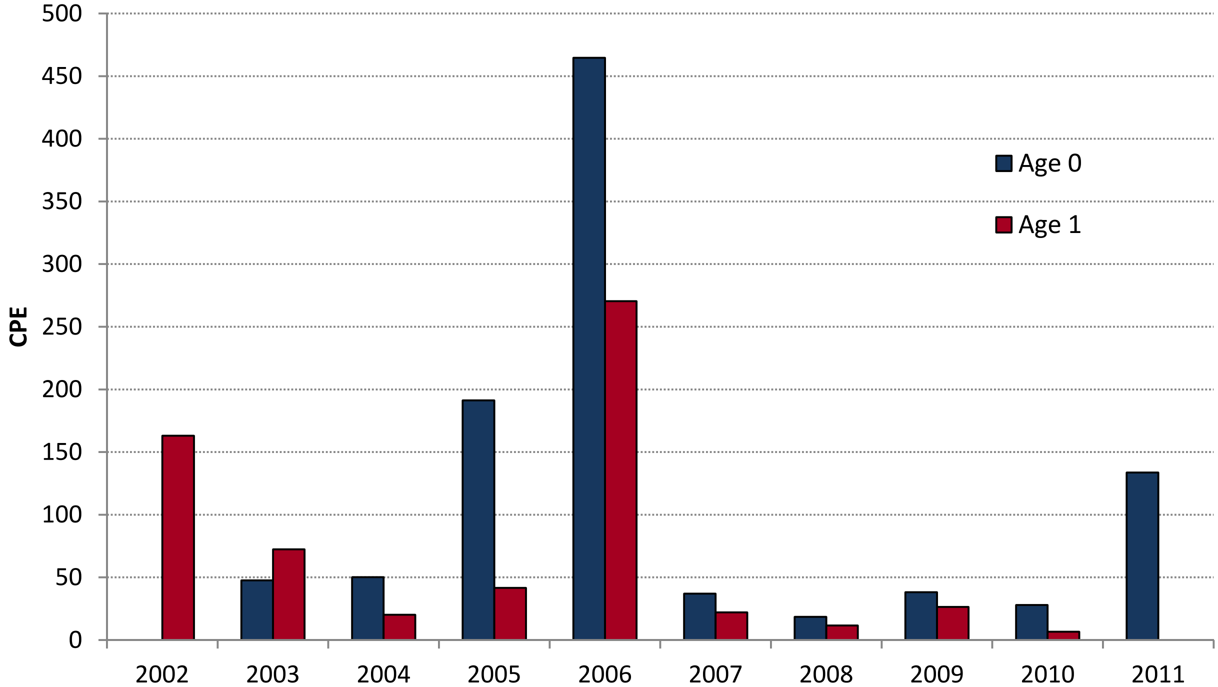

Figure 4. Age-0 and age-1 fall electrofishing catch-per-hour (CPE) data from Cadotte Lake, since 2002.

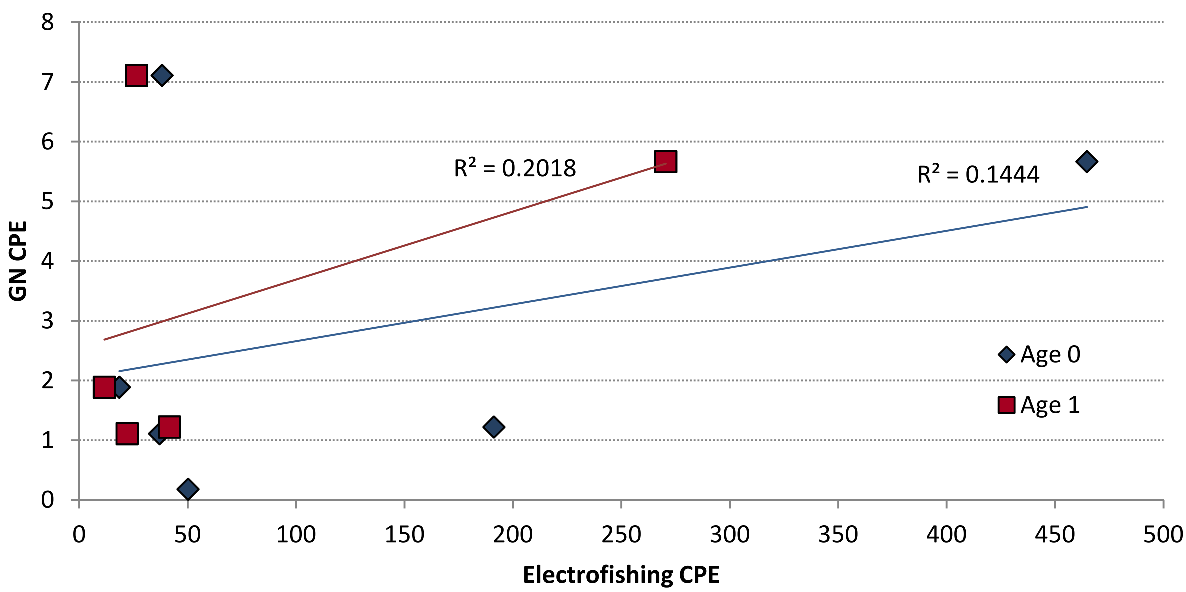

Figure 5. Relationship between fall electrofishing catch rates (#/hr) of age-0 and age-1 walleyes, and the subsequent catch of the same cohorts as adults in the MN DNR gill nets in Cadotte Lake. Cohorts selected for analysis are from the 2004 year class through the 2009 year class.

Table 3. Age frequency distribution of walleye from Cadotte Lake, St. Louis County, spring 2011, based upon the number of fish sampled and aged per size category.

Length Group		N				Age						
Inches	mm	Sampled	2	3	4	5	6	7	8	9	10	13
9.5	241	8	8									
10.0	254	41	41									
10.5	267	27	27									
11.0	279	17	15	2								
11.5	292	4										
12.0	305	13	2	11								
12.5	318	12		11	2							
13.0	330	23		6	12	6						
13.5	343	60			34	26						
14.0	356	156			89	67						
14.5	368	162				162						
15.0	381	112				87	25					
15.5	394	50			6	28	11	6				
16.0	406	42				25	8	8				
16.5	419	28				9	19					
17.0	432	23				4	8	4	8			
17.5	445	19				3	13			3		
18.0	457	11						6	6			
18.5	470	6					1	3	2			
19.0	483											
19.5	495	1							1			
20.0	508	0										
20.5	521	3	3					1	2			
21.0	533	1	1						1			
21.5	546	0										
22.0	559	0										
22.5	572	1	1								1	
23.0	584	0										
25.5	648	1										1
26.5	673	1										1
TOTAL		822	93	30	143	417	85	28	20	3	1	2

Table 4. Back-calculated lengths-at-age for walleye collected from Cadotte Lake, St. Louis County, Minnesota, April 2011.

Age Class	N	Length (mm)	Length (in)
1	124	128	5
2	124	232	9.1
3	106	298	11.7
4	89	349	13.7
5	76	393	15.5
6	43	431	17
7	26	461	18.1
8	15	491	19.3
9	4	530	20.9
10	3	588	23.1
11	2	628	24.7
12	2	650	25.6
13	2	668	26.3

Table 5. Proportional Stock Density (PSD) and Relative Stock Densities (RSD) with 95% confidence intervals for walleye sampled from Cadotte Lake (St. Louis Co.), and Fourmile and Tait Lakes (Cook Co.) Minnesota. Values are for spring electrofishing (EF) and MN DNR gill netting (GN) surveys conducted during the year indicated.

Lake	PSD	RSD S-Q	RSD Q-P	RSD P-M	RSD M-T
Cadotte – EF_{2011}	36.7 ± 3.3	63.3 ± 3.3	35.9 ± 3.3	0.6 ± 0.5	0.2 ± 0.3
Cadotte – GN_{2011}	51.2 ± 7.7	48.8 ± 7.7	48.8 ± 7.7	1.8 ± 2.1	0.6 ± 1.2
Cadotte – EF_{2003}	21.6 ± 2.0	78.4 ± 2.0	21.3 ± 2.0	0.2 ± 0.2	0.1 ± 0.2
Cadotte – GN_{2003}	27.7 ± 8.3	72.3 ± 8.3	26.8 ± 8.2	0.9 ± 1.7	0.0 ± 0.0
Fourmile – EF_{2011}	57.0 ± 3.7	43.0 ± 3.7	56.6 ± 3.7	0.4 ± 0.5	0.0 ± 0.0
Fourmile – GN_{2011}	40.1 ± 8.2	59.8 ± 8.2	37.2 ± 8.1	2.9 ± 2.8	0.0 ± 0.0
Fourmile – EF_{2006}	49.1 ± 3.1	50.9 ± 3.1	48.2 ± 3.1	0.7 ± 0.5	0.2 ± 0.3
Fourmile – GN_{2006}	45.3 ± 13.4	54.7 ± 13.4	45.3 ± 13.4	0.0 ± 0.0	0.0 ± 0.0

Table 5. Continued.

Tait -- EF_{2011}	51.9 ± 3.8	48.1 ± 3.8	51.5 ± 3.8	0.4 ± 0.5	0.0 ± 0.0
Tait -- GN_{2011}	50.0 ± 14.8	50.0 ± 14.8	45.4 ± 14.7	4.6 ± 6.2	0.0 ± 0.0
Tait -- EF_{2009}	47.8 ± 3.3	52.2 ± 3.3	46.7± 3.3	1.0 ± 0.7	0.1 ± 0.2
Tait -- GN_{2009}	57.9 ± 11.1	42.1 ± 11.1	55.3 ± 11.2	2.6 ± 3.6	0.0 ± 0.0

Fourmile Lake

Electrofishing activities were conducted on Fourmile Lake from 6 – 9 May (Figure 6). Dates of electrofishing activities, water temperature, water conductivity, shocking time, the voltage and amps, the number of walleye collected, and the number caught per hour of electrofishing (CPUE) are presented in Table 1. CPUE for each night was consistently high, more than 100 adult walleye per hour of sampling (Table 1). Catch rates ranged from 12.2 walleye / hour (EF3, 6 May) to 257.6 walleye / hour (EFD, 6 May) (Figure 6). At an 80% confidence interval, mean CPUE for Fourmile Lake, determined using each sampling station, was 104.8 ± 25.5 adults per hour of sampling effort. Sampling stations were those identified during previous surveys, where large spawning congregations were known to occur.

The length frequency of the walleye sampled from Fourmile is presented in Figure 7. Table 6 presents the age data for the walleye collected from Fourmile Lake. Of the 702 walleye sampled, 603 were assigned ages 4 - 7. Fall electrofishing assessments of age-0 and age-1 walleyes in Fourmile indicate abundant age-0 individuals in the 2005 and 2007 cohorts (Figure 8), corresponding to age-6 and age 4 walleyes in 2011, respectfully. Table 7 presents back-calculated lengths-at-age for walleye collected from Fourmile Lake. Instantaneous mortality (*Z*) for the Fourmile Lake walleye population is estimated at 63.6% (Figure 9). Total annual mortality (*A*) is estimated at 47.0%. These estimates higher than what was estimated after the 2006 survey, when instantaneous mortality (Z) was estimated at 48.1%, and total annual mortality at 38.2% (Borkholder and Edwards 2007).

Table 2 presents the population estimates based upon mark-recapture data. The electrofishing Schumacker and Eschmeyer population estimate is 1872 (Table 2). The electrofishing adjusted Petersen estimate is 2129 ± 865 with a 14.6% CV (Table 2). These estimates represent the population abundance of walleye using the sampled areas for spawning, and are not estimates of the walleye population within the entire Fourmile Lake. During summer 2011, the Minnesota Department of Natural Resources performed a standardized net assessment on Fourmile Lake (MN DNR, Finland Area Fisheries), sampling

139 walleyes (> 264 mm) in the gill nets that would have been 254 mm during the May assessments. Eleven individuals were observed to have the clipped dorsal fin ray and tag from the spring sampling. The adjusted Petersen estimate using both the summer and spring data is 8190 ± 6029, with a 26.5% CV (Table 2). The Schumacker and Eschmeyer population estimate from the net data is 2938 (Table 2). The estimates from our electrofishing survey are the highest observed in Fourmile Lake (Borkholder and Edwards 2002a; Borkholder et al., 2007) (Table 2).

PSD and RSD values determined by our spring electrofishing sampling are presented in Table 5. The electrofishing PSD of 57.0 ± 3.7 (Table 5) suggests the population is balanced, though characterized by larger individuals in the "quality" to "memorable" ranges (Anderson and Weithman 1978). The gill net PSD of 40.1 ± 8.2 was significantly different from the electrofishing PSD estimate (χ^2=13.1, P<0.05, critical Chi-square value of 3.841) (Table 5). PSD metrics calculated from the 2006 assessments are included for comparison (Table 5) (Borkholder et al. 2007). Significant differences were observed between the 2011 PSD and the 2006 PSD (χ^2=10.44, P<0.05, critical Chi-square value of 3.841). This would suggest that the stock structure may have changed since 2006, with more quality to preferred length walleye observed in 2011.

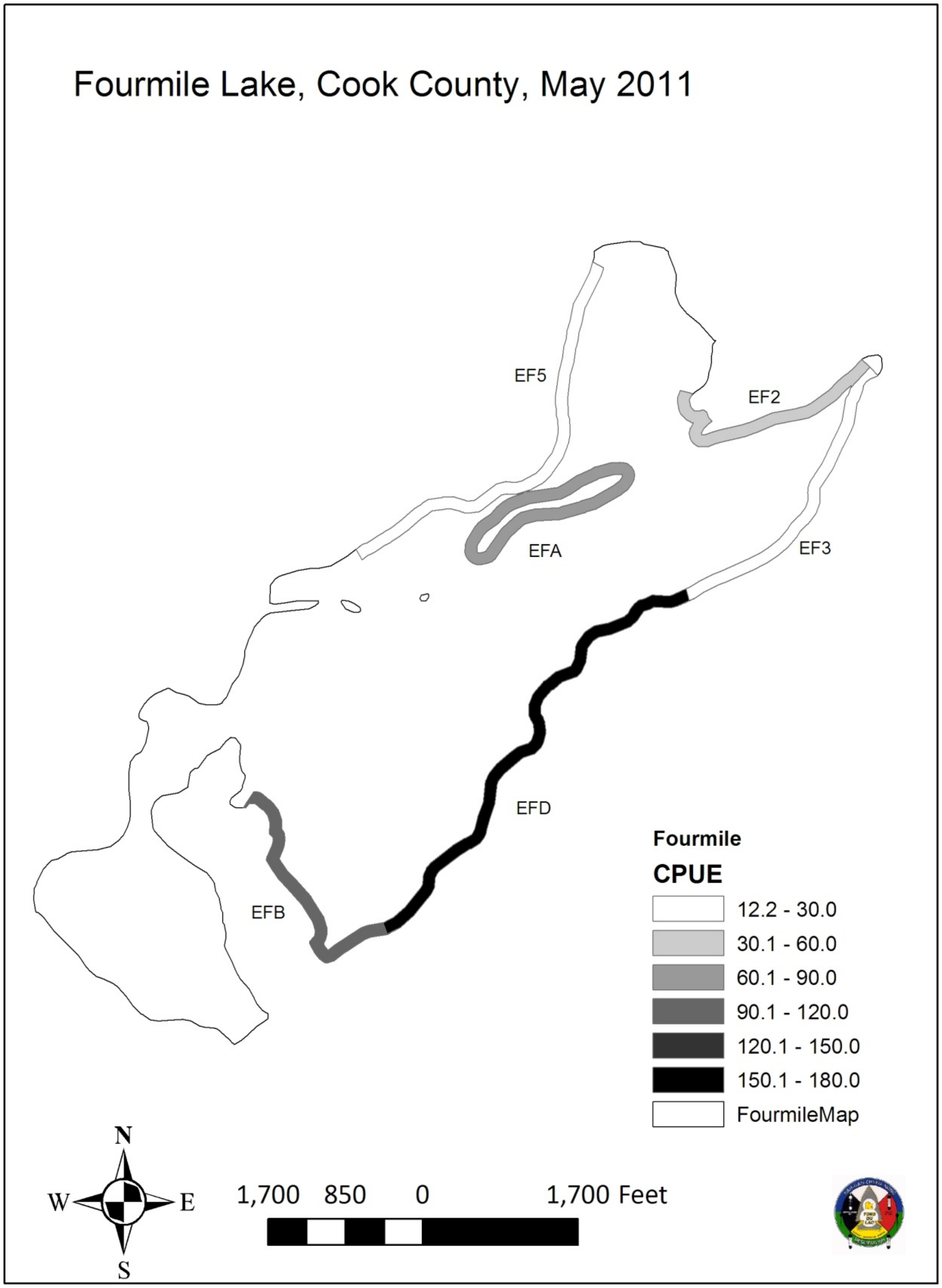

Figure 6. Catch per hour (CPE) of adult walleyes on Fourmile Lake, Cook County, during spring 2011 electrofishing surveys.

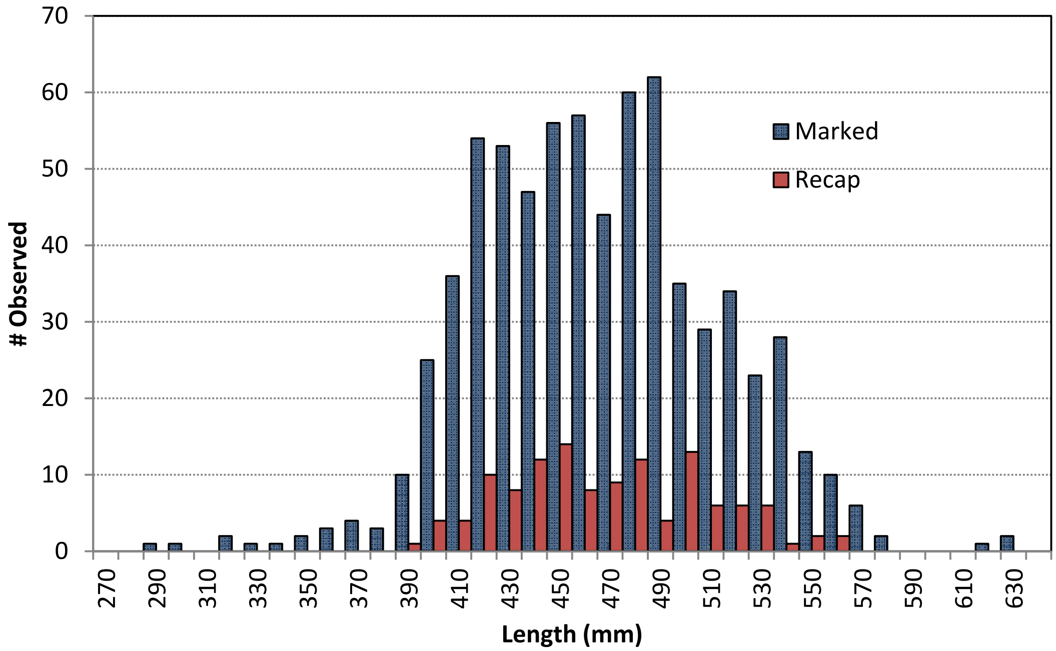

Figure 7. Length frequency distribution of walleye sampled from Fourmile Lake, Cook County, during spring 2011 electrofishing surveys. Blue bars represent unmarked walleyes observed, while red bars represent the length frequency distribution of the recaptured walleyes observed.

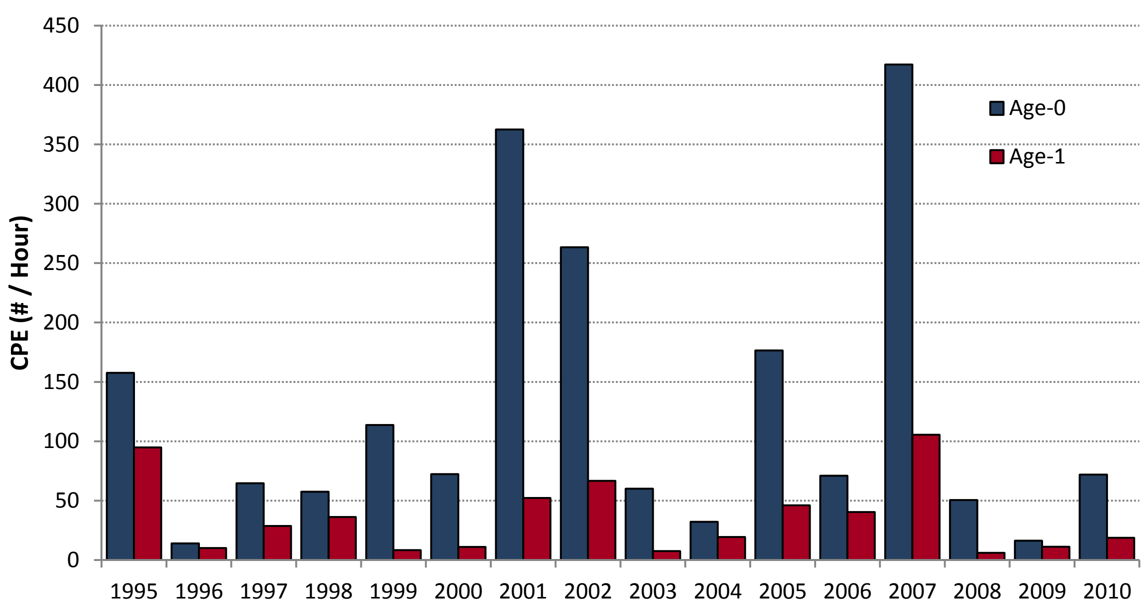

Figure 8. Age-0 and age-1 fall electrofishing catch-per-hour (CPE) data from Fourmile Lake, since 1995.

Table 6. Age frequency distribution of walleye from Fourmile Lake, Cook County, spring 2011, based upon the number of fish sampled and aged per size category.

Length Group		N					Age						
Inches	mm	Sampled	3	4	5	6	7	8	9	10	11	12	13
10.0	254	1	1										
10.5	267	2	2										
11.0	279	5	3	2									
11.5	292	5	2	3									
12.0	305	10	6	4									
12.5	318	29	5	24									
13.0	330	53		53									
13.5	343	65		56	9								
14.0	356	64		32	32								
14.5	368	68			68								
15.0	381	69		7	35	21	7						
15.5	394	71			20	41	10						
16.0	406	76			13	58	4						
16.5	419	43			4	36				4			
17.0	432	40				11	15	11	4				
17.5	445	36			4	6	8	10	8				
18.0	457	31				12	4	12	4				
18.5	470	16				2		7	2	5			
19.0	483	12					2		3	3	3		
19.5	495	3						1	1			1	
20.0	508												
20.5	521												
21.0	533												
21.5	546	3							1	1	1		
22.0	559												
TOTAL		702	19	181	185	187	50	41	23	13	4	1	

Table 7. Back-calculated lengths at each age class for walleye collected from Fourmile Lake, Cook County, Minnesota, spring 2011.

Age Class	N	Length (mm)	Length (in)
1	185	116	4.6
2	185	203	8.0
3	183	276	10.9
4	169	336	13.2
5	131	383	15.1
6	98	415	16.3
7	54	436	17.2
8	39	455	17.9
9	22	472	18.6
10	11	487	19.2
11	5	501	19.7
12	1	501	19.7

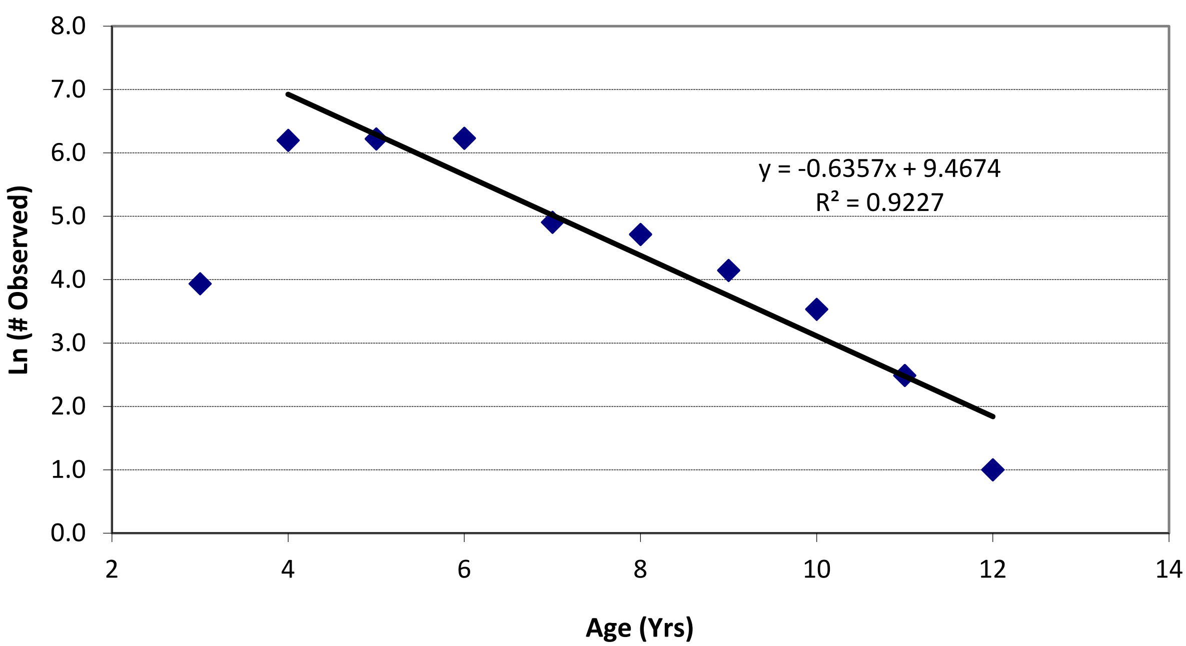

Figure 9. Instantaneous mortality (*Z*) of walleye from Fourmile Lake. Estimates are from spring 2011 electrofishing data.

Tait Lake

Electrofishing activities were conducted on Tait Lake between 10 - 12 May (Figure 10). Dates of electrofishing activities, water temperature, water conductivity, shocking time, the voltage and amps, the number of walleye collected, and the number caught per hour of electrofishing (CPUE) are presented in Table 1. Based upon previous surveys, areas characterized by soft muck bottom types were not sampled (Figure 10). CPUE for each night was high, ranging from 109.6 to 186.3 adult walleye per hour of sampling (Table 1). Catch rates ranged from 21.7 adult walleye per hour (EF6, 11 May) to 625.2 adults per hour (EF4, 11 May) (Figure 10). At an 80% confidence interval, mean CPUE for Tait Lake, determined using each sampling station, was 142.4 ± 64.5 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled is presented in Figure 11. Table 8 presents the age data for the walleye collected from Tait Lake. Greater than 71% of the fish were assigned as ages 3 – 6 (Table 8). More than half of the fish (59.9%) were assigned to the youngest ages (3 – 5). Table 9 presents back-calculated lengths-at-age for walleye collected from Tait Lake. Instantaneous mortality (Z) of the Tait Lake population was estimated at 43.5% (Figure 10). Total annual mortality (A) was estimated to be 35.3%.

Table 2 presents various population estimates based upon mark-recapture data for both the spring electrofishing survey and the summer gill-net assessment. The Schumacker and Eschmeyer population estimate from the electrofishing data is 705 (Table 2). The adjusted Petersen estimate is 1253 ± 386, with a 7.2% CV (Table 2). The 2011 population estimate of walleyes larger than 254 mm (10.0 inches) is lower than that estimated in 2009 (Table 2). Estimates of total mortality (Figure 12) are actually lower than expected, given the apparent decline in population abundance (Table 2) and low numbers of older aged individuals (Table 8). The estimate of total annual mortality is slightly higher than what was estimated in 2009 (35.2% in 2011 vs. 26.1% in 2009). Only three individuals larger than 20.0 inches were observed in the 2011 electrofishing assessment (Figure 11, Table 8). Fish were assigned ages up to 13 years (Table 8), which, given the age data and mortality estimate, suggests that growth may be limited in Tait Lake.

During summer 2011, the Minnesota Department of Natural Resources performed a standardized net assessment on Tait Lake (MN DNR, Grand Marais Area Fisheries). Forty-two walleyes (> 265 mm) were sampled in the gill nets that would have been 254 mm during the spring assessments, with twelve of those observed to have been tagged during the spring sampling. The adjusted Petersen estimate using both the summer and spring data is 2226 ± 1581, with a 22.3% CV (Table 2). The

Schumacker and Eschmeyer population estimate from the net data is 1325 (Table 2). The gill net PEs calculated in 2011 are not significantly different from those estimated in 2009.

PSD and RSD values determined by our spring electrofishing sampling and summer gill net survey are presented in Table 5. The electrofishing PSD of 51.9 ± 3.8 (Table 5) suggests a population characterized by larger individuals, larger than 15.0 inches (Anderson and Weithman 1978). The summer gill net PSD (50.0 ± 14.8) is not significantly different than the PSD estimate from the spring electrofishing survey (χ^2=0.06, P>0.05, critical Chi-square value of 3.841). No significant differences were observed in any of the RSD metrics between the electrofishing and gill net assessments during 2011 assessments (Table 5). PSD metrics calculated from the 2009 electrofishing assessments are included for comparison (Borkholder et al., 2010). No significant differences were observed between the 2011 electrofishing PSD and the 2009 electrofishing PSD (χ^2=2.6, P>0.05, critical Chi-square value of 3.841), nor between any of the RSD metrics of 2009 vs 2011. Likewise no differences were noted in any of the PSD / RSD metrics in the 2009 and 2011 gill net data. We do not have enough years of fall assessment data to identify any particularly strong or weak year classes.

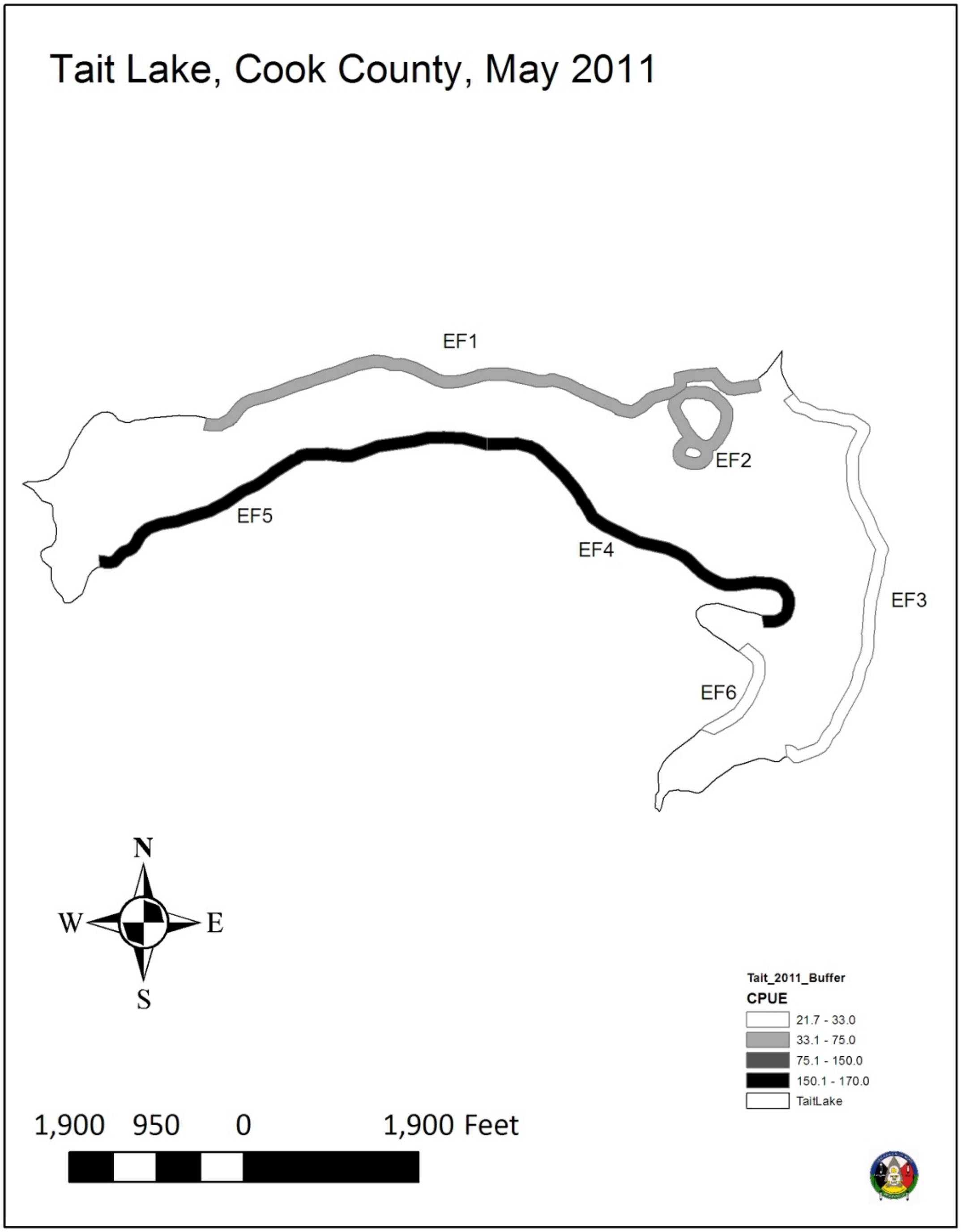

Figure 10. Catch per hour (CPUE) of adult walleyes on Tait Lake, Cook County, during spring 2011 electrofishing surveys.

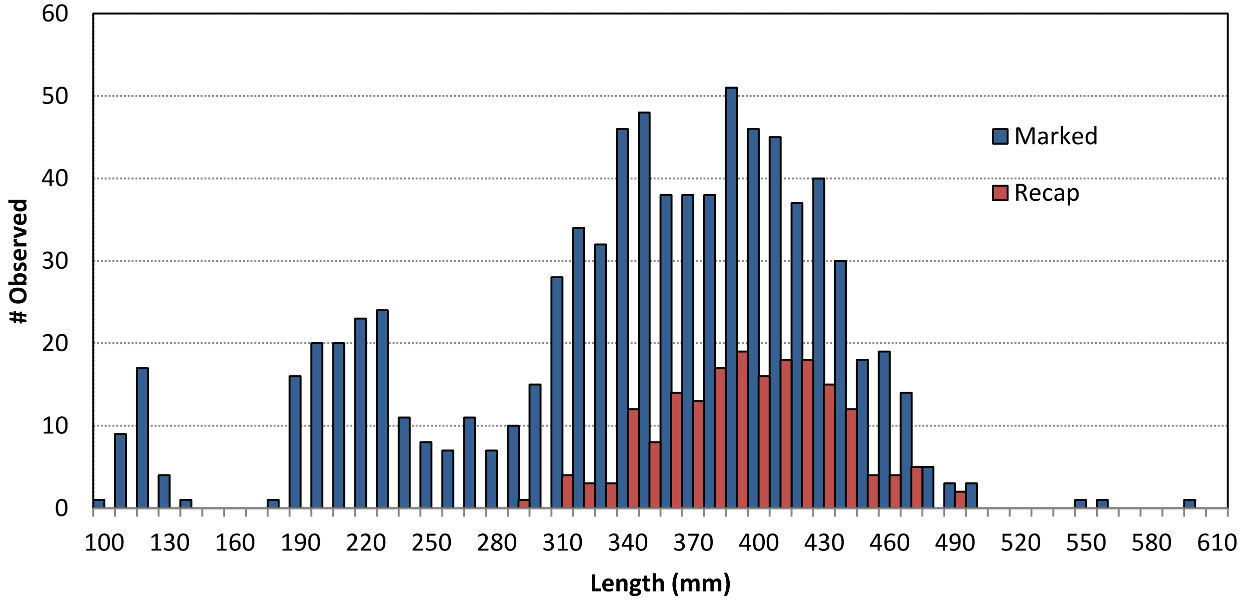

Figure 11. Length frequency distribution of walleye sampled from Tait Lake, Cook County, MN, during spring 2011 electrofishing assessments. Blue bars represent sample of marked individuals. Recaptured individuals were measured and are shown using the red bars.

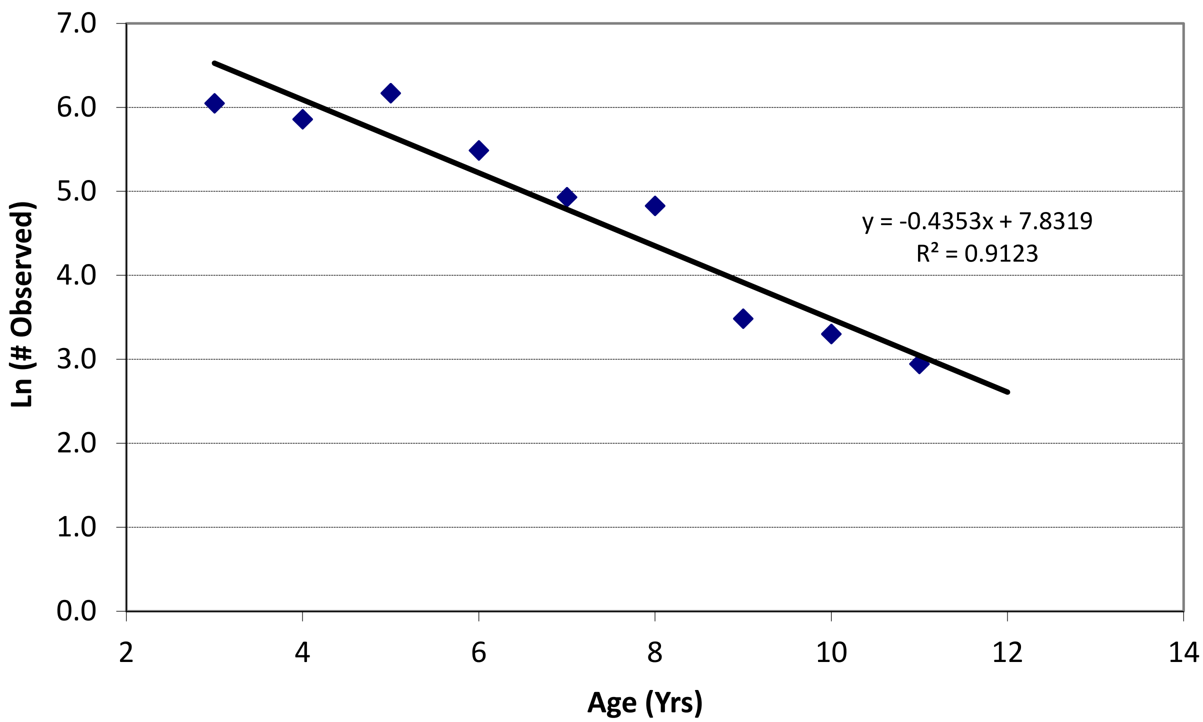

Figure 12. Instantaneous mortality (*Z*) of walleye from Tait Lake. Estimates are from spring 2011 electrofishing data.

Table 8. Age frequency distribution of walleye from Tait Lake, Cook County, spring 2011, based upon the number of fish sampled and aged per size category.

Length Group		N				------------------------ Age ------------------------							
Inches	mm	Sampled	2	3	4	5	6	7	8	9	10	11	12	13
8	203	24	24											
8.5	216	31	31											
9	229	28	28											
9.5	241	10		10										
10.0	254	16	5	11										
10.5	267	11	2	9										
11.0	279	8		8										
11.5	292	15		15										
12.0	305	29		29										
12.5	318	45		39	6									
13.0	330	51		23	28									
13.5	343	52		7	33	13								
14.0	356	55		5	40	10								
14.5	368	45			8	30	8							
15.0	381	56			14	42								
15.5	394	60				42	18							
16.0	406	61				26	26	9						
16.5	419	46				8	13	13	13					
17.0	432	47					19	14	9	5				
17.5	445	30				5	5	3	11		5			
18.0	457	21						5	8	5	3			
18.5	470	16						5	5	2		5		
19.0	483	7						2			2	2		2
19.5	495	3												
20.0	508													
20.5	521													
21.0	533													
21.5	546	1												
22.0	559	1												1
22.5	572													
23.0	584													
23.5	597	1												
24.0	610													
24.5	622													
TOTAL		770	90	156	129	176	89	51	46	12	10	7	0	3

Table 9. Back-calculated lengths at each age class for walleye collected from Tait Lake, Cook County, Minnesota, spring 2011.

Age Class	N	Length (mm)	Length (in)
1	163	124	4.9
2	163	217	8.5
3	157	291	11.5
4	116	344	13.5
5	92	383	15.1
6	61	409	16.1
7	41	430	16.9
8	28	442	17.4
9	13	456	18
10	9	471	18.5
11	5	490	19.3
12	2	518	20.4
13	2	527	20.7

Fall Assessments

Table 10 presents a summary of each evening of electrofishing assessments. CPUE for age-0 walleye ranged from 0.0 fish per hour (Devilfish and Wild Rice Lakes) to 752.1 fish per hour of electrofishing (Dumbbell Lake) (Table 10). CPUE for age-1 walleye ranged from 3.3 fish per hour (Silver Island Lake) to 125.2 fish per hour of electrofishing (Island Lake Reservoir) (Table 10). Figures 13 – 37 present length frequency data for each of the lakes surveyed. Table 11 presents the mean length for age-0 and age-1 individuals sampled during fall 2011 assessments. Mean lengths for age-0 walleye ranged from 113 mm (4.4 inches, Elbow Lake) to 160 mm (6.3 inches, Shagawa Lake). Mean lengths for age-1 walleye ranged from 183 mm (7.2 inches, Devilfish Lake) to 283 mm (11.1 inches, Cadotte Lake).

The difference between the 2011 observed CPE and each lake's historical mean, i.e. $CPE0_{2011}$ – $CPE0_{Mean\ (Year\ 1\ thru\ 2010)}$ by lake, is presented in Figure 38. Positive values indicate more age-0 walleyes were observed in 2011 relative to the lake's overall average, while negative values indicate fewer observed than normal. Overall, most lakes had fewer age-0 walleyes relative to historical averages, possibly due to the very late ice-out conditions in spring 2011, and the very cool early summer. The same was observed when analyzing the age-1 data (Figure 38). As additional data is collected in future MN DNR standard gill net surveys, we should gain further insight as to whether these presumed strong and weak year classes are reflected in the adult populations.

Overall, mean lengths observed in 2011 were larger than historically observed in most of the lakes (Table 11, Figure 38). The age-0 individuals may have been larger than historical averages due to higher growth rates associated with low intraspecific competition (Figure 38). The very large age-1's may have been a result of the very warm summer and autumn of 2010, allowing this cohort a much longer growing season as age-0's, and consequently a foraging and growth advantage in 2011 as age-1s that other year classes may not have had. These large age-1s (2010 cohort) also may have been large enough to significantly cannibalize on the 2011 year class, leading to the lower numbers observed this past autumn. In eight of the lakes, age-1 individuals were observed to be greater than 30mm larger than the historical mean (Figure 39), and in Silver Island, they were 55 mm larger than average (2.2 inches, Figure 38).

Several studies have suggested that age-0 walleye need to reach a certain critical size to have a chance at surviving their first winter (Forney 1976; Madenjian et al. 1991). Both Forney (1976) and Madenjian et al. (1991) attributed over-winter size-selected mortality of age-0 walleye to cannibalism. Forney (1976) suggested that this critical size is 175 mm (6.9 inches) in Oneida Lake, New York. If the bulk of the age-0 cohort exceeded this total length by the end of the growing season, the duration of their exposure to cannibalism would be reduced, and recruitment would be relatively high (Forney 1976). If first year growth was slower, age-0 walleye would be exposed to cannibalism by older walleye for longer periods of time.

The mean length of age-0 walleye observed since 1995 in our electrofishing assessments is 127.2 mm in lakes not stocked by the DNR with fingerling walleye prior to our assessments. Using the mean length criteria of 127 mm for average naturally-produced year classes, average or better 2011 year classes may be present in seventeen of the lakes surveyed (Table 11). Looking at each lake's historical mean length for age-0 and age-1 walleyes, and subtracting the historical mean from the observed 2011 mean length for age-0 and age-1 walleyes, it appears that walleye growth rates in NE Minnesota were higher than normal for both age-0 and age-1 walleyes. (Figure 38). In the future, we will be further investigating the predictive power mean length and CPUE of age-0 have on CPUE of 1+ the following sampling season in northern Minnesota lakes, with the goal of determining mean length and CPUE thresholds that can be used to predict year class strength. This will be possible as we continue to combine our electrofishing data with the State's gill net data for adults. Continued monitoring of walleye young-of-the-year and year-1 fish will give a better picture of recruitment patterns of walleye over time in these lakes, and give managers a better understanding of these walleye populations.

Acknowledgments

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Table 10. Total number and catch-per-unit-effort (CPUE) of age-0 and age-1 walleye collected from 25 lakes within the 1854 Ceded Territory of Northeastern Minnesota during September 2011.

Lake	Date	Temp (F)	Temp (C)	Cond.[1]	Age-0 Total[2]	Age-1 Total[3]	Seconds	CPUE Age-0[4]	CPUE 1+[5]
Ball Club	7-Sep	68	20.0	26.7	118	40	4947	85.9	29.1
Cadotte	15-Sep	60	15.6	37.4	239	12	6437	133.7	6.7
Caribou	9-Sep	70	21.1	65.5	272	60	6684	146.5	32.3
Cascade	13-Sep	64	17.8	22.2	140	7	4128	122.1	6.1
Crescent	9-Sep	71	21.7	33.0	14	31	3685	13.7	30.3
Crooked	20-Sep	56	13.3	49.7	24	37	5360	16.1	24.9
Devilfish	6-Sep	63	17.2	23.5	0	18	9096	0.0	7.1
Dumbbell	26-Sep	59	15.0	76.9	1206	18	5773	752.1	11.2
Elbow	8-Sep	72	22.2	38.1	9	63	3307	9.8	68.6
Fourmile	22-Sep	55	12.8	53.0	166	32	6151	97.2	18.7
Harriet	27-Sep	56	13.3	57.1	29	25	6296	16.6	14.3
Island Reservoir	16-Sep	64	17.8	72.5	241	339	9749	89.0	125.2
Ninemile	21-Sep	54	12.2	65.8	37	5	4888	27.3	3.7
N. McDougal	19-Sep	62	16.7	78.6	136	34	6557	74.7	18.7
Pike	7-Sep	66	18.9	57.3	36	8	4601	28.2	6.3
Shagawa	14-Sep	64	17.8	88.2	496	35	10526	169.6	12.0
Silver Island	26-Sep	56	13.3	41.2	24	5	5409	16.0	3.3
Tait	20-Sep	61	16.1	40.6	118	126	6597	64.4	68.8
Tom	6-Sep	67	19.4	32.5	2	65	5482	1.3	42.7
Two Island	20-Sep	58	14.4	30.7	68	22	4369	56.0	18.1
West Twin	8-Sep	69	20.6	34.2	217	6	4047	193.0	5.3
Whiteface Res.	15-Sep	65	18.3	68.1	244	9	6291	139.6	5.2
Wild Rice	17-Sep	58	14.4	115.1	0	5	4297	0.0	4.2
Wilson	28-Sep	62	16.7	48.4	95	32	5741	59.6	20.1
Windy	27-Sep	59	15.0	32.2	37	87	5028	26.5	62.3

[1] Conductivity, measured in MicroSiemens / cm.
[2] Indicates the number of age-0, young-of-the-year, walleye collected in each sample.
[3] Indicates the number of age-1 juvenile walleye collected in each sample.
[4] Indicates the catch rate of age-0 fish (fish per hour, 3600 sec, of electrofishing on time).
[5] Indicates the catch rate of age-1 fish (fish per hour, 3600 sec, of electrofishing on time).

Table 13. Mean length for age-0 and age-1 walleye sampled during fall 2011 assessments within the 1854 Ceded Territory of Northeastern Minnesota. Numbers in parentheses indicate sample sizes, and are presented when mean lengths are based upon few individuals.

Lake (County)	Date	Age-0 Mean Length (mm)	Age-1 Mean Length (mm)
Ball Club	7-Sep	133	245
Cadotte	15-Sep	158	283
Caribou	9-Sep	122	213
Cascade	13-Sep	136	209 (7)
Crescent	9-Sep	128	193
Crooked	0-Jan	145	233
Devilfish	6-Sep		183
Dumbbell	26-Sep	124	207
Elbow	8-Sep	113 (9)	185
Fourmile	22-Sep	146	244
Harriet	27-Sep	133	207
Island Reservoir	16-Sep	125	200
Ninemile	21-Sep	159	255 (5)
N. McDougal	19-Sep	127	204
Pike	7-Sep	140	226 (8)
Shagawa	14-Sep	160	238
Silver Island	26-Sep	156	250 (5)
Tait	20-Sep	124	202
Tom	6-Sep	123 (2)	205
Two Island	20-Sep	127	210
West Twin	8-Sep	140	252 (6)
Whiteface Res.	15-Sep	142	261 (9)
Wild Rice	17-Sep		232 (5)
Wilson	28-Sep	142	221
Windy	27-Sep	132	211

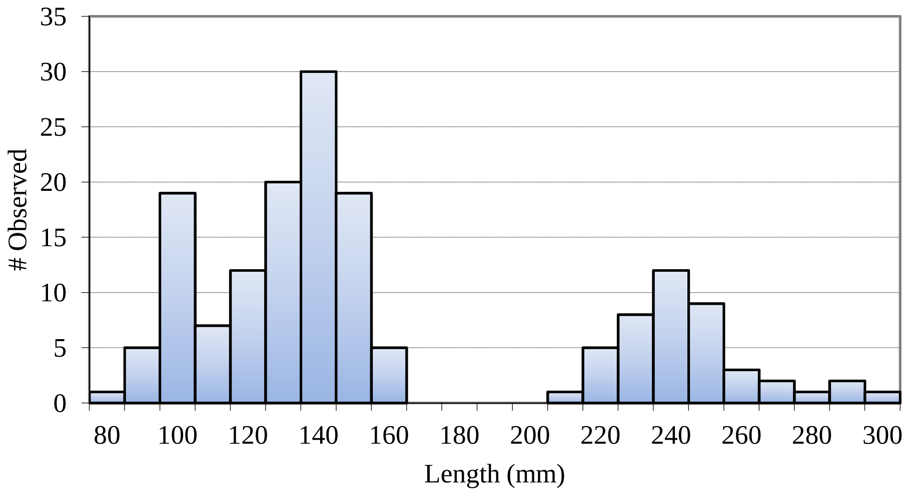

Figure 13. Length frequency distribution of walleye collected from Ball Club Lake, Cook County, during fall 2011 electrofishing assessments.

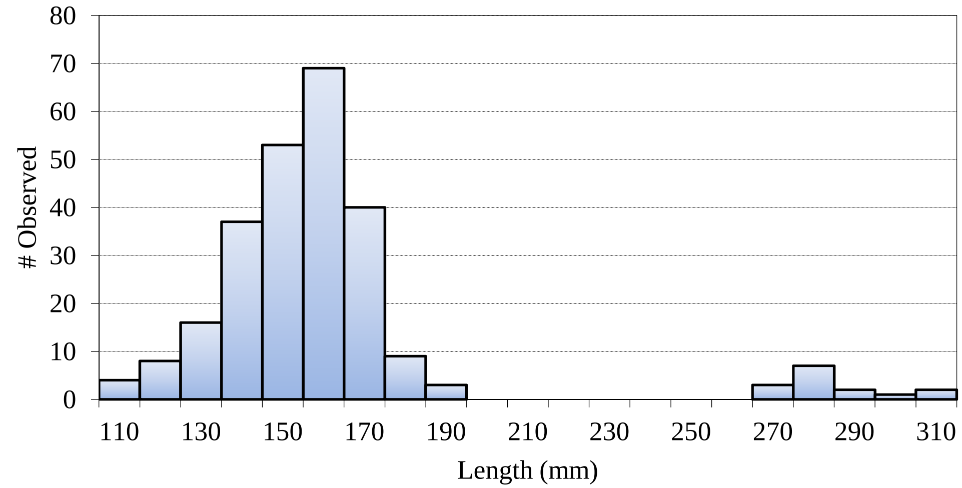

Figure 14. Length frequency distribution of walleye collected from Cadotte Lake, St. Louis County, during fall 2011 electrofishing assessments.

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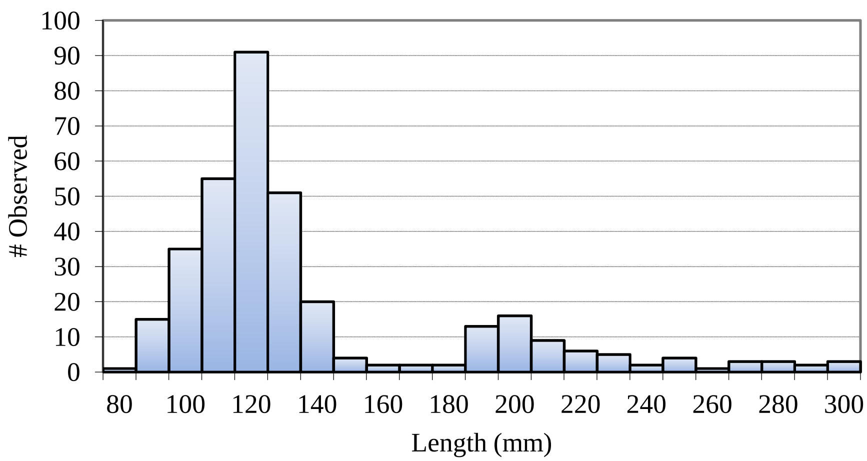


Figure 15. Length frequency distribution of walleye collected from Caribou Lake, Cook County, during fall 2011 electrofishing assessments.

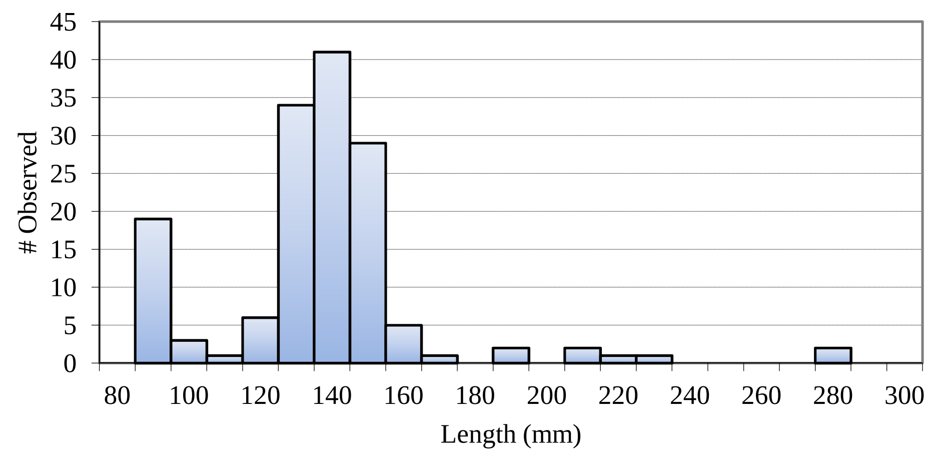


Figure 16. Length frequency distribution of walleye collected from Cascade Lake, Cook County, during fall 2011 electrofishing assessments.

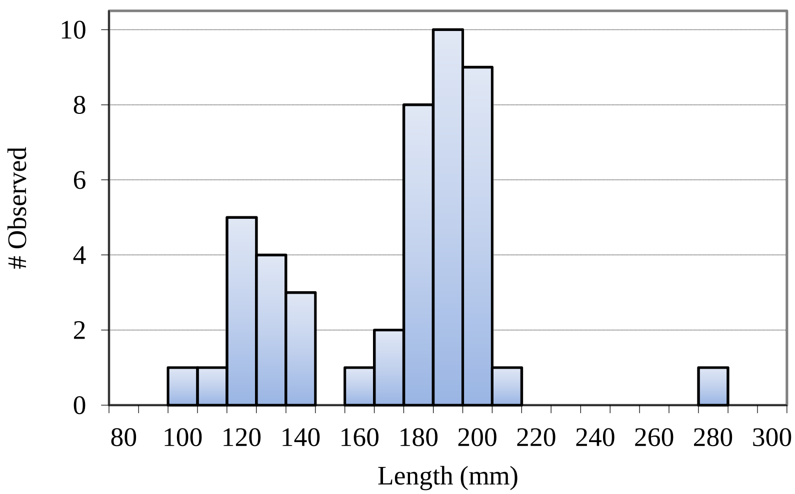


Figure 17. Length frequency distribution of walleye collected from Crescent Lake, Cook County, during fall 2011 electrofishing assessments.

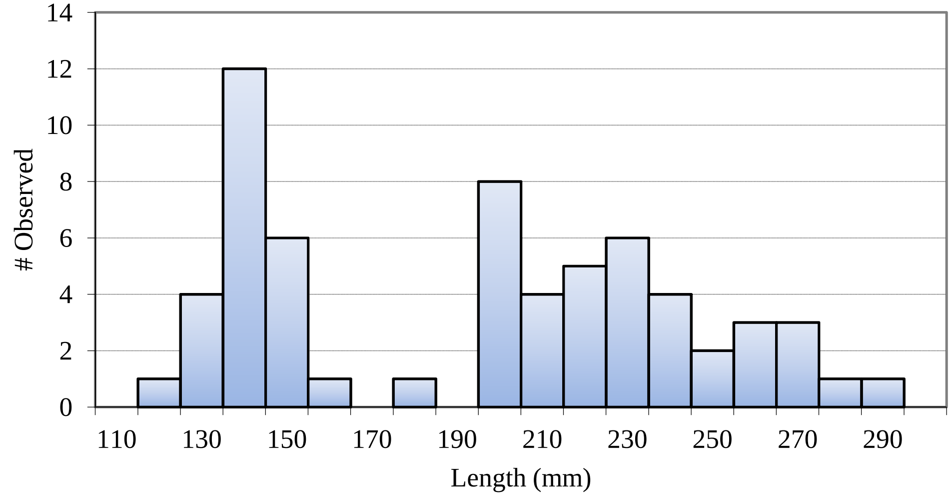


Figure 18. Length frequency distribution of walleye collected from Crooked Lake, Lake County, during fall 2011 electrofishing assessments.

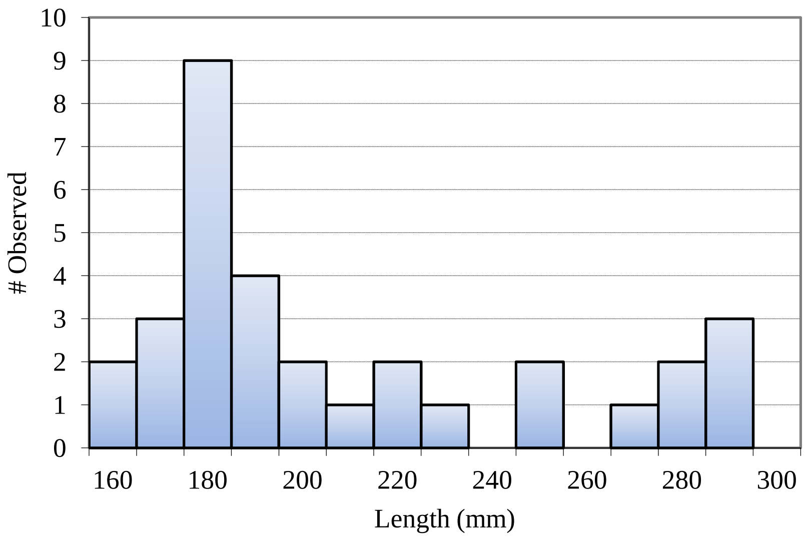


Figure 19. Length frequency distribution of walleye collected from Devilfish Lake, Cook County, during fall 2011 electrofishing assessments.

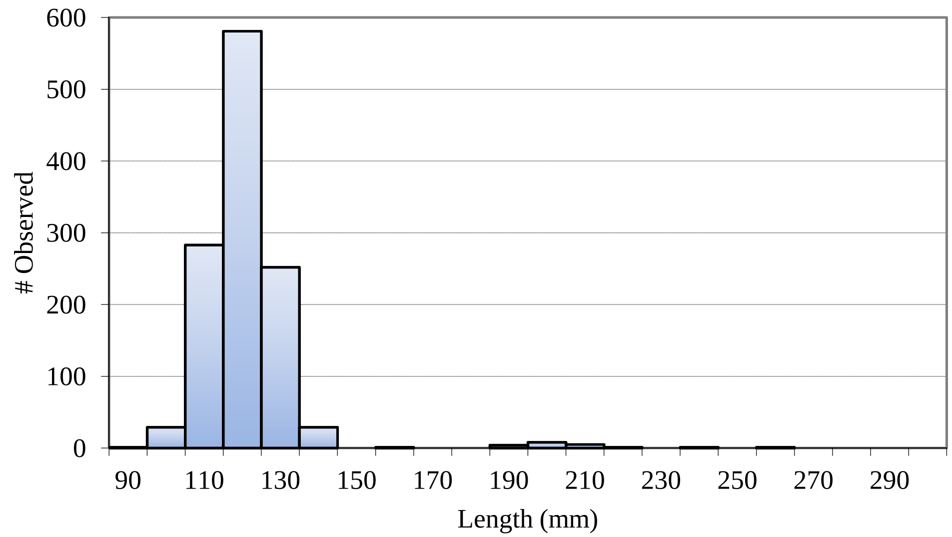


Figure 20. Length frequency distribution of walleye collected from Dumbbell Lake, Lake County, during fall 2011 electrofishing assessments.

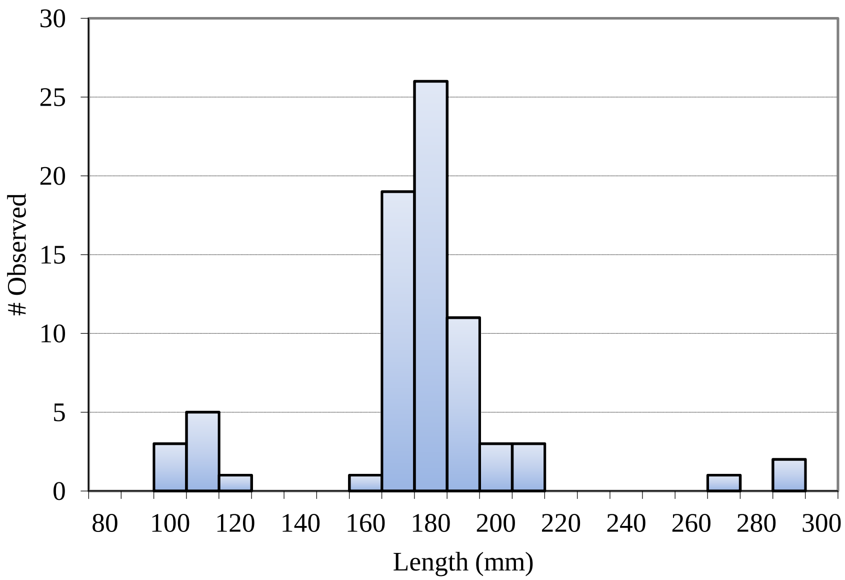


Figure 21. Length frequency distribution of walleye collected from Elbow Lake, Cook County, during fall 2011 electrofishing assessments.

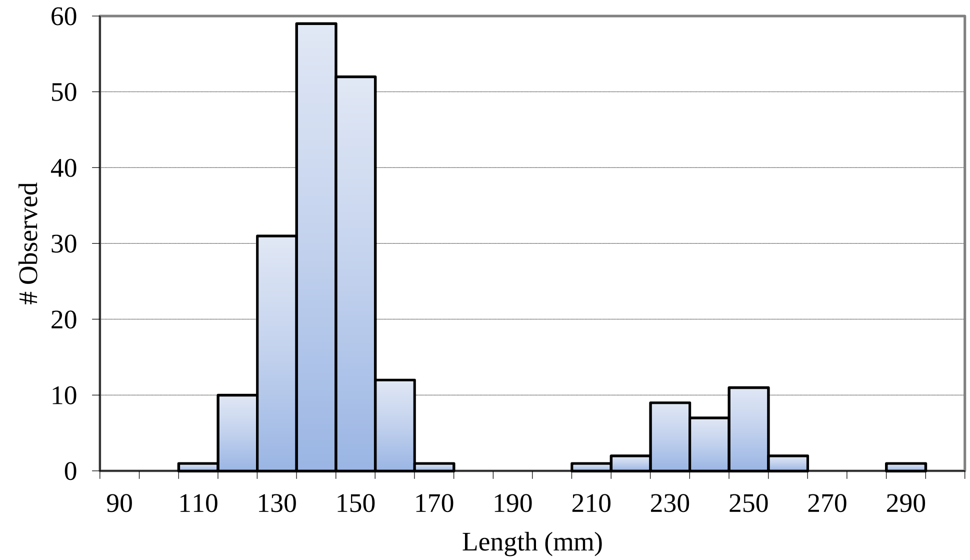


Figure 22. Length frequency distribution of walleye collected from Fourmile Lake, Cook County, during fall 2011 electrofishing assessments.

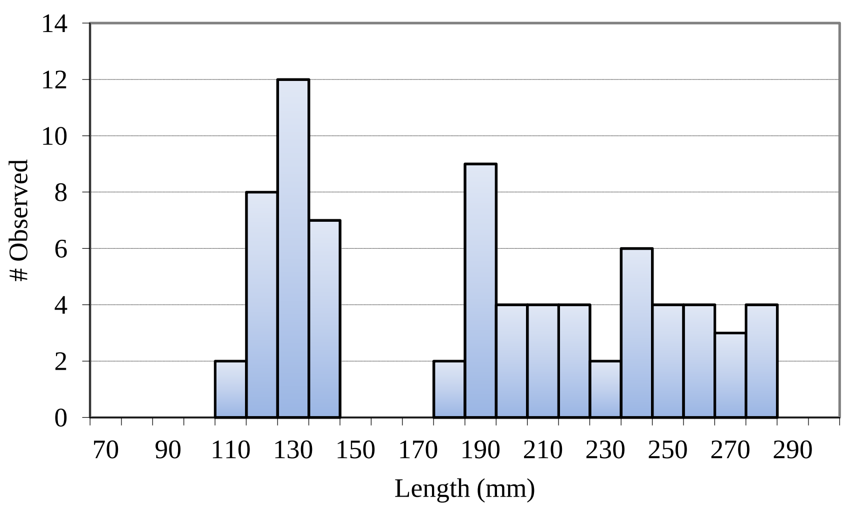


Figure 23. Length frequency distribution of walleye collected from Harriet Lake, Lake County, during fall 2011 electrofishing assessments.

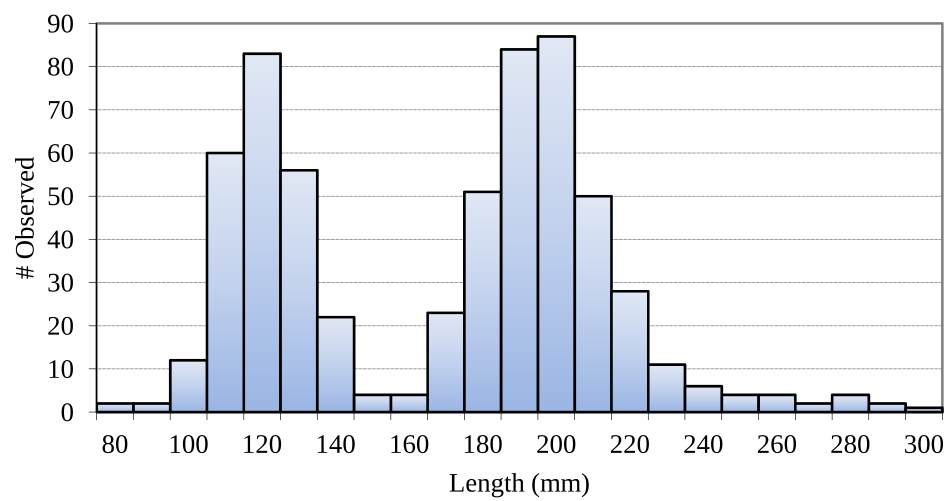


Figure 24. Length frequency distribution of walleye collected from Island Lake Res., St. Louis County, during fall 2011 electrofishing assessments.

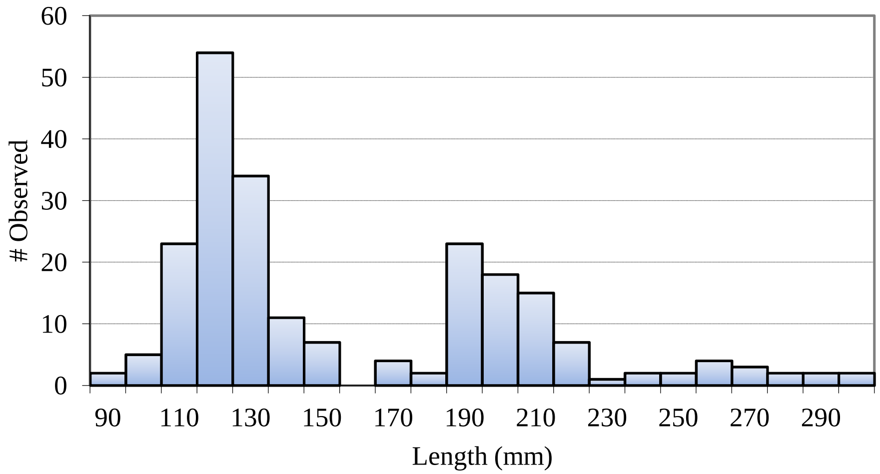


Figure 25. Length frequency distribution of walleye collected from North McDougal Lake, Lake County, during fall 2011 electrofishing assessments.

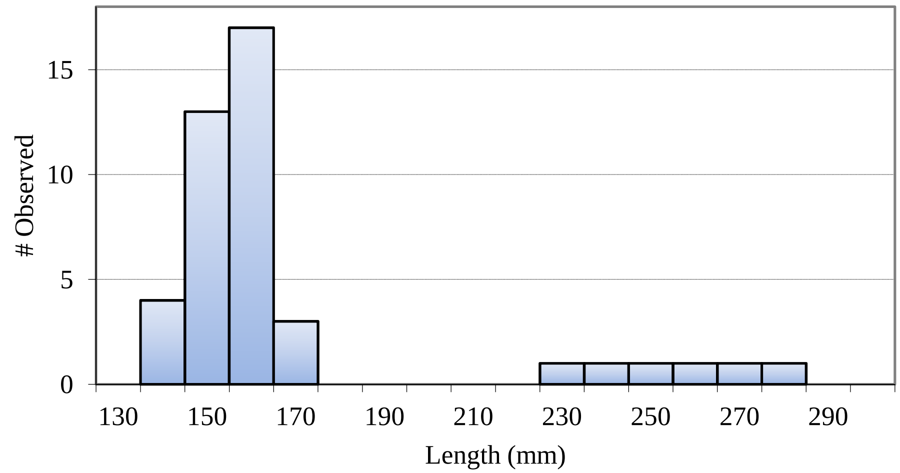


Figure 26. Length frequency distribution of walleye collected from Ninemile Lake, Lake County, during fall 2011 electrofishing assessments.

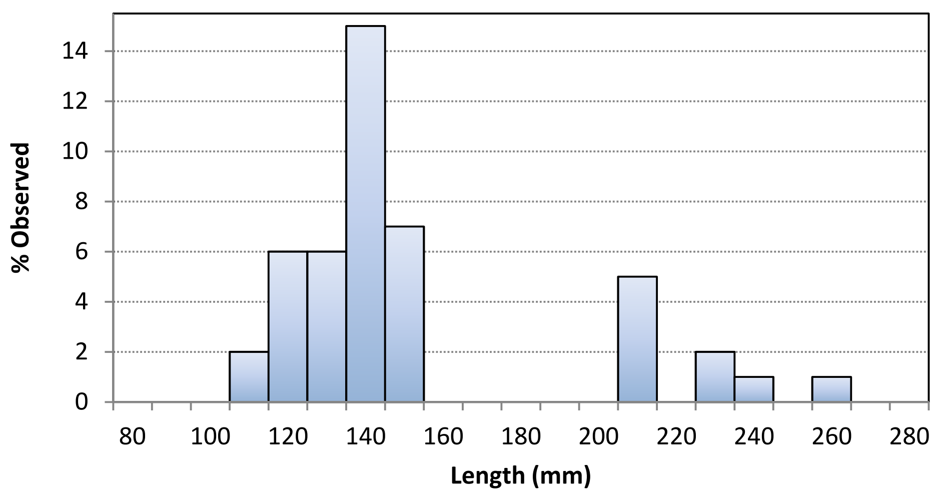


Figure 27. Length frequency distribution of walleye collected from Pike Lake, Cook County, during fall 2011 electrofishing assessments.

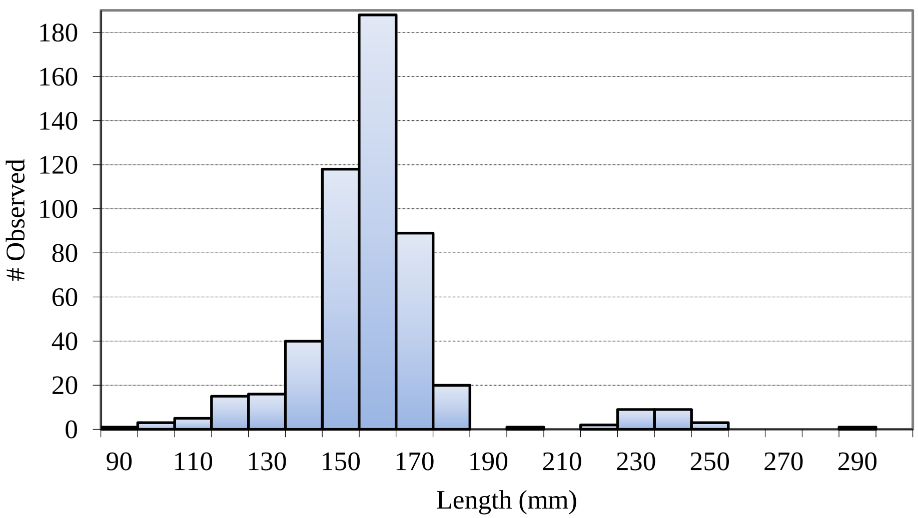


Figure 28. Length frequency distribution of walleye collected from Shagawa Lake, St. Louis County, during fall 2011 electrofishing assessments.

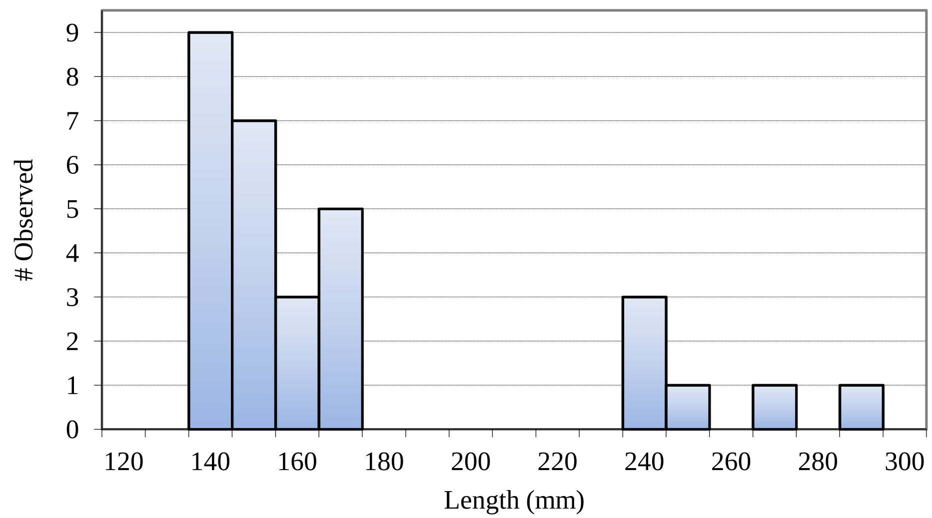


Figure 29. Length frequency distribution of walleye collected from Silver Island Lake, Lake County, during fall 2011 electrofishing assessments.

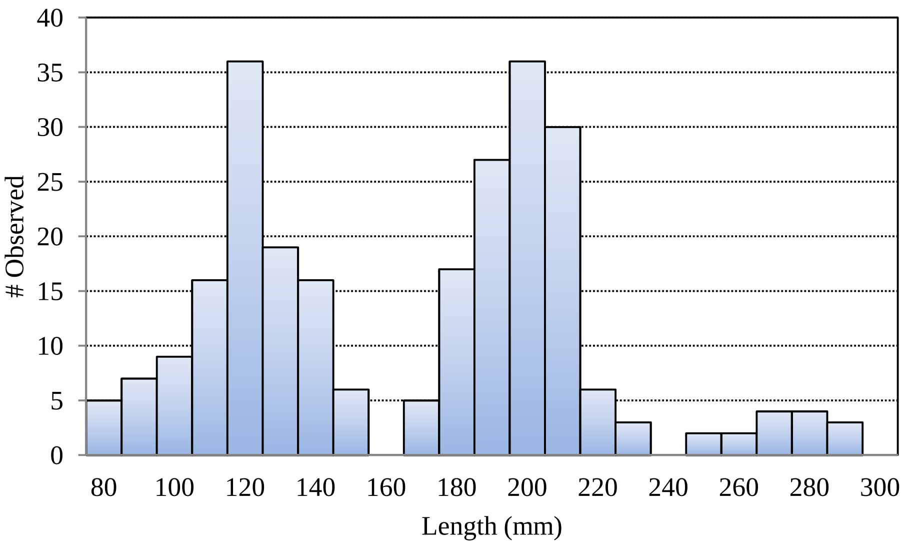


Figure 30. Length frequency distribution of walleye collected from Tait Island Lake, Cook County, during fall 2011 electrofishing assessments.

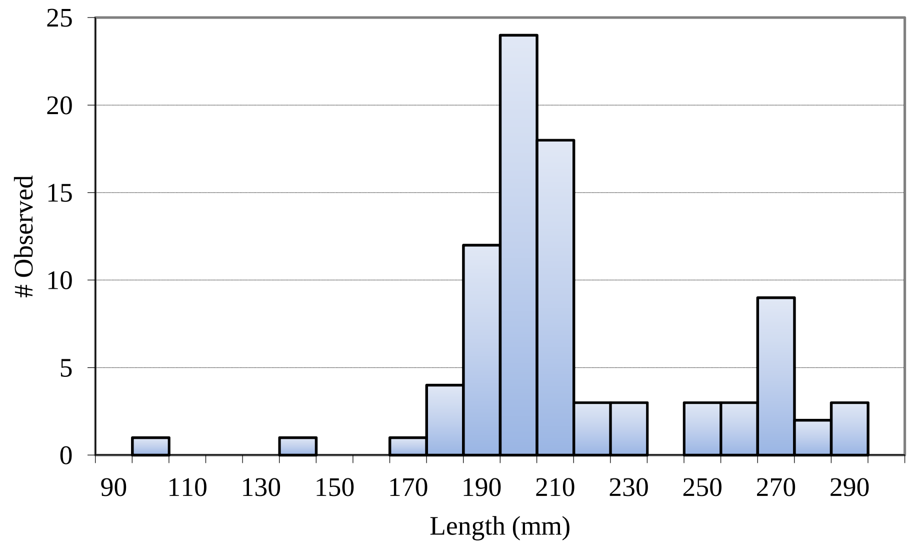


Figure 31. Length frequency distribution of walleye collected from Tom Lake Cook County, during fall 2011 electrofishing assessments.

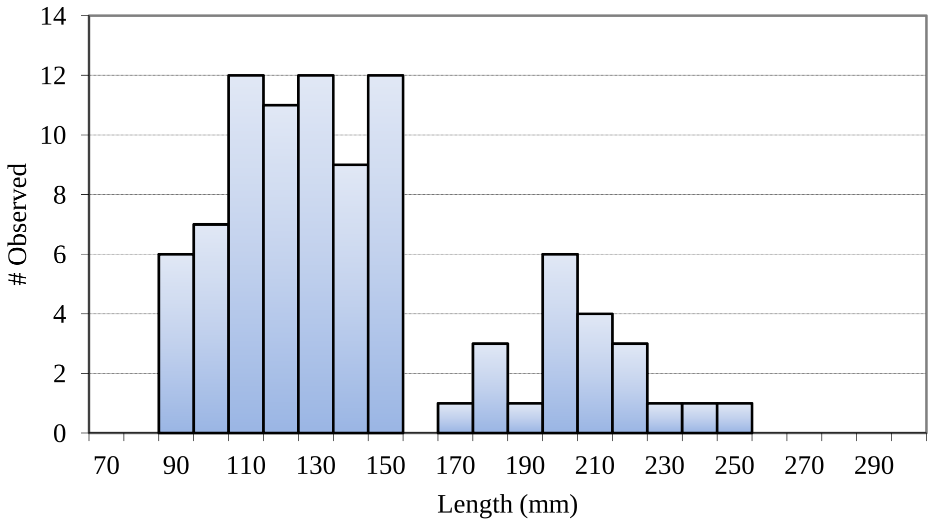


Figure 32. Length frequency distribution of walleye collected from Two Island Lake, Cook County, during fall 2011 electrofishing assessments.

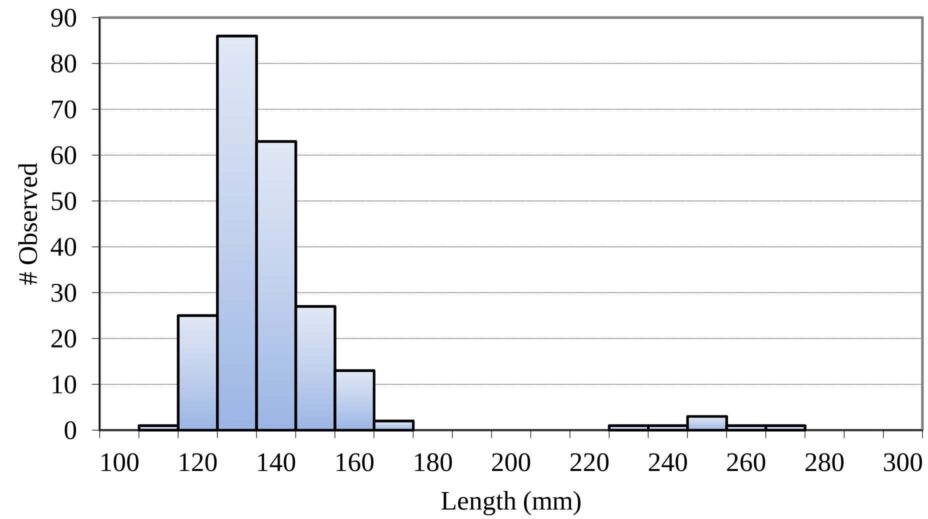


Figure 33. Length frequency distribution of walleye collected from West Twin Lake, Cook County, during fall 2011 electrofishing assessments.

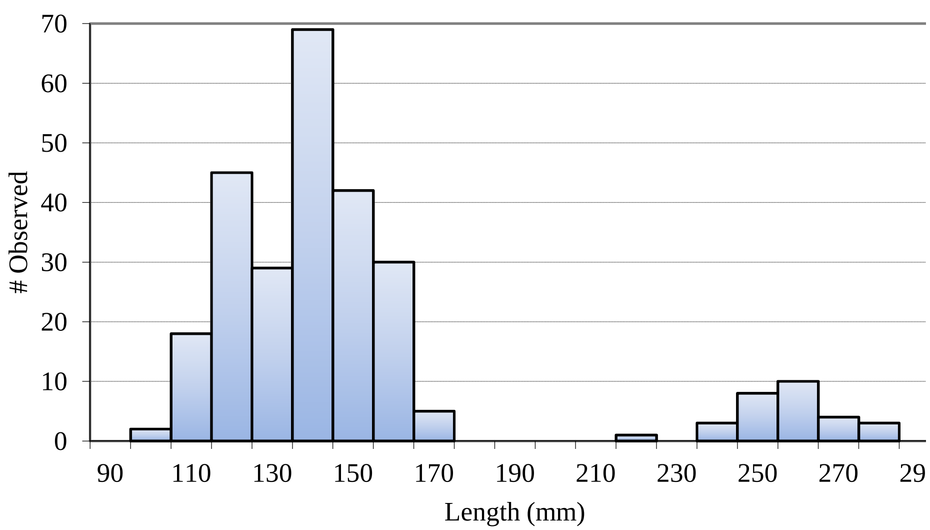


Figure 34. Length frequency distribution of walleye collected from Whiteface Reservoir, St. Louis County, during fall 2011 electrofishing assessments.

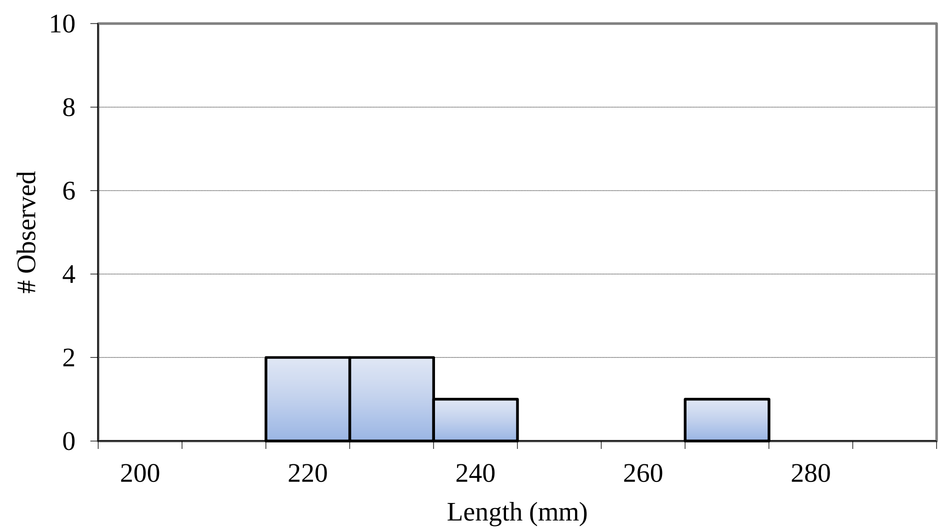


Figure 35. Length frequency distribution of walleye collected from Wild Rice Lake Reservoir, St. Louis County, during fall 2011 electrofishing assessments.

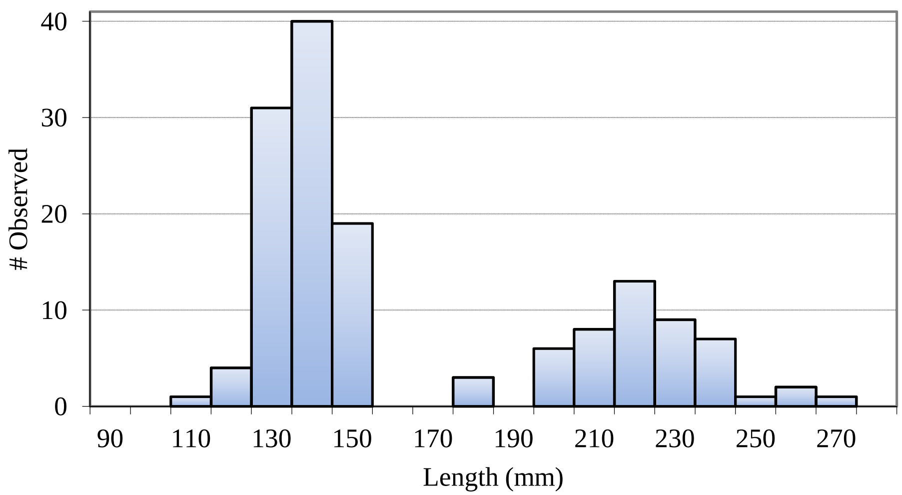


Figure 36. Length frequency distribution of walleye collected from Wilson Lake, Lake County, during fall 2011 electrofishing assessments.

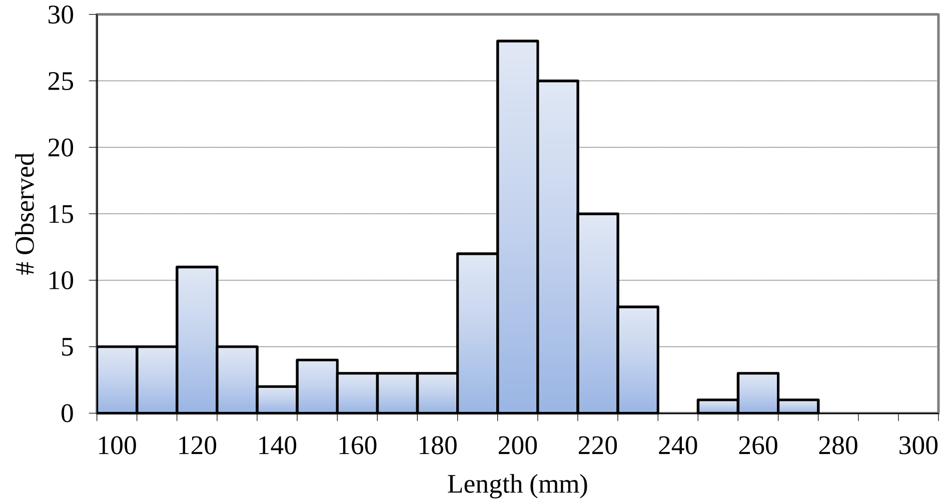
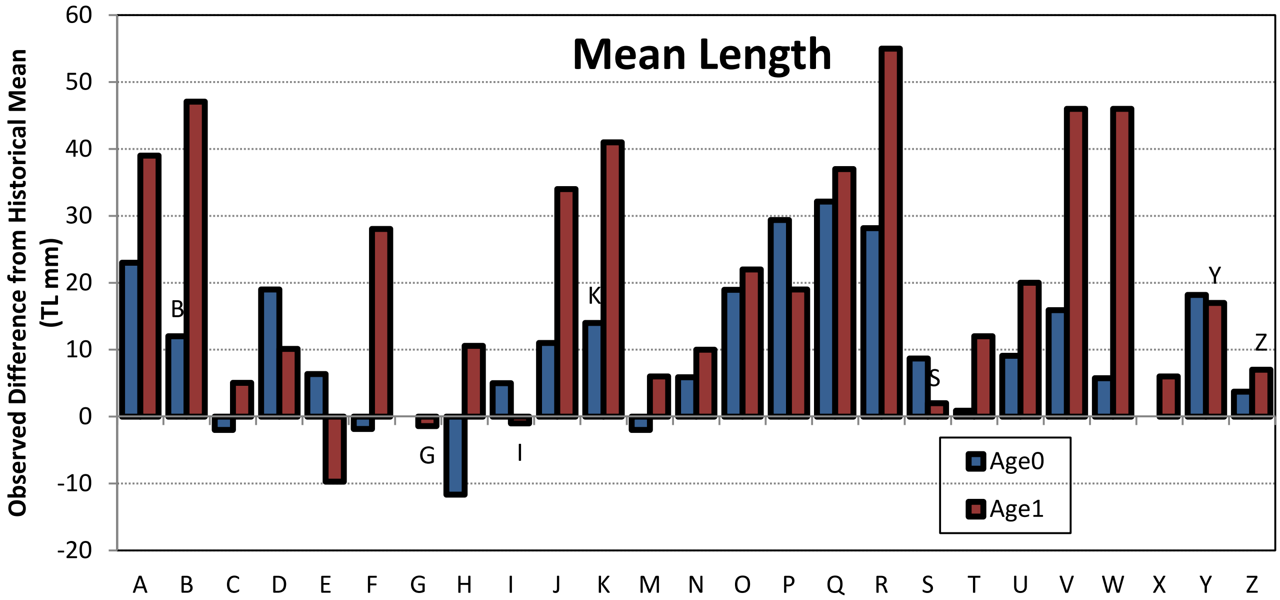


Figure 37. Length frequency distribution of walleye collected from Windy Lake, Lake County, during fall 2011 electrofishing assessments.



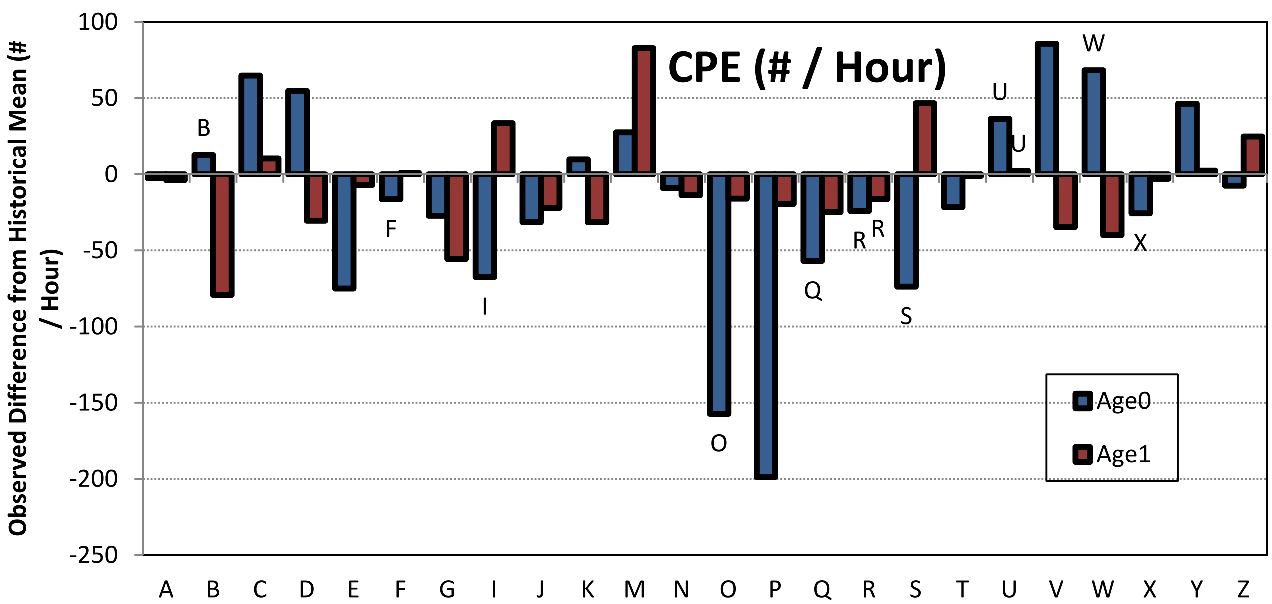


Figure 38. Plots of the differences between 2011 observed mean lengths (mm) and observed mean CPEs (# / hour) by lake and historical mean lengths and mean CPEs for age-0 and age-1 walleyes for each lake sampled during fall 2011. Each lake will have an age-0 and an age-1 point. A few data points are labeled as examples. Note that Dumbbell Lake is not included in the CPE graph, as catch rates were 752.1 age-0 / hr, and thus well above the historical average catch. The magnitude of the difference affected the scale, and made other comparisons difficult to note.

A - Ball Club
B - Cadotte
C - Caribou
D - Cascade
E - Crescent
F - Crooked
G - Devilfish

H - Dumbbell
I - Elbow
J - Fourmile
K - Harriet
M - Island

N - N. McDougal
O - Ninemile
P - Pike
Q - Shagawa
R - Silver Island
S - Tait
T - Tom

U - Two Island
V - West Twin
W - Whiteface
X - Wild Rice
Y - Wilson
Z - Windy

Appendix 1. Nightly Mark / Recapture Data for walleye > 254 mm sampled during spring 2011 assessments in Cadotte, Fourmile, and Tait Lakes, and observed in MN DNR summer gill net assessments.

Lake	Date	Marked in Population	Daily Catch	Daily Recap
Cadotte	28 April	---	301	---
	29 April	301	374	65
	30 April	610	342	132
	MNDNR GN	820	150	22
Fourmile	6 May	--	129	--
	7 May	129	189	21
	8 May	297	397	70
	9 May	624	108	31
	MNDNR GN	701	139	11
Tait	10 May	--	268	--
	11 May	268	219	71
	12 May	416	185	117
	MNDNR GN	484		