Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2012

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 2012 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. Given time and personnel constraints, we have chosen to accept conservative population estimates as a trade-off to the extra effort required to trap net for additional females.

The first objective of our assessments in 2012 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 2012 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 2012 spring survey were Silver Island Lake (Finland Area), and Ball Club, Cascade, and Devilfish Lakes (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 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 / or 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 either spiny dorsal fin clips (Ball Club and Devilfish Lakes) or non-numbered colored floy tags (red in Cascade Lake, green in Silver Island Lake) (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 2012 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

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

Cascade Lake

Ice-out during spring 2012 was one of the earliest ever on record for Minnesota. According to the MN Climatological website (http://climate.umn.edu/doc/journal/ice_out_recap_2012.htm), many lakes within the State set new records for ice-out. With the exception of just a few extreme northern lakes, most lakes were ice free in March. Electrofishing activities were conducted on Cascade Lake on 3, 9, 10, & 11 April (Figure 1). 3 April proved too early for walleye spawning activities. 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 11.9 (EF2, 3 April) to 237.9 (EF1, 9 April) adult walleye per hour of sampling (Table 1, Figure 1). At a 95% confidence interval, mean CPUE for Cascade Lake, determined using each sampling station, was 86.3 ± 41.3 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled in Cascade Lake is presented in Figure 2. Walleye as large as 593 mm (23.3 inches) were observed in the survey. Incidentally, 19 walleyes were observed to have the dorsal fin clip mark from the 2007 survey. Additional species observed included northern pike, white sucker, and yellow perch.

Cascade walleyes larger than 254 mm were marked with a non-numbered red floy tag along the distal portion of the spiny dorsal fin. Table 2 presents the population estimates based upon mark-recapture data. The electrofishing Schumacker and Eschmeyer population estimate is 1307 (Table 2). The electrofishing adjusted Petersen estimate is 1260 ± 473, with an 11.8% CV (Table 2). The population estimates presented in Table 2 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 2012, the Minnesota Department of Natural Resources performed a standardized net assessment on Cascade Lake (MN DNR, Grand Marais Area Fisheries). Sixty-seven (67) walleyes (> 330 mm) were sampled in the gill nets that would have been 254 mm during the April assessments. Twenty-three individuals were observed to have the clipped dorsal fin ray from the spring sampling (Appendix 1). The adjusted Petersen estimate using both the summer and spring data is 1400 ± 625, with a 16.1% CV (Table 2). The Schumacker and Eschmeyer population estimate from this gill net data is 1347 (Table 2). These estimates compare very closely with the spring PE's calculated (Table 2). The estimates from our 2012 surveys are not much different than those observed in 2007 (Table 2) (Borkholder and Edwards 2008).

Table 3 presents the age data for the walleye collected from Cascade Lake. Of the 532 unique fish sampled, almost half (248) were assigned to ages 4 and 5. More than 80% were assigned to age classes 3 – 7 (433). Total annual mortality (A) of the Cascade Lake population was estimated at 37.6%, using the equation $A = 1 - e^{(Z)}$, where Z is the slope of the catch-curve relationship, and an estimate of instantaneous total annual mortality (Figure 3). Table 4 presents back-calculated lengths-at-age for walleye collected from Cascade 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 53.8 ± 4.4 (Table 5) indicates a balanced population (Anderson and Weithman 1978). Further, there is a large portion of the population less than 15.0 inches that will be growing and recruiting into this “quality” 15 inch category. The summer gill net PSD (71.8 ± 10.0) was significantly different than the PSD estimate from the spring electrofishing survey (χ^2=8.9, P<0.05, critical Chi-square value of 3.841). Significant differences were observed in only the RSDS-Q metric between the electrofishing and gill net assessments during 2012 assessments (χ^2= -2.98, P<0.05, critical Chi-square value of -1.64) (Table 5).

PSD metrics calculated from the 2007 electrofishing assessments are included for comparison (Table 5) (Borkholder and Edwards 2008). Significant differences were observed between the 2012 PSD and the 2007 PSD (χ^2=27.2, P<0.05, critical Chi-square value of 3.841), and between the RSD Q-P metrics of the two assessments (χ^2=-5.2, P<0.05, critical Chi-square value of -1.64). This is largely attributable to many more individuals observed in 2007 between 10.0 and 15.0 inches, than what was observed in our 2012 survey. Our fall assessment data indicates relatively strong year classes in 2005 (age 7), 2006 (age 6), 2007 (age 5) and 2008 (age 4) (Figure 4). These four age classes are influencing the PSD values due to their relatively high abundance in the population (Table 3). Abundant age-3 and smaller age-4 individuals that are currently “stock” sized were observed in this survey (Table 3). Thus there does not seem to be a concern over lack of recruitment in recent years.

The relationships between age-0 and age-1 fall electrofishing data and adult walleye gill net data are presented in Figures 5 and 6. There may be some density dependent mechanisms affecting survival between age-0 and age-1 walleyes (Figure 5), evidenced by the decline in observed age-1 walleyes with high densities of age-0 individuals. Values of age-1 CPE above the red dotted 1:1 line would indicate that we observed more age-1 walleyes per hour than what we observed as age-0. We hypothesize that very small individuals may not be as catchable with electrofishing as we have assumed that they are. Thus, we don’t see them as very small age-0 walleyes, but we do at the larger size of age-1 individuals. We’ve always assumed equal catchability of walleyes across all size classes. This may not be the case, and may be a question to answer in subsequent studies.

The relationships observed between the age-0 and age-1 CPE data and the adult gill net CPE data suggest that there may be some utility in using age-0 and age-1 fall CPE data to identify subsequent adult abundance (Figure 6).

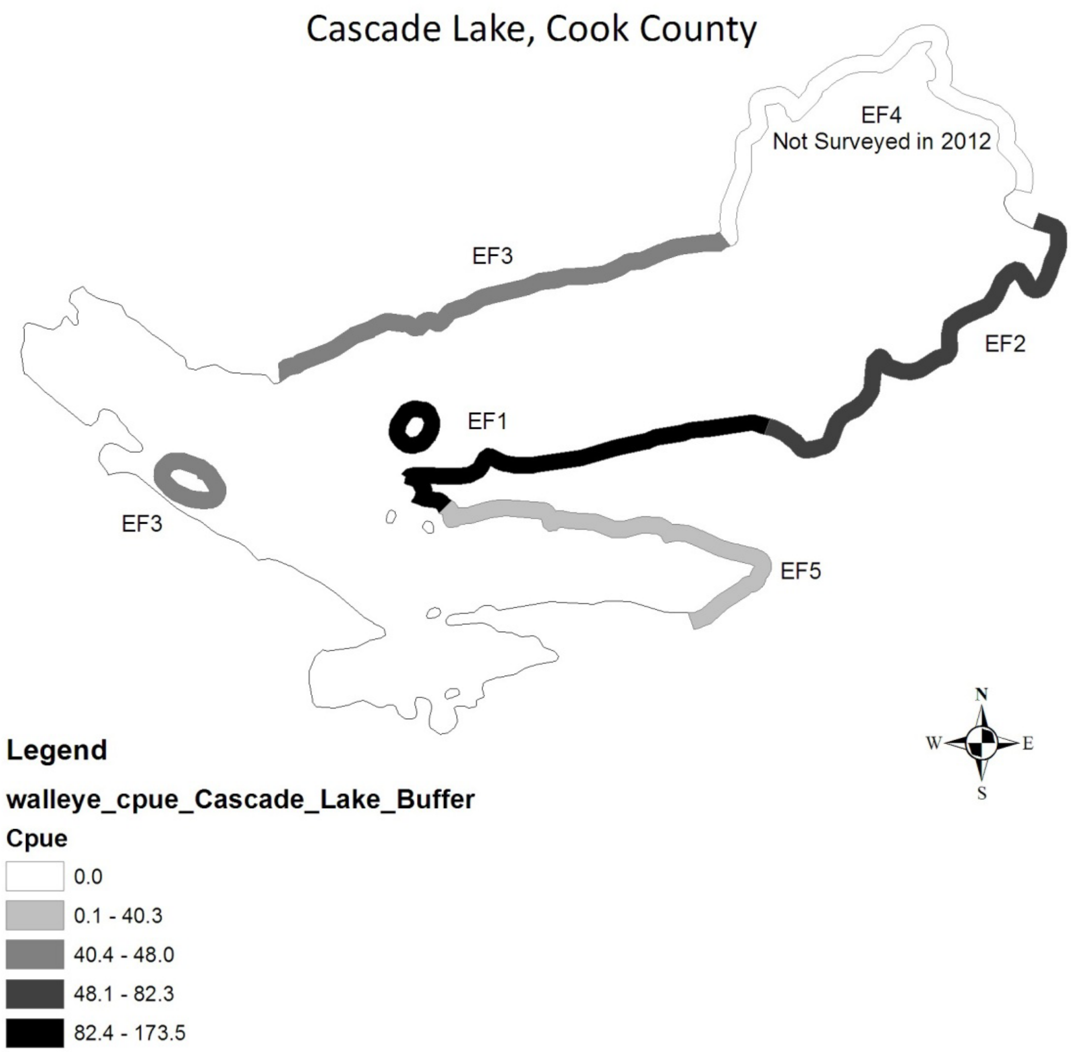

Figure 1. Catch per hour (CPE) of adult walleyes by electrofishing station, on Cascade Lake, Cook County, during spring 2012 electrofishing surveys.

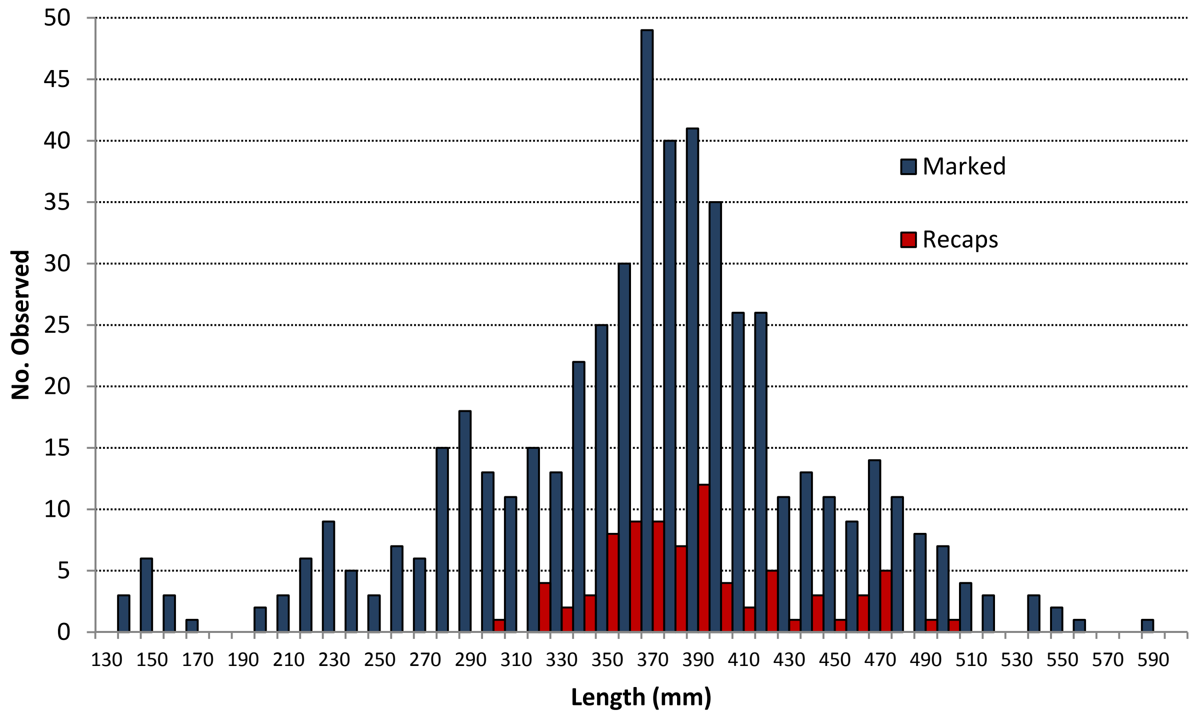

Figure 2. Length frequency distribution of walleye sampled from Cascade Lake, Cook County, MN, during spring 2012 electrofishing assessments. Length frequency distribution of recaptured walleyes is shown in red bars.

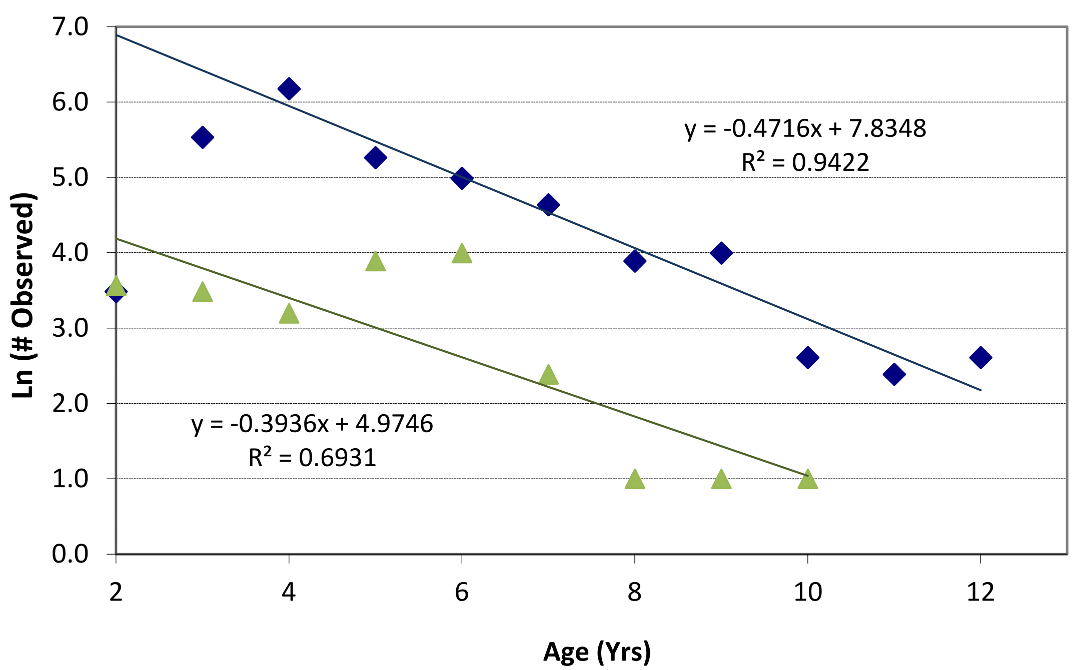

Figure 3. Catch curve analysis of walleyes in Cascade Lake, 2012, showing instantaneous mortality (*Z*). Estimates are made from April 2012 electrofishing data (blue diamonds), and from summer 2012 gill net assessments by the MNDNR (green triangles).

Table 1. Summary of electrofishing activities on four lakes surveyed within the 1854 Ceded Territory, Minnesota, during Spring 2012.

ID #	County	Lake	Area (Acres)	Max Depth	Date	Water Temp (F)	Conductivity[1]	Shocking Time (sec)	Voltage (PDC)	Amps	# WAE[2]	CPUE WAE[3]
16-0346	Cook	Cascade	451.5	17	4/3/2012	40	26.9	6414	High (45%)[4]	0.75	49	27.5
					4/9/2012	40	29.3	6527	High (45%)[4]	0.5	246	135.7
					4/10/2012	41	26.8	4520	High (45%)[4]	0.5	132	105.1
					4/11/2012	42	27.4	6759	High (40%)[4]	0.5	161	85.8
38-0219	Lake	Silver Island	1239	15	4/12/2012	46	44.9	5662	High (15%)[4]	1.0	342	217.4
					4/13/2012	46	45.0	6046	High (15%)[4]	0.5	242	144.1
					4/14/2012	46	45.4	5969	High (15%)[4]	0.5	267	161.0
16-0182	Cook	Ball Club	196	25	4/9/2012	43	26.0	2205	1061	2	43	70.2
					4/10/2012	44	26.4	5389	1061	4	88	58.8
					4/11/2012	45	27.2	5145	1061	3	88	61.6
					4/12/2012	45	26.2	4568	1061	3	98	77.2
					4/13/2012	46	26.3	3494	1061	4	46	47.4
16-0029	Cook	Devilfish	405	40	4/14/2012	46	21.0	8295	1061	3	151	65.5
					4/17/2012	43	20.4	7968	1061	2	141	63.7
					4/18/2012	42	21.3	8209	1061	2	122	53.5

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 Cascade, Silver Island, Ball Club, and Devilfish Lakes, Spring 2012. 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.

Lake	Population Estimate[1]	95% Confidence Limits Lower	Upper	Estimate[2]	C.V.[3]
Cascade – EF_{2012}	1307	1211	1420	1260 ± 473	11.8 %
Cascade – GN_{2012}	1347	1249	1462	1400 ± 625	16.1 %
Cascade – EF_{2007}	1166	851	1845	994 ± 256	8.1%
Cascade – GN_{2007}	1311	933	2204	2031 ± 1042	18.5%
Silver Island – EF_{2012}	1475	1387	1574	1487 ± 525	8.2%
Silver Island – GN_{2012}	2162	1231	8867	6094 ± 3180	22.2%
Silver Island – EF_{2008}	1586	1141	2601	1712 ± 785	10.7%
Silver Island – GN_{2008}	2705	1145	N/A	9762 ± 8667	21.8%
Silver Island – EF_{2003}	1137	-----[4]	-----[4]	1127 ± 530	10.9%
Silver Island - GN_{2003}	2063	-----[4]	-----[4]	5179 ± 6137	27.5%
Ball Club – EF_{2012}	916	725	1245	558 ± 303	19.6%
Ball Club – GN_{2012}	990	825	1236	1051 ± 720	26.6%
Ball Club – EF_{2004}	1216	872	2013	1331 ± 305	9.7%
Ball Club – GN_{2004}	1397	1000	2321	2258 ± 1147	21.6%
Devilfish – EF_{2012}	763	675	877	774 ± 424	12.8%
Devilfish – GN_{2012}	902	564	2248	1808 ± 1960	34.1%
Devilfish – EF_{2004}	495	412	620	494 ± 341	16.0%
Devilfish – GN_{2004}	736	405	4036	2018 ± 2721	42.4%

[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*)

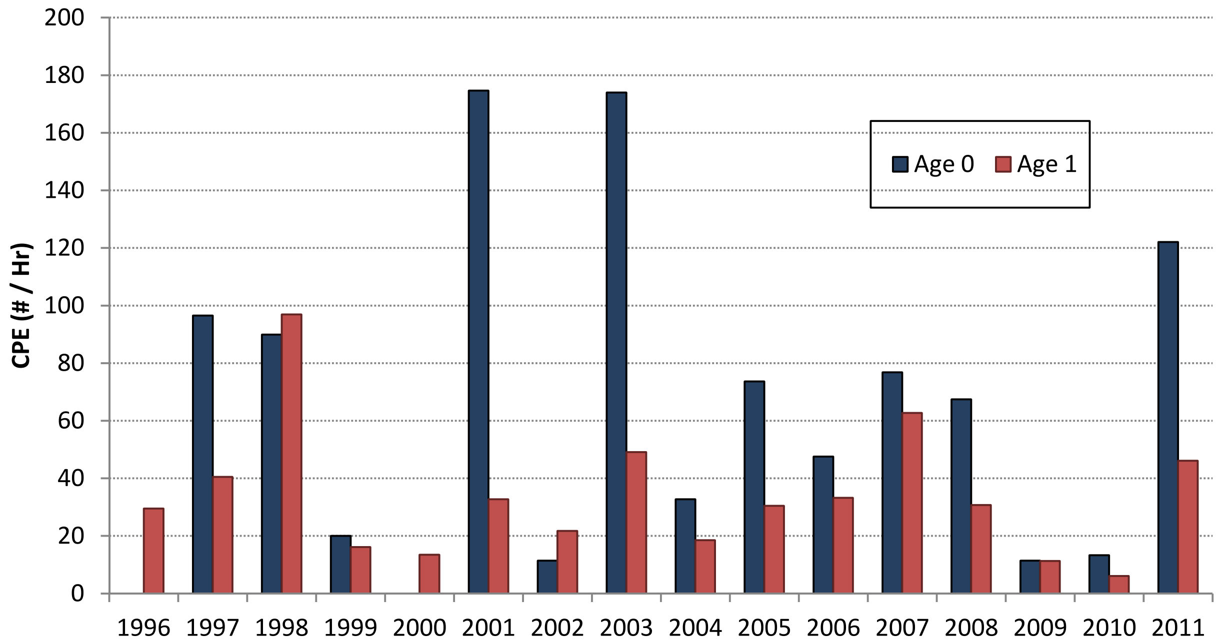

Figure 4. Age-0 and age-1 fall electrofishing catch-per-hour (CPE) data from Cascade Lake, since 1996.

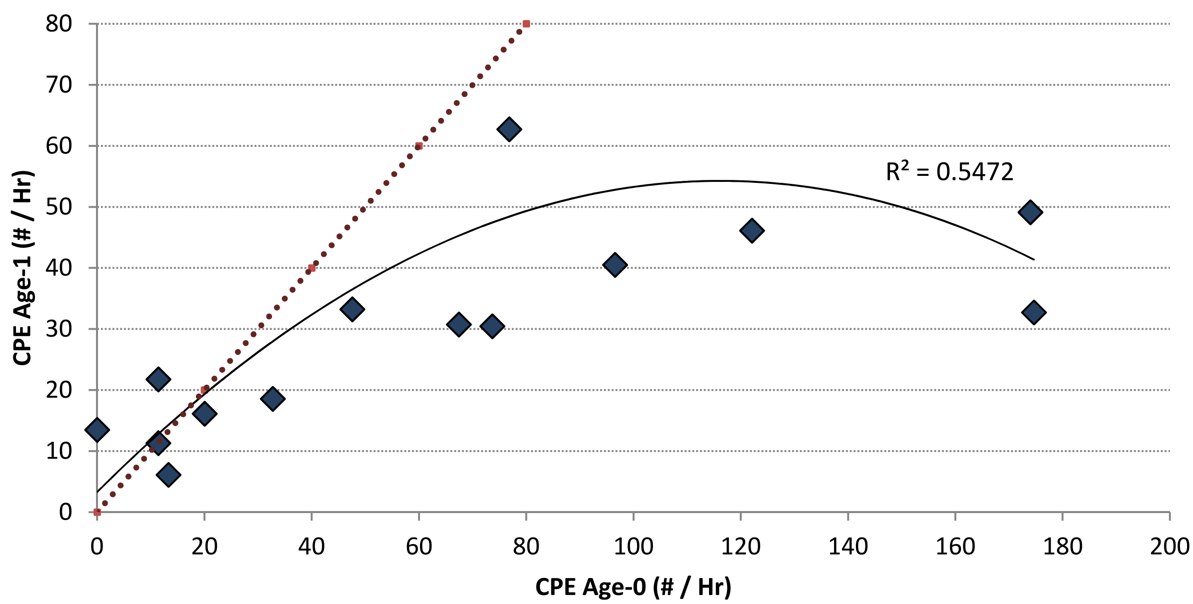

Figure 5. The relationship between age-0 fall electrofishing catch-per-hour (CPE) data in year$_{i}$, and fall CPE data of the same cohort as age-1 in year$_{i+1}$, from Cascade Lake since 1996. The red dotted line is a 1:1 line.

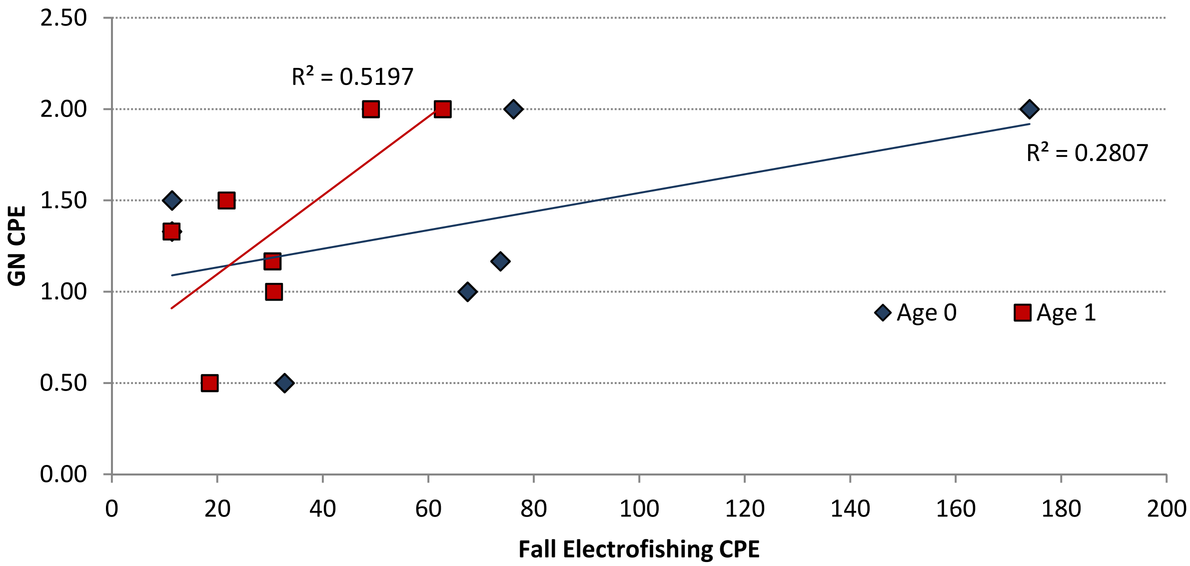

Figure 6. Relationship between fall electrofishing catch rates (#/hr) of age-0 (blue points) and age-1 (red points) walleyes, and the subsequent catch of the same cohorts as adults in the MN DNR gill nets in Cascade Lake. Cohorts selected for analysis are from the 2002 year class through the 2010 year class, and only use the gill net data for ages 2 - 5.

Table 4. Back-calculated lengths-at-age for walleye collected from Cascade Lake, Cook County, Minnesota, April 2012.

Age Class	N	Length (mm)	Length (in)
1	183	123	4.8
2	183	204	8
3	177	272	10.7
4	151	325	12.8
5	117	368	14.5
6	89	401	15.8
7	63	432	17
8	44	452	17.8
9	28	474	18.7
10	13	479	18.9
11	7	521	20.5
12	6	556	21.9
13	3	613	24.1
14	3	638	25.1
15	3	657	25.9

Table 3. Age frequency distribution of walleye from Cascade Lake, Cook County, spring 2012, 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
5.5	140	4	4										
6	152	7	7										
6.5	165	2	2										
8	203	4	4										
8.5	216	7	7										
9.0	229	9	9										
9.5	241	5	5										
10.0	254	7	5	2									
10.5	267	9	2	7									
11.0	279	20		20									
11.5	292	19		19									
12.0	305	16		16									
12.5	318	19		11	8								
13.0	330	20		14	6								
13.5	343	26		4	18	4							
14.0	356	38			38								
14.5	368	55			48	7							
15.0	381	55			22	28	5						
15.5	394	54			27	11	11	5					
16.0	406	32			5	6	16	5					
16.5	419	30			5	10	10	5					
17.0	432	13				4	2	4	2				
17.5	445	17				1	7	4	2		2		
18.0	457	10					3	4	3	1			
18.5	470	16						4	2	6	2		2
19.0	483	14						4	4	4		2	
19.5	495	9							2	5		1	1
20.0	508	5						3	1		1		
20.5	521	3								2			1
21.0	533	1								1			
21.5	546	3							1			1	
22.0	559	2							1	1			
22.5	572	0											
23.0	584	1											1
TOTAL		532	45	93	177	71	54	38	18	20	5	4	5

Table 5. Proportional Stock Density (PSD) and Relative Stock Densities (RSD) with 95% confidence intervals for walleye sampled from Cascade , Ball Club, and Devilfish Lakes (Cook County), and Silver Island Lake (Lake County) 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
Cascade – EF_{2012}	53.8 ± 4.4	46.2 ± 4.4	50.7 ± 4.4	3.0 ± 1.5	0.0 ± 0.0
Cascade – GN_{2012}	71.8 ± 10.0	28.2 ± 10.0	66.7 ± 10.5	5.1 ± 4.9	0.0 ± 0.0
Cascade – EF_{2007}	37.8 ± 4.0	62.2 ± 4.0	35.0 ± 3.9	2.6 ± 1.3	0.2 ± 0.3
Cascade – GN_{2007}	57.1 ± 15.0	48.3 ± 18.2	44.8 ± 18.1	6.9 ± 9.2	0.0 ± 0.0
Silver Island – EF_{2012}	30.2 ± 3.5	69.8 ± 3.5	29.6 ± 3.4	0.3 ± 0.4	0.3 ± 0.4
Silver Island – GN_{2012}	27.7 ± 7.2	72.3 ± 7.2	24.3 ± 6.9	3.4 ± 2.9	0.0 ± 0.0
Silver Island – EF_{2008}	36.7 ± 3.7	63.3 ± 3.7	34.4 ± 3.7	1.6 ± 1.0	0.8 ± 0.7
Silver Island – GN_{2008}	23.1 ± 6.3	76.9 ± 6.3	18.5 ± 5.8	2.9 ± 2.6	1.7 ± 2.0
Silver Island – EF_{2003}	45.4 ± 4.6	54.6 ± 4.6	42.8 ± 4.5	2.4 ± 1.4	0.2 ± 0.4
Ball Club – EF_{2012}	62.6 ± 5.1	37.4 ± 5.1	62.0 ± 5.1	0.3 ± 0.6	0.3 ± 0.6
Ball Club – GN_{2012}	32.8 ± 12.1	67.2 ± 12.1	32.8± 12.1	0.0 ± 0.0	0.0 ± 0.0
Ball Club – EF_{2004}	47.7 ± 4.1	52.3 ± 4.1	42.7 ± 4.1	5.0 ± 1.8	0.0 ± 0.0
Ball Club – GN_{2004}	30.8 ± 17.7	69.2 ± 17.7	29.9 ± 17.5	3.8 ± 7.4	0.0 ± 0.0
Devilfish – EF_{2012}	12.2 ± 3.5	87.8 ± 3.5	11.3 ± 3.8	0.6 ± 0.8	0.3 ± 0.6
Devilfish – GN_{2012}	30.3 ± 15.7	69.7 ± 15.7	69.7 ± 15.7	0.0 ± 0.0	0.0 ± 0.0
Devilfish – EF_{2004}	44.2 ± 6.8	55.8 ± 6.8	40.4 ± 6.7	3.8 ± 2.6	0.0 ± 0.0
Devilfish – GN_{2004}	21.0 ± 13.0	79.0 ± 13.0	10.5 ± 9.8	10.5 ± 9.8	0.0 ± 0.0

Silver Island Lake

Electrofishing activities were conducted on Silver Island Lake from 12 - 14 April (Figure 7). 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 140 adult walleye per hour of sampling (Table 1). Catch rates ranged from 114.8 walleye / hour (EFC, 14 April) to 338.4 walleye / hour (EFA, 14 April) (Figure 7). At a 95% confidence interval, mean CPUE for Silver Island Lake, determined using each sampling station, was 207.5 ± 32.3 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 Silver Island is presented in Figure 8. Table 6 presents the age data for the walleye collected from Silver Island Lake. Of the 703 walleye sampled, 600 were assigned ages 4 - 6. Fall electrofishing assessments of age-0 and age-1 walleyes in Silver Island indicate relatively abundant age-1 individuals in the 2006 and 2008 cohorts (Figure 9), corresponding to age-6 and age 4 walleyes in 2012, respectfully. The relationship between age-0 and age-1 CPE in the fall suggests that there may be a relationship between age-0 walleye density in year 1 and age-1 density in year 2 (Figure 10). The subsequent catch of each cohort as adult walleye in the gill nets is presented in Figure 11. In Silver Island, there does not appear to be a relationship between fall electrofishing, and recruitment to adults (Figure 11). Year class strength in Silver Island may be set by factors other than abundance of juvenile walleyes.

Table 7 presents back-calculated lengths-at-age for walleye collected from Silver Island Lake. Instantaneous mortality (*Z*) for the Silver Island Lake walleye population was estimated at 59.0% using the electrofishing data, and 46.5% using the MNDNR gill net data (Figure 12). Total annual mortality (*A*) was estimated at 44.5% using the electrofishing data, and 37.2% using the MNDNR gill net data. These estimates are almost identical to what was estimated from the 2008 survey, when instantaneous mortality (Z) was estimated at 53.7%, and total annual mortality at 41.6% (Borkholder and Edwards 2009).

Table 2 presents the population estimates based upon mark-recapture data. The electrofishing Schumacker and Eschmeyer population estimate is 1475 (Table 2). The electrofishing adjusted Petersen estimate is 1487 ± 525 with an 8.2% CV (Table 2). These estimates represent the population abundance of walleye using the sampled areas for spawning, and are not assumed to be estimates of the walleye population within the entire lake. During summer 2012, the Minnesota Department of Natural Resources performed a standardized net assessment on Silver Island Lake (MN DNR, Finland Area Fisheries), sampling 147 walleyes (> 264 mm) in the gill nets that would have been 254 mm during the May assessments. Sixteen individuals were observed to have the colored floy tag and clipped dorsal fin from the spring sampling (Appendix 1). The adjusted Petersen estimate using both the summer and spring data is 6094 ± 3180, with a 22.2% CV (Table 2). The Schumacker and Eschmeyer population estimate from the net data is 2162 (Table 2). The estimates from our electrofishing survey are in line with those observed during previous surveys of Silver Island (Borkholder and Edwards 2004; Borkholder and Edwards 2009) (Table 2).

PSD and RSD values determined by our spring electrofishing sampling are presented in Table 5. The electrofishing PSD of 30.2 ± 3.5 (Table 5) suggests the population is balanced, though characterized by smaller individuals (Anderson and Weithman 1978). The gill net PSD of 27.7 ± 7.2 was not significantly different from the electrofishing PSD estimate (χ^2=0.37, P>0.05, critical Chi-square value of 3.841) (Table 5). PSD metrics calculated from the 2008 assessments are included for comparison (Table 5) (Borkholder and Edwards 2009). Significant differences were observed between the 2012 PSD and the 2008 PSD (χ^2=6.40, P<0.05, critical Chi-square value of 3.841). This would suggest that the stock structure may have changed since 2008, with fewer quality to preferred length walleye observed in 2012.

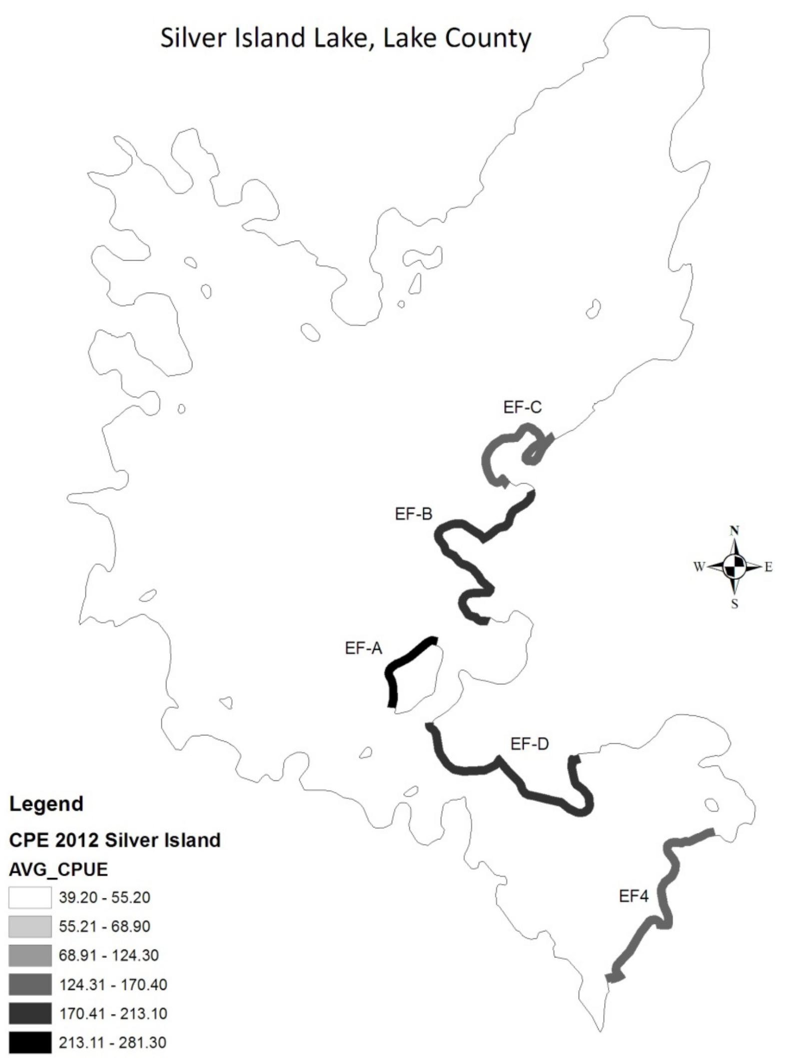

Figure 7. Catch per hour (CPE) of adult walleyes by electrofishing station, on Silver Island Lake, Lake County, during spring 2012 electrofishing surveys.

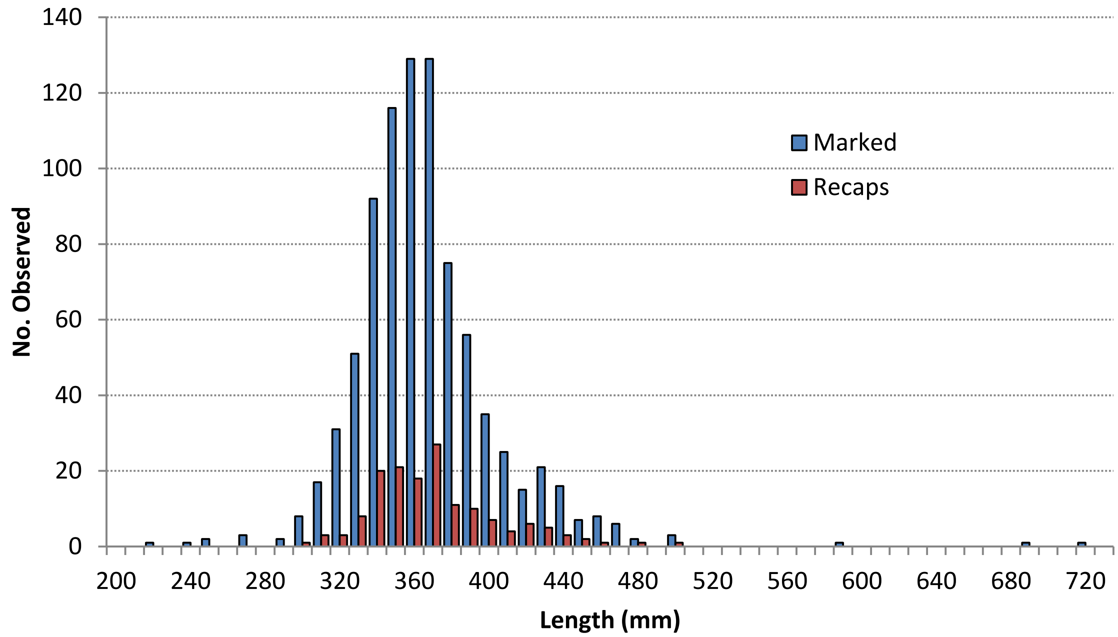

Figure 8. Length frequency distribution of walleye sampled from Silver Island Lake, Lake County, during spring 2012 electrofishing surveys. Blue bars represent unmarked walleyes observed, while red bars represent the length frequency distribution of the recaptured walleyes observed.

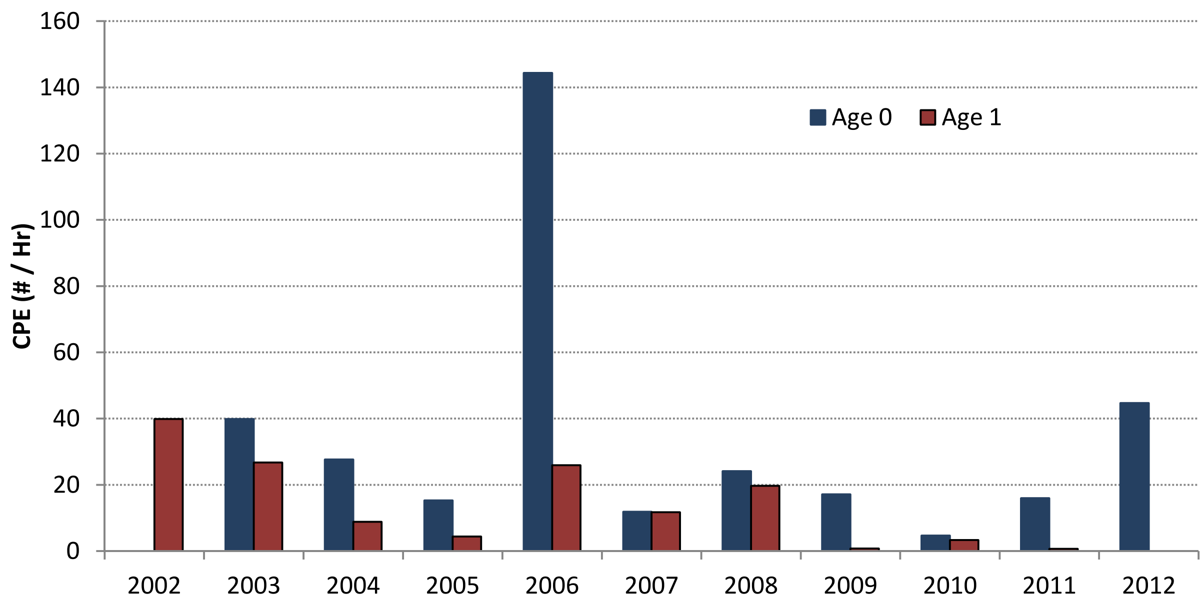

Figure 9. Age-0 and age-1 fall electrofishing catch-per-hour (CPE) data from Silver Island Lake, since 2002.

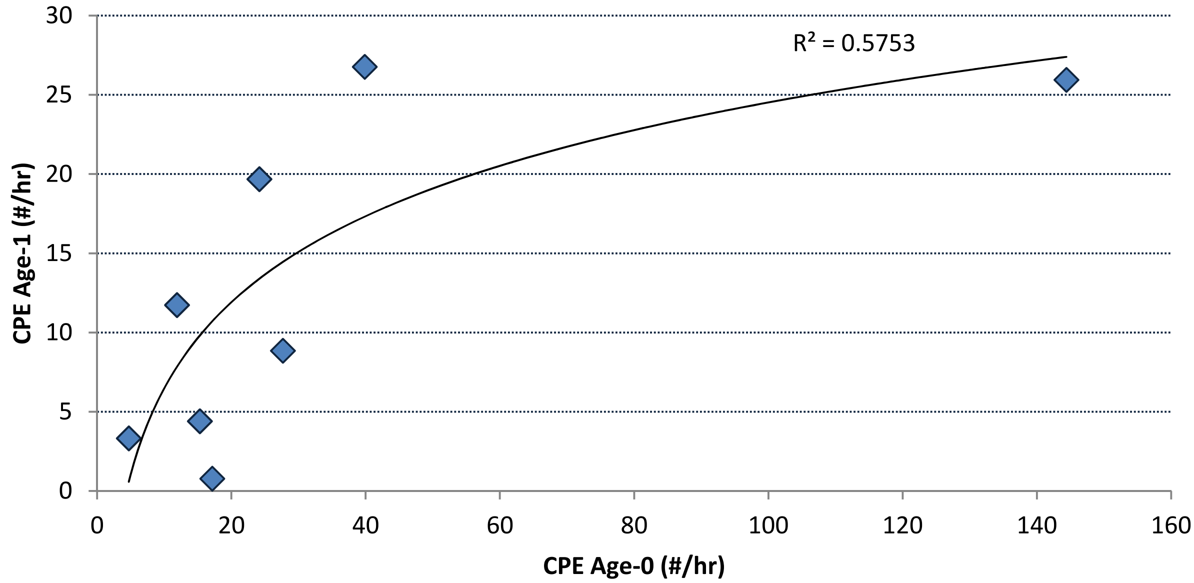

Figure 10. The relationship between age-0 fall electrofishing catch-per-hour (CPE) data in $year_i$, and fall CPE data of the same cohort as age-1 in $year_{i+1}$, from Silver Island Lake since 2003.

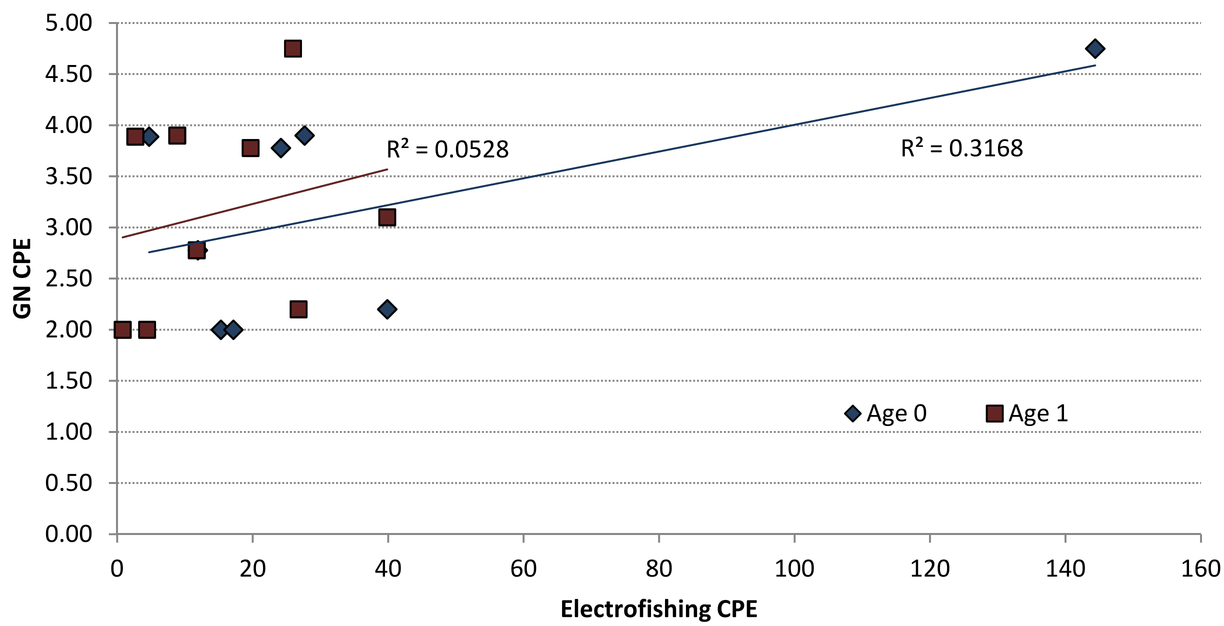

Figure 11. Relationship between fall electrofishing catch rates (#/hr) of age-0 (blue points) and age-1 (red points) walleyes, and the subsequent catch of the same cohorts as adults in the MN DNR gill nets in Silver Island Lake. Cohorts selected for analysis are from the 2002 year class through the 2010 year class, and only use the gill net data for ages 2 - 5.

Table 6. Age frequency distribution of walleye from Silver Island Lake, Lake County, spring 2012, 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	14	15	16	17
8.5	191	1	1															
9.0	229	0																
9.5	241	3	2	1														
10.0	254																	
10.5	267	3	1	2														
11.0	279																	
11.5	292	4		2	2													
12.0	305	13		8	5													
12.5	318	37		7	30													
13.0	330	63			63													
13.5	343	101			56	34	11											
14.0	356	143			24	48	72											
14.5	368	123			22	78	22											
15.0	381	75			8	59			8									
15.5	394	43					35	4	4									
16.0	406	31				9	15	3	3									
16.5	419	12					4	5	2	1	1							
17.0	432	17					3		8	3	3							
17.5	445	13						6	3	3	1							
18.0	457	8						2	2	3	1							
18.5	470	7							1	1	1	1	1					
19.0	483																	
19.5	495	1											1					
20.0	508	1									1							
20.5	521																	
21.0	533																	
21.5	546	1													1			
23.0		1														1		
27.0		1														1		
28.5	724	1																1
TOTAL		703	4	20	210	228	162	20	31	11	8	1	2	0	1	2	0	1

Table 7. Back-calculated lengths at each age class for walleye collected from Silver Island Lake, Lake County, Minnesota, spring 2012.

Age Class	N	Length (mm)	Length (in)
1	123	118	4.6
2	123	201	7.9
3	121	267	10.5
4	111	320	12.6
5	85	362	14.3
6	63	391	15.4
7	41	416	16.4
8	31	434	17.1
9	20	455	17.9
10	13	477	18.8
11	7	515	20.3
12	6	547	21.5
13	4	598	23.5
14	4	617	24.3
15	3	657	25.9
16	1	715	28.1
17	1	728	28.7

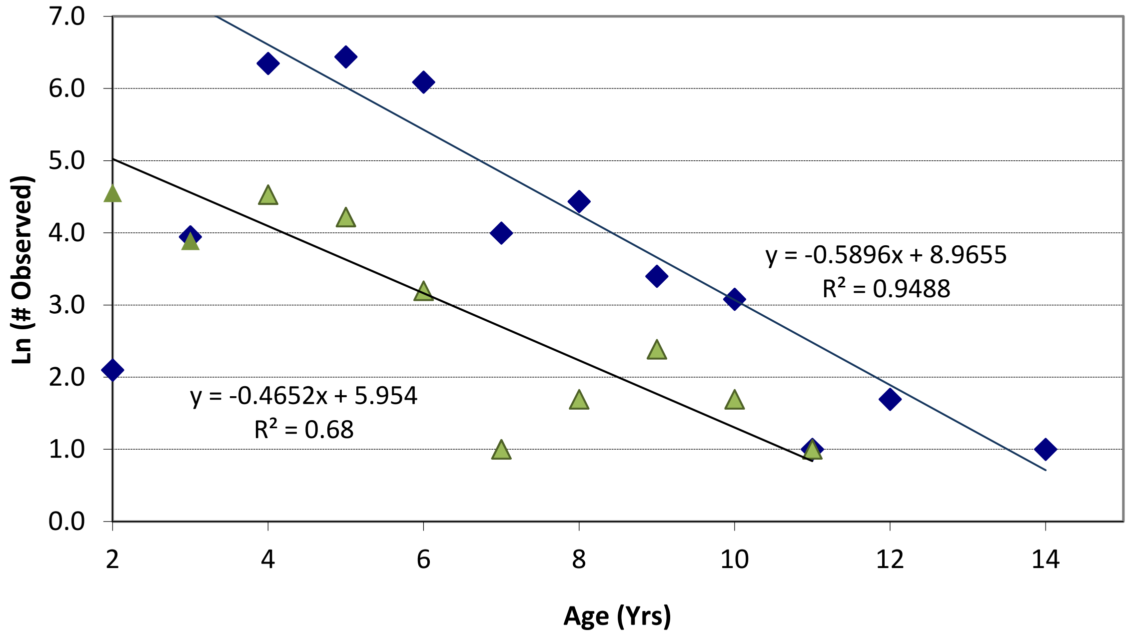

Figure 12. Catch curve analysis of walleyes in Silver Island Lake, 2012, showing instantaneous mortality (Z). Estimates are from spring 2012 electrofishing data (blue data points), and from summer MNDNR gill net data (green data points).

Ball Club Lake

Electrofishing activities were conducted on Ball Club Lake between 9 - 13 April (Figure 13). 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, nor were areas where we failed to observe spawning walleyes during previous surveys (Figure 13). CPUE for each night ranged from 47.4 to 77.2 adult walleye per hour of sampling (Table 1). Catch rates ranged from 0.0 adult walleye per hour (EF3, 11 April) to 154.6 adults per hour (EF6, 12 April) (Figure 13). At a 95% confidence interval, mean CPUE for Ball Club Lake, determined using each sampling station, was 57.5 ± 12.2 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled is presented in Figure 14. Table 8 presents the age data for the walleye collected from Ball Club Lake. Just under 65% of the fish were assigned as ages 3 – 6 (Table 8). Almost a fourth of the fish (24.9%) were assigned to age-3 (2009 cohort), which did not correspond to a particularly strong observed year class based upon our fall juvenile assessments (Figure 15).

Table 9 presents back-calculated lengths-at-age for walleye collected from Ball Club Lake. Instantaneous mortality (*Z*) of the Ball Club Lake population was estimated at 22.6% based upon our spring electrofishing samples, and estimated at 36.4% based upon the MNDNR gill net survey (Figure

16). Total annual mortality (*A*) was estimated to be 20.2% from the electrofishing data, and 30.5% using the gill net data.

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 916 (Table 2). The adjusted Petersen estimate is 558 ± 303, with a 19.6% CV (Table 2). The 2012 population estimate of walleyes larger than 254 mm (10.0 inches) is lower than that estimated in 2004 (Table 2) (Borkholder et al., 2005). Estimates of total mortality (Figure 16) are actually lower than expected, given the apparent decline in population abundance (Table 2) and the number of older aged individuals observed (Table 8). The estimate of total annual mortality is slightly lower than what was estimated in 2004 (20.2% in 2012 vs. 28.3% in 2004) (Borkholder et al., 2005). Only one individual larger than 20.0 inches (508 mm) was observed in the 2012 electrofishing assessment (Figure 14, Table 8). Fish were assigned ages up to 11 years (Table 8). Given the low estimate of total mortality (20.2%), the lack of older aged individuals observed in this survey is perplexing.

During summer 2012, the Minnesota Department of Natural Resources performed a standardized net assessment on Ball Club Lake (MN DNR, Grand Marais Area Fisheries). Thirty walleyes (> 330 mm) were sampled in the gill nets that would have been 254 mm during the spring assessments. Eight walleyes were observed to have been tagged during the spring sampling (Appendix 1). The adjusted Petersen estimate using both the summer and spring data is 1051 ± 720, with a 26.6% CV (Table 2). The Schumacker and Eschmeyer population estimate from the net data is 990 (Table 2). The gill net PEs calculated in 2012 are slightly smaller than those estimated in 2004 (Borkholder et al., 2005).

PSD and RSD values determined by our spring electrofishing sampling and summer gill net survey are presented in Table 5. The electrofishing PSD of 62.6 ± 5.1 (Table 5) suggests a population characterized by larger individuals, larger than 15.0 inches (Anderson and Weithman 1978). The summer gill net PSD (32.8 ± 12.1) is significantly different than the PSD estimate from the spring electrofishing survey (χ^2=18.0, 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 2012 assessments (Table 5). PSD metrics calculated from the 2004 electrofishing assessments are included for comparison (Borkholder et al., 2005). Significant differences were observed between the 2012 electrofishing PSD and the 2004 electrofishing PSD (χ^2=18.9, P<0.05, critical Chi-square value of 3.841), and between the RSD-Q-P metric of 2004 vs 2012 (χ^2=-4.35, P<0.05, critical Chi-square value of -1.64). This is due to fewer fish in the 10.0 – 14.9 inch range (254 mm – 380 mm) sampled in 2012 relative to the number observed in 2004.

Since adding Ball Club to our annual fall electrofishing schedule in 1996, we've observed several seemingly strong year classes at age-0, which have not been particularly strong at age-1 (Figure 15). The one recent exception would be the 2007 cohort, where age-1's were sampled in above average numbers. This cohort was age-5 at the time of the 2012 assessment, and contributed 10.5% of the total observed catch. Individuals from the 2008 cohort (age-4) and 2006 cohort (age-6) contributed 16.0% and 13.5%, respectively, to the total catch (Table 8), but those two cohorts didn't look particularly strong when sampled as age-0 and age-1 individuals (Figure 15). There does appear to be some predictive relationship between catch of age-0 walleyes in the fall and the catch of the same cohort as age-1 individuals (Figure 17). The relationship between juvenile catch rates and adult gill net catch rates may not be as useful (Figure 18).

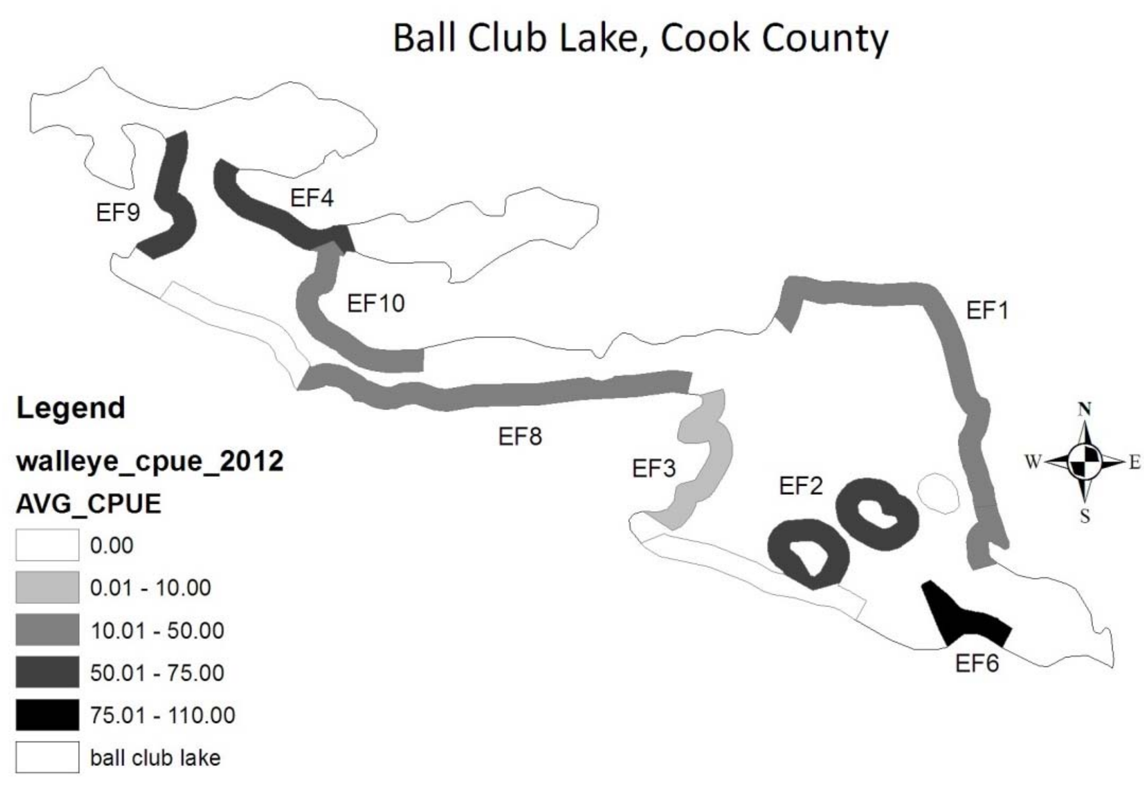

Figure 13. Catch per hour (CPUE) of adult walleyes by electrofishing station, on Ball Club Lake, Cook County, during spring 2012 electrofishing surveys.

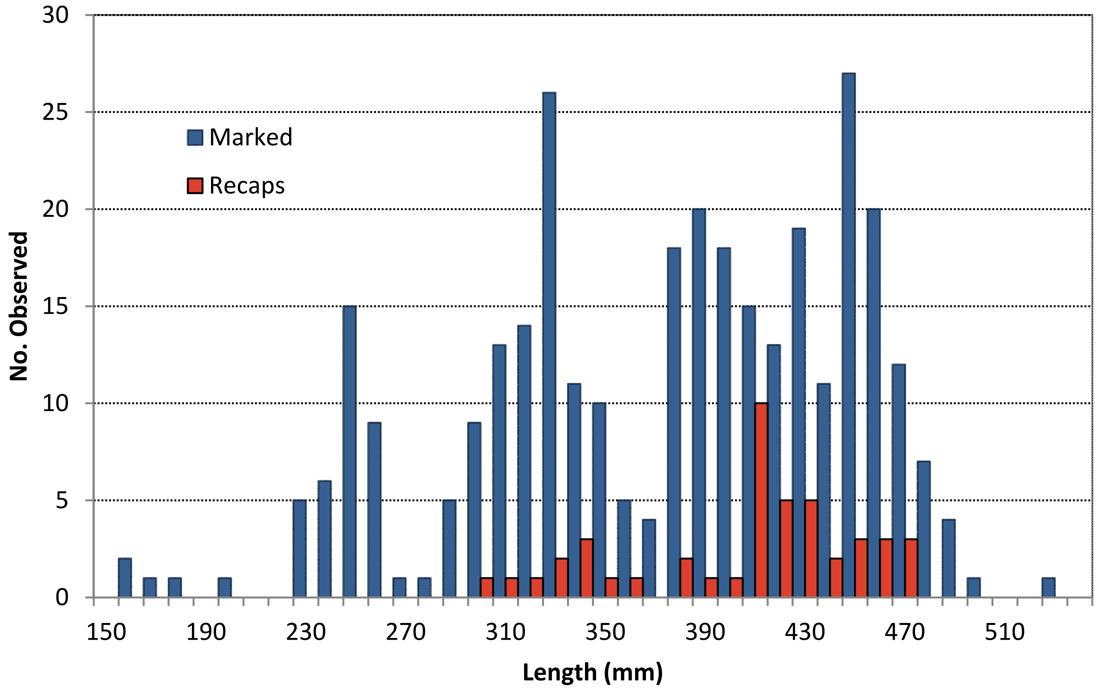

Figure 14. Length frequency distribution of walleye sampled from Ball Club Lake, Cook County, MN, during spring 2012 electrofishing assessments. Blue bars represent sample of marked individuals. Recaptured individuals were measured and are shown using the red bars.

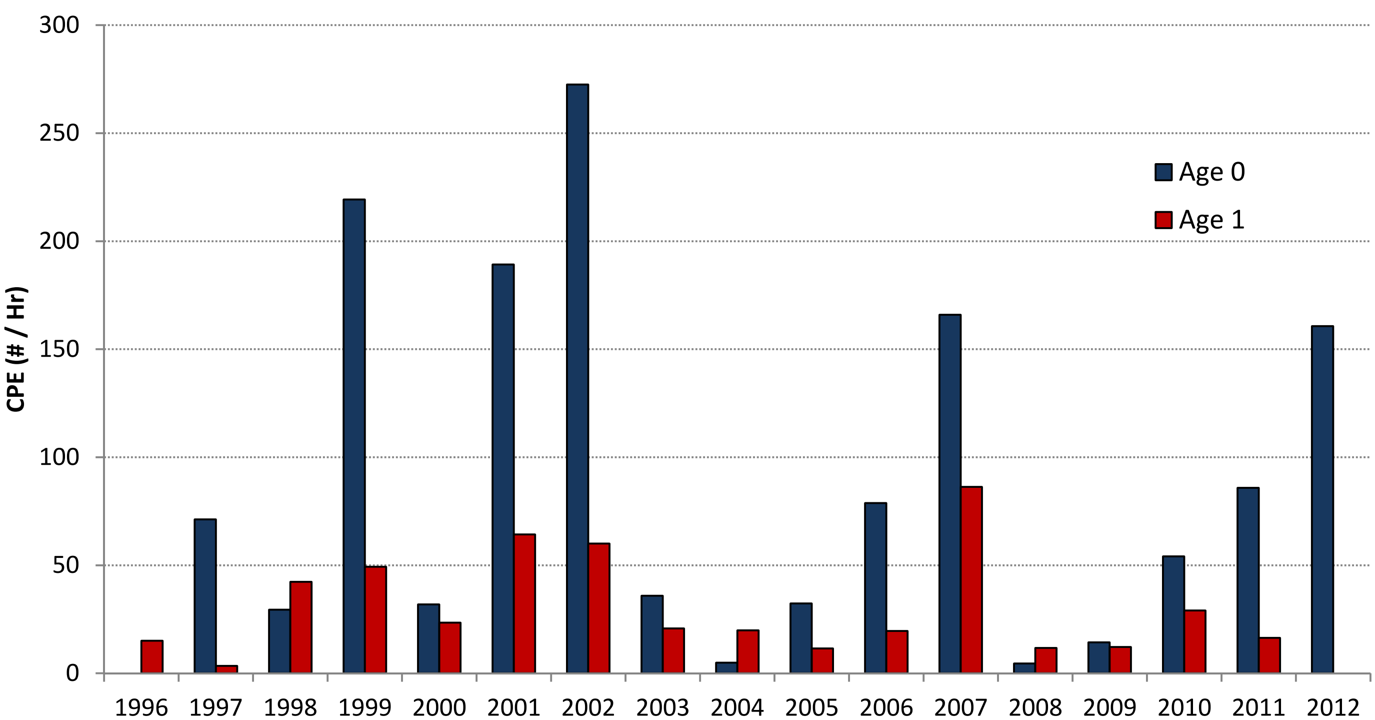

Figure 15. Age-0 and age-1 fall electrofishing catch-per-hour (CPE) data from Ball Club Lake, since 1996.

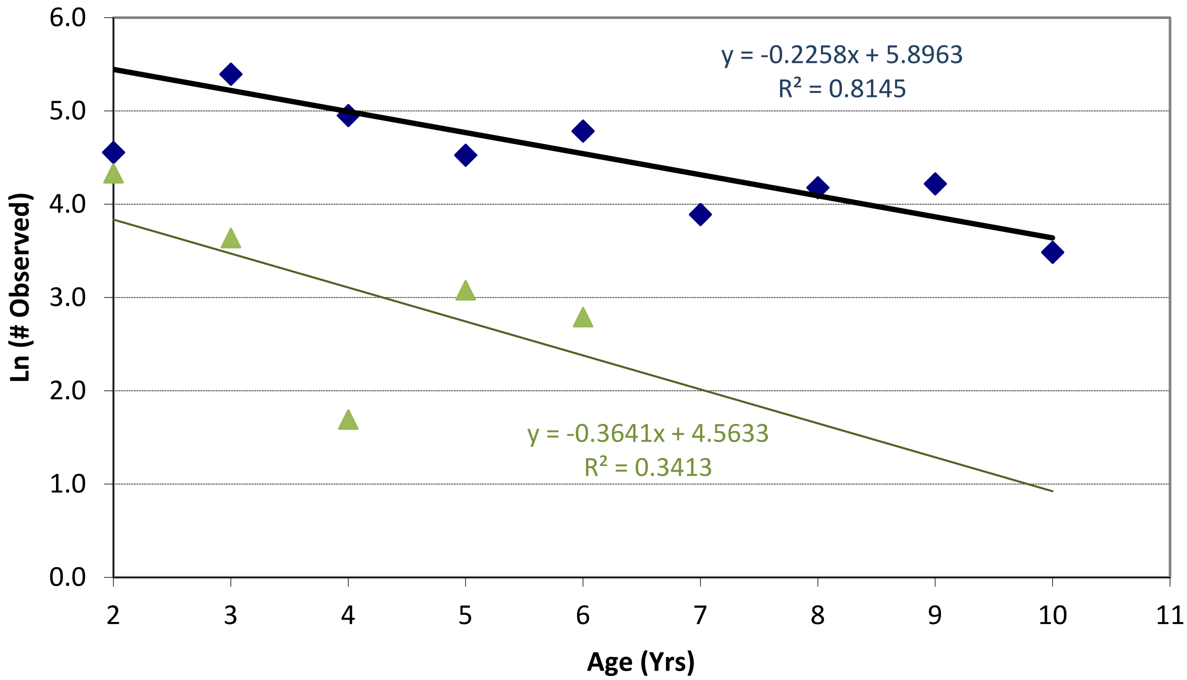

Figure 16. Catch curve analysis of walleyes in Ball Club Lake, 2012, showing instantaneous mortality (*Z*). Estimates from spring 2012 electrofishing data are illustrated with the blue data points, while the 2012 gill net assessment data is shown in the green data points.

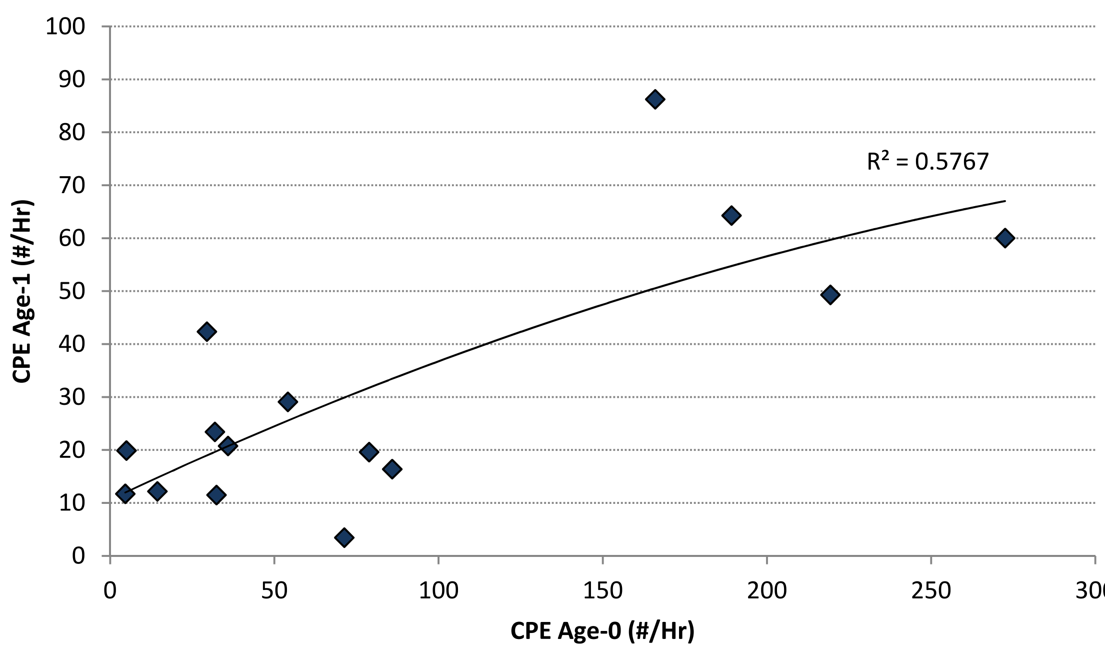

Figure 17. The relationship between age-0 fall electrofishing catch-per-hour (CPE) data in $year_I$, and fall CPE data of the same cohort as age-1 in $year_{i+1}$, from Ball Club Lake since 1996.

Table 8. Age frequency distribution of walleye from Ball Club Lake, Cook County, spring 2012, 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
6	152	2	2									
6.5	165	1	1									
7	178	1	1									
7.5	191	1	1									
9	229	7	7									
9.5	241	9	9									
10	254	19	14	5								
10.5	267	1		1								
11	279	1		1								
11.5	292	9		9								
12	305	15		15								
12.5	318	18		18								
13	330	29		29								
13.5	343	14		3	11							
14	356	7			6	1						
14.5	368	8			5	3						
15	381	23			13	10						
15.5	394	27			12	15						
16	406	18			5	2	9			2		
16.5	419	14					11	3				
17	432	25				3	7	5	7	3		
17.5	445	27					7	2	7	11		
18	457	24					8	4	6	4	2	
18.5	470	13						3	4	3	4	
19	483	8					2	1		1	4	
19.5	495	3								1	2	
20.0	508											
20.5	521	1										1
TOTAL		325	35	81	52	34	44	18	24	25	12	1

Table 9. Back-calculated lengths at each age class for walleye collected from Ball Club Lake, Cook County, Minnesota, spring 2012.

Age Class	N	Length (mm)	Length (in)
1	164	112	4.4
2	164	205	8.1
3	149	286	11.3
4	104	344	13.5
5	78	384	15.1
6	66	421	16.6
7	46	436	17.2
8	37	451	17.8
9	24	465	18.3
10	11	484	19.1
11	2	509	20

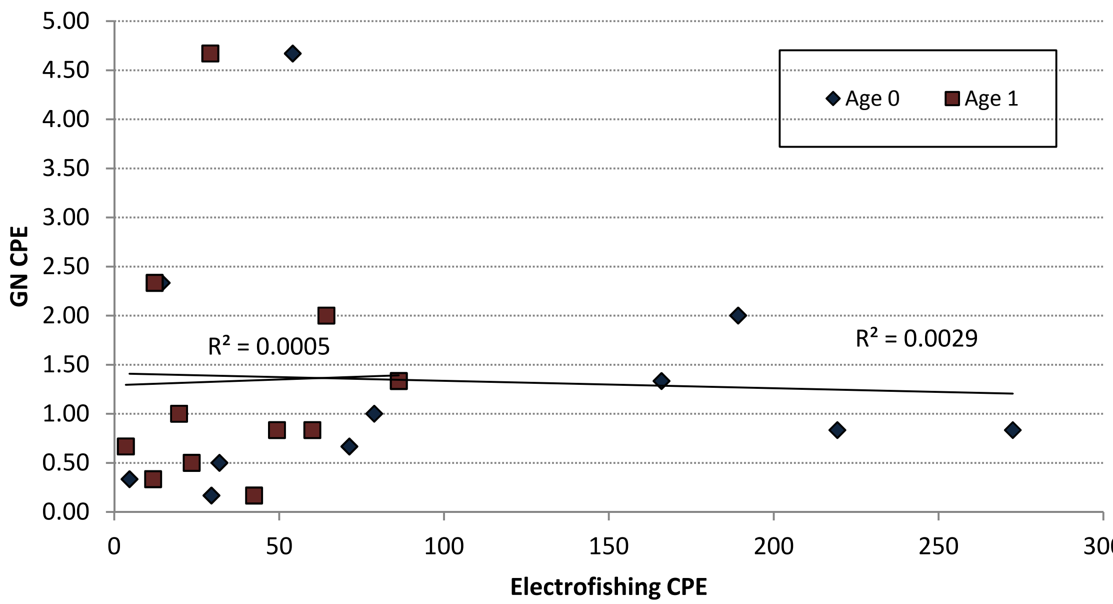

Figure 18. Relationship between fall electrofishing catch rates (#/hr) of age-0 (blue points) and age-1 (red points) walleyes, and the subsequent catch of the same cohorts as adults in the MN DNR gill nets in Ball Club Lake. Cohorts selected for analysis are from the 1996 year class through the 2010 year class, and only use the gill net data for ages 2 - 5.

Devilfish Lake

Electrofishing activities were conducted on Devilfish Lake on 14, 17, & 18 April (Figure 19). 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, nor were areas where we failed to observe spawning walleyes during previous surveys, for example, the shoreline between EF2 and EF3 (Figure 19). CPUE for each night ranged from 53.5 to 65.5 adult walleye per hour of sampling (Table 1). Catch rates ranged from 10.4 adult walleye per hour (EF2, 18 April) to 128.6 adults per hour (EF3, 14 April) (Figure 19). At a 95% confidence interval, mean CPUE for Devilfish Lake, determined using each sampling station, was 57.6 ± 13.3 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled is presented in Figure 20. Table 10 presents the age data for the walleye collected from Devilfish Lake. Fish ages 4 – 6 comprised 81.7% of the observed catch (Table 10). The 2007 cohort made up 42.4% of the catch, while 27.2% of the catch was assigned to the 2006 cohort. These cohorts were among relatively stronger ones observed in our fall juvenile assessments (Figure 21).

Table 11 presents back-calculated lengths-at-age for walleye collected from Devilfish Lake. Instantaneous mortality (*Z*) of the Devilfish Lake population was estimated at 64.7% based upon our spring electrofishing samples, and estimated at 61.6% based upon the MNDNR gill net survey (Figure 22). Total annual mortality (*A*) was estimated to be 47.6% from the electrofishing data, and 46.0% from the gill net data.

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 763 (Table 2). The adjusted Petersen estimate is 774 ± 424, with a 12.8% CV (Table 2). The 2012 population estimate of walleyes larger than 254 mm (10.0 inches) is slightly larger than what was estimated in 2004 (Table 2). Estimates of total mortality (Figure 22) are actually higher than expected, given the apparent increase in population abundance (Table 2) and the number of older aged individuals observed (Table 10). The estimate of total annual mortality is higher than what was estimated in 2004 (47.6% in 2012 vs. 34.0% in 2004) (Borkholder et al., 2005). Only three individuals larger than 20.0 inches (508 mm) were observed in the 2012 electrofishing assessment (Figure 20, Table 10). Fish were assigned ages up to 15 years (Table 10), but only ten were observed older than 10 years. Given the age data and mortality estimate, there could be a few hypotheses to consider: The first would be that angling mortality and exploitation may be higher than would be expected. The second hypothesis to consider is that survival of juvenile walleyes and recruitment into the adult population may not be consistent in Devilfish Lake. Erratic recruitment and poor year classes would cause estimates of total annual mortality to be higher, as an assumption to using catch curves to estimate mortality is constant recruitment (Chapman and Robson 1960).

During summer 2012, the Minnesota Department of Natural Resources performed a standardized net assessment on Devilfish Lake (MN DNR, Grand Marais Area Fisheries). Thirty-one walleyes (> 330 mm) were sampled in the gill nets and trap nets, that would have been 254 mm during the spring assessments (Appendix 1). Both net types were used due to low numbers sampled. Five individuals were observed to have been tagged during the spring sampling. The adjusted Petersen estimate using both the summer and spring data is 1808 ± 1960, with a 34.1% CV (Table 2). The Schumacker and Eschmeyer population estimate from the net data is 902 (Table 2).

PSD and RSD values determined by our spring electrofishing sampling and summer gill net survey are presented in Table 5. The electrofishing PSD of 12.2 ± 3.5 (Table 5) suggests a population characterized by small individuals, smaller than 15.0 inches (Anderson and Weithman 1978). The summer gill net PSD (30.3 ± 15.7) is significantly different than the PSD estimate from the spring electrofishing survey (χ^2=8.32, 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 2012 assessments (Table 5). PSD metrics calculated from the 2004 electrofishing assessments are included for comparison (Borkholder et al., 2005). Significant differences were observed between the 2012 electrofishing PSD and the 2004 electrofishing PSD (χ^2=71.7, P<0.05, critical Chi-square value of 3.841). This is likely due to the large proportion of the fish sampled in the 10.0 – 14.9 inch range (254 mm – 380 mm) in 2012 relative to the number observed in 2004. No significant differences were observed in any of the RSD metrics between the 2012 and 2004 surveys.

Since adding Devilfish to our annual fall electrofishing schedule in 1997, we've observed only a few seemingly strong year classes at age-0 (Figure 21). Unique to Devilfish is the apparent size-selectivity of the age-0 walleyes. In every cohort we've assessed since 1997, age-1 individuals show up in higher densities than were observed as age-0 individuals (Figure 21). In Figure 23, age-0 catch rates are used to predict subsequent catch rates of the same cohort at age-1. Every point in this relationship is above the red dotted 1:1 line. This would suggest that age-0 walleyes are too small to be vulnerable to our electrofishing equipment. The mean length of age-0 walleyes in Devilfish since 1997 is 101 ± 0.6 mm, which is much smaller than other lakes within the 1854 Ceded Territory of Minnesota. In spite of this apparent catchability issue, there appears to be a very good relationship between age-0 and age-1 electrofishing catch rates (Figure 23). Figure 24 presents the regression of age-0 and age-1 electrofishing CPE vs. subsequent gill net catch of the age 2 – 6 cohorts. It appears as though fall catch rates of juvenile walleye may be a good predictor of adult densities, as determined by catch rates in the MNDNR gill nets.

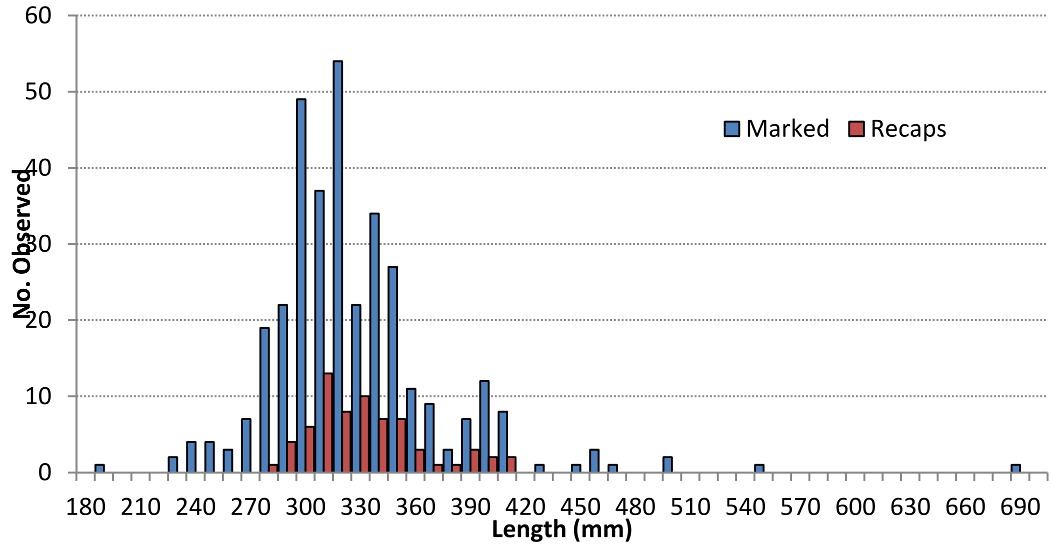

Figure 20. Length frequency distribution of walleye sampled from Devilfish Lake, Cook County, MN, during spring 2012 electrofishing assessments. Blue bars represent sample of marked individuals. Recaptured individuals were measured and are shown using the red bars.

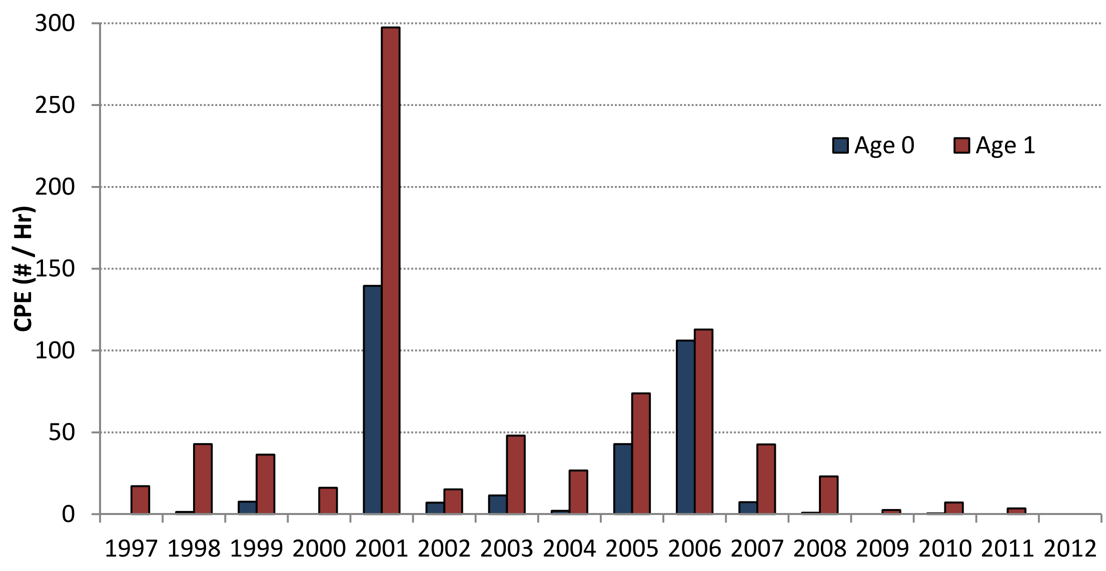

Figure 21. Age-0 and age-1 fall electrofishing catch-per-hour (CPE) data from Devilfish Lake, since 1997.

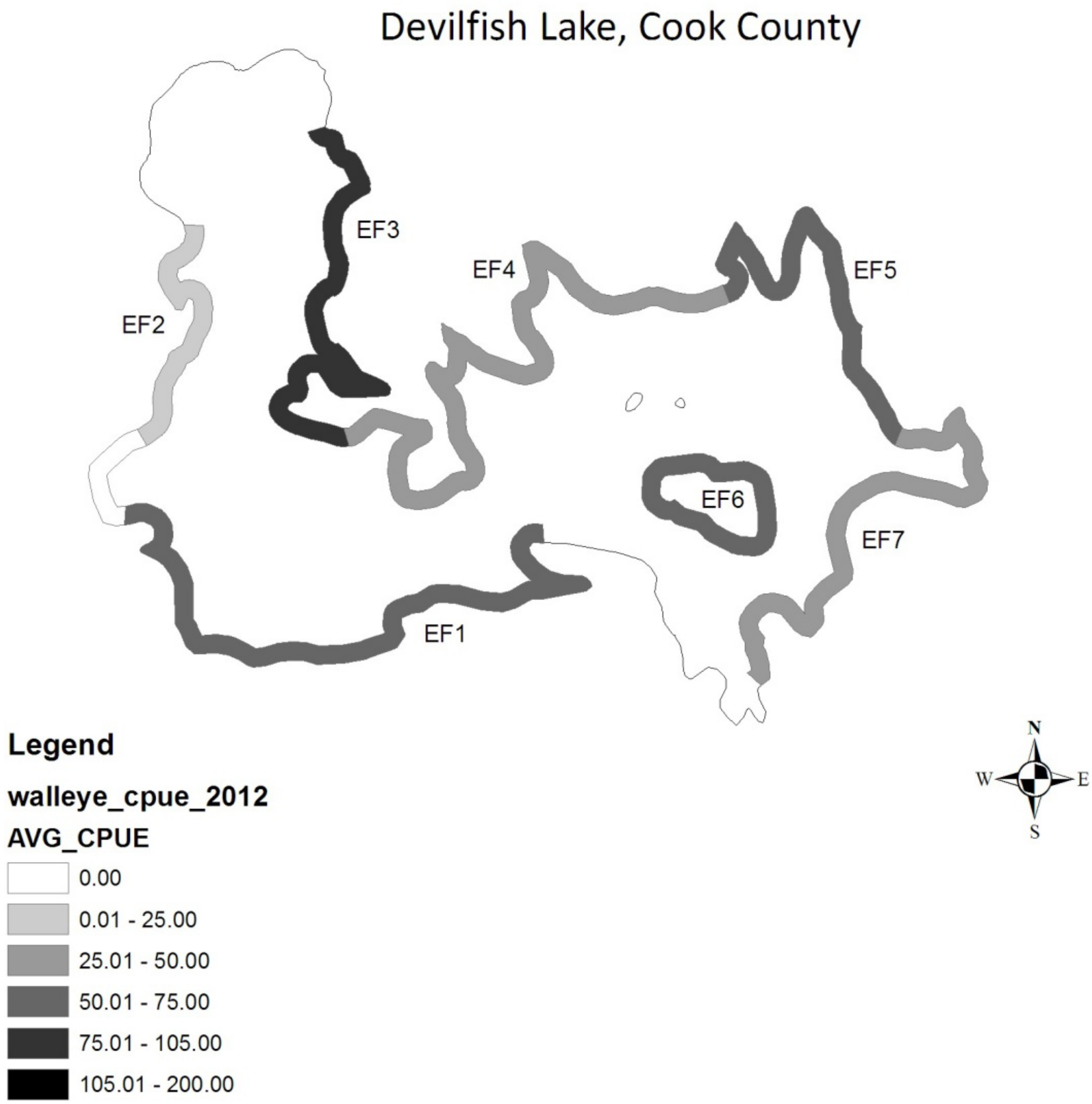

Figure 19. Catch per hour (CPUE) of adult walleyes by electrofishing station, on Devilfish Lake, Cook County, during spring 2012 electrofishing surveys.

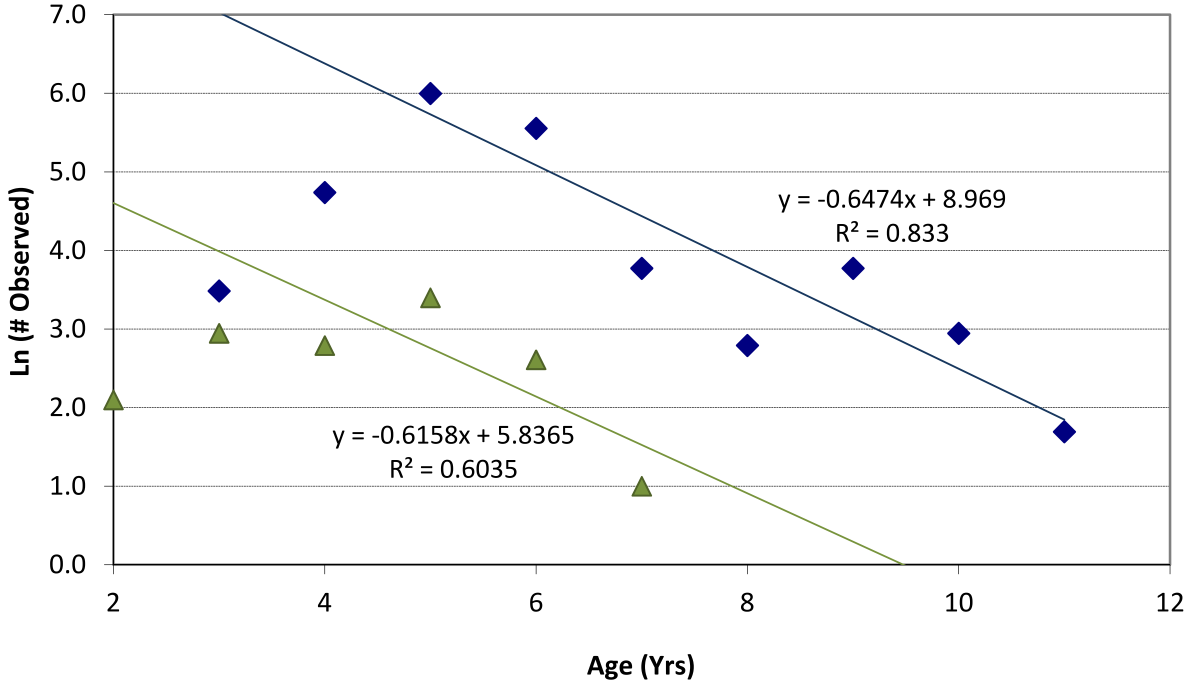

Figure 22. Catch curve analysis of walleyes in Devilfish Lake, 2012, showing instantaneous mortality (*Z*). Estimates from spring 2012 electrofishing data are illustrated with the blue diamonds, while the 2012 gill net assessment data is shown in the green triangles.

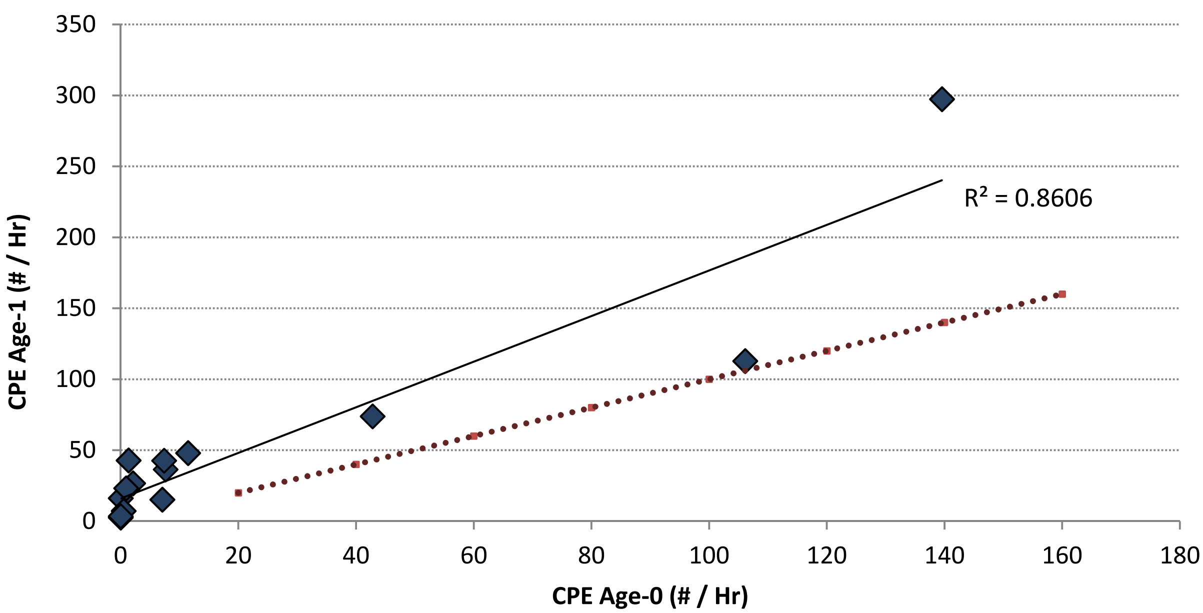

Figure 23. The relationship between age-0 fall electrofishing catch-per-hour (CPE) data in year$_i$, and fall CPE data of the same cohort as age-1 in year$_{i+1}$, from Devilfish Lake since 1997. The red dotted line is the 1:1 reference line.

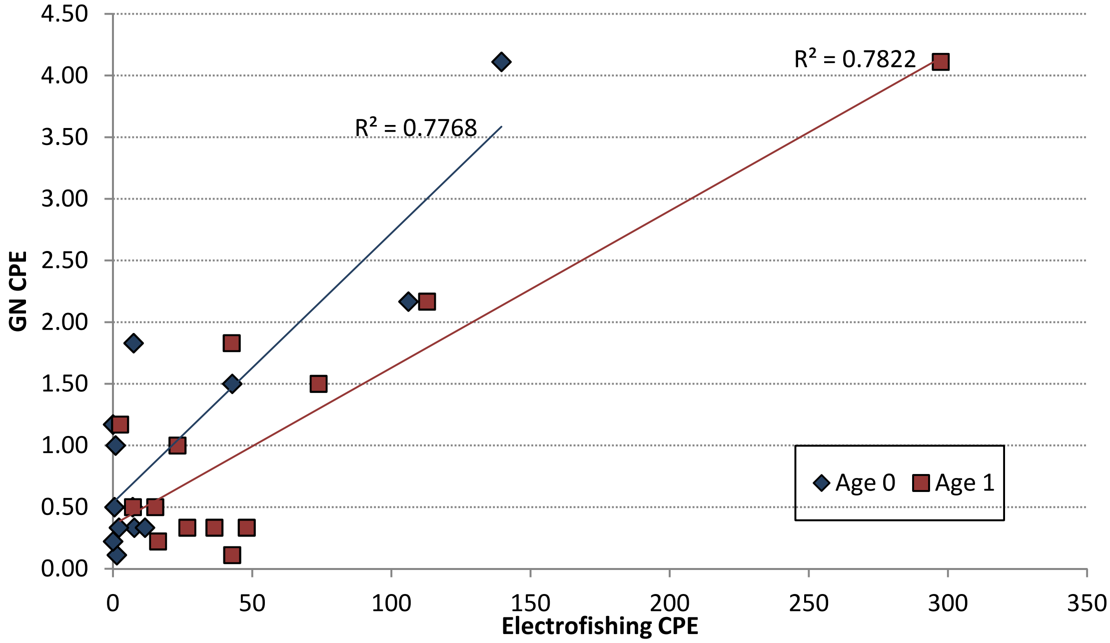

Figure 24. Relationship between fall electrofishing catch rates (#/hr) of age-0 (blue points) and age-1 (red points) walleyes, and the subsequent catch of the same cohorts as adults in the MN DNR gill nets in Devilfish Lake. Cohorts selected for analysis are from the 1997 year class through the 2010 year class, and only use the gill net data for ages 2 - 5.

Table 11. Back-calculated lengths at each age class for walleye collected from Devilfish Lake, Cook County, Minnesota, spring 2012.

Age	Length	Inches	N
1	95	3.7	102
2	165	6.5	102
3	230	9.1	102
4	280	11	95
5	321	12.6	81
6	357	14.1	54
7	390	15.4	31
8	413	16.3	23
9	439	17.3	18
10	477	18.8	8
11	544	21.4	3
12	647	25.5	1
13	670	26.4	1
14	683	26.9	1
15	695	27.4	1

Table 10. Age frequency distribution of walleye from Devilfish Lake, Cook County, spring 2012, 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	15
7.5	191	1	1									
9.0	229	2	2									
9.5	241	6	6									
10.0	254	5		5								
10.5	267	7	3	4								
11.0	279	22	3	13	6							
11.5	292	44		12	32							
12.0	305	52			39	13						
12.5	318	67		8	42	17						
13.0	330	24			12	12						
13.5	343	42			9	33						
14.0	356	23			6	10	7					
14.5	368	10			1	6	3					
15.0	381	7			1	1		2	3			
15.5	394	15				2	2	2	7	2		
16.0	406	10				1	3	1	3	1		
16.5	419											
17.0	432	1						1				
17.5	445	1							1			
18.0	457	5					1			3	1	
18.5	470	1							1			
19.0	483											
19.5	495	1							1			
20.0	508	1								1		
20.5	521											
21.0	533											
21.5	546	1									1	
22.0	559											
27.0	686	1										1
TOTAL		349	15	42	148	95	16	6	16	7	2	1

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 18 September 2012, later than normal. Due to this late start, and some equipment issues that arose throughout the season, these assessments didn't end until 3 October. Lake temperatures were observed below the 10°C lower threshold (Borkholder and Parsons, 2001) in two of the lakes (Table 12).

Table 12 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 428.8 fish per hour of electrofishing (Two Island Lake) (Table 12). CPUE for age-1 walleye ranged from 0.0 fish per hour (Silver Island and Wild Rice Lakes) to 237.6 fish per hour of electrofishing (Cadotte Lake) (Table 12). Figures 25 – 48 present length frequency data for each of the lakes surveyed. Table 13 presents the mean length for age-0 and age-1 individuals sampled during fall 2012 assessments. Mean lengths for age-0 walleye ranged from 103 mm (4.0 inches, Two Island Lake) to 163 mm (6.4 inches, Cadotte Lake). Mean lengths for age-1 walleye ranged from 183 mm (7.2 inches, Shagawa Lake) to 243 mm (9.6 inches, Cadotte Lake).

Overall, mean lengths observed in 2012 were larger than historically observed in most of the lakes (Table 13, Figure 49). Looking at each lake's historical mean length for age-0 and age-1 walleyes, and subtracting the historical mean from the observed 2012 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 49). The larger age-1's and age-0's may have been a result of the very warm summer and autumn of 2012, allowing these fish a much longer growing season.

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 128 mm in lakes not stocked by the DNR with fingerling walleye prior to our assessments. Using the mean length criteria of 128 mm for average naturally-produced year classes, average or better 2012 year classes may be present in twelve of the lakes surveyed (Table 13). 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 12. 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 and October 2012.

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	17-Sep	59	15.0	26.0	342	35	7660	160.7	16.4
Cadotte	3-Oct	56	13.3	34.0	151	383	5803	93.7	237.6
Caribou	23-Sep	55	12.8	45.0	586	3	6037	349.4	1.8
Cascade	19-Sep	57	13.9	27.0	24	90	7027	12.3	46.1
Crescent	24-Sep	56	13.3	34.9	18	7	2893	22.4	8.7
Crooked	26-Sep	50	10.0	53.0	235	2	3689	229.3	2.0
Devilfish	18-Sep	54	12.2	22.0	0	7	7265	0.0	3.5
Dumbbell	27-Sep	51	10.6	77.8	11	62	5056	7.8	44.1
Elbow	20-Sep	53	11.7	35.0	31	60	4622	24.1	46.7
Fourmile	26-Sep	49.9	9.9	56.1	313	18	6102	184.7	10.6
Harriet	25-Sep	52	11.1	59.0	27	26	5194	18.7	18.0
Island Reservoir	3-Oct	59	15.0	74.6	93	288	9369	35.7	110.7
Ninemile	25-Sep	49.9	9.9	66.0	59	1	3700	57.4	1.0
N. McDougal	28-Sep	60	15.6	59.0	27	60	4838	20.1	44.6
Pike	20-Sep	61	16.1	60.0	93	30	13962	24.0	7.7
Shagawa	1-Oct	61.5	16.4	90.3	63	17	8663	26.2	7.1
Silver Island	26-Sep	52	11.1	41.0	62	0	4990	44.7	0.0
Tait	26-Sep	51	10.6	45.2	846	14	7165	425.1	7.0
Tom	18-Sep	60	15.6	36.9	62	81	7237	30.8	40.3
Two Island	17-Sep	60	15.6	34.2	620	61	5205	428.8	42.2
West Twin	19-Sep	58	14.4	33.5	108	38	4611	84.3	29.7
Whiteface Res.	2-Oct	56	13.3	61.2	153	117	6718	82.0	62.7
Wild Rice	22-Sep	53	11.7	124.1	0	0	4069	0.0	0.0
Wilson	25-Sep	56	13.3	48.3	113	40	4535	89.7	31.8
Windy	27-Sep	55	12.8	31.0	24	26	4907	17.6	19.1

[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 2012 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	17-Sep	130	235
Cadotte	3-Oct	163	243
Caribou	23-Sep	136	223
Cascade	19-Sep	152	217
Crescent	24-Sep	129	223
Crooked	26-Sep	146	211
Devilfish	18-Sep	N/A	191
Dumbbell	27-Sep	130	196
Elbow	20-Sep	126	206
Fourmile	26-Sep	155	258
Harriet	25-Sep	112	199
Island Reservoir	3-Oct	126	194
Ninemile	25-Sep	150	199
N. McDougal	28-Sep	136	205
Pike	20-Sep	122	232
Shagawa	1-Oct	138	183
Silver Island	26-Sep	158	255
Tait	26-Sep	106	210
Tom	18-Sep	118	219
Two Island	17-Sep	103	200
West Twin	19-Sep	135	239
Whiteface Res.	2-Oct	140	216
Wild Rice	22-Sep	N/A	N/A
Wilson	25-Sep	152	211
Windy	27-Sep	143	216

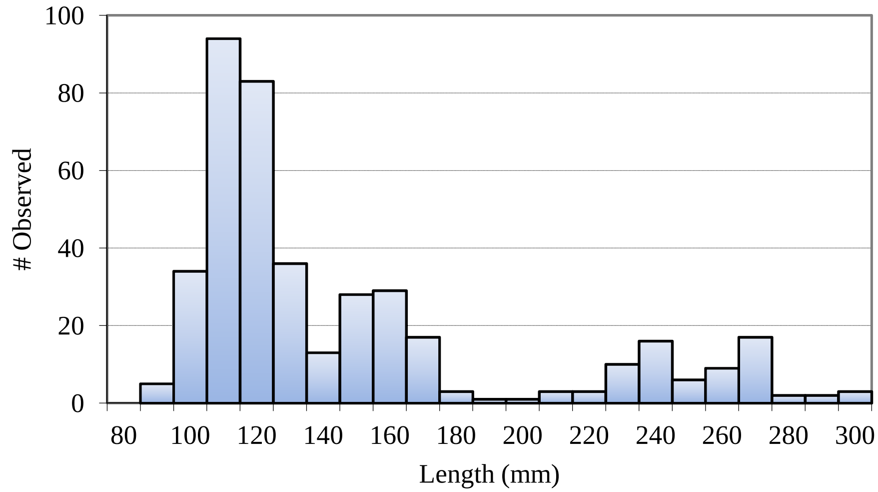


Figure 25. Length frequency distribution of walleye collected from Ball Club Lake, Cook County, during fall 2012 electrofishing assessments.

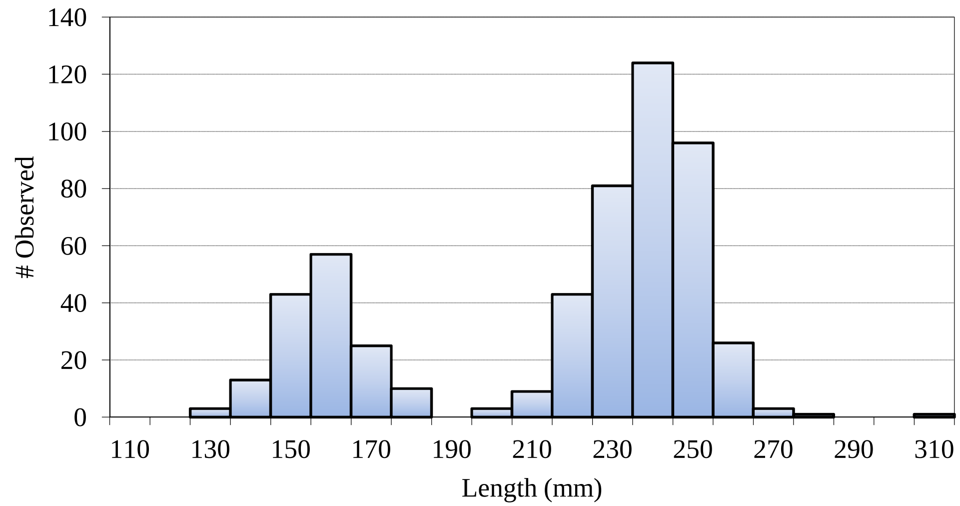


Figure 26. Length frequency distribution of walleye collected from Cadotte Lake, St. Louis County, during fall 2012 electrofishing assessments.

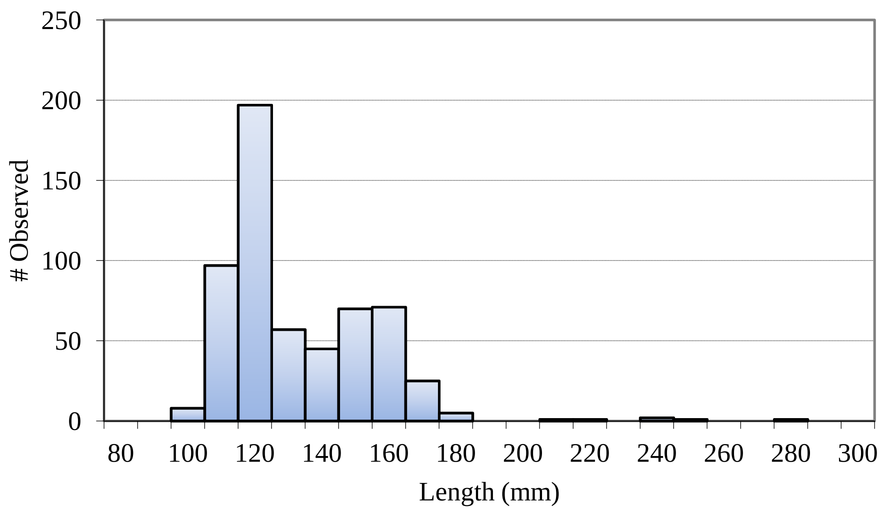


Figure 27. Length frequency distribution of walleye collected from Caribou Lake, Cook County, during fall 2012 electrofishing assessments.

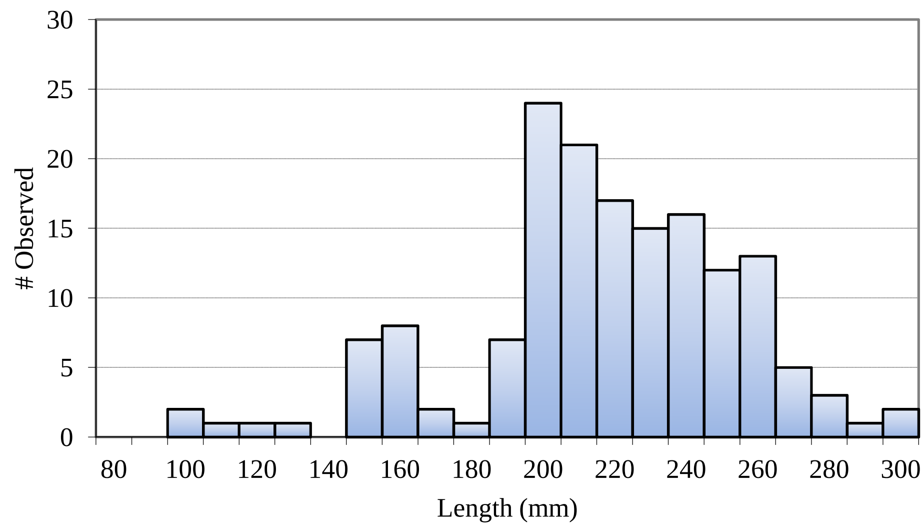


Figure 28. Length frequency distribution of walleye collected from Cascade Lake, Cook County, during fall 2012 electrofishing assessments.

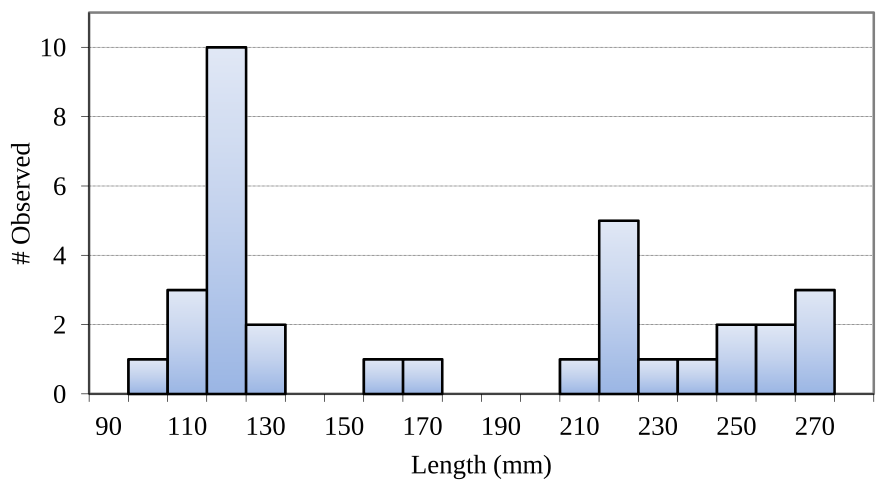


Figure 29. Length frequency distribution of walleye collected from Crescent Lake, Cook County, during fall 2012 electrofishing assessments.

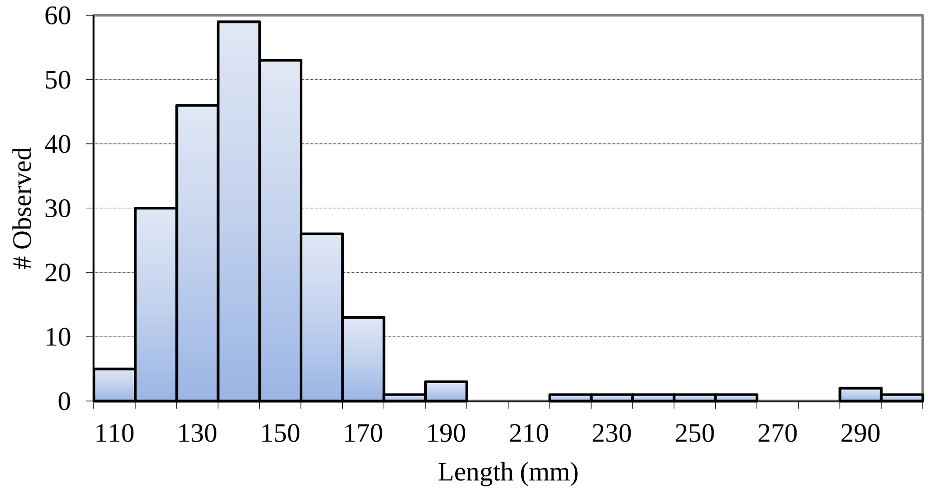


Figure 30. Length frequency distribution of walleye collected from Crooked Lake, Lake County, during fall 2012 electrofishing assessments.

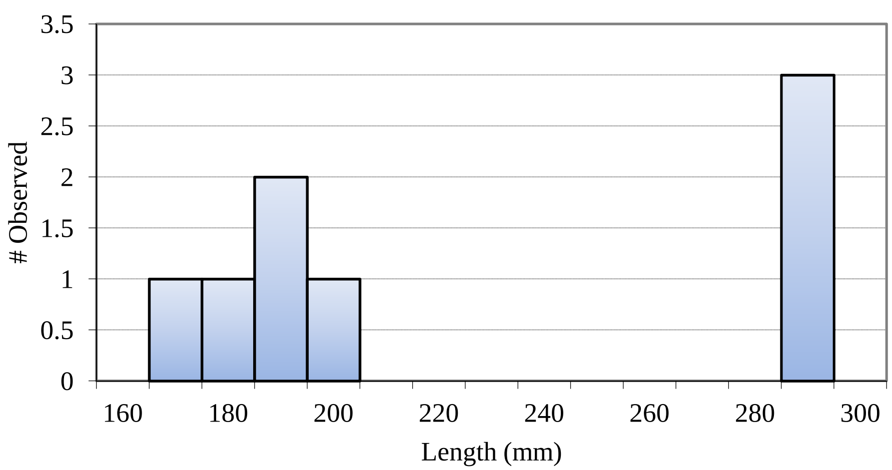


Figure 31. Length frequency distribution of walleye collected from Devilfish Lake, Cook County, during fall 2012 electrofishing assessments.

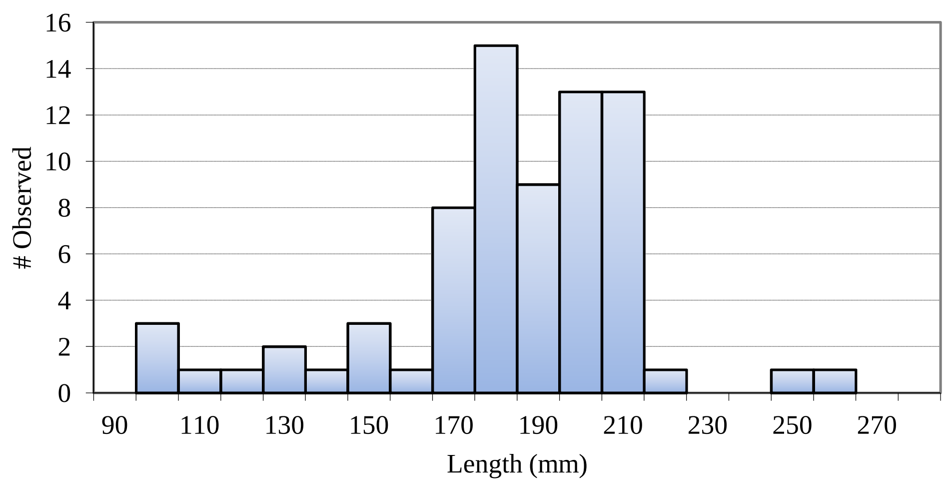


Figure 32. Length frequency distribution of walleye collected from Dumbbell Lake, Lake County, during fall 2012 electrofishing assessments.

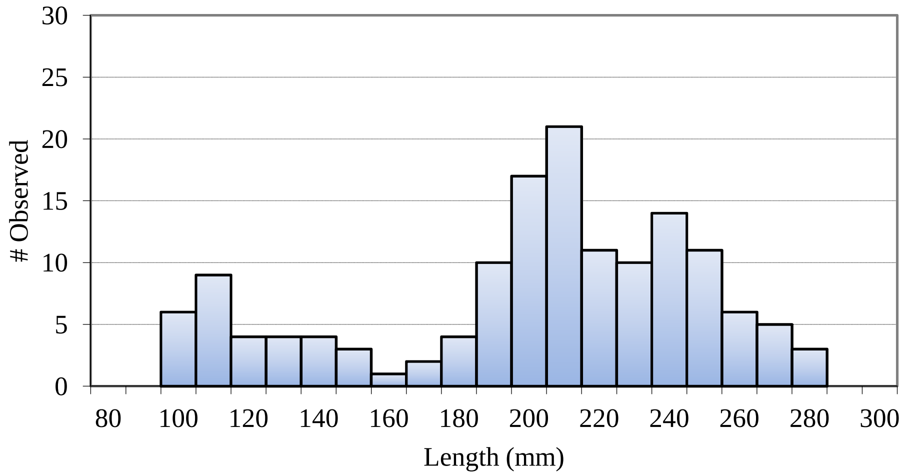


Figure 33. Length frequency distribution of walleye collected from Elbow Lake, Cook County, during fall 2012 electrofishing assessments.

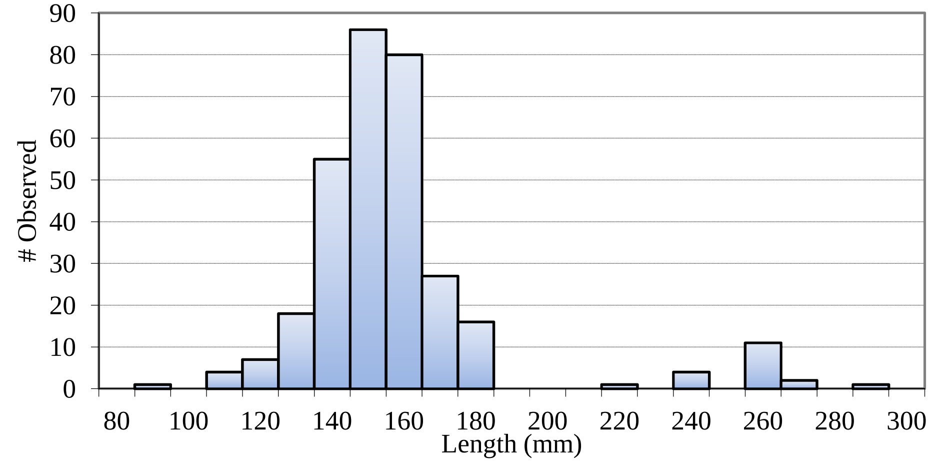


Figure 34. Length frequency distribution of walleye collected from Fourmile Lake, Cook County, during fall 2012 electrofishing assessments.

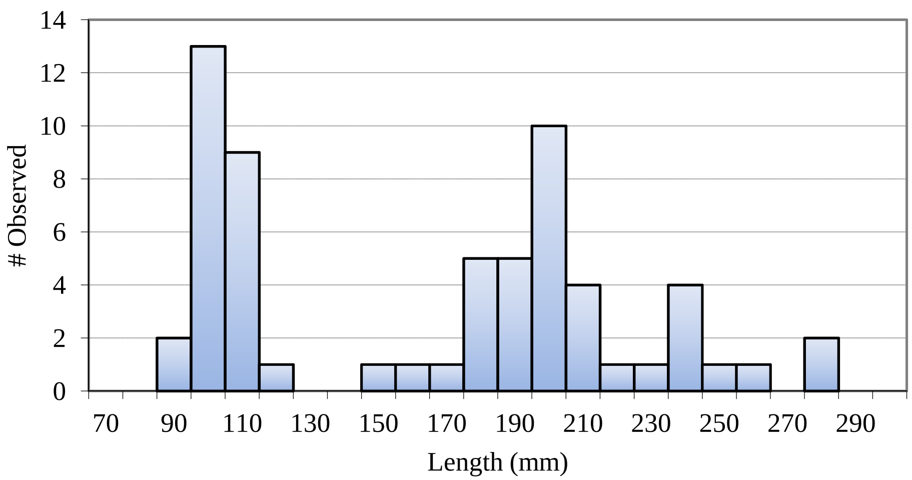


Figure 35. Length frequency distribution of walleye collected from Harriet Lake, Lake County, during fall 2012 electrofishing assessments.

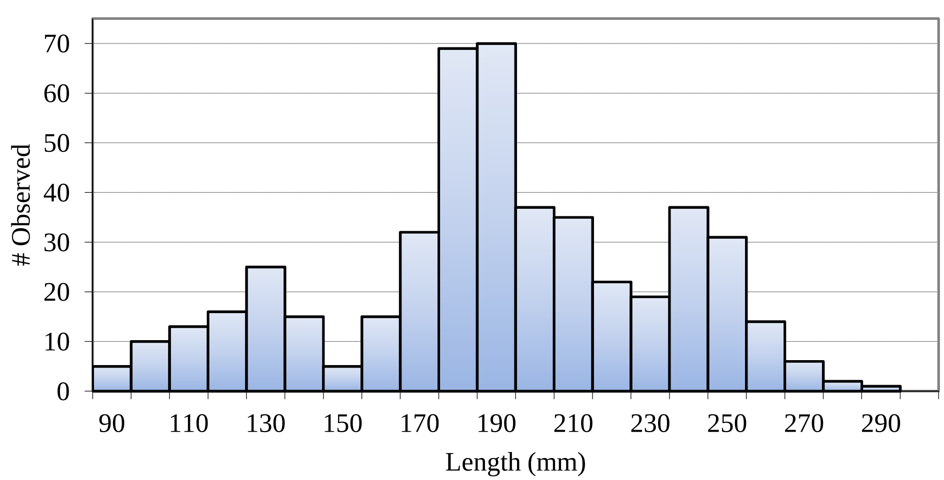


Figure 36. Length frequency distribution of walleye collected from Island Lake Res., St. Louis County, during fall 2012 electrofishing assessments.

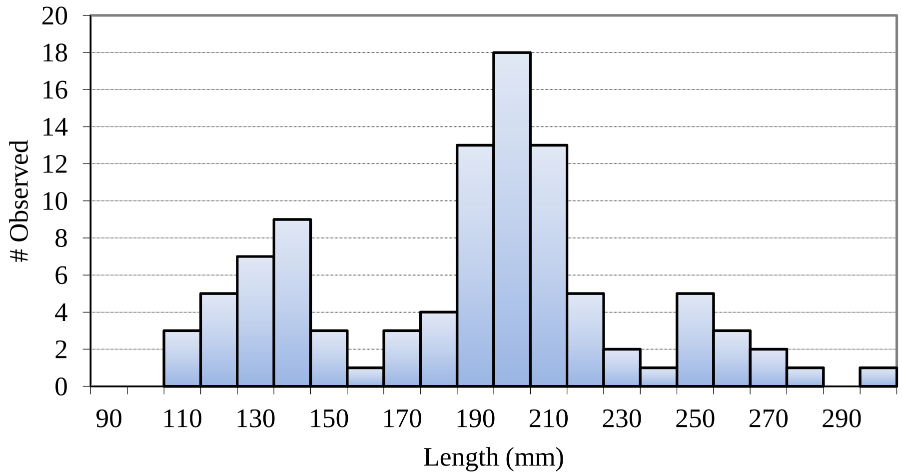


Figure 37. Length frequency distribution of walleye collected from North McDougal Lake, Lake County, during fall 2012 electrofishing assessments.

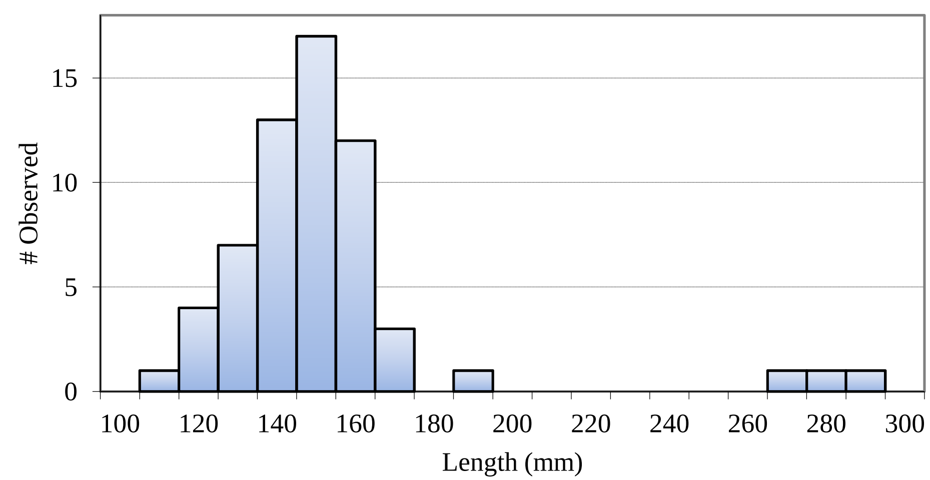


Figure 38. Length frequency distribution of walleye collected from Ninemile Lake, Lake County, during fall 2012 electrofishing assessments.

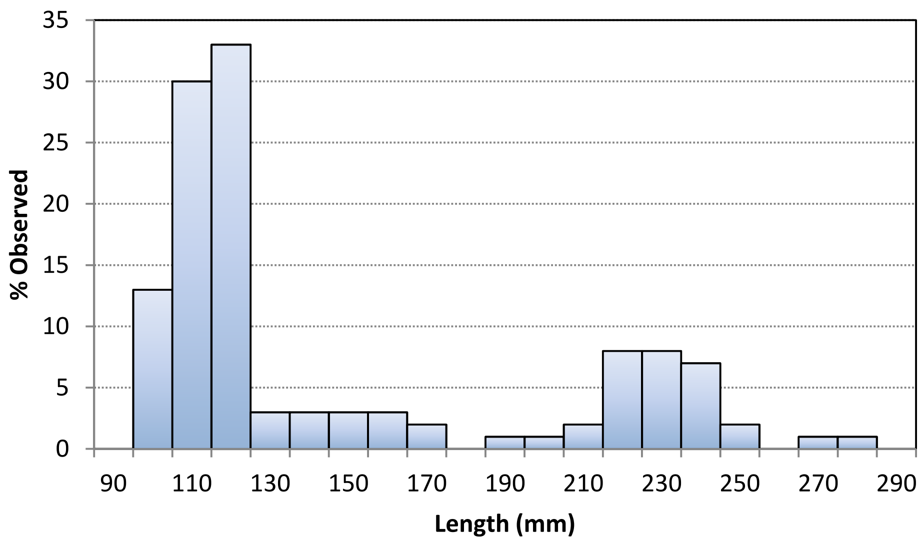


Figure 39. Length frequency distribution of walleye collected from Pike Lake, Cook County, during fall 2012 electrofishing assessments.

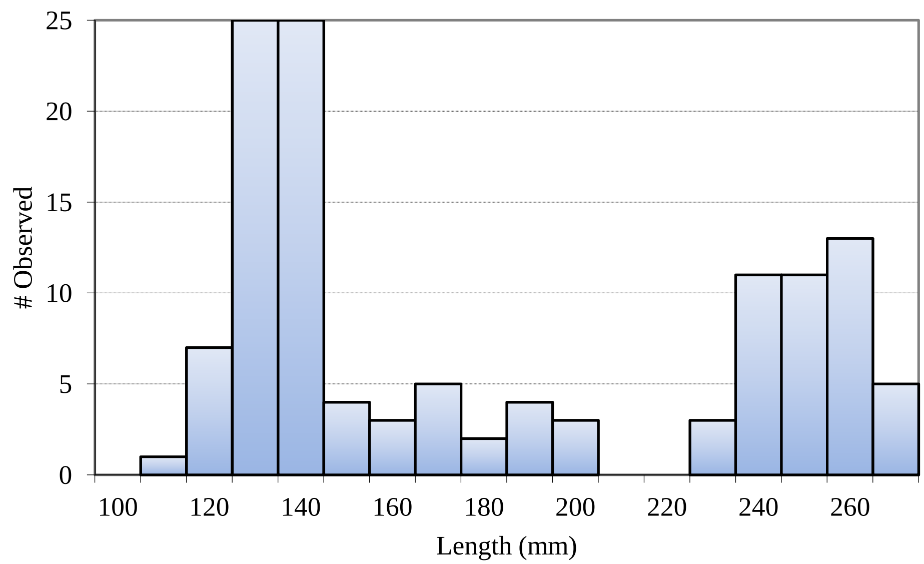


Figure 40. Length frequency distribution of walleye collected from Shagawa Lake, St. Louis County, during fall 2012 electrofishing assessments.

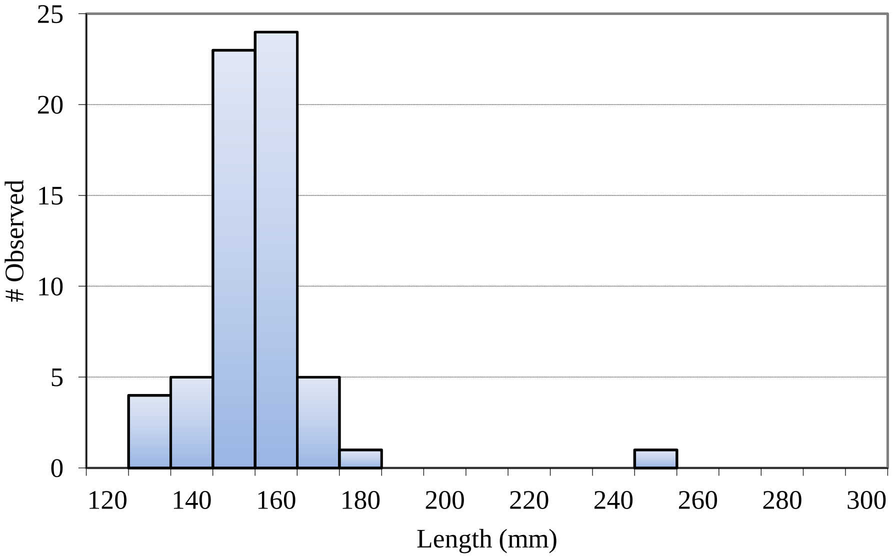


Figure 41. Length frequency distribution of walleye collected from Silver Island Lake, Lake County, during fall 2012 electrofishing assessments.

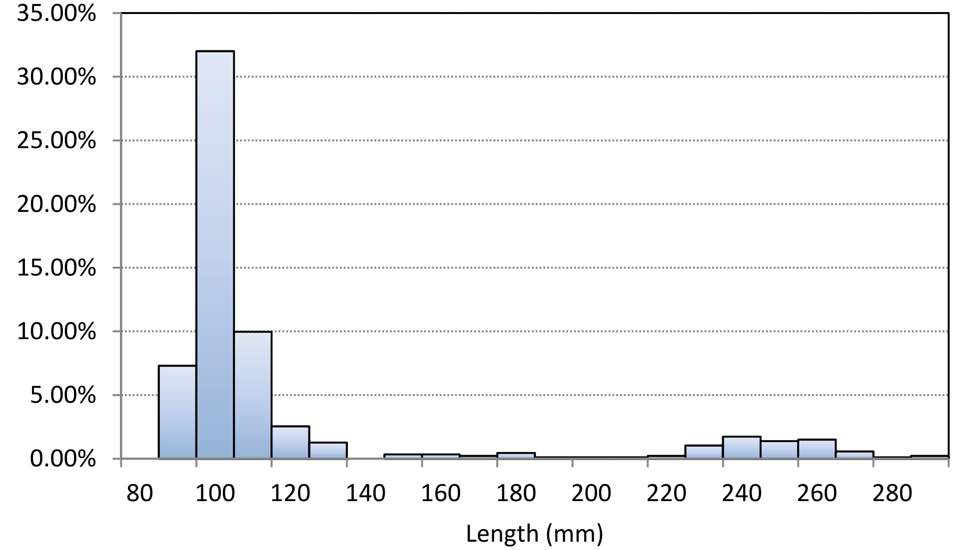


Figure 42. Length frequency distribution of walleye collected from Tait Lake, Cook County, during fall 2012 electrofishing assessments. Note that # Observed is reported as percentage, as 846 age-0 and 16 age-1 walleyes were sampled.

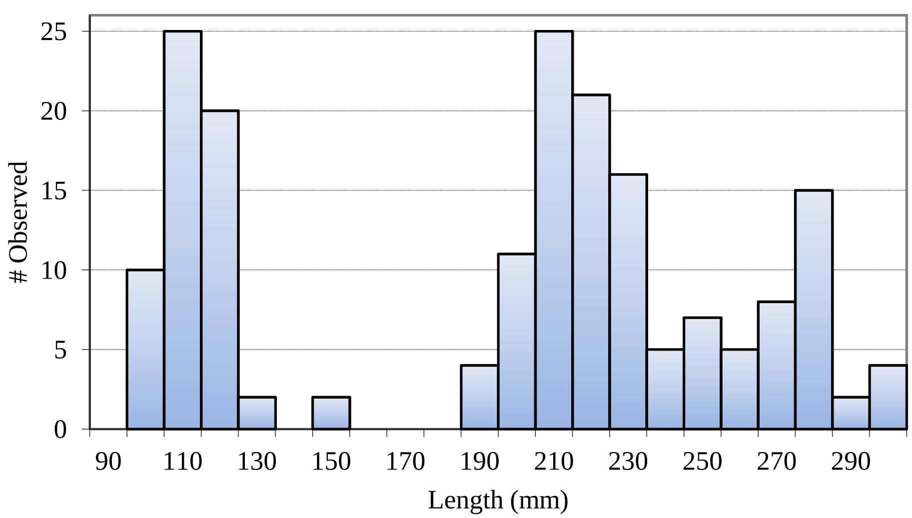


Figure 43. Length frequency distribution of walleye collected from Tom Lake Cook County, during fall 2012 electrofishing assessments.

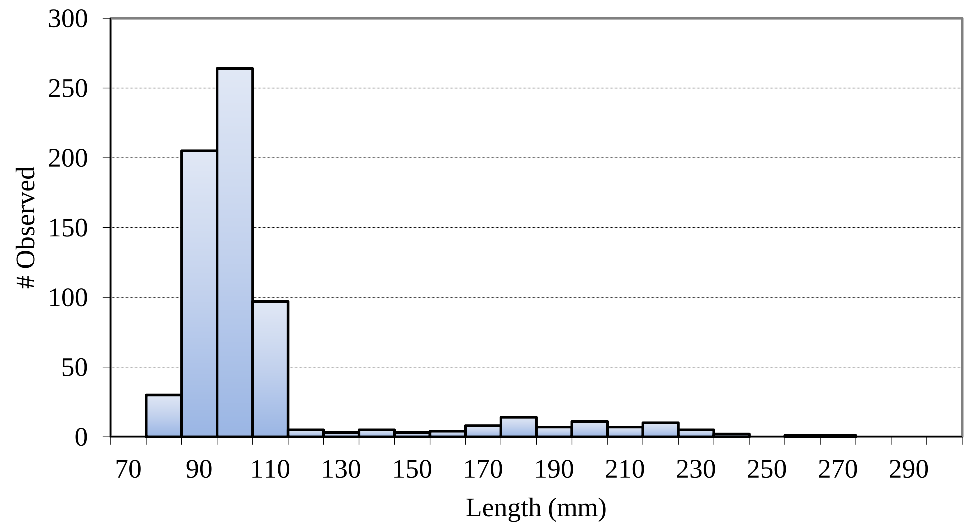


Figure 44. Length frequency distribution of walleye collected from Two Island Lake, Cook County, during fall 2012 electrofishing assessments.

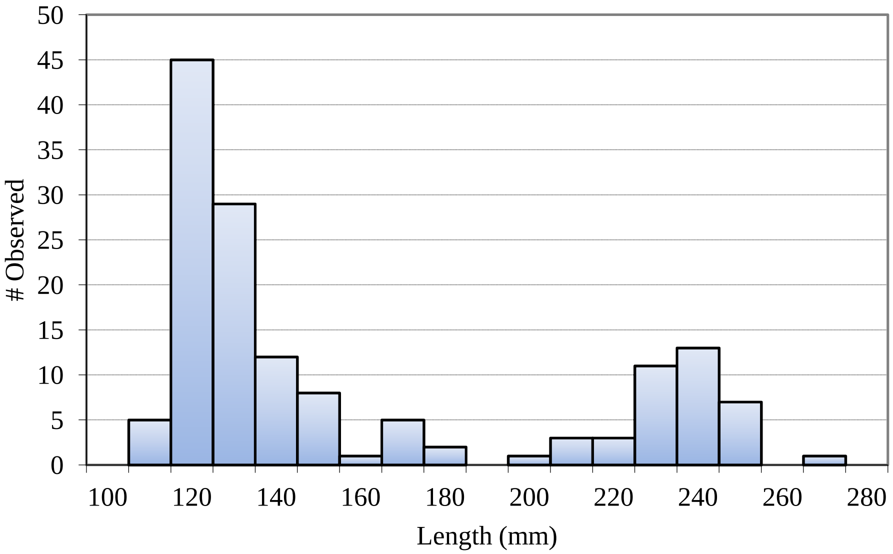


Figure 45. Length frequency distribution of walleye collected from West Twin Lake, Cook County, during fall 2012 electrofishing assessments.

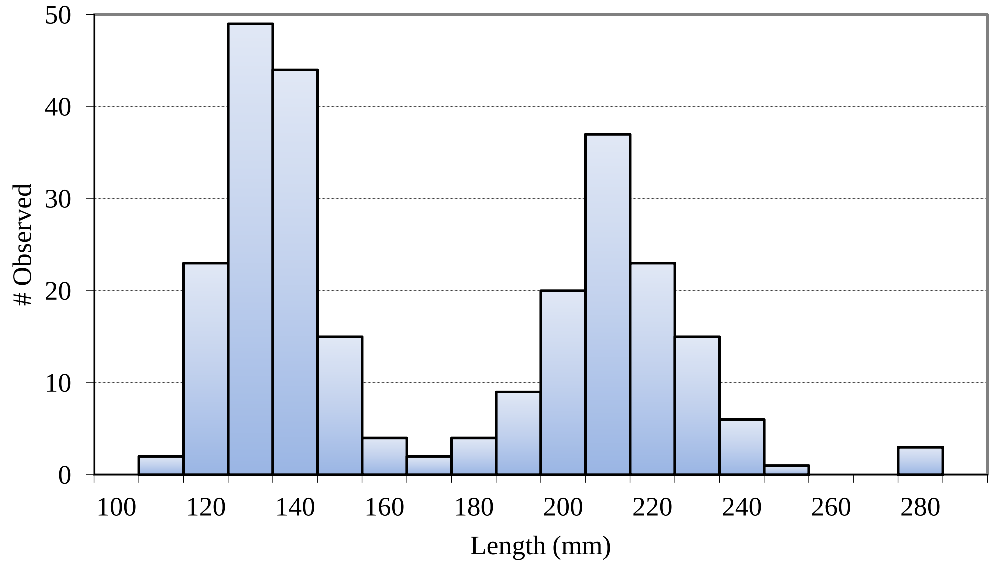


Figure 46. Length frequency distribution of walleye collected from Whiteface Reservoir, St. Louis County, during fall 2012 electrofishing assessments.

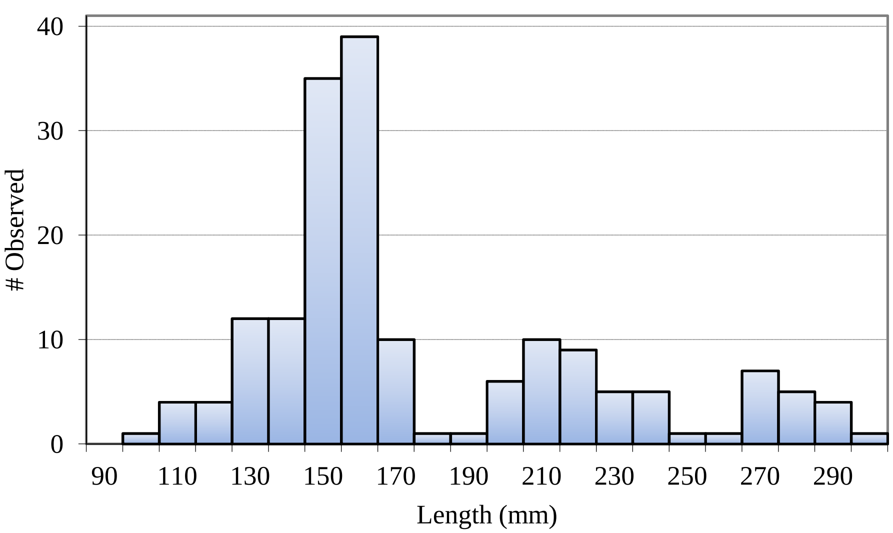


Figure 47. Length frequency distribution of walleye collected from Wilson Lake, Lake County, during fall 2012 electrofishing assessments.

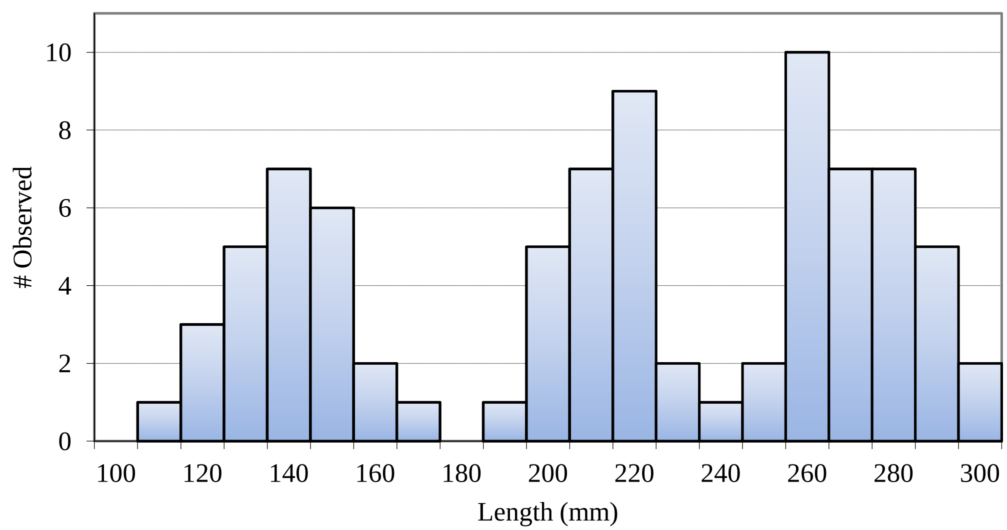
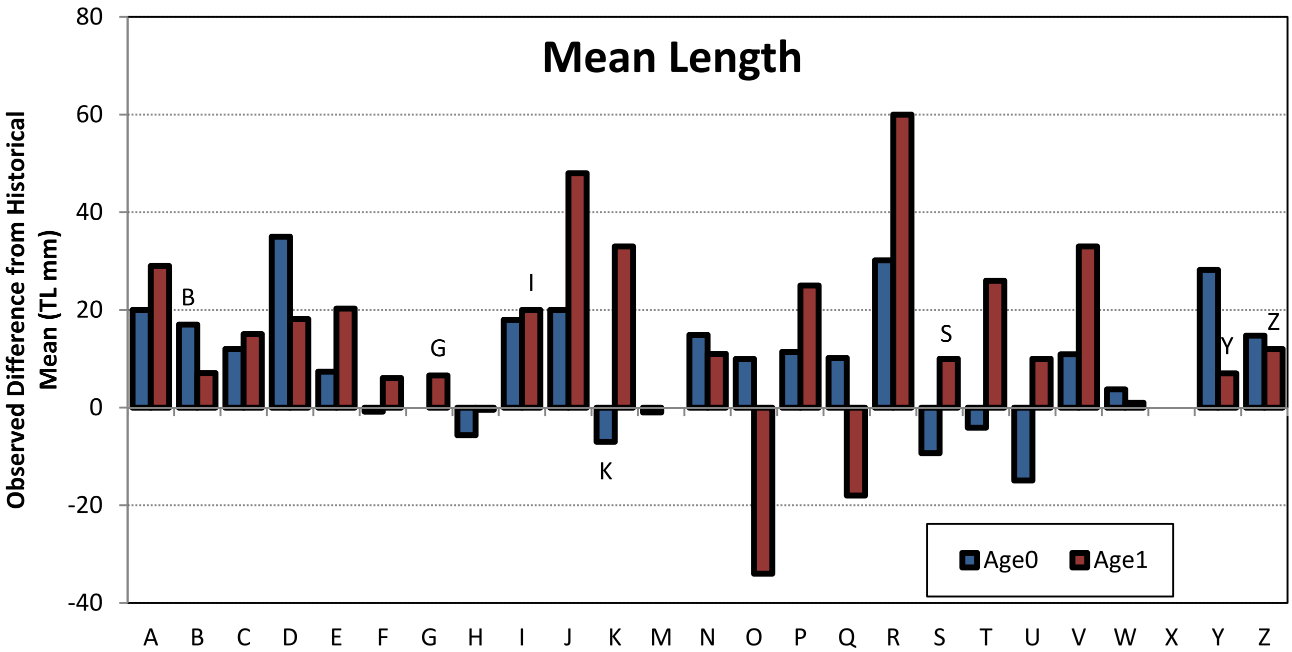


Figure 48. Length frequency distribution of walleye collected from Windy Lake, Lake County, during fall 2012 electrofishing assessments.



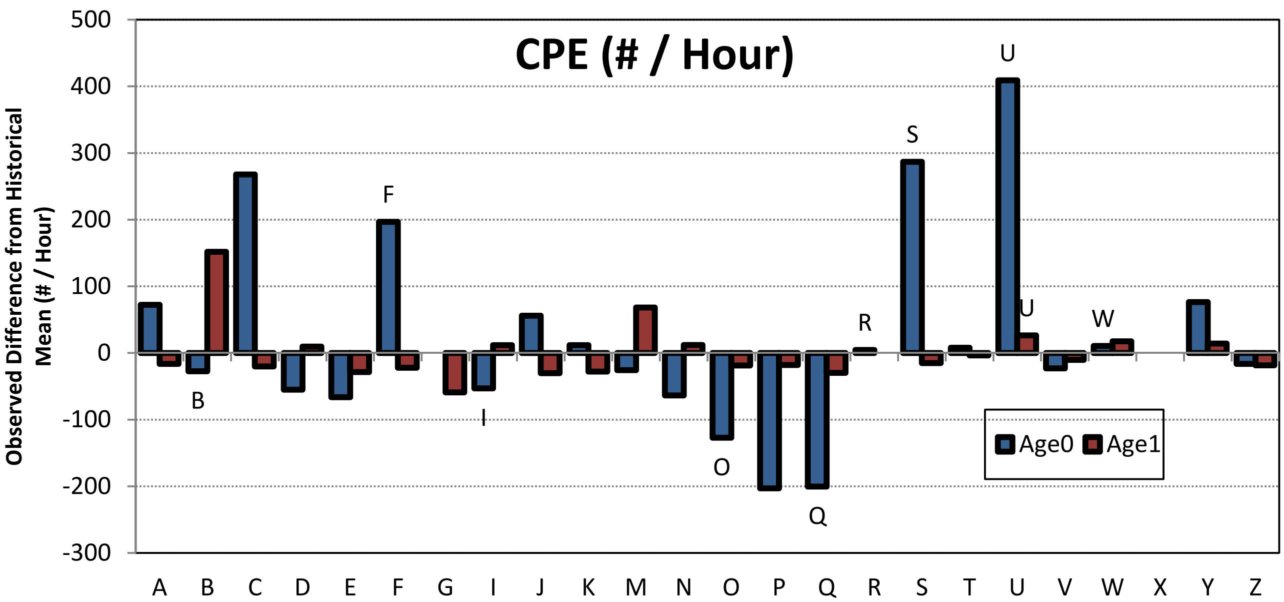


Figure 49. Plots of the differences between 2012 observed mean lengths (mm) and observed mean CPEs (# / hour) by lake and historical mean lengths and mean CPEs for age-0 and age-1 walleyes for each lake sampled during fall 2012. Each lake will have an age-0 and an age-1 point. A few data points are labeled as examples.

A - Ball Club	H - Dumbbell	N - N. McDougal	U - Two Island
B - Cadotte	I - Elbow	O - Ninemile	V - West Twin
C - Caribou	J - Fourmile	P - Pike	W - Whiteface
D - Cascade	K - Harriet	Q - Shagawa	X - Wild Rice
E - Crescent		R - Silver Island	Y - Wilson
F - Crooked	M - Island	S - Tait	Z - Windy
G - Devilfish		T - Tom	

Appendix 1. Nightly Mark / Recapture Data for walleye > 254 mm sampled during spring 2012 assessments in Cascade, Silver Island, Ball Club, and Devilfish Lakes, and observed in MN DNR summer gill net assessments.

Lake	Date	Marked in Population	Daily Catch	Daily Recap
Cascade	3 April	---	49	---
	9 April	49	235	7
	10 April	277	129	26
	11 April	380	161	48
	MNDNR GN	493	67	23
Silver Island	12 April	---	342	---
	13 April	342	242	58
	14 April	526	267	94
	MNDNR GN	699	147	16
Ball Club	9 April	---	41	---
	10 April	41	81	0
	11 April	122	84	13
	12 April	193	94	17
	13 April	270	49	15
	MNDNR GN	304	30	8
Devilfish	14 April	---	150	---
	17 April	150	138	29
	18 April	259	120	39
	MNDNR GN	338	31	5