Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2017

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 (*Sander vitreus*) 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 after 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). In order to maximize the number of fish handled and marked during the 2017 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. 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 2017 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, another 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 2017 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 by MNDNR Area Managers and Tribal biologists. The objective was to obtain adult walleye population estimates using mark-recapture methods and to determine the age structure and growth rates of the walleye population within the lakes surveyed. Fin clipped and colored floy-tagged walleye would then be available during summer gill net assessments. A second population estimate was obtained by the MNDNR in the course of conducting their standard summer gill net surveys.

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 non-numbered colored floy tags (green color used in 2017) (Super Swiftachment Fasteners available from the Dennison Fastener Division, Framingham, Massachusetts). The reason for this was because after many years of clipping dorsal fin spines, it would be impossible to differentiate 2017 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. Sampling stations were repeated from previous years' surveys.

Walleyes were aged by counting annuli on scales viewed under a microfiche reader (Borkholder and Edwards 2001). 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

Harriet Lake (DOW 38-0048)

Electrofishing activities were conducted on Harriet Lake, Lake County, on 19 – 22 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 0.0 (EF3, 20 & 21 April) to 73.6 (EF4, 22 April) adult walleye per hour of sampling (Figure 1). At a 95% confidence interval, mean CPUE for Harriet Lake, determined using each sampling station, was 20.9 ± 10.0 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled in Harriet Lake is presented in Figure 2. Walleye as large as 670 mm (26.4 inches) were observed in the survey. This 670 mm female fish was actually sampled on three of the four nights of activities (Figure 2). Additional species observed included yellow perch, northern pike and white sucker.

Walleyes larger than 254 mm were marked with a non-numbered green floy tag along the distal portion of the soft dorsal fin. Table 2 presents the population estimates based upon mark-recapture data. The electrofishing Schumacher and Eschmeyer population estimate is 198 (Table 2). The adjusted Petersen estimate is 181 ± 56, with a 9.7% CV (Table 2). The population estimates presented in Table 2 represent the population abundance of walleye using the sampled areas for spawning (Figure 1), and are not estimates of the walleye population within the entire lake.

During summer 2017, the Minnesota Department of Natural Resources performed a standardized net assessment on Harriet Lake (MN DNR, Finland Area Fisheries). Thirty-one (31) (> 274 mm) were sampled in the gill nets that would have been 254 mm during the April assessments. Eight individuals were observed to have the green floy tag from the spring sampling (Appendix 1). The adjusted Petersen estimate using both the summer and spring data is 491 ± 365, with a 26.8% CV (Table 2). The Schumacher and Eschmeyer population estimate from this gill net data is 254 (Table 2). Thirty-four (34) walleyes in total were sampled between the gill nets and trap nets, with ten recaptured individuals observed. Population estimates are included in Table 2.

Table 3 presents the age data for the walleye collected from Harriet Lake. Of the 137 unique fish sampled, 72 (52.6%) were assigned to ages 6 & 7. Total annual mortality (*A*) of the Harriet Lake population was estimated 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) (Chapman and Robson 1960). *A* was estimated at 26.8% (Figure 3, blue line). Using catch curve analysis assumes that; 1) there are no aging errors; 2) constant recruitment; 3) Z is constant over time, and; 4) above a certain age (sexual maturity for this data set) all individuals within the population are equally vulnerable to the sampling gear (Smith et al., 2012). For our walleye surveys, generally male walleyes are fully mature and vulnerable by age 4 or 5. The data suggests that, if recruitment was constant (assumption 2), full recruitment may not have been observed until age-6 (Figure 3). Total annual mortality (*A*) estimated using the MNDNR's gill net data was 16.9% (Figure 3, green triangles), lower than the estimates from the spring electrofishing assessment. Our spring estimate was made using 122 mature walleyes, age 6 – 15. The estimate from the gill and trap net assessment was made using 41 fish age 2 – 14.

Table 4 presents back-calculated lengths-at-age for walleye collected from Harriet Lake, as determined using dorsal fin spines.

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 was 91.9 ± 3.8 (Table 5). The electrofishing sample suggests that this population may be unbalanced (Gabelhouse 1984). Few fish were observed less than 15.0 inches (8.1% of sample) that will be growing and recruiting into this "quality" 15-inch category over the next few years. There has been very little natural recruitment observed over the last ten falls, with the only exception being the 2016 age-0 sample (Borkholder et al. 2017). The summer gill net PSD (45.7 ± 16.5) was significantly different than the PSD estimate from the spring electrofishing survey (χ^2=49.4, P<0.05, critical Chi-square value of 3.841) (Table 5), and does not suggest an unbalanced population. This netting estimate was derived from a much lower sample size than the electrofishing estimate, 35 fish in the gill nets versus 197 sampled by the electrofishing crew. Obviously the electrofishing samples target only the mature spawning portion of the population. Harriet Lake walleye may be maturing at a larger size and older age than other populations, and thus were not sampled by our spring electrofishing crews. Growth rates determined by back-calculating length-at-age estimates are lower than those observed in other area walleye populations (Table 4). Another hypothesis may be that there really is a large cohort of walleyes in the 15.0 – 19.9 inch range (380 – 505 mm) that we simply never observed in past fall electrofishing surveys. More intensive monitoring should be considered over the next several years to determine whether there's an issue with recruitment, growth and maturity, or fall sampling catchability.

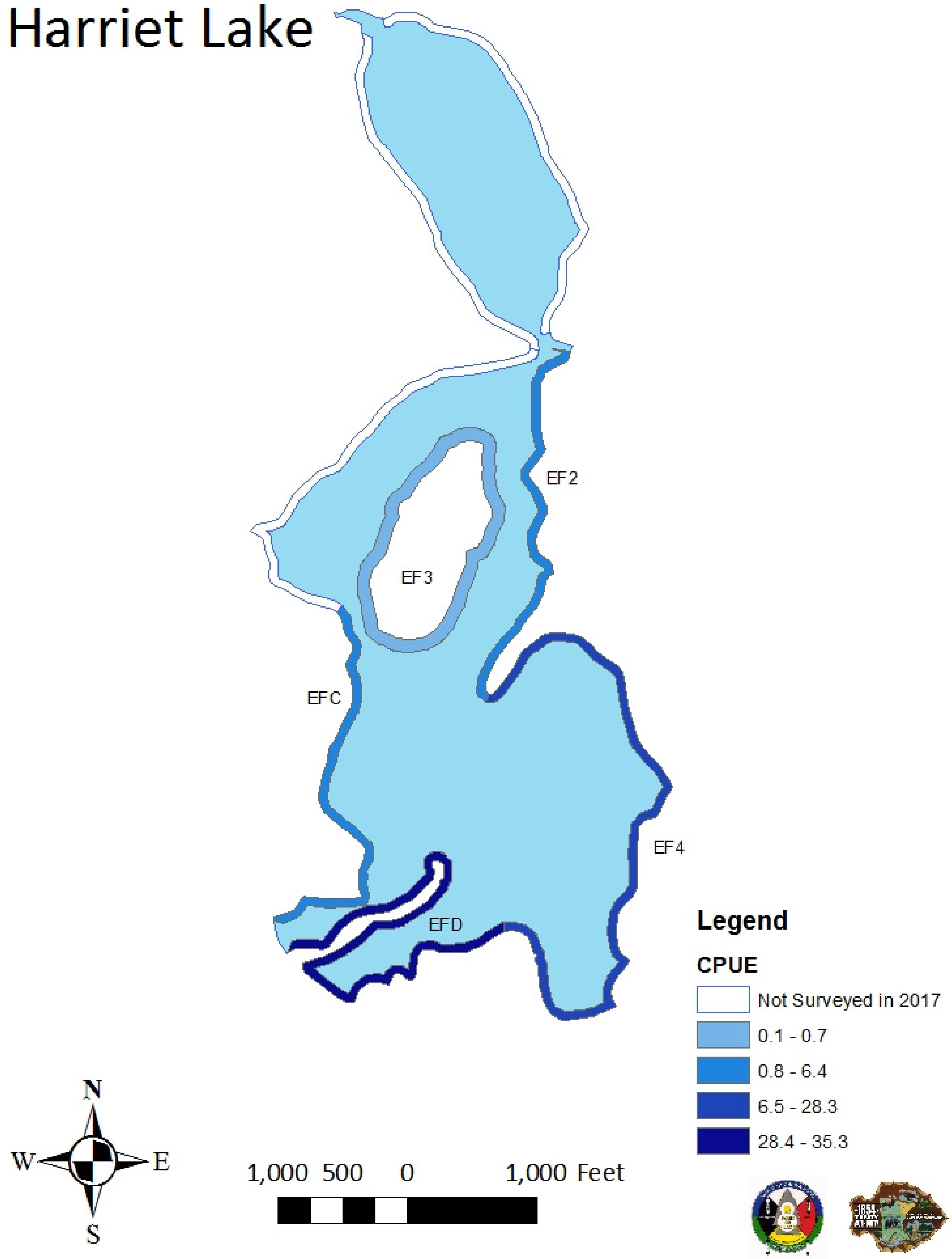

Figure 1. Catch per hour (CPUE) of adult walleyes (fish larger than 254 mm) by electrofishing station, on Harriet Lake, Lake County, during Spring 2017 electrofishing surveys. Based on past surveys and knowledge of spawning habitat, the entire north section was not surveyed in 2017.

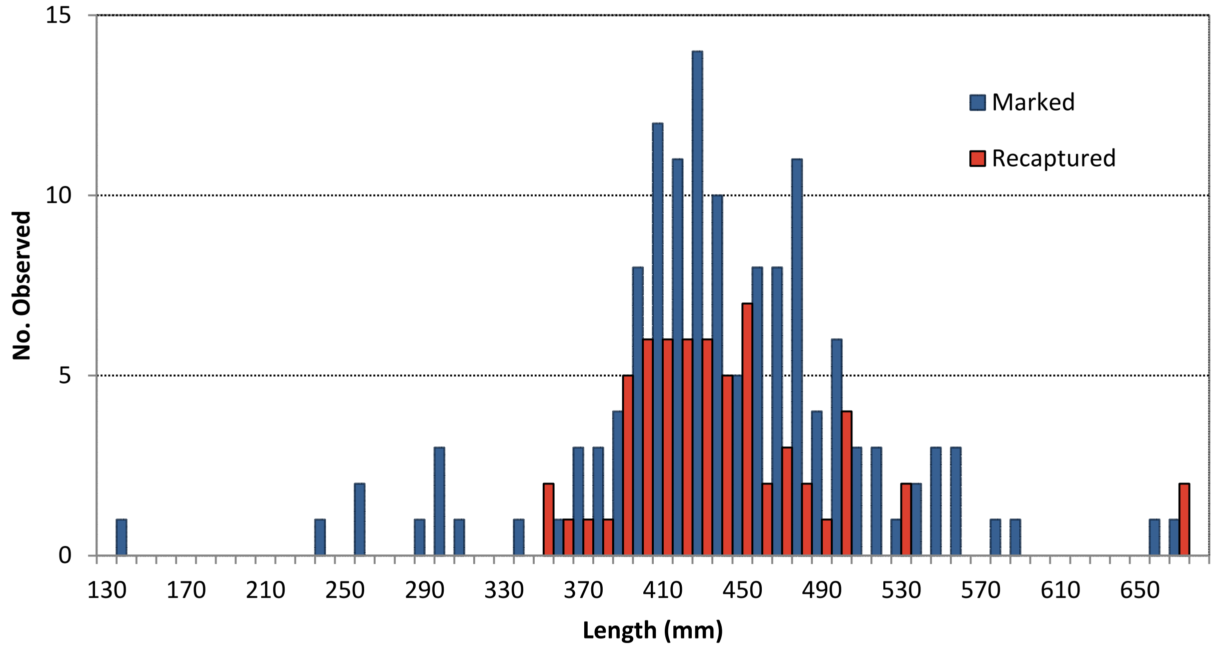

Figure 2. Length frequency distribution of walleye sampled from Harriet Lake, Lake County, MN, during spring 2017 electrofishing assessments. Length frequency distribution of recaptured walleyes is shown in red bars.

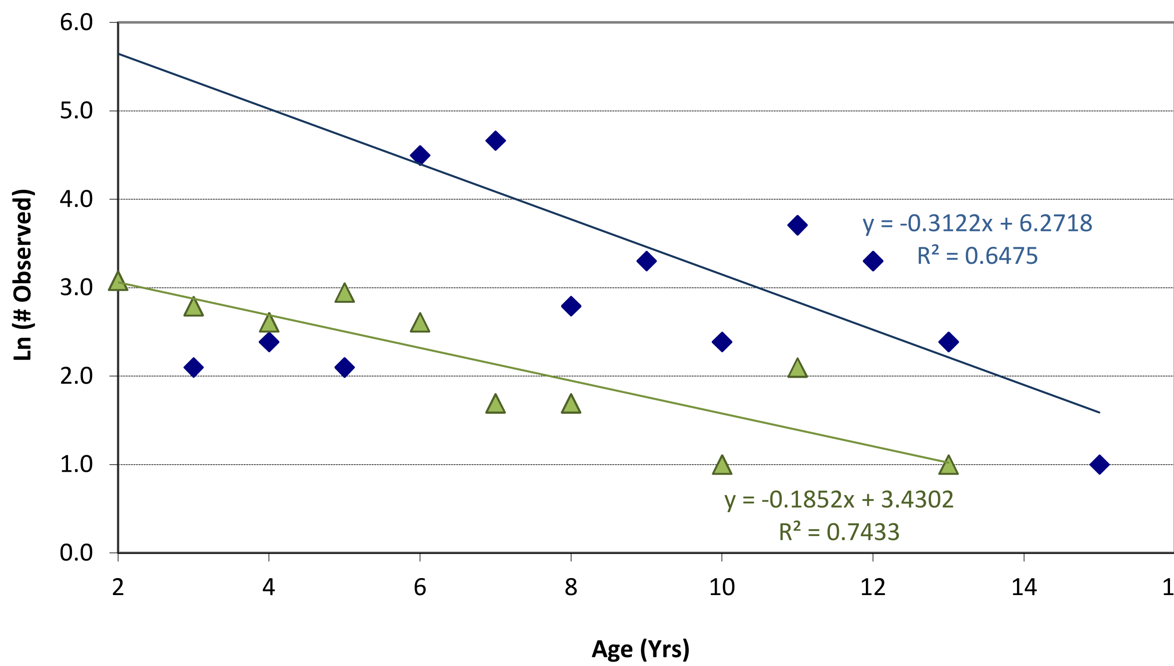

Figure 3. Catch curve analysis of walleyes in Harriet Lake, 2017, showing instantaneous mortality (*Z*). Estimates are made from April 2017 electrofishing data (blue diamonds) and summer MNDNR gill net data (green triangles).

Table 1. Summary of electrofishing activities on seven lakes within the 1854 Ceded Territory of Minnesota during spring 2017.

ID #	County	Lake	Area (Acres)	Max Depth (ft)	Date	Water Temp (F)	Conductivity[1]	Shocking Time (sec)	Voltage (PDC)[2]	Amps[3]	# WAE[4]	CPUE WAE[5]
38-0048	Lake	Harriet	265	37	4/19/2017	39.8	40	9629	High (50%)	1.5	54	20.2
					4/20/2017	38.7	48	8034	High (40%)	1.5	38	17.0
					4/21/2017	41.4	46	5873	High (40%)	1.5	33	20.2
					4/22/2017	42.2	50	6056	High (40%)	1.5	75	44.6
16-0384	Cook	Tait	355	15	4/23/2017	41.7	32	16570	1061	4	194	42.1
					4/24/2016	41.5	31	14397	1061	4	163	40.8
					4/29/2017	37.5	31	3944	High (65%)	1.5	44	40.1
16-0360	Cool	Caribou	721	30	4/25/2016	36	55	3566	1061	4	96	96.9
					4/27/2016	38	59	11701	1061	4	178	54.8
					4/28/2016	37.2	59	15740	1061/High (40%)	4 / 1.5	217	49.6
					4/29/2016	39	58	10058	1061/High (40%)	4 / 1.5	215	77.0

[1] Water conductivity measured in microSiemens / cm.
[2] Voltage is reported as actual voltage recorded from the SmithRoot Type VI-A, or as Low / High from the SmithRoot 5.0 GPP
[3] Amps are reported as from the 1854 Treaty Authority Boat / Fond du Lac Boat.
[4] WAE = walleye. Numbers in column represent the number of "stock" sized walleye (>254mm (10 inches)) collected. Includes marked and recaptured individuals.
[5] 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)).

Table 2. Walleye population estimates for Harriet Lake (Lake County), Tait Lake (Cook County), and Caribou Lake (Cook County), Spring 2017. 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 from samples collected during the MNDNR's summer netting assessments. GN/TN includes all of the MNDNR data from both the gill nets and trap nets.

Lake	Population Estimate[1]	No. / Acre	95% Confidence Limits Lower	95% Confidence Limits Upper	Estimate[2]	C.V.[3]
Harriet – EF_{2017}	198	0.7	154	279	181 ± 56	9.7 %
Harriet – GN_{2017}	254	1.0	162	584	491 ± 365	26.8%
Harriet – GN/TN_{2017}	254	1.0	165	557	452 ± 302	24.1%
Tait – EF_{2017}	710	2.0	372	7809	522 ± 257	11.4%
Tait – GN_{2017}	859	2.4	454	7836	2394 ± 3154	41.4%
Tait – GN/TN_{2017}	901	2.5	512	3758	1786 ± 1616	28.4%
Caribou – EF_{2017}	884	1.2	792	1002	893 ± 211	7.4%
Caribou – GN_{2017}	967	1.3	731	1430	1918 ± 1436	27.0%
Caribou – GN/TN_{2017}	985	1.4	720	1559	2150 ± 1642	27.5%

[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*)

Tait Lake (DOW 16-0384)

Electrofishing activities were conducted on Tait Lake, Cook County, on 23 – 24 & 29 April (Figure 4). 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 5.3 (EF1A, 23 April) to 90.4 (EF4, 23 April) adult walleye per hour of sampling (Figure 4). At a 95% confidence interval, mean CPUE for Tait Lake, determined using each sampling station, was 38.5 ± 13.6 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled in Tait Lake is presented in Figure 5. Walleye as large as 571 mm (22.5 inches) were observed in the survey. Additional species observed included yellow perch, pumpkinseed, northern pike and white sucker.

Table 3. Age frequency distribution of walleye from Harriet Lake, Lake County, spring 2017, 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
4.5	115																
5.0	127																
5.5	140	1															
9.5	241	1		1													
10.0	254	2		2													
10.5	267																
11.0	279																
11.5	292	3			3												
12.0	305	2			1	1											
12.5	318																
13.0	330																
13.5	343	1						1									
14.0	356	1						1									
14.5	368	3						2		1							
15.0	381	5					1	4									
15.5	394	7				2	5										
16.0	406	15					9	6									
16.5	419	16					7	7		2							
17.0	432	13					3	9	1								
17.5	445	10					2	5	1	1							
18.0	457	9					3	3	1	1							
18.5	470	12						1	3	3	4		1				
19.0	483	11					3			1		6					
19.5	495	6										6					
20.0	508	3								1		1	1				
20.5	521	3											2			1	
21.0	533	3										1	1	1			
21.5	546	2											1	1			
22.0	559	4										1	3				
22.5	572	1											1				
23.0	584	1															
26.0	660	2												2			
TOTAL		137	0	3	4	3	33	39	6	10	4	15	10	4	0	1	

Table 4. Back-calculated lengths-at-age for walleye collected from Harriet Lake, Lake County, Minnesota, Spring 2017.

Age Class	N	Length (mm)	Length (in)
1	104	109	4.3
2	104	178	7.0
3	104	237	9.3
4	102	291	11.5
5	98	346	13.6
6	96	396	15.6
7	71	426	16.8
8	48	452	17.8
9	43	474	18.7
10	34	498	19.6
11	29	520	20.5
12	17	541	21.3
13	8	563	22.2
14	3	589	23.2
15	2	563	22.2

Table 5. Proportional Stock Density (PSD) and Relative Stock Densities (RSD) with 95% confidence for Harriet Lake (Lake County), Tait Lake & Caribou Lake (Cook County). 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
Harriet – EF_{2017}	91.9 ± 3.8	8.1 ± 3.8	79.7 ± 5.6	10.1 ± 4.2	2.0 ± 2.0
Harriet – GN_{2017}	45.7 ± 16.5	54.3 ± 16.5	34.3 ± 15.7	11.4 ± 10.5	0.0 ± 0.0
Harriet – GN/TN_{2017}	46.2 ± 15.6	53.8 ± 15.6	30.8 ± 14.5	12.8 ± 10.5	2.6 ± 5.0
Tait – EF_{2017}	64.7 ± 5.1	35.3 ± 5.1	62.6 ± 5.1	2.1 ± 1.5	0.0 ± 0.0
Tait – GN_{2017}	27.6 ± 16.3	72.4 ± 16.3	27.6 ± 16.3	0.0 ± 0.0	0.0 ± 0.0
Tait – GN/TN_{2017}	40.8 ± 13.8	59.2 ± 13.8	34.7 ± 13.3	6.1 ± 6.7	0.0 ± 0.0
Caribou – EF_{2017}	73.0 ± 3.8	27.0 ± 3.8	65.9 ± 4.1	6.7 ± 2.2	0.4 ± 0.5
Caribou – GN_{2017}	51.4 ± 16.6	48.6 ± 16.6	40.0 ± 16.2	11.4 ± 10.5	0.0 ± 0.0
Caribou – GN/TN_{2017}	47.5 ± 15.5	52.5 ± 15.5	37.5 ± 15.0	10.0 ± 9.3	0.0 ± 0.0

Walleyes larger than 254 mm were marked with a non-numbered green floy tag along the distal portion of the soft dorsal fin. Table 2 presents the population estimates based upon mark-recapture data. The electrofishing Schumacher and Eschmeyer population estimate is 710 (Table 2). The electrofishing adjusted Petersen estimate is 522 ± 257, with an 11.4% CV (Table 2). This PE is likely biased low, after a spring ice storm prevented survey crews from returning to the lake. By the time crews were able to return on 29 April, many of the spawning fish had left the shallows, and were no longer vulnerable to our sampling gear.

During summer 2017, the Minnesota Department of Natural Resources performed a standardized net assessment on Tait Lake (MN DNR, Grand Marais Area Fisheries). Twenty-seven (27) (> 274 mm) were sampled in the gill nets that would have been 254 mm during the April assessments. Three individuals were observed to have the green tag from the spring sampling (Appendix 1). The adjusted Petersen estimate using both the summer and spring data is 2394 ± 3154, with a 41.4% CV (Table 2). The Schumacher and Eschmeyer population estimate from this gill net data is 859 (Table 2). Forty-six (46) walleyes in total were sampled between the gill nets and trap nets, with eight recaptured individuals observed. Population estimates are included in Table 2.

Table 6 presents the age data for the walleye collected from Tait Lake. Total annual mortality (A) of the Tait Lake population was estimated at 39.2%, 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 6). This estimate is comparable to that in 2015 (38.5%; Borkholder et al. 2016) and in 2013 (31.4%; Borkholder et al. 2014). Full recruitment of the males in this population likely occurs by age-4 (Figure 6). Total annual mortality (A) estimated using the MNDNR's gill net data was 20.6% (Figure 6, green triangles), lower than the estimates from the spring electrofishing assessment. Table 7 presents back-calculated lengths-at-age for walleye collected from Tait Lake, as determined by aging dorsal fin spines.

PSD and RSD values determined by our spring electrofishing sampling and summer gillnet survey are presented in Table 5. The electrofishing PSD of 64.7 ± 5.1 (Table 5). There is a strong 2012 year class that has recruited into the fishery, and may be accountable for this PSD estimate that is a bit higher than what is normally considered "balanced". The summer gill net PSD (27.6 ± 16.3) was significantly different than the PSD estimate from the spring electrofishing survey (χ^2=15.6, P<0.05, critical Chi-square value of 3.841) (Table 5).

Tait Lake has been intensively monitored since 2009. Every two years since, both State and tribal biologists have been surveying this lake. Trend data is presented in Figure 7. Population estimates each year suggest a declining population of adult walleyes (blue diamonds and trend line). Changes in stock structure (PSD; pink bars) is also presented over time. This data indicates a population of smaller fish in 2015 (PSD = 28.7) having grown and recruited into the sizes preferred by anglers in 2017 (PSD = 64.7).

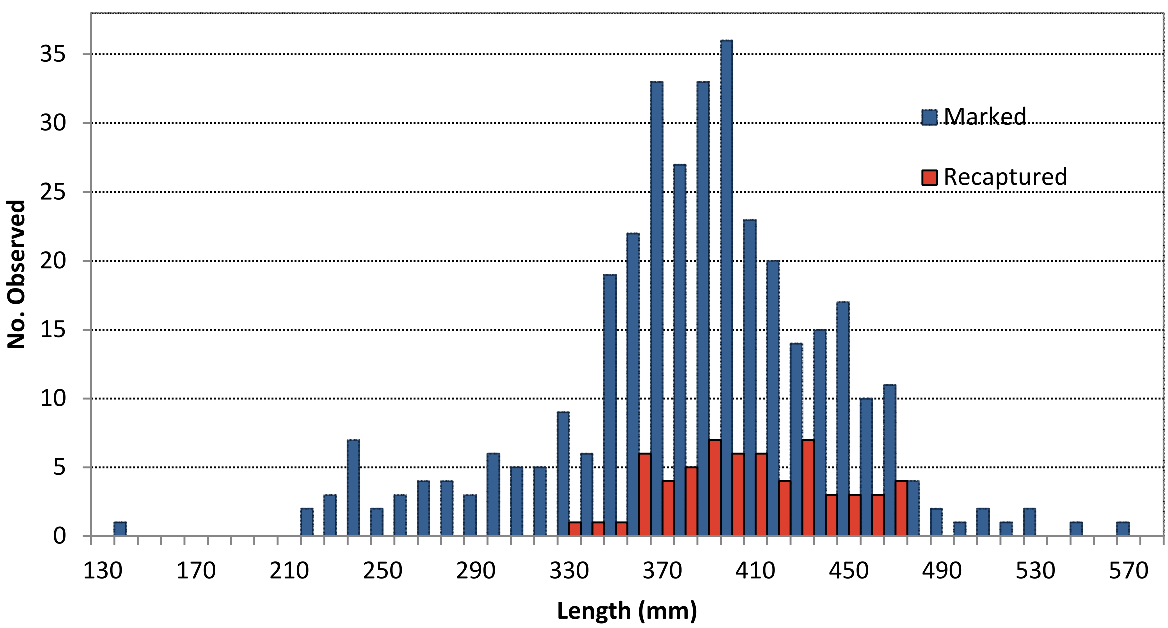

Figure 5. Length frequency distribution of walleye sampled from Tait Lake, Cook County, MN, during Spring 2017 electrofishing assessments. Length frequency distribution of recaptured walleyes is shown in red bars.

Tait Lake

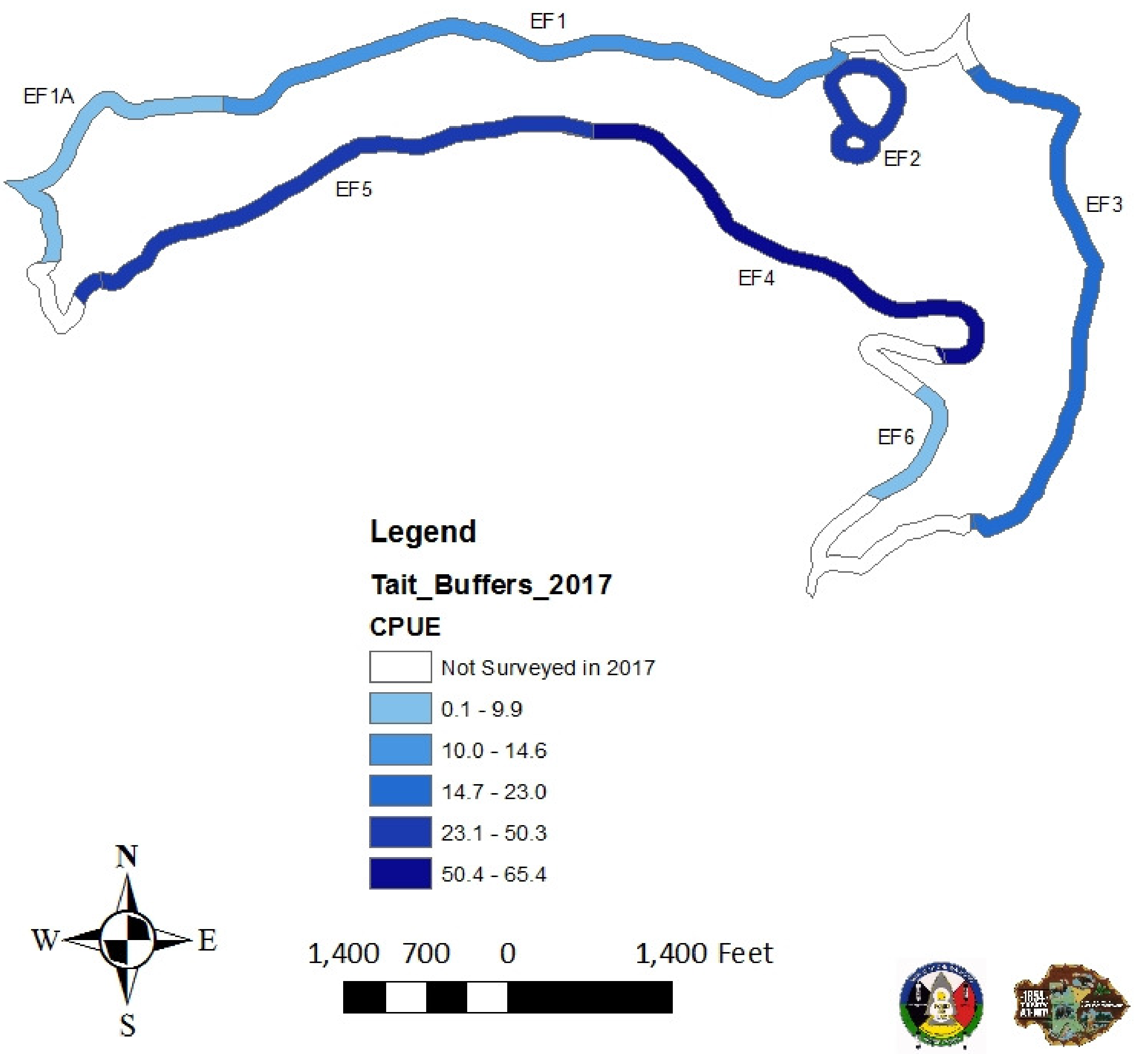

Figure 4. Catch per hour (CPUE) of adult walleyes (fish larger than 254 mm) by electrofishing station, on Tait Lake, Cook County, during Spring 2017 electrofishing surveys.

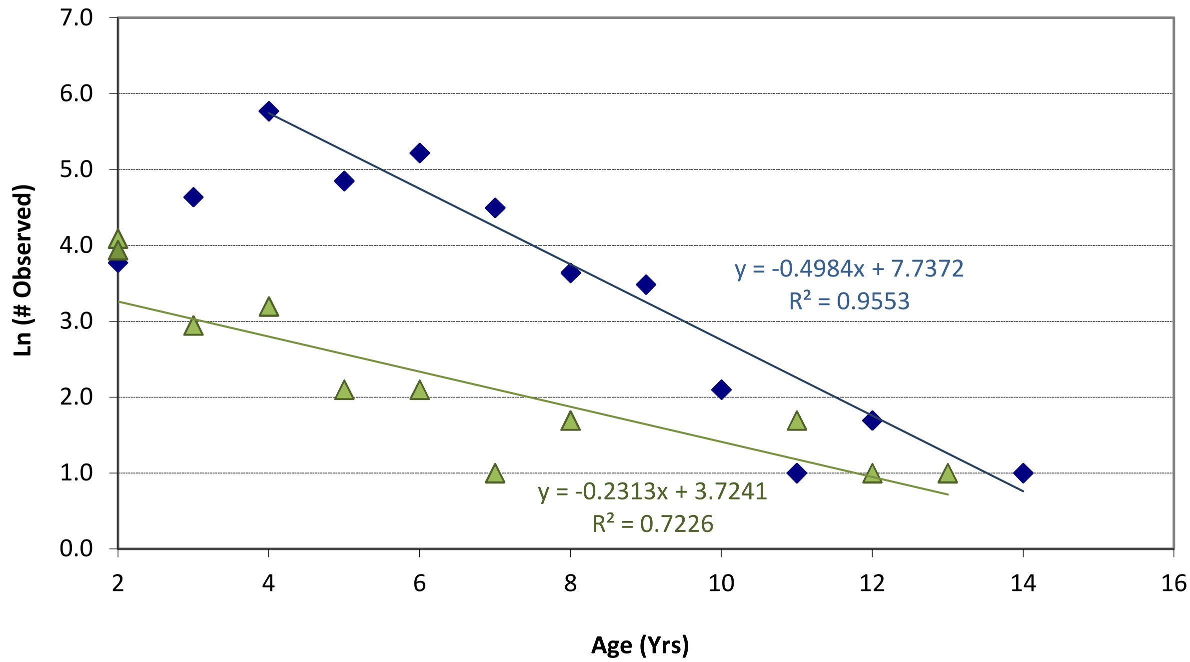

Figure 6. Catch curve analysis of walleyes in Tait Lake, 2017, showing instantaneous mortality (*Z*). Estimates are made from April 2017 electrofishing data.

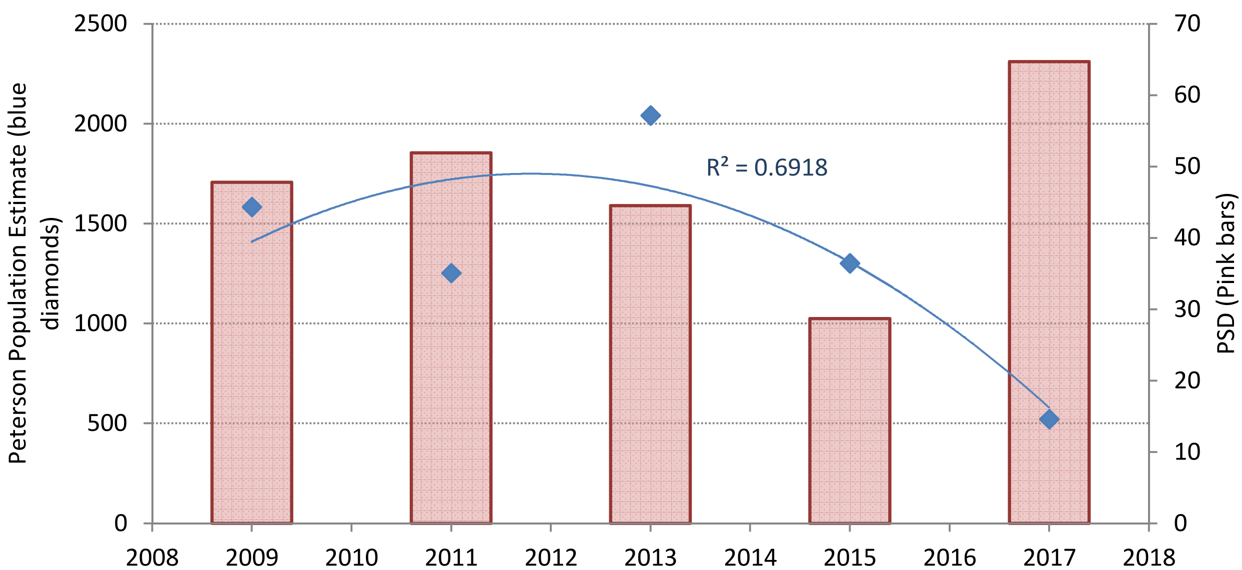

Figure 7. Long-term electrofishing data for Tait Lake, presenting Peterson population estimates (blue diamonds) and PSD estimates (pink bars) since the first electrofishing survey in 2009 .

Table 6. Age frequency distribution of walleye from Tait Lake, Cook County, spring 2017, 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	
5.5	140	1														
8.0	203															
8.5	216	2	2													
9.0	229	3	3													
9.5	241	8	8													
10.0	254	3	3													
10.5	267	5		5												
11.0	279	6		6												
11.5	292	4		4												
12.0	305	7		7												
12.5	318	6		5	1											
13.0	330	11		6	5											
13.5	343	15			15											
14.0	356	28			24	4										
14.5	368	37			36						1					
15.0	381	37		5	14	9	9									
15.5	394	44			23	6	10	4								
16.0	406	36				13	17	6								
16.5	419	26				13	11	2								
17.0	432	18					9	9								
17.5	445	19					9	6	2	2						
18.0	457	13				2	2	3	5	1						
18.5	470	13						3	4	6						
19.0	483	3					1		1			1				
19.5	495	2							1	1						
20.0	508	3							1	1					1	
20.5	521	2									2					
21.0	533															
21.5	546	1											1			
22	559	1											1			
TOTAL		354	16	38	118	47	68	33	14	11	3	1	2	0	1	0

Table 7. Back-calculated lengths-at-age for walleye collected from Tait Lake, Cook County, Minnesota, Spring 2017.

Age Class	N	Length (mm)	Length (in)
1	171	115	4.5
2	171	204	8
3	168	283	11.1
4	136	343	13.5
5	92	382	15
6	73	416	16.4
7	43	434	17.1
8	29	455	17.9
9	18	468	18.4
10	8	478	18.8
11	6	505	19.9
12	5	525	20.7
13	1	498	19.6
14	1	513	20.2

Caribou Lake (DOW 16-0360)

Electrofishing activities were conducted on Caribou Lake, Cook County, on 25 – 29 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 ranged from 7.2 (EFB, 27 April) to 121.8 (EF2, 25 April) adult walleye per hour of sampling (Table 1, Figure 7). At a 95% confidence interval, mean CPUE for Caribou Lake, determined using each sampling station, was 58.7 ± 16.8 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled in Caribou Lake is presented in Figure 8. Walleye as large as 740 mm (29.1 inches) were observed in the survey. Additional species observed included northern pike, white sucker, yellow perch, and trout perch.

Walleyes larger than 254 mm were marked with a non-numbered green floy tag along the distal portion of the soft dorsal fin. Table 2 presents the population estimates based upon mark-recapture data. The electrofishing Schumacher and Eschmeyer population estimate is 884 (Table 2). The electrofishing adjusted Petersen estimate is 893 ± 211, with a 7.4% CV (Table 2).

During summer 2017, the Minnesota Department of Natural Resources performed a standardized net assessment on Caribou Lake (MN DNR, Grand Marais Area Fisheries). Thirty-two (32) (> 274 mm) were sampled in the gill nets that would have been 254 mm during the April assessments. Eight individuals were observed to have the green floy tag from the spring sampling (Appendix 1). The adjusted Petersen estimate using both the summer and spring data is 1918 ± 1436, with a 27.0% CV (Table 2). The Schumacher and Eschmeyer population estimate from this gill net data is 967 (Table 2). Thirty-six (36) walleyes in total were sampled between the gill nets and trap nets, with eight recaptured individuals observed. Population estimates are included in Table 2.

Table 8 presents the age data for the walleye collected from Caribou Lake. Of the 523 unique fish sampled, 368 (70.3%) were assigned to ages 4 & 5 (Table 8). Total annual mortality (*A*) of the Caribou Lake population was estimated at 38.9%, 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 10). This estimate seems high, but is comparable to the estimate of total mortality in 2008 (33.8%; Borkholder and Edwards 2009) and in 2014 (36.5%; Borkholder et al. 2015). Total annual mortality (*A*) estimated using the MNDNR's gill net data was 32.8% (Figure 10), and was based on the aging of 56 walleyes age-2 and older. Table 9 presents back-calculated lengths-at-age for walleye collected from Caribou Lake, as determined by aging dorsal fin spines.

PSD and RSD values determined by our spring electrofishing sampling and summer gillnet survey are presented in Table 5. The electrofishing PSD is 73.0 ± 3.8 (Table 5). This estimate is on the high side, but reflects the contribution of two strong year classes, the 2011 and 2012 cohorts. The 2015 cohort was also observed to be high (Borkholder et al. 2016), and will begin recruiting into the spawning population in 2019. This will have the effect of lowering the PSD slightly, but which shouldn't be a concern. The summer gill net net PSD (51.4 ± 16.6) was significantly different than the PSD estimate from the spring electrofishing survey (χ^2=7.5, P<0.05, critical Chi-square value of 3.841), but was only based upon 35 fish stock-sized or larger.

Caribou Lake has been monitored since 1998. Trend data is presented in Figure 11. Population estimates each year suggest a stable population of adult walleyes around the 900 mark (blue diamonds and trend line). Observed stock structure (PSD; pink bars) is also presented over time. This data suggests a population that has not changed much since 2008.

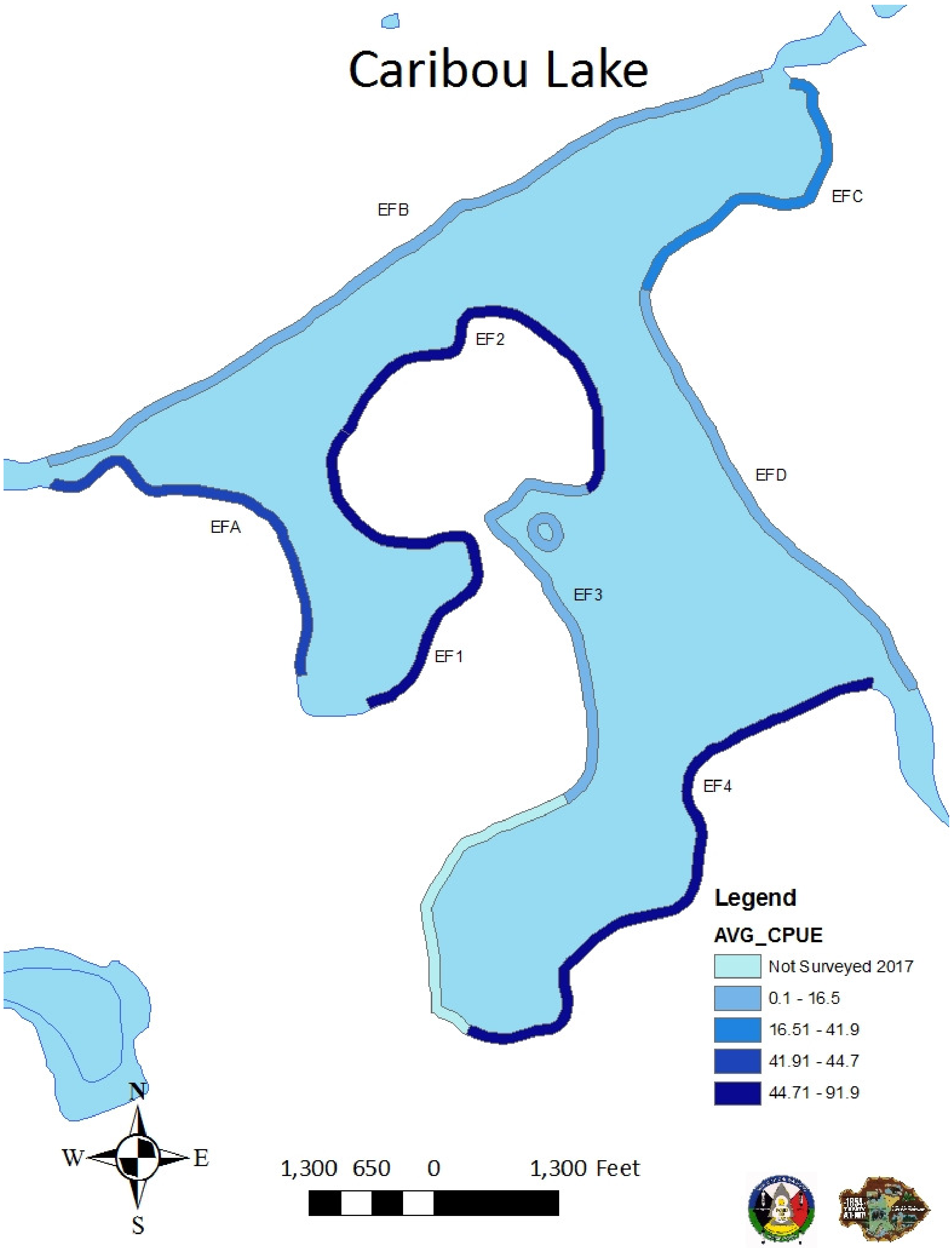

Figure 8. Catch per hour (CPUE) of adult walleyes (fish larger than 254 mm) by electrofishing station on Caribou Lake, Cook County, during Spring 2017 electrofishing surveys.

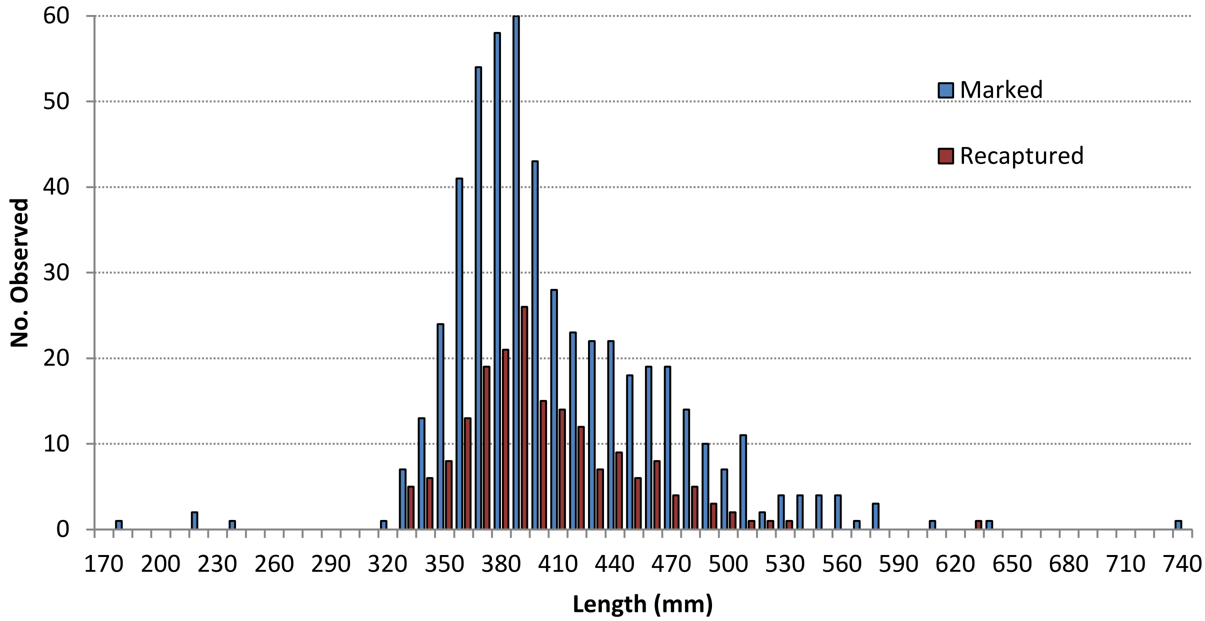

Figure 9. Length frequency distribution of walleye sampled from Caribou Lake, Cook County, MN, during Spring 2017 electrofishing assessments. Length frequency distribution of recaptured walleyes is shown in red bars.

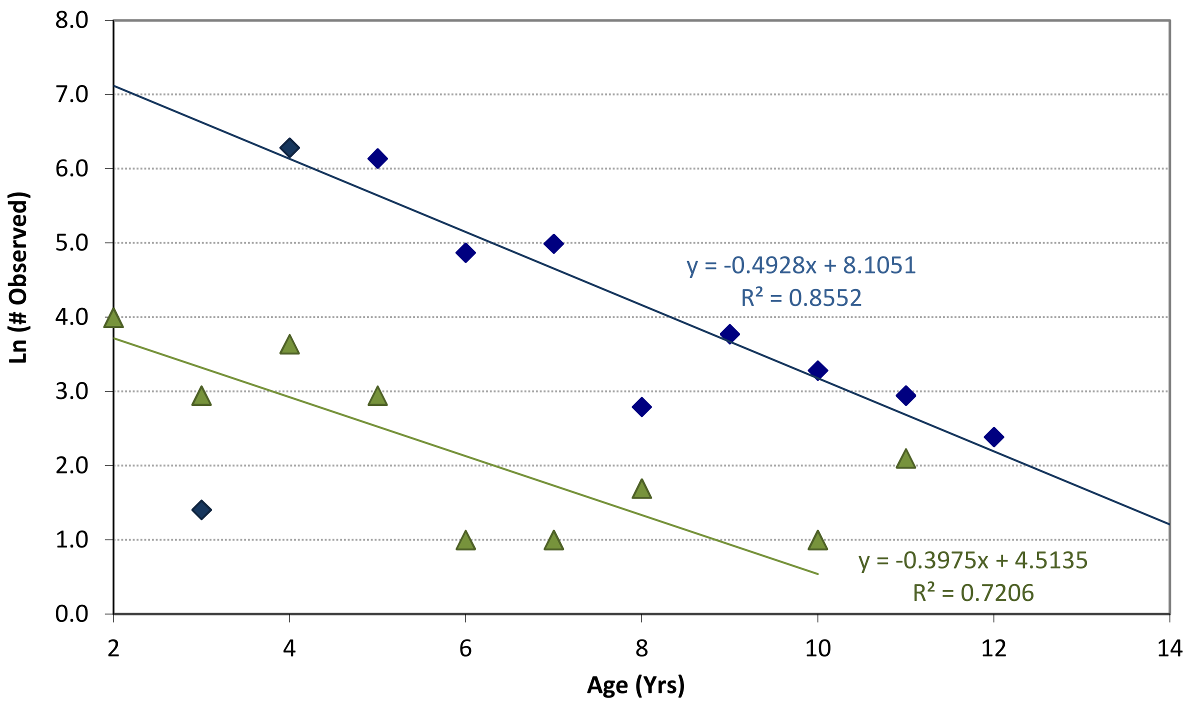

Figure 10. Catch curve analysis of walleyes in Caribou Lake, 2017, showing instantaneous mortality (*Z*). Estimates are made from Spring 2017 electrofishing data (blue diamonds), and from summer 2017 gill net assessments by the MNDNR (green triangles).

Table 8. Age frequency distribution of walleye from Caribou Lake, Cook County, spring 2017, 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		16
7.0	178	1												
8.5	216	2												
9.0	229	1												
12.0	305													
12.5	318	2		2										
13.0	330	9	2	6	1									
13.5	343	24		18	6									
14.0	356	47		47										
14.5	368	63		63										
15.0	381	83		27	56									
15.5	394	60		30	30									
16.0	406	41		5	31	5								
16.5	419	25			25									
17.0	432	34			11	18	4							
17.5	445	24			4	10	10							
18.0	457	21				7	14							
18.5	470	24			4	2	13	2	2	1				
19.0	483	14			2	4	6	2						
19.5	495	11					2	1	8					
20.0	508	12					3		4	4.8				
20.5	521	3					1		1					
21.0	533	5				2			1	1		1		
21.5	546	6					1				4	1		
22.0	559	5						1			3	1		
22.5	572	3								3				
23.0	584													
24.0	610	1										1		
25.0	635	1												
29.0	737	1												1
TOTAL		523	2	197	171	48	54	6	16	10	7	4	0	1

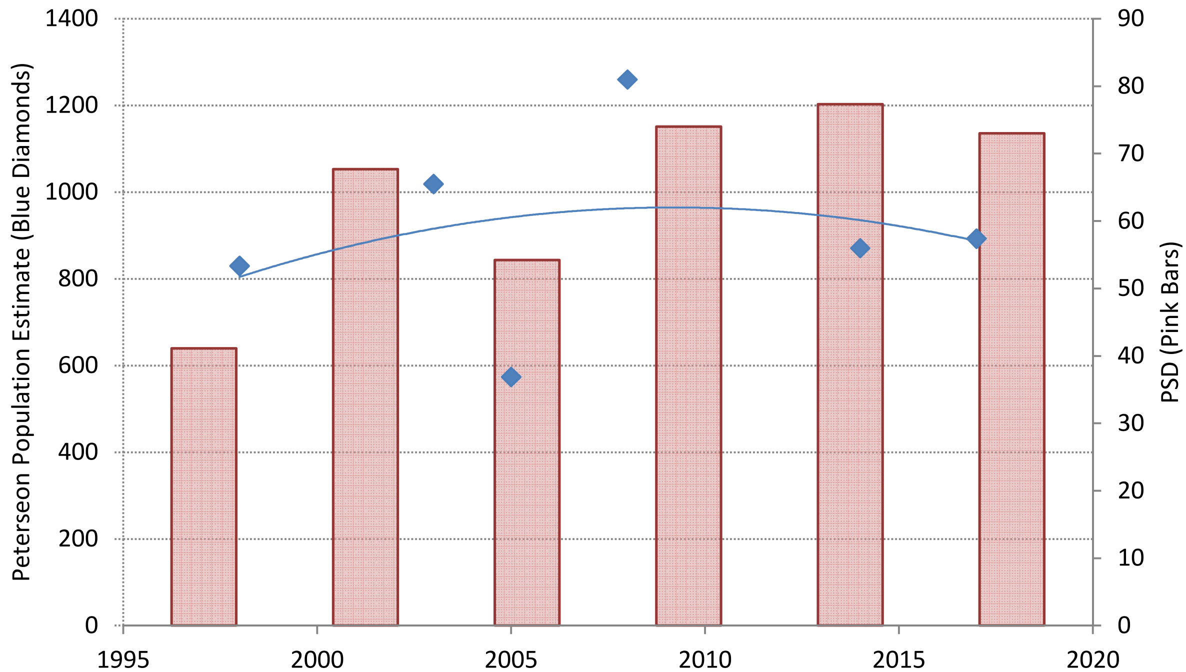

Figure 11. Long-term electrofishing data for Caribou Lake, presenting Peterson population estimates (blue diamonds) and PSD estimates (pink bars) since 1998 electrofishing surveys were initiated.
Table 9. Back-calculated lengths-at-age for walleye collected from Caribou Lake, Cook County, Minnesota, Spring 2017.

Table 9. Back-calculated lengths-at-age for walleye collected from Caribou Lake, Cook County, Minnesota, Spring 2017.

Age Class	N	Length (mm)	Length (in)
1	152	119	4.7
2	152	206	8.1
3	152	292	11.5
4	150	361	14.2
5	120	412	16.2
6	88	448	17.6
7	66	473	18.6
8	48	495	19.5
9	36	517	20.3
10	22	544	21.4
11	14	566	22.3
12	7	589	23.2
13	2	633	24.9
14	1	709	27.9
15	1	728	28.6
16	1	740	29.1

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 5 September 2017. This 20°C threshold was not exceeded on any of the lakes this season (Table 10). All of the lakes were surveyed before the lakes cooled to below the 10°C lower threshold.

Table 18 presents a summary of each evening of electrofishing assessments. CPUE for age-0 walleye ranged from 0.0 fish per hour (Devilfish Lake) to 166.9 fish per hour of electrofishing (Caribou Lake) (Table 10). Only one other lake had an age-0 CPUE greater than 100 fish / hour (Cadotte Lake, Table 10). CPUE for age-1 walleye ranged from 0.0 fish per hour (Windy Lake) to 104.5 fish per hour of electrofishing (Tait Lake) (Table 10). Figures 22 – 46 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 2017 assessments. Mean lengths for age-0 walleye ranged from 96 mm (3.8 inches, Tom Lakes) to 168 mm (6.6 inches, Ninemile Lake). Mean lengths for age-1 walleye ranged from 181 mm (7.1 inches, Tom Lake) to 265 mm (10.4 inches, Cadotte Lake).

Wild Rice Lake Reservoir Largemouth Bass

Eighty-three (83) largemouth bass (*Micropterus salmoides*) were sampled in Wild Rice Lake during fall 2015 assessments (Borkholder et al. 2016), the highest catch rates since they were first observed in 2009. In 2016, only 12 largemouth bass were sampled (Borkholder et al. 2017). This year, 40 individuals were sampled, with lengths ranging from 62mm (2.4 in) to 425mm (16.7 in) (Figure 46).

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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 Fall 2017.

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	5-Sep	60.8	16.0	24.0	87	56	4893	64.0	41.2
Cadotte	27-Sep	62.4	16.9	32.0	359	196	7769	166.4	90.8
Caribou	7-Sep	69.0	20.6	69.0	401	67	8649	166.9	27.9
Cascade	21-Sep	61.0	16.1	24.0	47	49	5434	31.1	32.5
Crescent	18-Sep	61.2	16.2	29.2	20	73	3406	21.1	77.2
Crooked	22-Sep	63.0	17.2	42.0	25	20	4484	20.1	16.1
Devilfish	6-Sep	59.9	15.5	13.0	0	8	9634	0.0	3.0
Dumbbell	26-Sep	63.4	17.4	70.8	79	75	6325	45.0	42.7
Elbow	8-Sep	59.8	15.4	32.0	25	101	4794	18.8	75.8
Fourmile	20-Sep	60	15.6	48.0	38	27	5541	24.7	17.5
Harriet	18-Sep	60.8	16.0	53.0	88	76	6794	46.6	40.3
Island Reservoir	28-Sep	61.5	16.4	73.9	46	130	10006	16.6	46.8
Ninemile	20-Sep	62.0	16.7	45.3	48	0	5971	28.9	0.0
N. McDougal	25-Sep	64.7	18.2	42.0	10	39	5795	6.2	24.2
Pike	7-Sep	62.1	16.7	56.1	184	1	8379	79.1	0.4
Shagawa	26-Sep	63.6	17.6	87.6	121	229	10736	40.6	76.8
Silver Island	19-Sep	60.6	15.9	40.0	15	15	4564	11.8	11.8
Tait	18-Sep	60.8	16.0	34.7	136	202	6957	70.4	104.5
Tom	6-Sep	60.8	16.0	32.7	2	40	8044	0.9	17.9
Two Island	5-Sep	60.8	16.0	28.5	11	11	4960	8.0	8.0
West Twin	7-Sep	59.2	15.1	31.8	86	8	5253	58.9	5.5
Whiteface Res.	27-Sep	62.9	17.2	62.4	16	31	6763	8.5	16.5
Wild Rice	13-Sep	68	20.0	144.6	6	2	5120	4.2	1.4
Wilson	17-Sep	63.0	17.2	45.1	150	107	7599	71.1	50.7
Windy	19-Sep	62.2	16.8	27.8	3	0	6472	1.7	0.0

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 11. Mean length for age-0 and age-1 walleye sampled during fall 2016 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 (N=<20).

Lake (County)	Date	Age-0 Mean Length (mm)	Age-1 Mean Length (mm)
Ball Club	5-Sep	101	211
Cadotte	27-Sep	141	265
Caribou	7-Sep	118	194
Cascade	21-Sep	128	196
Crescent	18-Sep	121 (N=20)	182
Crooked	22-Sep	142	226 (N=20)
Devilfish	6-Sep	----	186 (N=8)
Dumbbell	26-Sep	137	216
Elbow	8-Sep	115	183
Fourmile	20-Sep	134	212
Harriet	18-Sep	123	200
Island Reservoir	28-Sep	114	187
Ninemile	20-Sep	168	----
N. McDougal	25-Sep	123 (N=10)	191
Pike	7-Sep	142	210 (N=1)
Shagawa	26-Sep	149	197
Silver Island	19-Sep	133 (N=15)	209 (N=15)
Tait	18-Sep	129	200
Tom	6-Sep	96 (N=2)	181
Two Island	5-Sep	97 (N=11)	184 (N=11)
West Twin	7-Sep	112	223 (N=8)
Whiteface Res.	27-Sep	133 (N=16)	231
Wild Rice	13-Sep	147 (N=6)	235 (N=2)
Wilson	17-Sep	128	211
Windy	19-Sep	145 (N=3)	----

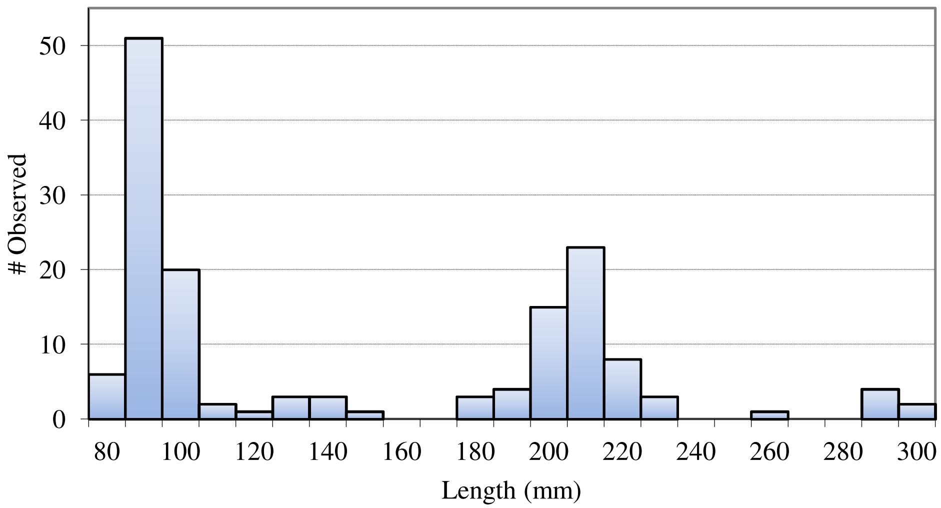

Figure 22. Length frequency distribution of walleye collected from Ball Club Lake, Cook County, during fall 2017 electrofishing assessments.

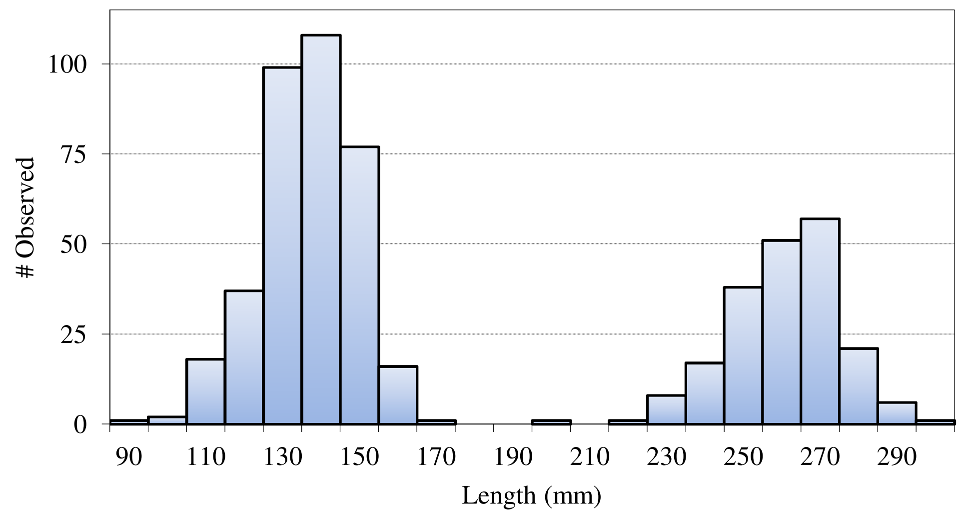

Figure 23. Length frequency distribution of walleye collected from Cadotte Lake, St. Louis County, during fall 2017 electrofishing assessments.

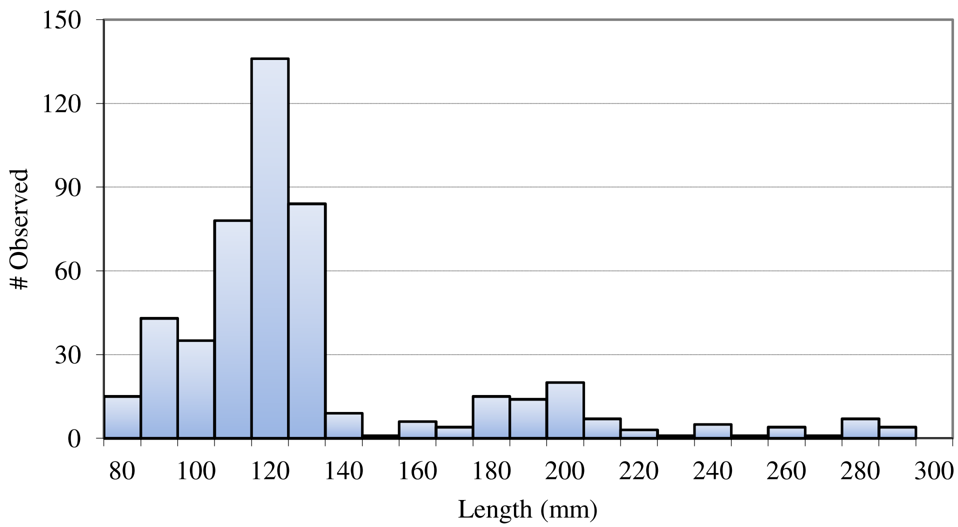

Figure 24. Length frequency distribution of walleye collected from Caribou Lake, Cook County, during fall 2017 electrofishing assessments.

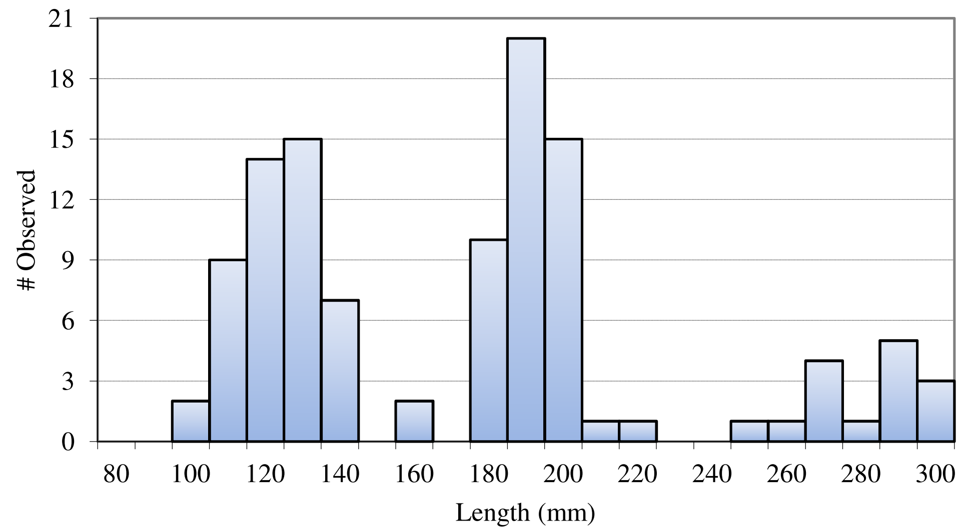

Figure 25. Length frequency distribution of walleye collected from Cascade Lake, Cook County, during fall 2017 electrofishing assessments.

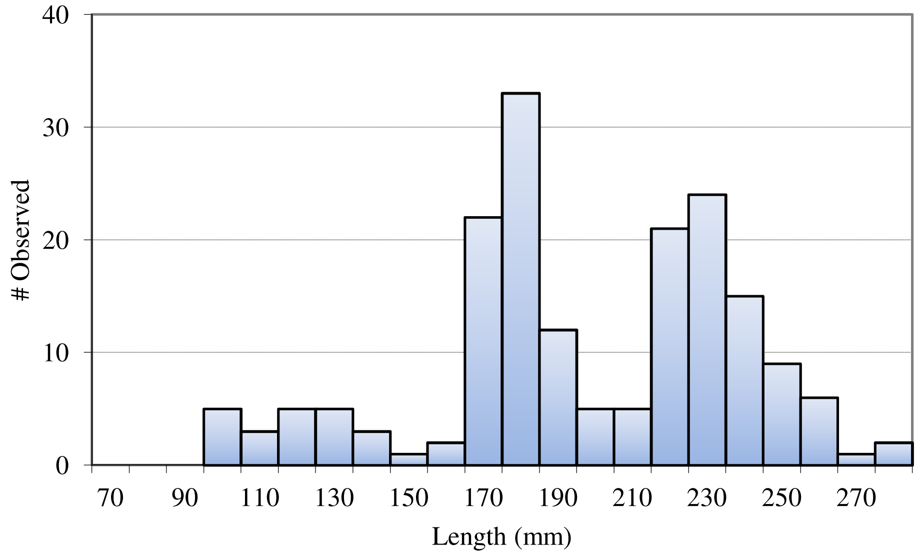

Figure 26. Length frequency distribution of walleye collected from Crescent Lake, Cook County, during fall 2017 electrofishing assessments.

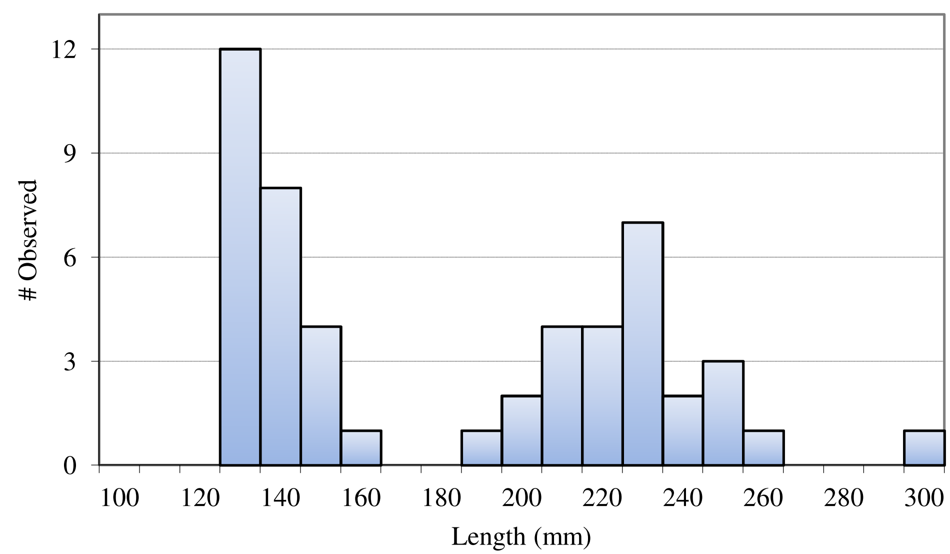

Figure 27. Length frequency distribution of walleye collected from Crooked Lake, Lake County, during fall 2017 electrofishing assessments.

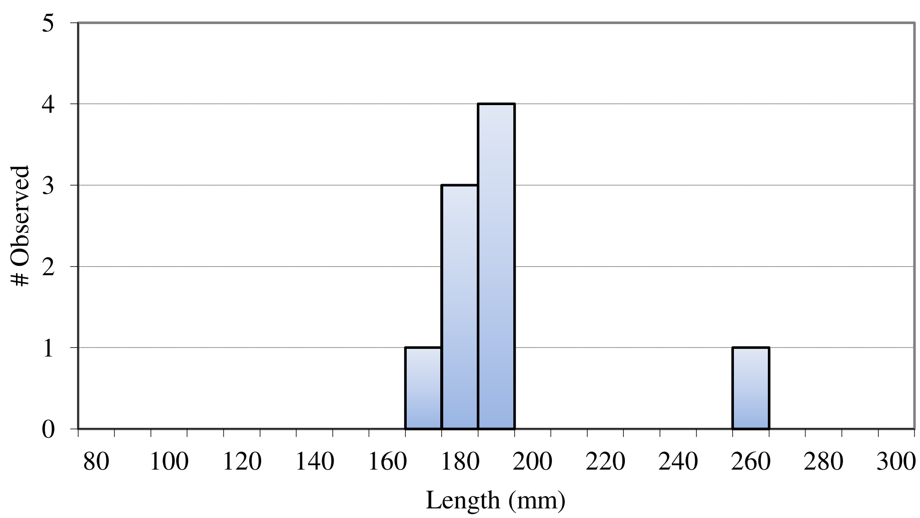

Figure 28. Length frequency distribution of walleye collected from Devilfish Lake, Cook County, during fall 2017 electrofishing assessments.

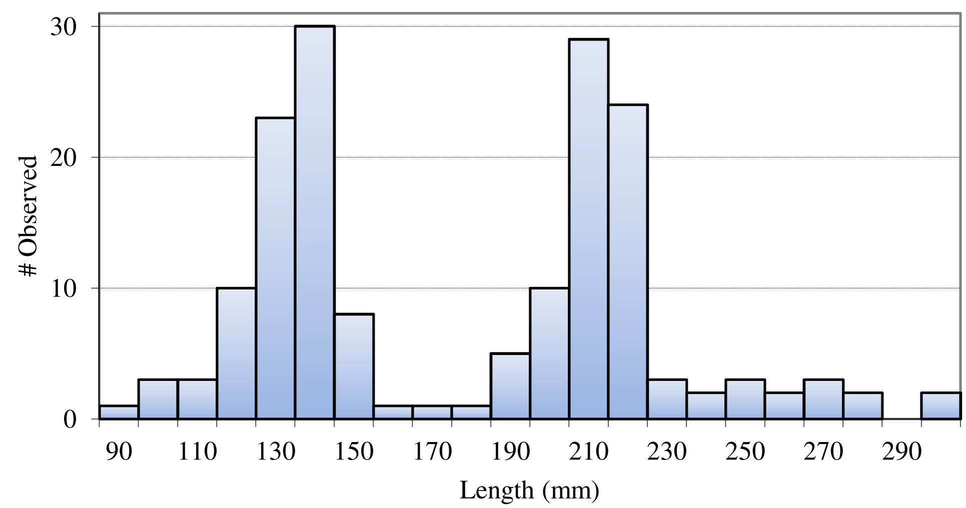

Figure 29. Length frequency distribution of walleye collected from Dumbbell Lake, Lake County, during fall 2017 electrofishing assessments.

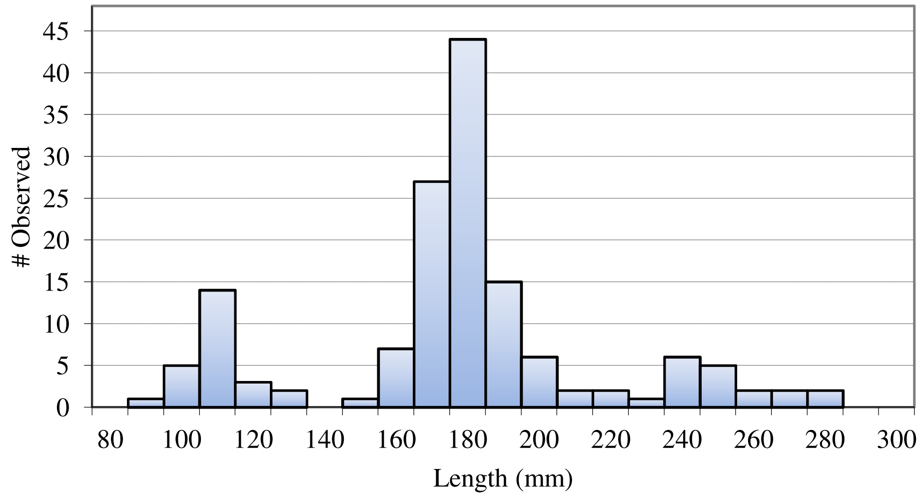

Figure 30. Length frequency distribution of walleye collected from Elbow Lake, Cook County, during fall 2017 electrofishing assessments.

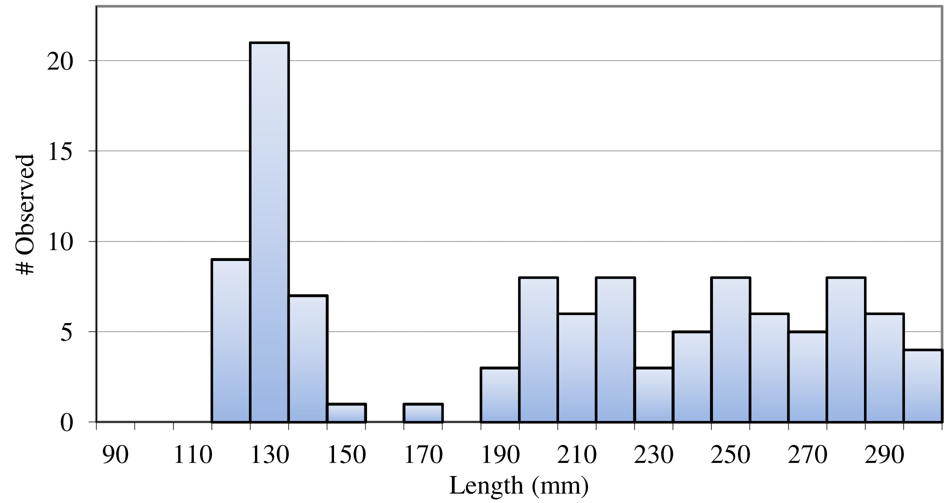

Figure 31. Length frequency distribution of walleye collected from Fourmile Lake, Cook County, during fall 2017 electrofishing assessments.

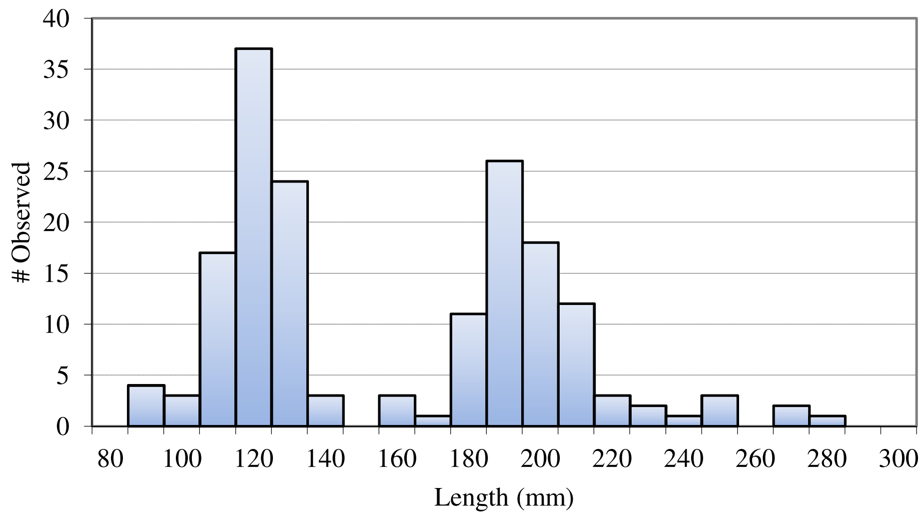

Figure 32. Length frequency distribution of walleye collected from Harriet Lake, Lake County, during fall 2017 electrofishing assessments.

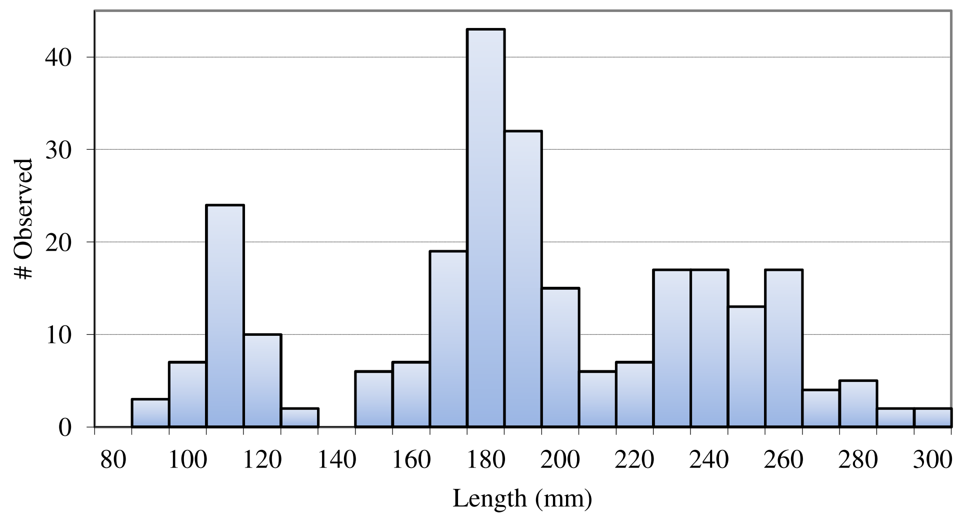

Figure 33. Length frequency distribution of walleye collected from Island Lake Reservoir, St. Louis County, during fall 2017 electrofishing assessments.

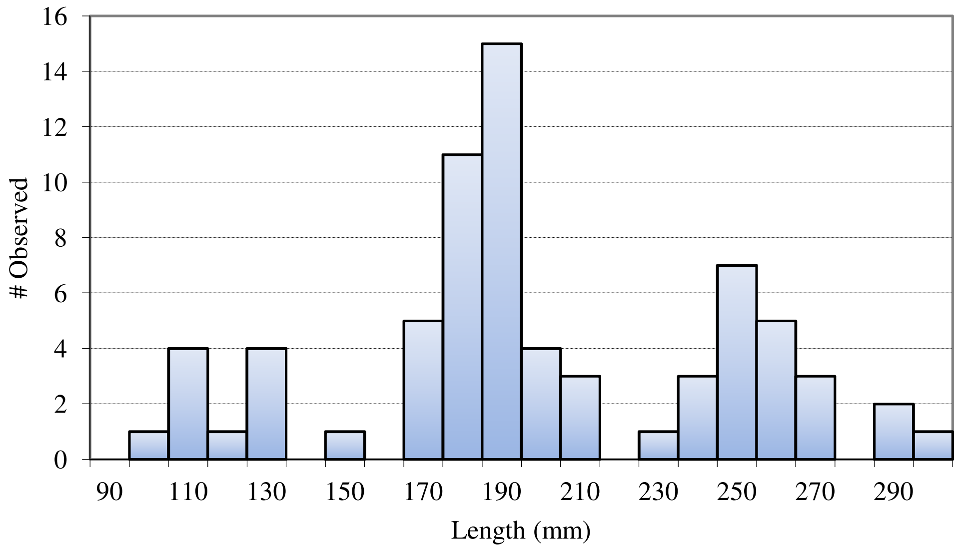

Figure 34. Length frequency distribution of walleye collected from North McDougal Lake, Lake County, during fall 2017 electrofishing assessments.

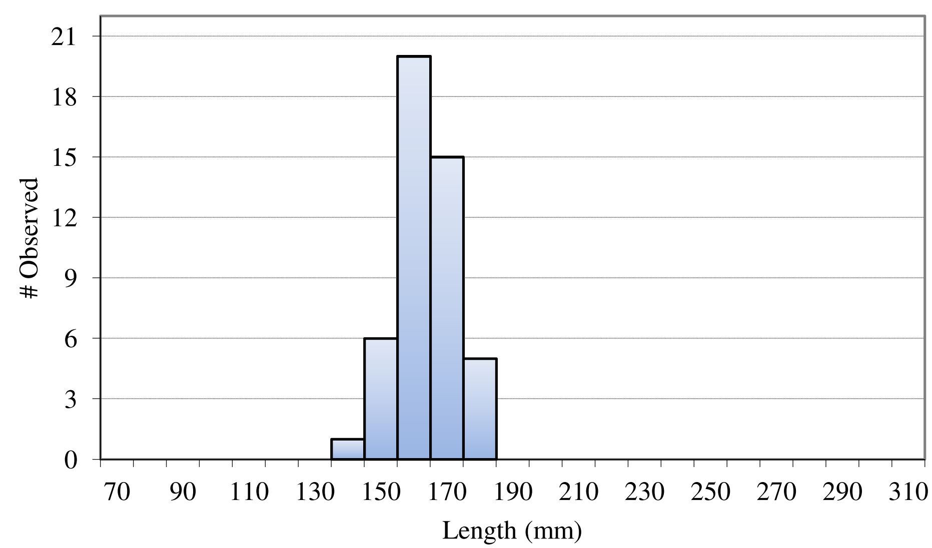

Figure 35. Length frequency distribution of walleye collected from Ninemile Lake, Lake County, during fall 2017 electrofishing assessments.

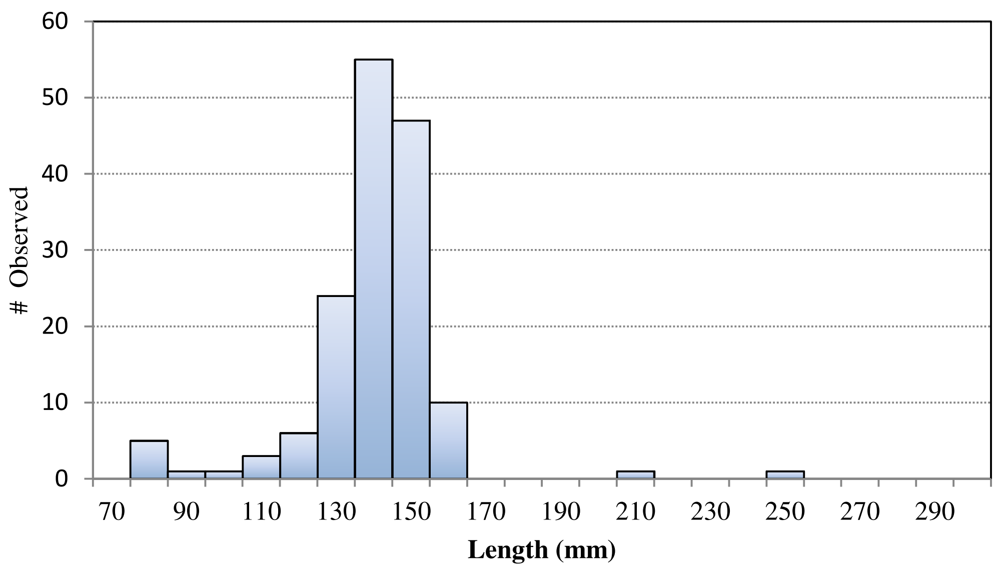

Figure 36. Length frequency distribution of walleye collected from Pike Lake, Cook County, during fall 2017 electrofishing assessments.

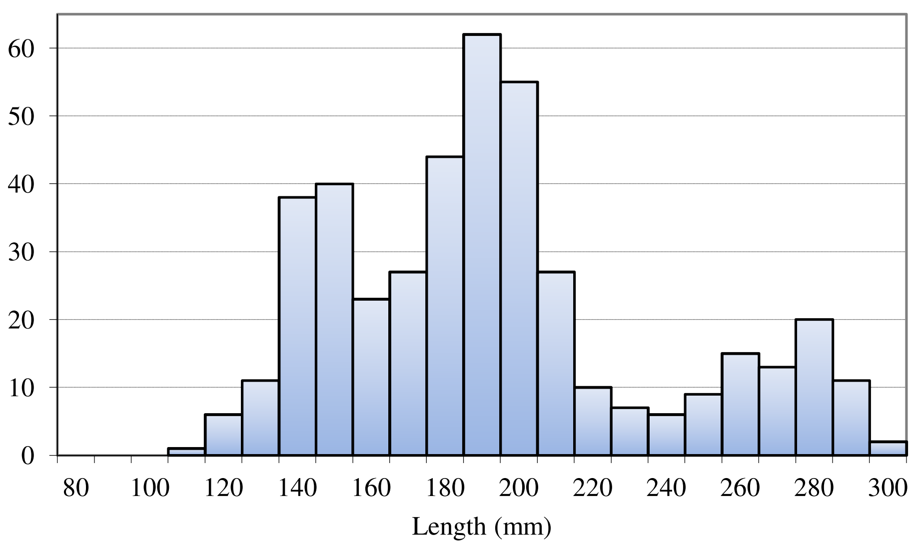

Figure 37. Length frequency distribution of walleye collected from Shagawa Lake, St. Louis County, during fall 2017 electrofishing assessments.

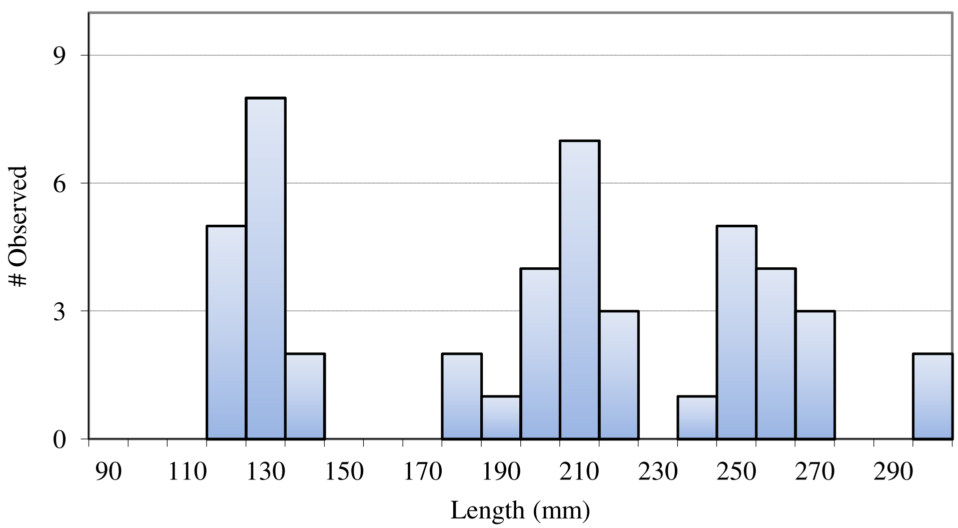

Figure 38. Length frequency distribution of walleye collected from Silver Island Lake, Lake County, during fall 2017 electrofishing assessments.

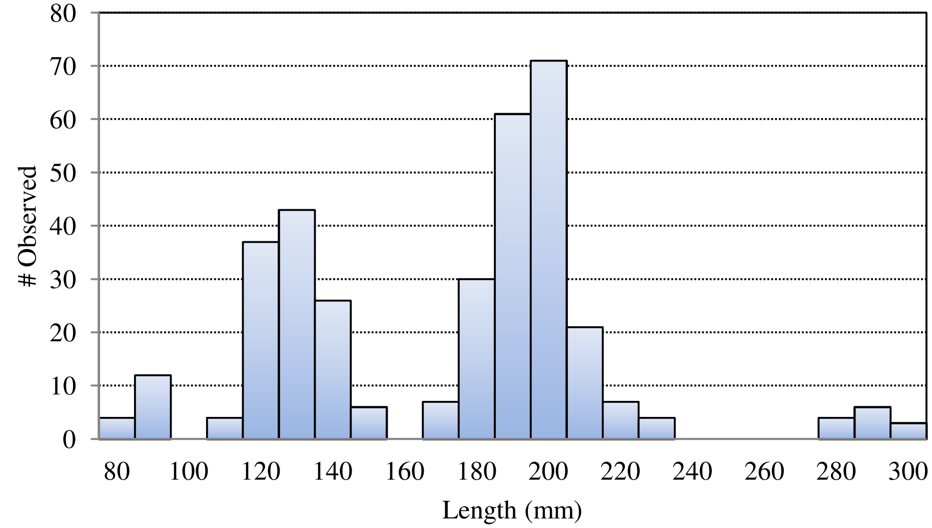

Figure 39. Length frequency distribution of walleye collected from Tait Lake, Cook County, during fall 2017 electrofishing assessments.

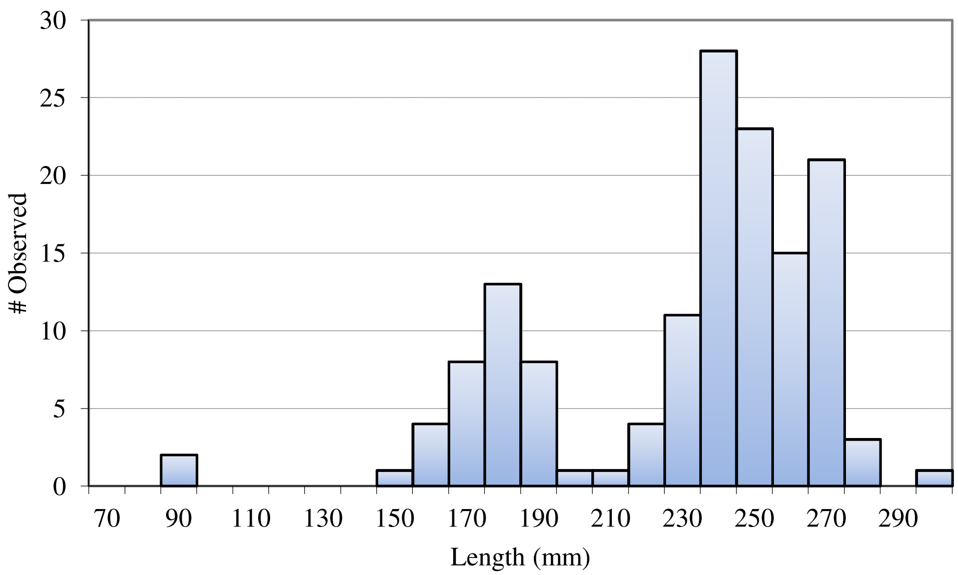

Figure 40. Length frequency distribution of walleye collected from Tom Lake Cook County, during fall 2017 electrofishing assessments.

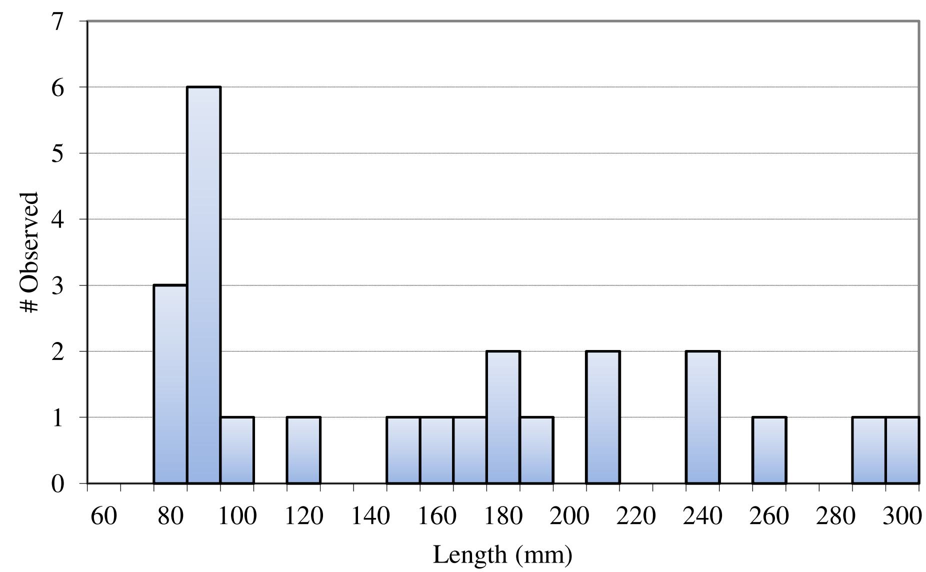

Figure 41. Length frequency distribution of walleye collected from Two Island Lake, Cook County, during fall 2017 electrofishing assessments.

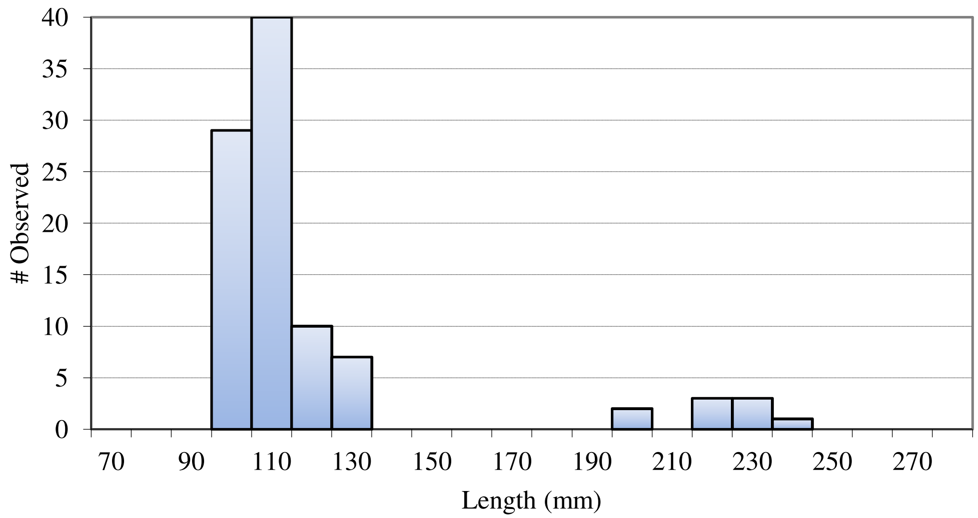

Figure 42. Length frequency distribution of walleye collected from West Twin Lake, Cook County, during fall 2017 electrofishing assessments.

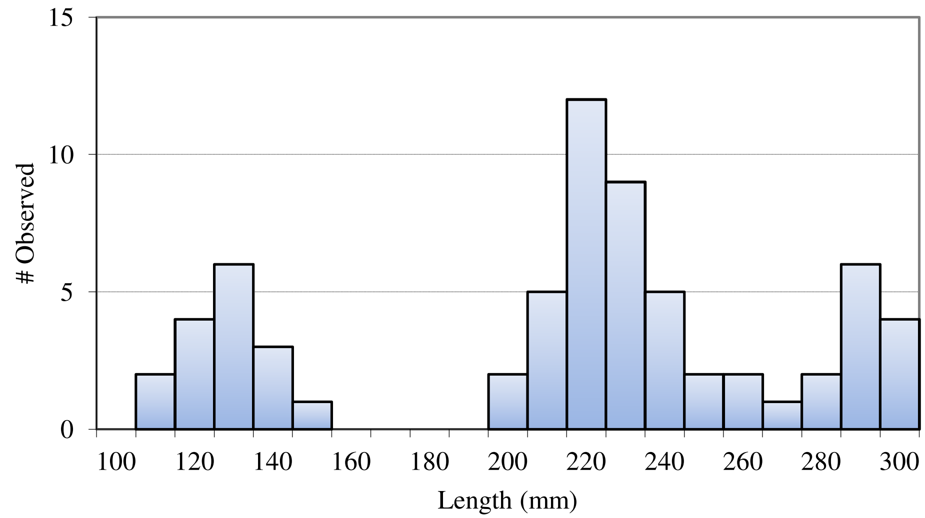

Figure 43. Length frequency distribution of walleye collected from Whiteface Reservoir, St. Louis County, during fall 2017 electrofishing assessments.

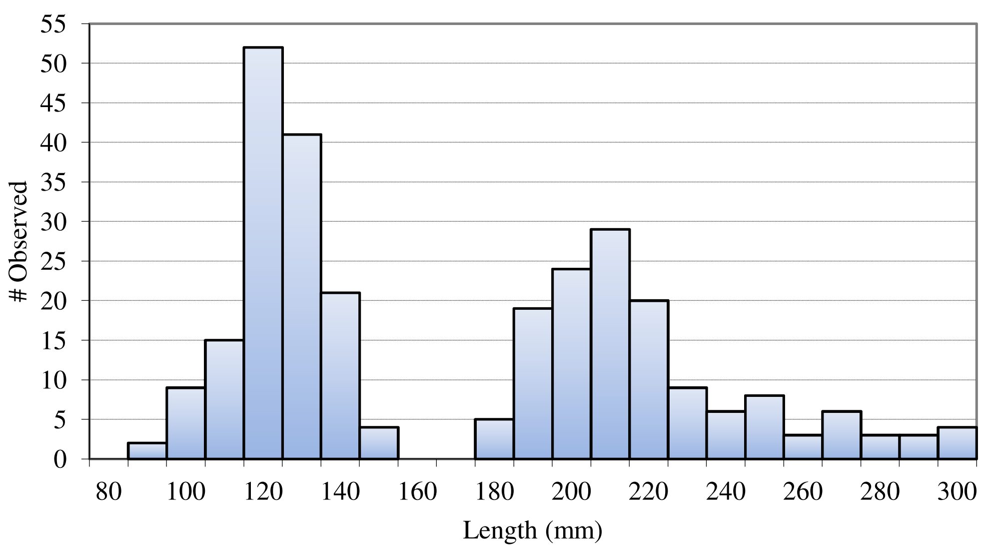

Figure 44. Length frequency distribution of walleye collected from Wilson Lake, Lake County, during fall 2017 electrofishing assessments.

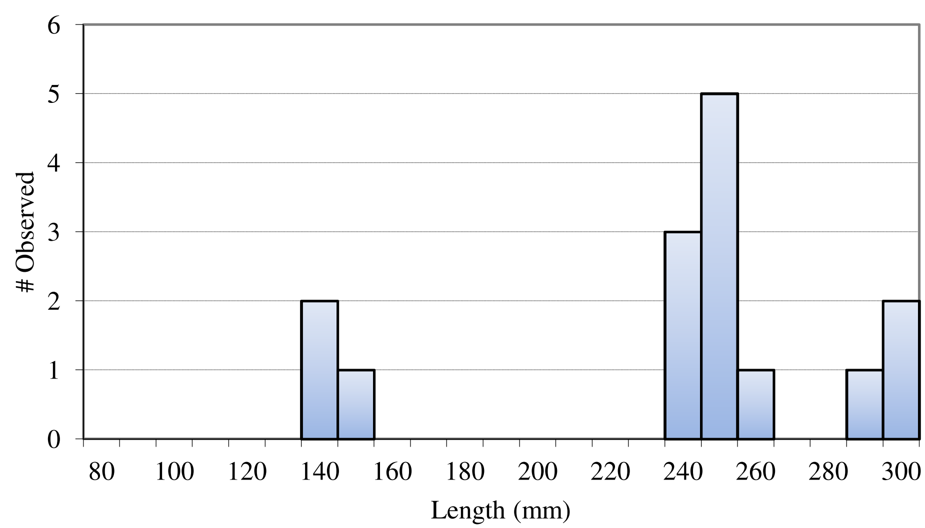

Figure 45. Length frequency distribution of walleye collected from Windy Lake, Lake County, during fall 2017 electrofishing assessments.

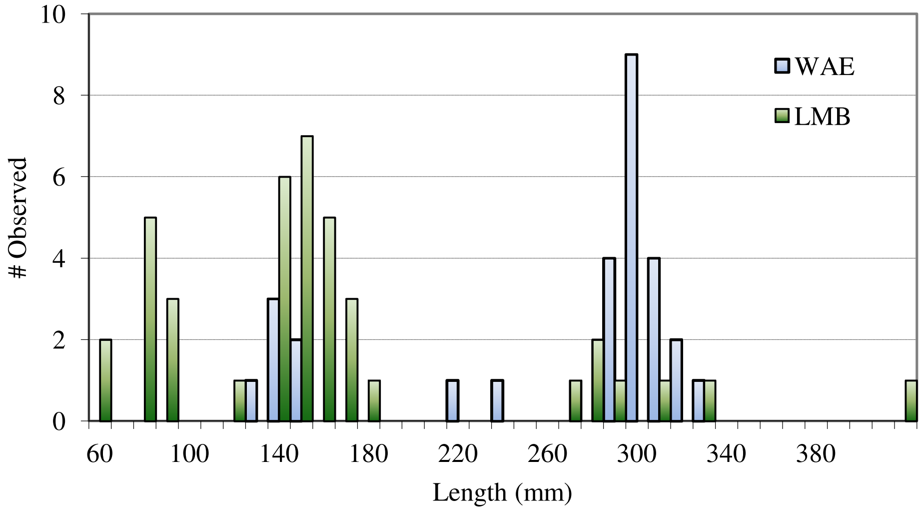

Figure 46. Length frequency distribution of walleye collected from Wild Rice Lake Reservoir, St. Louis County, during fall 2017 electrofishing assessments. Blue bars represent the walleye sampled while the green bars represent largemouth bass sampled.

Appendix 1. Nightly Mark / Recapture Data for walleye > 254 mm sampled during spring 2017 assessments in the 1854 Ceded Territory, and for walleye > 274mm observed in MN DNR summer gill net assessments.

Lake	Date	Marked in Population	Daily Catch	Daily Recap
Harriet	19 April	---	54	0
	20 April	54	36	9
	21 April	80	32	9
	22 April	103	75	43
	MNDNR GN	135	31	8
	MNDNR GN / TN	135	34	10
Tait	23 April	---	194	0
	24 April	194	163	33
	29 April	324	44	27
	MNDNR GN	341	27	3
	MNDNR GN / TN	341	46	8
Caribou	25 April	---	96	0
	27 April[1]	96	178	26
	28 April	247	217	60
	29 April	404	215	97
	MNDNR GN	522	32	8
	MNDNR GN / TN	522	36	8

[1] One fish was removed from "marked in population" after not recovering in the work-up tank