Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2018

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 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 the Fond du Lac, Grand Portage, and Bois Forte Bands. Surveys have indicated that walleye are the primary game fish sought after by band members in the 1854 Ceded Territory (Borkholder 1994b; Vogt 2004; Kaeske 2009).

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 within Wisconsin (Ngu and Kmiecik 1993; Goyke et al. 1993 and 1994) and within Northeastern Minnesota since 1994 (Borkholder 1994a). In order to maximize the number of fish handled and marked during the 2018 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 2018 was to obtain adult walleye population estimates (PE) during the spring spawning period using mark - recapture data. Our electrofishing PEs are likely 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 2018 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 also taken in order to properly set electrofishing power settings.

Electrofishing surveys were planned to begin soon after ice-out, and continued for as long as un-tagged walleye were abundant in the samples or when the percentage of recaptured individuals approached or exceeded 30%, normally 3 – 5 nights per lake. 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 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 (light blue color used in 2018) (Super Swiftachment Fasteners available from the Dennison Fastener Division, Framingham, Massachusetts). The reason for this recent change in marking was after many years of clipping dorsal fin spines, it would be impossible to differentiate 2018 marked fish from previously clipped individuals. A dorsal fin spine from five individuals per centimeter group and per sex was removed for age interpretations. 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

Boulder Lake Reservoir (DOW 69-0373)

Electrofishing activities were conducted on Boulder Lake, St. Louis County, on 7 - 11 May (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 (EFD, 7 May) to 142.0 (EFC, 11 May) adult walleye per hour of sampling (Figure 1). At a 95% confidence interval, mean CPUE for Boulder Lake, determined using each sampling station, was 44.0 ± 25.8 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled in Boulder Lake is presented in Figure 2. Walleye as large as 630 mm (24.8 inches) were observed in the survey. Additional species observed included yellow perch, northern pike, emerald shiner, burbot, black crappie, and white sucker.

Walleyes larger than 254 mm were marked with a non-numbered light blue 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 7852 (Table 2). The adjusted Petersen estimate is 7245 ± 9143, with a 39.7% CV (Table 2). The population estimates presented in Table 2 represent the population abundance of walleye using the spawning habitat sampled (Figure 1), and are not estimates of the walleye population within the entire lake.

During summer 2018, the Minnesota Department of Natural Resources performed a standardized net assessment on Boulder Lake (MN DNR, Duluth Area Fisheries). 172 individuals (> 274

mm) were sampled in the gill nets that would have been 254 mm during the May assessments. Three individuals were observed to have the blue floy tag from the spring sampling (Appendix 1). The adjusted Petersen estimate using both the spring and summer data is 21,236 ± 26,057, with a 44.2% CV (Table 2). The Schumacher and Eschmeyer population estimate from this gill net data is 13,416 (Table 2). 209 walleyes in total were sampled between the gill nets and trap nets, with four recaptured individuals observed. Population estimates are included in Table 2.

Table 3 presents the age data for the walleye collected from Boulder Lake. Of the 521 unique fish sampled, 342 (65.6%) were assigned to ages 3 & 4. Total annual mortality (*A*) of the Boulder 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 40.4% (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. Total annual mortality (*A*) estimated using the MNDNR's gill net data was 30.5% (Figure 3, green triangles), lower than the estimates from the spring electrofishing assessment. Our spring estimate was made using 512 mature walleyes, age 3 – 12. The estimate from the gill and trap net assessment was made using 100 fish age 2 – 11.

Table 4 presents back-calculated lengths-at-age for walleye collected from Boulder 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 35.6 ± 4.2 (Table 5). The electrofishing sample suggests that this population is balanced (Gabelhouse 1984). The majority of the fish sampled were less than 15.0 inches (64.4% of sample) that will be growing and recruiting into this "quality" 15-inch category over the next few years. The summer gill net PSD (34.3 ± 7.0) was not significantly different than the PSD estimate from the spring electrofishing survey (χ^2=0.098, P>0.05, critical Chi-square value of 3.841) (Table 5).

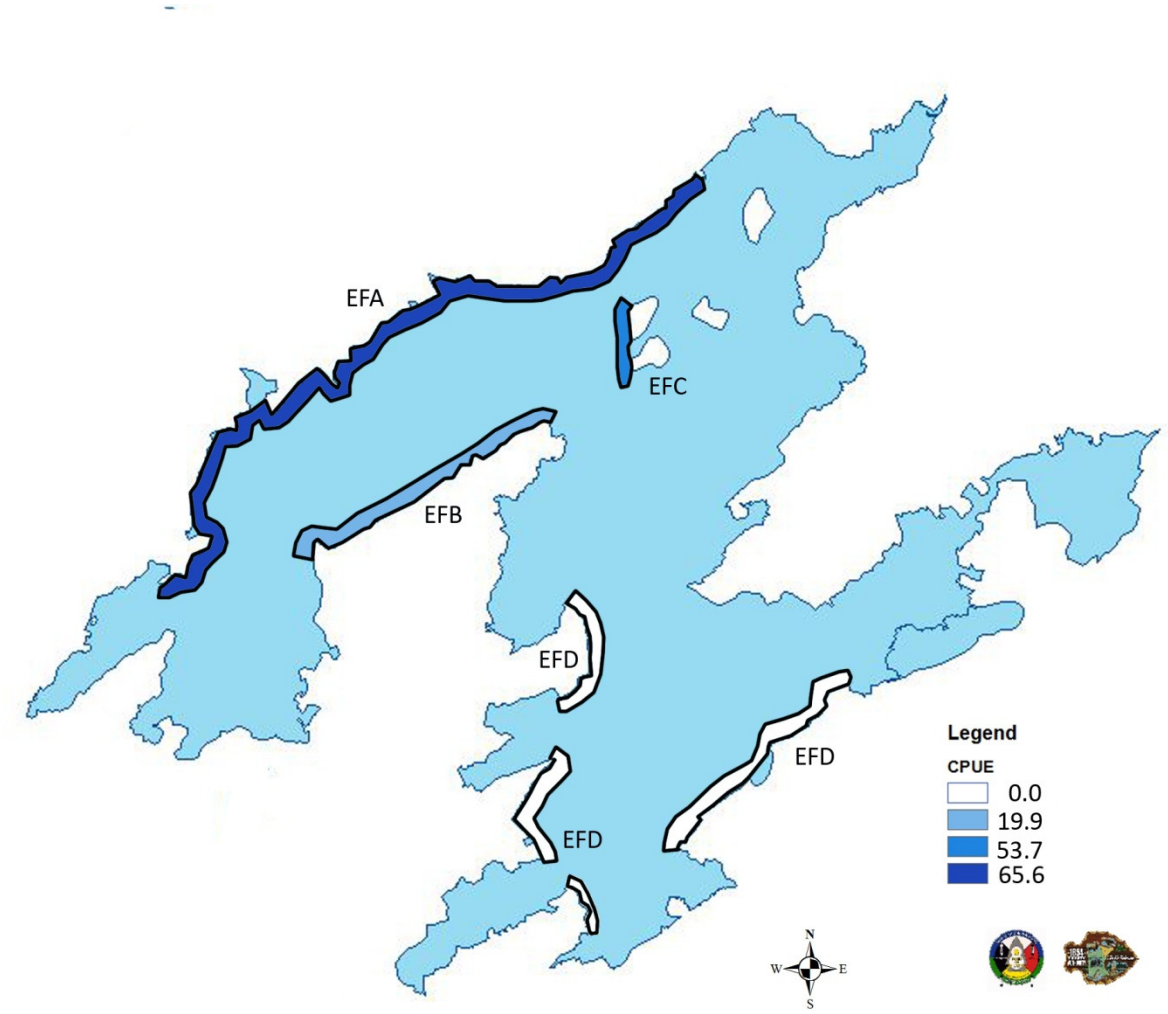

Figure 1. Catch per hour (CPUE) of adult walleyes (fish larger than 254 mm) by electrofishing station, on Boulder Lake, St. Louis County, during Spring 2018 electrofishing surveys.

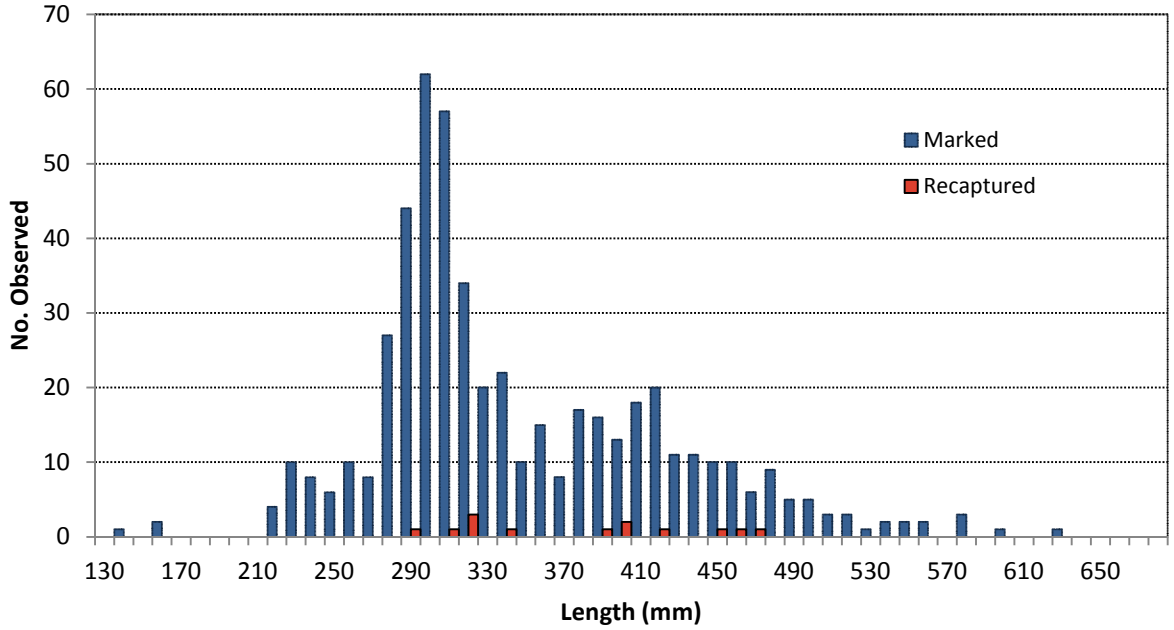

Figure 2. Length frequency distribution of walleye sampled from Boulder Lake, St. Louis County, MN, during spring 2018 electrofishing assessments. Length frequency distribution of recaptured walleyes is shown in red bars.

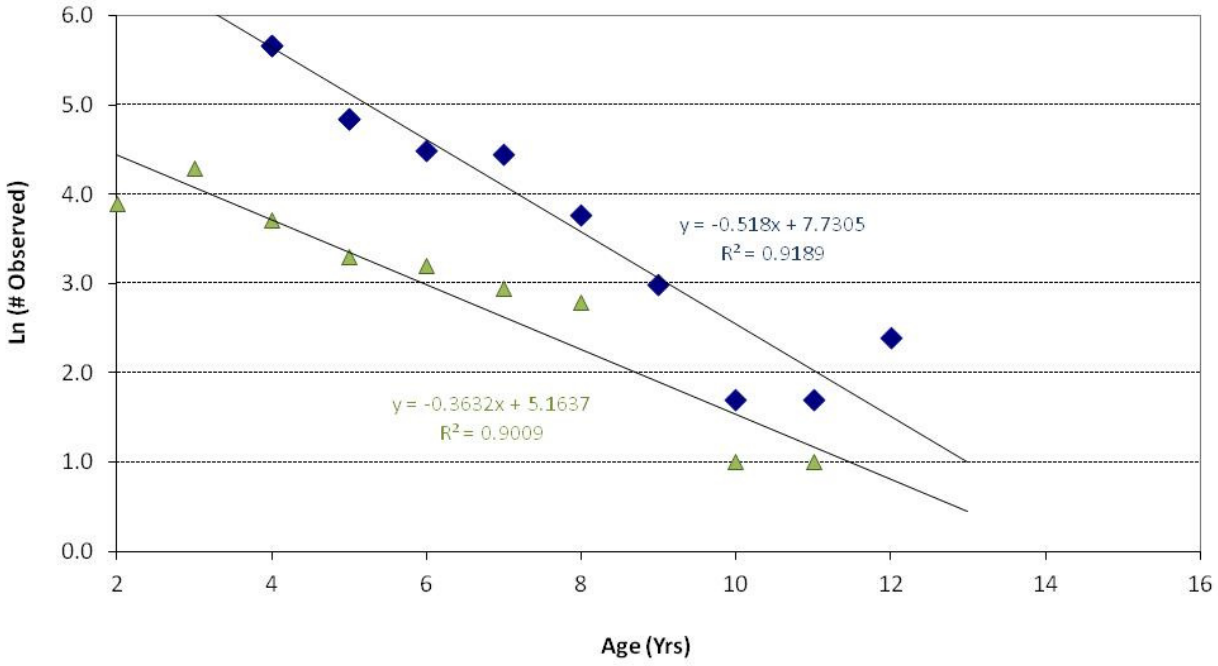

Figure 3. Catch curve analysis of walleyes in Boulder Lake, 2018, showing instantaneous mortality (*Z*). Estimates are made from May 2018 electrofishing data (blue diamonds) and summer MNDNR gill net data (green triangles).

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]
69-0373	St. Louis	Boulder	3207	18	5/7/2018	58	52	5495	300	7	152	99.6
					5/9/2018	51.5	52	4460	312	8.8	145	117.0
					5/10/2018	52.2	52	6772	274	7.8	117	62.2
					5/11/2018	52.5	59	3150	300	8.5	88	100.6
16-0346	Cook	Cascade	452	17	5/12/2018	48.0	22	9066	884	2.2	217	86.2
					5/13/2018	50.6	16	7921	884	1.6	203	92.3
					5/14/2018	52.6	18	7348	884	0.5	157	76.9

[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 Boulder Lake Reservoir (St. Louis County) and Cascade Lake (Cook County), Spring 2018. 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	Upper	Estimate[2]	C.V.[3]
Boulder – EF_{2018}	7852	2.4	5226	13,802	7245 ± 9143	39.7 %
Boulder – GN_{2018}	13,416	4.2	6845	334,192	21,236 ± 26,057	44.2%
Boulder – GN/TN_{2018}	13,824	4.3	7157	202,132	20,622 ± 23,091	40.3%
Cascade – EF_{2018}	1500	3.3	1230	1921	783 ± 427	12.7%

[1] Schumacher and Eschmeyer population estimate.
[2] Adjusted Petersen population estimate, with 95% confidence interval.
[3] Coefficient of variation for the Petersen estimate.

Table 3. Age frequency distribution of walleye from Boulder Lake, St. Louis County, Spring 2018, 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	1											
6.0	152	2											
8.5	216	4	4										
9.0	229	11	11										
9.5	241	10	10										
10.0	254	10	3	7									
10.5	267	11		9	2								
11.0	279	41		41									
11.5	292	57		57									
12.0	305	84		71	13								
12.5	318	46		26	20								
13.0	330	22		16	6								
13.5	343	24		8	14			1					
14.0	356	15		1	11	3							
14.5	368	14			12	2							
15.0	381	18			15	3							
15.5	394	21			8.8	11		1					
16.0	406	21			4.2	13	4						
16.5	419	21				9.3	7	2.3		2			
17.0	432	17				1.7	10	5.1					
17.5	445	14				2.3	4.7	7					
18.0	457	13					2.6	5.2	3.9	1.3			
18.5	470	7				1		2	3	1			
19.0	483	13					3.5	6	4				
19.5	495	4					1		1		1		
20.0	508	7				1		2	2	1			
20.5	521	2											2
21.0	533	2								1			1
21.5	546	2							1				
22.0	559	2							1	1			
22.5	572	1									1		
23.0	584	2										2	
23.5	597	1											
24.5	622	1											1
TOTAL		521	28	236	106	47	33	32	16	7	2	2	4

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

Age Class	N	Length (mm)	Length (in)
1	240	122	4.8
2	240	207	8.1
3	229	290	11.4
4	162	349	13.7
5	109	396	15.6
6	83	431	17
7	61	458	18
8	34	488	19.2
9	16	504	19.8
10	10	536	21.1
11	6	550	21.7
12	4	557	21.9

Table 5. Proportional Stock Density (PSD) and Relative Stock Densities (RSD) with 95% confidence for Boulder Lake (Lake County), and Cascade 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
Boulder – EF_{2018}	35.6 ± 4.2	64.4 ± 4.2	31.2 ± 4.0	4.4 ± 1.8	0.0 ± 0.0
Boulder – GN_{2018}	34.3 ± 7.0	65.7 ± 7.0	30.3 ± 6.8	3.4 ± 2.6	0.6 ± 1.1
Boulder – GN/TN_{2018}	36.4 ± 6.4	63.6 ± 6.4	28.6 ± 6.0	6.9 ± 3.4	0.9 ± 1.3
Cascade – EF_{2018}	66.3 ± 3.8	33.7 ± 3.8	64.9 ± 3.9	$1.2 \pm .9$	$0.2 \pm .3$

Cascade Lake (DOW 16-0346)

Electrofishing activities were conducted on Cascade Lake, Cook County, on 12 – 14 May (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 8.3 (EF1, 12 May) to 124.9 (EF3, 14 May) adult walleye per hour of sampling (Figure 4). At a 95% confidence interval, mean CPUE for Cascade Lake, determined using each sampling station, was 58.5 ± 20.4 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled in Cascade Lake is presented in Figure 5. Walleye as large as 672 mm (25.2 inches) were observed in the survey. Additional species observed included northern pike, white sucker, and yellow perch.

Walleyes larger than 254 mm were marked with a non-numbered blue 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 1500 (Table 2). The electrofishing adjusted Petersen estimate is 783 ± 427, with a 12.7% CV (Table 2).

Table 6 presents the age data for the walleye collected from Cascade Lake. Total annual mortality (*A*) of the Cascade Lake population was estimated at 33.4%, 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). Table 7 presents back-calculated lengths-at-age for walleye collected from Cascade Lake, as determined by aging dorsal fin spines.

PSD and RSD values determined by our spring electrofishing sampling is presented in Table 5. The electrofishing PSD was 66.3 ± 3.8 (Table 5). This estimate has been rising over the last 20 years (pink bars in Figure 7). There may be a strong 2015 year class recruiting into the fishery (age-3's in Table 3; Figure 8).

Cascade Lake has been surveyed four times since 1998 (Figure 7). Population estimates each year suggest a declining population of adult walleyes (blue diamonds and trend line in Figure 7). Changes in stock structure (PSD; pink bars) is also presented over time. Fall electrofishing data suggests that reproduction doesn't appear to be limited, as evident by relatively high numbers of age-0 walleyes sampled in 2011, 2013, and 2015 (Figure 8). However, after a year, these same cohorts were not observed to be as abundant, suggesting that overwinter survival may be an issue in Cascade Lake.

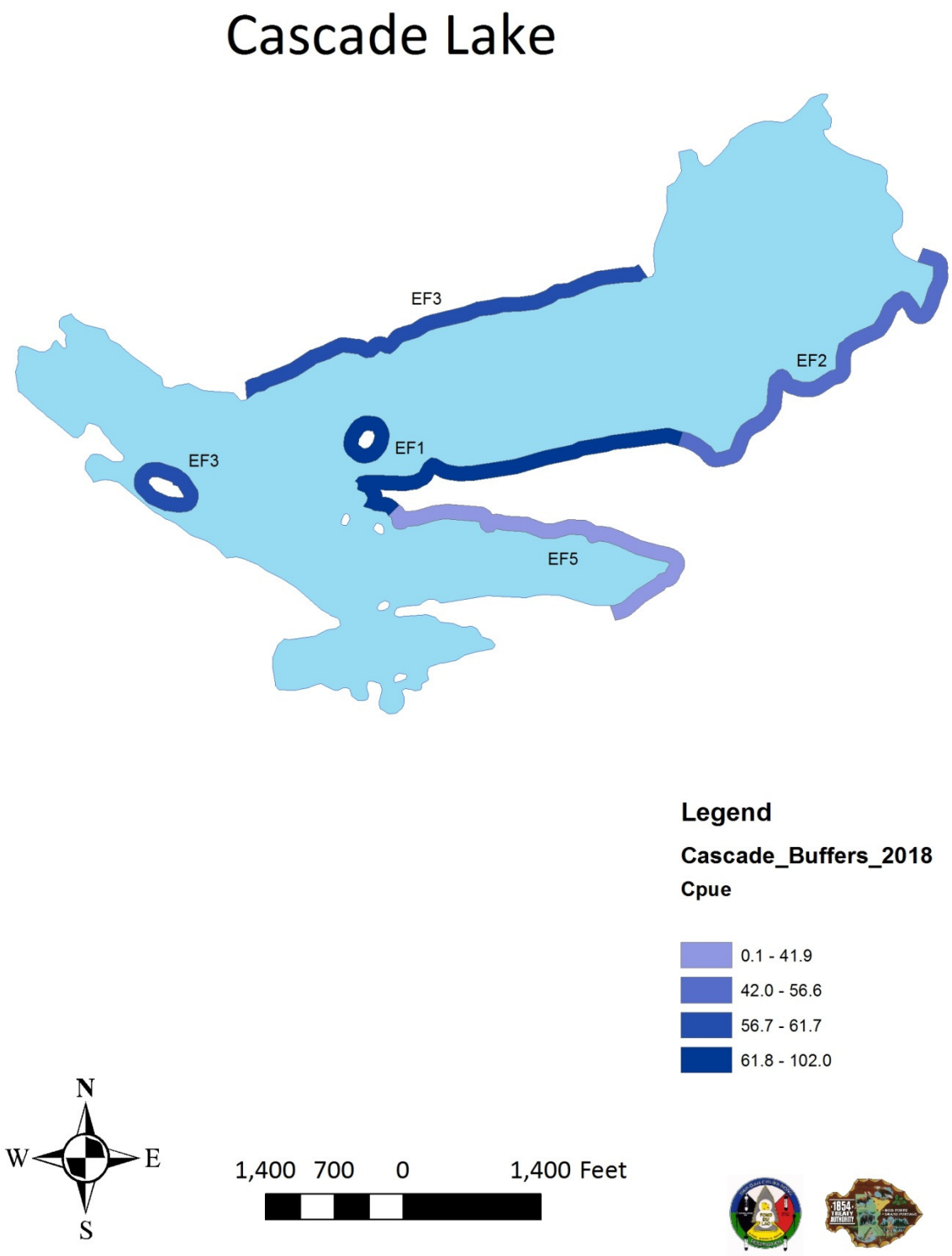

Figure 4. Catch per hour (CPUE) of adult walleyes (fish larger than 254 mm) by electrofishing station, on Cascade Lake, Cook County, during Spring 2018 electrofishing surveys.

Table 6. Age frequency distribution of walleye from Cascade Lake, Cook County, Spring 2018, 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		16
5.5	140	1													
7.0	178	9	9												
7.5	191	29	29												
8.0	203	18	18												
8.5	216	14	14												
9.0	229	9	1	8											
9.5	241	13		13											
10.0	254	16		16											
10.5	267	31		29	2										
11.0	279	18		17	1										
11.5	292	18		16	2										
12.0	305	21		16	5										
12.5	318	13		8	5										
13.0	330	9		5	2	2									
13.5	343	19			2	14	3								
14.0	356	13			1	11	2								
14.5	368	28				18	10								
15.0	381	51				24	20	7							
15.5	394	47				14	19	14							
16.0	406	49				11		35	3						
16.5	419	44					20	16	8						
17.0	432	41						29	8	4					
17.5	445	34						3	20	11					
18.0	457	22					2		2	11	4		2		
18.5	470	15							3	3	7	2			
19.0	483	7							1			5	1		
19.5	495	4										4			
20.0	508	4											4		
20.5	521	2										2			
21.0	533														
21.5	546														
22.0	559														
22.5	572	1													1
23.0	584														
24.0	610														
25.0	635	1													
29.0	737														
TOTAL		601	71	128	20	93	77	104	46	29	11	13	7		1

Table 7. Back-calculated lengths-at-age for walleye collected from Cascade Lake, Cook County, Minnesota, Spring 2018.

Age Class	N	Length (mm)	Length (in)
1	236	108	4.3
2	236	189	7.4
3	200	259	10.2
4	136	311	12.2
5	122	361	14.2
6	91	392	15.4
7	74	420	16.5
8	47	442	17.4
9	32	458	18.0
10	22	475	18.7
11	16	492	19.4
12	11	509	20.0
13	7	528	20.8
14	4	556	21.9
15	1	626	24.6
16	1	641	25.2

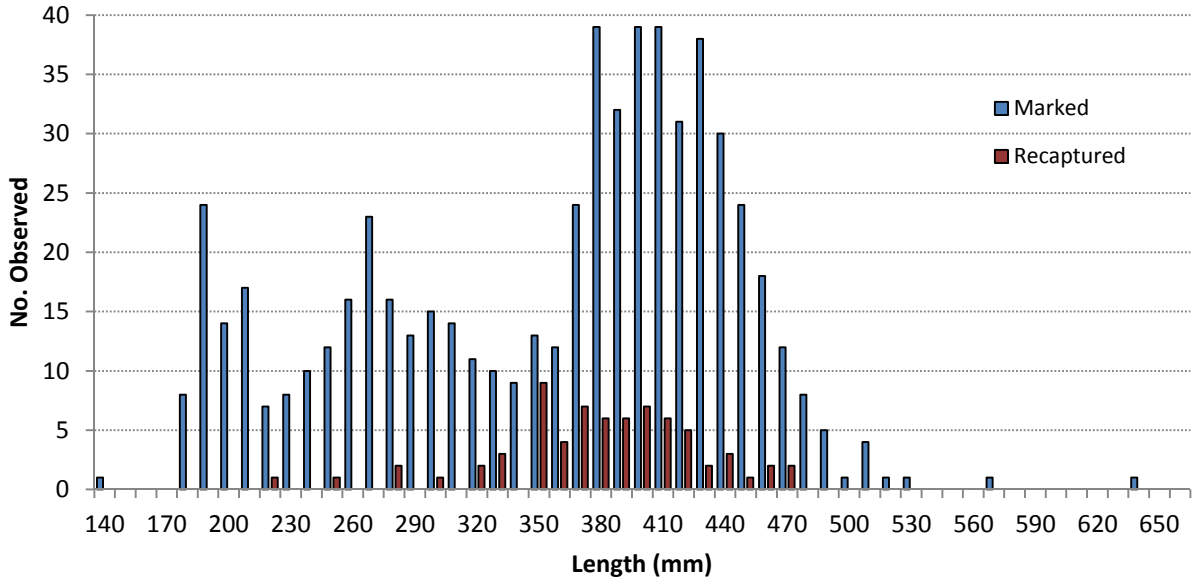

Figure 5. Length frequency distribution of walleye sampled from Cascade Lake, Cook County, MN, during Spring 2018 electrofishing assessments. Length frequency distribution of recaptured walleyes is shown in red bars.

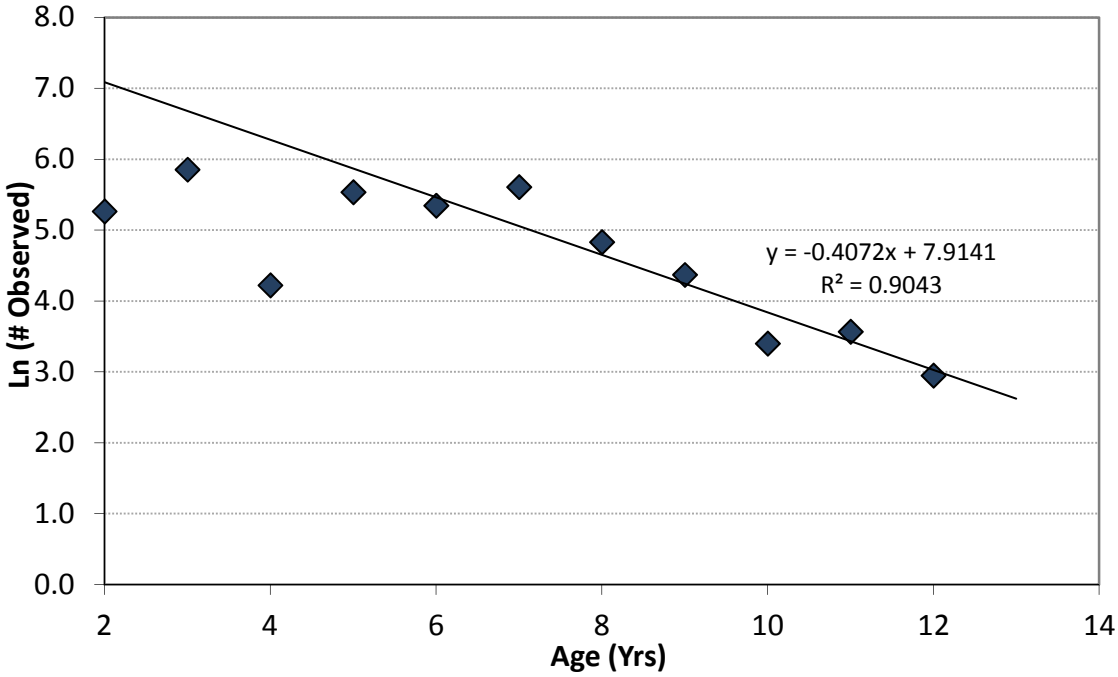

Figure 6. Catch curve analysis of walleyes in Cascade Lake, 2018, showing instantaneous mortality (*Z)*. Estimates are made from May 2018 electrofishing data.

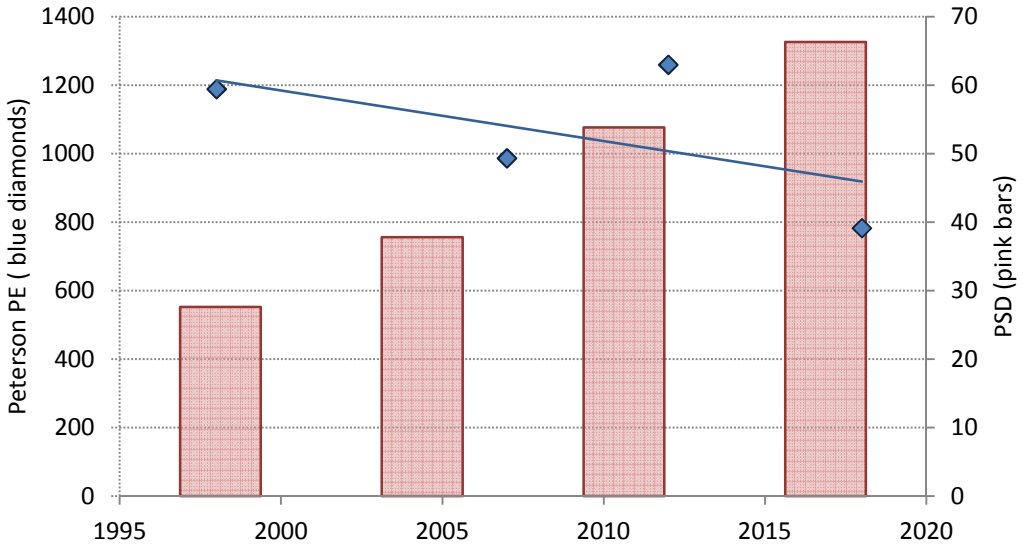

Figure 7. Long-term electrofishing data for Cascade Lake, presenting Peterson population estimates (blue diamonds) and PSD estimates (pink bars) since the first electrofishing survey in 1997.

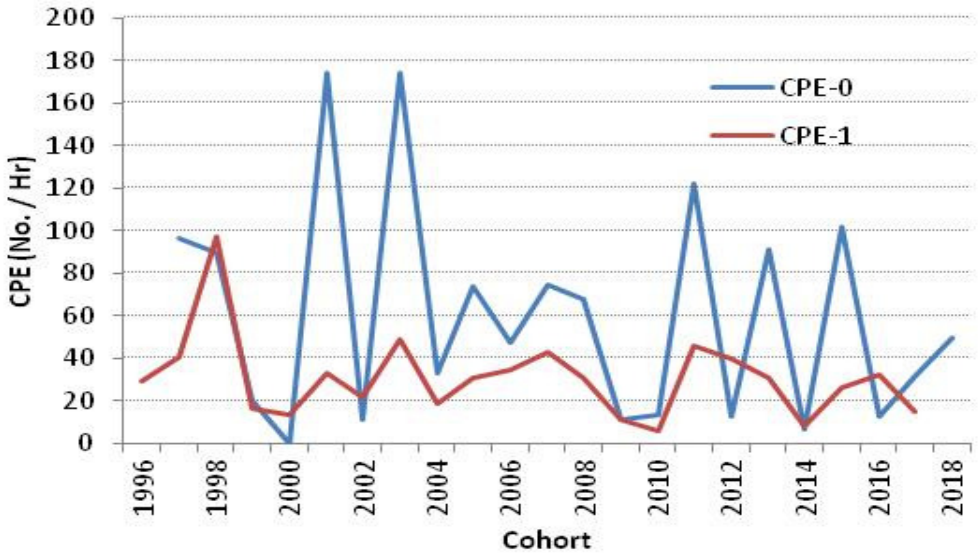

Figure 8. Catch-per-hour (CPE) of age-0 and age-1 walleyes in Cascade, Lake, Cook County, as determined during fall electrofishing assessments.

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 2018. This 20°C threshold was not exceeded on any of the lakes this season (Table 8). All of the lakes were surveyed before the lakes cooled to below the 10°C lower threshold.

Table 8 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 8). Figures 9 – 33 present length frequency data for each of the lakes surveyed. Table 9 presents the mean length for age-0 and age-1 individuals sampled during fall 2018 assessments. Mean lengths for age-0 walleye ranged from 96 mm (3.8 inches, Tom Lake) 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

This year, 188 largemouth bass (*Micropterus salmoides*) were sampled, with lengths ranging from 69mm (2.7 in) to 418mm (16.4 in) (Figure 33). Since they were first collected in 2009, the number of largemouth bass in the annual fall assessment has generally increased each year (Figure 34).

Devilfish Lake

Since Devilfish Lake was first added to the annual fall survey schedule in 1997, only two strong cohorts have been observed, one in 2001 and the other in 2006 (Figure 35). Very few fish have been observed since the 2008 cohort at age-1. For this reason, and unless there are compelling reasons otherwise, Devilfish Lake will likely be removed from the annual schedule beginning in 2019.

Table 8. 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 2018.

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	65.8	18.8	26.0	114	10	4704	87.2	7.7
Cadotte	19-Sep	64.6	18.1	21.2	2	235	6598	1.1	128.2
Caribou	25-Sep	56.3	13.5	47.0	286	102	6359	161.9	57.7
Cascade	13-Sep	67.7	19.8	24.0	71	23	5161	49.5	16.0
Crescent	13-Sep	66.3	19.1	31.1	296	22	3980	267.7	19.9
Crooked	26-Sep	53.0	11.7	35.0	20	16	4146	17.4	13.9
Devilfish	6-Sep	66.1	18.9	16.0	0	0	5577	0.0	0.0
Dumbbell	11-Sep	64.8	18.2	74.5	247	17	6338	140.3	9.7
Elbow	4-Sep	66.0	18.9	32.0	119	192	4947	61.9	44.4
Fourmile	10-Sep	64.2	17.9	56.0	141	28	6311	80.4	16.0
Harriet	10-Sep	64.1	17.8	45.8	115	42	5353	77.3	28.2
Island Reservoir	18-Sep	66.7	19.3	71.5	271	66	11196	87.1	21.2
Ninemile	20-Sep	70.0	21.1	64.4	303	3	5391	202.3	2.0
N. McDougal	11-Sep	66.5	19.2	56.0	30	16	5823	18.5	9.9
Pike	9-Sep	66.2	19.0	48.0	0	292	7524	0.0	139.7
Shagawa	17-Sep	66.9	19.4	80.2	48	196	11967	14.4	59.0
Silver Island	12-Sep	64.9	18.3	42.0	33	13	3928	30.2	11.9
Tait	13-Sep	66.8	19.3	38.0	604	111	8845	245.8	45.2
Tom	6-Sep	66.3	19.0	35.0	152	31	8202	66.7	13.6
Two Island	5-Sep	66.0	18.9	32.0	72	28	6258	20.7	8.1
West Twin	4-Sep	66.7	19.4	31.0	44	48	4564	34.7	37.9
Whiteface Res.	27-Sep	55.7	13.6	40.0	136	11	6743	72.6	5.9
Wild Rice	13-Sep	62.4	16.9	140.4	10	0	5917	6.1	0.0
Wilson	10-Sep	64.6	18.1	43.4	38	20	6223	22.0	11.6
Windy	12-Sep	65.8	18.8	29.1	32	1	6766	17.0	0.5

[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 9. Mean length for age-0 and age-1 walleye sampled during fall 2018 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	115	154 (N=10)
Cadotte	19-Sep	143 (N=2)	178
Caribou	25-Sep	126	168
Cascade	13-Sep	141	202
Crescent	13-Sep	117	201
Crooked	26-Sep	137	156
Devilfish	6-Sep	---	---
Dumbbell	11-Sep	165	216 (N=17)
Elbow	4-Sep	119	192
Fourmile	10-Sep	135	213
Harriet	10-Sep	107	185
Island Reservoir	18-Sep	129	198
Ninemile	14-Sep	126	196 (N=16)
N. McDougal	11-Sep	144	179 (N=3)
Pike	9-Sep	---	180
Shagawa	17-Sep	165	187
Silver Island	12-Sep	140	201 (N=13)
Tait	13-Sep	127	217
Tom	6-Sep	128	215
Two Island	5-Sep	118	201
West Twin	4-Sep	153	214
Whiteface Res.	27-Sep	140	223 (N=11)
Wild Rice	13-Sep	154 (N=10)	---
Wilson	10-Sep	135	204 (N=20)
Windy	12-Sep	154	224 (N=1)

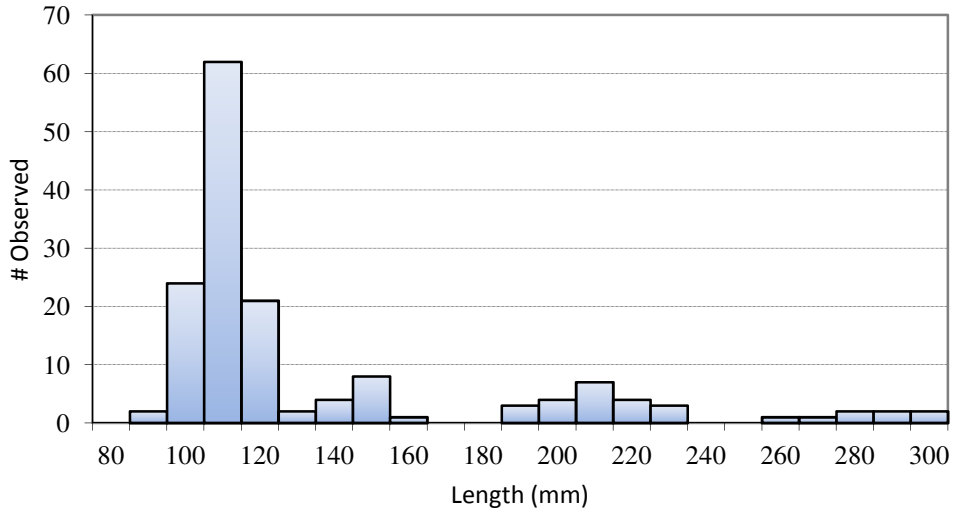

Figure 9. Length frequency distribution of walleye collected from Ball Club Lake, Cook County, during fall 2018 electrofishing assessments.

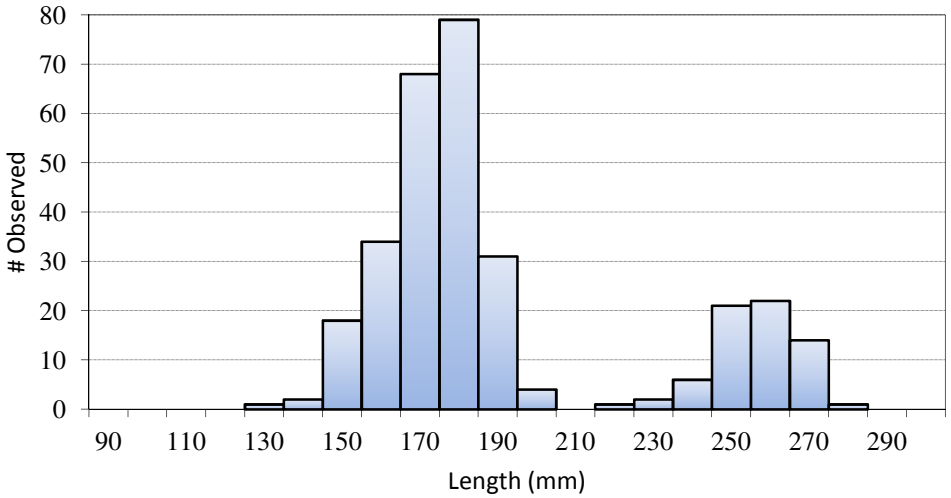

Figure 10. Length frequency distribution of walleye collected from Cadotte Lake, St. Louis County, during fall 2018 electrofishing assessments.

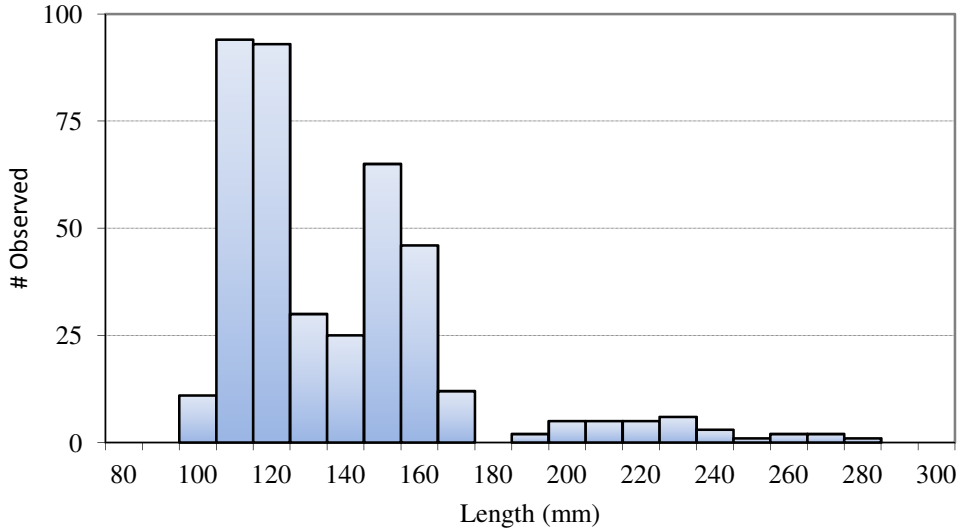

Figure 11. Length frequency distribution of walleye collected from Caribou Lake, Cook County, during fall 2018 electrofishing assessments.

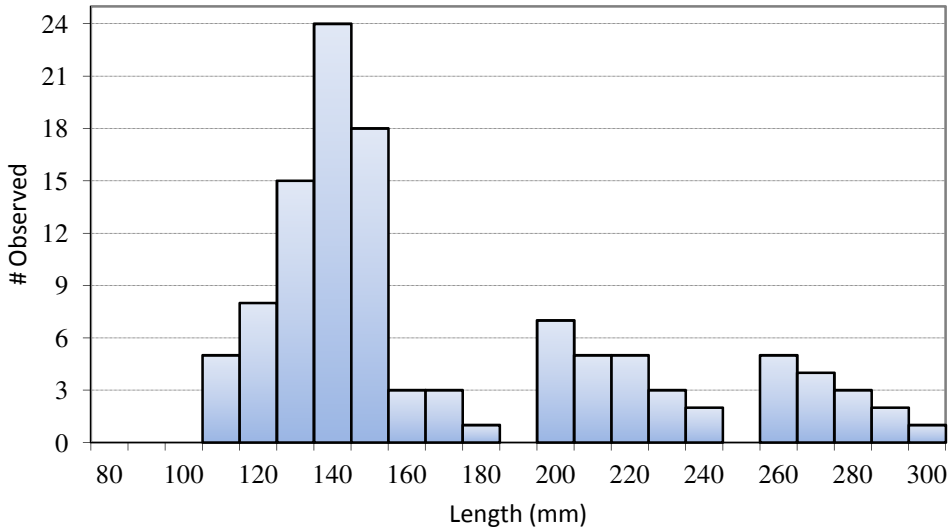

Figure 12. Length frequency distribution of walleye collected from Cascade Lake, Cook County, during fall 2018 electrofishing assessments.

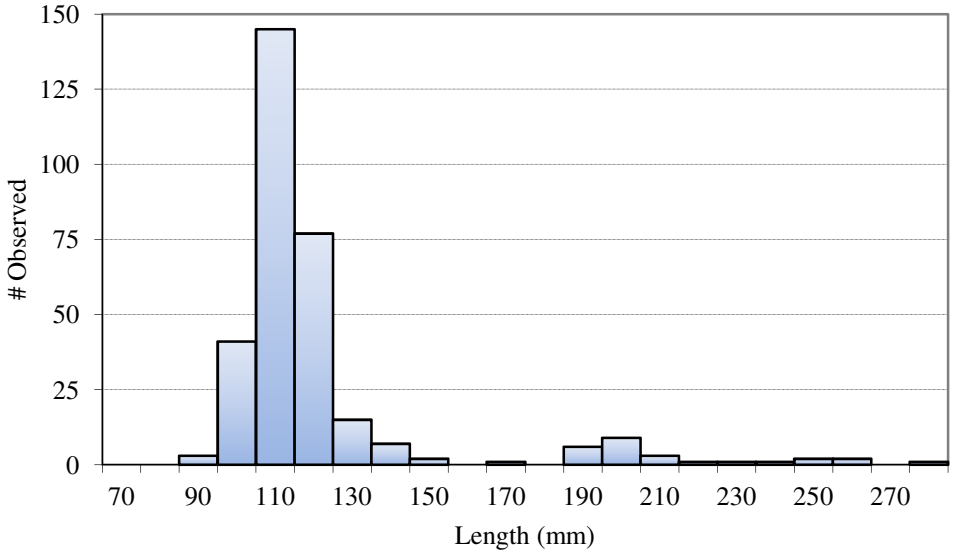

Figure 13. Length frequency distribution of walleye collected from Crescent Lake, Cook County, during fall 2018 electrofishing assessments.

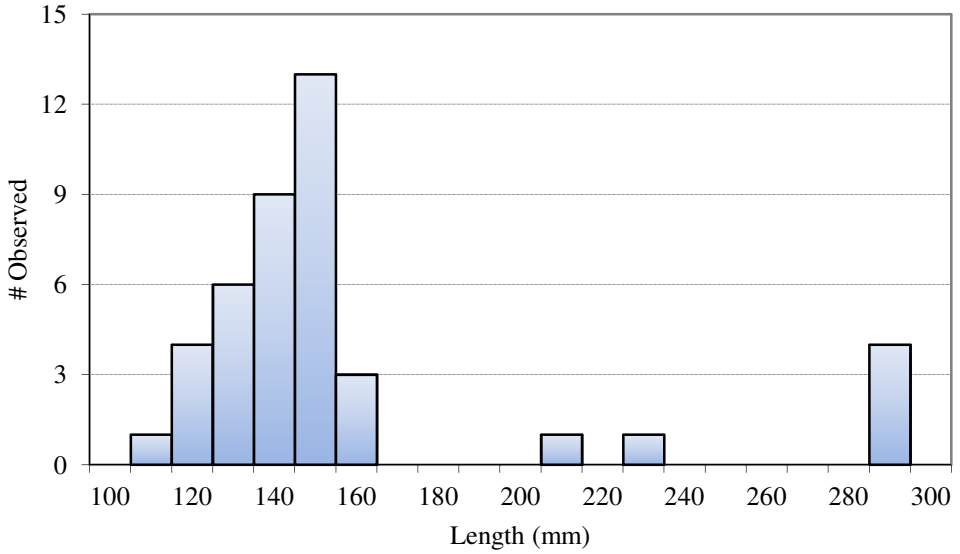

Figure 14. Length frequency distribution of walleye collected from Crooked Lake, Lake County, during fall 2018 electrofishing assessments.

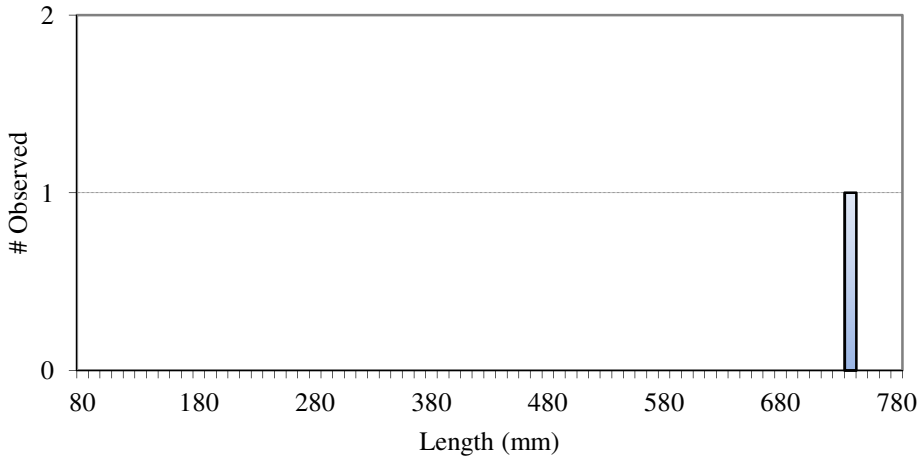

Figure 15. Length frequency distribution of walleye collected from Devilfish Lake, Cook County, during fall 2018 electrofishing assessments.

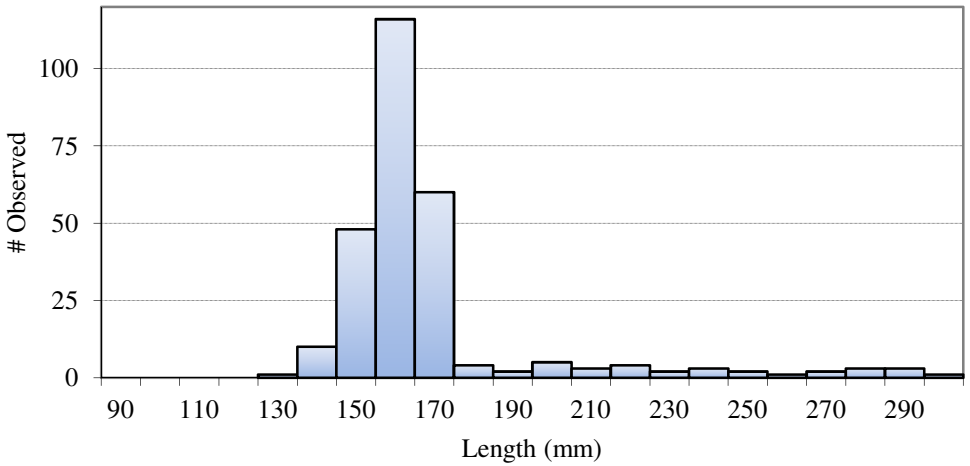

Figure 16. Length frequency distribution of walleye collected from Dumbbell Lake, Lake County, during fall 2018 electrofishing assessments.

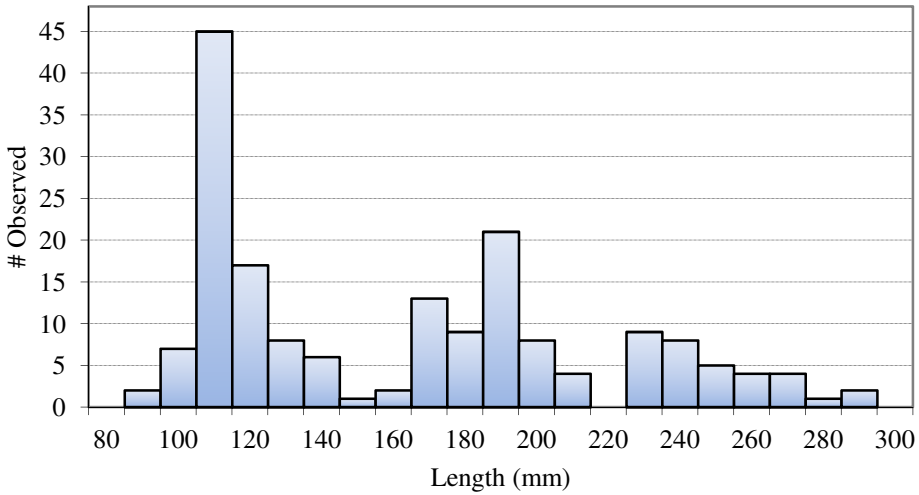

Figure 17. Length frequency distribution of walleye collected from Elbow Lake, Cook County, during fall 2018 electrofishing assessments.

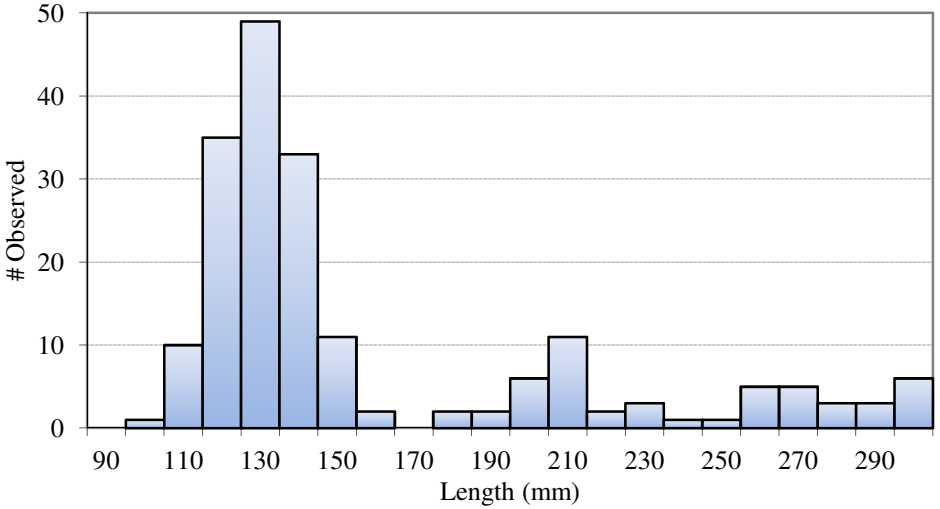

Figure 18. Length frequency distribution of walleye collected from Fourmile Lake, Cook County, during fall 2018 electrofishing assessments.

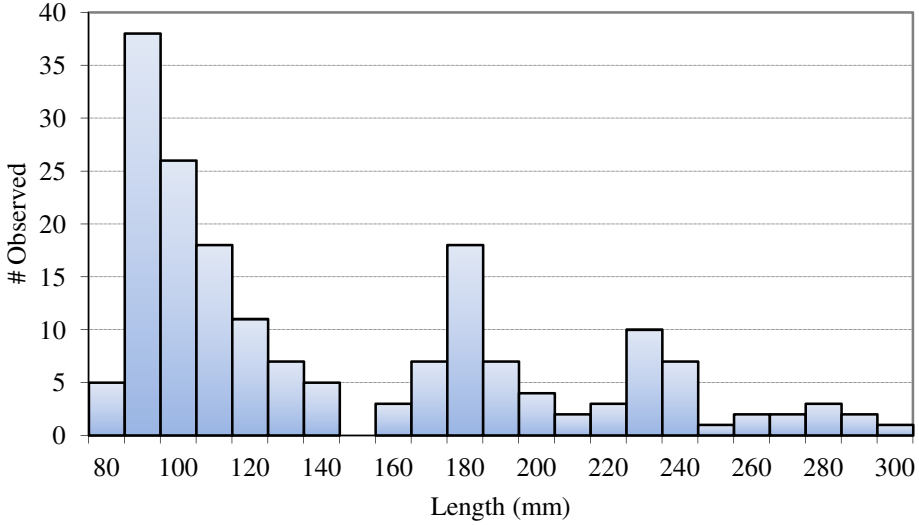

Figure 19. Length frequency distribution of walleye collected from Harriet Lake, Lake County, during fall 2018 electrofishing assessments.

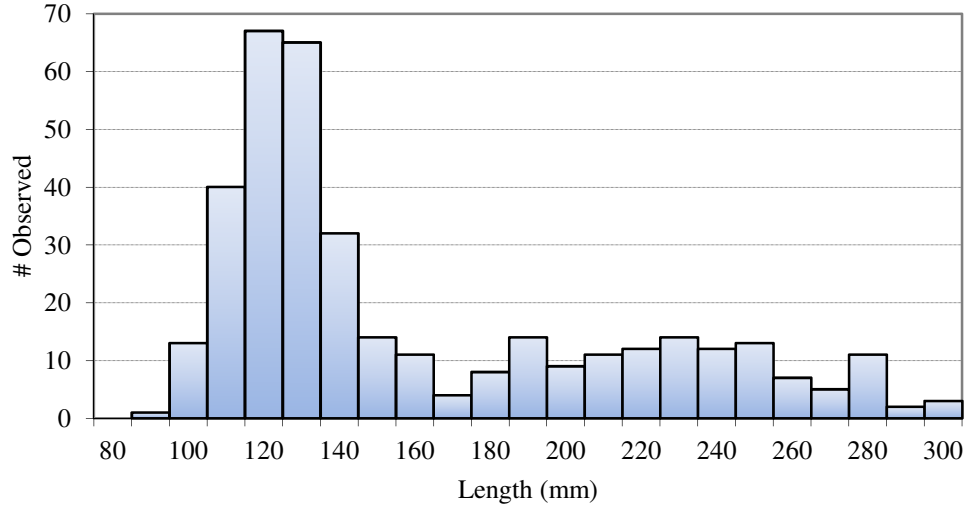

Figure 20. Length frequency distribution of walleye collected from Island Lake Reservoir, St. Louis County, during fall 2018 electrofishing assessments.

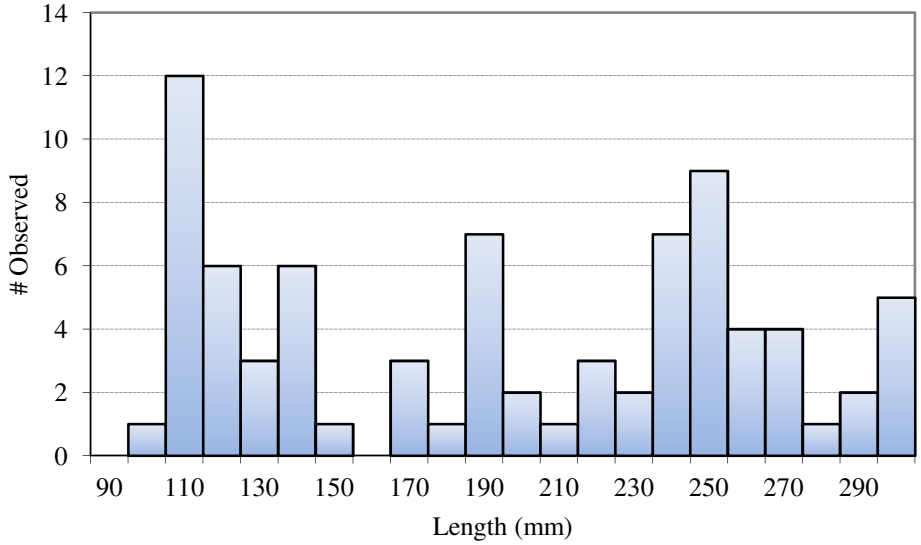

Figure 21. Length frequency distribution of walleye collected from North McDougal Lake, Lake County, during fall 2018 electrofishing assessments.

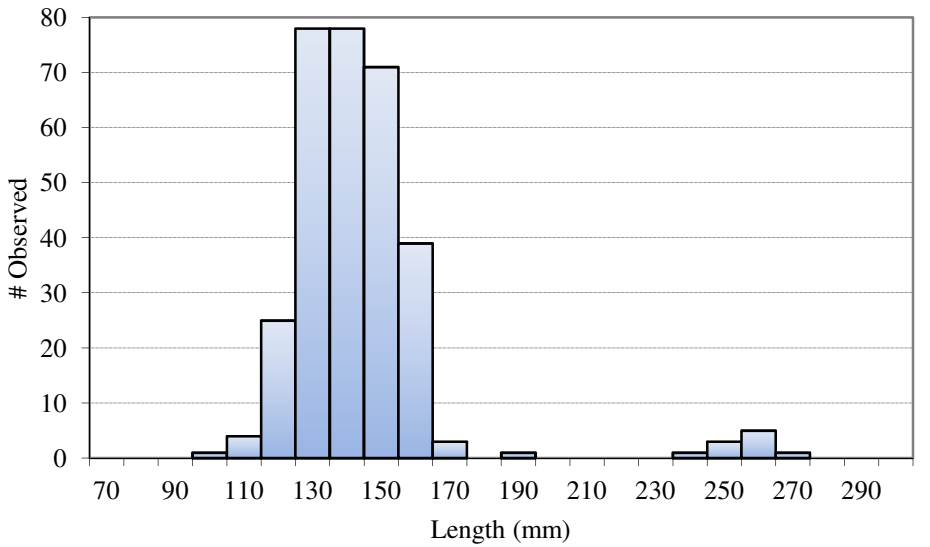

Figure 22. Length frequency distribution of walleye collected from Ninemile Lake, Lake County, during fall 2018 electrofishing assessments.

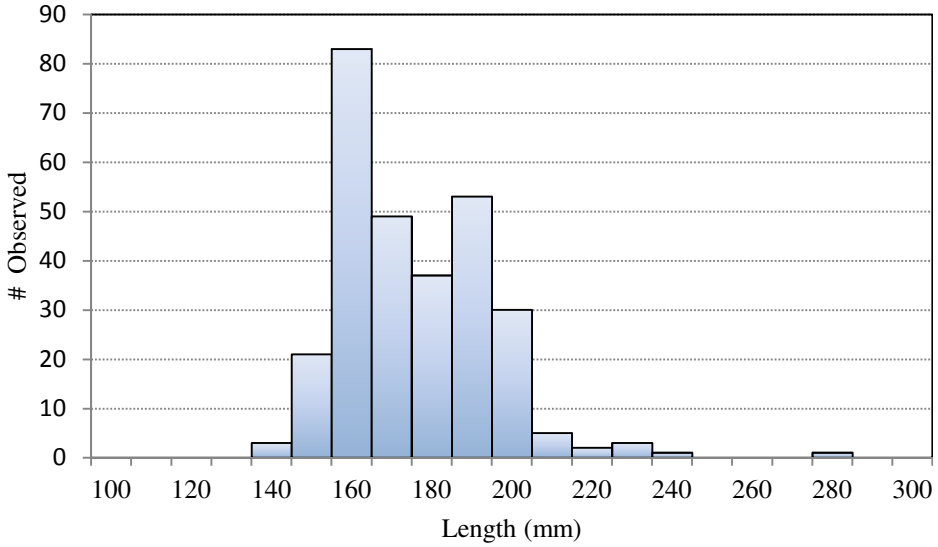

Figure 23. Length frequency distribution of walleye collected from Pike Lake, Cook County, during fall 2018 electrofishing assessments.

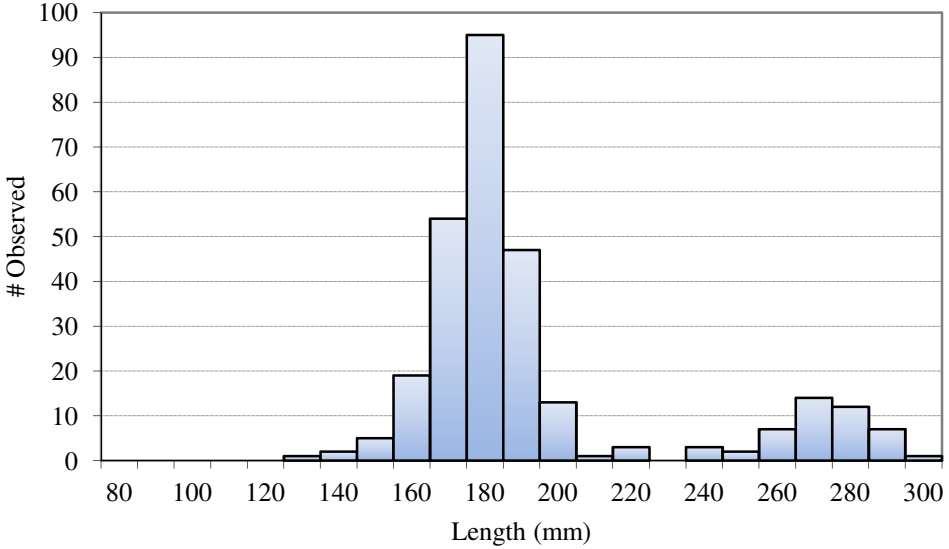

Figure 24. Length frequency distribution of walleye collected from Shagawa Lake, St. Louis County, during fall 2018 electrofishing assessments.

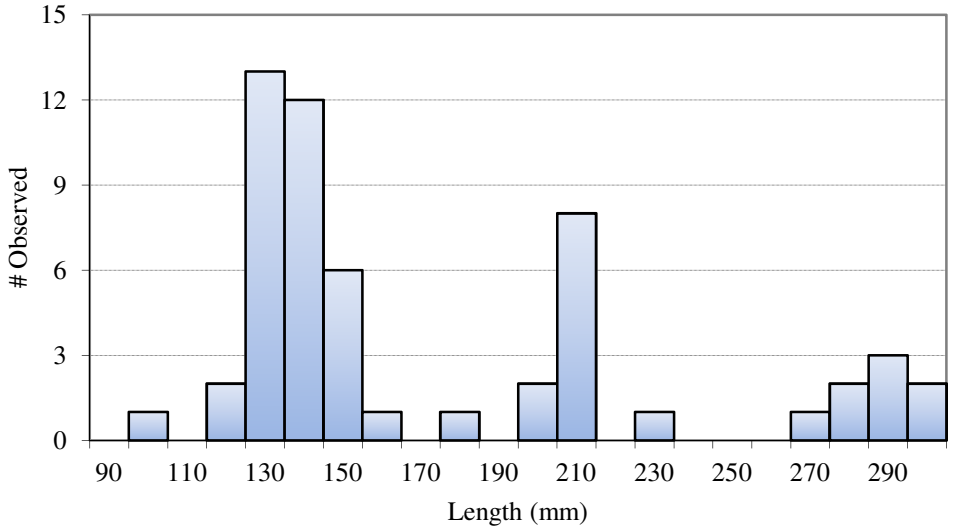

Figure 25. Length frequency distribution of walleye collected from Silver Island Lake, Lake County, during fall 2018 electrofishing assessments.

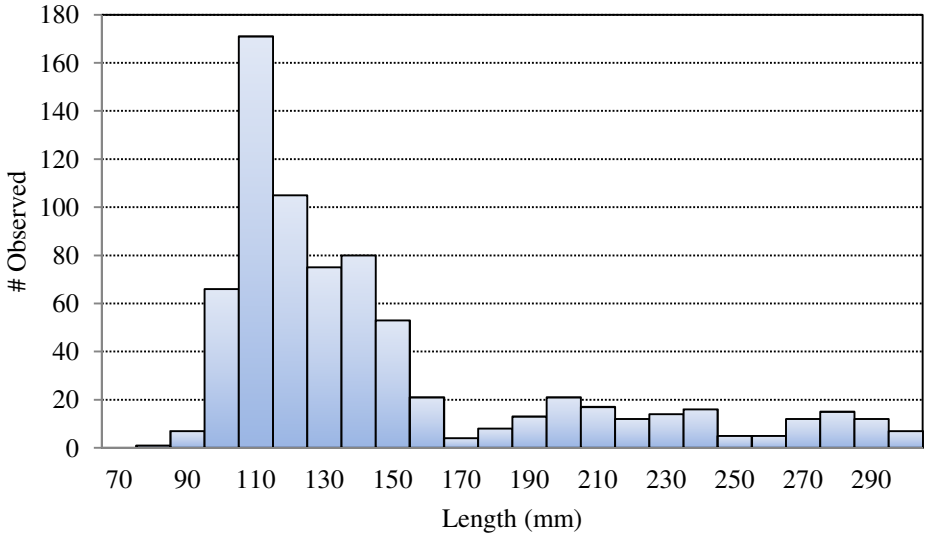

Figure 26. Length frequency distribution of walleye collected from Tait Lake, Cook County, during fall 2018 electrofishing assessments.

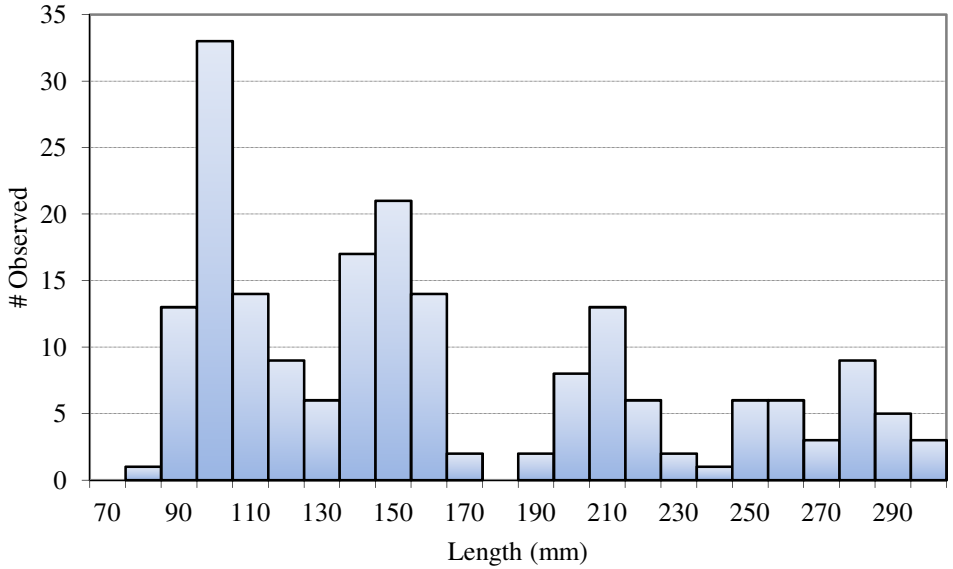

Figure 27. Length frequency distribution of walleye collected from Tom Lake Cook County, during fall 2018 electrofishing assessments.

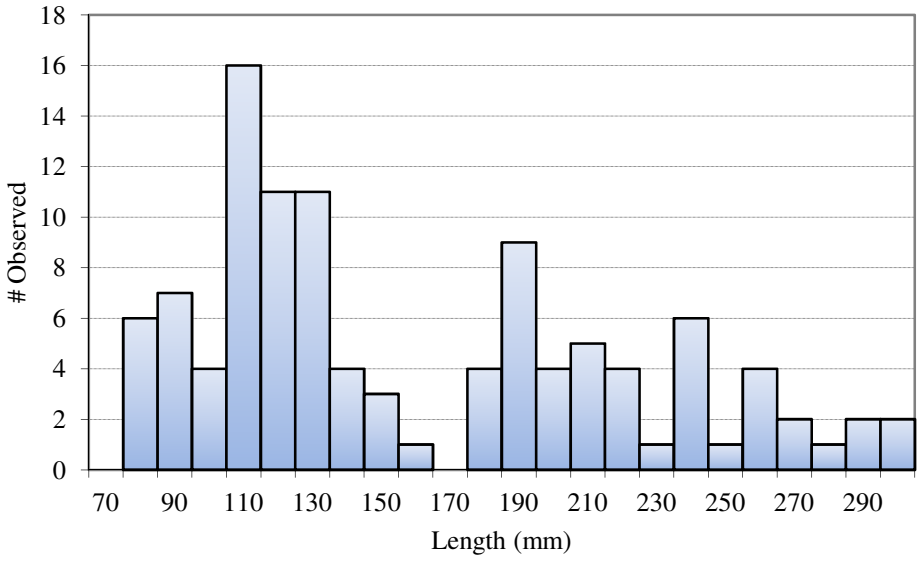

Figure 28. Length frequency distribution of walleye collected from Two Island Lake, Cook County, during fall 2018 electrofishing assessments.

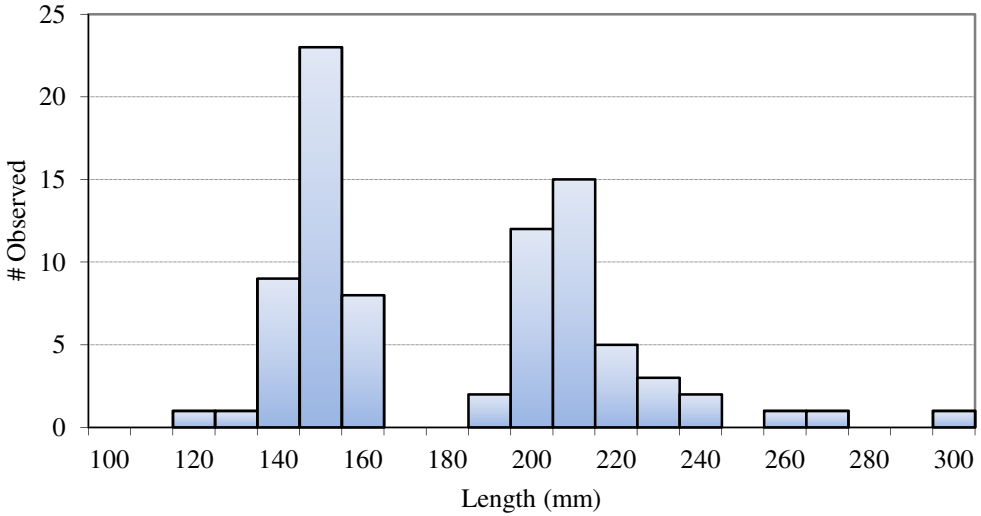

Figure 29. Length frequency distribution of walleye collected from West Twin Lake, Cook County, during fall 2018 electrofishing assessments.

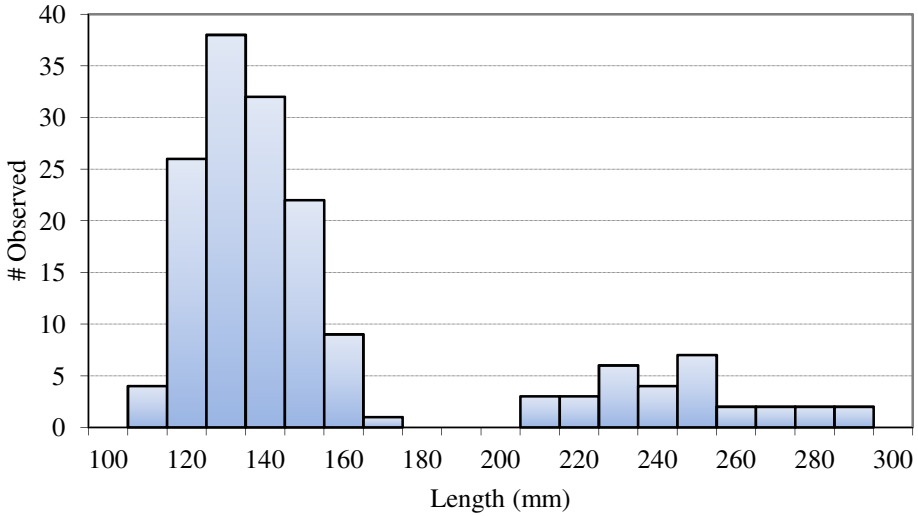

Figure 30. Length frequency distribution of walleye collected from Whiteface Reservoir, St. Louis County, during fall 2018 electrofishing assessments.

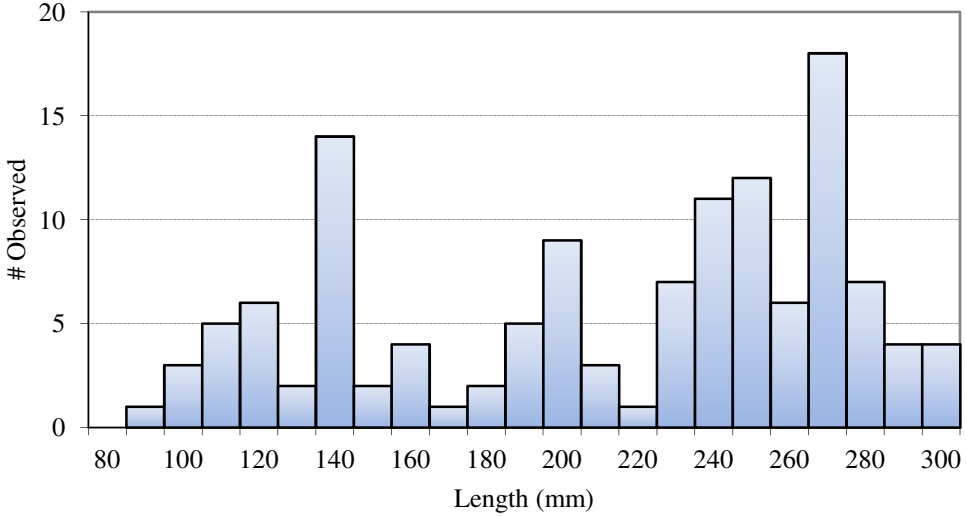

Figure 31. Length frequency distribution of walleye collected from Wilson Lake, Lake County, during fall 2018 electrofishing assessments.

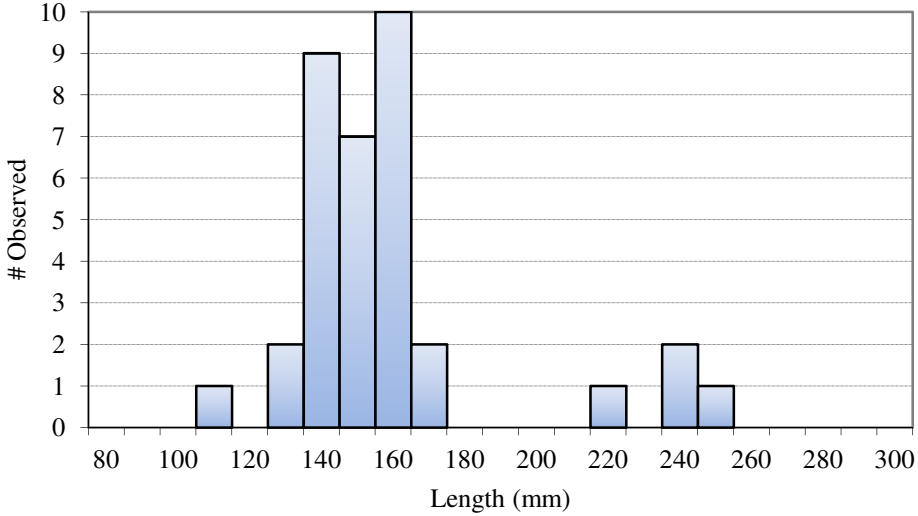

Figure 32. Length frequency distribution of walleye collected from Windy Lake, Lake County, during fall 2018 electrofishing assessments.

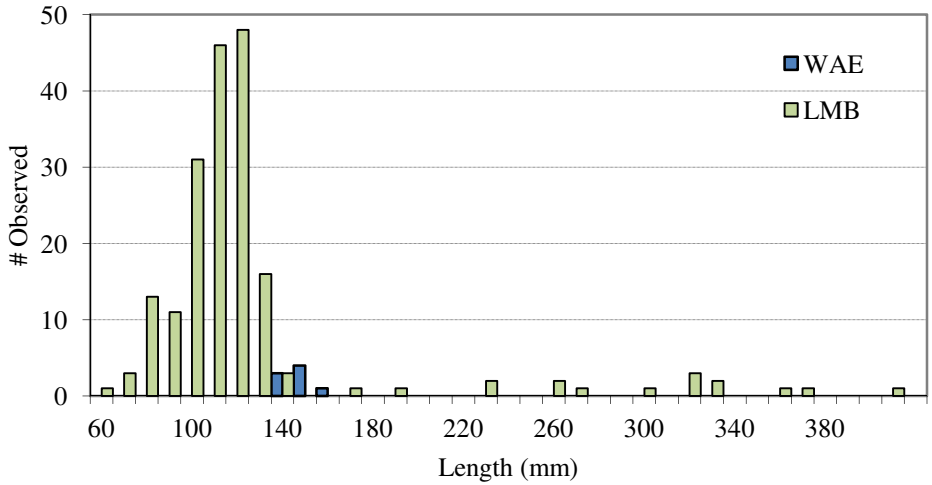

Figure 33. Length frequency distribution of walleye collected from Wild Rice Lake Reservoir, St. Louis County, during fall 2018 electrofishing assessments. Blue bars represent the walleye sampled while the green bars represent largemouth bass sampled.

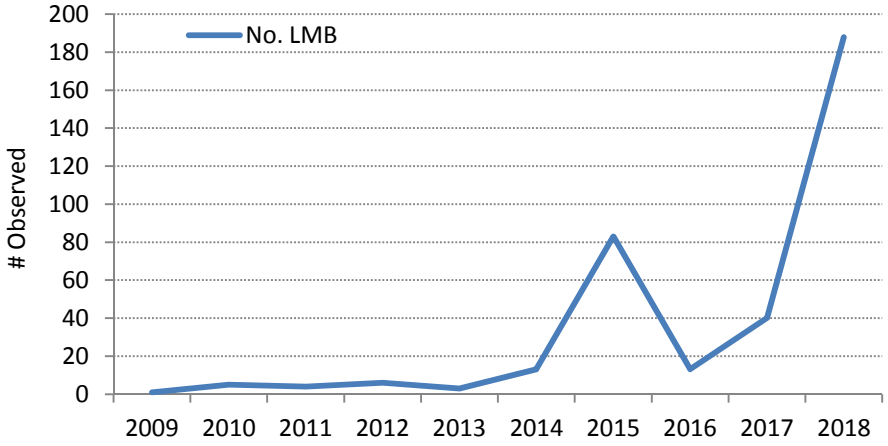

Figure 34. Number of largemouth bass collected from Wild Rice Lake Reservoir, St. Louis County, during fall electrofishing assessments since they were first observed In 2009.

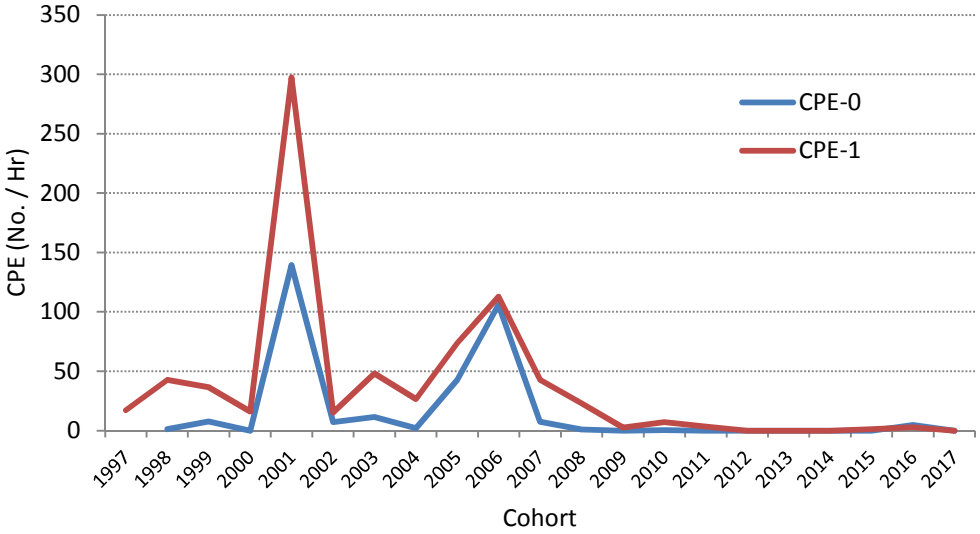

Figure 35. Historical catch rates (no. / hour) of age-0 and age-1 walleye from Devilfish Lake, Cook County, during fall electrofishing assessments.

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References

Anderson, R.O. 1976. Management of small warm water impoundments. Fisheries 1(6):5-7, 26-28.

Anderson, R.O. 1978. New approaches to recreational fishery management. pp 73 - 78 *in* G.D. Novinger and J.G. Dillard, editors. New approaches to the management of small impoundments. NCD-AFS, Spec Pub. 5, Bethesda, MD.

Borkholder, B.D. 1994a. Fish population assessments of three lakes within the 1854 Ceded Territory of Minnesota. Fond du Lac Ceded Territory Technical Report, No. 2. Cloquet, MN.

Borkholder, B.D. 1994b. Activities and opinions of Fond du Lac Band members related to the fisheries of the 1854 ceded territory. Fond du Lac Ceded Territory Technical Report, No. 1. Cloquet, MN.

Borkholder, B.D., N. Bogyo, and S. Thompson. 2017. Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2016. *Issued as both* Fond du Lac Ceded Territory Technical Report, No. 51. Cloquet, MN. *And* 1854 Authority, Biological Services Division, Technical Report #17-06.

Borkholder, B.D., N. Bogyo, S. Thompson, and A.J. Edwards. 2016. Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2015. *Issued as both* Fond du Lac Ceded Territory Technical Report, No. 50. Cloquet, MN. *And* 1854 Authority, Biological Services Division, Technical Report #16-04.

Borkholder, B.D., N. Bogyo, S. Thompson, and A.J. Edwards. 2015. Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2014. *Issued as both* Fond du Lac Ceded Territory Technical Report, No. 49. Cloquet, MN. *And* 1854 Authority, Biological Services Division, Technical Report #15-03.

Borkholder, B.D., N. Bogyo, S. Thompson, and A.J. Edwards. 2014. Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2013. *Issued as both* Fond du Lac Ceded Territory Technical Report, No. 48. Cloquet, MN. *And* 1854 Authority, Biological Services Division, Technical Report #14-05.

Borkholder, B.D., and A.J. Edwards. 2009. Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2008. *Issued as both* Fond du Lac Ceded Territory Technical Report, No. 43. Cloquet, MN. *And* 1854 Authority, Biological Services Division, Technical Report #09-01.

Borkholder, B.D., and A.J. Edwards. 2001. Comparing the use of dorsal fin spines with scales to back-calculate length-at-age estimates in walleyes. North American Journal of Fisheries Management 21:935-942.

Borkholder, B.D., and B G. Parsons. 2001. Relationship between electrofishing catch rates of age-0 walleyes and water temperature in Minnesota lakes. North American Journal of Fisheries Management 21:318-325.

Chapman, D.G., and D.S. Robson. 1960. The analysis of a catch curve. Biometrics 16:354-368.

Frie, Richard V. 1982. Measurement of fish scales and back-calculation of body lengths using a digitizing pad and microcomputer. Fisheries 7(5):5 - 8.

Gabelhouse, D.W., Jr. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:273-285.

Goyke, A.P., H.H. Ngu, and G.A. Miller. 1993. Fish population assessments of ceded territory lakes in Wisconsin and Michigan during 1992. Great Lakes Fish and Wildlife Commission Administrative Report. Odanah, WI.

Goyke, A.P., H.H. Ngu, and G.A. Miller. 1994. Fish population assessments of ceded territory lakes in Wisconsin, Michigan, and Minnesota during 1993. Great Lakes Fish and Wildlife Commission Administrative Report. Odanah, WI.

Kaeske, M. 2009. 1854 Treaty Authority 2009 Band Member Survey Results. 1854 Treaty Authority, Duluth, MN.

McFarlane, G.A., and R.J. Beamish. 1987. Validation of the dorsal spine method of age determination for spiny dogfish. Pages 287 - 300 *in* R.C. Summerfelt and G.E. Hall, eds. Age and Growth of Fish. Iowa State University Press, Ames, Iowa.

Meyer, F., ed. 1993. Casting light upon the waters: A joint fishery assessment of the Wisconsin ceded territory. U.S. Department of Interior, Bureau of Indian Affairs, Minneapolis, MN.

Ngu, H.H., and N. Kmiecik. 1993. Fish population assessments of ceded territory lakes in Wisconsin and Michigan during 1991. Great Lakes Fish and Wildlife Commission Administrative Report 93-1. Odanah, WI.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bulletin of the Fisheries Research Board of Canada.

Smith, M.W., A.Y. Then, C. Wor, G. Ralph, K.H. Pollock, and J.M. Hoenig. 2012. Recommendations for catch-curve analysis. North American Journal of Fisheries Management 32:956-967.

Vogt, D.J. 2004. Fish, wild game, and plant consumption survey results. 1854 Authority Technical Report #04-02. Duluth, MN.

Appendix 1. Nightly Mark / Recapture Data for walleye > 254 mm sampled during spring 2018 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
Boulder	7 May	---	152	0
	9 May	152	145	2
	10 May	295	117	6
	11 May	406	88	4
	MNDNR GN	490	172	3
	MNDNR GN / TN	490	209	4
Cascade	12 May	---	217	0
	13 May	217	203	26
	14 May	393[1]	157	43

[1] One fish was removed from "marked in population" after inadvertently being released without a blue tag