

Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2021

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

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Introduction

Under the Treaty of 30 September 1854, the Fond du Lac Band of Lake Superior Chippewa, the Grand Portage Band of Lake Superior Chippewa, and the Bois Forte Band 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 2021 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 throughout the 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.

The first objective of our assessments in 2021 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 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 2021 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 MN DNR 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. Tagged walleye would then be available during summer gill net assessments. A second population estimate was obtained by the MN DNR in the course of conducting their standard summer gill net surveys.

Electrofishing was performed at night using boom-shocking boats equipped with Smith-Root electrofishing 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 at each

station. 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 continue for as long as untagged 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 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 larger than 254 mm were marked using non-numbered colored floy tags (green color used in 2021) (Super Swiftachment Fasteners available from the Dennison Fastener Division, Framingham, Massachusetts). 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 (MN DNR personal communication).

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

Four Mile Lake (DOW 16-0639)

Electrofishing activities occurred on Four Mile Lake, Cook County, on 17 thru 21 April (Figure 1). Dates of electrofishing activities, water temperature, water conductivity, shocking time, the voltage and amps, the number of walleyes collected, and the number caught per hour of electrofishing (CPUE) are presented in Table 1. CPUE by station ranged from 6.6 to 712.2 adult walleye per hour of sampling (Figure 1). At a 95% confidence interval, mean CPUE for Four Mile Lake was 86.4 ± 48.4 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled in Four Mile Lake is presented in Figure 2. Walleye as large as 676 mm (26.6 inches) were observed in the survey. 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 1293 (Table 2). The adjusted Petersen estimate is 1128 ± 311 , with a 9.9% 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 2021, the Minnesota Department of Natural Resources performed a standardized net assessment on Four Mile Lake (MN DNR, Finland Area Fisheries). Eighty-three (83) individuals (> 274 mm) were sampled in the gill nets that would have been 254 mm during the assessments in April. This 274 mm threshold was determined in previous mark-recapture experiments using unique numbered floy tags (Borkholder et al. 2006). Twelve (12) individuals were recapture that had the green floy tag from the spring sampling (Appendix 1). The adjusted Petersen estimate using both the spring and summer data is 3774 ± 2384 , with a 24.6% CV (Table 2). The Schumacher and

Eschmeyer population estimate from this gill net data is 1325 (Table 2). Population estimates are included in Table 2.

Table 3 presents the age data for the walleye collected from Four Mile Lake. Of the 755 unique fish sampled, 536 (70.9%) were assigned to ages 3, 4 or 5. Total annual mortality (A) of the Four Mile 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). Annual mortality (A) was estimated at 45.6% (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). Total annual mortality (A) estimated using the MN DNR's gill net data was 42.4% (Figure 3, green triangles), essentially equivalent to the estimate from the spring electrofishing assessment. Our spring estimate was made using 750 walleyes age 3 – 16. The estimate from the gill net assessment was made using 71 fish aged 2 – 14.

Table 4 presents back-calculated lengths-at-age for walleye collected from Four Mile 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 46.0 ± 3.6 (Table 5). 406 of the 752 fish sampled were “stock” sized (10.0 – 14.9 inches) and will be growing and recruiting into this “quality” 15-inch category over the next few years, assuming that angling (or natural) mortality doesn't remove them before this. The summer gill net PSD (26.1 ± 9.1) was significantly different than the PSD estimate from the spring electrofishing survey ($\chi^2=12.633$, $P>0.05$, critical Chi-square value of 3.841) (Table 5).

Figure 4 shows historical data from Four Mile Lake. Since 1995, PSDs within Four Mile Lake are presented in the five historical electrofishing surveys (Figure 4). Observed walleye densities (no. / acre) estimated from the electrofishing data (red diamonds) has been steady since 1995, ranging from 1.5 walleye / acre in 1995 and 2001 to 3.2 walleye / acre in 2011 (Figure 4). All of the MNDNR gill net data available were processed thru two gill net selectivity models to calculate walleye density within Four Mile Lake (Anderson 2011; Radomski et al. 2019). Anderson's (2011) model suggests that the walleye density in Four Mile Lake may have increased since 2001 (purple triangles, Figure 4). Radomski's model (Radomski et al. 2019) seems to agree with Anderson's (2011) model that the walleye population has increased slightly since 2001 (green circles, Figure 4), although the density estimates from this model are quite a bit lower than those estimated using Anderson's (2011) model. Most of the population (76.1%) were aged at 5 years or younger (Table 3). The population growth rate levels off at less than 20 inches ("quality length") for males. A population characterized by young fish, high total mortality (>40%), and a low maximum length suggests that angling exploitation may be too high for the long term. For now, natural reproduction seems strong enough to maintain this population, with no obvious trends in declining juvenile walleye densities over time (see *Fall Assessments* portion of this report beginning on page 21). Four Mile Lake may be a good candidate for future creel surveys and estimates of angling exploitation within this population.

Table 1. Summary of electrofishing activities on Four Mile and Elbow Lakes within the 1854 Ceded Territory of Minnesota during spring 2021.

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
16-0639	Cook	Four Mile	593	20	4/17/2021	43.9	41.0	6379	High	1	114	41.8
					4/18/2021	43.0	44.0	5263	High	1	113	77.0
					4/19/2021	41.3	44.0	14863	884 / High	0.5 / 4	244	52.4
					4/20/2021	41.1	44.1	13246	884 / High	0.5 / 4	285	154.3
					4/21/2021	41.8	44.1	6395	884	3.5	159	81.1
16-0096	Cook	Elbow	408	9	4/21/2021	39.0	22.0	5649	Low	1	129	82.2
					4/22/2021	43.2	23.2	8600	Low / 1061	1 / 3.5	148	54.4
					4/23/2021	44.8	22.0	4721	1061	3	183	141.4

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)).

Fourmile Lake, Cook County, April 2021

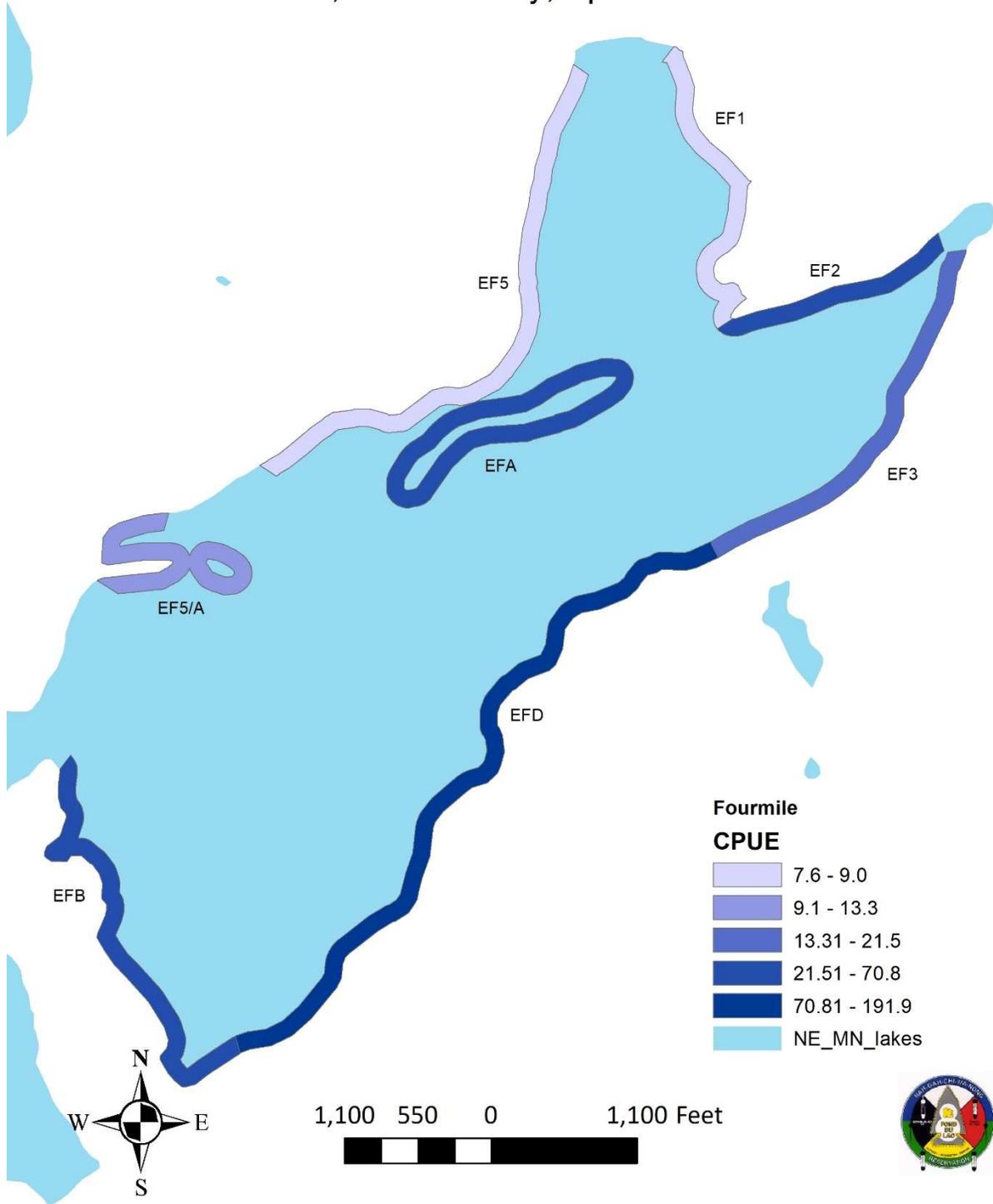


Figure 1. Catch per hour (CPUE) of adult walleyes (fish larger than 254 mm) by electrofishing station, on Four Mile Lake, Cook County, during spring 2021 electrofishing surveys.

Table 2. Walleye population estimates for Four Mile and Elbow Lakes (Cook County), spring 2021. Estimates are for walleye larger than 10 inches. EF denotes population estimates determined from spring electrofishing data. GN refers to population estimates from samples collected during summer netting assessments. GN/TN includes all of the MN DNR data from both the gill nets and trap nets.

Lake	Population Estimate ¹	No. / Acre	95% Confidence Limits		Estimate ²
			Lower	Upper	
Four Mile – EF ₂₀₂₁	1293	2.1	974	1922	1128 ± 311
Four Mile – GN ₂₀₂₁	1325	2.2	696	13,857	3774 ± 2384
Elbow – EF ₂₀₂₁	504	1.2	465	550	496 ± 182
Elbow – GN ₂₀₂₁	621	1.5	316	18,895	1052 ± 900

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

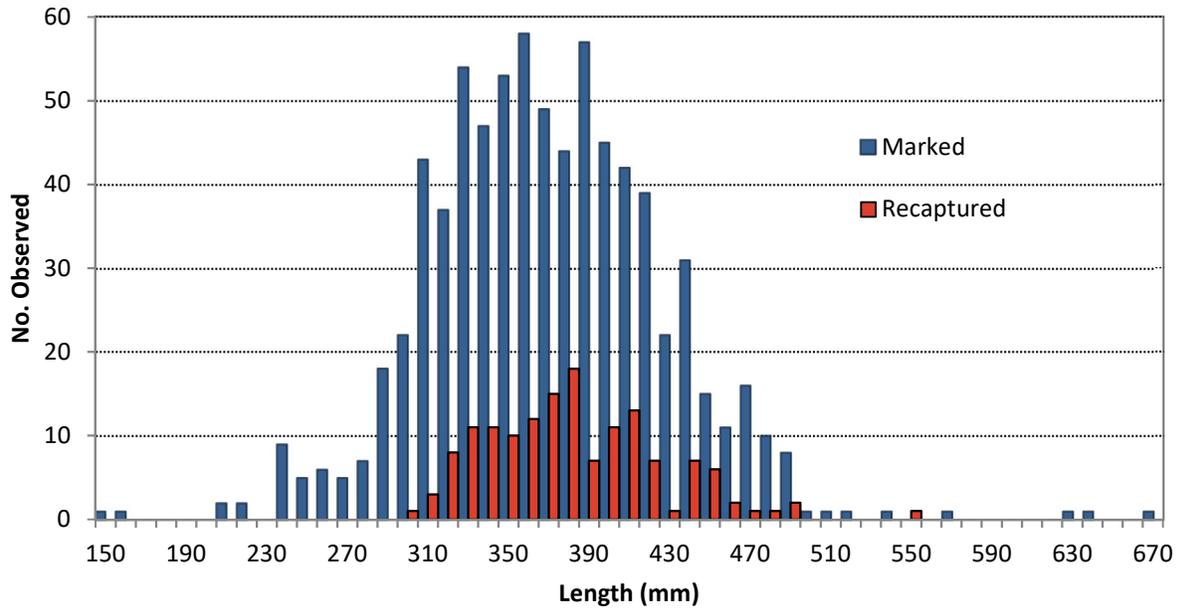


Figure 2. Length frequency distribution of walleye sampled from Four Mile Lake, Cook County, during spring 2021 electrofishing assessments. Length frequency distribution of recaptured walleyes is shown in red bars.

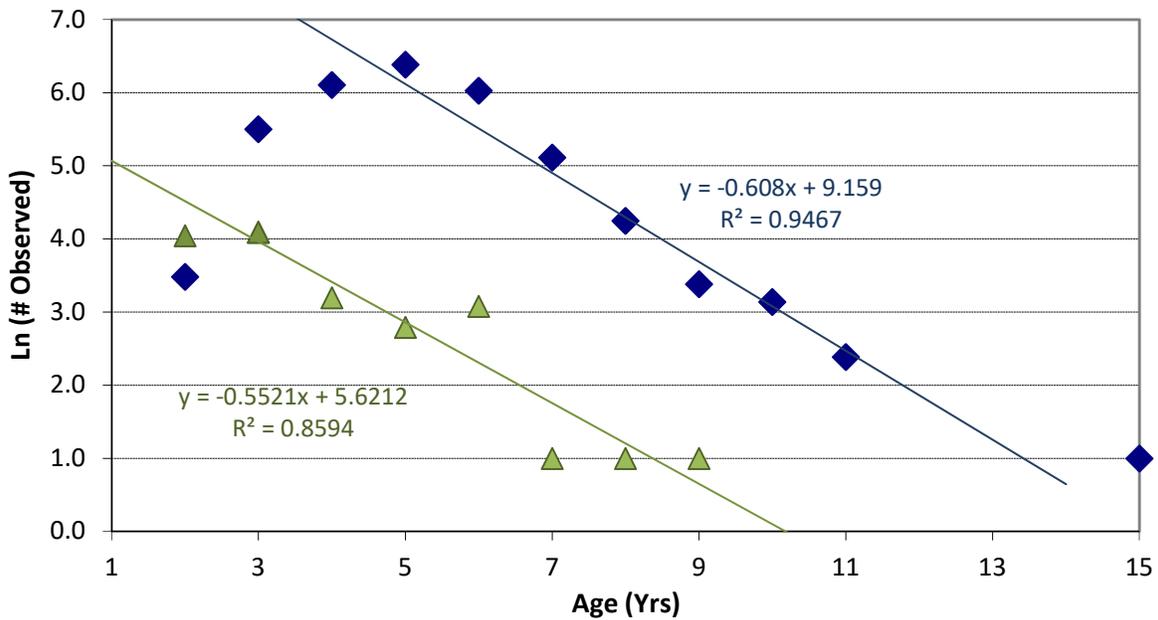


Figure 3. Catch curve analysis of walleyes in Four Mile Lake, 2021, showing instantaneous mortality (Z). Estimates are made from spring 2021 electrofishing data (blue diamonds) and summer 2021 MN DNR gill net data (green triangles).

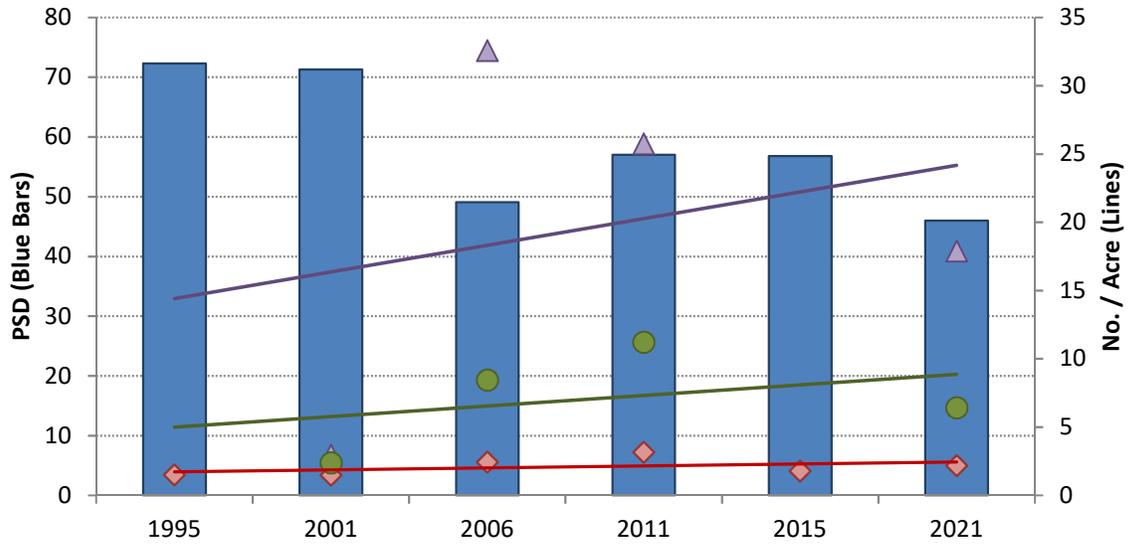


Figure 4. PSDs (blue bars) for walleye and adult walleye densities (no. / acre, colored lines) in Four Mile Lake as estimated during spring electrofishing surveys and MNDNR summer gill net assessments. Red line displays walleye density estimates from spring electrofishing surveys (No. / acre). Green line shows density estimates using MNDNR gill net data processed thru the Radomski et al. (2019) model. The purple line shows estimates from MNDNR gill net data processed thru Anderson's (2011) Q_{abg} gill net selectivity model.

Table 3. Age frequency distribution of walleye from Four Mile Lake, Cook County, spring 2021, based upon the number of fish sampled and aged per size category.

Length Group		N Sampled	Age														
Inches	mm		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
8.5	216	2															
9	229	1	1														
9.5	241	8	8														
10.0	254	9	3	6													
10.5	267	7		7													
11.0	279	15		13	2												
11.5	292	19		5	14												
12.0	305	47		18	29												
12.5	318	49		22	27												
13.0	330	68		19	39	10											
13.5	343	56			32	24											
14.0	356	80				69	11										
14.5	368	56				47	9										
15.0	381	63			18	27	18										
15.5	394	66				17	32	17									
16.0	406	57			4	16	33	4									
16.5	419	46				9	12	18	6								
17.0	432	31					19	8	4								
17.5	445	28					11	9	4		2	2					
18.0	457	13					2	2	7		2						
18.5	470	20					5	2	4	6			3	1			
19.0	483	14					1	1		5	2	1	1	2			
19.5	495	4						1			1	1	1				
20.0	508	1												1			
20.5	521	1												1			
21.0	533																
21.5	546	1									1						
22.0	559																
22.5	572	1														1	
23.0	584																
23.5	597																
24.0	610																
24.5	622	1															1
25.0	635	1												1			
26.5	673	1															1
TOTAL		755	12	90	165	218	153	61	26	11	8	4	5	6	0	2	1

Table 4. Back-calculated lengths-at-age for walleye collected from Four Mile Lake, Cook County, Minnesota, spring 2021.

Age Class	N	Length (mm)	Length (in)
1	177	126	5.0
2	177	196	7.7
3	177	270	10.6
4	175	322	12.7
5	149	367	14.4
6	123	403	15.9
7	56	437	17.2
8	35	452	17.8
9	29	468	18.4
10	20	481	18.9
11	17	491	19.3
12	14	507	19.9
13	8	522	20.5
14	3	599	23.6
15	2	604	23.8
16	1	676	26.6

Table 5. Proportional Stock Density (PSD) and Relative Stock Densities (RSD) with 95% confidence for Four Mile and Elbow Lakes (Cook County). Values are for spring electrofishing (EF) and MN DNR gill netting (GN) and trap netting (TN) surveys conducted during the year indicated.

Lake	PSD	RSD S-Q	RSD Q-P	RSD P-M	RSD M-T
Four Mile – EF ₂₀₂₁	46.0 ± 3.6	54.0 ± 3.6	45.1 ± 3.6	0.7 ± 0.6	0.3 ± 0.4
Four Mile – GN ₂₀₂₁	26.1 ± 9.2	73.9 ± 9.2	22.7 ± 8.8	2.3 ± 3.1	1.1 ± 2.2
Elbow – EF ₂₀₂₁	70.1 ± 5.0	29.9 ± 5.0	62.0 ± 5.3	7.1 ± 2.8	0.9 ± 1.0
Elbow – GN ₂₀₂₁	52.2 ± 11.8	47.8 ± 11.8	39.1 ± 11.5	11.6 ± 7.6	1.4 ± 2.8

Elbow Lake (DOW 16-0096)

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 by station ranged from 28.1 to 194.3 adult walleye per hour of sampling (Figure 5). At a 95% confidence interval, mean CPUE for Elbow Lake was 83.1 ± 31.5 adult walleye (>254mm) per hour of sampling effort.

The length frequency of the walleye sampled in Elbow Lake is presented in Figure 6. Walleye as large as 742 mm (29.2 inches) were observed in the survey. Additional species observed included yellow perch, northern pike, and golden shiner.

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 504 (Table 2). The adjusted Petersen estimate is 496 ± 182 , with an 8.5% CV (Table 2). The population estimates presented in Table 2 represent the population abundance of walleye using the spawning habitat sampled (Figure 6), and are not estimates of the walleye population within the entire lake.

During summer 2021, the Minnesota Department of Natural Resources performed a standardized net assessment on Elbow Lake (MN DNR, Grand Marais Area Fisheries). Fifty-eight (58) individuals (> 274 mm) were sampled in the gill nets that would have been 254 mm during the April electrofishing assessments. Sixteen (16) individuals were recapture that had the green floy tag from the spring sampling (Appendix 1). The adjusted Petersen estimate using both the spring and summer data is 1052 ± 900 , with a 19.9% CV (Table 2). The Schumacher and Eschmeyer population estimate from this gill net data is 621 (Table 2). Interestingly, five individuals were sampled that still had the yellow floy tag applied during the 2015 sampling survey.

Table 6 presents the age data for the walleye collected from Elbow Lake. Annual mortality (A) was estimated at 32.6% (Figure 7, blue line). Total annual mortality (A) estimated using the MN DNR's gill net data was 29.3% (Figure 7, green line), essentially equivalent to the estimate from the spring electrofishing assessment.

Table 7 presents back-calculated lengths-at-age for walleye collected from Elbow Lake, as determined using 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 was 70.1 ± 5.0 (Table 5). 201 of the 357 fish sampled were in the "quality" 15-inch category. This may be slightly on the "unbalanced" side, with fewer fish in

the “stock” to “quality” size category. The summer gill net PSD (52.2 ± 11.8) was significantly different than the PSD estimate from the spring electrofishing survey ($\chi^2=8.222$, $P<0.05$, critical Chi-square value of 3.841) (Table 5), and represents a more “balanced” fishery. The summer gill net PSD estimate was calculated using 69 fish.

Historical data for Elbow Lake is presented in Figure 8. Since 2010, PSDs within Elbow Lake have been rising in each of the last three electrofishing surveys (Figure 8). Walleye density (no. / acre) estimated from the electrofishing surveys have been relatively steady (red line in Figure 8), ranging from 3.3 walleye / acre in 2015 to 1.2 walleye / acre in 2021 (Figure 8). All of the MNDNR gill net data available were processed thru two gill net selectivity models to calculate walleye density within Elbow Lake (Anderson 2011; Radomski et al. 2019). The two MNDNR gill net models both show a trend of increasing walleye density over the last two decades (purple and green lines in Figure 8). In 2021, both models predicted walleye densities in excess of five walleye per acre. This may be the result of lower sample sizes in the gill nets and higher CV for the gill net population estimates. Walleye density in excess of 5 per acre in Elbow Lake seems unreasonably high.

Elbow Lake, Cook County, April 2021

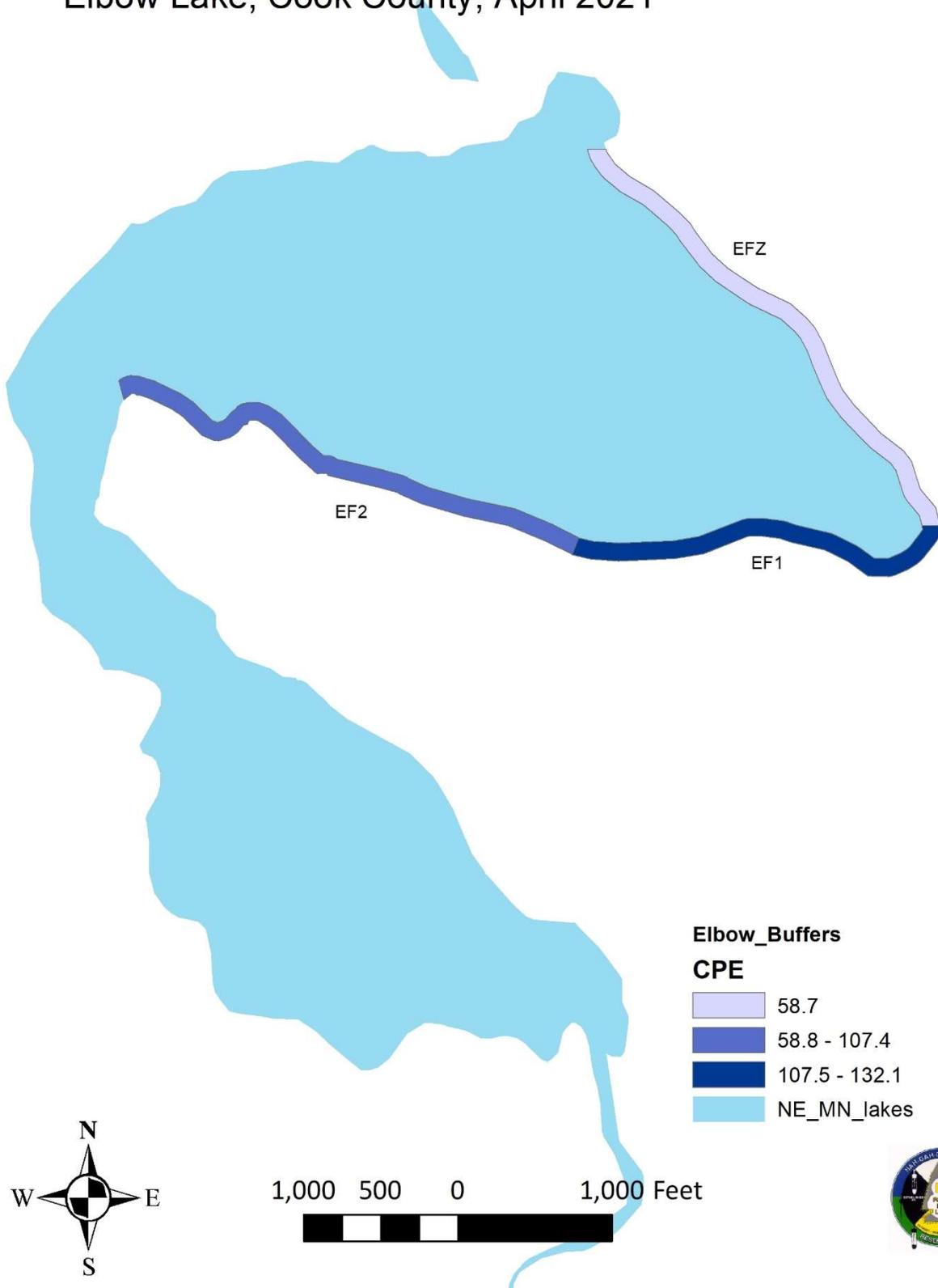


Figure 5. Catch per hour (CPUE) of adult walleyes (fish larger than 254 mm) by electrofishing station, on Elbow Lake, Cook County, during spring 2021 electrofishing surveys.

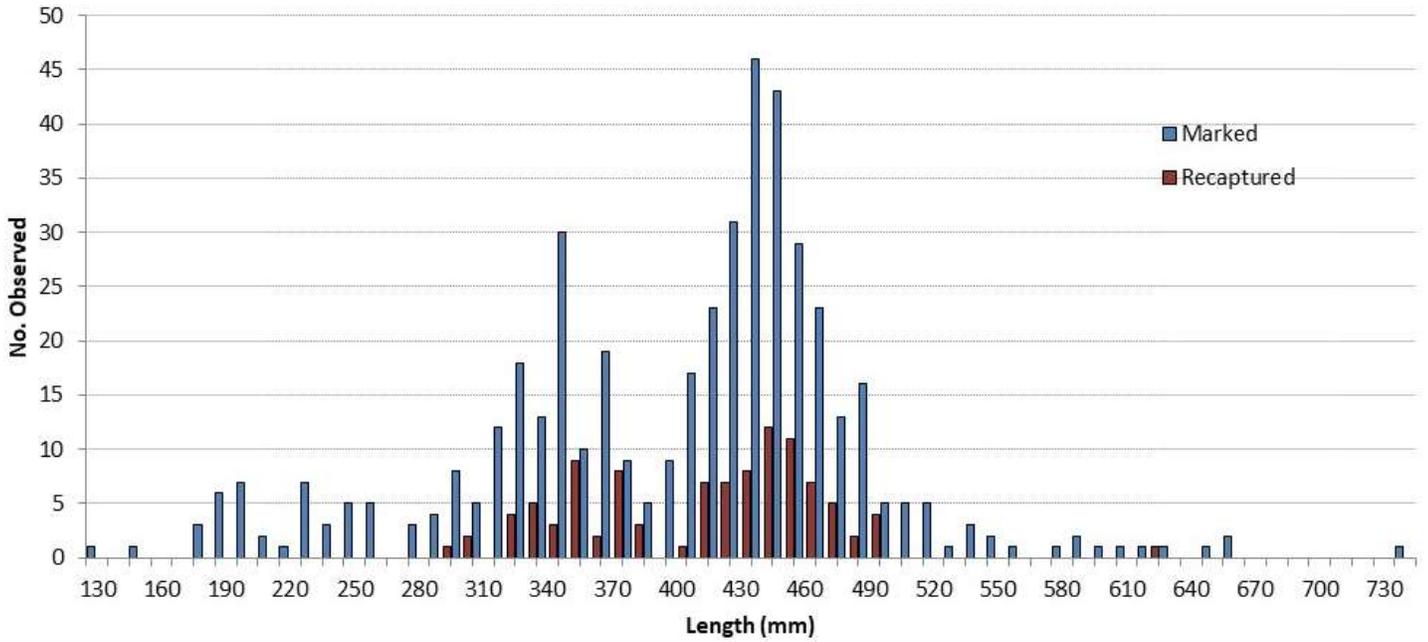


Figure 6. Length frequency distribution of walleye sampled from Elbow Lake, Cook County, during spring 2021 electrofishing assessments. Length frequency distribution of recaptured walleyes is shown in red bars.

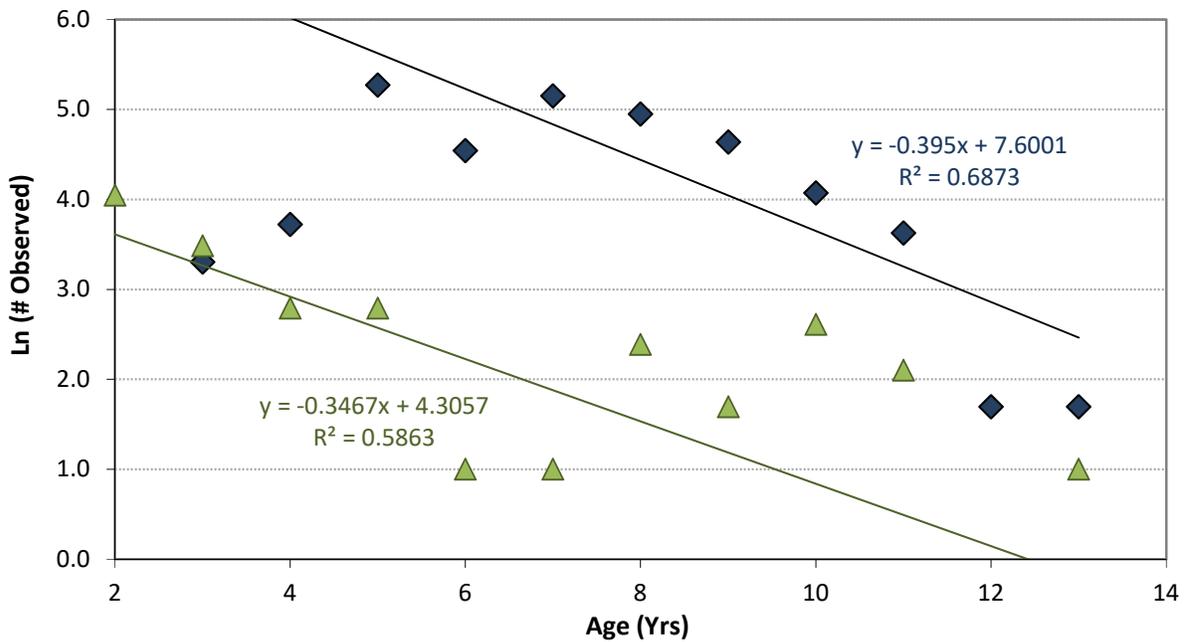


Figure 7. Catch curve analysis of walleyes in Elbow Lake, 2021, showing instantaneous mortality (Z). Estimates are made from spring 2021 electrofishing data (blue diamonds) and summer 2021 MN DNR gill net data (green triangles).

Table 6. Age frequency distribution of walleye from Elbow Lake, Cook County, spring 2021, based upon the number of fish sampled and aged per size category.

Length Group		N Sampled	Age												
Inches	mm		3	4	5	6	7	8	9	10	11	12	13	17	
10.0	254	8	8												
10.5	267														
11.0	279	3	2	1											
11.5	292	4		4											
12.0	305	8		7	1										
12.5	318	13		2	11										
13.0	330	13			11	2									
13.5	343	22			22										
14.0	356	11			6	3	2								
14.5	368	15			11	4									
15.0	381	7			2	5									
15.5	394	9			2	5	2								
16.0	406	12		2		3	2	5							
16.5	419	19			6	4	2	6	2						
17.0	432	36					22		14						
17.5	445	43				4	12	12	4	4	7.8				
18.0	457	29					12	12	5						
18.5	470	23				5		8	5	3	3				
19.0	483	15					3	5	2	5	2				
19.5	495	8					3		3	3					
20.0	508	6					1	3	1	1					
20.5	521	4					1	1		1					
21.0	533	4					2		2						
21.5	546	2						1		1					
22.0	559	1								1					
22.5	572														
23.0	584	2								1		1			
23.5	597	2									1	1			
24.0	610	1								1					
24.5	622	1											1		
25.0	635														
25.5	648	1											1		
26.0	660	1								1					
29.0	737	1												1	
TOTAL		313	10	15	72	35	64	52	38	22	14	2	2	0	1

Table 7. Back-calculated lengths-at-age for walleye collected from Elbow Lake, Cook County, Minnesota, spring 2021.

Age Class	N	Length (mm)	Length (in)
1	144	95	3.7
2	144	170	6.7
3	144	236	9.3
4	140	298	11.7
5	130	352	13.9
6	95	398	15.7
7	79	435	17.1
8	59	464	18.3
9	36	490	19.3
10	24	526	20.7
11	10	543	21.4
12	5	614	24.2
13	3	652	25.7
14	1	690	27.2
15	1	703	27.7
16	1	720	28.3
17	1	742	29.2

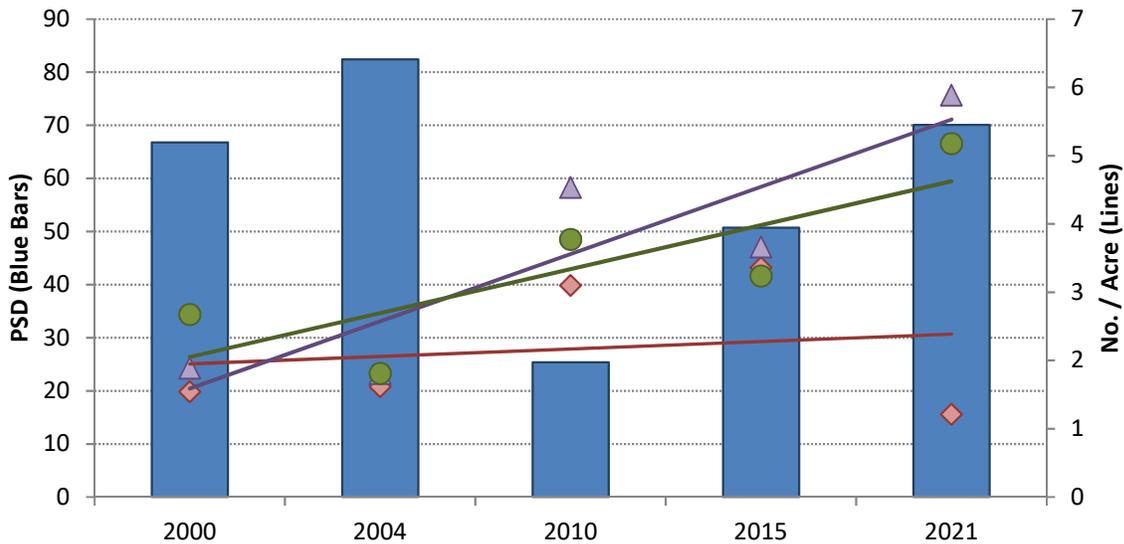


Figure 8. PSDs (blue bars) for walleye and adult walleye densities (no. / acre, colored lines) in Elbow Lake as estimated during spring electrofishing surveys and MNDNR summer gill net assessments. Red line displays walleye density estimates from spring electrofishing surveys (No. / acre). Green line shows density estimates using MNDNR gill net data processed thru the Radomski et al. (2019) model. The purple line shows estimates from MNDNR gill net data processed thru Anderson's (2011) Q_{abg} gill net selectivity model.

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 7 September 2022. This 20°C threshold was not exceeded in any of the lakes surveyed 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 0.5 fish per hour (Pike Lake) to 281.9 fish per hour of electrofishing (Two Island Lake). CPUE for age-1 walleye ranged from 0.7 fish per hour (Ninemile Lake) to 113.8 fish per hour of electrofishing (Cadotte Lake) (Table 8).

Table 9 presents the mean length for age-0 and age-1 individuals sampled during fall 2021 assessments. Mean lengths for age-0 walleye ranged from 94 mm (3.7 inches, Two Island Lake) to 168 mm (6.6 inches, Shagawa Lake). Mean lengths for age-1 walleye ranged from 174 mm (6.8 inches, Caribou Lake) to 246 mm (9.6 inches, Crescent Lake). Figures 9 – 29 present length frequency data for each of the lakes surveyed.

Of note, in 2021, crews were not able to launch electrofishing boats into either Windy or Wilson Lakes. Due to drought conditions, the landing pads were too high out of the water to risk damage to trailers, or simply not being able to pull loaded trailers up over the concrete pad faces.

Historical catch rates for all of the lakes in our schedule are presented in figures 30 – 50. These figures present the age-0 and age-1 catch per hour for all years surveyed by both Fond du Lac and the 1854 Treaty Authority. This data is presented mostly for the various MN DNR area office staff to see in a single snapshot how lakes within their areas have historically produced seemingly strong and weak year-classes of walleyes.

Table 8. Total number and catch-per-unit-effort (CPUE) of age-0 and age-1 walleye collected from 23 lakes within the 1854 Ceded Territory of Northeastern Minnesota during fall 2021.

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	8-Sep	62.8	17.1	26.0	123	3	4486	98.7	2.4
Cadotte	27-Sep	61.8	16.6	28.0	2	226	7150	1.0	113.8
Caribou	9-Sep	64.1	17.8	76.0	270	33	6578	147.8	18.1
Cascade	20-Sep	64.0	17.8	21.0	48	10	4407	39.2	8.2
Crescent	22-Sep	61.3	16.3	30.3	233	3	3789	221.4	2.9
Crooked	24-Sep	60.7	16.0	55	15	5	3880	13.9	4.6
Dumbbell	22-Sep	61.7	16.5	75.6	17	8	6644	9.2	4.3
Elbow	7-Sep	62.3	16.8	35	59	69	3959	53.6	62.7
Four Mile	23-Sep	62.7	17.0	55	285	6	5742	178.7	3.8
Harriet	23-Sep	62.1	16.7	62.6	124	20	5779	77.2	12.5
Island Reservoir	29-Sep	63.8	17.7	91.4	522	145	12336	152.3	42.3
Ninemile	20-Sep	65.3	18.5	68.7	153	1	5375	102.5	0.7
N. McDougal	22-Sep	62.8	17.1	123.4	154	25	6760	82.0	13.3
Pike	9-Sep	63.9	17.7	60.9	1	8	7424	0.5	3.9
Shagawa	28-Sep	63.7	17.6	99.0	20	61	11803	6.1	18.6
Silver Island	21-Sep	61.2	16.2	46.0	18	16	4801	13.5	12.0
Tait	21-Sep	61.9	16.6	42.4	668	35	8847	271.8	14.2
Tom	7-Sep	63.6	17.6	34.5	59	66	7919	26.8	30.0
Two Island	8-Sep	62.8	17.1	32.2	499	5	6374	281.9	2.8
West Twin	10-Sep	65.3	18.5	33.9	227	12	5214	156.7	8.3
Whiteface Res.	27-Sep	63.9	17.7	61.6	220	66	7554	104.8	31.4
Wilson	Could not launch boat due to extraordinarily low water								
Windy	Could not launch boat due to extraordinarily low water								

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 2021 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	8-Sep	148	217 (N=3)
Cadotte	27-Sep	138 (N=2)	179
Caribou	9-Sep	127	174
Cascade	20-Sep	127	200 (N=10)
Crescent	22-Sep	124	246 (N=3)
Crooked	24-Sep	145 (N=15)	187 (N=5)
Dumbbell	22-Sep	154 (N=17)	223 (N=8)
Elbow	7-Sep	104	198
Four Mile	23-Sep	148	224 (N=6)
Harriet	23-Sep	131	211 (N=20)
Island Reservoir	29-Sep	125	196
Ninemile	20-Sep	154	181 (N=1)
N. McDougal	22-Sep	152	225
Pike	9-Sep	102 (N=1)	216 (N=8)
Shagawa	28-Sep	168 (N=20)	191
Silver Island	21-Sep	145 (N=18)	184 (N=16)
Tait	21-Sep	125	220
Tom	7-Sep	117	221
Two Island	8-Sep	94	220 (N=5)
West Twin	10-Sep	136	239 (N=12)
Whiteface Res.	27-Sep	145	232
Wilson	Could not launch boat due to extraordinarily low water		
Windy	Could not launch boat due to extraordinarily low water		

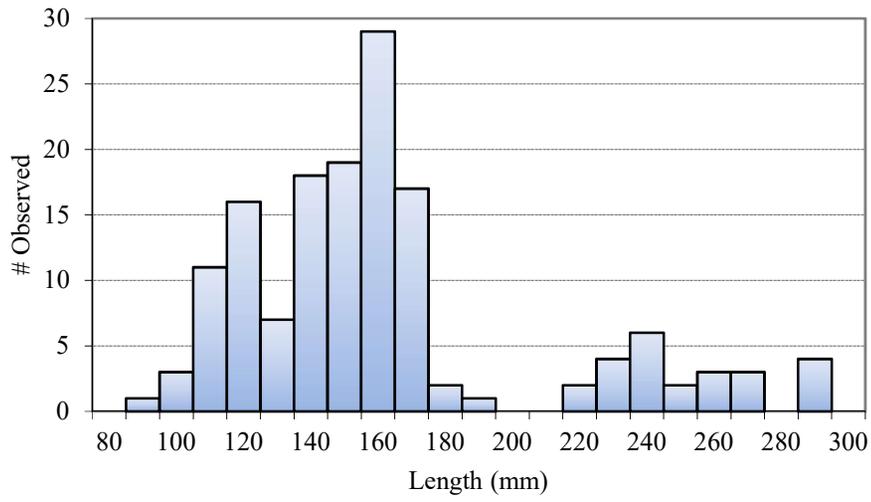


Figure 9. Length frequency distribution of walleye collected from Ball Club Lake, Cook County, during fall 2021 electrofishing assessments.

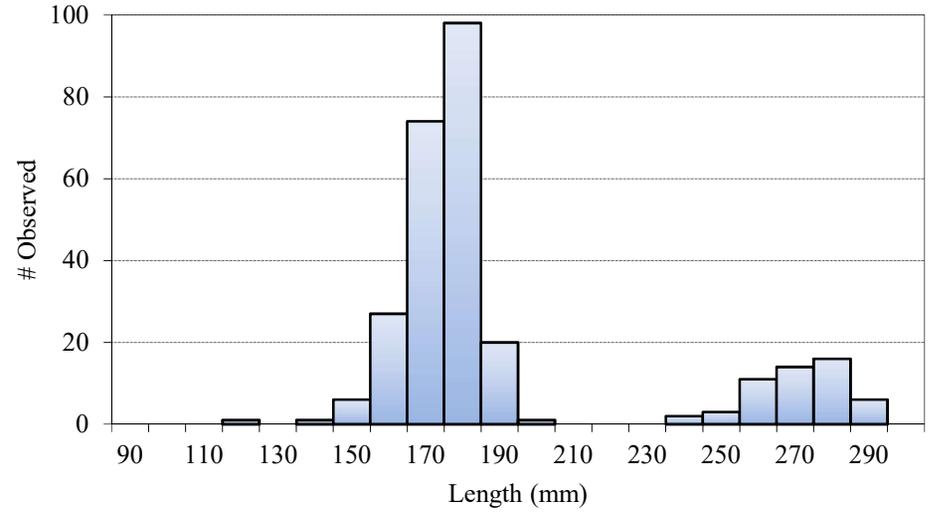


Figure 10. Length frequency distribution of walleye collected from Cadotte Lake, St. Louis County, during fall 2021 electrofishing assessments.

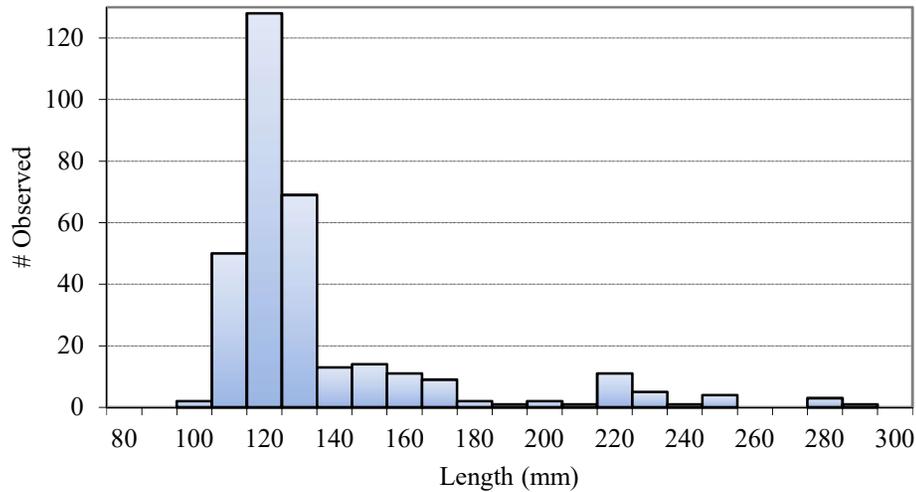


Figure 11. Length frequency distribution of walleye collected from Caribou Lake, Cook County, during fall 2021 electrofishing assessments.

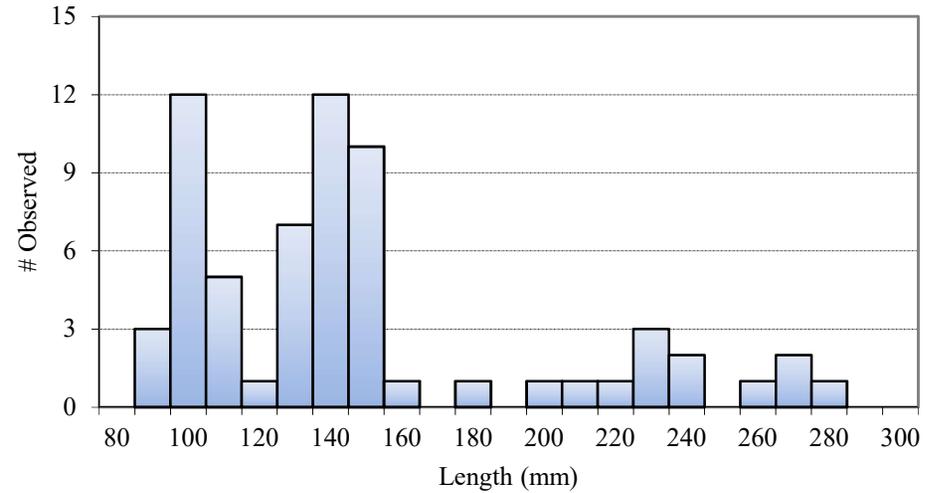


Figure 12. Length frequency distribution of walleye collected from Cascade Lake, Cook County, during fall 2021 electrofishing assessments.

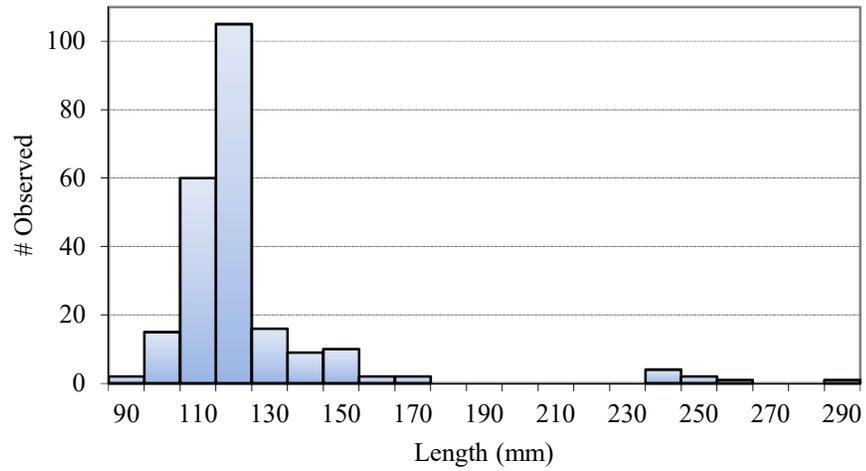


Figure 13. Length frequency distribution of walleye collected from Crescent Lake, Cook County, during fall 2021 electrofishing assessments.

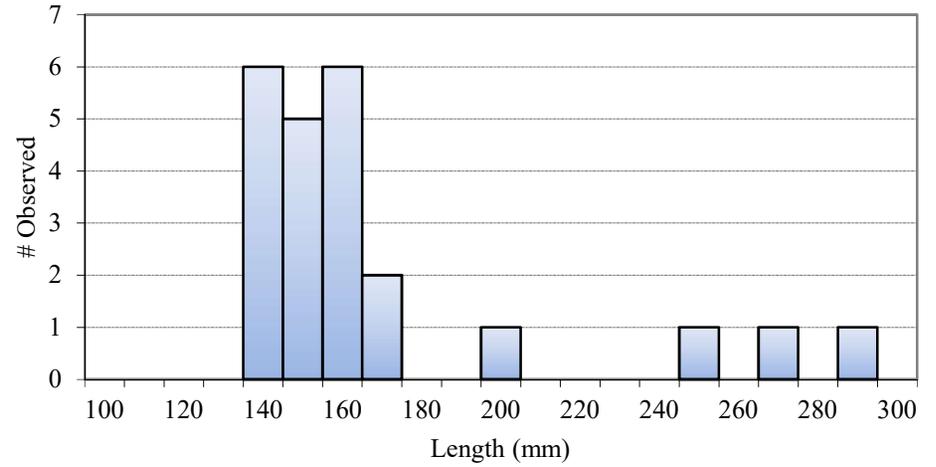


Figure 14. Length frequency distribution of walleye collected from Crooked Lake, Lake County, during fall 2021 electrofishing assessments.

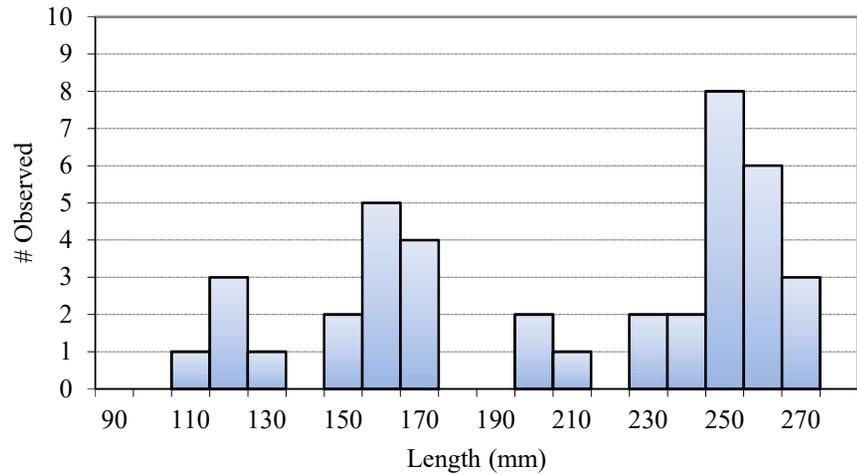


Figure 15. Length frequency distribution of walleye collected from Dumbbell Lake, Lake County, during fall 2021 electrofishing assessments.

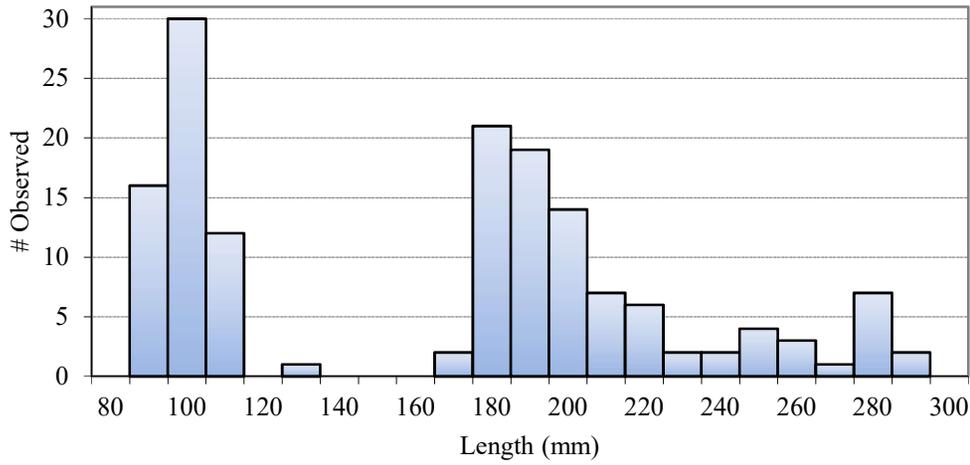


Figure 16. Length frequency distribution of walleye collected from Elbow Lake, Cook County, during fall 2021 electrofishing assessments.

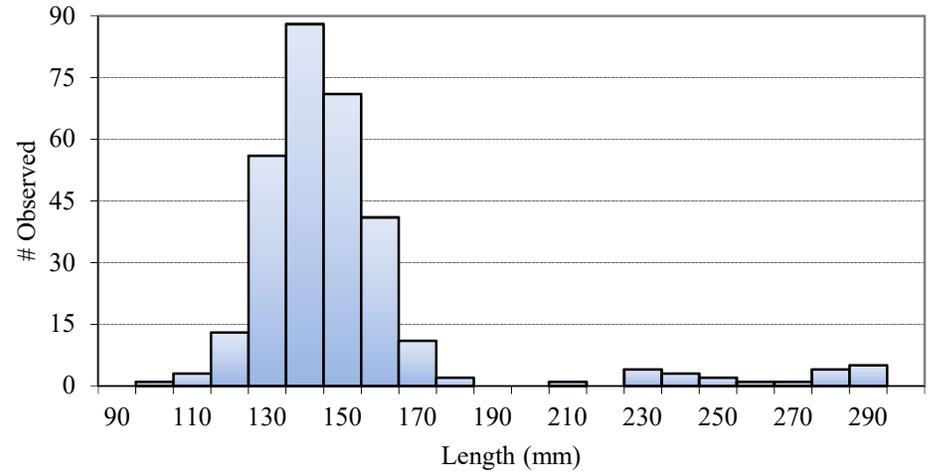


Figure 17. Length frequency distribution of walleye collected from Four Mile Lake, Cook County, during fall 2021 electrofishing assessments.

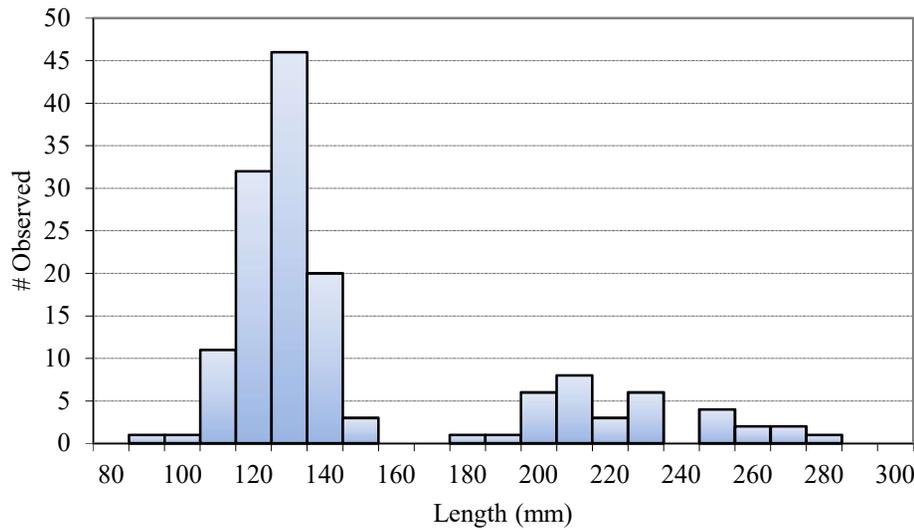


Figure 18. Length frequency distribution of walleye collected from Harriet Lake, Lake County, during fall 2021 electrofishing assessments.

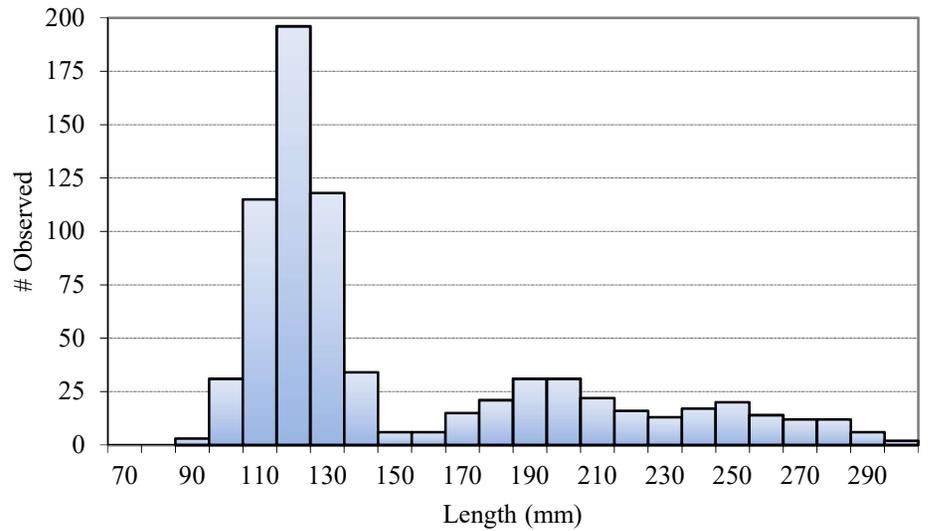


Figure 19. Length frequency distribution of walleye collected from Island Lake Reservoir, St. Louis County, during fall 2021 electrofishing assessments.

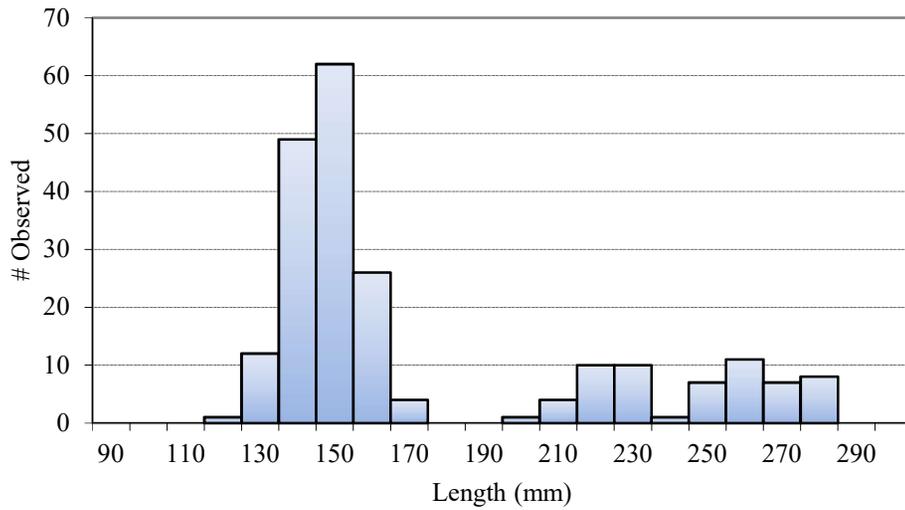


Figure 20. Length frequency distribution of walleye collected from North McDougal Lake, Lake County, during fall 2021 electrofishing assessments.

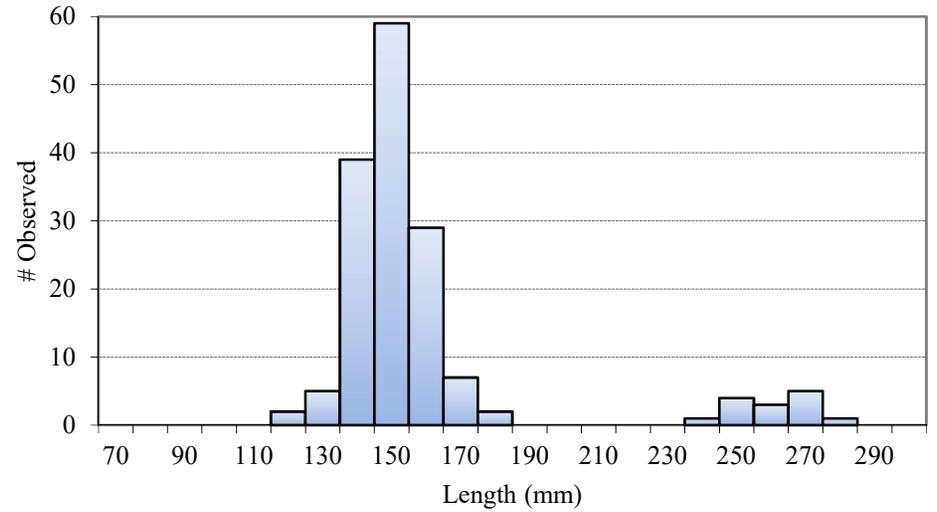


Figure 21. Length frequency distribution of walleye collected from Ninemile Lake, Lake County, during fall 2021 electrofishing assessments.

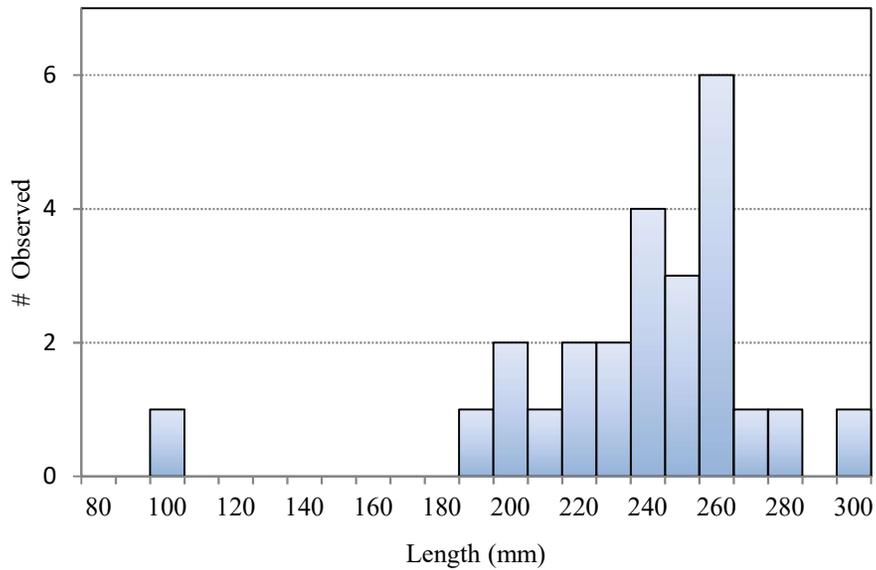


Figure 22. Length frequency distribution of walleye collected from Pike Lake, Cook County, during fall 2021 electrofishing assessments.

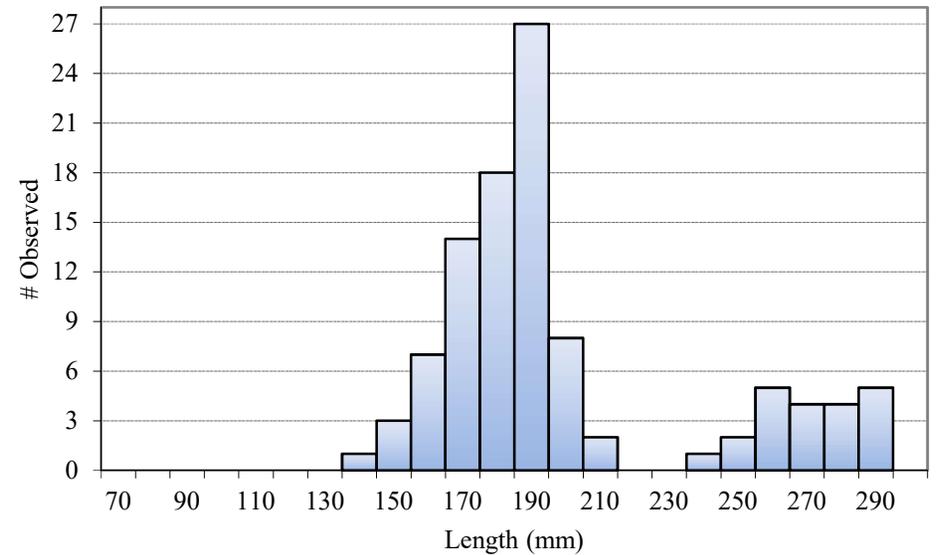


Figure 23. Length frequency distribution of walleye collected from Shagawa Lake, St. Louis County, during fall 2021 electrofishing assessments.

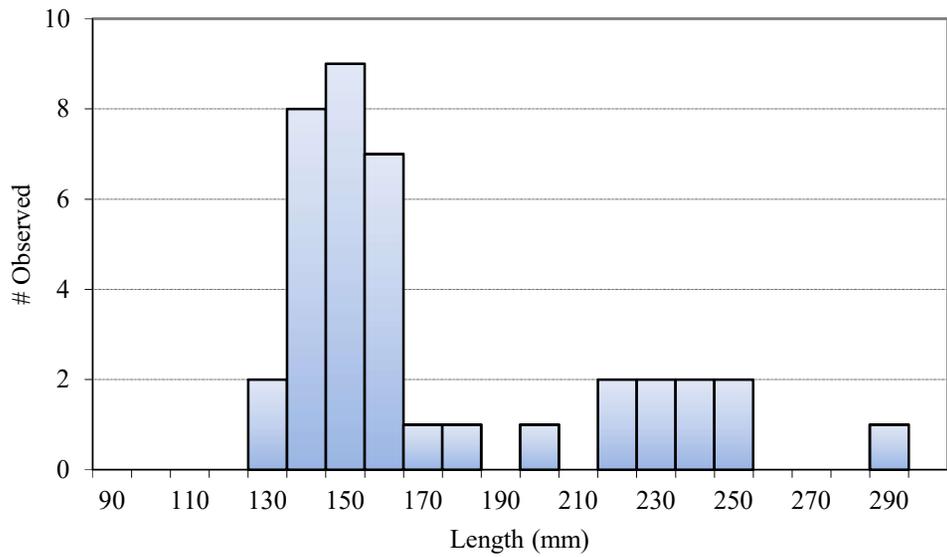


Figure 24. Length frequency distribution of walleye collected from Silver Island Lake, Lake County, during fall 2021 electrofishing assessments.

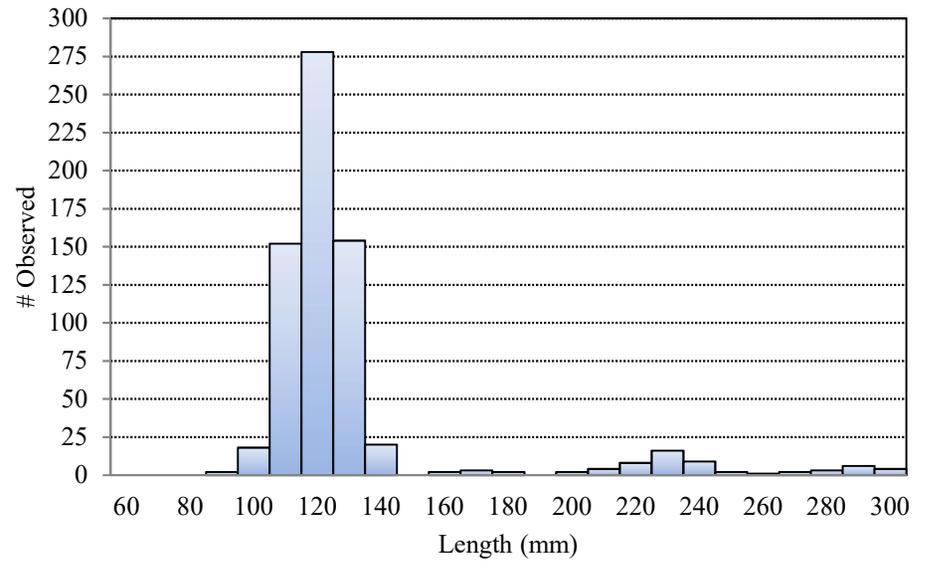


Figure 25. Length frequency distribution of walleye collected from Tait Lake, Cook County, during fall 2021 electrofishing assessments.

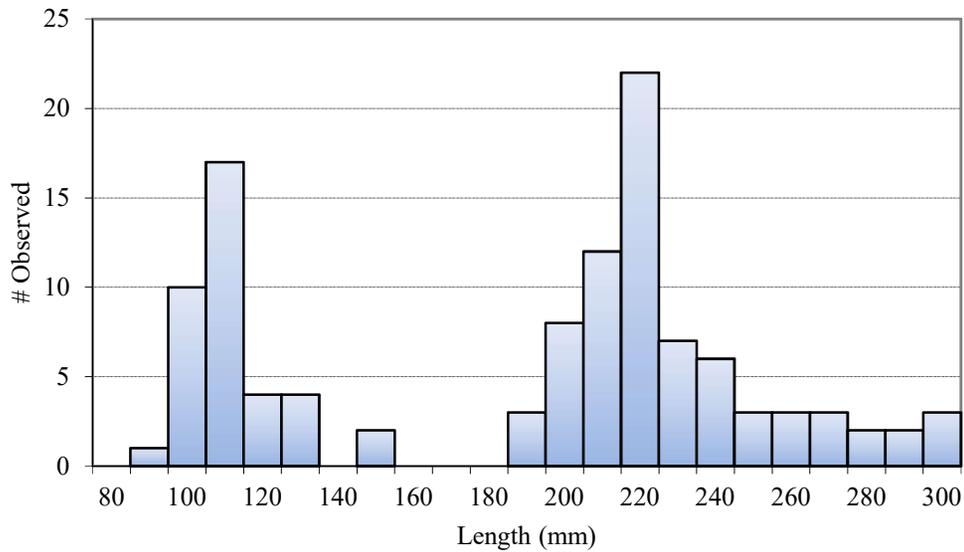


Figure 26. Length frequency distribution of walleye collected from Tom Lake, Cook County, during fall 2021 electrofishing assessments.

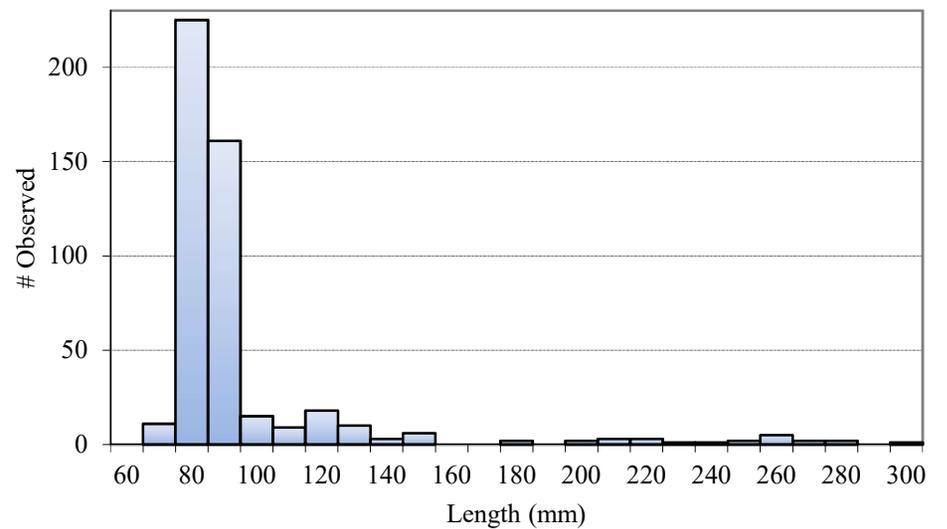


Figure 27. Length frequency distribution of walleye collected from Two Island Lake, Cook County, during fall 2021 electrofishing assessments.

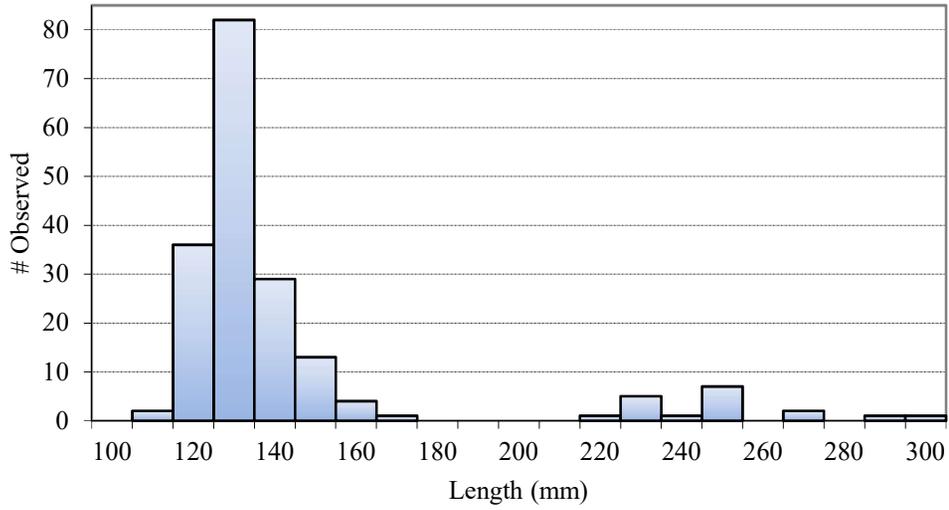


Figure 28. Length frequency distribution of walleye collected from West Twin Lake, Cook County, during fall 2021 electrofishing assessments.

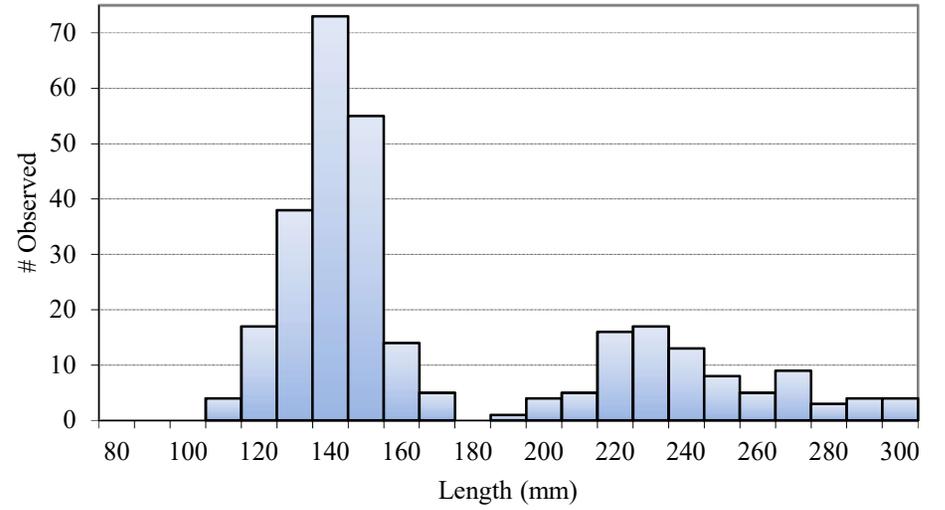


Figure 29. Length frequency distribution of walleye collected from Whiteface Reservoir, St. Louis County, during fall 2021 electrofishing assessments.

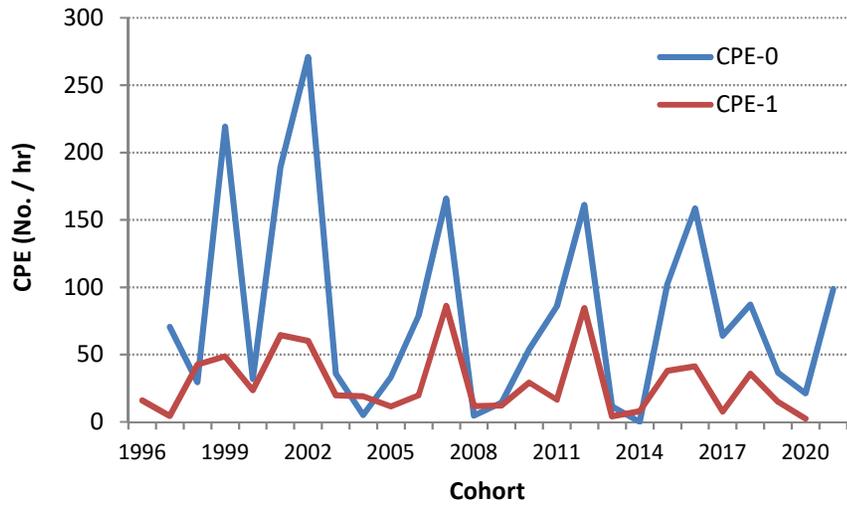


Figure 30. Walleye age-0 and age-1 electrofishing CPE, Ball Club Lake, Cook County, 1997-2021.

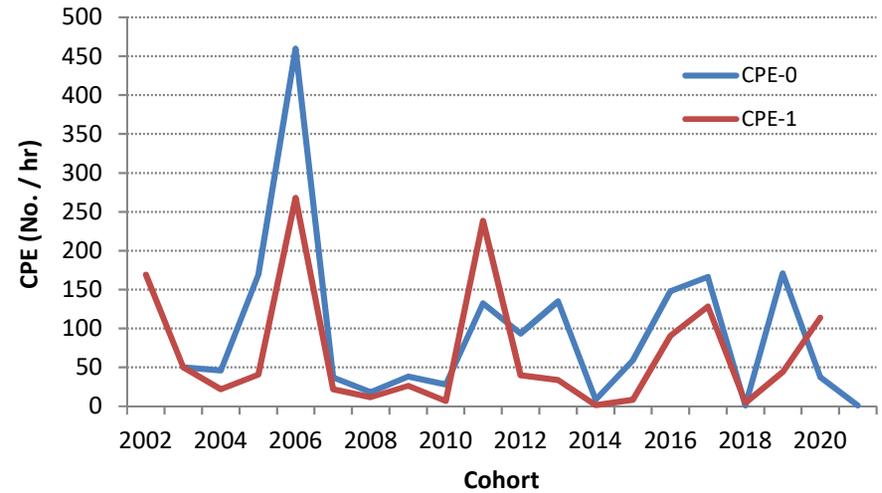


Figure 31. Walleye age-0 and age-1 electrofishing CPE, Cadotte Lake, St. Louis County, 2003-2021.

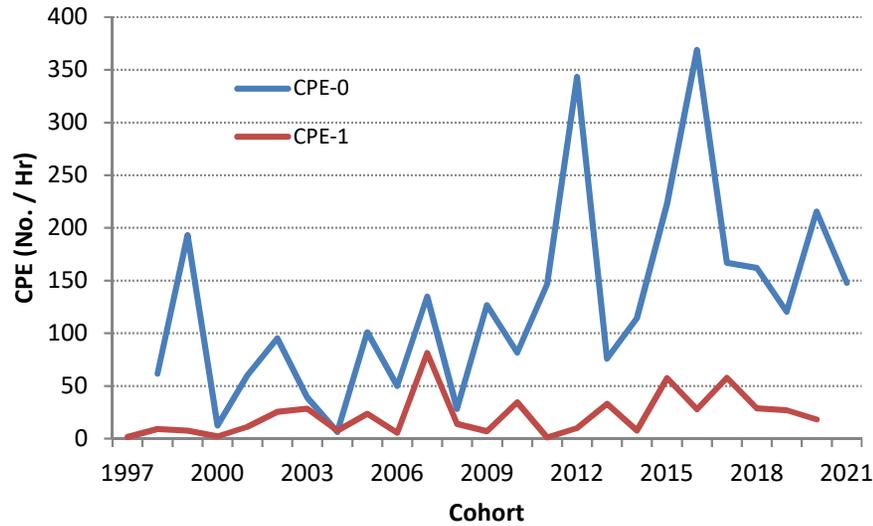


Figure 32. Walleye age-0 and age-1 electrofishing CPE, Caribou Lake, Cook County, 1998-2021.

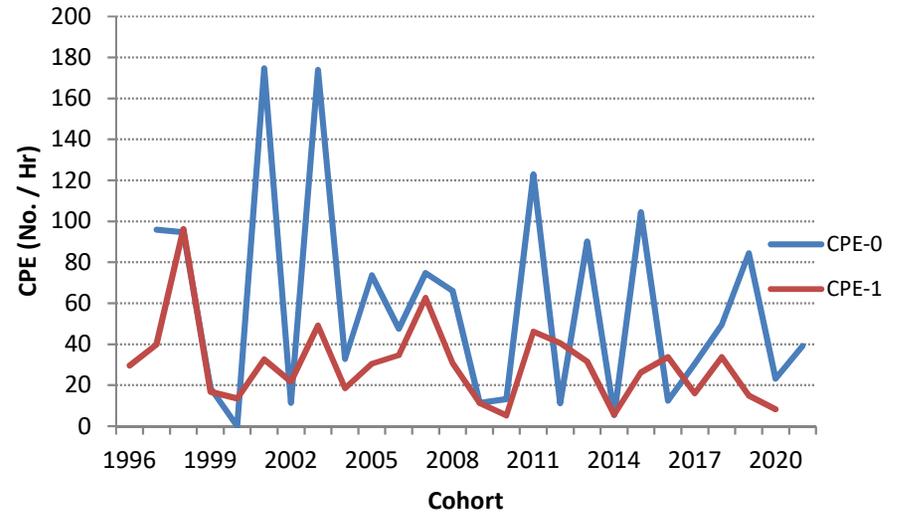


Figure 33. Walleye age-0 and age-1 electrofishing CPE, Cascade Lake, Cook County, 1997-2021.

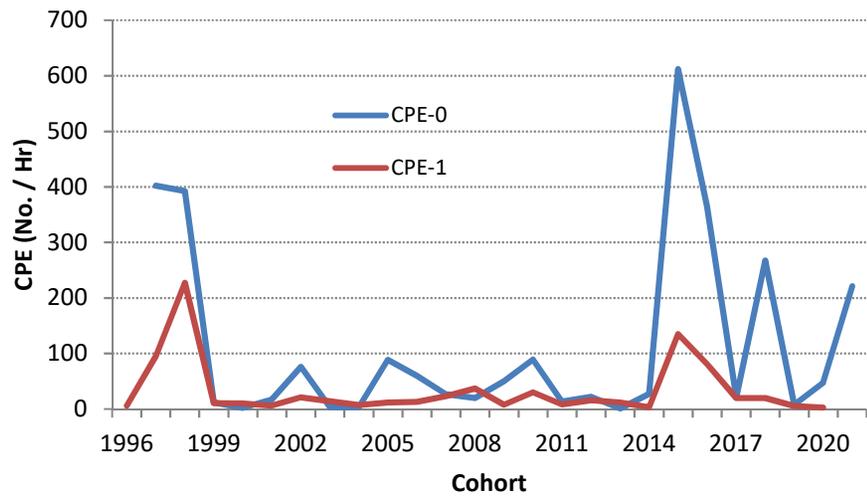


Figure 34. Walleye age-0 and age-1 electrofishing CPE, Crescent Lake, Cook County, 1997-2021.

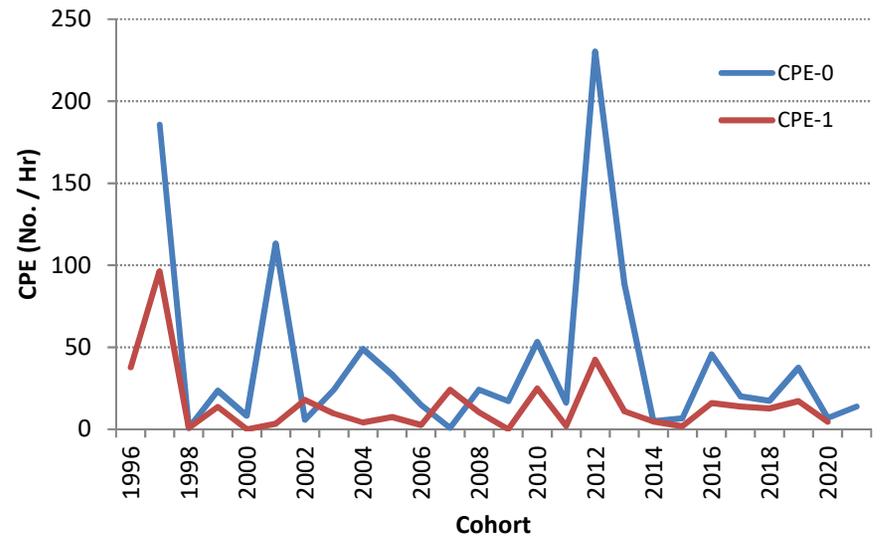


Figure 35. Walleye age-0 and age-1 electrofishing CPE, Crooked Lake, Lake County, 1997-2021.

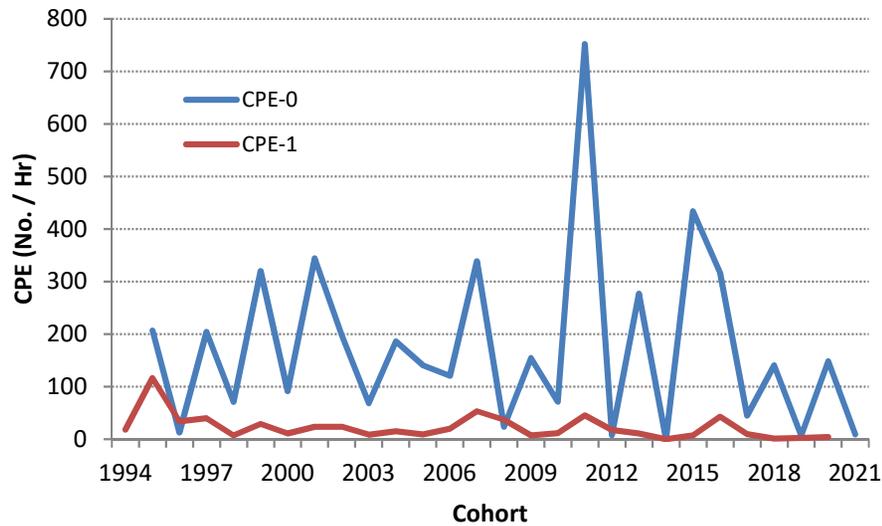


Figure 36. Walleye age-0 and age-1 electrofishing CPE, Dumbbell Lake, Lake County, 1995-2021.

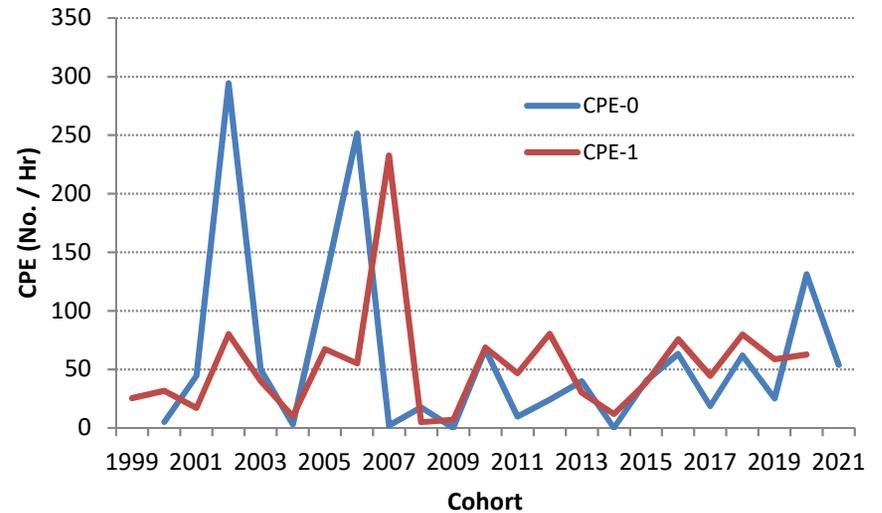


Figure 37. Walleye age-0 and age-1 electrofishing CPE, Elbow Lake, Cook County, 2000-2021.

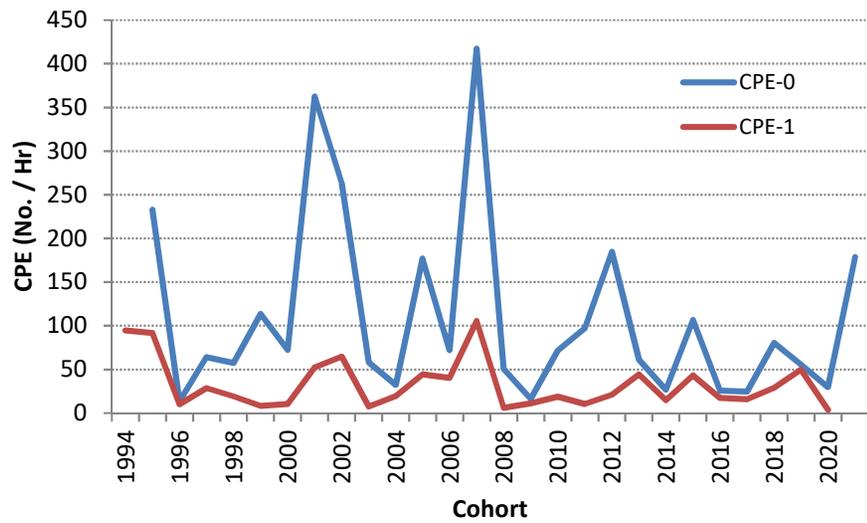


Figure 38. Walleye age-0 and age-1 electrofishing CPE, Four Mile Lake, Lake County, 1995-2021.

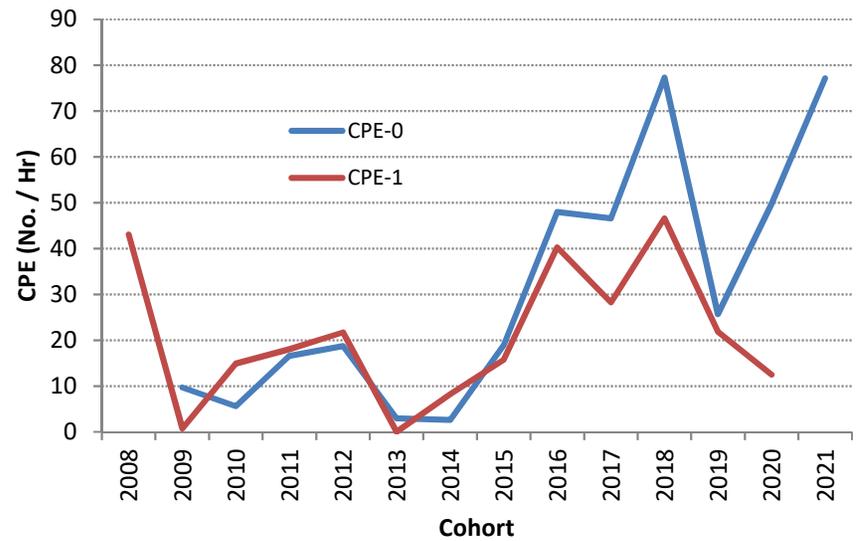


Figure 39. Walleye age-0 and age-1 electrofishing CPE, Harriet Lake, Lake County, 2009-2021.

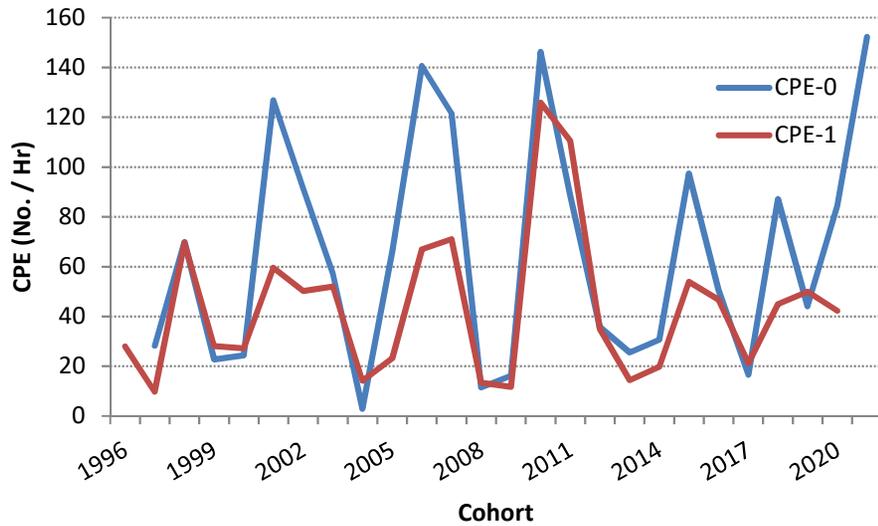


Figure 40. Walleye age-0 and age-1 electrofishing CPE, Island Lake, St. Louis County, 1997-2021.

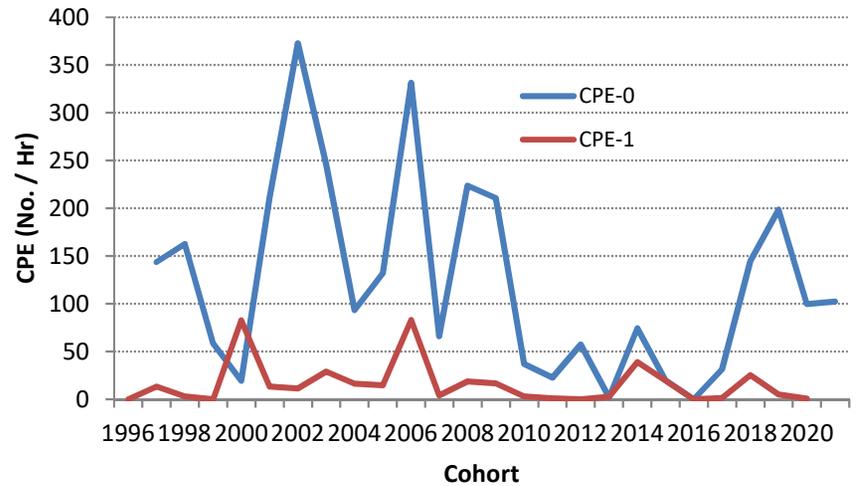


Figure 41. Walleye age-0 and age-1 electrofishing CPE, Ninemile Lake, Lake County, 1997-2021.

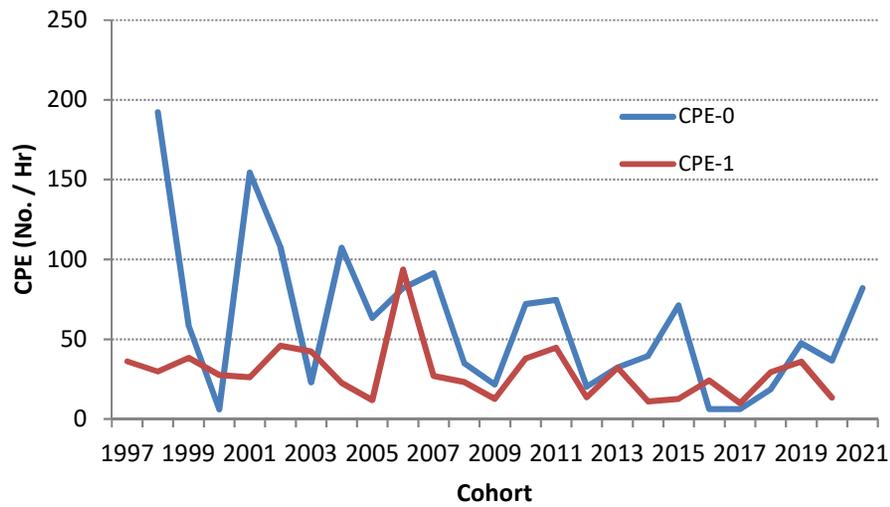


Figure 42. Walleye age-0 and age-1 electrofishing CPE, North McDougal Lake, Lake County, 1998-2021.

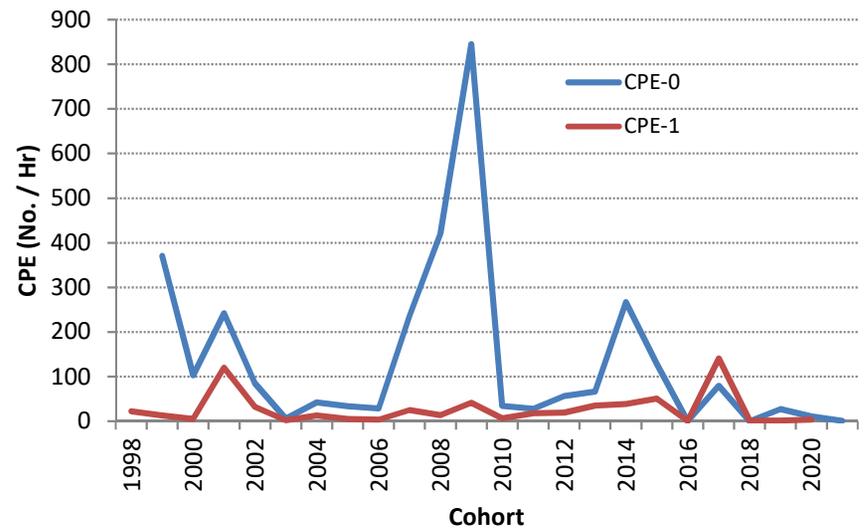


Figure 43. Walleye age-0 and age-1 electrofishing CPE, Pike Lake, Cook County, 1999-2021.

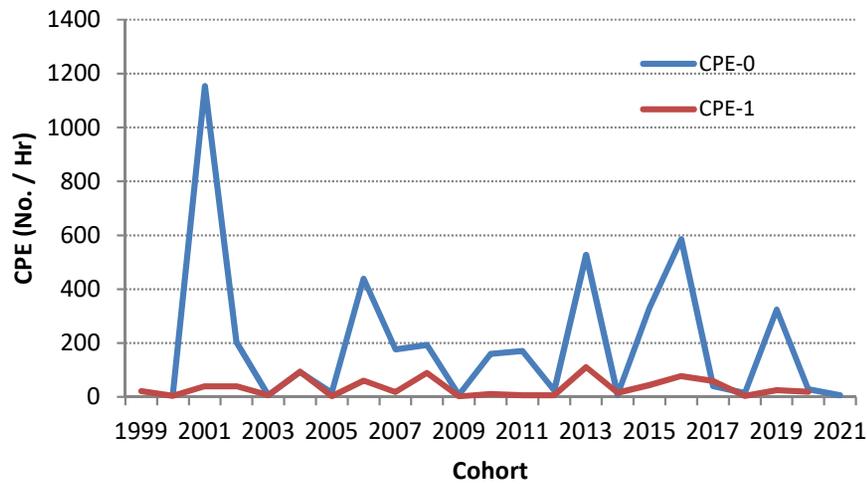


Figure 44. Walleye age-0 and age-1 electrofishing CPE, Shagawa Lake, St. Louis County, 2000-2021.

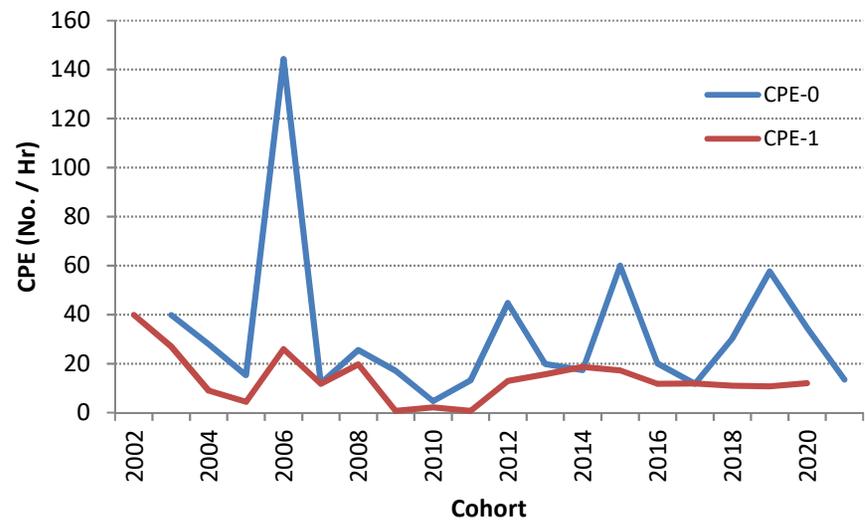


Figure 45. Walleye age-0 and age-1 electrofishing CPE, Silver Island Lake, Lake County, 2003-2021.

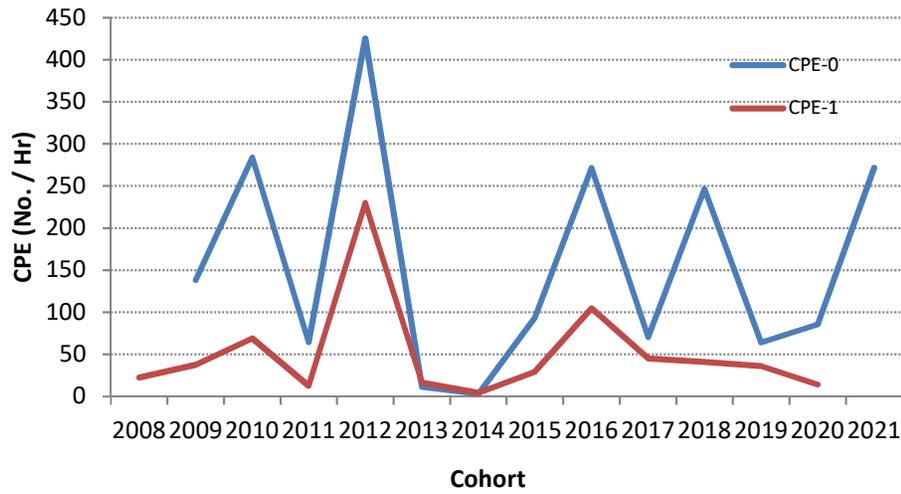


Figure 46. Walleye age-0 and age-1 electrofishing CPE, Tait Lake, Cook County, 2009-2021.

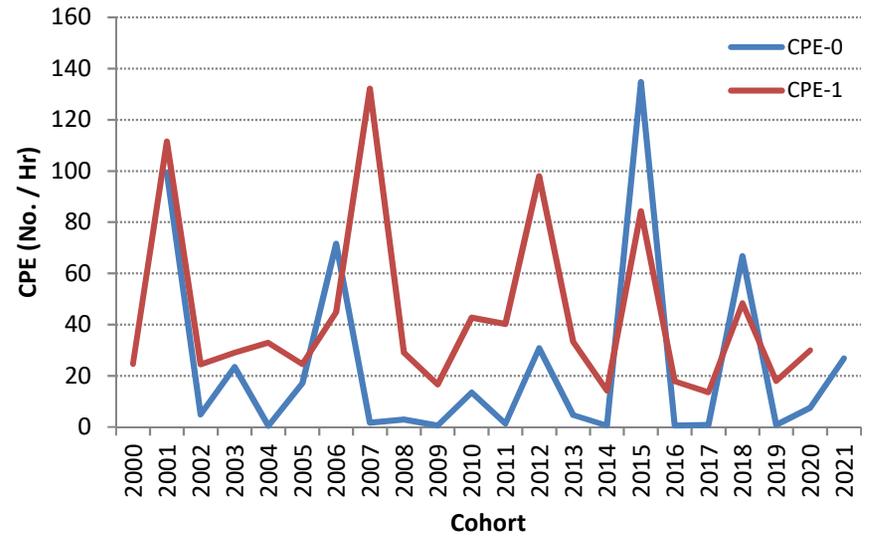


Figure 47. Walleye age-0 and age-1 electrofishing CPE, Tom Lake, Cook County, 2001-2021.

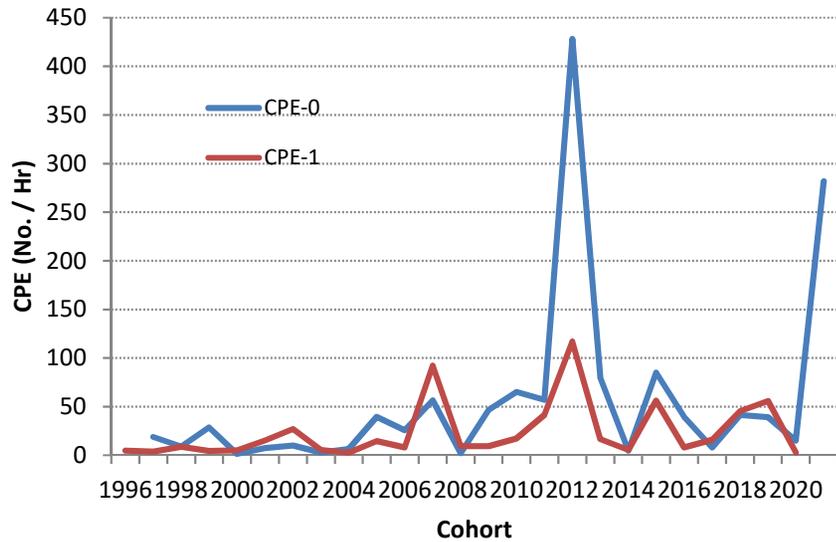


Figure 48. Walleye age-0 and age-1 electrofishing CPE, Two Island Lake, Cook County, 1997-2021.

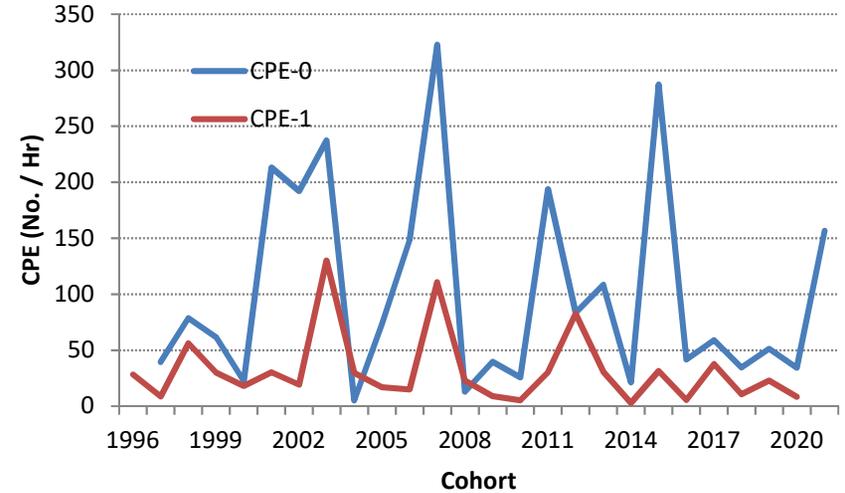


Figure 49. Walleye age-0 and age-1 electrofishing CPE, West Twin Lake, Cook County, 1997-2021.

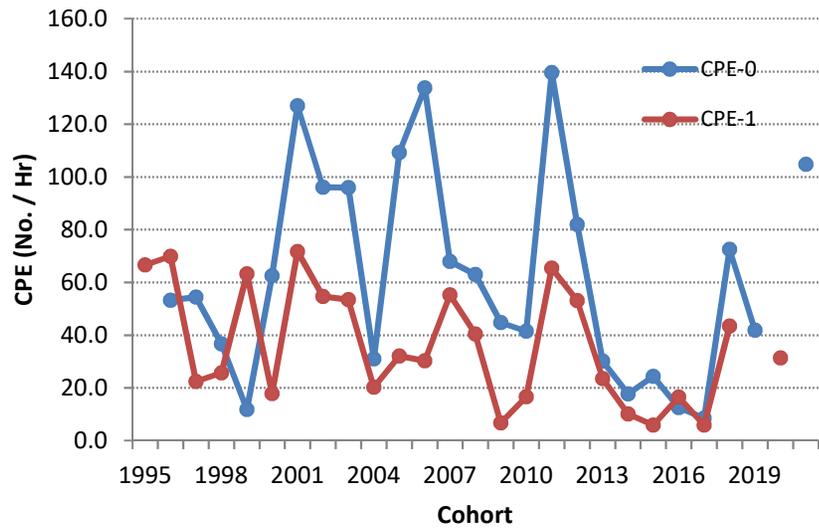


Figure 50. Walleye age-0 and age-1 electrofishing CPE, Whiteface Reservoir, St. Louis County, 1996-2019. Note that 2021 data is not presented here.

Acknowledgments

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Appendix 1. Nightly Mark / Recapture Data for walleye > 254 mm sampled during spring 2021 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
Four Mile	17 April	---	126	0
	18 April	126	141	12
	19 April	255	284	48
	20 April	491	136	106
	21 April	521	67	5
	MN DNR GN	583	83	12
Elbow	21 April	---	129	0
	22 April	119 ¹	126	28
	22 April	217	172	75
	MN DNR GN	302	58	16

¹ Ten walleyes were retained for mercury testing