Spring Adult and Fall Juvenile Walleye Population Surveys within the 1854 Ceded Territory of Minnesota, 2002

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

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Introduction

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

Along with the rights to utilize a resource comes the responsibility to manage and monitor the resource. Bands are taking an increased responsibility to monitor fish populations and to develop long term data bases 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 (Newman 1992; Stone 1992; Stone and Slade 1992; Goyke et al. 1993 and 1994; Ngu and Kmiecik 1993; and Borkholder 1994, 1995, and 1996).

The 1854 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 Authority and Fond du Lac identify priority natural resource projects for areas within the Ceded Territory. One goal is to assist with walleye assessments in the Ceded Territory.

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 the sampling of large areas, and has been used to sample walleye populations by other Native American agencies (Ngu and Kmiecik 1993; Goyke et al. 1993 and 1994; Borkholder 1994 and 1995). In order to rapidly sample fish populations, Fond du Lac and the 1854 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 in the recapture sample. Accurate estimates are obtained when a large portion of the population are 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 walleye remain in the shallows 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. Population estimates based upon electrofishing data alone, where females are not as vulnerable to the sampling gear, will be conservative estimates, lower than the true population size. The Great Lakes Indian Fish and Wildlife Commission and the U.S. Fish and Wildlife Service utilize trap nets to aid in the sampling of walleye females, thus improving the accuracy of their population estimates (Frank Stone, U.S.F.W.S., Ashland F.R.O., personal communication).

The first objective of our assessments in 2002 was to obtain adult walleye population estimates (PE) during the spring spawning period using mark - recapture data. Due to personnel and time constraints, trap netting was not used. Thus, our electrofishing PE estimates might be biased towards males in the populations. However, in cooperating with the area MN DNR offices, we obtain a second PE from the State's summer gill net assessments, with which to compare to the spring only electrofishing PE.

A second benefit of the spring electrofishing surveys is that it allows us to identify and determine key and critical spawning sites, i.e. where catch rates are the highest.

The second part of our 2002 walleye surveys targeted juvenile (age-1) and young-of-the-year (age-0) individuals in the fall. The purpose for assessing juvenile and fingerling individuals often is to evaluate recruitment and year-class strength, which was our objective for the fall assessments.

Methods

Spring Assessments

Six lakes within the 1854 Ceded Territory of Minnesota were originally selected for electrofishing surveys (Table 1), but due to spring conditions, our crews never were able to sample Boulder Lake (DOW# 69-0373) north of Duluth, Lax Lake (DOW# 38-0406) near Finland, or gain access to Toohey Lake (DOW# 16-0645). Bouder (DOW# 06-0383) and Crescent (DOW# 16-0454) Lakes are connected by a navigable channel, located in Cook County near Grand Marais, off of FR 165. Crooked Lake (DOW# 38-0024) is located northeast of Finland, in Lake County. The objective was to obtain adult walleye (*Stizostedion vitreum*) population estimates using mark-recapture methods and determine the age structure and growth rates of the respective walleye populations. Marked walleye would then be available during the summer gill net assessments conducted by the DNR, thus providing a second population estimate.

Electrofishing was performed at night using two boom shocking boats, both equipped with a Smith-Root Type VI-A electrofisher unit 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 the beginning of each evening. Ambient water conductivity measurements were taken using either a Hanna HI8733 conductivity meter (Ben Meadows Co., Atlanta, GA) or a Fisher Scientific Digital Conductivity Meter.

Electrofishing surveys were planned to begin soon after ice-out, and continue for as long as 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 revive. Walleye were measured to the nearest millimeter (mm), examined for previous marks, and the sex determined (male, female, unknown) based upon visual identification of gametes. Walleye that had been marked during any previous nights' collections were counted as recaptured fish. Unmarked individuals were marked by the removal of the second full dorsal fin spine. The dorsal fin spine from five individuals per centimeter group per sex was kept and placed in a labeled envelope for aging. 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). Previous walleye surveys have traditionally utilized the adjusted Peterson formula (Goyke et al. 1993 and 1994, and Ngu and Kmiecik 1993). 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 0.3 to 0.5 mm thin sections made 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, as per Duluth Area Fisheries (John Lindgren, personal communication).

Fall Assessments

Catch per unit effort (CPUE) for age-0 walleye was found to be the highest in the fall between 20.0°C and 10.0°C (Borkholder and Parsons, 2001). Due to the warm summer and fall of 2002, we postponed our start date by 7 days from previous years, beginning immediately after Labor Day. We did, however, run into a few instances where water temperatures were still observed to be greater than 20.0^{o}C.

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 revive. Walleye were measured to the nearest mm. Scales were taken for age analysis 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 Authority (Borkholder 1996, 1997, and 1998; Borkholder and Edwards 1999 and 2000). Sampling stations were repeated from previous years' surveys.

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

Results and Discussion

Spring Assessments

Bouder Lake

Electrofishing activities were conducted on Bouder Lake from 29 April to 3 May (Figure 1). Dates of electrofishing activities, mean water temperature, mean water conductivity, shocking time, the voltage and amps, the number of walleye collected, and the number caught per hour of electrofishing (CPUE) are presented in Table 1. CPUE for each night ranged from 1.3 to 8.7 adults per hour and 2.9 to 8.7 total walleye per hour of sampling (Table 1). At an 80% confidence interval, mean CPUE for Bouder Lake, determined using each sampling station, was 4.8 ± 1.5 adults per hour and 5.5 ± 1.6 total walleye per hour of sampling effort. The length frequency of the walleye sampled is presented in Figure 2. Additional species observed included yellow perch, white sucker, smallmouth bass, largemouth bass, and muskellunge. Interestingly, an individual marked in Crescent Lake during a previous year's survey, identified by the presence of a healed dorsal fin clip, was sampled in Bouder, suggesting that fish do migrate between the two lakes.

Few walleye were sampled in Bouder Lake. The first night of sampling effort identified the majority of the shoreline as being unsuitable spawning habitat, though a few locations contained decent substrate. Subsequent evenings of sampling along all of the available shoreline failed to locate large numbers or aggregations of walleyes.

Table 2 presents the population estimates based upon mark-recapture data. Since catch rates

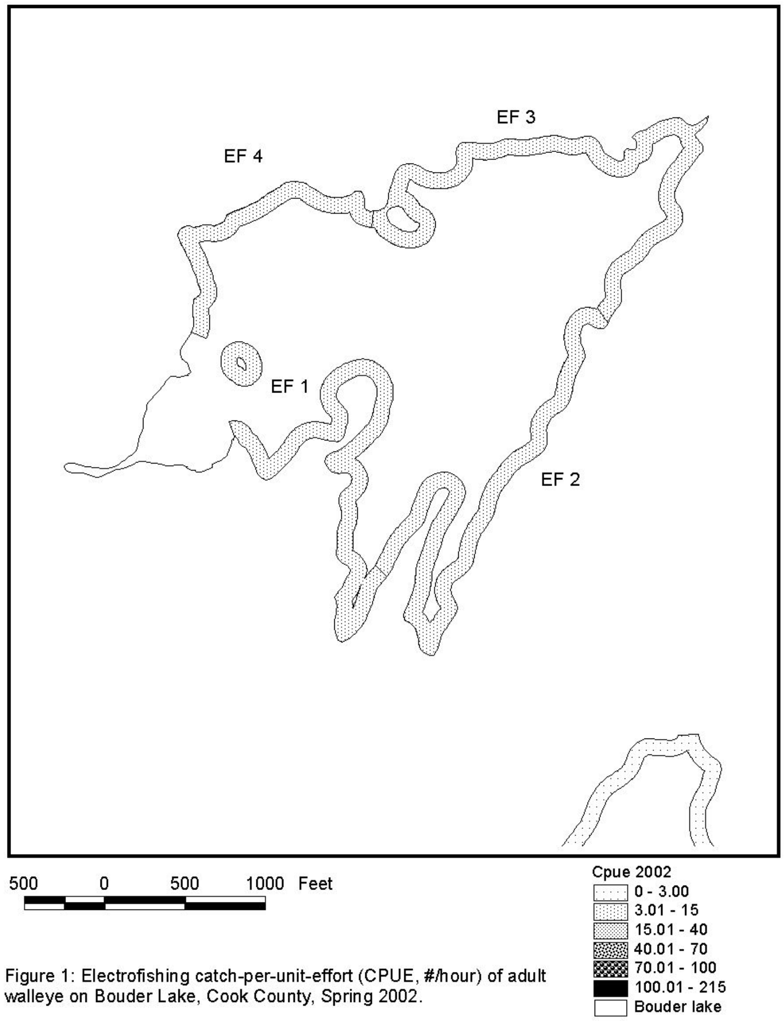

Figure 1: Electrofishing catch-per-unit-effort (CPUE, #/hour) of adult walleye on Bouder Lake, Cook County, Spring 2002.

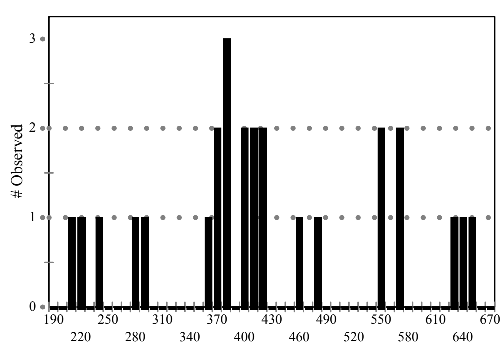

Figure 2. Length frequency distributiuon of walleye sampled from Bouder Lake, Cook County, MN, during Spring 2002 electrofishing assessments.

Table 1. Summary of night time electrofishing activities on three lakes surveyed within the 1854 Ceded Territory, Minnesota, during Spring 2002.

ID #	County	Lake	Area (Acres)	Max Depth	Date	Water Temp (F)	Conductivity*	Shocking Time (sec)	Voltage (PDC)	Pulse Width (ms)	Amps Drawn	# WAE**	CPUE WAE***
16-0383	Cook	Bouder	133.0	17.0	29-Apr-02	39	25.1	5978	1061	5	3	2 / 5	1.3 / 2.9
					30-Apr-02	41	25.5	6119	1061	5	3	9 / 10	5.7 / 6.5
					01-May-02	42	26.2	6361	1061	5	3	11 / 11	6.4 / 6.4
					03-May-02	44	27.7	1237	1061	5	3	3 / 3	8.7 / 8.7
											TOTALS	25 / 29	
16-0454	Cook	Crescent	744.0	28.0	29-Apr-02	37	25.1	3418	1061	5	3	15 / 16	15.8 / 16.8
					30-Apr-02	42	34.1	7050	1061	7	4	45 / 46	23.1 / 25.9
					01-May-02	42	28.0	11615	1061	6	4	144 / 146	41.8 / 42.4
					02-May-02	41	29.9	14978	1061	5	3.5	305 / 308	73.2 / 73.7
					03-May-02	42	30.0	15206	1061	5	4	329 / 337	79.4 / 81.0
											TOTALS	838 / 853	
38-0024	Lake	Crooked	283.0	18.0	04-May-02	43	No meter	6345	884	5	4	184 / 249	109.9 / 145.8
					05-May-02	43	No meter	5671	884	4	3.5	199 / 218	126.8 / 142.0
					06-May-02	43	No meter	5168	884	4	3.5	197 / 207	136.2 / 143.9
											TOTALS	580 / 674	

*Water conductivity measured in microSiemens / cm

**WAE = walleye. Numbers in column represent the number of "stock" sized walleye (>254mm (10 inches)) collected / the total number of walleye collected, including individuals < 10 inches.

***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)) / CPUE of all walleye sampled, including those < 10 inches.

Table 2. Walleye population estimates for Bouder and Crescent Lakes combined, and Crescent Lake alone, Cook County; and for Crooked Lake, Lake County, Spring 2002. Estimates are for walleye larger than 254 mm (10.0 inches). EF denotes population estimates determined from spring electrofishing data. GN refers to population estimates determined from gill net samples collected in the summer following marking with the electrofishing surveys. A separate population estimate was not obtained for Bouder Lake in 2002.

Lake	Population Estimate #1[1]	95% Confidence Limits Upper	Lower	Population Estimate #2[2]	C.V.[3]
Bouder & Crescent - EF	2026	2688	1625	1876 ± 466	9.0 %
Crescent - EF	1919	2484	1564	1789 ± 444	8.9 %
Bouder & Crescent - GN	3130	20238	1696	12000 ± 9957	32.3%
Crooked - EF	576	599	554	579 ± 159	6.4%
Crooked - GN	663	3763	363	1632 ± 1356	26.1%

[1] Schumacher and Eschmeyer population estimate.
[2] Adjusted Petersen population estimate.
[3] Coefficient of variation for the Petersen estimate.

were so low in Bouder Lake, we combined the data with Crescent Lake, due to the evidence that walleyes migrate between the two lakes. The Schumacker and Eschmeyer population estimate from electrofishing data for both lakes is 2026 (Table 2). The adjusted Petersen estimate is 1876 ± 466, with a 9.0% CV (Table 2).

Ages for the walleye collected from Bouder Lake were combined with Crescent Lake for the expanded age frequency distribution and reported back-calculated lengths (Table 3).

Crescent Lake

Electrofishing activities were conducted on Crescent Lake on 29 April to 3 May (Figure 3). Dates of electrofishing activities, mean water temperature, mean water conductivity, shocking time, the voltage and amps, the number of walleye collected, and the number caught per hour of electrofishing (CPUE) are presented in Table 1. CPUE for each night ranged from 15.8 to 79.4 adults per hour and 16.8 to 81.0 total walleye per hour of sampling (Table 1). At an 80% confidence interval, mean CPUE for Crescent Lake, determined using each sampling station, was 58.3 ± 9.2 adults per

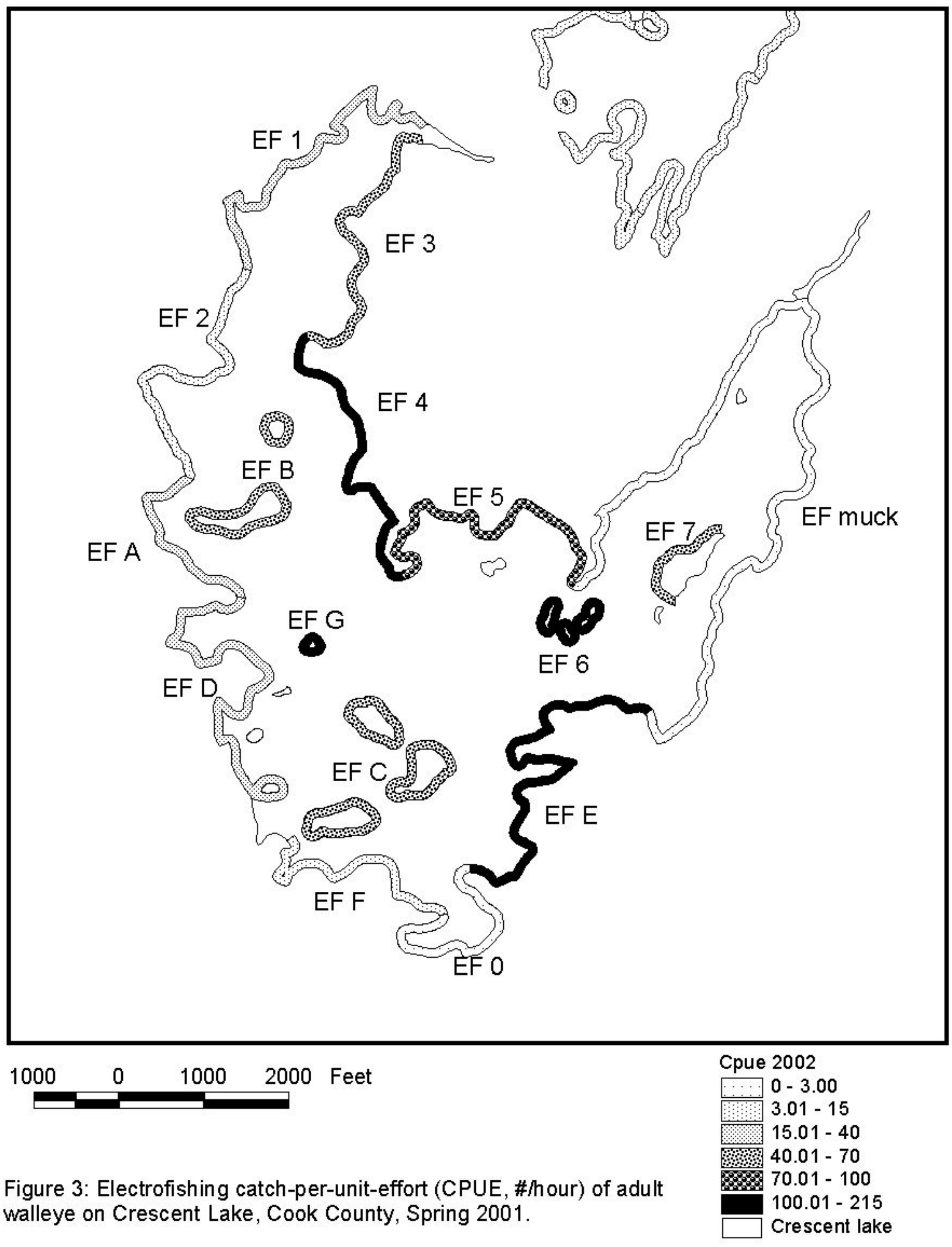

Figure 3: Electrofishing catch-per-unit-effort (CPUE, #/hour) of adult walleye on Crescent Lake, Cook County, Spring 2001.

hour and 59.1 ± 9.3 total walleye per hour of sampling effort. The length frequency of the walleye sampled is presented in Figure 4. Additional species observed included yellow perch, white sucker, smallmouth bass, and muskellunge. Fifteen individual muskellunge were collected, with lengths ranging from 352 mm to 962 mm.

Catch rates among the sampling stations varied. Catch rates were highest along stations EF-4, EF-6, EF-E, EF-G, EF-5, and EF-C, and were lowest along stations EF-1, EF-2, EF-F, EF-0, and EF-Muck (Figure 3).

Table 2 presents the three population estimates based upon mark-recapture data. The electrofishing Schumacker and Eschmeyer population estimate is 1919, with upper and lower 95% confidence limits of 2484 and 1564, respectively (Table 2). The electrofishing adjusted Petersen estimate is 1789 ± 444, with an 8.9% CV (Table 2). Our sampling covered most of the habitat available for use by spawning walleyes. Previous surveys indicated that the entire eastern bay (Figure 3, EF-Muck), contained unsuitable walleye spawning habitat, and was thus not included in this survey.

In July 2002, the Minnesota Department of Natural Resources performed a standardized net assessment on Crescent and Bouder Lakes (Paul Eiler, MN DNR, Grand Marais Area Fisheries). Of 127 walleye sampled larger than 254mm, 7 were observed to have the mark from the spring sampling. The adjusted Petersen estimate from the summer data is 12,000 ± 9957, with a 32.3% CV (Table 2). Not much weight should be placed on this estimate because of the large confidence interval, due to the relatively low sample size and few recaptured individuals.

In 1999 we performed similar spring electrofishing assessments on Crescent Lake (Borkholder and Edwards 2000). The Schumacker and Eschmeyer population estimate we calculated in 1999 was 668, with upper and lower 95% confidence limits of 1020 and 496, respectively, and a Petersen population estimate of 707 (Borkholder and Edwards 2000). Comparing our 1999 estimates with those from this year's assessments, it appears that the abundance of adult walleye has increased significantly since 1999.

Table 3 presents the age data for the walleye collected from Crescent Lake. Of the 722 fish sampled, 447 were assigned to age 4. Table 4 presents back-calculated lengths at each age class for walleye collected from Crescent Lake. Care needs to be taken when interpreting the growth rates for the oldest ages (ages 13 and 14), as they were calculated from a single, large female.

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

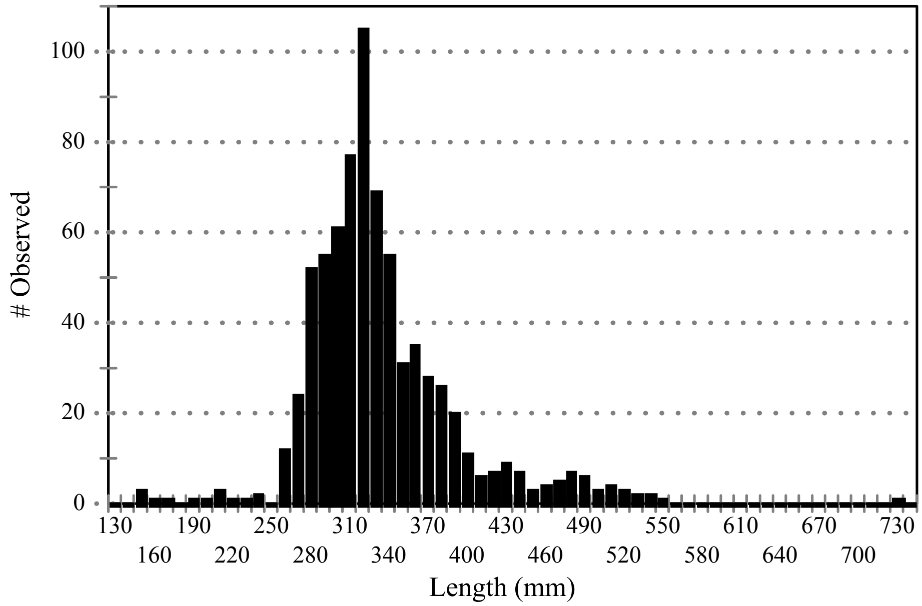

Figure 4. Length frequency distribution of walleye sampled from Crescent Lake, Cook County, MN, during Spring 2002 electrofishing assessments.

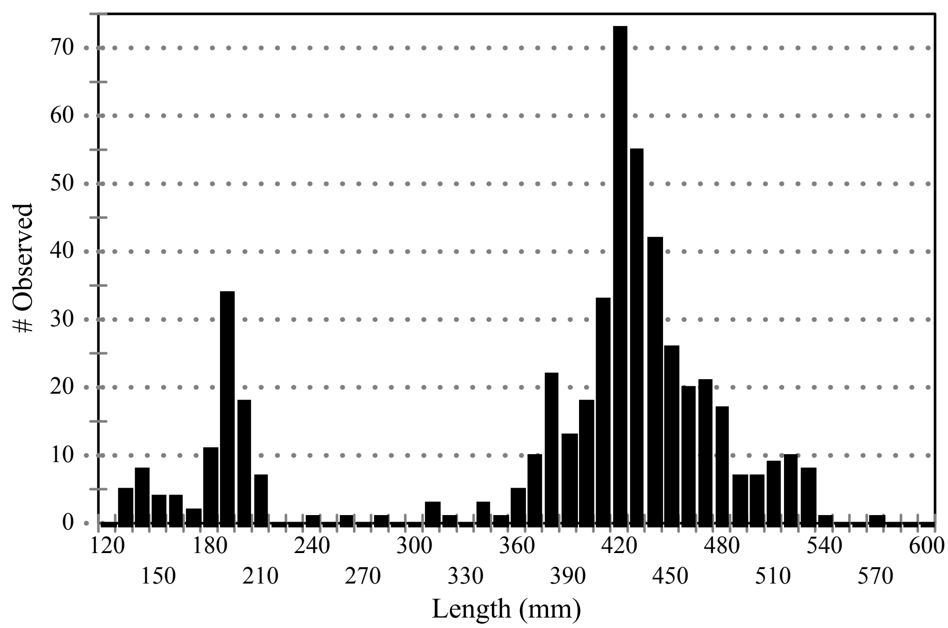

Figure 6. Length frequency distribution of walleye sampled from Crooked Lake, Lake County, MN, during Spring 2002 electrofishing assessments.

Table 3. Age frequency distribution of walleye from Crescent and Bouder Lakes, Cook County, spring 2002, based upon the number of fish sampled and aged per size category.

Length Group																	
Inches	mm	N Sampled	Ages	1	2	3	4	5	6	7	8	9	10	11	12	13	14
5.0	127	0															
5.5	140	3															
6.0	152	2															
6.5	165	0															
7.0	178	3															
7.5	191	1															
8.0	203	5	1-2		5												
8.5	216	1															
9.0	229	2	1-2		2												
9.5	241	4															
10.0	254	20	6-3, 2-4			15	5										
10.5	267	61	10-3, 4-4			44	17										
11.0	279	66	5-3, 5-4			33	33										
11.5	292	82	5-3, 7-4			34	48										
12.0	305	125	16-4				125										
12.5	318	96	8-4, 2-5				77	19									
13.0	330	67	2-3, 16-4, 2-5			6	54	7									
13.5	343	50	15-4, 9-5				31	19									
14.0	356	34	7-4, 3-5				24	10									
14.5	368	38	10-4, 8-5				21	17									
15.0	381	25	4-4, 9-5				8	17									
15.5	394	13	3-4, 6-5, 2-6				4	7	2								
16.0	406	7	3-5, 2-6					4	3								
16.5	419	13	11-5, 2-6					11	2								
17.0	432	9	2-5, 1-6, 4-7					3	1	5							
17.5	445	4	1-5, 2-6					1	2								
18.0	457	7	1-6, 4-7, 1-8						1	5	1						
18.5	470	8	2-7, 4-8, 2-10							2	4		2				
19.0	483	6	1-7, 2-8, 2-9							1	2	2					
19.5	495	5	1-7, 3-8, 1-9							1	3	1					
20.0	508	6	2-7, 2-8, 2-11							2	2			2			
20.5	521	2	1-7, 1-12							1					1		
21.0	533	4	4-7							4							
21.5	546	1	1-7, 1-12							1					1		
22.0	559	0															
22.5	572	0															
23.0	584	1	1-9									1					
23.5	597	2	1-8								1						
24.0	610	1	1-10										1				
24.5	622	0															
25.0	635	0															
28.5	724	1	1-14													1	
29.0	737	0															
TOTAL		775		0	7	132	447	115	11	22	13	4	3	2	2	1	0

Table 4. Back-calculated lengths at each age class for walleye collected from Crescent Lake, Cook County, Minnesota, Spring 2002.

Age Class	N	Length (mm)	Length (in)
1	235	121	4.8
2	235	208	8.2
3	233	276	10.9
4	204	337	13.3
5	110	391	15.4
6	54	435	17.1
7	44	470	18.5
8	25	485	19.1
9	12	497	19.6
10	8	513	20.2
11	5	532	20.9
12	3	567	22.3
13	1	681	26.8
14	1	724	28.5

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 are presented in Table 5. The electrofishing PSD of 13.9 ± 2.5 (Table 5) suggests the population is not balanced (Anderson and Weithman 1978), but is characterized by small individuals. Samples collected by electrofishing during spring 1999 and again in 2002 (PSD_{1999} = 47.3 ± 4.9, PSD_{2002} = 13.9 ± 2.5) showed that significant differences were observed in PSD values between the two years (χ^2 = 150.4, P<0.05, critical Chi-square value of 3.841) (Table 5). The PSD value from 1999 suggests that there is a high proportion of "quality" length walleye (381mm; 15.0 inches) relative to all walleye > 254 mm (10.0 inches). Significant differences in all RSD values were observed between the 1999 and 2002 samples.

Comparing the two gear types in 2002, i.e. gill nets and electrofishing, no significant differences in the proportion of "quality" length fish were observed (Table 5). The 2002 spring electrofishing survey ($PSD_{EF\ 2002}$ = 13.9) sampled walleye larger than 381 mm (15.0 inches) in the same proportion as the 2002 summer gill net assessments ($PSD_{GN\ 2002}$ = 4.9) (χ^2=2.58, P>0.05, critical

Chi-square value of 3.841). While the argument can be made that spring electrofishing targets only the larger individuals in the population, we did sample 627 stock-sized walleye (10.0 - 14.9 inches) in 2002, compared with 116 observed in the gill net assessments. There were no significant differences observed in any of the relative stock density (RSD) indices during 2002 assessments (Table 5), suggesting no differences in the proportion of "preferred" (> 508mm, 20 inches) and "memorable" (> 635mm, 25 inches) length fish between the two gear types.

It appears that the walleye population in Crescent Lake has changed dramatically over the last three years. Comparing our electrofishing PSD values, significant differences are observed not only between the PSD values, but between RSD Q-P, RSD P-M, and RSD M-T values (Table 5). The difference between RSD Q-$P_{Electro\ 2002}$ = 12.5 and RSD Q-$P_{Electro\ 1999}$ = 41.8 was significant (χ^2=150.42, P<0.05, critical Chi-square value of 3.841), and suggests that either mortality on walleye larger than 15 inches is too high, or that there are recruitment problems. We have no data on year classes that would be contributing to the >15 inch group. However, two very strong year classes were observed in 1997 and 1998 in our fall electrofishing surveys. These age-4 and age-5 fish are contributing to the exceptionally high numbers of stock sized fish (Table 3). If these fish continue to be observed in the fishery in later years, it would suggest that angling mortality is not limiting this population. It might be worth conducting another spring electrofishing and summer gill net survey within the next 3 years to monitor the 1997 and 1998 year classes.

Table 5. Proportional Stock Density (PSD) and Relative Stock Densities (RSD) with 95% confidence intervals for walleye sampled from Crescent, Crescent and Bouder Lakes combined (listed as B&C), Cook County; and Crooked Lake, Lake County, Minnesota. Values are for spring electrofishing (EF) in 2002 and MN DNR gill netting (GN) during summer 2002, except for the 1999 electrofishing (EF) sample from Crescent Lake and the 1997 electrofishing sample from Crooked Lake.

Lake	PSD	RSD S-Q	RSD Q-P	RSD P-M	RSD M-T
Crescent - EF_{2002}	13.9 ± 2.5	86.1 ± 2.5	12.5 ± 2.4	1.2 ± 0.8	0.1 ± 0.3
Crescent - EF_{1999}	47.3 ± 4.9	52.7 ± 4.9	41.8 ± 4.9	4.8 ± 2.1	0.8 ± 0.9
Crescent - GN_{2002}	4.9 ± 4.2	95.2 ± 4.2	3.9 ± 3.7	1.0 ± 1.9	0.0 ± 0.0
B&C - EF_{2002}	14.9 ± 2.6	85.1 ± 2.6	12.7 ± 2.4	2.1 ± 1.0	0.1 ± 0.3
B&C - GN_{2002}	8.7 ± 4.9	91.3 ± 4.9	6.3 ± 4.2	2.4 ± 2.6	0.0 ± 0.0
Crooked - EF_{2002}	88.5 ± 3.1	11.5 ± 3.1	83.3 ± 3.62	5.2 ± 2.1	0.0 ± 0.0
Crooked - EF_{1997}	67.6 ± 4.4	32.4 ± 4.4	66.2 ± 4.5	1.2 ± 1.0	0.2 ± 0.4
Crooked - GN_{2002}	55.1 ± 13.9	44.9 ± 13.9	44.9 ± 13.9	10.2 ± 8.5	0.0 ± 0.0

Crooked Lake

Electrofishing activities were conducted on Crooked Lake on 4, 5, and 6 May (Figure 5). Table 1 presents mean water temperature, conductivity, number of walleye sampled, and CPUE for walleye. CPUE for each night ranged from 109.9 to 136.2 adults per hour and 142.0 to 145.8 total walleye per hour of sampling (Table 1). At an 80% confidence interval, mean CPUE for Crooked Lake, determined using catch data from each sampling station, was 124.3 ± 20.1 adults per hour and 143.9 ± 17.3 total walleye per hour of sampling effort. Length frequency data of walleye collected is presented in Figure 6. Catch rates for walleye of all sizes were high among the stations sampled (Figure 5). We did not survey most of the available area in the two bays to the northwest and south, due to a general lack of suitable habitat.

Table 6 presents the age frequency distribution. Back-calculated length-at-age estimates are presented in Table 7.

Table 2 presents the three population estimates based upon mark-recapture data. The electrofishing Schumacker and Eschmeyer population estimate is 576, with upper and lower 95% confidence limits of 599 and 554, respectively (Table 2). The electrofishing adjusted Petersen estimate is 579 ± 159, with a 6.4% CV (Table 2).

In August 2002, the Minnesota Department of Natural Resources performed a standardized net assessment on Crooked Lake (Ron Van Bergen, MN DNR, Finland Area Fisheries). Of the 49 walleye sampled, 9 were observed to have the mark from the spring sampling. The adjusted Petersen estimate from the summer data is 1632 ± 1356, with a 26.1% CV (Table 2). The Schumacker and Eschmeyer population estimate was 663, with upper and lower 95% confidence limits of 3763 and 363, respectively (Table 2). The confidence limits are both high due to the relatively small number of recaptured individuals observed.

In 1997, we performed similar spring electrofishing assessments on Crooked Lake (Borkholder 1998). The Schumacker and Eschmeyer population estimate we calculated in 1998 was 783, with upper and lower 95% confidence limits of 1547 and 228, respectively, and the Petersen estimate of 1511 (CV 21.2%) (Borkholder 1998). Comparing our 1997 estimates with those from this year's assessments, it appears that the abundance of spawning adult walleye may have declined since 1997. Our fall age-0 and age-1 walleye survey results suggest that recruitment has been inconsistent, with relatively few strong year classes observed over the last 5 years.

PSD and RSD values determined by our spring electrofishing sampling are presented in Table 5. Samples collected by electrofishing during spring 1997 and again in 2002 ($PSD_{1997} = 67.6 \pm 4.4$, $PSD_{2002} = 88.5 \pm 3.1$) showed significant differences in PSD values between the two years

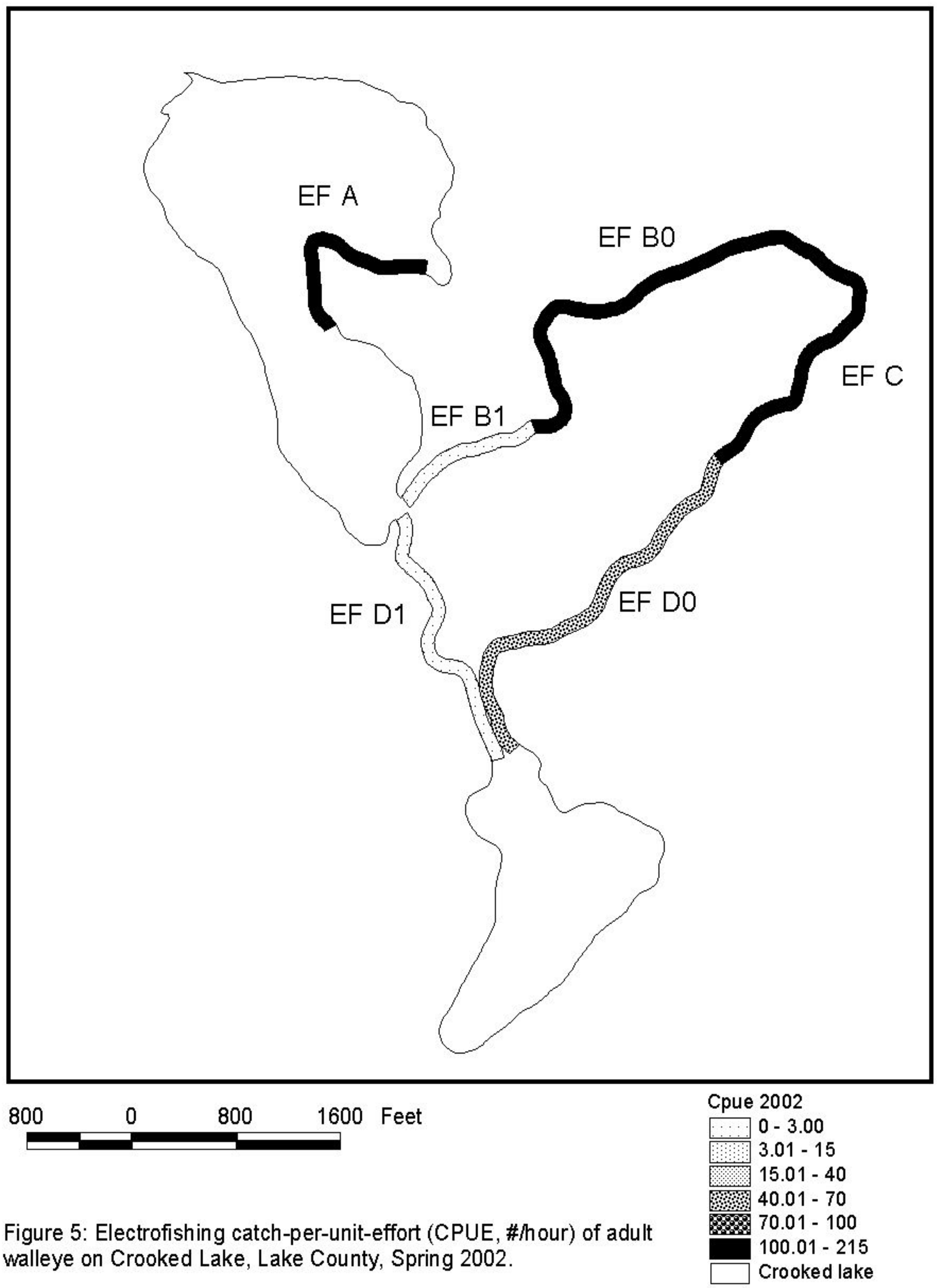

Figure 5: Electrofishing catch-per-unit-effort (CPUE, #/hour) of adult walleye on Crooked Lake, Lake County, Spring 2002.

Table 6. Age frequency distribution of walleye from Crooked Lake, Lake County, spring 2002, based upon the Number of fish sampled and aged per size category.

Length Group Inches	mm	N Sampled	Ages	1	2	3	4	5	6	7	8	9	10	11
4.5	114	2	2-1	2										
5	127	11	3-1	11										
5.5	140	4	2-1	4										
6	152	4	2-1	4										
6.5	165	9	3-1	9										
7	178	38	1-1, 1-2	19	19									
7.5	191	19	1-1, 3-2	5	14									
8	203	6	3-2		6									
8.5	216	0												
9	229	1	1-2		1									
9.5	241	0												
10	254	1	1-2		1									
10.5	267	0												
11	279	1	1-2		1									
11.5	292	2	2-3			2								
12	305	2	2-3			2								
12.5	318	0												
13	330	3	3-3			3								
13.5	343	3	3-3			3								
14	356	12	6-3			12								
14.5	368	23	4-3, 3-4			13	10							
15	381	17	4-4, 1-5				14	3						
15.5	394	33	2-4, 1-5				22	11						
16	406	77	1-4, 7-5				10	67						
16.5	419	73	11-5, 1-7					67		6				
17	432	48	4-5, 1-7					38		10				
17.5	445	24	5-5, 3-6, 1-7					13	8	3				
18	457	28	2-5, 3-6, 3-7, 1-8					6	9	9	4			
18.5	470	22	3-5, 2-6, 1-7, 2-8, 1-10, 1-11					7	4	2	4		2	2
19	483	7	1-7, 2-8, 2-9, 1-10							1	2	2	1	
19.5	495	11	2-6, 3-7, 1-8, 1-10						3	5	2		2	
20	508	12	3-8, 2-9, 1-10, 3-11								4	3	1	4
20.5	521	8	1-7, 1-9, 2-10, 1-11							2		2	3	2
21	533	1	1-10										1	
21.5	546	0												
22	559	1	1-10											
22.5	572	0											1	
23.0	584	0												
23.5	597	0												
TOTAL		503		54	42	35	56	212	24	38	16	7	11	8

Table 7. Back-calculated lengths at each age class for walleye collected from Crooked Lake, Lake County, Minnesota, Spring 2002.

Age Class	N	Length (mm)	Length (in)
1	135	126	5.0
2	122	219	8.6
3	112	305	12.0
4	92	362	14.3
5	82	415	16.3
6	49	442	17.4
7	39	462	18.2
8	27	480	18.9
9	18	494	19.4
10	13	507	20.0
11	5	508	20.0

(χ^2 = 52.899, P<0.05, critical Chi-square value of 3.841) (Table 5). The PSD value from 2002 suggest that the proportion of "stock" length walleye (between 10.0 and 14.9 inches) relative to all walleye > 254 mm (10.0 inches) is low, suggesting recruitment problems and resulting in an population characterized by larger, "quality"-sized individuals. No significant differences in any RSD values were observed between the 1997 and 2002 samples.

Comparing the two gear types in 2002, significant differences in the proportion of "quality" length fish were observed between the electrofishing collection and the gill net surveys (Table 5). No differences in any of the RSD metrics were noted between the two gear types. Between the two gear types in 2002, only 26 individuals were sampled larger than 508 mm (20.0 inches). In 1997, we observed 6 individuals larger than 508 mm. In both years, all of the available walleye spawning habitat was sampled, and large numbers of spawning walleye were collected during both assessments. This may reflect a situation where either mortality (angling harvest) is cropping out the largest individuals from the population, or food resources are limited. Many small yellow perch and shiners were observed, suggesting that food resources may not be limiting growth of walleye. Growth rates at the earliest ages do not appear to be too slow, thus suggesting that angling mortality might be limiting this population. Future studies may be planned to address this situation, e.g. a tagging study.

Fall Assessments

Table 8 shows a summary of each evening of electrofishing assessments. CPUE for age-0 walleye ranged from 2.4 fish per hour (Poplar Lake) to 372.9 fish per hour of electrofishing (Ninemile Lake) (Table 8). CPUE for age-1 walleye ranged from 5.4 fish per hour (Crescent Lake) to 297.4 fish per hour of electrofishing (Devilfish Lake) (Table 8). Figures 7 - 29 present length frequency data for each of the twenty-five lakes surveyed. Table 9 presents the mean length for age-0 and age-1 individuals sampled during fall 2002 assessments. Mean lengths for age-0 walleye ranged from 97 mm (3.8 inches, Homer and Devilfish Lakes) to 147 mm (5.8 inches, Eagle Lake).

Since initiating a regular fall electrofishing program for age-0 and age-1 walleye in 1995, and excluding lakes in years of stocking by the MN DNR and results from this year's assessments, our mean $CPUE_{Age\text{-}0}$ = 64.3 and our mean $CPUE_{1+}$ = 31.2. Using the mean $CPUE_{Age\text{-}0}$ as one criteria, average or better 2002 year classes were observed in 15 of the lakes (Table 8). Average or better 2001 year classes (age-1 walleye) were observed in 10 lakes (Table 8). As data is collected in future MN DNR standard gill net surveys, we should gain further insight as to whether these presumed strong year classes are in fact well represented as adults.

Several studies have suggested that age-0 walleye need to reach a certain critical size to have a chance at surviving their first winter (Forney 1976; Madenjian et al. 1991). Both Forney (1976) and Madenjian et al. (1991) attributed overwinter size-selected mortality of age-0 walleye to cannibalism. Forney (1976) suggested that this critical size is 175 mm (6.9 inches) in Oneida Lake, New York. If the bulk of the age-0 cohort exceeded this total length by the end of the growing season, the duration of their exposure to cannibalism would be reduced, and recruitment would be relatively high (Forney 1976). If first year growth was slower, age-0 walleye would be exposed to cannibalism by older walleye for longer periods of time. In Mille Lacs Lake, MN, year classes with mean lengths greater than 140 mm (5.5 inches) have typically led to strong year classes (R. Bruesewitz, personal communication). The 1988 year class was 160 mm (6.3 inches) going into the first winter, and has been an exceptional year class, while the 1985 year class, 93 mm (3.7 inches) at the end of the fall, was essentially non-existent in subsequent years (R. Bruesewitz, personal communication).

The average mean length of age-0 walleye observed since 1995 in our electrofishing assessments is 130 mm in lakes not stocked by the DNR with fingerling walleye prior to our assessments. Using the mean length criteria of 130 mm for average year classes, average or better 2002 year classes may be present in only 7 of the lakes surveyed in 2002 (Table 9). In the future, we will be further investigating the predictive power mean length and CPUE of age-0 has on CPUE of 1+ the following sampling season in northern Minnesota lakes, with the goal of determining mean length and CPUE thresholds that can be used to predict year class strength. This will be possible once we can combine gill net data for adults from the DNR several years from now.

Continued monitoring of walleye young-of-the-year and year-1 fish will give a better picture over time as to the nature of the walleye populations in these lakes. Monitoring these lakes over time will give managers a better understanding of walleye population dynamics and recruitment, and the relationship between year-1 age-0 walleye abundance and year-2 age-1 walleye abundance.

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Table 8. Total number and catch-per-unit-effort of age-0 and age-1 walleye collected by the 1854 Authority and the Fond du Lac Division of Resource Management from twenty five lakes within Northeastern Minnesota during Fall 2002.

Lake (County)	Date	Temp (^oC)	Conductivity[1]	On Time (sec)	#Age-0[2]	#1+[3]	$CPUE_{Age-0}$[4]	$CPUE_{1+}$[5]
Aspen (Cook)	5 September	20.0	52.9	3893	17	18	15.7	16.7
Ball Club (Cook)	6 September	19.4	32.7	4703	356	84	272.5	64.3
Caribou (Cook)	9 September	23.3	60.9	6801	181	21	95.8	11.1
Cascade (Cook)	3 September	19.4	26.4	4733	15	43	11.4	32.7
Crescent (Cook)	9 September	22.8	37.4	3960	82	6	74.6	5.4
Crooked (Lake)	19 September	19.4	51.1	4362	7	12	5.8	9.9
Devilfish (Cook)	4 September	20.6	23.3	8147	16	673	7.1	297.4
Dumbbell (Lake)	19 September	18.9	86.8	4725	226	31	172.2	23.6
Eagle (Carlton)	13 September	22.2	167.5	9045	34	35	13.5	13.9
Elbow (Cook)	6 September	20.6	37.6	3412	279	16	294.4	16.9
Fourmile (Lake)	17 September	20.0	50.3	7164	524	112	263.3	56.2
Homer (Cook)	3 September	20.0	33.6	5424	105	25	69.7	16.6
Island Lake Res. (St. Louis)	12 September	22.2	83.7	10255	277	169	97.2	59.3
Ninemile (Lake)	18 September	18.9	69.1	5455	565	20	372.9	13.2
North McDougal (Lake)	18 September	20.0	58.7	7295	222	47	109.6	23.2
Pike (Cook)	9 September	22.2	68.4	4631	103	135	80.1	104.9
Poplar (Cook)	5 September	19.4	40.8	5907	4	15	2.4	9.1
Prairie (St. Louis)	13 September	22.2	112.4	5725	10	10	6.3	6.3
Shagawa (St. Louis)	16 September	21.1	98.8	11784	672	127	205.3	38.8
Tom (Cook)	4 September	21.1	45.8	7229	9	221	4.5	110.0
Two Island (Cook)	6 September	20.6	42.0	5808	18	16	11.2	9.9
West Twin (Cook)	5 September	19.4	38.6	3786	185	33	175.9	31.4
Whiteface Res. (St. Louis)	12 September	20.6	71.5	7825	210	156	96.6	71.8
Wilson (Lake)	17 September	19.4	56.5	7092	47	17	23.9	8.6
Windy (Lake)	17 September	20.0	38.3	6148	121	40	70.8	23.4

1 Conductivity, measured in FSiemens / 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 2002 assessments in Northeastern Minnesota.

Lake (County)	Date	Age-0 Mean Length (mm)	Age-1 Mean Length (mm)
Aspen (Cook)	5 September	140	230
Ball Club (Cook)	6 September	108	224
Caribou (Cook)	9 September	125	246
Cascade (Cook)	3 September	116	196
Crescent (Cook)	9 September	115	246
Crooked (Lake)	19 September	127	259
Devilfish (Cook)	4 September	97	178
Dumbbell (Lake)	19 September	144	229
Eagle (Carlton)	13 September	147	233
Elbow (Cook)	6 September	115	213
Fourmile (Lake)	17 September	128	236
Homer (Cook)	3 September	97	194
Island Lake Res. (St. Louis)	12 September	132	203
Ninemile (Lake)	18 September	133	260
North McDougal (Lake)	18 September	129	203
Pike (Cook)	9 September	114	208
Poplar (Cook)	5 September	141	195
Prairie (St. Louis)	13 September	123	213
Shagawa (St. Louis)	16 September	115	230
Tom (Cook)	4 September	106	198
Two Island (Cook)	6 September	99	207
West Twin (Cook)	5 September	119	223
Whiteface Res. (St. Louis)	12 September	135	229
Wilson (Lake)	17 September	125	234
Windy (Lake)	17 September	115	218

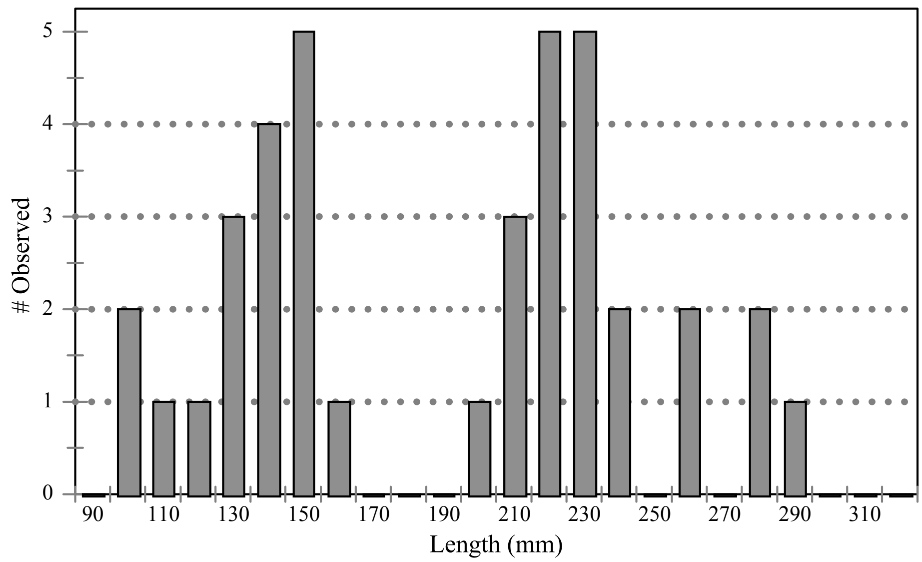

Figure 7. Length frequency distribution of walleye collected from Aspen Lake, Cook County, during fall 2002 electrofishing assessments.

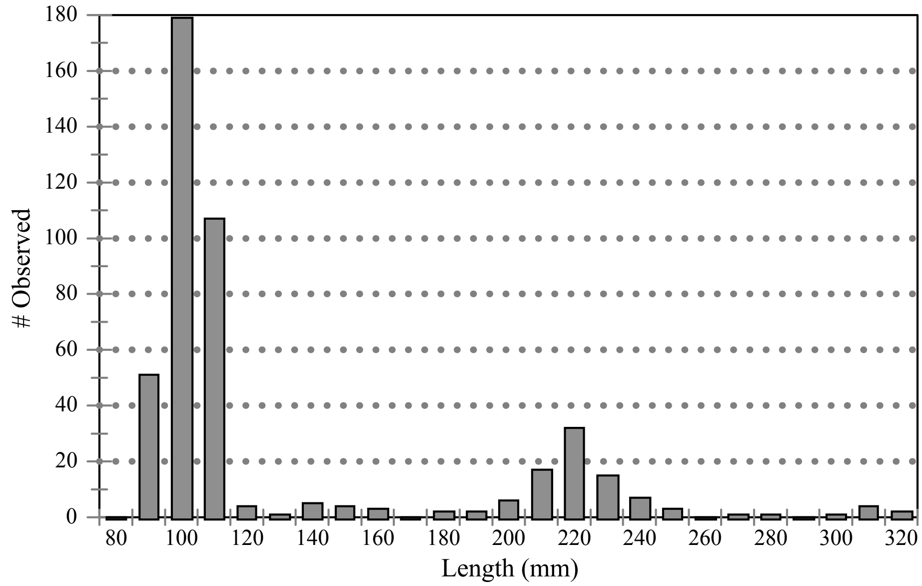

Figure 8. Length frequency distribution of walleye collected from Ball Club Lake, Cook County, during fall 2002 electrofishing assessments.

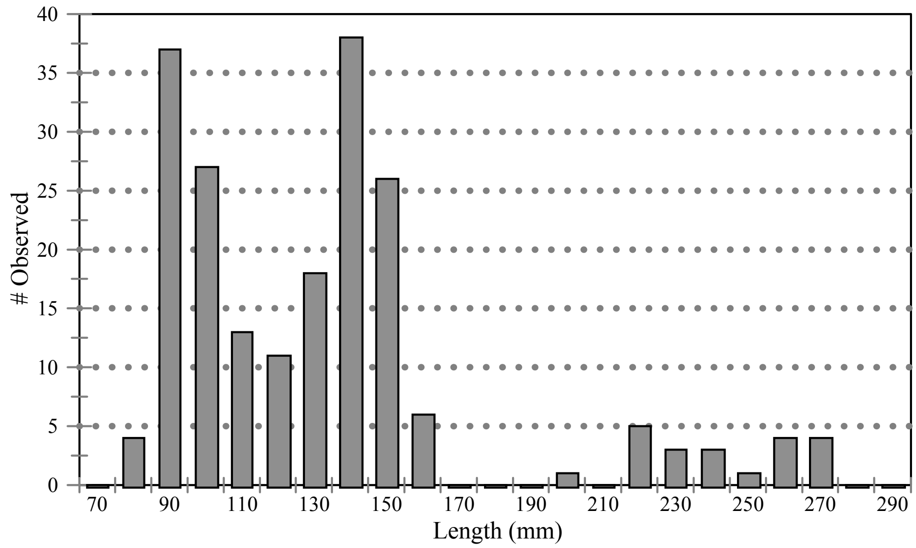

Figure 9. Length frequency distribution of walleye collected from Caribou Lake, Cook County, during fall 2002 electrofishing assessments.

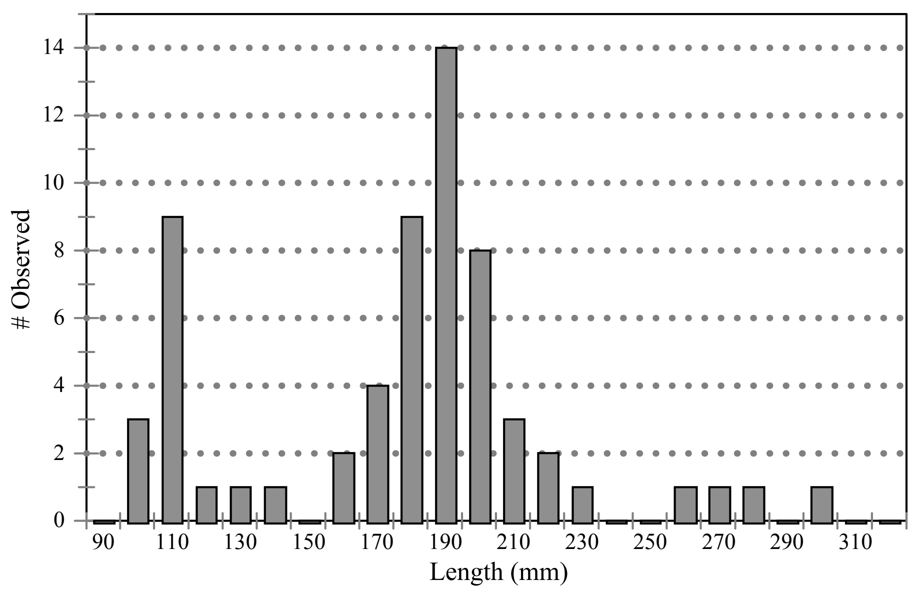

Figure 10. Length frequency distribution of walleye collected from Cascade Lake, Cook County, during fall 2002 electrofishing assessments.

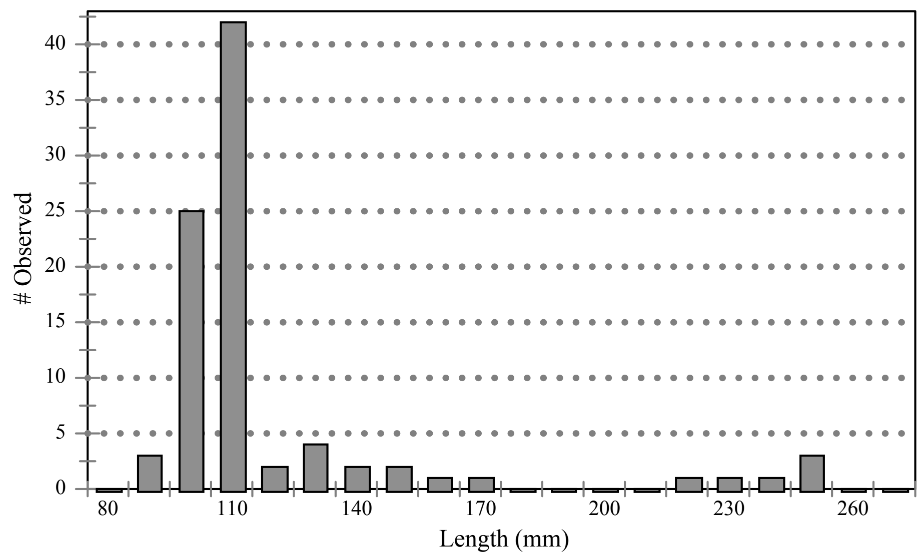

Figure 11. Length frequency distribution of walleye collected from Crescent Lake, Cook County, during fall 2002 electrofishing assessments.

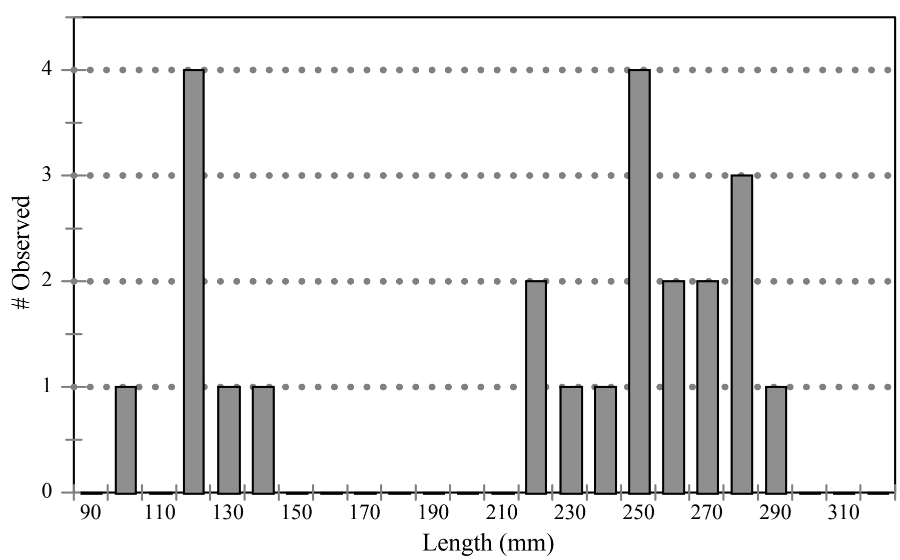

Figure 12. Length frequency distribution of walleye collected from Crooked Lake, Lake County, during fall 2002 electrofishing assessments.

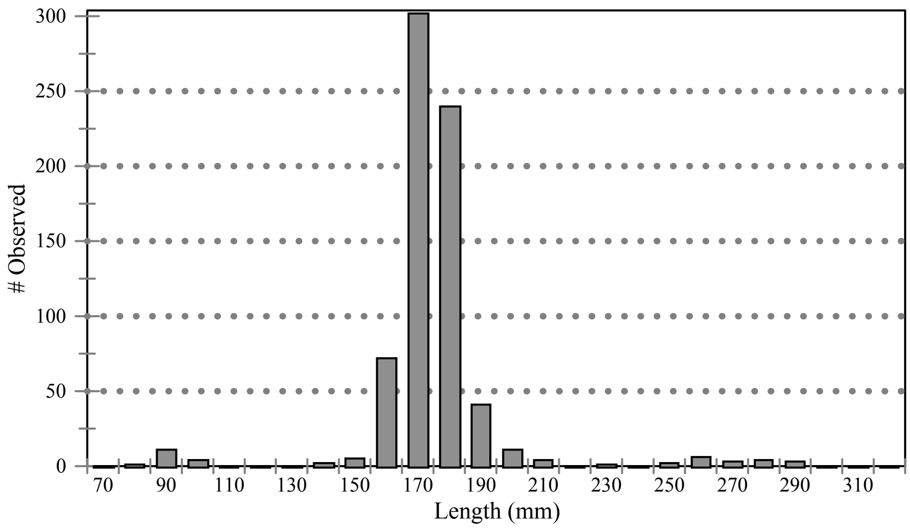

Figure 13. Length frequency distribution of walleye collected from Devilfish Lake, Cook County, during fall 2002 electrofishing assessments.

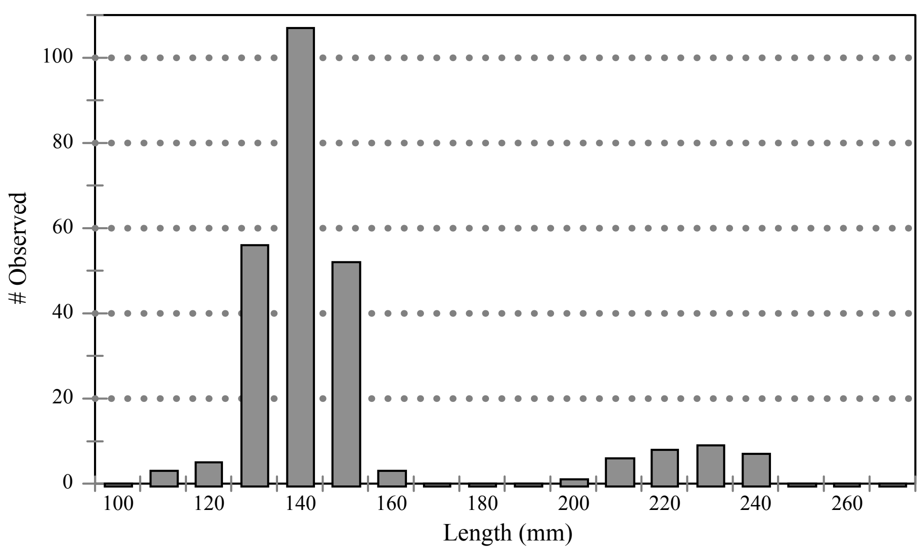

Figure 14. Length frequency distribution of walleye collected from Dumbbell Lake, Lake County, during fall 2002 electrofishing assessments.

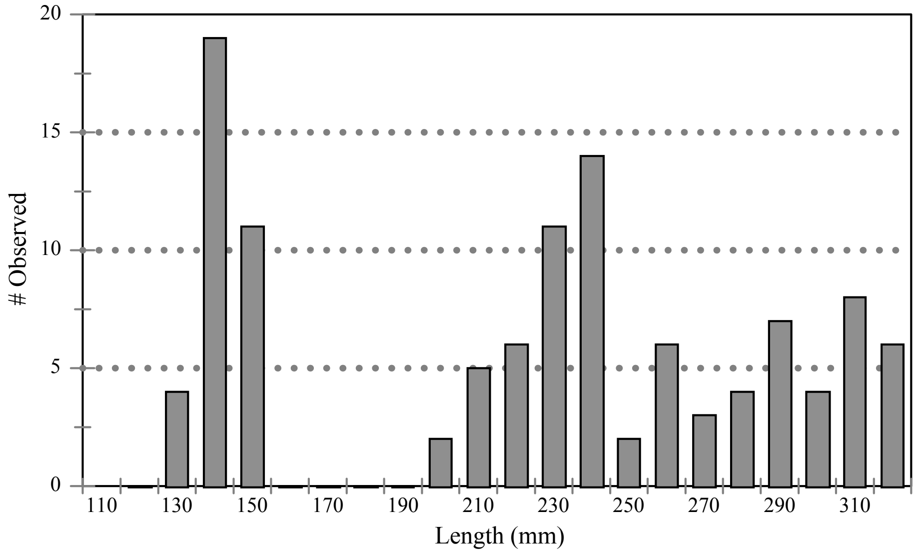

Figure 15. Length frequency distribution of walleye collected from Eagle Lake, Carlton County, during fall 2002 electrofishing assessments.

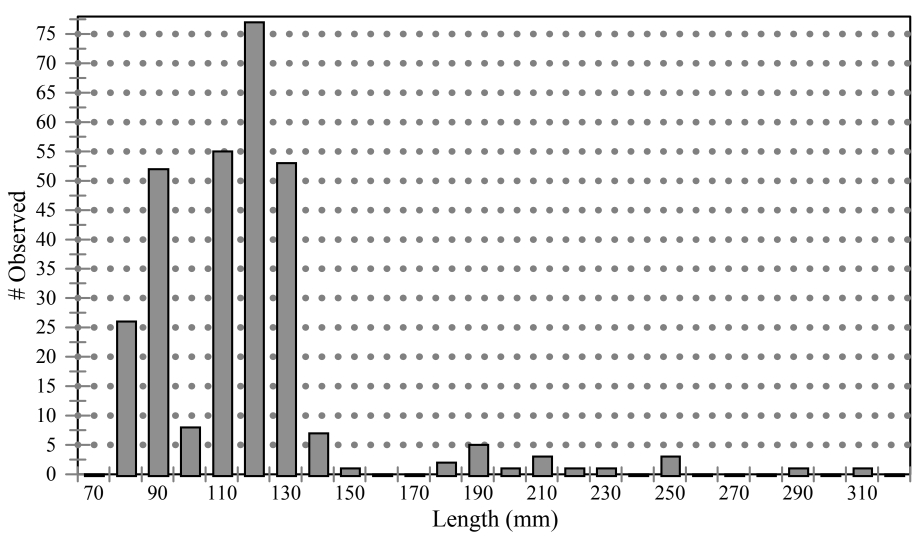

Figure 16. Length frequency distribution of walleye collected from Elbow Lake, Cook County, during fall 2002 electrofishing assessments.

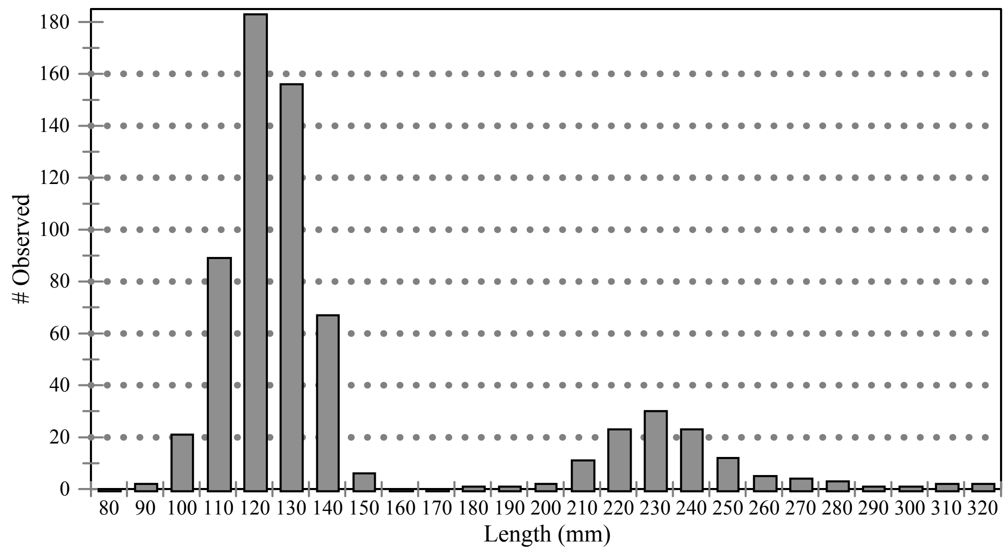

Figure 17. Length frequency distribution of walleye collected from Four Mile Lake, Cook County, during fall 2002 electrofishing assessments.

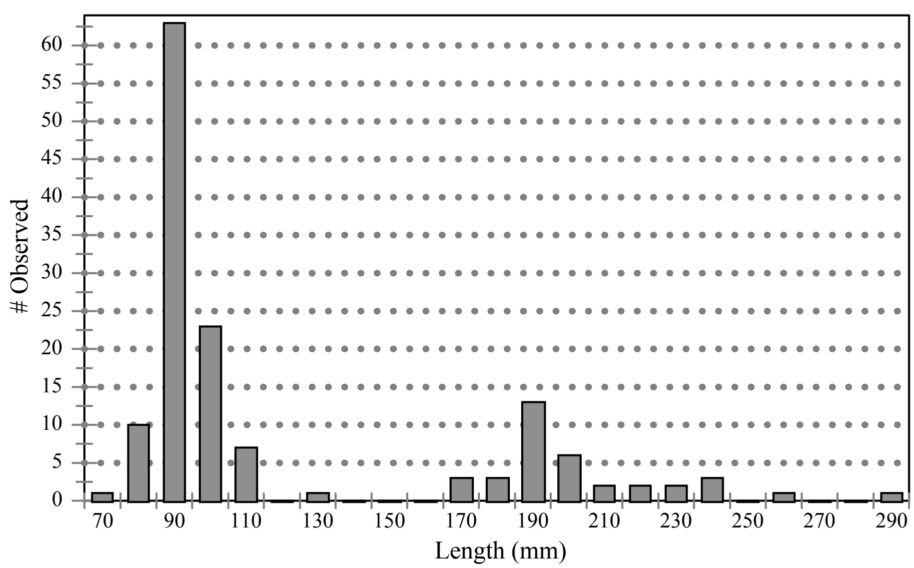

Figure 18. Length frequency distribution of walleye collected from Homer Lake, Cook County, during fall 2002 electrofishing assessments.

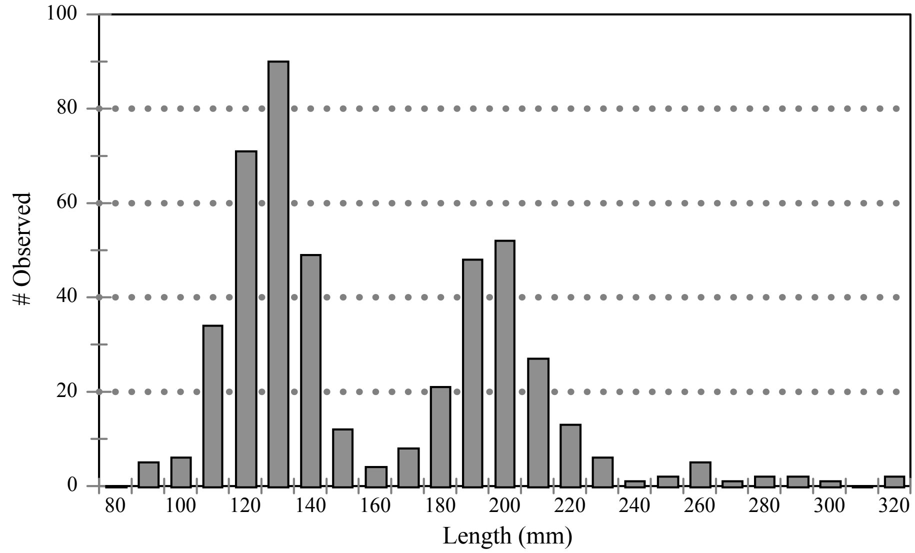

Figure 19. Length frequency distribution of walleye collected from Island Lake Reservoir, St. Louis County, during fall 2002 electrofishing assessments.

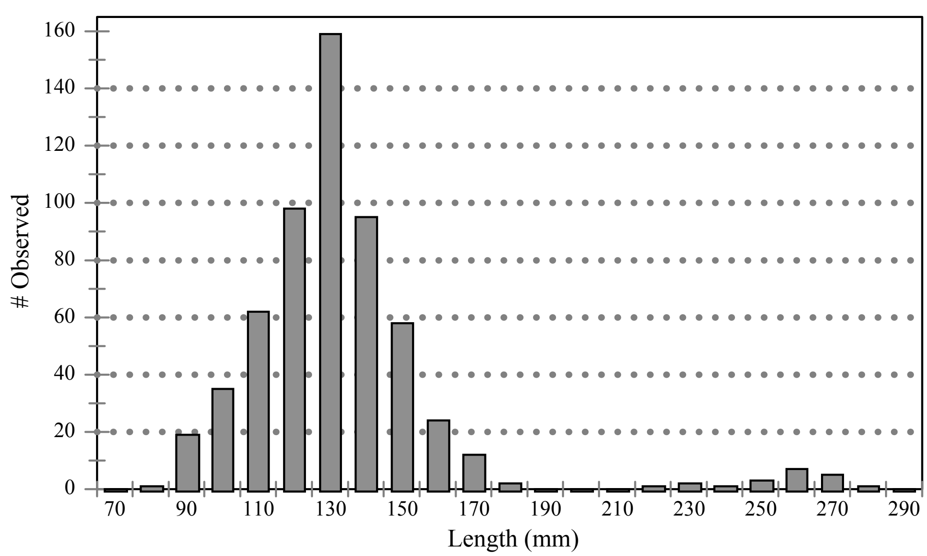

Figure 20. Length frequency distribution of walleye collected from Ninemile Lake, Lake County, during fall 2002 electrofishing assessments.

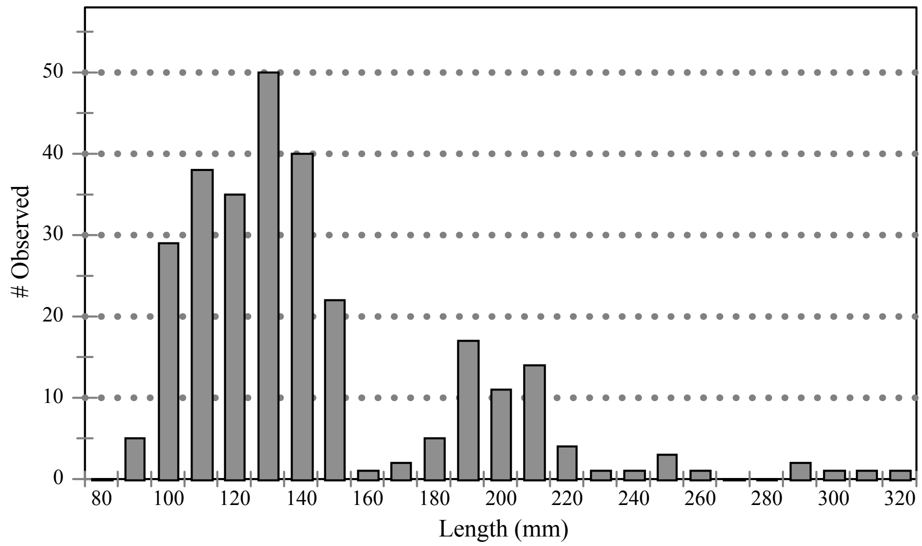

Figure 21. Length frequency distribution of walleye collected from North McDougal Lake, Lake County, during fall 2002 electrofishing assessments.

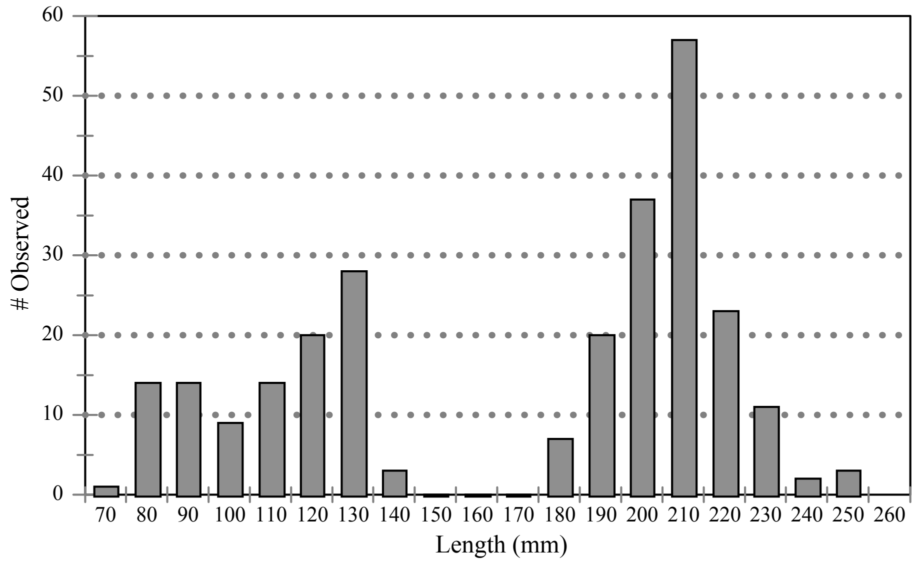

Figure 22. Length frequency distribution of walleye collected from Pike Lake, Cook County, during fall 2002 electrofishing assessments.

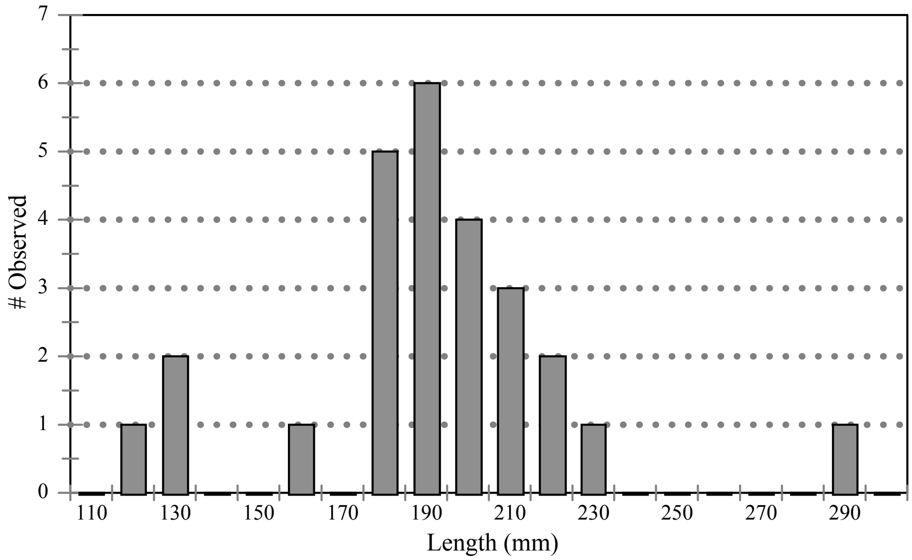

Figure 23. Length frequency distribution of walleye collected from Poplar Lake, Cook County, during fall 2002 electrofishing assessments.

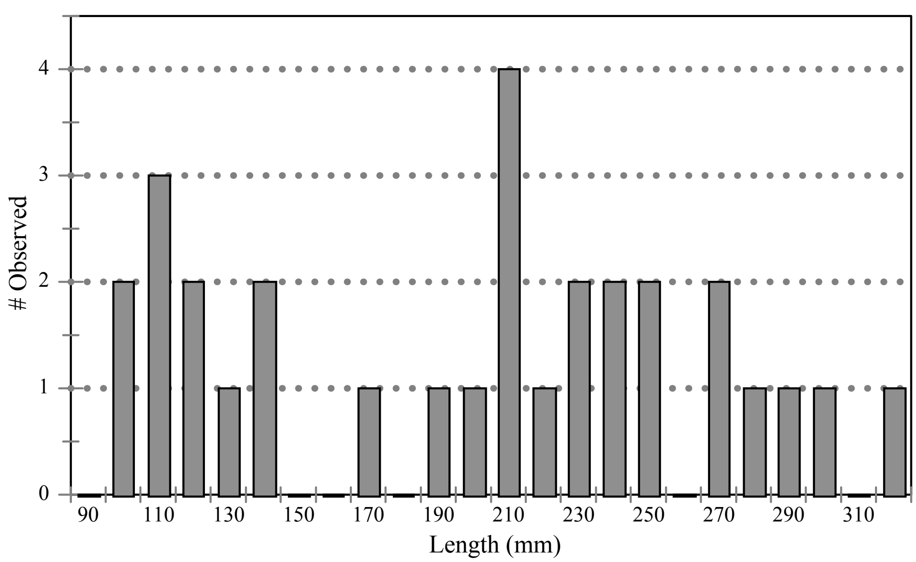

Figure 24. Length frequency distribution of walleye collected from Prairie Lake, Carlton County, during fall 2002 electrofishing assessments.

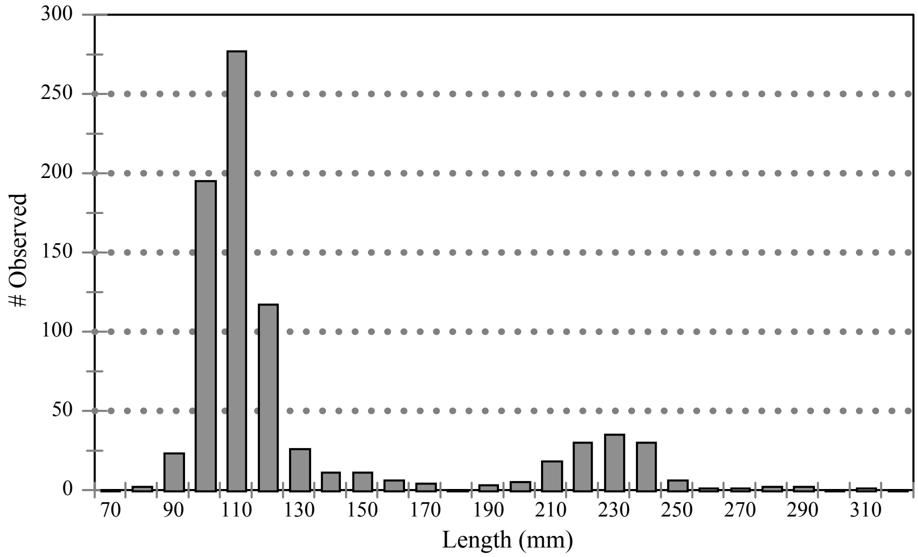

Figure 23. Length frequency distribution of walleye collected from Shagawa Lake, St. Louis County, during fall 2002 electrofishing assessments.

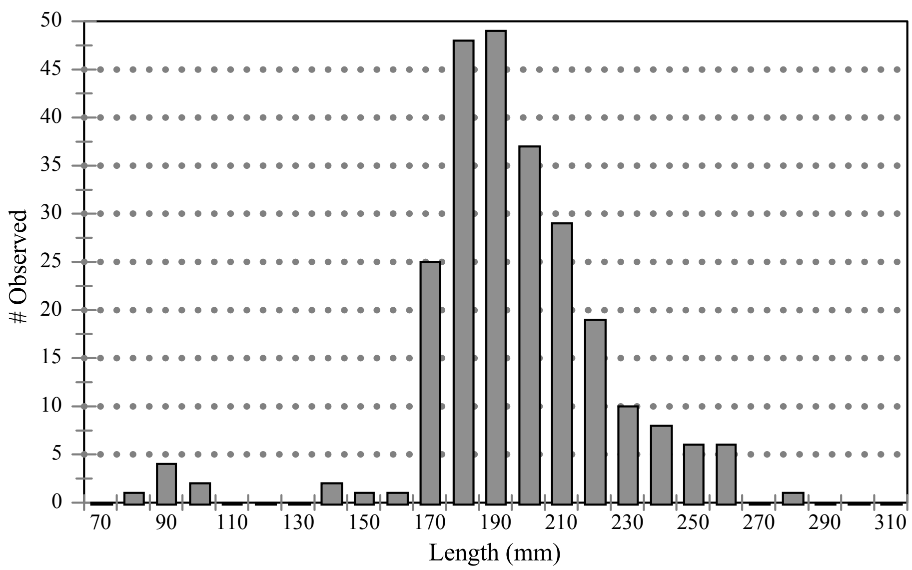

Figure 24. Length frequency distribution of walleye collected from Tom Lake, Cook County, during fall 2002 electrofishing assessments.

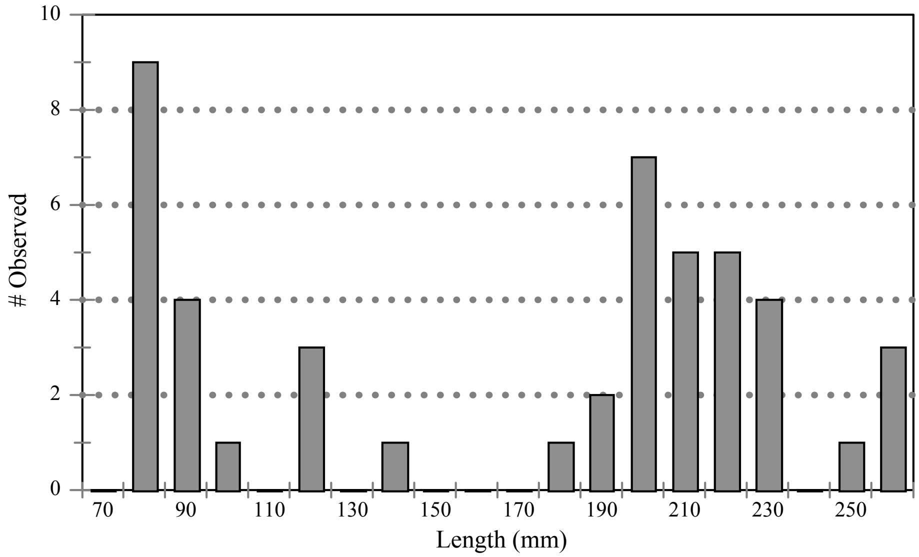

Figure 25. Length frequency distribution of walleye collected from Two Island Lake, Cook County, during fall 2002 electrofishing assessments.

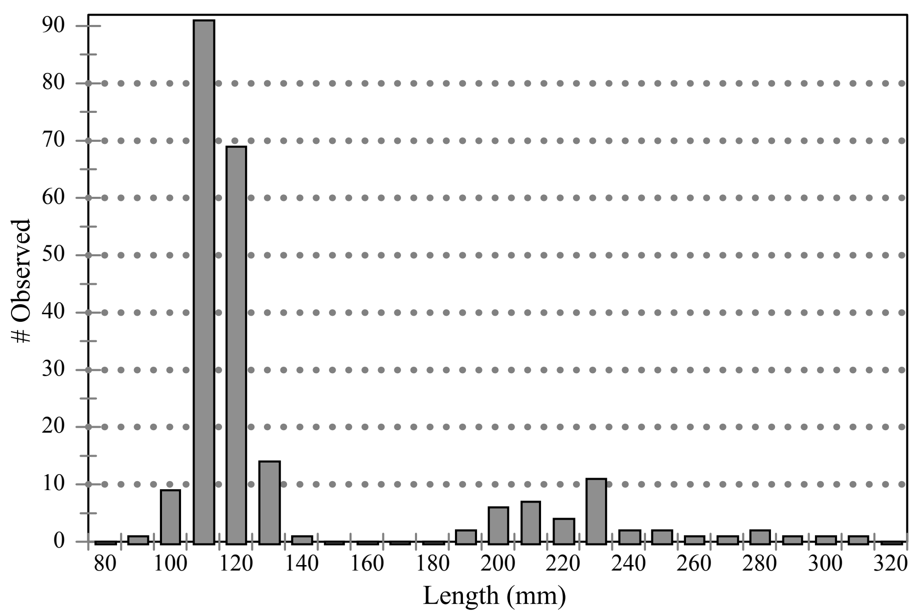

Figure 26. Length frequency distribution of walleye collected from West Twin Lake, Cook County, during fall 2002 electrofishing assessments.

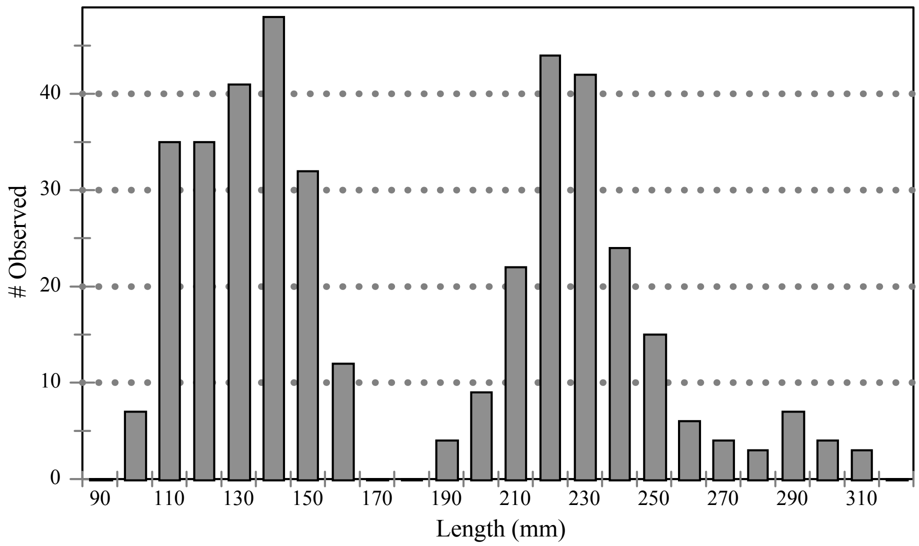

Figure 27. Length frequency distribution of walleye collected from Whiteface Reservoir, St. Louis County, during fall 2002 electrofishing assessments.

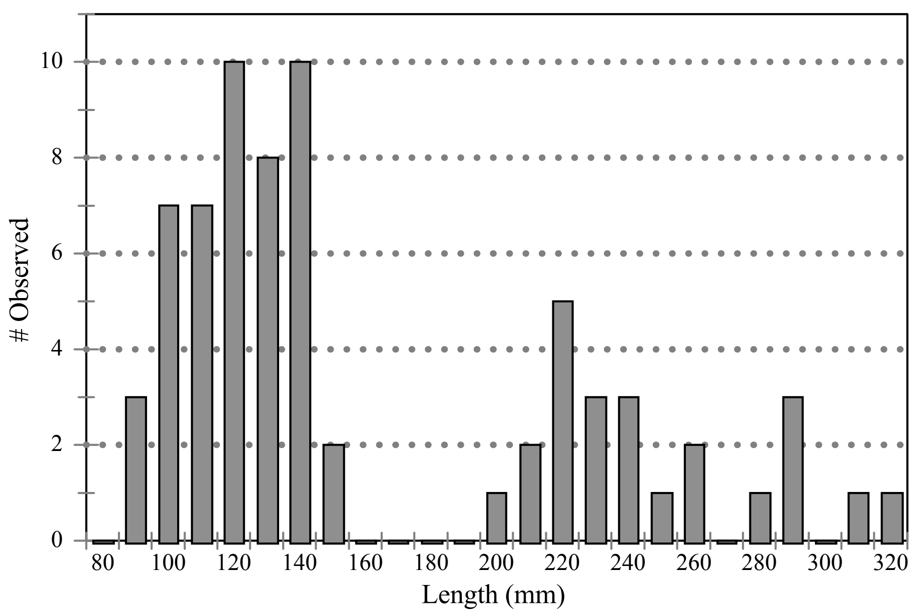

Figure 28. Length frequency distribution of walleye collected from Wilson Lake, Lake County, during fall 2002 electrofishing assessments.

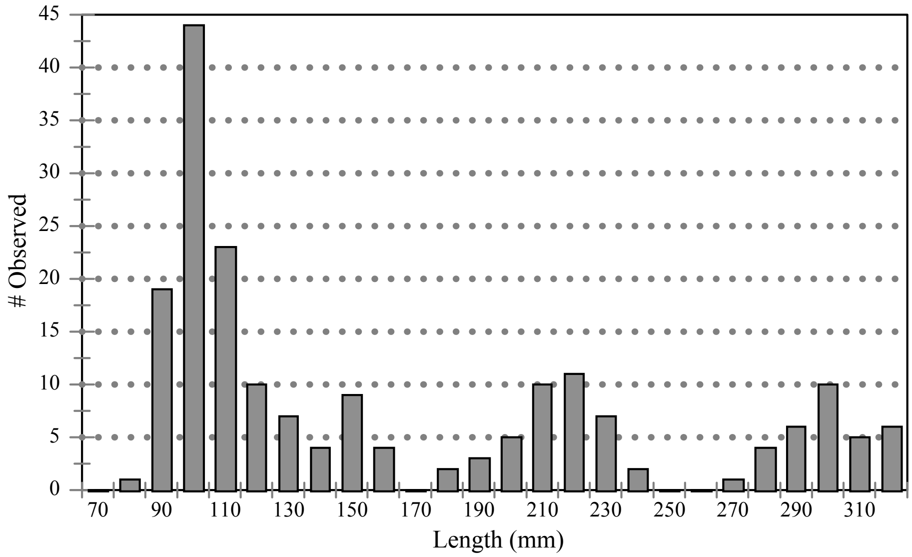

Figure 29. Length frequency distribution of walleye collected from Windy Lake, Lake County, during fall 2002 electrofishing assessments.