Relationship between Electrofishing Catch Rates of Age-0 Walleyes and Water Temperature in Minnesota Lakes

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Abstract - We compared catch data for age-0 walleyes *Stizostedion vitreum* using night electrofishing in 18 Minnesota lakes throughout the fall 1996 over a wide range of water temperatures (4-25°C). The relationship between electrofishing catch-per-hour (CPE) of age-0 walleyes and temperature showed a curvilinear pattern, with CPE rising and peaking at 18.6°C, and declining thereafter as water temperature cooled throughout the fall. Three different patterns of CPE were observed within subsets of the data, but peak CPE generally occurred at intermediate water temperatures, and declines in CPE generally occurred when water temperature dropped below 10°C. Mean lengths differed significantly between August and September in all but three lakes, but did not differ significantly between September and October except in two lakes. For managers wishing to assess age-0 walleye abundance prior to stocking advanced fall fingerlings, our data suggest that fall assessments should target water temperatures between 20° and 10°C. If the size of age-0 walleyes entering the first winter is critical data to obtain, assessments should be performed towards the end of September, but before the water temperature falls below 10°C. For reliable long-term data sets on individual lakes, we recommend managers plan sampling schedules so that individual lakes are sampled at similar temperature ranges from one year to the next.

Introduction

Monitoring relative abundance of age-0 walleyes *Stizostedion vitreum* is an important management activity for predicting future year class strength. Assessments targeting age-0 walleyes are typically performed using electrofishing at night in late summer and fall (Serns 1982, 1983; Ngu and Kmiecik 1993). Managers often use catch-per-unit-effort (CPE) indices to evaluate year class strength, often comparing CPE indices among lakes and years. This technique is generally accepted after Serns (1982) found a positive and significant relationship between fall electrofishing CPE and density of age-0 walleyes in Wisconsin lakes.

Water temperature has been reported to affect electrofishing catch rates of largemouth bass *Micropterus salmoides*. Carline et al. (1984) found that the vulnerability of largemouth bass to electrofishing was closely linked to water temperature, and presumed this was due to seasonal habitat shifts. Hall (1986) reported that largemouth bass of all sizes are not collected effectively with electrofishing gear in water temperatures below 6°C. However, similar information for walleye was unavailable.

Sampling for age-0 walleyes in the fall using electrofishing in Wisconsin dates back to the 1950's (Kempinger and Churchill 1972). Tribes in Wisconsin began using electrofishing to sample age-0 walleyes after they began to exercise treaty fishing rights in the mid 1980s (Goyke et al. 1993, 1994; Ngu and Kmiecik 1993). Electrofishing has only recently been used in Minnesota as a tool for establishing CPE indices for age-0 walleye. Based upon differing work loads both within the Minnesota Department of Natural Resources (MNDNR) and the various tribal natural resource departments, it has been difficult to reach a consensus as to when to conduct similar surveys in Minnesota, and to coordinate assessment activities to coincide over similar temperature conditions. Water temperatures throughout the fall in Minnesota can often vary substantially over a two-week period. Consequently, sampling schedules that span more than a two-week period will often encounter colder water temperatures in the later portion of the schedule than at the onset. If water temperature affects walleye electrofishing catch rates, this could bias results. Therefore, the Fond du Lac Band of Lake Superior Chippewa and the MNDNR developed this study as a cooperative effort to determine: 1) if catch rates of age-0 walleye were affected by water temperature within a lake; 2) if patterns of CPE versus water temperature were similar among lakes; and 3) when growth of age-0 walleye ceased.

Methods

Eighteen lakes were selected for this study that allowed replication in six Minnesota lake classes (Schupp 1992) representative of the variety of lake types in the state (Table 1). Study lakes in classes 5 and 16 were soft-water lakes located in northeast Minnesota. Class 22, 25, and 27 lakes were hard-water systems located in central and western Minnesota. Class 41 lakes were shallow, eutrophic lakes in southern Minnesota.

Pulsed DC electrofishing assessments were conducted on relatively calm nights using boom shocking equipment. If wind or rain was suspected to be a problem affecting dipnetter visibility and capture efficiency, surveys were suspended until the next evening. Boat, electrode configuration, and number of netters was held constant within each lake over the sampling period. Surface water temperatures were taken at each sampling station. The starting and ending points of each sampling station were identified and recorded using either a geographic positioning system unit or permanent landmarks to ensure that stations were accurately repeated in subsequent surveys.

Sampling began the last week of August at water temperatures equal to or greater than 20°C. Most lakes were assessed four to six times over the course of the study. Each lake was sampled approximately every 7 to 14 nights into late October or early November (water temperatures • 10°C). This allowed for sampling over the time period most often used by the Wisconsin DNR, Wisconsin Indian Tribes and the U.S. Fish and Wildlife Service (USFWS) for age-0 walleye sampling (Serns 1982; Frank Stone, USFWS, Ashland Fisheries Resources Office, personal communication).

Presumed age-0 and age-1 walleyes immobilized by the electrofishing gear were collected. Walleyes were measured to the nearest millimeter, and scales taken from five individuals per 10 mm size group for age analysis. Walleyes were aged by counting annuli on scales to separate age-0 from age-1 fish. Age-0 walleye CPE was calculated for each sampling station as catch-per-hour of electrofishing time. Due to substantial differences in CPE among lakes, CPE was standardized by dividing the number of age-0 walleyes sampled each night by the total number of age-0 walleyes sampled for each lake. This was multiplied by 100 to get a percentage for each night's sampling efforts. This method maintained the observed pattern of CPE within each lake while standardizing all lakes to the same scale. Regression analysis was performed on standardized CPEs.

One way analysis of variance was used to determine if mean length differed among samples for each lake. If statistically significant differences ($P < 0.05$) were detected, Bonferroni multiple comparisons were conducted.

Results and Discussion

Catch-per-effort of age-0 walleyes ranged from 0.0 fish/h

(White Earth Lake 8°C, and Spider Lake 4°C, Table 1) to 833.0 ± 115.2 fish/h of electrofishing (Jennie Lake 17°C, Table 1). Age-0 CPE was plotted against water temperature for each lake (Figure 1). No clear single pattern was observed between CPE and water temperature for all lakes. However, three patterns were observed in subsets of the data. In the two lakes representing lake class 27, Amelia and Big Wolf, and in Windy Lake (lake class 5), CPE declined as water temperature cooled (Table 1). Regression analysis on standardized CPEs showed this relationship to be significant (Figure 2, Pattern 1). With the exception of the sample collected at 19°C, CPE declined with decreasing temperature in Big Cormorant Lake as well (Table 1).

The most common pattern observed in the data was a relatively low CPE at the highest temperatures, CPE peaking at temperatures between 18°C and 13°C, then declining at lower temperatures. This pattern was observed in nine lakes representing five lake classes: Wilson (class 5); Wild Rice and Whiteface (class 16); Bass, White Earth, and Bemidji (class 22); Spider (class 25); and Washington and Jennie (class 41) (Figure 1). Pooling the standardized CPEs for these lakes showed a highly significant relationship (Figure 2, Pattern 2), with a maximum CPE observed at 16.6°C.

The third pattern was observed in two of the lakes within lake class 41. In Cannon and Upper Sakatah lakes, catch rates increased throughout the fall as temperatures declined (Table 1, Figure 1). Combined standardized CPEs for these 2 lakes are presented in Figure 2 (Pattern 3).

With the exception of Dumbbell (lake class 5), Upper Sakatah (lake class 41) and Sylvan lakes (lake class 25), all lakes surveyed at temperatures below 10°C showed some decline in catch rates (Table 1). However, the CPE values observed on Dumbbell and Sylvan lakes were very low at all temperatures sampled. Of the 20 lakes sampled, only Upper Sakatah had a high CPE and an increase in CPE at a temperature less than 10°C (Table 1). Pooling the standardized CPEs for all lakes showed an overall relationship between age-0 walleye CPE and water temperature to be quadratic, with a peak in CPE at 18.6°C, and CPEs declining above and below this temperature (Figure 3).

Mean length of sampled walleyes increased throughout the sampling season (Table 1). Walleyes from the first sampling date on most lakes were significantly smaller than walleyes from later samples (Table 1). Forney (1976) found that age-0 walleyes in Oneida Lake, New York, continued to grow in September, but very little growth occurred after October 1. In our study lakes, only Upper Sakatah Lake had a significant increase in mean length in October. Significant growth either was not observed in the other lakes, or catch rates were too low at the lower water temperatures to make any inferences concerning growth in October.

While growth may have accounted for some of the observed increase in mean length as the fall progressed, size-related mortality could also have been a factor (Larscheid 1995; Johnson et al. 1996). Predation by other species, e.g., northern pike *Esox lucius*, and cannibalism are most intense on smaller members of the age-0 cohort (Chevalier 1973). If this was the case on our study lakes, it could have caused the mean length of sampled age-0 walleyes to increase even if significant growth did not occur.

In addition, predation may have been the cause for declining CPEs in several of the lakes, as individuals were removed between sampling efforts. However, increases in CPEs observed in several of the lakes at intermediate temperatures (Table 1, Figure 1) suggest that temperature does have at least some effect on catch rates in age-0 walleye.

When planning age-0 walleye assessments, managers must target the time period when individuals are most likely to be vulnerable to the capture gear. The fish must be inshore and large enough to be effectively sampled (Coble 1992). In Minnesota, by late August, age-0 walleyes are both large enough and can be present in shallow water. Our data suggest that by late October or early November, age-0 walleyes are no longer as vulnerable to electrofishing, though some exceptions were noted. The age-0 walleyes may have left the shallows to find preferred water temperatures, to follow prey species, or to avoid predators. We did not collect other species or adult walleyes during electrofishing in order to concentrate on collecting all juvenile walleyes. However, when catch rates of age-0 walleyes were the lowest, more adult walleyes and northern pike were observed in the shallow water habitat.

Our data suggest that water temperature directly affected the catch rates for age-0 walleyes during the fall 1996. Ideally, age-0 walleye assessments should be conducted over the range of fall water temperatures. However, fishery managers responsible for multiple lakes often do not have this luxury, and must make decisions based on few, generally one, samples. We recommend that managers set sampling schedules that target water temperatures between 10 and 20^{o}C. We believe that among-lake comparisons are not as important to managers as among-year comparisons within lakes. We therefore recommend that managers set sampling schedules so that a lake is sampled around the same water temperature each year. Within-lake comparisons for long-term trend data will be much more reliable, even if the particular lake is sampled at either temperature extreme.

Samples collected early in the fall would allow managers to identify lakes with large numbers of naturally-produced or frystocking-produced walleye fingerlings, and target expensive and limited advanced-fall fingerlings to lakes without substantial numbers of age-0 walleye already present. Numerous studies have demonstrated that walleye or sauger *Stizostedion canadense* fingerling stockings are much more successful if an age-0 year class is not already present (LaJeone et al. 1992; Larscheid 1995; Heidinger and Brooks 1998). If no supplemental fingerling stocking is planned, sampling should be conducted toward the cooler end of our recommended temperature range when growth is completed. Previous studies have suggested that age-0 walleyes need to reach a certain critical size to have the highest rate of survival over their first winter (Forney 1976; Madenjian et al. 1991). Forney (1976) suggested that this critical size is 175 mm 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 walleyes would be exposed to cannibalism by older walleyes for longer periods of time. Both Forney (1976) and Madenjian et al. (1991) attributed overwinter size-selected mortality of age-0 walleyes to cannibalism. In Mille Lacs Lake, Minnesota, year classes with the largest mean lengths typically led to strong year classes, while the year classes with the shortest mean lengths were typically weak.

The 1988 year class averaged 160 mm going into the first winter, and an exceptional year class occurred, while the 1985 year class, 93 mm at the end of the fall, was essentially non-existent in subsequent years (R. Bruesewitz, Minnesota Department of Natural Resources, personal communication). Our data suggest that the mean length of age-0 walleyes in Minnesota does not change after the end of September, either because of a cessation of growth or smaller members of the cohort having been lost to predation. Managers interested in the mean length entering the first winter should concentrate sampling efforts towards the end of September and into October, but still prior to the water temperature dropping below 10^{o}C.

Acknowledgments

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Table 1. Summary statistics of nightly electrofishing for age-0 walleye collected from study lakes during fall 1996. Age 0 indicates the total number (N) of age-0 walleye sampled each night. The mean catch-per-effort (hour) (CPE) for age-0 walleye by sampling station, with the standard error in parentheses. Mean length is reported in mm, with the standard error in parentheses. Letters following mean length denote results of Bonferroni comparisons after significant analysis of variance results; means with different letters were significant at $\alpha = 0.05$.

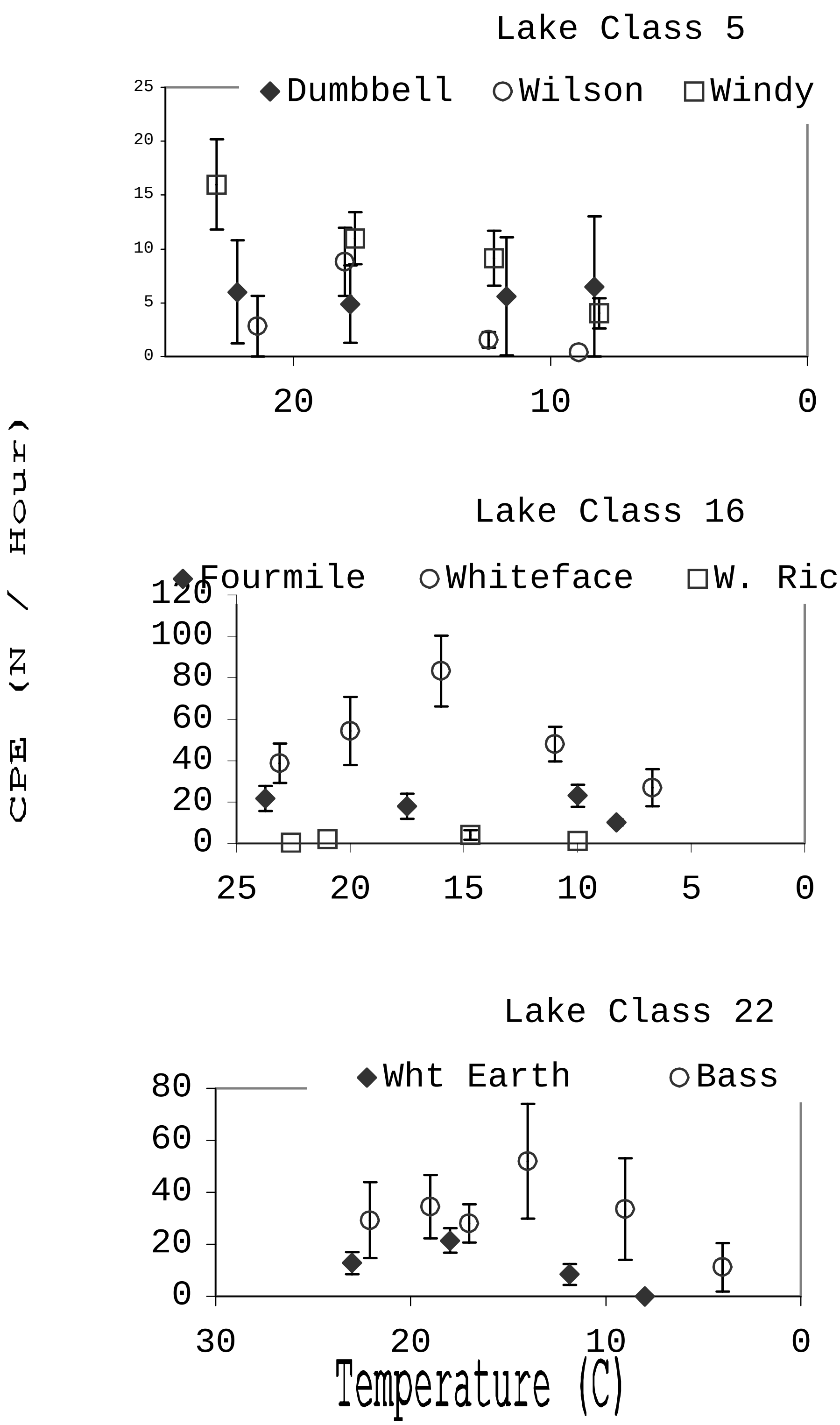
Lake (Lake class)	Date	Temp (°C)	Age 0 (N)	CPE(SE)	Mean length (SE)	
Dumbbell Lake	5 Sep	22	14	6.0(4.4)	127(2)	
(Lake class 5[a])	15 Sep	18	11	4.9(3.4)	130(3)	
	30 Sep	12	12	5.6(5.1)	129(3)	
	15 Oct	8	14	6.5(5.9)	140(5)	
Wilson Lake	2 Sep	21	9	2.8(2.8)	104(4)	
(Lake class 5)	16 Sep	18	19	8.8(3.2)	105(4)	
	1 Oct	12	3	1.5(0.7)	99(9)	
	16 Oct	9	1	0.4(0.4)	114(0)	
Windy Lake	4 Sep	23	33	16.0(4.2)	130(2)	z
(Lake class 5)	18 Sep	18	24	11.0(2.4)	140(3)	y
	29 Sep	12	18	9.2(2.6)	145(3)	y
	14 Oct	8	8	4.0(1.5)	147(4)	y
Whiteface	25 Aug	23	72	38.7(9.5)	119(1)	z
Reservoir	11 Sep	20	116	54.4(16.4)	130(1)	y
(Lake class 16[b])	22 Sep	16	158	83.2(17.0)	132(1)	y
	6 Oct	11	86	48.1(8.4)	137(1)	x
	27 Oct	7	38	26.8(8.9)	140(2)	x
Wild Rice Lake	27 Aug	23	1	0.3(0.2)	97(0)	
(Lake class 16)	10 Sep	21	3	1.9(1.3)	135(2)	
	24 Sep	15	6	4.1(2.4)	129(6)	
	7 Oct	10	3	1.2(0.8)	122(6)	
Fourmile Lake	3 Sep	24	36	21.6(6.1)	114(2)	z
(Lake class 16)	17 Sep	18	28	17.9(6.0)	127(3)	y
	2 Oct	10	34	23.0(5.3)	127(2)	y
	13 Oct	8	20	10.1(1.6)	119(4)	zy
Big Cormorant	26 Aug	22	41	20.5(10.3)	140(2)	z
(Lake class 22[c])	16 Sep	19	3	3.0(1.2)	152(6)	y
	24 Sep	16	30	16.2(6.6)	154(3)	y
	15 Oct	13	10	6.0(3.5)	159(5)	y
	22 Oct	9	3	3.3(0.6)	132(21)	z
White Earth	29 Aug	23	22	12.8(4.3)	134(2)	z
(Lake class 22)	17 Sep	18	30	21.4(4.7)	143(3)	y
	9 Oct	12	9	8.4(4.1)	125(5)	z
	23 Oct	8	0	0.0(0.0)		

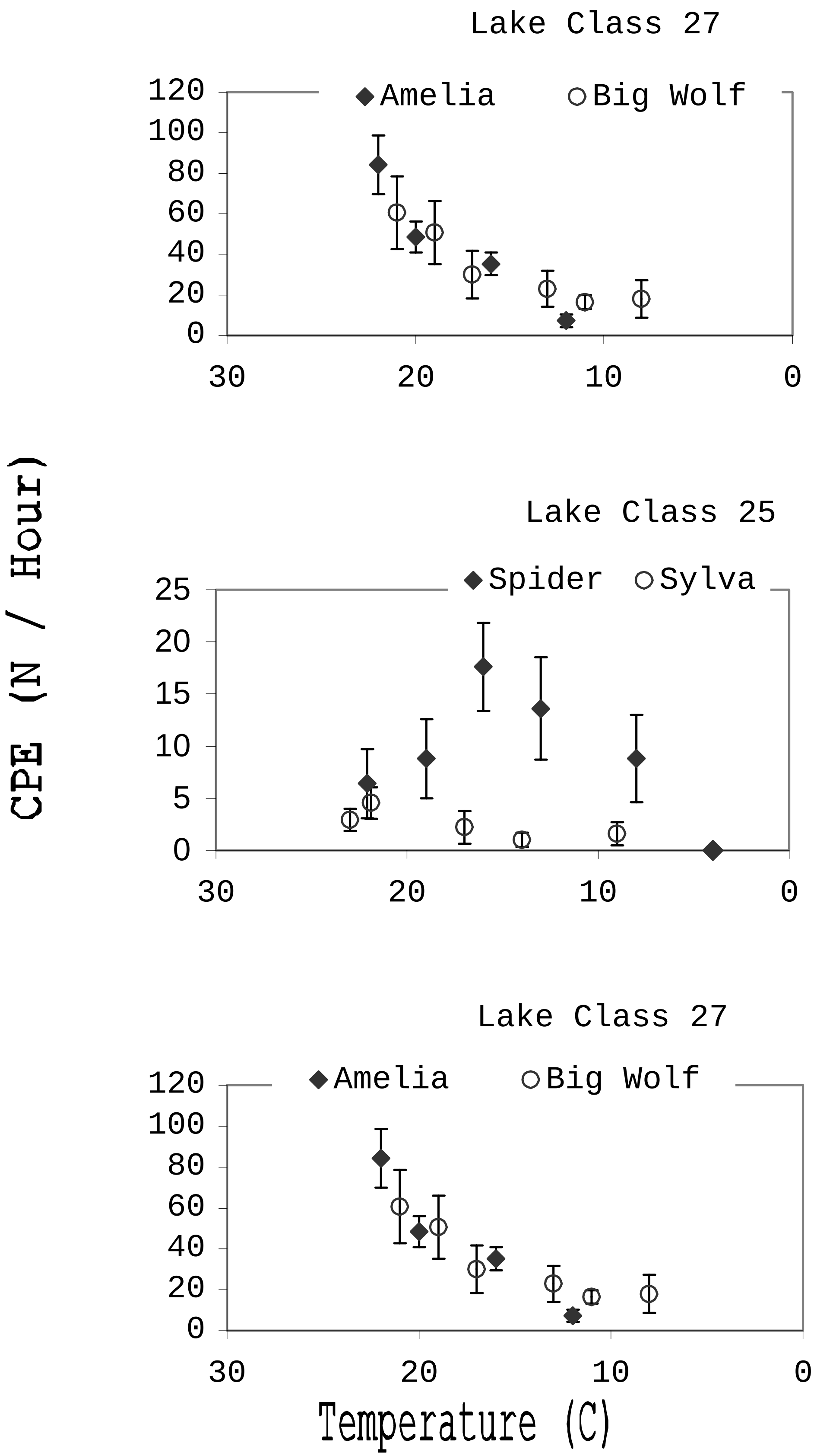
Bass	9 Sep	22	37	29.3(14.7)	148(1)	z
(Lake class 22)	16 Sep	19	43	34.4(12.2)	153(2)	y
	23 Sep	17	35	28.0(7.4)	158(2)	x
	30 Sep	14	65	52.0(22.1)	160(1)	x
	22 Oct	9	42	33.6(19.5)	165(1)	w
	4 Nov	4	14	11.2(9.3)	166(3)	w
Bemidji	8 Sep	22	5	2.5(1.5)	152(6)	zy
(Lake class 22)	12 Sep	19	13	8.7(3.3)	148(3)	z
	23 Sep	14	6	3.0(2.4)	153(3)	zy
	30 Sep	13	33	16.5(8.9)	154(3)	zy
	13 Oct	12	14	7.0(4.2)	170(3)	x
	22 Oct	7	4	2.0(1.2)	167(3)	yx
Spider	10 Sep	22	8	6.4(3.4)	163(3)	z
(Lake class 25[d])	18 Sep	19	11	8.8(3.9)	163(2)	z
	24 Sep	16	22	17.6(4.3)	167(2)	zy
	1 Oct	13	17	13.6(5.0)	169(2)	zy
	21 Oct	8	11	8.8(4.2)	174(3)	y
	5 Nov	4	0	0.0		
Sylvan	27 Aug	22	7	4.5(1.5)	148(2)	z
(Lake class 25)	10 Sep	23	3	2.9(1.0)	167(3)	y
	25 Sep	17	3	2.2(1.6)	176(3)	y
	8 Oct	14	1	1.0(0.7)	184(0)	y
	22 Oct	9	2	1.6(1.1)	169(1)	y
Amelia	26 Aug	22	144	84.2(14.4)	147(1)	z
(Lake class 27[e])	12 Sep	20	90	48.6(7.6)	156(1)	y
	24 Sep	16	52	35.3(5.8)	159(1)	y
	15 Oct	12	10	7.3(3.1)	163(4)	y
Big Wolf	10 Sep	21	90	60.7(18.0)	144(1)	z
(Lake class 27)	18 Sep	19	76	50.7(15.6)	150(1)	y
	24 Sep	17	60	30.0(11.7)	149(2)	zy
	2 Oct	13	46	23.0(8.8)	152(2)	yx
	10 Oct	11	32	16.5(3.3)	154(2)	yx
	23 Oct	8	36	18.0(9.4)	158(1)	x
Upper Sakatah	11 Sep	22	30	22.4(10.4)	149(2)	z
(Lake class 41[f])	19 Sep	18	40	24.6(5.9)	155(2)	z
	9 Oct	13	120	67.9(4.6)	162(1)	y
	24 Oct	8	112	83.7(3.7)	168(1)	x
Cannon	12 Sep	20	8	6.8(2.0)	139(2)	z
(Lake class 41)	24 Sep	18	94	58.6(1.5)	149(1)	zy
	8 Oct	14	92	60.3(3.4)	149(1)	zy
	28 Oct	10	276	223.2(58.7)	151(1)	y

Jennie	28 Aug	25	539	447.7(72.5)	163(1)	z
(Lake class 41)	17 Sep	19	604	604.0(33.1)	176(1)	y
	24 Sep	17	833	833.0(115.2)	180(1)	x
	3 Oct	13	565	565.0(13.5)	184(1)	x
	22 Oct	8	133	133.0(23.9)	186(2)	x
	7 Nov	3	19	19.0(4.9)	195(4)	x
Washington	27 Aug	24	19	14.1(3.2)	148(3)	z
(Lake class 41)	16 Sep	19	11	8.7(2.6)	171(5)	y
	23 Sep	16	32	25.1(4.4)	177(3)	y
	2 Oct	13	44	34.1(8.8)	184(3)	y
	21 Oct	9	7	5.8(2.8)	180(4)	y
	6 Nov	3	6	4.8(2.6)	163(5)	z

After Schupp (1992),
[a] and [b] Lake classes 5 and 16 are softwater lakes in northeastern Minnesota.
[c], [d], and [e] Lake classes 22, 25, and 27 are hardwater lakes in central and western Minnesota.
[f] Lake class 41 indicates shallow, eutrophic lakes in southern Minnesota.

Figure 1. Electrofishing catch-per-hour (CPE) of age-0 walleyes during fall 1996 on 18 lakes representing 6 different Minnesota lake classes.




Lake Class 27
Amelia
Big Wolf
120
100
80
60
40
20
0
30
20
10
0
Lake Class 25
Spider
Sylva
25
20
15
10
5
0
30
20
10
0
Lake Class 27
Amelia
Big Wolf
120
100
80
60
40
20
0
30
20
10
0
CPE (N / Hour)
Temperature (C)

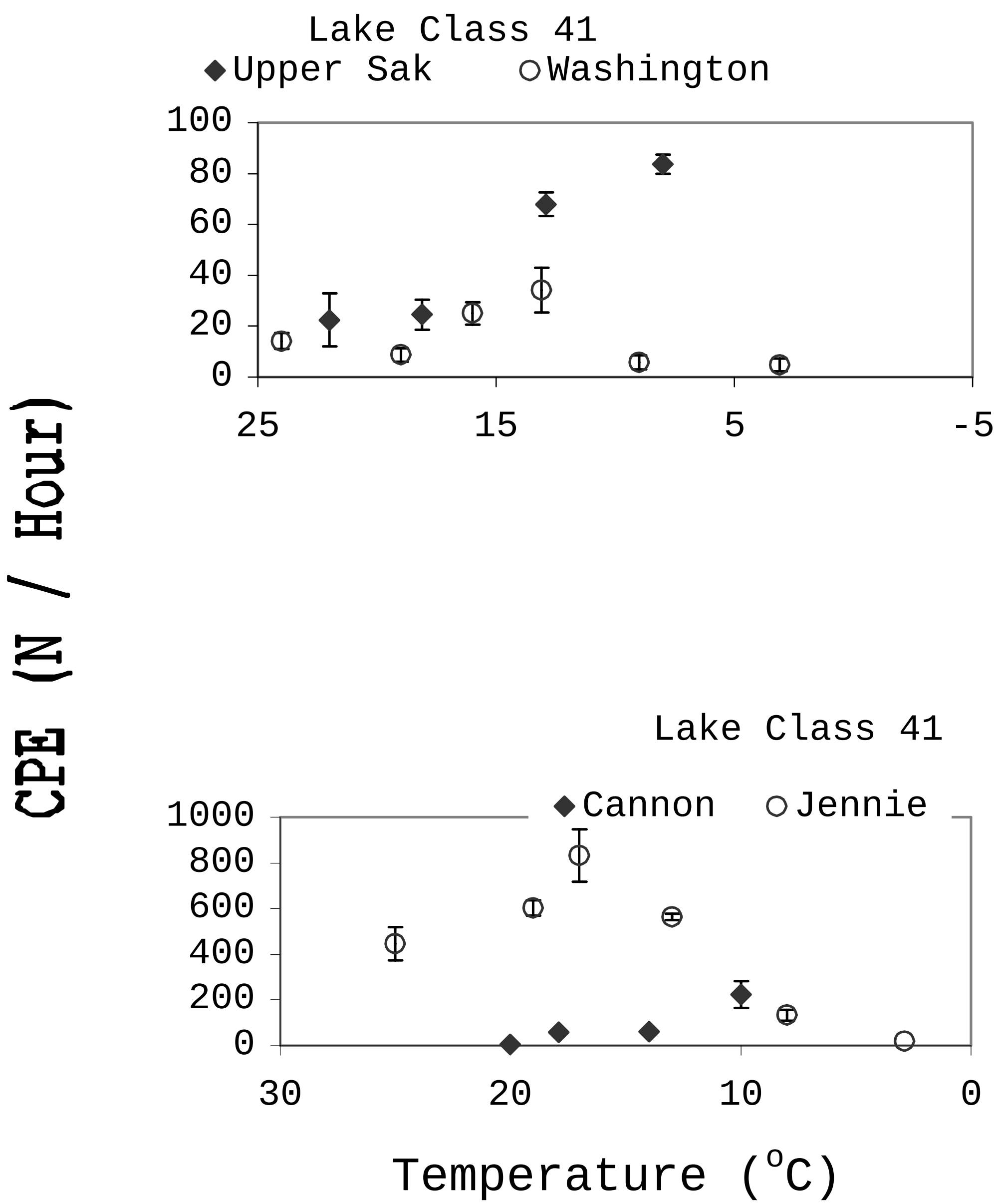

Lake Class 41
Upper Sak
Washington
100
80
60
40
20
0
25
15
5
-5
CPE (N / Hour)
Lake Class 41
Cannon
Jennie
1000
800
600
400
200
0
30
20
10
0
Temperature (oC)

Figure 2. Standardized catch rates (catch-per-hour, CPE) of age-0 walleyes verses temperature for lakes sampled during fall 1996. Catch rates were standardized by taking the number of age-0 walleyes sampled each night, dividing it by the total number of age-0 walleye sampled throughout the study for each lake, and multiplying by 100 to give a percentage for each night's sample. Pattern 1 lakes include Amelia, Big Wolf, and Windy Lakes. Pattern 2 lakes include Bass, Bemidji, Jennie, Spider, Washington, White Earth, Whiteface, Wild Rice, and Wilson Lakes. Pattern 3 lakes were Cannon and Upper Sakatah Lakes.

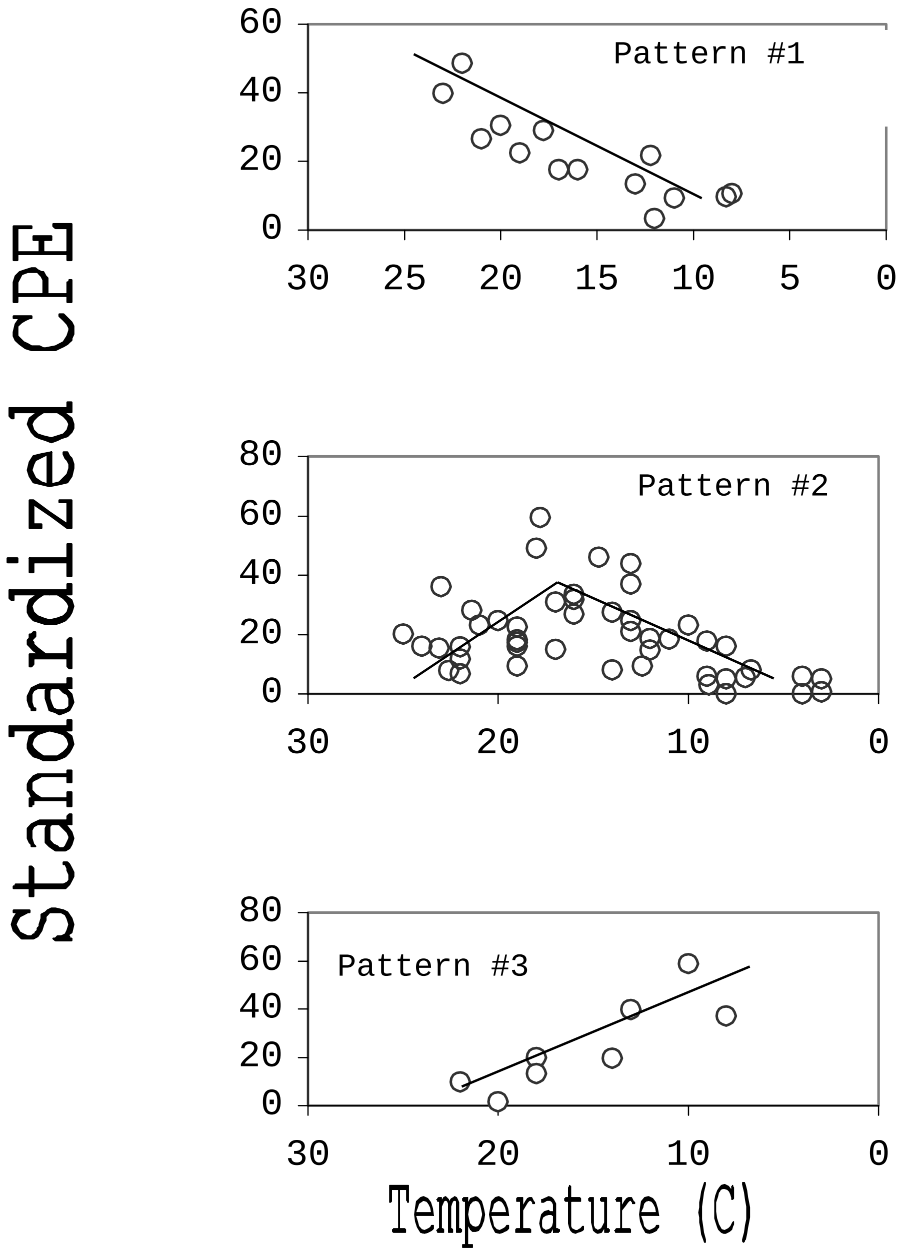


Figure 3. Standardized catch rates (catch-per-hour, CPE) of age-0 walleyes verses temperature for all lakes sampled during fall 1996. Catch rates were standardized by taking the number of age-0 walleye sampled each night, dividing it by the total number of age-0 walleye sampled throughout the study for each lake, and multiplying by 100 to give a percentage for each night's sample.