Evaluation of Oklahoma's Standardized Electrofishing in Calculating Population Structure Indices[1]

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Abstract: As an evaluation of Oklahoma's Standardized Sampling Procedures (SSP), Lakes Arbuckle and Thunderbird were electrofished monthly from April through October 1983. Monthly largemouth bass (*Micropterus salmoides*) population structure indices and length frequencies were calculated from blocks of effort and increasing sample sizes. Reliability of estimates was determined by comparisons with values calculated from total monthly effort and catch. Spring and fall indices and length frequencies calculated from sample sizes of 150 bass or 5 hours of electrofishing effort were considered adequate to accurately reflect population structure.

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The Oklahoma Department of Wildlife Conservation's Fish Division developed the Standardized Sampling Procedures (SSP) for Lake and Reservoir Management Recommendation in 1977 (Erickson 1978). Collection procedures and data analyses were standardized to allow comparisons among years and lakes within regions of the state.

The present spring and fall SSP electrofishing procedures, chosen for collection of data on largemouth bass, were outlined by Erickson (1981) as an effort quota of from 1.5 to 4.25 hours or a catch quota of 100 to 250 bass depending on lake surface area, conducted during daytime except in clear water impoundments when sampling was to be done at night. Data analyses consisted of the calculation of the following population structure indices: catch-per-unit-effort (C/f), Proportional Stock Density (PSD; Anderson 1976), Young-Adult-Ratio (YAR; Reynolds and Babb 1978), mean Relative Weights (Wr; Wege and Anderson 1978), and length-frequency plots by 20-mm length groups.

Researchers have recently pointed out conditions which make the interpretation of these indices difficult. Noble (1981) cautioned against using PSD where growth

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rates fluctuate and change the time when bass reach stock size. Carline et al. (1984) noted variations in largemouth bass PSD's within and among seasons, hypothesizing that differential behavior of stock and quality size bass influences their catchability by electrofishing gear. Other authors suggested that additional information should accompany PSD interpretations (Novinger and Legler 1978, Layzer and Clady 1981). In populations where slow growth and stockpiling are problems, bass of reproductive age may never reach the 305 mm length used in calculation of YAR (Mense 1981). Both Carline et al. (1984) and Mense (1981) expressed concern over wide variability in C/f and the relationship to bass abundance.

An in-depth evaluation of the SSP electrofishing and the reliability of the indices calculated was necessary to determine if methods and catch-effort quotas were adequate.

Methods

Arbuckle Reservoir, a deep, clear 951-ha impoundment in south-central Oklahoma and Lake Thunderbird, a moderately turbid 2,248-ha reservoir in central Oklahoma were selected because of different physical characteristics and bass populations. SSP quotas for these lakes were 3 hours of effort or sample sizes of 250 bass.

Monthly electrofishing samples using a boat-mounted Smith Root GPP electrofisher (400 V pulsed-DC) were collected from both lakes and consisted of 2-, 4-, and 6-hour blocks of effort. The sequence of these blocks was chosen at random and applied within a 2-week period on each lake from April through October. Daytime sampling was conducted on Lake Thunderbird, while night electrofishing was conducted on Arbuckle Reservoir. A day or night comparative 2-hour block of electrofishing was added on the same day or night as the assigned 2-hour block on each lake. One unit of SSP effort was 15 minutes of electrofishing giving a total of 48 units of effort plus an additional 8 units on the day/night comparison per lake per month.

Total length in millimeters and weight in grams were recorded for all largemouth bass collected. Surface water temperatures and daytime secchi disk transparencies were recorded on each sampling trip.

Analyses of these data consisted of statistical comparisons (at the $P \leq 0.05$ error level) within and among months, among the 2, 4, and 6-hour time blocks in terms of C/f, PSD, Wr, YAR, and length frequency. These same indices were calculated from sequentially accumulated sample sizes (50 fish at a time). Length frequencies, PSD, and C/f from the day/night comparisons were also calculated. Environmental variables were compared to C/f and PSD to determine if relationships existed.

Results

Catch-Per-Unit-Effort

A total of 14 hours of electrofishing per month resulted in the collection of 3,499 largemouth bass from Arbuckle and 1,192 bass from Thunderbird. Catch-per-unit-effort (C/f) ranged from 3 to 14 for Arbuckle and from 1 to 6 for Thunderbird (Table 1). Calculating C/f values within months by effort (hours) or sample size (N) gave similar results, however, those indices in the effort series showed wider variations (up to 250%). Significant differences among C/f by blocks of effort (Kruskal-Wallis test, Siegel 1956) were found between Thunderbird's September 2 and 4-hour blocks. Cumulatively increasing sample sizes produced more consistent C/f values within monthly samples (variation up to 75%). For sample periods when the SSP quota of 250 bass was met (combined April--May and September–October samples on Thunderbird), the quota C/f varied from the monthly (or seasonal) C/f by <25%. Comparing values between various sample sizes showed Thunderbird's May 50-fish versus 100-fish samples to be significantly different.

Comparisons between monthly C/f values showed differences between summer months' samples from Arbuckle, and conversely, all but July–August and August–September pairings from Thunderbird. Combined spring (April and May) and fall (September and October) samples were different on Arbuckle (C/f's of 14 and 12, respectively) but the same on Thunderbird (C/f's of 3).

Proportional Stock Density

Monthly PSD for Arbuckle remained relatively constant through 1983, ranging from 39 to 49, and on Thunderbird the range was 66 to 75 (Table 1). Calculating PSD by effort resulted in greater variations from the ultimate monthly PSD (55% and 17% for Arbuckle and Thunderbird, respectively), while calculations by sample size resulted in less variations (33% and 8%, respectively). For the months that the SSP quota was met on Arbuckle or for the combined spring and fall samples from Thunderbird, the calculated PSD from samples of 150 and 250 fish were both within 11% of the monthly or seasonal values.

Young-Adult-Ratio

Spring and early summer samples provided poor estimates of YAR (Table 1). Values from April through July samples were 0.0 to 0.5 from Arbuckle and 0.0 to 1.0 from Thunderbird. August through October samples gave more consistent YAR's compared to monthly values of 1.0 from Arbuckle and 0.5 from Thunderbird. Variation within months showed little difference on either lake when calculated by effort or sample size.

Relative Weight

Relative weight values for bass grouped into 100-mm length groups showed amount of electrofishing effort and sample size had only minor influences on Wr.

Table 1. Catch per 15 minutes of effort (C/f), Proportional Stock Density (PSD), and Young-Adult-Ratio (YAR) values of largemouth bass collected by electrofishing from Arbuckle Reservoir and Lake Thunderbird during 1983 by effort and increasing sample sizes (to monthly total effort and sample size *N*).

		April			May			September			October		
		C/f	PSD	YAR	C/f	PSD	YAR	C/f	PSD	YAR	C/f	PSD	YAR
Arbuckle													
Effort (hours)	2	16	37	0	13	39	0	13	36	1.0	18	36	2.5
	4	12	42	0	19	45	0	12	39	0.0	11	55	0.0
	6	14	45	0	13	52	0	11	40	1.0	15	45	1.5
	12	13	43	0	14	47	0	12	39	1.0	10	10	1.0
Sample size	50	16	29	0	8	40	0	8	52	2.5	12	42	0.5
	150	15	40	0	12	42	0	10	42	1.5	8	47	1.5
	250	15	41	0	12	47	0	10	40	1.5	11	44	1.5
	N	13	43	0	14	47	0	12	39	1.0	10	49	1.0
Thunderbird													
Effort (hours)	2	2	86	0	4	87	0	6[a]	94	2.0	3	3	1.0
	4	2	47	1.0	4	77	0	2	61	0.5	6	6	1.0
	6	3	67	0	5	70	0	1	75	0.5	4	4	0.5
	12	2	66	0.5	4	74	0	2	75	0.5	4	4	0.5
Sample size	50	2	42	0	4[a]	79	0	2	71	0.5	4	4	0.5
	150	2	63	0	4	70	0	—	—	—	4	4	0.5
	N	2	66	0	4	74	0	2	75	0.5	4	4	0.5

[a]Significantly different from other C/f values ($P \leq 0.05$).

Small numbers of bass in a given length group, or weighing errors with small bass probably caused most of the variations seen among the size and effort series. Despite these problems, most Wr values in each series are within 19% of the monthly Wr after 4 hours effort or 100 bass sampled.

Length Frequencies

Length frequencies from spring and fall months, compared using the Chi-square test of homogeneity (Snedecor and Cochran 1967), showed no difference among plots constructed from the various sample size data (Fig. 1, 2). Significant differences between 2 and 4-hour and 4 and 6-hour length frequencies (not shown) were found in September and October from Arbuckle and April, September, and October from Thunderbird. In each case, significantly larger modes at certain length groupings were responsible for the differences, rather than the range of sizes.

Between month comparisons were made by sample size only. During April and May, all sample sizes produced similar length frequencies from Arbuckle, and only the 100-fish samples from Thunderbird were significantly different. All September and October comparisons from Arbuckle resulted in significant differences, while only the 100-fish samples from Thunderbird were different. All spring versus fall comparisons from both lakes were significantly different.

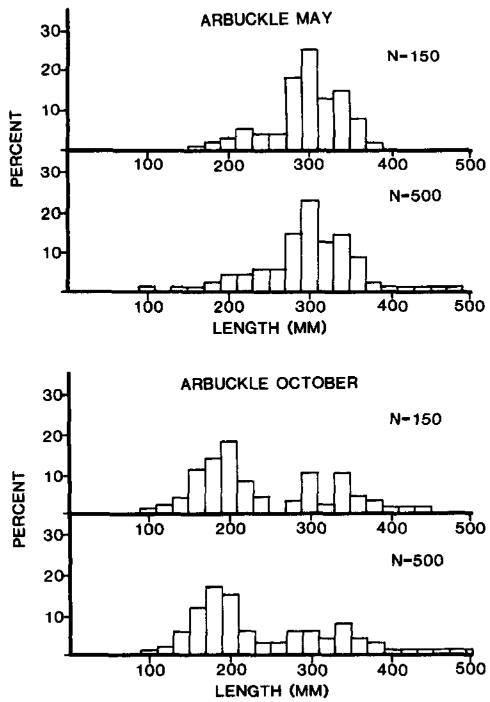

Figure 1. Length frequencies by sample size of largemouth bass collected by electrofishing from Arbuckle Reservoir during May and October 1983.

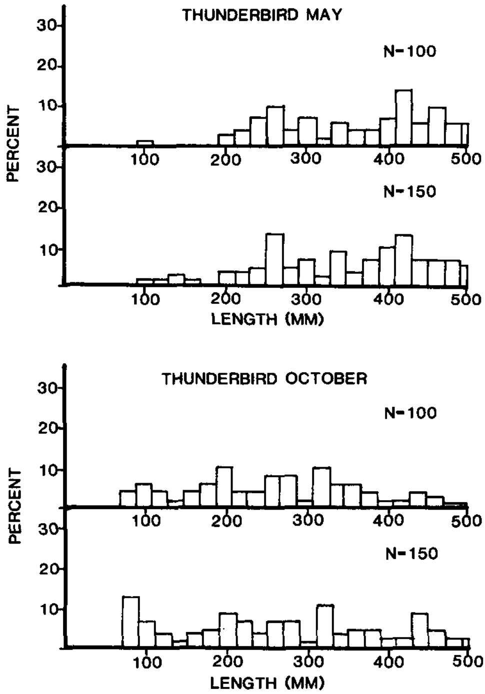

Figure 2. Length frequencies by sample size of largemouth bass collected by electrofishing from Lake Thunderbird during May and October 1983.

Day and Night Comparisons

Table 2 summarizes the indices calculated from the day/night samples, showing significantly higher night C/f in April from Arbuckle and in September and October from Arbuckle and Thunderbird. Overall C/f at night was significantly higher than daytime C/f. The night PSD's from both lakes more closely approximated the PSD from that month's total sample. Length frequency comparisons between day and night samples showed similarity on both lakes during April and May, but the October pairing on Arbuckle and the September pairing on Thunderbird showed significant differences. Night samples in fall showed a wider range of fish sizes and emphasized individuals >140 mm, whereas daytime samples emphasized young-of-the-year bass (Fig. 3).

Environmental Effects

Mean monthly water temperatures were plotted against C/f for each lake and showed a negative relationship to water temperature (Arbuckle, $r = -0.8$; Thunderbird, $r = -0.6$). Changes in water temperature had less obvious effects on PSD with no strong correlations being found. Peak PSD's were found in the 18° to 20° C range.

Secchi disk transparencies were plotted in a similar manner, but no relationships were found between water clarity and C/f or PSD.

Table 2. Monthly comparisons between day and night catch-per-unit-effort[a] (C/f) and Proportional Stock Density (PSD) values of largemouth bass collected during 1983 by electrofishing on Arbuckle Reservoir and Lake Thunderbird.

		Arbuckle		Thunderbird	
Month	Index	Day	Night	Day	Night
April	C/f	6	16[b]	2	2
	PSD	41	37	86	94
May	C/f	11	12	4	4
	PSD	35	40	87	67
June	C/f	3	8	4	7
	PSD	46	44	67	57
July	C/f	2	2	1	3
	PSD	29	29	80	82
August	C/f	1	2	2	5
	PSD	—[c]	36	50	71
September	C/f	1	13[b]	5	6
	PSD	100	36	94	58
October	C/f	7	20[b]	3	9[b]
	PSD	27	25	63	67

[a] 1 unit of effort = 15 minutes
[b] Significant difference within month C/f @ = 0.05
[c] No stock size fish collected

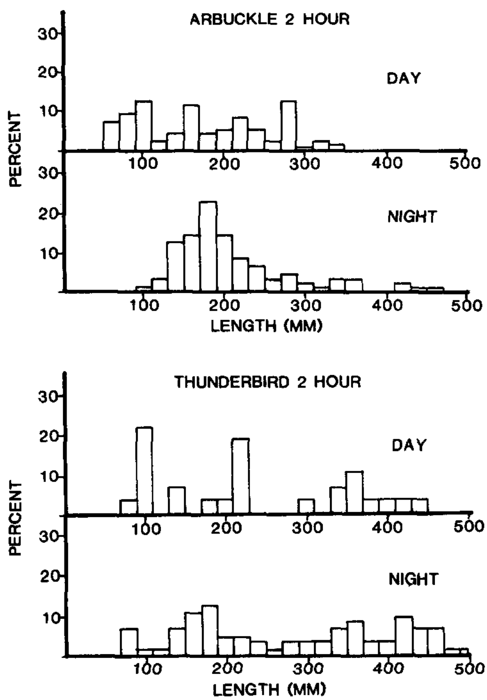

Figure 3. Length frequencies for largemouth bass from October, 1983 day/night electrofishing samples from Arbuckle Reservoir and Lake Thunderbird.

Discussion

Information on efficiency of electrofishing for sampling largemouth bass has dealt with accuracy in estimating relative abundance (Sanderson 1960, Bennet and Brown 1968) or size selectivity calculated into stock structure indices (Reynolds and Simpson 1978, Carline et al. 1984). Because PSD, Wr, and YAR were developed and tested in Missouri ponds (Anderson 1976, Reynolds and Babb 1978, Wege and Anderson 1978), testing of their utility in larger impoundments was important in a comprehensive sampling program such as Oklahoma's SSP.

SSP Quota System

The SSP catch and effort quotas produced indices on both lakes that were reliable and consistent when compared to values calculated from total monthly effort or sample sizes.

The majority of differences encountered in this study were seen when indices were calculated from effort data. An explanation of this lies in the experimental design. Date and habitat difference may account for the differences seen among blocks of effort. Examining the effort series for each index and calculating 3-hour (SSP quota) values, it was found that these indices varied from monthly total values by an average of 13% for each lake. The 2-hour block averaged 30% different from the final figures, the 4-hour averaged 11% different, then dropped to 5% for the value calculated from 5 hours of effort, then rose to 15% at 6 hours.

There is little reference in fishery literature to minimum effort required for good samples, but if this line of reasoning is sound, 5 hours of electrofishing produced the best estimates of these indices. This amount of effort also seems reasonable in terms of "on-the-lake" time available in 1 day or night's electrofishing when the time required to work up samples between units of effort is added. The increase in variation between 6-hour sample indices and monthly total indices may be due to the sample period being too long and more areas of poor habitat being sampled than was average for the month.

Indices calculated from sample size data were examined and showed little variation. Most differences were in the 50-fish samples where all fish came from 1 sampling trip and lack the across habitat homogeneity of large samples. Using the same line of reasoning for sample size as for effort, the average differences between all sample size indices and the monthly indices were 18%, 11%, 10%, 10%, and 6% for sample sizes of 50, 100, 150, 200, (or 250), and 500, respectively. The lowest variability was found in the largest sample sizes, but collecting 500 bass on Thunderbird would have taken an estimated 31 hours, an unreasonable amount of effort. There was little increase in variability between 100, 150, and the SSP quota 250 fish sample sizes. The smallest samples that gave reliable indices from Thunderbird were the 100-bass samples and the 150-bass samples from Arbuckle.

Wege and Anderson (1978) suggested samples of 10 to 20 bass to obtain reliable Wr values in small impoundments. Since very large sample sizes were obtained during this study and Wr values changed very little, it appeared that small samples were adequate. A caution is noted here that in lakes with very low YAR's, small samples may not detect subtle changes.

Samples to produce reliable PSD's depend on the true PSD of the population (Weithman et al. 1979). Anderson (1976) and Reynolds and Babb (1978) recommend PSD's in the range of 40 to 60 for balanced bass-bluegill populations. Weithman (1978) modified these recommendations to a range of 50 to 70 for shad forage based bass populations. The actual PSD was relatively unimportant, but its location in or out of these ranges was the key to interpretation. If the PSD was close to a boundary, this should signal the investigator that further study was in order. If the true PSD of the population approached 50, a larger sample size was necessary to estimate it, whereas unbalanced populations with PSD's of 30 or less, or 70 or more can be estimated with smaller samples (Weithman et al. 1979). An average sample of 70 fish is required for estimating PSD in balanced populations using a sequential sampling method described by Weithman et al. (1979). Following these recommendations, it appeared that in this study samples of 100 to 150 bass were adequate to estimate PSD with enough accuracy to make correct management decisions and allow some compensation for the lack of homogeneity noted earlier in small samples or amounts of effort.

Length frequencies from April and May showed no significant differences at sample sizes above 150 bass. Date and habitat differences, assumed to be responsible for the significant difference among indices, also apply to the length frequencies constructed from these data.

SSP Electrofishing Methods

Seasonal variation in C/f, PSD, and length frequency were of special interest. Many authors have concluded that late spring or early summer was the time of year for the most representative sampling (Novinger and Legler 1978, Simpson 1978, Carline et al. 1984). This optimum sampling period was closely associated with water temperatures. Carline et al. (1984) reported highest PSD's in May at water temperatures of 16° C. Our data indicated a peak PSD from Thunderbird in early May with water temperatures of 18° C. Late May temperatures of 21° C correspond with peak PSD's from Arbuckle. It is likely that PSD's were actually declining on Arbuckle from a higher level since temperatures had passed the 16°–18° C range earlier in the month (mid-April water temperatures were 13° C).

Although C/f values from both lakes in May were approximately equal for day and night samples, overall night C/f was higher than day C/f. Studies have shown that night electrofishing is more efficient, produced higher catch rates and yields a better representation of relative abundances (Loeb 1957, Witt and Campbell 1959). Simpson (1978) suggested that the optimum time to collect fish for estimating Wr and YAR was just after dusk. Daytime fall electrofishing on Arbuckle and Thunderbird produced more young-of-the-year bass than night samples, but appeared to underestimate adults (as predicted by Simpson 1978), causing an overestimation of YAR values.

The higher density bass population of Arbuckle required slightly more effort and larger samples to adequately estimate indices than did Thunderbird's, however, the recommended 5 hour/150 bass sample was sufficient in both cases. Very large reservoirs with diverse habitats and isolated sub-populations of bass may require separate quotas for each area. Managers must make individual assessments as to the benefits of expending more effort or collecting larger samples when increases in index reliability is minimal.

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