Comparison of Electrofishing and Gill Netting for Sampling Gizzard Shad

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Abstract: Gill netting (mesh sizes from 13 to 64 mm) and electrofishing were conducted in April and October 1987–1989, to compare their utility for providing precise estimates of relative abundance and size structure of gizzard shad (*Dorosoma cepedianum*) populations in 2 Ozark impoundments. Catches of gizzard shad <120 mm were extremely variable for electrofishing and very low for gill netting and were excluded from further analysis. Electrofishing captured more gizzard shad ≥120 mm with less effort (68-339 fish/hour) than gill netting (2–48 fish/net day). However, neither method provided precise estimates of catch per unit effort (CPUE) for gizzard shad ≥120 mm; coefficients of variation ranged from 44% to 144% for electrofishing and 39% to 131% for gill netting. Sample sizes required for a $CV_{\bar{x}}$ (SE/mean) of 20% ranged from 5 to 52 for electrofishing runs and 5 to 43 sets for gill netting. There was no significant difference in CPUE between April and October for either gear. Neither mean CPUE nor mean length of gizzard shad ≥120 mm were correlated between the 2 gears ($P > 0.64$), indicating that the gears did not reveal similar trends in mean CPUE or length. Electrofishing captured a wider length range of gizzard shad; gill netting rarely caught gizzard shad <180 mm.

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The gizzard shad is an important component of many reservoir ecosystems in the midwestern and southern United States. It is a significant prey species for many piscivorous sport fish (Aggus 1972, Noble 1981, Storck 1986) as well as a potential competitor (Noble 1981, Kirk et al. 1986). In spite of its importance, little effort has been directed toward developing sampling methods that will provide precise estimates of relative abundance and size structure of gizzard shad populations.

Cove rotenone samples have been widely used in the southern United States to estimate standing stock and size distribution of reservoir fishes, including gizzard shad (Hayne et al. 1967). Although cove rotenone can be an effective sampling method, it is very labor-intensive, is restricted to specific locations within a reservoir, and can produce highly variable results (Siler 1986). Quadrant rotenone sampling avoids some of the problems with cove sampling (Timmons et al. 1979, Shireman et al. 1981, Johnson et al. 1988). However, both methods have the disadvantage of causing nearly total mortality of all fish species in the sampling area.

Electrofishing and gill netting are also commonly used to survey reservoir fish populations. They can be used in a greater variety of habitats than rotenone, can be more species-selective, are not as labor-intensive, and usually do not cause complete mortality among sampled fish. Disadvantages of these methods include less effective sampling of age-0 shad compared with rotenone sampling, and fish standing stock cannot be measured directly (Bayley and Austen 1987, Mounce and Wahl 1989). However, except for age-0 shad, electrofishing can provide accurate estimates of the size structure of gizzard shad populations (Mounce and Wahl 1989).

In this study, I sampled gizzard shad with both electrofishing and gill netting in April and October 1987–1989 to determine the utility of these methods for providing precise estimates of the relative abundance and size structure of gizzard shad populations.

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Methods

Sampling

Gizzard shad were sampled with electrofishing and gill netting during late April and early October 1987–1989 in the Lindly Creek arm of Pomme de Terre Lake and the Sac River arm of Stockton Lake. Both lakes are U.S. Army Corps of Engineers impoundments located in the Ozark Uplands region of west-central Missouri. Pomme de Terre Lake is a 3,167-ha flood control impoundment, and Stockton Lake is a 10,072-ha impoundment used for flood control and hydropower generation. These impoundments are steep sided, fairly deep (mean depth about 10 m), and relatively clear, with secchi depths normally exceeding 1.5 m during the study period. Conductivities average about 240–250 μmho/cm^2 (Hoyer 1981).

Six and 8 fixed sites were sampled each trip for Pomme de Terre and Stockton lakes, respectively. Sites were distributed evenly between cove and main-shoreline areas along the longitudinal axes of the lakes to account for potential spatial differences in gizzard shad distribution.

Shoreline electrofishing was conducted at night (beginning 45 minutes after sundown) with a pulsed, direct current electrofishing boat (200 volts, 6–10 amps). Electrofishing runs lasted from 7 to 25 minutes (mean = 17 minutes) at each site. The boat was kept continually in motion as 1 person collected stunned fish with a dip net. All gizzard shad were counted and measured (total length, mm). Electrofishing catch per unit effort (CPUE) was expressed as number of gizzard shad per hour.

Experimental multifilament gill nets used in 1987 consisted of 7.6-m wide by 1.8-m deep panels of either 13-, 19-, 25-, 38-, and 51-mm square mesh or 19-, 25-, 38-, 51-, and 64-mm square mesh. Because only 2 gizzard shad were collected in the 13-mm mesh and none in the 64-mm mesh, I considered the nets to be equivalent. In 1988 and 1989, gill nets consisted of 6.1-m wide by 1.8-m deep panels of 13-, 19-, 25-, 32-, 38-, 44-, and 51-mm square mesh. Gill nets were set perpendicular to shore and on the bottom at depths of 2 to 6 m (top of net at 0 to 4 m). Gill netting CPUE was expressed as the number of gizzard shad per net day. A net-day consisted of 1 gill net set during the afternoon and retrieved the next day (average time = 21.3 hr, SD = 2.88). All fish captured were kept separate by mesh size, and were counted and measured.

Analysis

Because catches of gizzard shad <120 mm were extremely variable for electrofishing and very low for gill netting, mean CPUE and coefficients of variation of samples (CV_x, SD/mean × 100) were computed separately for gizzard shad < 120 mm and for those ≥120 mm for each gear and sampling trip. Sample sizes (*N*) required for a coefficient of variation of the mean ($CV_{\bar{x}}$, SE/mean × 100, Cyr et al. 1992) to equal 20% were computed for each length group (<120 mm and ≥120 mm), gear, and sampling trip using untransformed data with the formula modified from Cochran (1977):

$$N = (CV_x/CV_{\bar{x}})^2.$$

A $CV_{\bar{x}}$ of 20% represents a moderate level of precision that is acceptable for most management agencies.

To determine if trends in gizzard shad abundance and mean length as estimated by electrofishing and gill netting were similar, mean CPUE and mean length per sampling trip for electrofishing was compared with mean CPUE and mean length from gill netting using Pearson product-moment correlations. Significant positive correlation coefficients would indicate that the 2 gears had consistent sampling biases.

To determine if there were consistent differences in CPUE between April and October, analysis of variance (ANOVA) was conducted on CPUE of gizzard shad ≥120 mm for each gear, using lake, year, and month as main effects. Preliminary ANOVA revealed that habitat type (cove versus main shoreline) had no significant effect on CPUE and was not included in the final model because of inadequate degrees of freedom. The CPUE data was $\log_{10}(X + 1)$ transformed to remove the observed dependency of the variance on the mean CPUE and to normalize the data. All possible interaction terms were included in the model. A significance level of $P = 0.05$ was used for all statistical tests.

Length-frequency distributions for all gizzard shad ≥120 mm were determined for each gear by pooling fish into 10-mm length classes for each sampling trip. Length frequencies between the 2 gears were compared for each sampling trip using 2-sample Kolomogorov-Smirnov (K-S) tests. Probabilities for individual tests were adjusted with the Bonferroni procedure to maintain an overall $P \leq 0.05$.

Results

Relative Abundance

Electrofishing and gill netting CPUE for gizzard shad were temporally and spatially variable. Mean CPUE for gizzard shad <120 mm ranged from nearly 0 to 1,239 fish per hour for electrofishing and 0 to 2 fish per net day for gill

Table 1. Mean catch per unit effort (CPUE) and coefficient of variation for samples (CV) for electrofishing (*N*/hour) and gill netting (*N*/net-day) for 2 length groups of gizzard shad captured from Pomme de Terre and Stockton lakes, 1987–1989. Sample size equals 6 electrofishing runs or gill-net sets per sampling trip for Pomme De Terre Lake and 8 for Stockton Lake. Sample sizes (*N*) required for a CV_x (SE/mean) of 20% are listed.

	Electrofishing						Gill netting					
	<120 mm			≥120 mm			<120 mm			≥120 mm		
Date	CPUE	CV_x	*N*	CPUE	CV_x	*N*	CPUE	CV_x	*N*	CPUE	CV_x	*N*
Pomme de Terre Lake												
1987												
20 Apr	18	187	88	214	74	14	t[a]	155	60	22	43	5
13 Oct	2	169	72	90	64	11	0	0		2	100	26
1988												
25 Apr	11	218	119	99	144	52	2	158	63	9	91	21
11 Oct	23	161	65	339	98	25	0	0		4	80	17
1989												
17 Apr	1,239	74	14	166	53	8	0	0		13	39	4
10 Oct	17	163	66	141	117	34	0	0		9	86	19
Stockton Lake												
1987												
28 Apr	27	229	132	79	66	11	0	0		19	59	9
5 Oct	9	224	125	140	68	12	0	0		22	114	33
1988												
18 Apr	1	185	86	305	79	16	0	0		19	54	8
3 Oct	40	240	144	142	44	5	1	190	91	48	77	15
1989												
24 Apr	204	275	189	198	93	22	0	0		21	131	43
2 Oct	t[a]	283	200	68	82	17	0	0		18	76	15

[a]Trace (t) value <1.

netting (Table 1). No temporal trends in mean CPUE for either gear were evident. Coefficients of variation of samples for both gears usually exceeded 150% and the required number of samples for a $CV_{\bar{x}}$ = 20% usually exceeded 60. Mean CPUE for gizzard shad ≥120 mm ranged from 68 to 339 fish per hour for electrofishing and 2 to 48 fish per net day for gill netting (Table 1). Coefficients of variation of samples ranged from 44% to 144% for electrofishing and 39% to 131% for gill netting. Sample sizes required for a $CV_{\bar{x}}$ = 20% ranged from 5 to 52 runs for electrofishing and 5 to 43 sets for gill netting. Electrofishing and gill netting mean CPUE for gizzard shad ≥120 mm were not significantly correlated for either Pomme de Terre Lake ($r = 0.05$, $P = 0.93$) or Stockton Lake ($r = -0.05$, $P = 0.93$).

Analyses of variance of transformed CPUE of gizzard shad ≥120 mm did not reveal any significant differences by month for either gear. The ANOVA model for electrofishing data was not significant ($P = 0.10$). The ANOVA model for gill netting was significant ($P = 0.0001$), but month did not have a significant effect on CPUE. Lake was highly significant in this model ($P = 0.0001$) because CPUE was higher in Stockton Lake than in Pomme de Terre Lake. The lake by month and year by month interaction terms were significant ($P = 0.0003$ and $P = 0.05$, respectively), indicating that the effect of month varied with lake and year.

Size Structure

Length-frequency distributions of gizzard shad ≥120 mm collected by electrofishing and gill netting were temporally variable (Figs. 1, 2). Length frequencies were significantly different (K-S tests, overall $P < 0.05$) between the 2 gears on one-third of the sampling trips for Pomme de Terre Lake and on all but 1 of the sampling trips for Stockton Lake. Gill nets captured proportionally fewer fish <180 mm than electrofishing. Correlations between mean length of gizzard shad captured by electrofishing and gill netting were not significantly correlated for either lake ($P > 0.64$).

Discussion

It is unknown if either electrofishing or gill netting provided accurate estimates of the relative abundance or size structure of gizzard shad because actual population characteristics were unknown. However, electrofishing was more efficient at collecting larger numbers and size ranges of gizzard shad than gill netting. It would have required an average of 10 gill net sets to capture as many gizzard shad ≥120 mm as in 1 hour of electrofishing. Neither electrofishing nor gill netting provided precise estimates of CPUE. Electrofishing usually captured proportionally more smaller fish, while still sampling the largest fish captured with gill netting.

Relatively few small fish were captured by gill nets, partly because the small mesh sizes necessary to capture these fish are less efficient than the larger mesh

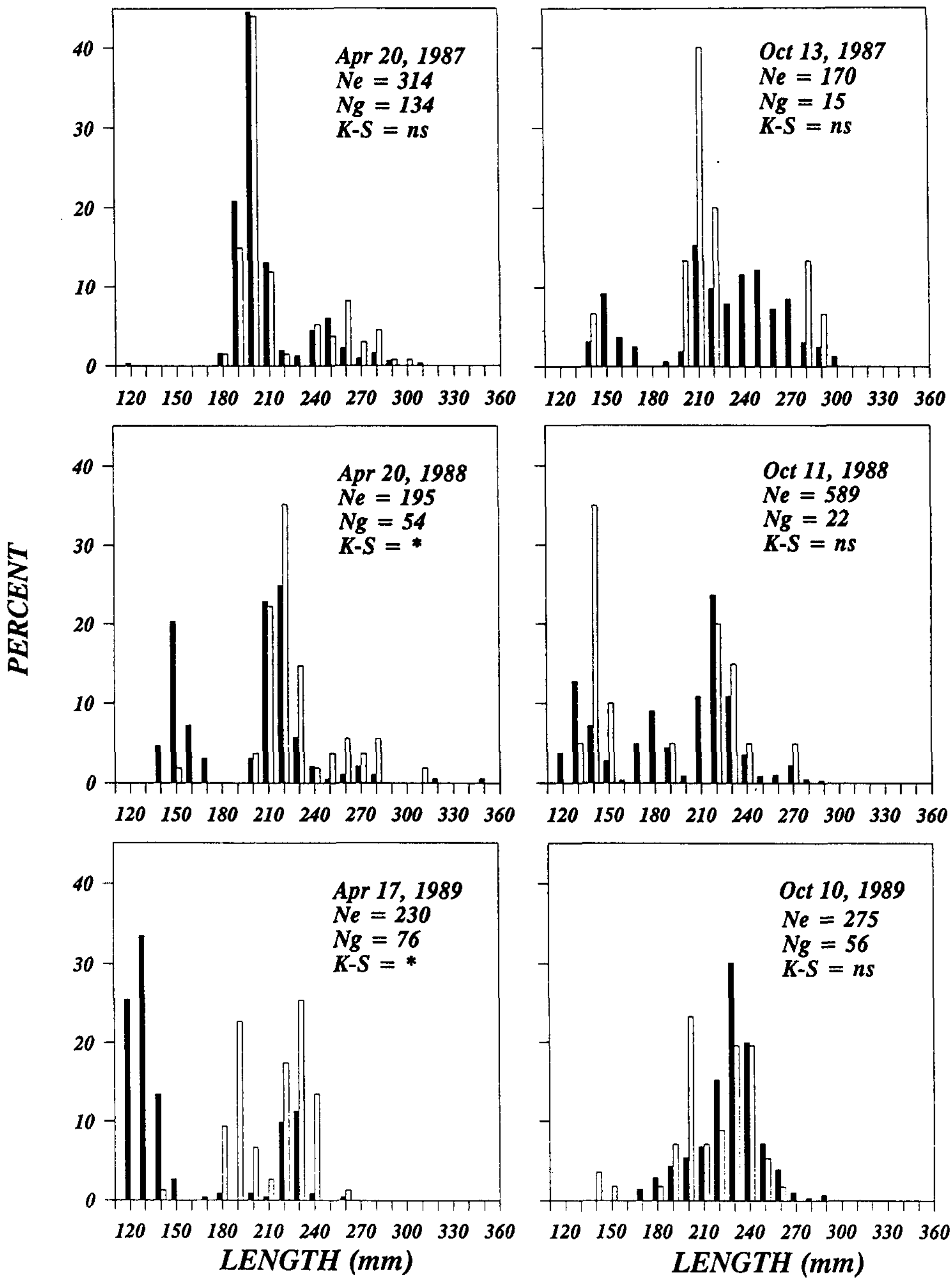

Figure 1. Length frequencies (%) of gizzard shad (≥120 mm) caught by electrofishing (solid bars) and gill netting (open bars) from Pomme de Terre Lake, 1987–1989. Ne and Ng indicate sample sizes for electrofishing and gill netting, respectively. Significant (*, $P \leq 0.05$) and non-significant differences (ns) are indicated for Kolomogorov-Smirnov (K-S) tests.

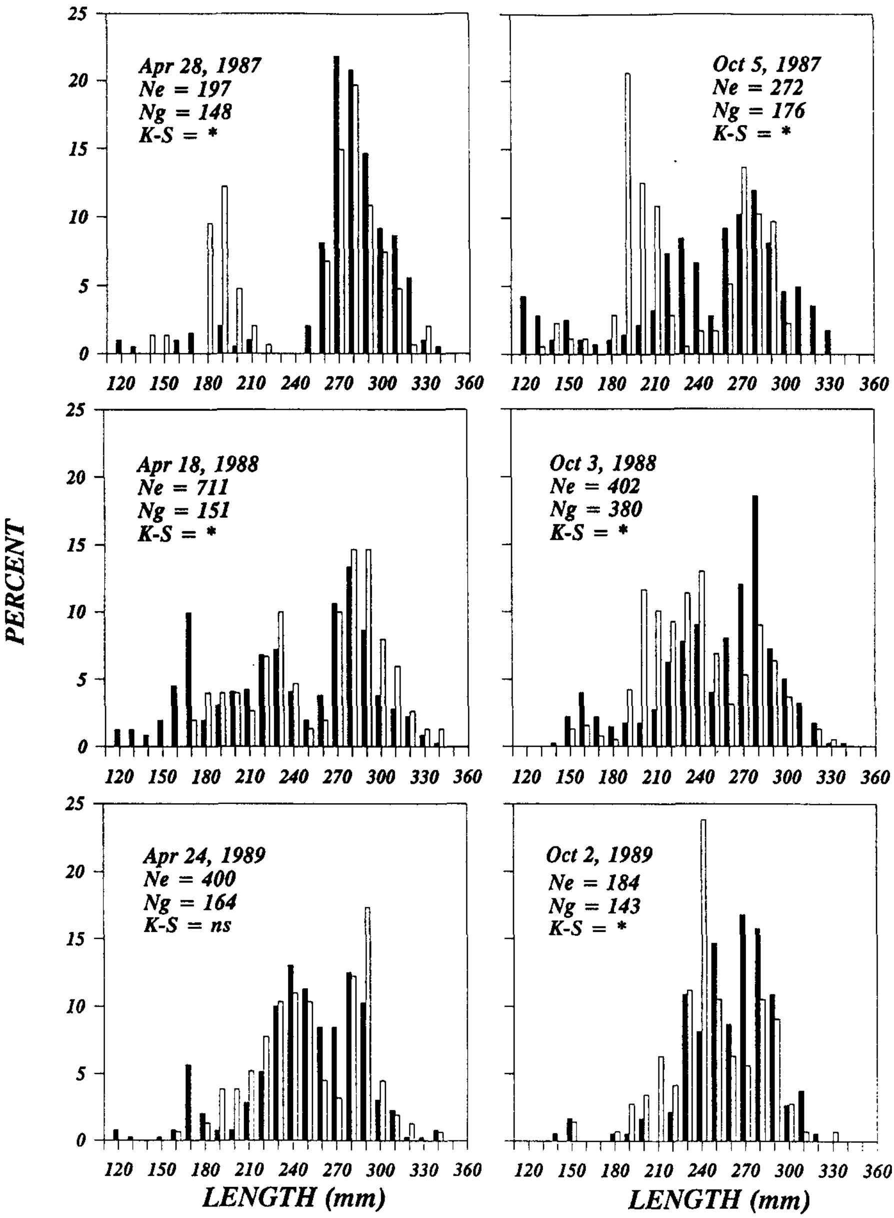

Figure 2. Length frequencies (%) of gizzard shad (≥120 mm) caught by electrofishing (solid bars) and gill netting (open bars) from Stockton Lake, 1987–1989. Ne and Ng indicate sample sizes for electrofishing and gill netting, respectively. Significant (*, $P \leq 0.05$) and non-significant differences (ns) are indicated for Kolomogorov-Smirnov (K-S) tests.

sizes (Hamley 1975). Additionally, small fish may have been more surface-oriented and not as available to the gill nets which sampled deeper water. I observed young gizzard shad swimming close to the surface during both spring and fall. The differences in length frequencies of gizzard shad collected by the 2 methods could have been caused by differences in gear efficiencies or in the size structure of fish available to each gear. However, it seems likely that electrofishing provides a more accurate estimate of small-sized gizzard shad CPUE.

The ANOVA indicated that sampling in either April or October yielded similar estimates of CPUE. Neither month proved superior in increasing the precision of CPUE. Consequently, other considerations may dictate when it is best to sample. If information on spawning adults is needed, it may be best to sample in April prior to or during spawning. Conversely, if size and condition of fish near or at the end of the growing season is needed, then October sampling would be appropriate.

Although only 1 person collected stunned fish during electrofishing in this study, I recommend that 2 persons be used. Because of their schooling nature, gizzard shad tend to occur in large groups, making it difficult for 1 person to collect them all. This is especially true when CPUE increases beyond 200 fish per hour.

In summary, electrofishing was more efficient in collecting large numbers of gizzard shad and was less size-biased than gill netting. Electrofishing may be a viable alternative to cove rotenoning. The CV_xs for electrofishing CPUE fell into the range estimated from rotenone surveys (summarized by Johnson et al. 1988). Electrofishing runs require far less effort than do rotenone surveys and, as a result, sample sizes can be increased much easier. Also, electrofishing can be accomplished in a greater variety of habitats and need not be restricted to shallow shorelines or coves.

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