Sampling Stream Centrarchids: Comparing Electrofishing and Underwater Observation

Danny D. McClendon, *Missouri Cooperative Fish and Wildlife Research Unit,[1] School of Forestry, Fisheries and Wildlife, 112 Stephens Hall, University of Missouri, Columbia, MO 65211*

Charles F. Rabeni, *Missouri Cooperative Fish and Wildlife Research Unit,[1] School of Forestry, Fisheries and Wildlife, 112 Stephens Hall, University of Missouri, Columbia, MO 65211*

Abstract: We compared electrofishing and underwater observations as different methods for estimating population characteristics of centrarchids in a medium-sized warmwater stream in Missouri. We evaluated how well each method determined length-frequency distribution of smallmouth bass (*Micropterus dolomieui*), rock bass (*Ambloplites rupestris*), and longear sunfish (*Lepomis megalotis*). Underwater observation was the more accurate technique, producing length-frequencies more typical of a catch curve. When compared to underwater observations, electrofishing sampled the largest size class of fish effectively, but not the smallest size classes. Electrofishing efficiency was species specific and was related to habitat preferences and fish behavior. Correction factors, developed from observational data, can be used to increase the accuracy of electrofishing data. An evaluation of recapture methods from mark-recapture analysis, after initial marking by electrofishing, showed recapture by observation to be no better than recapture by electrofishing.

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Capturing fish by electroshocking is a technique widely used by fishery biologists (Simpson and Reynolds 1977) and is often the only method of fish collection used in surveys and other studies. Despite its importance, little is known about how well electrofishing samples represent the actual stock present. Most evaluations have been carried out in lentic situations (e.g., Sanderson 1960, Swingle et al. 1966). Because electrofishing efficiency is influenced by characteristics of the fish and prevailing limnological conditions, it cannot be assumed that the results of these studies are necessarily applicable to other habitats. The few published reports on electrofishing in warmwater streams suggest that sampling efficiency is low (Jacobs

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and Swink 1982) and a function of both species (Larimore 1961) and size (Sullivan 1956); however, little quantifications of these relations has been made.

Underwater observations have been valuable in fisheries studies but have been generally limited to lentic situations (Hall and Werner 1977, Keast and Harker 1977, Turner and Mackay 1985) or small coldwater streams (Reed 1967, Everest and Chapman 1972, Griffith 1981, Schill and Griffith 1984). Evaluation of the technique in warmwater streams has only been documented in small, shallow streams (Goldstein 1978, Whitworth and Schmidt 1980). The approach that we used was to compare the length-frequency distributions of smallmouth bass, rock bass, and longear sunfish, collected by electrofishing with those derived from underwater observations. Size structure was examined because it is directly useful in assessing community and population structure (Anderson 1976), and because any size selectivity imposed by electrofishing can influence other estimates such as density and biomass (Sullivan 1956). We also evaluated underwater observation as a "recapture" technique using fin-clipped fish from the initial electrofishing sample for a mark-recapture population estimate. Finally, correction factors were developed for each species from the observational data, which would minimize size bias associated with electrofishing data.

The purpose of this study was to evaluate the efficacy of underwater observation as a fish census tool in a medium-sized warmwater stream, and examine how observational data could aid in studies that used electrofishing as the primary sampling tool.

Methods

Jacks Fork River, in south-central Missouri, supports an important recreational fishery and is a typical Ozark stream with clear water and a variety of physical habitat conditions. Fish were easily observed at distances of 6 m. Typical mean stream characteristics were annual discharge 12.5 m^3/second; alkalinity as $CaCO_3$, 165 mg/liter; turbidity 1 JTU; and dissolved oxygen at saturation. We termed this stream medium sized, where mean pool widths were 28 m, and mean maximum depth of pools was 2.1 m (Table 1).

Sixty-three species of fish have been collected from Jacks Fork River with suckers (Catostomidae), sunfish (Centrarchidae), and minnows (Cyprinidae) comprising most of the biomass. Smallmouth bass and rock bass are the major sportfish sought while longear sunfish are the most abundant, and probably most often caught, centrarchid. Smallmouth bass >150 mm in total length occurred at mean densities of 113/ha and biomasses of 23 kg/ha. Corresponding values for rock bass >135 mm were 107/ha and 13 kg/ha; for longear sunfish >100 mm there were 428/ha and 18 kg/ha (McClendon and Rabeni 1987).

We selected 10 sites from the Jacks Fork River for sampling in the summer of 1983 (Table 1). All sites included pools and runs with shallow riffles at each end. Fish were captured from a 4.9-m boat equipped with a 220-volt, DC electrofishing unit with electrical outputs of 3–10 amperes and 150–250 volts. The lower lobe of

Table 1. Morphometry of 10 study sites used for both underwater observation and electrofishing on the Jacks Fork River.

Variable	Site									
	1	2	3	4	5	6	7	8	9	10
Surface area (hectare)	0.26	0.52	0.61	0.91	0.25	1.31	0.50	0.55	0.80	0.30
Volume (m^3)	3,257	5,789	8,461	9,172	1,085	14,156	4,432	5,950	6,613	4,905
Mean width (m)	28.5	26.3	33.7	26.0	14.9	35.5	24.8	32.2	23.5	18.9
Mean depth (m)	0.9	1.1	1.0	1.8	0.6	1.0	0.9	0.8	0.8	1.0
Maximum depth (m)	1.8	4.0	2.4	2.2	1.3	3.0	2.1	2.8	1.6	3.0
Mean velocity (cm/second)	22	10	9	13	25	9	35	27	22	53
Maximum velocity (cm/second)	55	44	41	41	81	40	71	67	91	165
Gradient	1.19	1.19	1.33	1.31	1.31	1.33	1.33	1.33	1.33	0.99

the caudal fin was clipped on each fish from the initial electrofishing run in order to estimate densities by Chapman's modification of the Petersen formula (Ricker 1975) for the mark-and-recapture method using electrofishing and also to enable a diver to distinguish a marked fish in subsequent underwater runs. Sites were resampled using electrofishing approximately 10 days after the initial electrofishing run. Observational estimates were made within 15 days of the initial electrofishing.

Each site was swum once using wetsuit, fins, mask, and snorkel. Observations were made along the periphery of the sites and along the open, mid-water area. Whenever a fish was encountered, species, total length, and whether a fin was clipped or not were recorded on an opaque acetate sheet with a grease pencil. The sheet was marked off in centimeters along 1 edge and total length estimations were verified by marking visual reference points of snout and caudal fin on the substrate. With practice, lengths of the fish were easily judged to the nearest centimeter without the stream-bed measurement. The presence of a diver did not seem to cause the fish to be alarmed and most would initially orient themselves toward the diver, a behavior that has been noted by other divers monitoring fish populations (Keenleyside 1962, Northcote and Wilkie 1963, Schneberger 1977, Probst et al. 1984).

Results

Length-frequency Comparisons

Given equal time effort for both techniques, underwater observations consistently collected more total fish and more fish from smaller size classes than did electrofishing for 2 of the 3 species. For smallmouth bass >200 mm, there was no significant difference between length-frequency distributions for the 2 methods at 8 of 10 study sites (X^2 test of association, $P \leq 0.05$) (Fig. 1). The other 2 sites had no significant difference in frequency distributions between the 2 methods for fish >300 mm. When all sites were combined, there was no significant difference in frequency distributions between the 2 methods for size classes >200 mm (X^2 test of association, $P \leq 0.05$) (Fig. 1).

For rock bass, catch per unit effort for the 2 methods was similar. There were no significant differences in length-frequency distributions, for all size classes, between the 2 methods for 7 out of 10 study sites (X^2 test of association, $P \leq 0.05$) (Fig. 2). For all 10 sites combined, there were no significant differences in length-frequency distributions between the 2 methods for any size class (X^2 test of association, $P \leq 0.05$).

For longear sunfish, the length frequencies of the 2 methods did not coincide well. Only 2 out of 10 sites had no significant differences between the 2 methods for all size classes (Fig. 3). Electrofishing tended to severely underestimate the smaller size classes (<100 mm) (Fig. 3).

Although the true length frequencies were not known, the observation results most closely approximate what would be considered a normal catch curve for longear sunfish and smallmouth bass, while rock bass results were quite similar for both methods.

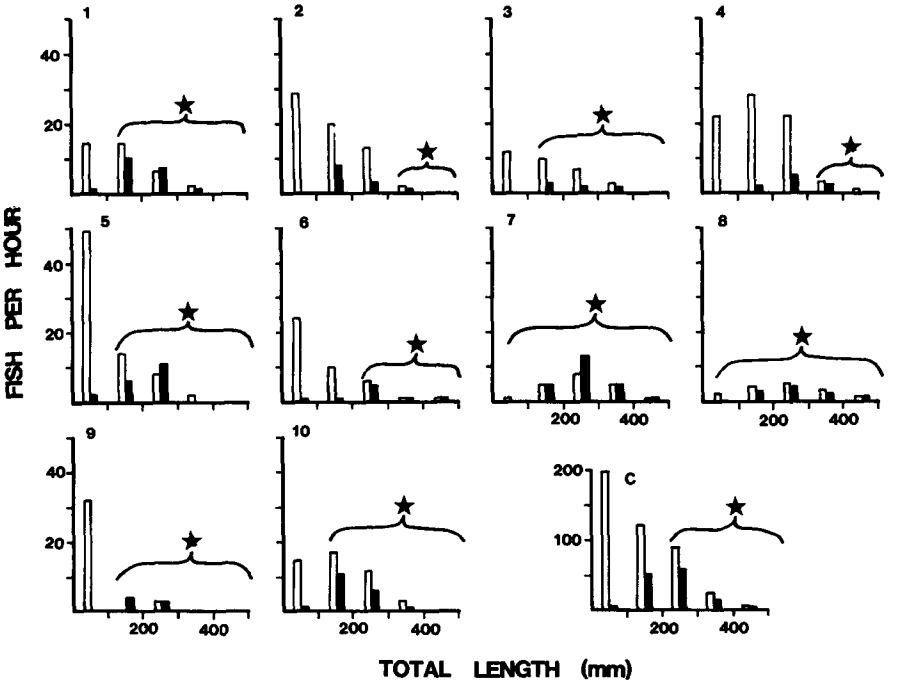

Figure 1. Catch per hour length frequencies for underwater observations and electrofishing for smallmouth bass from the 10 study sites. Open bars are underwater and solid bars are electrofishing. Stars indicate no significant differences between length frequency distributions (X^2 test of association, $P \leq 0.05$) for size classes. Site numbers in upper left of each graph except last graph (C), which is all sites combined.

Percent Recapture

In a population estimate using mark-recapture, capture probability of a fish may change greatly after the first capture. Because precision of estimates increases with increasing recaptures, we evaluated whether density estimates could be improved by using a different recapture technique (observation) from that of the original marking run (electrofishing) by examining the percent recapture of various size classes by each method (Table 2).

Recapture percentages of smallmouth bass by size classes (Table 2) indicate that electrofishing had a somewhat higher percentage recapture for the largest size class, while the other size classes were similar. For rock bass, the percentage recapture by size classes for both methods was similar only for fish <150 mm long (Table 2), but neither method consistently produced higher percentage recaptures of larger fish. The smallest size class had no fish marked after electrofishing; therefore, these fish were not available for visual underwater recapture. The percentage recaptures

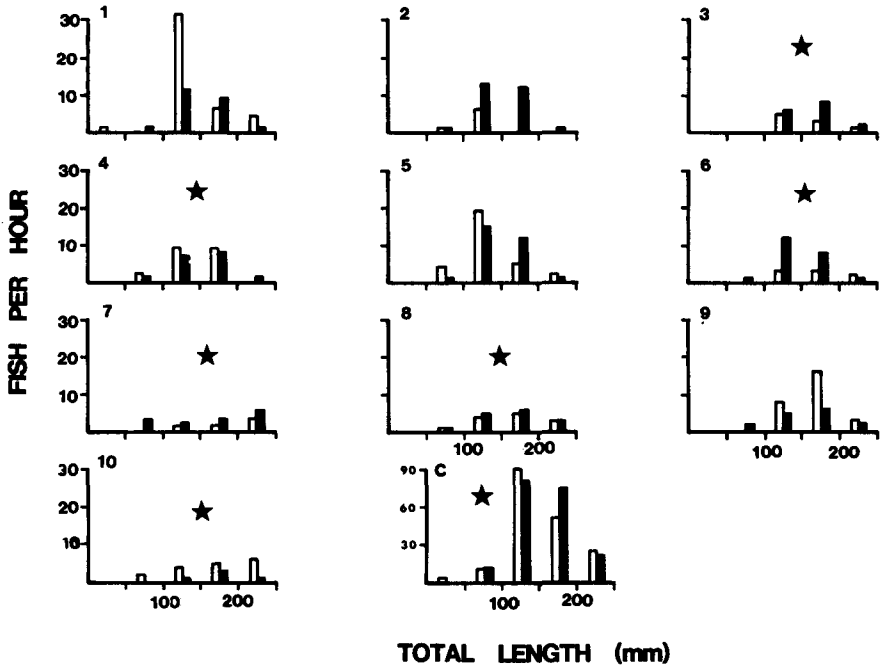

Figure 2. Catch per hour length frequencies for underwater observations and electrofishing for rock bass from the 10 study sites. Open bars are underwater and solid bars are electrofishing. Stars indicate no significant differences between length frequency distributions (X^2 test of association, $P \leq 0.05$) for size classes. Site numbers in upper left of each graph except last graph (C), which is all sites combined.

for longear sunfish were similar for each size class with each method (Table 2). We therefore concluded that for all species, mark-recapture population estimates using observation as the recapture technique would be no more efficient than using electrofishing on both sampling runs.

Correcting for Electroshocking Bias

We assumed length frequencies derived from underwater observation more closely represented the actual length frequency of the population. Correction factors applied to the electrofishing data (Table 3) were determined from the combined relative abundances of underwater observation for each species (Fig. 1C, 2C and 3C). Beginning with the largest fish from the observational data, we calculated the percent difference between adjacent size classes and corrected the electrofishing data accordingly (Table 3). No correction factors were made for the smallest size classes of longear sunfish or rock bass, and we concluded they were not adequately

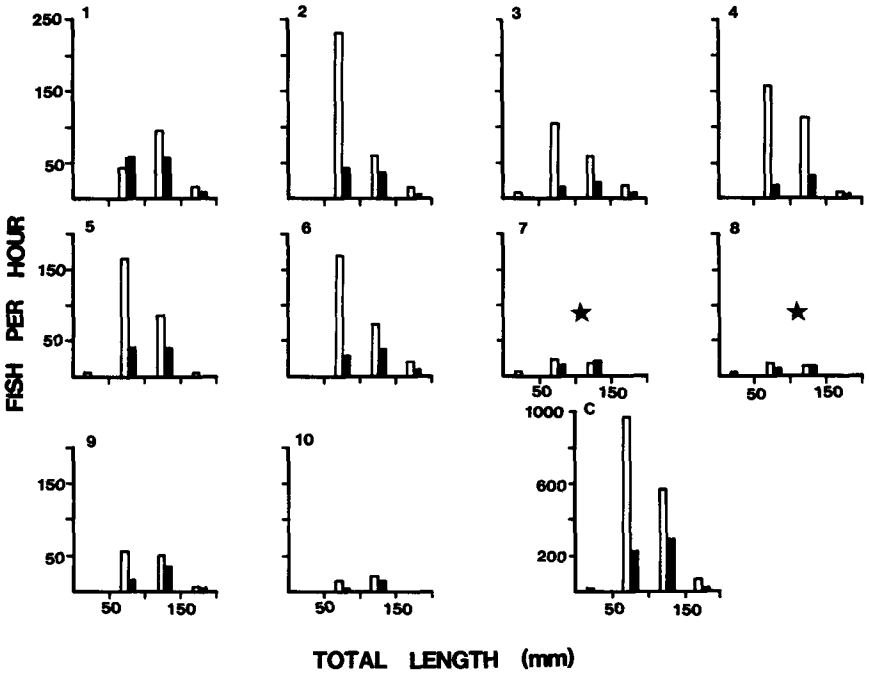

Figure 3. Catch per hour length frequencies for underwater observations and electrofishing for longear sunfish from the 10 study sites. Open bars are underwater and solid bars are electrofishing. Stars indicate no significant differences between length frequency distributions (X^2 test of association, $P \leq 0.05$) for size classes. Site numbers in upper left of each graph except last graph (C), which is all sites combined.

Table 2. Total percent recaptures by size class for underwater observations and electrofishing for smallmouth bass, rock bass, and longear sunfish.

	Percent recaptures					
	Smallmouth bass		Rock bass		Longear sunfish	
Size class (mm)	U[a]	E	U	E	U	E
≤49			–	–	0	0
50– 99	1	0	7	6	6	6
100–149			19	28	22	25
150–199			51	35	32	30
100–199	30	22				
200–249			25	50		
200–299	40	40				
300–399	37	36				
400–499	10	25				

[a]U = underwater observations; E = electrofishing.

Table 3. Factors used to correct for bias, derived from capture probabilities comparing electrofishing data to underwater observations. To use, multiply factor by the electrofishing result for the appropriate size class.

Size class (mm)	Smallmouth bass	Rock bass	Longear sunfish
≤49	–	–	–
50– 99	27	1	2.1
100–149		1.5	1
150–199		1	1
100–199	1.8		
200–249		1	
200–299	1		
300–399	1		
400–499	1		

sampled by either method. Generally, the smaller the fish, the greater the correction factor. Rock bass results of fish 50–100 mm represent either an inability to sample this size by either method, in which case they should not be included in any population estimate, or that there are missing year classes.

Discussion

Similarity of catch per unit effort between the 2 methods for the larger size classes of smallmouth bass is probably due to their high vulnerability for both methods. Larger fish were easier to observe than small fish. Probst et al. (1984), using underwater observations found that most smallmouth bass in the Jacks Fork River were positioned near cover rather than intimately associated with it, which made fish more visible. The smallest size class of rock bass was not collected by either method. This is probably due to their cryptic coloration and secretive nature (Pflieger 1975); even when immobilized by electroshocking, their placement in vegetation and rootwads makes them difficult to see and net.

Longear sunfish length frequencies by both methods were not similar; underwater observation had by far the most fish sampled. Differences between the 2 methods may be due to behavior patterns. Underwater observation was done during daylight, while electrofishing was conducted at night. Probst et al. (1984) found that longear sunfish were in open water during the day but shifted to heavy cover at night. Fish in boulders, deeper water, and heavy woody cover may not have been sampled as easily with electrofishing; they could have been more visible and easily observed out of cover with underwater observation during daylight hours.

Conclusion

Our results confirmed the suspected bias of electrofishing in which smaller size classes tend to be underestimated. However, the degree of under-representation

appeared to be species specific and related to the fish's behavior. Underwater visual observation was superior to electrofishing in determining population size structure. Where electrofishing must be used, for example with mark-recapture density estimates, underwater observation was valuable in determining correction factors to account for electrofishing biases.

For smallmouth bass and longear sunfish, underwater observation is a method that can sample smaller size classes not effectively sampled by electrofishing. This technique could allow fishery managers to sample these size classes of fish to better determine annual production, mortality, and size structure population. Underwater observations coincide with the findings of the electrofishing for larger size classes of smallmouth bass and all size classes of rock bass. Therefore, either method would be applicable for sampling these larger size classes in the Jacks Fork River. Underwater observations used as the recapture technique in mark-recapture density estimates did not increase the precision of the estimate over that determined from only electrofishing runs.

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