USING SNORKELING TO QUANTIFY FISH ASSEMBLAGE STRUCTURE IN ARKANSAS STREAMS

David G. Lonzarich, Mary E. Lonzarich, and Melvin L. Warren, Jr.[1]

Abstract—As a technique for surveying fish populations in low diversity, clear streams of the Pacific Northwest, snorkeling is a commonly used alternative to electrofishing. While the method is becoming more widely used in the high diversity streams of eastern North America, its efficacy as a tool for surveying fish assemblages in these streams is not known. In this study, we compared results from snorkeling and electrofishing surveys obtained from two clear, warmwater streams of the Ouachita Mountains, Arkansas. Surveying only water column species, we found that fish assemblage structure and species density estimates obtained by the two methods were statistically indistinguishable. These results have important implications for ecologists studying warmwater streams as snorkeling holds many advantages over invasive sampling methods, such as seining and electrofishing.

INTRODUCTION

When planning fish surveys, stream ecologists can choose from a variety sampling techniques, although seining, electroshocking, and underwater observation are the most widely used. Seining and electroshocking are both invasive sampling methods that traditionally have been favored in most stream surveys, especially in studies that do not require repeated measurements (e.g., collections of baseline population data, microhabitat use or feeding). Unfortunately, as with all sampling methods, seining and electrofishing possess potentially severe limitations. For example, habitat conditions can dramatically affect seining success. In streams with uneven bottoms and physical obstacles, such as large rocks, vegetation or woody debris, seining efficiency can be very low. Electrofishing is more effective under these conditions, but it too can suffer limited efficiency (e.g., Riley and Fausch 1992). Importantly, electrofishing can injure or kill collected individuals, an especially serious problem in waters with endangered or recreationally important fishes (Nielsen 1998). Finally, all invasive methods require the handling of individuals to retrieve necessary data. At worst, handling can cause injuries or death; at best, it may affect the behaviors of sampled individuals.

In many situations, snorkeling may be a solution to the limitations of invasive sampling. Snorkeling, which has advantages of versatility and cost effectiveness, can provide information on the composition, distribution, abundance, and behavior of fishes in streams (Dolloff and others 1996). Snorkeling is widely used in small, clear streams of the Pacific Northwest, especially in studies of trout and salmon (e.g., Hankin and Reeves 1988, Hillman and others 1992). Snorkeling provides several major benefits. A variety of habitat conditions can be surveyed in relatively short periods of time, and labor and equipment costs are low compared to other techniques. Importantly, fishes are not collected or handled in snorkeling surveys. Hence, studies requiring repeated observations (e.g., movement studies) are not compromised by handling stress, which can adversely affect behaviors of interest to the researcher and the experimental results (Lonzarich and others 1998, Lonzarich and others, in press). Moreover, survey efficiency is not impeded by physical factors such as wood, undercut banks, or uneven substrates. A major drawback to snorkeling is the requirement for clear waters with very high visibility > 2 m, (Whitworth and Schmidt 1980). Depending on the study objectives, snorkeling surveys also may require specialized training of observers to assure accurate, underwater identification of fishes.

Several studies have assessed the efficacy of snorkeling in low diversity, clear streams of the Pacific Northwest. The method can yield very precise results (e.g., Hillman and others 1992, Dolloff and others 1996), but efforts to assess snorkeling accuracy are difficult because true population densities are usually unknown (Dolloff and others 1996). In the more species rich streams of eastern North America, the precision and accuracy of this technique as a tool to survey fish assemblages are poorly documented. In two other studies, we monitored changes in the population and assemblage structure of stream pools. In conjunction with that research, we report here a study conducted to assess the effectiveness of snorkeling as a census method in streams of the Ouachita Mountains, Arkansas. Surveying water column fish species in two moderately diverse streams, our objective was to compare estimates of population density and assemblage structure from snorkeling with results obtained by backpack electrofishing.

METHODS

We conducted electrofishing and snorkeling surveys between June and July 1995 in two tributaries of the Little Missouri River in the Ouachita National Forest, Arkansas (34°22′30″ lat and 93°52′30″long). Long and Blaylock creeks are relatively short (< 10 km), low gradient systems that flow through forested and mountainous terrain. General characteristics of the streams included bedrock, cobble, and gravel substrates and dense riparian vegetation. Using habitat inventory data (Clingenpeel 1994) and data from our own surveys, we selected 12 pools in the two streams. For each

[1] Assistant Professor and Consultant, University of Wisconsin, Eau Claire, Department of Biology, Eau Claire, WI 54702; and Research Biologist, USDA Forest Service, Southern Research Station, Center for Bottomland Hardwoods Research, Oxford, MS 38655, respectively.

Citation for proceedings: Guldin, James M., tech. comp. 2004. Ouachita and Ozark Mountains symposium: ecosystem management research. Gen. Tech. Rep. SRS–74. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 321 p.

pool, we measured total length, width, area, maximum depth, and substrate composition (i.e., boulder, cobble, and gravel). We also measured biological characteristics including species richness, total assemblage densities, and individual species densities.

Fish Surveys

Fish species composition, rank dominance, and densities in Long and Blaylock creeks are very similar (Lonzarich and others 1998). In this study, we focused on a subset of fish species. Because of concerns over sampling efficiency, we did not include small, juvenile fish (< 25 mm) or bottom dwelling species that often hide within the substrate and can be difficult to locate without considerably increasing survey times. We excluded four bottom dwelling species from the survey: northern hog sucker, *Hypentelium nigricans* (Lesueur); orangebelly darter, *Etheostoma radiosum* (Hubbs and Black); greenside darter, *E. blennioides* Rafinesque; and yellow bullhead, *Ameiurus natalis* (Lesueur). Numerically, these species and small juveniles were a minor component of the pool assemblages, accounting for less than 10 percent of all fish collected by electrofishing (Lonzarich and others 1998). We included seven target species in the surveys: central stoneroller, *Campostoma anomalum* (Rafinesque); striped shiner, *Luxilus chrysocephalus* (Rafinesque); redfin shiner, *Lythrurus umbratilis* (Girard); bigeye shiner, *Notropis boops* Gilbert; northern studfish, *Fundulus catenatus* (Storer); creek chub, *Semotilus atromaculatus* (Mitchill); longear sunfish, *Lepomis megalotis* (Rafinesque); and smallmouth bass, *Micropterus dolomieui* Lacepede.

For each survey, we first snorkeled and then immediately electrofished the study pool. We began snorkeling surveys at the downstream end of the pool, continued in a zig-zag fashion to the upstream end of the pool, and then snorkeled downstream. We considered this a single pass, which generally took less than 30 min to complete. We counted fish individually except when fish were aggregated; for aggregations, we estimated numbers by counting individuals in groups of 5 to 10 individuals. To minimize observer error, the same observer conducted surveys of all pools censused. Each survey consisted of two passes with the average of the two counts used in all statistical analyses.

Immediately after the snorkeling survey, we electrofished experimental pools, isolating them with 6-mm mesh block seines and sampling with a Smith Root battery powered, backpack electrofisher. We sampled pools four to seven times until no fish were collected on two consecutive passes. Because of this intensive sampling effort and because we identified fish in the field, surveys of individual pools took 3 to 4 h to complete. We evaluated the effectiveness of the electrofishing technique in removing all target species by conducting snorkeling surveys in the isolated pools immediately upon the completion of sampling. In post-electrofishing snorkeling surveys of 6 of the 12 pools, we observed only 3 fishes from the target group of species.

Data Analysis

We estimated the efficiency of snorkeling relative to electrofishing. To do so, we compared assemblage structure (i.e., species richness, percent similarity, and total numbers) and species abundance (fish per m^2) results from snorkeling surveys with results from electrofishing surveys. We compared assemblage similarity using the Percent Similarity Index (Wolda 1981). We used correlation analysis to evaluate the strength of relationships between the two methods. When data met the assumption of normality, we used the Pearson Product Moment analysis. Otherwise, we used Spearman Rank analysis. We compared species and assemblage density estimates for the two methods by a two-sample t-test ($P < 0.05$).

RESULTS

Snorkeling surveys yielded results that were very comparable to those obtained in electrofishing surveys. With respect to the total number of fish per pool, estimates for the two methods were highly correlated (Pearson product moment correlation coefficient, $r^2 = 0.98$, n = 12, fig. 1). On average, total counts from snorkeling observations were within 10 percent of the total counts from electrofishing surveys (1.03 fish per m^2 versus 1.13 fish per m^2, respectively). Neither size of pool nor size of pool assemblages (range, 63 to 656 individuals per pool) affected this level of precision.

Estimates of assemblage structure (species composition, rank abundance, and relative abundance) for the two methods also were very similar. Across the 12 pools, we missed species in snorkeling surveys that were captured by electrofishing on only two occasions (out of 82 possibilities). Similarly, on a single occasion, we missed only one species in electrofishing surveys that we observed snorkeling. Correspondence in the rank abundance of species for the two methods was very high (Spearman Rank correlation coefficient, average = 0.97; range, 0.87 to 1.00). The relative abundances of species for each method also were very

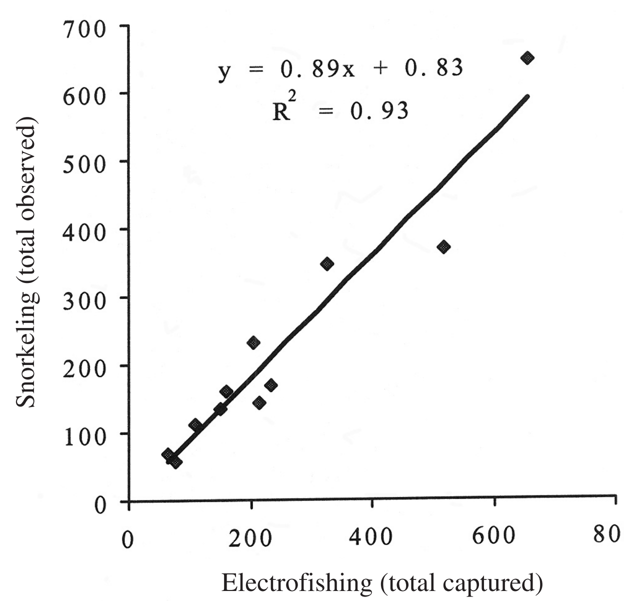

Figure 1—The relationship between electrofishing and snorkeling estimates (total counts per pool) for 12 experimental pools in Long and Blaylock Creeks, Ouachita Mountains, Arkansas.

Table 1—Comparison of mean fish densities[a] estimated from electrofishing and snorkeling surveys of 12 treatment pools in Long and Blaylock Creeks, Ouachita Mountains, Arkansas

Species	Snorkeling	Electrofishing	Difference
			Percent
Central stoneroller	50.5 ± 13.4	51.6 ± 10.8	2
Striped shiner	30.0 ± 6.1	30.0 ± 6.5	0
Longear sunfish	7.4 ± 1.6	10.4 ± 2.3	29
Creek chub	7.5 ± 3.2	9.3 ± 4.1	19
Northern studfish	2.5 ± 0.7	5.4 ± 1.7	54
Redfin shiner	2.3 ± 0.8	2.0 ± 0.6	15
Bigeye shiner	1.1 ± 0.6	1.9 ± 1.1	42
Smallmouth bass	1.6 ± 0.4	1.9 ± 0.5	16
All species	103.2 ± 14.5	113.2 ± 12.6	8

[a] Individuals/100 m^2 ± 1 standard error of the mean.

comparable, with an average assemblage similarity of 91 percent across the 12 pools (range, 84 to 94 percent).

Snorkeling proved to be nearly as effective as electrofishing in estimating species densities. On average, snorkeling estimates for the eight target species were slightly lower than electrofishing densities (table 1). Snorkeling efficiency was not related to abundance. Estimates for the two most common species, central stoneroller, and striped shiner, were nearly identical to electrofishing estimates (table 1). The weakest relationships were for northern studfish (54 percent deviation), longear sunfish (29 percent deviation) and bigeye shiner (42 percent deviation). However, neither these nor any other snorkeling and electrofishing estimates of species densities were significantly different (t-test, $P >$ 0.25, table 1). We attribute the northern studfish results to our failure to recognize their preference for shallow, marginal habitats in early surveys. Our efficiency likely improved in later surveys as we became more aware of their patterns of habitat use. We believe the longear sunfish results likely reflect their use of cover in the presence of a snorkeler, whereas the bigeye shiner finding is related to their rarity in the study pools.

DISCUSSION

Because we removed all target fish species from experimental pools during electrofishing surveys, we were able to simultaneously compare the effectiveness of snorkeling against electrofishing and to determine its accuracy. At least for the water column species targeted, our results show that snorkeling is a very accurate method for characterizing fish assemblage and species abundance patterns in small, clear warmwater streams. Our findings have several important implications. First, snorkeling required much less survey time (0.5 h versus 3 to 4 h) and labor than electrofishing. Hence, more area can be sampled by snorkeling than by electrofishing or seining. Second, snorkeling, unlike electrofishing, does not adversely affect surveyed fishes and can be used to describe short-term changes (e.g., days, weeks) in populations and assemblages. As we demonstrated elsewhere (Lonzarich and others 1998) (Lonzarich, D.G.; Lonzarich, M.R.; Warren, M.L., Jr. Effects of riffle length on the short-term movement of fishes among stream pools. Manuscript in preparation.) repeated snorkeling surveys can be used to quantify the daily movements of fish and their patterns of recolonization following disturbance. Recently, we repeatedly snorkeled pools in one Arkansas stream over the course of a summer to determine pool specific patterns of extinction and colonization of water column species (Lonzarich, D.G.; Lonzarich, M.R.; Warren, M.L., Jr. Effects of riffle length on the short-term movement of fishes among stream pools. Unpublished data. On file with: D. Lonzarich, University of Wisconsin, Eau Claire, Department of Biology, Eau Claire, WI 54702). Previously in this same region, Matthews and others (1994) used snorkeling to repeatedly census fishes from 14 pools over a 19-month period.

While advocating snorkeling surveys for selective fisheries applications, we are mindful of its many limitations. For example, although benthic species (e.g., darters, catfish, suckers) can be censused in snorkeling surveys, they likely cannot be surveyed by snorkeling as efficiently as water column species. Further, inclusion of benthic fishes would probably add significantly to the time needed to complete an assemblage survey. Nonetheless, in studies of clear streams, where it is not necessary (and possibly detrimental) to handle fish, the technique has important advantages over invasive sampling methods.

ACKNOWLEDGMENTS

Research support was provided through two projects “The Spatial Distribution and Size of Stream Habitat Patches: Consequences to Stream Fishes” dated August 1, 1996 through August 1, 1997 of Cooperative Agreement 30-CA-96-053 and “Trophic Dynamics in Streams: Effects of Habitat Isolation” dated June 1, 1999 through May 1, 2001 of Cooperative Agreement 33-CA-99-623.

We are grateful to the Ouachita National Forest for granting access to Long and Blaylock Creeks and to J. Guldin for administrative support. We are deeply indebted to both A.

Clingenpeel and B. Crump for logistical assistance while we were in the field. The work was funded by the USDA Forest Service, Southern Research Station, Ouachita Mountain Ecosystem Management Research Project.

LITERATURE CITED

Clingenpeel, J.A. 1994. A cumulative effects analysis of silvicultural best management practices using Basin Area Stream Survey (BASS) methods. Hot Springs, AR: U.S. Department of Agriculture, Forest Service, Southern Region, Ouachita National Forest. 53 p.

Dolloff, A.; Kershner, J.; Thurow, R. 1997. Underwater observation. Chapter 18. In: B.R. Murphy and D.W. Williss (eds.) Fisheries Techniques. 2nd edition. Bethesda, MD: American Fisheries Society: 533-554.

Hankin, J.D.; Reeves, G.H. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences. 45: 834-844.

Hillman, T.C.; Mullan, J.W.; Griffth, J.S. 1992. Accuracy of underwater counts of juvenile chinook salmon, coho salmon, and steelhead. North American Journal of Fisheries Management. 12: 598-603.

Lonzarich, D.G.; Warren, M.L., Jr.; Elger-Lonzarich, M.R. 1998. Effects of habitat isolation on the recovery of fish assemblages in experimentally defaunated stream pools in Arkansas. Canadian Journal of Fisheries and Aquatic Sciences. 55: 2141-2149.

Matthews, W.J.; Harvey, B.C.; Power, M.E. 1994. Spatial and temporal patterns in the fish assemblages of individual pools in a midwestern stream. Environmental Biology of Fishes. 39: 381-397.

Nielsen, J. 1998. Scientific sampling effects: electrofishing California's endangered fish populations. Fisheries. 23: 6-12.

Riley, S.C.; Fausch, K.D. 1992. Underestimation of trout population size by maximum-likelihood removal estimates in small streams. North American Journal of Fisheries Management. 12: 768-776.

Whitworth, W.R.; Schmidt, R.E. 1980. Snorkeling as a means of evaluating fish populations in small streams. New York Fish and Game Journal. 27: 91-94.

Wolda, H. 1981. Similarity indices, sample size and diversity. Oecologia. 50: 296-302.