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STREAM MORPHOLOGY AFFECTS TROUT CAPTURE EFFICIENCY OF AN AC BACKPACK ELECTROFISHER

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ABSTRACT--Stream morphology influenced trout capture efficiency with an AC backpack electrofisher and ultimately determined the success of renovation efforts in nine streams in the Great Smoky Mountains National Park. Significant reductions in density and standing crop of adult rainbow trout (*Oncorhynchus mykiss*) were achieved following 2 years of removal efforts in a group of streams with mean widths <6 m and less than two pools per kilometer exceeding 1 m in depth. Density and standing crop of adult rainbow trout could not be reduced and density of young-of-the-year significantly increased following removal efforts in another group of streams with mean widths >6 m and at least four pools per kilometer exceeding 1 m in depth. Failure to reduce populations of rainbow trout in the second group of streams could not be attributed to annual variations in trout catchability or immigration due to the absence of fish-passage barriers (i.e., waterfalls or cascades). These results suggest stream morphology must be carefully considered, even if fish-passage barriers are present, before attempts are made to eradicate undesirable salmonid populations by backpack electrofishing.

Reductions in the distribution of native brook trout (*Salvelinus fontinalis*) in the mountain streams of eastern Tennessee and western North Carolina since the early 1900s have been primarily attributed to competitive exclusion by introduced rainbow trout (*Oncorhynchus mykiss*; King, 1937; Jones, 1975; Kelly et al., 1980; Bivens et al., 1985; Larson and Moore, 1985). Interest in restoring native trout populations in this region has steadily increased during the past decade. Backpack electrofishing has been routinely employed by state and federal agencies to enhance brook trout populations in selected streams by removing rainbow trout from areas of sympatry. Moore et al. (1983, 1986) elicited increases in abundance and standing crop of brook trout in several streams in the Great Smoky Mountains National Park (GSMNP) by reducing numbers and standing crops of sympatric rainbow trout with a single AC electrofisher.

Efforts to enhance brook trout populations to date, however, have involved small streams in which the capture efficiency of a single electrofisher was not notably affected by morphological characteristics of the stream channel (e.g., width and pool depths). We define capture efficiency here as the percentage of the actual number of trout present that is captured (overall). Since brook trout historically occupied larger streams with channel morphologies that could affect electrofishing capture efficiencies, some of these streams will need to be reclaimed if efforts in brook trout restoration are to reach full potential. Several authors have noted that stream morphology can affect electrofishing capture efficiency (Haskell, 1940; Funk, 1949; Sullivan, 1956; Cuinat, 1967). Others (Moore et al., 1986; Riley, 1986) have suggested that efforts to control salmonid populations with a backpack electrofisher may be hindered by a stream's physical features (e.g., deep pools and mean width), but actual demonstrations are lacking. In this study, we assess the effects of stream width and the presence of deep pools (which cannot be thoroughly electrofished) on the trout capture efficiency of an AC backpack electrofisher. We also document responses to efforts to reduce rainbow trout populations in streams with two different channel morphologies.

MATERIALS AND METHODS

Twelve first- through third-order streams in the GSMNP (Table 1) containing sympatric populations of brook and rainbow trout (Riley, 1986; Habera, 1987) comprised the study streams, which were typical of montane, soft-water streams throughout the southern Appalachians. Conductivity averaged 24.7 µS/cm, pH averaged 6.3, and gradient averaged 10% in the 12 streams. Three streams served as controls from which no rainbow trout were removed. Rainbow trout were removed from the sympatric zones (averaging 1.4 km in length) of the other nine streams in 1984 and 1985 by Riley (1986) with one AC backpack electrofisher. There were no waterfall or cascade barriers at the downstream end of the study area in any stream. Allopatric populations of brook trout occupied each study stream above the upper boundary of the study area.

The nine removal streams were subdivided into two groups (A and B) based on two morphological characteristics (mean width and the number of pools per kilometer with depths in excess of 1 m). Group A streams (seven) had mean widths <6 m and fewer than two pools per kilometer with depths >1 m. Group B streams (two) had mean widths >6 m and at least four pools per kilometer with depths >1 m. The control streams averaged 5 m wide and had no pools with depths >1 m.

Estimates of rainbow trout populations were obtained in two 100-m sections representing the upper and lower portions of each study stream during summer and early fall of 1984, 1985, and 1986. Population estimation sampling was conducted prior to efforts to remove rainbow trout from the nine removal streams. Sampling methodology consisted of three-pass removal depletions (Carle and Strub, 1978; Bohlin, 1982; Bohlin et al., 1982; Van Deventer and Platts, 1983) with one backpack electrofisher producing 700 V AC and approximately 1 amp. All electrofishing for population estimation and rainbow trout removal took place during low, stable flow conditions, and little flow variability among study years was observed in any stream. Trout >90

TABLE 1. Study stream descriptions.

Stream	Location	Mean study area elevation (m)	Study area length (m)	Mean width (m)	Deep[1] pools/km
Controls					
Chasteen Creek	North Carolina	823	2613	5.2	0.0
Marks Creek	Tennessee	735	1075	4.9	0.0
Pretty Hollow Creek	North Carolina	1022	1671	5.1	0.0
Group A removals					
Collins Creek	North Carolina	799	2615	5.5	1.3
Cosby Creek	Tennessee	744	805	5.9	0.0
Grouse Creek	Tennessee	1073	805	5.3	1.2
Hyatt Creek	North Carolina	979	805	3.4	0.0
McGinty Creek	North Carolina	1067	805	4.7	1.2
Sahlee Creek	North Carolina	1133	2414	3.6	0.4
Woody Branch	North Carolina	972	1609	4.5	0.0
Group B removals					
Buck Fork	Tennessee	960	2011	8.1	8.5
Indian Flats Prong	Tennessee	872	1006	6.8	4.1

[1] >1 m.

mm were considered adults (>0+), while those ≤90 mm were classified as young-of-the-year (YOY; Moore et al., 1983). All rainbow trout captured in the nine removal streams were marked with a right (1984) or left (1985) pectoral fin clip and distributed 300 to 500 m downstream of the study areas.

Individual population estimates and capture probabilities (catchabilities) were obtained for adult and YOY rainbow trout using the Microfish 3.0 Software Package (Van Deventer and Platts, 1983), which incorporates the Burnham maximum likelihood model (Van Deventer and Platts, 1983). Catchability refers to a trout's estimated probability of capture on a given pass of a removal-depletion sample and serves to characterize the reliability of the sample (Armour et al., 1983).

Population estimates were used to compute annual densities of adult and YOY (number per hectare) and adult standing crops (kilograms per hectare) for the upper and lower portions of each study stream. Two-factor analysis of variance (ANOVA) was performed with PC-SAS ($P = 0.05$ level of significance) to compare adult densities, YOY densities, and adult standing crops among stream groups and years. Different electrofishing crews were used each year; therefore, trout catchability differences among stream groups and years were analyzed similarly for both adults and YOY. Density and standing crop data were log-transformed, and catchability data were square-root transformed to meet assumptions of ANOVA. Multiple comparisons using PC-SAS's REGWQ procedure, which incorporates the Ryan-Einot-Gabriel-Welsch multiple-range test, were employed with each ANOVA. We were primarily interested in pre- and post-removal density and standing crop means; thus, only the first (1984) and last (1986) study years were considered during multiple-comparison tests. Catchability comparisons included all three study years.

RESULTS

Neither mean adult density (Fig. 1A) nor mean adult standing crop (Fig. 1B) differed significantly ($P > 0.05$) among the three stream groups in 1984. In 1986, mean adult density and standing crop of group A were significantly lower than in control ($P < 0.001$) and group B ($P < 0.002$) streams. Adult density and standing crop differences between control and group B streams in 1986 were not significant ($P > 0.05$). Mean adult density and standing crop in the control streams and the group B streams did not change significantly ($P > 0.05$) from 1984 to 1986 (Fig. 1A,B), although the group B means tended to be higher in each successive year. The decrease in adult standing crop of group A between 1984 and 1986 was statistically significant ($P < 0.005$), while the decrease in adult density for this group was not. Mean YOY densities did not differ significantly among stream groups in either 1984 or 1986 (Fig. 1C), although the increase in YOY density in group B streams between 1984 and 1986 was significant ($P < 0.001$). Changes in YOY density for the other two stream groups during the study were not significant.

Annual mean catchabilities of adults ranged from 0.63 to 0.68, and YOY catchabilities ranged from 0.59 to 0.66 during the study. These values were within the range reported by Bohlin (1982) as typical for stream salmonids captured by electrofishing (0.50-0.70). The F-values for the ANOVAs of adult and YOY catchability were not significant ($P > 0.50$), indicating no differences among stream groups or years or between the various stream group-year combinations.

No marked rainbow trout were recaptured in group B streams during 1985 or 1986. Five marked rainbow trout were recaptured in the lower population estimate section of one group A stream (Grouse Creek) in 1985, and two more were recaptured in the same area in 1986.

DISCUSSION

Electrofishing efforts appeared to reduce at least the adult segment of the rainbow trout populations in group A streams but not in group B streams. The lack of population reductions in group B streams could not be related to catchability variations (i.e., improvements in crew efficiency) or reinvasion by fish removed from the study areas. Immigration of unmarked fish from downstream areas may have occurred in both removal stream groups, although Whitworth and Strange (1983) reported that adult rainbow trout from a southern Appalachian stream tend to be sedentary. However, Whitworth and Strange's (1983) trout did not experience sudden increases in competition for territories as did resident trout below the study areas in our removal streams following the release of fish captured upstream. Notwithstanding the impetus for movement, many rainbow trout would have had to travel >1 km upstream to enter the upper half of the group B study areas after the 1984 and 1985 removal efforts. It is unlikely, therefore, that replacement of

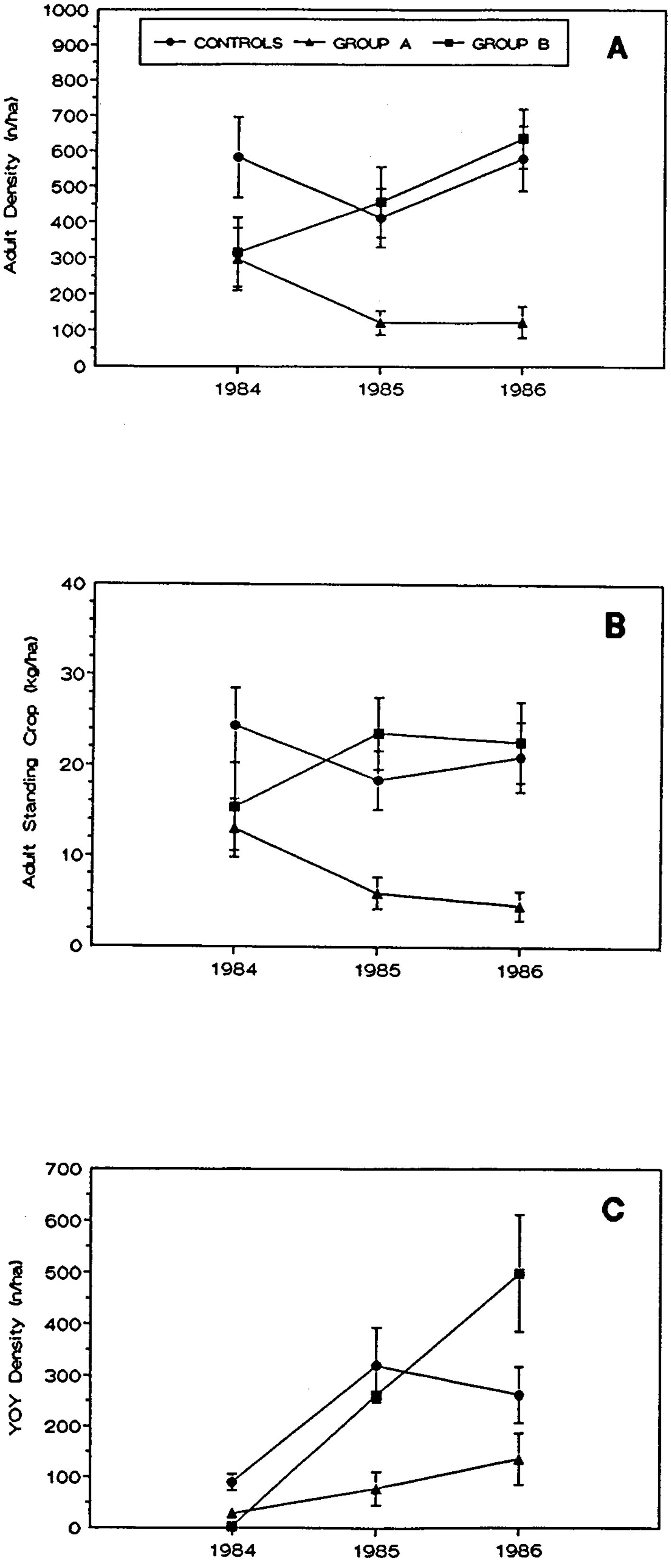

FIG. 1. Annual mean densities (A) and standing crops (B) of adult rainbow trout and annual mean densities of young-of-the-year rainbow trout (C) for control, group A, and group B streams. Bars indicate ±1 *SE*.

losses through immigration was totally responsible for the results observed in group B streams.

The factor most likely related to the lack of reductions of rainbow trout populations in group B streams was lower capture efficiency of the electrofisher caused by mean stream width (>6 m) and the presence of several (≥4/km) deep (>1 m) pools. Many group B trout were apparently "uncatchable" due to the morphological characteristics of these streams. Uncatchable fish would not affect catchability estimates, since these estimates are based only on those fish actually sampled, but would lower capture (removal) efficiencies. Lower capture efficiencies allowed a larger proportion of the initial rainbow trout populations to remain in group B streams after the completion of removal efforts; thus, these efforts were ineffective. Higher capture efficiencies permitted significant reductions of rainbow trout populations in group A streams; thus, these populations tended to decline, and one (Hyatt Creek) was apparently eliminated. Obviously, additional electrofishing units can be used in wider streams, and our experience has shown that about one electrofishing unit per every 3 m of mean stream width works well. The use of additional units, longer electrodes, or electric seines will not, however, significantly increase capture efficiencies in large, deep pools that simply cannot be waded and electrofished thoroughly.

The long-term success of any stream renovation effort would be limited in the absence of an effective fish-passage barrier, but, even where barriers are present, stream morphology should be carefully considered before attempting to eradicate a salmonid population by backpack electrofishing. Undesirable salmonid populations in streams similar to those in our group B might still be removed with other techniques, such as the use of chemical ichthyocides. These could be used throughout a stream or on a more controlled basis in pools not suited for electrofishing. A recent effort to remove rainbow trout from a stream in southeastern Tennessee (Brookshire Creek) employed an ichthyocide (rotenone) in combination with backpack electrofishing (Bivens and Williams, 1990) and has proven to be successful.

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LITERATURE CITED

ARMOUR, C. L., K. P. BURNHAM, AND W. S. PLATTS. 1983. Field methods and statistical analyses for monitoring small salmonid streams. US Fish Wildl. Serv., FWS/OBS-83/33:1-200.

BIVENS, R. D., AND C. E. WILLIAMS. 1990. Region IV stream fishery data collection report: 1989. Tennessee Wildl. Resources Agency, Nashville.

BIVENS, R. D., R. J. STRANGE, AND D. C. PETERSON. 1985. Current distribution of the native brook trout in the Appalachian region of Tennessee. J. Tennessee Acad. Sci., 60:101-105.

BOHLIN, T. 1982. The validity of the removal method for small populations--consequences for electrofishing practice. Rept., Inst. Freshwater Res., Drottningholm, 60:15-18.

BOHLIN, T., C. DELLEFORS, AND U. FAREMO. 1982. Electrofishing for salmonids in small streams--aspects of the sampling design. Rept., Inst. Freshwater Res., Drottningholm, 60:19-24.

CARLE, F. L., AND M. R. STRUB. 1978. A new method for estimating population size from removal data. Biometrics, 34:621-630.

CUINAT, R. 1967. Contribution to the study of physical parameters in electrical fishing in rivers with direct current. Pp. 131-173 *in* Fishing with electricity: its application to biology and management (R. Vibert, ed.). FAO, United Nations Fishing News Ltd., London, England.

FUNK, J. L. 1949. Wider application of the electrical method of collecting fish. Trans. Amer. Fish. Soc., 77:49-60.

HABERA, J. W. 1987. Effects of rainbow trout removal on trout poplations and food habits in Great Smoky Mountains National Park. M.S. thesis, Univ. Tennessee, Knoxville.

HASKELL, D. C. 1940. An electrical method of collecting fish. Trans. Amer. Fish. Soc., 69:210-215.

JONES, R. D. 1975. Regional distribution trends of the trout resource. Southeastern trout resource: ecology and management symposium proceedings. Southeastern Forest Exp. Sta., Asheville, North Carolina.

KELLY, G. A., J. S. GRIFFITH, AND R. D. JONES. 1980. Changes in distribution of trout in the Great Smoky Mountains National Park, 1900-1977. Tech. Paper, US Fish Wildl. Serv., 102:1-10.

KING, W. 1937. Notes on the distribution of the native speckled and rainbow trout in the streams of the Great Smoky Mountains National Park. J. Tennessee Acad. Sci., 12:351-361.

LARSON, G. L., AND S. E. MOORE. 1985. Encroachment of exotic rainbow trout into stream populations of native brook trout in the southern Appalachian mountains. Trans. Amer. Fish. Soc., 714:195-203.

MOORE, S. E., G. L. LARSON, AND B. RIDLEY. 1986. Population control of exotic rainbow trout in streams of a natural area park. Environ. Mgmt., 10:215-219.

MOORE, S. E., B. L. RIDLEY, AND G. L. LARSON. 1983. Standing crops of brook trout concurrent with removal of rainbow trout from selected streams in Great Smoky Mountains National Park. North Amer. J. Fish. Mgmt., 3:72-80.

RILEY, J. D. 1986. Brook trout enhancement through rainbow trout removal by electrofishing in the Great Smoky Mountains National Park. M.S. thesis, Univ. Tennessee, Knoxville.

SULLIVAN, C. R. 1956. The importance of size grouping in population estimates employing electric shockers. Prog. Fish-Cult., 18:188-190.

VAN DEVENTER, J. S., AND W. S. PLATTS. 1983. Sampling and estimating fish populations from streams. Trans. North Amer. Wildl. Nat. Resources Conf., 48:349-354.

----. 1989. Microcomputer software system for generating population statistics from electrofishing data--user's guide for Microfish 3.0. General Tech. Rept., USDA Forest Serv., INT-254:1-29.

WHITWORTH, W. E., AND R. J. STRANGE. 1983. Growth and production of sympatric brook and rainbow trout in an Appalachian stream. Trans. Amer. Fish. Soc., 112:469-475.