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Short-Term Mortality and Injury of Rainbow Trout Caused by Three-Pass AC Electrofishing in a Southern Appalachian Stream

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Abstract.—Short-term (7-d) mortality and injury rates were determined for 227 wild rainbow trout *Oncorhynchus mykiss* sampled by three-pass AC electrofishing (500 V) in a low-conductivity stream typical of those in the southern Appalachian Mountains. An additional 67 rainbow trout were captured by angling and served as controls. Half the fish in each group were anesthetized, measured for total length and weight, marked with an adipose fin clip, and sampled for scales to simulate the effects of a typical handling regimen; the other half were not handled. All fish were held in a partitioned raceway adjacent to the study stream. Two fish died during sampling (1%) and five other fish died within 24 h of the completion of electrofishing. All control fish survived. Thirteen electroshocked fish could not be accounted for after the 7-d observation period and were treated as sampling deaths. Mortality rates were 9% overall, 10% for handled fish, 7% for unhandled fish, and 12, 9, and 4% for the first, second, and third electrofishing passes, respectively. Mortality did not differ significantly between handled and unhandled fish or among electrofishing passes. Mortality rates for age-0 (<100 mm) and adult (100–234 mm) fish (20 and 6%, respectively) were significantly different. Seventy-six fish, including all 7 of the recovered fish that died, 57 survivors (including handled and unhandled fish from all passes), and 12 controls (handled and unhandled), were X-rayed and dissected to determine the incidence of spinal injuries and hemorrhages. Two electroshocked rainbow trout (3%) had spinal injuries and two others (3%) had hemorrhages along the spinal column but no spinal injuries; no injuries were detected among the seven fish that died or the controls. Based on these results and 4 years of data from a nearby monitoring station, we conclude that rainbow trout mortality and injury rates caused by three-pass depletion sampling with AC are tolerable. This conclusion is limited, however, to relatively small, short-lived fish inhabiting low-conductivity waters that characterize southern Appalachian streams.

Depletion sampling (Carle and Strub 1978; Raleigh and Short 1981; Van Deventer and Platts 1983) is an efficient means of obtaining reliable quantitative data from stream-dwelling salmonid populations. Consequently, three-pass depletion sampling with AC backpack electrofishers is employed in wadeable streams throughout the southern Appalachian Mountains to estimate the abundance of rainbow trout *Oncorhynchus mykiss*, brook trout *Salvelinus fontinalis*, and brown trout *Salmo trutta*. Even the recently developed basin-wide visual estimation technique for quantifying salmonid populations (Hankin and Reeves 1988) requires three-pass depletion electrofishing for calibration purposes (Dolloff et al. 1993).

Harmful effects of electrofishing on salmonids were recognized early in the development of this sampling tool (Hauck 1949; Pratt 1955), but subsequent studies reported negligible mortality and injury rates (McCrimmon and Bidgood 1965; Bouck and Ball 1966; Horak and Klein 1967; Maxfield et al. 1971; Hudy 1985). Recently, however, electroshock injury rates ranging from 26 to 86% have been reported for wild rainbow trout (Sharber and Carothers 1988; Meyer and Miller 1990), brook trout (Hollender and Carline 1994), and brown trout (Meyer and Miller 1990). Subsequently, Sharber et al. (1994) identified factors associated with reduced rates of electroshock injury to rainbow trout. Three-pass depletion sampling in southern Appalachian streams exposes some fish to multiple AC electroshocks over a relatively short time, but associated mortality and injury rates are undocumented.

With the exception of Hudy (1985) and Hollender and Carline (1994), studies that have examined electroshock effects on salmonids involved low to moderate AC or DC voltages (≤400 V) in moderately to high conductive waters (80–800 μS/cm). Results, therefore, cannot be extended to southern Appalachian streams, where extremely low conductivity waters (typically <30 μS/cm) often require AC outputs of 500–700 V for effective electrofishing. Direct current outputs, even at high voltages, are ineffective in these low-conductivity waters. Additionally, studies of wild rainbow trout (e.g., Hauck 1949; Sharber and Carothers 1988; Meyer and Miller 1990) have focused on relatively large specimens (>300 mm total length). Rainbow trout in southern Appalachian streams seldom exceed 254 mm in length (Habera and Strange 1993), are subject to smaller head-to-tail electric potential (Sharber and Carothers 1988), and may experience lower injury rates.

Salmonid mortality rates induced by electrofishing have typically been derived from studies of domestic fish at hatcheries (e.g., Pratt 1955; Bouck and Ball 1966; Hudy 1985; McMichael 1993). Hudy (1985) reported low immediate (<1%) and 15-d (<2%) mortality rates for domestic brook trout and rainbow trout electroshocked by high-voltage AC in low-conductivity (10 μS/cm) water. Our experience indicates that wild rainbow trout mortality during three-pass depletion sampling is similar (<5%), but delayed mortality rates are undocumented. Furthermore, wild salmonids sampled by electrofishing are routinely handled (anesthetized, measured, marked, confined in buckets and nets, etc.) before being released. The combined effects of electrofishing and handling involved in quantitative sampling techniques (e.g., three-pass depletion) also remain undocumented.

This study was conducted to address the paucity of electrofishing mortality and injury data for sampling gear, techniques, and conditions representative of those used or encountered in southern Appalachian streams. Specifically, our goal was to determine short-term (7-d) mortality and injury rates for wild rainbow trout sampled by three-pass depletion in low-conductivity waters with high-voltage AC electrofishing. We were particularly interested in comparing deaths caused by electroshock and those caused by electroshock combined with handling, deaths of age-0 fish and those of adult fish, and deaths among electrofishing passes. A secondary goal was to identify any population-level (long-term) effects of death and injury associated with three-pass depletion sampling.

Methods

Studies were conducted on lower Rocky Fork in Unicoi County, Tennessee. Rocky Fork (36°03′00″N, 82°34′20″W) is a typical southern Appalachian trout stream with extremely low conductivity (10–18 μS/cm) and buffering capacity (total alkalinity, 10 mg/L as $CaCO_3$). Water temperature was 15°C, pH was 6.5, and conductivity was 14 μS/cm when we electrofished on 24 August 1994. A 397-m stream segment was divided into three contiguous sampling stations (132, 138, and 127 m in length). Mean stream width for the three stations was 6.9 m, and depths were less than 1 m. Substrate was primarily gravel, cobble, and boulders. Streamflow was 0.5 m^3/s during sampling. Rainbow trout were the only fish present, except for a few blacknose dace *Rhinichthys atratulus*. No electrofishing had taken place in this portion of Rocky Fork during at least the previous 5 years.

A series of 30 × 3 × 1.5-m earthen raceways had been constructed along the stream by the Tennessee Wildlife Resources Agency (TWRA) in the early 1970s. One raceway (near the upper sampling station) was renovated to hold fish during the 7-d observation period. The raceway was framed, lined with seamless plastic sheeting, and divided into 10 compartments with 6-mm-mesh hardware cloth. Flow from Rocky Fork (0.05 m^3/s) was diverted into the raceway through an existing pipe. The surface area of the 10 compartments averaged 6.1 m^2; the water depth averaged 28 cm.

Block nets were used to maintain closed populations at each station. Effort at each station consisted of two backpack electrofishers and a crew of four (two operators and two netters). We used identical backpack electrofishers each comprising a gasoline-powered Honda EX350 generator (60 cycle) and a Coffelt WX-298 transformer that was capable of producing AC outputs of 100–700 V. Electrodes (Figure 1), constructed of 12-mm aluminum tubing, had dimensions of 24 × 20 cm and 30 × 32 cm. The larger electrode was fitted with a 4-mm-mesh nylon net to allow the operator to collect fish. Electrofishers were operated at the 500-V setting because this voltage was previously determined to adequately narcotize rainbow trout in Rocky Fork. This setting produced outputs of 512–575 V AC and 0.32–0.22 A with the electrodes totally submerged and held 0.3–1.2 m apart.

Depletion electrofishing typically yields decreasing catches with each successive pass. For

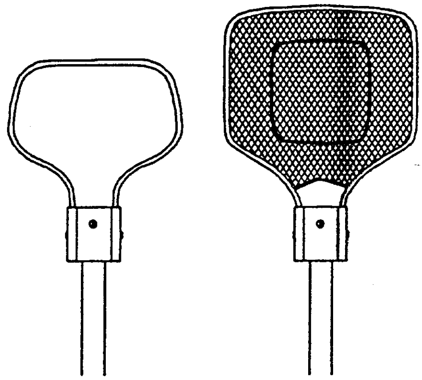

FIGURE 1.—Configuration of electrodes used with electrofishers. Dimensions were 30 × 32 cm (net electrode) and 24 × 20 cm.

example, the catch pattern for the three-pass depletion sample at our annual monitoring station on Rocky Fork (1.6 km downstream) in 1994 was 124, 20, and 8 rainbow trout. We considered it necessary, therefore, to depart from standard sampling technique to equalize catches among the three passes and thus facilitate stronger statistical comparisons. This was accomplished by assuming (conservatively) that the catch (n) from our first electrofishing pass at each station represented 50% of the rainbow trout present. The total number of rainbow trout present in each station was then estimated ($2n$), and the target catch for the first two passes was calculated ($2n/3$). For example, if 30 fish were captured on the first pass, 60 were estimated to be present, and the target catch for each of the first two passes would be 20. Each station was completely electrofished three times, and all stunned fish were collected on each pass. Those fish in excess of the target catch (10 in the preceding example) were removed from the total catch after the first and second passes and returned to the stream. All fish captured on the third pass were retained.

We counted the total catch from each of the first two passes as fish were visually assigned to one of two length-groups (<100 mm and ≥100 mm total length) and placed in separate buckets. These two groups roughly corresponded to age-0 and adult fish. Based on the relative percentages of age-0 and adult fish, specimens were then nonselectively removed from each bucket and released until the excess (total catch minus target catch) was eliminated.

The remaining fish in each bucket (i.e., each length-group) were poured and counted into an empty bucket until half of the fish were removed. These fish, defined here as "unhandled," were then placed in a labelled raceway compartment. The remaining fish in each length-group were anesthetized with tricaine methanesulfonate (MS-222) and subjected to a typical handling regimen that required about 15 s/specimen. Each was measured for total length (mm) and weight (g), the adipose fin was clipped, and a scale sample was taken. Handled fish from the first and second passes were held in live cages and were not subjected to further electroshock (per standard procedure). Upon completion of sampling at each station, handled fish (distinguishable by adipose clips) were placed in the raceway compartment with unhandled fish from the corresponding station and pass. Fish that died during sampling were frozen on dry ice for subsequent examination for injuries.

Control fish were collected the day before electrofishing by six anglers using artificial flies. Angling took place within 1 km upstream and 1 km downstream of the sampling stations. Anglers retained all rainbow trout landed, except for one small (<100 mm) individual hooked in the abdomen. Half of the controls were handled as previously described; then all control fish were placed in a raceway compartment.

Rainbow trout were monitored for 7 d after the completion of sampling. An observer remained onsite to recover dead fish, maintain an unobstructed water flow in the raceway, and prevent tampering. Data recorded for each fish that died included total length, station, electrofishing pass, and treatment group (handled or unhandled). Each dead fish was labeled and frozen on dry ice before transferral to the laboratory. Fish were fed earthworms twice during the observation period.

The raceway was drained following the observation period, and fish remaining in each compartment were recovered, anesthetized, and counted. Handled fish were remeasured and checked against previously recorded data. Unhandled fish were measured at this time. A subsample comprising 3–4 handled and 3–4 unhandled fish from each compartment was retained to determine sublethal injury rates. Subsamples were acquired by selecting approximately every third or fourth adult and every other age-0 specimen removed from the anesthetic bucket. Twelve control fish were similarly selected and sacrificed to determine background spinal injury rates.

All rainbow trout examined for injuries were thawed and X-rayed approximately a month after collection. X rays (5.0 mA s, 35 kV potential) were

TABLE 1.—Sample sizes and corresponding mortalities (numbers in sample/number dead) for two size-groups of rainbow trout sampled by three-pass electrofishing at three stations on Rocky Fork. The numbers of fish missing after the 7-d observation period are given in parentheses.

Electrofishing pass	Unhandled fish			Handled fish			All fish
	<100 mm	≥100 mm	All	<100 mm	≥100 mm	All	
Station 1							
1	1/1	13/1	14/2	3/0 (3)	12/0	15/0 (3)	29/2 (3)
2	2/0	6/0	8/0	2/0	6/0	8/0	16/0
3	2/0	12/0	14/0	3/0 (1)	12/0	15/0 (1)	29/0 (1)
All	5/1	31/1	36/2	8/0 (4)	30/0	38/0 (4)	74/2 (4)
Station 2							
1	4/0	10/0 (1)	14/0 (1)	3/0	11/1 (1)	14/1 (1)	28/1 (2)
2	2/1	10/0	12/1	3/0 (1)	9/0	12/0 (1)	24/1 (1)
3	0/0	10/0	10/0	2/0	8/0	10/0	20/0
All	6/1	30/0 (1)	36/1 (1)	8/0 (1)	28/1 (1)	36/1 (2)	72/2 (3)
Station 3							
1	5/0	12/0 (2)	17/0 (2)	6/0 (1)	11/0	17/0 (1)	34/0 (3)
2	1/0	11/0 (1)	12/0 (1)	3/0	9/2 (1)	12/2 (1)	24/2 (2)
3	1/1	10/0	11/1	2/0	10/0 (1)	12/0 (1)	23/1 (1)
All	7/1	33/0 (3)	40/1 (3)	11/0 (1)	30/2 (2)	41/2 (3)	81/3 (6)
All stations							
All	18/3	94/1 (4)	112/4 (4)	27/0 (6)	88/3 (3)	115/3 (9)	227/7 (13)
Controls							
None[a]	1/0	31/0	32/0	0/0	35/0	35/0	67/0

[a] Control fish were captured by hook and line.

made from the left side with Dupont Cronex Quanta Fast Detail 10 film at a focal distance of 17.7 cm. Each image was examined by a radiologist for any abnormalities. Each specimen was subsequently filleted on the left side to check for any hemorrhagic areas along the spine. Because these fish were small (88% < 170 mm; none >235 mm), epaxial and hypaxial myotomes were thin and translucent and their condition in the vicinity of the spine was readily observable. We found it necessary to fillet only one side to determine the presence or absence of hemorrhages.

Mortality data for each electrofishing station were categorized by electrofishing pass, handling status, and size-group, and an analysis of variance (ANOVA) employing a logit model (SAS Institute 1989) was performed. This model is appropriate for analyzing categorical data and fits the log of the ratio of percent alive to percent dead fish in each category. The effects of electrofishing pass, handling status, fish size, and the interactions of these variables on mortality were tested ($\alpha = 0.05$). Data from controls were used only to assess background injury rates and to provide a means for evaluating mortality associated with handling alone (i.e., not combined with any electroshock effects).

Because there is currently no quantitative tool for sampling trout in streams that is as effective as electrofishing and has a similar (or lower) associated mortality rate, a suitable control for assessing long-term effects of electrofishing at the population level was not available. Therefore, we inferred long-term effects of mortality associated with three-pass depletion electrofishing sampling by using unpublished data from a monitoring station on lower Rocky Fork (1.6 km downstream). This station was established in 1991 and has since been sampled annually by standard three-pass depletion (during late summer or early fall). It is very similar morphologically to those in the present study and is sampled with identical effort (a crew of four and two backpack electrofishers). Abundance (density and standing crop) and age structure data for rainbow trout from the monitoring station during 1992–1994 were compared with data for the first year of sampling (1991), which represented no electrofishing impacts.

Results

We captured 67 rainbow trout by angling and 227 in our three-pass electrofishing samples (Table 1). Our attempts to equalize sample sizes among electrofishing passes and provide adequate third-

TABLE 2.—Mean total lengths, SDs, and length ranges for rainbow trout from three-pass electrofishing samples and controls.

Treatment and length-group (mm)	N	Mean length (mm)	SD	Range (mm)
Electroshocked fish				
<100	45	76	13.14	47–99
≥100	182	134	25.14	100–234
Controls				
<100	1	95		
≥100	66	150	26.33	105–215
Combined	294	129	33.59	47–234

TABLE 3.—Summary of rainbow trout mortality rates (from three-pass electrofishing samples) by electrofishing pass, handling status, and length group.[a] Missing fish were included as sampling mortalities; there were no mortalities among controls.

Electro-fishing pass	Unhandled fish (%)			Handled fish (%)			
	<100 mm	≥100 mm	All	<100 mm	≥100 mm	All	All fish
1	10	11	11	33	6	13	12
2	20	4	6	13	13	13	9
3	33	0	3	14	3	5	4
All	17	5	7	22	7	10	9

[a] Overall mortality rates for the two length-groups were 20% (<100 mm) and 6% (≥100).

pass (three-exposure) sample sizes were generally successful (Table 1). Electroshocked age-0 fish averaged 76 mm in total length, and adults averaged 134 mm; controls had similar sizes (Table 2). We recovered seven electroshocked fish (3%) that did not survive for the duration of the study, whereas there were no deaths among controls (Table 1). Two deaths (one unhandled fish <100 mm; one handled fish ≥100 mm) occurred during sampling. All five delayed deaths occurred within the first 24 h following the completion of sampling, and only one involved a fish collected on a third electrofishing pass (Table 1).

Fourteen fish were missing after the raceway was drained and survivors were recovered. No particular pattern relative to their distribution among compartments, length-groups, or handling status was evident (Table 1). No predators or scavengers (e.g., birds) were observed and there was no evidence of any such activity (e.g., damage to the plastic liner or partitions). Six of these fish were age-0 (<100 mm) and may have been eaten by larger individuals. One of the missing fish (a 120-mm unhandled specimen) was discovered alive beneath the plastic liner when the raceway was dismantled; thus the other missing adults may also represent escapement.

Notwithstanding the fate of the 13 fish that remaining unaccounted for, we included them as sampling deaths. The overall mortality rate for electroshocked rainbow trout was 9% (Table 3). Total mortality was 10% for handled fish and 7% for unhandled fish. There was a larger difference in mortality between age-0 (<100 mm) and adult (≥100 mm) fish (20% versus 6%). However, this difference might be somewhat biased by the comparatively small total sample of age-0 fish (45; Table 1). Surprisingly, mortality appeared to decrease with successive electrofishing passes. Third-pass mortality was less than half of the first-pass mortality for both handled and unhandled fish (Table 3).

Unrecovered fish were also included as sampling deaths in the ANOVA. Results indicated that differences in mortality between handled and unhandled rainbow trout ($P = 0.541$) and among electrofishing passes ($P = 0.201$) were not significant, whereas the difference between length-groups was significant ($P = 0.014$). Interactions between handling status and length, electrofishing pass and length, and electrofishing pass and handling status were not significant ($P \geq 0.613$).

Sixty-four electroshocked rainbow trout (including the 7 recovered fish that died) and 12 control rainbow trout were X-rayed and dissected to determine the presence of spinal injury and hemorrhage. These subsamples represent 30 and 18%, respectively, of the total number of fish available for examination of each group. Injuries were detected in only four (6%) electroshocked fish (Table 4). Two fish exhibited subtle misalignments of thoracic vertebrae. Two others had hemorrhagic areas less than the width of two vertebrae adjacent to the spinal column, but no spinal injuries. All four injured fish were adults (range, 116–170 mm) and were captured on a second or third electrofishing pass. No injuries were detected among the control fish examined. We also detected no injuries among the seven recovered dead fish. Because of the small number of injured fish, we did not test for statistical differences between length-groups or among electrofishing passes.

Except for increases in 1993, total rainbow trout density and standing crop estimates at the monitoring station on lower Rocky Fork were quite similar from year to year (Figure 2). Recruitment from the strong 1992 cohort caused substantial increases in adult density and standing crop in 1993. Reproduction was even more successful in 1993, but

TABLE 4.—Incidence of internal injury (determined by X-ray and dissection) for rainbow trout from three-pass electrofishing samples.

Treatment and electrofishing pass	Length group (mm)	Number of rainbow trout				
		Examined[a]	Uninjured	With spinal injury	With hemorrhage[b]	Total injury rate (%)
Electroshocked fish						
1	<100	5 (28)	5	0	0	0
	≥100	17 (26)	17	0	0	0
2	<100	3 (25)	3	0	0	0
	≥100	20 (41)	17	2	1	15
3	<100	2 (22)	2	0	0	0
	≥100	17 (28)	16	0	1	6
All	<100	10 (26)	10	0	0	0
	≥100	54 (31)	50	2	2	7
All fish		64 (30)	60	2	2	6
Controls	≥100	12 (18)	12	0	0	0

[a] Parenthetical values are percentages of the total number of fish in that category available for examination (excludes missing fish).
[b] No fish had both spinal injury and hemorrhage.

recruitment of this cohort (and density of the 1994 cohort) was reduced by record flooding in March 1994. Similar reductions in wild trout abundance (1993–1994) were observed for monitoring stations throughout eastern Tennessee. Overall, abundance estimates from 1992 through 1994 were similar to or higher than 1991 (baseline) estimates. Variability in year-class strength and recruitment caused variability in age-class frequencies from year to year, particularly for age-0 and age-1 fish (Figure 3). However, frequency of age-3 fish in 1994 (the 1991 cohort) was similar to the frequency of age-3 fish in 1991. The 1991 cohort was subject to annual three-pass depletion sampling during its entire life span.

Discussion

Given that short-term mortality and injury were only absent among control rainbow trout, our results indicate three-pass depletion electrofishing with high-voltage AC produces some harmful effects. However, 91% of all experimental rainbow trout were recovered alive 1 week later. The occurrence of all known deaths within 24 h postsampling and the absence of any moribund fish afterward provide negative evidence for any significant mortality after the observation period. Other investigators (Meyer and Miller 1990; Dwyer and White 1995) have also reported that all electroshock-induced deaths of rainbow trout occurred within the first 24–48 h of 7–35-d observation periods.

Hollender and Carline (1994) noted the lack of electrofishing mortality information from field studies of salmonids and surmised that mortality of wild fish might be higher than that reported in hatchery studies (0–12%). The overall mortality rate we observed (9%) was within this range, even though half of our fish were handled and some received two or three electroshocks. Furthermore, our sampling mortality rate could have been as low as 3%, similar to the 2% rate reported for rainbow trout (mean length, 191–203 mm) electroshocked with AC in hatchery studies (Pratt 1955; Hudy 1985). One reason for the lack of field studies of electrofishing mortality may be the difficulty associated with holding wild fish under relatively natural conditions while retaining the ability to recover dead fish and survivors. Although natural conditions were not precisely duplicated in our raceway and some fish (4%) were lost, we believe it functioned adequately.

Most rainbow trout we examined were from second or third electrofishing passes and potentially experienced two or three electroshock exposures, but 94% were uninjured. Because we did not sacrifice and examine all survivors, the actual proportion of uninjured fish could have been different. Nevertheless, those fish not sacrificed for X-ray and dissection appeared normal (i.e., lacked "burn" marks and did not exhibit erratic swimming patterns). Hudy (1985) found only a 1% incidence of injured vertebrae in such fish. The overall spinal injury rate for rainbow trout we examined (3%) was similar to that reported by Hudy (1985; <3%) for domestic rainbow trout subjected to AC electroshock in low-conductivity water. These estimates are much lower than the AC injury rate (60%) reported by Hauck (1949) for large (1.7 kg), wild rainbow trout in more alkaline water. Overall spinal injury rates for wild rainbow trout sampled by DC in relatively high-conductivity water have ranged from 50% (Sharber and Carothers 1988) to 78% (Meyer and Miller 1990).

Electroshock elicits physiological stress in trout (Schreck et al. 1976), and multiple electroshocks increase the severity of that stress (Mesa and Schreck 1989). Although we detected no significant difference in mortality among electrofishing passes, we cannot document that all fish captured on second and third passes received two or three electroshocks. This is, however, consistent with actual three-pass depletion sampling.

Handling also induces physiological stress in salmonids (Strange et al. 1977; Woodward and Strange 1987). Therefore, survival could be further

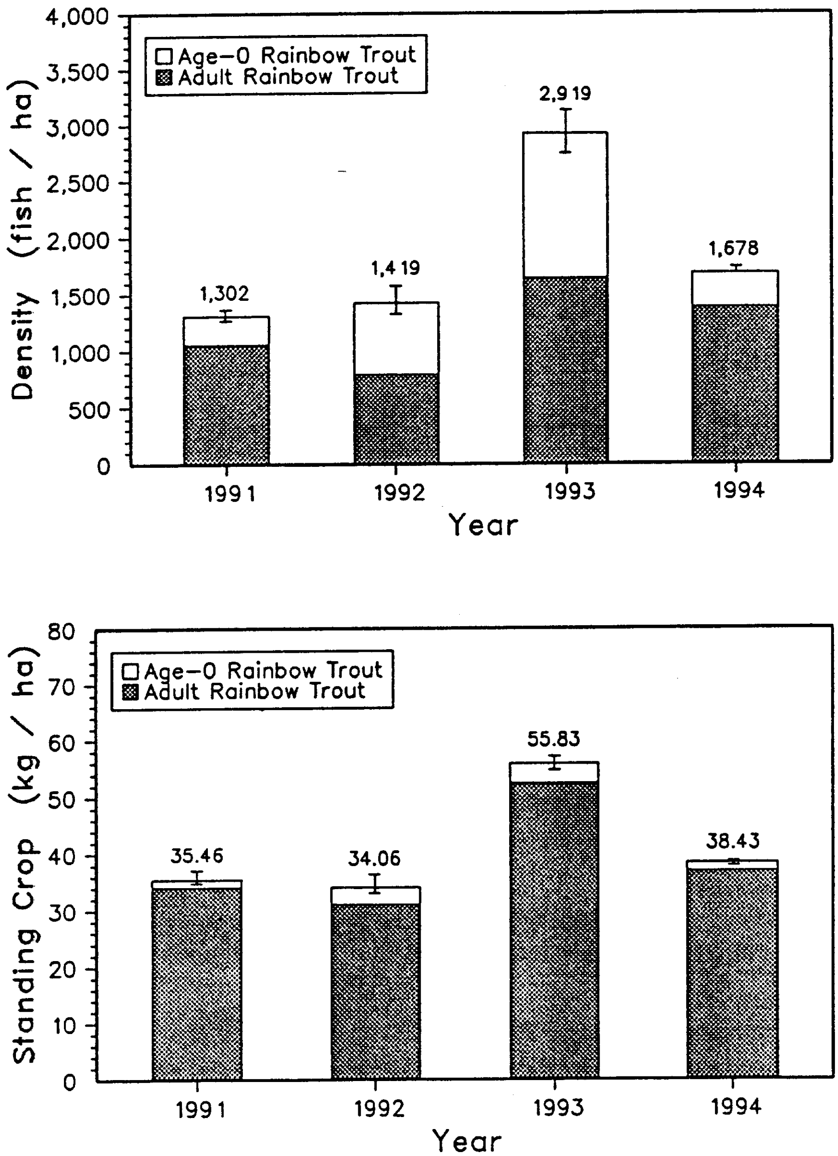

FIGURE 2.—Rainbow trout density and standing crop estimates (1991–1994) from three-pass depletion samples at the monitoring station on lower Rocky Fork (1.6 km downstream of station 1). Bars represent 95% confidence intervals. Values above bars are total density or standing crop for that year.

compromised if fish have been injured or weakened by exposure to electroshock. Barrett and Grossman (1988) reported that handling stress was the most important determinant of mortality among mottled sculpins *Cottus bairdi* collected in a low-conductivity (10–15 μS/cm) stream by DC electrofishing (600 V). Because mortality of handled and unhandled rainbow trout in our study was statistically similar and all handled controls survived, we regard effects of handling stress associated with our sampling technique as negligible. However, stress (i.e., from electroshock, handling, or both) potentially caused the five delayed deaths because they exhibited no evidence of physical damage. It should also be recognized that stress resulting from improper handling (e.g., overcrowding in buckets or holding cages, excessive anesthesia, etc.) can substantially increase mortality.

Population-level impacts resulting from sam-

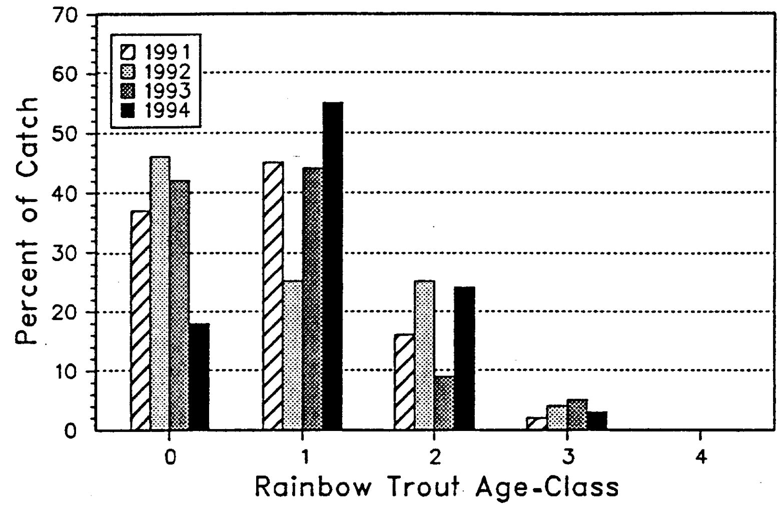

FIGURE 3.—Age structures (1991–1994) of the rainbow trout population at the monitoring station on lower Rocky Fork (1.6 km downstream of station 1).

pling mortality are ultimately important to fishery managers, and any comprehensive assessment of sampling mortality in a wild salmonid population must consider that subject. Wild rainbow trout in the southern Appalachians sustain high natural mortality rates (e.g., 60–70% annually) and rarely surpass age 3 (Habera and Strange 1993). These characteristics suggest that a large degree of sampling mortality would be necessary to substantially reduce abundance or alter population structure. Data from Rocky Fork monitoring station are limited by the presence of only one reference year (1991) for comparison and the potential for natural variability to mask some electrofishing-induced effects. Nevertheless, abundance and age structure trends through 1994 do not suggest that mortality from three-pass depletion sampling with AC has any long-term effect. The level of sampling mortality identified in this study, even for age-0 fish, appears to be compensatory (i.e., it replaces mortality that would otherwise occur naturally).

Sharber (1986) expressed concern about the use of AC electrofishing as a routine management tool, and later, biologists were advised against using AC (Reynolds and Kolz 1988). Our results indicate that AC electrofishing, particularly within the scope of three-pass depletion sampling, is an acceptable means for sampling rainbow trout populations in southern Appalachian streams. It must be recognized, however, that three-pass electrofishing with high-voltage AC could result in higher mortality rates (and important long-term effects) where larger rainbow trout, more conductive waters, or both are involved.

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The Interface between Fisheries Research and Habitat Management

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Abstract.—Successful natural resource management requires a balance between the social and economic demands placed on the resource and the absolute biological limit to resource harvesting. We outline a procedure to assist managers in prioritizing scientific information in relation to this biological limit. All life history stages of a target species are considered, relative to their habitat requirements, and a determination is made whether or not there is an essential habitat for any of the life history stages. We define an essential habitat as being physically discrete and indispensable for the survival of at least one life stage of the target species. Managers determine if the essential habitat is vulnerable to anthropogenic impacts; the scientific community investigates the ramifications of a particular management strategy or studies the interdependence of life history stage and habitat. We suggest that economically important fisheries that have relatively small essential habitats and habitats that are important for more than one target species rank higher in terms of management priority. This scheme offers an objective way for managers to weigh social and economic demands against the biological constraints within which a sustainable fishery must operate.