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Fate, Dispersal, and Persistence of Recently Stocked and Resident Rainbow Trout in a Tennessee Tailwater

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Fate, Dispersal, and Persistence of Recently Stocked and Resident Rainbow Trout in a Tennessee Tailwater

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Abstract.—A popular trout fishery in the Clinch River below Norris Dam, Tennessee, is maintained by an extensive stocking program. However, survival and return rates of rainbow trout *Oncorhynchus mykiss* stocked as catchables are low. Twenty rainbow trout (mean total length [TL] = 307 mm) that had resided in the tailwater at least 5 months were collected from the river and implanted with radio transmitters in June 1998. Similarly sized rainbow trout were implanted with radio transmitters at a hatchery and stocked into the Clinch River on 8 July 1998 (N = 19; mean TL = 304 mm) and 16 September 1998 (N = 11; mean TL = 311 mm). The stocked rainbow trout dispersed rapidly and nearly all (93%) of those fish died quickly or emigrated from the tailrace. Resident fish were significantly less active than stocked fish, and they persisted significantly longer (Kruskal–Wallis tests, P = 0.0001). Poor return rates and survival of rainbow trout stocked as catchables were attributed to their rapid, long-range movements and high levels of activity. Such behaviors are energetically inefficient and probably rendered them more vulnerable to predation.

The Clinch River below Norris Reservoir, Tennessee, provides an excellent recreational fishery for rainbow trout *Oncorhynchus mykiss* and brown trout *Salmo trutta*; in 1996 alone nearly 100,000 h of fishing pressure were directed towards trout species (Bettoli and Bohm 1997). Rainbow trout were first stocked into the river in 1950 by the Tennessee Game and Fish Commission (Yeager et al. 1987) and a popular put-and-take and put-grow-and-take fishery quickly developed. Little if any natural reproduction occurs in the Clinch River, and the trout fishery is maintained by an extensive stocking program. In 1996 approximately 138,000 rainbow trout fingerlings (<125 mm total length [TL]), 14,000 brown trout fingerlings (<150 mm TL), and nearly 32,000 catchable (>200 mm TL) rainbow trout were stocked into the Clinch River.

Bettoli and Bohm (1997) noted good annual survival rates for rainbow trout (26%) and brown trout (52%) stocked as fingerlings. However, the annual survival of four cohorts of rainbow trout stocked as catchables was poor (2–6%), and the average return rate (to the creel) for rainbow trout stocked as catchables was low (19%). Substantial numbers of trout in the Clinch River survived into subsequent fishing seasons, which provided anglers with the opportunity to catch larger fish. The poor survival of rainbow trout stocked as catchables suggested that many of the holdovers were stocked as fingerlings and that the quality of the fishery was maintained by fish that had resided in the river for several months (i.e., ‘‘residents’’), as opposed to recently stocked fish. Therefore, the activity and movements of recently stocked and resident Clinch River rainbow trout were monitored to provide insight into the low survival and poor returns of stocked catchables. The specific objectives of this study were to (1) determine the fate, dispersal, and persistence of recently stocked catchable rainbow trout in the Clinch River, and (2) compare the activity of recently stocked catchable rainbow trout and resident rainbow trout of a similar size.

Study Area

Norris Dam is located on the Clinch River at river kilometer (rkm, from the mouth of the river) 128 in Anderson County in eastern Tennessee. The dam was constructed by the Tennessee Valley Authority (TVA) in 1936 for the purposes of flood control and hydroelectric power generation. The tailwater below the dam extends about 23 km downstream to the headwaters of Melton Hill Reservoir and covers about 251 ha during periods of generation. Stream gradient is approximately 0.4 m/km. Average width of the tailwater is approximately 132 m during generation and 95 m at base flow. During base flow the macrohabitat is pre-

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dominated by long, deep (1–4 m) pools separated by short, shallow (<0.5 m) riffles or shoals. The predominate substrate is bedrock with small patches of cobble and gravel. The main source of cover for salmonids in the Clinch River is tilted bedrock shoals; large woody debris is scarce due to fluctuating water levels.

Hypolimnetic discharges through two turbines maintain coldwater habitat throughout the tailwater. Maximum discharge through each turbine is approximately 114 m^3/s. Water levels fluctuate about 1.8 m between base flow and maximum discharge.

Releases from Norris Dam in the past have had dissolved oxygen concentrations as low as 1 mg/L. Before 1984 there were no provisions for minimum flows (Yeager et al. 1987). In 1980, the TVA initiated a program to increase late summer dissolved oxygen concentrations and to provide minimum flows below all their dams (Yeager et al. 1987). Dissolved oxygen concentrations are currently maintained by an autoventing turbine system designed to keep dissolved oxygen concentrations above 6 mg/L. A reregulation weir located approximately 3.2 km below the dam provides a minimum flow of 5.7 m^3/s when the turbines are idle.

Methods

Resident rainbow trout were captured using DC electrofishing gear from the lower portion of the tailwater between rkm 112 and 107. The differentiation of resident fish from recently stocked fish was facilitated by removing the adipose fin of all catchable-size rainbow trout stocked in the spring 1998. Based on stocking records and first-year growth rates of fingerling rainbow trout in the Clinch River (0.7 mm/d; Bettoli and Bohm 1997), it was known that all resident fish implanted with radio transmitters had persisted in the river for at least 5 months before surgery. Radio transmitters were implanted in 20 resident rainbow trout (mean TL = 307 mm) on 24 and 25 June 1998 (Table 1). Thirteen of the implanted residents were probably fingerlings stocked in January 1998; the other seven fish were larger and probably stocked as catchables in late 1997.

Two groups of hatchery raised rainbow trout of the Arlee strain were implanted with radio tags at Buffalo Springs State Fish Hatchery, Clinton, Tennessee 2 weeks before stocking. Hatchery fish in the first group (mean TL = 304 mm, N = 19) were implanted on 23 June 1998 and stocked into the Clinch River on 8 July 1998 when generators were idle (Table 2). Hatchery fish in the second group (mean TL = 311 mm, N = 11) were implanted on 3 September 1998 and stocked on 16 September 1998 during two-turbine generation. All hatchery fish were stocked at a site 16 km below Norris Dam at rkm 111. Water temperatures were similar during the July (14°C) and September (15°C) stocking events. Average discharge the week following the July stocking (3.5 m^3/s) was lower than the average discharge the week following the September stocking (6.6 m^3/s).

Rainbow trout were anesthetized with a 40-mg/L concentration of clove oil (Anderson et al. 1997). Radios were inserted through an incision slightly off the midventral line and anterior to the pelvic girdle by using the shielded-needle technique (Ross and Kleiner 1982). The incision was closed with 3-0 or 4-0 silk nonabsorbable sutures. When fish recovered they were released near the capture site (resident fish) or transferred to a raceway (hatchery fish).

Radio transmitters manufactured by Advanced Telemetry Systems (Isanti, Minnesota) were

TABLE 1.—Summary of resident rainbow trout in the Clinch River, Tennessee, implanted with transmitters in June 1998. Origin codes are as follows: F = fingerling stocked January 1998, U = unknown (fish was stocked as a fingerling or catchable fish before January 1998. Fate codes are as follows: DIC = dead in channel, MI = missing, H = harvested, DOB = dead on bank, and S = survived through end of study. Asterisks denote large (>355 mm total length) resident rainbow trout.

Identification frequency	Total length (mm)	Weight (g)	Origin	Fate
Implanted 24 Jun 1998				
150.011	238	187	F	MI
150.043	282	275	F	DIC
150.062	343	482	U	H
150.092	248	182	F	DIC
150.103	272	229	F	S
150.112*	420	685	U	MI
150.123*	370	634	U	S
150.145	283	257	F	MI
150.153	262	221	F	H
150.162	272	224	F	S
Implanted 25 Jun 1998				
150.311	266	233	F	DOB
150.352	265	229	F	S
150.413	341	462	U	H
150.433	250	181	F	DIC
150.632*	430	886	U	S
150.642*	440	775	U	S
150.662*	394	748	U	MI
150.721	280	222	F	DIC
150.742	240	171	F	MI
150.931	240	171	F	DIC

TABLE 2.—Summary of hatchery rainbow trout implanted with transmitters in 1998 and stocked into the Clinch River, Tennessee. Fate codes are as follows: DIC = dead in channel, MI = missing, H = harvested, and DOB = dead on bank. Dispersal is the distance traveled (m) from stocking site during the first 24 h and 6 d after stocking; negative numbers indicate downstream movement.

Identification frequency	Total length (mm)	Weight (g)	Fate	Dispersal	
				24 h	6 d
Stocked 8 Jul 1998					
150.022	280	256	DIC	50	−7,979
150.032	322	369	MI	−2,437	−4,386
150.053	310	345	MI		
150.084	293	366	DIC		−20
150.131	299	297	DIC	−1,374	−3,840
150.372	315	356	DIC	210	392
150.542	317	362	MI	250	1,589
150.552	329	383	DIC	−745	−887
150.562	280	245	MI		4,639
150.652	271	233	DIC	237	526
150.682	305	301	MI	−2,345	
150.702	300	290	MI	2,776	4,950
150.783	299	312	MI	2,200	2,285
150.882	320	375	MI	107	795
150.902	304	301	DIC	−3,308	−6,835
150.922	310	361	MI		
150.942	299	307	H	−2,721	625
150.952	320	382	H	−1,892	−2,301
150.962	302	355	MI	−378	785
Stocked 16 Sep 1998					
150.062	305	316	DIC	−2,946	−4,946
150.073	277	242	DIC	−7,419	−4,946
150.092	307	296	DIC	−1,467	5,571
150.240	314	315	DIC	−399	−310
150.372	318	366	DOB	1,284	−2,019
150.413	295	299	DIC	−12,198	−12,198
150.552	317	337	DIC	−2,408	−7,470
150.652	336	431	DIC	−3,254	−3,753
150.783	318	345	DIC	−1,948	−1,875
150.942	300	299	DIC	−3,650	−5,412
150.952	333	337	MI	−5,034	−8,643

equipped with a 20-cm whip antenna, possessed a battery life of at least 140 d, and broadcast a unique frequency between 150 and 151 MHz. Each transmitter weighed less then 3.8 g in air, which was 2.2% of the weight of the smallest trout and 1.1% of the weight of the average trout tagged. Each tag also had a label with our phone number and the word ''REWARD'' printed on it.

During the summer months (June–August 1998) we attempted to locate each radio-implanted fish at least twice per week. After August, we attempted to locate each fish at least twice every 2 weeks. Because fish may exhibit erratic behavior after implant surgery (Mesing and Wicker 1986), location data collected within 2 weeks of surgery were eliminated from any analysis.

Rainbow trout were located during periods of generation from a 4.3-m boat in the daytime using a scanning receiver from Advanced Telemetry Systems, a three-element yagi antenna, and an omnidirectional whip antenna (i.e., a bare piece of coaxial cable with a range of 10–15 m). Precise locations during generation were determined following the techique of Niemela et al. (1993). When a strong signal was received, the location of the fish was recorded using a Global Positioning System (GPS) receiver. During base flow, fish were located by traversing the river in a canoe, and attempts were made to visually spot fish before locations were recorded. Visual observation of tagged fish was often impossible due to water depth or fish movement; in these instances, a point was recorded where the strongest signal was achieved or when a strong signal faded rapidly, indicating the fish moved. The GPS receiver locations were differentially corrected using Pathfinder Office (volume 3, 1996) software and plotted, using Arc/View software (version 3.0, 1992), on a digitized map (U. S. Geological Survey 1:24,000) of the river.

We considered two possible fates for radio-implanted rainbow trout in the Clinch River. The fish could remain alive in the fishery until the conclusion of the study, or they could be lost from the fishery. The fishery was defined as the reach from Norris Dam to the headwaters of Melton Hill Reservoir at State Highway 61 bridge, a distance of 23 km. Three subcategories were used to describe the fate of fish lost from the fishery: harvested, dead, or missing. We posted signs at all major access points informing the public of the ongoing telemetry study and offering anglers a reward for returning transmitters. Only after we received a transmitter from an angler did we consider the fish harvested. We assumed a fish had died when a transmitter was found in the channel or on the bank or when a fish did not move after four locations. Fish were placed in the missing category when we were no longer able to locate the transmitter.

Dispersal was defined as the distance traveled by individual fish from the stocking site and was calculated to the nearest meter using Arc/View. Mean dispersal was calculated for fish stocked in July and September at 24 h and at 6 d after stocking.

Persistence was defined as the number of days a recently stocked or resident rainbow trout remained alive in the fishery. Persistence in the fishery was compared among resident rainbow trout and both groups of recently stocked rainbow trout using a Kruskal–Wallis test. Multiple comparisons were analyzed using Dunn's test for nonparametric multiple comparisons (Zar 1996). Data from two fish from the first hatchery group were eliminated because their frequencies were also being generated by two 30 MHz radio tags at large in the study area, and three fish from the resident group were also eliminated because they did not survive the 14-d recovery period.

Activity was defined as the distance (m) between consecutive locations of individual fish and calculated using Arc/View. Distance traveled could have been influenced by days between locations because every fish was not located during every location attempt. We used Spearman's rank correlation to assess this potential bias because the data did not meet the assumption of normality. Differences in activity among large resident (N = 5, >355 mm TL), small resident (N = 12, <355 mm TL), July-stocked, and September-stocked rainbow trout were investigated using a Kruskal–Wallis test; multiple comparisons were evaluated using Dunn's test (Zar 1996). Comparisons of activity among the groups were limited to the first 30-d after stocking for hatchery fish and the first 30 d after the 14-d recovery period for resident fish.

Range, defined as the distance (m) between extreme upstream and extreme downstream locations for individual fish, was calculated using Arc/View. Only resident fish that were located at least five times after the 2-week recovery period were used in range analysis (N = 17). Range analysis for recently stocked rainbow trout was limited to fish that were located at least five times after 1 week poststocking (N = 6). Range values were log-transformed to normalize the data. Differences in mean range for resident and recently stocked rainbow trout were investigated using analysis of variance (ANOVA). Regression analysis was used to determine if the number of times a fish was located or the total length of fish influenced range.

Kruskal–Wallis tests, ANOVA, regression analyses, Spearman's rank correlation, and measures of central tendency were calculated using SAS (SAS Institute 1989). Dunn's nonparametric multiple comparisons and confidence intervals were calculated by hand (Zar 1996). Tests were considered statistically significant at $\alpha = 0.05$.

Results

Of the 20 resident rainbow trout implanted with radio transmitters on 24–25 June 1998, 5 were missing after 56–127 d postimplantation, 3 were harvested (2 d, 13 d, and 44 d postimplantation),

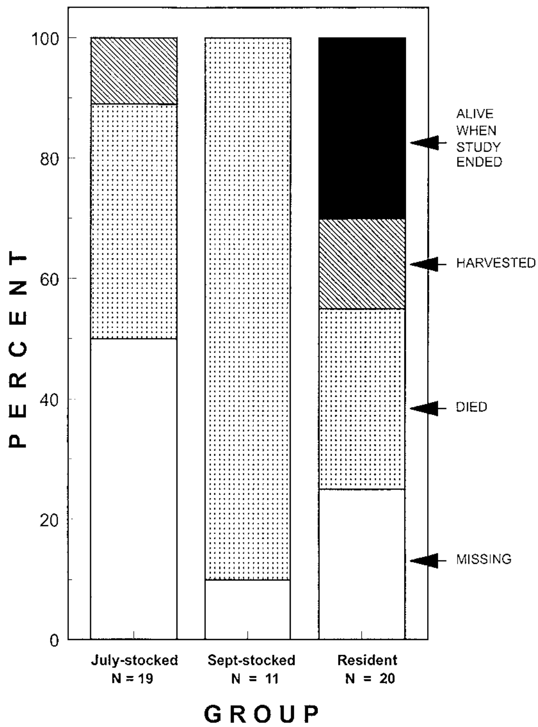

FIGURE 1.—The fate of three groups (two stocked and one resident) of rainbow trout implanted with radio tags in the Clinch River, Tennessee.

and 6 died (1 within the 14-d recovery period and 5 between 43 and 107 d postimplantation; (Table 1; Figure 1). Six fish were still alive on 10 December 1998 when the study ended.

Of the 19 radio-implanted rainbow trout stocked on 8 July 1998, 7 fish died (3 within 14 d and 4 between 20 and 78 d poststocking.), 2 fish were harvested (at 10 and 31 d poststocking), and 10 fish were missing (5 within 14 d and 5 between 20 and 71 d poststocking; Table 2; Figure 1). Of the 11 rainbow trout stocked on 16 September 1998, 8 died within 9 d and 2 others died subsequently (22 and 30 d poststocking); 1 fish was tracked for 62 d before it went missing.

Hatchery rainbow trout dispersed rapidly from the stocking site. Those stocked in July 1998 occurred over 6 rkm at 24 h poststocking; the mean dispersal was 1.4 rkm and only seven trout remained within 1 rkm of the stocking site (Table 2; Figure 2). After 6 d, those fish occurred over a 13-rkm reach, and roughly equal numbers moved upstream (N = 9) and downstream (N = 7). The rainbow trout stocked in September 1998 dispersed more rapidly. Within 24 h, those 11 fish were scattered over 13 rkm and mean dispersal

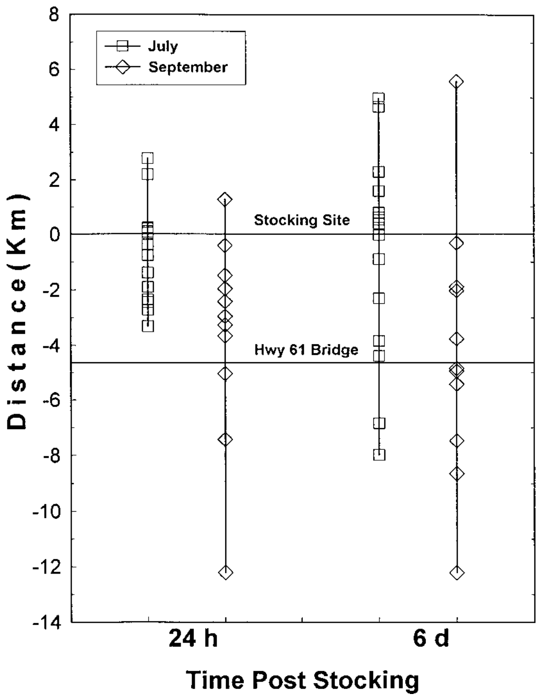

FIGURE 2.—Dispersal of rainbow trout at 24 h and at 6 d after being stocked into the Clinch River, Tennessee, during July and September 1998.

was 3.8 rkm. After 6 d, those fish occurred over 18 rkm, and all but one moved downstream. Six of 11 September-stocked rainbow were located below the boundaries of the fishery at 6 d poststocking.

Stocked rainbow trout persisted poorly in the fishery. Only 3 of the 17 hatchery fish stocked on 8 July 1998 remained in the fishery for 5 weeks and none of those fish survived for 11 weeks (Figure 3). None of the hatchery fish stocked on 16 September 1998 were alive in the fishery after 5 weeks. Resident rainbow trout survived much longer; only two fish died within the first 6 weeks. At the conclusion of this study (21 weeks postimplantation), six resident rainbow trout were still at large in the fishery. Resident fish persisted significantly longer in the fishery (median = 93 d) than either group of recently stocked rainbow trout (Table 3).

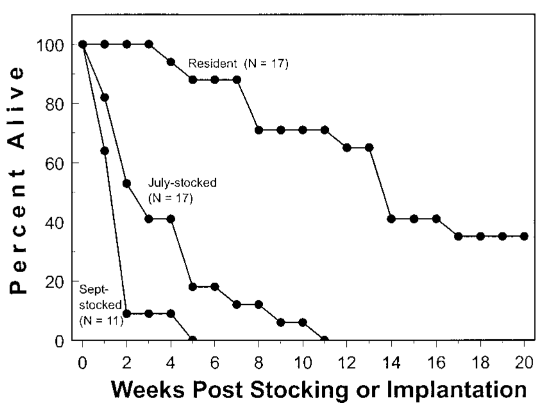

FIGURE 3.—Persistence of resident, July-stocked, and September-stocked catchable-size rainbow trout in the Clinch River, Tennessee, in 1998.

TABLE 3.—Median persistence (days alive in fishery) and 95% confidence intervals (CIs) for three groups of Clinch River, Tennessee, rainbow trout implanted with radio transmitters in 1998. Medians sharing the same letter were not significantly different (Dunn's test; $P > 0.05$); N = number of trout.

Group	N	Persistence (d)	
		Median	95% CI
Resident	17	93 z	56–132
Stocked in Jul	17	20 y	7–29
Stocked in Sep	11	7 y	1–9

Both sizes of resident rainbow trout were significantly less active than recently stocked rainbow trout (Table 4; Kruskal–Wallis test; $P = 0.0001$). Days between locations and distances moved were not significantly correlated ($P > 0.05$, $r^2 = 0.12$).

Range of movement for radio-implanted rainbow trout varied between 22 and 1,517 m. Range of movement did not differ significantly among the three groups of rainbow trout (Table 5; ANOVA; $P = 0.41$). There was not a significant relationship between range of movement and the number of times a fish was located ($P = 0.11$, $r^2 = 0.12$) or between range of movement and the total length of fish ($P = 0.65$, $r^2 = 0.01$).

TABLE 4.—Median activity and 95% confidence intervals (CIs) of rainbow trout implanted with radio transmitters in the Clinch River, Tennessee, in 1998 and tracked during the first 30 d after their release. Medians sharing the same letter were not significantly different (Dunn's test; $P > 0.05$); N = number of locations; TL = total length.

Group	N	Activity (m)	
		Median	95% CI
Resident, >355 mm TL	33	37 z	19–70
Resident, <355 mm TL	78	47 z	28–69
Stocked in Jul	64	208 y	116–319
Stocked in Sep	34	536 y	219–1,318

TABLE 5.—Geometric mean range and 95% confidence intervals (CIs) for rainbow trout implanted with radio transmitters and tracked in the Clinch River, Tennessee, during 1998. No significant differences in fish range were detected (analysis of variance; $P > 0.05$); N = number of rainbow trout; TL = total length.

Group	N	Geometric range (m)	
		Mean	95% CI
Resident, >355 mm TL	5	299	128–703
Resident, <355 mm TL	12	246	111–544
Recently stocked	6	515	219–1,208

Discussion

Although we assumed a fish had died when we found a transmitter in the river channel or the fish did not move after several locations, it is possible that some fish expelled their transmitters. Transmitter expulsion has been documented for rainbow trout (Chisholm and Hubert 1985). Transmitter expulsion may have occurred in some fish and would have inflated the mortality estimates. However, transmitter expulsion should have been similar for hatchery fish and resident fish and therefore should not have influenced comparisons between groups.

The strain of rainbow trout stocked into the Clinch River varies from year to year, depending on availability. During 1998 all catchable-size rainbow trout stocked were Arlee strain, but in other years the Fish Lake DeSmet strain were stocked as catchables. Most (80%) fingerling rainbow trout stocked during 1997 were of the Fish Lake DeSmet strain; therefore, most of the resident rainbow trout we implanted with radio transmitters were probably that strain. Comparisons between recently stocked and resident rainbow trout could have been confounded by the different strains of rainbow trout stocked into the Clinch River. Empirical data on how different strains perform in Tennessee rivers are lacking, and peer-reviewed data are scarce for large rivers in other locales; thus, we cannot say what effect, if any, trout strain may have had on dispersal and persistence of the trout we tagged.

Harvest rates for stocked radio-implanted rainbow trout in the Clinch River (6.6%) were considerably lower than five studies summarized by Cresswell (1981; pooled average = 32%) for catchable rainbow trout stocked in other locales. Similarly, 40% of catchable rainbow trout stocked into the Portneuf River, Idaho, were harvested (Heimer et al. 1985), and return rates for catchable rainbow trout stocked into Virginia streams averaged 41% (Fay and Pardue 1986). Poor return rates (<30%) of rainbow trout stocked as catchables are common in Tennessee tailwaters (e.g., Devlin 1999), although some Tennessee tailwater fisheries experience excellent harvest rates (e.g., South Fork of the Holston River; Bettoli et al. 1999).

The condition of catchable-size rainbow trout at the time of stocking may have contributed to their poor survival. Although rainbow trout raised at Buffalo Springs State Hatchery were in good condition with regards to their weight, many fish were missing multiple fins. Trout reared to catchable size in hatcheries often lose some paired fins due to abrasion.

The dispersion of stocked rainbow trout in a downstream direction is well documented (Creswell 1981; Kendall and Helfrich 1982; Heimer et al. 1985; Fay and Pardue 1986). In Virginia streams, only 12% of the total catch occurred beyond 1 km downstream of the stocking site (Fay and Pardue 1986). Another Virginia study found that few (5%) rainbow trout were collected beyond 960 m downstream of the stocking site (Kendall and Helfrich 1982). Heimer et al. (1985) found that most (66%) trout were captured within a few hundred meters of their release site. Although most rainbow trout in these studies remained close to their stocking sites, many researchers documented exceptional movements by a small portion of stocked fish. Eight fish moved more than 117 km downstream from their stocking site in the Portneuf River, Idaho (Heimer et al. 1985). In Michigan streams, Shetter (1947) found that 10% of stocked rainbow trout moved more than 16 km downstream. In our study recently stocked rainbow trout in the Clinch River dispersed great distances upon stocking.

The large proportion of fish moving downstream in the Clinch River in September may be attributed to higher levels of discharge. July-stocked rainbow trout were released when turbines were idle, but September-stocked fish were released during full generation. High stream velocities associated with generation may have caused the long-range, downstream emigration of September-stocked rainbow trout. Rainbow trout accustomed to hatchery raceways may not have been able to cope with high water velocities during generation and subsequently moved downstream where stream velocity was lower and less variable.

Resident rainbow trout in the Clinch River were significantly less active than recently stocked rainbow trout. The median activity of fish stocked in July was over 4 times greater than either group of resident fish, and the activity of fish stocked in September was more than 11 times greater than either resident group. Similar results were obtained by Bachman (1984) in a Pennsylvania stream, where he observed that recently stocked brown trout moved almost constantly and were less likely to use energy-efficient foraging sites. He hypothesized that the excessive expenditure of energy by hatchery trout was a factor contributing to their high mortality. Fenderson et al. (1968) suggested that the high aggressiveness of stocked juvenile Atlantic salmon *Salmo salar* may contribute to mortality because of excessive energy expenditure, loss of feeding time, and increased exposure to predation. Similarly, Jenkins (1971) concluded that behavioral traits of domesticated trout adapted to hatchery conditions may not be successful adaptations in the natural environment. It is likely that the increased activity of recently stocked rainbow trout in the Clinch River was a large factor contributing to their poor survival.

A rich literature exists on movements of stream-resident salmonids (see review by Gowan et al. 1994; Burrell et al. 2000), but not for rainbow trout. Cargill (1980) found that rainbow trout in a small Minnesota stream moved little and spent most of their lives in a single stream reach of about 165 m. In a mark–recapture survey of Prickley Pear Creek, Montana, most (55%) of the recaptured rainbow trout were collected within the same 46-m reach where they were previously observed (Stefanich 1952). Rainbow trout tracked in the Clinch River had much larger ranges; the average range for all resident rainbow trout was 424 m (range, 22–1,517 m), and most (65%) had home ranges greater than 200 m. The larger range of rainbow trout in the Clinch River could be due to their tailwater environment. Rapid fluctuations in flow are common in tailwaters below hydroelectric peaking operations and have been associated with a reduction in river productivity (Cushman 1985). Because of reduced productivity, rainbow trout in the Clinch River may need to range farther to forage than fish in unregulated streams. Additionally, many areas of the Clinch River are dewatered when generators are idle, which could force fish to move. In the Caney Fork River, Tennessee, rainbow trout moved up to 463 m during generation to seek hydraulic refuges (Niemela 1989). Pert and Erman (1994) hypothesized that a mobile lifestyle may be more successful in rivers below hydroelectric peaking operations and suggested that these environments may select for fish with different strategies than environments with less variable flows.

The results from this study supported earlier observations that few rainbow trout stocked into the Clinch River as catchables are harvested or survive long enough to contribute to the fishery as holdover trout. Stocking catchable-size rainbow trout in the Clinch River may only be cost-effective during late spring and early summer when angling pressure is high (Bettoli and Bohm 1997), and only at popular access areas where angling pressure is intense. This study also demonstrated that stocked rainbow trout (principally fingerlings) that successfully adapted to the tailwater environment below Norris Dam behaved in a manner similar to wild trout in unregulated rivers, and they experienced good survival rates.

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