Evaluation of Rainbow Trout Stockings on Richard B. Russell Reservoir[1]

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Abstract: Establishment of a trophy (≥500 mm TL) rainbow trout, *Oncorhynchus mykiss*, put, grow, and take fishery was evaluated with tag rewards and creel surveys. Over 310,000 catchable rainbow trout were stocked in Richard B. Russell Reservoir from 1988 to 1991. A $5.00 reward was offered for return of tags from 28,000 trout. Yearly tag returns ranged from 9.8% to 2.6%. Average tag reporting rate was 42% with a high of 50% and a low of 37%. Tag loss was estimated at 16.6% in 1991. About 60% of tags returned were captured within 14 days after stocking and an additional 19% between 61 and 210 days after stocking. Creel surveys since 1988 indicated an increase in the weight of trout harvested the first 3 years before a decline in the last year. Growth of trout within the year of stocking approached 150 mm; carryover exceeded 250 mm. Low dissolved oxygen levels in 1990 and 1991, resulting from Lake Hartwell releases, appeared to limit the development of the trophy fishery. However, improvements in water quality of late summer releases would offer the potential for a quality (≥400 mm TL) trout fishery.

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Richard B. Russell Reservoir was impounded in 1984 by the U.S. Army Crops of Engineers between the existing Strom Thurmond (formerly Clarks Hill Reservoir) and Hartwell reservoirs on the Savannah River (Fig. 1). The reservoir was constructed for multipurpose uses and has a surface area of 10,789 ha at a full pool of 145 m above mean sea level (Kennedy 1987).

The principal water supply for Richard B. Russell is the deep water releases of Lake Hartwell during generation. The water is cold (10° to 16° C) and displaces 6 to 7 km of the upper reservoir during generation. Preimpoundment studies in this reach

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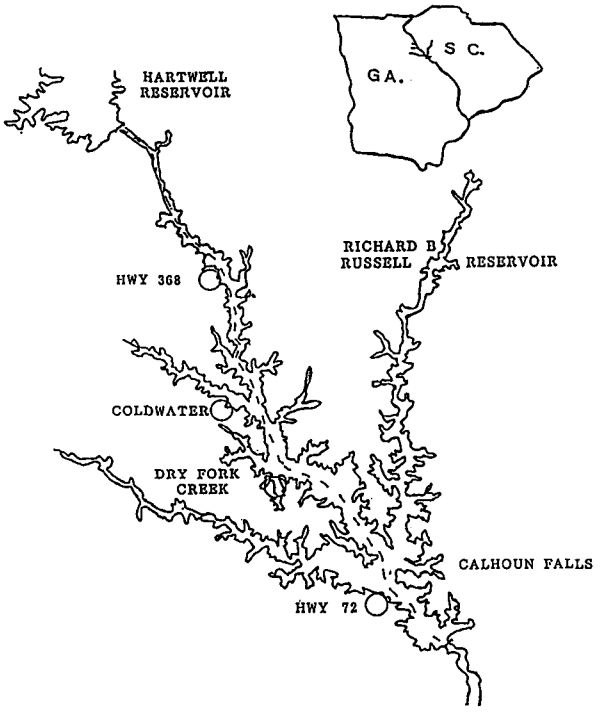

Figure 1. Richard B. Russell Reservoir and rainbow trout stocking locations: Georgia Highway 368 (Hwy. 368), Coldwater Creek, Dry Fork Creek, and Georgia Highway 72 (Hwy. 72).

of the river (Barwick and Oliver 1982) demonstrated the presence of brown trout (*Salmo trutta*) and rainbow trout that had resulted from a managed put and take trout program by Georgia and South Carolina on the Lake Hartwell tailwaters.

Prior to impoundment, a diffused oxygen injection system was constructed approximately 2.4 km above the Richard B. Russell Dam and was inundated by waters 42 to 45 m deep. The system was designed to provide a discharge dissolved oxygen standard of 6.0 ppm into downstream waters (James et al. 1985). Routine monitoring by the Waterways Experiment Station of the Corps of Engineers indicated that significant habitat was present for a coldwater species (1986 and 1987 U.S. Army Eng. Waterways Exp. Sta., quarterly summaries, unpubl. data).

Because of these factors, biologists anticipated that the impounded cooler waters would provide habitat for a trophy put, grow, and take rainbow trout fishery in a large area of Richard B. Russell Reservoir, although the primary fishery of the reservoir would be composed of warmwater species (Germann and Bunch 1990).

Georgia Department of Natural Resources implemented and initiated an effort in 1988 to establish a trophy (≥500 mm TL) rainbow trout fishery in Richard B. Russell Reservoir. Since 1988, 315,657 rainbow trout have been stocked, 28,000 of which have been tagged in an effort to monitor growth and harvest. The purpose of this study was to evaluate the growth and survival of stocked rainbow trout, to

determine if a trophy fishery was feasible, and to evaluate the contribution of rainbow trout to the overall fishery of the reservoir.

Methods

Seven thousand catchable rainbow trout were tagged yearly from 1988 to 1991 with Floy FD68-B type anchor tags and stocked into Richard B. Russell Reservoir. Tags were placed on the left side just posterior to the dorsal fin of fish averaging 230 to 260 mm TL. In 1991, 50% of the 7,000 rainbow trout were double-tagged with both tags being placed in the left dorsal area. Individual lengths and weights were recorded from a subsample of 100–200 fish prior to stocking each year.

Tagged rainbow trout were stocked at 3 locations within the reservoir each year (Fig. 1 and Table 1). Each stocking of tagged fish for evaluation purposes contained tagged and untagged trout, with untagged fish being 2 to 3 times more numerous in an effort to dampen the effect of immediate harvest of tagged fish.

An angler reward of $5.00 was offered for every returned trout tag. Information requested from each angler included date and location caught, trout size, and whether the trout were kept or released. The program was advertised using posters, news releases, and word of mouth. Non-reporting of tag returns was obtained from South Carolina Wildlife and Marine Resources Department creel personnel who recorded the numbers of tagged trout seen in creel interviews on the reservoir. The actual returns were compared to those seen by clerks to calculate a "nonreporting" rate. Tag return data were evaluated using exploitation rates and standard errors developed with the assistance of Southeastern Cooperative Wildlife and Fisheries Statistics Project personnel at North Carolina State University.

Catch, harvest, and effort data were obtained from non-uniform probability roving creel surveys conducted during the day on Richard B. Russell from 1988 through 1991. A night trout fishery did not develop during the study period.

A 2-way analysis of variance test was used to evaluate yearly tag returns and stocking location. Chi-square tests were used to assess annual tag return patterns and the effect of time of stocking on tag returns. A significance level of $P = 0.05$ was used for all tests.

Growth of rainbow trout was monitored from fisherman responses with tag returns and from field measurements of monthly food habits collections taken 1 January 1990 to 30 June 1991.

Results

Overall, 28,000 tagged rainbow trout were stocked into Richard B. Russell from 1988 to 1991 with 2,016 tags (7.2%) being returned during the study (Table 2). An additional 16 tags were returned from catches which had overwintered. Yearly tag returns ranged from 9.8% in 1988 to 2.6% in 1990. The Dry Fork Creek boat ramp (DFC) was used as a stocking location in 1988. Since rainbow trout stayed near the ramp for >6 weeks and were readily harvested, the Coldwater site was used in

Table 1. Summary of rainbow trout stockings[a] in Richard B. Russell Reservoir, 1988 to 1991.

Year	Date	Strain	Location[b] DFC	H-368	H-72	Coldwater	Total *N*	Total weight (kg)
1988	5–10 Feb	Erwin	14,440	0	19,844	0	34,284	5,222
	1–8 Mar	Erwin	14,955	10,692	10,353	0	36,000	6,539
1989	27 Feb 1 Mar	Mixed[c]	0	7,188	20,939	12,241	40,368	7,339
1989	15 Mar	Mixed[c]				5,000	5,000	809
1989–90	21 Dec 10 Jan	Wytheville	0	10,000	10,000	15,000	35,000	7,486
1990	9–13 Feb	Wytheville	0	20,000	22,000	23,000	65,000	10,502
1990	18–19 Dec	Wytheville	0	0	10,094	12,178	22,272	3,530
1991	3–11 Jan	Wytheville	0	20,500	8,740	10,310	39,550	7,009
1991	13–28 Feb	Wytheville	0	17,698	0	20,485	38,183	6,400

[a] Average annual stockings of approximately 30,000 catchable rainbow trout in the Lake Hartwell tailwaters for a put and take fishery were not included.

[b] DFC = Dry Fork Creek, Ruckersville boat ramp; H-368 = Highway 368 fishing pier; H-72 = Highway 72 boat ramp; Coldwater = Richard Russell Park boat ramp.

[c] Mixed: Wytheville, Winthrop, and Tasmanian rainbow trout strains.

Table 2. Total number of rainbow trout tag returns for each year of stocking from 1988–1991, Richard B. Russell Reservoir. Percent return by site is in parenthesis.

Year	Location H-72	DFC/Coldwater	H-368	Total
1988	251 (8.4)	386 (12.9)	53 (5.3)	690 (9.8)
1989	316 (10.5)	117 (3.9)	90 (9.0)	523 (7.5)
1990	45 (1.5)	80 (2.7)	61 (6.1)	186 (2.6)
1991	334 (11.1)	182 (6.1)	101 (10.1)	617 (8.8)
Total	946 (7.9)	765 (6.4)	305 (7.6)	2,016 (7.2)

1989 and immediate harvest was reduced. Tag returns for 1990 appeared to be dissimilar to returns in other years; however, a 2-way analysis of variance indicated no significant difference ($P = 0.05$). The Georgia Highway 72 location yielded the highest returns for the study period (7.9%).

Tagged rainbow trout catches were reported to us at an average of 42% from 1988 to 1990. The reporting rate ranged from a high of 50% in 1988 to a low of 37% in 1990. South Carolina creel clerks did not interview any fisherman with tagged rainbow trout in 1991. Tag loss was estimated in 1991 at 16.6%. When tag returns were adjusted to reflect nonreporting rates and tag loss rates for the study period, the overall tag return rate increased from 7.2% to 20.4%.

During the study, 1,913 tags were returned with a known capture date (Table 3). About 60% of all tagged fish were caught within 2 weeks of release into the reservoir. An additional 21% and 19% were caught between 15 and 60 days, and 61 and

Table 3. Number and percent of rainbow trout tag returns by interval captured on Richard B. Russell Reservoir.

	Time (Days after stocking)						
	0–14		15–60		61–210		
Year	*N*	%	*N*	%	*N*	%	Total *N*
1988	436	68	141	22	67	10	644
1989	265	53	111	22	123	25	499
1990	19	11	33	20	114	69	166
1991	420	70	122	20	62	10	604
Total	1,140	60	407	21	366	19	1,913

210 days after stocking, respectively, Rainbow trout returns were similar for all years except for 1990. A chi-square test for independence indicated that time of capture and year were related ($P = 0.05$).

Stocking of tagged rainbow trout in 1990 was evenly divided between late December–early January and mid-February. Statistical analysis using the chi-square distribution demonstrated a significant relationship ($P = 0.05$) between time of stocking and tag returns. Fish stocked early yielded almost twice as many tag returns as those stocked in mid-February. Durniak et al. (1987) described a similar occurrence for Lake Lanier when early stocking subjected trout to longer angling periods prior to reservoir warming.

Creel returns since 1988 have fluctuated with highest harvest occurring in 1990, when 13,279 trout weighing 8,672 kg were creeled (Table 4). The weight harvested

Table 4. Estimates of rainbow trout harvest and effort in the 10,754-ha main reservoir, Richard B. Russell Reservoir, 1988–1991 (Williams 1989; Self 1990 and 1991; 1991 data from Wade Bales, S.C. biologist, pers. commun.).

	Year			
	1988	1989	1990	1991
N Stocked	70,284	45,368	100,000	100,005
N Harvested	10,112	1,469	13,279	2,091
%*N* Returned	14.4	3.2	13.3	2.1
Wt. (kg) stocked	11,761	8,147	17,989	16,944
Wt. (kg) harvested	3,197	653	8,672	976
%Wt. returned	27.2	8.2	48.2	5.8
Total effort (hours)	282,601	407,330	685,842	768,470
Trout fished-for effort (hours)	6,501	2,843	23,385	5,476
%Effort for trout	2	1	3	1
% of total creel by numbers	4	1	3	1
% of total creel by weight	3	1	4	1

represented a 48.2% return of the weight stocked (17,988 kg). Harvest in number and weight returned demonstrated a marked decline in 1991 to 2.1% and 5.8%, respectively. Angling effort directed exclusively at trout has accounted for 1% to 3% of the total fishing effort in the reservoir since 1988. Rainbow trout contribution to the reservoir fishery has varied from 1% to 4% total creel by numbers and weight.

Tagged rainbow trout average size increased from a range of 230 to 260 mm at stocking to approximately 300 mm within 3 months following stocking (Fig. 2). Growth increased monthly from April through September when returns from tagged trout indicated that trout lengths neared 400 mm. Returns in 1989 and 1990 of overwintering tagged trout (11 tagged trout) indicated that total lengths had exceeded 500 mm. Estimated weights of these fish ranged from 1.0 to 2.3 kg. Trout tagged in 1990 and 1991 were not reported by fisherman returns after July and after April, respectively. Catches of overwintering fish were not reported in 1991.

Discussion

During the course of the study, trout regulations changed several times, and angler catch and release of rainbow trout appeared to reflect the creel changes (Table 5). No size limit was in effect in 1988, thus early catches of rainbow trout were harvested rather than returned to the lake as evidenced by the low 17% release rate. During the entire fishing season, fishermen typically harvested >80% of the trout they caught. A 36-cm size limit was established from 1 December to the end of March in

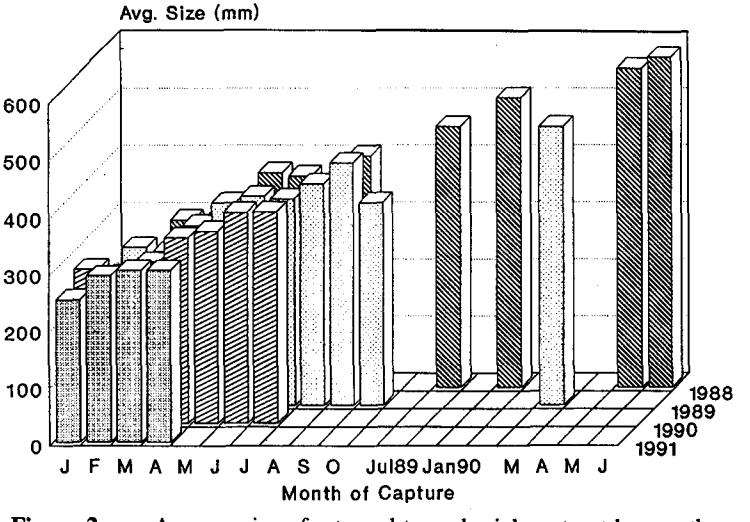

Figure 2. Average size of returned tagged rainbow trout by month and year of capture as measured by fishermen, Richard B. Russell Reservoir, 1988–1991.

Table 5. Number of rainbow trout tags returned with kept or released data by time caught from Richard B. Russell Reservoir, 1988–1991.

	Time (Days from Stocking)							
	0–14		15–60		61–210		Total *N*	
Year	*N* Tags returned	% Fish released	*N* Tags returned	% Fish released	*N* Tags returned	% Fish released	*N* Tags returned	% Fish released
1988	435	17	141	15	67	8	643	16
1989	265	60	105	29	110	20	480	44
1990	19	85	33	25	96	14	148	25
1991	420	98	117	85	31	20	568	91
Total	1,139	58	396	40	304	15	1,839	47

1989 in Georgia with no size limit the remainder of the year. South Carolina implemented a 30-cm size limit year round. A threefold increase (60%) occurred in the release of trout caught within 14 days of stocking. Fewer trout were released as the fishing season progressed and creel size increased. Both states enacted a 30-cm size limit year round in 1990. By 1991, >95% of the trout caught within 2 weeks after stocking were released. Over the entire study period about 47% of all rainbow trout were released after capture.

Tag return rates over the study period were comparable to those reported for the Lake Lanier trout fishery by Durniak et al. (1987) and Weaver and England (1982). The tag recovery rate for this study (42%) closely agreed with the 39% rate reported by Weaver and England (1986) and the 50% rate reported by Durniak et al. (1987). Publicity and advertisement of a reward for returned tags did not appear to improve the return rates in this study, although angling pressure for trout was high immediately following stocking as evidenced by the catch of approximately 60% of the returned trout within 2 weeks of stocking (Table 3).

Returns from trout tagged in 1989–1990 indicated that stocked trout grew approximately 100 mm by July and August or about 14mm/month after stocking. This was comparable to growth rates reported by Baker (1959) for Bull Shoals tailwaters trout stockings in 1958 and greater than the 10 mm/month reported for Lake Taneycomo by Fry and Hanson (1968). Estimated growth of Richard B. Russell trout was less than the average rates reported by Axon (1971) on Lake Cumberland, Kentucky.

Catches of rainbow trout occurred from January through September with peaks occurring near stocking dates and in late April through early June. Samples from fisherman harvest in May 1990 yielded rainbow trout ranging from 300 to 420 mm in length and 0.3 to 0.8 kg in weight. Although trout were harvested after June in 1988–1990, fisherman activity became restricted as the reservoir warmed and the trout moved to deeper, cooler waters. Approximately one-third of the reservoir bottom was left in standing timber (Kennedy 1987) and posed a threat to the gear of the unwary angler. After June, fishing generally occurred in the vicinity of the Georgia Highway 72 boat ramp to the Russell Dam and in the lake headwaters area.

Creel estimates for the main reservoir indicated that rainbow trout was the third most important species harvested by weight in 1988 and 1990. Estimated angler effort of >23,000 hours exclusively for trout in 1990 was indicative of positive fisherman response to the fishery. Percent harvest in 1990 approached the 50% return weight recommended by Bivens and Strange (1987) for trout stockings and was comparable to the harvest return reported for Lake Lanier by Kirkland and Bowling (1966). Average weight for trout in the Richard B. Russell creel increased from 0.3 kg in 1988 to 0.6 kg in 1990. It appeared that a quality trout fishery (≥400 mm TL) was beginning to develop. However, estimates of 1991 harvest demonstrated a marked decline in the fishery.

This decline was noted in the pattern of tag returns and apparently began to occur in 1990 (Fig. 2). The return of overwintered trout in 1989 and 1990 suggested that development of a trophy fishery was possible, although the short return season in 1991 with no overwintered returns indicated that survival of stocked trout had been impacted.

Food did not appear to be a limiting factor in the decline of the harvest of rainbow trout in 1990 and 1991. Threadfin shad first occurred as a food item in February 1990 when they were found in 34% of the stomachs examined. Consumed shad ranged in size from 35 to 40 mm. Shad occurrence had increased to 92% of all stomachs examined by May 1990, and larger shad (45 to 70 mm in length) were being utilized. Threadfin shad were first observed in March collections during 1991, at which time they occurred in 40% of the stomachs containing food items. Since 1986, threadfin shad have experienced annual die-offs that extended into late winter, thus increasing their availability as prey and possibly facilitating trout food shifts from insectivorous to piscivorous diets.

The critical period for trout survival in the reservoir was from August through October when the epilimnion began to cool and mix with the hypolimnion. Water quality of Richard B. Russell contained extensive trout habitat, i.e., water temperatures ≤21°C and dissolved oxygen ≥3.0 ppm during this time in 1988 and 1989 (Fig. 3). In August 1990, the epilimnetic waters increased in depth and the oxygen poor hypolimnetic waters moved upstream, thereby narrowing trout habitat. Trout habitat in September 1991 was restricted to the lower pool waters associated with the oxygenation system.

One possible cause for the habitat failure in 1991 may have been the increased generation schedule at Hartwell Dam in August (Mike Alexander, Corps of Eng. biologist, pers. commun.) Apparently, the schedule allowed for frequent generation of daily discharges approaching twice the average August flow volumes, thereby depleting the oxygenated hypolimnetic waters in the lake. Water generated into the reservoir in September was near anoxic (DO ≤ 1.0 ppm) and probably critically affected the trout population. Although the occurrence was not as severe, dissolved oxygen levels of inflowing waters in Septemer 1990 were also periodically deficient.

Recently, the Corps of Engineers undertook an investigation to develop rationale and alternatives to minimize blueback herring fish kills resulting from hydroelectric generation at Lake Hartwell (Alexander et al. 1991). Blueback herring en-

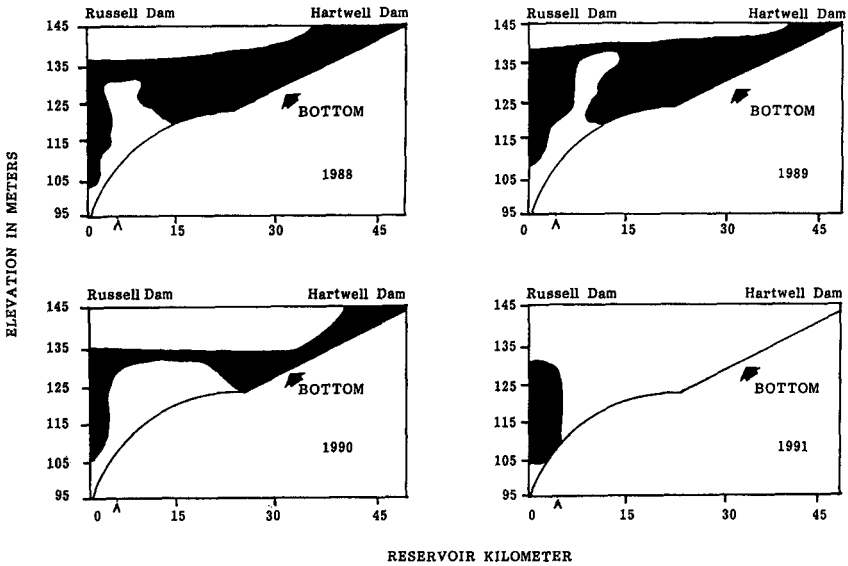

Figure 3. Trout habitat (shaded area) in Richard B. Russell Reservoir on 27 September 1988, 22 August 1989, 8 August 1990, and 18 September 1991 based on maximum 21° C temperature and minimum 3 ppm dissolved oxygen (from 1988–1991 U.S. Army Corps Eng. Waterways Exp. Sta. quarterly summaries, unpubl. data). Carat (^) indicates placement of the oxygenation system.

trainment occurred in the late summer/fall and appeared to result from habitat restriction in cool hypolimnetic waters having the highest dissolved oxygen concentrations. One of the alternatives under study was the aeration of hypolimnetic waters upstream of Hartwell Dam to increase the habitat area. This alternative would also improve dissolved oxygen in the discharges and provide long term trout habitat in Richard B. Russell. A second alternative, operative in 1992, involved a water management technique that called for the blending of generation flows with spillway released flows such that water temperature did not exceed 23.3° C. This technique, although it must be considered temporary, would increase dissolved oxygen in the discharges and benefit trout habitat in Richard B. Russell.

Results of this study indicated that low dissolved oxygen levels during the late summer months critically limited the development of a put, grow, and take trophy fishery in Richard B. Russell. A quality trout fishery was developing and carryover did occur, offering the possibility of a trophy fishery. Although angling effort for rainbow trout was <5% of the total lake effort throughout the study, the marked increase in fisherman effort for trout in 1990 suggested that the potential for a viable fishery existed before the 1991 decline. Commitment by the Corps of Engineers to improve and stabilize the discharge of cool oxygenated waters into Richard B. Russell would greatly enhance the establishment of the reservoir trout fishery.

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