Evaluation of a Southeastern, Two-story Rainbow Trout Fishery

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Abstract: A stocked rainbow trout (*Salmo gairdneri*) fishery in newly impounded Tellico Reservoir, Tennessee, was evaluated through creel surveys. In 1980, the first year of impoundment, trout made up 41.1% by weight of all fish harvested declining to a mean of 9.8% over the next 4 years. Estimated annual effort for trout averaged 53,000 hours. Rainbow trout catch rate averaged 0.067 fish per hour, and the harvest return of stocked rainbow trout averaged around 69% by weight over the 5-year period. Average catch per hour was lower than observed from other southeastern, 2-story trout fisheries. Insects comprised the primary food source and fish were second, based on percent total weight of food items ingested. Coefficients of condition indicated that the upper reservoir area was superior to the lower reservoir as trout habitat during spring and summer, apparently due to cool water releases of an upstream reservoir.

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Tellico Reservoir was created by the Tennessee Valley Authority (TVA) in 1979 through impoundment of the Little Tennessee and Tellico rivers. The reservoir is impounded at Little Tennessee River (LTR) km 0.5 and extends upstream 53.4 km to the tailrace of Chilhowee Dam and approximately 32.2 km up the Tellico River, the major tributary. All outflow is via a crossover canal connecting Tellico with Fort Loudoun Reservoir. At full pool (247.8 m mean sea level), Tellico Reservoir has a surface area of 6,600 ha, a drainage area of 6,830 km^2, and 499 km of shoreline. The reservoir has a normal depth just above the dam of approximately 27 m (TVA 1969, 1983).

Prior to impoundment, the Little Tennessee River below Chilhowee Dam supported a trout fishery of regional note (Boles 1968). At the time of impoundment, upper Tellico Reservoir already had a holdover trout population, and rainbow trout have been stocked annually since 1980 by the Tennessee Wildlife Resources

Agency (TWRA) on a "put-grow-take" basis. Management goals have been to develop and maintain a 2-story trout fishery with an average annual creel return rate of at least 50% by weight of trout stocked.

Most other studies of southeastern 2-story trout fisheries are of relatively short duration and do not begin immediately after impoundment (Kirkland and Bowling 1966; Baker and Mathis 1967; Wilkins et al. 1967; Axon 1971, 1974; Jones 1982; Weaver and England 1982). The objective of this study was to evaluate the Tellico Reservoir fishery in terms of creel return for 5 years beginning with impoundment. This paper is a contribution of the Federal Aid in Fish Restoration, Dingell-Johnson Project.

Methods

A diurnal, non-uniform probability creel survey was conducted on Tellico Reservoir. Creel data and trout stomachs were collected on 3 random days of each week from 2 March 1980 to 27 June 1981 and on 2 random days of each week from 28 June 1981 to 31 December 1984. Expanded estimates of total effort, harvest, and catch rates were calculated with a TWRA computer expansion program that uses pressure counts and predetermined probabilities. Number and weight of rainbow trout stocked were estimated from hatchery records. Percent returns by numbers and weights were calculated from the above estimates. Actual catch per hour was calculated from unexpanded data by dividing the rainbow trout harvest recorded by the creel clerk by number of hours fished for rainbow trout. The reservoir was divided into 2 areas with the U.S. Highway 411 bridge (LTR km 31) being the dividing line. The lower area extended from Tellico Dam, including the crossover canal, upstream to the 411 bridge. The upper area extended from the bridge to the Chilhowee Dam tailrace, including all of the Tellico River embayment. The approximate location where each fish was caught was recorded along with total length and weight. When time permitted, stomachs were excised, preserved in 10% formalin, and later transferred to 50% isopropanol.

In the laboratory, stomach contents were examined with a 40X dissecting microscope, and food items identified to lowest practical taxon, enumerated, and wet weight obtained for each taxon. For analysis, these taxa were integrated into larger groups of insects, crustacea, fish, other invertebrate classes, plant material, bait items, and miscellaneous items.

A coefficient of condition (K) was calculated for each fish using the formula described by Moyle and Cech (1982):

$$K = \frac{W \times 100}{L^3}$$

where K = coefficient of condition; W = weight (in grams); L = total length (in centimeters).

Water quality data used in this paper were collected by TVA from June 1980 through September 1981; methods of sample collection were described by TVA

(1983). Parameters of primary interest to the trout fishery were temperature and dissolved oxygen (DO).

Results

Creel Return

During 1980, the first year of impoundment, trout made up 30.5% by number and 41.1% by weight of all fish harvested in Tellico Reservoir (Table 1). Trout, as a percentage of all fish harvested, declined to a mean of 9.2% by number and 9.8% by weight during the next 4 years. By 1984, trout were the third most creeled species by weight in the reservoir, after black bass (*Micropterus* spp.) and crappie (*Pomoxis* spp.).

Estimated effort for trout ranged from a high of 141,805 angler-hours in 1980 to a low of 44,470 hours in 1983. After the high in 1980, effort averaged about 53,000 hours over the next 4 years (Table 1). Fishing pressure for trout was high from April through August and generally peaked during June and July of each year. The least effort generally occurred from November through January each year.

Rainbow trout catch rate averaged 0.067 fish per hour over the 5-year period. It dropped from 0.151 fish per hour in 1980 to 0.037 fish per hour in 1981, a decrease of about 75%. The catch rate increased slightly each year from 1982 to 1984 (Table 1). Peak monthly catch rates were variable over the 5-year period. In 1980 and 1981, the highest catch rates were 0.405 and 0.138 fish per hour, respectively, and occurred in July both years. In 1982, the peak catch rate occurred in March and was 0.109 fish per hour. In 1983, it occurred in January and was 0.388 fish per hour, and in 1984, the highest catch rate occurred in February and was 0.222 fish per hour. Catch rates were the lowest in October in all 5 years. Like the

Table 1. Stocking and creel summary for rainbow trout during the first 5 years of Tellico Reservoir.

	1980	1981	1982	1983	1984
Estimated					
Number stocked	300,547	72,800	97,854	77,126	50,022
Number harvested	55,073	31,969	29,192	20,000	19,763
Percent return by numbers	18.3	43.9	29.8	25.9	39.5
Kilograms stocked	14,237	8,690	14,905	9,814	6,563
Kilograms harvested	17,653	6,346	7,143	3,919	3,953
Percent return by weight	124.0	73.0	47.9	39.9	60.2
Angler-hours	141,805	58,284	58,559	44,470	50,756
Actual					
Catch per hour	0.151	0.037	0.044	0.045	0.056
Percent of total creel by numbers	30.5	8.7	9.9	8.9	9.1
Percent of total creel by weight	41.1	9.1	13.3	7.8	9.0

annual catch rate, the number of trout stocked was greatest in 1980 when about 300,500 rainbow trout were placed in Tellico Reservoir, compared to 50,000 to 100,000 stocked from 1981 to 1984 (Table 1). The percent return by weight of stocked rainbow trout in Tellico Reservoir averaged 69.0% and ranged from 39.9% to 124.0% over the 5-year period (Table 1).

Stomach Content Analysis

The stomachs of 190 rainbow trout were examined, of which 8 (4.2%) were empty. About 65 different food items were found, comprising 7 major groups (Table 2). Insects contributed 26.5% of the total weight of all food items consumed and 35.5% by number. Dipterans were the most common order of insects found in the stomachs, making up 71.4% by number of insects consumed but only 11.7% of weight. Midge larvae and pupae (Chironomidae) were the most abundant dipterans, but phantom midge larvae (*Chaoborus* spp.) were also plentiful. Coleopterans were the most important insect constituent of trout diets in terms of weight (44.1%). The bulk of these were Japanese beetles (*Popilla japonica*). Ants and wasps (Hymenoptera) also contributed to the insect portion of the diet. Crustaceans made up over half of the total number of food items, but accounted for only 2.0% of the total weight. The vast majority (>90%) of these were cladocerans. Fish, mostly gizzard and threadfin shad (*Dorosoma cepedianum* and *D. petenense*), comprised only 0.2% of the total numbers but made up 7.4% of the weight of all food items ingested (Table 2). Plant material and bait items also made up substantial portions by weight of the stomach contents.

Coefficient of Condition

Coefficient of condition (K) values are computed for 378 rainbow trout and ranged between 0.54 and 1.39 with an overall 4-year mean of 0.94. Rainbow trout greater than 380 mm exhibited a significantly higher ($P > 0.05$) mean K value (1.02) than did smaller size rainbow trout (0.94) in Tellico Reservoir. Over the 4-year period, rainbow trout in the lower reservoir had a significantly lower ($P > 0.05$)

Table 2. Percentages of food items grouped into 7 categories in the stomach contents of 190 rainbow trout collected from Tellico Reservoir between March 1980 and February 1983.

Food group	Percent by numbers	Percent by weight
Insecta	35.5	26.5
Crustacea	52.4	2.0
Fish	0.2	7.4
Other invertebrates	3.7	0.5
Plant material	3.4	17.3
Bait items	3.6	41.8
Miscellaneous items	1.2	4.4

mean K value of 0.85. Rainbow trout in the upper area had an overall mean K value of 1.00. The overall mean condition ranged from a maximum of 0.98 in 1980, the year after the reservoir was closed, to a minimum of 0.89 the following year (Fig. 1). In 1982 and 1983 the mean condition of trout had improved and was 0.93 both years.

In the upper reservoir area, rainbow trout over the entire study period exhibited the highest mean condition in spring and summer months and the lowest during fall and winter months (Fig. 2). In the lower area, they exhibited the highest mean condition in fall and winter months; the lowest occurred in spring and summer months. Mean conditions were more similar for both areas during fall and winter months (Fig. 2).

Discussion

Rainbow trout were most important in the Tellico Reservoir fishery during the first year of impoundment, 1980. This was due to hold-over fish from the river as well as the high stocking rate that year. In addition, other sport fish populations in the reservoir consisted of immature individuals and the primary fishing pressure was directed at trout. For these reasons, 1980 should not be considered a typical year, and 1981 through 1984 are probably more representative of the continuing Tellico Reservoir rainbow trout fishery. Actual catch rates for rainbow trout in Tellico Reservoir, 0.037 to 0.056 fish per hour for 1981 through 1984, were subsequently lower than other southeastern 2-story reservoirs. Daytime catch rates for rainbow trout were 0.16 per hour in Lake Lanier, Georgia (Weaver and England 1982), and 0.13 fish per hour in Lake Cumberland, Kentucky (Axon 1971).

Peak catch rates in Tellico Reservoir occurred in July the first 2 years after impoundment (1980 and 1981), but during the winter from 1982 through 1984. Day and night combined success rates in Lake Lanier, Georgia, were highest in May and June (Weaver and England 1982); May was the month with the highest day and night catch rate in Laurel River Lake, Kentucky (Jones 1982). There was a night fishery for rainbow trout in Tellico Reservoir, but there was no night creel survey. Data from a night survey might have changed the months with the highest catch rates in 1982 through 1984 from the winter to spring or summer.

Insects were the most important natural food by weight (Table 2). Japanese beetles accounted for only 2.7% of the total number of insects, but made up 26.3% of the total weight of all insects consumed. They were abundant in summer months in trout from Chilhowee tailrace. Dipterans were the next most important insect order in the diet of Tellico rainbow trout and have been reported to be important in other populations (Pennak 1978, Efford and Tsumura 1973, Marrin and Erman 1982).

Fish, mostly clupeids, were the second most important natural food. In most 2-story reservoirs, threadfin shad are the most important food item in the diets of rainbow trout (Kirkland and Bowling 1966). Baker and Mathis (1967) considered the presence of threadfin shad critical to the success of 2-story fisheries in Southeastern reservoirs. Threadfin shad were scarce in the Tellico Reservoir in 1981 and

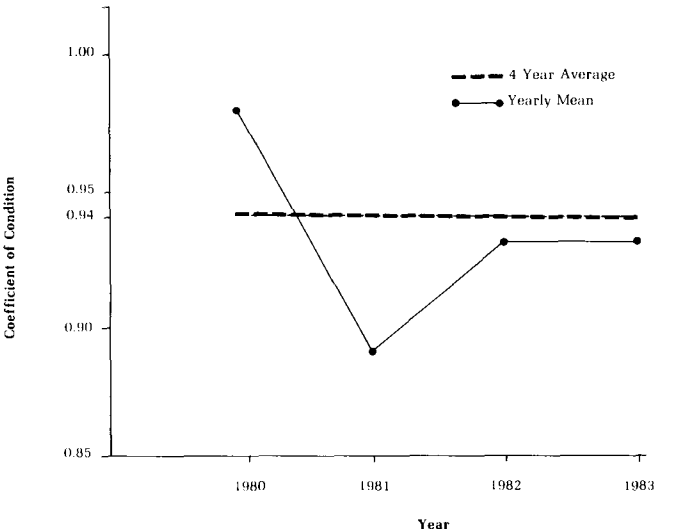

Figure 1. Average annual coefficient of condition for rainbow trout from Tellico Reservoir.

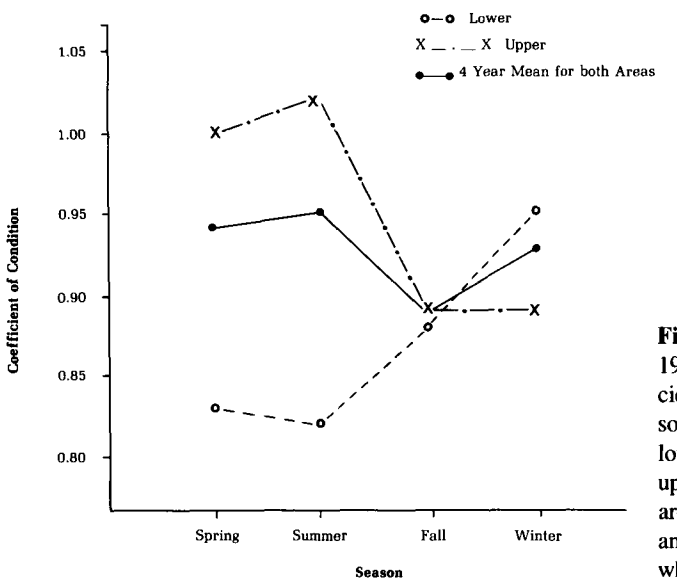

Figure 2. Average (for 1980 through 1983) coefficients of condition, by season, for rainbow trout in the lower (below Hwy. 411) and upper (above Hwy. 411) areas of Tellico Reservoir and for the reservoir as a whole.

this may have contributed to the emaciated condition of rainbow trout collected in the lower end of the reservoir by late August of that year. By 1984, threadfin shad made up 84.7% of the forage population, yet rainbow trout in Tellico Reservoir appeared to feed more heavily on insects than shad. This may have been the result of spatial segregation of trout from the threadfin shad during periods of thermal stratification; also, the stocked trout may not have had time to convert to a shad diet prior to capture by anglers.

Average condition factor of rainbow trout from Tellico Reservoir (0.94) was in the lower range of values reported by Carlander (1969). Rainbow trout in the upper reservoir had a higher condition factor than those in the lower area. This was probably due to the greater availability of food items in the upper area. Fish collected in the upper area had a significantly higher ($P > 0.05$) mean weight of food per stomach than did fish collected in the lower reservoir area.

In the newly impounded reservoir, food was abundant and there was little competition from immature fish populations in the new reservoir. The highest reservoir-wide coefficient of condition occurred in 1980, reflecting these favorable conditions (Fig. 1). By 1981, conditions were changing in the reservoir; threadfin shad had declined in number and competition from maturing sport fish populations was probably also beginning to take effect. During spring and summer months, trout in the upper area (Chilhowee tailrace) were able to utilize the entire water column and feed on both terrestrial and aquatic invertebrates. Trout in the lower area were restricted to a small zone below the thermocline during this period. Since insects (primarily terrestrials) comprise a large portion of the rainbow trout's diet in Tellico Reservoir, it is probable that the trout's relationship to the surface may have influenced the differences observed in mean conditions between the upper and lower areas of the reservoir in spring and summer months (Fig. 2). During fall and winter, the situation changed. Water temperatures became isothermal throughout the reservoir and terrestrial insects became less abundant. A decrease in condition factor of rainbow trout in the upper area between summer and fall may be attributed to a decline in the availability of insects at that time while the increase in condition of rainbow trout in the lower reservoir resulted from their ability to feed throughout the water column.

All of Tellico Reservoir was suitable trout habitat from November to March based on 1980–81 water quality data. Thermal stratification began in mid–April and lasted to late September. Dissolved oxygen concentrations followed thermal stratification with DO depletion occurring in the lower hypolimnion from Tellico Dam to between LTR km 16 and 29 by late summer.

The cold, dense inflow of the Chilhowee Dam releases had a significant impact on the water quality and biology of Tellico Reservoir. Releases from Chilhowee Dam during summer stratification were above 3 ppm DO and dipped below the warmer epilimnion, passing through the reservoir at a depth between 5 and 13 m. This created a "flowing density current" trout habitat within Tellico Reservoir instead of a "winter stored water" trout habitat that is typical of many southeastern

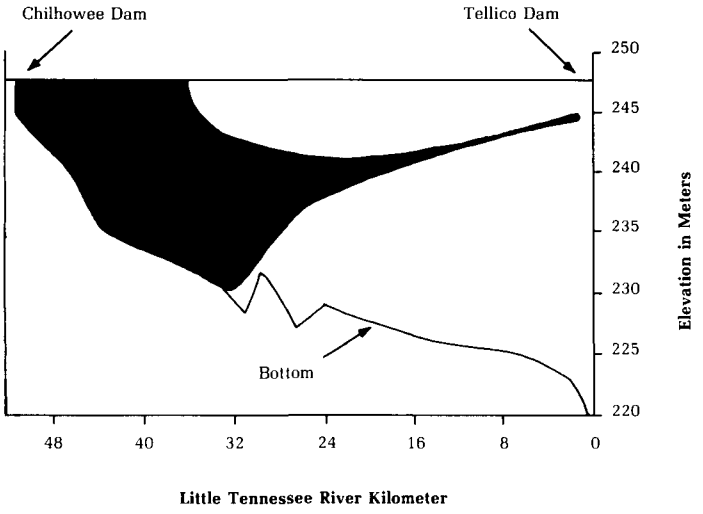

Figure 3. Trout habitat (shaded area) in Tellico Reservoir on 29 September 1980, based on maximum 20 C temperature and minimum 3 ppm dissolved oxygen (from TVA 1983).

2-story trout fisheries. This density underflow resulted in a shorter retention time of metalimnetic water and may cause large, short-term variations in temperature and DO gradients in the reservoir. The trout habitat varied during summer months depending on these inflows from Chilhowee Dam.

The critical period for trout in 2-story fisheries is just prior to fall turnover when DO in the lower strata reaches minimal proportions (Wilkins et al. 1967). In Tellico Reservoir this period occurred in late August through September in the lower reservoir. The end of September was the most critical period for trout in 1980 (Fig. 3). The trout habitat was only about 1 m thick in the first 16 km above Tellico Dam. The volume of the trout pool increased above LTR km 24 due to Chilhowee Dam releases. In 1981, the last part of September was again the most critical period; however, conditions were improved from the previous year (Fig. 4). In 1981, the thickness of the trout pool averaged around 5 m in the lower reservoir area and increased upstream of LTR km 34 to Chilhowee Dam.

Wilkins et al. (1967) stated that the oxygen demand of decomposing organic materials is great enough in newly-impounded reservoirs that they may be unsuitable for trout. This may well have been the case for lower Tellico Reservoir. Prior to impoundment, much of the already-cleared brush and understory vegetation was re-established during the mid–1970s and inundated in 1979 when the dam was closed. The TVA (1983) stated that as Tellico Reservoir ages, this oxygen demand should gradually decrease and may result in higher DO levels in the hypolimnion.

The trout fishery in Tellico Reservoir has become very popular and complements the existing warm water fishery. It has been successful in that return by weight to the creel of stocked rainbow trout averaged 69%, meeting TWRA's stock-

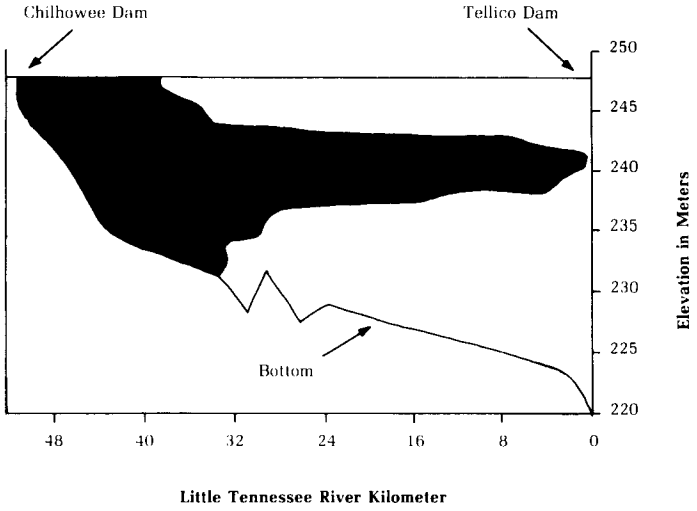

Figure 4. Trout habitat (shaded area) in Tellico Reservoir on 22 September 1981, based on maximum 20 C temperature and minimum 3 ppm dissolved oxygen (from TVA 1983).

ing policy that return should exceed 50%. However, actual catch per hour was lower than in other southeastern, 2-story trout fisheries. The absence of a night creel probably resulted in an underestimate of the fishery. Future management alternatives include institution of a night creel, increased summer stocking in the upper reservoir, and the stocking of brown trout.

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