5-1992

Special regulations increase angler success on the Hiwassee River Tennessee

Dennis Robin Lindbom

To the Graduate Council:

I am submitting herewith a thesis written by Dennis Robin Lindbom entitled "Special regulations increase angler success on the Hiwassee River Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

David J. Strange, Major Professor

We have read this thesis and recommend its acceptance:

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by Dennis R. Lindbom entitled "Special Regulations Increase Angler Success on the Hiwassee River Tennessee." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife and Fisheries Science.

Richard J. Strange
Major Professor

We have read this thesis
and recommend its acceptance:

David A Etnier

J Larry Wilson

Accepted for the Council:

C W Minkel

Associate Vice Chancellor and
Dean of the Graduate School

SPECIAL REGULATIONS INCREASE ANGLER SUCCESS ON THE HIWASSEE RIVER TENNESSEE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Dennis Robin Lindbom

May 1992

Abstract

The Hiwassee River tailwater was created in 1943. In 1986, the Tennessee Wildlife Resources Agency put special regulations in effect on a 4.8-km section of river designed to allow anglers using artificial lures an opportunity to catch trophy rainbow trout (Oncorhynchus mykiss) and brown trout (Salmo trutta). The regulations allow a limit of two trout per day, 14 in (356 mm) or longer, and anglers must use artificial lures. This study was implemented to evaluate the success of these special regulations.

For three summers in 1989-1991, a roving creel survey was conducted in the special regulations area (Area 2) and the 4.8 km of river above it (Area 1). Water temperature data from this three-year period were also examined. Each year the number of anglers increased in both areas. Trip length remained the same, resulting in greater effort. In 1989, 219 anglers fished Area 1 for 8,469 hours, and 77 anglers fished Area 2 for 3,262 hours. In 1991, 355 anglers fished Area 1 for 12,387 hours, and 137 anglers fished Area 2 for 4,959 hours. In Area 2, at least 96% of the rainbow trout caught were released each year. In Area 1, only 26% were released in 1989, but 52% were released by 1991.

Catch rates were high in both areas, but higher in Area 2. The three-year average from Area 1 was 1.0 fish per angler hour, and 1.8 fish per angler hour from Area 2.

Water temperature at the lower end of Area 2 was significantly higher than water temperature at the upper end of the area. The average coefficient of condition of rainbow trout sampled from Area 1 (1.05) was significantly higher than that of rainbow trout from Area 2 (0.90). Condition factors for brown trout were similar (about 1.00) for both areas.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The Hiwassee River and the Appalachia Tailwater are located in Polk County, Tennessee. The tailwater was created in 1943 when the Tennessee Valley Authority (TVA) constructed Appalachia Dam. Cold water from the reservoir travels 19.4 km to the Smith Creek Powerhouse through underground pipes. This water powers two turbines and then merges with the Hiwassee River, creating the Appalachia Tailwater. Tailwater rivers potentially provide a superior environment for trout because of their large size, abundant food supply, controlled flow, and narrow water temperature range (Little 1975). The Appalachia Tailwater supports over 30.6 km of trout habitat.

Within the Appalachia Tailwater little natural reproduction of rainbow trout (*Oncorhyncus mykiss*) or brown trout (*Salmo trutta*) occurs (Little 1975). As a result, in 1957, the Tennessee Wildlife Resources Agency (TWRA) began stocking the river with rainbow and brown trout, implementing a put-and-take management plan. A creel survey conducted by Myhr (1976) showed impressive growth rates in the stocked fish. On March 1, 1986, TWRA designated the section of river between the United States Forest Service (USFS) Big Bend Parking Area and the L&N railroad bridge as a trophy trout section. Special regulations were established for this 4.8-km section of river to allow anglers an opportunity to catch trophy trout. The regulations allow a limit of two fish per day, 14 in (356 mm) or longer, and anglers must use artificial lures. Anglers reported many 12-16 in (305-406 mm) fish from the trophy section in 1986 and early 1987, but then the quality of fishing dropped. Later, in 1987 and 1988, small stocked rainbow and brown trout were reported captured, but few larger holdover trout were seen (Bettoli 1988), causing concern over the effectiveness of the new special regulations.

Many factors can limit fish populations. In some cases, density-dependent mechanisms, such as predation and competition for food and space, are limiting. In others, climatic or abiotic factors control densities of aquatic organisms. In a given situation, either type of factor or an interaction of factors may restrict production (Harshbarger 1975).

Water temperature is the most critical characteristic of trout habitat. Trout streams are exceptionally sensitive aquatic systems. Water temperature is the key parameter and final determinant of whether a stream can or cannot support salmonids. Temperature affects all metabolic activities of fish including such critical functions as growth, swimming, and the ability to capture and assimilate food (Tebo 1975).

For rainbow trout, temperatures of 22.8 C - 23.3 C are tolerable for 3 to 4 days, with an absolute maximum lethal temperature of 23.9 C (Bender and Hauser 1987). Temperatures at or above 19 C should be avoided in streams that support brown or rainbow trout fisheries (McMichael et al. 1991). Tebo (1975) suggested that the maximum weekly average temperature for rainbow trout should not exceed 19 C, with short term maxima for survival of 24 C. Temperature requirements for brown trout are very similar to those for rainbow trout (Needham 1969; Mills 1971; Harshbarger 1975), although brown trout can tolerate slightly higher temperature maxima.

The amount of dissolved oxygen in the water is also very important in maintaining a trout fishery. Salmonids exhibit high basal rates of oxygen consumption (Ferguson 1958). Dissolved oxygen levels must not drop below 6.0 parts per million (ppm) in order to meet these high oxygen demands (Yeager et al. 1987).

Competition for the available food is another important consideration. Many fishes compete with trout for food. Those with the most similar food and/or habitat requirements are the greatest competitors. These fishes include various cold-water suckers, minnows, sculpins, centrarchids, and catfishes (McAfee 1966). Even in the face of competition from such fishes, trout may still maintain the upper hand as long as water temperatures remain cold. At low temperatures, trout have comparatively high standard metabolic rates and tend to be more active. Therefore, they are able to utilize the food resources more effectively than most other species (Moyle and Cech 1988).

This study was undertaken to evaluate the status of the Hiwassee River trout fishery and to determine what factors are limiting trout production. For the purpose of this study, the tailwater was divided into four areas. The focus of study was the section of river designated by TWRA as the trophy section (Area 2) and the 4.8 km of river above it (Area 1). There were five major goals:

1. Fin clip all trout stocked in Areas 1 - 4.
2. Conduct a roving creel survey.
3. Supplement the creel survey with data gathered in the trophy section using primer cord.
4. Monitor summer water temperature and dissolved oxygen concentrations in Area 1 near Smith Creek Powerhouse and in the upper and lower parts of the trophy section.
5. Sample benthic macroorganisms at two different sites.

CHAPTER II

METHODS

The Hiwassee River below the Smith Creek Powerhouse was divided into four areas to conduct a roving creel survey. The survey was designed by the North Carolina State University (NCSU) Statistics Department. It was conducted from May 15 to August 15 in 1989-91. Data were collected only in Areas 1 and 2. Anglers were creeled on all holidays and weekends and randomly one weekday each week for a total of 26 sample days each year. The data forms (Appendix 1) were then sent to NCSU for statistical evaluation.

All trout stocked in the river during creel years were fin clipped to determine any movement and growth patterns. Fish to be stocked in each of the four sections of river received a unique clip. In order to facilitate the fin clipping, Finquel® (tricaine methanesulfonate) was used to calm the fish. The fish were then held another 30 days in the hatchery raceways as dictated by the federal government after the use of Finquel®. Sub-samples of fish from each clip type were weighed and measured at Dale Hollow National Fish Hatchery prior to stocking in an attempt to determine growth patterns.

The river was divided as follows: Area 1 was from the Smith Creek Powerhouse to the USFS Big Bend Parking Area.

Fish stocked in this area had the right pectoral fin clipped. Area 2 extended from Big Bend to the L & N railroad bridge, and the stocked fish had the adipose fin clipped. Area 3 continued from the railroad bridge to the U.S. Highway 411 bridge, and the fish had the left pectoral fin clipped. Area 4 was the first three miles below the U.S. 411 bridge, and these fish had the right pelvic fin clipped.

The fish were spread throughout each area as much as possible when they were stocked. It was especially difficult to spread the fish out in Area 2 because stocking trucks could only use access points located in the upstream or downstream portions of the area. In 1989 and 1990 fish destined for Areas 1 and 2 were stocked with a helicopter in an attempt to further disperse them.

The creel clerk spent equal time in each area interviewing anglers. When anglers were found to have trout, the fish were weighed and measured. Weights were taken to the nearest gram using a hand-held Pesola® spring scale, and lengths were taken to the nearest millimeter, maximum total length.

Area 2 was located in the special regulations section of the river. Designed to create a trophy trout fishery, these regulations emphasized catch and release. Very few trout were seen in the creel survey from Area two for these reasons. Sampling was done with explosives (primer cord) in

1990 and 1991 to collect data on the fish in this section of river. Biologists from TWRA supervised the handling of explosives. The USFS, TVA, Trout Unlimited (TU), and the University of Tennessee (UTK) all participated in this phase of the project. On the mornings set for sampling, TVA turned off both of the generators at the Smith Creek Powerhouse, allowing easier access to the river. Block nets were strung across the lower end of the selected sample area. The explosives were strung back and forth along the river bottom and weighted down with rocks. After the explosives were touched off, as many fish as possible were collected. These fish were weighed and measured at the collection site using the same procedures described earlier.

A coefficient of condition (K) was calculated for all the trout from the creel survey and the primer cord sampling using the formula described by Nielsen and Johnson (1983):

$$K = W / (L3)(100,000)$$

where: K = Condition Factor

W = Weight (in grams)

L = Total Length (in centimeters)

Bottom samples were taken in 1990 and 1991 using a Surber Square Foot Bottom Sampler. The samples were taken four times in 1990 and eight times in 1991. There were two sample sites. Site one was in Area 1 below Towee Creek and site two was in Area 2 below Lost Creek. The samples contained two square feet of bottom each and were preserved in 70% isopropyl alcohol. TWRA fisheries biologists classified the sample specimens.

The upstream and downstream temperature of the river in Area 2 was monitored throughout the study using Ryan submersible Model J thermographs. The thermographs were checked at three-month intervals and reloaded with paper. In 1990 and 1991, during the time of the creel survey, the temperature was also checked using a hand held thermometer. This thermometer was used in the same locations as the thermographs as well as below the powerhouse in Area 1. The dissolved oxygen was also monitored using a portable Hach Kit (Loveland, CO) in 1990 and 1991 at the same time and locations the hand held thermometer was used.

Travel distance for each angler was calculated using zip code data analyzed by computer programs. The average distance anglers traveled to fish in Area 1 was compared to the average distance anglers traveled to fish in Area 2 to determine if anglers traveled farther to fish in either area.

In analyzing the data, analysis of variance was used to detect any significant differences. In order to meet the assumptions of the analysis of variance, transformations using natural logs were used when analyzing bottom samples, temperature, travel, and flow data. Reports of significance will be given at the 95% confidence level ($\alpha = 0.05$) unless otherwise noted.

CHAPTER III

RESULTS

Creel Survey

For the 1989 - 1991 survey periods, combined fishing effort in both areas was estimated at between 11 - 18,000 angler-hours per year (Table 1). Area 1 had between 8 - 13,000 angler-hours per year, and Area 2 had between 2 - 5,000 angler-hours per year. Area 1 had significantly greater fishing pressure than Area 2 in all three survey years. Each year more than 80% of the total effort in Area 1 was directed toward trout. Area 2 had at least 95% trout effort each year.

The number of trips anglers made to the Hiwassee River increased each year of the survey (Table 2). During the May 15 - August 15 sample period in 1989, anglers made 296 trips to the river. By 1991 this number had risen to 492. The average time an angler spent fishing remained fairly constant. In all three years, trip length was approximately 3.5 hours.

The combined number of trout caught in both areas during the sample period increased each year (Table 3). In 1989 over 13,000 trout were caught, in 1990 over 15,000, and in 1991 over 17,000. From 1989 to 1990 the combined number

Table 1. Estimated angler effort on the Hiwassee River, presented by year and effort. Survey conducted May 15 through August 15 of each year.

	1989		1990		1991	
	TOTAL ANGLER HOURS	PERCENT TROUT EFFORT	TOTAL ANGLER HOURS	PERCENT TROUT EFFORT	TOTAL ANGLER HOURS	PERCENT TROUT EFFORT
AREA 1	8,469	85	11,015	90	12,387	75
AREA 2	3,262	95	2,976	98	4,959	95
COMBINED	11,731		13,991		17,346	

Table 2. Number of interviews of anglers on the Hiwassee River by year and area, and average fishing time. Interviews were conducted during the May 15 to August 15 sampling period each year.

	1989		1990		1991	
	AREA 1	AREA 2	AREA 1	AREA 2	AREA 1	AREA 2
NUMBER OF INTERVIEWS	219	77	275	90	355	137
AVERAGE FISHING TIME (hr)	3.19	3.26	3.18	4.01	3.38	4.24

Table 3. Stocking and angler success on the Hiwassee River, presented by year and area. Values listed under total caught are estimates and include fish kept and released. Percent caught represents the estimated percentage of stocked trout caught by year from May 15 through August 15. The total number of trout stocked and caught each year is shaded.

		TOTAL STOCKED		TOTAL CAUGHT		
		RAINBOW TROUT	BROWN TROUT	RAINBOW TROUT	BROWN TROUT	PERCENT CAUGHT
1989	AREA 1	5,205	4,000	5,590	1,910	
	AREA 2	5,122	18,000	4,105	1,456	
	OTHER	14,116	8,000	-	-	
	COMBINED	24,443	30,000	9,695	3,366	
	TOTAL	54,443		13,061		24
1990	AREA 1	10,038	-	8,928	133	
	AREA 2	10,123	-	6,463	89	
	OTHER	20,030	-	-	-	
	COMBINED	40,191	-	15,391	222	
	TOTAL	40,191		15,613		39
1991	AREA 1	15,044	5,000	7,939	3,083	
	AREA 2	15,177	5,000	6,321	404	
	OTHER	30,130	10,000	-	-	
	COMBINED	60,351	20,000	14,260	3,487	
	TOTAL	80,351		17,747		22

of rainbow trout caught in both areas increased from just under 9,700 to nearly 15,400 and dropped to just under 14,300 in 1991. In 1989 and 1991 the combined number of brown trout caught in both areas was over 3,000. However, in 1990 only 222 were caught, presumably because none were stocked that year.

The number and species of trout stocked in the river had a great influence on the percent return to the creel. When fewer trout were stocked in the river, a higher percentage returned to the creel (Table 3). Higher returns were found for rainbow trout over brown trout. In 1989, 54,000 trout were stocked in the Hiwassee River with a 24% return. There were 24,000 rainbow trout and 30,000 brown trout stocked, with 18% of the rainbow trout caught and 6% of the brown trout caught. In 1990, when the only stocking was 40,000 rainbow trout, 39% returned to the creel. In 1991, 80,000 trout were stocked with a 22% return. There were 60,000 rainbow trout and 20,000 brown trout stocked, with 18% of the rainbow trout caught and 4% of the brown trout caught.

The creel survey indicated that catch and release was very popular in Area 2 and is becoming more popular in Area 1 (Table 4). In Area 2, anglers released at least 90% of the trout they caught each year of the survey. In Area 1, these release numbers were not as high but showed an increase each year. In 1989 anglers released only about 25%

Table 4. Fish kept and released as a percentage of total caught on the Hiwassee River, presented by year and area. Values listed under rainbow trout and brown trout are estimates of the total percentage of each species harvested (KEPT) and returned to the stream (RELEASED).

		RAINBOW TROUT		BROWN TROUT	
		KEPT	RELEASED	KEPT	RELEASED
1989	AREA 1	74	26	42	58
	AREA 2	4	96	4	96
	COMBINED	44	56	25	75
1990	AREA 1	61	39	62	38
	AREA 2	1	99	4	96
	COMBINED	36	64	39	61
1991	AREA 1	48	52	50	50
	AREA 2	2	98	10	90
	COMBINED	28	72	45	55

of the rainbow trout they caught. However, in 1990 nearly 40% of the rainbow trout caught were released, and by 1991 over 50% were released. Anglers fishing in Area 1 released around 50% of the brown trout they caught in all three survey years.

The creel survey showed Area 1 of the Hiwassee River to be a good place to catch trout. In all three years of the creel survey, anglers fishing in this area caught about 1.0 fish per hour. Area 2 proved to be an even better place to catch trout; anglers fishing in that area caught an average of 1.8 fish per hour during the three-year survey.

Growth and Movement

It was hoped that growth and movement data could be determined by using fin clips. However, the fin clips did not work to determine growth of the stocked trout. In all three years of the survey, fish stocked in a given area had the same fin clipped. It was assumed that the creel clerk would be able to distinguish from which year and stocking an individual fish came by looking at the regeneration level of the clipped fin. This was not possible due to the variable fin regeneration levels of each fish.

The fin clips were effective in determining movement of the stocked fish, however. Even though fish showed variable fin regeneration, it was still apparent whether any given fish had been clipped or not. Each area of the river was stocked with about 35,000 trout during the three-year survey. Very few fish moved out of the area into which they were stocked during the May 15 - August 15 sample period each year. Trout stocked in Area 4 were never seen in Areas 1 or 2. The only movement observed during the creel survey in 1989 was 4 rainbow trout and 25 brown trout moving from Area 2 into Area 1. In 1990 2 rainbow trout were found that had moved from Area 1 into Area 2, 3 that had moved from Area 2 into Area 1, 5 that had moved from Area 3 into Area 1, and 5 that had moved from Area 3 into Area 2. In 1991 1 rainbow trout was found that had moved from Area 1 into Area 2, 1 that had moved from Area 2 into Area 1, 1 that had moved from Area 3 into Area 1, and 24 that had moved from Area 3 into Area 2. Only 71 (13%) of the 560 trout sampled in the Hiwassee River during the three-year study moved out of the area into which they were stocked. Very few trout stocked into the Hiwassee River left their original areas. When fish did move between areas, they tended to travel upstream more often than downstream.

Coefficient of Condition

Coefficient of condition (K) values were computed for all trout creeled or otherwise captured throughout the study. Rainbow trout taken from Area 1 were in significantly better condition then rainbow trout taken from Area 2 in all three survey years (Table 5). Area 1 rainbow

Table 5. Creel survey and primer cord results from the Hiwassee River by year and area. Number of rainbow trout (RBT), and brown trout (BRT) in the sample and average coefficient of condition (K) are presented. The average K value for three years in each area is shaded.

	AREA 1				AREA 2			
	# RBT	(K)	# BRT	(K)	# RBT	(K)	# BRT	(K)
1989	8	0.97	50	0.96	7	0.93	21	1.0
1990	68	0.98	2	1.02	96	0.86	4	0.9
1991	82	1.13	5	1.10	197	0.93	14	0.9
AVERAGE		1.05		0.98		0.90		1.0

trout had an average K value of 1.05, while Area 2 fish had an average K value of 0.90. There was no significant difference in the condition of brown trout taken from either area. They showed good condition in both areas for all three years.

Because of the difficulty in obtaining fish from Area 2, primer cord was used to supplement the creel survey in 1990 and 1991 . There are two factors that are important when considering the K values from the primer cord samples: 1) which section of Area 2 was sampled (upstream, middle, or downstream), and 2) in what month sampling occurred. The primer cord sampling in 1990 indicated the rainbow trout had poor K values (Table 6). In early August, at the lower reach of Area 2, a K value of 0.90 was found. In mid-August, in the mid-portion of the area, a K value of 0.89 was found. On that same day, at the lower reach of the area, a K value of 0.79 was found. The average K value from the 1990 Area 2 primer cord samples was 0.87. Rainbow trout collected in mid-June of 1991, in the upper portion of Area 2, showed a K value of 1.05. This sample was taken nearly two months earlier than the first 1990 sample and the trout were still in good condition. One month later, in mid-July, at the downstream portion of Area 2, rainbow trout showed a K value of only 0.89. The average K value from the 1991 Area 2 primer cord samples was 0.91.

Table 6. Primer cord results (number in sample (#), average coefficient of condition (K)) from the Hiwassee River for rainbow trout (RBT) and brown trout (BRT) by date and location. Average K values for each year are shaded.

DATE	# RBT	(K)	# BRT	(K)	LOCATION
AUGUST 6, 1990	31	0.90	1	1.08	DOWNSTREAM / AREA 2
AUGUST 13, 1990	47	0.89	-	-	MID-PORTION / AREA 2
AUGUST 13, 1990	18	0.79	3	1.51	DOWNSTREAM / AREA 2
1990 AVERAGE		0.87		1.40	
JUNE 17, 1991	29	1.05	3	1.05	UPSTREAM / AREA 2
JULY 12, 1991	165	0.89	11	0.93	DOWNSTREAM / AREA 2
1991 AVERAGE		0.91		0.96	

Combining the numbers of trout collected during the creel survey with those collected using primer cord and calculating K values by month revealed that the K values of rainbow trout were significantly higher in May and June than in July and August (Table 7). Rainbow trout from the May and June samples were in good condition, average K value = 1.06, but by July and August the average K value had dropped to 0.91. Brown trout condition factors did not change significantly during the sampling period.

Water Flow

Water flow into the Hiwassee River through the Smith Creek powerhouse is controlled by TVA. They provided data on the flow rates from 1989 through 1991. These data were analyzed, and no significant differences in flow levels were found during the three-year survey period.

Dissolved Oxygen

On the days the creel survey was conducted in 1990 and 1991, dissolved oxygen was measured approximately 275 m below the Smith Creek Powerhouse and at the upstream and downstream limits of Area 2 (Tables 8 and 9). During this sample time in each year, the lowest level of dissolved oxygen observed was 8.0 ppm. The average level of dissolved oxygen for the 1990 sample period was 10.0 ppm at all three sample sites and 11.0 ppm at all three sites in the 1991 sample period.

Table 7. The average coefficient of condition of rainbow trout (RBT) and brown trout (BRT) collected from the Hiwassee River, by month. Trout were collected from 1989 through 1991.

MONTH	CONDITION	
	RBT	BRT
MAY	1.07	1.04
JUNE	1.05	0.96
JULY	0.94	0.97
AUGUST	0.90	1.05

Table 8. Hiwassee River dissolved oxygen levels (ppm) from 1990. Measurements were taken on creel days below the Smith Creek Powerhouse, at Big Bend parking area, and below Childers Creek.

DATE	SMITH CREEK POWERHOUSE	BIG BEND PARKING AREA	CHILDERS CREEK
5/19/90	13	12	11
5/20/90	12	11	11
5/26/90	11	11	11
5/28/90	11	11	11
5/29/90	11	11	11
6/03/90	11	11	10
6/07/90	11	10	11
6/09/90	11	11	10
6/10/90	11	11	10
6/16/90	9	8	9
6/17/90	9	9	8
6/23/90	9	9	8
6/24/90	9	8	8
6/26/90	10	11	9
6/30/90	11	11	10
7/11/90	11	11	10
7/15/90	11	11	10
7/16/90	11	11	10
7/21/90	11	11	10
7/22/90	10	11	10
7/27/90	10	12	11
7/28/90	9	10	10
8/03/90	10	11	10
8/04/90	10	10	9
8/10/90	10	10	9
8/12/90	9	9	9
AVERAGE	10	10	10

Table 9. Hiwassee River dissolved oxygen levels (ppm) from 1991. Measurements were taken on creel days below the Smith Creek Powerhouse, at Big Bend parking area, and below Childers Creek.

DATE	SMITH CREEK POWERHOUSE	BIG BEND PARKING AREA	CHILDERS CREEK
5/15/91	13	12	11
5/18/91	12	11	11
5/19/91	11	11	11
5/22/91	11	11	11
5/25/91	11	11	11
5/26/91	11	11	10
5/30/91	11	10	11
6/01/91	11	11	10
6/05/91	11	11	10
6/09/91	9	8	9
6/13/91	9	9	8
6/15/91	9	9	8
6/23/91	9	8	8
6/28/91	10	11	9
7/04/91	11	11	10
7/08/91	11	11	10
7/14/91	11	11	10
7/20/91	11	11	10
7/28/91	11	11	10
8/01/91	10	11	10
8/03/91	10	12	11
8/06/91	9	10	10
8/10/91	10	11	10
8/11/91	10	10	9
8/14/91	10	10	9
AVERAGE	11	11	11

Measurements of dissolved oxygen taken by TVA at Appalachia Dam were also obtained for 1987 through 1991 (Table 10). The measurements were taken at the point water entered the pipes leading to the Smith Creek Powerhouse. These values indicated unsatisfactory dissolved oxygen levels (3 - 6 ppm), each year from late August through early September. These values do not reflect the levels of oxygen that entered the water when it was discharged from the turbines at the Smith Creek powerhouse and into the Hiwassee River.

Temperature

TVA monitors the temperature of the water in Appalachia Reservoir as it enters the pipes leading to the Hiwassee River. They provided the results from these temperature readings for 1987 through 1990 (Table 11). These results indicated that the water at Appalachia was often at or above 18 C from late July through mid-October each year. The highest temperature recorded by TVA was 20 C.

Thermographs put in the river at the upstream and downstream limits of Area 2 revealed temperatures at or above 18 C in all three survey years (Table 12). Water temperatures were 18 - 19 C a total of 24 days at the upstream portion and 34 days at the downstream portion from July through October of 1989. During the same time, water temperatures were 20 C or higher for 3 days at both the

Table 10. Dissolved oxygen levels in Appalachia Reservoir at the point water enters the pipes leading to the Smith Creek Powerhouse (source: TVA 1992).

	DISSOLVED OXYGEN (ppm)			
DATE	1987	1988	1989	1990
08/03		5.8		
08/07			6	6.1
08/13	6			
08/18		5		
08/22			5.1	4.8
08/27	3.7			
09/02		5.1		
09/04				4.4
09/05			4.4	
09/08	4.3			
09/13		4.3		
09/17				4.3
09/19			4.8	
09/21	3.9			
10/01				4.4
10/03			3	
10/04		4.1		
10/05	3			
10/13	6.2			
10/14		5.9		

Table 11. Temperatures in Appalachia Reservoir taken at the point water enters the pipes leading to the Smith Creek Powerhouse (source TVA 1992).

	TEMPERATURE (C)			
DATE	1987	1988	1989	1990
07/27	17			18
08/03		14		
08/07			17.5	17.5
08/13	18			
08/18		17		
08/22			17.5	18.5
08/27	18			
09/02		17.5		
09/04				19
09/05			19.5	
09/08	19			
09/13		19		
09/17				20
09/19			19	
09/21	20			
10/01				19.5
10/03			19.5	
10/04		19		
10/05	20			
10/13	18			
10/14		19.5		
10/16			18	

Table 12. Number of days each year from July through October that temperatures in the upstream (UP) and downstream (DOWN) portions of Area 2 of the Hiwassee River were 18 - 19 C, or 20 C. Temperatures were taken using continuous reading, submersible thermographs.

	1989		1990		1991	
TEMPERATURE	UP	DOWN	UP	DOWN	UP	DOWN
18 - 19	24	34	7	12	28	41
≥ 20	3	3	14	15	5	31

upstream and downstream portions of the area. In 1990, water temperatures were 18 - 19 C for 7 days in the upstream portion and 12 days downstream from July through October and were 20 C or higher 14 days upstream and 15 days downstream. From July - October of 1991 Area 2 had water temperatures of 18 - 19 C for 28 days upstream and 41 days downstream and 20 C or higher for 5 days upstream and 31 days downstream. The highest temperature recorded by thermograph was 22.5 C.

Water temperatures collected by thermograph from the upstream portion of Area 2 were combined and temperatures from the downstream portion of Area 2 were combined. It was determined that temperatures in the downstream portion of Area 2 were significantly higher than temperatures in the upstream portion at the 90% confidence level ($\alpha = 0.10$). The upstream area had 59 days and the downstream area had 87 days with the water temperature at 18 - 19 C. With the water temperature at or above 20 C, the upstream and downstream areas had 22 and 49 days, respectively.

Bottom Samples

In 1990 and 1991 bottom samples from two different locations were collected. There were 12 different orders of benthic macroorganisms found (Table 13). Trichoptera, Ephemeroptera, and Plecoptera were the three orders found most often. There was no significant difference in the number of orders collected per m^2 at each sample site.

Table 13. Benthic macroorganisms found in the Hiwassee River by order and number. Samples were taken at two sites in 1990 and 1991 and covered a total of 4.46 m^2.

ORDER	NUMBER
EPHEMEROPTERA	32
TRICHOPTERA	29
PLECOPTERA	27
COLEOPTERA	9
DIPTERA	7
MEGALOPTERA	6
PELECYPODA	5
ODONATA	2
GASTROPODA	2
DECAPODA	1
ISOPODA	1

There were also no significant differences in the number of benthic macroorganisms found per m^2 by month, year, or location.

The volume of benthic macroorganisms collected per m^2 in 1991 was significantly higher than the volume collected in 1990. In 1991, 1.83 ml were collected per m^2 and in 1990, 0.57 ml were collected per m^2. There was no significant difference in the volume of benthic macroorganisms collected per m^2 due to location. However, there was a significant difference in the volume collected per m^2 due to month. Significantly more benthic macroorganisms were collected in June than July or August.

Travel Distance

Over the course of the three-year survey, anglers fishing in Area 2 of the Hiwassee River traveled a significantly longer distance than anglers fishing in Area 1. Anglers traveled an average of 102 km to fish in Area 2 and an average of 77 km to fish in Area 1.

CHAPTER IV

DISCUSSION

Creel Survey

The Hiwassee River produced good fishing in Areas 1 and 2 from 1989 to 1991. The average number of trout caught per angler-hour in both areas combined ranged from 1.02 to 1.27 during the May 15 to August 15 creel surveys of each year. These values are much higher than previously reported values from the Hiwassee River. A creel survey done from July 1973 through December 1975 indicated that from May - August of 1974 and 1975, anglers caught only 0.30 and 0.20 trout per hour respectively, (Myhr 1977). When compared to other tailwaters, the Hiwassee River is an excellent place to catch trout. Year-long creel surveys conducted on 10 other Southern tailwaters yielded a range of trout per angler-hour of from 0.07 to 0.66, with an average of 0.41 trout per angler-hour (Swink 1983). The Norris tailwater produced 0.30 fish per angler-hour in 1980. That value is comparable to the 1974 and 1975 Hiwassee River values (Swink 1983).

A 6-year creel survey of the Fontenelle tailwater trout fishery in Wyoming indicated an average of 0.28 trout caught per hour (Wiley and Dufek 1980). Surveys conducted on five different Oregon streams yielded an average of 0.83 trout per hour in 1975 and 0.64 in 1976 (Moring 1985). The Hiwassee River certainly ranks as a top trout fishery.

The catch per hour rates of each area were good in all three survey years (Figure 1). Area 1 had consistently steady catch rates, even with fishing pressure increasing each year. Angler hours rose from just over 7,000 in 1989 to over 12,000 in 1991 (Figure 2). Anglers fishing in Area 2 caught more trout per hour then anglers fishing in Area 1 in all three years of the creel survey. There are two reasons for this: 1) the special regulations on Area 2, and 2) each year Area 2 received half as much fishing pressure as Area 1 (Figure 2). The special regulations of area two promoted catch-and-release. This allowed anglers to catch trout without lowering their numbers in this area. The special regulations also attracted a select group of anglers, mostly fly fishers. Many of these anglers did not fish to "catch dinner" and seldom kept a legal size trout when the opportunity arose. This attitude further promotes the recycling of trout in Area 2 by allowing them to be caught more than once.

Area 2 also had lower fishing pressure than Area 1 each year (Figure 2). This lower fishing pressure helped keep the number of trout caught per hour high. Both areas were stocked with the same number of trout at each stocking (Appendix 2). Anglers fishing in Area 2 were fishing in an area with a relatively constant high number of trout, thus the higher catch rates. Most anglers fishing in Area 1 kept what they caught, so after a period of time there were more

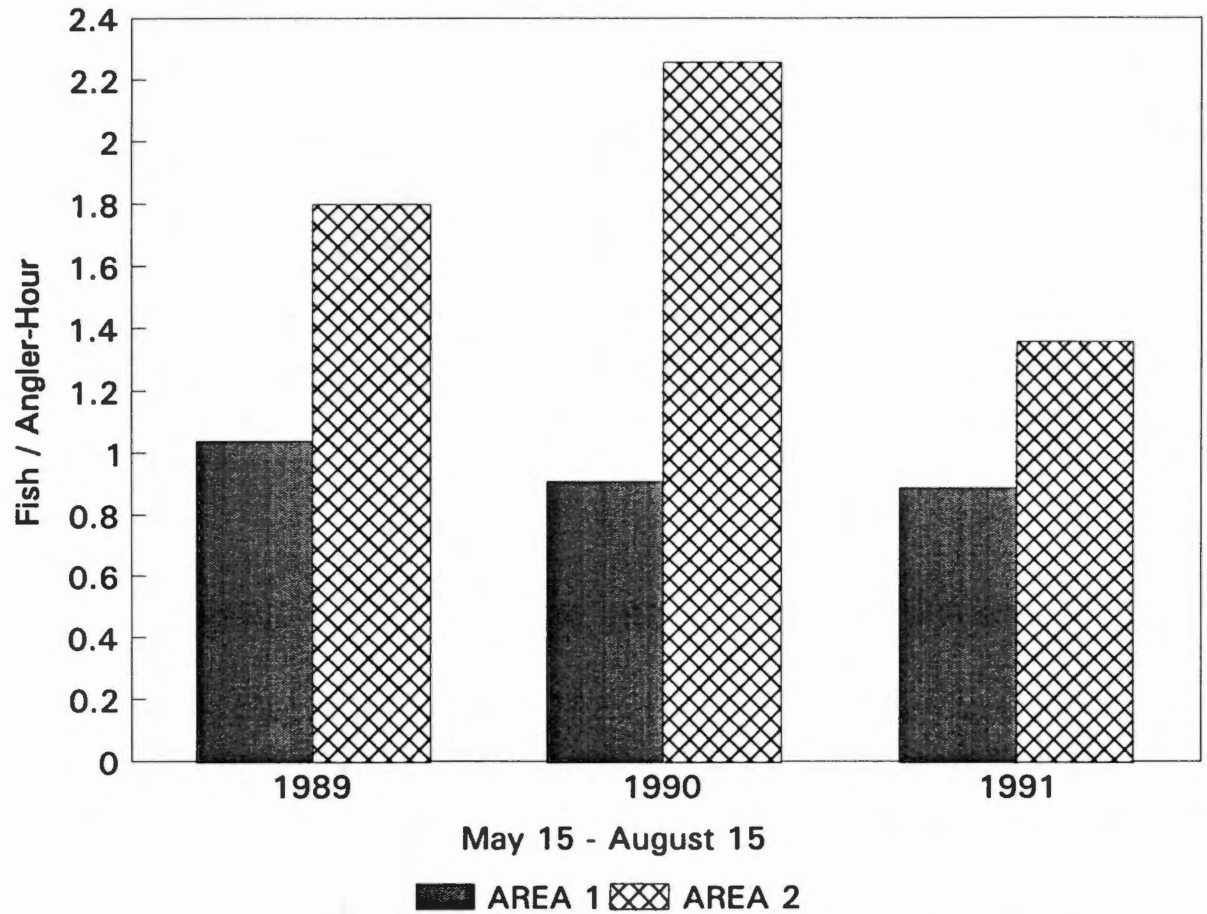

Figure 1. Number of fish caught per angler hour from May 15 through August 15 of 1989 through 1991 in Areas 1 and 2 of the Hiwassee River.

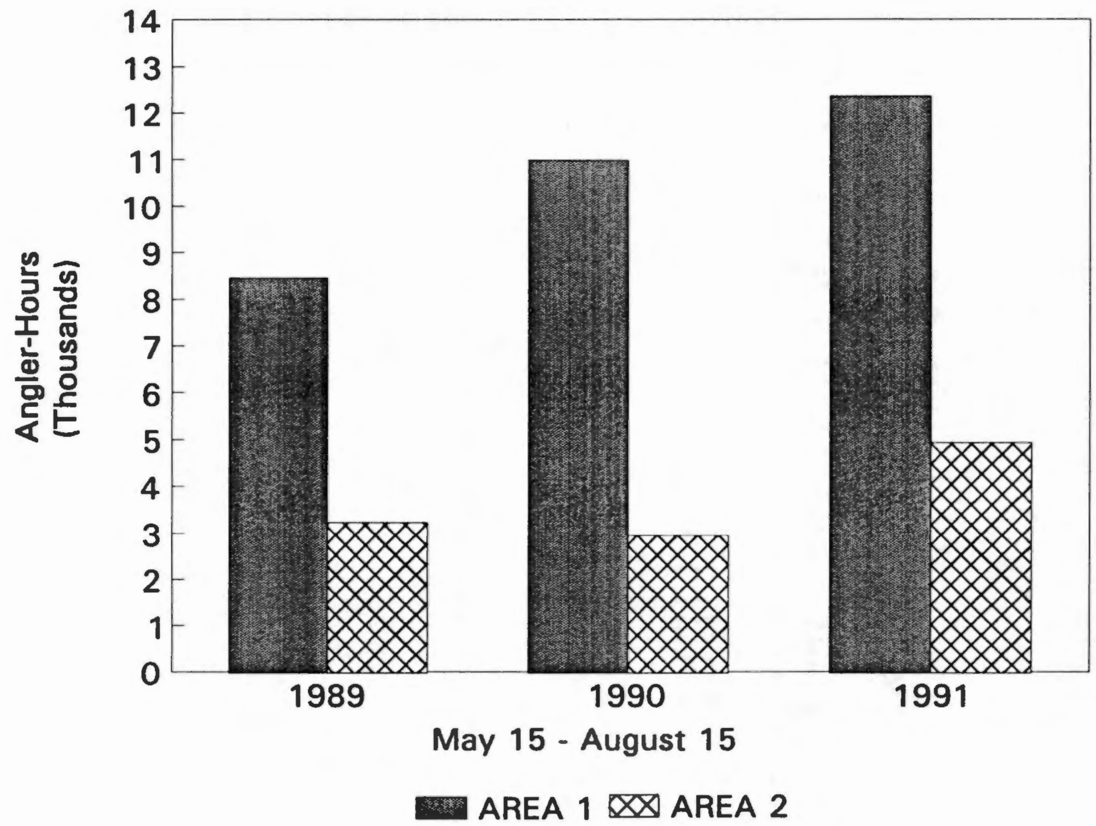

Figure 2. Number of angler hours spent fishing from May 15 through August 15 of 1989 through 1991 in Areas 1 and 2 of the Hiwassee River.

anglers fishing for fewer fish. As a result, catch rates dropped. However, it is interesting to note that even as fishing pressure in Area 1 increased each year, the catch rate dropped only slightly.

The percentage return to the creel of stocked trout in the Hiwassee River appears to be fairly constant (Figure 3). In the 1989 creel survey, 24% of the trout stocked in the river were caught; in 1990, 39% were caught; and in 1991, 29% were caught. From May - August 1974, over one third (37%) of the trout stocked in the river were caught (Myhr 1977). These return rates are somewhat low when compared to other Southern trout tailwaters. The average return of stocked trout in 10 Southern tailwaters was 55%; one of these was the Norris tailwater, where a 63% return was found (Swink 1985).

The total number of trout caught in the Hiwassee River increased in each year of the creel survey (Figure 4). The number of trout caught in each area also increased each year (Figure 5).

More anglers came to the Hiwassee River in each succeeding year of the creel survey (Figure 6). The average time spent fishing was just over 3.0 hours in all three years of the survey; therefore, total angler effort increased each year (Figure 7). The percentage effort spent fishing for trout was high in both areas during all three years. Trout fishing effort in Area 1 ranged from 75 to

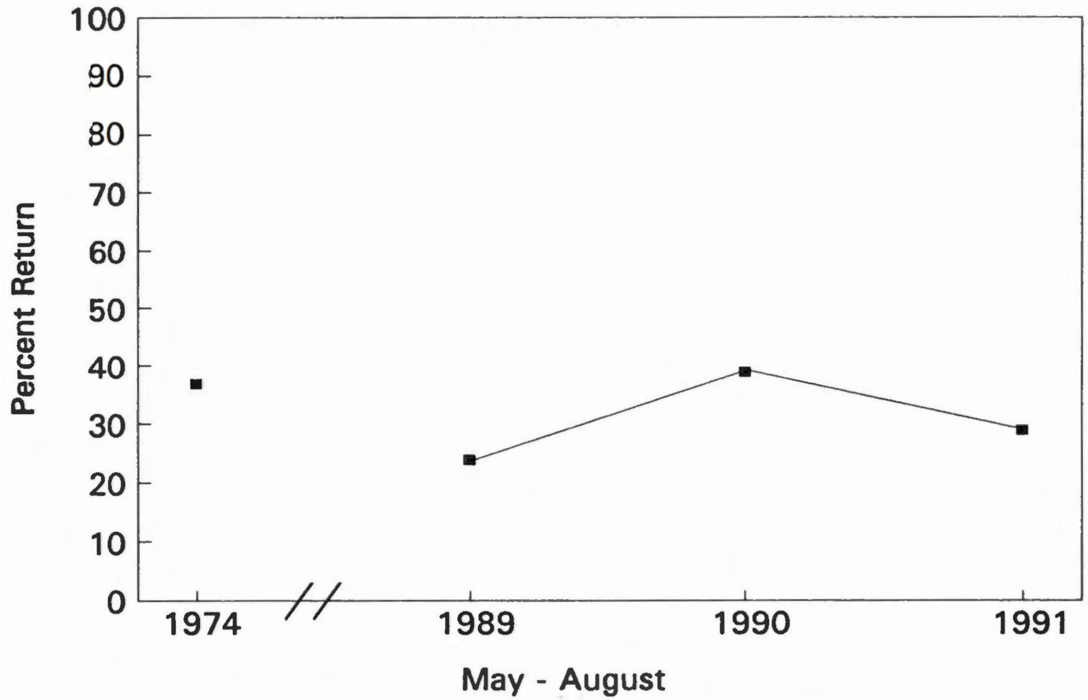

Figure 3. Percent return to the creel of stocked trout in the Hiwassee River from May through August of 1974 and 1989 through 1991.

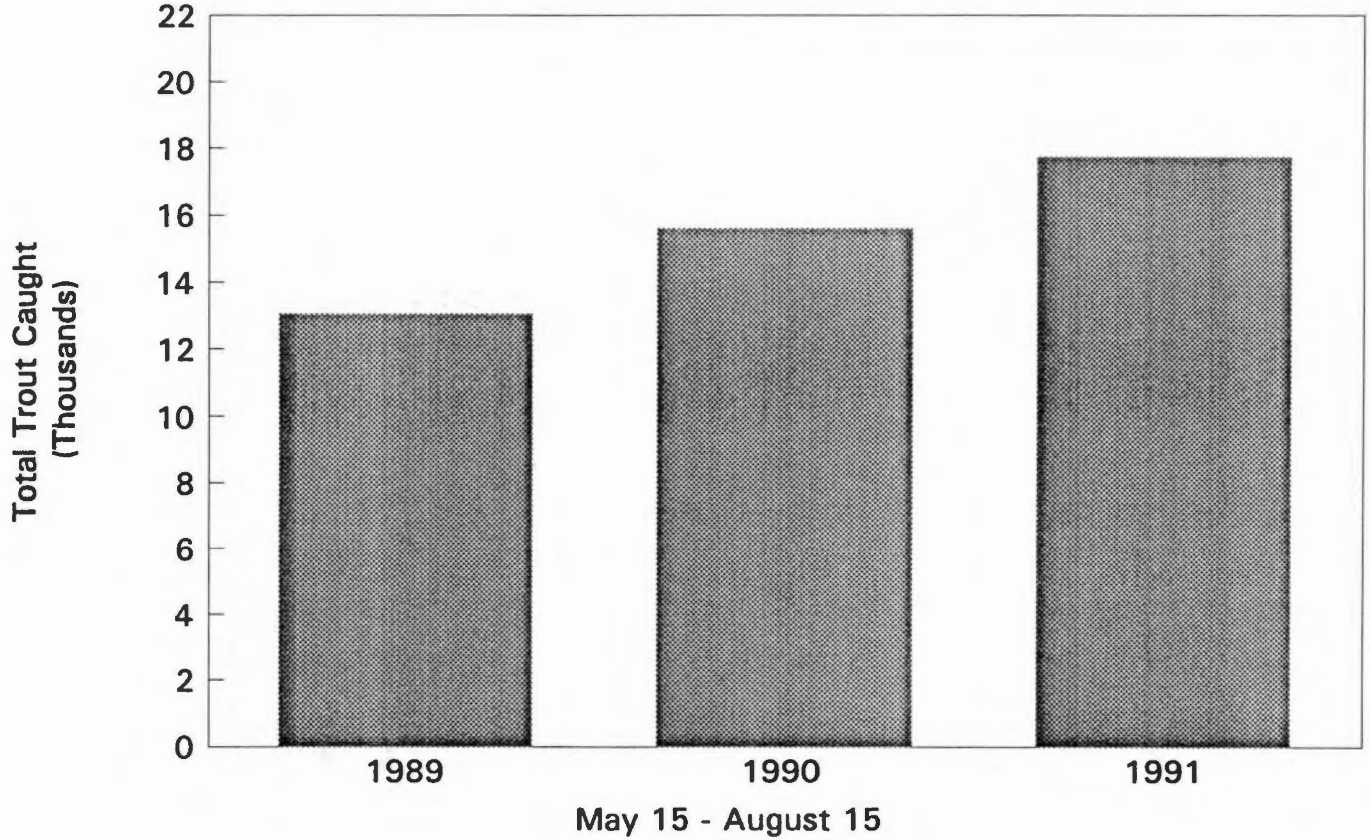

Figure 4. Total number of trout caught in the surveyed areas of the Hiwassee River from May 15 through August 15 of 1989 through 1991.

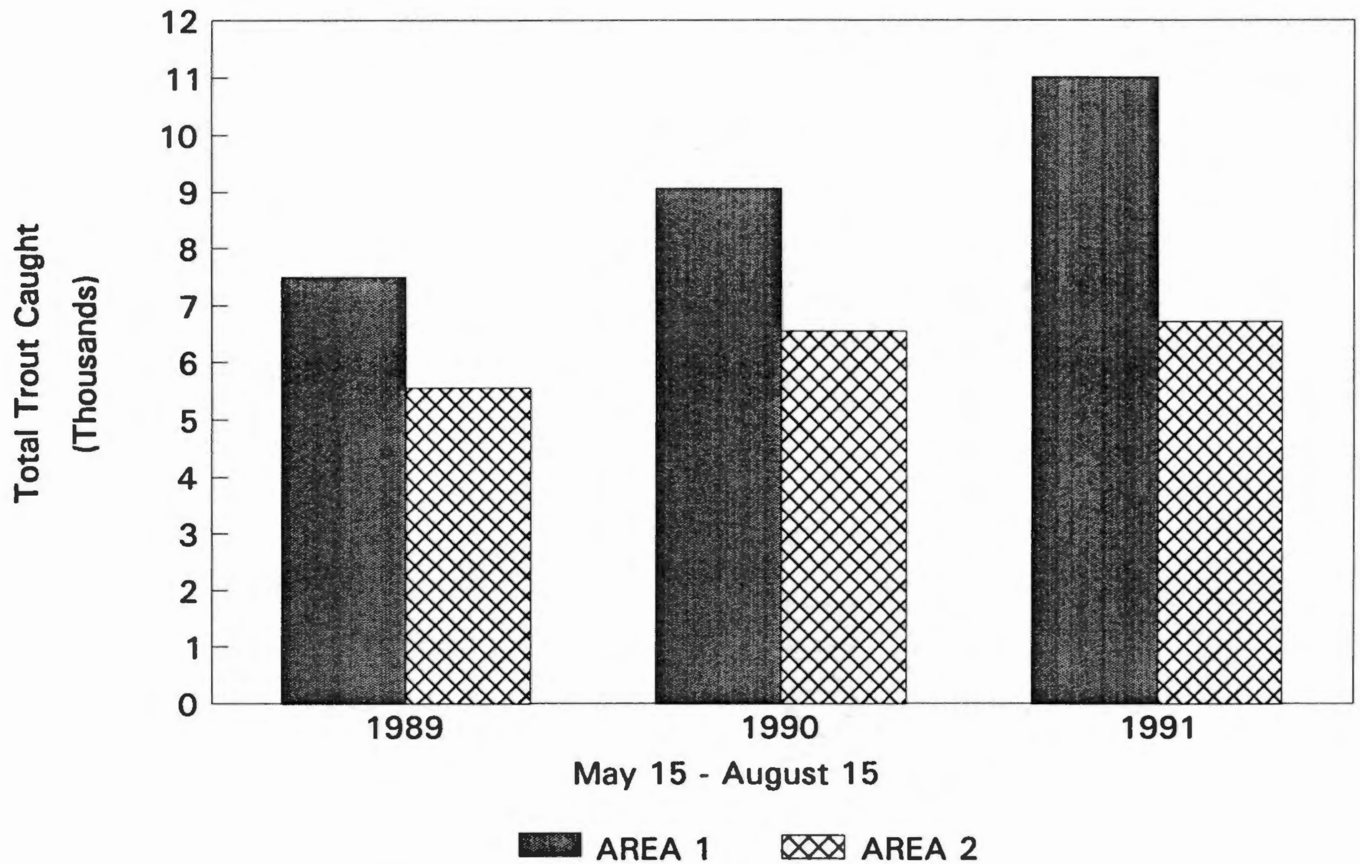

Figure 5. Total number of trout caught in Areas 1 and 2 of the Hiwassee River from May 15 through August 15 of 1989 through 1991.

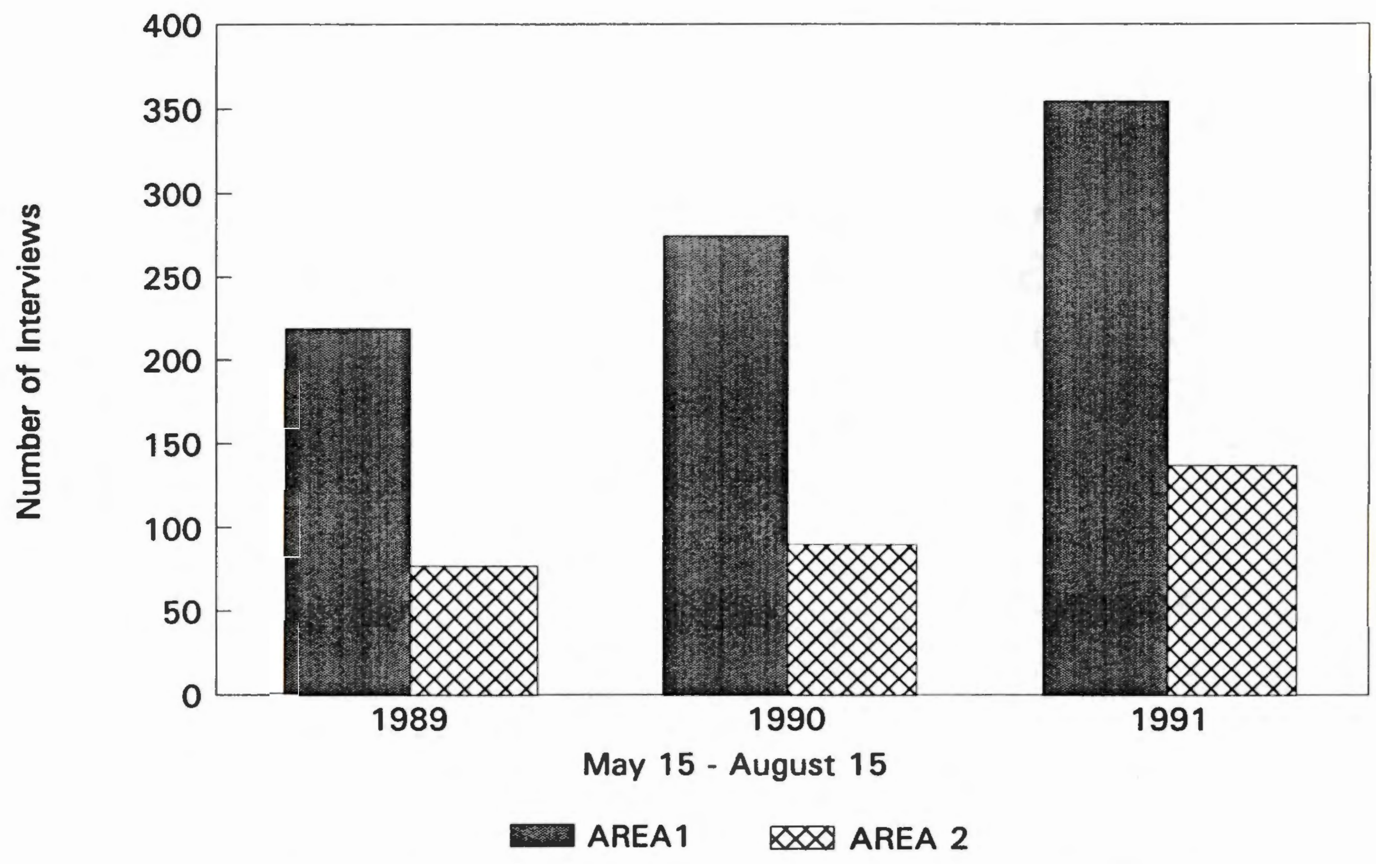

Figure 6. Number of angler interviews conducted in each area of the Hiwassee River from May 15 through August 15 of 1989 through 1991.

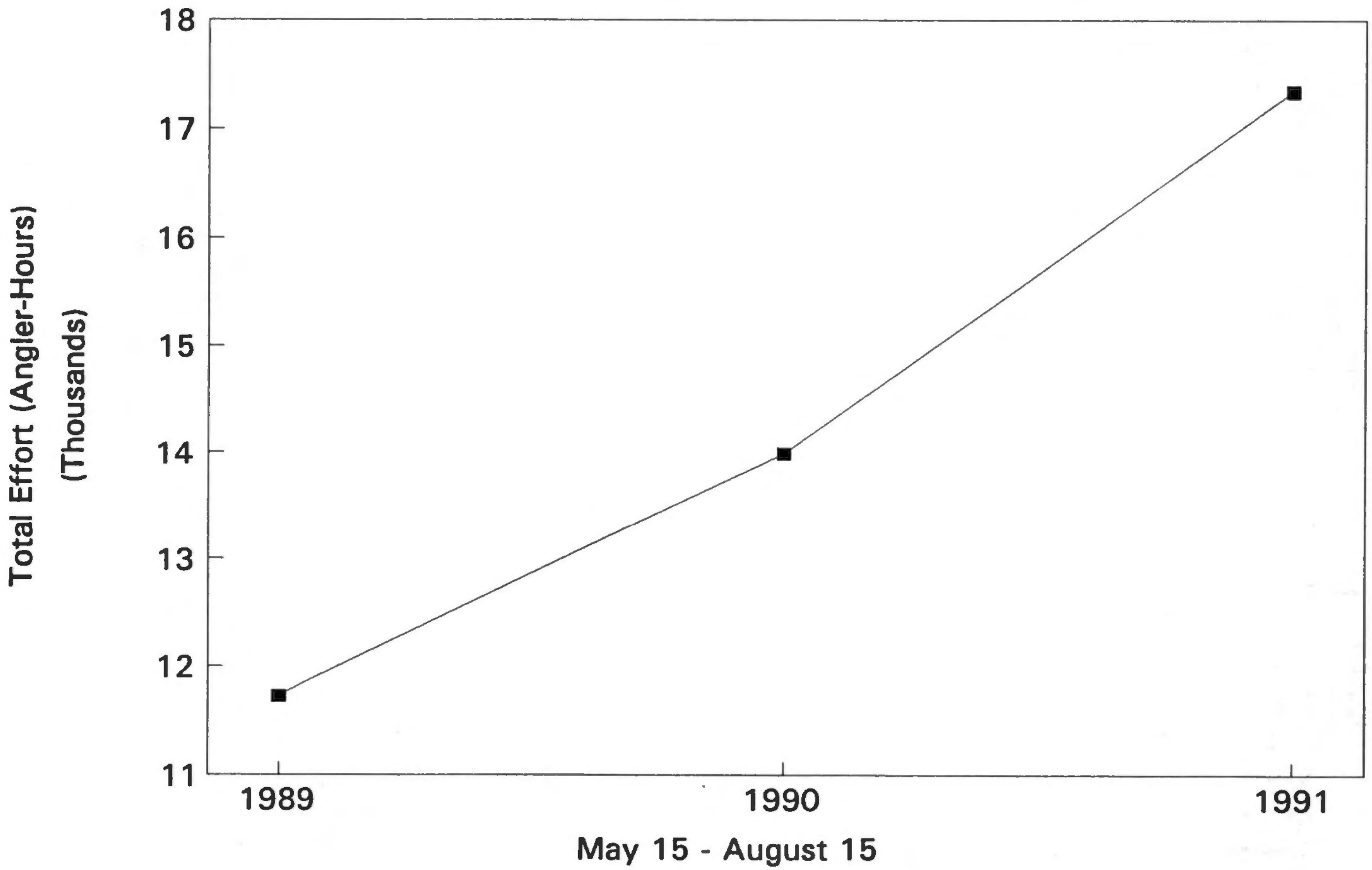

Figure 7. Total angler effort in the Hiwassee River from May 15 through August 15 of 1989 through 1991.

90%, and in Area 2 it never dropped below 95%. The Hiwassee River trout fishery is attracting more anglers each year. The creel survey indicated that both Areas 1 and 2 are attracting more anglers. With the high catch rates, anglers are experiencing a high quality trout fishery.

Growth and Movement

Growth and movement data were to be obtained by using a unique fin clip in each area. The growth of any stocked trout could then be calculated by matching the fin clip it had with its length and weight at stocking. However, this did not work because the creel clerk could not determine from which stocking an individual fish came. The trout regenerated their fins at different rates, and it was difficult to determine in which year they were stocked and from which individual stocking they came. Fin clipping is a good method to determine growth rates. The problem encountered in this study was keeping the same fin clip for each area. In order for the creel clerk to have a better idea from which stocking an individual fish came, a system of rotating which fin clip is stocked in each area would work better.

The fin clipping and stocking system that was used for the Hiwassee River was ideal in determining the movement of the stocked trout. Each type fin clip was used only in one area, so it was easy to tell if an individual fish had moved from the area in which it was stocked. Over 175,000 trout were stocked in four different areas of the Hiwassee River in the course of the three-year study. These fish simply did not move. Only 71 trout, or 13% of the trout sampled, were recaptured in a different area. Only one trout traveled more than one area. These findings in the Hiwassee River are not uncommon. Creswell (1980) reported that the majority of stocked brown trout tended to remain close to the area of stocking. Cargill (1980) reported no significant upstream or downstream movement of rainbow trout over a 2.5-year period in a Minnesota stream. It could be that the stock of trout used in the Hiwassee river is genetically nonmigratory. Several researchers have demonstrated nonmigratory strains of rainbow trout (Calhoun 1966; Northcote et al. 1970; Huzyk and Tsuyuki 1974). This would explain the lack of movement of the trout in the Hiwassee River.

Water Flow

There were no significant differences in the total flow of water through the Smith Creek Powerhouse during the three-year survey. However, in 1991 TVA committed to a new policy of pulsing the water flow to the powerhouse every hour during periods of no generation. There had been many areas where the river bed was exposed or the water was very shallow during periods of no generation. The new policy to pulse the water keeps these areas from extended "dry" periods and helps keep the water temperature down.

Dissolved Oxygen

Trout show the effects of stress when dissolved oxygen levels fall below 6 ppm (Davis 1975; Yeager et al. 1987). Dissolved oxygen in the Hiwassee River was monitored from May 15 - August 15 at three different locations in 1990 and 1991. The average dissolved oxygen level during this time frame in 1990 was 10 ppm, and in 1991 it was 11 ppm. Each year the lowest level of dissolved oxygen found was 8 ppm in mid- to late June. These levels pose no problem to the trout population in the river.

The data from TVA indicated that dissolved oxygen levels drop as low as 3 ppm in early September. However, TVA measured the dissolved oxygen at Appalachia Dam where the water entered the pipes leading to the powerhouse, so their measurements did not reflect the true levels of oxygen in the river. When the water is discharged from the turbines into the river it is thoroughly mixed with air, raising the dissolved oxygen levels. When TVA found levels of 6 ppm in mid-August at the dam, levels of 9 and 10 ppm were found by the author 275 m below the powerhouse. Therefore, when dissolved oxygen levels drop as low as 3 ppm at the dam, levels in the river should still be above the critical level.

Coefficient of Condition, Competition, and Temperature

In all three survey years the average K values of rainbow trout from Area 1 of the Hiwassee River were significantly higher than the average K values of rainbow trout from Area 2 of the river. A K value of 1.00 is considered good condition for rainbow and brown trout (Swingle and Smith 1971). The average K value of all the rainbow trout collected throughout the study from Area 1 was 1.05, and from Area 2, 0.90. There was no significant difference in the K values of brown trout from either area. Brown trout from each area had K values around 1.00 in all three survey years.

One explanation for the differences in K values of the rainbow and brown trout could be competition for food. Competition for food is widely considered to be a major factor in structuring assemblages of stream fishes (Grossman et al. 1982). When rainbow and brown trout are in competition for available food, brown trout are expected to fare better (Loar 1985). This may be part of the reason brown trout had such good K values.

Competition from nongame fishes is frequently given as a major cause of the decline of gamefish densities in streams, especially populations of salmonids (Baltz and Moyle 1985). The Hiwassee River is home to many warm and cool water fishes, but since trout are stocked regularly, these fishes would not cause the density of trout in the river to decline. However, they may be out-competing rainbow trout for available food.

Rainbow trout were sampled from Area 2 in 1990 and 1991 using primer cord. The K values of rainbow trout dropped from June - August (Table 14). These values dropped the most in the downstream portion of the area.

The drop in K values observed in the rainbow trout from Area 2 coincided with the rising temperatures found in that area. From July - October, in each year of the study, there were several days when the temperature in the river rose to and/or exceeded 18 C (Figure 8). Temperatures in the downstream portion of Area 2 were significantly higher than temperatures upstream in all three years of the study. These higher temperatures downstream help explain the poor K values of the rainbow trout sampled there. Rainbow trout prefer temperatures of 13 - 15 C (Garside and Tait 1958; Coutant 1977; Peterson et al. 1979) and avoid temperatures of 19 C or greater (Coutant 1977). Lethal temperatures for rainbow trout have been reported from 25.6 C (Hokanson et al. 1977) to 25.8 C (Alabaster 1982).

The higher temperature downstream in Area 2 increases the maintenance requirements of the trout. Standard metabolism increases with temperature (Wurtsbaugh and Davis 1977), and the fish must eat more to maintain body weight.

It has been noted that K values of trout decline after stocking (A. Myhr, TWRA, pers. commun.). The trout stocked

Table 14. Primer cord results (number in sample (#), average coefficient of condition (K)) from the Hiwassee River for rainbow trout (RBT) by date and location.

DATE	#	K	LOCATION
JUNE 17, 1991	29	1.05	UPSTREAM / AREA 2
JULY 12, 1991	165	0.89	DOWNSTREAM / AREA 2
AUGUST 6, 1990	31	0.90	DOWNSTREAM / AREA 2
AUGUST 13, 1990	47	0.89	MID-PORTION / AREA 2
AUGUST 13, 1990	18	0.79	DOWNSTREAM / AREA 2

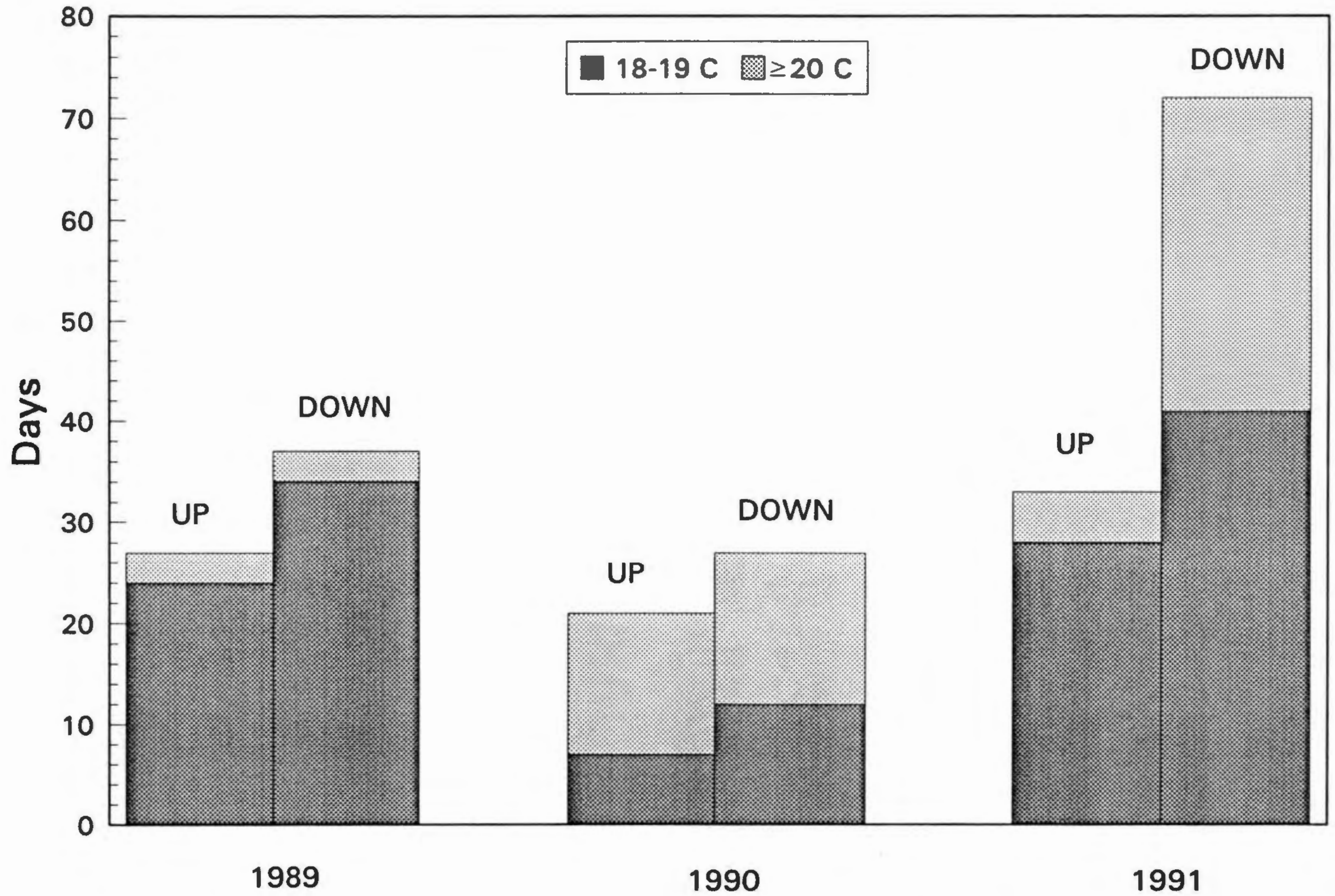

Figure 8. Number of days in the upstream (UP) and downstream (DOWN) portions of Area 2 of the Hiwassee River that temperatures reached 18 - 19 C or 20 C and greater in 1989 through 1991.

in Area 1 are usually caught soon after they are stocked. Many of these trout were kept, and they still have high K values. The trout stocked in Area 2 are often caught, but seldom kept. Therefore, trout stocked in Area 2 stay in the river longer than trout stocked in Area 1. It is possible that rainbow trout samples from Area 2 had lower K values than rainbow trout from Area 1 due to having stayed in the river longer.

Bottom Samples

The effect of increased water temperature on aquatic insect production is not clear. Some researchers report an increase in production as temperatures rise and some report a decrease (Wurtsbaugh and Davis 1977). A significantly greater volume of benthic macroorganisms was found in 1991 in the Hiwassee River than in 1990. The author believes the reason for this is the new pulsing policy that TVA adopted in 1991. In 1991 the river bed was not exposed for extended periods of time as it had been in 1990. This kept water temperatures from remaining high for long periods.

Travel Distance

Anglers traveled significantly farther to fish in Area 2 of the Hiwassee River than anglers who came to fish in Area 1. Area 1 of the Hiwassee River is a good place to catch trout. However, area 1 has the same rules and regulations on it as the many other southeastern rivers and streams in which trout anglers can fish. Therefore, anglers who just want to fish for trout can usually find a spot close to home. Area 2 of the Hiwassee River is unique, as it has a set of special regulations that attract a special kind of angler. Often these anglers are first drawn to the Hiwassee River by the special regulations, and return when they find good fishing. They come to fish for trout with fly rods and are not usually interested in keeping what they catch. This type of angler is willing to travel that extra mile to get the special kind of fishing experience that can be found in the special regulations section (Area 2) of the Hiwassee River.

Further research on the Hiwassee River trout fishery is needed. The effects of the pulsing policy implemented in 1991 by TVA need to be assessed. Only one summer of data is available at this time. If the creel survey is continued, extending the time frame it is conducted in should be considered. Many larger trout caught in the Hiwassee River are caught in late-winter and early-spring. Extending the survey time frame would help to document this and provide a clearer picture of the fishery. Further studies may also wish to find out why an individual angler chose the Hiwassee River to fish in on a given day. The special regulations section of the river attracted more anglers in each of the three years surveyed, but so did Area 1. It may be that anglers are coming to the Hiwassee River because they have the opportunity to fish for "trophy" trout in the special regulations area and catch fish to bring home in the nearby open fishing areas.

LIST OF REFERENCES

LIST OF REFERENCES

ALABASTER, J.S., and R. Lloyd. 1982. Water quality criteria for freshwater fish. University Press, Cambridge, Great Britain. 361 pp.

BALTZ, D.M., and P.B. Moyle. 1985. Segregation by species and size classes of rainbow trout, *Salmo gairdneri*, and Sacramento sucker, *Catostomus occidentalis*, in three California streams. Environ. Biol. Fishes. 10(1/2):101-110.

BALTZ, D.M., P.B. Moyle, and N.J. Knight. 1982. Competitive interactions between benthic stream fishes, riffle sculpin (*Cottus gulosus*) and speckled dace (*Rhinichthys osculus*). Can. J. Fish. Aquatic Sci. 39:1502-1511.

BENDER, M.D., and G.E. Hauser. 1987. Temperature modeling to investigate the use of reservoir releases to create trout fishery between Appalachia Dam and Powerhouse. Tennessee Valley Authority, Water Quality Branch Report No. WR28-1-15-102, Norris, Tennessee. 51 pp.

BETTOLI, P.W. 1988. Survey of the recreational fisheries in the Caney Fork, Elk, and Hiwassee Rivers. Tennessee Cooperative Fishery Research Unit, Tennessee Technological University. 45 pp.

CALHOUN, A. 1966. The importance of considering the strain of trout stocked. Inland fisheries management, California Dept. of Fish and Game, Sacramento, California. 181-184 pp.

CARGILL, A.S., II. 1980. Lack of rainbow trout movement in a small stream. Trans. Amer. Fish. Society. 109:484-490.

COUTANT, C.C. 1977. Compilation of temperature preference data. J. Fish. Res. Board Can. 31:739-745.

CRESWELL, R.C. 1980. Post-stocking movements and recapture of hatchery-reared trout released into flowing waters - a review. J. Fish. Biol. 18:429-442.

DAVIS, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. J. Fish. Res. Board Can. 32:2295-2332.

FERGUSON, R.G. 1958. The preferred temperature of fish and their midsummer distribution in temperature lakes and streams. J. Fish. Res. Board Can. 15:607-624.

GARSIDE, E.T., and J.S. Tait. 1958. Preferred temperature of rainbow trout (*Salmo gairdneri* Richardson) and its unusual relationship to acclimation temperature. Can. J. Zool. 36:563-567.

GROSSMAN, G.D., P.B. Moyle, and J.O. Whitaker, Jr. 1982. Stochasticity in structural and functional characteristics of an Indiana stream fish assemblage: a test of community theory. Amer. Nat. 120:423-454.

HARSHBARGER, T.J. 1975. Factors affecting regional trout stream productivity. Southeastern Trout Resource: Ecology and Management Symposium, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 11-27 pp.

HOKANSON, K.E., C.F. Kleiner, and T.W. Thorslund. 1977. Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates and yield of juvenile rainbow trout, *Salmo gairdneri*. J. Fish. Res. Board Can. 34:639-648.

HUZYK, L., and H. Tsuyuki. 1974. Distribution of LDH-B" gene in resident and anadromous rainbow trout (*Salmo gairdneri*) from streams in British Columbia. J. Fish. Res. Board Can. 31:106-108.

LITTLE, J.D. Coldwater Fishery Resources and Management program in Tennessee. Southeastern Trout Resource: Ecology and Management Symposium, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. 104-110 pp.

LOAR, J.M., editor. 1985. Application of habitat evaluation models in southern Appalachian trout streams. U.S. Dept. of Energy. Oak Ridge National Laboratory, Environmental Sciences Division, Publication No. 2383. ORNL/TM-9323. Oak Ridge, Tennessee. 310 pp.

MCAFEE, W.R. 1966. Rainbow trout. Inland fisheries management, Department of Fish and Game, The Resources Agency, State of California. 192-215 pp.

MCMICHAEL, G.A., and C.M. Kaya. 1991. Relations among stream temperature, angling success for rainbow trout and brown trout, and fisherman satisfaction. N. Amer. J. Fish. Manag. 11:190-199.

MILLS, D. 1971. Salmon and trout: a resource, its ecology, conservation and management. St. Martains Press, New York, USA. 351 pp.

MORING, J.R. 1985. Relation of angler catch rates and effort to reductions in numbers of trout stocked in five Oregon streams. N. Amer. J. Fish. Manag. 5:575-579.

MOYLE, P.B., and J.J. Cech, Jr. 1988. Fishes: an introduction to Ichthyology. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, USA. 559 pp.

MYHR, A.I. 1977. Hiwassee River investigations. Tennessee Wildlife Resource Agency. Tech. Report. No. 77-51. 86 pp.

NEEDHAM, P.R. (Revised by C.F. Bond). 1969. Trout streams - conditions that determine their productivity and suggestions for stream and lake management. Holden-Day, San Francisco, California.

NIELSEN, L.A., and D.L. Johnson. 1983. Fisheries techniques. Southern Printing Company, Inc., Blacksburg, Virginia. 468 pp.

NORTHCOTE, T.G., S.N. Williscroft, and H. Tsuyuki. 1970. Meristic and lactate dehydrogenase genotype differences in stream populations of rainbow trout below and above a waterfall. J. Fish. Res. Board Can. 27:1987-1995.

PETERSON,R.H., A.M. Sutterlin, and J.L. Metcalfe. 1979. Temperature preference of several species of *Salmo* and *Salvelinus* and some of their hybrids. J. Fish. Res. Board Can. 36:1137-1140.

SWINGLE, W.E., and E.W. Shell. 1971. Tables for computing relative conditions of some common freshwater fishes. Agricultural Experiment Station, Circular 183, Auburn, Alabama.

SWINK, W.D. 1983. Survey of stocking policies for tailwater trout fisheries in the southern United States. Prog. Fish-Cult. 45(2):67-71.

TEBO, L.B, Jr. 1975. Review of selected parameters of trout stream quality. Symposium on trout habitat research and management. 20-33 pp.

WILEY, R.W., and D.J. Dufek. 1980. Standing crop of trout in the Fontenelle tailwater of the Green River. Trans. Amer. Fish. Society. 109:168-175.

WURTSBAUGH, W.A., and G.E. Davis. 1971. Effects of temperature and ration level on the growth and food conversion efficiency of *Salmo gairdneri*, Richardson. J. Fish Biol. 11:87-98.

YEAGER, B.L., W.M. Seawell, C.M. Alexander, D.M. Hill, and R. Wallus. 1987. Effects of aeration and minimum flow enhancement on the biota of Norris tailwater. Tennessee Valley Authority, Office of Natural Resources and Economic Development. AWR 87/41. Knoxville, Tennessee. 90 pp.

APPENDIXES

APPENDIX 1

HIWASSEE RIVER INTERVIEW SHEETS

Appendix 1. Interview Sheets/Hiwassee River

Completed trip: 1=Yes, 2=No ___ (2)

Interview Number ___ ___ ___ (20 21 22)

Area 01=upper 02=lower ___ ___ (3 4)

Start of Fishing (military time) ___ ___ ___ ___ (23 24 25 26)

Period ___ ___ (5 6)

End of Fishing or Time of Interview ___ ___ ___ ___ (27 28 29 30)

Kind of Day 01=Weekday 02=Weekend/Holiday ___ ___ (7 8)

No. in Party NP ___

Time Fishing (Party Hours) HR ___ MIN ___

Sample No. ___ ___ (9 10)

Date (mo/day/yr) ___ ___ ___ ___ ___ ___ (14 15 16 17 18 19)

Species	Species Fished for (check only one)	No. Kept	No. Released	Total No. Caught
Trout	TRF ___			
Rainbow		RTK ___	RTR ___	RTN ___
Brown		BTK ___	BTR ___	BTN ___
OtherA (Specify) ___	OTAF ___	OTAK ___	OTAR ___	OTAN ___
OtherB (Specify) ___	OTBF ___	OTBK ___	OTBR ___	OTBN ___

METHOD (check only one)	BAIT USED	TECHNIQUE
Cast/Spin MCS ___	Artificial BA ___	Bank/Wading TBW ___
Flyfishing MFY ___	Bait BN ___	Floating TLT ___

MARKED FISH MEASUREMENTS

Fill in the identification blanks in the following order followed by the observed length and weight.

Species (SP)	Type Mark (MARK)	Type Measurement (TM)
R=Rainbow	AD=Adipose	L=Length (mm)
B=Brown	LP=Left Pelvic	K=Weight (g)
	AN=Anal	

LENGTH (mm)

SP	MARK	TM	OBSERVED
___	___	L	___
___	___	L	___
___	___	L	___
___	___	L	___
___	___	L	___
___	___	L	___
___	___	L	___
___	___	L	___

WEIGHT (g)

SP	MARK	TM	OBSERVED
___	___	W	___
___	___	W	___
___	___	W	___
___	___	W	___
___	___	W	___
___	___	W	___
___	___	W	___
___	___	W	___

ZIP CODE (ZC) ___

APPENDIX 2

HIWASSEE RIVER STOCKING RECORDS

Appendix 2. Stocking data for the Hiwassee River, 1989 – 1991.

DATE STOCKED	RIVER SECTION	SPECIES	TYPE CLIP	NUMBER STOCKED	LENGTH AVE.(mm)	WEIGHT AVE.(g)	CONDITION FACTOR
3-22-89	2	BRT	ADIPOSE	12,000	186	75	1.17
4-12-89*	1	BRT	ANAL	4,000	191	83	1.19
4-12-89*	1	RBT	RT.PEC.	5,205	129	23	1.07
4-12-89*	2	RBT	ADIPOSE	5,122	129	23	1.07
4-12-89*	2	BRT	ADIPOSE	6,000	191	83	1.19
4-12-89	3	BRT	RT.PELVIC	4,000	191	83	1.19
4-12-89	3	RBT	L.PEC.	5,124	129	23	1.07
4-12-89	4	BRT	L.PELVIC	4,000	191	83	1.19
4-12-89	4	RBT	RT.PELVIC	4,977	129	23	1.07
5-22-89	2	RBT	L.PELVIC	4,015	266	222	1.18
3-20-90	4	RBT	RT.PELVIC	5,000	215	118	1.19
3-20-90	3	RBT	L.PEC.	5,002	211	100	1.06
3-27-90*	2	RBT	ADIPOSE	5,115	218	127	1.23
3-27-90*	1	RBT	RT.PEC.	5,038	211	100	1.06
6-06-90	1	RBT	RT.PEC.	5,000	232	138	1.11
6-06-90	2	RBT	ADIPOSE	5,008	229	133	1.11
6-25-90	3	RBT	L.PEC.	5,023	225	126	1.11
6-25-90	4	RBT	RT.PELVIC	5,005	227	130	1.11
1-23-91	1	RBT	RT.PEC.	5,024	242	141	0.99
1-23-91	2	RBT	ADIPOSE	5,005	238	140	1.04
1-24-91	3	RBT	L.PEC.	5,003	240	140	1.01
1-24-91	4	RBT	RT.PELVIC	5,003	231	130	1.05
3-11-91	1	RBT	RT.PEC.	5,002	234	142	1.11
3-11-91	2	RBT	ADIPOSE	5,016	235	144	1.11
3-12-91	3	RBT	L.PEC.	5,016	232	139	1.11
3-12-91	4	RBT	RT.PELVIC	5,025	227	129	1.10
4-15-91	1	BRT	NO CLIP	5,000	203	84	1.00
4-15-91	2	BRT	NO CLIP	5,000	203	84	1.00
4-15-91	3	BRT	NO CLIP	5,000	203	84	1.00
4-15-91	4	BRT	NO CLIP	5,000	203	84	1.00
6-04-91	1	RBT	RT.PEC.	5,018	235	144	1.11
6-04-91	2	RBT	ADIPOSE	5,156	239	150	1.10
6-11-91	3	RBT	L.PEC.	5,031	220	117	1.10
6-11-91	4	RBT	RT.PELVIC	5,052	233	140	1.11

(*) represents trout stocked with a helicopter

VITA

Dennis Robin Lindbom was born in Martin Army Hospital, Fort Benning, Georgia, on February 2, 1964. He spent the next twelve years growing up on North Long Lake in Brainerd, Minnesota. It was there that his interest for science and fishes in particular was born. After living in Seoul Korea for two years, he and his family moved to Harlem, Georgia, in 1978. He graduated from Harlem High School in 1983. In 1989 he received the outstanding senior biologist award from Augusta College, Augusta, Georgia. He received a Bachelor of Science degree in Biology from Augusta College that same year.

In January of 1990, he entered Graduate School at the University of Tennessee, Knoxville, with a research assistantship in Forestry, Wildlife, and Fisheries. In May of 1992, he received a Masters of Science degree in Wildlife and Fisheries Science, with specialization in fisheries.