FISHERIES REPORT:

Region IV Coldwater Streams 2021

Tennessee Wildlife Resources Agency
Fisheries Report 22-05

Above photo: Collection of native Brook Trout from Indian Camp Creek (GSMNP) for translocation to Norton Creek, 23 September 2021.

Cover photo: Native Brook Trout translocation team for the Norton Creek restoration project, 23 September 2021. Back row, left to right: Mike Prater (TWRA), Carl Williams (TWRA), Bart Carter (TWRA), Matt Kulp (NPS), Caleb Abramson (NPS), Scott Sellers (USFWS), and Matt Padgett (USFWS). Middle row, left to right: Alan Beach (TWRA), Rob Lindbom (TWRA), Jim Habera (TWRA), Alex Walters (NPS seasonal), Maggie Coffey (NPS intern), Katharine Gilbert (NPS intern), Phillip Abegg (NPS intern), and Kayona Tucker (NPS intern). Front row, left to right: Earl Worsham, Sally Petre (TWRA), Branden Kohler (NPS seasonal), and Levi Morgan (NPS seasonal).

John Hammonds (TWRA), Ricky Bean (TWRA), Kenny Goodman (TWRA), Devin Hevener (TWRA intern), Dalton Bonds (TWRA intern), Jenny Isham (TWRA intern), Katy Tramel (NPS fisheries intern), and James Miles (NPS seasonal) also assisted with earlier efforts but were not present on 23 September 2021.

Visit TWRA's website at www.tnwidlife.org, where you can learn more about Tennessee's trout fisheries across the state.

FISHERIES REPORT:

REGION 4 COLDWATER STREAMS

2021

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TENNESSEE WILDLIFE RESOURCES AGENCY
FISHERIES REPORT 22-05

June 2022

This report contains progress and accomplishments for the following TWRA Projects: "Stream Survey".

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Executive Summary

Wild Trout Monitoring: Five wild trout streams (Doe Creek, Laurel Fork, Beaverdam Creek, Left Prong Hampton Creek, and Right Prong Middle Branch) were quantitatively sampled during 2021 at established monitoring stations (only Station 2 was sampled in Laurel Fork). Wild trout abundance generally improved in these streams relative to the 2020 estimates.

Sympatric Brook/Rainbow Trout streams: Relative Brook Trout biomass in Briar Creek (23%) decreased relative to the last survey (2019), although total trout biomass was only 3 kg/ha and has declined substantially since 2014 (32 kg/ha). However, the Briar Creek Brook Trout population has continued to exist in sympatry with Rainbow Trout for nearly 40 years.

Native Brook Trout Restoration and Enhancement: Successful Brook Trout reproduction was observed in Green Mountain Branch and Phillips Hollow in 2021. Rainbow Trout removals were completed in Trail Fork Big Creek and continued in the lower 1.2-km reach of Little Jacob Creek (to extend that Brook Trout population). Native Brook Trout from Wolf Creek (27) were translocated to upper Trail Fork Big Creek and nine adults being held at the Tellico Hatchery (from Gulf Fork Big Creek populations) were released there as well. The existing hatchery-origin Brook Trout population in upper 2 km of Norton Creek was removed and replaced by 293 native fish translocated from three streams in Great Smoky Mountains National Park. Preliminary work for restoring native Brook Trout in Right Prong Rock Creek continued, including modification of the plunge pool below the potential box culvert barrier.

Norris tailwater: Mean CPUE for all trout and trout within the PLR (356-508 mm) declined relative to 2020, although PLR CPUE and RSD-14 for Rainbow Trout and Brown Trout remained above corresponding objectives for the current Norris tailwater management plan (2020-2025). Results from the ongoing Tennessee Cooperative Fisheries Research Unit (TN CFRU) research project (including shoreline electrofishing in 2021) continue to suggest that natural reproduction by Rainbow Trout contributes substantially to this fishery.

Cherokee tailwater: Mean CPUE for trout ≥178 mm and ≥356 mm from the fall (October) monitoring sample declined somewhat relative to the corresponding 2020 levels. Mean CPUE for trout ≥178 mm in the June 2021 sample (18 fish/h) did not change from the June 2020 sample. June CPUEs (2018-2021) tend to be about 50% higher than subsequent fall catch rates, but they also exhibit higher variability among sites. There was no coldwater habitat (minimum daily water temperature exceeded 21° C) for 31 days at the Blue Spring monitoring site (19 September to 25 October). Water temperatures in the Cherokee tailwater typically exceed 21° C during September through mid- to late October.

Wilbur tailwater: Mean CPUE for Brown Trout ≥178 mm in the upper portion of the tailwater (Stations 1-6) fell below 300 fish/h in 2021 and has declined 43% since 2019. However, this is more comparable to CPUE estimates for 2010-2016 (prior to the substantial increase during 2017-2020. Mean Rainbow Trout CPUE in the lower tailwater improved nearly 30% from the low of 8.4 fish/h observed in 2020. Results from the 2020 angler survey indicated that angling pressure and trips, as well as catch and harvest (for both Rainbow and Brown Trout) all increased relative to the 2018 survey.

Ft. Patrick Henry tailwater: Mean CPUE for all trout ≥178 mm declined to 11 fish/h (the lowest CPUE observed to date) and catch rates for larger trout (≥356 mm and ≥457 mm) were also substantially lower in 2021. However, RSD-18 for Rainbow Trout remained well above the objective (20) established in the Boone and Ft. Patrick Henry Tailwater Trout Fisheries Management Plan. Preliminary results of TN CFRU's research indicate that adult-stocked (~254 mm or 10 in.) Rainbow Trout primarily support that fishery and data from recaptured PIT-tagged fish indicate that they grow 26.0 to 27.7 mm/month.

Boone tailwater: Mean CPUE for trout ≥178 mm and ≥457 mm increased relative to corresponding 2020 CPUEs. RSD-18 values for Rainbow Trout and all trout continued to exceed the objectives in the Boone and Ft. Patrick Henry Tailwater Trout Fisheries Management Plan. Adult Cutthroat Trout (Snake River fine-spotted subspecies; 2,600 fish) were stocked in the Boone tailwater and at a few other locations in Tennessee in 2021.

South Holston tailwater: Mean CPUEs for Brown Trout and Rainbow Trout ≥178 mm decreased relative to 2020 levels, while the overall PLR catch rate increased slightly (from to 10.5 to 11.5 fish/h). PLR catch rates have typically ranged from 9-15 fish/h since 2010. Brown Trout RSD-16 also declined in 2021 (to 4) and has remained in the 3-8 range since 2010, indicating that Brown Trout population size structures have not maintained the shift toward larger fish that occurred during 2005-2007.

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1. Introduction

The Tennessee Wildlife Resources Agency (TWRA) manages trout fisheries in a variety of waters in Tennessee including streams, tailwater rivers, and reservoirs, providing a popular and important set of angling opportunities. A 2021 mail/email survey of 5,952 anglers licensed to fish for trout in Tennessee produced 638 respondents who participated in trout fishing during the previous six years (Poudyal and Cavasos 2022). These anglers reported an average of 7.22 trout fishing trips in 2020, spending an average of $194 per trip (Poudyal and Cavasos 2022). Trout anglers across the state spent an estimated $46 million in 2021 (Poudyal and Cavasos 2022).

The Agency's current statewide trout management plan (TWRA 2017) features management goals and strategies designed to manage stocked trout and conserve wild trout and their habitat while providing a variety of angling experiences. Accordingly, while TWRA management emphasizes habitat preservation and maintenance of wild stocks where they occur, artificially propagated trout are essential for managing substantial portions of the coldwater resource. About 1.3 million trout were produced or grown annually at five state (TWRA), one municipal (Gatlinburg), and two federal (USFWS) facilities to be stocked in Tennessee's hatchery-supported fisheries during 2021 (Roddy 2022). Most (79%) were Rainbow Trout and 90% were adult fish, including 5,000 Cutthroat Trout *Oncorhynchus clarkii*, which had not been stocked in Tennessee since the 1960s. Just under half (49%) of all trout stocked in 2021 went to Region IV waters, with 60% of those fish used to support tailwater fisheries, 20% for reservoir fisheries, and 20% for smaller streams, ponds, winter trout program fisheries, etc. (Roddy 2022).

The Blue Ridge physiographic province of eastern Tennessee contains about 1,000 km (621 mi) of coldwater streams inhabited by wild (self-sustaining) populations of Rainbow Trout *Oncorhynchus mykiss*, Brook Trout *Salvelinus fontinalis*, and Brown Trout *Salmo trutta*. Wild trout occur in 9 of Region IV's 21 counties (primarily those that border North Carolina). Most of Region IV's wild trout resource is within the U.S. Forest Service's (USFS) 253,000-hectare (625,000-acre) Cherokee National Forest (CNF) with about 30% on privately owned lands and includes some of the State's best wild trout streams. Many streams with unregulated flows can support trout fisheries but are limited by marginal summer habitat or levels of natural production insufficient to meet existing fishing pressure. TWRA provides or supplements trout fisheries in 36 streams in Region IV by annually stocking hatchery-produced (adult) Rainbow Trout. Some stocked streams (e.g., Beaverdam Creek, Doe Creek, Laurel Fork, and Doe River) support excellent wild trout populations as well, but the moderate stocking rates employed are considered to pose no population-level problems for the resident fish (Meyer et al. 2012).

Brook Trout are Tennessee's only native salmonid and once occurred at elevations as low as 490 m (1,600 ft.) in some streams (King 1937). They currently occupy about 230 km (144 mi) in 113 streams, or about 24% of the stream length supporting wild trout outside Great Smoky Mountain National Park GSMNP). Brook Trout occur allopatrically (no other trout species are present) in 45 streams totaling 75 km (47 mi.), representing 33% of the Brook Trout resource. A new genetic survey using microsatellite DNA markers indicated that 83 populations can be considered native, 23 are of hatchery origin, and 7 are hatchery-influenced.

Cold, hypolimnetic releases from five Tennessee Valley Authority (TVA) dams in Region IV (Norris, Ft. Patrick Henry, South Holston, Wilbur, and Boone) also support year-round trout fisheries in the tailwaters downstream. The habitat and food resources that characterize these tailwaters provide for higher carrying capacities and allow trout to grow larger than they normally do in other streams. Tailwaters are typically stocked with fingerlings (100-150 mm) in the early spring and adult fish (229-305 mm) throughout the summer. Stocked adult trout supplement the catch during peak angling season and by fall, fingerlings reach a catchable size and have begun to enter these fisheries. Natural reproduction entirely supports the Brown

Trout fisheries in the South Holston and Wilbur (Watauga River) tailwaters. Recent surveys have also shown natural reproduction by Rainbow Trout may be significant in those tailwaters, as well as in Norris tailwater. The Holston River below Cherokee Reservoir also supports a tailwater trout fishery, although high water temperatures (>21° C) during late summer and early fall limit survival and carryover. No fingerlings are stocked there, as few would survive the thermal bottleneck to recruit to the fishery. Research is underway to determine how stocked and wild fish are currently contributing to the trout fisheries in several Region 4 tailwaters.

One of TWRA's core functions identified in its Strategic Plan (TWRA 2014) is outdoor recreation, and a primary objective is to maintain or improve programs that promote high user satisfaction for hunters, anglers, and boaters. Over three-quarters (77%) of survey respondents indicated being either somewhat or very satisfied with their recent fishing experience in Tennessee and nonresidents reported a 91% level of satisfaction (Poudyal and Cavasos 2022). Maintaining this level of satisfaction will require effective management of existing resources and opportunities—as well as development of new ones. TWRA's statewide trout management plan for 2017-2027 (TWRA 2017) addresses how these goals can be accomplished. This plan includes management guidelines for Tennessee's native Brook Trout, particularly given the new genetics data available for all Brook Trout populations. Acquisition of trout population status and dynamics data from streams and tailwaters through standardized stream survey techniques (e.g., abundance trends and size structures, etc.) will also continue to be an important strategy for managing these fisheries.

2. Wild Trout Monitoring

Selected Region IV wild trout streams are sampled annually at established monitoring stations to provide baseline trout abundance data and assess trends for management purposes. This annual monitoring began in the early 1990's and provides valuable information for angling regulation establishment, evaluation, and changes, as well as documentation of annual variability (e.g., associated with droughts and floods). Doe Creek, Laurel Fork, and Beaverdam Creek were quantitatively sampled during the 2021 field season (June-October). Most wild trout monitoring streams are now sampled on a rotational basis (every third year). Previously (1991-2010), several streams were sampled annually. Archived reports from earlier years, many of which contain more detailed survey data and stream history information, can be found on the TWRA website at: https://www.tn.gov/content/tn/twra/fishing/trout-information-stockings.html#FisheriesReport.

Sampling Methods

Wild trout stream sampling was conducted with battery-powered backpack electrofishing units employing inverters to produce AC outputs to complete TWRA's standard protocol for three-pass depletion. Output voltages were 125-600 VAC, depending upon water conductivity. Stocked Rainbow Trout, distinguishable by dull coloration, eroded fins, atypical body proportions, and large size (usually >229 mm), compared to wild Rainbow Trout were noted on data sheets but were not included in any analyses. Stream sample sites are part of TWRA Region 4 annual monitoring. Streams sampled this year include Doe Creek, Laurel Fork, Beaverdam, Left Prong Hampton, and Right Prong Middle Branch.

Removal-depletion data were analyzed with MicroFish 3.0 for Windows (http://microfish.org/). Trout ≤90 mm in length were analyzed separately from those >90 mm due to their lower catchabilities (Lohr and West 1992; Thompson and Rahel 1996; Peterson et al. 2004; Habera et al. 2010), making separate analysis necessary to avoid bias. These two groups also roughly correspond to young-of-the-year (YOY or age-0) and adults.

Doe Creek

Doe Creek is one of Tennessee's most productive wild trout streams and TWRA is committed to maintaining it. The seasonal hatchery-supported trout fishery in Doe Creek is popular (Habera et al. 2004), but management of this stream should feature the outstanding wild trout population. The current stocking program is not incompatible with the wild trout management and native fish assemblages (Weaver and Kwak 2013), but it should not be expanded in scope or scale. Annual monitoring at the site near Lowe Spring should continue. Trout abundance does not seem to be affected, however. Citizens inquired during the 2020 sample if we were investigating a fish kill related to the "white sludge" that came down the creek the previous weekend, although they did not report seeing any dead fish. Trout abundance was lower in 2020 than in any previous sample, although, other species did not appear to be affected. Data for the 2021 survey are provided in Tables 1 and 2. Rainbow Trout density increased in 2021 (Figure 1) and the population appears to be healthy. No management change is recommended.

Table 1. Site and sampling information for Doe Creek in 2021.

Location	**Site 1**	
Site code	420212501	
Sample date	07 September 2021	
Watershed	Watauga River	
County	Johnson	
Lat-Long	36.42709 N, -81.93725 W	
Elevation (ft)	2,210	
Land ownership	Private	
Fishing access	Good	
Description	Site ends at small dam just below Lowe spring.	
Effort		
Station length (m)	134 m	1126 m2
Electrofishing units	3	250 V AC
Habitat		
Mean width (m)	8.4	
Canopy cover (%)	45	
Est. % site pool/riffle	37	63
Habitat assessment score	155 (suboptimal)	
Water Quality		
Flow (cfs; visual)	17.9	normal
Temperature (C)	15.4	
pH	8.3	
Dissolved oxygen (mg/L)	NM	
Alkalinity (mg/L $CaCO_3$)	NM	

Table 2. Fish population abundance estimates (with 95% confidence limits) for Site 2 on Doe Creek sampled in 2021.

	Total	Pop. Size		Biomass (kg/ha)		Density (fish/ha)	
Species	Catch	Est.	C.I.	Est.	C.I.	Est.	C.I.
RBT ≤90 mm	10	12	(0-24)	0.70	(0.00-1.36)	107	(0-213)
RBT >90 mm	99	102	(97-108)	30.30	(28.77-32.04)	906	(861-959)
Creek Chub	2	2	(2-2)	0.00	(0.01-0.01)	18	(18-18)
Blacknose Dace	486	569	(528-610)	13.90	(12.66-14.63)	5053	(4689-5417)
Fantail Darter	59	76	(50-102)	0.90	(0.62-1.27)	675	(444-906)
Mottled Sculpin	595	1,166	(823-1509)	32.10	(22.66-41.54)	10355	(7309-13401)
C. Stoneroller	110	122	(108-136)	34.10	(30.21-38.05)	1083	(959-1208)
N. Hogsucker	1	1	(1-1)	0.50	(0.48-0.48)	9	(9-9)
Snubnose Darter	1	1	(1-1)	0.00	(0.02-0.02)	9	(9-9)
Green Sunfish	1	1	(1-1)	0.10	(0.11-0.11)	9	(9-9)

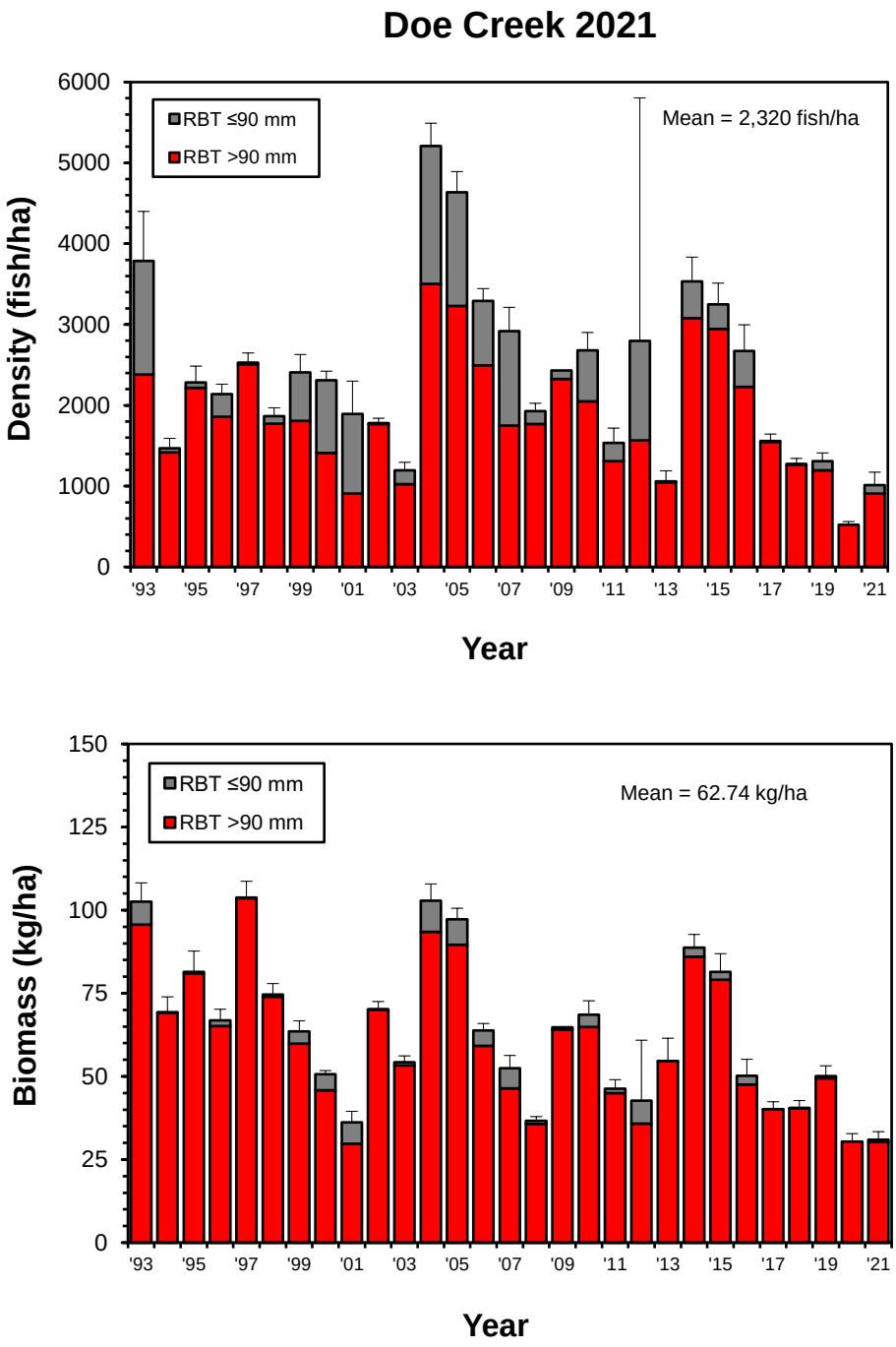


Figure 1. Doe Creek 2021 trout abundance (density and biomass) with 95% confidence limits.

Laurel Fork

Laurel Fork is one of the few Tennessee streams where wild Brown Trout dominate. Many of Laurel Fork's tributaries have Brook Trout, and they often appear in monitoring samples along with Brown Trout. Only Site 2 was sampled in 2021 because of high stream flows. Site and sampling data are provided in Tables 3 and 4. Abundance estimates (Figure 3) for 2021 were consistent with previous years, with total trout density slightly above average and total trout biomass slightly below average (Figure 3). Inconsistent depletion patterns for age-0 Brook Trout and Brown Trout resulted in the large confidence interval for the 2021 density estimate. No management change is suggested.

Table 3. Site and sampling information for Laurel Fork in 2021.

Location	**Site 1**	**Site 2**	
Site code	Not sampled this year	420212402	
Sample date		30 August	
Watershed		Watauga River	
County		Carter	
Lat-Long		36.23972N, -82.08056W	
Elevation (ft)		2,880	
Land ownership		USFS	
Fishing access		Good	
Description		Begins ~300 m above the mouth of Leonard Br. at a large campsite	
Effort			
Station length (m)		236 m	2077 m²
Electrofishing units		3	400 V AC
Habitat			
Mean width (m)		8.8	
Canopy cover (%)		75	
Est. % site in pool/riffle		47	53
Habitat assessment score		160 (sub-optimal)	
Water Quality			
Flow (cfs; visual)		15.1	normal
Temperature (C)		19.5	
pH		6.8	
Dissolved oxygen (mg/L)		NM	
Alkalinity (mg/L $CaCO_3$)		15	

Table 4. Fish population abundance estimates (with 95% confidence limits) for Site 2 on Laurel Fork sampled in 2021.

	Site 2						
	Total	Pop. Size		Biomass (kg/ha)		Density (fish/ha)	
Species	Catch	Est.	C.I.	Est.	C.I.	Est.	C.I.
BKT ≤90 mm	0	-	-	-	-	-	-
BKT >90 mm	2	2	(2-53)	0.37	(0.37-9.70)	10	(10-255)
BNT ≤90 mm	25	44	(25-101)	1.08	(0.61-2.48)	212	(120-486)
BNT >90 mm	55	59	(51-67)	18.67	(16.13-21.19)	284	(246-323)
Bluegill	9	9	(6-12)	0.24	(0.16-0.32)	43	(29-58)
Creek Chub	29	32	(24-41)	1.21	(0.91-1.56)	154	(116-197)
Blacknose Dace	168	196	(172-220)	3.04	(2.65-3.39)	944	(828-1059)
White Sucker	11	14	(11-29)	5.27	(4.14-10.92)	67	(53-140)

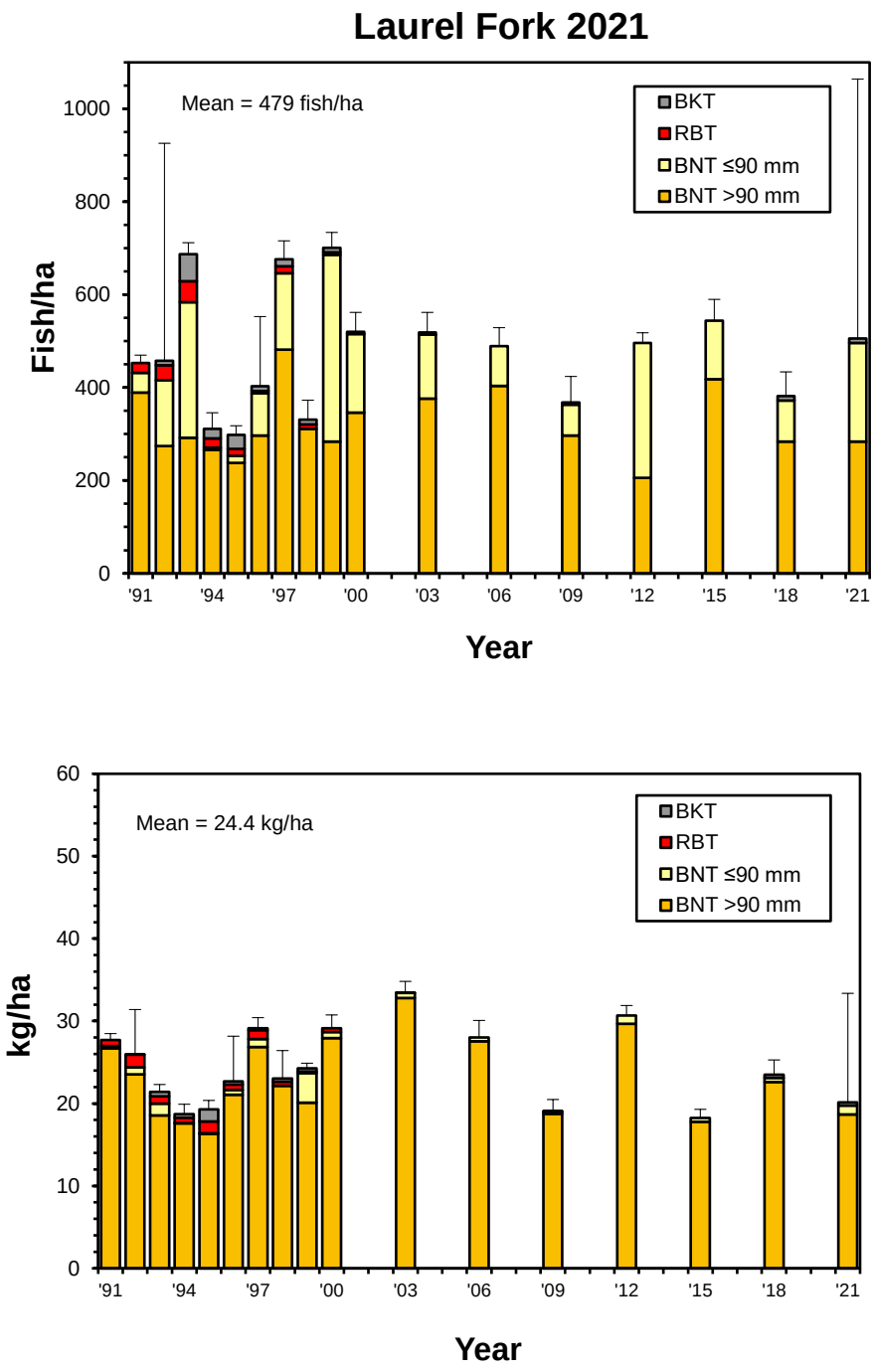


Figure 2. Laurel Fork Site 2 2021 trout abundance (density and biomass) with 95% confidence limits.

Beaverdam Creek

Beaverdam Creek is one of Tennessee's best-known wild trout streams and is on an annual monitoring schedule. It was not sampled in 2018 (high flows in late August and September) or in 2020 (to COVID-19). Site and sampling data are provided in Tables 5 and 6. Abundance estimates increased relative to 2019 and were comparable to long-term averages (Figure 3). Beaverdam will continue to be monitored annually and no management change is recommended.

Table 5. Site and sampling information for Beaverdam Creek in 2021

Location	**Site 1**		**Site 2**	
Site code	420212301		420212302	
Sample date	24 August		25 August	
Watershed	S. Fork Holston River		S. Fork Holston River	
County	Johnson		Johnson	
Lat-Long	36.59176 N, -81.81847 W		36.56576 N, -81.87315 W	
Elevation (ft)	2,160		2,440	
Land ownership	USFS		USFS	
Fishing access	Excellent		Excellent	
Description	Begins at Tank Hollow Rd. near Backbone Rock.		Begins at Hwy. 133 mile marker 5 near Arnold Br.	
Effort				
Site length (m)/ Area (m2)	200	2380	177	2407
Electrofishing units	4	250 V AC	4	250 V AC
Habitat				
Mean width (m)	11.9		13.6	
Canopy cover (%)	70		60	
Est. % site pool/riffle	50	50	51	49
Habitat assessment score	166 (optimal)		162 (optimal)	
Water Quality				
Flow (cfs; visual)	16.8	normal	20.2	normal
Temperature (C)	21.1		20.8	
pH	7.3		7.4	
Conductivity (µS/cm)	55		60	
Alkalinity (mg/L $CaCO_3$)	35		40	

Table 6. Fish population abundance estimates (with 95% confidence limits) for Beaverdam Creek sampled in 2021.

	Site 1							Site 2						
	Total	Pop. Size		Biomass (kg/ha)		Density (fish/ha)		Total	Pop. Size		Biomass (kg/ha)		Density (fish/ha)	
Species	Catch	Est.	C.I.	Est.	C.I.	Est.	C.I.	Catch	Est.	C.I.	Est.	C.I.	Est.	C.I.
RBT ≤90 mm	112	120	(110-130)	2.25	(2.08-2.46)	504	(462-546)	112	118	(109-126)	2.21	(2.04-2.36)	490	(453-523)
RBT >90 mm	57	57	(54-59)	18.37	(17.40-19.01)	239	(227-248)	68	68	(67-70)	17.45	(17.20-17.97)	283	(278-291)
BNT ≤90 mm	11	11	(7-15)	0.26	(0.16-0.35)	46	(29-63)	12	12	(8-16)	0.27	(0.18-0.35)	50	(33-66)
BNT >90 mm	45	46	(42-50)	13.58	(12.39-14.75)	193	(176-210)	32	32	(30-34)	16.46	(15.43-17.49)	133	(125-141)
Fantail Darter	119	144	(118-170)	1.01	(0.84-1.21)	605	(496-714)	102	214	(38-390)	1.28	(0.22-2.27)	889	(158-1620)
Tennessee Shiner	2	2	(0-53)	0.02	(0.00-0.45)	8	(0-223)	-	-	-		-		-
Greenfin Darter	10	12	(0-24)	0.45	(0.00-0.91)	50	(0-101)	3	3	(3-3)	0.04	(0.04-0.04)	12	(12-12)
Longnose Dace	57	65	(52-78)	1.25	(1.01-1.51)	273	(218-328)	28	28	(25-31)	0.51	(0.46-0.57)	116	(104-129)
N. Hogsucker	22	22	(19-25)	13.29	(11.47-15.09)	92	(80-105)	22	29	(9-49)	0.98	(0.30-1.65)	120	(37-204)
Snubnose Darter	17	17	(14-20)	0.13	(0.11-0.16)	71	(59-84)	10	49	(0-521)	0.31	(0.00-3.25)	204	(0-2165)
Mottled Sculpin	489	713	(596-930)	13.36	(11.27-15.69)	2996	(2504-3487)	620	1102	(842-1362)	22.01	(16.79-27.16)	4578	(3498-5658)
Warpaint Shiner	156	240	(159-322)	1.98	(1.34-2.71)	1008	(668-1353)	47	55	(41-69)	0.53	(0.39-0.66)	229	(170-287)
Swannanoa Darter	12	13	(6-20)	0.30	(0.14-0.46)	55	(25-84)	22	23	(18-29)	0.21	(0.16-0.27)	96	(75-120)
Saffron Shiner	281	317	(293-341)	1.55	(1.48-1.72)	1332	(1231-1433)	197	225	(203-247)	0.97	(0.84-1.03)	935	(843-1026)
Blacknose Dace	-	-	-	-	-	-	-	20	22	(14-30)	0.08	(0.05-0.11)	91	(58-125)
Central Sonteroller	269	286	(272-300)	22.64	(21.49-23.70)	1202	(1143-1261)	113	121	(111-131)	3.26	(3.00-3.54)	503	(461-544)
Creek Chub	1	1	(1-1)	0.01	(0.01-0.01)	4	(4-4)	1	1	(1-1)	0.00	(0.00-0.00)	4	(4-4)
River Chub	210	255	(221-289)	5.77	(5.01-6.56)	1071	(929-1214)	182	213	(188-239)	13.96	(12.34-15.69)	885	(781-993)
Bluegill	-	-	-	-	-	-	-	3	3	(0-15)	0.08	(0.00-0.42)	12	(0-62)

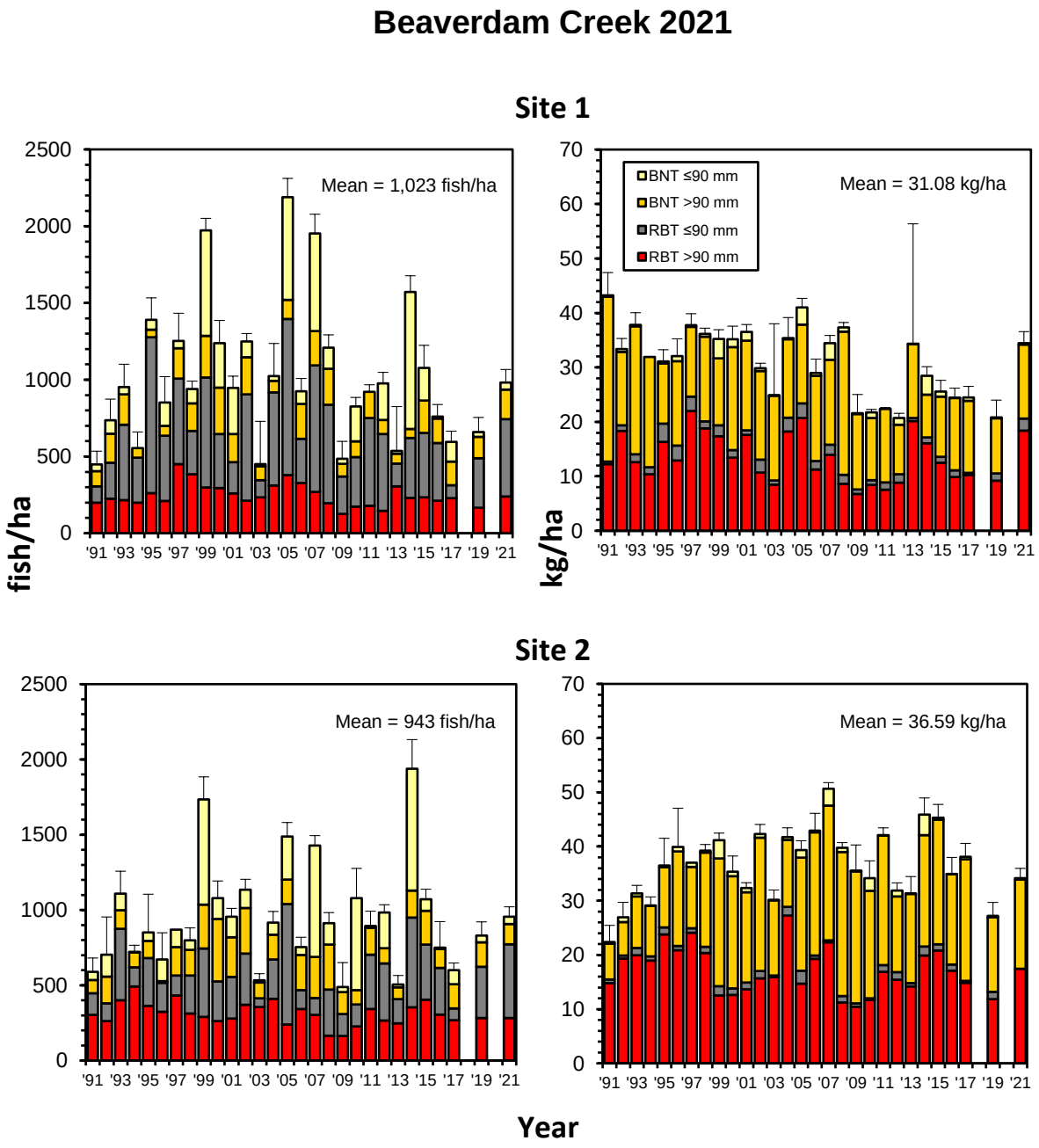


Figure 3. Beaverdam Creek Sites 1 and 2 2021 trout abundance (density and biomass) with 95% confidence limits.

Left Prong Hampton Creek

Site and sampling data for the 2021 survey are provided in Tables 5 and 6. Upper Left Prong Hampton Creek's Brook Trout population has made it one of Tennessee's premier Brook Trout fisheries. Since fully established in 2003, mean Brook Trout biomass for the upper station (69.6 kg/ha) has historically exceeded the statewide average for other streams (about 21 kg/ha). However, the mean trout abundance has declined over the last ten years, particularly in Sites 1 (Rainbow Trout) and 3 (Figure 4). Decreasing abundance trends may be related to decreasing quantity and quality pools related to siltation. Deployment of instream water temperature loggers show maximum water temperatures in 2019 and 2020 to be ≤17.7 C, well below the thermal maximum for Brook Trout, thus temperature is not a contributing factor to decreasing Brook Trout abundance. Trout Unlimited (TU) has worked with the caretaker to improve fences on the property and add fences in areas of high erosion from cattle being grazed on the property. These actions should ultimately help reduce erosion and the sediment load in Left Prong. Management of Left Prong Hampton Creek should feature its Brook Trout fishery and development of this important database should continue through annual monitoring at all three sites.

Table 7. Site and sampling information for Left Prong Hampton Creek in 2021.

Location	**Site 1**		**Site 2**		**Site 3**	
Site code	420211801		420211802		420211803	
Sample date	20-Jul		20-Jul		20-Jul	
Watershed	Watauga River		Watauga River		Watauga River	
County	Carter		Carter		Carter	
Lat-Long	36.15132 N, -82.05324 W		36.14673 N, -82.04917 W		36.13811 N, -82.04473 W	
Elevation (ft)	3,080		3,240		3,560	
Stream order	2		2		2	
Land ownership	State (Hampton Cove)		State (Hampton Cove)		State (Hampton Cove)	
Fishing access	Good		Good		Good	
Description	Begins ~10 m upstream of the first foot bridge.		Begins 50 m upstream of the fish barrier.		Begins 880 m upstream of the upper end of Site 2.	
Effort						
Station length (m)	106 m	339 m²	94	498 m²	100	360 m²
Electrofishing units	2	250 V AC	1	550 V AC	1	400 V AC
Habitat						
Mean width (m)	3.2		5.3		3.6	
Canopy cover (%)	70		90		95	
Aquatic vegetation	scarce		scarce		scarce	
Estimated % site riffle	62		NM		NM	
Habitat assessment score	158 (suboptimal)		157 (suboptimal)		159 (suboptimal)	
Water Quality						
Flow (cfs; visual)	2.67	high	NM	high	NM	high
Temperature (C)	NM		15.2		NM	
pH	NM		6.5		NM	
Conductivity (µS/cm)	NM		16		NM	
Alkalinity (mg/L $CaCO_3$)	NM		NM		NM	

Table 8. Fish population abundance estimates (with 95% confidence limits) for the monitoring stations on Left Prong Hampton Creek sampled 20 July 2021.

	Site 1							
	Total	Pop. Size		Biomass (kg/ha)		Density (fish/ha)	
Species	Catch	Est.	C.I.	Est.	C.I	Est.	C.I.
RBT ≤90 mm	91	104	(88-120)	6.17	(5.19-7.08)	3,066	(2596-3540)
RBT >90 mm	13	13	(13-13)	16.43	(16.43-16.43)	383	(383-383)
Blacknose dace	72	76	(68-83)	9.91	(8.22-10.04)	2,242	(2006-2448)
Fantail darter	6	6	(0-12)	0.35	(0.00-0.71)	177	(0-354)
	Site 2						
	Total	Pop. Size		Biomass (kg/ha)		Density (fish/ha)	
	Catch	Est.	C.I.	Est.	C.I	Est.	C.I.
BKT ≤90 mm	52	56	(48-64)	3.31	(2.80-3.73)	1,124	(964-1285)
BKT >90 mm	22	22	(20-24)	11.69	(10.64-12.77)	442	(402-482)
	Site 3						
	Total	Pop. Size		Biomass (kg/ha)		Density (fish/ha)	
	Catch	Est.	C.I.	Est.	C.I	Est.	C.I.
BKT ≤90 mm	39	47	(31-63)	3.56	(2.50-5.08)	1,306	(861-1750)
BKT >90 mm	67	68	(64-72)	41.67	(39.29-44.20)	1,889	(1778-2000)

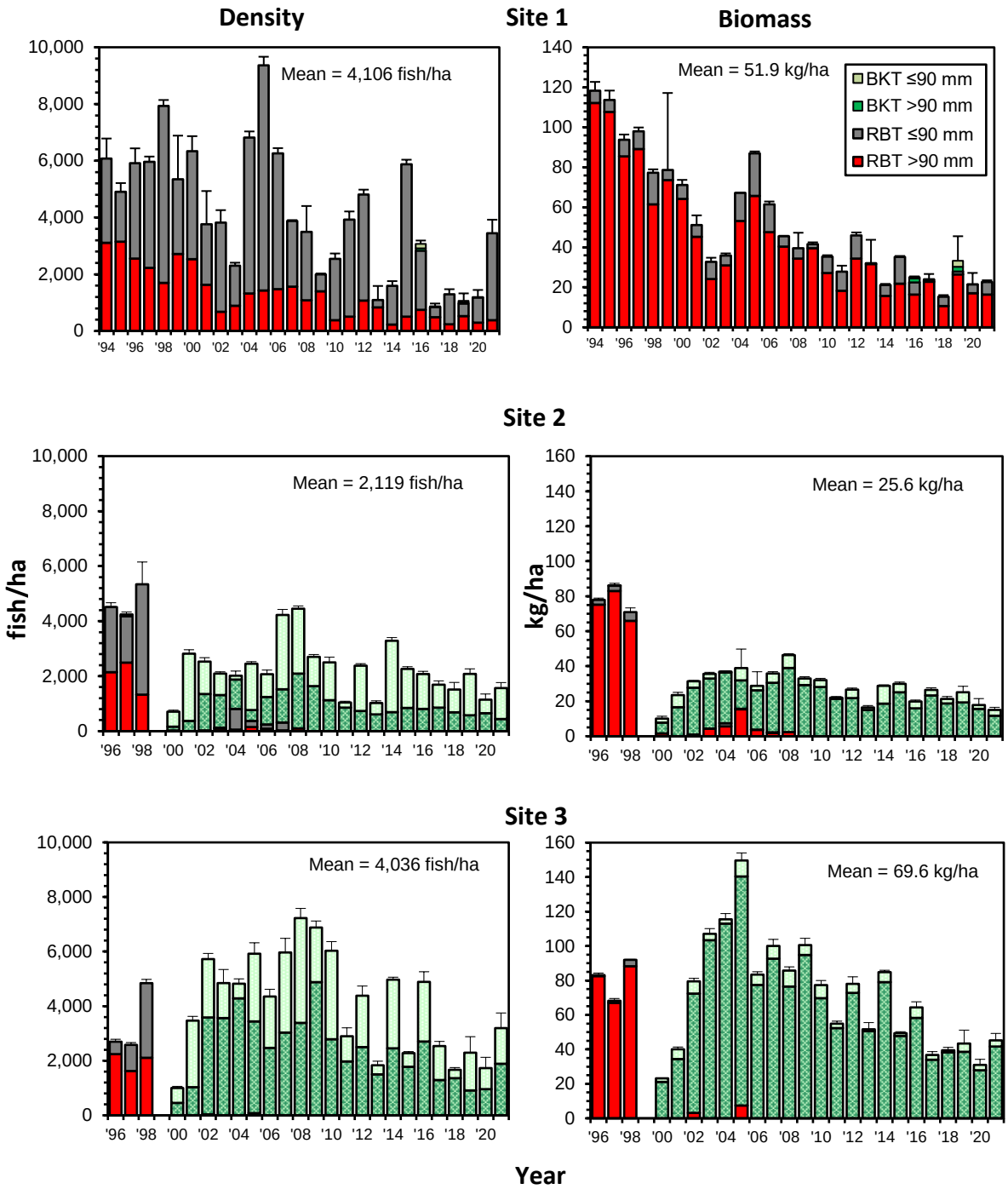


Figure 4. Abundance estimates for the Left Prong Hampton Creek sites in 2021.

Right Prong Middle Branch

Right Prong Middle Branch is a headwater tributary to the Doe River. Its Roan Mountain watershed is forested and located largely within the CNF in Carter County. It supports an allopatric population of native Brook Trout upstream of State Route 143. The current monitoring station represents a high-elevation (above 4,000' or 1,220 m) native Brook Trout population. A temperature logger was placed here in 2021 to gather baseline information on high elevation Brook Trout streams (see section 5. below).

Site and sampling data are provided in Tables 9 and 10. Brook Trout abundance estimates were at or slightly above term averages in 2021 (Figure 5). No special management of Right Prong Middle Branch is suggested at this time other than protection of the resource. Because of the small size of this stream and its relative obscurity, angling pressure is probably light. Continued sampling at the monitoring station will help increase our understanding of Brook Trout population dynamics, particular in higher-elevation streams.

Table 9. Site and sampling information for Right Prong Middle Branch in 2021.

Location	**Station 1**	
Site code	420212201	
Sample date	5 August	
Watershed	Watauga River	
County	Carter	
Lat-Long	36.12007 N, -82.09574 W	
Elevation (ft)	4,070	
Land ownership	USFS	
Fishing access	Limited	
Description	Begins at head of small island ~270 m upstream of Rt. 143.	
Effort		
Station length (m)	90 m	279 m²
Electrofishing units	1	250 V AC
Habitat		
Mean width (m)	3.1	
Canopy cover (%)	95	
Est. % of site in riffles/pools	41	59
Habitat assessment score	NM	
Water Quality		
Flow (cfs; visual)	0.2	normal
Temperature (C)	14	
pH	6.5	
Conductivity (µS/cm)	40	
Alkalinity (mg/L $CaCO_3$)	NM	

Table 10. Fish population abundance estimates (with 95% confidence limits) for the monitoring station on Right Prong Middle Branch sampled 5 August 2021.

	Total	Pop. Size		Biomass (kg/ha)		Density (fish/ha)	
Species		Est.	C.I.	Est.	C.I.	Est.	C.I.
BKT ≤90 mm	36	37	(33-41)	4.09	(3.78-4.70)	1,326	(1183-1470)
BKT >90 mm	38	38	(35-41)	44.19	(28.78-47.61)	1,362	(1254-1470)

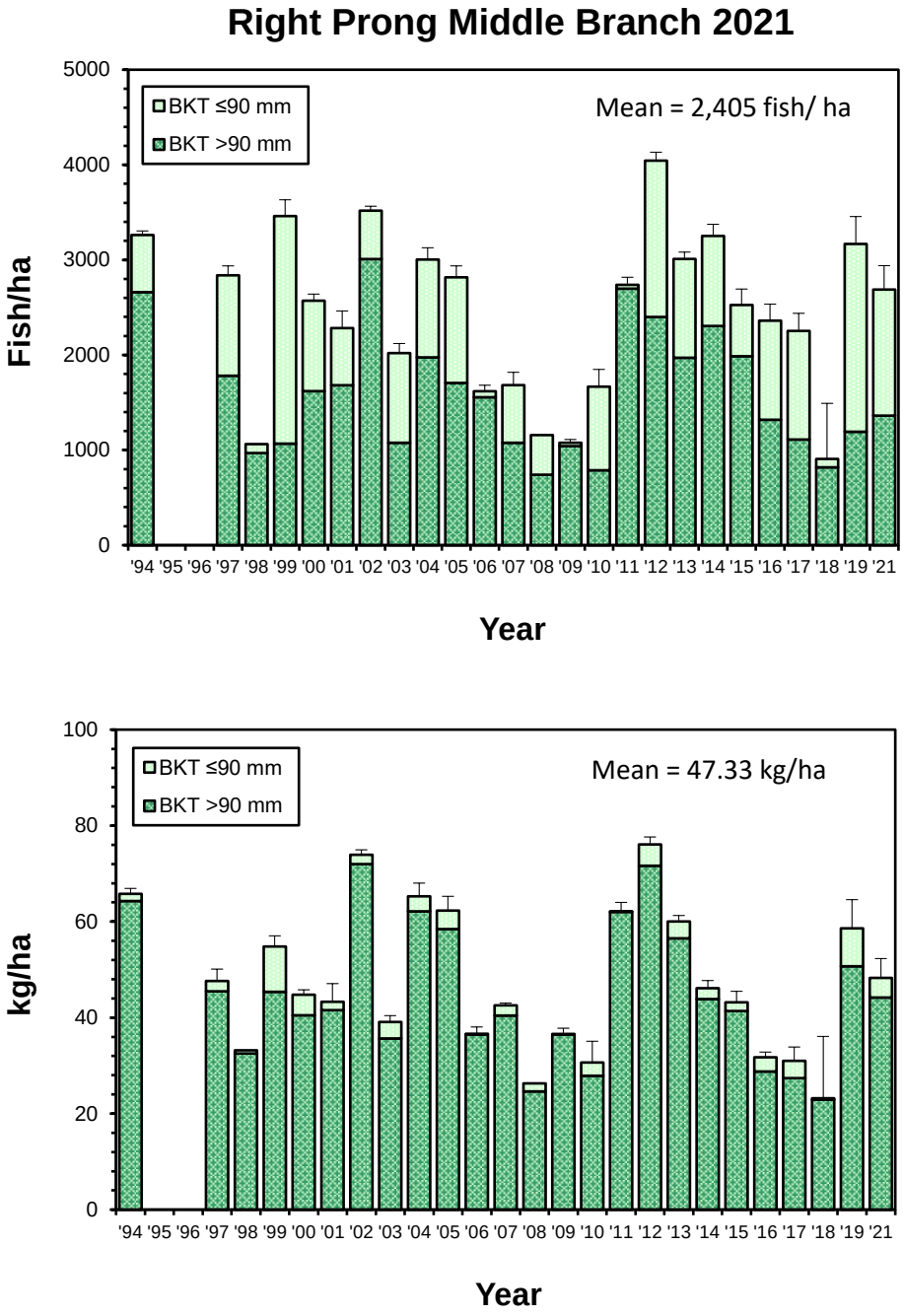


Figure 5. Abundance estimates for Right Prong Middle Branch in 2021.

3. Sympatric Brook Trout / Rainbow Trout Monitoring

Brook Trout would have historically occurred in most coldwater streams in eastern Tennessee and were the dominant salmonids before the 1900s. Logging and the resulting habitat loss between 1903 and 1937 and the introduction of nonnative Rainbow Trout (beginning in 1910) and Brown Trout (after 1950) negatively affected wild Brook Trout populations (Kelly et al. 1980; Larson and Moore 1985; Larson et al. 1995). Monitoring between 1900 and 1977 caused managers to be concerned that Rainbow Trout might displace native Brook Trout (Kelly et al. 1980).

Moore et al. (1983) and Larson and Moore (1985) showed that Rainbow Trout suppress Brook Trout abundance and reproduction, and Whitworth and Strange (1983) showed that Rainbow Trout are the dominant trout where Brook Trout and Rainbow Trout coexist. Allopatric Brook Trout range decreased by 60% between 1935 and 1977 in the Great Smoky Mountains National Park, apparently because of nonnative salmonid encroachment primarily by Rainbow Trout (Larson and Moore 1985).

Consequently, managers have been concerned about the potential range expansion by Rainbow Trout and associated loss of Brook Trout distribution. However, Larson et al. (1995) found Brook Trout density and distribution ebbs and flows even in the presence of Rainbow Trout and Strange and Habera (1998) found that Rainbow Trout were not affecting downstream limits of Brook Trout distribution in Tennessee streams. These results, as well as our long-term monitoring, indicate that Brook Trout and Rainbow Trout distribution and relative abundance in the southern Appalachian streams will ebb and flow in response to environmental factors such as droughts and floods.

Relative Brook Trout abundance (% density and % biomass) has been monitored in four streams (elevations range from 640-984 m) with sympatric Rainbow trout populations since 1995 (see graph for Briar Creek below). The objective is to determine if, over time, Rainbow Trout can displace Brook Trout in these populations, or if variations in relative abundance are attributable to stochastic events. Previous coldwater reports, detailing site location and specific annual data can be found at https://www.tn.gov/content/tn/twra/fishing/trout-information-stockings.html#FisheriesReport.

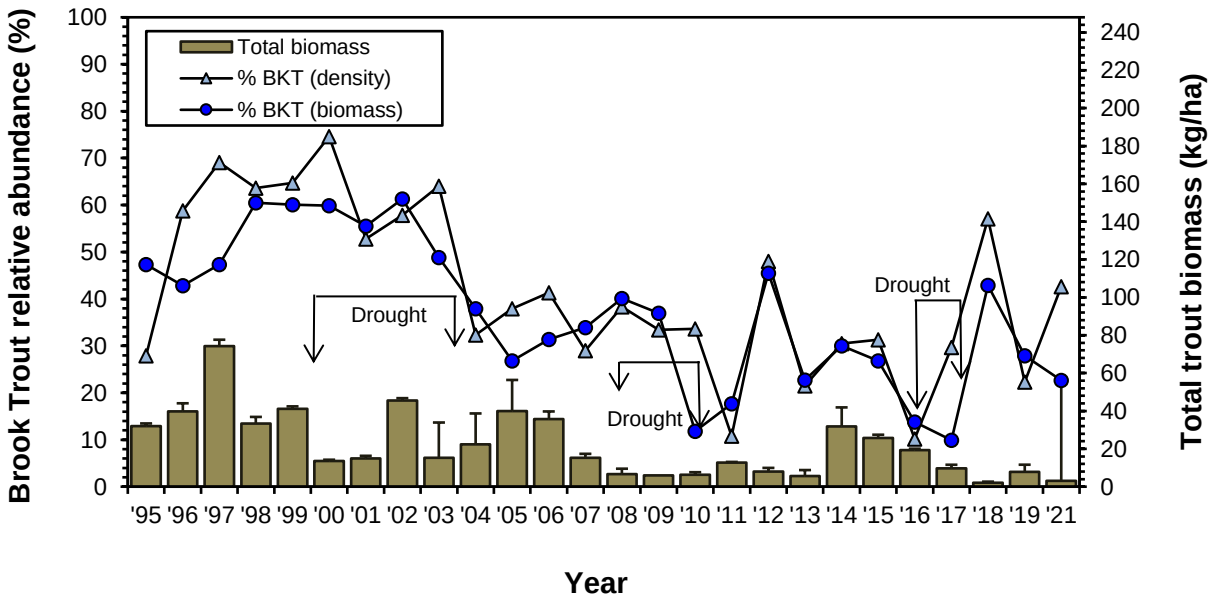


Figure 6. Brook Trout and Rainbow Trout relative abundance and biomass estimates for Briar Creek.

Briar Creek was the only one of the four Brook/Rainbow Trout monitoring streams to be sampled in 2021. Total trout biomass and relative Brook Trout biomass have generally decreased since the early 2000s, although Brook Trout relative abundance can increase during droughts, when Rainbow Trout appear to be more negatively impacted (Figure 6). Extended drought, however, may eliminate Brook Trout populations in marginal habitats regardless of the presence of any sympatric salmonids (Habera et al. 2014). A temperature logger placed in Briar Creek indicated that maximum water temperature exceeded 20C on only two days during the summer of 2021 (see section 5. below), suggesting that elevated temperatures are not a limiting factor.

Although Brook Trout relative abundance has fluctuated over the years in Briar Creek and at the other Brook/Rainbow Trout monitoring stations, it appears that Rainbow Trout have no particular competitive advantage, thus these species can coexist for many years at some general equilibrium. Strange and Habera (1998) and Habera et al. (2014) found no broad-scale loss of distribution or inexorable replacement by Rainbow Trout in sympatric populations. Furthermore, Brook Trout have gained distribution (2 km or more in some cases) in the presence of Rainbow Trout in several streams since the 1990s (Habera et al. 2014). Future monitoring of these streams will be on a triennial schedule to further document relative abundance trends.

4. Native Brook Trout Restoration and Enhancement Projects

TWRA's Native Brook Trout Management Plan (TWRA 2017) includes a list of potential restoration, enhancement, and reintroduction projects for 2017-2027 developed cooperatively with the USFS. These projects involve re-establishing native Brook Trout in suitable streams by completely removing any existing nonnative trout (Tier 1—highest priority) or only initially thinning existing nonnative trout (Tier 2). Tier 2 projects are generally lower priority but provide opportunities to return native Brook Trout to streams or watershed where they have long been absent. These would be managed as sympatric populations unless enhancement become feasible. Tier 1 projects involve re-establishing an allopatric native Brook Trout population and maintaining it as such. Enhancement projects remove Rainbow Trout from an existing sympatric native Brook Trout population and extend Brook Trout distribution downstream to a natural barrier. Native Brook Trout restoration projects are listed in Tables 11 and 12 and work completed in 2021 is summarized in the following stream accounts. These projects involve the efforts of several partners including TWRA Region 3, the USFS, USFWS, TU, the Tennessee Division of Forestry, Tennessee Aquarium Conservation Institute (TNACI), and private landowners.

Table 11. Potential Tier 1 Brook Trout restoration and enhancement projects in Region 4. BKT = Brook Trout, RBT = Rainbow Trout, and BNT = Brown Trout.

Stream	Watershed	Species present	Barrier	Start elevation (ft)	Length (miles)	Comments	Current status
Green Mountain Branch	South Fork Holston	BKT	Yes	3,130	1.0	Barrier may be ineffective at high flow	Translocation complete. Monitoring in 2022
Little Jacob Creek	South Fork Holston	RBT/BKT	Yes (2)	2,270	1.0	Extended down to barrier at USFS Job Corp.	Translocation and monitoring complete in upper section. RBT removal ongoing in lower section
Phillips Hollow	Nolichucky	BKT	Yes (2)	2,230	0.6	Fish from N. Toe River system in NC	Monitoring in 2022 to evaluate population development

Little Paint Creek	French Broad	None	Yes	2,000	1.5	TBD; may obtain fish from suitable GSMNP streams.	In progress—temperature monitoring in 2020 and 2021.
Devil Fork	Nolichucky	RBT	Yes (3)	1,900	0.5	Restore between lower 2 falls; no fish above upper falls	Not in progress
Trail Fork Big Creek	French Broad	None	Yes	2,640	2.2	Fish from Gulf Fork tribs.; may translocate more in 2022	In progress; RBT removal, initial BKT translocation, and AOP project completed 2021
Jennings Creek	Nolichucky	RBT	TBD	TBD	TBD	Use fish from Phillips Hollow; account for Round Knob Branch	Not in progress
Horse Creek	Nolichucky	RBT	TBD	TBD	TBD	Remove RBT if barrier exists; otherwise move to Tier 2	Not in progress
Right Prong Rock Creek	Nolichucky	RBT	Yes?	2,220	1.7	Potential barrier (Hwy. culvert) located; moved to Tier 1	Mark and move RBT to evaluate barrier in 2020 and 2021 in progress

Table 12. Potential Tier 2 Brook Trout re-introduction projects in Region 4.

Stream	Watershed	Species present	Barrier	Start elevation (ft)	Length (miles)	Comments	Current status
Sinking Creek	Watauga	RBT/BNT	No	2,060	1.3	Initially thin RBT/BNT; include Basil Hollow trib.	No barrier present; check downstream for end of trout distribution in 2022
Upper Granny Lewis Creek	Nolichucky	RBT	No	2,800	1.0	Initially thin RBT	Not in progress

Green Mountain Branch

Five electrofishing passes through Green Mountain Branch since 2018 removed 780 Rainbow Trout (including 580 age-0 fish). A total of 91 Brook Trout were translocated from Beaverdam Creek tributaries into the upper third of Green Mountain Branch in August 2020 (22 from Chalk Branch, 26 from Maple Branch, and 43 from Birch Branch). A pelvic fin clip was taken from each fish and preserved to characterize the genetic composition of the founding population. An assessment in July 2021 found both adult and age-0 Brook Trout throughout the stream, indicating Brook Trout successfully spawned in the fall of 2020 after

being translocated. However, 7 age-0 Brown Trout, 3 adult Rainbow Trout, and 31 age-0 Rainbow Trout were found in the 500 m reach upstream of the barrier, indicating that it is ineffective. Future work in Green Mountain Branch will entail removal of non-native trout species above the barrier and building a more effective crib-type barrier like those on Maple Branch and Chalk Branch.

Little Jacob Creek

Brook Trout have been established in Little Jacob Creek down to the culvert at the USFS road (FR 4002) crossing (Habera et al. 2019). Another barrier ~1.2 km further downstream (on USFS Job Corp property (36.56090 N, -81.97489 W; elevation 1,913 ft) was evaluated in 2019 to determine the feasibility of extending Brook Trout range down to this barrier. This barrier is a 2 m (6.5 ft) high concrete structure that should block Rainbow Trout movement upstream. Temperature logger data at this barrier in 2019 determined that the 7-day mean (MEANT) and maximum (MAXT) temperatures were 20.0°C and 20.8°C, respectively, for August and 19.9°C and 20.8°C for September. These temperatures were below the upper thermal tolerance limits for MEANT and MAXT (23.3°C and 25.4°C, respectively for Brook Trout) as described by Wehrly et al. (2007). However, fish community composition near the barrier includes Central Stoneroller *Campostoma anomalum*, Creek Chub *Semotilus atromaculatus*, and Blacknose Dace *Rhinichthys atratulus*) suggests water temperature is marginal for Brook Trout as well. Although this lower appears to be marginal habitat, Brook Trout abundance improves upstream, suggesting more favorable water temperatures.

A total of 224 Rainbow Trout (24 age-0, 131 sub-adults, 69 adults) were removed between the FR 4002 culvert and the barrier downstream at the USFS Job Corps in 2020. Brook Trout had already colonized this reach and were reproducing (age-0 fish were present). Another removal pass in July 2021 produced two adult and 48 age-0 Rainbow Trout, along with five adult and 20 age-0 Brook Trout, indicating that more work is needed in 2022. Replacement of the FR 4002 culvert (original barrier) with a bottomless arch structure designed to allow for aquatic organism passage (AOP) is being considered, along with habitat improvement in the lower portion of the creek to increase pool frequency and depth—and ultimately Book Trout abundance. This habitat work would include porous jams created in partnership with TU and the USFS in 2023.

Phillips Hollow

TWRA partnered with North Carolina Wildlife Resources Commission (NCWRC), private landowners in North Carolina, USFS, USFWS, and TU to translocate 76 Brook Trout (including 13 adults) from the North Toe River system (Nolichucky River basin) to Phillips Hollow in September 2019. No reproduction (age-0 Brook Trout) was detected in the 800-m restoration zone in June 2020, although several adults were present. Another assessment in 2021 produced 13 adult and 30 age-0 Brook Trout, with higher densities toward the upper end of the restoration zone. This population will be monitored again in 2022 to further evaluate its development and once established, it will provide fish for native Brook Trout restorations in other Nolichucky-basin streams in Tennessee (e.g., Right Prong Rock Creek).

Trail Fork of Big Creek

Just over 700 Rainbow Trout were removed from the 3.5-km restoration area in Trail Fork of Big Creek during 2018-2019. An additional electrofishing pass made through Trail Fork of Big Creek in 2020 removed only two adult Rainbow Trout, thus it was considered ready to receive native Brook Trout. Attempts to spawn 41 native Brook Trout collected from three Gulf Fork of Big Creek tributaries in 2019 and 2020 were unsuccessful, thus none were available for release into Trail Fork in 2020. The nine surviving broodstock

were released into the upper portion of Trail Fork in September 2021, along with 12 adults and 15 age-0 Brook Trout translocated from nearby Wolf Creek. Previous genetic assessment data indicated Wolf Creek has native fish suitable for the Trail Fork restoration. Additional Brook Trout are needed to complete the Trail Fork restoration, but abundance in Wolf Creek was low in 2021, thus fish from the Gulf Fork of Big Creek tributaries may be translocated in September 2022.

The double culvert on this stream was replaced with a span bridge conducive to aquatic organism passage through a partnership including TU, TWRA, USFS, USFWS, TNC, the Tennessee Wildlife Resources Foundation, and the Eastern Brook Trout Joint Venture.

Right Prong Rock Creek

This stream currently supports wild Rainbow Trout but has a perched box culvert at a road crossing that may be an effective barrier. It was considered for Brook Trout restoration in 2019 and the culvert, evaluated using USFWS SARP protocols, was found to be a severe barrier. Temperature monitoring data (Section 5) suggest that this stream will support Brook Trout. Rainbow Trout from above this crossing were marked (adipose clip) and released in the plunge pool directly below the crossing culvert in 2020 to assess potential movement upstream. One marked Rainbow Trout was recaptured upstream of the culvert in 2021, thus TWRA partnered with TU and USFS to remove an old tarp and rocks that were deepening the plunge pool. Future efforts will include removal of Rainbow Trout upstream of the culvert and another 'mark and move' assessment to determine if modification of the plunge pool to increase the height of the culvert's perch has made the crossing impassable.

Norton Creek

TWRA has worked with the owners of upper Norton Creek (the Worshams) to manage Rainbow and Brook Trout fisheries there over the years. Recently, the Worshams expressed an interest in replacing the existing hatchery-origin (nonnative) Brook Trout population in the upper Norton Creek with a native population obtained from appropriate sources in GSMNP. Consequently, a partnership including the landowners, TWRA, the National Park Service—GSMNP, and TU was established in May 2021 to accomplish this goal. The Norton Creek project would restore native Brook Trout to habitat in a patch or sub-watershed where they had been extirpated and eventually provide a potential source of fish for future restorations within the French Broad River basin. In addition to the removal of an existing Brook Trout population, the project is unique for TWRA in that it is located entirely on private land. The Worshams have established a conservation easement on Norton Creek and the surrounding land to protected it in perpetuity.

Partnership personnel (including TU volunteers) trimmed riparian rhododendron and brush along the lower portion of the Norton Creek restoration zone (including two tributaries) in May 2021. A distribution survey of Norton Creek and the tributaries in June 2021 determined that Brook Trout were present in 1.25 mi. (2 km) of Norton Creek extending from the swimming pool up to the old pond basins in the headwaters (3,400' elevation; 35.70297 N, -86.58345 W). No fish were present in the small tributary entering Norton Creek about 100 m upstream of the swimming pool. A few age-0 Brook Trout were present in the 10-20 m section of the Green Ridge Hollow tributary between Norton Creek and a cascade area. These fish were removed and no fish were present upstream of the cascade. No additional work was necessary in the tributaries. Removal of the existing hatchery-origin Brook Trout population in Norton Creek began in June 2021 and was completed in August. Multiple electrofishing passes (one backpack electrofishing unit) were made throughout the restoration zone, resulting in the removal of 173 Brook Trout—32 adults and 141 age-0 fish, most of which were about 100 mm (4 in.) in length and large enough to facilitate complete removal.

Three teams from the NPS, TWRA, and U.S. Fish and Wildlife Service (USFWS) collected native Brook Trout from Toms Creek (138), Indian Camp Creek (120 Trout), and Road Prong (35) in GSMNP on 23 September 2021. Brook Trout were collected by backpack electrofishing in each stream and carried in aerated backpack containers to larger oxygenated holding tanks on TWRA (Toms Creek and Indian Camp Creek) or NPS (Road Prong) vehicles. Fish were then transported to Norton Creek, where all were placed in one tank to ensure a random mixture and distribution of all three source stocks. Fish were distributed uniformly throughout the stream with 2-3 adults placed in pools to help facilitate spawning (October 2021). Average Brook Trout density after translocation was 1 fish/6.8 m of stream length (formerly 1 fish/11.6 m). A subsample of 57 fish released in the lower restoration zone section was weighed and measured to provide a baseline size distribution and mean relative weights (Wr) for adult and age-0 fish. This information will be available for evaluating the success of the supplemental feeding program planned for this area.

The Norton Creek restoration zone will be checked during summer 2022 to determine if adult Brook Trout translocated in September 2021 successfully reproduced (presence of age-0 fish). Previous native Brook Trout restoration work by TWRA and NPS has shown that three years are typically required for a restored population to become established and approach carrying capacity for their new habitat. Accordingly, two representative sites will be selected, and three-pass depletion samples conducted to estimate population size, density, and biomass in 2024. Average density and biomass for wild Brook Trout populations based on TWRA data are 1,285 fish/ha (SE, 82.9) and 20.1 kg/ha (SE, 1.4), respectively. If Brook Trout abundance estimates for Norton Creek approach or exceed these levels in 2024, it would indicate successful establishment. Brook Trout in the supplementally-fed area can also be sampled at that time to compare size distributions and relative weights (*Wr*) with corresponding data from the initial translocation and from other sample areas to determine effectiveness of that program.

Stream Temperature Monitoring

Temperature loggers were deployed during 2021 in various wild trout streams (Table 13) across elevational and geographical gradients to collect baseline summer water temperature data and determine suitability for supporting Brook Trout or trout stocking (Doe River)). Temperature monitoring data indicated that most streams would be suitable for supporting Brook Trout, although the higher temperatures in Fishdam Creek and lower Little Jacob Creek could suppress populations in those streams (Figure 7).

Table 13. Streams with temperature loggers in them in 2021. Elevation (ft) indicates elevation the temperature logger was placed.

Stream	Elevation (ft)	Trout Present
Little Stony Creek	1,846	Brook Trout
Fishdam Creek	1,848	Rainbow Trout
Round Knob Branch	1,937	Brook Trout
Squibb Creek	1,962	Brook Trout
Little Jacob Creek	1,996	Brook Trout, Rainbow Trout
Sinking Creek	2,089	Rainbow Trout
Little Paint Creek	2,105	None
Briar Creek	2,238	Brook Trout, Rainbow Trout
Phillips Hollow	2,300	Brook Trout
Doe River	2,341	Rainbow Trout, Brown Trout
Right Prong Rock Creek	2,459	Rainbow Trout
Trail Fork Big Creek	2,732	Brook Trout
Left Prong Hampton Creek	3,262	Brook Trout
Right Prong Middle Branch	3,845	Brook Trout

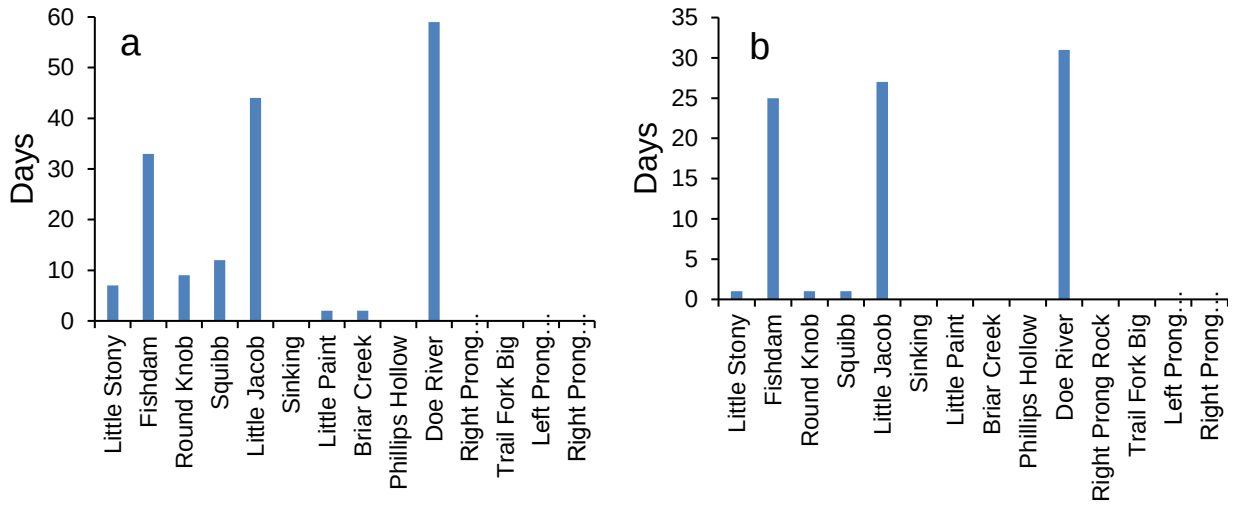


Figure 7. a) Number of days with maximum temperature exceeding 20C; b) number of days with average temperature >20C.

5. Tailwater Monitoring

Region IV's tailwater trout fisheries present unique fishery management problems and opportunities for which no standard solutions or practices apply (Hill 1978). The problems inherent in sampling tailwaters, such as their large size, fluctuating flows, and the lack of any practical means for maintaining closed populations, make it difficult at best to collect quantitative data from these systems. Natural reproduction is variable and most tailwater trout fisheries are substantially hatchery-supported, with abundances and size/age-class densities related to stocking rates. However, Brown Trout fisheries in the South Holston and Wilbur tailwaters are self-sustaining and substantial natural reproduction by Rainbow Trout has also recently been documented in these tailwaters, as well as Norris. TWRA prefers to manage for wild trout fisheries where possible (TWRA 2017), thus management strategies in these tailwaters (e.g., fingerling Rainbow Trout stocking) will be adjusted accordingly.

Six Region IV tailwater trout fisheries (Norris, Cherokee, Wilbur, Ft. Patrick Henry, Boone, South Holston) are currently monitored annually. Sampling is conducted annually in late February or March (except Cherokee) to assess the overwintering trout populations present before stocking begins. The Cherokee tailwater (Holston River) monitoring stations are currently sampled in the summer (June) and fall (late October/early November). Trout survival over the summer is the most important issue for the Cherokee tailwater fishery, so sampling is timed to document trout abundance before and after the high water temperatures (daily minimum >21° C) that occur in late summer/early fall. Catch per unit effort (CPUE) for each species at each site (fish/h), as well as means for each tailwater, are calculated annually to monitor trout abundance trends. Annual monitoring samples have occasionally been cancelled (e.g., 2015 at Norris, 2008-09 at Wilbur, and 2008 at South Holston) because appropriate flows were unavailable.

Updated trout fishery management plans are now in place for the Norris (Habera et al. 2020), Wilbur (Habera et al. 2022a), and South Holston tailwaters (Habera et al. 2022b). The Boone and Ft. Patrick Henry tailwater trout fisheries are managed under a plan developed in 2018 (Habera et al. 2018) and a management plan for the Cherokee tailwater will be developed by the end of 2023.

Sampling Methods and Conditions

Sampling effort for the Norris, Cherokee, South Holston, and Wilbur tailwaters annually consists of 600-s (pedal time) runs at each of 12 monitoring stations with boat-mounted electrofishing systems (120 pulses/s DC, 4-5 amps). The smaller Ft. Patrick Henry and Boone tailwaters are sampled using 900-s runs at 4 stations. Electrofishing on these tailwaters (except Norris) is conducted during the day with generation by one unit (turbine). Only trout are collected during these efforts. Tailwater sampling conditions and effort are summarized in Table 5-1 below:

Table 5-1. Tailwater sampling conditions and effort.

Tailwater	Year annual monitoring began	Sample time	Stations	Approximate flow	Total effort (h)
Norris	1999	Night	12	114 m^3/s (4,000 cfs)	2.00
Cherokee	2003	Day	12	114 m^3/s (4,000 cfs)	2.00
Ft. Patrick Henry	2002	Day	4	88 m^3/s (3,100 cfs)	1.00
Wilbur	1999	Day	13[1]	71 m^3/s (2,500 cfs)	2.16
Boone	2009	Day	4	88 m^3/s (3,100 cfs)	1.00
South Holston	1999	Day	12	71 m^3/s (2,500 cfs)	2.00

[1]An extra site was added in 2010 to help evaluate the Quality Zone; effort there (600 s) is not included in total effort.

Norris (Clinch River)

Catch and Length Frequency

The 12 Norris tailwater monitoring stations (Figure 5-1) produced 242 trout weighing nearly 129 kg in 2021 (Table 5-2; Figure 5-2). The catch included 223 Rainbow Trout and 19 Brown Trout. No Brook Trout were captured, although 16,000 were stocked in 2020. Trout in the 356-508 mm (14-20 in.) protected length range (PLR) were present at all 12 monitoring stations (Table 5-2). Overall, 49% of Rainbow Trout and 37% of Brown Trout >178 mm were within the PLR (Figure 5-2). Another 59% of the Brown Trout catch was >508 mm. None of the sub-adult (<229 mm) Rainbow Trout had fin clips, indicating that these fish represent natural reproduction.

A large Brown Trout from the 2021 Norris tailwater sample.

CPUE

The mean electrofishing CPUE for all trout ≥178 mm in 2021 (121 fish/h) was 26% below the 2020 estimate (164 fish/h) and outside the typical post-PLR range (150-200 fish/h; Figure 5-3). Brown Trout CPUE remained at 9 fish/h, which is the lowest catch rate observed to date (Figure 5-3) and is likely related to reduced stocking rates during 2018-2020(16,000-20,000/year). Mean CPUE for trout within the PLR (356-508 mm) has increased substantially since 2008 and exceeded 100 fish/h for the first time in 2020 but fell to 58 fish/h in 2021 (Figure 5-3). The PLR catch rate objective for the current Norris tailwater management plan is a mean of ≥56 fish/h for 2020-2025 (Habera et al. 2020).

RSD-14

Relative stock density for trout ≥356 mm or 14 in. (RSD-14) has improved for both Rainbow Trout and Brown Trout post-PLR, with values often exceeding 50 and seldom below 30 since 2011(Figure 5-4). These consistently higher RSD-14 values indicate that trout population size structures have shifted toward larger fish (≥14 in.)—which is what PLR regulations are intended to accomplish. An RSD-14 value of 50 indicates that 50% of all stock-size trout—those at least 10 in. in length—are 14 in. or larger and is representative of a trout fishery with an exceptional proportion of larger fish. RSD-14 for Rainbow Trout (62) and Brown Trout (95) in 2021 (Figure 5-4) were within the objective for the current Norris tailwater management plan (mean RSD-14 ≥45; Habera et al. 2020).

Stocking

Norris typically has the highest trout stocking rate of any Tennessee tailwater (about 237,000/year). Annual allocations have been 197,000 Rainbow Trout (160,000 4-5 in. fingerlings and 37,000 9-12 in. adults), 40,000 Brown Trout (6-8 in. sub-adults) and 20,000 Brook Trout (8-9 in. adults). Stocking rates have varied recently (Figure 5-5) because of Dale Hollow National Fish Hatchery's (DHNFH) need to stock fish early in 2016 and 2017 (poor fall water quality) and inconsistent availability of Brook Trout and Brown Trout. Additionally, the 2019-2021 fingerling Rainbow Trout stocking rates were reduced (to 111,000, 18,000, and 88,000) to accommodate marking these fish (fin clips/coded wire tags) for the TN CFRU research project. Only 18,000 fingerlings could be marked in March 2020 before Covid-19 restrictions at DHNFH curtailed that effort.

Angler Surveys

Because of Covid-19 considerations, the number of angler interviews during the 2020 Norris tailwater creel survey (94) was about 75% fewer than for the four surveys during 2013-2019 (average, 401 interviews; range 323-459). Trout anglers made an estimated 7,657 trips comprising 25,732 hours of effort in 2020 (Black 2021), which is only slightly below effort estimates for the 2019 survey (8,813 trips, 26,726 hours; Black 2020). However, total estimated trout catch for 2020 declined 50% from 2019 and harvest declined 94%, suggesting that catch and harvest were underestimated in 2020 because of the low number of angler interviews. Angling pressure may have also been somewhat underestimated in 2020, as TWRA fishing license sales increased substantially that year and angling pressure (h) for the Wilbur tailwater increased 51% from 2018 to 2020 (there was no survey in 2019). Despite Covid-19 constraints, the Wilbur tailwater creel clerk was able to conduct similar numbers of angler interviews in 2018 (553, Black 2019) and 2020 (501). A new creel survey was conducted in 2021 and anglers (n=210) reported that 41% of Rainbow Trout and just over 1% of Brown Trout they caught were in the PLR. Angler catch rates for trout above the PLR (>20 in.) in 2021 were 4.4% for Rainbow Trout and 0.5% of Brown Trout. Additional results for the 2021 Norris tailwater creel survey will be available in the 2022 report.

Research

Results from the ongoing TN CFRU study for 2021 continue to indicate that Norris tailwater's Rainbow Trout population is substantially supported by natural reproduction. No Rainbow Trout captured by TWRA in March 2021 had the mark (clip) indicating they were part of the 18,000. fingerlings (4.78-in.) stocked in April 2020. Five PIT-tagged Rainbow Trout were recaptured; however, all but one of those fish were ≥335 mm (13.2 in.) when tagged in July or October 2020 and none had a fingerling mark. Additionally, wild (unmarked) young-of-the-year Rainbow Trout were notably more abundant in shoreline backpack electrofishing samples during June, August, and October 2021 than were fingerling Rainbow Trout stocked in May (mean CPUE of 48.5 fish/h vs. 5.0 fish/h). Additional work during 2022 will help accurately determine survival, growth, and recruitment of stocked and wild Rainbow Trout in the Norris tailwater and this information will help guide future management of the. As part of the ongoing TN CFRU project, ~100,000 fingerling and 37,000 adult Rainbow Trout will be marked prior to stocking in 2022 (at DHNFH and Buffalo Springs Hatchery, respectively).

A wild young-of-the-year Rainbow Trout from the Norris tailwater (2021)

Management Recommendations

TWRA's current management goal for the Norris tailwater is to maintain the enhanced quality of trout angling opportunities available to the variety of anglers who enjoy this fishery (Habera et al. 2020). The PLR regulation, established in March 2008, has successfully increased abundances of 14-20-inch trout, improving trout population size structures (RSD-14), and maintained these improvements. Anglers have recognized this by overwhelmingly expressing their support for the PLR during the 2013 and 2019 creel surveys. Accordingly, the PLR regulation continues to be the primary strategy for attaining the goal during 2020-2025. Future fingerling Rainbow Trout stocking may be adjusted or eliminated given the results TN CFRU's research and TWRA's policy to manage for wild trout where feasible (TWRA 2017; Hatchery-Supported Fisheries Goal 1: Optimize use of hatchery trout, Strategy 1). The notable increase in Rainbow Trout reproduction throughout the tailwater may reflect the increased number of potential spawners resulting from the PLR regulation.

Norris Tailwater

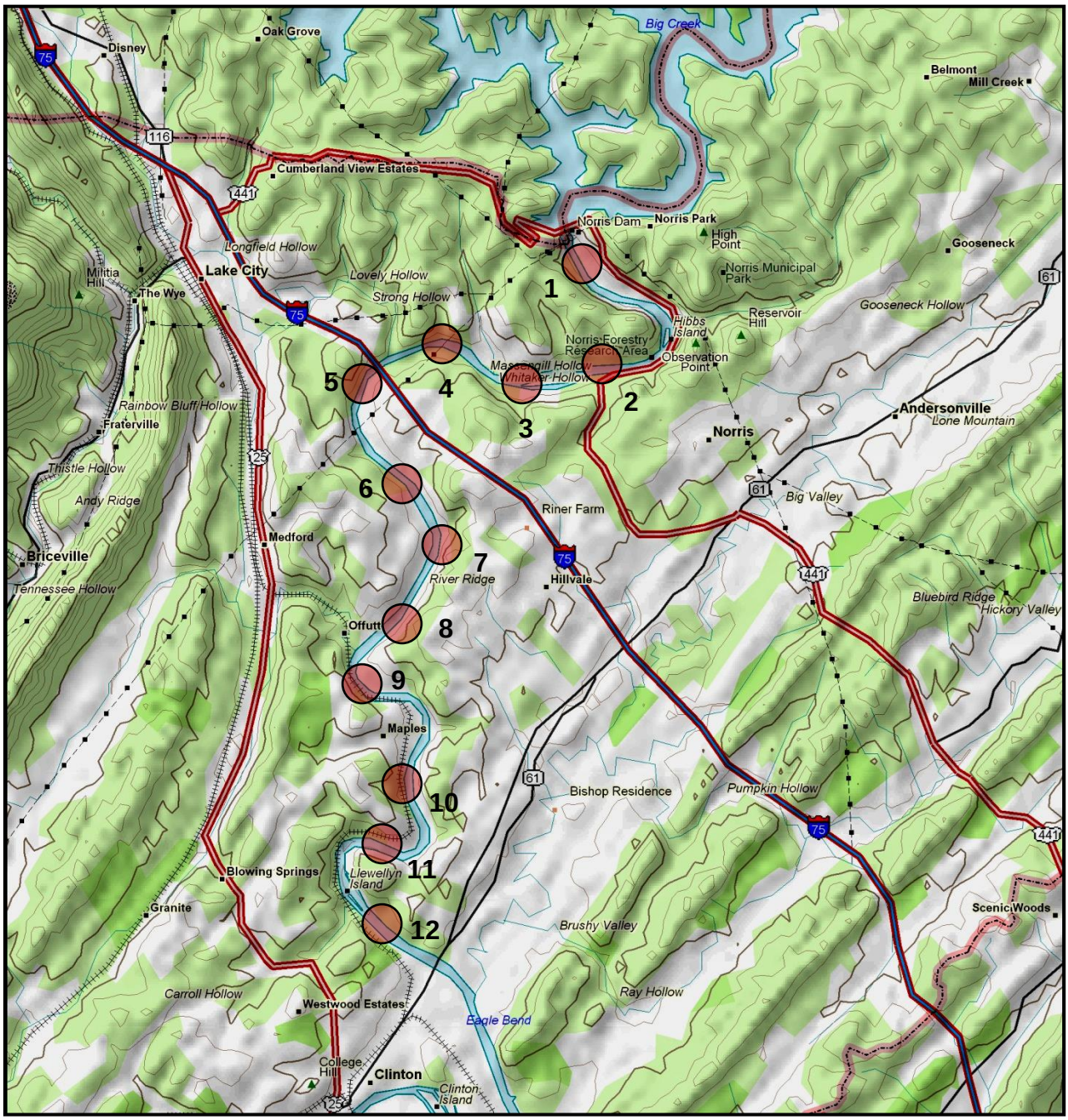


Figure 5-1. Locations of the Norris tailwater (Clinch River) monitoring stations.

Table 5-2. Catch data for the12 electrofishing stations on the Norris tailwater sampled 23 March 2021.

Station	Species	Total catch	Size range (mm)	Total weight (g)	% Abundance (number)	% Abundance (weight)
1	Rainbow	9	244-518	6,188	75	63
	Brown	3	387-506	3,642	25	37
Totals		**12**		**9,830**	**100**	**100**
2	Rainbow	28	177-562	15,794	100	100
Totals		**28**		**15,794**	**100**	**100**
3	Rainbow	31	186-505	10,611	97	97
	Brown	1	337	320	3	3
Totals		**32**		**10,931**	**100**	**100**
4	Rainbow	15	197-491	8,365	100	100
Totals		**15**		**8,365**	**100**	**100**
5	Rainbow	11	205-455	4,293	100	100
Totals		**11**		**4,293**	**100**	**100**
6	Rainbow	13	193-487	6,150	87	70
	Brown	2	483-519	2,678	13	30
Totals		**15**		**8,828**	**100**	**100**
7	Rainbow	23	205-466	10,706	82	61
	Brown	5	483-569	6,954	18	39
Totals		**28**		**17,660**	**100**	**100**
8	Rainbow	20	219-489	9,498	100	100
Totals		**20**		**9,498**	**100**	**100**
9	Rainbow	21	178-496	7,938	91	73
	Brown	2	498-516	2,882	9	27
Totals		**23**		**10,820**	**100**	**100**
10	Rainbow	19	180-507	8,519	83	45
	Brown	4	535-770	10,526	17	55
Totals		**23**		**19,045**	**100**	**100**
11	Rainbow	11	208-510	3,934	92	68
	Brown	1	560	1,848	8	32
Totals		**12**		**5,782**	**100**	**100**
12	Rainbow	22	195-464	6,569	96	84
	Brown	1	519	1,224	4	16
Totals		**23**		**7,793**	**100**	**100**
Total Rainbow Trout		223	177-562	98,565	92	77
Total Brown Trout		19	337-770	30,074	8	23
Overall		**242**		**128,639**	**100**	**100**

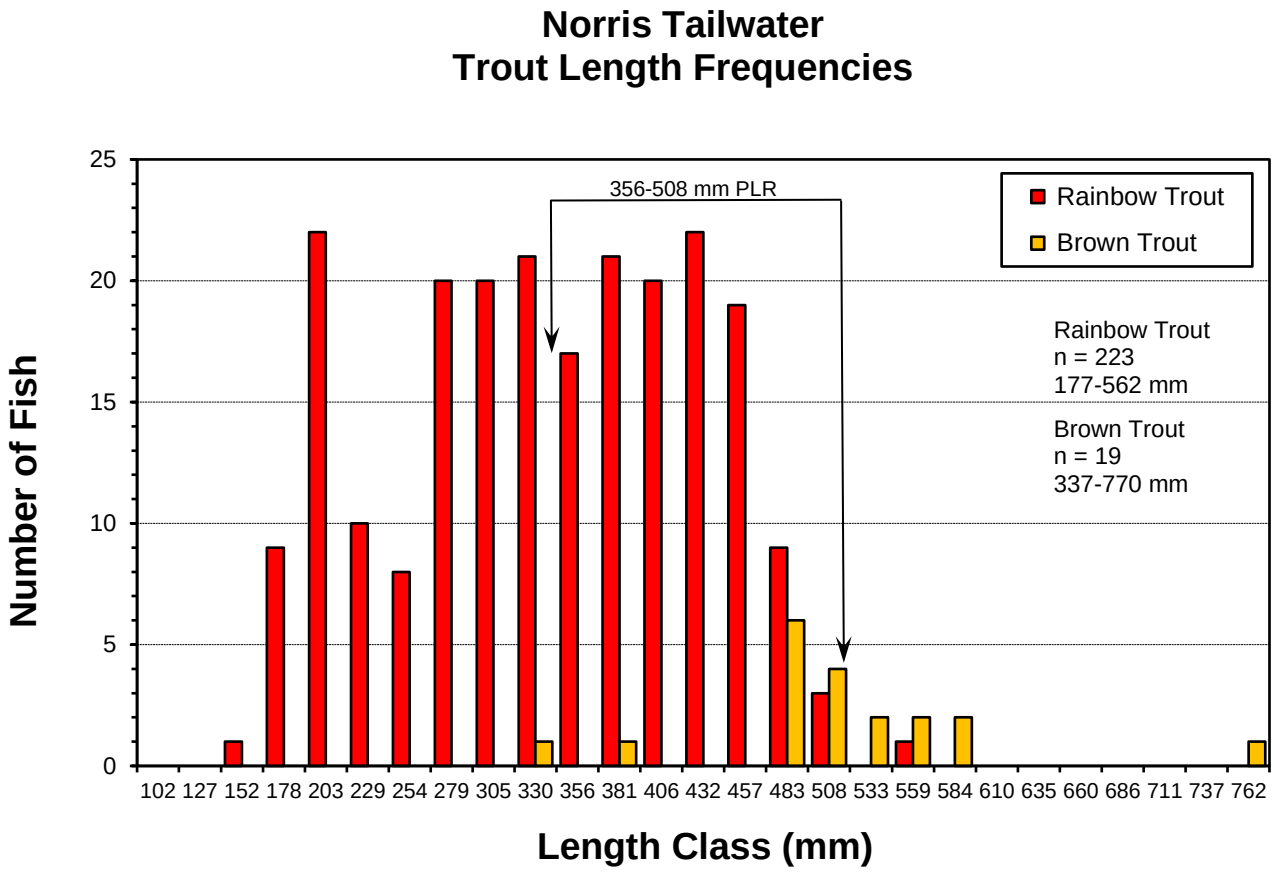


Figure 5-2. Length frequency distributions for trout from the Norris tailwater monitoring stations in 2021. No Rainbow Trout had fin clips—indicating they were not stocked (as fingerlings).

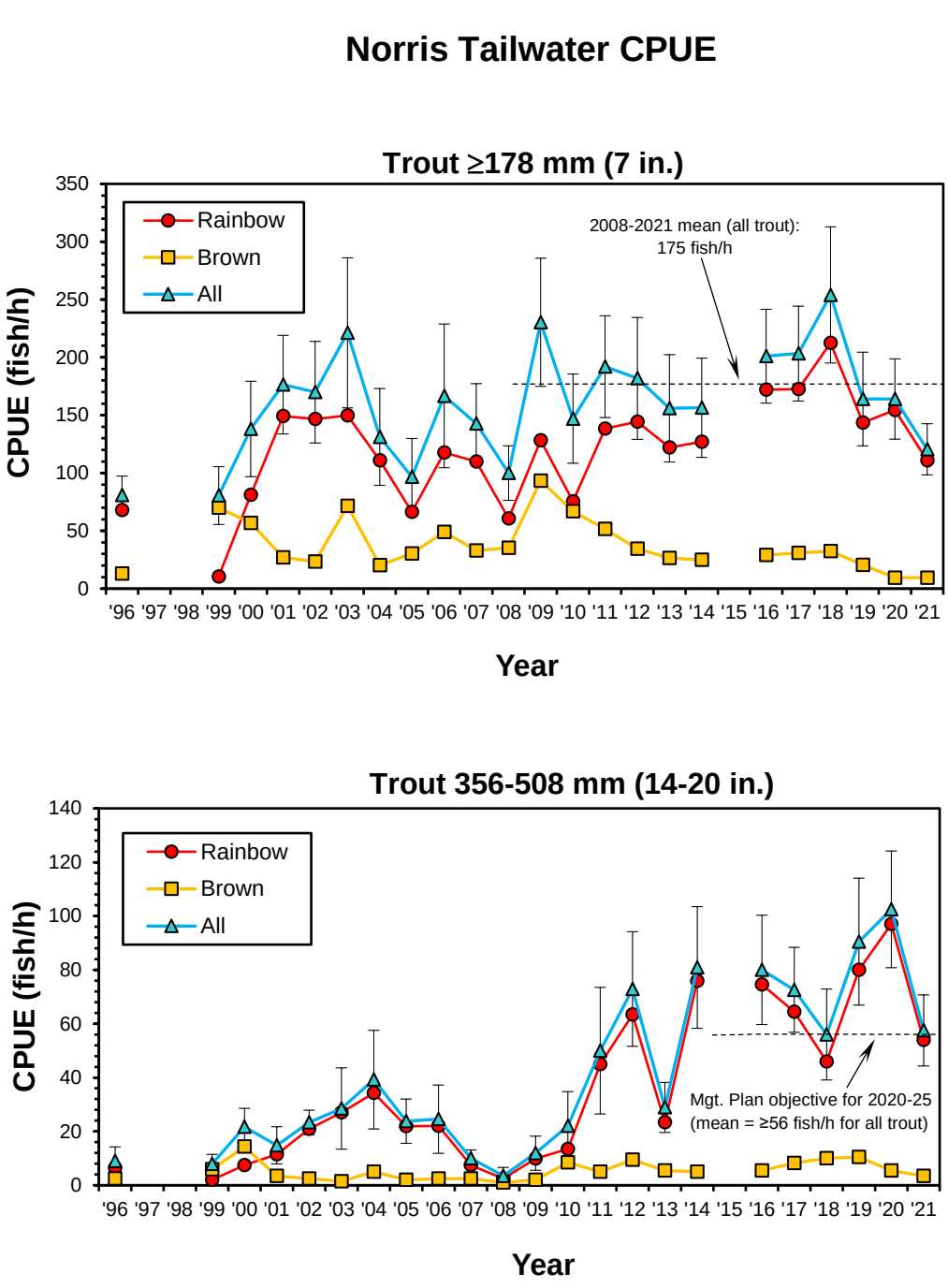


Figure 5-3. Mean trout CPUEs for the Norris tailwater samples. Bars indicate 90% confidence intervals. The 356-508 mm PLR regulation was established in 2008.

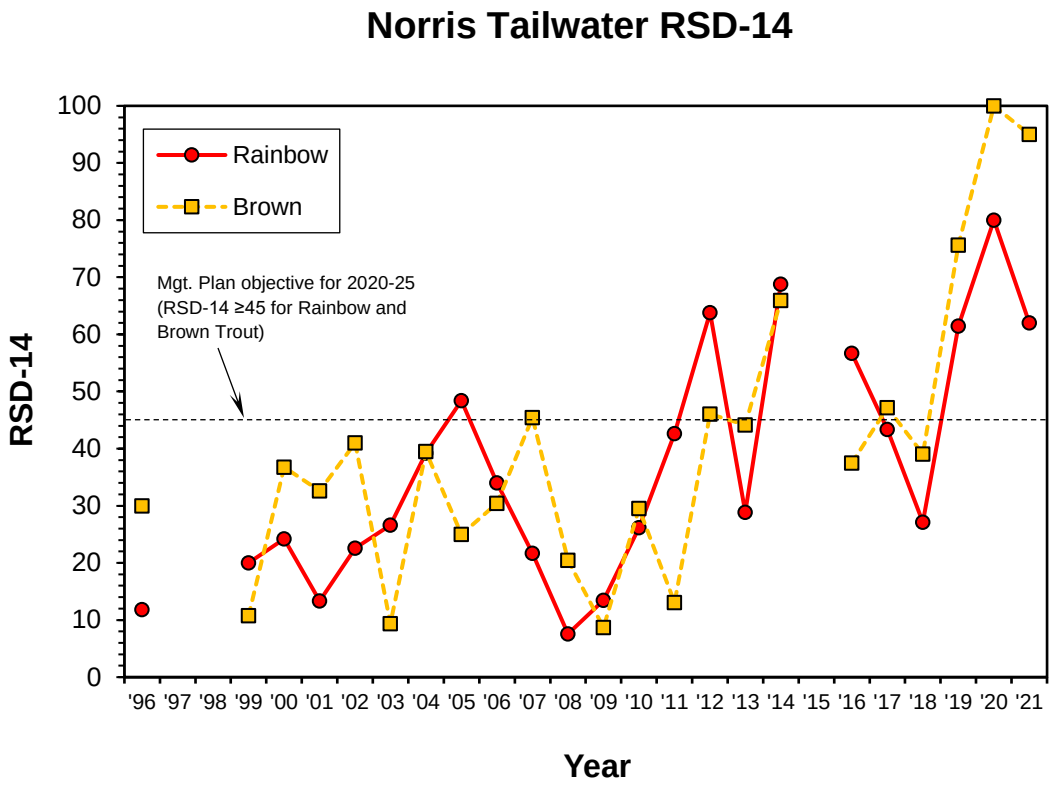


Figure 5-4. Relative stock densities for Norris tailwater Rainbow Trout and Brown Trout ≥14 in. (RSD-14) for 1996-2021.

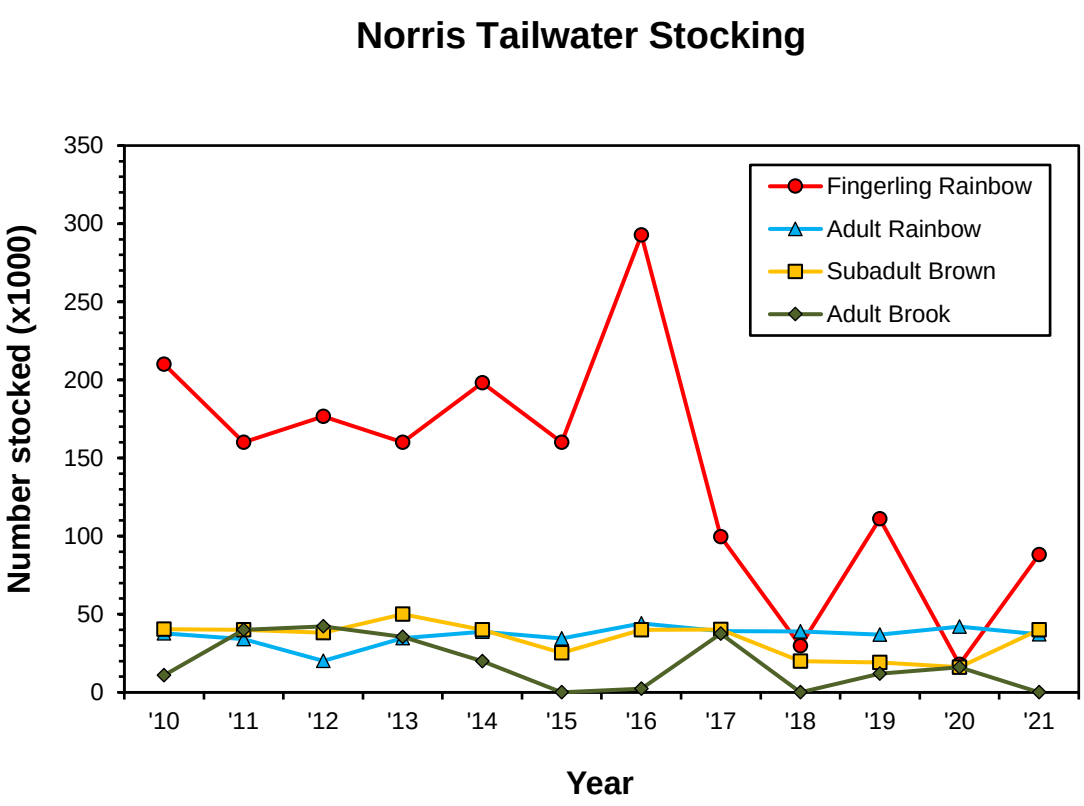


Figure 5-5. Trout stocking rates for the Norris tailwater (2010-2021). The 2019-2021 fingerling Rainbow Trout stocking rates (111,000, 18,000, 88,000) were reduced to accommodate marking (fin clips coded wire tags) for the TN CFRU research project.

Cherokee (Holston River)

Catch and Length Frequency

The 12 Cherokee tailwater monitoring stations (Figure 5-6) produced 36 trout (33 Rainbow Trout, 3 Brown Trout) weighing over 37 kg in June 2021 (Table 5-3). Water temperature on that date averaged 15.5° C. Rainbow Trout were predominantly in the 356- to 381-mm (14-15 in.) and 457- to 508-mm (18-20 in.) size classes (Figure 5-7). The November 2021 sample produced 24 trout (20 Rainbow Trout, 4 Brown Trout) weighing just under 19 kg (Table 5-3); water temperature averaged 19.9° C during that effort. All Rainbow Trout captured in November were in the 356- to 432-mm (14-17 in.) size classes except for two fish in the 508-mm (20 in.) class (Figure 5-7). Brown Trout captured in November had grown from the 254-mm (10 in.) size class to the 305- to 330-mm (12-13 in.) size classes (Figure 5-7).

The Cherokee tailwater near Blue Spring (base flow).

CPUE

The 2021 mean CPUE for the November sample (10.5 fish/h) decreased slightly relative to 2020 (12.5 fish/h) but remained near the average for the past 10 years (10.1 fish/h; Figure 5-8). The mean catch rate for larger trout in November 2021 (8.7 fish/h ≥356 mm) also decreased slightly relative to 2020 while remaining above the past 10-year average (6.0; Figure 5-8).

Mean CPUE for trout ≥178 mm (18 fish/h) in June 2021 was the same as for the June 2020 and June 2018 samples (Figure 5-9). The relatively consistent mean summer (June) CPUEs have been, on average, 50% higher than subsequent fall catch rates and also exhibit higher variability among sites (wider 90% confidence intervals; Figure 5-9). Given the annual thermal bottleneck in this tailwater, it is unsurprising that trout catch rates decline from June through the late October/early November.

Stocking

The Cherokee tailwater received 34,000 adult (229-254 mm) Rainbow Trout and 30,000 sub-adult (203-229 mm) Brown Trout in 2021 (Figure 5-10). Annual stocking rates during the past five years have averaged 32,000 adult Rainbow Trout and 26,000 sub-adult Brown Trout.

Angler Survey

A creel survey of the Cherokee tailwater was conducted during 2021. Results of this survey will be available in the 2022 annual report.

Water Temperature Monitoring

Hourly water temperature data were collected (Onset TidbiT® *v2* loggers) at the monitoring site at Blue Spring (13 km downstream of Cherokee Dm) during June through mid-November 2021. Maximum daily water temperature at the Blue Spring site (13 km below Cherokee Dam) was ≥21° C for 69 days in 2021 (consistently from 20 August-31 October; Figure 5-11) but reached 24° C on only four days during the first week of October. Minimum daily water temperature reached 21° C on 19 September and remained ≥21° C during all but six days through 25 October (31 days total; Figure 5-11), thus there was no coldwater habitat

during that period. Based on 2003-2021 data, there is typically no coldwater habitat (daily minimum water temperature is ≥21° C) at Blue Spring during 1 September-13 October (43 days; Figure 5-11).

Fall electrofishing catch rates appear to be generally correlated with summer/early fall water temperatures, which in turn are related to variability in flow from Cherokee Dam during March-September. Above average precipitation in some years (e.g., 2003, 2013, 2017- 2019) results in higher average flows from Cherokee Dam, earlier depletion of cold water stored in the reservoir, and unsuitably warm tailwater temperatures for long periods of time. The reverse is true during dry years such as 2007 and 2008. Consequently, there is a relatively strong (R^2 = 0.50) inverse relationship (2nd order polynomial) between the number of days where minimum water temperature was ≥22° C at the Blue Spring site and the electrofishing catch rate (log_{10}-transformed +1) for all trout ≥178 mm (Figure 5-12). There is also a relatively strong (R^2 = 0.56) positive relationship (2nd order polynomial) between water temperatures (expressed as the number of days where the minimum was ≥21° C at Blue Spring) and mean flow during March-September (Figure 5-13). Extended periods of low flows and high air temperatures in late summer (e.g., in 2016; Figure 5-13) can also raise water temperatures to levels that impact trout survival.

Management Recommendations

Trout in the Cherokee tailwater are subject to a lack of coldwater habitat (i.e., minimum daily temperatures exceed >21° C during September and part of October each year. Consequently, most trout survive less than a year. Some fish do find thermal refugia such as groundwater upwellings or cooler tributaries (Baird and Krueger 2003) and survive through at least one thermal bottleneck to produce the large (≥457 mm) fish that are captured in most monitoring samples.

A large (583 mm, 2.35 kg) Rainbow Trout from the June 2021 Cherokee tailwater sample.

Current management policy excludes stocking fingerling Rainbow Trout because of their low recruitment potential and avoids stocking fish during July-October because of high water temperatures (>21° C) during those months. General, statewide angling regulations for trout are appropriate for maintaining this fishery. Trout harvest estimated by the 2014 creel survey (Black 2015) was relatively high, representing 45% of all trout stocked that year (52,300 fish). However, special regulations (minimum size or slot limits) would offer little benefit, as few fish protected by such measures would survive the next summer thermal bottleneck. Summer and fall electrofishing at the 12 existing monitoring stations, annual water temperature monitoring, and periodic angler surveys should continue. This information will be used to develop a trout fishery management plan for this tailwater. Objectives of the plan will likely focus on determining optimal annual stocking rates and evaluating survival and growth of various stocked cohorts.

Cherokee Tailwater

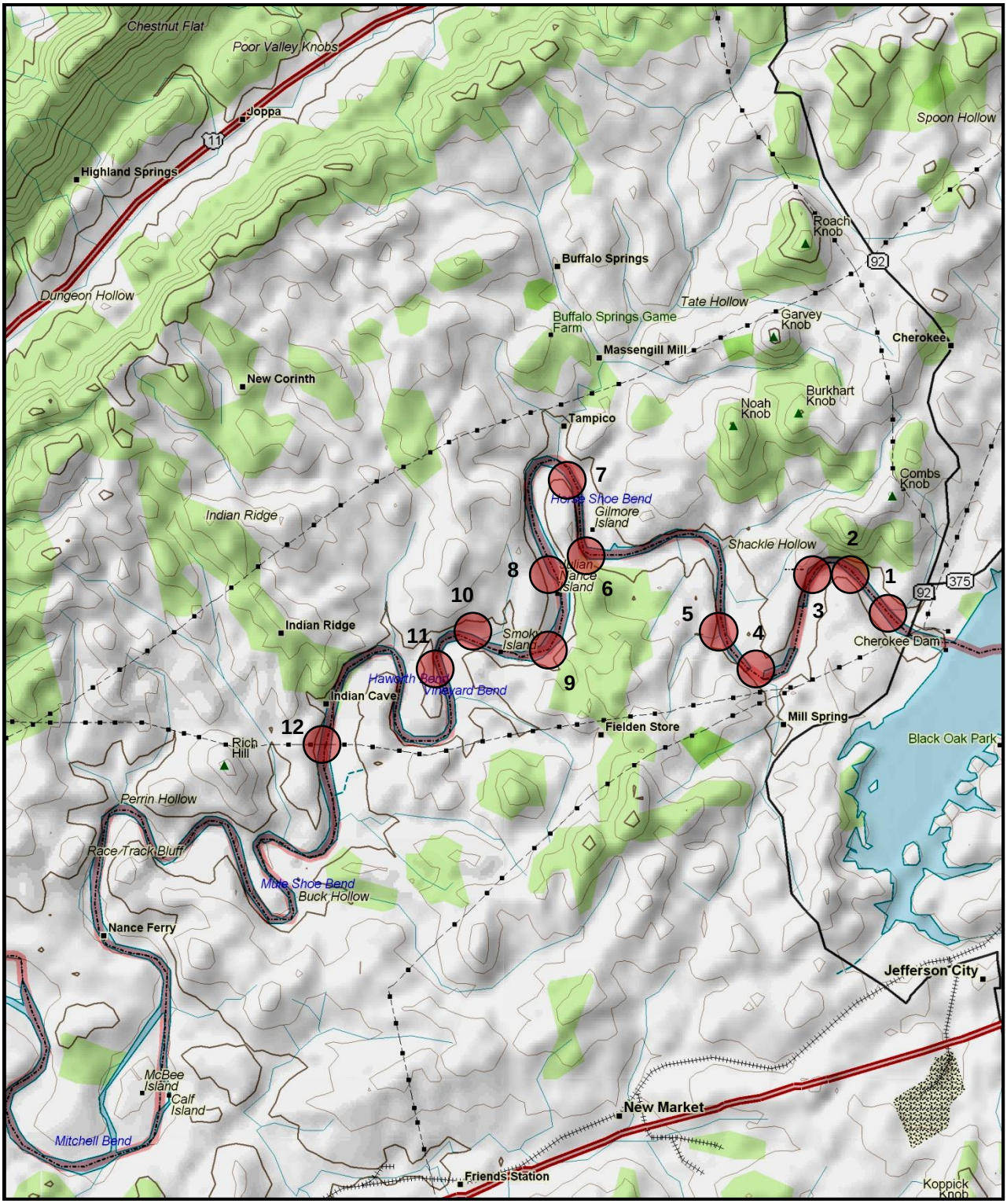


Figure 5-6. Locations of the Cherokee tailwater (Holston River) monitoring stations.

Table 3-4. Catch data for the 12 electrofishing stations on the Cherokee tailwater (June and November 2021).

		11 June 2021 Sample			2 November 2021 Sample		
Station	Species	Total Catch	Size Range (mm)	Total Weight (g)	Total Catch[2]	Size Range (mm)	Total Weight (g)
1	Rainbow	2	374-455	1,921	8	365-446	6,505
	Brown	0	--	0	1	335	364
Totals		**2**		**1,921**	**9**		**6,869**
2	Rainbow	7	353-512	8,990	1	517	1,648
	Brown	0	--	0	0	0	0
Totals		**7**		**8,990**	**1**		**1,648**
3	Rainbow	0	--	0	0	0	0
	Brown	0	--	0	0	0	0
Totals		**0**		**0**	**0**		**0**
4	Rainbow	3	471-583	4,912	1	443	872
	Brown	0	--	0	0	0	0
Totals		**3**		**4,912**	**1**		**872**
5	Rainbow	7	309-522	6,956	2	443-443	1,902
	Brown[1]	3	239-251	361	1	329	436
Totals		**10**		**7,317**	**3**		**2,338**
6	Rainbow	5	242-509	6,344	0	0	0
	Brown	0	--	0	0	0	0
Totals		**5**		**6,344**	**0**		**0**
7	Rainbow	2	402-521	2,078	0	0	0
	Brown	0	--	0	0	0	0
Totals		**2**		**2,078**	**0**		**0**
8	Rainbow	1	241	144	0	0	0
	Brown	0	--	0	0	0	0
Totals		**1**		**144**	**0**		**0**
9	Rainbow	3	387-491	2,939	1	398	752
	Brown	0	--	0	0	0	0
Totals		**3**		**2,939**	**1**		**752**
10	Rainbow	1	484	1,410	2	403-440	1,648
	Brown	0	--	0	0	0	0
Totals		**1**		**1,410**	**2**		**1,648**
11	Rainbow	0	--	0	2	384-401	1,416
	Brown	0	--	0	1	334	323
Totals		**0**		**0**	**3**		**1,739**
12	Rainbow	2	337-465	1,594	3	380-508	2,676
	Brown	0	--	0	1	315	322
Totals		**2**		**1,594**	**4**		**2,998**
Rainbows		33	241-583	37,288	20	365-517	17,419
Browns		3	239-251	361	4	315-335	1,445
Overall		**36**		**37,649**	**24**		**18,864**

[1]Length and weight for one Brown Trout was not obtained at Station 5 in June.
[2]Sample time at Station 1 in November was 900 s.

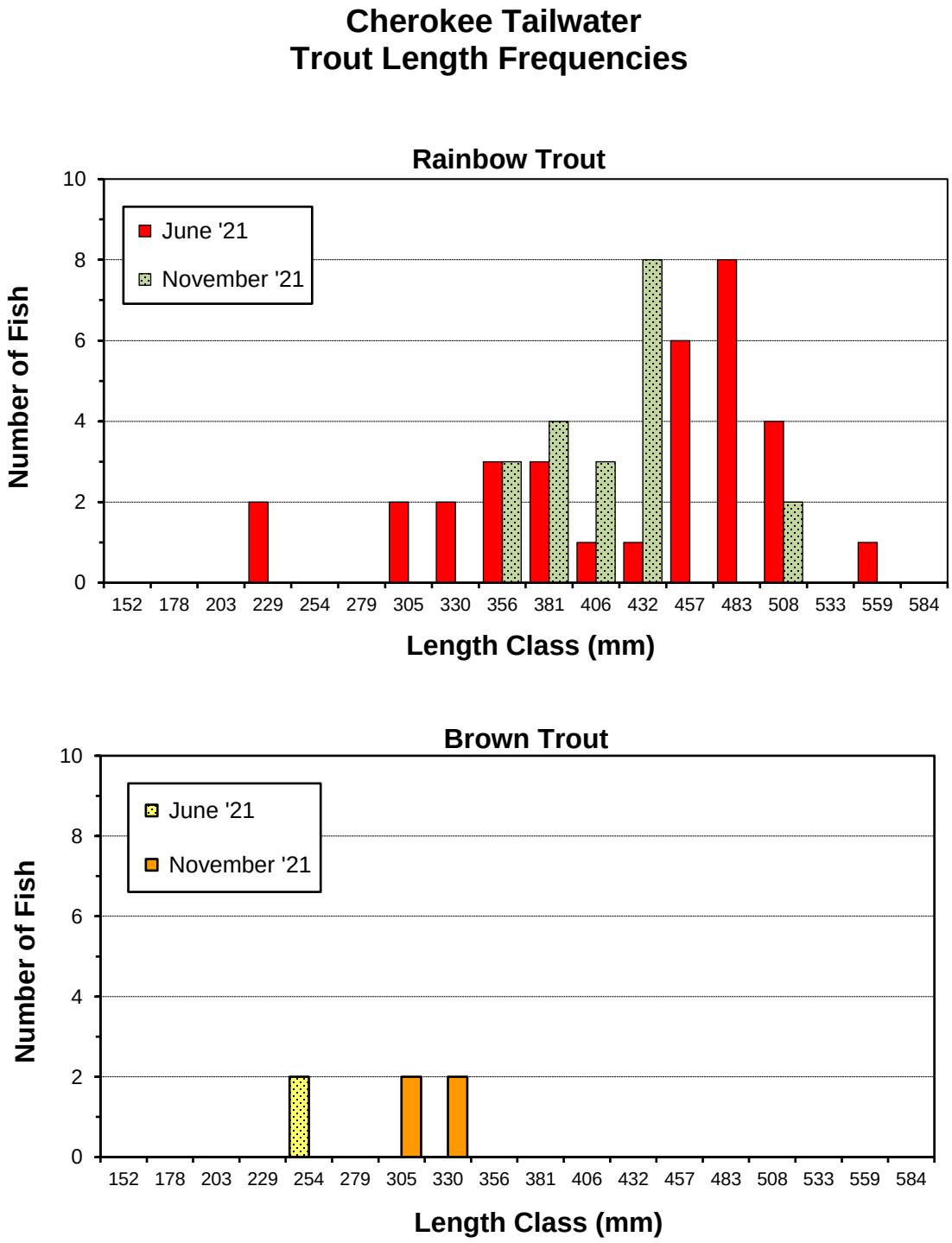


Figure 5-7. Length frequency distributions for trout from the Cherokee tailwater monitoring stations during the June and November 2021 samples.

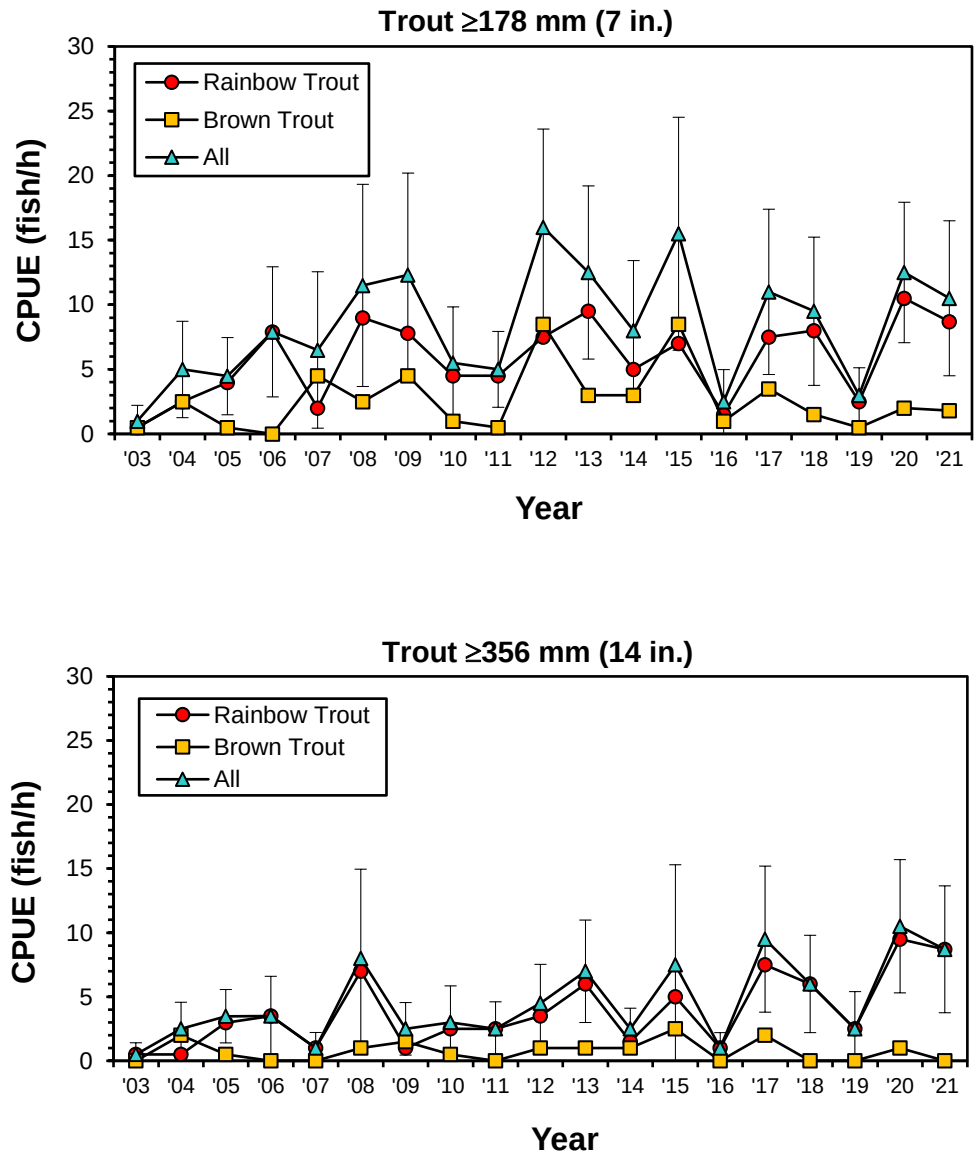


Figure 5-8. Mean trout CPUEs for the annual October/November Cherokee tailwater samples. Bars indicate 90% confidence intervals.

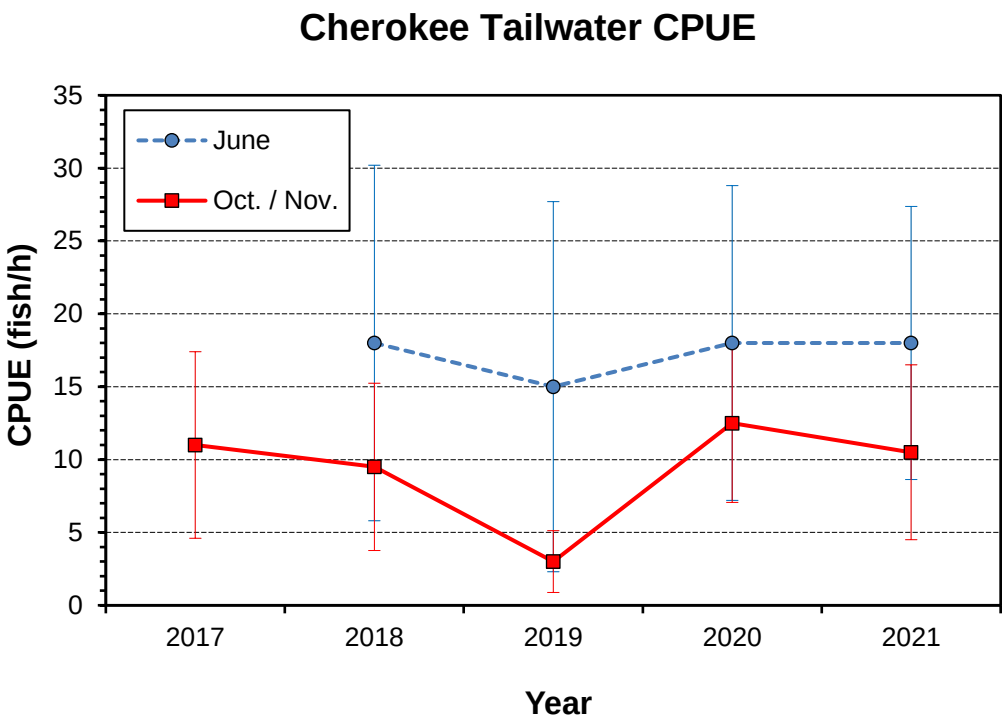


Figure 5-9. Comparison of mean CPUEs (trout ≥178 mm) for June and October/November samples from the Cherokee tailwater. Bars indicate 90% confidence intervals.

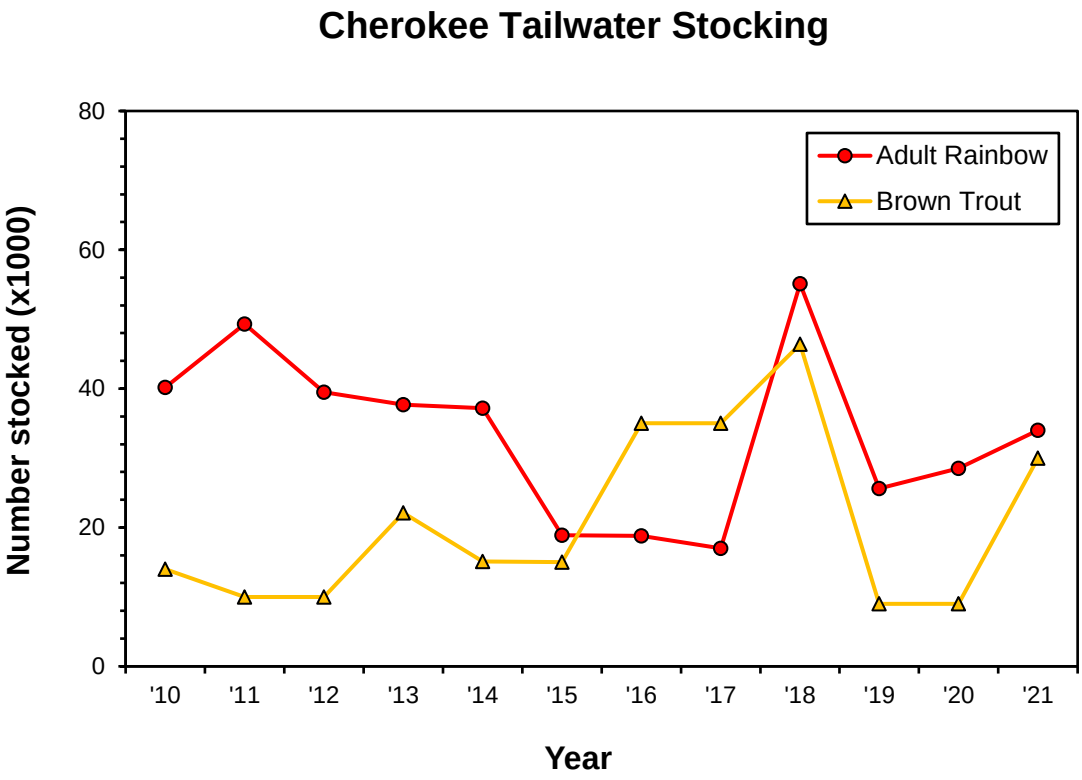


Figure 5-10. Recent trout stocking rates for the Cherokee tailwater. About 32,000 adult Rainbow Trout and 26,000 adult/sub-adult Brown Trout have been stocked annually since 2017.

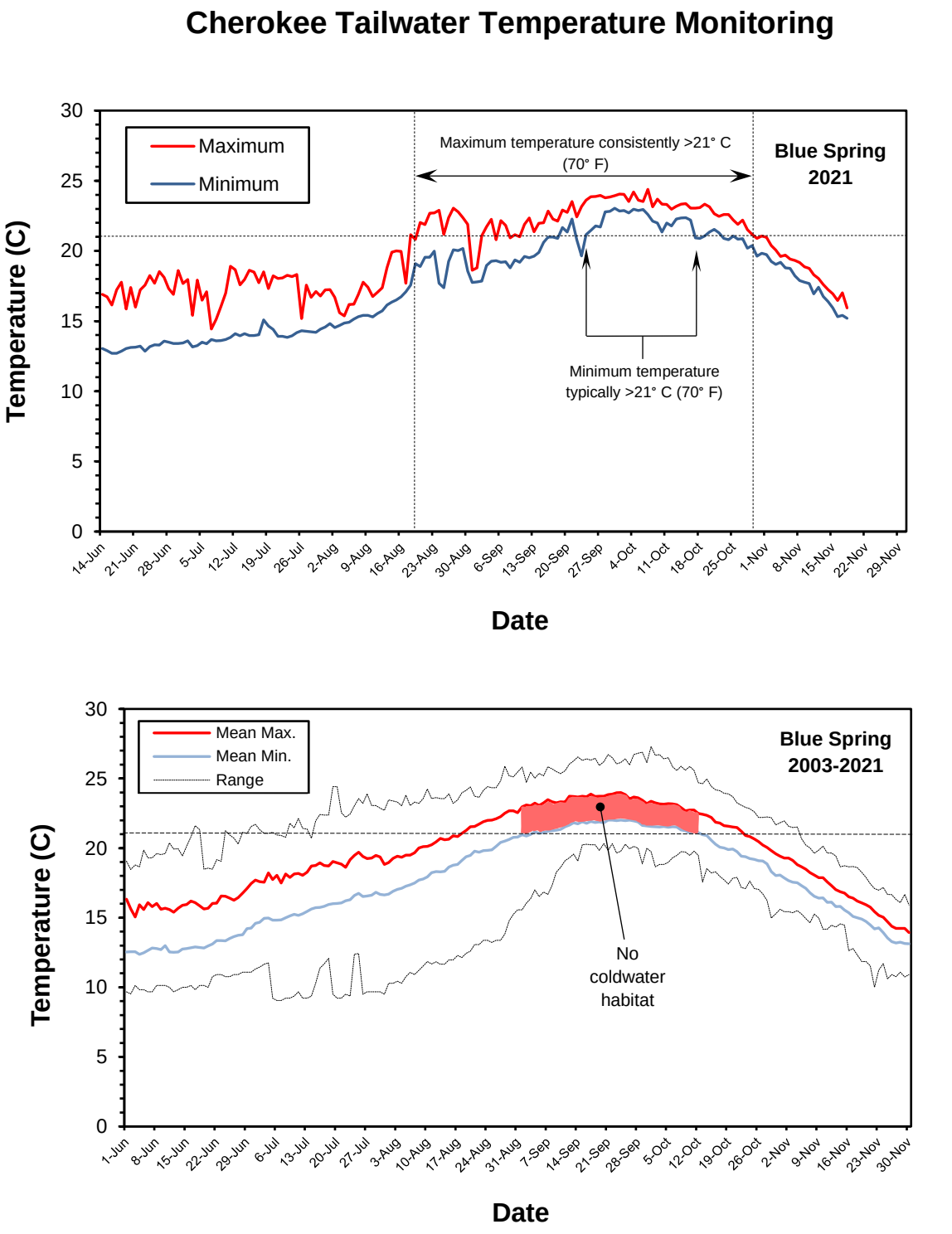


Figure 5-11. Daily temperature maxima and minima for June through mid-November at Blue Spring (~13 km below the dam) in 2021 (upper graph) and 2003-2021 means (lower graph, with range).

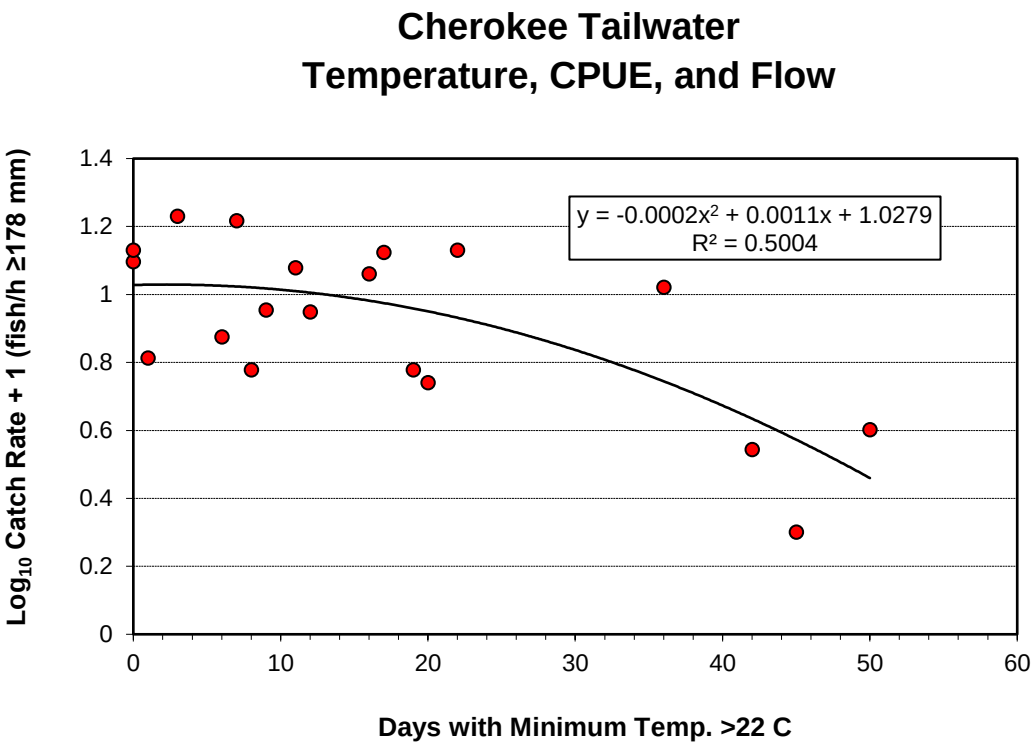


Figure 5-12. Inverse relationship between temperature (days during June-Oct. with minimum >22 C at Blue Spring) and October/November electrofishing catch rate for the Cherokee tailwater.

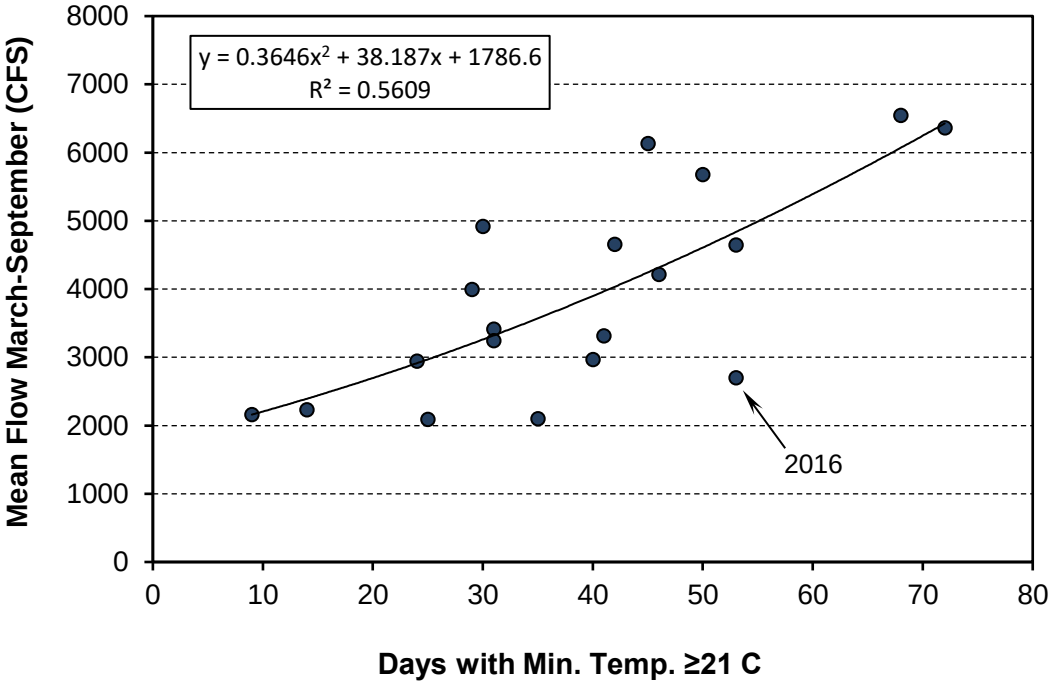


Figure 5-13. Relationship between mean flow (March-August) and temperature (days during June-October with minimum ≥21 C at Blue Spring) for the Cherokee tailwater.

Wilbur (Watauga River)

Catch and Length Frequency

The 12 Wilbur tailwater monitoring stations (Figure 5-14) produced 358 trout weighing nearly 86 kg in 2021 (Table 5-4) and Brown Trout represented 84% of the total catch. The total catch in the sample was down from 2019 (625) and 2020 (473). Most Brown Trout (75%) and Rainbow Trout (88%) in 2021 were in the 203-305 mm size range (Figure 5-15). Four Brown Trout captured in 2021 were ≥508 mm (20 in.) (Figure 5-16), which is comparable to the 1999-2020 average (3.4).

CPUE

Mean CPUE for Brown Trout ≥178 mm (all sites) declined to 141 fish/h in 2021, the lowest catch rate obtained since 2015 (133 fish/h in 2015; Figure 5-16). Additionally, mean Brown Trout CPUE for the upper portion of the tailwater (Stations 1-6) fell below 300 fish/h for the first time since 2016 (Figure 5-17). Mean Rainbow Trout CPUE remained near 30 fish/h overall in 2021 (Figure 5-16), although there was a 29% increase for the lower tailwater (Figure 5-18). Total trout CPUE (≥178 mm) was below 200 fish/h for the first time since 2013 (Figure 5-17).

Wilbur tailwater near the lower end of the Quality Zone.

The mean catch rate for larger trout (≥356 mm) has been in the 20-27 fish/h range since 2010 but fell just below this range in 2021 (19 fish/h; Figure 5-17). Most of the fish in this size range are Brown Trout (Figure 5-17). Two large Rainbow Trout (397-427 mm) captured at Station 5 and identified as retired brood-stock from Erwin National Fish Hatchery (ENFH) were not included in the analyses.

Stocking

The annual allocation of adult Rainbow Trout for the Wilbur tailwater is 40,000 fish, but only 25,500 were stocked during 2021 (Figure 5-19) because of production shortfalls at DHNFH. Retired Rainbow Trout broodstock from ENFH are now allocated for the Wilbur tailwater and 1,834 of these fish (averaging 457 mm or 18 in.) were stocked in 2021, particularly in the reach below Blevins Bend. No fingerling Rainbow Trout were stocked in 2021 and stocking of these fish will be suspended (potentially through 2027) while the contribution of natural reproduction by Rainbow Trout is under evaluation during the updated Wilbur tailwater trout fishery management plan (Habera et al. 2022a)

2020 Angler Survey

The 2020 Wilbur tailwater creel survey (Black 2021) indicated that trout anglers made an estimated 16,998 trips comprising 93,320 hours of effort (Figure 5-20). Although angling pressure (hours) in 2020 increased 50% relative to the 2018 survey, it remained below the 112,740 hours estimated for 2016 (Figure 5-20). Estimated trips for 2020 matched the average (17,000) for the past three surveys (Figure 5-20). Both Rainbow Trout and Brown Trout catch increased in 2020 relative to 2018 but were within the range of estimates for previous creel surveys (Figure 5-21). However, Rainbow Trout harvest in 2020 (34,000 fish; Figure 10) exceeded all previous estimates (<20,000 fish), as did the Rainbow Trout harvest rate (35%; Figure 5-22). Anglers have been encouraged to harvest more smaller (8-12 in.) Brown Trout for the past few

years as the population in the upper portion of the tailwater has increased, but 2020 was the first year that there was an apparent change in harvest. Estimated Brown Trout harvest increased to 4,000 fish in 2020 (from 900-2,600 during 2013-2018; Figure 5-21) and harvest rate increased for the first time (Figure 5-22).

A 627 mm (24.7 in.), 2.61 kg (5.7 lb.) Brown Trout from the 2021 Wilbur tailwater sample (Station 5).

The proportion of non-resident anglers fishing the Wilbur tailwater has been ≥50% during the past three creel surveys (50% in 2020, 57% in 2016; Black 2017, and 54% in 2018; Black 2019). Non-resident anglers were primarily from North Carolina in 2020, as in the previous surveys.

Anglers (n=383) were also asked in 2020 about their use of and success in the QZ, as well as their overall perception of the trout fishery in the lower portion of the tailwater (below Blevins Bend). Only 30% indicated they had fished in the QZ during the previous year and of those, most (54%) said they did not catch more trout ≥14 in. in the QZ than elsewhere in the tailwater. A substantial majority (72%) rated the trout fishery in the lower portion of the tailwater as excellent (5 on a 1-5 scale) and no one gave a 1 or 2 rating (13% had no opinion).

Management Recommendations

The wild Brown Trout fishery in the upper half of the tailwater has expanded substantially during the past few years. There also appears to be a notable wild component to the Rainbow Trout fishery now as well—indicated by the abundant age-0 fish observed during collection of *M. cerebralis* screening samples in 2019. Accordingly, new objectives were developed for the Wilbur tailwater management plan update for 2022-2027 (Habera et al. 2022a).

Although none of the 383 anglers interviewed during the 2020 creel survey rated the trout fishery in the lower Wilbur tailwater (below Blevins Bend) any lower than 'okay' (3 on a 1-5 scale), TWRA has responded to concerns that Striped Bass predation is having a negative effect there. Retired Rainbow Trout broodstock from ENFH are now allocated for stocking in this area during the summer and fall (when Striped Bass are present). Additionally, some of Wilbur tailwater's adult Rainbow Trout stocking allocation (from DHNFH) during the summer months was redirected to the lower reach in November and December as part of the updated trout fishery management plan (Habera et al. 2022a).

The new Wilbur tailwater management plan (Habera et al. 2022a) also recommends increasing the overall adult Rainbow Trout stocking rate from 40,000/year to 47,000/year, which would align it with the corresponding stocking rate for the South Holston tailwater. This increase would be appropriate given that recent (2019-2020) angling pressure, trips, and Rainbow Trout harvest estimates are comparable for these two tailwaters. Most (or all) of the additional 7,000 fish would likely need to come from DHNFH, thus it will be necessary to discuss the feasibility of this increase during the 2022 annual trout allocation meeting hosted by TWRA.

Wilbur Tailwater

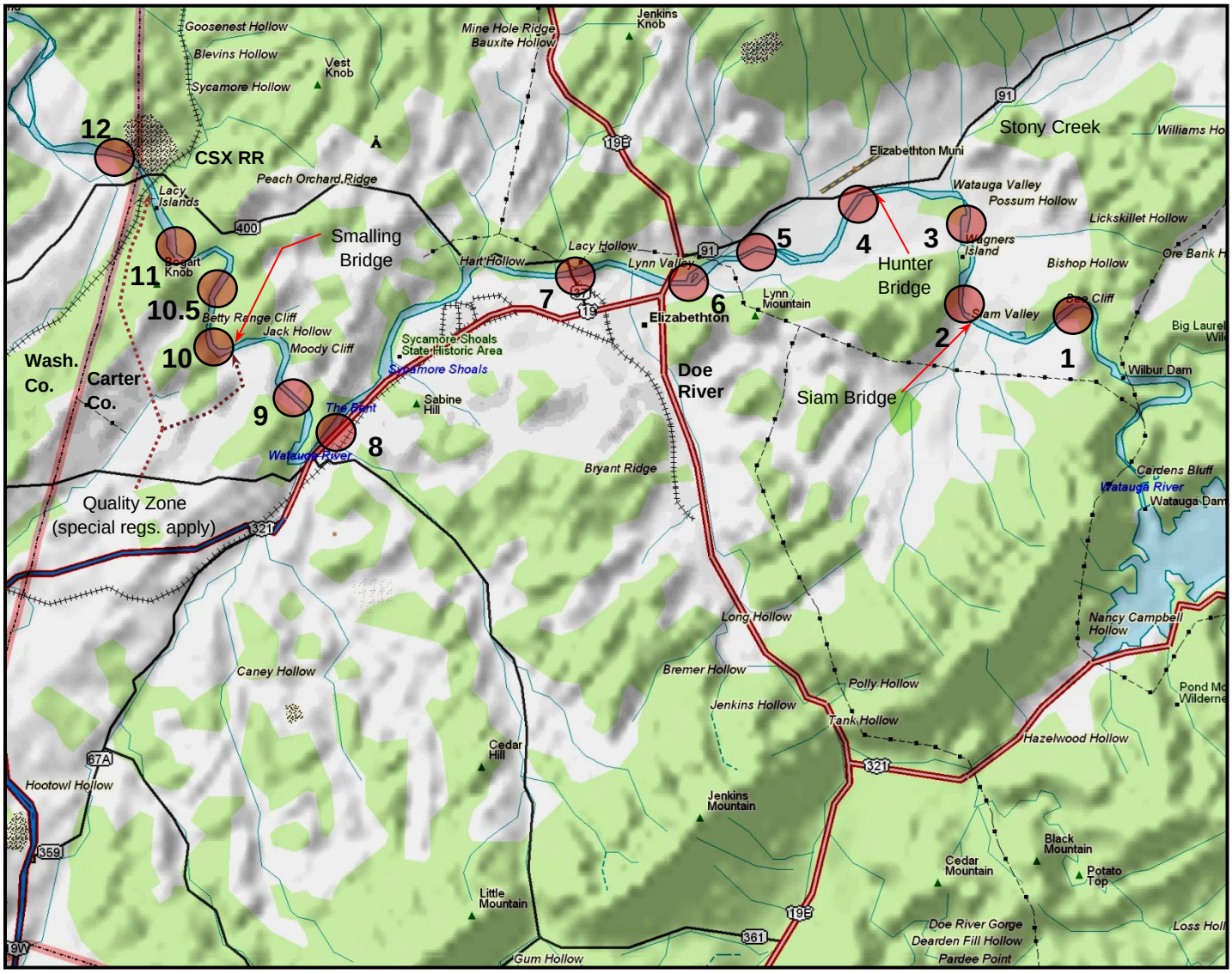


Figure 5-14. Locations of the Wilbur tailwater (Watauga River) monitoring stations. Station 10.5 was added in 2010 to help evaluate the Quality Zone (which also includes stations 10 and 11).

Table 3-6. Catch data for the 13 electrofishing stations on the Wilbur tailwater sampled 4 March 2021.

Station	Species	Total Catch	Size Range (mm)	Total Weight (g)	% Abundance (number)	% Abundance (weight)
1	Rainbow	10	220-333	2,084	22	27
	Brown	36	170-328	5,707	78	73
Totals		**46**		**7,791**	**100**	**100**
2	Rainbow	6	232-326	950	13	13
	Brown	41	125-328	6,142	87	87
Totals		**47**		**7,092**	**100**	**100**
3	Rainbow	6	193-280	756	15	12
	Brown	35	132-407	5,714	85	88
Totals		**41**		**6,470**	**100**	**100**
4	Rainbow	5	230-314	894	15	13
	Brown	28	171-375	6,099	85	87
Totals		**33**		**6,993**	**100**	**100**
5	Rainbow	6	176-317	1,176	7	6
	Brown	81	130-627	19,098	93	94
Totals		**87**		**20,274**	**100**	**100**
6	Rainbow	3	220-295	469	13	9
	Brown	21	139-428	4,495	88	91
Totals		**24**		**4,964**	**100**	**100**
7	Rainbow	13	181-416	3,080	30	24
	Brown	31	159-497	9,592	70	76
Totals		**44**		**12,672**	**100**	**100**
8	Rainbow	1	296	240	33	22
	Brown	2	162-446	859	67	78
Totals		**3**		**1,099**	**100**	**100**
9	Rainbow	2	269-271	397	25	12
	Brown	6	292-488	3,054	75	88
Totals		**8**		**3,451**	**100**	**100**
10	Rainbow	1	440	679	20	13
	Brown	4	435-620	4,490	80	87
Totals		**5**		**5,169**	**100**	**100**
10.5	Rainbow	0	--	0	0	0
	Brown	5	322-560	3,259	100	100
Totals		**5**		**3,259**	**100**	**100**
11	Rainbow	4	234-393	1,192	29	19
	Brown	10	300-521	5,068	71	81
Totals		**14**		**6,260**	**100**	**100**
12	Rainbow	2	246-312	540	33	15
	Brown	4	357-558	3,136	67	85
Totals		**6**		**3,676**	**100**	**100**
Total Rainbows[1]		59	176-440	12,457	16	14
Total Browns[1]		299	125-627	73,454	84	86
Overall totals[1]		**358**		**85,911**	**100**	**100**

[1]Overall totals do not include Station 10.5, which was added in 2010 to help evaluate the Quality Zone (stations 10, 10.5, and 11 are in the QZ). Rainbow Trout data do not include retired brood fish from Erwin National Fish Hatchery.

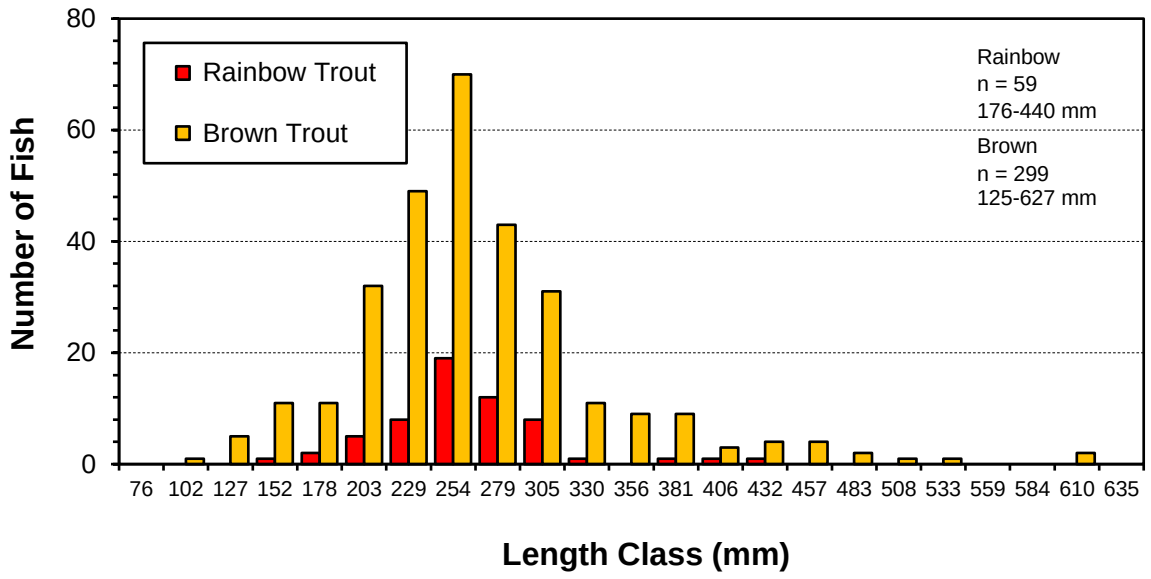


Figure 5-15. Length frequency distributions for trout from the Wilbur tailwater monitoring stations in 2021 (excluding Station 10.5).

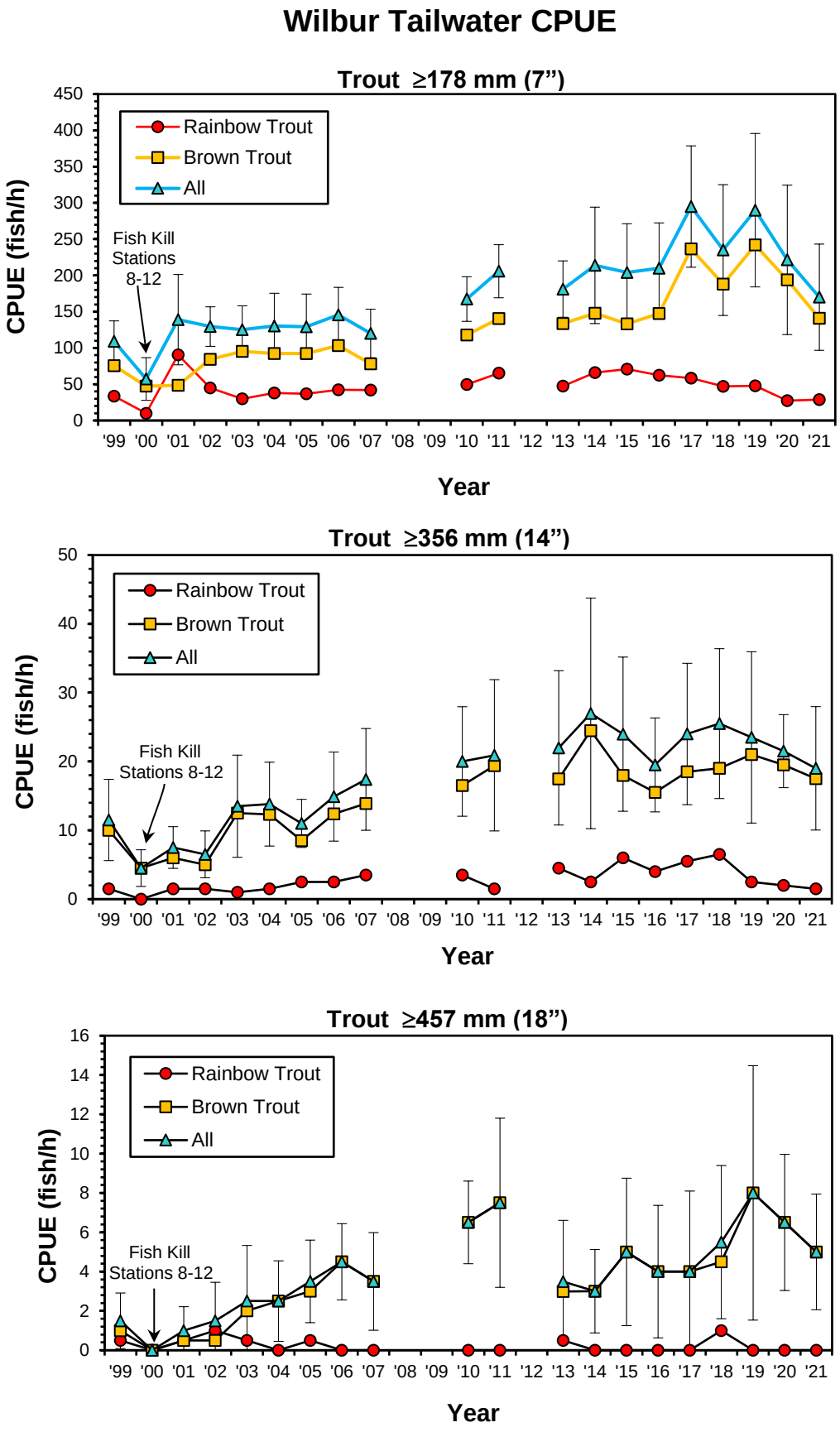


Figure 5-16. Mean trout CPUEs for the Wilbur tailwater samples. Bars indicate 90% confidence intervals.

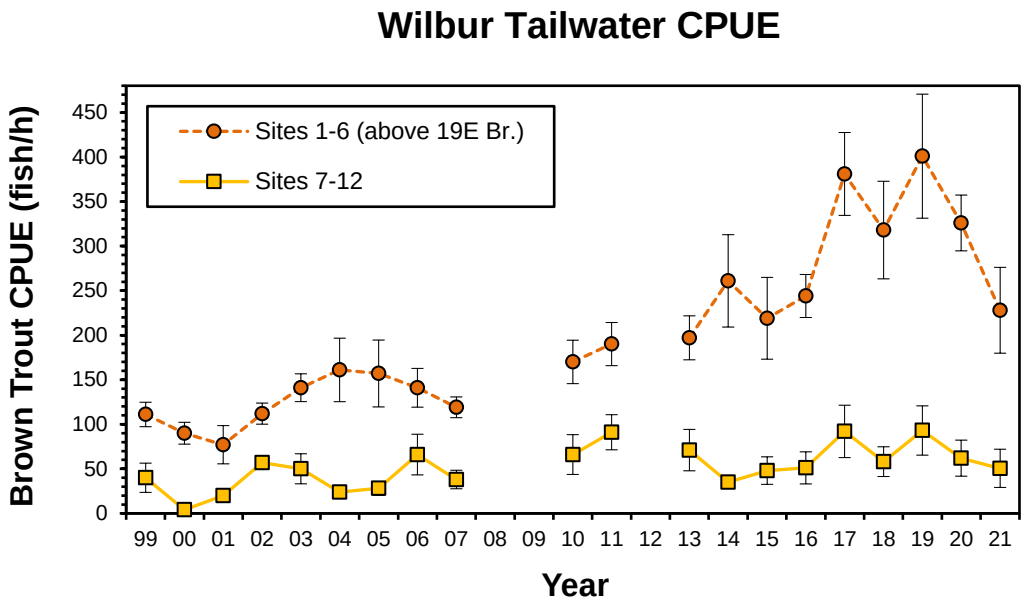


Figure 5-17. Mean Brown Trout CPUEs for the upper (Stations 1-6) and lower (Stations 7-12) portions of the Wilbur tailwater. Bars indicate 90% upper confidence limits.

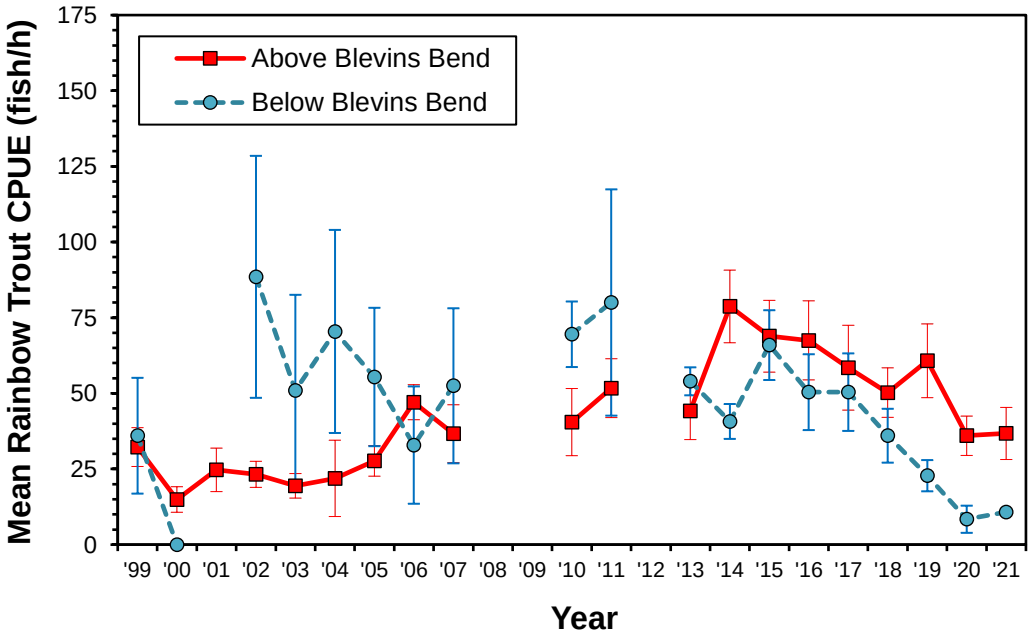


Figure 5-18. Mean Rainbow Trout CPUEs (fish ≥178 mm) for the Wilbur tailwater above (Stations 1-8) and below (Stations 9-12) Blevins Bend. Bars indicate standard errors (SE).

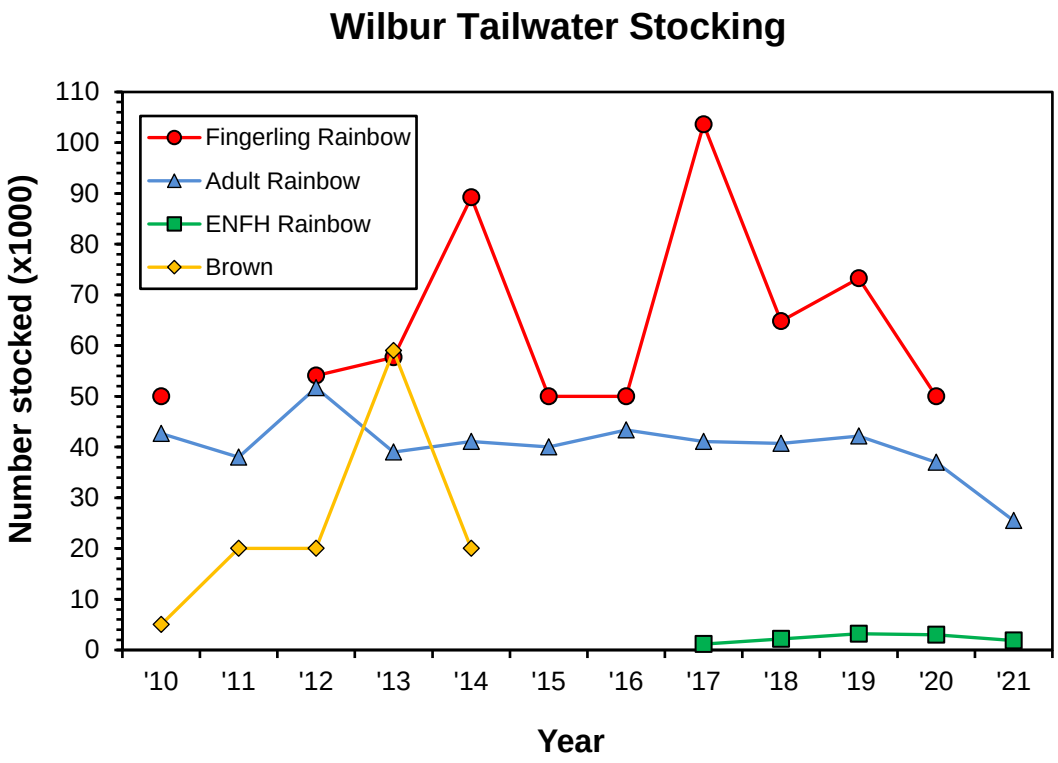


Figure 5-19. Recent trout stocking rates for the Wilbur tailwater. Stocking rates under the 2015-2020 were 40,000 adult and 50,000 fingerling Rainbow Trout annually. Fingerling Rainbow Trout stocking was suspended in 2021 to determine the contribution of natural reproduction as part of the updated (2022-2027) management plan. Erwin National Fish Hatchery stocked 1,400 retired brood Rainbow Trout (18 in.) in 2021.

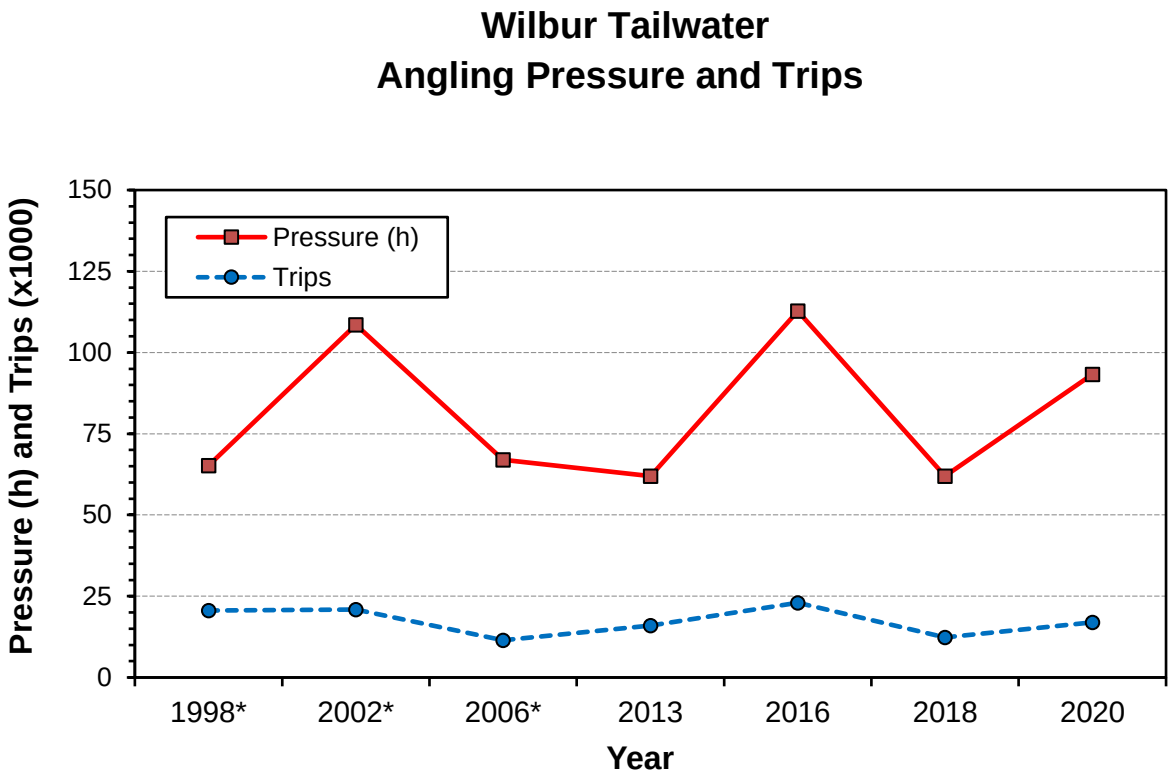


Figure 5-20. Angler use (pressure and trips) estimated by Wilbur tailwater creel surveys (1998-2020). The 1998-2006 surveys covered only March-October.

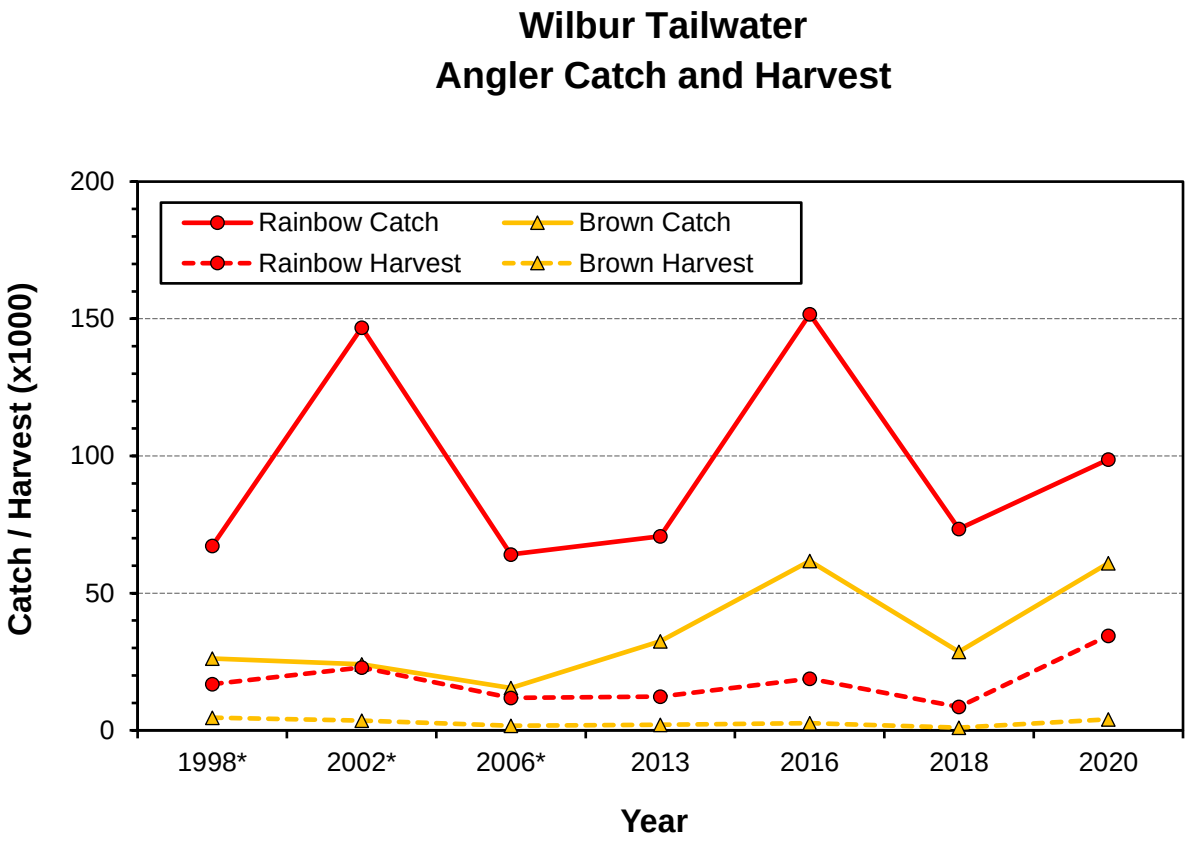


Figure 15-21. Angler catch and harvest estimated by Wilbur tailwater creel surveys (1998-2020). The 1998-2006 surveys covered only March-October.

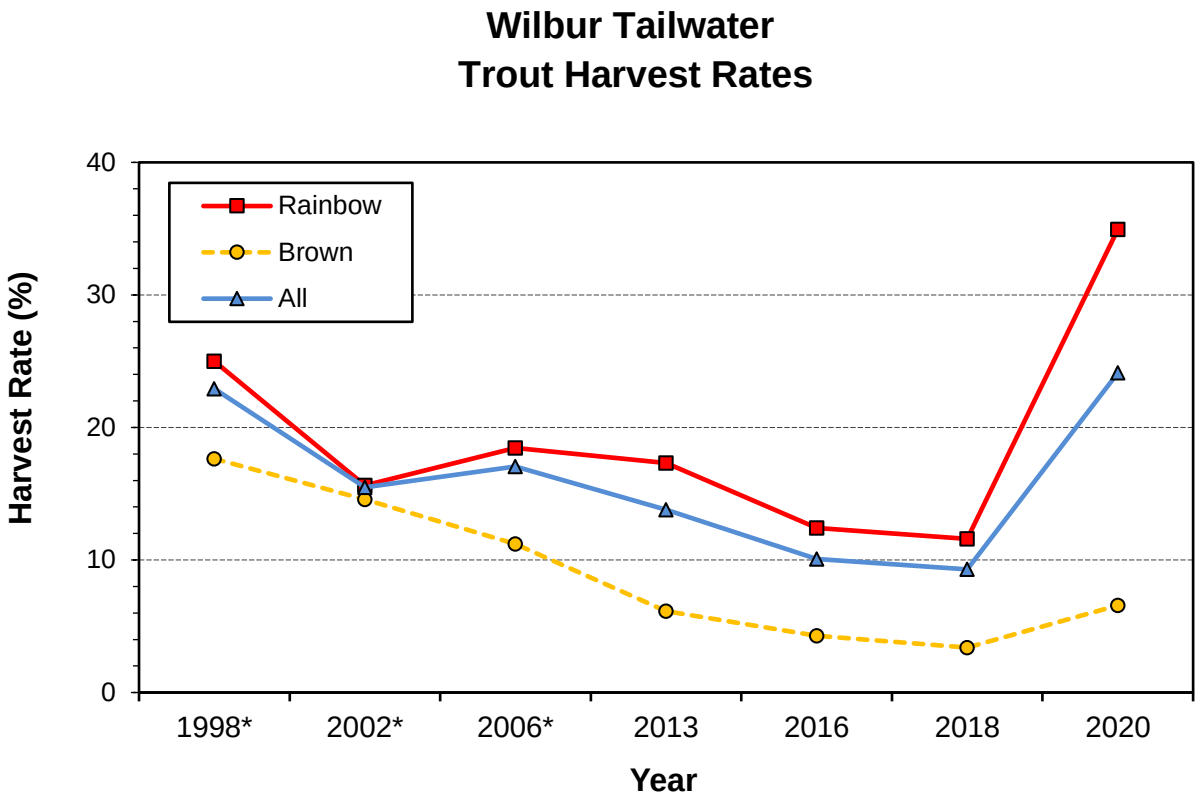


Figure 5-22. Trout harvest rates for the Wilbur tailwater (1998-2020). The 1998-2006 surveys covered only March-October.

Fort Patrick Henry (South Fork Holston River)

Catch, Length Frequency, and W_r

The four Ft. Patrick Henry tailwater electrofishing stations (Figure 5-23) produced only 11 trout weighing 11 kg in 2021 (Table 5-5), which was the fewest fish captured since monitoring began in 2002. Rainbow Trout ranged from 228-560 mm and were in the 208-279 and ≥432 mm (8-11 and ≥17 in.) size classes (Figure 5-24). The two Brown Trout captured ranged from 505-522 mm (Figure 5-23). Mean relative weight (W_r) was 112 (SE=5.27) for Rainbow Trout and 121 (SE=5.38) for Brown Trout.

The Ft. Patrick Henry tailwater.

Scanning a Ft. Patrick Henry Rainbow Trout for a PIT tag as part of the ongoing TN CFRU research project.

CPUE

Mean electrofishing catch rates for trout ≥178 mm have declined since 2017 and fell to 11 fish/h in 2021, which is the lowest catch rate yet obtained (Figure 5-25). Rainbow Trout CPUE in 2021 (9 fish/h) was also lower that for any previous sample. The catch rate for trout ≥356 mm has also declined (since 2016) and fell to 6 fish/h in 2021, which is the lowest CPUE since 2007 (Figure 5-24). Catch rates for the largest trout (≥457 mm) had increased during 2018-2020 but dropped 74% to 5 fish/h in 2021 (Figure 5-25). The abundance of trout ≥457 mm was previously low during 2004-2010 (0 to 4 fish/h) but had improved to an average 16 fish/h during 2011-2020 (Figure 5-25).

RSD-18

The relative stock density for Rainbow Trout 18 in. (457 mm) and larger (RSD-18) has regularly exceeded 20 in the Ft. Patrick Henry tailwater (Figure 5-24). An RSD-18 value of 20 indicates that 20% of all stock-size trout—i.e., those at least 254 mm (10 in.) in length—are 457 mm (18 in.) or larger. RSD-18 for Ft. Patrick Henry tailwater Rainbow Trout was 50 in 2021 has been >20 since 2015 (Figure 5-26). Maintaining a mean RSD-18 of ≥20 during 2019-2024 is an objective of the current Boone and Ft. Patrick Henry Tailwater Trout Fisheries Management Plan (Habera et al. 2018).

Stocking

The Ft. Patrick Henry tailwater was stocked with 18,700 adult Rainbow Trout, 8,000 fingerling Rainbow Trout, and 10,000 subadult Brown Trout in 2021 (Figure 5-27). All of Rainbow Trout were marked

with fin clips as part of the ongoing TN CFRU research project (see below). The 2021 stocking rates, except for adult Rainbow Trout, were consistent with rates established in the Boone and Ft. Patrick Henry Tailwater Trout Fisheries Management Plan for 2019-2024 (Habera et al. 2018). An additional 8,700 adult Rainbow Trout were marked and stocked during July 2021 because of the lack of fish present for the research project and angler complaints about low catch rates.

Research

Results from the ongoing TN CFRU research project indicate that the Fort Patrick Henry tailwater Rainbow Trout population is primarily supported by stocked adults, as stocked fingerlings are infrequently captured and disappear after reaching 200 mm. Some naturally reproduced fingerlings have been captured in Kendrick Creek, thus there likely is a wild component to the Rainbow Trout fishery as well. Data from recaptured (PIT-tagged) fish indicate that adult-stocked Rainbow Trout fish grow 26.0 to 27.7 mm/month. This research, which will provide a better understanding of survival, recruitment, and growth of Rainbow Trout in this tailwater, will continue through 2022. Identification of optimal stocking rates is an objective of the current trout fisheries management plan for the Ft. Patrick Henry tailwater (Habera et al. 2018) and results from this work will help inform future stocking strategy, particularly regarding the efficacy of Rainbow Trout fingerlings.

Management Recommendations

The Ft. Patrick Henry tailwater provides a relatively unique fishery that consistently produces large, extremely well-conditioned trout. This attribute is recognized in the management goal for this tailwater, which focuses on fully developing and maintaining this potential and the exceptional angling opportunities it provides. TWRA will continue to use stocked Rainbow Trout and Brown Trout fisheries to attain the management goal and no changes are recommended at this time. The cause of the recent decline in trout abundance (particularly Rainbow Trout) is unknown at this time but can be addressed through increased stocking rates if necessary.

Ft. Patrick Henry Tailwater

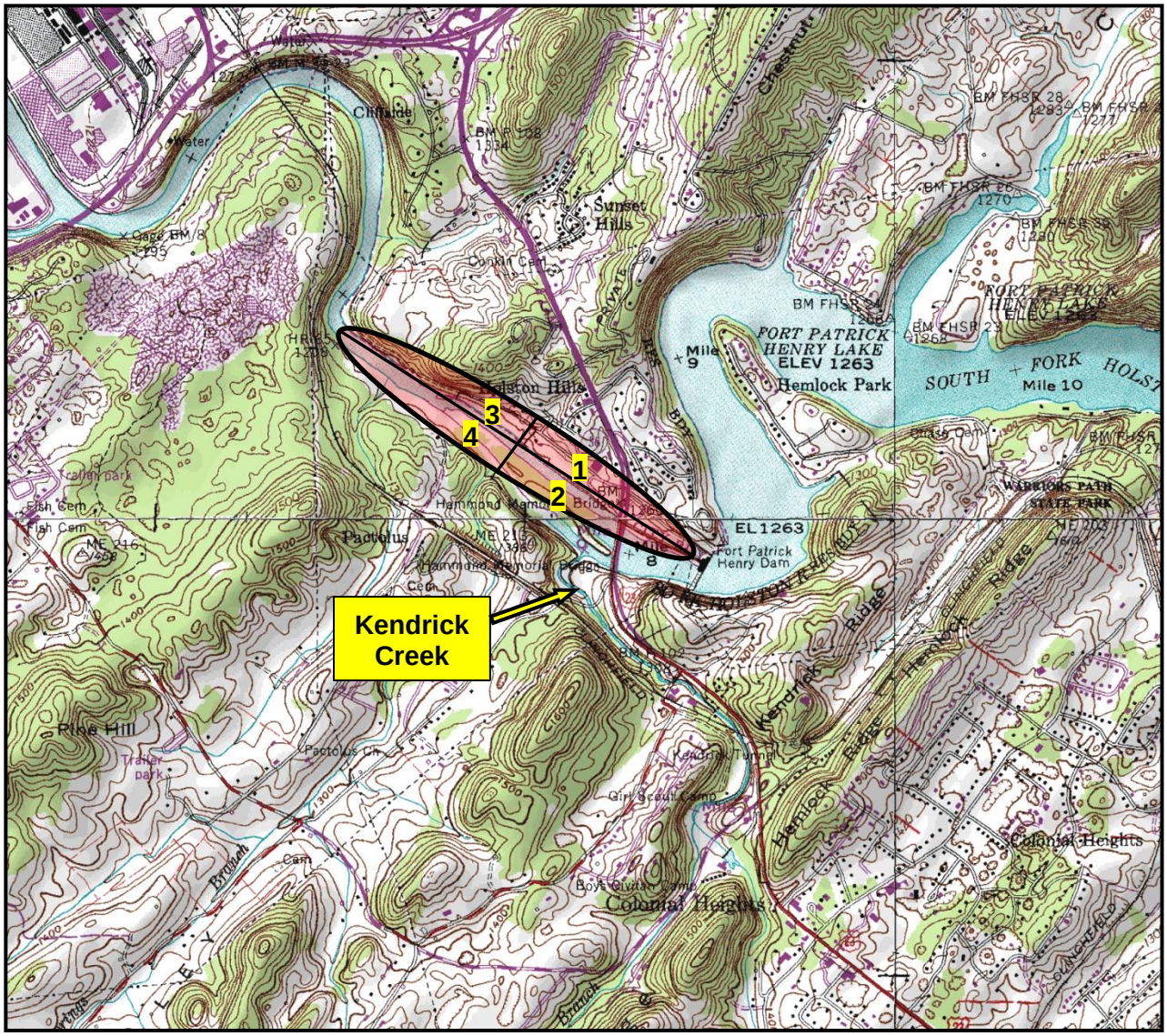


Figure 5-23. Location of the Ft. Patrick Henry tailwater (South Fork Holston River) monitoring stations.

Table 5-5. Catch data for the four electrofishing stations on the Ft. Patrick Henry tailwater sampled 9 March 2021.

Station	Species	Total Catch	Size Range (mm)	Total Weight (g)	% Abundance (number)	% Abundance (weight)
1	Rainbow Trout	2	228-290	438	100	100
	Brown Trout	--	--	--	0	0
Totals		**2**		**438**	**100**	**100**
2	Rainbow Trout	4	232-555	4,176	80	73
	Brown Trout	1	505	1,574	20	27
Totals		**5**		**5,750**	**100**	**100**
3	Rainbow Trout	2	256-436	1,210	67	39
	Brown Trout	1	522	1,898	33	61
Totals		**3**		**3,108**	**100**	**100**
4	Rainbow Trout	1	560	1,920	100	100
	Brown Trout	--	--	--	0	0
Totals		**1**		**1,920**	**100**	**100**
Total Rainbow Trout		**9**	228-560	**7,744**	82	69
Total Brown Trout		**2**	540-629	**3,472**	18	31
Overall totals		**11**		**11,216**	**100**	**100**

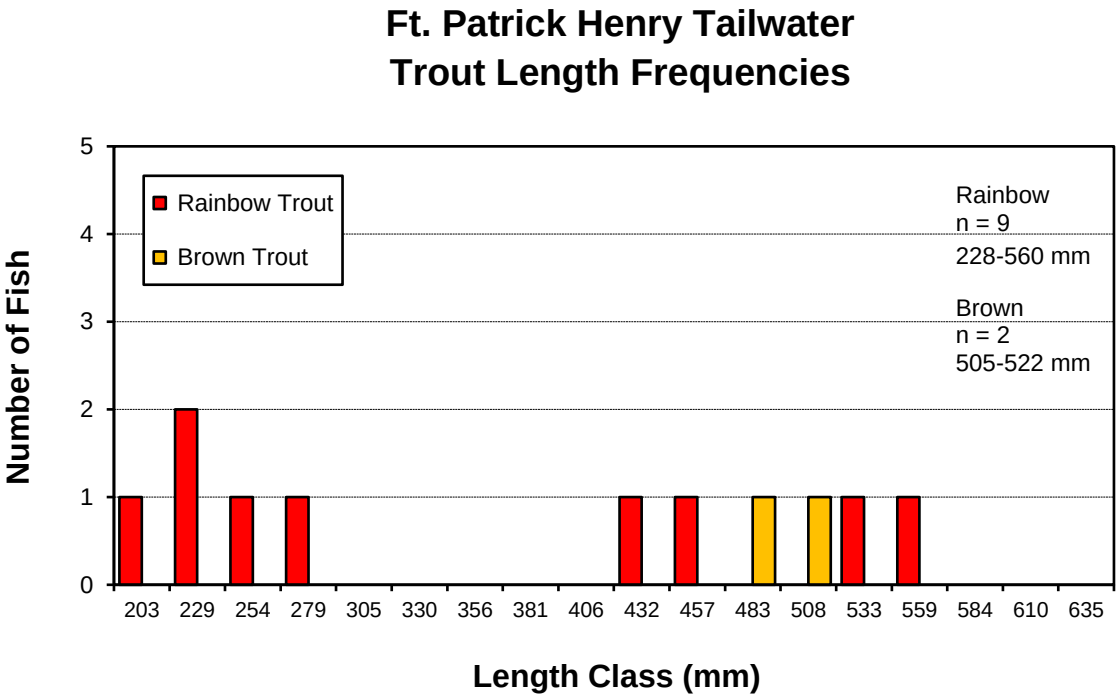


Figure 5-24. Length frequency distributions for trout from the Ft. Patrick Henry tailwater monitoring stations in 2021.

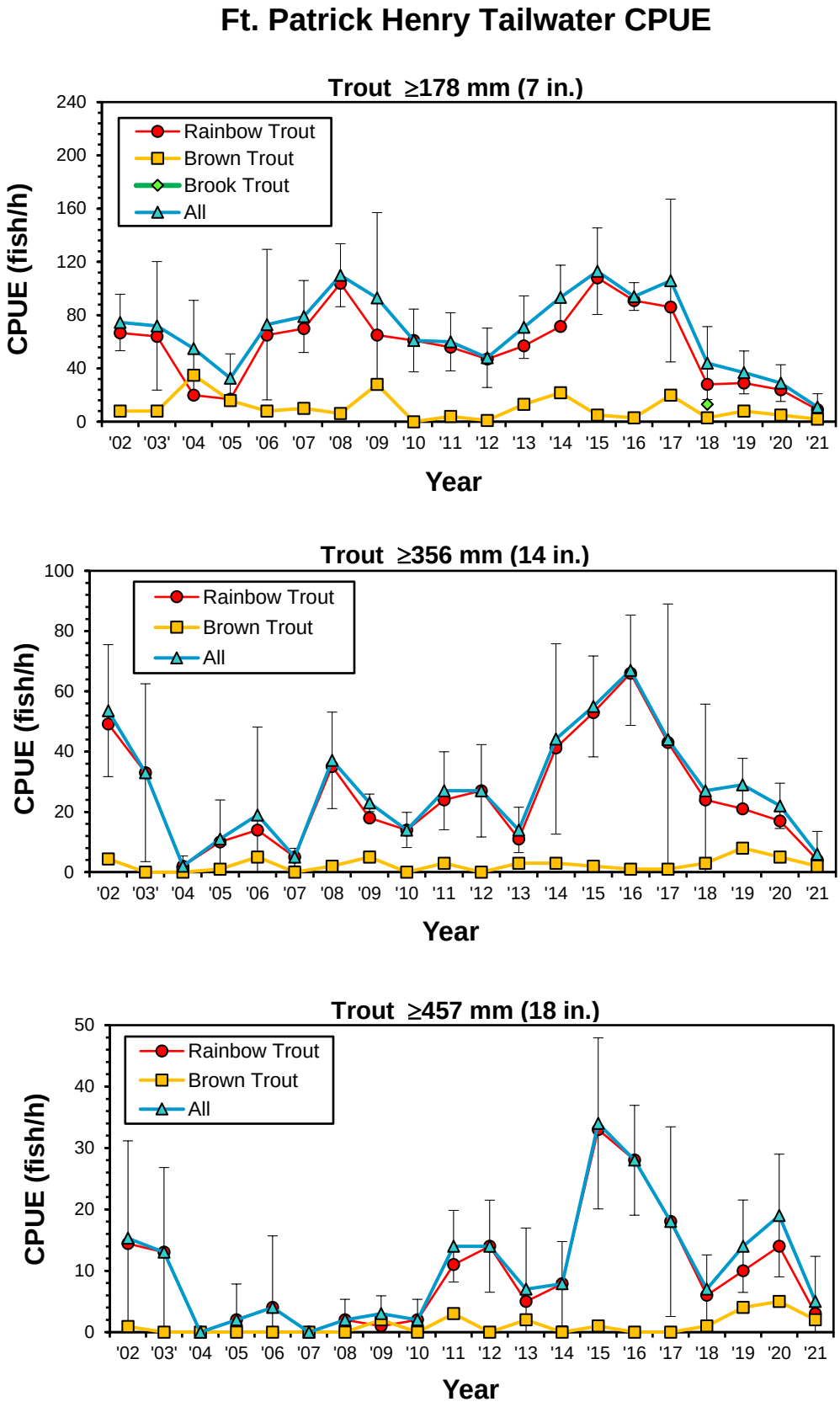


Figure 5-25. Mean trout CPUEs for the Ft. Patrick Henry tailwater sample. Bars indicate 90% confidence intervals.

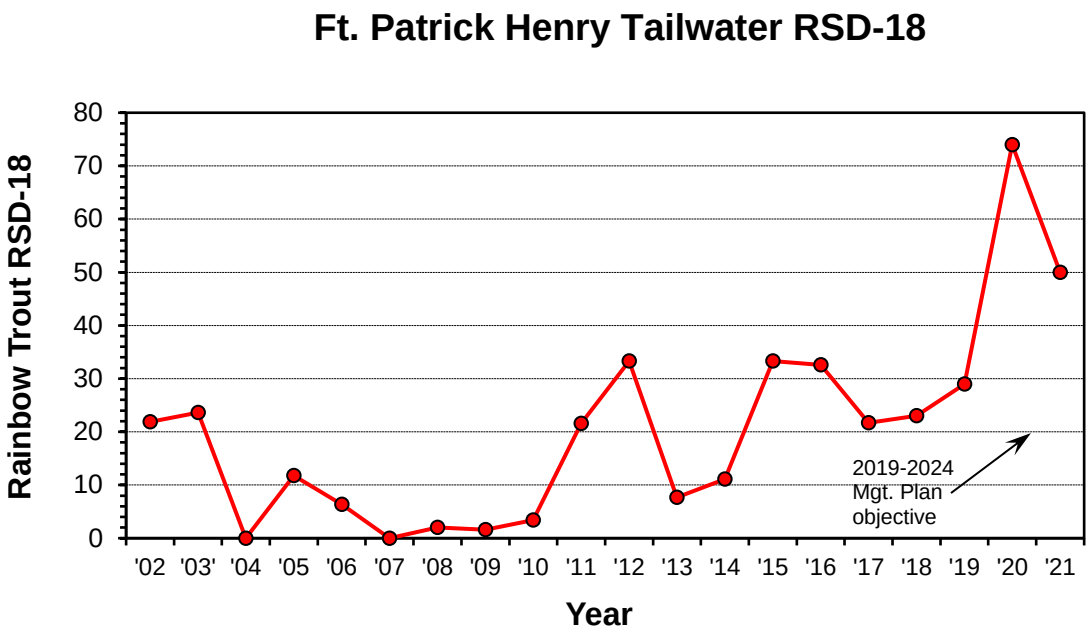


Figure 5-26. RSD-18 for Ft. Patrick Henry tailwater Rainbow Trout.

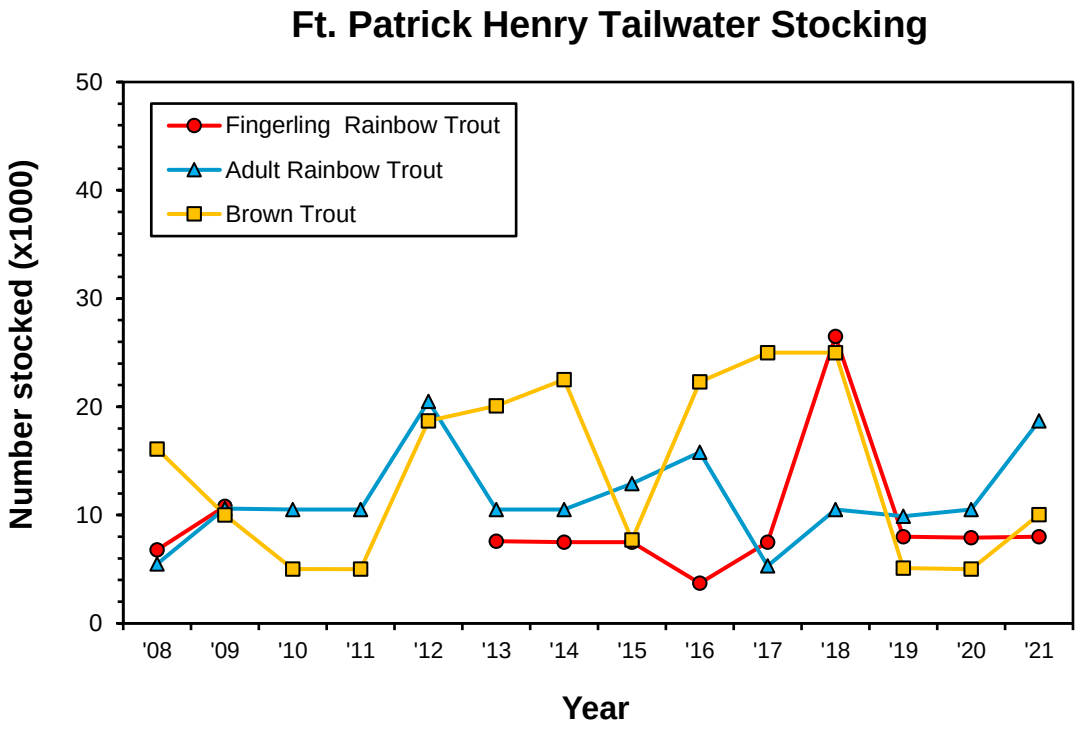


Figure 5-27. Recent trout stocking rates for the Ft. Patrick Henry tailwater.

Boone (South Fork Holston River)

Catch, Length Frequency, and W_r

The four Boone tailwater monitoring stations (Figure 5-28) produced 91 trout (82 Rainbow Trout and 9 Brown Trout) weighing over 51 kg in 2021 (Table 5-6). Rainbow Trout in the 203-279 mm (8-11 in.) size classes were most abundant, although fish ranging up to 660 mm (26 in.) were also captured (Figure 5-29). Brown Trout ranging up to 643 mm (25.3 in.) were captured and all 9 were ≥432 mm or 17 in. (Figure 5-29). Mean relative weight (W_r) was 106 (SE=1.42) for Rainbow Trout and 133 (SE=4.26) for Brown Trout.

A 26 in., 7.8 lb. Rainbow Trout (W_r = 1.24) from the 2021 Boone tailwater sample.

A 25.3 in., 8.5 lb. Brown Trout (W_r = 1.46) from the 2021 Boone tailwater survey.

CPUE

The mean electrofishing catch rate for all trout ≥178 mm increased to 90 fish/h in 2021 (Figure 5-30) and was driven by the increase in the CPUE for Rainbow Trout ≥178 mm (to 82 fish/h). However, mean CPUE for all trout ≥356 mm decreased 45% to 17 fish/h, primarily because of a decrease in the catch of Rainbow Trout in the 356-457mm size range (Figures 5-29 and 5-30). The catch rate for trout ≥457 mm did slightly increase relative to 2020, with higher CPUE for Rainbow Trout ≥457 mm (Figure 5-30). Brown Trout CPUE for all three size ranges declined somewhat relative to 2020 (Figure 5-30).

RSD-18

The relative stock density for Rainbow Trout ≥457 mm or 18 in. (RSD-18) regularly reaches or exceeds 10, while RSD-18 often exceeds 20 for all trout in the Boone tailwater (Figure 5-31). An RSD-18 value of 20 indicates that 20% of all stock-size Rainbow and Brown Trout—i.e., those at least 254 mm (10 in.) in length—are 457 mm (18 in.) or larger. RSD-18 for Boone tailwater increased to 18 for Rainbow Trout and 30 for all trout in 2021 (Figure 5-31). The 2021 values exceed the objectives for Rainbow Trout (10) and all trout (20) established in the 2019-2024 management plan for the Boone tailwater trout fishery (Habera et al. 2018).

Stocking

The Boone tailwater was stocked with 14,400 adult Rainbow Trout, 7,500 fingerling Rainbow Trout, 10,000 subadult Brown Trout, and 2,600 adult (229 mm) Cutthroat Trout (Snake River fine-spotted subspecies *Oncorhynchus clarkii behnkei*) in 2021 (Figure 5-32). The Cutthroat Trout were produced by DHNFH and were stocked at a few select locations in Tennessee during 2021 as a novelty to

Cutthroat Trout were stocked in the Boone tailwater in December 2021.

generate some additional interest in trout fishing. Cutthroat Trout had not been stocked in Tennessee since the 1960s. The 2021 stocking rates for Rainbow and Brown Trout were consistent with the annual stocking rates established in the 2019-2024 Boone tailwater trout fishery management plan (Habera et al. 2018), except that an additional 4,400 adult Rainbow Trout were stocked. The effectiveness of fingerling Rainbow Trout stocking has not yet been evaluated but results from the ongoing research project on the Ft. Patrick Henry tailwater (summarized above) should provide some insight and may help guide future stocking strategy.

Boone Reservoir Drawdown Effects

The extended drawdown of Boone Reservoir for repairs at the dam concluded in 2021 as the reservoir elevation returned to full summer pool (elevation of 1,382') in July. Although dissolved oxygen (DO) levels fell below 6.0 mg/l on 76 days during summer and early fall 2020 (and were in the 3.0 mg/l range on 13 days in September), the 2021 electrofishing data do not indicate any impacts from these DO depressions.

Management Recommendations

The Boone tailwater provides a relatively unique fishery that consistently produces large, extremely well-conditioned trout. This attribute is recognized in the management goal for this tailwater, which focuses on fully developing and maintaining this potential and the exceptional angling opportunities it provides. TWRA will continue to use put-and-grow and put-and-take Rainbow Trout and Brown Trout fisheries to attain the management goal and no changes are recommended at this time.

Boone Tailwater

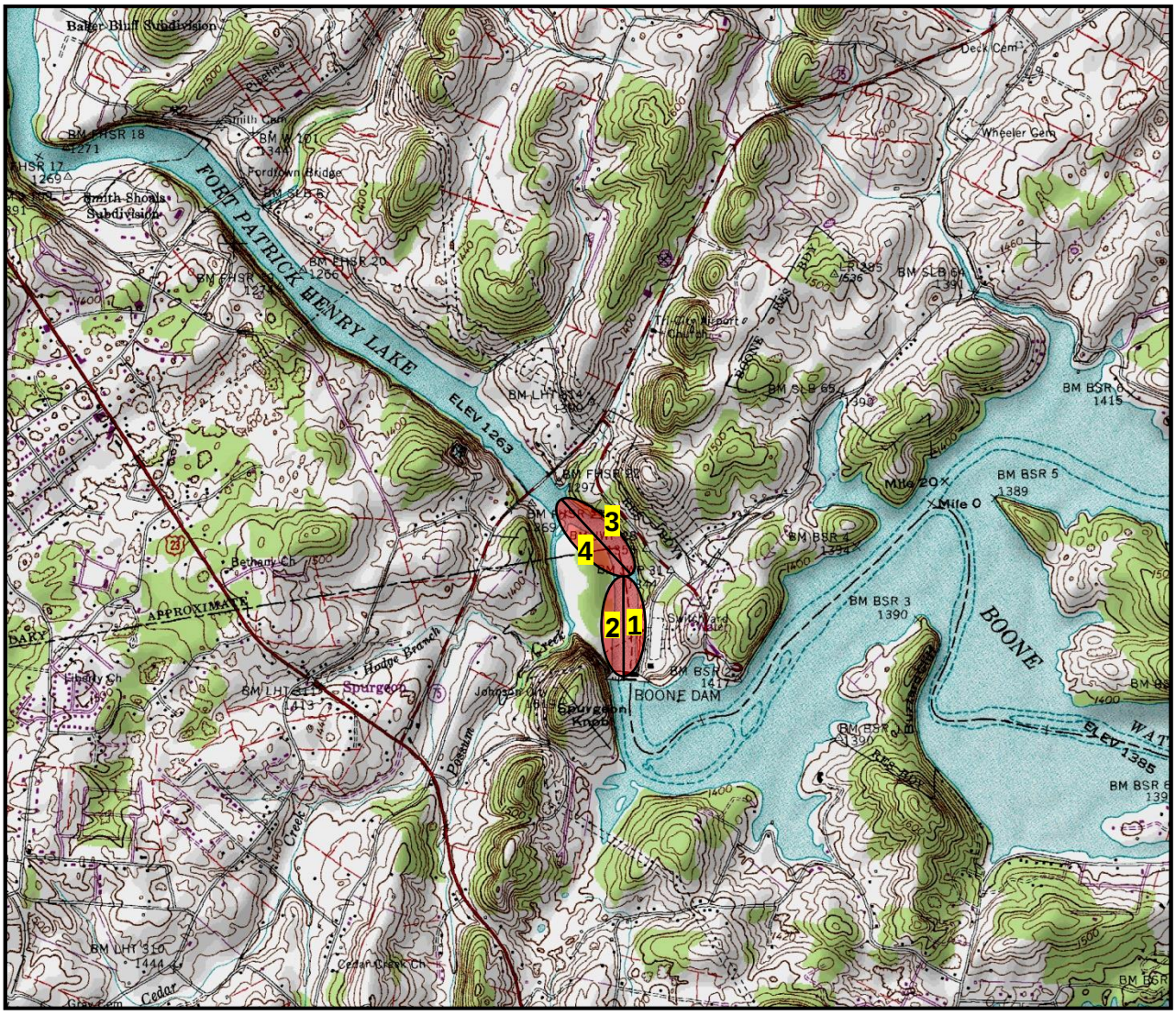


Figure 5-28. Location of the Boone tailwater (South Fork Holston River) monitoring stations.

Table 5-6. Catch data for the four electrofishing stations on the Boone tailwater sampled 9 March 2021.

Station	Species	Total Catch	Size Range (mm)	Total Weight (g)	% Abundance (number)	% Abundance (weight)
1	Rainbow Trout	27	220-596	9,144	93	69
	Brown Trout	2	538-560	4,110	7	31
Totals		**29**		**13,254**	**100**	**100**
2	Rainbow Trout	33	202-281	5,688	100	100
	Brown Trout	--	--	--	0	0
Totals		**33**		**5,688**	**100**	**100**
3	Rainbow Trout	9	257-660	12,159	64	49
	Brown Trout	5	473-643	12,848	36	51
Totals		**14**		**25,007**	**100**	**100**
4	Rainbow Trout	13	242-485	4,050	87	55
	Brown Trout	2	449-516	3,293	13	45
Totals		**15**		**7,343**	**100**	**100**
Total Rainbow Trout		**82**	202-660	**31,041**	90	61
Total Brown Trout		**9**	449-643	**20,251**	10	39
Overall totals		**91**		**51,292**	**100**	**100**

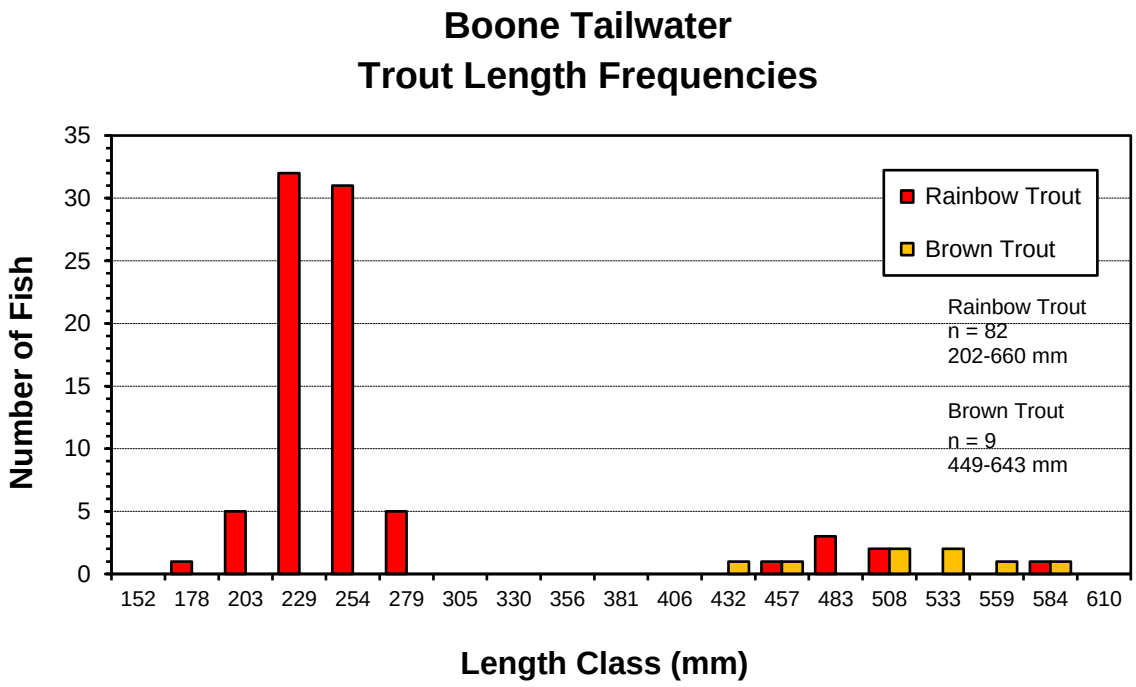


Figure 5-29. Length frequency distributions for trout from the Boone tailwater monitoring stations in 2021.

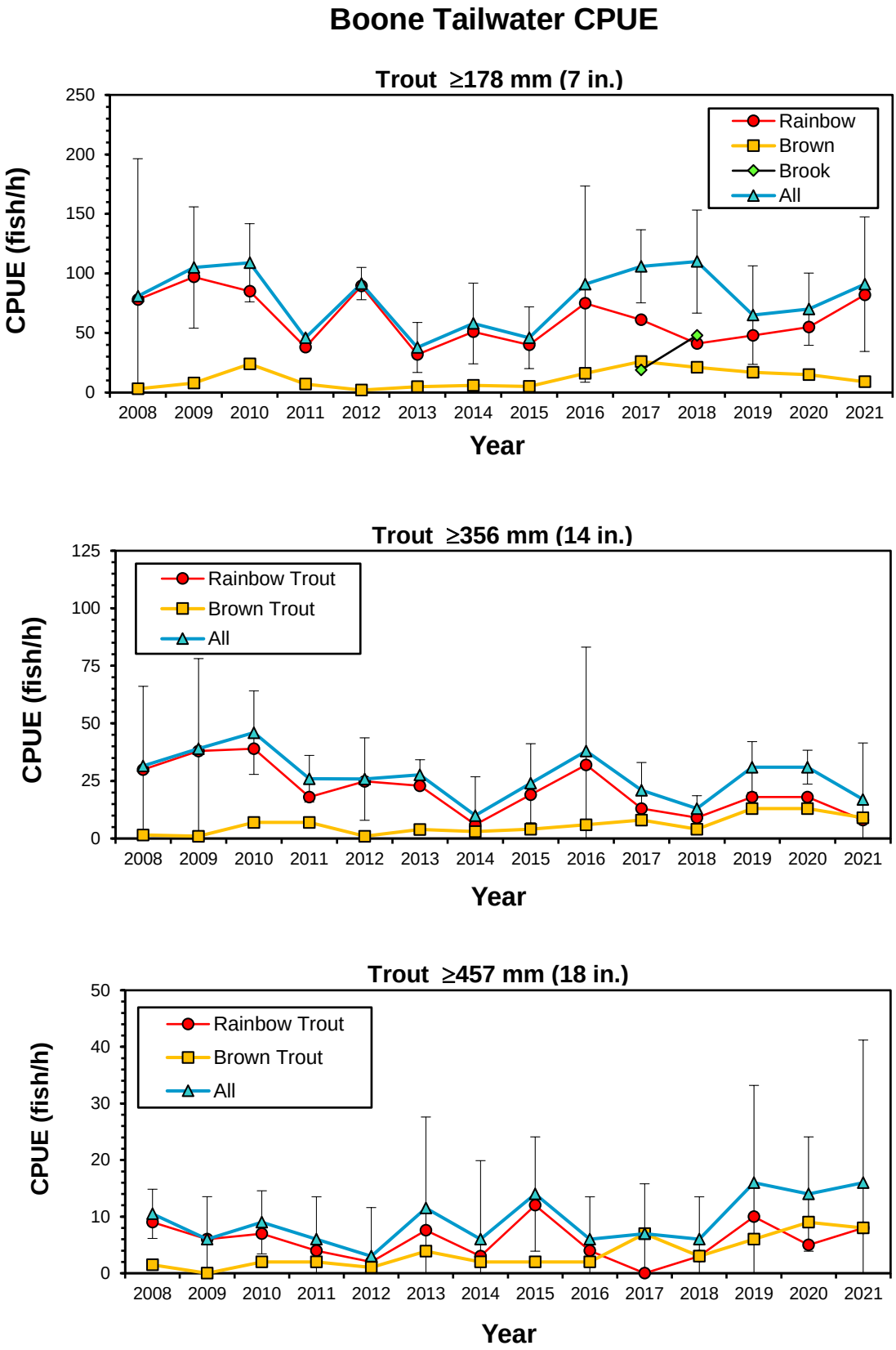


Figure 5-30. Mean trout CPUEs for the Boone tailwater samples. Bars indicate 90% confidence intervals.

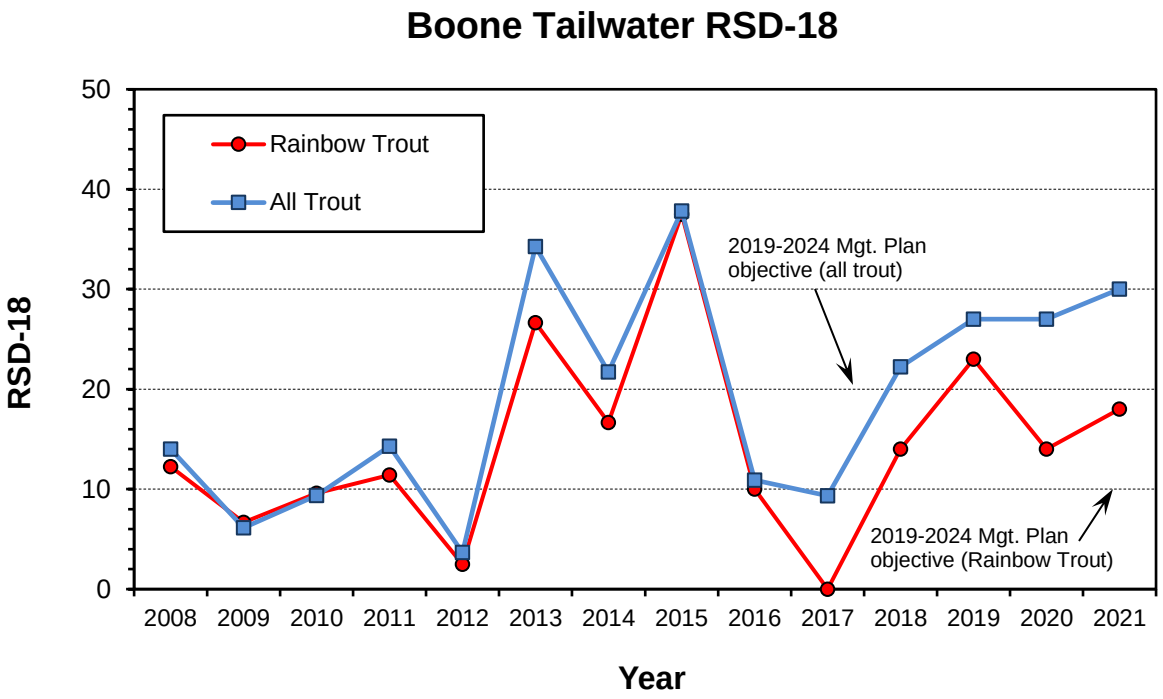


Figure 5-31. RSD-18 for Boone tailwater trout.

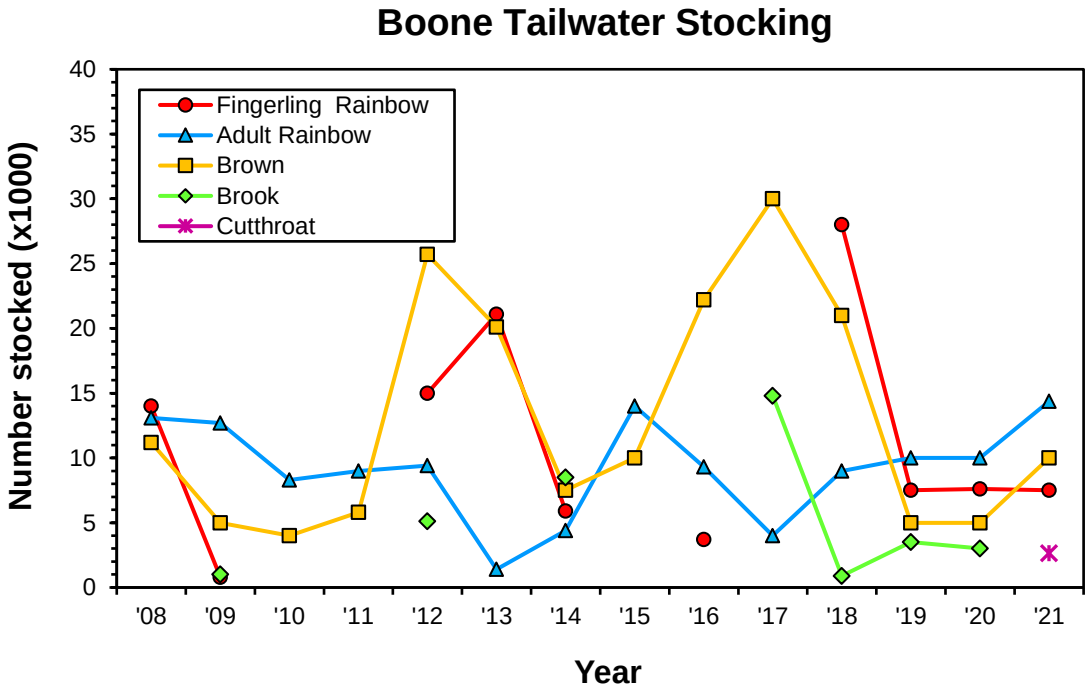
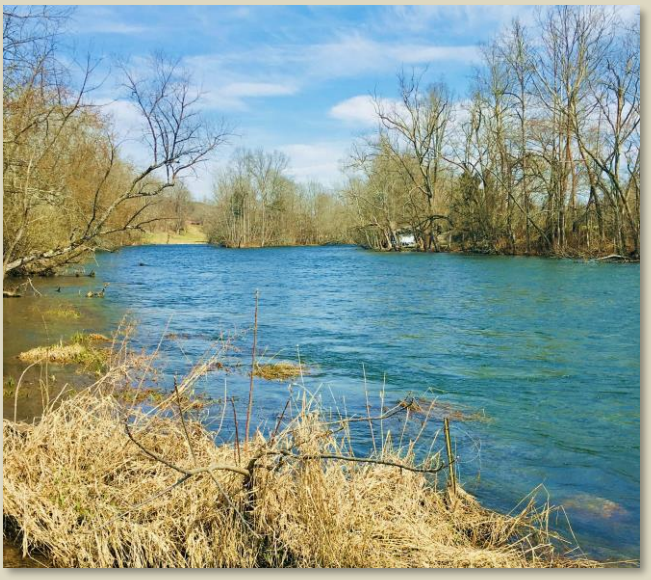


Figure 5-32. Recent trout stocking rates for the Boone tailwater.

South Holston (South Fork Holston River)

Catch and Length Frequency

The 12 South Holston tailwater monitoring stations (Figure 5-33) produced 680 trout weighing over 164 kg in 2021 (Table 5-7). Brown Trout represented 89% of the catch by number and 88% by biomass. Brown Trout in the 254-305-mm size classes were most abundant (65%; Figure 5-34) and likely represent age-2 fish. Age-1 fish were primarily in the 178 mm size class based on the length frequency distribution of smaller fish (Figure 5-34). Brown Trout catch in the PLR (19) was the same in both in 2020 and 2021. Most Rainbow Trout (67%) were in the 229-305 mm size classes and three fish were within the PLR (Figure 5-34).



The lower South Holston tailwater.

CPUE

The mean electrofishing catch rate (CPUE) for all trout ≥178 mm decreased 23% to 322 fish/h in 2021, with Brown Trout CPUE responsible for most of the change (Figure 5-35). Rainbow Trout CPUE has been relatively stable during the past five years at 30-40 fish/h and was 37 fish/h in 2021 (Figure 5-35). The overall PLR catch rate increased slightly to 11.5 fish/h in 2021 and has typically ranged from 9-15 fish/h since 2010 (Figure 5-35)—well below the range observed during 2005-2007 (25-29 fish/h).

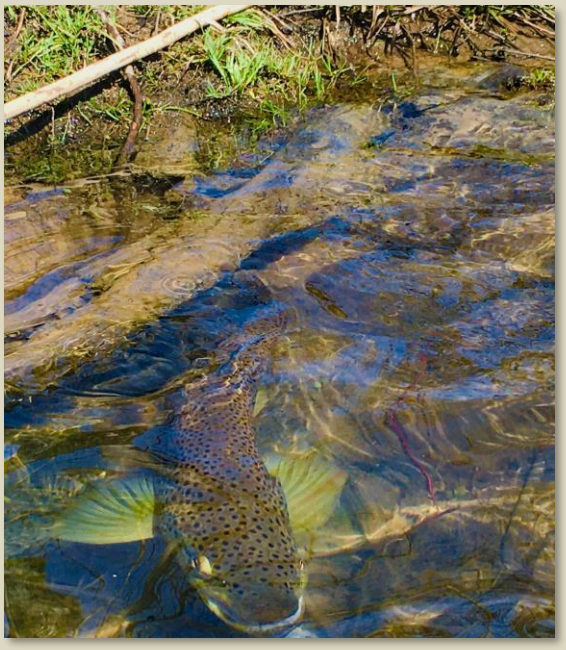
RSD-16

Relative stock density for Brown Trout ≥406 mm (RSD-16)—based on a stock size of 254 mm (Willis et al. 1993)—declined in 2021 to 4 (Figure 5-36). Brown Trout RSD-16 exceeded 20 during 2005-2007 (following establishment of the PLR) but has declined as total trout CPUE (≥178 mm) increased into the 300-400 fish/h range. Brown Trout RSD-16 has remained in the 3-8 range since 2010 (Figure 5-36) and indicates that Brown Trout population size structures have not maintained the shift toward larger fish (the basic intent of a PRL) achieved prior to 2010. Brown Trout RSD-16 could improve if mean CPUE for trout ≥178 mm returns to the 150-200 fish/h range), but that currently seems unlikely. Rainbow Trout ≥406 mm are uncommon in the South Holston tailwater and corresponding RSD-16 has averaged 3 both pre- and post-PLR.

Relative Weight (W_r)

Mean W_r for Brown Trout in the PLR and the size classes just below the PLR (305-406 mm) has generally declined since 2005 (Figure 5-37). Although mean W_r for fish in the PLR size classes increased somewhat in 2021 (to 85.3), mean W_r has remained below 90 since 2014 (Figure 5-37). Several studies have shown that density-dependent factors can limit growth, condition, and recruitment into the larger size classes for trout and other gamefish (McKinney et al. 2001; Fox and Neal 2011; Dibble et al. 2015; Yard et al. 2015). Dreves et al. (2016) observed a three-fold increase in Brown Trout CPUE over 10 years in the Lake Cumberland tailwater (KY) following establishment of a 508-mm (20-in.) minimum size limit and 1

fish/day creel limit. Brown Trout size structure also improved, but overall abundance (CPUE of 89 fish/h) most likely remained below the tailwater's carrying capacity and density-dependent responses were not triggered (Dreves et al. 2016). Ultimately, if food availability and fish growth are limited in tailwater trout fisheries (e.g., in high abundance populations), then restrictive angling regulations (e.g., PLRs) may be unsuccessful (Flinders and Magoulick 2017).



South Holston tailwater Brown Trout.

Management Recommendations

The goal for the updated South Holston tailwater trout fishery management plan (Habera et al. 2022b) is to continue providing a high-quality, largely self-sustaining trout fishery that offers a variety of angling opportunities. The South Holston tailwater's exceptional wild Brown Trout fishery is the primary means for attaining the management goal, but Rainbow Trout remain an important part of the fishery as well—particularly in terms of angler harvest. Management has sought to maintain the Rainbow Trout fishery through annual stocking of adults and fingerlings, but an assessment of fingerling stocking is now in order given the recent presence of substantial numbers of wild age-0 Rainbow Trout. Therefore, the updated South Holston tailwater trout fishery management plan includes an objective to determine the contribution of wild Rainbow Trout to the fishery by suspending fingerling Rainbow Trout stocking (beginning in 2021). A mean Rainbow Trout CPUE of ≥36 fish/h by 2024 would indicate adequate natural reproduction (and subsequent recruitment) and that fingerling stocking is unnecessary.

South Holston Tailwater

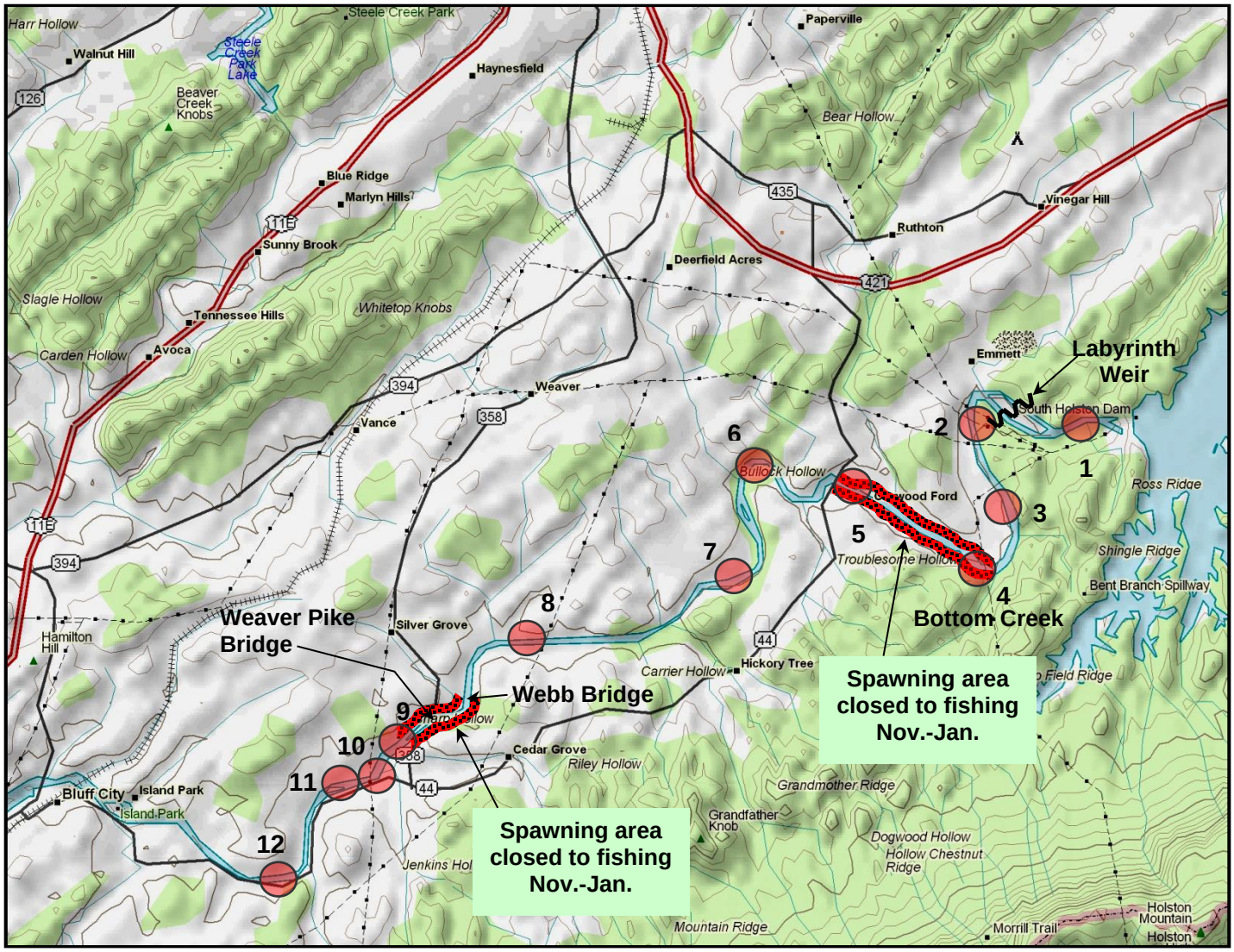


Figure 5-33. Locations of the South Holston tailwater (South Fork Holston River) monitoring stations.

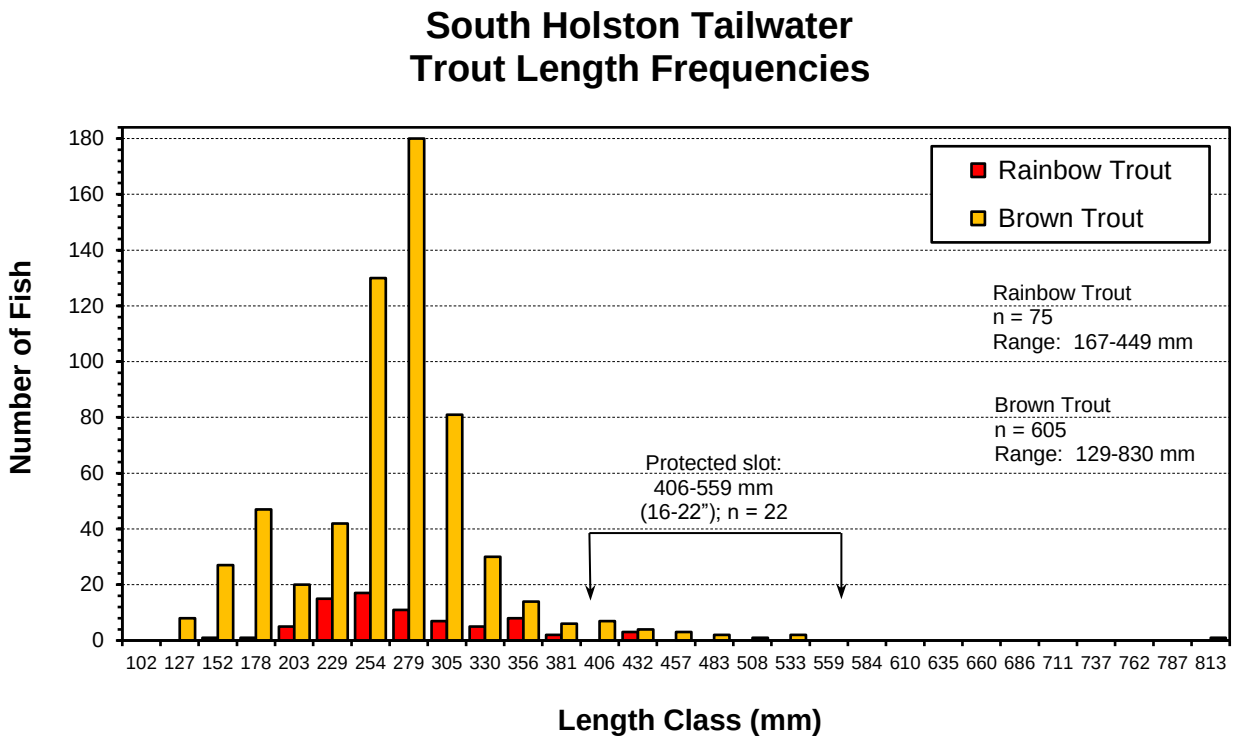


Figure 5-34. Length frequency distributions for trout from the South Holston tailwater monitoring stations in 2021.

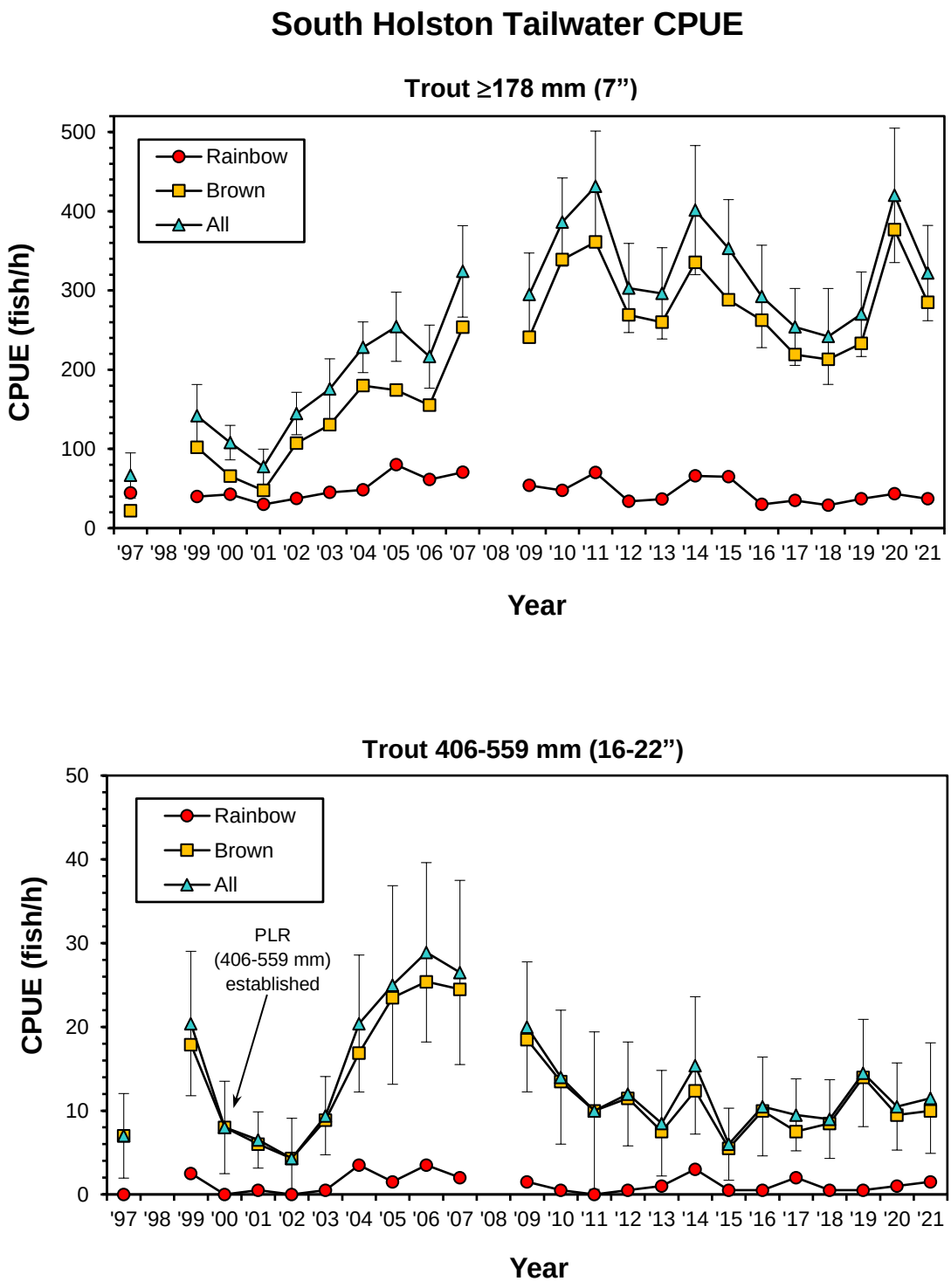


Figure 5-35. Mean trout CPUEs for the South Holston tailwater samples. Bars indicate 90% confidence intervals.

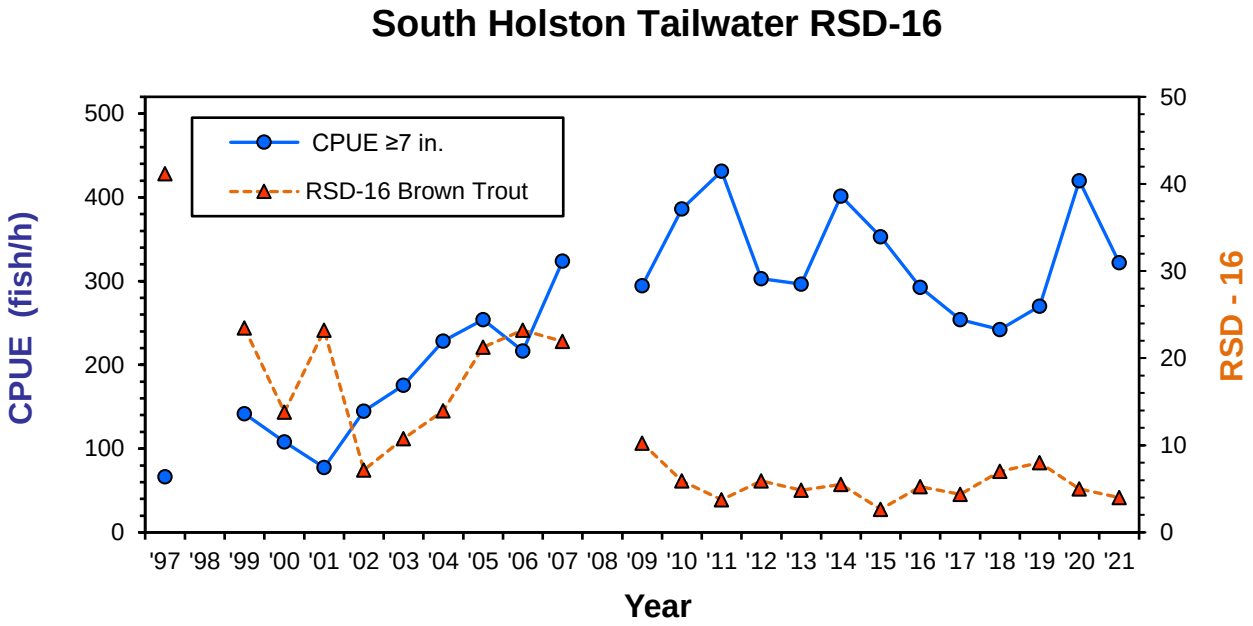


Figure 5-36. Comparison of mean CPUE (fish/h) for all trout ≥178 mm and RSD-16 (all trout) for the South Holston tailwater.

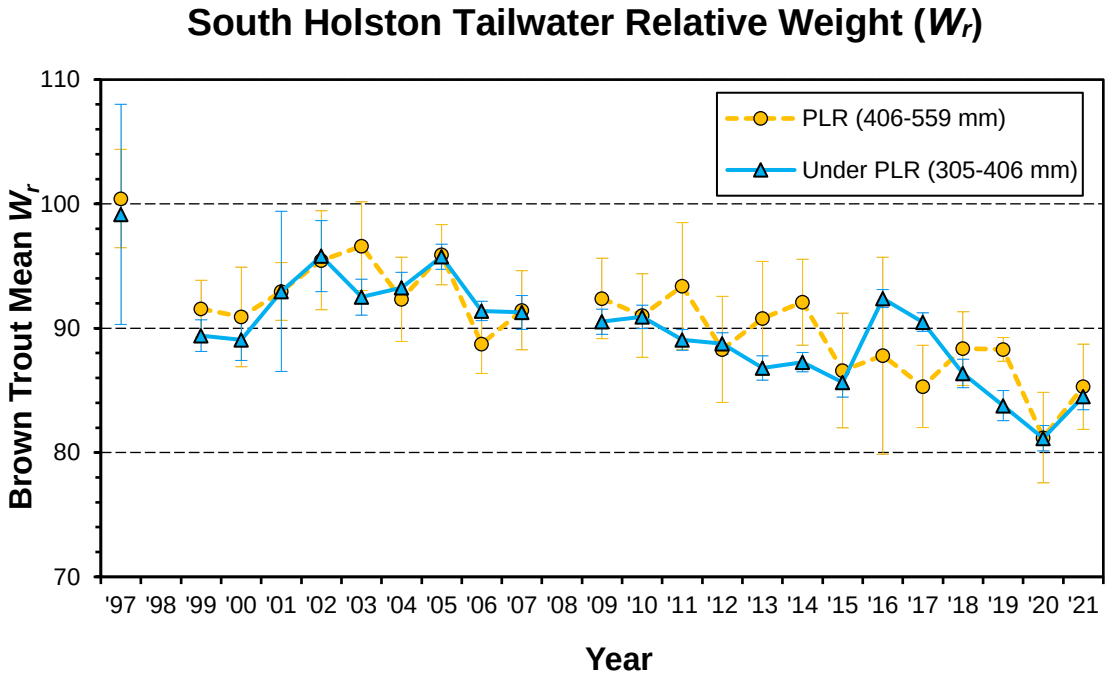


Figure 5-37. Mean relative weights (W_r) for Brown Trout from the South Holston tailwater. Bars indicate 90% confidence intervals.

REFERENCES

Baird, O. E., and C. C. Krueger. 2003. Behavioral thermoregulation of brook and Rainbow Trout: comparison of summer habitat use in an Adirondack river, New York. Transactions of the American Fisheries Society 132:1194-1206.

Black, W. P. 2015. Tennessee Statewide Creel Survey: 2014 Results: Final Report. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Black, W. P. 2019. Tennessee Statewide Creel Survey: 2018 Results. Fisheries Report 19-06. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Black, W. P. 2020. Tennessee Statewide Creel Survey: 2019 Results. Fisheries Report 20-07. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Black, W. P. 2021. Tennessee Statewide Creel Survey: 2020 Results. Fisheries Report 21-06. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Dibble, K. L., C. B. Yackulic, T. A. Kennedy, and P. Budy. 2015. Flow management and fish density regulate salmonid recruitment and adult size in tailwaters across western North America. Ecological Applications 25:2168-2179.

Dreves, D. P., J. R. Ross, and J. T. Kosa. 2016. Effect of trophy regulations and reservoir discharge on a population of stocked Brown Trout in a large, southeastern United States tailwater. Journal of the Southeastern Association of Fish and Wildlife Agencies 3:167-177.

Flinders, J. M., and D. D. Magoulick. 2017. Spatial and temporal consumption dynamics of trout in catch-and-release areas in Arkansas tailwaters. Transactions of the American Fisheries Society 146:432-499.

Fox, C. N., and J. W. Neal. 2011. Development of a crowded largemouth bass population in a tropical reservoir. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies. 65:98-104.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2004. Region IV trout fisheries report: 2003. Fisheries Report No. 04-04. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., M. A. Kulp, S. E. Moore, and T. B. Henry. 2010. Three-pass depletion sampling accuracy of two electric fields for estimating trout abundance in a low-conductivity stream with limited habitat complexity. North American Journal of Fisheries Management 30:757-766.

Habera, J. W., R. D. Bivens, B. D. Carter, and C. E. Williams. 2014. Region IV trout fisheries report: 2013. Fisheries Report No. 14-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., S. J. Petre, B. D. Carter, and C. E. Williams. 2018. Management plan for the Boone and Fort Patrick Henry tailwater trout fisheries 2019-2024. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., S. J. Petre, B. D. Carter, and C. E. Williams. 2019. Region IV trout fisheries report: 2018. Fisheries Report No. 19-08. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., S. J. Petre, B. D. Carter, and C. E. Williams. 2020. Management plan for the Norris tailwater trout fishery 2020-2025. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., S. J. Petre, B. D. Carter, and C. E. Williams. 2022a. Management plan for the Wilbur tailwater trout fishery 2022-2027. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Habera, J. W., S. J. Petre, B. D. Carter, and C. E. Williams. 2022b. Management plan for the South Holston tailwater trout fishery 2022-2027. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Hill, D. M. 1978. Tailwater trout management. Pages 66-75 in Southeastern trout resource: ecology and management symposium proceedings. USDA Forest Service, Southeastern Forest Experiment Station, Asheville, North Carolina.

Kelly, G. A., J. S. Griffith, and R. D. Jones. 1980. Changes in distribution of trout in Great Smoky Mountains National Park, 1900–1977. U.S. Fish and Wildlife Service Technical Papers 102.

King, W. 1937. Notes on the distribution of native speckled and rainbow trout in the streams of Great Smoky Mountains National Park. Journal of the Tennessee Academy of Science 12:351-361.

Larson. G. L., and S. E. Moore. 1985. Encroachment of exotic rainbow trout into stream populations of native brook trout in the southern Appalachian Mountains. Transact.

Larson, G. L., S. E. Moore, and B. Carter. 1995. Ebb and flow of encroachment by nonnative Rainbow Trout in a small stream in the southern Appalachian Mountains. Transactions of the American Fisheries Society 124:613-622.

McKinney, T., D. W. Speas, R. S. Rogers, and W. R. Persons. 2001. Rainbow Trout in a regulated river below Glen Canyon Dam, Arizona, following increased minimum flows and reduced discharge variability. North American Journal of Fisheries Management 21:216-222.

Meyer, K. A., B. High, and F. S. Elle. 2012. Effects of stocking catchable-sized hatchery Rainbow Trout on wild Rainbow Trout abundance, survival, growth, and recruitment. Transactions of the American Fisheries Society 141:224-237.

Moore, S. E., B. Ridley, and G. L. Larson. 1983. Standing crops of brook trout concurrent with removal of rainbow trout from selected streams in Great Smoky Mountains National Park. North American Journal of Fisheries Management 3:72-80.

Peterson, J. T., R. F. Thurow, and J. W. Guzevich. 2004. An evaluation of multipass electrofishing for estimating the abundance of stream-dwelling salmonids. Transactions of the American Fisheries Society 113:462-475.

Poudyal, N. C., and K. Cavasos. 2022. Tennessee Trout Anglers Survey 2021: Final Report. Department of Forestry, Wildlife and Fisheries, University of Tennessee, Knoxville

Roddy, D., editor. 2022. Coldwater fish production—statewide hatchery report 2021. Fisheries Report No. 22-01. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Strange, R. J., and J. W. Habera. 1998. No net loss of brook trout distribution in areas of sympatry with Rainbow Trout in Tennessee streams. Transactions of the American Fisheries Society 127:434-440.

Thompson, P. D., and F. J. Rahel. 1996. Evaluation of depletion-removal electrofishing of brook trout in small Rocky Mountain streams. North American Journal of Fisheries Management 16:332-339.

TWRA (Tennessee Wildlife Resources Agency). 2014. Protecting, preserving, and perpetuating Tennessee's wildlife and ecosystems: Strategic plan 2014-2020. Tennessee Wildlife Resources Agency, Nashville, Tennessee.

TWRA (Tennessee Wildlife Resources Agency). 2017. Trout management Plan for Tennessee 2017-2027 (J. Habera, editor). Tennessee Wildlife Resources Agency, Nashville, Tennessee.

Weaver, D. M., and T. J. Kwak. 2013. Assessing effects of stocked trout on nongame fish assemblages in southern Appalachian Mountain streams. Transaction of the American Fisheries Society 142:1495-1507.

Wehrly, K. E., L. Z Wang, and M. Mitro, M. 2007. Field-based estimates of thermal tolerance limits for trout: Incorporating exposure time and temperature fluctuation. Transactions of the American Fisheries Society 136, 365-374.

Whitworth, W. E., and R. J. Strange. 1983. Growth and production of sympatric brook and Rainbow Trout in an Appalachian stream. Transaction of the American Fisheries Society 112:469-475.

Willis, D. W., B. R. Murphy, and C. S. Guy. 1993. Stock densities: development, use, and limitations. Reviews in Fisheries Science 1(3):203-222.

Yard, M. D., J. Korman, C. J. Walters, and T. A. Kennedy. 2015. Seasonal and spatial patterns of growth of Rainbow Trout in the Colorado River in Grand Canyon, Arizona. Canadian Journal of Fisheries and Aquatic Sciences 73:125-139.