Using an Angler Creel Survey to Supplement a Stocked Trout Fishery Evaluation in a North Carolina Reservoir

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Abstract: Creel surveys are a common method for collecting information from anglers, and when biological data are sparse, can provide needed data to help biologists evaluate fisheries. For instance, only 272 trout were collected in gill-net and electrofishing samples conducted annually from 2012–2015 to evaluate an experimental trout fishery in Apalachia Reservoir, North Carolina. Thus, we conducted a 12-mo, non-uniform probability creel survey to determine the return of stocked trout to anglers. Because the impoundment had a remote location, we utilized game cameras at two boating access areas to improve our estimates of angler effort. A total of 1535 parties were observed on cameras and 250 were interviewed by creel clerks. Boat anglers expended an estimated 14,410 angler-h (SE = 528) or 32.4 angler-h ha^{-1} of total fishing effort, with an estimated 3447 angler-h (SE = 643) directed at trout. An estimated total of 2059 (SE = 704) trout were caught, with 60% (1237; SE = 419) being brown trout (*Salmo trutta*), and the balance being rainbow trout (*Oncorhynchus mykiss*; 822; SE = 293). Trout catch rates were highest in the months immediately following stocking (1.22 fish h^{-1}; SE = 0.45), and the majority of brown trout (76%) and rainbow trout (97%) examined were from the previous year's (2014) stocking. In addition, length-frequency data obtained from the creel survey allowed further evaluation of the performance of stocked trout. Ninety-four percent of trout over 500 mm TL were brown trout. These creel data supplemented limited biological information collected using conventional gears and allowed us to develop recommendations to better meet our management goals for the fishery.

Key words: access point survey, reservoir trout stocking, brown trout, rainbow trout, cameras

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Creel surveys are a common method used by fisheries managers and researchers to gain information about fisheries of interest. Angler effort, catch, and harvest data provide valuable insight into the influences of anglers on a fisheries resource (Guthrie et al. 1991, Malvestuto 1996). Additionally, creel data have been used independently (Bivens and Strange 1987, Bugas 2006) or in conjunction with biological data collected via gill-net or electrofishing samples (Jones 1982, Barwick and Geddings 1985) to evaluate the performance of stocked salmonids. The North Carolina Wildlife Resources Commission (NCWRC) relies on these statistics to inform management decisions on impoundments in the western region of the state, where salmonid fisheries are managed (Yow et al. 2002, Yow 2012).

Previous NCWRC creel surveys have been used to characterize existing fisheries (Yow et al. 2002, Yow 2012, Yow et al. 2016, Yow et al. 2019). We initiated our 12-mo creel survey, however, to aid efforts in evaluating the suitability of stocked brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*) for trophy management in Apalachia Reservoir. Given its ample trout habitat and abundant alosine forage base, Apalachia Reservoir provided a unique opportunity to establish a trophy salmonid (> 600 mm TL) fishery in a southeastern U.S. reservoir (Bushon et al. 2018).

Bushon et al. (2018) detailed efforts to recapture stocked trout in the reservoir using gill-net and electrofishing samples, but only 272 trout were collected from 2012–2015, making it difficult to characterize their growth and survival. Salmonids often inhabit deeper, offshore waters in lentic systems during much of the year, seeking cooler water temperatures and feeding on pelagic prey (Olson et al. 1988). Anticipating the challenge of fish recapture, while also wishing to describe angler patterns associated with a new fishery, we initiated a non-uniform probability creel survey in 2014 to estimate angler effort, catch, and harvest, and to collect additional information on stocked trout performance. The objectives of this study were to: 1) evaluate the return of trout stocked into Apalachia Reservoir to the angler creel; and 2) augment biological information being collected to determine the optimal size and species of trout to stock to create a trophy trout fishery.

Study Area

Located adjacent to the Tennessee-North Carolina border, Apalachia Reservoir was the westernmost hydroelectric reservoir in North Carolina. Located directly below the Hiwassee Reservoir tailrace, the 445-ha impoundment maintained cold, oxygenated water that supported a variety of fisheries (Bushon et al. 2018). Nantahala National Forest comprised the majority of the reservoir's shoreline, so residential development was sparse and most anglers accessed the reservoir from public boat access areas (BAA). Historically, Apalachia Reservoir had two boating access areas: the more developed and accessible Hiwassee Dam BAA (paved ramp, lights, entrance via state-maintained roads, accommodations for more than 15 vehicles with trailers) and the underdeveloped and more inaccessible Apalachia Dam BAA (gravel ramp, entrance via fording Hiwassee River, accommodations for less than 10 vehicles with trailers). The Apalachia Dam BAA was closed permanently on 22 October 2015 due to a history of vandalism.

Methods

Trout Stocking

Full details about the trout stocking protocols used for Apalachia Reservoir are given in Bushon et al. (2018). Briefly, brown trout and rainbow trout were stocked at two size groups (254 [small] and 380 [large] mm TL) and marked with a combination of visible implant elastomer (VIE) and coded-wire tags to denote cohort and size group. Approximately 1500 small and 1000 large trout of both species were stocked annually in November 2012–2015.

Creel Survey

A non-uniform probability creel survey was designed according to the methods of Malvestuto et al. (1978) to determine the return of stocked trout to the angler creel. The survey was conducted on pre-assigned sample days from 1 December 2014 through 31 November 2015 at the two access points, although sampling ceased at Apalachia Dam BAA after its closure. Potential sample days included all weekdays, Saturdays and Sundays, as well as Good Friday, Memorial Day, Independence Day, Labor Day, and Veterans Day holidays. Weekdays and weekend days/holidays were randomly chosen with equal probability to produce five sample days within each seven-day week. Each sample day began at 0700 hours Eastern Daylight Time and concluded at 0100 hours the following day and was divided into three 6-h work periods.

To increase the precision of angler effort estimates, two automated game cameras (Moultrie M-990i, Moultrie, Birmingham, Alabama) were installed at each of the BAAs. Cameras were locked to trees and positioned to take hourly photographs of the parking areas during the entire creel period. All camera data were analyzed using Timelapse software (Greenberg 2013, Greenberg and Godin 2015) to determine an hourly trailer count used in conjunction with interview data to calculate angler effort.

Initially, work periods were chosen for each sample day with uneven probabilities, reflecting the greater likelihood of fishing trips concluding in the evening based on patterns observed on other put-grow-and-take trout fisheries in the southeastern United States (Kirkland and Bowling 1966, Baker and Mathis 1967, Jones 1982, Bivens and Strange 1987). As the creel survey progressed, the temporal distribution of trailers in the camera data was used to develop work period probabilities for subsequent months. This approach improved survey efficiency by establishing work periods at times and boat ramps, with the highest likelihood of angler encounters (Yow et al. 2019).

On each sample day, the creel clerk remained at the access area for the duration of the assigned work period, recorded exit times of anglers, and interviewed anglers as they exited the reservoir. All anglers were asked for the start time of their fishing trip, the species or species group targeted, the number and species of fish caught, and the number and species of fish harvested. Harvested trout were counted, identified, measured (TL; mm) and weighed (g) by the clerk. In addition, all brown trout and rainbow trout harvested were examined for VIE marks using an ultra-violet flashlight under low-light to dark conditions and coded-wire tags using a detection wand (Northwest Marine Technology, Inc., Shaw Island, Washington).

Fishing effort (E) was estimated for each sample stratum (day type and month or season) by counting the number of angling party hours (e) recorded by cameras during all days within that stratum, and multiplying the total party-hour count by angling rate (R_a), where R_a = the proportion of boating parties engaged in angling activity as determined by clerk interviews on each sample day within the stratum. Approximate standard error for E was estimated as

$$SE\ (E) = \sqrt{(e^2 \times \mathrm{Var}R_a)},$$

where $\mathrm{Var}R_a$ is the variance of the sample mean of daily angling rates for all sample days within the stratum.

For each sample day, a daily catch rate was computed as the quotient of daily catch (all fish reported caught by angling parties interviewed) divided by total daily effort (all hours spent fishing by all parties interviewed, in party hours). Daily rates were then averaged to obtain a catch rate R_c for each sample stratum. Catch (C) was then estimated as

$$C = E \times R_c$$

for each sample stratum. Approximate standard error for C was estimated as

$$SE\ (E) = \sqrt{(e^2 \times \mathrm{Var}R_aR_c)},$$

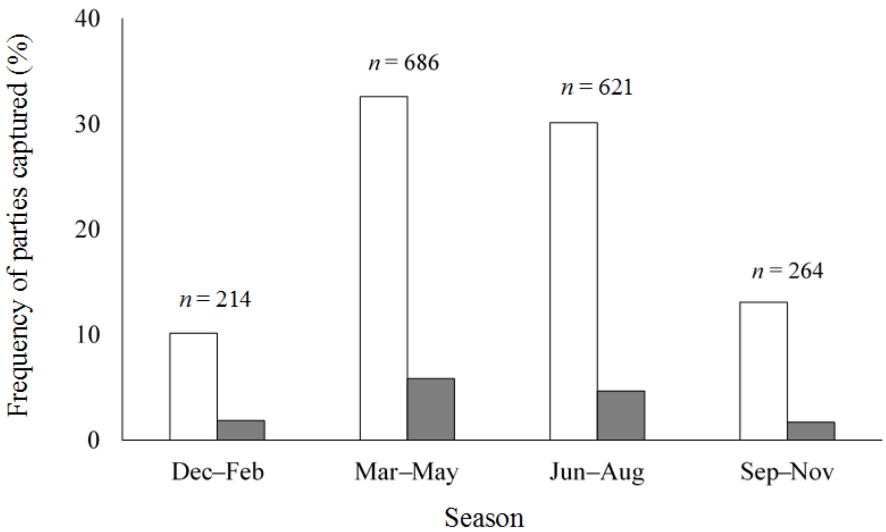

Figure 1. Frequency of boating parties captured on game cameras (hollow bars) and interviewed (grey bars) by season during the creel survey conducted 1 December 2014–30 November 2015 on Apalachia Reservoir, North Carolina. Total parties captured per season are reported. Total party records over the period were 1535 and 250 for game cameras and interviews, respectively.

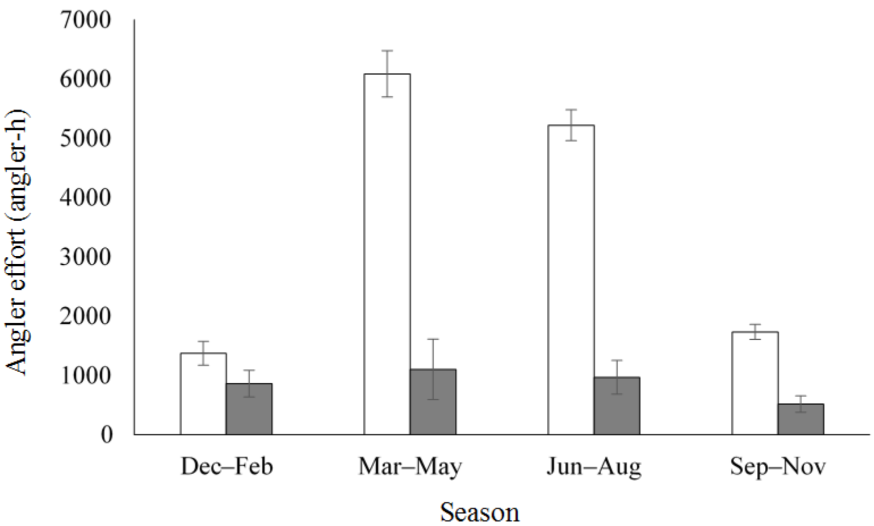

Figure 2. Angler effort (angler-h) for all anglers (hollow bars) and anglers targeting trout (grey bars) by season on Apalachia Reservoir, North Carolina, 1 December 2014–30 November 2015. Error bars represent SEs.

where VarR_aR_c is the variance of the product of mean daily angling rates × mean daily angling rates for all sample days within the stratum. Harvest (H) and associated standard error was similarly estimated for each stratum, as were species-specific catch and harvest estimates. The percent return of the 2014 cohort of brown trout and rainbow trout to the angler creel by number and weight were also calculated.

Results

A total of 1535 parties were observed on cameras placed at the two access points between 1 Dec 2014–30 Nov 2015; 250 of those parties were interviewed. Approximately 61% of parties captured on camera launched from Hiwassee Dam BAA and 73% of interviews occurred at Hiwassee Dam BAA. Cameras found that 61% of the boating parties occurred on weekdays, but only 39% of angler interviews occurred on those days. More boating parties were observed at access points by creel clerks and cameras in Mar–May and Jun–Aug than in the other seasons (Figure 1).

Apalachia Reservoir boat anglers expended an estimated 14,410 angler-h (SE = 528) or 32.4 angler-h ha^{-1} of total fishing effort (Figure 2). Anglers spent an estimated 8080 angler-h (SE = 454) fishing during weekdays (SE = 454) and 6330 angler-h (SE = 268) during weekends. March–May (6085 angler-h; SE = 391) was the most visited time frame followed by Jun–Aug (5219 angler-h; SE = 263; Figure 2). Estimated angling effort directed at trout was 3447 angler-h (SE = 643) and accounted for 24% of total boat angling effort, with 1821 angler-h (SE = 567) occurring during the weekdays and 1626 h (SE = 304) during the weekend.

Table 1. Mean catch and harvest estimates (SE) for Apalachia Reservoir, North Carolina, 1 December 2014 to 30 November 2015. Estimates are given for all days in the survey year, by day type and season.

Estimate	All days in survey year	Day type		Season			
		Weekday	Weekend	Dec–Feb	Mar–May	Jun–Aug	Sep–Nov
Catch							
Brown trout	1237 (419)	637 (354)	599 (224)	951 (414)	180 (50)	94 (41)	12 (8)
Rainbow trout	822 (293)	492 (252)	331 (150)	623 (288)	129 (39)	54 (35)	16 (9)
Trout combined	2059 (704)	1129 (602)	930 (365)	1574 (698)	309 (71)	148 (55)	28 (12)
Lepomis spp.	3959 (718)	1992 (539)	1967 (474)	0 (0)	1277 (432)	2199 (540)	484 (189)
Micropterus spp.	2602 (315)	1480 (249)	1123 (193)	58 (26)	1395 (228)	611 (131)	537 (58)
Yellow perch	1351 (568)	1036 (562)	314 (81)	12 (7)	1184 (565)	136 (55)	18 (13)
Total	10,054 (1,153)	5703 (990)	4351 (590)	1645 (686)	4222 (659)	3105 (604)	1082 (241)
Harvest							
Brown trout	479 (228)	110 (62)	369 (220)	343 (225)	93 (36)	34 (19)	9 (7)
Rainbow trout	150 (48)	67 (40)	82 (27)	46 (26)	43 (18)	50 (35)	11 (8)
Trout combined	629 (230)	177 (73)	451 (219)	389 (223)	136 (43)	84 (39)	20 (10)
Lepomis spp.	1918 (578)	1248 (512)	670 (269)	0 (0)	546 (311)	1061 (449)	311 (190)
Micropterus spp.	273 (80)	169 (71)	104 (38)	4 (4)	120 (50)	75 (36)	75 (51)
Yellow perch	1088 (583)	897 (578)	191 (74)	9 (5)	1006 (581)	67 (42)	6 (4)
Total	3981 (909)	2557 (830)	1424 (371)	401 (223)	1856 (712)	1297 (483)	426 (190)

Table 2. Mean catch, catch rate (fish h^{-1}), harvest, and harvest rate (fish h^{-1}) estimates (SE) for trout-directed effort (all days in survey year) on Apalachia Reservoir, North Carolina, 1 December 2014–30 November 2015.

Species	Catch	Harvest	Catch rate (fish h^{-1})	Harvest rate (fish h^{-1})
Brown trout	804 (395)	310 (157)	0.20 (0.10)	0.06 (0.02)
Rainbow trout	565 (365)	118 (54)	0.19 (0.10)	0.05 (0.02)
All trout	1369 (751)	428 (167)	0.38 (0.20)	0.12 (0.03)

An estimated total of 10,054 fish (SE = 1153) was caught during the creel survey (Table 1). Sunfish (*Lepomis* spp.) comprised the largest portion of catch (39%), followed by black bass (*Micropterus* spp.; 26%), trout (21%), and yellow perch (*Perca flavescens*; 13%). Anglers also caught low numbers of channel catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*), and walleye (*Sander vitreus*). A total of 2059 (SE = 704) trout were caught; brown trout made up 60% (1237; SE = 419) of the total trout catch (Table 1). Anglers targeting trout caught 1369 trout (SE = 751), representing about 67% of the total trout catch (Table 2), and 59% of those were brown trout.

An estimated 629 trout were harvested during the creel survey, most of which (76%) were brown trout (Table 1). Approximately 39% of brown trout that were caught were also harvested; whereas, only 18% of caught rainbow trout were harvested. Anglers targeting trout harvested 428 trout (SE = 167), which accounted for 68% of all trout harvested (Table 2).

Overall trout catch and harvest rates for all anglers were 0.32 fish h^{-1} (SE = 0.11) and 0.07 fish h^{-1} (SE = 0.03), respectively. Trout catch rate was relatively similar between weekend and weekdays (30% higher on weekends) but harvest was roughly 2.5 times higher on the weekend compared to the weekday. Trout catch rates were 1.22 fish h^{-1} (SE = 0.45) in the months immediately following stocking (December–February) and decreased to 0.01 fish h^{-1} (SE = 0.01) in September–November (Figure 3). Harvest rates followed the same trend: angler harvest ranged from 0.25 fish h^{-1} (SE = 0.11) in December–February to 0.01 fish h^{-1} (SE = 0.00) in September–November (Figure 3). Brown trout catch and harvest rates were 0.18 fish h^{-1} (SE = 0.06) and 0.05 fish h^{-1} (SE = 0.02), respectively, whereas, rainbow trout catch and harvest rates were 0.14 fish h^{-1} (SE = 0.05) and 0.02 fish h^{-1} (SE = 0.01), respectively (Figure 3). Trout catch and harvest rates for anglers targeting trout were 0.38 fish h^{-1} (SE = 0.20) and 0.12 (SE = 0.03), respectively (Table 2). The return of the 2014 cohort by number to angler harvest was estimated to be 15% for brown trout and 6% for rainbow trout.

Creel clerks were able to measure 122 harvested trout. The largest trout harvested were brown trout, and all but one of the trout over 500 mm TL were brown trout. Returns to angler creel appeared to vary between the two size classes of stocked rainbow trout and brown trout. Almost 75% of the 88 brown trout mea-

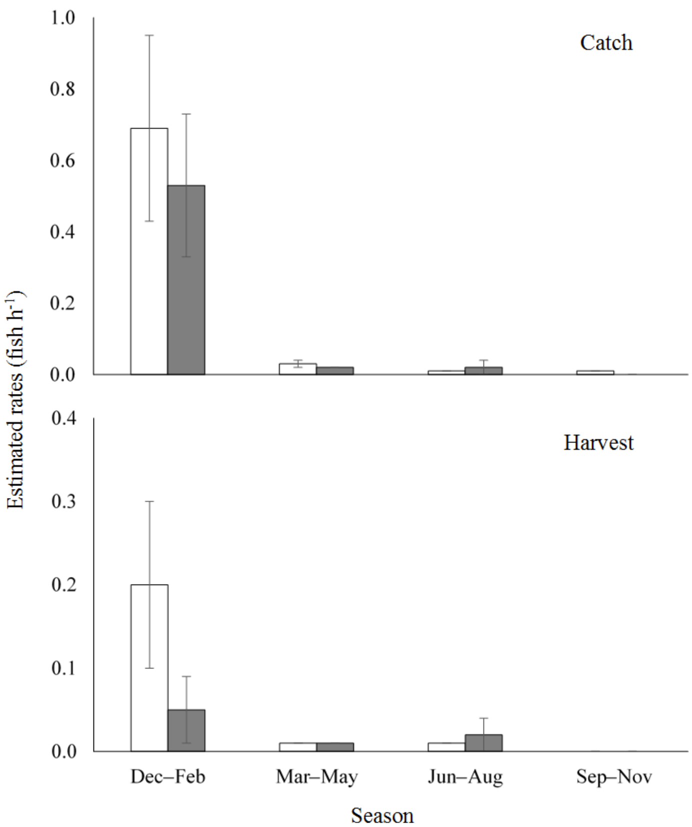

Figure 3. Mean catch and harvest rate estimates (fish h^{-1}) of brown trout (hollow bars) and rainbow trout (grey bars) for all anglers by season on Apalachia Reservoir, North Carolina, 1 December 2014–30 November 2015.

sured during the creel survey were from the large size class. However, small brown trout from the 2012 stocking comprised more than 25% of harvested brown trout over 500 mm TL. Brown trout from the small size cohorts that were harvested averaged 337 mm TL (SE = 27), whereas fish from the large size cohorts that were harvested averaged 415 mm TL (SE = 11). In contrast, rainbow trout measured during the creel were much more evenly split between the stocked size classes, with 56% from the large size class and 44% from the small size class. Mean TL of harvested rainbow trout was 319 mm (SE = 6) and 426 mm (SE = 9), from the small and large cohorts, respectively. Most harvested brown trout (76%) and rainbow trout (97%) measured by creel clerks were from the previous year's (2014) stocking. Only one rainbow trout measured was from an earlier stocking, but 15% and 9% of brown trout were from the 2012 and 2013 stockings, respectively. The oldest trout examined during the creel was a large brown trout from the 2012 cohort that had been in the reservoir for 32 months.

Discussion

Bushon et al. (2018) found that Apalachia Reservoir produced trophy-sized (>600 mm TL) brown trout due to the combination of fast growth and high survival of stocked brown trout. In this study, the creel survey demonstrated that the brown trout and rainbow trout stockings produced a popular trout fishery, with 25% of all anglers targeting trout. In general, total annual estimated fishing pressure on Apalachia Reservoir (14,410 angler-h) was in the range of effort reported on other North Carolina reservoir stocked trout fisheries (1666–30,979 angler-h; Yow 2012 and Yow et al. 2002). However, trout-directed effort on Apalachia Reservoir was low (3447 angler-h) compared to similar North Carolina reservoir fisheries (8326–29,267 angler-h). Lower trout fishing pressure on Apalachia Reservoir may be related to the remote location of the impoundment, as it is a 32-km drive from the nearest town (Murphy, North Carolina) and 210 km from the largest city in western North Carolina (Asheville). It is also important that anglers are aware of an available fishery (Schramm et al. 2003). The Apalachia Reservoir trout fishery was new compared to other reservoir trout fisheries in North Carolina that have existed for decades, so it may take some time for anglers to fully exploit the new resource.

Overall, trout catch rates in Apalachia Reservoir were comparable to other North Carolina reservoir trout fisheries (Yow 2012, Yow et al. 2012), and in the range of those reported for other notable southeastern U.S. reservoir trout fisheries (Bivens and Strange 1987, Bugas 2006). However, trout harvest rates in Apalachia Reservoir were low compared to most other North Carolina reservoir trout fisheries (Yow et al. 2002): trout were not the primary species caught or harvested during the creel survey, although they did account for 96% of the total catch and 97% of the total harvest during the first three months following stocking. In general, Apalachia Reservoir was not a harvest-oriented trout fishery, but anglers preferred to harvest brown trout rather than rainbow trout. An estimated 82% of rainbow trout caught were released compared to only 61% of brown trout. These numbers are very similar to the findings on Lake Moomaw, Virginia, where 86% of rainbow trout caught by anglers were released compared to only 60% of brown trout (Bugas 2006). The 2014 cohort of trout was stocked in Apalachia Reservoir at the beginning of the creel survey and anglers harvested 15% of the 2014 brown trout by number and 24% by weight. In contrast, only 6% and 8% of the 2014 rainbow trout were harvested by number and weight, respectively. Higher return rates of stocked brown trout versus rainbow trout have been found on other southeastern reservoirs (Barwick and Geddings 1985, Durniak et al. 1987).

In addition to higher return rates, older cohorts of brown trout on Apalachia Reservoir also composed a greater portion of the angler harvest. Twenty-four percent of harvested brown trout were from stockings prior to the cohort that was stocked immediately before the beginning of the creel survey. In contrast, all but one harvested rainbow trout were from this cohort. This suggests that rainbow trout had a shorter residence time in the reservoir than brown trout. Bushon et al. (2018) found similar trends in gill-net and electrofishing samples, where brown trout were collected up to 33 months after stocking; whereas rainbow trout were only collected up to 16 months post stocking. Due to higher survival and consistent growth rates, brown trout were able to reach trophy sizes. In contrast, rainbow trout returned to the angler creel in low numbers and failed to reach larger sizes. Our findings agree with those of Bushon et al. (2018), who concluded that brown trout outperformed rainbow trout in the reservoir due to their higher residency times, growth, and popularity with anglers.

As noted, creel data illustrated that elevated levels of effort and harvest in Apalachia Reservoir occurred immediately after stocking. This information (coupled with knowledge of brown trout performance) allows us to develop size and creel regulations that increases the probability of stocked trout surviving their most critical period (December–February; months immediately post stocking). The implemented regulation of three trout per day, with only one greater than 356 mm TL, should allow stocked brown trout to persist longer in the reservoir and grow to desired trophy sizes (Bushon et al. 2018).

Unlike traditional creel surveys that rely solely upon a creel clerk to conduct boat trailer counts manually, we used game cameras to maximize staff efficiency and increase estimates of angler effort (Stahr et al. 2018). The cameras allowed a more precise estimate of effort to be obtained than would have been possible using only in-person surveys given the remote location of the reservoir and the considerable time constraint associated with manual trailer counts during the survey. Because fishing access to the reservoir is mostly restricted to the two BAAs in our study, we believe the cameras were able to account for most of the angling effort that occurred on the reservoir at a minimal cost to the NCWRC.

Results obtained in this study were successful in augmenting biological data collected, describing a newly created trout fishery, and ultimately, informing management recommendations (Bushon et al. 2018). Consideration should always be given to the tradeoffs associated with conducting these surveys (expenditure of time and money) versus conducting other fisheries activities. However, advancements in technology may continue to lessen the burden on staff, while providing a more cost-effective alternative. As in this study, we will continue to evaluate those options as data needs are identified.

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