Creel Survey of North Carolina's Hatchery-supported Trout Fisheries

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Abstract: Roving creel surveys were conducted on nine hatchery-supported trout streams in western North Carolina during 1998 and 1999. The objective of this study was to describe angler use patterns and trip characteristics for selected waters in the hatchery-supported trout program. A total of 5,452 angler interviews were conducted during the two-year survey. Overall, anglers caught trout >203 mm (considered stocked) at an average rate of 1.38 trout/h. This catch rate exceeded the North Carolina Wildlife Resources Commission (NCWRC) programmatic goal of 1.00 trout/h. Hatchery-supported trout anglers were harvest oriented and creeled 75% of all stocked trout caught. Rainbow trout (*Oncorhynchus mykiss*), brook trout (*Salvelinus fontinalis*), and brown trout (*Salmo trutta*) were harvested in proportions similar to those stocked. Brook trout were most likely to be captured within two days of stocking, whereas rainbow trout and brown trout persisted longer in the streams before being harvested. The varied species stocking mixture used by the NCWRC appears to providing anglers with a diverse catch experience as well as meeting the NCWRC goal of extending trout catch over time. Overall, approximately 10% of effort, 15% of catch, and 16% of harvest occurred on opening day of trout season alone in 1998 and 1999. Most anglers fishing hatchery-supported trout waters were North Carolina residents, ≥16 years of age, male, and used natural bait. Most hatchery-supported anglers rated their trips as good; however, only 10% rated their trips as excellent. Angler trip rating satisfaction was moderately related to trout catch and was not related to trip length suggesting that moderate catch rates are important to hatchery-supported trout anglers.

Key words: creel, hatchery, trout, fisheries

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North Carolina has thousands of miles of streams capable of providing angling opportunities for salmonids. These streams are managed by the North Carolina Wildlife Resources Commission (NCWRC) under two distinct, yet complementary, management programs (NCWRC 1989). The wild trout management program emphasizes maintenance and enhancement of self-sustaining trout populations whereas the hatchery-supported trout management program involves primarily stocking hatchery-produced trout into 155 streams covering 1,551 km of western North Carolina. Streams in the program vary from short segments of high-gradient first order streams to >48-km sections of fifth- and sixth-order rivers. Stocking rates for hatchery supported streams are often variable, based on land ownership and access, and range from 101 to 26,500 trout/km. Approximately 750,000 catchable-sized trout averaging 260 mm in length are stocked each year by the NCWRC. All hatchery-supported waters are stocked prior to opening day of trout season (first Saturday in April) and thereafter at bi-weekly or monthly intervals through June; a sub-set of these streams is stocked through August.

Angling pressure, catch and harvest rates, and angler demographics were last evaluated on hatchery-supported streams in the 1950s and 1960s (Ratledge 1958, Ratledge and Louder 1967). Those surveys revealed a typical catch rate of 1.00 trout/h. This catch rate remains the hatchery-supported trout program objective.

North Carolina Wildlife Resources Commission's hatchery-supported trout program has changed considerably since the 1950s. Wildlife Management Areas, which were specialized trout fishing areas within the National Forests managed by the NCWRC, were formally dissolved in 1972. The NCWRC's fisheries management responsibilities were consequently broadened across the entire Pisgah and Nantahala National Forests in addition to private lands. Although the scope of trout management increased across North Carolina, management practices by the NCWRC still emphasized supplemental stocking of hatchery-raised trout on top of wild populations in most cases. A shift in management philosophy occurred in the 1980s that distinguished self-sustaining wild trout fisheries from stocked trout fisheries. The hatchery-supported program target catch rate (1.00 trout/h) became to be based on stocked trout rather than stocked and wild trout combined. No recent efforts have been made to determine catch rates under the hatchery-supported program. Additionally, the number and distance of streams influenced by NCWRC trout stocking has increased since the 1950s, and much of that increase has occurred on privately-owned lands. The composition of species stocked was also standardized to a mixture consisting of 40% (by number)

brook trout (*Salvelinus fontinalis*) and rainbow trout (*Oncorhynchus mykiss*), and 20% brown trout (*Salmo trutta*) to influence the distribution of catch over time.

Angler use of trout fisheries in North Carolina has increased since the 1950s. The most recent agency surveys indicate that between 25% and 42% of statewide angler survey respondents fished for trout, with a majority of trout anglers fishing in both hatchery-supported and wild trout waters (Finke and Van Horn 1993). The hatchery-supported and wild trout programs in North Carolina in 2001 combined to generate an estimated 961,000 trout fishing days by more than 170,000 anglers (USDI 2003). As the general popularity of fishing increases, the demand for trout angling opportunities is expected to continue to increase.

These factors pointed to the need for a systematic assessment of angler use patterns and characteristics of the fisheries created through the catchable-size trout stocking program. The objectives of this study were to evaluate a subset of these trout fisheries and describe angler use patterns and trip characteristics.

Methods

Creel Design

Creel surveys were conducted in 1998 and 1999 on nine hatchery supported streams located in western North Carolina. Creel surveys employed a roving-roving design (Pollock et al. 1994) using a vehicle-based "instantaneous" count to expand angling effort, catch, and harvest data. Creel surveys were stratified into early fishing days (ED), defined as the afternoon period of stocking days and the following four days; and late fishing days (LD), defined as the remaining days within the sample period (2–4 weeks) until the next stocking, including the morning period on the day of stocking. Clerks always conducted surveys during the afternoon period of the first ED and one randomly-selected period on each of the four following EDs. The selection of LDs within each sample period was allocated based on a 40-h creel clerk work week and randomized to the extent practicable within this constraint. Daily periods were defined as "AM," starting 1 hour after sunrise to 1300 hours, or "PM," from 1300 hours to sunset, with start and stop times adjusted weekly. Creel survey AM periods had a 0.35 probability of being selected and PM periods had a 0.65 probability of being selected. Count circuits were performed by car 2–3 times per day to estimate total effort for the period.

Angler interview data collected during each daily period included time spent fishing, numbers, species, and length group of fish caught and harvested (≤203 mm or >203 mm), angler age (<16 or ≥16) and gender, type of tackle used (artificial flies, artificial lures, natural bait), residency (zip code), and trip satisfaction rating (poor, fair, good, excellent).

Effort, Catch, and Harvest Estimates

Effort, catch, and harvest estimates followed roving-roving procedures described by Pollock et al. (1994). Expanded estimates of total effort, catch, and harvest were generated for each stream by period. Estimates of total effort, catch, harvest, and variances for all creel periods were summed to obtain totals for each stream. Expanded estimates of catch and harvest were calculated by stream for all trout and by species for three size groups: (1) all sizes combined, (2) trout ≤203 mm, and (3) trout >203 mm.

To assess the relationship of trout harvest over time, the total number of trout harvested (by species) was regressed against days post-stocking for 1998–1999 combined data. In addition, angler trip satisfaction rating was regressed against the number of trout caught for 1998–1999 combined data. All statistical tests were evaluated with $\alpha = 0.10$.

Results

Effort, Catch, and Harvest

A total of 5,452 angler interviews (range, 250–1,114) were conducted on nine streams during the 1998 and 1999 hatchery-supported creel surveys. Angler effort estimates varied substantially among streams and years (range, 1,147–8,721 angler-h). Over 45,000 trout were caught during the hatchery-supported creel surveys. Estimated total catch (all species, all sizes) in 1998 and 1999 was variable among streams (range, 1,525–9,710). Overall, 78% of all captured trout (combined species) were harvested.

North Carolina Wildlife Resources Commission's hatchery-supported target catch rate of 1.00 trout >203 mm/h (presumed stocked) was surpassed during the creel survey. During 1998 and 1999, the average catch rate of trout >203 mm was 1.38 trout/h (range, 0.98–2.00 trout/h) for all streams combined (Table 1). The overall catch rate of trout (all species, all sizes) was 1.56 trout/h (range, 1.00–2.45 trout/h). Harvest rates of stocked trout (>203 mm) during the current hatchery-supported creel surveys were also high. Mean harvest rates of all trout >203 mm were 1.18 trout/h (range, 0.85–1.70 trout /h) for all streams combined from 1998 and 1999 (Table 1).

On average, 56% of anglers captured at least one trout at the time of interview during the 1998 and 1999 hatchery supported creel surveys. A majority of anglers (76%) captured ≤2 trout (combined species) at the time of interview (mean trip length, 1.32 h). Only 4% of anglers had caught their legal daily creel limit of seven trout at the time they were interviewed. Overall, there was a significant positive linear relationship between angler trip satisfaction and the number of trout caught ($P \leq 0.10$) (Fig. 1). In contrast, overall angler trip satisfaction did not significantly improve with time fishing, even though total catch generally increased with time.

Table 1. Estimated catch and harvest rates (number/h) of all trout (combined species) with associated standard errors (SE) from streams included in the 1998 and 1999 hatchery-supported trout waters creel surveys.

	Catch rate (number/h)						Harvest rate (number/h)					
Stream	**Mean**	**SE**	**≤203 mm**	**SE**	**>203 mm**	**SE**	**Mean**	**SE**	**≤203 mm**	**SE**	**>203 mm**	**SE**
Mill Creek	1.31	0.12	0.30	0.05	1.01	0.10	0.92	0.10	0.05	0.02	0.88	0.09
Curtis Creek	1.42	0.13	0.18	0.03	1.23	0.13	1.07	0.11	0.03	0.01	1.04	0.10
Alarka Creek	1.67	0.11	0.08	0.02	1.59	0.11	1.43	0.10	0.04	0.01	1.39	0.10
S. Prong Lewis Fork	1.26	0.11	0.14	0.06	1.11	0.09	1.14	0.10	0.05	0.02	1.09	0.09
Big Rock Creek	2.23	0.16	0.23	0.04	2.00	0.15	1.74	0.15	0.03	0.02	1.70	0.14
Little Rock Creek	2.45	0.17	0.47	0.07	1.98	0.16	1.52	0.13	0.04	0.02	1.48	0.13
Cranberry Creek	1.00	0.07	0.02	0.01	0.98	0.07	0.86	0.06	0.00	ND	0.85	0.06
Meadow Fork	1.35	0.11	0.15	0.03	1.20	0.11	1.11	0.10	0.01	0.01	1.10	0.10
Snowbird Creek	1.38	0.06	0.08	0.02	1.30	0.06	1.08	0.05	0.02	0.01	1.06	0.05
1998–1999 Mean	1.56	0.16	0.18	0.05	1.38	0.13	1.21	0.10	0.03	0.01	1.18	0.10

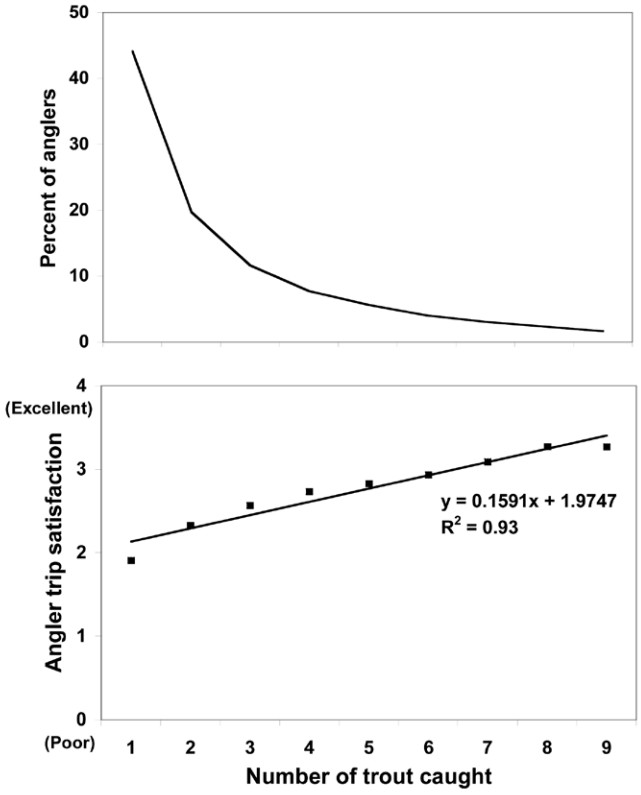

Figure 1. Percent of anglers that caught trout and angler trip satisfaction plotted against the number of trout caught for combined creel data collected during the hatchery-supported trout waters creel surveys, 1998–1999. Angler trip satisfaction rating 1 = poor, 2 = fair, 3 = good, 4 = excellent. The linear regression equation for angler trip satisfaction compared to the number of trout caught is also reported ($P \leq 0.10$).

A large proportion of trout stocked during the 1998 and 1999 hatchery-supported creel surveys were harvested by anglers. Overall, 75% of all stocked trout (>203 mm) (combined species) were harvested. The estimated percentage of stocked trout harvested exceeded 100% on Mill Creek (132%) and Little Rock Creek (168%) which may have been due to the contribution of wild trout >203 mm. Stocked trout were not marked and could not be distinguished from wild trout during the creel survey. As a result, the reported percentage of stocked trout harvested was capped for data analysis purposes at 100% for both streams. Overall, the percentage of stocked trout harvested varied dramatically among streams (Table 2). Rainbow trout, brook trout, and brown trout were harvested at similar percentages over the 2-year creel survey. The average return (all years, all streams) of trout >203 mm was 73% for rainbow trout, 74% for brook trout, and 79% for brown trout.

All species of trout were harvested in similar proportions to

Table 2. Percent of stocked (>203 mm) rainbow trout, brook trout, and brown trout harvested with associated standard errors (SE) from streams included in the 1998–1999 hatchery-supported trout waters creel surveys.

	Percent of stocked trout harvested							
Stream	**Overall**	**SE**	**Rainbow**	**SE**	**Brook**	**SE**	**Brown**	**SE**
Mill Creek	100	48	100	71	100	61	100	31
Curtis Creek	86	19	83	20	83	20	99	56
Alarka Creek	54	12	57	17	47	10	65	18
S. Prong Lewis Fork	71	22	59	24	73	23	90	24
Big Rock Creek	64	10	66	10	56	12	73	22
Little Rock Creek	100	37	100	44	100	47	100	20
Cranberry Creek	63	14	78	21	54	11	52	12
Meadow Fork	79	26	63	29	93	30	75	24
Snowbird Creek	56	11	54	8	59	18	54	10

the numbers stocked. During the 1998 and 1999 hatchery-supported creel survey the actual overall mean stocking proportion was 43% rainbow trout (by number), 38% brook trout, and 19% brown trout. Actual overall mean harvest proportion during the creel survey was 44% rainbow trout, 37% brook trout, and 19% brown trout.

Capture and harvest differed substantially among the three trout species. Rainbow trout were least likely to be harvested if captured (66%) whereas brook trout were most likely harvested (88%). Brown trout were moderately (77%) selected for by anglers if captured. Anglers were less likely to harvest trout <203 mm regardless of species, although some variation in harvest preference existed among rainbow trout (17%), brook trout (22%), and brown trout (16%).

Opening Day

Over 10% of all angler effort directed at hatchery-supported streams in 1998 and 1999 occurred on opening day of trout season (first Saturday in April). The percentage of total angler effort directed at opening day was variable among streams (range, 7%–22%). Approximately 15% of each stream's total catch and 16% of total harvest occurred on opening day. As with angler effort, the percentage of total catch (range, 6%–29%) and harvest (range, 5%–29%) that occurred on opening day was variable among streams.

The majority of trout were harvested within two weeks of being stocked. Harvest of each trout species occurred at different rates following stocking (Fig. 2). The harvest of rainbow trout was best described with a linear relationship (Fig. 2). The harvest of brook trout post-stocking was rapid and was best described with a power function. The harvest of brown trout post-stocking was also best described with a power function although the decline was at a much slower rate than brook trout over the same two-week period (Fig. 2).

Angler Demographics

Anglers that fished hatchery-supported streams during the 1998 and 1999 creel surveys were similar demographically. Most anglers fishing hatchery-supported trout waters were North Carolina residents, ≥16 years of age, male, and used natural bait. Among all streams and all years, approximately 83% (range, 55%–91%) of anglers were ≥16 years of age, 92% (range, 89%–94%) were male, and 96% (range, 80%–100%) were North Carolina residents. Over-

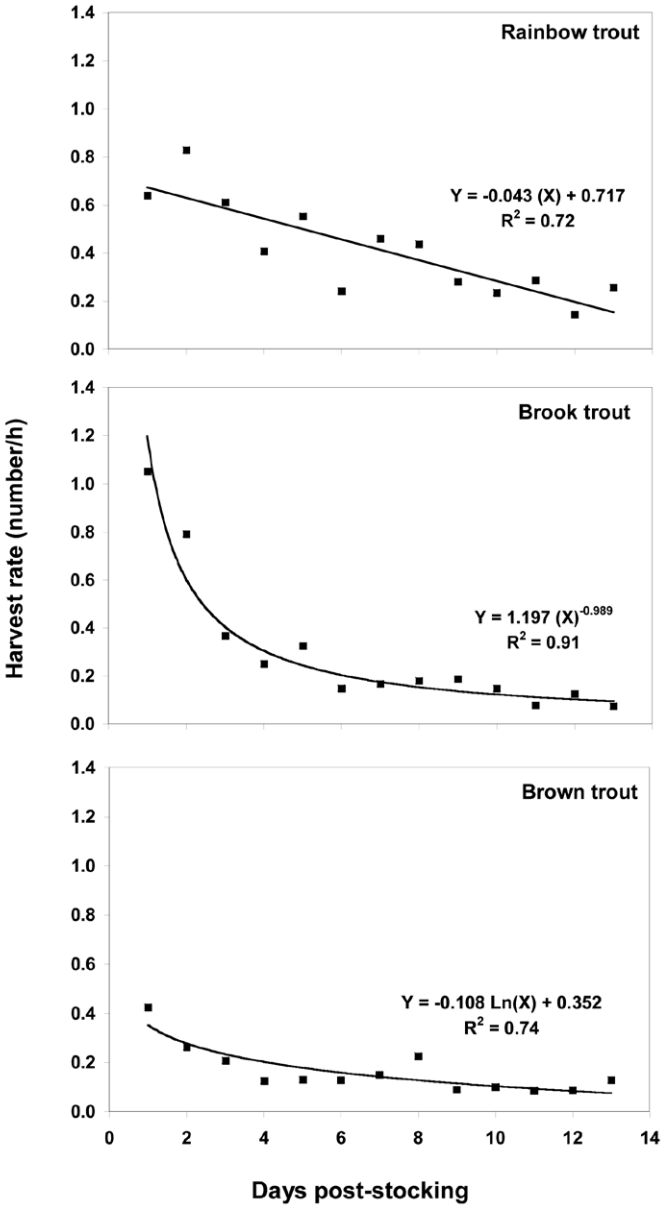

Figure 2. Mean harvest rate (number/h) of trout in post-stocking creel samples collected during the hatchery-supported trout waters creel surveys, 1998–1999. Results show combined data at all sites for all creel samples. Days post-stocking 0 corresponds to stocking event that began each new creel period. Equations shown describe significant relationships in harvest decline post-stocking ($P < 0.10$).

all, approximately 75% (range, 57%–88%) of anglers used natural bait, 20% (range, 9%–26%) used artificial lures, whereas only 5% (range, 1%–17%) used artificial flies.

Hatchery-supported trout anglers were generally satisfied with their overall trout angling experience. The mean angler trip satisfaction rating among all streams over all years was "good." Only 10% of anglers, however, rated their experience as "excellent," whereas the majority of anglers (53%) rated their experience as either "fair" or "poor."

Discussion

Effort, Catch, and Harvest

Angling effort estimates generated for the 1998 and 1999 creel surveys were considerably higher per stream than effort reported for streams in Wildlife Management Areas during the 1950s (Ratledge 1958). Angling effort directed at hatchery-supported trout streams was intermediate when compared to more recent data reported for streams in other NCWRC trout programs that have more restrictive regulations (Borawa and Clemmons 1998, Borawa et al. 2002).

Overall mean catch rates during the recent hatchery-supported creel surveys were higher than those reported for previous NCWRC hatchery supported creel surveys. Ratledge (1958) reported a mean capture rate of 0.96 trout/h (range, 0.85–1.08 trout/h) on Wildlife Management areas from 1956–1958. Williams et al. (2004) reported catch rates (mean, 1.25 trout/h) similar to this study for catchable-size trout in the White River, Arkansas. O'Bara et al. (1995) reported a mean harvest rate of 1.43 trout/h for catchable-size trout for three streams in Tennessee, which was similar to that reported during the current study (mean, 1.21 trout/h). The relatively high capture and harvest rates found in this study suggest that current stocking practices (i.e., stocking rates and distribution patterns) are achieving, and exceeding, the goal of 1.00 trout/h of angler effort.

The high harvest percentage, particularly of stock-size trout (75%), indicates that anglers fishing hatchery-supported streams are harvest-oriented. The relatively low harvest percentage of trout <203 mm (21%) indicates that anglers did not prefer to harvest small trout even though they were legal to creel. Alternative stocking strategies such as stocking larger numbers of smaller trout would probably not be acceptable to North Carolina anglers and would likely result in lower hatchery supported harvest rates.

Differences in capture and harvest rates were found among trout species during the hatchery-supported creel surveys. Capture rates of rainbow trout and brook trout >203 mm were equal (mean, 0.61 trout/h) and approximately double the catch rate of brown trout (mean, 0.27 trout/h). These observed differences, however, coincide with variation in stocking rates between species. The species-specific differences in angler catch rates appears to be a close reflection of NCWRC stocking practices rather than selectivity for a particular trout species by anglers. Not surprisingly, moderate catch rates appear to be more important than time spent fishing to anglers as part of their overall trip satisfaction (Fig. 1). Better detailed information on angler attitudes about trip satisfaction; however, might be better obtained through a directed angler opinion survey rather than as supplemental information obtained through a creel survey.

The high proportion of stocked trout returned to the creel during the current survey was similar to the average percent returned (mean, 71%) during creel surveys on Wildlife Management Areas in the 1950s (Ratledge 1958). The high return rates of stocked trout reported in this study were somewhat higher than that reported for other stocked trout fisheries. O'Bara and Eggleton (1995) reported a mean return rate of 23% (range, 13%–29%) for three Tennessee streams stocked with harvestable-size trout. Wiley et al. (1993) reported a relatively low mean return rate (28%) for harvestable-size trout stocked into 34 Wyoming streams from 1987–1990, although results were highly variable (range, 8%–65%). Low harvest of stocked trout by anglers was also reported for the White River, Arkansas, from 1998 to 2001 (range, 8%–22%) (Williams et al. 2004). Factors that might have artificially inflated return estimates of stocked trout, such as the presence of wild trout in the streams (Vincent 1987, Moring 1993), were not evaluated in the current study.

High return rates of stocked trout appear to be meeting several goals of the hatchery-supported trout program. First, the high returns indicate that the quality and size of trout stocked by the NCWRC are acceptable to anglers for harvest. Second, the quality of instream habitat (i.e., water temperature) is apparently sufficient to support stocked trout for periods long enough to allow harvest of the majority of stocked trout in each stream. Development of comprehensive stocking guidelines could help moderate the variation in the percent of stocked trout harvested among streams and improve overall return to the creel

Similarities in trout stocking and harvest ratios have also been found in previous NCWRC stream creel surveys. Ratledge (1958) reported proportions of harvested rainbow trout and brook trout similar to the proportion stocked; however, brown trout were always harvested at a slightly lower proportion than stocked. The similar stocking and harvest ratios found in the current creel survey suggests that hatchery-supported stream anglers did not have a preference for any single species of trout and that ultimately all trout species were susceptible to harvest, even if their susceptibility to catch was slightly lower (i.e., brown trout).

The stocking ratio of 40% brook trout, 40% rainbow trout, and 20% brown trout in each hatchery-supported stream appears to provide several benefits. Variability in catch rates by species resulted in a distribution of trout catch over an approximate two-week period after each stocking. Since the vast majority of each species was ultimately harvested, the goal of providing a varied species mixture for anglers was also accomplished.

Opening Day

Opening day of trout season is a significant event for the hatchery-supported trout program. In addition to a high proportion of hatchery-supported angling effort directed to opening day, a significant percentage of each stream's total catch and harvest also occurred on opening day. Overall, anglers harvested 85% of the trout captured on opening day, which is similar to the total creel average, suggesting there is not a significant difference in the harvest preferences of anglers that choose only to fish opening day.

Harvest rates of brook trout fell off sharply after the first two days post-stocking suggesting that stocked brook trout are more susceptible to angling than either rainbow trout or brown trout. These differences suggest that the three species of trout stocked by the NCWRC have unique susceptibilities to capture by anglers. Differences in the persistence of each trout species in hatchery-supported streams over time supports NCWRC's objective of distributing catch over time. Altering stocking ratios and schedules may allow resource managers to specifically manipulate catch and harvest of trout over time, by stream, to achieve overall management objectives.

Angler Demographics

Demographic similarities were found between the current hatchery-supported creel surveys and other NCWRC management program creel surveys. The low percentage of out-of-state anglers found in the current creel survey was similar to that found for wild trout streams with a natural bait allowance (range, 0%–14%) (Borawa and Clemmons 1998). In contrast, non-resident use on delayed harvest streams, which are popular with tourists, has been reported as high as 48% (Borawa et al. 2002). Surprisingly, the majority (58%) of anglers utilizing hatchery-supported streams during the current survey were considered non-local; i.e., living outside the county in which the stream is located. This suggests that most hatchery-supported trout fisheries are used primarily by local anglers that were willing to travel moderate distances to fish.

Catch rate data from the creel survey suggests that anglers catching >2 trout tended to rate their trip as "good" or "excellent" (Fig. 1). There was no correlation between angler trip satisfaction and the number of stockings per month or the number of trout stocked/km. Comments on the interview forms support the conclusion that angler trip satisfaction is driven largely by moderate catch rates.

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