Fisheries Session

Multispecies Trout Management on a Small Ozark Tailwater

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Abstract: Beginning in September 1998, the Arkansas Game and Fish Commission (AGFC) conducted a three-year creel survey on the trout fishery below Beaver Dam, Arkansas, to collect current information on angler effort, catch, and harvest. Angler catch rates for rainbow trout *(Oncorhynchus mykiss)* remained high (>1.0 fish/h) throughout the study. However, a reduction in angling effort coupled with a high rate of voluntary release resulted in low exploitation of the put-and-take rainbow trout fishery. The annual catch of brown trout *(Salmo trutta)* exceeded the number stocked in all three years suggesting that survival rates for this species are high. Conversely, mean catch rates for brook trout *(Salvelinus fontinalis)* (0.06 fish/h) and cutthroat trout *(Oncorhynchus clarkii)* (0.03 fish/h) were very low and the annual catch was typically much lower than numbers stocked. Few of the brown trout, cutthroat trout, or brook trout caught were above the respective minimum length limits for these species, suggesting that poor growth or high mortality could be limiting the success of these regulations. The results of this study suggest that multispecies trout management is unsuccessful on Beaver Tailwater and that AGFC could make better use of available resources by focusing on fewer species.

Key words: trout, tailwaters, creel surveys, management

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The Arkansas Game and Fish Commission (AGFC) manages the White River below Beaver Dam, Arkansas, as a four-species trout fishery. The four trout species currently stocked in Beaver Tailwater are rainbow trout *(Oncorhynchus mykiss),* brown trout *(Salmo trutta),* cutthroat trout *(Oncorhynchus clarkii),* and brook trout

(Salvelinus fontinalis). Rainbow trout were first stocked in 1966 after hypolimnetic discharge from the dam created coldwater habitat that was less suitable for native fish species (Bacon et al. 1968). Brown trout were introduced in 1985 to improve quality (>330 mm) and trophy (>508 mm) trout fishing opportunities below Beaver Dam (Hudy 1990). Cutthroat trout and brook trout were stocked into Beaver Tailwater in 1990 and 1994, respectively, to add diversity to the angling experience.

AGFC manages four other tailwaters in the state as four-species trout fisheries: Bull Shoals Tailwater, Norfork Tailwater, and Greers Ferry Tailwater. The decision to stock an additional species in Beaver Tailwater followed a successful introduction in one of these other areas. This multispecies approach is unique to the Southeast where most states manage their tailwater trout fisheries for one or two primary species, rainbow trout and brown trout (Epifanio 2000).

Effective management of tailwater trout fisheries requires accurate and current data on angling effort, catch, and harvest (Axon 1975). Creel surveys are the most common method of obtaining this information (Axon 1975, Malvestuto 1996). Prior to this study, the only creel information for the Beaver Tailwater trout fishery was from a survey conducted in 1980 by the National Reservoir Research Program (Morais 1981). Consequently, no information was available to evaluate the success of brown trout, brook trout, or cutthroat trout introductions or the efficacy of a four-species management approach. In order to obtain this needed information, a three-year creel survey was initiated on the Beaver Tailwater in 1998. The objectives of this survey were as follows: 1) to estimate the current level of angling effort directed toward this fishery, 2) to quantify catch and harvest for each of the four species, and 3) to evaluate the effectiveness of regulations on brown trout, brook trout, and cutthroat trout. This paper will discuss the results of that creel survey and their implications to management of the trout fishery below Beaver Dam.

Management History

The multispecies trout fishery below Beaver Dam is managed primarily through stocking and regulation with a mix of put-and-take, put-grow-and-take, and put-and-grow techniques. Intensive stocking is needed because of limited natural reproduction (Pender 1998). Rainbow trout are managed mainly as a put-and-take fishery, and at the time of this study were regulated by a six fish/day creel limit (the daily limit has since been lowered to five fish/day) with no length restrictions. The U.S. Fish and Wildlife Service's Norfork National Fish Hatchery supplies most of the rainbow trout stocked below Beaver Dam with these fish averaging 230 mm in length. Smaller numbers of larger trout (mean length = 300 mm) are obtained from state hatchery facilities and private vendors. Rainbow trout are stocked year round with seasonal stocking levels adjusted to match expected angling pressure. The number of rainbow trout stocked annually has risen substantially over the years in an effort to maintain the fishery against a presumed increase in angler effort. In 1980, approximately 54,000 rainbow trout were stocked into Beaver Tailwater. Two decades later, the number of rainbow trout stocked annually was over 210,000, a 290% increase.

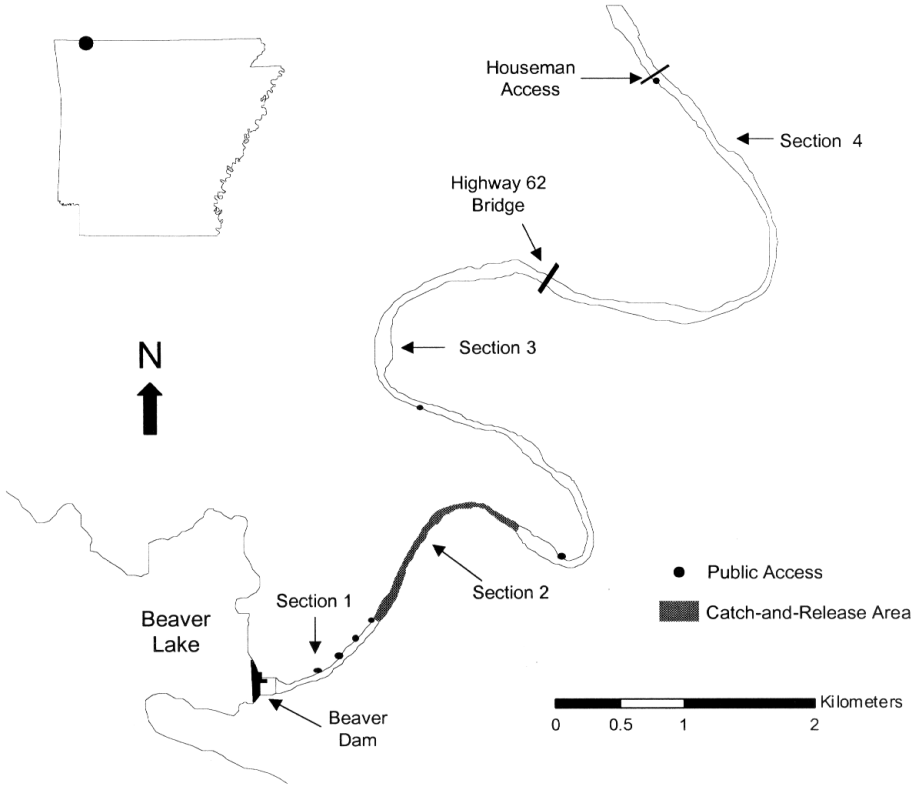

Figure 1. Map depicting the four study sections used during a three-year creel survey on the trout fishery below Beaver Dam, Arkansas.

In 1995 a catch-and-release area was created with the goal of increasing the density of larger (> 406 mm) rainbow trout (Stark 1994) (Fig. 1). This area begins 1.0 km below Beaver Dam and extends downstream for a total length of approximately 1.6 km. Angling in this area is restricted to artificial lures with single, barbless hooks, and all trout caught must be released immediately.

Initial stockings of yearling (mean length = 152 mm) brown trout exhibited moderate growth (10 mm/month); however, high annual mortality (> 90%) prevented realization of management goals (Hudy 1990, Hudy and Rider 1989). In an effort to reduce exploitation, a 406-mm minimum length limit, two fish/day creel limit on brown trout was approved in 1988 (Hudy and Rider 1989). About 10,000 yearling brown trout are now released into Beaver Tailwater annually. These fish are stocked in late fall or winter to maximize post-stocking growth.

Each year approximately 12,000 brook trout and 22,000 cutthroat trout are re-

leased below Beaver Dam in late fall or early winter at an average length of 152 mm. A 406-mm minimum length limit, two fish/day creel limit for cutthroat trout is designed to reduce exploitation on these fish until they reach a larger size. Brook trout are protected by a 356-mm minimum length limit, two fish/day creel limit.

Methods

Study Site

Beaver Dam is located on the White River at river kilometer 980 in Carroll County, Arkansas. The dam was built by the U.S. Army Corps of Engineers for the purposes of flood control and hydroelectric power generation and was the last project to be constructed on the upper White River. Construction on the dam began in 1959 and hydroelectric power generation commenced in 1965. Beaver Lake covers an area of 11,420 ha at power-pool elevation and has a drainage basin of 3,072 km^2. Releases from the dam's two turbines normally range from 2 to 142 m^3/s. Leakage from the dam and discharge from the facility's house generator provide a base flow of approximately 2 m^3/s. The resulting Beaver Tailwater flows approximately 12.1 km before entering Table Rock Lake, but only the upper 10.8 km are managed as trout waters.

Creel Survey Implementation

The three-year creel survey on Beaver Tailwater began 1 September 1998 and ended 31 August 2001. A "creel year" ran from September of a given year through August of the following year. Access point interviews were used to gather data for calculating angler catch and harvest rates and aerial counts were made for angling effort estimation. Separate schedules were generated for the aerial counts and the angler interviews.

For the purposes of this survey, the Beaver Tailwater was divided into four study sections (Fig. 1). These sections were: Section 1, beginning 0.1 km below Beaver Dam and ending at the upstream boundary of the catch-and-release area (length = 0.9 km); Section 2, the catch-and-release area (length = 1.6 km); Section 3, beginning at the downstream boundary of the catch-and-release area and ending at the Highway 62 Bridge (length = 4.6 km); and Zone 4, extending from the Highway 62 Bridge to the Houseman access area (length = 3.6 km).

Ten aerial flights were scheduled each month for a total of 120 flights each year of the survey. Flight dates were stratified by day type [weekday or weekend (including holidays)], and five dates were randomly selected from each stratum. Start times were chosen randomly from a list of possible start times for each date, beginning at 8 am and every one hour thereafter until approximately two hours before sunset. Each flight lasted approximately two hours during which a pilot and observer flew the entire length of the tailwater and recorded the number of anglers in each section. When a flight had to be canceled due to inclement weather, no attempt was made to reschedule that flight.

Sampling dates for the access point interviews were stratified by day type [weekday or weekend (including holidays)], and five dates were randomly selected

Table 1. Total angler effort, rainbow trout stocking rates, and rainbow trout catch statistics for the Beaver Tailwater, Arkansas, during a three-year creel survey. Standard errors for effort estimates are shown in parenthesis.

Variable	1998–1999	1999–2000	2000–2001	Mean
Angler effort (h)	106,682	85,024	65,181	85,629
	(4,906)	(5,605)	(4,031)	
Total stocked	178,225	191,922	210,384	193,510
Total catch	124,435	123,464	74,557	107,485
Catch rate (fish/h)	1.17	1.45	1.14	1.25
Total harvest	39,656	26,538	16,168	27,454
Harvest rate (fish/h)	0.37	0.31	0.25	0.31

from each stratum. The creel clerk worked in only one section of the tailwater on each sampling day. Sampling days were divided into two equal shifts, morning and afternoon, depending on sunrise and sunset times. Both the shift and the section to be covered on each sampling day were chosen with equal probabilities. During interviews, the clerk recorded the species and length (in mm) of all harvested fish. Anglers provided information on the species, number, and approximate length of fish that were caught and released.

Instantaneous counts were expanded to estimate annual fishing effort (Lambou 1961, Malvestuto 1996). Catch and harvest rates were calculated using the total ratio estimator (Malvestuto 1996). Total catch and total harvest were then calculated by multiplying effort estimates by catch and harvest rates.

Results

Angler Effort

Angling effort declined from 106,682 hours in 1998–1999 to 85,024 hours in 1999–2000, and declined further in 2000–2001 to 65,181 hours (Table 1). These figures represent a 20% decrease in fishing effort each year, or a 39% decline overall. Mean angling effort on the Beaver Tailwater was 85,629 hours.

Catch and Harvest

Rainbow Trout. —The put-and-take rainbow trout fishery was supported by an average stocking rate of 193,510 fish per year (Table 1). Annual stockings increased from 178,225 in 1998–1999 to > 210,000 in 2000–2001. Total catch of rainbow trout declined from 124,435 in 1998-1999 to < 75,000 in 2000–2001. Mean annual catch of rainbow trout was 107,485, which accounted for 79% of the total annual catch of all trout species combined. Catch rates for rainbow trout ranged from 1.14 fish/h in 2000–2001 to 1.45 fish/h in 1999–2000. The annual catch of rainbow trout was composed primarily (86%) of stock-size fish (≤ 300 mm). The percentage of the catch

Table 2. Stocking rates and catch statistics for brown trout in the Beaver Tailwater, Arkansas, during a three-year creel survey.

Variable	1998–1999	1999–2000	2000–2001	Mean
Total stocked	20,000	10,000	10,000	13,333
Total catch	22,351	28,643	11,222	20,739
Catch rate (fish/h)	0.21	0.34	0.17	0.24
Total harvest	114	49	12	58

made up of rainbow trout in the 300–406 mm size class averaged 13% over the study period. In all years, < 1% of all rainbow trout caught were > 406 mm.

Annual harvest of rainbow trout followed a pattern of decline similar to that observed in total catch. In 1998–1999, anglers harvested almost 40,000 rainbow trout while in 2000–2001 harvest was just over 16,000. In 1998–1999, the harvest rate for rainbow trout was 0.37 fish/h, but in 2000–2001 the harvest rate was 0.25 fish/h despite similar catch rates (Table 1). Harvest efficiency (the percentage of stocked rainbow trout that were harvested by anglers) (Oliver 1984) was low and ranged from 22% in 1998–1999 to 8% in 2000–2001. This change in efficiency resulted from the reduction in harvest and a nearly 20% increase in the number of rainbow trout stocked. Voluntary catch-and-release was prevalent on the Beaver Tailwater. After excluding those rainbow trout caught in the catch-and-release area, anglers released 68% of the rainbow trout caught in Sections 1, 3, and 4.

Brown Trout. —Brown trout stocking rates decreased from 20,000 in 1998–1999 to 10,000 the last two years of the survey (Table 2). Catch rates for brown trout were consistently lower than those observed for rainbow trout. The annual catch rate for brown trout increased from 0.21 fish/h in 1998–1999 to 0.34 fish/h in 1999–2000. In 2000–2001, however, the catch rate dropped to 0.17 fish/h.

The annual catch of brown trout exceeded the number stocked in all years of the survey. Total catch estimates ranged from 28,643 in 1999–2000 to 11,222 in 2000–2001 with a mean of 20,739. Approximately 91% of the annual catch of brown trout was composed of fish < 300 mm. Brown trout > 406 mm were rare, contributing < 1% to total catch.

Almost none (< 1%) of the brown trout caught during this study were harvested. Total harvest estimates declined from 114 fish in 1998–1999 to only 12 fish in 2000–2001. Some illegal harvest of sub-legal brown trout did occur. The first year of the survey, 62% of the total estimated brown trout harvest was made up of fish in the 406–508 mm size class with sub-legal fish accounting for the remaining 38%. In 1999–2000, all of the brown trout harvested were of sub-legal size. The following year, all of the brown trout harvested were of legal size.

Cutthroat Trout. —Annual stockings of cutthroat trout averaged 28,500 the first two years of the survey, but declined to 8,472 in the final year (Table 3). Catch rates for cutthroat trout were the lowest observed among all four species with a mean of 0.03 fish/h. Total catch estimates increased from 2,271 trout in 1998–1999 to 4,439

Table 3. Stocking rates and catch statistics for cutthroat trout in the Beaver Tailwater, Arkansas, during a three-year creel survey.

Variable	1998–1999	1999–2000	2000–2001	Mean
Total stocked	27,000	30,000	8,472	12,367
Total catch	2,771	4,439	986	2,732
Catch rate (fish/h)	0.03	0.05	0.02	0.03
Total harvest	8	0	0	3

Table 4. Stocking rates and catch statistics for brook trout in the Beaver Tailwater, Arkansas, during a three-year creel survey.

Variable	1998–1999	1999–2000	2000–2001	Mean
Total stocked	10,000	8,100	19,000	12,367
Total catch	10,084	5,568	1,926	5,859
Catch rate (fish/h)	0.10	0.07	0.03	0.06
Total harvest	0	0	0	0

trout in 1999–2000, but declined to < 1,000 trout for the final year. The number of cutthroat trout caught annually by anglers averaged 12% of the number stocked. Harvest of cutthroat trout was negligible with 8 being harvested in 1998–1999 and zero being harvested the remainder of the study.

Cutthroat trout < 300 mm accounted for an average of 80% of all those caught. The annual percentage increased from 68% in 1998–1999 to 83% in 2000–2001. Conversely, the percentage of cutthroat trout in the 300–406 mm size class decreased from 32 % in 1998–1999 to 17% in 2000–2001. Less than 1% of the cutthroat trout caught were at or above the 406-mm minimum length limit.

Brook Trout. —Catch rates for brook trout declined from 0.10 fish/h in 1998–1999 to 0.07 fish/h in 1999–2000, which coincided with a nearly 20% reduction in the number of brook trout stocked annually (Table 4). Angler success decreased to 0.03 fish/h in 2000–2001 even though the number stocked (19,000) was the highest during the study. Annual harvest estimates indicated that no brook trout were harvested during the 3-year survey period. Catch of brook trout declined from 10,084 in 1998–1999 to 5,568 in 1999–2000 and to 1,926 in 2000–2001.

Over 90% of all brook trout caught were < 300mm. The remainder of the brook trout catch consisted of fish in the 300–406 mm size range. Because of the manner in which anglers were asked to classify the size of fish caught and released, it is unknown whether any of these fish exceeded the 356-mm minimum length limit. No brook trout > 406 mm were caught during the study.

Discussion

Catch rates for rainbow trout in this study were higher than those observed on other Arkansas trout waters managed under a multispecies approach. Todd et al. (1999) found that catch rates on Bull Shoals and Norfork Tailwaters ranged between 0.81 and 0.97 fish/h during a 1995–1998 survey. Catch rates for rainbow trout on Greers Ferry Tailwater averaged 0.73 fish/h (Bowman et al. 1994). Low exploitation coupled with increasing stocking rates resulted in low (8%–22%) harvest efficiency during the present study. This indicates that AGFC could decrease the current rainbow trout stocking rates for Beaver Tailwater to bring it more in line with angler harvest practices and increase stocking efficiency. Two factors that contributed to the low rainbow trout harvest were high voluntary release rates and reduced angling effort. It is unknown what factors contributed to the decline in angling effort and whether this has continued.

The high rate of voluntary release could indicate a shift in angler behavior toward catch-and-release fishing and the need to evaluate the put-and-take management strategy for rainbow trout in the Beaver Tailwater. Size selective harvest on other Arkansas tailwater trout fisheries has been found to contribute to a high rate of release of legally harvestable fish. Todd et al. (1999) found that anglers on the Bull Shoals and Norfork Tailwaters selectively harvested rainbow trout between 305 and 381 mm, but released fish above and below this size range. Since most of the rainbow trout that anglers caught were $<$ 300 mm, it is difficult to conclude if size selective harvest occurred during this study. It is possible, however, that many anglers felt that the 229 mm size at stocking was too small to keep. In 2002, the state and federal hatcheries that supply rainbow trout to Arkansas waters moved to a standard 279 mm stocking length. The goal of this change was to increase harvest and to reduce losses of stocked fish to other sources of mortality (e.g. predation, hooking mortality, culling). Additional creel surveys will be required to measure the effect of this action on rainbow trout harvest on Beaver Tailwater.

The three species managed through put-grow-and-take techniques are experiencing differing levels of success. Brown trout catch rates, although low compared to those of rainbow trout, are adequate and higher than those observed on Greers Ferry Tailwater (0.08 fish/h) (Bowman et al. 1994), Bull Shoals Tailwater (0.10 fish/h) (Todd et al. 1999), or Norfork Tailwater (0.09 fish/h) (Todd et al. 1999). More brown trout were caught than were stocked throughout the survey, which indicates good survival of stocked cohorts. Conversely, catch rates for brook trout and cutthroat trout were very low and annual catch was typically much lower than numbers stocked. Low numbers of brook trout and cutthroat trout were observed in population samples conducted on the Beaver Tailwater in September 2002 (Williams et al. 2003a). Electrofishing catch rates for cutthroat trout were extremely low (2.0 fish/h) with only four cutthroat trout being collected from the entire tailwater. Brook trout (8.0 fish/h) were slightly more abundant than cutthroat trout, but were present in substantially lower numbers than rainbow trout (140 fish/h) or brown trout (120 fish/h). Population sampling in 2003 on the Norfork Tailwater produced higher electrofishing catch rates

for both brook trout (69 fish/h) and cutthroat trout (27 fish/h) (J. S. Williams, AGFC, unpublished data). These results suggest that unlike brown trout, cutthroat trout and brook trout in the Beaver Tailwater are experiencing poor post-stocking survival.

The relative scarcity of larger brown trout, cutthroat trout, and brook trout in the Beaver Tailwater indicates that the minimum length limits on these species are not achieving desired results. Williams et al. (2003a) provide further evidence that these regulations are not performing as expected. Approximately 72% of brown trout sampled were < 300 mm in length and only 4% were at or above the 406-mm minimum length limit. Brook trout collected had a mean length of 258 mm with none exceeding the 356-mm minimum length limit. In contrast, 23% of the brown trout and 36% of the cutthroat trout collected during the 2003 population sample on Norfork Tailwater were > 406 mm (J. S. Williams, AGFC, unpublished data). Thirteen percent of the brook trout collected during the Norfork sample were > 356 mm.

According to Clark et al. (1981), minimum size limits will increase the number of larger trout in populations where growth rates are good and harvest is high. However, in systems where exploitation contributes only a small portion to total mortality, minimum size limits may be of little value (Noble and Jones 1999). Given that mortality for brown trout appears low, the success of the minimum length limit for this species is likely limited by poor growth. In addition to poor survival, slow growth rates could be limiting the success of minimum length limits for brook trout and cutthroat trout.

Past studies have shown that benthic macroinvertebrate densities in Beaver Tailwater are low compared to other Arkansas trout waters (Blanz et al. 1969, Brown et al. 1967, Pender 1998), suggesting that trout growth in this system may be limited by food availability. Competitive interactions among trout species could also be contributing to poor growth in Beaver Tailwater, especially for brook trout and cutthroat trout. Wang and White (1994) observed that brown trout displaced cutthroat trout from energetically favorable feeding locations. Following the removal of brown trout from a Michigan stream, Fausch and White (1981) found that brook trout chose resting positions with more favorable water velocity. Increased competition resulting from high stocking rates of rainbow trout would only exacerbate this situation. Weiland and Hayward (1997) attributed the decline in the number of large rainbow trout in Lake Taneycomo, Missouri, to increased stocking rates and resultant degradation of the food base.

The low harvest rates observed in this study suggest that exploitation is not a major source of total trout mortality in Beaver Tailwater. Although only a small number of sub-legal brown trout were harvested from Beaver Tailwater, illegal harvest has been found to reduce the effect of minimum length limits (Gigliotti and Taylor 1990). Considering that 62% of the anglers on Beaver Tailwater used bait, either alone or in combination with artificial lures (Williams et al. 2003b), and the high rate of catch-and-release, hooking mortality could account for a significant portion of total mortality.

As a result of this study, AGFC will likely move away from multispecies trout management on the Beaver Tailwater. As a management plan is developed for this

tailwater, management will focus on just two species, rainbow trout and brown trout. The put-and-take strategy for rainbow trout will continue, although adjustment to the current stocking program is necessary. Brown trout will still be managed to provide a quality fishing experience in the Beaver Tailwater. However, modification of current strategies will be required to achieve management goals.

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