Response of Brown Trout in Lake Cumberland Tailwater to a Trophy Regulation

Jeff R. Ross, *Lake Fisheries Research Section, Kentucky Department of Fish and Wildlife Resources, 1 Game Farm Road, Frankfort, KY 40601*

Jarrad T. Kosa, *Office of Energy Products, Federal Regulatory Commission, 888 First Street NW, Washington, D.C. 20426*

Abstract: The objective of this study was to evaluate the use of a 508-mm minimum length limit in conjunction with a 1-fish-per-day creel limit to determine its effectiveness in improving the size structure of the brown trout *(Salmo trutta)* fishery resource in the Lake Cumberland Kentucky tailwater. The ultimate goal is to increase the number of trophy (>508 mm) brown trout within the tailwater. When sample sites were combined, a significant increase in brown trout CPUE was seen across years for all size-classes. The time required to detect this increase in trophy brown trout was approximately 4 years and was dependent on growth. On a site-by-site basis, however, variability between sites tended to mask findings of significance. Such variability may lead to important management implications when planning a large tailwater-stocking regime. This study has shown that the trophy regulation resulted in increased numbers and sizes of brown trout within the Cumberland tailwater.

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Use of coldwater habitats below high-head dams for fisheries has become commonplace in the Southeastern United States (Axon 1974). The presence of suitable physical habitat, environmental conditions, and food has resulted in thriving trout populations in these specialized areas (Vt. Dep. Fish and Wildl. 1993). In tailwaters managed for increased potential to catch large trout (trophy fisheries), excessive fishing pressure and high harvest rates can limit such potential.

Low-density brown trout stockings in conjunction with rainbow trout *(Oncorhynchus mykiss)* can produce trophy brown trout fisheries (Hudy 1990). They have shown multiple season survival and can withstand higher fishing pressure and competition from other species (Staley 1966). Special regulations, however, ultimately may be necessary if harvest of brown trout becomes excessive.

Special regulations alone cannot improve a river's natural capacity to support trout (Vt. Dep. Fish and Wildl. 1993) as each body of water will have its own set limits for growth, size, and age structure (Behnke 1990). These "set values" will limit a tailwater's ability to produce trophy-sized fish. However, if favorable growth and survival are possible, but not realized due to high harvest, special fishing regulations can be used to enhance trophy trout production. An additional factor that must be considered is knowledge of angler attitudes, as success of trophy regulations ultimately depends on angler acceptance (Anderson and Nehring 1984, Fatora 1976).

The Kentucky Department of Fish and Wildlife Resources has developed a trophy brown trout fishery on its largest tailwater below Lake Cumberland. Brown trout were first introduced into the Cumberland tailwater in 1982. In 1995, harvest percentage of brown trout within the 3 uppermost stocking sites ranged from 51–82%. Regulations at that time were an 8-trout daily limit with only 3 brown trout of any size allowed (Kosa 1999). To increase the potential for developing a trophy brown trout fishery, a 508-mm length and 1-fish-per-day creel limit were implemented for brown trout in the Cumberland tailwater in 1997.

The objective of this study was to evaluate the use of a 508-mm minimum length limit in conjunction with a 1-fish-per-day creel limit to determine its effectiveness in improving the size structure of the brown trout (*Salmo trutta*) fishery resource in the Lake Cumberland Kentucky tailwater. The ultimate goal is to increase the number of trophy brown trout (>508 mm) within the tailwater.

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Methods

Our study area was the 54.2-km section of the Cumberland River immediately below Wolf Creek Dam and is located in the highland rim province of southern Kentucky (Fig. 1). Average discharge, released from 31 m below normal pool, is 283 m^3/second, but can fluctuate from <1 to 425 m^3/second within 3 hours. Daily discharge fluctuations and length of minimum flow are variable and depend on generation schedules. Daily river level fluctuations range from 6.1 m in the upper reaches of the tailwater to 1.8 m at the lower end of the study reach. River width varies from 61 to 122 m. Long (0.8–6.4 km) pools interspersed with riffles (0.2–1.6 km) characterize the river. Shoals associated with islands and small streams make up the primary instream structure with stumps and large woody debris occurring along the banks (Coopwood et al. 1987, Kosa 1999).

Stock-size (mean total length 178 mm) brown trout were stocked at age-1 in early April of each year from 1995 to 2000 (Table 1). Stocking was discontinued at the dam in 1996. These fish were distributed further downstream to reduce angling mortality. Fingerling (mean total length 74 mm) brown trout were stocked at each site except the dam in early July from 1997 to 2000 (Table 1). Variability in fingerling brown trout stocking numbers was due to differences in yearly egg survival at the Wolf Creek National Fish Hatchery.

In order to distinguish year classes, uncoded wire tags were inserted into either

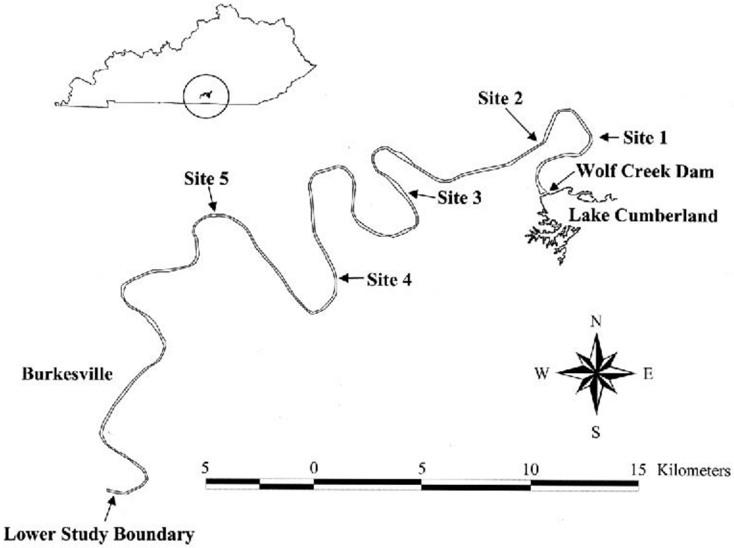

Figure 1. Location of brown trout sample sites on Lake Cumberland tailwater, Kentucky.

Table 1. Brown trout stockings in the Lake Cumberland tailwater, 1995–2000. Mean total length of stock size = 178 mm and fingerling = 74 mm.

Stocking site	River kilometer	Year 1995	1996	1997	1998	1999	2000
		Stock size					
Dam	0.0	2,984					
Little Indian Creek	3.2	3,152	6,000				
Helm's Landing	7.2	7,506	7,000	3,000	6,500	7,407	3,006
Winfrey's Ferry	25.3	6,959	7,000	9,000	8,985	7,407	9,018
Crocus Creek	41.4	5,053	5,000	9,000	6,150	5,752	9,018
Burkesville Ramp	53.9	4,506	5,000	9,000	6,345	5,752	5,010
Hwy. 61 Ramp	61.5			5,000	1,237	5,752	4,008
Total		30,160	30,000	35,000	29,217	32,070	30,060
				Fingerling size			
Dam	0.0						
Little Indian Creek	3.2			2,630	7,342	2,688	3,800
Helm's Landing	7.2			7,890	14,184	6,720	7,832
Winfrey's Ferry	25.3			10,520	17,605	5,376	6,488
Crocus Creek	41.4			18,710	10,921	6,720	4,160
Burkesville Ramp	53.9			8,190	7,342	2,016	4,160
Hwy. 61 Ramp	61.5			16,380	7,342	2,016	4,160
Total				64,320	64,736	25,536	30,600

the caudal or dorsal region of stock-size brown trout, alternating each year using a Mark IV CWT microtagging unit (Northwest Mar. Tech., Inc., Olympia, Wash.). Fingerling cohorts of brown trout were either wire-tagged in the snout or left untagged to separate year classes. Tricaine methane sulfonate (MS-222) or carbon dioxide (CO_2) were both used as anesthetizing agents prior to tagging. All fish were checked for tag loss at time of tagging. If a tag was not detected, fish were re-tagged. Short-term (approximately 1 month) tag loss was recorded just prior to stocking. Values used for initial numbers stocked were compensated (reduced) in our population estimate equations to reflect tag loss. A random subsample of fish was measured for total length and weight prior to stocking.

Trout were collected at night in November of each year from 1995–2000 using 4 to 5 boats, each mounted with DC electrofishing gear. Multiple timed samples (15 minute) were collected at each site using 9–10 amperes of electricity pulsed at 120 pulses per second. On each run, 2 people on the front of the boat attempted to net all trout seen. Trout captured were measured to the nearest mm total length, weighed to the nearest g, and identified by tagging method and location. Data collected were used to calculate catch-per-unit-effort (fish/hour) (CPUE), growth, and condition as relative weight (W_r). Relative weight was calculated as: $W_r = W/Ws \times 100$ where W is the weight of an individual fish and W_s is a length-specific standard weight calculated as $W_s = a'L^{b'}$ (Wege and Anderson 1978).

The 5 sites sampled in this study included Above Helm's Landing (Site 1) located at river km 5.0, Below Helm's Landing (Site 2) at river km 7.2, Above Winfrey's Ferry (Site 3) at river km 18.0, Below Winfrey's Ferry (Site 4) at river km 25.3, and Crocus Creek (Site 5) at river km 41.4 (Fig. 1). Sampling effort consisted of 3 runs at each site in 1995 (Sites 1, 2, and 3) and 4 runs at each site in 1996 (Sites 1, 2, 3, and 5). From 1997–2000, Site 4 was added and sampling effort was increased to 5 runs at each site.

Site 3 was sampled monthly from July to December in 1997, 1998, and 2000 to obtain CPUE data and monthly change in length, weight, and W_r of brown trout. In each year, successive 15-minute runs were made until 30 stock-size brown trout (stocked in the current year) were collected. All trout collected from each run were measured, weighed, and identified as described above.

A trout population estimate was made in June 1998 and 2000 using the change-in-ratio (CIR) method (Paulik and Robson 1969) and estimated using the equation:

$$N_1 = (R_x - P_2R)/(P_2 - P_1)$$

Betolli et al. (1999) defines the variables as follows: N_1 is the number of trout in the river at time 1 (before stocking), R_x is the net change in the number of tagged trout in the river (equals number of tagged trout stocked), and R is the net change in the number of trout in the river (also equals the number of tagged trout stocked), P_2 is the proportion of tagged trout in the sample at time 2, and P_1 is the proportion of tagged fish in the population at time 1 (equals zero). The P_2 can be modified to estimate densities of different trout species or differentiate between cohorts stocked in different years.

The variance of the density estimate was calculated as follows from Paulik and Robson (1969):

$$V(N_1) = (P_2–P_1)^{-2}[N_1^2V(P_1) + (N_1 + R)^2V(P_2) + (1–P_2)^2V(R_x) + P_2^2V(R_y)],$$

where V is the variance, and R_y is the change in number of untagged trout (equals zero). Ninety-five percent confidence intervals were calculated by doubling the square root of the variance and adding and subtracting it from the density estimate.

Four size-classes (all sizes, 381–457 mm, 458–508 mm, and >508 mm) of brown trout were used for data analysis. These size-classes allowed for detection of changes taking place as brown trout progressed up to trophy size. Regression analysis was used to detect significant trends in density across years for each size-class of brown trout. Comparison of density among years for each size-class was made using the general linear models statement within the Statistical Analysis System (SAS 1988). If a significant difference ($P \leq 0.10$) was identified, results were investigated further with the Duncan's multiple-range test. The general linear models statement was also used for comparison of length attained at age of collection and yearly late fall condition of brown trout. Growth rates were compared by taking the $\log_e$ of both length increment and days post stocking and using analysis-of-covariance to detect differences in regression slopes between years at the $P \leq 0.10$ significance level.

Results

Fall Nocturnal CPUE

Total Brown Trout.—With all sites combined, fall brown trout CPUE, calculated for all sizes, ranged from 23.3 fish/hour in 1996 to 105.8 fish/hour in 2000 (Fig. 2). Regression analysis also showed a significant positive increase ($P = 0.01$, $r^2 = 0.82$, df = 5) in overall brown trout CPUE across sample years. A comparison among sample years supports this increase with significantly higher ($P < 0.001$) CPUE in 2000 than any other year. On a site-by-site basis, a general increasing trend was seen at all sites but Site 2, with Site 1 ($P = 0.05$, $r^2 = 0.64$, df = 5), Site 3 ($P = 0.04$, $r^2 = 0.70$, df = 5), and Site 5 ($P = 0.01$, $r^2 = 0.84$, df = 5) all showing significant increasing trends (Fig. 2). Due to site variability, detection of significance among sample years was less effective with only Site 2 ($P = 0.08$) and Site 3 ($P = 0.01$) showing significant differences among years. Site 2 was the only site to show decreased CPUE in 2000 as compared to previous sample years. Brown trout CPUE from 1997–2000 was also compared among sites with years combined. Site 3 and Site 4 tended to produce the highest number of brown trout, whereas Sites 1 and 2 produced the lowest.

Brown Trout 381–457 mm.—Fall 381–457 mm brown trout CPUE for all sites combined ranged from 0.9 fish/hour in 1995 to 18.6 fish/hour in 2000 (Fig. 3). Regression analysis also showed a significant positive increase ($P = 0.09$, $r^2 = 0.54$, df = 5) in 381–457 mm brown trout CPUE across sample years. This increase was again supported by comparisons among sample years with significantly higher ($P > 0.001$) CPUE seen in 2000 than any other year. On a site-by-site basis, a general increasing

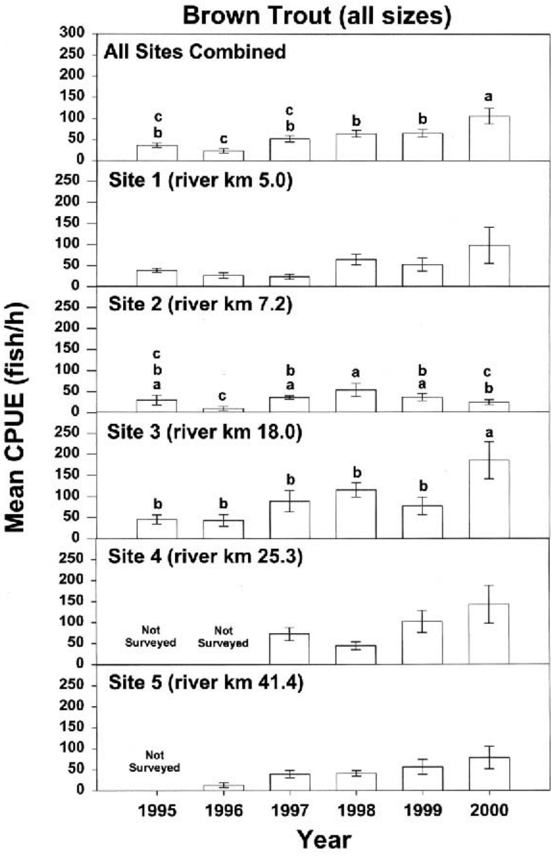

Figure 2. Mean electrofishing catch-per-unit-effort (CPUE) of brown trout in the Lake Cumberland tailwater, fall 1995–2000. Years with different letters are significantly different ($P \leq 0.10$) within each graph. Vertical bars indicate standard error.

trend in CPUE of 381–457 mm brown trout across years was seen at all sites, with statistically significant increases at Site 1 ($P = 0.06$, $r^2 = 0.62$, df = 5), Site 2 ($P = 0.08$, $r^2 = 0.59$, df = 5), and Site 5 ($P = 0.04$, $r^2 = 0.69$, df = 5) (Fig. 3). Significance among sample sites was found only at Site 3 ($P = 0.08$) and Site 4 ($P = 0.03$) but all sites produced generally higher CPUE in 2000 as compared to previous sample years. CPUE of 381–457 mm brown trout from 1997–2000, among sites with years combined, were highest at Sites 3 and 4 and lowest at Sites 1 and 2.

Brown Trout 458–508 mm.— With all sites combined, fall brown trout 458–508 mm CPUE ranged from 0.5 fish/hour in 1995 to 6.6 fish/hour in 2000 (Fig. 4). Regression analysis also showed a significant positive increase ($P = 0.02$, $r^2 = 0.76$, df = 5) in CPUE across sample years. A comparison among sample years found significantly higher ($P > 0.01$) CPUE in 2000 than 1995, 1996, 1997, and 1998. On a site-by-site basis, a general increasing trend in CPUE of brown trout across years was seen at Site 4 with significant increases at Site 1 ($P = 0.06$, $r^2 = 0.62$, df = 5), Site 3 ($P = 0.05$, $r^2 = 0.65$, df = 5), and Site 5 ($P = 0.09$, $r^2 = 0.55$, df = 5) (Fig. 4). Brown trout

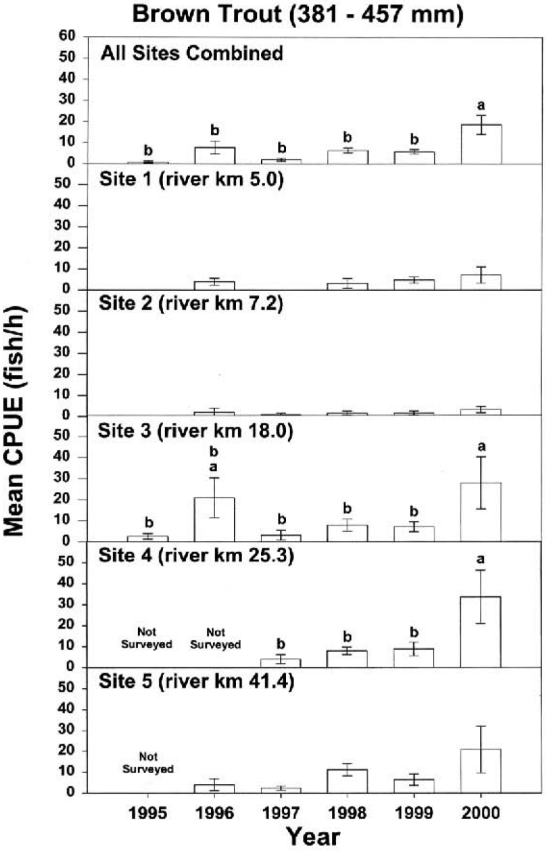

Figure 3. Mean electrofishing catch-per-unit-effort (CPUE) of brown trout 381–457 mm in the Lake Cumberland tailwater, fall 1995–2000. Years with different letters are significantly different ($P \leq 0.10$) within each graph. Vertical bars indicate standard error.

458–508 mm were never present in samples from Site 2 during the study. No significant differences in densities across years were detected within individual sample sites for this size-class of brown trout. Densities of 458–508 mm brown trout from 1997–2000, among sites with years combined, were highest at Sites 3 and 4 and lowest at Sites 1and 2.

Brown Trout >508 mm.— Mean site CPUE of brown trout >508 mm for all sites combined ranged from 0.0 fish/hour in 1995 to 9.0 fish/hour in 2000 (Fig. 5). Regression analysis also showed a significant positive increase ($P = 0.08$, $r^2 = 0.76$, df = 5) in CPUE of brown trout >508 mm across sample years. This trend was supported by comparison among sample years with significantly higher ($P < 0.001$) CPUE seen in 2000 than any other year. Analysis of individual sites revealed a general increasing trend in CPUE of brown trout >508 mm at all sites but Site 1, with significant increases seen at Site 2 ($P = 0.04$, $r^2 = 0.69$, df = 5) and Site 5 ($P = 0.03$, $r^2 = 0.74$, df = 5) (Fig. 5). Site variability limited detection of statistical significance among sample years with only Site 4 ($P = 0.01$) showing significant differences

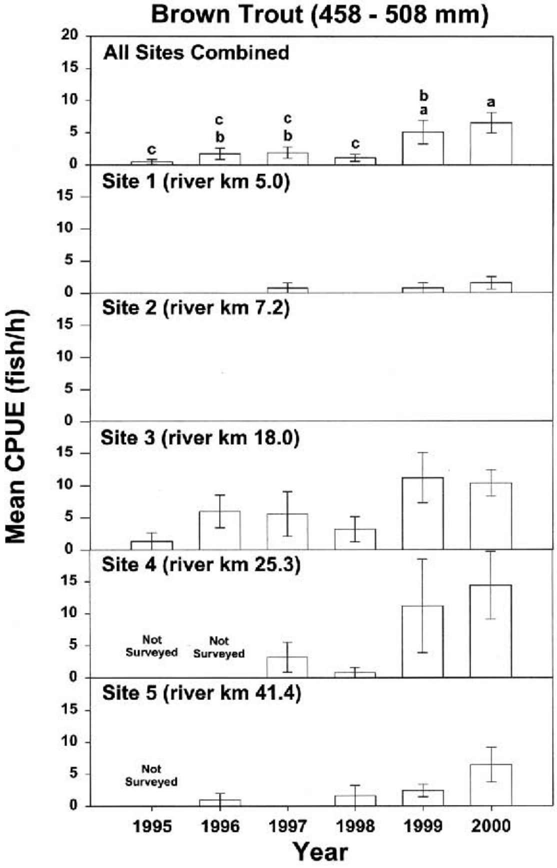

Figure 4. Mean electrofishing catch-per-unit-effort (CPUE) of brown trout 458–508 mm in the Lake Cumberland tailwater, fall 1995–2000. Years with different letters are significantly different ($P \leq 0.10$) within each graph. Vertical bars indicate standard error.

among years. Site 1 was the only site to show lower CPUE in 2000 as compared to previous sample years. CPUE of brown trout > 508 mm from 1997–2000, among sites with years combined, were once again highest at Sites 3 and 4 and lowest at Sites 1 and 2.

Change-in-Ratio Population Estimates

The total brown trout population estimate conducted in 1998 was 38,849 (717 fish/km) whereas in 2000, estimates rose to 47,668 (880 fish/km) (Table 2). Population estimates of trophy brown trout (>508 mm) were over 13 times higher in 2000 than 1998.

Growth and Condition

First year brown trout growth rate (mm/days post stocking) from time of stocking to late fall varied by year stocked (Table 3, Fig. 6). A comparison of regression

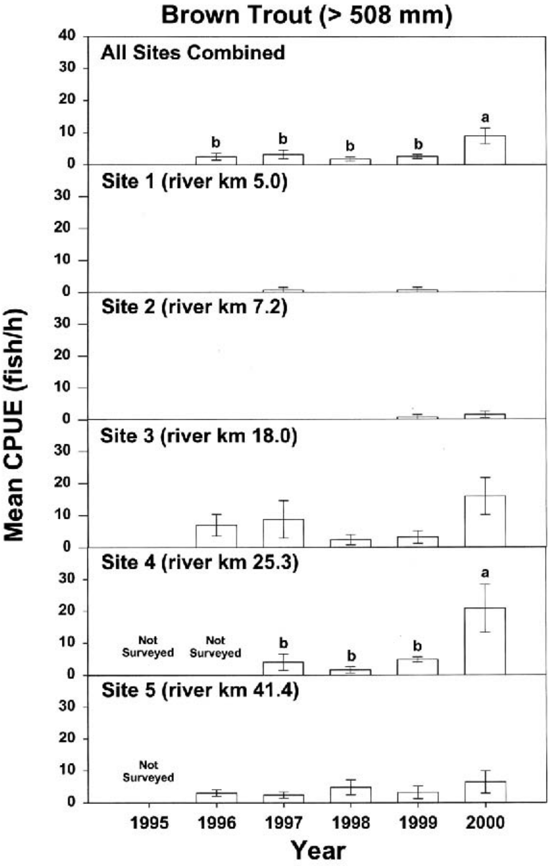

Figure 5. Mean electrofishing catch-per-unit-effort (CPUE) of brown trout >508 mm in the Lake Cumberland tailwater, fall 1995–2000. Years with different letters are significantly different ($P \leq 0.10$) within each graph. Vertical bars indicate standard error.

slopes of $\log_e$ (length) versus $\log_e$ (days post stocking) revealed the 2000 year class had a greater growth rate than did the 1997 and 1998 year class (ANCOVA; $P < 0.01$). Mean W_r for the 1997 and 1998 year classes rose from the time of stocking until June–July and then declined into late fall (Fig. 7). Mean W_r of the 2000-year class rose until into June, remained there until August, and then declined into late fall. Mean late fall W_r was highest in 2000, followed by 1998, and then 1997 ($P < 0.001$).

Growth Beyond Year One

Age-2 growth-per-month of brown trout stocked at stock-size (calculated for 1997, 1998, and 1999 year-classes) was significantly higher for the 1997-year class ($P \leq 0.01$) (Table 3). There was no difference between age-2 growth-per-month of the 1998 and 1999-year classes or between age-3 growth-per-month of the 1997 and 1998 year-classes ($P > 0.10$)

Table 2. Yearly change-in-ratio population estimates taken in June 1998 and 2000. Approximate 95% confidence intervals (CI) and their percentage of the estimate are also shown.

	1998			2000		
Size class	Estimate	95‰ CI	% (CI / pop. estimate)	Estimate	95‰ CI	% (CI / pop. estimate)
Total brown trout	38,849	6,224	16	47,668	10,288	22
Brown trout 381–457 mm	2,676	1,118	42	2,362	1,479	63
Brown trout 458–508 mm	642	530	83	2,577	1,550	60
Brown trout > 508 mm	321	372	116	4,294	2,053	48

Table 3. Monthly and annual growth summary for brown trout stocked at catchable size and collected by electrofishing in mid-November from Lake Cumberland tailwater. Standard errors are in parentheses. Total lengths were measured to the nearest mm and weights measured to the nearest g.

Year stocked	Sample year	Age	Statistic	Size at stocking	Average size in November	Growth per month	Growth per year
1997	1997	2	total length	191 (2)	287 (1)	13[a]	
			weight	N/A	209.8 (4.4)		
	1998	3	total length		403 (7)	10	120
			weight		695.5 (36.7)	40.5	486.0
	1999	4	total length		471 (5)	6	72
			weight		1056.2 (55.4)	30.1	361.2
	2000	5	total length		524 (6)	5	60
			weight		1613.4 (54.0)	46.4	556.8
1998	1998	2	total length	209 (2)	295 (2)	12[a]	
			weight	104.5 (3.1)	266.6 (8.3)	23.2[a]	
	1999	3	total length		373 (7)	7	84
			weight		545.2 (34.3)	23.2	278.4
	2000	4	total length		437 (9)	5	60
			weight		1069.5 (45.5)	43.7	524.4
1999	1999	2	total length	207 (2)	298 (2)	12[a]	
			weight	107.8 (2.8)	249.3 (4.5)	19.2[a]	
	2000	3	total length		378 (3)	7	84
			weight		656.6 (19.1)	33.9	406.8
2000	2000	2	total length	178 (1)	312 (2)	18[b]	
			weight	66.5 (1.5)	341.6 (6.1)	37.0[b]	

a. April to mid-November.

b. April to end of October.

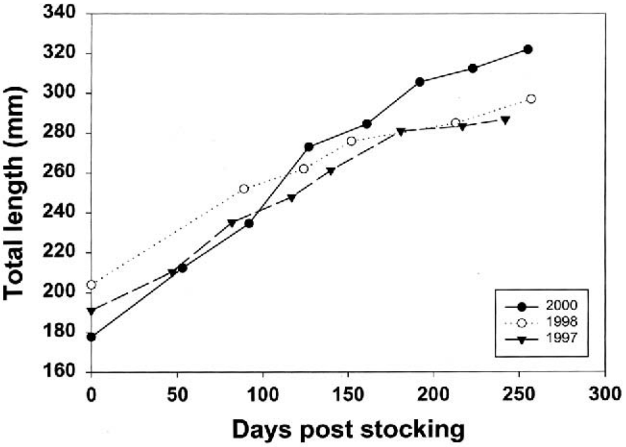

Figure 6. Catchable-size brown trout length at days post stocking collected monthly form Site 3, 1997, 1998, and 2000. Lengths represent stocked brown trout only.

Discussion

The effectiveness of the trophy brown trout regulation on the Cumberland tailwater can be assessed in 2 ways. The first is to take a whole system approach across the entire study reach. When this method is used, we see that there was a significant increase in brown trout CPUE across years for all size-classes. Further analysis of differences among sample years shows that the time required to detect significant differences in CPUE may be prolonged due to growth rates. The larger the size-class you are interested in, the longer it will take to see an increase in CPUE due to the length of time it takes fish to reach that size. In our case, it took approximately 4 years to see a significant increase in the trophy brown trout densities and 3 years to begin to see changes in densities of the 458–508 mm size-class. At this time, we must be cautious with our conclusions since significant changes in trophy brown trout CPUE have only been documented for one year. We are, however, fairly confident that the increase in trophy brown trout CPUE seen in 2000 reflects the effectiveness of the new regulation. Future increases in CPUE of trophy brown trout appear likely, as increases seen in 1999 and 2000 of the 458–508 mm size-class should eventually enter the trophy size-class barring excessive natural or fishing mortality. Additional years of data will provide a clearer view of any long-term trends.

Densities of smaller size-classes such as the 381–457 mm group may not accurately predict future densities of trophy brown trout. Brown trout in the Cumberland tailwater quickly grew through the smaller size-class with little or no accumulation of multiple year-classes taking place. Densities of brown trout in this size-class will be influenced to a greater degree by yearly changes in first year survival and growth.

Change-in-ratio population estimates made in 1998 and 2000 reflect increases seen in CPUE during our fall night sampling. Variability (95% CI) in both estimates was not excessively high (16% and 21.6% of the estimate). Total number of brown

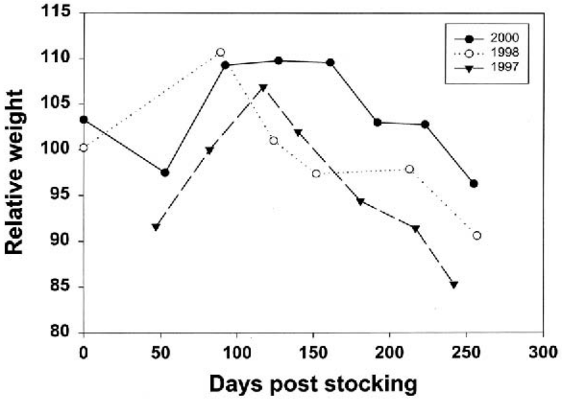

Figure 7. Catchable-size brown trout relative weight at days post stocking collected monthly from Site 3, 1997, 1998, and 2000. Relative weight represents stocked brown trout only.

trout, brown trout 381–457 mm, brown trout 458–508 mm and brown trout >508 mm all increased between 1998 and 2000.

First year growth rates through November in the tailwater were similar in comparison to other tailwaters in the United States and ranged from 12 mm/month in 1998 to 18 mm/month in 2000. Brown trout growth rates in other tailwaters were as follows: Missouri River, Montana (9 mm/month); White River, Arkansas (17 mm/month); Clinch River, Tennessee (12 mm/month); Caney Fork River, Tennessee (8 mm/month); and South Fork of Holston River, Tennessee (11 mm/month) (Betolli et al. 1999). In this study, growth was determined from brown trout stocked at stock-size. Fingerling-stocked brown trout growth rates were not presented in this study due to low presence of these fish in our samples. The exact reasons for this are unknown but might include high predation by large brown trout and striped bass and/or competition for habitat and food by an already well-established trout population.

With an increasing density of all sizes of brown trout in 2000, one might expect to see a consequential decrease in growth rates (Weiland and Hayward 1997, Wiley et al. 1993). A decrease in growth rates will result in a longer time (and older age) required to reach 508 mm. This will allow natural mortality to play a greater role in the success of these fish in reaching trophy size. When looking at data from 1997–2000, second year growth in the tailwater was highest in 1997. First year growth in the tailwater, however, was highest in 2000. This was also the year class with the highest densities in fall. These fish were stocked at a smaller size than other study years, but reached a larger size by fall. Condition of these fish was also very good going into winter (W_r = 96), and was higher than both 1997 and 1998 brown trout stocks. It appears that under favorable conditions, the Cumberland tailwater has the ability to support an even greater stocking density of stock-size brown trout. Favorable conditions would include stable flow, adequate dissolved oxygen levels, and temperatures below 21 C. Such conditions would improve habitat for brown trout, aquatic invertebrates, and other forage species. Potential habitat improvements, including pulsing of discharge and addition of aeration baffles, were initiated in 2000 and may have played a role in the high growth rates of stock-size brown trout seen in that year. Improved water level stabilization through pulsing could prevent some stranding and flushing of invertebrates within the tailwater. Such stabilization has been found to benefit invertebrate production and usable habitat in a tailwater system (Jacobs et at. 1987, Walburg et al. 1981). The effect of these improvements, along with increasing total brown trout densities, on growth rates of the larger brown trout will have to be closely monitored.

The effectiveness of the trophy brown trout regulation can also be assessed on a site-by-site basis. In this case, the tailwater is assessed in segments. Brown trout densities in the Cumberland tailwater were variable between individual sites each year. The general trend, however, was for the lower sites (usually Sites 3 and 4) to produce higher densities of brown trout than the upper sites (Sites 1 and 2). Several reasons may exist for disparity between sites. Sites 1 and 2 had no upstream stocking sites, while Sites 3 and 4 were located centrally to all stocking sites. These centrally located sites may have reaped the benefits of both upstream and downstream movement of brown trout. Preferred habitat along with greater forage availability may also have allowed for higher densities of brown trout at the lower sites. Specific substrate size within riffles can limit invertebrate production in tailwaters (Pfitzer 1954). Competition with other trout species could result in spatial density differences. In the Cumberland tailwater, rainbow trout stocking densities are higher in the reach just below the dam and may have influenced brown trout densities in the upper sample sites.

Differences in angling pressure between upper and lower sites could also affect brown trout densities. A creel of anglers on the Cumberland tailwater in 1995 showed that angler pressure in the 7.2 km of the tailwater nearest the dam was substantially higher (39,134 hours/km) than the 54.3 km immediately below that point (7,600 hours/km) (Kosa 1999). In addition, relatively few brown trout were harvested in the lower reach. This may be because the majority of boat ramp access sites are located in the upper reach.

Higher angling pressure also may lead to increased hooking mortality. While hooking mortality for trout species was found to average only 5% for artificial lures and flies, it can be as high as 25%–50% for natural baits (Mongillo 1984, Wydoski 1977). In the Cumberland tailwater, still fishing (primarily with natural bait) represented 79% of the total fishing pressure in the upper reach, whereas it only comprised 52% in the lower reach (Kosa 1999). The decision to move brown trout stocking sites away from the dam, and subsequently away from the highest fishing pressure, most likely benefited total brown trout numbers in the lower tailwater.

Water temperature most likely did not play an important role in brown trout density differences between sites. Water temperatures have ranged from 3.6 to 17.4°C seasonally within the study reach and only differ by a few degrees Celsius between upper and lower sample sites.

The variability in brown trout densities among sites has important management implications. The fact that one site might react differently than another may necessitate different stocking regimes. Stocking numbers could be increased for sites that tend to provide higher brown trout carrying capacities. In addition, spatial regulations such as catch-and-release zones might be established on stretches of tailwater with the greatest carrying capacity and growth potential.

This study has shown that trophy regulations can positively alter brown trout size structure within the Cumberland tailwater. Detection of such changes, however, will require several years of monitoring. In the current study, variability in sampling, environmental conditions, and growth rates delayed detection of significant changes in brown trout size structure for several years. Judgment of regulation changes affecting brown trout size structure within a tailwater system should be made only after a sufficient number of monitoring years have elapsed to account for such variability.

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