Low Intensity Supplemental Feeding of a Wild Stream-dwelling Rainbow Trout Population

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Abstract: The objectives of this study were to evaluate the biological impacts and cost effectiveness of a low intensity supplemental feeding program on a wild rainbow trout (*Oncorhynchus mykiss*) population. Using volunteers to distribute feed at predetermined amounts and frequencies, wild trout population densities, standing crops, and length-frequencies were monitored for 18 months on Looking Glass Creek near Brevard, North Carolina. A priori success criteria included an increase of 60 fish/km >254 mm and a cost to produce each trout >254 mm <$5.00. Both densities and standing crops of rainbow trout >100 mm increased significantly following 18 months of feeding. The number of rainbow trout >254 mm increased by an estimated 110 fish/km after 6 months and to 315/km after 18 months, excluding harvested fish. Each fish was estimated to cost $3.44 to produce. Supplemental feeding of wild trout populations is a viable management option that can be used to enhance wild trout growth.

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Researchers and fishery managers have been interested in trout stream productivity and its influence on resident trout populations since the 1940s. In many cases their objective has been to increase trout production. Huntsman (1948) observed that numbers of fish generally increased in streams flowing through farmlands when compared to those in non-farmlands. Ellis and Gowing (1957) found lower and more variable condition of brown trout (*Salmo trutta*) above a domestic sewage outfall than below the outfall in a Michigan stream. In a stream enriched with sucrose, Warren et al. (1964) determined food consumption by trout increased about 2-fold and overall trout production increased 7-fold compared to untreated areas. More recently, Slaney et al. (1986) found adding ammonium phosphate and ammonium nitrate to a nutrient-deficient stream appeared to increase survival and growth of steelhead smolt and parr.

Whereas these studies show trout production is increased indirectly by increasing the basic fertility of trout streams, other studies have tested the feasibility of direct enhancement of trout growth through supplemental feeding (Anonymous 1968, England and Fatora 1974, Borawa et al. 1995). England and Fatora (1974) demonstrated that under restricted harvest and effort, stocked and wild trout that were supplementally fed grew to >500 mm. Under moderately liberal harvest regulations (4 fish daily creel limit, 178 mm minimum length limit), Borawa et al. (1995) produced rainbow trout densities ≥200% higher in intensively fed sections compared to unfed sections. Trout up to 500 mm were produced in study streams where few trout >254 mm were found prior to feeding. However, because mechanical feeders and paid labor were used, each trout >254 mm was estimated to cost $12.50–$30.00 more to produce than comparable-length, hatchery-reared trout ($1.69 each). These high costs made such a program impractical for public waters. Borawa et al. (1995) also recognized that using volunteers to distribute feed and reduced feeding levels were potential methods of lowering agency costs sufficiently to make supplemental feeding a practical management option.

The objectives of this study were to evaluate the changes in fish population characteristics and cost effectiveness of a low intensity supplemental feed program on a wild stream-dwelling rainbow trout population.

This was a cooperative study of the North Carolina Wildlife Resources Commission (NCWRC) and Pisgah Chapter of Trout Unlimited (PCTU). I thank the PCTU members who assisted with feeding and fish population monitoring. Tim Lauffer of PCTU is specially commended for his effort in ensuring the feeding schedule was maintained and for coordinating chapter member participation in the project. Dr. Kevin O'Brien of East Carolina University is also thanked for his assistance with the statistical analysis. This project was partially funded under Federal Aid in Sport Fish Restoration Project F-24 of NCWRC.

Methods

The study was completed on a 1,582-m section of Looking Glass Creek beginning approximately 50 m above Looking Glass Falls near Brevard, North Carolina. Rainbow trout were the only game fish found within this reach. Harvest was limited by a 4 fish ≥ 178 mm daily creel limit and terminal tackle restricted to single-hook artificial lures.

Fish Population Monitoring

Fifteen feeding stations were established at approximately 100-m intervals and a sixteenth at the study reach's upper end (82 m). Each 100-m section between feeding stations was considered a fish population monitoring sample site. The 15 100-m sections were divided into 3 groups of 5 sampling sites. One fish sample site was randomly selected from each group; all 3 sites were sampled in April (spring) and November (fall) of 1996, and May (spring) and October–November (fall) of 1997. The surface area of each sample site was determined in April 1996 by multiplying the mean of widths taken at 10-m intervals and total site length. One backpack electrofishing unit was used for each 3 m, or portion thereof, of average stream width. At site 2 in November 1997 only 3 units were used instead of 4. Block nets were installed at both ends of each sample site to prevent movement of fish into or out of the area during sampling. Three-pass depletion sampling was conducted in an upstream direction (Armour et al. 1983). Total length in millimeters and weight in grams were recorded for each trout captured.

Fish Feeding

Floating trout feed consisting of 3.2-mm pellets was fed at a 4% daily ration based on the pre-study estimated 33.1 kg of trout present in the entire study reach. The total weekly ration (0.04×33.1 kg $\times 7$ days = 9.1 kg) was calculated and arbitrarily doubled to 18.2 kg to account for loss of feed to eddy areas. Feeding began in May 1996. One-half the weekly feed allotment was premeasured at the Pisgah Forest Fish Hatchery by PCTU members. The 9.1 kg of feed was equally distributed daily over all feeding stations during the first 10 days of the program to acclimate the fish to receiving feed. After the training period, the same amount of feed was distributed on 1 weekend day at odd-numbered stations and Tuesday, Wednesday, or Thursday at even-numbered stations each week. During December, January, and February, the weekly ration was dispersed 1 time per week, weather permitting, and equally distributed from all 16 feeding stations.

Data Analysis

Pre- and post-feeding fish population densities (*N*/ha) and standing crops (kg/ha) were estimated using outputs of Microfish 3.0 (Van Deventer and Platts 1989) and the April 1996 sample site area estimates. Numbers of rainbow trout >254 mm within the entire study reach in spring and fall 1996 and fall 1997 were estimated by proportionately expanding the number of fish captured in the 3 sample sites.

Length-frequency distributions of rainbow trout were plotted for each group of population samples. The pre-feeding, spring 1996 length-frequency distribution of rainbow trout >100 mm was compared to post-feeding distributions using individual fish lengths in Kolmogorov-Smirnov (KS) tests (Sokal and Rohlf 1981). Statistical differences in pre-feeding spring 1996 and fall 1997 densities and standing crops of rainbow trout >100 mm were computed using 1-sided paired *t*-tests. Tests were carried out at the $\alpha = 0.10$ significance level.

The direct NCWRC cost to produce rainbow trout >254 mm was calculated by dividing total feed costs by the change in number of fish of that length present prior to feeding and on 1 November 1997.

Success Criteria

An immediate objective of the NCWRC and PCTU study was to improve the rainbow trout length distribution by fall 1996 or the feeding would be terminated. A priori feeding treatment success criteria included: 1) an increase in the number of trout >254 mm by 60/km, and 2) to have direct NCWRC cost per fish >254 mm produced <$5.00.

Results and Discussion

Fish Population Monitoring

All fish population samples were collected as planned, except in November 1996 when, because of rain, only 1 of 3 sites was sampled. Densities and standing crops (Fig. 1) showed similar trends throughout the study. Both densities ($P = 0.08$) and

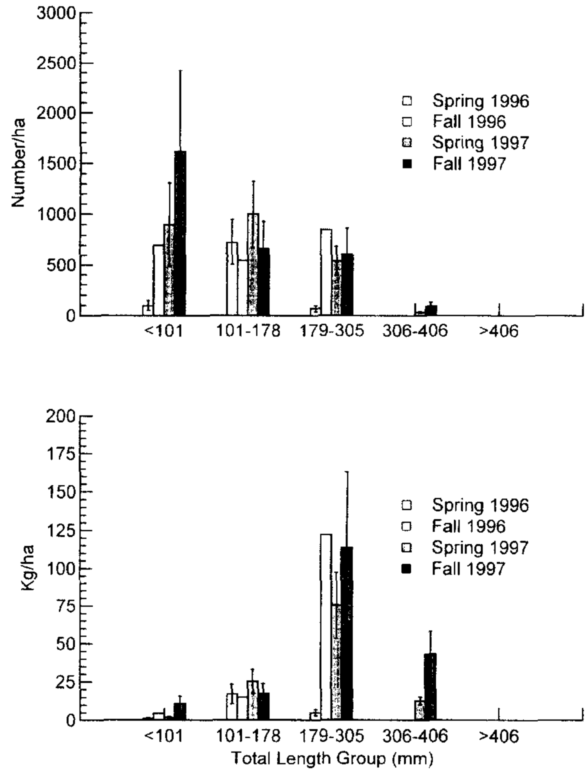

Figure 1. Looking Glass Creek wild rainbow trout densities and standing crops by length group prior to (spring 1996) and after (fall 1996, spring and fall 1997) initiation of a supplemental feeding program ($N = 3$ for each sample, except $N = 1$ for fall 1996). SE of the means are depicted by vertical lines.

standing crops ($P = 0.04$) of rainbow trout >100 mm were significantly greater in November 1997 compared to April 1996. It appears the improved food availability not only increased fish growth, but also may have increased survival of fish. The increases in both densities and standing crops are easily explained by the increases of larger length fish groups (Fig. 2). While legal-length size groups of rainbow trout (179–305 mm and 306–406 mm) showed ≥10-fold increases in both densities and standing crops, fish in the 101–178-mm length group did not show major changes. Although the pelleted feed was manufactured for fish >100 mm, these results suggest larger fish may outcompete smaller fish for feed. As a result, the group of smaller fish (101–178 mm) did not appear to benefit from the feeding program. The density of rainbow trout 306–406 mm continued to increase through fall 1997 (Fig. 1) indicating fish > 406 mm would be produced after the conclusion of the study. These results are similar to those previously found for Looking Glass Creek by Borawa et al. (1995).

The apparent increase of y-o-y rainbow trout produced in 1997 compared to 1996 is explained by differences in sampling dates (Fig. 1). Spring 1997 samples

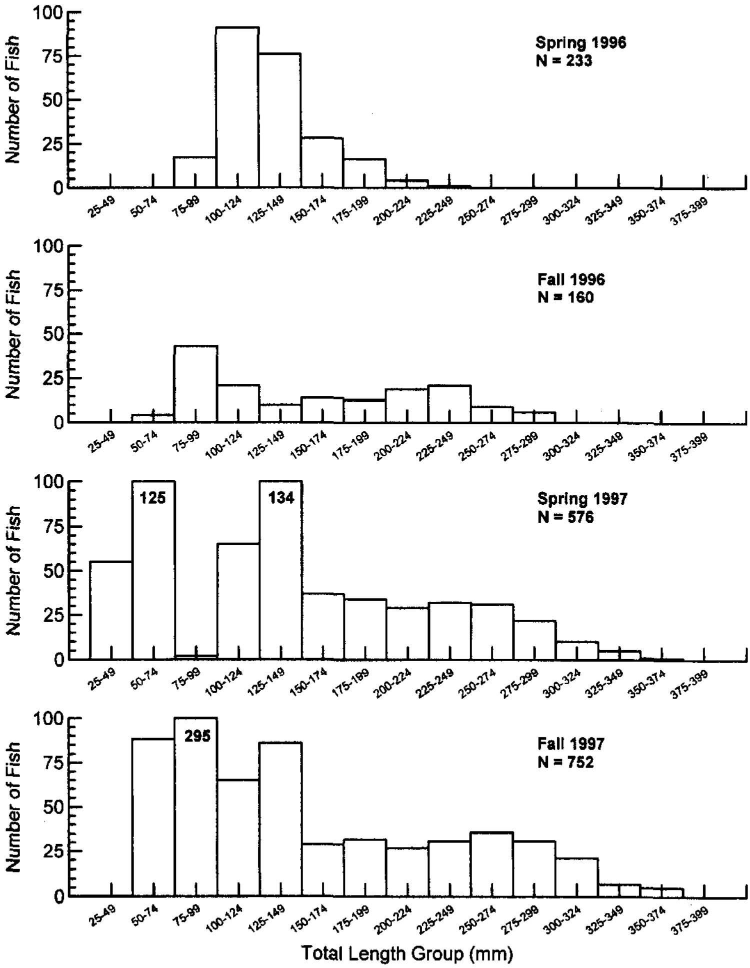

Figure 2. Looking Glass Creek rainbow trout length-frequency distributions prior to (spring 1996) and after (fall 1996, spring and fall 1997) initiation of a supplemental feeding program ($N = 3$ for all samples, except $N = 1$ for fall 1996).

were taken 7 weeks later than those of 1996 and, as a consequence, the young fish were larger and more susceptible to capture. It is possible that enhancement of the adult trout population may lead to enhanced y-o-y production. Borawa et al. (1995) found higher y-o-y densities in fed sections in fall samples, but in only 1 of 4 streams were they statistically different from control sections. Even if y-o-y production is enhanced, it doesn't appear necessary to ensure recruitment of fish to the size where they can utilize the supplemental feed. It may, however, increase the number of young fish surviving and thus reduce yearly fluctuations in densities of fish reaching 100 mm. Several years of additional sampling would be necessary to assess this effect.

An estimated 110 rainbow trout >254/km were present in the study reach by fall 1996. This exceeded the preset target of 60/km after only 6 months of feeding. This number increased to an estimated 315 fish >254 mm/km by the end of the study. This is quite remarkable considering there were few fish of this size present before feeding began and does not include trout harvested by anglers. It also reveals how trout growth in nutrient-poor systems like Looking Glass Creek can be enhanced with supplemental feeding.

The length distribution of rainbow trout shifted markedly following the start of the feeding program (Fig. 2) with fish approaching 375 mm by fall 1997. All post-feeding length-frequency distributions of fish >100 mm were significantly different from the pre-feeding distribution ($P < 0.001$ for all KS tests). The results also suggest the maximum number and size of rainbow trout that could be produced under this feeding regime had not yet been reached.

Fish Feeding

Approximately 1,526 kg of feed costing $1,719 was distributed during the study. The estimated number of rainbow trout >254 mm within the study area increased from 0 on 1 May 1996 to 449 by 1 November 1997. Thus, the direct cost to the NCWRC to produce these fish was $3.44 each. This was well below the threshold success value of $5.00/fish and was much lower than the $14.12–31.02/fish cost, including those harvested by anglers, estimated by Borawa et al. (1995) during their 3-year study. It is higher, however, than the $1.69 maximum estimated per fish cost ($0.43 for feed, $1.26 for overhead and distribution) of hatchery-reared fish (M. Martin, NCWRC, pers. commun.). While it is obviously less expensive to rear the hatchery fish, the extra $1.75/fish can be considered the intrinsic value of the fish being stream-reared. Adding the expenses incurred by the volunteers results in an even higher per fish cost, but it appears they were willing to accept those costs to have the enhanced growth of the wild trout population. The differences between stream-reared and hatchery-reared trout, whether real or perceived, may also be the reason there has been no shortage of PCTU volunteers to feed the fish. This contradicts my experience with other long-term projects dependent on volunteer participation, such as angler diary programs, where motivation to participate is difficult to maintain (Borawa 1990).

Finally, a concern about the feeding program expressed by some anglers, but not examined in this study, was the impact on the water quality of Looking Glass Creek. However, Gilliam and Cady (1997) found only subtle enriching effects on water quality during the Borawa et al. (1995) intensive feeding study and concluded little deterioration of water quality would occur at those levels. The amount of feed used on an annual basis in this study appeared comparable to Borawa et al. (1995), but the treated section was twice as long and averaged 30%–50% wider. Therefore, I expect the localized impacts of feeding on water quality should be of little concern. I do concur with Gilliam and Cady (1997), however, that at some unknown level of feeding, water quality deterioration could be expected to occur.

Conclusion

This project was successful by the predefined criteria. Supplemental feeding is an effective means to increase the number of larger wild rainbow trout in nutrient-poor streams, even where harvest is allowed. Although the fish are more expensive to grow than comparable length hatchery-reared trout, the intrinsic value of these fish being of wild stocks appears important to PCTU volunteers and a cost they are willing to accept. Considering this factor, agency costs to produce wild rainbow trout >254 mm were reduced to a level where supplemental feeding could be considered a viable management option.

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