



## Wiscoy Creek, New York; A 60-year Transition from Put-and-take Stocking to Wild Trout Management

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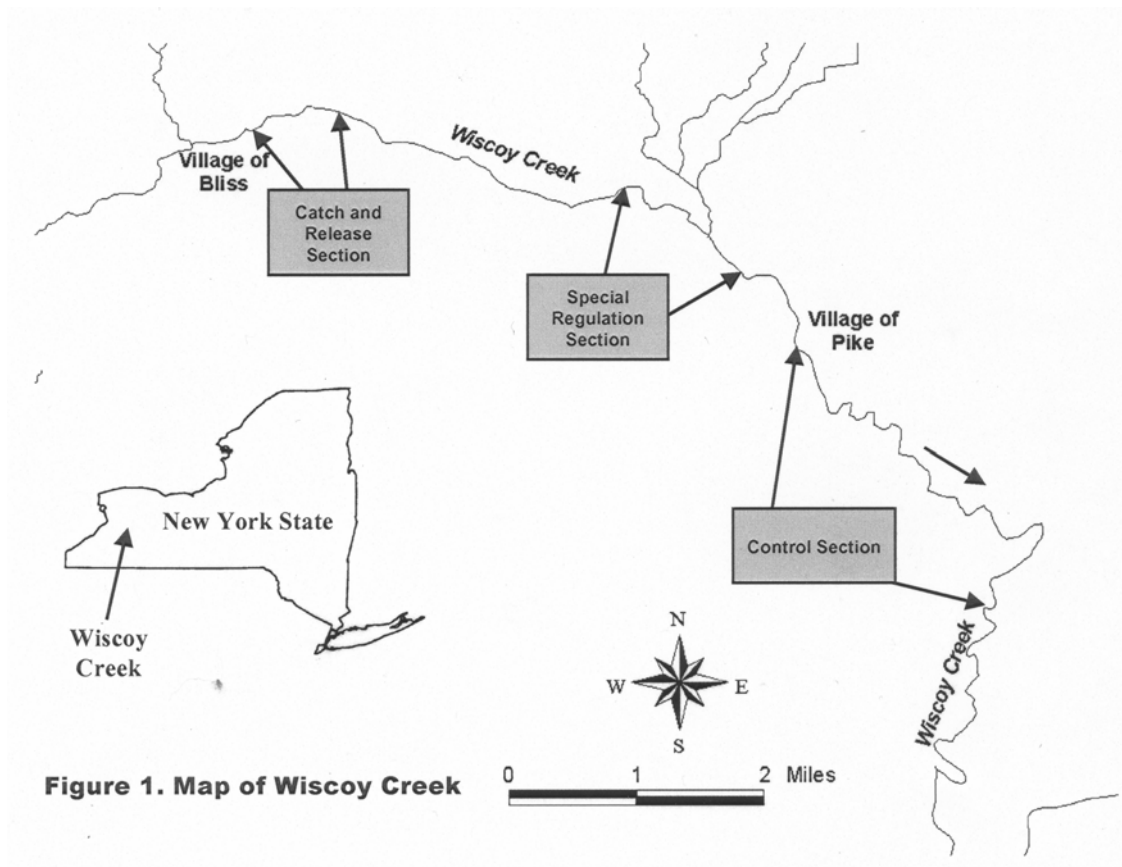
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**ABSTRACT**—Wiscoy Creek currently supports one of New York’s premier wild brown trout (*Salmo trutta*) populations. From 1940 to 2001, the stream experienced a management transition from liberal harvest strategies and high stocking levels to restrictive harvest regulations and the elimination of stocking. Surveys in 20 individual years showed the abundance of wild brown trout increased from less than 200 fish/mi to greater than 1,700 fish/mi. From 1940-1944 summer water temperatures exceeded 75° F and few wild trout were collected. By 1968, greater numbers of wild trout were present. To maximize the contribution of wild trout, a special regulation section was established and hatchery stockings were eliminated in that section. Within three years wild trout abundance had doubled in the special regulation section, while abundance dropped in the control section. In 1994 a catch and release regulation was applied on one mile of Wiscoy Creek. By 2001, wild brown trout abundance averaged 1,707 fish/mi, with some stations in the catch and release section supporting over 3,000 fish/mi. Several factors likely contributed to the increased abundance of wild trout: improvements in water quality, decreased summer water temperatures, cessation of stocking, restrictive harvest regulations, decreases in fishing pressure, and voluntary decreases in angler harvest. This paper examines the roles these factors have played in improving Wiscoy Creek’s wild trout population over the last 60 years.

### Introduction

Wiscoy Creek, located in southern Wyoming County, NY (Figure 1), supports one of the most abundant wild brown trout (*Salmo trutta*) populations in New York State (Evans and Cornett 2002). In 2001, there was an estimated average wild trout biomass of 155 lbs/ac. The stream, which has an average summer width of 30 ft and an average gradient of 35 ft/mi, flows for 22 mi before joining with the Genesee River. The upper 17 miles are considered the best trout water. Abundant spring water influence due to deep glacial gravel deposits underlying the watershed (Miller and Staubitz 1985) help to keep the stream’s temperature in the optimum range for brown trout growth and survival (Bachman 1991). Wiscoy Creek is a highly productive stream (specific conductivity: 360-390  $\mu\text{mho/cm}$ ) flowing through a mixture of agricultural and forested landscapes. Stream flows in the late summer average 30 cfs. Wiscoy Creek is located approximately an hours drive from the cities of Buffalo and Rochester. The stream is popular with anglers from across western New York, supporting an estimated 4,380 angler days per year (Evans and Cornett 1998).

Brook trout (*Salvelinus fontinalis*) were the native trout species in Wiscoy Creek. They are still encountered occasionally in the stream’s upper section and in several tributaries. When the area was originally settled, brook trout populations declined significantly due to the clearing of surrounding forests, elevated stream temperatures, water pollution from local dairy processing plants



**Figure 1. Map of Wiscoy Creek**

and possibly from competition with brown trout. The earliest stocking records for Wiscoy Creek indicate brown trout fingerlings were first stocked in 1889.

New York State began purchasing Public Fishing Rights Easements in 1936, which allowed anglers to access the bed and banks of trout streams. The first such easements were purchased in 1936 on Wiscoy Creek and a major tributary, East Koy Creek. Today over 12 mi of Wiscoy Creek and 13 mi of tributaries are permanently open to anglers because of these easements.

Trout populations in Wiscoy Creek have been intensively studied over four main time periods: 1940-1944, 1966-1974, 1978-1981 and 1988-2001. Angler-use studies have also been conducted in the 1966-1974 and 1988-2001 time periods. Since 1966 several management regimes utilizing different sets of fishing regulations and trout stocking policies have occurred on Wiscoy Creek. Major changes occurred in 1968 when an artificial lure only, 12 in size limit, 3 trout/day section was established, in 1972 when all stocking of hatchery trout in the study section ceased, and in 1994 when a catch and release section was established. Table 1 lists the regulation and stocking history for several time periods from 1966 through the present.

**Table 1. Wiscoy Creek fishing regulations and trout stocking, 1966-2004.**

<b>Time Period</b>	<b>Regulations and stocking</b>
1966-1967	Entire stream: No size limit, 10/day, 10 miles stocked with 15,500 brown trout yearlings.
1968-1971	Special reg section: 12" size limit, 3/day, art. lures only. Rest of stream: no size limit, 10/day. Special regulations section not stocked.
1972-1977	Special regulations section: 10" size limit, 5/day, art. lures only. Rest of stream: no size limit, 10/day. Stocking removed on all study sections.
1978-1981	Special regulations section: 10" size limit, 5/day, art. lures only. Rest of stream: 9" size limit, 5/day. No stocking.
1982-1993	Special regulations section: 10" size limit, 3/day, art. lures only. Rest of stream: 10" size limit, 3/day. No stocking.
1994-2004	Special regulations section removed in 1994. New catch and release section established in 1994. Rest of stream: 10" size limit, 3/day. No stocking.

## Methods

Changes in the Wiscoy Creek brown trout population and fishery were examined by searching New York State Department of Environmental Conservation file data and sampling reports. Surveys in the 1940-1944 period utilized both angler catch data (1943 and 1944) and electrofishing data (1940 and 1941). The exact methodology for surveys in this time period could not be ascertained. However, for the purposes of this project, trout population estimates are assumed to be valid. The primary reason for the 1940-1944 study was to assess the values of different stocking regimes and techniques on angler catch. Values of angler pressure were not collected.

Data from the 1966-1974 time period included both angler contact surveys in 1966, 1972, and 1974, and electrofishing data in eight of the nine years. Data from the 1978-1981 period included electrofishing surveys for all four years, with no angler contact data. Surveys in the 1988-2001 time period included electrofishing in four years, an angler contact survey in 1997, and angler diary programs in 1997 and 2001. Electrofishing in all surveys from 1966-2001 utilized two pass population removal methodology (Ricker 1975, Van Deventer and Platts 1989). The exact location of sampling sites varied over time. Population estimates stated for trout throughout the rest of this report are for yearling and older trout, as no attempt was made to estimate young-of-year populations.

## Results

### 1940-44

In August of 1940 and 1941, biologists utilized electrofishing to sample trout populations at five sites in the mid to lower Wyoming County sections of the stream, near the Village of Pike. Sampling both years indicated that there were about 500 brown trout/mi of stream, however researchers did not determine what percentage of these fish were of wild origin (Heacox 1943). Angler creel surveys conducted in 1943 and 1944 determined that about 90% of the trout caught by anglers were fin-clipped hatchery fish (Heacox 1944). Since hatchery brown trout can be as much as four times more catchable by anglers than wild brown

trout (Engstromg-Heg and Hulbert 1982), the 10% wild brown trout component for the recreational fishery may have reflected an actual abundance of 50/mi to 200/mi for wild brown trout.

### 1966-74

Electrofishing in 1966 occurred in both public and posted sections of streams with estimates for trout numbers roughly 2-3 times as high in the posted unstocked sections (Pomeroy 1975). Eight electrofishing sites were established beginning in 1968, four in the special regulation section and four downstream of the Village of Pike (referred to as the control section) (Figure 1). In 1966 there were an estimated 248 wild brown trout/mile in the control section and 341 wild brown trout/mi in what would become the special regulation section. By 1971, the estimated number of wild brown trout in the control section was 192/mi, while the estimated population in the special regulation section had increased to 701 wild brown trout/mi. The average estimated number of wild brown trout in the control section from 1972-1974 was 419/mi, while the estimated number in the special regulations section for that time period was 669 trout/mi (Table 2) (Pomeroy 1975). Based on the three years in which angler contact surveys were conducted in this time period, angler use dropped considerably. The estimated pressure in 1966 was 966 hrs/ac. In 1972, pressure was estimated at 461 hrs/ac and in 1974 it was estimated at 479 hrs/ac (Pomeroy 1975).

**Table 2. Wild brown trout population (number/mi) estimates for yearling and older fish in Wiscoy Creek, 1940-2001.**

Year (s)	Control section	Special regulation section <sup>1</sup>	Catch and release section <sup>2</sup>
1940-41	50 to 200	---	---
1966	248	341	---
1968	240	545	---
1969	354	607	---
1970	201	549	---
1971	192	701	---
1972	217	406	---
1973	421	683	---
1974	619	918	---
1978	315	629	---
1979	276	459	---
1980	476	650	---
1981	421	---	---
1988	1,680	1,570	---
1991	1,515	1,601	---
1992	---	---	1,609
1993	---	---	2,478
1997	850	886	2,686
2001	1,256	1,452	2,897

<sup>1</sup> Regulation section established in 1968 and removed in 1994.

<sup>2</sup> Catch and release section established in 1994.

### 1978-81

Stocking of hatchery trout in the section studied ceased in 1972, thus subsequent estimated trout populations studied in the remainder of this report can be assumed to be fish of wild origin. In 1978, the special regulation section had an estimated average of 629 brown trout/mi, while the control section averaged 315 brown trout/mi. The special regulation section in 1979 had an estimated average of 459 brown trout/mi and the control section had an average of 276 brown trout/mi. By 1980, the special regulation section average had increased to 650 brown trout/mi, while the control section had also increased with an average of 476 brown trout/mi. The 1981 estimate for the control section was 421 brown trout/mi (Table 2) (NYS DEC file data).

### 1988- 2001

In 1988, seven electrofishing sites, roughly corresponding to the sites sampled in 1968-1974 and 1978-1980, were sampled. The average estimated number of brown trout in the control section was 1,680/mi and in the special regulation section the estimated number was 1,570/mi (Table 2) (Evans 1990).

Eight electrofishing sites were used in the 1991 sampling, with three sites located in the special regulation section and five in the control section. The average estimated number of brown trout in the control section was 1,515/mi and the average number in the special regulation section was 1,601 brown trout/mi (Table 2) (Evans 1992). In 1992 and 1993, two sites in what would become the catch and release section were electrofished. The average number of brown trout/mi in this section was estimated to be 1,609/mi in 1992 and 2,478 in 1993 (Table 2) (Evans 1995).

In 1997, six electrofishing sites were sampled in the former study sections and two sites were sampled in the new catch and release section. In the control section the average estimated number of brown trout was 850/mi and the average number for the former special regulation section was 886 brown trout/mi. In the catch and release section, there were an average estimated 2,686 brown trout/mi (Table 2) (Evans and Cornett 1998). An angler contact survey, conducted from April through June, was completed in 1997. This survey showed there were an estimated 4,380 angler days (355 hrs/ac) on Wiscoy Creek for the 1997 season. The average angler catch rate was 0.70 trout/hr. In 1997, angler diarists reported making 411 trips, catching 1,600 brown trout, for an average catch rate of 1.27 trout/hr (Evans and Cornett 1998).

Five sites were electrofished in the control section in 2001, while one site was surveyed in the former special regulation section. Two sites were sampled in the catch and release section. The average estimated number of brown trout was 2,897/mi in the catch and release section. In the control section there were an average of 1,256 brown trout/mi and at the site in the former special regulation section there were an estimated 1,452 brown trout/mi (Table 2). In 2001, angler diarists reported an average catch rate of 1.20 trout/hr (Evans and Cornett 2002).

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## Discussion

The 1940-1944 sampling indicated that Wiscoy Creek was a heavily stocked, heavily harvested stream. Wild trout were uncommon, likely due to high water temperatures, which reached the upper 70's °F. Fish species indicative of warm water such as creek chub (*Semotilus atromaculatus*), central stoneroller (*Campostoma anomalum*), and redbreast dace (*Clinostomus elongatus*) were

abundant (Heacox 1944). The Wiscoy Creek watershed was being intensively farmed, with the pasturing of cattle in riparian areas a common practice. Riparian vegetation and stream shading were limited. Water withdrawal for irrigation may also have been impacting trout populations at this time.

By 1966, electrofishing results indicated that wild trout populations were much higher in private, unstocked, lightly fished sections of the stream than in the stocked, public water. Fishing pressure was relatively high at over 900 hrs/ac. Through the application of restrictive fishing regulations, biologists hoped to maximize the Wiscoy Creek wild trout fishery (Pomeroy 1975). In 1968, a one mile long section of the stream was restricted to artificial lures only, with a 12 inch minimum size limit and a creel limit of 3 trout/day. The special regulation section was no longer stocked with trout. By 1971, the numbers of wild trout had doubled in the special regulation section to more than 600/mi, while abundance had declined in the lower, control section. Pomeroy (1975) attributed the doubling of trout in the special regulation section to allowing more trout to reach reproductive age. All trout stocking in the study section of Wiscoy Creek was removed after 1971. With the removal of stocking, fishing pressure dropped to under 500 hrs/ac by 1974.

From 1978-1981, there was an increase in the number of wild brown trout in the control section, while the numbers in the special regulation section remained steady. There was also a large increase in populations of non-trout (primarily white sucker, *Catostomus commersoni*) in the control section. Pomeroy (1979) speculated that prior to 1978, the use of copper sulfate in several large ponds adjacent to the stream but upstream of the control sampling section had a detrimental effect on insect and fish populations. In addition, the amount of Wiscoy Creek water diverted through these ponds decreased substantially after 1980, likely improving water temperatures (Evans 1990).

Beginning in 1982 and continuing to the present, the Wyoming County section of Wiscoy Creek (including the control section) was regulated with a 10 inch minimum size limit, 3 trout/day creel limit, with no lure or bait restrictions. From 1982 to 1994, the one-mile long special regulation section retained the same size and creel limits with only artificial lures allowed.

The 1988 electrofishing survey showed large changes in the Wiscoy Creek wild brown trout population. Estimated numbers of brown trout in the special regulation section had increased to 1,570/mi and the population in the control section increased to 1,680/mi (Evans 1990). These increases were confirmed in 1991, with an estimated 1,601 brown trout/mi in the special regulation section and 1,515/mi in the control section (Evans 1992). It is unlikely that these increases could be explained by regulation changes. In 1980, both sections had five trout/day creel limits, with the special regulation section having a 10 inch size limit and the control section a 9 inch size limit. By 1988, both sections had 10 inch size limits and 3 trout/day creel limits. Modest differences in fishing regulations between 1981 and 1988 would not be expected to account for such a substantial increase in trout numbers.

More likely explanations for increased wild trout abundance include improved water quality, decreased water temperatures, decreases in fishing pressure, and voluntary decreases in angler harvest. While we have no direct evidence for water quality and temperature improvements on Wiscoy Creek during this time, such improvements do correspond to increasing wild trout populations on many streams across western New York (NYS DEC file data). From the 1977 to the 1988 Statewide Angler Surveys, angler use on inland trout

streams in New York dropped substantially (Connelly et al 1990, Kretser and Klatt 1981), perhaps associated with increased use of the Great Lakes salmonid fishery that is readily accessible to western New York anglers. The 1997 angler contact survey showed that angler use had dropped to almost half of what it had been in 1974 and anglers reported voluntarily releasing 72% of the legal size fish they caught (Evans and Cornett 1998). Similar high release rates have been noted for other western New York waters (Evans 1994, Evans 1998a, Evans 1998b).

Sampling in 1997 indicated that there were over 40% fewer trout in the control and former special regulation sections of Wiscoy Creek than in 1988 or 1991. Severe flooding in January 1996 eliminated much of the 1996-year class of brown trout that would have contributed to the yearling catch in 1997. Yearlings normally make up 40-50% of the Wiscoy Creek trout population. By the 2001 sampling, estimated trout numbers had rebounded to nearly those found in 1991 (Evans and Cornett 2002).

The brown trout population in the catch and release section of Wiscoy Creek has shown a steady increase from 1992-2001 surveys. Some of this increase occurred before the catch and release regulation went into effect in late 1994, perhaps as a result of more favorable water temperatures and increased trout reproduction in this section of Wiscoy Creek. The continued increase has occurred mainly through the stockpiling of age 1-3 fish. There has been an increase from 6 trout/mi to 27 trout/mi for the estimated number of fish >14 inch, but large fish are still rare in the catch and release section. This may be a function of high intraspecific competition for food and habitat, short life expectancy, out-migration of larger fish, or a combination of these causes (Evans and Cornett 2002). Barnhart and Engstrom-Heg (1984) and Thorn and Anderson (1993) reported similar age and size structures for wild brown trout in other small streams with highly restrictive harvest regulations. The trout population in the catch and release section (lying nearer the headwaters) was not affected by the January 1996 flooding, thus 1997 population estimates did not show the decreases found in the lower sections.

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## Conclusion

Wiscoy Creek's trout fishery has developed from one relying almost exclusively on hatchery trout to today's fishery based solely on wild brown trout. From 1940 to 1968, the increased abundance of wild trout was related to improvements in riparian habitat associated with changes in livestock pasturing and land use practices. From 1968 through the late 1970's, the implementation of restrictive angling regulations and the cessation of stocking hatchery trout were likely causes for improvements. Improvements in water quality, reductions in angler pressure, the voluntary release of legal size trout by anglers, and the implementation of the catch and release section have been associated with additional increases in wild trout abundance observed during the latter portion of this study.

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innovative fisheries managers who saw the potential in Wiscoy Creek's wild trout fishery and made the difficult decisions needed to accomplish that mission.

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## A Case History in Fishing Regulations in Great Smoky Mountains National Park: 1934-2004

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**ABSTRACT**—Since the establishment of Great Smoky Mountains National Park (GRSM) in 1934, managers have used nearly every regulation in the toolbox to manage salmonids. This study determined if regulations affected the age/size structure, growth, and population dynamics of wild rainbow trout populations within GRSM. The number of legal trout per km of stream ranged from 215-885 throughout the 70 year study period regardless of regulation. There were no statistical differences in trout relative stock densities (RSD) on Little River between the 1930's, 1950's, 1980's and 1990's, despite liberal regulations prior to 1960. Rainbow trout mean length at age data indicate no differences among populations for age-1 to age-4 trout. There was no statistical difference between age-1 to age-4 trout collected in 1945 and 1993. Water quality data indicate GRSM streams are naturally acidic and infertile which results in populations that exhibit fast growth and high annual mortality rates. Regulations provided no discernable effect on wild rainbow trout populations in GRSM. Most regulations were put in place for social reasons and were never evaluated over long-term periods (>5 years). Abiotic events (i.e. droughts and floods) have a much greater effect on salmonid abundance in GRSM than regulations or fishing pressure.

### Introduction

Fishing has been a traditional recreational activity of the National Park Service system since congressional authorization of Yellowstone National Park in 1872 (Panek 1994). Every year, over 50 million Americans enjoy fishing in National Parks, one of the few consumptive resource activities available to National Park visitors (Recreational Fishery Resource Plan 1997). Fishing for salmonids is an ever popular and growing recreational activity in the United States, however, pristine coldwater habitat continues to diminish putting additional pressure on finite resources (Epifanio 2000).

Traditionally, fishing regulations for coldwater streams were generally used to protect or enhance a fishery for the benefit of various users (Noble and Jones 1999). However, National Park Service policies mandate that fishing regulations are geared towards the “protection” of native species *first* and the “enhancement” of fisheries second. Emphasis is placed on naturally reproducing populations before any resource allocations are made for angling (Jones 1984).

Fishing regulations typically play a greater role in the management of coldwater fisheries due to the low water fertility and slow growth of fishes in these unproductive areas, such as in Great Smoky Mountains National Park (GRSM) (Noble and Jones 1999). Few comparative studies of the effects of various fishing regulations as management techniques for salmonid populations exist (Power and Power 1996). Between 1934 and today, fishery managers in GRSM used a wide variety of regulations to manage salmonids. Formal reviews of these regulation changes and their effectiveness, in many cases, were never attempted. The objective of this study was to determine if various fishing

regulations were effective in enhancing or influencing salmonid age structure, size structure, growth, and population dynamics over 70 years (1934-2004). Consistent population data for native brook trout and non-native brown trout were lacking throughout the study period. Only rainbow trout data were consistently available throughout the study period, therefore, we only analyzed rainbow trout data in this study.

## Methods

A time series plot was used to evaluate rainbow trout abundance from 1938 to 2003 on similar sections of East Prong Little River. For each year, mean number of rainbow trout >178mm (7 inches) per stream km were reported. No standard deviations or raw data were available from 1938 to 1956, therefore only means were reported for all data. The data were divided into two groups (pre-1960 and post-1960) and analysis of variance (ANOVA) was used to test for differences in the mean number of legal rainbow trout per km between groups. The year 1960 was used as a break point because regulations prior to 1960 were rather liberal compared to those after 1960. Significant differences were noted at  $P < 0.05$  in all tests.

Rainbow trout size structures were compared using relative stock density (RSD) among several length categories. Traditional length categories assigned to rainbow trout (Anderson and Neumann 1996) could not be used due to the relatively small total lengths of wild rainbow trout in GRSM (*i.e.* ~80% of population <250mm or traditional “stock” size). Therefore, length categories were assigned with stock size equaling all rainbow trout >150mm. Relative stock densities (RSD’s) were then calculated for subsequent 25.4mm size classes from 178mm (current legal size) through 381mm. RSD values were compared in East Prong Little River between samples collected in the 1930’s, 1940’s, 1950’s, 1980’s and 1990’s time periods. The 1930’s, 1940’s, and 1950’s data were collected from intensive annual creel surveys on Little River during each period. In each period, the mean of two years of data (one year in 1940) were used to represent the period. RSD values were also compared between the 1985 and 1999 regulation periods on Abrams Creek. In each comparison, current data (*i.e.* 1990’s or 1999) were assigned as expected values and were compared to similar historic RSD values. Chi-square analysis was used to test for significant differences between historic and current RSD values.

Rainbow trout age structures were generated using scales samples collected from East Prong Little River in 1945 and 1993. Representative samples of the population were collected in 1945 using cresol while the 1993 data was collected using backpack electrofishing gear. Age structure distributions were compared using Chi-square analysis using the 1993 data as expected values.

Mean total lengths at capture ( $TL_c$ ) were generated for rainbow trout collected in 1942, 1945, and 1995 in East Prong Little River. Scales were used to age rainbow trout for each year. Because only mean  $TL_c$  was reported for 1942 and 1945 (no raw data), no statistical comparisons could be calculated among mean  $TL_c$  for the three time periods. Mean  $TL_c$  and standard error bars are reported for 1995 data to indicate the relationship of the 1995 data to the 1942 and 1945 data.

Rainbow trout instantaneous mortality rates ( $Z$ ) and total annual mortality rates ( $A$ ) were calculated using catch curves (Van Den Avyle and Hayward 1999). Age groups with less than five fish were excluded from the analysis.

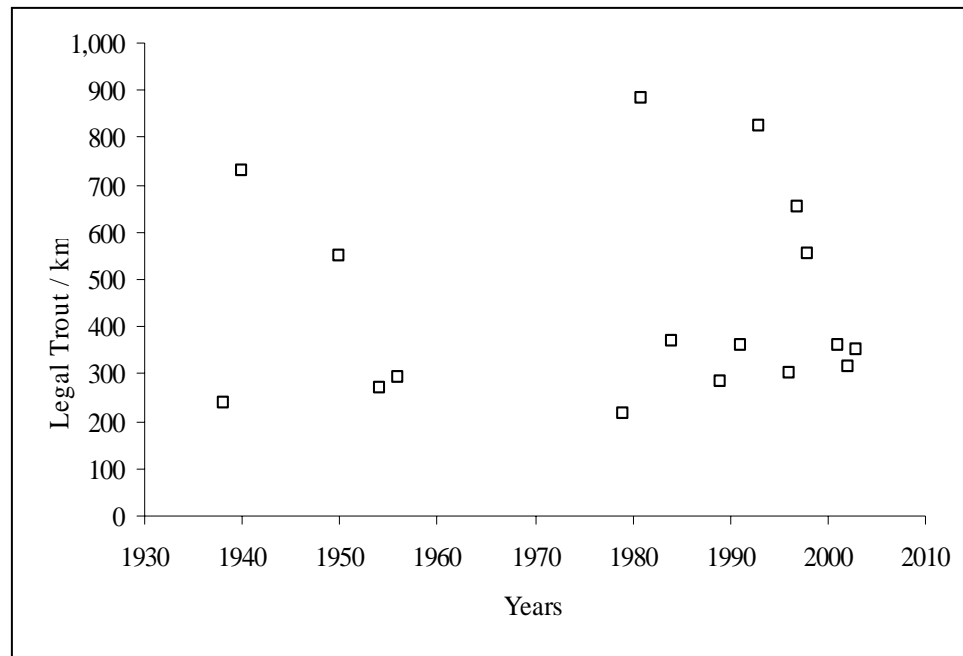
Rainbow trout total annual mortality rates from age-2 to age-4 were compared between 1957 and 1994 on Abrams Creek. Rainbow trout total annual mortality rates from age-1 to age-3 were also compared among Fish Camp Prong (1945), Little River (1996), and Sams Creek (1998). While Fish Camp Prong and Little River have always been open to fishing under given regulations of the time, Sams Creek has been closed to fishing for 28 years.

Visual implant (VI) tags were placed in all adult rainbow trout collected biannually (May & October) in standardized annual monitoring sites on East Prong Little River from 1991 to 1996. Sampling was conducted in roughly the same two months during the six year period. Scales were collected from all previously marked rainbow trout to enumerate age and record changes in total length (mm) and weight (g).

## Results

The evaluation of the effects of various fishing regulations on GRSM salmonid populations was difficult for two reasons. Although numerous publications and internal summary reports are available throughout the study period (King 1942; Holloway 1945; King and Currier 1950; Lennon 1953; Lennon 1954; Lennon and Parker 1956; Lennon and Parker 1960), historical datasets were rarely published or archived making data comparisons over time very difficult. In addition, there was little consistency among the types of data collected, areas sampled, or sampling methodologies. A second reason the evaluation of effects was difficult was that the effectiveness of regulation changes was traditionally based upon short-term evaluations (i.e. <2 years).

Despite a wide variety of regulations and heavy stocking from 1934 to today, the number of legal rainbow trout per km of Little River from 1938 to 2003 remained consistent (215-885 per km) and variation appears similar throughout the study period (Figure 1). In addition, there was no significant difference



**Figure 1.** Time series plot of the mean number of legal rainbow trout (>178mm) per km in East Prong Little River from 1938 to 2003. No standard deviations were reported from 1938 to 1956, therefore only means were reported for all data.

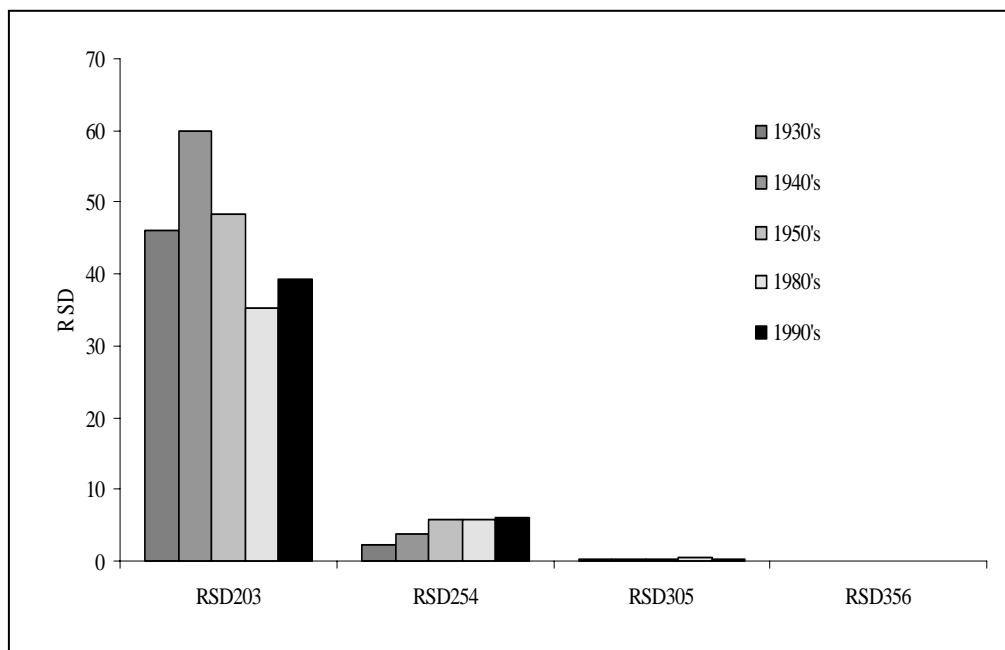
between the number of legal rainbow trout among pre-1960 and post-1960 data (df=15, p=0.73), despite the stocking of fingerlings and catchables coupled with rather liberal regulations in the pre-1960 period.

RSD values in East Prong Little River in the 1930's, 1940's, 1950's, and 1980's indicate no significant difference between the 1930's (df=3, F=3.57), 1950's (df=3, F=2.10), 1980's (df=3, F=0.73) and the 1990's (Figure 2). There was a significant difference (df=3, F=11.92) between the RSD values for East Prong Little River in the 1940's and 1990's samples. RSD value comparisons between 1985 and 1999 on Abrams Creek indicate RSD values were significantly greater in 1999 than 1985 (df=5, F=20.87, p>0.05).

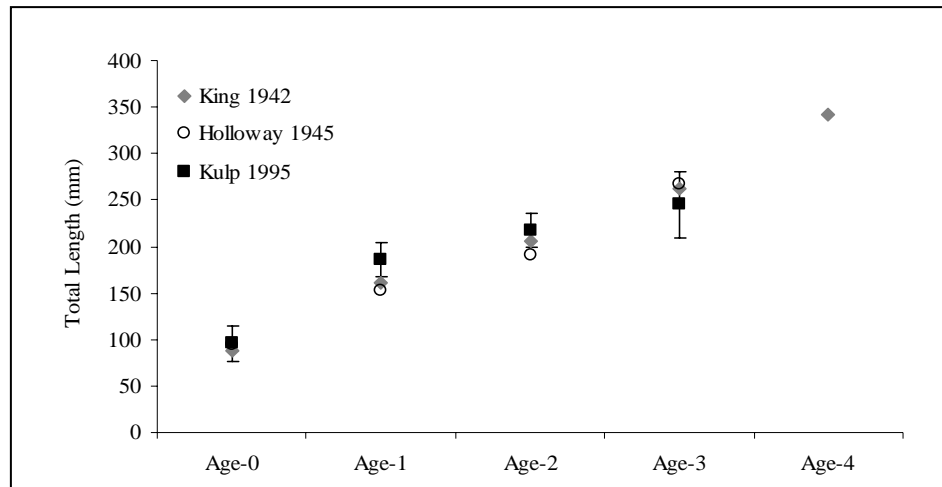
Rainbow trout age structure was compared between representative samples collected parkwide in 1945 (N=928) and in 1993 (N=107). Five age classes were represented in 1945 and four in 1993 (including age-0), with both datasets were dominated by age-1 fish (60 and 69% respectively). There were no significant differences (df=3, F=4.04) in the age structure distributions for age-1 to age-4 rainbow trout collected in 1945 and 1993.

Because only mean TL<sub>c</sub> was reported for 1942 and 1945 (no raw data), no statistical comparisons could be conducted among mean TL<sub>c</sub> for the three time periods. However, visual comparisons of the 1995 TL<sub>c</sub> standard error bars (SE) indicate the bars overlap the means for age-0 and age-3 fish in 1942 and 1945 suggesting no major differences in TL<sub>c</sub> among the three time periods (Figure 3). In addition, the mean TL<sub>c</sub> for age-1 and age-2 fish in 1942 and 1945 are extremely close the SE bars for 1995 indicating these growth patterns are probably also similar.

Total annual mortality rates (A) for Abrams Creek were nearly identical between 1957 (58%) and 1994 (57%) for age-2 to age-4 rainbow trout. Instantaneous mortality rates (Z) ranged from 0.85-0.89. Total annual mortality



**Figure 2. Relative stock densities (RSD) of rainbow trout collected in East Prong Little River in the 1930s, 1940s, 1950s, and 1980s compared to the same sites in the 1990's. The 1930s, 1940s, and 1950s data were collected using angler creel surveys whereas the 1980s and 1990s data were collected using backpack electrofishing techniques.**



**Figure 3. Mean total length at capture for rainbow trout collected in East Prong Little River during fall large stream samples in 1942, 1945, and 1995. Note: Raw data was not available for the 1942 and 1945 data, therefore only means without standard deviations are reported. The 1995 data include the mean total length at capture (black box) and standard error (bars).**

rates of age-1 to age-3 rainbow trout were also compared among three streams sampled in 1945 (Fish Camp Prong), 1996 (Little River), and 1998 (Sams Creek).

Total annual mortality rates (A) among the streams ranged from 56-80% and Z ranged from 0.82-1.65. Fish Camp Prong (178mm size limit, 10 fish creel limit) and Little River (178mm size limit, 5 fish creel limit) were open to fishing under similar regulations during each period, although anglers were allowed to keep *injured* fish in 1945. Sams Creek had the highest A (80%) although it has been closed to fishing for 30 years.

## Discussion

After reviewing the data throughout the 70 year regulation period, we could detect no changes in population dynamics that could be attributed to fishing regulations. A common problem among previous studies in GRSM and elsewhere was that adequate (*i.e.* 3-6 years) follow-up evaluations seldom occurred, making it difficult to evaluate the effectiveness of regulation changes.

Long-term data sets are difficult for many agencies to maintain, but are essential in order to evaluate the effectiveness of regulation changes. In the case of GRSM, a 3 to 6 year evaluation period would allow managers to evaluate the regulation change over at least one to two full generations. In short-lived salmonid populations such as in GRSM, it is even more important to evaluate a change over several generations in order to delineate regulation effects versus environmental effects such as major droughts and floods.

Stocking of fingerlings and/or catchable size trout appeared to augment the underlying wild trout populations in GRSM. Stocked trout met the demand of anglers who wanted fish that could be easily caught to fill their creel. In fact, 61-90% of catchable rainbow and brook trout were traditionally caught within three months of stocking (King and Currier 1950; Lennon 1953; Lennon 1954). The information presented by these authors strongly suggests that stocked trout buffered the wild trout from harvest and added no long-term benefit to the wild population.

Despite a diverse regulation history, heavy stocking rate (>1,000 fish/mile), and streams that historically represent some of the highest fishing pressure throughout the Park (Lennon 1953), the number of legal (>178mm) rainbow trout per km appears consistent and varied uniformly among study periods. Growth rates observed in the 1940's were nearly identical to those observed today, regardless of regulation type. The age structures of rainbow trout and the maximum age of rainbow trout (age-4) were statistically similar between two different regulation periods. Recent studies indicate the underestimation of rainbow trout age in the southeast when using scales (Hining *et al.* 2000; Cooper 2003), however these studies also recognize underestimations may only be one to three years and did not change total annual mortality or growth estimates. Total annual mortality rates were similar throughout the study period, regardless of regulation type. In fact, total annual mortality rates were actually higher in an unfished population (80%) than in heavily fished populations of 1945 (69%) and today (56-69%) (GRSM 1993). Total annual mortality rates (A) of age 1-4 rainbow trout in GRSM (56-80%) are similar to studies of Habera *et al.* (2001) (68%) and Cooper (2003) (34-89%) in surrounding Tennessee wild trout waters. Annual angling mortality rates (15%) in GRSM (GRSM 1993) comprise such a small proportion of the total annual mortality (56-80%), minimum size limits are of little value on a population scale (Noble and Jones 1999).

By adapting RSD's to GRSM populations, we were able to compare the contribution of various size groups to the whole population of "stock" size (>150mm) rainbow trout. Comparative data from East Prong Little River across regulation periods indicates the proportions of rainbow trout in four length categories are not significantly different from 1934 to today. Despite heavy fishing pressure, heavy stocking rates, and rather liberal regulations from 1936-1954, only the RSD values for East Prong Little River during the 1940 time period were significantly different than those of the 1990's. The higher proportion of rainbow trout >203mm in 1940 than in other periods may be explained by GRSM stocking records. These records indicate 11,132 fingerling and catchable size (>178mm) rainbow trout were stocked in Little River in 1940 versus 0-19,250 fingerlings annually in the 1930's (dependent on year) and <6,000 catchable size annually in the 1950's. The size composition of the 1940 stockings is unknown, but it is interesting to note that only the RSD<sub>203</sub> category for this period appears to be different.

RSD values within Abrams Creek were significantly higher in 1999 (178mm size limit) than in 1985 (305mm size limit) suggesting regulations played little role in the ability to protect and recruit large rainbow trout in the population. Personal communications of one of the authors (S.E. Moore) with early Park descendants point out that a large majority (>80%) of the rainbow trout caught by anglers during the 1930's and 1940's ranged from 150-254mm with very few reaching sizes >305mm (<10%). These observations are supported by current data which indicate only 17% of rainbow trout reach 254mm and 3.2% reach 305mm. Additionally, size structure data collected in 1992 from Little River (open to fishing) and Sams Creek (closed to fishing since 1976) were nearly identical.

The productivity of southern Appalachian headwater streams is extremely low in comparison to wild trout streams in other parts of the world (Cada *et al.* 1987). The low productivity, subsequent naturally occurring food limitations, extremes in temperature and stream discharge, and high stream gradients inhibit rainbow and brook trout from attaining larger sizes in southern Appalachian

headwater streams (Lennon 1967; Ensign *et al.* 1990; Borowa *et al.* 2001). In most areas, rainbow and brook trout simply run out of food resources to maintain metabolic demands, begin to lose weight, and die (Ensign *et al.* 1990, Cada *et al.* 1987). Ensign *et al.* (1990) determined that metabolic maintenance requirements of rainbow trout in GRSM typically drop below daily maintenance requirements and fish actually lose biomass over the June to September period. Visual implant (VI) tag data collected in GRSM support Ensign *et al.* (1990) and indicates annual rainbow trout net weight (g) change ranges from 17.71-28.47g/yr up to 178-203mm then steadily declined to a loss of 3.00g/yr in fish greater than 230mm. Whereas rainbow trout >178mm will grow 15-25mm and gain 15-32g from September to May, these same fish will only grow 1-16mm and lose 4-10g from May to September. The combination of high summer water temperatures (15-22°C), higher metabolic rate, and food limitation create a critical period for salmonids in GRSM, especially those >203mm.

Borowa *et al.* (1995) found that supplemental feeding of a wild rainbow trout population resulted in numerous fish up to 406mm, whereas few fish >177mm existed before. Furthermore, Borowa *et al.* (1995) found that less than 1 year after feeding began, roughly 60% of the fish >100mm were over 176mm. In typical GRSM and east Tennessee wild rainbow trout populations, <25-40% of the entire population reaches 178mm (GRSM 1993; Habera *et al.* 2001). King (1938) and current GRSM (1993) data suggest that droughts, major spring floods, and food availability (Habera *et al.* 2003; Cooper 2003) play a much larger role in population abundance, growth, and annual mortality than any regulations employed throughout the history of GRSM (Thorn *et al.* 1997; Freeman *et al.* 1988; Grossman *et al.* 1998). King (1942) recognized droughts and floods play a major role in salmonid dynamics in GRSM, however data were not collected to support his hypothesis.

The southern Appalachian Mountains receive some of the highest loading of nitrate and sulfate due to episodic acidification of anywhere in North America (Robinson *et al.* 2001). To date, stream acidification impacts have been restricted to streams at elevations >875m. Episodic acidification has the potential to reduce the abundance, growth and reproductive potential of salmonids in small streams (Baker *et al.* 1996). Comparisons of data from Robinson *et al.* (2001) and Powers (1929) indicates that water quality has not significantly changed in lower elevation streams (<875m), such as those examined in this study, in the last 75 years. However, if current modeling trends continue as projected, all GRSM streams will be at or <6.0 in 32 years (Robinson *et al.* 2001) potentially increasing natural mortality and further reducing growth rates.

Based upon our review of the fishing regulation history of GRSM, the goal of most regulations was to produce higher densities and larger trout for the angler. The naturally acidic, high gradient, and food limited streams of GRSM produce short lived and relatively fast growing rainbow trout populations. Given these natural limitations, it is not difficult to understand why fishing regulations with these objectives failed to produce changes in rainbow trout population dynamics over the 70 year study period. If previous investigators had synthesized water quality and fish population data available at the time instead of using emotional and social views, they may have avoided implementing regulations that raised false hopes of anglers.

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## An Analysis of Wild Trout Anglers in Virginia

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**ABSTRACT**—Virginia is blessed with over 2,300 miles of wild trout streams. Under Virginia's current licensing system, it is difficult to accurately determine how many anglers target wild trout. However, recent surveys indicate that the number of wild trout anglers could approach 60,000. Understanding Virginia's wild trout anglers and their impacts on the resource will be important components in making future management decisions. A survey protocol was developed to have volunteers conduct roving angler/creel surveys on selected wild trout streams. Members of Trout Unlimited (N=60) surveyed thirteen streams over a three-year period (2001-2003). The streams selected varied in angler access difficulty, land management responsibility, and fishing regulations. Three-hundred-forty-three anglers were interviewed during the study. We found that wild trout streams are a valuable economic resource, generating an average trip expenditure of \$34.00. Wild trout anglers in Virginia are a dedicated group that averaged eighteen wild trout outings a year. However, angling pressure on individual streams was light (mean=283 angler hours/km). Angling pressure was generally higher on streams managed under special regulations ( $P<0.05$ ). Wild trout anglers experienced excellent catch rates (mean=1.67 fish/hr), practiced catch-and-release (>99%), and were satisfied with their angling experience (90%). Angler creel surveys are often time consuming and costly. With increasing natural resource agency budget shortfalls, this project demonstrated that valid data can be obtained utilizing volunteers at minimal expense.

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### Introduction

There are two critical components in managing a fishery: understanding the biological functions of the fish population and determining the interactions of anglers with that fish population (Matlock 1991). Virginia contains over 2,300 miles of wild trout streams. The biology of these wild trout fisheries is well understood (Mohn and Bugas 1980). However, there is little information available regarding fishing pressure on wild trout fisheries or wild trout anglers in Virginia. Currently, most wild trout populations in Virginia are managed by factors other than angling pressure. Understanding Virginia's wild trout anglers and their impacts on wild trout resources will become more important in making future management decisions. Under Virginia's current licensing system, it is difficult to accurately determine how many anglers target wild trout. The state of Virginia does not require a special trout license or trout "stamp" to fish for wild trout. Anglers are only required to possess a trout license to fish in streams stocked with hatchery-reared fish. The state does stock some streams that contain wild trout populations, but the vast majority of wild trout streams do not receive hatchery fish. Stream creel surveys have traditionally been conducted by seasonal employees of the Virginia Department of Game and Inland Fisheries (VDGIF) in the Commonwealth. With increasing budget reductions, an alternative method to acquire angler/creel data requiring no funding was investigated.

## Methods

We visited several Trout Unlimited chapters prior to the start of the project. During this visit the goals and objectives of the study were discussed and survey protocols were explained. A letter explaining the project procedures and survey schedule were also given to volunteers that planned to participate. As an incentive to increase volunteer participation, creel clerks were encouraged to fish while conducting the survey. The author was in contact with a volunteer coordinator for each stream throughout the survey period. VDGIF personnel also assisted in conducting surveys. A random stratified roving creel design was chosen (Malvestudo 1996).

It was decided that a minimum of six survey days per month were required to get meaningful data. Based on prior knowledge it was determined that more angling pressure would occur during weekend days than during the week. Therefore, four weekend days and two weekdays were randomly chosen each month. Equal probability was used for selecting individual weekdays. The survey period for each year was 01 March through 30 June. This was considered to be the time period when the majority of angling pressure would occur on the study streams. Each survey day was stratified into either a six-hour morning or afternoon period. The afternoon time period was shifted as daylight length increased to cover the evening hours. The thirteen streams chosen for the study were all located in western Virginia (Figure 1).

One objective was to select study streams with different degrees of accessibility, public land management, and fishing regulations. Surveying an equal number of streams with different fishing regulations, angler access, and land ownership was not achieved. Nine of the thirteen streams were managed under some form of special regulation. These special regulations involved either 9-inch minimum size limits or catch and release, and gear restrictions. The remaining four streams were managed under statewide regulations for trout (7-inch minimum size, no gear restrictions). Four streams were located within the Shenandoah National Park (SNP). Nine of the study streams were located within land managed by the United States Forest Service. Two of the streams were located within designated “Wilderness Areas” on the National Forest. Angler accessibility also varied among the study streams. Two streams had easy roadside

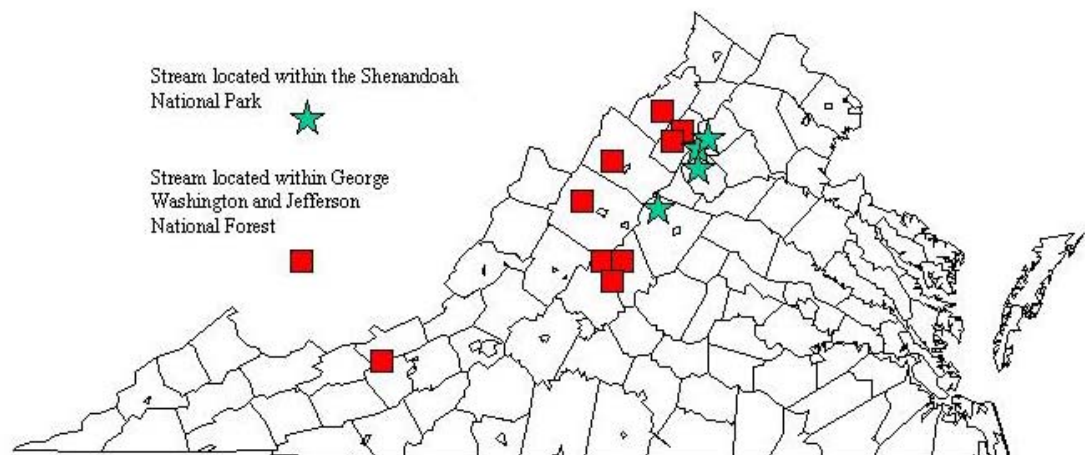


Figure 1. Map of Virginia with locations of streams surveyed during wild trout angler/creel surveys 2001-2003.

access while the remaining streams surveyed were accessible only by foot trails. Study reaches were all “headwater” first through third order streams. Characteristics of the study streams are summarized in Table 1.

All the study streams contained excellent wild brook trout populations, and one stream also contained a wild rainbow trout fishery. To estimate angling pressure, the creel clerk was instructed to travel/fish through the study reach during the first half of the survey period (3 hr), and to make a progressive total angler count. Then the clerk was instructed to travel/fish back through the study reach the second half of the survey period (3 hr) and to make a second progressive total angler count. To determine trip length all anglers were asked how long they had been fishing and how long they planned to fish if it was not a completed trip. In determining catch and harvest rates, anglers were asked how many fish they had caught and released or harvested. They were also asked to estimate the size (inches) of each trout angled. To gather wild trout angler information, a series of questions were asked to all willing anglers encountered during the survey (Figure 2). All daily angler count forms and questionnaire forms were returned to biologists at the end of each month. Data analysis was performed by Steve Malvestudo (private consultant) and the authors.

**Table 1. Stream characteristics and creel survey statistics from Virginia Wild Trout Angler/Creel Surveys conducted 01 March-30 June, 2001, 2002, and 2003.**

Stream	Land Ownership <sup>1</sup>	Angler Access	Special Regulations <sup>2</sup>	Days Surveyed	Anglers Interviewed	Est. Angler Hours (SE)	Angler Hours per Kilometer
<b>2001</b>							
Jeremy's Run	NPS	Walk-in	Yes	24	32	776 (32)	119
L. Stony Creek (Craig Co.)	USFS	Walk-in	Yes	24	40	834 (24)	208
Rapidan River	NPS	Vehicle	Yes	20	99	10,215 (13)	1,517
Shoe Creek	USFS	Vehicle	No	21	8	181 (44)	120
St. Mary's River	USFS*	Walk-in	Yes	15	29	1,488 (26)	330
<b>2002</b>							
Gum Run	USFS	Walk-in	No	9	4	130 (61)	43
Madison Run	NPS	Walk-in	Yes	10	5	367 (49)	183
Cub Run	USFS	Vehicle	No	20	5	344 (78)	172
N.F. Buffalo R.	USFS	Walk-in	Yes	16	16	462 (40)	154
Pitt Spring Run	USFS	Vehicle	No	20	4	120 (63)	40
Rose River	NPS	Walk-in	Yes	12	44	2,542 (25)	508
<b>2003</b>							
L. Stony Creek (Shen. Co.)	USFS	Walk-in	Yes	25	13	267 (45)	59
Ramsey Draft	USFS*	Walk-in	Yes	12	3	663 (49)	189
Rose River	NPS	Walk-in	Yes	20	41	1,577 (29)	315
Mean						1,426	283
Total					343		

<sup>1</sup> NPS refers to National Park Service (Shenandoah National Park); USFS refers to United States Forest Service (George Washington or Jefferson National Forest)

<sup>2</sup> Special regulations = catch-n-release or minimum length limit with gear restriction.

\* denotes Wilderness Area



**Figure 2. Volunteer creel clerk interviewing a wild trout angler.**

## Results

Thirteen streams were surveyed over a three-year period (2001-2003). One stream (Rose River) was surveyed in both 2001 and 2002. Sixty Trout Unlimited members representing five Virginia chapters helped to conduct the surveys. A total of three-hundred-forty-three anglers were interviewed during the project. The majority of interviews came from five streams. Each stream was scheduled to be surveyed 24 days during the study. However, volunteer participation varied and survey effort was not equal among all streams. Some streams were only surveyed 40% of the scheduled days. The mean number of days a stream was surveyed was 18 (Range 9-24).

Estimated fishing pressure ranged from 120-10,215 angler hrs/survey period, and averaged 1,426 angler hrs/survey period among all the streams. The mean relative standard error of total estimated angler hours for all streams was 51. The length of stream reaches surveyed ranged from 1.5 to 6.5km. Total estimated seasonal angling pressure on the study streams ranged from 40 to 1,571 hours/km. Angling pressure was roughly four times greater on streams managed with special regulations ( $P < 0.05$ ). Mean spatial angling pressure for special regulation streams and open regulation streams were 358 hrs/km and 94 hrs/km respectively. Streams located in the SNP received three and one half times the angling pressure than those streams located on National Forest land ( $P < 0.05$ ). Overall, there was no correlation between angler accessibility and fishing pressure. It should be mentioned that the Rapidan River in SNP received almost eight times the angling pressure, as did all the other streams in the study. The Rapidan River is the only stream survey managed under a catch and release/single-hook-artificial-lure only regulation, and had the easiest angler access. The Rapidan's notoriety can be attributed to the presidential Camp Hoover being located along its banks. It was also the first wild trout stream in Virginia to be managed with a special regulation.

Wild trout anglers experienced a mean catch rate of 1.67 fish/hr during the project. Catch rates ranged from 0.3 to 3.72 fish/hr. Almost every angler exclusively practiced catch and release (>99%), as only one angler interviewed harvested trout. Anglers were asked if they would harvest legal-size wild trout.

Eighty-seven percent of the anglers responded that they would not harvest a legal-size trout. We were curious if anglers only practiced catch and release because they were not catching fish of legal size. In the study streams a trout had to be either a minimum of 7" or 9" in total length (depending upon the stream) to be legally harvested. Using the estimated lengths of fish that anglers reported catching, we found that 50% of the anglers caught fish of legal size. Anglers were asked how often they fished the study stream in a year. Wild trout anglers indicated that they made an average of 4.4 fishing trips a year on that particular stream. Days fished a year on individual streams ranged from 1.3 to 6.9. Anglers were also asked how many days a year they fished wild trout streams in Virginia. Wild trout anglers in Virginia are a dedicated group that averaged 18 wild trout outings a year. Anglers were asked to rate their fishing experience for that particular day on a scale of 1-5. Responses of 3, 4, or 5 were considered to be a "satisfactory" angling trip. It appears that wild trout anglers in Virginia are happy with the status of the wild trout fisheries in the commonwealth. Ninety percent of the anglers interviewed indicated that they were satisfied with their angling experience on that day. In determining what gear type wild trout anglers prefer, we found that 87% of the anglers interviewed used fly rods. Even though any single-hook artificial lure could be used on nine of the study streams, 90% of the anglers on these streams fished with artificial flies. Out of the four study streams open to bait fishing, only 40% of the anglers fishing these streams used live bait. None of the volunteer creel clerks encountered anyone fishing with illegal gear during the study.

Collecting demographic and economic information was also an important part of the project. We found that wild trout fisheries outside of SNP are local fisheries. The majority of anglers fishing these streams lived within the county in which the stream was located or an adjacent county. Streams within the SNP were fished by anglers from all over Virginia and many different states. A high proportion of anglers fishing streams within the SNP resided in the highly populated area of Northern Virginia and Washington D.C. In 2001 the Rapidan River within SNP was fished by anglers from ten different states. Anglers were asked how much money they spent on gasoline, food, lodging, equipment, and additional fees for that individual fishing trip. The average trip expenditure was \$34.00. Traveling to the stream was the greatest expense to anglers, as most money was spent on gasoline.

As was stated earlier, a trout license is only required to fish for stocked trout in Virginia. In an attempt to determine the estimated number of wild trout anglers in Virginia, all anglers surveyed were asked if they also fished for stocked trout. A majority of anglers (60%) indicated that they also fished stocked trout streams. We also asked anglers if they possessed a valid trout license. Surprisingly, 93% of the wild trout anglers surveyed indicated that they had purchased a trout license. Regardless of their answer, creel clerks were asked to notify anglers that a trout license was not required to fish in un-stocked streams. For possible use in conducting future angler surveys, we asked anglers if they belonged to any fishing organizations or clubs. Slightly less than half (43%) of the anglers indicated that they belong to an angling organization. This was considerably higher than the 10% of trout license holders that said they belonged to a fishing organization in a recent Virginia trout angler survey (Mohn in-press). Trout Unlimited was the angling organization mentioned with the highest frequency.

## Discussion

Most roving stream creel surveys are conducted by one or two trained creel clerks that are employed by the managing agency. We were unaware of any previous creel studies where multiple, untrained volunteers were used to survey an individual stream. It was not known what the participation level of volunteer creel clerks would be at the onset of the project. We felt that anglers would be reliable volunteer creel clerks. TU chapters were chosen as a source of volunteer creel clerks that could be easily mobilized. One incentive to get people to volunteer was that they could fish while surveying the stream. Unfortunately, survey effort varied greatly (Range 9-24 days) for individual streams during the study. The goal was to survey each stream 24 days (6 days/month) between 01 March and 30 June. Although sampling effort appeared minimal, estimated angler hours/km and corresponding standard errors were similar to other creel surveys conducted on wild trout streams in the eastern U.S. that utilized greater survey effort. Greene (1996) surveyed a Pennsylvania wild trout stream similar to the ones in this study 20 days a month for a three month period, and reported similar angling pressure. A North Carolina creel study revealed similar angling pressure estimates while surveying streams 20+ days/month for an eight month period (Borawa and Clemmons 2000). In comparison, a seven day/month creel survey was conducted on another Virginia wild trout stream producing similar angling pressure (Palmer 2000). The high angling pressure observed on the Rapidan River (1,571 angling hrs/km) can be explained by easy angler access and the stream's reputation. Palmer (2000) reported similar angling pressure (1,070 angler hrs/km) on Whitetop Laurel Creek in southwest Virginia. Whitetop Laurel Creek is also easily accessible with a great reputation. Rapidan River and Whitetop Laurel Creek are considered to be two of the best wild trout streams in Virginia (Ross 1999; Hart 2002). Catch rates in this study were similar to those reported from other wild trout stream creel surveys in the eastern U.S. (Borawa and Clemmons 2000; Palmer 2000; Greene 1996).

Estimating the number of wild trout anglers in Virginia is difficult under the current licensing system. A recent survey of trout license holders revealed that 55.5% of Virginia's trout anglers fish for wild trout (Mohn, in-press). In contrast, 93% of the wild trout anglers interviewed during this study purchased a trout license. Sixty percent of the anglers in this study did indicate they fished for stocked trout, in which case a trout license would be required. While it is not a requirement to fish for wild trout in Virginia, anglers that fish solely for wild trout might be purchasing a trout license to support the program or the agency. Roughly 100,000 trout licenses are sold annually in the commonwealth (VDGIF Licensing Dept. 2001). Based on what we learned from this study, the number of wild trout anglers in Virginia could approach 60,000.

The economic value of fisheries is becoming increasingly more important in making management decisions (Knuth and McMullin 1996). The average daily trip expenditure in this study (\$34.00) was similar to that of the average daily trip expenditure in Virginia (\$30.00) (USFWS 2001). Wild trout fisheries appear to be just as economically important as more "high-profile" fisheries in Virginia. Rundle (2000) reported a mean trip expenditure of \$18.85 for Smith Mountain Lake, one of Virginia's most popular reservoirs. Anglers spent between \$21-\$38 a trip in 1999-2001 while fishing Briery Creek Lake, Virginia's "trophy" largemouth bass fishery (D. Michaelson pers. Comm.).

In this study streams managed with special regulations received greater angling pressure than streams under general statewide regulations. Many of the best wild trout streams in Virginia are currently managed with special regulations. There are no historical records of what fishing pressure was like on these streams prior to being managed with special regulations. Other fisheries managers have reported higher angling pressure on wild trout streams managed with special regulations (Greene and Weber 1996; Todd et al. 1999).

With increasing natural resource agency budget shortfalls, we demonstrated that reliable creel and angler survey data can be obtained by utilizing volunteers at minimal expense.

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## McGee Lake, Wisconsin: 35 Years of Trout Management—Past Successes and Future Challenges

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**ABSTRACT**—McGee Lake is a 9.2 ha spring pond that has been intensively managed as a trout fishery for the last 35 years following state purchase in 1968. Initial fisheries surveys in 1969 revealed a natural reproducing *Salvelinus fontinalis* (brook trout) population with great potential. Unfortunately, there were also warmwater fish species present competing with the trout for food and space. The lake was chemically renovated in 1974, restocked with brook trout in 1975, and opened to fishing in 1976. The first several years provided great fishing with brook trout up to 584 mm harvested under liberal size and bag limits. The lake went through two regulation changes in the 1980's to try and build up numbers of larger fish and instill more of a catch and release ethic among anglers. Creel and fish population studies done in the 1980's showed that these regulation changes were not successful, although the lake still provided above average fishing for trout up to 381 mm. In the mid 1990's, *Micropterus salmoides* (largemouth bass) were illegally introduced to the lake and numbers and natural recruitment of brook trout vanished as the largemouth bass population quickly became established. We are now at a crossroads of either continuing to manage the lake for trout, realizing that illegal introductions of fish species that are competitors with and predators of trout may continue to happen, or switching gears and managing for warmwater fish species or as a combination warmwater/coldwater fishery. Several potential options will be discussed as well as a simple cost-benefit analysis supporting complete renovation and restocking with brook trout.

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### Background Information

McGee Lake, a 9.2 ha spring pond, has been intensively managed for trout since state purchase of the land surrounding the pond in 1968. McGee Lake lies in south central Langlade County WI, in the northeast part of the state. This region is home to one of the largest known concentrations of natural spring ponds. In Langlade County alone there are approximately 250 spring ponds ranging in size from less than 0.1 to 21.4 ha (Steuck et al. 1977). Most (64%) are less than 0.4 ha in size and McGee Lake is one of the four largest in the county. Spring ponds are spring-fed lakes that rarely have permanently flowing inlets, but always have substantial outlet creeks due to the influx of large amounts of spring water. Spring ponds are usually the headwaters, or in the upper watersheds of our native *Salvelinus fontinalis* (brook trout) streams. Rarely do spring pond outlet creeks in this region flow to warmwater streams. Spring ponds are highly productive systems when compared to other waters in this part of the state. Table 1 shows the chemical characteristics of McGee Lake.

**Table 1. Chemical characteristics of McGee Lake based on a surface water sample taken on April 10, 1981.**

Parameter	Value
pH	8.1
Total Alkalinity (mg/l as CaCO <sub>3</sub> )	174
Specific Conductance (umhos/cm at 25°C)	340
Nitrates (mg/l)	0.07
Phosphates (mg/l)	0.02
Ammonia (mg/l)	0.03
Chlorides (mg/l)	2
Calcium (mg/l)	41
Magnesium (mg/l)	20
Potassium (mg/l)	2
Sodium (mg/l)	2
Sulfates (mg/l)	9
Iron (mg/l)	0.1
Turbidity	0.35

**Table 2. Stocking history at McGee Lake 1938-2003. Numbers and species stocked by year(s).**

1938 <sup>1</sup>	1939-1953	1954-1974	1975-2003
<b>Warmwater Species</b>	<b>Trout</b>	<b>No Stocking<sup>2</sup></b>	<b>Trout</b>
18,000 <i>Perca flavescens</i> (Yellow Perch)	77,425 <i>Oncorhynchus mykiss</i> (Rainbow Trout)		78,300 <i>Salvelinus fontinalis</i> (Brook Trout)
10,000 <i>Lepomis gibbosus</i> (Pumpkinseed)	39,350 <i>Salmo trutta</i> (Brown Trout)		25,700 <i>Oncorhynchus mykiss</i> (Rainbow Trout)
3,000 <i>Lepomis macrochirus</i> (Bluegill)	2,550 <i>Salvelinus fontinalis</i> (Brook Trout)		
3,000 <i>Ictalurus spp.</i> (Bullhead spp.)			

<sup>1</sup> First recorded stocking in the files.

<sup>2</sup> No stocking recorded, presumably due to lack of public access.

The first recorded fish management activity for McGee Lake was stocking done in 1938 (Table 2). The 1938 stockings of warmwater fish species were consistent with the state's practice of indiscriminate stocking done throughout the region at the time. From 1939-53 only trout were stocked. No stocking occurred from 1954-75. In 1968, the state purchased 22 ha of land, including all the shoreline around McGee Lake and 91 m along both sides of the outlet creek. The following spring and fall, the first recorded fish surveys of McGee Lake were completed. In addition to the presence of warmwater fish species, these surveys revealed a self-sustaining brook trout population with great potential; trout up to 417 mm were surveyed (Table 3). On July 25, 1969, a warm summer day with an air temperature of 26°C, a temperature and oxygen profile of McGee Lake was done. It was discovered that there was at least 6 ppm oxygen down to a depth of 6.7 m and temperature of 11°C. There was a 4-5 m band of cold, well-oxygenated water for trout to live in. It was decided to manage the lake as a trout fishery and plans to chemically renovate the lake began.

In October 1974, McGee Lake was simultaneously treated with a 3 ppm concentration of rotenone and a 10 ppb concentration of antimycin. The lake stayed toxic to fish for several months under the ice and it was believed that a total kill of all fish was attained. In spring and early summer 1975, the lake was restocked with 3,700 yearling brook trout (229 mm), 300 fingerling brook trout (76 mm), and 40 adult brook trout (254-381 mm).

**Table 3. Initial fish surveys done at McGee Lake in 1969. Species, numbers, and sizes collected by survey period.**

May Boom Electrofishing Survey	September Gillnetting Survey
<i>Salvelinus fontinalis</i> (Brook Trout) 3: 137-185 mm	<i>Salvelinus fontinalis</i> (Brook Trout) 19: 203-417 mm
<i>Perca flavescens</i> (Yellow Perch) Thousands: 51-229 mm	<i>Perca flavescens</i> (Yellow Perch) 87: 152-279 mm
<i>Catostomus commersoni</i> (White Sucker) Thousands: 76-432 mm	<i>Catostomus commersoni</i> (White Sucker) 166: 152-457 mm
<i>Notemigonus crysoleucas</i> (Golden Shiner) Thousands: 51-178 mm	<i>Notemigonus crysoleucas</i> (Golden Shiner) 18: 127-178 mm
<i>Lepomis gibbosus</i> (Pumpkinseed) 7: 127-178 mm	<i>Lepomis gibbosus</i> (Pumpkinseed) 1: 188 mm
<i>Lepomis cyanellus</i> (Green Sunfish) 6: 102-127 mm	<i>Lepomis cyanellus</i> (Green Sunfish) 7: 102-203 mm
<i>Ictalurus melas</i> (Black Bullhead) 4: 178-203 mm	
<i>Cottus spp.</i> (Sculpin spp.) 1: 122 mm	
<i>Phoxinus spp.</i> (Dace spp.) Noted as common	
<i>Notropis spp.</i> (Shiners spp.) Noted as common	

Since 1975, only trout have been stocked (Table 2). From 1976-1988, and in 1990, 4,000 yearling brook trout (152-254 mm) were stocked. In 1989, 3,000 yearling *Oncorhynchus mykiss* (rainbow trout; 229-279 mm) were stocked. Two thousand yearling brook trout and 2,000 yearling rainbow trout were stocked from 1991-2000 with exceptions in 1996 (1,500 of each), 1997 (1,500 brook trout only), and 1998 (2,000 brook trout and 200 rainbow trout). In the years 2001-2003, 2,000-3,000 rainbow trout yearlings have been stocked.

The lake was closed to fishing in 1975. In May 1976, McGee Lake opened to fishing with the following regulations: first Saturday in May through November 15 season, 152 mm minimum length limit, 5 trout per day in May and 10 per day June through November, and no minnows allowed as bait. Fishing from 1976-1979 was phenomenal for a Wisconsin brook trout fishery with stringers of above average size fish being caught and harvested by anglers (Hunt 1979, 1984, 1989, Johnson 1976). Brook trout from 432-584 mm were not uncommon in anglers' creels. The fishery could not sustain the amount of fishing and harvest pressure it was receiving and still continue to consistently produce quality brook trout of these sizes. Therefore, the regulations were changed in 1980 and again in 1986. The objectives of these regulation changes were two-fold: to determine if they would provide adequate constraint on harvest to allow an abundant stock of large brook trout to remain throughout the fishing season, and to determine if they would attract a majority of anglers with more of a "catch and release" attitude instead of "catch and keep".

In 1980, fishing regulations at McGee Lake changed to the following: first Saturday in May through September 30 season, no minimum length limit, 2 trout per day, and no minnows allowed as bait. In 1986, the regulations remained the same except that only artificial lures were allowed. Hunt (1979, 1984, 1989) followed the fishery through creel and fish population surveys in 1977, 1980, 1981, 1982, 1986, and 1988 (Table 4). Evaluation of the 1980 regulation change

determined that the two objectives were not being met, as average size of harvested brook trout did not increase significantly. Catch and keep fishing was more prevalent and did not allow McGee Lake to grow and sustain a large population of quality size brook trout. The regulation change to artificial lures only in 1986 was a next step approach to attempt to meet the objectives by attracting more non-local anglers that may have more of a catch and release attitude. This regulation also failed to meet the objectives as anglers continued to harvest more trout than they released. Throughout these studies and regulation changes it was noted that for a Wisconsin fishery, McGee Lake still provided above average fishing for quality size (> 203 mm) brook trout (Table 5; Hunt 1984, 1989; David A. Seibel, WDNR, unpublished data).

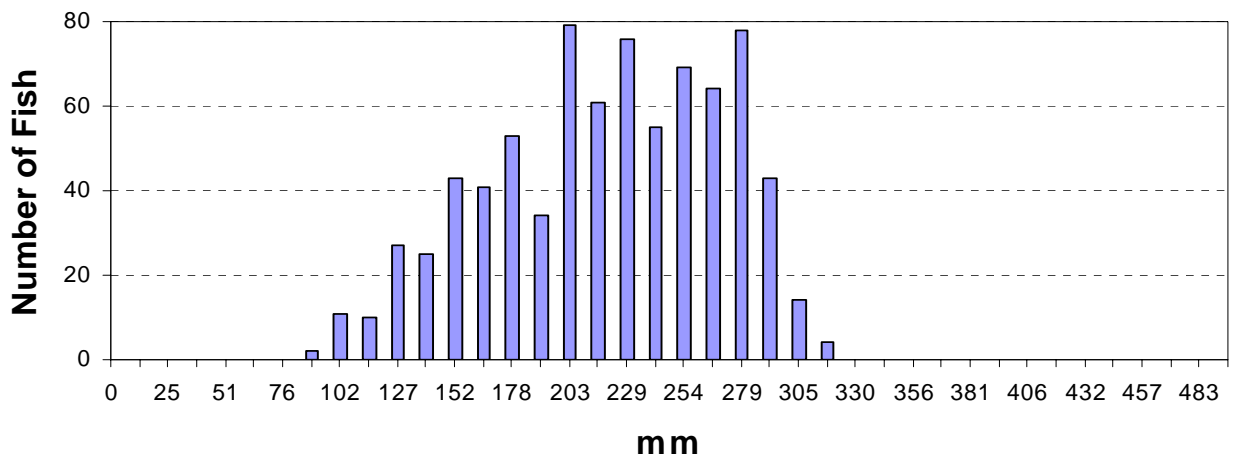
Trout regulations were changed once again in 1990 to a 305 mm minimum length limit but due to drought conditions and special regulations from 1989-1991, the new length limit didn't actually go into effect until the 1992 fishing season. In August and September 1989 and all of 1991, trout fishing rules were no harvest (catch and release only) and artificial lures only. Trout fishing was closed statewide in 1990. Figure 1 reveals that in 1994 brook trout appeared to be cropped off starting at about 292 mm, indicating that the new length limit regulation worked to protect brook trout up to this size.

**Table 4. Numbers of brook trout captured, harvested, and released from McGee Lake based on a summary of angler creel surveys conducted in 1977, 1980, 1981, 1982, 1986, and 1988. Data is presented in hours per hectare, number per hour, number per hectare, and kilograms per hectare.**

Year	Fishing Pressure	Brook Trout Catch		Brook Trout Harvest			Brook Trout Released			
	h/ha	No./h	No./ha	No./h	No./ha	kg/ha	Average Size (mm)	No./h	No./ha	% Released
1977	1129	0.58	655	0.51	581	-	-	0.07	84	11
1980	465	0.71	329	0.37	171	28	229	0.34	158	48
1981	507	0.67	339	0.45	230	39	241	0.22	111	32
1982	425	0.60	255	0.35	151	22	213	0.25	106	41
1986	151	1.10	166	0.57	86	13	249	0.53	79	48
1988	111	0.57	64	0.31	35	7	262	0.26	30	46
1980-82 <sup>1</sup>	465	0.66	306	0.39	183	30	231	0.27	126	40
1986 & 88 <sup>2</sup>	131	0.88	116	0.46	59	10	254	0.42	54	49

<sup>1</sup> Average of years 1980, 1981, and 1982.

<sup>2</sup> Average of years 1986 and 1988.



**Figure 1. Length frequency histogram of brook trout surveyed with electrofishing in April 1994.**

**Table 5. Summary of brook trout population survey estimates at McGee Lake in 1980-82, 1985-88, 1994, and 2000-01. Data is presented in number  $\geq$  152 mm, number per hectare, and kilograms per hectare.**

Year	Month <sup>1</sup>	Population Estimate						
		All Brook Trout			Wild Brook Trout			% Wild <sup>2</sup>
		No. $\geq$ 152	No./h	kg/ha	No. $\geq$ 152	No./h	kg/ha	
1980	April	292	32	12	292	32	12	-
	October	500	54	15	198	22	7	40
1981	April	371	40	18	145	16	8	39
	October	685	75	15	349	38	7	51
1982	April	464	51	15	240	26	7	52
	October	1358	148	29	568	62	12	42
1985	April	-	-	-	-	-	-	-
	October	1170	127	27	899	98	21	77
1986	April	574	62	10	518	56	8	86
	October	1439	157	30	573	62	10	35
1987	April	648	71	15	340	37	6	39
	October	754	82	13	377	41	6	44
1988	April	1283	140	24	832	91	13	55
	October	1596	174	26	1056	115	18	68
1994	April	1102	120	-	-	-	-	-
	October	-	-	-	-	-	-	-
2000	April	-	-	-	-	-	-	-
	October	95	10	-	95	10	-	-
2001	April	-	-	-	-	-	-	100
	October	198	22	-	198	22	-	100

<sup>1</sup> Within a couple of weeks after the April population survey estimates, standing stocks of brook trout were bolstered by annual stockings of 4,000 (435/ha; 36 kg/ha) domestic yearling brook trout (1980-88; 1990) and 1,500-2,000 (163-218/ha; 10-23 kg/ha) domestic yearling brook trout (1991-1999). 2,000 domestic fingerling brook trout were stocked in fall 2000 (218/ha; 6kg/ha).

<sup>2</sup> Brook trout stocked prior to 1980 or of wild origin.

## Present Status of the Fishery

A 1994 brook trout population estimate revealed good natural reproduction with all size classes represented and above average size quality (Figure 1). It was decided to discontinue stocking brook trout to see if the population could sustain itself entirely through natural reproduction and recruitment. Then in the mid-1990's anglers started reporting catches of *Micropterus salmoides* (largemouth bass) in McGee Lake. In June 1999, an electrofishing survey found a well established largemouth bass population, likely the result of an illegal introduction. Subsequent electrofishing surveys from 2000-2002 further documented a significant bass population as well as a dramatic decrease in the

brook trout population (Table 6). No brook trout less than 254 mm were present in the fishery, presumably due to predation by largemouth bass.

During the 1999-2002 electrofishing surveys, we removed all the largemouth bass we captured from McGee Lake. A total of 2,859 bass (311/ha) were removed from the lake during these surveys. No resurgence in the brook trout population was noted as the bass population rebounded quickly from these removals. In 2002, we enacted a fishing regulation (no size limit on bass) allowing harvest of all bass caught up to the daily bag limit of 5 fish. The trout season framework, and artificial lures only regulations still had to be followed. This was to encourage angler harvest of all bass captured to help reduce predation of, and competition with, brook trout. Although this regulation can only help, we are not optimistic that it will adequately keep bass numbers in check to have a positive response on the brook trout population.

### Future Plans

We are now at a crossroads with fish management at McGee Lake. We would like to manage for the native species, i.e. brook trout, in its native habitat, preferably through a self-sustaining, natural-reproducing population. To do this we feel we must substantially reduce or eliminate the largemouth bass population in the lake. If the bass population is not controlled, they will continue to suppress the survival and recruitment of young brook trout and keep the total trout population numbers down. On the other hand, we could let the bass go unchecked and manage the lake solely as a bass fishery, or as a combination bass and stocked trout fishery. The angling public and local chapters of Trout Unlimited (TU) would prefer the lake be managed solely for quality size brook trout. They remember the great years of trout fishing following state acquisition, renovation, and management as a quality trout fishery, and desire to have this type of fishery back at McGee Lake.

Managing the lake solely for largemouth bass and panfish would be the least costly option, in terms of dollars spent. No stocking would have to occur and

**Table 6. Electrofishing catch rates at McGee Lake in 1994 and 1999-2002. Data is presented in number per hour and number per hectare.**

Year	Month <sup>1</sup>	Brook Trout		Largemouth Bass	
		No./h	No./h	No./h	No./ha
1994	April	282	31	0	0
1999	June	3	0.3	171	19
2000	October	15	2	223	24
2001	June	0	0	523	57
	October	18	2	96	10
2002	June	5	0.5	307	33

<sup>1</sup> Within a couple of weeks after the April population survey estimates, standing stocks of brook trout were bolstered by annual stockings of 4,000 (435/ha; 36 kg/ha) domestic yearling brook trout (1980-88; 1990) and 1,500-2,000 (163-218/ha; 10-23 kg/ha) domestic yearling brook trout (1991-1999). 2,000 domestic fingerling brook trout were stocked in fall 2000 (218/ha; 6kg/ha).

bass and panfish populations could be managed through regulations and periodic surveys. This type of management is the least expensive as annual costs would be less than \$200/year and \$4,500 over the next 25 years (2004 U.S. dollars).

Another option would be to manage the lake as a two-story fishery for largemouth bass and trout (rainbow and/or brook) in combination. We would have to annually stock larger trout at a higher expense to reduce predation on trout by bass. The current state budget situation is very tight and we have experienced complete cuts in stocked yearling trout fisheries in 2004 and 2005. Trying to get an even larger trout to stock into McGee Lake in these tough budget times is not a reality and would come at an even higher annual cost. Stocking 4,000 yearling trout averaging 279 mm would cost \$6,000/year and at least \$150,000 over the next 25 years.

We could continue to remove largemouth bass through the use of electrofishing. Studies have shown, as well as our experience with removing largemouth bass at McGee Lake, that partial removals are at best a very short-term solution and not a long-term fix. Despite our efforts to annually remove a large standing stock of bass from the lake, we did not see any positive response in the brook trout population. Young brook trout were not recruiting to the fishery. Removals would have to be done several times annually, to try to stay on top of the bass population. We could never get them all and it would quickly become a scheduling problem with our other fish management responsibilities. It would also be an expensive course of action as biannual largemouth bass electrofishing removal trips to McGee Lake would cost \$1,500/year and \$37,500 over 25 years.

Partial renovation is an option we have considered. We could treat the littoral areas with antimycin while the bass are spawning. The thought is, we could hit the bass while they are vulnerable and sustain limited trout mortality, as they should be out in deeper water at this time of year. We feel that this is not a very good option because it would likely not get enough largemouth bass to have a long-term, positive response on the brook trout population. At best, it would work for a limited time and would likely have to be repeated every couple of years. The costs of doing partial renovations every few years would be much more expensive than doing one complete renovation both in terms of money spent on chemical and on public relation efforts (information sessions, news releases, warnings, etc.)

A complete renovation seems to be the best long-term solution and most cost-effective option to manage the lake as a natural, self-sustaining brook trout fishery. We plan to use rotenone and/or antimycin to get a complete kill of all fish in the lake, just as in 1974. To help get that process started, we plan to use electrofishing to collect as many brook trout as possible from McGee Lake just prior to their spawning. These fish will be spawned, and they and their progeny kept at a local hatchery over winter. Renovation would again occur in October, prior to ice-cover, to maximize the length of toxicity and ensure as much of a total fish kill as possible under the ice. The trout held at the hatchery over winter will be restocked into McGee Lake when it detoxifies the following spring. Fishing will be closed for 2 years following renovation to give the adult fish 2 spawning cycles before being subject to fishing harvest. This time will also allow young fish to recruit to the fishery.

This winter (2004-05) we plan to write a project proposal to secure funding to renovate McGee Lake. We anticipate that the local TU chapters will be key partners with, and contributors to the project. Once the funding is secured, we

will obtain the necessary permits, hold public informational meetings, and establish local support for the project. We plan to do a media blitz educating the public about the harmful effects of illegal fish introductions and the values of our native fisheries. Costs to carry out this renovation plan are around \$25,000, or \$1,000/year over 25 years (the first renovation lasted 25 years). Compared to the costs of hatching, rearing, and annually stocking 4,000 yearling trout over the last 30 years (1975-2003; \$100,000 in 2004 U.S. dollars or \$4,000/year), this plan appears to be a bargain.

Barring another illegal introduction of a species that significantly preys on brook trout or competes directly with them for food and space, we feel that this is the best, most economical solution (Table 7). We also have many supporters in the community watching out for the resource and educating people about illegal introductions. These watch dogs know that McGee Lake is a special resource and will do everything in their power to avoid an illegal stocking from happening again. We would also have the satisfaction of managing the lake for its native species as well as providing the fishery most anglers desire. It is hard to put a price on restoring a native, self-sustaining brook trout population.

**Table 7. Estimated costs for future fish management options at McGee Lake. Costs are in 2004 U.S. dollars and include equipment, materials, maintenance, and salary/wage costs.**

Management Option	Annual Cost (\$)	25 Year Cost (\$)	Prognosis
Manage for Largemouth Bass and Panfish (Non-Trout Management)	200	5,000	Mediocre bass and panfish fishery; One of over 1,000 bass and panfish lakes in the county
Stock Larger Trout (Two-Story Management)	6,000	150,000	Mediocre bass, panfish, and trout fishery; Will not reach trout fishery potential
Largemouth Bass Removals	1,500	37,500	Probably will not have the desired positive effect on the trout population; Possible to have limited short-term success but not a long-term solution
Partial Renovations (Largemouth Bass Removal)	4,000	100,000	Probably will not have the desired positive effect on the trout population; Possible to have limited short-term success but not a long-term solution
Complete Renovation (Start Over)	1,000	25,000	Long-term success barring another illegal fish introduction

## Acknowledgments

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## The Development and Evaluation of Conservative Trout Regulations in Southeast Alaska Based on Length at Maturity

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**ABSTRACT**—Populations of wild cutthroat and rainbow trout occur in streams and lakes throughout Southeast Alaska and are available to anglers year-round. In the late 1980s and early 1990s, biologists became increasingly concerned that these species were being overharvested. Emergency order closures of trout fisheries began in 1991 and continued during the following two years. In 1992 and 1993, an extensive literature review was completed and researchers from West Coast states and British Columbia were consulted on their trout management strategies. A public review process, including extensive public meetings and mail-out questionnaire, also contributed to a set of regulations adopted in 1994.

The cornerstone of the new regulations is a series of minimum size limits to protect 65% or—in areas with higher angling pressure—100% of trout from harvest until they have spawned at least once. Minimum size limits are only effective if hooking mortality is minimal; a ban on bait in fresh water was therefore considered an essential component of the new regulations. This paper reviews development of current regulations and our ongoing efforts to evaluate the effectiveness of minimum size limit regulations based on length at maturity research.

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### Introduction

Populations of wild cutthroat trout, rainbow trout, and steelhead occur in approximately 5,000 streams and lakes throughout Southeast Alaska and are available to anglers year-round. In the late 1980s and early 1990s biologists from the Alaska Department of Fish and Game (ADF&G), Sport Fish Division, became increasingly concerned that trout were being overharvested. These concerns stemmed from research findings as well as concerns expressed by fishing guides and the angling public. The only large-scale monitoring of freshwater angler effort, catch, and harvest was the Alaska Statewide Harvest Survey (SWHS). Trends reported in the SWHS showed a 72% increase in the number of days anglers fished in fresh water in Southeast Alaska between the 3-year averages of 1980–1982 and 1990–1992 (Mills 1983, 1993), whereas numbers of cutthroat trout harvested declined by 43% between the same time periods.

Because of these concerns, ADF&G used its “Emergency Order” (EO) authority to close several steelhead and cutthroat trout sport fisheries. In 1991, the Situk River was closed to steelhead retention (catch-and-release-only), and Turner Lake was closed to cutthroat trout retention. The following year, EO closures were issued for 24 steelhead systems and 3 cutthroat trout lakes (Turner, Wilson, and Reflection lakes). In 1993, the department closed 48 steelhead streams to retention of steelhead and retained the restrictions on the 3 cutthroat

trout lakes. ADF&G staff and the public recognized a need to evaluate existing trout regulations and to develop new management strategies and regulations to protect trout resources in Southeast Alaska while providing maximum fishing opportunity.

## Development of Wild Trout Regulations

The strategy adopted in 1992 to develop new trout regulations was to combine information collected from our trout research projects with the best management practices, then develop management options and present these options to the public for their input and preferences. Starting in fall 1992 and continuing through 1993, Southeast Alaska Sport Fish staff collected background information on cutthroat trout management through an extensive literature review and interviewed trout management biologists along the west coast of Canada and the U.S. to learn from their trout and steelhead management strategies. This information contributed significantly towards drafting ADF&G regulations.

ADF&G staff held two series of public meetings throughout Southeast Alaska. In the first, we shared our concerns about declining trout populations and sought input from citizens about their opinions of the status of trout stocks in their local areas. After all input was reviewed, angler preferences were incorporated into our “draft trout management options,” and a second series of public meetings was held. Objectives at these meetings were to garner comments on our “draft trout management options” and to develop support for our preferred management options.

We decided to combine the regulations for cutthroat trout and rainbow trout because of difficulties anglers had in distinguishing between the two species. Moreover, because cutthroat trout are more vulnerable to angling pressure and habitat degradation (Behnke 1992), we felt that the biological principles used to protect cutthroat trout should also serve to adequately protect rainbow trout populations. We also discussed steelhead stock status and management options at our public meetings, and new steelhead regulations were developed concurrently with the proposed trout (cutthroat and rainbow trout) regulations.

## Review of Literature and Trout Management Strategies

A review of the existing literature and contacts with other trout and steelhead managers revealed that cutthroat are the most easily caught of the trout species. Cutthroat trout are aggressive feeders and can be caught on a wide variety of gear types. They are particularly vulnerable to bait, and studies (Mongillo 1984, Wright 1992, Taylor and White 1992, Pauley and Thomas 1993) show that mortality rates for cutthroat caught and released using natural bait are as high as 48%, whereas mortalities from artificial gear (lures, flies, etc.) are lower than 5% (3,981 fish, in 16 total studies). Mortality rates for rainbow trout caught and released with bait were 28%, still much higher than artificial gear types (6.8%) (7,234 fish in 21 studies).

Hunt (1970) stated that size limits, if wisely applied, are the best regulations for preventing excessive angler harvest, because the size limit applies to every fish caught and thus can be related to specific biological parameters. Wright (1992) expanded upon Hunt in his review of the regulatory selection process for Washington State by discussing their regulation preference to protect a full age-class of female spawners. To maintain a trout population’s reproductive potential, the minimum size limit should be set at a level that provides an opportunity for a

full age-class of females to spawn at least once. However, because sport fishing regulations are based on length and not age-class, a minimum size limit was needed that would protect all female trout until they reached the size at which they were mature. Males typically mature when they are somewhat younger and smaller (Downs et al. 1997), thus any minimum size limit regulation designed to protect females should adequately protect males.

Length at maturity data for Alaska cutthroat trout stocks were limited to several years of data collected during the 1960s from sea-run fish in Petersburg Creek (ADF&G unpublished data). Other sources we used in establishing our minimum size limits came from landlocked populations in Mosquito Lake in the Queen Charlotte Islands, British Columbia (Leeuw 1987) and literature on trout populations in Washington and Oregon (Wright 1992). Information from these sources suggested that a 12-inch minimum size limit would allow approximately 85% of cutthroat trout in Southeast Alaska an opportunity to spawn at least once, and a 14-inch size limit would allow nearly all fish an opportunity to spawn at least one time.

One concern with size limits is the potential adverse effect of long-term size selectivity on heritable traits. ADF&G biologists believed that as long as “an adequate number” of fish above the minimum size limit are not harvested and allowed to spawn multiple times, then the genetic structure would not adversely change. At the time the regulations were developed, we knew of no sport fishery in Southeast Alaska that was so intense that every fish above the minimum legal size limit would be harvested. We also realized this might change and that ongoing monitoring would be necessary to maintain genetic integrity of our trout stocks.

Upon completing the literature review, ADF&G Sport Fish staff agreed that the two key management issues with trout (cutthroat and rainbow) were (1) establishing an appropriate minimum size limit and (2) restricting use of bait. A minimum size limit could be effective only if hooking mortality was low, and it would be meaningless without concurrent bait restrictions; a ban on bait in fresh water was an essential element of the new regulations. Further, because Southeast Alaska has thousands of remote lakes and streams, we can evaluate abundance in only a few; therefore, the new trout regulations needed to cover a wide range of situations and levels of angler pressure. Many of the trout populations were known to be small and unable to sustain much harvest. Thus, a minimum size limit that protected the majority of fish until they had the opportunity to spawn at least once made the most sense to ADF&G biologists.

A major concern was that the public might view new hatchery production as an option for increasing harvest. After reviewing the literature and history of trout hatcheries and associated problems, there was internal agreement that we did not want hatchery stocking of trout or steelhead in Southeast Alaska. The emphasis needed to be on implementing regulations that would protect and insure continuation of existing wild stocks.

### **Overview of Our Public Process**

During February and March of 1993, biologists from ADF&G Sport Fish held 14 public meetings in large and small communities throughout Southeast Alaska with a wide variety of groups to discuss their concerns and determine if the angling public had information and/or similar concerns for trout stocks. Additionally, we distributed over 7,000 copies of an informational leaflet briefly outlining trout life history and our management concerns in newspapers around

Southeast Alaska, primarily to the smallest communities. We set up booths at each of the main boat shows in Southeast to talk with anglers and distribute the informational leaflet. The leaflet was distributed as well to everyone who reserved a U.S. Forest Service cabin at a cutthroat lake in 1992, and a questionnaire accompanied, requesting opinions on proposed management options.

Public response to our request for trout management input was generally supportive. Anglers concurred with the department's concerns and agreed that there was a problem with declining numbers and/or sizes of trout. Many anglers also highlighted specific systems where they had seen declining catches and/or sizes of cutthroat trout and steelhead. At the end of each public presentation, we distributed the trout questionnaire to evaluate public opinion and solicit suggestions on potential management options.

We received 192 responses to our questionnaires. Nearly 76% of the respondents favored a 14-inch minimum size limit, and support for bait restrictions was even stronger (80%) for cutthroat trout in fresh water. Most questionnaires (81%) were from Alaska residents; 19% were from nonresident anglers. Responses from both groups were strongly in favor of both the 14-inch limit and bait restrictions. Over 70% of the respondents were in favor of making all sea-run cutthroat populations catch-and-release-only. Nearly 60% favored special restrictions for the 13 lakes in Southeast Alaska that are known for their trophy-size cutthroat trout.

By fall 1993, the Sport Fish Division had developed a set of draft trout regulations and, through another series of public meetings, presented the management package to all communities with local Fish and Game Advisory Committees.

Concurrent with the public process to develop the trout regulations, the Division of Sport Fish initiated a separate planning process to evaluate steelhead regulations and public attitudes about future management strategies. At the time, the steelhead bag limit was 1 fish per day with 2 in possession and no minimum size limit. The Commissioner of ADF&G appointed a 9-member citizen committee to make recommendations on how to manage steelhead in Southeast Alaska. Committee members included steelhead anglers from Anchorage, Yakutat, Juneau (two members), Sitka, Petersburg, Ketchikan (two members), and Prince of Wales Island. This committee developed a survey that was sent to 1,768 steelhead anglers. The list of anglers surveyed included all respondents to the SWHS who had fished on a steelhead system in Southeast Alaska in 1992 or 1993.

The 678 returned surveys confirmed that most steelhead anglers felt steelhead should be managed more conservatively to rebuild abundance and provide continued fishing opportunity. When asked why anglers fish for steelhead, most answered that they liked to fish (55%) and enjoy the outdoors (35%) as prime reasons, while keeping a trophy or eating a steelhead were minor considerations (<10%). If restrictive regulations are necessary (i.e., steelhead populations continue to decline), most respondents preferred a catch-and-release-only management option (42% of the residents and 49% of the nonresidents); reducing the total harvest (daily bag limit) was a preferred (33%) second option (36% of the residents and 32% of the nonresidents). If there is a harvestable surplus of steelhead, 39% of the respondents preferred management options that include an annual bag limit (38% of the residents and 34% of nonresidents) and gear restrictions (34% of the residents and 32% of the nonresidents).

## Adoption of new regulations

The Alaska Board of Fisheries (BOF) is responsible for enacting regulations, which conserve and develop the State of Alaska's commercial, subsistence, sport, and personal use fisheries. The BOF meets on a 3-year cycle for fisheries regulations in each region of Alaska and considers changes to regulations from individuals, groups, or by ADF&G.

In early 1994, new trout regulations were adopted in Southeast Alaska by the BOF, combining bag limits, size limits, and bait restrictions. A 12-inch minimum size limit for cutthroat and rainbow trout was implemented throughout the region to (1) provide protection for juvenile steelhead and sea-run cutthroat trout before they emigrate to the ocean, and (2) protect cutthroat and rainbow trout until the majority can spawn at least once. A larger size limit (14-inch minimum size) was adopted for areas with developed access and/or intensive fisheries, i.e., "high use." Under this more restrictive limit, all female cutthroat trout are protected from harvest until they have had the opportunity to spawn at least one time. A maximum size limit of 22 inches (fish greater than this size cannot be legally harvested) was also implemented to protect returning adult steelhead. In addition, a 10-month (November 16 through September 14) ban on fishing with bait was implemented in freshwater systems to reduce hooking mortality on trout and steelhead. The 2-month period in which bait is allowed provides anglers the opportunity to use bait when adult coho salmon are present in fresh water. A year-round bait ban was adopted in all areas where the 14-inch minimum size was implemented. More conservative steelhead regulations were adopted by the BOF: a minimum size limit of 36 inches, and a bag limit of 1 steelhead per day and an annual limit of 2 steelhead per year.

The regionwide minimum size limit provides a practical and cost-effective way to manage the numerous trout populations throughout Southeast Alaska without the need for detailed biological data on each system. However, because of diverse management situations, the BOF also provided several exceptions to the regionwide minimum size limit, including "high-use," "trophy" (25-inch minimum size limit), "stocked lakes," "small lakes" (9-inch minimum size limit), and "special lakes" (one catch-and-release-only lake and one lake with less restrictive harvest regulations).

## Alaska Board of Fisheries Actions Since New Trout Regulations Adopted

### 1997 BOF Meeting

During 1997, the BOF again considered trout and steelhead regulations in Southeast Alaska. Thirty proposals related to trout and steelhead were submitted and discussed. There was general agreement that steelhead populations had not had time to respond to the new regulations and should be left unchanged, but trout regulations were more contentious. One of the primary concerns expressed by the public was that young anglers could not use bait and were being excluded from fishing. The board implemented a provision that allowed each of the primary communities in Southeast to designate a nearby lake at which the use of bait would be allowed. During 1997 the board asked ADF&G to evaluate cutthroat trout length at maturity in more lakes and report the results during the next meeting (2000). As a result, in 1997 and 1998, Sport Fish Division funded and conducted a study on cutthroat trout length at maturity at 21 lakes throughout Southeast Alaska (see Evaluation of New Trout Regulations below).

### 2000 BOF Meeting

In February 2000, the BOF received only 12 proposals that directly addressed trout or steelhead management in Southeast Alaska. Six other proposals addressed fishing methods, means or general provisions that might be applicable to trout or steelhead fishing.

ADF&G staff submitted a proposal requesting the BOF to reduce the regionwide trout minimum size length limit from 12 inches to 11 inches. This proposal stemmed from results of the maturity work the BOF requested in 1997.

The other 11 proposals included a mix of public requests. One asked the BOF to repeal existing trout regulations and return management to pre-1994 regulations. Another proposal would have repealed steelhead changes, and three others asked for lower size minimum size limits for steelhead in specific waters. Four proposals requested catch-and-release fishing in the Mendenhall River drainage and Montana Creek near Juneau.

The 1997–1998 Length at Maturity Study revealed that there was no significant difference between the percentage of mature female cutthroat trout at 11 inches or 12 inches. On the basis of these results, the BOF adopted the department’s recommended 11-inch minimum size limit.

The BOF enacted three trout regulations during its 2000 meeting relating to the “high-use” (14-inch minimum size limit) category. The BOF adopted regulations that: (1) extended the “high-use” area along the Juneau road system to a line ¼-mile offshore; (2) moved three Prince of Wales Island lakes into the “high-use” category; and (3) removed Thayer Lake on Admiralty Island and three Sitka area streams from “high-use” category and placed them under general regionwide trout regulations.

### 2003 BOF Meeting

During the 2003 BOF meeting, 9 proposals dealing with trout and/or steelhead were discussed; 4 were submitted by ADF&G. Most of the proposals were seeking more restrictive gear regulations in trout and salmon waters; i.e., requesting waters be made fly-fishing-only or single barbless hooks. One ADF&G proposal dealt with removing the ability of anglers to legally harvest adipose clipped steelhead in any waters; this proposal was submitted to simplify existing regulations and eliminate the perception that hatchery fish were available throughout Southeast Alaska. Another ADF&G proposal requested a year-round bait closure on several anadromous lakes on the Juneau road system. The other two ADF&G proposals requested specific exceptions to the regionwide 11-inch size limit: (1) that Winstanley Lake be managed as a “high use” lake with a minimum size limit of 14 inches, and (2) that the minimum size limit at Lost Lake be reduced from 11 inches to 9 inches.

All ADF&G proposals with the exception of Winstanley Lake were adopted by the BOF. The only public trout proposal adopted by the BOF made unbaited, single hook, artificial lures the only legal gear in the Karta River drainage. Karta River is the one of the most heavily fished steelhead streams in southern Southeast Alaska.

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## Evaluation of New Trout Regulations

The backbone of Southeast Alaska trout regulations is the concept that wild populations of trout will be adequately protected if a majority or, in higher use areas, all cutthroat trout can spawn at least once, or have the opportunity to

spawn at least once, before being available for harvest. There are two components to evaluating the new trout regulations: (1) is the minimum size limit appropriate for a particular water body; i.e., does the water body produce trout of that size? and (2) does the regulation adequately protect the trout stocks?

At the time the new trout regulations were adopted in 1994, an obvious need existed for more extensive length at maturity data for cutthroat trout from a variety of populations and lake types throughout Southeast Alaska. During the past 10 years, most of the public comments, complaints, and BOF proposals have been about increasing the opportunity to harvest more trout. Advisory Committee reports and public testimony given at the 1997 BOF meeting, for example, indicated current regulations in some lakes were too restrictive. Anglers have provided testimony and comments that they believe that some lakes have never produced any legally harvestable trout; that is, no trout ever attain the minimum size limit of 11 inches. In general, we recognized that length and/or age at maturity in fish populations was an expression of the growth of individual populations (Tipple and Harvey 1990, Clark 1992) and the type, size, and location of the lake (Schmidt 1994, Harding 1995). Below is a brief review of our 1997–1998 length at maturity study and how this study was used to evaluate our new trout regulations.

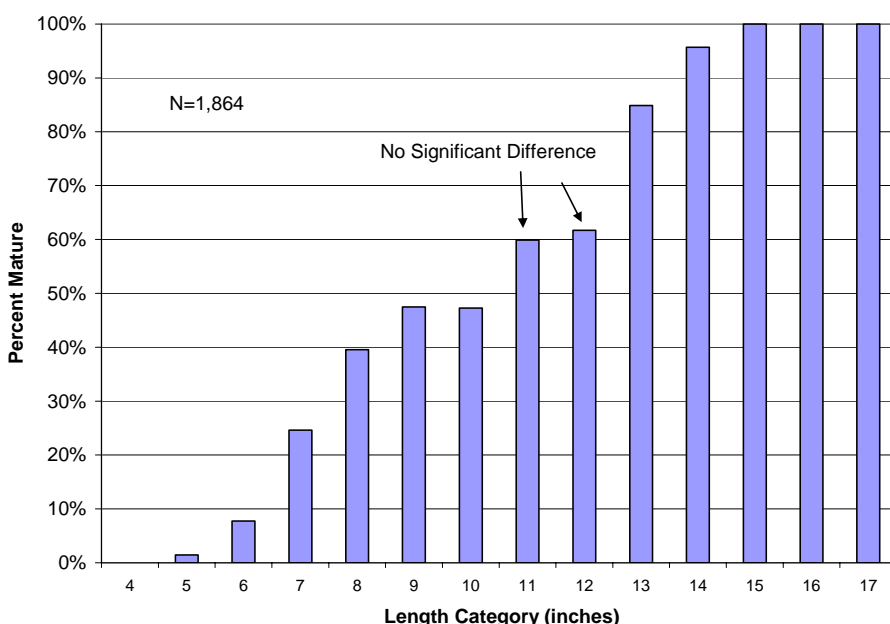
### **Cutthroat Trout Maturity Studies**

The goal of the “length-at-maturity” study was to estimate, within 1-inch size increments, the proportion of female cutthroat trout that were sexually mature in typical lakes in Southeast Alaska. With this in mind, ADF&G biologists selected 21 lakes spanning the range of lake and fish sizes present in the region. We believed these lakes were, in general, not heavily exploited, so that a range of fish sizes were present, and that the sampling would not jeopardize the health of the populations.

Sampling occurred between late September and mid-November in 1997 and 1998. While cutthroat trout in Southeast Alaska typically spawn in early spring, gonads must be in an advanced stage of development by fall if the fish are going to spawn in the succeeding spring (Behnke 1992). Test sampling at Florence Lake during July, August, and September of 1997 (Foster 2003), and at Little Lake on Prince of Wales Island during September 1997 indicated that sexual maturity could be determined with confidence by mid-October. Samples were thus collected late enough in each year so that maturity stage could be easily determined, but before inclement weather, freezing conditions, and spring spawning occurred. Our sampling included 5 sea-run (mixed stock overwintering) lakes and 16 resident only cutthroat trout lakes.

Samples in each lake were collected by using three gear types: floating and sinking variable mesh gill nets, hoop traps, and hook-and-line gear. Whenever possible samplers strove to: (1) sample similar numbers of fish with each gear type; (2) sample the diverse range of lake habitats and depths (<30 m) present in the lake, and (3) meet overall sample size requirements for each 20-mm size interval. Target sample sizes for 1997 were not attainable in some small lakes, but the 2-year sampling design allowed samples to be pooled across years (i.e., 1997–1998) in lakes with similar characteristics, to obtain the desired (provisional or final) statistics. Each cutthroat trout captured was measured and a subset was sacrificed and sampled for sex and maturity following procedures described by Downs et al. (1997).

From the 21 lakes studied, we sampled 1,864 female trout ranging from 5 to 17 inches in total length. Sixty percent (60%) of the female trout we sampled were mature in the 11-inch length category, and 62% of the females were mature in the 12-inch minimum size limit (Figure 1). As a result of this finding, we recommended a reduction in the Southeast regionwide minimum size limit from 12 to 11 inches; this recommendation was ultimately adopted into regulation by the BOF in 2000. Below 11 inches, the sea-run cutthroat maturity rate falls quickly; at 10 inches, only 28% of the sea-run females were mature. Because many of the most productive lakes with cutthroat trout in Southeast Alaska contain sea-run cutthroat, setting the minimum size limit below 11 inches could put these populations at risk. An additional finding of this study was that cutthroat trout have fewer eggs per ripe female (or lower reproductive potential) than previously believed: on average, an 11-inch female cutthroat has only 263 eggs.



**Figure 1. Percentages of female cutthroat trout that were mature in 21 Southeast Alaska lakes sampled during 1997 and 1998.**

### Recommendations for Future Work

Fisheries managers must be aware that there will be continued pressure to “relax” the conservative regulations, and they must therefore design appropriate research projects to collect data to defend and maintain the regulations as well as collect lake-specific maturity information. Any future length at maturity projects should incorporate ultrasound technology as a non-lethal method of sampling (Martin et al. 1983).

In order for any sport fish regulation to be effective, there must be a high degree of compliance. ADF&G biologists are concerned that substantial illegal harvest may be occurring in Southeast Alaska, especially in some of our remote “fly-in” lakes. There must be ongoing efforts to educate the public about our regulations and to keep the regulations posted in these remote sites.

## Acknowledgements

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## Writings on Angling and Ethics

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**ABSTRACT**—There is a growing body of information that fishing as sport is as ancient as fishing itself. Many of the world’s cultures have ancient angling traditions. According to the limited written record, fishing as sport began in Europe by the Roman era and a thousand years earlier. The popularity of fishing with rod and line in medieval Europe appears to have pre-dated the development of the sport in the British Isles by a century. In America, our first fishing publication is a defense of fishing with rod and line as recreation. The detractors of angling are equally ancient. Discussions of the lack of pain in fish, the questionable ethics of harassing living creatures for our enjoyment, and the idea of releasing a portion of one’s catch date back centuries. Managers who serve a diversity of cultures should understand the antiquity of the sport they manage and honor older and different traditions if they want to safeguard native trout fisheries and gain acceptance from recreational anglers.

### Early History of Sport Angling

Three thousand years ago, Asian sport fishing included bamboo rods, silk lines, feathered hooks, and barbless hooks (Radcliffe 1926). There is evidence that the reel was in use in China centuries before it was “invented” in the west (Trench 1974). Even so, fishing traditions that influence American angling today is based on western traditions. The early distinction between recreational angling and subsistence fishing in history is noted by Charles Trench in *A History of Angling*. The distinction is made perfectly clear by two Egyptian drawings: one, of about 2000 B.C., shows a man fishing who is poor, perhaps, or a professional

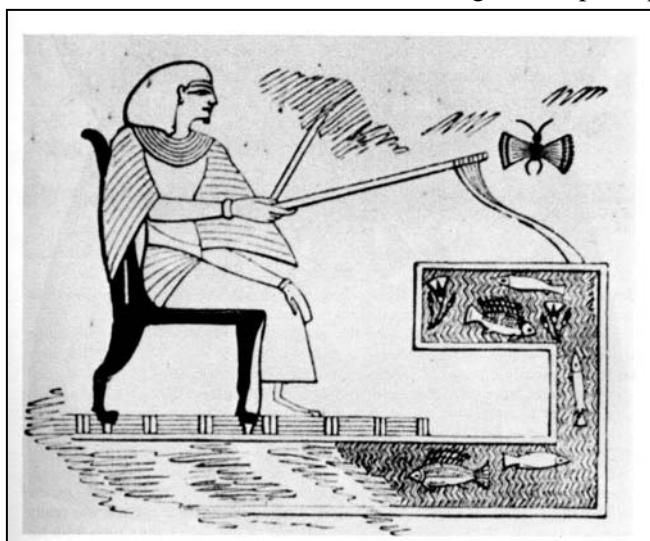


Figure 1. Charles Trench, a history of angling. Another dating from 1400 B.C shows a gentleman of leisure angling.

fisherman. Another, dating from about 1400 B.C., shows a gentleman of leisure angling

Early images imply that angling for food was different from recreational fishing. A poem by Theocritus, written in approximately 280 B.C. blurs this distinction (Hine, 1976). This is the first Big Fish story. “... Holding on tight to the pole, which was bent in my hand by the motion, as I extended my arms leaning

forward I found it a struggle, How was I going to land that big fish with my flimsy equipment..." In this translation, *The Fishermen* reads as a recreational story with the stalk, the hook-up, and the fight on light tackle. Fishing from the earliest times was fun, even when it was for food. Aeilian, who is credited with the first writings about fly fishing (200 A.D.), also describes fishing with hook and line as "being the most skillful and becoming for free men..." (Trench 1974). The Roman poet Martial, (100A.D.) mentioned fishing with a fly. An early translation reads: "gifts are like hooks; for who does not know that the greedy sea-bream is deceived by the fly he has gorged?" (Ker 1978)

During the Middle Ages, fishing grew in its importance as a food resource in Europe. The growth of the Catholic Church and the subsequent rise in the number of holy days annually resulted in between 140 and 160 days each year when fish were the only flesh consumed (Hoffman, 1997). Fishing, and possibly fly fishing, became the sport of the common man during this time. Fishing with the "vederangle", or feathered hook, appears in German literature in 1210. Wolfram Von Eschenbach's hero Schionatulander wades into a mountain stream, casting for trout and grayling ([WWW.flyfishinghistory.com](http://WWW.flyfishinghistory.com)).

Humanism began in the first half of the 14<sup>th</sup> century in Italy. Many writers trace its roots, and the emergence from the Dark Ages, to Francis Petrarch. His writings in the vernacular tell of country life, fishing, and climbing mountains. (Shepard, 1930) Petrarch is credited with the rise in vernacular literacy in Italy and the growing interest in life in the out of doors.

Perhaps the earliest naming of fishing done with rod and line as sport is found in Peter Crecentrensis' middle English translation (1600) from the Italian *The Countrye Farm* (1307). Chapter XVI begins with an apology for the previous chapters on fish husbandry and harvest by net, drain, or poison, and continues...



Figure 2. Four centuries of sport in America, H. Manchester. The recreations of the gentlemen of Virginia, 1607.

I will wade a little further in this art and shew you the manner of taking all sorts of fish by the angle, which is the most generous and best kind of all other, and may truly be called the Emperor of all Exercises. To speak then first of this art of angling or taking of fish with the angle, you shall understand that it consists of three especial things, that is to say, in the instrument which is the angle, in the instrument which is the bait, and in the true use of them both together, which is the seasons and time of year for the sport.(Country Farm 1307)

The author indicates how popular angling had become in the 14<sup>th</sup> century when he writes “But because the trouble of making (hooks) is a little noisome, it shall be best to buy them from such as make a living or trade thereof...”

Hoffman establishes that vernacular literacy had reached 20 percent in Italy by the 1500s and in England and Germany by the 1600s. This expansion in literacy led to changes in what was published. Works with topics as diverse as the plague, hair color, and fishing survive. The Heidelberg Fishing Text (1493) is a how-to-fish handbook in 27 chapters that was copied and altered to meet local fishing situations across Germany in the early part of the 16<sup>th</sup> century. It appears as part of the Tegernsee Fishing Advice. This collection of fishing materials written by monks in the Tegernsee Abby begins with more than 50 fly patterns. Beyond their early date and the fact they were copied, modified for local fishing, and distributed, the true significance of both works is that they were written in the vernacular. They were intended as advice for everyman.

Roman water law dictated that all flowing waters belonged to all freemen in common. This practice carried into the late Middle Ages. The birth of industry, especially in England, even on a local scale, disrupted this public access. In the Domesday book of 1086, there appear 5,624 listings of mills in England. Certain streams had a density of one to three mills per mile. (Getzler 2004) The restriction these mills and their dams placed on the commoner’s right to fish became so onerous that the Magna Carter banned weirs except along the coast. Fishing in church waters supported by the clergy appears to have been delayed in coming to England. When it did, the church brought its understanding of the importance of fish as food and recreation with it.

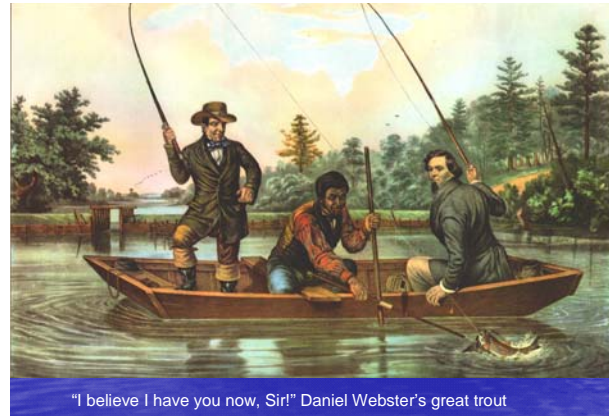
It is interesting to note, as Francis Francis did, “Grayling are supposed not to have been indigenous to England, but to have been transplanted hither by the monks...”(Francis, 1867). The monks may not have imported grayling, but most monasteries were built near graylings streams. Grayling are of note because they are at their prime as a food source during the winter months.

With the rise of the middle class in England an earlier egalitarian fishing tradition was lost. Flowing waters became a source of power and a crucial resource of the industrial revolution. By 1700 there existed between 10,000 and 20,000 mills in England. The density of up to five mills per mile near some industrial centers multiplied during the industrial revolution of the 19<sup>th</sup> century. As part of Great Britain’s rigid social structure, sport fishing became a class specific activity. Access to and participation in fly fishing, associated with clean, flowing waters, denoted status. Private waters were the preserve of the gentle classes. In England, this restriction of access provided impetus for fly fishing as a field rich with technical innovation, literature, and art.

England was not the sole source for the renaissance in early fishing. The more egalitarian nature of fishing on the Continent was captured in the first literature associated with the sport. Many writers claim more has been written about angling than any other field sport, yet few angling text are “Literature.” Most are extensions of the ephemera of magazines; detailing the how, when, and

where of angling. For angling writing to exceed this, it must reach beyond fishermen to a wider audience. The first work to achieve this in English is Izaak Walton's *The Compleat Angler* (1653). Of an earlier date and publication in Spain, Fernandro Basurto's *Dialogo* (1539), is regarded by many as the first true literature of sport fishing. The contrast in persons who fished and their relationships in both England and Spain is made clear in the difference between the protagonists in the two works. In Walton's "*Compleat*", two Gentlemen discourse over several days about the sport. Basurto's "*Dialogo*" also takes the form of a conversation between two protagonists. One is a young, uninformed, aristocratic hunter, the other an older angler. The angler is well read and well traveled, but poor. He declares that if there were but one river in the world, and that thousands of miles distant, he would fish it. He is the first trout bum: he lives to fish, and if he could not, "death would fish him" (Hoffman, 1997).

Western angling traditions diverged with industrialization in England. The Continent's populist sport of fly fishing became the providence of a more moneyed class. In England, the system of access, rules of sport, and harvest were structured to both keep fly angling exclusive and develop the courtly, gentlemanly sport of the later 19<sup>th</sup> century. This distinction between fishermen of different classes runs up against the abundance of resources in America and is changed once again.



"I believe I have you now, Sir!" Daniel Webster's great trout

## American Angling

Fishing as sport moved in two directions in America in the 17<sup>th</sup> and 18<sup>th</sup> centuries. The first was the popularizing effort of the commoner angler; the second was the sporting traditions of the British officer class. The early literature of fishing in America was that of the visiting British, allowing the admonition by William Chatto in *The Angler's Souvenir* (1835), "Brother Jonathan is not yet sufficiently civilized to produce anything original on the gentle art" (Schullery, 1987). This lack of fishing writings has led some to say that angling, as sport was not popular in early America.

The historical record shows differently. In 1619, *Recreations of Gentlemen in Virginia* depicted an angler attempting to take a very large fish (Manchester, 1991). In the 1640s, Boston protected the public's rights to fishing waters. In 1659, Governor Peter Stuyvesant, when proclaiming a day of fasting, wrote: "We shall prohibit all exercise and games of tennis, ball playing, hunting, fishing,...." If America has a counterpart to England's Dame Juliana Barnes (late 15<sup>th</sup> century), being the first to write of ethics and fishing as sport, it is the Reverend Joseph Seccombe. His *A Discourse utter'd in Part at Ammauskeeg-Falls, in the Fishing Season* (1739) explains that the business of America is business. The Lord is pleased with the fruits of our labors, however, He gives but one day for renewal each week. According to Reverend Seccombe, the best way to re-create oneself to do the work of the Lord in the marketplace is to fish on the Sabbath (Milne Collection UNH).

Fishing clubs were established very early in Philadelphia and New York. Five clubs existed in Philadelphia before the revolution. As Paul Schullery wrote about the colonial angler, “What we know already assures us that they were there, and that they knew as well as we how to enjoy fishing, but there is little flesh on the bones; we know too few names, too little about their tackle and their exploits, and much too little about their connections with their European counterparts” (Schullery, 1987).

The American struggle as depicted in myth and letters was man against nature. The general belief that American sport fishing began with the close of the frontier had to do with the transfer of the class struggle in Europe to the struggle against wilderness in America. As Schullery pointed out, “The other argument that colonists had no time for fishing, because they were too embattled by bears, Indians, and other survival problems, is also in error.”

The belief in the expanding frontier and the man-versus-nature myth was, perhaps, best rendered in the novels of James Fenimore Cooper. Mark Twain once remarked Cooper’s boats didn’t fit in his rivers (Twain, 1895); however, Cooper’s character Leatherstocking was the innocent confronting and subduing wilderness. Cooper’s writings were popular because his characters spoke to the beliefs of his age. An element of this myth was that the innocent had no time to recreate when faced with the burden of taming wilderness. (Smith, 1970) The truth is that lives were lived in the westward expansion. The peoples of Europe brought their older, more egalitarian fishing traditions with them when they immigrated to America, and those traditions helped us fish our way westward. From fishing with decoys in Minnesota to cane poles and bird flies in the south, there exists a rich, culturally diverse, history to regional angling in the United States. As Schullery said, we know “much too little about their connections with their European counterparts.”

There were three angling texts published prior to the Civil War that set the stage for the popularization of field sport. George Bethune’s American edition of *The Complete Angler* (1843) is noteworthy because Bethune’s notes provide a decidedly American air to the work. The first American text on angling was New York tackle dealer John Brown’s *American Angler’s Guide* (1845). While Brown objected to the idea that we owed our angling traditions to England, much of his work continued the old English tradition of lifting passages or whole sections of earlier work from older British authors. Perhaps the author with the greatest influence on angling in America prior to the Civil War was Henry William Herbert, author of *Frank Forester’s Fish and Fishing of the United States* (1849) and *Frank Forester’s Complete Manual for Young Sportsmen* (1854). It is somehow appropriate that “Frank Forester” was an expatriate Briton who brought his understanding of field sports with him. Even so, the next generation of American writers had their locally published works, of British invention, to build upon.

The growth of the Romantic Era in America during the middle years of the 19<sup>th</sup> century, the immigration of legions of anglers from Europe, the bloody legacy of the Civil War, and the birth of industrial tourism combined to change the public perception of field sports. This led to a tremendous increase in sport fishing’s popularity during the last half of the century. “Uncle Thaddeus Norris”, who is known as America’s Izaak Walton, published *The American Angler’s Book* in 1864. In his introduction “to the reader,” Thaddeus Norris declared that he wrote “(w)ith a view to filling up the blank left by my predecessors,...correcting some erroneous ideas...not only concerning fish but the adaptation of English rules and theories ...to our waters...” (Norris 1864). He does

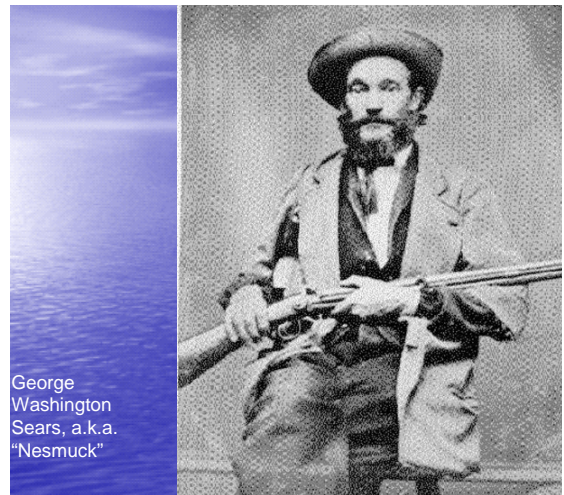
so admirably. At a time when industrial growth and westward expansion dominated popular thinking, Uncle Thaddeus spoke against pollution of the nation's waters and for conservation and wise management of fisheries. Uncle Thaddeus was, perhaps, the first American writer to release fish nearly as often as he kept them, and to intentionally fish the floating fly.



**Figure 3. Paul Schullery, American Fly Fishing, Murray's Fools.**

Many fly fishers believe that if Thaddeus Norris is our Izaak Walton, then Theodore Gordon is our Charles Cotton. Gordon's contribution to entomology and fly tying has been elevated to the status of myth. He had little to say on conservation. One understated reference on the need to limit harvest was; "If everyone is to have equal opportunity, then the rank and file will have to exercise some self restraint." (FG, Oct. 12, 1912). Gordon heralded the coming great age of fishing writing in America. In the decades between 1900 and 1940, much of our best angling literature was written and the rules of our sport expanded. This remarkable growth in letters came about because of the revolution in attitude toward nature after the Civil War.

The period between the Civil War and the turn of the Century saw a flowering in American field sports. The public embraced nature as a healer and a source of renewal. One of the most influential authors of the post war era who proselytized for nature as healer was William Henry Harrison Murray, a minister from Boston who camped in the Adirondack Mountains each summer. He was known as "Adirondack Murray." In his introduction to *Adventures in the Wilderness* (1869), Murray related the tale of a sickly youth from the city, recently arrived at the Adirondacks, intent upon being carried into the wilderness to die. One guide refused his request: the guide would not want to have to carry his body out. Another guide took pity and set off with the youth. Within a few days, the balsamic airs started to heal him. After weeks in the wilderness, he returned to the bosom of his family, well and whole. This vision of nature as healer was repeated by the next generation of scribblers, notably George Washington Sears, who wrote under the pen name 'Nessmuk.' Nature never did cure "Nessmuk" of his tuberculosis; even so, he published popular letters in *Field and Stream* magazine in the 1880s touting the healing powers of Nature.



George Washington Sears, a.k.a. "Nessmuk"

This vision of nature as a source of renewal was capitalized on by the railroad companies. They were desperate to market the lands received for building their lines across America. The railroad owners had to find a way to generate revenue from their lines. Part of their solution was to market the wilderness as healer. “Murray’s fools,” hordes of urban dwellers looking to escape intolerable summers, eagerly fled to new lodges and faux wilderness on trains. This was the birth of today’s industrial tourism, and remains an indicator of the death of wilderness (Limerick 1987).

A willing public made the leap from Adirondack Murray to John Muir, T. R. Roosevelt, and Gifford Pinchot. Muir sought nature to heal him after a loss of sight in an industrial accident and took his first great hike to the Gulf. Roosevelt traveled to Montana to be in on the killing of the last buffalo and heal his frail health. Pinchot flyfished on a camping trip with his father while the family stayed at one of the great Adirondack camps first popularized in Murray’s writing. The belief that nature is a healing agent is a crucial change in both the growth of environmental thought and the relationship between the angler and his quarry.

The speed with which the public attitudes toward wildlife changed at the close of the 19<sup>th</sup> century may be seen in the story of *Stickeen*, by John Muir (1909). Muir owed his popularity as a naturalist writer to the ease with which he anticipated public attitudes. He had to moderate his beliefs about animals throughout much of his writing career (Limbaugh, 1984). It was not until Muir became America’s premier nature writer that he dared to break with his readers and publish what he truly believed.

In 1880, on his second voyage through Southeast Alaska, Muir took a day’s walk on the glacier at the head of Taylor Bay. Muir may have been accompanied that day by a small, mongrel dog. When Muir first related the difficulties of the day, which culminated in a hazardous escape across a narrow ledge of ice, he failed to mention the dog. Over the ensuing years, he told the tale of his narrow escape to children and, then, adult audiences. Slowly the dog entered the story and grew in importance: Muir’s long abiding belief that animals have souls, emerged. In the final version, first published as a magazine article in 1897, Muir and the dog *Stickeen* share a deep bond. Muir related that he had come to recognize through their shared adventure the divine in all living things. During the twenty-seven years between the event and the book, Muir gauged that his reader’s sensibilities toward animals had changed to the point that he could now publish his long held feelings.

The need of the country to heal from the Civil War, the advent of industrial tourism, and the remnants of the Romantic Era combine to popularize wilderness in the final decades of the 19<sup>th</sup> century. Given the backdrop of American’s continuing belief in the need to subdue nature, this rapidly emerging belief in nature as healer leads to conflicting attitudes toward wildlife. Manifest Destiny and the burden of our frontier myths insisted that we become the masters of nature. The romantic vision quietly urged that Americans concerned with nature regard the living targets of bloodsports as equal and worthy opponents.

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### Toward an Angling Ethic

Only an epigram of Martial’s from the first century, dealing with the release of mullet under three pounds, (Ker 1978) and a line from *Piers Ploughman* (1300-1400) to release small fish may predate the mythic Dame Juliana Bernes’ admonitions about ethics. Her final commandments in *The Treatise* were to

respect private property, take only those fish you will consume, and do all you can to nourish the fish you seek (McDonald, 1963). It was a fine start toward today's code of angling ethics. In the early literature of angling, the Dame stood nearly alone in advocating for a general code of behavior. John Denny, in *Secrets of Angling* (1613), listed twelve virtues of the angler, which hint at appropriate behaviors. Bethune's edition of Izaak Walton and Charles Cotton's *The Complete Angler* nowhere detailed appropriate behavior; however, their contribution to ethics was to show how angling makes for a good life. The narrator's pupil Venator learned the generous spirit of angling as much as he did the particulars of the sport.

Early arguments against angling compared its rustic behavior to the virtues of parlors and gaming houses (Dennys 1613). This was part of the popular vilification of field sports as portrayed in Fielding's *A History of Tom Jones* (1749).

By 1828, Sir Humphrey Davy felt obliged to spend the first several pages of "*Salmonia*" defending the sport of angling from its detractors. "Hal. I have already admitted the danger of analyzing too closely, the moral character of any of our field sports;..." (Davy 1828). Lord

Byron, in *The Cantos of Don Juan* (1821), wrote: "And angling too, that solitary vice, whatever Izaak Walton sings or says; the quaint, old, cruel coxcomb, in his gullet should have a hook, and a small trout to pull it."

Fishing as a blood sport was discussed in the 19<sup>th</sup> century, and the need to release at least a portion of one's catch was well established in England during that time. In *Salmonia*, after discussing the cruelty of the hook, Davy's protagonist Halieus says, "...every good angler, as soon as his fish is landed, either destroys his life immediately, if he is wanted for food, or returns him into the water." He continued with comments on the survival of fish released and their poorly developed nervous system for sensing pain. Davy wrote that fish under two pounds should be returned to the water. Francis Francis, in *A Book on Angling*, wrote, "I hate a man who slaughters kelts and ill-conditioned fish more than any other species of poacher going. What good does it do him? He has had his sport. Let him be satisfied; and let the poor beast live and grow fat and healthy, and don't take a mean advantage of starvation and illness." (Francis, 1867)

Fredrick Halford, in *The Dry Fly Man's Handbook*, provided very modern instructions on how to handle and release fish not kept as food. He concluded, "A fish just up to the limit should invariably have the benefit of the doubt and be restored to its native element." (Halford, 1913) In chapters on fisheries management, Halford spoke for conservative size and bag limits. He also provided an argument for releasing undersized fish: "Let there be no mistake about it! The pot-hunter wishes to kill all he can, regardless of size, and the sportsman is not only willing to return any below the legal limit of the water, but exercises the greatest care both in extracting the hook and returning the fish to the water."



## Ethics in America

The superabundance of fish and game resources in America during the colonial period and during western expansion allowed anglers to have no regard for the health of populations of wild fish. Americans took full advantage of their right to fish. Thaddeus Norris wrote of anglers who routinely harvested 500 plus brook trout in a single day's fishing.

Even so, there were persons who felt that fishing, as a diversion was cruel. The Reverend Secombe addressed this in 1739: "(in their Apprehension)...He that takes Pleasure in the Pains and Dying Agonies of any lower Species of Creatures is either a stupid soul or a Murderer in Heart" (McPhee, 2002). Thoreau began as an avid angler. He evolved from being both hunter and fisher, to fisher only, to being revolted by any blood sports (Owen, 1981). In *Walden* (1854) he wrote, "I cannot fish without failing a little in self respect...Yet with every year I am less a fisherman,...at present I am no fisherman at all. But I see that if I were to live in wilderness, I should again be tempted to become a fisher and hunter in earnest."

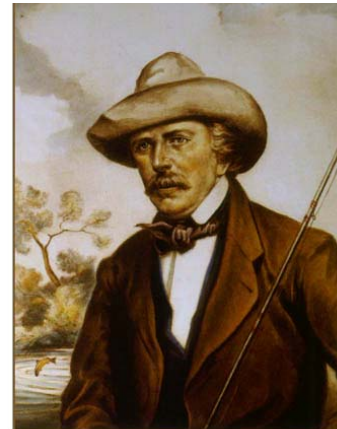
Murray spoke of the healing power of nature while he related taking forty shots to destroy a loon. He also wrote of releasing half of his catch at the side of the boat.

The movement on the part of anglers to release a portion of their catch became specific with Uncle Thad. He expressed his concern for the declines in numbers of fishes in American waters. He blamed pollution, timber harvest, farming, and mining, as well as urban forces for these declines. He then detailed huge harvests by anglers of hundreds of pounds of trout in a day. Norris implied disgust for this waste, and wrote of releasing nearly as many fish as he kept.

Regardless of the growth of angling literature and concern, sport fishing in America in the middle decades of the 19<sup>th</sup> century was becoming bleak. As early as 1856, George Perkins Marsh had reported to the Vermont Legislature "mills and factories dammed streams, polluted waters, and killed fish" (Taylor, 1999). Marsh implicated farming and logging. He concluded: "It is enough to say that human improvements have produced an almost total change in all the external conditions of piscatorial life." By the time "Murray's Minions" descended upon the wildlands of eastern America, there was little left. The Eastern brook trout was soon fished out and European browns and rainbows had not yet taken hold. Hatcheries became the panacea for ailing fisheries.

From the admonitions of Zane Grey at the Long Key fishing club to release most of your catch, to the efforts of President T. R. Roosevelt to set aside much of the remaining forests for the public good, the public soon came to support conservation. The turn of the last century was the time when anglers stepped forward to rescue their sport. In the next decades, most angling authors recognized their responsibility for anglers' impacts. Writings on angling and angling ethics flourished.

Louis Rhead might have played a pivotal role similar to Muir's in angling and conservation if he had been more moderate in his vision. Rhead wrote the first book on stream entomology in America, published articles on the nymph and successful nymph fishing techniques decades before their time, and included



Uncle Thaddeus Norris

in a very popular book on bait fishing a full chapter on the need for conservation and the question of the ethics of angling. He was also credited with bringing the barbless hook into fashion in the first decade of the century. Rhead was regarded poorly for many years more because of his personality than his writing. He is gaining in popularity again as American anglers have come to respect innovation over tradition. During the first half of the 20<sup>th</sup> century, many fishing writers chose to copy or build on his work.

The contrast between Muir's continuing popularity and Rhead's decline speaks loudly to the tradition of a dialogue of ideas in fishing writing. During the years between 1900 and 1939, authors addressed the question of angling ethics in small steps. The use of barbless hooks, the fish hog, the need to support conservation, all were discussed in fishing magazines and books. An example of the evolution of ideas on ethics in print is growth in interest in catch and release. During the first decades of the 20<sup>th</sup> century, there were many references to releasing fish printed.

Theodore Gordon remarked on the growing practice of releasing fish. "Some say it is well to kill off the big fish. I doubt this greatly" (F&G magazine, Aug 18, 1905). And, "I know Mr. LaBranche by reputation, and his ideals are high. He fishes the floating fly only and kills a few of the large trout. All others are returned to the water.... I fancy that a trout should be big enough to take line from the reel before it is considered large enough to kill."(McDonald, 1947)

In *Streamcraft* (1919), George Parker Holden took time out from describing the habits and lures of trout and bass to declare "not the least of the beauties" of fly fishing is that the quarry is hooked "lightly through the lip." Holden then instructed on how to release fish easily, with minimal damage. He quoted Mr. Harold Trowbridge (*Outlook* magazine, Aug. 6, 1919) extensively on the use of barbless hooks. Here was perhaps the first documented example of catch and release with no intent to harvest:

"In one morning's fishing out of fifty successive fish which I hooked I found it necessary to take only three out of the water in order to release them from the line. Two dropped off as they came over the side of the boat, and only one required an instant's touch before the hook could be slipped from its jaw."(Holden, 1919)

Holden declared: "Do not be afraid to join the slowly growing fraternity of those anglers whose password is 'We put'em back alive!'" and "(s)ince the impulse that Mr. Pulsifer's article gave to this movement, barbless hooks both bare and dressed have come into quite general use..."

*Hewitt's Handbook of Fly Fishing* (1933) touched briefly on releasing fish in the section on "Articles Carried in Pockets":

"It is surprising what freedom and relief one feels when the basket is left home. I rarely carry one any more, as I seldom kill more than one or two fish for a day's sport, knowing only too well how long it takes to grow these fish and how few of them are in any stream. I do not want to injure my own sport or the sport of others in future."(Hewitt 1933)

In 1936, Gifford Pinchot published *Just Fishing Talk*. He referred repeatedly to releasing fish.

"We love the search for fish and the finding, the tense eagerness before the strike and the tenses excitement afterward; the long hard fight, searching the heart, testing the body and soul; and the supreme moment when the glorious creature, fresh risen from the depths of the sea, floats to your hand and then, the

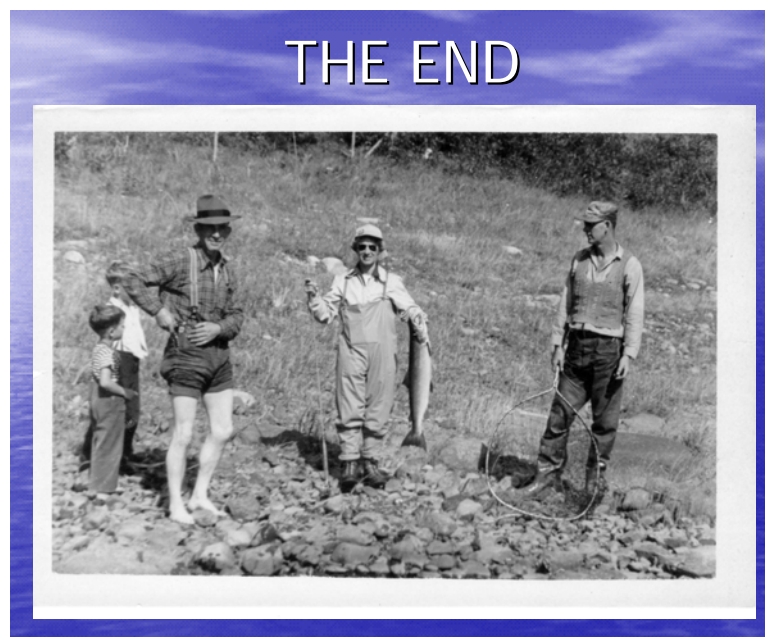
hook removed, sinks with a gentle motion back from whence it came, to live and fight another day.”(Pinchot,1970)

These writings and many others led to Lee Wulff’s famous “Game fish are too valuable to be caught only once.” And “The fish you release is your gift to another angler and remember, it may have been someone’s similar gift to you.”(Wulff 1939)

I have only scratched the surface in this attempt to document the early discussions of ethics and releasing fish. It seems lately that every old book, every early article, every piece of ephemera I read has some reference, however small, to the appropriate behavior of anglers towards fish and each other. The works cited in this paper are simply representative of the discussions of their time. The questions asked today about angling ethics, fish feeling pain, and catch and release have been discussed by anglers and the non-fishing public for centuries.

Skipping far ahead in the continuing dialogue in print about the nature of angling ethics, I would like to recommend the final chapter in Roderick Haig-Brown’s *A Primer of Fly Fishing* (1964). Just a few lines of introduction will do: “There is, I think, not much point in being a fly fisherman unless one is prepared to be generous and fairly relaxed about it all. Competition has no place at the streamside...The generosity I am thinking of is an attitude, a whole approach to the whole subject. It implies generosity to other fishermen, to the fish themselves, to the water and surrounding in which they live” (Haig-Brown, 1964).

Let me conclude with a comment from Marty Sherman: “Today’s biologists and fishery managers need to get away from their computers, and go fishing with an appreciation of the mystique and traditions of our sport to understand why anglers and fishery conservationists are so emotionally involved in these magnificent resources. Beneficial partnerships can result when professionals and their publics can build positive relationships. With this kind of a base, the angling community can be a strong advocate for scientific fishery management in the political arena where professionals fear to tread.”



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## Effects of Increased Angler Use on a Native Cutthroat Trout Population in Slough Creek, Yellowstone National Park

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**ABSTRACT**—Catch and release has been the method of choice for fishery protection in Yellowstone Park for several decades and is now mandated parkwide for native species by National Park Service (NPS) regulations. At some of the more popular fisheries, the number of anglers has increased dramatically as catch and release angling became more accepted. Trail access to many of its backcountry areas and a reputation for an exceptional native cutthroat trout population make Slough Creek an ideal angling stream. Recreational use in the area increased by nearly 50% during the early 1990s, and by 1994 Slough Creek was second only to Yellowstone River in terms of annual angler use. Park managers became concerned that the high levels of visitor use (including angling) at Slough Creek were beginning to have a significant negative impact on the fishery and riparian resources; however, electrofishing surveys begun in 2001 failed to reveal population-level changes since the previous survey in 1988. A high percentage of the fish captured during our surveys had hook scars attesting to the recatchability of the Yellowstone cutthroat trout. These electrofishing results indicate that the cutthroat population in Slough Creek has remained vigorous even during extreme drought years. Many of the negative impacts to the visitor experience seem to arise solely from individual perceptions of an overcrowded fishing area, because catch rates have remained high despite increased use. Of far greater concern to NPS fishery managers is the recent capture of rainbow trout in an area previously presumed to be isolated from hybridizing species.

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## Factors Affecting Special Angling Regulations

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### Extended Abstract

Special angling regulations have been used successfully to protect and rebuild fisheries in many regions of the USA and Canada, but it is important to recognize their limitations (Gresswell and Harding 1997). For example, when special regulations are successful, hooking mortality is usually low and the probability of recapture is high. Unless angler harvest represents a major portion of total mortality, reductions in angler harvest through special angling regulations may not have the desired effect. Where the environment limits growth, fish may not attain large sizes even when there is no angling. Furthermore, even when a fish population is protected from overharvest, arbitrary size targets or success rates may not be attainable in the sport fishery. Although densities may be high, species (or segments of a population) that are not vulnerable to angling can depress overall angling quality. In cases where there are a variety of species (stocks) in a fishery, unequal susceptibility to angling may also lead to unintended consequences.

It is apparent the success of special regulations varies with species, communities, and specific habitats. Although it may be possible to generalize for some species, response to particular regulations may be different when other species are present. Furthermore, habitat variables that influence growth, mortality, and distribution can influence the response to regulations even when biological assemblages are similar. These factors underscore the fact that agency and angler objectives should be concordant with the target species and site-specific environment prior to the implementation of special angling regulations.

Success of special angling regulations is often contingent on the size and age structure of the target population. To be effective, size limits must protect a significant portion of mature adult fish assemblage. Sometimes focusing harvest on a segment of the catchable population that has not become fully recruited to the fishery (maximum-size or slot-size limits) can provide sufficient protection. On the other hand, the size of fish available for harvest may not be acceptable (too small) to anglers. The potential biological outcomes of a regulation can be examined using simulation modeling; however, it is still important to monitor after the regulation is initiated. If regulations cause major changes in size distribution of the catch, size limits may need to be readjusted.

Public support and angler compliance are critical to the success of special angling regulations. It is important to consider angler preferences when developing new regulations, but at the same time, it is important to recognize the complexities of values among anglers and stakeholders. For instance, management responsibility extends beyond immediate constituencies to future generations of anglers and non-anglers alike, and therefore, the ecological basis for management should be clearly communicated.

It is commonly the responsibility of fishery managers to inform the public of resource problems, generate support for general management goals, and integrate

diverse values and opinions when developing management actions. Furthermore, a broad information base and a strong public education program are integral to successful management, and continued monitoring is needed to determine if future adjustments are required. Proclamations of success or failure of a particular special regulation are no longer sufficient. Instead, managers must synthesize factors related to site-specific effects and begin to develop general principles to guide implementation of special regulations for protecting and rebuilding fish populations.

Finally, it is important to recognize that the use of special angling regulations to limit harvest is simply one part of an integrated fishery management program. In areas where aquatic habitats have been severely degraded by land management activities, or biological assemblages have been disrupted by the introduction of nonnative species, other management actions may be necessary. Even in pristine areas, low productivity may limit the effectiveness of special regulations. These few examples underscore the necessity of developing realistic management goals and objectives that are concordant with the other components of the aquatic systems under consideration. It is apparent, however, many native fishes are highly susceptible to capture by anglers, and although angler harvest may not be the direct cause of population decline, it is often wise to incorporate special regulations in any integrated effort to maintain or rebuild populations of native fishes.

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## References

- Gresswell, R. E., and R. D. Harding. 1997. Role of special angling regulations in maintaining and rebuilding sea-run coastal cutthroat trout populations. Pages 151-156 in J. D. Hall, P. A. Bisson, and R. E. Gresswell, editors, *Sea-run cutthroat trout: biology, management, and future conservation*. Oregon Chapter, American Fisheries Society.