Evaluation of a catch and release fishery for brown trout regulated by an unprotected slot length. No. 173 1991

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Cover: A portion of the special regulation reach on Timber Coulee Creek. Drawing by Ruth King.

ABSTRACT

Timber Coulee Creek, a fertile (methyl orange alkalinity of 225 ppm) 8-mile-long trout stream in southwest Wisconsin (Vernon Co.), was selected in 1983 for evaluating a special opportunity fishing regulation never tried before in Wisconsin. The regulation, an unprotected slot length (14.0-16.9 inches in this case), has rarely been used anywhere in the nation to manage trout fisheries where catch and release (C/R) angling is emphasized. Anglers were also limited to a daily bag of one trout and use of artificial lures only.

Two contiguous study zones were established: a mile-long Treatment Zone (TZ) and an upstream half-mile-long Reference Zone (RZ). Standing stocks of wild brown trout (*Salmo trutta*) were inventoried with electrofishing gear (*DC* mark/recapture population estimates by inch group) in early October of 1983-85 (pretreatment phase) and in mid-April and early October of 1986-88 (posttreatment phase). A few wild brook trout (*Salvelinus fontinalis*) were also present in each study zone. The minor contributions of this species to the fishery are discussed in Appendix A.

Season-long creel surveys, featuring interviews and hourly counts of angler vehicles during each 7-hour on-site tour of duty, were conducted 5 days/week during the 9-month (Jan-Sep) 1984 season and the 5-month (May-Sep) 1986-88 seasons. The change in season length in 1986 was part of an unforeseen change in angling regulations applied to Timber Coulee Creek and all other trout streams in Vernon County and adjoining LaCrosse County. Accompanying the shortened season (in both study zones) were 2 other changes in the RZ: the minimum size limit increased from 6 inches to 9 inches and the daily bag limit decreased from 5 to 3.

Despite unexpected complications from changing regulations between pretreatment and posttreatment phases, enough clear-cut results were gathered to conclude that 2 of the 3 major goals of the special regulations were attained:

1. An excellent C/R fishery evolved in the TZ supported primarily by brown trout less than 14 inches. The catch per hour (CPH) averaged 1.84 for the 1986-88 seasons and peaked at 2.11 the third season. The 3-season average exceeded the baseline 1984 season CPH (kept or released) by 82%. The abundance of trout at the season's start to sustain this C/R fishery increased from 1,149/mile in 1986 to 3,366/mile (193%) in 1987 and to 3,555/mile (6%) in 1988. An average of 836 trout were released for every trout creeled.
2. Harvest within the unprotected slot length was negligible each season (7, 8, and 2 trout/season), but opportunity to see and catch such trout and keep one per day improved substantially. Legal-sized (14-17 inch) brown trout increased from 9/mile at the beginning of the 1986 season to at least 50/mile at the beginning of the 1987 and 1988 seasons. Each season anglers reported releasing legal-sized trout.
3. The third goal, an improved C/R fishery for brown trout 17 inches or larger (and especially in the "trophy size" category of 20 inches or larger) was not attained. The abundance of such trout fluctuated from spring to fall each year and reached a peak density of only 9/mile in October 1986 vs. a peak pretreatment density of 10/mile in October 1983. No causes were identified for the failure of large trout to accumulate or stabilize in the TZ despite increased abundance of trout in the 14-16 inch range as the study progressed. Study zones longer than one mile may be needed to encompass year-round movement ranges of large brown trout.

Angling pressure increased in both zones from 1986 to 1987, then unexpectedly declined to intermediate values in 1988. Declines were attributed to 2 environmental factors: exceptionally hot weather (throughout Wisconsin and the nation) during most of the season and the worst prolonged drought (most of 1987 and 1988) in the state in several decades. In July 1988, the water temperature reached 82 F at the RZ/TZ boundary. Despite lower use in 1988, average use for the 1986-88 seasons ranks among the highest observed on Wisconsin trout streams: 2,637 hr/mile or 906 hr/acre in the RZ; 1,681 hr/mile or 601 hr/acre in the TZ.

The new regulations implemented in the RZ in 1986, plus an unknown but potentially important change in angler clientele (due to crossovers from the TZ), reduced harvest in the RZ by 72% during the posttreatment seasons. Average length of brown trout creeled increased from 10.7 inches in 1984 to 11.5 inches in 1986-88. More trout were kept in the 11-inch group than in the 9-inch and 10-inch groups. Many characteristics of the RZ fishery during 1986-88 resembled a C/R fishery more than they did a catch-to-keep fishery. Fly fishers were more common than natural bait fishers. Nine trout were released for every trout kept.

Fisheries management and research recommendations include: (1) Support for the DNR fisheries management decisions to replace the unprotected slot length with a simpler 14-inch minimum size limit, retain the one trout/day bag limit and artificial lure regulations, and extend the length of the TZ to reduce future crowding, thereby enhancing angling quality. (2) Investigate the habitat requirements of large brown trout and experiment with techniques to enhance stream carrying capacity for such trout. (3) Initiate studies in Wisconsin, and especially on Timber Coulee Creek, to document economic benefits to local communities from nonlocal and nonresident anglers attracted to special regulation waters. (4) Gather better sociological data on angler attitudes toward special opportunity regulations. (5) Continue to give high priority to fisheries management activities on this stream, especially trout habitat improvement and maintenance. (6) Encourage greater recognition that beneficial biological and sociological impacts of special regulations extend beyond the borders of the designated zones where they are applied.

Key Words: Trout, trout streams, fishing regulations, trout management, trout research.

Evaluation of a Catch and Release Fishery For Brown Trout Regulated by an Unprotected Slot Length

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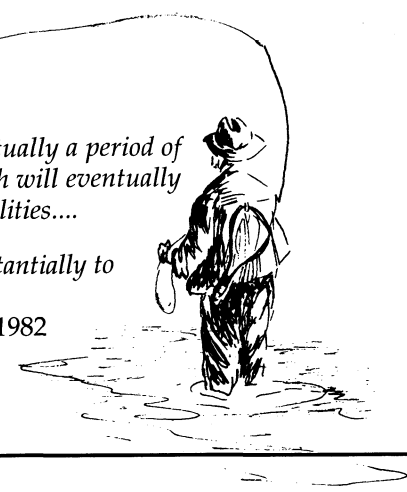
We are in an early period of evaluation of special regulations—actually a period of trial and error—and it is to be expected that further scientific research will eventually enlighten us in ecological knowledge and increase our predictive capabilities....

It's time to try them out...special regulations may prove to add substantially to the recreational value and diversity of trout angling.

Waters 1982



INTRODUCTION

This prognosis less than a decade ago now appears conservative. Special opportunity regulations applied to trout fisheries have proliferated rapidly. Evaluations have quickly moved them from a "trial and error" peripheral management concept to a broadly accepted, dependable option that substantially enhances and diversifies trout angling experiences. For example, plans and predictions for trout fisheries in Colorado (Nehring and Anderson 1984), Missouri (Turner 1986), Montana (Wells 1984), New York (Barnhart and Engstrom-Heg 1984), Pennsylvania (PA Fish Comm. 1986), Washington (WA Dept. of Game 1984), Wisconsin (Claggett 1988); Wyoming (Baughman 1984); and in Yellowstone Park (Varley 1980) all highlight continuing or expanding special opportunity regulations that shift the management emphasis from the quantity of trout harvested to the quality of the total fishing experience. Special regulations have also been championed as a management technique to hasten recovery of populations of salmonid species that are highly vulnerable to angler exploitation (Behnke 1980) or urgently need preservation as rare or endangered species (Behnke 1976).

Most of these special regulations, designed to optimize recreational quality, require anglers to release all or most of the trout caught in the normal season or during special extended season periods. Consequently regulations generally restrict the kinds of baits that can be used, prohibiting natural baits, which tend to cause much higher post-release mortality than artificial lures (Wydoski 1977, Mongillo 1984).

Regulations that emphasize the recreational concept of "catch and release" (C/R) angling can be subdivided into several categories. Four of the most common are:

1. A no-kill category requiring release of all trout caught (Ball 1971, Kerr 1982, Jones 1984, Seehorn 1984).
2. A trophy trout category which allows for harvesting one or perhaps two exceptionally large trout per day (Nehring and Anderson 1984, Seehorn 1984) or even per season (Falk, et. al. 1973).
3. A quality-size category featuring allowable harvest of 1 to 3 trout of above-average size for that fishery. In essence, this is simply a higher than normal minimum size limit coupled with a sparse bag limit and bait restricted to artificial lures (Lantiegne 1974, Hunt 1981, Seehorn 1984, Turner 1986, Nehring 1987).
4. A slot length limit category designed to protect intermediate size trout while allowing anglers to keep a few trout each day from the abundant supply of those smaller than the protected slot range plus one or two trout larger than the slot range (McDowell 1980, Rohrer 1983, Nehring 1987).

The Wisconsin Department of Natural Resources (DNR) began using such site-specific special regulations in 1955 to improve fishing quality and reduce emphasis on harvest in trout streams. Portions of 2 streams in northeastern Wisconsin were designated as "fly fishing only" waters (Burdick and Brynildson, 1960). At the same time, the minimum legal size limit was increased from 6 inches to 12 inches and the daily bag limit was reduced from 10 to 5 trout. These reaches of the Peshtigo River (Marinette County) and Wolf River (Langlade County) continue to be managed under regulations more restrictive than those generally in effect in the region. However, the minimum legal size limit was reduced to 10 inches in 1971.

No other trout streams in Wisconsin were designated for special regulations until 1977. That year a 2.4 mile stretch of Castle Rock Creek in southwest Wisconsin and a 1.4 mile stretch of Doc Smith Branch, a tributary entering Castle Rock Creek within its special regulation portion, were designated for special management. The regulations required using artificial baits only and releasing all trout caught. Also in 1977, the trout fishery in the Race Branch, a mile-long side-channel of the Willow River in west-central Wisconsin, came under rules that allowed harvesting only one trout/day that was 13 inches or larger. Anglers were also required to fish with artificial baits.

During 1978-88, portions of 6 more trout streams were designated for special, more restrictive regulations. The regulations varied from stream to stream (Append. Table C.1), but in every case the managerial intent was to improve fishing quality and reduce harvest.

Anglers are required to release all or most of the trout that they catch in 5 of these special regulation zones. One of these zones receives little angler use because of its small size (less than one cfs base flow). Although a no-harvest restriction is in effect on the upper 800 feet of Paradise Springs Creek in southeast Wisconsin, the focus of angler use is on an adjacent 1.25 acre headwater spring pond where the same no harvest limitation applies.

The other 4 streams in Wisconsin where C/R regulations applied by 1988 are Castle Rock Creek and its tributary, Doc Smith Branch in Grant County, the Race Branch in St. Croix County, and a mile-long stretch of Timber Coulee Creek in Vernon County about 55 miles northwest of Castle Rock Creek. Timber Coulee Creek is the stream reported on in this Technical Bulletin. Combined length of these 4 C/R reaches is about 6 miles, which represents only 0.06% of the total length of trout streams in the state. The combined length of all 11 special regulation zones established by 1988 is approximately 32 miles, representing only 0.3% of the present official total length of trout streams in Wisconsin, some 9,560 miles (Wis. DNR Publ. 6-3600-80).

Beginning in 1990 a radically revised framework of trout fishing regulations was approved for implementation throughout the state. All inland trout waters (streams, ponds and lakes) were assigned to one or more of 5 categories of regulations (Claggett 1988). Fishing regulations for all except Category One are generally more restrictive than the previous regulations in effect. All waters managed with special opportunity regulations are assigned to Category 5. The number of streams in this category increased from 11 to 91 and the cumulative length increased from approximately 32 miles to 280 miles, a nearly 8-fold increase.[1]

STUDY OBJECTIVES AND REVISIONS

A fifth and rarer category of special regulations requiring release of most of the trout caught is a slot length regulation targeted at *harvest within the specified slot range* rather than protection of that range (Clark and Alexander 1985). Evaluating the effectiveness of this unusual C/R regulation became the objective of the research study that I conducted on a portion of Timber Coulee Creek during the first 3 years (1986-88) of the regulation's operation. It was the first application of an unprotected slot length regulation on a sport fishery in Wisconsin.

During those 3 years, anglers were permitted to keep one trout/day that was 14.0 inches or larger but less than 17.0 inches long. Angling was permitted only with artificial lures in the 0.99 mile reach designated as the Treatment Zone (TZ). The unprotected slot length, bag limit of one per day, and bait restriction combination of regulations tested during the 1986-88 fishing seasons was proposed with 3 major fisheries management goals in mind:

1. Provide a high quality C/R fishery, sustained primarily by trout less than 14 inches, i.e., high catch rates of trout large enough to provide a satisfying "fight."
2. Provide anglers with the option of keeping one trout/day of substantial size, if they were successful in catching one or more within the unprotected slot range, i.e., something to take home and eat plus tangible proof of angling skill.
3. Provide opportunities to fish a mile-long reach of stream in Wisconsin that holds a standing stock of large trout (17 inches or larger, and especially "trophy size" trout—20 inches or larger) at or near carrying capacity. Although the few such trout present in the TZ would have to be released if caught, their primary recreational value would be an "anticipatory contribution." The probability of catching one of these sparsely present fish would be low but knowing of their presence should add value to the angler's total experience.

If these 3 management goals could be attained by applying this special regulations package built around an unprotected slot length, fisheries managers would have another proven strategy for meeting the growing demand for C/R management of trout fisheries.

I hypothesized that the abundance of trout less than 14 inches, the number recruited into the unprotected slot range, and the number 17 inches or larger would all increase from season to season when harvest below and above the slot range was eliminated. This greater abundance of trout of all sizes should, in turn, enhance angling quality by providing more trout to see while fishing and more trout to catch. No other set of special regulations in effect in Wisconsin provided the same kind of simultaneous focus on 3 special opportunity goals for a C/R fishery.

When this study was initiated in 1983 the evaluation plan called for standing stock inventories that fall, a season-long intensive creel survey during January-September 1984, a postseason assessment of standing stocks in the 2 study zones in early October and then implementation of the experimental regulations in the TZ on 1 January 1985 when the 9-month trout fishing season began. Three successive seasons of creel surveys and postseason inventories of standing stocks would complete the field evaluation in the fall of 1987. Quantitative and qualitative

[1] In a block of 11 southwestern counties and a block of 10 northeastern counties, the new 5-category system of trout fishing regulations was not imposed in 1990 as scheduled. Due to a severe, prolonged drought and poor natural reproduction of trout in these regions, emergency regulations were substituted. In the southwest block only C/R (no harvest) fishing was permitted. In the northeast block the 1990 season was closed. In 1991, emergency regulations continued that restricted trout angling to C/R only in 8 southwestern counties (6 of them the same as those in 1990) and in the block of 10 northeastern counties.

changes in the sport fishery and standing stock of trout in the TZ during 1985-87 would be assessed in relation to baseline data collected in that zone during 1983-84. Comparisons would also be made between TZ trends during 1985-87 and contemporary changes observed in the RZ where fishing regulations would be constant throughout the 1983-87 study period.

By the spring of 1984, however, the research plan needed adjustments. An unanticipated delay occurred in the administrative process of authorizing the special regulations. Approval was linked to revisions in trout fishing regulations throughout Vernon County and adjacent LaCrosse County. Consequently, implementing the special regulations in the TZ was delayed one year beyond the 1985 season.

Postponement until the 1986 trout fishing season was largely due to lack of public support from trout anglers in Vernon County, and to a lesser degree in adjacent counties. Public opposition appeared to be related only indirectly to the special regulations proposal that would affect only a mile of Timber Coulee Creek. It was more directly related to withholding public support for the DNR proposal until broad-scale changes in trout fishing regulations were approved by the DNR for the majority of trout streams in Vernon County. A series of public meetings between fisheries management personnel and trout angling groups produced a compromise package of new regional regulations to be implemented in 1986. Authorization for testing the unprotected slot regulation in the TZ on Timber Coulee Creek was included.

The new regulation package included cancelling the 4-month "early season" in Vernon and adjacent LaCrosse counties—a season first imposed in 1976 in 10 southern and southwestern Wisconsin counties. Opening day was returned from 1 January to the more traditional first Saturday in May. The minimum size limit was also increased from 6 inches to 9 inches and the daily bag was changed to 3 fish throughout the new 5-month May through September season. The former bag limit had been 2/day during the 1 January to first Saturday in May period, then 5/day for the remainder of the season ending on 30 September.

The delay and the unforeseen changes in season length, size, and bag limits impacted my evaluation plan in several ways. Creel survey data gathered during the 9-month 1984 season lost some of their usefulness for comparison with creel survey data that would be gathered during 5-month seasons in 1986-88. Changes in the RZ regulations from 1984 to 1986-88 also reduced the usefulness of this study zone as a "reference" or "control" site.[2]

Two other midcourse adjustments in the evaluation plan offered potentially positive additions. Switching opening day from 1 January to early May provided an opportunity to carry out preseason (mid-April) trout population inventories in the study zones. Those inventories would provide more reliable assessments of angler exploitation rates (harvest in relation to preseason abundance) and more accurate "recycling rates" (total catch in relation to preseason abundance). It was impossible to make preseason assessments of standing stocks before 1 January opening days because of ice cover over most of the study zones.

Although the switch in regulations applying to the RZ reduced its usefulness as a reference site in the experimental design, the trout population and sport fishery data gathered in this zone in 1984 and again during 1986-88 fortuitously allowed me to evaluate the new regulations initiated in 1986. This evaluation would have potential managerial significance to much of Timber Coulee Creek and perhaps to most of the trout stream fisheries in Vernon and LaCrosse counties. An assessment of the RZ sport fishery from this perspective is also included in this report.

STUDY AREA

Timber Coulee Creek is located in northwest Vernon County, about 20 miles southeast of the city of LaCrosse (population approx. 50,000) (Fig. 1). It is in the unglaciated "coulee region" of Wisconsin. Approximately 208 miles of streams in Vernon County are managed as trout water, including all 8.2 miles of Timber Coulee Creek. During the study period, about 60% of Timber Coulee Creek was managed as Class I water, where no domestic trout were stocked, and 40% was managed as Class II water annually stocked with approximately 5,000 age 0 brown trout each fall of 1983-86. Since 1987, the entire stream has been managed as Class I.

The stream is very fertile (methyl orange alkalinity of 225 ppm), alkaline (pH of 8.0), and has a moderately high gradient (40 ft/mile) for a trout stream in Wisconsin. The surface area of the stream is about 14 acres.

Much of the watershed of 18 square miles is agricultural, with some hardwood forests along the hilltops. The

[2] To partially offset the loss of comparative usefulness that the pretreatment 1984 data would have had, I prepared an unscheduled report on the 9-month creel survey that treated both study zones as a single 1.6 mile unit. The objective of this report was to simply describe characteristics of a trout fishery in southwest Wisconsin within the "early season" zone and suggest some fisheries management implications of such seasons (Hunt 1985). Only one previous account of a 9-month creel survey on a Wisconsin trout stream had been published (Larson 1982).

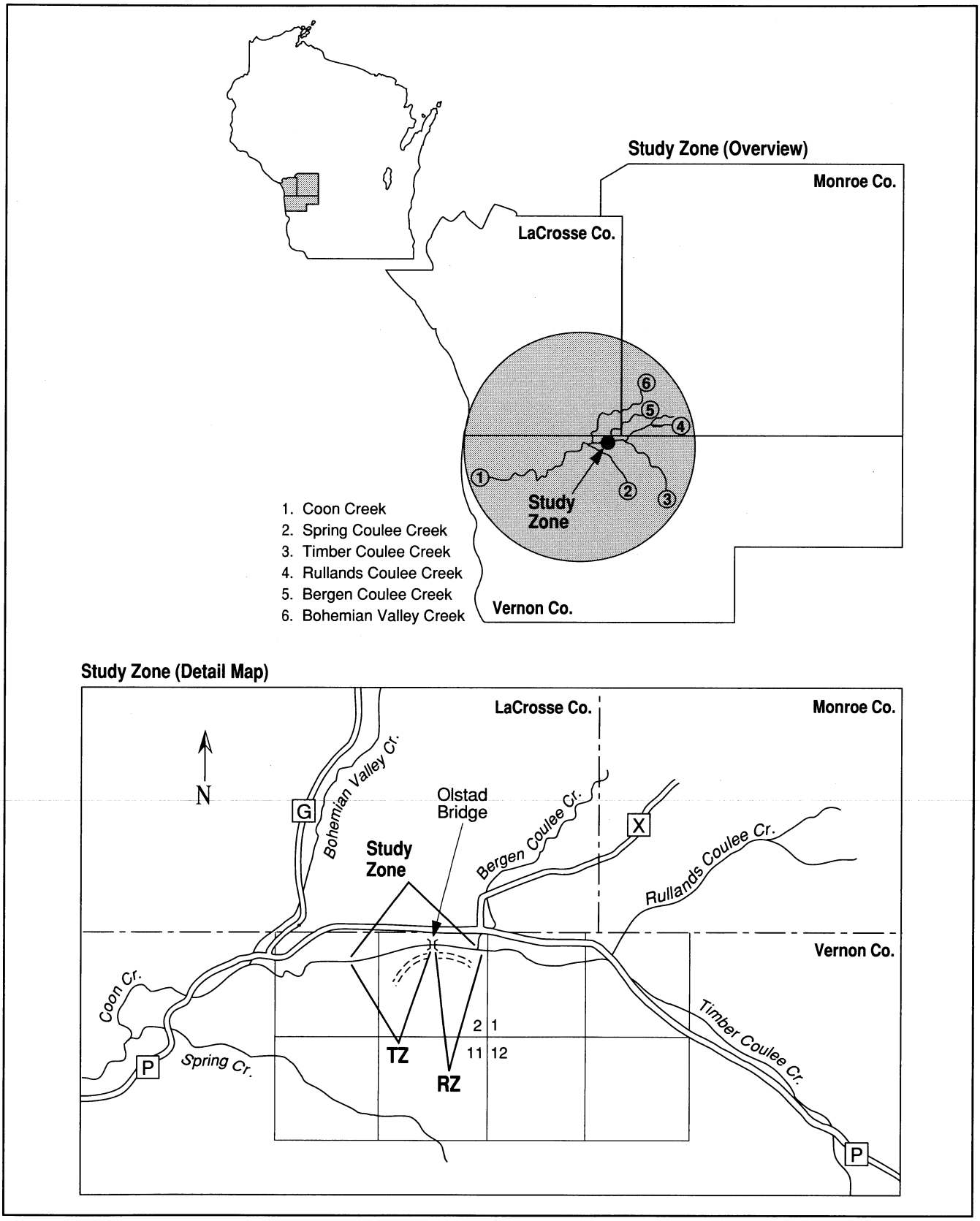


Figure 1. *Site map of the 1.6 mile study area on Timber Coulee Creek in Vernon County. Timber Coulee Creek is one of several trout streams making up the Coon Creek system in LaCrosse, Monroe, and Vernon counties. The upper end of the study area is at the confluence of Bergen Coulee Creek and Timber Coulee Creek. Much of Timber Coulee Creek is paralleled by County Road P.*

riparian zone is predominantly pastureland for dairy cattle. About 90% of the stream frontage is included in perpetual easements owned by the state. Public access, therefore, is excellent, and the stream is easily fished. County Road P closely borders much of the stream, easing access for anglers. Timber Coulee Creek is one of several trout streams that together form the Coon Creek system (Fig. 1). Large portions of the stream have been intensively modified with trout habitat improvement structures made of large rock supported by wooden subsurface platforms. These narrow and deepen the stream and increase pool area and underbank hiding cover (Vetrano 1988). The riffle:pool ratio is excellent (47%:53%). The substrate of the riffles is dominated by well-armored cobble (fist-sized stones) and gravel.

At about the midportion of Timber Coulee Creek, 2 contiguous study zones were established in 1983 to periodically monitor standing stocks of trout and carry out creel surveys before and during imposition of the special regulations to be tested in the Treatment Zone (TZ). The upper boundary of the total study area (both study zones) is the confluence of Bergen Coulee Creek and Timber Coulee Creek. A road bridge (Olstad Bridge) spans the study area 0.56 mile below the upstream boundary. The reach of stream from the upstream boundary to Olstad Bridge was designated as the Reference Zone (RZ). The reach from Olstad Bridge downstream for a midchannel distance of 0.99 mile constituted the TZ. The lower boundary is marked by a farm fence. A farm lane also ends near the lower boundary. Anglers were permitted to use this trail for vehicular or walking access, but no parking area was designated.

In July 1983 the average width of the RZ was determined to be 24.0 feet; its surface area was approximately 1.63 acres. The average width of the TZ was 23.0 feet, and its surface area was 2.77 acres. These values determined in 1983 were used throughout the 1983-88 study period to calculate standing stock and sport fishery indices on a "per acre" basis.[3]

A typical portion of the Treatment Zone on Timber Coulee Creek, bordered by a riparian zone of pasture land. County Road P runs along the base of the hill in the background. The terrain is typical of the "coulee country" portion of southwestern Wisconsin.

[3] The surface area of the study zone undoubtedly decreased in 1987-88 during an increasingly severe drought period. However, no measurements were made to determine impacts of declining baseflow on surface area. Fortunately, nearly all expressions of relative values for the standing stocks of trout and creel survey information are on a "per mile" basis, not "per acre" basis.

In early January 1984 two minimum/maximum temperature recorders were installed and monitored weekly through September. At the upper boundary of the RZ water temperatures during this 9-month period ranged from 32 F to 73 F. The 9-month mean was 52.7 F. At the lower boundary of the TZ the water temperature range was 31-73 F. The 9-month mean was slightly lower (51.8 F) than at the upstream recording site (Append. Table C.2).

The baseflow discharge was not measured until June 1986 when it was approximately 24.4 cfs at the upper boundary of the RZ and 26.3 cfs at the lower boundary of the TZ.

The sport fishery in both study zones throughout the study period was highly dependent on wild brown trout (*Salmo trutta*). A few wild brook trout (*Salvelinus fontinalis*) were also present in both study zones and especially in a localized reach of the TZ where a small tributary entered. Throughout this report, however, the word "trout" will refer to brown trout only. Changes in standing stocks of brook trout and contributions of this species to the fishery in the study area are briefly reported in Appendix A.

No domestic brown trout were stocked in either study zone during the 1983-88 study period, but brown trout were stocked annually in portions of Timber Coulee Creek above the study zones through the fall of 1986. It was not possible to positively identify all domestic brown trout that may have migrated into the study zones. However, it is likely that they contributed a maximum of 5% to any numeric or biomass assessment of standing stocks during the study period. Unmeasured free movement of wild trout between study zones, and into the study zones from upstream and downstream, undoubtedly contributed to dynamic changes in standing stocks too. Such biases of unknown magnitude are inherent in a field study on a portion of a trout stream that has no natural or artificial barriers to isolate study zones.

METHODS

Stream Morphometry

The length of each study zone was determined along a midchannel course by wading the channel and measuring it with a 50 ft tape measure. Electric fence rods were temporarily staked at channel midpoints around bends to guide the tape along the midcourse. At 50 ft intervals stream widths were measured to the nearest 0.1 ft from wetted edge to wetted edge. Width measurements within each zone were summed and divided by the number of measurements to derive an average width. Surface area (in square feet and acres) was calculated as the simple product of average width and midchannel length.

Stream flow was determined with a Gurley Pygmy Meter. The velocity-area method of calculating discharge was used, based on velocity measurements at one ft intervals across transects of the stream. The meter was set on the depth measurement/support rod at 0.4 of the water depth at each interval.

Trout Population Assessments

Nine mark and recapture estimates were made in each study zone during 1983-88. Six estimates were made in early October each year and 3 estimates were made in April of 1986-88. A standard DNR stream shocker unit was used. It had a 220-volt *DC* generator and 3 positive hand-held electrodes. Electrofishing proceeded upstream from the lower boundary of each study zone. Trout collected by the crew were held temporarily in a tub of water on the electrofishing boat. Trout were collected for distances varying from 50 to 200 yards depending on the number collected. The entire length of each study zone was surveyed. A processing crew followed behind the collecting crew until sufficient trout had been captured to make it worthwhile to set up processing procedures.

Trout captured on the first or "marking" run were measured to the nearest 0.1 inch (total length) and weighed to the nearest gram. Each received a temporary mark (excision of lower lobe of caudal fin) prior to being released. After examination and marking, trout were placed in a perforated garbage can partially filled with water and moved downstream to the point where collection of that lot of trout began. Then they were released. (Releasing captured trout at the downstream boundary of each collecting station is extremely important to minimize post-release movements out of the study zones.)

Trout population inventories were made with DC electrofishing gear before (mid-April) and after (early October) each trout fishing season during the study.

Meanwhile the electrofishing crew continued collecting until the processing crew could catch up or another tub of trout had been collected.

All age 0 trout collected in October were given a permanent year class mark (fin clips) to aid in establishing known-age individuals in future electrofishing inventories and in the catch by anglers. Age 0 was clearly separated from age I by a gap of at least 0.5 inch between the length frequency ranges of each age group.

On the second or "recapture" electrofishing run through the study zones the following day, trout were tallied by inch groups and by permanent year class marks, if present. Age 0 trout captured for the first time were permanently marked before release.

Population estimates for each species of trout were made by inch group using the Chapman modification of the Petersen mark and recapture formula. Estimates by inch group were added to obtain estimates for the population in the study zone.

Estimates of biomass were derived for each inch group from the product of average weight per inch group and estimated number per inch group. Whenever possible, average weights were based on sample sizes of 50 individual weights.

Creel Surveys

Partial creel surveys were carried out in the study zones throughout the 9-month 1984 season and the 5-month 1986-88 seasons. Each survey combined hourly "instantaneous counts" (taking only a few minutes to complete) of angler vehicles and between-count interviews of anglers. Vehicles were counted at parking areas and along the road that parallels the study zones. Anglers fishing in the RZ were also counted hourly. The entire 0.56 mile reach of stream in the RZ could be observed from its lower boundary (Olstad Bridge) or from County Road P (Fig. 1). Not all of the TZ was visible from the vehicle-counting route. The number of anglers in the TZ was collected through interviews. Anglers were asked how many anglers were in their fishing party.

During the 1984 season, the starting and ending times of on-site surveys were adjusted progressively in response to weather conditions, hours of daylight and behavior of anglers. During January-March work shifts of 7 hours in the study zones normally began no earlier than 9 a.m. and usually ended by 6 p.m. During April-September of 1984 and May-September of 1986-88 survey shifts were randomly assigned to one of two 7-hour periods; either 7 a.m.-2 p.m. or 1 p.m.-8 p.m. Shifts were also randomly assigned to one of 4 weekend work periods and to 4 of 8 weekday periods throughout the season. At the discretion of the survey technician, shifts were occasionally extended if there appeared to be opportunities to interview anglers about to finish fishing. Opening days of the 1986-88 seasons were treated differently. Work shifts of 14 hours (6 a.m.-8 p.m.) covered approximately 100% of angler use.

Between vehicle counts the survey technician interviewed anglers who had completed their fishing trips, or who were returning for some other reason to their vehicles, or were moving from one study zone to the other. Anglers were seldom interviewed at streamside while they were fishing. Length of a fishing trip was defined as the amount of time an individual angler reported fishing in one study zone while at the stream. If the same angler crossed over to the other study zone, the time spent fishing there was logged as a separate trip. If an angler left the stream and returned later the same day and was interviewed again these were counted as separate trips. Interview data included name and residency information, number of anglers/party, time spent fishing, baits employed, number of trout kept by species, and number released by species. Creeled trout were measured for length and examined for year class marks. Interviewed anglers were also offered a printed paper telling about the special regulations study in the TZ (Appendix B).

Fishing pressure, catch, and related fishery statistics were calculated monthly. Separate monthly estimates were made for weekdays vs. weekends and holidays. Calculations followed routine procedures used in several previous DNR creel surveys (Avery 1983, Hunt 1981, Lambou 1961).

Creel census clerk Linda Wilson interviews an angler on Timber Coulee Creek.

The nonparametric Mann-Whitney U test was used to compare pretreatment estimates of standing stock and biomass with posttreatment values. The reference and treatment zones were compared separately. There are 3 estimates of each parameter for both time periods. With 3 observations per group, the smallest level of statistical significance attainable is 0.05. The Mann-Whitney U test was also used to compare the 2 time periods with respect to differences between reference and treatment zones (one difference was calculated for each parameter for each year). A significant difference between time periods would also suggest an effect of the "treatment"—the change to special regulations—independent of any factors affecting both study zones similarly.

Only one year of creel survey data was available for the pretreatment period and three years for the posttreatment period. Because the Mann-Whitney U test cannot be applied in this situation, *t* tests were used to compare time periods. Results of these tests should be interpreted cautiously since the single pretreatment observation may not be representative and there was no way to assess the assumption that the posttreatment variance is the same as the unknown pretreatment variance. Nevertheless, *P* values from the *t* tests indicate where pretreatment to posttreatment differences may have occurred.

RESULTS

The Sport Fishery

Overview of 1984 Season

During the 9-month 1984 baseline season, when fishing regulations were the same in both study zones, angler vehicles were counted and interviews were conducted on 67% of the weekdays and 60% of the weekend and holiday days. Interview data were obtained from approximately 19% (480 interviews) of the estimated total number of anglers using the RZ and 22% (286 interviews) of all anglers who fished in the TZ.

Angler use in the RZ (reported in Table 1) exceeded that in the TZ by 50% in terms of trips/mile (2,543 vs. 1,282) and by 64% in terms of hours/mile (4,023 vs. 2,450). Length of the average fishing trip was somewhat longer in the TZ than in the RZ (1.9 vs. 1.6 hour).

Harvest of brown trout was 51% greater by number (1,529 vs. 1,013/mile) and 49% greater by weight (704 vs. 473 lb/mile) in the RZ than in the TZ. In both study zones, anglers released more brown trout than they kept. In the RZ the ratio was 3.1:1; in the TZ the ratio was 2.4:1 (Table 1).

The catch per hour (CPH) for the season for trout kept was slightly higher in the TZ than in the RZ. Average CPH for trout released was higher in the RZ.

In both zones, average length of brown trout creeled was 10.7 inches (total length) and average weight was 0.46 lb.

In the RZ, during the "early season" portion of the 9-month season (46% of 274-day total), 38% of the total hours of fishing, 24% of the total harvest, and 30% of the total catch of trout released were recorded. In the TZ during the same 4-month period, 26% of the total hours of fishing but only 9% of the total harvest and 13% of the total catch of released trout occurred (Figs. 2-4).

Anglers using natural baits accounted for approximately 45% of all trips, 46% of all hours fished, 49% of the harvest of brown trout, and 22% of the catch of released trout in the RZ (Table 2; details are reported in Append. Tables C.3-C.6). Anglers who fished exclusively with flies ranked second in the proportion of trips, hours, and harvest in this zone but first in the proportion of trout released, accounting for 60% of the total. These 2 groupings of anglers according to type of bait used also ranked first (natural baits) and second (flies) in the TZ based on contributions to all trips, hours fished, and trout kept. Fly fishers accounted for 58% of all trout released, while natural-bait fishers accounted for 34%.

In the RZ, fly fishers released an average of 6.3 trout for each trout kept. In the TZ the ratio was 10.1:1.

Only 9% of 856 brown trout kept in the RZ were less than 9 inches. In the TZ such trout accounted for 14% of the total harvest of 1,003 brown trout (Fig. 5). All brown trout creeled in the RZ were less than 16 inches. In the TZ 9 were kept in the 16-inch category but none larger. Trout in the 9-, 10- and 11-inch size groups were most abundant in the harvest, accounting for 76% of the total harvest in the RZ and 69% in the TZ.

Wisconsin resident anglers living within a 24-mile radius of the study area dominated the angler clientele in both zones. Such "local residents" accounted for 81% of all trips in the RZ and 83% of all trips in the TZ (Table 3). Anglers not resident to Wisconsin contributed only 8% of the total trips in each study zone. Table 3 also summarizes resident (4 mileage categories) and nonresident angler contributions to total hours of fishing in each zone and their catches of trout kept and released.

Table 1. *Angling effort, catch, and catch rates of brown trout in the study zones on Timber Coulee Creek during the 9-month 1984 season and the 5-month 1986-88 seasons.*

	Reference Zone							Treatment Zone						
	Base Year	Experimental Years			1986-88	%	*P*	Base Year	Experimental Years			1986-88	%	*P*
Item	1984	1986	1987	1988	Avg.	Diff.*	Value	1984	1986	1987	1988	Avg.	Diff.*	Value**
Angling effort														
Trips/mile	2,543	1,320	1,568	1,410	1,433	-44	0.03	1,282	629	868	712	736	-43	0.10
Trips/acre	874	453	538	485	492			458	225	310	255	263		
Hours/mile	4,023	2,382	3,003	2,525	2,637	-34	0.09	2,450	1,352	2,045	1,647	1,681	-31	0.24
Hours/acre	1,382	818	1,032	868	906			876	483	731	589	601		
Trout kept														
No./mile	1,529	555	450	263	423	-72	0.10	1,013	7	8	2	6	-99	0.03
No./acre	525	191	154	90	145			362	3	3	1	2		
Lb/mile	704	294	263	151	236	-66	0.03	473	7	9	2	6	-99	0.03
Lb/acre	242	101	90	52	81			169	3	3	1	2		
Avg. length (inches)	10.7	11.3	11.6	11.7	11.5	+7	0.07	10.7	14.7	14.5	15.3	14.7	+37	0.01
Avg. weight (lb)	0.46	0.53	0.58	0.57	0.56	+22	0.08	0.46	1.0	1.1	1.0	1.0	+117	0.01
Trout released														
No./mile	4,780	2,738	4,689	3,837	3,755	-21	0.46	2,473	2,639	3,173	3,467	3,093	+25	0.31
No./acre	1,642	940	1,611	1,318	1,290			884	943	1,134	1,239	1,105		
Catch/hour														
Trout kept	0.38	0.23	0.15	0.10	0.16	-58	0.20	0.41	0.01	<0.01	<0.01	<0.01	-99	0.04
Trout released	1.19	1.15	1.56	1.52	1.42	+19	0.50	1.01	1.95	1.55	2.11	1.87	+85	0.08
Total catch	1.57	1.38	1.71	1.62	1.58	-1	0.98	1.42	1.96	1.55	2.11	1.87	+32	0.29
No. trout released per trout kept	3.1	4.9	10.4	14.6	8.9	+187	0.24	2.4	377	397	1,733	836	+3,473	0.03

*% difference = $\frac{\text{(1986-88 average)} - \text{(1984 value)}}{\text{1984 value}}$

**P values are from a 2-sample t test of log-transformed data to compare the posttreatment average to the pretreatment measurement.

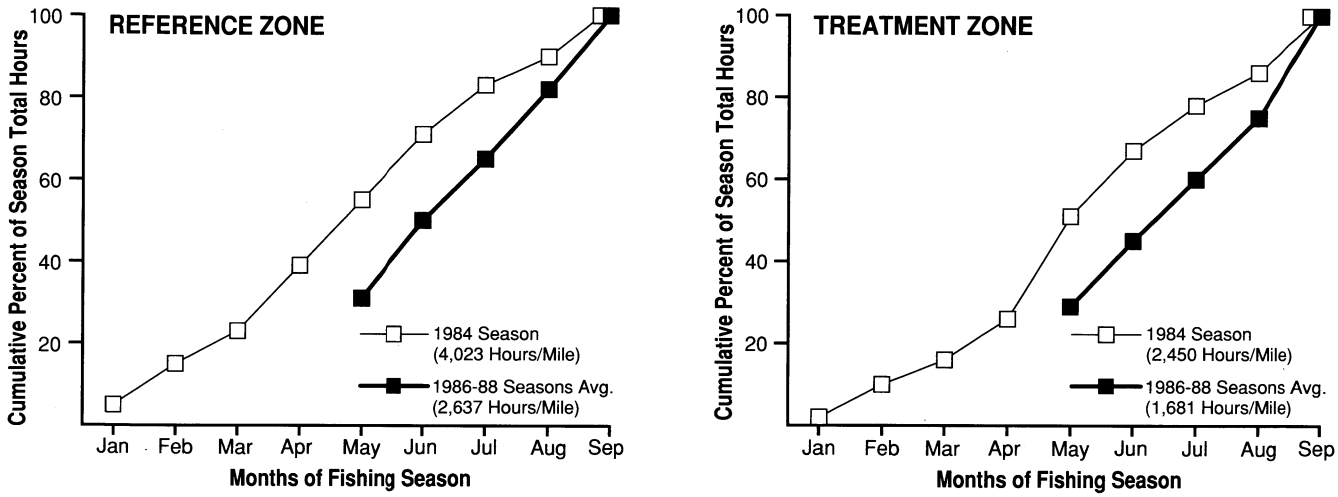


Figure 2. *Hours of angling in the Reference and Treatment Zones on Timber Coulee Creek during the 9-month 1984 fishing season and the 5-month 1986-88 seasons, summarized by monthly cumulative percentages.*

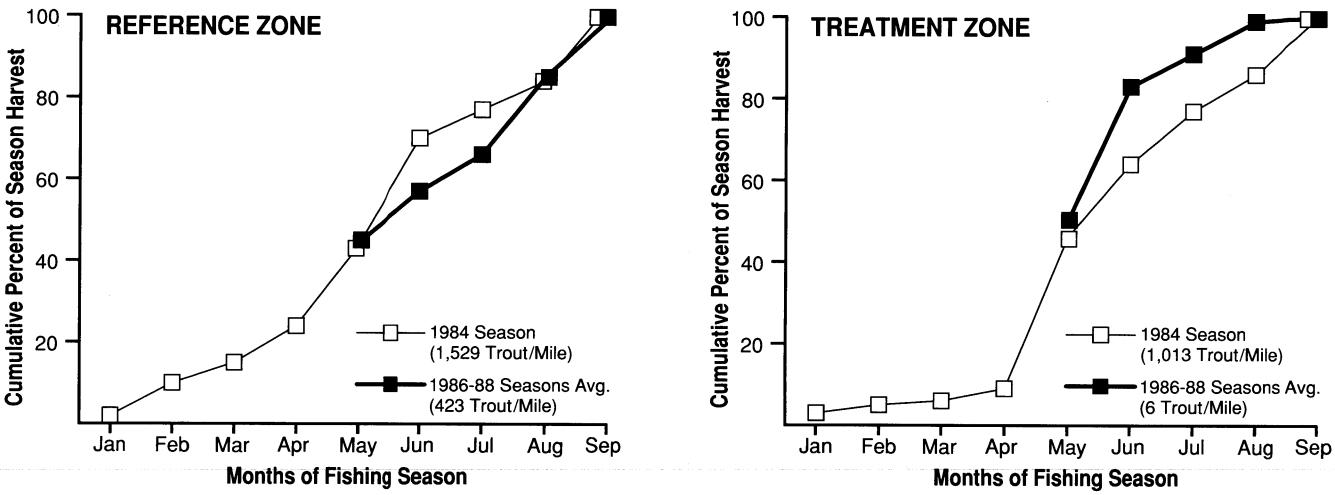


Figure 3. *Harvest of brown trout in the Reference and Treatment Zones on Timber Coulee Creek during the 9-month 1984 fishing season and the 5-month 1986-88 seasons, summarized by monthly cumulative percentages.*

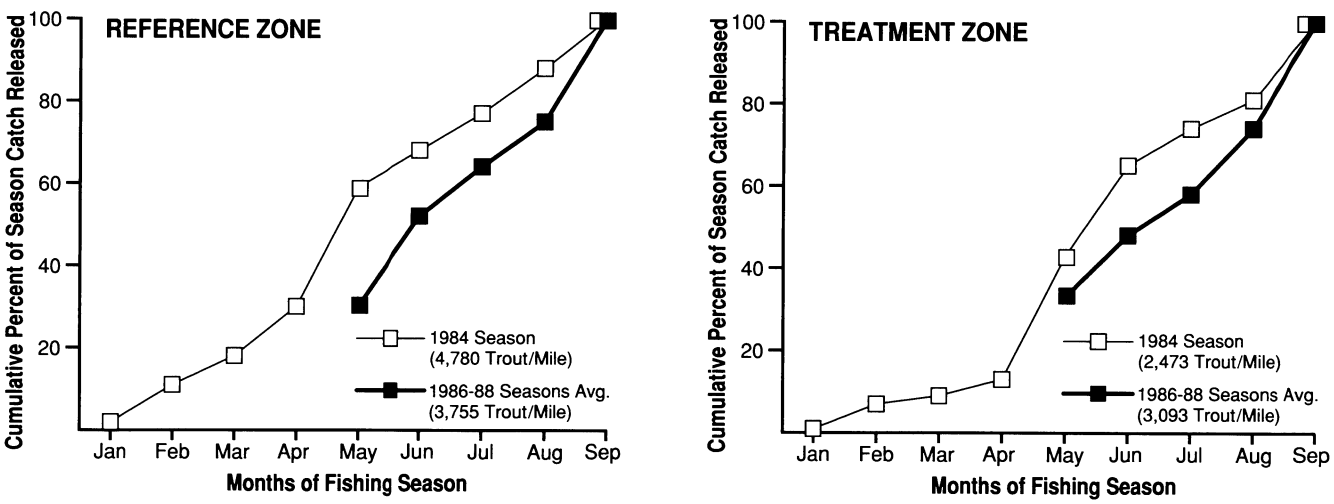


Figure 4. *Number of brown trout released by anglers in the Reference and Treatment Zones on Timber Coulee Creek during the 9-month 1984 fishing season and the 5-month 1986-88 seasons, summarized by monthly cumulative percentages.*

Table 2. *Angling effort, catch, and catch rates of brown trout in the study zones on Timber Coulee Creek during the 9-month 1984 season and the 5-month 1986-88 seasons, summarized by bait type used.**

Item	Natural			Spin			Fly			Combination			All	
	No.	% of Total	*P* Value**	No.	% of Total	*P* Value	No.	% of Total	*P* Value	No.	% of Total	*P* Value	No.	*P* Value
REFERENCE ZONE														
1984 Fishing Season														
Trips/mile	1,135	44.6		433	17.0		740	29.1		235	9.3		2,543	
Hours/mile	1,837	45.7		585	14.5		1,176	29.2		425	10.6		4,023	
Trout kept/mile	754	49.3		227	14.8		451	29.5		97	6.4		1,529	
Trout released/mile	1,030	21.5		682	14.3		2,858	59.8		210	4.4		4,780	
No. trout released/ trout kept	1.4			3.0			6.3			2.2			3.1	
Catch/hour														
Trout kept	0.41			0.39			0.38			0.23			0.38	
Trout released	0.56			1.16			2.43			0.49			1.19	
Total catch	0.97			1.55			2.81			0.72			1.57	
1986-88 Fishing Seasons (averages)*														
Trips/mile	411	28.7	0.17	246	17.2	0.21	628	43.8	0.56	148	10.3	0.20	1,433	0.03
Hours/mile	691	26.2	0.17	350	13.3	0.03	1,299	49.3	0.90	297	11.2	0.47	2,637	0.09
Trout kept/mile	232	54.8	0.28	86	20.3	0.21	77	18.2	0.14	28	6.7	0.24	423	0.10
Trout released/mile	387	10.3	0.35	459	12.2	0.49	2,731	72.7	0.85	178	4.8	0.70	3,755	0.46
No. trout released/ trout kept	1.7		0.16	5.3		0.56	35		0.23	6.4		0.47	8.9	0.24
Catch/hour														
Trout kept	0.34		0.56	0.25		0.02	0.06		0.12	0.09		0.30	0.16	0.20
Trout released	0.56		0.82	1.31		0.93	2.10		0.14	0.60		0.61	1.42	0.50
Total catch	0.90		0.72	1.56		0.91	2.16		0.08	0.69		0.84	1.58	0.98
TREATMENT ZONE														
1984 Fishing Season														
Trips/mile	734	57.3		151	11.8		289	22.5		108	8.4		1,282	
Hours/mile	1,418	57.9		246	10.0		551	22.5		235	9.6		2,450	
Trout kept/mile	668	65.9		102	10.1		141	13.9		102	10.1		1,013	
Trout released/mile	839	33.9		103	4.2		1,423	57.5		108	4.4		2,473	
No. trout released/ trout kept	1.3			1			10.1			1.1			2.4	
Catch/hour														
Trout kept	0.47			0.41			0.25			0.44			0.41	
Trout released	0.59			0.42			2.58			0.45			1.01	
Total catch	1.06			0.83			2.83			0.89			1.42	
1986-88 Fishing Seasons (averages)*														
Trips/mile	—[a]			186	25.3	0.05	538	73.1	0.14	12	1.6	0.03	736	0.10
Hours/mile	—			251	14.9	0.86	1,405	83.6	0.09	25	1.5	0.11	1,681	0.24
Trout kept/mile	—			4	66.7	0.03	2	33.3	0.05	0	0	0	6	0.03
Trout released/mile	—			353	11.4	0.27	2,701	87.3	0.04	39	1.3	0.42	3,093	0.31
No. trout released/ trout kept	—			132		0.08	1,646		0.02	39		0.19	836	0.03
Catch/hour														
Trout kept	—			0.02		0.02	<0.01		<0.01	0.00		0.00	<0.01	0.04
Trout released	—			1.41		0.27	1.92		0.25	1.56		0.45	1.84	0.08
Total catch	—			1.43		0.63	1.92		0.16	1.56		0.87	1.84	0.29

* Data for each of the 1986-88 seasons are summarized in Appendix Tables C.3-C.5.

**P* values are from a 2-sample *t* test of log-transformed data to compare the posttreatment average to the pretreatment measurement.

[a] Use of natural baits was prohibited in the Treatment Zone during the 1986-88 trout fishing seasons.

Table 3. *Percentage distributions of angler trips, angler hours, and catches of brown trout for the study zones on Timber Coulee Creek during the 9-month 1984 season and the 5-month 1986-88 seasons, summarized by distance travelled and residency status.**

Residency Status	Miles Travelled	% of Angler Trips			% of Angler Hours			% of Trout Kept			% of Trout Released		
		1984	1986-88 Avg.	*P* Value**	1984	1986-88 Avg.	*P* Value	1984	1986-88 Avg.	*P* Value	1984	1986-88 Avg.	*P* Value
Reference Zone													
Wis. resident	0-24	81	57	0.14	77	51	0.20	86	66	0.36	88	46	0.25
	25-49	1	2	—[a]	1	2	0.53	0	1	0.67	1	2	0.67
	50-99	7	11	0.45	8	14	0.45	8	12	0.85	5	20	0.17
	100+	3	12	0.13	3	13	0.26	7	15	0.35	2	13	0.42
	Total	92	82	0.17	89	80	0.48	95	94	0.48	96	81	0.34
Nonresident	All	8	18	0.17	11	20	0.48	5	6	0.48	4	19	0.34
Treatment Zone													
Wis. resident	0-24	85	46	0.05	79	36	0.04	84	75	0.78	78	44	0.02
	25-49	2	4	0.32	1	5	0.38	0	0	—[a]	1	3	0.67
	50-99	4	11	0.21	8	12	0.40	3	0	—[a]	5	19	0.19
	100+	1	12	<0.01	3	14	0.03	4	25	0.54	1	15	0.04
	Total	92	73	0.04	91	67	0.03	91	100	—[a]	85	81	0.46
Nonresident	All	8	27	0.04	9	33	0.03	9	0	0	15	19	0.46

* Data for each of the 1986-88 seasons are summarized in Appendix Table C.6.
** *P* values are from a 2-sample *t* test to compare the posttreatment average to the pretreatment measurement.
[a] Data set not adequate for calculating a *P* value.

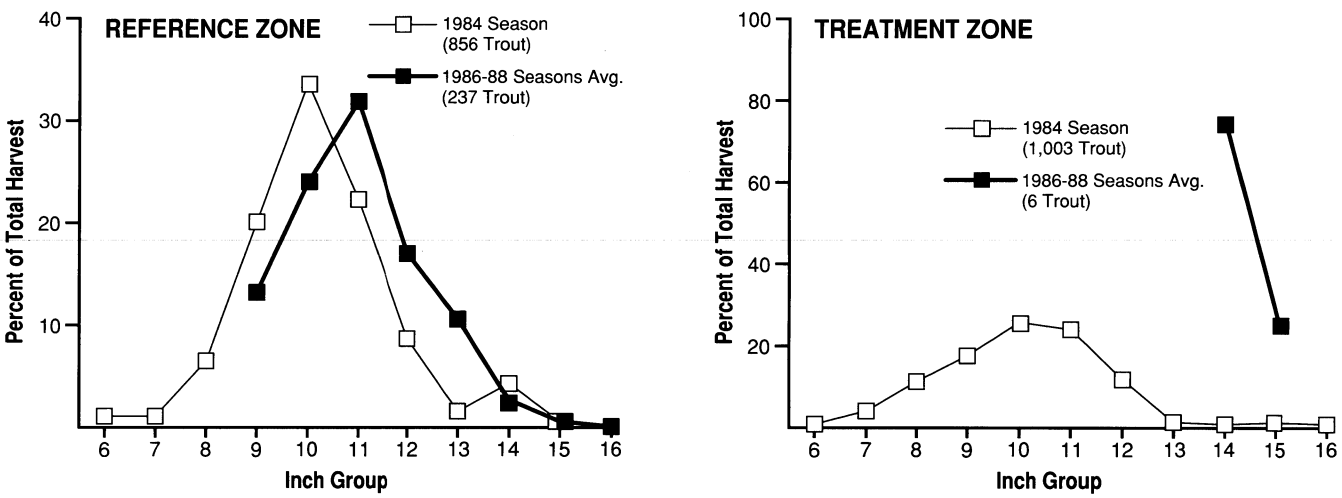


Figure 5. *Percentage frequency distribution, by inch group, of brown trout harvested from the Reference and Treatment Zones on Timber Coulee Creek during the 9-month 1984 fishing season and the 5-month 1986-88 seasons.*

Overview of 1986-88 Seasons

The creel survey was conducted on 86% of the weekdays and 70% of the weekend and holiday days of the 151-day 1986 season. Interview data were obtained from approximately 33% (439 interviews) of all anglers in the RZ and 35% (223 interviews) of all anglers who fished in the TZ. In 1987, on-site data were obtained on 66% of the weekdays and 76% of all weekend days and holidays during the 152-day season. The survey included interviews with approximately 36% (316 interviews) of the anglers using the RZ and 38% (327 interviews) of those using the TZ. During the 147-day 1988 season, the creel survey was conducted on 72% of all weekdays and 76% of the weekend/holiday days. Approximately 39% (307 interviews) of the anglers fishing in the RZ and 42% (303 interviews) of those who fished the TZ were interviewed.

Similar patterns of angling pressure were observed in both study zones during the 5-month 1986-88 fishing seasons (Fig. 6). Use declined substantially in 1986 versus that recorded during the 9-month 1984 baseline season. There were 48% fewer trips in the RZ and 51% fewer trips in the TZ. Season-long use (trips) then increased in 1987—up by 19% in the RZ and by 38% in the TZ—but angler use was still well below the totals for the 1984 season. The 1988 season was characterized by declining angler use; 10% fewer trips in the RZ and 18% fewer trips in the TZ compared to the previous year.

Average angler use in the RZ during 1986-88 amounted to 1,433 trips/mile or 2,637 hours/mile, values representing significant declines of 44% ($P = 0.03$) and 34% ($P = 0.09$) when compared to the 1984 season (Table 1). In the TZ average use values for 1986-88 were 736 trips/mile and 1,681 hours/mile, equivalent to declines of 43% ($P = 0.10$) and 31% ($P = 0.24$) respectively from use levels for the 1984 fishing season.

During all 3 seasons of testing the special regulations in the TZ, there was less intense fishing pressure in the TZ than in the RZ—43% fewer hours/mile in 1986, 32% fewer in 1987 and 35% fewer in 1988.

In both study zones the average time fished per trip increased from 1984 to 1986-88. During the 9-month 1984 season the average fishing trip lasted 1.6 hours in the RZ and 1.9 hours in the TZ. During the 5-month seasons of 1986-88, the length of the average trip increased by 19% to 1.9 hours in the RZ and by 21% to 2.3 hours in the TZ.

Imposing more restrictive size and bag limits in both study zones, plus prohibiting use of natural baits in the TZ, dramatically reduced the harvest of brown trout in the RZ and virtually eliminated harvest in the TZ (Fig. 6). The average number of brown trout creeled in the RZ during 1986-88 declined by 72% ($P = 0.10$) to 423/mile. In the TZ an average of only 6 trout/season were kept, a 99% reduction ($P = 0.03$) from the harvest in this zone during the 1984 season (Table 1).

Average length of brown trout creeled in the RZ during 1986-88 was 11.5 inches and average weight was 0.56 lb, values 7% ($P = 0.07$) and 22% ($P = 0.08$) greater than comparable averages for the catch retained by anglers in 1984. In the TZ the average length increased from 10.7 inches in 1984 to 14.7 inches for 1986-88, a 37% increase ($P = 0.01$). The average weight of the trout creeled by anglers in the TZ increased from 0.46 lb in 1984 to 1.0 lb for the 1986-88 seasons, a 117% improvement (Table 1).

Despite the increase in the minimum size limit from 6 inches to 9 inches in the RZ starting in 1986, anglers still appeared to select for trout of even larger size than 9 inches. More brown trout were creeled in the 10-, 11- and 12-inch groups than in the 9-inch group. Almost one-third of the brown trout kept during 1986-88 were in the 11-inch group (Fig. 5).

During each of the 5-month 1986-88 fishing seasons, anglers in the RZ released fewer trout than they did during the 9-month 1984 season (Fig. 6). The 3-season average of 3,755 trout/mile released was 21% less than the number released in 1984.

In the TZ a different season to season pattern developed for total catch of released trout. More trout were released per season during each of the shorter 1986-88

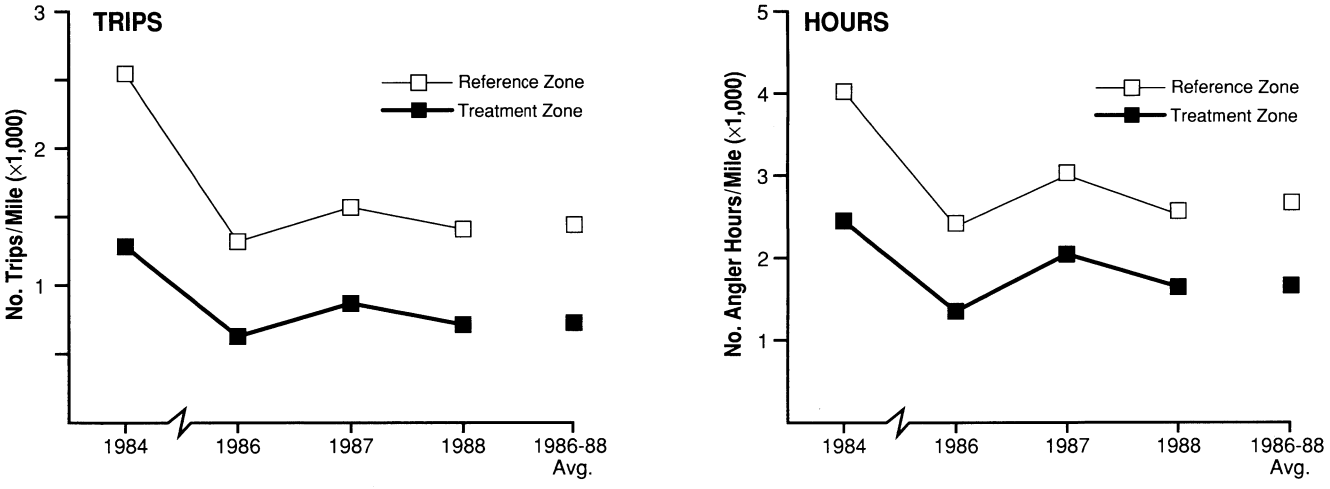


Figure 6. *Number of angler trips, hours of fishing, number of brown trout kept, and number of brown trout released in the Reference and Treatment Zones on Timber Coulee Creek during the 9-month 1984 fishing season and the 5-month 1986-88 seasons, summarized by number/mile/zone/season.*

special regulation seasons than were released during 1984, and each season the total increased. The 3-season average of 3,093 trout/mile released was 25% higher than the 1984 season value (Table 1). Anglers in the TZ released 9% more trout in 1988 than they did in 1987 despite a 20% decrease in hours of fishing. The 1988 total was 40% greater than the number released in 1984.

The average number of trout released for each trout kept in the RZ increased each season, starting at 3.1 in 1984, then increasing to 4.9, 10.4, and 14.6 during the 1986-88 seasons. The 3-season average for 1986-88 was 8.9. In the TZ very dramatic increases occurred in the ratios of trout released to trout kept. From the 1984 base value of 2.4 trout released for each trout kept, seasonal averages during 1986-88 jumped to 377:1, 397:1, and peaked at 1,733:1. The 3-season average ratio was 836:1, an increase of nearly 3,500% over the 1984 season ratio (Table 1).

The catch rate for trout kept averaged 0.16 for the RZ fishery during 1986-88, a rate 58% lower ($P = 0.20$) than that recorded for the 1984 season. Average catch per hour (CPH) for trout released increased by 19% to 1.42. Total CPH (trout kept or released) stayed about the same for the RZ fishery, averaging 1.58 for the 1986-88 seasons and 1.57 for the 1984 season.

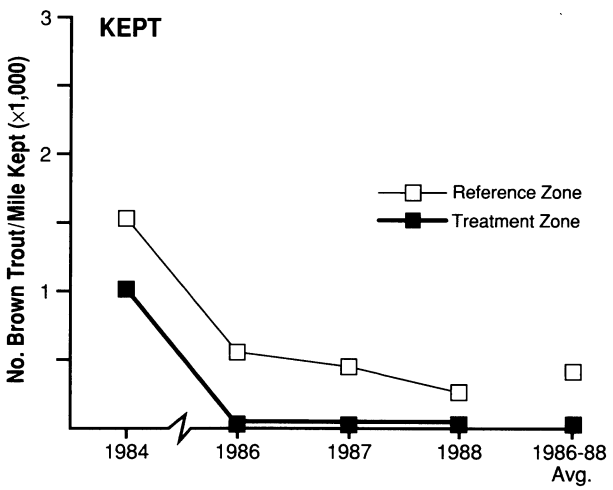
In the TZ anglers creeled an average of only 3 brown trout per 1,000 hours of fishing during the 1986-88 seasons. The comparable value for the 1984 season was 410 trout. CPH for trout released improved by 85% to an average of 1.87 ($P = 0.08$) for the 1986-88 seasons.

Anglers who chose to fish with natural baits in the RZ during 1986-88 accounted for approximately 29% of all trips, 26% of all hours fished, and 55% of all brown trout kept, but only 10% of those released (Table 2). These anglers released an average of 1.7 trout for each trout creeled. Fly fishers in this zone accounted for 44% of all trips, 49% of all hours fished, 18% of the trout kept, and 73% of those released. Approximately 35 trout were released for each trout kept. Anglers using spin-cast lures took 20% of the total harvest during 13% of the total hours fished in the RZ. Average CPH by bait type categories was highest for fly fishers who kept or released 2.16 trout/hour during 1986-88.

In the TZ, fly fishers outnumbered spin fishers about 3 to 1 in terms of trips/season and more than 5 to 1 in terms of hours fished during 1986-88. Of the 17 brown trout kept, however, 11 were caught on spin-cast lures. Approximately 9 of every 10 trout released were caught by fly fishers. The 3-season average ratio for trout released per trout kept was 132:1 for spin fishers, 39:0 for anglers who used both spinning lures and flies on the same trip and 1,646:1 for anglers who fished only with flies.

Anglers considered to be local residents (residing within a 24 mile radius of the study area) accounted for 57% of all angler trips in the RZ and 46% of all angler trips in the TZ during 1986-88. These proportional contributions were much lower than those made during the 1984 season (Table 3). In both study zones angler use by 2 categories of anglers increased substantially during 1986-88 as compared to 1984. These 2 categories were Wisconsin resident anglers traveling more than 100 miles one way to reach the study zones and nonresident anglers. In the RZ, for example, nonresidents contributed only 8% of all trips in 1984 but an average of 18% during the 1986-88 seasons ($P = 0.17$). The proportional increase for nonresident anglers interviewed in the TZ was even greater: from 8% in 1984 to an average of 27% for 1986-88 ($P = 0.04$). The absolute number of trips and hours fished by these 2 categories of anglers increased in both zones too, despite declines in total trips per season and total number of angler hours per season during 1986-88 vs. 1984.

May, the first month of the 5-month 1986-88 seasons, was the month during which the greatest angler use and total catch occurred in both zones (Table 4). June was second in importance (hours/mile) in terms of angler use of the RZ, but in the TZ September was second. More trout were kept in both zones and more were released in



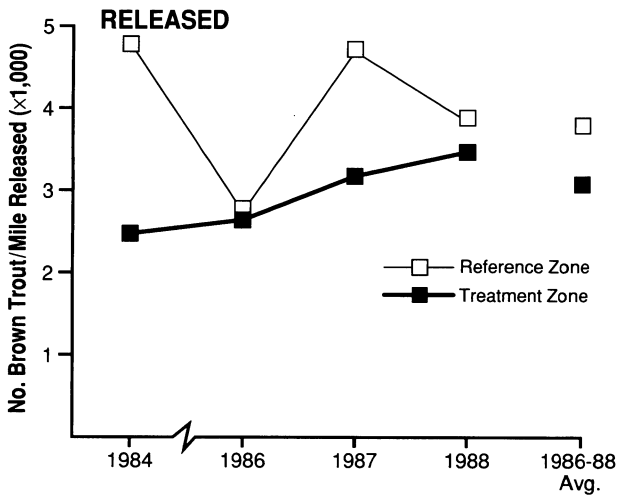


Figure 6. *Continued.*

both zones in May, but the number released in September was also a prominent component of the season total for each zone.

Distribution of angling effort over the course of an average "fishing day" stayed about the same in the TZ during 1986-88 as it was during 1984 (Table 5). The 11 a.m.-2 p.m. period continued to be the most popular 3-hour period to fish. In the RZ there was a modest shift toward proportionately greater angler use before 11 a.m., but the 11 a.m.-2 p.m. slot continued to be the most frequently used 3-hour period in this zone too.

Table 4. *Angling effort and catches of brown trout in the study zones on Timber Coulee Creek during the 9-month 1984 season and the 5-month 1986-88 seasons, summarized by month and year.*

		Angling Effort/Mile and Trout Caught/Mile by Zone							
		Angler Trips		Angler Hours		Trout Kept		Trout Released	
Year	Month of Fishing Season	RZ*	TZ*	RZ	TZ	RZ	TZ	RZ	TZ
1984	Jan	98	54	182	57	36	30	87	18
	Feb	220	103	404	192	121	24	432	147
	Mar	221	61	325	141	71	11	343	54
	Apr	296	82	625	238	143	29	575	97
	May	488	320	634	604	298	375	1,409	745
	Jun	337	256	627	402	420	182	445	551
	Jul	354	134	477	268	107	133	430	232
	Aug	186	83	271	188	104	93	529	168
	Sep	343	189	478	360	229	136	530	461
	Total	2,543	1,282	4,023	2,450	1,529	1,013	4,780	2,473
1986-88 Avg.	May	434	210	810	492	190	3	1,112	1,017
	Jun	263	134	514	269	52	2	811	461
	Jul	267	119	406	258	36	<1	448	295
	Aug	236	105	441	245	81	<1	426	503
	Sep	233	168	466	417	64	0	958	817
	Total	1,433	736	2,637	1,681	423	6	3,755	3,093

*RZ = Reference Zone; TZ = Treatment Zone.

Table 5. *Percentage distributions of the hours of angling effort recorded in the study zones on Timber Coulee Creek during the 9-month 1984 season and 5-month 1986-88 seasons, summarized by 3-hour intervals.*

	% of Total Hours for Season			
	Reference Zone		Treatment Zone	
3-Hour Interval	1984	1986-88 Avg.	1984	1986-88 Avg.
5 a.m.-8 a.m.	4.6	8.3	4.9	5.5
8 a.m.-11 a.m.	14.7	24.2	20.8	22.6
11 a.m.-2 p.m.	34.8	29.1	35.8	31.6
2 p.m.-5 p.m.	29.0	19.1	27.1	21.6
5 p.m.-8 p.m.	16.0	17.3	10.6	17.3
8 p.m.-11 p.m.	0.9	2.0	0.8	1.4

Brown Trout Population Dynamics

At End of 1983-85 Fishing Seasons

During the 1983, 1984, and 1985 seasons, when fishing regulations were identical in both study zones, the number (age 0+) of brown trout present at the close of the fishing season was highest in both zones in 1983, declined in 1984 and declined again in 1985 (Fig. 7). The RZ held 3,178 trout/mile in early October 1983. A year later there were 39% fewer trout in this study zone, and the next fall abundance was 42% less than in 1983. In the TZ the standing stock in October 1983 numbered 1,984/mile. A year later there were 29% fewer brown trout and 2 years later 39% fewer (Table 6).

Brown trout 9 inches or larger declined in both study zones from October 1983 to October 1984 (by 47% in the RZ and by 28% in the TZ), then such trout increased in both zones from October 1984 to October 1985 (by 41% in the RZ and by 13% in the TZ), but densities remained below those present in the fall of 1983 (Fig. 8).

Postseason densities of brown trout 14 inches or larger declined substantially in both zones during 1983-85. Both zones held 70 such trout/mile in October 1983 but only 16/mile in October 1985 (Fig. 9).

Abundance of brown trout 17 inches or larger increased in the RZ from 5/mile in the fall of 1983 to 9/mile in the fall of 1984, then fell to 5/mile again in early October 1985. The TZ held 10 such trout in October 1983, 5 in October 1984, and only 2 in October 1985 (Fig. 10).

The biomass of brown trout was proportionately higher in the RZ than in the TZ when the first electrofishing assessment was made in October 1983 (778 vs. 527 lb/mile). Biomass declined in both zones by the following October, improved slightly in the RZ during the next year and stayed about the same in the TZ (Fig. 11). Biomass was 48%, 10%, and 33% greater (lb/mile) in the RZ than in the TZ when monitored each October of 1983-85.

At Beginning and End of 1986-88 Fishing Seasons

Abundance of brown trout of all sizes (Fig. 7), of those 9.0 inches or larger (Fig. 8), 14.0 inches or larger (Fig. 9), 17.0 inches or larger (Fig. 10), and total biomass (Fig. 11) all followed generally similar trends in the 2 study zones for any one of the 5 population parameters quantified each April and October of 1986-88. The relative abundance of trout of all sizes, trout over 9 inches, and total biomass in the RZ always exceeded comparable values in the TZ. The TZ, however, always held a greater density of brown trout over 14 inches each April and October of 1986-88.

Standing stocks of age 0+ brown trout increased in both study zones from October 1985 to October 1986 to October 1987, then declines occurred in both zones a year later when the last electrofishing inventory of the study was made. The average abundance of age 0+ trout in the RZ in October of 1986-88 exceeded the October 1983-85 average abundance by 93% (4,459 vs. 2,314/mile) ($P = 0.05$). In the TZ, comparable 3-year averages differed by 123% (3,418 vs. 1,536/mile) ($P = 0.05$). Increased densities of trout in both study zones in the fall were due in part to recruitment contributions (counted in fall but not in spring) of much stronger age 0 stocks. Age 0 abundance averaged 153% higher ($P = 0.05$) in the RZ and 265% higher ($P = 0.05$) in the TZ for October of 1986-88 vs. October of 1983-85 (Table 6). Age 0 densities peaked in October 1986 at 2,129/mile in the RZ and 1,866/mile in the TZ.

Postseason standing stocks of trout 9 inches or larger (legal size in the RZ) reached densities in the TZ during 1986-88 that were greater than any density of such trout observed during 1983-85. In the RZ 2 of the 3 highest fall densities were observed during 1986-88. The average density in October of 1986-88 was 35% greater ($P = 0.20$) in the RZ and 46% greater ($P = 0.05$) in the TZ than the averages for October of 1983-85. Although a greater percentage gain in trout 9 inches or larger occurred in the TZ during the second 3-year phase of the study, the density of such trout (no./mile) was always lower in the TZ than in the RZ during both 3-year phases (Fig. 8). The peak abundance of brown trout 9 inches or larger was recorded in April 1988 at densities of 1,982/mile in the RZ and 1,595/mile in the TZ.

The average postseason density of brown trout 14 inches or larger declined by 21% ($P = 0.35$) in the RZ during the 1986-88 period vs. the 1983-85 period (26 vs. 33/mile). In the TZ a different pattern emerged. The average postseason abundance of brown trout 14 inches or larger during 1986-88 was 49% greater ($P = 0.35$) than the average number present at the close of the 1983-85 seasons (58 vs. 39/mile). From about the same starting density in both zones in April 1986, the 6 paired estimates of abundance of brown trout 14 inches or larger made during 1986-88 differed by an average of 129% ($P = 0.05$) in favor of the TZ. In both zones the abundance of these high quality trout was lowest in April 1986, peaked in October 1987 at 34/mile in the RZ and 69/mile in the TZ, then declined in April 1988, and declined again when last inventoried in October (Fig. 9).

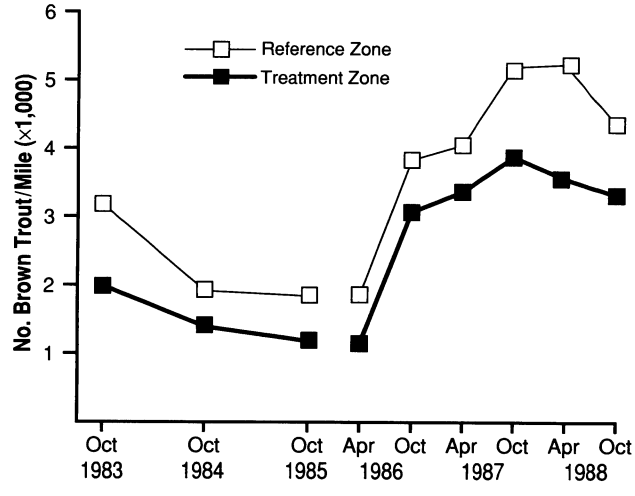


Figure 7. *Number of brown trout per mile in the Reference and Treatment Zones on Timber Coulee Creek in October of 1983-85 and April and October of 1986-88.*

The number of brown trout 17 inches or larger (protected from harvest in the TZ during 1986-88) oscillated from spring to fall in both study zones during 1986-88. Neither zone consistently held the greater density of such trout, and no accumulation of such trout occurred from spring to spring or fall to fall during 1986-88 in either the RZ or in the TZ, where such an accumulation was predicted (Fig. 10). An initial positive response occurred in the TZ through the first 2 special regulation seasons, but for unknown reasons the abundance of brown trout 17 inches or larger declined from 6 in October 1987 to zero the following April and rose to only 2 by October 1988. A similar October 1987 to April 1988 decline occurred in the RZ.

The peak biomass recorded during 1986-88 occurred in both study zones in April 1988 reaching 1,305 lb/mile or 448 lb/acre in the RZ and 1,022 lb/mile or 365 lb/acre in the TZ (Table 6). Throughout the 6-year study period that included 6 postseason and 3 preseason estimates of population biomass in each study zone, biomass was always greater in the RZ on any given sampling date (Fig. 11). Average postseason biomass improved in both study zones for the 1986-88 period vs. the 1983-85 period, but the percentage gain (74%, ($P = 0.05$) was greater in the TZ where the more stringent harvest regulations were imposed in 1986.

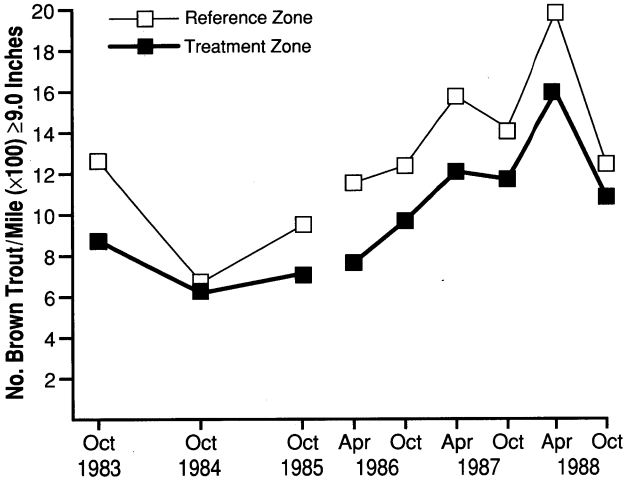


Figure 8. *Number of brown trout per mile 9.0 inches or larger in the Reference and Treatment Zones on Timber Coulee Creek in October of 1983-85 and April and October of 1986-88.*

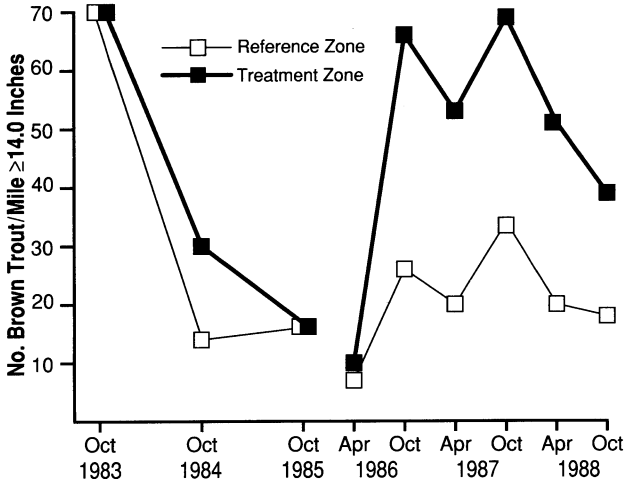


Figure 9. *Number of brown trout per mile 14.0 inches or larger in the Reference and Treatment Zones on Timber Coulee Creek on October of 1983-85 and April and October of 1986-88.*

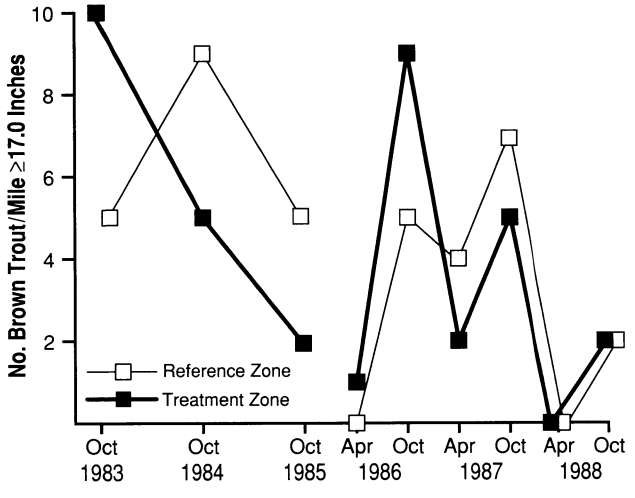


Figure 10. *Number of brown trout per mile 17.0 inches or larger in the Reference and Treatment Zones on Timber Coulee Creek in October of 1983-85 and April and October of 1986-88.*

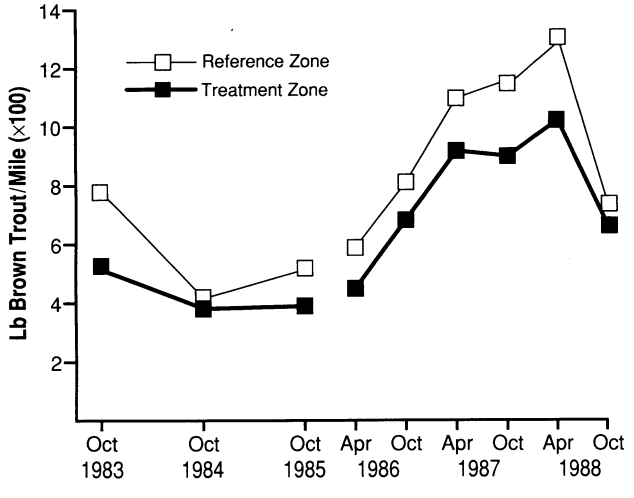


Figure 11. *Biomass of brown trout in the Reference and Treatment Zones on Timber Coulee Creek in October of 1983-85 and April and October of 1986-88.*

Table 6. *Standing stocks of brown trout in the Reference Zone and Treatment Zone on Timber Coulee Creek before (1983-85) and after (1986-88) application of special regulations in the Treatment Zone only.*

Attribute	Study Zone*	Study Phase: Pretreatment 1983	1984	1985	Posttreatment 1986	1987	1988	Pre-Avg.	Post-Avg.	Posttreatment Avg.-Pretreatment Avg.: Absolute Diff.	% Diff.	*P* Values**	*P* Values[a]
Trout/mile in April													
Total no. (age I+)	RZ				1,860	4,047	5,228		3,712				
	TZ				1,149	3,366	3,555		2,690				
No. ≥ 9.0 inches	RZ				1,155	1,575	1,982		1,571				
	TZ				765	1,209	1,595		1,190				
No. ≥ 14.0 inches	RZ				7	20	20		16				
	TZ				10	53	51		38				
No. ≥ 17.0 inches	RZ				0	4	0		1				
	TZ				1	2	0		1				
Biomass in April													
Lb/mile	RZ				588	1,097	1,305		997				
	TZ				449	917	1,022		796				
Lb/acre	RZ				202	377	448		342				
	TZ				161	328	365		285				
Trout/mile in October													
Age 0	RZ	962	805	463	2,129	2,002	1,509	743	1,880	1,137	+153	0.05	
	TZ	572	428	316	1,866	1,747	1,193	439	1,602	1,163	+265	0.05	
	Remainders[b]	-390	-377	-147	-263	-255	-316	-304	-278				0.35
Total no. (age 0+)	RZ	3,178	1,930	1,833	3,830	5,192	4,355	2,314	4,459	2,145	+93	0.05	
	TZ	1,984	1,413	1,212	3,066	3,872	3,317	1,536	3,418	1,882	+123	0.05	
	Remainders	-1,194	-517	-621	-764	-1,320	-1,038	-778	-1,041				0.20
No. ≥ 9.0 inches	RZ	1,263	673	946	1,238	1,421	1,245	961	1,301	340	+35	0.20	
	TZ	873	628	712	969	1,172	1,085	738	1,075	337	+46	0.05	
	Remainders	-390	-45	-234	-269	-249	-160	-223	-226				0.50
No. ≥ 14.0 inches	RZ	70	14	16	26	34	18	33	26	-7	-21	0.35	
	TZ	70	30	16	66	69	39	39	58	19	+49	0.35	
	Remainders	0	16	0	40	35	21	6	32				0.05
No. ≥ 17.0 inches	RZ	5	9	5	5	7	2	6	5	-1	-17	0.35	
	TZ	10	5	2	9	5	2	6	5	-1	-17	0.50	
	Remainders	5	-4	-3	4	-2	0	0	0				0.35
Biomass in October													
Lb/mile	RZ	778	420	514	811	1,158	736	571	902	331	+58	0.10	
	TZ	527	381	386	682	899	662	431	748	317	+74[c]	0.05	
	Remainders	-251	-39	-128	-129	-259	-74	-140	-154	-14			0.35
Lb/acre	RZ	267	144	177	279	398	253	196	310	114	+58	0.10	
	TZ	188	136	138	244	321	221	154	262	108	+70[c]	0.05	
	Remainders	-79	-8	-39	-35	-77	-32	-42	-48	-6			0.50

* RZ = Reference Zone; TZ = Treatment Zone.

**Mann-Whitney nonparametric test. $P = 0.05$ is the smallest significance value possible with 2 data sets of 3 values per set.

[a] Test for no difference between average remainder values for posttreatment vs. pretreatment phases, based on Mann-Whitney nonparametric test.

[b] Remainders = (TZ values) - (RZ values).

[c] These 2 percentages should be similar; the slight difference is due to rounding annual and average values to the nearest whole number.

DISCUSSION

The Fishery in the Treatment Zone

Two of the three major goals of the special regulations package imposed in the Treatment Zone were attained during the 3-year assessment period. An excellent catch and release fishery for wild brown trout was achieved. CPH for trout released averaged 1.84 for the 1986-88 fishing seasons and peaked the third season at 2.11. The 3-season average exceeded the baseline 1984 season CPH for the TZ fishery by 82% ($P = 0.08$).

The average CPH of 1.84 is remarkably high for a trout fishery, even one governed by special regulations, and especially one that is dependent on wild brown trout. Among more than 40 seasonal CPH values assembled from a literature review of special regulation trout fisheries (Append. Table C.7), only CPH values for Hot Creek in 1985 and 1987 were higher for a fishery dependent entirely or partly on brown trout, and only a CPH of 2.5 for cutthroat trout (*Oncorhyncus clarki*) in a portion of the St. Joe River, Idaho, and the Hot Creek fishery in 1985 was greater, regardless of the trout species present.

The number of brown trout released each season in the TZ also increased from 1986 to 1987 to 1988 despite a decline in angler use in 1988 over that recorded in 1987. More trout were also released each of the 5-month 1986-88 seasons than were released in the TZ during the 9-month 1984 season.

Total catch (kept or released) in the TZ for the 1986 season exceeded the preseason standing stock (age I+) by 130%, an indication that some brown trout were caught more than once. Such "recycling" was probably less common during the 1987 and 1988 fishing seasons. Total catch those 2 seasons was slightly less than the number of age I+ brown trout present in mid-April. Catch was equivalent to approximately 95% of the preseason abundance in 1987 and 98% of the 1988 preseason abundance.

The number of brown trout available in the TZ to sustain the C/R fishery for trout less than 14 inches increased, as hypothesized, during the experimental years. Diminution of harvest during the 1986-88 seasons undoubtedly enhanced the accumulation of sublegal trout, but fortuitous recruitment of strong 1986 and 1987 year classes also helped the process.

The opportunity to achieve the second major goal also improved as the study progressed. Although the estimated harvest of browns within the unprotected slot range was less for the 1988 season than for the 1986 and 1987 seasons, there were more legal-sized trout to fish for. At the beginning of the 1986 season the TZ held only 9 brown trout of slot-size length. At the beginning of the 1987 and 1988 seasons there were at least 50 such trout in the TZ (Table 6).

The number of anglers who reported releasing trout in the TZ that could have been kept was not recorded, but each season a few anglers voluntarily reported such releases. In 1988 in particular the unprotected slot restriction had about the same impact on the trout population as a total release regulation would have had. Only 2 brown trout were creeled that season.

Release of trout that could be legally kept is not unusual for special regulation fisheries and may be more common than is generally believed for normal regulation fisheries too (Clark 1982). Barnhart and Engstrom-Heg (1984) reported that almost half of the legal brown trout caught in a special regulations zone on the Batten Kill River were released, and Alexander et al. (1979) reported release rates of 35-56% of legal brown trout in sections of the AuSable River, Michigan that were restricted to fly fishing only. Under a subsequent slot length limit regulation on the same river, release rates of legal-sized brown trout as high as 85% were recorded (Clark 1982).

The third major goal of the special regulations—enhanced opportunity to fish a reach of stream containing a high standing stock of brown trout 17 inches or larger—was not attained during the 3-year test period. The TZ held only one such brown trout when the 1986 season began, 2 at the beginning of the 1987 season, and none at the beginning of the 1988 season (Fig. 10). The abundance of trout exceeding the unprotected slot length increased from April to October each year, probably due to movement into the TZ rather than within-zone growth, but even these within-season densities remained well below expectations. The TZ held 10 brown trout/mile over 17 inches in October 1983. An assumption of the study design was that this density would be substantially surpassed once the harvest of such trout was prohibited. In actuality, however, that density remained the highest observed during the 8 following electrofishing surveys—5 in October and 3 in April. No cause-effect evidence can be offered to explain the failure of large brown trout to accumulate in the TZ to densities greater than 10/mile, but my suspicion is that lack of an abundant food supply of large prey items such as crayfish or minnows, rather than physically unsuitable habitat, is a primary limiting factor. The length of the TZ, approximately one mile, may also have detracted from seeing an increase of brown trout over 17 inches. Clapp (1988) suggested that a special regulation reach should exceed 5 miles to encompass the normal annual home range of large stream-resident brown trout.

Brown trout larger than 20 inches were rarely collected in the TZ during the study—one in October 1984, 2 in October 1986, 2 in October 1987, and none in any of the 3 population inventories made in April. Movement out of the study zone to other portions of the stream to spawn (in October or November) may have contributed to lack of such large trout in April.

Among several special regulation studies reviewed, the abundance of "quality sized" trout usually increased, but there were some failures. Evaluations showing essentially no increase include those by Klein (1974) for rainbow trout (*Oncorhynchus mykiss*) and brown trout 12 inches or larger in the Cache la Poudre River, by Barnhart and Engstrom-Heg (1984) for brown trout over 16 inches

in the Amawalk River, by Clark and Alexander (1984) for brown trout over 16 inches in the AuSable River, and by Wells (1984) for brown trout over 13 inches in the Gallatin River.

Documentation of significant increases in the abundance of quality-sized trout following imposition of highly restrictive harvest regulations includes studies by Johnson and Bjornn (1978) for cutthroat trout over 12 inches, Cresswell (1980) for adult cutthroat (spawning runs) in Yellowstone Lake, Yundt (1980) for brown trout over 14 inches, Hunt (1981) for brown trout over 13 inches, Kerr (1982) for brown trout over 13 inches and over 20 inches, Barnhart and Engstrom-Heg (1984) for lake trout (*Salvelinus namaycush*) over 21 inches, Wells (1984) for rainbow and brown trout over 13 inches, Turner (1986) for brown and rainbow trout over 15 inches, Snigg (1987) for brown trout over 16 inches, and Nehring (1987) for brown and rainbow trout over 14 inches in several rivers in Colorado.

The Fishery in the Reference Zone

The change to more restrictive angling regulations in the RZ in 1986 triggered major changes in its sport fishery and in its standing stocks of brown trout. Most of the quantified changes were desirable from a fisheries management perspective.

Harvest during each of the 1986-88 fishing seasons was substantially reduced compared to the baseline 1984 season, and the reductions were proportionately greater than the reductions in angling pressure resulting from the change to a 5-month season. The average number of trout harvested per season declined by 72%; angler hours declined an average of only 34%. The average length of trout creeled improved from 10.7 inches in 1984 to 11.5 inches for the 1986-88 seasons. The reduced CPH for trout kept was offset by an increased CPH for trout released.

The RZ fishery during 1986-88 tended to become increasingly typical of a C/R fishery even though that was not the major intent behind the new regulations. The harvest/season progressively declined, exploitation rate/season progressively declined, and the ratio of trout released to trout kept progressively increased. Exploitation rates (percentage of preseason population harvested) were 30% in 1986, 11% in 1987, and only 5% in 1988. Ratios of trout released to trout kept rose from approximately 5:1 in 1986 to 10:1 in 1987 to 15:1 in 1988.

Compared to the 1984 season, a smaller proportion of the anglers interviewed during the 1986-88 seasons in the RZ chose to fish with natural baits and a much larger proportion chose to fish with flies (Fig. 12), an adjustment also typical of sport fisheries where C/R is emphasized. The dramatic reversal of dominance of natural baits over flies does not seem to be the kind of shift that should result from changing size or bag limit regulations. It is more likely that more fly fishers used both study zones because they were attracted to the study area by the special regulations in the TZ.

A significant reduction in harvest during the 1986-88 seasons of 72% ($P = 0.10$) is additional evidence for a major shift toward voluntary catch and release in the RZ. Such a large reduction cannot be attributed to the added harvest restrictions that increased the minimum size limit to 9 inches and reduced the daily bag limit to 3. If these regulations had been in effect during 1984, the harvest during May-September would have been theoretically reduced only 11% by the more restrictive size limit (Append. Table C.8) and only 8% by the more restrictive bag limit (Append. Table C.9). Clearly, factors other than constraints on the number and size of trout creeled must have come into play to produce this 72% decline in harvest.

Evidence for more frequent voluntary release of trout in the RZ in 1986-88 vs. 1984 is also provided by the larger proportion of angler trips during 1984 on which all trout were released. During May-September of the 1984 season, anglers released all trout on 48% of the trips on which one or more trout were caught ("successful" trips). During the 1986-88 seasons that proportion increased to 54%, 75%, and 77% respectively (Append. Tables C.10-C.12).

Abundance and biomass of brown trout in the RZ tended to increase from October of 1985 through April 1988, then both declined somewhat by October 1988.

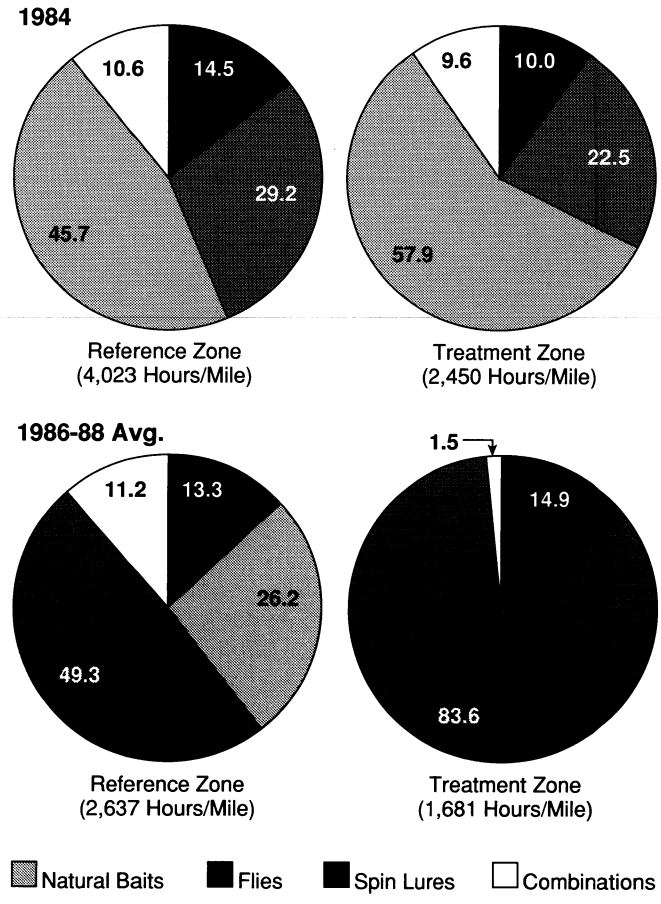


Figure 12. *Percentage distributions of angler hours per mile within the Reference and Treatment Zones on Timber Coulee Creek during the 1984 and 1986-88 trout fishing seasons, summarized by type of bait used.*

Trends in abundance and biomass were generally similar to those occurring in the TZ, but the RZ consistently supported more trout (Fig. 7) and greater biomass (Fig. 11). The RZ appeared to have an inherently superior trout carrying capacity, a capacity used more fully during 1986-88 than during 1983-85. Its trout population, like that in the TZ, responded positively during 1986-88 to greatly reduced exploitation plus recruitment of strong 1986 and 1987 year classes.

RZ-TZ Comparisons

Although harvest in the RZ during the years 1986-88 was substantially reduced, harvest of brown trout 12 inches or larger was still great enough to depress the abundance of brown trout over 14 inches in comparison to the buildup that occurred in the TZ (Fig. 9). Brown trout 12 inches or larger comprised an average of 31% of the total harvest in the RZ during 1986-88 vs. 15% of the 1984 season harvest. Harvest in the RZ during 1986-88 was reduced by an average of 72% (Append. Table C.8) but the number kept over 12 inches was reduced by only 44% (from 232/mile to 131). As a consequence of the skewed emphasis on harvest of these trout that could have grown to 14 inches or larger during the fishing season, the density of such trout was consistently less in the RZ than in the TZ throughout 1986-88. Among the several population parameters quantified in each study zone, only density of trout over 14 inches was consistently greater in the TZ during the 1986-88 posttreatment phase ($P = 0.05$ for "remainders"). This diagnostic attribute stands out as the most conspicuous benefit to the TZ trout population derived from imposing special regulations for 3 fishing seasons.

The unprotected slot length restriction (coupled of course to a bag limit of one per day and artificial lures only) had about the same affect on the sport fishery in the TZ as a simple minimum size limit of 14 inches would have had. All trout known to be kept in the TZ during the 1986-88 seasons were less than 16 inches (Fig. 5). Changes in abundance of brown trout 17 inches or larger during 1986-88 (Fig. 10) appeared to be independent of protection provided by the slot length. Fluctuations in the number of such trout from April to October and year to year were generally similar in both study zones.

Declines in population abundance (Fig. 7) and biomass (Fig. 11) in both study zones from April to October 1988 were probably related primarily to environmental stress. A deleterious combination of severe drought, the most severe in Wisconsin since 1936 (U.S. Geol. Survey 1989), and abnormally high air temperatures persisted throughout the spring and summer of 1988. Because of persistently low stream flow and abnormally warm weather during April and May, a minimum-maximum temperature recorder was installed at the RZ/TZ boundary in June to document potentially detrimental high water temperatures during the remainder of the summer. The recorder was monitored weekly through September. Maximum water temperatures of 82 F in mid-July and 79 F in mid-August were recorded. These temperatures are well above the preferred range for brown trout and several degrees higher than the 73 F maximum observed in 1984 at the RZ and TZ recording sites. Monthly mean water temperatures for July and August 1988 were 74 F, about 10 F higher than the monthly means for July and August 1984 (Append. Table C.2).

Yearling and older brown trout in the TZ declined in number by 40% from April to October 1988, and biomass declined by 35% in the virtual absence of angler exploitation. In the RZ there was a 44% decrease in the number of age I+ brown trout and a 54% decrease in biomass. Exploitation rate was only 5%.

The April to October period of 1988 was also the only one of 3 such posttreatment periods when abundance of brown trout 14 inches or larger did not increase in the TZ (Table 5). Such trout increased by 560% in 1986 and by 30% in 1987, but in 1988 there was a 24% decline from April to October. As a consequence of this decline, rather than an expected increase from spring to fall, maximum observed abundance of brown trout over 14 inches (69/mile) during the posttreatment phase did not surpass maximum pretreatment abundance (70/mile). Whether the TZ can sustain densities of such trout significantly greater than 70/mile under normal stream flow and temperature regimes remains a question only future population monitoring will resolve.

Both study zones supported impressive densities of brown trout over 9 inches and above normal biomass densities for a trout stream in Wisconsin (Avery 1983). However, the average abundance of brown trout 15 inches or larger (14/mile for the TZ and 8/mile for the RZ) fell only within an intermediate range in comparison to densities of such brown trout in other Wisconsin streams where this species predominates (Append. Table C.13). Greater densities, ranging from 21/mile to 92/mile, have been recorded in reaches of 12 other trout streams in the state (42/mile average).

The combination of abnormally low stream flow and abnormally hot, dry weather probably contributed to reduced fishing pressure during the 1988 season too. Angler use increased in both study zones from 1986 to 1987, and it was expected to increase again in 1988, but such was not the case. Angler trips and angler hours declined to values between those for the 1986 and 1987 seasons (Fig. 6). These declines in angler participation in 1988 should not have been influenced by any deterioration in angling quality. The average length of trout creeled in the RZ was slightly better in 1988 than in 1987; the average CPH was only slightly poorer in 1988 than in 1987 and better than the average CPH in 1984 and 1986. In the TZ average CPH was better than in any of the previous 3 seasons surveyed. Both study zones also held record high April densities of trout to fish for and observe.

Three factors confounded my evaluation of the unprotected slot length regulation as initially planned. Two were unavoidable and have been discussed above, namely the change in regulations in the RZ after the study was underway and the exceptionally hot summer and severe drought of 1988. The third factor, in retrospect, is one that could have been circumvented. Although using contiguous study zones is a common experimental design for evaluating fishing regulations (Barnhart and

Engstrom-Heg 1984; Hunt et. al. 1962, 1964; Klein 1974; Rohrer 1983; Shetter 1969; Shetter and Alexander 1962), locating the RZ immediately adjacent to the TZ in my study probably biased creel survey information collected in both zones, and especially in the RZ.

Special regulation waters tend to attract anglers seeking such recreation (Ball 1971; Hunt 1964; Kerr 1982; Nehring 1987; Rohrer 1983). This was certainly the case at Timber Coulee Creek. Use of the TZ by nonlocal and nonresident anglers, especially fly fishers, increased substantially. Some of these anglers probably decided to also fish the adjacent RZ because it was convenient and is physically similar to the TZ.

Such conjecture, and real or imagined influences on the RZ fishery due to influx of anglers from the TZ, could have been reduced by locating the RZ on a more distant reach of Timber Coulee Creek, or even on another trout stream in Vernon Co. to make it more difficult for anglers to fish the TZ and RZ on the same fishing trip. An even better but more costly and more complicated experimental design would have been one that included 2 reference zones, one isolated from the TZ and one adjacent to it. This design would have provided less biased data from the isolated RZ to compare with data from the TZ to evaluate pretreatment vs. posttreatment differences due to changing regulations in the TZ only. In the other RZ, the one contiguous with the TZ, perturbations that related to its proximity to the TZ could be assessed.

On Timber Coulee Creek, at least, circumstantial evidence is strong that the fisheries management benefits achieved by imposing the experimental slot length restriction on a mile of the TZ achieved spillover benefits on at least the adjacent half-mile reach of the RZ. These benefits would not have been detected if a contiguous RZ had not been included in the study. Such potential spillover benefit is a phenomenon that deserves greater attention. It should be considered in reassessing past applications of special opportunity regulations on trout streams and given more focused, premeditated attention and measurement in future evaluations. On-site interviews of anglers, for example, should include questions aimed at detecting why anglers fished a reference zone before or after fishing a treatment zone. More effort should also be made to quantify the extent of "crossover" trips.

FISHERIES MANAGEMENT IMPLICATIONS AND SPECULATIONS

1. Despite complications in the evaluation process due to uncontrollable variables, enough clear-cut results were gathered to conclude that the experimental regulations applied in the TZ during the 1986-88 trout fishing seasons accomplished 2 of the 3 major management goals:
   a. An excellent catch and release fishery developed in the TZ. The average CPH for the 1986-88 seasons was 1.84, an exceptionally high value, especially for a C/R fishery sustained by wild brown trout. The number of trout in the TZ at the beginning of each fishing season (to fish for and observe) also increased—by 193% from 1986 to 1987 and by another 6% from 1987 to 1988.
   b. The opportunity to catch and keep one trout/day within the unprotected slot length of 14.0-16.9 inches was enhanced five-fold from 1986 to 1987 and 1988. Although the harvest of trout within the slot length declined from 1986 to 1987 to 1988, these declines were probably due to voluntary release of trout that could have been kept, not to lack of trout within the slot length range.

   Based on these results, I support the DNR fisheries management decisions to:
   a. Replace the unprotected slot length with a simpler 14-inch minimum size limit that will provide comparable protection.
   b. Retain the bag limit of one/day.
   c. Retain the artificial lures only regulation.
   d. Extend the present mile-long TZ downstream to reduce future crowding.[4]
2. A buildup of brown trout over 17 inches (and especially over 20 inches)—the third major goal of the regulations—did not occur in the TZ during the first 3 posttreatment years despite protection from harvest. Longer special regulation zones that encompass the entire behavioral movement range of such large trout may be necessary to determine if the abundance of such trout is enhanced when angling mortality is eliminated. Both the complex environmental requirements (physical habitat and food) of trophy size trout and techniques to enhance carrying capacity for such trout deserve greater investigation.

[4] These fisheries management decisions included consideration of personal communications recommendations from the author during 1988-89 while this report was in preparation. Unfortunately these regulations in the expanded TZ did not go into effect in 1990 because of an emergency DNR ruling. The recommended regulation did go into effect for the 1991 trout fishing season in an expanded TZ.

3. Nonlocal and nonresident anglers, especially fly fishers, were attracted to the TZ by the special opportunity regulations. In absolute terms (hours/season), contributions of these 2 angler groups increased by 109% and 151%, respectively, during the 1986-88 seasons despite a reduction in the season length from 9 months to 5 months. The percentage contribution of nonlocal anglers (including nonresidents) toward the total hours fished/season in the TZ increased from 21% in 1984 to an average of 64% during the 1986-88 seasons. The corresponding percentage contributions of nonresident anglers increased from 9% in 1984 to an average of 33% (Table 3). Stated somewhat differently (for added emphasis), chances of encountering a nonresident angler in the TZ changed from approximately 1 in 10 in 1984 to 1 in 3 during the 1986-88 fishing seasons.

   Although no economic assessment was made, it seems likely that the community nearest to the TZ, the Town of Coon Valley, must have benefitted financially from the influx of nonlocal trout fishers during 1986-88. I recommend that a study be initiated in Wisconsin to quantify economic benefits to local communities that are derived from establishing special regulation waters that attract nonlocal anglers (Copes and Knetsch 1981; Lantiegne 1974; Richards and Wood 1985; Nehring 1987). Such an assessment could provide DNR fisheries managers with valuable economic data to complement biological data. This combination of positive data would help dispel potential antipathy of local residents toward establishing special regulation waters. The TZ on Timber Coulee Creek is a logical candidate site to include in such an economic impact analysis.

4. Several biological benefits (reduced harvest, increased average size and increased average weight creeled, reduced exploitation, increased standing stocks) were also achieved in the RZ after new regulations were invoked there (and on all other Vernon County and LaCrosse County trout streams) in 1986. Although it was not possible to quantitatively isolate the benefits of each regulation change, the reduction in season length from 9 to 5 months probably had the greatest benefit, followed by the increased size limit and reduced daily bag limit.

   The number of angler trips/season in the RZ was reduced by an average of 44% from 1984, a reduction that was probably less than on other trout streams in the county because the RZ was adjacent to the TZ, which attracted new anglers to the study area. (For additional details on characteristics of a 9-month trout fishing season see Hunt (1985)).

   Collectively the new regulations imposed in the RZ in 1986 were highly successful, but I caution against full-scale extrapolation of results from the RZ to fisheries on other trout streams in LaCrosse and Vernon counties. This precaution is necessitated by the unknown but potentially major impact on the RZ fishery made by anglers crossing over from the TZ.

5. The sociological reasons why anglers sought out the TZ were not quantified during angler interviews. In retrospect, including some unbiased questions to identify such reasons would have enhanced my evaluation and the fisheries management insights gained, especially for the third management goal: the buildup of trout over 17 inches and the "anticipatory contribution" such trout make to angling quality.

   Anglers interviewed in the special regulations zone on Castle Rock Creek ranked the number of trout hooked and average size of trout caught as 2 of the most important factors contributing to satisfactory recreational quality (Kerr 1982). These 2 components of a fishing experience would probably have been ranked high by anglers in the TZ at Timber Coulee Creek too. Seasonal CPH values and abundance of medium-sized and large trout were generally as good or better at Timber Coulee Creek than at Castle Rock Creek.

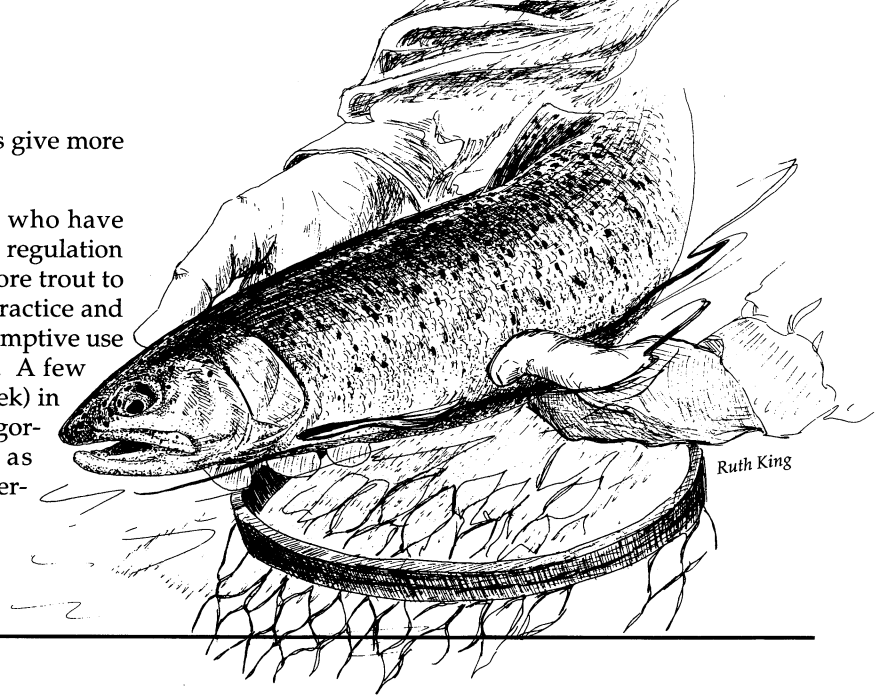
   I recommend that in future evaluations of special opportunity regulations more effort be made to gather sociological data that would quantify angler attitudes toward such regulations and their expected versus experienced rankings of angling satisfaction.

6. Angler use indices for both the TZ and RZ during the 1986-88 fishing seasons rank near the top in relation to angling pressure recorded on Wisconsin trout streams (Append. Table C.14). Timber Coulee Creek as a whole also ranks as one of the most popular trout streams in the state, a ranking likely to climb as more of its length has its trout carrying capacity enhanced via a proven habitat improvement program (Vetrano 1988). Popularity will increase as the stream's reputation grows for being one of the sites in Wisconsin where catch and release regulations apply, and as its statewide and national reputation expands in response to publicity. For example, a national sporting magazine published in 1989 listed the stream among the best 100 in America (Clark 1989). Because of its showcase, blue-ribbon status, I recommend that Timber Coulee Creek continue to receive high priority for fisheries management, especially for trout habitat improvement and maintenance, watershed and water quality preservation, and trout population and fisheries monitoring.

7. Special opportunity regulations applied to specific portions of streams can biologically and sociologically benefit adjacent normal regulation reaches of those streams, too. This spillover phenomenon has been insufficiently appreciated or investigated to date. Adult trout surviving in greater numbers in such special regulation reaches, due to harvest elimination or drastic reduction, may move out to spawn elsewhere, thereby bolstering the strength of subsequent year classes throughout the streams involved. Trout resident to special regulation reaches may also move to normal regulation reaches as standing stocks become denser in the special regulation reaches. I suggest that

both fisheries managers and administrators give more attention to such spillover benefits.

From a sociological perspective, anglers who have experienced the better recreation in special regulation zones (higher CPH, larger average size, more trout to observe) may later decide to voluntarily practice and promote better fishing ethics and nonconsumptive use where catch and release is not obligatory. A few sites (such as the TZ on Timber Coulee Creek) in the state where such angling behavior is vigorously promoted or required can serve as small-scale training grounds for much larger-scale voluntary implementation.



APPENDIXES

Appendix A. Brook Trout Population Dynamics and Fishery

At the close of the 1984 fishing season the RZ held no brook trout and the TZ held only one. When the 1985 season closed there were again no brook trout in the RZ and only 2 in the TZ. Postseason abundance increased to 27/mile in the RZ and to 29/mile in the TZ in 1985 (Append. Table A.1). These densities represented only 1.5% of all trout in the RZ and only 2.3% of all trout in the TZ (Append. Table A.2).

Throughout the 1986-88 posttreatment phase, when both spring and fall standing stocks of brook trout were monitored, abundance and biomass of brook trout were consistently greater in the TZ than in the RZ (Append. Fig. A.1). Average density in April was 118% greater in the TZ (48 vs. 22/mile) for brook trout of all sizes and 383% greater in the TZ (48 vs. 22/mile) for brook trout 9 inches or larger. Average biomass in April was 160% greater in the TZ (17.4 vs. 6.7 lb/mile). Brook trout accounted for less than 1% of all trout in the RZ in April and a maximum of 3.2% of all trout in the TZ in April.

The changes to special regulations in the TZ and to more restrictive harvest regulations and a shorter fishing season in the RZ in 1986 benefited standing stocks of brook trout in both study zones and especially in the TZ. Average density of brook trout in October of 1986-88 was 564% greater ($P = 0.05$) in the TZ and 22% greater ($P = 0.35$) in the RZ compared to average density for October of 1983-85, the pretreatment phase (Append. Fig. A.1*a*). There was no improvement in average abundance of brook trout 9 inches or larger in the RZ from October 1983-85 to October 1986-88, but in the TZ average abundance of such brook trout increased from 3/mile for October of 1983-85 to 26/mile for October of 1986-88 (Append. Fig. A.1*b*), a 767% improvement ($P = 0.05$). In fact, there were no brook trout present over 9 inches in the fall of 1983 and 1984.

The postseason biomass stayed about the same from the pretreatment to posttreatment phase in the RZ (average of 1.1 lb/mile vs. 1.2 lb/mile), but in the TZ postseason biomass jumped from an average of 1.5 lb/mile (1983-85) to an average of 16.6 lb/mile (1986-88) (Append. Fig. A.1*c*).

During the 9-month 1984 fishing season, the harvest of brook trout was equivalent to 14/mile in the RZ and 19/mile in the TZ. No brook trout were reported released in either study zone that season.

During the 5-month 1986-88 fishing seasons, harvests of brook trout were equivalent to 16/mile, 12/mile, and 4/mile in the RZ. Exploitation rates, based on mid-April standing stock assessments, were 76%, 75%, and 14%, respectively. Only one brook trout of legal size was kept in the TZ during the 1986 season and none were kept in 1987 or 1988.

If they identified the species and the numbers of trout released accurately, anglers released approximately 140 brook trout in the TZ in 1986, 211 in 1987, and 156 in 1988. These catches in relation to preseason densities represent "turnover rates" of 3.9, 3.3, and 3.7 for the 1986-88 seasons, respectively. These rates substantially exceed the corresponding rates of 1.3, 0.95 and 0.98 for brown trout in the TZ the same 3 fishing seasons.

Differences between the turnover rates for brook trout vs. brown trout probably reflect both the great differences in abundance of the 2 species in the study zones and the greater vulnerability of brook trout to being caught by anglers (Cooper 1959).

Releases of brook trout in the RZ during the 1986-88 seasons were equivalent to 47/mile, 94/mile, and 22/mile, respectively. These estimated release totals, plus seasonal catches of brook trout creeled, represent turnover rates of 3.0, 6.6, and 0.9, respectively.

Although the number of brook trout present in the TZ was always rather small in relation to the number of brown trout present, the brook trout population seemed to benefit more from the special regulations imposed in 1986 than did the brown trout population. In both study zones statistically significant ($P < 0.05$) increases occurred in several attributes of the standing stocks of brook and

brown trout during 1986-88, but for brown trout only the October increase in abundance of such trout 14 inches or larger was significantly greater in the TZ than in the RZ where new and more stringent regulations were also imposed in 1986 (see Table 6, remainder $P = 0.05$ for no./mile > 14 inches). For brook trout, however, 3 of 4 population attributes quantified each October—number of age 0+, number 9 inches or larger, and total biomass—showed significantly greater increases in the TZ than in the RZ during 1986-88 vs. 1983-85 (see Append. Table A.1; remainder P values for each = 0.05).

Appendix Table A.1. *Standing stocks of brook trout in the Reference Zone and Treatment Zone on Timber Coulee Creek before (1983-85) and after (1986-88) application of special regulations in the TZ only.*

		Study Phase								Posttreatment Avg.-Pretreatment Avg.			
		Pretreatment			Posttreatment								
Attribute	Study Zone*	1983	1984	1985	1986	1987	1988	Pre-Avg.	Post-Avg.	Absolute Diff.	% Diff.	*P* Value**	*P* Value[a]
Trout/mile in April													
Total no. (age I+)	RZ				21	16	29		22				
	TZ				36	65	43		48				
No. ≥ 9.0 inches	RZ				0	12	7		6				
	TZ				17	51	19		29				
Biomass in April													
Lb/mile	RZ				7.5	6.4	6.2		6.7				
	TZ				10.4	27.6	14.3		17.4				
Lb/acre	RZ				2.6	2.2	2.1		2.3				
	TZ				3.7	10.0	5.1		6.3				
Trout/mile in October													
Age 0	RZ	0	0	9	2	13	5	3	7	4	+133	0.20	
	TZ	0	0	20	2	56	4	7	21	14	+200	0.20	
	Remainders[b]	0	0	11	0	43	-1	4	14				0.50
Total no. (age 0+)	RZ	0	0	27	4	20	9	9	11	2	+22	0.35	
	TZ	1	2	29	52	127	39	11	73	62	+564	0.05	
	Remainders	1	2	2	48	107	30	2	62				0.05
No. ≥ 9.0 inches	RZ	0	0	4	2	2	0	1	1	0	0	0.50	
	TZ	1	1	6	26	38	14	3	26	23	1,767	0.05	
	Remainders	1	1	2	24	36	14	2	25				0.05
Biomass in October													
Lb/mile	RZ	0.0	0.0	3.4	0.7	2.0	0.9	1.1	1.2	0.1	+9[c]		
	TZ	0.3	0.6	3.7	16.8	23.9	9.2	1.5	16.6	15.1	+1,006[c]		
	Remainders	0.3	0.6	0.3	16.1	21.9	8.3	0.4	15.4				0.05
Lb/acre	RZ	0.0	0.0	1.2	0.2	0.7	0.3	0.4	0.4	0	0[c]		
	TZ	0.1	0.2	1.3	6.0	8.6	3.3	0.5	6.0	5.5	+1,100[c]		
	Remainders	0.1	0.2	0.1	5.8	7.9	3.0	0.1	5.5				0.05

* RZ = Reference Zone; TZ = Treatment Zone.

**Mann-Whitney nonparametric test. $P = 0.05$ is the smallest significance value possible with 2 data sets of 3 values each.

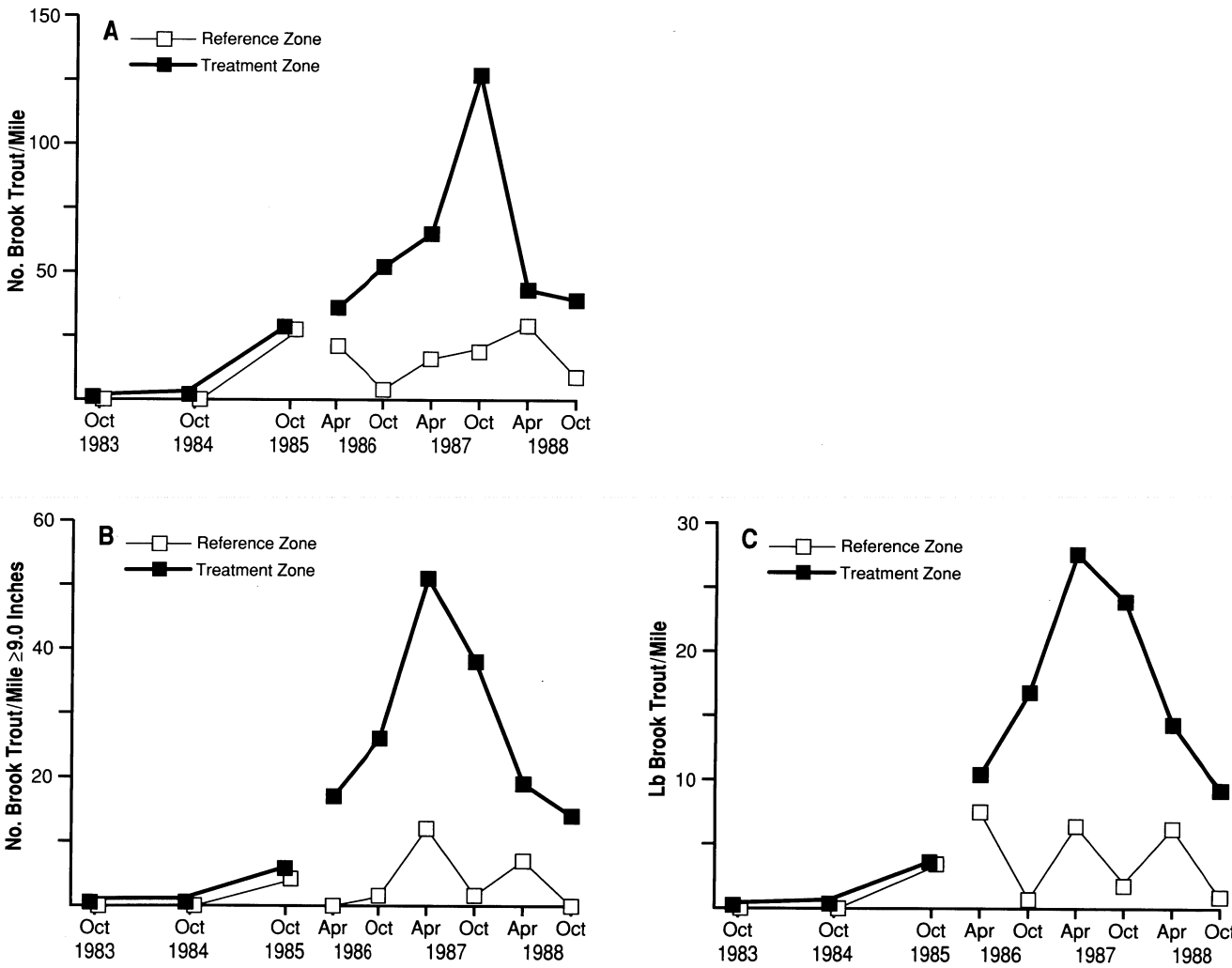
[a] Test for no difference between average remainder values for pretreatment vs. posttreatment phases, based on Mann-Whitney nonparametric tests.

[b] Remainders = (Treatment Zone values) - (Reference Zone values).

[c] These 2 percentages should be similar; the difference is due to rounding annual and average values.

Appendix Table A.2. *Comparative densities of brown trout and brook trout in the study zones on Timber Coulee Creek in October of 1983-88 and April of 1986-88.*

		Reference Zone (RZ)		Treatment Zone (TZ)		Brook Trout as % of the Total Population in Zone	
Year	Month	Brown	Brook	Brown	Brook	RZ	TZ
1983	October	3,178	0	1,984	1	0	0.05
1984		1,930	0	1,413	2	0	0.1
1985		1,833	27	1,212	29	1.5	2.3
1986		3,830	4	3,066	52	0.1	1.7
1987		5,192	20	3,872	127	0.4	3.2
1988		4,355	9	3,317	39	0.2	1.2
1986	April	1,860	21	1,149	36	1.1	3.0
1987		4,047	16	3,366	65	0.4	1.9
1988		5,228	29	3,555	43	0.6	1.2



Appendix Figure A.1. *Number of brook trout per mile (a), number per mile 9 inches or larger (b), and biomass in lb per mile (c) in the Reference and Treatment Zones on Timber Coulee Creek in October of 1983-85 and April and October of 1986-88.*

Appendix B. Public Relations Flyer Given to Interviewed Anglers

THANK YOU FOR YOUR COOPERATION in our Department of Natural Resources interview of anglers fishing Timber Coulee Creek. These interviews are part of a three-year research project to evaluate a set of experimental fishing regulations never tried in Wisconsin before.

The goal of this project is to develop a high quality sport fishery in the mile of stream constituting the special regulation zone. Management of this fishery is aimed at anglers primarily interested in "catch and release" recreation rather than "catch to keep."

The slot limit regulation of 14 inches to 17 inches is designed to provide exciting catch and release fishing for the abundant trout less than 14 inches, plus an opportunity to take home one medium-sized trout per day if that experience is important to the satisfaction of your fishing trip. And, you will also have the opportunity to fish a portion of trout stream holding its full capacity of large brown trout.

During the 1986-88 fishing seasons the following regulations will apply to the mile of stream below Olstad Road bridge:

1. Each season will begin at 5 a.m. on the first Saturday in May and end on September 30.
2. All trout less than 14 inches must be released.
3. All trout 17 inches or larger must be released.
4. One trout may be kept daily within the slot length of 14.0 to 16.9 inches.
5. Only artificial lures may be used.

If you have comments and observations you wish to share about this experiment, please send them to the person and address listed below.

Robert L. Hunt

Department of Natural Resources
11084 Stratton Lake Road
Waupaca, WI 54981

Appendix C. Miscellaneous Information on Timber Coulee Creek and Other Trout Streams

Appendix Table C.1. *Special opportunity regulation trout waters in Wisconsin established during 1955-88.*

Name of Water	County	Miles or Acres	Year Special Regulations Initiated	Season	Bag Limit	Size Limit*	Other Special Regulations
Castle Rock Cr.	Grant	2.4 miles	1977	1 Jan-30 Sep	0	0	artificial lures only
Doc Smith Brch.	Grant	1.4 miles	1977	1 Jan-30 Sep	0	0	artificial lures only
McGee L.	Langlade	22.7 acres	1986	1st Sat. May-30 Sep	2	0	artificial lures only
Namekagon R.	Sawyer	6.6 miles	1984	1st Sat. May-30 Sep	10 but only 5 brown or rainbow	protected slot: < 6 inches and 10-15 inches	artificial lures only
Oconto R.	Oconto	5.0 miles	1988	1st Sat. May-30 Sep	3	brook: 10 inches brown: 13 inches rainbow: 6 inches	artificial lures only
Paradise Spring Cr. and Pond	Waukesha	0.1 miles & 1.3 acres	1985	1 Jan-30 Sep	0	0	artificial lures only
Peshtigo R.	Marinette	5.0 miles	1955	1st Sat. May-30 Sep	5	10 inches	flies only
Plover R.	Marathon	0.4 mile	1986	1st Sat. May-30 Sep	10 but only 5 brown or rainbow	brook: 13 inches brown: 6 inches rainbow: 6 inches	artificial lures only
Race Brch.	St. Croix	1.0 mile	1977	1st Sat. May-30 Sep	1	13 inches	artificial lures only
Timber Coulee Cr.	Vernon	1.0 mile	1986	1st Sat. May-30 Sep	1	unprotected slot: 14-17 inches	artificial lures only
Trout Cr.	Iowa	5.3 miles	1983	1 Jan-30 Sep.	3 but only 1 > 18 inches	protected slot: 14-18 inches	artificial lures only
Wolf R.	Langlade	4.4 miles	1955	1st Sat. May-30 Sep	5	10 inches	flies only

*Minimum legal size, unless a slot length is specified.

Appendix Table C.2. *Monthly maximum, minimum, and mean water temperatures at the upper boundary of the Reference Zone and lower boundary of the Treatment Zone on Timber Coulee Creek during January-September 1984, and July-September 1988.*

	Water Temperatures (F)								
	1984 Reference Zone			1984 Treatment Zone			1988 RZ-TZ Boundary**		
Month	Max	Min	Mean*	Max	Min	Mean*	Max	Min	Mean*
Jan	38	32	35.0	39	32	35.5			
Feb	52	33	41.2	48	32	39.6			
Mar	53	32	40.9	52	31	40.2			
Apr	59	39	50.0	61	37	48.5			
May	71	43	57.1	65	42	55.1			
Jun	73	48	62.0	73	47	61.4			
Jul	72	55	64.1	71	54	63.4	82	68	74.0
Aug	73	56	64.9	73	54	63.8	79	62	74.0
Sep	72	46	59.1	71	44	58.8	68	51	57.9
Season range	73	32		73	31		82	51	
Grand mean			52.7			51.8			68.3

* Mean monthly values are calculated from more than one value each month of maximum and minimum temperatures. Temperature recorders were usually monitored weekly.

**RZ = Reference Zone; TZ = Treatment Zone.

Appendix Table C.3. *Angling effort, catch, and catch rates in the study zones on Timber Coulee Creek during the 5-month 1986 trout fishing season, summarized by bait types used.*

	Reference Zone					Treatment Zone			
Item	**Natural**	**Spin**	**Fly**	**Combination**	**All Baits**	**Spin**	**Fly**	**Combination**	**All Baits**
Angling effort									
Trips/mile	499	196	478	147	1,320	191	430	8	629
Trips/acre	171	68	164	50	453	68	154	3	225
Hours/mile	952	321	824	285	2,382	274	1,069	9	1,352
Hours/acre	327	110	283	98	818	98	382	3	483
Trout kept									
No./mile	339	83	101	32	555	5	2	0	7
No./acre	117	28	35	11	191	2	1	0	3
Lb/mile	180	43	54	17	294	5	2	0	7
Lb/acre	62	15	19	5	101	2	1	0	3
Trout released									
No./mile	526	255	1,833	124	2,738	254	2,379	6	2,639
No./acre	181	87	629	43	940	91	850	2	943
Catch/hour									
Kept	0.36	0.26	0.12	0.11	0.23	0.02	<0.01	0.00	0.01
Released	0.55	0.79	2.22	0.44	1.15	0.93	2.23	0.67	1.95
Total	0.91	1.05	2.34	0.55	1.38	0.95	2.23	0.67	1.96

Appendix Table C.4. *Angling effort, catch, and catch rates in the study zones on Timber Coulee Creek during the 5-month 1987 trout fishing season, summarized by bait types used.*

	Reference Zone					Treatment Zone			
Item	**Natural**	**Spin**	**Fly**	**Combination**	**All Baits**	**Spin**	**Fly**	**Combination**	**All Baits**
Angling effort									
Trips/mile	504	211	673	180	1,568	190	665	13	868
Trips/acre	173	72	231	62	538	68	237	5	310
Hours/mile	709	373	1,503	418	3,003	232	1,780	33	2,045
Hours/acre	244	128	516	144	1,032	83	636	12	731
Trout kept									
No./mile	279	86	64	21	450	5	3	0	8
No./acre	96	29	22	7	154	2	1	0	3
Lb/mile	172	27	44	20	263	12	4	0	16
Lb/acre	59	9	15	7	90	4	1	0	5
Trout released									
No./mile	512	686	3,202	289	4,689	186	2,965	22	3,173
No./acre	176	236	1,100	99	1,611	66	1,060	8	1,134
Catch/hour									
Kept	0.39	0.23	0.04	0.05	0.15	0.02	<0.01	0.00	<0.01
Released	0.72	1.84	2.13	0.69	1.56	0.80	1.67	0.67	1.55
Total	1.11	2.07	2.17	0.74	1.71	0.82	1.67	0.67	1.56

Appendix Table C.5. *Angling effort, catch, and catch rates of brown trout in the study zones on Timber Coulee Creek during the 5-month 1988 trout fishing season, summarized by bait type used.*

	Reference Zone					Treatment Zone			
Item	**Natural**	**Spin**	**Fly**	**Combination**	**All Baits**	**Spin**	**Fly**	**Combination**	**All Baits**
Angling effort									
Trips/mile	230	332	732	116	1,410	177	519	16	712
Trips/acre	79	114	252	40	485	63	186	6	255
Hours/mile	413	355	1,568	189	2,525	248	1,365	34	1,647
Hours/acre	142	122	539	65	868	89	488	12	589
Trout kept									
No./mile	79	89	66	29	263	2	0	0	2
No./acre	27	31	22	10	90	1	0	0	1
Lb/mile	46	51	38	16	151	2	0	0	2
Lb/acre	15	18	13	6	52	1	0	0	1
Trout released									
No./mile	123	436	3,157	121	3,837	619	2,760	88	3,467
No./acre	42	150	1,085	41	1,318	221	986	32	1,239
Catch/hour									
Kept	0.19	0.25	0.04	0.15	0.10	0.01	0.00	0.00	0.01
Released	0.30	1.23	2.01	0.64	1.52	2.50	2.02	2.59	2.11
Total	0.49	1.48	2.05	0.79	1.62	2.51	2.02	2.59	2.11

Appendix Table C.6. *Percentage distributions of angler trips, angler hours, and catches of brown trout for the study zones on Timber Coulee Creek during the 9-month 1984 season and the 5-month 1986-88 trout fishing seasons, summarized for each season by distance travelled and angler residency status.*

Residency Status	Miles Travelled	% of Angler Trips				% of Angler Hours				% of Trout Kept				% of Trout Released			
		1984	**1986**	**1987**	**1988**	**1984**	**1986**	**1987**	**1988**	**1984**	**1986**	**1987**	**1988**	**1984**	**1986**	**1987**	**1988**
Reference Zone																	
Wis. Resident	0-24	81	67	54	51	77	64	47	41	80	81	65	52	88	72	35	31
	25-49	1	2	2	2	1	4	1	2	0	0	4	0	1	1	3	1
	50-99	7	9	9	16	8	12	10	21	8	2	4	30	5	17	16	27
	100+	3	9	15	11	3	10	20	10	7	12	21	11	2	3	21	14
	Total	92	87	80	80	89	90	78	74	95	95	94	93	96	93	75	73
Nonresident	All	8	13	20	20	11	10	22	26	5	5	6	7	4	7	25	27
Treatment Zone																	
Wis. Resident	0-24	85	55	42	42	79	44	34	30	84	100	75	50	78	49	44	40
	25-49	2	3	6	4	1	2	6	3	0	0	0	0	1	1	6	1
	50-99	4	8	11	15	8	9	12	16	3	0	0	0	5	17	14	26
	100+	1	12	13	12	3	14	15	12	4	0	25	50	1	15	12	17
	Total	92	78	72	73	91	69	67	61	91	100	100	100	85	82	76	84
Nonresident	All	8	22	28	27	9	31	33	39	9	0	0	0	15	18	24	16

Appendix Table C.7. *Catch rates for trout fisheries managed with special opportunity regulations that emphasize catch and release.*

Reference	Primary Trout Species	Lake or Stream	Year	Catch/Hour
Abraham 1976	Brown	Oatka Cr.	1970	0.41
Anderson and Nehring 1984	Rainbow	S. Platte R., Cheeseman R.	1979	0.25
	Rainbow	S. Platte R., Cheeseman R.	1980	0.33
	Rainbow	S. Platte R., Cheeseman R.	1981	0.44
Barnhart and	Brown	Batten Kill R.	1973	0.40
Engstrom-Heg 1984	Brown	Wiscoy Cr.	1972	0.14
	Brown	Wiscoy Cr.	1974	0.43
	Brown	Beaver Kill R.	1965	1.68
	Brown	Beaver Kill R.	1966	1.14
	Brown	E. Walker R.	1980-82 avg.	0.66
	Lake	Raquette L.	1973-78 avg.	0.29
Clark and Alexander 1984	Brown	AuSable R.	1980-83 avg.	0.22
Cresswell 1987	Cutthroat	Yellowstone L.	1975-85 avg.	0.94
Deinstadt 1984	Brown	E. Walker R.	1980-82 avg.	0.66
Deinstadt 1987	Brown, Rainbow	Crowley L.	1985	1.49
	Brown, Rainbow	Crowley L.	1986	0.93
	Brown, Rainbow	Crowley L.	1987	0.97
	Cutthroat	Heenan L.	1985	1.33
	Cutthroat	Heenan L.	1986	1.39
	Brown, Rainbow	Hot Cr.	1985	2.50
	Brown, Rainbow	Hot Cr.	1986	1.55
	Brown, Rainbow	Hot Cr.	1987	1.98
Fatora 1970	Brook, Brown, Rainbow	Noontootla R.	1964-69 avg.	0.88
Hunt 1981	Brown, Rainbow	Race Brch.	1977	1.08
	Brown, Rainbow	Race Brch.	1978	1.46
	Brown, Rainbow	Race Brch.	1979	1.48
Hunt 1984	Brook	McGee L.	1980	0.71
	Brook	McGee L.	1981	0.77
	Brook	McGee L.	1982	0.70
Johnson and Bjornn 1978	Cutthroat	Kelly Cr.	1975	1.30
	Cutthroat	St. Joe R.	1975	2.50
Jones 1984	Cutthroat	Yellowstone R.	1983	1.06
	Cutthroat	Slough Cr.	1981	1.48
	Cutthroat	Slough Cr.	1983	1.03
Kerr 1982	Brown	Castle Rock Cr.	1979	1.64
Klein 1974	Brown, Rainbow	Cache la Poudre R.	1963	0.88
	Brown, Rainbow	Cache la Poudre R.	1964	1.53
	Brown, Rainbow	Cache la Poudre R.	1967	0.99
Rohrer 1983	Rainbow	Henrys Fk. Snake R. (6 sections avg.)	1982	0.90
Snigg 1987	Brown, Rainbow	North Platte R.:		
		Treasure Is.-Bank	1986	0.96
		Treasure Is.-Boat	1986	0.97
Turner 1986	Brown, Rainbow	Meramec R.	1982	0.31
	Brown, Rainbow	Meramec R.	1983	0.45
	Brown, Rainbow	Meramec R.	1984	0.53

Appendix Table C.8. *Percentage frequency distribution of the harvest of brown trout from the study zones on Timber Coulee Creek during the 9-month 1984 season and 5-month 1986-88 trout fishing seasons, summarized by inch groups and months.*

Inch Group	1984 Jan-Apr RZ*	1984 Jan-Apr TZ	1984 May-Sep RZ	1984 May-Sep TZ	1984 Jan-Sep RZ	1984 Jan-Sep TZ	1986 May-Sep RZ	1986 May-Sep TZ	1987 May-Sep RZ	1987 May-Sep TZ	1988 May-Sep RZ	1988 May-Sep TZ	1986-88 Avg. May-Sep RZ	1986-88 Avg. May-Sep TZ
6	1.8	4.1	0.8	0.0	1.1	0.9	—	—	—	—	—	—	—	—
7	1.8	8.2	0.8	2.9	1.1	4.1	—	—	—	—	—	—	—	—
8	0.0	4.1	9.2	13.4	6.5	11.3	—	—	—	—	—	—	—	—
9	11.1	2.0	23.8	22.1	20.1	17.6	17.4	—	7.9	—	13.6	—	13.2	—
10	42.6	20.4	30.0	27.3	33.7	25.8	24.8	—	20.2	—	27.2	—	23.9	—
11	27.8	26.5	20.0	23.3	22.3	24.0	32.2	—	36.5	—	22.4	—	31.9	—
12	7.4	16.3	9.2	10.5	8.7	11.8	18.3	—	18.3	—	12.9	—	17.0	—
13	1.8	4.1	1.5	0.5	1.6	1.4	5.8	—	15.1	—	14.3	—	10.6	—
14	5.7	4.1	3.9	—	4.3	0.9	0.6	85.7	2.0	87.5	8.2	50.0	2.7	75.0
15	—	6.1	0.8	—	0.6	1.3	0.6	14.3	—	12.5	1.4	50.0	0.6	25.0
16	—	4.1	—	—	—	0.9	0.3	—	—	—	—	—	0.1	—
Harvest total (no./mile)	371	95	1,158	918	1,529	1,013	555	7	450	8	263	2	423	6

*RZ = Reference Zone; TZ = Treatment Zone.

Appendix Table C.9. *Distributions of angler trips in the study zones on Timber Coulee Creek during the 9-month 1984 trout fishing season, based on the number of brown trout kept per trip and number released per trip.*

Period	Study Zone	No. Kept/Trip	No. Trips According to No. Trout Released/Trip: 0	1	2	3	4	5	6-9	10+	Total No. Trips	Total No. Released	Total No. Kept
Jan-Apr	Reference Zone	0	222	34	17	13	13	12	22	1	334	386	0
		1	13	19	9	9	8	1	1	0	60	108	60
		2	9	14	14	5	4	5	18	5	74	311	148
		Trip totals	244	67	40	27	25	18	41	6	468		
		Total no. released	0	67	78	81	100	90	325	64		805	
		Total no. kept	31	47	37	19	16	11	37	10			208
May-Sep	Reference Zone	0	386	77	46	23	48	15	14	48	657	1,171	0
		1	61	15	8	7	2	3	5	5	106	163	106
		2	38	15	5	5	14	5	4	3	89	227	178
		3	13	13	7	2	3	1	12	8	59	232	177
		4	9	9	14	1	2	1	2	0	38	68	152
		5	1	1	5	0	0	0	0	0	7	11	35
		Trip totals	508	130	85	38	69	25	37	64	956		
		Total no. released	0	130	170	114	276	125	278	779		1,872	
		Total no. kept	217	125	120	27	47	20	57	35			648
Jan-Apr	Treatment Zone	0	160	27	26	7	7	2	1	1	231	156	0
		1	11	14	3	3	0	3	4	0	38	74	38
		2	6	2	6	3	3	5	3	0	28	83	56
		Trip totals	177	43	35	13	10	10	8	1	297		
		Total no. released	0	43	70	39	40	50	59	12		313	
		Total no. kept	23	18	15	9	6	13	10	0			94
May-Sep	Treatment Zone	0	353	53	52	33	6	13	20	77	607	1,464	0
		1	72	13	6	2	1	2	5	9	110	207	110
		2	60	7	16	3	6	6	4	0	102	196	204
		3	17	20	9	3	1	1	0	0	51	56	153
		4	27	10	10	9	3	2	7	0	68	100	272
		5	10	6	1	4	1	1	11	0	34	112	170
		Trip totals	539	109	94	54	18	25	47	86	972		
		Total no. released	0	110	188	162	72	125	370	1,108		2,135	
		Total no. kept	401	157	110	73	33	30	96	9			909

Appendix Table C.10. *Distributions of angler trips in the study zones on Timber Coulee Creek during the 5-month 1986 trout fishing season, based on the number of brown trout kept per trip and number released per trip.*

Study Zone	No. Kept/Trip	No. Trips According to No. Trout Released/Trip											Total No. Trips	Total No. Released	Total No. Kept
		0	1	2	3	4	5	6	7	8	9	10+			
Reference Zone	0	278	70	57	17	23	3	20	0	10	0	47	525	1,137	0
	1	67	46	17	13	0	0	0	0	0	4	4	151	207	151
	2	12	0	0	4	0	6	0	2	3	0	2	29	106	58
	3	7	12	5	5	0	0	0	1	3	0	1	34	83	102
	Trip totals	364	128	79	39	23	9	20	3	16	4	54	739		
	Total no. released	0	128	158	117	92	45	120	21	128	36	688		1,533	
	Total no. kept	112	82	32	36	0	12	0	7	15	4	11			311
Treatment Zone	0	204	54	40	41	38	56	13	15	18	36	101	616	2,562	0
	1	1	0	0	3	0	0	0	0	0	0	3	7	51	7
	Trip totals	205	54	40	44	38	56	13	15	18	36	104	623		
	Total no. released	0	54	80	132	152	280	78	105	144	324	1,264		2,613	
	Total no. kept	1	0	0	3	0	0	0	0	0	0	3			7

Appendix Table C.11. *Distributions of angler trips in the study zones on Timber Coulee Creek during the 5-month 1987 trout fishing season, based on the number of brown trout kept per trip and number released per trip.*

Study Zone	No. Kept/Trip	No. Trips According to No. Trout Released/Trip											Total No. Trips	Total No. Released	Total No. Kept
		0	1	2	3	4	5	6	7	8	9	10+			
Reference Zone	0	320	66	90	47	33	34	26	10	19	3	89	737	2,347	0
	1	28	1	9	13	2	1	4	2	1	0	1	62	130	62
	2	29	1	6	4	3	2	0	1	1	0	0	47	68	94
	3	11	1	2	7	6	3	0	1	0	1	0	32	81	96
	Trip totals	388	69	107	71	44	40	30	14	21	4	90	878		
	Total no. released	118	6	27	42	26	15	4	7	3	3	1		2,626	
	Total no. kept	0	69	214	213	176	200	180	98	168	36	1,272			252
Treatment Zone	0	306	83	88	70	43	43	50	34	41	4	89	851	3,130	0
	1	3	1	2	1	1	0	0	0	0	0	0	8	12	8
	Trip totals	309	84	90	71	44	43	50	34	41	4	89	859		
	Total no. released	0	84	180	213	176	215	300	238	328	36	1,372		3,142	
	Total no. kept	3	1	2	1	1	0	0	0	0	0	0			8

Appendix Table C.12. *Distributions of angler trips in the study zones on Timber Coulee Creek during the 5-month 1988 trout fishing season, based on the number of brown trout kept per trip and number released per trip.*

Study Zone	No. Kept/Trip	No. Trips According to No. Trout Released/Trip											Total No. Trips	Total No. Released	Total No. Kept
		0	1	2	3	4	5	6	7	8	9	10+			
Reference Zone	0	362	69	47	51	15	25	18	15	18	15	58	693	1,921	0
	1	18	13	17	3	4	1	1	0	0	0	0	57	83	57
	2	8	6	6	1	0	0	1	0	2	4	2	30	122	60
	3	6	0	0	2	0	0	0	0	1	1	0	10	23	30
	Trip totals	394	88	70	57	19	26	20	15	21	20	60	790		
	Total no. released	0	88	140	171	76	130	120	105	168	180	971		2,149	
	Total no. kept	52	25	29	11	4	1	3	0	7	11	4			147
Treatment Zone	0	233	115	62	50	22	29	41	7	15	14	115	703	3,424	0
	1	0	1	0	0	0	0	0	1	0	0	0	2	8	2
	Trip totals	233	116	62	50	22	29	41	8	15	14	115	705		
	Total no. released	0	116	124	150	88	145	246	56	120	126	2,261		3,432	
	Total no. kept	0	1	0	0	0	0	0	1	0	0	0			2

Appendix Table C.13. *Number of brown trout per mile that were ≥ 15 inches in 29 surveyed portions of 24 trout streams in Wisconsin in which brown trout are numerically predominant.*

Reference	Stream	County	Class	Miles Surveyed	Survey Year(s)	No./mile ≥ 15 inches
R. DuBois*	Brule R.	Douglas				
	Upper Twin Sta.		I	0.2	1987-88 avg.	92
	Cedar Is. Sta.		I	0.1	1986-88 avg.	90
M. Johnson*	Prairie R.	Lincoln	I	0.3	1987	69
	Hunting R.	Langlade	I	1.2	1982	49
Avery 1990	White R.	Bayfield				
	Primitive Site Sta.		I	1.0	1984-88 avg.	49
	Stanley Sta.		I	1.0	1984-88 avg.	31
R. Kerr*	Little Green R.	Grant	I	0.4	1980	44
Kerr 1982	Castle Rock Cr.	Grant	II	2.4	1979	31
CWG**	Mt. Vernon Cr.	Dane	I, II	6.1	1978-79 avg.	30
Avery 1983	Eighteen Mile Cr.	Bayfield	I	5.3	1979-80 avg.	28
G. VanDyck*	Trout Cr.	Iowa	I, II	6.1	1978-79 avg.	26
F. Pratt*	Namekagon R.	Sawyer				
	Seeley Sta.		II	6.6	1981-84-86 avg.	25
	Phipps Sta.		II	4.4	1981-84-86 avg.	11
M. Johnson*	Prairie R.	Lincoln	I	0.3	1981	23
CWG**	Campbell Cr.	Adams	I	0.8	1963-65 avg.	21
Avery 1983	N. Brch. Beaver Cr.	Marinette	I	3.4	1979	21
Hunt 1981	Race Brch.	St. Croix	II	1.0	1976-79 avg.	14
R. Hunt, this report	Timber Coulee Cr.	Vernon				
	Treatment Zone		I	1.0	1983-88 avg.	14
	Reference Zone		I	0.6	1983-88 avg.	8
Hunt 1981	Willow R.	St. Croix	II	1.0	1976-79 avg.	11
M. Johnson*	Plover R.	Marathon	I	5.4	1975	10
R. Cornelius*	Yellow R.	Barron	I	0.8	1978	9
R. Kerr*	Big Green R.	Grant	II	8.6	1979	8
J. Tally*	Beef R.	Jackson	I	1.0	1977	7
Avery and Hunt 1981	Emmons Cr.	Waupaca	I	1.2	1975-77 avg.	6
	Mecan R.	Waushara	I	1.4	1975-77 avg.	6
	Radley Cr.	Waupaca	I	1.5	1975-77 avg.	6
Hunt 1986	Parker Cr.	St. Croix	I	0.9	1981	5
J. Tally*	Trempealeau R.	Jackson	I	0.8	1977	5

* Personal communications; unpublished file data from DNR biologists.

**CWG = Cold Water Group stream survey files of unpublished data. DNR, 11084 Stratton Lake Rd., Waupaca, Wis. 54981.

Appendix Table C.14. *Intensities of angler use recorded on trout lakes, trout ponds, and trout streams in Wisconsin.*

Reference	Predominant Trout Species*	Water Body	County	Creel Survey Year(s)	Fishing Intensity	
					Hours/acre	Hours/mile
Avery 1974*a*	D. Brown	Seas Brch. Cr.	Vernon	1971-73 avg.	187	351
Avery 1974*b*	D. Brown	Westfield Cr.	Marquette	1974	52	221
Avery 1983	W. Brook, W. Brown	Eighteen Mile Cr.	Bayfield	1979-80 avg.	39	104
Avery 1990	W. Brown	White R.	Bayfield	1984-85 avg.	96	513
Avery**	D. and W. Brook	Pemebonwon R.	Marinette	1982-84-86 avg.	75	210
Avery and Hunt 1981	W. Brown	Emmons Cr.	Waupaca	1976-77 avg.	344	819
	W. Brown	Mecan R.	Waushara	1976-77 avg.	388	1,026
	W. Brown	Radley Cr.	Waupaca	1976-77 avg.	330	683
	W. Brown	S. Brch. Wedde Cr.	Waushara	1976-77 avg.	428	622
Brynildson et al. 1970	D. Brown, D. Rainbow	Devils L.	Sauk	1968-69 avg.	111	
Carline and Brynildson 1977	W. Brook	Rabe L.	Langlade	1969-75 avg.	578	
	W. Brook	Clubhouse Sp.	Langlade	1969-75 avg.	548	
	W. Brook	Hoglot Sp.	Langlade	1969-72 avg.	235	
	W. Brook	Maxwell Sp.	Langlade	1969-70 avg.	68	
Fassbender and Churchill 1967	D. and W. Brown	Bohemian Valley Cr.	LaCrosse	1965	563	
A. Hauber**	D. and W. Brook, D. and W. Brown	E. Brch. Eau Claire R.	Langlade	1974	147	
Hunt et al. 1962	W. Brook	Lawrence Cr.	Adams/ Marquette	1955-60 avg.	324	1,026
Hunt 1979*a*	W. Brook	Little Plover R.	Portage	1976	434	714
Hunt 1979*b*	D. Brook	Adams L.	Portage	1977	176	
	D. and W. Brook	McGee L.	Langlade	1977	457	
Hunt 1981	D. and W. Brown, D. Rainbow	Race Brch.	St. Croix	1976-70 avg.	856	4,070
	D. Brown, D. Rainbow	Willow R.	St. Croix	1976-79 avg.	673	3,585
Hunt 1984	D. and W. Brook	McGee L.	Langlade	1980-82 avg.	188	
Hunt 1989	W. Brook, W. Brown	N. Fk. Thunder R.	Oconto	1987	117	187
	W. Brook	Wisconsin Cr.	Florence	1988	136	252
Hunt (this report)	W. Brown	Timber Coulee Cr.				
		Reference Zone	Vernon	1986-88 avg.	906	2,637
		Treatment Zone	Vernon	1986-88 avg.	601	1,681
Jesien 1977	D. Rainbow	Sunset L.	Portage	1975	122	
Kerr 1982	D. Brown	Castle Rock Cr.	Grant	1979	369	1,398
	D. Brown	Big Green R.	Grant	1979	220	734
Kerr 1986**	D. Brown	Blue R.	Iowa	1985	238	704
Larson 1982	D. and W. Brown	Rowan Cr.	Columbia	1979	474	759
Lowry 1971	D. and W. Brown	McKenzie Cr.	Polk	1957 & 1963 avg.	160	338
Meyers 1985	W. Brook, D. Brown	N. Brch. Embarrass R.	Shawano	1985	153	454
Meyers and Thuemler 1976	D. and W. Brown	N. Brch. Beaver Cr.	Marinette	1975	458	
T. Thuemler 1981	D. Brook	Sand L.	Florence	1976	90	
	D. Brook	Montgomery L.	Florence	1976	68	
	D. Rainbow	Anna L.	Florence	1976	8	
Thuemler 1983	W. Brook, W. Brown	N. Brch. Pike R.	Marinette	1977	203	905
J. Warren 1981**	W. Brown	Trout Cr.	Iowa	1979	574	925
	W. Brown	Mt. Vernon Cr.	Dane	1979	682	1,255
White 1972	W. Brook, W. Brown	Big Roche-a-Cri Cr.	Waushara	1957-59 avg.	250	

* D. = Domestic; W. = Wild.

**Personal communication; unpublished DNR file data.

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Approximate Metric-English Equivalents
1 ha = 2.47 acres
1 m = 3.28 ft
1 cm = 0.39 inches
1 km = 0.62 miles
1 m^2 = 1.20 yd^2

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