Biological and social dynamics of the White River brown trout fishery, 2003-2005

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Executive Summary

The White River, in Bayfield County, is one of only eight trout streams in Wisconsin containing more than 40 miles of Class I or II trout water. The river is known for its top quality brown trout, *Salmo trutta,* fishery that is relatively inaccessible by roads. A three year study (2003 to 2005) of the White River was initiated to address concerns from the public as well as from the Department of Natural Resources that declines in both the brown trout population and sport fishery have occurred. We hypothesized that angler exploitation, northern pike, *Esox lucius,* predation, reduced natural recruitment, and changing environmental factors, especially water temperature, may have affected brown trout abundance. The study used many of the same methodologies that were developed in historic surveys on the White River.

Study results confirm a decline in the brown trout population ≥ 6 in., but an increase in the population of brown trout ≥ 15 in. When combining consecutive years and stations (excluding 2005 which utilized alternate stations) brown trout populations ≥ 6 in. (total length) increased from 529 fish/mile to 656 fish/mile from 1984-1986 to 1988-1989, then decreased to 528 fish/mile and 367 fish/mile from 1992-1993 to 2003-2004. Brown trout populations ≥15 in. increased from 27 fish/mile to 57 fish/mile, and then to 64 fish/mile from 1984-86 to 1988-1989 to 1992-1993 and then declined slightly to 60 fish/mile in 2003-2004.

The decline in the brown trout population ≥ 6 in. was likely not due to angler exploitation since exploitation rates before the 1990 regulation change were an average of 35% in 1984-1985 and after the regulation exploitation rates declined to an average of 18% in 1992-1993 and 2004-2005. Regulation changes may have been partly responsible for the higher proportion of brown trout ≥ 15 in. observed in surveys post regulation change. Some of this size structure shift had begun prior to the regulation change which may be explained by the posting of signs in the study area that encouraged voluntary compliance with the regulations that went into effect in 1990, or the effect of increasing practice of live release of legal length fish. Average exploitation of brown trout ≥ 9 in. and ≥ 15 in. has decreased by 25% and 93%, respectively, since the implementation of special regulations.

Northern pike predation was likely not a factor in the decline in brown trout based on low abundance of northern pike found in surveys. Because this survey collected the first continuous water temperature data, no comparisons could be made to historic data.

Variable natural recruitment remains the most likely cause of the observed population changes in brown trout. Changes in spawning habitats, reduced access to spawning habitats, flooding/drought conditions, and intra-specific competition can all negatively affect natural recruitment levels and need to be examined.

Two hundred and thirty three anglers responded to an angler questionnaire of which 57% had fished the White River for 11 or more years. In 2004 and 2005, 84% of respondents said they were either very satisfied or somewhat satisfied with their fishing experiences on the White River. There was nearly an even split of bait choices among anglers. The preferences for future regulatory changes on the White River were equally split among anglers depending on their bait choice when fishing.

Management recommendations for the White River include;

1) A management goal of 300-550 brown trout/mile ≥ 6 in. At this density recruitment should be adequate to support the fishery. 2) Retain current regulations at this time because harvest in the most recent creel surveys on the White River indicates angler exploitation was not limiting abundance of brown trout. Although a more conservative regulation may have the potential of further increasing size structure in the brown trout population, implementing it would also coincide with the restriction of live bait use due to concerns regarding high catch and release mortality while using live bait. According to the angler questionnaire results, approximately half of anglers surveyed oppose implementing the restriction of live bait use on the White River. 3) Monitor recruitment by attempting to quantify year class strength, identifying areas with high contributions to recruitment, investigating potential fish passage issues and preventing excess sedimentation and habitat loss in the watershed. 4) Discern through the use of telemetry studies movement patterns of adult brown trout to identify spawning areas and summer and winter home ranges. 5) Continue an active monitoring program. Population estimates should be conducted every 10 years along with creel surveys and angler questionnaires using lessons learned to increase efficiency and accuracy. Continue annual index station survey work to establish a long term data set and help to determine changes in brown trout recruitment, relative abundance and length frequency. 6) Work with interested parties to assist in accomplishing management recommendations. Encourage and support the many groups that are protecting and preserving the White River and its watershed.

Contents

Introduction

Authors note: This report makes comparisons with previous studies conducted on the White River. These comparisons are often presented in graphic form. More detailed numeric summaries of many of these graphic comparisons are included in the appendices to aid with future comparisons.

The White River is one of only eight trout streams in Wisconsin containing more than 40 miles of Class I or II trout water and has been known as a top quality brown trout fishery with limited road access. The 2003 to 2005 White River study was initiated in response to concerns of the angling public, recommendations from previous survey reports (Avery 1990; Avery 1999) and Wisconsin Department of Natural Resources (WDNR) staff about a perceived decline in brown trout populations within the Bibon Swamp section of the White River. The reasons for the perceived reduction in brown trout abundance were thought to include but not be limited to: reduction of brown trout recruitment, increased northern pike abundance and subsequent predation on brown trout, increased angler exploitation of brown trout, and increased water temperatures. This survey was designed to determine the current status of the brown trout population and, if needed, gather information on the cause of a decline.

The White River watershed is located in northwestern Wisconsin. The river originates in the Chequamegon National Forest in central Bayfield County and is the largest river in the county. The river flows east from its origin near Delta, 32 miles and enters Ashland County. A forty-nine foot power dam, located just inside Ashland County, creates the 56-acre White River Flowage and prevents upstream movement of fish from Lake Superior. Below the power dam, the river flows northeast 14 miles to its junction with the Bad River near Odanah and then another 4 miles into Lake Superior (Avery 1990). Numerous tributaries enter the White River, the largest of which is the Long Lake Branch that originates from Lake Owen in Bayfield County and joins the White River near the downstream end of the Bibon Swamp Natural Area. Eighteen Mile and Twenty Mile Creeks are the second and third largest tributaries to the White River and join the Long Lake Branch north of Grandview in the southern edge of the Bibon Swamp (Figure 1).

The average daily discharge of the White River (1949 to 2005) near the power dam is 277 cubic feet per second (cfs) (USGS, real time river data, *http://waterdata.usgs.gov/nwis/uv?04027500* visited in December 2006). April has the highest monthly average discharge (590 cfs) and January has the lowest monthly average discharge (186 cfs). Peak streamflow from 1949 to 2004 was 6,630 cfs recorded on April 23, 2001.

In the late 1800s the White River and its tributaries were used extensively to transport and process timber logged in the watershed. Many of the dams found throughout the watershed had their origins from the logging period. These dams were used either for power production for mills or as storage devices that could be opened or blown out in spring to float the logs to downstream locations. Logging activity from the turn of the 20th century still has impacts today on water quality and channel morphology.

Citizens as well as local politicians and resource managers have worked to protect the White River watershed since the 1950s. Motor boats have been prohibited on the White River above State Highway 63 since 1967 when the Delta and Mason town boards adopted such action to secure the future of the unique recreational opportunities offered by the river. In addition, there are four major land protection areas on the White River that now encompass the area from the headwaters to where the White River enters Tribal lands. The four protection areas include two fisheries areas (White River Fishery Area and the White River Fisheries - Expansion), a natural area (Bibon Swamp Natural Area) and a wildlife area (White River Wildlife Area). The White River Fisheries Area was established in 1961 and expanded most recently in 2004.

The White River and its tributaries have a diverse fishery with nearly 40 species of fish identified (Appendix I, Table 1). Historic fish management of the White River and its watershed has included fisheries surveys, stocking, various length and bag regulations, installation of instream habitat improvement structures, headwater spring pond dredging and beaver, *Castor canedensis*, control activities. Trout population surveys in the Bibon Swamp section of

Coauthor (ST) with a White River brown trout.

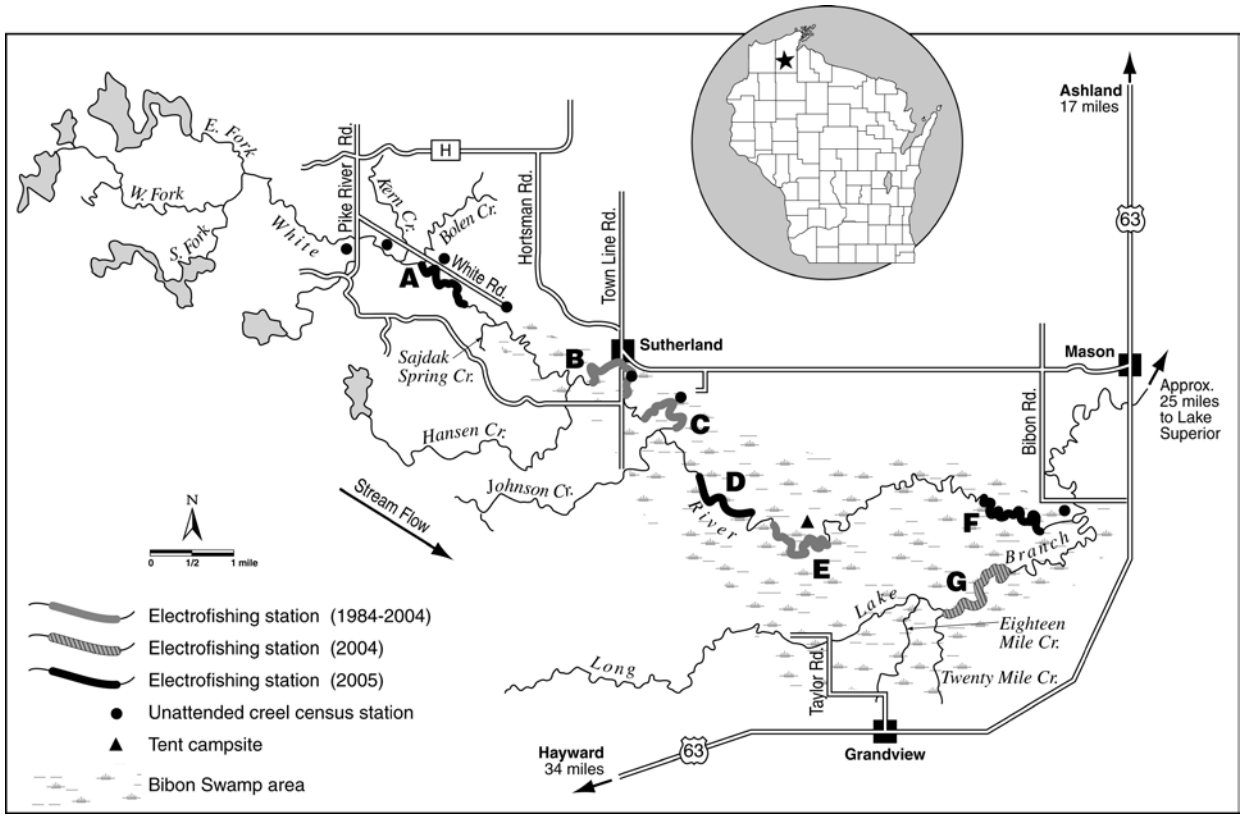

Figure 1. Map of electrofishing and unattended creel census stations from 1984 to 2005, White River, Bayfield County, Wisconsin. Sampling sites include: A = Bolen Creek, B = Sutherland Bridge, C = Goldberg Landing, D = Johnson Creek, E = Primitive Campsite, F = Lower Bibon, G = Upper Long Lake Branch.

the White River occurred in 1984, 1985, 1986, 1988, 1989, 1992 and 1993. Creel surveys occurred in 1984, 1985, 1992 and 1993. Various other surveys have occurred on upper sections of the White River and its tributaries. These surveys mainly utilized backpack and towable electrofishing units. Objectives of these surveys were to assess fish passage and instream habitat improvement, or as part of the statewide wadable baseline monitoring program.

The White River has a long stocking history and has been stocked predominately with brook trout, *Salvelinus fontinalis*, brown trout and rainbow trout, *Oncorhynchus mykiss*, since at least 1920 according to records from the Wisconsin Fish Commission, and 1933 according to records from the Brule DNR office file (Appendix I, Table 2). The exception was one stocking of black bass (unknown species) in 1935. From 1933 to 1948 a combination of brook trout, brown trout, and rainbow trout were stocked primarily as fingerlings. Stocking from 1949 to 1969 consisted mostly of brown trout and brook trout; however the age of fish stocked during this period was mostly yearlings. An intra-office memorandum from August 8, 1951 (Fallis 1951) refers to stocking considerations on the White River:

"Below Sutherland Bridge the water slows, picks up discoloration from the clay soil through which it flows and warms rapidly. This is the point where it enters the Bibon Swamp and should be considered the lower limits of the area to be considered for stocking".

Brown trout were stocked from 1949 to 1981 as predominately yearlings. A report from a survey conducted in September, 1965 showed that stocked trout were not present in the survey. It was surmised in this report that heavy angling pressure and multiple stocking locations away from the survey sites limited the presence of the stocked trout in the surveys (Weiher 1966). Since 1981 no stocking has occurred and the fishery has been maintained by natural reproduction. Historic hatchery records indicate that the strain of brown trout stocked into the White River originally came from Europe in the early 1900s. The strain was started in the Nevin Hatchery and transferred to the Wild Rose Hatchery in 1946 where it was crossed with a strain from Cortland, New York.

The fishing season on the White River opens the first Saturday in May and ends September 30. Trout fishing regulations have changed over time on the White River. Prior to 1990, bag and length restrictions on the White River included a 6 in. minimum length limit, a daily bag limit of 10 trout in May (only 5 browns and rainbows), and a daily bag of 10 trout of any species from June through September. In 1990, from downstream of Pikes River Road bridge to the White River dam was changed to a Category 5 (3 trout over 9 in., only 1 brown trout over 15 in.; Figure 1). Upstream from Pikes

River Road bridge the fishing regulation was changed to a Category 2 (7 in. minimum length and 5 trout daily bag limit). The 1990 change in regulations was in response to excessive angler exploitation of brown trout ≥ 15 in. (Avery 1990).

Recent management efforts have focused on fisheries surveys, beaver control, land acquisition, evaluation of regulation changes and habitat improvement and protection. Land acquisition has been occurring in all of the various management areas as funding has been available and where landowners have been willing to sell or provide easements. Stream habitat projects have mainly been focused on stretches of stream near the headwaters area.

The objective of the 2003-2006 survey was to determine the current status of brown trout populations along with sport angler use of this species on the White River, and compare with historic information. More specifically, we were interested in determining population abundance, growth, size structure, movement and harvest of brown trout. Angler opinions were also surveyed in order to determine attitudes of people who fish this section of the White River. We also attempted to determine population parameters for brook trout and northern pike, along with determining summer water temperatures in the White River system.

Methods

Trout Populations

A 21.3 mile reach of the White River, beginning at Pikes River Road Bridge and continuing downstream to Bibon Road Bridge was selected for the study and was the same reach studied in historic fishery surveys (Avery 1990; Avery 1999; Figure 1). Three, 1-mile long electrofishing stations were surveyed in 2003 and 2004 and replicated historic survey stations. Station midpoints were located at Sutherland Bridge, at Goldberg's Landing and at the Primitive Campsite (Figure 1). Data collected in 2003-2004 was compared to data collected in 1984-1986, 1988-1989 and 1992-1993.

Three alternate 1-mile electrofishing stations were surveyed in 2005 (Figure 1). Starting points were at Bolen Creek (Bolen Creek Station), approximately 1.6 miles below Goldberg's Landing (Johnson Creek Station) and 1.5 miles upstream from the confluence with the Long Lake Branch of the White River (Lower Bibon Station). A one-mile station on the Long Lake Branch was also sampled in the spring of 2004, beginning 150 feet below the confluence of 20 Mile Creek and preceding downstream (Figure 1).

Mark-recapture electrofishing surveys using two mini-boomshocker boats, one following the other a short distance behind, were conducted from 2003-2005. The first mini-boomshocker utilized two-booms and the second one-boom. All electrofishing surveys progressed downstream during daylight using DC electricity. Two passes were completed for each station for both the mark and recapture portions of the survey. Both brown and brook trout captured on the marking run were measured to the nearest 0.1 in. total length, weighed to the nearest gram, given a temporary fin clip and released near the midpoint of the portion of the station sampled. Scale samples were taken from 5 brown trout per 0.5 in. group for age and growth analysis. In 2003-04, brown trout ≥ 9 in. were also given an individually numbered anchor tag (Floy FD-94) near the base of the dorsal fin. Both brown and brook trout captured on the recapture run were examined for marks, measured to the nearest inch, weighed to the nearest gram and also released near the middle portion of the station sampled. In 2003 and 2004 during the recapture run, trout ≥ 9 in. that were not marked and did not have a floy tag were given a floy tag. Mark and recapture electrofishing runs were separated by one day to allow fish to redistribute between runs. Although some 3.0 - 5.9 in. brown trout were captured each spring, the efficiency of their capture was poor, thus this discussion refers only to brown trout ≥ 6 in.

Brown trout population abundance was estimated with the Bailey modification of the Petersen estimator for trout ≥ 6 in. (Ricker 1975). Population estimates for each station were divided into inch groups based upon the proportion of unmarked trout captured in each inch group on both the mark and recapture runs. Estimates and their variances were combined to determine total population parameters. Confidence intervals for average populations (combination of consecutive years) were computed using a formula for the standard error of the mean, assuming individual observations were independent (Avery 1999). Changes in populations for historic to recent population change (1984-1986, 1988-1989, 1992-1993 vs. 2003-2004) were determined using a z-test for two sample means and a standard normal distribution. Average lengths of trout were determined based on measurements from all stations. Proportion of brown trout ≥ 15 in. was calculated using brown trout ≥ 6 in. and 95% confidence intervals where determined for PSD using the equation in Gustafson (1988). Population estimates were not calculated for brook trout due to their low abundance.

Age and growth of brown trout was determined by viewing scales under a 30X microfilm projector. Age at length was back calculated using annulus measurements in 2003 and 2005 due to growth observed after annulus formation. Back calculation of lengths from scales relies on recognition of annual growth markings (annuli) on scales to calculate an estimated body length associated with each annulus. Body lengths estimated in this way make up a growth history, from which growth rate can be inferred (Pierce et al. 1996). The Fraser-Lee proportional method was used in back calculation of scales (Fraser 1916; Lee 1920). In 2004, age at length was not back calculated because annulus formation was taking place at the time of the capture.

Brown trout tagging was used to qualitatively assess movement within the White River system. In addition to tagging at the above mentioned stations, brown trout from Eighteen Mile Creek ≥ 7 inches in. 2001 and ≥ 8 inches in 2002 were also tagged. In 2005, both brown and brook trout captured in each half of the Johnson Creek and Lower Bibon sampling stations were given different fin clips in an additional effort to discern trout movement into and out of sampling stations.

Sport Fishery

Assessment of the sport fishery in the White River study area was accomplished by partial creel surveys throughout the 2004 and 2005 trout fishing seasons. Angler interviews were conducted by DNR creel clerks to determine the number of anglers per vehicle and the length of time spent fishing, the number and kind of fish caught and harvested, and fishing methods. Anglers were usually interviewed as they returned to their vehicles upon finishing their fishing trip. Harvested trout were measured to the nearest 0.1 in. and observed for tags and fin clips by the creel clerk.

The creel survey used a stratified, random sampling design and replicated the methodology of previous creel surveys conducted on the White River by WDNR in 1984, 1985, 1992, and 1993 (Avery 1990; Avery 1999). In general, the creel clerk worked either an approximately eight-hour "AM" (600 – 1400) or "PM" (1400 – 2200) shift, with the exception of opening weekend, when double shifts (16 hr days) were worked. Both weekend days and three randomly selected weekdays were worked each week. During the *Hexagenia limbata* hatch (i.e., *Hex*. hatch) that occurs in late June/early July, the PM shifts (and vehicle counts) were adjusted to start and finish two hours later to better sample the intensified angling pressure that extends well past dark during the mayfly hatch (Avery 1990).

Vehicle counts were made at all access points at approximately two-hour intervals in order to estimate angling pressure (as angler hours), with angling pressure estimated monthly or by strata for each year using formulas given by Avery (1990). Monthly angling pressure was then summed to achieve a total estimate for angling pressure for the season. Weekend and holiday data was calculated separately from weekday data for each month. Angling pressure on opening weekend of the fishing season was also estimated separately.

In addition to data gathered through angler interviews, voluntary angler information was collected at seven unattended creel census stations located at established access points along the river (Figure 1). This was done following methods described by Avery (1990; 1999) and the use of voluntary angler interview cards. Angler fishing diaries were also given out to some anglers who, by creel clerk judgment, fished in the study area frequently. This procedure was similar to what had been done in past creel survey years. Data collection through the use of trout angler diaries and voluntary angler interview cards was done in the event that an adequate sample size of angler interviews were not obtained by the creel clerk and also to replicate methodology used in previous creel surveys.

Previous White River creel surveys combined angler interviews conducted by DNR creel clerks with voluntary information from anglers and provided rationale for justifying the combination of data (Avery 1990; Avery 1999). Several other creel census studies that have shown no serious bias (Calhoun 1950; Schearer et al. 1962) or even a positive bias (Simpson and Bjornn 1965; Carline 1972), when data from nonrandom sources (voluntary returns) and random sources (angler interviews) are combined.

In 2004 and 2005, we were able to obtain an adequate sample size of angler interviews during most creel survey strata that allowed us the option of using data collected from creel clerk-angler interviews only, without the need to include voluntary returns. However, for comparative purposes, we report our results for catch and harvest statistics by two methods at times in this report: (Method 1) by combining angler interviews with voluntary returns, and (Method 2) using data from angler interviews only.

The combined information (Method 1) is the primary procedure for processing results, analyses and discussion when making comparisons with catch and harvest statis-

tics reported from previous creel surveys and creel surveys conducted in 2004 and 2005. Results calculated using information obtained only from angler interviews conducted by DNR creel clerks (Method 2) was used to present catch and harvest statistics from 2004 and 2005 when no comparisons are made to previous creel surveys. We feel it is important to document Method 2 results because it permits the potential opportunity for future creel surveys on the White River to be conducted without gathering voluntary angler information (with the extra cost associated with voluntary returns in preparation, distribution, additional data entry and subsequent analyses) and still have results that would be directly comparable to those documented from 2004 and 2005. A t-test was used to determine differences between mean length of trout from data obtained by angler interviews and voluntary returns.

Similar to previous creel surveys in the 1980s and 1990s, exploitation values fail to consider recruitment due to growth and immigration into the length ranges reported. Values may therefore be inflated, but as noted by Avery (1990; 1992) they provide a point of reference for comparison with previous studies and with future research conducted on the White River.

Angler Questionnaire

We used a mail questionnaire to survey 320 anglers who fish the White River. Angler motivation, satisfaction, participation, and years experience were some attributes we identified. Sections of the survey pertained to where and how anglers fished in 2004 and 2005, each angler's history on the White River, and angler opinions on regulations and the fish they catch. We also wanted to determine if angler opinions and attitudes were different depending on what type of gear or bait they fished with (i.e. worms/live bait, artificial lures, or fly fishing). Almost all of the questions included in the survey were close-ended questions where the answer choices were provided (see Appendix II for the complete questionnaire and answers by percentage). Close-ended questions are preferable when data is desired on participation rates and the intensity of feelings pertaining to issues regarding the fishery (Dillman 1978; Fenske 1983).

We sent a questionnaire, with cover letter describing the survey, in April 2006 to anglers who had voluntarily provided their mailing address to the creel clerk when interviewed or on a filled out angler interview card during creel surveys conducted in 2004 and 2005. To increase response rate, one additional mailing was made of the questionnaire to nonrespondents, as well as "reminder" post-cards sent on two occasions. In all, anglers were given approximately two months to respond. A return envelope, with postage was included with each questionnaire. Return rate was 72.8% (233 out of 320).

Differences in angler opinions by gear or bait choice were compared using a chi-square test. We only used those respondents who answered "always" for Question 3 in Section 1, pertaining to their chosen method of fishing the White River (live bait always=29%, artificial lures always=18%, fly fishing always=35%). All comparisons were made using a level of significance of 0.05.

Northern pike

Northern pike sampled in all stations during 2003-2005 were processed much like the trout captured. However, no northern pike were given a floy tag and all northern pike captured in 2004-2005 had their stomachs pumped for dietary analysis. Abundance could not be determined for northern pike due to the low numbers handled.

Temperature Monitoring

Onset© Computer Corporation Hobo® Water Temp Pro continuous temperature monitoring devices were installed at 19 sites in the White River Watershed to record water temperatures during 2002-2005 (Figure 2). Water temperatures were recorded at ½ to 1 hour increments. The Wild Rivers Chapter of Trout Unlimited deployed, maintained and downloaded water temperature data using Box Car Pro 4.3 software. Maximum daily mean temperatures from June through August (summer) were used for site comparison purposes and to determine whether the stream was cold (< 72°F), cool (72°F to 77°F) or warm (> 77°F) (Lyons et al. 1996).

Results

Trout populations

Brown trout (N = 2,687), brook trout (N = 41), and tiger trout *Salvelinus fontilalis* X *Salmo trutta* (N = 2) were captured during spring electrofishing surveys of the White River in 2003-2005 (N excludes recaptured fish). Brown trout comprised more than 97% of the trout captured and therefore is the

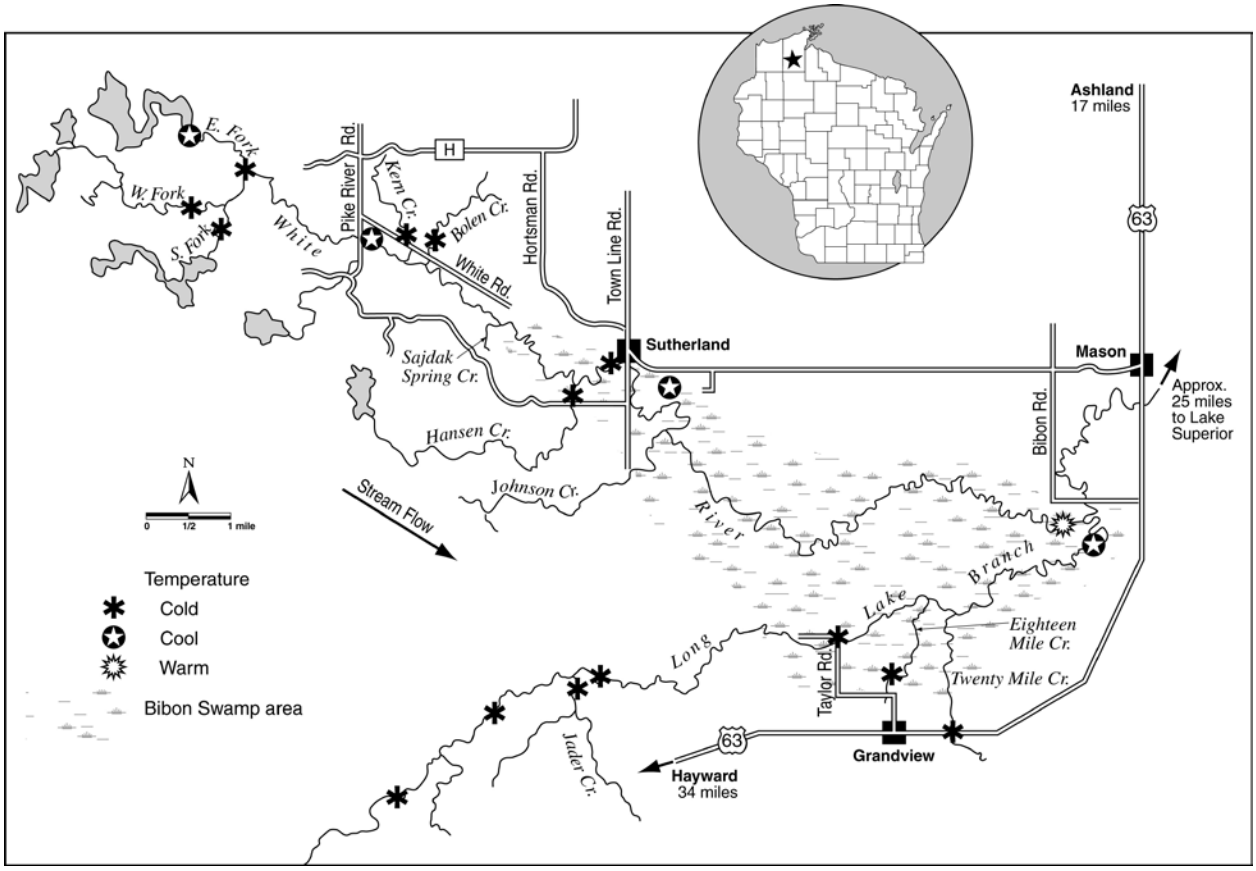

Figure 2. Map of continuous temperature monitoring locations, White River watershed, Bayfield County, Wisconsin.

primary species referred to in this report. The low frequency of brook trout is similar to historic surveys (Avery 1990).

Brown trout density (≥ 6 in.) was significantly different in 2003-2004 compared to previous survey periods ($Z = 2.46$, $P = 0.0069$; Figure 3). Brown trout density reached its highest level in 1988-1989 at 656 fish/mile and declined to its lowest level in 2003-2004 at 367 fish/mile (Figure 3; Appendix I, Table 3).

Yearly and within station variation of brown trout density was often considerable. Annual brown trout density averaged 514 fish/mile (1984-2005) but ranged from 358 fish/mile (2003) to 757 fish/mile (1988; Figure 4; Appendix I, Table 4). Individual station brown trout density also differed but generally showed a decline with time. Between 1984 and 2005, density of brown trout (≥ 6 in.) ranged from 224 fish/mile to 964 fish/mile in the various stations sampled (Appendix I, Table 4).

Density of brown trout in alternate stations sampled in 2005 and the Long Lake Branch tributary were comparable with historical White River stations. The Lower Bibon station, located further downstream than any other station in the survey, had the highest brown trout density ≥6 in. of 496 fish/mile for any station sampled during 2003-2005. The lowest brown trout density during this period was the Johnson Creek station at 267 fish/mile. The Bolen Creek station had a density of 460 fish/mile (Appendix I, Table 4). Density of brown trout ≥ 6 in. in the Long Lake Branch station in 2004 was 390 fish/mile (± 95% CI = 92 fish/mile).

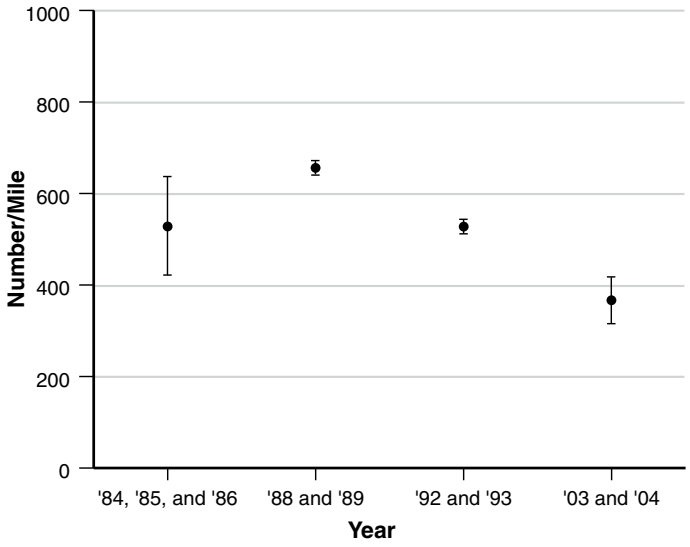

Figure 3. Density of brown trout ≥ 6 in (fish/mile ± 95% confidence intervals) by consecutive years combined and all stations combined in White River, Bayfield County, Wisconsin.

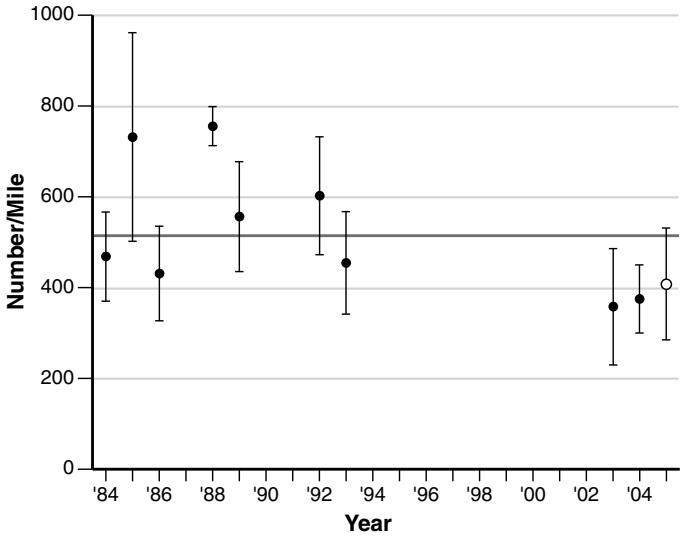

Figure 4. Number of brown trout ≥ 6 in (fish/mile ± 95% confidence intervals) by year with all stations combined in White River, Bayfield County, Wisconsin. Numbers reported for 1984, 1985 and 1986 (Avery 1990); 1988, 1989, 1992 and 1993 (Avery 1999). Survey in 2005 utilized alternate stations within the study area. Horizontal line represents average brown trout density (514 fish/mile).

Length frequencies of brown trout exhibited large spikes in the 7.0 – 9.0 in. length groups, most notably in 1985 and 1988 (Figure 5). Avery (1990) found these length groups consisted of age II trout, indicating large year classes occurred in 1983 and 1986. Density of 6 to 8.9 in. brown trout by sampling period ranged from 56 fish/mile to 196 fish/mile, but annually these densities ranged from a low of 33 fish/mile to 299 fish/mile (Appendix I, Tables 3 and 4). Brown trout densities between 9 and 14.9 in. by sampling period ranged from 192 fish/mile to 409 fish/mile, while annually they ranged from 185 fish/mile to 500 fish/mile. Brown trout ≥15 in. density ranged from 27 fish/mile to 64 fish/mile by sampling period (Figure 6) and 20 fish/mile to 75 fish/mile annually (Figure 7).

The proportion of large brown trout (≥ 15 in.) in the population has increased since the mid-1980s, reaching its highest level in 2004. In 2004, 18.6% of the brown trout ≥ 6 in. were at least 15 in. (Figure 8). The proportion of brown trout ≥ 20 has increased steadily from 0 in 1984-1986, 0.2% (1988-1989), 0.4% (1993), and to 1.5% (2003-2005).

Brown trout sampled during 2003-2005 ranged in age from I to VIII (Figure 9). Age-II brown trout accounted for 38%, 39% and 43% of the population in 2003, 2004 and 2005, respectively. Age-II and Age-III brown trout accounted for 65%, 69% and 74% of the populations during the same period. Brown trout reached the minimum legal length of 9 in. between the ages of II and III, and 15 in. between the ages of IV and V. Brown trout reached 20 in. by age-VII .

Brook trout represented 1.6% of all trout captured in the White River from 2003-2005. Relative abundance of brook trout for Sutherland Bridge, Goldberg's Landing and Primitive Campsite in 2003 and 2004 averaged 0.30 fish/hr, 0.47 fish/hr and 0.19 fish/hr, respectively. In 2005, relative abundance of brook trout for Bolen Creek, Johnson Creek and Lower Bibon was 3.9 fish/hr, 0.3 fish/hr and 0.8 fish/hr, respectively. No relative abundance values were available from previous work on the White River.

Brown trout movement

A total of 908 brown trout were tagged in 2003 and 2004. Brown trout demonstrated an ability to move long distances within the White River system. Fish number 84 (13.4 in.) was tagged in May of 2003 in the Goldberg's Landing station and encountered again in May of 2004 in the Long Lake Branch station, a movement of 14.5 miles. Fish number 618 (13.5 in.) was tagged in May of 2004 in the Long Lake Branch Station and encountered again in April of 2005 in the Johnson Creek Station, a movement of 12.0

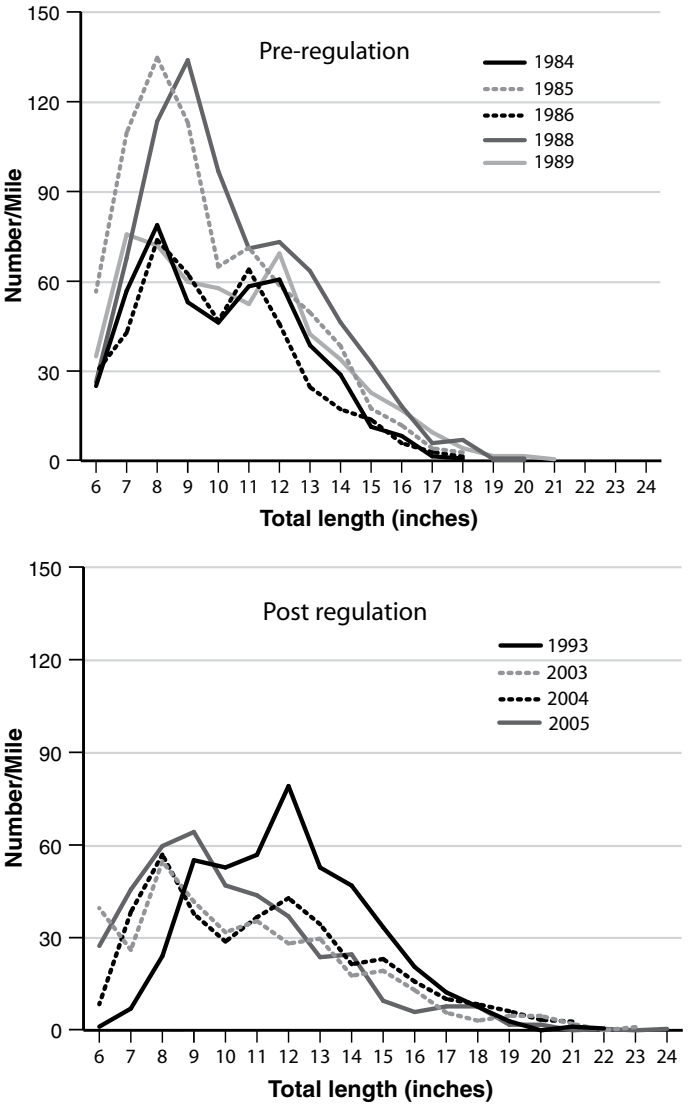

Figure 5. Brown trout abundance by length with all stations combined, pre and post regulation change, White River, Bayfield County, Wisconsin, 1984 to 2005.

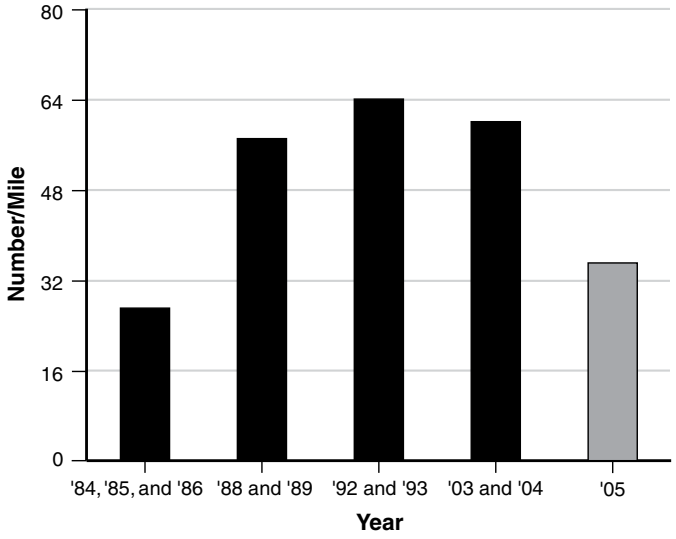

Figure 6. Density of brown trout ≥ 15 in consecutive years combined and all stations combined in White River, Bayfield County, Wisconsin. Survey in 2005 utilized alternate stations within the study area.

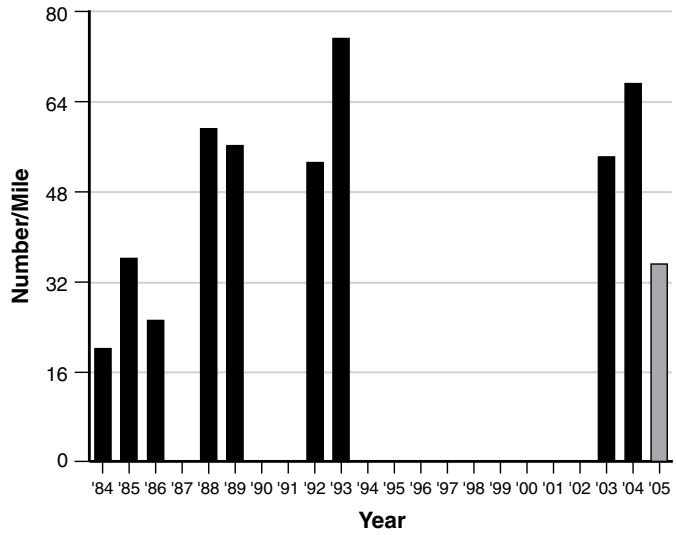

Figure 7. Density of brown trout ≥ 15 in by year with all stations combined in White River, Bayfield County, Wisconsin. Numbers reported for 1984, 1985 and 1986 (Avery 1990), 1988, 1989 and 1992 (Avery 1999). Survey in 2005 utilized alternate stations within the study area.

miles. Fish number 821 (10.0 in.) was tagged in Eighteen Mile Creek in October of 2002 and encountered again in the Long Lake Branch in May of 2004, indicating that this fish moved downstream 2.8 miles through a highly braided section of Eighteen Mile Creek into the Long Lake Branch.

Anglers returned 35 floy tags during the study period and reported the location where the fish was caught for 26 of the tags. Distances traveled from the station in which angler caught trout from where they were marked ranged from 0 to 13.4 miles. Average distance traveled was 3.5 miles. Fish number 249 (8.8 in.) was marked in Eighteen Mile Creek in August of 2001 and captured nearly three years later by an angler in the Long Lake Branch in May of 2004 (15.5 in.). This fish also moved downstream through the highly braided section of Eighteen Mile Creek to the Long Lake Branch.

One day after being fin clipped, brown trout tended to stay in the same ½ mile station in which they were marked. In 2005, 189 brown trout were marked with distinctive fin clips designating which half of the Johnson Creek Station they were captured. During the recapture electrofishing run the number of marked fish encountered was 76. Of those recaptured fish 78% (N = 59) were in the same portion of the station in which they were marked and 22% (N = 17) were

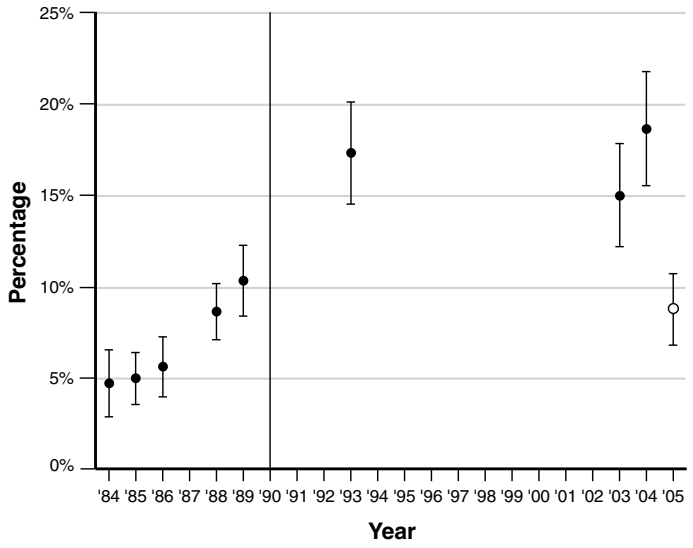

Figure 8. Proportion of brown trout ≥ 15 in (± 95% confidence intervals) by year with all stations combined in White River, Bayfield County, Wisconsin. Survey in 2005 utilized alternate stations within the study area. Proportion calculated from number of brown trout ≥ 6 in. Vertical line represents when regulation change occurred (1990).

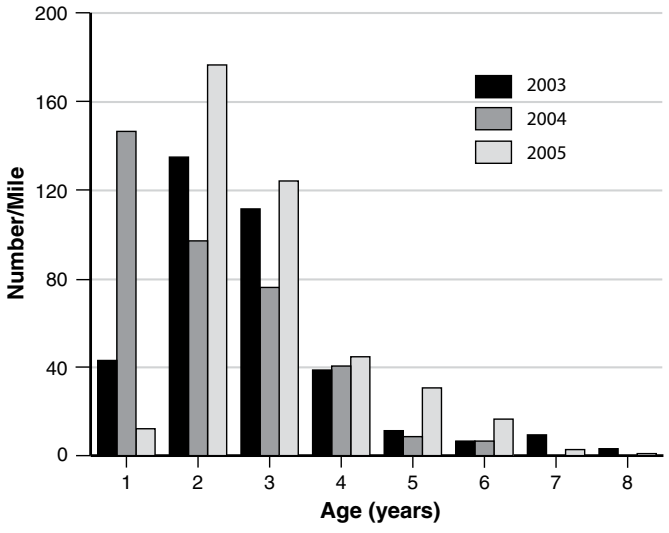

Figure 9. Density of brown trout by age and year, White River, Bayfield County, Wisconsin.

Table 1. Estimated angling pressure and trout harvest during 2004 in the White River study area, Bayfield County, Wisconsin. Total trout harvest is based on harvest rates determined only using angler interviews conducted by DNR creel clerks.

Creel Census Dates	Creel Census Period	Hours Fished	No. of Trout Harvested: Brown trout	No. of Trout Harvested: Brook trout	Total No. Harvested	Percent Harvested
May						
1-2	Opening Weekend	786.3	173	8	181	13.0
3-31	Weekends and holidays	789.8	253	16	269	19.3
	Weekdays	1,051.6	337	21	358	25.7
	Subtotals	2,627.7	762	45	807	58.1
June						
1-25	Weekends and holidays	434.5	43	0	43	3.1
	Weekdays	357.8	36	0	36	2.6
	Subtotals	792.3	79	0	79	5.7
June - July						
June 26-July 16	*Hexagenia* mayfly hatch					
	Weekends and holidays	745.7	89	0	89	6.4
	Weekdays	1,241.2	149	0	149	10.7
	Subtotals	1,986.9	238	0	238	17.1
July						
17-31	Weekends and holidays	124.8	11	0	11	0.8
	Weekdays	159.3	14	0	14	1.0
	Subtotals	284.1	26	0	26	1.9
August						
Entire month	Weekends and holidays	224.6	20	0	20	1.5
	Weekdays	350.5	32	0	32	2.3
	Subtotals	575.1	52	0	52	3.7
September						
Entire month	Weekends and holidays	337.5	84	0	84	6.1
	Weekdays	409.7	102	0	102	7.4
	Subtotals	747.2	187	0	187	13.5
	Totals	7,013.3	1,344	45	1,389	100.0

from the adjacent ½ mile of stream. In the Lower Bibon station, 303 brown trout were marked with distinctive fin clips in each half of the station. During the recapture electrofishing run the number of marked fish encountered was 117. Of those recaptured fish, 87% (N = 102) were in the same ½ mile of the station in which they were marked and 13% (N = 15) were in the adjacent ½ mile of the station. Interestingly, during the same survey of the Lower Bibon station, brown trout with fin clips from both the Johnson Creek station and the Bolen Creek station were captured documenting movements of 13.8 miles in 9 days and 4.8 miles in 6 days.

Sport Fishery

Angling Pressure. Total angling pressure[1] was similar for the 2004 and 2005 fishing seasons (Tables 1 and 2). Anglers fished an estimated 7,013 total hrs in 2004 (61.7 hrs/acre) and 7, 061 total hrs in 2005 (62.2 hrs/acre), and averaged 3.7 and 3.5 hrs/trip in 2004 and 2005, respectively. This is equal to 89 angler trips/mile of river in 2004 and 95 angler trips/river mile in 2005. The average number of angler trips made daily to the study area (21.3 mi) in 2004 was 12.4 trips/day and in 2005 was 13.7 trips/day.

Although total angling pressure was very similar in 2004 and 2005, angling pressure from month to month was variable (Figures 10 and 11). Angling pressure was greatest in the month of May for both years; however, it was 32% higher in 2005 (3,457 hrs) than it was in 2004 (2,628 hrs) even though there were six less fishing days in 2005 (due to a May 7th opening day in 2005 and a May 1st opening day in 2004).

About half of the disparity in hours of angling pressure between May, 2004 and May, 2005 were made up by having an extended *Hex*. hatch in 2004, compared to a more typical *Hex*. hatch in 2005. Due to cold weather in mid- to late June

[1] Only angler interviews conducted by WDNR creel clerks were used in calculations of angling pressure, without use of any voluntary angler information.

Table 2. Estimated angling pressure and trout harvest during 2005 in the White River study area, Bayfield County, Wisconsin. Total trout harvest is based on harvest rates determined only using angler interviews conducted by DNR creel clerks.

Creel Census Dates	Creel Census Period	Hours Fished	No. of Trout Harvested		Total No. Harvested	Percent Harvested
			Brown trout	Brook trout		
May						
7-8	Opening Weekend	595.1	202	6	208	15.1
9-31	Weekends and holidays	973.9	243	10	253	18.3
	Weekdays	1,888.2	472	19	491	35.6
	Subtotals	3,457.2	918	35	952	69.0
June						
1-22	Weekends and holidays	140.7	30	0	30	2.1
	Weekdays	523.9	110	0	110	8.0
	Subtotals	664.6	140	0	140	10.1
June - July						
June 23 - July 5	*Hexagenia* mayfly hatch					
	Weekends and holidays	822.8	58	0	58	4.2
	Weekdays	744.0	52	0	52	3.8
	Subtotals	1,566.8	110	0	110	8.0
July						
6-31	Weekends and holidays	106.2	12	5	17	1.2
	Weekdays	208.8	23	10	33	2.4
	Subtotals	315.0	35	16	51	3.7
August						
Entire month	Weekends and holidays	202.8	6	12	18	1.3
	Weekdays	255.9	8	15	23	1.7
	Subtotals	458.7	14	28	42	3.0
September						
Entire month	Weekends and holidays	156.3	22	0	22	1.6
	Weekdays	441.9	62	0	62	4.5
	Subtotals	598.2	84	0	84	6.1
	Totals	7,060.5	1,301	79	1,380	100.0

in 2004, the *Hex*. hatch started late (June 26) and went longer than normal (Table 3), with heavier angling pressure during the hatch lasting about twenty-one days. In contrast, in 2005 the *Hex*. hatch started sooner; with heavier angling pressure lasting only about 15 days, from June 23 to July 5. The six-day difference in length of the *Hex*. hatch resulted in 27% higher angling pressure in 2004 (1,987 hrs) than in 2005 (1,567 hrs). Angling pressure in July after the *Hex*. hatch was over and throughout the remainder of the season (August and September) was considerably lower, with this time period contributing only 22.9% of the total angling pressure for the 2004 fishing season, and 19.4% of the total pressure in 2005.

Angling pressure in the study area of the White River was significantly lower during the 2004 and 2005 fishing seasons than it has been historically (Figure 12). A mean angling pressure of 62 hrs/acre in 2004-2005 was 46% lower than in 1992-1993 (115 hrs/acre) and 35% lower than in 1984-1985 (96 hrs/acre; Avery 1999). Although total angling pressure on the White River has decreased significantly when compared to previous years, within season allocation of angling pressure has not changed. An average of 43% of the season's total angling pressure occurred by the end of May in 2004 and 2005, which is comparable to an average of 42% in 1992-1993, and 47% in 1984-1985 (Appendix I, Table 5). Furthermore, an average of 79%, 85%, and 81% of the season's angling pressure had already taken place by the end of the peak period of the *Hex*. hatch during the 2004-2005, 1992-1993, and 1984-1985 fishing seasons, respectively.

The amount of overall angling pressure that occurs during the *Hex*. hatch from late-June to early-July can be variable, being related to the duration of the hatch (Table 3). In 2004 and 2005, angling pressure during this time period averaged 25% of the season's total pressure (average duration of the *Hex*. hatch time period = 17 days), compared to 30% for 1992-1993 (avg. duration = 24.5 days) and 17% for 1984-1985 (avg. duration = 9.5 days).

Catch and Harvest. Anglers caught an estimated 5,573 trout from the White River in 2004, of which 5,001 (89.7%)

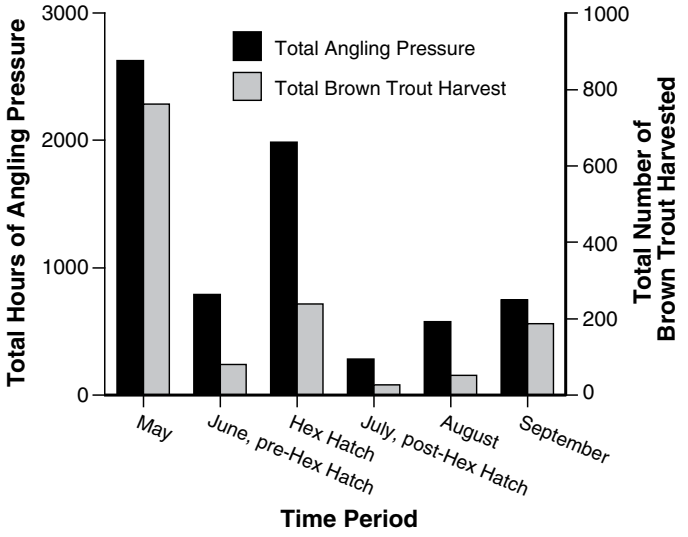

Figure 10. Total angling pressure and brown trout harvest by month or time period for the White River study area, Bayfield County, Wisconsin in 2004.

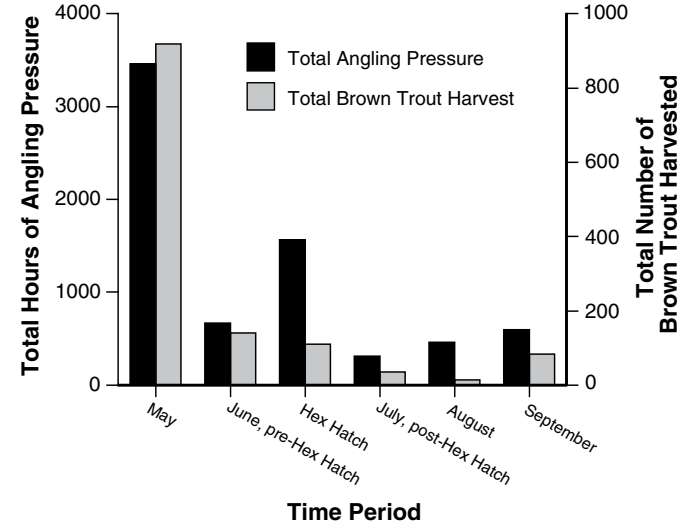

Figure 11. Total angling pressure and brown trout harvest by month or time period for the White River study area, Bayfield County, Wisconsin in 2005.

were brown trout and 572 (10.3%) were brook trout. Estimated angler harvest of trout was 1,389 or 65.2 fish/mile (Table 1). Ninety-seven percent (N = 1,344) of the estimated harvest were brown trout and the remaining three percent (N = 45) were brook trout. Season catch and harvest rates were 0.67 and 0.20 trout/hr, respectively (Table 4). Anglers released an estimated 76% of their catch.

In 2005, anglers caught an estimated 4,317 trout from the White River, of which 3,918 (91.0%) were brown trout and 399 (9.0%) were brook trout. Estimated angler harvest of trout was slightly less than 2004 at 1,380 or 64.8 fish/mile

Table 3. Time periods for the *Hexagenia limbata* mayfly hatch during all years in which creel census took place on the White River, Bayfield County, Wisconsin.

Year	*Hexagenia limbata* Hatch Dates	Length of Hatch (days)
1984	July 1 to July 7	7
1985	June 28 to July 9	11
1992	June 20 to July 12	23
1993	June 20 to July 15	26
2004	June 26 to July 16	21
2005	June 21 to July 5	15
Average	June 24 to July 11	17

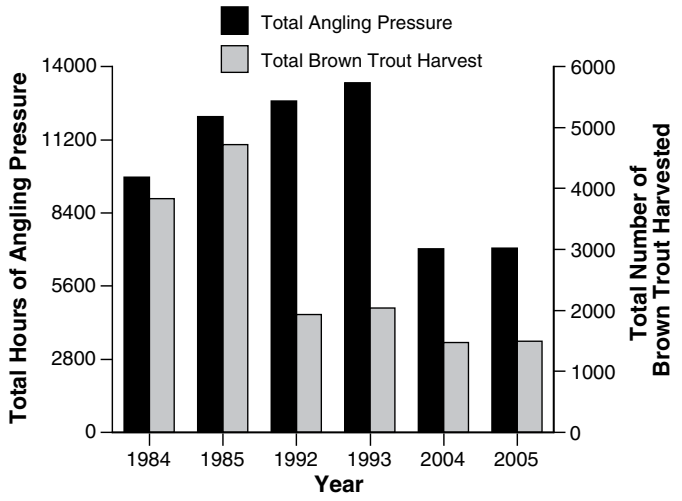

Figure 12. Total angling pressure and brown trout harvest for all years of creel census on the White River study area, Bayfield County, Wisconsin. Note: Creel survey in 1993 went only through July 15, with the remainder of the open season pressure and harvest estimated from 1992 percentages.

(Table 2). Ninety-four percent (N = 1,301) of the harvest were brown trout and the remaining six percent (N = 79) were brook trout. Season catch and harvest rates were also similar to 2004, at 0.61 fish/hr and 0.20 fish/hr (Table 4). Anglers released an estimated 69% of their catch.

No other salmonids were caught or harvested within the study area during either census year, although the creel clerk did measure one rainbow trout that was harvested upstream of the study area in 2004. Using angler interviews only, two northern pike were reported harvested (five caught) in 2004 and eight were reported harvested (eleven caught) by anglers in 2005. Mean length of harvested northern pike measured for both years combined was 26.7 in. (N = 12, SD = 3.6), with a length range of 21.8 – 35.0 in. No northern pike were reported in previous creel surveys of 1984-1985 or 1992-1993. It is unknown if this is because no northern pike were caught/harvested by anglers, or that creel clerks did not record northern pike. Twenty white suckers were also harvested by

Table 4. Catch and harvest rates of trout for the 2004 and 2005 fishing season from the White River study area, Bayfield County, Wisconsin. Calculated using data obtained from creel clerk interviews.

Creel Survey Period	Trout Species	2004 Catch/Hour	2004 Harvest/Hour	2005 Catch/Hour	2005 Harvest/Hour
May					
Opening Weekend	Brown	0.42	0.22	0.51	0.34
	Brook	0.02	0.01	0.02	0.01
	Total	**0.44**	**0.23**	**0.53**	**0.35**
Remainder	Brown	0.79	0.32	0.72	0.25
	Brook	0.07	0.02	0.05	0.01
	Total	**0.86**	**0.34**	**0.77**	**0.26**
June					
Prior to *Hex.* hatch	Brown	0.88	0.10	0.81	0.21
	Brook	0.01	0.00	0.09	0.00
	Total	**0.89**	**0.10**	**0.90**	**0.21**
Hex. hatch	Brown	0.52	0.12	0.23	0.07
	Brook	0.00	0.00	0.02	0.00
	Total	**0.52**	**0.12**	**0.25**	**0.07**
July					
Remainder	Brown	1.06	0.09	0.55	0.11
	Brook	0.27	0.00	0.11	0.05
	Total	**1.33**	**0.09**	**0.66**	**0.16**
August					
Entire Month	Brown	1.06	0.09	0.41	0.03
	Brook	0.27	0.00	0.19	0.06
	Total	**1.33**	**0.09**	**0.60**	**0.09**
September					
Entire Month	Brown	0.77	0.25	0.49	0.14
	Brook	0.25	0.00	0.05	0.00
	Total	**1.02**	**0.25**	**0.54**	**0.14**
Season Average	Brown	0.62	0.19	0.55	0.19
	Brook	0.05	0.01	0.06	0.01
	Total	**0.67**	**0.20**	**0.61**	**0.20**

anglers in 2004 and 2005. Creek chub and shorthead redhorse were the only other two fish species caught by anglers.

Estimated trout harvest by month for all trout in 2004 and 2005 reflected angling pressure by month (Figures 10 and 11). Overall harvest was highest in May, followed by the *Hex*. hatch time period. Trout harvest in May was higher in 2005, accounting for 69% of the total harvest, compared to 58% in 2004 (Tables 1 and 2). During the *Hex*. hatch, angler harvest of trout decreased from 17% in 2004 to about 8% in 2005. Decreased angler harvest during the *Hex*. hatch in 2005 was likely related to an abbreviated hatch. Trout harvest in June, before the start of the *Hex*. hatch, was 6% and 10% for 2004 and 2005 respectively. After the *Hex*. hatch finished, harvest of trout in July and August was low (range ≈ 2 to 4%) each year, but increased in September to about 14% and 6% of the total annual harvest (Tables 1 and 2). On average, 84% of the annual harvest of trout had already occurred by the end of the *Hex*. hatch in 2004 and 2005.

Mean length of brown trout harvested and measured by DNR creel clerks in 2004 and 2005 was similar (2004 mean = 12.9 in., SD = 2.8, N = 195; 2005 mean = 12.7 in., SD = 2.5, N = 188; Appendix I, Tables 6 and 7). Lengths of harvested brown trout reported from voluntary returns (mean 2004 = 12.3 in., SD = 2.7; mean 2005 = 12.2 in., SD = 2.4) were not significantly different from creel clerk measured fish, however it should be noted that P values are near statistical significance at the 0.05 level (2004: $t = 1.976$, $df = 308$, $P = 0.0569$; 2005: $t = 1.976$, $df = 314$, $P = 0.0531$). Harvested brown trout ranged in length from 8.0 – 25.8 in. (including two sublegal length brown trout < 9.0 in.) in 2004, and from 8.5 – 22.5 in. (including one sublegal brown trout < 9.0 in.) in 2005. In addition to several brown

Table 5. Mean catch and harvest rates of trout for each two-year creel census period from the White River study area, Bayfield County, Wisconsin, determined from combining angler interviews performed by DNR creel clerks with voluntary return information from anglers.

Creel Census Period	1984-85 Averages		1992-93* Averages		2004-05 Averages	
	Catch/hr	Harvest/hr	Catch/hr	Harvest/hr	Catch/hr	Harvest/hr
May Opening Weekend	0.52	0.34	0.44	0.21	0.56	0.29
May Remainder	0.77	0.41	0.56	0.19	0.89	0.31
June Prior to *Hex.* hatch	1.17	0.45	0.68	0.15	0.93	0.16
Hex. hatch June 23 - July 5	0.94	0.41	0.64	0.10	0.75	0.12
July Remainder	1.11	0.31	1.20	0.20	1.40	0.20
August Entire month	0.75	0.45	0.50	0.04	1.04	0.14
September Entire month	0.65	0.36	0.50	0.20	0.77	0.18
Season Average	0.80	0.39	0.51	0.15	0.80	0.21

*No creel survey took place after the *Hex.* hatch in 1993. Catch and harvest rates during this time period are based on catch and harvest ratios from 1992.

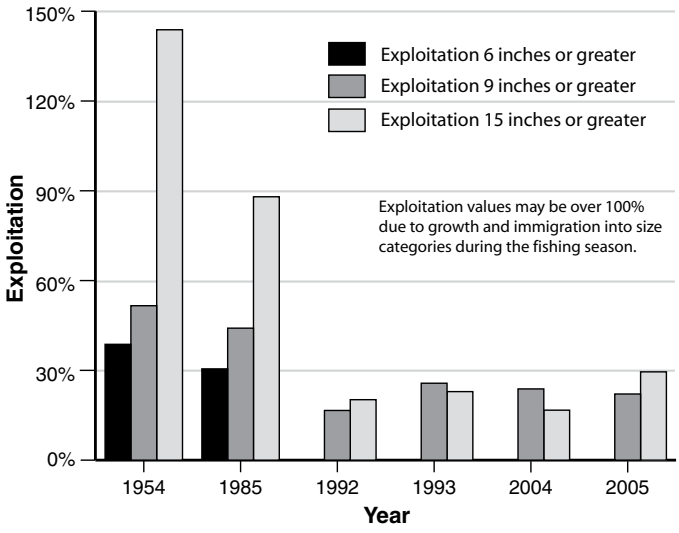

Figure 13. Angler exploitation (%) of brown trout in the White River study area, Bayfield County, Wisconsin for each year creel census was conducted. The legal length for brown trout in 1984 and 1985 was 6 in., while in 1992, 1993, 2004, and 2005 the legal length was 9 in.

trout harvested that were under the legal length of 9.0 in. (in the study area), several brown trout may have been included from returns that were harvested just upstream of the study area where the legal minimum length is 7.0 in.

A total of 88% of the brown trout harvested in both 2004 and 2005 were ≥10.0 in, with brown trout ≥15.0 in. accounting for 17% of the harvest each year. In 2004, six percent of the total harvest was ≥18.0 in. In 2005 angler harvest of brown trout ≥18.0 in. declined to 3.3% of the total season harvest.

Annual harvest of trout on the White River has decreased substantially from what it has been in the past (Figure 12; Appendix I, Table 8). Annual harvest of brown trout in 2004 and 2005 ($\bar{x}$= 66.3 fish/mi) decreased 27% since 1992 and 1993 ($\bar{x}$ = 91.5 fish/mi), and 66% since 1984 and 1985 ($\bar{x}$= 193.8 fish/mi). Comparisons of annual harvest from 1984 and 1985 are not direct due to regulation changes that occurred in 1990.

Annual harvest of brown trout in 2004-2005 decreased the most in the 9.0 – 14.9 in. length range since 1992-1993 (Appendix I, Table 9). Estimated annual harvest of brown trout ≥15.0 in. in 2004-2005 ($\bar{x}$= 11.6 fish/mi) was similar to what it was in 1992-1993 ($\bar{x}$= 13.6 fish/mi) after the initial implementation of special regulations in 1990, while still being much lower than in 1984-1985 ($\bar{x}$= 30.5 fish/mi), before special regulations were implemented. Annual harvest of brown trout ≥15.0 in. has averaged 12.7 fish/mi (SD = 1.97)

during the 1992, 1993, 2004, and 2005 fishing seasons, with a range in harvest of 11.5 fish/mi (2005) to 15.6 fish/mi (1993). In terms of contribution to harvest, brown trout ≥15.0 in. made up 21.2% of the overall harvest during 2004-2005 compared to 18.7% in 1984-1985 and 17.5% in 1992-1993.

The decrease in trout harvest from 1984-1985 to 1992-1993 was primarily due to the implementation of category-5 regulations in 1990 and was a function of lower harvest rates, and not of angling pressure (Avery 1999). While angling pressure increased during that time period (Figure 12), average harvest rate decreased from 0.39 fish/hr in 1984-1985 to 0.15 fish/hr in 1992-1993 (Table 5). In contrast, the decrease in harvest from 1992-93 to 2004-05 is correlated with a decrease in angling pressure, since average harvest rates actually increased slightly between 1992-1993 (0.15 fish/hr) and 2004-2005 (0.21 fish/hr).

Brook trout continue to be a minor component in terms of their contribution to the sport fishery in the White River

Brook trout made up a small portion (3-6%) of the trout harvested from the White River.

study area. Estimated angler harvest of brook trout was 2.1 fish/mile in 2004 and 3.7 fish/mile in 2005. During both 2004 with 2005, anglers caught the most brook trout during May, followed by August, September, and the *Hex*. hatch time period. Brook trout harvested in 2004 and 2005 averaged 9.4 in. (N = 21, SD = 0.90), with a range of 7.7 – 10.9 in. Anglers harvested an average of 1.8 brook trout/mile in 1992-1993, and an average of 6.5 brook trout/mile in 1984-1985.

Overall angler success in 2004 and 2005 was higher than it was in 1992-1993, but lower than it was in 1984-1985 (Appendix I, Table 10). On average, anglers caught at least one trout/angling trip approximately 6% more often during 2004-2005 than they did in 1992-1993, but about 10% less often than during the 1984-1985 fishing seasons. Despite catching a minimum of one trout/trip more often in 2004-2005 than in 1992-1993, anglers harvesting one or more brown trout/trip was similar during 2004-2005 ($\bar{x}$= 37.9%) as it was in 1992 or 1993 ($\bar{x}$= 36.9%). However, anglers in 1992 kept their daily bag limit of three brown trout slightly more often on average (14.9%) than did anglers in 2004 (11.7%) and 2005 (9.8%). The percentages for anglers who keep three brown trout or more per trip in 1992-1993 and 2004-2005 are still much lower compared to harvest prior to special regulations on the White River. In 1984-1985 anglers kept three or more brown trout on 28% of their trips on average, and kept five or more brown trout on 12% of their angling trips (Avery 1990).

Exploitation. Total angler exploitation of legal-length (≥9.0 in.) brown trout in 2004 was 23.8% and in 2005 was 22.1% (Figure 13). Exploitation of brown trout ≥15.0 in. increased from 16.7% in 2004 to 29.5% in 2005. However, some caution should be taken when making comparisons between years because mean densities of trout/mi were calculated based on different sampling stations in 2005 than in 2004, even though all stations sampled were within the study reach and equal in length.

Exploitation rates of brown trout in 2004-2005 were slightly higher than they were in 1992-1993 (Appendix I, Table 10). Exploitation of legal-length brown trout increased from an average of 21.2% in 1992-1993 to an average of 24.2% in 2004-2005, with exploitation of brown trout ≥15.0 in. increasing from a mean of 21.6% in 1992-1993 to 25.0% in 2004-2005. Increased exploitation rates from 1992-1993 to 2004-2005 is the result of lower brown trout abundance within the study area since overall brown trout harvest has decreased.

Exploitation rates in 2004-2005 were much lower than they were before the implementation of special regulations in 1990 (Figure 13). Eliminating all legal harvest of 6.0 – 8.9 in. brown trout and reducing the total bag limit from five to three trout ≥ 9 in./day, including only one fish ≥15.0 in. reduced total exploitation from an average of 35% in 1984-1985 to an average of 18% for years after the regulation change. Average exploitation of brown trout ≥9.0 in. and ≥15.0 in. has decreased by 25% and 93%, respectively, since implementation of special regulations.

Angler Questionnaire

Respondents to the questionnaire comprised a broad spectrum of ages and experience, and traveled from near and far to fish the White River. While most (94%) respondents were male, 17% were less than 30 years old, 14% from 30 to 40 years old, 21% from 40 to 50 years old, 21 percent from 50 to 60 years old, and 27% over sixty years of age. Amazingly, the age of the oldest respondent was 98 years. Anglers had a broad range of experience fishing the White River. Nearly half (43%) had fished the White River one to ten years, 38% had 11 to 30 years experience, and 19% had more than 30 years experience. The longest any of the respondents had fished the White River was 58 years. Just over half (52%) of respondents were local anglers, traveling less than 50 miles one way to reach their fishing location, while 37% traveled between 50 and 200 miles, and 11% traveled over 200 miles. In 2004 and 2005, 84% of respondents said they were ei-

ther very satisfied or somewhat satisfied with their fishing experiences on the White River. The majority (61%) responded that the number of days in a year that they fish the White River has stayed about the same, and 52% said the number of fish they catch has been decreasing. Fishing the White River ranks as one of the most important recreational activities they participate in for 66% of respondents. Fifty seven percent of respondents who also fish other trout waters in Wisconsin said that the White River was either much better or somewhat better. Nearly half (49%) of respondents thought that fishing on the White River has probably or definitely worsened. This was interesting considering 84% of respondents (mentioned above) were satisfied with their fishing experiences on the White River.

Anglers were passionate with regard to how they fish the White River. Popular angling methods include fly fishing, use of live bait (worms), and artificial lures. A total of 39% of respondents answered they would never use live bait and 44% answered that they would never fly fish. Thirty six percent of respondents answered that they would never use artificial lures.

Anglers had different thoughts regarding the length a brown trout needs to be to be considered a trophy. Many (72%) felt a trophy brown trout was at least 20 in. Others (24%) felt a brown trout should be 23 in. or longer to be a trophy, while some (28%) felt a trophy was between 14 and 19 in. A total of 46% of respondents said the largest brown trout they have caught on the White River was over 20 in.

Many White River anglers practice live release of legal length trout. The majority (90%) of respondents said they released some legal trout and kept others, with 28% of those releasing all legal trout. Only 7% of respondents said they kept all legal trout. Most anglers (89%) felt that the practice of live release of legal length trout has either increased or remained the same since they have been fishing the White River.

The more conservative regulation enacted in 1990[2] on the White River was viewed as having a positive impact on the fishery by 77% of respondents. However, respondents were mixed when asked if they would favor "trophy" brown trout regulations on designated sections of the White River. Over half (55%) said they would definitely or probably favor trophy regulations, but 32% said would definitely or probably oppose trophy regulations. Feelings were also mixed regarding bait restrictions such as artificial lure and fly fishing only on sections of the White River. A total of 49% of respondents would likely favor bait restrictions, while 46% would likely oppose bait restrictions. Anglers who never use live bait were significantly more likely (82%) than live bait anglers (29%) to favor management for a brown trout "trophy" fishery ($P < 0.001$). Anglers who never use live bait were also significantly more likely (89%) than live bait anglers (13%) to favor designated fly/artificial lure-only sections of the White River. As would be expected, bait anglers strongly oppose the idea (78% oppose; $P < 0.001$).

Northern pike abundance in the study area was low and not expected to have an effect on brown trout numbers.

Northern pike

A total of 49 northern pike were captured in White River surveys from 2003-2005. Mean length of northern pike was 21.0 in. (SD = 6.3; N = 49) and ranged from 7.2 to 35.8 in. Stomach content analysis was completed on 30 northern pike in 2004 and 2005. Forty percent of stomachs were empty, 37% contained fish and 23% contained mayfly nymphs, angle worms or crayfish. Five brown trout, 2 white suckers, 1 mottled sculpin, 1 johnny darter and 2 unidentified fish were found in the 11 northern pike stomachs that contained fish. Length of brown trout found in northern pike stomachs ranged from 4.0 to 15.2 in.

Temperature Monitoring

Water temperatures during summer months in the White River system were coolest near headwater areas and in tributaries without impoundments, and warmest at locations downstream (Figure 2). In 2002, maximum summer daily mean temperatures (MSDMT) on the White River indicated cold water conditions below the confluence of the South, East and West Forks of the White River, (68.2°F), Pike River Road (71.1°F) and Sutherland Road (70.1°F). Cool water conditions were recorded at Goldberg's Landing (72.7°F) and warm water conditions were recorded approximately 100 yards upstream of the confluence with the Long Lake Branch (77.6°F). In 2003, MSDMT on the White River again indicated cold water conditions at Delta Drummond Road (69.0 F) however; Pike River Road (72.3°F) and Goldberg's Landing (67.5°F) were inversely related when compared to 2002. The furthest downstream location on the White River that MSDMT was determined was in Ashland County in

[2]Downstream of Pikes River Road bridge to the White River dam was changed to a Category 5 (3 trout over 9 in, only 1 brown trout over 15 in). Upstream from Pikes River Road bridge the fishing regulation was changed to a Category 2 (7 in minimum length and 5 trout daily bag limit).

2006 located 3.2 river miles upstream from the hydro-electric dam, here the river was considered a warm water system at 78.1°F (MSDMT). Both the sites at Delta Drummond Road and in Ashland County on the White River were located outside of the study area in which the trout population estimates and creel census were conducted. Water temperatures in the Long Lake Branch, a major tributary of the White River, warmed progressively downstream. In 2002, the Long Lake Branch exhibited cold water conditions at Taylor Lane (70.3°F) and cool water conditions 100 yards above its confluence with the White River (75.6°F). In 2003, MSDMT at the lower station was considered cold water (69.5°F).

Eighteen Mile and Twenty Mile Creeks (tributaries to the Long Lake Branch) both exhibited cold water conditions in 2002 and 2003. Eighteen Mile Creek was the colder of the two tributaries during both years with MSDMT values of 68.0°F and 63.2°F, respectively. Twenty Mile Creek had corresponding MSDMT values of 70.7°F and 70.5°F, respectively. Water temperatures in headwater tributaries of the White River were monitored in 2004. The South and West forks had cold water MSDMT values of 66.6 and 71.2°F. The East fork of the White River had a cool water MSDMT value of 75.1°F. Bolen, Kern and Hansen Creeks (White River tributaries within the 21.3 mile study area) exhibited cold water conditions in 2005, with MSDMT values of 62.4°F, 64.8°F and 67.3°F, respectively.

Summary and Discussion

The White River was surveyed in 2003-2005 to determine the status of the fishery and to investigate a perceived decline in brown trout abundance. We initially hypothesized several factors that could have affected brown trout abundance including angler exploitation, northern pike predation, reduced natural recruitment, and changing environmental factors, especially water temperature.

Brown trout density in the White River has been variable from year to year and station to station from 1984 to 2005. When consecutive years and stations within years are combined however, the trend indicates a decrease in the brown trout abundance ≥ 6 in. Densities of brown trout reached levels greater than 650 fish/mile in the late 1980s, compared to 367 fish/mile estimated from the current survey. These higher densities were likely the result of one or more large year classes of fish in the system.

There has been a shift in the brown trout population size structure since the late 1980s toward larger fish. Interestingly, this shift began prior to the regulation change in 1990 that afforded more protection to brown trout. Signs posted by WDNR requesting voluntary compliance to the same regulations that were later enacted in 1990 may have prompted an increasing practice of live release of legal length fish. Similar effects resulting from voluntary release of legal length fish have been observed in muskellunge *Esox masquinongy* (Simonson and Hewett 1999). A shift in size structure toward larger fish seems desirable but also warrants concern. Proportional indices that depict a fishery of more large fish (Figure 11) can be misleading. Reduction of new recruits into a population will shift a population size structure to larger, older fish, and create a high index value if recruitment is low (Toshner 2004a; Margenau et al. 2008).

Our results indicate the brown trout decline in density is likely not from angler over-harvest. The average exploitation of brown trout ≥ 6 in. declined from 35% in 1984-1985 to 19% in 1992-1993 to 17% in 2004-2005. Exploitation of large brown trout (≥ 15 in.) was 25% in the current survey but similar to the 1992-1993 post-regulation exploitation rate of 21.6%.

Implementation of a more restrictive regulation would be a conservative measure in light of the variability of recruitment, however, no year class failures have been observed and harvest in the most recent creel survey on the White River indicates exploitation was not limiting abundance of brown trout. A more restrictive regulation would likely increase size structure of the population not the abundance of the population. Potential outcomes of a more restrictive regulation may also include a decreased abundance of brown trout if intra-specific competition i.e., predation of large brown trout on small brown trout is affecting recruitment (Dong and DeAngelis 1998). In an analysis of brook and brown trout regulations on Michigan trout streams, Clark et al. (1981) found that as length limit increased, the number of larger trout harvested increased but, at the same time, total number of trout harvested declined. Thus increasing the length limit on the White River could increase total yield (i.e. weight of brown trout harvested) by increasing the total number of larger trout harvested, however total number of trout harvested could decline.

Anderson and Nehring (1984) found that a catch-and-release regulation in a wild trout population in Colorado had catch rates that average 48% greater than in the standard regulation of the same stream that had the additional benefit of catchable-size trout stocking. They also found that catch rate of trophy sized trout (≥ 15 in.) was 28 times greater in the catch and release section than in the harvest section. Carline et al. (1991) similarly found that catch rates of brown trout increased from 0.2 to 1.3/h after the implementation of a catch and release only regulation on a Pennsylvanian trout stream, they also found that abundance of age-I and older brown trout increased by 165%. Biologically, a more conservative regulation could provide benefits that would enhance a trophy fishery but may not increase the abundance of brown trout on the White River.

The decline in brown trout abundance is likely not due to northern pike predation. Northern pike were in low abundance during surveys conducted from 2003 to 2005. Stomach contents indicated northern pike are opportunistic predators and eat a variety of fish species and invertebrates, including brown trout. In addition, there is some evidence that brown trout may not be excessively vulnerable to northern pike predation due to their behavior (Hunt 1965). Northern pike may be present in higher abundance

during the summer months when water temperature increases, however quantifying this would require surveys during a time when trout mortality would likely be high. Continuous temperature monitoring in the White River watershed provided valuable baseline data. In general, the maximum summer daily mean temperature indicated that the White River has temperatures within thermal requirements of brown trout in the study area. However, results from stations located furthest downstream in the study area also indicated that if MSDMT increase by only a few degrees Fahrenheit they could become outside tolerances of brown trout. In addition, temperature data collected on tributaries to the White River indicated likely thermal impacts of impoundments (both human and beaver constructed) to the system and may partially explain differences in relative abundance of brown trout at these locations.

The decrease in density of brown trout ≥ 6 in. since the mid 1980s may be due to several factors including, recruitment variability or decline (losses or changes in spawning habitats, access to spawning habitats and timing of flood events), movement (changes in summer feeding and overwintering areas), intra-specific competition and/or increased water temperatures. Shirvell and Dungey (1983) suggested brown trout population size may be limited by the amount of the least abundant activity-specific microhabitat (either feeding or spawning). Beard and Carline (1991) found that redd density was positively correlated with age-0 brown trout as well as age-I and older brown trout densities. McRae and Diana (2005) found that percent gravel substrate and percent emergent vegetation accounted for 62% of the variance in age-0 brown trout densities, while Marret et al. (1993) found a significant inverse relationship between percent fine sediment and survival of brown trout embryos to emergence. Numerous studies have found that stream discharge significantly affected brown trout recruitment (Nelson 1986, Spina 2001, Lobón-Cerviá 2003, Carline 2006). Flood events in the White River system may partially explain the variability in recruitment. Flood events have also been thought to effect rainbow, brown and brook trout recruitment variability on most Bayfield County tributary steams to Lake Superior (D.Pratt, WDNR, personal communication). Correlating discharge measurements from the gauging station located on the power dam to year class strength in the White River system may help to discern the effects of magnitude and timing of flood events on brown trout recruitment.

Brown trout can travel long distances in the watershed (up to 14.5 miles). Brown trout also moved between the White River and the Long Lake Branch. Since our tagging only offered qualitative information such as tagging and recapture location we could not determine movement through time. Of particular interest was the finding that brown trout moved though the confluence area of Eighteen Mile Creek and the Long Lake Branch. This was interesting because it had been thought that the highly braided channel condition in the confluence area of Eighteen and Twenty Mile Creeks with the Long Lake Branch near Grandview (Figure 1) was prohibiting movement of trout. However the extent and amount of movement through this heavily braided stream channel is unknown. The social component of anglers on the White River is complex. There is a nearly even split of bait type choices among anglers. The angler questionnaire suggested 39% of anglers answered they would "never" use live bait and 44% said they would "never" fly fish. The preferences for future regulatory changes on the White River were equally split among anglers depending on their bait choice when fishing. Anglers who never use live bait were significantly more likely than live bait anglers to favor management for a brown trout trophy fishery. Anglers who never use live bait are significantly more likely than bait anglers to favor designated fly/artificial lure-only sections of the White River. Live bait anglers strongly oppose the idea. Interestingly, Aas et al. (2000) uncovered the same major differences in preferences for fishing opportunities between fly-only anglers and other angler groups in Norway. They found that the fundamental differences between the main angling groups suggests that spatial segregation of these segments should be an essential management strategy, if both groups are to be provided with satisfactory experiences. This principal was applied on the White River by the regulation change that occurred in 1990 which recognized the differences of preference between angler groups and attempted to satisfy both on separate sections of the river, while also attempting to improve the overall fishery.

A recaptured White River brown trout

Management Recommendations

Population goals. Mean density of brown trout (≥ 6 in.) since 1984 has been 514 fish/mile. We propose a management goal of 300-550 brown trout/mile ≥ 6 in. At this density recruitment should be adequate to support the fishery.

Regulations. Implementation of regulation changes are not advised at this time because harvest in the most recent creel surveys on the White River indicates angler exploitation was not limiting abundance of brown trout. Although a more conservative regulation may have the potential of further increasing size structure in the brown trout population, implementing it would also coincide with the restric-

tion of live bait use due to concerns regarding high catch and release mortality while using live bait. According to the recent angler questionnaire results, approximately half of anglers surveyed oppose implementing the restriction of live bait use on the White River. Future angler questionnaire surveys will be important in tracking angler attitudes.

Monitor recruitment. Counting redds in the fall in tributaries that are known recruitment sources for the White River and comparing those to year class strength may provide information on the importance of the specific habitat types in the watershed. Exploring the condition of fish passage from Eighteen Mile Creek to the Long Lake Branch is currently underway and is warranted due to historic concentrations of redds located in Eighteen Mile Creek in the past (E. Avery, WDNR-retired, personal communication). Maintaining spawning substrates and potentially increasing them in tributaries along with prohibiting fine sediments from entering these areas may reduce variability and strengthen recruitment. Identifying the strongest sources of recruitment and how they relate to mainstream abundance on the White River is a crucial step in protecting and potentially enhancing these areas.

Measuring changes in microhabitats in an area as large as the White River may be unrealistic, however, attempts should be made to prevent excess sedimentation in the watershed and to preserve, protect and enhance feeding and spawning habitat. Correlating discharge measurements from the gauging station located on the power dam to year class strength in the White River system could help to discern the effects of magnitude and timing of flood events on brown trout recruitment. Continuous temperature monitoring data should be collected in the future coinciding with population and creel surveys.

Trout movement/passage. Brown trout radio tagging studies have been used to define seasonal movement of trout (Bettinger and Bettoli 2004; Burrell et al. 2000; Meyers et al. 1992; Clapp et al 1990). Studying movement patterns of brown trout could also provide information regarding summer and winter home ranges (Bettinger and Bettoli 2004; Burrell et al. 2000; Meyers et al. 1992; Clapp et al. 1990). We also recommend completion of relative abundance surveys on the area of the White River from State Highway 63 downstream to the dam. The first fisheries survey ever completed was done in the fall of 2005. Funding has been approved to survey this area in spring in order to quantify seasonal use of this area by brown trout. Additional funding should be pursued to design and implement the telemetry study mentioned above. Because of the intensive nature of telemetry studies, this project would likely be a joint venture with WDNR, conservation groups and a university program.

Movement/passage of brown trout into Eighteen Mile Creek is of special importance. Capturing and marking brown trout from Eighteen Mile Creek and moving them physically to the Long Lake Branch of the White River downstream of the confluence could provide information relating the extent of fish passage through the confluence. This technique was successful in defining fish passage on Eighteen Mile Creek at the State Highway 63 culvert (Toshner 2004b). Trout population declines observed in 1992-1993 (Avery 1999) roughly corresponded to the disintegration of the stream channel in the lower ½ mile of Eighteen Mile Creek (Avery, WDNR-retired, personal communication). Ensuring continued funding of beaver control activities is important for the White River system as a whole both for fish passage and water temperature concerns from dams.

Northern pike. While northern pike were not a significant factor in the current survey, if their numbers increased could have an effect on trout abundance. Future surveys should continue to monitor the presence of northern pike in the White River.

Age validation. Results from this study suggest brown trout longevity in the White River is about eight years. Scale interpretation is difficult however, especially on larger/older fish because of deterioration of circuli near the scale's outer edge, causing some concern about aging accuracy. Otoliths are used in many fishes for age determination and provide a better assessment of true age. Unfortunately, extraction of an otolith requires a dead fish. It may be possible for creel clerks to sample otoliths from angler caught fish, or to collect otoliths from incidental mortalities that occur during sampling. Regardless, accurate age assessment is critical for proper understanding and management of this fishery.

Future surveys. Future population, creel and continuous temperature monitoring surveys on the White River should be conducted every 10 years. Surveys should utilize stations that are longer in length due to movement out of the one mile stations and considerable differences found between the alternate stations surveyed in 2005 and the historic locations. However, historic stations would be kept separate to provide comparable data with previous studies. In this way longer stations could be surveyed with similar effort as in the past while maintaining acceptable statistical variance and including a larger proportion of the study area. Using one pass and two boats would also lower the probability of growth disruptions and spinal injury to trout (Carline 2001; Thompson et al. 1997; Gatz et al. 1986). We propose three stations of four miles in length all located within the historic study area; 1) from ½ mile upstream of Bolen Creek, 2) from Sutherland Bridge, and 3) from four and ½ miles upstream of the chanellized portion on the downstream end of the Bibon Swamp. In addition, an annual electrofishing survey will be completed utilizing one mini-boomshocker with one pass. This effort would require one day and would provide relative abundance, length frequency and year class strength information on brown trout. This annual survey may be required to identify the relationships between year class strength and brown trout population abundance. Waters (1999) emphasized the importance of long-term data sets to better understand changes in trout populations. The four mile Sutherland Bridge station is being utilized for this annual survey due to its central location in the study area.

Future creel surveys may consider working ten-hour shifts four days a week instead of five, eight hour shifts as has

been the case. This would still allow for interviewing anglers who fish late into the evening during the *Hex*. hatch time period, without missing time intervals during the day by having to adjust the evening shifts later. Also, randomized times for car counts may be a better option than standardized count times. Consideration of shortening the creel surveys should be made to reduce the cost of gathering data. This has been done in the past and seasonal angling trends seem to be consistent to justify it again. Finally, future creel surveys should continue to collect volunteer information to further analyze potential biases resulting from combining data from voluntary returns with data from actual angler interviews. For example: 1) are certain types of anglers (successful anglers/anglers fishing by certain methods) more likely to fill out volunteer creel forms than other types, and 2) does inherent bias toward artificially elevated catch rates exist due to "expert" anglers who receive trout angler diaries? Angler questionnaire surveys should be repeated every 10 years also. This will help to shed light on changing angler opinions through time and help gauge angler attitudes about their White River fishing experiences.

Partners. Work with interested parties to assist in accomplishing the above management recommendations, the completion of which will help further our understanding of the unique fishery that the White River supports. Encourage and support the many groups that are protecting and preserving the White River and its watershed.

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References

Aas, Ø., H. Wolfgang, and L. Hunt. 2000. Angler responses to potential harvest regulations in a Norwegian sport fishery: A conjoint-based choice modeling approach. North American Journal of Fisheries Management 20:940–950.

Anderson, R. M. and R. B., Nehring. 1984. Effects of a catch-and-release regulation on a wild trout population in Colorado and its acceptance by anglers. North American Journal of Fisheries Management 4:257–265.

Avery, E. L.. 1990. The White River trout population and sport fishery: an exploratory study 1984-1986. Wisconsin Department of Natural Resources Research Report 150, Madison.

Avery, E.L. 1992. Assessment of category 5 trout angling regulations on the White River, Bayfield County. Wisconsin Department of Natural Resources, Bureau of Research Progress Report. Study No. 422.

Avery, E. L. 1999. Site specific assessment of three sets of angling regulations designed to improve stream trout fisheries. Wisconsin Department of Natural Resources Research Report 180, Madison.

Beard, T. D., Jr. and R. F. Carline. 1991. Influence of spawning and other stream habitat features on spatial variability of wild brown trout. Transactions of the American Fisheries Society 120:711–722.

Bettinger, J. M. and P. W. Bettoli. 2004. Seasonal movement of brown trout in the Clinch River, Tennessee. North American Journal of Fisheries Management 24:1480–1485.

Burrell, K. H., J. J. Isely, D. B. Bunnell, Jr, D. H. Van Lear and C. A. Dolloff. 2000. Seasonal movement of brown trout in a southern Appalachian river. Transactions of the American Fisheries Society 129:1373–1379.

Calhoun, A.J. 1950. California angling catch records from postal card surveys: 1936 – 1948; with evaluation of postal card non-response. California Fish and Game 36 (3): 177-234.

Carline, R. F. 2006. Regulation of an unexploited brown trout population in Spruce Creek, Pennsylvania. Transactions of the American Fisheries Society 135:943–954.

Carline, R. F. 2001. Effects of high-frequency pulsed-DC electrofishing on a wild brown trout population. North American Journal of Fisheries Management 21:571–579.

Carline, R. F., T. D. Beard, and B. A. Hollender. 1991. Response of wild brown trout to elimination of stocking and to no-harvest regulations. North American Journal of Fisheries Management 11:253–266.

Carline, R.F. 1972. Biased harvest estimates from a postal survey of a sport fishery. Transactions of the American Fisheries Society 101: 262-266.

Clapp, D. F., R. D. Clark, Jr. and J. S. Diana. 1990. Range, activity, and habitat of large, free-ranging brown trout in a Michigan stream. Transactions of the American Fisheries Society 119:1022–1034.

Clark, R. D. Jr., G. R. Alexander and H. Gowing. 1981. A history and evaluation of regulations for brook trout and brown trout in Michigan streams. North American Journal of Fisheries Management 1:1–14.

Dong, Q. and D. L., DeAngelis. 1998. Consequences of cannibalism and competition for food in a smallmouth bass population: an individual-based modeling study. Transactions of the American Fisheries Society 127:174–191.

Dillman, D. A. 1978. Mail and telephone surveys: The total design method. New York, NY: John Wiley & Sons.

Fallis, H. 1951. Intra-office memorandum: White River, Bayfield County. Wisconsin Department of Natural Resources, Brule – office file.

Fenske, J. L. 1983. Attitudes and attributes of anglers who fish for trout in Michigan. (Fisheries research report: 1916) Michigan Department of Natural Resources, Fisheries Division; Lansing, MI.

Fraser, C. M. 1916. Growth of the spring salmon. Transactions of the Pacific Fisheries Society 1915:29-39.

Gatz, A. J. Jr., J. M. Loar, and G. F. Cada. 1986. Effects of repeated electroshocking on instantaneous growth of trout. North American Journal of Fisheries Management 6:176–182.

Gustafson, K. A. 1988. Approximating confidence intervals for indices of fish population size structure. North American Journal of Fisheries Management 8:139-141.

Hunt, R. L. 1965. Food of northern pike in a Wisconsin trout stream. Transactions of the American Fisheries Society 94: 95-97.

Lee, R. 1920. A review of the methods of age and growth determination in fishes by means of scales. Fishery Investigations, Series 2, Marine Fisheries, Great Britian Ministry of Agriculture, Fisheries and Food 4(2).

Lobón-Cerviá, J. 2003. Spatiotemporal dynamics of brown trout production in a Cantabrian stream: effects of density and habitat quality. Transactions of the American Fisheries Society 132:621–637.

Lyons, J.., L. Wang, and T. Simonson. 1996. Development and validation or an index of biotic integrity for coldwater streams in Wisconsin. North American Journal of Fisheries Management 16:241–256.

Margenau, T.L., S. P. AveLallemant, D. Giehtbrock, and S. T. Schram. 2008. Ecology and management of northern pike in Wisconsin. Hydrobiologia 601: 111-123.

Marret, T. R., T. A. Burton, G. W. Harvey, and W. H. Clark. 1993. Field testing of new monitoring protocols to assess brown trout spawning habitat in an Idaho stream. North American Journal of Fisheries Management 13:567–580.

McRae, B. J. and J. S., Diana. 2005. Factors influencing density of age-0 brown trout and brook trout in the Au Sable River, Michigan. Transactions of the American Fisheries Society 134:132–140.

Meyers, L. S., T. F. Thuemler and G. W. Kornely. 1992. Seasonal movements of brown trout in northeast Wisconsin. North American Journal of Fisheries Management 12:433–441.

Nelson, F.A. 1986. Effect of flow fluctuations on brown trout in the Beaverhead River, Montana. North American Journal of Fisheries Management 6:551–559.

Pierce, C. L., J. B. Rasmussen, and W. C. Leggett. 1996. Back calculation of fish length from scales: empirical comparison of proportional methods. Transactions of the American Fisheries Society 125;889-898.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191. Department of the Environment, Fisheries, and Marine Science, Ottawa. 382 p.

Schearer, L.W., D.E. Ritchie, Jr., and C.M. Frisbie. 1962. Sport fishing survey in 1960 of the lower Patuxent estuary and the 1958 year-class of striped bass. Chesapeake Sci. 3 (1): 1-17.

Shirvell, C. S. and R. G. Dungey. 1983. Microhabitats chosen by brown trout for feeding and spawning in rivers. Transactions of the American Fisheries Society 112:355–367.

Simonson, T. D., and S. W. Hewett. 1999. Trends in Wisconsin's muskellunge fishery. North American Journal of Fisheries Management 19:291-299.

Simpson, J.C. and T.C. Bjornn. 1965. Methods used to estimate salmon and steelhead harvests in Idaho. Proc. 45th Annu. Conf. West. Assoc. State Game and fish Comm. Anchorage, Alaska. 45: 217-226.

Spina, A. P. 2001. Incubation discharge and aspects of brown trout population dynamics. Transactions of the American Fisheries Society 130:322–327.

Thompson, K. G., E. P. Bergersen, R. B. Nehring and D. C. Bowden. 1997. Long-term effects of electrofishing on growth and body condition of brown trout and rainbow trout. North American Journal of Fisheries Management 17:154–159.

Toshner, S. 2004a. Fishery survey – Namakagon and Jackson Lakes, Bayfield County, 2002-2003. Wisconsin Department of Natural Resources unpublished report, Brule – office file.

Toshner, S. 2004b. Eighteen Mile Creek - Highway 63 culvert fish passage evaluation -summary of 2001 and 2002 electrofishing and marking surveys. Wisconsin Department of Natural Resources, unpublished report, Brule – office file.

Waters, T. F. 1999. Long-term trout production dynamics in Valley Creek, Minnesota. Transactions of the American Fisheries Society 128:1151–1162.

Weiher, W. 1966. Intra-office memorandum: White River, Bayfield County. Wisconsin Department of Natural Resources, Brule – office file.

Appendices

Appendix I, Table 1. Common and scientific names of fish species found in the White River, Bayfield County, Wisconsin.

Common Name	Scientific Name
Chestnut lamprey	*Ichthyomyzon castaneus*
Northern brook lamprey	*Ichthyomyzon fossor*
Brook trout	*Salvelinus fontilalis*
Brown trout	*Salmo trutta*
Rainbow trout	*Oncorhynchus mykiss*
Tiger trout	*Salvelinus fontilalis X Salmo trutta*
Central mudminnow	*Umbra limi*
Northern pike	*Esox lucius*
Blackchin shiner	*Notropis heterodon*
Blacknose dace	*Rhinichthys atratulus*
Blacknose shiner	*Notropis heterolepis*
Bluntnose minnow	*Pimephales notatus*
Brassy minnow	*Hybognathus hankinsoni*
Common shiner	*Luxilus cornutus*
Creek chub	*Semotilus atromaculatus*
Fathead minnow	*Pimephales promelas*
Finescale dace	*Phoxinus neogaeus*
Golden shiner	*Notemigonus crysoleucas*
Hornyhead chub	*Nocomis biguttatus*
Longnose dace	*Rhinichthys cataractae*
Mimic shiner	*Notropis volucellus*
Northern redbelly dace	*Phoxinus eos*
Pearl dace	*Margariscus margarita*
White sucker	*Catostomus commersoni*
Shorthead redhorse	*Moxostoma macrolepidotum*
Black bullhead	*Ameiurus melas*
Tadpole madtom	*Noturus gyrinus*
Troutperch	*Percopsis omiscomaycus*
Brook stickleback	*Culaea inconstans*
Largemouth bass	*Micropterus salmoides*
Smallmouth bass	*Micropterus dolomieu*
Bluegill	*Lepomis macrochirus*
Pumpkinseed	*Lepomis gibbosus*
Rock bass	*Ambloplites rupestris*
Iowa darter	*Etheostoma exile*
Johnny darter	*Etheostoma nigrum*
Yellow perch	*Perca flavescens*
Mottled sculpin	*Cottus bairdi*
Slimy sculpin	*Cottus cognatus*

Appendix I, Table 2. Fish stocking history of White River, Bayfield County, Wisconsin.

Year	Species	Number Stocked	Size
1933	Brook Trout	4,800	
1934	Brook Trout	4,776	
1935	Brown Trout	18,000	Fingerling
	Bass	480	
1936	Brook Trout	9,990	Fingerling
1937	Brook Trout	24,000	Fingerling
1939	Rainbow Trout	25,000	Fingerling
	Brown Trout	4,000	Fingerling
1940	Rainbow Trout	40,026	Fingerling
	Brown Trout	2,000	Fingerling
1941	Brown Trout	15,000	Fingerling
	Rainbow Trout	32,000	Fingerling
	Rainbow Trout	225	Adult
1942	Brown Trout	48,812	Fingerling
	Rainbow Trout	25,500	Fingerling
1943	Rainbow Trout	12,000	Fingerling
	Brown Trout	34,600	Fingerling
1944	Rainbow Trout	9,000	Fingerling
	Brown Trout	19,000	Fingerling
1946	Brown Trout	23,500	Fingerling
1947	Brown Trout	40,000	Fingerling
	Rainbow Trout	30,000	Fingerling
1948	Brown Trout	52,200	Fingerling
1949	Brown Trout	1,600	Yearling
	Brown Trout	28,100	Fingerling
1950	Brown Trout	2,100	Yearling
	Brown Trout	26,100	Yearling
1951	Brown Trout	850	Yearling
	Brown Trout	6,000	Fingerling
1952	Brown Trout	6,000	Yearling
1953	Brown Trout	4,800	Yearling
1954	Brown Trout	2,000	Yearling
1955	Brook Trout	1,000	Yearling
	Brown Trout	500	Yearling
	Rainbow Trout	1,000	Yearling
1956	Brown Trout	3,386	Yearling
1957	Brown Trout	2,850	Yearling
1958	Brown Trout	2,000	Yearling
1959	Brown Trout	1,500	Yearling
	Rainbow Trout	1,000	Yearling
1963	Brown Trout	6,750	Yearling
	Brown Trout	3,876	Fingerling
	Rainbow Trout	5,467	Yearling
1964	Brown Trout	7,250	Yearling
1965	Brown Trout	4,750	Yearling
	Brown Trout	5,000	Fingerling
1966	Brown Trout	5,750	Yearling
1967	Brook Trout	4,500	Yearling
1967	Brown Trout	5,000	Yearling
1968	Brook Trout	2,500	Yearling
	Brown Trout	5,000	Yearling
1969	Brook Trout	15,000	Fingerling
	Brown Trout	7,000	Yearling
1970	Brown Trout	4,200	Yearling
1971	Brown Trout	6,250	Yearling
1972	Brown Trout	4,250	Yearling
1973	Brown Trout	4,250	Yearling
1974	Brown Trout	4,250	Yearling
1975	Brown Trout	4,250	Yearling
1976	Brown Trout	4,250	Yearling
1977	Brown Trout	6,250	Yearling
1978	Brown Trout	3,000	Yearling
1979	Brown Trout	2,000	Yearling
1980	Brown Trout	2,000	Yearling
1981	Brown Trout	2,000	Yearling

Appendix I, Table 3. Average spring brown trout density (fish/mile) by length intervals and station in the White River, Bayfield County, Wisconsin. Includes only trout ≥ 6 in. 95% confidence intervals are in parenthesis.

	1984-86 Stations				1988-89 Stations			
Length Group (in.)	Sutherland	Goldberg	Primitive	Avg.	Sutherland	Goldberg	Primitive	Avg.
6.0 - 8.9	133	211	245	196	134	176	260	190
9.0 - 14.9	256	383	279	306	409	461	357	409
≥ 15.0	19	21	40	27	28	60	84	57
Total	408 (115)	615 (314)	564 (147)	529 (108)	571 (103)	697 (50)	701 (57)	656 (15)

	1992-93 Stations				2003-04 Stations			
Length Group (in.)	Sutherland	Goldberg	Primitive	Avg.	Sutherland	Goldberg	Primitive	Avg.
6.0 - 8.9	75	42	51	56	114	104	126	115
9.0 - 14.9	514	328	383	408	238	169	168	192
≥ 15.0	35	49	109	64	73	64	44	60
Total	624 (115)	419 (41)	543 (60)	528 (15)	425 (76)	337 (49)	338 (161)	367 (51)

Appendix I, Table 4. Spring brown trout density (fish/mile) by length intervals and station in the White River, Bayfield County, Wisconsin. Includes only brown trout ≥ 6 in. 95% confidence intervals are in parenthesis.

	1984 Stations				1985 Stations			
Length Group (in.)	Sutherland	Goldberg	Primitive	Avg.	Sutherland	Goldberg	Primitive	Avg.
6.0 - 8.9	94	109	229	144	198	361	338	299
9.0 - 14.9	282	229	267	259	282	582	329	398
≥ 15.0	22	17	20	20	25	21	62	36
Total	532 (229)	355 (72)	516 (139)	468 (98)	505 (92)	964 (214)	729 (180)	733 (230)

	1986 Stations				1988 Stations			
Length Group (in.)	Sutherland	Goldberg	Primitive	Avg.	Sutherland	Goldberg	Primitive	Avg.
6.0 - 8.9	108	163	168	146	154	196	245	198
9.0 - 14.9	203	337	240	260	536	536	427	500
≥ 15.0	9	26	39	25	30	72	74	59
Total	320 (48)	526 (80)	447 (78)	431 (104)	720 (156)	804 (74)	746 (68)	757 (43)

	1989 Stations				1992 Stations			
Length Group (in.)	Sutherland	Goldberg	Primitive	Avg.	Sutherland	Goldberg	Primitive	Avg.
6.0 - 8.9	114	155	275	181	101	57	80	79
9.0 - 14.9	282	386	287	318	551	356	504	470
≥ 15.0	26	48	94	56	12	42	108	53
Total	422 (70)	589 (67)	656 (94)	556 (121)	664 (86)	454 (54)	692 (93)	603 (130)

continued on next page

Appendix I, Table 4 (cont.). Spring brown trout density (fish/mile) by length intervals and station in the White River, Bayfield County, Wisconsin. Includes only brown trout ≥ 6 in. 95% confidence intervals are in parenthesis.

	1993 Stations				2003 Stations			
Length Group (in.)	Sutherland	Goldberg	Primitive	Avg.	Sutherland	Goldberg	Primitive	Avg.
6.0 - 8.9	49	27	22	33	166	141	52	120
9.0 - 14.9	477	300	262	346	250	174	130	185
≥ 15.0	58	56	110	75	63	56	41	54
Total	584 (75)	384 (58)	394 (72)	454 (113)	479 (91)	371 (60)	224 (56)	358 (128)

	2004 Stations				2005 Stations			
Length Group (in.)	Sutherland	Goldberg	Primitive	Avg.	Bolen Creek	Johnson Creek	Lower Bibon	Avg.
6.0 - 8.9	63	67	200	110	123	74	198	132
9.0 - 14.9	226	164	206	199	296	142	285	241
≥ 15.0	82	71	46	67	41	50	13	35
Total	371 (68)	302 (63)	452 (120)	375 (75)	460 (70)	267 (37)	496 (58)	408 (123)

Appendix I, Table 5. Chronology of estimated angling pressure (hours) for the White River study area, Bayfield County, Wisconsin during all years of creel census.

Time Period	1984	1985	1992	1993	2004	2005
May	4,524	5,861	5,673	5,367	2,628	3,457
June - before *H. limbata* hatch	1,436	2,382	1,570	1,627	792	665
Hexagenia limbata hatch time period	1,610	2,080	3,469	4,312	1,987	1,567
Subtotal	7,570	10,323	10,712	11,306	5,407	5,689
July - after *H. limbata* hatch	564	553	392	414*	284	315
August	479	583	639	675*	575	459
September	1,147	628	930	982*	747	598
Total	9,760	12,087	12,673	13,377*	7,013	7,061
Hours/Acre**	86	106	112	118*	62	62
Average hours/acre	96		115		62	

*Expanded total based on the ratio of the subtotal to total season estimate in 1992 (Avery 1999).
**Based on an estimated surface area of 113.6 acres (Avery 1999).

Appendix I, Table 6. Length frequency of estimated season harvest of brown trout in 2004 from the White River study area, Bayfield County, Wisconsin. Calculated using data obtained from creel clerk interviews.

Inch Group	Number of Brown Trout Creeled/Month						Season Total
	May	June 1 - 25	June 26- July 16	July 17 - 31	Aug	Sep	
8	11	0	0	0	0	0	11
9	74	26	0	0	0	51	152
10	92	9	16	0	0	34	151
11	103	31	33	0	0	68	235
12	132	9	49	17	0	0	207
13	115	4	16	9	0	0	144
14	103	0	33	0	52	17	205
15	46	0	25	0	0	17	87
16	29	0	16	0	0	0	45
17	23	0	8	0	0	0	31
18	6	0	0	0	0	0	6
19	17	0	16	0	0	0	34
20	0	0	16	0	0	0	16
21	6	0	0	0	0	0	6
22+	6	0	8	0	0	0	14
Totals	762	79	238	26	52	187	1344
Avg. length (in..)	12.9	11.0	14.6	12.5	NA	11.2	12.9

Appendix I, Table 7. Length frequency of estimated season harvest of brown trout in 2005 from the White River study area, Bayfield County, Wisconsin. Calculated using data obtained from creel clerk interviews.

Inch Group	Number of Brown Trout Creeled/Month						Season Total
	May	June 1 - 22	June 23- July 5	July 5 - 31	Aug	Sep	
8	6	0	0	0	0	12	18
9	99	35	0	0	5	0	138
10	136	23	18	7	0	24	208
11	160	12	37	0	5	0	213
12	142	23	28	14	0	0	207
13	105	23	18	7	0	12	165
14	99	12	9	0	0	12	131
15	68	12	0	0	0	0	79
16	31	0	0	0	0	12	43
17	31	0	0	7	5	12	54
18	25	0	0	0	0	0	25
19	6	0	0	0	0	0	6
20	6	0	0	0	0	0	6
21	0	0	0	0	0	0	0
22+	6	0	0	0	0	0	6
Totals	918	140	110	35	14	84	1301
Avg. length (in..)	12.8	11.8	12.1	13.2	12.7	13.2	12.7

Appendix I, Table 8. Brown trout harvest by month or time period: indicating the number harvested by month, percent of season harvest, cumulative percent of season harvest, and season harvest totals for each year of creel census on the White River study area, Bayfield County, WI. Determined from combining angler interviews performed by DNR creel clerks with voluntary return information from anglers.

Year and Harvest Statistic	Number and Percent of Brown Trout Creeled per Month						Season Total Harvest
	May	June (before hatch)	*Hex.* hatch	July (after hatch)	August	Sept.	
1984: Number harvested	1581	718	634	192	240	318	3683
Percent of season harvest	42.9	19.5	17.2	5.2	6.5	8.6	172.9/Mi
Cumulative % of harvest	42.9	62.4	79.6	84.8	91.4	100.0	0.38/Hr
1985: Number harvested	2279	936	827	110	225	197	4574
Percent of season harvest	49.8	20.5	18.1	2.4	4.9	4.3	214.7/Mi
Cumulative % of harvest	49.8	70.3	88.4	90.8	95.7	100.0	0.38/Hr
1992: Number harvested	1128	152	347	78	19	170	1894
Percent of season harvest	59.6	8.0	18.3	4.1	1.0	9.0	88.9/Mi
Cumulative % of harvest	59.6	67.6	85.9	90.0	91.0	100.0	0.15/Hr
1993: Number harvested*	1004	305	422	79	19	173	2002
Percent of season harvest	50.1	15.2	21.1	3.9	0.9	8.6	94.0/Mi
Cumulative % of harvest	50.1	65.4	86.5	90.4	91.4	100.0	0.15/Hr
2004: Number harvested	809	111	238	45	92	135	1430
Percent of season harvest	56.6	7.8	16.6	3.1	6.4	9.4	67.1/Mi
Cumulative % of harvest	56.6	64.3	81.0	84.1	90.6	100.0	0.20/Hr
2005: Number harvested	923	113	141	60	32	126	1395
Percent of season harvest	66.2	8.1	10.1	4.3	2.3	9.0	65.5/Mi
Cumulative % of harvest	66.2	74.3	84.4	88.7	91.0	100.0	0.20/Hr
Averages for each two-year creel census period							
1984-85: No. harvested	1930	827	731	151	233	258	4128.5
Percent of season harvest	46.7	20.0	17.7	3.7	5.6	6.2	193.8/Mi
Cumulative % of harvest	46.7	66.8	84.5	88.1	93.8	100.0	0.38/Hr
1992-93: No. harvested	1066	229	385	79	19	172	1948
Percent of season harvest	54.7	11.7	19.7	4.0	1.0	8.8	91.5/Mi
Cumulative % of harvest	54.7	66.5	86.2	90.2	91.2	100.0	0.15/Hr
2004-05: No. harvested	866	112	190	53	62	131	1412.5
Percent of season harvest	61.3	7.9	13.4	3.7	4.4	9.2	66.3/Mi
Cumulative % of harvest	61.3	69.2	82.7	86.4	90.8	100.0	0.20/Hr

*No creel survey occurred after the *Hex.* hatch was over in 1993. Harvest for that time period in 1993 was estimated or expanded based on the harvest ratio for the July 15 subtotal to total season harvest estimate in 1992.

Appendix I, Table 9. Density (fish/mile) of angler harvested brown trout by inch group and size class from the White River study area, Bayfield County, Wisconsin for all creel census years, determined from combining angler interviews performed by DNR creel clerks with voluntary return information from anglers.

Inch Group	Number harvested per mile						1984-1985 Average	1992-1993 Average	2004-2005 Average
	1984	1985	1992	1993*	2004	2005			
6	3.76	0.56	0.00	0.00	0.00	0.00	2.16	0.00	0.00
7	6.90	6.43	0.00	0.00	0.00	0.00	6.66	0.00	0.00
8	10.66	24.68	<0.10	0.00	0.94	1.03	17.67	<0.10	0.99
9	12.02	29.46	6.10	8.31	7.37	7.04	20.74	7.21	7.20
10	30.00	36.46	13.75	12.06	10.46	10.85	33.23	12.90	10.66
11	16.95	23.93	14.93	13.58	9.85	9.16	20.44	14.25	9.50
12	24.88	27.68	18.45	14.77	11.92	10.75	26.28	16.61	11.34
13	16.67	15.72	15.25	13.85	7.98	8.17	16.19	14.55	8.07
14	20.89	19.00	8.68	15.86	6.85	6.95	19.95	12.27	6.90
15	12.11	11.92	2.77	4.34	4.36	4.70	12.01	3.56	4.53
16	7.04	7.98	3.29	5.48	2.25	2.25	7.51	4.39	2.25
17	6.01	6.19	1.88	3.69	1.64	2.68	6.10	2.79	2.16
18	2.44	3.14	1.60	0.22	0.19	1.13	2.79	0.91	0.66
19	1.97	0.61	0.70	1.25	1.45	0.38	1.29	0.98	0.92
20	0.33	0.38	0.84	0.22	0.75	0.23	0.35	0.53	0.49
21	0.09	0.47	0.38	0.38	0.48	0.00	0.28	0.38	0.24
22+	0.19	0.11	0.28	0.00	0.60	0.20	0.15	0.14	0.40
Totals	172.9	214.7	88.9	94.0	67.1	65.5	193.8	91.5	66.3
Size Class									
6.0 - 8.9 in.	21.3	31.7	<0.1	0.0	0.9	1.1	26.5	<0.1	1.0
9.0 - 14.9 in.	121.4	152.2	77.2	78.4	54.4	52.9	136.8	77.8	53.7
15.0 - 17.9 in.	25.2	26.1	7.9	13.5	8.3	9.6	25.6	10.7	8.9
>17.9 in.	5.0	4.7	3.8	2.1	3.5	1.9	4.9	2.9	2.7
Totals	172.9	214.7	88.9	94.0	67.1	65.5	193.8	91.5	66.3
Avg. length	12.2	11.8	12.8	12.9	12.8	12.7	12.0	12.9	12.8

*No creel survey occurred after July 15 in 1993. Harvest during that time period was estimated or expanded based on the harvest ration for the July 15 subtotal to season total harvest estimate in 1992. Season total in 1993 = 2002 brown trout.

Appendix I, Table 10. Comparisons between selected years of study on the White River, Bayfield County, Wisconsin for various statistics such as: brown trout population densities, angling pressure statistics, catch and harvest rates, harvest, exploitation, angler success, and mean length of brown trout harvested. Determined from combining angler interviews performed by DNR creel clerks with voluntary return information from anglers.

Statistical Category	1984	1985	1986	1988	1989	1992	1993*	2003	2004	2005**
Brown trout density/mile ≥ 6 in.	468	733	431	757	556	603	454	358	375	408
Brown trout density/mile ≥ 15 in.	20	36	25	59	56	53	75	54	67	35
Angling pressure - total hours	9,760	12,087	***	***	***	12,673	13,377	***	7,013	7,061
Total angling pressure in hrs/acre	86	106	***	***	***	112	118	***	61.7	62.2
Angler trips/mile of river	115	121	***	***	***	135	137	***	89	95
Mean number of hrs/angler trip	4.0	4.7	***	***	***	4.3	4.6	***	3.7	3.5
Mean number of angler trips/day	16.0	17.0	***	***	***	19.0	19.8	***	12.4	13.7
Catch Rates per Hour	0.79	0.80	***	***	***	0.50	0.52	***	0.83	0.76
Harvest Rates per Hour	0.39	0.40	***	***	***	0.15	0.15	***	0.21	0.21
Total Trout harvest/mile	180.1	221.8	***	***	***	90.6	95.9	***	69.2	70.4
Brown trout harvest/mile	172.9	214.7	***	***	***	88.9	94.0	***	67.1	65.5
Exploitation of brown trout ≥ 6.0 in.	38.7%	30.5%	***	***	***	14.7%	23.9%	***	18.1%	16.1%
Exploitation of brown trout ≥ 9.0 in.	51.6%	44.1%	***	***	***	16.6%	25.7%	***	24.4%	23.9%
Exploitation of brown trout ≥ 15.0 in.	143.8%	88.0%	***	***	***	20.2%	22.9%	***	17.1%	32.9%
Angler Success-A (catch 1 trout min.)	77.9%	76.0%	***	***	***	60.0%	62.0%*	***	67.4%	66.7%
Angler Success-B (keep 1 brown min.)	58.1%	60.7%	***	***	***	36.0%	37.8%*	***	34.3%	41.4%
Mean length (in.) of brown trout creeled	12.2	11.8	***	***	***	12.8	12.9	***	12.8	12.7

* Creel survey in 1993 only went through July 15. Estimates for pressure, harvest, and exploitation are expanded based on the ratio of the July 15 subtotal to total season estimate in 1992 (Avery 1999).
** Different stations used during population estimates in 2005.
*** No creel survey performed in 1986, 1988, 1989, and 2003.
****Angler success A: is defined as catching at least one trout (brown or brook)/angling trip. Angler success B: is defined as keeping at least one brown trout/angling trip. Percentages are based on angler interviews and voluntary creel returns.

APPENDIX II
White River Angler Questionnaire
Final Results

SECTION I: FISHING THE WHITE RIVER IN 2004 & 2005

1. What area of the White River (see map) did you fish most often in 2004 and 2005?

	Percent
From Pikes Road Bridge upstream, including headwater areas	13
From Pikes Road Bridge downstream to Sutherland Bridge	48
From Sutherland Bridge downstream to Bibon Road Bridge	30
Downstream of Bibon Road Bridge	9

2. During 2004 and 2005, about how many days did you spend at least part of the day fishing the White River?

Days	2004 Percent (%)	2005 Percent (%)
0	7	11
1 – 2	23	24
3 – 4	28	27
5 – 10	21	24
> 10	20	16
Ave. days	8	7
Max	200	150 (Outliers)
	60	60

3. In 2004 and 2005, how did you typically fish the White River – did you fly fish, use live bait, or artificial lures?

	Live bait	Artificial	Fly fishing
Never	39%	36%	44%
Sometimes	8%	23%	12%
Often	24%	23%	9%
Always	29%	18%	35%

4. How many miles one-way did you typically travel to reach your fishing location on the White River during 2004 and in 2005?

1-way miles	Percent (%)
1 – 10	24
11 – 20	14
21 – 50	14
51 – 100	17
101 – 200	20
> 200	11
Ave. miles	87
Max	650

5. Overall, how satisfied were you with your 2004 and 2005 fishing experiences on the White River? (check one)

	Percent (%)
Very satisfied	37
Somewhat satisfied	47
Not too satisfied	14
Not at all satisfied	2

6. Your satisfaction with White River fishing may have been influenced by some of the following. To what extent do you disagree or agree that each of the following statements affected your satisfaction with fishing the White River.

(Percent responding read across)

	Strongly disagree	Slightly disagree	Neither	Slightly agree	Strongly agree
Water quality on the river is poor	54%	19	14	11	2
There are too many anglers	26%	33	17	20	5
I don't catch many fish	22%	28	14	27	9
I catch too many small fish	25%	22	31	16	6
I don't catch enough trophy fish	15%	19	27	27	12
The daily bag limit is too low	51%	13	20	13	3
The regulations are complicated	42%	15	19	15	10
The regulations are restrictive	43%	15	24	13	5

SECTION II: YOUR HISTORY ON THE WHITE RIVER

1. For about how many years have you fished the White River in Bayfield County in the Bibon Swamp area, anywhere between Pikes Road Bridge and Bibon Road Bridge?

Years	Percent
1 – 2	11% (7% 1 year)
3 – 5	14
6 – 10	18
11 – 20	19
21 – 30	19
> 30	19
Ave. yrs	18
Max	58

2. In what year did you first fish the White River?

Year(s)	Percent (%)
2005	4
2004	5
2000 – 03	15
1990 – 99	26
1980 – 89	14
1970 – 79	21
Before 1970	14
Mean	1986
Min	1940

3. In the past ten years (1996 – 2005) how many years have you fished the White River?

	Percent (%)
Less than 3 years	14
3 – 4 years	13
5 – 6 years	10
7 – 8 years	10
9 – 10 years	53

4. Compared to past years, in general, would you say the number of days in a year you fish the White River has been increasing, decreasing or staying about the same? (check one)

	Percent (%)
Increasing	9
Decreasing	29
Staying about the same	61

5. Compared to past years, in general, would you say the number of fish you catch on the White River has increased, decreased or stayed about the same?

	Percent (%)
Increasing	6
Decreasing	52
Staying about the same	42

6. How important is fishing the White River to you in comparison to all of your other recreational activities? Would you say that fishing the White River is…

	Percent (%)
My most important recreational activity	5
One of the more important recreational activities I participate in	66
No more important than any other of my recreational activities	21
Less important than most of my other recreational activities	8
Not at all important to me as a recreational activity	1

7. In the past three years have you fished other rivers or streams for trout in Wisconsin?

	Percent (%)
Yes	84
No	16

8. Of those of you who answered "Yes" to Question 7, compared to other trout rivers or streams in Wisconsin would you say the fishing quality on the White River is…

	Percent (%)
Much better	17
Somewhat better	40
About the same	25
Somewhat worse	14
Much worse	4

9. In the years that you've fished the White River, how would you say each of the following has changed?

(Percent responding read across)

	Higher	Remained stable	Lower
Fish population	4%	40	56
Average fish size	Larger	Remained stable	Smaller
	9%	53	38
Water quality	Better	Remained stable	Worse
	2%	86	12
Crowding from anglers	More	Remained stable	Less
	32%	53	15
Management of river	Better	Remained stable	Worse
	23%	65	13

10. In general, would you say that fishing the White River has improved or worsened in the years you've been fishing?

	Percent (%)
Definitely improved	2
Probably improved	15
Remained about the same	33
Probably worsened	33
Definitely worsened	16

11. Your answer to the previous question may have been influenced by various factors. Please check the two factors that most influenced your answer to question 10 above.

Worsened	Percent (%)
Too much fishing pressure	17
Other anglers keeping too many fish	14
Ineffective or detrimental regulations	12
Loss of trout habitat	9
Water quality becoming worse	2
Lower trout population levels	14
Higher water temperatures	2
Fewer large brown trout	4
Too many northern pike	5
Poor fish management (excluding regs)	0
Increase in other predators (such as otter and herons)	0
Additional responses	
Reduced fishing pressure	4
More catch and release being practiced	11
Improved trout habitat	2
More large brown trout	1

Improved	Percent (%)
Reduced fishing pressure	3
More catch and release being practiced	8
Improved fishing regulations	5
Improved trout habitat	2
Improved water quality	0
Higher trout populations	2
Cooler water temperatures	0
More large brown trout	1
Fewer northern pike	4
Improved fish management (excl. regs)	6
Decrease in other predators (such as otter and herons)	1
Additional responses	
Other anglers keeping too many fish	2
Ineffective or detrimental regulations	2
Loss of trout habitat	1
Water quality becoming worse	3
Lower trout population levels	7
Higher water temperatures	4
Fewer large brown trout	10
Too many northern pike	12
Poor fish management (excluding regs	2
Increase in other predators	3

SECTION III: REGULATIONS AND THE FISH YOU CATCH

1. How many inches long was the largest brown trout that you ever caught from the White River?

Inches	Percent (%)
0	3
< 11	3
11 – 17.9	24
18 – 19.9	24
20 – 21.9	16
22 – 23.9	18
24 or longer	12
Ave.	19
Max	28

2. How many inches long would a brown trout from the White River need to be for you to consider it a "trophy" fish?

Inches	Percent (%)
14 – 17	11
18 – 19	17
20	34
21 – 22	14
23 or longer	24
Ave.	20
Max	28

3. Think about the legal sized trout you caught from the White River during 2004 and 2005. Would you say that you released all legal trout, released some and kept others, or kept all legal trout from the White River?

	Percent (%)
I did not catch a legal-sized trout	3
Released all legal trout	28
Released some legal trout and kept others	62
Kept all legal trout	7

4. In the years that you've been fishing the White River, would you say that your catch-and-release fishing of legal sized trout has…

	Percent (%)
Definitely increased	30
Probably increased	16
Remained about the same	43
Probably decreased	9
Definitely decreased	3

5. Before 1990 the trout regulations for the White River included a bag limit of five trout with a 7-inch minimum length. In 1990 the regulations were changed to a bag limit of three trout with a 9-inch minimum length with one trout of 15-inches or greater allowed. Do you feel this change in the trout regulations has had a positive or negative impact on the White River fishery? If you did not fish the White River prior to 1990, please just give us your best impression.

	Percent (%)
Definitely positive	33
Probably positive	44
Neither positive nor negative	18
Probably negative	3
Definitely negative	2

6. Would you favor or oppose brown trout regulations on designated sections of the White River geared toward managing for a trophy fishery? This would likely mean a longer length limit and/or a reduced bag limit.

	Percent (%)
Definitely favor	38
Probably favor	17
Probably oppose	16
Definitely oppose	16
I'm not sure	12

7. Would you favor or oppose a section or sections of the White River that restricted use of bait choice to artificial lure and fly fishing only?

	Percent (%)
Definitely favor	38
Probably favor	11
Probably oppose	12
Definitely oppose	34
I'm not sure	6

These last two questions will help us compare your answers to those of other White River anglers.

8. Are you:

	Percent (%)
Male	94
Female	6

9. How old are you? _____ years old

Age	Percent (%)
Less than 20	5
20 – 29	12
30 – 39	14
40 – 49	21
50 – 59	21
60 and older	27
Ave. age	48
Max	98

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE. PLEASE RETURN IT IN THE POSTAGE-PAID ENVELOPE AT YOUR EARLIEST CONVENIENCE.

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Notes