FINAL REPORT

ECONOMIC CONSEQUENCES OF WHIRLING DISEASE IN MONTANA AND COLORADO TROUT FISHERIES

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John W. Duffield
Department of Economics, University of Montana
3699 Larch Camp Road, Missoula, MT 59803
Phone & Fax: 406-728-9510 e-mail: bioecon@marsweb.com

David A. Patterson
Department of Mathematical Sciences
University of Montana, Missoula, 59812
Phone: 406-243-6748 Fax: 406-243-2674 e-mail: davep@selway.umt.edu

Christopher J. Neher
Bioeconomics, Inc.
315 South 4th East, Missoula, MT 59801
Phone & Fax: 406-721-2265 e-mail: bioecon@marsweb.com

John B. Loomis
Department of Agricultural and Resource Economics, Colorado State University
Fort Collins, CO 80523
Phone: 940-491-2495 Fax: 940-491-2067 e-mail: jloomis@ceres.agsci.colocstate.edu

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Executive Summary

This paper reports on a preliminary analysis of the economic impacts of whirling disease in Montana and Colorado coldwater fisheries.

The potential impact of whirling disease on local economies can occur through two connected relationships: 1) reductions in trout populations affecting angler use and 2) reduced angler use and related expenditures impacting local economies. The work reported here for Colorado is limited to a review of the literature on angler expenditures and valuation and to empirical estimates of the relationship between catch rates and angler use. This paper provides a similar review of the literature for Montana on the first stage of the problem.

The main focus of this study was on collecting and analyzing new data for two evolving case studies of the impacts whirling disease - on the Missouri River and on the Madison River. Whirling disease substantially reduced trout populations on the Madison River above Ennis beginning in about 1991. On the Missouri whirling disease is now present in several of the major spawning tributaries of the Holter-Cascade section, but no population impacts are yet apparent on catchable trout in the mainstem. On-site angler surveys were conducted in the summer of 1998 on both streams with a focus on 1) estimating angler pressure, and 2) collecting information on angler expenditure and valuation. One motivation for sampling in 1998 is that the Montana Department of Fish, Wildlife and Parks (MDFWP) angler pressure survey (conducted by mail) is only done every other year, in odd-numbered years. The information from these surveys was used along with previous angler use estimates and other data to examine potential economic impacts to date on the Madison.

The basic finding of the literature and data review for both Colorado and Montana is that one would generally expect a considerable, though less than proportional, response of angler pressure to changes in fish populations. For example, the Colorado data suggests that a 10% decrease in the number of catchable trout stocked resulted in a 4.3% decrease in lake angler use and a 2.3% decrease in stream angler use based on a cross-sectional sample. Similar results held for the relationship of catch rates and angler use. In Montana, a cross-sectional sample of 27 streams showed that on average Montana resident angler use declined by about 6.0% for a 10.0% reduction in trout population. However, these results are sensitive to outliers and the form of the model.

With regard to estimating angler pressure on the two stream segments (Missouri River, Holter to Cascade section and Madison River, Ennis Lake to Hebgen Dam), postcards were distributed to cars parked at fishing access sites following the methods of Robson and Jones (1989). A carefully designed schedule was followed by survey agents that randomly varied the start time, start location, and day of the week for the survey route. A total of 4,787 postcards were distributed on the Missouri and 1,099 on the Madison. The large sample on the Missouri was possible due to the full-time cooperation of a MDFWP technician in May-September. For efficiency, the Madison sample was designed to collect the minimum data necessary for adequate precision of use estimates. Unfortunately, the Madison postcards for May-July were lost in the mail and only a small sample with full information was available for August-September. However, since the postcard count was known for May-July, a May-September estimate could still be developed (but with lower precision). Based on the available data, the estimated use on the Missouri was 39,275 (3,167 standard error) and on the Madison 31,480 (6,959 standard error). The 95 percent confidence interval on the Missouri for this data set is plus or minus 16 percent, which is in the same range as the precision on the biannual mail angler pressure conducted by MDFWP. This point estimate for 1998 is about 20 percent lower than the average of angler use estimates from DFWP for 1993, 1995 and 1997 for the Missouri. The estimates for the Madison have a large confidence interval of plus or minus 43 percent. The point estimate is about half of the DFWP 1993 to 1997 estimates, but is obviously imprecise.

In addition to the postcard-angler use survey, an angler intercept survey was also conducted on the two rivers in the summer of 1998. This was a convenience sample collected as possible as a secondary objective and subject to following the scheduling for the postcard route. A total of 220 surveys were collected on the Missouri and 48 on the Madison. In general the responses show that trips to the Madison tend to be longer (5.4 days versus 2.1) and are more likely to be guided. In general the Missouri is more of local fishery with considerable day-use by residents of Great Falls and Helena, while the Madison is more of a destination fishery. The average expenditure per day reported was $222 for Madison anglers and $48 per day for the Missouri. Contingent valuation estimates were also developed of angler willingness-to-pay for each stream. Based on logistic regression models, the median net economic value per trip was estimated to be $119 on the Missouri and $475 on the Madison. Given the small size of the Madison sample, the results for this stream should be interpreted with caution.

To date the Madison River is one of only two major stream fisheries in Montana where whirling disease is known to have substantially impacted the trout population (the other is Rock Creek near Clinton, MT). Time-series data were assembled for the Madison on angler use, client days for guides and outfitters, and for personal income for tourism related sectors for Madison County. Somewhat surprisingly, none of these measures show a significant and consistent decline that coincides with the measured change in rainbow trout populations in the Madison River beginning in 1991. The rainbow trout population for 10 inch and larger fish dropped from a mean of 1597 per mile to 412 per mile (a 75 percent reduction) when comparing 1983-90 versus 1991-97. By contrast, angler use has been fairly constant since the mid-1980's, with the exception of a spike in use measured for 1993. This surge in use was primarily nonresident and, whether coincidental or causal, the timing coincides with the release of the film "A River Runs through It". The pre-whirling disease impact average pressure on the upper Madison (DFWP section 2) averaged 58,923 angler days per year (from 1982-89) and increased by an average of 18% to 69,261 from 1991-97. Accordingly, the decline in trout populations does not appear to have resulted to date in a reduction in a consistent picture of reduced angler use.

The angler use data is also consistent with the personal income data series for Madison County (including Ennis) which shows a steady increase for tourism-related sectors in the 1990's. Another data series is for client days for guides; however, this data is only available back to about 1989. This data shows a steady increase on the Madison through 1996 and then a decline in 1997. However, of the ten major streams for which client data have been tabulated five of the ten showed a decline in 1997. Because of year-to-year variations due to confounding variables (such as water levels or weather or substitute quality) and due to the statistical variability in these estimates, it is difficult to identify, to date, a consistent and significant measure that shows a negative economic impact due to whirling disease on the Madison River. This may change.

For the present, there are a number of possible reasons as to why there are no obvious changes in these data series to date. These include the continued presence of a substantial brown trout population that has not been impacted, and the fact that the Madison is still a very good fishery relative to others in Montana and elsewhere. It is also possible that the Madison will prove to be a special case because of its enduring reputation and mystique.

In the absence of a significant decline in angler use on the Madison, no quantification of economic impacts to the local economy of Madison County (including the town of Ennis) was undertaken.

The basic conclusion here is that there is little in the way of solid examples that fishery economists can point to in either Colorado or Montana to show that whirling disease has heavily impacted a given local economy. Nonetheless, the potential for major impact on anglers and local communities is certainly there in both states and, unfortunately, may well be realized in coming years.

The primary limitation of this study was the relatively small size of the sample obtained for the Madison River on-site angler pressure and intercept surveys. Priorities for future economic research on this issue in Montana should include continuing to closely monitor the time series data (angler use, personal income, client days) for both the Missouri and Madison. The Missouri in particular appears vulnerable to substantial impacts given that it is primarily a rainbow fishery. It would be worthwhile to continue to survey these streams in the years in which MDFWP does not do a mail survey. It would also be worthwhile to extend the sampling and analysis to include the other major impacted fishery which is Rock Creek. In Colorado it will also be worthwhile to continue to track the availability of time series data for impacted waters; at the time of this review there were no such consistent data available. The analysis undertaken to date has been limited to the demand side of the issue - impacts arising from possible changes in angler use. However, particularly with regard to Colorado, there are also economic impacts of interest that arise from the supply side. This could include quantification of the costs of limiting and eliminating whirling disease in hatcheries.

1.0 Introduction

This paper describes research on the economic consequences of whirling disease for Montana and Colorado cold water fisheries. Although research on whirling disease to date has been focused on the biological side of the problem, economic impacts are also of considerable interest to policy makers.

This study was conducted in two stages: first, examining the link between fish populations and angler use, and second, the relationship of angler use and local economies. In addition to the costs that whirling disease may impose on anglers and local communities, there may also be substantial costs on the management side - for example in limiting whirling disease in hatchery operations. The latter type of costs are relatively more straightforward to estimate and, while possibly substantial in some cases, are not examined in this study.

Our work on the economics of Colorado fisheries is limited to a review of the literature on angler expenditures and valuation, and to empirical estimates of the relationship between catch or stocking rates and angler use. The work in Montana includes similar work on the first stage of the problem. In addition, two case studies are underway that include the second stage of the problem - measuring impacts through regional economic models. The two case studies focus on the Madison River and the Missouri River. Both streams are major fisheries where whirling disease is present and both have reliable long-term measures of trout populations and angler pressure. The two case studies provide an interesting comparison in that the Madison is quite far along in terms of whirling disease impacts. Here the trout population impacts are substantial and measurable since at least 1991 (Vincent 1998). By contrast, the Missouri is potentially at the beginning of a period of major change. For better or worse, this provides a good opportunity for establishing an economic baseline. Angler creel surveys were implemented on both streams in May-September 1998. Data is available to construct multi-county regional economic models for Gallatin-Madison and for Cascade-Lewis and Clark and for the communities of Ennis, West Yellowstone and Cascade as necessary to evaluate any angler use impacts that are identified.

2.0 Methods

This study draws on several different areas of specialization within economics. One general area is recreation economics and the associated field of nonmarket valuation. The other general area is regional economics. These two areas of specialization are used to examine the fish population-angler use relationship and the angler use-local economy relationships, respectively.

Two different accounting frameworks apply. The impact on anglers is best described in terms of a net change in economic welfare or so-called consumer surplus (a benefit-cost framework). The impact on local and regional economies is measured in a regional economic framework in terms of changes in employment, income and output. While the effects of changes in fish populations and angler use due to whirling disease is a fairly new area of research, the effects of changes in fish populations due to a variety of other environmental or management influences is not. More generally, there has been considerable research into the effect of quality changes on recreational demand. There are two general types of models that have been applied - travel cost and contingent valuation. In Montana a state-level model of stream fisheries using the zonal travel cost model was developed by Duffield et al. (1987). The measure of change in fishing quality used was the number of large trout caught. More recently two discrete choice models have been applied, based on survey data collected in the 1991 to 1993 time period. A state-level model of both Montana lake and stream fisheries by Desvousges and Waters (1995) uses trout populations per 1000 linear feet as the quality measure. A study by Hagler Bailly Consulting, Inc. (1995) uses reported angler catch rates as the starting point for the quality measure. Both of these models have been developed in the context of litigation that has recently settled. Other studies of the effect of catch rates on trips include Loomis and Cooper's (1990) study of the North Fork of the Feather River in California.

The other line of research into the problem of nonmarket valuation (such as the value of a day of fishing) is the stated preference or contingent valuation approach (Mitchell and Carson, 1989). In this survey approach, respondents are faced with a hypothetical situation, for example the opportunity to purchase access to a fishery, and asked about their willingness to pay. In this study, the nonmarket commodities measured through the use of contingent valuation were fishing trips to the Madison or Missouri River. Well established markets for fishing on public lands in Montana do not exist. Therefore, the basic problem to be faced in determining the economic value of fishing trips to this region is one of measuring these nonmarket values. Contingent valuation has been widely applied (Cummings et al. 1986, Mitchell and Carsen 1989) and is recognized by the U.S. Water Resources Council (1983) as an appropriate method. This approach has also been designated in federal guidelines (U.S. Department of Interior 1986, 1991) as a best available procedure for valuation of damages arising in superfund natural resource damage cases. The contingent valuation method has been employed numerous times to inform state and federal agency decision making on resource issues. In Montana, CV has been used to value coldwater fishing on all major fisheries in the state (Duffield and Allen 1988, Duffield and Patterson 1991)).

The essence of the CV approach is to ask individuals their willingness to pay contingent on a hypothetical situation. The application of the CV method involves three elements: 1) a description of the resource which is to be valued; 2) the "payment vehicle," or method by which the respondent will pay for the resource; 3) the "question format" or specific method by which the value of the resource will be elicited. We will discuss how each of these elements is addressed in turn.

In the Madison and Missouri River on-site angler survey, anglers were asked to place a value on their current fishing trip to the river.

The "payment vehicle," or method by which respondents were asked to place a value on their recreational experience was an increase in travel costs to the site. The use of increased travel costs as a payment vehicle has been used extensively in CV studies and has the advantage of being relatively neutral. Other possible payment vehicles, such as site access fees or increased taxes, may elicit a "no" response from the respondent, not because they would not pay the amount, but because they are fundamentally opposed to increased taxes or site fees.

The third feature of all CV applications is the method by which the resource value is elicited from respondents. There are several basic genres of CV elicitation techniques including open-ended CV questions and dichotomous choice CV questions. In the open-ended CV method respondents are asked what the maximum amount they would be willing to pay for a good or resource would be. In the dichotomous choice method, respondents are asked a simple "yes" or "no" question: whether they would pay a specified amount for the specified good or resource. This study utilized the dichotomous choice contingent valuation method. The dichotomous choice question format has the advantage of presenting respondents with a simple yes or no decision on whether the described "economic good" is worth the dollar amount asked. This type of decision making is similar to the decisions we make every day when we decide to buy, or not buy, goods and services based on the qualities of the goods and services and also upon their price.

After answering the survey questions on trip expenditures on their current fishing trip, Madison and Missouri River anglers were asked the following question.

> The cost if visiting a river changes over time. For example, gas prices rise and fall. Would you still have made this trip if your share of total costs was $_______ more than the amount you just reported? ________ YES _________ NO

The bid amounts asked of anglers were randomly varied between 8 levels (10, 25, 50, 100, 200, 250, 500, and 1000).

An important consideration in study design is the availability of data on both angler use and fish populations. Montana Department of Fish, Wildlife and Parks (MDFWP) has conducted large scale surveys of licensed anglers for a number of years (McFarland, 1995). These surveys are typically for a license year (1 March through February) and have been completed for 1982, 1983, 1985, 1989, 1991, 1993, 1995 and 1997. The most comprehensive fish population data on Montana streams has also been collected by MDFWP. The extent of this data is quite variable. For example on 80 river segments defined by McFarland, about one-third have no measurements at all. On a few rivers there are several years of data for one or two sites within a McFarland-defined stream segment. There are also occasionally MDFWP angler creel surveys that sometimes collect both pressure and catch data, but generally on smaller segments than the McFarland-defined sites.

With regard to the creel survey methods, the specific problems of designing and interpreting angler surveys has received considerable attention in the biometric literature (e.g. Robson, 1961; Malvestuto, 1983; Robson and Jones, 1989). The authors of the current paper participated in the design and application of an angler creel survey to 27 stream sites in 1992 (including the Madison and Missouri) utilizing a combination of roving creel and other procedures. These same procedures were applied to the upper Madison and the Missouri Holter to Cascade section in 1998. The main features of the approach are contact methods varying with site-specific access, the use of lattice-sampling to ensure randomness over time and space, a postcard approach to sample vehicles for pressure estimates and an intercept survey to collect economic and angler catch data. The sample periods and sites are designed to match exactly the McFarland sites and summer (May-September) estimates. Summer use on the upper Madison was 86 percent of the year total in 1993 (McFarland, 1995). Sampling was approximately twice weekly in a stratified weekday-weekend design. This rate is double that of the 1992 survey and is expected to produce standard errors on the order of 10 percent of the means for pressure. No other creel survey was planned by MDFWP for the Madison in 1998; however, the Missouri study was in cooperation with MDFWP. Region 4 supported a full-time fishery technician for the purposes of the angler creel May-September of 1998.
Time series models can be estimated for the study sites using multiple regression techniques. The dependent variable is angler pressure and the independent variables include fish populations and environmental factors. Observed and predicted changes from these models for the Madison and Missouri can be used in conjunction with economic valuation parameters from the existing literature.

Regional economic models are being developed at the multi-county and community level for the study sites using IMPLAN (Minnesota IMPLAN Group, Inc. 1996) software. Angler expenditure data is being developed from the 1998 on-site angler surveys and the literature. Self-reported angler information on the location of expenditures provides a means of allocating aggregate changes in angler expenditures to the relevant spatial economy.

3.0 Data Collection

A major emphasis of this study was the data collection effort necessary to generate estimates of angling pressure on the Upper Madison and Missouri Rivers. Two surveys were implemented in the summer of 1998. A postcard angler pressure survey was implemented to enable the estimation of total angling pressure on those waters. An angler intercept survey was also implemented to gather information on angler and trip characteristics. The primary emphasis of the survey effort was the postcard pressure survey, with the angler intercept survey being a secondary task of survey personnel.

3.1 Survey Design and Scheduling

The Madison and Missouri Rivers angler pressure survey was designed in order to provide estimates of total angler trips for the May through September period on the river sections.

Additionally, the portions of the rivers surveyed were chosen to correspond to river segments for which the Montana DFWP provides bi-annual pressure estimates. On the Madison River, the portion of the river surveyed was the reach from the head of Ennis Lake to Hebgen Dam. On the Missouri River, the surveyed reach was from the Cascade, MT bridge to Holter Dam. The two river segments were discussed in detail with DFWP personnel, and, in the case of the Missouri River, DFWP personnel traveled the river section with survey designers to identify all possible survey locations on the section. Survey routes along the river sections were designed based on traveling the rivers and information from DFWP personnel. These routes included two survey site definitions, "bus-stop" and "roving." A bus-stop survey site is a location (such as an official fishing assess point) where the survey agent stops and surveys available cars and anglers for a predetermined length of time. A roving survey site is a section of river that can be accessed continually from a frontage road. For a roving site, the survey agent travels continually along the site length (2 miles, for example) during a predetermined span of time. As they travel the stretch, they stop and place postcards on all cars parked along the river, and, if time allows, survey available anglers in person.

The resulting product of the survey design process was a route and timing map for each river section that showed each bus-stop and roving survey site along the rivers and outlined the length of time that the survey agents should spend surveying each site. More time was allocated to the most popular fishing sites along each river based on the professional judgement of the DFWP biologists for the rivers.

A randomly generated schedule was developed for each survey day that specified the start time for the survey day (7:30 am, 11:00 am, or 2:30 p.m.), and the starting point on the river. Survey agents were given a schedule for each survey day showing them exactly where they should be during every minute of the 7 hour survey day.

On the Madison River, one weekend day and one weekday per week were surveyed. The days were randomly chosen within each week. On the Missouri River, three randomly chosen weekdays and both weekend days were surveyed each week. Over the course of the summer 4,787 postcards were distributed on the Missouri River and 1099 were distributed on the Madison River. Of these distributed cards, 1,586 Missouri River cards were returned and 1,440 contained the information necessary for inclusion in the angling pressure program. On the Madison River, 235 cards were returned and 182 of these contained all needed information. The response rate on the Madison River appears very low due to the unfortunate loss of a portion of the returned postcards as they were mailed from the Bozeman office of Montana DFWP to the Missoula office of Bioeconomics, Inc. The result of this data loss was that pressure information on the Madison was only collected for the months of August and September. Data from these months, along with supplementary information was used to estimate total use on the river for the entire May through September period.

4.0 Missouri and Madison 1998 Angler Pressure Estimates

As noted above, during the period May through September 1998, two surveys were implemented on the Madison River (Ennis Lake to Hebgen Dam) and the Missouri River (Holter Dam to Cascade). (Appendix A contains the survey instruments used on the rivers and associated material.) The primary survey was a "postcard" pressure survey designed to estimate the number of angler days of fishing on these river stretches during the May through September period. The second survey was an in-person angler survey asking questions on trip characteristics, catch, and expenditures.

Table 4-1 shows the estimated 1998 May through September angling pressure for the two river sections. It was estimated that during this period the Missouri River section saw 39,275 angler days of use, and the Madison River section saw 31,480 angler days of use. These estimates are somewhat below recent estimates for these stretches by McFarland of Montana DFWP, however given the year to year variation in the McFarland estimates the estimates seem quite plausible. It must be remembered that the 1998 estimates are for a year not estimated by the McFarland survey and thus it may be most appropriate to compare 1998 use estimates to the range of estimates from McFarland over recent years.

Table 4-1. Comparison of 1998 May through September angler use estimates to recent year McFarland use estimates.

Study / Year	Missouri River (std.error)	Madison River (std.error)
Current study / 1998	39,275 (3,167)	31,480[a] (6,959)
DFWP / 1997	60,773 (3,799)	55,151 (3,993)
DFWP / 1995	50,022 (3,572)	59,995 (3,590)
DFWP / 1993	43,538 (2,966)	70,495 (4,970)
DFWP / 1991	39,977 (2,377)	61,120 (3,765)

[a] note that the Madison River estimate from the current study for the May through September period is based on partial season data and thus should be interpreted with caution.

5.0 On-Site Angler Survey Results

As previously noted, an on-site angler intercept survey was conducted in conjunction with the angler pressure postcard survey on the Madison and Missouri Rivers in the summer of 1998. This intercept survey collected data on angler and trip characteristics on the two rivers. Tables 5-1 and 5-2 show mean responses from the survey. The sample sizes for the two surveys are quite different with 220 surveys being completed on the Missouri River and 48 on the Madison River.

Table 5-1 shows a comparison of responses on the two rivers regarding trip characteristics. The trips on the Madison River were significantly longer than those on the Missouri (5.4 vs. 2.1 days respectively). Additionally a much larger percentage of Madison anglers than Missouri anglers were on guided trips. The percentage of guided trips sampled on the Missouri River (3.0%) is consistent with the range of percentages for recent years calculated from outfitter tally sheets and total angler use estimates. The Madison River share of guided trips (20.5%), however, is above the 5%-7% range for this statistic in recent years calculated from outfitter and total angler use statistics. While this difference may be an artifact of the somewhat small sample size on the Madison River (48 surveys) it may also indicate that guided trips on the river were oversampled relative to nonguided in the angler intercept survey.

There is a significant difference in the types of anglers who visit the two rivers. On the Madison River, 90% of anglers are fly fishermen, and 10% use lures, and none of the sample used bait. On the Missouri River, less than a third of anglers are fly fishermen, and 46% use bait. Another significant difference between the characteristics of trips to the two rivers is found in the reported trip expenditures for the trips (Table 5-2). Reported total expenditures for the Madison River trips are approximately $1200. On the Missouri River this reported total expenditure is $100. When average length of trip is considered, the average expenditure per day on the waters is $222 on the Missouri and $48 on the Missouri. These differences are likely attributable to the "local fishery" nature of the Missouri River stretch and the "destination fishery" nature of the Madison River. Many Missouri river anglers are day-trip anglers who incur no lodging, or guide expenses, and only minimal travel and food expenses on their trips from the relatively nearby cities of Great Falls and the Helena area. On the other hand, the Madison River trips reported in our sample appeared to be largely destination trips with a much larger percentage being guided trips. If the percentage of guided trips in the survey sample is higher than the overall percentage on the river, then the reported expenditures for the Madison River could be somewhat inflated by this overrepresentation of this higher-spending angler group.

Table 5-1. Madison and Missouri River Angler and Trip Characteristics		
Statistic	**Madison**	**Missouri**
Average number of people in group	2.02	2.11
Average number of days per trip	5.44	2.08
Percent of respondents who were guided	20.5	3.0
Percent using flies only	90.2	29.0
Percent using lures only	9.8	15.1
Percent using other bait (worms)	0	45.7
Percent using any combination of lures and bait	0	10.2
Satisfaction rating for number of fish caught[a]	3.18	3.03
Satisfaction rating for size of fish caught	3.27	3.04
Sample size	46	206

[a] Satisfaction ratings are based on a scale of 1 to 5 with 1 being very unsatisfied and 5 being very satisfied.

Table 5-2. Average Reported Angler Expenditures per trip on Madison and Missouri Rivers		
Category	Madison	Missouri
Lodging spending	$530	$9
Travel spending	$374	$49
Food spending	$230	$24
Guide spending	$270	$3
Other spending	$182	$18
Total spending per trip	$1208	$100
Total spending per day	$222	$48
Local area spending per trip	$775	$45
Percent of total spent in Montana	75.2%	96.3%
Sample size	46	206

<u>Estimated models of angler willingness to pay</u>

In the on-site angler intercept survey respondents were asked one question on their willingness to pay additional amounts for their current trip to fish the river. Table 5-3 shows the estimated models of average willingness to pay based on the angler responses.

Statistically significant models were estimated using survey responses from both river samples. The estimated median net economic value for Missouri River trips was $119 while the median value for Madison River trips was $476. The truncated mean net economic value for these trips (using the top bid level, or $1000, as the truncation level) was $256 for the Missouri River trips and $534 for the Madison River trips (Table 5-3).

Table 5-3. Bivariate Models of Willingness to Pay: Madison and Missouri Rivers		
Statistic	**Madison**	**Missouri**
Intercept (standard deviation)	4.5306 (1.6097)	5.1281 (.7721)
Log (bid) (standard deviation)	-0.7349 (0.2969)	-1.0722 (0.1529)
Sample size	46	206
Median willingness to pay	$475.76	$119.44
Truncated mean willingness to pay ($1000 truncation level)	$534.12	$256.41

6.0 Cross-Sectional Model of Angler Use vs. Trout Populations in Montana

A sample of 27 Montana streams for which there were both trout abundance estimates and angler pressure estimates (Table 6-1) was used to estimate a cross-sectional model of the trout/angler pressure relationship. A cross-sectional model was estimated on this sample of fish population data (trout per mile) and angler use per mile - with separate estimates for resident anglers and nonresident (out of state) anglers. A general finding is that nonresident use is more responsive to changes in fish population than resident use. Elasticities are in the range reported below for Colorado, but are sensitive to outliers and specification of functional form. The estimated elasticity for the Montana resident sample is +0.66 while the estimated nonresident elasticity is +1.22.

Table 6-1. Cross-sectional data of trout populations and angler pressure for 27 Montana fisheries.

DFWP Stream Sections	Total trout per mile	Total angler pressure per mile	Resident angler pressure per mile	Nonresident angler pressure per mile
Bighorn R. Sec 03	5,892	3,773	1,608	2,165
East Gallatin	3,346	274	250	24
Madison R. Sec. 01	2,789	1,124	742	381
Missouri R Sec. 09	2,713	1,777	1,433	343
Stillwater R. Sec 01	2,590	748	677	71
Madison R Sec. 02	2,058	1,571	399	1,172
Yellowstone R Sec. 8a	1,704	1,879	1,381	498
Gallatin R. Sec. 03	1,617	325	123	202
Boulder R. Sec. 01	1,615	601	396	205
Rock Creek Sec. 01	1,312	545	418	127
Belt Cr.	1,198	82	58	24
Yellowstone R Sec. 09	1,102	649	434	214
Yellowstone R. Sec. 05	1,058	410	382	28
Blackfoot R. Sec. 01	935	497	400	97
Yellowstone R Sec. 7a	913	242	180	62
Yellowstone R. Sec. 06a	913	266	231	35
Bitterroot R. Sec. 02	912	1,210	911	299
Bighorn R. Sec 02	859	405	273	132
Boulder R. Sec. 02	832	53	43	10
Smith R. Sec. 02	831	165	110	55
Yellowstone R Sec. 08b	790	344	196	148
Yellowstone R Sec. 7b	760	1,102	831	271
Blackfoot R. Sec. 02	431	208	147	60
Clark Fork R. Sec 02	393	555	412	142
Bitterroot R Sec. 01	296	673	574	99
Blackfoot R. Sec. 03	236	127	108	19
Stillwater R. Sec 02	224	176	141	35

Cross-sectional Model of Resident Angler Pressure and Trout Populations

Regression Statistics	
Multiple R	0.571927226
R Square	0.327100752
Adjusted R Square	0.288639214
Standard Error	351.8667532
Observations	27

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1564808.928	1564808.928	12.63877109	0.001537244
Residual	26	3219065.511	123810.212		
Total	27	4783874.44			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A
Total trout per mile	0.28779485	0.036520113	7.880448052	2.3432E-08	0.212726634

Cross-sectional Model of Non-resident Angler Pressure and Trout Populations

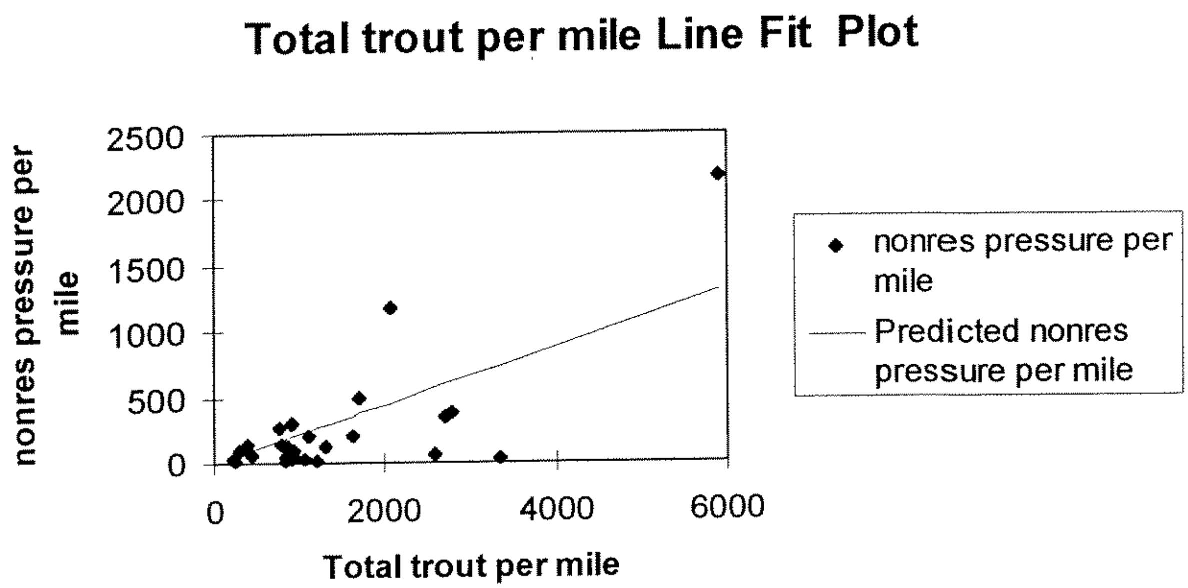
Regression Statistics	
Multiple R	0.725053
R Square	0.525702
Adjusted R Square	0.487241
Standard Error	308.132
Observations	27

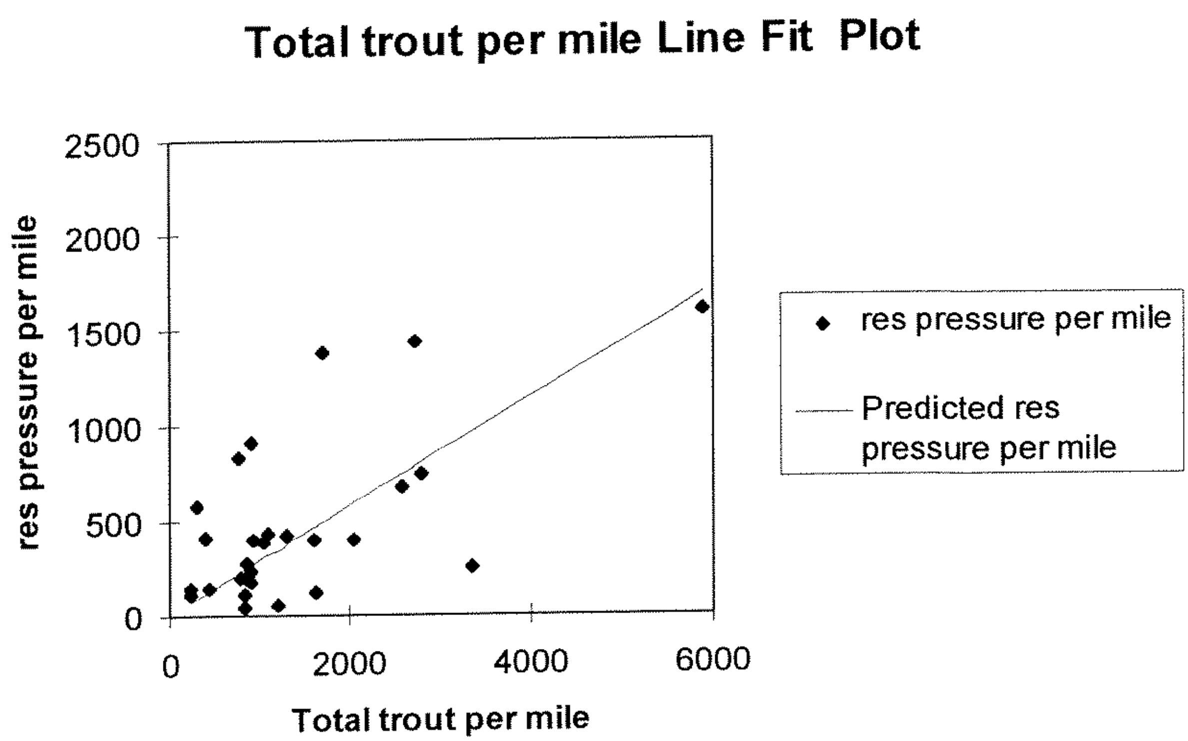
ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2736122	2736122	28.81787	1.44E-05
Residual	26	2468579	94945.33		
Total	27	5204701			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Total trout per mile	0.220394	0.031981	6.891432	2.57E-07	0.154656	0.286132

Figure 1. Line fit plots for resident and nonresident cross-sectional models and data.





7.0 Case Studies

With regard to the case studies, both Madison and Missouri time series of angler use and biological data were developed. The angler creel data for 1998 provided an additional data point to the odd-number years MDFWP statewide pressure surveys.

7.1 Madison River

A somewhat surprising finding for the Madison River is that despite the substantial decline in rainbow trout (Table 7-2 and Figure 2) there is no consistent or obviously related pattern of decline in angler use (Figure 3). Figure 2 shows that since approximately 1990, populations of rainbow trout in the Pine Butte Section of the Upper Madison have dropped by 75 percent. While the rainbow fishery has declined, the substantial brown trout populations appear to remain unimpacted. The combined trout population, while about one-third below the 1983 through 1990 population, still places the Madison among the very top rivers in the state. Perhaps because the Madison River still has abundant trout populations overall, no significant statistical relationship could be found between trout abundance and angler pressure over the period 1982 through 1998. Excluding the spike in increased angler use in 1993 (Figure 3), angler use on the Madison from 1995 through 1997 is remarkably stable.

The data on relatively stable angler use of the Madison River from the DFWP angler surveys is consistent with both data on fishing guide use of the river and data on economic activity in key tourism and recreation associated sectors of the Madison County economy. Table 7-1 shows outfitted use on the Madison River for selected years since 1989 as reported in the Montana Board of Outfitters tally sheets. While outfitted use on the Madison has varied from year to year, there does not appear to be any clear trend downward associated with declines in trout populations on the river. Regression analysis of the outfitted use and trout population data showed no consistent statistically significant relationship between the data.

Table 7-1. Time-series data on outfitted use and trout abundance on the Madison River.

Year	Outfitted Client Days[a]	2 year and older rainbow trout[b]	2 year and older brown trout
1991	6575	696	423
1993	7316	393	573
1994	4556	235	915
1995	7605	175	580
1996	5735	247	445
1997	5984	536	986

[a] Source of outfitted days: Montana Board of Outfitters annual tally sheets

[b] trout populations for Pine Butte Section of Madison River

Data from the U.S. Department of Commerce, Bureau of Economic Analysis for Madison County, Montana shows a clear upward trend in personal income associated with sectors of the economy associate with tourism spending and that would include angler expenditures and guide activity (Figure 4). Overall, the available data provides a consistent picture. Time-series analysis of estimated angler use, guided client days, and economic activity in the county do not show any significant and consistent declines associated with the declines in trout populations on the river. It is still possible that this situation could change and that there is a fairly long lagged response on the part of anglers to changes in fishing quality on the Madison.

7.2 Missouri River

By contrast with the Madison River, on the Missouri Holter-Cascade section whirling disease is just beginning to show up. To date there are no observable whirling disease-related declines to date in catchable size trout. However, that may soon change as whirling disease has been identified recently in some spawning tributaries. The 1998 pressure estimate derived from the postcard survey provides a baseline data point at the beginning of the expected period of whirling disease impacts. If trout populations suffer from this disease in future years, the 1998 angler pressure estimate will be a valuable baseline estimate of use against which angler pressure on an impacted Missouri River trout population can be compared.

Table 7-2. Time series of rainbow trout and brown trout populations in the Pine Butte Section of the Madison River (2 years and older).		
Year	**Rainbow trout per mile**	**Brown trout per mile**
1983	1841	1212
1984	1884	904
1985	1486	567
1986	1241	1090
1987	1416	894
1988	1824	941
1989	1696	1370
1990	1388	592
1991	696	423
1992	604	477
1993	393	573
1994	235	915
1995	175	580
1996	247	445
1997	536	986
1998	562	826

Figure 2.

Madison River - Pine Butte Section, 2 yr old and older Rb and LL trout population estimates per mile: 1978-1998

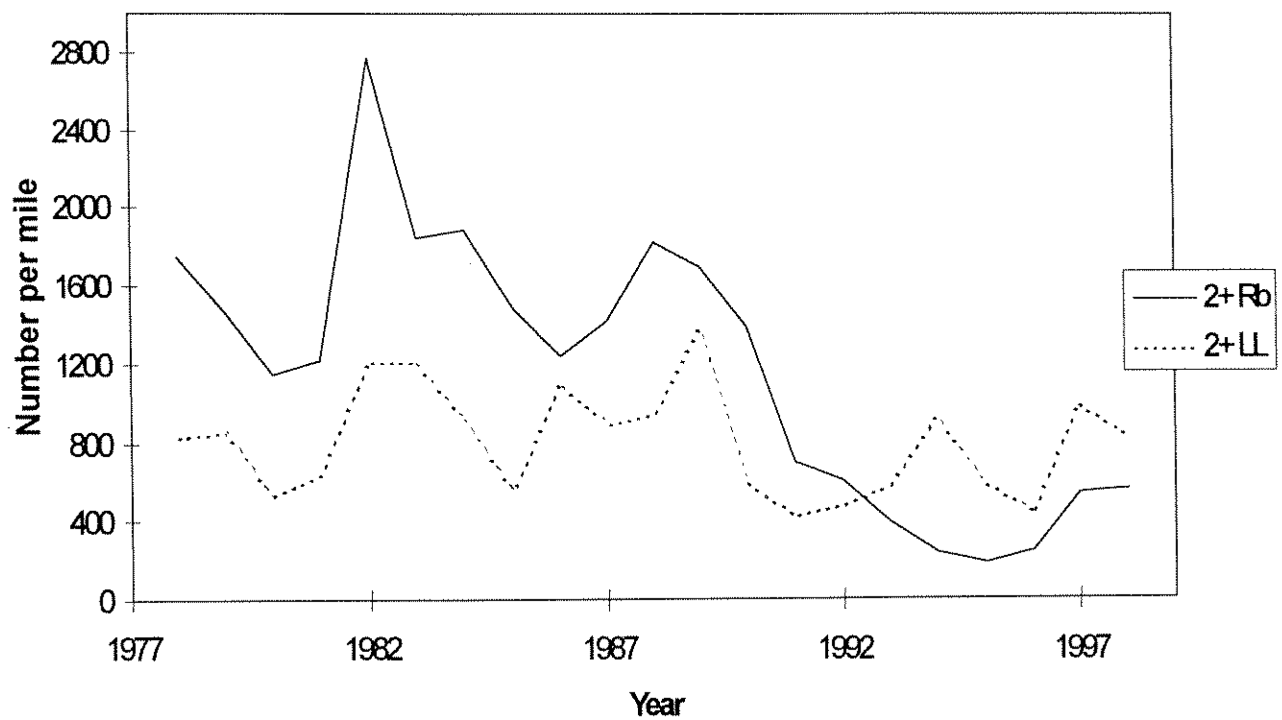


Figure 3.

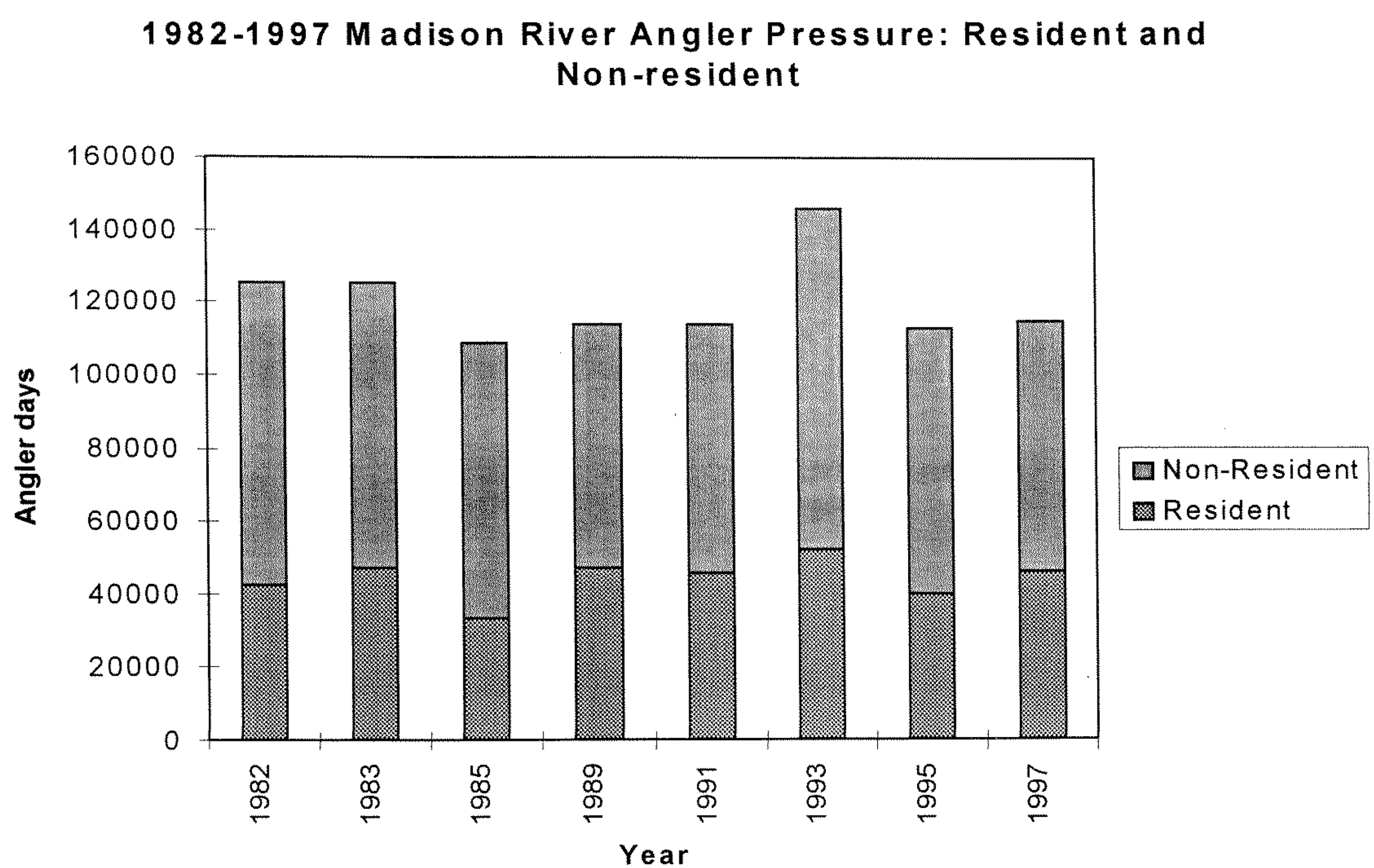
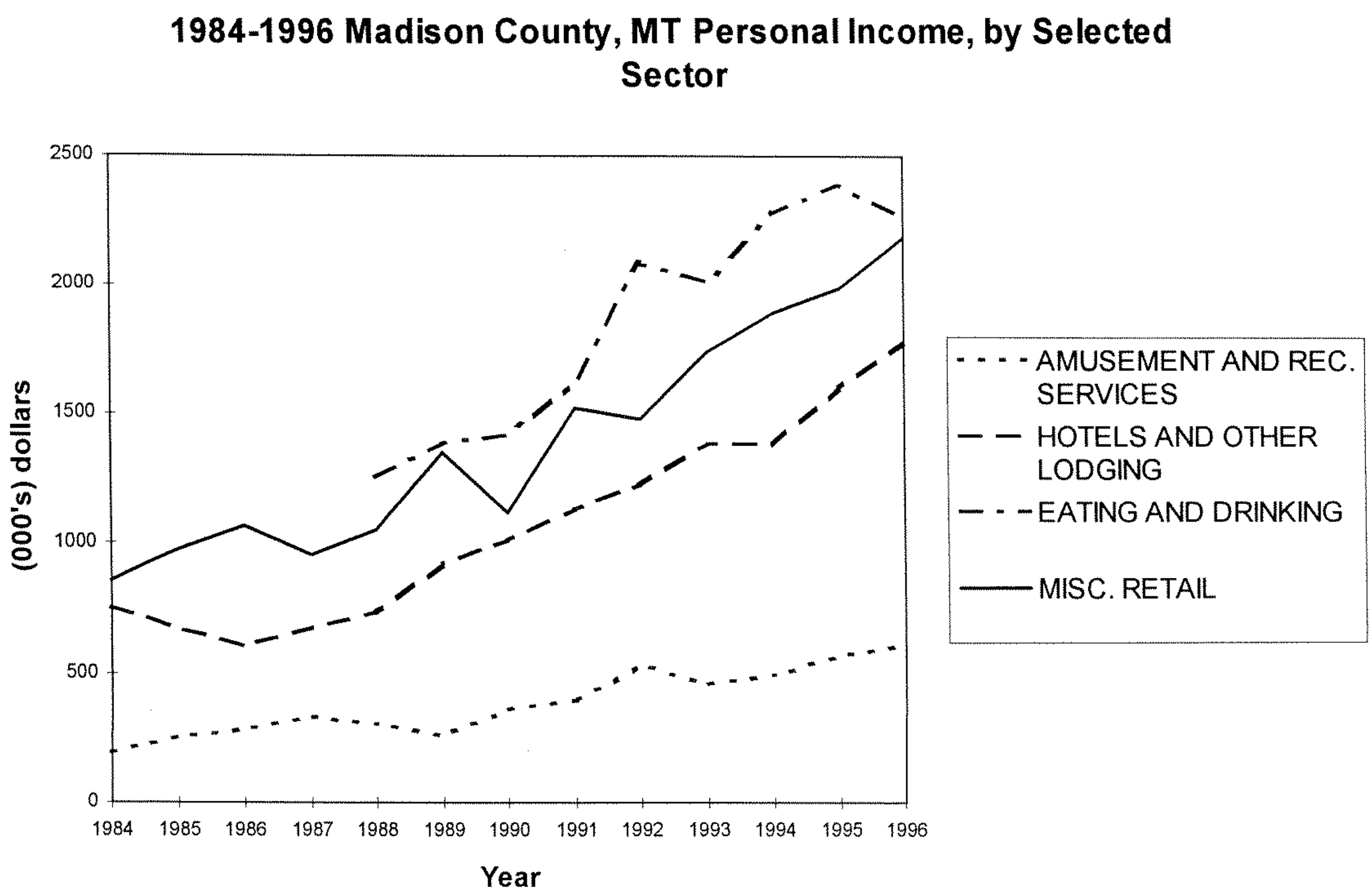

1982-1997 Madison River Angler Pressure: Resident and Non-resident
Angler days
160000
140000
120000
100000
80000
60000
40000
20000
0
1982
1983
1985
1989
1991
1993
1995
1997
Year
Non-Resident
Resident

Figure 4.


1984-1996 Madison County, MT Personal Income, by Selected Sector
2500
2000
1500
1000
500
0
(000's) dollars
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
Year
AMUSEMENT AND REC. SERVICES
HOTELS AND OTHER LODGING
EATING AND DRINKING
MISC. RETAIL

8.0 Regional Economies Surrounding Madison and Missouri River Segments

The potential impact of whirling disease on local economies can occur through two connected relationships: 1) reductions in trout populations affecting angler use and 2) reduced angler use and related expenditures impacting local economies. The degree to which a given local economy would be impacted by reduced local-area angler expenditures depends on the structure of the local economy. A small local economy that is largely dependent on tourist spending would be much harder hit by significant reductions in spending by visiting anglers than would a large diversified local economy.

The Madison River above Ennis Lake is located in the middle of Madison County, MT. Madison County is a small county with a 1997 population of 6,878. In 1997, Madison County had a per capita personal income of $14,983. This is compared to a State of Montana average of $19,660 and a U.S. average of $25,288. In Madison County, the three largest industries in 1997 were services (comprising 21.2% of total earnings), government and government enterprises (22.95% of earnings), and retail trade (16.34% of earnings) (Table 8-1).

The largest community in Madison County is the town of Ennis, MT. Dominant businesses in this town are eating, lodging, guiding, and retail establishments. The "world-class" reputation of the Madison River fishery has led to a substantial portion of the Ennis area economy being tied to tourism. Madison County and the town of Ennis are, due to their economic reliance on visiting angler expenditures, susceptible to suffering economically should Madison River angling, and associated angler spending, significantly drop in the future due to continued impacts of whirling disease. To date, however, no clear evidence of such an economic impact is clear from the angler use, guide use, or economic activity data.

Table 8-1. Industry Breakdown of Earnings for Madison County, MT, 1997		
Industry	Madison County 1997 earnings	Percent of total county earnings
Total Farm	(265)	--
Total Non-farm	48,696	--
Private:	37,521	77.05%
Misc. Ag. and Forestry	D	D
Mining	D	D
Construction	7,787	15.99%
Manufacturing	1,897	3.90%
Transport/Utilities	4,368	8.97%
Wholesale	708	1.45%
Retail	7,957	16.34%
Insurance/Real Estate	2,723	5.59%
Services	10,281	21.11%
Government	11,175	22.95%

Note: D indicates that the amount for the sector is not disclosed in order to protect financial information for companies in very small sectors.

SOURCE: U.S. Dept. of Commerce, Bureau of Economic Analysis, Regional Economic Information System, 1998.

The Missouri River section from Cascade, MT to Holter Dam is located in Cascade and Lewis and Clark Counties, and is between the two major Montana towns of Great Falls and Helena. Lewis and Clark County had a 1997 population of 53,319. The 1997 Cascade County population was 79,039. In 1997, the per capita personal incomes for Cascade and Lewis and Clark Counties were nearly identical at $21,630 and $21,635 respectively. These are compared to a statewide average per capita personal income of $19,660.

The economy's of Lewis and Clark and Cascade Counties are much larger and more diverse than that of Madison County (Table 8-2). The impact, therefore, of whirling disease related reductions in angler spending in the counties would likely have a very small relative impact on total economic activity in the counties. There are, however, small towns located along the Missouri River Cascade to Holter Dam stretch that could suffer to a relatively larger extent in the case of future whirling disease related reductions in angler spending. Towns such as Wolf Creek, Craig, and Cascade would, because of their proximity to the river and small economies that are to a much larger extent geared towards tourist spending, see significant economic impacts from the loss of angler spending.

Table 8-2. Industry Breakdown of Earnings for Lewis & Clark and Cascade Counties, MT, 1997

Industry	Lewis & Clark and Cascade County earnings (1997)	Percent of total counties' earnings
Total Farm	25,137	1.30%
Total Non-farm	1,953,679	98.70%
Private:	1,405,742	72.00%
Misc. Ag. and Forestry	2,487	0.10%
Mining	3,219	0.20%
Construction	125,070	6.40%
Manufacturing	75,604	3.90%
Transport/Utilities	107,645	5.50%
Wholesale	92,590	4.70%
Retail	237,702	12.20%
Insurance/Real Estate	152,482	7.80%
Services	600,439	30.70%
Government	547,937	28.00%

SOURCE: U.S. Dept. of Commerce, Bureau of Economic Analysis, Regional Economic Information System, 1998.

9.0 A Preliminary Review of the Potential Effects of Whirling Disease on Recreational Trout Fisheries In Colorado

9.1 Summary of findings

The threat of whirling disease is not only a biological threat to stocked and wild trout, but potentially a threat to recreational benefits that such fish provide and to the local economies that depend, in part, on trout anglers. Trout angling makes up slightly more than half the angler days in Colorado, so threats to trout fishing can have a significant impact on fishing benefits.

There are 700,000 trout anglers in Colorado taking 4.8 million angler days (Waddington and Laughland, 1996). With average angler expenditures per day of $33 (U.S. Fish and Wildlife Service, 1997) the $158 million in expenditures makes trout fishing in Colorado an important commercial activity in Colorado as well.

Relying on existing data, we purse several strategies to estimate what the potential effect of continued and/or expanded whirling disease would be on Colorado trout fishing. The first approach is to quantify how trout anglers in Colorado respond to changes in catch rate. Whirling disease will likely reduce catch rates directly through fish mortality and reduced reproduction as well through restrictions on stocking. Cross-section regressions across lakes and streams in Colorado found that a 10% decrease in current season catch rates would result in a 5.1% decrease in total angler hours (both boat and bank). For bank anglers only, a 10% decrease in current season catch rates results in a 4.76% decrease in bank angler hours.

The response of angler use to stocking of catchable trout is somewhat less sensitive than overall angler catch rates. In particular, a 10% decrease in the number of catchable trout stocked resulted in a 4.3% decrease in lake angler use and 2.3% decrease in stream angler use. Although we find less than proportionate changes in trout angler use to catch rates and stocking, with 4.8 million angler days, even a 20% decrease in catch would result in a 10% reduction in angler use, which is equal to 480,000 angler days. With average benefits of fishing per day of $42 per day (Waddington, et al.) this 10% loss is a reduction of $20 million dollars in angler benefits. Lost spending would be $15.8 million annually from a 10% reduction in trout angler days.

The second approach is to utilize the few available pre- and post-whirling disease creel census that have been performed in Colorado. Statistical analysis of angler use on several streams and lakes prior to whirling disease and after whirling disease finds no statistically significant decrease in angler use over the 6-8 year period. This may in part be due to large growth in human population in Colorado during this time that off-sets any reduction due to whirling disease. This possibility is corroborated by multivariate regression models which show, accounting for catch rate or stocking, angler use had a statistically significant increases during this time period.

The tentative conclusion from the results of these two research strategies are: (1) whirling disease has the long run potential to reduce angler use and economic benefits by a sizeable amount. The reduction in angler use will be less than proportional than the change in rainbow trout populations. However, the pre- and post-whirling disease creel census does not reveal any absolute reductions in angler use over the last decade. Whether use would have actually increased in absence of whirling disease, is difficult to ascertain, however.

9.2 Purposes of Report

There are four main purposes of this report:
1. To use existing data to summarize what is known about the effect of trout populations, stocking and catch rates on angler visits in Colorado. We also analyze one of the few angler use studies that compares pre-whirling disease vs post-whirling disease.
2. To synthesize the existing data on the economic value of trout fishing in Colorado to the angler.
3. To summarize the available data on angler expenditures in Colorado that may be at risk from whirling disease.

4. To contribute to a comparison with the more detailed, primary data analysis of similar concerns in Montana.

The basic premise of this study is that analysis of recent data can inform managers about the potential benefits to anglers and businesses in Colorado from reducing the effects of whirling disease. The foundation of this analysis, is how angler use responds to changes in trout populations. If angler use is sensitive to reductions in trout populations brought about by whirling disease then the economic losses to anglers themselves and the economies that depend on anglers will suffer as well.

9.3. A Brief Introduction to Whirling Disease in Colorado

Whirling disease is believed to have been introduced into Colorado in the 1980's. This disease is found in 13 of Colorado's 15 major river drainages including the Colorado, South Platte, Gunnison, Arkansas and Rio Grande (Satterfield, 1995). Whirling disease primarily affects rainbow trout, which are stocked by Colorado Division of Wildlife in large numbers. Eight of Colorado Division of Wildlife trout hatcheries have tested positive for whirling disease and 90% of the states annual production of 5 million catchable trout may be whirling disease suspect (Satterfield, 1995). As a result, the allocation of stocked fish has been altered to avoid stocking whirling disease suspect fish in streams that are currently whirling disease free. While this will help to avoid the spread of the disease, it will change trout abundance, reducing it at whirling disease free waters no longer stocked, but increasing fish at other waters receiving the additional fish. Further, since whirling disease primarily affects young fish, it may be several years before population of adult fish reflect the decline in younger fish.

9.4. Estimating the Potential Effects of Whirling Disease on Recreational Trout Angling

A. Literature Review of Effects of Catch Rates on Angler Use

We begin with a broad literature review. Generally speaking there are numerous studies that find a statistically significant link between angler catch rates (of all fish, stocked and natural) and visitation. For example, Loomis and Cooper's (1990) study of trout fishing on the North Fork of the Feather River in California found that a 1% change in trout catch rates resulted in 0.41% to 0.83% increases in number of fishing trips during the years 1981-1985. For steelhead fishing in Idaho and Oregon, a 1% increase in steelhead catch rates result in 0.524% and 0.32% increase in angler trips, respectively (Loomis, 1992). Johnson and Walsh (1987) found that one additional fish caught per day at Blue Mesa Reservoir in Colorado would increase annual angler days by 0.46. Fish catch explained just 10% of the total variation in number of angler days. Size of fish had a larger effect on increasing angler days and slightly higher explanatory power than number of fish caught.

As can be seen in all of these empirical studies, there is a much less than proportionate relationship between changes in angler catch rates and number of trips. The relationship between the percent change in angler catch rates and percent change in visitation is defined in economics as an elasticity. A relationship is said to be quite responsive or elastic if a one percent change in a given variable (e.g., price or catch rates) results in more than a 1% change in quantity of use (e.g., angler days, trips). The opposite case of a relatively unresponsive relationship or inelastic relationship occurs when a 1% change in a given variable leads to less than a 1% change in quantity of use. This is the case for trips in response to catch rates.

Perhaps this less than proportionate relationship between fish catch rates and angler use should not be surprising. There are at least two reasons to suspect the relationship would be less than proportionate. First, is the economic concept of diminishing marginal returns or diminishing marginal utility. Each additional unit of any non-addictive good results in smaller and smaller increases in enjoyment and satisfaction. For example, the second cup of tea in the morning probably adds less enjoyment than the first cup. The same is true for fishing. While the first fish caught adds a great deal to the enjoyment of a fishing trip, each additional fish adds less and less enjoyment than the previous fish caught. Therefore, increases in fish stocking, will stimulate smaller and smaller increases in fishing trips as anglers become satiated. This is one reason demand curves for nearly all goods slope downward.

The second reason for less than a proportionate response of angler use to fish catch comes from the literature on the multiple motivations for fishing. As illustrated by the research of Harris and Bergersen (1985), many anglers place greater emphasis on being in the out of doors in areas of high scenic beauty and opportunities for solitude than they do on catching their limit. The Harris and Bergersen survey of Colorado anglers also found that not only was catching your limit ranked only 9th in importance rating, but that "Catching trout not raised in hatcheries" rated 8th. Other objectives of anglers include catching large fish rather than catching many smaller fish. Ten years later another survey of Colorado anglers found that 70% preferred to fish for wild trout in streams rather than stocked trout in streams (Standage Market Research, 1994).

B. Angler Hours Response to Current Season Catch Rates in Colorado

Given that our analysis is limited to the available data, one comprehensive model applicable to all waters in Colorado where there is angler census data is a rather simple model:

(1) $(\ln AnglerHours_{ij}) = Bo - B1(\ln FISHCATCH_{ij})$

where:

$\ln AnglerHours_{ij}$ = number of angler hours at site i using fishing mode j, where j is bank or boat.

$\ln FISHCATCH_{ij}$ = current catch this season at site i, using fishing mode j

Since the functional form of this model is double log, B1 can be interpreted as an elasticity. Also we can compute the 95% confidence interval around this elasticity as:

(2) $95\%CI = B1 \pm 1.96*\text{Std. Error}$

Based on the previous literature we hypothesize that:

(3) Ho: $1 > B1 > 0$

Data Sources

Data to estimate equation (1) and to test the hypothesis in equation (3) comes from compilation of Colorado Department of Wildlife's (CDOW) angler counts and creel census from 1977 to 1994. This data set contains 784 observations. It includes waters that are not stocked (including wild trout waters) as well as waters that are occasionally stocked with rainbow trout.

C. Angler Use Response to Trout Stocking in Colorado

To test whether angler effort is sensitive to the level of trout stocking, we use a cross-sectional approach. This analyzes whether there is any systematic variation in the level of visitation across sites that is due to different stocking levels at those sites. This is carried out by regressing angler use from creel census information collected at a variety of stocked waters in Colorado against seasonal fish stocking at these same waters. Each site i is a unit of observation in this model. In many cases we have 1-2 years of previous observations of stocking and angler use so we can test for the significance of lags in this model as well.

The model that pools data across streams and lakes is of the form:

(4) $(AnglerUse_{ij}) = Ao - A1(CURRENTCATABLES_i) + A2(PREVSUB_i) + A3(LAKE)$

where:
Angler Use_{ij}= number of anglers or angler hours at site i using fishing mode j, where j is bank or boat.
$CURRENTCATCHABLES_i$ = number of catchable coldwater fish stocked at site i in the current year.
$PREVSUB_i$= number of subcatchable coldwater fish stocked at site i in the previous year.
LAKE= 1 if water is a lake, zero if stream.

This basic model results in two variations of the dependent variable:
(a) anglers, measured as total number of anglers visiting the particular water over the season (labeled **Total Bank Anglers** or **Total Boat Anglers**)
(b) angler use, measured as total hours over the season (labeled **Total Angler Hours**)
Given the data, this results in 7 distinct regressions: two models which pool data from lakes and streams, two for just streams only and three for lakes. Lakes have more models since there were sufficient number of observations of boaters at lakes to estimate a separate boating model.

Due to the presence of frequent zero values for stocking, log transformations are not possible. Therefore the 7 models are estimated in linear form. To calculate the elasticity of angler use with respect to stocking, we relied upon a formula for the elasticity (E) from a linear regression model: E = Slope coefficient* (mean of the independent variable/mean of the dependent variable), see Loomis and Walsh (1997) for more details.

1. Hypotheses
We test whether the number of catchable trout planted in the current year and subcatchable trout planted in the previous year has any systematic effect of **number of anglers** or **angler hours** of effort. Referencing regression equation (4), the null and alternative hypotheses are:
(5) Ho: $A1(CURRENTCATCHABLES_i)=0$ vs Ha: $A1(CURRENTCATCHABLES_i) > 0$
(6) Ho: $A2(PREVSUB_i)=0$ vs Ha: $A2(PREVSUB_i) > 0$

2. Testing Stocking Elasticities
If the null hypotheses are rejected in favor of the alternative hypotheses of statistically significant positive relationships, then testing the next set of hypotheses regarding the magnitude of the relationship is in order.

The null hypotheses is that there is a proportionate relationship between number of anglers or angler hours and fish stocking in equation (1). In particular:
(7) Ho: $F_{anglers}ed=1$ vs Ha: $F_{anglers}ed<1$
(8) Ho: $F_{hours}ed=1$ vs Ha: $F_{hours}ed<1$

where $F_{anglers}ed$ and $F_{hours}ed$ is the elasticity of number of anglers and angler hours, respectively, to fish stocking levels. This is calculated by A1* (mean CURRENTCAT/mean of the dependent variable).

This can be statistically tested by calculating the 95% confidence interval around the calculated elasticity to see if it includes one or not. If the 95% confidence interval is less than one, we would reject a proportionate relationship between stocking and angler use.

3. Data Sources

Examining the relationship between stocking and angler use, involved matching creel census information for specific waters and stocking information specific to that water. This information was available in two databases, the first database contained the census information collected by the CDOW and the second database contained the stocking by each water. Both of these databases were sorted by the CDOW's five digit water code, allowing for the integration of these two databases.

The first step to combining these two databases was to screen the fish stocking to only those dates matching the years of the angler use census. It was decided to use the catchable and subcatchable fish stocked in the same year as the census, the year previous to the census, and two years prior to the census for subcatchables. Further, this analysis only examined coldwater fishing and therefore the bodies of water which were primarily stocked with warmwater fish were not considered.

The next step was to combine the number of fish stocked in the current year, the previous year, and two years prior with the corresponding creel census information. Not all waters with census information had stocking for every year. If there was no stocking in one or more years then a zero was entered. This was done because it was not a case of missing data but rather the zero represents valuable data: CDOW did not stock that water body in those years. Our dataset included 168 observations for coldwater streams and 45 for coldwater lakes, for a total of 213 observations in the pooled dataset. This data reflects over 100 different water bodies throughout Colorado and a sampling of years from 1980 to 1994.

There are several alternative measures of angler use. **Total bank anglers** or **total boat anglers** are the seasonal estimates from CDOW for that water body, for that fishing mode, based on the days sampled. The total seasonal estimate represents an expansion based on the number of fishing hours surveyed relative to the total fishing hours for the season. The total fishing hours for the season accounts for the length of time the water is accessible (e.g., not frozen over, trail not snowed over) as well as the amount sunlight fishing hours received by the site (e.g., if in a narrow canyon, there are fewer hours of direct sunlight). We estimated seven regressions that reflect combinations of fishing mode (boat versus bank for lakes) and definitions of the dependent variable. We also pooled the lake and stream data while including a intercept shift variable for lake (coded as 1).

D. Angler Hours Pre- and Post Whirling Disease on Rivers and Lakes in Colorado

Another approach to investigating the effect of whirling disease on angler use of rivers and lakes is to compare use prior to (e.g., 1989) and after whirling disease (e.g., 1997). Such a dataset has been compiled by CDOW. Two rivers (Clear Creek and Big Thompson) representing six separate segments were surveyed in 1989 and again in 1997. Six lakes were surveyed prewhirling disease (e.g., 1990-1994) and then post-whirling disease (e.g., 1997). The effect of whirling disease can be manifested in two ways: (a) reduced or eliminated stocking of rainbow trout; (b) reduced rainbow trout production.

Given the available data three model specifications were estimated for rivers and for lakes. The two lake models were:
(9) Log(Angler Hours per Surface Acre)= Bo+B1(Log(Catch per Surface Acre)) + B2(YEAR)
(10) Log(Total Angler Hours) = Bo+B1(Log(Trout Stocking))+ B2(YEAR)
(11) Total Angler Hours= Bo+ B1(YEAR)

where YEAR equals zero if the data was collected prior to whirling disease and one if angler use data was collected after whirling disease. Thus YEAR serves as a shift variable to test whether, other things remaining equal, use has fallen with whirling disease or reduced stocking due to concerns about whirling disease.

Three River models were estimated:
(12) Log(Angler Hours per River Mile)= Bo+B1(Log(Catch per Mile))+ B2(YEAR)
(13) Log(Total Angler Hours)=Bo+B1(Log(Catch per Mile))+ B2(YEAR)+B3(River Miles)
(14) Total Angler Hours= Bo+ B1(YEAR)

<u>Hypotheses</u>
If Whirling Disease is reducing angler use, one would expect that YEAR would be negative, especially if it were the only variable as in equations (11) and (14). Thus the null and alternative hypotheses are:
(15) Ho:B2(YEAR) = 0; vs Ha:B2(YEAR) $<$ 0

Equations (9), (10), (12), (14), test whether whirling disease was perceived by anglers as reducing the quality such that even accounting for catch (lakes and rivers) or stocking (lakes), use went down. The null and alternative hypotheses are identical to equation (15).

D. Urban Fishery

CDOW also suggested that evaluation of two Denver lakes, might provide some data for evaluating the effect of trout stocking on angler use in an urban setting. We obtained Federal Aid reports from Bill Babcock. Unfortunately, the level of data on stocking and angler use was incompatible. While daily stocking records were kept, angler use data is not reported on a daily basis. For Main Lake it is presented on an annual basis for just 1980. At Smith Lake, there is monthly use data, but the only recorded plants took place in the month before the angler use data and the first month of the angler use data. Thus, there is one data point on stocking and six data points on angler use. Given the mis-match between reported angler use and stocking data, no statistical analysis is possible.

E. Arkansas River

Arkansas river was suggested as a possible site where several years of creel census, angler use and trout population data were available. After obtaining the Federal Aid reports of Barry Nehring, we did find four years worth of angler data. However, as shown below, the length of the survey period, and/or the method of survey was different in every year. Since data is only reported on a total annual aggregate , this makes pooling the data across years to statistically test for any trend impossible. Any result obtained could be due to real changes or simply from changes in the length of time sampled or method used. Therefore no formal modeling of this was possible. The problematic data collection pattern is presented below:

ARKANSAS RIVER DATA COLLECTION SAMPLING PERIOD AND METHOD

YEAR	SURVEY TIME PERIOD	METHOD
1978	July-September	Angler Count/Interview
1979	May-September	Angler Count/Interview
1980	May-October	Angler Count/Interview
1981	June-October	Postcard Method

9.5. Statistical Results

A. Angler Hours Response to Current Season Catch Rates in Colorado

Table 9-1 presents both the overall response of total angler hours to current season catch and the response of bank angler hours to bank catch. The coefficient on current season catch is quite significant in both equations. The estimated elasticities of hours with respect to catch are .51 for total angler hours and .476 for bank anglers. Thus, the null hypothesis is supported, as the elasticities are greater than zero, but less than one (95%CI= .48 to .55 for total angler hours and .43 to .50 for bank anglers). Therefore, whirling disease induced decrease in angler use would be expected with decreases in catch rate, the decrease is far less than proportional. It is worth noting, that while these are simple models, their explanatory power is quite good for pooled cross-section, time-series models. The model of bank angling hours explains 45% of the variation in bank angler hours, while the other model explains 48% of the variation in total angler hours.

B. Angler Use Response to Trout Stocking in Colorado

As summarized in Table 9-2, for the 7 regression models of the form given in equation (4), the number of current catchables had a statistically significant effect in all 7, while the number of subcatchables was only significant in 1 of the 7. Note that we also tested longer lags in terms of stocking of catchables in the previous year and stocking of subcatchables two years earlier. These two longer lag variables were not significant predictors in combination with the current levels for the total bank anglers and total angler hours in the pooled model regression.

In terms of our hypotheses, the level of stocking of catchable trout does have a statistically significant effect on the total number of anglers visiting a stream and lake over the season as well as total angler hours. Thus reductions in stocking due to whirling disease will have a statistically significant effect on angler use.

Since the catchable trout variables are statistically significant we can calculate the elasticity of number of anglers and angler hours with respect to catchable trout. These elasticities are summarized in Table 9-3. In general we reject the null hypotheses of proportional relationship (elasticity =1) and accept the alternate hypothesis that the elasticity is less than one. As can be seen in Table 9-3, five out of seven of the upper 95% confidence interval on the elasticity of stocking are less than one, indicating a less than proportionate relationship between stocking and angler use. The mean estimates of the elasticities are well below one and for everything but lakes, average around .25. This means a 10% reduction in stocking would result in a 2.5% decrease in angler days. Thus, while angler use will fall in response to reduced stocking levels due to whirling disease, the reduction in angler use will generally be less than proportional to the reduction in stocking.

For the models which pool data across lakes and streams, bank anglers elasticity of demand is 0.285 for number of anglers and 0.284 for total hours. This means that a 1% change in the number of catchable trout planted results in a 0.28% change in number of anglers and angler hours. This would be classified by economists as being in the inelastic or relatively insensitive range. However, anglers fishing lakes from the bank appear more responsive to levels of stocking. Number of bank anglers and bank angler hours at *lakes* decreases by 0.489% and 0.427%, respectively, for every one percent decrease in catchable trout stocked. Lake boat anglers are less responsive, with a 1% decrease in stocked trout resulting in only a 0.21% change in number of anglers fishing from a boat. Thus it appears that bank anglers will reduce their numbers more rapidly in response to whirling disease induced reductions in rainbow trout stocking than would lake boat anglers.

Due to using available visitation data which aggregates all types of anglers together, we cannot estimate the differential effect that reduced stocking has on different types of anglers. While there is a small net overall effect, for some types/styles of fishing or angler motivations, there may be a large drop in use due to whirling disease, while other types of anglers may reduce their fishing only by a small amount. However, to determine the differential effect on various types of anglers of whirling disease requires surveys that stratify and track angler types or motivations.

C. Angler Hours Pre- and Post Whirling Disease on Rivers and Lakes in Colorado

Table 9-4 presents the results of the analysis of angler use pre and post whirling disease at lakes and rivers. In Table 9-4 we see that the YEAR dummy variable by itself, would have us accept the null hypothesis that there is no difference between angler hours before and after whirling disease. When we control for stocking in lakes, YEAR has a positive and significant effect on total angler hours ($p=.0000$). When we control for catch rate, there is a positive effect of time on angler hours per surface acres ($p=.02$). In the case of rivers, controlling for catch per mile, total angler hours and angler hours per mile also increases since whirling disease, although both are significant at only the .1 level. It is quite possible that with the significant population growth along the front range of Colorado, the underlying increase in angler numbers is masking the effect of whirling disease in these before vs after comparisons.

9.6. Economic Value of Trout Fishing in Colorado

The benefits to the anglers of fishing is measured as their willingness to pay over and above their existing cost, not their expenditures. Measuring benefits using willingness to pay (WTP) is the conceptually correct measure of benefits (Sassone and Schaffer, 1978)) and is the currently accepted norm among Federal agencies for benefit-cost analysis (U.S. Water Resources Council, 1979, 1983) and Natural Resource Damage Assessment (U.S. Department of Interior, 1986, 1994).

There are two techniques to measure the economic benefits of fishing: Contingent Valuation and the Travel Cost Method. The Travel Cost Method does not use travel costs as a measure of value. Rather, this method uses variation in travel costs of visitors living at different distances from the site as prices and associated number of trips taken as a measure of quantities to statistically trace out a demand curve for recreation to a particular site. From the demand curve the consumer surplus or net WTP for recreation is calculated (Loomis and Walsh, 1997).

Contingent Valuation Method

The contingent value method (CVM) is a survey technique that constructs a hypothetical market to measure willingness to pay or accept compensation for different levels of fishing quality. The method involves in-person or telephone interviews or a mail questionnaire. CVM is capable of measuring the value of fishing under alternative levels of trout abundance, crowding, instream flow, etc. The basic notion of CVM is that a realistic but hypothetical market for "buying" use and/or preservation of a nonmarketed natural resource can be credibly communicated to an individual. Then the individual is told to use the market to express his or her valuation of the resource. Key features of the market include: (1) description of the resource being preserved; (2) means of payment (often called payment vehicle) and (3) the value elicitation procedure.

The U.S. Fish and Wildlife Service used CVM to estimate the value of trout fishing in Colorado (Waddington, et al., 1994). They calculated an average value of $42 per day of trout fishing. This value is considerably higher than Walsh, et al. (1980), estimated the average value of trout fishing on rivers and streams in Colorado at $12.

9.7. State Economic Impact of Trout Fishing in Colorado

The 1996 U.S. Fish and Wildlife Service, National Survey of Fishing, Hunting and Wildlife Associated Recreation provides estimates of the trip related expenditures for fishing in Colorado. The anglers spend an average of $33 per day. Of this amount, $14 is for food/lodging, $11 is for transportation to and from the site and $8 is for miscellaneous expenses. Given the 4.8 million trout angler days in Colorado the $33 per day translates into about $158 million in expenditures annually in Colorado related to trout fishing. While not all of this expenditures is retained as value added in Colorado, the portion that is results in a multiplier effect as well. It is beyond the scope of this study to estimate such a multiplier effect. However, the Montana analysis will perform the necessary input-out modeling to estimate multiplier effects in Montana.

9.8. Conclusion

The threat of whirling disease is not only a biological threat to stocked and wild trout, but potentially a threat to recreational benefits that such fish provide and to the local economies that depend, in part, on trout fishing. Trout fishing makes up slightly more than half the angler days in Colorado, so threats to trout fishing can have a significant impact on fishing benefits. There are 700,000 trout anglers in Colorado taking 4.8 million angler days (Waddington and Laughland, 1996). With average angler expenditures per day of $33 (U.S. Fish and Wildlife Service, 1997) the $158 million in expenditures makes trout fishing in Colorado an important commercial activity in Colorado as well.

Relying on existing data, we used two strategies to estimate what the potential effect of continued and/or expanded whirling disease would be on Colorado trout fishing. The first approach quantified how trout anglers in Colorado respond to changes in catch rate. Whirling disease will likely reduce catch rates directly through fish mortality and reduced reproduction as well through restrictions on stocking. Cross-section regressions across lakes and streams in Colorado found that a 10% decrease in current season catch rates would result in a 5.1% decrease in total angler hours (both boat and bank). For bank anglers only, a 10% decrease in current season catch rates results in a 4.76% decrease in bank angler hours. The response of angler use to stocking of catchables is somewhat less sensitive than overall angler catch rates. In particular, a 10% decrease in the number of catchable trout stocked resulted in a 4.3% decrease in lake angler use and 2.3% decrease in stream angler use.

Although we find less than proportionate changes in trout angler use to catch rates and stocking, with 4.8 million angler days, even a 20% decrease in catch would result in a 10% reduction in angler use, which is equal to 480,000 angler days. With average benefits of fishing per day of $42 per day (Waddington, et al.) this 10% loss is a reduction of $20 million dollars in angler benefits. Lost spending would be $15.8 million annually from a 10% reduction in trout angler days.

The second approach utilized the few available pre- and post-whirling disease creel census that have been performed in Colorado. Statistical analysis of angler use on several streams and lakes prior to whirling disease and after whirling disease finds no statistically significant decrease in angler use over the 6-8 year period. This may in part be due to large growth in human population in Colorado during this time that off-sets any reduction due to whirling disease. This possibility is corroborated by multivariate regression models which show, accounting for catch rate or stocking, angler use had a statistically significant increases during this time period.

The tentative conclusion from the results of these two research strategies is: whirling disease has the long run potential to reduce angler use and economic benefits by a sizeable amount. The reduction in angler use will be less than proportional than the change in rainbow trout populations. However, the pre- and post-whirling disease creel census does not reveal any absolute reductions in angler use over the last decade. Whether use would have actually increased in absence of whirling disease, is difficult to ascertain, however, without primary survey data. Thus, more precise estimates of the effect of whirling disease on different types of anglers in Colorado will likely take primary data collection through surveys. This may be worthwhile if this problem is expected to persist in Colorado.

Table 9-1. Effect of Catch on Angler Hours in Colorado: 1977-1994				
Variable / Statistic	Log(Total Angler Hours)		Log(Total Bank Angler Hours)	
	Coefficient	T-Statistic	Coefficient	T-statistic
Constant	4.85	29.43	5.07	31.97
log(Current Season Catch)	0.5138	27.12	0.4764	25.29
R square	0.484		0.45	
Sample Size	784		784	

Table 9-2. Summary of Coefficients and T-Statistics on Trout Stocking and Angler Use

Dependent Variable	Current catchables Sample	Coeff.	T-statistic	Previous subcatchables Coeff.	T-statistic	R^2
Total bank anglers	Stream	.357	3.352[c]	-.001	-.567	.065
Total angler hours	Stream	.353	3.253[c]	-.001	-.57	.061
Total bank anglers	Lake	.965	5.277[c]	-.017	-1.075	.404
Total boat anglers	Lake	.12	1.754[a]	.015	2.479[b]	.250
Total angler hours	Lake	1.085	4.915[c]	-.002	-.117	.393
Total bank anglers	Pooled	.535	5.941[c]	-.001	-.641	.240
Total angler hours	Pooled	.592	6.107[c]	-.001	-.371	.305

a, b, c indicate significant at the .1, .05 and .01 levels, respectively.
Total bank (boat) = the total number of people fishing from the bank (boat) during the survey period -- this is a CDOW estimated number.
Total hours = the total hours of angling during the survey period -- this is a CDOW estimated number.
Stream = a sample with only coldwater streams, N=168; **lake** = a sample with only coldwater lakes, N=45; **pooled** = a sample with both coldwater streams and lakes, N=213.

Table 9-3. Summary of Elasticity of Anglers and Hours to Stocking of Trout in Colorado

Dependent Variable	Sample	Mean Elasticity Current catchables	Upper 95% CI
Total bank anglers	Stream	.236	.891
Total angler hours	Stream	.230	.858
Total bank anglers	Lake	.489	1.26
Total boat anglers	Lake	.213	.706
Total angler hours	Lake	.427	1.06
Total bank anglers	Pooled	.285	.946
Total anglers hours	Pooled	.284	.923

Total bank (boat) = the total number of people fishing from the bank (boat) during the survey period.,
Total hours = the total hours of angling during the survey period.
Stream = a sample with only coldwater streams, N=168; lake = a sample with only coldwater lakes, N=45; pooled = a sample with both coldwater streams and lakes, N=213.

Table 9-4. Results of Pre- and Post Whirling Disease Angler Use at Lakes and Rivers

Dependent Variable	Sample	Log of catch or stocking		Log of water body size		Year		R^2
		Coeff.	T-stat	Coeff.	T-stat	Coeff.	T-stat	
Total angler hours	Rivers	--	--	--	--	-994.37	-0.22	.01
Log angler hours/mile	Rivers	0.911	6.06	--	--	0.553	2.01	.80
Log Total angler hours	Rivers	1.01	6.86	0.246	3.98	0.611	2.44	.86
Total angler hours	Lake	--	--	--	--	5555.1	0.94	.06
Log angler hours/acre	Lake	0.623	8.62	--	--	0.67	2.63	.86
Log Total angler hours	Lake	1.005	7.95	--	--	1.41	6.53	.84

10.0 Conclusions

To date there is little in the way of solid examples that fishery economists can point to in either Colorado or Montana to show that whirling disease has heavily impacted a given local economy. Certainly in Colorado the direct expenses associated with limiting or eliminating whirling disease in hatcheries are the obvious major kind of costs. Nonetheless, the potential for major impact on anglers and local communities is certainly there in both states and, unfortunately, may well be realized in coming years. With hindsight, the Madison may prove to be a special case due to the existence of a substantial brown trout fishery, or due also in part to the special mystique of this river (or its proximity to Yellowstone National Park as a magnet for nonresidents). The extensive economics literature as well as the simple cross-sectional models (angler pressure on biomass or catch rates) indicate that generally one would expect a considerable, though less than proportional, response to changes in fish populations. However, even if a given fishery is heavily impacted, substitution among sites on the part of anglers is an offsetting factor that may be important from the standpoint of maintaining total regional fishing pressure.

References

Bennett, J., B. Nehring, D. Krieger, L. Harris and T. Nesler. (1996). An Assessment of Fishery Management and Fish Production Alternatives to Reduce the Impact of Whirling Disease in Colorado. Colorado Division of Wildlife, Denver, CO.

Desvousges, William and Steve Waters. 1995. Report on Potential Economic Losses Associated with Recreation Services in the Upper Clark Fork River Basin. Triangle Economic Research.

Duffield, John and Stewart Allen. 1988. Contingent Valuation of Montana Trout Fishing by River and Angler Subgroup. Montana Department of Fish, Wildlife and Parks.

Duffield, John and Thomas Brown. 1995. "Testing Part-Whole Valuation Effects in Contingent Valuation of Instream Flow Protection". 31 Water Resources Research (9):2341-2351 (September).

Duffield, John, John Loomis and Rob Brooks. 1987. The Net Economic Value of Fishing in Montana. Montana Department of Fish, Wildlife and Parks, Helena.

Duffield, John, Chris Neher and Thomas Brown. 1992. "Recreation Benefits of Instream Flow: Application to Montana's Big Hole and Bitterroot Rivers", Water Resources Research Vol. 28, No. 9, pages 2169-2181, September.

Duffield, John and David Patterson. 1991. "Inference and Optimal Design for a Welfare Measure in Dichotomous Choice Contingent Valuation". Land Economics 67(2):225-239 (May).

Duffield, J., J. Loomis and R. Brooks. (1987). The Net Economic Value of Fishing in Montana. Montana Department of Fish, Wildlife and Parks. Bozeman, MT.

Hagler Bailly Consulting, Inc. 1995. Revised Report and Rebuttal: Assessment of Damages to Anglers and Other Recreators from Injuries to the Upper Clark Fork River Basin. Helena: State of Montana Natural Resource Damage Program.

Harris, Charles and Eric Bergersen. (1985). Survey on Demand for Sport Fisheries. North American Journal of Fisheries Management 5,400-410.

Johnson, Donn, Robert Behnke, David Harpman and Richard Walsh. (1995). Economic Benefits and Costs of Stocking Catchable Rainbow Trout: A Synthesis of Economic Analysis in Colorado. North American Journal of Fisheries Management 15, 400-410.

Johnson, Donn and Richard Walsh. (1987). Economic Benefits and Costs of the Fish Stocking Program at Blue Mesa Reservoir, Colorado. Colorado Water Resources Research Institute Technical Report 49. Colorado State University, Fort Collins, CO.

Loomis, J. and J. Cooper. (1990). Comparison of Environmental Quality Induced Demand Shifts Using Time Series and Cross Section Data. Western Journal of Agricultural Economics 15, 83-90.

Loomis, J. (1992). The Evolution of a More Rigorous Approach to Benefit Transfer: Benefit Function Transfer. Water Resources Research 28, 701-705.

Loomis, J. and R. Walsh. (1997). Recreation Economic Decisions. 2nd Edition. Venture Press, State College PA.

Malvestuto, S.P. 1983. "Sampling the Recreational Fishery" pp. 397-419 in L.A. Nielsen and D.L. Johnson, eds., Fisheries Techniques, Bethesda: American Fisheries Society.

McFarland, Robert. 1995. Montana Statewide Angling Pressure 1993. Helena: Montana Department of Fish, Wildlife and Parks.

Minnesota IMPLAN Group, Inc. 1996. IMPLAN software. Stillwater, MN.

Mitchell, Robert C. and Richard T. Carson. 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington, D.C.: Resources for the Future.

Robson, Douglas S. 1961. "On the Statistical Theory of a Roving Creel Census of Fishermen". Biometrics 17:415-437.

Robson, Douglas S. and Cynthia M. Jones. 1989. "The Theoretical Basis of an Access Site Angler Survey Design". Biometrics 45:83-98.

Sassone, P. and W. Schaffer. 1978. Cost-Benefit Analysis-A Handbook. Academic Press, San Diego, CA.

Satterfield, J. 1995. Whirling Disease Facts, July/August 1995. Colorado Division of Wildlife. Denver, Colorado.

Standage Market Research, Inc. (1994). A Survey of Anglers. Report to the Colorado Division of Wildlife, Denver, CO.

U.S. Department of Interior. Natural Resource Damage Assessments; Final Rule. Federal Register 51. Washington DC. 1986.

U.S. Department of Interior. Natural Resource Damage Assessments; Final Rule. Federal Register 59(58):14261-14288. Washington DC. March 25, 1994.

U.S. Water Resources Council. 1979. Procedures for Evaluation of National Economic Development (NED) Benefits and Costs in Water Resources Planning. Final Rule. Federal Register 44(242):72892-72976. December 14, 1979.

U.S. Water Resources Council. 1983. Economic and environmental principles for water and related land resources implementation studies. Washington, DC.

Vincent, Dick. 1998. Essay. Whirling Disease and Wild Trout: the Montana Experience. American Fisheries Society (http://www.esd.ornl.gov/societies/AFS/whirl-mt.html).

Waddington, D. and A. Laughland. 1996. Trout Fishing in the U.S. Report 91-5. U.S. Fish and Wildlife Service, Washington DC. December 1996.

Waddington, D., K. Boyle and J. Cooper. 1994. 1991 Net economic values for bass and trout fishing, deer hunting and wildlife watching. Report 91-1, Division of Federal Aid, U.S. Fish and Wildlife Service, Washington, DC.

Walsh, R., R. Ericson, D.Arosteguy and M. Hansen. An Empirical Application of a Model for Estimating the Recreation Value of Instream Flow. Colorado Water Resources Institute A-036. Colorado State University, Fort Collins, CO. 1980.

Appendix A: Postcard and Angler Intercept Survey Instruments and Associated Materials

Madison River Intercept Survey 1998

Interview # : ___________ **Date:** ___ / _____ / 98 **Interview time:** _____:____

Day of Week: 1- weekend 2- holiday 3- weekday
River site: _____________

Number of anglers in party _________

Time started fishing _____:_____ **Hours fished** _____:_____ **Time not fishing** _____:_____

Done fishing for the day? 1-yes 2-no ------> **IF NO: What time do you think you will quit fishing today?** ____:____

How long do you think you will be at this access after you quit fishing today?
____Hrs.____Min.

In total, how many days will you fish the Madison River on this trip? _______days

(Record the following for only 1 member of party per survey form)

Type of fishing: 1-boat 2-shore/wade 3-tube

Area Fished: Launch Point (or interview location if shore fishing) _________
Take out point ____________

Guided trip? 1-yes 2-no -------> **IF YES: Guide operates out of** ______________ (town)

Equipment type: 1-lures 2-flies 3-spawn bags
4-other bait (ie. worms) 5-Any combination

Species:

	Rainbow trout	*Brown trout*	*Cutthroat trout*	*Grayling*	*Whitefish*
# Kept					
# Released					
Total #					

How many days have you fished the Madison above Ennis Lake since May 1, 1998? _______days

How many more days do you anticipate you will fish this section between now and September 30th? ________more days (best estimate)

Have you been surveyed in person before on this river since May 1st? ____yes ____no

How satisfied are you on this trip with the number of fish you caught? 1 2 3 4 5

How satisfied are you on this trip with the size of fish you caught? 1 2 3 4 5

Was fishing the Madison River

- ____ the primary purpose of your trip away from home
- ____ one of several things you had planned to do on your trip.
- ____ something you decided to do after being in the area.

During this trip, how much did you personally spend for lodging, travel, food, and other items?

Total spent this trip		Amount spent in local area including Ennis, Cameron, and West Yellowstone
$____________	LODGING (motel, camping, etc.)	$________________
$____________	TRAVEL (gas, air/bus/train fare, etc.)	$________________
$____________	FOOD (restaurant, groceries, etc.)	$________________
$____________	GUIDE FEES	$________________
$____________	OTHER (entrance fees, film, tours, gifts, etc.)	$________________
$____________	TOTAL COSTS	$________________

Of the total expenditures you just listed, what percentage was spent in the State of Montana? ____%

The cost of visiting a river changes over time. For example, gas prices rise and fall. Would you still have made this trip if your share of total cost were [BID AMOUNT] more than the amount you just reported? _____yes _____no

Angler origin: zip code (if US resident) ______________
Country (if not US res) ______________

It is often helpful to know a persons general income level when interpreting survey responses. Could you please look at this card and tell me which letter corresponds with your total before tax household income in 1997? _________

Interviewer note gender. ______ female ________male

Missouri River Intercept Survey 1998

Interview # : ____________ **Date:** ___ / _____ / 98 **Interview time:** _____:____

Day of Week: 1- weekend 2- holiday 3- weekday
River mile: ____. ____

Number of anglers in party _________

Time started fishing _____:_____ **Hours fished** _____:_____ **Time not fishing** ____:_____

Done fishing for the day? 1-yes 2-no ------> **IF NO: What time do you think you will quit fishing today?** ____:____

How long do you think you will be at this access after you quit fishing today?
____Hrs.____Min.

In total, how many days will you fish the Missouri River on this trip? _______days

(Record the following for only 1 member of party)

Type of fishing: 1-boat 2-shore 3-tube

Area Fished: Launch Point (or interview location if shore fishing) __________
Take out point _____________

Guided trip? 1-yes 2-no -------> **IF YES: Guide operates out of** _______________ (town)

Equipment type: 1-lures 2-flies 3-spawn bags
4-other bait (ie. worms) 5-Any combination

Target Species:

	Rainbow trout	***Brown Trout***	***Whitefish***	***Walleye***
# Kept				
# Released				
Total #				

How many days have you fished the Missouri River between Cascade and Holter Dam since May 1, 1998? _______days

How many more days do you anticipate you will fish this section between now and September 30th? ________more days (best estimate)

Have you been surveyed in person before on this river since May 1st? ____yes ____no

How satisfied are you on this trip with the number of fish you caught? 1 2 3 4 5

How satisfied are you on this trip with the size of fish you caught? 1 2 3 4 5

Was fishing the Missouri River

- ____ the primary purpose of your trip away from home
- ____ one of several things you had planned to do on your trip.
- ____ something you decided to do after being in the area.

During this trip, how much did you personally spend for lodging, travel, food, and other items?

Total spent this trip		Amount spent in local area including Wolf Ck., Craig, and Cascade
$______________	LODGING (motel, camping, etc.)	$____________________
$______________	TRAVEL (gas, air/bus/train fare, etc.)	$____________________
$______________	FOOD (restaurant, groceries, etc.)	$____________________
$______________	GUIDE FEES	$____________________
$______________	OTHER (entrance fees, film, tours, gifts, etc.)	$____________________
$______________	TOTAL COSTS	$____________________

Of the total expenditures you just listed, what percentage was spent in the State of Montana? _____%

The cost of visiting a river changes over time. For example, gas prices rise and fall. Would you still have made this trip if your share of total cost were [BID AMOUNT] <u>more</u> than the amount you just reported? _____yes _____no

Angler origin: zip code (if US resident) _______________
Country (if not US res) _______________

It is often helpful to know a persons general income level when interpreting survey responses. Could you please look at this card and tell me which letter corresponds with your total before tax household income in 1997? _________

Interviewer note gender. ______ female ________male

Appendix B: SAS Programing for estimating Madison and Missouri River angler pressure

```
DATA whirl.NEWCARD;
  SET whirl.POST;


IF MONTH IN(5,6,7,8,9);
if code =" ";

IF RIVER=2 THEN DO;
IF MONTH IN(8,9);END;



DATA whirl.STEP2;
 SET whirl.NEWCARD;




/*  ASSIGN A WEEKDAY  WEEKEND VARIABLE  */

IF MONTH=5 THEN DO;
  IF DAY IN(2,3,9,10,16,17,23,24,30,31) THEN WEEKEND=1;
  ELSE WEEKEND=0;
  END;
ELSE
IF MONTH=6 THEN DO;
  IF DAY IN(6,7,13,14,20,21,27,28) THEN WEEKEND=1;
  ELSE WEEKEND=0;
  END;
ELSE
IF MONTH=7 THEN DO;
  IF DAY IN(4,5,11,12,18,19,25,26) THEN WEEKEND=1;
  ELSE WEEKEND=0;
  END;
ELSE
IF MONTH=8 THEN DO;
  IF DAY IN(1,2,8,9,15,16,22,23,29,30) THEN WEEKEND=1;
  ELSE WEEKEND=0;
  END;
ELSE
IF MONTH=9 THEN DO;
  IF DAY IN(5,6,12,13,19,20,26,27) THEN WEEKEND=1;
  ELSE WEEKEND=0;
```

```
  END;

/*  ASSIGN A WAIT TIME FOR EACH UNIQUE RIVER-SITE PAIRING  */


IF RIVER=1 THEN DO;
  IF SITE=1 THEN WAIT=40 ;
  IF SITE=2 THEN WAIT=0 ;
  IF SITE=3 THEN WAIT=40;
  IF SITE=4 THEN WAIT=0 ;
  IF SITE=5 THEN WAIT=40 ;
  IF SITE=6 THEN WAIT=0 ;
  IF SITE=7 THEN WAIT=20 ;
  IF SITE=8 THEN WAIT=0 ;
  IF SITE=9 THEN WAIT=20 ;
  IF SITE=10 THEN WAIT=0 ;
  IF SITE=11 THEN WAIT=20 ;
  IF SITE=12 THEN WAIT=0 ;
  IF SITE=13 THEN WAIT=30 ;
  IF SITE=14 THEN WAIT=0 ;
  IF SITE=15 THEN WAIT=15 ;
  IF SITE=16 THEN WAIT=0 ;
  IF SITE=17 THEN WAIT=25 ;
  IF SITE=18 THEN WAIT=0 ;
  IF SITE=19 THEN WAIT=25 ;
  IF SITE=20 THEN WAIT=30 ;
  IF SITE=21 THEN WAIT=35 ;
  IF SITE=22 THEN WAIT=35 ;
  IF SITE=23 THEN WAIT=30 ;
END;

IF RIVER=2 THEN DO;
  IF SITE=1 THEN WAIT=30 ;
  IF SITE=2 THEN WAIT=40 ;
  IF SITE=3 THEN WAIT=30 ;
  IF SITE=4 THEN WAIT=30 ;
  IF SITE=5 THEN WAIT=40 ;
  IF SITE=6 THEN WAIT=20 ;
  IF SITE=7 THEN WAIT=30 ;
  IF SITE=8 THEN WAIT=0 ;
  IF SITE=9 THEN WAIT=40 ;
  IF SITE=10 THEN WAIT=40 ;
  IF SITE=11 THEN WAIT=20 ;
  IF SITE=12 THEN WAIT=30 ;
```

```
  IF SITE=13 THEN WAIT=0 ;
  IF SITE=14 THEN WAIT=25 ;
  IF SITE=15 THEN WAIT=20 ;
  IF SITE=16 THEN WAIT=20 ;
  IF SITE=17 THEN WAIT=0 ;
  IF SITE=18 THEN WAIT=20 ;

END;


/*  ASSIGN VARIABLES (r,s, AND t) FOR EACH RIVER GROUP   */

IF WEEKEND=1 THEN DO;

IF RIVER=1 THEN DO;   R=11;  S=19;  T=12;   END;
IF RIVER=2 THEN DO;   R=2 ;  S=5;  T=2 ;   END;
END;

IF WEEKEND=0 THEN DO;

IF RIVER=1 THEN DO;   R=18;  S=30;  T=18;   END;
IF RIVER=2 THEN DO;   R=3 ;  S=5;  T=1 ;   END;
END;

IF RIVER=1 THEN DO; DISTRIB=4787; RETURN=1586; VALID=1440;  END;
IF RIVER=2 THEN DO; DISTRIB=620; RETURN=235; VALID=182 ;  END;


/* CALCULATE EFFECTIVE RESPONSE RATE */

RESPONSE=VALID/DISTRIB;


/*  CALCULATE H(1), H(2), H(3), AND H(4) FOR EACH POSTCARD  */

PARK=-9;      PARKH=-9;  PARKM=-9;
LEAVE=-9;     LEAVEH=-9; LEAVEM=-9;


PARKH=HOUR(TIMEPARK);
PARKM=MINUTE(TIMEPARK);
IF AMPMPARK='PM' AND PARKH LT 12 THEN PARKH=PARKH+12;
```

```
LEAVEH=HOUR(TIMEAWAY);
LEAVEM=MINUTE(TIMEAWAY);
IF AMPMAWAY='PM' AND LEAVEH LT 12 THEN LEAVEH=LEAVEH+12;

IF RIVER=1 THEN DO;
IF SERIAL=21 THEN DO; LEAVEH=23;END;
IF SERIAL=55 THEN DO; PARKH=6; END;
IF SERIAL=58 THEN DO; PARKH=6; END;
IF SERIAL=742 THEN DELETE;
IF SERIAL=743 THEN DELETE;
IF SERIAL=4659 THEN DO; LEAVEH=23; END;
IF SERIAL=4660 THEN DO; LEAVEH=23; END;
IF SERIAL=3512 THEN DO; LEAVEH=23; END;
IF SERIAL=3953 THEN DO; PARKH=6;   END;
IF SERIAL=3884 THEN DO; LEAVEH=23; END;
IF SERIAL=3885 THEN DO; LEAVEH=23; PARKH=6; END;
END;

IF RIVER=2 THEN DO;
IF SERIAL=953 THEN DO; LEAVEH=23; PARKH=6;END;
END;



LEAVE=(LEAVEH*60)+LEAVEM;
PARK=(PARKH*60)+PARKM;

IF LEAVE GE 1290 THEN DO;

  IF PARK GT 1080 THEN DO;
H4=1290-PARK;
H3=0;
H2=0;
H1=0;
     END;  ELSE
  IF PARK LE 1080 AND PARK GT 870 THEN DO;
H4=1290-1080;
H3=1080-PARK;
H2=0;
H1=0;
     END;  ELSE
  IF PARK LE 870 AND PARK GT 660 THEN DO;
H4=1290-1080;
H3=1080-870;
```

```
H2=870-PARK;
H1=0;
     END;  ELSE
  IF PARK LE 660 AND PARK GE 450 THEN DO;
H4=1290-1080;
H3=1080-870;
H2=870-660;
H1=660-PARK;
     END;  ELSE
  IF PARK LT 450 THEN DO;
H4=1290-1080;
H3=1080-870;
H2=870-660;
H1=660-450;
     END;
END;

ELSE

IF LEAVE LE 1290 AND LEAVE GT 1080 THEN DO;

  IF PARK GT 1080 THEN DO;
H4=LEAVE-PARK;
H3=0;
H2=0;
H1=0;
     END;  ELSE
  IF PARK LE 1080 AND PARK GT 870 THEN DO;
H4=LEAVE-1080;
H3=1080-PARK;
H2=0;
H1=0;
     END;  ELSE
  IF PARK LE 870 AND PARK GT 660 THEN DO;
H4=LEAVE-1080;
H3=1080-870;
H2=870-PARK;
H1=0;
     END;  ELSE
  IF PARK LE 660 AND PARK GE 450 THEN DO;
H4=LEAVE-1080;
H3=1080-870;
H2=870-660;
H1=660-PARK;
```

```
     END;  ELSE
  IF PARK LT 450 THEN DO;
H4=LEAVE-1080;
H3=1080-870;
H2=870-660;
H1=660-450;
     END;
END;

IF LEAVE LE 1080 AND LEAVE GT 870 THEN DO;

  IF PARK LE 1080 AND PARK GT 870 THEN DO;
H4=0;
H3=LEAVE-PARK;
H2=0;
H1=0;
     END;  ELSE
  IF PARK LE 870 AND PARK GT 660 THEN DO;
H4=0;
H3=LEAVE-870;
H2=870-PARK;
H1=0;
     END;  ELSE
  IF PARK LE 660 AND PARK GE 450 THEN DO;
H4=0;
H3=LEAVE-870;
H2=870-660;
H1=660-PARK;
     END;  ELSE
  IF PARK LT 450 THEN DO;
H4=0;
H3=LEAVE-870;
H2=870-660;
H1=660-450;
     END;
END;
ELSE

IF LEAVE GE 660 AND LEAVE LE 870 THEN DO;

  IF PARK LE 870 AND PARK GT 660 THEN DO;
H4=0;
H3=0;
H2=LEAVE-PARK;
```

```
H1=0;
     END;  ELSE
  IF PARK LE 660 AND PARK GE 450 THEN DO;
H4=0;
H3=0;
H2=LEAVE-660;
H1=660-PARK;
     END;  ELSE
  IF PARK LT 450 THEN DO;
H4=0;
H3=0;
H2=LEAVE-660;
H1=660-450;
     END;
END;
ELSE

IF LEAVE GE 450 AND LEAVE LE 660 THEN DO;

   IF PARK LE 660 AND PARK GE 450 THEN DO;
H4=0;
H3=0;
H2=0;
H1=LEAVE-PARK;
     END;  ELSE
  IF PARK LT 450 THEN DO;
H4=0;
H3=0;
H2=0;
H1=660-450;
     END;
END;




IF H1 GE 0 THEN H1=H1/60;ELSE H1=0;
IF H2 GE 0 THEN H2=H2/60;ELSE H2=0;
IF H3 GE 0 THEN H3=H3/60;ELSE H3=0;
IF H4 GE 0 THEN H4=H4/60;ELSE H4=0;
IF H5 GE 0 THEN H5=H5/60;ELSE H5=0;
```

```
/* CALCULATE TOTAL NUMBER OF ANGLERS PER RESPONSE CARD  */

ANGLERS=ANGLERS;


IF TIMEPARK NE .;
IF AMPMPARK IN('AM','PM');
IF TIMEAWAY NE .;
IF AMPMAWAY IN('AM','PM');

/*  CALCULATION OF CONDITIONAL PROBABILITIES FOR INCLUSION   */

WAIT=WAIT/60;

N=R+S+T;

U=(R+T)/2;


Q1=MIN((H1+H2+WAIT)/7,1);
Q2=MIN((H2+H3+WAIT)/7,1);
Q3=MIN((H3+H4+WAIT)/7,1);

PROB=(U/N)*Q1+(S/N)*Q2+(U/N)*Q3;

IF WEEKEND=1 THEN DO;
IF RIVER=1  THEN SAMPDAY=42;
IF RIVER=2  THEN SAMPDAY=9;
END;

ELSE
IF WEEKEND=0 THEN DO;
IF RIVER=1  THEN SAMPDAY=66;
IF RIVER=2  THEN SAMPDAY=9;
END;

IF WEEKEND=0 THEN TOTDAYS=109  ;ELSE
IF WEEKEND=1 THEN TOTDAYS=44   ;

INVPROB=1/PROB;

DAYANG=(INVPROB*ANGLERS)/response;
```

```
IF RIVER=1  THEN WATER='Missouri River - Holter to Cascade  ';
IF RIVER=2  THEN WATER='Madison River - Ennis Lk. to Hebgen ';



PROC SUMMARY NWAY;
CLASS WEEKEND TOTDAYS RIVER water N SAMPDAY MONTH DAY RESPONSE DISTRIB RETURN VALID;
VARIABLE DAYANG;
OUTPUT OUT=WHIRL.TAUSUBI SUM(DAYANG)=TOTANGDY ;
RUN;

DATA WHIRL.STUFF;
  SET WHIRL.TAUSUBI;

SURVEYED=TOTDAYS/SAMPDAY;


PROC SUMMARY NWAY;
CLASS WEEKEND RIVER water N SURVEYED RESPONSE DISTRIB RETURN VALID TOTDAYS;
VARIABLE TOTANGDY;
OUTPUT OUT=WHIRL.TAU SUM(TOTANGDY)=TOTRIVER;



DATA WHIRL.TAU;
  SET WHIRL.TAU;

TAU=(SURVEYED*TOTRIVER);

RUN;



DATA WHIRL.VAR;
 MERGE WHIRL.TAUSUBI WHIRL.TAU;BY WEEKEND RIVER;



VAR1=(TOTDAYS*TOTANGDY-TAU)**2;



PROC SUMMARY NWAY;
CLASS WEEKEND RIVER N SAMPDAY SURVEYED RESPONSE DISTRIB RETURN VALID TOTDAYS;
```