MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
FISHERIES DIVISION

JOB PROGRESS REPORT

State: MONTANA **Project Title:** STATEWIDE FISHERIES INVESTIGATIONS

Project No: F-46-R-6 **Study Title:** SURVEY AND INVENTORY OF COLDWATER STREAMS

Job. No: I-h **Job Title:** UPPER BIGHORN RIVER INVESTIGATIONS

Project Period: April 1, 1991 - March 31, 1993

ABSTRACT

After abnormally high flows and warm water temperatures in 1991, environmental conditions returned to more normal levels in 1992. Flows fluctuated just under the recommended minimum level of 2,000 cfs during most of the summer, dropping to almost 1,800 cfs for a short time in the spring. Water temperatures warmed slowly during the summer, reaching a maximum temperature of 60°F during late August. Mean summer water temperatures in 1992 were approximately 3° below the long term average.

Angling pressure remained heavy on the Bighorn during 1992 with a large percentage of the anglers coming from out of state. The river ranger contacted over 3,600 anglers and handed out a comprehensive mail-back survey to each. No analysis has been completed on these surveys.

Both brown trout and rainbow trout population estimates in this report were influenced by variations in sampling times and by a change in the mark/recapture analysis conducted. As a result, no direct comparisons of population numbers are made with past data.

Brown trout populations in both shocking sections showed impacts of poor recruitment experienced during the poor flow conditions in 1988 and 1989. Population levels remained in the desirable range, but these populations were dominated by young fish as the weak older year classes worked through the system. Brown trout recruitment appears good since 1989, so population levels should be increasing in the future. High natural mortality rates continued to indicate that environmental factors are more important than angler harvest in controlling trout population levels in the

Bighorn River.

Rainbow trout populations continued to look good in the upper Bighorn River with population levels reaching new record highs in 1991 (based on very limited recapture data). Rainbow populations declined below the desired level in the upper river in 1992, but the overall population looked good with representation from several year classes of fish. Growth rates were excellent providing many "trophy" fish for the angler. Rainbow populations in the lower shocking section declined to record low levels in 1992, but most of this decline was in age 1 rainbow. Most of the young-of-year (YOY) rainbow from the 1991 spawn apparently remained in the upper river not migrating downstream to contribute to the lower section population in 1992.

TABLE OF CONTENTS

PAGE

ABSTRACT 1,2

LIST OF FIGURES 3

LIST OF TABLES 4

OBJECTIVES AND DEGREE OF ATTAINMENT 5,6

PROCEDURES 6-10

RESULTS AND DISCUSSION 10-22

- Stream Flow 10
- Water Temperatures 10
- Gas Supersaturation 12
- Fishing Pressure and River Ranger Survey 12
- Population Estimates 12,13
  - Brown Trout 13-18
    - Standard Section 13-16
    - Lower Section 16,17
    - Summary and Discussion - Brown Trout 17,18
  - Rainbow Trout 18-22
    - Standard Section 18-20
    - Lower Section 20-22
    - Summary and Discussion - Rainbow Trout 22

MANAGEMENT RECOMMENDATIONS 23

LITERATURE CITED 24

LIST OF FIGURES

FIGURE		PAGE
1	Map of the Upper Bighorn River showing location of electrofishing sections.	7
2	Estimated number of brown trout in the standard shocking section in 1991 and 1992 by age groups.	14
3	Estimated number of rainbow trout in the standard shocking section in 1991 and 1992 by age groups.	19
4	Length frequency distribution of rainbow trout collected from the St. Xavier shocking section during one day of survey shocking in December 1991.	21

LIST OF TABLES

TABLE		PAGE
1	Maximum summer water temperature, mean summer water temperature (July-September) and mean daily summer discharge (July-September) at the Afterbay Dam on the Bighorn River during 1966-1992.	11
2	Average length (in) by age class of brown trout from the standard electrofishing section (RM 3.8-8.0)* of the Bighorn River during September 1981-1990, December 1991, June 1992.	16
3	Average length (in) by age class of rainbow trout from the standard electrofishing section (RM 3.8-8.0)* of the Bighorn River during September from 1983-1990, December 1991, and June 1992.	20

OBJECTIVES AND DEGREE OF ATTAINMENT

1. To maintain a year-round minimum flow in the upper Bighorn River of at least 2,000 cfs in eight out of 10 years and at least 2,500 cfs in five out of 10 years.

   Following extremely high flows experienced in 1991, flows remained above 2,500 cfs through mid-February. Discharges slowly declined, dropping below 2,000 cfs on April 15. Flows declined to just over 1,800 cfs through the spring then increased to just under 2,000 cfs through the summer and fall.

2. To eliminate gas bubble trauma as a significant cause of trout mortality.

   Continued to work with the Bureau of Reclamation on this problem. Attended planning meetings to provide fisheries input as the Bureau of Reclamation began reevaluating the problem and some possible solutions.

3. To maintain average population densities of 5,000 to 7,000 age one and older brown trout and at least 500 18-inch and longer brown trout per mile in the Bighorn River upstream of Bighorn Fishing Access Site (FAS), and to maintain 1,500 to 2,500 age one and older brown trout per mile between Bighorn FAS and Two Leggins FAS.

   Brown trout populations in both sections of river continued to show the impacts of low flow conditions experienced in 1988 and 1989. Population densities in the upper river remained slightly above the management objective, but the brown trout population in the lower river remained well below 1,500 fish per mile.

   Numbers of 18" and longer brown trout per mile exceeded our management goal of 500 per mile for the first time in 1991, but these numbers reflected the combined impacts of abnormally warm water temperatures and later than normal sampling. The number of 18" and longer brown trout declined to almost half the management level in 1992. The major cause of this decline was an early sampling date that occurred before the summer growth period.

4. To maintain average population densities of at least 1,000 age one and older rainbow trout and 150 18-inch and longer rainbow trout per mile in the Bighorn River upstream of Bighorn FAS, and to maintain at least 500 age one and older rainbow trout per mile between Bighorn FAS and Two Leggins FAS.

   The rainbow population reached a new record level in the upper Bighorn River in 1991, but low recapture numbers made this

estimate questionable. Rainbow population densities in the upper river declined below the desired management level in 1992. The rainbow population declined to historic low levels in the lower river in 1992. Most of this decline was due to a lack of young fish. Young-of-year rainbow apparently remained in the upper river during the high flows experienced in 1991.

The number of 18" and longer rainbow in the upper Bighorn River exceeded the management goal of 150 per mile by over 5 fold in 1991. This number declined to just over the stated management goal in 1992, but most of this decline was due to an earlier than normal sampling time.

5. To redistribute angler use to achieve use levels of no more than 3,000 angler-days per month above Bighorn FAS and at least 10,000 angler-days annually between Bighorn and Two Leggins FAS (state funded).

   No good pressure estimates were obtained for the Bighorn River in 1992. Angler use appeared to exceed 3,000 angler-days per month during late summer based on comparisons to historic car counter data. Little increased use was documented at the lower fishing access site. Efforts continued to acquire an additional access site between Bighorn Access and Mallards Landing in hopes of redistributing angler use downstream of Bighorn Access.

6. To make at least 750 creel census contacts per year to assess angler success and opinions (state funded).

   Contacted 3,738 angler on the Bighorn River between May 1, 1992 and April 30, 1993. Conducted on-site creel surveys and handed out mail-back surveys. Followed up on all mail surveys with post cards and additional questionnaires if necessary. Entered all collected data into a computer data base.

PROCEDURES

The study area, consisting of the Bighorn River in south central Montana from Yellowtail Afterbay Dam downstream to Two Leggins Fishing Access Site, has been described previously (Fredenberg 1984) (Figure 1). River miles (RM) denoted in this report refer to distance downstream from the Afterbay Dam.

Two new programmable car counters were installed on the Bighorn River in May 1992, one at Bighorn Access and one at Lind Access. These counters were programmed to record accumulated counts every six hours onto a removable data chip. These memory chips were changed on a periodic basis and the recorded data transferred directly into an office computer.

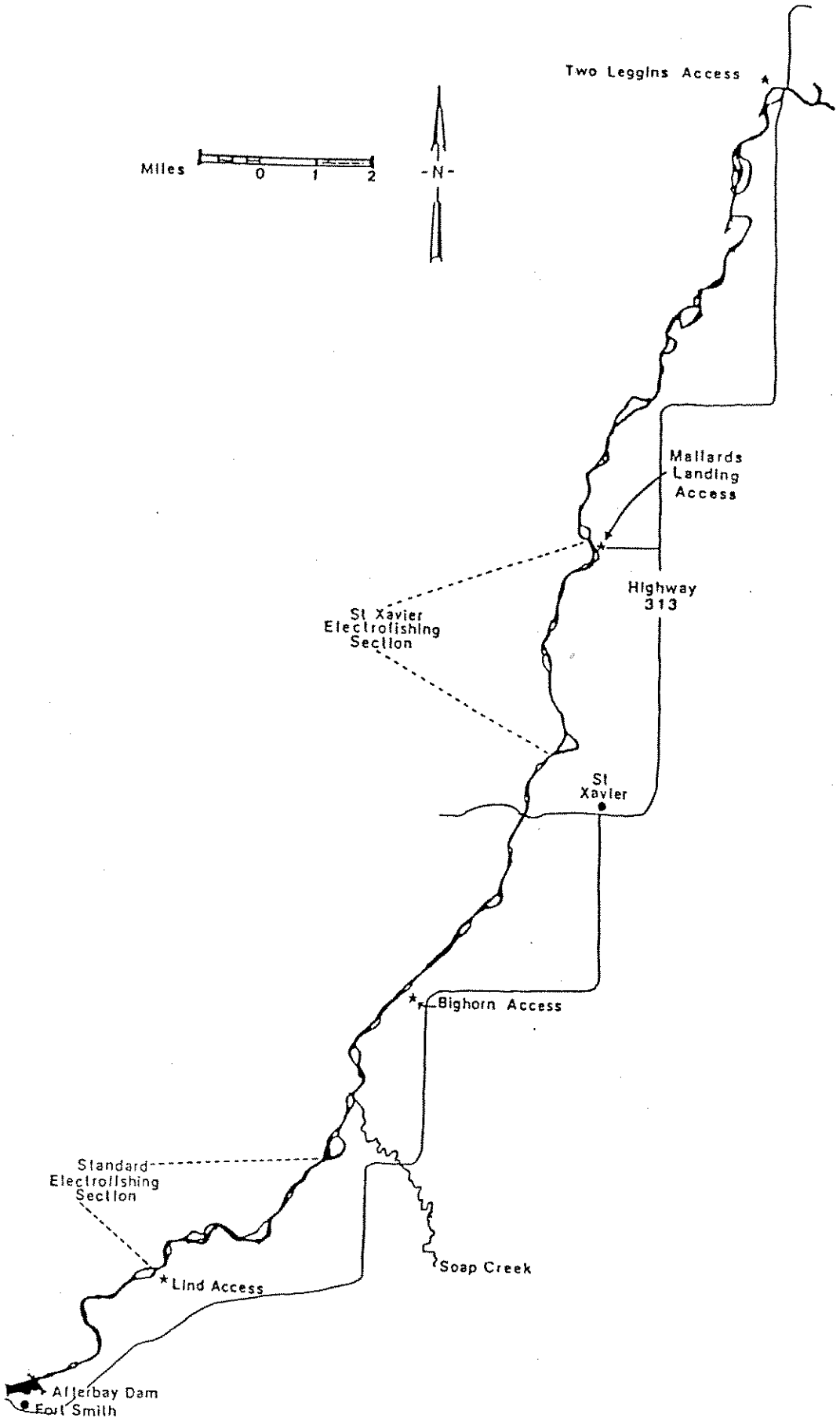


Figure 1. Map of the upper Bighorn River showing location of electrofishing sections.

The river ranger position initiated on the Bighorn River in the spring of 1990 was continued through April 1993. This position had two major objectives: 1) to be a highly visible representative of the Department while collecting attitude and opinion information from the anglers on the river; and 2) to conduct a general creel census. The major emphasis of the river ranger position during this study period was the distribution and tracking of a comprehensive mail-back angler survey.

The mail-back survey and accompanying on-site questionnaire were developed and pretested during the summer and fall of 1991 as part of a personal service contract with John Duffield (Bioeconomics Associates) of Missoula. Department personnel, Rob Brooks, Dana Dolson and Bob McFarland, also assisted with the development of the surveys and associated sampling protocol. Some minor changes were made after the pretest, and final surveys were printed in the spring of 1992. Surveys were distributed to anglers on the Bighorn River beginning in May 1992 and continuing through April 1993.

The survey goal was to distribute 4,000 surveys over a one year period. Car counter data recorded at the Bighorn Access car counter during 1989 and 1990 were used to determine the number of surveys to be handed out monthly. Because car counter data were similar during these two years, they were pooled to calculate monthly use on a percentage basis. These percentage values were used to distribute 4,000 surveys over one year resulting in monthly quotas ranging from 60 surveys each during December and January to 760 surveys each during the peak months of August and September.

The ranger used a 17-foot square-end canoe equipped with an electric trolling motor to float between Afterbay Access and Bighorn Access (Figure 1) to contact anglers and hand out surveys. Floating dates were selected during most of the year by randomly selecting four weekdays and three weekend or holidays out of each two-week period. During the winter, sampling dates were selected based on the weather, with the surveys being conducted on the better days in an attempt to contact the maximum number of anglers possible for a given effort. During the winter, most angler contacts were made at the access sites rather than by floating.

It was necessary to contact as many angers as possible on a designated sampling day in order to distribute the monthly quota of surveys. Very cold weather during December, January and February severely limited angler use and made it difficult to distribute surveys during this period. As a result, extra surveys were distributed during March and April 1993 in an attempt to get better representation from local anglers that don't fish the Bighorn during the busy summer season.

Each angler was asked a series of questions concerning residency, hours fished, numbers of fish caught, and perceived

crowding problems. They were then asked if they would be willing to fill out a more comprehensive mail-back survey. A name and address were obtained from each angler who received a mail-back survey so that follow-up could be conducted as necessary. Approximately two weeks after the survey was handed out, a follow-up postcard was sent to all anglers thanking them for participating and reminding them to send in their survey if they hadn't already done so. Approximately two weeks after the follow-up postcard, a letter and second survey were sent to everyone not responding to the first survey.

Electrofishing on two sections (Figure 1) of the Bighorn River was conducted during daylight using a fixed-boom electrofishing boat powered by an outboard jet engine. The electrofishing apparatus was a Coffelt VVP-15 powered by a 6,500 watt Onan generator. Beginning in 1992, all electrofishing on the upper Bighorn River was conducted using straight DC current producing about 2,000 W of power at an output of 200 V and 7 to 10 amps.

In the past, mark/recapture estimates were conducted in the fall (September and October) in both shocking sections. Warm water temperatures in the fall of 1991 forced shocking to be postponed on both sections until December. Due to the shorter daylight period at this time of year, only 2.5 miles of the normal 4.2 mile long standard shocking section was worked. Due to time constraints, one day of survey shocking was conducted on the lower St. Xavier shocking section in 1991 with no attempt to do a mark/recapture estimate. In 1992 a mark/recapture estimate was conducted on the standard shocking section in late June and early July in order to avoid the warm water problem experienced in 1991, and to take advantage of a period when angling pressure normally drops off on the Bighorn. A mark/recapture estimate was conducted on the lower shocking section during the normal late September period in 1992.

All fish were measured to the nearest 0.1" and weighed on a standard spring platform scale. Ten fish-scale samples were taken per 1/2" size group, from an area above the lateral line posterior to the dorsal fin. Samples were mounted on acetate sheets, and the impressions were read on a microfiche reader.

Population estimates were obtained using a computer program developed by the MDFWP. In the past, a mark/recapture program has been used which based estimates on standard Peterson's mark-recapture calculations. During 1992 a new mark/recapture program was developed by MDFWP that used a log-likelihood method to calculate estimates. This method is supposed to be more accurate than the old method, especially in estimating numbers of small and very large fish. This new program was used in calculating the estimates presented in this report. No attempt was made in this report to compare older data using this new method.

Bighorn River water temperatures were monitored with a Taylor 30-day recording thermograph located in the U.S. Geological Survey (USGS) gauge house on the right bank 200 yards downstream from the Afterbay Dam. Flow records from the site were obtained from the USGS.

RESULTS AND DISCUSSION

Stream Flow

Flows in the Bighorn River in 1992 were near the lower range of flow levels recorded since 1966 (Table 1), but still much better than the flows seen during the drought in 1988 and 1989. Following the extremely high flows seen in 1991, discharges remained above the optimum level of 2,500 cfs until mid-February. Flows then slowly declined, dropping below the preferred minimum flow of 2,000 cfs on April 15. Flows dropped to just over 1,800 cfs during the spring, then remained just under 2,000 cfs through the rest of the summer.

Despite reported flow levels close to 2,000 cfs while the crew was sampling the lower shocking section in late September, it was difficult to run the jet boat through one of the major riffles at the lower end of the section. This riffle has been negotiated in the past, at lower reported flows with no difficulty, indicating that something had changed. Either this riffle configuration changed during the high flows experienced in 1991, or the rating curve at the upstream gage has changed so that a reported flow of 2,000 cfs no longer represents as much water in the river. Additional study is needed to determine whether the requested flows developed for the informal agreement with the Bureau of Reclamation still provide the desired fisheries benefits.

Water temperatures

Abnormally high flows combined with a spill of warm surface water from Yellowtail Dam in 1991 pushed Bighorn River water temperatures up to 60°F by July 1, and resulted in near record average summer water temperatures. Water temperatures in the Bighorn followed a more normal pattern in 1992, remaining in the mid- to high 40° range through July, then slowly increasing to a maximum summer water temperature of 60°F in late September and early October. Mean summer water temperatures in 1992 were approximately 3°F below the historic average (Table 1).

Table 1. Maximum summer water temperature, mean summer water temperature (July-September), and mean daily summer discharge (July-September) at the Afterbay Dam on the Bighorn River during 1966-1992.

Year	Maximum Summer Temperature (·F)	Mean Summer Temperature (·F)	Mean Daily Summer Discharge(cfs)
1966	62	55.2	1,241
1967	69	64.0	8,713
1968	62	58.3	2,990
1969	61	52.5	3,869
1970	62	54.0	3,754
1971	64	60.7	3,972
1972	62	60.2	3,434
1973	58	52.3	3,400
1974	65	60.6	4,334
1975	65	60.0	5,932
1976	60	57.7	3,017
1977	50	43.8	1,896
1978	65	60.0	6,745
1979	59	51.5	2,950
1980	62	56.2	3,740
1981	60	57.0	2,751
1982	65	58.0	4,747
1983	67	63.1	5,879
1984	64	59.3	3,876
1985	53	46.9	1,999
1986	67	63.5	4,306
1987	60	52.8	2,112
1988	56	47.9	1,766
1989	59	50.9	1,572
1990	60.0	53.1	2,036
1991	66.0	63.9	3,988
1992	60.0	53.3	2,253
MEAN	61.6	56.2	3,602

Gas Supersaturation

Gas supersaturation levels remained low during 1992, and visible symptoms of gas bubble trauma were rare. The Bureau of Reclamation continued to use the radial gates in the Afterbay Dam as much as possible to try and keep supersaturation levels down. They also began an Environmental Assessment to restudy the gas supersaturation problem as a water quality issue. The DFWP participated in this process, which was later abandoned.

Fishing Pressure and River Ranger Survey

Fishing pressure continued to be very heavy on the Bighorn in 1992; however, no good estimates of total pressure were obtained. Two programmable car counters were installed at Lind and Bighorn accesses in May 1992, and set to record vehicle counts every 6 hours. On-site surveys need to be conducted at each counter over a full season of use to establish a relationship between recorded counts and angler use. Manpower was not available to do this during 1992.

Past reports have discussed the problems associated with trying to extrapolate angler use from car counter counts collected at Bighorn Access (Frazer 1990). The installation of two counters should help overcome some of these problems. Once calibrated, these counters should provide data needed to calculate angler use on the upper Bighorn.

Total counts recorded at Bighorn Access were compared to past counts to look at general trends in use. Angling pressure in 1992 appeared to be similar to use observed in 1990 and 1991. In recent years, angling pressure has been increasing later into the fall season. Based on October counts recorded at Bighorn Access this trend continued in 1992.

Between May 1, 1992 and April 30, 1993, the river ranger conducted 3,638 on-site angler surveys and handed out mail-back angler surveys to each respondent. Monthly response rates for the mail-back surveys ranged from 48% to 73% with an overall response rate of 66%. These data have all been entered into a computer database, but no analysis has been completed to date.

Population Estimates

Trout population estimates presented in this report were influenced by two factors which precluded direct comparisons of these data with population data reported in the past.

The MDFWP has developed a new mark/recapture program which uses a log-likelihood analysis rather than a modified Peterson's

analysis to calculate population estimates from mark/recapture data. This program is more reliable in estimating numbers of small and very large fish. Past estimates on the Bighorn have often underestimated the number of age 1 trout in the population. This problem has shown up as large increases in year class strength between age 1 and age 2. The new program was used to analyze 1991 and 1992 mark-recapture data. No attempt was made to go back and rerun old data for this report using the new program. As data are rerun in the future it is likely the analyses will show an overall increase in population levels for both brown trout and rainbow, with most of this increase seen as age 1 fish. Until these new analyses are completed, no direct comparisons will be made between 1991 and 1992 data and past population numbers.

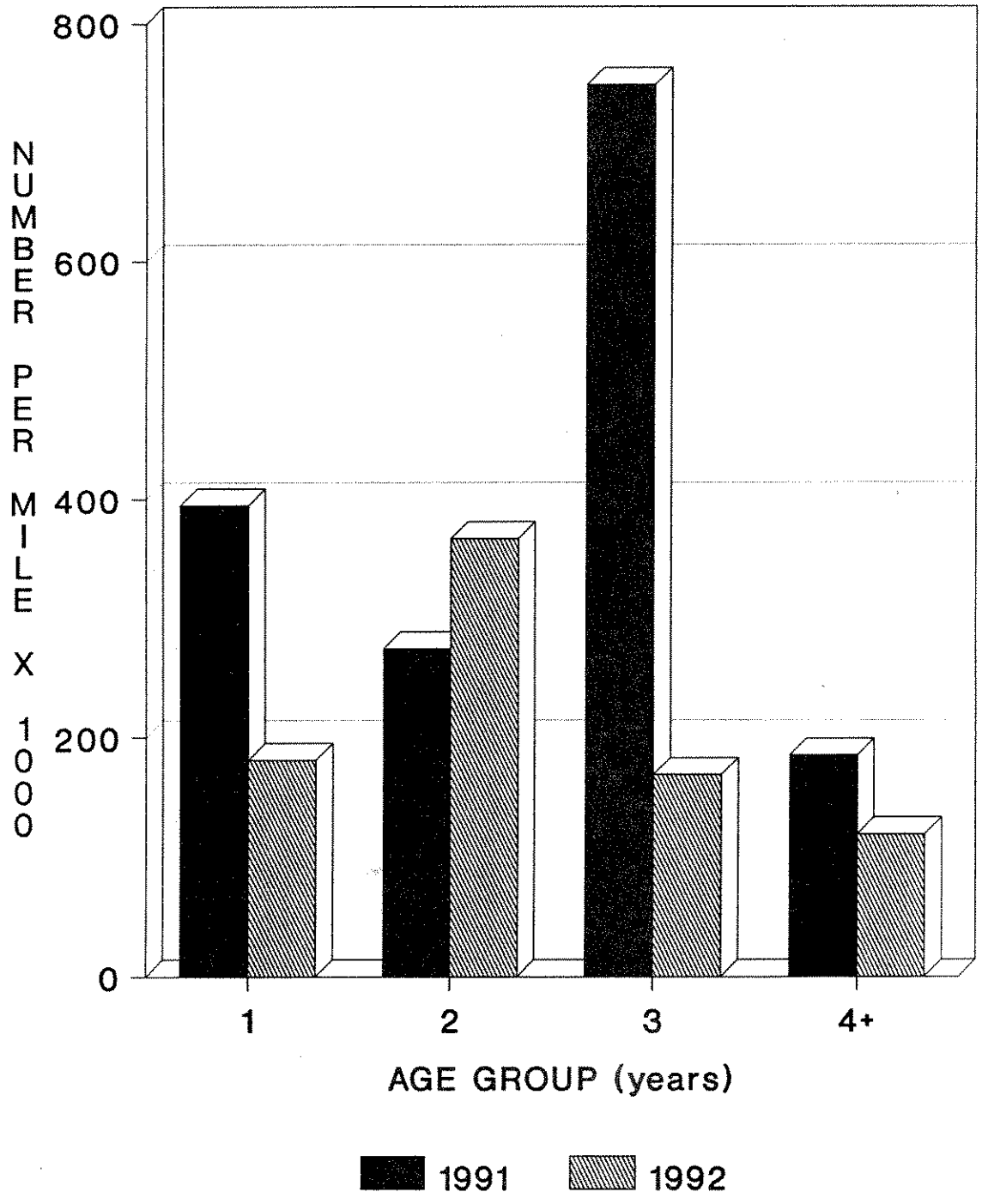
Variations in sampling times also affected the data obtained during 1991 and 1992. Past reports have discussed the relationship between water temperatures and flows in the Bighorn River (Frazer 1990; Fredenberg 1986). High flows in the Bighorn in the spring and summer of 1991 combined with the spill of warm water from the surface of Bighorn Lake resulted in abnormally high water temperatures in the Bighorn River in late September when fall population estimates have been conducted in the past. Concerns over shocking and handling fish at these warmer water temperatures caused a delay of fall shocking until December in 1991. In 1992 the sampling time for the standard section was changed again to avoid future problems with fall water temperatures, and to reduce conflicts with anglers. Population estimates in 1992 were conducted in late June and early July when water temperatures were cooler and when angling pressure declined between the early spring and summer fisheries. Impacts of these sampling changes are discussed in this report.

Brown Trout

Standard Section. Brown trout populations in the standard electrofishing section continued to show the impacts of weak year classes produced during low flow conditions in 1988 and 1989. A population of 4,526 age 1 and older brown trout per mile was estimated during December 1991. Population densities increased slightly in 1992 to 5,056 trout per mile.

A shift in 1990 from an older aged brown trout population to a population dominated by younger fish was discussed by Frazer (1991). Two years of poor recruitment during low flow conditions followed by good reproduction in 1989 was a major factor in this observed shift. This pattern continued in 1991 and 1992 with younger fish dominating the population (Figure 2). Age 1 fish comprised 47.7% of the brown trout population in 1991 and 76.5% of the population in 1992. The strong age 1 year class observed in 1990 was evident in the 1991 population, but not in the 1992 population. The new mark/recapture program may have accounted for some of the increase observed in the estimated number of age 1

Figure 2. Estimated numbers of brown trout in the Standard Shocking Section in 1991 and 1992 by age groups.



brown trout in the population; however, visual observation while shocking in 1990, 1991 and 1992 indicated there were strong year classes of brown trout produced each of those years.

Mortality rates between 1991 and 1992 were high for all age classes ranging from 61.4% for age 2 brown trout to 88.7% for age 4 fish. The overall mortality rate of 73.8% was high compared to rates observed in the past which have ranged from 1.6% to 75.2% (Frazer 1991). A major factor in these observed differences is probably the change in mark/recapture analysis. Past data have shown significant increases in the numbers of fish estimated for a given year class especially between age 1 and age 2. One possible explanation discussed in the past has been movement of fish in and out of the shocking section (Frazer 1990). It now appears that some of the apparent increase was due to the old mark/recapture program, which seriously underestimated the age 1 population. As old data are rerun using the new mark/recapture program, age 1 population estimates will probably increase for most years. The resulting increase in observed mortality rates between age 1 and age 2 brown trout will increase total annual mortality rates and bring them more in line with the total mortality rate observed between 1991 and 1992.

High natural mortality rates continue to substantiate past discussions concerning the impacts of angler harvest on the brown trout population in the upper Bighorn River (Frazer 1990, 1991). Between May 1990 and April 1991, anglers kept only 3.4% of the 16,154 trout reportedly caught on the upper river. This angler-induced mortality is insignificant when compared to an annual natural mortality rate of 60% to 70%. Past reports have discussed in detail other factors contributing to these observed natural mortality rates (Frazer 1990, 1991; Fredenberg 1985a, 1987).

Sampling time and water temperature played major roles in brown trout growth rates observed in 1991 and 1992. High flows during the spring and summer of 1991 caused water temperatures in the upper Bighorn River to warm up much earlier than normal and remain warmer throughout the summer. High water temperatures caused a delay in fall shocking until December which gave the trout an extra two months of growing time before being sampled. The warm water temperatures and late sampling date combined to produce the largest average lengths yet recorded for age 2 and older brown trout on the upper Bighorn River (Table 2). In 1992 sampling was conducted in late June, a full three months earlier than in previous years. Water temperatures were still cold and brown trout were just beginning their summer growth so average lengths were much shorter than reported in the past. Average sizes would have been even smaller in 1992 had it not been for the excellent growth seen in 1991.

Table 2. Average length (in) by age class of brown trout from the standard electrofishing section (RM 3.8-8.0)* of the Bighorn River during September 1981-1990, December 1991, and June 1992.

Year/Age	0	1	2	3	4	5+
1981	5.8	11.6	15.4	18.1	19.8	21.2
1982	5.1	11.0	15.4	17.8	20.0	20.8
1983	4.3	9.5	14.8	17.4	20.0	20.8
1984	-	9.4	14.3	17.6	19.2	21.9
1985	-	8.0	13.5	16.2	18.6	19.9
1986	4.1	8.0	13.0	16.8	19.4	21.2
1987	3.6	8.9	12.6	15.9	18.9	22.3
1988	-	9.8	13.6	16.8	18.1	21.3
1989	-	7.8	13.6	16.7	19.4	21.7
1990	-	7.6	13.7	18.0	18.9	-
1991	5.7	10.4	15.4	18.5	21.2	-
1992	-	6.3	12.3	17.0	18.9	-

*RM 2.4-9.6 for 1981 through 1987.

Variations in sampling times also affected the number of large sized (18" and larger) brown trout estimated in the population. Over 600 18" and larger brown trout per mile were estimated in the upper Bighorn River in December 1991. This was the best population of large brown trout yet recorded, and the first time this number has exceeded our management goal of 500 18" and longer brown trout per mile (Montana Department of Fish, Wildlife and Parks 1987). However, this number is not comparable to previous data due to the warmer water and change in sampling times. In contrast, in 1992 there were only 266 18" and larger brown trout per mile estimated in the population in June, and this number would have been lower if growth rates hadn't been so good in 1991. Many of the 16" and 17" brown trout captured in June would have exceeded 18" in length by the normal September sampling time, resulting in large brown trout numbers near the upper range of levels reported in the past (Frazer 1991). Future management goals for large brown trout in the standard shocking section may have to be changed to reflect the change in sampling time.

Lower Section. Because shocking had to be postponed until December and sampling time was limited, no brown trout estimate was conducted in the lower St. Xavier shocking section during 1991. One day of survey shocking during mid-December captured 197 brown trout ranging from 4.1 to 21.2 inches total length. The majority

of fish captured were Young of year or age 1 fish. Only 24% of the brown trout collected were greater than 13" long, and only one of the 120 fish was over 2 years old.

Sampling time had a major influence on these data. Most brown trout spawning in the Bighorn River occurs upstream of the lower shocking section. Sampling was conducted at the end of brown trout spawning in 1991, and it appeared that most mature brown trout had migrated upstream out of the shocking section. There were more older fish present in the section than indicated by the age data, but scales were not obtainable from these fish due to their spawning condition.

Average lengths of YOY, age 1 and age 2 brown trout collected from the lower shocking section in 1991, were 5.3", 11.6" and 16.7", respectively. The average length of YOY brown trout was slightly less that the YOY average length found in the standard section. Age 1 and age 2 brown trout averaged over one inch longer than comparable year classes in the standard section for 1991. Age 1 and 2 year classes were 2.5" and 2.8" longer than comparable year classes from the lower section in 1990. These large average sizes reflect the warmer water temperatures and late sampling time in 1991.

The estimated brown trout population in the St. Xavier shocking section in June of 1992 was 681 age 1 and older brown trout per mile. This was comparable to population levels reported for this section following the poor flow conditions in 1988 and 1989 (Frazer 1991). Poor recruitment during these drought years was reflected in the 1992 population with age 2 and older brown trout comprising only 30% of the estimated population and representing the fewest age 2 and older brown trout recorded in this section since sampling began in 1984. The reduced number of older fish was also evident in the biomass estimate which dropped to just under 500 pounds per mile, down considerably from the next lowest estimate of 767 pounds per mile recorded in 1989.

Brown trout growth rates in 1992 were slightly better than growth rates reported for this section in the past (Frazer 1991). Age 1 through 4 fish averaged 9.8, 15.0, 19.5, and 20.4 inches, respectively. Most of this growth was probably due to the excellent growing conditions experienced in 1991.

Summary and Discussion - Brown Trout. Effects of the poor brown trout year classes produced during the drought years in the late 1980s were still evident in the 1991 and 1992 brown trout populations. As these weak year classes move through the population, the numbers of older brown trout in the Bighorn River have shown a significant decline. Fortunately this loss in older aged fish was masked by the extremely rapid growth rates experienced in 1991 which pushed 2 year old brown trout over 15" in length, and 3 year old fish over 18" in length by late fall. Brown

trout recruitment appeared to be good each year since 1989 which should result in increasing numbers of older fish in the population in the future. The brown trout fishery should remain good in the Bighorn over the next several years, but the data presented in this report continue to show the importance of environmental factors in controlling the trout population in the Bighorn River.

Rainbow Trout

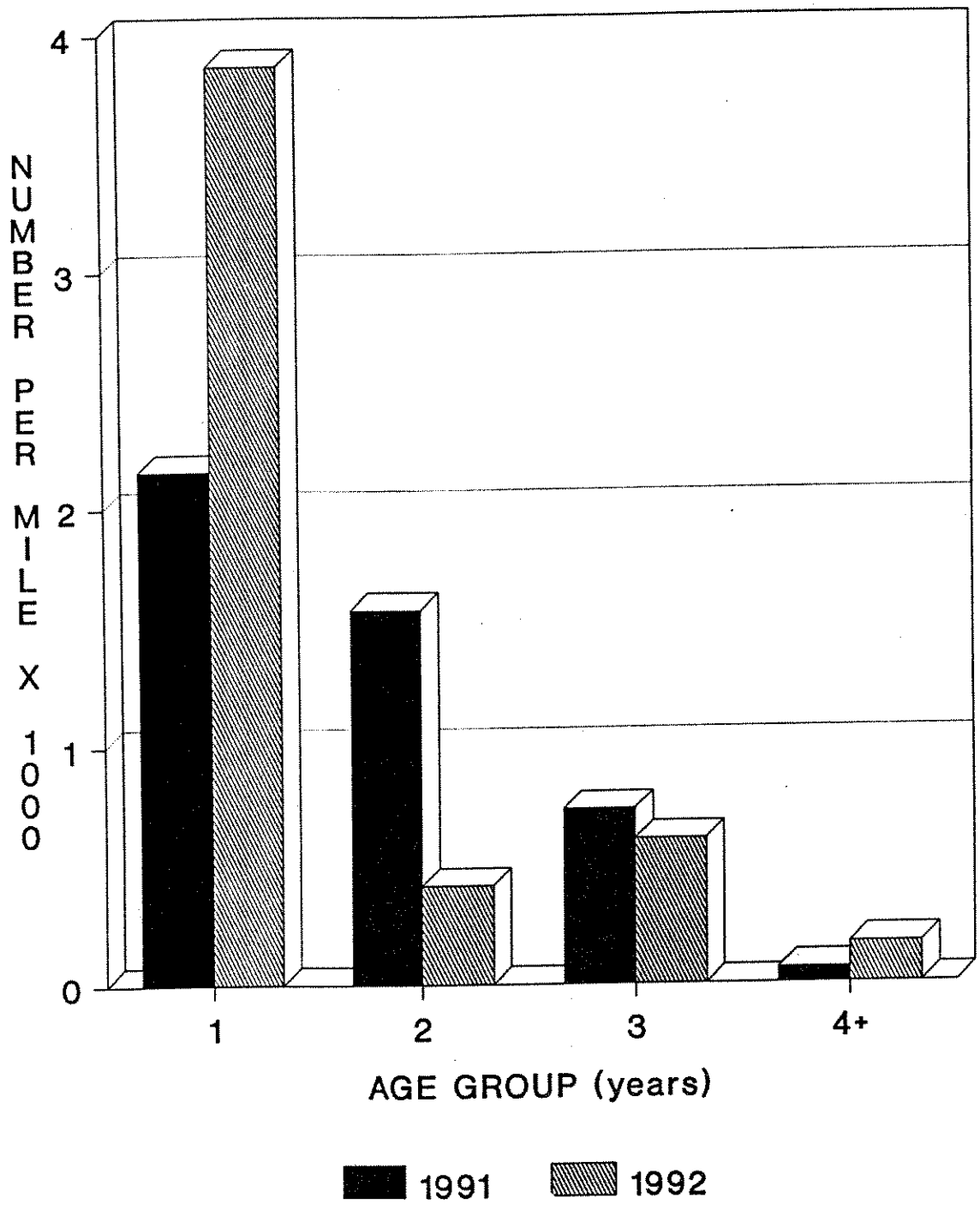
Standard Section. Rainbow trout densities appeared to be very good in the standard shocking section in 1991. Despite a shortened shocking section and short days, 181 rainbow were marked during three days of shocking. Only 5 of the 113 recaptured rainbow were marked indicating there were significant numbers of rainbow present in the river. The new mark/recapture program calculated a statistically valid estimate using these 5 recaptures. These numbers are presented for discussion, but with reservation due to the low number of recaptures. The program estimated 1,603 age 1 and older rainbow per mile in the upper section in December 1991. This was considerably higher than the previous record level of 1,163 rainbow per mile recorded in 1989. The 1989 estimate included age 2 and older rainbow with no estimate for age 1 rainbow. Age 1 rainbow accounted for 24% of the estimated population in 1991 (Figure 3). The estimated population of age 2 and older rainbow was 1,208 per mile which was very close to the estimate obtained in 1989. It remains to be seen if an estimate for age 1 rainbow will be obtained for 1989 when these data are rerun using the new mark/recapture program.

The 1992 rainbow population in the standard section declined to 836 age 1 and older rainbow per mile which was comparable to the population level reported in this section in 1990 (Frazer 1991). This population showed good representation from several year classes (Figure 3).

Previous reports have discussed the problem of rainbow movement in the Bighorn River and the resulting difficulty in getting an accurate picture of the rainbow population present in the river (Frazer 1990, 1991). Movement remained a problem with the 1991 and 1992 data. The 1991-1992 period was the first time an annual mortality was recorded for age 1 rainbow in the upper river since an over-winter mortality was observed for the rainbow planted in the Bighorn in 1983. Over-winter mortality is natural in any population and would be expected every year in the Bighorn River. Hopefully the new mark/recapture program will provide a more reliable picture of what is occurring with the small fish.

Average lengths of the rainbow collected in 1991 and 1992 reflect the differences in sampling times and the warmer 1991 water temperatures discussed previously under "Brown Trout". Average lengths of most year classes in 1991 were comparable to lengths

Figure 3. Estimated number of rainbow trout in the Standard Shocking Section in 1991 and 1992 by age groups.



recorded in the early 1980's when the rainbow population was dominated by fast growing hatchery fish (Table 3).

Table 3. Average length (in) by age class of rainbow trout from the standard electrofishing section (RM 3.8-8.0)* of the Bighorn River during September from 1983-1990, December 1991, and June 1992.

Year/Age	0	1	2	3	4	5+
1983	5.0	10.3	15.9	18.3	20.3	21.1
1984	-	11.4	15.1	18.1	19.1	21.1
1985	-	9.3	15.2	17.7	19.4	21.1
1986	3.8	8.6	13.8	16.9	19.3	21.3
1987	-	10.1	13.9	16.6	18.9	20.8
1988	-	-	15.0	17.4	19.6	20.5
1989	-	-	14.7	17.1	19.5	20.4
1990	-	7.6	15.2	17.8	19.7	20.5
1991	4.4	11.2	15.6	18.6	20.0	20.4
1992	-	6.1	13.9	17.4	19.9	21.3

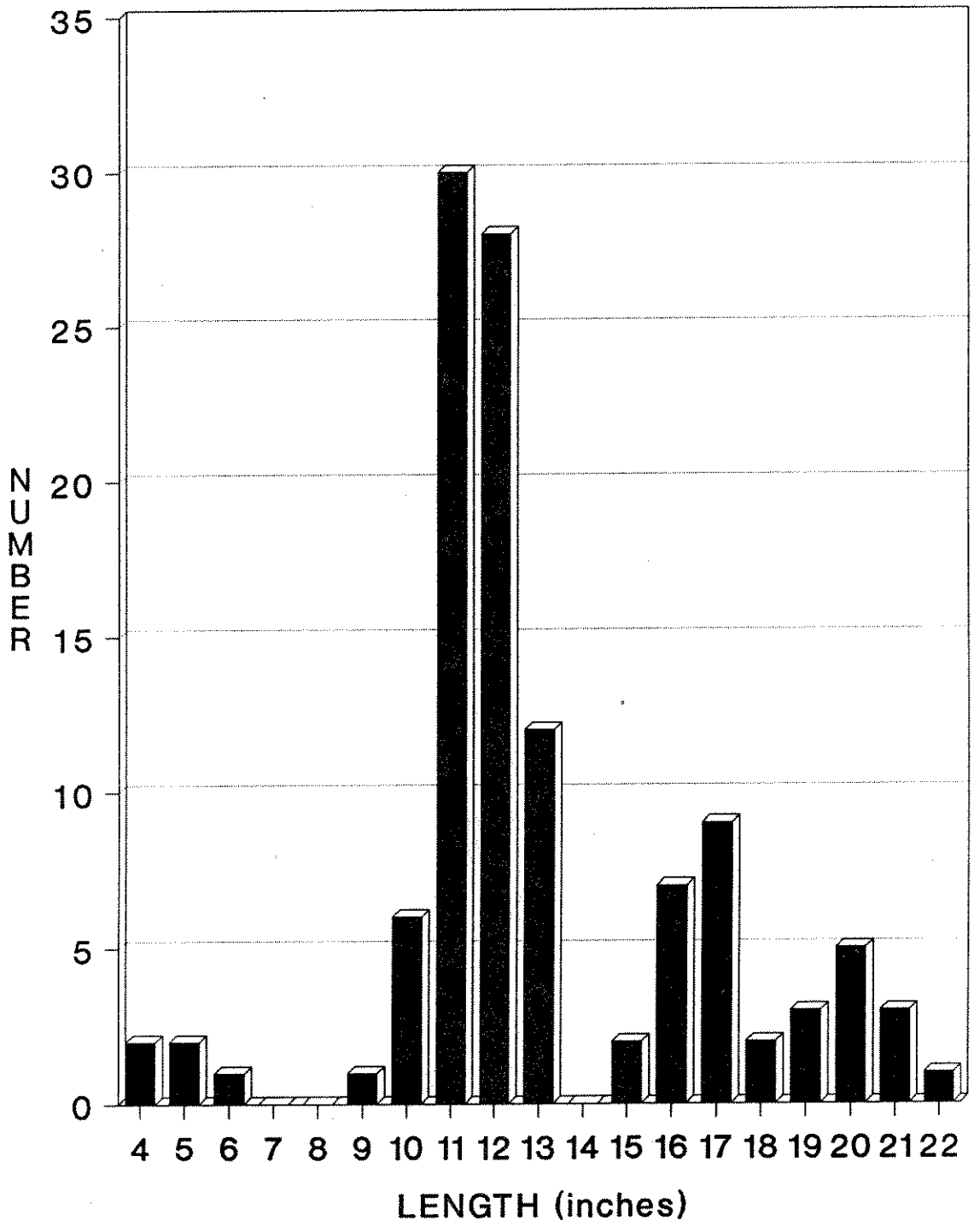
*RM 2.4-9.6 for 1983 through 1986

The average size of age 1 rainbow in 1992 was the lowest yet recorded, which was a reflection of the June sampling date. The average lengths of older year classes of rainbow in 1992 were comparable to past years despite the June sampling date. These lengths reflect the extra growth experienced in the warm water temperatures during 1991.

Variable sampling times and the rapid growth experienced in 1991 also had a major influence upon the number of large (18" and longer) rainbow estimated in the population each year. Over half of the 1,603 rainbow per mile estimated in December 1991 were 18" or longer. In contrast, the number of 18" and longer rainbow estimated in the population in June 1992 declined to 166 per mile which was the lowest number of large rainbow recorded in several years. This number was seriously depressed by the June sampling date which occurred before the major summer growing period. Even this lower number still exceeded our stated management goal of 150 18" and longer rainbow per mile (Montana Department of Fish, Wildlife and Parks 1987). This management goal may have to be changed if sampling continues in the spring.

Lower Section. No mark/recapture estimate was conducted on the lower St. Xavier shocking section in 1991. One day of survey shocking collected 114 rainbow ranging from 4.2" to 22.0" in length. Age 1 rainbow (approximately 10" to 13" long) were the dominant group of fish captured, comprising approximately 66% of the rainbow collected (Figure 4), indicating that rainbow

Figure 4. Length frequency distribution of rainbow trout collected from the St. Xavier Shocking Section during one day of survey shocking in December 1991.



recruitment was good in 1990. The strong age 1 year class observed in 1990 continued to be represented in the 1991 population as 15" to 17" fish.

Average lengths of rainbow collected in the lower shocking section in 1991 were almost 1" longer than the excellent average lengths observed in the upper shocking section. Average lengths of age 0, 1, 2, 3 and 4+ rainbow from the St. Xavier section were 5.0", 12.0", 16.8", 20.1", and 20.8", respectively.

Only 178 age 1 and older rainbow per mile were estimated in the St. Xavier section in 1992. This was the smallest rainbow population estimated in this section since sampling began in 1984. A major factor in this decline was the low number (9 per mile) of age 1 rainbow found in this section in 1992. Past reports have discussed the apparent movement of YOY rainbow downstream after emergence and have related this movement to flow conditions in the upper river (Frazer 1990, 1991). Abnormally high flows and warmer water temperatures when the rainbow fry were emerging in 1991 may have held most of these young fish in the upper river. The last time very low numbers of age 1 rainbow were recorded in the St. Xavier section was in 1987 following the above average flows and warm water in 1986 (Table 1). As noted above, 1991 and 1992 were the first years age 1 estimates were obtained in the standard shocking section since 1987. Although some of this apparent increase in age 1 rainbows may have been due to the new mark/recapture program, the data also indicate that YOY rainbow were remaining in the upper river. The number of age 2 and older rainbow estimated for the St. Xavier section in 1992 was comparable to estimates for age 2 and older fish seen in this section in the past.

Summary and Discussion - Rainbow Trout. The wild rainbow fishery in the Bighorn River continued to thrive with population levels reaching record levels in 1991 based on very limited recapture data. Movement continued to be a major problem in trying to evaluate year class strength and determine total rainbow population levels in the river. Age 1 year class strength remains a major factor affecting total population estimates in both shocking sections. Both movement and age 1 estimates appear to be strongly influenced by flow conditions in the river.

The future of the rainbow fishery continues to look very good with large numbers of big fish available for anglers and as future brood stock.

MANAGEMENT RECOMMENDATIONS

1. Continue efforts to maintain target flow levels of at least 2,000 cfs in the Bighorn River year-round. Reevaluate the recommended flow levels in relationship to the current rating curve being used on the Bighorn River.

2. Continue to work with the Bureau of Reclamation to resolve the gas supersaturation problems in the river.

3. Complete analysis of angler survey data collected by the river ranger during 1992. Develop and implement a follow-up survey that will concentrate on contacting local anglers who have quit fishing the Bighorn River to determine why they quit.

4. Conduct on-site interviews at the car counters at Bighorn and Lind accesses to establish a relationship between recorded counts and angler use.

5. Solicit the guides, outfitters and anglers using the Bighorn for ideas on ways to better manage the overcrowding problem on the upper 12 miles of river.

6. Continue to monitor the expanding rainbow population and its effects on the brown trout population. Explore new sampling and/or tagging methods that could provide additional data on rainbow movement.

7. Continue to promote some harvest of smaller brown trout toward achieving a population balance that will provide enough fish to maintain good catch rates, yet be low enough to allow the maintenance of a good population of large brown trout.

8. Rerun estimates on older data using the new mark/recapture program and reevaluate population trends.

LITERATURE CITED

Frazer, K. 1990. Upper Bighorn River investigations, survey, and inventory of coldwater streams. Montana Department of Fish, Wildlife and Parks Job Progress Report F-46-R-3-I-h.

Frazer, K. 1991. Upper Bighorn River investigations, survey, and inventory of coldwater streams. Montana Department of Fish, Wildlife and Parks Job Progress Report F-46-R-4-I-h.

Fredenberg, W. 1985a. South central Montana fisheries investigations, Bighorn Lake and Bighorn River post-impoundment study. Montana Department of Fish, Wildlife and Parks Job Progress Report F-20-R-29-IV-a.

_____. 1986. South central Montana fisheries investigations, Bighorn Lake and Bighorn River post-impoundment study. Montana Department of Fish, Wildlife and Parks Job Progress Report F-20-R-30-IV-a.

_____. 1987. South central Montana fisheries investigations, Bighorn Lake and Bighorn River post-impoundment study. Montana Department of Fish, Wildlife and Parks Job Progress Report F-20-R-31-IV-a.

Montana Department of Fish, Wildlife and Parks. 1987. Upper Bighorn River Fisheries Management Plan.

Prepared by: Kenneth J. Frazer

Date: September 20, 1993