MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

FISHERIES DIVISION
JOB PROGRESS REPORT

STATE: MONTANA

PROJECT TITLE: STATEWIDE FISHERIES INVESTIGATIONS

PROJECT NO: F-46-R-3

STUDY TITLE: SURVEY AND INVENTORY OF COLDWATER STREAMS

JOB NO: I-h

JOB TITLE: UPPER BIGHORN RIVER INVESTIGATIONS

PERIOD COVERED: April 1, 1988 through March 31, 1990

ABSTRACT

Drought in Wyoming and Montana during 1988 and 1989 resulted in the lowest flows in the Bighorn River since Yellowtail Dam was completed. Low flows were accompanied by low water temperatures, resulting in a major decline in the brown trout population. The number of age 1 and older brown trout in the standard electrofishing section declined from a record high of 8,458 per mile recorded in 1987 to only 4,601 per mile in 1989. Brown trout numbers in the lower river also declined. The younger age classes were affected most.

As the total number of brown trout declined, mortality rates decreased and condition factors improved for large (age 4+) brown trout, verifying the density-dependent relationship observed in the past. Despite the overall decline in brown trout numbers in the upper river, the number of 18 in and longer brown trout reached the second highest level (412 per mile) recorded since 1981.

Younger age classes of rainbow trout were also impacted by the low flows in 1988 and 1989. However, the overall population of wild rainbow continued to increase, largely due to the continued contribution of strong year classes of wild rainbow produced in 1985 and 1986. The rainbow population reached a new high of 1,163 age 2 and older fish per mile in the upper river in 1989. This population included 612 18 in and longer rainbow per mile.

Fishing pressure continued to increase on the Bighorn River with an increasing dominance by nonresident anglers. Despite decreasing fish populations, angler catch rates continued to increase while the number of fish harvested continued to decline.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (CONTINUED)

OBJECTIVES AND DEGREE OF ATTAINMENT

1.) To maintain a year around 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.

Drought conditions in Montana and Wyoming during 1988 and 1989 resulted in the worst two years of flows on the Bighorn since Yellowtail Dam was completed. Even the recommended minimum flow of 2,000 cfs was not maintained either year.

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

Continued to work with Bureau of Reclamation on this problem.

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 declined below these levels in both river sections as a result of low flows.

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.

Both goals were exceeded in 1989 for the river above Bighorn FAS. Work continues on the lower river section.

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).

Angling pressure continued to increase on the Bighorn River in 1988 and 1989 with angler use exceeding 3,000 angler-days per month during periods of both years. An additional fishing access site was maintained downstream of Bighorn FAS, but little increase in use was documented.

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

Over 1,100 angler were contacted in 1988. No creel census was conducted in 1989, but a creel census and angler use survey was developed for the new River Ranger position which started in May of 1990.

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.

Fishing pressure estimates for the Bighorn River were calculated from car counter data taken at Bighorn FAS according to methods developed during the Bighorn River creel census (Fredenberg 1985b). Fishing pressure in the upper 12 mi of the river was estimated using the equation $y + 1.09x - 55.57$, where y = angler-days of use and $x = 1/2$ the car count. Pressure was calculated for monthly intervals.

A partial creel census was conducted on the upper 12 mi of Bighorn River for eighteen days between May 8, 1988 and October 15, 1988. A creel clerk was stationed at Bighorn FAS. Anglers were interviewed as they ended their float trip, and during or after shore fishing.

Dates creeled were randomly selected. During June, July, and August, four days were creeled - two weekend days and two weekdays. In May and October, two weekend days were creeled. In September one weekend day was creeled.

Each sample day, the census was begun between 11:30 a.m. and 2:30 p.m., and ending up to 1 hour after dark. Generally by the time the clerk left, most parties with a vehicle parked at the access had been interviewed.

Two areas were sampled (Figure 1): from the Afterbay Dam down to and including Bighorn FAS, and from Bighorn FAS down to Mallards Landing FAS. The angler may have floated through all or only part of a section.

Anglers were interviewed by party. One or more anglers in the party answered the questions. Information recorded included date, number of anglers in the party, angler origin, whether guided or unguided, bait type, area fished, and total hours actually fished. Origin was coded as: (1) local - Fort Smith and Hardin area, (2) Billings area, (3) the rest of Montana, or (4) out of state. In the comments, the state or town or origin was recorded. The party was asked what type of tackle they used (artificial flies, lures, bait, or some combination of the three).

Catch data included the number of fish caught, number kept, and species. Fish kept were measured. The party was also asked how many fish over 18 inches (by species) they released. All data was entered into a computer and sorted and summarized using Database III Plus.

Interviews were recorded by party rather than by individual to simplify data collection during periods of intense use. Combining caused some problems with interpretation because parties were often from mixed origin, used a variety of tackle types, etc. In such cases, the dominant origin or tackle type was coded for the entire group. With only one creel clerk, individual interviews were not feasible during periods of heavy pressure.

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. Generally, the controls were set on midrange at about 100 pulses per second and 50% pulse width, producing about 2,500 W of power at an output of 250 V and 10 amps.

Generally, four marking and four recapture runs were completed by alternating daily between the left and right banks. Flows were too low during 1988 and 1989 to work most of the side-channels. Both banks were occasionally electrofished on the same day in the lower (Saint Xavier) section. About 10 days were allowed between mark and recapture.

Typically, in all sections 300-1,000 trout were handled in a day of electrofishing. All fish were measured to the nearest 0.1 in and weighed on a standard spring platform scale. Ten fish scale samples were taken per 1/2 in size group, from an area above the lateral line posterior to the dorsal fin. Samples were mounted on acetate sheets with the impressions read on a microfiche reader at 43X.

Population estimates were obtained using a computer program developed by the MDFWP (Vincent et al. 1981), which utilizes standard Petersen mark-recapture calculations.

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

Stream flows in the Bighorn River were seriously impacted by the continuing drought that plagued Montana and Wyoming during 1988 and 1989. The flows in 1988 and 1989 were the lowest recorded since Yellowtail Dam was first being filled back in 1966 (Table 1). The mean daily summer discharge was only 1,766 cfs in 1988. This figure dropped to 1,572 cfs in 1989. The minimum sustained flow in 1988 was only 1,417 cfs recorded during 26 days in October and November. In 1989, a minimum sustained flow of 1,536 cfs occurred for 41 days in July and August.

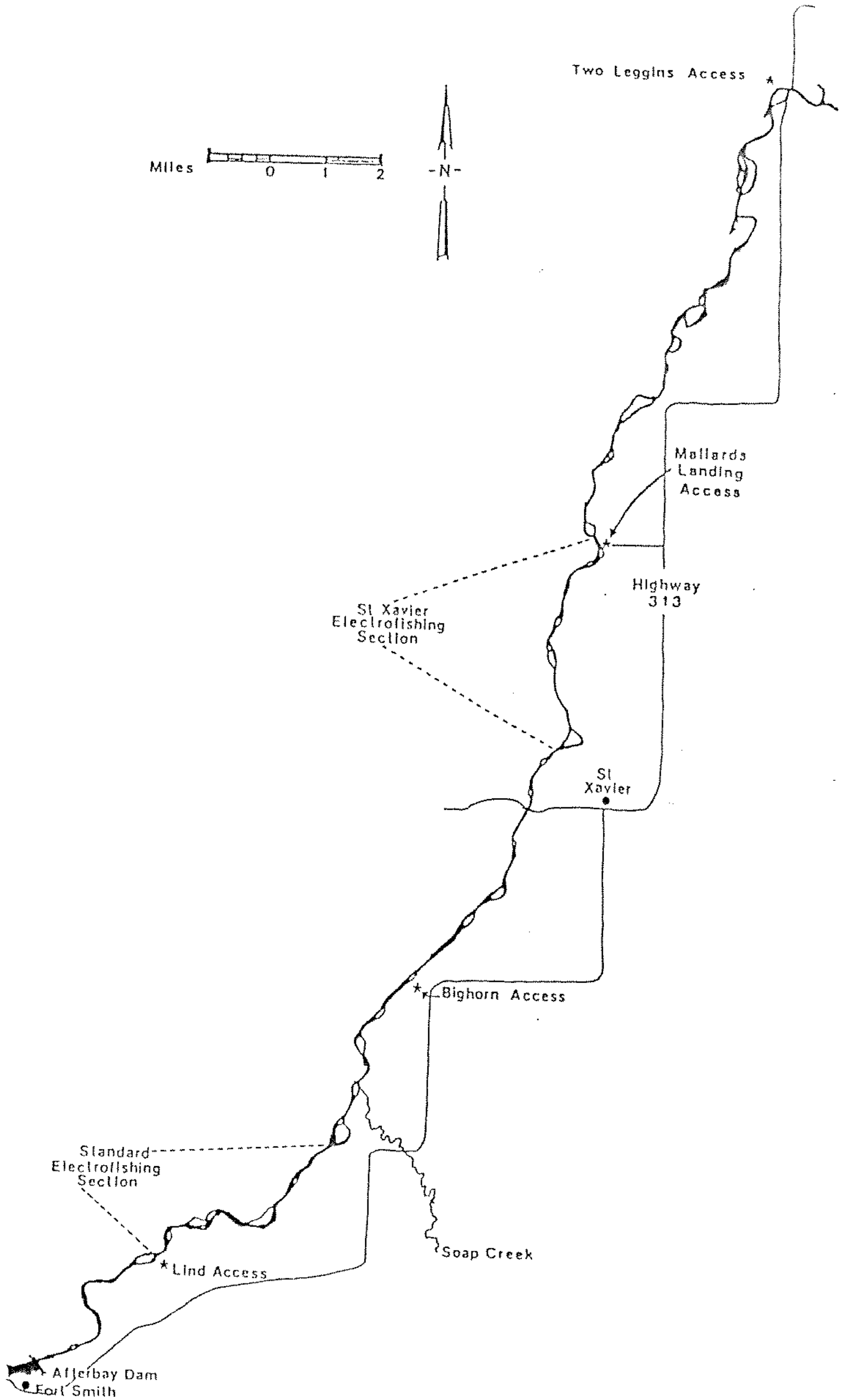

Figure 1. Map of the upper Bighorn River showing location of electrofishing sections.

Past work has shown that there is a major loss of side-channel habitat in the Bighorn as flows drop below 2,000 cfs, and that below 1,500 cfs, side-channels are virtually eliminated (Fredenberg 1988). Flows dropped below the minimum target flow of 2,000 cfs on June 17, 1988, and only rose above this level on 9 days through September 1989, when fall population estimates were conducted. The effects of these low flows on the brown trout population were evident during fall estimates.

Water Temperatures

Water temperatures in the Bighorn River were very low in 1988 and 1989 (Table 1). Past reports have discussed the relationship between stream flow and water temperature in the river. A significant positive linear correlation ($p < 0.01$) has been found between these two factors (Fredenberg 1986). The third and fourth coldest mean summer temperatures recorded since 1966 occurred during these two years. A mean summer temperature of 47.9^{0} F, recorded in 1988, was only one degree warmer than the mean summer temperature recorded in 1985. Maximum water temperatures only reached 56^{0} F and 59^{0} F in 1988 and 1989, respectively.

The impacts of these cold water temperatures on the growth rates of trout have been discussed in past reports (Fredenberg 1987). Trout growth rates in 1988 and 1989 showed some effects from these cold water temperatures, but the impacts were not as obvious as after the cold water temperatures recorded in 1985 for reasons discussed under Brown Trout, Standard Section.

Gas Supersaturation

Gas supersaturation levels in 1988 and 1987 were similar. The incidence of gas bubble trauma was less evident in 1988. Gas supersaturation levels were very low in 1989, and visible symptoms of gas bubble trauma were rare.

The Bureau of Reclamation conducted several tests using different combinations of sluiceway and radial gate releases to reduce gas supersaturation. Based on the results of these tests, the Afterbay Dam was managed with a combination of sluiceway and radial gates in 1989. The reduced levels of supersaturation observed in 1989 were probably due to a combination of improved afterbay operation and lower than normal discharges.

Fishing Pressure

Fishing pressure continued to increase on the Bighorn River through 1988 and 1989, probably reaching a new high in 1989. In the past a car counter maintained at the Bighorn Access has been used to project annual fishing pressure on the Bighorn. These projections were based on a formula developed using data collected during a creel census conducted during 1982 and 1983 (Fredenberg

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 1966-1989.

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	67.5	2,112
1988	56	47.9	1,766
1989	59	50.9	1,572
MEAN	61.6	56.7	3,708

1985b). This car counter was maintained during 1988 and 1989. Using data from this counter and the formula developed in 1985, there was an estimated 15,548 angler-days of use on the upper 12 miles of river in 1988 and 16,604 in 1989. These numbers were both substantially below the record use level of 21,724 angler-days recorded in 1986.

Observation of use on the river plus conversations with guides and outfitters working the river indicated that angler use in 1989 exceeded the 1986 level. A couple of changes in recent years have made the use of the Bighorn car counter data and the formula developed in 1985 obsolete. The most significant change has been the development of several private accesses along the river between Lind Access and Bighorn Access. The low flows of 1988 and 1989 made for a long day floating and fishing the full 12 miles down to Bighorn Access. Also the fishing was usually better near the upper end of the section. With other options available, many of the guides started taking out at the private accesses upstream of Bighorn Access, allowing them to spend more time fishing the upper section of river, and less time floating. As a result, a large percentage of the anglers fishing the upper river were not counted by the Bighorn Access car counter. Because of this change, inaccurate pressure estimates were obtained for 1988 and 1989. Data collected by the river ranger and boater registration stations in 1990 should provide enough information to allow recalibration of this car counter and development of a new formula for estimating fishing pressure.

Total fishing pressure declined 18% in 1987 after reaching peak levels in 1986, indicating this pressure may be somewhat self limiting. Based on 1987 data, a threshold level around 2,700 angler-days of use per month triggered many complaints about overcrowded fishing conditions (Fredenberg 1988). Levels of almost 3,000 angler-days per month were recorded in August 1988, and 3,200 and 3,100 in August and September of 1989, respectively at the Bighorn car counter and these figures do not include a large part of the use on the river.

There was a significant increase in angler use in the fall of 1989 with the river remaining crowded during most of October. Monthly car counter estimates at Bighorn Access in September and October of 1989 were higher than levels recorded in 1986, despite many anglers taking out upstream at private accesses not being counted.

The Bighorn River continues to receive regular worldwide publicity, and the number of visiting nonresident anglers continues to grow. Overcrowding has become the major management problem on the upper 12 mi of Bighorn.

A second car counter has been maintained at Mallards Landing since 1987. This counter has never been calibrated to allow its use in making pressure estimates, but there have been no obvious trends in increasing or decreasing use since it was installed. It was hoped that the addition of this access would shift some angling pressure downstream of Bighorn Access. This shift did not appear to be happening through 1989.

Creel Census

A partial creel census of the upper 12 mi of the Bighorn River was conducted on 18 days from May through October in 1988. A total of 1,144 anglers fishing 9,313 hours was surveyed.

The trend continued towards increasing number of nonresident anglers on the Bighorn. The percent of Billings residents in the anglers surveyed dropped from 29% in 1987 to 24% in 1988, while the number of nonresidents increased from 54% to 64%.

Twenty-five percent of the parties interviewed in 1988 were fishing with a guide compared to 16% of the parties interviewed in 1987 and 19% in 1983 (Fredenberg 1988). Over 93% of these guided anglers were nonresidents, and over 98% were exclusively fly-fishermen.

All data summarized for this creel census were collected at a check station set up at Bighorn Fishing Access. As discussed previously, many of the guides were taking out at private accesses upstream of Bighorn Access and were not interviewed by the creel clerk. As a result, the number of guided parties on the river, as well as the percent of nonresident anglers in the fishing population, were underestimated by this creel census.

Catch rates for 1988 were the highest yet recorded for the Bighorn River. Anglers caught an average of 1.02 fish per hour. The lowest monthly catch rate recorded in 1988 was 0.85 fish per hour in May. By comparison, the best monthly catch rate recorded in 1983 was 0.49 fish per hour in September (Fredenberg 1985b).

Overall, 71% of the anglers used flies in 1987, 12% used lures, and 17% used a combination. The shift towards more fly fishermen is a continuation of a trend seen in the past (Fredenberg 1988). Anglers using flies caught an average of 1.14 trout per hour versus 0.75 fish per hour for lures and 0.50 per hour for combinations.

The catch was composed of 77% brown trout and 23% rainbow, a reversal of the trend towards fewer rainbow seen in 1987 (Fredenberg 1988). Catch rates for rainbow also continued to increase to an average of 0.19 rainbow per hour compared to catch rates of 0.16 per hour in 1987 and 0.11 per hour in 1983.

The average angler caught 8.1 fish in 1988 and kept 0.54 fish, representing an increase in the average catch rate, but a decrease in the number of fish kept over past years (Fredenberg 1988). The number of catch-and-release anglers is increasing on the upper 12 mi of the Bighorn River.

A total of 406 harvested brown trout were measured by the creel clerk. They averaged 15.2 in long and ranged from 10.2 to 22.5 in. Only 7 rainbow were measured. They averaged 17.6 in long and ranged from 13.8 to 28.0 in.

Brown Trout

Standard Section

Based on management recommendations from the 1987 study year (Fredenberg 1988), spring electrofishing was discontinued in 1988 and the standard shocking section was shortened by 3.0 miles. This section now extends from RM 3.8 to RM 8.0. Fall population estimates were conducted in September of 1988 and 1989.

The cumulative impacts of low flows and colder water temperatures took their toll on the brown trout population in the standard section during 1988 and 1989. After reaching a peak fall population of 8,458 age 1 and older brown trout per mile in 1987, the brown trout population in the standard section experienced a major decline during 1988 and 1989 (Figure 2). Populations of 5,228 and 4,601 age 1 and older brown trout were recorded in 1988 and 1989, respectively.

Since 1981, the trend has been towards increasing dominance of age 2 and 3 fish in the population (Table 2). The record population recorded in 1987 was composed of 42% age 2 and 38% age 3 brown trout (Fredenberg 1988). During 1988 and 1989 dominance of age 3 fish increased in the population, with these fish comprising 49.5% and 55.4% of the 1988 and 1989 populations, respectively.

Table 2. Estimated number of brown trout per mile in the standard electrofishing section (RM 3.8-8.0)* of the Bighorn River during fall 1981-1989.

Age	12/81	12/82	9/83	9/84	9/85	9/86	9/87	9/88	9/89
0	7,198	4,952	7,312	--	--	--	--	--	--
1	922	1,957	2,526	4,468	2,294	2,787	1,537	685	873
2	870	954	1,024	2,103	1,615	2,948	3,518	1,861	1,002
3	183	267	519	871	909	1,036	3,219	2,585	2,550
4+	243	190	117	203	428	260	184	97	156
Total (1+)	2,218	3,368	4,186	7,645	5,246	7,031	8,458	5,228	4,601

*RM 2.4-9.6 for 1981-1987.

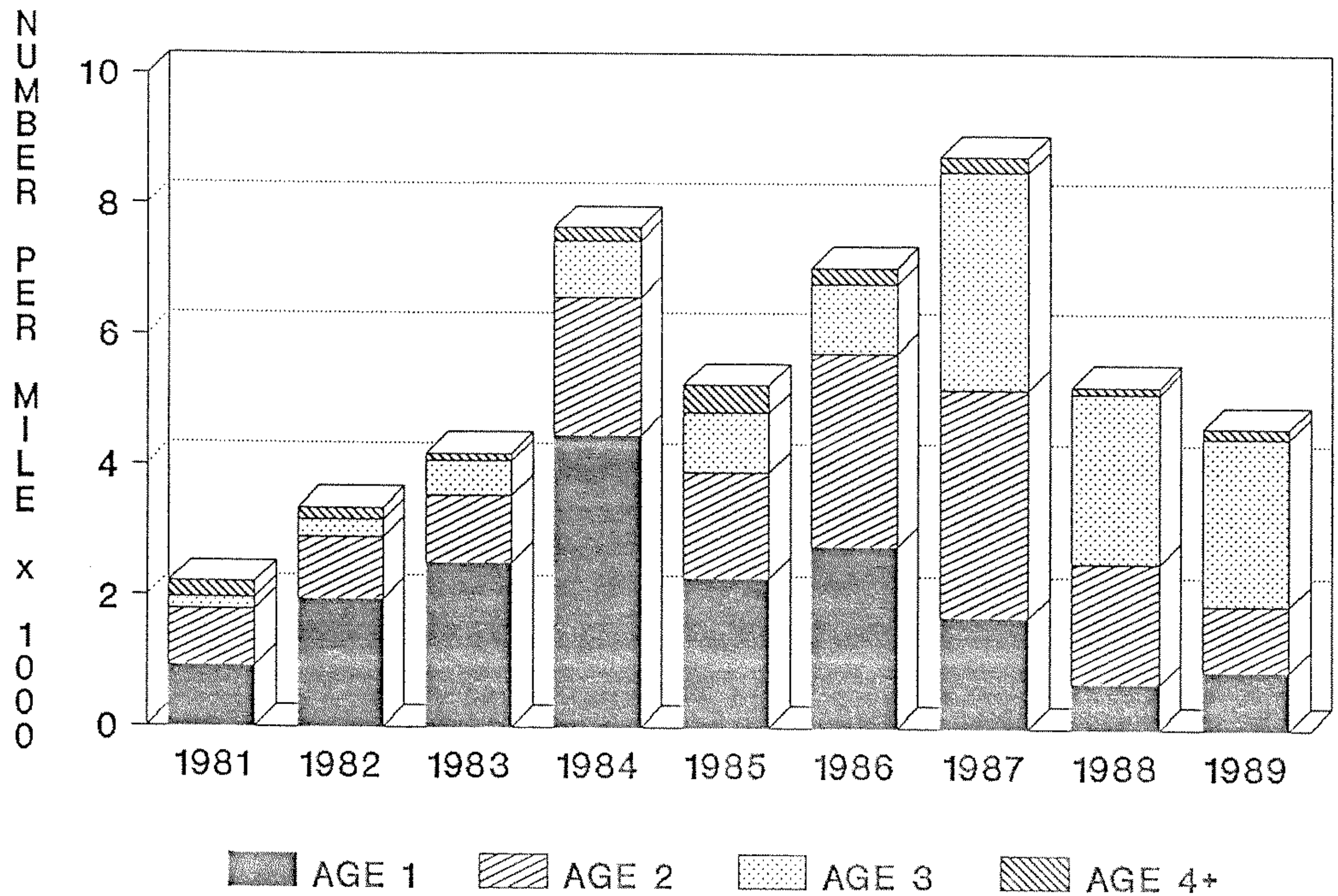

Figure 2. Estimated number (and age composition) of brown trout per mile in the standard electrofishing section (RM 3.8-8.0)* of the Bighorn River during fall 1981-1989.

*RM 2.4-9.6 for 1981-1987.

The number of age 3 and 4 brown trout in the population has remained consistent during the past three years despite the major drop in the overall population size. The major decline occurred in the age 1 and 2 year classes. The decline in age 1 brown trout was first observed in 1987 despite the record population level recorded for the year. The number of age 1 fish (1,537 per mile) estimated in 1987 was the lowest fall estimate since December 1981 (Fredenberg 1988). In 1988, the number of age 1 fish declined again by more than 50% to a record low of 685 fish per mile. The slight rebound in 1989 back up to 893 age 1 and older brown trout per mile was still below the level recorded during December 1981. These major declines in age 1 fish have been followed by a corresponding decline in age 2 fish the next year. In 1989, the estimated number of age 2 fish dropped to 1,002 fish per mile, a 71.5% decline from the record high level recorded in 1987.

On the other hand, the number of "trophy sized" (18 in and longer) brown trout increased during 1988 & 1989. In 1987, 146 brown trout per mile 18 in and longer were estimated for the standard section (Fredenberg 1988). This number increased to 309 per mile in 1988 and 412 per mile in 1989. The number of trophy sized brown trout estimated in 1989 is still below the goal of 500 18 inch and longer brown trout per mile in the upper river, but is the second highest fall estimate since sampling began in 1981.

Biomass estimates dropped to 7,373 lbs of brown trout per mile in 1988 and just over 7,000 pounds per mile in 1989. This was a 27% decline in biomass between 1987 and 1989 compared to a 46% decline in total population numbers, reflecting the increasing dominance of larger fish in the population. The biomass in 1987 was composed of 53% age 3, 37% age 2, 6% age 1 and 5% age 4 and older (Fredenberg 1988). In comparison, the 1989 biomass was 69% age 3, 23% age 2, 6% age 4 and older and 2% age 1.

Changes in the fall biomass of age 1 and older brown trout measured in the standard section correlate closely with summer flows in the Bighorn River (Figure 3). For each year since 1981, every increase or decrease on the flow curve is followed by a corresponding increase or decrease in biomass recorded the following fall. A given volume of water will only support a certain biomass of fish flesh. As river flows decrease, biomass also declines. Other factors such as cold water temperatures and more rainbow trout play a role in this relationship, but the continued decline in flows during 1989, will likely cause one more year of declining biomass before recovery begins.

Mortality rates were extreme for age 3 fish during both 1988 and 1989 (Table 3) with a record loss of 97% of the age 3 population between September 1987 and September 1988. Angler harvest undoubtedly played a part in this mortality. Age 3 brown trout averaged 15.9 in in 1987 and 16.8 in in 1988, compared to average lengths of 12.6 in and 13.6 in for age 2 fish. During the 1988 creel census, the average size of brown trout kept was 15.2 in

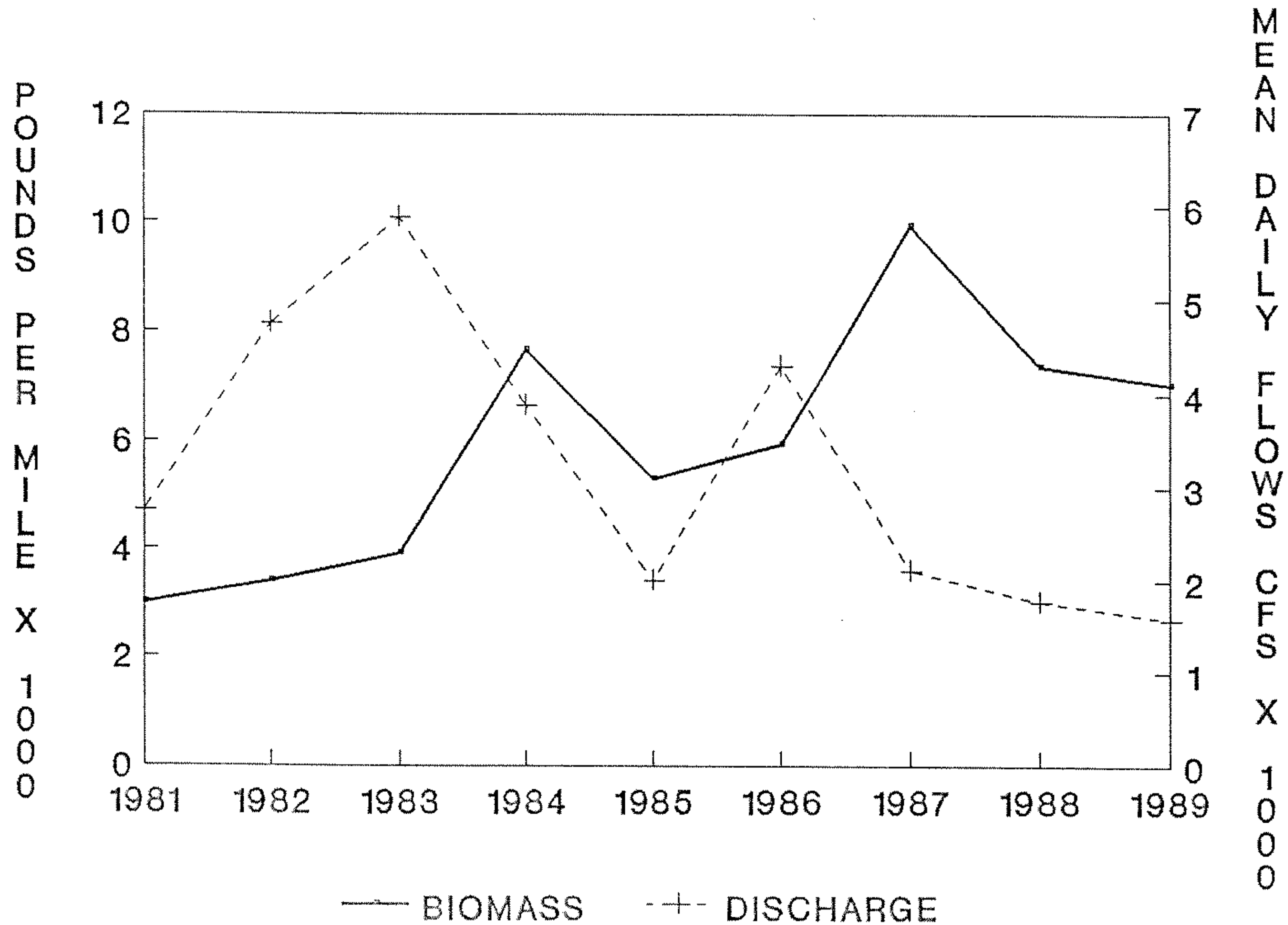

Figure 3. Biomass of brown trout estimated in the standard electrofishing section of the Bighorn River during fall 1981-1989 compared to mean daily summer (July-September) flows recorded in the Bighorn River for the same period.

indicating age 3 fish were a major part of the harvest. During 1987 and 1988 as in the past, environmental factors such as flow levels and water temperatures played a greater role in brown trout mortality on the upper Bighorn River than did angler harvest (Fredenberg 1985a, 1987). The 1988 creel census data indicated that anglers kept an average of 0.54 brown trout per angler-day. Multiplied by 15,548 angler-days estimated by the Bighorn car counter, this accounts for 8,394 brown trout harvested over 12 miles of river, or 700 per mile of river. Based on the population estimates, there was a one year loss of 3,122 age 3 brown trout per mile between 1987 and 1988. Even assuming that all brown trout kept by anglers in 1988 were age 3 fish, angling mortality still only accounted for slightly more than 22% of this loss.

Table 3. Comparison of estimated annual mortality rates (percent change) for brown trout in the standard electrofishing section (RM 3.8-8.0)* of the Bighorn River from 1981-1989. Age class indicated is age at beginning of time interval.

Age Class	12/81-12/82	12/82-9/83	9/83-9/84	9/84-9/85	9/85-9/86	9/86-9/87	9/87-9/88	9/88-9/89
1	+ 3.4	-47.7	-16.7	-63.7	+28.5	+26.2	+21.1	+46.3
2	-69.3	-45.6	-14.9	-56.8	-35.9	+ 9.2	-26.5	+37.0
3	-42.4	-69.7	-63.4	-58.8	-75.7	-92.9	-97.0	-94.0
4 and older	-65.3	-81.2	-88.5	-68.0	-90.8	-97.6	-92.4	-73.0
Total	-36.4	-50.7	-24.1	-61.4	-75.2	- 1.6	-46.3	-29.1

*RM 2.4-9.6 for 1981-1987.

As discussed in the section on fishing pressure, the estimates obtained using the Bighorn car counter are no longer reliable because many of the guides were taking out above Bighorn Access, and their clients are not being counted or interviewed. Total fishing pressure was therefore substantially higher than estimated by the car counter. On the other hand, most of the anglers fishing with these guides were catch-and-release anglers and contributed little to the estimated angling mortality.

Low flows in 1988 and 1989 were probably the major factor responsible for the high mortality observed in the age 3 population. As discussed above, a certain volume of water can only support a given biomass of fish. Good flows in 1986 resulted in strong year-classes of age 1 and 2 brown trout, and this lead to a record brown trout population in 1987, with age 3 fish making up 52% of the total biomass (Fredenberg 1988). Flow levels dropped significantly in 1987 and continued to decrease in 1988 and 1989. As a result, the biomass that could be supported by these lower flows also declined. Age 3 fish represented the major part of the biomass in both 1987 and 1988 and the suffered the greatest mortality.

Mortality rates of age 4 and older brown trout decreased and were actually below mortality rates observed for age 3 fish during both years. This is a reversal of the trend of increasing mortality of these fish observed since 1986. A comparison of the annual mortality rate of age 4 and older brown trout to the corresponding population of age 2 brown trout for the same year demonstrates a density-dependent relationship (Figure 4). As brown trout numbers reached record numbers in 1987, mortality rates for age 4 and older fish reached almost 98%. As the brown trout population declined during 1988 & 1989, the age 4+ mortality rate also declined. Declining mortality rate for the larger fish in the face of continually increasing fishing pressure is another good indication that angling mortality was not a major factor affecting their mortality compared to competition with smaller fish for food and space.

Past seasonal sampling indicates age 2 brown trout move into the standard shocking section during the summer. A mass-marking effort was not successful in identifying the source of these fish (Fredenberg 1988). The unaccounted-for increase in age 1 fish in 1988 and age 1 and 2 fish in 1989, can be best explained by movement of these smaller fish into the shocking section between sampling periods. These smaller fish may have been staying in areas too shallow to work with a shocking boat during low flows, or they may have been completely outside of the section. More work is needed to determine the location of these fish during fall sampling.

Brown trout growth rates in the Bighorn River are affected by both water temperature and total fish densities (Fredenberg 1986, 1987, 1988). The interaction of these two factors in 1988 and 1989 made identification of consistent patterns in growth rates difficult. Water temperatures were very cold both years, which should have suppressed growth rates. At the same time, total fish densities in the river were decreasing, which should have removed some of the density-dependent stress inhibiting growth rates. Also, the older age classes of fish were still affected by lower growth rates resulting from cold water temperatures in 1985. In general, the average size in 1988 and 1989 was better than it had been since 1985 (Table 4). Effects of 1988 cold water temperatures were evident in the age 1 year class in 1989. These fish only averaged 7.8 in, which was the shortest average length yet recorded for this age group.

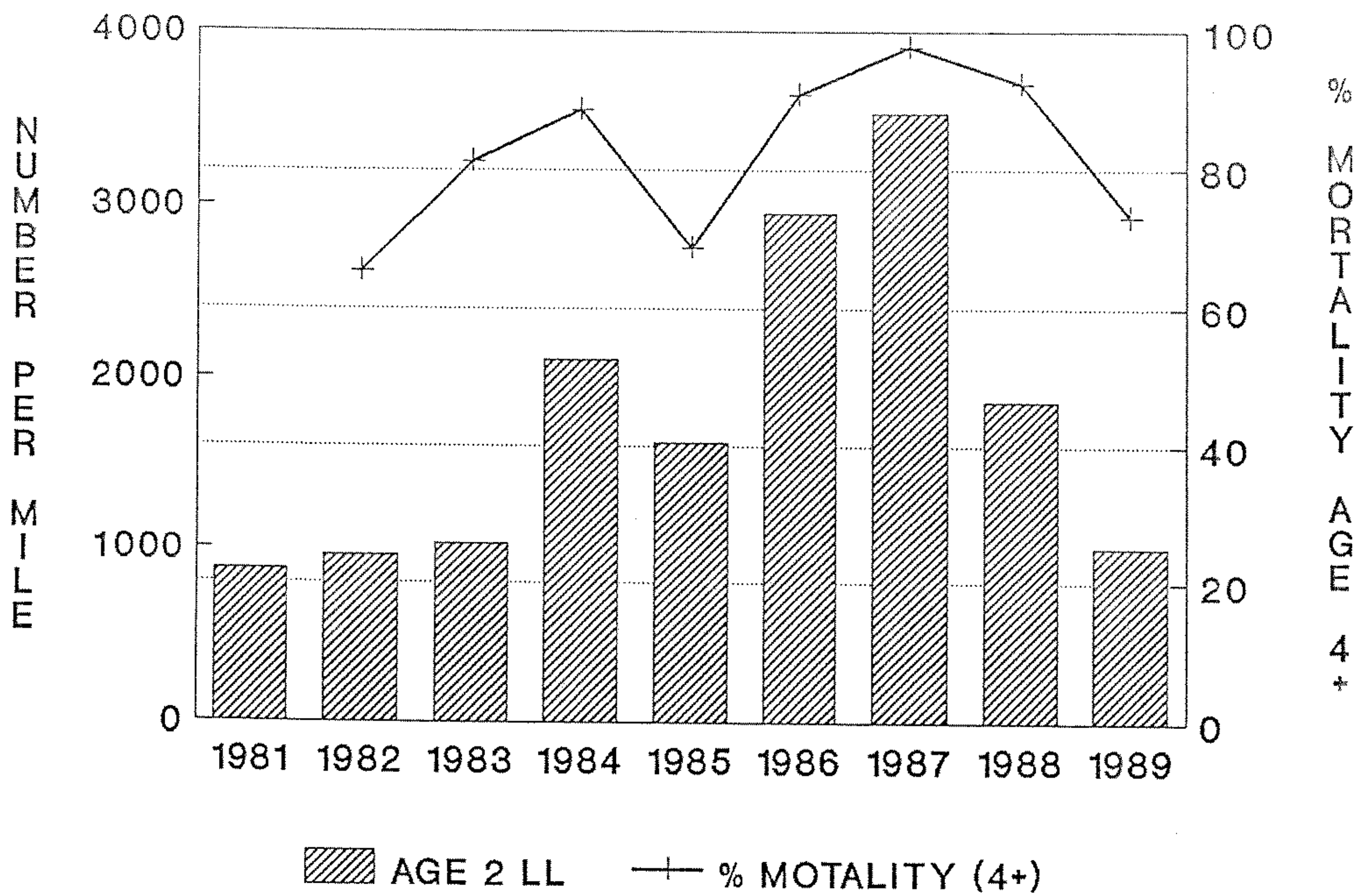

Figure 4. Comparison of annual mortality of age 4 and older brown trout to the estimated number of age 2 brown trout per mile in the standard electrofishing section of the Bighorn River during fall 1981-1989.

Table 4. 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 1981-1989.

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

*RM 2.4-9.6 for 1981 through 1987.

In 1989, few brown trout between 9.0 and 13.0 in were collected leading to speculation that an age class was missing from the population. Age data analyses showed that this gap in the population was a result of varying growth rates caused by large differences in water temperatures over several years. Comparing the length-frequencies of estimated brown trout populations sampled in the fall of 1987 and 1989 (Figure 5) shows the large gap between 9.0 and 13.0 in in 1989. In 1987, age 1 brown trout grew well as a result of warm water temperatures in 1986 and 1987. These fish averaged 8.9 in in by fall. Growth rates of age 2 fish in 1987 were impacted by cold water temperatures in 1985; these fish averaged only 12.6 in in the fall. In contrast, age 1 fish in 1989 averaged 7.8 in, or 1.1 in shorter than their 1987 counterparts. Age 2 fish in 1989 got a good start on growth with warmer water temperatures in 1987 and, despite cold water in 1988, averaged 13.6 in by fall (1.0 in longer than age 2 fish in 1987). This large spread between age 1 and age 2 fish resulted in the large gap seen in 1989.

Lower Section

Fall population estimates were conducted on the lower Saint Xavier section (RM 17.6-21.6) during September and October 1988 and 1989. The brown trout population in this section did not decline between 1987 and 1988 as did the population in the upper (standard) section. Numbers of age 1 and older brown trout remained almost constant during 1987 and 1988 (Table 5). The major population decline in the lower section did not occur until 1989 when the population of age 1 and older brown trout dropped from 1,416 during 1988 to 573 per mile, a 60% decline in one year.

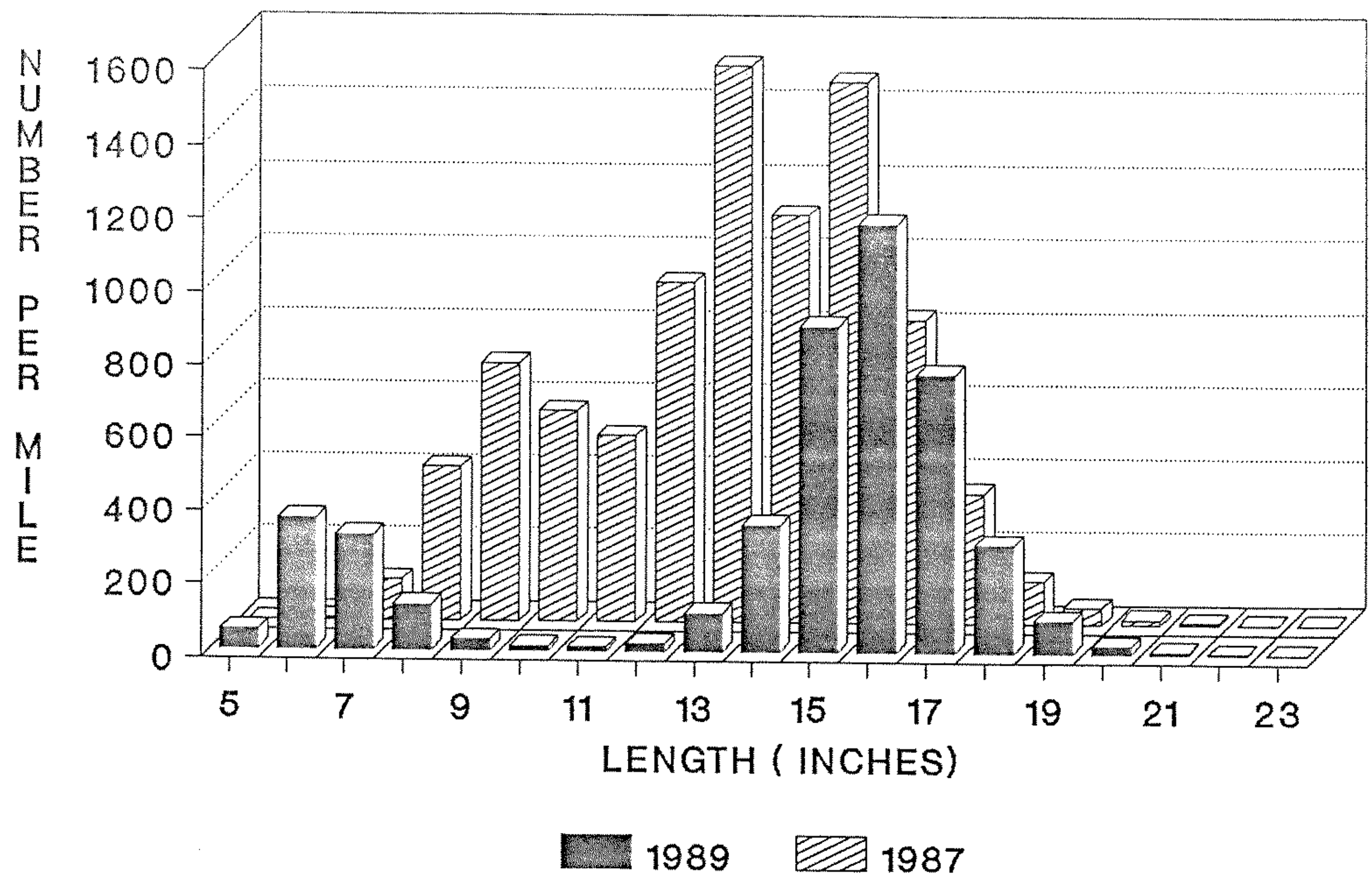

Figure 5. Estimated length-frequencies of brown trout populations in the standard electro-fishing section of the Bighorn River during September 1987 and 1989.

Table 5. Estimated number of brown trout per mile in the lower or Saint Xavier electrofishing section (RM 17.6-21.6) of the Bighorn River during September 1984-1989.

Age	9/84	9/85	9/86	9/87	9/88	9/89
1	1,538	698	1,046	633	767	168
2	558	622	409	488	366	143
3	234	185	212	221	208	199
4+	42	63	40	49	75	63
Total (1+)	2,372	1,568	1,707	1,391	1,416	573

The brown trout population levels in this section are highly dependent on the year class strength of age 1 fish (Figure 6). There has been very little fluctuation in the population levels of age 3 and 4 fish over the past 6 years. Age 2 year classes remained fairly constant through 1988 except for a slight increase in 1985 following the strong age 1 year class in 1984. The age 2 population showed a major decline between 1988 and 1989.

The biomass of brown trout in the lower section increased to 1,493 pounds per mile in 1988, then recorded a major decline to 767 pounds per mile in 1989. Most of this decline occurred in the age 1 and 2 fish (Table 6). There was only a slight loss of biomass in the age 3 and age 4 and older fish. In 1988, age 1 brown trout comprised 29% of the brown trout biomass in this section; 1989, 9% of the biomass.

Table 6. Estimated biomass (pounds per mile) of brown trout by age class in the lower (Saint Xavier) electrofishing section (RM 17.6-21.6) of the Bighorn River during 1988 and 1989.

Age	Biomass (pounds per mile) 1988	1989
1	414	66
2	499	197
3	375	367
4 & Older	151	136
Total	1,439	767

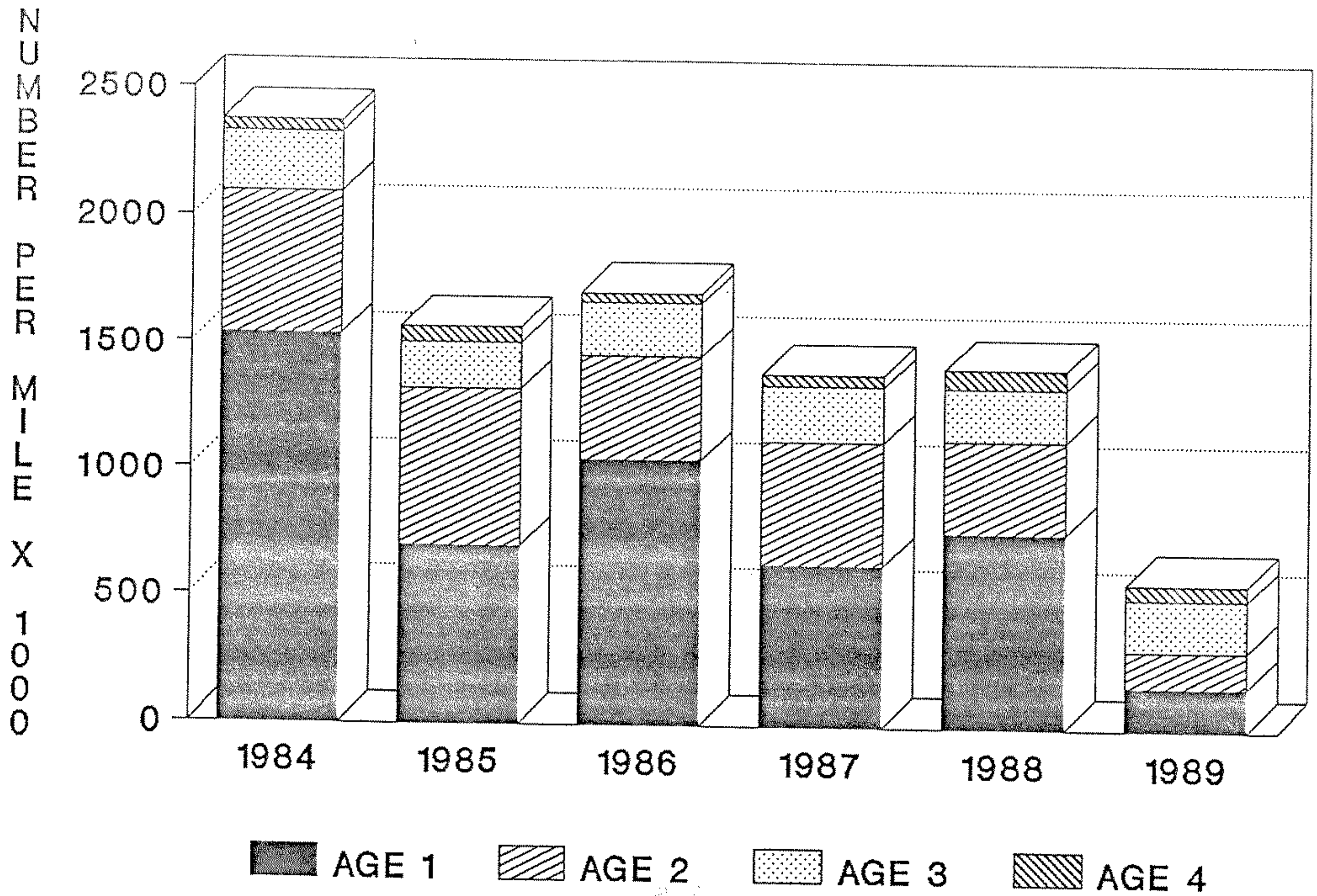

Figure 6. Estimated number (and age composition) per mile in the lower (Saint Xavier) electrofishing section (RM 17.6-21.6) of the Bighorn River during fall 1984-1989.

Mortality rates for the lower section remained higher than mortality rates observed in the standard section (Fredenberg 1988). The mortality rates of age 1 and 2 fish between 1987 and 1988 were similar to those seen in the past (Table 7). Mortality rates for age 3 fish decreased slightly in both 1988 and 1989, while record high mortality rates were observed for age 4 and older fish. (In comparison, mortality rates of age 3 fish in the standard section reached record high levels both years and mortality of age 4 and older fish decreased.) A major increase in the mortality of age 1 brown trout in the lower section between 1988 and 1989 probably accounts for the large decline in the brown trout population between these two years.

Table 7. Comparison of estimated annual mortality rate (percent change) for brown trout in the lower (Saint Xavier) electrofishing section (RM 17.6-21.6) of the Bighorn River from 1984-1989. Age class indicated is age at beginning of time interval.

Age Class	9/84-9/85	9/85-9/86	9/86-9/87	9/87-9/88	9/88-9/89
1	-59.6	-41.4	-53.3	-42.2	-81.3
2	-66.8	-65.9	-46.0	-57.4	-45.6
3	-74.9	-82.7	-82.5	-66.1	-69.7
4 & Older	-90.5	-87.3	-70.0	-97.9	-100.0
Total	-63.3	-57.8	-55.6	-53.3	-71.4

By 1988, brown trout in the lower section recovered from the growth decline caused by cold 1985 water temperatures. The average length of age 1 through 3 fish in 1988 averaged 1.1 in longer than comparable groups in 1987. Lower section brown trout averaged 0.5 to 1.0 in longer than comparable age groups from the standard section. Cold water temperatures in both 1988 and 1989 reduced the growth rate of age 1 fish in 1989. They averaged 9.4 in compared to 11.1 in during 1988.

Average condition factors in the lower section have been consistently 2 to 3 points lower than the standard section in the past (Fredenberg 1988). This trend changed in 1988 when the condition factor for brown trout in the lower section (45.20) averaged almost 3 points higher than in the standard section (42.45). Apparently, low flows and low water temperatures in 1988, although bad enough to cause major losses in numbers and condition of fish in the standard section, were not bad enough to seriously impact the lower section. In 1989, after a second bad water year and a major decline in the brown trout population in the lower section, the average condition factor in the lower section (41.65) was 1 point below the upper (standard) section (42.66).

Summary and Discussion - Brown Trout

The brown trout population in the upper section of the Bighorn River increased dramatically from 1981 through 1986. The population increased annually during this period except in 1985 when flows and corresponding water temperatures were well below normal. The flow conditions in 1985 resulted in a significant one year decline in the brown trout population in the upper river. Flows were very good in 1986 and fair in 1987 and brown trout responded by increasing to record densities in 1987. In 1988 and 1989 flows were again very low, resulting in a major decline in the brown trout population to 1985 levels. Several factors contributed to this decline. The young year classes of brown trout were the most severely impacted.

Two major problems associated with low flows have been discussed: dewatering of important side-channel habitat and cold summer water temperatures. Both can cause serious problems for small fish. Side-channels in the Bighorn are important as spawning and as rearing habitat, so dewatering can impact recruitment. Colder water temperatures delay hatching dates and result in slower growth of fish that are produced. The limited availability of side-channel habitat for rearing in 1988 and 1989 forced most of the small fish out into the main river with the larger fish. Numbers of large brown trout remained fairly high through 1989, so predation probably took a major toll on the limited number of small brown trout that were produced.

As water levels dropped in 1988 and 1989, all fish from the record 1987 population were crowded into a smaller volume of water. Crowding increased competition among all fish for a limited food supply, causing higher than normal mortality and increased movement of brown trout.

High mortality rates and poor condition factors for large brown trout in the upper river became more pronounced as the brown trout population continued to increase, indicating a density-dependent relationship (Fredenberg 1988). As expected, when the total brown trout population declined during 1988 and 1989, the condition factors increased and mortality rates decreased for larger brown trout. Large brown trout are apparently unable to compete effectively for food and space with large numbers of small fish in the Bighorn.

Past data has shown that the Bighorn River is an extremely productive river, and that given good conditions, is capable of producing tremendous numbers of fish. These large populations, however, are produced at the expense of the large brown trout that the anglers want. Future management must be designed to reach a balance that will maintain a population level high enough to maintain good catch rates, but low enough to provide a reasonable number of trophy sized trout.

The 1988 and 1989 data also indicated the brown trout population in the lower river was affected less by the low flows than the population in the upper river. The brown trout population in the lower river actually increased slightly between 1987 and 1988 while a major decline occurred in the upper river. Several factors were probably involved. The 1988 brown trout population in the lower section may have been supplemented by fish moving out of the upper river. Mortality data indicated there was considerable movement of small brown trout during 1988 and 1989. Water temperatures are normally warmer in the lower river due to the influence of tributaries and natural warming by sun and friction. Because there were fewer large brown trout in the lower river, predation on small trout was probably less of a problem.

Despite these differences, even the lower section suffered a major decline in the brown trout population by the second year of low flows. As in the standard section, the small fish were the most severely impacted.

Rainbow Trout

Standard Section

The rainbow trout population in the Bighorn River has been increasing since stocking was discontinued in 1983. This trend continued through 1989 (Table 8). A new high of 961 age 1 and older fish per mile was estimated for the standard section in 1987 (Fredenberg 1988). This population was dominated by wild rainbow from strong year classes produced in 1985 and 1986; however, it also contained a number of larger fish from the last plant of DeSmet rainbow made in 1983. Too few age 1 rainbow were captured in 1988 to allow for a valid estimate for this group. A population of 713 age 2 and older rainbow per mile was estimated, which was almost identical to the population of 721 age 2 and older rainbow per mile found in 1987. The 1988 population was composed almost entirely of wild rainbow since the majority of hatchery fish had been lost from the population by that time. In 1989, age 1 fish were again too few low to estimate, but the rainbow population again attained a new high of 1,163 age 2 and older fish per mile. This estimate was well above our goal of 1,000 age 1 and older rainbow per mile. Both 1988 and 1989 rainbow populations continued to show dominance of the strong year classes of wild rainbows produced in 1985 and 1986 (Figure 7).

Several interesting trends are evident when Figure 7 is looked at in conjunction with past rainbow planting records (Table 9). Over 40,000 6 in Arlee rainbow trout were planted in the upper Bighorn River in August of 1981. These fish showed up as a strong age 1 year class in the fall. The contribution of this plant can be followed through 1985. In 1982 1,300 Madison River rainbow were planted in the Bighorn in May, and 40,000 3 inch Arlee were planted in the afterbay. These fish were not captured in large enough numbers in the standard section to allow for an estimate of age 1 rainbow in the fall of 1982. The last rainbow plant was made in

Table 8. Estimated number of rainbow trout number per mile in the standard electrofishing section of the Bighorn River (RM 3.8-8.0)* during fall 1981-1989.

Age	12/81	12/82	09/83	09/84	09/85	09/86	09/87	09/88	09/89
1	431	-	205	-	-	338	240	-	-
2	42	295	181	153	180	65	457	324	61
3	20	35	195	158	146	177	164	321	646
4+	17	17	22	57	98	110	100	68	466
1(2+)	79	347	398	368	424	352	721	713	1,163

Table 9. Plants of hatchery rainbow trout in Yellowtail Afterbay and the Bighorn River above Bighorn Access during 1980-1984.

PLACE	DATE	SIZE	STRAIN	NUMBER
YELLOWTAIL AFTERBAY	05/27/80	5"	ARLEE	40,700
	05/05/81 10/21/81	3" 8"	ARLEE	40,200
	10/21/81	8"	ARLEE	5,100
	06/10/82	5"	ARLEE	40,000
	05/06/83 10/22/83	4" 5"	ARLEE DeSMET	9,900 27,610
	04/19/83 11/14/84	19" 5"	DeSMET BROOD DeSMET	1,084 40,000
BIGHORN RIVER	1980	-	-	NONE
	08/28/81	6"	ARLEE	40,514
	05/05/82	7"	MADISON	1,325
	10/24/83	5"	DeSMET	45,591
	1984	-	-	NONE

*RM 2.4-9.6 from 1981 through 1987.

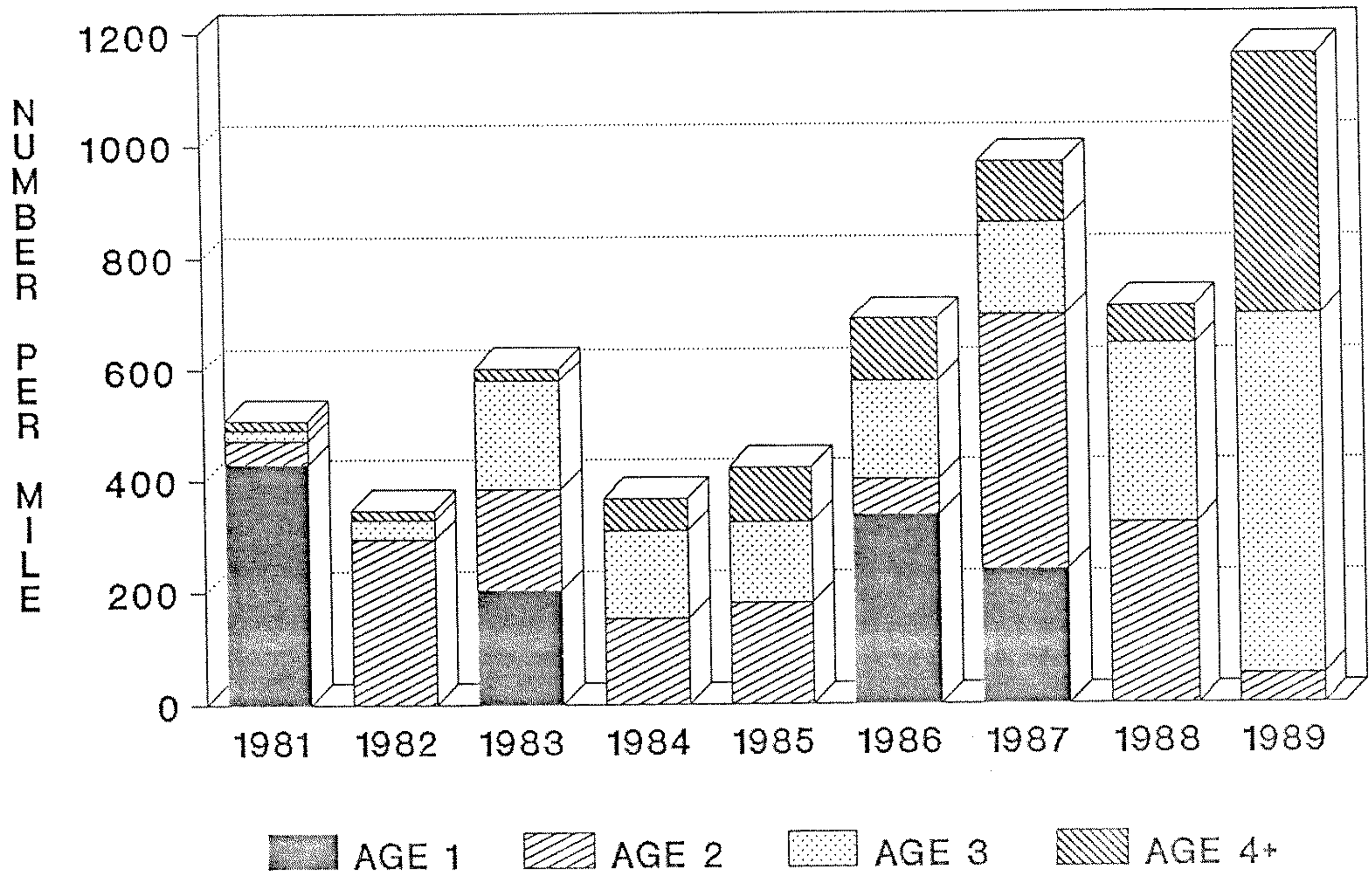

Figure 7. Estimated number (and age composition) per mile in the standard electrofishing section (RM 3.8-8.0)* of the Bighorn River during fall 1981-1989.

*RM 2.4-9.6 from 1981 through 1987.

the upper Bighorn River in the fall of 1983. when over 45,000 5 inch, wild DeSmet rainbow were planted on October 24. These were planted after fall estimates were completed, so the age 1 year class in 1983 had to have been from natural production in 1982 and/or from Arlee rainbow from the 1982 afterbay plant drifting down to the shocking section. The DeSmet rainbow did not show up as age 1 fish in the standard section in the fall of 1984, however, a strong age 1 year class was found in the lower (Saint Xavier) shocking section that fall (Figure 8). The strong year classes from natural production in 1985 and 1986 showed up as age 1 fish in 1986 and 1987. These two year classes dominated the rainbow population through 1989, comprising over 92% of the population.

The rainbow trout biomass also continued to increase in the standard section. The estimated fall biomass of 1,315 lbs per mile in 1988 was a slight increase over the 1987 estimate of 1,206 lbs per mile. Between 1988 and 1989, the biomass of rainbow in the upper river more than doubled to 2,663 lbs per mile due to a continued increase in the number of large rainbow in the population.

Catch-and-release regulations were adopted for the Bighorn River upstream of Bighorn Access beginning March 1, 1987. Mortality rates of older rainbow have decreased since that time, but it is difficult to determine how much of this is due to the regulation changes. The mortality rate of age 2 and older rainbow was 46% between September 1987 and September 1988. This rate was high when compared to the mortality rates reported for the same group in the past (Table 10). This high mortality rate appears to have been due largely to the loss of the remaining hatchery fish from the population. The 1987 rainbow population had a bimodal size distribution with the larger fish consisting mostly of 4 year old DeSmet rainbow from the 1983 plant (Fredenberg 1988). A 97% mortality in this age group between 1987 and 1988 indicated that most of the remaining hatchery fish were lost during that period. Catch-and-release regulations were in effect during most of this time, so it appears that these losses were due to natural mortality. Mortality rates of age 3 fish between 1987 and 1988 were also quite high at 61%. The 35% increase in 1987 age 1 year class in the 1988 population estimate indicates small fish moved into the shocking section.

Only age 4 and older fish showed any actual mortality between September 1988 and September 1989. Their 44.1% annual mortality rate was considerably lower than the average annual mortality rate of 60% measured for age 3 and older rainbow in the past (Table 10). The age 1, 2 and 3 fish all increased in numbers between 1988 and 1989, indicating major movement into the shocking section during 1989. The low mortality rate of age 4 and older fish plus the movement of age 3 fish into the population resulted in a new population structure. The rainbow population in 1989 was composed of 40% age 4 and older fish and 55.6% age 3 fish. In contrast, the

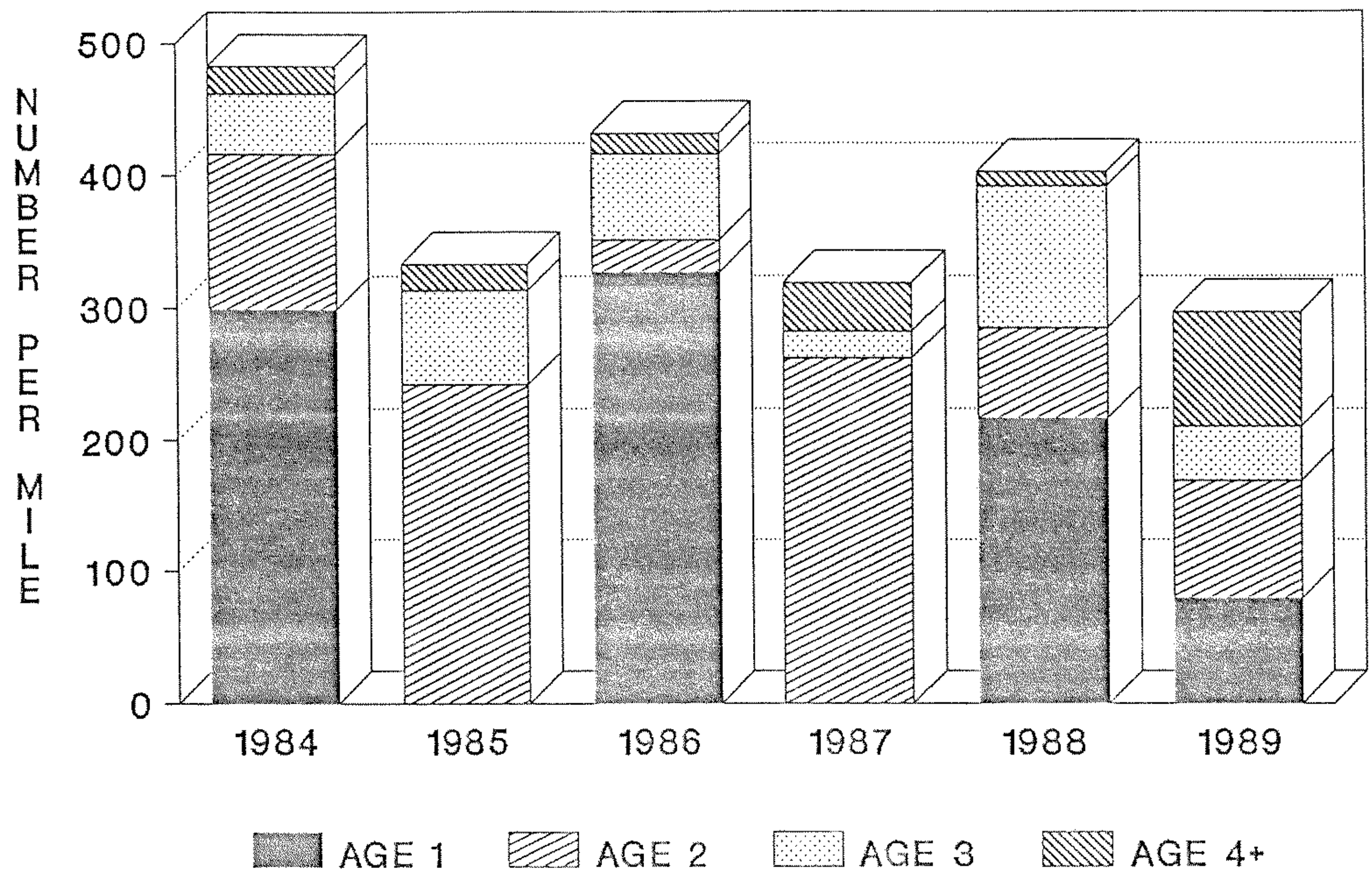

Figure 8. Estimated number (and age composition) of rainbow trout per mile in the lower (Saint Xavier) electrofishing section (RM 17.6-21.6) of the Bighorn River during fall 1984-1989.

Table 10. Comparison of estimated annual mortality rate (percent change) for rainbow trout in the standard electrofishing section (RM3.8-8.0)* of the Bighorn River from 1981-1989. Age class indicated is age at beginning of time interval.

Age Class	12/81 - 12/82	12/82 - 09/83	09/83 - 09/84	09/84 - 09/85	09/85 - 09/86	09/86 - 09/87	09/87 - 09/88	09/88 - 09/89
1	-31.6	-	-25.4	-	-	+35.2	+35.0	(+)
2	-16.7	-33.9	-12.7	-4.6	-1.7	+152.3	-29.8	+99.4
3 & OLDER	-54.1	-57.7	-73.7	-54.4	-54.9	-49.7	-61.0	+33.3
4 & OLDER	-	-	-	-	-	-88.2	-96.6	-44.1
TOTAL (2+)	-34.2	-37.5	-50.0	-33.7	-32.3	-25.0	-46.8	+56.0

Table 11. 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 - 1989.

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

*RM 2.4-9.6 for 1983 through 1986

next highest representation of age 4 and older rainbow trout was recorded in 1987 when this group comprised 14% of the age 2 and greater population.

All 1988 age classes grew faster than those experiencing the cold water in 1985. However, average length remained below age classes sampled prior to 1985 (Table 11). In 1989, the growth rate of age 2 and 3 fish was suppressed by cold water temperatures during 1988.

Despite considerable fluctuations in the population structure, the number of rainbow 18 in and longer has remained fairly stable in the past in the standard section, ranging from 112 to 148 fish per mile (Fredenberg 1987, 1988). This number remained consistent in 1988 with 110 18 in and longer rainbows per mile. As the 1985 year class of wild rainbow reached age 4 in 1989, the number of 18 in and longer rainbows jumped to 612 per mile, four times the goal for the upper river. If mortality rates remain low for the older rainbow, the number of "trophy-sized" fish should remain high through 1990 as the 1986 year class reaches age 4 with the apparent weak year classes of wild rainbow produced in 1987 through 1989, however, this number may decline noticeably in the future.

<u>Lower Section</u>

The total estimate of fall rainbow in the Saint Xavier section increased between 1987 and 1988, entirely due to a strong year class of age 1 rainbow trout not found in 1987 (Table 12). The estimated number of age 2 and older fish in the lower section decreased from a near peak of 319 per mile in 1987 to only 185 per mile in 1988, then the number rebounded slightly to 218 per mile in 1989.

Table 12. Estimated number of rainbow trout (per mile) in the lower (Saint Xavier) electrofishing section (RM 17.6-21.6) of the Bighorn River during September 1984-1989.

AGE	SEPTEMBER 1984	SEPTEMBER 1985	SEPTEMBER 1986	SEPTEMBER 1987	SEPTEMBER 1988	SEPTEMBER 1989
1	299	---	327	---	218	80
2	117	243	24	263	67	91
3	46	70	65	20	107	41
4+	20	20	16	36	11	86
TOTAL (2+)	183	333	105	319	185	218

Biomass estimates for age 2 and older fish dropped from about 500 lbs per mile in 1987 (Fredenberg 1988), to 400 and 421 lbs per mile in 1988 and 1989, respectively.

The strong 1987 age 2 year class experienced a 59% mortality rate between September 1987 and September 1988. Age 3 and older fish from 1987 experienced an 80% mortality rate in 1988. Mortality rates between 1988 and 1989 were 58% for age 1, 39% for age 2 and 20% for age 3, yet age 4 and older rainbow increased 200% in the lower section between 1988 and 1989. Downstream movement from the strong age 4+ class seen in the upper section may explain this increase.

Rainbow population fluctuations in the lower section have also been influenced by year class strength of age 1 fish (Figure 8). The strong age 1 year class in 1984 was probably comprised mostly of DeSmet rainbow planted in the upper river in the fall of 1983. As indicated above, these fish did not show up during 1984 fall population estimates in the upper section. Apparently most of them moved downstream after being planted. Approximately equal numbers of age 1 fish from the strong 1985 year class were found in both the standard (338 per mile) and lower (327 per mile) sections in the fall of 1986. Few rainbows spawn downstream of Soap Creek (Fredenberg 1986). It appears there was a major downstream movement of small rainbow between emergence in 1985 and fall sampling in 1986. Based on 1987 fall sampling in the standard section, a strong year class of wild rainbow was produced in 1986. Numbers of age 1 rainbow in the lower section were too low in 1987 to allow for a valid estimate. Apparently, most of the small fish from the 1986 spawn remained in the upper river through 1987. Age 1 rainbow were almost non-existent in the standard section during the fall of 1988 and 1989, yet enough age 1 recaptures were obtained to allow populations estimates in the Saint Xavier section both years. An estimated 218 age 1 rainbow per mile occupied the lower section in 1988, with 80 per mile in 1989. These data all point to significant movement of small rainbow within the Bighorn River. The apparent increase in numbers between years for older groups of rainbow, seen in 1987 through 1989 in the standard section and in 1989 in the lower section, also indicates there is considerable movement of these age groups.

Because of the extensive movement within the rainbow population, mortality rate calculations are of questionable value when trying to evaluate a specific factor such as angler-caused mortality. An angler can still keep a rainbow in the lower section, plus this area is open to bait fishing which may increase mortality of released fish. Yet this section showed a 200% increase in large rainbow, the ones mostly kept by anglers. Movement of small fish makes the evaluation of year class strength for rainbow difficult based on a fall estimate of age 1 fish.

Growth rates in the lower section continued to exceed those in the upper section in 1988 as they have in the past. In 1989, growth rates of age 2 and 3 fish were about the same in both sections, while age 4 and 5 fish were 0.7 - 1.0 in longer in the upper section. In the past, average condition factors have been 2 - 3 points lower in the Saint Xavier section than in the standard section (Fredenberg 1988). This trend reversed in 1988 and 1989. The average condition factor for rainbow in the lower section in 1988 was 44.35 which was 2.6 point higher than the average condition factor calculated for the standard section. In 1989, the average condition factors were only 0.67 points apart, but again , the lower section was highest.

Summary and Discussion - Rainbow Trout

The wild rainbow fishery in the Bighorn River improved in 1988 and 1989 despite the low flows that seriously impacted brown trout. Rainbow trout numbers have been on the rise in the upper river since stocking was discontinued. In 1989 the rainbow population reached a new high above established goals. These findings corroborate past work that has indicated gas supersaturation rather than flows may be the most important factor affecting rainbow production (Fredenberg 1987, 1988; White et al. 1988).

Even though poor flow conditions are not the major factor effecting rainbow trout, they still impact rainbow in many of the same ways they affect brown trout. Dewatered side-channels result in a loss of spawning and rearing habitat. Small rainbow are forced out into the main channel, and like smaller brown trout, are susceptible to predation by large brown trout. Slow growth rates, due to cold water keeps rainbow trout susceptible to this predation for a longer time.

Small rainbow trout were almost absent from the standard section in 1988 and 1989, but age 1 year classes were estimated both years in the lower section. Small rainbows appear to move more as a result of changing river conditions than do brown trout, making estimates of year class strength based on fall estimates of age 1 fish more difficult.

Large rainbow trout appear to be more efficient in competing with big populations of small fish than do large brown trout. The large increase in age 3 and 4 rainbow in 1989 was related more to year class strength than any density related factors. The rainbow population level recorded in 1989 may be artificially high due to the strong 1985 and 1986 year classes represented. These strong year classes should continue to make a major contribution to the population for several more years. As these year classes begin to die off, there will probably be some decline in the rainbow population. In the mean time, the large numbers of adult rainbow trout have the potential to produce some very strong year classes for the future.

The overall rainbow fishery looked very good at the end of 1989. During the drought conditions experienced in 1988 and 1989, the expanding rainbow population helped fill in for the losses in the brown trout population (Figure 9). Between 1986 (when the rainbow population was dominated by hatchery fish) and 1989, age 2 and older rainbow trout represented between 3.4% and 9.5% of the estimated trout population in the Bighorn River. In 1989, age 2 and older rainbows represented 20.2% of the estimated trout population. Based on these figures, the wild rainbow program is working well on the Bighorn River and should provide a fishery at least as good as any provided by annual stocking in the past.

CONCLUSIONS

The drought conditions experienced during 1988 and 1989 provided an opportunity to evaluate the Bighorn River fishery under some of the worst flow conditions that would normally be expected to occur on the river. Results showed the impacts low flows and cold water temperatures can have on the trout population, (especially the young age groups) and helped reemphasize density dependent relationships in the population. They pointed out differences between rainbow and brown trout and between river sections. The amazing productivity of the Bighorn River and its ability to provide an exceptional trout fishery even under adverse conditions were demonstrated.

Data collected in 1988 and 1989 pointed out the need to manage for a balance between total brown trout numbers and brown trout quality (size and condition) based on a density - dependent relationship. These data also showed that the wild rainbow program is working on the Bighorn with current management practices.

The information and insight gained during the drought conditions of 1988 and 1989 will be used in developing future fishery management objectives for the Bighorn. Future work should place more emphasis on gathering data needed to better manage the angler population on the river. Because of the productivity and resilience of the Bighorn river, a good fishery has continued despite high and increasing fishing pressure. As the number of angler using the Bighorn continues to increase, however, the quality of the fishing experience on the river will decrease despite fishing success, unless the social problems of overcrowding are also managed.

MANAGEMENT RECOMMENDATIONS

1. Continue efforts to maintain target flow levels of 2,000 cfs in the Bighorn River year-round.

2. Continue to work with the Bureau of Reclamation to resolve the gas supersaturation problem using additional data provided by the final report from the Cooperative Fisheries Research Unit.

3. Develop a river ranger program on the Bighorn that will put a Department employee on the upper river 3 to 4 days per week. Design interview forms and a boater registration form

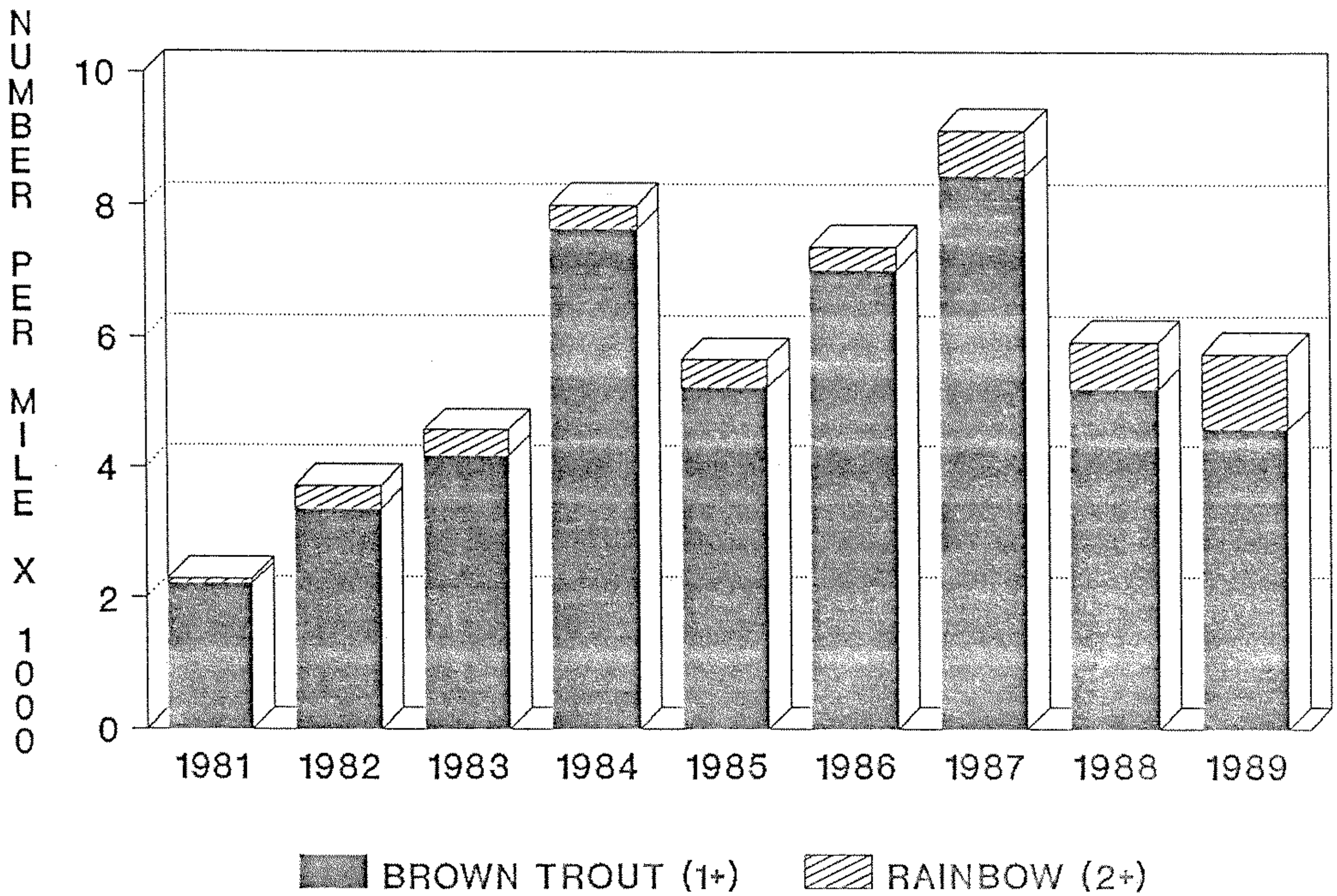

Figure 9. Estimated number of combined brown (age 1 and older) and rainbow trout (age 2 and older) per mile in the standard electrofishing section (RM 3.8-8.0)* of the Bighorn River during fall 1981-1989.

* RM 2.4-9.6 for 1981-1987.

to collect data necesssary to recalibrate the car counter at Bighorn Access. Collect angler attitude and opinion data and document social conflicts on the river.

4. Start soliciting the guides and outfitters and other anglers on the river on ways to better manage the overcrowding problem on the upper 12 miles of Bighorn River.

5. Devise new sampling methods to determine the location of smaller (age 1 and 2) brown trout during fall sampling.

6. Explore regulation changes such as a slot limit which could be used to promote greater harvest of age 2 and 3 brown trout. As flow conditions improve on the Bighorn, some harvest of brown trout will be necessary in order to achieve a population balance that will provide enough fish to maintain good catch rates, and yet is low enough to allow the goal of 500 18 in and longer brown trout per mile to be achieved.

LITERATURE CITED

Fredenberg, W. 1984. 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-27 IV-a.

________________. 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.

________________. 1985b. Bighorn River creel census. 1982-1983. Montana Department of Fish, Wildlife and Parks, Helena.

________________. 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.

________________. 1988. Upper Bighorn River investigations, survey and inventory of coldwater streams. Montana Department of Fish, Wildlife and Parks Job Progress Report F-46-R-1-I-h.

Vincent, E.R., G. Holton, R. McFarland and B. Gooch. 1981. A computer system to compute fish population statistics. Montana Department of Fish, Wildlife and Parks, unpublished report.

White, R.G., G. Phillips, G. Liknes, C. Sprague, J. Brammer, W. Connor, L. Fidler, T. Willimas, and W.P. Dwyer. 1987. The effects of supersaturation of dissolved gases on the fishery of the Bighorn River downstream of the Yellowtail Afterbay Dam. 1987 Annual report. Montana Cooperative Fishery Research Unit, Montana State University, Bozeman.

Prepared by Ken Frazer

Date July 10, 1990

Waters referred to:

22-0490 Bighorn River, Sec. 1
22-0495 Bighorn River, Sec. 2

Key words or fish species:

Brown trout
Rainbow trout
Water temperature
Electrofishing
Population estimate
Denisty-dependent relationship
Growth rate
Condition factor
Mortality rate
Gas supersaturation