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INVENTORY AND SURVEY OF THE SALMONID POPULATIONS OF THE BIG HOLE RIVER OF SOUTHWEST MONTANA, 1981 - 1999.

By:

Richard A. Oswald

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Montana Department of Fish, Wildlife & Parks
Region Three
1400 S. 19th Avenue
Bozeman, Montana

ABSTRACT

River discharge and thermal data are summarized for the Big Hole River at the USGS Melrose Gage site for the water year 1989 through 1999 period of record. A prolonged period of drought persisted through 1994 and dominated flow and temperature regimes over the 1985 through 1994 period resulting in the longest duration, highest amplitude deviation from average flow recorded in a Montana river. The 1995 through 1997 period was dominated by ample flow regimes resulting in above average dominant discharge events which altered habitat niche and affected rainbow trout recruitment. Rainbow trout population studies were conducted from fall estimates in the Jerry Creek, Maiden Rock, and Melrose study sections while brown trout population studies were conducted from spring estimates in the Maiden Rock, Melrose, and Hog Back study sections. Analysis of rainbow trout populations demonstrated strong recruitment and high population density despite drought conditions while brown trout populations exhibited a tendency to decline following extremely low summer flow events in 1988 and 1994. High runoff peaks over the 1995 - 1997 period were associated with weak rainbow trout recruitment while brown trout recruitment appeared to be unaffected and numbers of mature brown trout flourished at observed peak density. Analysis of special restrictive angling regulations strongly suggest that rainbow trout populations were unaffected while populations of large brown trout increased within the first five years of regulation. It is further suggested that habitat conditions and the voluntary catch and release practices of the angling public have probably combined to maintain trout populations within the range of natural mortality, rendering angler harvest and restrictive regulations moot in recent years.

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INTRODUCTION

The Big Hole River is a major tributary of the upper Missouri River drainage in southwest Montana. It merges with the Beaverhead River near Twin Bridges, Montana to form the Jefferson River, one of the three major forks of the Missouri River named by Lewis and Clark. The Big Hole drainage supports native populations of westslope cutthroat and lake trout, arctic grayling; mountain whitefish, burbot, white, longnose, and mountain sucker, longnose dace, and mottled sculpin. The sport fisheries of the drainage, however, are dominated by introduced populations of rainbow, brown and brook trout which were stocked into the drainage in the late 1930's and early 1940's. Stocking of hatchery rainbow trout into the Big Hole River and its tributaries was ceased in 1974 in favor of management for wild trout populations

While the sport fishery of the Big Hole River is dominated by the introduced rainbow and brown trout populations, recent interest in the conservation of native salmonids has expanded research within the drainage. Extensive genetic research has been conducted on tributary populations of native westslope cutthroat trout by Montana Department of Fish, Wildlife and Parks and the Beaverhead National Forest. A native glacial relict population of lake trout in Twin Lakes was studied extensively (Oswald and Roberts 1998) and subjected to genetic testing to confirm its native origins (Oswald 2000). Liknes (1981) and Oswald (1984) initiated research on the fluvial arctic grayling population of the Big Hole River. Since Oswald (Vincent et al 1989) last reported on the status of the arctic grayling population, arctic grayling research has been conducted under the auspices of the grayling recovery program and reported by Byorth (1991 - 1996) and, more recently, Magee and Byorth (1998) and Magee (1999). For this reason, arctic grayling population data will not be included in this report

The wild brown and rainbow trout populations of the Big Hole River were last described in Vincent et al (1989) for the Jerry Creek, Maiden Rock, Melrose, and Hog Back study sections. Since that time, Big Hole River flow regimes emerged from drought conditions after 1994 to enter into a very wet climatic period which resulted in extremely high flow regimes during the 1995 - 1997 period. High amplitude and duration of runoff events during this period significantly modified the geomorphology of the Big Hole River channel and trout habitat niche provided therein, at least on a localized basis. Drought conditions in 1994 precipitated a cooperative effort between sportsmen and irrigators under which irrigation withdrawal was mitigated and the river was closed to angling in August. Subsequent to the events of 1994, a Big Hole River Watershed Committee was formed at the governor's request and a drought response plan was adopted for use under future drought conditions

Whirling disease, caused by infections of the protozoan parasite, *Myxobolus cerebralis*, was discovered in yearling rainbow trout from the Big Hole River in 1996. Subsequent research suggests that the disease has remained present at a relatively low frequency of infectivity within the trout populations and relatively low grade of infection among individual fish (MFWP Unpub. Data).

Angler use of the Big Hole River increased markedly during the 1990's. Angling pressure increased from an estimated 51,203 angler days in 1991 to an estimated 83,408 angler days in 1997 (MFWP 1991 and 1997). While resident angler pressure increased 22.6% between 1991 and 1997, nonresident angler use increased 158%. This increase in pressure has led to the 1999 formation of a citizens advisory committee which is currently studying the issue of crowding on the Big Hole River. This study included summer user surveys in 1999 and 2000 which will gather data on the demographics and use patterns of anglers and other users of the Big Hole River.

METHODS

Trout populations were sampled through the use of electrofishing techniques based on mark-recapture methodologies described by Vincent (1971). Electrofishing was conducted via boat mounted, mobile anode techniques which utilize a 3500 watt generator and Leach type rectifying box. A straight or continuous wave DC current is used at 1,000 to 1,500 watts. Fish captured within the field were drawn to the boat, netted, and deposited into a live car. Individual fish captured were anesthetized, segregated by species, measured for length and weight, marked with a small identifying fin clip, and released. Scale samples for age determination were collected from a representative subsample by length. Multiple marking runs and recaptures runs were made through each of the study sections until predetermined goals were achieved in mark and capture totals.

Trout population statistics were analyzed under a log-likelihood methodology developed and described by Montana Fish, Wildlife and Parks (1994) under guidelines presented by Brittain, Lere, and McFarland (1998). Population estimates were calculated for brown trout from March samples collected from the Maiden Rock, Melrose, and Hog Back study sections while rainbow trout population estimates were calculated from September samples collected from the Jerry Creek, Maiden Rock, and Melrose study sections. The seasonal segregation of brown and rainbow trout population estimates was applied to avoid estimate bias due to spawning movements and migrations.

Flow and temperature data were gathered at the Melrose Gage (USGS 1989-1999), by water year, for the report period. Additional stream gages have recently been installed through the Big Hole Watershed Committee's actions and need to gather additional data. Data presented in this report, however, were limited to the Melrose Gage site because it has been operated from 1923 through the present.

RESULTS

Flow and Temperature Regimes

Summary statistics for dominant flow regimes (Table 1) adequately depict the drought conditions which dominated the Big Hole River for the 1989-1994 period. Vincent et al. (1989) presented graphic depictions of flow patterns for the 1985-1988 segment of the drought episode. Low mountain snowpack resulted in low runoff peaks which were generally of short duration and annual water yield varied approximately between 400,000 and 700,000 acre feet. The relatively high runoff peak of 1991 and persistent summer rainfall in 1993 resulted in relatively high water yields for the period but summer minimum flows were still below average in 1991. Minimum July and August streamflow fell far below the respective long term averages of 1,340 cfs and 477 cfs for those two months, with the exception of 1993. Instream flow requirements for aquatic organisms have been calculated at 650 cfs to maintain optimum habitat and 260 cfs to maintain minimum habitat conditions (MFWP 1989). In all of the drought years except 1993, July minimum flows dropped below the optimum point while August minimum flows fell below minimum habitat conditions.

Flow regimes improved significantly in the 1995 water year and maintained ample flow regimes through 1998. Annual water yield approached or exceeded one million acre feet in each of the years and summer flow minima generally exceeded optimal habitat conditions in July and exceeded minimum habitat requirements in August. The 1995-1997 water years were marked by above average runoff peaks which significantly altered channel geomorphology. The peak instantaneous flow of the 1997 event at 13,000 cfs came closest to approximating the record high runoff of 1972 at 14,300 cfs. The runoff events of 1995-1997 were also of prolonged duration and were marked by temperature regimes that were far below average. Below average spring and summer precipitation in 1999 was bolstered by above average snowpack which maintained late summer flow at levels comparable to those observed in 1990.

Table 1 Average daily flow statistics for the Big Hole River at the USGS Melrose Gage for the 1989 - 1999 period of record.

Water Year	Runoff Peak Flow (Cfs)	July Minimum Flow (Cfs)	August Minimum Flow (Cfs)	Annual Water Yield (Acre - feet)
1989	3,660	441	185	486,700
1990	3,130	385	228	518,100
1991	9,710	450	175	646,500
1992	1,710	421	178	393,900
1993	4,910	982	674	716,200
1994	3,150	272	152	439,800
1995	11,300	983	342	954,200
1996	11,600	606	320	1,199,000
1997	12,800	1,010	514	1,352,000
1998	4,980	866	299	934,400
1999	6,830	407	228	767,900

Low flow regimes during the drought influenced 1989-1994 period were often accompanied by elevated thermal regimes (Table 2). July and August maxima often exceeded 21.1 degrees C. (70 degrees F.) at low summer flow during the period while mean July temperatures of

18.0 degrees C were observed in 1989 and 1991. High summer flows in 1993 resulted in the lowest observed July and August temperatures in the 1989-1999 period. While low flow conditions generally resulted in elevated water temperatures, high July and August temperatures were also associated with relatively abundant flows in 1998. Vincent et al. (1989) reported the 1988 occurrence of thermally induced fish kills affecting mountain whitefish and brown trout in lower reaches of the Big Hole River. The only fish kill observed during the 1989-1994 period occurred in 1994 and affected mountain whitefish, arctic grayling and brook trout in July near the mouth of Pintler Creek (Byorth 1995).

Table 2. Temperature range and mean daily temperature in degrees Centigrade for July and August measured at the USGS Melrose Gage for the 1989 - 1999 period of record.

	JULY				AUGUST		
Year	Max.	Min.	Mean		Max.	Min.	Mean
1989	23.5	13.0	18.0		21.5	10.5	16.5
1990	23.0	13.0	17.5		22.5	12.0	16.5
1991	23.0	12.5	18.0		21.5	14.0	18.0
1992	22.5	12.5	16.5		23.0	8.0	17.0
1993	19.5	10.5	14.0		20.5	10.0	15.0
1994	24.0	10.5	17.5		22.5	11.5	17.5
1995	20.5	11.5	16.1		21.0	12.0	16.4
1996	23.0	13.5	17.7		21.0	11.0	16.5
1997	21.5	10.0	16.5		21.0	13.0	16.5
1998	23.5	15.0	18.5		23.0	13.0	17.1
1999	21.5	11.0	16.5		21.5	13.0	17.5

Rainbow Trout Populations

Jerry Creek Section: Rainbow trout studies were initiated in the Jerry Creek study section in the fall of 1986. Trends in estimated rainbow trout density and standing crop for Age I and older fish are presented in Figure 1 for the 1986-1999 period. No electrofishing was conducted in 1994 due to low flow and high water temperature in keeping with a drought induced closure of angling on the Big Hole River. Despite drought conditions which predominated between 1985 and 1994, rainbow trout populations in the Jerry Creek section expanded and remained at high density. Population densities exceeding 2,000 Age I and older fish per mile were observed in 1987, 1990, 1991, and 1993. These peaks in population were not associated with dramatic rises in standing crop which tended to remain very stable at approximately 1,000 pounds per mile. Peaks in rainbow trout population were associated with strong recruitment cohorts of Age I rainbow trout (Figure 2). The strong recruitment cohorts of 1987, 1990, 1991, and 1993 were associated with moderate runoff peaks (Table 1) observed in the prior year when the fish were incubating or hatching. Conversely, poor recruitment of yearling rainbow trout observed in 1992, and 1996-1998 was associated with runoff peaks of 9,700 cfs and higher. Poor recruitment of yearling rainbow trout into the population between 1995 and 1998 was directly correlated with rainbow trout population declines over that period. While rainbow trout populations declined dramatically from 1993 through 1998. Standing crop did not decline significantly until 1998. This suggests that numbers of adult rainbow trout remained relatively stable despite poor recruitment into the population. Moderate runoff flow regime in 1998 resulted in relatively good yearling recruitment in the 1999 sample.

Special regulations similar to those placed in the Divide to Melrose reach in 1981 took affect in 1988 in the Dickie Bridge to Divide reach which encompasses the Jerry Creek section. This "slot limit" regulation mandated the use of artificial lures and limited harvest to three fish under 13.0 inches in length and one fish in excess of 22.0 inches in length, effectively requiring the release of all trout between 13 and 22 inches. In 1996, the slot limit was deleted from the regulation while the artificial lure restriction was maintained for the Dickie Bridge to Divide reach. As such, prior analyses (Oswald 1984 and 1986 and Vincent et al. 1989) considered 13 inch and larger and 16 inch and larger rainbow trout numbers as valid parameters for the assessment of the special regulations. Numbers of 13 inch and larger rainbow trout Figure 3) increased steadily throughout the 1986-1997 period. This increase was gradual and occurred prior to the establishment of the special regulation in 1988 and continued through 1997 after the slot limit was discontinued in 1996. The highest observed densities of 13 inch and larger rainbow trout occurred in 1996 and 1997. Recent declines in 13 inch and larger fish followed poor yearling recruitment in the 1995-1999 period. Densities of 16 inch and larger rainbow trout are depicted in Figure 4. Numbers of these larger fish appear somewhat limited in the Jerry Creek section and appear maximized, with the exception of 1987, at approximately 40 per mile. While the slot limit regulation was in affect in the Jerry Creek Section, 16 inch and larger rainbow trout did not demonstrate any significant increase and exhibited a declining trend between 1991 and 1996. The highest observed densities of 16 inch and larger rainbow trout occurred in 1987 and 1997, both years under regulations without the slot limit protection.

Affects of special regulations have been monitored (Oswald 1986, Vincent et al. 1989) through comparisons of study sections under special regulations with the Melrose study section which has never been managed under special regulations. A meaningful method of comparison has been devised to analyze the shifts in the percent of standing crop which is occupied by fish in discreet length ranges under the protection of the special regulations for both rainbow and brown trout. This method is based on the assumption that protection of larger or mature fish will result in an upward shift in the percent of the biomass occupied by those fish if harvest is keeping numbers of large fish substantially below carrying capacity. This method also utilizes the stability of standing crop as compared with density statistics which can be significantly influenced by recruitment class strength. Figure 5 depicts the percent of standing crop accounted for by 13 inch and larger rainbow trout in the Jerry Creek and Melrose sections. Over the 1981 - 1999 period the 13 inch and larger rainbow trout's contribution to the Melrose section's standing crop has tended to improve, rising gradually from near 60% in the early 1980's to highs in excess of 80%. The special regulations period in the Jerry Creek section resulted in no appreciable shift in the biomass contribution of 13 inch and larger rainbow trout and only recently attained levels comparable to the Melrose section under low population densities and poor recruitment classes. Similar trends can be seen in a comparison of the biomass statistics for 16 inch and larger rainbow trout (Figure 6) although the differences between the Melrose and Jerry Creek sections are more distinct. The Melrose section consistently has supported higher relative biomass of fully mature rainbow trout than the Jerry Creek Section and demonstrated an improved condition in the 1990's despite the lack of any special regulation.

Maiden Rock Section: Rainbow trout population study in the Maiden Rock section was initiated in order to study the affects of special angling regulations applied to the river reach between Divide and Melrose, Montana. No sampling was conducted in 1994 due to drought conditions and sampling was not conducted in 1998 and 1999 due to other demands and time limitations. Rainbow trout population density and standing crop are presented in Figure 7 for Age I and older fish over the 1981-1997 period. Rainbow trout densities and standing crops in the Maiden Rock section approximate 50% of those observed in the Jerry Creek Section. While populations over the 1982-1987 period slightly exceeded 1,000 per mile, densities since 1988 declined slightly with the exception of observed highs recorded in 1990 and 1991. Significant recent declines in 1996 and 1997 mimicked those observed in the Jerry Creek Section and were associated with poor recruitment (Figure 8) of Age I fish. Recruitment of Age I fish has remained relatively constant at approximately 400 per mile in the Maiden Rock Section. Strong recruitment classes observed in 1990, 1991, and, to a lesser extent, 1987 paralleled observations made in the Jerry Creek section, however, strong recruitment observed in 1993 in the Jerry Creek section was not observed in the Maiden Rock section. The strong recruitment of 1990 and 1991 did not result in expected increases in rainbow trout populations in subsequent years in the Maiden Rock section.

The previously discussed special regulations involving imposition of a "slot limit" and artificial lure restriction were originally imposed in the Maiden Rock section in 1981. Immediately following the imposition of the regulation, numbers of 13 inch and larger and 16 inch and larger rainbow trout (Figures 9 and 10) exhibited a marked increase through 1988. Until recent recruitment declines in 1996 and 1997, numbers of 13 inch and larger rainbow trout had stabilized at approximately 200 per mile, substantially below densities observed shortly after the special regulations were imposed. Numbers of 16 inch and larger rainbow declined significantly after 1988 and have remained far below numbers observed in the mid 1980's despite the continuation of the special regulations and improved streamflow conditions.

Comparisons of the percent of biomass accounted for by 13 inch and larger and 16 inch and larger rainbow trout in the Maiden Rock and Melrose study sections are depicted in Figures 11 and 12. Following the imposition of special regulations in 1981, biomass percentages increased for both size analysis groups in the Maiden Rock section to attain their respective observed highs in 1986. A similar trend, however, was observed in the Melrose section despite a lack of special regulations Since 1989, a significantly higher percentage of the Melrose section rainbow trout biomass has been accounted for by 13 inch and larger fish when compared with the Maiden Rock section This difference was more substantial for the comparison of mature, 16 inch and larger fish which have occupied a markedly higher percentage of the rainbow trout standing crop in the Melrose section since 1989 despite a lack of the special regulations applied in the Maiden Rock section

Melrose Section: Trends in rainbow trout population density and standing crop are depicted in Figure 13 for the 1981-1999 period. Rainbow trout densities in the Melrose section average far below those observed in the Jerry Creek section and slightly lower than those observed in the Maiden Rock section. Although rainbow trout densities in the Melrose section tended to be slightly lower than those observed in the Maiden Rock section, standing crops, since 1989, have matched or exceeded those observed in the Maiden Rock section, indicative of larger fish at lower density or a slightly more productive environment. As was the observed case in both the Jerry Creek and Maiden Rock study sections, population peaks in the Melrose section were associated with strong recruitment of Age I fish (Figure 14) while recent declines in population were associated with weak recruitment. While the 1999 recruitment of Age I rainbow trout influenced a population recovery in the Jerry Creek section, the observed recruitment peak and population recovery in the Melrose section was far more substantial.

Numbers of 13 inch and larger rainbow trout are depicted in Figure 15 for the Melrose section over the 1981 - 1999 period. Densities of 13 inch and larger rainbow trout have demonstrated a long term trend of increase over the period although recent declines in 1998 and 1999 have been associated with poor recruitment. Numbers of 16 inch and larger rainbow trout (Figure 16) have increased dramatically since 1989 and remain far higher than those observed in the Jerry Creek and Maiden Rock study sections despite the lower observed rainbow trout populations characteristic of the Melrose section and lack of any special regulation restrictions.

Brown Trout Populations

Maiden Rock Section: Brown trout population studies were initiated in the spring of 1981 to assess the affects of the previously discussed special angling regulations. Affects of the special regulations have been previously evaluated by Oswald (1986) and Vincent et al. (1989). Brown trout populations and standing crops (Figure 17) have demonstrated an expanding trend since 1981. Populations increased markedly after 1984, declined somewhat during the 1989-1992 drought influenced period, and recovered to observed high densities over the 1993-1998 period. Recent populations generally exceed 1,000 Age II and older fish per mile with standing crops ranging between 1,100 and 1,500 pounds per mile.

Numbers of 13 inch and larger brown trout increased markedly from about 400 per mile to 600 per mile between 1985 and 1992 following the imposition of special regulations. Numbers of 13 inch and larger fish again increased to approximately 800 per mile and twice nearly reached or exceeded 1,000 per mile between 1993 and 1998. Numbers of 18 inch and larger brown trout (Figure 19) increased sharply upon initiation of the special regulations to an observed high of 135 per mile in 1986. Since 1986, numbers of 18 inch and larger brown trout have fluctuated between highs in excess of 85 per mile and an observed low of 40 per mile until the most recent upsurge in number resulted in an estimate of 126 per mile in 1998 Despite dropping to a low of 40 per mile in 1992, numbers of 18 inch and larger brown trout have not been observed to decline as low as the 26 per mile estimate prior to the inception of special regulations in 1981. Observed brown trout biomass peaks in which standing crop markedly exceeded density in 1986, 197, and 1998 (Figure 17) were correlated with observed peaks in the density of 18 inch and larger brown. High numbers of 18 inch and larger fish, however do not explain the observed biomass - density differentials in 1991 and 1993 although the 1993 differential can be attributed to high numbers of 13 inch and larger brown trout (Figure 18)

Similar to the rainbow trout, brown trout population data were also subjected to comparative analysis of the percent of the standing crop occupied by 13 inch and larger and 18 inch and larger fish under special regulations The 18 inch standard was selected for brown trout as indicative of a fully mature (4 to 5 year old minimum) individual for the species A comparison of the percent of the brown trout biomass accounted for by 13 inch and larger fish is presented in Figure 20 for the Maiden Rock and Melrose sections In the years immediately following the enactment of special regulations in 1981, the percent of biomass accounted for by 13 inch and larger brown trout increased markedly in the Maiden Rock section while remaining relatively static in the Melrose section Beginning in 1989, however, the contribution of 13 inch and larger brown trout to the standing crop rose sharply in the Melrose section to approximate the numbers observed in the Maiden Rock section in comparable years Since 1989, 13 inch and larger brown trout have accounted for 83 to 93 percent of the brown trout biomass in both study sections in comparable years. Comparisons of the percentage of the brown trout biomass accounted for by the fully mature 18 inch and larger fish (Figure 21) demonstrate a rapid increase to more than 30% in the Maiden Rock section while observed percentages in the Melrose section remained relatively static at approximately 10% through 1993 Since 1995, the percent of the Melrose section brown trout biomass occupied by 18 inch and larger fish has increased to approximate that observed for the Maiden Rock section although the Maiden Rock percentage has been below highs observed in the 1980's

Melrose Section: Age II and older brown trout population densities and standing crops of the Melrose section are exhibited in Figure 22 for the 1981-1999 period. Brown trout populations in the Melrose section have fluctuated between an observed low of 526 and high of 1,569 per mile but have generally varied between 800 and 1,000 per mile in most of the sample years. Prior to 1989, population density generally exceeded standing crop in the one to one comparison of Figure 22 but subsequent samples have revealed higher standing crops indicative of an increase in the size of the average fish Brown trout populations declined during drought influenced years following the observed high of 1985 but have remained relatively constant in the 800 to 1,000 per mile range since 1993

Numbers of 13 inch and larger brown trout (Figure 23) increased dramatically after 1984 and have maintained densities approximating or in excess of 600 per mile in all but the 1991 and 1995 samples. While numbers of 18 inch and larger brown trout (Figure 24) had varied between an observed low of 22 per mile and high of 56 per mile over the 1981-1993 period, numbers of these mature fish increased substantially, in a linear fashion, over the 1993-1999 period. The 1999 sample revealed the highest density of 18 inch and larger brown trout in the past two decades in the Melrose Section.

Although neither the Melrose study section or the Hog Back study section have been subject to special regulations, it is useful to compare the percent of standing crop occupied by 13 inch and larger and 18 inch and larger brown trout between the two study areas. The percent of the brown trout biomass accounted for by 13 inch and larger is compared for both study sections in Figure 25. Since 1989, the percent of the Melrose section brown trout biomass accounted for by 13 inch and larger fish has generally remained higher than that observed for the Hog Back study section. In the most recent samples, however, 13 inch and larger fish accounted for more than 87% of the Hog Back section brown trout standing crop and exceeded the comparable value for the Melrose section in 1999. In the similar comparison of the two study sections for 18 inch and larger brown trout (Figure 26), the Melrose section generally far exceeded the Hog Back section in terms of the percentage of standing crop occupied by these larger mature fish. The recent trend since 1995 in the Hog Back section, however, has exhibited an increase in the percent of the standing crop occupied by 18 inch and larger fish. Almost 15% of the 1998 brown trout standing crop was composed of 18 inch and larger fish in the Hog Back section representing an observed high in the sampling history of the study section

Hog Back Section: The Hog Back study section was initiated in the spring of 1987 in order to monitor the brown trout dominated lower reaches of the Big Hole River (Vincent et al 1989). Estimated spring densities and standing crops of Age II and older brown trout are presented in Figure 27. The brown trout populations of the Hog Back section average at a slightly higher density than those of the Maiden Rock and Melrose sections, however, biomass generally has been maintained below density in a one to one comparison. This is generally descriptive of a smaller average fish in the population when compared with samples in the other two study sections and is probably related to higher brown trout density and slight differences in productivity. Despite these limitations, brown trout biomass exceeded or equaled density in the 1998 and 1999 samples. Brown trout density declined steadily over the drought influenced 1987-1990 period, rebounded slightly in the 1991-1993 period, and underwent a second decline prior to attaining observed population highs in 1997 and 1998.

Estimated densities of 13 inch and larger brown trout in the Hog Back section (Figure 28) have varied over the study period in a manner quite similar to the trends of the brown trout population (Figure 27). Estimated densities of 13 inch and larger brown trout generally exceed those observed in the Melrose section and compare favorably with those observed in the Maiden Rock section, particularly at high levels observed in the recent 1997-1999 estimates. Estimated numbers of 18 inch and larger brown trout (Figure 29) have typically remained relatively low when compared with the Maiden Rock and Melrose Sections over the study period. More recent samples during the abundant flow regimes of the 1995-1999 period, however, have revealed rapidly increasing populations of 18 inch and larger fish to an observed high of 88 per mile in 1998.

DISCUSSION

Flow and Temperature Regimes

Summer flow and temperatures in the Big Hole River, over the early portions of this report period, were dominated by drought conditions marked by below average mountain snowpack, below average spring and summer precipitation, and high ambient summer air temperatures. Drought influenced conditions on the Big Hole River persisted over the 1985 through 1994 period resulting in a below average flow pattern which exhibited the longest duration and greatest amplitude of deviation from average recorded in a gaged river in the state of Montana (Mt. Dept. Nat. Resources, Unpub. Data). The 1988 water year resulted in the lowest August and September flow minima recorded at the USGS Melrose Gage over the 1924-1999 period of record (USGS 1999). With the exception of 1993, the mean annual water yield of the Big Hole River averaged 40% below average over the 1989-1994 period at the Melrose Gage. Trout population data strongly suggest that the limited flows of the drought period resulted in substantial reductions in numbers of brown trout, particularly large brown trout. Similar reductions in large brown trout numbers were discussed on the Big Hole River in Vincent et al. (1989) and on the Beaverhead River (Oswald and Brammer 1993). Data also suggest, however, that the moderate runoff events of the drought period often resulted in strong, if not exceptional recruitment of juvenile rainbow trout into the population.

High summer water temperatures also marked the 1985-1994 drought period. Maximum July water temperatures recorded at the USGS Melrose Gage ranged between 22.5 and 24.0 degrees C. Over the 1989-1994 report period, with the exception of 1993 which was marked by abundant summer precipitation and cool air temperatures. Thermally induced localized fish kills were documented in 1988 (Vincent et al. 1989) and in 1994 (Byorth 1995). Other indications of stress such as reduced yearling rainbow trout growth, reduced condition factor in mature brown and rainbow trout, and fungal disease were noted in field observations.

The 1995-1997 period was marked by abundant flow regimes supported by above average mountain snowpack and spring and summer precipitation. Spring runoff events were far above average in peak and duration. Mean June flows averaged 77% above the prior 1924-1995 average for the month over the 1995-1997 water years. These runoff events, exceeding average daily peaks of 11,000 cfs in 1995 and 1996, and 12,000 cfs in 1997, resulted in substantial geomorphic alteration of in-channel habitats. The 1995-1997 runoff events were typical of high energy dominant discharges which tend to deepen and widen channels and alter microhabitats contained within (Hunter 1991). Trout population data strongly suggest that the abundant flow regimes of the late 1990's resulted in significant increases in the numbers of large brown trout in the Maiden Rock, Melrose, and Hog Back study sections. Similar increases in the number of large brown trout (Oswald 1986, Vincent et al. 1989) were noted in the Big Hole River following abundant flow regimes in the early 1980's. Rainbow trout population data, however, suggest that the high amplitude, prolonged duration runoff events of the period resulted in poor recruitment of yearling fish into the population. Oswald (2000a) reported poor rainbow trout spawning runs under prolonged cold spring water conditions in 1997 and 1999.

Rainbow Trout Populations

Rainbow trout populations in the Jerry Creek, Maiden Rock, and Melrose study sections demonstrated increasing trends through the 1980's into the early 1990's in terms of population density and standing crop. Expanding populations occurred despite predominant drought conditions and different regulation treatments among the study sections. Rainbow trout populations benefited from strong recruitment of Age I fish in many of the drought affected years but suffered from poor recruitment associated with high amplitude runoff regimes in recent years. The poor recruitment ultimately affected rainbow trout standing crops and numbers of 13 inch and larger and 16 inch and larger rainbow trout by 1998 and 1999. Good recruitment of yearling rainbow trout in 1999, however, bolstered rainbow trout populations and should provide for future replacement of mature fish lost to mortality.

Special regulations including a restriction to artificial lures and flies and a "slot limit" which mandated the release of trout between 13 and 22 inches in length were implemented on the Big Hole River in 1981 on the Divide to Melrose reach which included the Maiden Rock study section. The special regulations were extended upstream to Dickie Bridge, the reach incorporating the Jerry Creek study section, in 1988 but the "slot limit" stipulation was removed in the 1996 fishing season over concern for arctic grayling management and data analyses which indicated that the regulation was ineffective regarding rainbow trout, the dominant sport fish of the reach. The regulations were implemented in response to angler's concerns that numbers of larger trout, particularly large brown trout, were being limited by angler harvest. While Kozakiewicz (1979) indicated that angler harvest was not a limiting factor for Age IV and older brown trout in the Big Hole River, Wells and Decker-Hess (1980) suggested that angler harvest might have been limiting the 18 inch and larger segment of this age group. Avery and Hunt (1981) cited selective harvest of larger fish as the major factor limiting numbers of large brown trout in central Wisconsin streams. Oswald (1986) reported on the apparent early success of the special regulation in increasing numbers of larger brown trout but suggested that improvement in numbers of larger rainbow trout was not significant and further documented declines in numbers of the large brown trout entering the drought period (Vincent et al. 1989). Recent comparative analysis of biomass composition among the three study sections strongly suggests that the special regulations have had no affect in improving the contribution of 13 inch and larger or 16 inch and larger rainbow trout. The rainbow trout populations appear to be strongly driven by recruitment class strength and density dependant factors. While the Melrose section has never been managed under the special restrictive regulations, the highest percentage of biomass occupied by 13 inch or 16 inch and larger rainbow has consistently been observed in this study section. At low rainbow trout density, the Melrose section has produced the highest observed densities of 16 inch and larger rainbow trout in the system. Length frequency analysis and scale aging techniques indicate that yearling rainbow trout in the Jerry Creek section average approximately one inch smaller in length than the yearling rainbow trout of the Melrose section in fall samples, further limiting the size potential of fish in the upper river environments. Data further suggest that the prevailing practice of anglers on most of the major river fisheries of Montana has become voluntary catch and release despite angling regulations allowing harvest. This suggests that carrying capacity and natural mortality rates, under varying habitat conditions, probably are more important in dictating recent

population trends than special restrictive regulations on the Big Hole River.

The recent discovery of whirling disease in Big Hole River trout has raised concern over the future of the river's rainbow trout populations. Data collected to date are indicative of a low frequency of infected fish within the population and a low grade of infection in the fish that have been infected (MFWP Unpub. Data). Random samples of yearling rainbow and brown trout have been collected from the wild populations in the four study sections and sentinel cages of juvenile rainbow trout have been placed into the Big Hole River for later analysis. Future sampling will determine if the disease ultimately results in deleterious effects on the rainbow trout population or remains present at low levels of infectivity.

Brown Trout Populations

The brown trout populations of the Big Hole River proliferated with abundant flow regimes during the early 1980's, declined during the 1985-1994 drought period, and recovered substantially with the ample flow regimes that predominated since 1994. Oswald (1986) and Vincent et al. (1989) discussed the affects of flow on brown trout populations and Oswald and Brammer (1993) documented the affects of low flows on numbers of large brown trout in the Beaverhead River. The recent high flow regimes resulted in high densities of 13 inch and larger brown trout and extremely high densities of 18 inch and larger brown trout in all three of the study sections. In fact, the 1999 estimates for 18 inch and larger brown trout in the Melrose and Hog Back study sections resulted in the highest observed densities of these large fish in the period of study. In contrast with the rainbow trout, the high spring runoff events of the 1995-1997 period did not hamper brown trout recruitment.

The previously discussed special regulations applied within the Divide to Melrose reach in 1981 were assessed by comparing the Maiden Rock and Melrose study sections for brown trout populations. Oswald (1986) reported on early increases in the number of 13 inch and 18 inch and larger brown trout following implementation of the special regulations but, in 1989, observed that little difference existed between the two sections in terms of 13 inch and larger fish (Vincent et al. 1989). Figure 20 portrays obvious increases in the percent of biomass occupied by 13 inch and larger brown trout in the Maiden Rock section when compared with the Melrose section over the 1981-1986 period. Since 1989, however, differences between the two study sections have been negligible in terms of the biomass comparison for 13 inch and larger fish. Close analysis by inch group of brown trout protected under the slot limit in 1989 led Oswald (Vincent et al. 1989) to suggest that the slot limit had been effective in increasing the abundance of 16 inch and larger brown trout despite the fact that fish in excess of 13 inches were protected under the law. He further discussed declines in brown trout density and standing crop as numbers of large brown trout increased and dominated the population. Clark and Alexander (1984) noted a decline in total brown trout numbers and a decline in the numbers of brown trout protected under a "slot limit" regulation on the Au Sable River in Michigan but did not observe a concomitant increase in large fish. Comparisons of 18 inch and larger brown trout suggested that special regulations were effective in shifting the Maiden Rock brown trout population toward larger fish through 1994 (Figure 21). Since 1995, however, substantial increases in large brown trout in both the Melrose and Hog Back study sections suggest that differences between sections with and without special restrictive regulations have become virtually undetectable. This could be the result of habitat conditions favorable to brown trout which have influenced the system with ample flow regimes since 1995. Similar increases in numbers of large brown trout were observed in the Beaverhead and Ruby Rivers under ample flow regimes of the 1995-1999 period (Oswald 2000b). It could also be the result of voluntary catch and release practices adopted by most anglers utilizing the major rivers of southwest Montana in recent years (MFWP Unpub. Data). In lieu of significant harvest or substantial release mortality, brown trout populations would be subject to habitat limited carrying capacity and natural mortality factors and likely would not be influenced by differences in regulations.

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Report Prepared By: Richard A. Oswald, MFWP, Region 3, Bozeman June 2000

All Work Included in this Report in Conjunction with Federal Aid in Fish and Wildlife Restoration Acts:
Project Numbers: F-78-R-1; F-78-R-2; F-78-R-3; F-78-R-4; and F-78-R-5

Montana Fish, Wildlife & Parks Project Number 3304

APPENDIX OF FIGURES

Figure 1. Estimated fall density and standing crop of Rainbow Trout in the Jerry Creek Section of the Big Hole River, 1986 - 1999.

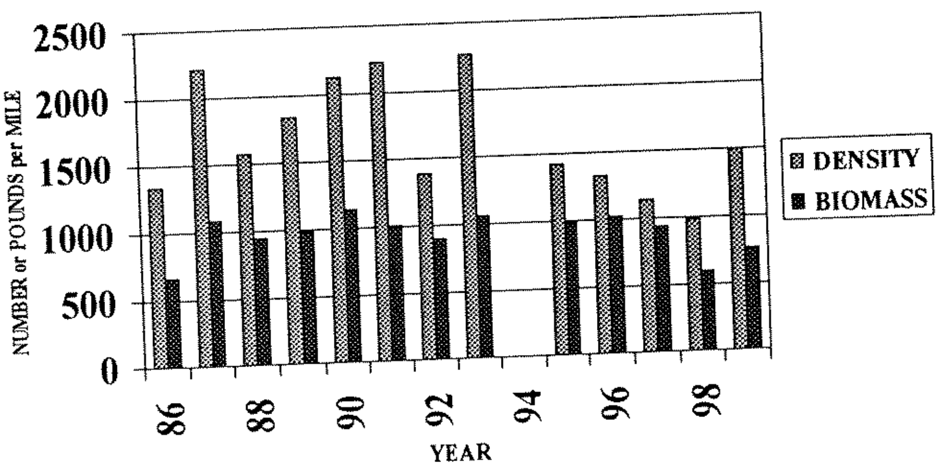

Figure 2. Estimated fall density of Age I Rainbow Trout in the Jerry Creek Section of the Big Hole River, 1986 - 1999.

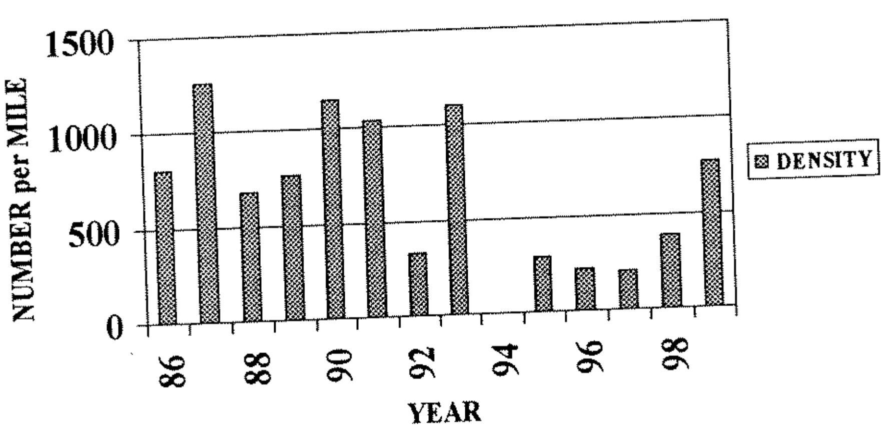

Figure 3. Estimated fall density of 13 inch and larger Rainbow Trout in the Jerry Creek Section of the Big Hole River 1986 - 1999.

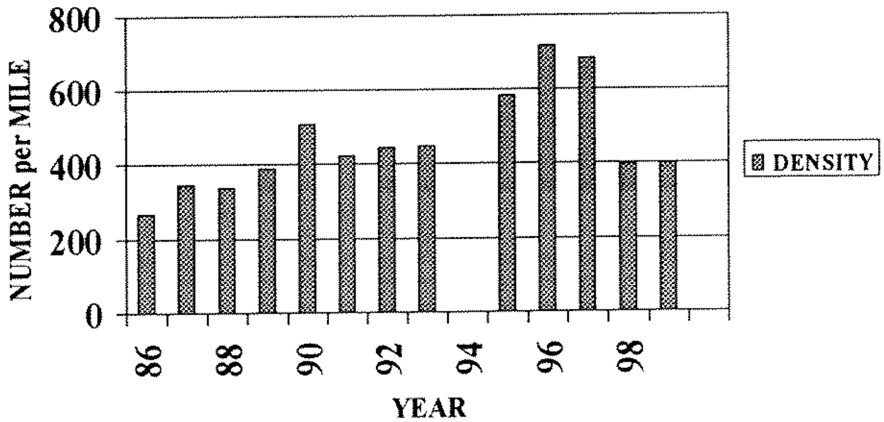

Figure 4. Estimated fall density of 16 inch and larger Rainbow Trout in the Jerry Creek Section of the Big Hole River, 1986 - 1999.

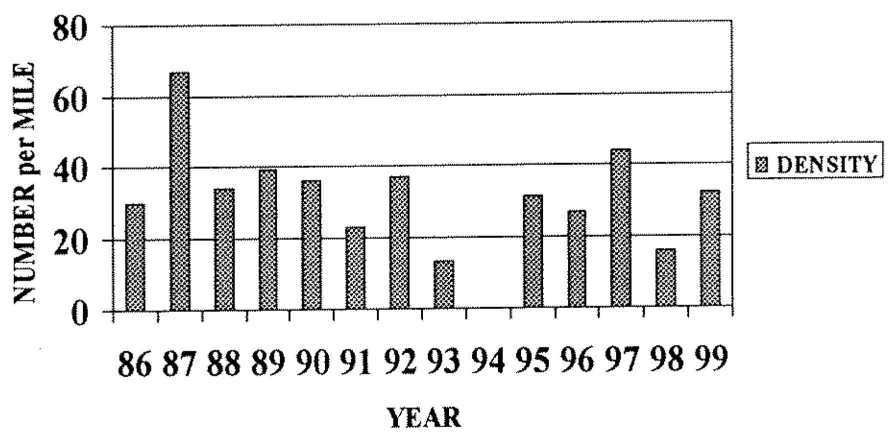

Figure 5. Biomass of 13 inch and larger Rainbow Trout as a percent of the total Rainbow Trout biomass for the Jerry Creek and Melrose Sections of the Big Hole River, 1981 - 1999.

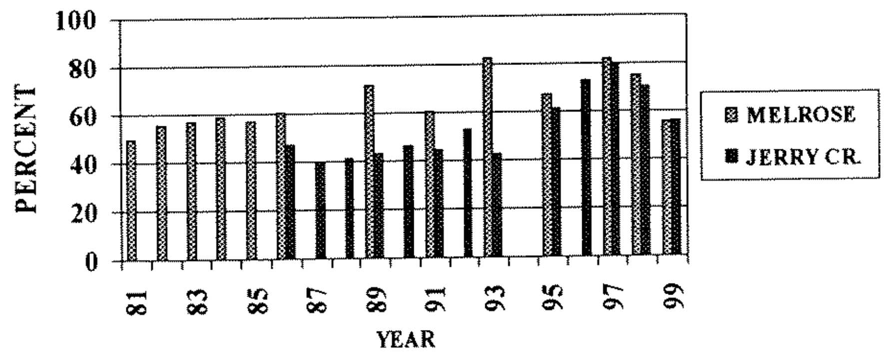

Figure 6. Biomass of 16 inch and larger Rainbow Trout as a percent of the total Rainbow Trout biomass for the Jerry Creek and Melrose Sections of the Big Hole River, 1981 - 1999.

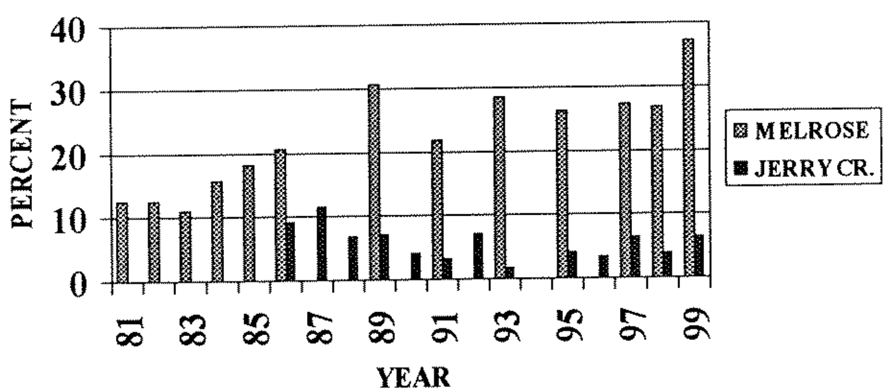

Figure 7. Estimated fall density and standing crop of Rainbow Trout in the Maiden Rock Section of the Big Hole River, 1981 - 1997.

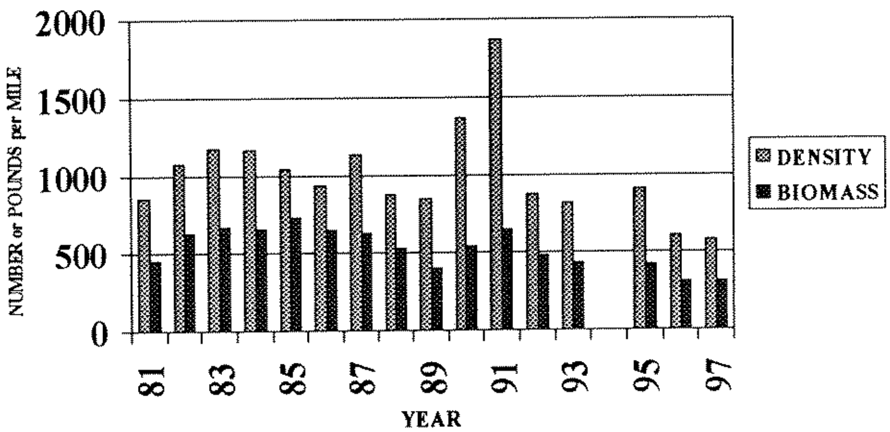

Figure 8. Estimated fall density of Age I Rainbow Trout in the Maiden Rock Section of the Big Hole River, 1981 - 1997.

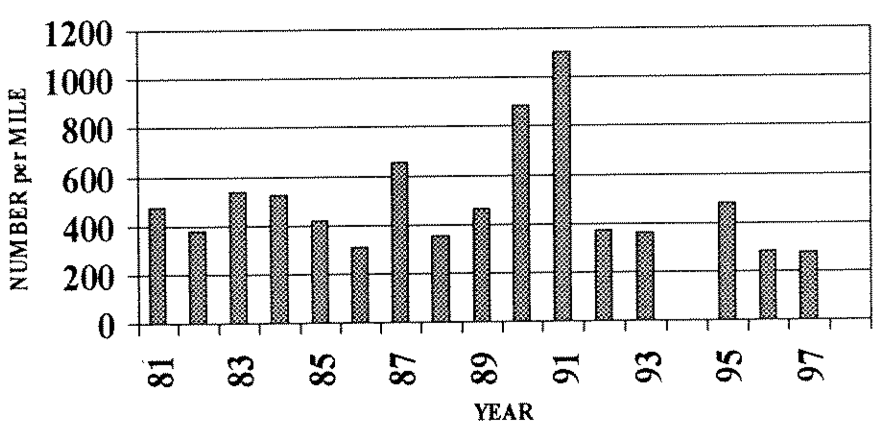

Figure 9. Estimated density of 13 inch and larger Rainbow Trout in the Maiden Rock Section of the Big Hole River, 1981 - 1997.

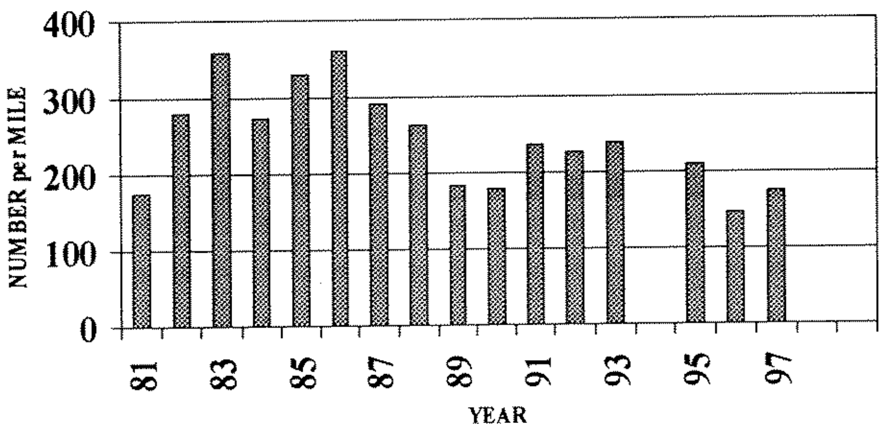

Figure 10. Estimated fall density of 16 inch and larger Rainbow Trout in the Maiden Rock Section of the Big Hole River, 1981 - 1997.

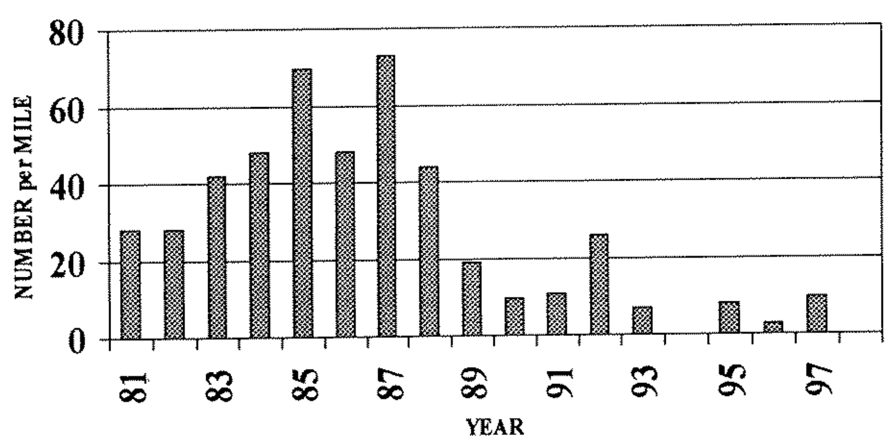

Figure 11. Biomass of 13 inch and larger Rainbow Trout as a percent of the total Rainbow Trout biomass for the Maiden Rock and Melrose Sections of the Big Hole River, 1981 - 1999.

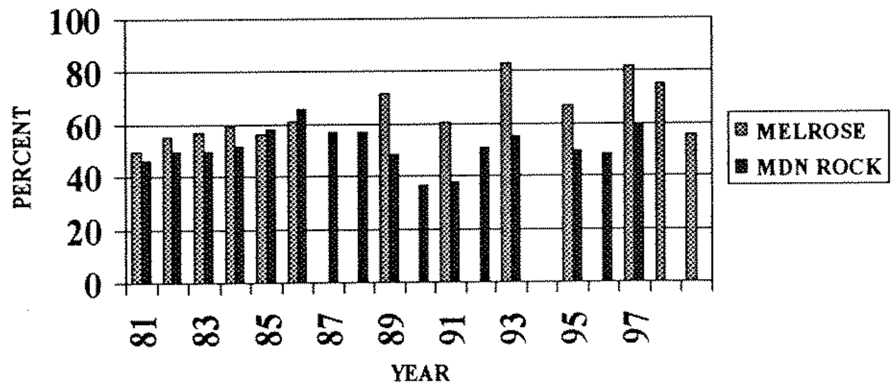

Figure 12. Biomass of 16 inch and larger Rainbow Trout as a percent of the total Rainbow Trout biomass for the Maiden Rock and Melrose Sections of the Big Hole River, 1981 - 1999.

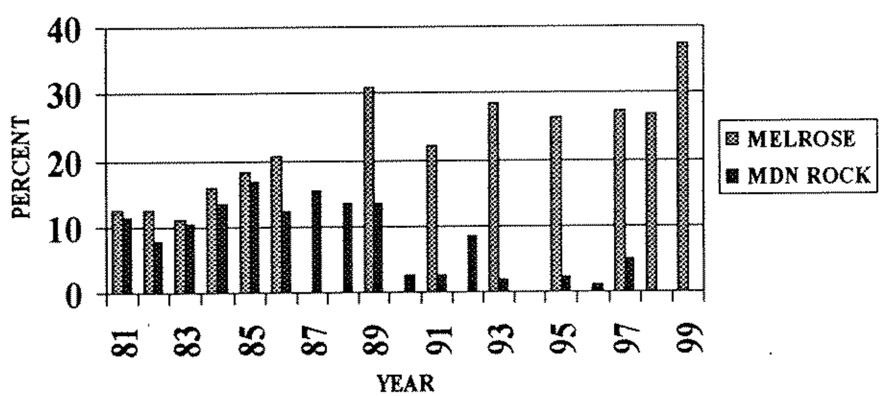

Figure 13. Estimated fall density and standing crop of Rainbow Trout in the Melrose Section of the Big Hole River, 1981 - 1999.

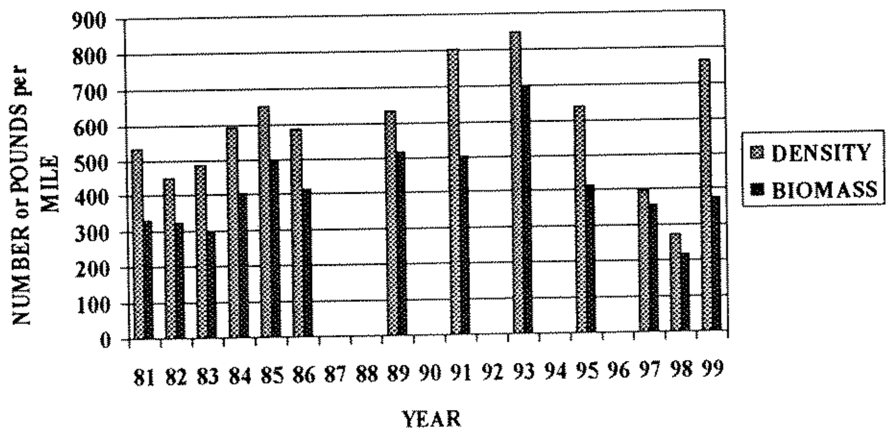

Figure 14. Estimated fall density of Age I and older Rainbow Trout in the Melrose Section of the Big Hole River, 1981 - 1999.

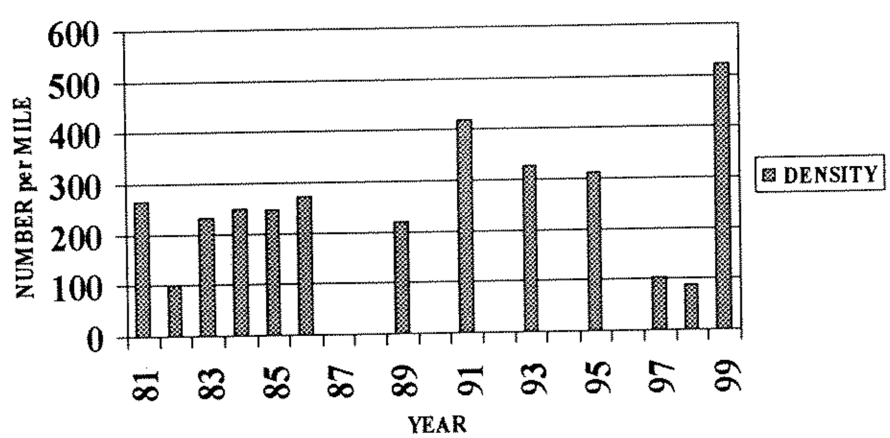

Figure 15. Estimated fall density of 13 inch and larger Rainbow Trout in the Melrose Section of the Big Hole River, 1981 - 1999.

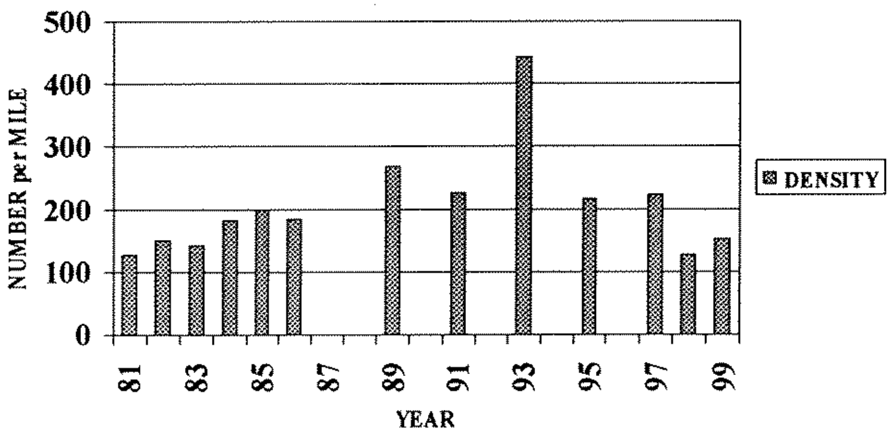

Figure 16. Estimated fall density of 16 inch and larger Rainbow Trout in the Melrose Section of the Big Hole River, 1981 - 1999.

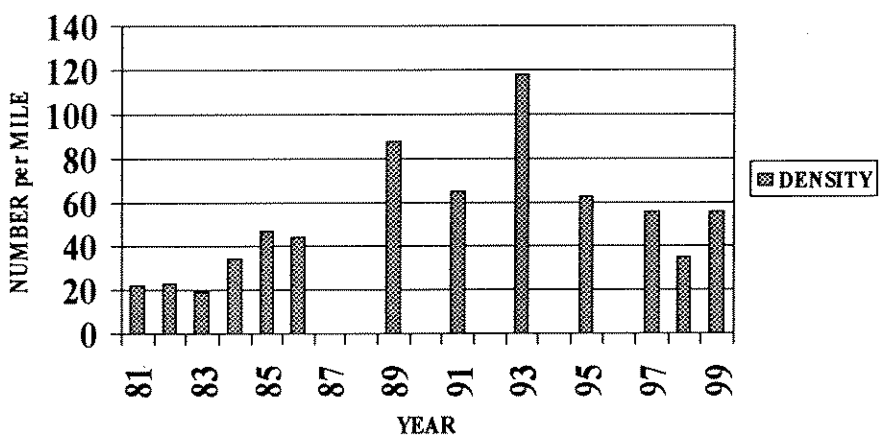

Figure 17. Estimated spring density and standing crop of Brown Trout in the Maiden Rock Section of the Big Hole River 1981 - 1998.

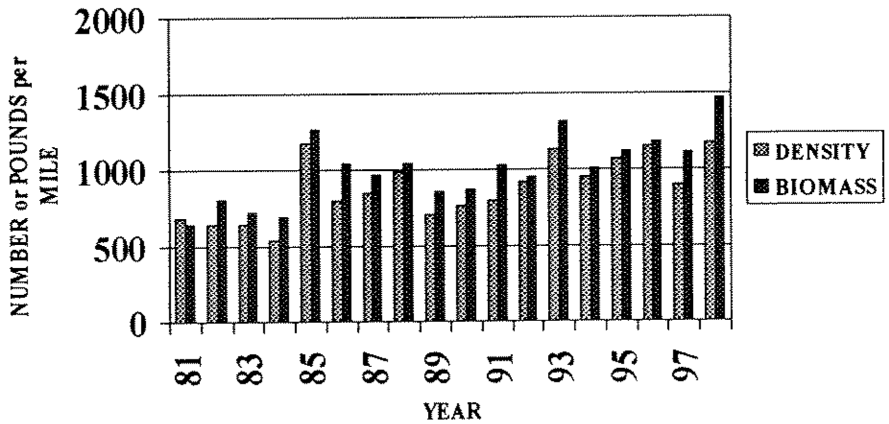

Figure 18. Estimated spring density of 13 inch and larger Brown Trout in the Maiden Rock Section of the Big Hole River, 1981 - 1998.

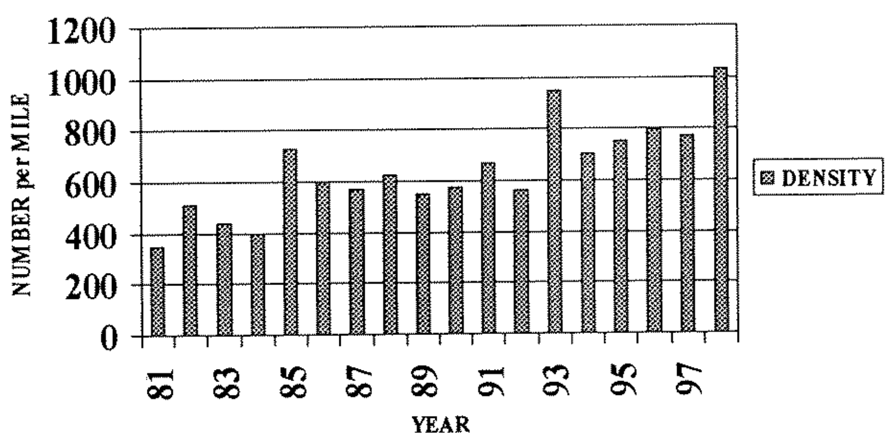

Figure 19. Estimated spring density of 18 inch and larger Brown Trout in the Maiden Rock Section of the Big Hole River, 1981 - 1998.

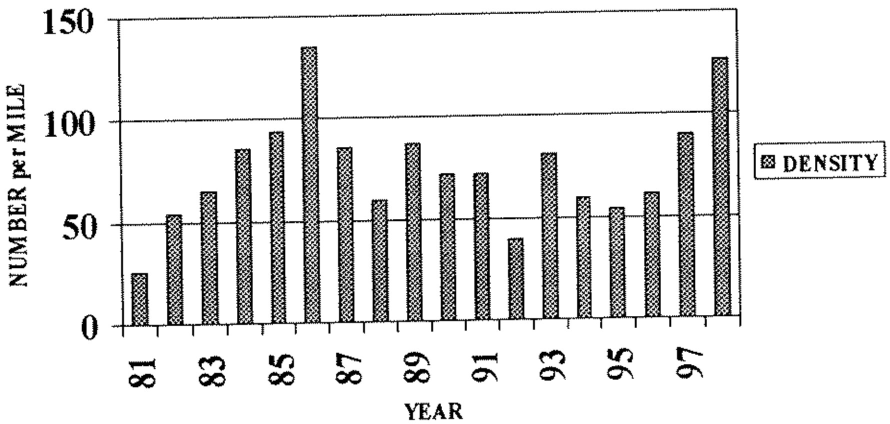

Figure 20. Biomass of 13 inch and larger Brown Trout as a percent of the total Brown Trout biomass for the Maiden Rock and Melrose Sections of the Big Hole River, 1981 - 1999.

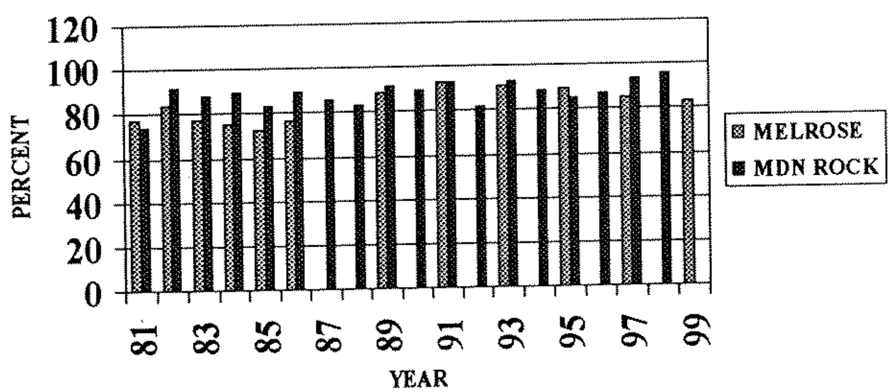

Figure 21. Biomass of 18 inch and larger Brown Trout as a percent of the total Brown Trout biomass for the Maiden Rock and Melrose Sections of the Big Hole River, 1981 - 1999.

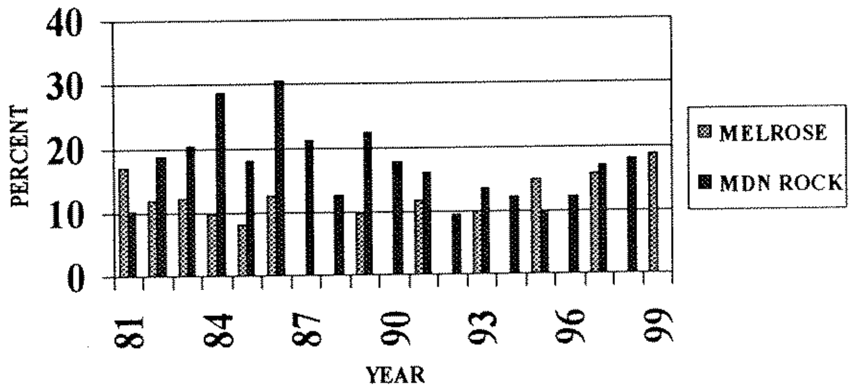

Figure 22. Estimated spring density and standing crop of Brown Trout in the Melrose Section of the Big Hole River, 1981 - 1999.

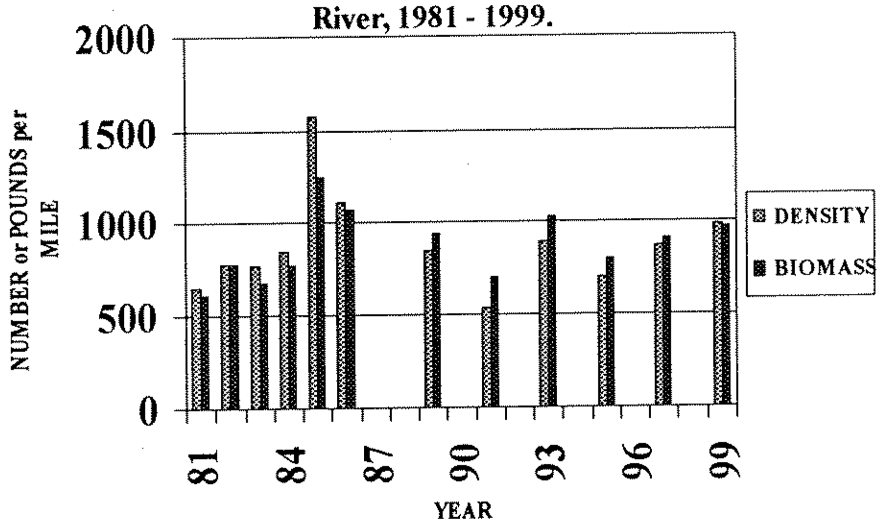

Figure 23. Estimated spring density of 13 inch and larger Brown Trout in the Melrose Section of the Big Hole River 1981 - 1999.

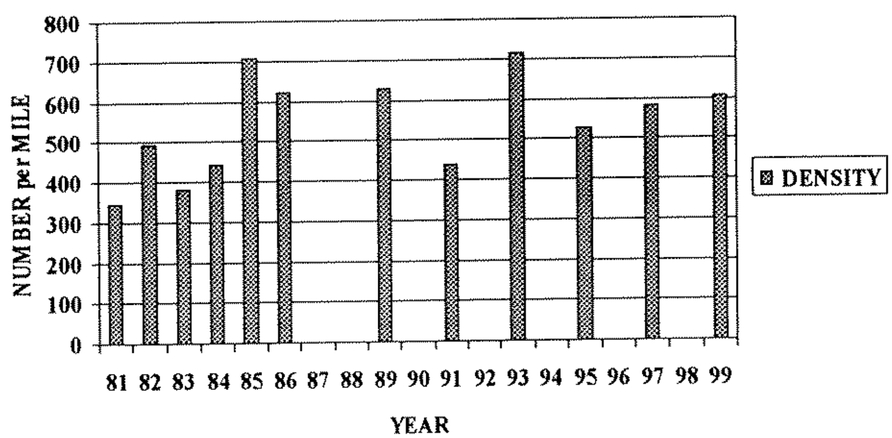

Figure 24. Estimated spring density of 18 inch and larger Brown Trout in the Melrose Section of the Big Hole River, 1981 - 1999.

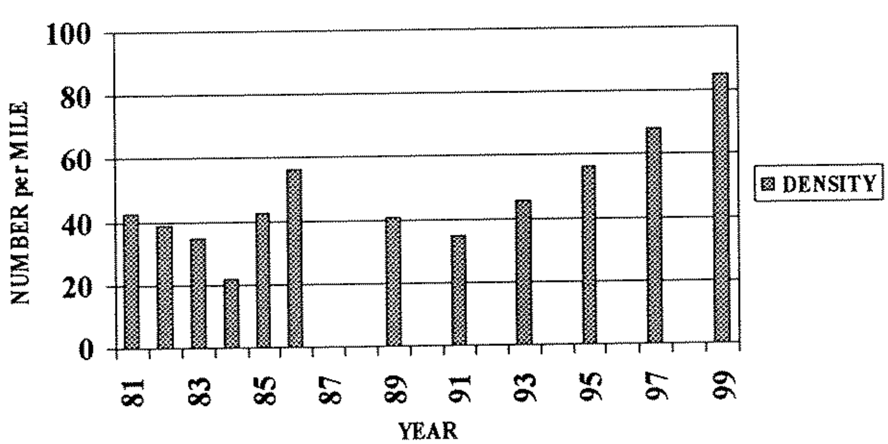

Figure 25. Biomass of 13 inch and larger Brown Trout as a percent of the total Brown Trout biomass for the Melrose and Hog Back Sections of the Big Hole River, 1981 - 1999.

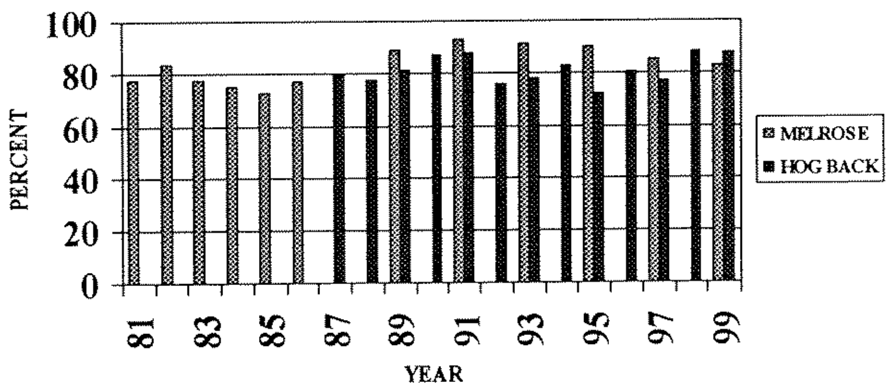

Figure 26. Biomass of 18 inch and larger brown trout as a percent of the total Brown Trout biomass for the Melrose and Hog Back Sections of the Big Hole River, 1981 - 1999.

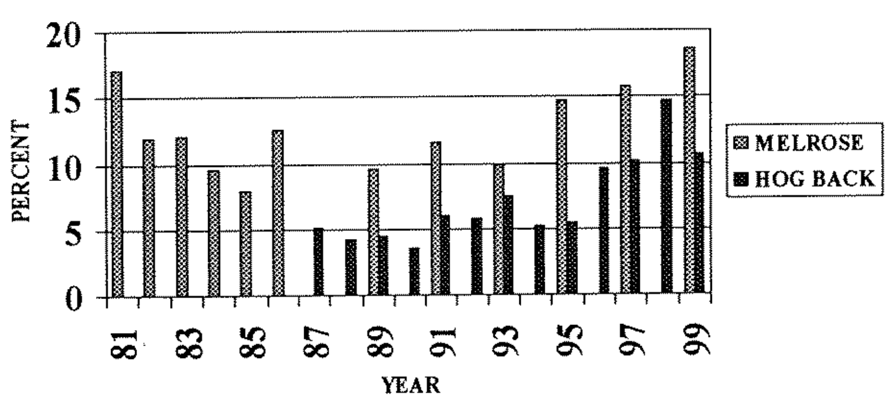

Figure 27. Estimated spring density and standing crop of Brown Trout in the Hog Back Section of the Big Hole River, 1987 - 1999.

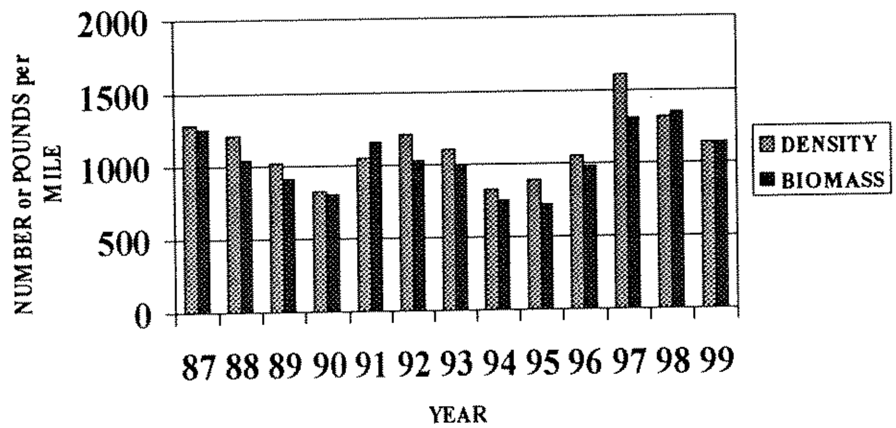

Figure 28. Estimated spring density of 13 inch and larger Brown Trout in the Hog Back Section of the Big Hole River, 1987 - 1999.

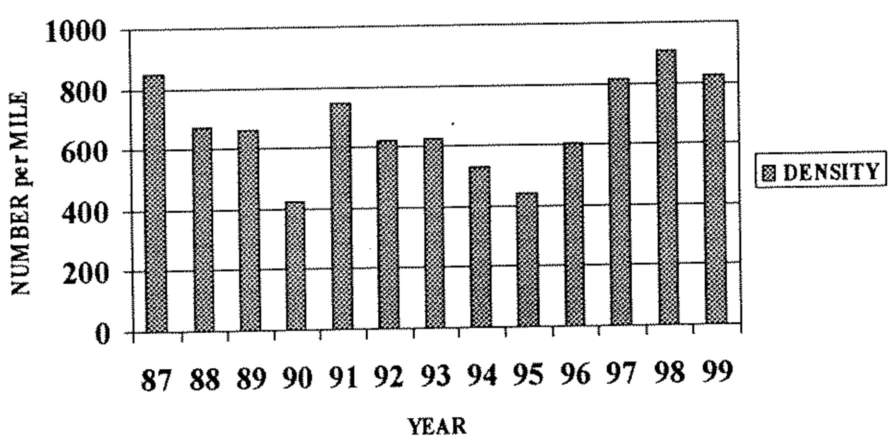

Figure 29. Estimated spring density of 18 inch and larger Brown Trout in the Hog Back Section of the Big Hole River, 1987 - 1999.