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Nelson

BEAVERHEAD RIVER

AND

CLARK CANYON RESERVOIR FISHERY STUDY

by
Frederick A. Nelson
Montana Department of Fish and Game
Bozeman, Montana 59715

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PART I

FISHERY AND FLOW RELATIONSHIPS IN THE BEAVERHEAD RIVER BELOW CLARK CANYON RESERVOIR

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ABSTRACT

The effects of varied flow patterns on trout populations and the physical and hydraulic characteristics in a 6455 ft section of the upper Beaverhead River below Clark Canyon Reservoir, Montana, were measured between 1966 and 1976. Population estimates were made using electrofishing techniques. The WSP (Water Surface Profile) computer program of the Bureau of Reclamation was used to predict physical and hydraulic values at various flows.

The survival of age III and older rainbow trout was directly related to the magnitude of flows during the nonirrigation season (approximately October 15 to April 15). During this period, water for irrigation is being stored in the reservoir and releases into the river are minimal. Results of this study suggest that average daily flows greater than approximately 250 cfs are needed to provide a high quality, trophy rainbow trout fishery. Flows during this study were not sufficiently reduced to adversely affect the survival of older brown trout.

Poor reproductive success was the major factor limiting the total numbers and biomass of trout throughout much of this study. Reproductive success, as measured by the estimated numbers of age I trout, appears to be related to flow patterns during the brown and rainbow trout spawning periods. With flow releases favorable to both reproduction and the survival of older trout, the upper Beaverhead River is capable of supporting greater numbers and biomass of trout of all age groups than those which existed throughout much of this study.

The physical and hydraulic characteristics most affected by flow reductions were cross sectional area and current velocity. Top width and wetted perimeter were least affected. The rate of loss for

all six of the measured characteristics was greatly accelerated at flows less than approximately 200 cfs.

An evaluation of biological, chemical, discharge, and habitat data for a series of nine study sections suggests that other factors are operating in conjunction with flows to limit numbers and biomass of trout in much of the Beaverhead River below the confluence of Grasshopper Creek.

CONCLUSIONS

The following conclusions pertain to the Beaverhead River between Clark Canyon Dam and the confluence of Grasshopper Creek (mile 0 to 12).

1. The survival of age III and older rainbow trout is directly related to the magnitude of flows during the nonirrigation season (approximately October 15 to April 15). During this period, Clark Canyon Reservoir is storing water for irrigation and releases into the Beaverhead River are minimal. Results of this study suggest that one average daily flow $\leq$ 150 cfs is sufficient to adversely affect the survival of older rainbow trout. Average daily flows greater than approximately 250 cfs are needed to provide a high quality, trophy rainbow trout fishery.
2. Flows were not sufficiently reduced during this study to adversely affect the survival and numbers of older brown trout.
3. The reproductive success of brown trout, as measured by the estimated numbers of age I brown trout, appears to be related to flow patterns during the brown trout spawning period. Spawning flows devoid of violent fluctuations and gradually decreasing to a minimum of approximately 150 cfs during the 47 day spawning period (September 15 through October 31) yielded the highest estimates of numbers of age I brown trout two years later. The number of age I brown trout in turn was the major factor influencing numbers of age II and age III brown trout in succeeding years.

4. Spawning flows also appear to affect the numbers of age I rainbow trout. Spawning flows devoid of violent fluctuations and increasing from approximately 200 cfs to approximately 700 cfs during the 61 day spawning period (March 1 through April 30) yielded the highest estimates of age I rainbow trout 18-months later. The number of age I rainbow trout in turn was the major factor influencing the number of age II rainbow trout the following fall.
5. Poor reproductive success was the major factor limiting the total numbers and biomass of trout throughout much of this study.
6. With flow releases favorable to both reproduction and the survival of older trout, this portion of the Beaverhead River is capable of supporting greater numbers and biomass of trout of all age groups than those which existed throughout much of this study.
7. Relationships between the magnitude of flows and trout growth were not demonstrated during this study.
8. The physical and hydraulic characteristics most affected by flow reductions were cross sectional area and current velocity. Top width and wetted perimeter were least affected. The rate of loss for all six of the measured characteristics was greatly accelerated at flows less than approximately 200 cfs.

The following conclusions pertain to the Beaverhead River below the confluence of Grasshopper Creek (mile 12 to 69).

1. Average daily flows less than 25 cfs, which have occurred in sections of the river 18 and 38 miles below Clark Canyon Dam, have undoubtedly affected aquatic life.
2. The numbers and biomass of trout in only one of six study sections in this portion of the Beaverhead River increased following the flow increases that occurred between Spring, 1975 and 1976.
3. Other factors, notably sediment, cover, and toxic metals, are operating in conjunction with flow to limit trout populations in much of the river below Grasshopper Creek.
4. Sedimentation appears to be a major factor limiting trout populations in the lower reaches of the river (mile 52 to 69).

RECOMMENDATIONS

1. The management of the rainbow trout provides the greatest potential for enhancing the upper Beaverhead fishery. Emphasis should be directed towards this species.
2. Violent fluctuations in the flow releases at Clark Canyon Dam should be avoided during the rainbow and brown trout spawning periods. Results of this study suggest that flow releases decreasing and then increasing by 125 cfs or more within a two week period are undesirable during spawning. Further evaluation of the relationship between the reproductive success of brown and rainbow trout and the flow patterns during spawning is needed.
3. A minimum flow release of approximately 200 cfs is needed at Clark Canyon Dam to provide a high quality, trophy rainbow trout fishery in the upper Beaverhead River.
4. Average daily flows of 50 cfs throughout the Beaverhead River are adequate only for the short term survival of trout. A reduction in trout numbers can be expected if average daily flows of approximately 50 cfs are maintained for periods greater than a few days.
5. The Montana Department of Fish and Game should continue to monitor trout populations semiannually in the upper Beaverhead River. If reproduction problems in the upper river are eliminated in future years, flow patterns may have a more pronounced influence on trout populations.
6. A flow management plan to minimize the impact of flow reductions and fluctuations on trout populations should be developed for all portions of the Beaverhead River.

7. The sediment-flow-biological relationships should be evaluated for the Beaverhead River. This would provide background data for the evaluation of other projects which divert a large volume of flow during the spring runoff period.
8. Further evaluation of the effects of toxic metals, cover, and food supply on trout populations in the Beaverhead River is needed.

INTRODUCTION

The effects of flow releases from Clark Canyon Reservoir on trout populations in the Beaverhead River have been investigated by the Montana Department of Fish and Game since 1966. The purpose of this study, which was funded by the Bureau of Reclamation, was to measure changes in the fishery caused by varied flow patterns, particularly during the non-irrigation season when irrigation water is stored in the reservoir. The study will provide biological criteria for recommending flows that will maintain a desirable river fishery.

METHODS

Trout populations in the Beaverhead River were sampled using a boat mounted electrofishing unit. The weight and total length of each captured fish were measured to the nearest 0.02 pound and 0.1 inch, respectively. Scales were taken for age determination. Some young-of-the-year and yearling trout were permanently marked by removing an adipose or pelvic fin. Trout $\geq$8 inches were tagged with numbered T-tags. All trout were marked with a partial fin clip and released for mark-recapture population estimates. As many as three marking and two recapture runs were made per estimate. Estimates of numbers, biomass, age structures, mean weights by age groups, and appropriate confidence intervals were calculated using methods summarized by Vincent (1971) and adapted for computer analyses.

Average daily flows at each study section were derived from U.S.G.S. records and known daily irrigation withdrawals. A plot of the average daily flows for each study section was obtained using computer techniques. For statistical purposes, the average daily flows between successive fall and successive spring population estimates were averaged to obtain a mean flow. These periods were further divided into irrigation and nonirrigation seasons and a mean flow obtained for each. Between successive spring estimates, April 15 through October 15 was termed the irrigation season. The remaining period was the nonirrigation season. Between fall estimates, April 15 to the time of the fall estimate was the irrigation season. The nonirrigation season occurred from the time of the preceding fall estimate through April 14.

The WSP (Water Surface Profile) computer program of the Bureau of Reclamation was used to predict hydraulic values at various flows. The procedures followed are outlined by Spence (1975) and Dooley (1976).

The percentage of willow cover along the banks of the Beaverhead River was assessed using color infra-red photography and a stereo-comparator. Photogrammetry work was done by graduate students at Colorado State University. Sinuosity and section length were determined from aerial photographs using computer facilities of the Civil Engineering Department, Montana State University.

Simple and multiple linear regressions were derived on a computer using the method of least squares. Unless noted, the term significant refers to statistical significance at the 5% level ($p \leq .05$).

DESCRIPTION OF STUDY AREA

Prior to the construction of Clark Canyon Reservoir in 1964, the Beaverhead River originated at the confluence of the Red Rock River and Horse Prairie Creek. The Beaverhead River now originates at the outlet of Clark Canyon Reservoir and flows for 69 miles to its confluence with the Big Hole River near Twin Bridges, Montana. Between

Clark Canyon Dam and the Big Hole River, the Beaverhead drops 850 feet, an average fall of 11.8 ft/mile. River elevations at the dam outlet and mouth are 5450 and 4600 ft, respectively.

Chemical analyses of water samples collected at sites 0.25, 6, 15, and 27 miles below Clark Canyon Dam in the summer of 1972 yielded these mean results (Smith, 1973):

	Site (miles)			
	0.25	6	15	27
Turbidity (JTU)	4	4	7	5
Conductivity (umhos @ 25C)	565	572	555	617
pH	8.1	8.2	8.2	8.1
Dissolved Oyxgen (ppm)	9.6	9.7	9.3	10.0
Total Alkalinity (ppm $CaCO_3$)	198	199	190	218
Total Hardness (ppm $CaCO_3$)	220	230	216	252
Ammonia (ppm NH_3-N)	.14	.08	.05	.02
Nitrate (ppm NO_3^--N)	.057	.110	.089	.285
Nitrite (ppm NO_2^--N)	.015	.018	.015	.006
Orthophosphate (ppm PO_4^{-3})	.11	.10	.08	.05

Smith (1973) evaluated the effects of Clark Canyon Reservoir on some chemical characteristics of the Beaverhead River. The reservoir had its greatest effect upon the dissolved oxygen levels in the tail-waters. DO levels in the tailwaters were well above saturation levels while the reservoir tributaries had mean saturation levels below or near saturation. He concluded that critically low DO due to bottom releases from the reservoir is not likely to become a problem. Compared to the reservoir tributaries, ammonia, nitrite and pH in the tailwaters increased sufficiently to be considered changed by the reservoir. The increase in ammonia and nitrite was attributed to the reduction of nitrates and/or the decomposition of organic matter in the deeper parts of the reservoir.

Pre- and postimpoundment flows at the Barretts gage, located approximately 15 miles below the dam, are compared in Figure 1. From October through March, Clark Canyon Reservoir stores water, therefore, inflows exceed outflows. However, average monthly discharges (October through March) during preimpoundment years were not greater than those after impoundment. The similarity of average monthly discharges (October through March) is a result of above normal inflows in postimpoundment years. Although pre- and postimpoundment average monthly discharges were similar (October through March), the variability of average monthly discharges was greatest after impoundment. The major impact of the reservoir on the upper reaches of the river was to extend the high flow period an additional five months from April through September. This extension occurs at the expense of October through March flows.

Pre- and postimpoundment flows at the near Twin Bridges gage, located approximately 52 miles below the dam, are compared in Figure 2. The major effect of the reservoir on the lower reaches of the river was to increase flows during the preimpoundment low flow months of May, July, August and September. November and late spring remained high flow periods.

The influence of Clark Canyon Reservoir on water temperatures in the Beaverhead River is shown in Figure 3. The Grant and Blaine stations are located on the Beaverhead River approximately 0.25 and 52 miles, respectively, below the dam. The Red Rock River, which is the major tributary to the reservoir, reflects the temperature of the

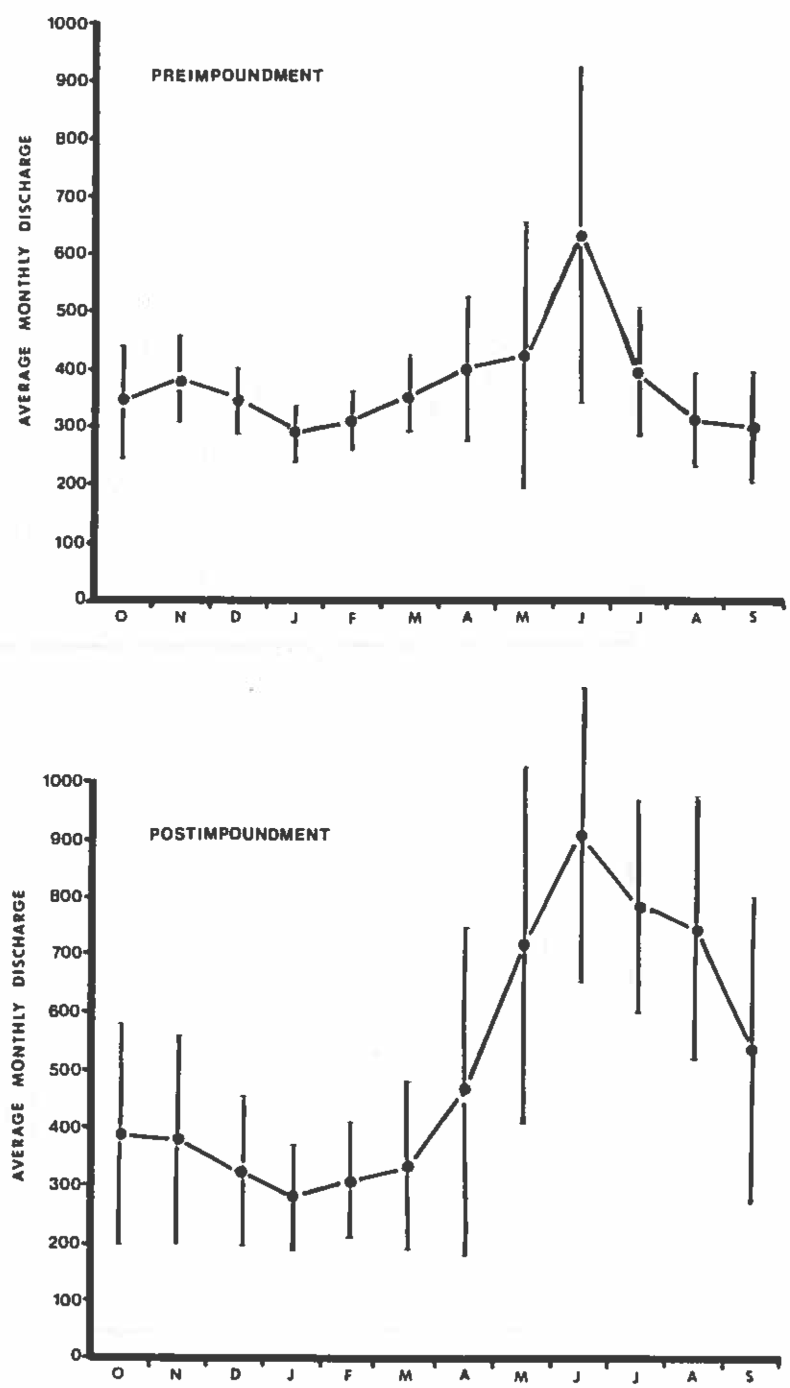


FIGURE 1. Average monthly discharges (cfs) ± 1 standard deviation in the Beaverhead River at the U.S.G.S. gage at Barretts before impoundment (1950-63 water years) and after impoundment (1965-75 water years).

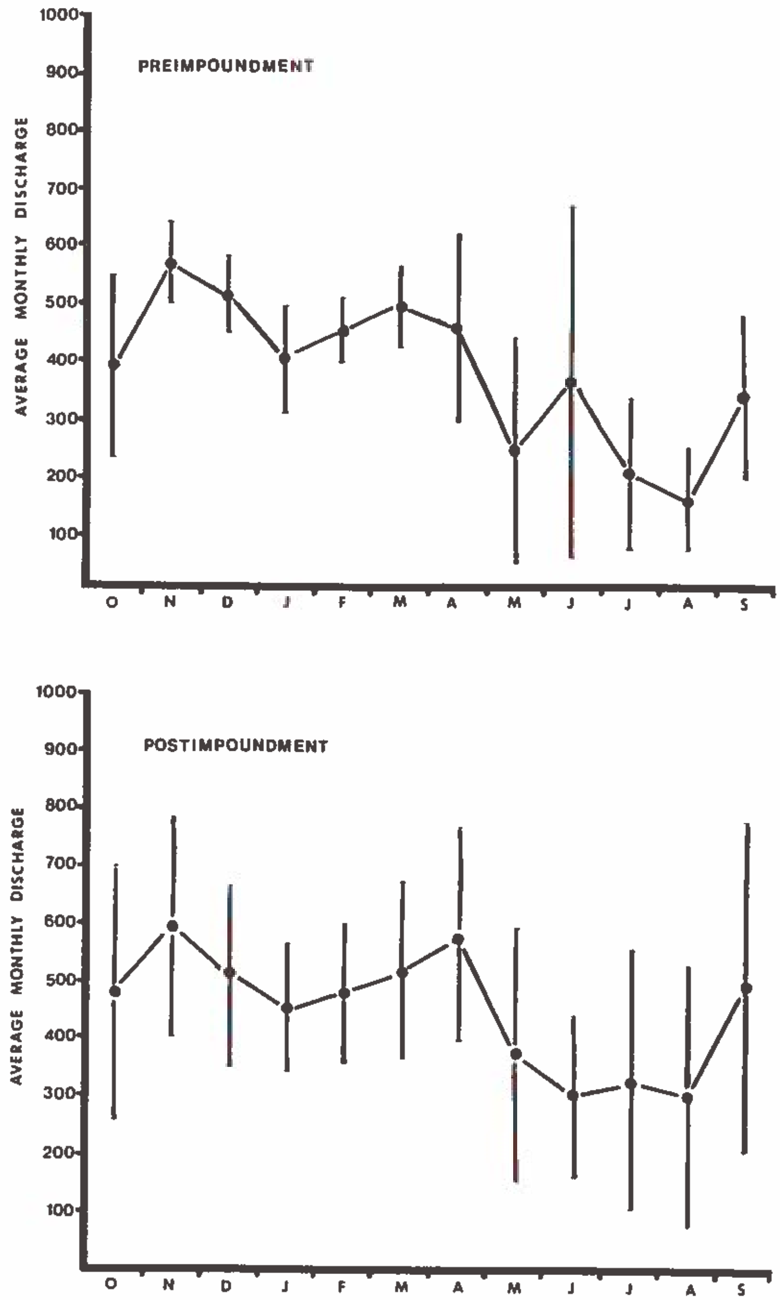


FIGURE 2. Average monthly discharges (cfs) ± 1 standard deviation in the Beaverhead River at the U.S.G.S. gage near Twin Bridges before impoundment (1951-63 water years) and after impoundment (1965-75 water years).

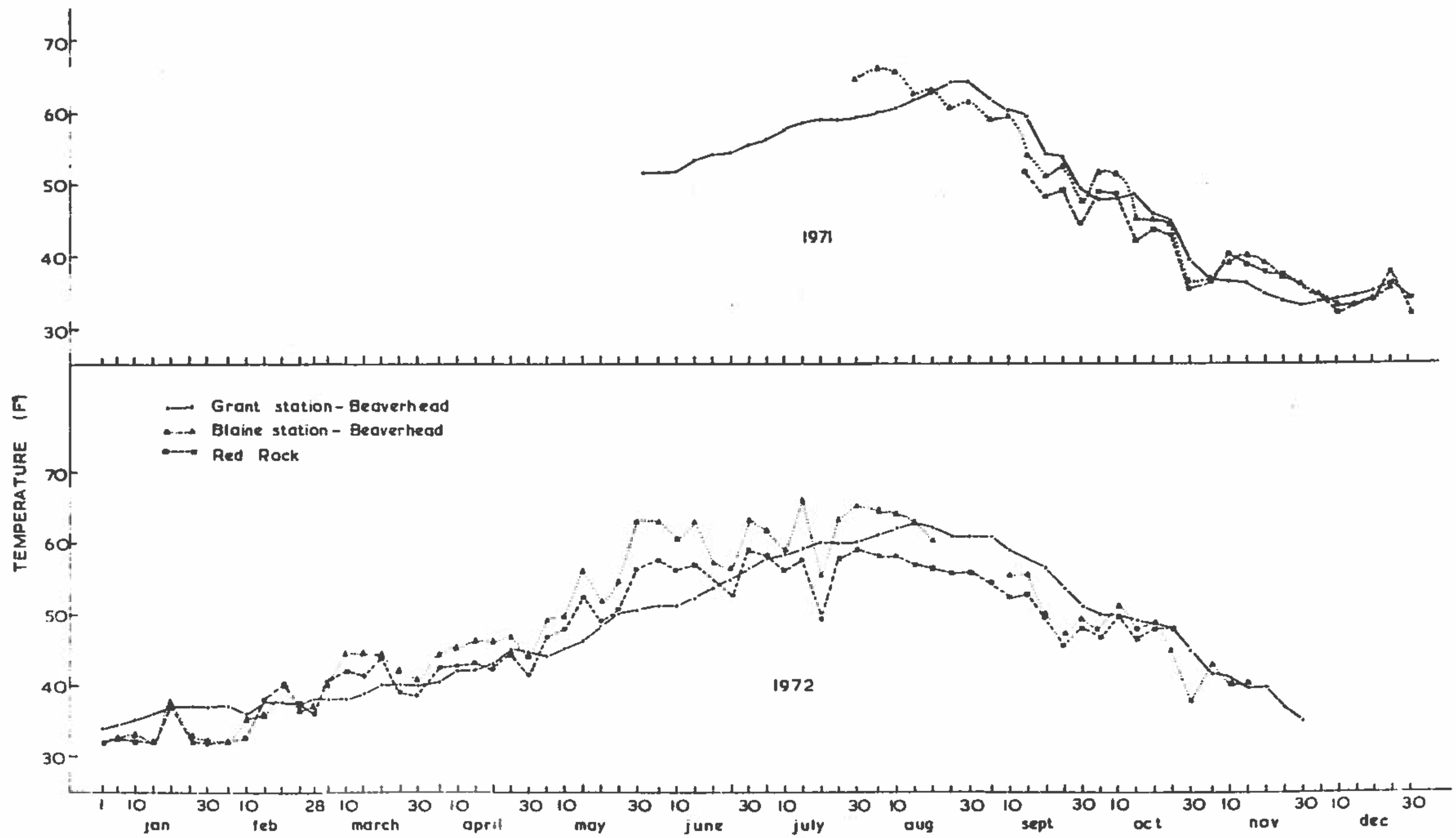


FIGURE 3. Mean daily water temperatures at three stations on the Beaverhead and Red Rock Rivers, 1971-72.

Beaverhead River before impoundment. The primary effect of the reservoir has been to reduce fluctuations in water temperature near the dam's outfall. Diel fluctuations in the summer of 1971 and 1972 at the Grant station had a range of approximately 2F while those at the Red Rock River station had a range of approximately 9F (Smith, 1973). From July through September, 1972, mean water temperatures at the Grant station exceeded those at the Red Rock River station by approximately 5F. This is a result of the solar heating of the reservoir.

Water temperature fluctuations at the Blaine and Red Rock River stations were similar, even though these two stations are separated by a distance of over 50 miles. Water temperature fluctuations at these two stations were similar because they both reflect variations in air temperatures.

Additional water temperature data was collected on the Beaverhead River between 1963 and 1968 at three stations, located approximately 0.25, 15, and 52 miles below the dam. The maximum water temperature recorded at the three stations during this period was 76.5 F. It would appear that water temperatures in the Beaverhead River are not high enough to adversely affect the survival of trout. The temperature data is presently being analyzed using a computer program developed by the Civil Engineering Department, Montana State University. The results will be presented in a separate report.

Nine study sections were selected along the Beaverhead River primarily on the basis of differences in annual flow patterns. Due to irrigation withdrawals, annual flow patterns, as indicated by Figures 1 and 2, vary greatly between the upper and lower river. Selected physical and cover characteristics of these sections are given in Table 1.

TABLE 1. Selected physical and cover characteristics of the study sections in the Beaverhead River.

Section	Sinuosity	Gradient(%)[1/]	Riprap(%)[2/]	Willow Bank Cover(%)[3/]
Grant (.01)	1.19	.21	14.6	-
Hildreth (2)	-	-	2.3	77
Hildreth Extended (2)	1.32	.33	1.2	67
Pipeorgan (8)	-	-	3.4	50
Pipeorgan Extended (8)	1.62	.24	5.2	48
Barretts Upstream (15)	-	-	3.1	37
Barretts Ups. Ext. (15)	1.22	.31	15.4	27
Barretts Downstream (18)	1.19	.29	0.7	50
Wheat (27)	1.60	.14	6.1	30
Westside Canal (29)	1.33	.24	10.5	29
Anderson Lane (38)	1.46	.17	0.0	54
Blaine (52)	1.66	.12	4.3	34

1/ $\% = \frac{\text{rise}}{\text{run}} \times 100$

2/ $\% = \frac{\text{Total length of riprap on both banks}}{2 \times \text{section length}} \times 100$

3/ $\% = \frac{\text{Total length of willow cover on both banks}}{2 \times \text{section length}} \times 100$

These sections are indicated on the map (Figure 4) and are described as follows:

Section 1. Grant (0.1).[1/] This section began approximately 0.1 mile below Clark Canyon Dam. Section length was 8589 feet.

Section 2. Hildreth (2). This section began approximately 2 miles below Clark Canyon Dam at the I-15 bridge. Section length was 6455 feet. In the spring of 1975 and 1976, the lower boundary was extended an additional 6048 feet downstream.

Section 3. Pipeorgan (8). This section began approximately 8 miles below Clark Canyon Dam at the I-15 bridge. Section length was 8513 feet. In the spring of 1975 and 1976, the lower boundary was extended an additional 5649 feet downstream.

Section 4. Barretts Upstream (15). This section began approximately 15 miles below Clark Canyon Dam. Section length was 5792 feet. In the spring of 1975 and 1976, the upper boundary was extended an additional 9866 feet upstream to approximately 0.2 mile below the mouth of Grasshopper Creek.

Section 5. Barretts Downstream (18). This section began approximately 18 miles below Clark Canyon Dam at the Barretts diversion dam. Section length was 10296 feet.

Section 6. Wheat (27). This section began approximately 27 miles below Clark Canyon Dam. The lower boundary was approximately .25 mile upstream of the Westside Canal diversion dam. Section length was 9908 feet.

Section 7. Westside Canal (29). This section began approximately 29 miles below Clark Canyon Dam at the Westside Canal diversion dam. Section length was 14533 feet.

1/ Miles below dam.

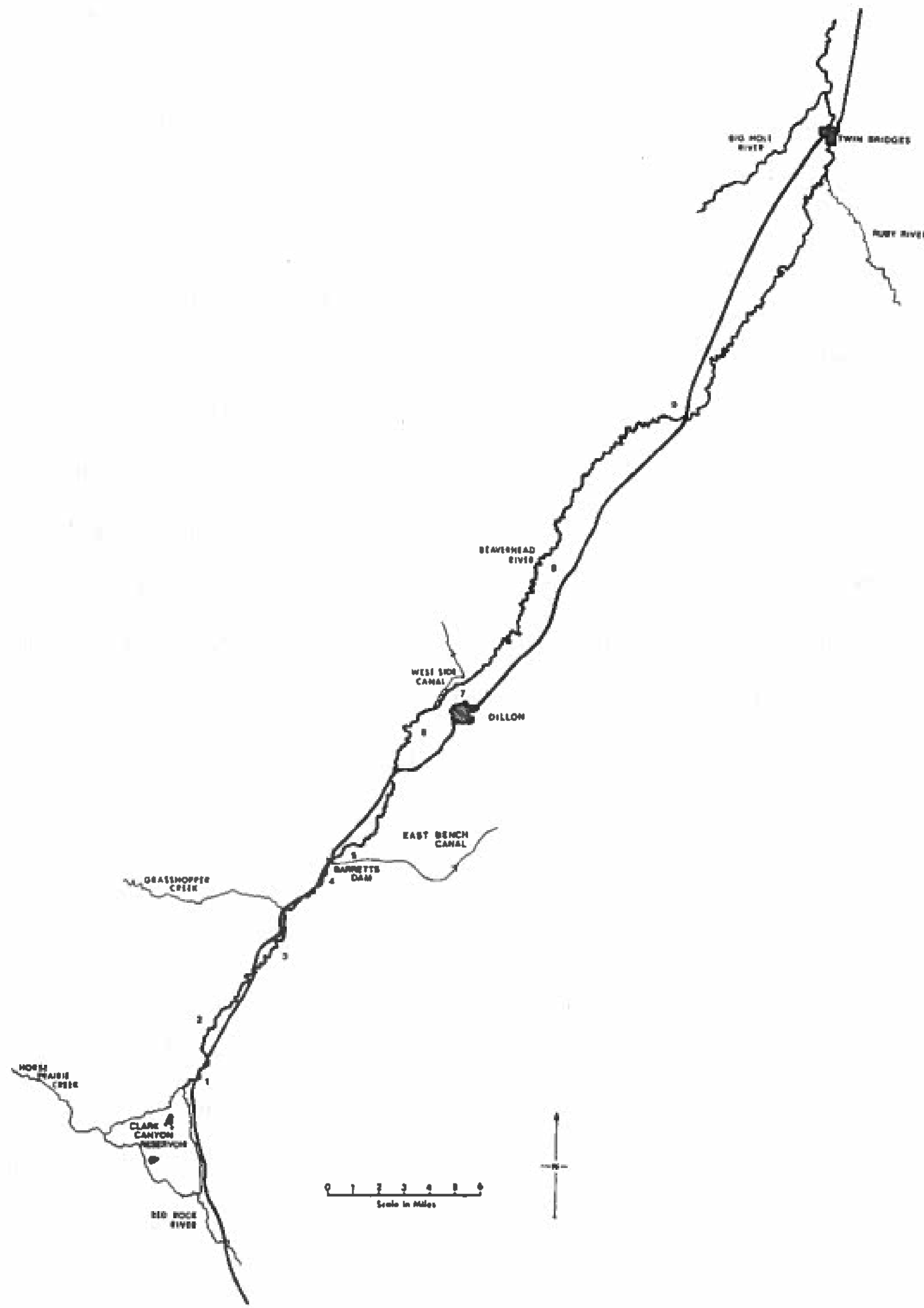


FIGURE 4. Map of the Beaverhead River showing the approximate location of the 9 study sections.

Section 8. Anderson Lane (38). This section began approximately 38 miles below Clark Canyon Dam at the Anderson Lane bridge. Section length was 9930 feet.

Section 9. Blaine (52). This section began approximately 52 miles below Clark Canyon Dam at a point approximately 0.2 mile upstream of Point of Rocks. Section length was 17837 feet.

Brown trout (*Salmo trutta*), rainbow trout (*Salmo gairdneri*), mountain whitefish (*Prosopium williamsoni*), burbot (*Lota lota*), white sucker (*Catostomus commersoni*), longnose sucker (*Catostomus catostomus*), mottled sculpin (*Cottus bairdi*), and longnose dace (*Rhinichthys cataractae*) were common in the study sections of the Beaverhead River. Brook trout (*Salvelinus fontinalis*) and mountain sucker (*Catostomus platyrhynchus*) were uncommon. Carp (*Cyprinus carpio*) were common in the Blaine (52) Section and uncommon elsewhere.

RESULTS

Trout-Flow Relationships in the Hildreth Section

Results for the Hildreth Study Section will be discussed separately. More flow and fish population data was collected in this section than in the other study sections.

Numbers and biomass of brown and rainbow trout in the Hildreth Section were estimated in the spring and fall between October, 1966 and March, 1976. Fall estimates during this period were made between September 20 and October 28. Spring estimates were made between March 1 and April 2. Age I and age II trout were the youngest group estimated in the fall and spring, respectively.

Flows, which are completely regulated by Clark Canyon Reservoir, are summarized for the Hildreth Section in Table 2. Average daily flows were derived from U.S.G.S. records for the gage near Grant, located 0.4 mile below the dam. From October through March and April through September, 35 and 45 cfs, respectively, were added to the average daily flows near Grant to account for accretion. Due to accretion and leakage at the dam, the lowest instantaneous flow that can occur in the Hildreth Section is approximately 50 cfs. During the study, average daily flows ranged from 57 to 1365 cfs. Mean irrigation flows ranged from 320 to 870 cfs and mean nonirrigation flows ranged from 97 to 467 cfs.

Trout populations in the Hildreth Section early in this study may reflect water quality problems in addition to flows. In January of 1965, a fish kill attributed to toxic concentrations of hydrogen sulfide in reservoir releases occurred in the river immediately below the dam (Wipperman, 1965). Results of field bioassays with caged fish and censusing with electrofishing gear indicated that the kill was restricted to approximately the upper 1.5 miles of river. This did not include the Hildreth Section. Elevated concentrations of hydrogen sulfide were measured in the summer of 1965 and were believed to have eliminated fish in the upper 1.5 miles of river, although a fish kill was not documented (Needam and Wipperman, 1967). A kill also attributed to hydrogen sulfide occurred in September of 1967 in approximately the upper 3 miles of river (Wipperman and Elser, 1968). This partially included the Hildreth Section.

Numbers of trout (Hildreth Section)

Brown Trout

The estimated numbers of brown trout by age groups are given in

TABLE 2. Mean flows (cfs) between successive spring and fall estimates of trout populations in the Hildreth Section of the Beaverhead River between 1966 and 1976. Range of average daily flows in parenthesis.

Fall to Fall	No. of Days	Mean Flow (cfs)	Mean Flow (cfs) Irrigation	Mean Flow (cfs) Nonirrigation
1966-67	371	215 (82-692)	325	112
1967-68	374	372 (84-858)	484	261
1968-69	363	535 (105-1115)	687	377
1969-70	369	478 (107-1033)	654	292
1970-71	358	637 (169-1020)	870	394
1971-72	342	607 (139-1105)	768	467
1972-73	378	453 (167-1115)	616	316
1973-74	379	433 (57-1065)	675	200
1974-75	376	451 (60-1365)	773	97
Spring to Spring				
1967-68	398	272 (110-692)	320	230
1968-69	350	416 (84-858)	489	336
1969-70	358	523 (105-1115)	690	347
1970-71	365	512 (155-1033)	665	356
1971-72	370	643 (139-1020)	868	421
1972-73	-	-	-	-
1973-74	-	-	-	-
1974-75	382	394 (57-1065)	681	126
1975-76	351	624 (101-1365)	792	439

Table 3. Fall estimates of age II and older brown trout are inflated due to the upstream movement of spawning fish into the Hildreth Section. While fall estimates of age groups II and older may reflect numbers of brown trout of spawning age, they do not reflect numbers of resident trout. Fall estimates of age I brown trout are valid. These fish are sexually immature and, therefore, considered residents.

Spring estimates of age II and older brown trout are compared in Figure 5. Total numbers decreased substantially between 1967 and 1968, remained relatively stable between 1968 and 1974, then increased between 1974 and 1976. An elevated mortality of age III and older trout was responsible for the decrease between 1967 and 1968. The increase between 1974 and 1976 reflects strong 1973 and 1974 year classes.

Strengths of the 1965 through 1974 year classes of brown trout are shown for an 18-month period in Table 4. The data suggests that some movement of brown trout into the Hildreth Section did occur following a poor yearling crop. Although movement may have occurred, the number of yearlings still had a strong influence on year class strength in succeeding years. Simple linear regression analyses (Figure 6) show that the number of yearlings explain 83 and 84%, respectively, of the annual variation in numbers of age II and age III brown trout in succeeding years. Numbers of age IV and older brown trout were not related to the numbers of age III and older brown trout the previous spring nor to the magnitude of mean irrigation and nonirrigation flows (Appendix Table 5).

TABLE 3. Estimated numbers of brown trout by age groups in the Hildreth Section (6455 ft) of the Beaverhead River between 1966 and 1976. 80% confidence interval in parenthesis.

<table>
<tr><th></th><th></th><th colspan="4">Age Group</th><th></th></tr>
<tr><th></th><th></th><th>I</th><th>II</th><th>III</th><th>IV & Older</th><th>Total</th></tr>
<tr><td>1966</td><td>Fall</td><td>55</td><td>447</td><td colspan="2">237</td><td>739(±154)</td></tr>
<tr><td>1967</td><td>Spring</td><td>-</td><td>54 1/</td><td colspan="2">717 1/</td><td>771(±135)</td></tr>
<tr><td></td><td>Fall</td><td>39 1/</td><td colspan="3">545 1/</td><td>584(±155)</td></tr>
<tr><td>1968</td><td>Spring</td><td>-</td><td>65</td><td>133</td><td>173</td><td>371(±69)</td></tr>
<tr><td></td><td>Fall</td><td>474</td><td>213</td><td>131</td><td>25</td><td>843(±157)</td></tr>
<tr><td>1969</td><td>Spring</td><td>-</td><td>237</td><td>111</td><td>171</td><td>519(±147)</td></tr>
<tr><td></td><td>Fall</td><td>438</td><td>512</td><td>151</td><td>44</td><td>1145(±281)</td></tr>
<tr><td>1970</td><td>Spring</td><td>-</td><td>151</td><td>205</td><td>144</td><td>500(±74)</td></tr>
<tr><td></td><td>Fall</td><td>164</td><td>613</td><td>141</td><td>56</td><td>974(±234)</td></tr>
<tr><td>1971</td><td>Spring</td><td>-</td><td>237</td><td>133</td><td>165</td><td>535(±100)</td></tr>
<tr><td></td><td>Fall</td><td>141</td><td>107</td><td>339</td><td>264</td><td>851(±172)</td></tr>
<tr><td>1972</td><td>Spring</td><td>-</td><td>74</td><td>121</td><td>209</td><td>404(±53)</td></tr>
<tr><td></td><td>Fall</td><td>158</td><td>86</td><td>167</td><td>147</td><td>558(±116)</td></tr>
<tr><td>1973</td><td>Spring</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td></td><td>Fall</td><td>57</td><td>165</td><td>234</td><td>187</td><td>643(±123)</td></tr>
<tr><td>1974</td><td>Spring</td><td>-</td><td>32</td><td>90</td><td>195</td><td>317(±50)</td></tr>
<tr><td></td><td>Fall</td><td>908</td><td>201</td><td>272</td><td>203</td><td>1584(±286)</td></tr>
<tr><td>1975</td><td>Spring</td><td>-</td><td>467</td><td>61</td><td>142</td><td>670(±82)</td></tr>
<tr><td></td><td>Fall</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>1976</td><td>Spring</td><td>-</td><td>624</td><td>420</td><td>139</td><td>1183(±285)</td></tr>
</table>

1/ Age groups separated by length-frequency distribution.

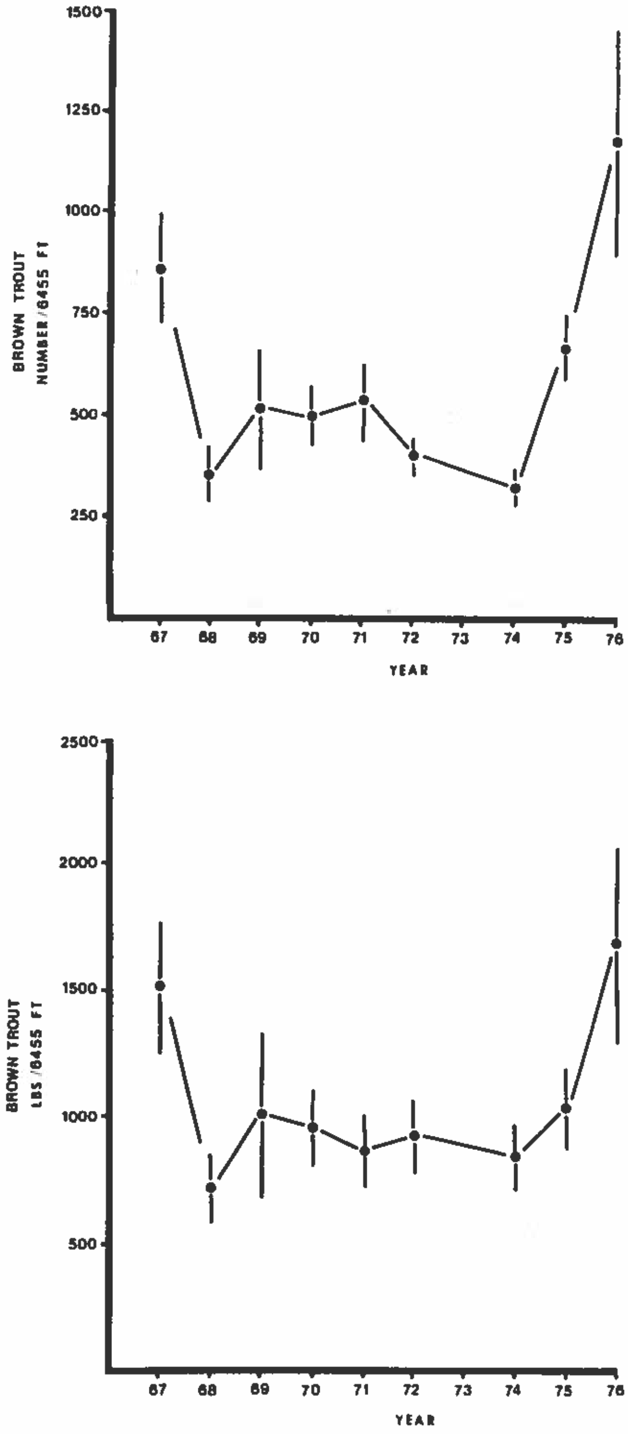


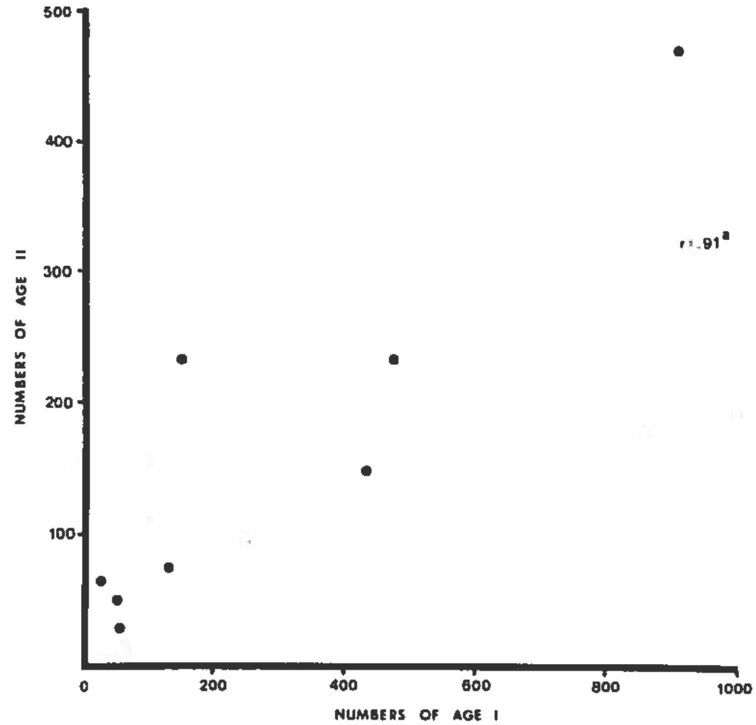
FIGURE 5. Spring estimates of numbers (N/6455 ft) and biomass (lbs/6455 ft) with 80% confidence intervals of age II and older brown trout in the Hildreth Section of the Beaverhead River between 1967 and 1976.

TABLE 4. Estimated numbers of brown trout in the 1965 through 1974 year classes in the Hildreth Section (6455 ft) of the Beaverhead River.

Year Class	Fall Age Group I	Spring Age Group II	Spring Age Group III
1965	55	54	133
1966	39	65	111
1967	474	237	205
1968	438	151	133
1969	164	237	121
1970	141	74	-
1971	158	-	90
1972	57	32	61
1973	908	467	420
1974	-	624	-

The plot of average daily flows for the Hildreth Section for the 1964-76 period was visually inspected to determine if the extreme variation in the estimated numbers of age I brown trout was related to the magnitude of flows during the 17-month period between fry emergence and the fall yearling estimate. Visual inspection showed the highest yearling estimate (908/6455 ft) followed a low winter flow period. Based on the large number of age II trout in the spring of 1976, a conservation approximation of the number of yearling brown trout the previous fall would be 624/6455 ft. This high number of yearlings followed the lowest winter flow period of the study. Flows during the first summer of growth of the 1967 year class were the lowest during the study, yet year class strength (474/6455 ft) was relatively high in the fall of 1968. It appears unlikely that reduced flows during the 17-month period pre-ceeding the fall estimates were the principle factor depressing numbers of age I brown trout.

Flows during the brown trout spawning period (September 15 - October 31) were examined for a possible flow-yearling relationship. Visual inspection of the plot of average daily flows during the 1964



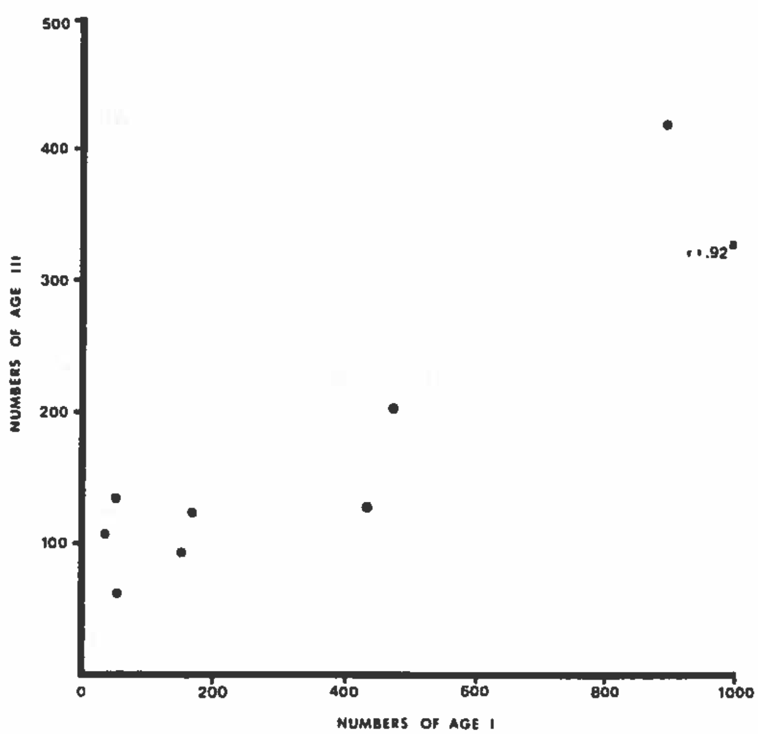


FIGURE 6. Relationships between the fall estimates of numbers (N/6455 ft) of age I brown trout and the estimated numbers of age II and age III brown trout of the same year class in succeeding springs in the Hildreth Section of the Beaverhead River.

a/ Indicates significance at 5% level.

through 1973 spawning periods (Figure 7) indicates that gradually decreasing flows devoid of violent fluctuations yielded the highest yearling estimates two years later.

The variance of the 47 average daily flows during each of the 1964 through 1973 spawning periods was calculated. Variance, a coarse measure of the fluctuation of spawning flows, was regressed against the estimated number of age I brown trout two years later. The estimated numbers of age I brown trout in 1966, 1967, and 1968 may reflect water quality problems in addition to spawning flows. When these three observations are removed, the variance of spawning flows explains 71% of the annual variation in numbers of age I brown trout (Appendix Figure 8).

Results of this study suggest the degree of fluctuation of spawning flows is the dominant factor influencing numbers of age I brown trout, which in turn influence numbers of age II and age III brown trout in succeeding years. Numbers of age IV and older brown trout were not related to the numbers of age III and older brown trout the previous spring nor to the magnitude of mean irrigiation and nonirrigation flows. Those factors influencing the numbers of older brown trout, which remained relatively stable throughout the study, were not identified.

Rainbow Trout

Estimated numbers of rainbow trout by age groups are given in Table 6. Due to the movement of spawning fish into the Hildreth Section, spring estimates of age II and older rainbow trout are not valid estimates of resident fish.

Fall estimates of age I and older rainbow trout are compared in Figure 9. Total numbers remained relatively stable between 1966 and

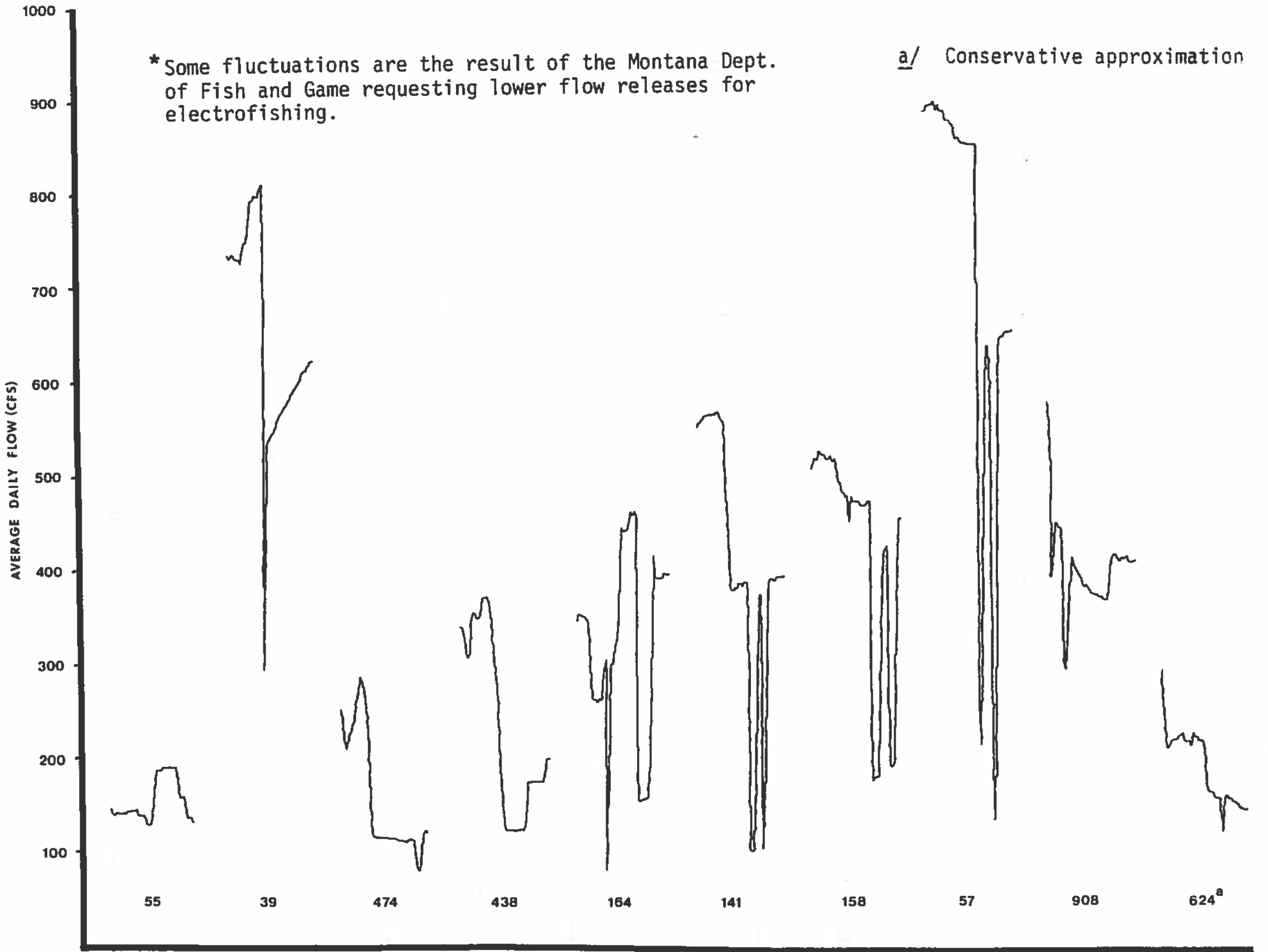


FIGURE 7. Average daily flows*(cfs) during the 1964 through 1973 spawning periods (September 15 - October 31) of brown trout in the Hildreth Section of the Beaverhead River. Estimated number of age I brown trout (N/6455 ft) two years later is under each plot.

TABLE 6. Estimated numbers of rainbow trout by age groups in the Hildreth Section (6455 ft) of the Beaverhead River between 1966 and 1976. 80% confidence interval in parenthesis.

		Age Group				
		I	II	III	IV & Older	Total
1966	Fall	73		39		112(±28)
1967	Spring	-		95 1/		95(±42)
	Fall	17 1/		99 1/		116(±40)
1968	Spring	-	16	53	43	112(±45)
	Fall	81	14	19	16	130(±32)
1969	Spring	-	99	9	74	182(±51)
	Fall	81	61	27	18	187(±41)
1970	Spring	-	35	105	61	201(±36)
	Fall	56	41	43	10	150(±38)
1971	Spring	-	40	89	123	252(±59)
	Fall	10	25	69	34	138(±51)
1972	Spring	-	-	30	185	215(±59)
	Fall	140	0	14	60	214(±68)
1973	Spring	-	-	-	-	-
	Fall	136	114	28	53	331(±75)
1974	Spring	-	107	107	101	315(±70)
	Fall	997	143	55	15	1210(±253)
1975	Spring	-	595	121	96	812(±81)
	Fall	796	281	26	4	1107(±321)
1976	Spring	-	915	476	161	1552(±328)

1/ Age groups separated by length-frequency distribution.

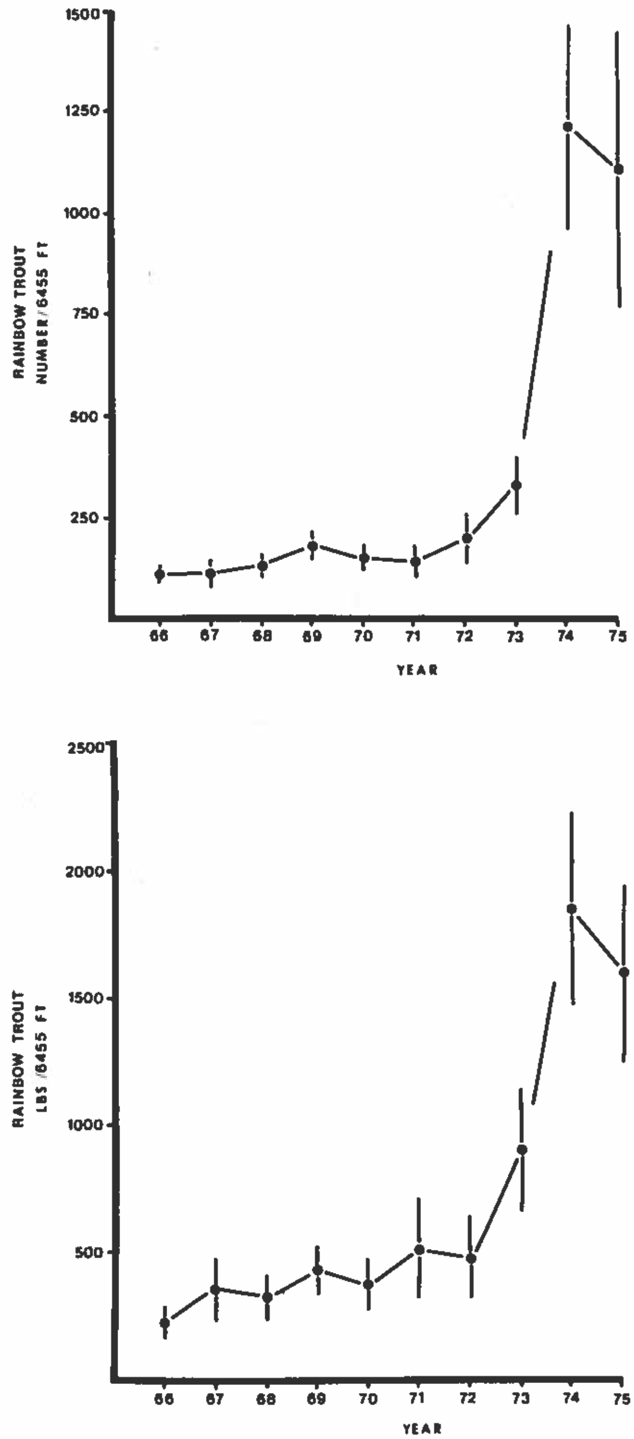


FIGURE 9. Fall estimates of numbers (N/6455 ft) and biomass (lbs/6455 ft) with 80% confidence intervals of age I and older rainbow trout in the Hildreth Section of the Beaverhead River between 1966 and 1975.

1972, increased slightly in 1973, increased substantially in 1974, then decreased slightly in 1975. Strong 1973 and 1974 year classes were responsible for the elevated numbers in 1974 and 1975.

Strengths of the 1965 through 1974 year classes are shown for a two year period in Table 7. The data suggests that some movement of rainbow trout into the Hildreth Section occurred following a poor yearling crop. Although movement may have occurred, the number of yearlings still had a strong influence on the number of age II rainbow trout in the following fall (Figure 10). Numbers of yearlings explain 83% of the annual variation in numbers of age II rainbow trout one year later. Numbers of yearlings had little influence on numbers of age III rainbow trout two years later. Numbers of yearlings explain only 14% of the annual variation in numbers of age III rainbow trout.

TABLE 7. Estimated numbers of rainbow trout in the 1965 through 1974 year classes in the Hildreth Section (6455 ft) of the Beaverhead River.

Year Class	Fall Age Group I	Fall Age Group II	Fall Age Group III
1965	73	-	19
1966	17	14	27
1967	81	61	43
1968	81	41	69
1969	56	25	14
1970	10	0	28
1971	140	114	55
1972	136	143	26
1973	997	281	-
1974	796	-	-

Multiple linear regressions were computed to evaluate the relationship between mean irrigation and nonirrigation flows and numbers of age III and age IV and older rainbow trout (Appendix Table 8). In combination, the numbers of age III and older rainbow trout the previous fall and mean

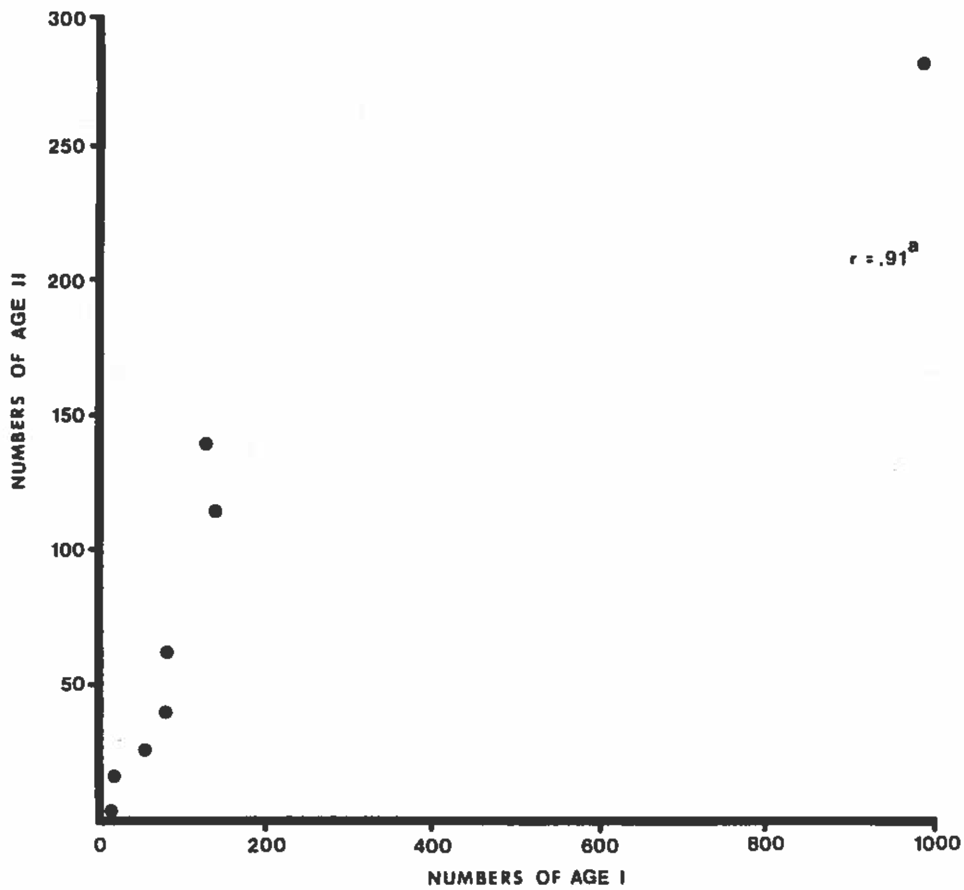


FIGURE 10. Relationship between the fall estimates of numbers (N/6455 ft) of age I rainbow trout and the estimated numbers of age II rainbow trout of the same year class in the following fall in the Hildreth Section of the Beaverhead River.

a/ Indicates significance at 5% level.

nonirrigation flows explain 81% of the annual variation in the fall estimates of age IV and older rainbow trout. The other relationships were not significant.

Visual inspection of the plot of average daily flows for the 1965-75 period showed that low winter flows were not the principle factor depressing numbers of yearling rainbow trout during the 16-month period between fry emergence and the fall estimate. The 1975 estimate of yearlings (796/6455 ft) followed the lowest winter flow period of the study. The highest estimate (997/6455 ft) also followed low winter flows.

Average daily flows during the 1965 through 1974 rainbow trout spawning periods (March 1 - April 30) are compared in Figure 11. Visual inspection shows that spawning flows devoid of violent fluctuations and increasing from approximately 200 cfs to approximately 700 cfs during the 61 day spawning period yielded the highest yearling estimates 18-months later. The estimated number of yearlings in 1966, 1967, and 1968 may reflect water quality problems in addition to spawning flows.

Multiple linear regression analyses (Table 9) suggest the magnitude of winter flows partially determines the numbers of spawning age rainbow trout present in the spring. In combination, numbers of age I and older trout in the fall and the mean flows between fall and spring estimates explain 94% of the annual variation in spring estimates of numbers of age II and older rainbow trout. When mean fall-spring flows were less than approximately 275 cfs, estimates of numbers decreased between fall and spring and increased when mean flows were greater than approximately 275 cfs (Table 10). The lowest mean winter flow (94 cfs) produced the greatest decrease (33%).

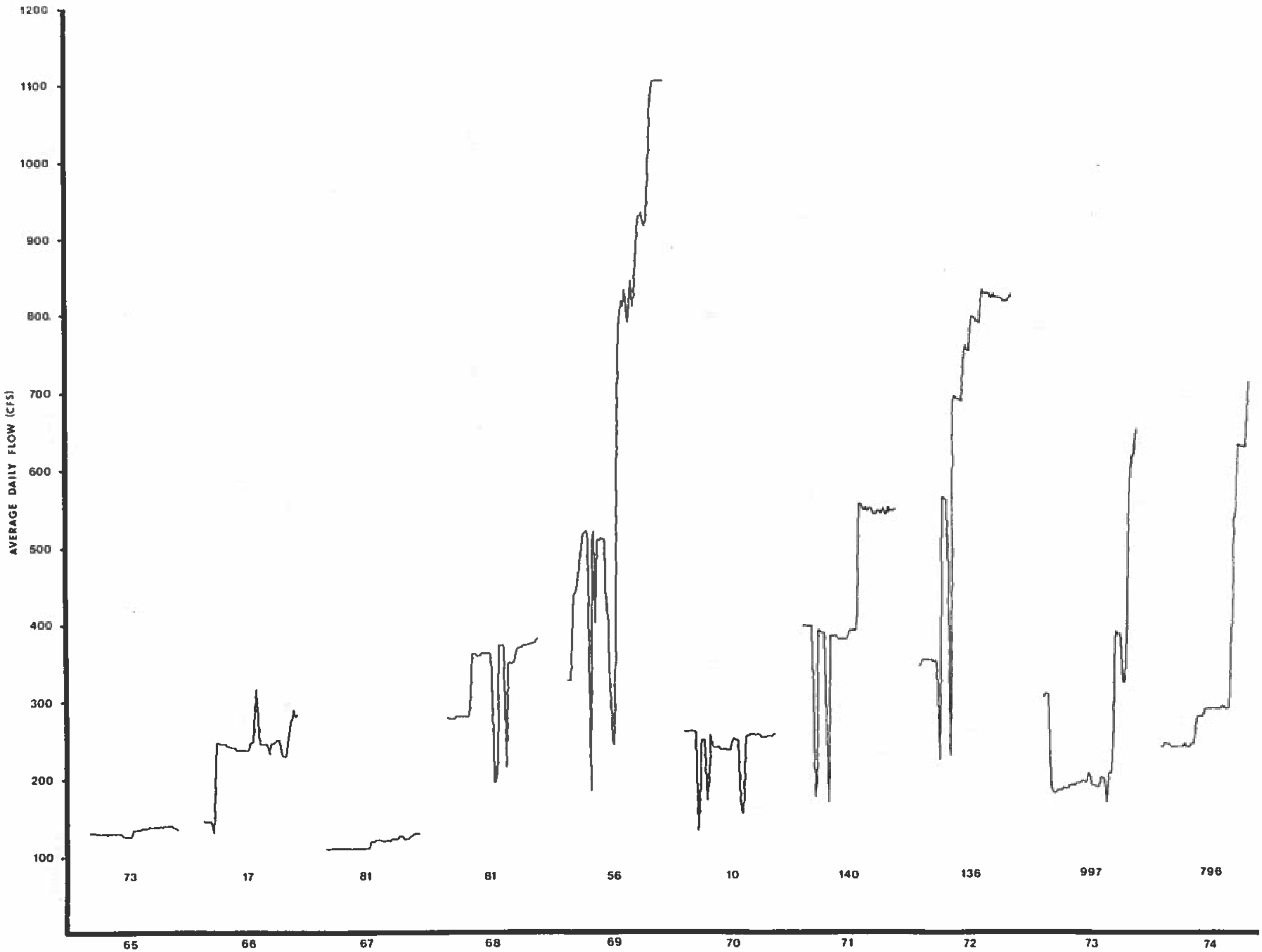


FIGURE 11. Average daily flows (cfs) during the 1965 through 1974 spawning periods (March 1 - April 30) of rainbow trout in the Hildreth Section of the Beaverhead River. Estimated number of age I rainbow trout (N/6455 ft) 18 months later is under each plot.

TABLE 9. Correlation coefficients for the multiple linear relationships between the spring estimates of numbers of age II and older rainbow trout and mean fall to spring flows in the Hildreth Section of the Beaverhead River.

Dependent Variable	Partial Correlation Coefficients: No. of I & Older Rainbow Trout Previous Fall	Partial Correlation Coefficients: Mean Flow Fall-Spring	Multiple Correlation (r)
No. of II & Older Rainbow Trout - Spring	.9658 1/	.8510 1/	.9712 1/

1/ Indicates significance at 5% level.

Limited evidence suggested spawning flows influenced numbers of yearling rainbow trout. The number of yearlings in turn determined the number of age II rainbow trout one year later. Numbers of age IV and older rainbow trout were influenced by the magnitude of mean flows during the nonirrigation season.

Biomass of Trout (Hildreth Section)

Brown Trout

Spring and fall biomass estimates of brown trout by age groups are given in Table 11. Spring biomass estimates of age II and older brown trout are compared in Figure 5. Biomass decreased between 1967 and 1968, remained relatively stable between 1968 and 1975, then increased in 1976. The decrease between 1967 and 1968 reflects an elevated mortality of age III and older brown trout. Strong 1973 and 1974 year classes primarily account for the increase in 1976.

The biomass of the 1965 through 1973 year classes are shown for an 18-month period in Table 12. Significant relationships between the magnitude of mean flows during the irrigation and nonirrigation seasons

TABLE 10. Relationship between relative change in the fall to spring estimates of number of age I and older rainbow trout and mean fall to spring flows (cfs) in the Hildreth Section of the Beaverhead River. Range of average daily flows in parenthesis.

Fall-Spring	Number of Days	Mean Flow Fall-Spring	Relative change in no. of rainbow trout (%) 1/ Fall-Spring
1974-75	159	94 (60-123)	-33
1966-67	148	111 (82-127)	-15
1973-74	156	184 (127-260)	- 5
1967-68	175	257 (125-365)	- 3
1969-70	146	305 (107-403)	7
1968-69	151	340 (160-523)	40
1970-71	142	389 (175-460)	68
1971-72	153	423 (139-660)	68 2/
1975-76	134	480 (335-587)	40

1/ $\% = \frac{\text{No. age II \& older (spring)} - \text{No. age I \& older (fall)}}{\text{No. age I \& older (fall)}} \times 100$

2/ = % change of age II & older rainbow trout. Valid spring estimate of age II trout not available.

TABLE 11. Estimated biomass (lbs/6455 ft) of brown trout by age groups in the Hildreth Section of the Beaverhead River between 1966 and 1976. 80% confidence interval in parenthesis.

		Age Group				
		I	II	III	IV & Other	Total
1966	Fall	49	872	754		1675(±356)
1967	Spring	-	54	1457		1511(±272)
	Fall	34	1372			1406(±379)
1968	Spring	-	65	213	443	721(±130)
	Fall	512	468	443	119	1542(±306)
1969	Spring	-	245	226	537	1008(±328)
	Fall	339	1192	525	220	2276(±766)
1970	Spring	-	142	388	429	959(±161)
	Fall	145	1196	456	217	2014(±452)
1971	Spring	-	207	230	437	874(±151)
	Fall	109	163	755	947	1974(±449)
1972	Spring	-	70	221	643	934(±144)
	Fall	108	167	438	553	1266(±287)
1973	Spring	-	-	-	-	-
	Fall	41	331	738	931	2041(±457)
1974	Spring	-	34	167	645	846(±129)
	Fall	644	411	881	980	2916(±726)
1975	Spring	-	406	121	503	1030(±146)
	Fall	-	-	-	-	-
1976	Spring	-	503	666	512	1681(±371)

and the estimated biomass for any group of brown trout were not demonstrated. The biomass of age I brown trout did explain 83 and 79%, respectively, of the annual variation in the biomass of age II and age III brown trout in succeeding years.

TABLE 12. Estimated biomass (lbs/6455 ft) of brown trout in the 1965 through 1974 year classes in the Hildreth Section of the Beaverhead River.

Year Class	Fall Age Group I	Spring Age Group II	Spring Age Group III
1965	49	54	213
1966	34	65	226
1967	512	245	388
1968	339	142	230
1969	145	207	221
1970	109	70	-
1971	108	-	167
1972	41	34	121
1973	644	406	666
1974	-	503	-

Rainbow Trout

Spring and fall biomass estimates (lbs/6455 ft) of rainbow trout by age groups are given in Table 13. Fall biomass estimates of age I and older rainbow trout are compared in Figure 9. The biomass increased slightly between 1966 and 1973, increased substantially between 1972 and 1974, then decreased slightly in 1975. The elevated biomass in 1974 and 1975 primarily reflect strong 1973 and 1974 year classes.

The biomass of the 1965 through 1973 year classes are shown for a two year period in Table 14. Significant relationships between the magnitude of mean flows during the irrigation and nonirrigation seasons and the estimated biomass of any group of rainbow trout were not demonstrated. However, the biomass of age I rainbow trout did explain 83% of the annual variation in the biomass of age II rainbow trout the following fall.

TABLE 13. Estimated biomass (lbs/6455 ft) of rainbow trout by age groups in the Hildreth Section of the Beaverhead River between 1966 and 1976. 80% confidence interval in parenthesis.

		Age Group				
		I	II	III	IV & Older	Total
1966	Fall	80	——	144	——	224(±55)
1967	Spring	-	——	240	——	240(±106)
	Fall	22	——	329	——	351(±122)
1968	Spring	-	13	143	197	353(±158)
	Fall	109	31	80	101	321(±89)
1969	Spring	-	158	23	358	539(±159)
	Fall	78	176	105	78	437(±103)
1970	Spring	-	32	199	223	454(±98)
	Fall	54	99	173	49	375(±97)
1971	Spring	-	46	242	454	742(±208)
	Fall	9	61	270	171	511(±206)
1972	Spring	-	-	59	779	838(±253)
	Fall	146	0	33	301	480(±177)
1973	Spring	-	-	-	-	-
	Fall	164	306	113	320	903(±251)
1974	Spring	-	163	335	512	1010(±267)
	Fall	1189	321	270	77	1857(±379)
1975	Spring	-	871	314	405	1590(±190)
	Fall	721	676	84	23	1504(±352)
1976	Spring	-	905	1235	614	2754(±630)

TABLE 14. Estimated biomass (lbs/6455) of rainbow trout in the 1965 through 1974 year classes in the Hildreth Section of the Beaverhead River.

Year Class	Fall Age Group I	Fall Age Group II	Fall Age Group III
1965	80	-	80
1966	22	31	105
1967	109	176	173
1968	78	99	270
1969	54	61	33
1970	9	0	113
1971	146	306	270
1972	164	321	84
1973	1189	676	-
1974	731	-	-

Annual Rates of Population Change (Hildreth Section)

Annual spring to spring rates of population change of brown trout by age groups are given in Table 15. Annual population increases probably reflect the immigration of younger age groups following poor yearling crops. Significant relationships between the annual rates of change for any age group of brown trout and the magnitude of mean nonirrigation flows were not demonstrated by simple regression analyses. The elevated rate of population decrease of older brown trout between 1967 and 1968 reflects water quality problems in addition to reduced flows.

TABLE 15. Annual rates of population change (%) of brown trout by age groups in the Hildreth Section of the Beaverhead River between 1967 and 1976.

Spring to Spring	Brown Trout Age Group		
	II-III	II & Older-III & Older	III & Older-IV & Older
1967 - 68	+146	-60	-76
1968 - 69	+ 71	-24	-44
1969 - 70	- 14	-33	-49
1970 - 71	- 12	-40	-53
1971 - 72	- 49	-38	-30
1972 - 73	-	-	-
1973 - 74	-	-	-
1974 - 75	+ 91	-36	-50
1975 - 76	- 10	-17	-32

Annual fall to fall rates of population change of rainbow trout by age groups are given in Table 16. The annual rate of population change of age III and older rainbow trout was significantly correlated with the magnitude of mean flows during the nonirrigation season (Figure 12). Mean nonirrigation flows explain 66% of the annual variation in the rate of decrease of age III and older rainbow trout. The annual rates of decrease for all age groups of rainbow trout were elevated during the period (1974-75) containing the lowest nonirrigation flows of the study.

TABLE 16. Annual rates of population change (%) of rainbow trout by age groups in the Hildreth Section of the Beaverhead River between 1966 and 1975.

Fall to Fall	Rainbow Trout Age Group				
	I-II	II-III	I & Older-II & Older	II & Older-III & Older	III & Older-IV & Older
1966 - 67	-	-	-12	-	-
1967 - 68	- 18	-	-58	-65	-
1968 - 69	- 25	+93	-18	- 8	-49
1969 - 70	- 49	-30	-50	-50	-78
1970 - 71	- 55	+68	-15	+10	-36
1971 - 72	-100	-44	-46	-42	-42
1972 - 73	- 19	-	- 9	+ 9	-28
1973 - 74	+ 5	-52	-36	-64	-81
1974 - 75	- 72	-82	-74	-86	-94

Tag returns by fishermen were consistently low throughout the study (Table 17). Although the river was open to year-round fishing, most of the tagged fish were caught between April and September. Angler tag returns were not elevated when mean April - September flows were lowest, suggesting excessive harvesting by anglers was not the major cause of the elevated rates of population decrease of older trout in low water years.

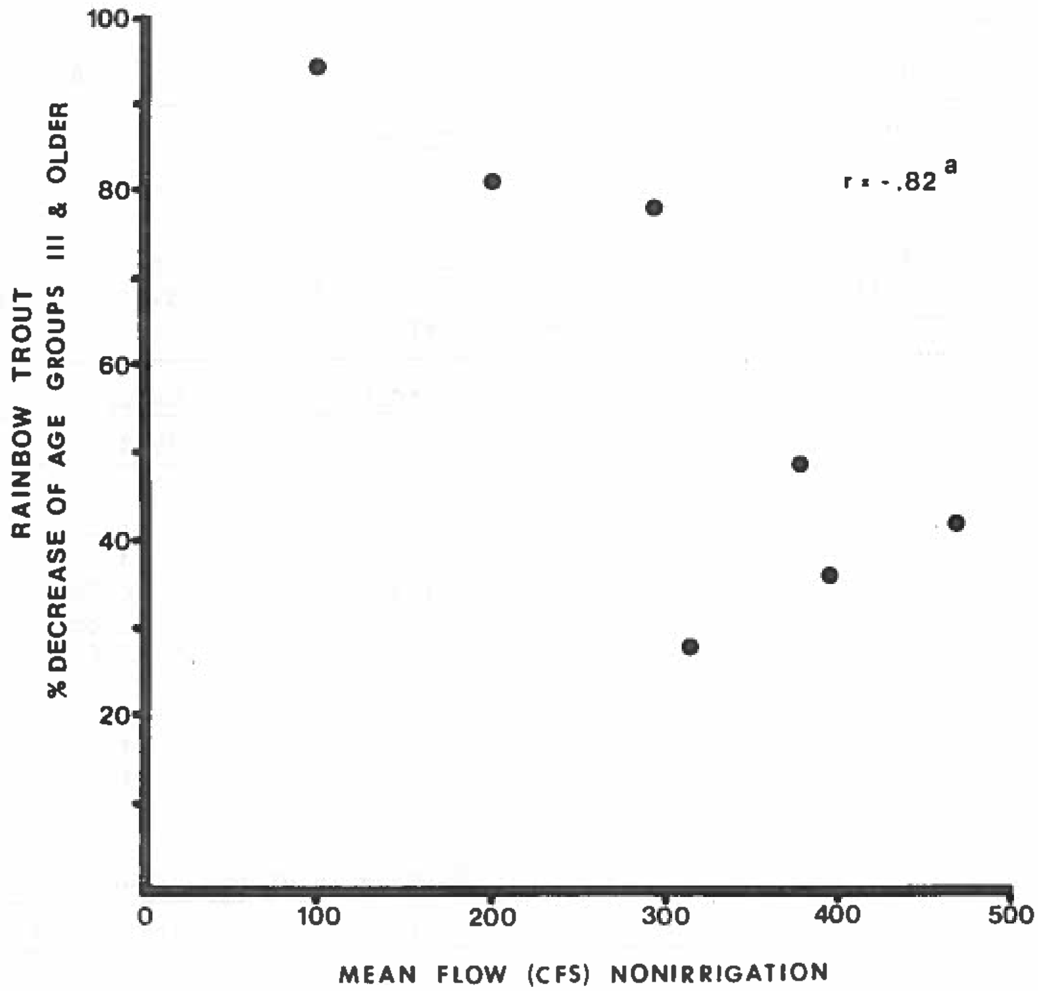


FIGURE 12. Relationship between the annual rates of population decrease (%) of age III and older rainbow trout and mean nonirrigation flows (cfs) in the Hildreth Section of the Beaverhead River.

a/ Indicates significance at 5% level.

TABLE 17. Relationship between tag returns of brown and rainbow trout by anglers and mean April through September flows (cfs) for the Hildreth Section of the Beaverhead River. Number of tag returns in parenthesis.

Period	% Return 1/	Mean Flow April - September
1967, March - 1968, March	7.7 (28)	312
1968, March - 1968, October	2.2 (4)	481
1970, March - 1971, March	6.5 (23)	647
1973, October - 1974, October	5.0 (17)	679
1974, March - 1974, December	4.0 (16)	679
1972, March - 1973, March	13.6 (35)	749
1971, March - 1972, March	5.6 (29)	847

1/ $\% = \frac{\text{No. of angler tag returns during period}}{\text{No. of new fish tagged at start of period}} \times 100$

TABLE 18. Mean weights (lbs) by age groups of brown and rainbow trout captured by electrofishing in the Hildreth Section of the Beaverhead River during the 1966 through 1976 sampling periods.

	Brown Trout Age Group		
Spring	II	III	IV & Older
1967	1.01	-	-
1968	1.01	1.60	2.55
1969	1.03	2.04	3.14
1970	.94	1.89	2.98
1971	.87	1.73	2.65
1972	.94	1.82	3.07
1973	-	-	-
1974	1.06	1.87	3.30
1975	.87	1.98	3.55
1976	.81	1.59	3.68

	Rainbow Trout Age Groups			
Fall	I	II	III	IV & Older
1966	1.10	-	-	-
1967	1.29	-	-	-
1968	1.35	2.30	4.33	6.12
1969	.97	2.88	3.92	4.45
1970	.97	2.43	4.06	4.71
1971	.93	2.47	3.93	5.01
1972	1.05	-	2.37	5.02
1973	1.20	2.68	4.06	6.09
1974	1.19	2.24	4.94	5.23
1975	.91	2.40	3.26	5.64

Growth of Trout (Hildreth Section)

Mean weights by age group of brown trout in the spring and rainbow trout in the fall are given in Table 18. Mean weights of all age groups are exceptional compared to most other rivers in Montana. The growth of trout in the Big Horn River, another tailwater fishery, is similar to that in the Hildreth Section of the Beaverhead River (Stevenson, 1975). Mean weights of age II and older brown trout in the fall and age II and older rainbow trout in the spring are considered biased due to the movement of nonresident spawning fish into the Hildreth Section.

Since growth-flow relationships for any age group of trout could not be demonstrated, the influence of densities on growth was investigated. Mean weights of age II brown trout in the spring appear density related (Figure 13). The estimated numbers of age II brown trout explain 66% of the annual variation in the mean weights of age II brown trout. Density-growth relationships were not demonstrated for any other age group of trout.

Trout-Flow Relationships in All Sections

During the Spring of 1975 and 1976, numbers and biomass of trout were estimated in a series of sections in the Beaverhead River (Appendix Tables 19 and 20). In the spring of 1976, two sections, Grant (0.1) and Pipeorgan Extended (8), were added. Estimates in 1975 were made between March 6 and April 14 and in 1976 between March 10 and May 20. Except for Grant (0.1), brown trout was the dominant species of trout in the sections. The cause of the resurgence of rainbow trout numbers in the Wheat (27) and Westside Canal (29) Sections is unknown. Spring creeks in this area may be providing spawning habitat and recruits.

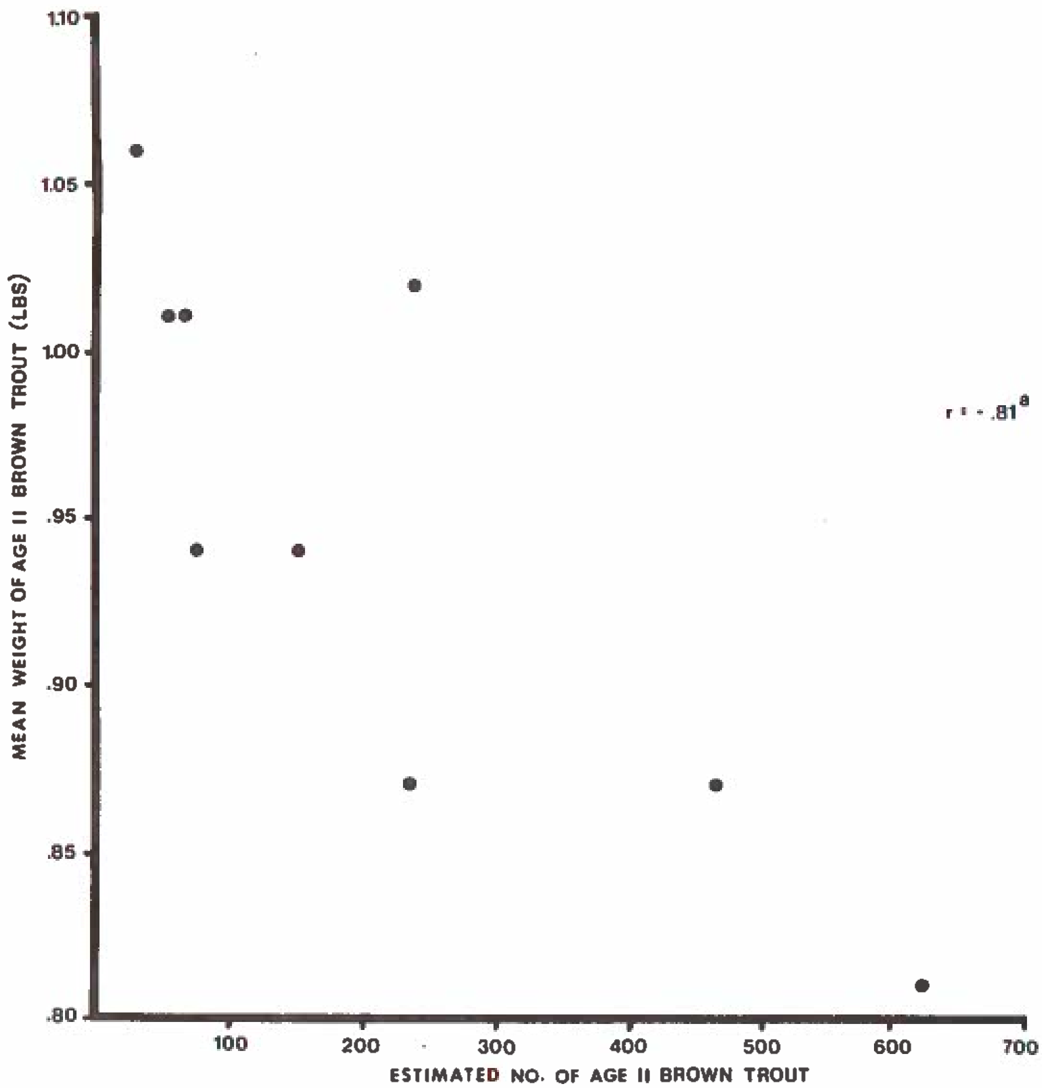


FIGURE 13. Relationship between the estimated numbers (N/6455 ft) and the mean weights (lbs) of age II brown trout during the spring in the Hildreth Section of the Beaverhead River.

a/ Indicates significance at 5% level.

Sections were selected primarily on the basis of differences in annual flow regimes due to irrigation withdrawals and accretion. A comparison of the minimum and maximum average daily flows in the nine study sections provides a measure of the variations in flow that occur between sections and between years (Table 21). The severe dewatering of the Grant (22 cfs on October 16, 1974), Barretts Downstream (0 cfs on August 10, 1973), and Anderson Lane (21 cfs on July 14, 1973) Sections has undoubtedly affected aquatic life.

TABLE 21. Minimum and maximum average daily flows (cfs) between April 1 and March 31 in 9 sections of the Beaverhead River in 1973-74, 1974-75, and 1975-76.

Section	1973-74	1974-75	1975-76
Grant (0.1)	92-1070	22-1020	56-1320
Hildreth (2)	127-1115	57-1065	101-1365
Pipeorgan (8)	122-1110	52-1060	96-1360
Barretts Up. (15)	172-1150	110-1210	157-1480
Barretts Down. (18)	0- 746	62- 711	157- 933
Wheat (27)	148- 701	165- 702	238-1049
Westside Canal (29)	70- 701	90- 702	201- 974
Anderson Lane (38)	21- 725	100- 703	163- 997
Blaine (52)	75- 800	107- 772	153-1600

Comparison of trout populations in 1975 and 1976

The flows in the Beaverhead River in 1974-75, which preceeded the Spring, 1975 population estimates, were considerably lower than those which preceeded the Spring, 1976 estimates (Table 21). Between 1974-75 and 1975-76 minimum average daily flows in the nine study sections increased by 43-155% and maximum average daily flows increased by 22-107%. Trout populations in all nine sections would be expected to increase following these dramatic flow increases if flow was the major limiting factor throughout the system.

Population estimates in 1975 and 1976 were considered significantly different if 80% confidence intervals did not overlap. Of these estimates, numbers of age II and older brown trout in the Hildreth Extended (2), Barretts Upstream Extended (15), and Barretts Downstream (18) Sections increased significantly between years. Numbers of age II and older brown trout within each of the lower four sections were not significantly different between years. Numbers of age II and older rainbow trout in the Hildreth Extended (2) Section were significantly greater in 1976, although this increase partially reflects a greater movement of spawning fish rather than an absolute increase in residents. Numbers of rainbow trout within the Wheat (27) and Westside Canal (29) Sections were not significantly different between years.

The increase in the estimated numbers of age II and older brown trout between years in the Hildreth Extended (2), Barretts Upstream Extended (15), and Barretts Downstream (18) Sections may partially reflect low annual rates of population decrease resulting from greater flows between the 1975 and 1976 estimates (Table 22). Although flows in the lower river also increased dramatically, annual rates of population decrease in the Wheat (27), Westside Canal (29) and Anderson Lane (38) Sections were more than two times that in the other sections, suggesting factors other than flow were limiting the survival of brown trout in these sections.

Between 1975 and 1976, the biomass of age II and older brown trout increased significantly in the Hildreth Extended (2) and Barretts Downstream (18) Sections, was not significantly different in the Barretts Upstream Extended (15) and Blaine (52) Sections, and decreased significantly in the Wheat (27), Westside Canal (29), and Anderson Lane

(38) Sections. Growth, in addition to numbers of trout, influenced the differences in biomass between years. Mean weights at capture, as indicated by age II brown trout, were lower in all sections in Spring, 1976 (Figure 14). Greater densities of trout in 1976 may explain the lower mean weights in the Hildreth Extended (2), Barretts Upstream Extended (15) and Barretts Downstream (18) Sections. However, densities were similar in the lower four sections in both years. The consistency of the weight decreases throughout the river would suggest that the exceptionally high flows occurring between Spring, 1975 and 1976 retarded growth. High flows may affect growth by lowering both water temperatures and the availability of food.

TABLE 22. Relationship between annual rates of population decrease (%) of age II and older brown trout and mean flows (cfs) in a series of study sections in the Beaverhead River between spring, 1975 and spring, 1976. Range of average daily flows in parenthesis.

Sections	Decrease (%) II & Older-III & Older	Mean Flow (cfs) Spring, 1975-Spring, 1976	Mean Flow (cfs) Irrigation	Mean Flow (cfs) Non-Irrigation
Hildreth Extended (2)	26	624 (101-1365)	792	439
Barretts Up. Extended (15)	30	702 (144-1480)	956	462
Barretts Down. (18)	27	535 (144- 933)	618	460
Wheat (27)	61	624 (226-1049)	678	572
Westside Canal (29)	66	592 (201- 974)	622	567
Anderson Lane (38)	71	634 (163- 997)	622	644
Blaine (52)	30	749 (153-1600)	717	775

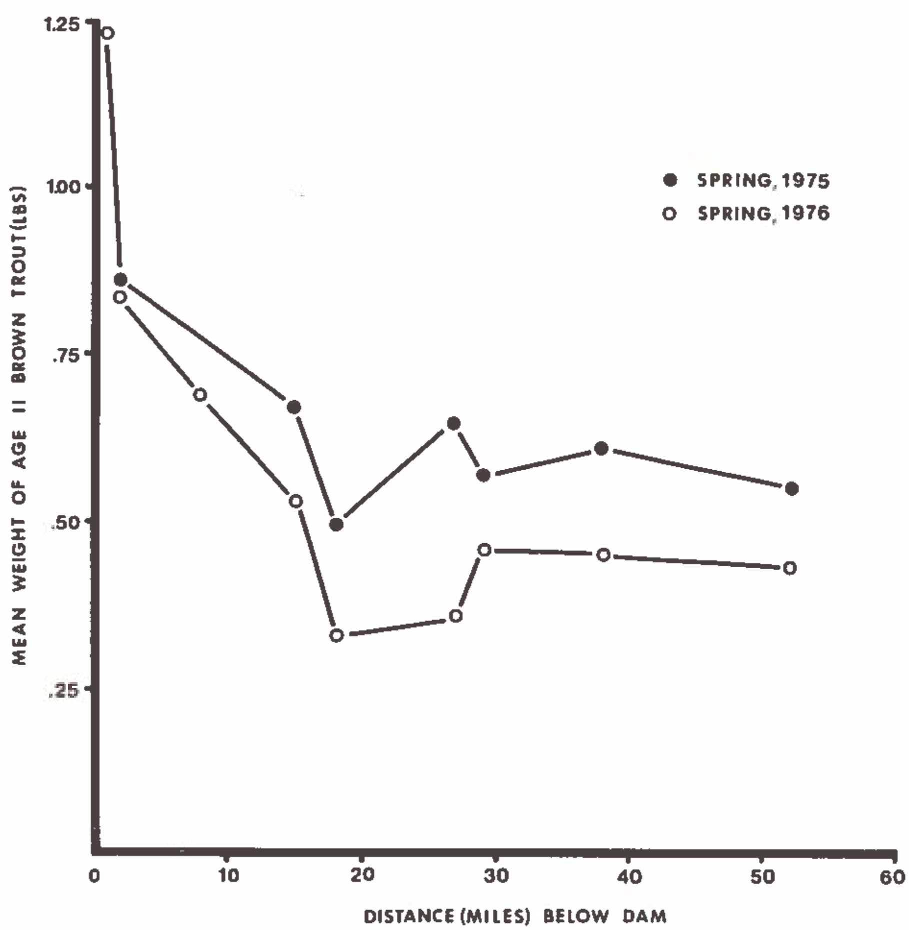


FIGURE 14. Mean weights (lbs) of age II brown trout in a series of study sections in the Beaverhead River in spring, 1975 and spring, 1976.

Only the Hildreth Extended (2) and Barretts Downstream (18) Sections showed significant increases in both the numbers and biomass of brown trout between 1975 and 1976. Biomass actually decreased significantly in three of the study sections. The results presented earlier (Hildreth Section) show that the flow increases that occurred between the 1975 and 1976 estimates were not the primary factor causing the population increase in the Hildreth Extended (2) Section. It appears that the volume of flow is not the only factor limiting trout populations in much of the Beaverhead River.

Comparison of trout populations between sections

Differences in the estimated numbers and biomass of trout between study sections (Figures 15 and 16) reflect a myriad of limiting factors not common to all sections nor of the same magnitude. In addition to flow differences, sedimentation and cover are factors of major concern. Although the effects of sedimentation were not quantified in this study, the decline in numbers and biomass of trout between the upper and lower river is believed to partially reflect increasing sedimentation. Sediment transport in the Beaverhead system is hindered by the diversion of reservoir releases for irrigation. Removal of large amounts of water reduce water velocities in the river to a point where the sediments can no longer remain suspended and, therefore, are deposited in the lower river. Mean turbidity measurements show that levels of suspended sediments were lowest in the upper river (Table 23). Grasshopper Creek, a major contributor of sediments to the Beaverhead River, is primarily responsible for the increase in mean turbidity between miles 8 and 18.

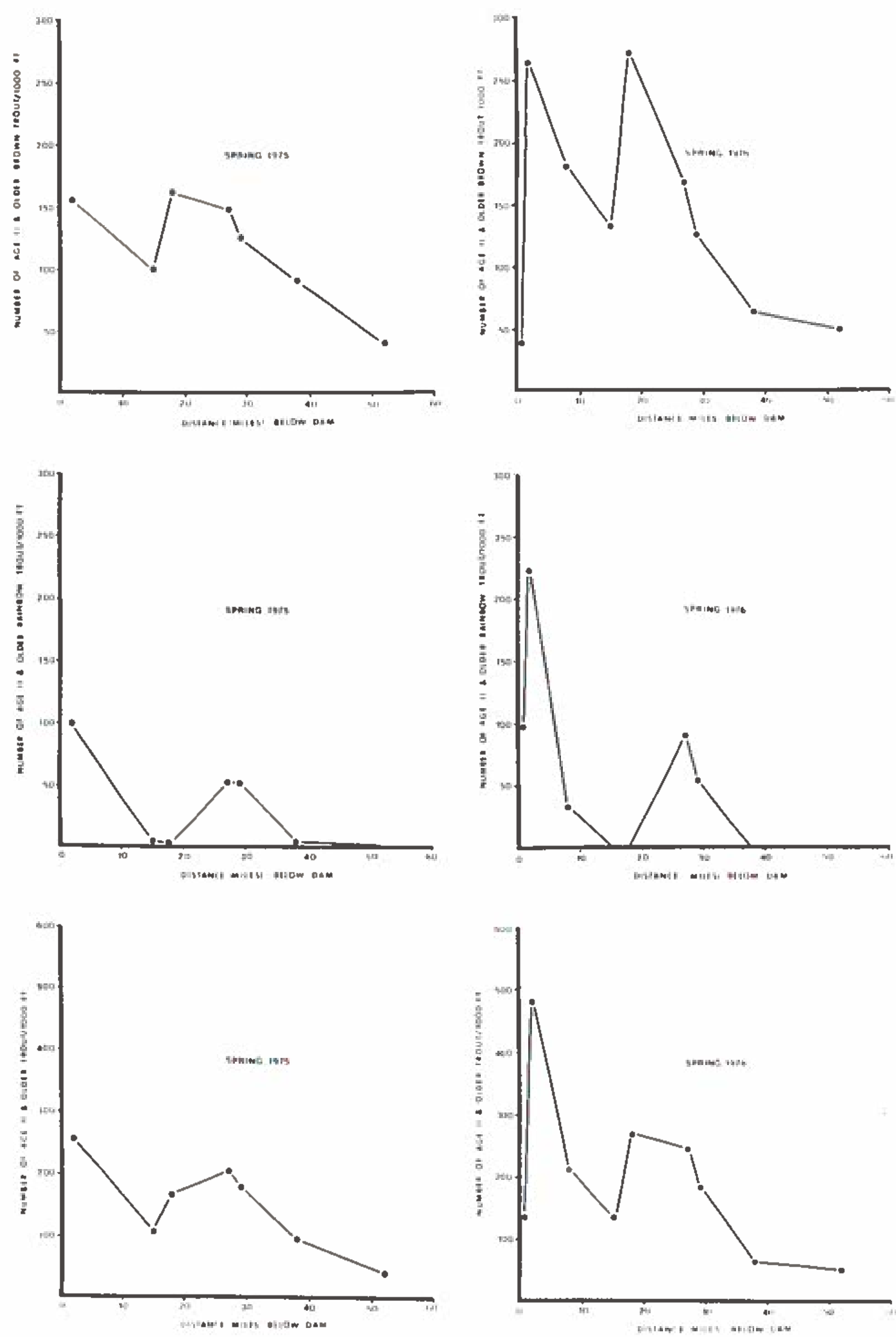


FIGURE 15. Estimated numbers (N/1000 ft) of age II and older brown, rainbow, and total trout in a series of study sections in the Beaverhead River in spring, 1975 and spring, 1976.

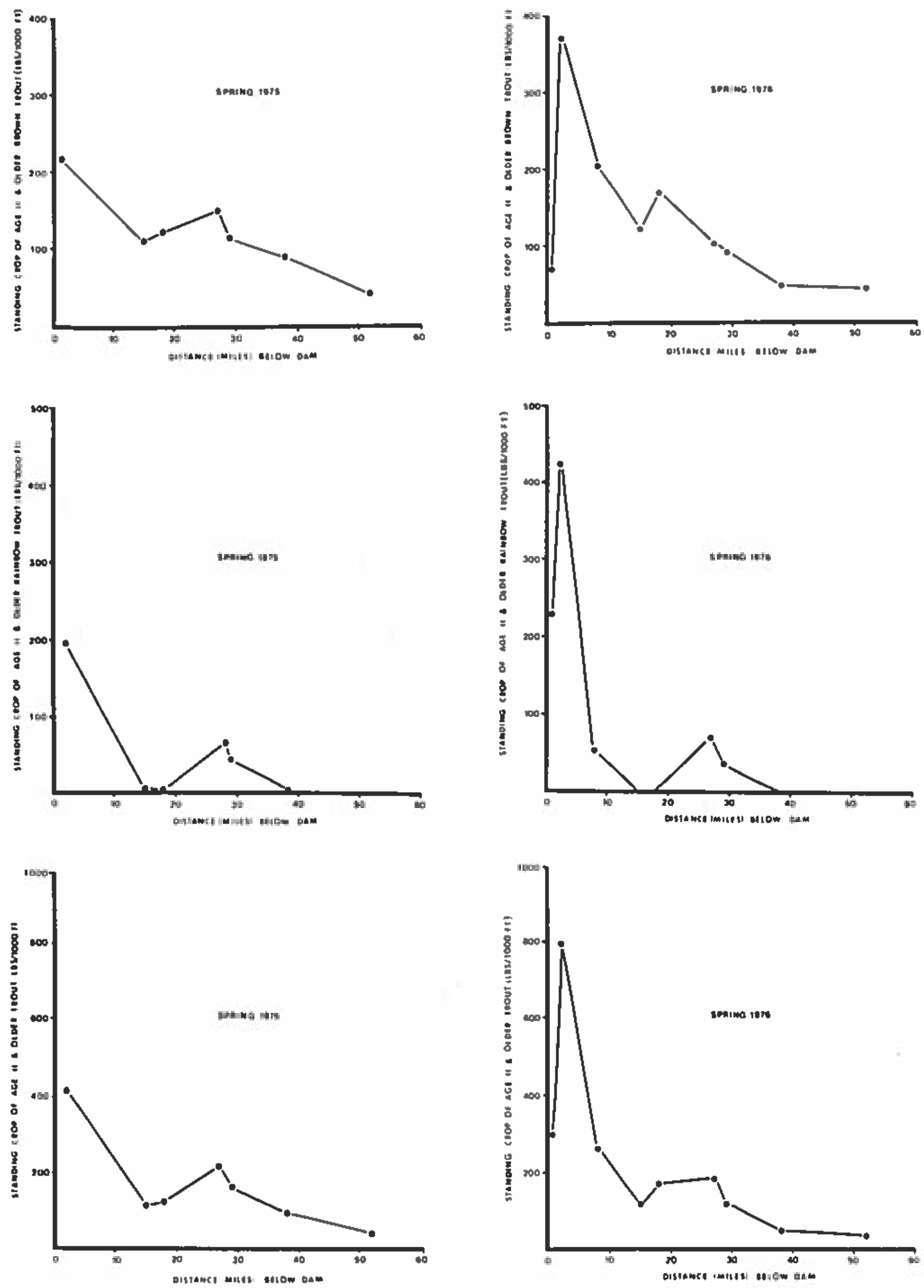


FIGURE 16. Estimated biomass (lbs/1000 ft) of age II and older brown, rainbow, and total trout in a series of study sections in the Beaverhead River in spring, 1975 and spring, 1976.

TABLE 23. Summary of turbidity (JTU) measurements for 10 sites on the Beaverhead River. Samples were collected between March 13, 1975 and February 27, 1976.

Approximate Distance Below Dam (miles)	No. Samples	Turbidity (JTU)	
		Range	Mean
1.9	20	0.0- 7.0	2.0
2	20	0.8- 42.0	4.1
8	21	0.7- 32.0	4.5
18	21	0.7-110.0	11.1
24	21	0.8-110.0	12.6
30	21	0.8-110.0	12.0
30.5	20	0.8-108.0	13.5
38	21	0.9- 92.0	12.0
52	20	1.0- 54.0	13.5
67	21	1.2- 45.0	14.0

Cover plays an important role in limiting numbers of trout in the upper river. The spring estimates of numbers of age II and older trout in the Hildreth Extended (2) through Barretts Downstream (18) Sections in both 1975 and 1976 (Figure 15) followed the same general trend as willow bank cover (Table 1). Both decreased between the Hildreth (2) Extended and Barretts Upstream Extended (15) Sections, then increased substantially in the Barretts Downstream (18) Section. In the Wheat (27) through Blaine (52) Sections, willow bank cover and numbers of trout did not display similar trends, suggesting cover was not a major factor influencing the decline in numbers of trout between these sections.

The low number of trout in the Grant (0.1) Section in Spring, 1976 (Figure 15) may partially reflect inferior cover. Compared to the Hildreth Extended (2) Section, willow bank cover in the Grant (0.1) Section was rated as poor. However, the low population of trout may also reflect flow reductions and water quality. Average daily flows as low as 22 cfs have occurred in the Grant (0.1) Section in recent years (October 16, 1974). Fish kills, caused by toxic levels of hydrogen sulfide in reservoir releases, were documented in the Grant (0.1) Section at the beginning of this study. Ammonia concentrations were also elevated (see page 19). The severity and frequency of water quality problems in the Grant (0.1) Section throughout the study period are unknown.

Water quality problems also exist in other sections of the Beaverhead River. Sampling by the Montana Department of Fish and Game and the U.S. Food and Drug Administration in 1970-71 indicated that mercury pollution occurred in the vicinity of Dillon. Some fish in this area contained mercury greatly in excess of FDA standards. Natural spring discharges, seed-potato treatment, the leaching of old mill tailings, and possible industrial activity were considered the sources of mercury. Above Grasshopper Creek, the Beaverhead River did not appear to contain elevated levels of mercury.

Growth, in addition to numbers of trout, influenced the differences in biomass between sections. A measure of the differences in growth rates between study sections is provided by the mean weights at capture of age II brown trout in Spring, 1975 and 1976 (Figure 14). Mean weights decreased dramatically between the Grant (0.1) and Barretts Downstream (18) Sections. The growth differences in the upper river are partially attributable to Clark Canyon Reservoir, which has reduced diel fluctuations in water temperature and has probably provided temperatures more favorable for trout growth. However, the influence of the dam on water temperatures decreased rapidly in approximately the upper 15 miles of river.

Food supply also influences the growth differences shown in Figure 14. Smith (1973) found a substantial increase in zooplankton immediately below the dam and speculated that this increase may provide additional food for small fish through the first 6 miles of river below the reservoir. Invertebrates also appear more abundant in the upper river. Limited kick sampling in October, 1975 showed a greater abundance of invertebrates in the riffles of the Hildreth (2), Pipeorgan (8), and Barretts Upstream (15) Sections (Table 24). Tipulid larvae primarily accounted for the greater volume of invertebrates in the Hildreth (2) and Barretts Upstream (15) Sections.

TABLE 24. Summed results for kick samples collected in a series of study sections in the Beaverhead River on October 22, 1975. Three samples were collected in a riffle in each section.

Section	No. Invertebrates Collected	Vol. Invertebrates Collected (ml)
Hildreth (2)	144	20.3
Pipeorgan (8)	179	6.8
Barretts Up. (15)	311	23.4
Barretts Down. (18)	39	2.6
Wheat (27)	44	1.3
Westside Canal (29)	118	3.7
Anderson Lane (38)	137	4.8
Blaine (52)	86	1.4

Comparison of trout populations throughout the study

All estimates of numbers and biomass of trout for the Pipeorgan (8), Barretts Upstream (15), Wheat (27), and Blaine (52) Sections throughout this study are given in Appendix Tables 25 through 29. It is doubtful estimates in the Wheat (27) and Blaine (52) Sections primarily reflect annual variations in flow. The consistently low estimates of numbers and biomass of total and younger brown trout in the Blaine (52) Section throughout this study suggest that reproduction is a problem. Reproductive success is probably limited by the heavy deposition of sediments in spawning gravels. Too few estimates are available in the Barretts Upstream (15) Section to evaluate the impact of flows.

Spring estimates of age II and older brown trout in the Hildreth (2) and Pipeorgan (8) Sections are compared in Table 30. Except for 1972, total numbers exhibited similar trends in both sections. Fall estimates of age I brown trout also displayed similar trends (Table 31), although numbers of yearlings in 1967 and 1971 were considerably greater in the Pipeorgan (8) Section. The similarity of population trends in sections having similar flow regimes suggests flow was the dominant factor influencing numbers of trout in both the Hildreth (2) and Pipeorgan (8) Sections.

Physical and Hydraulic Characteristics

Physical and hydraulic values at various flows were predicted for 20 cross sections in the Hildreth Section of the Beaverhead River using the WSP (Water Surface Profile) computer program of the Bureau of Reclamation. Each cross section was classified as a pool, run, or riffle. Mean physical and hydraulic values were calculated for each water type. The mean values at various flows in percent of the mean values at 1000 cfs, the approximate bank full flow, are given in Appendix Table 32.

Flow reductions affected riffle areas in the Hildreth Section more severely than pools and runs. Five of the six measured characteristics showed the greatest rates of loss in riffles (Appendix Table 32). Riffles are important to trout because they are the primary food producing and spawning areas in a stream. The importance of desirable flow patterns in riffle areas during the rainbow and brown trout spawning periods was demonstrated during this study.

TABLE 30. Comparison of the spring estimates of numbers (N/1000 ft) of age II and older brown trout in the Pipeorgan (8513 ft) and Hildreth (6455 ft) Sections of the Beaverhead River between 1968 and 1976. 80% confidence interval in parenthesis.

Spring	Brown Trout N/1000 ft	
	Pipeorgan	Hildreth
1968	96 (±23)	58 (±11)
1970	122 (±16)	77 (±11)
1971	138 (±37)	84 (±15)
1972	166 (±21)	62 (± 8)
1974	74 (±14)	49 (± 8)
1976	171 (±36)	184 (±44)

TABLE 31. Comparison of the fall estimates of numbers (N/1000 ft) of age I brown trout in the Pipeorgan (8513 ft) and Hildreth (6455 ft) Sections of the Beaverhead River between 1967 and 1973.

Fall	Brown Trout N/1000 ft	
	Pipeorgan	Hildreth
1967	24	6
1968	88	73
1969	83	68
1970	34	25
1971	72	22
1972	33	25
1973	8	9

Top width and wetted perimeter were proportionately less affected by changes in discharge than were the other characteristics in pools, runs and riffles of the Hildreth Section. In pools, mean velocity and cross sectional area were most affected by changes in discharge, followed in order by mean depth and maximum depth. In runs, cross sectional area was most affected, followed in order by mean velocity, mean depth, and maximum depth. The order for riffles was cross sectional area, mean depth, maximum depth, and mean velocity.

Mean physical and hydraulic values in percent of the mean values at 1000 cfs for all 20 cross sections in the Hildreth Section are compared in Figure 17. Mean values for the various characteristics increase as streamflow increases, but the rate of gain becomes less as the volume of flow fills the river channel. Visual inspection of Figure 17 shows that the rate of loss for all of the measured characteristics was greatly accelerated at flows less than approximately 200 cfs. For all water types combined, cross sectional area was most affected by changes in discharge, while top width and wetted perimeter were least affected.

Cross sectional area, an index of the total amount of living space available for fish, was greatly affected by changes in discharge in all water types. Based on the mean values at bank full flow (1000 cfs), mean cross sectional area in pools, runs, and riffles in the Hildreth Section is reduced by 50% at flows of approximately 275, 311, and 380 cfs, respectively (Appendix Table 32). Average daily flows as low as 57 cfs (October 16, 1974) were recorded in the Hildreth Section during this study. At this flow, mean cross sectional area in pools, runs, and riffles was approximately 25, 18, and 14%, respectively, of the mean values at bank full flow.

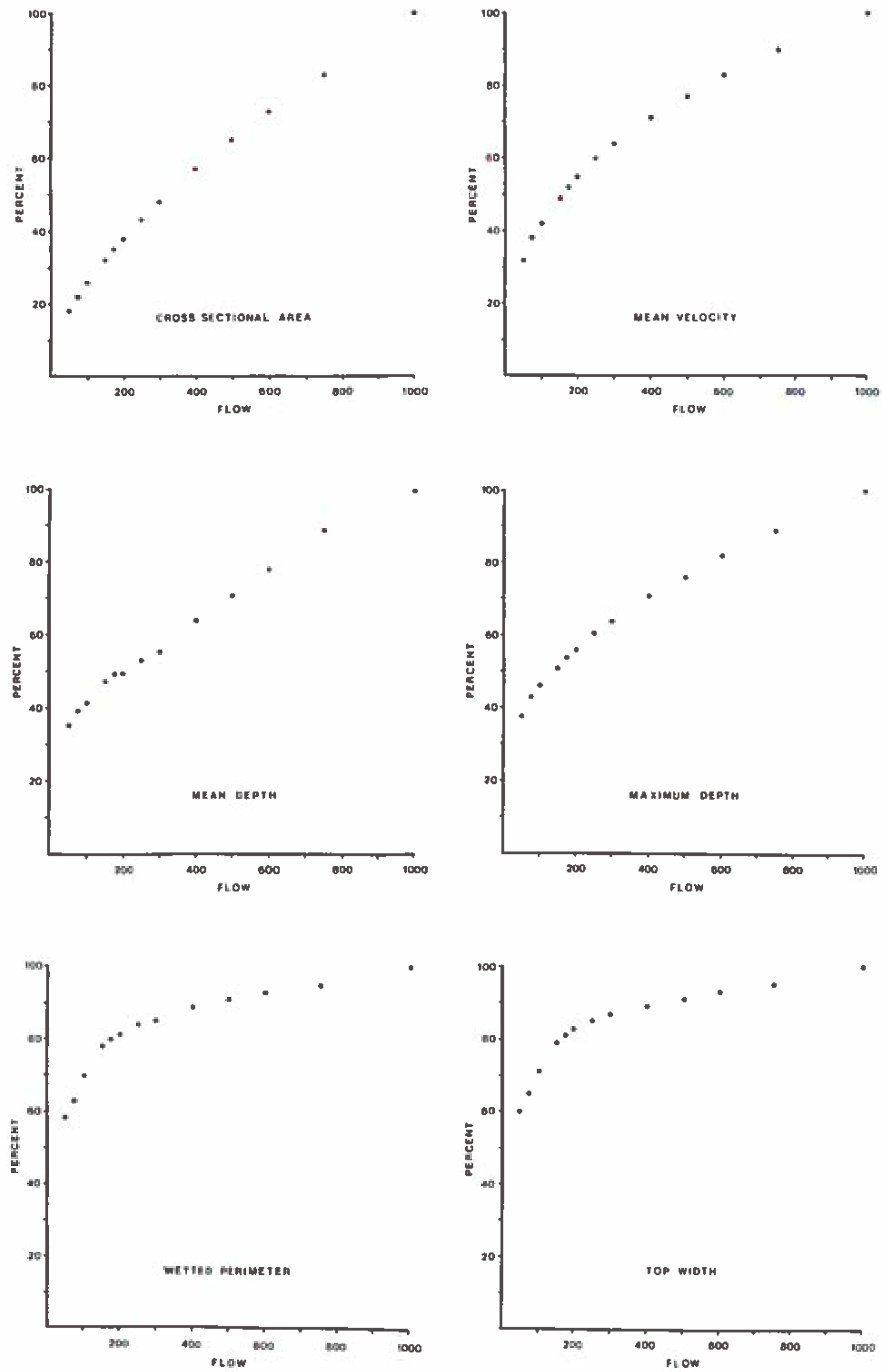


FIGURE 17. Mean values of physical and hydraulic characteristics at various flows (cfs) in percent of the mean values at 1000 cfs for 20 cross sections in the Hildreth Section of the Beaverhead River.

Values of the six physical and hydraulic characteristics at various flows were predicted for a total of 66 cross sections in 7 other study sections in the Beaverhead River. Based on the values at 1000 cfs, changes in the six characteristics with respect to discharge were generally similar to those trends which occurred in pools, runs, and riffles of the Hildreth Section. Appendix Table 33 lists those flows yielding a 50% reduction in the measured characteristics based on the mean values at 1000 cfs. Again, cross sectional area, an index of the total amount of living space available for fish, was greatly affected by changes in discharge. Based on 1000 cfs, flows of approximately 340 cfs throughout the Beaverhead River for all water types combined would yield an approximate 50% reduction in the amount of living space available for fish.

DISCUSSION

The presence of large numbers of trophy size trout characterizes the quality fishery of the upper Beaverhead River. Brown and rainbow trout as large as 12.0 and 13.25 lbs, respectively, were captured by electrofishing during this study. Numbers of trophy trout ($\geq$ 5.0 lbs) were not estimated due to small sample size. However, numbers of trout $\geq$ 5.0 lbs captured during each of the sampling periods between 1966 and 1976 provide an index of the abundance of trophy fish (Table 34). Trophy brown trout were not captured until the last five years of the study. Changes in numbers captured did not appear to relate to flows. Trophy rainbow trout were captured throughout the study. Numbers captured, which were greatest in 1973 and 1974, crashed in 1975. This dramatic reduction followed the lowest mean nonirrigation flow (97 cfs) of the study.

TABLE 34. Numbers of brown and rainbow trout ≥ 5.0 lbs captured by electrofishing in the Hildreth Section (6455 ft) of the Beaverhead River between 1966 and 1976.

	Brown Trout ≥ 5.0 lbs		
Spring	Number Captured	No. Electrofishing Runs	No. Captured/Run
1967	0	2	0
1968	0	3	0
1969	0	4	0
1970	0	3	0
1971	0	4	0
1972	3	4	0.8
1973	-	-	-
1974	10	4	2.5
1975	13	5	2.6
1976	4	4	1.0

	Rainbow Trout ≥ 5.0 lbs		
Fall	Number Captured	No. Electrofishing Runs	No. Captured/Run
1966	3	2	1.5
1967	2	2	1.0
1968	11	3	3.7
1969	5	3	1.7
1970	8	4	2.0
1971	11	4	2.8
1972	9	4	2.3
1973	16	3	5.3
1974	13	3	4.3
1975	1	4	0.3

The survival of the larger and older rainbow trout in the Hildreth Section of the Beaverhead River is directly related to the magnitude of flows during the nonirrigation season (approximately October 15 - April 15). During this period, Clark Canyon Reservoir is storing water for irrigation and releases into the Beaverhead River are minimal. A measure of the absolute minimal average daily flow that will maintain adequate survival and numbers of older rainbow trout is provided by the distribution of average daily flows between successive Fall estimates (Appendix Table 35). The three Fall to Fall periods having the lowest rates of population decrease of age III and older rainbow trout and the greatest numbers of age IV and older rainbow trout remaining at the end of each period are 1970-71, 1971-72, and 1972-73. Compared to the other Fall to Fall periods, 1970-71, 1971-72, and 1972-73 have fewer average daily flows in the 101-150 cfs interval and none in the 57-100 cfs interval. The data suggests that one average daily flow $\leq$ 150 cfs is sufficient to adversely affect the annual survival of older rainbow trout (Figure 18).

Few rivers in Montana are capable of producing a trophy rainbow trout fishery equal to the potential of the upper Beaverhead River. The ability of the upper Beaverhead to produce trophy rainbow trout is dependent on flow releases from Clark Canyon Reservoir. Appendix Table 35 provides an index of the minimum average daily flow that will maintain desirable numbers of trophy rainbow trout. The highest estimate of numbers of age IV and older rainbow trout followed a period (1971-72) in which only 6 of the average daily flows were $\leq$ 250 cfs and 7 were $\leq$ 300 cfs. It appears that the management of the Hildreth Section of

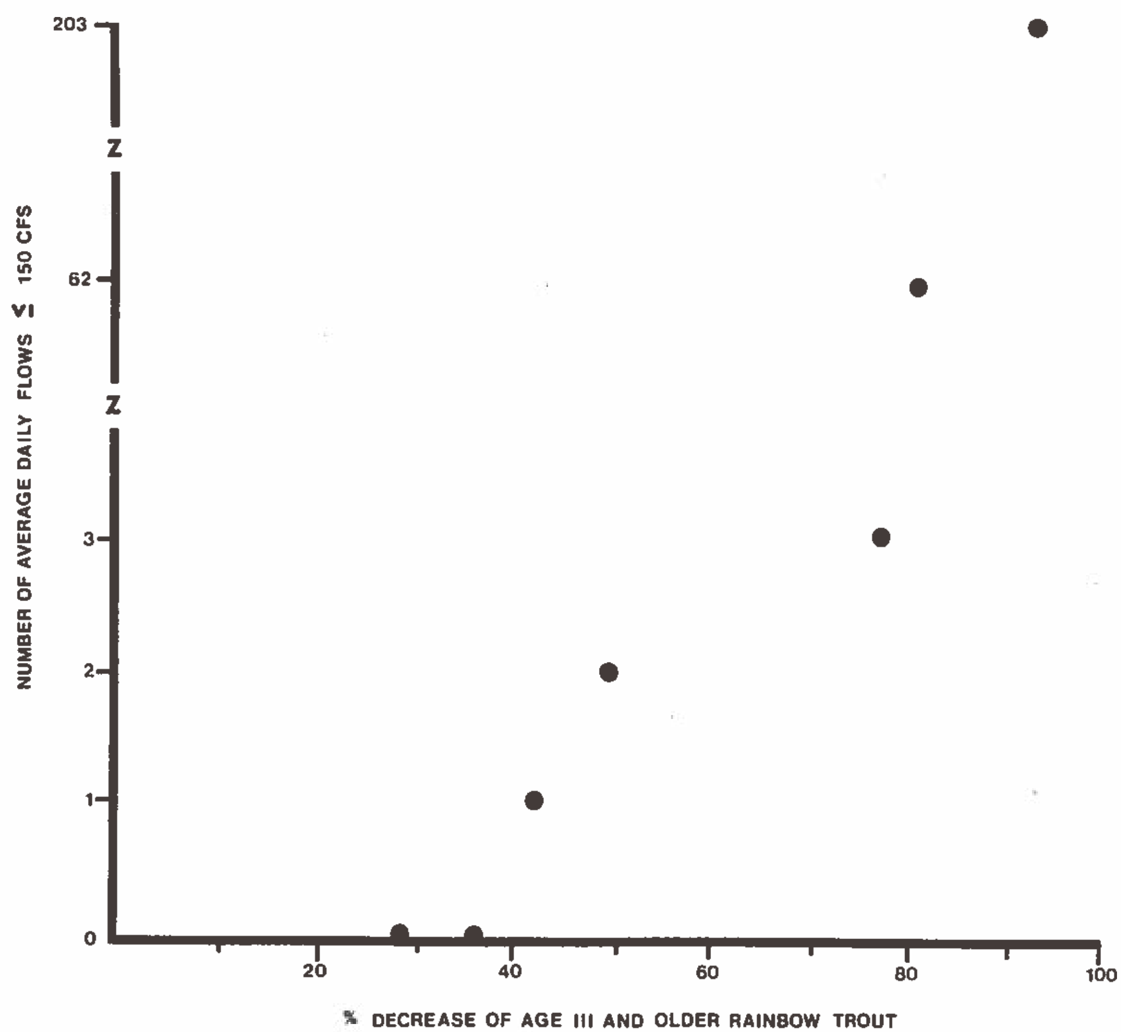


FIGURE 18. Relationship between the annual rates of population decrease (%) of age III and older rainbow trout and the number of average daily flows ≤ 150 cfs between successive fall population estimates.

the upper Beaverhead River as a high quality, trophy rainbow trout fishery will require average daily flows greater than approximately 250 cfs. This corresponds to a flow release of approximately 200 cfs at Clark Canyon Dam.

Positive relationships between the magnitude of flows during the nonirrigation season and the survival and numbers of older brown trout were not demonstrated during this study. However, the period (1971-72) producing the lowest rate of population decrease of age III and older brown trout and having the highest number of age IV and older brown trout at the end of the period has the fewest average daily flows in the 101-300 cfs interval (Appendix Table 34).

The annual rates of population decrease of older rainbow trout during low flow periods were greater than those of older brown trout. During the period containing the lowest nonirrigation flows of the study (1974-75), age III and older rainbow trout showed a 94% rate of decrease, while that of age III and older brown trout was only 50%. The relative stability of the estimates of numbers of age IV and older brown trout and the instability of estimates of age IV and older rainbow trout throughout this study primarily reflect a differential rate of decrease during low flow periods.

Habitat preferences may explain the differential rates of population decrease documented in this study. Although the components of the preferred habitat of brown and rainbow trout are poorly understood, some difference have been measured. Lewis (1969) found cover (primarily overhanging vegetation, undercut banks, and brush) to be the most important factor influencing numbers of brown trout in stream pools, while current velocity was most important for rainbow trout. Kraft

(1968) measured the rate of change of cover (overhanging vegetation and undercut banks) and current velocity with respect to flows. He concluded that cover was not greatly reduced by high levels of dewatering, while current velocity showed the greatest rate of change of the physical parameters measured. When flows are reduced, the preferred habitat of older rainbow trout in the Hildreth Section may be diminishing at a faster rate than that of older brown trout. This may account for the elevated rates of population decrease of older rainbow trout during low flow periods.

Poor reproductive success was the major factor limiting the total numbers and biomass of trout in the Hildreth (2) Section. Reproductive success throughout much of this study was inadequate for providing sufficient numbers of trout to fill all available living space. It is doubtful populations of brown trout of age groups I, II and III and rainbow trout of age groups I and II reflect the carrying capacity of the Hildreth Section, even during low water years. The simultaneous increases in the estimated total numbers and biomass of brown and rainbow trout, which occurred in the Hildreth Section during the last two years of the study, demonstrate the inadequacy of reproductive success in previous years. These increases, which coincide with some of the lowest mean nonirrigation flows of the study, were the result of two strong year classes (1973 and 1974) in succession. With flow releases favorable to both reproduction and the survival of older trout, the Hildreth Section is capable of supporting greater numbers and biomass of trout of all age groups than those which existed throughout much of this study.

The biological and water surface profile data collected in this study would support the management of the upper Beaverhead River (Hildreth Section) for a minimum average daily flow of approximately 250 cfs. An evaluation of the water surface profile data suggests the 250 cfs minimum would apply to the lower river as well. However, other factors adversely affecting fish populations in the lower river may minimize any benefits gained by increased flows during the irrigation and non-irrigation seasons. Limited biological data collected during this study does suggest that factors other than flow are contributing to the decline in numbers and biomass of trout that occurs between the upper and lower river.

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APPENDIX

TABLE 5. Correlation coefficients for the multiple linear relationships between the spring estimates of numbers of age IV and older brown trout and mean irrigation and nonirrigation flows in the Hildreth Section of the Beaverhead River.

	Partial Correlation Coefficients		
Dependent Variables	No. III & Older Brown Trout Previous Spring	Mean Flow Non-irrigation	Multiple Correlation (r)
No. IV & Older Brown Trout	.4616	.4618	.5266

	Partial Correlation Coefficients		
	No. III & Older Brown Trout Previous Spring	Mean Flow Irrigation	Multiple Correlation (r)
No. IV & Older Brown Trout	.5196	.4537	.5200

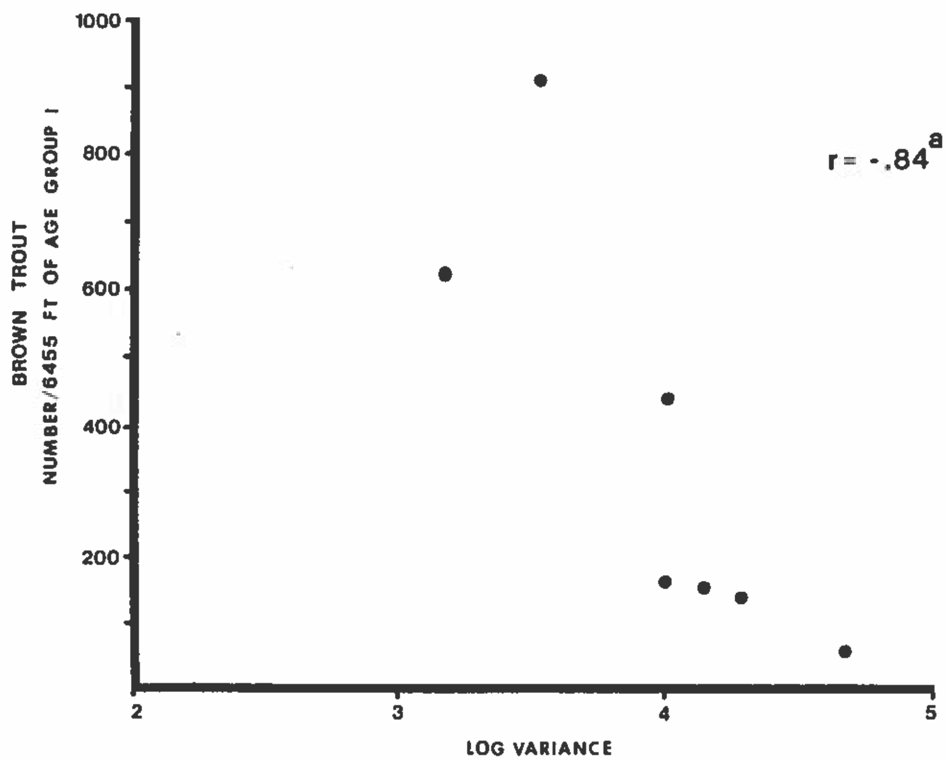

FIGURE 8. Relationship between the log variance of the average daily flows (cfs) during the brown trout spawning period (September 15 - October 31) and the estimated number of age I brown trout two years later in the Hildreth Section of the Beaverhead River.

a/ Indicates significance at 5% level.

TABLE 8. Correlation coefficients for the multiple linear relationships between fall estimates of numbers of age III and age IV and older rainbow trout and mean irrigation and nonirrigation flows in the Hildreth Section of the Beaverhead River.

Dependent Variables	Partial Correlation Coefficients		
	No. of age II Rainbow Trout Previous Fall	Mean Flow Nonirrigation	Multiple Correlation (r)
No. of age III Rainbow Trout	.2432	.1614	.2603
	No. of age II Rainbow Trout Previous Fall	Mean Flow Irrigation	Multiple Correlation (r)
No. of age III Rainbow Trout	.1599	.2876	.3493
	No. of age III & Older Rainbow Trout Previous Fall	Mean Flow Nonirrigation	Multiple Correlation (r)
No. of age IV & Older Rainbow Trout	.7789 1/	.8534 1/	.9019 1/
	No. of age III & Older Rainbow Trout Previous Fall	Mean Flow Irrigation	Multiple Correlation (r)
No. of age IV & Older Rainbow Trout	.5577	.0184	.5598

1/ Indicates significance at 5% level.

TABLE #9. Estimated numbers (N/1000 Ft) and standing crops (Lbs/1000 Ft) of brown trout by age groups in nine sections of the Beaverhead River during Spring, 1975 and 1976. 80% confidence interval in parenthesis.

	N/1000 Ft								Lbs/1000 Ft							
	1975				1976				1975				1976			
Section	II	III	IV & Older	Total	II	III	IV & Older	Total	II	III	IV & Older	Total	II	III	IV & Older	Total
Grant		No Estimate			20	—	20 —	40(±12)					25.3	—	45.4 —	70.7(±18.2)
Hildreth Extended	113	14	29	156(±15)	148	80	35	263(±58)	97.3	27.5	91.9	216.7(±24.5)	117.0	127.1	123.9	368.0(±84.5)
Pipeorgan Extended		No Estimate			93	—	87 —	180(±30)					63.7	—	140.6 —	204.3(±32.1)
Barretts Up. Extended	61	23	16	100(± 5)	62	—	70 —	132(±20)	41.0	33.2	35.5	109.7(± 5.7)	32.7	—	94.0 —	126.7(±18.8)
Barrets Down.	114	43	5	162(±10)	153	—	118 —	271(±39)	56.2	55.8	9.8	121.8(± 6.4)	50.5	—	116.5 —	167.0(±19.2)
Wheat	88	—	60 —	148(±15)	110	—	57 —	167(±36)	56.7	—	92.3 —	149.0(±15.4)	40.3	—	65.3 —	105.6(±17.5)
Westside Canal	81	—	44 —	125(±10)	84	—	42 —	126(±14)	46.0	—	67.5 —	113.5(± 8.4)	39.2	—	52.6 —	91.8(± 8.2)
Anderson Lane	55	—	35 —	90(± 9)	38	—	26 —	64(±18)	33.8	—	56.3 —	90.1(± 7.4)	16.9	—	32.7 —	49.6(±11.0)
Blaine	14	—	26 —	40(± 4)	22	—	28 —	50(±11)	7.5	—	34.1 —	41.6(± 3.8)	9.5	—	36.2 —	45.7(±10.9)

TABLE 20. Estimated numbers (N/1000 Ft) and standing crops (Lbs/1000 Ft) of rainbow trout by age groups in nine sections of the Beaverhead River during Spring, 1975 and 1976. 80% confidence interval in parenthesis.

	N/1000 Ft								Lbs/1000 Ft							
	1975				1976				1975				1976			
Section	II	III	IV & Older	Total	II	III	IV & Older	Total	II	III	IV & Older	Total	II	III	IV & Older	Total
Grant		No Estimate			54	— 44 —		98(±36)					90.4	— 145.2 —		235.6(±85.9)
Hildreth Extended	72	14	14	100(±10)	122	75	26	223(±45)	104.2	35.3	56.9	196.4(±20.6)	125.2	201.5	98.8	425.5(±100.4)
Pipeorgan Extended		No Estimate			19	— 14 —		33(±15)					21.7	— 34.4 —		56.1(±26.0)
Barretts Up. Extended	—	7	—	7(± 2)		Too Few to Estimate			—	7.9	—	7.9(± 1.9)				
Barretts Down.	—	4	—	4(± 1)		Too Few to Estimate			—	3.8	—	3.8(± 1.0)				
Wheat	32	— 23 —		55(±10)	28	— 53 —		81(±27)	22.6	— 44.4 —		67.0(±12.3)	11.7	— 60.1 —		71.8(±23.5)
Westside Canal	39	— 14 —		53(± 9)	36	— 22 —		58(±12)	24.9	— 21.3 —		46.2(± 8.1)	17.5	— 19.9 —		37.4(± 7.2)
Anderson Lane	—	5	—	5(± 2)		Too Few to Estimate			—	4.1	—	4.1(± 1.6)				
Blaine		Too Few to Estimate				Too Few to Estimate										

TABLE 25. Estimated numbers (N/1000 ft) and biomass (lbs/1000 ft) of brown trout by age groups in the Pipeorgan Section (8513 ft) of the Beaverhead River between 1967 and 1976. Rainbow trout were too scarce to estimate. 80% confidence interval in parenthesis.

		Brown Trout									
		N/1000 Ft					Lbs/1000 Ft				
		I	II	III	IV & Older	Total	I	II	III	IV & Older	Total
1967	Oct.	24	——	59	——	83 (±22)	——	——	136.5	——	136.5 (±38.4)
1968	Apr.	--	51	24	21	96 (±23)	----	——	143.2	——	143.2 (±37.9)
	Oct.	88	60	—— 27	——	175 (±39)	64.0	111.7	—— 74.4	——	250.1 (±69.4)
1969	Oct.	83	96	18	<1	197 (±34)	52.6	167.5	47.8	.7	268.6 (±51.8)
1970	Mar.	--	64	54	4	122 (±16)	----	47.2	83.8	9.9	140.9 (±17.7)
	Oct.	34	108	—— 33	——	175 (±27)	22.6	174.9	—— 80.4	——	277.9 (±51.5)
1971	Mar.	--	32	74	32	138 (±37)	----	24.3	94.0	56.3	174.6 (±40.4)
	Oct.	72	35	—— 70	——	177 (±29)	36.3	37.8	—— 152.3	——	226.4 (±41.0)
1972	Mar.	--	72	43	51	166 (±21)	----	45.9	54.8	103.4	204.1 (±30.0)
	Sept.	33	47	26	29	135 (±28)	19.9	79.0	58.6	90.2	247.7 (±64.2)
1973	Oct.	8	32	28	14	82 (±14)	4.8	53.0	75.0	49.3	182.1 (±34.3)
1974	Mar.	--	9	37	28	74 (±14)	---	7.0	62.2	65.7	134.9 (±26.1)
1976	Mar.	---	91	—— 80	——	171 (±36)	---	62.9	—— 122.3	——	185.2 (±35.6)

TABLE 26. Estimated numbers (N/1000 ft) and biomass (lbs/1000 ft) of brown trout by age groups in the Barretts Upstream Section (5792 ft) of the Beaverhead River between 1967 and 1976. Rainbow trout were too scarce to estimate. 80% confidence interval in parenthesis.

		Brown Trout									
		N/1000 Ft					Lbs/1000 Ft				
		I	II	III	IV & Older	Total	I	II	III	IV & Older	Total
1967	Mar.	--	31	—— 41 ——		72 (±13)	--	29.0	—— 69.3 ——		98.3 (±16.7)
	Oct.	--	30	29	24	83 (±25)	--	25.4	49.1	55.5	130.0 (±43.0)
1975	Mar.	--	83	28	12	123 (± 8)	--	52.6	38.5	23.2	114.3 (± 7.8)
1976	Mar.	--	94	—— 93 ——		187 (±40)	--	46.4	——111.1 ——		157.5 (±36.6)

TABLE 27. Estimated numbers (N/1000 ft) and biomass (lbs/1000 ft) of brown trout by age groups in the Wheat Section (9908 ft) of the Beaverhead River between 1968 and 1976. 80% confidence interval in parenthesis.

		Brown Trout									
		N/1000 Ft					Lbs/1000 Ft				
		I	II	III	IV & Older	Total	I	II	III	IV & Older	Total
1968	Jun.	57	———— 81 ———			138 (±30)	16.9	—— 106.3 ———			123.2 (±23.0)
1971	Jul.	45	25	26	8	104 (±25)	10.8	24.5	37.5	15.7	88.5 (±22.9)
1972	Jul.	34	41	23	8	106 (±16)	10.7	36.8	31.4	15.3	94.2 (±13.3)
1973	Jul.	22	———— 61 ———			83 (±19)	7.3	—— 77.3 ———			84.6 (±19.8)
1974	Oct.	128	26	41	16	211 (±43)	70.7	36.2	73.9	38.1	218.9 (±36.4)
1975	Mar.	--	88	— 60 ——		148 (±15)	----	56.7	—— 92.3 ——		149.0 (±15.4)
1976	Mar.	--	110	— 57 ——		167 (±36)	----	40.3	—— 65.3 ——		105.6 (±17.5)

TABLE 28. Estimated numbers (N/1000 ft) and biomass (lbs/1000 ft) of rainbow trout by age groups in the Wheat Section (9908 ft) of the Beaverhead River between 1968 and 1976. 80% confidence interval in parenthesis.

		Rainbow Trout									
		N/1000 Ft					Lbs/1000 Ft				
		I	II	III	IV & Older	Total	I	II	III	IV & Older	Total
1968	Jun.	———	———	———	———	No	Estimate	———	———	———	———
1971	Jul.	———	———	———	———	No	Estimate	———	———	———	———
1972	Jul.	--	21	20	7	48 (±12)	----	20.0	29.2	11.5	60.7 (±15.5)
1973	Jul.	———	28	———	———	28 (±11)	———	———	41.8	———	41.8 (±16.2)
1974	Oct.	26	18	16	13	73 (±17)	15.4	26.4	35.7	36.7	114.2 (±26.8)
1975	Mar.	--	32	—	23 —	55 (±10)	----	22.6	—	44.4 —	67.0 (±12.3)
1976	Mar.	--	28	—	53 —	81 (±27)	----	11.7	—	60.1 —	71.8 (±23.5)

TABLE 29. Estimated numbers (N/1000 ft) and biomass (lbs/1000 ft) of brown trout by age groups in the Blaine Section (17837 ft) of the Beaverhead River between 1971 and 1976. Rainbow trout were too scarce to estimate. 80% confidence interval in parenthesis.

		Brown Trout									
		N/1000 Ft					Lbs/1000 Ft				
		I	II	III	IV & Older	Total	I	II	III	IV & Older	Total
1971	Aug.	--	9	9	3	21 (± 6)	---	8.4	13.3	8.3	30.0 (±7.0)
1972	Sept.	9	10	10	4	33 (± 5)	3.9	11.3	15.9	9.1	40.2 (±6.4)
1975	Apr.	--	14	—	26 —	40 (± 4)	---	7.5	—	34.1 —	41.6 (±3.8)
1976	May	--	22	—	28 —	50 (±11)	---	9.5	—	36.2 —	45.7 (±10.9)

TABLE 32. Mean values of hydraulic characteristics at various flows (cfs) in percent of the mean values at 1000 cfs for pools, runs, and riffles in the Hildreth Section of the Beaverhead River.

Flow (cfs)	Mean Vel.	Max. Depth	Mean Depth	Top Width	Cross Sect. Area	Wetted Perimeter
			Pools			
50	21	48	46	67	24	66
75	26	51	49	73	28	71
100	31	54	50	77	31	75
150	38	58	53	85	37	83
175	42	60	55	85	40	85
200	45	62	55	86	43	84
250	50	66	59	87	48	85
300	55	69	62	89	52	87
400	64	74	68	90	61	89
500	72	80	77	92	68	91
600	79	84	83	94	75	93
750	88	90	91	96	84	95
			Runs			
50	29	35	32	56	16	53
75	32	42	37	65	23	63
100	36	46	41	72	27	75
150	44	52	47	78	33	78
175	47	54	50	81	37	83
200	50	56	50	83	39	84
250	56	61	53	85	45	86
300	62	66	55	86	49	87
400	68	72	65	89	58	91
500	75	76	69	92	66	93
600	81	82	76	93	74	96
750	89	89	88	95	84	97
			Riffles			
50	41	30	26	56	13	54
75	50	33	29	59	15	56
100	54	37	32	64	18	61
150	60	43	39	74	25	73
175	62	46	43	77	28	73
200	64	49	43	79	31	77
250	71	54	45	81	35	79
300	71	58	48	86	42	83
400	77	66	58	88	52	86
500	82	72	66	90	61	89
600	86	78	74	91	69	91
750	92	87	87	95	81	93

TABLE 33. Approximate flows (cfs) at which various hydraulic characteristics are reduced by 50% in relation to the mean values at 1000 cfs in pools, runs, and riffles in a series of study sections in the Beaverhead River.

Sections	No. Cross Sections	Mean Vel.	Max. Depth	Mean Depth	Top Width	Cross Sect. Area	Wetted Perimeter
POOLS							
Hildreth	7	250	75	100	<50	275	<50
Pipeorgan	5	250	75	150	<25	240	<25
Barretts Up.	2	<25	250	300	75	400	75
Barretts D.	3	250	75	75	38	250	38
Wheat	1	125	225	200	25	350	38
Westside C.	3	300	<25	<25	100	188	88
Anderson L.	3	175	125	150	38	360	38
Blaine	1	300	38	<25	<25	188	<25
RUNS							
Hildreth	5	200	150	200	<50	300	<50
Pipeorgan	4	125	200	175	25	360	25
Barretts Up.	1	150	225	250	<25	340	<25
Barretts D.	1	150	175	300	25	340	38
Wheat	6	163	125	163	<25	300	<25
Westside C.	3	300	<25	<25	50	200	50
Anderson L.	5	75	238	275	50	400	50
Blaine	3	200	175	113	<25	350	<25
RIFFLES							
Hildreth	8	75	200	320	<50	380	<50
Pipeorgan	4	100	188	240	88	380	63
Barretts Up.	4	38	300	450	50	500	50
Barretts D.	4	88	250	300	<25	400	25
Wheat	2	88	350	400	<25	450	<25
Westside C.	4	100	213	225	38	380	25
Anderson L.	0	--	--	--	--	--	--
Blaine	7	75	300	325	<25	450	<25
TOTAL							
Hildreth	20	150	150	200	<50	320	<50
Pipeorgan	13	175	150	200	<25	300	25
Barretts Up.	7	38	275	370	50	450	63
Barretts D.	8	150	175	210	25	325	25
Wheat	9	100	163	225	<25	350	<25
Westside C.	10	225	25	<25	50	275	50
Anderson L.	8	100	188	225	38	400	50
Blaine	11	125	250	250	<25	400	<25

TABLE 35. Distribution of the average daily flows between successive fall and spring estimates of trout populations in the Hildreth Section of the Beaverhead River.

	Number of days in each flow interval										Rainbow Trout	
Fall-Fall	57-75	76-100	101-150	151-200	201-250	251-300	301-400	401-500	501-750	≥751	Decrease (%) age III & older during period	No. age IV & older end of period.
1966-67	0	3	248	8	7	10	43	15	37	0	-	-
1967-68	0	1	10	15	32	126	81	21	79	9	-	16
1968-69	0	0	2	5	2	47	98	50	68	91	49	18
1969-70	0	0	3	9	19	113	76	25	39	85	78	10
1970-71	0	0	0	5	4	2	75	85	39	149	36	34
1971-72	0	0	1	0	5	1	72	57	103	103	42	60
1972-73	0	0	0	51	47	35	63	50	76	56	28	53
1973-74	2	1	59	39	69	32	20	23	52	82	81	15
1974-75	11	98	94	1	5	11	1	6	40	109	94	4
Spring-Spring											Brown Trout	
1967-68	0	0	113	19	36	120	58	15	37	0	76	173
1968-69	0	1	0	9	4	61	134	48	84	9	44	171
1969-70	0	0	5	2	3	65	104	25	63	91	49	144
1970-71	0	0	0	11	19	51	53	107	39	85	53	165
1971-72	0	0	1	1	6	2	94	56	61	149	30	209
1972-73	-	-	-	-	-	-	-	-	-	-	-	-
1973-74	0	0	56	66	76	19	19	7	60	56	-	195
1974-75	13	99	53	0	17	23	20	23	52	82	50	142
1975-76	0	0	44	1	5	11	31	42	108	109	32	139

PART II

FISH POPULATIONS IN
CLARK CANYON RESERVOIR AND TRIBUTARIES

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CONCLUSIONS

1. Clark Canyon Reservoir develops a thermocline, turning over in spring and fall. The reservoir can be classified as a fertile environment.
2. White sucker was the most numerous fish species netted in the reservoir between 1964 and 1972, comprising from 40 to 93% of the net catches.
3. Hatchery rainbow trout comprised over 90% of the annual catch of game species by anglers. An estimated 41,000 and 39,000 rainbow trout were harvested in 1971 and 1972, respectively. Brown trout and burbot were also taken.
4. Few carp have been observed in the reservoir. Their impact on the trout fishery appears negligible.
5. Reservoir populations of white and longnose suckers use Horse Prairie Creek for spawning.
6. Conflict between resident trout populations in Clark Canyon tributaries and spawning populations of suckers could not be determined from limited biological data collected in this study.
7. Preimpoundment populations of trout in the Red Rock River appear to be greater than those after impoundment. However, this may reflect habitat differences rather than factors related to impoundment.
8. Growth of hatchery rainbow trout during their first year in the reservoir is dependent on planting time.
9. Estimates of fishing pressure in fisherman days were 30,400 in 1971, 36,000 in 1972, and 40,587 in 1975-76 (May-April). Fishing pressure increased by approximately 34% over a 6-year period.

RECOMMENDATIONS

1. The optimum storage pool necessary to maintain a desirable reservoir fishery was not determined in this study. Additional information should be gathered during years of abnormal fluctuation.

2. Hatchery rainbow trout should be planted in the reservoir annually in the early spring just after the reservoir turnover, 3 to 7 weeks after ice-out.

INTRODUCTION

The Montana Department of Fish and Game has monitored fish populations in Clark Canyon Reservoir and its tributaries since 1964. The purpose of the study was to determine the relative abundance of game and nongame fish within the reservoir and to determine the influence of rough fish populations on resident fish in tributaries to the reservoir.

DESCRIPTION

Physical Reservoir Statistics

Clark Canyon Reservoir (Figure 1) was constructed on the Beaverhead River in southwestern Montana during the period 1961 to 1964. The primary functions of the reservoir are irrigation and flood control. The drainage area for the reservoir encompasses 2321 square miles. At maximum water surface elevation (5571.9 ft), the reservoir has a surface area of 6600 acres and a storage capacity of 328,979 acre feet. Morphometric characteristics of the reservoir at the average operating level of 5540 ft are given in Table 1. The maximum depth of 93.5 ft is located approximately

TABLE 1. Morphometric data for Clark Canyon Reservoir at the average operating level--elevation 1688.6 m (5540 ft).

Maximum Depth	28.5 m (93.5 ft)
Mean Depth	9.35 m (30.68 ft)
Maximum Length	6.47 km (4.02 mi)
Maximum Breadth	5.01 km (3.11 mi)
Mean Breadth	3.06 km (1.90 mi)
Area	19.789×10^6 m^2 (4.890×10^3 acres)
Volume	18×10^6 m^3 (150×10^3 acre-ft)
Length of Shoreline	26.01 km (16.16 mi)
Shoreline Development	1.65

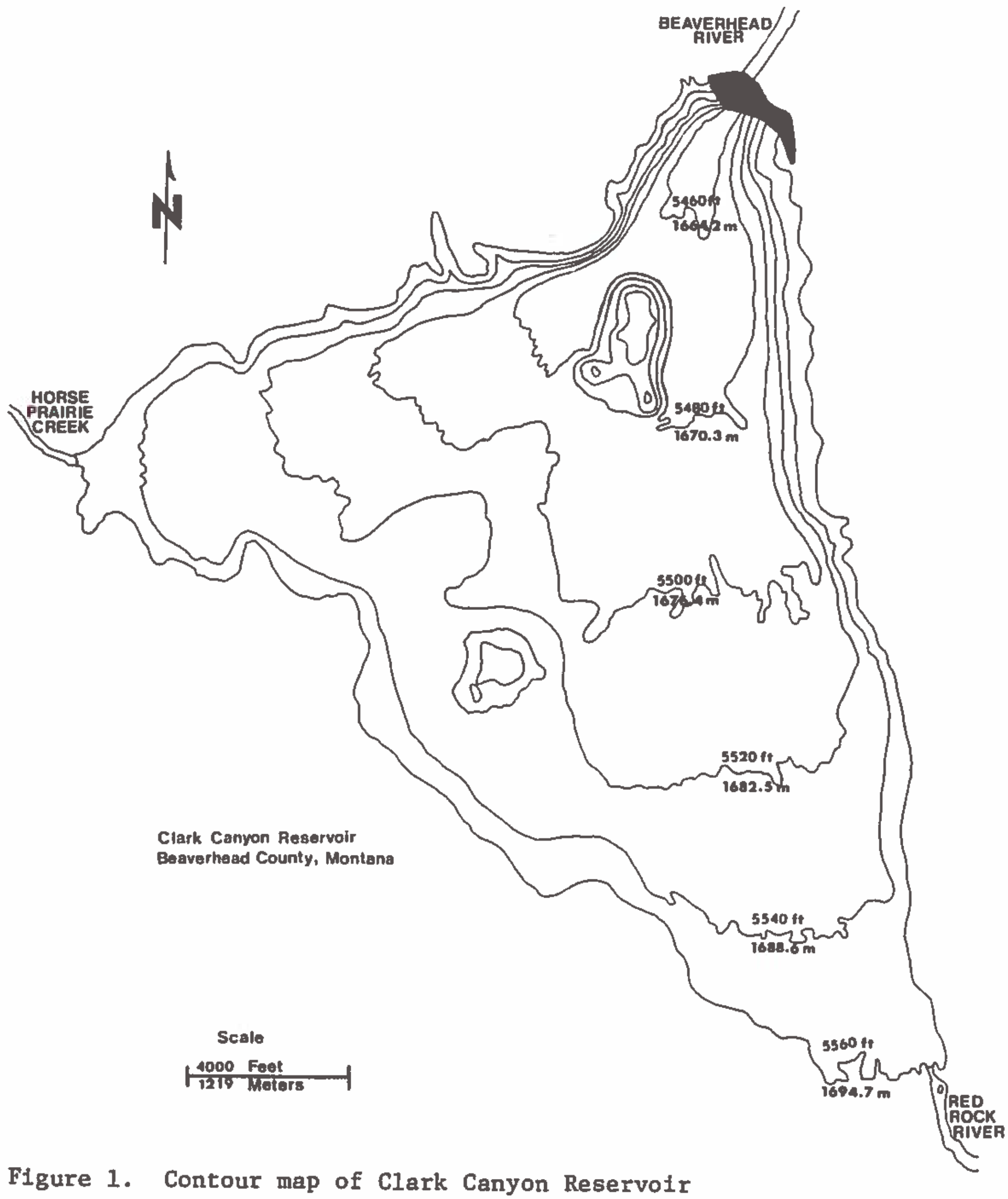

Figure 1. Contour map of Clark Canyon Reservoir

600 ft from the dam. Since the inverted outlet is only 8.5 ft above the old streambed, discharge into the Beaverhead River comes from the deepest part of the reservoir. Generally, the reservoir is completely ice covered by mid-December and ice-out occurs by mid-April.

The maximum and minimum storage pools in the reservoir for the 1965 through 1976 water years are compared in Figure 2. The severe drawdown in the summer of 1975 is the result of basing water allotments on predicted inflows from watershed snowpack information, rather than the known content of the reservoir. This procedure is no longer practiced.

Limnology

Limnological data was taken from a study conducted by Berg (1974) between June, 1971 and November, 1972.

Clark Canyon Reservoir characteristically develops a thermocline, turning over in spring and fall. Thermocline depth ranged from 6.6 to 73.8 ft and euphotic zone depth ranged from 16.4 to 50.9 ft. The minimum and maximum conductivity readings were 420 and 650 uohms, respectively. Dissolved oxygen near the surface ranged from 6.5 to 10.8 ppm and from 0.2 to 11.1 ppm on the bottom. Low DO concentrations in water over 50 ft in depth limit the use of this portion of the reservoir by fish. The pH ranged from 7.8 to 8.6 and, as with DO, highs occurred during overturn and lows during summer stagnation. Following spring and summer overturn, levels of plant nutrients in the euphotic zone were reduced, probably as a result of uptake by phytoplankton and transfer to the deep water zone by sinking. Ranges of total alkalinity and total hardness were 177 to 222 ppm as $CaCO_3$ and 157 to 230 ppm as $CaCO_3$, respectively.

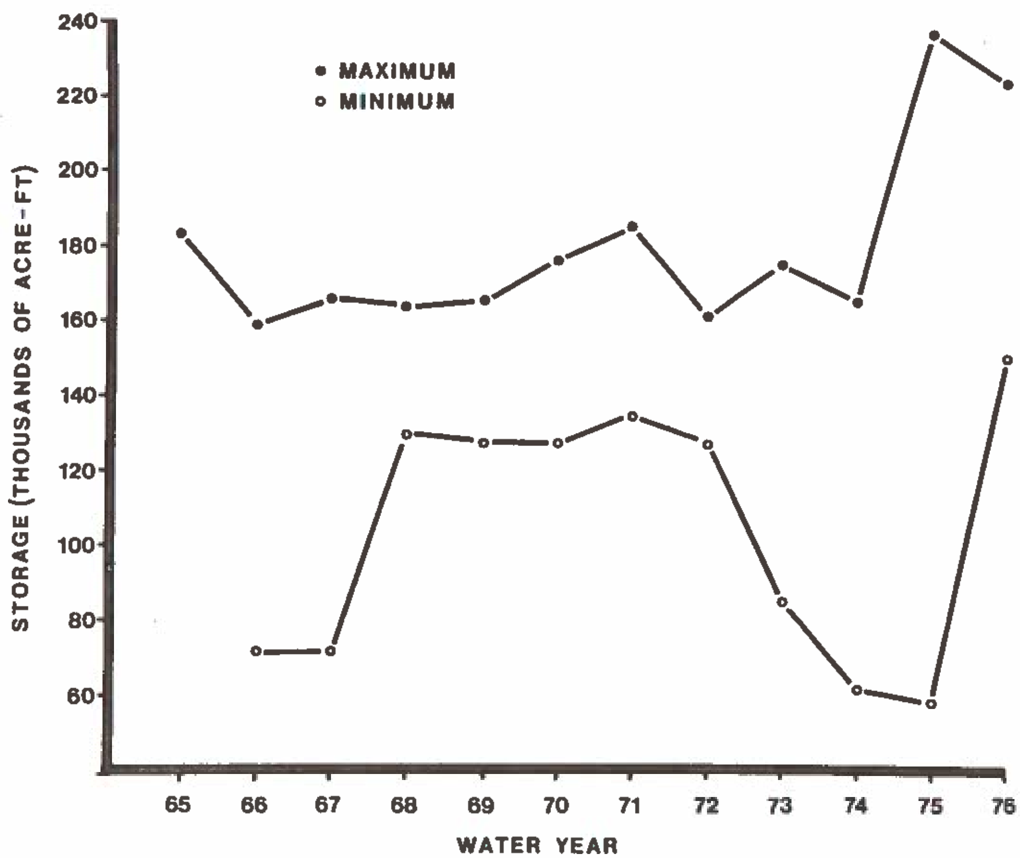

Figure 2. Maximum and minimum storage pools in Clark Canyon Reservoir for the 1965 through 1976 water years.

A calcium ion concentration of 2.99 me/l was measured in a euphotic zone water sample during the fall overturn, 1972. According to Reid's (1961) classification for biological productivity, a calcium ion concentration greater than 1.25 me/l is considered "rich". Clark Canyon contains over twice this amount and must be considered a fertile environment.

From December, 1971 to November, 1972, thirty-one algal genera (6 classes) were observed in the euphotic zone of Clark Canyon Reservoir. In order of decreasing abundance, the five genera with the largest mean annual standing crops were: Asterionella, Aphanizomenon, Cryptomonas, Rhodomonas, and Synedra. The seasonal abundance of these genera are compared in Figure 3. A blue-green algae bloom, composed primarily of Aphanizomenon sp., peaked in September, 1972. Water temperature was the only variable measured that was significantly correlated with phytoplankton standing crops.

Five major zooplankton taxon were encountered during the study. Daphnia schodleri and Cyclops bicuspidatus thomasii were the dominant zooplankters during all seasons. D. schodleri became the first abundant zooplankter, appearing in large numbers in mid-May. Water temperatures and chlorophyll a concentrations were the only measured variables significantly correlated with populations of D. schodleri.

METHODS

Fish were sampled in Clark Canyon Reservoir using gill nets, trap nets, and seine nets. The gill nets used were 125-foot x 6 foot experimental nets

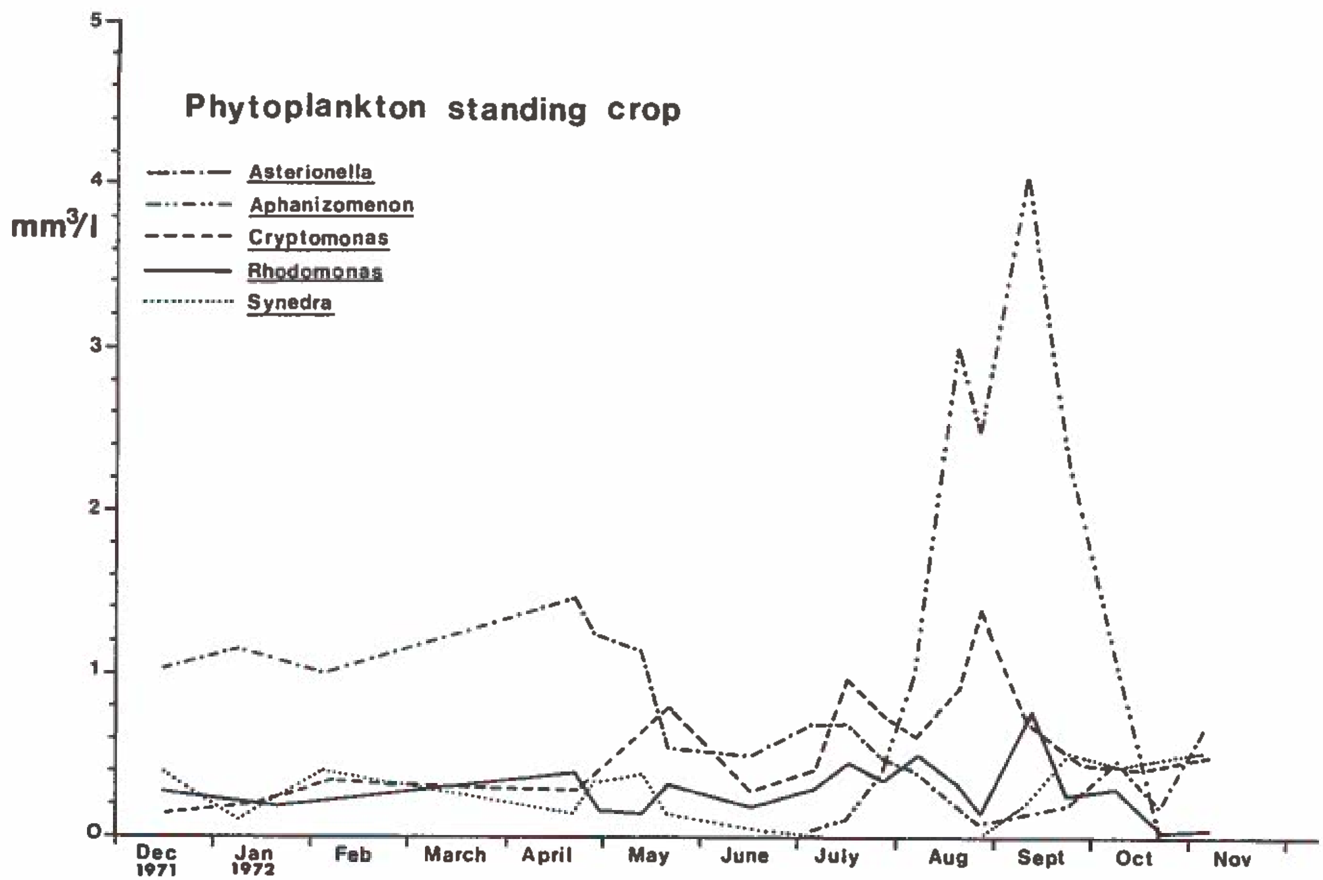

Figure 3. Seasonal abundance of the five major algal genera in Clark Canyon Reservoir (from Berg, 1974).

with five 25-foot panels of different mesh size: 3/4, 1, 1¼, 1½ and 2-inch. Trap nets were 4 x 7-foot frames covered with 1-inch mesh net; leads were approximately 25 yards. The nylon seine was 100 x 12 ft.

A percentage of the hatchery rainbow trout stocked in Clark Canyon were marked for future identification using fin clips. Clips used were: adipose-- 1970, left pelvic-- 1971, and adipose-- 1972. Rainbow trout in creels of reservoir fishermen were checked for these marks and also were identified as wild or hatchery by the appearance and shape of the fins. Hatchery fish had fins with bent rays and rounded tail fins.

Fish from Red Rock River and Horse Prairie Creek were sampled using boat electrofishing gear as described by Vincent (1971). Fish population estimates were made using the mark and recapture method as expressed by $\frac{(M+1)\ (C+1)}{(R+1)}$, where M is the number of fish marked, C is the number of fish recaptured, and R is the number of marked fish recaptured. Population estimation calculations were done on a hand calculator prior to 1969. The 1969-1972 fish population calculations were done on a computer using the most recent Montana Fish and Game computer format.

Fishing pressure on Clark Canyon Reservoir was determined in 1971 using pressure curves as outlined by Peterson (1970). In 1972, fishing pressure was determined using the method of Neuhold and Lu (1957). This method is based on a stratified random sample. The year was stratified into 4-week periods starting March 15 and further stratified into week-days and weekend days. Two weekdays per week were selected at random with subsequent weekdays in the following 3-week period selected such that each weekend was sampled at least once per 4-week period. The weekdays were thus sampled 8 days out of 20 per period. Every other weekend day was sampled. The first weekend day per sampling period was selected at random, then every other weekend day was sampled. Holidays were treated as weekend days. Each selected sample day was divided into four 4-hour periods. On each sample day, two counts were made, one in one 4-hour period and one in a different period. The 4-hour periods were selected at random while the hours within periods were in sequential order after the first random selection.

Catch was determined by contacting fishermen and recording number, species and size of fish in the creel, plus the number of hours required to take the fish.

RESULTS

Reservoir Fish Populations

Gill and trap nets were used to census fish populations in Clark Canyon Reservoir from 1964 through 1972. Catch statistics for each year are given in Tables 2 through 10. White sucker (*Catostomus commersoni*) was the dominant species in the catch in all years. Other species captured were longnose sucker (*Catostomus catostomus*), burbot (*Lota lota*), mountain whitefish (*Prosopium williamsoni*), brown trout (Salmo trutta), rainbow trout (*Salmo gairdneri*), brook trout (*Salvelinus fontinalis*), and carp (*Cyprinus carpio*).

White and Longnose Suckers

Average lengths of white and longnose suckers at capture are compared in Figure 4. The average length of both species remained fairly constant between 1964 and 1968. Between 1968 and 1969, both species attained the greatest annual increase in average length during the study period. After

TABLE 2. Fish caught in three gill net sets, Clark Canyon Reservoir, August, 1964

Species	Number caught	Percent of catch	Size range in inches	Ave. length in inches	Ave. weight in pounds
White Sucker	378	67.0	6.8-18.5	11.1	0.76
Longnose Sucker	108	19.1	6.6-19.8	10.9	0.78
Mountain Whitefish	29	5.1	8.5-15.8	14.2	1.39
Rainbow Trout	5	0.9	10.8-13.4	11.5	0.63
Brown Trout	39	6.9	8.0-23.3	12.3	1.04
Brook Trout	5	0.9	9.7-15.8	12.3	0.90

Taken from Wipperman, 1965.

TABLE 3. Fish caught in seven gill net sets, one surface set and six bottom sets Clark Canyon Reservoir, September, 1965

Species	Number caught	Percent of catch	Size range in inches	Ave. length in inches	Ave. weight in pounds
White Sucker	391	81.8	6.3-17.3	11.8	0.81
Longnose Sucker	20	4.2	9.4-18.9	12.2	0.85
Mountain Whitefish	31	6.5	8.0-17.4	12.0	0.88
Rainbow Trout	25	5.2	8.4-14.5	11.5	0.69
Brown Trout	8	1.7	11.0-23.3	18.1	2.81
Brook Trout	3	0.6	10.9-16.4	13.9	1.38

Taken from Needham and Wipperman, 1967.

TABLE 4. Fish caught in six gill net sets, two surface sets and four bottom sets Clark Canyon Reservoir, September, 1966.

Species	Number caught	Percent of catch	Size range in inches	Ave. length in inches	Ave. weight in pounds
White Sucker	490	73.3	6.0-19.4	11.4	0.75
Longnose Sucker	114	17.1	6.7-19.5	11.7	0.74
Mountain Whitefish	31	4.6	9.5-18.3	14.5	1.46
Rainbow Trout	4	0.6	18.8-21.2	19.7	3.19
Brown Trout	22	3.3	15.1-22.0	18.8	2.90
Brook Trout	3	0.4	15.0-16.2	15.7	1.87
Burbot	4	0.6	7.9-16.2	11.6	0.46

Taken from Wipperman, 1967.

TABLE 5. Fish caught in 18 gill net sets, 9 surface sets and 9 bottom sets, Clark Canyon Reservoir, June, 1968.

Species	Number caught	Percent of catch	Size range in inches	Ave. length in inches	Ave. weight in pounds
White Sucker	490	42.6	7.3-16.2	12.3	0.92
Longnose Sucker	311	27.0	7.4-19.5	11.6	0.68
Mountain Whitefish	71	6.2	11.5-19.6	15.8	1.97
Rainbow Trout	9	0.8	11.0-21.2	17.2	2.67
Brown Trout	61	5.3	6.2-24.3	19.4	3.30
Brook Trout	1	0.1	----	16.4	2.20
Burbot	207	18.0	8.0-22.8	14.2	0.85
Carp	1	0.1	----	7.8	0.32

Taken from Elser, 1969.

TABLE 6. Fish caught in three gill net sets, Clark Canyon Reservoir, June, 1969.

Species	Number caught	Percent of catch	Size range in inches	Ave. length in inches	Ave. weight in pounds
White Sucker	475	90.1	6.1-17.0	13.6	----
Longnose Sucker	13	2.5	11.6-16.0	13.3	----
Mountain Whitefish	1	0.2	----	----	----
Rainbow Trout	1	0.2	----	13.0	----
Brown Trout	17	3.2	7.1-24.2	20.5	----
Brook Trout	1	0.2	----	----	----
Burbot	19	3.6	12.3-22.1	15.5	----

Unpublished data from Marcoux, 1969.

TABLE 7. Fish caught in 21 trap net sets, Clark Canyon Reservoir, June, 1969. Nets set selectively to catch burbot.

Species	Number caught	Percent of catch	Size range in inches	Ave. length in inches	Ave. weight in pounds
White Sucker	1297	39.5	7.8-18.2	13.9	1.19
Longnose Sucker	373	11.3	9.9-21.3	15.8	1.50
Mountain Whitefish	20	0.5	8.2-19.2	16.2	----
Rainbow Trout	9	0.3	14.3-24.8	20.3	2.97
Brown Trout	15	0.5	19.5-23.9	21.7	3.12
Brook Trout	1	0.0	----	14.1	1.08
Burbot	1570	47.8	11.9-27.0	16.8	0.96
Carp	4	0.1	11.5-14.4	13.2	1.61

Unpublished data from Marcoux, 1969.

TABLE 8. Fish caught in eight trap net sets, Clark Canyon Reservoir, May, 1970.

Species	Number caught	Percent of catch	Size range in inches	Ave. length in inches	Ave. weight in pounds
White Sucker	1937	92.6	7.3-18.8	14.8	1.62
Longnose Sucker	47	2.2	13.2-19.4	15.9	1.67
Mountain Whitefish	6	0.3	11.9-18.2	16.1	1.50
Rainbow Trout	4	0.2	13.0-17.5	14.8	1.36
Brown Trout	8	0.4	19.2-23.1	20.6	2.53
Burbot	89	4.3	14.2-30.4	19.9	1.98

Taken from Peterson, 1971.

TABLE 9. Fish caught in two gill net sets, Clark Canyon Reservoir, May, 1971.

Species	Number caught	Percent of catch	Size range in inches	Ave. length in inches	Ave. weight in ponds
White Sucker	30	46.9	9.3-16.8	14.2	----
Longnose Sucker	3	4.7	6.8-12.3	10.5	----
Mountain Whitefish	1	1.6	----	16.8	----
Rainbow Trout	23	35.9	11.4-18.4	13.9	----
Brown Trout	6	9.4	17.1-22.5	19.3	----
Burbot	1	1.6	----	15.6	----

Taken from Montana Department of Fish and Game, 1975.

TABLE 10. Fish caught in eight gill net sets, Clark Canyon Reservoir, July, 1972.

Species	Number caught	Percent of catch	Size range in inches	Ave. length in inches	Ave. weight in pounds
White Sucker	381	78.1	8.8-17.6	15.2	----
Longnose Sucker	37	7.6	7.6-18.3	15.4	----
Mountain Whitefish	0	0.0	----	----	----
Rainbow Trout	41	8.4	7.2-21.6	14.2	----
Brown Trout	8	1.6	15.7-21.6	14.2	----
Burbot	21	4.3	13.2-17.6	15.6	----

Taken from Montana Department of Fish and Game, 1975.

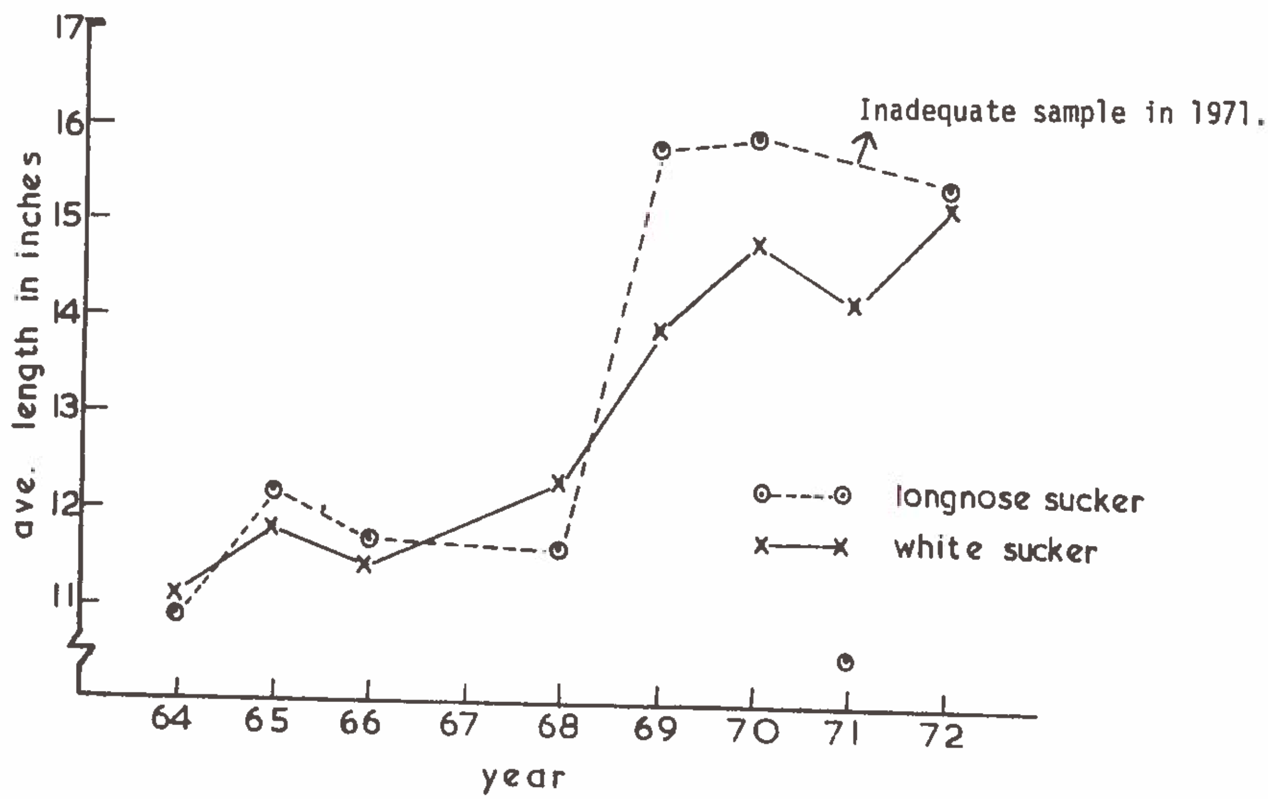

FIGURE 4. Average length of suckers caught by gill nets and trap nets, Clark Canyon Reservoir, 1964-72 (From Montana Department of Fish and Game, 1975).

1970, average weights were relatively stable.

The average length at each annulus for white suckers were as follows: age I - 1.5 inches; II - 5.4 inches; III - 10.6 inches; IV - 13.4 inches; V - 14.7 inches; VI - 16.3 inches; and VII - 17.0 inches (Peterson, 1971). Suckers do not appear in the net catch in significant numbers until they are at least 3 years old.

Brown Trout

Brown trout were first captured in 1964. Between 1964 and 1969 mean lengths increased, peaked in 1969, then decreased between 1969 and 1972 (Figure 5).

Burbot

Burbot were first captured in 1966. Mean lengths increased between 1966 and 1970, peaked in 1970, then decreased between 1970 and 1972 (Figure 5).

Other Species

A few brook trout were netted through 1969, after which no brook trout were captured. Mountain whitefish never comprised more than 6.5% of the catch. No whitefish were captured in 1972. A few carp were captured in 1968 and 1969. Seven small carp, 3.8 to 4.4 inches in length, were taken by seining at night in 1970. Clark Canyon Reservoir does not support a prolific population of carp.

Tributary Fish Populations

Horse Prairie Creek

Trout population estimates for a section of Horse Prairie Creek, located approximately two miles upstream of Clark Canyon Reservoir, are given in

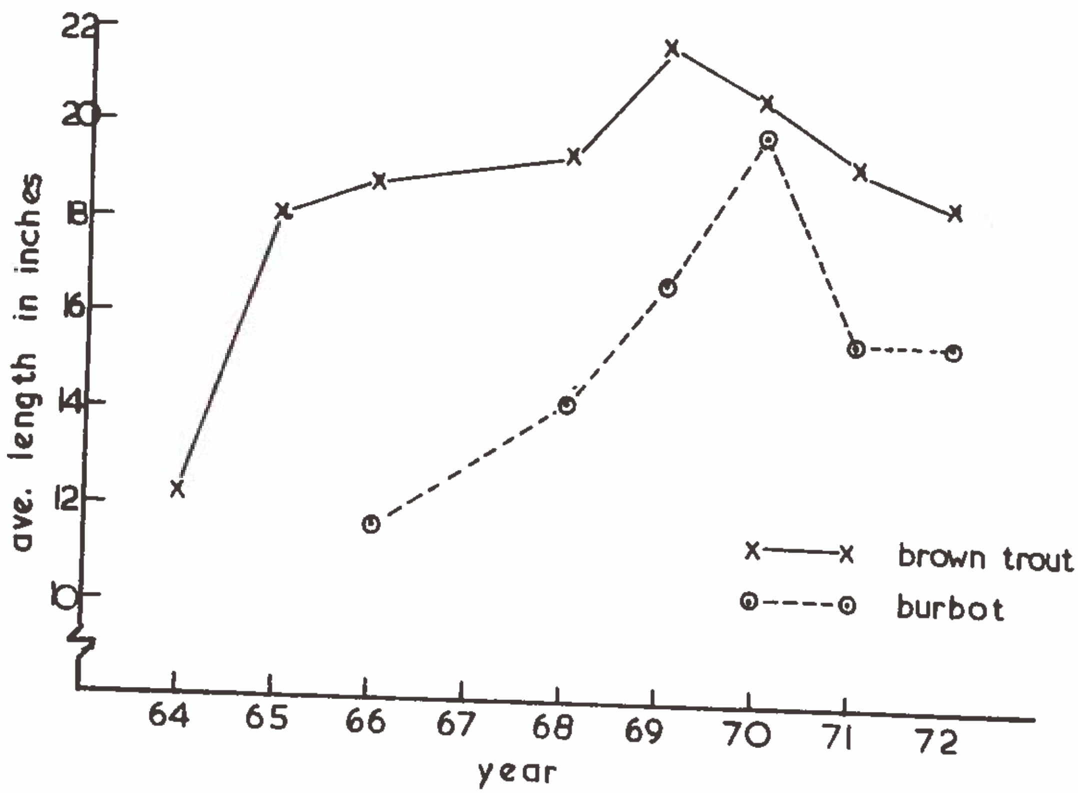

FIGURE 5. Average length of brown trout and burbot caught by gill nets and trap nets, Clark Canyon Reservoir, 1964-72 (from Montana Department of Fish and Game, 1975).

Table 11. Estimates of numbers and biomass of total trout decreased 42 and 28%, respectively, between 1970 and 1972. However, the biomass decrease was not significant on the basis of overlapping 80% confidence intervals. The number and biomass of rainbow trout showed the greatest decrease, 73 and 67%, respectively. Water withdrawals for irrigation have affected this stream in the past and may be partially responsible for these reductions.

TABLE 11. Estimated trout populations for a 7590 ft section of Horse Prairie Creek located two miles upstream of Clark Canyon Reservoir. 80% confidence limit in parenthesis.

Species	Size group (in)	July, 1970		May, 1972	
		Number	Pounds	Number	Pounds
Brown Trout	> 6.0	345 (±60)	365 (±84)	230 (±30)	294 (±38)
Rainbow Trout	> 7.0	100 (±35)	79 (±27)	27 (± 9)	26 (± 9)
TOTAL		445 (±69)	444 (±88)	257 (±31)	320 (±39)

During the summer of 1969, about 1800 white suckers and 400 longnose suckers greater than 7.8 inches were tagged in Clark Canyon Reservoir. In the Spring of 1972, 6 tagged white suckers were recovered in Horse Prairie Creek, approximately two miles upstream of the reservoir. In May of 1972, in the same location in Horse Prairie Creek, 2813 white and 421 longnose suckers were marked. During July, two marked suckers were recovered in the reservoir, showing movement out of Horse Prairie Creek following spawning.

In one week in approximately 3000 feet of Horse Prairie Creek, 1,387 white and 345 longnose suckers were captured of which 70 white and 3 long-nose suckers were marked. In a small stream such as this where a high efficiency would be expected, the small number of recaptures indicates a migrating population.

Red Rock River

A trout population estimate for a 5500 ft section of the Red Rock River, located approximately two miles upstream of the reservoir, was made in August, 1969 (Table 12). Total numbers and biomass of age 1 and older trout were 182/1000 ft and 135 lbs/1000 ft, respectively. Brown trout comprised 91 and 92% of the estimated number and biomass of trout, respectively. Mountain whitefish and longnose suckers were abundant, but were not quantitatively sampled. Tagging results indicate trout movement does occur. Within one year, two tagged trout from this section were caught in the reservoir, another had moved through the reservoir and was caught seven miles downstream in the Beaverhead River, and one was captured ten miles upstream from the section.

A trout population estimate for a 6250 ft section of the Red Rock River, located several miles upstream of the section sampled in 1969, was made in June, 1974 (Table 13). Brown trout comprised 85 and 79% of the estimated number and biomass of trout, respectively. The total number and biomass of trout/1000 ft were 135 and 124%, respectively, of those estimated in the downstream section in 1969.

In 1961, a total of 128 rainbow and brown trout greater than 7 inches and weighing 135 pounds were captured by electrofishing in 659 ft of the Red Rock River, now inundated by the reservoir. This is 197 and 208 lbs/1000 ft by number and weight, respectively. An actual estimate would be higher, since it is unlikely that all trout in the section were captured. Consider-

TABLE 12. Estimated trout populations for a 5500 ft section of the Red Rock River in August, 1969. 80% confidence limit in parenthesis (from Peterson, 1971).

Species	Age group	Number/1000 ft	Pounds/1000 ft
Brown Trout	I	79	19.9
	II	46	29.4
	III	28	47.4
	IV	11	23.4
	V and older	2	4.9
Total		166 (±32)	125.0 (±24)
Rainbow Trout	I	7	1.5
	II	5	2.9
	III	3	3.6
	IV and older	1	2.3
Total		16 (±5)	10.3 (±3)
Total Brown and Rainbow Trout		182 (±32)	135 (±24)

TABLE 13. Estimated trout populations for a 6250 ft section of the Red Rock River in June, 1974. 80% confidence limit in parenthesis (From Peterson, 1975).

Species	Age or size group	Number/1000 ft	Pounds/1000 ft
Brown Trout	I and older	209(±23)	132(±12)
Rainbow Trout	> 8.7 in (mostly II and older)	36(± 8)	36(± 8)
Total Brown and Rainbow Trout		245(±24)	168(±14)

ing these conservative totals, the number of trout was comparable to the number estimated for the two upstream sections, while weight was at least 24 and 54% greater than the biomass estimated for the two upstream sections.

Fishery (1964-1976)

Since Clark Canyon Reservoir began impounding water in 1964, the Montana Department of Fish and Game has annually stocked rainbow trout. Trout have been planted in varying numbers and sizes and at different times of the year (Table 14). Creel census information during 1967, 1968, 1970 and 1973-76 showed over 90% of the catch to be rainbow trout, of which 90-95% were of hatchery origin. Brown trout was the other trout species taken.

Growth of Hatchery Rainbow Trout

Characteristic of most newly created reservoirs, trout growth was exceptional immediately following impoundment. One and one-half years after introduction, the 3-5 inch fingerlings planted in October, 1964 averaged greater than 17.5 inches. After being in the reservoir 27 months, these fish averaged 21.0 inches in length. Hatchery rainbow were marked and their growth monitored by creel census from 1970 through 1975. Trout growth was not as great during this period as in 1965 and 1966. Twelve months following introduction, the trout planted in 1970, 1971 and 1972 averaged about 15.0 inches (Figure 6). After two years, these rainbow trout averaged between 18.5 and 19.0 inches. Only a few known age trout were creeled after three years and these averaged 21.0 inches.

TABLE 14. Number and size of rainbow trout stocked in Clark Canyon Reservoir, 1964 to 1976 (from Montana Department of Fish and Game, 1975).

Time interval	Total number planted	Fish size in inches	Percent in size
10/1/64 - 10/16/64	180,085	3 4 5	30 50 20
3/9/65	351,700	3	100
1/18/66	262,126	3	100
9/13/66	44,000	3-4	100
4/17/67 - 4/26/67	170,460	4	100
9/20/67 - 9/26/67	83,340	4	100
4/29/68 - 5/6/68	165,465	4	100
6/18/69 - 7/23/69	128,140	6	100
6/4/70 - 8/6/70	151,556	6 7	77 23
5/4/71 - 7/6/71	144,657	5 6	25 75
4/4/72 - 5/30/72	252,920	5 6	84 16
5/7/73 - 6/11/73	256,104	5 5	39 61
4/9/74 - 4/17/74	150,000	5	100
4/28/75 - 5/14/75	198,535	5 6	67 33
4/19/76 - 5/13/76	210,586	5 6	18 82

Growth during the first year in the reservoir appears to be directly related to the planting time (Figure 6). The trout planted in April and May (1972) displayed greater growth than those planted in June, July or August (1970, 1971). Seven months following introduction, the trout planted in April and May, 1975 averaged 14.3 inches, about 4 inches longer than rainbow trout planted for the same duration in 1970. During the second year in the reservoir, the greatest variation between years is about 1.5 inches while during the third year there is very little difference.

During the study, storage in the reservoir varied greatly between years (Figure 1). Growth of hatchery rainbow trout did not appear to be related to either the maximum or minimum storage pools.

Fishing Pressure

In 1971 and 1972, an intensive creel census was conducted. Ice fishing data were included with the data for bank fishing. Although some ice fishermen were fishing with the intent of catching burbot, trout were kept when caught.

Fishing pressure in 1971 for bank and boat fishing was 53,241 and 60,201 fisherman hours, respectively, and for 1972, 67,631 and 67,939 fisherman hours, respectively. Total fishing pressure increased about 20% between 1971 and 1972. Bank fishing increased 27% while boat fishing increased 16%. The greatest increase in bank fishing occurred during the weekdays (49%). The greatest increase in boat fishing occurred on the weekends (16%)

The estimated number of fisherman days for 1971 was 30,400 and 36,000 for 1972. Most fishermen had not completed fishing when contacted.

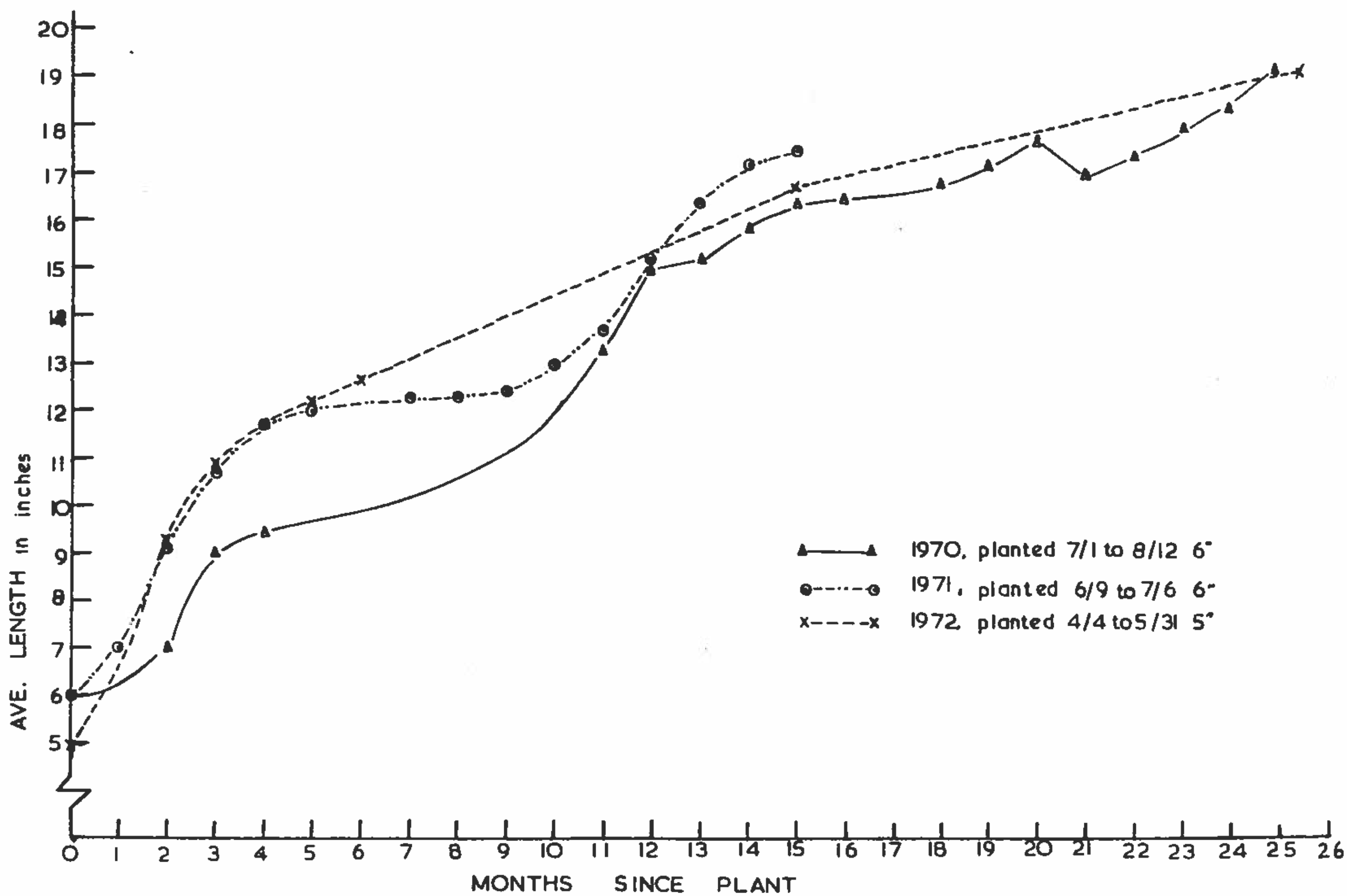

FIGURE 6. Growth of hatchery rainbow trout. Clark Canyon Reservoir, 1970, 71 and 72 (from Montana Department of Fish and Game, 1975).

Estimates of fisherman days are slightly elevated, since fisherman hours were divided by the average hours fished in obtaining pressure in fisherman days.

A statewide fishing pressure survey, conducted by mail during 1975-76, indicated the following pressure in fisherman days for Clark Canyon Reservoir:

Period	Fisherman Days (80% confidence interval)
May 1, 1975 - September 30, 1975	30,329 (± 4347)
October 1, 1975 - April 30, 1976	10,258 (± 4602)
	40,587 (± 6331)

Catch rates ranged from 0.25 to 0.45 in 1971 and 0.19 to 0.36 in 1972 for individual time periods. The catch rate/hour was greater for boat fishermen for both 1971 and 1972.

Yield

An estimated 41,000 and 39,000 rainbow trout were harvested in 1971 and 1972, respectively. In 1971, 67% of the catch was taken during the five month period between May 17 and October 17. In 1972, 93% of the catch was taken during the seven month period between March 4 and October 15. During both years, the catch was comprised almost entirely of two age groups of hatchery rainbow trout.

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