MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

FISHERIES DIVISION

JOB PROGRESS REPORT

STATE:	Montana	TITLE:	Southwest Montana Fisheries Study
PROJECT NO.:	F-9-R-27		
JOB NO.:	I-b	TITLE:	Inventory of Waters of the Project Area
PROJECT PERIOD:	July 1, 1977 through June 30, 1978		
REPORT PERIOD:	July 1, 1977 through June 30, 1978		

ABSTRACT

Discharge and water temperatures were monitored at three sites on the Big Hole River from July 26 - September 15 and indicated 1978 to be a high water year. Flow did not drop below 75, 282 and 408 cfs at the Hirschy, Dickey Bridge and Melrose sites, respectively. Water temperatures were lowest at the Hirschy site and highest at Dickey Bridge.

Mountain whitefish were the dominant game fish in the Hirschy Section followed by brook trout, Artic grayling, rainbow, and cutthroat trout. Mountain whitefish were the dominant game fish in the Bryant Creek Section followed by rainbow trout, grayling, brown trout and brook trout.

Brown and rainbow trout populations in the Melrose and Mel-Glen Sections were greater in the fall of 1978 than the fall of 1977. Fishing pressure and harvest was reduced in the Mel-Glen Section from 1977. The magnitude of flow in the Mel-Glen Section appeared to regulate trout mortality and angler harvest, particularly of older brown trout.

A fixed positive electrofishing system was constructed for studies on the Jefferson and Missouri Rivers. Initial sampling accomplished during the fall of 1978 and spring of 1979 should average sampling efficiencies per trip to vary from 2.4 to 7.1 percent. Difficulty was encountered in achieving adequate sample size for trout less than 12 inches. Sampling effectiveness was lower in the Jefferson River due to more secure habitat.

Macroinvertebrate sampling in the Jefferson River showed two distinct zones. The invertebrate community was mainly characterized by forms tolerant of sedimentation, high water temperatures and low current velocities. The insect density as compared to other large Missouri River tributaries was low.

BACKGROUND

The Big Hole River is one of Montana's blue ribbon waterways and receives a great deal of fishing pressure. The waters of the Big Hole are also used by irrigated hay and cattle ranches and, during low water years, this demand is sufficient to totally dewater the river near its mouth. Dams have been, or currently are, proposed for this free flowing river and many of its tributaries.

Fisheries studies have been proposed on the Missouri (above Canyon Ferry) and the Jefferson Rivers as early as 1969. Due to other areas of more urgent need and funding limitations, the studies were not initiated until 1977 (Wells and Nelson, 1978). It became apparent that the traditional means of sampling salmonids (mobile positive boat electrofishing apparatus) was not satisfactory for use on these larger rivers.

Research done in Wisconsin (Novotany and Pr egel, 1974) and later adopted here in Montana (Peterman, 1978) suggested that the present "state of the art" technique had advanced far enough to make boom shocking a potential tool on these rivers.

OBJECTIVES AND DEGREE OF ATTAINMENT

1. To investigate the relationship between irrigation season flow and water temperatures at selected sites on the Big Hole River. Data is presented.

2. To determine trout and mountain whitefish populations in at least two of these selected sites. Data is presented.

3. To make spring and fall population estimates of wild trout in the 4.5 mile Melrose and 10 mile Mel-Glen Section of the Big Hole River. Data is presented.

4. To measure fisherman use and harvest on the 10 mile Mel-Glen Section of the Big Hole River from May 20 through September 10, 1978. Data is presented.

5. To determine invertebrate species present in selected study sections on the Big Hole and Jefferson Rivers as an index of fish food production and water quality. Data is presented for the Jefferson River. Work on the Big Hole River was suspended due to lack of sufficient funds.

6. To determine the suitability of using electrofishing equipment for sampling fish populations in the main channels of the Jefferson and Missouri Rivers as a preliminary to determining factors limiting these sport fisheries. Data is presented.

PROCEDURES

Duro thermographs were installed at two locations on the Big Hole River and discharge measured weekly from July 26 through September 15.

Discharge and water temperature were recorded at the U.S.G.S. gage station near Melrose.

Fish populations in the Big Hole River were censused using a boat-mounted electrofishing unit. Population and standing crop estimates were made using methods summarized by Vincent (1971 and 1974) and adapted for computer analysis.

Attempts were made to census trout populations in the Missouri and Jefferson Rivers using a fixed-positive electrode boat shocker. Population estimates were made and recapture efficiencies determined according to methods described by Vincent (1971 and 1974).

FINDINGS

Big Hole River

Flow

Discharge in the Big Hole River during the 1978 water year was considerably greater than the previous water year. Average daily flow (ADF) at the U.S.G.S. station near Melrose peaked at 7,240 cfs on June 10, 1978, and reached a low of 408 cfs on September 3, 1978.

Diversion of river water for irrigation purposes occurs throughout the length of the Big Hole, but is most apparent in the lower river from Melrose to Twin Bridges. Irrigation diversions have the greatest impact on natural flows during August, the most critical flow month on the lower Big Hole River. Table 1 depicts mean and minimum recorded August flows at the U.S.G.S. gaging station near Melrose from 1968-1978 and indicates 1978 to be a fairly high water year. Minimum August flow in 1978 was nearly three times as great as during August of 1977.

TABLE 1. Mean and minimum August flow in the Big Hole River (U.S.G.S. gaging site near Melrose) from 1968-1978.

	Mean	Minimum
1968	626	411
1969	407	230
1970	504	248
1971	611	301
1972	650	503
1973	165	113
1974	341	290
1975	1457	925
1976	927	715
1977	304	174
1978	691	479

Discharge was also measured weekly from July 26 through September 15 near Wise River at Dickey Bridge and near Jackson, Montana (Figure 1). Weekly discharges at the Hirschy, Dickey Bridge and Melrose sites are compared in Figure 2. These three sites (Melrose, Dickey Bridge and Hirschy) represent entirely different flow and habitat regimes in the Big Hole River and were located in reaches 1, 2 and 3 respectively, of the department's flow reservation request for the Missouri River Basin Commision Level B study (Montana Fish and Game, 1979). Flow was greatest in late July at all three sites, decreased to a low in late August and then increased through the first two weeks of September. The 1978 water year was a plentiful one and while irrigation dewatering occurred, flow at the Hirschy, Dickey Bridge and Melrose sites did not drop below 75 cfs, 282 cfs and 408 cfs, respectively, during the irrigation season.

Water Temperatures

Water temperatures were monitored at the Hirschy site, Dickey Bridge site and at the U.S.G.S. site near Melrose, Montana. Figure 3 depicts maximum daily temperatures at the three sites from July 26 through September 16, 1978. Maximum daily temperatures at the Hirschy site were generally 5-9 degrees less than at the Dickey Bridge site. Maximum daily temperatures at the Melrose site were either slightly less or slightly greater than at the Dickey Bridge site. The greatest maximum temperatures occurred during the August 4-9 period at all three sites. Ths period corresponded to the highest air temperatures of the July 26 through September 15 period (National Climatic Center, 1978).

In general, maximum daily temperatures at the three sites appeared to be related to daily air temperature and flows. Highest maximums occurred during the August 4-9 period when air temperatures at Dillon, Glen and Wisdom, Montana were the highest of the July 26 through September 15 period and during late August when flows were at their lowest. Lowest maxima occurred August 13-17 and September 8-15 when air temperatures were the lowest of the period.

Fish Populations

Hirschy Section. This section of the river is located in the upper Big Hole basin near the town of Jackson and is approximately four miles long. The river meanders across wild hay meadows and is lined with willows for much of its length. Portions of this section have been severely impacted by man in the form of willow removal, diking, rip-rap and channel alteration.

Mountain whitefish were the most numerous game fish in this section. Brook trout were common, grayling and rainbow trout were uncommon and cutthroat trout rare. Other species present included burbot, longnose suckers, mountain suckers, common suckers, longnose dace and mottled sculpins.

A population estimate for mountain whitefish is presented in Table 2.

Figure 1. Map of the Big Hole River Study Area.

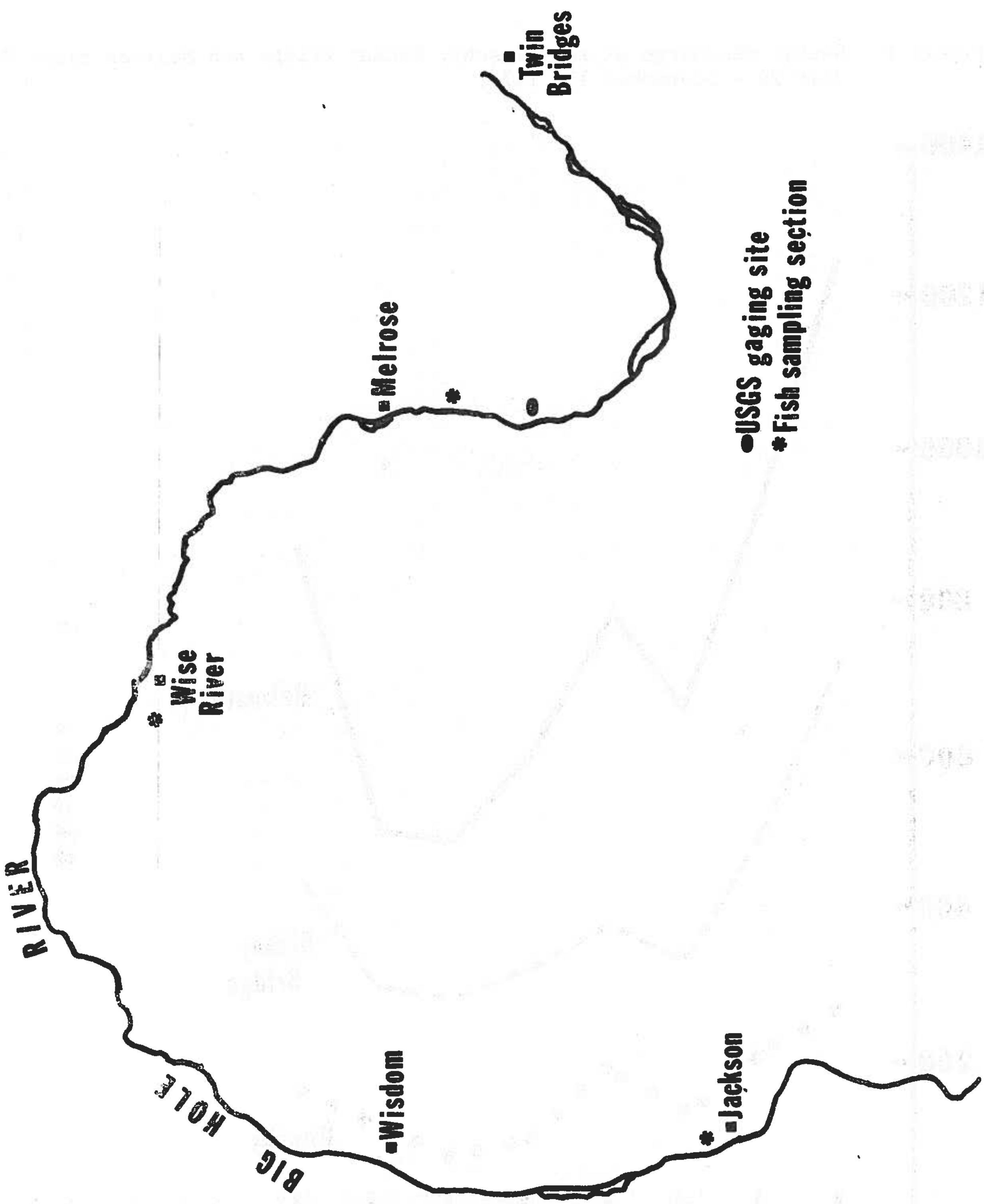

Figure 2. Weekly discharge at the Hirschy, Dickey Bridge and Melrose sites from July 26 - September 15, 1978.

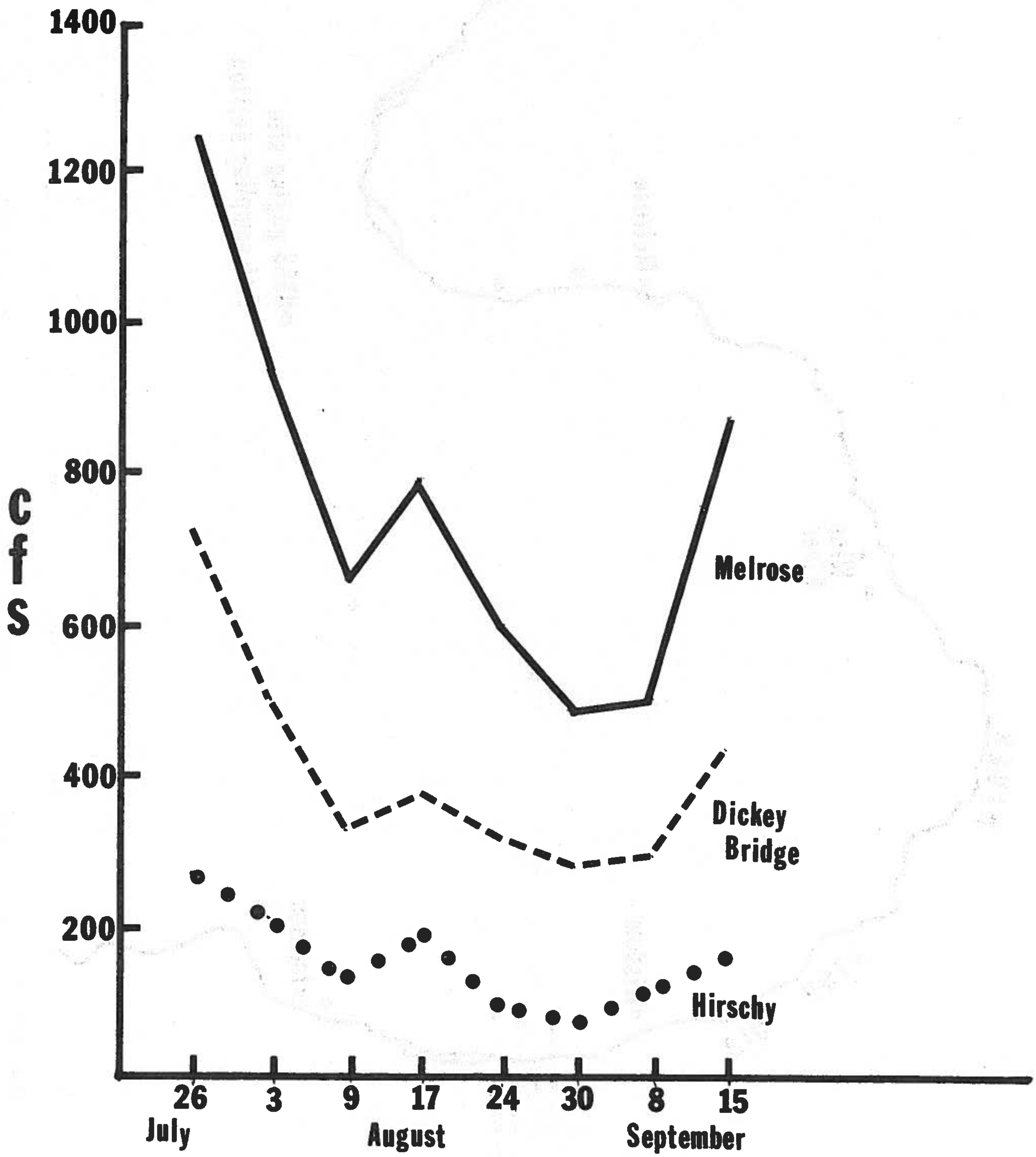

Figure 3. Maximum daily water temperatures at the Hirschy, Dickey Bridge and Melrose sites from July 26 - September 16, 1978.

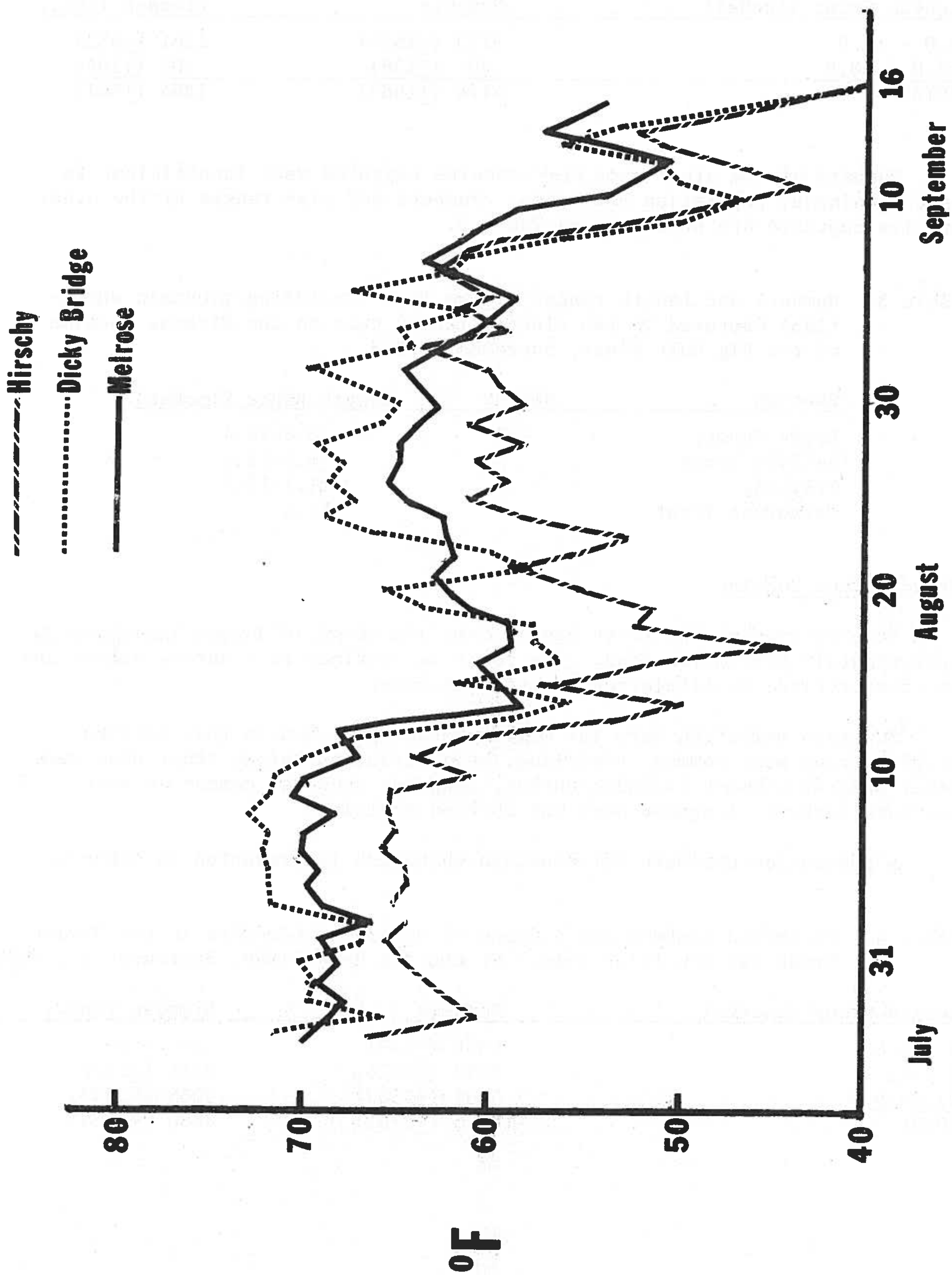

Table 2. Estimated numbers and biomass of mountain whitefish in the upper two miles of the Hirschy Section of the Big Hole River, September 7, 1978 (80% Confidence Intervals).

Length Group (inches)	Numbers	Biomass (lbs.)
8.0 - 11.9	3773 (±1577)	1561 (±652)
12.0 - 18.9	401 (±138)	303 (±104)
TOTAL	4174 (±1583)	1864 (±661)

Numbers of the other game fish species captured were insufficient to make meaningful population estimates. Numbers and size ranges of the other species captured are presented in Table 3.

Table 3. Numbers and length ranges of game fish (excluding mountain whitefish) captured in two electrofishing runs in the Hirschy Section of the Big Hole River, September, 1978.

Species	Number	Length Range (inches)
Brook Trout	155	3.6-14.4
Rainbow Trout	8	6.7-15.2
Grayling	5	11.1-13.7
Cutthroat Trout	1	12.3

Bryant Creek Section

This section of the river begins near the mouth of Bryant Creek and is approximately five miles long. The river is confined to a narrow valley and is characterized by little vegetative bank cover.

Mountain whitefish were the most numerous game fish in this section. Rainbow trout were common. Grayling, brook trout and brown trout were rare. Other species present included burbot, longnose suckers, common suckers, mountain suckers, longnose dace and mottled sculpins.

A population estimate for mountain whitefish is presented in Table 4.

Table 4. Estimated numbers and biomass of mountain whitefish in the Bryant Creek Section (five miles) of the Big Hole River, September 13, 1978.

Length Group (inches)	Numbers	Biomass (lbs.)
8.0-9.6	1386 (±553)	416 (±166)
9.7-11.9	7052 (±2926)	3316 (±1376)
12.0-19.9	5237 (±2307)	5068 (±2233)
TOTAL	13675 (±3767)	8800 (±2628)

Numbers of the other game fish species captured were insufficient to make meaningful population estimates. Numbers and size ranges of the other species captured are presented in Table 5.

Table 5. Numbers and length ranges of game fish (excluding mountain whitefish) captured in four electrofishing runs in the Bryant Creek Section (five miles) of the Big Hole River, September, 1978.

Species	Number	Length Range (inches)
Rainbow Trout	79	7.2-23.9
Grayling	19	8.5-13.5
Brown Trout	8	12.7-27.0
Brook Trout	3	10.0-11.1

Melrose Section

This section was established in 1969 and its trout population has been described by Elser and Marcoux (1972), Peterson (1973) and Wells and Nelson (1978).

Population estimates for brown trout in this section for spring and fall of 1977 and 1978 are compared in Table 6.

Table 6. Comparison of spring and fall 1977 and 1978 brown trout population estimates for the 4.5 mile Melrose Section of the Big Hole River (80% Confidence Intervals).

1977

	April				September			
Age	Ave. Length"	Number	Biomass (lbs.)		Age	Ave. Length"	Number	Biomass (lbs.)
II	9.6	1063	353		II	13.2	566	510
III	12.9	998	840		III	15.2	792	1072
IV+	17.2	732	1361		IV+	18.0	498	1132
TOTAL		2793	2554				1856	2714
		(±835)	(±440)				(±425)	(±604)

1978

	April				September			
Age	Ave. Length"	Number	Biomass (lbs.)		Age	Ave. Length"	Number	Biomass (lbs.)
II	9.7	748	265		II	12.6	1117	903
III	13.6	1314	1272		III	15.0	619	828
IV+	16.6	1458	2469		IV+	17.8	729	1591
TOTAL		3520	4006				2465	3322
		(±765)	(±811)				(±501)	(±591)

Unseasonably high water during the spring of 1978 interfered with recapture runs and may have biased the population estimate. Therefore, the population estimates in the falls of 1977-78 offer the best comparisons. Numbers of age II and older brown trout in the fall of 1978 were nearly one-third greater than in the fall of 1977. This was primarily due to a strong year class of age II fish and apparent increased survival of age IV and older fish.

Fall population estimates for rainbow trout during 1977 and 1978 are compared in Table 7.

Table 7. Comparison of fall 1977 and 1978 rainbow trout population estimates for the 4.5 mile Melrose Section of the Big Hole River (80% Confidence Intervals).

	1977				1978		
Age	Ave. Length"	Number	Biomass	Age	Ave. Length"	Number	Biomass
II	12.2	253	172	II	11.8	585	395
III+	15.0	226	290	III+	14.9	489	679
TOTAL		479	462			1074	1074
		(±179)	(±150)			(±472)	(±478)

Numbers of age II and older rainbow trout were over twice as great in fall 1978 as in fall 1977. This was due to a strong year class of age II fish and apparent increased survival of age III and older fish.

Discharge in the Big Hole during the summer of 1978 was considerably greater than in 1977 (Table 1) and may have resulted in increased survival of trout, particularly the older and larger fish.

Melrose-Glen Section

Fish Populations. This ten mile section was established in the spring of 1977 as part of a cooperative study to investigate the effect of fishermen on the trout population. The results of the 1977 portion of the study were reported by Wells and Nelson (1978).

Spring and fall 1977 and 1978 population estimates for brown and rainbow trout are compared for this section in Table 8.

Table 8. Comparison of spring and fall 1977-78 brown and rainbow trout population estimates for the ten mile Mel-Glen Section of the Big Hole River (80% Confidence Intervals).

APRIL

Species	Age	Ave. Length" 1977	Ave. Length" 1978	Number 1977	Number 1978	Biomass (lbs) 1977	Biomass (lbs) 1978
Brown	II	9.3	9.7	4951	4419	1417	1551
Trout	III	12.9	13.3	3729	4187	3009	3759
	IV+	17.0	16.3	2176	3224	3807	5144
TOTAL				10856	11831	8233	10455
				(±2771)	(±2348)	(±1071)	(±1405)
Rainbow	II	9.5	9.8	442	1674	140	628
Trout	III	12.1	12.8	465	567	327	452
	IV+	15.0	15.7	655	528	851	768
TOTAL				1563	2769	1318	1848
				(±393)	(±744)	(±330)	(±548)

SEPTEMBER

Species	Age	Ave. Length" 1977	Ave. Length" 1978	Number 1977	Number 1978	Biomass (lbs) 1977	Biomass (lbs) 1978
Brown	II	12.6	12.7	2805	2991	2192	2472
Trout	III	15.3	14.9	1974	2075	2698	2674
	IV+	17.9	17.6	1376	1617	2936	3373
TOTAL				6146	6683	7826	8519
				(±982)	(±1181)	(±1206)	(±1184)
Rainbow	II	12.2	11.7	377	1030	257	656
Trout	III	14.5	13.5	137	262	152	267
	IV+	16.5	16.2	201	189	345	318
TOTAL				715	1481	754	1241
				(±315)	(±574)	(±264)	(±413)

Unusually high water during the spring of 1978 interfered with recapture runs and may have biased the population estimates. Therefore, the fall estimates offer the best comparisons. Numbers of age II and older brown trout were slightly greater in 1978 than 1977. This was due mostly to increased numbers of age IV and older fish. The increase in numbers of age IV and older fish was similar to that found in the Melrose Section and appears to be due to increased flows during 1978.

Numbers of age II and older rainbow trout were over twice as great in fall 1978 as fall 1977. This was due almost entirely to a strong year class of age II rainbow entering the population. The reasons for this strong year class are not clear, but may be related to favorable spawning flows during the spring of 1976 and increased flow in 1978.

Fishing Pressure and Harvest

Estimates of fishermen pressure, catch rates and harvest were obtained from a cooperative Fish and Game and Montana Cooperative Fishery Unit study. A complete analysis is found in a thesis by Kozakiewicz (1979).

The following data is from the abstract of the thesis by Kozakiewicz:

> A partial creel census to determine the fishermen use and harvest was conducted during 1977 and 1978 on a 16 km section of the lower Big Hole River. Approximately 41 and 47% of the estimated total number of anglers using the study area in 1977 and 1978 respectively, were interviewed. Anglers residing within 80 km of the study area comprised 62% of the fishermen interviewed in 1977 and 65% in 1978. About 64 and 62% of the anglers kept zero fish in 1977 and 1978, respectively. In 1977, 0.05% of the anglers kept the bag limit of ten trout. Less than 3% of the anglers kept the bag limit of five trout in 1978. Catch rates of fish kept were 0.25 and 0.28 fish/hour in 1977 and 1978, respectively. In 1977 an estimated 5,397 anglers fished 15,698 hours on the study area. Bank anglers accounted for about 80% of the total number of anglers and 76% of the total hours fished. An estimated 3,987 anglers fished 9,945 hours on the study area in 1978. Bank anglers accounted for 62% of the anglers and 61% of the hours fished in that year. A total of 1,088 boats used the study area during the study with 41% of the use occurring in 1977. A total of 3,974 trout were harvested in 1977 with bank anglers catching 66%. In 1978, about 2,746 trout were harvested with bank anglers catching 48%. Brown trout constituted an estimated 78% of the harvest in 1977 and 72% in 1978. Age II and older fish comprised 99 and 98% of the brown trout harvest in 1977 and 1978, respectively. The April to September 1977 mortality rate for these brown trout was 43% with fishing mortality accounting for 64% of that mortality. Harvest of Age II and older brown trout was responsible for 70% of the annual mortality from fall 1977 to fall 1978. Harvest accounted for 44% of the annual mortality of Age III and older brown trout during the same period.

Mortality Rates

While the rainbow population made up only 13 and 19 percent of the estimated numbers of age II and older trout during 1977 and 1978 respectively, it contributed 22 and 28 percent of the creel during the two respective seasons of study. Summer mortality rates were nearly 70% for age II and older rainbow during 1977 (Wells and Nelson, 1978) and nearly as high in 1978 (Table 8). During both years angler harvest accounted for nearly all of the summer mortality of these older fish.

Brown trout make up the bulk of the trout population and fishermen creel. Table 9 represents mortality of brown trout by age groups from April 1 through September 9, 1977. Data is from Table 8 and Kozakiewicz (1979), and uses point estimates only. Mortality represents loss of fish from the population and is separated into harvest mortality and other mortality. This "other" mortality represents natural mortality plus mortality due to catch and release.

Table 9. Summer 1977 mortality rates of brown trout by age group in the Mel-Glen Section of the Big Hole River.

Age Group	Spring Population Estimate	Fall Population Estimate	Summer Mortality(%)	Total Angler Harvest(%)	Other Mortality(%)
II	4951	2805	43%	18%	25%
III	3729	1974	47%	34%	13%
IV+	2176	1376	37%	37%	--
	10856	6146	43%	28%	15%

During the 1977 census season, brown trout age II and older experienced an overall mortality rate of 43 percent, 38 percent due to angler harvest and 15 percent due to other forms of mortality. Angler harvest had differential effects on age groups, accounting for less than half of the mortality of age II fish, but nearly three-fourths of and apparently nearly all of the mortality of ages III and IV+ brown trout, respectively. These figures depict the effect of angler harvest and other mortality, from spring to fall during the low water year of 1977 on the Big Hole River.

Table 10 gives the annual mortality rates of brown trout by age groups from fall 1977 to fall 1978.

Table 10. Annual mortality rates of brown trout by age group in the Mel-Glen Section from fall 1977 to fall 1978.

Age Group	Fall 1977 Pop. Est.	Fall 1978 Pop. Est.	Annual Mortality%	Total Angler Harvest%	Other Mortality%
II & older → III & older	6146	3692	40%	24%	16%
III & older → IV & older	3350	1617	52%	20%	32%

This table reflects mortality incurred from fall 1977 to fall 1978 including angler harvest during the 1978 creel census. It does not reflect mortality of brown trout age II in 1978.

Annual mortality of the II and older to III and older age group during this period was 40 percent, 24 percent due to harvest and 16 percent due to other mortality. Annual mortality of the III and older to IV and older age group was 52 percent, 20 percent due to harvest and 32 percent due to other mortality. These figures represent the effect of angler harvest during the high flow year of 1978 and the effect of other mortality from fall 1977 to fall 1978.

It appears that angler harvest had a greater, and other mortality a lesser impact on annual mortality of the age group including the younger fish. The effects were reversed in the older age group with angler harvest having less impact than other forms of mortality.

Winter mortality rates could not be directly determined from fall 1977 to spring 1978 due to a biased population estimate in spring 1978. However, comparisons of Tables 9 and 10 suggest that winter mortality may have been substantial for the older age group of brown trout.

The mortality incurred by brown trout age II and older in the spring of 1977 through the fall of 1978 when this group was age III and older is expressed in Table 11. It also depicts the mortality incurred by brown trout age III and older in the spring of 1977 through the fall of 1978 when this group was age IV and older.

Table 11. Mortality rates of brown trout by age group in the Mel-Glen Section from spring 1977 to fall 1978.

Age Group	Spring 1977 Pop. Est.	Fall 1978 Pop. Est.	Mortality%	Total Angler Harvest%	Other Mortality%
II & older → III & older	10856	3692	66%	41%	25%
III & older → IV & older	5905	1617	73%	47%	26%

This table depicts angler harvest during the 1977 and 1978 creel census periods and other mortality incurred from spring 1977 to fall 1978. Sixty-six percent (66%) of the brown trout age II and older in the spring of 1977 had been removed from the population by the fall of 1978 when this group was age III and older. Angler harvest accounted for 41 percent and other mortality, 25 percent.

Seventy-three percent (73%) of the brown trout age III and older in the spring of 1977 had been removed from the population by the fall of 1978 when they were age IV and older fish. Angler harvest accounted for 47 percent and other mortality, 26 percent.

The extreme difference in the 1977 and 1978 water years appears to have had significant effect on mortality of brown trout. A comparison of Tables 9, 10 and 11 indicates that of the 66 percent mortality incurred by the age II and older fish from spring 1977 to fall 1978 when they were age III and older, 43 percent occurred during the low water summer of 1977 and only 23 percent from fall 1977 to fall 1978.

Similarly, of the 73 percent mortality incurred by the age III and older to age IV and older fish during the same period, 43 percent occurred during the low water summer of 1977 and only 30 percent from fall 1977 to fall 1978.

It appears that the mortality rates of brown trout in this section of the Big Hole River were directly related to the magnitude of flow. The low water summer of 1977 resulted in considerably higher mortality rates for brown trout than the high water year of 1978. These differences in mortality rates were reflected in both angler harvest and other forms of mortality.

Missouri and Jefferson Rivers

Electrofishing Equipment

The primary consideration in construction of a "boom shocker" for the Missouri and Jefferson Rivers was fitting the size and power of the boat to these waterways. The Missouri's velocity is quite slow, depths are not usually limiting, and the banks have few obstructions to negotiate. In contrast, the Jefferson River's velocity varies from slow to quite fast (to 6.5 ft./sec.), depth during the irrigation season became very limiting to boat travel, and the banks are commonly lined with "snags." Based on these concerns it was decided that minimizing the size and draft of the boat to maintain maximum maneuverability was essential to the success of this sampling technique.

The boat used for this project was a Polarcraft "john" boat (length, 16 feet; width, 69 inches; draft, 18.5 inches). The motor employed was a 50 hp Evinrude equipped with a Berkley jet unit. An electric starter was added as a safety feature to insure fast starting ability. The mode of operation was maintained with the tiller style to avoid the added weight of other options.

The electrical power source for this system was a 3500 watt, 230 volt alternating current generator. A Coffelt Model VVP-15 rectifying unit was used to change the current to direct current and regulate the output.

The electrode design closely follows that described by Novotony and Priegel (1974). The positive electrode system consists of 12 "dropper" electrodes clipped to each of 2, 3 foot diameter support rings. These rings were positioned side by side, six feet in front of the boat with their centers five feet apart. The electricity as well as mechanical support was supplied through fiberglass booms.

The negative electrode system consists of four, one-half inch diameter copper cables, six feet long at each side and positioned toward the rear of the boat.

All electrical circuitry in the boat was encased in half inch conduit for protection. All connectors are of the amphenol type. Safety features include a manual switch located on the guard rail in front and a switchmat on which dip netters must stand.

Electrofishing Estimates

Missouri River

Upon completion of boat construction, the test of effectiveness was initiated on the Missouri River between Toston and Deepdale, Montana during the fall of 1978 and again in the spring of 1979 (Table 1). The estimates were hand calculated and intended only for measurement of sampling efficiency.

Table 1. Estimated number of brown trout per mile and average sampling efficiencies on the Missouri River between Toston and Deepdale, fall 1978 and spring 1979.

Length Interval	Estimate Per Mile		Average Efficiency per Marking Run (%)	
	1978	1979	1978	1979
7.0-10.4"	115	35	5.7	3.1
10.5-11.9"	25	75	7.1	2.4
12.0-15.9"	115	153	3.0	4.1
>16.0"	1/	58	---	5.5
	255	321		

1/ Sample size not sufficient for estimate.

Table 1 indicates that meaningful population estimates for brown trout larger than 12 inches may be possible with this equipment. Meaningful estimates for trout smaller than 12 inches may not be possible on this large river.

The fall 1978 estimate required three marking runs and three recapture runs to attain these data. The largest size interval was not estimated due to insufficient numbers of recaptures. To achieve this estimate more sampling trips would have been required.

Electrofishing done during the spring of 1979 was focused on marking increased numbers of brown trout. Five marking runs and two recapture runs were used. This added sampling effort did yield an excellent estimate for trout over 16 inches which was not the case in the fall of 1978. However, this estimate was questionable for brown trout less than 12 inches. Generally, this work showed sampling efficiency to increase with fish size. This trend has been observed by other researchers (Vincent, personal communication).

Jefferson River

During the spring of 1979, the electrofishing system was used on the Jefferson River between Willow Creek and Three Forks, Montana (7.0 river miles). The estimate calculated (Table 2) required four marking runs and four recapture runs.

Table 2. Estimated numbers of brown trout per mile and average sampling efficiencies on the Jefferson River between Willow Creek and Three Forks, spring 1979.

Length Interval	Estimated Number Per Mile	Average Efficiency Per Marking Run(%)
8.0-11.4"	1/	---
11.5-13.4"	97	2.9
>13.5	164	2.5
	261	

1/ Sample size not sufficient for estimate.

Experience on the Jefferson again verifies difficulty in sampling younger/ smaller fish in the large river setting. Sampling efficiencies for the larger brown trout are considerably less on the Jefferson than on the Missouri River. This results from the better security afforded by "snags" and debris which line much of the Jefferson River's banks. This habitat is commonly associated with excessive current velocities which adversely affect efficiency by causing the boat to pass through before fish can show adequate galvanotaxis.

Invertebrate Investigation

Macroinvertebrate sampling on the Jefferson River during 1978 was limited to four stations. These sites (Three Forks, Cardwell, Waterloo, and Silver Star) were sampled monthly from July through November.

Identification and complete analysis was done by Richard Oswald (1979). This report is attached as Addendum I.

In general the analysis of these samples revealed two distinct river zones, the upper river (Silver Star and Waterloo) and the lower river (Three Forks and Cardwell). The upper reach of the Jefferson supported a greater diversity and greater numbers while the biotic index valves indicated poorer water quality.

The macroinvertebrate community was dominated by forms tolerant of sedimentation, high water temperatures, and lower current velocities during late summer. The more desirable cold-swift water-cobble substrate forms were most plentiful in late fall. Water quality, as indicated by the biotic index showed a similar trend.

The density of macroinvertebrates in the Jefferson River was low when compared to other large Missouri tributaries.

RECOMMENDATIONS

This project should be continued. Efforts should be continued to assess the effects of flow and water temperatures on trout populations in the Big Hole River.

Instream flow needs and trout populations should be determined in the Missouri and Jefferson Rivers as well as their t_ibutaries. Water temperatures and discharge should be monitored.

LITERATURE CITED

Elser, A. A. and R. G. Marcoux, 1972. Inventory of the waters of the project area. Job Progress Report, Federal Aid in Fish and Wildlife Restoration Acts. Montana Project No. F-9-R-19, Job I-a, 38 pp.

Kozakiewicz, V. J., 1979. Trout fishery of the lower Big Hole River, Montana during 1977 and 1978. M.S. thesis, Montana State University, Bozeman, Montana, 74 pp.

Montana Department of Fish and Game, 1979. Instream flow evaluation for selected streams in the upper Missouri River basin, 254 pp.

National Climatic Center, 1978. Climatological Data, Annual Summary for Montana. Vol. 81, No. 13, 21 pp.

Novotony, D. W. and G. R. Priegel, 1974. Electrofishing boats-improved designs and operational guidelines to increase the effectiveness of boom shockers. Wisconsin Dept. of Natural Res. Tech. Bull. No. 73, 48 pp.

Oswald, R. A., 1979. The distribution and abundance of aquatic macroinvertebrates as related to instream flows in the Jefferson River, Montana. Montana Department of Fish and Game Publication, 32 pp.

Peterman, L. G., 1978. Electrofishing large rivers-the Yellowstone experience. Montana Department of Fish and Game Publication, 29 pp.

Peterson, N. W., 1973. Inventory of the waters of the project area. Job Progress Report, Federal Aid in Fish and Wildlife Restoration Acts. Montana Program No. F-9-R-20, Job I-b, 11 pp.

U. S. Department of Interior, Geological Survey, 1968-78, Water Resources Data for Montana, Surface Water Records.

Vincent, E. R., 1971. River electrofishing and fish population estimates. Prog. Fish Cult. 33(3):163-167.

Vincent, E. R., 1974. Addendum to river electrofishing and fish population estimates. Prog. Fish Cult. 36(3):182.

Wells, J. D. and F. A. Nelson, 1978. Inventory of waters of the project area. Job Progress Report, Federal Aid Project No. F-9-R-26, Job I-b. Montana Department of Fish and Game, 13 pp.

Prepared By: Jerry D. Wells and Bruce J. Rehwinkel

Date: February 22, 1980

Waters Referred To:

Big Hole River, Sec. 1	3-02-0425-01
Big Hole River, Sec. 2	3-02-0450-01
Big Hole River, Sec. 3	3-02-0475-01
Jefferson River	3-10-3840-01
Missouri River, Sec. 11	3-17-4928-01

ADDENDUM I

THE DISTRIBUTION AND ABUNDANCE OF AQUATIC MACROINVERTEBRATES AS RELATED TO INSTREAM FLOWS IN THE JEFFERSON RIVER, MONTANA

by

Richard A. Oswald

May 15,1979

Report presented in fulfillment of a contract between the author and the Montana Dept. of Fish and Game.

CONTENTS

INTRODUCTION

Recent concern over in-stream flow requirements for the maintainance of minimum, low, and high levels of aquatic habitat potential in Montana's streams has resulted in a need to gather information on the physical, chemical, and biological characteristics of these streams. Water in Montana's streams is used for agricultural, municipal, industrial, and recreational purposes. Dewatering of streams, particularly in the low flow months of August and September, can severely affect the quality of water available for irrigation and municipal consumption and significantly reduce the aquatic habitat potential for recreational purposes.

This study was initiated by the Montana Dept. of Fish and Game to determine the characteristics of the macroinvertebrate communities of the Jefferson River and to relate some of these characteristics to the discharge of the river. The Jefferson River is heavily used as a source of irrigation water and ranks fourth among the ten major rivers in the upper Missouri drainage in southwest Montana in fishing pressure (MDFG 1979).

Effects of stream dewatering have been known to cause significant qualitative and quantitative changes in macroinvertebrate communities. These effects include; elevated water temperatures, reduced current velocity, increased deposition of sediments, concentration of nutrients and dissolved salts, and decreased ability to dilute substances that increase biological oxygen demand (Gore 1976, Newell 1976). Results of this study can be used as basis for future comparisons to determine changes in the macroinvertebrate communities under lower or higher flow regimes than those observed during this study.

DESCRIPTION OF STUDY AREA

The Jefferson River is formed by the confluence of the Big Hole and Beaverhead Rivers near Twin Bridges, Montana and flows in a northeasterly direction to join with the Madison and Gallatin Rivers at Three Forks, Montana to form the Missouri River. The river is 77 mi long with an average width of 197 ft, an average gradient of 7.3 ft per mi, and a sinuosity of 1.60 (MDFG 1979). Flows for a 25 year period of record at the USGS gauge station near Silver Star on the upper river ranged from 50 to 20,300 cfs with a mean of 1,714 cfs and flows at the USGS gauge near Sappington on the lower river ranged from 134 to 21,000 cfs with a mean of 2,121 cfs. The high water period occurs from April through July during spring runoff and the low water period occurs during August and September reflective of dewatering through the summer irrigation season (MDFG 1979). Flows recorded at a USGS gauge near Three Forks during the period of this study ranged from 1,040 to 2,650 cfs (USGS unpub. data). Temperatures recorded in the lower river in 1963 and from 1971 through 1974 exhibited daily maxima that ranged from 74 to 79 F during the summer months. The substrate of the river is composed primarily of small to medium cobble interspersed with gravel.

Macroinvertebrate sample stations were selected by MDFG personnel at Silver Star (Station 4) and Waterloo (Station 3) in the upper river and at Cardwell (Station 2) and Three Forks (Station 1), Montana in the lower river (Figure 1). Sample stations were located at the bridges that span the river at Stations 4,3, and 2 and about one mile above the bridge at Three Forks.

METHODS

Macroinvertebrates were collected by MDFG personnel from riffle areas by means of a modified Hess sampler (Waters and Knapp 1961) which sampled an area of .093 m^2. Samples were collected from depths that ranged from approximatly 30 to 45 cm from substrates composed of small cobble interspersed with large amounts of gravel and finer sediments. Three Hess samples were collected at each station on July 19, August 15, September 13, October 10, and November 13 and 16, 1978. Samples were placed in containers, preserved in 10% formalin, and returned to the laboratory where macroinvertebrates were separated from the samples by MDFG personnel and stored in 70% ethanol. During the separation process, the three .093 m^2 samples taken at each station on each date were combined to yield a single sample of .28 m^2.

Macroinvertebrates were identified to the lowest practical taxon, usually genus or species, by using keys written by Bauman et al. (1977), Brinkhurst and Jameison (1971), Brown (1972), Edmunds et al. (1976), Hamilton and Saether (1970), Hilsenhoff (1975), Hiltunen (1970),

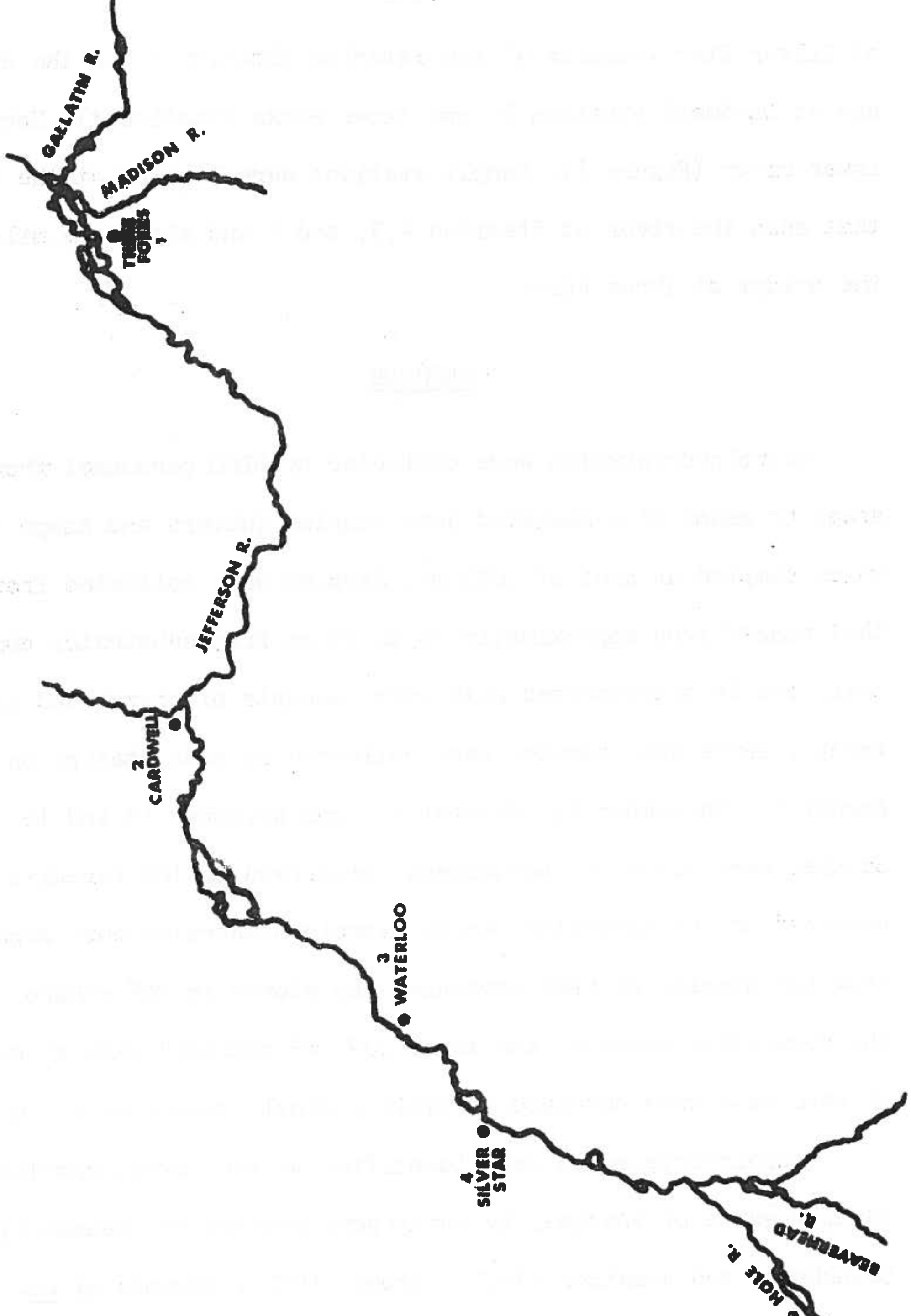

Figure 1. Map of the Jefferson River showing sample stations.

Jensen (1966), Johannsen (1934, 1935), Usinger (1971), and Wiggins (1977). Members of the families Chironomidae, Tubificidae, and Haplotaxidae were mounted on permanent microscope slides for identification and tubificid and haplotaxid oligochaetes were cleared in Amman's lactophenol prior to mounting.

Macroinvertebrate distributions were analyzed, in part, through the calculation of a coefficient of similarity (S) developed by Czekanowski (Clifford and Stephenson 1975). The index is described by:

$$S = \frac{2C}{A+B} = 1.0 \text{ maximum similarity}$$

where A = the number of taxa occurring at station A

B = the number of taxa occurring at station B

C = the number of taxa common to both stations A and B

The coefficient is a nearest neighbor comparison of one station with all other stations.

Water quality in the Jefferson River was assessed by utilizing a trial biotic index (B.I.) patterned after one developed by Hilsenhoff (1977). The index is described by:

$$B.I. = \frac{\text{Summation } n_i \ a_i}{N}$$

where n_i = the number in each taxon

a_i = the quality value assigned to that taxon (0 to 5)

N = the total number of macroinvertebrates in the sample

High index values indicate poor water quality while lower values indicate good water quality. Quality values that were assigned to the taxa collected in the Jefferson River are presented in Appendix Table 11. Very intolerant organisms are assigned a quality value of 0 while extremely tolerant forms are assigned a value of 5 and forms of intermediate tolerance are assigned an appropriate value between 0 and 5 which increases with the tolerance of the organism to disturbance of the environment. Chironomid pupae and nematodes were excluded from the biotic index calculation.

RESULTS

Distribution

A checklist of all taxa collected and their distributions is presented in Table 1. Seventy-five taxa were identified of which 43 (57%) were collected at Station 1, 40 (53%) were collected at Station 2, 56 (75%) were collected at Station 3, and 52 (69%) were collected at Station 4. Twenty-eight taxa were found to be common to all four stations while four were collected only at Station 1, two at Station 2, 8 at Station 3, and 7 at Station 4. Four taxa were collected only in the lower river (Stations 1 and 2) and 10 taxa were found only at the upper two stations (Stations 3 and 4). The fauna was characterized by rheophilous forms (e.g., *Ameletus*, *Rhithrogena*, *Epeorus*, *Claassenia sabulosa*, *Hesperoperla pacifica*, *Glossosoma*, *Lepidostoma*, and *Diamesa*), burrowers (e.g., *Ephemera simulans*, *Chironomus*, *Dicrotendipes*, and *Rhyacodrilus coccineus*), and forms tolerant of slow flows, sedimentation, or high temperatures (e.g., *Baetis*, *Tricorythodes minutus*, *Paralepto-*

Table 1. Checklist and distributions of macroinvertebrate taxa collected in the Jefferson River at Three Forks (St. 1), Cardwell (St. 2), Waterloo (St. 3), and Silver Star (St. 4), Montana from July through November, 1978.

Taxa	STATION 1	2	3	4
EPHEMEROPTERA				
Siphlonuridae				
Ameletus sp.	-	-	X	X
Baetidae				
Baetis spp.	X	X	X	X
Pseudocloeon sp.	X	X	X	X
Heptageniidae				
Epeorus sp.	-	-	X	-
Heptagenia spp.	X	X	X	X
Rhithrogena sp.	X	X	X	X
Leptophlebiidae				
Choroterpes albiannulata McD.	X	X	X	X
Paraleptophlebia bicornuta (McD.)	-	-	X	X
P. debilis (Walker)	-	-	X	-
P. heteronea (McD.)	-	-	X	X
Traverella albertana (McD.)	X	-	-	-
Ephemerellidae				
Ephemerella inermis Eaton	X	X	X	X
E. margarita Needham	-	X	X	X
E. tibialis McD.	-	-	-	X
Tricorythidae				
Tricorythodes edmundsi Allen	X	-	X	X
T. minutus Traver	X	X	X	X
Ephemeridae				
Ephemera simulans Walker	-	-	-	X
ODONATA				
Gomphidae				
Ophiogomphus spp.	-	-	X	X
PLECOPTERA				
Pteronarcydae				
Pteronarcella badia (Hagen)	X	X	-	X
Pteronarcys californica Newport	-	X	-	-
Perlodidae				
Isogenoides sp.	X	X	X	X
Isoperla spp.	X	X	X	X
Skwala sp.	-	X	X	X

Table 1. (Continued)

	STATION			
	1	2	3	4
Perlidae				
Claassenia sabulosa (Banks)	X	X	X	-
Hesperoperla pacifica (Banks)	-	-	X	X
Chloroperlidae				
Chloroperlinae *	X	X	-	-
HEMIPTERA				
Corixidae				
Sigara sp.	-	-	-	X
TRICHOPTERA				
Psychomyiidae				
Psychomyia sp.	-	-	-	X
Hydropsychidae				
Cheumatopsyche spp.	X	X	X	X
Hydropsyche spp.	X	X	X	X
Glossosomatidae				
Glossosoma sp.	X	X	X	X
Hydroptilidae				
Hydroptila sp.	X	X	X	X
Brachycentridae				
Brachycentrus sp.	X	X	X	X
Limnephilidae				
Onocosmoecus sp.	-	-	X	-
Lepidostomatidae				
Lepidostoma sp.	-	-	-	X
Leptoceridae				
Ceraclea sp.	-	-	X	-
Nectopsyche sp.	-	-	X	-
Oecetis sp.	X	-	X	X
LEPIDOPTERA				
Pyralidae				
Paragyractis sp.	X	-	X	X
COLEOPTERA				
Dytiscidae				
Deronectes sp.	X	-	X	-
Elmidae				
Cleptelmis sp.	-	-	-	X
Dubiraphia sp.	X	-	-	-
Heterlimnius sp.	X	X	-	-

Table 1. (Continued)

	STATION			
	1	2	3	4
Microcylloepus pusillus (LeConte)	X	-	-	-
Optioservus quadrimaculatus Horn	X	X	X	X
Zaetzevia parvula (Horn)	-	X	-	-
DIPTERA				
Tipulidae				
Gonomyia group **	X	X	-	-
Hexatoma spp.	X	X	X	X
Tipula spp.	X	X	X	X
Simuliidae				
Simulium spp.	X	X	X	X
Chironomidae				
Thienemannimyia group ***	X	X	-	-
Diamesa spp.	X	X	X	X
Chironomus sp.	-	-	X	X
Dicrotendipes sp.	-	-	-	X
Microtendipes sp.	X	X	X	X
Phaenopsectra sp.	-	-	X	X
Polypedilum spp.	X	X	X	X
Rheotanytarsus spp.	X	X	X	X
Tanytarsus sp.	X	-	X	-
Cardiocladius sp.	-	X	X	X
Cricotopus spp.	X	X	X	X
Eukiefferiella spp.	X	X	X	X
Orthocladius spp.	X	X	X	X
Rheocricotopus sp.	X	-	-	-
Rhagionidae				
Atherix variegata Walker	X	X	X	X
Empididae	-	X	X	-
TURBELLARIA	-	-	X	X
NEMATODA	X	-	-	X
OLIGOCHAETA				
Lumbriculidae	-	-	X	-
Haplotaxidae				
Haplotaxis sp.	-	-	X	-
Tubificidae				
Rhyacodrilus coccineus (Vejdovsky)	X	X	X	X
Lumbricidae				
Eiseniella sp.	-	X	X	-

Table 1. (Continued)

	STATION			
	1	2	3	4
ISOPODA ****	-	-	X	X
GASTROPODA				
Ancylidae				
Ferrissia sp.	-	-	X	X
PELECYPODA				
Sphaeriidae				
Sphaerium sp.	-	-	X	-

* Nymphs of sub-family Chloroperlinae not seperable to genus.

** Group of 4 unseperable genera in larval stage; *Gonomyia*, *Molophilus*, *Helobia*, and *Trimicra*.

*** Group of 4 unseperable genera in larval stage; *Thienemannimyia*, *Conchapelopia*, *Arctopelopia*, and *Rheopelopia*.

**** Terrestrial or semi-aquatic forms, not *Asellus racovetzia* which is the common aquatic isopod in Montana.

phlebia bicornuta, *Cheumatopsyche*, *Nectopsyche*, *Oecetis*, *Dubiraphia*, *Thienemannimyia* group, *Cricotopus*, and *Orthocladius*).

Distribution of macroinvertebrate taxa among the sampling stations was tested through the calculation of Czekanowski coefficients of similarity (Table 2). The highest degrees of similarity (S = .796 and .795) were observed between Stations 3 and 4 and between Stations 1 and 2. No other combination of stations revealed an S value greater than .688 (Stations 2 and 3).

Table 2. Czekanowski coefficients of similarity (S) between stations on the Jefferson River.

Stations	1	2	3
2	.795	-	-
3	.667	.688	-
4	.674	.674	.796

Twenty-five taxa were collected only at Stations 3 and/or 4 and 10 taxa were found only at Stations 1 and/or 2. The fauna that was restricted to the lower river (Stations 1 and 2) was characterized by thermally tolerant forms (*e.g.*, *Dubiraphia*, *Microcylloepus pusillus*, *Theinemannimyia* group, and *Rheocricotopus*) and relatively intolerant forms (*e.g.*, Chloroperlinae, *Pteronarcys californica*, and *Heterlimnius*). The fauna that was found only in the upper river was characterized by burrowers (*e.g.*, *Ephemera simulans*, *Chironomus*, *Dicrotendipes*, Phaenopsectra, and Haplotaxis), forms tolerant of a wide range of conditions (e.g., Nectopsyche, Tubellaria, Isopoda, and Sphaerium), and relatively intolerant rheophilous forms (e.g., Ameletus, Epeorus, Ephemerella tibialis, Hesperoperla pacifica, and Cleptelmis).

Numbers of taxa collected per sample at each station and the mean numbers per sample for each month and each station are given in Table 3. Numbers of taxa per sample were highest at Stations 3 and 4 ($\bar{X}$ = 27.4 and 25.8) and lowest at Stations 1 and 2 ($\bar{X}$ = 19.4 and 21.6). The highest numbers of taxa per sample were collected in August ($\bar{X}$ = 28.8) and November ($\bar{X}$ = 26.8) and the lowest in September ($\bar{X}$ = 20.0).

Abundance

Numbers of macroinvertebrates collected per sample at each station and the mean numbers per sample for each station and month are given in Table 4. Macroinvertebrate numbers were highest at Stations 3 and 4 ($\bar{X}$ = 822.0 and 644.2) and lowest at Stations 1 and 2 ($\bar{X}$ = 183.8 and 353.6). The highest numbers of macroinvertebrates were collected in August ($\bar{X}$ = 667.0) and November ($\bar{X}$ = 1179.8) and the lowest in October ($\bar{X}$ = 159.5).

Numbers of macroinvertebrates collected in the lower river (Stations 1 and 2) were compared with numbers collected in the upper river (Stations 3 and 4) by calculating mean numbers of macroinvertebrates per sample for the upper and lower river for each month and for the total series of samples (Table 5). These data were tested by means of a t test to

Table 3. Numbers of sub-ordinal taxa collected per sample (.28 m^2) and mean numbers of taxa collected per station and per month from the Jefferson River, Montana.

	STATION				
	1	2	3	4	$\bar{X}$/month
July	15	23	28	22	22.0
August	27	30	29	29	28.8
September	24	9	22	25	20.0
October	16	18	25	22	20.3
November	15	28	33	31	26.8
$\bar{X}$/station	19.4	21.6	27.4	25.8	

Table 4. Numbers of macroinvertebrates collected per sample (.28 m^2) and mean numbers of macroinvertebrates collected per station and per month from the Jefferson River, Montana.

	STATION				
	1	2	3	4	$\bar{X}$/month
July	101	151	327	249	207.0
August	452	583	879	754	667.0
September	228	175	411	351	291.3
October	54	129	270	185	159.5
November	84	730	2223	1682	1179.8
$\bar{X}$/Station	183.8	353.6	822.0	644.2	

determine the probability at which numerical differences between the upper and lower river were significant. The mean number of macroin-

Table 5. Mean numbers of macroinvertebrates per sample (.28 m^2) collected in the lower (Stations 1 and 2) and upper (Stations 3 and 4) Jefferson River.

	$\bar{X}$ Lower River	$\bar{X}$ Upper River	Prob. of Sig.*
July	126.0	288.0	$P < .07$
August	517.5	816.5	$P < .05$
September	201.5	381.0	$P < .05$
October	91.5	227.5	$P < .14$
November	407.0	1952.5	$P < .07$
Total	268.7	733.1	$P < .06$

* Probability at which differences between means are significant

vertebrates of the total series of samples for the upper river (733.1) was approximately 2.7 times that of the lower river (268.7). This difference was not significant at the commonly accepted interval of $P < .05$ but was significant at $P < .06$. Monthly mean numbers of macroinvertebrates ranged from approximately 1.5 to 4.8 times greater in the upper river than in the lower river samples. Samples collected in August and September yielded significantly different mean numbers at $P < .05$.

Numbers per sub-ordinal taxa are given in Appendix Tables 7,8, and 9. Two patterns of seasonal abundance were observed among the numerically dominant forms. Baetis, Choroterpes albiannulata, Tricorythodes minutus, Isogenoides, Claassenia sabulosa, Polypedilum, and Cricotopus were most abundant in August or September while Ephemerella inermis, Rhithrogena, Isoperla, Diamesa, Microtendipes, and Orthocladius were most abundant in November. Hydropsyche and Cheumatopsyche, the most abundant genera collected, reached maximum abundance in November but also reached relatively high numbers in August. Most of the other taxa collected were present in relatively low numbers with the exception of Heptagenia in July, Turbellaria in October and November at Station 3, and Rhyacodrilus coccineus at Stations 3 and 4 in September, October, and November.

Trial Biotic Index

Results of a trial biotic index patterned after Hilsenhoff (1977) are given in Table 6. Quality values assigned to the various taxa are

Table 6. Trial biotic index (B.I.) values per sample (.28 m^2) and mean B.I. per sample collected in the Jefferson River for each station and month.

	Station				
	1	2	3	4	$\bar{X}$ B.I./month
July	2.41	2.37	2.35	2.56	2.42
August	2.24	2.50	2.72	2.55	2.50
September	2.81	3.01	2.73	3.10	2.91
October	2.29	2.20	2.04	2.88	2.35
November	1.25	1.93	2.98	2.96	2.28
$\bar{X}$ B.I./station	2.20	2.40	2.56	2.81	

presented in Appendix Table 11. Mean B.I. values increased from Station 1 to Station 4 and ranged from 2.20 to 2.81. On a monthly basis, mean B.I. values increased from July (2.42) to a maximum in September (2.91), dropped in October, and were at a minimum in November (2.28).

DISCUSSION

River Zonation

Data indicated that the study area on the Jefferson River was divided into two distinct zones, an upper river section (Stations 3 and 4) and a lower river section (Stations 1 and 2). This was evidenced by the alliances of the two lower and upper stations that were detected with coefficients of similarity and by the markedly higher numbers of macroinvertebrates and taxa that were collected at Stations 3 and 4 than at Stations 1 and 2. A previous study has also divided the Jefferson River into upper and lower river zones (MDFG 1979). This study, however, set the boundary between the upper and lower reaches at the mouth of the Boulder River below Cardwell thus including Station 2 of the present study in the upper reach. Results of this study suggest that the division between upper and lower river zones on the Jefferson River probably occurs upstream of the Boulder River confluence.

The upper river zone was richer in macroinvertebrate numbers and taxa than the lower river despite the fact that mean monthly discharges in the critical months of August (652 cfs) and September (800 cfs) in the upper river fall far below the 1200 cfs that has been recommended to maintain a high level of aquatic habitat potential within the reach during this period (MDFG 1979). Mean discharges in August (745 cfs) and September (969 cfs) in the lower river differ less markedly from the minimum recommended discharge for high level habitat potential for that reach (1000 cfs) than do those of the upper zone. The upper section has also supported more abundant trout and whitefish populations than the lower section (Wells and Nelson 1978). The more diverse and abundant fauna of the upper river zone may be reflective of the relatively high flows that dominated the river in 1978. Flow data from a gauge station near Three Forks show that discharges in the period spanning August 15 through November 16,1978 ranged from 1040 to 2650 cfs (USGS unpublished data). Discharges of these magnitudes exceed the minimum recommended discharge required to support a high level of aquatic habitat potential in the lower Jefferson River during that period. It is plausible that during a year of high flows the upper river section supports richer macroinvertebrate populations than the lower section due to natural longitudinal changes in the river concomitant with loss of gradient, i.e., higher water temperatures, increased sedimentation, slower current velocities, and less diversity of niches (Hynes 1970). Thus the aquatic habitat potential of the lower river may be naturally lower than that of the upper section.

Distribution

The Jefferson River supported a relatively rich macroinvertebrate fauna in terms of the numbers of taxa collected. Seventy-five taxa were collected during the study. This can be compared with 59 taxa that were identified from the Madison River (Fraley 1978) and 66, exclusive of Chironomidae and Oligochaeta, that were collected in the East Gallatin River (Luedtke et al. 1974).

Many of the taxa collected in the Jefferson River were forms that are known to be tolerant of high temperatures, sedimentation, and slow flows. Such forms were often collected throughout the study area. Many of the intolerant forms that were collected were limited to the upper river section.

Most of the taxa collected in the Jefferson River have also been collected in the Madison and East Gallatin Rivers (Fraley 1978, Luedtke et al. 1974). A comparative list of taxa that were unique to the Jefferson and lower Madison Rivers is presented in Appendix Table 10. It should be noted that the caddisfly Helicopsyche borealis, which was not collected from the Jefferson River, probably does inhabit the river because larval cases of the species were found in some of the samples.

Of particular interest, was the collection of the mayfly Tricorythodes edmundsi. This species has, until recently, been known only from northern Mexico and Utah (Allen 1977). It has since been collected from the lower Yellowstone River and in the present study. It has been theorized that this species develops and emerges very rapidly under optimal conditions and may be more widely distributed than was previously believed (G.F. Edmunds Jr. personal communication).

Abundance

The Jefferson River supported relatively low numbers of aquatic macroinvertebrates when compared with other major tributaries of the Missouri River headwaters. Population estimates of 658.7, 1267.3, 2946.0, and 2308.8 macroinvertebrates per m^2 for Stations 1 through 4 on the Jefferson River can be compared with 3760 and 5012 per m^2 in the Madison River at Norris Bridge and Three Forks (Fraley 1978), 7669.1 per m^2 in the East Gallatin River near Belgrade (Luedtke *et al.* 1974), and 4916.3 (major insect orders only) per m^2 in the West Gallatin River at Moose Meadows (Roemhild 1971). The station at Three Forks on the Madison River supported 7.6 times the macroinvertebrate numbers than did the Three Forks station on the Jefferson River. Low macroinvertebrate numbers in the Jefferson River may be due to elevated water temperatures, sedimentation and reduced current velocities associated with dewatering.

The most abundant genera and species collected in the Jefferson River were classified into two groups based on their seasonal patterns of abundance. The long or winter cycle forms which over-winter in the larval form and complete their development and emerge in spring or early summer were characterized by an absence or presence in very low numbers in the critical flow period of August and September, began a numerical recovery in the October samples and reached maximum abundance in November. This group was typified by rheophilous forms such as Rhithrogena, Isoperla, and Diamesa. The short or summer cycle forms which rapidly complete their development in summer and emerge in August or September were characterized by an absence or presence in very low numbers in early summer or fall and reached maximum abundance in August or September. This group was typified by tolerant forms such as Choroterpes albiannulata, Tricorythodes minutus, Cricotopus, and Polypedilum. Although Claassenia sabulosa and Isogenoides both reached maximum abundance in August, they are actually long or winter cycle forms. Isogenoides emerges in early spring and has been collected in the adult form in May in the Jefferson, Gallatin and Missouri Rivers (Unpublished records, Montana State Univ.). Claassenia sabulosa emerges from June through September (Bauman et al. 1977) and has been collected in adult form in July and August from the Gallatin and Yellowstone Rivers (Unpublished records, Montana State Univ.). All of the Isogenoides and the majority of the C. sabulosa that were present in the August samples were early instar forms. A strong numerical reduction of both genera that occurred in September was followed by numerical recovery in larger later instars in October and November. Emergence, therefore can be eliminated as a cause of the numerical reduction of Isogenoides and C. sabulosa in September. It is suggested that the numerical reduction may have been related to elevated summer water temperatures, low current velocities, or sedimentation, or a combination of these factors, due to low summer discharges. These factors may have been responsible for the low summer numbers of some of the other rheophilous cold-water forms such as Rhithrogena and Isoperla which did not begin a numerical recovery until October and were most abundant in November. Gore (1976) found that current specialists such as Rhithrogena, Ephemerella, and Isogenoides drifted out of previously occupied areas when flows were decreased in the Tongue River.

Trial Biotic Index

A trial biotic index revealed that water quality steadily decreased going upstream from Station 1 to Station 4. On a monthly basis, water quality was highest in October and November and showed a steady decrease from July to September when water quality was lowest. Hilsenhoff (1977) determined that biotic index values of less than 1.75 indicated excellant water quality, a range of 1.75 to 2.25 indicated good water quality with some disturbance, a range of 2.25 to 3.00 indicated fair water quality with moderate disturbance, and a range of 3.00 to 3.75 indicated poor water quality. All of the mean B.I. values indicated that the Jefferson River has fair water quality and shows some moderate disturbance. Index values for September samples at Stations 2 and 4 were in the poor water quality range. High index values for November samples at Stations 3 and 4 were due to very large populations of Cheumatopsyche and Hydropsyche; however, these genera occurred with many intolerant forms that reached their maximum abundance in these samples. Fraley (1978) calculated mean biotic index values for samples collected at Norris Bridge and Three Forks on the lower Madison River and presented values of 2.64 and 2.68 for these stations.

CONCLUSIONS

1. Data indicated that the four macroinvertebrate sample stations represented two river zones, an upper river section (Silver Star and Waterloo) and a lower river section (Cardwell and Three Forks).

2. The upper river section supported a greater diversity and greater numbers of macroinvertebrates than the lower river section; however, biotic index values indicated slightly poorer water quality in the upper section.

3. The macroinvertebrate community was dominated by forms tolerant of sedimentation, high water temperatures, and low current velocities in August and September while rheophilous forms, typical of rubble or cobble substrates, low temperatures, and swift flows, were absent or present in low numbers in these months and most abundant in November. Biotic index values indicated that water quality was lowest in September and August and highest in November and October.

4. Macroinvertebrate numbers in the Jefferson River were low when compared with the other major tributaries that join to form the Missouri River.

5. Data collected in this study can be applied as a basis for comparison with future investigations under different flow regimes.

LITERATURE CITED

Allen, R.K. 1977. A new species of Tricorythodes with notes (Ephemeroptera:Tricorythidae). J. Kans. Ent. Soc. 50:431-435.

Bauman, R.W., A.R. Gaufin, and R.F. Surdick. 1977. The stoneflies (Plecoptera) of the Rocky Mountains. Mem. Am. Ent. Soc. 31:1-208.

Brinkhurst, R.O. and B.G.M. Jamieson. 1971. Aquatic Oligochaeta of the world. Oliver and Boyd, Edinburgh. 860 pp.

Brown, H.P. 1972. Aquatic dryopoid beetles (Coleoptera) of the United States. Biota of freshwater ecosystems, identification manual No. 6 Water pollution control research series 18050 ELD, USEPA. 81 pp.

Clifford, H.T. and W. Stephenson. 1975. An introduction to numerical classification. Academic Press, New York. 229 pp.

Edmunds, G.F., Jr., S.L. Jensen, and L. Berner. 1976. The mayflies of North and Central America. U. of Minnesota Press, Minneapolis. 330 pp.

Fraley, J.J. 1978. Effects of elevated summer water temperatures below Ennis Reservoir on the macroinvertebrates of the Madison River, Montana. M.S. thesis, Montana State Univ., Bozeman. 120 pp.

Gore, J.A. 1976. In-stream flow requirements of benthic macroinvertebrates in a prairie river. M.S. thesis, U. of Montana, Missoula. 172 pp.

Hamilton, A.L. and O. A. Saether. 1970. Key to the genera of midge larvae. (Unpublished) Freshwater Inst., FRBC, Winnipeg, Manitoba.

Hilsenhoff, W.L. 1975. Aquatic insects of Wisconsin. Tech. Bull. No. 89, DNR, Madison, Wisconsin. 52 pp.

_________. 1977. Use of arthropods to evaluate water quality of streams. Tech. Bull. No. 100, DNR, Madison, Wisconsin. 15 pp.

Hiltunen, J.K. 1970. Keys to the tubificid and naidid Oligochaeta of the Great Lakes region. (Unpublished). Great Lakes Fishery Lab., Ann Arbor, Michigan. 26 pp.

Hynes, H.B.N. 1970. The ecology of running waters. U. of Toronto Press, Toronto, Ontario. 555 pp.

Jensen, S.L. 1976. The mayflies of Idaho. M.S. thesis, U. of Utah, Salt Lake City. 367 pp.

Johannsen, O.A. 1934. Aquatic Diptera. Part 1. Nemocera, exclusive of Chironomidae and Ceratopogonidae. Mem. Cornell U. Ag. Exp. Sta. 164:1-71.

__________. 1935. Aquatic Diptera. Part 2. Orthorrapha-Brachycera and Cyclorrhapha. Mem. Cornell U. Ag. Exp. Sta. 177:1-62.

Luedtke, R.J., D.M. Gillespie, and R.V. Thurston. 1974. Macroinvertebrate distribution in the East Gallatin River, Montana. Tech. Report No. 74-4, FBL, Montana State U., Bozeman. ?7 pp.

Montana Department of Fish and Game 1979. Instream flow evaluation for selected streams in the upper Missouri River basin. MDFG, Helena, Montana. 254 pp.

Newell, R.L. 1976. Yellowstone River study final report. MDFG and Intake Water Co. 259 pp.

Roemhild, G.R. 1971. Aquatic invertebrates and water quality: the effect of human ingress in a semi-primative area. Gallatin Canyon study report, Montana State U., Bozeman. 15 pp.

Usinger, R.L. (ed.) 1971. Aquatic insects of California. U. of California Press, Berkeley. 508 pp.

Waters, T.F. and R.J. Knapp. 1961. An improved stream bottom fauna sampler. Trans. Am Fish. Soc. 90:225-226.

Wells, J.D. and F.A. Nelson. 1978. Inventory of waters of the project area. Job Progress Rept., Fed. aid in fish and wildlife restoration acts. Mont. Proj. No. F-9-R-26, Job 1-b. 13 pp.

Wiggins, G.B. 1977. Larvae of the North American caddisfly genera (Trichoptera). U. of Toronto Press, Toronto. 401 pp.

APPENDIX

Table 7. Numbers per sub-ordinal taxa of macroinvertebrates collected in .28 m^2 bottom samples on July 19 and August 15, 1978.

	July				August			
Stations	1	2	3	4	1	2	3	4
EPHEMEROPTERA								
Ameletus sp.	--	--	--	--	--	--	--	--
Baetis spp.	33	54	62	26	21	89	67	50
Pseudocloeon sp.	10	10	28	7	1	9	--	--
Epeorus sp.	--	--	1	--	--	--	--	--
Heptagenia spp.	4	5	58	27	1	1	7	8
Rhithrogena sp.	3	9	1	--	14	7	--	3
Choroterpes albiannulata	1	--	--	--	1	7	102	10
Paraleptophlebia bicornuta	--	--	--	--	--	--	--	--
P. debilis	--	--	4	--	--	--	--	--
P. heteronea	--	--	1	--	--	--	--	--
Traverella albertana	--	--	--	--	2	--	--	--
Ephemerella inermis	13	29	47	40	--	--	--	2
E. margarita	--	--	4	4	--	1	9	12
E. tibialis	--	--	--	1	--	--	--	--
Tricorythodes edmundsi	--	--	--	--	--	--	11	8
T. minutus	15	7	8	10	180	115	325	264
Ephemera simulans	--	--	--	--	--	--	--	--
ODONATA								
Ophiogomphus spp.	--	--	1	--	--	--	4	1
PLECOPTERA								
Pteronarcella badia	--	--	--	--	1	2	--	--
Pteronarcys californica	--	--	--	--	--	--	--	--
Isogenoides sp.	4	1	3	--	19	39	8	55
Isoperla spp.	--	3	8	17	--	--	--	--
Skwala sp.	--	--	--	--	--	--	4	8
Claassenia sabulosa	--	5	1	--	36	41	--	--
Hesperoperla pacifica	--	--	--	1	--	--	--	--
Chloroperlinae	--	--	--	--	--	--	--	--
HEMIPTERA								
Sigara sp.	--	--	--	--	--	--	--	--
TRICHOPTERA								
Psychomyia sp.	--	--	--	--	--	--	--	--
Cheumatopsyche spp.	1	5	18	22	39	61	177	216
Hydropsyche spp.	3	2	15	48	60	93	41	29
Glossosoma sp.	--	1	--	4	9	5	6	15
Hydroptila sp.	--	1	--	2	--	1	--	--
Brachycentrus sp.	1	--	--	1	1	1	2	2
Onocosmoecus sp.	--	--	--	--	--	--	1	--
Lepidostoma sp.	--	--	--	--	--	--	--	--
Ceraclea sp.	--	--	--	--	--	--	--	--
Nectopsyche sp.	--	--	--	--	--	--	--	--
Oecetis sp.	1	--	2	--	--	--	--	1

Table 7. (Continued)

Stations	July 1	July 2	July 3	July 4	August 1	August 2	August 3	August 4
LEPIDOPTERA								
Paragyractis sp.	--	--	--	--	--	--	5	17
COLEOPTERA								
Deronectes sp.	--	--	--	--	--	--	--	--
Cleptelmis sp.	--	--	--	--	--	--	--	--
Dubiraphia sp.	--	--	--	--	--	--	--	--
Heterlimnius sp.	--	--	--	--	1	--	--	--
Microcylloepus pusillus	--	--	--	--	2	--	--	--
Optioservus quadrimaculatus	--	--	--	1	3	1	2	--
Zaetzevia parvula	--	--	--	--	--	2	--	--
DIPTERA								
Gonomyia group	--	--	--	--	--	--	--	--
Hexatoma spp.	--	--	--	--	4	4	--	2
Tipula spp.	--	--	--	--	--	--	--	--
Simulium spp.	1	1	--	1	--	7	--	--
Thienemannimyia group	--	--	--	--	3	1	--	--
Diamesa spp.	--	--	--	--	--	--	--	--
Chironomus sp.	--	--	--	--	--	--	--	--
Dicrotendipes sp.	--	--	--	--	--	--	--	--
Microtendipes sp.	--	--	1	--	--	--	4	6
Phaenopsectra sp.	--	--	--	--	--	--	1	1
Polypedilum spp.	6	3	32	9	26	19	21	16
Rheotanytarsus spp.	--	--	--	--	7	11	6	4
Tanytarsus sp.	--	--	--	--	--	--	--	--
Cardiocladius sp.	--	2	2	8	--	1	--	1
Cricotopus spp.	5	2	11	14	2	33	44	3
Eukiefferiella spp.	--	1	8	2	1	10	6	3
Orthocladius spp.	--	1	1	3	--	--	1	1
Rheocricotopus sp.	--	--	--	--	1	--	--	--
Chironomid pupae	--	1	2	--	1	2	4	7
Atherix variegata	--	--	--	--	5	6	1	1
Empididae	--	1	1	--	--	1	--	--
TURBELLARIA	--	--	3	--	--	--	15	--
NEMATODA	--	--	--	--	--	--	--	--
OLIGOCHAETA								
Lumbriculidae	--	--	--	--	--	--	--	--
Haplotaxis sp.	--	--	--	--	--	--	1	--
Rhyacodrilus coccineus	--	6	3	1	11	12	3	6
Eiseniella sp.	--	1	--	--	--	1	1	--
ISOPODA	--	--	--	--	--	--	--	--
GASTROPODA								
Ferrissia sp.	--	--	--	--	--	--	--	--
PELECYPODA								
Sphaerium sp.	--	--	1	--	--	--	--	--

Table 8. Numbers per sub-ordinal taxa of macroinvertebrates collected in .28 m^2 bottom samples on Sept. 13 and Oct. 10, 1978.

	September				October			
Stations	1	2	3	4	1	2	3	4
EPHEMEROPTERA								
Ameletus sp.	--	--	--	--	--	--	--	1
Baetis spp.	10	154	253	97	3	1	1	1
Pseudocloeon sp.	3	--	--	--	1	--	--	--
Epeorus sp.	--	--	--	--	--	--	--	--
Heptagenia spp.	--	1	1	8	--	1	2	--
Rhithrogena sp.	3	--	3	4	3	13	43	6
Choroterpes albiannulata	1	2	3	--	--	--	--	--
Paraleptophlebia bicornuta	--	--	1	2	--	--	--	--
P. debilis	--	--	7	--	--	--	--	--
P. heteronea	--	--	--	--	--	--	--	1
Traverella albertana	--	--	--	--	--	--	--	--
Ephemerella inermis	1	--	--	4	3	5	7	5
E. margarita	--	--	--	--	--	--	--	--
E. tibialis	--	--	--	--	--	--	--	--
Tricorythodes edmundsi	2	--	--	--	--	--	--	--
T. minutus	3	2	20	27	--	--	1	1
Ephemera simulans	--	--	--	--	--	--	--	--
ODONATA								
Ophiogomphus spp.	--	--	--	--	--	--	--	--
PLECOPTERA								
Pteronarcella badia	1	--	--	--	--	--	--	--
Pteronarcys californica	--	--	--	--	--	--	--	--
Isogenoides sp.	15	--	--	--	9	18	3	4
Isoperla spp.	--	--	--	--	--	--	4	7
Skwala sp.	--	--	--	--	--	--	2	2
Claassenia sabulosa	1	--	--	--	--	11	1	--
Hesperoperla pacifica	--	--	--	--	--	--	--	1
Chloroperlinae	1	--	--	--	--	--	--	--
HEMIPTERA								
Sigara sp.	--	--	--	5	--	--	--	1
TRICHOPTERA								
Psychomyia sp.	--	--	--	--	--	--	--	--
Cheumatopsyche spp.	28	--	10	126	2	7	33	45
Hydropsyche spp.	127	--	1	15	9	44	11	61
Glossosoma sp.	--	--	--	--	--	--	--	1
Hydroptila sp.	--	--	--	--	--	2	3	1
Brachycentrus sp.	--	--	--	1	--	--	--	--
Onocosmoecus sp.	--	--	--	--	--	--	--	--
Lepidostoma sp.	--	--	--	2	--	--	--	--
Ceraclea sp.	--	--	--	--	--	--	--	--
Nectopsyche sp.	--	--	--	--	--	--	--	--
Oecetis sp.	--	--	--	--	--	--	--	--

Table 8. (Continued)

	September				October			
Stations	1	2	3	4	1	2	3	4
LEPIDOPTERA								
Paragyractis sp.	1	--	2	5	1	--	--	4
COLEOPTERA								
Deronectes sp.	1	--	6	--	--	--	--	--
Cleptelmis sp.	--	--	--	--	--	--	--	--
Dubiraphia sp.	--	--	--	--	1	--	--	--
Heterlimnius sp.	--	--	--	--	1	--	--	--
Microcylloepus pusillus	1	--	--	--	1	--	--	--
Optioservus quadrimaculatus	1	--	--	1	--	--	2	--
Zaetzevia parvula	--	--	--	--	--	--	--	--
DIPTERA								
Gonomyia group	4	1	--	--	--	--	--	--
Hexatoma spp.	10	--	--	2	5	1	1	--
Tipula spp.	1	--	6	2	--	--	1	2
Simulium spp.	--	6	4	--	--	1	2	--
Thienemannimyia group	--	--	--	--	--	--	--	--
Diamesa spp.	--	1	--	--	--	--	1	--
Chironomus sp.	--	--	3	4	--	--	--	--
Dicrotendipes sp.	--	--	--	1	--	--	--	--
Microtendipes sp.	--	--	--	4	3	2	4	7
Phaenopsectra sp.	--	--	4	2	--	--	--	--
Polypedilum spp.	--	--	--	--	--	--	--	--
Rheotanytarsus spp.	--	--	--	6	--	1	1	--
Tanytarsus sp.	1	--	1	--	--	--	--	--
Cardiocladius sp.	--	--	--	--	--	--	--	--
Cricotopus spp.	8	7	1	4	--	1	3	7
Eukiefferiella spp.	--	--	--	--	--	--	--	--
Orthocladius spp.	--	--	--	3	9	12	11	15
Rheocricotopus sp.	--	--	--	--	--	--	--	--
Chironomid pupae	--	--	2	--	2	1	5	4
Atherix variegata	2	--	--	--	1	1	--	1
Empididae	--	--	--	--	--	--	--	--
TURBELLARIA	--	--	4	--	--	--	25	--
NEMATODA	--	--	--	--	--	--	--	--
OLIGOCHAETA								
Lumbriculidae	--	--	--	--	--	--	--	--
Haplotaxis sp.	--	--	1	--	--	--	--	--
Rhyacodrilus coccineus	2	1	74	26	--	7	99	11
Eiseniella sp.	--	--	--	--	--	--	--	--
ISOPODA	--	--	4	1	--	--	--	--
GASTROPODA								
Ferrissia sp.	--	--	--	1	--	--	--	--
PELECYPODA								
Sphaerium sp.	--	--	--	--	--	--	--	--

Table 9. Numbers per sub-ordinal taxa of macroinvertebrates collected in .28 m^2 bottom samples on Nov. 13 and 16, 1978.

	November			
Stations	1	2	3	4
EPHEMEROPTERA				
Ameletus sp.	--	--	1	--
Baetis spp.	1	1	12	4
Pseudocloeon sp.	--	--	--	--
Epeorus sp.	--	--	--	--
Heptagenia spp.	--	1	--	--
Rhithrogena sp.	30	78	5	5
Choroterpes albiannulata	--	--	--	--
Paraleptophlebia bicornuta	--	--	--	--
P. debilis	--	--	--	--
P. heteronea	--	--	3	--
Traverella albertana	--	--	--	--
Ephemerella inermis	11	209	128	131
E. margarita	--	--	--	--
E. tibialis	--	--	--	--
Tricorythodes edmundsi	--	--	--	--
T. minutus	--	--	5	1
Ephemera simulans	--	--	--	2
ODONATA				
Ophiogomphus spp.	--	--	1	1
PLECOPTERA				
Pteronarcella badia	--	3	--	1
Pteronarcys californica	--	1	--	--
Isogenoides sp.	3	21	1	6
Isoperla spp.	9	80	72	76
Skwala sp.	--	1	--	2
Claassenia sabulosa	--	17	--	--
Hesperoperla pacifica	--	--	1	7
Chloroperlinae	--	8	--	--
HEMIPTERA				
Sigara sp.	--	--	--	--
TRICHOPTERA				
Psychomyia sp.	--	--	--	3
Cheumatopsyche spp.	4	43	721	619
Hydropsyche spp.	11	199	710	542
Glossosoma sp.	--	--	--	--
Hydroptila sp.	2	4	8	3
Brachycentrus sp.	--	2	2	3
Onocosmoecus sp.	--	--	--	--
Lepidostoma sp.	--	--	--	1
Ceraclea sp.	--	--	1	--
Nectopsyche sp.	--	--	3	--
Oecetis sp.	--	--	1	13

Table 9. (Continued)

	November			
Stations	1	2	3	4
LEPIDOPTERA				
Paragyractis sp.	--	--	2	5
COLEOPTERA				
Deronectes sp.	--	--	--	--
Cleptelmis sp.	--	--	--	1
Dubiraphia sp.	--	--	--	--
Heterlimnius sp.	1	1	--	--
Microcylloepus pusillus	--	--	--	--
Optioservus quadrimaculatus	--	2	1	--
Zaetzevia parvula	--	2	--	--
DIPTERA				
Gonomyia group	--	--	--	--
Hexatoma spp.	2	16	--	--
Tipula spp.	--	4	1	2
Simulium spp.	1	6	19	20
Thienemannimyia group	--	--	--	--
Diamesa spp.	5	14	283	9
Chironomus sp.	--	--	--	--
Dicrotendipes sp.	--	--	--	--
Microtendipes sp.	--	3	7	146
Phaenopsectra sp.	--	--	1	19
Polypedilum spp.	--	--	--	--
Rheotanytarsus spp.	2	--	5	--
Tanytarsus sp.	--	--	--	--
Cardiocladius sp.	--	2	4	--
Cricotopus spp.	--	--	--	--
Eukiefferiella spp.	--	--	4	--
Orthocladius spp.	1	6	64	--
Rheocricotopus sp.	--	--	--	--
Chironomid pupae	--	--	17	3
Atherix variegata	--	2	6	3
Empididae	--	1	--	--
TURBELLARIA	--	--	66	1
NEMATODA	1	--	--	1
OLIGOCHAETA				
Lumbriculidae	--	--	1	--
Haplotaxis sp.	--	--	--	--
Rhyacodrilus coccineus	--	3	67	50
Eiseniella sp.	--	--	--	--
ISOPODA	--	--	--	--
GASTROPODA				
Ferrissia sp.	--	--	1	2
PLECYPODA				
Sphaerium sp.	--	--	--	--

Table 10. Macroinvertebrate taxa collected in the Jefferson River but absent from collections made on the lower Madison River* contrasted with taxa collected in the lower Madison River which were absent from collections in the Jefferson River.

Present in Jefferson, Absent from Madison.	Present in Madison, Absent from Jefferson.
EPHEMEROPTERA	EPHEMEROPTERA
Paraleptophlebia bicornuta	*Ephemerella grandis*
P. debilis	*Ephoron album*
Traverella albertana	PLECOPTERA
Ephemerella margarita	*Cultus* sp.
E. tibialis	TRICHOPTERA
Tricorythodes edmundsi	*Amiocentrus* sp.
PLECOPTERA	*Protoptila* sp.
Isogenoides sp.	*Leuchotrichia pictipes*
TRICHOPTERA	*Zumatrichia notosa*
Onocosmoecus sp.	*Helicopsyche borealis*
COLEOPTERA	COLEOPTERA
Deronectes sp.	*Lara* sp.
Cleptelmis sp.	DIPTERA
Dubiraphia sp.	*Antocha* spp.
Heterlimnius sp.	*Nilotanypus* sp.
Zaetzevia parvula	*Paracladopelma* sp.
DIPTERA	*Nanocladius* (Microcricotopus)
Gonomyia group	AMPHIPODA
Rheocricotopus sp.	*Hyalella azteca*
Tanytarsus sp.	DECAPODA
Empididae	*Orconectes* sp.
OLIGOCHAETA	GASTROPODA
Lumbriculidae	*Physa* spp.
Haplotaxis sp.	PELECYPODA
Rhyacodrilus coccineus	*Pisidium* spp.
Eiseniella sp.	
TURBELLARIA	
NEMATODA	

* From Fraley (1978) collections made at Norris Bridge and Three Forks on the Madison River.

Table 11. Quality values (a_i) assigned to macroinvertebrate taxa from Hilsenhoff (1977), Fraley (1978)*, and author** and used in calculating trial biotic index (B.I.) for the Jefferson R..

EPHEMEROPTERA	Ameletus sp. 1**, Baetis spp. 3, Pseudocloeon sp. 2, Epeorus sp. 0, Heptagenia spp. 2, Rhithrogena sp. 0, C. albiannulata 3*, P. bicornuta 1**, P. debilis 1**, P. heteronea 1, T. albertana 3**, E. inermis 2*, E. margarita 2**, E. tibialis 2**, T. edmundsi 2, T. minutus 2, E. simula s 1.
ODONATA	Ophiogomphus spp. 0.
PLECOPTERA	P. badia 1*, P. californica 1, Isogenoides sp. 0, Isoperla spp. 0, Skwala sp. 1*, C. sabulosa 1*, H. pacifica 1*, Chloroperlinae 0*.
HEMIPTERA	Sigara sp. 3**
TRICHOPTERA	Psychomyia sp. 2, Cheumatopsyche spp. 4, Hydropsyche spp. 3, Glossosoma sp. 1, Hydroptila sp. 3, Brachycentrus 1, Onocosmoecus sp. 0, Lepidostoma sp. 2, Ceraclea 2, Nectopsyche sp. 2, Oecetis sp. 2.
LEPIDOPTERA	Paragyractis sp. 3*
COLEOPTERA	Deronectes sp. 3**, Cleptelmis sp. 1**, Dubiraphia sp. 3, Heterlimnius sp. 1**, M. pusillus 1, O. quadrimaculatus 2**, Z. parvula 1**.
DIPTERA	Gonomyia gr. 3**, Hexatoma spp. 3, Tipula spp. 2, Simulium spp. 3, Thienemannimyia gr. 4, Diamesa spp. 2, Chironomus sp. 5, Dicrotendipes sp. 3, Microtendipes sp. 2, Phaenopsectra sp. 1, Polypedilum spp. 3, Rheotanytarsus spp. 0, Tanytarsus sp. 0, Cardiocladius sp. 4, Cricotopus spp. 4, Eukiefferialla spp. 2, Orthocladius spp. 4, Rheocricotopus sp. 1, A. variegata 2, Empididae 4.
OLIGOCHAETA	Lumbriculidae 2**, Haplotaxis sp. 1**, R. coccineus 2**, Eiseniella sp. 2**.
MISCALLANEOUS	Turbellaria 2**, Isopoda 5, Ferrissia sp. 2**, Sphaerium sp. 4**.