FLATHEAD RIVER BASIN FISHERY STUDY

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We would like to thank Senator Max Baucus for his foresight and commitment to this study. We also appreciate the concern of all members of the Montana Congressional Delegation.

IN MEMORY OF

Leland "Schoony" Schoonover

We oftentimes think of the purpose of an organization such as this as being responsible for the welfare of our wildlife. We have today broadened the scope of our thinking to where we are interested in all phases of resource management and development. Our creed is that we are merely serving as stewards for the future generations and when the time comes for an accounting, our record will show a balance in our favor resulting from wise management and courageous leadership.

Schoony

When serving as president of the
Montana Wildlife Federation-1963

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INTRODUCTION

This study is part of a baseline environmental assessment funded by the EPA under the direction of the Flathead River Basin Steering Committee, a 15-member committee representing land management agencies, political bodies and private citizens or groups in the area.

This is the second Annual Progress Report and presents a large amount of data collected during the preceding year. Because most phases of the study are on-going there is minimal discussion and much of the data will be integrated in a more sophisticated analysis in succeeding reports. It should be noted that data are reported in metric units except for stream flows. These are reported in English units because most stream discharge information collected by other agencies is reported in English units. Also, agencies responsible for adjudicating water do so in English units. Flow data from this report will be easier to assimilate and use by a broad range of people.

A description of developmental problems facing the basin, the objectives of Department studies in the Flathead River Basin, conceptual assessment of the objectives and data analyses are contained in a report by Graham (1979) Appendix .

STUDY OBJECTIVES

A. North Fork of the Flathead River Funded Projects

1. Assess relative importance of tributary streams for producing migratory and resident populations of westslope cutthroat and bull trout.
2. Develop a long-term monitoring index for juvenile trout in major tributaries and the main river for correlation with habitat inventories and to monitor changes in environmental quality.
3. Identify the timing and distribution of spawning and feeding and "smolt" migrations for major fish species.
4. Assess existing aquatic habitat in major tributary streams and the main river. Habitat components will be assessed to determine their importance in maintaining the existing cutthroat trout, bull trout and sculpin community. Stream reaches will be ranked in relation to relative importance for providing spawning and rearing areas.
5. Determine habitat requirements and species interaction for juvenile bull trout and westslope cutthroat trout.
6. Quantify instream flows for maintenance of native fish species in the North Fork of the Flathead River.

B. Middle Fork of the Flathead River Fisheries Study

1. Assess relative importance of tributary streams for producing migratory and resident populations of westslope cutthroat and bull trout. To compare the potential contribution of juvenile fish from the North and Middle Forks to Flathead Lake.

2. Develop a long-term monitoring index for juvenile trout in major tributaries and the main river for correlation with habitat inventories and to monitor changes in environmental quality in a natural system in the event development continues in the North Fork drainage.
3. Identify the timing and distribution of spawning and feeding and "smolt" migrations for major fish species.

DESCRIPTION OF STUDY AREA

North Fork of the Flathead River

The North Fork of the Flathead River originates in the Rocky Mountains of British Columbia, Canada and flows south cross the U.S. Canadian boundary into Montana (Figure 1). According to U.S. Geological Survey records, 28 percent of the drainage lies in Canada and contributes 32 percent of the total mean annual North Fork discharge (Table 1).

The North Fork crosses the international boundary at 1210m elevation and flows approximately 92km south to its confluence with the Middle Fork above Blankenship Bridge located between West Glacier and Coram, Montana (Figure 1). The upper section of the U.S. portion of the river flows through a broad, glaciated valley approximately 12.9km in width and was classified in 1976 as a Scenic River under the National Wild and Scenic Rivers Act. The lower 24km of the river is confined in a steep sidewall valley which exists between the Whitefish and Apgar mountain ranges and is classified as Recreational River.

The U.S. portion of the drainage receives water from approximately 15 major tributaries which differ in character depending upon their location. Creeks draining the Whitefish Range on the west side of the North Fork originate at elevations of 1824 and 2128 meters where approximately 203cm of precipitation falls annually. Several small lakes are found on the west side.

Creeks on the east side of the North Fork drain the precipitous and scenic 3040 meter Livingston Range on the west side of Glacier National Park. These mountains receive up to 305cm of annual precipitation (Delk 1972) and form a portion of the Continental Divide. Five of the east side drainages are interrupted by large, deep fjord-type lakes which noticeably affect the quality and thermal regimes of their outflowing waters.

During the past year research conducted in the North Fork drainage by the Montana Department of Fish, Wildlife and Parks was concentrated on creeks draining the west side of the U.S. portion of the river and on the North Fork itself. During September a small amount of survey work was done on Canada's portion of the drainage.

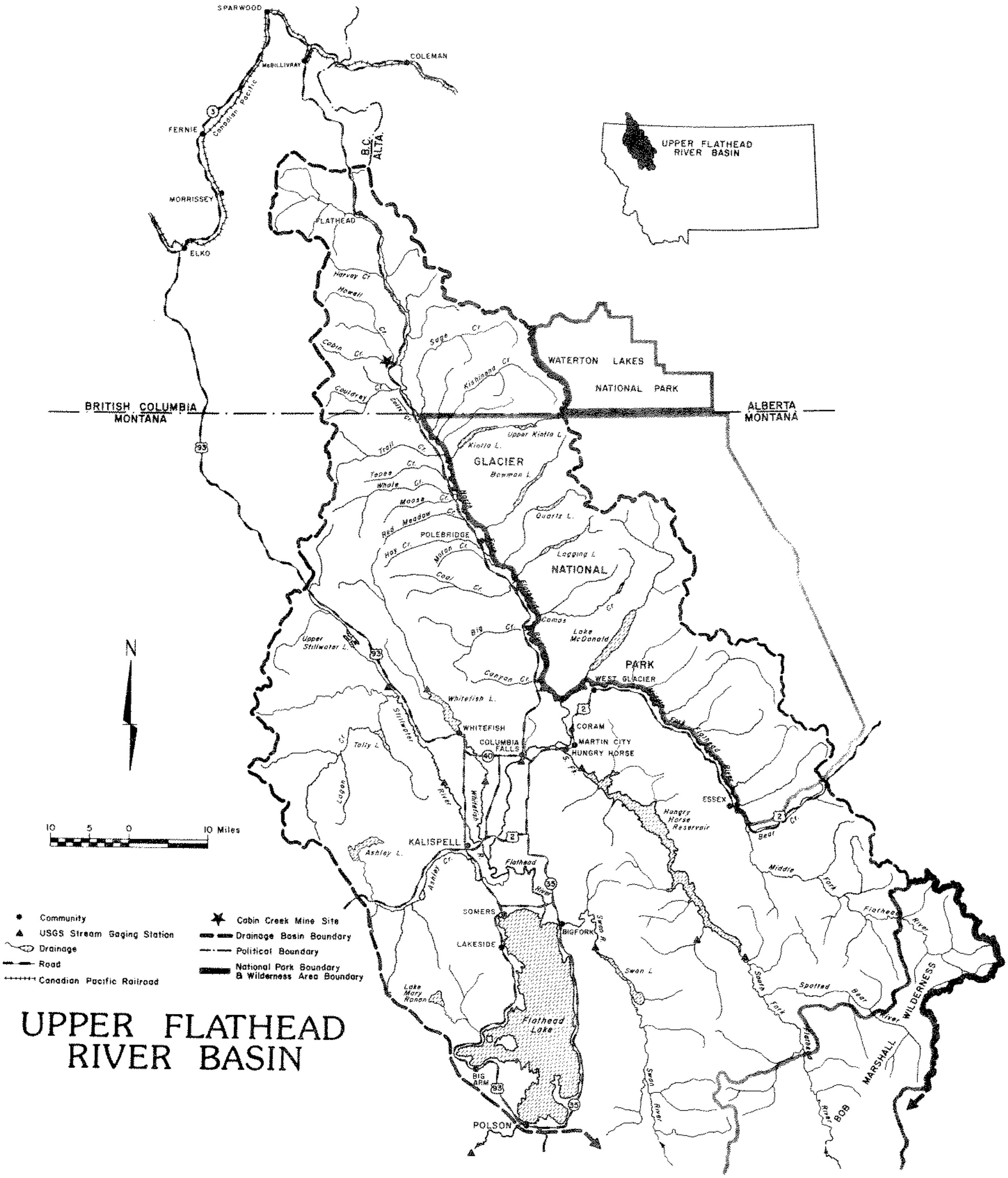


Figure 1. Drainage map of the upper Flathead River Basin (adapted from Mont. Dept. Natural Resources and Conservation, 1977).

Table 1. Discharge (cubic feet per second) and drainage areas of the North and Middle Forks of the Flathead River (U.S. Geological Survey 1977).

Drainage	Drainage area (km^2)	Mean annual flow (cfs)	Maximum flow (cfs)	Minimum flow (cfs)
North Fork near Intl. boundary	1,106	974	16,300	65
North Fork near Columbia Falls	4,009	3,004	69,100	198
Middle Fork near West Glacier	2,922	2,956	140,000	<173

Middle Fork of the Flathead River

The Middle Fork of the Flathead River originates at the confluence of Strawberry and Trail Creeks at the northern end of the Bob Marshall Wilderness along the Continental Divide (Figure 2). From this point it flows in a general northwesterly direction approximately 146km to its point of juncture with the North Fork. A total of 715 meters of elevation are lost along its course which translates to an average drop of 4.9 meters per kilometer. The U.S. Portion of the North Fork drops an average of 2.9 meters per kilometer along its length.

The drainage area of the Middle Fork ($2922km^2$, Table 1) is only 73 percent as large as that of the North Fork yet their average annual discharges are quite similar; 2956 and 3004 cfs (cubic feet per second) respectively. The maximum flow of 140,000cfs observed on the Middle Fork on June 9, 1964 is more than twice as large as that observed on the North Fork which is 69,100 cfs on June 4, 1964. These record flows constituted the infamous 1964 flood which caused an estimated 28.4 million dollars damage to the upper Flathead Valley (USDA, Forest Service 1964). The Middle Fork was particularly hard hit by the flood which was calculated to have a recurrence interval of 200 years, versus 100 years for the North Fork. Middle Fork creeks and the river itself were heavily scoured. An average of 26.7cm of rain fell during June 7 and 8 on a higher than average snowpack (USDA, Forest Service 1964).

The section of the Middle Fork above Bear Creek is referred to as the upper Middle Fork (Figure 2) and was classified as a Wild River under the Wild and Scenic Rivers act in 1976. This upper portion drains areas of the Bob Marshall and Great Bear Wildernesses and is primarily roadless. With the exception of the basin-like area around Schafer Meadows, this portion of the river is deeply entrenched and has many steep sidewalls whose erosion was accelerated by the 1964 flood. Tributaries entering this section of river are numerous and have smaller drainage areas than their North Fork counterparts. The Lewis and Clark Range of the Rocky Mountains which form the Continental Divide along the east side of the upper Middle Fork and the Flathead Range on the west are generally 2128 to 2432m in height.

The lower Middle Fork displays a similar pattern of entrenchment in many areas and is classified as a recreational river. The northeast side of this reach drains the previously mentioned Livingston Range and forms a large portion of the southern boundary of Glacier National Park. Tributaries draining the park are large and similar to North Fork tributaries although in general they lack the large fjord-type lakes, with the exception of McDonald and Harrison Creeks. Tributaries draining the Flathead Range on the southwest side of the lower Middle Fork are high gradient mountain streams.

Montana Department of Fish, Wildlife and Parks research on the Middle Fork during 1979 was concentrated in the upper river itself and the tributaries to the upper river downstream from Schafer Meadows.

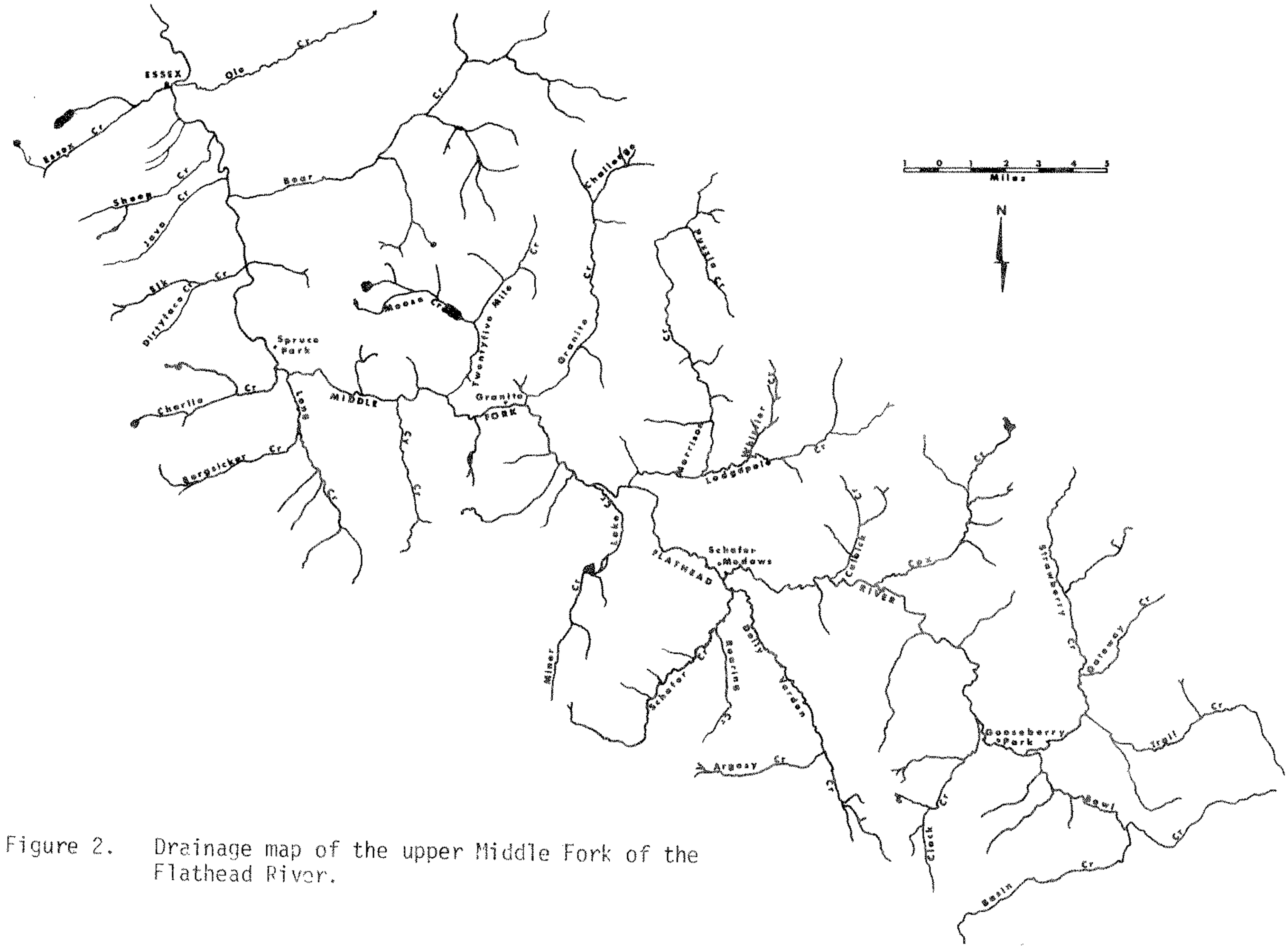


Figure 2. Drainage map of the upper Middle Fork of the Flathead River.

Geology

Most of the upper Flathead River Basin is underlain by Precambrian argillite, quartzite and carbonate rocks (Johns 1963). In a more recent publication, Johns (1970) presented complete geological maps of Flathead County. These maps include all of the North and Middle Fork drainages with the exception of those portions lying in Glacier National Park. United States Geological Survey personnel are currently mapping the area within Glacier Park (Al Martinson, soil scientist for the Flathead National Forest, personal communication).

A major fault called the Lewis Overthrust extends through much of the upper Flathead Basin and is responsible for layers of very old Precambrian rocks thousands of feet in thickness overlying limestones, dolomites, shales and sandstone of the more recent Paleozoic and Mesozoic eras. This fault passed through the upper portion of the upper Middle Fork and has resulted in a distinctly different geological pattern in this portion of the drainage. Fisheries investigations planned for 1980 in creeks draining this area should aid in addressing the complex relationship between drainage geomorphology and fish habitat suitability.

Water Quality

Existing Water Quality Information

During the past decade a large amount of water quality information regarding the North Fork of the Flathead River and its tributaries has been collected (Table 2). Most of the major tributaries in the United States portion of the drainage have been examined by either the Flathead Drainage 208 Project (1976) or by the U.S. Fish and Wildlife Service (1977). The 208 study represents the most intensive survey performed to date.

As has been pointed out by Stanford et al (1979) creeks draining the large lakes on the Glacier Park side of the North Fork are noticeably less well buffered and exhibit lower values for standard conductance and total dissolved solids than do their counterparts on the west side of the river. The large pristine lakes within the park are commonly referred to as sinks which trap many of the biologically important chemical constituents of water.

The North Fork itself is characterized by Nunnallee (1976b)as having a mildly alkaline bicarbonate water with low nutrient levels; phosphorus concentrations are frequently below the limits of detectability. Values for specific conductance were found to range 30 percent annually around a mean of 205 micromhos$\cdot$cm^{-1}, total dissolved solids average 155mg$\cdot\ell^{-1}$ and alkalinity ranges between 65 and 129mg$\cdot\ell^{-1}$ as $CaCo_3$.

Information concerning the water quality of tributaries to the Middle Fork is virtually nonexistent with the exception of McDonald Creek (Table 3). Two sets of data exist (Nunnallee 1976 and Flathead Drainage 208 Project 1976) which allow direct comparison between North and Middle Fork physiochemistry at points near their confluence. The chemical and physical

Table 2. Sources of information concerning water quality of the North Fork of the Flathead River and its tributaries

Sampling station	Year(s)	Number sampling dates	Information source
River at Columbia Falls	1972 & 1973	15	Nunnallee (1976a)
River at Polebridge	1975 & 1976	12	Flathead Drainage 208 Project (1976)
River at Polebridge	1978 & 1979	11	Stanford et al. (1979)
12 tributaries within Flathead Ntl. Forest	1975 & 1976	12	Flathead Drainage 208 Project (1976)
Whale Creek	1977	6	U.S. Forest Service records
Whale Creek	1978 (2 stations)	5	U.S. Forest Service records
Whale Creek	1979 (2 stations)	4	U.S. Forest Service records
Red Meadow Creek	1978	7	U.S. Forest Service records
Red Meadow Creek	1979 (2 stations)	8	U.S. Forest Service records
Big Creek	1978	6	U.S. Forest Service records
Big Creek	1979 (2 stations)	8	U.S. Forest Service records

Table 3. Sources of information concerning water quality of the Middle Fork of the Flathead River

Sampling station	Year(s)	Number sampling dates	Information source
River near West Glacier	1972 & 1973	15	Nunnallee (1976)
River near West Glacier	1975 & 1976	12	Flathead Drainage 208 Project (1976)
River at Walton	1978 & 1979	17	Stanford et al (1979)
River at Schafer Meadows	1977 & 1978	4	Montana State Dept. Health
McDonald Creek	1977	2	U.S. Fish and Wildlife Service (1977)
McDonald Creek	1978 & 1979	23	Stanford et al (1977)
Schafer Creek	1973	1	Montana State Health Dept.
Schafer Creek	1974	1	Montana State Health Dept.

chacteristics of waters from each drainage are quite similar although Middle Fork values for standard conductance, total dissolved solids, alkalinity and hardness are generally 2 to 10 percent lower than those of the North Fork.

Temperature and Flows in North Fork Tributaries

Monthly summaries of temperature information obtained for selected North Fork tributaries during 1977, 1978 and 1979 are presented in Tables 4 through 6. Results from 1977 are based on solely maximum-minimum thermometers checked daily whereas 1978 and 1979 data are from seven-day continuous recording thermographs or daily maximum-minimum thermometer readings.

With few exceptions, maximum summer water temperatures in North Fork tributaries were attained during August. Creeks draining west side of the river generally reached maximum temperatures of 16-18^{o}C (61-66^{o}F) and mean monthly maximum temperatures exceed 10^{o}C (50^{o}F) only during the months of July, August and September.

Bowman Creek represents a typical creek draining a large lake on the east side of the North Fork and exhibited uniformly higher water temperatures than west side tributaries (Table 6). Maximum water temperatures on east side tributaries exceeded 24^{o}C (76^{o}F) as was found in Camas Creek in August of 1978 (Table 5). Elevated water temperature in several park streams draining large lakes presumably accounts for the anomalous presence of riverine-type benthic invertebrates (Stanford et al 1979) and tolerant fish species such as the largescale sucker (*Catostomus macrocheilus*) (U.S. Fish and Wildlife Service 1977).

Water levels of nine west side North Fork tributaries were monitored during 1978 and 1979 via placement of permanent gauges at or near the point where creeks cross the North Fork Road. Stream gauges were read weekly and the results are depicted in Figures 3 through 7. Stream discharges were measured at high and low water using a Price current meter and the results appear in Table 7. Current velocity measurements were taken at 0.4 of the total depth (from the bottom) at two-foot intervals across the channel of large streams or at four equally spaced points across small tributaries.

At the present time gauge height readings can not be transposed to discharge values due to a lack of discharge data during periods of intermediate flow. However, the gauge height information does appear to adequately represent seasonal flow fluctuations. The water levels of most tributaries rose rapidly in April, attained maximal values between mid-May and mid-June then declined swiftly to relatively stable levels by August 1 (Figures 3 through 7). This pattern agreed closely with flow curves presented in Delk (1972) for the North and Middle Fork Rivers. Gauge height readings also indicate that 1978 flows were higher than those of 1979 (Figures 3 through 7).

Autumn discharge data for most of the larger Canadian tributaries to

Table 4. Monthly averages of minimum and maximum water temperatures (°C) in the North Fork tributaries during 1977.

Month Water temperature 1/	Big Creek 2/	Coal Creek 3/	Red Meadow Creek 4/	Whale Creek 5/	Trail Creek 6/	Akakola Creek 7/
July						
Mean minimum	8.1	9.4	11.1	8.3	6.7	10.6
Mean maximum	15.0	15.0	16.1	13.3	13.3	16.1
Range	5.0-17.8	5.0-17.8	8.9-17.8	5.6-16.7	4.4-16.7	8.9-18.9
August						
Mean minimum	8.9	8.9	11.1	8.3	7.8	10.0
Mean maximum	15.0	15.0	16.7	12.8	14.4	15.6
Range	7.2-18.3	5.6-17.8	5.6-18.9	5.6-15.6	6.1-16.7	6.7-18.9
September						
Mean minimum	6.7	6.7	7.8	5.6	3.9	7.2
Mean maximum	10.6	10.6	11.7	9.4	5.6	11.1
Range	5.0-13.3	5.6-13.3	5.6-14.4	4.4-13.3	1.1-7.8	6.1-13.3
October						
Mean minimum	3.3	3.3	2.2	2.8	3.9	--
Mean maximum	6.7	7.2	6.7	6.1	5.0	--
Range	2.2- 7.8	2.2- 8.3	0.6- 8.9	1.1- 6.7	2.8- 5.6	--

1/ Data collected using minimum-maximum thermometers

2/ In: July 6 - out: October 20

3/ In: July 5 - out: October 20

4/ In: July 6 - out: October 20

5/ In: July 7 - out: October 20

6/ In: July 8 - out: October 14

7/ In: July 8 - out: September 24

Table 5. Monthly averages of minimum and maximum temperatures (^{o}C) in the North Fork tributaries during 1978.

Month Water temperature	Big Creek[1/]	Coal Creek[2/]	Whale Creek[3/]	Trail Creek[4/]	Camas Creek[5/]	Ford Creek[6/]	Kishenehn Creek[7/]
May							
Mean minimum	5.6	3.9	4.4	3.9	--	--	--
Mean maximum	6.7	4.4	6.1	5.0	--	--	--
Range	4.4- 8.3	3.9- 4.4	3.3- 8.3	3.3- 6.1	--	--	--
June							
Mean minimum	7.2	6.1	6.7	5.0	--	--	--
Mean maximum	10.0	6.1	8.3	7.2	--	--	--
Range	5.6-13.3	3.9- 8.3	5.0-11.1	3.9-10.0	--	--	--
July							
Mean minimum	10.6	8.3	8.9	7.2	--	8.3	--
Mean maximum	13.9	10.0	11.7	12.2	--	12.2	--
Range	8.3-17.8	7.8-16.1	7.2-14.4	5.6-15.0	--	6.7-14.4	--
August							
Mean minimum	10.6	8.3	8.9	6.7	13.3	--	8.9
Mean maximum	13.9	12.8	11.7	8.9	20.0	--	12.2
Range	7.2-18.3	6.1-17.2	6.7-15.0	4.4-14.4	11.1-24.4	--	6.7-17.2
September							
Mean minimum	8.9	6.7	7.8	6.1	13.9	--	--
Mean maximum	11.1	10.0	9.4	8.9	17.8	--	--
Range	6.1-13.9	3.3-13.9	4.4-12.8	3.9-12.2	11.1-18.9	--	--
October							
Mean minimum	5.6	4.4	--	3.9	--	--	--
Mean maximum	7.2	6.1	--	7.2	--	--	--
Range	3.3- 9.4	3.3- 8.9	--	2.8- 8.3	--	--	--

Table 5. Continued

1/ Thermograph - in: May 10 - out: October 28

2/ Thermograph - in: May 30 - out: July 13

3/ Thermograph - in: May 10 - out: September 30

4/ Thermograph - in: May 10 - out: October 27

5/ Minimum-maximum thermometer - in: August 6 - out: September 8

6/ Minimum-maximum thermometer - in: July 12 - out: July 29

7/ Minimum-maximum thermometer - in: August 8 - out: August 31

Table 6. Monthly averages of minimum and maximum water temperatures (°C) in the North Fork tributaries during 1979.

Month / Water temperature	Big Creek 1/	Coal Creek 2/	Hay Creek 3/	Red Meadow Creek 4/	Trail Creek 5/	Bowman Creek 6/	River Trap 7/
May							
Mean minimum	3.9	4.1	--	4.4	5.0	4.4	--
Mean maximum	6.7	7.2	--	6.7	5.0	6.7	--
Range	3.3- 7.8	3.3- 8.3	--	3.9- 7.2	4.4- 6.7	3.3-10.0	--
June							
Mean minimum	6.1	6.1	--	6.7	5.0	9.4	--
Mean maximum	8.9	8.9	--	9.4	5.6	11.1	--
Range	3.9-13.3	4.4-12.2	--	4.4-12.2	3.3-12.2	7.2-15.6	--
July							
Mean minimum	8.9	8.3	8.3	10.0	6.1	14.4	--
Mean maximum	13.3	13.3	6.7	12.8	12.2	16.1	--
Range	5.6-16.7	5.0-15.6	6.7-15.6	6.7-15.0	5.0-15.6	11.1-18.3	--
August							
Mean minimum	10.1	8.3	--	10.6	7.2	15.0	--
Mean maximum	14.4	13.9	--	13.3	13.3	17.2	--
Range	8.9-16.1	7.8-15.6	--	10.0-14.4	6.1-15.6	14.4-21.1	--
September							
Mean minimum	8.9	5.6	--	8.3	6.1	13.3	8.3
Mean maximum	10.6	11.7	--	10.6	11.1	13.9	12.8
Range	8.9-11.7	2.8-15.6	--	6.7-12.2	4.4-13.3	11.1-15.6	7.2-13.3
October							
Mean minimum	--	3.9	--	5.6	4.4	8.3	5.6
Mean maximum	--	6.7	--	6.7	6.7	8.9	10.6
Range	--	2.8- 8.3	--	2.2- 8.9	2.2-10.6	6.7-11.1	3.3-14.4

Table 6. Continued

Month Water temperature	Big Creek 1/	Coal Creek 2/	Hay Creek 3/	Red Meadow Creek 4/	Trail Creek 5/	Bowman Creek 6/	River Trap 7/
November							
Mean minimum	--	1.1	--	2.2	2.8	--	--
Mean maximum	--	1.7	--	3.3	3.3	--	--
Range	--	0.6- 2.2	--	2.2- 3.3	2.2- 3.9	--	--

1/ Thermograph - in: May 17 - out: August 23; in: September 1 - out: September 6

2/ Thermograph - in: May 17 - out: October 20; in: November 1 - out: November 6

3/ Minimum-maximum thermometer - in: July 3 - out: July 24

4/ Thermograph - in: May 17 - out: November 7

5/ Thermograph - in: May 17 - out: November 7

6/ Thermograph - in: May 17 - out: October 25

7/ Minimum-maximum thermometer - in: September 23 - out: October 12

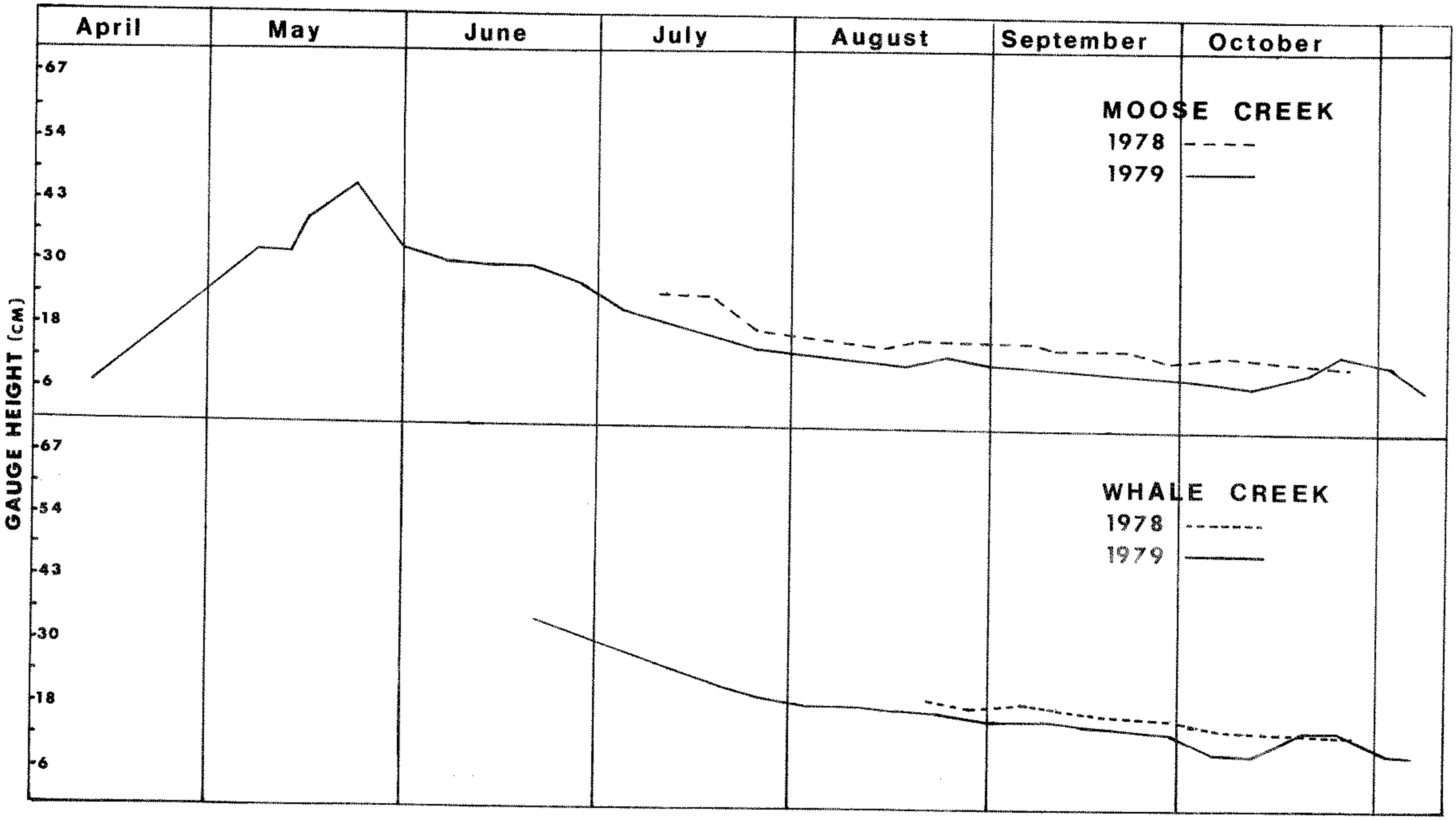


Figure 3. Seasonal water level fluctuations in Moose & Whale Creeks during 1978 and 1979

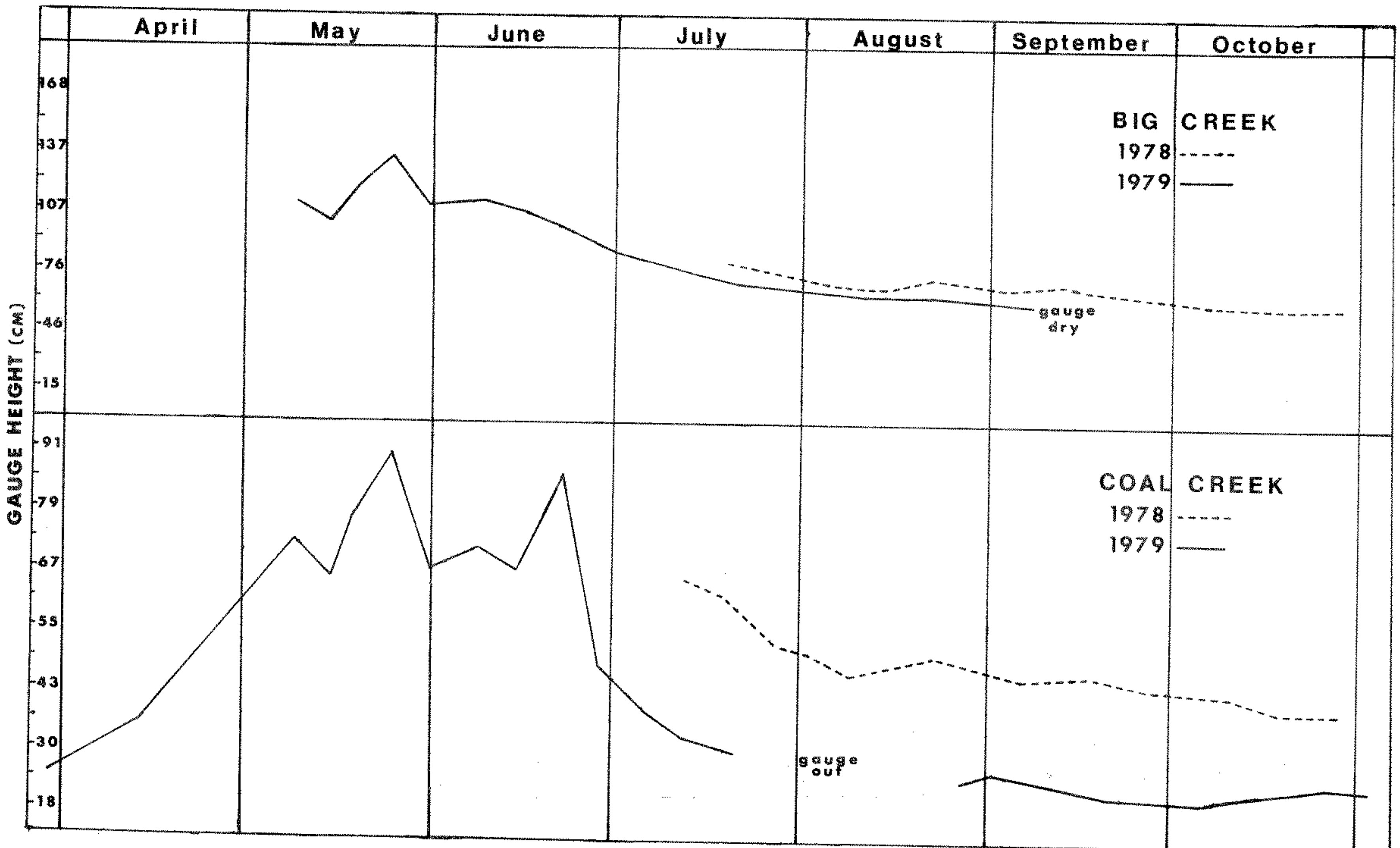


Figure 4. Seasonal water level fluctuations in Big and Coal Creeks during 1978 and 1979

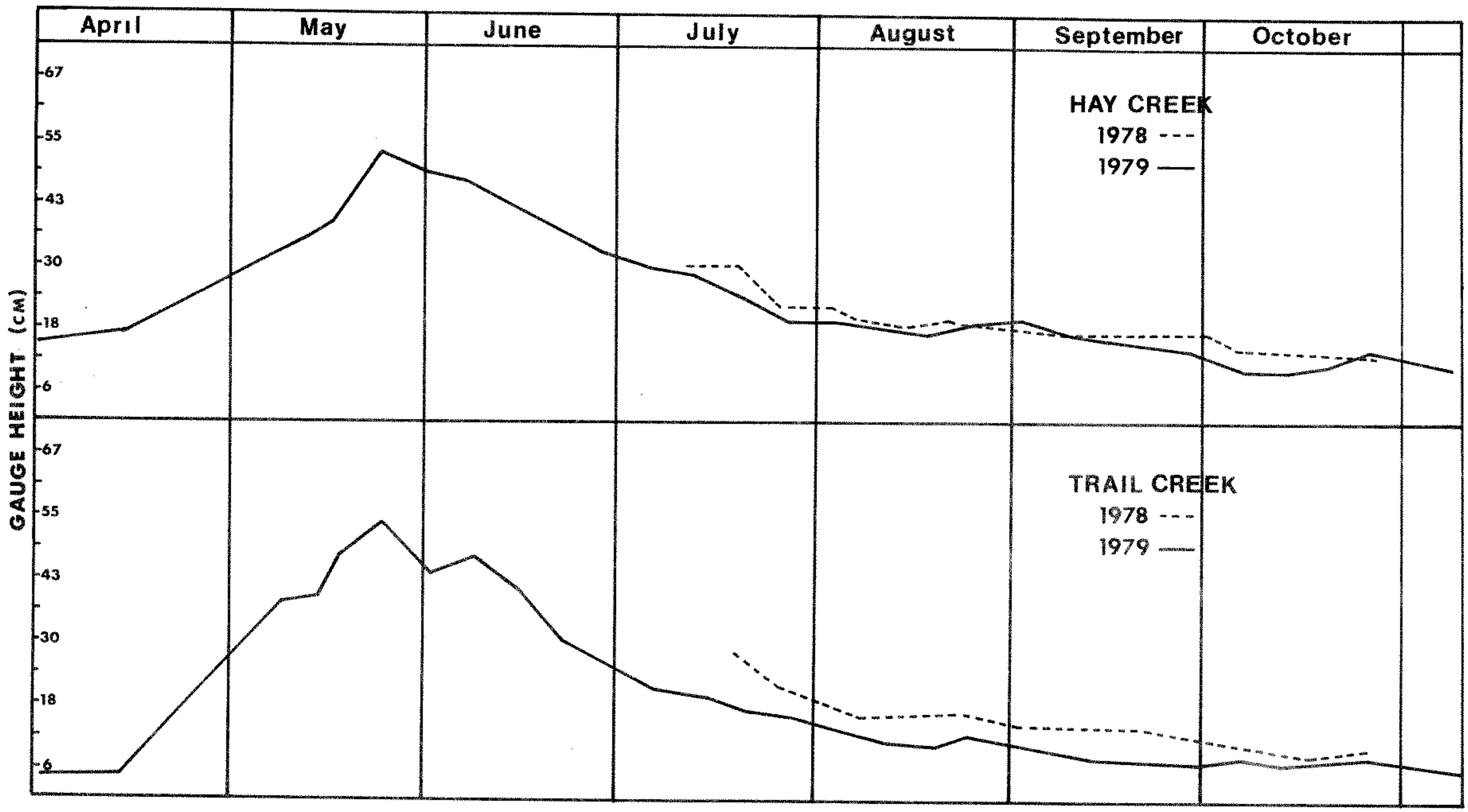


Figure 5. Seasonal water level fluctuations in Hay and Trail Creeks during 1978 and 1979

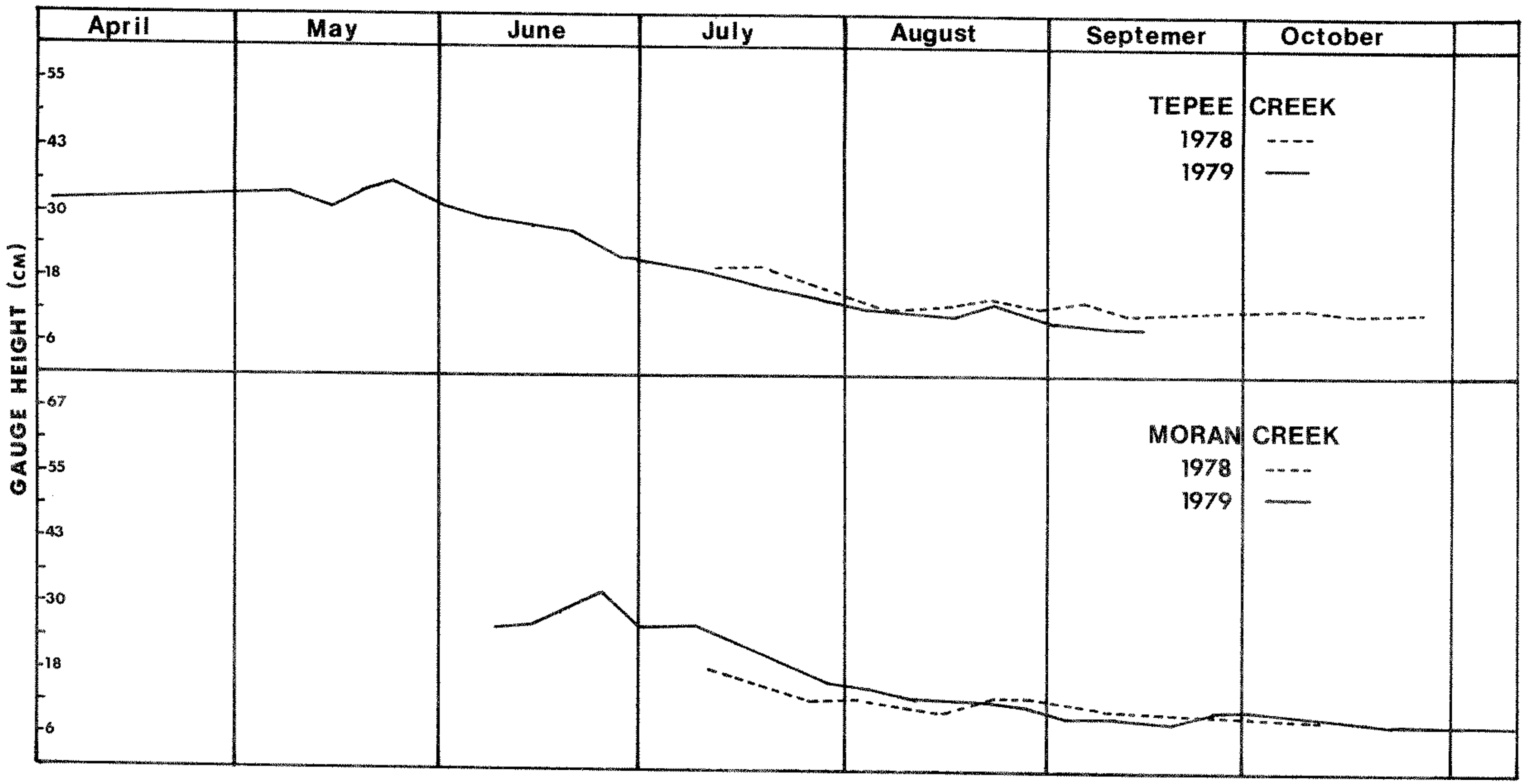


Figure 6. Seasonal water level fluctuations in Tepee and Moran Creeks during 1978 & 1979

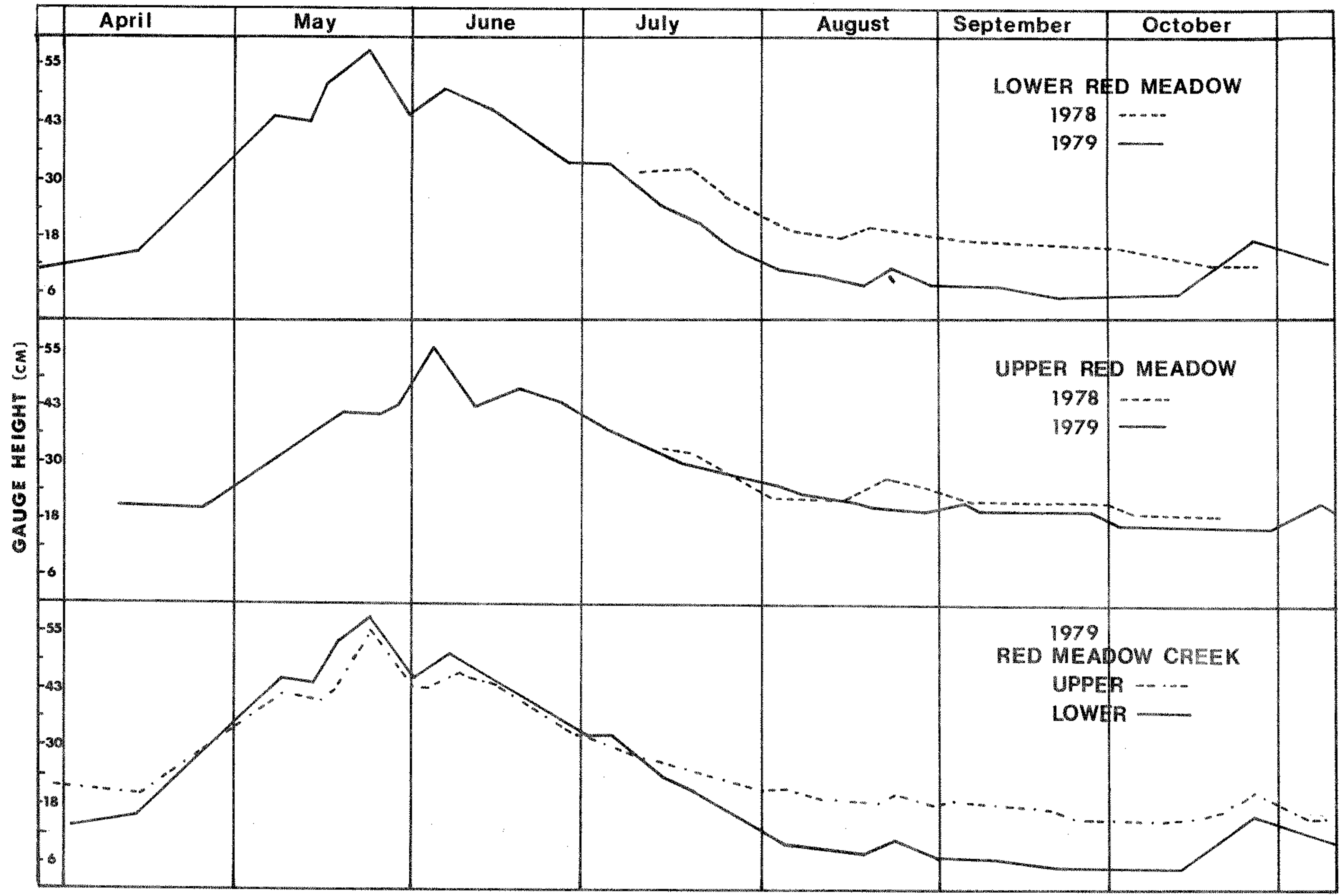


Figure 7. Seasonal water level fluctuations in upper & lower Red Meadow Creek during 1978 & 1979 & comparison between upper & lower gauge height readings during 1979

Table 7. High and low discharge for 1979 in North Fork tributaries. All measures were taken near the North Fork road bridge.

Drainage	High water 1/			Low water		
	Date	Discharge(cfs)	Gauge height(cm)	Date	Discharge(cfs)	Gauge height(cm)
Big Creek	6/30	886.1 2/	116	10/25	39.0	dry
Coal Creek	5/17	none	82	10/25	36.6	34
Moran Creek	5/24	89.8	37	10/25	5.7	12
Hay Creek	6/ 7	179.9 2/	46	10/25	25.4	15
Red Meadow Creek	5/14	153.2	43	10/25	18.1	15
Moose Creek	5/17	75.1	40	10/25	55.3	15
Whale Creek	5/17	206.7	43	10/25	37.3	15
Teepee Creek	5/14	22.2	34	10/25	1.2	__3/
Trail Creek	5/14	295.4	40	10/25	33.4	9

1/ Peak flow occurred sometime between May 14, 1979 and May 31, 1979.

2/ Flows were obtained from Forest Service records.

3/ Forest Service built a gabion just below the gauge, raising water levels. The gauge heights were therefore uncomparable and not used.

to the North Fork are presented in Table 8. It is important to note that the combined discharge of Cabin and Howell Creeks (39.6cfs) constitutes nearly one-third of the total flow of the North Fork (130.5cfs) at that point.

Fish Species

There are at least 22 fish species present in the Flathead River upstream from Flathead Lake and in Flathead Lake (Table 9). Several coolwater fish species have been introduced into the drainage and have maintained populations in sloughs along the lower river and to some degree in Flathead Lake. Possibly the most important introduction was kokanee salmon (*Oncorhynchus nerka*) officially planted in Flathead Lake in 1935. However, introductions may have been as early as 1916 (Hanzel 1970)

The most common species in the North and Middle Forks of the Flathead River are native and include bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Salmo clarki lewisi*), mountain whitefish (*Prosopium williamsoni*), slimy sculpin (*Cottus cognatus*) and mottled sculpin (*Cottus bairdi*). Largescale suckers (*Catostomus macrocheilus*) have also been collected in large numbers in some streams. Sucker fry were collected in several side channels to the North Fork as far upstream as Red Meadow Creek during July and August, 1979. However, no suckers were collected in three nights of electrofishing in the main river during July 1979. Suckers concentrate in the lower ends of some streams draining large lakes from Glacier National Park, probably related to the warmer temperatures.

Kokanee salmon are abundant in the Flathead River from September through November and create a popular snagging fishery (Hanzel 1977). Concentrations of kokanee were also observed this fall in the North Fork near the mouths of several streams draining large lakes (S. McMullin, MT. Dept. of Fish, Wildlife and Parks, personal communication). A large run of kokanee occurs in McDonald Creek,downstream from McDonald Lake,each fall and kokanee also spawn in springs at Nyack Flats on the lower Middle Fork. Survival of kokanee eggs is dependent on the minimum water temperature during incubation. Those eggs which hatch successfully will obviously produce fish which will home to the areas as adults to spawn again.

Bull trout are widely distributed in the Flathead River drainage and are an important trophy sport fish. Most of the life history data presently available on this fish is for the coastal Dolly Varden and is not necessarily useful for comparison in this drainage. The question of taxanomic classification of the bull trout or Dolly Varden has resurfaced. Cavender (1978) determined through comparisons of morphometric, meristic, osteological, and distributional information that the species, *Salvelinus malma* (Walbaum) should be split into two species *S. malma and S. confluentus* . *Salvelinus malma* would be called Dolly Varden, at least officially and *S. confluentus* the bull trout. Such a change is proposed by the American Fisheries Society (Reeve Bailey, University of Michigan, personal communication in 1979).

Table 8. Discharge and location of several Canadian streams in the North Fork drainage on September 27, 1979.

Drainage - location	River kilometers	Discharge(cfs)
McLatchie Creek	159	6.4
North Fork below McLatchie	158	9.1
Squaw Creek	156	3.9
Pollock Creek	148	2.6
Harvey Creek	136	2.3
Howell Creek	108	22.4
Cabin Creek	111	11.2
Confluence of Cabin and Howell	111	39.6
North Fork below Cabin and Howell	108	130.5
Cauldrey Creek	101	18.3
Sage Creek	92	2.2

Table 9. A list of fish species in Flathead Lake and Flathead River upstream from Flathead Lake and their relative abundance: C - common, U - uncommon, and R - rare.

Fish species	Abundance: Flathead River	Abundance: Flathead Lake
Cutthroat trout		
Westslope (Salmo clarki lewisi)	C	C
Yellowstone (Salmo clarki bouvieri)	R	R
Bull trout (Salvelinus confluentus)	C	C
Rainbow trout (Salmo gairdneri)	U	R
Brook trout (Salvelinus fontinalis)	R	R
Lake trout (Salvelinus namaycush)	R	C
Kokanee (Oncorhynchus nerka)	C*[1/]	C
Lake whitefish (coregonus clupeaformis)	C*	C
Pygmy whitefish (Prosopium coulteri)	C*	C
Mountain whitefish (Prosopium williamsoni)	C	U
Arctic grayling (Thymallus arcticus)	R	-
Slimy sculpin (Cottus cognatus)	C	R
Shorthead sculpin (Cottus confusus)	?	-
Mottled sculpin (Cottus bairdi)	C	-
Longnose sucker (Catostomus catostomus)	U	C
Largescale sucker (Catostomus macrocheilus)	C	C
Peamouth (Mylocheilus caurinus)	C	C
Northern squawfish (Ptychocheilus oregonensis)	C	C
Northern pike (Esox lucius)	R[2/]	R
Redside shiner (Richardsonius balteatus)	R[2/]	C
Largemouth bass (Micropterus salmoides)	R[2/]	U
Pumpkinseed (Lepomis gibbosus)	R[2/]	R
Yellow perch (Perca flavescens)	R[2/]	C
Black bullheads (Ictalurus melas)	R[2/]	R

1/ * refers to seasonal abundance

2/ common in some sloughs along the lower river

Major differences between *S. malma* and *S. confluentus* were in the cranium and are possibly adaptations to their different food and feeding habits (Cavender 1978). *S. confluentus*, primarily a freshwater species, is more predacious than its coastal, anadromous counterpart. The bull trout is widely dispersed east and west of the Continental Divide in Canada, although its distribution east of the Divide is limited to the Saskatchewan River drainage in Montana.

Westslope cutthroat trout are also distributed widely in the Flathead River drainage and provide a summer and fall fishery in the rivers. Behnke (1979) presents a good review of information and status of the westslope cutthroat. Westslope cutthroat trout are found both east and west of the Continental Divide through northern Idaho, western Montana, southern Alberta and part of British Columbia and Saskatchewan (Behnke 1979). The natural range of the Yellowstone cutthroat (*S.c. bouvieri*) is the Yellowstone River drainage, northern Wyoming and the upper Snake River drainage.

Yellowstone cutthroat have been introduced in the Flathead River drainage and are present in several lakes. Limited hybridization has been found between *S. c. lewisi* and *S.c. bouvieri* (L. Marnell, personal communcation Glacier National Park, 1980). Yellowstone cutthroat were seldom collected by Department personnel in North Fork tributaries. In the remaining text every reference to cutthroat trout is to *S.c. lewisi* unless otherwise stated.

Little is known about specific aspects of sculpin life history, habitat requirements and population dynamics in the Flathead River system. Taxonomists disagree on species identification in the drainage as well. Measurements were made on preserved field specimens collected in the North and Middle Forks and their tributaries. Twenty measurements were taken based on key characteristics described in the literature (Bailey and Bond 1963, Brown 1971, McAllister and Lindsey, 1959, McAllister 1964, Scott and Crossman 1973). Results will be compared with different phenological characteristics observed on live field specimens. Preliminary data indicates that three species may occur in the drainage including *Cottus bairdi* (mottled sculpin), *C. confusus* (shorthead sculpin) and *C. cognatus* (slimy sculpin).

Bailey and Bond (1963) report that *C. bairdi* do not occur west of the Continental Divide; however, Simpson and Wallace (1979) report that they occur on both sides. *C. confusus* is reported to occur only west of the Continental Divide and were first described by Bailey and Bond (1963), but previously described only as *Cottus sp.* by McAllister and Lindsey (1961). *C. cognatus* is widely distributed in northern North America and exhibits more morphological variation than *C. bairdi* (McAllister 1964).

It has been difficult to differentiate between *C. bairdi* and *C. cognatus* and no single measurement could be used to differentiate the two species. It was even more difficult to differentiate between *C. bairdi* and *C. confusus* and most measurements for *C. confusus* were intermediate to those of the other two species. Work is continuing on species identification.

Land Use Patterns

Land use patterns differ significantly between the Middle and North Fork drainages of the Flathead River. While both forks are designated Wild and Scenic, the Middle Fork is currently less prone to exploitation. Of the 325 kilometers of Middle Fork river frontage, 146km (45%) lie in wilderness areas, 72km (23%)front Glacier National Park, 61km (19%) lie along non-wilderness National Forest and 43km (14%) are privately owned (USDA, Forest Service 1974). In theory then, a maximum of 33 percent of Middle Fork frontage land could possibly be subjected to logging or other commercial development.

At the present time most development on the lower Middle Fork is in the West Glacier and Nyack Flats areas, with most logging occurring on the lower ends of tributaries draining the Flathead range between Essex and the John F. Stevens Canyon. In the upper Middle Fork, logging activities have occurred on the upper Twenty Five Mile, Granite and Morrison Creek drainages (Figure 2).

Although the entire 92km of the east side of the North Fork is protected by virtue of its being part of Glacier National Park, the west side is subject to heavy use. Over one-half the west side frontage is privately owned with the remainder being property of the State of Montana or part of the Flathead National Forest. The two major forces acting upon the North Fork today are logging and private non-logging development. Although lands immediate to the river are spared these impacts, those away from the banks are not.

Mountain pine beetle infestation of lodgepole pine has accelerated timber harvest throughout the North Fork. During 1978 more than 90 million board feet of timber was harvested in Canada and cutting on the U.S. side of the border amounted to over 50 million board feet by all ownerships combined (Ahner, 1978). Much of this salvage cutting is taking place in lower elevations along major streams where important fish and wildlife habitat can be affected. United States logging interests have increased the harvest rate for beetle-killed timber in spite of the fact that the U.S. Forest Service Multiple Use Plan for the North Fork Unit (1974) calls for more conservative cutting rates. Seventeen million board feet of timber is scheduled to be removed in the Ketchikan Creek area of the Trail Creek drainage alone during the next two years. According to the State Forestry report most large scale removal of lodgepole in the U.S. should taper off by mid-1980; however, large scale species cutting of lodgepole will continue in British Columbia for the next several years (Ahner 1978). A Final Environmental Assessment Report concerning the treatment of the beetle epidemic in the Flathead National Forest has been published recently (USDA, Forest Service 1979).

Exploration of the Cabin Creek area in the Canadian portion of the North Fork (Figure 8) during the early 1970's identified economic reserves

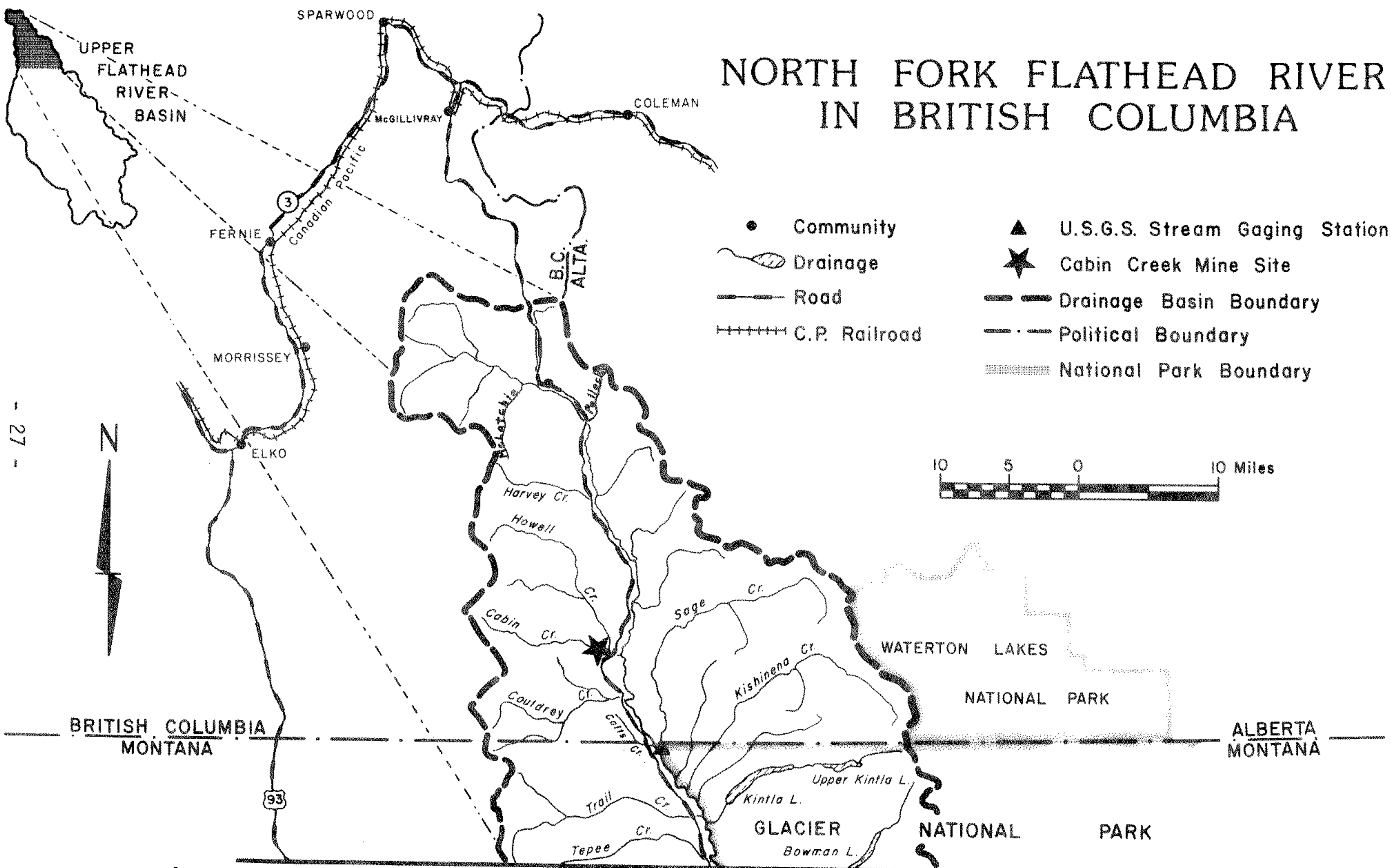


Figure 8. Drainage map of the upper North Fork of the Flathead River (adapted from Mont. Dept. Natural Resources & Conservation (1977)

of 132 million tons of high grade coal suitable for use as a coking coal in the production of steel (Montana Dept. Natural Resources and Conservation 1977). In the process of mining this coal, the Sage Creek Company Ltd. proposes the establishment of two open-pit mines, the creation of a new hill in the Cabin Creek Valley and the elimination of the Cabin-Howell Creek confluence by diverting the latter. The Company also proposes the construction of an on-site coal preparation plant and upgrading the present road system to transport the predicted 1.5 million metric tons of coal produced annually to a nearby railhead. The potential impacts of the proposed project on Flathead Basin water quality and on the spawning and rearing success of migratory salmonids are numerous.

Subdivision of North Fork land is probably increasing more rapidly than on lands along the Middle Fork. Combined effects of subdivision and increased timber harvest can have a severe impact upon the watershed and points to the necessity for instream flow reservations to protect fish and wildlife habitat.

Oil and gas leasing and recreational use affect both the North and Middle Forks. Oil and gas exploration has progressed more rapidly in the North Fork due to its non-wilderness status, but it is becoming increasingly apparent that wilderness classification does not include blanket protection to an area from such exploration and development.

Both the North and Middle Forks provide extensive opportunities for the popular sport of rafting which thrives in the West Glacier area during the summer months. During normal flows the North Fork is floatable for most of the summer (Delk 1972) whereas a popular float on the upper Middle Fork starting at Schafer Meadows becomes marginal in mid-July as runoff rapidly subsides. A preliminary draft of the Flathead Wild and Scenic Management Plan has been recently published by the Forest Service.

METHODS

Electrofishing

Various methods of electrofishing were used during the past season. In March and April, shocking was conducted at night in the lower Flathead River with boat-mounted electroshocking gear. The target species at this time was upstream migrating westslope cutthroat spawners. Fish were held in a live car after capture. Lengths were measured to the nearest 2.5mm, scales were taken below the dorsal fin and above the lateral line, and Floy anchor tags were placed in fish over 25.0cm. Boat shocking generally required three people, a boat operator and two netters.

On the larger North Fork streams such as Trail and Red Meadow Creeks electrofishing involved the use of shore or boat-mounted gas generator and two hand-held electrodes. Fish collected in these tributaries were usually juvenile westslope cutthroat and bull trout less than 30cm.

At least five people were needed for this operation. In small tributaries, two meters or less in width, such as Langford Creek, a gas-powered back-pack shocker was utilized. This lightweight and maneuverable shocker was effective in small channels and only two people were required for this operation.

Electrofishing during 1979 served several purposes. Large numbers of fish could be collected and marked either by cold-branding or tagging. By periodically shocking the same sections of stream distribution and movement of juvenile fish could be studied. For example, five sections were sampled on Trail Creek. Each was shocked on three separate occasions in 1979; mid-April, late July and mid-October. Scale samples were taken from most westslope cutthroat and bull trout for age-growth calculations. Electro-fishing was also used in conjunction with snorkeling. After a section was snorkeled a crew came in to compare the relative effectiveness of each census technique.

Underwater Fish Census

Underwater observations of fish have often been used for studying the behavior and density of fish (particularly salmonids) in streams. In streams like those in the upper Flathead River drainage, low conductivity and high water clarity limit the effectiveness of electrofishing. Many researchers have thus resorted to taking underwater counts of fish populations using a single observer (Keenleyside, 1962 , Reed 1967, Pollard and Bjornn 1973, Everest and Chapman 1972). The reproducibility and reliability of such counts was assessed for large streams by Northcote and Wilkie (1963) and for smaller streams by Graham and Seckulich (in preparation).

Representative sections of stream, 120 to 150m long, were selected and fish were counted in each habitat type (pool, riffle, run) by a single observer. Observers wore a wet suit, snorkel and diving mask and counted fish while pulling themselves upstream. Movement upstream was preferred over downstream movement because of increased control of movements and the elimi-nation of bottom disturbances which may alter fish behavior. Location of the observer depended on the width and configuration of the site. Sites more than 10m wide were usually counted on two passes, one along each bank; the observer looked toward mid-stream on each pass. In sites less than 10m wide, counts were made on one pass. When such sites had a symmetric stream bottom and were shallow, the observer positioned himself at mid-stream and counted fish while looking alternately toward each bank.

Good concentration and peripheral vision were essential when fish numbers were large or when the observer's view was obstructed. If the site was deep on one side, the observer positioned himself on the shallow side and looked toward the deeper water. Slight modificaion of these procedures were necessary when fish were hidden by water turbulence, boulders, log jams, algae mats or undercut banks.

Size groups of fish were used to assess the abundance of each age group. Size groups were determined from age and growth and length frequency analysis. Length frequencies of juvenile bull trout were relatively discrete (Figure 9). Age 0 fish were those under 50mm, age I fish were from 50 to 90mm, age II fish were from 90 to 140mm and age III and older fish were over 140mm. Mature adults were over 400mm. Length frequency analysis of juvenile cutthroat trout did not show as distinct a break between age II and age III. Age 0 fish were under 40mm, age I fish were from 40 to 70mm, age II fish from 70 to 130 and age III and older fish over 130mm.

Stream Trapping

Fish trapping was conducted during the field season of 1979 to monitor upstream and downstream movements of juvenile and adult bull trout, cutthroat trout and mountain whitefish. Upstream and downstream traps were placed in Trail and Red Meadow creeks and downstream traps were placed in Hay Creek and the North Fork River (Figure 10).

Low water enhanced the trapping conditions this past summer although there were the usual problems associated with heavy rainfall and leaf buildup. Trapping efficiency improved due to low water conditions and the fact that a smaller-sized wire mesh (13mm square) was used for trap leads compared to 25mm square mesh used in previous years.

Tag Returns

Fish tag return information from 1951 to the present has been put in computer storage. These include data from several studies (Block 1954, Johnson 1961, Hanzel 1966) as well as tag returns from Canadian Fishery Studies. Fish have been tagged with individually numbered plastic jaw tags and Floy anchor tags. Returns have largely been from anglers.

A computer program developed by Graham et al (1980) facilitated sorting the large numbers of tag returns. Data can be sorted by: 1) species, tag type and color, 2.a) species and location of tagging (river and river mile interval) and time of tagging (month and year interval), 2.b) species and location of tagging only, 3.a) species, location of recapture and time of recapture, 3.b) species and location of recapture only, and 4) specific fish by tag type, color and number. The program also calculates distance and direction a fish moved between tagging and recapture locations in one or more rivers.

Redd Measurements

Ten major drainages were surveyed for bull trout redds in the North and Middle Forks during October 1979. Redds were counted and the following parameters measured: length, width, depth, distance to nearest cover and location in the stream. Depth was measured at the approximate level eggs

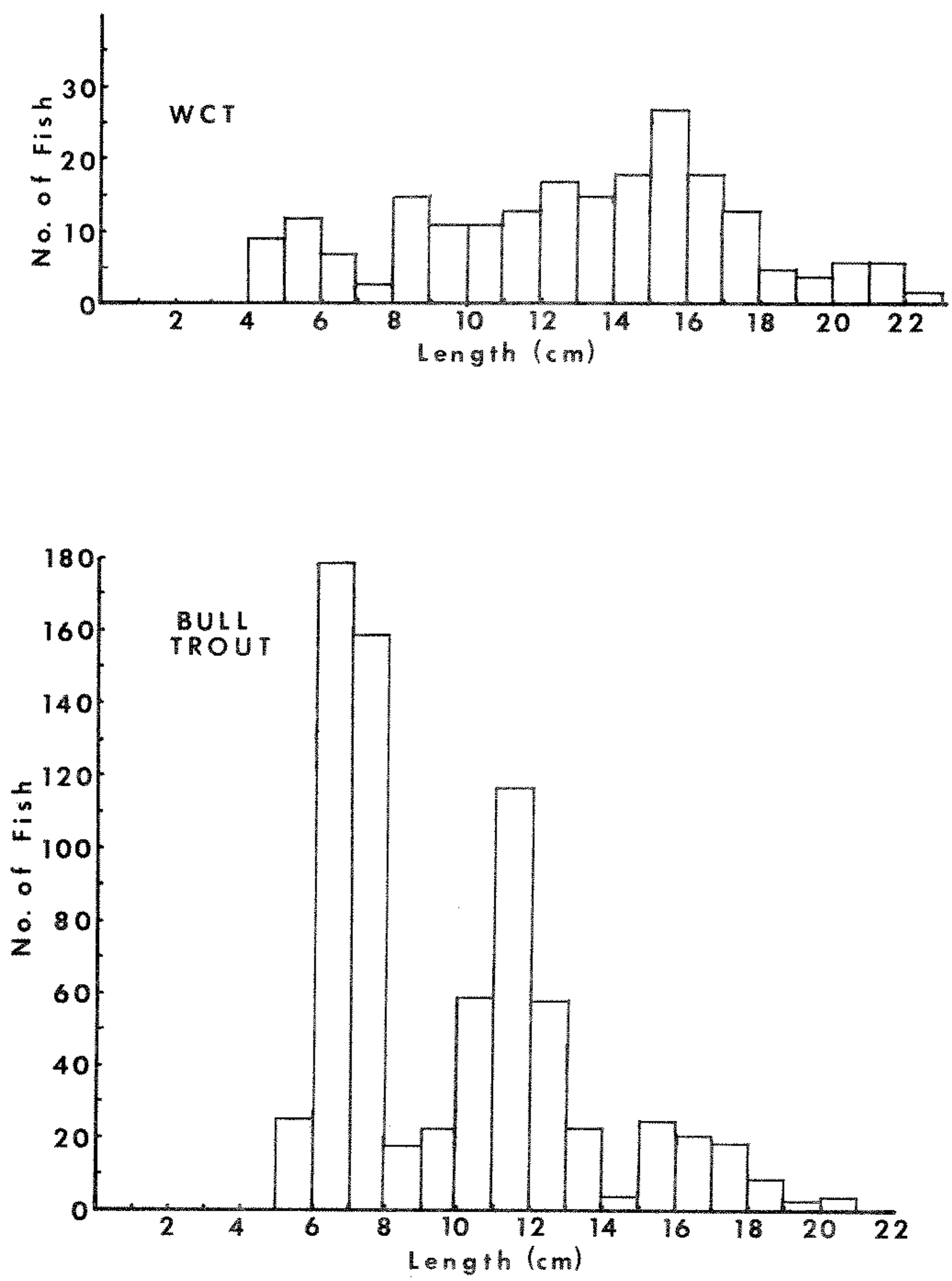


Figure 9. Length frequencies of juvenile bull trout from Trail Creek in the spring of 1979 and for juvenile cutthroat trout from Trail and Red Meadow Creeks in the spring and late fall of 1979.

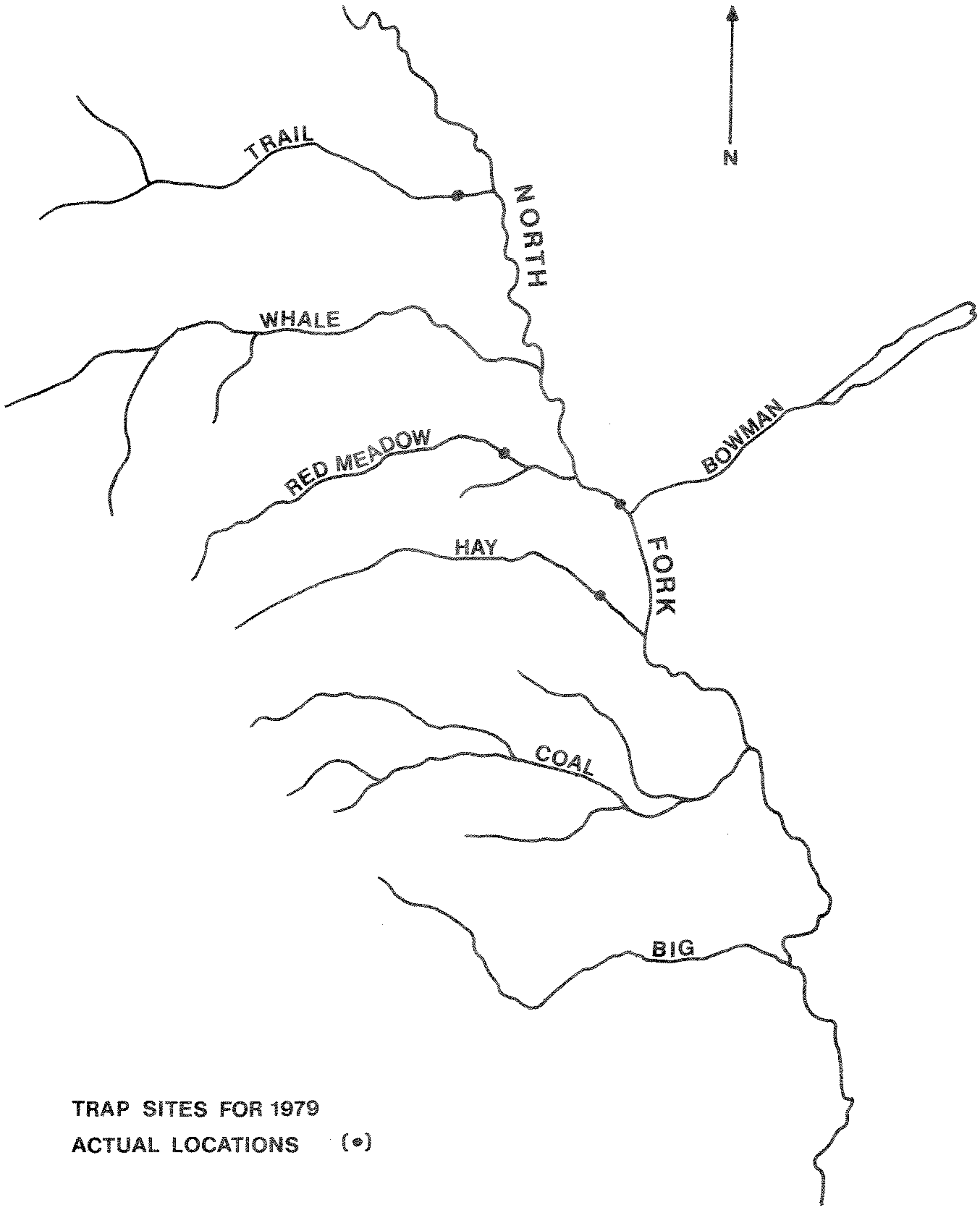


Figure 10. North Fork trap sites for 1979.

would be located in the redd. Five gravel samples from bull trout redds were collected, thoroughly dried and run through a series of graduated sieves to separate particle size. Using either a Pygmy or Price current meter, velocities were determined at the head of a redd. Velocities were determined proportionally 0.4 of the distance from the stream bottom. Areas of numerous redd sites were noted on topographic maps and compared with previous year's findings. An overall index of spawning bull trout distribution and concentrations will result from annual surveys in the upper Flathead drainages.

Habitat Evaluation

Existing stream habitat was inventoried using a modification of a system developed by the Resource Analysis Branch of the British Columbia Ministry of the Environment which has been used in the Canadian portion of the North Fork drainage. It draws upon multidisciplinary knowledge in attempting to describe the various biological and physical factors which interact to form the environment of a particular reach of stream.

Drainages were partitioned into one or more reaches. A reach is defined as a segment within the drainage having distinct associations of stream habitat components. Stream gradient was usually the overriding factor considered in reach delineation as slight gradient changes (on the order of tenths of one percent) were found to noticeably alter channel morphology and bed material composition.

Reaches on all Middle Fork and some North Fork tributaries were identified by survey parties consisting of two or three persons traveling down the stream on foot. During the latter part of the summer, two North Fork drainages (Big and Coal creeks) were surveyed by helicopter prior to ground surveys. This method was a rapid and effective means for delineating reaches and identifying important stream features such as mass wasting areas, zones of debris accumulation, avalanche chutes and potential barriers to fish migration. Important stream features and representative portions of each reach were later checked by ground crews. Representative sections of reaches vary from 1 to 4km in length depending upon the length and uniformity of the entire reach. Discharge was measured using a Gurley Pygmy current meter.

A habitat inventory card was completed by survey crews for each reach or portion of reach surveyed (Figure 11). The extensive abbreviation system developed by the Canadian agency allows a large amount of information and commentary to be effectively recorded on the compact water-resistent cards. Virtually all of the important physical and biological components of the stream are addressed. Major headings include bed materials, stream hydraulics, channel configuration, channel cover, gradient, riparian vegetation, debris load, pool classification, percent pool-riffle-run, bank texture, stream features, substrate embeddedness, abundance of stream biota and fisheries observations. Field personnel carried a 36-page glossary

REACH

Reach No. 1

SYSTEM NAME (or Alias) Yakinikak Creek

SYSTEM NO

Crew J.M. D.R. Agency F.G. Date 79 08 15 (yr mo day) Time

Air Temp 63°F Water temp. 44°F

Access Foot Weather clear

Field Photo Init. D.R. Photo Nos Roll 5 #10-20

Photo Interp Init NTS Sheets

Air Photo (s) Yr Scale

BED MATERIAL

	Ice Scouring	Y ? (N)
	Imbric	Nil (L) M H
C-1	Compac	Nil L (M) H
	Log	Nil (L) M H
	D_{90} (cm)	33

Texture	%
Organic	T
Clay	
Silt	24
Sand	
S. Grav	42
L. Grav	
Cobble	30
Boulder	
Bedrock	T

CHANNEL COVER

Level	% Area	Distr
Crown	30	7
Overhang	20	7

RIPARIAN VEG.

Storey	Sp	Distr
Coniferous	S-1	6
Deciduous	S-2	0
Understorey	S-3	7
Ground	S-4	7

HYDRAULICS

			Meth
C-2	Valley Flat W(m)	40	E
C-3	Chan Width (m)	6	M
C-4	Wet Width (m)	3.4	M
C-5	Slope (%)	4	C1
	Max Depth (cm)	150	M
	Avg Depth (cm)	15	M
	Wet X sec area	.59	M
	Velocity (m/sec)	.43	C2
	Flow (m³/sec)	.22	C2
	Bank (m)	1	M
	Flood Signs Ht		Type
	Scour	Nil L M H	

POOLS

	%	#
C1	<1	1
C2	5	18
C3	6	20
C4	81	250
C5	5	18

DEBRIS

Channel	Nil L M (H)
Stable %	20
Floodplain	Nil (L) M H

BIOTA

C		Sp	Abun
C-11	Aquatic Veg.		H
	Invertebrates		L
	Algae		M

	Stage	Dry L (M) H Fld
	Flow Char.	P S R (B) T
	Valley Chan	0-2 2-5 (5-10) 10+ N/A
C8	Confinement	Ent Conf (Fr) Oc Un N/A
	Pattern	St (Sin) Ir Im Rm Tm
C9	Vert Stab	(Deg) ? Agr N/A
C10	Side Chan	Nil (L) M H
	Turbidity	Nil (L) M H

FEATURE	%
Pool	30
Riffle	50
Run	20

BANK

Form K S

Genetic Mat. F

Texture	%
Organic	20
Clay .004	
Silt .062	35
Sand 2	
S. Grav. 16	20
L. Grav. 64	
Cobble 256	15
Boulder	
Bedrock	10

FISH SUMMARY

C	Species	Use	Ref	Mcp
15	WCT	R, Sc		

C-1 - Compaction increased in lower end of reach up to cemented gravel type in lowest 50 m of reach.
C-2 - At one point valley flat widened to >100m
C-3 - In lower ¼ mile of reach channel narrowed to 2m
C-4 - see C3
C-6 - Flood signs (debris - old channels) lower ¼ mile only
C-7 - Scour lower in upper end - increases markedly in last ¾ mile of stream
C-8 - Confinement frequent - lowest ½ mile entrenched
C-9 - little degradation except last mile
C-11 - much permanently attached moss in stream

S-1 - Alpine fir, spruce, lodgepole pine
S-2 - none taller than 3m
S-3 - menziesia, whortleberry, bedstraw, twinberry, baneberry
S-4 - Equisetum, beargrass, moss, clintonia, pussytoes, mtn. gentian

C-15 - many WCT observed in upper part of reach, ranged in size from 2-10"

IMBEDDEDNESS

Pools <25%	Pools 25-50%	Pools 51-75%	Pools >75%	Riffles <25%	Riffles 25-50%	Riffles 51-75%	Riffles >75%
	X				X		

STREAM FEATURE

C	Type	Ht (m)	Length (m)
15	cascade	10	20
	12 % grade		(C1)
10	side channels		
		—	50
12	Bank		
	Slough	9	15
13	log jam	1	6
14	cascades	2	7

Figure 11. Completed reach card for reach 1 of Yakinikak Creek, tributary to Trail Creek of the North Fork Flathead River drainage.

of terminology published by the Resource Analysis Branch to aid in completing the cards. One significant addition by our group to the Canadian system was the pool rating scheme outlined in Table 10, which is currently being used in Forest Service stream inventories in the Kootenai National Forest. We also included imbeddedness of bed material which is thought to be a particularly important factor in riffle areas.

Fish populations within reaches were sampled by either electrofishing or snorkeling one or more representative sections as described elsewhere in this report. A limited preliminary statistical analysis consisting of simple linear correlation and multiple regression was conducted using only North and Middle Fork snorkel transect information. Relationships between several basic habitat characteristics (pool class, stream width, average depth, surface area, volume, transect elevation, reach number, reach gradient, and width:depth ratio) and the density and abundance of specific age groups of cutthroat and bull trout were tested. A program entitled "MREGRESS" in the Montana State University Statistical Analysis Package (MSUSTAT) was employed in all cases. Electrofishing information was not utilized in the analysis as the degree of comparability between snorkeling and electrofishing results has not yet been clearly defined.

Age and Growth

Juvenile westslope cutthroat and bull trout were collected using stream electrofishing equipment and traps. Fish were handled and data collected as described in a previous section. Scales were taken between the lateral line and dorsal fin on all fish or a large representative sample of fish during each collection. Cellulose acetate impressions of all scales were examined at 67 X magnification.

To obtain back-calculated lengths at annulus, a curvelinear equation was used to describe the total length:anterior scale radius relationship.

$$L = k + n \ln S$$

where:

L = total fish length
S = total scale radius
k = intercept on the ordinate
n = slope

This equation expressed the relationship as well as, or better than, the linear equation (method 2 in Tesh 1971) for both species. The relationships for each species were:

westslope cutthroat trout	$L = 5.2 + 3.3 \ln S$	$R^2 = .74$
bull trout	$L = 6.24 + 3.8 \ln S$	$R^2 = .69$

Lengths of young-of-the-year fish collections and length frequency analysis of juvenile bull trout agreed closely with length at annulus estimates. A

Table 10. Pool rating system used in habitat inventories conducted on North and Middle Fork Flathead River tributaries during 1979.

Parameter	Description	Points
Area	The length or width of the pool is much larger than the average stream width	3
	The length or width of the pool is nearly equal to average stream width	2
	The length or width of the pool is much smaller than the average stream width	1
Depth	The deepest part of the pool is greater than three feet deep	3
	The deepest part of the pool is two to three feet deep	2
	The deepest part of the pool is less than two feet deep	1
Cover	Abundant cover	3
	Partial cover	2
	Exposed	1

Total points		Pool class
8 - 9	=	1
7	=	2
5[1/] - 6	=	3
4 - 5	=	4
3	=	5

1/ The total of five points for class 3 pools must include two points for depth and two points for cover.

random collection of otoliths verified the aging of juvenile bull trout with scales. Analysis of juvenile cutthroat trout data was more complex. In 1978, the predicted fish lengths for each age group were quite variable. Insufficient data was available to assess fish growth using length frequencies. In 1979 we sampled intensively for young-of-the-year cutthroat trout in tributaries to the North Fork. Samples from fry collected from late July into September ranged from 23 to 60mm in length. The average length of fry collected in late fall, early spring and and over winter was 46mm. Three fry collected from Langford Creek in the North Fork on December 12, 1979 were examined for scales. They were dyed in a solution of KOH and Alizarine red. Small scales were observed on the lateral line and on the caudal peduncle of two fish, both 38mm long. A third fry, 43mm long, had a few small scales dorsal to the lateral line. Brown and Bailey (1952) found that scales did not form on the body area we were sampling until the fish were 50 to 63mm long for Yellowstone cutthroat trout.

In assessing our collection from 1979 it was determined that 69 percent of the fish examined were missing their first annulus. The small size of the cutthroat trout at the end of their first growing season was due in part ot late emergence, slow growth, a short growing season or some combination of these factors. At the end of the growing season the scale either has not formed or is too small to show the slow over-winter growth. This occurs in other populations of westslope cutthroat as well (Johnson and Bjornn 1977, G. Oliver, personal communication, B.C. Fish and Wildlife, Cranbrook, 1979).

Taking scales from the caudal peduncle, the area where they first form, reduces the chance of fish having a missing annulus (B. May, Montana Fish, Wildlife and Parks, Libby, 1979). Future collections will be made from that area; however, for this study only those fish with a distinguishable first annulus were used to estimate length at age I.

Because scales were generally small or lacking for young-of-the-year and age I fish, both linear and curvelinear estimates of a length:scale relationship were variable in estimating fish length under 60mm. The curvelinear relationship under-estimated by less than 20 percent the average size of cutthroat trout fry collected in late fall and winter and age I trout collected in the spring. The linear relationship over-estimated their lengths from 30 to 100 percent.

Food Habits

A cursory look at food habits of fishes in the North Fork drainage was conducted during 1978 and 1979. Stomachs were taken from juvenile bull trout, juvenile as well as adult resident westslope cutthroat trout, some mountain whitefish and sculpin. Spring and fall sampling was made using electrofishing, while summer samples were collected using electrofishing and trapping mortalities. Stomachs from the base of the esophagus to the pylorus were placed in labeled vials of either 10 percent formalin or plankton preservative.

Preserved stomachs were emptied and analyzed in the lab. All contents were identified, counted and volumes measured. Insects were identified to order and many to family. Order classifications were used in analysis for the sake of consistency. Insect head capsules were counted to determine numbers. A 50 milliliter self-zeroing buret was used and volumes were measured by displacement with any volume less than .05ml assigned to a trace value of .01. Data was organized by drainage, species and, where sample sizes permitted, by season.

Although no baseline insect studies were conducted simultaneously, some earlier insect information is available through the Flathead 208 Study (1976). Unfortunately,insect availability and food preference of fish could not be compared using existing data.

Stomach contents are expressed in percent number, percent volume, or frequency of occurrence. Several authors have combined two of these values in an effort to reduce the bias of any single method (Tester 1932, Bogorov 1939, Prozhnikov 1955). Recently an index of Relative Importance (IRI) was developed. It combines values from all three analytical tehcniques into an arithmetic mean ranging from 1 to 100. An IRI value of 100 indicates exclusive use of a food item.

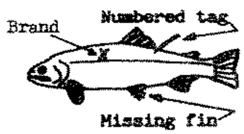
Energy analysis was expressed for each food item as a percentage of the total caloric intake. Total calories were calculated by multiplying the percent volume of each food item by the rate of digestion and caloric value (Alexander and Gowing 1976, McMullin 1980). Caloric values were taken from condensed charts (McMullin 1980, Alexander and Gowing 1976) derived from a recent publication (Cummins and Wuycheck 1971).

Upper Middle Fork Creel Card Survey

A voluntary creel card survey was designed and implemented during the summer of 1979 to obtain information concerning angler utilization of the upper Middle Fork fishery. Card distribution stations were established in early July at the Twenty Five Mile Creek trailhead (USFS Trail 159), Granite Creek trailhead (USFS Trail 156), and at the edge of the Great Bear Wilderness Area near Bear Creek on the Big River Trail (USFS Trail 155). An additional station was installed at the Schafer Meadows airstrip in early September.

Two types of self-addressed postage-paid creel cards were used in the survey. Card type A (Figure 12) was designed primarily for obtaining information on a daily basis whereas type B (Figure 13) was intended for use when trips were in excess of one day. Both types of cards were available at the Bear Creek Station, type B was supplied at the Twenty Five Mile Creek trailhead and type A was available at the Granite Station. In addition, type A cards were supplied to Joe Harper (Wilderness Guard -- Hungry Horse Ranger District) and Don Hauth (Wilderness Ranger -- Spotted Bear Ranger District) who distributed them during the course of their normal duties within the Middle Fork drainage. Cards were corner-clipped to indicate origin.

LOOK FOR ANY OF THESE MARKS:



Note tag color & #, brand symbol, fin clip (fishes' right or left)

MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

FLATHEAD RIVER BASIN CREEL CENSUS

Date ________________

Area Fished __________

____

Number of Anglers _____

Number of Anglers Catching Fish ______

Angler Residence ______

I caught the following fish today:

____
(Town, State)

SPECIES	FISH KEPT		FISH RELEASED	
	NO.	Tag Identification	NO.	Tag Identification
Cutthroat Trout				
Dolly Varden (Bull Trout)				
Whitefish				
Others:				

My fishing was by _____ Boat _____ Shore _____ Both

I fished during these hours (Circle hours fished) Total hours fished _____

Midnight ← a.m. → Noon ← p.m. → Midnight

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

Figure 12. Type A creel card used in the voluntary creel survey conducted on the upper Middle Fork during 1979

LOO FOR ANY OF THESE MARKS:

Note tag color & #, brand symbol, fin clip (fishes' right or left)

ONE CARD PER GROUP

MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS

MIDDLE FORK FLATHEAD RIVER CREEL CENSUS

Date(s) of trip ____________

Number of anglers in party ______

Number who caught fish ______

Number of days in trip ______

CIRCLE DAYS FISHED:

S M T W T F S

CIRCLE GROUP RESIDENCE STATUS:

All Mt. residents All nonresidents Mixed

Total hours fished by group during trip (approx.) ____________

I (we) handled the following fish during the trip:

SPECIES	FISH KEPT		FISH RELEASED	
	NO.	Size Range (inches)	NO.	Size Range (inches)
Cutthroat trout				
Dolly Varden (bull trout)				
Whitefish				
Other:				

My (our) fishing was by _____ Boat _____ Shore _____ Both

CIRCLE AREA(S) FISHED:

Middle Fork above Schafer Middle Fork below Schafer Middle Fork tributaries Other

Figure 13. Type B creel card used in the voluntary creel survey conducted on the upper Middle Fork during 1979.

RESULTS

Trapping

A combined total of 2,695 bull trout, cutthroat trout, grayling and mountain whitefish were caught in the traps. Results of 1979 trapping efforts are compared to previous years in Table 11. All fish were marked with either tags, brands, or fin clips. Trapping results from Trail and Red Meadow creeks are shown on Appendix A, Figures 1 through 6. Because of the small sample size and short trapping period, graphs were not presented for Hay Creek or the North Fork traps.

A partial trap was installed in the North Fork on September 19 and was removed on October 12. Total catch was 22 cutthroat trout (112 - 193mm), 41 bull trout (140-251mm), and 102 mountain whitefish (122-185mm). Downstream migration of juvenile trout appears to occur throughout the summer and into the fall. The Hay Creek trap was installed on July 2 and was removed on July 24. Total catch was 57 cutthroat (197-218mm) and 3 bull trout (145, 211 and 188mm). Fyke nets and minnow traps were used in several tributaries during the high water period from late May to mid-June without results.

Bull Trout

Size and age classes of juvenile bull and cutthroat trout migrating out of Red Meadow and Trail creeks have been compiled (Figures 14 and 15). The majority of emigrating bull trout were age II and III. Comparisons between Red Meadow and Trail creeks show that fish larger than 152mm (mostly age III) made up the largest percentage of emigrating bull trout in Red Meadow Creek whereas fish smaller than 152mm(mostly age II) made up the largest percentage of emigrants in Trail Creek. Growth rates of fish collected by electrofishing were similar in both creeks.

The predominance of larger fish emigrating from Red Meadow Creek may be due in part to the low water year in 1979. Holding capacity for larger fish may have been reduced by a larger proportion than in Trail Creek because of its small size. Burns (1971) believed that the amount of living space limited density of young-of-the-year salmonids in streams he studied.

The small percentage of larger bull trout emigrating from Trail Creek during the summer may be a result of a lack of suitable overwintering habitat for larger fish in Trail as compared to Red Meadow Creek. Results from stream electrofishing samples revealed that 20 percent of the bull trout were larger than 120mm in the summer and 12 percent were larger than 140mm in October. However, in spring sampling only two percent of the bull trout were larger than 140mm (Figure 16). Other researchers have observed downstream movements of salmonids in the fall and suggested they were seeking

Table 11. Trap catch of emigrating bull trout and cutthroat trout in the North Fork drainage during 1976,77,78 and 79 represented by number caught and percentage of each species in the total juvenile catch for each trap site.

Creek	Total number bull trout	Percent bull trout	Total number cutthroat	Percent cutthroat
		1976		
Big	0	0	0	0
Coal	19	42	26	58
Cyclone	0	0	0	0
Logging	1	14	6	86
Moran	0	0	0	0
Akokala	0	0	36	100
Red Meadow	7	5	102	95
		1977		
Big	79	39	129	62
Coal	53	9	535	91
Red Meadow	21	18	98	82
Whale	100	48	109	52
Trail	157	65	83	35
Akokala	2	1	361	99
River traps	145	61	227	39
		1978		
Camas	1	4	25	96
Anaconda	1	43	4	57
Ford	0	0	3	100
Starvation	41	52	38	48
Kishenehn *	--	--	34	--
		1979		
Hay	3	5	57	95
River trap	41	65	22	35
Red Meadow	185	27	496	73
Trail Creek	313	43	416	57

* Kishenehn Creek did not have a downstream trap; these fish were gilled in the leads of the upstream trap.

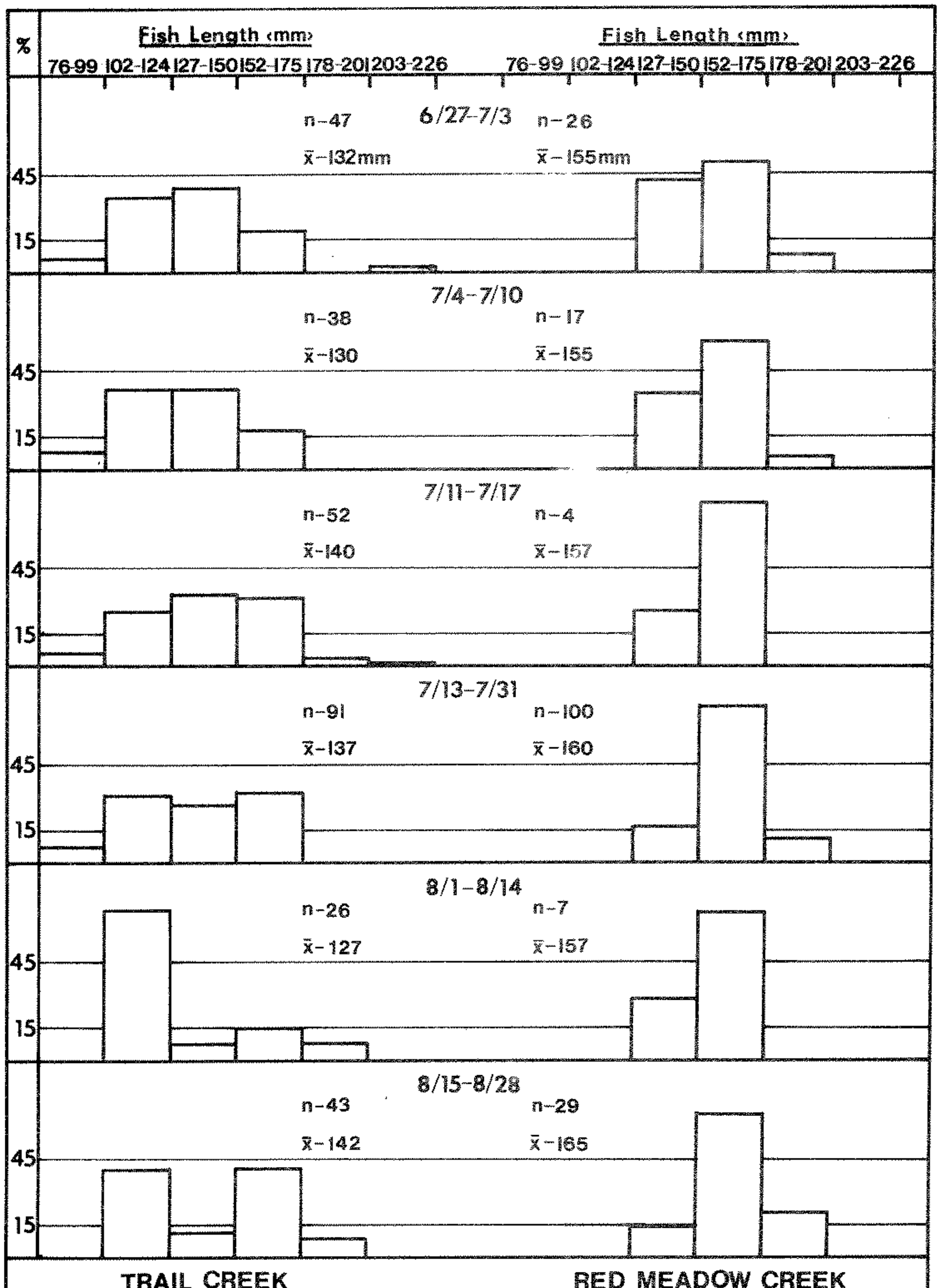


Figure 14. Percent abundance and lengths of juvenile bull trout emmigrating downstream through Trail and Red Meadow creek traps in 1979.

*Consolidated into two-week time periods due to small sample size.

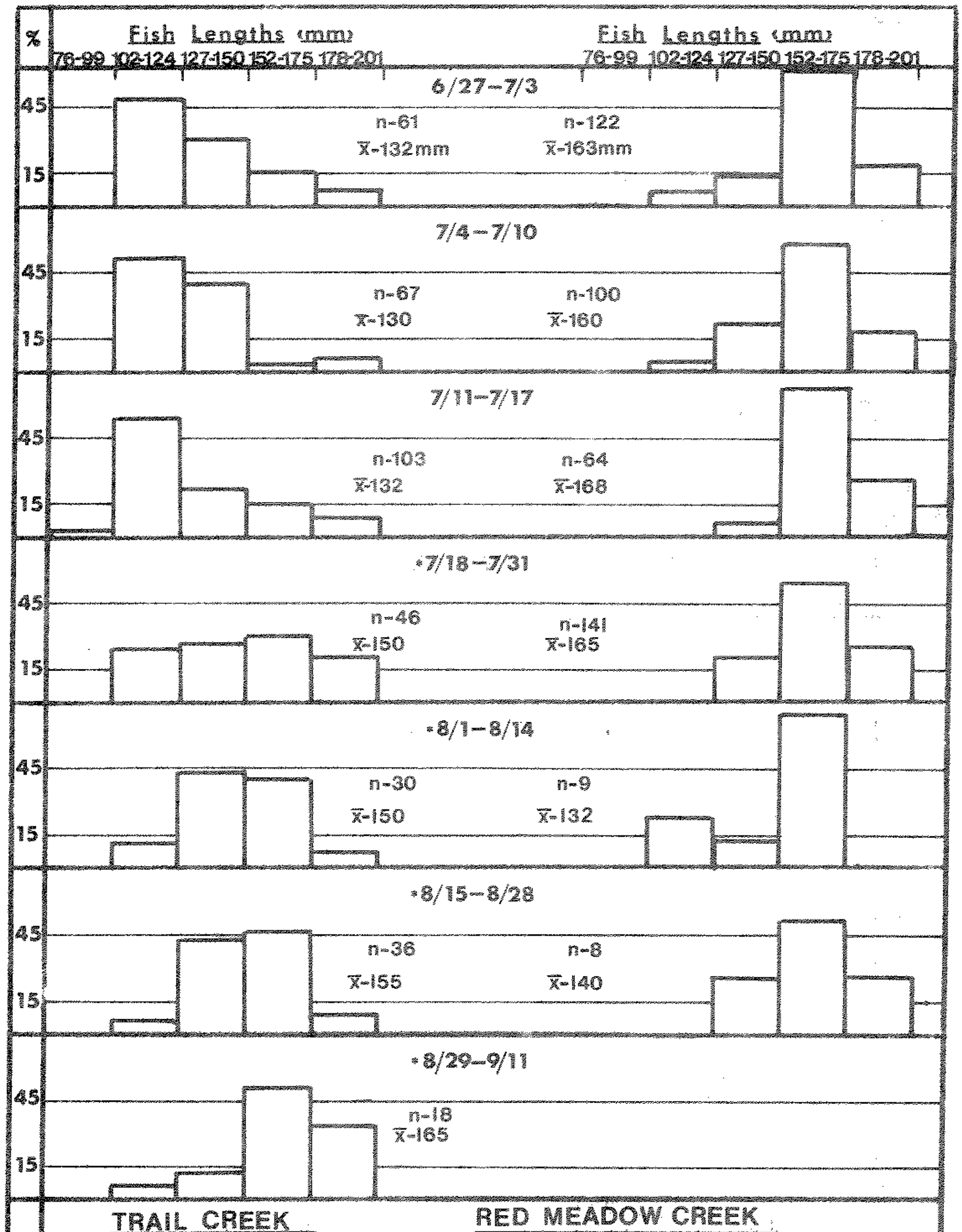


Figure 15. Percentage abundance and lengths of juvenile westslope cutthroat trout emmigrating downstream through Trail and Red Meadow Creek traps in 1979.

*Consolidated into two-week time periods due to small sample size.

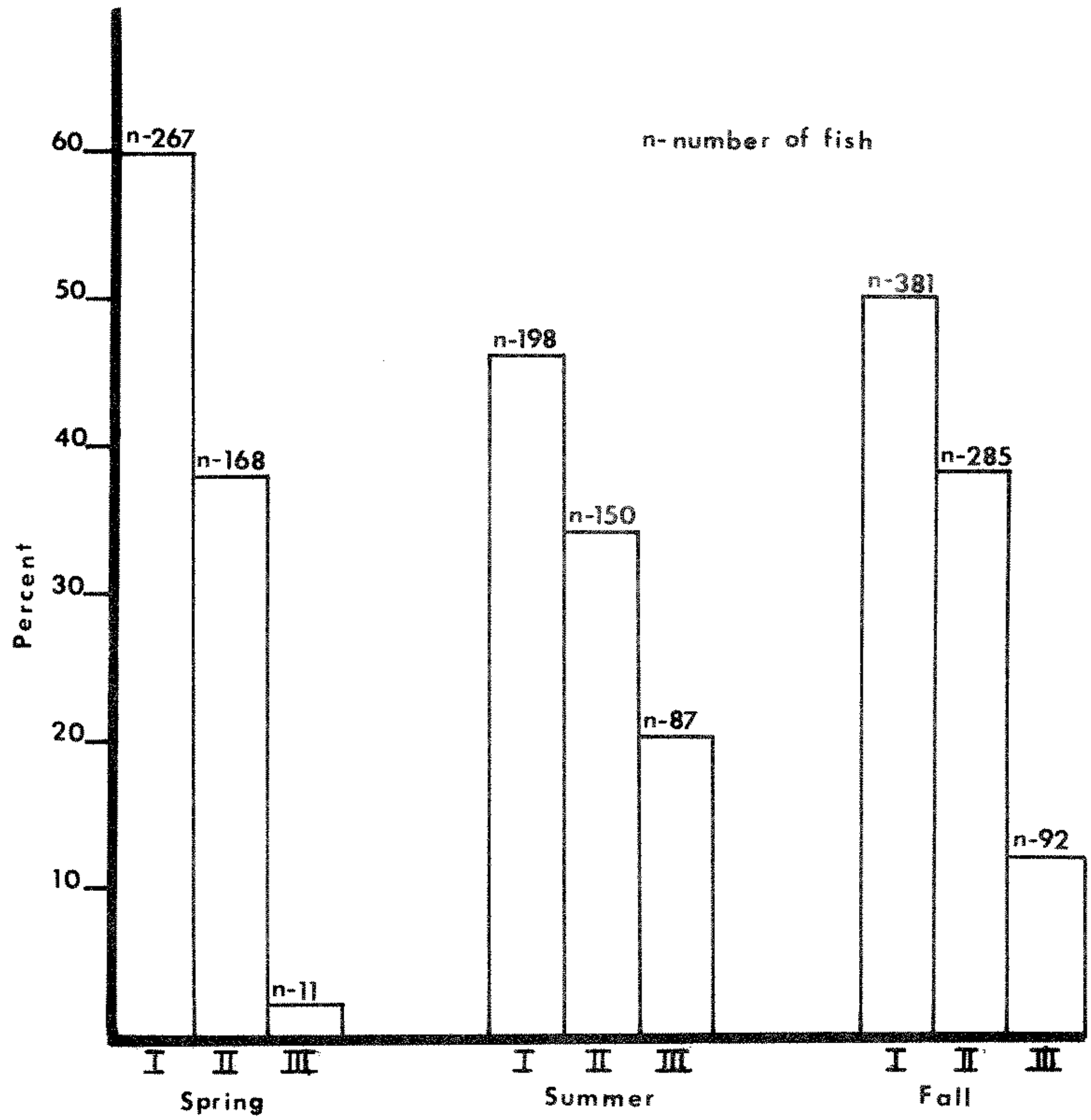


Figure 16. Seasonal comparison by percent and number of age I, II, and III and older bull trout collected by electrofishing in Trail Creek during 1979. Ages were assigned to the following length groups: During fall and spring, age I (40-68mm), age II (68-120mm) and age III and older (>120mm); during summer, age I (50-90mm) age II (90-140mm) and age III and older (>140mm).

suitable overwintering habitat such as deep pools or larger bed material (Everest 1969, Bjornn 1971, Thurow 1976). Juvenile salmonids have been observed burying themselves in streambed material or seeking cover in the debris in pools (Everest 1969, Bustard and Narver 1975, Hanson 1977).

Adult Bull Trout

Only three adults (686-737mm) were collected in upstream traps in Trail Creek and six adults (406-559mm) were caught in the Red Meadow Creek trap in 1979. The Trail Creek trap was removed in September. In October, 35 redds were counted in Trail Creek but only two were counted in Red Meadow Creek. In 1977 an estimated 84 adult bull trout entered Red Meadow Creek (Montana Dept. of Fish, Wildlife and Parks 1 79).

Juvenile Cutthroat Trout

Age II and III cutthroat comprised a large majority of emigrants from Red Meadow and Trail creeks (Table 12). Fish in the 152-175mm class made up the largest percentage of emigrants from Red Meadow Creek from July through August (Figure 15). In early summer, fish in the 102-124mm size group made up the largest percentage of migrants in Trail Creek, but by mid-summer the majority of migrants were from the larger size classes (Figure 15). Growth rates and length at annulus were nearly equal for cutthroat trout collected in Trail and Red Meadow creeks during 1979.

May and Huston (1980) found that the majority (86-97 percent) of the westslope cutthroat trout emigrating from a tributary to Libby Reservoir resided two to three years in the creek. They observed that peak out-migration of juveniles occurred with the receding high water in June and July. Traps were placed in most North Fork tributaries near the end of spring runoff and probably missed the majority of downstream migrants. Seckulich and Bjornn(1977) found that summer trap catches of juvenile chinook were not necessarily good indicators of total outmigration. However, trap catches in North Fork tributaries are useful in identifying streams which produce adfluvial and fluvial strain of cutthroat.

Adult Cutthroat Trout

Few adult spawners were caught in downstream traps in Red Meadow and Trail creeks. Four spawned-out fish (351-391mm) were caught in the down-stream trap in Trail Creek and one 351mm cutthroat was caught in the down-stream in Red Meadow Creek. May and Huston (1980) found that the peak of spawning occurred from mid-May through mid-June and adults spent two to four weeks in the stream with late arrivals spending the shortest time in the stream.

Table 12. Age-growth data from downstream trap catches of juvenile cutthroat trout in Trail and Red Meadow creeks for 1979.

TRAIL CREEK

TIME PERIOD		AGE I+	AGE II+	AGE III+	AGE IV+	PERCENT OF SAMPLE AGED
6/27—7/3	n	1	40	7	—	79
	$\bar{x}$	94	124	173	—	
	percent of total	2	83	15	—	

RED MEADOW CREEK

6/27—7/3	n	—	6	46	1	53
	$\bar{x}$	—	137	168	190	
	percent of total	—	11	87	2	

FISH TAG RETURNS

Since 1952, when tagging was initiated in the Flathead River drainage, 587 tag returns have been recorded by the Montana Department of Fish, Wildlife and Parks. The majority were angler returns of westslope cutthroat and bull trout. These fish were tagged at one of three general locations: Flathead Lake, the Salmon Hole-Steel Bridge area of the lower Flathead River, or in tributary streams to the North and Middle Forks of the Flathead River. All fish were 25cm or larger when tagged until recently when we began investigating movements of juvenile fish.

Bull Trout

The bull trout population in the Flathead drainage is almost entirely adfluvial, living in a lake as subadults or adults and migrating into tributaries to spawn. The migratory pattern of bull trout is similar in the North and Middle Forks. These fish reside in Flathead Lake, begin moving up the lower Flathead River in early spring, start to arrive in their spawning tributaries in late summer and begin returning to the lake in the fall (Figures 17,18 and 19).

Two bull trout tagged in North Fork tributaries traveled downstream over 193km. North Fork bulls tagged during late summer were often caught near the same area when they returned to spawn the following year (Figure 17).

A Canadian tagging program was operated from 1976 to 1978 on Cauldrey and Howell creeks in British Columbia. A total of 213 bull trout were tagged during this time and 23 have been recaptured. Canadian tagged bulls moved downstream an average 177km. Eleven traveled over 193km and one moved 224km. Canadian returns exhibited the same movement pattern as Montana returns (Figure 20). There appears to be no resident adult bull trout in the Flathead River. Nearly all bull trout tagged in the upper tributaries were recaptured downstream and all bulls tagged in Flathead Lake exhibited some upstream movement (Figure 19). A majority of trout tagged in streams and recovered later in the fall or early winter were found in the lake or lower river. Bull trout tagged in or near Flathead Lake during the spring were usually recovered in the upper river or in tributary streams. Six percent of the bull trout tagged in 1979 were recaptured the same year. Table 13 summarizes the bull trout movement data collected from the tagging program.

Westslope Cutthroat Trout

Three basic life history patterns have been identified throughout the range of westslope cutthroat trout. These patterns are migratory between lakes and streams, migratory from small tributaries to main rivers, and non-migratory stocks (Behnke 1979) which we refer to as adfluvial, fluvial and resident, respectively.

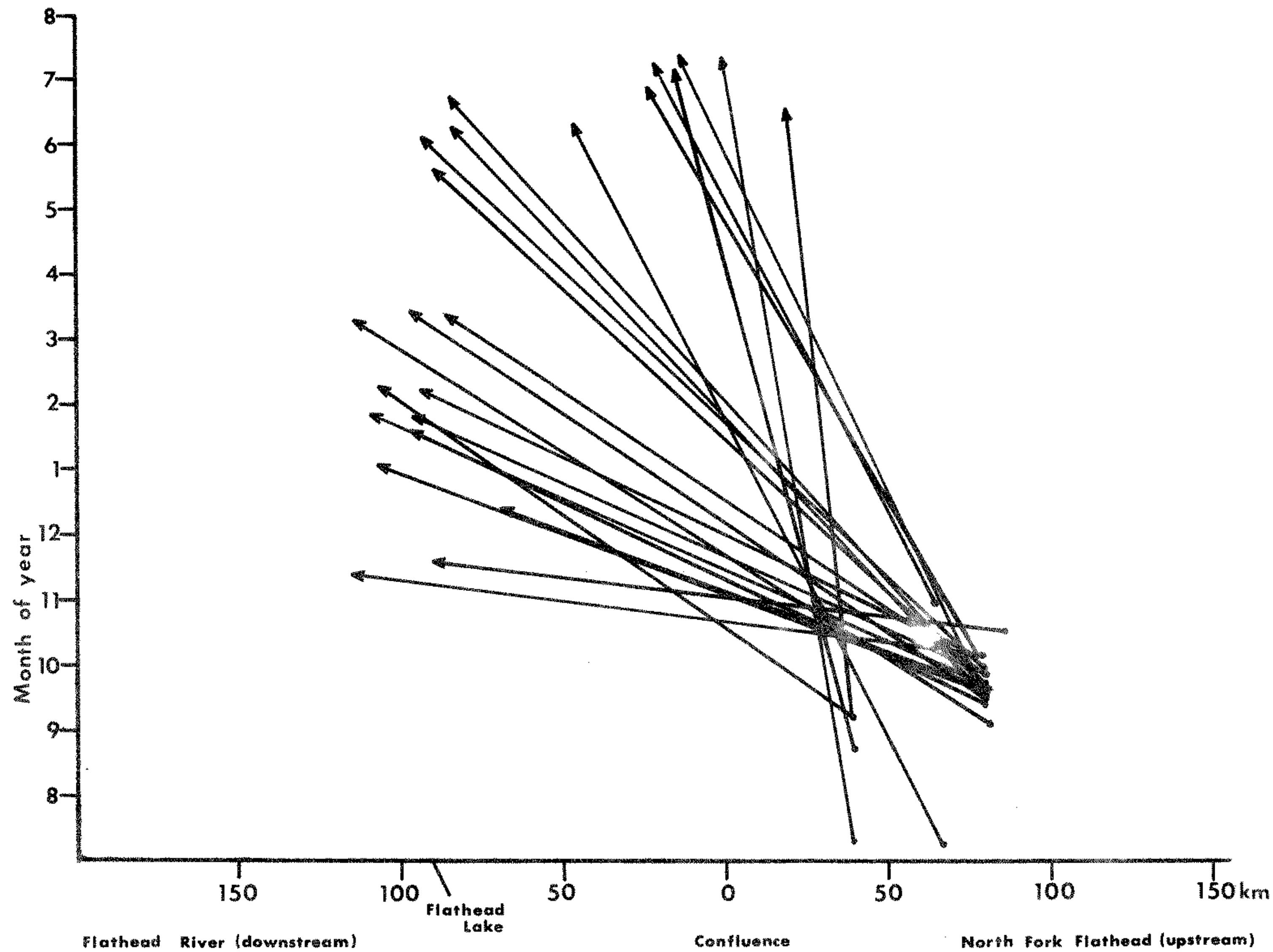


Figure 17. Date and location of bull trout tagged (•) in the upper North Fork of the Flathead River and recaptured (→) in the Flathead River or Flathead Lake. All movements are for fish tagged and recaptured within a 12 month period.

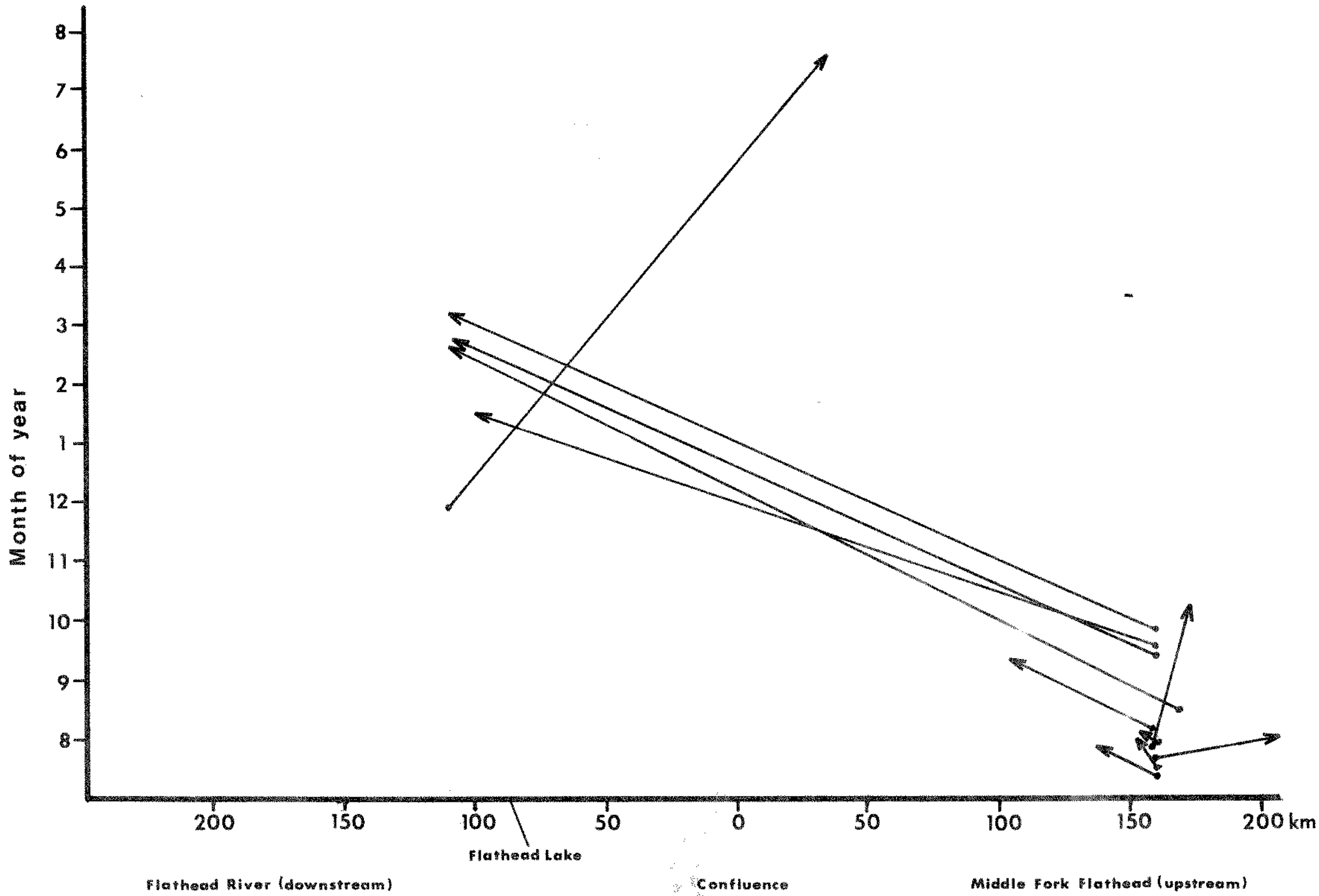


Figure 18. Date and location of bull trout tagged (•) in Flathead Lake or the Middle Fork Flathead River and recaptured (→) in the Middle Fork or Flathead Lake. All movements are for fish tagged and recaptured within a 12 month period.

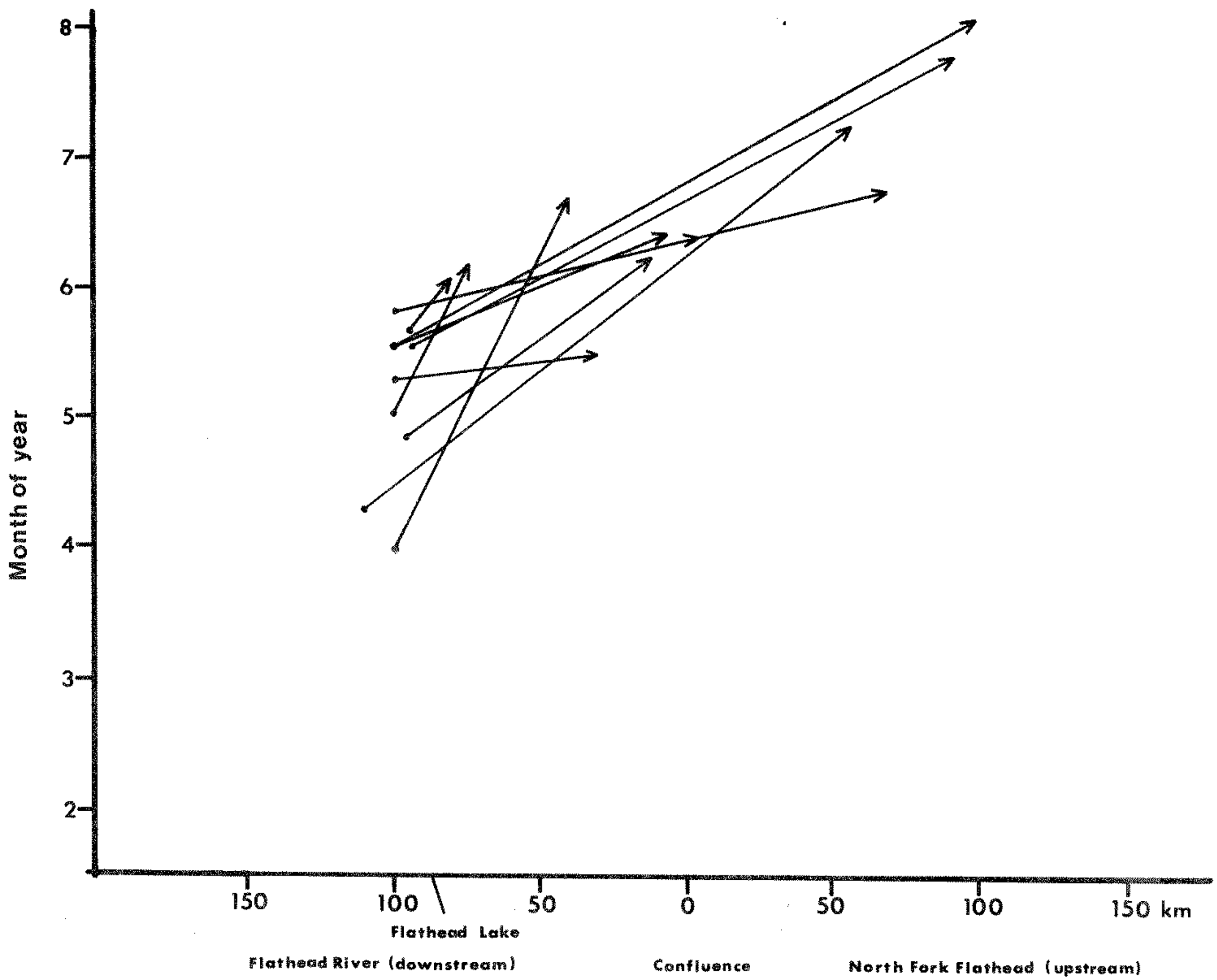


Figure 19. Date and location of bull trout tagged (·) in Flathead Lake and recaptured (→) in the Flathead River or tributaries. All movements are for fish within a 6 month period although the years may not necessarily be consecutive.

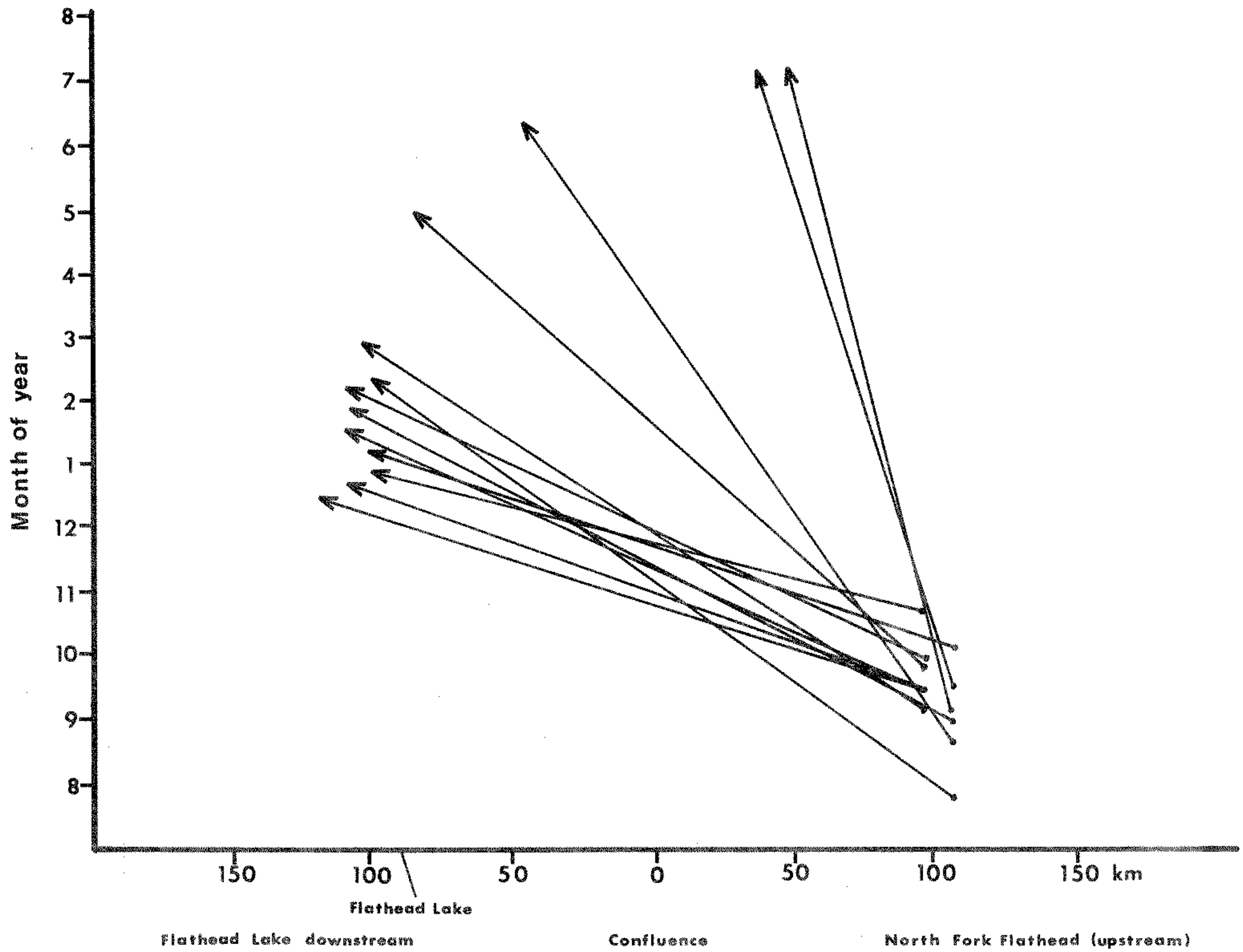


Figure 20. Date and location of bull trout tagged (•) in Howell or Couldrey Creeks in British Columbia and recaptured (→) in the United States portion of the Flathead. All movements are for fish tagged and recaptured within a 12 month period.

Table 13. Summary of bull trout movement from designated tagging locations.

		Movement				
		Percent		Average kilometers		
Tagging location	Number tagged	upstream	downstream	upstream	downstream	Range (km)
Upper North Fork	54	--	100	--	150	5 - 224
Upper Middle Fork	11	18	82	30	158	2 - 295
Flathead Lake	11	100	--	100	--	10 - 199

Table 14. Summary of westslope cutthroat movement from designated tagging locations

		Movement					
		Percent			Average kilometers		
Tagging location	Number tagged	Upstream	Downstream	No movement	Upstream	Downstream	Range (km)
Upper North Fork	113	12	68	20	15	53	0 - 214
Upper Middle Fork	62	16	53	31	8	74	0 - 225

Adfluvial westslope cutthroat spawners begin moving up the lower Flathead as early as February and probably move into tributaries sometime in April or May. They spend a varying amount of time on the spawning grounds and most return to the main river around the time of peak runoff. Block (1955) found spawners in North Fork streams June 17 and Johnson (1963) felt cutthroat spawning peaked in mid-June. Time spent in the river between the tributaries and the lake appears quite variable. Studies of cutthroat in three Idaho streams indicated a movement pattern upstream to upper drainages in spring and early summer, no movement during the summer and movement to the lower drainages in the fall (Johnson and Bjornn 1978, Thurow and Bjornn 1978). Cutthroat tagged and recaptured in the North Fork during an earlier study all moved downstream or remained near the tagging location (Johnson 1963). Johnson reasoned that some cutthroat remain in the North Fork the entire year.

Cutthroat tagged in the lower Flathead and recaptured in the North or Middle Forks during the same year (within 6 months) represent the adfluvial segment of the population (Figures 21 and 22). Returns from fish tagged at the upper ends of the drainages probably represent both fluvial and adfluvial portions of the population (Figures 23,24 and 25). Movement of the downstream migrants can be quite rapid as indicated by the nearly horizontal arrows in Figures 23 and 24. An individual tag return from a cutthroat tagged in Howell Creek by Candian biologists showed one trout moved to below Columbia Falls, Montana (a distance of 112 kilometers) in less than 24 hours.

A number of cutthroat were captured at or near the point of tagging even after long periods of time as indicated by the nearly vertical movement line (Figures 24 and 25). This could be fluvial or resident segments of the population. However, most trout tagged in the upper ends of the drainage exhibited some downward movement. Three cutthroat moved downward in a surprising pattern. One tagged in Howell Creek, British Columbia, and another tagged in Trail Creek were captured in Kintla Lake. Another tagged in Howell Creek, British Columbia, entered Flathead Lake, then moved up the Swan River east of Bigfork (Figure 23). This return from Swan River traveled 214 kilometers downstream which is the longest cutthroat movement recorded for the Flathead drainage.

One hundred seventy-nine cutthroat over 25 centimeters in length were tagged in 1979 and 25 (14%) of these were recaptured. Seventeen of the 179 were tagged in the North Fork and 5 (29%) of these were caught by anglers. Although the sample size of trout tagged in the North Fork is small, twenty-nine percent return is high compared with most tagging programs (Johnson and Bjornn 1978, Thurow and Bjornn 1978).

Table 14 displays the movement summary for westslope cutthroat tagged in the upper North and Middle Fork drainages.

Mountain Whitefish

The Department of Fish, Wildlife and Parks initiated a whitefish tagging

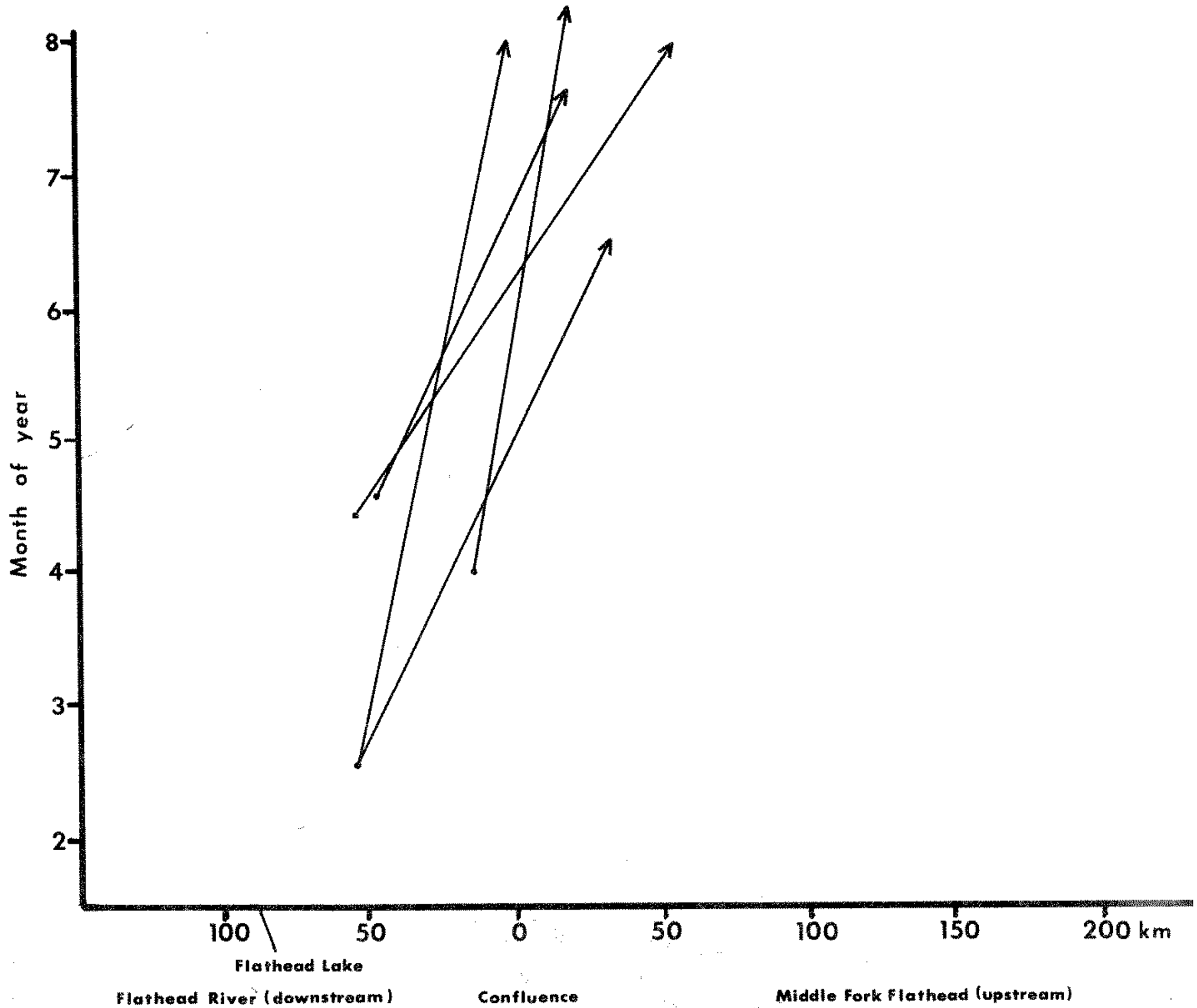


Figure 21. Date and location of westslope cutthroat tagged (·) in the lower Flathead River and recaptured (→) in the Middle Fork of the Flathead River. All movements are for fish tagged and recaptured within a 6 month period.

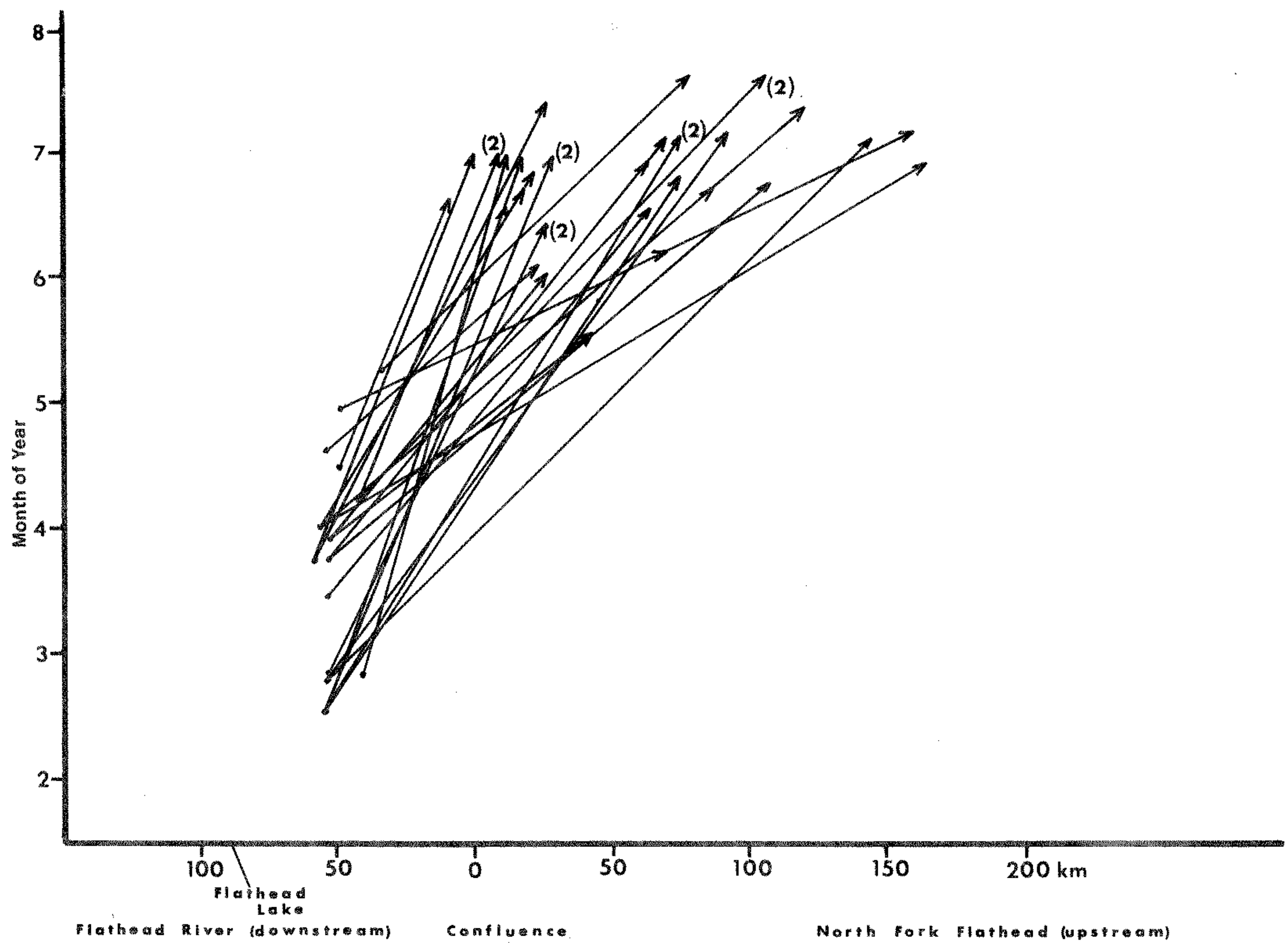


Figure 22. Date and location of westslope cutthroat tagged (·) in the lower Flathead River and recaptured in the North Fork or lower Flathead Rivers. All movements are for fish tagged and recaptured within a 6 month period.

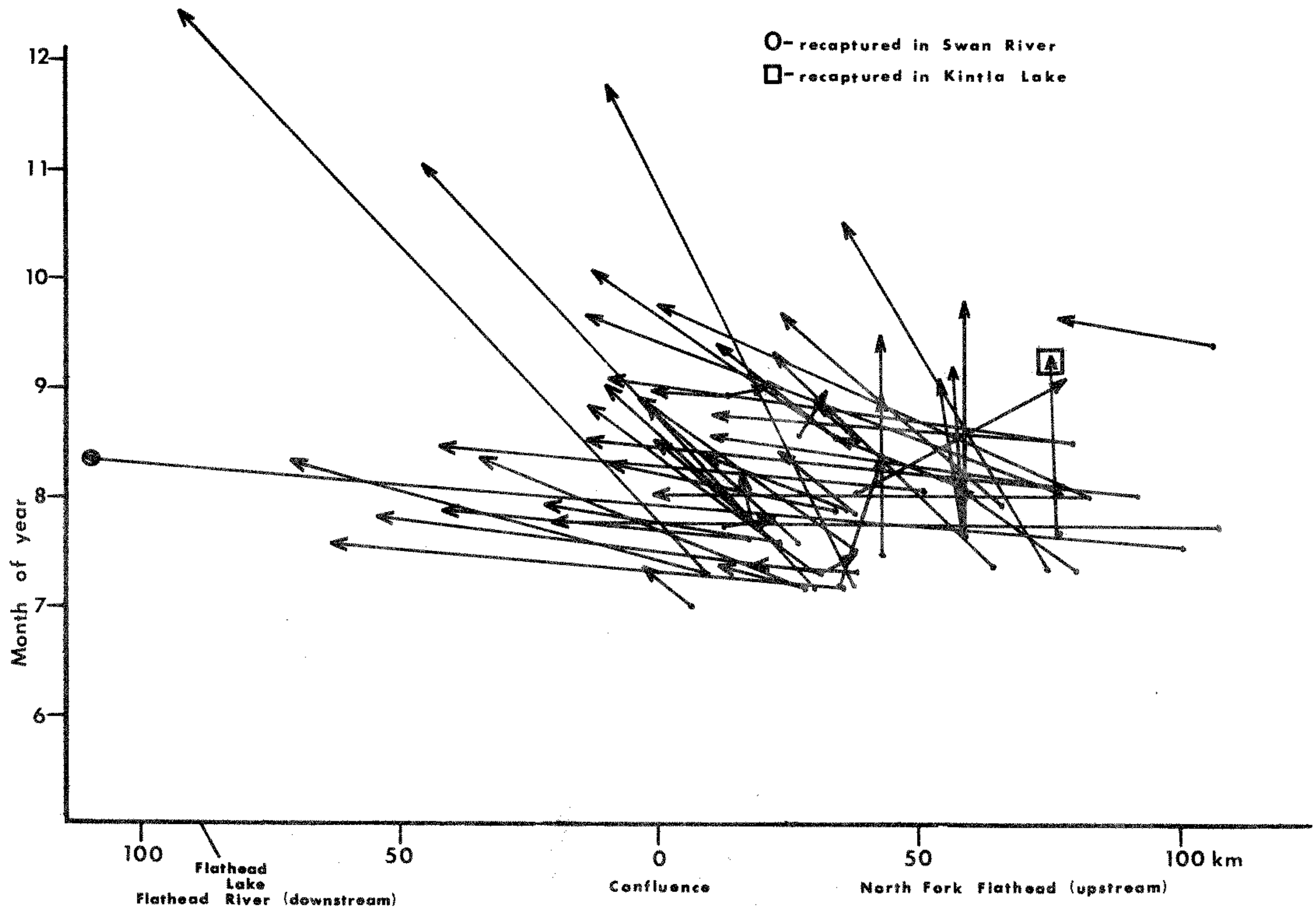


Figure 23. Date and location of westslope cutthroat tagged (•) in the North Fork of the Flathead River and recaptured (→) at various points in the drainage. All movements are for fish tagged and recaptured within a 6 month period.

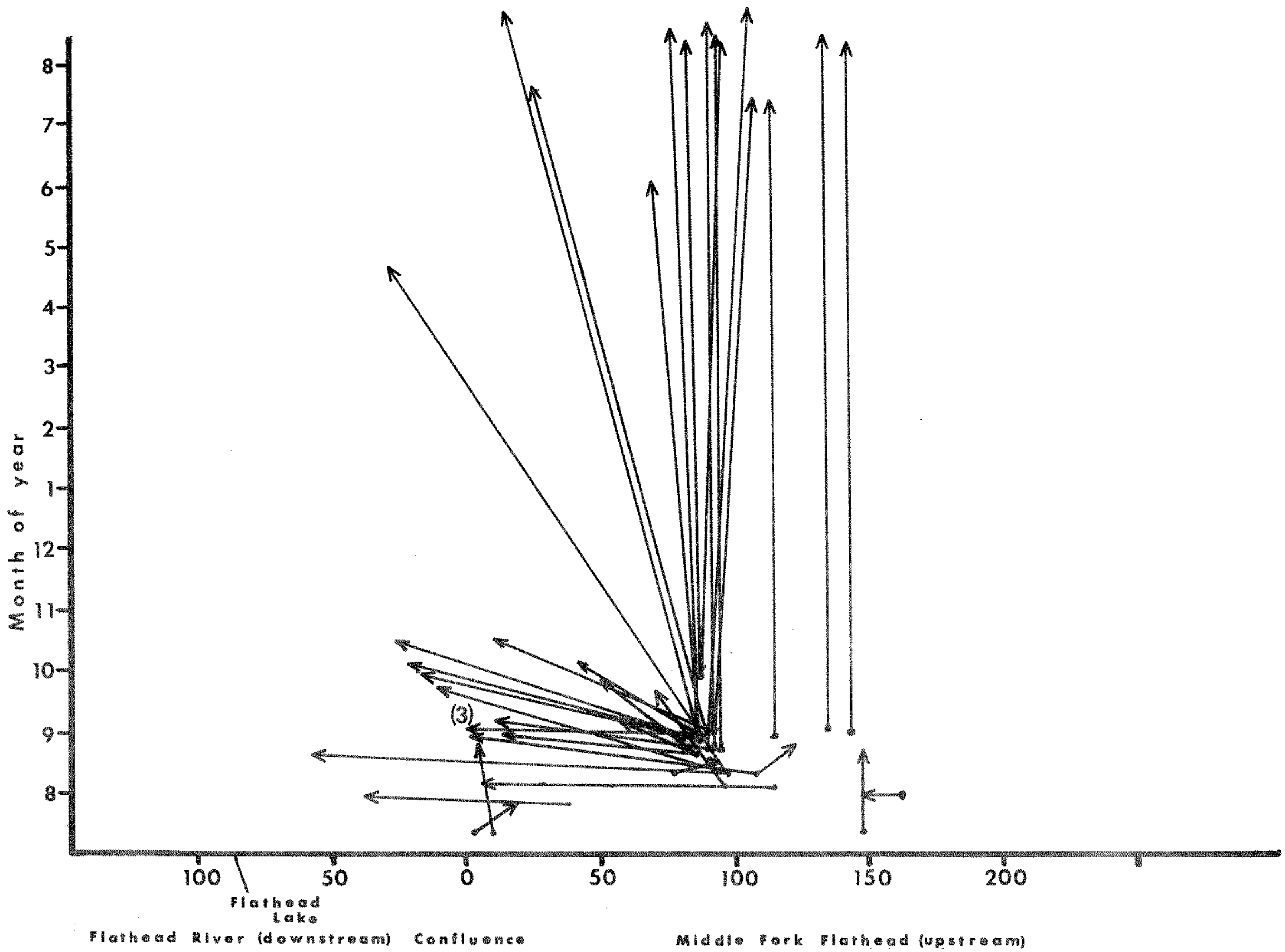


Figure 24. Date and location of westslope cutthroat tagged (·) in the Middle Fork of the Flathead River and recaptured (→) in the Middle Fork or lower Flathead Rivers. All movements are for fish tagged and recaptured within a 12 month period.

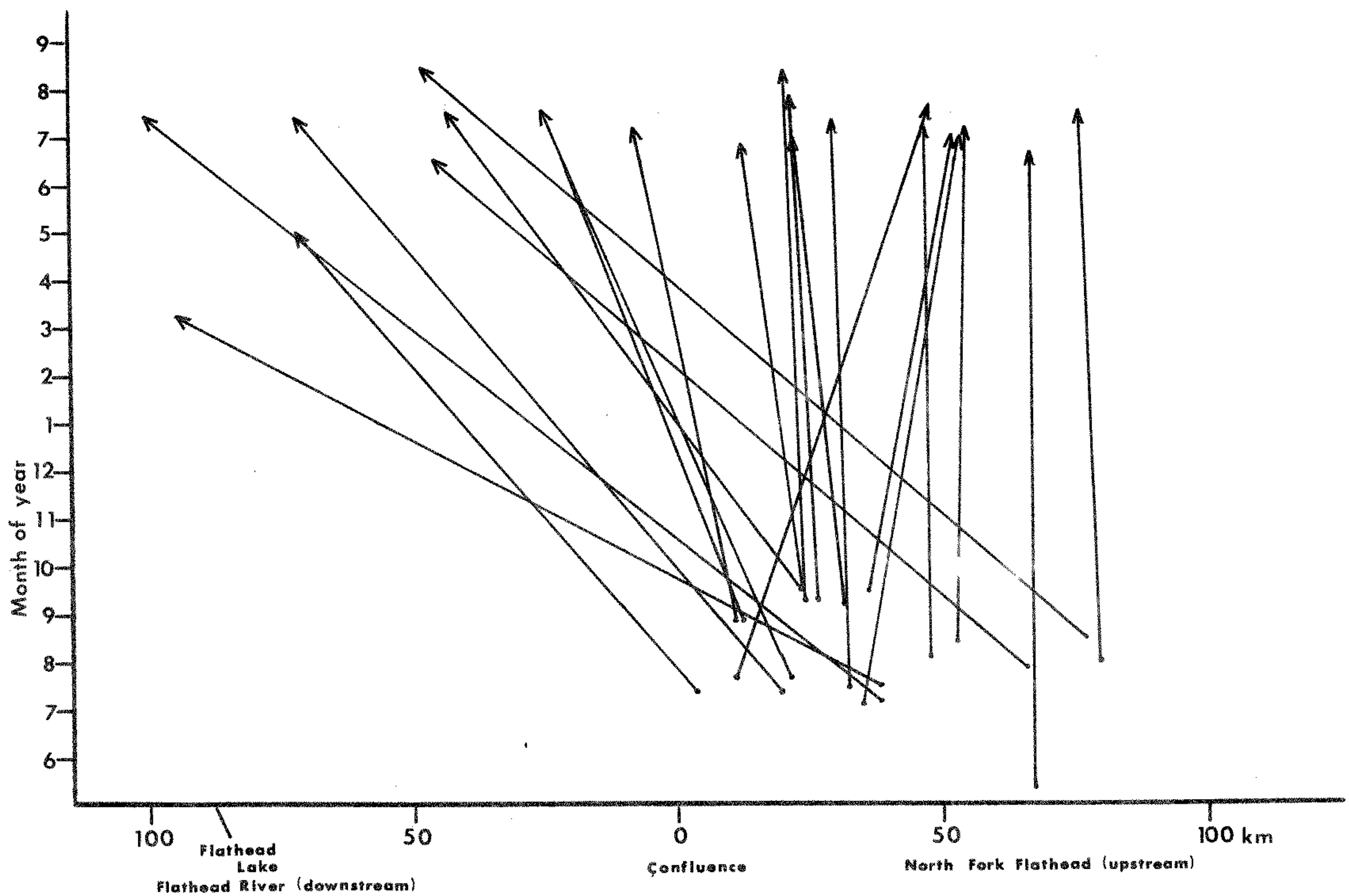


Figure 25. Date and location of westslope cutthroat tagged (•) in the North Fork of the Flathead River and recaptured (→) in the North Fork or lower Flathead Rivers. All movements are for fish tagged and recaptured within a 12 month period.

program during 1979 in order to derive information on movement, distribution and use of rivers and tributaries in the Flathead drainage. Nearly 700 whitefish over 25cm were tagged and only three have been recovered to date. Possible reasons for this low return of whitefish include: 1) angling catchability of whitefish was less than for bull or cutthroat trout, 2) the whitefish population is much larger than either trout population, 3) there is little or no fishing pressure on whitefish, or a combination of the above. To better assess movements in the future, we plan to compare relative abundance of whitefish in various sections of the river during the spring, summer and fall using underwater census techniques.

Juvenile Trout Movement

Both bull and cutthroat trout fry appear to remain in or near tributary streams and small river side channels after hatching. Shallow secondary tributaries such as Cyclone, Langford and Argosy creeks harbor large concentrations of fry. Numerous fry were collected during a brief survey of small side channels in the North Fork. Most of these were mountain whitefish and a few bull or cutthroat trout were also collected. Three cutthroat redds were found in a side channel near Moran Creek in July.

Juvenile trout spend from one to four growing seasons in the tributaries before moving into the main river. The majority spend two to three seasons in the tributaries. Attempts have been made to mass mark large numbers of these juveniles while they reside in the tributaries by fin clipping and cold branding. Fin clipping is a short-term marking procedure since the clipped fin usually regenerates within a year. Cold branding with liquid nitrogen leaves a permanent mark and was applied on the right side of the fish between the lateral line and dorsal fin. Individual brands for North Fork tributaries in 1979 were as follows.

Big Creek	ш	Whale Creek	ꓘ
Coal Creek	m	Trail Creek	ꓘꓘ
Akokala Creek	p̄	Howell Creek	IQ̲
Red Meadow Creek	b̲		

Brands increased in size as the fish grew, but were difficult to distinguish on juvenile fish. On at least two occasions, brands were found by project personnel on juvenile fish in angler's creels. These marked fish went unnoticed by fishermen. As a result, return information is scarce on branded fish even though an effort was made for recovery through a partial creel census along the North Fork during the summer of 1979.

During the 1980 field season some juvenile bull and cutthroat trout will be marked with small fingerling tags in an attempt to better study movement and distribution within the river system. These tags have been used with some success in Washington (Lestelle 1978) and Oregon (Korn 1980 personal communication) on fish as small as 7.5cm. Although the tags are small, they may be more visible to fishermen than cold brands.

Probably the best emigration data on juvenile bulls and cutthroat that we now have comes from trapping records and electrofishing in tributaries. This is covered in more detail in the section on trapping.

Redd Measurements

Redd counts can be an excellent indicator of the number of spawning bull trout returning to tributaries. When conducted on an annual basis, these surveys reveal the importance of each tributary for spawning and distribution of spawners within a tributary and throughout the drainage. Long-term annual monitoring of spawning sites will help identify changes in trout populations including those due to environmental alterations.

Previous investigators have reported that bull trout may arrive in tributaries as early as August and continue arriving until early November (Block 1955). Tagging records have shown that mature bull trout were present in the tributaries as early as the first week of July. One adult bull trout was seen in Red Meadow Creek on July 5 and some were found in Trail Creek as early as August. On August 5 some mature bulls were noticed in lower Long Creek and 28 were counted in a 2.5 kilometer section of Granite Creek on August 16. There is evidence that bull trout, especially early arrivals, spend some time in the rivers and tributaries before actually spawning. Eleven adult bulls were counted while electrofishing the North Fork the nights of July 24-26. A group of 12 to 15 bulls was seen at the mouth of Kintla Creek when it was snorkeled September 19. Dolly Varden Creek was checked in early September and no redds were located although mature fish were present. However, in early October, 20 redds were counted in the same area. Whale and Coal Creeks in the North Fork and Lodgepole Creek in the Middle Fork contained the largest number of redds (Table 15). Whale and Coal creeks have the highest flows of any streams on the west side of the North Fork in late summer.

Block (1955) found that the average depth and size of redds was 30 centimeters and 1.5 by 2.4 meters, respectively. Redds were generally located in areas with medium to coarse gravel. Studying bull trout in aquaria, Legget (1969) found spawning occurred at depths of 0.73 to 0.84m. Depth measurements of Dolly Varden redds in Washington State showed a range in depth of 0.21 to 0.43m with a mean of 32cm (Hunter 1973). In recent surveys, the average lengths, widths and depth of redds were consistent in both drainages. Redd size averaged .84 by 1.46m and 20cm in depth. The average distance to cover varied considerably and could possibly be due to the size of the particular stream (Table 16). Many redds were found in the same general areas as in 1977 and 1978. In fact, some redds in Whale and Trail Creeks were in exactly the same location as in previous years. Block (1955) also observed this in Trail Creek. While definite concentrations of redds existed in certain reaches of these creeks, we have not yet determined

Table 15. Numbers of bull trout redds found in North and Middle Fork Flathead River tributaries during fall surveys.

Drainage	Number of Redds 1979	1978	1977	1954	1953
North Fork					
Big Creek	12	--	--	6	--
Hallowat	2	--	--	20	--
Coal Creek	44	--	--	--	--
Mathias	2	--	--	--	--
South Fork Coal	4	--	--	--	--
Red Meadow Creek	2	4	10	--	--
Trail Creek	35	3	15	48	18
Whale Creek	34	2	11	--	--
Shorty Creek	33	--	3	--	--
Middle Fork					
Dolly Varden Creek	20	--	--	--	--
Schafer Creek	16	--	--	--	--
Morrison Creek	25	--	--	--	--
Lodgepole Creek	32	--	--	--	--
Granite Creek	14	--	--	--	--
Twenty-five Mile Creek	2	--	--	--	--
Long Creek	15	--	--	--	--
Charlie Creek	3	--	--	--	--
Dirtyface	1	--	--	--	--

Table 16. Average measurements of bull trout redds in tributaries of the North and Middle Forks of the Flathead River during 1979

Drainage	No. redds	Length (meters)	Width (meters)	Depth (meters)	Distance to nearest cover (meters)
North Fork					
Big Creek	12	1.11	.66	.22	1.73
Coal Creek	49	1.37	.89	.24	3.68
Red Meadow Creek	2	1.07	.76	.19	3.20
Trail Creek	32	1.46	.92	.29	2.67
Whale Creek	68	1.24	.90	.25	3.67
North Fork Average		1.25	.83	.24	2.99
Middle Fork					
Dolly Varden Creek)	33	2.25	1.25	.21	--
Schafer Creek)			1.03	.20	--
Morrison Creek)	27	1.81			
Lodgepole Creek)					
Granite Creek	14	.93	1.00	.19	6.92
Long Creek	14	2.03	1.01	.20	3.8
Charlie Creek	3	1.57	.85	.17	1.75
Middle Fork Average		1.64	.86	.16	4.16
Overall Average		1.46	.84	.20	3.43

what the triggering factor(s) may be for redd construction.

Redd gravel samples analyzed from Coal and Whale creeks in 1979 were similar to those analyzed from Whale, Trail and Red Meadow Creeks in 1979 and 1978 (Montana Dept. Fish and Game 1979). The dominant size of bed material in bull trout redds was gravel in the 2.5 to 5cm and .84 to .64cm range (Appendix B, Figures 1 through 4). Material over 10cm was seldom found in redd samples. In the future all samples will be sorted using the Wentworth scale.

The majority of velocities measured at bull trout redds were less than 0.8 feet per second and ranged from 0 to 2.0 feet per second (Figure 26). Block (1955) reported redds were never located in "fast water or in backwater." Legget (1969) found surface velocities in aquaria ranged 0.13 to 2.01 feet per second and Hunter (1973) measured focal point velocities (13cm above redds) in Washington State at 1.11 to 2.16 feet per second for anadromous Dolly Varden. Depth of redds appeared to center about .25 meters and ranged from .0 to .5 meters (Figure 27). Use of probability curves to evaluate redd data for instream flow use has been demonstrated by the Fish and Wildlife Service (Bovee and Cochnauer 1977 and Bovee 1978). Although our sample size was relatively small, the patterns approximate probability use curves for depth and velocity.

Spawning areas for bull trout and westslope cutthroat trout as well as other habitat parameters will be documented on drainage maps as part of this study. An example of this can be seen in Figure 28.

Abundance and Distribution

Electrofishing and snorkeling were methods used to gather information about abundance and distribution of juvenile trout in North and Middle Fork tributaries. When replicated periodically, information gathered by electrofishing and/or shocking could result in a long-term monitoring index for populations of juvenile cutthroat and bull trout. Underwater census to determine fish abundance has been successfully demonstrated in Idaho streams (Graham and Sekulich, in preparation). In studies on the St. Joe River and Kelly Creek, transects were counted each year near the same date in late summer (Thurow and Bjornn 1978, Johnson and Bjornn 1978).

Most snorkeling transects in the upper Flathead drainage were established in conjunction with surveyed stream reaches. However, one snorkel transect was done on four kilometers of the North Fork River itself above Canyon Creek. Tables 17 and 18 show the results of snorkel transects in the North and Middle Fork for 1979. This year's data are mainly baseline information. However, some trends in fish abundance are apparent from the snorkeling and electrofishing data.

In most cases, where cutthroat trout densities were large, bull trout densities were small and vice versa. Sixty-two percent of 43 shocking or snorkeling transects had comparatively large densities (3:1) of either

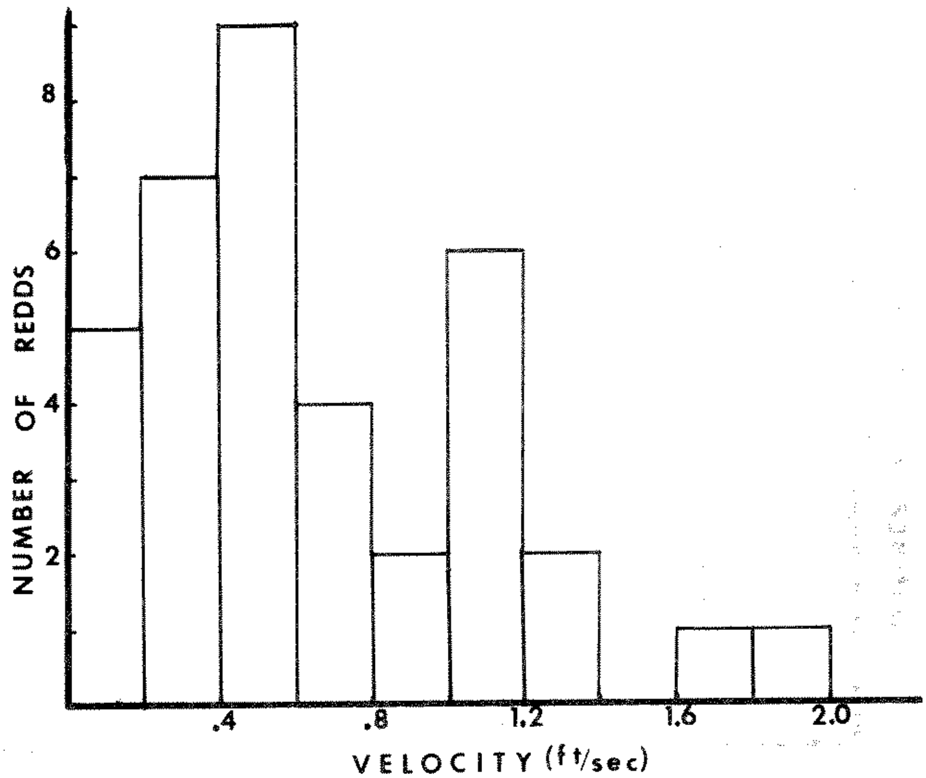


Figure 26. Velocities recorded at the head of 37 bull trout redds located in tributaries of the North and Middle Forks of the Flathead. All measurements were taken with either Pygmy or Price A current meters.

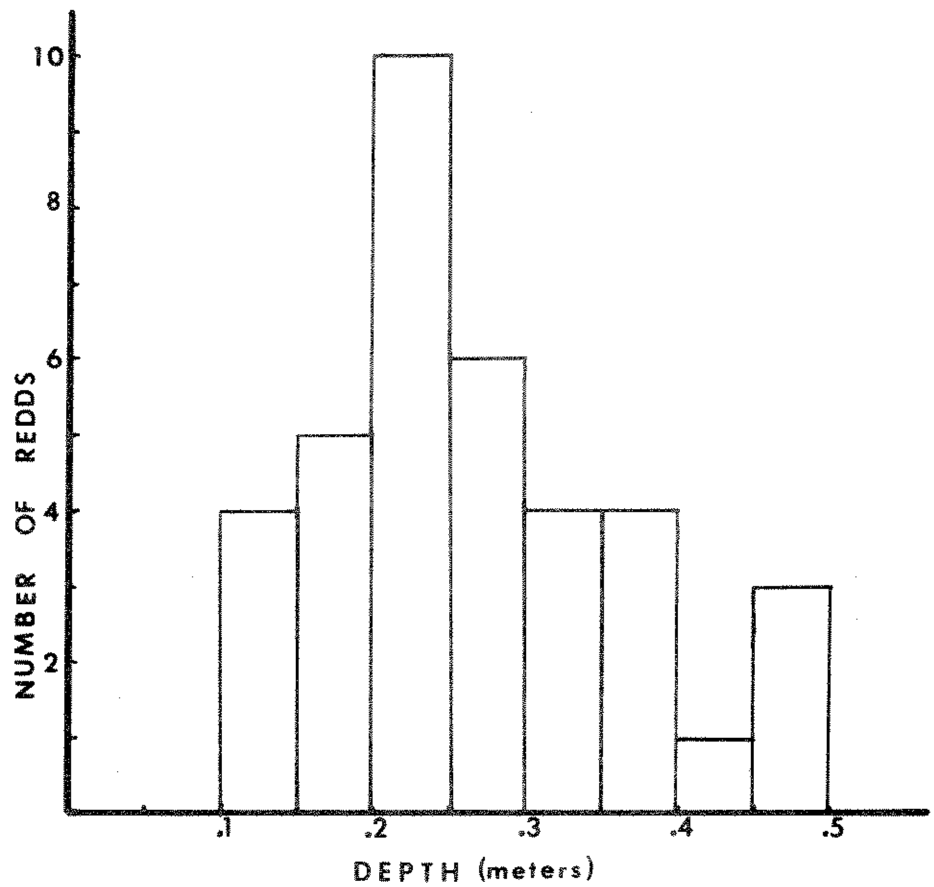


Figure 27. Depths recorded at the sites of 37 bull trout redds located in tributaries of the North and Middle Forks of the Flathead River.

Table 17. Fish species density (numbers per 100 meters^2) in underwater fish census transects in tributaries to the North Fork of the Flathead River during the summer of 1979

Drainage	Date	Reach number	Transect length(m)	Transect area(m)^2	Cutthroat trout Fry	Cutthroat trout Age I	Cutthroat trout Age II+	Bull trout Fry	Bull trout Age I	Bull trout Age II +	Bull trout A[2/]	Mountain whitefish
Big Creek	9/3/79	2D[1/]	122	1159	--	--	--	1.5	0.1	0.6	0.1	--
	9/3/79	2U[1/]	116	541	--	--	--	--	0.2	1.7	--	--
Hallawat	9/2/79	1	122	412	--	--	0.2	0.5	--	1.0	--	--
Coal Creek	9/4/79	1	122	1159	--	--	0.1	--	--	--	--	--
	9/14/79	2	150	1260	no fish observed							
	9/13/79	3	150	600	0.8	1.8	7.3	--	2.2	0.5	--	--
Mathias	9/13/79	1	129	411	--	--	1.2	--	--	1.0	1.5	--
Red Meadow Creek	8/8/79	1D	122	736	4.8	9.4	5.0	--	--	0.7	--	2.5
	8/8/79	1U	122	974	0.7	0.9	2.1	--	--	0.1	--	--
	8/17/79	2D	150	840	--	1.3	5.0	--	0.5	2.4	--	0.4
	8/17/79	2U	150	558	1.1	.5	1.6	1.1	--	0.9	--	--
	8/3/79	3	122	500	--	--	4.6	--	--	4.0	--	--
Trail Creek	8/13/79	1	122	756	--	--	.5	0.3	0.1	1.5	--	2.1
	8/16/79	5	150	507	--	--	5.7	--	--	--	--	--
	8/16/79	6	150	487	--	--	1.2	--	--	--	--	--
Tuchuck	8/14/79	1	122	488	2.1	2.5	13.9	--	--	--	--	--
Whale Creek	8/27/79	1D	150	1452	--	--	0.6	1.0	--	1.2	0.1	0.6
	8/27/79	1U	150	1033	--	--	0.6	0.1	0.2	1.0	0.6	0.2
Shorty	8/18/79	1	150	825	--	0.5	1.0	1.1	0.7	1.3	0.1	--

1/ If more than one snorkel transect done in a reach, "D" refers to downstream transect; "U" refers to upstream transect

2/ "A" refers to mature adfluvial bull trout

Table 18. Fish species density (numbers per 100 meters^2) by age group in underwater fish census transects in tributaries to the Middle Fork of the Flathead River during summer 1979.

					Fish per 100 meters^2 surface area							
					Cutthroat			Bull Trout				Mountain
Drainage	Date	Reach No.	Transect Length (m)	Transect Area (m)^2	Fry	Age I	Age II+	Fry	Age I	Age II+	A 2/	Whitefish
Charlie Crk	7/21/79	1	131	393	0.3	0.5	1.8	0.8	2.8	3.6	--	0.3
	7/21/79	2	128	486	--	--	0.2	--	4.5	4.7	--	--
Long Creek	8/7/79	1	122	908	--	--	0.1	0.1	--	0.3	0.1	0.4
	8/16/79	3	131	489	--	0.6	5.1	0.8	0.6	3.5	--	--
Bergsicker	8/2/79	1	122	622	--	--	0.5	--	--	0.3	--	--
Twenty-five Mile Creek	8/21/79	3	125	404	--	6.2	8.2	--	--	--	--	--
Granite Crk	8/9/79	1	125	897	--	--	0.1	--	--	0.1	0.7	--
Dolly Varden Creek	9/3/79	1	149	1295	--	0.2	--	--	0.2	--	--	1.0
	9/3/79	2	158	1391	--	0.2	0.4	2.4	0.3	0.3	--	2.7
	9/1/79	3D 1/	137	721	--	0.4	2.6	3.1	1.8	12.9	--	--
	9/1/79	3U 1/	150	1162	--	--	1.2	--	0.1	1.0	0.2	0.4
Argosy	8/31/79	1	122	537	--	0.2	2.6	--	--	0.7	--	--
	8/31/79	3	130	212	55.7	11.0	13.2	--	--	--	--	--
Challenge	8/15/79	1	122	395	1.3	3.8	9.6	--	--	0.3	--	--

1/ If more than one snorkel transect done in a reach, "D" refers to downstream transect; "U" refers to upstream transect.

2/ "A" refers to mature adfluvial bull trout cutthroat or bull trout but not both. The remaining 38 percent had a more even mixture of the two species.

Juvenile cutthroat were relatively abundant in upper reaches (3,4,5, etc.). As the reach number increases, the flow within the reach generally decreases (Tables 22 and 23). Middle Fork flows averaged 5.8 cubic feet per second (cfs) in transects where bull trout were predominant and 3.7cfs in reaches where westslope cutthroat were most abundant. The same pattern was observed in the North Fork. In reaches where bull trout were most abundant, flows were 25.6cfs compared to 9.1cfs in transects where cutthroat were most abundant. We found no significant correlation between reach number and abundance of younger cutthroat. In part, this could be the result of grouping all creeks together in the analysis, rather than separating smaller tributaries such as Tuchuck and Charlie from larger ones such as Red Meadow. Some of the largest densities were found in Reach one of Red Meadow Creek, where fry and age I fish were found in small side channels along the larger main channel.

Hartman and Gill (1967) also identified headwater streams as being important rearing areas for cutthroat trout. They believed that spatial differences between juvenile cutthroat and steelhead trout was a function of stream size and gradient. Hanson (1977) believed interactive segregation was occurring between juvenile cutthroat and steelhead trout. He did not find sympatric populations of steelhead and cutthroat trout in streams he studied in Idaho.

Griffith (1972) examined habitat utilization of brook trout and cutthroat trout. He concluded that underyearling trout of the two species occupied different microhabitats, probably a function of size differences. He also found that there was considerable habitat overlap at age group I and II. Older fish were segregated more so, with brook trout living closer to cover and associating more with the stream bottom.

From general observations to date in our study streams, Griffith's findings may be quite similar to interactions between bull and cutthroat trout. Although differences in habitat selection by underyearling trout based on macrohabitat would be a function of spawning location in the stream, this in turn is a function of stream discharge and gradient.

No studies of habitat selection by sympatric populations of juvenile bull and cutthroat trout in streams is available in the literature. We will be undertaking such a study during the summer of 1980.

By midsummer, several long sections in Trail and Granite Creeks had gone dry about 10 kilometers up from their mouths. A few other creeks also had dry sections of smaller lengths. Although these dry sections carry water during runoff periods, there were no, or very limited populations, of juvenile bull trout upstream from these areas in Trail and Granite creeks. Of seven snorkeling or electrofishing transects done above dry areas, none contained bull trout. In direct contrast, we found cutthroat trout densities of .5 to 13.9 fish per 100 square meters above the dry area in Trail Creek. These sections apparently went dry before the arrival of bull trout spawners and created a migration barrier. There was no apparent upstream movement of juveniles into these areas when they carried water.

Densities of mountain whitefish in tributaries were much different than those found in the Middle Fork River pools. The highest density of whitefish in any tributary was 2.7 fish per 100 square meters of surface area in Dolly Varden Creek. Most whitefish found in tributaries were in the downstream reaches. Largest densities of whitefish in tributary streams apparently occurred near the runoff period in early summer. In two sections snorkeled on the Middle Fork, densities were 37.0 and 14.6 fish per 100 square meters. These counts were made in late July and August. Downstream movement of whitefish began to occur in Trail Creek during July and August (Figure A5).

Electrofishing helped in determining distribution and relative abundance in tributary streams (Table 19). More electrofishing took place in the North Fork than the Middle Fork due to restricted use of gas generators in wilderness areas. Shocking sections on Trail Creek can be seen in Figure 28. The most recent information on fish distribution in the North Fork compiled from Fish, Wildlife and Parks, the U.S. Fish and Wildlife Service (1977) and Glacier National Park records can be found in Tables 20 and 21. This information will be useful in assessing stream suitabilities and the potential recruitment of juvenile cutthroat and bull trout to Flathead Lake.

An attempt was made to compare shocking and snorkeling sections. After a transect was snorkeled, it was shocked the same day. In the transects where this was tried, it turned out that fish densities were too low to yield significant results.

Habitat Evaluation

1979 Reach Surveys

A total of 178km of 17 North Fork tributaries was surveyed during 1979 (Table 22). This total represents 38 reaches in five major drainages. A total of 80.5km of eight tributaries to the Middle Fork was surveyed during 1979 (Table 23). This sum includes 25 reaches in five major drainages.

The five major North Fork tributaries had average drainage areas of 170.5 km^2 and average late summer flows of 37.3cfs. Middle Fork drainages were much smaller, draining an average area of 56.1km^2 and having an average late summer discharge of 6.9cfs. The smallest major North Fork tributary (Red Meadow Creek; Table 22) had a larger drainage area than the largest Middle Fork tributary (Granite Creek; Table 23). Stream reach gradients ranged between 0.3 and 15 percent.

Table 19. Fish species density (numbers per 100 meters^2) by age group in electrofishing transects in tributaries to the North Fork of Flathead River during summer of 1979.

					Fish per 100 meters^2 surface area							
					Cutthroat			Bull Trout				Mountain
Drainage	Date	Reach No.	Transect Length(m)	Transect Area (m)^2	Fry	Age I	Age II+	Fry	Age I	Age II+	A[1/]	Whitefish
Big Creek	9/10/79	1	150	2100	--	--	0.1	0.1	0.1	0.4	--	--
	9/15/79	2	150	1050	--	--	--	0.6	0.8	2.8	--	--
Hallawat	9/19/79	2	150	750	--	--	1.1	1.5	0.8	1.7	--	--
Skookoleel	9/15/79	1	150	1200	1.4	0.3	1.1	--	--	--	--	--
	9/2/79	2	150	600	--	--	1.17	--	--	--	--	--
Werner	9/3/79	1	150	900	0.2	1.6	4.1	--	--	0.3	--	--
Nicola	8/31/79	1	150	750	No fish collected							
Kletomus	9/3/79	1	150	300	--	--	0.3	--	--	7.3	0.3	--
Langford	9/2/79	1	150	225	9.3	2.7	13.8	--	--	1.3	--	--
Coal Creek	4/26/79	1	303	4545	.02	--	0.3	0.4	0.2	0.4	--	--
	7/23/79	1	120	1800	--	0.2	0.2	--	0.2	0.2	--	0.3
	9/14/79	2	303	3484	--	0.3	--	1.2	0.2	0.1	--	--
	9/13/79	3	150	600	0.3	2.5	8.2	2.0	0.8	2.7	--	--
	9/13/79	4	150	600	No fish collected							
Mathias	9/11/79	2	150	525	No fish collected							
South Fork of Coal	9/13/79	1	150	900	0.3	0.1	2.1	1.7	1.3	2.0	0.2	--
	9/13/79	2	150	525	No fish collected							
Deadhorse	10/18/79	2	150	300	3.3	3.7	10.3	--	--	--	--	--

Table 19. Continued

					Fish per 100 meters^2 surface area								
		Reach	Transect	Transect	Cutthroat			Bull Trout				Mountain
Drainage	Date	No.	Length(m)	Area(m)^2	Fry	Age I	Age II+	Fry	Age I	Age II+	A1/	Whitefish
Cyclone	9/20/79	2	120	360	5.0	10.8	6.7	--	--	--	--	--
Red Meadow Creek	8/13/79	1	120	1000	0.3	0.6	3.3	--	--	0.6	--	1.7
	8/8/79	∠	150	900	--	0.4	1.9	--	--	1.0	--	--
	8/8/79	2	303	1818	--	0.2	1.4	0.1	--	0.7	--	--
Trail Creek	7/19/79	3	90	900	--	--	0.9	--	--	--	--	--
	8/15/79	4	180	1260	--	0.2	2.1	--	--	--	--	--
	8/16/79	5	150	1200	0.4	0.2	1.3	--	--	--	--	--
	8/16/79	6	150	510	--	--	5.1	--	--	--	--	--
Tuchuck	7/19/79	1	120	480	--	--	5.4	--	--	--	--	--
	8/14/79	1	150	600	--	1.0	8.2	--	--	--	--	--

(m) = meter

M^2 = meters squared

A1/ = refers to mature adfluvial bull trout

Table 20. Current information on fish distribution in west bank North Fork creeks: + = species present, - = species absent, ? = unknown, needs further study.

Creek	Cutthroat Adfluvial	Cutthroat Resident	Bull trout	Sculpin
Canyon	?	+	-	?
McGinnis	?	+	+	?
Big	+	+	+	+
Langford	?	+	+	+
Lookout	?	+	?	?
Elelehum	-	?	-	?
Hallawat	+	+	+	+
Skookoleel	?	+	+	-
Nicola	?	+	+	-
Kletomus	+	+	+	?
Werner	+	+	+	-
Coal	+	+	+	+
Cyclone	?	+	-	+
Deadhorse	?	+	-	-
South Fork Coal	+	+	+	?
Mathias	+	+	+	?
Moran	?	+	+*	+
Hay	?	+	+*	+
Red Meadow	+	+	+	+
Moose	?	+	?	+
Whale	+	+	+	+
Shorty	+	+	+	-
Ninko	?	+	-	?
Teepee	-	+	-	?
Trail	+	+	+	+
Ketchikan	?	?	?	?
Yakinikak	?	+	-	-
Antley	?	?	-	?
Nokio	?	+	-	?
Tuchuck	?	+	-	-
Colts	-	+	-	?

* possible resident population

Table 21. Current information on fish distribution in Glacier Park and Canadian creeks: + = species present, - = species absent, ? = unknown, needs further study.

Creek	Cutthroat Adfluvial	Cutthroat Resident	Bull trout	Sculpin
Glacier Park				
Camas	+	+	?	+
Anaconda	+	+	?	+
Dutch	?	+	?	?
Logging	?	+	?	+
Quartz	?	+	?	+
Bowman	-	+	-	+
Akokala	+	+	-	+
Ford	?	+	?	+
Kintla	?	+	-	+
Spruce	+	+	?	?
Starvation	+	+	+	+
Kishenehn	+	+	+	+
Sage	+	+	+	+
British Columbia				
Howell	+	+	+	+
Cabin	+	+	+	+
Couldrey	+	+	+	+

Table 22. Reach information concerning tributaries surveyed in the North Fork during the summer of 1979.

Drainage	Reach Number	Drainage Area(km^2)	Length (km)	Gradient (%)	Late Summer Flow(cfs)
Big Creek		212.5	17.0	3.4	--
	1	--	7.0	1.5	33.4
	2	--	6.5	2.0	24.8
	3	--	3.5	10.0	--
Hallawatt		42.1	8.0	3.0	--
	1	--	4.0	3.0	--
	2	--	4.0	3.0	9.8
Skookoleel		22.2	7.3	8.3	--
	1	--	4.8	10.0	--
	2	--	2.5	5.0	3.3
Werner		10.3	1.5	10.0	--
	1	--	1.5	10.0	1.6
Nicola		13.6	3.5	8.0	--
	1	--	3.5	8.0	2.7
Kletomus		14.1	4.0	7.0	--
	1	--	4.0	7.0	2.7
Langford		12.4	3.0	3.0	--
	1	--	1.5	3.0	1.4
	2	--	1.5	3.0	--
Coal Creek		211.5	25.5	2.3	--
	1	--	6.0	2.0	29.3
	2	--	7.5	1.0	20.1
	3	--	10.5	2.5	1.2
	4	--	1.5	9.0	1.3
Mathias		13.2	4.0	7.0	--
	1	--	1.5	2.0	2.8
	2	--	2.5	10.0	1.9
South Fork Coal		34.4	10.5	4.0	--
	1	--	8.0	3.5	3.0
	2	--	2.5	5.5	1.7
Deadhorse		25.2	7.5	6.0	--
	1	--	5.5	4.5	6.8
	2	--	2.0	10.0	3.3
Cyclone		34.9	6.0	1.5	--
	1	--	2.0	1.5	6.6
	2	--	4.0	1.5	1.5

Table 22. Continued.

Drainage	Reach Number	Drainage Area(km^2)	Length (km)	Gradient (%)	Late Summer Flow(cfs)
Red Meadow Creek		76.8	21.0	3.7	--
	1	--	8.0	1.7	16.7
	2	--	11.0	1.7	12.4
	3	--	3.0	15.0	.8
Trail Creek		186.1	23.3	2.5	--
	1	--	8.5	2.0	42.8
	2	--	4.0	2.0	--
	3	--	3.0	2.0	23.8
	4	--	2.5	0.5	15.1
	5	--	2.1	1.0	16.2
	6	--	3.2	4.0	8.0
Tuchuck		27.2	6.9	2.0	--
	1	--	6.9	2.0	8.1
Whale Creek		165.5	18.0	1.2	--
	1	--	8.0	1.5	64.3
	2	--	10.0	1.0	25.8
Shorty		22.4	11.0	3.6	--
	1	--	5.0	2.0	13.0
	2	--	6.0	5.0	7.8

Table 23. Reach information concerning tributaries surveyed in the Middle Fork during the summer of 1979.

Drainage	Reach Number	Drainage Area(km^2)	Length (km)	Gradient (%)	Late Summer Flow(cfs)
Charlie Creek		27.2	6.4	3.0	0.7
	1	--	2.9	2.2	--
	2	--	2.9	2.4	--
	3	--	0.6	7.6	--
Long Creek		57.0	12.6	3.6	7.8
	1	--	2.6	2.3	--
	2	--	1.4	1.7	--
	3	--	4.7	3.1	--
	4	--	1.1	10.3	--
	5	--	2.8	3.9	--
Bergsicker		22.8	8.9	3.9	dry at mouth
	1	--	4.3	1.8	--
	2	--	1.8	2.8	--
	3	--	2.8	7.8	--
Twentyfive Mile Creek		53.6	11.7	4.5	6.1
	1	--	1.0	5.1	--
	2	--	3.9	1.7	--
	3	--	4.9	6.0	--
Granite Creek		74.6	13.8	1.4	4.9
	1	--	6.9	1.8	--
	2	--	6.9	1.0	--
Challenge		18.9	4.5	3.3	1.1
	1	--	4.5	3.3	--
Dolly Varden Creek		68.4	17.3	1.1	15.0
	1	--	4.7	0.3	--
	2	--	3.9	0.7	--
	3	--	5.5	1.1	--
	4	--	2.2	2.6	--
	5	--	1.0	2.4	--
Argosy		15.4	5.3	3.6	2.5
	1	--	1.7	5.9	--
	2	--	1.0	1.9	--
	3	--	2.6	2.8	--

Figure 28 depicts a preliminary inventory map of several key biological and physical aspects of the Trail Creek drainage of the North Fork. The mapping system will be upgraded to provide a larger amount of useful information on all tributaries surveyed in the upper Flathead River Basin.

Underwater Fish Census Transects

Data from 17 North Fork and 14 Middle Fork tributary underwater fish census transects (Table 17 and 18) were analyzed. Of the 1300 fish tallied, 87 percent were either cutthroat or bull trout (Table 24). Cutthroat were the most commonly encountered fish species, outnumbering bull trout by a factor of nearly two. This may be due in part to the fact that of the two species, cutthroat are in general less secretive and therefore more observable by divers. However, the above might be moderated by the fact that data from several North Fork tributaries known to have high cutthroat densities (Skookoleel, Werner, Langford and Cyclone Creeks; Table 19) were not used in the analysis because fish densities were estimated by electrofishing rather than snorkeling.

Several arctic grayling observed in Red Meadow Creek on the North Fork represent the only other fish species observed in the snorkel transects. These fish evidently drift downstream from Red Meadow Lake, where they have been stocked in the past.

Preference of Cutthroat and Bull Trout for Major Habitat Types

A total of 306 habitat units were snorkeled, including 135 pools, 88 runs and 83 riffles (Table 25). The average density and abundance of age I and older (I+) cutthroat and bull trout in pools, runs and riffles is presented in Table 25.

Density and abundance of cutthroat and bull trout were highest in pools, lowest in riffles and intermediate in runs (Table 25). Average density of age I and older (I+) cutthroat and bull trout in all habitat types of all tributaries was 9.4 and 4.2 fish per $100m^2$ surface area, respectively. The average density of age I and older (I+) cutthroat in pools (16.7 fish per $100m^2$) was somewhat lower than the value of 20.4 fish per $100m^2$ reported by Hanson (1977) for nine pools snorkeled in a tributary to the St. Joe River in northern Idaho. However, this figure was significantly higher than that reported by Hanson (1977) for St. Joe River pools (3.3 fish per $100m^2$).

Affinity for pool habitats was more strongly expressed by age I and older (I+) bull trout than by cutthroat. Bull trout density in runs (1.8 fish per $100m^2$) was 24 percent of pool density (7.4 fish per $100m^2$), whereas cutthroat density in runs (6.0 fish per $100m^2$) was 36 percent of pool density (16.7 fish per $100m^2$; Table 25). Cutthroat were less abundant in riffles than bull trout. Age I and older (I+) cutthroat density in riffles (1.2 fish per $100m^2$) was 20 percent of

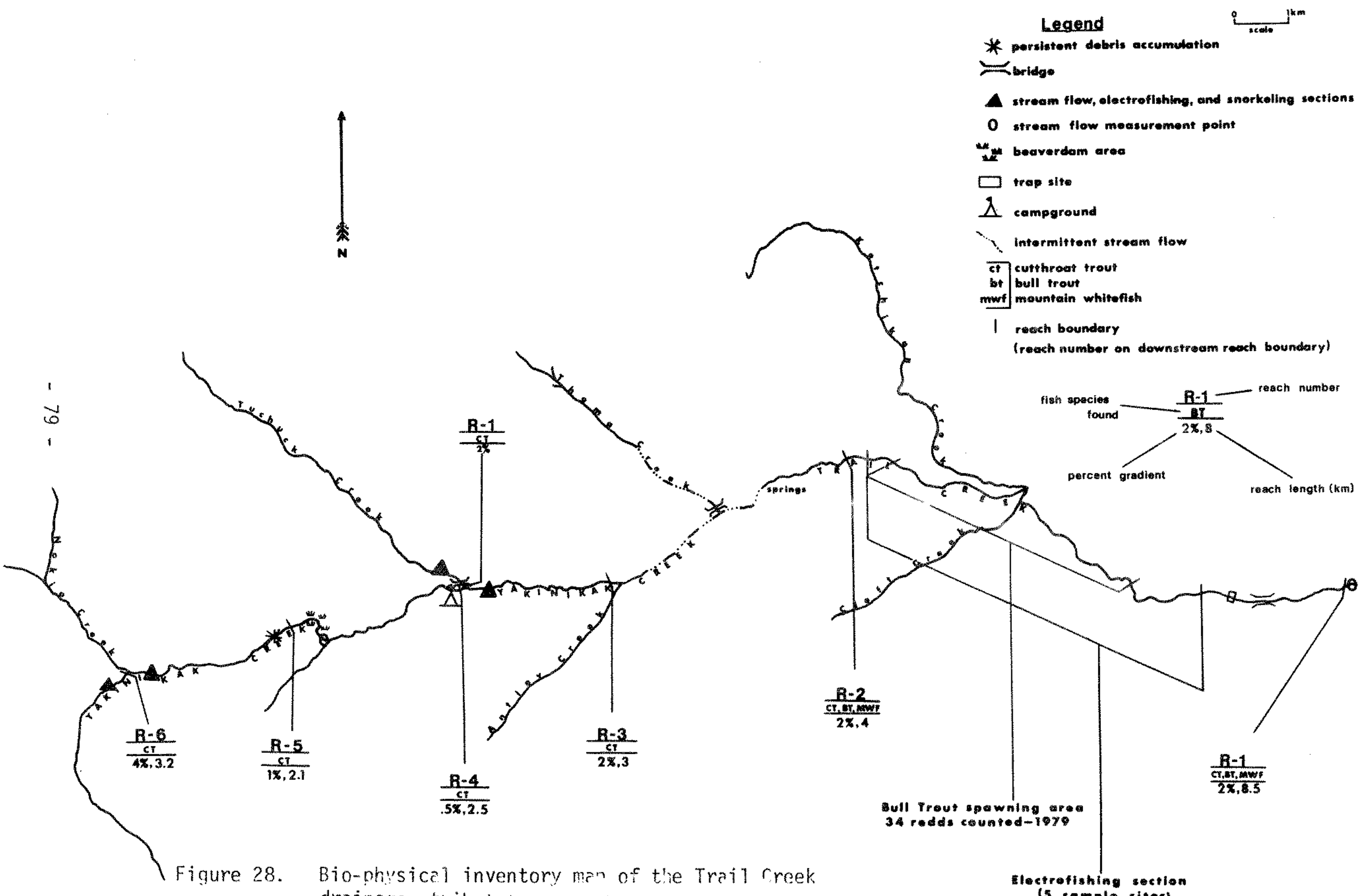


Figure 28. Bio-physical inventory map of the Trail Creek drainage, trilutatary to the North Fork of the Flathead River.

Table 24. Species composition by numbers and percent of fish observed in 31 underwater fish census transects in tributaries to the North and Middle Forks of the Flathead River during 1979.

	Cutthroat	Bull trout	Mountain whitefish	Sculpins	Total
Number observed	740	397	115	48	1,300
Percent of total	56.9	30.5	8.8	3.7	--

Table 25. Average density (fish per 100 m^2 surface area) and abundance of age I and older (referred to as I+) cutthroat and bull trout by habitat feature (pools-runs-riffles) in underwater fish census transects in tributaries to the North and Middle Forks of the Flathead River during 1979. Abundance values are in parentheses.

	Number examined	Age I+ cutthroat	Age I+ bull trout
Pools	135	16.7(3.4)	7.4(1.6)
Runs	88	6.0(1.9)	1.8(1.0)
Riffles	83	1.2(0.7)	1.6(0.8)

run density whereas bull trout density in riffles (1.6 fish per $100m^2$) was nearly identical to run density (Table 25).

All age groups of both cutthroat and bull trout achieved larger densities in pool habitats as opposed to riffle-run habitats (Table 26). Data presented in Table 26 reveal some interesting distribution patterns by age groups of the two species.

Fry of both species were observed in pool and riffle-run habitats with equal frequency. Age I cutthroat were more frequently encountered in pools but densities were quite similar in both habitat types; 16.7 fish per $100m^2$ in pools versus 13.9 fish per $100m^2$ in riffle-run habitat (Table 26). Age II and older (II+) cutthroat more strongly preferred pools. They were observed in 49 percent more pool habitats than riffle-run types and pool densities were markedly higher (19.0 fish per $100m^2$ in pools, 5.6 fish per $100m^2$ in riffle-runs)

Age I bull trout were more frequently found in riffle-run habitats than pool habitats although densities in pools were much larger (17.9 fish per $100m^2$) than densities in riffle-runs (4.9 fish per $100m^2$). Age II and older (II+) bull trout show a slight preference for pool habitats. Compaison of age I and older (I+) fish of both species reveals that although the predilection towards pool habitats appears to be stronger in cutthroat, both species achieve significantly larger densities in pool habitats as opposed to riffle-run habitats. Bull trout may be able to inhabit a wider variety of habitats more effectively than cutthroat. Expansion of the data base during the next year will provide additional information to test the validity of this hypothesis.

Correlation Between Habitat Variables and Cutthroat and Bull Trout Density and Abundance

The following represents a preliminary attempt at identifying habitat components which exert significant influence on fish populations in tributaries to the North and Middle Forks of the Flathead River. This analysis has been conducted using roughly one third of the information we plan to eventually have at our disposal. Investigation of habitats in upper Middle Fork tributaries and those draining Glacier Park on the North Fork during next summer will provide a more diverse data base which is invaluable to the process of statistical inference.

A total of 268 simple linear correlation coefficients and their associated levels of significance are presented. They basically represent the same set of data handled in two different ways. In the first analysis, the dependent variable is density (fish per $100m^2$) of specific age groups of cutthroat and bull trout. As described previously, these age groups (fry, age I, age II and older, and age I and older) were selected to represent size classes of fish. Numerous studies have shown that fish body size is

Table 26. Frequency of occurrence and density (fish per 100 m^2) of cutthroat trout and bull trout in pool and riffle-run habitat in 31 underwater fish transects in tributaries to the North and Middle Forks of the Flathead River during 1979. Age I+ refers to age I and older fish; age II+ refers to age II and older fish.

Species and age group	Pools		Riffle-run	
	Frequency of occurrence	Average density (fish per 100 m^2)	Frequency of occurrence	Average density (fish per 100 m^2)
Cutthroat				
Fry	13	78.1	14	18.6
Age I	38	16.7	29	13.9
Age II+	76	19.0	39	5.6
Age I+	82	25.4	52	11.9
Bull trout				
Fry	15	7.8	14	3.7
Age I	19	17.9	23	4.9
Age II+	48	13.0	42	3.6
Age I+	54	17.8	53	5.0

related to habitat size (Everest and Chapman, 1972; Chapman and Bjornn, 1969; Hanson, 1977).

The second analysis employs fish abundance (simply the number of fish observed in a given pool or riffle-run) as the dependent variable. As in the first analysis, fish abundance is broken down into age groups by species.

Both analyses are partitioned into regressions involving fish populations in pools and in riffle-run habitats. Since both abundance and density of cutthroat and bull trout were noticeably higher in pools (Table 26) it was felt that separation of the two major habitat types would shed some light on the habitat preferences of these two species.

The preliminary nature of this analysis is underscored by the fact that most of the independent variables employed are physical measurements taken directly from underwater fish census t ansect cards. These variables were chosen because many of them have in the past been correlated with salmonid population levels (Burns 1971; Hanson 1977; Platts 1976; Sekulich and Bjornn 1977).

Density

Statistical relationships between densities of specific age classes of cutthroat and bull trout and several independent habitat variables in pool and riffle-run habitats are summarized in Tables 27 through 30. With a few exceptions, densities of all age groups of both species decreased as stream width, surface area, mean depth and volume increased. The most significant correlation coefficients (r) describing these relationships ranged between -0.500 and -0.664.

Cutthroat fry densities were positively correlated with reach number, elevation and gradient in both pool and riffle-run habitats (Tables 27 and 28). This indicates that cutthroat fry attain higher densities in the high elevation upper reaches of higher gradient tributaries. These findings are accepted with caution since one-third of the fry observations were from Argosy Creek, which is a small headwater tributary to Dolly Varden Creek in the upper Middle Fork. Argosy Creek supported very high densities of cutthroat fry (Table 18). Cutthroat fry densities in pools were strongly correlated with pool width:depth ratio (r=0.697, p=.01; Table 27) indicating that fry preferred wide, shallow pools.

Relationships between fish populations and pool class can be deceiving. The pool classification system employed in our survey (Table 10) attempts to describe pool habitat quality by rating width, depth and cover. Theoretically, class 1 pools offer high quality fish habitat, class 5 afford poor habitat. Consequently, the strong, positive correlation coefficient describing the relationship between age I cutthroat density and pool class (r=.558, p=.01,; Table 27) indicates that as pool class number increases, densities of age I cutthroat increase. In other words, age I cutthroat

Table 27. Simple correlation coefficients (r) and associated levels of significance (p) relating age specific cutthroat trout densities (number per 100 m^2) in North and Middle Fork tributary pools to measured habitat parameters.

Variable	Cutthroat trout density (and sample size) in pools							
	Fry (n = 13)		Age I (n = 38)		Age II+ (n = 76)		Age I+ (n = 82)	
	r	p	r	p	r	p	r	p
Reach number	.684	.01	.149	n.s.	.073	n.s.	.115	n.s.
Pool class	insuffícent data		.558	<.01	.172	n.s.	.234	.07
Width	-.459	n.s.[1]	-.599	<.01	-.448	<.01	-.519	<.01
Surface area	-.396	n.s.	-.391	.02	-.318	.01	-.356	<.01
Mean depth	-.664	.01	-.376	.02	-.192	.10	-.266	.02
Volume	-.490	.09	-.375	.02	-.301	.01	-.330	<.01
Elevation	.705	.01	.146	n.s.	.128	n.s.	.147	n.s.
Gradient (%)	.505	.08	.403	.01	.142	n.s.	.173	n.s.
Width:depth ratio	.697	.01	-.242	n.s.	-.292	.01	-.284	.01

1/ n.s. = not significant

Table 28. Simple correlation coefficients (r) and associated levels of significance (p) relating age specific cutthroat trout densities (number per 100 m^2) in North and Middle Fork tributary riffle-run habitats to measured habitat parameters.

Variable	Cutthroat trout density (and sample size) in riffle-run habitats							
	Fry (n = 14)		Age I (n = 29)		Age II+ (n = 39)		Age I+ (n = 52)	
	r	p	r	p	r	p	r	p
Reach number	.575	.03	.283	n.s.	.344	.03	.098	n.s.
Width	-.520	.06	-.351	.06	-.508	<.01	-.295	.03
Surface area	-.496	.07	-.289	n.s.	-.386	.02	-.180	n.s.
Mean depth	-.379	n.s.1/	-.182	n.s.	.134	n.s.	-.116	n.s.
Volume	-.402	n.s.	-.252	n.s.	-.333	.04	-.188	n.s.
Elevation	.526	.05	.338	.07	.325	.04	.258	.06
Gradient (%)	.286	n.s.	-.028	n.s.	-.031	n.s.	-.042	n.s.
Width:depth ratio	-.180	n.s.	-.155	n.s.	-.349	.03	-.143	n.s.

1/ n.s. = not significant

densities were highest in low class pools which presumably offer the lower quality habitat. It is uncertain whether cutthroat prefer these pools or inhabit them because they are competively displaced into these supposed marginal habitats by larger fish.

The positive relationship between pool class and age II and older cutthroat (r=.172, n.s.; Table 27). is not as strong as that observed for age I fish. Interestingly, age II and older fish were the only cutthroat whose densities increased with increasing riffle-run depth, although the relationship was not significant (r=.134; Table 28).

Bull trout results are inconsistent and offer little opportunity for generalization. Fewer significant correlations were found between bull trout density and elevation, gradient, and width:depth ratio than were observed between cutthroat density and these variables. Five significant relationships (at the .05 level) were noted for bull trout versus 11 significant cutthroat correlations.

It appears that densities of all bull trout age classes were consistently higher in pools that were wide relative to depth. This relationship between bull trout density and pool width:depth ratio was uniformly strong. Values for "r" ranged between -.418 and -.523 (Table 29). This indicates that bull trout fry prefer relatively deep pools which is the reverse of the pattern noted for cutthroat fry. This may eventually be related to differences in spawning habitat selected for by fall spawning bull trout versus spring spawning cutthroat.

Abundance

Relationships between fish numbers and stream width, surface area, mean depth, and volume were highly variable (Tables 31 through 34). Of a possible total of 64, only eight regressions between fish density and these variables were significant at the .05 level. Of these eight regressions, seven were significant positive relationships, i.e. fish numbers increased as stream size increased. Sekulich and Bjornn (1977) found consistently positive relationships between anadromous salmonid numbers and stream size and consistently negative relationships between fish densities and stream size in Idaho streams. Burns (1971) obtained his best correlation between absolute salmonid biomass and stream surface area (r=0.898)in seven northern California streams.

The positive relationship between numbers of age II and older cutthroat and mean depth in riffle-run habitats (r=.381, p=.02; Table 32) is the only cutthroat abundance regression in this habitat type which is significant at the .05 level. This again points to the fact that these fish prefer deeper water when found in this habitat type.

Table 29. Simple correlation coefficients (r) and associated levels of significance (p) relating age specific bull trout densities (number per 100 m^2) in North and Middle Fork tributary pools to measured habitat parameters.

Variable	Bull trout density (and sample size) in pools							
	Fry (n = 15)		Age I (n = 19)		Age II+ (n = 48)		Age I+ (n = 54)	
	r	p	r	p	r	p	r	p
Reach number	-.123	n.s.[1]	-.299	n.s.	.050	n.s.	-.047	n.s.
Pool class	insufficient data		.345	n.s.	-.030	n.s.	.043	n.s.
Width	-.554	.03	-.624	<.01	-.414	<.01	-.399	<.01
Surface area	-.492	.06	-.361	n.s.	-.247	.09	-.222	n.s.
Mean depth	.202	n.s.	-.147	n.s.	.124	n.s.	.066	n.s.
Volume	-.398	n.s.	-.341	n.s.	-.216	n.s	-.191	n.s.
Elevation	.080	n.s.	-.329	n.s.	-.035	n.s.	-.098	n.s.
Gradient (%)	.061	n.s.	.329	n.s.	.086	n.s.	.056	n.s.
Width:depth ratio	-.435	n.s.	-.523	.02	-.442	<.01	-.418	<.01

1/ n.s. = not significant

Table 30. Simple correlation coefficients (r) and associated levels of significance (p) relating age specific bull trout densities (number per 100 m^2) in North and Middle Fork tributary riffle-run habitats to measured habitat parameters.

Variable	Bull trout density (and sample size) in riffle-run habitats							
	Fry (n = 14)		Age I (n = 23)		Age II+ (n = 42)		Age I+ (n = 53)	
	r	p	r	p	r	p	r	p
Reach number	.312	n.s.[1/]	-.121	n.s.	.130	n.s.	-.004	n.s.
Width	-.233	n.s.	-.603	<.01	-.396	.01	-.517	<.01
Surface area	-.231	n.s.	-.472	.02	-.383	.01	-.425	<.01
Mean depth	-.379	n.s.	-.273	n.s.	-.085	n.s.	-.201	n.s.
Volume	-.266	n.s.	-.418	.05	-.350	.02	-.397	<.01
Elevation	.541	.05	.123	n.s.	.126	n.s.	.084	n.s.
Gradient (%)	-.590	.03	.312	n.s.	.113	n.s.	-.005	n.s.
Width:depth ratio	-.002	n.s.	-.271	n.s.	-.172	n.s.	-.220	n.s.

1/ n.s. = not significant

Table 31. Simple correlation coefficients (r) and associated levels of significance (p) relating age specific cutthroat trout abundance (numbers present) in North and Middle Fork tributary pools to measured habitat parameters.

Variable	Cutthroat trout abundance (and sample size) in pools							
	Fry (n = 13)		Age I (n = 38)		Age II+ (n = 76)		Age I+ (n = 82)	
	r	p	r	p	r	p	r	p
Reach number	.549	.05	-.390	.01	-.115	n.s.	-.166	n.s.
Pool class	insufficient data		-.179	n.s.	-.414	<.01	-.419	<.01
Width	-.179	n.s.[1]	.100	n.s.	.187	n.s.	.148	n.s.
Surface area	-.154	n.s.	-.011	n.s.	-.191	n.s.	-.024	n.s.
Mean depth	-.482	.10	-.423	.01	.276	.02	.284	.01
Volume	-.306	n.s.	-.031	n.s.	.013	n.s.	.014	n.s.
Elevation	.547	.05	-.462	.04	-.106	n.s.	-.211	.06
Gradient (%)	.369	n.s.	-.163	n.s.	-.070	n.s.	-.088	n.s.
Width:depth ratio	.596	.03	-.203	n.s.	-.040	n.s.	-.086	n.s.

[1] n.s. = not significant

Table 32. Simple correlation coefficients (r) and associated levels of significance (p) relating age specific cutthroat trout abundance (numbers present) in North and Middle Fork tributary riffle-run habitats to measured habitat parameters.

Variable	Cutthroat trout abundance (and sample size) in riffle-run habitats							
	Fry (n = 14)		Age I (n = 29)		Age II+ (n = 39)		Age I+ (n = 52)	
	r	p	r	p	r	p	r	p
Reach number	.210	n.s.[1]	-.196	n.s.	.054	n.s.	-.164	n.s.
Width	-.178	n.s.	-.064	n.s.	-.231	n.s.	-.154	n.s.
Surface area	.056	n.s.	-.063	n.s.	-.172	n.s.	-.155	n.s.
Mean depth	-.250	n.s.	.049	n.s.	.381	.02	.218	n.s.
Volume	-.037	n.s.	-.052	n.s.	-.045	n.s.	-.087	n.s.
Elevation	.101	n.s.	-.055	n.s.	.173	n.s.	.033	n.s.
Gradient (%)	-.034	n.s.	-.198	n.s.	.149	n.s.	.002	n.s.
Width:depth ratio	-.061	n.s.	-.111	n.s.	-.279	.09	-.211	n.s.

1/ n.s. = not significant

The highly significant correlation between numbers of age II and older cutthroat and pool class ($r=-.414$, $p<.01$; Table 31) indicates that large cutthroat prefer high class pools which are characteristically larger and deeper than lower class pools. In addition, a significantly positive correlation was obtained between numbers of age II and older cutthroat and mean pool depth ($r=.276$, $p=.02$; Table 31). A strong negative correlation was noted between numbers of age I cutthroat and mean pool depth ($r=-.423$, $p=.01$; Table 31), indicating that small cutthroat were most numerous in shallow pools. These findings agree closely with those of Everest and Chapman (1972), Hanson (1977) and Chapman and Bjornn (1969). In general, as stream dwelling juvenile chinook salmon, steelhead and cutthroat trout (all members of the genus *Salmo*) increase in body size they select habitats having deeper, faster water. Underwater fish census data from 12 upper Middle Fork River pools snorkeled in late 1979 tend to further support this hypothesis. A total of 46 cutthroat trout were observed, all were estimated to be age III and older fish.

Few significant relationships between numbers of bull trout and measured habitat variables were noted (Tables 33 and 34). Fry and age II and older fish in riffle-run habitats increased significantly in numbers as stream surface area increased ($r=.646$ and $.313$, $p=.01$ and $.04$ respectively; Table 34). The negative correlation between numbers of age II and older bull trout and pool class ($r=-.360$, $p=.03$; Table 33) may indicate that these fish prefer high class pools although the density regression (Table 29) does not support this conclusion

Age and Growth

A total of 456 juvenile cutthroat trout and 468 juvenile bull trout collected during the spring, summer and fall of 1979 were used to determine age and growth in four major tributaries to the North Fork of the Flathead River. Annulus formation occurred in late spring for both species; however, an annulus did not form on many age I cutthroat trout as described in the methods section.

Growth of juvenile cutthroat trout was similar in all four tributaries, although age I fish averaged 18 percent larger in Big and Coal creeks than in Red Meadow and Trail creeks. This difference was maintained through age II (Tables 35 and 36). Length at annulus for age III fish was similar for all four streams. Length at annulus at age I and II compared favorably with lengths calculated for cutthroat trout in tributary streams to the North Fork in 1959 and 1960 (Johnson 1963). Johnson determined age I fish averaged 58mm compared to 57mm in this study and age II fish averaged 114mm compared to 108mm in this study (Table 37). Length at annulus for age III fish was 20 percent larger in Johnson's analysis; however, we purposely did not include age IV and older or mature resident fish in our analysis. Estimated length at annulus at age III may therefore be low if time of downstream migration is size related. The faster growing age II plus and age III fish may leave the streams sooner.

Table 33. Simple correlation coefficients (r) and associated levels of significance (p) relating age specific bull trout abundance (numbers present) in North and Middle Fork tributary pools to measured habitat parameters.

Variable	Bull trout abundance (and sample size) in pools							
	Fry (n = 15)		Age I (n = 19)		Age II+ (n = 48)		Age I+ (n = 54)	
	r	p	r	p	r	p	r	p
Reach number	-.069	n.s.[1]	-.415	.08	.220	n.s.	.172	n.s.
Pool class	insufficient data		.060	n.s.	-.360	.03	-.384	.02
Width	.307	n.s.	-.172	n.s.	-.105	n.s.	.072	n.s.
Surface area	.148	n.s.	.010	n.s.	-.067	n.s.	.044	n.s.
Mean depth	.340	n.s.	-.083	n.s.	.181	n.s.	.209	n.s.
Volume	.103	n.s.	.008	n.s.	-.054	n.s.	-.031	n.s.
Elevation	.124	n.s.	-.198	n.s.	.130	n.s.	.130	n.s.
Gradient (%)	-.505	.06	-.016	n.s.	-.090	n.s.	-.095	n.s.
Width:depth ratio	-.141	n.s.	-.136	n.s.	-.190	n.s.	-.177	n.s.

1/ n.s. = not significant

Table 34. Simple correlation coefficients (r) and associated levels of significance (p) relating age specific bull trout abundance (numbers present) in North and Middle Fork tributary riffle-run habitats to measured habitat parameters.

Variable	Bull trout abundance (and sample size) in riffle-run habitats							
	Fry (n = 14)		Age I (n = 23)		Age II+ (n = 42)		Age I+ (n = 53)	
	r	p	r	p	r	p	r	p
Reach number	.414	n.s.[1]	.269	n.s.	.096	n.s.	.083	n.s.
Width	.397	n.s.	-.101	n.s.	.059	n.s.	-.002	n.s.
Surface area	.646	.01	.033	n.s.	.313	.04	.303	.03
Mean depth	-.211	n.s.	-.262	n.s.	-.030	n.s.	-.083	n.s.
Volume	.534	.05	-.058	n.s.	.243	n.s.	.206	n.s.
Elevation	.301	n.s.	.145	n.s.	.110	n.s.	.071	n.s.
Gradient (%)	-.605	.02	-.086	n.s.	.083	n.s.	-.114	n.s.
Width:depth ratio	.112	n.s.	-.005	n.s.	-.056	n.s.	-.072	n.s.

1/ n.s. = not significant

Table 35. Average calculated total length and increment of length for juvenile cutthroat trout in Big and Coal Creeks collected during the summer and fall of 1979.

Year class	Number of fish[1]	Length (mm) at annulus formation 1	2	3
Big Creek				
1976	4	71	115(7)	153(10)
1977	5	68	113(10)	
1978	7	74		
Grand mean calculated length	16	71	114(17)	153(10)
Grand mean increment of growth		71	43	39
Coal Creek				
1976	2	69	114(3)	163(3)
1977	13	60	121(14)	
1978	8	69		
Grand mean calculated length	23	63	120(17)	163(3)
Grand mean increment of growth		63	57	43

1/ Number of cutthroat used to calculate age 1 fish length; numbers of fish used to calculate length at ages 2 and 3 are in parentheses.

Table 36. Average calculated total length and increment of length for juvenile cutthroat trout in Red Meadow and Trail Creeks collected during the spring, summer and fall of 1979.

Year class	Number of fish1/	Length (mm) at annulus formation 1	2	3
Red Meadow Creek				
1976	12	46	104(95)	151(95)
1977	30	51	111(60)	
1978	9	70		
Grand mean calculated length	51	53	107(155)	151(95)
Grand mean increment of length		53	54	44
Trail Creek				
1976	41	53	102(77)	149(77)
1977	96	51	111(142)	
1978	24	79		
Grand mean calculated length	161	56	108(219)	149(77)
Grand mean increment of length		56	52	41

1/ Number of cutthroat used to calculate age 1 fish length; numbers of fish used to calculate length at ages 2 and 3 are in parentheses.

Table 37. Average calculated total length and increment of length for juvenile cutthroat trout in combined tributary streams from the North Fork drainage collected during 1979.

Year class	Number of fish[1/]	Length (mm) at annulus formation 1	2	3
Combined Streams				
1976	59	53	104(185)	150(185)
1977	144	52	112(223)	
1978	48	75		
Grand mean calculated length	251	57	108(408)	150(185)
Grand mean increment of length		57	51	42

1/ Number of cutthroat used to calculate age 1 fish length; numbers of fish used to calculate length at ages 2 and 3 are in parentheses.

Growth of juvenile bull trout was similar in Coal, Red Meadow and Trail creeks and slower in Big Creek (Tables 38 and 39). Increment of length was largest at age I (80mm) and decreased to 18mm by age III for the combined streams (Table 40). Outmigration of faster growing age II plus and age III fish may also be occurring with bull trout. The back-calculated lengths for age III fish was 26 percent smaller at age I than the average for all fish (Table 40). This may be an expression of Lee's phenomenon (Lee 1912, Van Oosten 1929, and Ricker 1969) or a function of outmigration of faster growing fish.

Few comparisons of growth rates of bull trout are available in the literature. Bjornn (1961) found length at annulus for age I through age III fish from Priest and upper Priest Lakes were 71 and 66mm, 114 and 102mm, and 183 and 155mm, respectively. He reported that, as in the Flathead, juvenile bull trout spent two to three years in tributaries before entering the lake. These lengths were 11 to 18 percent smaller at age I, 8 to 18 percent smaller at age II and 9 to 22 percent larger at age III in Priest Lakes than was found in this study. Growth rates of bull trout in the Bow River, Alberta (Miller 1949) were considerably faster than in the Flathead. Length at annulus at age I was double that observed in the Flathead and 70 percent larger at age II.

A length frequency of sculpins collected in early spring and fall of 1979 in Trail Creek is presented in Figure 29. The spring collection was made just prior to the spawning season. A limited sample of otoliths indicate that the three modes in the spring sample may approximate age II, III and IV fish.

Food Habits

Stomach contents of sculpins, cutthroat and bull trout were examined to determine their food habits. All samples except one were collected in Trail Creek; the other was collected in Red Meadow Creek. Samples were taken during several seasons in 1978 and 1979. The IRI values and percent calories for each food item are presented by species for seasonal comparisons in Trail Creek (Figures 30,31 and 32). Stomach contents from each species by season are expressed in percent number, percent volume and frequency of occurrence as well as in total and percent calories (Appendix C, Tables 1 through 20).

Mayflies (Ephemeroptera) were the major food item for sculpins, cutthroat and bull trout during all seasons in Trail Creek samples (Figures 30,31 and 32). Stoneflies (Plecoptera) and caddisflies (Trichoptera) were seasonally important for all three species. From insect data collected seasonally during 1975-76 by the Flathead 208 Study (File Copy, MT. Fish, Wildlife and Parks, Kalispell), mayflies were generally the most abundant insect order throughout the year. Stoneflies increased in abundance in the winter and spring and they were important in the diet of bull trout during those seasons.

Table 38. Average calculated total length and increment of length for juvenile bull trout in Big and Coal Creeks collected during the summer and fall of 1979.

Year class	Number of fish	Length (mm) at annulus formation 1	2	3
Big Creek				
1976	17	57	107	137
1977	19	72	112	
1978	10	76		
Grand mean calculated length	46	67	110	137
Grand mean increment of length		67	43	27
Coal Creek				
1976	2	61	117	141
1977	19	83	124	
1978	13	88		
Grand mean calculated length	34	84	123	141
Grand mean increment of length		84	39	18

Table 39. Average calculated total length and increment of length for juvenile bull trout in Red Meadow and Trail Creeks collected during the spring, summer and fall of 1979.

Year class	Number of fish	Length (mm) at annulus formation 1	2	3
Red Meadow Creek				
1976	17	61	117	157
1977	53	86	137	
1978	13	79	—	—
Grand mean calculated length	83	80	132	157
Grand mean increment of length		80	52	24
Trail Creek				
1976	19	63	109	157
1977	144	78	121	
1978	76	85	—	—
Grand mean calculated length	239	80	120	157
Grand mean increment of length		80	40	37

Table 40. Average calculated total length and increment of length for juvenile bull trout in combined tributary streams from the North Fork drainage collected during 1979.

Year class	Number of fish	Length (mm) at annulus formation 1	2	3
Combined Streams				
1976	55	60	111	142
1977	278	81	126	
1978	135	87	—	—
Grand mean calculated length	468	80	124	142
Grand mean increment of length		80	44	18

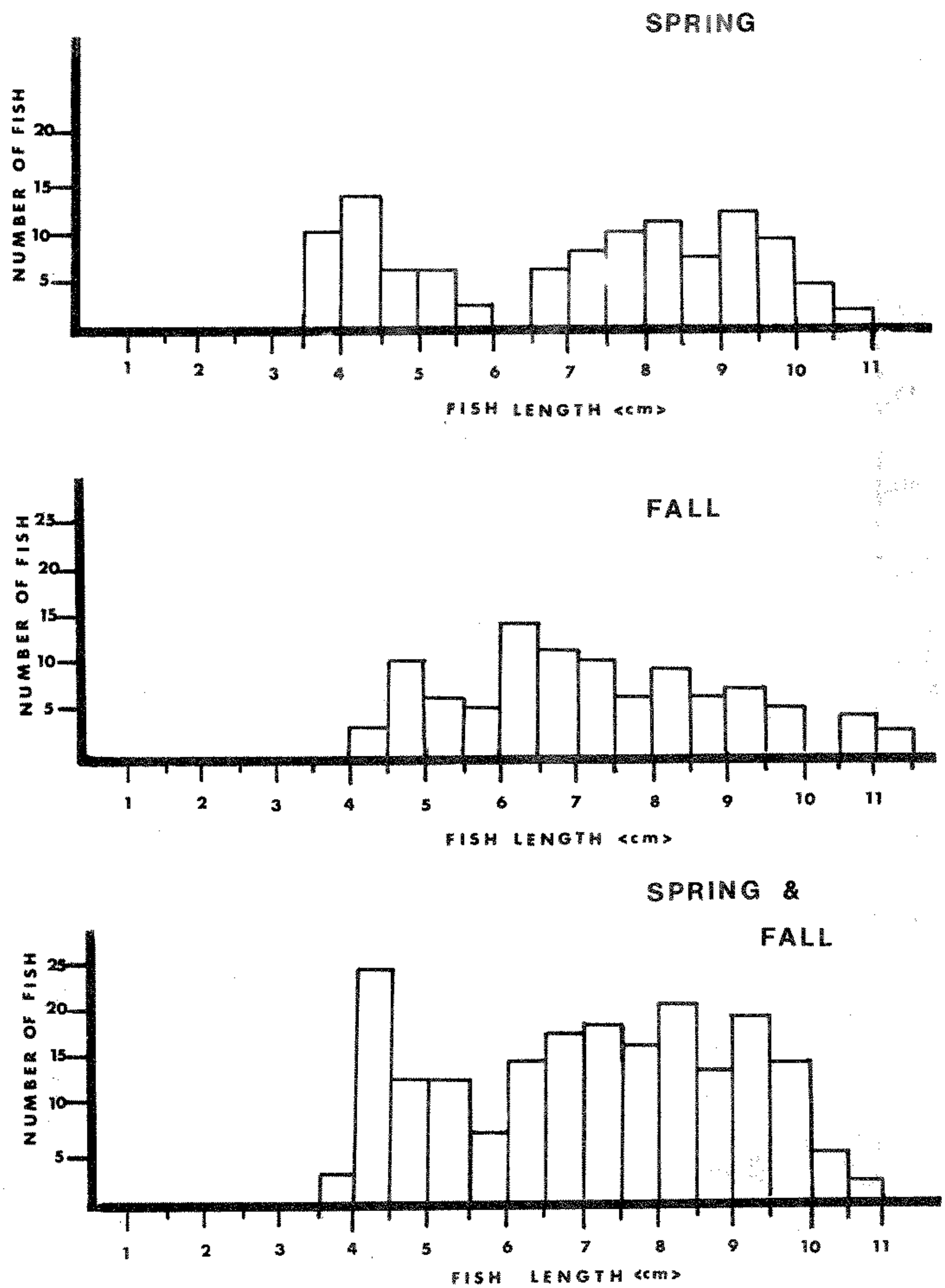


Figure 29. Length frequency of sculpins in Trail Creek. All sculpins were found in Sections 3,4, and 5. No more than 2 sculpins were found in Section 3 in any season.

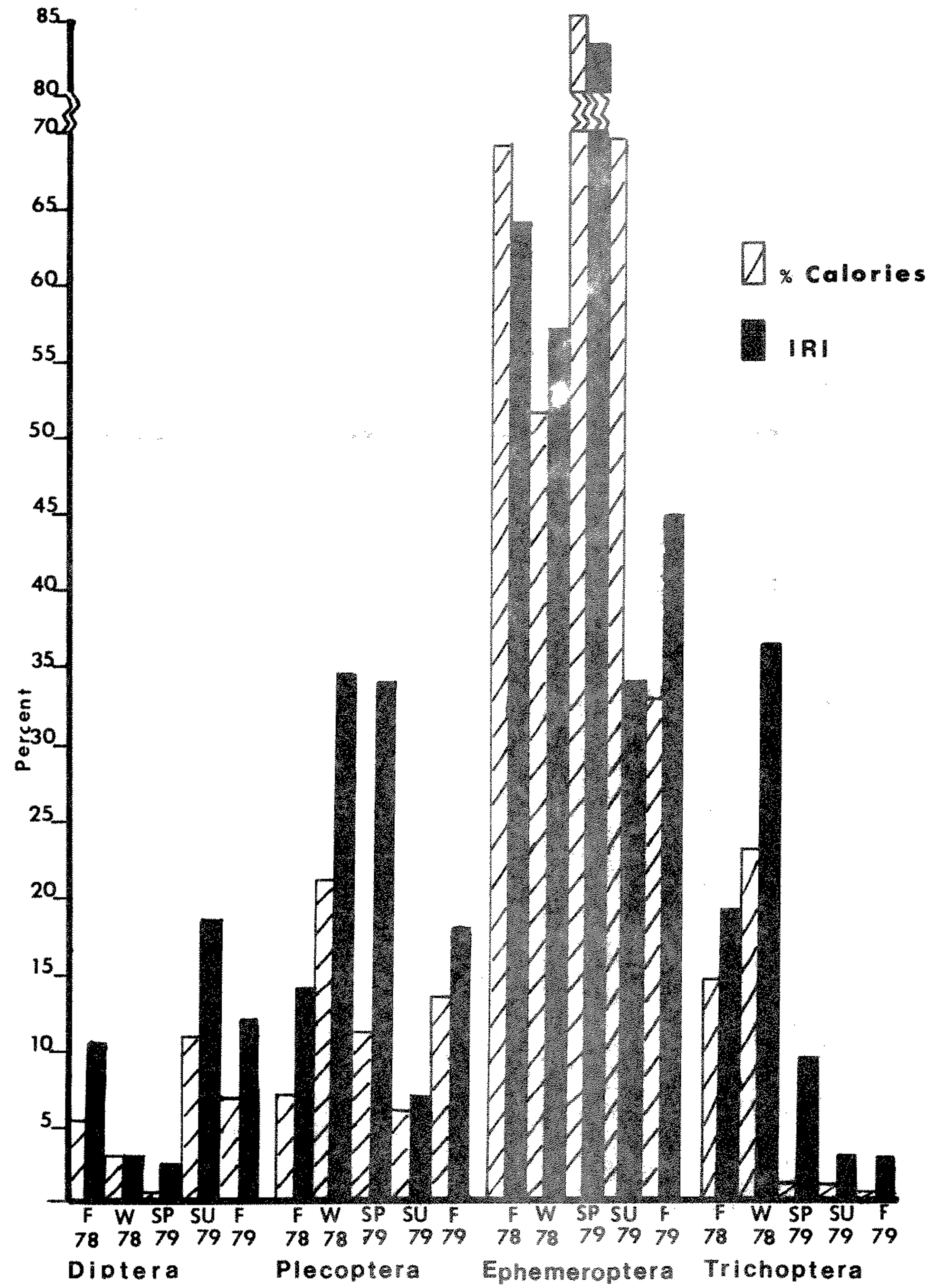


Figure 30. Seasonal comparison of major food items of bull trout collected in Trail Creek during 1978 and 1979. Small quantities of Hymenoptera, Coleoptera, Hemiptera, Annelida, Arachnida, and plant material were also present.

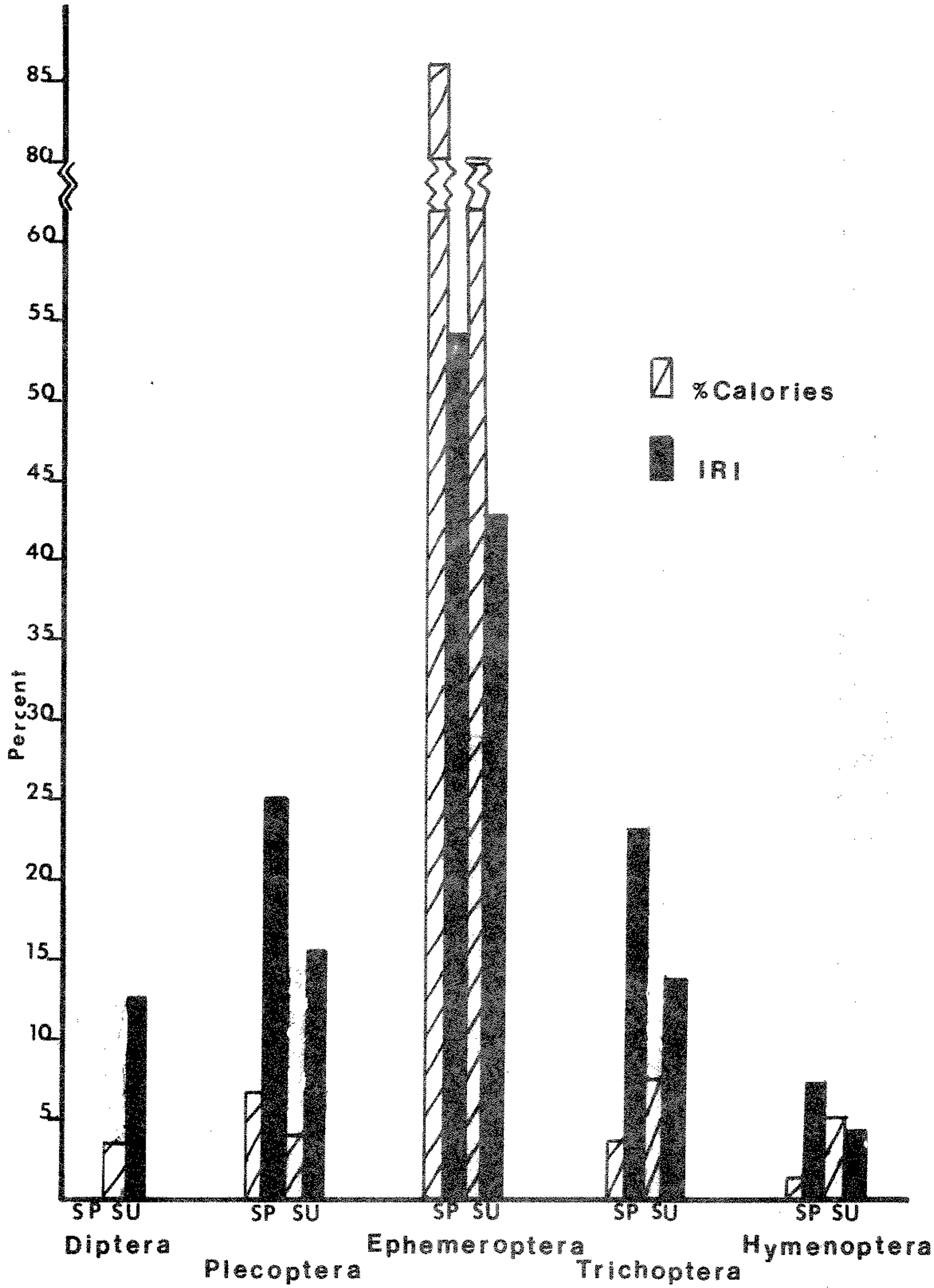


Figure 31. Food intake of westslope cutthroat collected in Trail Creek during 1979 compared seasonally. Small quantities of Orthoptera and Hemiptera were present in summer and Coleoptera in spring samples.

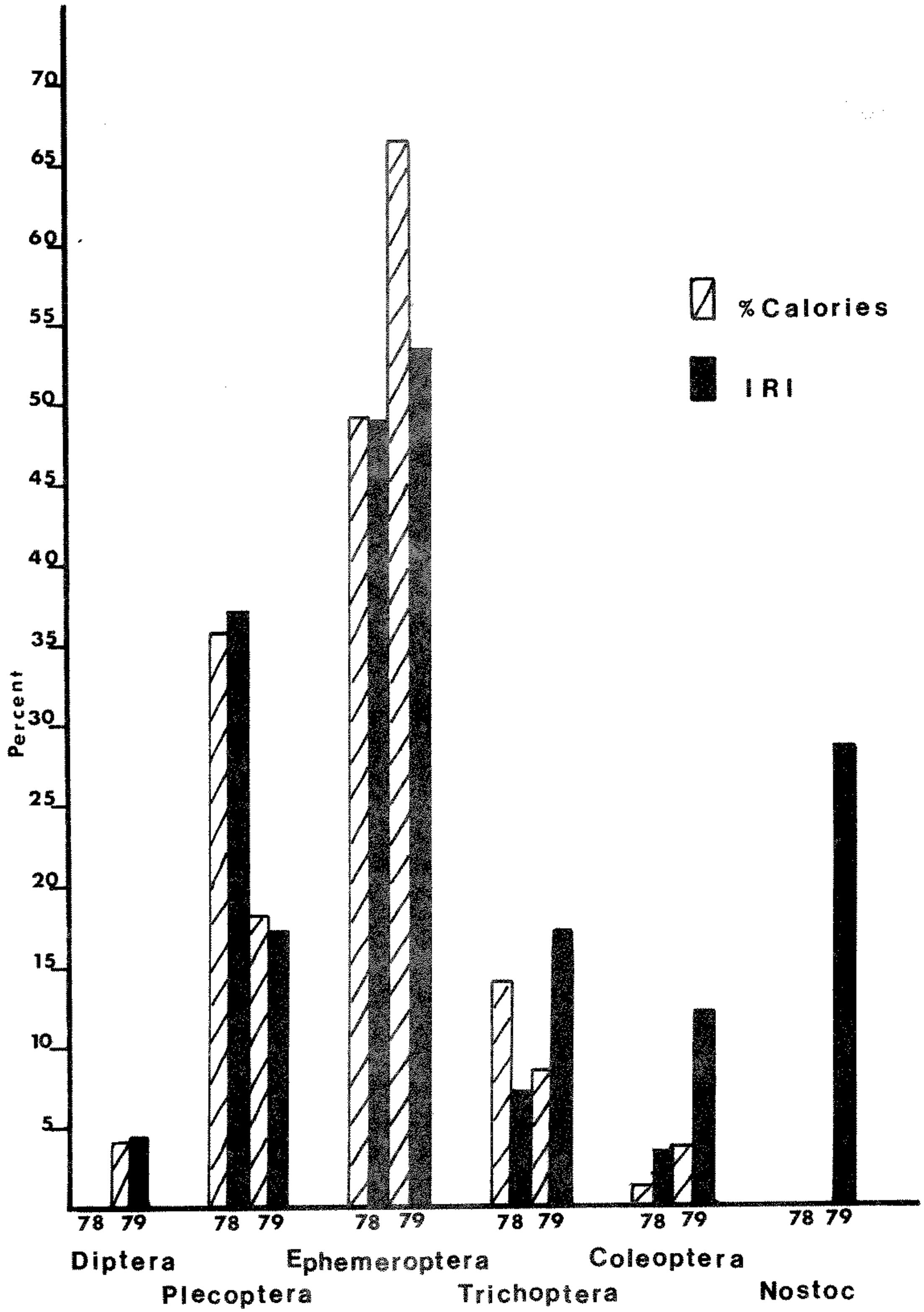


Figure 32. Food intake of sculpins collected in Trail Creek during the fall of 1978 and 1979. Digestive rates and caloric value for Nostoc were not available for analysis.

Over 50 percent of the estimated caloric value for bull trout was obtained from mayflies in every season except the fall of 1979 when fish provided the largest percentage of caloric value (45 percent) (Figure 30). Even during the fall sample the IRI value was considerably higher for mayflies. Stoneflies were the next most significant in the diet during the year, followed closely by caddisflies. Horner (1978) determined that juvenile bull trout were generally more predacious than other trout he studied. Sculpins and other small fish, in particular the seasonal abundance of fry, may play a more important role in the growth of juvenile bull trout than demonstrated here because of their high caloric value.

Mayflies were the major food item for cutthroat trout collected in Trail Creek during the spring and summer of 1979. Approximately 85 percent of the caloric intake in the spring was from mayflies (Figure 31). Stoneflies and caddisflies were relatively important as indicated by their IRI values. By contrast, food habits of cutthroat trout in Red Meadow Creek were more balanced (Figure 33). Terrestrial insects predominated stomach contents in the Red Meadow Creek sample (Appendix C, Tables 15 and 16). The IRI values of Trichoptera and Hymenoptera were slightly higher than for Ephemeroptera, although the caloric value remained higher for mayflies (Figure 33). A larger amount of overhanging vegetation and suspended debris in Red Meadow than in Trail Creek may provide more opportunity for terrestrial insects to fall into the water.

Mayflies also predominated the food intake of sculpins in fall sampling in Trail Creek (Figure 32). Both stoneflies and caddisflies were relatively important. In 1979, Nostoc, a small, globular, blue-green algae was common in the stomach samples. Sculpins were only found in the lower few miles of Trail Creek during all seasons.

In the spring of 1979, there appeared to be little difference in either IRI or percent calories for the major food items of both bull and cutthroat trout (Figure 34). However, stoneflies and mayflies were more important for cutthroat trout. In the summer sample from Trail Creek, mayflies were separated by families. Baetidae were important for both species but Ephemerellidae were more important for cutthroat trout in terms of percent calories (Figure 35). Diptera were more important for bull trout, while caddisflies were more important for cutthroat trout.

In the fall sample, a comparison of bull trout and sculpin stomach contents revealed more similarities than differences (Figure 36). Baetidae, Heptageniidae and Plecoptera were important to both species. Diptera and Hymenoptera were more important for bull trout and Trichoptera was a more important food item for sculpins. Food habits will be studied in other streams to see if these results are consistent.

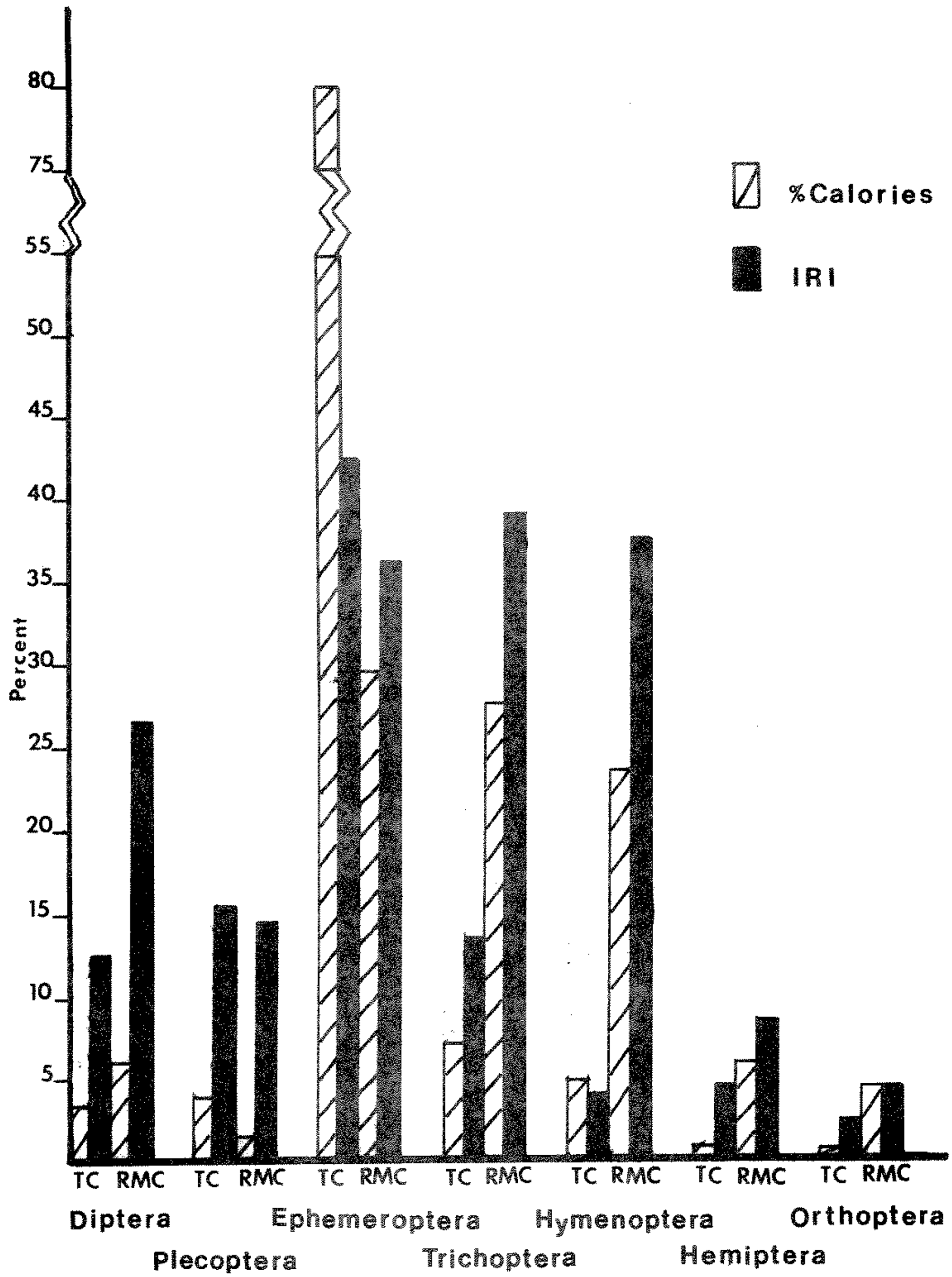


Figure 33. Comparisons of summer food intake of cutthroat trout collected in Red Meadow and Trail Creeks in 1979. Small numbers of Coleoptera, Homoptera and Arachnida were present in the Red Meadow sample.

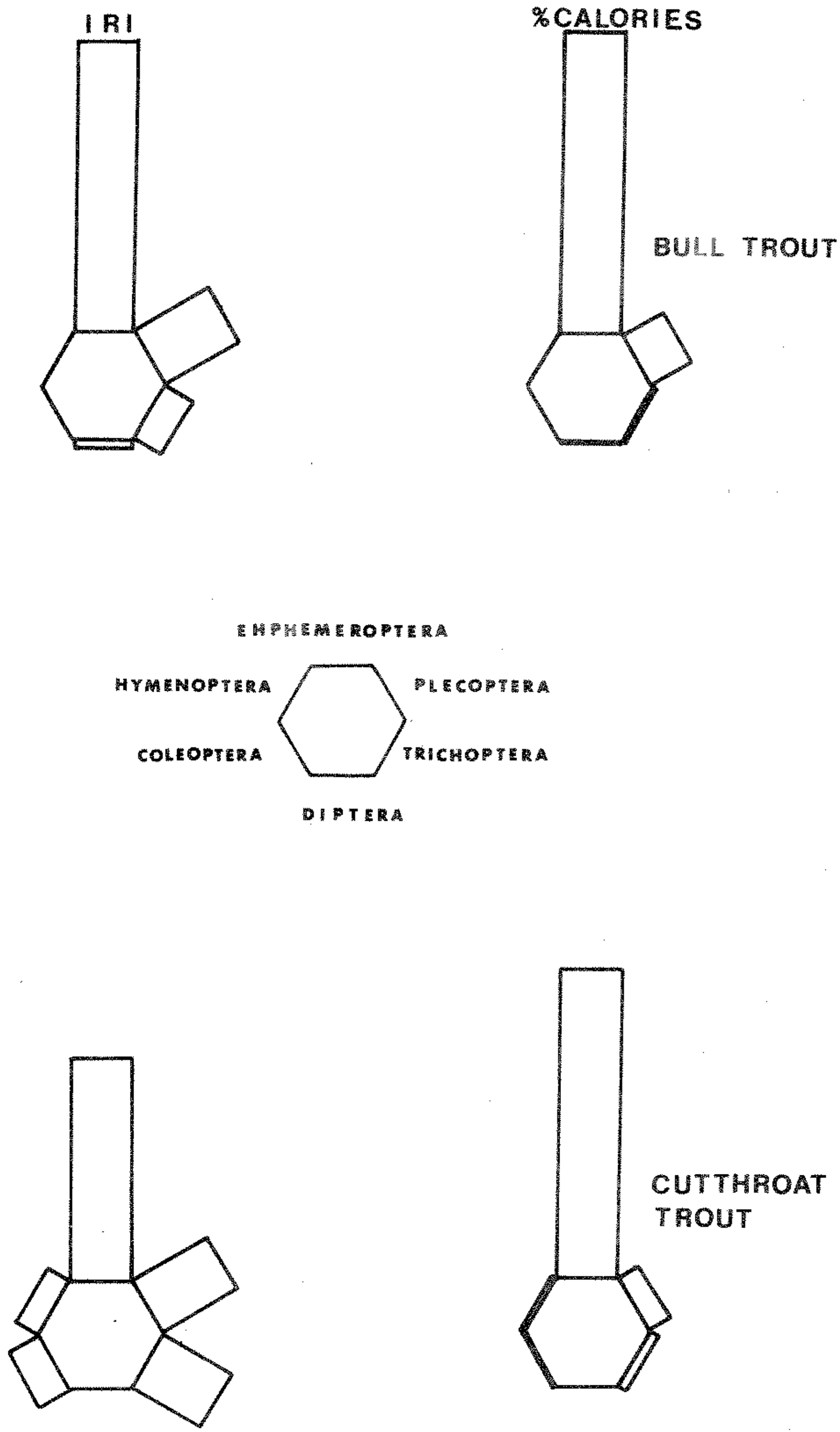


Figure 34. Spring 1979 food habits of cutthroat and bull trout in Trail Creek.

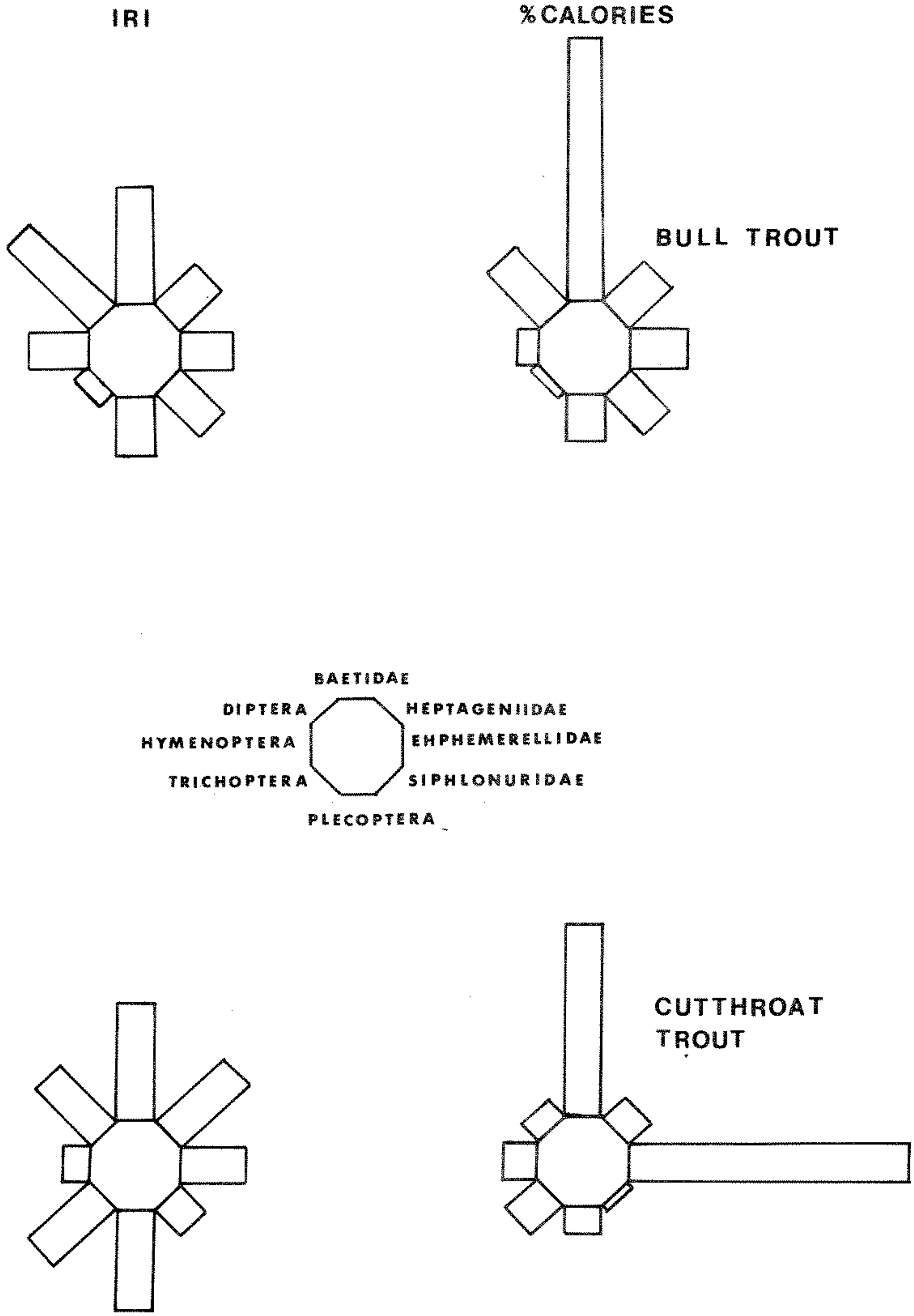


Figure 35. Summer 1979 food habits of cutthroat and bull trout collected in Trail Creek. Mayflies are expressed by family and other major food items by order.

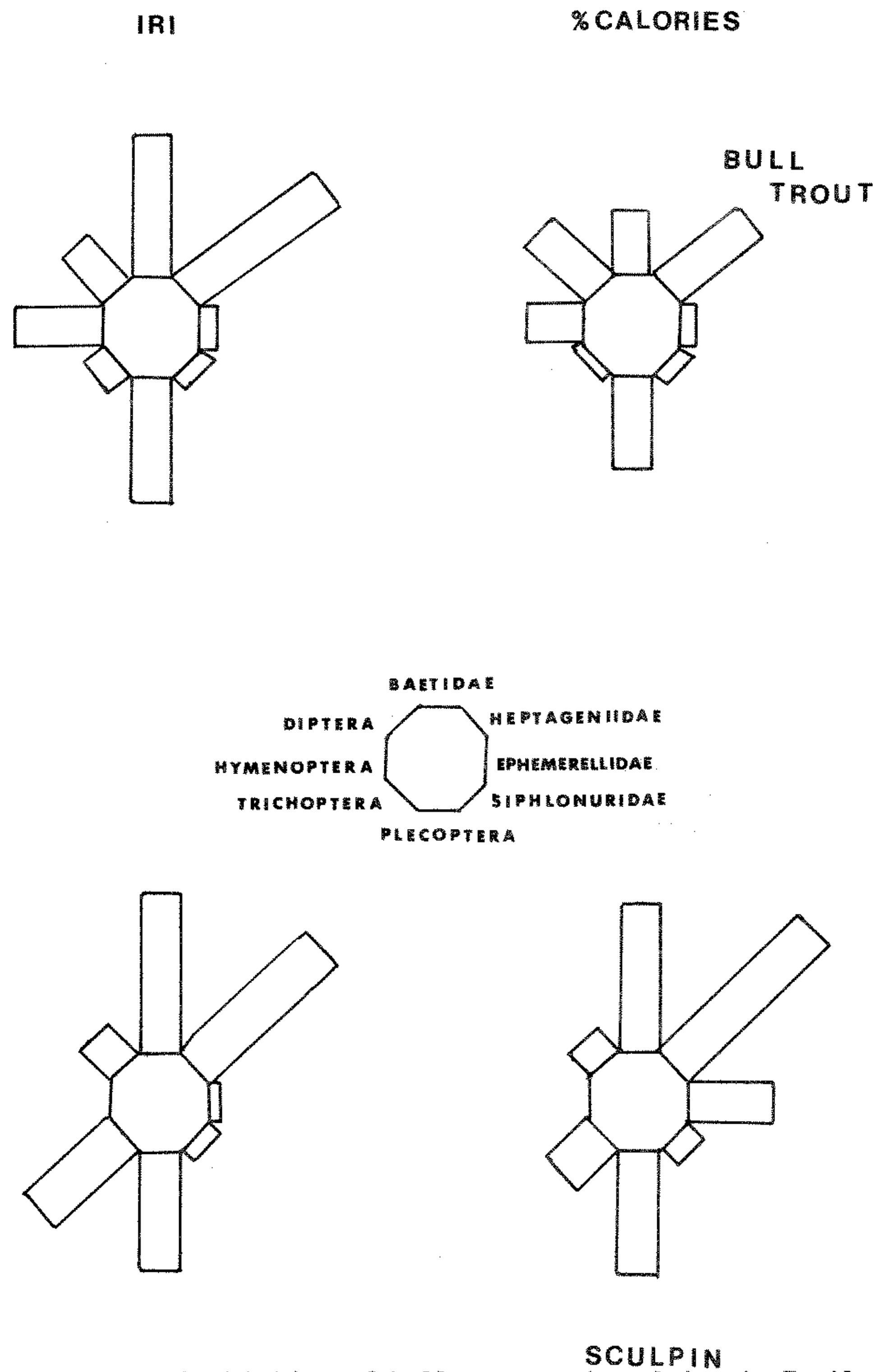


Figure 36. Fall 1979 food habits of bull trout and sculpins in Trail Creek. Mayflies expressed by family and other major food items by order.

Upper Middle Fork Creel Card Survey

A total of 18 voluntary creel census cards were returned during 1979 (Table 41) and returns were equally divided among the summer months (Table 42). Most of the returned cards originated at the Bear Creek access point or were distributed by U.S. Forest Service personnel (Table 41).

Analysis of trip information revealed that the average reported trip length was 3.3 days (n=9) and fishing was conducted on 60 percent of the days of the trip. Of the eight Bear Creek returns, only two were one day trips. The average number of anglers per group was 2.4 (n=18) and fisherman success was 93 percent. Three of 19 parties were nonresidents or had nonresident members. Only one of the parties reported using a boat. It is hoped that more boat fishermen will be surveyed during 1980 via the Schafer Meadows station which was established after the 1979 floating season ended. It was found that the average angler fished 2.9 hours per day as compared to 3.4 hours per angler per day reported by Hanzel (1975) for the entire Middle Fork.

The 1979 card returns indicate that 44 anglers caught a total of 583 fish of which 385 (66%) were released (Table 43). Composition of the 1979 catch (63% cutthroat, 3% bull trout and 34% whitefish, Table 44) was similar to that observed in 1962 (Montana Fish & Game, unpublished data) when 164 man-hours of fishing effort were expended.

The observed 1979 catch rate of 2.55 fish per hour is quite high when compared to the values of 0.49 and 1.02 observed in 1975 and 1962 respectively (Table 44). The 1979 results are based on a small sample size and voluntary information whereas the 1975 information is based primarily on angler interviews and in the 1962 study the anglers were Fish and Game personnel. However, the high catch rates may indicate better fishing in the upper Middle Fork. Examination of the 1962 data revealed that catch rates of 0.38 and 0.68 fish per hour were noted in two sections below Bear Creek whereas values ranging between 0.75 and 1.40 were found in five areas of the upper river. The average catch per hour in the lower Middle Fork was 0.7 fish based upon 94 voluntary creel census cards returned to Glacier National Park biologists during the years 1959-1966 (Morton 1968).

Table 41. Summary of voluntary creel card returns by location on the upper Middle Fork of the Flathead River during 1979.

	Twentyfive Mile Creek	Bear Creek	Granite Creek	Schafer Air Strip	Hungry Horse Guard	Spotted Bear Ranger	Total
Number of Returns	0	8	1	1	4	4	18

Table 42. Summary of voluntary creel card returns by month on the upper Middle Fork of the Flathead River during 1979.

Month	Number of returns
July	5
August	6
September	6
October	1

Table 43. Fishing pressure and catch information obtained via the voluntary creel card survey conducted on the upper Middle Fork of the Flathead River during 1979.

			Fish caught (Number released in parentheses)			
Number of anglers	Number of anglers who caught fish	Total hours fished	Cutthroat	Bull trout	Mountain whitefish	Total
44	39	228	367(205)	19(17)	197(163)	583(385)

Table 44. Comparison of 1979 upper Middle Fork catch information derived from voluntary creel census card returns with Middle Fork results from Hanzel (1975) and from seven float fishing trips conducted by Montana Fish and Game during July and August of 1962.

	Study year	Cutthroat	Bull trout	Mountain whitefish	Other	Total
Percent composition of catch	1979	63.0	3.0	34.0	0.0	--
	1975	66.9	11.3	9.8	12.0	--
	1962	69.5	6.0	24.5	0.0	--
Percent of fish kept	1979	44.0	11.0	18.0	--	34.0
	1975	--	--	--	--	70.0
Catch per hour	1979	1.61	0.08	0.91	--	2.55
	1975	--	--	--	--	0.49
	1972	0.71	0.06	0.25	--	1.02

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APPENDIX A

Figures 1 - 6   Trap Movements

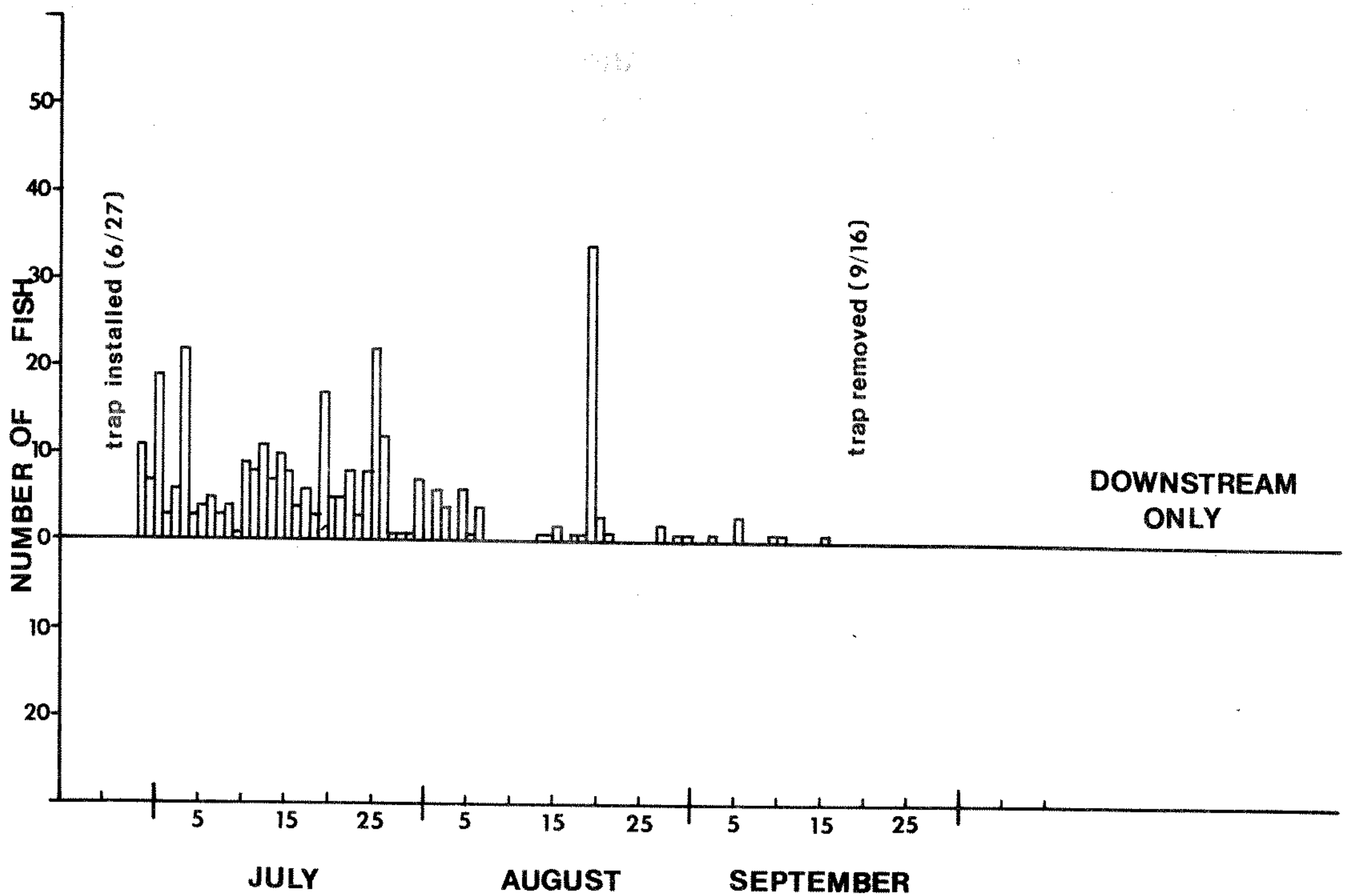

Figure 1. Downstream trap catch of juvenile bull trout in Trail Creek for 1979.

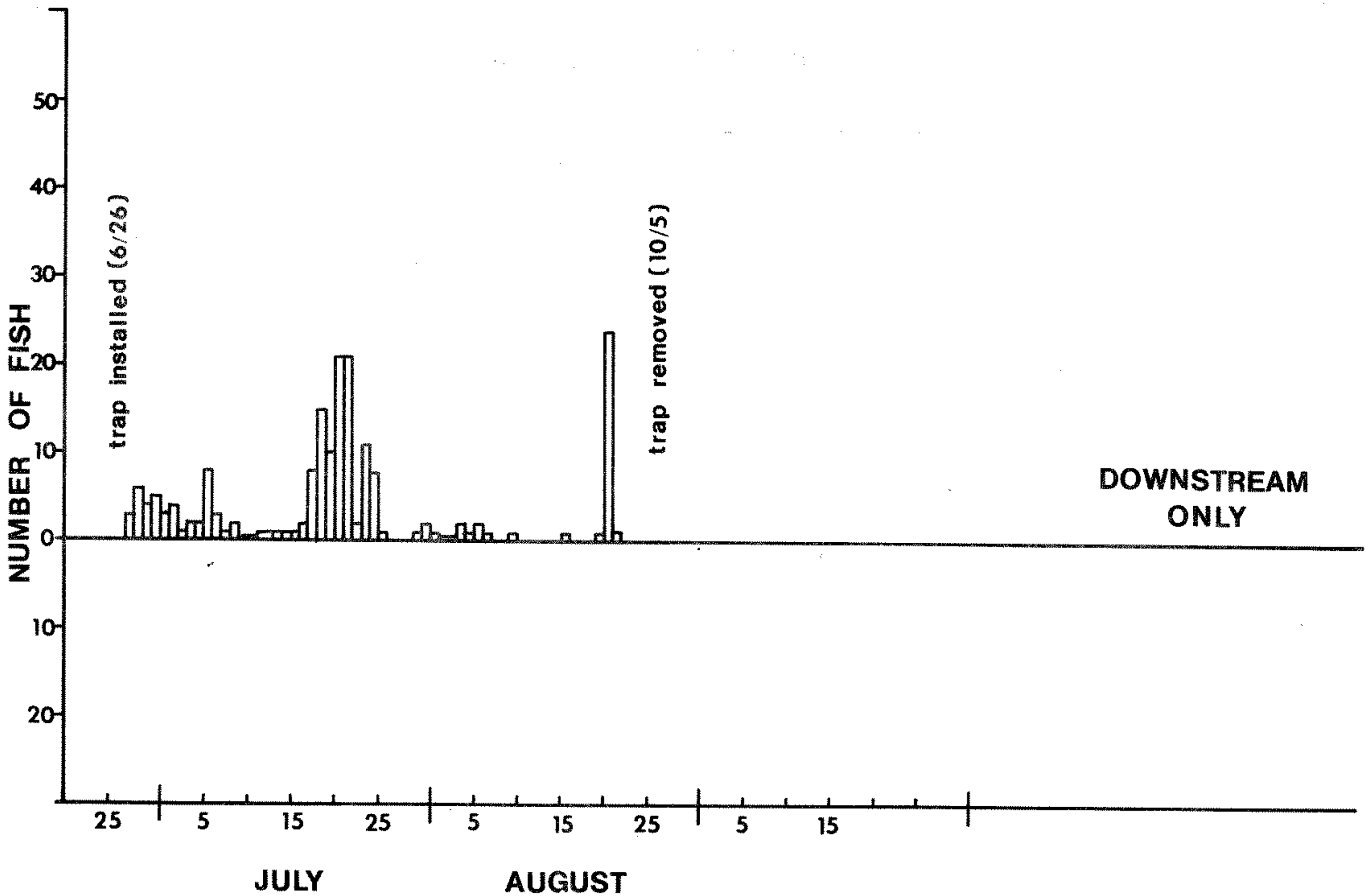

Figure 2. Downstream trap catch of juvenile bull trout in Red Meadow Creek for 1979.

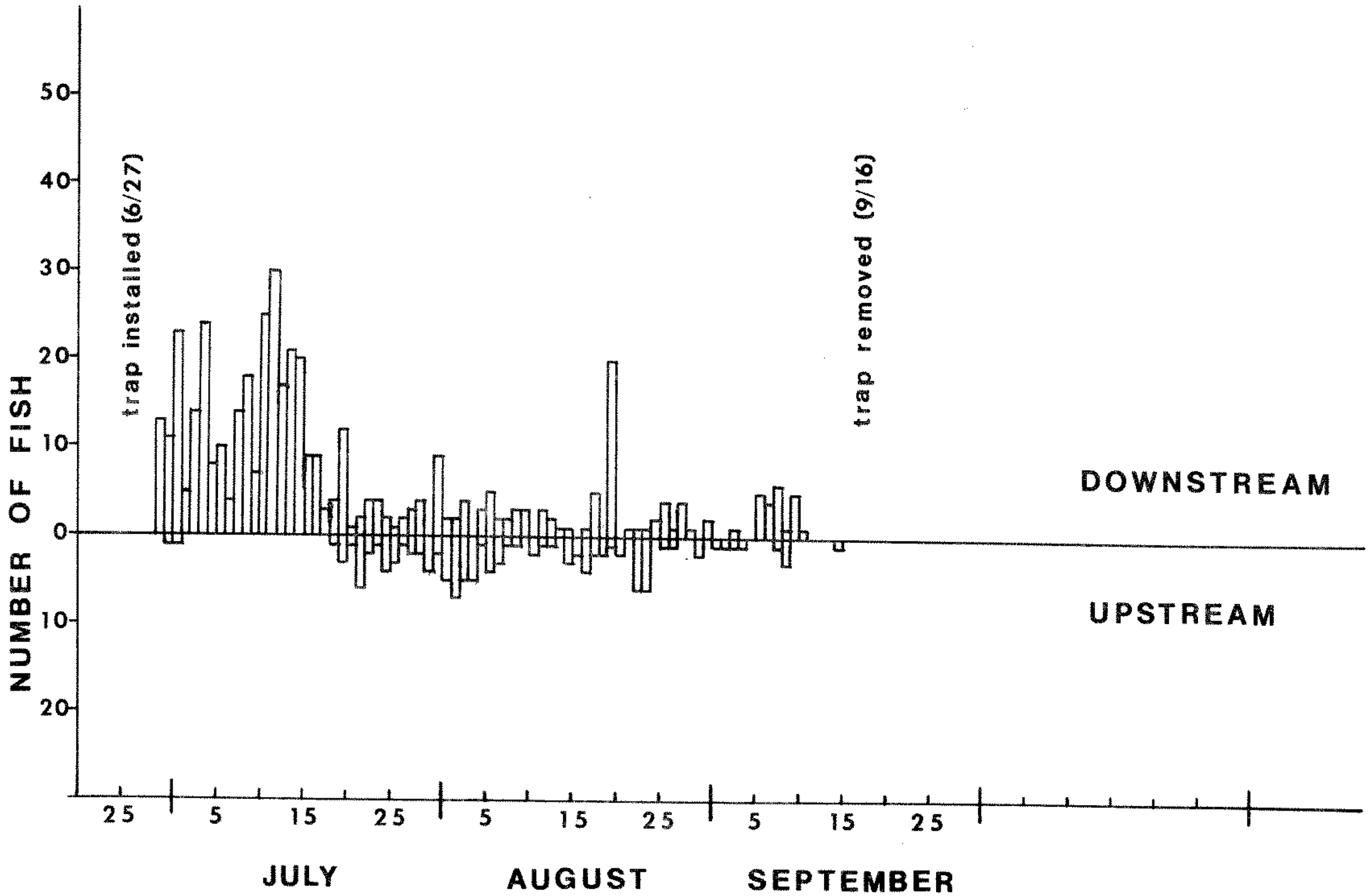

Figure 3. Upstream and downstream trap catches of juvenile westslope cutthroat trout in Trail Creek for 1979.

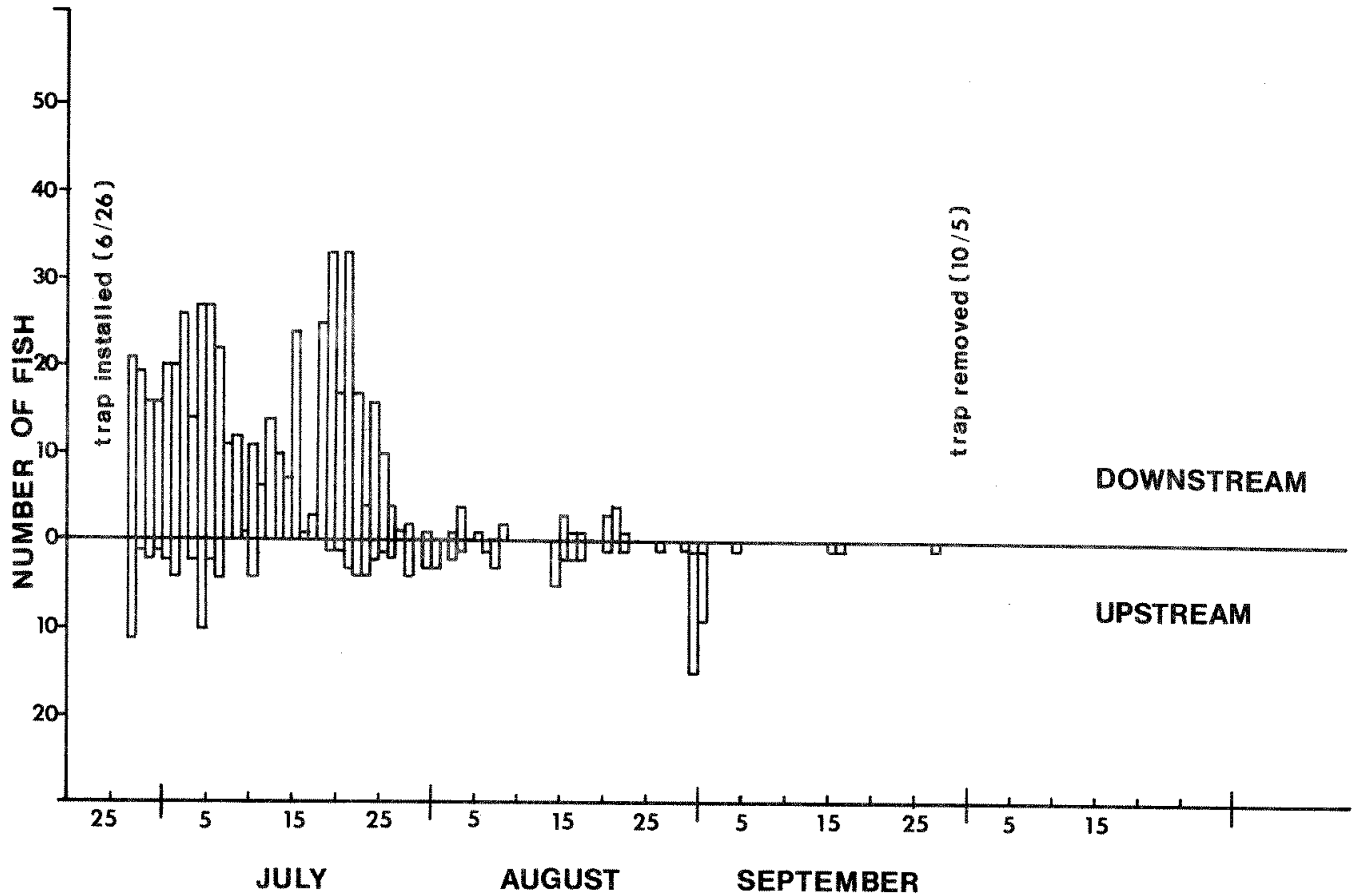

Figure 4. Upstream and downstream trap catches of juvenile westslope cutthroat trout in Red Meadow Creek for 1979.

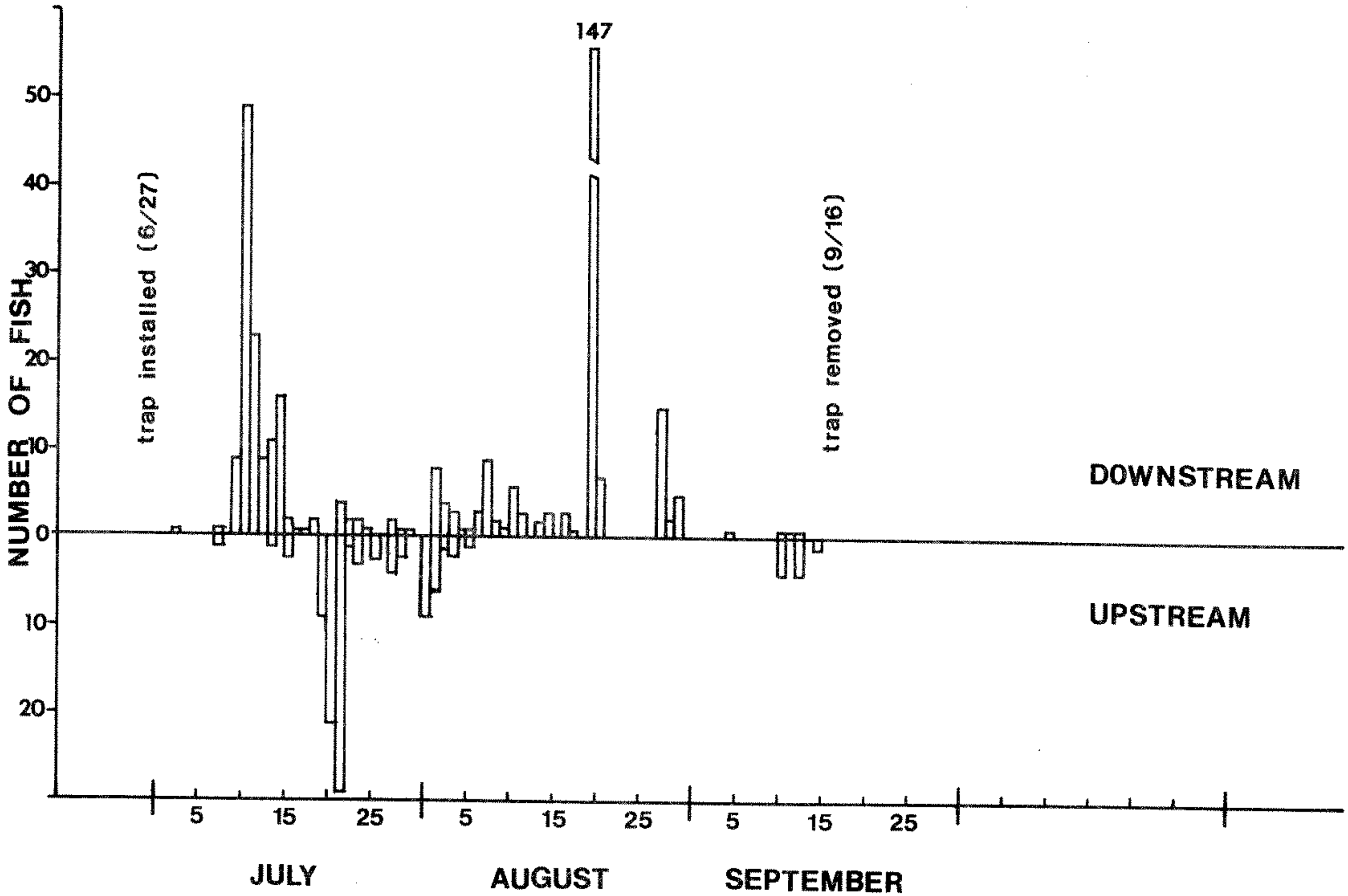

Figure 5. Upstream and downstream trap catches of mountain whitefish in Trail Creek for 1979.

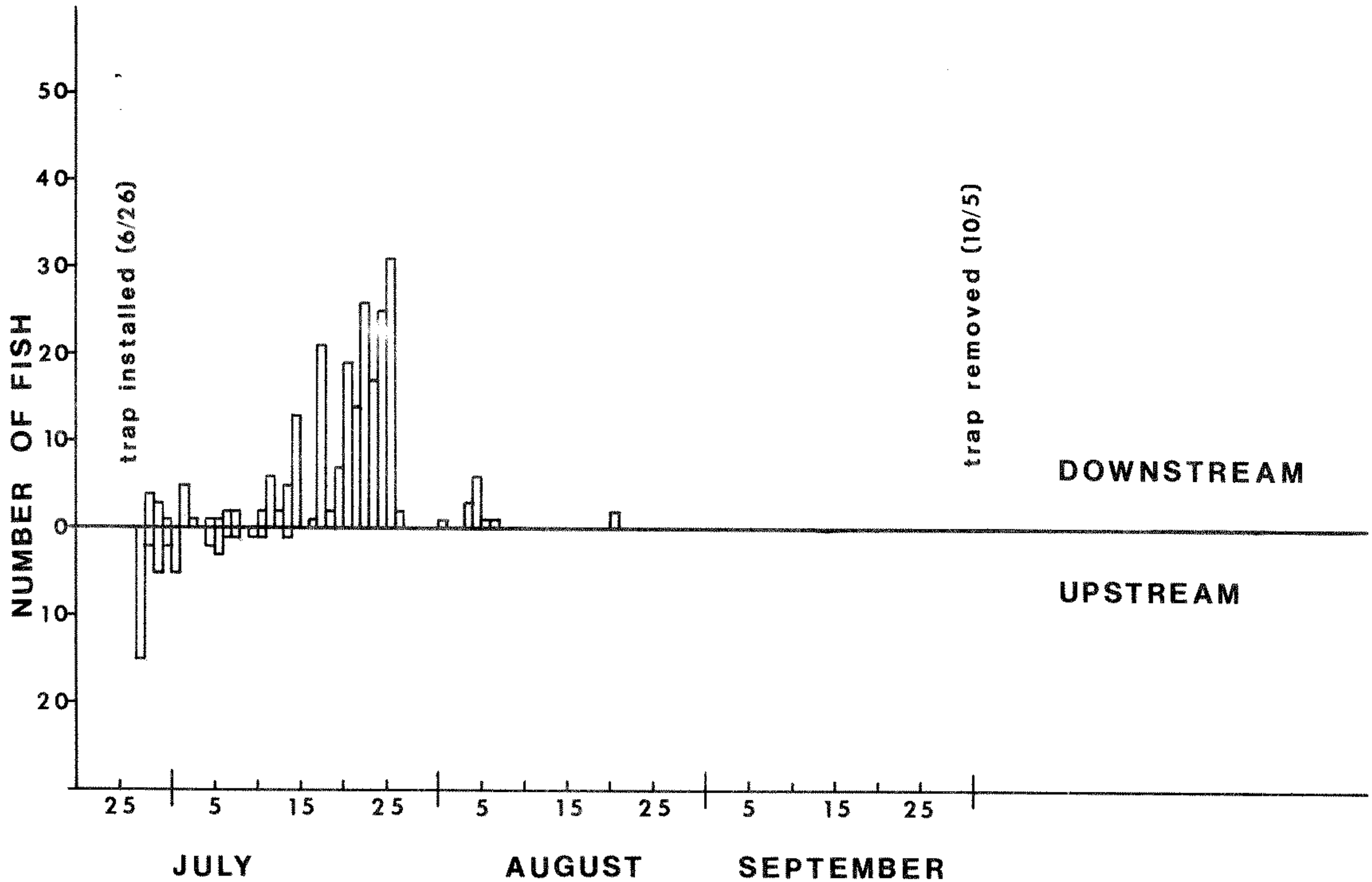

Figure 6. Upstream and downstream trap catches of mountain whitefish in Red Meadow Creek for 1979.

APPENDIX B

Figures 1 - 4 Redd Gravel Samples

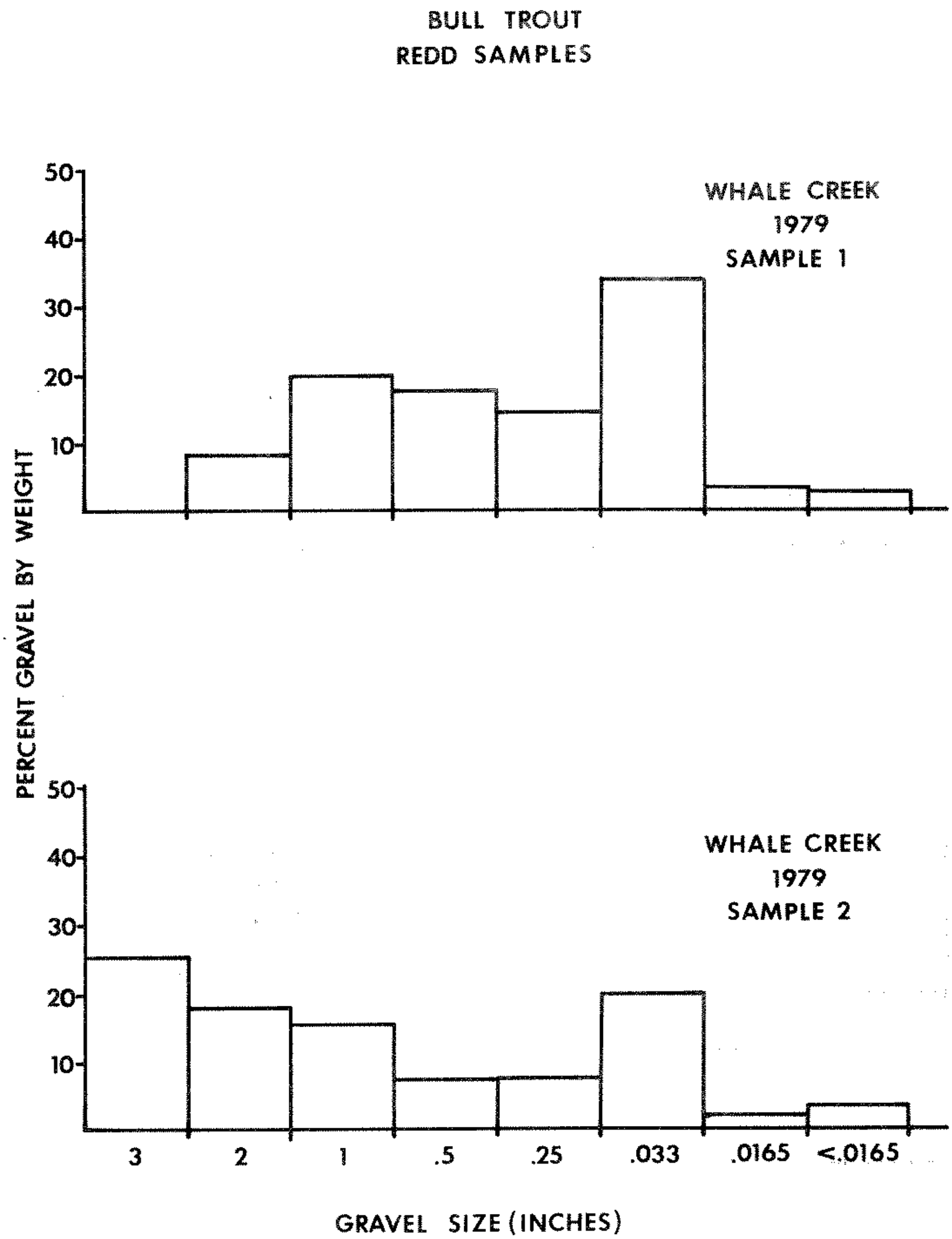

Figure 1. Bull trout gravel samples taken from Whale Creek. Each size gravel is expressed as a percent of total gravel weight.

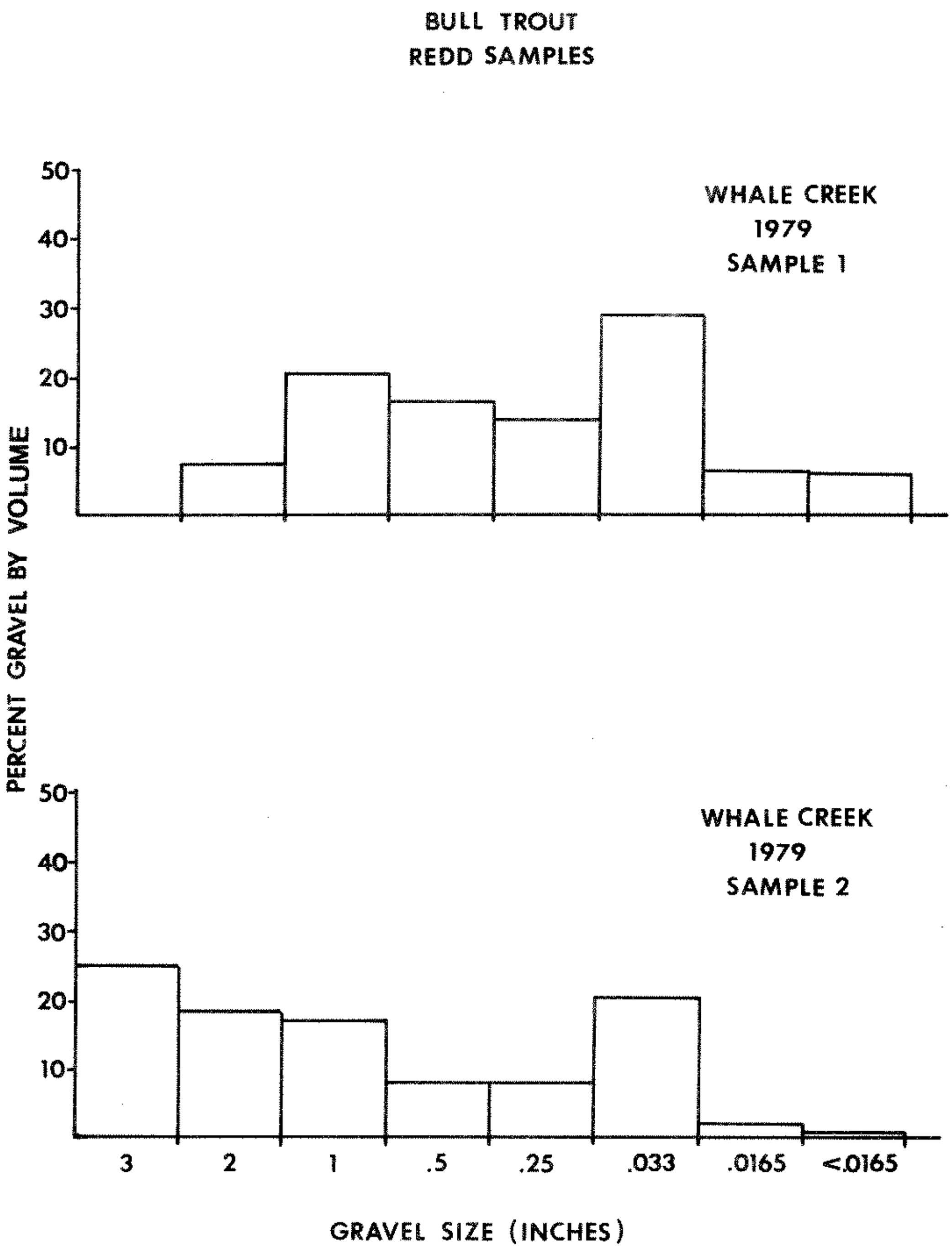

Figure 2. Bull trout gravel samples taken from Whale Creek. Each size gravel is expressed as a percent of the total gravel volume.

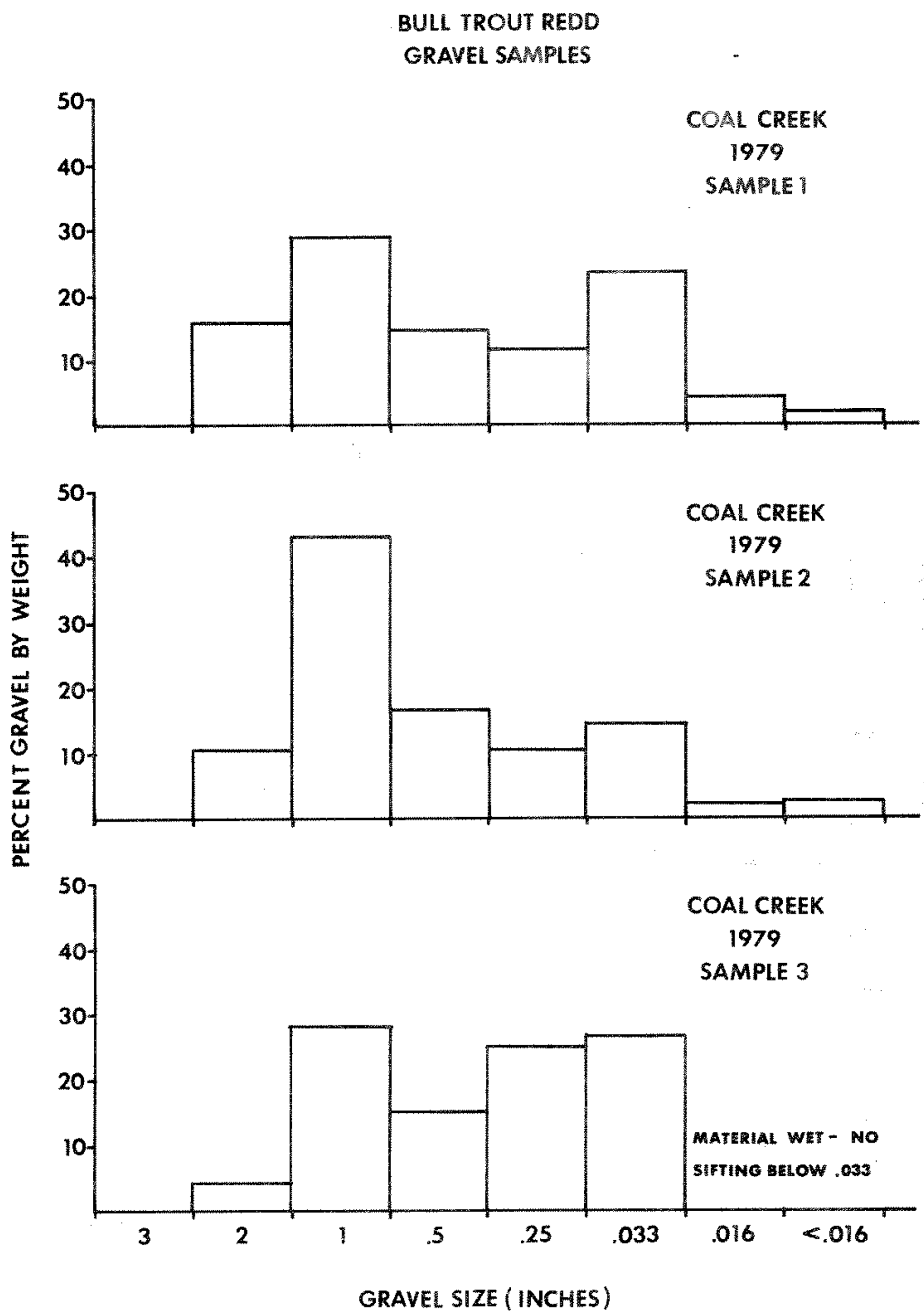

Figure 3. Bull trout gravel samples taken from Coal Creek. Each size gravel is expressed as a percent of the total gravel weight.

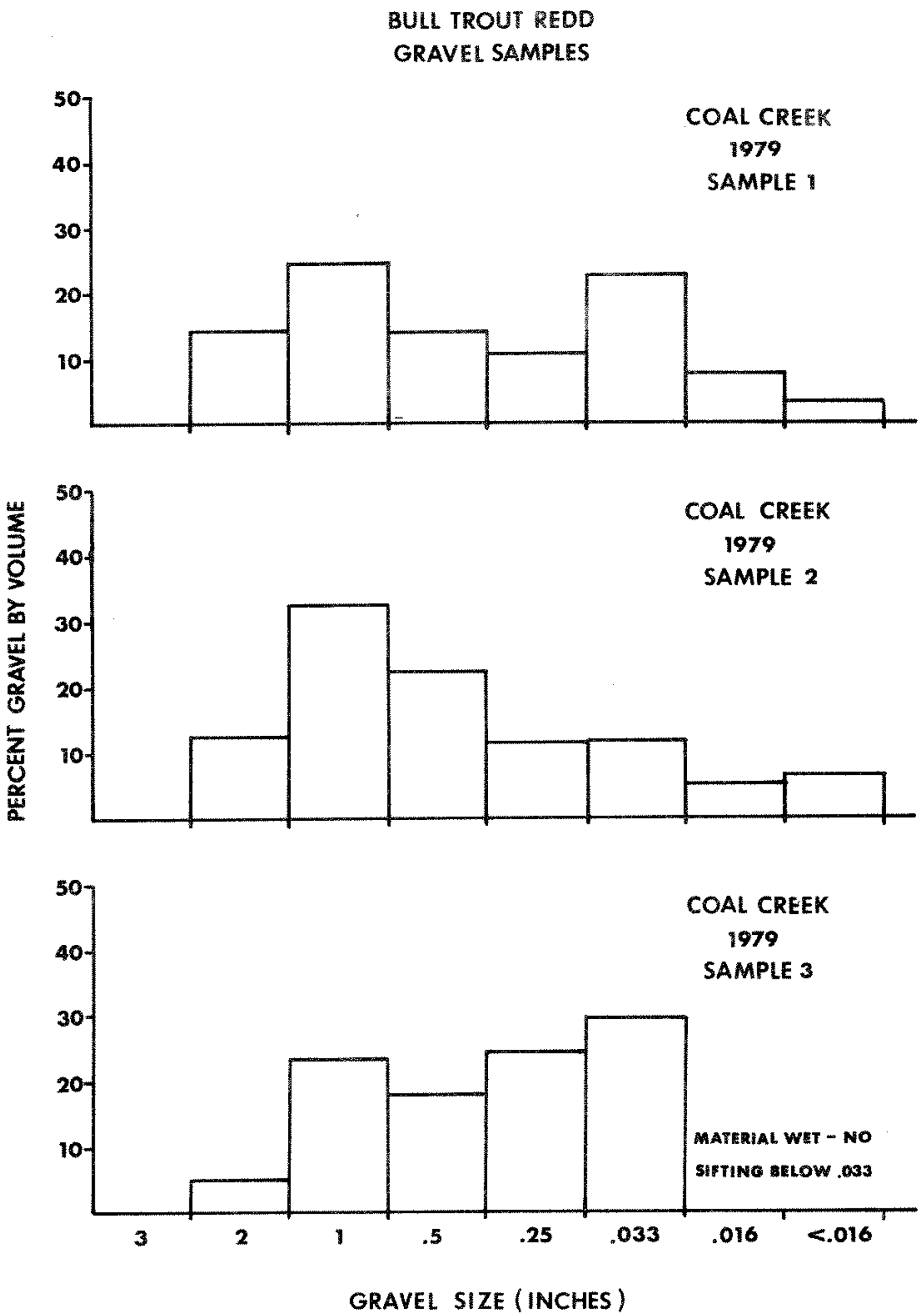

Figure 4. Bull trout gravel samples taken from Coal Creek. Each gravel size is expressed as a percent of total gravel volume.

APPENDIX C

Tables 1 - 20 Stomach Analysis Calculations

Table 1. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 40 juvenile bull trout collected in Trail Creek during the fall of 1978. Average fish length (range) was 102 mm (51 - 170 mm).

Stomach Contents	Number			Occurrence	Frequency	Volume(ml)			IRI
	Total	Percent	Mean		Occurrence	Total	Percent	Mean	
Miscellaneous	--	--	--	23	57.5	.57	24.4	.02	--
Diptera	12	5.7	1.3	9	22.5	.09	3.8	.01	10.7
Hymenoptera	11	5.0	1.4	8	20.0	.11	4.7	.01	9.9
Ephemeroptera	150	70.8	4.7	32	80.0	.96	41.0	.03	63.9
Trichoptera	16	7.5	1.2	13	32.5	.41	17.5	.03	19.2
Plecoptera	19	9.0	1.7	11	27.5	.11	4.7	.01	13.7
Coleoptera	3	1.4	1.0	3	7.5	.03	1.3	.01	3.4
Hemiptera	1	.5	1	1	2.5	.01	.4	.01	1.1
Plant	--	--	--	5	12.5	.05	2.1	.01	--
Total	212					2.34			

Table 2. Energy analysis of items in the stomachs of 40 juvenile bull trout collected in Trail Creek during the fall of 1978. Average fish length (range) was 102 mm (51 - 170 mm).

Stomach Contents	Percent Volume	Rate of Digestion	Percent Volume X Rate of Digestion	Caloric Value	Total Calories	Percent Calories
Diptera	3.8	.86	3.3	656	2,144	5.3
Hymenoptera	4.7	.15	.7	2,008	1,416	3.5
Ephemeroptera	41.0	.60	24.6	1,124	27,650	68.9
Trichoptera	17.5	.33	5.8	1,000	5,775	14.4
Plecoptera	4.7	.60	2.8	1,000	2,820	7.0
Coleoptera	1.3	.17	.2	1,074	237	.6
Hemiptera	.4	.25	.1	1,008	101	.3
Total					40,143	

Table 3. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 38 juvenile bull trout collected during December of 1978. Average fish length (range) was 91 mm (58 - 130 mm).

Stomach Contents	Number			Occurrence	Frequency	Volume (ml)			
	Total	Percent	Mean	Occurrence	Occurrence	Total	Percent	Mean	IRI
Miscellaneous	--	--	--	24	63.2	.56	20.5	.02	--
Diptera	4	1.0	2.0	2	5.3	.06	2.2	.03	2.8
Ephemeroptera	175	42.9	4.7	37	97.4	.83	30.4	.02	56.9
Trichoptera	130	31.9	6.8	19	50.0	.76	27.8	.04	36.6
Plecoptera	99	24.3	4.0	25	65.8	.38	13.9	.02	34.7
Plant	--	--	--	14	36.8	.14	5.1	.01	--
Total	408					2.73			

Table 4. Energy analysis of items in the stomachs of 38 juvenile bull trout collected in Trail Creek during December, 1978. Average fish length (range) was 91 mm (58 - 130 mm).

Stomach Contents	Percent Volume	Rate of Digestion	Percent Volume X Rate of Digestion	Caloric Value	Total Calories	Percent Calories
Diptera	2.2	.86	1.9	656	1,241	3.2
Ephemeroptera	30.4	.60	18.2	1,124	20,502	52.2
Trichoptera	27.8	.33	9.2	1,000	9,174	23.4
Plecoptera	13.9	.60	8.3	1,000	8,340	21.2
Total					39,257	

Table 5. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 30 bull trout collected in Trail Creek during the spring of 1979. Average fish length (range) was 102 mm (76 - 206 mm).

Stomach Contents	Number			Occurrence	Frequency	Volume(ml)			IRI
	Total	Percent	Mean		Occurrence	Total	Percent	Mean	
Miscellaneous	--	--	--	14	46.7	.36	5.6	.03	--
Diptera	2	.4	1	2	6.7	.02	.3	.01	2.5
Ephemeroptera	445	82.9	16.5	27	90.0	4.92	75.9	.18	82.9
Trichoptera	11	2.0	1.6	7	23.3	.16	2.5	.02	9.3
Plecoptera	79	14.7	3.6	22	73.3	.90	13.9	.04	34.0
Plant	--	--	--	3	10.0	.12	1.9	.04	--
Total	537					6.48			

Table 6. Energy analysis of items in the stomachs of 30 bull trout collected in Trail Creek during the spring of 1979. Average fish length (range) was 102 mm (76 - 206 mm).

Stomach Contents	Percent Volume	Rate of Digestion	Percent Volume X Rate of Digestion	Caloric Value	Total Calories	Percent Calories
Diptera	.4	.86	.3	656	226	.3
Ephemeroptera	82.9	.60	49.7	1,124	55,907	85.2
Trichoptera	2.0	.33	.7	1,000	660	1.0
Plecoptera	14.7	.60	8.8	1,000	8,820	13.4
Total					65,613	

Table 7. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 17 bull trout collected in Trail Creek during the summer of 1979. Average fish length (range) was 124 mm (102 - 208 mm).

Stomach Contents	Number			Occurrence	Frequency	Volume (ml)			IRI
	Total	Percent	Mean		Occurrence	Total	Percent	Mean	
Miscellaneous	--	--	--	10	58.8	1.85	82.6	.18	--
Diptera - Adult	2	4.2	2.0	1	5.9	.01	.4	.01	18.3
- Immature	12	25.0	3.0	4	23.5	.04	1.8	.01	
Hymenoptera	5	10.4	1.7	3	17.6	.03	1.3	.01	9.8
Ephemeroptera	21	43.8	2.6	8	47.1	.25	11.2	.03	34.0
Trichoptera - Adult	1	2.1	1.0	1	5.9	.01	.4	.01	2.8
Plecoptera	4	8.3	1.3	3	17.6	.03	1.3	.01	9.1
Crustacea	1	2.1	1.0	1	5.9	.01	.4	.01	2.8
Annelida	2	4.2	2.0	1	5.9	.01	.4	.01	3.5
Total	48					2.24			

Table 8. Energy analysis of items in the stomachs of 17 bull trout collected in Trail Creek during the summer of 1979. Average fish length (range) was 124 mm (102 - 208 mm).

Stomach Contents	Percent Volume	Rate of Digestion	Percent Volume X Rate of Digestion	Caloric Value	Total Calories	Percent Calories
Diptera	2.2	.86	1.9	656	1,241	11.4
Hymenoptera	1.3	.15	.2	2,008	392	3.6
Ephemeroptera	11.2	.60	6.7	1,124	7,553	69.4
Trichoptera	.4	.33	.1	1,000	132	1.2
Plecoptera	1.3	.60	.8	1,000	780	7.2
Crustacea	.4	1.32	.5	782	413	3.8
Annelida	.4	1.68	.7	550	370	3.4
Total					10,881	

Table 9. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 69 bull trout collected in Trail Creek during the fall of 1979. Average fish length (range) was 86 mm (64 - 183 mm).

Stomach contents	Number			Occurrence	Frequency	Volume (ml)			IRI
	Total	Percent	Mean		occurrence	Total	Percent	Mean	
Miscellaneous	--	--	--	60	87.0	1.40	36.7	.02	--
Diptera - Adult	4	1.4	1.0	4	5.8	.04	1.0	.01)	12.2
- Immature	16	5.5	1.0	15	21.7	.15	3.9	.01)	
Hymenoptera	15	5.1	2.0	8	11.6	.27	7.1	.03	7.9
Ephemeroptera	189	64.5	5.4	35	50.7	.72	18.9	.02	45.0
Trichoptera - Adult	3	1.0	1.0	3	4.3	.03	.8	.01)	3.2
- Immature	1	.3	1.0	1	1.4	.01	.3	.01)	
Plecoptera - Adult	1	.3	1.0	1	1.4	.01	.3	.01)	18.2
- Immature	38	13.0	1.8	21	30.4	.35	9.2	.02)	
Chilopoda	2	.7	1.0	2	2.9	.02	.5	.01	1.4
Arachnida	8	2.7	2.7	3	4.3	.03	.8	.01	2.6
Plant	14	4.8	1.7	8	11.6	.27	7.1	.03	7.8
Fish	2	.7	1.0	2	2.9	.51	13.4	.26	5.7
Total	293					3.81			

Table 10. Energy analysis of items in the stomachs of 69 bull trout collected in Trail Creek during the fall of 1979. Average fish length (range) was 86 mm (64 - 183 mm).

Stomach contents	Percent volume	Rate of digestion	Percent volume X rate of digestion	Caloric value	Total calories	Percent calories
Diptera	4.9	.86	4.4	656	2,863	6.5
Hymenoptera	7.1	.15	1.1	2,008	2,138	4.9
Chilopoda	.5	--	--	--	--	--
Arachnida	.8	.15	.1	2,008	241	.5
Ephemeroptera	18.9	.60	11.3	1,124	12,746	28.9
Trichoptera	1.1	.33	.4	1,000	363	.8
Plecoptera	9.5	.60	5.7	1,000	5,700	12.9
Fish	13.4	1.00	13.4	1,493	20,006	45.4
Total					44,057	

Table 11. Energy analysis of items in the stomachs of 11 westslope cutthroat trout collected in Trail Creek during the spring of 1979. Average fish length (range) was 132 mm (46 - 216 mm).

Stomach Contents	Percent Volume	Rate of Digestion	Percent Volume X Rate of Digestion	Caloric Value	Total Calories	Percent Calories
Hymenoptera	1.2	.15	.18	2,008	361	1.1
Ephemeroptera	42.9	.60	25.7	1,124	28,931	87.9
Trichoptera	3.7	.33	1.2	1,000	1,220	3.7
Plecoptera	3.7	.60	2.2	1,000	2,200	6.7
Coleoptera	1.2	.17	.2	1,074	219	.7
Total					32,931	

Table 12. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 11 westslope cutthroat trout collected in Trail Creek during the spring of 1979. Average fish length (range) was 132 mm (46 - 216 mm).

Stomach Contents	Number			Occurrence	Frequency Occurrence	Volume (ml)			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Miscellaneous	--	--	--	9	81.8	.66	41.0	.07	--
Hymenoptera	2	1.8	1	2	18.2	.02	1.2	.01	7.1
Ephemeroptera	63	57.8	6	10	90.9	.69	42.9	.07	63.9
Trichoptera	12	11.0	2	6	54.5	.06	3.7	.01	23.1
Plecoptera	18	16.5	3	6	54.5	.06	3.7	.01	24.9
Coleoptera	14	12.8	14	1	9.1	.10	6.2	.10	9.4
Plant	--	--	--	2	18.2	.02	1.2	.01	--
Total	109					1.61			

Table 13. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 17 westslope cutthroat trout collected in Trail Creek during the summer and fall of 1979. Average fish length (range) was 122 mm (94 - 234 mm).

Stomach contents	Number Total	Number Percent	Number Mean	Occurrence	Frequency occurrence	Volume (ml) Total	Volume (ml) Percent	Volume (ml) Mean	IRI
Miscellaneous	--	--	--	16	94.1	6.97	77.1	.44	--
Diptera - Adult	3	1.8	3.0	1	5.9	.01	.1	.01	12.5
- Immature	9	5.3	2.3	4	23.5	.06	.7	.01	
Nematoda	2	1.2	2.0	1	5.9	.01	.1	.01	--
Hymenoptera	6	3.6	6.0	1	5.9	.20	2.2	.20	3.9
Orthoptera	1	.6	1.0	1	5.9	.01	.1	.01	2.4
Hemiptera	2	1.2	1.0	2	11.8	.02	.2	.01	4.4
Ephemeroptera	108	64.3	13.5	8	47.1	1.40	15.5	.18	42.3
Trichoptera - Adult	3	1.8	3.0	1	5.9	.10	1.1	.10	13.4
- Immature	10	6.0	2.0	5	29.4	.15	1.7	.03	
Plecoptera - Adult	2	1.2	2.0	1	5.9	.01	.1	.01	15.3
- Immature	14	8.3	2.8	5	29.4	.07	.8	.01	
Plant	8	4.8	2.7	3	17.6	.03	.3	.01	7.6
Total	168					9.04			

Table 14. Energy analysis of items in the stomachs of 17 westslope cutthroat trout collected in Trail Creek during the summer and fall of 1979. Average fish length (range) 122 mm (94 - 234 mm).

Stomach contents	Percent volume	Rate of digestion	Percent volume X rate of digestion	Caloric value	Total calories	Percent calories
Diptera	.8	.86	.69	656	451	3.4
Hymenoptera	2.2	.15	.33	2,008	663	5.1
Orthoptera	.1	.15	.015	2,008	30	.2
Hemiptera	.2	.15	.03	2,008	60	.5
Ephemeroptera	15.5	.6	9.30	1,124	10,453	79.7
Trichoptera	2.8	.33	.92	1,000	924	7.0
Plecoptera	.9	.60	.54	1,000	540	4.1
Total					13,121	

Table 15. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 10 westslope cutthroat trout collected in Red Meadow Creek during the summer of 1979. Average fish length (range) was 165 mm (102 - 234 mm).

Stomach Contents	Number			Occurrence	Frequency	Volume (ml)			IRI
	Total	Percent	Mean		Occurrence	Total	Percent	Mean	
Miscellaneous	--	--	--	8	80.0	5.11	50.1	.64	--
Diptera - Adult	11	5.4	1.6	7	70.0	.16	1.6	.02	26.5
- Immature	4	2.0	1.3	3	30.0	.04	.4	.01	
Coleoptera - Adult	3	1.5	1	3	30.0	.03	.3	.01	14.1
- Immature	1	.5	1	1	10.0	.01	.1	.01	
Arachnida	3	1.5	1.5	2	10.0	.02	.2	.01	3.9
Nematoda	9	4.4	4.5	2	20.0	.05	.5	.01	8.3
Hymenoptera	37	18.2	4.6	8	80.0	1.52	14.9	.19	37.7
Orthoptera	1	.5	1	1	10.0	.30	2.9	.3	4.5
Hemiptera	2	1.0	1	2	20.0	.40	3.9	.06	8.3
Homoptera	4	2.0	2	2	20.0	.02	.2	.01	7.4
Ephemeroptera	80	39.4	13.3	6	60.0	.86	8.4	.14	35.9
Trichoptera - Adult	17	8.4	2.8	6	60.0	.54	5.3	.09	38.9
- Immature	25	12.3	4.2	6	60.0	1.09	10.7	.18	
Plecoptera	6	3.0	1.5	4	40.0	.05	.5	.01	14.5
Total	203					10.20			

Table 16. Energy analysis of items in the stomachs of 10 westslope cutthroat trout collected in Red Meadow Creek during the summer of 1979. Average fish length was 165 mm (102 - 234 mm).

Stomach Contents	Percent Volume	Rate of Digestion	Percent Volume X Rate of Digestion	Caloric Value	Total Calories	Percent Calories
Diptera	2.0	.86	1.72	656	1,128	5.9
Coleoptera	.4	.15	.06	2,008	120	.6
Arachnida	.2	.15	.03	2,008	60	.3
Hymenoptera	14.9	.15	2.24	2,008	4,488	23.4
Orthoptera	2.9	.15	.44	2,008	873	4.6
Hemiptera	3.9	.15	.59	2,008	1,175	6.1
Homoptera	.2	.15	.03	2,008	60	.3
Ephemeroptera	8.4	.60	5.04	1,124	5,665	29.6
Trichoptera	16.0	.33	5.28	1,000	5,280	27.6
Plecoptera	.5	.60	.3	1,000	300	1.6
Total					19,149	

Table 17. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 18 sculpins collected in Trail Creek during September, 1978. Average length (range) was 84 mm (72 - 96 mm).

Stomach Contents	Number			Occurrence	Frequency	Volume (ml)			IRI
	Total	Percent	Mean	Occurrence	Occurrence	Total	Percent	Mean	IRI
Miscellaneous	--	--	--	16	88.9	.16	41.0	.01	--
Ephemeroptera	44	56.4	4.0	11	61.1	.11	28.2	.01	48.6
Trichoptera	4	5.1	2.0	2	11.1	.02	5.1	.01	7.1
Plecoptera	29	37.2	3.2	9	50.0	.09	23.1	.01	36.8
Coleoptera	1	1.3	1.0	1	5.6	.01	2.6	.01	3.2
Total	78					.39			

Table 18. Energy analysis of items in the stomachs of 18 sculpins collected in Trail Creek during September, 1978. Average fish length (range) was 84 mm (72 - 96 mm).

Stomach Contents	Percent Volume	Rate of Digestion	Percent Volume X Rate of Digestion	Caloric Value	Total Calories	Percent Calories
Ephemeroptera	28.2	.60	16.9	1,124	19,018	49.0
Trichoptera	5.1	.33	5.4	1,000	5,430	14.0
Plecoptera	23.1	.60	13.9	1,000	13,860	35.7
Coleoptera	2.6	.17	.44	1,074	475	1.2
Total					38,783	

Table 19. Number, occurrence, volume and IRI (Index of Relative Importance) of items in the stomachs of 19 sculpins collected in Trail Creek during October, 1979. Average fish length (range) was 78 mm (58 - 109 mm).

Stomach contents	Number			Occurrence	Frequency occurrence	Volume (ml)			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Miscellaneous	--	--	--	18	94.7	.55	47.4	.03	--
Diptera	2	1.6	1.0	2	10.5	.02	1.7	.01	4.6
Ephemeroptera	66	52.8	4.1	16	84.2	.26	22.4	.01	53.1
Trichoptera	9	7.2	1.3	7	36.8	.07	6.0	.01	16.7
Plecoptera	11	8.8	1.6	7	36.8	.08	6.9	.01	17.2
Nematoda	2	1.0	1.0	2	10.5	.02	1.7	.01	4.4
Coleoptera	7	5.6	1.4	5	26.3	.05	4.3	.01	12.1
Plant 1/	28	22.4	2.5	11	57.9	.11	9.4	.01	29.9
Total	125					1.16			

1/ All plant material was nostoc.

Table 20. Energy analysis of items in the stomachs of 19 sculpins collected in Trail Creek during October, 1979. Average fish length (range) was 78 mm (58 - 109 mm).

Stomach Contents	Percent Volume	Rate of Digestion	Percent Volume X Rate of Digestion	Caloric Value	Total Calories	Percent Calories
Diptera	1.7	.86	1.46	656	959	4.2
Ephemeroptera	22.4	.60	13.44	1,124	15,106	65.8
Trichoptera	6.0	.33	1.98	1,000	1,980	8.6
Plecoptera	6.9	.60	4.14	1,000	4,140	18.0
Coleoptera	4.3	.17	.73	1,074	785	3.4
Total					22,970	

APPENDIX D

Perspectives on the Fisheries Study

FLATHEAD RIVER BASIN ENVIRONMENTAL IMPACT STUDY

Perspectives on the Fisheries Study

Prepared For

Flathead River Basin Steering Committee

and

Environmental Protection Agency

by

Patrick J. Graham

Montana Dept. of Fish, Wildlife and Parks

January 1980

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INTRODUCTION

This document was prepared for the Flathead River Basin Steering Committee to help them assess the direction, progress and eventual results which the fisheries study will provide as part of the Basin-Wide Impact Assessment. It may also reveal some perspectives and strategies developed to meet the challenges of this study.

A fisheries and water quality baseline inventory was started in 1978 as a major part of the Flathead River Basin Environmental Impact Study. The emphasis was on the aquatic ecocystem because its quality can be a good indicator of the aggregate impacts of man's use or abuse of air, land and water resources. But, some people wondered, this is the Flathead Basin surrounded by Glacier Park, the Bob Marshall Wilderness and Great Bear Wilderness Areas and Flathead Lake; what could possibly happen here?

We are nearing the half-way point in our research and the need for the Environmental Impact Study is already becoming far too clear. A global energy crisis and inflation coupled with the more localized problems of pine beetle kill in our forests and the often subtle effects of community growth are coming to rest in the Flathead Basin.

The Cabin Creek coal development, stalled for a time, now appears to be on track again. Shell Oil Company set off a series of blasts along the Trail Creek Road this summer exploring for oil and gas. The effect of these blasts on the water tables in the underground limestone formations is unknown. Presently there are in excess of 900,000 acres under application for lease for oil and gas in the Flathead Forest.

An exploration firm is planning to do seismic work in the wilderness areas next summer. Their plans include the use of 124 tons of explosives along a 207-mile course. Two oil wells were drilled near Cabin Creek in Canada this summer and fall. Widespread harvest of beetle-killed timber is occurring on both private and government owned land. Beetle-killed timber also extends into Glacier Park and Canada.

A more subtle change is the increase in community growth. The population of Flathead County, the sixth largest in the state, has increased by an estimated 41 percent in the last ten years. Unemployment rates in northwestern Montana are traditionally high annually and seasonally.

To better understand, predict and mitigate the impacts of these developments on the quality environment in the Flathead River Basin, a systems approach to analysis of baseline data is necessary. States et al. (1978) prepared a detailed report on a systems approach to baseline studies. Some of the terms and techniques they discussed should be useful in analysis of results from our studies. However, that study was specifically geared for assessing impacts of known development, while this study is designed to provide baseline data for use in a systems analysis as future developments are planned. Presently baseline data is being collected on the fishery and aquatic resource through three groups of studies. These include: 1) studies funded by the Environmental Protection Agency (EPA) on the North and Middle Forks of the Flathead River and Flathead Lake, 2) studies funded by the Water and Power Resources Service (WPRS), formerly the Bureau of Reclamation, on the Flathead River downstream from the South Fork and 3) studies funded by the state on Flathead Lake, Whitefish Lake, Swan, Stillwater and Whitefish river drainages. The EPA and WPRS studies are being directed and coordinated by Patrick Graham and all studies are coordinated by the Regional Fisheries Manager, Robert E. Schumacher and Joe E. Huston, Fisheries Biologist Supervisor.

Fish species of special concern in these studies are westslope cutthroat trout, bull trout and kokanee salmon. A second group includes species of sculpin and whitefish. All of these species are migratory with the possible exception of sculpins of which we know little about. The three species of special concern utilize Flathead Lake, main stem rivers and tributary streams during specific periods in their life cycles. A general outline of present knowledge about their life cycles is presented in the Flathead River Basin Fisheries Investigations Report for 1979 which will be available in late February 1980.

STUDY OBJECTIVES

Objectives of fisheries studies presently engaged in by the Department of Fish, Wildlife and Parks in the Flathead River Basin are summarized below.

I. Environmental Protection Agency Funded Projects

A. North Fork of the Flathead River Funded Projects

1. Assess relative importance of tributary streams for producing migratory and resident populations of westslope cutthroat and bull trout.
2. Develop a long-term monitoring index for juvenile trout in major tributaries and the main river for correlation with habitat inventories and to monitor changes in environmental quality.
3. Identify the timing and distribution of spawning and feeding, and "smolt" migrations for major fish species.
4. Assess existing aquatic habitat in major tributary streams and the main river. Habitat components will be assessed to determine their importance in maintaining the existing cutthroat trout, bull trout and sculpin community. Stream reaches will be ranked in relation to relative importance for providing spawning and rearing areas.
5. Determine habitat requirements and species interaction for juvenile bull trout and westslope cutthroat trout.
6. Quantify instream flows for maintenance of native fish species in the North Fork of the Flathead River.

B. Middle Fork of the Flathead River Fisheries Study
   1. Assess relative importance of tributary streams for producing migratory and resident populations of westslope cutthroat and bull trout. To compare the potential contribution of juvenile fish from the North and Middle Forks to Flathead Lake.
   2. Develop a long-term monitoring index for juvenile trout in major tributaries and the main river for correlation with habitat inventories and to monitor changes in environmental quality in a natural system in the event development continues in the North Fork drainage.
   3. Identify the timing and distribution of spawning and feeding, and "smolt" migrations for major fish species.

C. Flathead Lake -- Fish Food Habits Study
   1. Assess food habits of westslope cutthroat trout, bull trout and kokanee salmon seasonally in representative areas of the lake to predict and, if need be, document negative impacts of development in the upper basin on the food chain.
   2. Begin to develop a method for long-term monitoring of relative abundance of westslope cutthroat and bull trout in the lake.
   3. Determine growth rates and the condition of bull and cutthroat trout in the lake.

D. Creel Census: 1981
   The specifics of this study have yet to be completely evaluated by the Water Quality Technical Committee or the Steering Committee. The census would have a two-fold purpose.
   1. To help quantify the relative contribution of upper river components to the Flathead Lake fishery.
   2. Determine recreational value of the aquatic resource.

This census would culminate the five-year baseline inventory of the Flathead River Basin. It would provide relatively accurate fishing pressure estimates on Flathead Lake, determine seasonal changes in pressure, fisherman satisfaction and other related information. Besides looking at the recreational values and use, information on fish movements from and within the lake could be assessed. The composition of the catch from the specific upriver streams could be assessed in magnitude, distribution and time.

The census could be used to determine a dollar value for water related recreation. This would require the use of both field and mail questionnaires specifically designed to answer these questions. The number of recreation types to be assessed and the study boundaries would determine the dollar value needed to complete the study.

II. Water and Power Resources Funded Projects

Studies funded by WPRS for an Appraisal and Feasibility Level Study on "Powerplant Enlargement and Reregulating Dam Below Hungry Horse Dam."

A. Fishery Study

1. To provide the Bureau of Reclamation with the Department of Fish, Wildlife and Park's best estimate of minimum flows which will result in the most desirable level of reproduction and survival of kokanee salmon, mountain whitefish and fish food organisms.
2. To determine the effects of reservoir discharge fluctuations on survival of incubating whitefish and kokanee salmon eggs in the Flathead River below the South Fork junction.
3. To quantify the suitable kokanee habitat at staged flows in Flathead River Basin on additions of flow increments with one to eight turbine generators; that is, natural flows from above the South Fork plus increments of approximately 2,500 cfs per generator.
4. To monitor delays in upstream migration of adult cutthroat trout as a result of unnatural seasonal flow and temperature regimes caused by discharges from Hungry Horse Dam.

B. Aquatic Invertebrate Study

1. To estimate biomass and species diversity and to compare life history characteristics of major macroinvertebrates in the Flathead River above and below the confluence of the South Fork and in the South Fork of the Flathead River below Hungry Horse Dam.
2. To make estimates of macroinvertebrate habitat loss as related to extended periods of minimum discharges from Hungry Horse Dam.
3. To compare the biomass, composition and life histories of the macroinvertebrate communities altered by reservoir discharges. Cooperation and coordination with the Flathead Basin Study under the Environmental Protection Agency's (EPA) guidance will be necessary to interpret altered and non-altered riverine relationships.

III. State: Dingell-Johnson Funded Projects

Fisheries activities under state funded or cost-shared with Dingel-Johnson funds are projected here for the remainder of the present 1979-80 biennial budget and for the next biennium (1981-83). A major priority item will be gathering data needed to justify instream flows to be requested as water reservations. Support projects will try to fill data gaps of the EPA and WPRS grant contract studies and will be in the second high priority area.

The major objective of work in 1979-81 will be to make water reservations as legal instream water rights to maintain the flows required to sustain fish and wildlife in each stream or stream reach. In addition, fish population estimates and habitat classifications will be made in several streams.

A. Stillwater River

An ocular habitat survey was made in the autumn of 1979 in cooperation with the Soil Conservation Service and the U.S. Forest Service. Fish population estimates, species distribution plus age and rate of growth parameters will be determined in 1980-81 Fiscal Year for the surveyed segments of the river. Physical measurements at river controls will include depth, width and current velocity in increments of two feet or less of stream width. Streambed materials will be classified as to particle size and percent composition in riffles and/or pools.

Measurements of physical habitat will be made on cross-sections for principal tributaries. Fish population estimates will be made, species distribution described and fisheries habitat classified.

1. Logan Creek

   Water quality and temperature data were collected by the Flathead National Forest and the Department of Health and Environmental Sciences for the water years 1975,1976, and 1977. Insect abundance was determined at water quality stations under contract with the Biology Department of the Flathead Valley Community College in 1975.

   The Department plans to make a fisheries habitat survey, fish population estimates and estimates of age and rate of growth of important fish species in Logan Creek and its major tributaries. It is believed that resident trout make a major portion of stream populations. Stream cross-section surveys in representative and critical habitat will be made as part of the instream water reservation filing in 1980.

2. Martin, Good and Sunday Creeks

   The Department will collect limited water quality samples. Ocular surveys and stream cross-section data will be gathered for instream water reservation filing in 1981. Fish population data will be gathered in 1982.

3. Upper Stillwater River

   Ocular habitat surveys will be made in 1981. Stream cross-section data will be gathered in 1980 for instream water reservation filing. Fish population work will be done in the 1981-83 biennium along with surveys of the lower and upper Stillwater lakes.

B. Whitefish River

An ocular habitat survey was done for the Whitefish River below Whitefish Lake in 1976 (Hager et al 1977). Water quality data was collected by the Department of Health and Environmental Sciences during water year 1973. Fish population data will be collected in the 1981-83 biennium. The Department will be measuring stream cross-sections, width, depth and velocity over controlling riffles and bed material and particle size classification in cross-sections.

Ocular physical habitat and stream cross-section surveys will be done in 1980 on Swift Creek. Some water quality data has been gathered by the Department of Health and Environmental Sciences. The Department of Fish, Wildlife and Parks has been operating a continuous recording temperature station near the mouth since 1977. Fish population data will be obtained in 1981.

C. Swan River

Ocular habitat surveys will begi on the main Swan River in 1981. Stream cross-section surveys in representative habitat and bed type classification will be conducted in 1981. Some water quality data was gathered by the Department of Health and Environmental Sciences in 1972-73. Temperature data was collected for the years 1972 and 1973 by the Department of Fish, Wildlife and Parks and flow data has been collected at two stations for at least four years (1977-1980). Fish population data will be obtained in 1983.

1. Swan River Tributaries

Most significant tributaries to the Swan River had summer temperatures and water profiles taken for two years (1972-73), by the Department when population data was gathered. Most streams should have an ocular survey made in 1982. Stream cross-section surveys should be done in 1981.

2. Holland and Lindberg Lakes

Headwater lakes of the Swan drainage should be surveyed for chemical and limnological parameters in 1983 if sufficient data are not now available Fish population data (acoustic) will be gathered in 1980.

3. Swan Lake

This lake should also have acoustical fish population data plus limnological characteristics gathered in 1983.

D. Flathead Lake Project

Fish population, composition and relative abundance from netting was gathered from 1976 through 1980. Acoustical population assessment started in 1974 and is currently being refined to give reliable population densities of salmon and perhaps lake trout and the three species of whitefish (lake, pygmy and mountain).

Recruitment studies of kokanee fry to the lake are underway and results obtained from 1980 through 1983 should give base recruitment levels.

STUDY PERSPECTIVES

The purpose of the following sections are; 1) to review existing or potential types of developments in the Flathead River Basin and point out some of the negative impacts they have or could have on the aquatic resource, 2) to discuss the complexity of temporal and spatial distribution of fish species in the Flathead drainage, 3) to review how critical life history stages of important fish species are being addressed in respect to potential or existing impacts from development, and 4) to discuss the importance of quantifying the relative importance of each component of the basin, how this information can be used and its limitations.

Developments: Existing and Potential

To assess the relevancy and approach of the studies which the Montana Department of Fish, Wildlife and Parks are presently engaged requires a review of existing and probable developments in the drainage and the scope of their impacts. Two major categories were used to classify developments in general. Large-scale, localized developments are those with perturbations of magnitude to create localized and/or far-reaching adverse impacts. Small-scale, incremental developments usually have minimal, localized impact but the accumulative and aggregate effects of these developments may have a significant basinwide impact. Accumulative impacts are defined as the total effect over time resulting from the sum of the variety of environmental perturbations produced by one project, development or facility. Aggregate impacts are the sum of a variety of environmental changes and their total effect resulting from several projects, developments or facilities.

Examples of large-scale,localized developments are dams, coal-fired generation facilities, strip mines, pipe lines or communities. Examples of small-scale incremental developments are water withdrawal from streams, logging, road construction, oil and gas development or subdivisions. Examples of accumulative impacts from a large-scale development include the initial impact of construction of a dam on the immediate area and the resulting loss of stream habitat following the filling of the reservoir plus those impacts on the aquatic environment which accumulate over time including altered water temperature and flows in waters below the dam. The latter impacts can disrupt fish migrations, food production, spawning success and rearing. An example of aggregate impacts of a small-scale development would be a series of water withdrawals along a stream. As the number of water users increases a point is reached where stream discharge is reduced to levels which become less and less suitable for rearing or spawning for fish. Reductions in fish food production can result and water quality can be rendered unsuitable for irrigation. Increased water consumption will eventually dewater the stream and kill the remaining aquatic biota. By themselves, no single water user may be responsible, but as an aggregate, their impacts can be severe.

Existing major developments in the Flathead River Basin include Hungry Horse, Kerr and the Swan River Dams, Anaconda Aluminum Plant, lumber mills, the communities in the valley and others. Dams in the Flathead River System have been detrimental to both river and Flathead Lake fish populations by blocking migrations of cutthroat and bull trout, altering annual and daily water temperatures and flow regimes, and altering natural lake level patterns. Air pollution and subsequent water pollution can result from emissions from smelters, mills and other facilities. The Anaconda Aluminum Smelter is presently in the process of improving emission controls to significantly reduce fluorides from the smelter. Communities and large subdivisions contribute to deteriorating ground water quality through extensive use of septic tanks. Nutrient loading can and does occur from local sewage plants as well as from certain agricultural practices (Bodmen and Stark 1980). Other impacts of development along waterways are discussed by Dunne and Leopold (1978) including floodplain development, stream channelization, etc.

Potential and probably major developments include coal mining in the Cabin-Howell Creek area in Canada and oil and gas development throughout the upper Flathead River drainage in the United States and Canada. Input of organic and inorganic materials into streams will be the largest environmental perturbation in the aquatic systems. Localized impacts from strip-mining will likely result in accumulative impacts in the aquatic system over a long period of time (Matter 1978). The proposed railroad system might also have impacts on the aquatic system, similar to those observed on the Fisher River (May 1972). Aggregate impacts will result from localized activity in many relatively small basins due to surface mining, road and pipeline construction and timber harvest. These perturbations will impact their respective river systems and Flathead Lake. Studies underway should help identify the nature and extent of the impacts.

Transportation of oil and gas would require pipelines which inevitably will leak. The potential for leaking of pipelines would be significant in this area where annual variation in stream flow is large and climatic conditions severe. Knudson (1979) said 20 pipeline breaks occurred during 1978 in Montana and 11 of these incidents resulted in oil and other petroleum related products reaching state waters. Pipelines often follow streams closely as a matter of convenience and are subject to floods, bank cutting and other normal stream actions. Underwater crossings of perennial streams is particularly dangerous. Energy developments threaten to put increased pressures on the aquatic resources throughout the west. Additional developments which could occur in the Flathead Basin or be close enough to influence the environmental quality are coal-fired and nuclear powerplants. Emissions from coal-fired plants contain sulfur and nitrogen oxides which can be chemically converted to sulfuric (H_2SO_4) and nitric (HNO_3) acid in the atmosphere by oxidation. Transport of these materials can occur over long distances crossing both geographical and political boundaries. These materials may return to earth as rain and snowfall known as acid rain. According to a recent EPA document (EPA 1979) acid rain may be one of the most significant environmental problems of the coming decade.

Water quality data from various parts of the Flathead River Basin indicate that those streams draining the west-facing slopes are poorly buffered due primarily to the nature of bed material and the presence of large lakes in those drainages which act as nutrient traps. Aquatic life in these lakes and streams would be particularly susceptible if acid rains occur.

Another type of development which will probably occur in the drainage is pump storage. As peaking power from hydroelectric projects become more valuable it will be economically feasible to pump water into storage reservoirs during off-peak periods at night, on weekends and during high stream flow periods and releasing it when peak power is needed. This will result in the loss of more miles of streams and disruption of downstream temperature and flow regimes. An inventory of pump storage sites in the northwest was prepared by the U.S. Army Corps of Engineers (1976).

Existing small-scale incremental developments include timber harvest, road construction, subdivision, water diversions or withdrawals and others. Timber harvest is a significant existing and continuing form of resource development that can have both localized and large-scale aggregate environmental impacts. Timber harvest can alter water quality and quantity, nutrient input into streams, disrupt streambank stability, reduce cover and increase sediments into streams. Road construction and associated sediment runoff is also a major impact of timber harvest.

Harvest of beetle-killed lodgepole pine in the Flathead River drainage is resulting in clearcutting large areas. One cut proposed for a small tributary to Trail Creek on the North Fork would result in the harvest of over 17 million board feet of timber without a draft EIS being filed. Large clearcuts and roads are increasing in numbers in many parts of the drainage such as the upper North Fork and upper Stillwater River drainages and will probably increase in the Swan River drainage. Land clearing has also been extensive in some areas for agricultural land during the last 10-15 years. Harvest is occurring on both private and government owned land in the United States and Canada. Large cuts are planned for the upper reaches of Spruce and Kishenena Creek in Canada. These streams drain into a section of Glacier National Park set aside as a primitive area.

Low hydroelectric dams, those with less than 20 meters of head, are being billed in some camps as a significant source of electrical energy which does not cause air or water pollution. The Swan River is presently cutoff from Flathead Lake by one such dam. One site is being developed by the Forest Service on Addition Creek near Spotted Bear and reportedly they want to develop a similar site on Big Creek up the North Fork. The cumulative effect of these low-head hydro projects on the migratory fish populations in the North Fork would be nothing less than disastrous. Studies are underway to assess the potential for low-head hydro in the northwest (Lomax and Robinette 1978).

Road construction can result in environmental perturbations by altering the hydraulic nature of a stream through channelization and constriction resulting from narrow bridges or culverts. Migration barriers can result from improper placement or size of culverts. Input of sediment is probably the single largest negative impact of road construction of forest lands. Sediment input can result from failure of old roads, runoff near stream crossings etc..

Subdivisions can contribute to ground water pollution through septic tanks. This is particularly true in areas with high water tables or in floodplains.

Water diversions for domestic or agricultural use may be a significant form of development in certain parts of the drainage such as the lower Whitefish and Stillwater Rivers and some smaller streams in the area.

Fish Distribution and Movements

Most of the historical data collected on the fisheries in the Flathead River Basin was collected for specific management objectives and is low in resolution. Confounding present investigations are the relatively low fish densities spread across a large and diverse drainage and the complexity of temporal and spatial distributions of the major fish species including cutthroat and bull trout, mountain whitefish and kokanee which require much effort just to obtain basic life history information.

The major native fish species in the drainage have developed a migratory pattern that takes them through nearly every aquatic habitat type in the system during their life cycle. These wide ranging movements must be assessed to lay the framework for identifying habitat components that are critical to maintenance of life cycle processes. The relatively short time frame of this study necessitates studying all the components of the system simultaneously to reduce the effect of natural variation of the study results. Another approach would be to follow one or two year-classes through an entire life cycle which would require seven to eight years of study or longer. Although it is probably the best approach, it is not suited to this study because of time constraints.

The annual fisheries report for 1979 contains a detailed description of the life history of each major fish species under investigation. Brief descriptions of general life history patterns are presented below to illustrate the complexity of fish movements and distribution in the drainage. The following information is a composite of data collected using traps, mark and recapture fish, general seasonal sampling (electrofishing, snorkeling etc.), creel census and a review of available literature.

Westslope cutthroat trout native to the Flathead River Basin exhibit three main life history patterns across their range: 1) migratory between lakes and streams, 2) migratory from small tributaries to main rivers and 3) non-migratory tributary stocks. These life history patterns have been referred to as adfluvial, fluvial and resident, respectively. Adfluvial and resident forms are found in all three forks of the Flathead River. Adfluvial fish in the North and Middle Forks migrate to and from Flathead Lake, while those in the South Fork use Hungry Horse Reservoir. Spring spawning cutthroat from Flathead Lake have traveled upstream as far as 136 miles before entering a tributary stream. Juvenile cutthroat rear two to three years in tributary streams and attain lengths of four to seven inches before moving downstream through the river system into the lake. Sexual maturity is generally reached after two years in the lake at a size of 12-16 inches. They feed primarily on invertebrates throughout their life cycle.

The distribution of fluvial cutthroat trout in the drainage is under study. It appears that a significant population is present in both the North and Middle Forks. A creel census in 1975 found that the cutthroat trout larger than ten inches comprised 54 percent and 16 percent of the catch in the Middle and North Forks, respectively (Hanzel 1977). Cutthroat smolts are generally less than ten inches long. Therefore, these fish are probably residents of the river or fluvial. Work is continuing in both drainages to determine and assess movements and growth of fluvial cutthroat trout.

Slow growth and low densities of cutthroat trout in the tributaries have made collection and analysis of population data in this drainage difficult. Short growing seasons, low water temperatures and low productivity are some of the apparent limiting factors to growth and population size. The harsh and relatively unproductive nature of the upper river system has favored the development of migratory fish forms.

Bull trout are native to the Flathead River drainage and occur in all three forks. Bull trout in the Flathead River Basin are largely adfluvial in nature with only small groups of resident populations occurring in a few small streams. They have a life history similar to the adfluvial cutthroat trout except the bull trout spawn in September and October. Juvenile bull trout generally spend two years in tributary streams growing five to seven inches in length. The time required to move from the tributaries to the lake is unknown but out-migration from tributary streams occurs during the spring runoff and into early summer. Sexual maturity generally occurs at five to six years of age with fish ranging from 20 to 26 inches in length. Mature bull trout have traveled over 120 miles upstream from Flathead Lake to spawn in tributaries in Canada.

Mountain whitefish spend most of their lives in large rivers, although they do migrate within the river. Juvenile and adult whitefish have been observed in the lower reaches of several of the larger tributaries to the North Fork during the summer, possibly a feeding movement. Spawning migrations have not been observed in small tributary streams in the Flathead River drainage although they do occur in the Kootenai River drainage (Huston 1973). Spawning occurs in late fall and is known to occur in many areas throughout the river system. Young-of-the-year whitefish were collected in several backwaters and side-channels of the upper North Fork this summer. Work is continuing on assessing seasonal movements and growth rates through river electrofishing, snorkeling, river traps and tagging.

Sculpins are the only other native fish species in the upper Flathead River drainage. Identification of the two or three species present in the system is difficult using morphometric and meristic characters. Two species are reportedly in the basin, the shorthead (Cottus confusus) and slimy sculpins (Cottus cognatus). Fish examined thus far indicate considerable overlap in morphological characteristics. A third sculpin species, the mottled sculpin (Cottus bairdii), has been identified in a North Fork tributary but this is under further study. Studies are continuing on species separation with emphasis on determining a relatively accurate field identification key. Sculpins have been found in all tributaries to the North Fork and in the main North Fork where electrofishing samples were taken. They spawn in the spring on the underside of stones. It is believed they exhibit migratory movements. They are found in the river and in the lower reaches of some streams. They feed primarily on aquatic invertebrates and their small size makes them suitable as a food source for trout. Work is continuing on species distribution, movements and feeding habits. Their importance as an indicator species for environmental quality is also under review.

Fish Population Status and Habitat Assessment

Monitoring the status of the aquatic environment, documenting changes and managing it as a resource requires that sufficient data regarding existing conditions are collected. This information should be collected in such a way that it can be integrated into inventory systems that are used in planning and decision making. For example, the Land System Inventory is used extensively by the U.S. Forest Service in land mangement decisions (U.S. Forest Service 1976). Platts (1976) discussed the difficulties in integrating fishery information into the planning process. Platts (1979) also described a system that could be used to integrate fishery data into the land classification system in the area and in Idaho where extensive fishery data has been collected.

In British Columbia, the Resource Analysis Branch of the Ministry of Environment is charged with the inventory of the river basins throughout the province. We met with the Head of Aquatic Systems, Tom H. Chamberlin, and reviewed their system and methods. Their system was the basis for our habitat inventory cards. Their multidisciplinary approach offers many advantages over any system observed thus far in the United States. Some of the data we collect pertains more directly to the watershed than directly to the fishery, but should be useful in a land inventory system. We employed terminology common to hydrology and geology where possible. The Resource Analysis Branch has inventoried most of the tributaries on the Canadian portion of the Flathead River. Their inventories were of somewhat lower resolution than ours, although stream reaches were mapped.

Another facet of the planning system involving the aquatic resource is the allocation of water. In Montana, Senate Bill 76, enacted in 1978, set up state water courts to adjudicate water rights which existed prior to July 1, 1973. Those water rights must be refiled by December 31, 1981. The Montana Department of Fish, Wildlife and Parks acquired water rights for instream flows in the North Fork, Middle Fork and parts of the South Fork and main Flathead Rivers prior to July 1, 1973 under what has become known as Murphy's Law which was enacted in 1970 to provide for instream flows for fish and wildlife in several blue-ribbon trout streams in Montana.

The Department intends to refile these claims to December 31, 1981 to assure legal protection for instream flows needed to maintain the aquatic resource. In the process of documenting the status of the aquatic environment in the upper Flathead River drainage in this study, this data will also be useful in establishing the quantities of water necessary to maintain native, cold water fish species.

Our studies are geared to fit into existing planning processes. Funding sources and objectives vary in specific intent, but our approach is to coordinate all fisheries studies presently being conducted by the Department in the Flathead River Basin for use in systems inventories and predictive models.

Fish species under study were selected: 1) to represent the variety of life cycles present in the system, 2) because they were native or a valuable local, regional, or national resource, and 3) if their distribution or sensitivity to disturbances made them useful in predicting or documenting changes in the aquatic environment. Methods and information from studies of cutthroat trout, bull trout and kokanee salmon are discussed semi-annually or more frequently with researchers in British Columbia, Idaho and Montana. These interchanges occur with field biologists as well as university fisheries scientists. This has been particularly helpful in developing a habitat analysis program and in unraveling problems encountered in studies of life history and development of westslope cutthroat trout.

In the field, a coordinated effort is ongoing to correlate various physical habitat components with fish use. Hydraulic stream measurements including discharge, wetted width, bank stability, average depth, gradient and valley flat, bed material measurements including compaction, lag deposits, D90, inbeddedness and texture and such parameters as percent of five pool classes, percent pool:riffle:run, bank material, debris, riparian vegetation, and channel cover. This system is similar to the multi-disciplinary system used by the Fish and Wildlife Branch in Victoria, British Columbia. Water temperature, aquatic invertebrate and water quality samples are also available for many streams. Fish census are conducted using both snorkeling and when possible, electrofishing.

Correlations are presently being assessed to determine habitat suitability of each stream reach and identify important variables. Although habitat component analysis has been done in several areas, we are not aware of any detailed analysis in a drainage with a dominant cutthroat and bull trout species complex. Habitat preference data for bull trout is scarce.

Therefore, we are developing a study to begin this summer to delineate habitat preference and species interaction of juvenile cutthroat and bull trout. This study will attempt to bridge the gap between habitat surveys and fish censuses and provide data much more suitable for site specific impact assessments. We are presently assessing food habits, movement and distribution of both species. The habitat selection study tentatively will be done in Trail and Red Meadow Creeks in the North Fork drainage. Trail Creek is predominated by bull trout in the lower reaches and cutthroat trout in upstream areas. Red Meadow is comprised of relatively evenly mixed populations of both species.

A map of ecological subsections for western Montana was prepared by the Forest Service (1976). It breaks down land units, climate, vegetation type and geology and attempts to describe the general characteristics. It is a valuable tool but the resolution is too low to be useful in describing land types. The hierarchy used in the Forest Service land classification (Wertz and Arnold 1972) is as follows:

1.	Physiographic Province	)	
2.	Section	)	group similar features
3.	Subsection	)	
4.	Land type associations	)	
5.	Land type	)	
6.	Land type phase	)	split out differences
7.	Site	)	

A personal communication with Al Martinson, a soil scientist for Flathead National Forest, explained that the first three groups are the result of combining similar features at different scales. The last four groups are the result of splitting differences at decreasing scales (i.e. a land type association may cover five square miles and be broken into land types that encompass only one-half square mile).

In order to incorporate fishery data into these groups and maintain the necessary resolution, sufficient data must be gathered at each level to identify the relationship between the watersheds and the fish populations. This requires more intense study as land units are subdivided. The Flathead National Forest is presently identifying land types and the North Fork is programmed for the summers of 1980 and 1981. More limited work will be done in the wilderness areas including the upper Middle Fork of the Flathead River. When the land types are identified, data from this study will be valuable for integrating fishery information with the land type common in the Flathead River drainage and other similar areas.

Another important aspect of this study which will be initiated this summer is the quantification of instream flows in the North and Middle Fork Rivers for maintenance of native fish species. Initial investigations in side channel areas on the North Fork showed their importance as spawning and rearing areas for mountain whitefish. We will continue to determine other important flow related habitat components. Methods presently being used for instream flow determinations are being evaluated to develop a practical method for the North and Middle Forks. The methods used will be determined by their ability to describe the effects of flow on maintaining specific aspects of the aquatic environment, i.e. flows needed for fish migrations, spawning and channel maintenance.

The Flathead Lake fish food habits study will help establish a better relationship between water quality and fish population density. Because of the immensity of the lake and the variety of fish species, two projects will be ongoing simultaneously. The study funded by the Flathead Basin Steering Committee will assess the food habits of cutthroat and bull trout and kokanee salmon, and begin to develop an index of abundance for the two species of trout for long-term monitoring. The study will also investigate the present growth rates and condition of these species in the lake. Another study funded by the Department of Fish, Wildlife and Parks will assess food habits of lake whitefish and lake trout. Laney Hanzel is presently in the process of analyzing age and growth data on kokanee salmon in the lake. He has also developed a method for assessing the relative abundance of kokanee in the lake using electronic acoustical gear. This culminates many years of studies on Flathead Lake and a report should be forthcoming in the next year.

Hungry Horse Dam has caused the single, largest impact on the fishery in the Flathead Basin. Besides present impacts on waters below the dam caused by peaking discharges, it reportedly isolated 60 percent of the cutthroat and bull trout spawning and rearing areas in the drainage from the fish population in Flathead Lake. Investigations funded by the Water and Power Resources Service are underway to determine the feasibility of powerplant enlargement and reregulating dam below Hungry Horse Dam. The study is geared toward determining the specific impacts of the existing water discharges and temperatures on the critical life stages of fish and invertebrate populations in the Flathead River. Under study are the effects of discharge from Hungry Horse Dam on: 1) spawning success of kokanee salmon, 2) upstream spawning migration of cutthroat trout and 3) aquatic invertebrate populations. A progress report will be available in April 1980.

Kokanee salmon spawning is being assessed in upstream areas such as McDonald Creek and Nyack Flats for control purposes. Studies downstream from the South Fork involve delineating spawning areas at dewatered, partially watered and control sites. Monthly collections of all fish are made at three sites in the Flathead River except during the spring spawning period when weekly collections are made to assess upstream movement. Radio transmitters are being implanted in cutthroat trout to more accurately monitor their movement patterns in respect to changes in discharges from Hungry Horse Dam. Presently the aquatic invertebrate study is collecting baseline information in regulated and unregulated portions of the river. Experimental work will begin on the effect of flow fluctuations on community composition and fish food abundance during the next phase of the study.

Basin Component Analysis

A major emphasis of this study is quantification of the relative importance of each component of the basin for providing habitat, food and the medium necessary for maintenance of the aquatic ecosystem. Historically, resource protection when pitted against development was a win or lose confrontation. Today, efforts to minimize and mitigate development are becoming more common. In fact, alternatives for many developments previously accepted as necessities are actively being sought as we quickly squander our diminishing resources. Understanding of the inter-relationships and relative importance of various components of the river basin are necessary to provide wise decision makers with the information needed to balance development and resource exploitation to assure that natural systems are preserved and that human needs can be met in future generations.

Major breakdowns of the component analysis include: 1) a tributary stream rating system, 2) a comparison of the North Fork and Middle Fork River Basins, 3) the Flathead River downstream from the South Fork (the regulated stream reach), and 4) the components of Flathead Lake including the "estuary" area from the Foys Bend to the river delta, the major arms of the lake and Polson Bay.

Tributary streams and their respective segments or reaches will be rated as to their known or predicted value for spawning, rearing, passage and other processes in the life of the major native fish species. The inventory methods we are employing should aid in determining the sensitivity of various stream reaches into certain types of development. The inventory begins by breaking streams down into reaches based on repeating patterns of homogenous variability. These units are a type of ecological response unit (ERU) referred to by States et al (1978). The ERU's are geographical units of land that, 1) possess common vegetative, topographic, elevational and edaphic or aquatic characteristics, and 2) respond to environmental influences more of less uniformly throughout. This information can be incorporated into the Land System Inventory when it is completed.

Reaches are classified and within each reach a representative segment is quantitatively inventoried and fish are counted in each habitat type and tallied by size class and species. A second-year study is being initiated to determine specific habitat requirements of juvenile cutthroat and bull trout. Other inventory data includes a large-scale inventory of bull trout spawning areas by counting redds in the fall and measuring depth, velocity, gravel size, distances to cover etc. Single and multiple parameters or groups of parameters for associated stream reaches.

As with the structure of the Land System Inventory, stream classifications must start by grouping similar characteristics before they are split by differences. The variability of productivity, runoff patterns and other characteristics from east to west slope streams and between river basins are ways of grouping streams. Unfortunately, no one or two streams are representative of the basin. We found it necessary to inventory both the North and Middle Fork River basins. Only in this way can we assess the relative contribution of each drainage to the Flathead Lake fishery. Estimates are that 60 percent of the spawning and rearing area for production of fish for the Flathead Lake fishery was lost wheh Hungry Horse Dam was built. Incremental development in the upper basin, although not necessarily causing the loss of any one tributary system, may be reducing the carrying capacity of several tributary streams thereby having the same effect.

The Flathead River downstream from the South Fork is important seasonally for spawning and incubation of kokanee salmon eggs during the fall and winter and as a conduit for upstream migrating cutthroat trout in the spring, bull trout in the summer and downstream migrating juveniles from the spring through autumn. It also provides year-around residence for mountain whitefish and probably for some forms of westslope cutthroat and rainbow trout. This segment of the river is under intensive investigation in a study funded by the Water and Power Resources Service.

Flathead Lake provides an area where most of the major game fish in the basin can grow to maturity. Migratory species then return to upstream waters to spawn while other species such as lake trout and lake whitefish spend their entire life in the lake. Upstream developments which affect the chemical composition of the water could alter the food chain of this large, oligotrophic lake. Besides studies on food habits, growth rates and developing indices of abundance, a creel census is necessary on the Flathead System to; 1) quantify the present harvest, pressure, success, species composition etc., 2) assess recreational value of the aquatic resource, 3) determine relative importance of various river or tributary systems to the lake and river fishery, and 4) assess relative importance of each segment of the basin in providing quantity and quality recreation.

The value of a natural ecosystem is hard to determine in dollars and cents. This creel census would add another dimension to the study that would be valuable for planning the future of the basin. It should not be the only source by which the value of aquatic resource is measured. The number of visitors to Glacier Park and increased popularity of the wild and scenic rivers in the area also serve to illustrate the importance of the intrinsic values of coexistence with nature.

Lands and resources once considered untouchable are only beginning to feel the pressures of an energy hungry country These studies alone will not protect or mitigate the loss of our natural resources. Only man can do that. While it has long been argued that we can not put a dollar amount on intrinsic values of our natural resources it should be remembered that is is not the fault of the resources but of our own value system.

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