F-07/08-58

COAL BEETLE SALVAGE FISHERIES MONITORING STUDY

Final Report

January, 1983

By

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and Parks
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Under Contract No. 53-0385-2-2626
To
USDA Forest Service - Flathead National Forest

EXECUTIVE SUMMARY

This report summarizes data collected during 1982 on the fish resource in Coal Creek. Fish habitat was assessed in three areas of Coal Creek, across 25 random transects within one kilometer sample sections. Inventories of organic debris abundance and stability in three one-kilometer sample sections and two 100 to 150 meter long mapped segments of the creek revealed that old, large organic debris were stable while new, smaller debris (the majority were contributed by logging) were generally unstable and moved during spring runoff. Streambed sampling in known bull trout spawning areas of Coal, Big, Whale and Trail creeks in the fall, 1982 showed that Coal Creek's spawning areas contained a significantly higher percent of fine material (less than 2 mm) than any of the other three creeks. Little difference in streambed composition was found between fall, 1981 and fall, 1982 in sampled spawning areas of Coal Creek. Fish abundance was estimated using three electrofishing techniques at three sites in Coal Creek. Juvenile bull trout were most abundant in the two lower sites (Cyclone Bridge and Dead Horse Creek Road Bridge), and present in limited numbers in the upper site (South Fork Coal Creek Road Bridge). Westslope cutthroat trout were abundant in the lower site (bull and cutthroat trout were equally abundant) and in the upper site, but found in limited numbers at the Dead Horse Creek Road Bridge site. Bull trout spawning site (redd) surveys conducted during the fall in the North and Middle Fork drainages located more redds in 1982 (1,129) than in any of the previous three years (704, 574 and 292 in 1981, 1980 and 1979, respectively).

The following recommendations are presented: 1) use caution when logging in riparian zones; 2) ensure implementation of properly planned and designed road systems through positive incentives to the contractor or close supervision to reduce the amount of sediment transported to the stream channel; and 3) continue monitoring fish resources under various forest management activities to provide data to evaluate the effects of past management so that future management activities can be planned effectively.

ACKNOWLEDGEMENTS

We would like to extend our appreciation to the following individuals and organizations who made this study possible. Tom Weaver, Karen Pratt and Gary Micheals played a valuable role in data collection, data analysis and report preparation. Mark Schafer and Mary Lennon helped collect field data.

The United States Forest Service, Flathead National Forest funded the study under the direction of Paul Brouha, Regional Fisheries Biologist, and Hank Dawson, Flathead National Forest Fisheries Biologist. Wally Page, Phyllis Marsh and Al Martinson of the Flathead National Forest's Supervisor's Office provided professional insight and information. Sonny Danielson of the Flathead National Forest's Soils Laboratory helped analyze streambed samples. Bonner Armstrong and Larry Thompson of the Glacier View District (Flathead National Forest) provided detailed sale area maps and assisted our field crews in every way possible. Dick Call, Glacier View District Ranger, was instrumental in initiating the study.

The Montana Department of Fish, Wildlife and Parks Fisheries Division and the Regional Fisheries Managers, Bob Schumacher and Jim Vashro, provided office space, equipment and background information. Mary Chubb typed the draft and final manuscripts.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

LIST OF TABLES

LIST OF TABLES (cont.)

LIST OF FIGURES

LIST OF FIGURES (cont.)

INTRODUCTION

The upper Flathead River basin supports native populations of westslope cutthroat and bull trout (Graham et al. 1980, Fraley et al. 1981). Many tributaries in the upper river basin provide important spawning and rearing habitat for these fish. The Coal Creek drainage, a tributary to the North Fork of the Flathead River, was found to provide spawning and rearing areas for migratory cutthroat and bull trout and resident cutthroat trout.

The Flathead National Forest, Glacier View District had been planning a timber harvesting program in the Coal Creek drainage, named the Coal Ridge Sale. This sale was to begin sometime after 1981. A spruce bark beetle infestation was identified in the Coal Creek drainage during 1981. In an attempt to control this infestation, the sale was changed to harvest primarily spruce in two stages and renamed the Coal Creek Beetle-Salvage Timber Sale. The first stage was a selective 10 percent cut to remove beetle infested and "high risk" spruce from 600 acres in the riparian zone of Coal Creek, adjacent and upstream from the South Fork Coal Creek Road bridge (Road No. 317). This harvest occurred during the winter of 1981-82 when snow cover was present and no road construction was required. The second stage planned for a harvest of 11 million board-feet of primarily spruce along both ridges of the upper Coal Creek drainage, construction of 19 kilometers (12 miles) of new road, and reconstruction of 34 kilometers (21 miles) of road.

The National Forest Management Act of 1976 passed on 22 October, 1976 required the Forest Service to develop regulations for National Forest System Land and Resource Management Planning. The Act also stated (Sec. 2(6)) "the Forest Service,..., has a responsibility and an opportunity to be a leader in assuring that the nation maintains a natural resource conservation posture that will meet the requirements of our people in perpetuity...." The revised regulations (36 CFR, Part 219, revised 30 September, 1982) states (219.19) "Fish and wildlife habitat shall be managed to maintain viable populations of existing native and desired non-native vertebrate species in the planning area." The regulations further state (219.11) that "The forest plan shall contain...: (d) Monitoring and evaluation requirements that will provide a basis for a periodic determination and evaluation of the effects of management practices."

Based on the preceding common goals of the Flathead National Forest (FNF) and the Montana Department of Fish, Wildlife and Parks (MDFWP), those two agencies met in the summer of 1981. At that time we discussed a study to assess the status of the fish resource in Coal Creek with an understanding that long-term monitoring was needed to evaluate the effect of forest management activities on that fish resource. Out of that and subsequent meetings, a contract (No. 53-0385-2-2626) was begun by the MDFWP for the FNF. The specific activities and types of information to be included were:

1. Assess aquatic habitat at three predetermined sites in the Coal Creek drainage - Glacier View District.

2. Document instream debris frequency of occurrence and map two areas to monitor debris movement.

3. Complete fish abundance estimates by electrofishing and snorkeling methods.

4. Document the number and location of bull trout redds in Coal Creek and known spawning areas in Big, Whale and Trail creeks.

5. Determine streambed composition of known bull trout spawning areas in Coal Creek and compare streambed composition of known bull trout spawning areas of Big, Whale and Trail creeks.

6. Report the above results.

The following report summarizes data collected during 1982 and recommends future data needs and potential impacts of future forest management activities on the fish resource in the Coal Creek drainage.

DESCRIPTION OF STUDY AREA

Coal Creek is a major tributary to the North Fork of the Flathead River, entering the North Fork 38.9 kilometers (24.2 miles) above the junction of the North and Middle forks of the Flathead River near Blankenship Bridge (Figure 1). Coal Creek drains an area of 211.5 square kilometers and is 31.2 kilometers in length with an average channel gradient of 1.9 percent. Major tributaries to Coal Creek include Cyclone, Dead Horse and the South Fork of Coal creeks.

Land ownership in the Coal Creek drainage is mixed between private owners who own approximately 25 square kilometers in the lower portion of the drainage, the Montana Department of State Lands (Coal Creek State Forest) which controls approximately 44.5 square kilometers in the middle portion of the drainage and the Flathead National Forest which manages 164.2 square kilometers in the upper basin and the Wild and Scenic River corridor of 0.3 square kilometers along the North Fork of the Flathead River. The Glacier View District estimated that since 1955, 10.3 square kilometers have been clearcut on Forest Service land and 3.3 square kilometers were cut using seed tree, shelterwood or overstory removal prescriptions. The estimated area cut did not include salvage sales. Approximately 153 kilometers of road exists on Forest Service land. The Department of State Lands estimated that 3.6 square kilometers of state land have been clearcut and 1.2 square kilometers have been partially cut. Approximately 43.4 kilometers of road exist on state land.

The bedrock underlying the Coal Creek drainage is predominated by argillites and limestones. Quartzites and sandstones are also present. This material was classified by Martinson et al. (1982) as having a silty soil texture and moderately fast sediment transport capability. The valley walls adjacent to Coal Creek and its tributaries frequently have steep slopes (greater than 40 percent) increasing erosion and sediment transport potential.

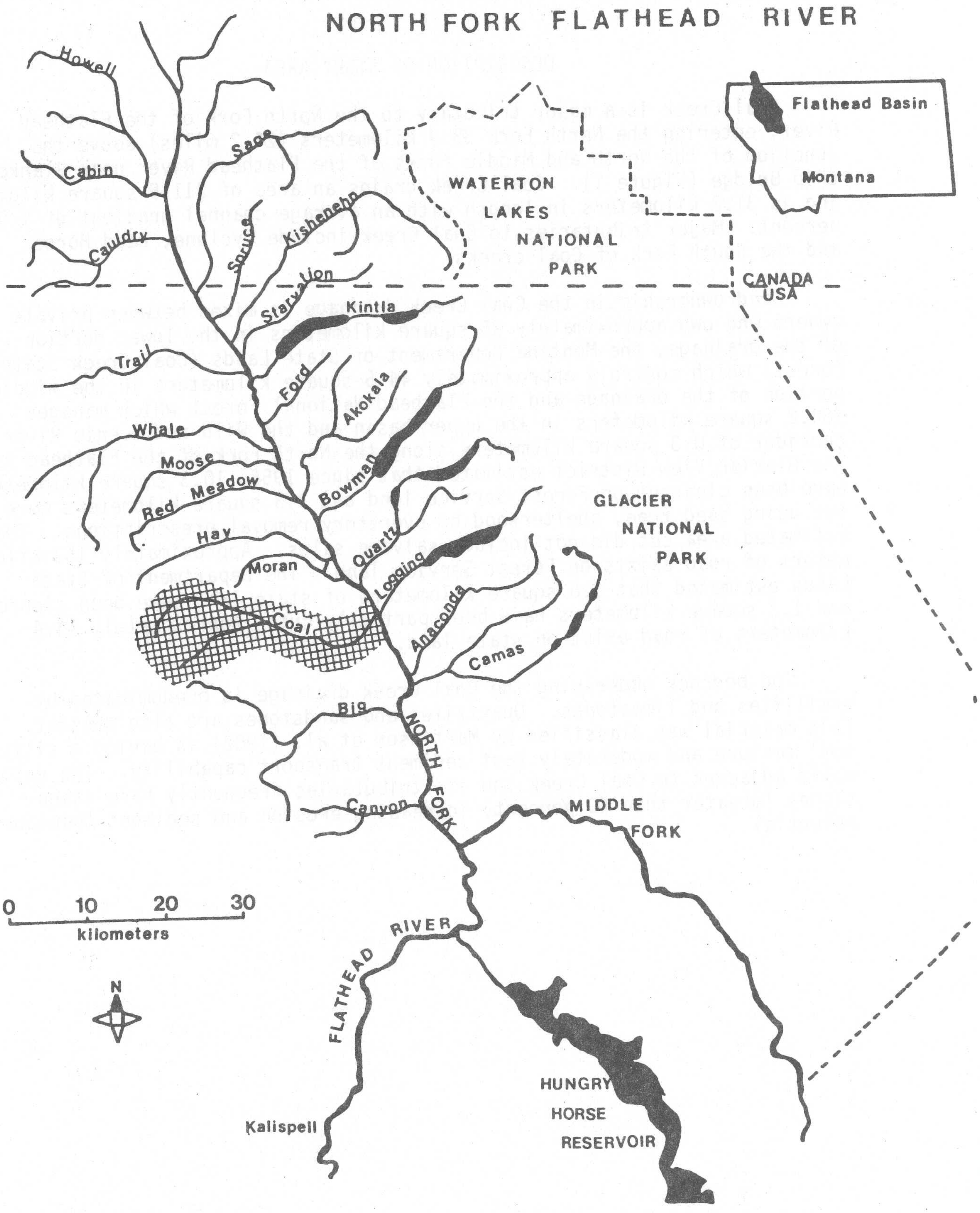

Figure 1. Drainage map of the North Fork of the Flathead River showing the Coal Creek drainage (cross-hatched area).

METHODS

HABITAT

Streamflow and Water Temperature

The water level of Coal Creek was monitored from April through November, 1982 at three bridge crossings: 1) South Fork of Coal Creek Road (Road No. 317); 2) Dead Horse Creek Road (Road No. 1693); and 3) main Coal Creek Road (Road No. 317) which we designated as "Cyclone Bridge" (Figure 2). In early spring (26 April), reference nails were located on bridges and heights were measured from these reference nails down to the water's surface. On 14 July, after the snow had melted, staff gauges were installed on each of the three bridge abutments and referenced to both the nails located on the bridges and to established benchmarks. All water level information presented in this report were standardized as staff gauge heights (in feet). Water levels were also monitored in nine west-side tributaries to the North Fork of the Flathead River at North Fork Road crossings, including Coal Creek, from May through October.

Minimum-maximum thermometers were placed in Coal Creek at the same three bridge sites described above on 26 April and were replaced on 14 July with weekly recording thermographs. Minimum-maximum thermometers were read weekly from 26 April to 14 May. On 11 June, the thermometers at the main Coal Creek Road bridge and the South Fork Road bridge were missing. Recording thermographs were checked once a week throughout the summer and fall until their removal on 8 November. On 12 October, the thermograph at the Dead Horse Road (1693) bridge was moved down to the North Fork Road bridge and operated until 8 November, at which time the mechanism froze. The thermograph at the South Fork Coal Creek Road bridge malfunctioned on 4 August and was replaced on 1 September.

Line Transects

Aquatic habitat was quantified using a line transect methodology similar to that described by Herrington and Dunham (1967). Transects were sampled at a frequency of twenty-five randomly selected sites per kilometer along three one-kilometer sections of Coal Creek. Mabbott (1982) found that 95% confidence intervals estimated from 20 transects generally bounded actual parameters in mapped areas. He further concluded that 95% confidence intervals could be narrowed by increasing the sample size to 30 transects. These three one-kilometer sections were located:

1. below the Dead Horse Creek Road bridge (HS1);
2. above the South Fork Coal Creek Road bridge (HS2); and
3. above the Coal Ridge Lookout trailhead (HS3) (Figure 2).

The following parameters were measured at one meter intervals across each transect:

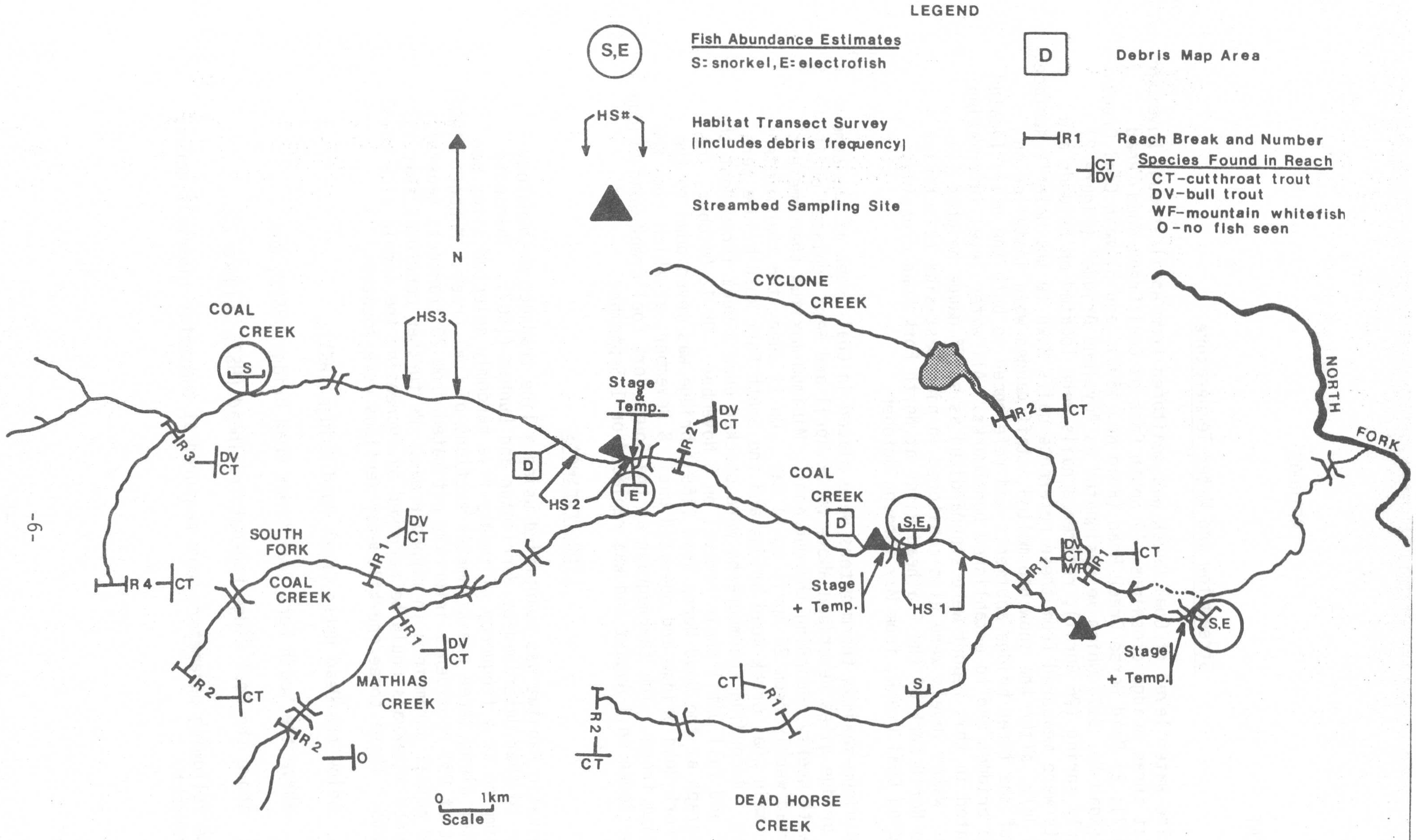

Figure 2. Drainage map of the Coal Creek drainage showing physical and biological sampling sites, reach breaks, and the species observed in each reach (original map from MDFWP, 1983).

1. depth to the nearest centimeter;

2. instream cover;

3. bank cover; and the

4. two predominant substrate size classes (Table 1).

Visual estimates of substrate imbeddedness, D-90, percentages of each substrate size class, percentage of instream cover, and percentage overhead (bank) cover were also made at each transect site according to methods presented by Graham et al. (1980). Wetted width and bank full channel width were measured at each transect.

All habitat transect data was entered into data files on the ICIS 850 computer located at the Montana Department of Fish, Wildlife and Parks Regional Headquarters, Kalispell, Montana. A computer program was developed to summarize all habitat information by survey section.

Organic Debris

The frequency of occurrence for organic debris by type and size (Table 2) was recorded for each one-kilometer section surveyed during the line transect sampling.

Rough maps were produced in the field of two portions of Coal Creek to document the presence and approximate location of each piece of organic debris. One mapped area covering approximately 150 meters of the creek was located approximately 0.5 kilometer above the Dead Horse Creek Road bridge. Another mapped area was located between the South Fork of Coal Creek Road bridge and the Coal Ridge Lookout trailhead and was approximately 115 meters long (Figure 2).

Permanent reference points were marked with rebar stakes driven into the streambank at the upstream and downstream boundary of each mapped section. A 30 meter tape was stretched down the length of the stream and each piece or accumulation of organic debris was located and referenced to a distance measured from this tape. Stream widths were recorded at several points down the length of the mapped section. Field maps were later transcribed to graph paper in the office. The maps presented were not designed to be precise representations of the stream channel, but do accurately document the amount and location of debris.

Point Sources of Inorganic Sediment

Frequencies (number by kilometer) of all point sources of sediment visible from stream channels in the South Fork of Coal Creek and main Coal Creek from the South Fork bridge downstream to its mouth were noted during the 1982 spawning site inventory. These areas were located by referencing their location as a distance to recognizable landmarks in the stream channel. Sediment sources were classified (Table 3) and listed by class and distance from landmarks.

Table 1. Substrate size class, instream cover and bank cover criteria.

Substrate size class

1. Particulate organic matter-silt or detritus
2. Less than 2.0 mm in diameter - sand
3. 2.0 to 6.4 mm in diameter - pea gravel
4. 6.4 to 64.0 mm in diameter - pebble
5. 64.0 to 254.0 mm in diameter - cobble
6. Larger than 254.0 mm in diameter - boulder, bedrock

Instream cover codes

0. None
1. Aquatic vegetation
2. Logs
3. Debris
4. Boulders

2–4: Below water surface

5. Logs
6. Debris
7. Boulders

5–7: Above water surface

8. Man made structure

Bank cover codes

0. None
1. Undercut bank, log or root mass
2. Overhang <2 m above water surface
3. Overhang from 2 m up to canopy overstory
4. Overstory canopy

Table 2. Criteria used to classify organic debris by type and age in Coal Creek.

Type	Diameter
Large	> 305 mm (> 12 in.)
Medium	152 - 305 mm (6 to 12 in.)
Small	52 - 151 mm (2 to 6 in.)
Branches	< 52 mm (< 2 in.)
Jams	Accumulation of debris
AGE	
Old	Past Years
New	This year (natural)
Logged	This year (cut)

Table 3. Classification criteria for point sources of inorganic sediment to Coal Creek used during a fall, 1982 survey.

Classification	Criteria
Cut Bank	
Huge	>1,000 m^2 exposed
Large	>200 m^2 exposed
Moderate	>100 m^2 exposed
Small	$\leq$100 m^2 exposed
Braided channel	More than one channel
Major debris jam	Only jams capable of diverting stream channel
Beaver pond	Self explanatory
Bridge	Self explanatory

STREAMBED COMPOSITION IN BULL TROUT SPAWNING AREAS

Hollow core samples (McNeil and Ahnell 1964) were removed from eight sites in the Cyclone Lake Road cutoff (Road No. 909) area of Coal Creek, 12 sites immediately above the Dead Horse Creek Road bridge, and 10 sites approximately 0.5 km above the South Fork Road bridge (Figure 2). Sampling was done following methods presented in Shepard and Graham (1982). The area above the South Fork Road bridge was not an important bull trout spawning area; however, the Forest Service requested that one sampling area be located within the riparian timber sale area. We selected an area where a bull trout redd had been observed during 1981. The area sampled was located immediately above a large log jam which had trapped a large amount of gravel and smaller size particles. This trapped gravel provided the only identified suitable spawning substrate in this portion of the creek. We recognized that the area sampled was not representative of this portion of the creek and that the log jam not only trapped gravels, but fine particles as well. All areas were sampled during October, 1982 and April, 1982, and all areas excluding the area above the South Fork Road bridge were also sampled during October, 1981.

To compare the streambed composition of Coal Creek with other west-side tributaries to the North Fork of the Flathead River, core sampling was conducted in two areas of Trail Creek, one area of Whale Creek, and one area of Big Creek during October, 1982, March and April, 1982 and October, 1981 (Table 4). Streambed composition was computed as percent by dry weight for each size class.

A Kruskal-Wallis test was run to determine if the median percentages of material less than 2 mm were different between Coal, Whale, Trail and Big creeks (Lund 1979). Percentages of material less than 2 mm in streambed samples from undisturbed areas of streambed in the four creeks were then compared between creeks using a multiple comparison test (Daniel 1978). For these tests the sample area above the South Fork bridge was excluded. Cumulative percentages of material less than 6.34 mm and less than 2 mm were plotted on graphs of chinook salmon survival curves (adapted from Tappel 1981).

FISH ABUNDANCE

Fish abundance estimates were conducted in three sections of Coal Creek during April and May of 1982 and again during August, 1982. Each section was approximately 150 m long. The sections were located:

Cyclone Bridge: below the first bridge crossing of Coal Creek by the main Coal Creek Road (SE¼, NW¼, SE¼, Section 36, Township 34 North, Range 21 West);

Dead Horse Bridge: below the Dead Horse Creek Road bridge (NW¼, SE¼, SW¼, Section 28, Township 34 North, Range 21 West); and

Table 4. Location of substrate coring transects sampled for the Flathead National Forest during 1981-82.

Creek	Transect numbers (4 cores per transect)1/	Legal description
Big Creek	9, 10, 11	NE¼, SE¼, NE¼, Sec. 33 T33N, R21W
Coal Creek2/	4, 5, 6	SW¼, NE¼, SW¼, Sec. 28 T34N, R21W
	7, 8	SE¼, NW¼, NE¼, Sec. 34 T34N, R21W
Whale Creek	1, 2, 3	SE¼, NW¼, SE¼, Sec. 20 T36N, R22W
Trail Creek	12, 13, 14	NW¼, NW¼, SW¼, Sec. 29 T37N, R22W
	15, 16	SW¼, SW¼, NE¼, Sec. 30 T37N, R22W

1/ Whale Creek, transect 2 had one additional natural redd site sampled during the fall of 1981.

2/ Ten cores were taken in Coal Creek above the South Fork Coal Creek Road bridge (SE¼, NE¼, SW¼, Sec. 24, T34N, R22W).

South Fork Bridge: above the South Fork Coal Creek Road Bridge (SE$\frac{1}{4}$, NE$\frac{1}{4}$, SW$\frac{1}{4}$, Section 24, Township 34 North, Range 22 West).

Electrofishing was used to capture fish after both ends of the section were blocked with 12.7 mm mesh block fences. Mark-recapture (Vincent 1971), two-catch (Seber and LeCren 1967), and multiple-catch (Zippin 1958) population estimation techniques were used to estimate fish numbers in all three sites. In the spring a mark-recapture estimate could not be completed in site 3 due to increased spring streamflows which prevented the maintenance of block fences and made wading dangerous. Snorkel counts were also made in sites 2 and 3 either very early or late in the day to allow sufficient time for electrofishing. Counts conducted during these times yielded unreliable results. Estimates were computed using mark-recapture, two-catch and multiple-catch estimators for bull and cutthroat trout 75 mm and longer for each site and season. Ninety-five percent confidence intervals were computed for all estimates.

Surface areas of all fish abundance estimate sections were estimated by measuring the length and several widths of each section. Fish densities were computed by dividing the estimated number of fish derived using two-catch estimators by the estimated surface area. These densities were standardized as the number of fish per 100 square meters of wetted surface area.

The number of age I+ bull trout and age II+ westslope cutthroat trout were estimated by site for both seasons (spring and summer). Age II+ westslope cutthroat were assumed to be fish larger than 70 mm during the spring estimates and fish larger than 90 mm during the summer estimates. Age I+ bull trout included fish larger than 60 mm during the spring estimates and fish larger than 75 mm during the summer estimates. These age class distinctions were based on age-length analyses from scales taken during the spring and length-frequency distributions.

A snorkel count was conducted in a section of upper Coal Creek (NW$\frac{1}{4}$, NW$\frac{1}{4}$, NE$\frac{1}{4}$, Sec. 19, T34N, R22W) on 6 August, 1982 to assess the relative abundance of cutthroat and bull trout. Snorkel counts were also conducted in this section during 1979 and 1981 (Graham et al. 1980, Shepard et al. 1982).

In an effort to account for natural fluctuation in population levels, two-catch population estimates were also conducted in Langford, Cyclone and Morrison creeks for all fish 75 mm and larger to compare fish numbers and densities between creeks.

BULL TROUT SPAWNING SITE SURVEYS

Bull trout spawning sites (redds) in the Coal Creek drainage were counted and their location in the drainage plotted. Redd surveys were also completed in the Trail, Whale and Big creek drainages in the U.S. portion of the North Fork drainage, and Howell and Cabin creeks and the upper Flathead River in the Canadian portion of the drainage.

We surveyed Coal Creek from 0.5 km above the fork in Coal Creek (North Fork of Coal Creek) located near the end of Road 317B down to its junction with the North Fork of the Flathead River. The South Fork of Coal Creek was surveyed from 1.0 km above the mouth of Mathias Creek down to Coal Creek, and all of Reach I of Mathias Creek was surveyed (Figure 2).

Bull trout redds were usually easy to identify in the field. They appeared as large "cleaned" areas of the streambed with a discernible pit and tailspill (Shepard et al. 1982). We ranked redd observations based on our confidence that what we saw was indeed a redd using the following criteria:

Definite: No doubt. The area was definitely "cleaned" and a pit and tailspill were easily recognized. Not in an area normally cleaned by stream hydraulics.

Probable: A "cleaned" area that may have been caused by stream hydraulics, but a definite pit and tailspill were recognizable. OR An area that was not "brightly cleaned", but had a definite pit and tailspill.

Possible: A "cleaned" area that was probably caused by stream hydraulics and had no recognizable pit and tailspill.

For final counts, only definite and probable redd observations were used.

RESULTS

HABITAT

Streamflow and Water Temperature

Water levels peaked sometime in early June at all three recording sites (Figures 3, 4 and 5). It appeared that the water level at the uppermost site (South Fork of Coal Creek Road bridge) rose early in response to spring rains, then peaked in June (Figure 5). The peak flow in Big Creek, the next drainage to the south (Figure 1) occurred on 26 May (files, USGS, Kalispell, Montana). Peak flows in lower Coal Creek probably occurred at a similar time, while peak flows in upper Coal Creek occurred later. Stage-discharge relationships were developed for the three sites based on the limited data collected during this study and by Flathead Forest personnel during the past year (Figure 6).

Mean weekly minimum and maximum water temperatures followed the same trend at all three sites (Figure 7). Differences in mean weekly maximum water temperatures between the South Fork and Dead Horse bridge were small from the middle of July to the middle of September. Differences between mean weekly minimum and mean weekly maximum water temperatures were also relatively small for these two sites, illustrating the relatively constant temperature of upper Coal Creek. Conversely, the difference between the mean weekly minimum and mean weekly maximum water temperatures at Cyclone bridge were relatively larger. The maximum diurnal difference between the minimum and maximum water temperatures were 3.3°C at the South Fork bridge, 5.6°C at the Dead Horse bridge, and 6.1°C at the Cyclone bridge. Minimum temperatures in early spring and late fall approached 0°C. Maximum temperatures in early spring (April and May) reached 7.5°C. The highest maximum water temperature, recorded at the Cyclone bridge site, was 14.4°C.

Line Transects

Averages of physical habitat measurements showed that Coal Creek's physical characteristics were similar in both the riparian "cut area" (HS3, above the Coal Ridge Lookout trailhead) and above the South Fork bridge (HS2) (Tables 5 and 6). Coal Creek was confined to a relatively narrow channel in these two areas due to the steep, V-shaped valley walls. The similar average wetted widths recorded at different discharges during the spring and summer reflected the confined nature of the channel.

In HS3, random transects occurred at four pools and eight runs in the summer, and no pool and 14 runs during the spring. It is possible that areas classified as pools during low summer discharges (39 cfs) were classified as runs during the spring survey due to high discharges (100 cfs).

Mean wetted width, depth and thalweg depths were larger for the summer habitat survey of the Dead Horse Creek Road bridge section (HS1) than for the spring survey. This difference can be attributed to differences in streamflow. The spring habitat transects were measured 22 April, at

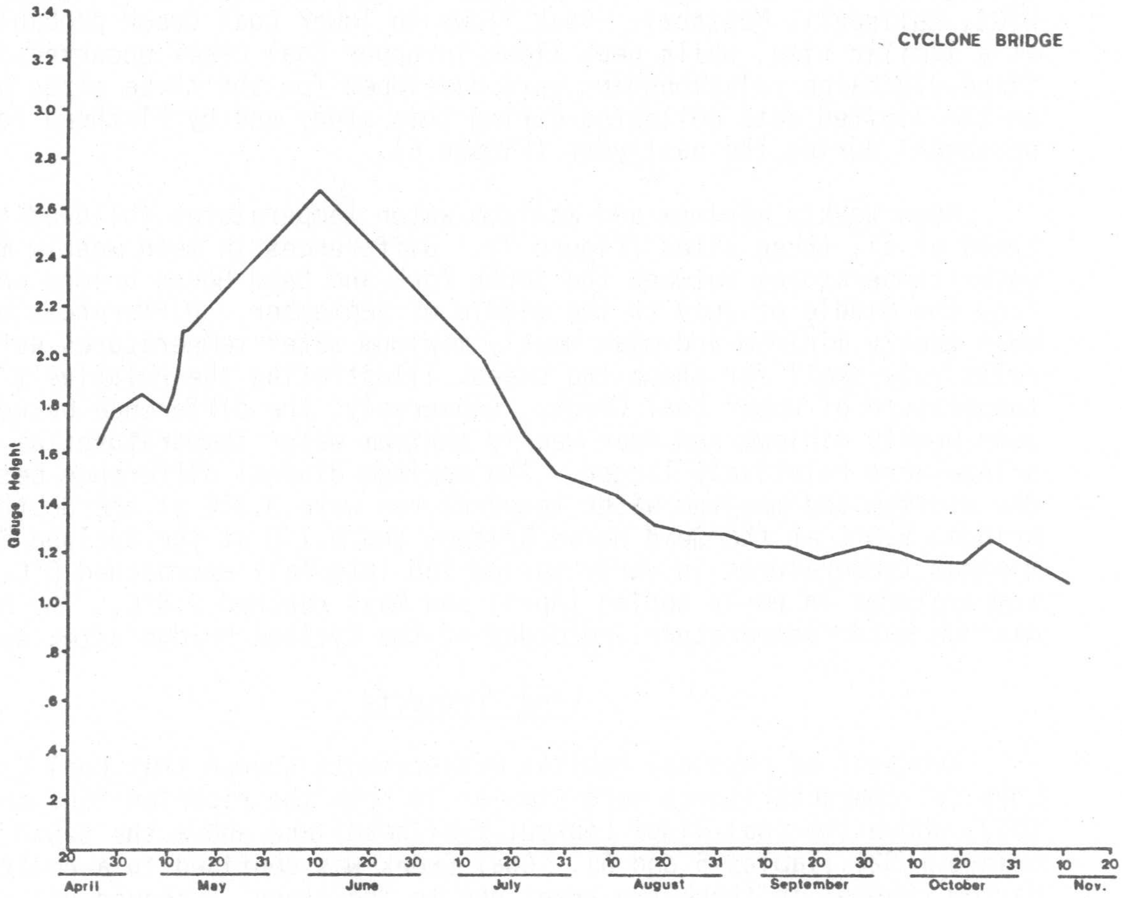

Figure 3. Gauge height (in feet) of Coal Creek at the lower bridge on the main Coal Creek Road (Road No. 317) from 26 April to 12 November, 1982.

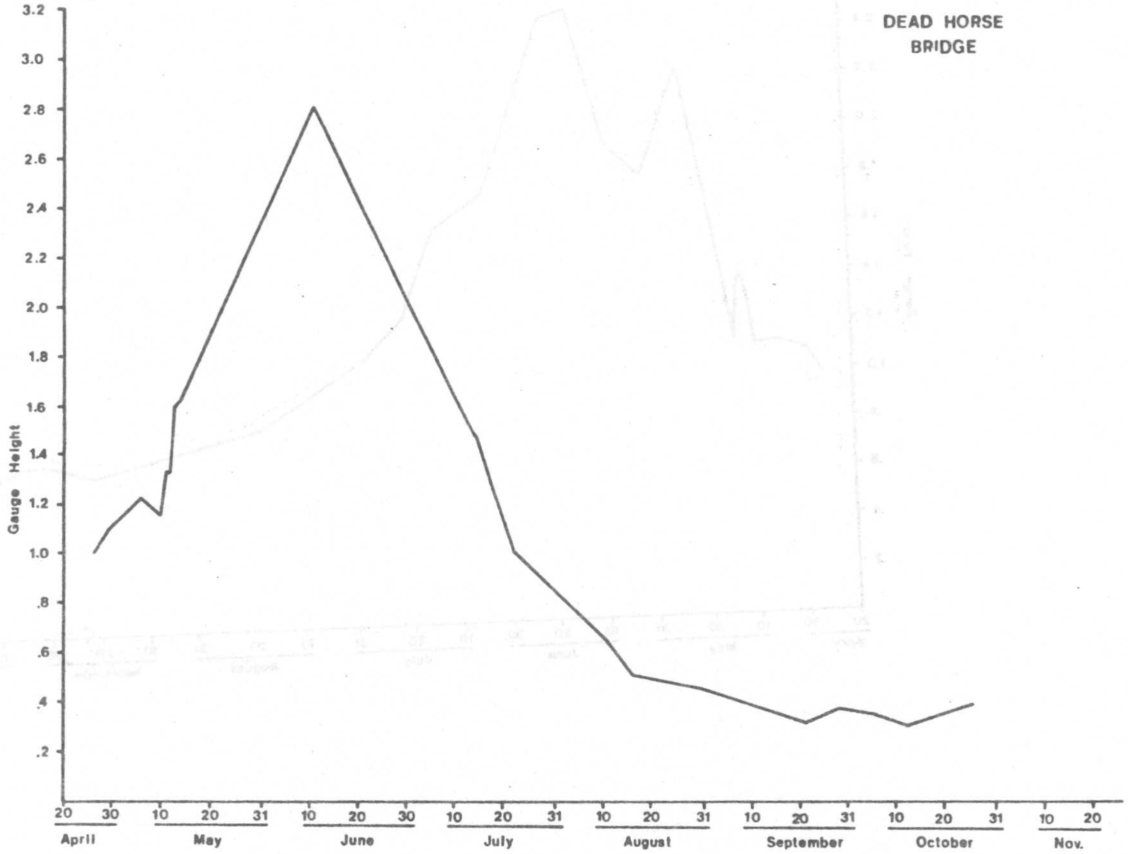

Figure 4. Gauge height (in feet) of Coal Creek at the Dead Horse Creek Road bridge (Road No. 1693) from 26 April to 26 October, 1982.

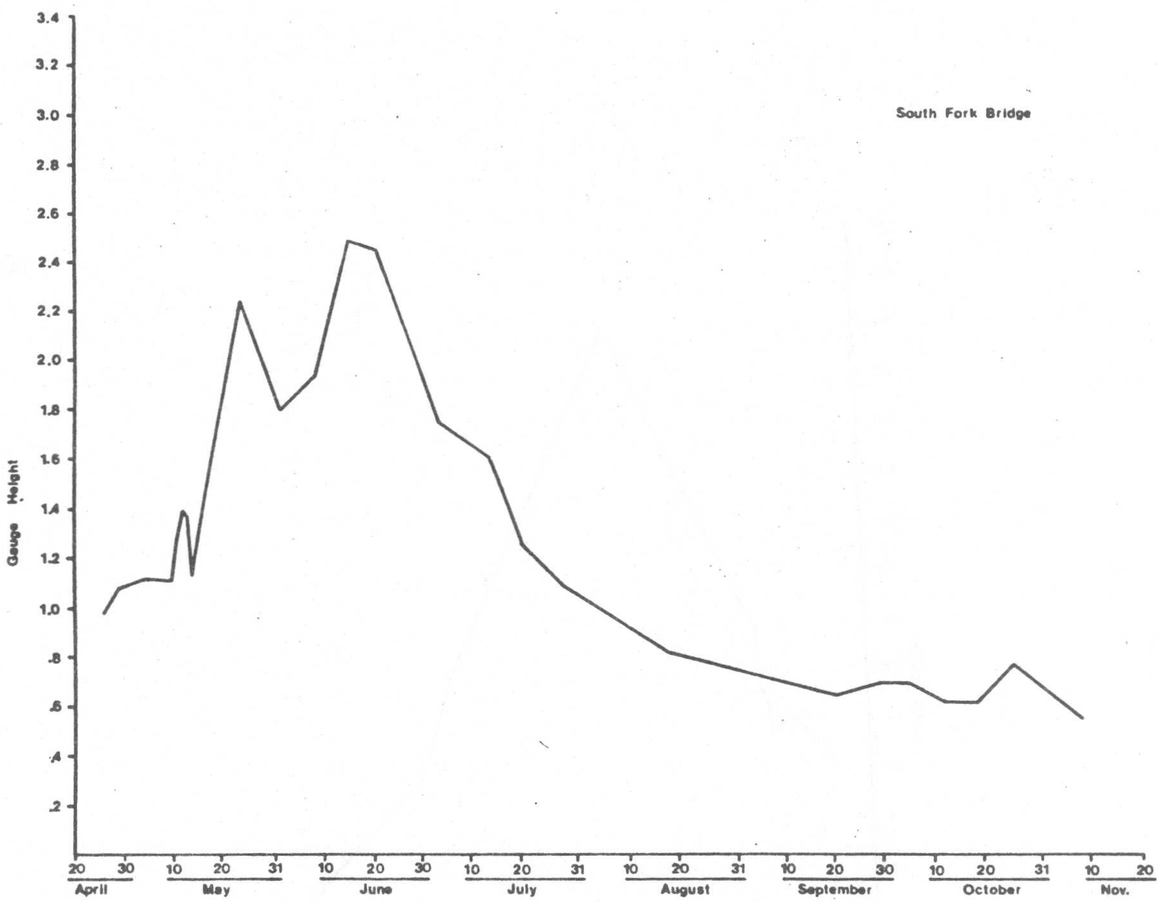

Figure 5. Gauge height (in feet) of Coal Creek at the South Fork of Coal Creek Road bridge (Road No. 317) from 26 April to 8 November, 1982.

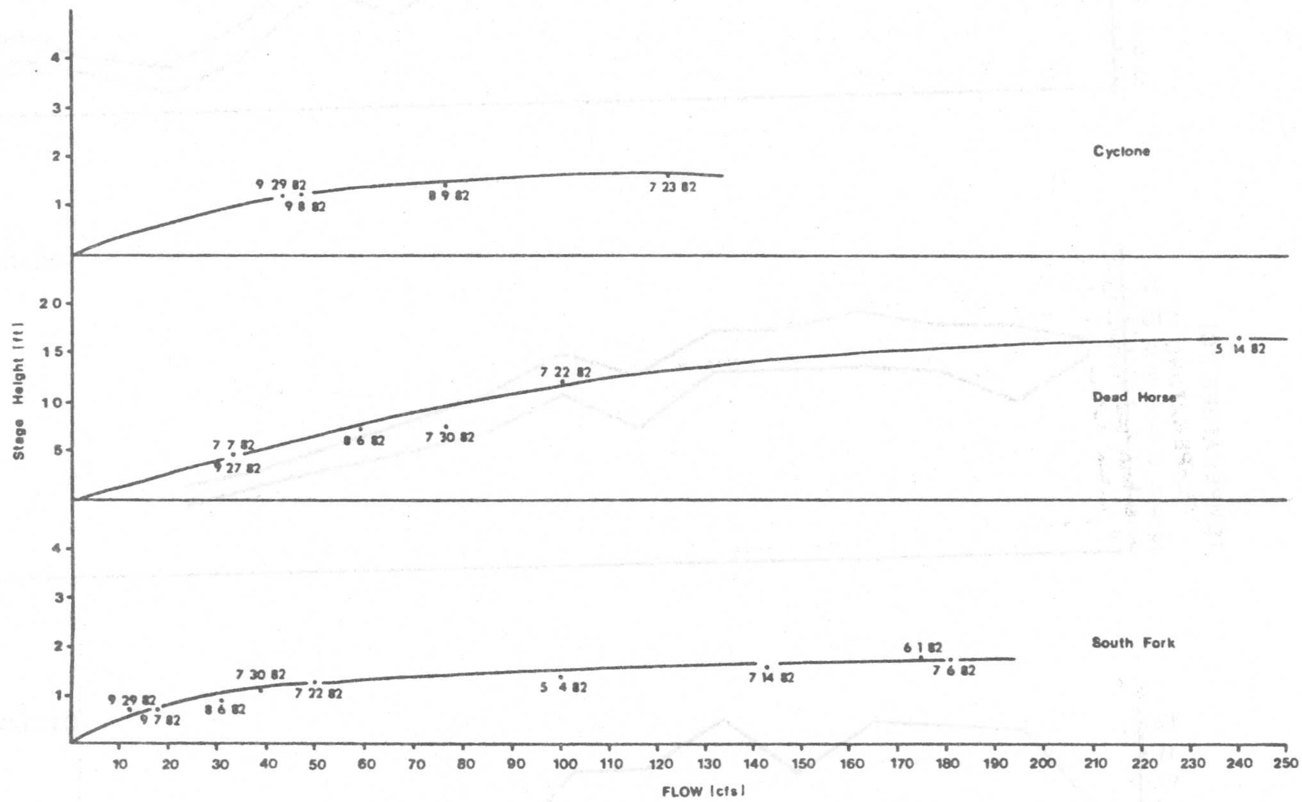

Figure 6. Stage-discharge relationships for staff gauge sites on Coal Creek at bridge crossings. Points are measured discharges and numbers are dates discharges were measured.

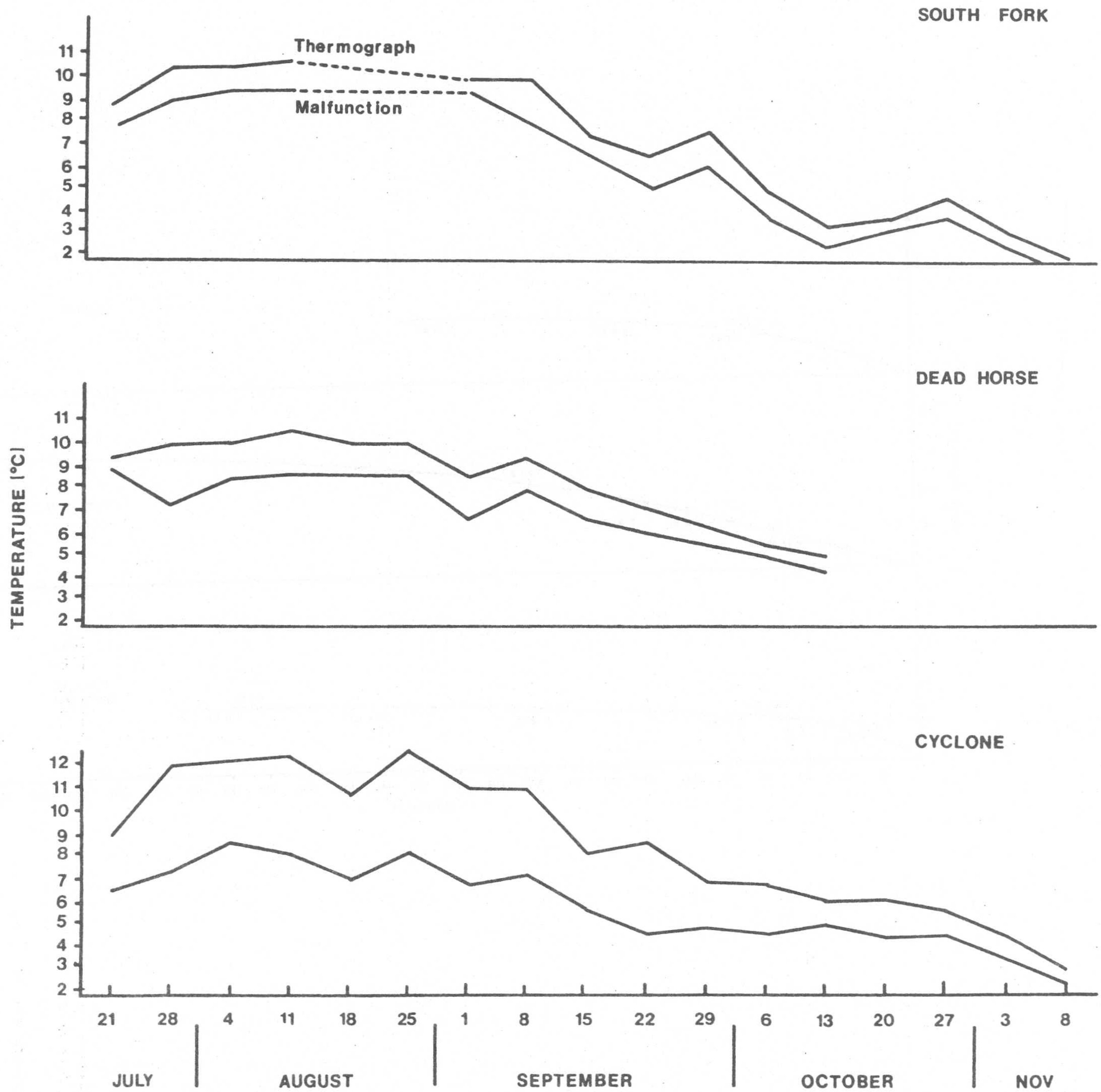

Figure 7. Mean weekly (for week ending at date indicated) minimum and maximum water temperatures at three sites in Coal Creek recorded by thermographs.

Table 5. Mean physical habitat measurements in three study sections of Coal Creek by habitat feature, fall, 1982.

Feature	No.	Date	Flow (cfs)	Channel width (m)	Wetted width (m)	Average depth (cm)	Average thalweg depth(cm)	Maximum depth (cm)	D-90 (cm)
Riparian cut area - Above Coal Ridge Lookout trailhead (HS3) (transects 1-25)									
Pool	0	5/13/82	100						
Riffle	5	5/13/82	100	10.7	8.9	30.6	50.6	66	26
Run	14	5/13/82	100	13.6	9.5	32.5	52.3	64	32
Pocket water	0	5/13/82							
Other	5	5/13/82	100	17.1	10.2	37.6	61.0	74	38
AVERAGE				13.8	9.5	31.2	53.7	74	32
Above South Fork Coal Creek Road bridge (HS2) (transects 26-50)									
Pool	3	5/12/82	100	12.6	10.9	43.7	78.7	94	--
Riffle	3	5/12/82	100	12.2	10.5	33.7	50.0	51	--
Run	12	5/12/82	100	10.8	9.2	37.2	53.7	74	--
Pocket water	5	5/12/82	100	12.3	10.4	37.4	55.4	64	--
Other	2	5/12/82	100	27.6	17.9	20.0	61.0	94	
AVERAGE				12.8	10.5	36.2	57.2	94	
Below Dead Horse Creek Road bridge (HS1) (transects 51-75)									
Pool	4	4/22/82	28	22.7	10.9	78.2	118.5	163	24
Riffle	2	4/22/82	28	24.6	18.0	16.0	43.5	46	26
Run	14	4/22/82	28	49.1	10.9	35.8	55.4	81	21
Pocket water	0								
Other	5	4/22/82	28	29.1	17.3	20.4	46.2	73	24
AVERAGE				31.9	12.8	38.0	62.7	163	23

Table 6. Mean physical habitat measurements in three study sections of Coal Creek by habitat feature, summer, 1982.

Feature	No.	Date	Flow (cfs)	Channel width (m)	Wetted width (m)	Average depth (cm)	Average thalweg depth(cm)	Maximum depth (cm)	D-90 (cm)
Riparian cut area - Above Coal Ridge Lookout trailhead (HS3) (transects 76-100)									
Pool	4	7/29/82	39	15.1	9.7	42.5	77.7	109	50.5
Riffle	5	7/29/82	39	15.4	10.3	21.2	37.0	45	36.4
Run	8	7/29/82	39	15.2	9.0	25.6	47.1	57	43.5
Pocket water	6	7/29/82	39	12.5	9.8	25.0	42.8	51	56.3
Other	2	7/29/82	39	15.1	10.5	18.5	44.0	54	40.0
AVERAGE				14.6	9.7	26.7	48.7	109	46.0
Above South Fork Coal Creek Road bridge (HS2) (transects 101-125)									
Pool	2	7/29/82	39	17.7	15.6	47.0	84.0	88	23.1
Riffle	5	7/29/82	39	13.9	10.8	27.8	56.2	88	39.2
Run	9	7/29/82	39	14.9	10.8	39.3	73.5	100	39.2
Pocket water	9	7/29/82	39	11.6	10.1	31.7	61.7	85	68.2
Other	0	7/29/82	39	--	--	--	--	--	--
AVERAGE				13.7	10.9	34.9	66.7	100	48.6
Below Dead Horse Creek Road bridge (HS1 (transects 126-150)									
Pool	5	7/30/82	76	19.7	16.4	65.8	127.2	195	21.6
Riffle	10	7/30/82	76	23.3	19.8	33.5	60.1	78	18.6
Run	9	7/30/82	76	23.6	16.9	46.0	82.3	115	23.3
Pocket water	0	7/30/82	76	--	--	--	--	--	--
Other	1	7/30/82	76	23.7	21.7	23.0	141.0	141	24.0
AVERAGE				22.7	18.2	44.0	84.7	195	21.1

a low flow (28 cfs), while the summer habitat transects were measured at a flow of 76 cfs.

The Dead Horse section of Coal Creek was very different from the other two areas surveyed. The Dead Horse section was below the mouth of the South Fork of Coal Creek, consequently, Coal Creek normally transported nearly twice the volume of water through this portion of the creek compared to the channel above the mouth of the South Fork. The channel gradient of the Dead Horse section was also lower than the upper two habitat survey sections (0.6% versus 1.1%). For these reasons the Dead Horse section of Coal Creek had larger wetted widths, average depths and thalweg depths and smaller D-90 measurements than the other two areas.

The large difference in average channel widths between spring and summer habitat surveys in HS1 were caused by measuring channel width differently during the two surveys. During the spring survey, the channel width measurements extended to maximum high water marks resulting in large channel measurements. We later decided to limit channel measurements to the normal "bank full" water level; therefore, the summer channel widths for HS1 were narrower and more meaningful when comparing channel widths of all three habitat survey sections.

The substrate composition of the three habitat survey sections changed slightly between the spring and summer surveys (Tables 7 and 8). The percentage of silt and sand combined increased in HS2 and HS3, but decreased in HS1. The mean D-90 and percent imbeddedness values were nearly identical between the spring and summer surveys in HS1 and HS2; however, there were large differences in average D-90 and percent imbeddedness values for HS3. We showed earlier (Shepard and Graham 1982) that visual estimates of streambed composition compared closely to point estimates and the results from the summer surveys further substantiated this favorable comparison (Table 9).

Overhead cover was limited in all three surveyed areas of the creek (Tables 10 and 11). Instream cover and overhead cover results were similar for spring and summer surveys. During summer surveys instream cover was segregated into in-water and over-water cover. The only noticeable difference in estimates of cover between spring and summer surveys occurred for instream debris in the riparian cut (HS3) area, probably originating from the cutting activity. Visual estimates of cover significantly ($p<0.05$) underestimated both instream and overhead cover (Table 12).

Organic Debris

The number and percent of debris by size and age class were different for HS2 and HS3 between the spring and summer surveys (Tables 13 and 14). The major cause of this difference was explained by the narrow stream width and excessive snow depths which made observing debris difficult during spring surveys. Conversely, the number of large and medium stable debris and jams in HS1 remained relatively constant, while the number of small debris and branches increased between spring and summer surveys.

Table 7. Estimates of streambed composition, D-90 and percent imbeddedness by habitat feature in three study sections of Coal Creek during spring, 1982.

		SUBSTRATE						
		% Point Estimate						
Feature	No.	Silt and sand	Small gravel	Large gravel	Cobble	Boulder	D-90 (cm)	Imbeddedness (%)
Riparian Cut Area - Above Coal Ridge Lookout trailhead (HS3) (transects 1-25)								
Pool	0							
Riffle	5	8	11	41	35	5	25.6	27
Run	14	4	17	36	33	10	31.7	21
Pocket water	0							
Other	5	24	20	22	19	15	38.2	37
AVERAGE		9	16	34	30	10	31.8	26
Above South Fork Coal Creek Road bridge (HS2) (transects 26-50)								
Pool	3	26	23	16	22	13	--	29
Riffle	3	2	5	17	41	34	--	12
Run	12	5	6	15	44	30	--	19
Pocket water	5	4	8	19	42	27	--	17
Other	2	17	24	34	20	5	--	37
AVERAGE		9	11	19	37	24		19
Below Dead Horse Creek Road bridge (HS1) (transects 51-75)								
Pool	4	37	24	25	11	3	24.0	31
Riffle	2	7	19	38	36	0	26.5	12
Run	14	27	21	29	21	2	21.5	36
Pocket water	0							
Other	5	15	24	35	25	1	24.4	32
AVERAGE		23	22	31	23	1	24.1	32

Table 8. Estimates of streambed composition, D-90 and percent imbeddedness by habitat feature in three study sections of Coal Creek during summer, 1982.

		SUBSTRATE						
		% Point Estimate						
Feature	No.	Silt and sand	Small gravel	Large gravel	Cobble	Boulder	D-90 (cm)	Imbeddedness (%)
Riparian Cut Area - Above Coal Ridge Lookout Trailhead (HS3) (transects 76-100)								
Pool	4	25	19	21	21	14	50.5	50
Riffle	5	5	9	40	38	8	36.4	23
Run	8	9	11	30	34	16	43.5	47
Pocket water	6	7	11	26	36	20	56.3	37
Other	2	47	12	15	18	8	40.0	37
AVERAGE		15	12	28	31	14	46.0	39
Above South Fork Coal Creek Road Bridge (HS2) (transects 101-125)								
Pool	2	47	27	8	10	8	23.0	50
Riffle	5	2	5	27	42	43	39.2	17
Run	9	21	17	19	26	17	39.2	26
Pocket water	9	6	6	20	37	31	68.2	13
Other	0	--	--	--	--	--	--	--
AVERAGE		15	12	20	31	22	48.4	21
Below Dead Horse Creek Road Bridge (HS1) (transects 126-150)								
Pool	5	19	27	29	23	2	21.6	47
Riffle	10	14	15	38	32	1	18.6	27
Run	9	13	16	37	32	2	23.3	35
Pocket water	0	--	--	--	--	--	--	--
Other	1	7	8	43	21	0	24.0	13
AVERAGE		14	18	37	30	2	21.1	33

Table 9. Comparison of point and visual estimates to describe streambed composition in three one kilometer sections of Coal Creek during the summer, 1982.

Habit Survey Section --->	HS1		HS2		HS3	
	Point	Visual	Point	Visual	Point	Visual
Substrate Size Class						
Silt and sand	14	14	15	10	15	9
Small gravel	18	19	12	15	12	13
Large gravel	37	30	20	22	28	26
Cobble	30	35	31	32	31	34
Boulder	2	2	22	22	14	18

Table 10. Estimated percent of overhead and instream cover by habitat feature in three study sections of Coal Creek, spring, 1982.

		COVER										
		Point Estimates										
		Overhead (%)					Instream (%)					
Feature	No.	None	Under cut	Overhang <2m	Overhang 2-Canopy	Canopy	None	Log	Debris	Boulder	Over-head	In-stream
Above Coal Ridge Lookout trailhead (HS3) (transects 1-25)												
Pool	0											
Riffle	5	79	5	16	0	0	70	3	8	19	10	16
Run	14	81	3	11	1	3	66	6	7	21	11	13
Pocket water	0											
Other	5	66	9	23	0	2	52	14	18	16	10	20
AVERAGE		77	5	15	1	2	64	7	9	20	11	15
Above South Fork Coal Creek Road bridge (HS2) (transects 26-50)												
Pool	3	69	9	13	0	9	56	6	25	3	Not	Done
Riffle	3	62	14	17	7	0	48	3	7	42	"	"
Run	12	68	3	22	2	5	48	10	6	36	"	"
Pocket water	5	56	4	38	2	0	40	19	14	27	"	"
Other	2	76	9	15	0	0	64	21	9	6	"	"
AVERAGE		66	6	23	2	3	50	12	10	28		
Below Dead Horse Creek Road bridge (HS1) (transects 51-75)												
Pool	4	68	7	5	2	17	46	49	5	0	15	20
Riffle	2	89	8	0	3	0	80	11	9	0	15	20
Run	14	84	7	5	1	3	67	19	7	7	1	6
Pocket water	0											
Other	5	80	4	12	1	3	77	11	8	4	15	15
AVERAGE		81	6	6	2	5	68	20	7	5	9	13

Table 11. Estimated percent of overhead and instream cover by habitat feature in three study sections of Coal Creek, summer, 1982.

		COVER														
		POINT ESTIMATES													Visual %	
		Overhead %					Instream %									
			Under	Overhang	Overhang			Aquatic	Over-water			In-water				
Feature	No.	None	Cut	<2m	2-Canopy	Canopy	None	veg.	Log	Debris	Boulder	Log	Debris	Boulder	Overhead	Instream
Riparian Cut Area - Above Coal Ridge Lookout Trailhead (HS3) (transects 76-100)																
Pool	4	72	6	14	0	8	39	3	14	3	0	3	25	14	23	38
Riffle	5	60	8	29	0	4	73	0	6	6	0	6	19	4	11	16
Run	8	75	3	16	1	4	64	0	3	1	0	1	6	25	13	23
Pocketwater	6	73	4	14	2	6	43	0	6	2	0	6	12	31	21	48
Other	2	67	9	9	3	12	45	0	3	6	0	3	39	3	23	38
Average		70	6	17	1	6	55	0	5	3	0	3	17	17	17	31
Above South Fork Coal Creek Road Bridge (HS2) (transects 101-125)																
Pool	2	73	3	23	0	0	67	0	0	0	0	3	20	10	11	13
Riffle	5	53	2	27	14	4	55	0	4	6	0	6	12	18	15	15
Run	9	53	8	29	6	4	39	0	10	1	0	10	21	19	16	14
Pocketwater	9	48	1	33	12	8	34	0	5	3	0	2	1	55	21	39
Other	0	--	--	--	--	--	--	0	--	--	--	--	--	--	--	--
Average		54	4	29	9	5	44	0	6	3	0	6	12	30	17	23
Below Dead Horse Creek Road Bridge (HS1) (transects 126-150)																
Pool	5	75	4	7	3	11	63	0	4	0	0	15	13	4	9	18
Riffle	10	84	3	7	5	2	76	1	6	0	0	9	6	2	5	9
Run	9	90	1	5	3	1	72	0	8	0	0	6	9	5	6	7
Pocketwater	0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Other	1	90	10	0	0	0	90	0	0	0	0	5	5	0	0	5
Average		85	3	6	4	3	73	1	6	0	0	9	8	3	6	11

Table 12. Comparisons between estimates of overhead and instream fish cover using transect point sampling and visual estimates, and Wilcoxon matched-pairs signed-ranks test results (Daniel 1978). Test of H_0:Visual estimates do not underestimate transect point estimates.

	Total Overhead Cover			Total Instream Cover		
	Percent			Percent		
	Transect points	Visual	D_i(Rank)	Transect points	Visual	D_i(Rank)
Spring[1/]						
HS1	19	9	+10(+2)	32	13	+19(+3)
HS3	23	11	+12(+3)	36	15	+21(+4)
Summer						
HS1	15	6	+ 9(+1)	27	11	+16(+2)
HS2	46	17	+29(+5)	56	23	+33(+5)
HS3	30	17	+13(+4)	45	31	+14(+1)
AVERAGE	26.6	12.6	+14.6	39.2	18.6	+20.6
Sum of Ranks			(+15)			(+15)
Test Statistic		$T_- = 0$			$T_- = 0$	
Significant		$(p<0.05)$			$(p<0.05)$	

1/ No visual estimates of cover were done in HS2 during the spring.

Table 13. Number and percent (in parentheses) of organic debris by type and age in three sections of Coal Creek, spring, 1982.

Area and Type	AGE Old	New	Logged	Total
Below Dead Horse Bridge (HS1)				
Large	92(53)	2(17)	0(0)	94(51)
Medium	55(32)	7(58)	0(0)	62(33)
Small	7(4)	0(0)	0(0)	7(4)
Branches	2(1)	3(25)	0(0)	5(3)
Jams	17(10)	0(0)	0(0)	17(9)
TOTAL	173(93)	12(7)	0(0)	185(100)
Above South Fork Coal Creek Road bridge (HS2)				
Large	71(58)	2(17)	1(2)	74(42)
Medium	26(21)	3(25)	1(2)	30(17)
Small	12(10)	3(25)	2(5)	17(10)
Branches	10(8)	4(33)	38(91)	52(29)
Jams	4(3)	0(0)	0(0)	4(2)
TOTAL	123(69)	12(7)	42(24)	177(100)
Above Coal Ridge Lookout Trailhead (HS3)				
Large	78(56)	2(13)	0(0)	80(47)
Medium	41(30)	6(37)	1(6)	48(28)
Small	18(13)	8(50)	7(47)	33(20)
Branches	0(0)	0(0)	7[1](47)	7(4)
Jams	1(1)	0(0)	0(0)	1(1)
TOTAL	138(82)	16(9)	15(9)	169(100)

[1] All green branches were placed in the "logged" category.

Table 14. Number and percent (in parentheses) of organic debris by type and age in three sections of Coal Creek, summer, 1982.

Area and type	Age: Old	Age: New	Logged	Total
Below Dead Horse Bridge (HS1)				
Large	90(39)	1(13)	0(0)	91(38)
Medium	59(26)	2(24)	0(0)	61(25)
Small	25(11)	3(37)	0(0)	28(12)
Branches	41(18)	1(13)	4(100)	46(19)
Jams	13(6)	1(13)	0(0)	14(6)
TOTAL	228(95)	8(3)	4(2)	240(100)
Above South Fork Coal Creek Bridge (HS2)				
Large	179(44)	0(0)	0(0)	179(41)
Medium	103(25)	1(50)	0(0)	104(24)
Small	66(16)	1(50)	1(4)	68(15)
Branches	55(13)	0(0)	27(96)	82(19)
Jams	7(2)	0(0)	0(0)	7(1)
TOTAL	410(93)	2(1)	28(6)	440(100)
Above Coal Ridge Lookout Trailhead - Riparian Cut (HS3)				
Large	153(34)	3(33)	0(0)	156(33)
Medium	128(28)	2(22)	0(0)	130(27)
Small	100(22)	3(33)	0(0)	103(22)
Branches	66(14)	0(0)	11(100)	77(16)
Jams	9(2)	1(12)	0(0)	10(2)
TOTAL	456(96)	9(2)	11(2)	476(100)

Maps of debris locations in two areas of Coal Creek showed that all types of organic debris were relatively abundant in both areas (Figures 8 and 9). The area within the riparian cut contained numerous live branches and broken tops of trees during the spring. This area contained few live branches when it was resurveyed on 30 July. High spring flows apparently transported the majority of these unstable live branches and broken tops out of the riparian cut area of Coal Creek (Figure 8). Much of the moderate and large sized debris moved a short distance downstream and accumulated at the lower end of the mapped section.

The mapped area above Dead Horse Creek Road bridge changed little between the spring and summer surveys (Figure 8). One medium submerged log present during the spring moved completely out of the mapped area before the summer survey and branches were found to have moved out of certain areas and accumulated in other areas of the mapped section between the two surveys.

Point Sources of Inorganic Sediment

The most abundant class of sediment point sources in Coal Creek was cut banks along the stream channel (Table 15 and Appendix A). These cut banks were associated with natural and clearcut areas. Turbid water from the South Fork of Coal Creek caused an observable increase in turbidity of main Coal Creek during the bull trout spawning site inventory. Beaver activity also appeared to be increasing in the Coal Creek drainage. Several areas of new channel cutting were seen. Most of these areas were associated with beaver activity or major debris jams. One incident occurred during the summer, involving a road contractor working in a live stream channel, which significantly raised turbidity levels in Coal Creek causing the water to appear chalky white. The Forest Service was notified and worked with the contractor to insure that this type of pollution was not repeated.

STREAMBED COMPOSITION IN BULL TROUT SPAWNING AREAS

Coal Creek's bull trout spawning areas contained a high percentage of fine sediments (Figure 10 and Appendix B). A multiple comparison test found that the percent of sediment less than 2 mm in diameter was significantly higher in Coal Creek than in Whale ($p<0.20$), Trail ($p<0.005$) and Big ($p<0.005$) creeks (Table 16). Daniel (1978) stated that the value of α (significance level) selected for multiple comparison tests is usually larger than α-values customarily encountered in single-comparison inference procedures, and further said that α-values of up to 0.25 are reasonable depending upon the number of comparisons. The multiple comparison test excluded the sample area above the South Fork Coal Creek Road bridge (Riparian Cut), since this area was believed to contain an unusually high amount of fine sediment (<2 mm) in the streambed due to the "sediment trapping" effect of a large log jam (Figure 11 and Appendix B).

Comparisons between fall, 1982 and fall, 1981 core samples from undisturbed streambed sites in bull trout spawning areas in Coal Creek found the percentage of sediment less than 2 mm had changed little over the course of one year. The average percentage of 1981 was 16.7 and the average

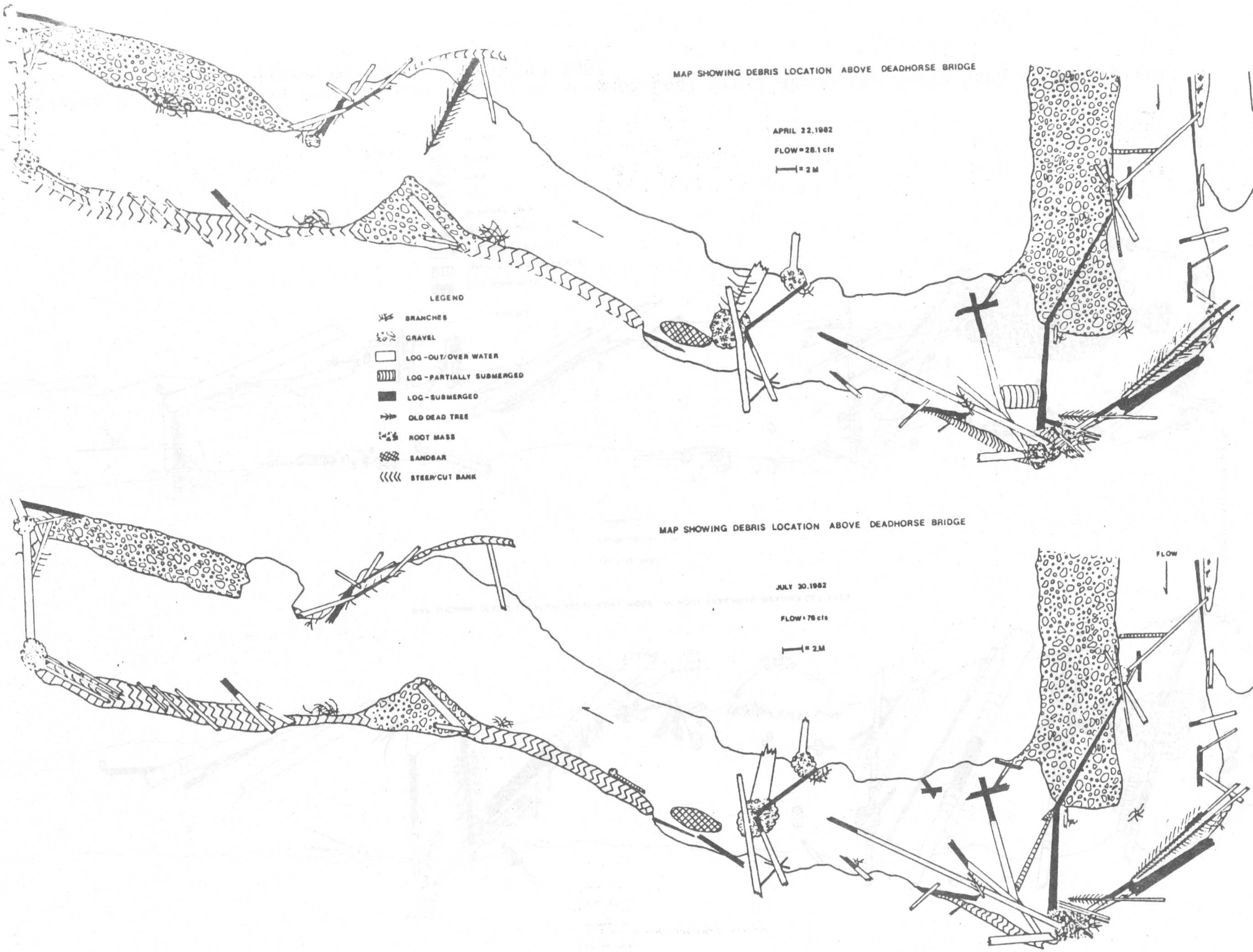

Figure 8. Map showing debris locations in an area of Coal Creek above Dead Horse bridge on 22 April and 30 July, 1982.

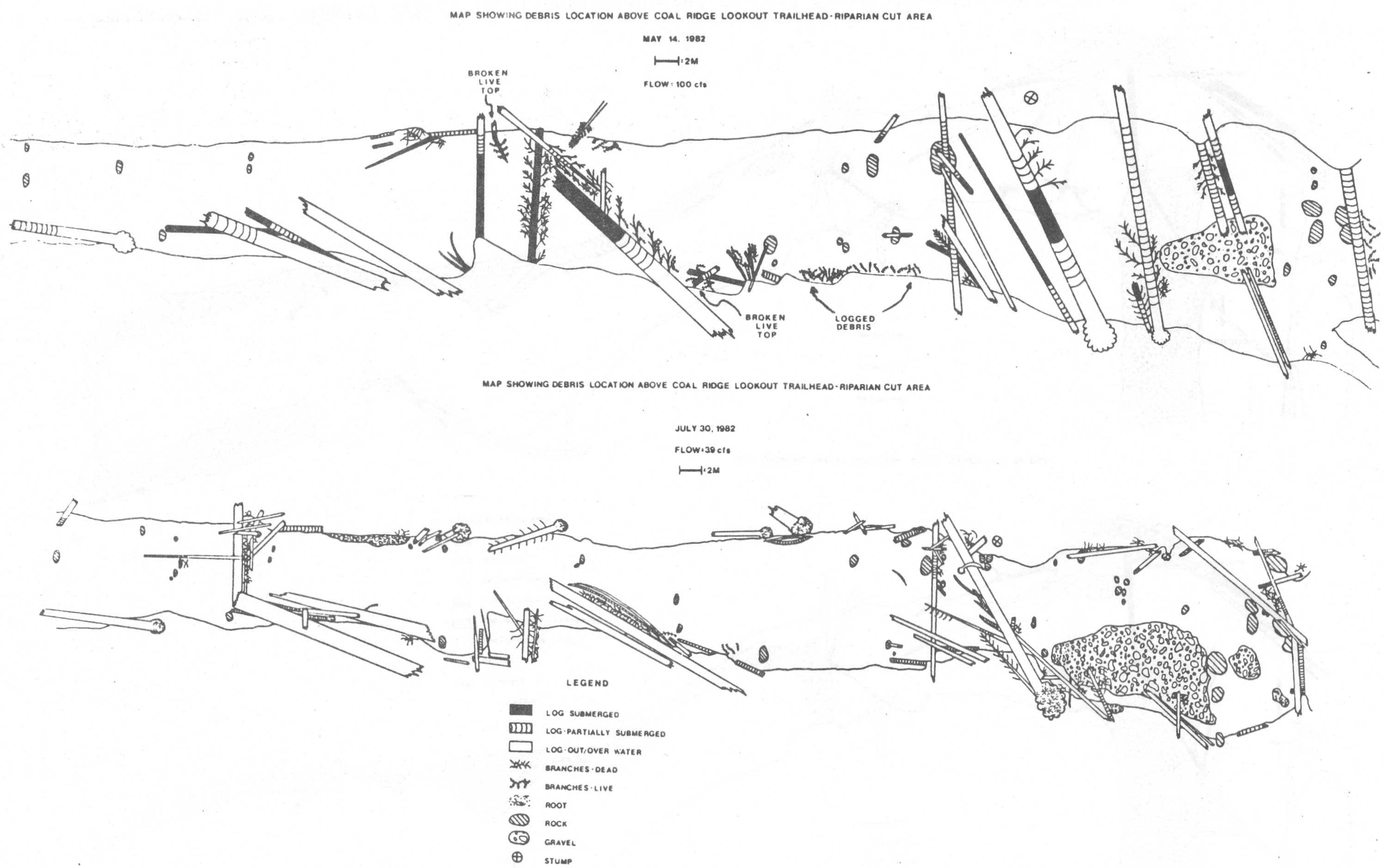

Figure 9. Map showing debris locations in an area of Coal Creek above the South Fork of Coal Creek Road bridge on 14 May and 30 July, 1982.

Table 15. Frequencies of point sources of inorganic sediment by class in Coal Creek (from the South Fork Road bridge downstream to the North Fork of the Flathead River) and the South Fork of Coal Creek (from 1.0 km above Mathias Creek downstream to main Coal Creek) in 1982.

Drainage	Sediment Source	Frequency(#/km)
Main Coal Creek	Cut banks	1.31
	Huge	.47
	Large	.42
	Medium	.16
	Small	.26
	Braided channels	.32
	Major debris jam	.21
	Bridge	.16
	Beaver activity	.16
South Fork Coal Creek	Cut banks	1.20
	Huge	.20
	Large	.20
	Medium	.00
	Small	.80
	Braided channels	.10
	Major debris jam	.20
	Bridge	.30
	Beaver activity	.00

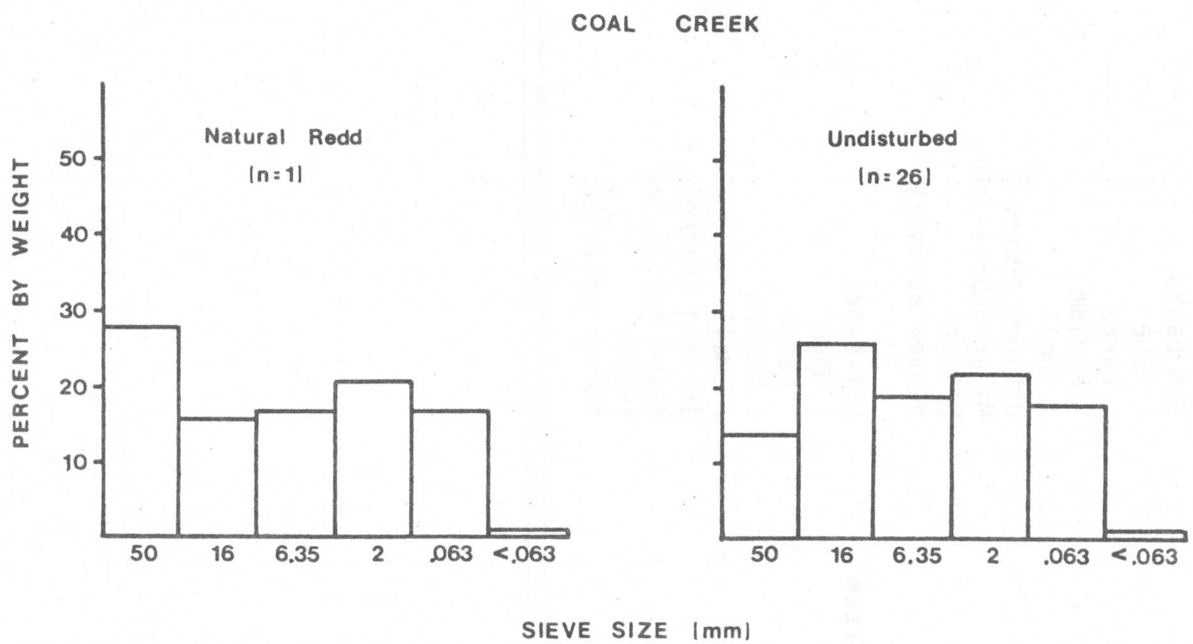

Figure 10. Composite graph (percent of each size class by dry weight) of streambed samples from natural redds and undisturbed sites in Coal Creek.

Table 16. Multiple comparison tests (Daniel 1978) comparing the percent of sediment less than 2 mm in undisturbed streambed samples between Coal Creek and Big, Whale and Trail creeks sampled during Fall, 1982.

	Percent of material less than 2 mm (rank)			
	Coal Creek	Big Creek	Whale Creek	Trail Creek
	20(44)	1(1.5)	5(8)	17(38)
	14(30.5)	3(4)	4(5)	9(15.5)
	17(38)	11(22)	11(22)	7(12.5)
	5(8)	10(18)	14(30.5)	19(43)
	21(45.5)	12(25.5)	24(48.5)	1(1.5)
	11(21.5)	2(3)	26(52)	5(8)
	12(25.5)	13(27.5)	13(27.5)	11(22)
	15(33)	8(14)	7(12.5)	5(8)
	25(50.5)	16(34.5)		10(18)
	21(45.5)			11(22)
	18(41.5)			5(8)
	16(34.5)			10(18)
	25(50.5)			14(30.5)
	24(48.5)			6(11)
	17(38)			9(15.5)
	17(38)			14(30.5)
	22(47)			
	17(38)			
	18(41.5)			
Mean	17(37.9)	8.4(16.7)	13(25.7)	9.5(18.9)
Sample size	n = 19	n = 9	n = 8	n = 16
Mean rank (R) Differences	$(\bar{R}_{coal} - \bar{R}_x)$	21.2	12.2	19.0
Significance level		p<0.005	p<0.20	p<0.005

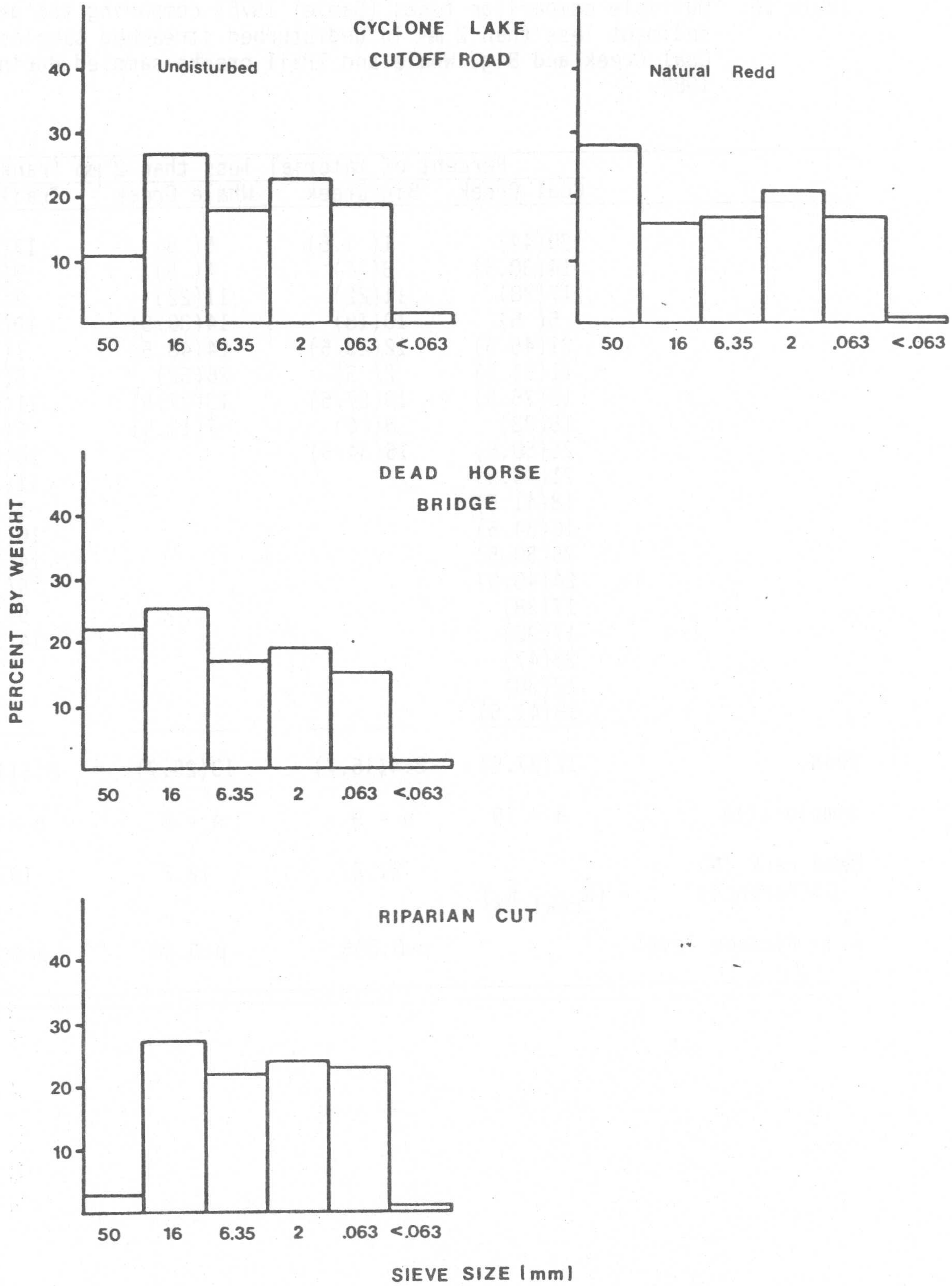

Figure 11. Composite graphs (percent of each size class by dry weight) of streambed samples from natural redd and undisturbed sites in three areas of Coal Creek.

in 1982 was 17.0 (Table 17).

To predict survival of bull trout embryos, the average percent of material less than 2 mm and less than 6.35 mm sampled from undisturbed streambed areas during October, 1982 were plotted over approximate survival bands estimated for chinook salmon embryos (Tappel 1981). The predicted survival of bull trout embryos in Coal Creek's spawning areas was estimated to be between 40 and 60 percent (Figure 12). Predicted embryo survival in Whale, Trail and Big creeks were all higher than 80 percent.

FISH ABUNDANCE

Three techniques estimated similar numbers of westslope cutthroat for all cases, except in the Cyclone bridge section during August (Table 18). Mark-recapture estimates were consistently higher than estimates computed using the other two methods for bull trout. Bull trout were most abundant in the Cyclone bridge and Dead Horse bridge sections. Westslope cutthroat trout were most abundant in the Cyclone bridge and South Fork bridge sections and present in limited numbers in the Dead Horse bridge section.

Average growth increments between age classes ranged from 32 to 49 mm for westslope cutthroat and from 33 to 66 mm for bull trout (Table 19). It was believed that the single age IV bull which accounted for the 66 mm growth increment had spent the majority of its fourth year in the North Fork of the Flathead River before moving up into Coal Creek. This belief was based on the accelerated growth represented by the large distance between the third and fourth annuli indicating a more favorable growing environment.

The length-frequency distribution for westslope cutthroat trout showed that fish longer than 150 mm made up a large percentage of the catch in the South Fork bridge section, indicating that cutthroat spending their entire life in Coal Creek (residents) were probably the primary inhabitants of this portion of the creek (Figure 13). The lack of definite modes in the composite length-frequency distribution for cutthroat suggests Coal Creek may be used by both migratory and resident stocks of cutthroat as this type of length-frequency distribution is indicative of a mixed stock representation. The bull trout length-frequency distributions illustrated the model configuration more common for a single stock and could be used to segregate age classes (Figure 14).

Results from snorkel counts in a sample section of upper Coal Creek found that both westslope cutthroat and bull trout were abundant in the upper reach of Coal Creek (Table 20). No age 0 or age I cutthroat were seen during the 1982 snorkel counts, but age 0 bull trout were observed for the first time.

Two-catch population estimates for cutthroat trout in Langford and Cyclone creeks in 1981 and 1982 were higher than any Coal Creek sections (Table 21). This difference may be related to the smaller stream size

Table 17. Comparison of the percentaged material less than 2 mm from undisturbed streambed samples in Coal Creek in the fall, 1981 and the fall, 1982.

	Percent of material less than 2 mm	
	1981	1982
	9	20
	17	14
	18	17
	10	5
	22	21
	11	11
	23	12
	19	15
	22	25
	16	21
		18
		16
		25
		24
		17
		17
		22
		17
		18
MEAN	16.7	17.0

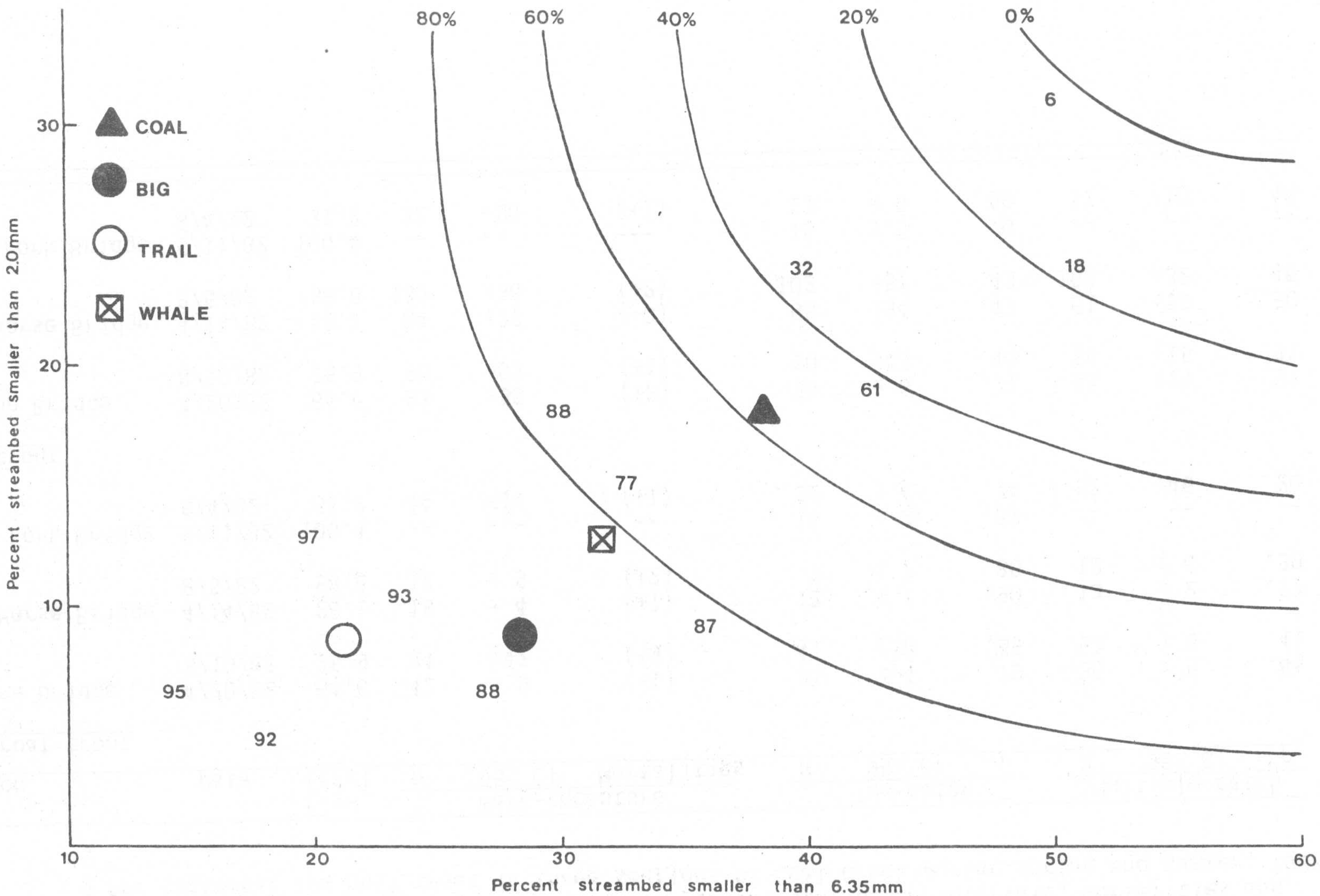

Figure 12. Graph showing estimated survival bands for chinook salmon embryos adapted from Tappel (1981). Streambed composition (expressed as a plot of percent material less than 2 mm versus percent less than 6.35 mm) for undisturbed sites in bull trout spawning areas of Big, Coal, Whale and Trail creeks over lay the graph. The numbers and curved lines which overlay the graph represent the percent survival for chinook salmon found by Tappel (1981) in laboratory tests (numbers) and predicted survival bands (curved lines) adapted from Tappel's original data.

Table 18. Comparison between estimates of fish numbers computed using mark-recapture, two-catch and multiple-catch estimators, and associated 95 percent confidence intervals, mortalities and $\hat{p}$ for cutthroat and bull trout in three sections of Coal Creek during spring and summer, 1982.

Section	Date	Flow (cfs)	Mark-recapture $\hat{N}$	Mark-recapture 95% CI	Mark-recapture Mortalities	Two-catch $\hat{N}$	Two-catch 95% CI	Two-catch $\hat{p}$	Multiple-catch $\hat{N}$	Multiple-catch 95% CI	Multiple-catch $\hat{p}$
Cutthroat trout											
Cyclone Bridge	4/20/82	64.6	42	± 9	(+1)	31	± 4	.79	35	± 5	.65
	8/10/82	75.9	84	±47	(+9)	41	±18	.55	53	± 5	.41
Dead Horse Bridge	4/14/82	28.1	15	± 4	(+1)	12	± 1	.90	13	± 2	.77
	8/5/82	58.8	12	± 9	(+2)	7	± 2	.80	12	± 6	.30
South Fork Bridge	5/11/82	100.4	--	---	--	18	± 2	.87	--	--	--
	8/4/82	31.2	44	±14	(+1)	32	± 6	.74	52	±46	.20
Bull trout											
Cyclone Bridge	4/20/82	64.6	93	±55	(+2)	30	± 6	.71	48	±19	.37
	8/10/82	75.9	90	±63	(+1)	50	±43	.40	59	±15	.31
Dead Horse Bridge	4/14/82	28.1	84	±27	(+0)	65	±34	.47	61	±13	.50
	8/5/82	58.8	130	±36	(+2)	102	±51	.43	102	±32	.46
South Fork Bridge	5/11/82	100.4	--	--	---	15	± 5	.70	--	--	--
	8/4/82	31.2	32	±20	(+1)	17	± 9	.60	37	±10	.48

Table 19. Summary of average lengths, weights and growth increments from known age westslope cutthroat and bull trout by age class.

Species	Age	No.	Average weight (g)	Average length (range) (mm)	Growth increment (mm)
Cutthroat trout	1	8	1	55 (50-60)	39
	2	7	8	94 (70-108)	47
	3	16	25	141 (112-166)	49
	4	5	55	190 (174-196)	32
	5	1	101	222	
Bull trout	1	64	3	76 (64-95)	45
	2	23	16	121 (100-138)	33
	3	7	28	154 (145-168)	66
	4	1	100	220	

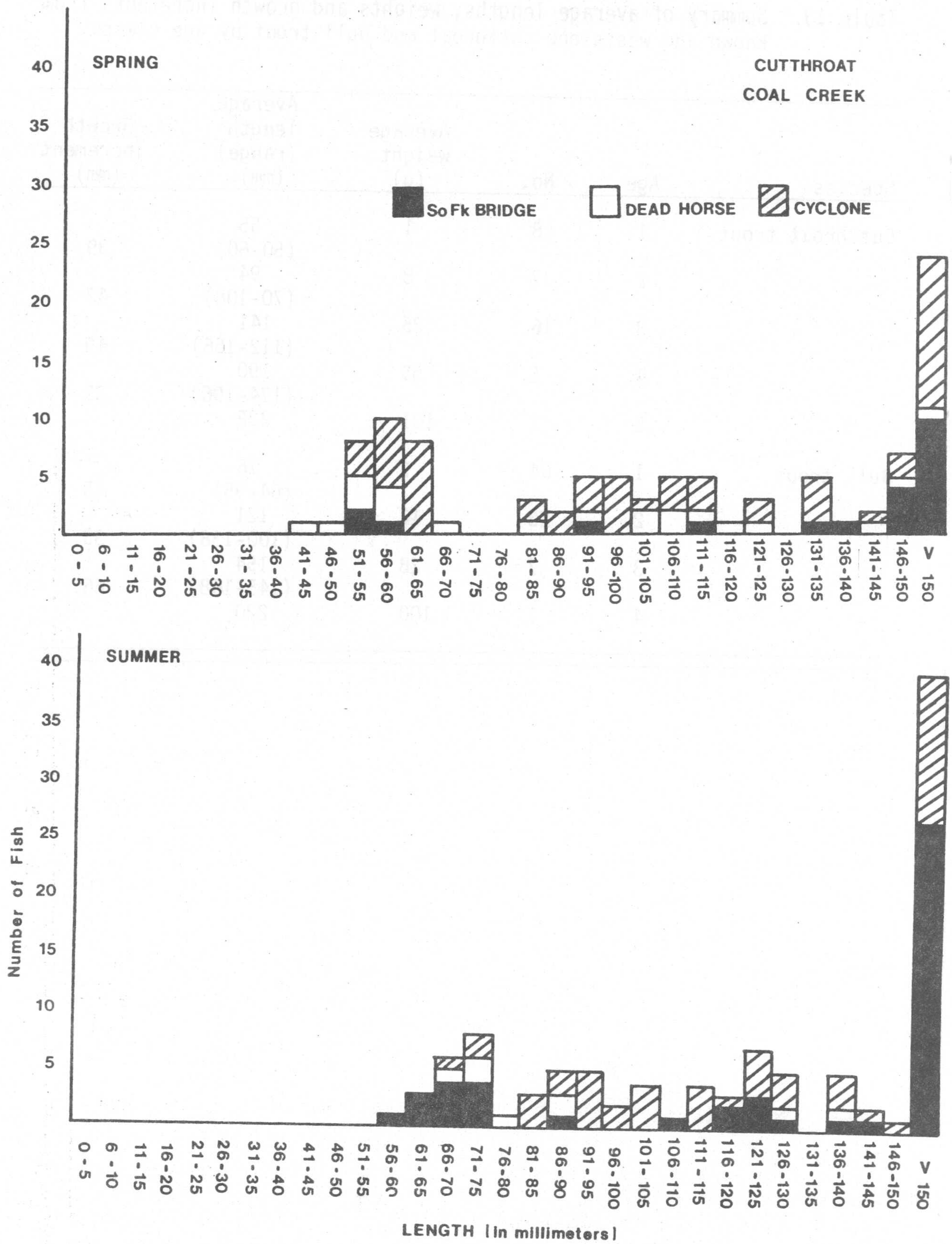

Figure 13. Length-frequency distributions for westslope cutthroat trout captured via electrofishing in three sections of Coal Creek during the spring and summer, 1982.

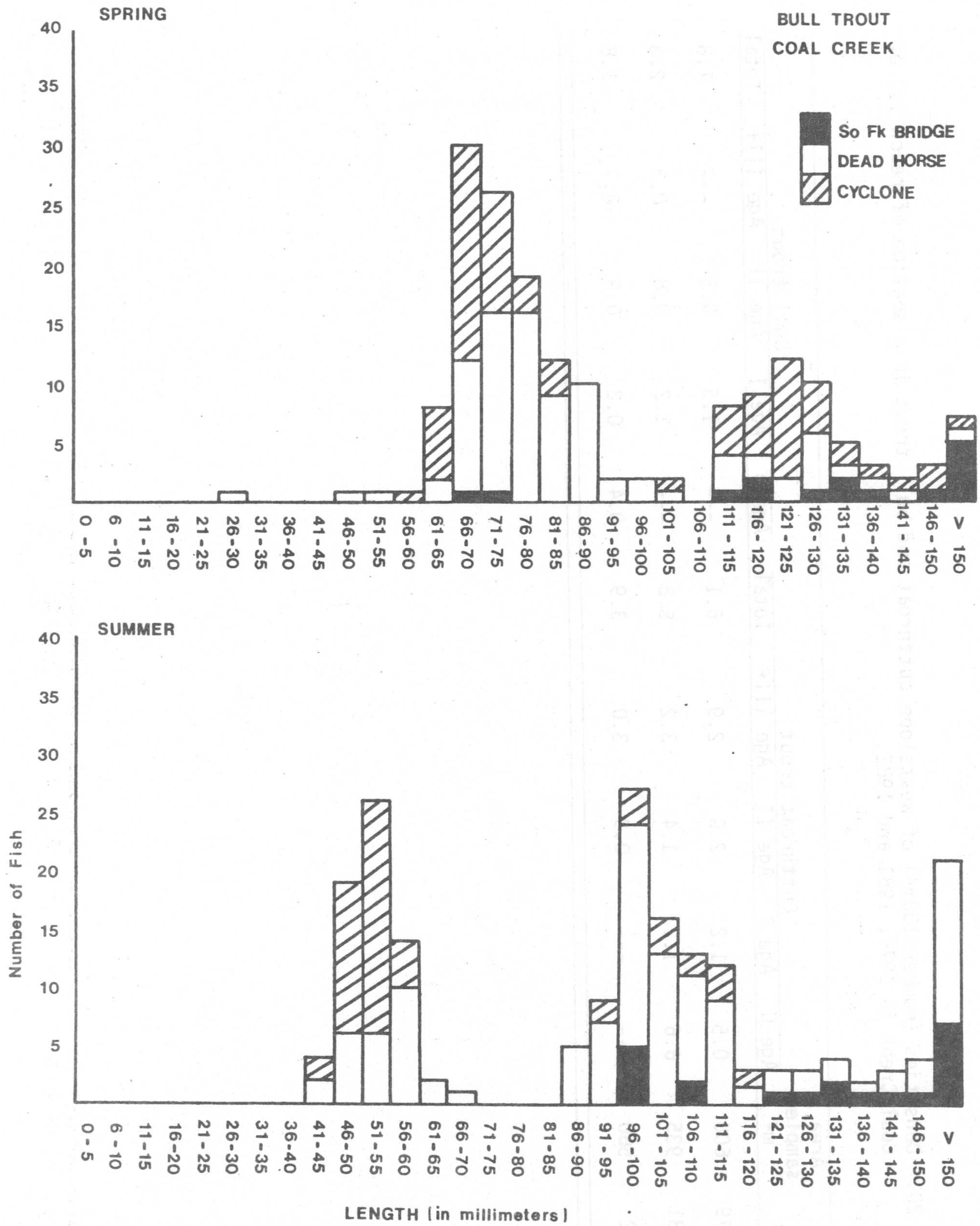

Figure 14. Length-frequency distributions for bull trout captured via electrofishing in three sections of Coal Creek during the spring and summer, 1982.

Table 20. Densities (number/100m²) of westslope cutthroat and bull trout in a section of reach III of Coal Creek in 1979, 1981 and 1982.

Date	Area sampled m²	Cutthroat trout					Bull trout				
		Age 0	Age I	Age II	Age III+	Total	Age 0	Age I	Age II	Age III+	Total
9/13/79	600	0.5	1.2	2.0	2.9	6.1	---	1.5	0.3	---	1.8
8/18/81	935	6.6	1.2	1.4	3.2	5.8	---	1.2	0.8	0.3	2.3
8/6/82	560	---	---	0.9	3.0	3.9	0.4	0.2	0.9	0.7	1.8

Table 21. Two-catch population estimates, associated 95 percent confidence intervals, $\hat{p}$ values, areas of sample section and densities (number estimated per 100 m^2) for cutthroat and bull trout 75 mm and larger.

Creek section	Date	Flow (cfs)	Area sampled (m^2)	$\hat{N}$	95% CI	$\hat{p}$	Density
Cutthroat trout							
Coal Creek							
Cyclone Bridge	4/20/82	64.6	1,863	31	± 4	.79	1.7
Cyclone Bridge	8/10/82	75.9	1,809	41	±18	.55	2.3
Dead Horse Bridge	4/14/82	28.1	1,621	12	± 1	.90	0.7
Dead Horse Bridge	8/5/82	58.8	1,745	7	± 2	.80	0.4
South Fork Bridge	5/11/82	100.4	---	18	± 2	.87	---
South Fork Bridge	8/4/82	31.2	1,268	32	± 6	.74	2.5
Langford Creek	8/8/81	---	297	93	±15	.66	31.3
Langford Creek	7/16/82	4.4	352	87	± 9	.73	24.7
Cyclone Creek	7/23/81	---	569	177	±21	.65	31.1
Cyclone Creek	7/19/82	11.5	721	131	± 3	.90	18.2
Bull trout							
Coal Creek							
Cyclone Bridge	4/20/82	64.6	1,863	30	± 6	.71	1.6
Cyclone Bridge	8/10/82	75.9	1,809	50	±43	.40	2.8
Dead Horse Bridge	4/14/82	28.1	1,621	65	±34	.47	4.0
Dead Horse Bridge	8/5/82	58.8	1,745	102	±51	.43	5.8
South Fork Bridge	5/11/82	100.4	---	15	± 5	.70	---
South Fork Bridge	8/4/82	31.2	1,268	17	± 9	.60	1.3
Morrison Creek	9/1/82	3.6	603	93	± 5	.83	15.4

and dominance of cutthroat in Langford and Cyclone creeks. Fraley and Graham (1981) found that smaller streams supported larger densities of westslope cutthroat. Both Langford and Cyclone creeks supported few bull trout, while Coal Creek supported relatively large numbers of bull trout. There was little difference in the estimated number of cutthroat in Langford Creek between 1981 and 1982, and a slight decrease in Cyclone Creek.

Juvenile bull trout densities were relatively high in all three fish abundance sections in Coal Creek, especially the Dead Horse bridge section (Table 21). The density of juvenile bull trout in Morrison Creek (Reach IV, a reach which supported one of the highest densities of age I+ bull trout (Fraley et al. 1981), was 15.4 fish per 100 square meters.

The difference in the estimated numbers of age I and older bull trout was small in all study sections between the spring and summer estimates (Figure 15). Estimated numbers of age II and older westslope cutthroat trout appeared to be constant or decline slightly in the Cyclone bridge and Dead Horse bridge sections, but increased in the South Fork bridge section between the spring and summer estimates (Figure 16).

BULL TROUT SPAWNING SITE SURVEYS

The 1982 spawning site counts were the highest yet recorded for the North Fork Flathead drainage indicating conditions five to seven years ago were favorable to bull trout survival (Table 22). Several areas not previously surveyed were found to contain redds, but even in areas consistently surveyed the number of redds were higher than any previous year. Coal Creek was no exception, and the number of redds in areas previously surveyed in main Coal Creek jumped from a previous high of 48 in 1980 to 67 in 1982. A previously unsurveyed area in the upper basin contained 20 redds and 8 redds were observed from the Cyclone bridge down to the North Fork of the Flathead River (Figures 17, 18 and 19). The South Fork of Coal Creek had fewer redds in 1982 (9) than in 1981 (24). Seventeen redds were seen in Mathias Creek during 1982 compared to ten in both 1980 and 1981 (Figures 20 and 21).

We were able to closely monitor spawning activity in Coal Creek during the past year. Spawning activity appeared to peak at two distinctly separate times during September. Actively spawning adults were first seen on 7 September and spawning appeared to have been initiated in response to declining maximum water temperatures (Figure 22). A peak in spawning activity was noted the week of 6-13 September. An apparent lull in spawning activity occurred during the next week with few adult fish observed. Then, on 21 September, spawning activity again peaked with numerous new redds and adults observed.

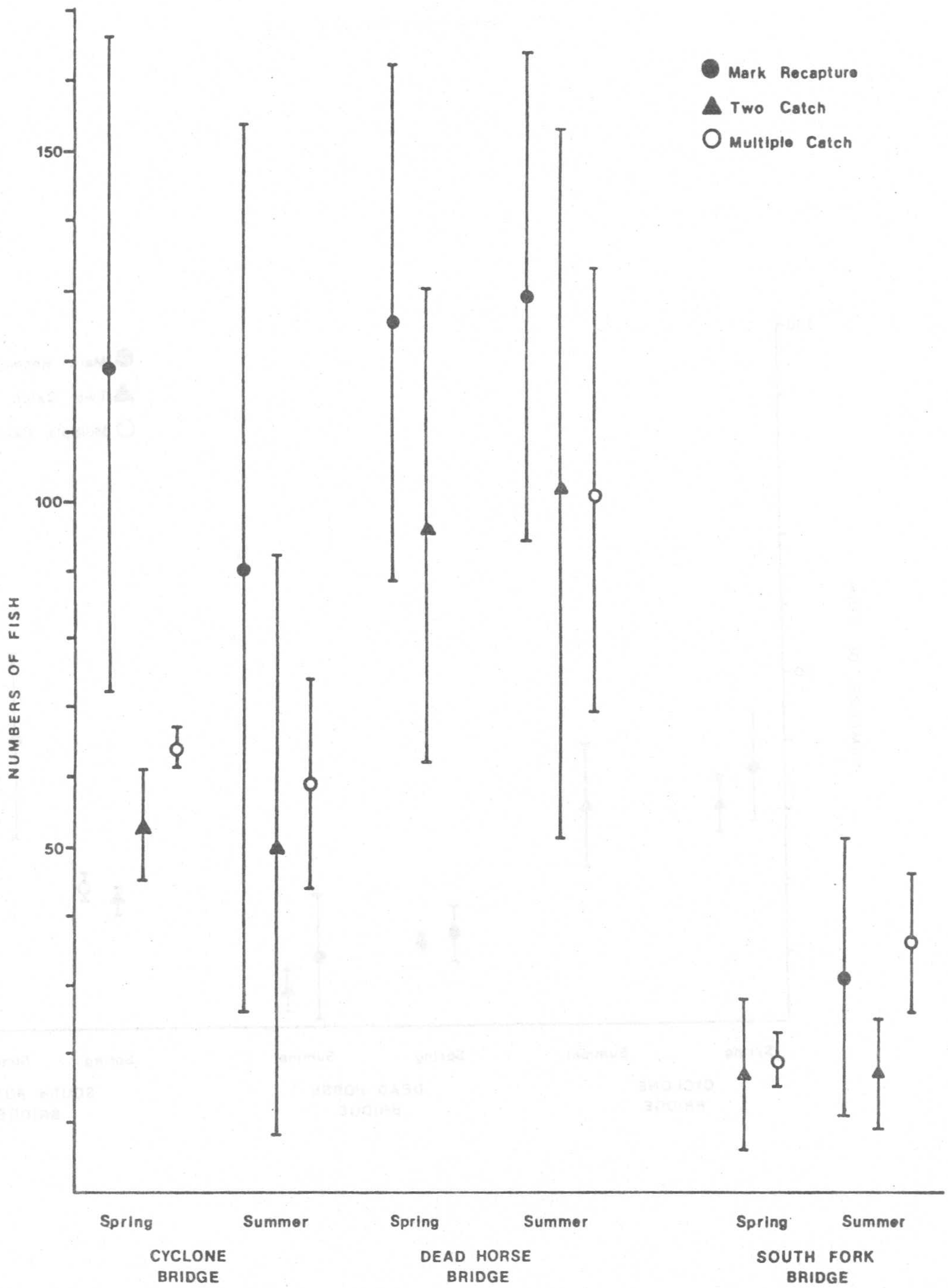

Figure 15. Estimates of the number of age I and older bull trout and their associated 95% confidence intervals for three sections of Coal Creek during the spring and summer, 1982. Estimates were computed using mark-recapture, two-catch and multiple-catch techniques.

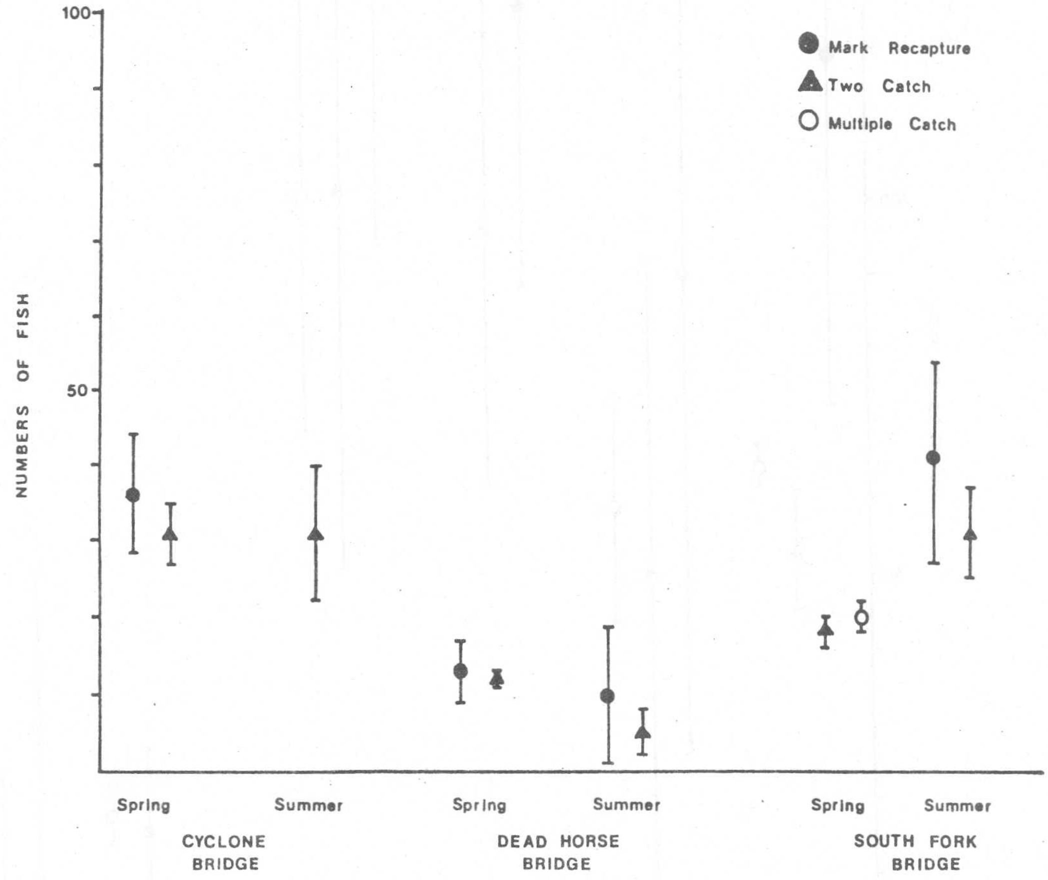

Figure 16. Estimates of the number of age II and older westslope cutthroat trout and their associated 95% confidence intervals for three sections of Coal Creek during the spring and summer, 1982. Estimates were computed using mark-recapture, two-catch and multiple-catch techniques.

Table 22. Numbers and frequencies of bull trout redds (by reach) in North Fork Flathead River tributaries surveyed during 1979, 1980, 1981 and 1982.

Stream	Reach	1982	1981	1980	1979
Cabin	I,II	0	2 1/	2	*
Howell	I,II	103 3/	72	47 2/	*
Couldrey	I,II	9 4/	24 1/	15 2/	*
Sage	I	4 4/	*	6	*
Kishenehn	I	23 4/	13	16	*
Flathead River (in Canada)		17	34 1/	10	*
Starvation	I,II	*	1	1	*
Trail	I	99 3/	82 3/	31	35
Whale	I	54	22	12	10
	II	174	79	35	24
Shorty	I	56	17	4	33
Red Meadow	II	*	19	6	2
Coal	I	9	0	1	0
	II	64	29	47	40
	III	22 3/	1	0	4
South Fork	I	9	24	2	4
Mathias	I	17	10	10	2
Big	I	0	1	0	6
	II	45	23	15	6
Hallowat	I	31	14	8	2
		736	467	268	168

1/ Counts made by helicopter
2/ Results from survey by B.C. Research, Vancouver, B.C.
3/ Surveyed more of the stream than previous years
4/ Results from survey by NORELCOL, Vancouver, B.C.
* Reaches not surveyed.

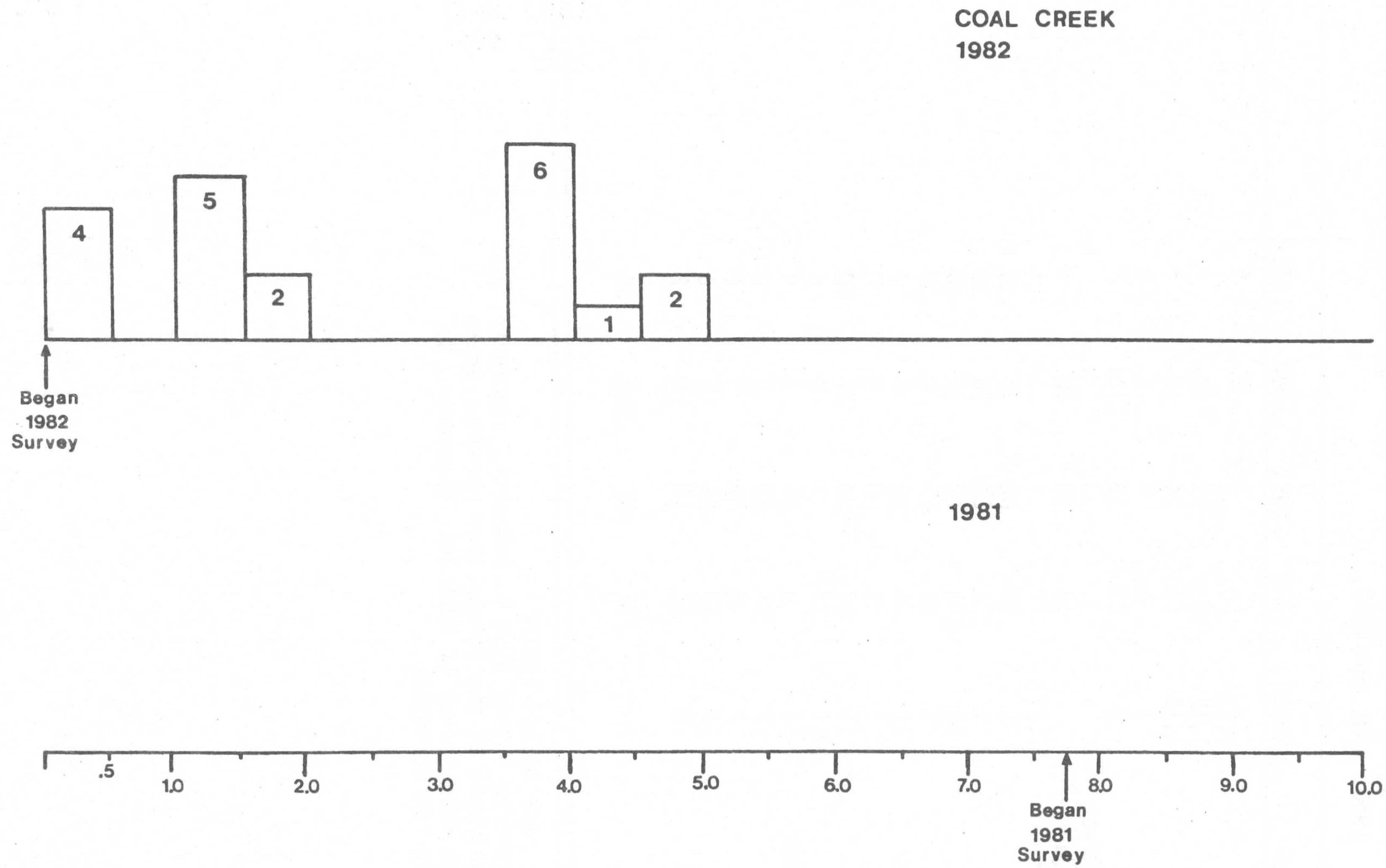

Figure 17. Bull trout redd densities by 0.5 km in the upper portion of Coal Creek during 1981 and 1982.

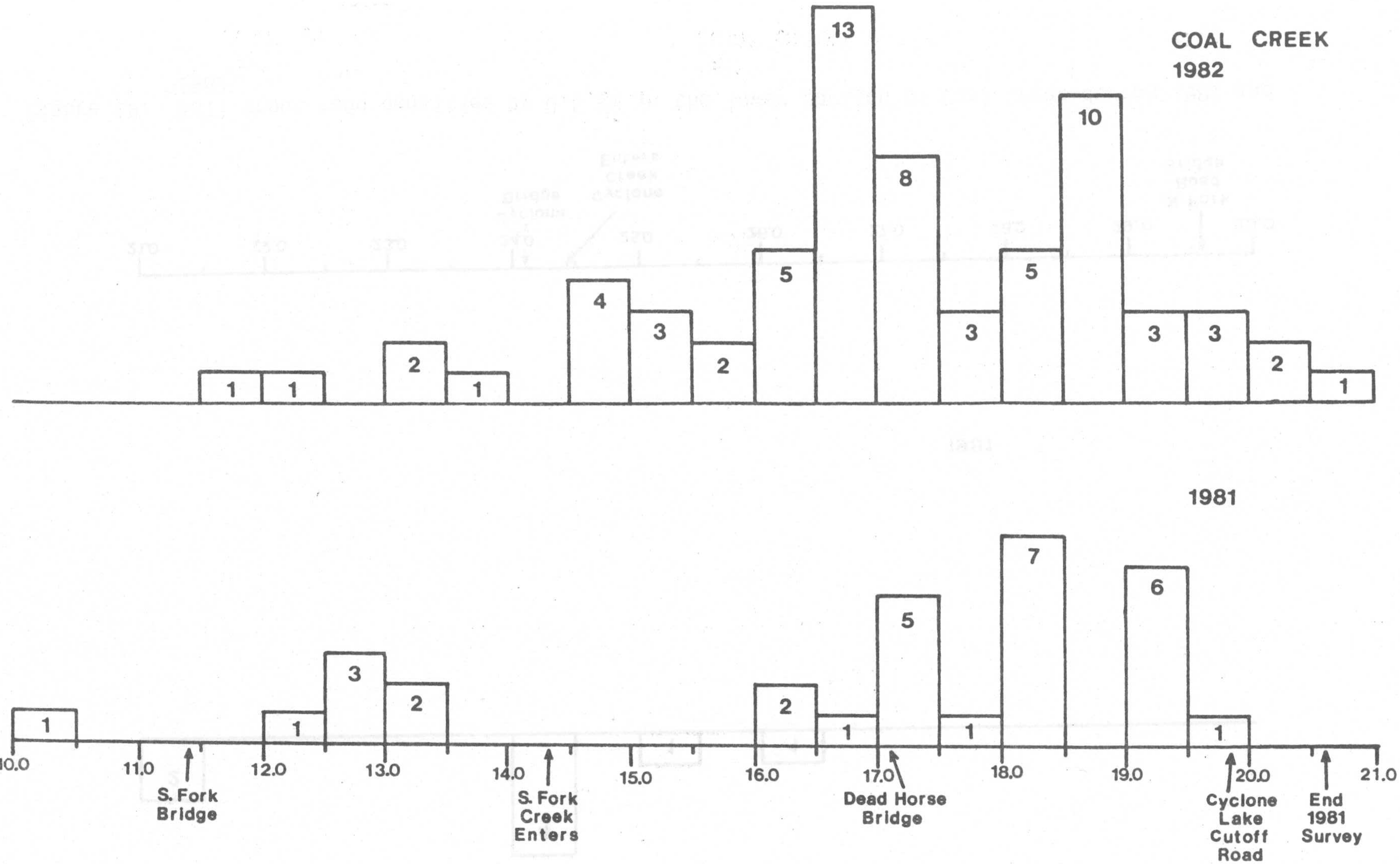

Figure 18. Bull trout redd densities by 0.5 km in the middle portion of Coal Creek during 1981 and 1982.

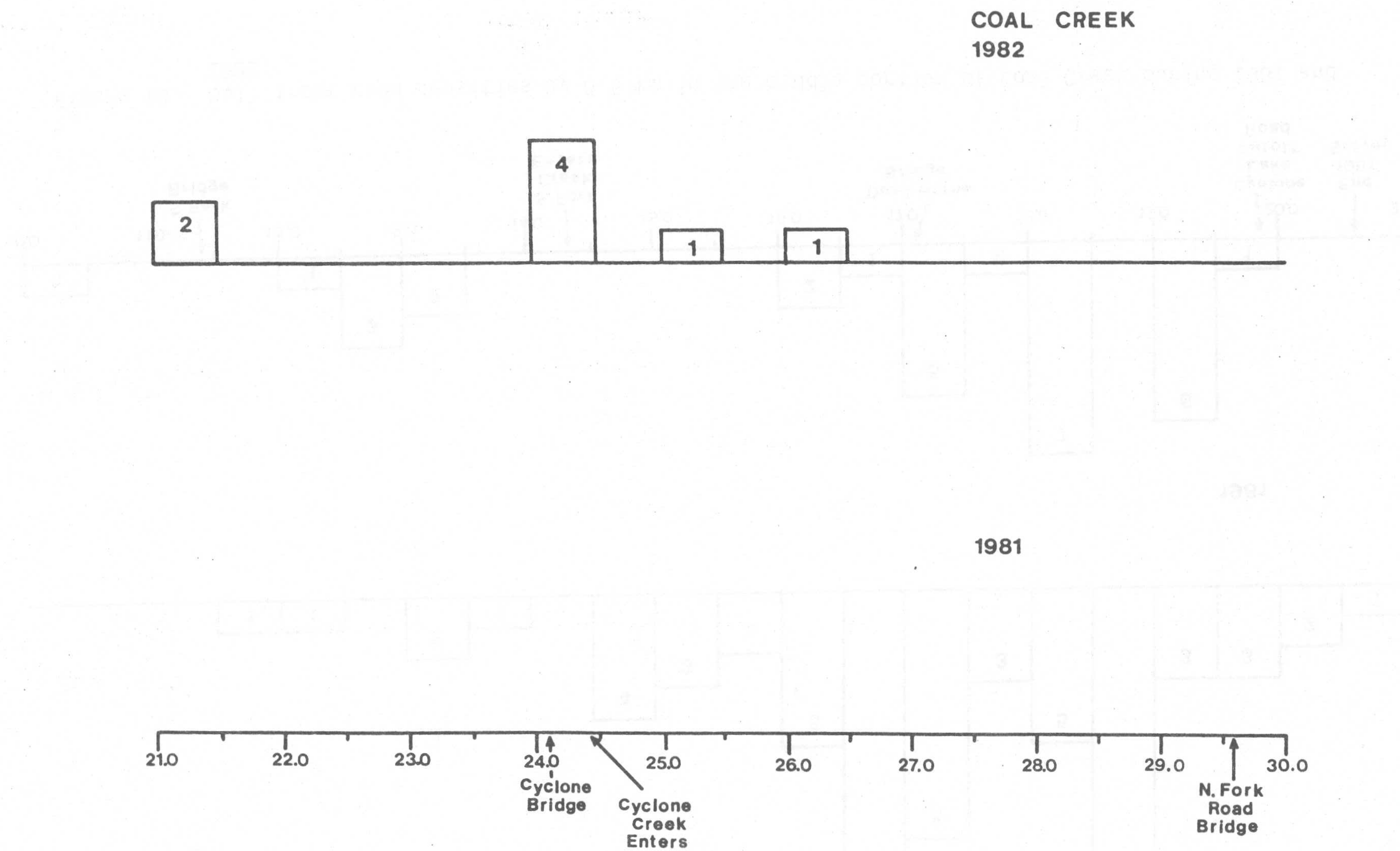

Figure 19. Bull trout redd densities by 0.5 km in the lower portion of Coal Creek during 1981 and 1982.

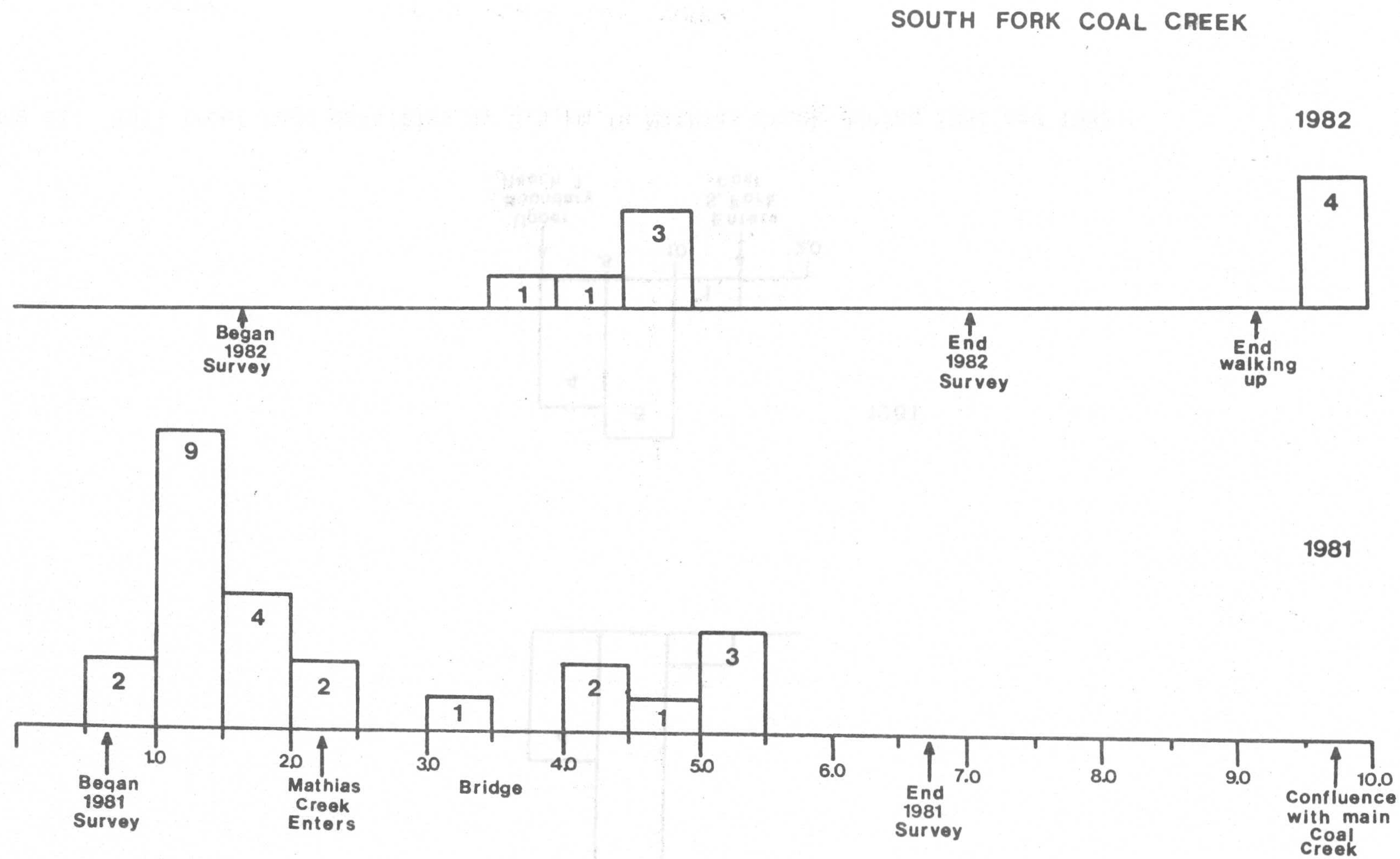

Figure 20. Bull trout redd densities by 0.5 km in the South Fork of Coal Creek during 1981 and 1982.

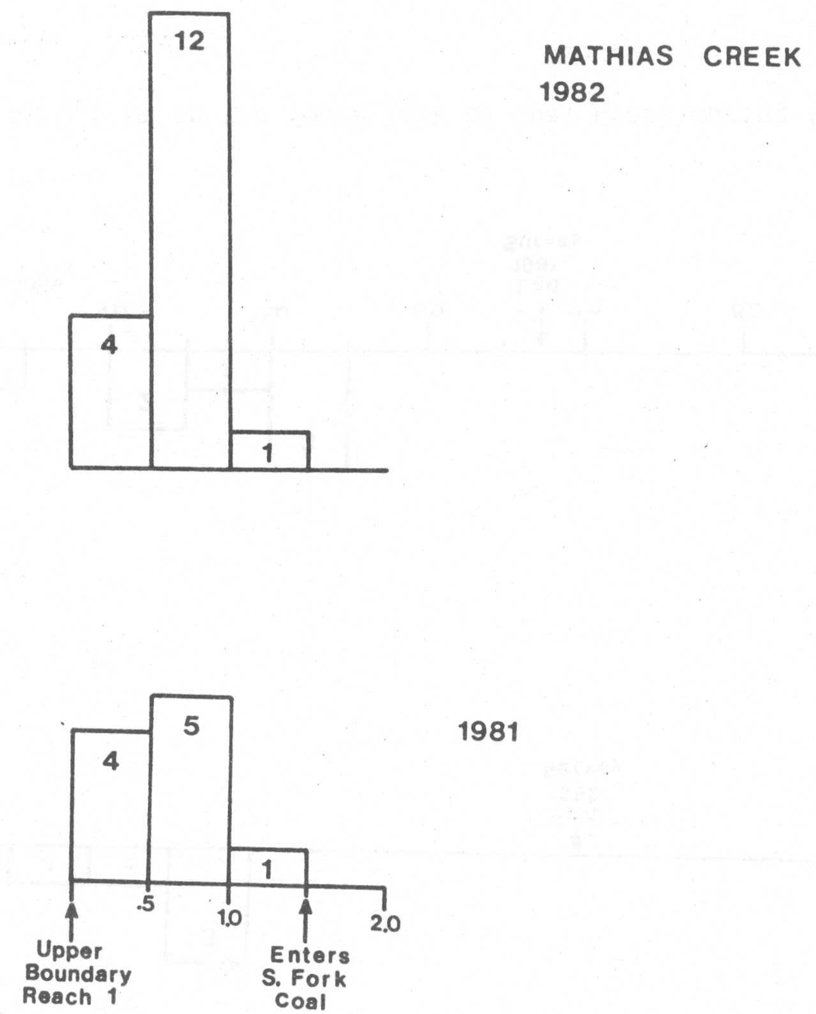

Figure 21. Bull trout redd densities by 0.5 km in Mathias Creek during 1981 and 1982.

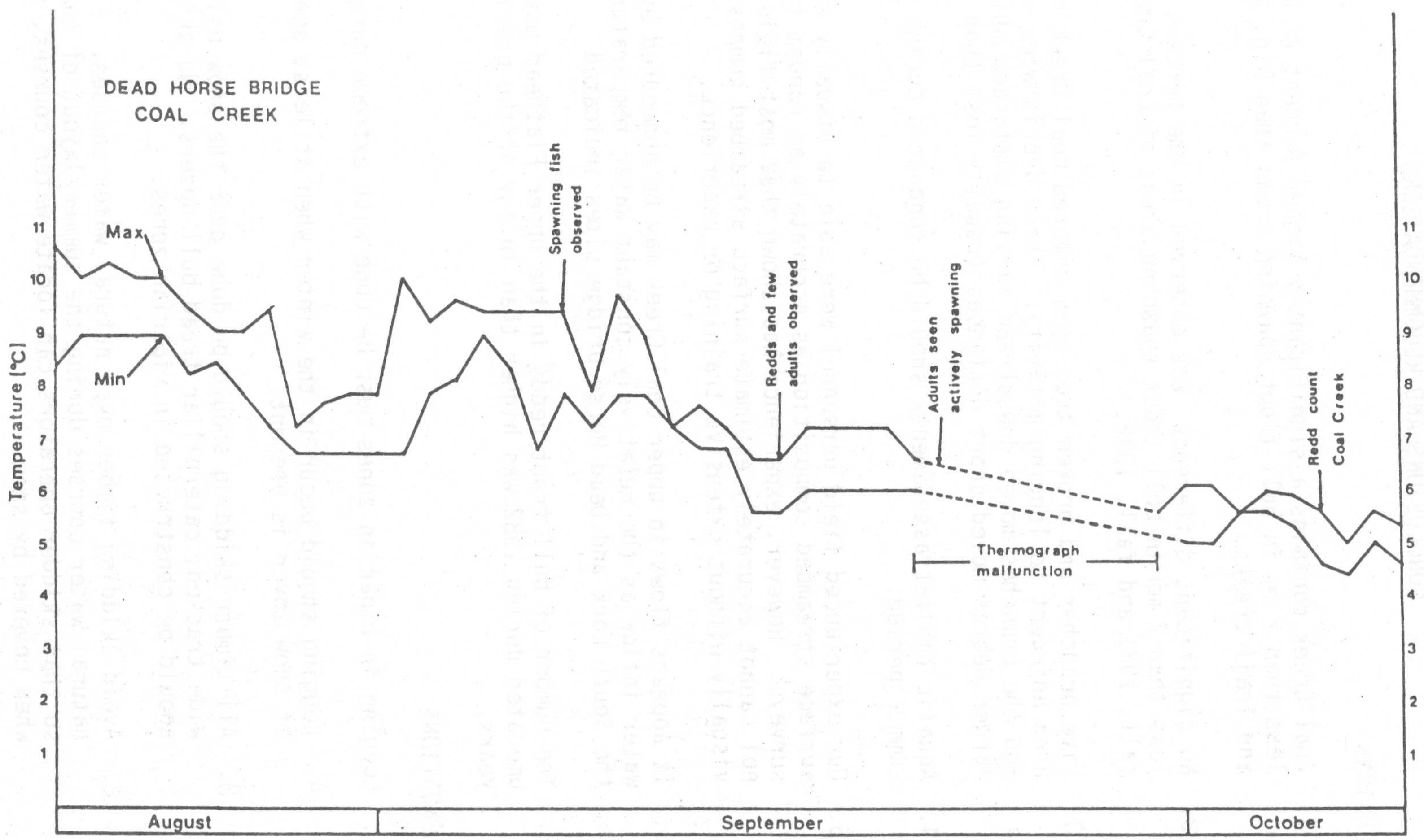

Figure 22. Minimum and maximum daily temperatures in Coal Creek near the Dead Horse Creek Road bridge during the early fall showing when bull trout spawning activity occurred.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Coal Creek contains a significantly higher percent of material less than 2 mm in bull trout spawning areas than Big, Whale, and Trail creeks.

2. No significant difference was observed in the percent of material less than 2 mm in bull trout spawning areas of Coal Creek between fall, 1981 and fall, 1982.

3. Live branches and broken tree tops entered Coal Creek in the area adjacent to logging activity. These debris were unstable and the branches moved downstream varying distances while the larger debris moved short distances (usually less than 100 m).

4. Aquatic habitat assessments should be conducted during the late summer period.

5. Our experienced field personnel were able to visually estimate surface streambed composition as accurately as random transect surveys. However, experience has shown that most field personnel cannot accurately estimate surface streambed composition visually without extensive training or experience.

6. It appears flows in upper Coal Creek may be augmented by ground water inflow as the relatively constant water temperatures at the South Fork and Dead Horse bridge sites indicated.

7. The number of bull trout redds in the upper Flathead basin enumerated during 1982 was higher than in any of the previous three years.

RECOMMENDATIONS

1. Logging in riparian zones must be done with extreme care.

   A. Logging should occur in the winter when at least one meter of snow cover is present.

   B. All timber skidding should be done over the snow using small wide tracked, caterpillar tread bull dozers. No skid roads should be constructed in riparian zones.

   C. Avoid skidding timber over natural water courses. Flag any natural water courses during the summer layout of the sale so that skidder operators can locate water courses, even when covered by snow.

2. The impacts of transported sediment on the aquatic environment can be minimized by preventing sediment from reaching the stream channel.

A. Even when forest road systems are well planned and properly designed (following criteria recommended by Yee and Roelofs (1980)), protection of high quality stream habitat can only be insured if the contractor implements the design in a proper and timely manner. This may require offering the contractor positive incentives or closely supervising the contractor to provide adequate protection for aquatic habitat during development of timber resources.

B. Prohibit road construction activities in live stream channels, especially after August when adult bull trout are in tributary streams.

3. Monitoring of the effects of forest management activities on the fish resources of the Flathead National Forest needs to be continued. Planning future forest road systems and timber harvest practices requires monitoring the effects present forest management activities have on the fish resource, so that future impacts can be predicted and mitigated. A commitment must be made for long-term fish resource monitoring under various forest management activities if we are to improve multiple-use management.

   A. Continue monitoring the fish resource in Coal Creek through the course of the Coal Beetle Salvage Timber Sale to assess the immediate impacts of development. After that time, monitoring should be conducted at three to five year intervals to document long-term changes, and possible recovery, of aquatic habitat and fish abundance.

   B. Map the debris map sections in Coal Creek using a technique of either large-scale aerial photographs (Greentree and Aldrich 1976), or computer mapping (Ruediger and Engles 1982) to more accurately document channel changes and debris locations.

   C. Continue recording water levels and water temperatures in Coal Creek to obtain long-term records for assessing changes in flow and temperature regimes associated with development.

   D. Determine the relationship between bull trout egg-to-fry survival and streambed composition in bull trout spawning areas.

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APPENDIX A

Distribution of point sources of sediment
in main Coal Creek and the South Fork of Coal Creek.

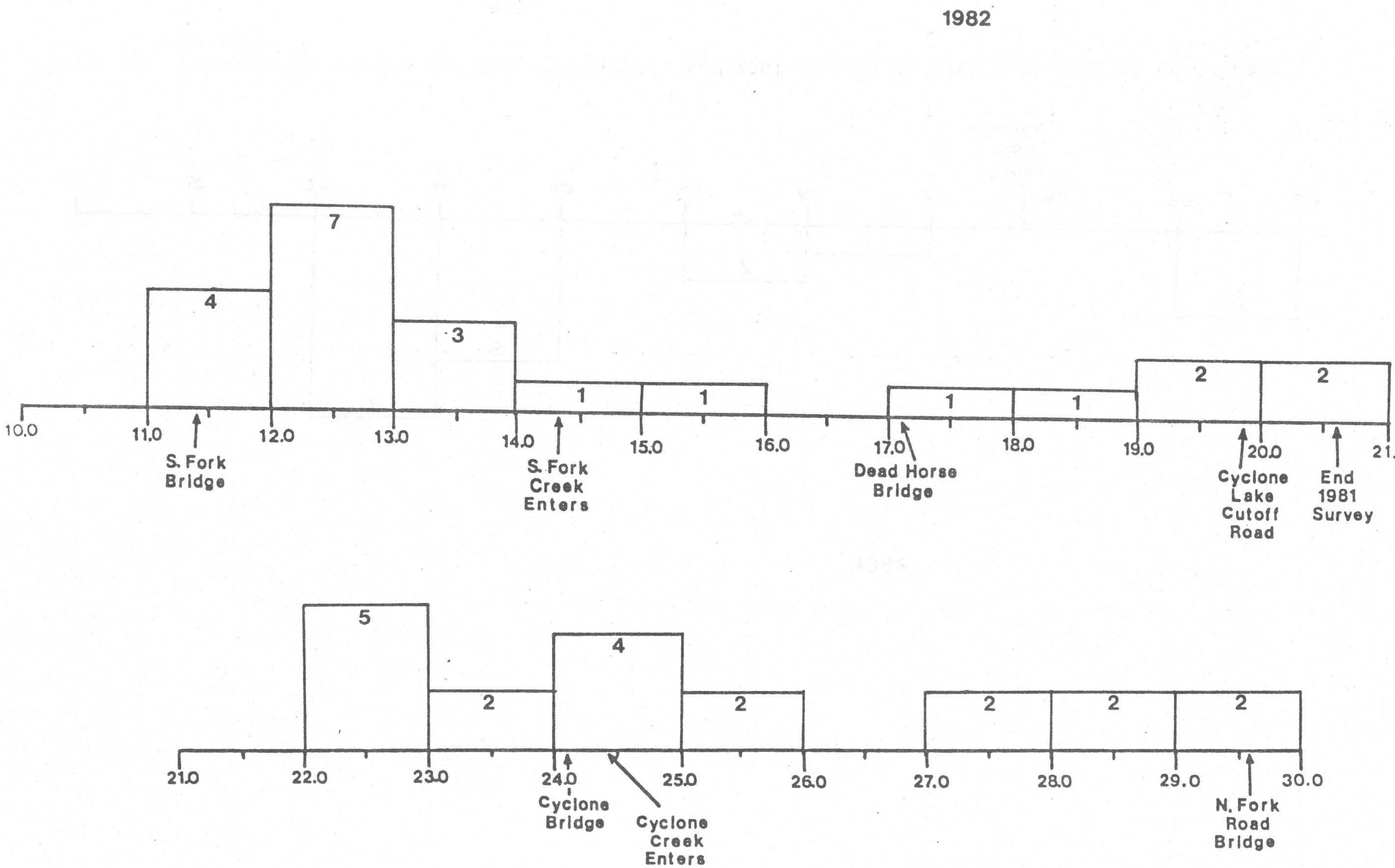

Figure 1. Frequencies (number per km) of inorganic sediment sources in main Coal Creek, from the South Fork Road bridge downstream to the junction with the North Fork of the Flathead River in 1982.

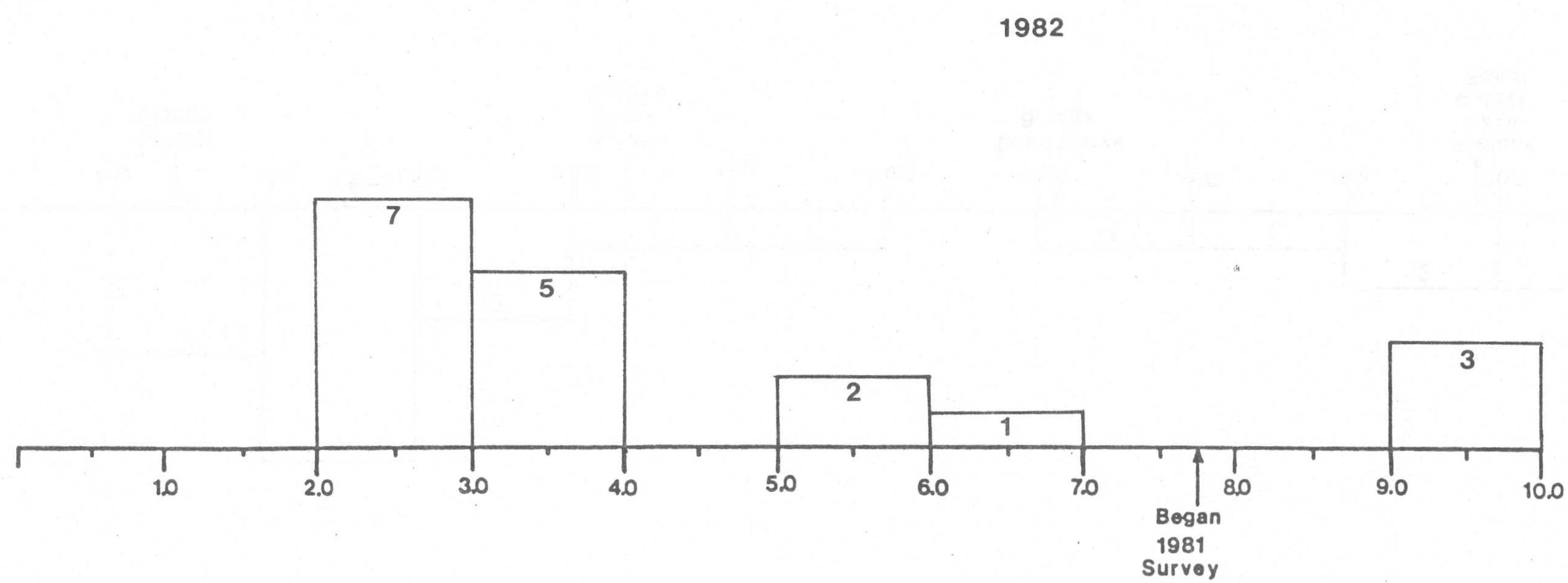

Figure 2. Frequencies (number per km) of inorganic sediment sources to the South Fork of Coal Creek in 1982.

APPENDIX B

Bar graphs of substrate composition for each site
sampled during October, 1982 in Coal Creek
presented as percent by dry weight
versus sieve size

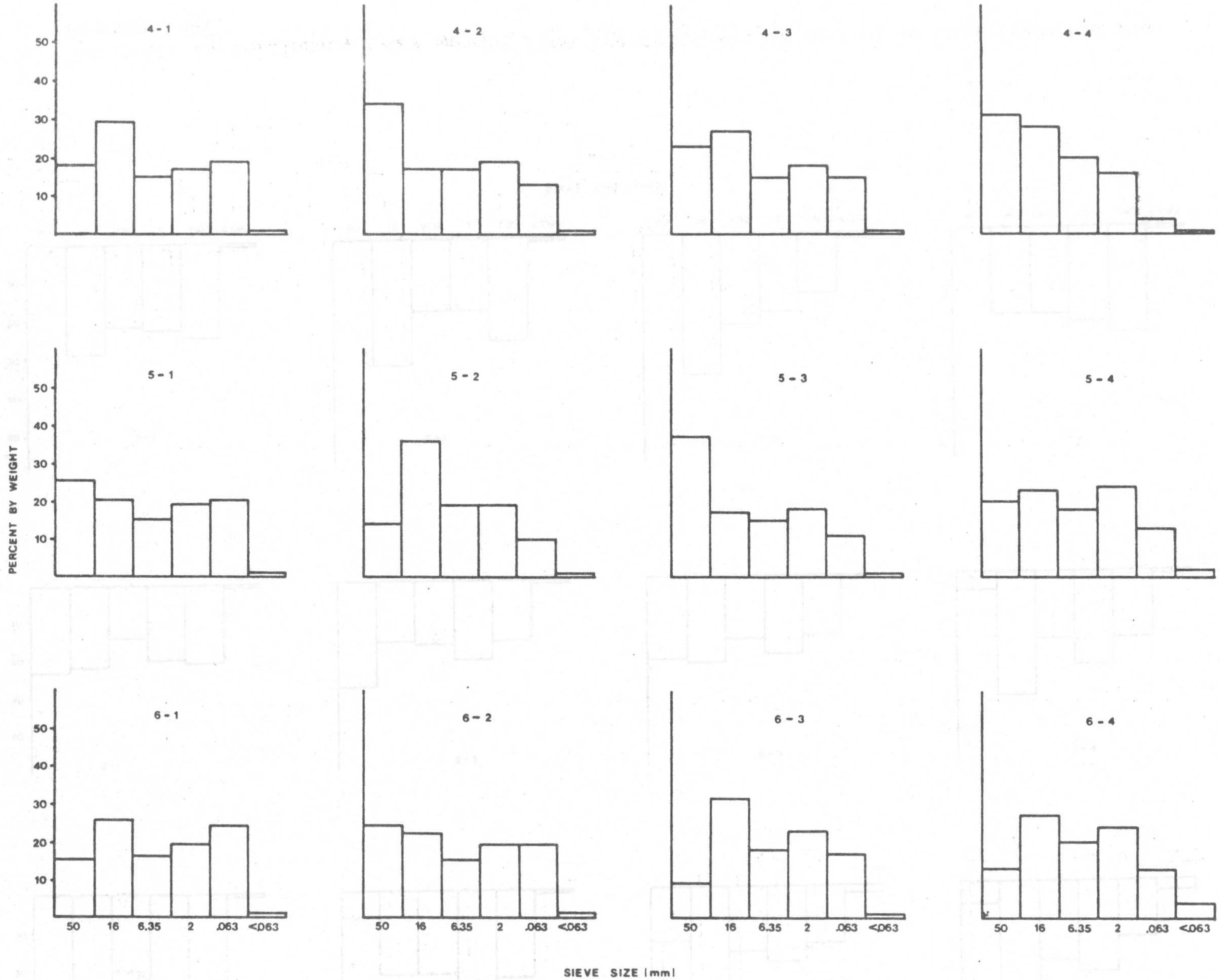

Figure 1. Substrate compositions by dry weight from transects #4, #5 and #6 in Coal Creek during October, 1982.

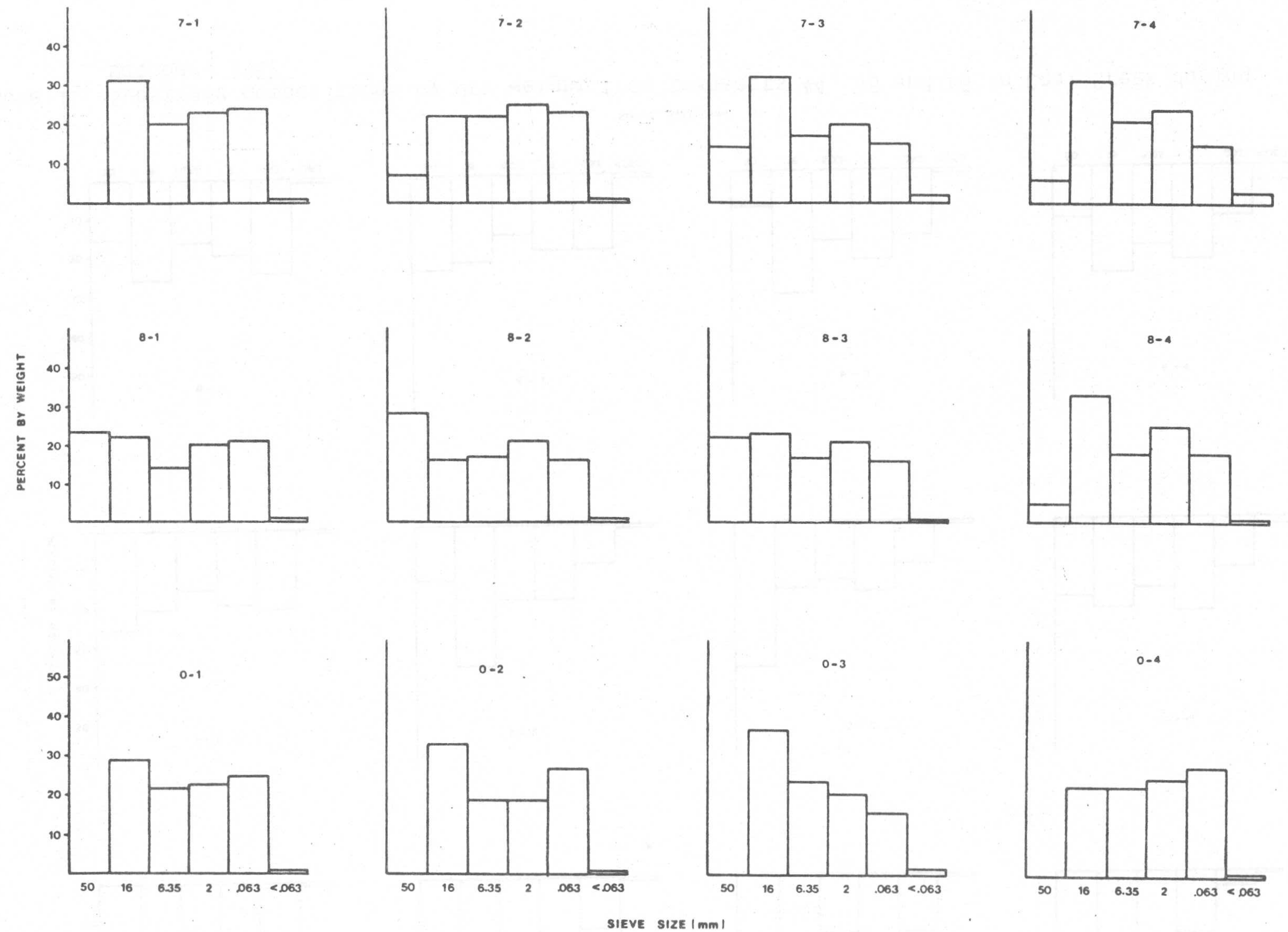

Figure 2. Substrate composition by dry weight from transects #7, #8 and #0 in Coal Creek during October, 1982.

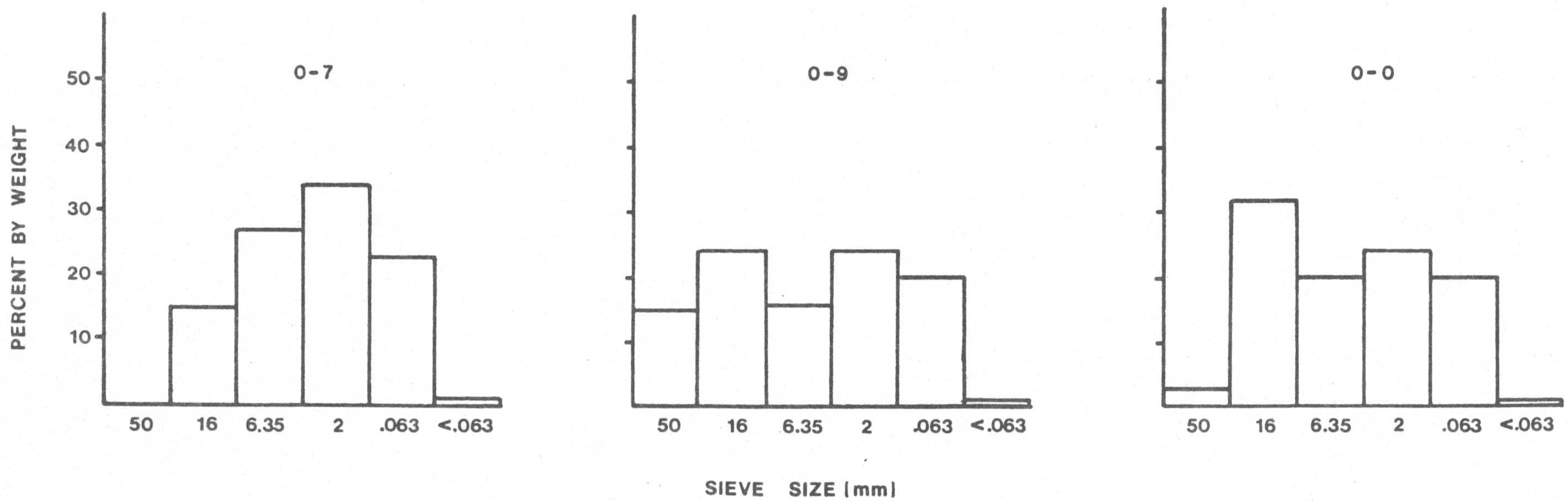

Figure 3. Substrate composition by dry weight from transect #0 in Coal Creek during October, 1982.

APPENDIX C

Seasonal water level fluctuations in selected tributaries to the North Fork of the Flathead River during the summer and fall, 1979, 1980, 1981 and 1982 recorded at North Fork Road bridge crossings.

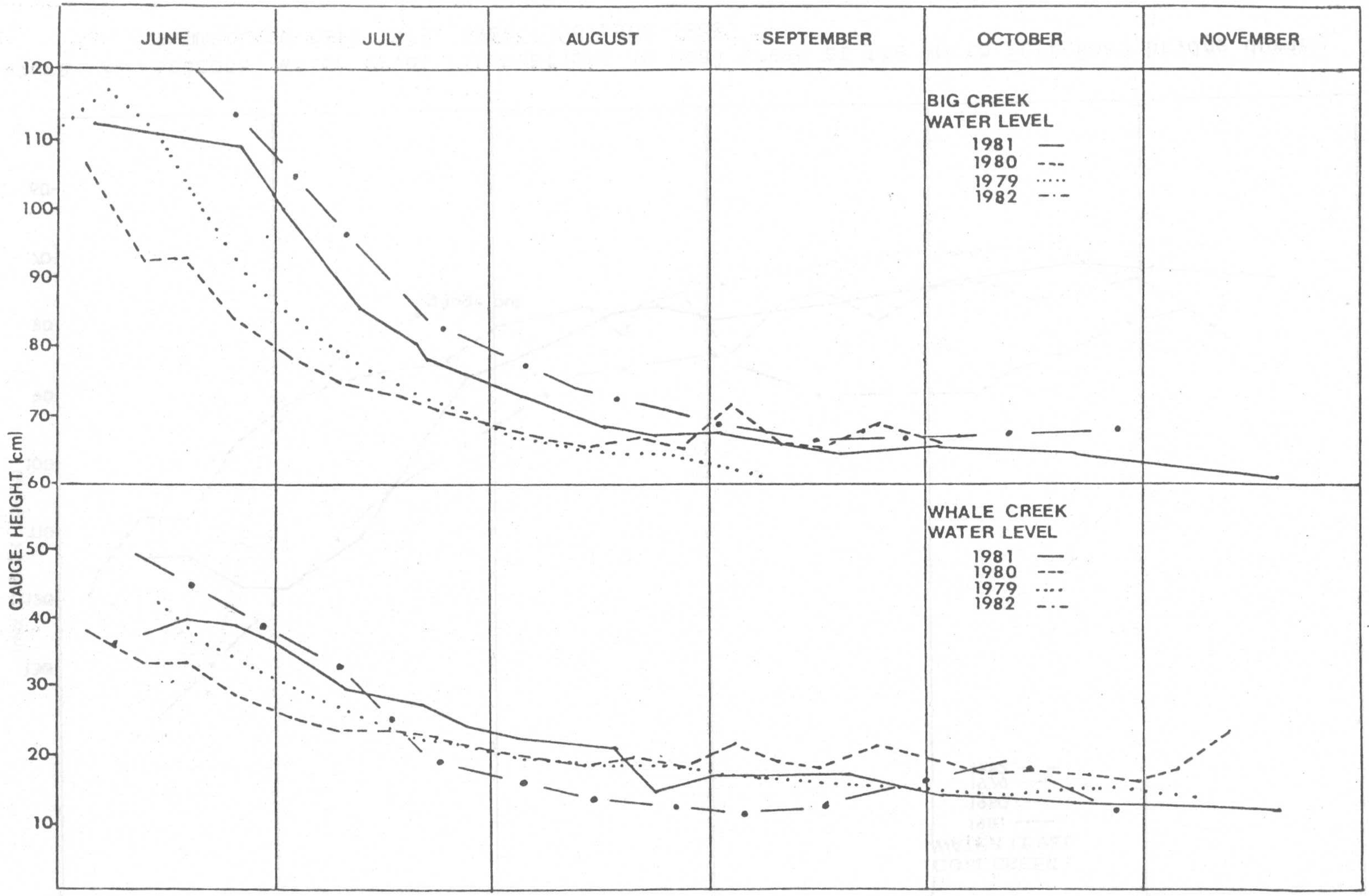

Figure 1. Seasonal water level fluctuations in Big Creek (top) and Whale Creek (bottom) during the summer and fall 1979, 1980, 1981 and 1982.

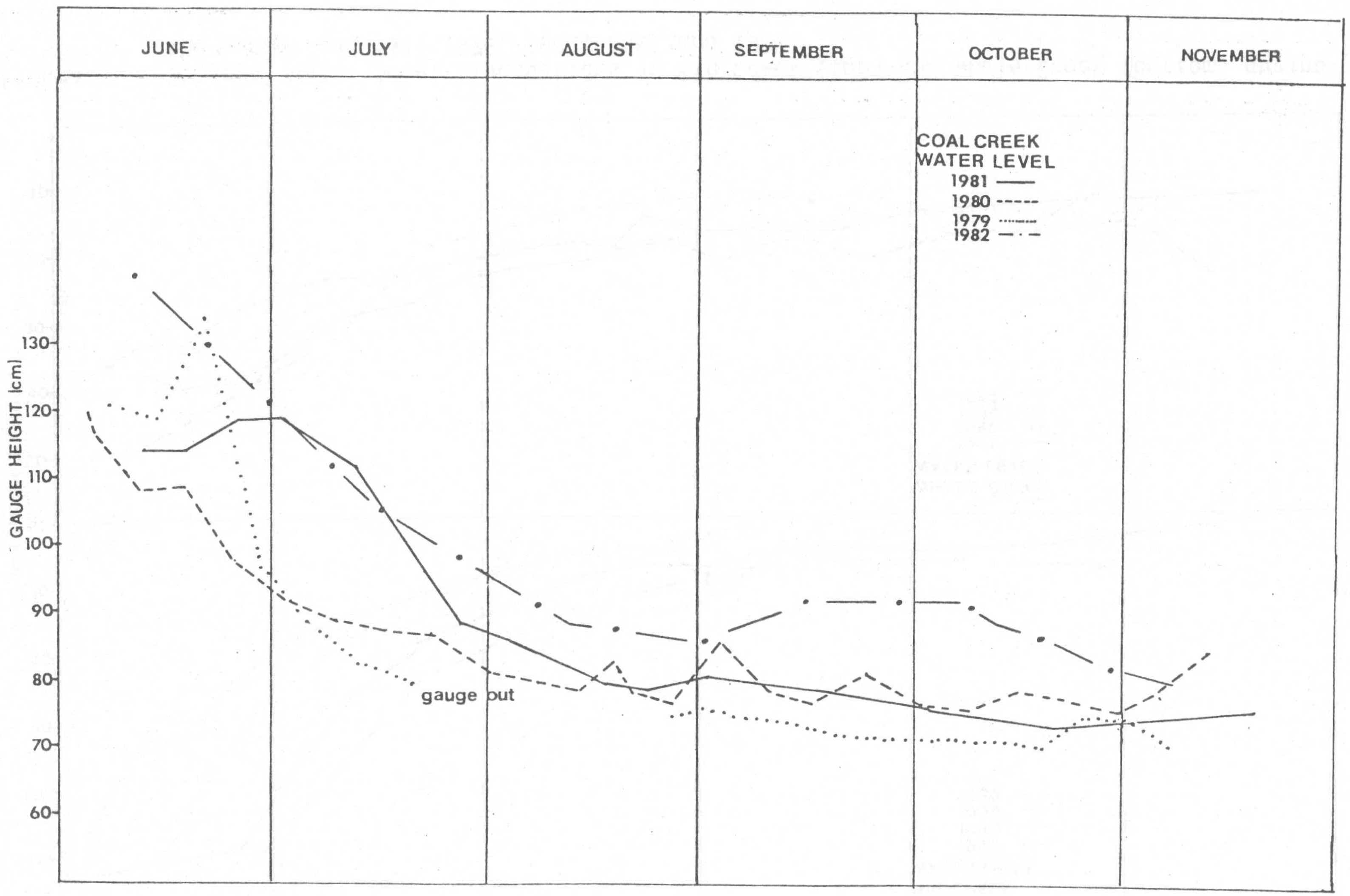

Figure 2. Seasonal water level fluctuations in Coal Creek at the North Fork Road bridge during summer and fall 1979, 1980, 1981 and 1982.

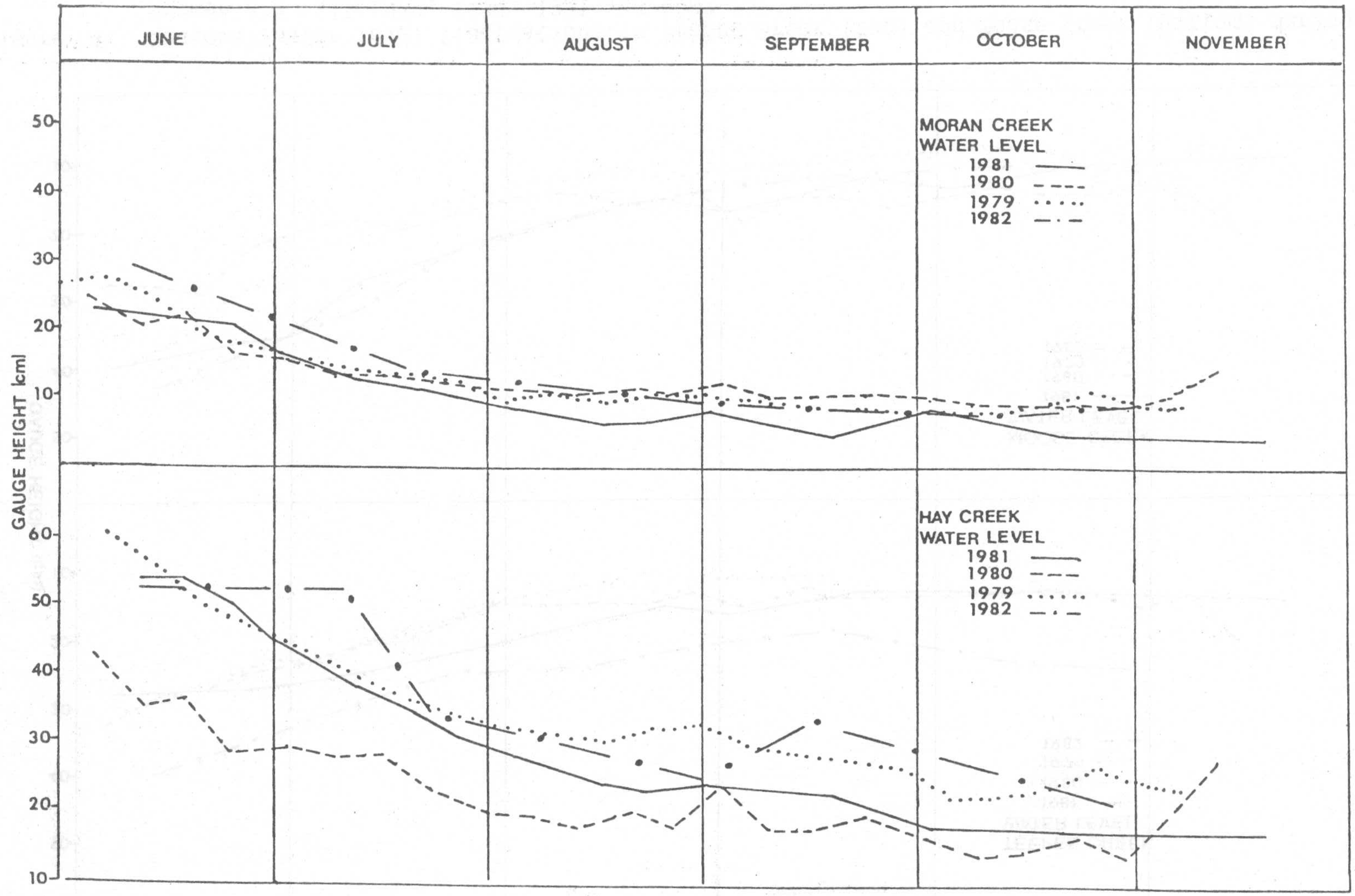

Figure 3. Seasonal water level fluctuations in Moran Creek (top) and Hay Creek (bottom) during the summer and fall 1979, 1980, 1981 and 1982.

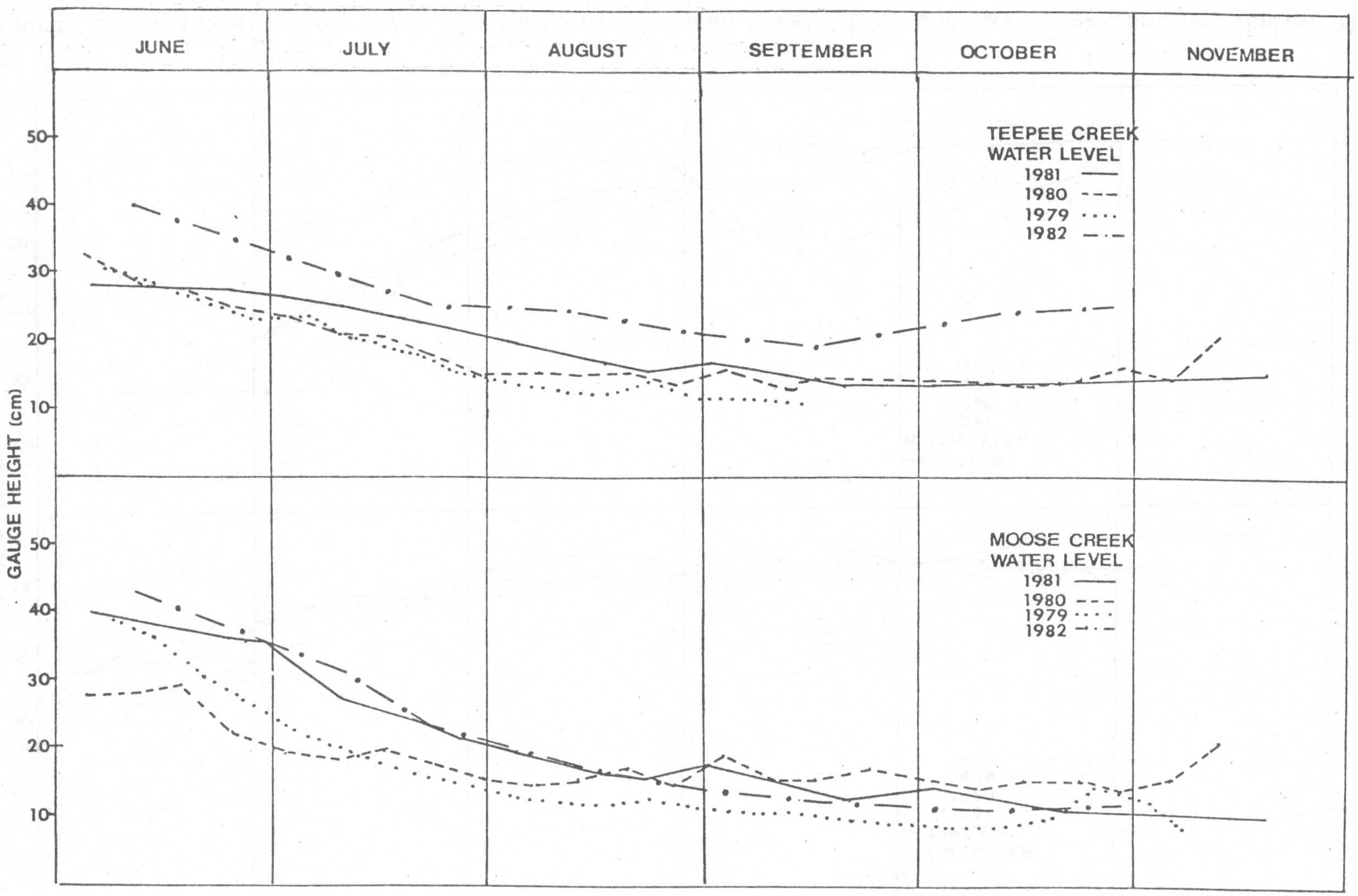

Figure 4. Seasonal water level fluctuations in Teepee Creek (top) and Moose Creek (bottom) during summer and fall 1979, 1980, 1981 and 1982.

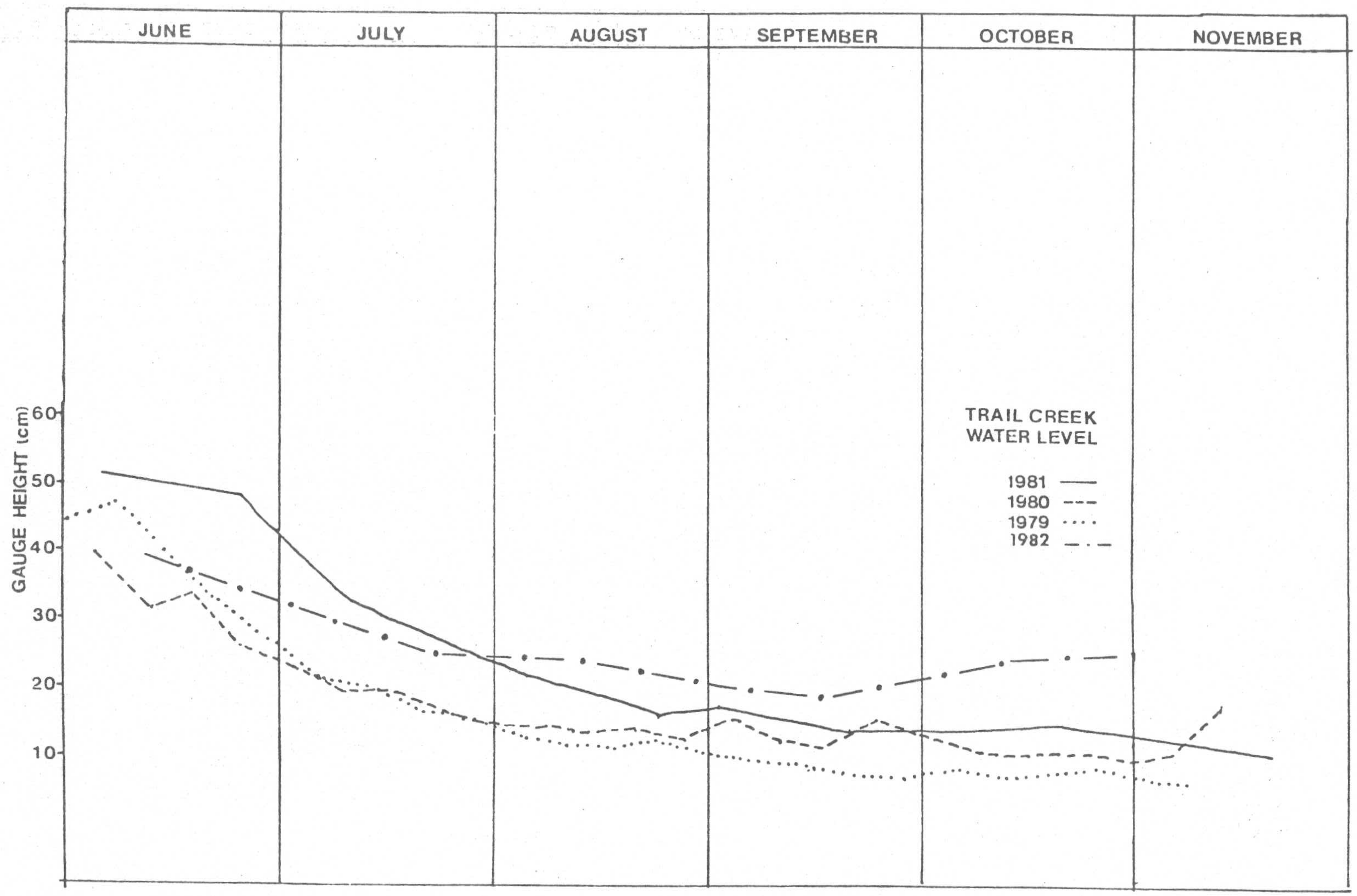

Figure 5. Seasonal water level fluctuations in Trail Creek during the summer and fall 1979, 1980, 1981 and 1982.