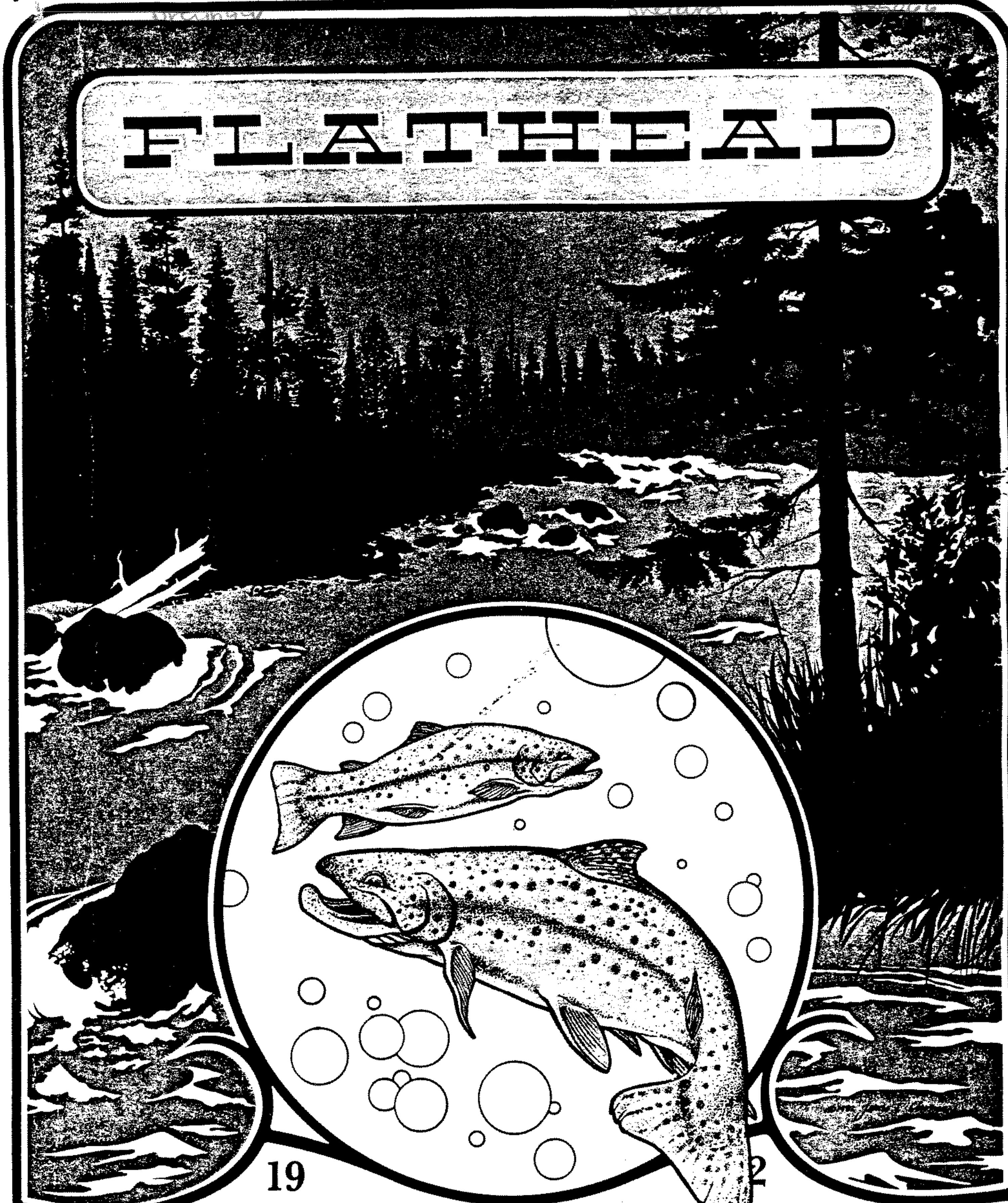

FLATHEAD RIVER FISHERIES STUDY—1982

Research Conducted by: MONTANA DEPARTMENT OF FISH, WILDLIFE AND PARKS
Sponsored by: ENVIRONMENTAL PROTECTION AGENCY

FLATHEAD RIVER FISHERIES STUDY - 1982

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Sponsored by:
Environmental Protection Agency
Region VIII, Water Division
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Through the Steering Committee for the
Flathead River Basin Environmental Impact Study

EXECUTIVE SUMMARY

This report documents fishery information collected during the 1981 calander year as part of a baseline environmental assessment of the Upper Flathead Drainage, which began in 1978 and will be completed in 1982. The report summarizes data for cutthroat and bull trout distribution and abundance, movement, fish habitat, spawning, food habits, and evaluates the methodology used to collect fish habitat and fish abundance data.

Fish distribution and abundance was studied in the North, Middle and South Fork drainages during 1979, 1980 and 1981 to determine the relative importance of tributaries as rearing areas for juvenile trout, and to initiate a long-term monitoring program to document changes in trout abundance. Westslope cutthroat were found in all 47 tributaries surveyed in the North Fork, 42 (93%) of the tributaries surveyed in the Middle Fork, and all 5 of the tributaries surveyed in the upper South Fork. Bull trout were found in 27 (57%) tributaries surveyed in the North Fork, 36 (80%) tributaries surveyed in the Middle Fork, and 2 (40%) tributaries surveyed in the upper South Fork. Fish abundance estimates were made by snorkeling in 186 tributary reaches. A total of 7,207 cutthroat trout, 933 juvenile bull trout, 327 eastern brook trout, and 1,747 mountain whitefish were observed in the 159 reaches which contained fish. The average density of cutthroat trout in the 151 reaches in which they were observed was 6.9 fish per 100 m^2. Juvenile bull trout densities averaged 1.5 fish per 100 m^2 in the 79 reaches where they were observed. Eastern brook trout densities averaged 1.7 fish per 100 m^2 for the 13 Middle Fork tributaries in which they were observed. Critical rearing areas for westslope cutthroat trout were identified and included 17 reaches in North Fork tributaries and 13 reaches in Middle Fork tributaries. Critical rearing areas for bull trout included 7 reaches in North Fork tributaries and 15 reaches in Middle Fork tributaries.

Pools contained the highest densities of all ages of cutthroat and bull trout when compared to other habitat features. Comparisons between electrofishing and snorkeling fish abundance estimates suggests that snorkeling is more effective in open streams while electrofishing is preferred in streams with abundant debris and bank cover. Snorkeling was more efficient in estimating cutthroat abundance, but was much less efficient in estimating juvenile bull trout abundance. Snorkeling efficiency was related to water temperature and type of habitat feature.

Lower densities of cutthroat trout were observed in the Middle Fork River below Bear Creek than in the upper Middle Fork, North Fork and upper South Fork rivers.

A total of 1,108 fish were trapped in Middle Fork tributaries. Westslope cutthroat, mountain whitefish, bull trout and eastern brook trout were the species captured, in decreasing order of abundance. Adult bull trout were trapped in Ole and Bear creeks and out-migrating juvenile bull trout were trapped in Ole, Bear, Geifer and Stannard creeks. Resident and migratory adult westslope cutthroat trout were trapped in Dodge and Challenge creeks.

Cutthroat trout redds were located in Cyclone, Skyland, Tumbler and Challenge creeks, but not in Dodge or Geifer creeks. Migratory cutthroat redds were seen in Cyclone and Challenge creeks.

A total of 704 redds were counted during a basin-wide bull trout redd inventory including 467 in the North Fork drainage (323 in the United States and 144 in Canada), and 237 in the Middle Fork drainage. The highest number of redds (118) were seen in the Whale Creek drainage, a North Fork tributary. The Morrison Creek drainage contained 50 redds, the highest number observed in a Middle Fork tributary. An estimated 2,500 to 3,050 adult bull trout reached tributary spawning areas in North and Middle Fork tributaries. Comparisons between redd inventories by helicopter versus ground crews for eight streams showed that helicopter counts were similar to ground counts in all reaches except Shorty Creek, a small brushy stream with a natural forest canopy resulting in low helicopter counts.

Analysis of food habits of cutthroat and bull trout illustrated that both species are opportunistic feeders. Fish of both species less than or equal to 110 mm in length utilized primarily organisms of the order Diptera with Ephemeroptera, Plecoptera and Trichoptera also well represented. Some divergence in prey selection between cutthroat and bull trout was seen when fish longer then 110 mm were examined. Larger bull trout used fish to a greater extent and the larger cutthroat fed more from the water's surface. Cutthroat longer than 110 mm also selected for Trichoptera larvae.

Aquatic habitat surveys were completed in the remaining tributaries to the lower Middle Fork and in five upper South Fork tributaries. A total of 186 tributary reaches have been inventoried from 1979 to 1981. The replicability of habitat surveys was tested and all measured parameters were estimated to within 6 to 21 percent when compared between years and between different crews. Parameters estimated using subjective ocular percentages had higher percent errors when compared between years and crews; however, it is believed those methods could detect significant habitat changes.

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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 fifteen-member group representing land managment agencies, political bodies, and private citizens or groups in the area.

This is the fourth Annual Progress Report, and presents a large amount of data collected during the preceding year. Two separate reports were prepared this year. This report covers work in the North and Middle Forks of the Flathead River. In general, this report presents baseline data that will be useful to identify, quantify, and monitor the affects of perturbations in the upper watershed of the Flathead River Basin. The river-lake ecosystem is nationally recognized for its uniqueness including its Wild and Scenic Rivers, Flathead Lake, Glacier National Park, and the Bob Marshall Wilderness area, which comprise a valuable recreation resource and symbolize the quality of life in the Flathead River Basin. The completion report, due in the spring of 1983, will contain life-history information for all species studied, the relationships between fish abundance and habitat parameters, and present a program for monitoring fish abundance and habitat quality. Two papers relating habitat variables to fish densities and bull trout spawning, were presented at a Symposium on the Acquisition and Utilization of Aquatic Habitat Inventory Information held in Portland, Oregon on October 28-30, 1981 (Fraley and Graham 1982, Graham et al. 1982).

It should be noted that data are reported in metric units except for streamflows. These are reported in English units because most stream discharge information collected by other agencies is reported in English units. A separate report is being prepared on instream flow requirements for maintenance of the native cold water fisheries in the Flathead River system. This will include the North Fork, Middle Fork, South Fork upstream from Hungry Horse Reservoir, and the main Flathead River downstream to Flathead Lake. Separate reports are also being prepared summarizing fish and habitat information by stream reach, and including a habitat and a fish map of each stream, with a brief description of each reach and tables of all the physical and biological data collected.

STUDY OBJECTIVES

A. North Fork of the Flathead River

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, 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

1. Assess relative importance of tributary streams for producing migratory and resident populations of westslope cutthroat and bull trout. 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 of habitat inventories and to monitor changes in environmnetal quality in a natural system in the event development continues in the North Fork drainage.

3. Identify the timing and distribution of spawning, feeding, and "smolt" migrations for major fish species.

DESCRIPTION OF STUDY AREA

A complete description of the upper Flathead River system was presented in Graham et al. (1980a). The following description includes recent geologic surveys and detailed descriptions of areas inventoried during 1981. Water temperature, streamflow and water quality information collected in the upper Flathead River drainage during 1981 are presented in Appendix A.

NORTH FORK OF THE FLATHEAD RIVER

All tributaries to the North Fork of the Flathead River studied in 1981 were described in Graham et al. (1980a) and Fraley et al. (1981).

Geology

The geology of the west side of the North Fork was described by Johns (1980) and the geology of Glacier National Park was described by Mudge (1977). The upper and middle portions of the west side tributaries to the North Fork consists primarily of sedimentary rocks of the Missoula, Piegan and Ravalli

Groups. These include the Roosville, Phillips, Kintla and Shepard formations in the Missoula Group and Siyeh, Grinnel and Lower Piegan formations in the Piegan Group. The lower reaches of most westside tributaries flow through Quaternary Glacier deposits.

Eastside tributary headwater areas drain a mixture of Precambrian rock of the Missoula Group including the Helena, Spokane, Greyson and Altyn formations. Streams flowing out of the lakes present in most eastside drainages pass through Quaternary Glacial deposits.

MIDDLE FORK OF THE FLATHEAD RIVER

The Middle Fork of the Flathead River drainage was described by Fraley et al. (1981).

Geology and Water Chemistry

The geology of the Middle Fork drainage downstream from Bear Creek was described by Johns (1970) and Mudge (1977). The west side of the Middle Fork is almost entirely underlain by Precambrian rock of the Missoula Group including the Helena, Snowslip, Shepard and Shields formations. The streams draining Glacier National Park flow through Precambrian rock of the Missoula Group including the Spokane, Greyson and Altyn formations. The lower reaches of several Park streams pass through a belt of Quaternary Glacial deposits just prior to joining the Middle Fork River.

Water chemistry information from the Middle Fork River has been reported by several sources. Nunnalee (1976), the Flathead Drainage 208 Project (1976) and Stanford et al. (1979, 1980) have all conducted studies on the Middle Fork below Bear Creek. The river above Bear Creek was sampled in the Schafer Meadows area by the Montana Department of Health in 1976. The Flathead Research Group also collected water samples in the Middle Fork near Schafer Meadows in 1980.

Limited water chemistry data area available for tributaries to the Middle Fork. Stanford et al. (1979) reported the chemical parameters for McDonald Creek. The U.S. Forest Service conducted water chemistry studies on Challenge, Skyland, Morrison and Puzzle creeks. Fraley et al. (1981) made point measurements of alkalinity, conductivity and flow in 10 tributaries of the upper basin and in the upper Middle Fork River.

SOUTH FORK OF THE FLATHEAD RIVER

Fish and habitat surveys were conducted in the upper South Fork of the Flathead River and several of its major tributaries in 1981. The South Fork of the Flathead River originates at the junction of Danaher and Young's creeks and flows in a northerly direction for 95 km before entering Hungry Horse Reservoir. The upper South Fork drainage lies entirely within the boundaries of the Bob Marshall Wilderness and is bordered by the Swan Range to the west and the Lewis and Clark and Flathead Ranges to the east.

Recreational use in the South Fork drainage is high, with horse packing, backpacking, hunting and fishing being the primary activities. Many outfitters guide parties into the area during the summer and fall months.

The White River, Little Salmon, Gordon, Danaher and Young's creeks as well as two 3 km sections of the main stem South Fork were surveyed during 1981.

Geology and Water Chemistry

The geology of the South Fork drainage above Hungry Horse Reservoir was described by Johns (1970). The river corridor and floodplains of the major tributaries consist of narrow belts of Quaternary Glacial deposits, along with some alluvium in the downstream portion of the South Fork drainage. Formations of the Missoula Group, including the Upper Missoula, Lower Missoula and Bonner extend to the river corridor at several locations as do Cambrian and Devonian undifferentiated materials.

The Quaternary Glacial deposits through which the major tributaries flow are generally encompassed by Cambrian and Devonian undifferentiated materials and by Precambrian rock of the Missoula Group, including the Shepard, Snowslip, Shields, Upper Missoula and Lower Missoula formations.

Limited information on the water chemistry of the South Fork of the Flathead River drainage exists in the Water Quality files of the Flathead National Forest Supervisor's Office, Kalispell, Montana.

METHODS

FISH DISTRIBUTION AND ABUNDANCE

North, Middle and South Fork Tributaries

Fish population estimates were made in one randomly chosen 150 m long long section of each North, Middle and South Fork tributary reach surveyed during the summer of 1981. In the North Fork drainages, estimates were conducted in Canyon, Big, Coal, Moran, Red Meadow, Moose, Whale and Trail creeks on the west side and Akokala Creek on the east side (Figure 1). In the Middle Fork drainage, estimates were made in all major tributaries below and including Bear Creek (Figure 2). The streams surveyed included the Bear Creek drainage and Essex, Dickey, Paola, Tunnel, Stanton and Deerlick creeks which drain Flathead National Forest land to the southwest, and Ole, Park, Muir, Coal, Pinchot, Nyack, Harrison, Walton, Lincoln and McDonald creeks which drain Glacier National Park to the northeast. In the South Fork drainage, estimates were made in the White River and Little Salmon, Gordon, Danaher and Young's creeks (Figure 3). An observer wearing a wet suit, diving mask and snorkel estimated the number of fish in each age class by species as he pulled himself upstream.

The distinction of age classes were predetermined from past length frequency analyses. Cutthroat trout of age 0, I and II, had maximum

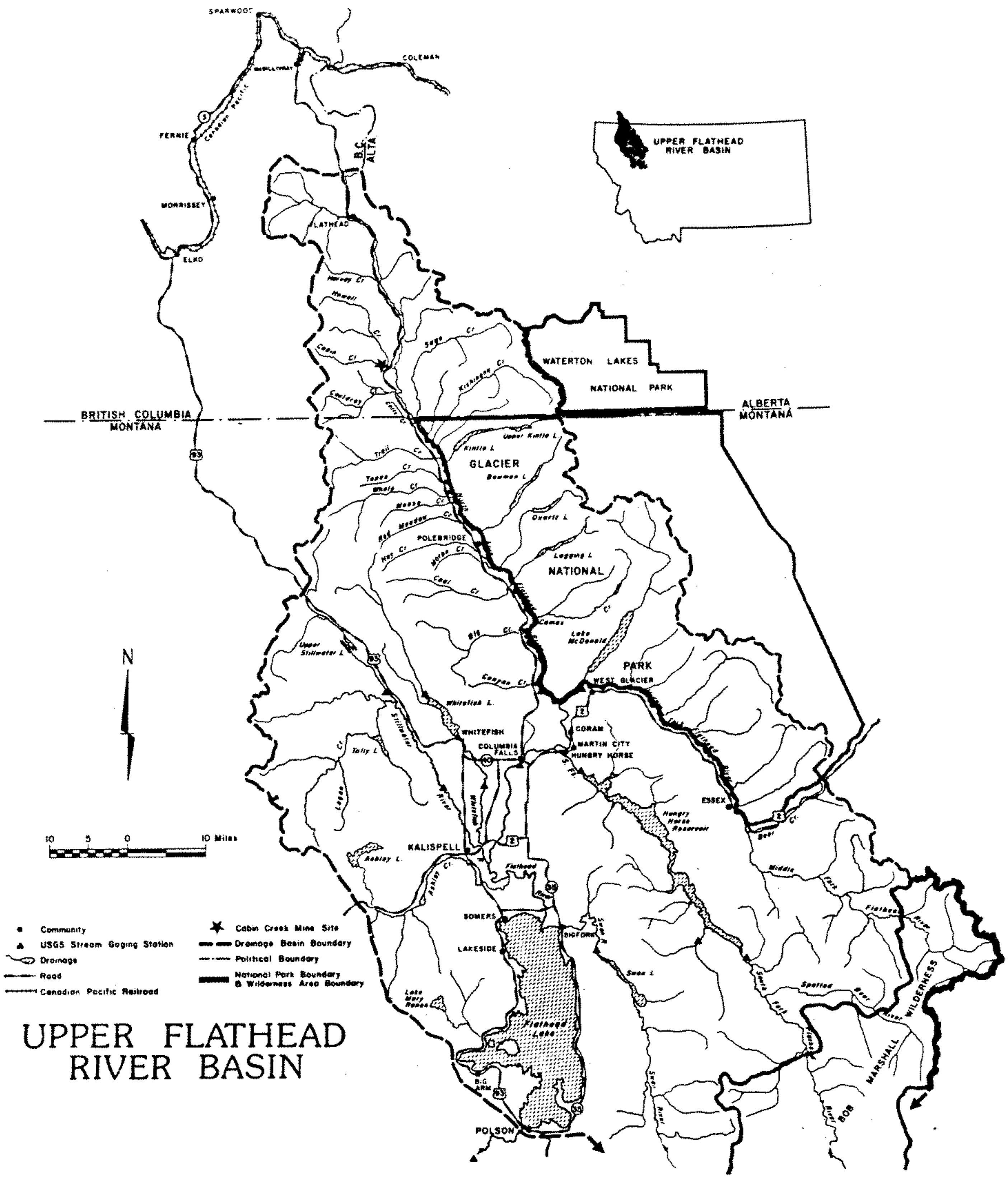

Figure 1. Drainage map of the upper Flathead River Basin (adapted from Montana Department Natural Resources and Conservation, 1977).

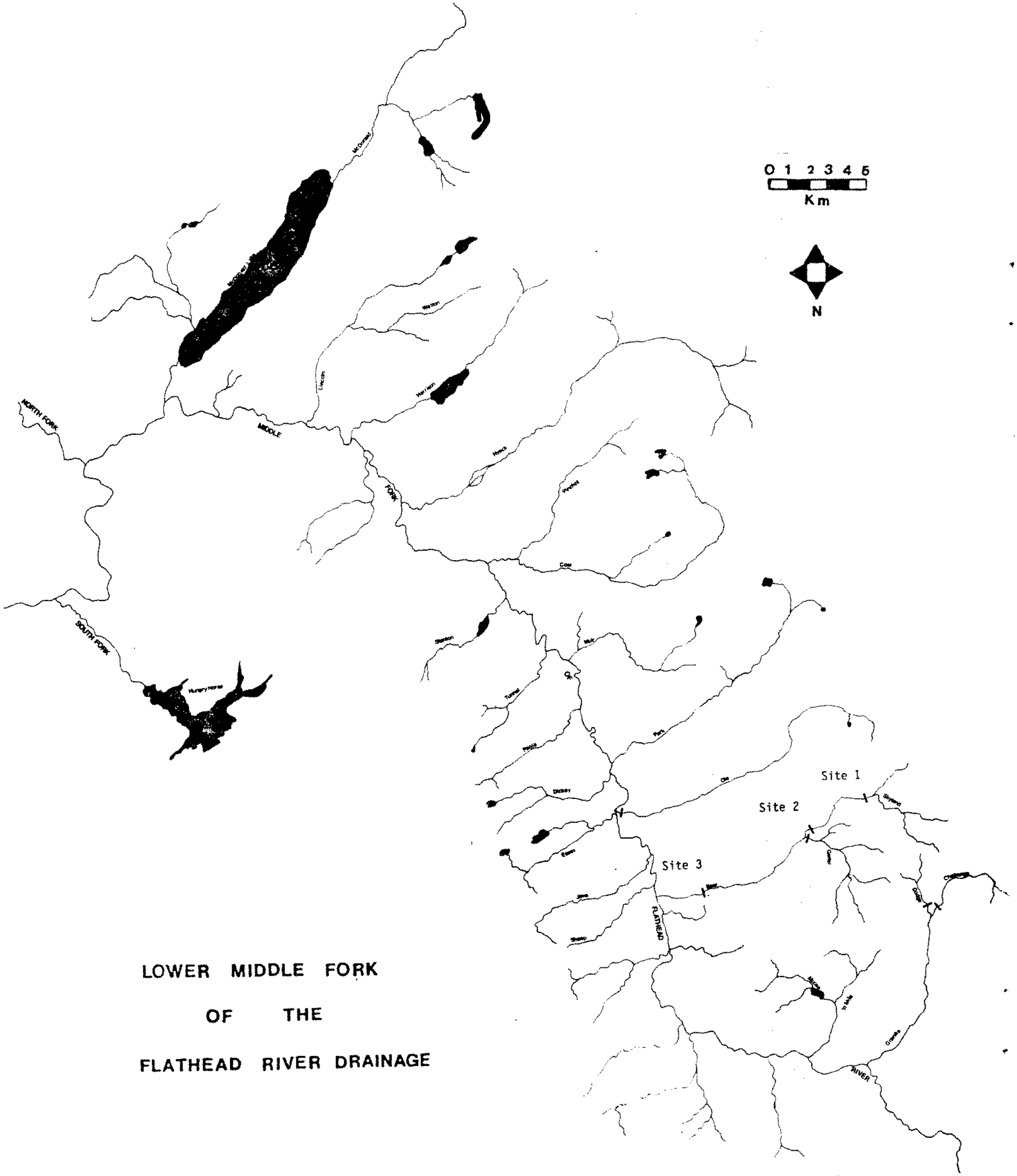

Figure 2. Drainage map of the lower portion of the Middle Fork of the Flathead River showing fish trapping sites (-).

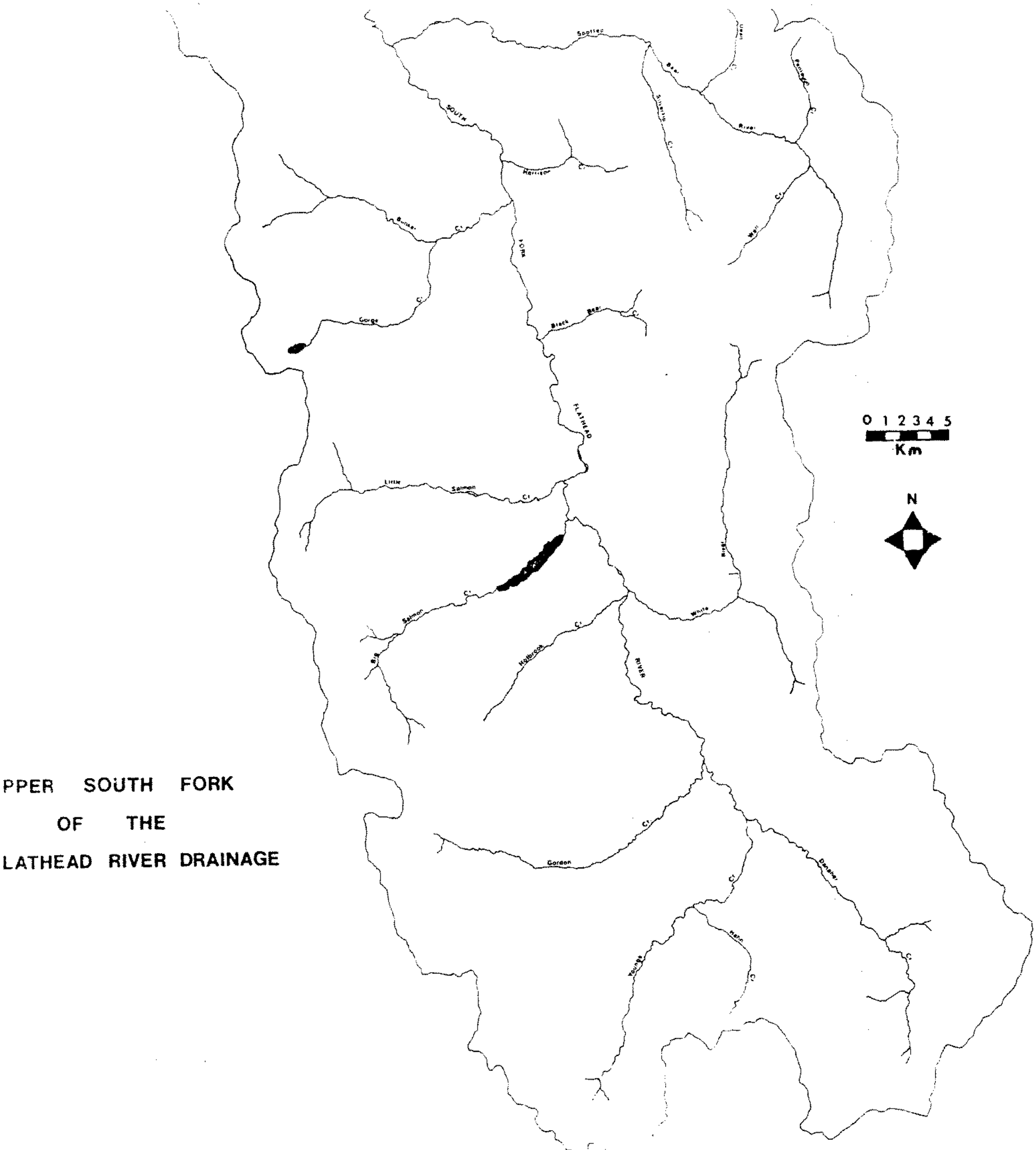

Figure 3. Drainage map of the South Fork of the Flathead River above Hungry Horse showing the major tributaries.

lengths of 40, 80 and 130 mm, respectively. Juvenile bull trout had maximum lengths of 50, 90 and 140 mm for age classes 0, I and II, respectively. These length classes were adjusted to some degree, following initial observation in a creek. For example, maximum lengths of each class would be adjusted downward in a small, cold stream snorkeled early in the summer to reflect slower growth. Surface areas of all features were calculated using average length and width measurements and summed for each section snorkeled. Fish density was computed for each section and reported in number of fish per 100 m^2 surface area.

Snorkeling was preferable to electrofishing in most streams in the Flathead drainage because of good water clarity, low conductivities and inaccessibility. In wilderness areas and Glacier National Park, where regulations prohibit electrofishing equipment, snorkeling was the only practical and effective method for obtaining fish abundance estimates. Underwater fish censuses have been used with success in other drainages of high water clarity (Northcote and Wilkie 1963, Goldstein 1978, Whitworth and Smith 1980, Griffith 1981).

Densities of Trout by Stream Feature

Westslope cutthroat and bull trout densities were computed by feature, averaged and compared.

Comparing Several Methods of Estimating Fish Abundance

Seven sections varying in length from 100 to 165 m in four North Fork tributaries and three Middle Fork tributaries were sampled to compare the effectiveness of snorkeling and electrofishing methods of estimating fish abundance. One run and one pool in Trail Creek, a tributary to the North Fork, were also sampled.

In North Fork tributaries, block nets (12.7 mm mesh) were placed at the lower and upper ends of each section and a diver crawled upstream counting all fish observed in each feature by species and age class. The following day, after allowing fish to redistribute (Everest 1969), each habitat feature was electrofished using a two-pass technique described by Seber and LeCren (1967). Block nets were moved upstream feature by feature. All electrofishing was done with a V.V.P. and gas generator located on shore, with an aluminum plate placed in the stream as a negative electrode and a hand held positive electrode. Fish captured on the first pass were held in live cars during the second electrofishing run. The lower block was checked for fish after each pass which consisted of a downstream shocking run. After two passes were completed on a feature, another snorkel count was made after which the lower block net was removed, checked for fish, then reset as the upper block net on the next feature upstream.

It was assumed the fish in the next upstream feature would resume normal activity during the time data was recorded from captured fish and be equally susceptible to capture by electrofishing. The fish captured were measured to the nearest mm, weighed to the nearest gram or .01 pound (converted to grams later) on a spring scale.

Comparisons of fish abundance estimates were made between the initial snorkel count, the two-pass estimate and the combined electrofishing catches plus the resnorkel count for each feature by species and age class.

In the three Middle Fork tributary streams, sections were blocked by 12.7 mm mesh hardware cloth at each end and a snorkel pass was made to count all fish by species and age class. Electrofishing was done in a similar manner to the North Fork method; however, each pass of the two-pass estimate consisted of a downstream and upstream shocking run. All fish captured during the two-pass estimate were marked and a recapture run was made three to four days later. During the time interval between marking and recapture runs, block nets were maintained to prevent movement into and out of the section. Fish populations in the sections were estimated by the Peterson mark-recapture method reported in Vincent (1971), and two-pass method described by Seber and LeCren (1967). No snorkel count was made after electrodishing in the Middle Fork tributaries.

Comparisons were made between the initial snorkel counts, the two-pass estimate and the mark-recapture estimate.

Spring Population Estimates

Two-pass and mark-recapture population estimates were made in Paola, Stannard, Dodge and Deerlick creeks in the Middle Fork drainage. A mark-recapture estimate was made in Langford Creek in the North Fork drainage. Estimates were made during the spring and early summer of 1981. Both ends of each sample section were blocked using 12.7 mm mesh hardware cloth or netting. Fish were captured by electrofishing, tagged with dangler or floy tags, measured to the nearest mm, and weighed to the nearest gram. Scale samples were taken and the fish were returned to the section. Block nets were kept in place for two to four days to prevent fish movement until the recapture run was made. Population estimates and the associated 95 percent confidence intervals were calculated for all sections (Vincent 1971, Seber and LeCren 1967).

North, Middle and South Fork Rivers

North Fork

Two snorkel observation floats were made in the North Fork of the Flathead River from Ford Station (river km 326.5) to Polebridge (river km 308.7). The first snorkel float was conducted on 4 July and the second on 14 August. The objectives of these floats were to observe the relative abundance of juvenile cutthroat trout, mature upstream migrating bull trout and mountain whitefish. A single diver floated downstream and observed and recorded the relative abundance of all species.

Middle and South Forks

Two 2.9 km-long sections in the Middle Fork and two 3 km-long sections in the South Fork were sampled to estimate fish abundance. The sections in the Middle Fork were located near Nyack and upstream from the mouth of Park Creek, and the South Fork sections were located immediately below the mouth of the White River and between the mouths of Butcher and Gordon creeks. Every pool, 50 percent of the runs, and two or three riffles and/or pocketwaters in each section were snorkeled to estimate fish abundance. The surface area of each feature snorkeled was measured to calculate fish densities. Every feature in the section was counted and the lenghts and widths of all features were measured by pacing or by measuring tape. Fish densities were calculated for each section by feature then expanded to obtain a population estimate for the total section by multiplying the average fish density for each type of feature times the total area of that feature in the section.

HABITAT EVALUATION

Stream habitat was evaluated using a modification of the system developed by the Aquatic Studies Branch of the British Columbia Ministry of the Environment (Chamberlin 1980a, 1980b). Methods used were described by Fraley et al. (1981). At the start of the 1981 field season, field personnel completed a two day training program.

The repeatability of the habitat surveys was tested using two approaches. Observer bias was evaluted using three crews of two people each to survey the lower 0.8 km (0.5 mile) of Kimmerly Creek, a tribuatary to Canyon Creek. Annual variability in habitat measurements was compared by resurveying eight North Fork tributary reaches which had initially been surveyed during 1979. Two habitat parameters, brush overhang and canopy cover, were identified differently in 1979 than in 1981. The pocketwater habitat feature category and channel stability ratings were added in 1980, so 1981 habitat surveys rated these two parameters while 1979 surveys did not. The average percent errors between crews and between years were calculated for all habitat parameters according to methods presented by Beamish and Fournier (1981).

All physical-chemical habitat parameters measured for each tributary reach were entered on standard Montana Interagency Stream Fishery Data forms (Fish, Wildlife and Parks, Helena 1980 and Fraley et al. 1981). A format "dictionary" defining locations of each habitat and fish population variable in the data base was constructed on the Montana State University CP-6 Interactive Data Base Processing System. The dictionary enabled the user to request information on any physical, chemical or biological parameter available for each stream reach.

STREAM TRAPPING

Trapping in tributaries to the Middle Fork of the Flathead River during 1981 was used to determine the presence and relative abundance of migratory trout populations in each stream. Trapped westslope cutthroat, bull trout, eastern brook trout and whitefish were weighed, measured and tagged.

Traps and leads were constructed of wire mesh (12.7 mm) similar to that used in 1979 (Graham et al. 1980a). Traps were checked early in the morning and after sunset.

Upstream and downstream traps were installed on 30 May 1981 in Bear Creek above the mouth of Skyland Creek (Site 1 on Figure 2). The primary objective was to monitor spawning migration of westslope cutthroat trout. Because of receding streamflows and diminished fish movement, the traps were relocated downstream on 22 June (Site 2). On 15 July, the traps were again moved downstream to a point 1.2 km above the junction of Bear Creek and the Middle Fork of the Flathead River (Site 3). The traps were operated at this site until 8 September 1981 to monitor upstream migration of spawning bull trout and downstream migration of juvenile bull and cutthroat trout.

Upstream and downstream traps were installed on 3 June in Geifer Creek, approximately 100 m upstream from its mouth (Figure 2). Due to heavy precipitation and high spring streamflows, the wire leads became clogged with debris and were forced down 10 days in June (the 6th through the 11th and the 16th through the 19th) allowing fish to move past the trap. The traps were removed on 21 July 1981. Upstream and downstream traps were placed five meters above the mouth of Stannard Creek on 20 May and removed on 28 May.

Upstream and downstream traps were installed in Challenge Creek near the Challenge Creek Forest Service cabin on 18 May 1981 and removed on 18 July 1981 (Figure 2).

Upstream and downstream traps were installed in Ole Creek 100 m above its mouth on 19 July and removed 7 September 1981 (Figure 2).

INVENTORIES OF WESTSLOPE CUTTHROAT AND BULL TROUT SPAWNING SITES

<u>Westslope Cutthroat Trout Spawning Sites</u>

Westslope cutthroat spawning sites (redds) are extremely difficult to identify and enumerate since spawning occurs in the spring during high streamflows. High spring streamflows carry large volumes of suspended sediment which limits observation of the redds. For this reason, inventories of cutthroat redds were conducted in small tributary drainages. The number of cutthroat trout redds counted in these drainages aid in identifying those drainages as important spawning areas.

Counts were conducted in Cyclone Creek, a tributary to Coal Creek in the North Fork drainage, and Challenge, Tumbler, Dodge, Skyland and Geifer creeks in the Middle Fork drainage during June and eary July. While conducting these counts in the Middle Fork tributaries, physical measurements were made of several parameters believed to be important in determining whether the redd was constructed by migratory or resident cutthroat trout. At each redd, a measurement was taken from the upstream edge of the depression to the downstream end of the tailspill area to determine redd length. Redd width was measured across the widest point in the depression. Depth was measured at the upstream edge of the depression.

Bull Trout Spawning Sites

Distribution and Abundance

Fourteen Middle Fork tributary drainages, nine North Fork tributary drainages and a portion of the North Fork of the Flathead River from Polebridge upriver into Canada were surveyed for bull trout spawning sites (redds) during September and October, 1981. The survey in the North Fork was conducted from 19 September through 14 October and the Middle Fork survey began on 30 September and was completed on 1 November. Redds were counted using a combination of ground and low level helicopter surveys.

In the North Fork, redds in the Big, Coal, Red Meadow, Whale and Trail drainages were counted from the ground. Cauldrey, Cabin, Howell, Kishenehn and Starvation creeks were surveyed by helicopter, flying at a slow speed as close to the creeks as the streamside canopy would allow. The North Fork of the Flathead River was surveyed by helicopter from Polebridge upriver to the mouth of Squaw Creek, 41.8 km (26 miles) north of the Canadian border. To insure optimum visibility from the helicopter, flying was done during clear weather with the helicopter oriented to keep the sun at the observers back (Eicher 1953).

In the Middle Fork,ground surveys were conducted on Morrison, Schafer, Ole, Lodgepole, Clack, Park, Bear, Nyack, Granite, Strawberry, Bowl, Coal, Trail and Dolly Varden creeks. All surveys were conducted in areas known to be used for spawning from previous redd surveys, as well as areas which contained suitable spawning habitat.

The criteria used to classify a redd were 1) presence of a depression (pit) and associated tailspill area of loosely piled gravel (Reiser and Bjornn 1979) and 2) redds appeared "cleaned" due to the disturbance of the substrate during redd construction. On the ground, observers could check each potential redd for the above characteristics, while helicopter observers relied exclusively on the cleaned appearance of disturbed redd sites to distinquish redds. Both ground and aerial observers ranked each redd observation as definite, probable and possible based on the following criteria:

A. Definite. The redd was located in an area that would not be cleaned due to stream hydraulics and contained either a recognizable pit and tailspill area or was easily observed from the helicopter.

B. Probable. A definite cleaned area of streambed located in an area that would not normally be cleaned by stream hydraulics. The pit and tailspill areas were not easily discernible or observed from a high altitude in a helicopter.

C. Possible. A clean area of streambed that could be attributed to stream hydraulics. No discernible pit or tailspill area or an area which may have a pit and tailspill area but was not "clean" due to sediment deposition or algal growth.

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

Comparison of Helicopter and Ground Surveys to Enumerate Bull Trout Spawning Sites

To verify the accuracy of helicopter counts, a comparison was made between helicopter and ground counts on portions of four North Fork tributaries and four Middle Fork tributaries. Helicopter and ground counts were replicated for identical segments of each stream. Helicopter counts were conducted during, or the day following ground counts. Due to limited field personnel, helicopter observers had counted portions of some of the sections on the ground. It was assumed observer bias was minimized because helicopter observers only counted limited portions of a section by ground.

Substrate Composition of Spawning Sites

Changes in streambed substrate composition resulting from natural or man-caused sources can significantly reduce fry production (Cordone and Kelly 1961, Iwamoto et al. 1978, Reiser and Bjornn 1979). Hollow core samples of spawning sites were collected using methods described by McNeil and Ahnell (1964). Samples were transported to the Flathead National Forest's Soils Laboratory for analysis. Percent of each size class was determined after oven drying and sieving using sieve sizes of 50, 19, 16, 6.35, 2 and .063 mm. Percent by weight and percent by volume were computed.

An effort was made to more effectively sample material less than .063 mm which often remains in suspension. An Imhoff settling cone was used to determine the volume of fine sediment in suspension within the corer. Total percent of material less than .063 mm was calculated for the volume of sediment in suspension, multiplied by a wet to dry conversion factor of 0.44 (Shirazi and Seim 1979), added to the volume of sediment less than .063 mm obtained after sieving.

When presenting the results, material retained on the 19 and 16 mm sieves were added together resulting in a size class of 16 to 50 mm. Bimodel results obtained by Fraley et al. (1981) were probably related to the size class intervals used in the sieve analysis. The size class interval between 19 and 50 was 31 mm and the interval between 2 and 16 mm was 14 mm, while between 16 and 19 the interval was only 3 mm. The 3 mm interval would logically contain less material.

The 6.35 mm sieve was used to analyze substrate samples in 1981 to allow further separation of small material to better assess impacts of sediment as a function of size. Koski (1966), Phillips et al, (1975) and Hausle and Coble (1976) observed the creation of a physical barrier to fry emergence when a significant percentage of material in the 2 to 6.35 mm size range was present. To compare the spawning site gravel composition between 1980 and 1981, only the 50, 16, 2 and .063 mm size classes were used.

Substrate samples were collected from two cutthroat redds in Challenge Creek and one cutthroat redd in both Skyland and Tumbler Creeks during June. Substrate samples were collected from bull trout redds, undisturbed streambed areas and artificially constructed redds in Big, Coal, Whale and Trail creeks in the North Fork drainage during October.

FOOD HABITS OF CUTTHROAT, BULL AND BROOK TROUT

Major Fish Food Organisms

Some knowledge of the aquatic insect community is necessary to evaluate availability and selection of prey items in the diet of trout. The benthic insect community of the lower Middle Fork was sampled by personnel of the Flathead 208 project in 1975 and 1976. Stanford et al. (1979, 1980, 1981) have studied the lower and middle portions of the drainage. Fraley et al. (1981) and Peterson et al. (1980) have completed baseline investigations establishing the taxa present and relative abundance of benthic insects in the Middle Fork River and the tributaries in Glacier National Park.

Benthic insect samples were colleced from Deerlick Creek in 1981, to determine the nature of the benthic community in a spring influenced stream. Information on this type of stream was not previously available from our study area. These samples were collected from two 0.33 m^2 portions of stream bottom with a modified kick net and processed following methods in Graham et al. (1980b).

Adult aquatic insects were collected by field crews throughout the drainage during summer and fall. These insects were preserved in labeled vials of 70 percent ethanol at the time of collection. Identifications to species were provided by Dr. George Romehild, Montana State University (Plecoptera and Ephemeroptera) and Dr. D. G. Denning (Trichoptera).

Analysis of Cutthroat, Bull and Brook Trout Stomachs

Stomachs were taken from mortalities at stream traps during spring and summer in Challenge, Geifer and Dodge creeks, and from electrofishing associated with surveys and population estimates in Park, Deerlick, Essex and Challenge Creeks. For fish larger than 70 mm, stomachs were sectioned from the base of the esophagus to the pylorus and placed in labeled vials of 10 percent formalin. Fish smaller than 70 mm were preserved whole in in the same solution.

The preserved samples were emptied in the lab and the contents were analyzed by department personnel. The contents were identified, counted and volumes were measured. Aquatic insects were identified to family and terrestrial insects keyed to order using the following taxonomic references:

Ephemeroptera - Edmunds et al. (1976)
Plecoptera - Bauman et al. (1977)
Trichoptera - Wiggins (1977)
Diptera - Merritt and Cummins (1978)
Coleoptera - Merrit and Cummins (1978)
Terrestrials - Borror and White (1970).

Insect head capsules were counted to determine numbers. A 10 ml, self-zeroing buret was used to deliver water into a 10 ml graduated cylinder which contained the food type. Volumes were measured by displacement, with any volume less than .05 ml assigned to a trace value of .01.

Data from stomach analyses were expressed as percentage of total number, percentage of total volume and frequency of occurrence of each taxa. These measurements all contain biases which limit their usefulness, especially when any one method is used alone (Windell 1971). An index of relative importance (IRI) was developed which combines percent number, percent volume and frequency of occurrence into an arithmetic mean ranging from one to 100 (George and Hadley 1979). An IRI value of 100 indicates exclusive use of that food type.

MIDDLE FORK CREEL CARD SURVEY

Creel Card Returns

Voluntary creel cards described in Graham et al. (1980a) were available during the 1981 angling season on the Middle Fork above Bear Creek. Card distribution boxes were located at the Bear Creek trail head and at Schafer Meadows airstrip. The cards were addressed and stamped and could either be mailed or returned to the card distribution boxes by anglers. Data from returned cards were used to calculate percent composition and catch rates per hour for each species.

Hook and Line Sampling

Department personnel sampled the fish population in most tributaries by fly fishing with both dry and submerged flies. The percent composition and catch rate for each species was calculated and compared to results from previous years.

RESULTS AND DISCUSSION

FISH DISTRIBUTION AND ABUNDANCE

North, Middle and South Fork Tributaries

Fish Distribution and Density Estimates

Fish abundance estimates were made in 16 North Fork, 36 Middle Fork and eight South Fork tributary reaches during the summer of 1981. The sections censused were randomly selected to be representative of the entire reach. Two of the 16 sections in North Fork tributaries were censused once in mid-July and again late in the summer to assess seasonal variation in fish abundance. Fish abundance estimates in 16 North Fork tributary reaches were conducted during previous years allowing analysis of annual variation in abundance. Reaches censused in the Middle Fork and South Fork tributaries were done for the first time during 1981.

Estimates have been made in a total of 186 tributary reaches during the three years of the study. In the 159 reaches surveyed which contained fish, observers recorded a total of 7,207 cutthroat, 933 juvenile bull trout, 327 eastern brook trout, and 1,747 mountain whitefish. Cutthroat were present in 151 reaches (95 percent of the total) of which 81 contained cutthroat exclusively. Bull trout were observed in 79 reaches (50 percent of the total) and in seven of these reaches only bull trout were seen. Eastern brook trout were observed in 13 Middle Fork tributary reaches, but were absent from all other reaches surveyed. Mountain whitefish were observed in a total of 55 tributary reaches.

Bull trout were seen in 36 (80 percent) of the tributaries surveyed in the Middle Fork and two (40 percent) of the tributaries surveyed in the South Fork during the study period (Tables 1 and 2). Inventories in 1981 recorded the presence of bull trout in two additional tributaries in the North Fork drainage bringing the total number of tributaries containing bull trout to 27 (57 percent) (Tables 3 and 4). Cutthroat trout were observed in 42 (93 percent) of the tributaries surveyed in the Middle Fork, all five tributaries surveyed in the South Fork, and all 47 tributaries surveyed in the North Fork. The three Middle Fork tributaries where no cutthroat were seen were Deerlick, Dickey and Paola creeks. Deerlick and Dickey creeks contained eastern brook trout and Paola Creek supported bull trout exclusively. Eastern brook trout were observed in ten lower Middle Fork tributaries (Table 2).

It appears that in some tributaries juvenile bull trout may emerge as fry from spawning areas located in the lower portions of the streams and actively migrate upstream to rear in the upper portions of the streams. No age 0 bull trout were observed in upper reaches of Trail and Coal creeks in the North Fork drainage and Morrison, Bear and Paola creeks in the Middle Fork drainage, while all these reaches contained bull trout age I and older. In Trail Creek, a portion of the creek dries up in the fall

Table 1. Current information on fish distribution in upper (above Bear Creek) Middle Fork tributaries, + = species present, - = species absent, * = migratory cutthroat, ? = unknown, needs further study.

	Cutthroat trout		
	Adfluvial	Resident	Bull trout
Charlie	?	+	+
Long	?	+	+
Bergsicker	?	+	+
Twenty-five Mile	?	+	—
Granite	*	+	+
Challenge	*	+	+
Dodge	*	+	+
Lake	?	+	+1/
Miner	?	+	—
Morrison	*	+	+
Lodgepole	?	+	+
Whistler	?	+	+
Schafer	?	+	+
W. Fork Schafer	?	+	—
Dolly Varden	?	+	+
Argosy	?	+	+
Calbic	?	+	+
Cox	?	+	—
Clack	?	+	+
Bowl	?	+	+
Basin	?	+	+
Strawberry	?	+	+
E. Fork Strawberry	?	+	+
Trail	?	+	+
S. Fork Trail	?	+	—
Gateway	?	+	+

1/ Bull trout were present below the falls.

Table 2. Current information on fish distribution in lower (below Bear Creek) Middle Fork tributaries. + = species present, - = species absent, * = migratory cutthroat, ? = unknown, needs further study.

	Cutthroat trout			
	Adfluvial	Resident	Bull trout	Eastern Brook trout
Glacier Park				
McDonald	+	+	+	—
Lincoln	?	+	+	+
Walton	?	+	—	+
Harrison	?	+	+	+
Nyack	?	+	+	—
Coal	?	+	+	+
Pinchot	?	+	+	—
Muir	?	+	+ 1/	—
Park	?	+	+	—
Ole	+	+	+	+
Forest Service				
Deerlick	—	—	+	+
Stanton	—	+	+	+
Tunnel	—	+	—	—
Paola	—	—	+	—
Dickey	—	—	—	+
Essex	?	+	—	—
Bear	*	+	+	+
Geifer	?	+	+	+
Skyland	?	+	+	—

1/ One mature bull trout and no juvenile bull trout were observed.

Table 3. Current information on fish distribution in westside North Fork tributaries. + = species present, – = species absent, ? = unknown, needs further study.

	Cutthroat		
	Adfluvial	Resident	Bull trout
Canyon	–	+	+[2/]
McGinnis	+[1/]	+	+[2/]
Kimmerly	–	+	–
Big	+	+	+
Langford	+	+	+
Lookout	–	+	–
Elehehum	–	+	–
Hallowat	+	+	+
Werner	+	+	+
Skookoleel	+	+	+
Nicola	?	+	+
	–	+	+
Coal	+	+	+
Cyclone	+	+	+
Dead Horse	?	+	+
South Fork Coal	+	+	+
Mathias	+	+	+
Moran	+	+	+[3/]
Hay	?	+	+[3/]
Red Meadow	+	+	+
Moose	+	+	+
Whale	+	+	+
Shorty	+	+	+
Teepee	–	+	–
Trail	+	+	+
Ketchikan	+	+	–
Yakinikak	+	+	+
Antley	–	+	–
Nokio	–	+	–
Tuchuck	+	+	–
Colts	–	+	–

1/ Cutthroat present below a falls located 1.34 km above mouth.
2/ Bulls present below a falls located .15 km above mouth.
3/ Bull trout in these tributaries may be resident bull trout. Access into these creeks is blocked during the fall months.

Table 4. Current information on fish distribution in Glacier Park and Canadian tributaries to the North Fork. + = species present, — = species absent, ? = unknown, needs further study.

	Cutthroat trout		
	Adfluvial	Resident	Bull trout
Glacier Park			
Camas	+	+	—
Dutch	+	+	—
Anaconda	+	+	—
Logging	?	+	+
Quartz	?	+	+
Cummings	?	+	—
Bowman	?	+	—
Akokala	+	+	—
Parke	?	+	—
Long Bow	?	+	—
Ford	?	+	—
Kintla	?	+	—
Starvation	+	+	+
Kishenehn	+	+	+
Spruce	+	+	—
Sage	+	+	+
British Columbia			
Howell	+	+	+
Cabin	+	+	+
Cauldrey	+	+	+

preventing adult bull trout from spawning in the upper drainage, yet electrofishing captured juvenile bull trout above this barrier. In upper Coal Creek, no age 0, but numerous age I and older bull trout were observed during late summer of 1980 and 1981. Although age 0 bull trout are often difficult for divers to see, no bull trout redds have been seen in any surveys at or above this location.

Cutthroat and bull trout densities were computed for all 58 reaches censused during 1981 which supported fish (Tables 5-7). Total density for each species includes age I and older trout because estimates of age 0 trout may not be as accurate due to variation in time of emergence and difficulty in observation.

Density calculations for each species were computed using only those reaches where the species was present. Densities of age I and older cutthroat in 151 reaches ranged from 0.1 to 74.4 fish per 100 m^2 surface area. Mean density of age I and older cutthroat was 6.9 fish per 100 m^2 for tributaries in the North, Middle and South Fork drainages.

North Fork tributaries had consistently higher densities of age I and older cutthroat, averaging 10.1 fish per 100 m^2 in 1981, the same as the mean density calculated for 1979-80 (Fraley et al. 1981). Lower Middle Fork tributaries had a density of 3.8 cutthroat per 100 m^2 compared to 4.2 fish per 100 m^2 in upper Middle Fork tributaries (Fraley et al. 1981). Tributaries inventoried in the South Fork averaged 3.4 cuthroat per 100 m^2.

Mean total bull trout densities were 1.4 fish per 100 m^2 in the North Fork during 1981, 1.0 fish per 100 m^2 in the lower Middle Fork, and 0.8 fish per 100 m^2 in the upper South Fork. In 1980, Fraley et al. (1981) calculated bull trout densities of 1.5 fish per 100 m^2 in the North Fork drainage and 1.7 fish per 100 m^2 in the upper Middle Fork drainage. The bull trout density for all Middle Fork tributaries was 1.4 fish per 100 m^2. The mean total eastern brook trout density for lower Middle Fork tributaries was 1.7 age I and older fish per 100 m^2.

Stream reaches important for a species of fish were identified as "critical reaches" based on the relative abundance of that species within the reach. The criterian used in identifying particularly critical or unique reaches for cutthroat trout was that the reach supported total cutthroat densities higher than 10 fish per 100 m^2. It was recognized that this figure is arbitrary and reaches supporting lower densities are also important cutthroat rearing areas. Critical cutthroat rearing areas identified in the North Fork drainage include 17 reaches in Langford, Moose, Ketchikan, Moran, Cyclone, Tuchuck, Bowman, Red Meadow, Sage, Dutch and the South Fork of Coal creeks. Rearing areas critical for cutthroat in the Middle Fork drainage were found in 13 reaches in Walton, Muir, Essex, Gateway, Basin, Challenge, Twenty-five Mile, Argosy, Cox and the East Fork of Strawberry creeks. Additional reaches were seasonally important, providing overwinter habitat (Everest 1969, Bjornn 1971, Thurow 1976) and migration corridors.

Table 5. Mean densities (no./100m²) of cutthroat and juvenile bull trout in North Fork tributaries surveyed during the summers of 1979, 1980 and 1981. Total for each species refers to age classes I, II and III+ combined.

Stream	Reach	Date	(m²) Area	Cutthroat trout Age 0	Cutthroat trout Age I	Cutthroat trout Age II	Cutthroat trout Age III+	Cutthroat trout Total	Bull trout Age 0	Bull trout Age I	Bull trout Age II	Bull trout Age III+	Bull trout Total
Canyon	1	8-17-81	1119	---	---	0.2	0.9	1.1	---	---	---	---	---
	1	9-4-80	1000	---	---	0.2	0.8	1.0	---	---	---	---	---
Langford	1	7-8-81	310	---	1.3	5.5	1.3	8.1	---	---	---	---	---
	1	8-7-81	296	11.8	7.8	3.0	5.4	16.2	---	---	0.3	---	0.3
	1	9-14-80	143	2.7	1.8	---	38.6	40.4	---	---	---	---	---
	2	7-8-81	209	---	2.9	1.9	3.8	8.6	---	---	---	---	---
	2	9-14-80	118	5.0	---	13.5	60.9	74.4	---	---	---	---	---
Coal	3	8-18-81	935	6.6	1.2	1.4	3.2	5.8	---	1.2	0.8	0.3	2.3
	3	9-13-79	600	0.5	1.2	2.0	2.9	6.1	---	1.5	0.3	---	1.8
Mathias	1	7-12-81	745	---	---	---	0.5	0.5	---	---	0.7	1.2	1.9
	1	9-13-79	411	---	---	1.2(II+)	---	1.2	---	---	1.0(II+)	---	1.0
Cyclone	1	7-23-81	569	6.3	20.6	16.0	8.3	44.9	---	0.2	0.2	0.2	0.6
	1	9-12-80	587	34.9	2.9	5.1	4.9	12.9	---	---	---	---	---
Dead Horse	1	7-9-81	297	---	3.4	6.1	9.8	19.2	---	---	---	---	---
	1	9-13-80	406	1.7	---	0.6	0.3	0.9	---	---	---	---	---
	2	7-9-81	247	---	2.2	4.0	6.7	12.9	---	---	---	---	---
	2	9-13-80	177	---	0.6	---	1.2	1.8	---	---	---	---	---
So. Fork Coal	1	7-12-81	737	---	---	---	0.4	0.4	---	---	---	---	---
	1	9-12-80	616	---	---	0.2	0.2	0.4	---	---	0.3	1.2	1.5
Moran	1	8-19-81	562	1.6	7.3	5.5	5.7	18.5	0.2	0.2	0.3	0.2	0.7
	1	7-26-80	542	0.6	4.2	9.8	6.9	20.9	---	0.7	---	0.4	1.1
	3	7-11-81	443	---	---	0.3	0.8	1.1	0.2	---	0.2	0.6	0.8
	3	7-26-80	423	---	---	0.2	0.2	0.4	---	---	---	---	---
Akokala	1	8-19-81	1261	30.1	3.9	2.7	2.8	9.4	---	---	---	---	---
	1	8-19-80	1577	0.6	0.4	0.1	1.3	1.8	---	---	---	---	---
Moose	3	7-14-81	640	---	---	1.3	4.5	5.8	---	---	---	---	---
	3	9-7-81	603	1.2	2.3	3.6	5.7	11.6	---	---	---	---	---
	3	7-28-80	593	---	5.9	10.1	46.0	62.0	---	---	---	---	---
Whale	2	8-10-81	1754	---	---	0.2	0.5	0.7	---	---	---	---	---
	2	8-20-80	1186	---	---	---	0.6	0.6	1.5	1.0	1.1	0.5	2.6
Ketchikan	1	7-10-81	206	---	9.2	8.3	8.7	26.3	0.1	0.2	0.1	0.7	1.0
	1	8-26-80	104	29.8	4.8	11.5	17.3	33.6	---	---	---	---	---
Red Meadow	2	7-30-81	1808	0.3	1.3	1.6	6.0	9.8	---	---	---	---	---
	2	7-5-79	360	14.7	0.3	4.7	6.9	18.8	0.9	0.1	0.1	0.5	0.7
	2	9-11-80	1263	1.5	3.5	3.7	2.5	9.7	7.5	1.1	4.4	1.6	7.1
									---	0.1	0.2	---	0.3

Table 6. Mean densities (no./100m²) of cutthroat, eastern brook and juvenile bull trout in lower Middle Fork tributaries surveyed during the summer of 1981. Total for each species refers to age classes I, II and III+ combined.

Stream	Reach	(m²) Area	Cutthroat trout					Bull trout					Eastern brook trout			
			Age 0	Age I	Age II	Age III+	Total	Age 0	Age I	Age II	Age III+	Total	Age I	Age II	Age III+	Total
McDonald	1	4500	---	0.1	0.2	0.4	0.7	---	---	---	0.1	0.1	---	---	---	---
Lincoln	1	1448	---	---	0.1	0.7	0.8	---	---	0.1	---	0.1	---	---	0.1	0.1
	2	745	---	0.3	0.5	2.1	2.9	---	---	0.1	0.1	0.2	---	0.9	0.5	1.4
Walton	1	945	---	0.1	0.9	2.4	3.4	---	---	---	---	---	---	0.1	0.2	0.3
	2	708	---	3.1	4.1	4.7	11.9	---	---	---	---	---	---	2.4	0.6	3.0
Deerlick	1	1007	---	---	---	---	---	---	---	---	---	---	---	1.1	---	1.1
Harrison	1	1595	---	0.1	---	0.5	0.6	---	---	---	---	---	---	---	0.1	0.1
Nyack	1	568	---	---	---	---	---	---	0.1	---	---	0.1	---	---	---	---
	2	2996	---	---	---	0.1	0.1	---	---	---	0.1	0.1	---	---	---	---
Coal	1	1862	---	---	0.4	0.7	1.1	---	0.1	0.1	---	0.2	---	1.5	0.5	2.0
	2	2795	0.2	0.5	1.7	0.7	2.9	0.1	0.2	0.4	0.2	0.8	0.5	2.4	0.9	3.8
	3	1533	---	0.3	0.8	0.6	1.7	---	---	0.1	0.7	0.8	---	0.2	---	0.2
Pinchot	1	1128	---	0.4	1.3	0.7	2.4	---	0.4	2.0	0.2	2.6	---	---	---	---
	2	842	---	1.3	2.6	1.9	5.8	---	0.2	---	---	0.2	---	---	---	---
Stanton	1	1613	---	---	0.6	0.2	0.8	---	---	---	---	---	---	---	---	---
Tunnel	1	1178	---	---	---	0.1	0.1	---	---	---	---	---	---	---	---	---
	2	1420	---	---	0.1	---	0.1	---	---	---	---	---	---	---	---	---
Muir	1	713	---	---	1.7	9.9	11.6	---	---	---	0.1	0.1	---	---	---	---
	2	1318	---	---	1.8	3.5	5.3	---	---	---	---	---	---	---	---	---
	3	734	---	2.6	8.6	8.4	19.6	---	---	---	---	---	---	---	---	---
Paola	1	1167	---	---	---	---	---	---	0.2	0.2	0.4	0.8	---	---	---	---
Park	1	1514	---	0.2	0.4	0.7	1.3	---	0.1	---	0.1	0.2	---	---	---	---
	2	1172	---	0.6	2.6	0.6	3.8	---	---	0.2	0.2	0.4	---	---	---	---
	3	1172	---	3.4	1.3	0.4	5.1	---	0.2	---	---	0.2	---	---	---	---
	4	927	---	---	1.1	3.2	4.3	---	---	---	---	---	---	---	---	---
Ole	1	1380	---	---	0.4	1.2	1.6	---	1.6	0.7	1.8	4.1	---	---	---	---
	2	1211	---	0.7	1.2	3.0	4.9	---	0.3	0.7	0.7	1.7	---	---	---	---
	3	1437	---	0.6	2.6	1.5	4.7	---	0.8	1.6	0.8	3.2	---	---	---	---
Essex	1	888	---	3.3	6.6	7.3	17.2	---	---	---	---	---	---	---	---	---
Bear	1	1296	---	---	---	0.3	0.3	---	---	0.1	2.7	2.8	---	---	0.5	0.5
	2	1319	---	1.5	0.1	0.5	2.1	---	0.2	0.1	0.2	0.5	1.5	2.5	2.3	6.4
	3	1195	---	---	0.3	0.3	0.6	---	0.1	0.3	0.7	1.1	0.2	---	0.4	0.6
Geifer	1	568	---	0.2	1.6	2.3	4.1	---	---	---	0.4	0.4	---	1.1	1.2	2.3
Skyland	1	662	---	0.4	0.3	0.5	1.2	---	0.8	1.5	1.1	3.4	---	---	---	---

Table 7. Mean densities (no./100m²) of cutthroat, eastern brook and juvenile bull trout in South Fork tributaries surveyed during the summer of 1981. Total for each species refers to age class I, II, and III+ combined.

				Cutthroat trout					Bull trout					Eastern brook trout			
Stream	Reach	Date	(m²) Area	Age 0	Age I	Age II	Age III+	Total	Age 0	Age I	Age II	Age III+	Total	Age I	Age II	Age III+	Total
Little Salmon	1	8-31-81	2383	---	---	0.1	0.3	0.4	---	---	---	---	---	---	---	---	---
White River	1	8-31-81	1602	0.2	---	0.3	0.9	1.2	---	---	---	---	---	---	---	---	---
	2	9-1-81	1414	---	---	0.2	3.0	3.2	---	---	---	0.1	0.1	---	---	---	---
Gordon	1	8-27-81	2055	1.5	0.3	---	---	0.3	---		---	---		---	---	---	---
	3	8-25-81	1330	1.7	1.1	4.3	3.3	8.7	---	1.3	0.7	1.3	3.3	---	---	---	---
	4	8-25-81	1206	---	0.2	7.7	3.7	11.6	---	0.1	0.3	0.2	0.6	---	---	---	---
Danaher	1	8-29-81	1639	0.1	0.4	0.4	0.6	1.4	---	---	---	---	---	---	---	---	---
Youngs	1	8-28-81	2744	---	---	---	0.6	0.6	---	---	---	---	---	---	---	---	---

Total bull trout densities higher than 1.5 fish per 100 m^2 identified areas critical for bull trout rearing. Seven reaches in Red Meadow, Starvation, Trail, Coal, Whale, Shorty and McGinnis creeks in the North Fork drainage were identified as critical for bull trout rearing. Critical bull trout rearing areas were identified in 15 reaches in Pinchot, Ole, Bear, Skyland, Whistler, Morrison, Charlie, Strawberry, Granite, Long and Trail creeks in the Middle Fork drainage.

Spring and early summer mark-recapture population estimates were completed for Langford Creek in the North Fork drainage and four Middle Fork tributaries (Table 8). An estimate conducted in Langford Creek on 8 August found 128 age I and older cutthroat compared to 142 estimated on 22 June.

Densities of Trout by Stream Feature

During 1981, 61 pools, 133 riffles, 212 runs and 80 pocketwater areas were snorkeled to estimate fish abundance. Pools contained the highest densities of all ages of cutthroat trout (Table 9). The average density of age I and older cutthroat trout in pools for combined upper drainage tributaries was 19.6 fish per 100 m^2 during 1981, the same as Fraley et al. (1981) reported for 1979 and 1980. The densities of age I and older bull trout were similar for all features during 1981. The only difference appeared in age III and older bull trout which were slightly more abundant in pools. Densities for bull trout by feature were similar when compared between 1981 and the previous two years.

During the course of the study, 394 pools, 637 runs, 574 riffles, and 188 pocketwater areas were snorkeled. Mean fish densities by age class were calculated for each feature (Table 10). Pools contained the highest densities of all ages of cutthroat and bull trout. Age III+ cutthroat and age II bull trout were much more numerous in pools, than in any other feature.

Comparing Several Methods of Estimating Fish Abundance

In North Fork tributaries differences and percent differences in the estimates of age I and older cutthroat were computed between; 1) snorkel counts and two-pass estimates, 2) snorkel counts and combined estimates, and 3) two-pass estimates and combined estimates (Table 11). In pools and runs snorkeling proved to be nearly as effective as the two-pass method to estimate numbers of age I and older cutthroat. When comparing differences by creek, it is clear that snorkeling in pools was more efficient in Cyclone Creek, an open meadow type section compared to streams containing abundant debris like Langford and Red Meadow creeks. Snorkeling in runs estimated fish numbers within three to 11 percent of the two-pass estimates in all three streams. The two-pass method estimated larger numbers of age I and older cutthroat than snorkeling in riffles and pocketwaters in all streams. The combined estimates, two electrofishing passes followed by a snorkel count, were very similar to the two-pass estimates in all cases except for pools in Cyclone Creek, where the original snorkel count observed more fish.

Snorkeling did not prove to be as effective a technique to estimate

Table 8. Spring and early summer electrofishing population estimates in 100 meter long sections for four Middle Fork tributaries and one North Fork tributary during 1981. Ninety-five percent confidence intervals are in parentheses.

Creek	Reach	Date	Flow (cfs)	Temp (°C)	Species	Age	Estimate
Middle Fork							
Paola	001	4/81	13.6	3.9	Bull trout	I+	26 (19-33)
Deerlick	001	4/81	31.1	5.5	Eastern brook trout	I+	77 (48-104)
Stannard	001	6/81	2.5 1/	7.7	Westslope cutthroat	I+	33 (23-37)
					Bull trout	I+	22 (11-33)
					Eastern brook trout	I+	33 (0-64)
Dodge	001	6/81	6.6	12.2	Westslope cutthroat	I+	130 (88-152)
North Fork							
Langford	001	6/81	---	7.8	Westslope cutthroat	I+	142 (78-196)

1/ Estimated flow on 4 July 1981.

Table 9. Density of westslope cutthroat and bull trout (number/100m^2) by feature in the North, Middle and South forks, and combined upper drainage in 1981. WCT=westslope cutthroat, DV=bull trout

Drainage and feature	No. of reaches	No. of WCT reaches	No. of features	WCT 0	WCT I	WCT II	WCT III+	WCT Total	No. of DV reaches	DV 0	DV I	DV II	DV III+	DV Total
North Fork														
Pool	14	14	(36)	7.7	7.4	7.7	10.8	26.0	8	0.6	0.3	0.4	0.9	1.6
Riffle	17	17	(76)	2.8	2.1	1.3	0.9	4.3	9	0.1	0.3	0.5	0.2	1.0
Run	17	17	(74)	5.2	4.1	4.6	5.1	13.8	9	0.2	0.4	0.4	0.6	1.5
Pocket	10	10	(19)	2.0	3.4	3.9	5.0	12.2	5	0.2	---	---	0.5	0.5
Middle Fork														
Pool	15	13	(20)	T[1/]	0.9	5.8	9.3	16.0	11	---	0.2	0.1	1.0	1.3
Riffle	22	22	(47)	---	0.4	0.5	0.4	1.3	16	T[1/]	0.1	0.1	0.2	0.4
Run	33	32	(114)	T[1/]	0.8	1.7	2.3	4.9	23	T[1/]	0.2	0.4	0.4	1.0
Pocket	21	20	(56)	---	0.3	1.3	1.8	3.4	15	---	0.3	0.4	0.4	1.1
South Fork														
Pool	5	5	(5)	1.1	0.4	6.7	4.0	11.1	3	---	0.2	0.4	0.4	0.9
Riffle	6	6	(10)	---	---	T	T	0.1	2	---	1.0	---	0.3	1.3
Run	8	8	(24)	0.5	0.3	2.2	1.8	4.3	4	---	0.4	0.2	0.4	1.1
Pocket	3	3	(5)	---	T	1.9	2.3	4.2	3	---	---	0.1	0.1	0.2
Combined														
Pool	34	32	(61)	3.5	3.7	6.8	9.1	19.6	22	0.2	0.2	0.2	0.9	1.3
Riffle	45	45	(133)	1.1	1.0	0.7	0.6	2.3	27	T[1/]	0.3	0.2	0.2	0.7
Run	58	57	(212)	1.6	1.7	2.7	3.1	7.5	36	0.1	0.3	0.4	0.5	1.1
Pocket	34	33	(80)	0.6	1.2	2.2	2.8	6.2	23	T[1/]	0.2	0.3	0.4	0.9

1/ Trace values indicate a density less than 0.05 fish per 100 m^2.

Table 10. Mean densities (number of fish/100 m^2) by age class of westslope cutthroat and bull trout in run, riffle, pool, and pocketwater habitat features snorkeled during 1979, 1980 and 1981. Number of features snorkeled is in parentheses.

Species	Feature: Pool (394)	Run (637)	Riffle (574)	Pocketwater (188)
Cutthroat trout				
Age 0	1.4	1.3	0.6	0.5
Age I	1.7	1.4	0.4	0.7
Age II	4.7	2.2	0.4	2.1
Age III+	11.3	3.5	1.2	2.3
Ages I and older	17.7	7.1	2.0	5.0
Bull trout				
Age 0	0.3	0.3	0.1	0.1
Age I	0.6	0.5	0.5	0.1
Age II	1.6	0.4	0.3	0.4
Age III+	0.4	0.2	0.1	0.2
Ages I and older	2.6	1.1	0.9	0.7
Total trout density (ages I and older)	20.3	8.2	2.9	5.7

Table 11. July and August, 1981 population estimates for age I and older cutthroat trout in three North Fork tributary sections by feature using snorkel counts, two-pass electrofishing and combined (two electrofishing passes followed by a snorkel count) estimates and the differences between the estimates.

Feature	Stream	Reach	Temp °C	A Snorkel count	B Two-pass estimate	C Combined estimate	A-B Difference (Percent)	A-C Difference (Percent)	B-C Difference (Percent)
Pools	Red Meadow	2	10.5	80	105	97	-25(31)	-17(21)	8(8)
	Cyclone	1	15.0	134	91	120	43(32)	14(10)	-29(32)
	Langford	1	10.5	31	61	53	-30(97)	-22(71)	8(13)
	TOTAL			245	257	270	-12(5)	-25(10)	-13(5)
Riffles	Red Meadow	2	10.5	12	25	23	-13(108)	-11(92)	2(8)
	Cyclone	1	15.0	24	30	29	- 6(25)	- 5(21)	1(3)
	TOTAL			36	55	52	-19(53)	-16(44)	3(5)
Runs	Red Meadow	2	10.5	39	38	42	1(3)	- 3(8)	- 4(11)
	Cyclone	1	15.0	95	98	107	- 3(3)	-12(13)	- 9(9)
	Langford	1	10.5	28	31	34	- 3(11)	- 6(21)	- 3(10)
	TOTAL			162	167	183	- 5(3)	-21(13)	-16(10)
Pocketwater	Red Meadow	2	10.5	20	37	36	-17(85)	-16(80)	1(3)
	Langford	1	10.5	7	17	13	-10(143)	- 6(86)	4(24)
	TOTAL			27	54	49	-27(100)	-22(81)	5(9)

Table 12. August, 1981 population estimates for age I and older bull trout in three North Fork tributary sections by feature using snorkel counts, two-pass electrofishing and combined (two electrofishing passes followed by a snorkel count) estimates and the differences between the estimates.

Feature	Stream	Reach	Temp °C	A Snorkel count	B Two-pass estimate	C Combined estimate	A-B Difference (Percent)	A-C Difference (Percent)	B-C Difference (Percent)
Pools	Red Meadow	2	10.5	3	9	8	- 6(200)	- 5(167)	1(11)
	Whale	2	10.0	15	21	22	- 6(40)	- 7(47)	- 1(5)
	Trail	1	7.8	1	28	21	-27(2700)	-20(2000)	7(25)
	TOTAL			19	58	51	-39(205)	-32(168)	7(12)
Riffles	Red Meadow	2	10.5	5	2	2	3(60)	3(60)	0(0)
	Whale	2	10.0	35	37	36	- 2(6)	- 1(3)	1(3)
	TOTAL			40	39	38	1(3)	2(5)	1(3)
Runs	Red Meadow	2	10.5	1	4	4	- 3(300)	- 3(300)	0(0)
	Whale	2	10.0	4	25 1/	14	-21(525)	-10(250)	11(44)
	Trail	1	7.8	0	57	48 2/	-57(-)	-48(-)	9(19)
	TOTAL			5	86	66	-81(1620)	-61(1220)	20(23)
Pocketwaters	Red Meadow	2	10.5	2	1	2	1(50)	0(0)	- 1(100)

1/ Two-pass estimate did not provide a reliable estimate (probably a high bias) because seven fish were captured on the first pass and five fish were captured on the second pass.

2/ During the snorkel count following the two electrofishing passes, a conscious effort was made to observe fish by removing rocks in the streambed.

age I and older bull trout abundance. Riffles and pocketwaters were the only habitat features where snoreling estimates were close to estimates obtained using two-pass and combined methods (Table 12). In pools and runs, electrofishing estimates were much higher than snorkel estimates. The behavior of bull trout may cause the difference in snorkel and electrofishing estimates between shallow-fast water areas (riffles and pocketwaters) and deep-slow water areas (pools and runs). Bull trout tend to seek cover in slow water areas making them more difficult to observe when snorkeling. Combined estimates were close to two-pass estimates in all cases but runs in Whale Creek. This discrepency was probably caused by an inflated estimate resulting from a low catch during the first electrofishing pass (seven fish), compared to the second pass catch of five fish.

Snorkeling efficiencies for juvenile bull trout in Trail Creek were low. The juvenile bull trout were lying in the substrate, and in most cases under the substrate, where they could not be easily observed. After electrofishing a run in Trail Creek, two divers snorkeled the area and located nine more juvenile bulls by lifting streambed material.

Comparisons were made between population estimates done using snorkel counts, two pass electrofishing, and mark-recapture electrofishing obtained in three Middle Fork tributaries (Table 13). The sections were approximately 100 m long in Geifer and Essex creeks, and 140 m long in Challenge Creek. The population estimates were compared for age II and older cutthroat trout in Challenge Creek (adjusted to 100 m of stream length), because age I and younger fish were less than 75 mm and could not be sampled effectively. In Geifer and Essex creeks, estimates were compared for age I and older cutthroat, bull and eastern brook trout.

The three methods produced similar estimates of cutthroat trout in Geifer and Essex creeks, but divers did not see as many fish as were estimated by the two electrofishing estimates in Challenge Creek. The water temperature in Challenge Creek was under 9° C at the time the estimates were made compared to 14° C in Geifer Creek and 10° C in Essex Creek. The Challenge Creek snorkel counts were done during cloudy weather and turbid water conditions, both factors which reduce snorkeling efficiencies. Estimates of eastern brook and bull trout in Geifer Creek were similar for all three methodologies.

Low water temperature appears to reduce the efficiency of snorkel counts. Cooler water temperatures cause fish to seek cover becoming less active and making it more difficult for divers to observe them. In Trail Creek, for example, the water temperature was 8° C during the survey and all juvenile bull trout were found hiding in the substrate. Work will continue during the next year to evaluate the effect temperature, streamflow and cover variables have on the efficiency of population estimators. In the future, fish abundance estimates will be adjusted based on the relative efficiencies of the methods used to obtain the estimates. Variation in results obtained using snorkel counts can be minimized by conducting the counts during the same time of year. Water temperature, streamflow and water clarity all affect the efficiency of snorkel counts.

Table 13. July and August, 1981 population estimates for age I and older cutthroat trout, bull trout and eastern brook trout in three Middle Fork tributary sections using snorkel counts, two-pass electrofishing and mark-recapture electrofishing estimates and the differences between the estimates.

Stream	Reach	Water temp. (°C)	A Snorkel count	B Two-pass estimate (95% CI)	C Mark-recapture estimate (95% CI)	A-B Difference (Percent)	A-C Difference (Percent)	B-C Difference (Percent)
Westslope cutthroat trout								
Challenge[1/]	1	8.9	23	32 (±1)	54 (±9)	-9(39)	-31(135)	-22(69)
Geifer[2/]	1	14.4	22	26 (±5)	27 (±4)	-4(18)	- 5(23)	- 1(4)
Essex[2/]	1	10.0	87	94 (±23)	111 (±17)	-7(8)	-24(28)	-17(18)
TOTAL			132	152	192	-20(15)	-60(45)	-40(26)
Bull trout								
Geifer	1		7	7	7	0(0)	0(0)	0(0)
Eastern brook trout								
Geifer	1		15	15 (±2)	19 (±6)	0(0)	- 4(27)	- 4(27)

1/ Age II and older cutthroat trout, estimates were adjusted to 100 m section.
2/ Age I and older cutthroat trout.

North, Middle and South Fork Rivers

North Fork

Quantitative fish abundance estimates were difficult to obtain in the North Fork of the Flathead River due to its large size, limited underwater visibility and transitory habits of the fish populations. During 1981, the relative abundance of westslope cutthroat, juvenile and adult bull trout, and mountain whitefish were compared by snorkeling the river from Ford Station downriver to Polebridge on 4 July and 14 August. Flows were 6770 cfs on 4 July and 1770 cfs on 14 August near Columbia Falls, Montana making observations more difficult in July.

Juvenile cutthroat trout were observed more frequently during the August observation. Few juvenile bull trout were seen in the North Fork during either census due in part to their close association to cover. Adfluvial adult bull trout were seen more frequently during the 4 July census. These adults were seen holding in deep pools. Mountain whitefish were more abundant in the North Fork during the 14 August census. Few mountain whitefish were seen during the 4 July snorkel census. In August, large schools of twenty to eighty whitefish were seen in most of the pools and smaller groups were observed in other areas of the river.

Middle Fork

Fish populations in the Middle Fork of the Flathead River below Bear Creek were censused in August, 1981 to compare fish density estimates between the lower and upper Middle Fork as well as between the Middle Fork, North Fork and South Fork. This information can be used to monitor the effects of development on fish abundance in these rivers.

Underwater counts were made in four pool, eight run, five riffle and one pocketwater habitat units in the lower Middle Fork below Bear Creek during the summer of 1981. A total of 31 westslope cuttroat trout, eight juvenile bull trout, five mature bull trout and 1,280 mountain whitefish were observed by divers.

Density estimates were made in two 2.9 km long sections of the Middle Fork, at Nyack and above Park Creek. Total age I and older cutthroat densities were 0.06 fish per 100 m^2 in the Nyack section and 0.03 in the section above Park Creek (Table 14). Fraley et al. (1981) observed densities of 0.29 and 0.14 age I and older cutthroat trout per 100 m^2 above and below Schafer Meadows, respectively. No cutthroat younger than age III were observed in the lower river. The low densities of age I and older cutthroat trout in the lower river could be related to changes in the amount of suitable habitat per unit of surface area and transitory

Table 14. Fish densities (number/100m²) by age class for pool, riffle, run and pocketwater habitats in 2.9 km sections of the Middle Fork of the Flathead River at Nyack and above Park Creek during late summer 1981. Number of features snorkeled and number of fish observed are in parentheses.

Feature	Westslope cutthroat			Bull trout			Mountain whitefish	
	Age I	Age II	Age III+	Age I	Age II	Age III+	<152mm	>152mm
Middle Fork at Nyack (8-18-81)								
Pool (1)	---	---	0.04 (4)	---	---	---	0.11 (11)	0.26 (25)
Run (4)	---	---	0.06 (8)	---	---	---	0.44 (58)	2.68 (351)
Riffle (2)	---	---	---	---	---	---	0.11 (13)	0.07 (8)
Combined (7)	---	---	0.03 (12)	---	---	---	0.24 (82)	1.13 (384)
Middle Fork above Park Creek (8-17-81)								
Pool (3)	---	---	0.18 (11)	---	---	---	0.33 (20)	5.58 (334)
Run (4)	---	---	0.03 (5)	0.01 (1)	---	0.01 (1)	0.32 (48)	1.95 (289)
Riffle (3)1/	---	---	0.01 (1)	---	---	0.05 (5)	0.14 (14)	0.46 (45)
Pocketwater(1)	---	---	0.10 (2)	---	---	0.05 (1)	0.29 (6)	2.78 (58)
Combined (11)	---	---	0.06 (19)	0.003 (1)	---	0.02 (7)	0.27 (88)	2.22 (726)

1/ Two adult adfluvial bull trout observed in one riffle.

habits of the fish. Graham (1977) found steelhead trout densities were lower (0.9 to 4.3 age I and older fish per 100 m^2) in large streams of Idaho, such as the Lochsa and Selway rivers, when compared to small tributaries in the same drainage (3.1 to 7.0 fish per 100 m^2).

Juvenile bull trout densities (age I and older) were 0.02 fish per 100 m^2 in the section above Park Creek (Table 14). No juvenile bull trout were seen in the Nyack section. Fraley et al. (1981) also found low densities of age I and older bull trout in the upper Middle Fork during 1980. Juvenile bull trout were difficult to observe in the river.

Five adult bull trout were seen in the entire 2.9 km long section of river above Park Creek. No adult bull trout were seen in the Nyack section. Fewer adult bull trout were observed in the lower river than in the upper river when snorkel counts were compared between 1980 (Fraley et al. 1981) and 1981. Fraley et al. (1981) counted a total of 42 and 58 adult bull trout in two 16 km sections in the upper river during late summer counts in 1980. The counts in the lower Middle Fork observed zero and five adult bull trout in two 2.9 km sections during late summer of 1981. The low numbers of adult bull trout observed in the lower river during 1981 could indicate that adult bull trout moved through the lower river early in the summer, or they did not hold in the lower river to the same extent as in the upper river. Densities of mountain whitefish were similar to those reported by Fraley et al. (1981) for the upper Middle Fork.

South Fork

Two 3.0 km long sections of the upper South Fork of the Flathead River were censused in late August to estimate fish abundance. The sections were located downstream from the mouth of the White River and between the mouths of Butcher and Gordon creeks.

Underwater snorkel observations were made in three pool, 12 run, and one riffle habitat units in the South Fork. A total of 193 westslope cutthroat, two juvenile bull trout, two mature bull trout and 1,191 mountain whitefish were observed by divers.

Total age I and older cutthroat trout densities were 0.39 fish per 100 m^2 in the section below the mouth of the White River and 0.91 per 100 m^2 in the Gordon Creek to Butcher Creek section (Table 15). No bull trout were observed in the section below the White River. Densities of age I and older juvenile bull trout of 0.01 per 100 m^2were observed in the Gordon Creek to Butcher Creek section. Five mature bull trout were seen in the Butcher Creek section. Relatively high mountain whitefish densities were observed in these snorkel sections.

Based on a sample of 23 cutthroat from the Big Prairie area of the South Fork of the Flathead River, Phelps (1982) determined that these cuttroat trout were genetically "pure" westslope cutthroat using electrophoretic analysis.

Table 15. Fish densities by age class for pool, riffle, run and pocketwater habitats in 3.0 km sections of the South Fork of the Flathead River below the mouth of the White River and between the mouths of Gordon and Butcher creeks during late summer 1981. Number of features snorkeled and number of fish observed are in parentheses.

Feature	Cutthroat trout			Bull trout			Mountain whitefish	
	Age I	Age II	Age III+	Age I	Age II	Age III+	<152mm	>152mm
South Fork below mouth of the White River (8-31-81)								
Run (5)	---	---	0.52 (45)	---	---	---	0.61 (53)	4.19 (365)
Riffle (2)	---	---	---	---	---	---	0.14 (4)	0.11 (3)
Combined (7)	---	---	0.39 (45)	---	---	---	0.49 (57)	3.19 (368)
South Fork between the mouths of Gordon and Butcher creeks (8-27-81)								
Pool (3)	---	1.37 (43)	2.07 (65)	0.03 (1)	---	---	0.48 (15)	4.40 (138)
Run (7)	0.008 (1)	0.09 (12)	0.22 (28)	---	---	0.008 (1)	0.84 (107)	3.96 (506)
Riffle (1)	---	---	---	---	---	---	---	---
Combined (11)	0.006 (1)	0.33 (55)	0.57 (93)	0.006 (1)	---	0.006 (1)	0.74 (122)	3.92 (644)

Fish populations were calculated for the two lower Middle Fork and two upper South Fork sections by multiplying observed fish densities (averaged within features) by the total surface area of that feature and summing the results. Estimates of abundance were reported as the number of fish per km of river length for comparison (Table 16).

Mountain whitefish were numerous in all surveyed river sections. Age II and older westslope cutthroat were second in abundance, but were less numerous than mountain whitefish by a factor of ten. Mature bull trout were more numerous in the Middle Fork above Bear Creek.

Fish densities in run habitats were compared between the North Fork, the upper Middle Fork above Bear Creek (1980), the Middle Fork below Bear Creek (1981) and the upper South Fork (1981). Densities of age III+ cutthroat trout were similar in the North, upper Middle and upper South Forks (Table 17). Densities of all ages of cutthroat trout were extremely low in the lower Middle Fork. Age II cutthroat trout densities were similar in the North and upper Middle Forks, but were low in the upper South Fork. Densities of age I cutthroat were low in all river sections suggesting that age I cutthroat rear in tributaries or were not observed in the rivers.

Densities of juvenile bull trout were low in all main rivers, probably due in part, to the difficulty in observing them.

HABITAT EVALUATION

Fish Habitat Characteristics of Middle and South Fork Tributary Reaches

Habitat surveys on the Middle Fork of the Flathead River were conducted in 186 kilometers of 19 tributaries, separated into 36 reaches. Surveys were also completed in eight reaches of five tributaries to the upper South Fork of the Flathead River covering a total of 56 kilometers.

The drainage areas, reach lengths and channel gradients were measured for the 36 Middle Fork tributary reaches surveyed during 1981 (Appendix B, Table 1). Late summer flows will be measured during 1982 for the Middle Fork tributaries below Bear Creek. Drainage areas, reach lengths, channel gradient and late summer flows were measured for the eight South Fork tributary reaches (Appendix B, Table 2). Drainage areas ranged from 21.9 to 440.1 km^2 in the lower Middle Fork tributaries and 101.7 to 336.8 km^2 in the upper South Fork tributaries. Late summer flows ranged from 34.1 to 50.7 cfs in the five South Fork tributaries. Detailed streamflow, water temperature and water chemistry information are presented in Appendix A.

Evaluation of Habitat Inventory Replicability

Comparisons between years and between crews yielded average percent errors ranging from six to 21 percent for objectively measured physical habitat parameters (valley flat, channel width, wetted width, average depth, maximum depth and D-90) (Table 18). Estimates of the percent

Table 16. Estimates of the number of cutthroat trout, bull trout and mountain whitefish per km in the upper Middle Fork during 1980, the lower Middle Fork during 1981 and the upper South Fork during 1981. The number of mature bull trout per km was based on actual counts in the census sections.

River and area	Year	Cutthroat trout			Bull trout				Mountain whitefish	
		Age I	Age II	Age III+	Age I	Age II	Age III+	Mature	<152 mm	>152 mm
Middle Fork										
Above Schafer Meadows	1980	1	3	42	4	3	<1	3	45	366
Below Schafer Meadows	1980	2	<1	25	<1	3	<1	4	14	666
At Nyack	1981	<1	<1	12	<1	<1	<1	<1	86	481
Above Park Creek	1981	<1	<1	9	2	<1	4	3	67	434
South Fork										
Below the White River	1981	<1	<1	82	<1	<1	<1	<1	111	673
Between Gordon and Butcher creeks	1981	1	18	35	<1	<1	1	1	172	837

Table 17 . Comparisons of mean densities of fish per $100m^2$ in North Fork, Middle Fork, and South Fork rivers run habitats snorkeled during 1980 and 1981. Number of features snorkeled and number of fish observed are in parentheses.

Feature	Year	Fish per $100m^2$ surface area							
		Cutthroat trout			Bull trout			Mountain whitefish	
		Age I	Age II	Age III+	Age II	Age III+	Mature	<152mm	>152mm
North Fork	1980								
Run average (11)		.01 (3)	.31 (117)	.37 (113)	---	.01 (3)	<.01 (1)	.59 (220)	1.18 (444)
Lower Middle Fork (below Bear Cr.)	1981								
Run average (8)		---	---	.04 (13)	<.01 (1)	---	<.01 (1)	.38 (106)	2.31 (640)
Upper Middle Fork (above Bear Cr.) (7/24 to 8/12)	1980								
Run average (10)		.06 (4)	.36 (22)	.41 (24)	---	---	.10 (6)	.34 (21)	4.98 (290)
Upper South Fork	1981								
Run average (12)		<.01 (1)	.05 (12)	.34 (73)	---	<.01 (1)	---	.74 (160)	4.05 (871)

Table 18. Average percent errors calculated for habitat parameters estimated in habitat surveys compared between crews and between years.

Habitat parameter	Between-year[1/] comparison	Between-crew comparison
Valley flat	19	10
Channel width	14	20
Wetted width	21	6
Average depth	14	8
Maximum depth	12	7
D-90	17	16
MEAN	16	12
Cover		
Overhang	50[2/]	9
Canopy	63[2/]	10
Features		
% Pool	31	53
% Riffle	43	34
% Run	15	22
% Pocketwater	--[3/]	67
MEAN	30	44
Bed Material		
% Organic	55	0
% Fines	22	9
% Gravel	22	17
% Cobble/Boulder	18	5
MEAN	29	8
Bank Material		
% Organic	34	56
% Fines	18	39
% Gravel	23	52
% Cobble/Boulder	13	45
MEAN	22	48
Channel Stability	--[3/]	6
OVERALL MEAN	29	23

1/ Between year comparisons may be influenced by differences in streamflow and possible changes in habitat parameters between years.

2/ Between year cover comparisons have high errors due to the differences in identifying both cover types for all replicate sections in the 1979 survey and possible changes in cover between years (flow, debris).

3/ Parameters not measured in 1979.

of each habitat feature, bed material and bank material had average errors of five to 60 percent. The highest average percent errors occurred for parameters with trace (less than one) or low estimated values, an inherent problem with the formula to compute percent error. Overall, the results obtained between crews and between years were similar and could detect most significant changes in habitat. The high percent errors between years for the cover parameters can be attributed to differences in identifying cover types and possible changes in the amount of cover between years.

Relationships Between Habitat Variables and Fish Densities

Fraley and Graham (1982) reported that trout cover, D-90 and stream order formed the best model describing age I and older westslope cutthroat and bull trout densities in 112 tributary reaches which contained fish ($R=0.64$, $P<0.001$). The correlation between actual trout densities and densities predicted by the model for 23 new reaches surveyed during 1981 was 0.63 with a least squares fit, and 0.84 when fitted with a zero Y-intercept. Discriminant analysis of the data produced similar results to those of multiple regression. Trout densities and physical stream habitat parameters differed significantly between reaches within geologic groups based on their underlying bedrock.

STREAM TRAPPING

All stream trapping during 1981 was conducted in Middle Fork tributaries. A combined total of 1,108 fish were collected in traps, of which 36 were captured more than once. A total of 106 cutthroat moved through upstream traps and 359 moved downstream. Twenty-one mature and 11 juvenile bull trout were captured as they moved upstream and 17 mature and 129 juveniles moved downstream through our traps. Five eastern brook trout moved upstream and 54 passed downstream. Mountain whitefish made up a large portion of our trap catch with 128 upstream and 285 downstream migrants. Records of trapping data by species and by creek are presented in Appendix C, Figures 1 through 8.

Ole Creek was selected for trapping to monitor the upstream migration of adult bull trout and the downstream movement and age composition of juvenile bull and cutthroat trout. Twelve mature bull trout were captured and tagged as they moved through the upstream trap. Eleven were captured moving back downstream, of which four had been previously marked. Of the 21 juvenile bull trout captured in the downstream trap, 30% were age class II, 60% were age class III and 10% were age class IV. Outmigrating cutthroat trout also numbered 21, of which 67% were age class III and 33% were age class IV. Mountain whitefish and eastern brook trout were also represented in the trap catch from Ole Creek. The traps were removed on 9 September to allow the passage of mature bull trout which had congregated below the leads.

Upstream and downstream traps were installed at three sites along Bear Creek during the summer of 1981. The uppermost site was utilized earliest in the season and the traps were moved progressively downstream as the volume of flow decreased.

The majority of fish captured in our traps at Site 1 were cutthroat trout. Twenty-five cutthroat trout passed through the upstream trap, three of which had been previously captured and tagged in the downstream trap. Fifteen cutthroat passed through the downstream trap, six of which had been marked previously when they moved through the upstream trap. This type of movement is believed to be seasonal movement of resident fish for spawning, feeding or other reasons, since this portion of the creek is isolated by barriers at each end. A single juvenile bull trout and one brook trout moved upstream through the traps.

On 22 June, the traps were moved downstream to Site 2 due to the lack of fish movement at Site 1. The upstream catch consisted of four cutthroat (two of which were recaptures from the downstream trap), one brook trout and two mountain whitefish. The downstream catch included seven cutthroat, three juvenile bull trout, three brook trout and four mountain whitefish. One 115 mm cutthroat captured moving downstream on 13 July, had been previously captured and tagged in the downstream trap in Geifer Creek on 13 June. It is believed that the majority of trout captured at Site 2 were residents of Bear Creek and its tributaries, since there is little suitable spawning habitat located in this section of the creek to attract the larger migratory cutthroat and bull trout.

The traps were moved downstream to Site 3 on 15 July to monitor the spawning migration of adfluvial bull trout. Mountain whitefish comprised the majority of the upstream movement. Cutthroat trout, brook trout and juvenile bull trout were also represented in the upstream trap catch. Nine mature bull trout were tagged as they passed through the upstream trap at this site. The downstream catch at Site 3 included 30 cutthroat and 28 juvenile bull trout. Two of the cutthroat and three of the juvenile bulls were previously tagged in the upstream trap at this site. Five of the nine mature bull trout which we tagged in the upstream trap and one previously untagged mature bull trout were captured moving back downstream.

There were no fish captured which moved through two successive trap sites in Bear Creek. Of the total outmigrating cutthroat trout (43 fish from all three sizes), 9% were age class II, 56% were age class III, 33% were age class IV and 2% were age class V. The net movement of mountain whitefish in Bear Creek was downstream, with 223 outmigrants and only 75 upstream migrants.

Geifer Creek was trapped to evaluate its importance as a nursery stream for fish species in Bear Creek. Geifer Creek and several of its tributaries were inventoried for cutthroat spawning on 4 July 1981, but no evidence of spawning was found. It is possible that cutthroat spawned before our survey was conducted and high flows made redds impossible to distinguish. Upstream and downstream traps were installed in Geifer Creek appproximately 100 m above its confluence with Bear Creek on 3 June.

The upstream trap catch consisted of 17 whitefish, 7 cutthroat, 2 brook and 4 juvenile bull trout. The downstream trap catch consisted of 83 cutthroat trout, 75 juvenile bull trout, 46 brook trout and 13 mountain whitefish. The age composition of the outmigrating cutthroat trout was 51% age class II, 48% age class III and 1% age class IV. For bull trout the age composition of outmigrants was 41% age class II and 59% age class III. Two juvenile bull trout were captured in a downstream trap in Stannard Creek.

Dodge and Challenge creeks join approximately 1 km downstream from the Challenge Creek Forest Service cabin to form Granite Creek. Granite Creek is an important rearing area for cutthroat and bull trout. A downstream trap was installed in Dodge Creek approximately 0.5 km above its mouth on 16 June. Only cutthroat trout were captured in this trap. Of the 33 fish captured, 19% were age II, 18% were age III and 64% were over three years of age.

Water temperatures in Dodge Creek were much lower than in other streams in this area and data from electrofishing in September of 1979 indicate that adult resident fish were less than 215 mm in total length. One-third of our trap catch was over 225 mm in length. These results suggest that Dodge Creek supported spawning runs of both resident and migratory populations of cutthroat trout. The number of larger fish captured indicated that Dodge Creek contributes substantially to the cutthroat population in Granite Creek.

On 21 June, an upstream trap was installed in Dodge Creek, but no fish were captured in this trap before it was removed on 13 July. Several baited minnow traps were placed near the trap site on 12 June. The catch consisted of three age I cutthroat trout, one age II bull trout and two age III bull trout.

Challenge Creek was selected for a trap site to monitor the spawning migration of cutthroat trout. Data indicated it was important as a rearing area for juvenile fish for both Granite Creek and the Middle Fork River. A total of 35 cutthroat trout and eight mountain whitefish were captured in the upstream trap. It was determined that both a resident population (<225 mm) and a migratory population (>225 mm) utilized Challenge Creek for spawning. Sixteen resident spawners passed through the upstream trap (13 males, one female, and two undetermined). Seventeen migratory cutthroat passed through the upstream trap (11 males, three females, and three undetermined). The downstream catch consisted of 85 cutthroat, one juvenile bull trout and 21 mountain whitefish. Eighteen of these cutthroat were residents (7 males, one female and 10 undetermined) and 45 were migratory (18 males, 19 females and eight undetermined). Nine migratory fish were recaptured in the downstream trap. The cutthroat of undetermined sex may have been juvenile fish. Sex ratios for resident cutthroat moving through our traps in Challenge Creek were 10 males to one female. For migratory fish, sex ratios were much closer to even. The sex ratio of the combined catch of mature fish was two males to one female. Similar sex ratios were described for spawning populations of cutthroat trout in Utah's Logan River by Fleener (1952). Sex ratios of a spawning run of coastal cutthroat in Oregon were 48 females to 52 males (Cramer 1940). Irving (1953) found 100 females to 96 males in spawning populations of cutthroat from Henry's Lake, Idaho. Huston (Montana Department of Fish, Wildlife and Parks files) found male:female sex ratios ranging from 1:3.2 to 1:6.2 in spawning populations of adfluvial westslope cutthroat in Hungry Horse Creek from 1965 through 1972.

The number of migratory cutthroat captured moving downstream compared to the number captured moving upstream indicated that our traps were not set early enough to monitor the entire spawning migration.

INVENTORIES OF WESTSLOPE CUTTHROAT AND BULL TROUT SPAWNING SITES

Westslope Cutthroat Trout Spawning Sites

North Fork Drainage

Cyclone Creek was surveyed on 24 June 1981 to count cutthroat trout spawning sites (redds). The survey was conducted from the mouth upstream to the end of Reach I, a distance of 2.0 km. Streamflow at this time was high and redds were difficult to see. Twelve possible redds were observed. Five of these may have been large enough to have been constructed by adfluvial or fluvial adults. Cyclone Creek probably provides important spawning and rearing habitat for adfluvial cutthroat trout.

Middle Fork Drainage

Redd surveys were conducted during mid to late June and early July on several streams in the Middle Fork drainage. Surveys were made on Dodge, Skyland, Tumbler, Geifer and Challenge creeks.

Dodge Creek was surveyed once on 14 June and again on 19 June. A 3.5 km section of this stream above the mouth contained the majority of suitable spawning habitat. No redds were observed during either survey, despite the presence of spawners moving downstream through traps. High water and an unstable streambed made detection of redds difficult.

The West Fork of Skyland Creek was surveyed on 19 June. No redds were found in a 2.1 km section above the confluence of the West Fork with Skyland Creek. The substrate was generally too large for cutthroat spawning and several possible barriers resulting from past logging operations were encountered.

Skyland Creek, from the West Fork to its junction with Bear Creek, was surveyed for cutthroat redds on 26 June and 8 July. A total of eight resident redds were observed in the canyon section, approximately 2.5 km above Bear Creek. Measurements were made on three of these redds (Table 18) and one was selected for core sampling to determine percent composition of different size classes of substrate (Figure 4).

A redd count was conducted on Tumbler Creek, from its confluence with Granite Creek upstream for 2.1 km on 19 June. The water was slightly turbid. Two redds were located below the Skyland Road crossing. Small

CUTTHROAT TROUT REDD SAMPLES

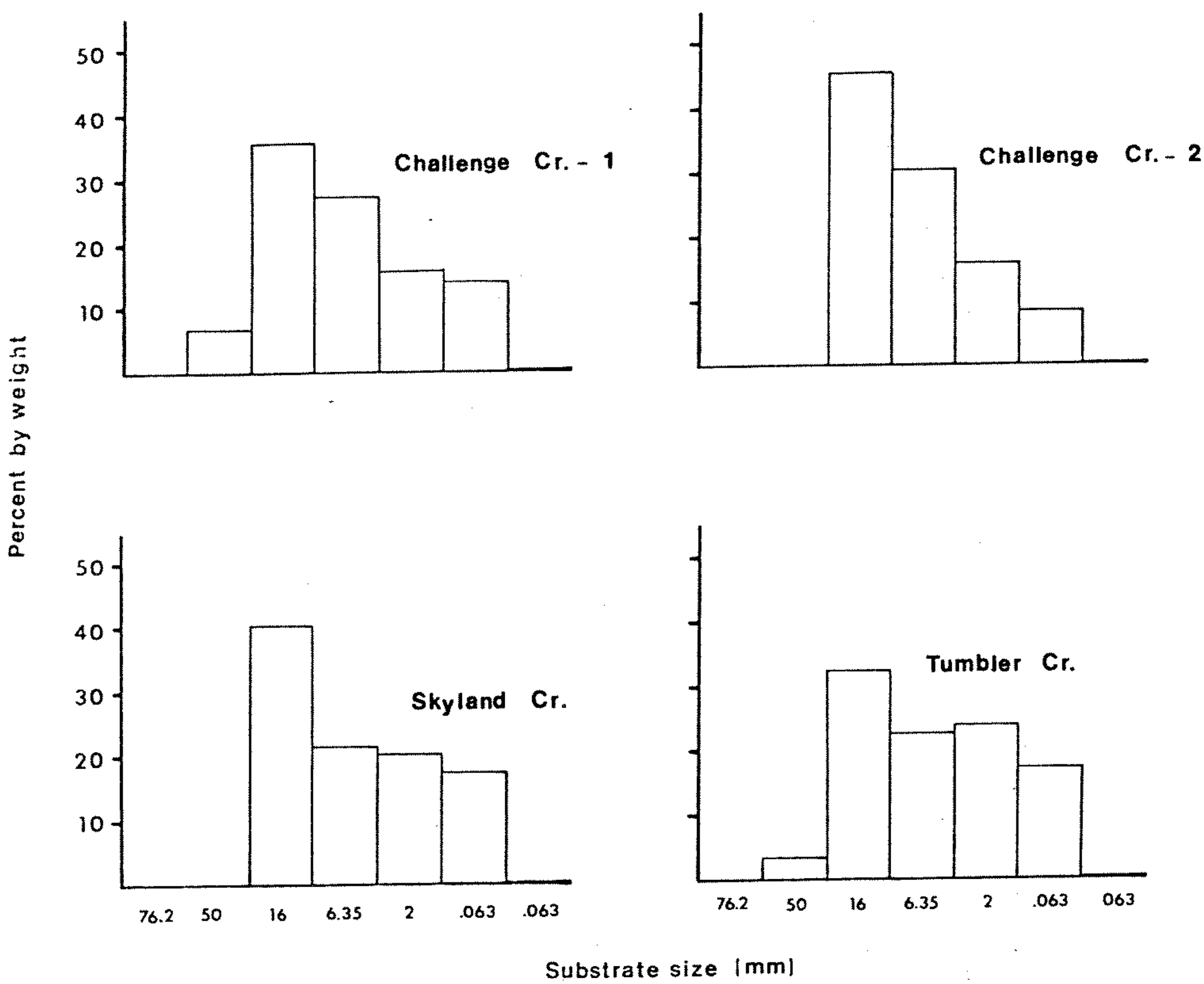

Figure 4. Substrate composition of gravels collected from cutthroat trout redds in Middle Fork tributaries in 1981. Each size class is expressed as a percent of the total sample weight.

resident fish were observed on both redds. Measurements were taken on both of these redds (Table 19) and one was selected for core sampling (Figure 4). Above the road crossing approximately 0.5 km, a barrier falls prevents further upstream migration. Several resident fish redds were observed above the barrier.

Geifer Creek was surveyed for cutthroat redds on 4 July from the mouth Mule Creek upstream to the forks. Snake Creek, a tributary to Geifer, was also surveyed at this time. No definite redds were observed during any of these surveys.

Our best observations of cutthroat spawning were in Challenge Creek. Our upstream trap identified movement of migratory fish into spawning areas and the downstream trap allowed us to enumerate the migratory fish moving back downstream after spawning was completed. A number of fish were observed while in the act of redd construction.

On 14 June, 26 redds were counted in Challenge Creek. Of the 25 redds above our traps, 21 were constructed by migratory fish. The numbers and sex ratio of nonresident cutthroat moving through the downstream trap indicated that approximately 20 spawning pairs utilized the creek above the trap for spawning. It appeared that migratory cutthroat in this stream constructed one redd per spawning pair.

Analysis indicated little difference existed in size composition of substrate in resident and migratory cutthroat redds (Figure 4). However, measurements of redd size indicate resident redds can generally be distinquished from migratory redds by size (Table 19).

Bull Trout Spawning Sites

Distribution and Abundance

Enumeration of bull trout spawning sites (redds) is an excellent method of obtaining information on the distribution of spawners within a drainage, identifying the relative importance of each tributary for spawning, and monitoring trends in population abundance. Adult bull trout spawn in the fall, generally from mid to late September, when streamflows are low and clear. Experienced observers easily identified bull trout redds during ground surveys since redds were large and had a "cleaned" appearance.

A total of approximately 750 km of stream was available to adult bull trout on their upstream spawning migration in the study area, including the Flathead River above the Canadian Border.

Of the 750 km available, 295 km were surveyed using ground and helicopter observers, concentrating in areas where spawning occurred in the past or in areas where juvenile bull trout were observed. Redds were seen in approximately 215 km of stream or 28 percent of the waters accessible

Table 19. Average measurements of resident and migratory stocks of westslope cutthroat trout redds in tributaries to the Middle Fork Flathead River during June of 1981. (n=number of redds measured).

Creek	Stock	Velocity m/sec.	Depth cm	Length (m)	Width (m)	n
Challenge	Fluvial	.34	17.2	1.0	.45	22
Challenge	Resident	.29	11	.6	.35	4
Tumbler	Resident	.34	18.5	.6	.25	2
Skyland	Resident	.30	22.0	.6	.35	3
Means (Range)	Fluvial	.34	17.2 (8-30)	1.0 (.7-1.4)	.45 (.3-.6)	22
Means (Range)	Resident	.30	17.2 (8-28)	.6 (.5-.65)	.32 (.25-.4)	9

to bull trout. Redds have been found in 48 of the 186 stream reaches classified during the study. A 66 km segment of the Flathead River from Polebridge upriver to Squaw Creek across the Canadian Border was surveyed by helicopter, but no evidence of bull trout spawning was observed in the 40 km portion below the Canadian Border.

There were 704 redds counted during the 1981 survey. A total of 467 were located in the North Fork drainage with 144 found in Canada and 323 seen in the U.S. portion of the drainage. A total of 237 redds were located in the Middle Fork drainage. Spawning was concentrated in several major tributaries in the North and Middle Fork drainages (Tables 20 and 21). Redds were often concentrated in specific areas within reaches. Areas of the stream longer than one kilometer which contained a large number of redds were considered to be high use areas.

Comparisons were made between the number of redds counted in the same stream reaches surveyed during 1979, 1980 and 1981 for the North Fork drainage (Table 22) and the Middle Fork drainage (Table 23). More redds were seen in the North Fork tributaries during 1981 surveys than in any previous survey. A toal of 279, 171 and 168 redds were counted in 1981, 1980 and 1979, respectively. The 1981 count was 63% higher than the 1980 count. The 1979 and 1980 counts were nearly identical. The number of redds seen in Middle Fork tributary reaches was lower in 1981 than 1980. The number of redds counted in Middle Fork tributary reaches surveyed during all three years was similar in 1981 (108) and 1979 (95). Redd numbers were higher in 1980 (150).

The location of redds within drainages was usually consistent. Adult bull trout appeared to spawn in similar areas of a stream each year. An exception was observed in Coal Creek in the North Fork drainage. During 1981, 24 redds were observed in the South Fork of Coal Creek, contrasted to two and four redds counted during 1980 and 1979, respectively. Conversely, reach two of Coal Creek, located immediately below the mouth of the South Fork, contained 29 redds in 1981 compared to 47 and 40 in 1980 and 1979 (Table 22).

Redd frequency distributions were plotted for each surveyed stream by 0.5 km increments (Appendix D; Figures 1-17). Redd locations in North Fork tributaries were plotted for 1981. Redd locations in Middle Fork tributaries were plotted for both 1980 and 1981. Monitoring bull trout redd numbers and distributions provides valuable information to evaluate the relative abundance of bull trout and the potential impacts development might have on bull trout recruitment.

An estimate of the number of adult bull trout which migrated upriver in the Flathead drainage to spawn was made using the ratio of the number of spawners per redd and our estimated efficiency in counting redds. We estimated that 85 and 75 percent of all redds present were counted in the U.S. portion of the North Fork drainage and the Middle Fork drainage, respectively. An estimated 70% of all redds present in the Flathead basin

Table 20 . Numbers and densities of bull trout redds (by reach) in North Fork tributaries surveyed in 1981.

Stream	Reach	Number of redds	Density(#/km) (high use area)	Density(#/km) (entire reach)
Cabin 1/	I	2		
Howell	I	0		
	II	72	9.0	4.6
Couldrey 1/	I	1		
	II	23		
Kishenehn 2/	I	13		
Flathead River 1/				
(Polebridge to border)		0		
(Border to Squaw Creek)		34		
Starvation 1/	I	1		
Trail	I	82	26.7	9.7
Whale	I	22		
	II	79	17.5, 11.6 3/	7.9
Shorty	I	17	8.7	3.4
Red Meadow	II	19	7.0	1.7
Coal	I	0		
	II	29	8.7	3.9
	III	1		
South Fork Coal	I	24	14.0	3.0
Mathias	I	10	9.0	6.7
Big	I	1		
	II	23	7.3	3.3
Hallawat	I	14	8.0	3.5
TOTAL		467		

1/ Counts made by helicopter
2/ Counts made by helicopter, 12 redds in Canada and 1 redd in U.S.
3/ Two separate high density spawning areas were located in Whale Creek

Table 21. Numbers and densities of bull trout redds (by reach) in Middle Fork tributaries surveyed in 1981.

Stream	Reach	Number of redds	High use area density(No./km)	Entire reach density(#/km)
Nyack	I	7		0.6
	II	7	7.0	3.6
Coal	II	4		0.3
Park	I	3		0.8
	II	7	6.0	0.8
	III	3		0.4
Ole	II	19	9.5	4.7
	III	4		0.3
Bear	II	12	6.0	1.6
Granite	II[1]	14	4.7	2.5
Morrison	I[1]	24	8.0,5.3[2]	3.2
	III	8		0.9
Lodgepole	I	18	7.2	2.7
Schafer	I	12	8.0	2.6
Dolly Varden	I	31	9.0	2.4
Clack	I	7		2.5
Bowl	I	2		0.8
	II	5		1.2
	III	3		1.9
Strawberry	I	15	10.0	3.1
	II	3		0.4
	IV	3		1.3
Trail	I	26	7.0,8.0	3.4
TOTAL		237		

[1] Ice covered 20 to 40 percent of these creeks during spawning site surveys. Up to 20 percent of the redds may have been missed by observers.

[2] Two separate high density spawning areas were located in Morrison Creek

Table 22. Comparison of redd numbers by year for similar areas of the North Fork drainage surveyed during 1979, 1980 and 1981.

Stream	Reach	Number of redds 1981	1980	1979
Cabin	I	2 3/	2	*
Howell	II	72 3/	53 1/	*
Couldrey	II	23 3/	15 1/	*
Kishenehn	I	13 3/	16 2/	*
Starvation	I	1 3/	1	*
Trail	I	44	31	35
Whale	I	19	12	10
	II	79	35	24
Shorty	I	17	4	33
Red Meadow	II	19	6	2
Coal	I	0	1	0
	II	29	47	40
	III	1	0	4
South Fork Coal	I	24	2	4
Mathias	I	10	10	2
Big	I	1	0	6
	II	23	15	6
Hallawat	I	13	8	2
TOTAL		390	258	168
(Total for reaches surveyed all three years)		(279)	(171)	(168)

* Not surveyed in 1979
1/ Results from survey by B.C. Research, Vancouver.
2/ Combined for Canada and U.S.
3/ Counts made by helicopter.

Table 23. Comparison of redd numbers by year for similar areas of the Middle Fork drainage surveyed during 1979, 1980 and 1981.

Stream	Reach	Number of redds 1981	1980	1979
Strawberry	I	15	4	*
	II	3	9	*
	IV	3	4	*
Trail	I	26	31	*
Bowl	II	5	19	*
	III	3	7	*
Clack	I	7	10	*
Schafer	I	12	10	15
Dolly Varden	I	31	21	20
Morrison	I	24	32	12
	III	8	39	4
Lodgepole	I	18	14	32
Granite	I	14	34	12
Bear	II	12	9	*
Ole	II	19	19	*
Nyack	I	7	14	*
TOTAL		207	276	95
(Total for reaches surveyed all three years)		(107)	(150)	(95)

*Not surveyed in 1979.

in Canada were counted. We again used an estimated ratio of 3.2 fish per redd (Fraley et al. 1981) based on past trapping and redd count information.

An estimated 2500 to 3050 adult bull trout moved upriver and reached tributary areas to spawn during 1981. An estimated 1590 to 1940 adult bull trout moved into the North Fork drainage, with 990 to 1215 fish entering tributaries in the U.S. and 595 to 725 fish entering Canada to spawn. An estimated 900 to 1,110 adult bull trout reached streams in the Middle Fork of the Flathead drainage to spawn. Estimates for the Canadian portion on the North Fork and the upper Middle Fork may be low because fishing for adult bull trout is allowed in some spawning tributaries.

Comparison of Helicopter and Ground Surveys to Enumerate Bull Trout Spawning Sites

A comparison was made between two methods of counting bull trout spawning sites. Replicate counts were made of known bull trout spawning areas by ground crews and by helicopter. The helicopter counts generally recorded fewer redds than ground counts (Table 2.4). Factors affecting the effectiveness of the helicopter survey results were stream width, weather, sun orientation, and riparian canopy height and density.

The largest percent difference occurred for Shorty Creek a tributary to Whale Creek. Shorty Creek was a moderate sized stream (late summer flow of 13.0 cfs) with abundant mature spruce and other conifers in the riparian area. The helicopter had to fly at a higher altitude when surveying this creek than the other creeks, and abundant shrubs along the streambanks made it difficult to observe the streambed.

Generally, helicopter counts provided reliable information on the number of redds in a shorter time and at a comparable cost to ground counts. Aerial surveys should only be conducted during clear weather on calm (windless) days. Every effort should be made to fly with the sun at the observers back and the observer should wear high quality polaroid sunglasses.

Timing of Spawning

Bull trout spawning occurred approximately one week later in 1981 than in 1980. Spawning in Middle Fork tributaries was initiated between 10 September and 16 September. Spawning in North Fork tributaries began as early as 4 September, but the majority of the spawning occurred between 9 September and 20 September. Several researchers have observed spawning to occur during September and early October (McPhail and Murray 1979, Block 1955, Heimer 1965 and Leggett 1969).

Several physical factors were probably important in triggering spawning activity including water temperature, photoperiod and streamflow. Water temperatures were monitored in Ole, Bear, Lodgepole and Morrison creeks in the Middle Fork during September. Bull trout were observed spawning

Table 24. Comparison of ground versus helicopter counts of bull trout redds in selected North and Middle Fork tributaries, 1981. Helicopter counts were done by different observers in the North and Middle Fork drainages.

Stream	Ground count	Helicopter count	Difference (%)
North Fork			
Trail Creek	82	84	+2(2)
Howell Creek	17	16	-1(6)
Whale Creek	101	90	-11(11)
Shorty Creek	17	6	-11(65)
Middle Fork			
Ole Creek	18	16	-2(11)
Park Creek	12	8	-4(33)
Coal Creek	4	2	-2(50)
Nyack Creek	14	13	-1(7)

at slightly warmer temperatures in lower Middle Fork tributaries than in North and upper Middle Fork tributaries. In Ole, Bear, Lodgepole and Morrison creeks, water temperatures during the period of active redd construction varied from a maximum of 12°C to a minimum of 8°C. In Big Creek, a tributary to the North Fork, a pair of bull trout were observed on a redd on 29 September. At this time, the water temperature was 7°C. Fraley et al. (1981) reported peak spawning occurred at mean maximum water temperatures of 8 to 9°C. Dolly Varden (*Salvelinus malma*) in Hood Bay Creek, Alaska were 5.6 to 6.7°C (Blackett 1968). Spawning occurred at 5.0°C in Twin Creek, Idaho (Needham and Vaughan 1952). McPhail and Murray (1979) reported water temperatures of 9°C and below during spawning activity.

Spawning Site Preference

Bull trout spawned in 215 kilometers (28%) of the 750 kilometers available to spawning adults. Graham et al. (1982) found that stream order, channel gradient and two channel substrate variables were significantly correlated ($P<0.05$) with bull trout redd frequencies (number of redds per kilometer of stream length). Stream order and D-90 was the variable combination which best predicted redd frequencies ($R=0.47$, $P<0.01$). Variables ranked in order of their discriminating ability were stream order, D-90, channel gradient, overhanging bank cover and percent of the streambed in gravel and cobble combined. Two discriminating functions using only measurements of habitat parmeters correctly classified 58% of the stream reaches into: 1) no-redd; 2) low-redd frequency; and 3) high-redd frequency categories. Other factors including side channel development, groundwater recharge and possible social behavior of bull trout adults may also influence spawning site selection.

A total of 319 redds were measured in North Fork tributaries. The average length was 2.0 m and the average width was 1.2 in 1981 (Table 25) compared to 2.1 and 1.1 m, respectively, in 1980 (Fraley et al. 1981).

Frequency distribution curves were compiled for velocity and depth measurements taken at the head of redds sampled in North and Middle Fork tributaries during 1979, 1980 and 1981 (Figures 5 and 6). Average water velocities were higher for redds sampled during 1980 than in either 1979 or 1981. (Figure 5).

Most redds in 1979 and 1981 were constructed in areas where water velocities were less than 1.2 feet per second. Leggett (1969) recorded focal point velocities, of 0.30 to 0.56 ft/sec. at 13 cm above the redds in aquaria studies. McPhail and Murray (1979) found water velocities measured 1 cm above the gravel of bull trout redds in a study of the Arrow Lakes system were 1.86 to 2.1 ft/sec. Hunter (1973) measured a range of focal point velocities at redd sites of 1.11 to 2.16 ft/sec. with a mean of 1.70 ft/sec.

The majority of redds we observed were in water between 0.15 and

Table 25. Average measurements of bull trout redds in tributaries of the North Fork of Flathead River during 1981.

Drainage	Year	Number of redds	Length	Width	Depth
Big Cr.	1980	15	2.3	1.3	.32
	1981	24	2.3	1.2	.42 1/
Hallawat Cr.	1980	8	2.0	1.0	.31
	1981	14	1.8	1.0	.32
Coal Cr.	1980	48	1.9	1.1	.26
	1981	30	1.7	1.0	.32
So. Fork Coal Cr.	1980	2	2.3	1.0	.31
	1981	24	1.8	1.0	.24
Mathias Cr.	1980	10	1.9	0.9	.30
	1981	10	1.6	1.0	.22
Red Meadow Cr.	1980	6	1.8	0.8	.31
	1981	19	1.9	1.1	.29
Whale Cr.	1980	47	1.9	1.2	.30
	1981	101	1.9	1.2	.435 1/
Shorty Cr.	1980	4	2.0	1.1	.19
	1981	17	1.9	1.2	.33 1/
Trail Cr.	1980	31	2.4	1.5	.33
	1981	82	2.4	1.4	.41 1/
MEAN	1980	171	2.1	1.1	.29
	1981	321	2.0	1.2	.28 2/

1/ Measured to the bottom of the depression (pit). All other depth measurements were measured at the front edge of the depression.

2/ Depth measurements measured to the bottom of the depression (pit) were not included.

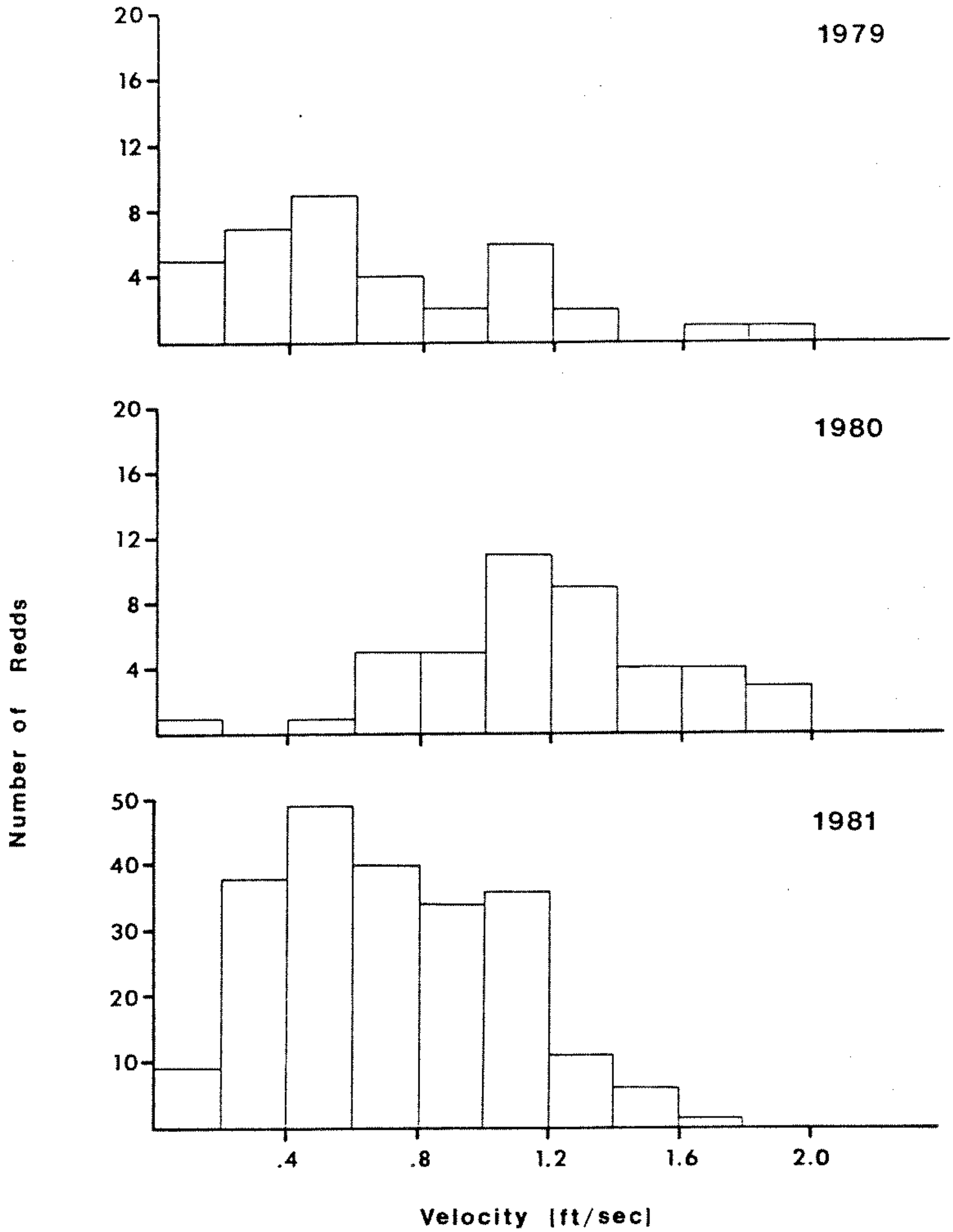

Figure 5. Velocities recorded at the head of 37 North and Middle Fork bull trout redds in 1979, 43 North Fork bull trout redds in 1980, and 224 North and Middle Fork bull trout redds in 1981. All measurements were taken with either Pygmy, Price AA or Marsh McBirney current meters.

.35 m deep during all three years (Figure 6). Block (1955) reported the majority of redds he observed were in approximately 0.30 m of water. Blackett (1968) reported that the average depths of spawning areas were 0.2 to 0.7 m in Hood Bay Creek, Alaska. Hunter (1973) observed Dolly Varden spawning in Washington State and recorded depths of 0.21 to 0.43 m, with a mean of 0.32 m.

Substrate samples collected as part of a study contracted with the Flathead National Forest were analyzed to determine the composition of streambed material bull trout selected for spawning. Four redds were sampled in both Whale and Trail creeks and two redds were sampled in both Big and Coal creeks. Undisturbed areas of streambed in bull trout spawning areas were also sampled to determine the substrate composition in areas adjacent to redds. Ten samples were collected in both Coal and Trail creeks and six samples were collected in both Big and Whale creeks.

Bed material from 16 to 50 mm was the predominate size in bull trout redds (Figure 7). Large percentages of material 2 to 6.35 mm and 6.35 to 16 mm were present in redds in all four creeks. Coal Creek had the highest percentage of material less than 6.35 mm (37.5%) followed by Whale (33.5%), Trail (32%) and Big (23.5%) creeks. Blackett (1968) cored anadromous Dolly Varden redds in Hood Bay Creek, Alaska and found material in the 6 to 50 mm size predominated (approximately 60%). McPhail and Murray (1979) reported the size class 13-75 mm contained more than 70% of the composition by weight of three *Salvelinus sp.* redds in a tributary to Arrow Lakes, B.C.

Streambed areas located adjacent to redds, but undisturbed by bull trout spawning, contained a higher percentage of material larger than 50 mm and lower percentages of material 16 to 50 mm than in spawning sites (Figure 7).

Composite substrate compositions in bull trout redds were similar from 1977 to 1981 (Figure 8). The substrate composition in redds during 1980 varied slightly from other years, possibly due to the smaller sample size. When substrate compositions were compared for 1981 as percent by volume versus percent by weight, very little difference existed. The material less than .063 could only be measured volumetrically with any degree of precision.

FOOD HABITS OF CUTTHROAT, BULL AND BROOK TROUT

Major Fish Food Organisms

Results of the Flathead 208 study in 1975 and 1976 indicate that Dipterans (two-winged flies) were the dominant order of insects in the lower Middle Fork, comprising 64% of the benthic community. Ephemoroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) made up 25, 7 and 4 percent of the benthic community, respectively. Fraley et al. (1981) reported that Ephemeroptera and Diptera dominated the benthic samples from the Middle Fork at Bear Creek, comprising 48 and 47

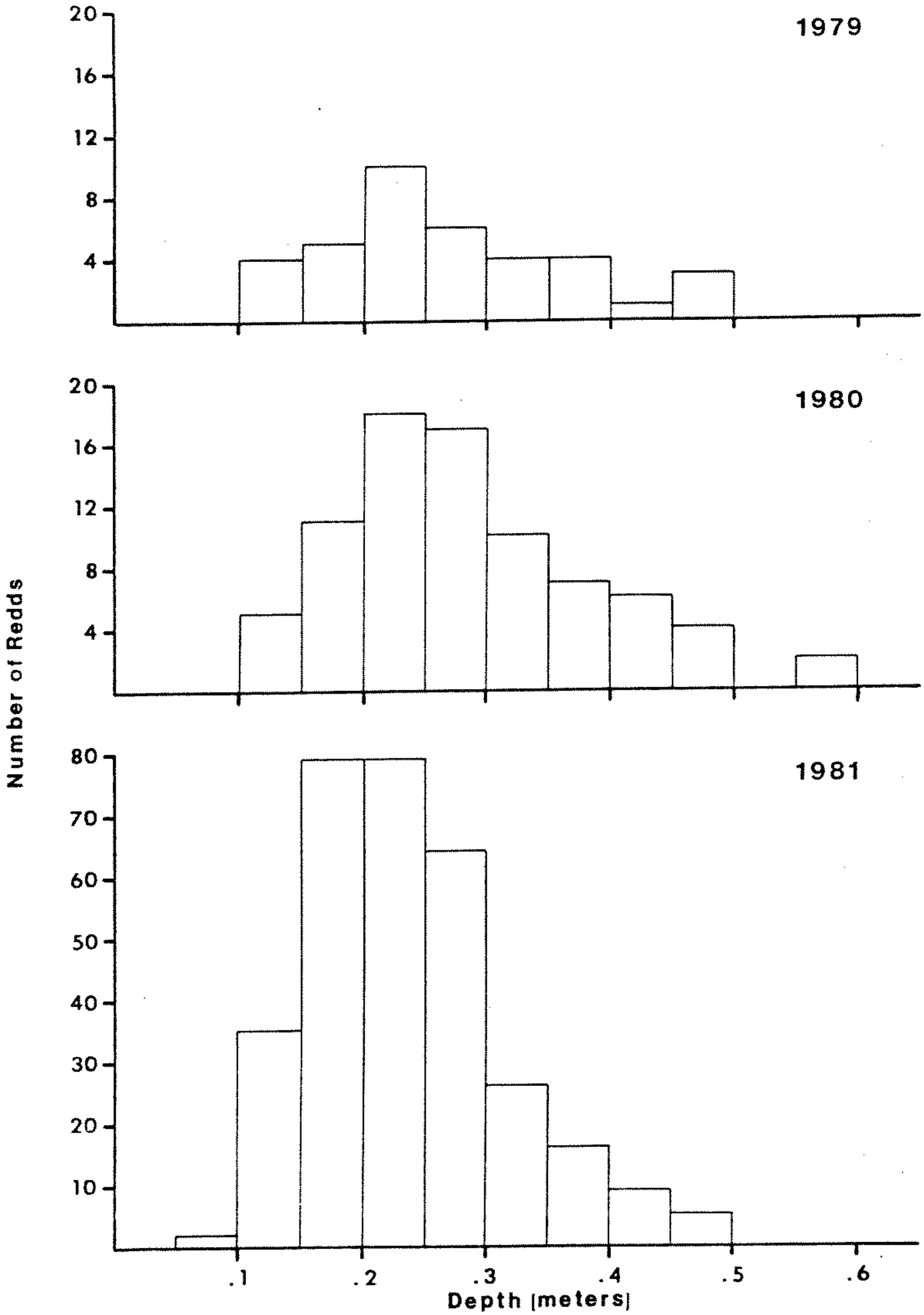

Figure 6. Depths recorded at 37 bull trout redds in North and Middle Fork tributaries in 1979, 43 bull trout redds in North Fork tributaries in 1980 and 315 bull trout redds in North and Middle Fork tributaries in 1981.

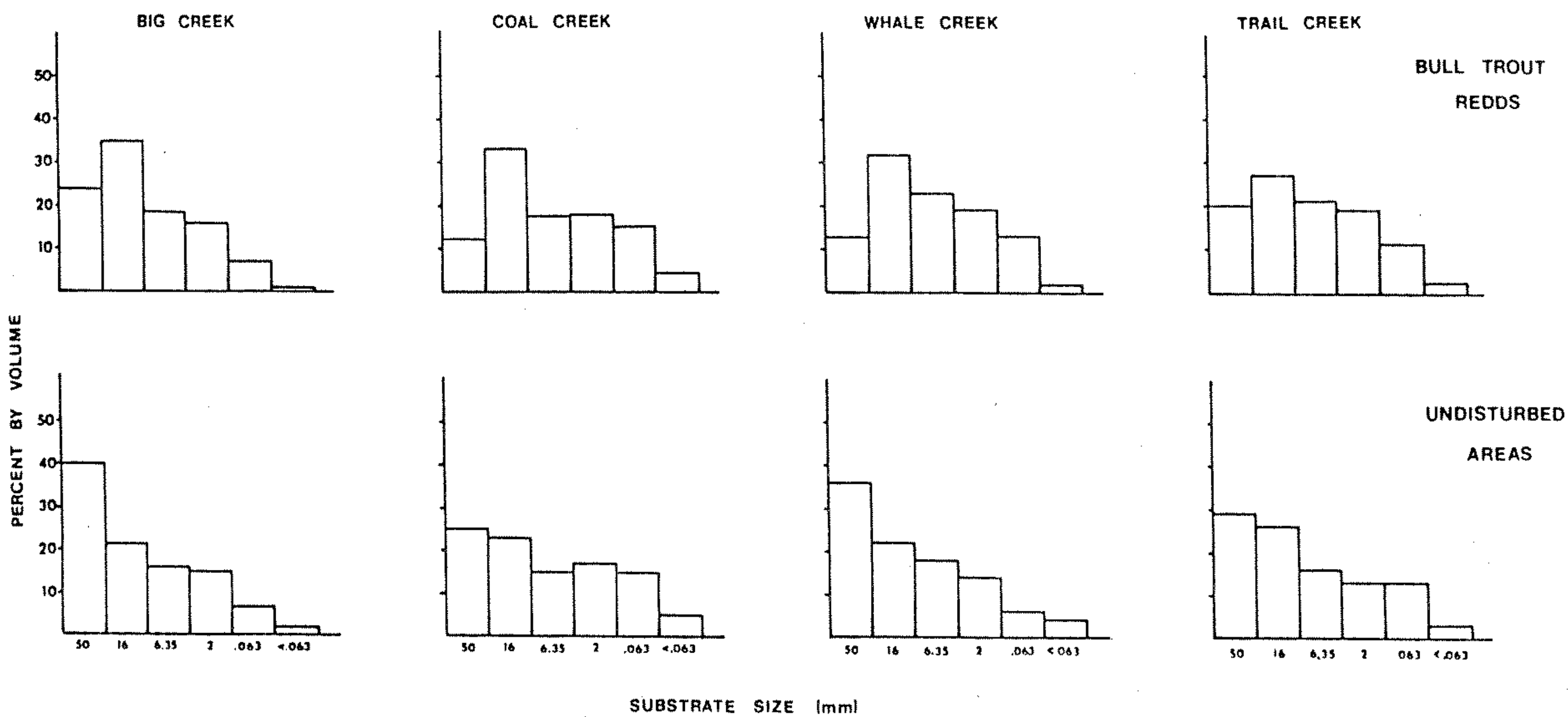

Figure 7. Composite substrate composition of gravels collected from bull trout redds and undisturbed areas in North Fork tributaries during 1981. Each size class is expressed as a percent of the total sample volume.

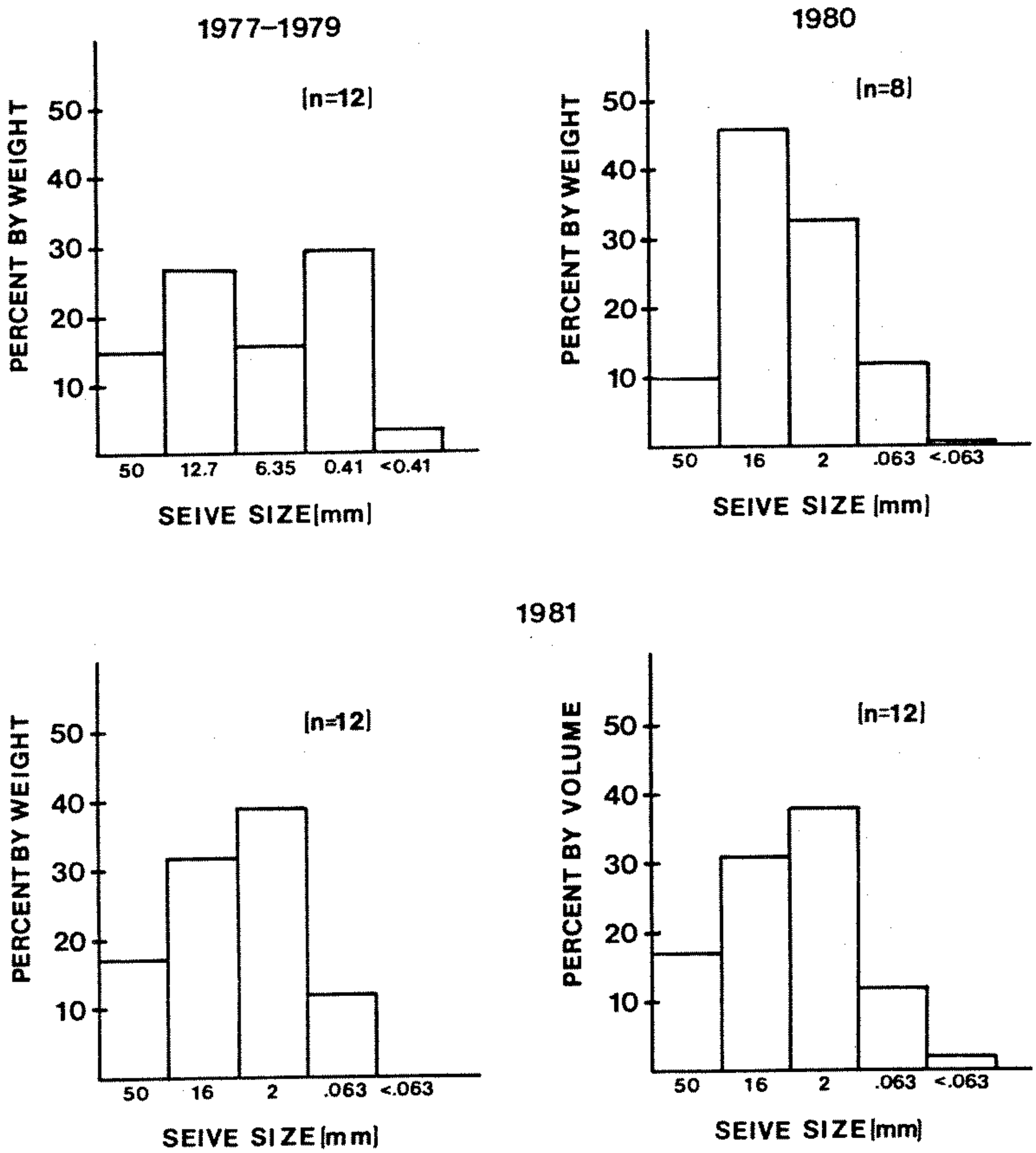

Figure 8. Composite substrate composition of gravels collected from bull trout redds in North Fork tributaries from 1977 to 1981. Percent composition by weight and volume are compared for 1981.

percent of the total numbers. The dominant familes of Ephemeroptera were Heptageniidae, Baetidae and Ephemerellidae. Chironomidae was by far the dominant Dipteran. Plecoptera and Trichoptera made up three and two percent of the total numbers in the sample taken at Bear Creek, respectively. The dominant family of Plecoptera was Chloroperlidae and Hydropsychidae was the most numerous family of Trichoptera. Benthic samples from seven of the tributaries to the Middle Fork show Ephemeroptera as the dominant order, ranging from 51 to 81 percent of the total insect community (Peterson et al. 1980). Plecoptera, Diptera, Trichoptera and Coleoptera (beetles) follow in order. Average percent composition of taxa for the three studes was 48, 39, 20 and 3 for Ephemeroptera, Diptera, Plecoptera, and Trichoptera, respectively.

The majority of the brook trout stomach samples came from Deerlick Creek, which was partially influenced by springs. Benthic samples were collected due to the lack of information concerning streams of this nature in our study area. Results of these samples showed Diptera as the dominant order comprising 29 percent of the benthic insect community. Ephemeroptera, Trichoptera, Coleoptera and Plecoptera were also represented with 25, 24, 14 and 8 percent, respectively. The dominant family of Ephemeroptera was Heptageniidae, and Hydroptilidae was the major family of Trichoptera.

Adult aquatic insects were collected by Middle Fork field crews throughout the summer and fall of 1981. These adult collections were valuable for checking identifications of immature forms and as a basic partial species list for the drainage. Approximately 35 species of Plecoptera, 16 species of Ephemeroptera and 23 species of Trichoptera were collected (Table 26).

Particularly valuable records of Plecoptera were *Mesocapnia oenone* and *Neaviperla forcipata*. *Neaviperla forcipata* was collected from five drainages in the Middle Fork and from the White River in the South Fork of the Flathead. This insect appears in Bauman et al. (1977) in a list or rarely collected Plecoptera of the Rocky Mountain area. An extremely valuable record of Trichoptera was *Rhyacophila harmstoni*. This species had not been previously collected in Montana.

Analysis of Cutthroat, Bull and Brook Trout Stomachs

Stomach contents from 90 cutthroat, 13 juvenile bull and 27 brook trout were examined to determine food habits recorded by number, occurrence, volume and IRI values (Appendix E, Tables 1 through 19). Data were organized by species and length to compare small and large fish of each species. The two size groups for each species were fish smaller than or equal to 110 mm and fish larger than 110 mm in total length. Cutthroat trout from Challenge Creek were compared by age class to evaluate potential food partitioning.

Cutthroat

Diptera and Ephemeroptera were the major orders in the diet of

Table 26. Adult aquatic insects collected from the Middle and South Fork drainages during 1981. Locations marked * are in South Fork drainages, all other locations are in Middle Fork drainage.

Taxa	Date of Collection	Location
PLECOPTERA		
Capniidae		
Eucapnopsis brevicauda	17 June	Bear Creek
" "	21 June	Bear Creek
Isocapnia missourii	22 April	Middle Fork Flathead River
Mesocapnia oenone	18 September	Morrison Creek
" "	17 September	Ole Creek
Utacapnia trava	24 May	Stanton Lake Shore
Nemouridae		
Malenka californica	10 September	Morrison Creek
Prostoia besametsa	22 April	Muir Creek
Zapada cinctipes	11 June	Bear Creek
Zapada frigida	11 June	Essex Creek
Zapada haysi	2 July	Dodge Creek
Nemoura sp. female	20 April	Middle Fork near Ole Creek
Leuctridae		
Paraleuctra purcellana	11 June	Essex Creek
Paraleuctra vershina	29 June	Geifer Creek
Pteronarcidae		
Pteronarcella badia	19 July	Ole Creek
" "	22 July	Middle Fork near Essex
" "	22 July	Ole Creek
Perlidae		
Calineuria californica	15 August	Bear Creek
Perlodidae		
Cultus tostonus	12 August	Ole Creek
" "	30 September	Strawberry Creek
" "	25 August	Gordon Creek *
" "	12 September	Morrison Creek
" "	6 August	Lincoln Creek
" "	6 August	Park Creek
" "	12 September	Lodgepole Creek

Table 26. (Continued).

Taxa	Date of Collection	Location
Plecoptera - Perlodidae (continued)		
Diura knowltoni	28 May	Challenge Creek
" "	22 April	Middle Fork near Muir Creek
Kogotus modestus	8 August	Bear Creek
" "	11 August	Coal Creek
Megarcys watertoni	12 August	Ole Creek
" "	12 August	Ole Creek
" "	3 July	Challenge Creek
" "	4 August	Essex Creek
" "	21 June	Bear Creek
" "	3 June	Bear Creek
" "	25 July	Skyland Creek
" "	30 July	Essex Creek
" "	23 July	Essex Creek
" "	4 July	Middle Fork near Bear Creek
" "	11 June	Essex Creek
" "	29 June	Geifer Creek
" "	2 July	Dodge Creek
Skwala parallela	22 April	Middle Fork near Park Creek
Skwala curvata	20 April	Middle Fork near Ole Creek
Isoperla petersoni	14 September	Morrison Creek
" "	8 August	Park Creek
Isoperla sordida	22 July	Essex Creek
Chloroperlidae		
Alloperla delicata	22 April	Park Creek
" "	12 August	Ole Creek
Kathroperla perdita	11 June	Essex Creek
" "	21 May	Autumn Creek
Neaviperla forcipata	11 September	Bear Creek
" "	12 September	Morrison Creek
" "	18 September	Morrison Creek

Table 26. (Continued).

Taxa	Date of Collection	Location
Plecoptera - Chloroperlidae (continued)		
Naeviperla forcipata	29 August	White River *
" "	30 August	White River *
" "	15 October	Park Creek
" "	13 October	Ole Creek
" "	5 November	Nyack Creek
Paraperla frontalis	11 June	Bear Creek
Suwallia pallidula	8 August	Lincoln Creek
" "	11 August	Coal Creek
" "	6 August	Lincoln Creek
" "	12 August	Park Creek
" "	12 September	Morrison Creek
" "	11 August	Coal Creek
" "	11 September	Bear Creek
" "	27 July	Muir Creek
" "	30 August	White River *
" "	29 August	White River *
" "	11 August	Ole Creek
Suwallia lineosa	12 August	Ole Creek
" "	31 July	Ole Creek
" "	10 September	Morrison Creek
" "	25 July	Skyland Creek
" "	3 July	Muir Creek
Suwallia sp.	22 April	Park Creek
" "	20 April	Coal Creek
Sweltsa albertensis	7 August	Middle Fork near Walton
" "	11 August	Ole Creek
Sweltsa borealis	17 June	Bear Creek
Sweltsa fidelis	12 August	Ole Creek
" "	25 July	Skyland Creek
" "	11 June	Essex Creek
" "	17 June	Bear Creek
" "	2 July	Dodge Creek

Table 26. (Continued).

Taxa	Date of Collection	Location
Plecoptera - Chloroperlidae (continued)		
Sweltsa lamba	15 June	Bear Creek
Sweltsa revelstoka	11 June	Essex Creek
Utaperla sopladora	21 June	Bear Creek
" "	11 June	Essex Creek
ODONATA		
Cordullidae		
Cordulia shurtleffi	1 August	Middle Fork near Coal Creek
EPHEMEROPTERA		
Baetidae		
Baetis bicaudatus	30 August	White River *
" "	25 September	Middle Fork Flathead
" "	14 September	Morrison Creek
" "	22 July	Ole Creek
" "	23 October	Nyack Creek
Callibaetis doddsi	21 August	Paola Creek
Siphlonuridae		
Ameletus similor	25 August	Gordon Creek *
Ameletus sparsatus	5 October	Dolly Varden Creek
Ameletus sp. subimagos	30 September	Strawberry Creek
" "	25 September	Middle Fork Flathead
" "	20 August	Coal Creek
" "	17 June	Bear Creek
" "	15 August	Coal Creek
" "	25 August	Gordon Creek *
Ameletus sp.	5 November	Nyack Creek

Table 26. (Continued).

Taxa	Date of Collection	Location
Ephemeroptera - Siphlonuridae (continued)		
Siphlonurus occidentalis	14 September	Morrison Creek
" "	27 August	South Fork Flathead River *
Leptophlebiidae		
Paraleptophlebia heteronea	6 August	Park Creek
Paraleptophlebia sp.	28 August	South Fork Flathead River *
Ephemerellidae		
Drunella grandis ingens	15 August	Pinchot Creek
Drunella sp. subimago	17 September	Ole Creek
" "	10 October	Bowl Creek
" "	28 July	Essex Creek
" "	20 August	Muir Creek
" "	8 August	Park Creek
" "	2 August	Gordon Creek *
" "	3 July	Challenge Creek
" "	5 October	Dolly Varden Creek
" "	27 August	South Fork Flathead River *
" "	12 August	Ole Creek
" "	26 August	Gordon Creek *
" "	12 August	Ole Creek
" "	30 July	Muir Creek
" "	25 August	Gordon Creek *
" "	6 August	Park Creek
Heptageniidae		
Cinygmula rameleyi	14 September	Morrison Creek
Heptagenia criddelyi	6 August	Essex Creek
Epeorus longimanus	27 July	Muir Creek
" "	25 July	Geifer Creek

Table 26. (Continued)

Taxa	Date of Collection	Location
Ephemeroptera - Heptageniidae (continued)		
Rithrogena futilis	22 July	Middle Fork Flathead River
" "	1 August	Bear Creek
" "	4 August	Middle Fork
" "	21 July	Ole Creek
Rithrogena sp.	22 July	Essex Creek
" "	30 July	Middle Fork Flathead River
" "	12 August	Ole Creek
TRICHOPTERA		
Rhyacophilidae		
Rhyacophila vaccua	10 September	Harrison Creek
" "	3 September	Long Creek
Rhyacophila colo/idaho	2 August	Middle Fork Flathead River
" "	20 April	Middle Fork Flathead River
Rhyacophila verrula	1 October	Bowl Creek
" "	18 September	Morrison Creek
" "	13 September	Morrison Creek
" "	13 September	Dolly Varden Creek
Rhyacophila harmstoni	18 September	Morrison Creek
Rhyacophila spp. females	5 August	Park Creek
Rhyacophila coloradensis	10 August	Gateway Creek
Rhyacophila alberta	10 August	Gateway Creek
Rhyacophila bifila	8 August	Middle Fork Flathead River
Rhyacophila sp.	5 September	Morrison Creek
Glossosomatidae		
Glossosoma sp. females		Middle Fork Flathead River
Glossosoma velona	22 July	Middle Fork Flathead

Table 26. (Continued)

Taxa	Date of Collection	Location
Trichoptera (continued)		
Hydropsychidae		
Arctopsyche grandis	22 July	Bear Creek
" "	17 July	Bear Creek
" "	16 July	Bear Creek
Limnephilidae		
Amphicosmoecus canax	5 October	Dolly Varden Creek
" "	15 October	Park Creek
" "	21 October	Morrison Creek
Onocosmoecus unicolor	4 August	Essex Creek Middle Fork
Oligophlebodes ruthae	12 August	Ole Creek Middle Fork
" "	12 August	Ole Creek Glacier Park
" "	6 August	Park Creek Glacier Park
Limnephilus hyalinatus	15 September	Pinchot Creek Middle Fork
Limnephilus spp. females	20 July	Middle Fork Flathead River
Apatania comosa	22 March	Muir Creek
" "	22 April	Muir Creek
Psychoglypha alascensis	14 September	Bear Creek
Psychoglypha subborealis	1 October	Bowl Creek
Psychoglypha spp. females	30 September	Strawberry Creek
" " "	13 October	Ole Creek
Dicosmoecus atripes	5 September	Morrison Creek
Neophylax rickeri	15 October	Park Creek
" "	5 November	Nyack Creek
Brachycentridae		
Brachycentrus occidentalis	10 September	Morrison Creek

cutthroat smaller than or equal to 110 mm in length in Middle Fork tributaries (Figure 9). Trichoptera and Plecoptera were also common in the smaller fish. In cutthroat larger than 110 mm, Trichoptera, Ephemeroptera and Diptera were the dominant orders. Hymenoptera (ants), Plecoptera and Coleoptera were also well represented in the larger fish.

Similar results were observed in the diet of the three age classes of cutthroat trout from Challenge Creek (Figure 9). Age I fish (<85 mm) showed similar feeding habits to the smaller than 110 mm size group. In age II cutthroat (89-135 mm), there was a decline in the use of Diptera and Ephemeroptera became the dominant order in their diet. Trichoptera, Plecoptera and Hymenoptera were all more common in age II fish than in age I. The age III+ cutthroat (>136 mm) showed feeding habits similar to the larger than 110 mm size group.

Heptageniidae and Baetidae were the dominant Ephemeroptera families in small cutthroat, while Ephemerellidae and Baetidae were the major families in fish larger than 110 mm in length (Figure 10). Also depicted in Figure 10 are the important families of Trichoptera found in cutthroat stomachs from the Middle Fork tributaries. Rhyacophilidae was the dominant family in fish smaller than 110 mm, followed by Limnephilidae and Hydropsychidae. In the larger fish, Limnephilidae was the most important family with Rhyacophilidae, Hydropsychidae and Brachycentridae also well represented.

Examination of the available benthic food supply and the stomach contents of the small size class of cutthroat trout indicates that feeding was generally opportunistic. Diptera and Ephemeroptera were the major insect orders in both fish diet and benthic insect community. This relationship can also be been at the family level where Chironomidae was the dominant Dipteran family, Heptageniidae and Baetidae were the major families of Ephemeroptera and Limnephilidae, and Rhyacophilidae were the dominant families of Trichoptera. Similar results have been found by Griffith (1974) and by Fraley et al. (1981). The larger fish fed to a greater degree on the surface, as indicated by the IRI values associated with Hymenoptera, Coleoptera and Arachnida adults. Trichoptera was not a major order in the benthic insect community (approximately 3 percent); however, its dominance in the stomachs of cutthroat larger than 110 mm indicates selection for the larvae of this order.

Bull Trout

Bull trout smaller than 110 mm utilized primarily Diptera with Ephemeroptera, Plecoptera and Trichoptera also well represented (Figure 11). Feeding was generally opportunistic, similar to small cutthroat.

Heptageniidae and Baetidae were the dominant families in juvenile bull trout diets, again showing opportunistic feeding habits at the family level. In bull trout larger than 110 mm in total length, fish was an important part of the diet (Figure 11). Horner (1978) found that bull trout were generally more predacious than other trout species

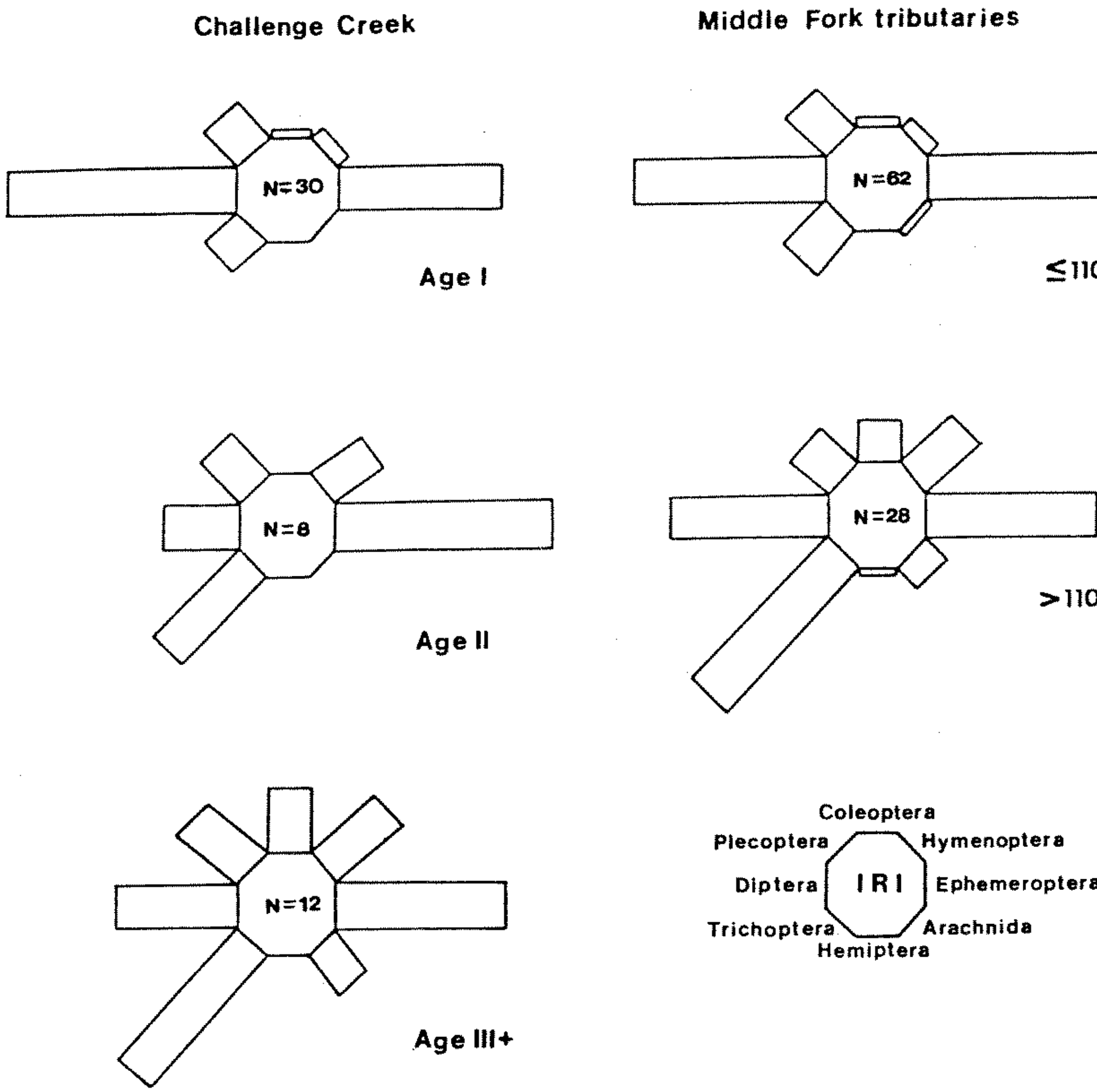

Figure 9. Relative Importance (IRI) of insect orders in the diets of cutthroat trout $\leq$ 110 mm and > 110 mm in length from Middle Fork tributaries and cutthroat trout by age class from Challenge Creek. Stomachs were collected during spring and summer of 1981.

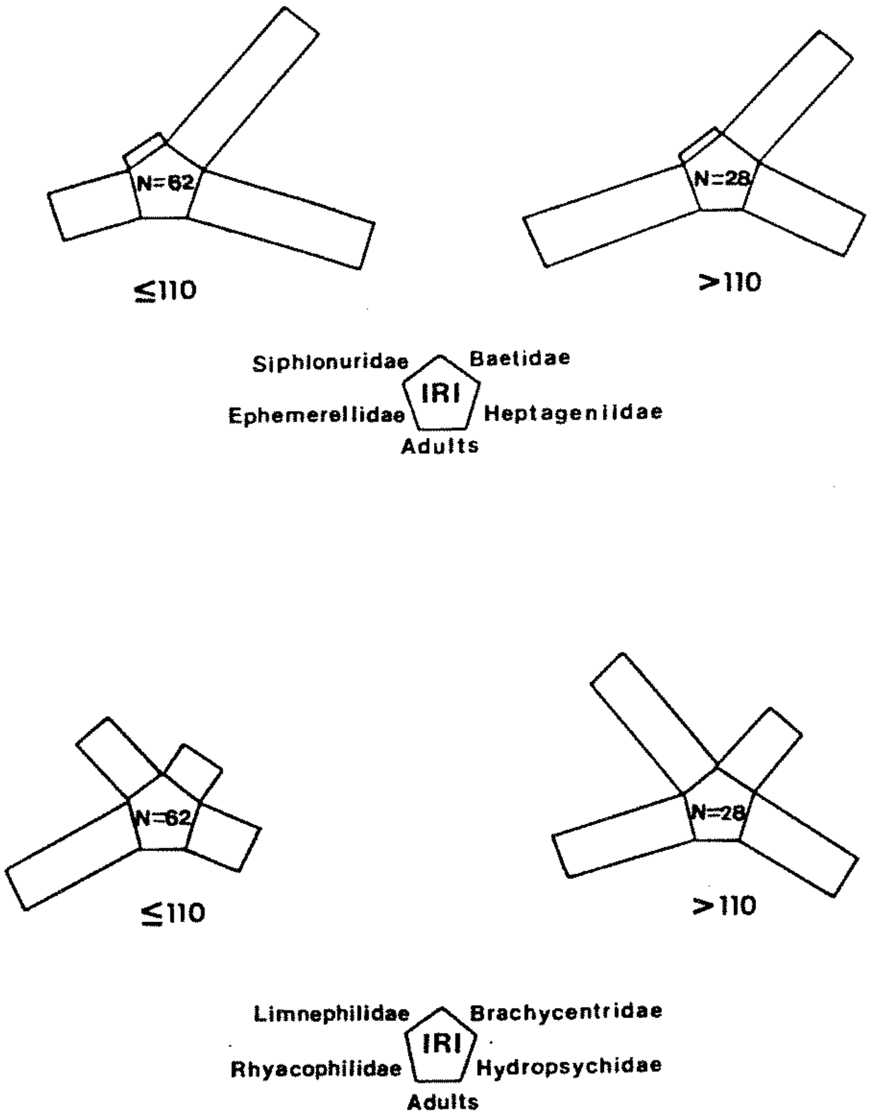

Figure 10. Relative Importance (IRI) of major families of Ephemeroptera and Trichoptera in the diets of cutthroat trout ≤ 110 mm and > 110 mm in length from Middle Fork tributaries. Stomachs were collected during spring and summer of 1981.

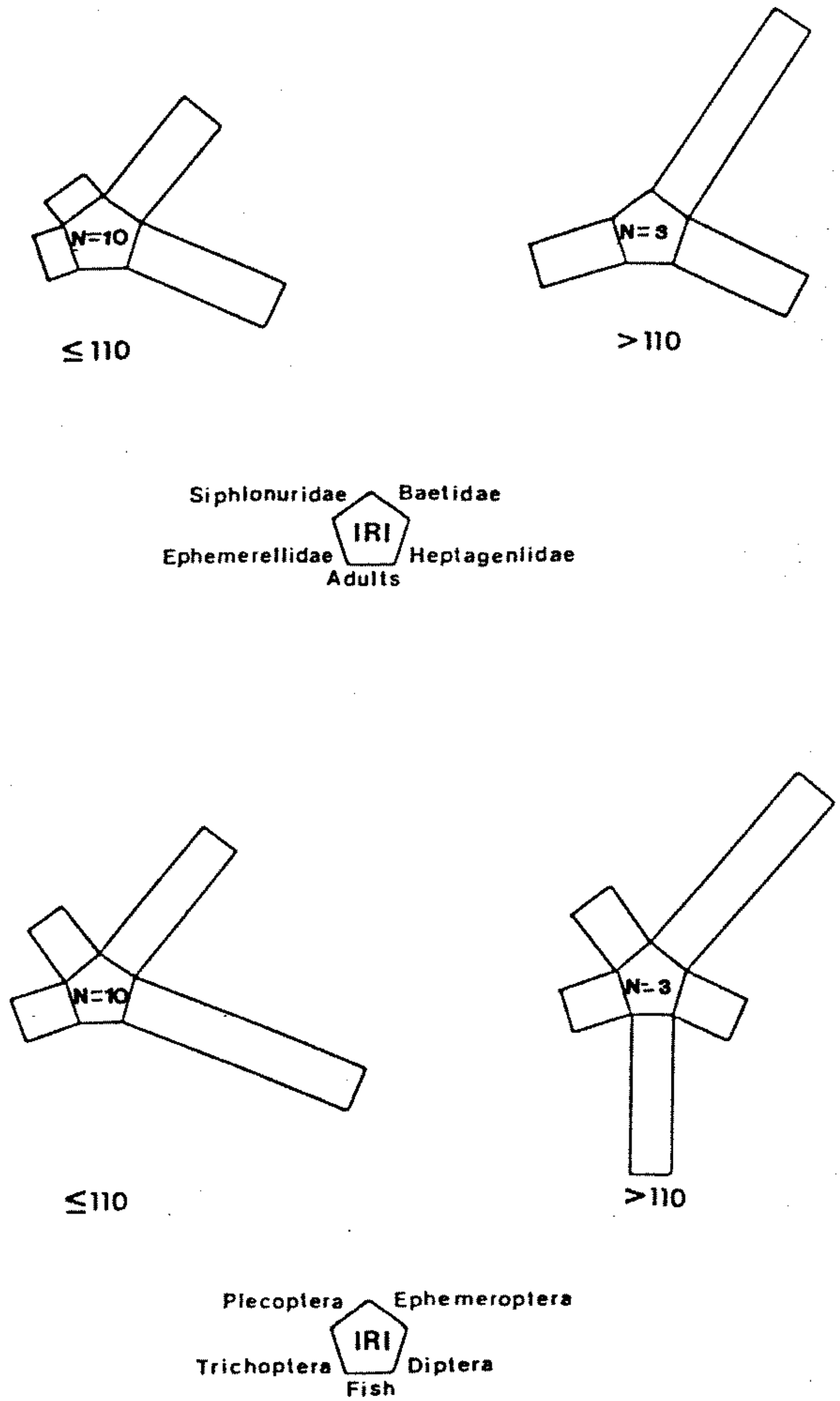

Figure 11. Relative Importance (IRI) of major families of Ephemeroptera (top) and insect orders (bottom) in the diets of bull trout ≤110 mm and >110 mm from Middle Fork tributaries. Stomachs were collected during spring and summer of 1981.

observed. Graham et al. (1980a) suggested that sculpins and the seasonal abundance of fry play an important part in the growth of juvenile bull trout.

Brook Trout

Ephemeroptera and Trichoptera were the dominant orders in the diet of brook trout (Figure 12). Diptera and Plecoptera were also present in both size groups.

On the family level, Baetidae was the dominant Ephemeroptera in brook trout stomachs, but made up only 20 percent of the Ephemeroptera in the benthic samples taken in Deerlick Creek (Figure 13). Although the family Heptageniidae was the dominant Ephemeroptera present in our sample, they were not a major portion of the diet. Baetidae are unique among stream invertebrates in that they often hold their bodies up above the boundary layer while at rest and they also swim about a great deal (Hynes 1980). These habits may make the Baetidae more common in the drift and an easier prey item than the substrate dwelling Heptageniidae. Jenkins (1969) and Ware (1972 and 1973) found prey movement to be a major factor in detection by visual predators. Ringler (1979) states that prey movement is an important criterion of prey recognition by benthic feeders, especially younger fish.

Hydroptilidae was the major family of Trichoptera found in both size groups of brook trout (Figure 13). Limnephilidae was also important in the size group larger than 110 mm. These two families accounted for the majority of Trichoptera present in the benthic sample taken in Deerlick Creek comprising 73 and 23 percent, respectively.

These analyses represent a general baseline examination of the diet of cutthroat, bull and brook trout in the lower Middle Fork drainage. Seasonal study, larger sample sizes and comparison of digestive rates and caloric values would be needed to establish indepth relationships between the trout and their food supply in the Middle Fork drainage.

MIDDLE FORK CREEL CARD SURVEY

Creel Card Returns

A total of 11 creel cards were returned during 1981. Nine of the 11 cards were for one-day trips. The two over-night trips averaged four days. The average number of anglers per trip was 2.4 and the angler success rate for all trips was 69 percent.

The number of anglers and composition of the catch for cards returned during 1979 to 1981 is presented in Table 27. Cutthroat dominated the catch during 1981 with an average composition of 75.5 percent. Whitefish made up 22.3 percent of the catch, while bull trout comprised only 3.3 percent. In 1981, anglers released 50, 33 and 78 percent of the cutthroat, bull trout and whitefish caught.

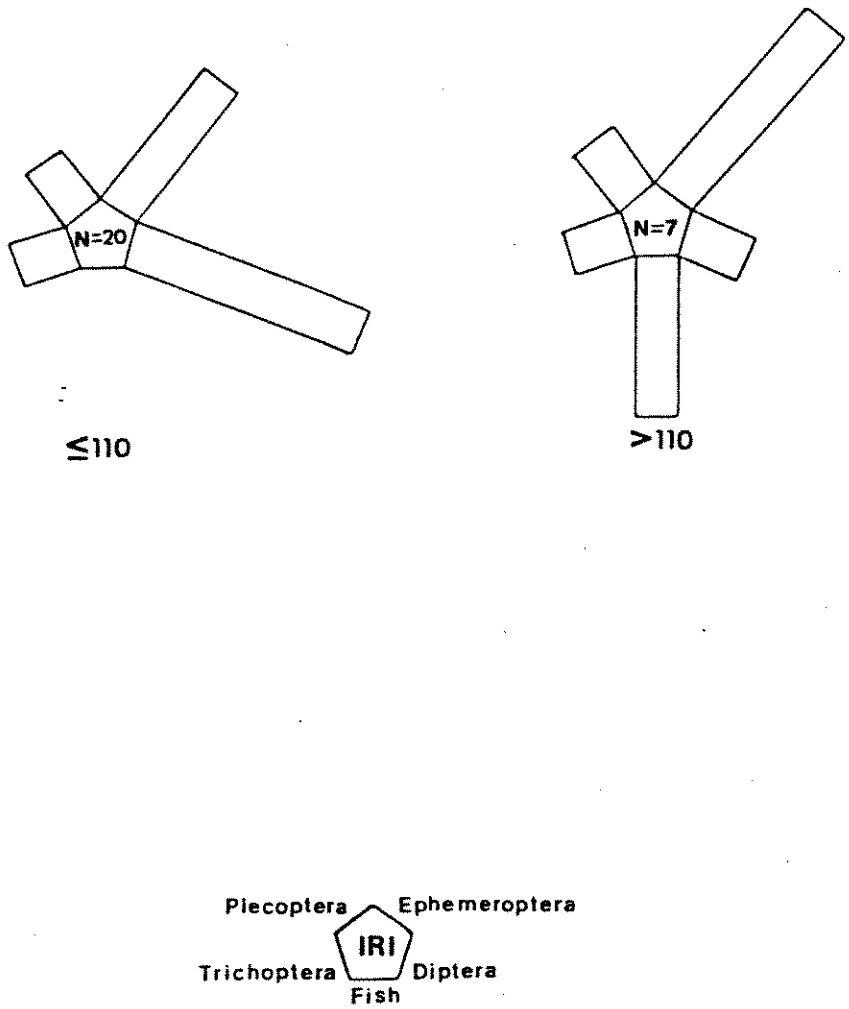

Figure 12 . Relative Importance (IRI) of insect orders in the diets of brook trout ≤110 mm and >110 mm in length from Middle Fork tributaries. Stomachs were collected in spring and summer of 1981.

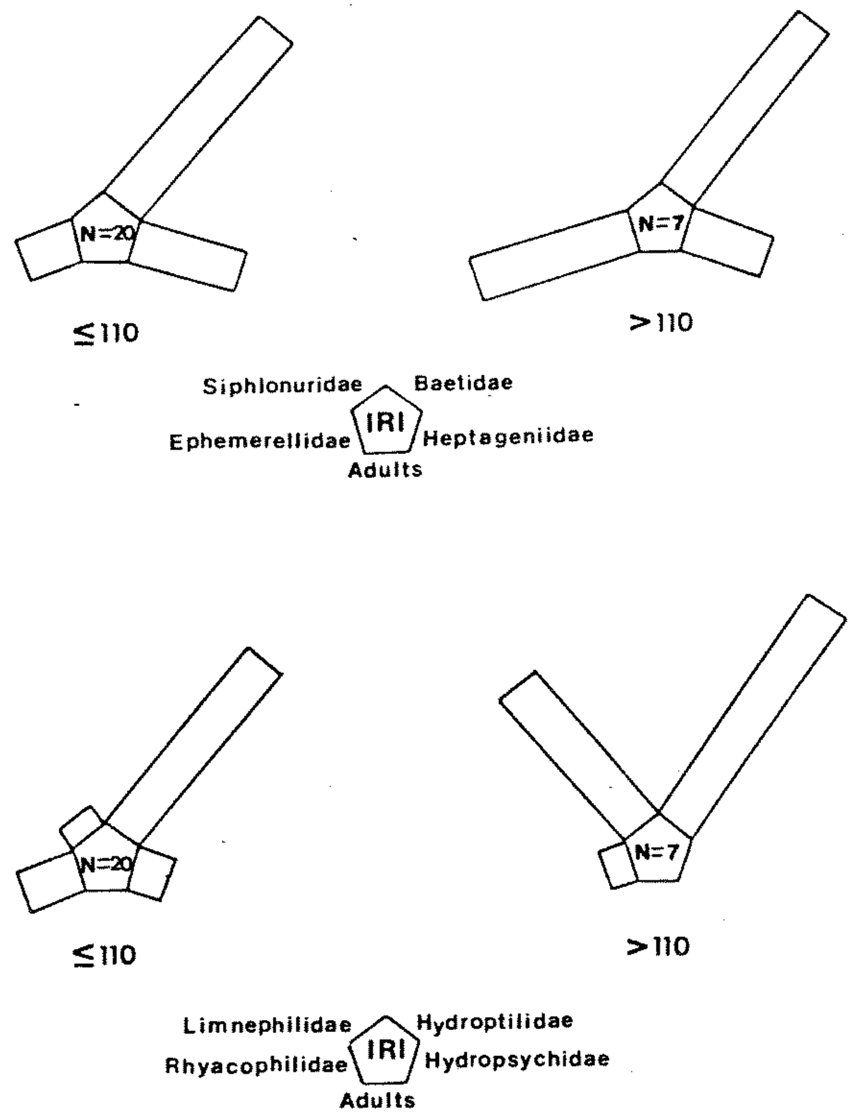

Figure 13. Relative Importance (IRI) of major families of Ephemeroptera and Trichoptera in the diets of brook trout ≤110 mm and >110 mm in length from Middle Fork tributaries. Stomachs were collected during spring and summer of 1981.

Table 27. Catch information from voluntary creel cards returned in 1979, 1980 and 1981. Numbers of fish caught are in parentheses from the Middle Fork Flathead River.

Year	Number of anglers	Total angler hours	Catch per hour			
			Cutthroat trout	Bull trout	Mountain whitefish	Total
1979	44	228	1.61(367)	.08(19)	.91(197)	2.60(583)
1980	38	243	1.68(408)	.05(11)	.97(236)	2.70(655)
1981	26	113	1.21(137)	.05(6)	.36(41)	1.63(184)

Hook and Line Sampling

Department personnel fished a total of 157 hours collecting scales and tagging fish during 1981 (Table 28). Twenty-two percent of this angling time was spent on the main North and Middle Forks of the River. These data were compared to catch information from hook and line sampling by department personnel in the North and Middle Forks of the Flathead River in 1961, 1962 and 1980, to evaluate changes in catch rates and species composition (Table 29).

Fraley et al. (1981) reported that cutthroat accounted for the majority of the catch in both the North and upper Middle Fork rivers. During 1981, cutthroat were still the major portion of the catch in the North Fork; however, mountain whitefish accounted for the majority of the catch in the lower section of the Middle Fork River. Eastern brook trout were also caught in the lower Middle Fork and an arctic grayling was captured in the North Fork River at Polebridge. Twenty-five percent of the total angling time was spent on the South Fork of the Flathead River, where cutthroat again dominated the catch.

Cutthroat trout made up 96 percent of the catch in tributaries to the lower Middle Fork tributaries and 99 percent in South Fork tributaries, where 53 percent of the total angling time was spent. Catch rates for cutthroat during 1981 averaged 9.6 fish per hour in Middle Fork tributaries (10.6 in tributaries draining Glacier National Park and 6.1 in tributaries draining Flathead National Forest lands), while catch rates in South Fork tributaries averaged 6.6 cutthroat per hour (Table 30 and 31). Higher catch rates in Glacier National Park streams may be due in part to the fact that most of these creeks have been closed to fishing and that department personnel spent more time fishing streams where success was higher. Consequently, catch rates during 1981 in Middle Fork tributaries, particularly Glacier National Park streams may be positively biased.

Table 28. Number of fish caught and total hours fished during hook and line sampling by Fish, Wildlife and Parks personnel on the Flathead River and tributaries during the summer of 1981.

Creek name	Total fisherman hours	Number Caught: Cutthroat trout	Bull trout	Brook trout	Mountain whitefish	Grayling
South Fork Drainage						
Gordon	7.0	90	---	---	---	---
White	9.9	41	1	---	---	---
Little Salmon	4.0	4	---	---	---	---
Youngs	1.0	10	---	---	---	---
Danaher	1.0	7	---	---	---	---
South Fork River	40.5	151	---	---	11	---
TOTAL	63.4	303	1	---	11	---
Middle Fork Drainage						
Lincoln-Walton	5.0	70	---	2	---	---
Coal-Pinchot	12.8	114	---	9	5	---
Muir	14.5	167	---	---	---	---
Park	3.5	60	---	---	---	---
Ole	11.0	87	6	---	---	---
Bear	2.0	---	1	---	---	---
Essex	4.0	24	---	---	---	---
Stanton	1.5	8	---	---	---	---
Geifer	1.0	5	1	---	---	---
Dodge	1.0	3	---	---	---	---
Challenge	4.0	42	---	---	---	---
Middle Fork River	10.5	17	1	2	23	---
TOTAL	70.8	597	9	13	28	---
North Fork Drainage						
North Fork River	23.5	20	1	---	---	1
TOTAL	23.5	20	1	---	---	1
GRAND TOTAL	157.6	920	11	13	39	1

Table 29. Catch rates (# of fish/hr.) from hook and line sampling by Fish, Wildlife and Parks personnel on the North, Middle and South forks of the Flathead River during the summers of 1961, 1962, 1980 and 1981. The number of fish caught of each species is in parentheses.

Year	Total fisherman hours	Number of Fish Caught Per Hour				
		Cutthroat trout	Bull trout	Brook trout	Mountain whitefish	Grayling
North Fork						
1961	146	1.97(288)	.14(21)	0(0)	.25(36)	0(0)
1962	233	2.78(648)	.03(6)	0(0)	.24(55)	0(0)
1980	120	2.15(259)	0(0)	0(0)	.07(9)	.04(1)
1981	23.5	.85(20)	.04(1)	0(0)	0(0)	.04(1)
Middle Fork						
1961 1/	170	---	---	---	---	---
1962 1/	164	.71(117)	.06(10)	---	.25(39)	0(0)
1980	104	2.15(224)	.33(11)	---	.62(20)	0(0)
1981	10.5	1.62(17)	.09(1)	.19(2)	2.19(23)	0(0)
South Fork						
1981	40.5	3.73(151)	.02(1)	0(0)	.17(11)	0(0)

1/ Data from 1961 and 1962 are from Hanzel, unpublished data.

Table 30. Catch information from hook and line sampling by Fish, Wildlife and Parks personnel in the Middle and South Fork tributaries during the summer of 1981. Number of fish caught are in parentheses.

Year	Total fisherman hours	Cutthroat trout	Bull trout	Brook trout	Mountain whitefish
Middle Fork					
1981	60.25	9.63(580)	.13(8)	.18(11)	.08(5)
South Fork (Bob Marshall Wilderness)					
1981	22.9	6.64(152)	.04(1)	0(0)	0(0)

Table 31. Catch information from hook and line sampling by Fish, Wildlife and Parks personnel in Glacier National Park tributaries and U.S. Forest Service tributaries to the Middle Fork during the summer of 1981. Number of fish caught are in parentheses.

Year	Total fisherman hours	Cutthroat trout	Bull trout	Brook trout	Mountain whitefish
Glacier National Park					
1981	46.75	10.65(498)	.13(6)	.24(11)	.11(5)
U.S. Forest Service					
1981	13.5	6.07(82)	.15(2)	0(0)	0(0)

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APPENDIX A

Water temperature, stream flow and water quality information collected in the upper Flathead drainage during 1981

Temperature and Flows in North Fork Tributaries

Minimum-maximum thermometers were placed in westside tributaries near the North Fork road bridge in July and checked every two weeks until their removal on 19 November. Monthly summaries of temperature information are presented for the six westside tributaries (Table 1).

During August, streams reached maximum temperatures ranging from 15.0°C in Whale and Trail creeks to 18.9°C in Coal Creek. The maximum summer temperatures in 1980 were recorded in July. The later maximum temperatures in 1981 were probably due to June rains which kept streamflows high well into July. These increased flows caused temperatures to remain cooler throughout July.

Water levels of nine westside tributaries were again monitored biweekly by reading permanent stage gauges, located on or near the North Fork road bridges, from June through October. Water level fluctuations are presented in Figures 1 through 6.

Peak flows resulting from snow melt were not recorded in May; however, streamflows were recorded in late June and early July when they increased following heavy precipitation. The June and July flows were higher in 1981 than the two previous years; however, flows from August through November were similar during all three years of study.

Streamflow was measured in nine westside tributaries three times during the summer of 1981 at the North Fork road bridges. These point measurements of flow represent high, moderate and low streamflows. The high and low flow measurements taken during the summer of 1981 are presented in Table 2.

The 1980 gauge heights were adjusted to a common baseline for comparison to the 1981 data. Stage-discharge rating curves were calculated for all nine westside tributaries (Figures 7-13).

Water Quality and Temperatures in the Middle Fork Drainage

Point measurements of the alkalinity, conductivity and flow were made on tributaries to the lower portion of the Middle Fork during fall of 1981. Alkalinity ($CaCO_3$) was measured by field crews following titration procedures described in Orland (1965). Total conductivity was measured using a Markson Sciences Inc. Model 10 portable conductivity meter. Point measurements of flow in tributaries from Schafer Meadows upstream were made using a Teledyne Gurley Pygmy current meter. In the tributaries below Schafer Meadows, flow measurements were made with a Marsh-McBirney current meter. Results of these physical and chemical measurements are presented in Table 3.

Continuous recording thermographs were installed at two sites in the Middle Fork and one site in Bear and Ole creeks during the 1981 field season (Figures 14-17). Monthly summaries of this temperature information

Table 1. Monthly mean maximum and minimum water temperatures (range in parentheses) in North Fork tributaries recorded by maximum-minimum thermometers during the summer of 1981.

Month	Big Creek 1/	Coal Creek 1/	Hay Creek 2/	Red Meadow Creek 1/	Whale Creek 1/	Trail Creek 1/
July						
Mean minimum	6.1	7.8	8.0	8.6	6.7	5.0
Mean maximum	14.7	16.1	12.4	15.0	13.9	14.4
	(5.5-15.0)	(7.8-16.1)	(6.7-13.3)	(8.3-15.5)	(6.7-14.4)	(5.0-14.4)
August						
Mean minimum	7.2	8.0	9.1	9.4	8.3	5.5
Mean maximum	16.1	18.1	16.3	17.4	12.6	14.4
	(7.2-16.7)	(7.8-18.9)	(8.9-16.7)	(8.9-17.8)	(7.2-15.0)	(5.5-15.0)
September						
Mean minimum	5.0	5.0	5.8	5.8	3.9	3.9
Mean maximum	11.4	15.3	11.9	12.2	11.9	12.5
	(3.9-13.3)	(3.9-18.3)	(4.4-13.3)	(4.4-13.9)	(3.3-13.3)	(3.3-13.9)
October						
Mean minimum	0.5	---	1.7	0.5	0.5	1.1
Mean maximum	8.9	11.7	10.0	8.9	8.9	8.9
	(0.5-8.9)	(0.5-11.7)	(1.7-10.0)	(0.5-8.9)	(0.5-8.9)	(1.1-8.9)
November						
Mean minimum	0.0	0.0	0.5	0.5	1.1	0.5
Mean maximum	8.9	6.7	8.9	5.0	6.1	7.2
	(0.0-8.9)	(0.0-6.7)	(0.5-8.9)	(0.5-5.0)	(1.1-6.1)	(0.5-7.2)

1/ Thermometers in: July 22 - out: November 19
2/ Thermometers in: June 25 - out: November 19

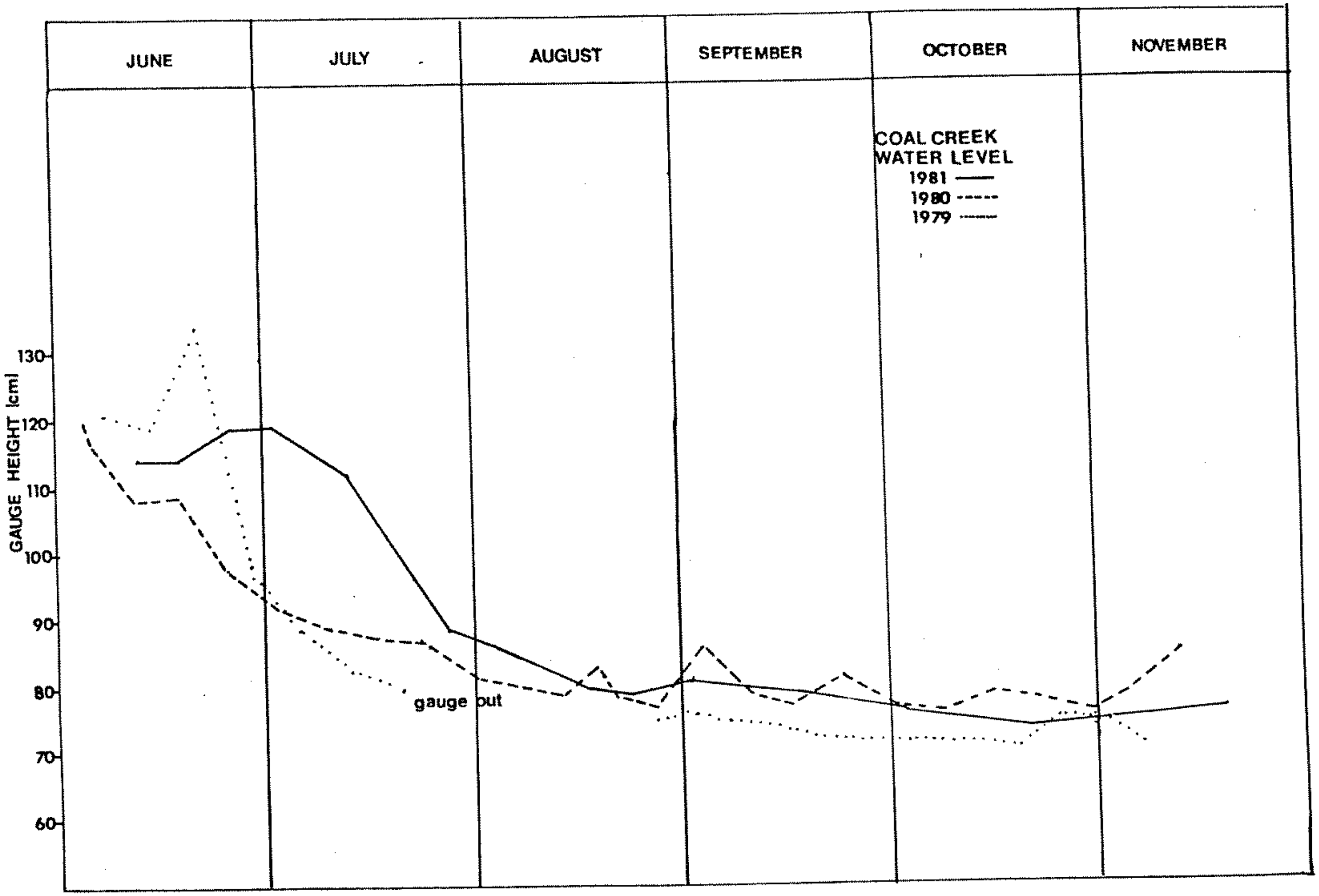

Figure 1. Seasonal water level fluctuation in Coal Creek during 1979, 1980 and 1981.

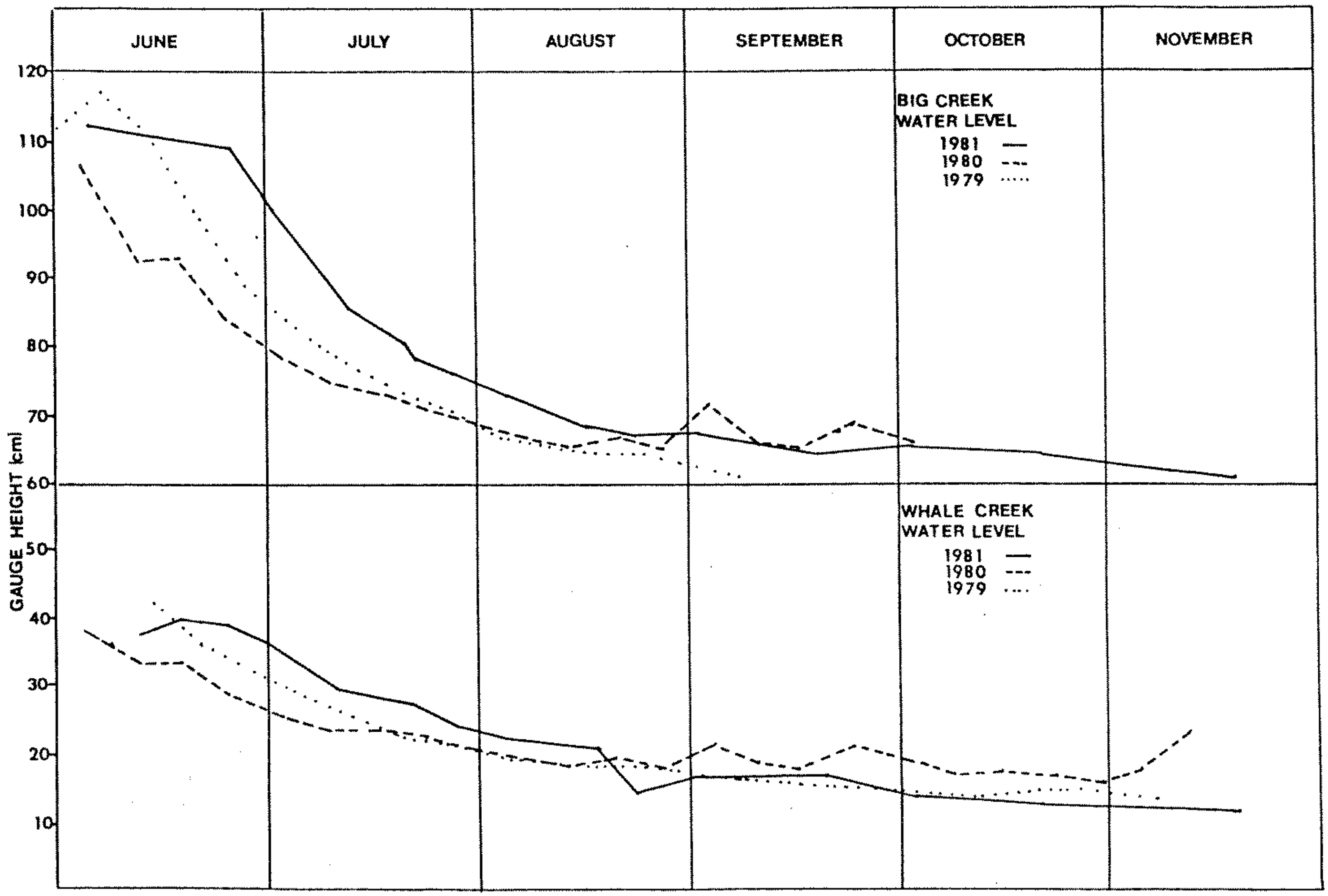

Figure 2. Seasonal water level fluctuation in Big Creek (top) and Whale Creek (bottom) during 1979, 1980 and 1981.

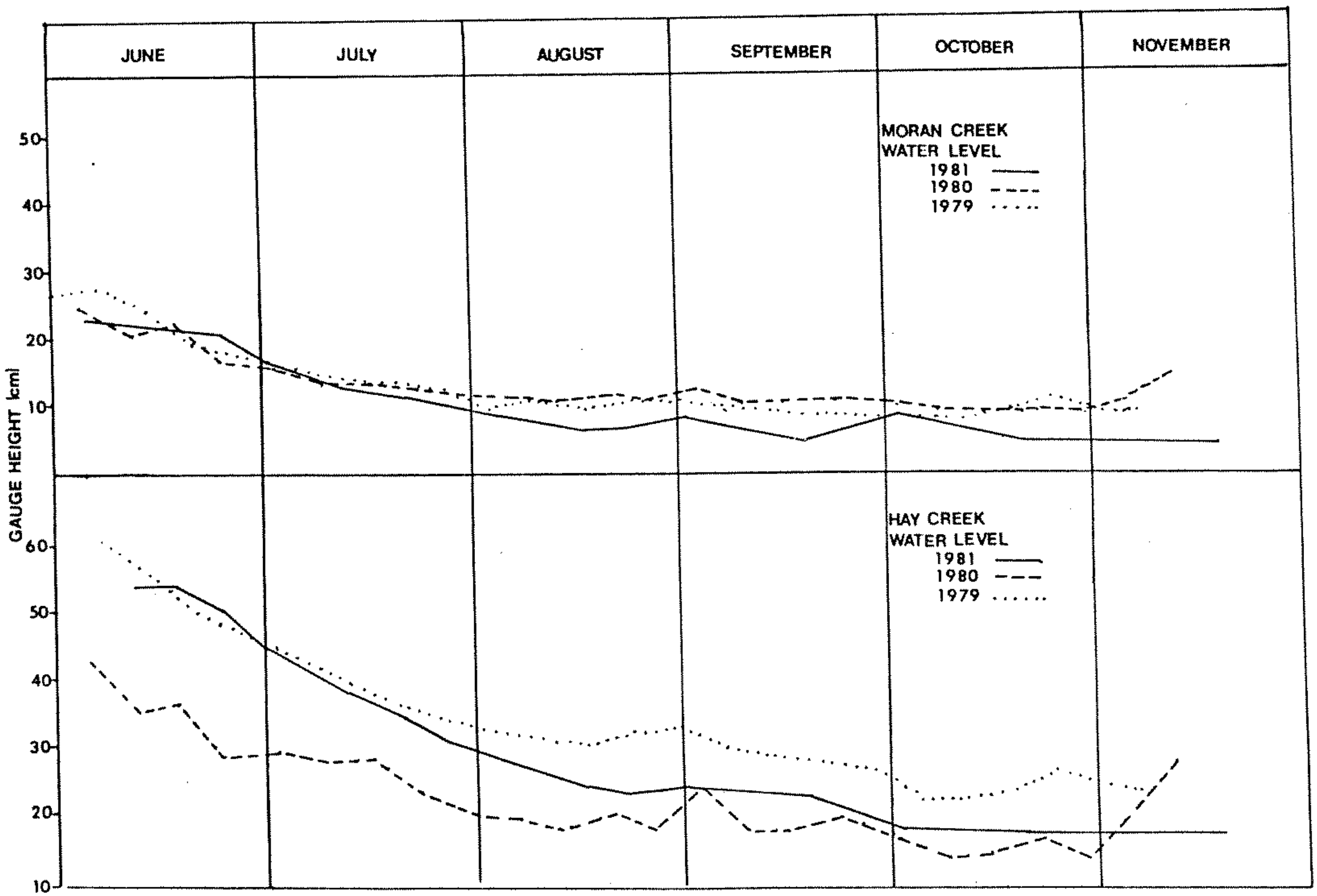

Figure 3. Seasonal water level fluctuation in Moran Creek (top) and Hay Creek (bottom) during 1979, 1980 and 1981.

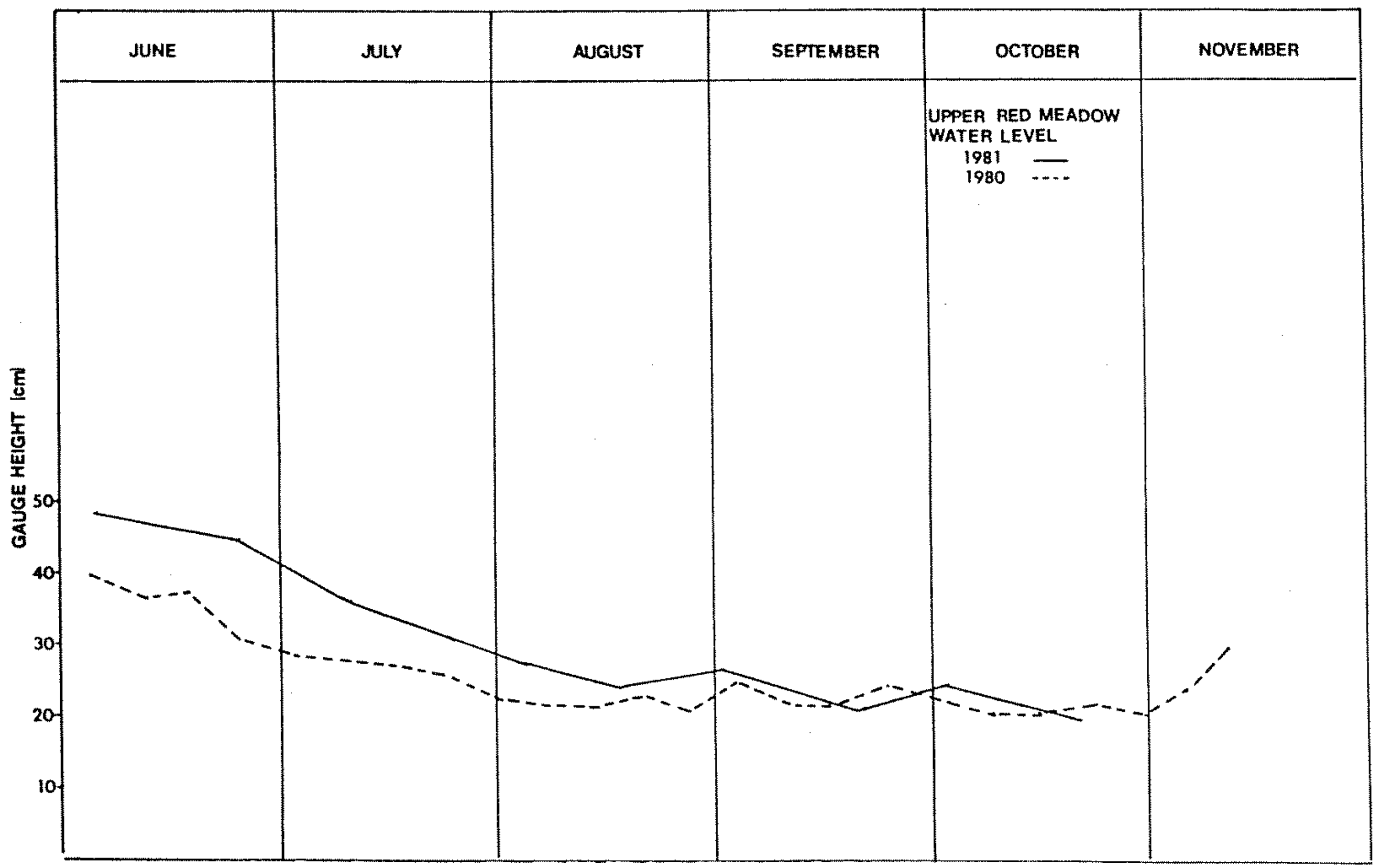

Figure 4. Seasonal water level fluctuation in upper Red Meadow Creek during 1980 and 1981.

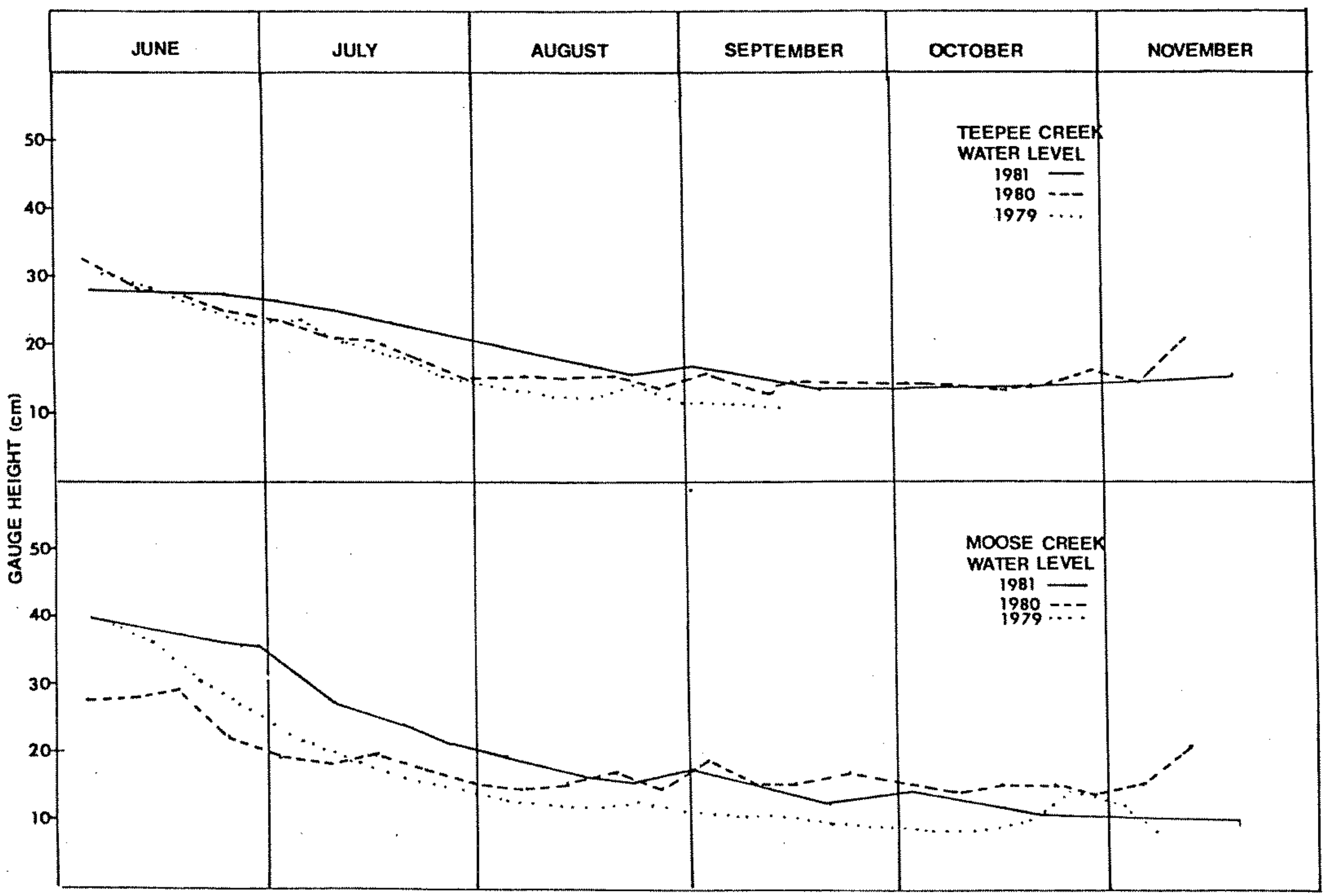

Figure 5. Seasonal water level fluctuation in Teepee Creek (top) and Moose Creek (bottom) during 19179, 1980 and 1981.

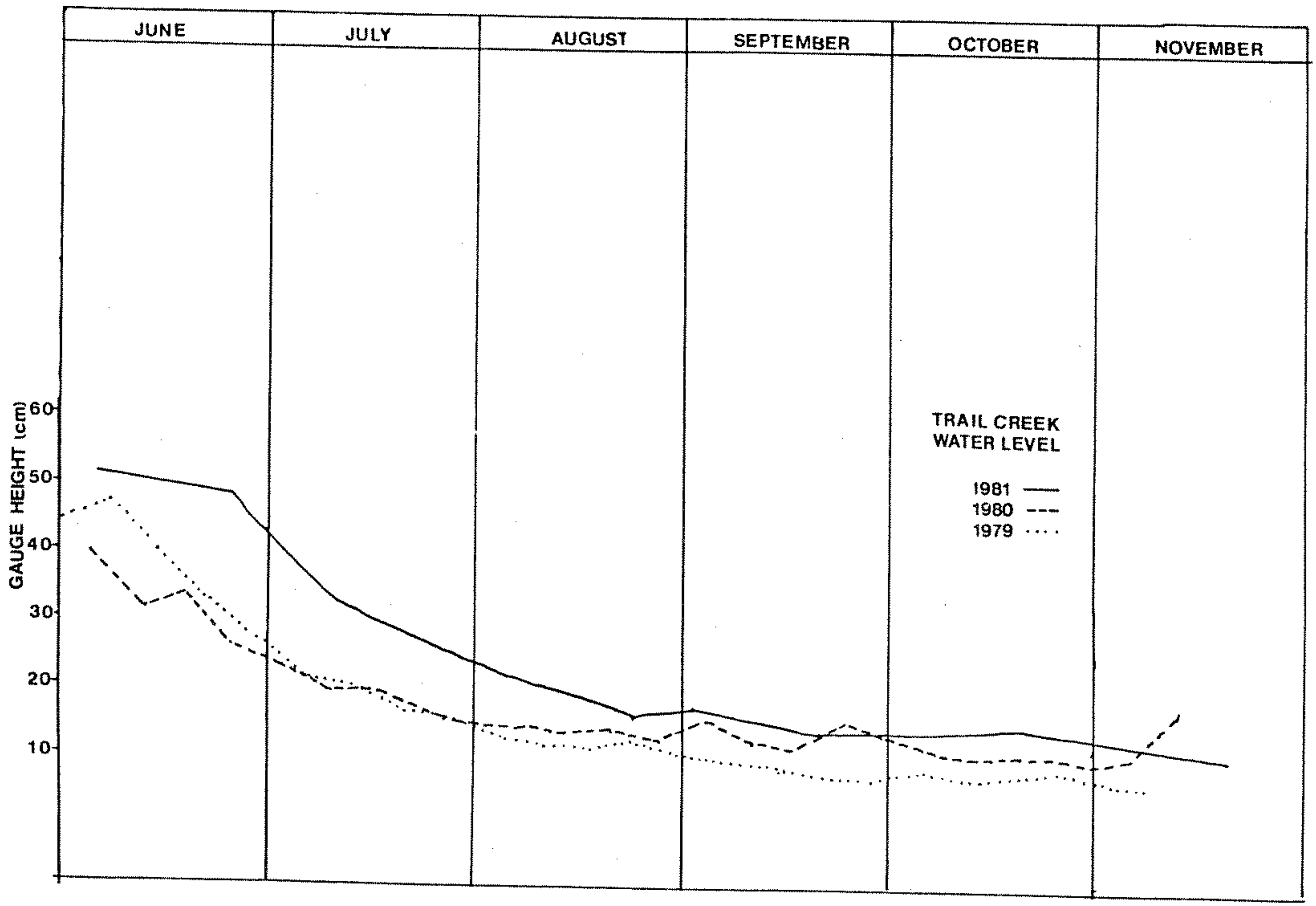

Figure 6. Seasonal water level fluctuation in Trail Creek during 1979, 1980 and 1981.

Table 2. 1981 discharges for North Fork tributaries representing relatively high and low flows. All measurements were taken near the North Fork Road bridges.

Drainage	High flow[1/]			Low flow[2/]		
	Date	Discharge (cfs)	Gauge (cm)	Date	Discharge (cfs)	Gauge (cm)
Big	5/23	1,180[3/]	142.9	8/23	81.3	67.1
Coal	7/1	495.6	119.2	8/23	47.5	78.3
Moran	7/1	27.3	16.4	8/23	5.3	6.7
Hay	6/30	124.8	105.8	8/23	20.5	83.8
Red Meadow	6/25	140.9	157.6	8/23	15.6	144.8
Moose	6/30	56.8	35.4	8/23	9.5	15.2
Whale	6/30	498.7	110.3	8/23	82.9	89.0
Teepee	7/2	15.6	26.5	8/23	0.9	15.5
Trail	6/30	333.9	41.4	8/23	72.8	16.4

1/ The peak discharge occurred sometime between May 15 and June 10, 1981, a second somewhat lower peak, caused by June rainstorms, occurred in late June to early July.

2/ Low flows were measured near the end of August. Lower flows occurred later in the fall.

3/ From U.S.G.S.

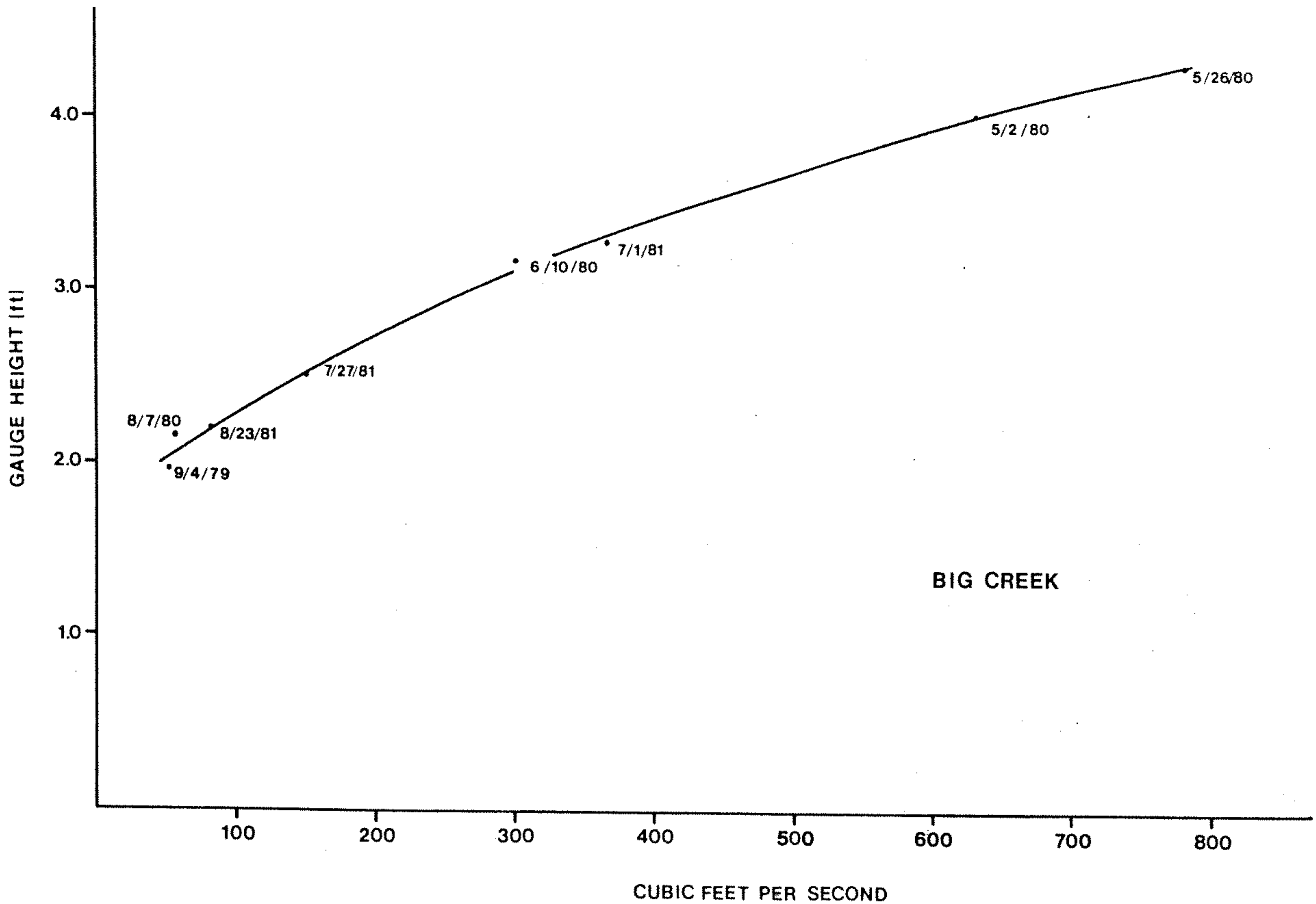

Figure 7. Gauge height and flow relationship for Big Creek. Dates of flow measurements are indicated along the discharge curve.

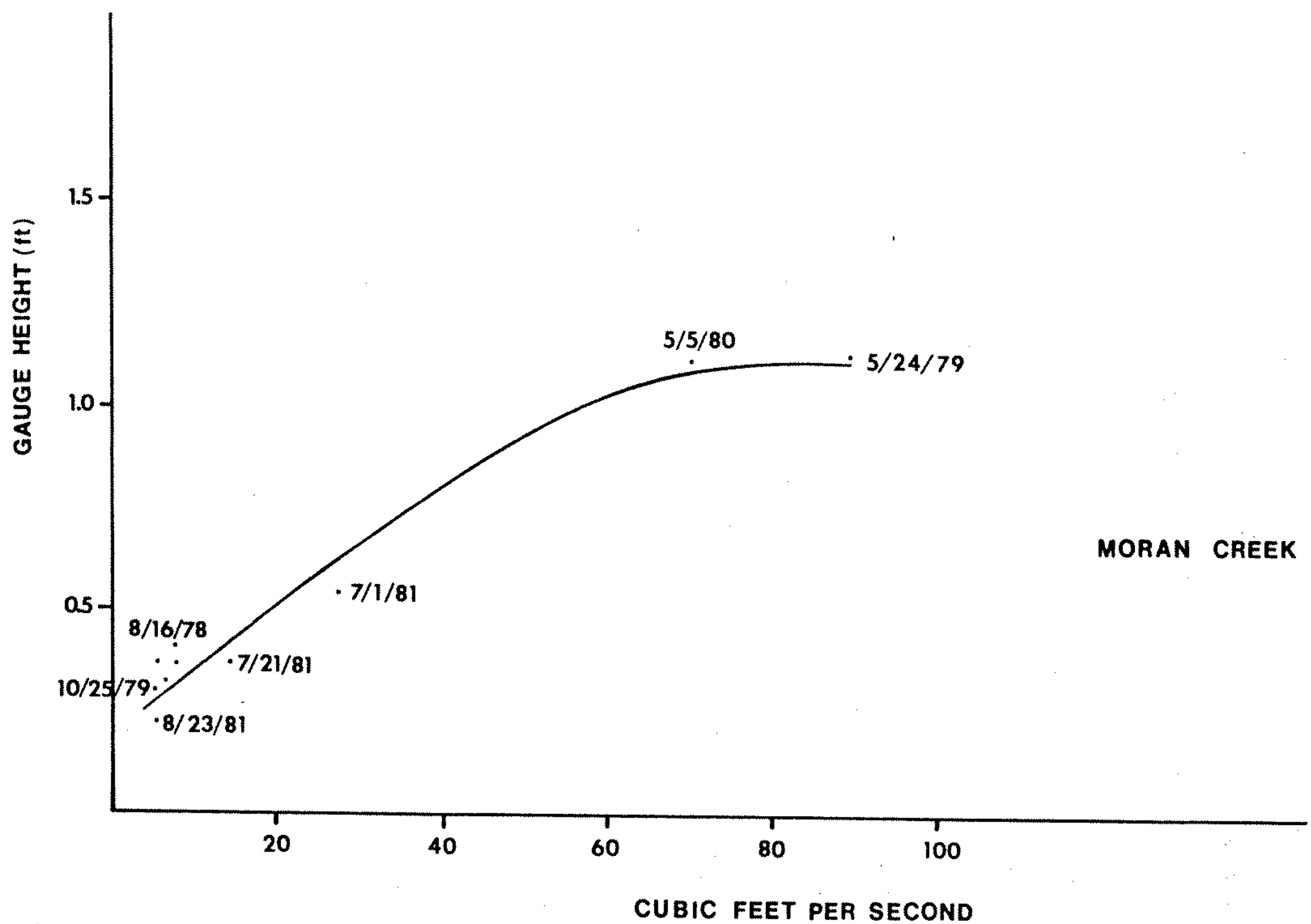

Figure 8. Gauge height and flow relationship for Moran Creek. Dates of flow measurements are indicated along the discharge curve.

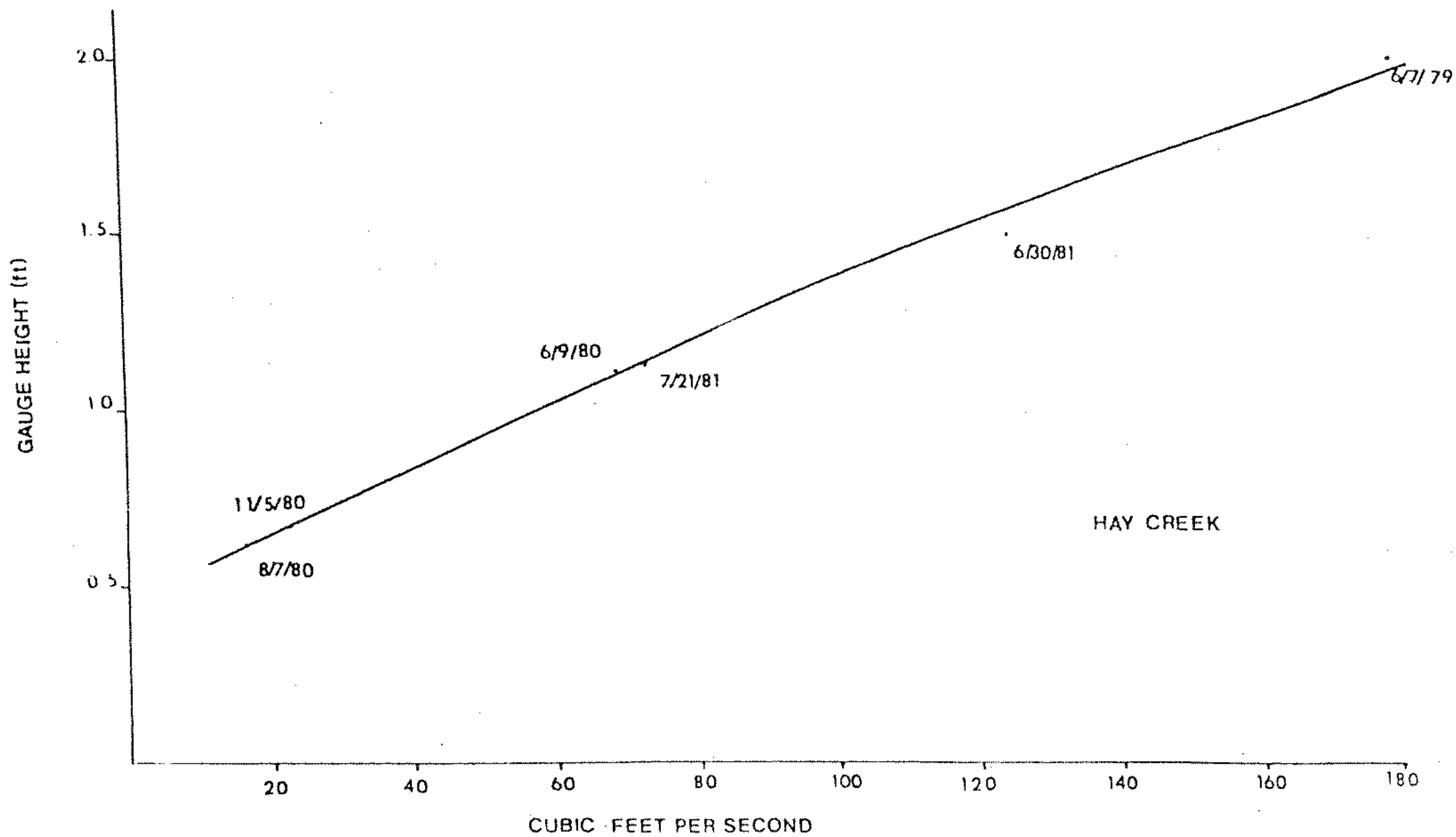

Figure 9. Gauge height and flow relationship for Hay Creek. Dates of flow measurement are indicated along the curve.

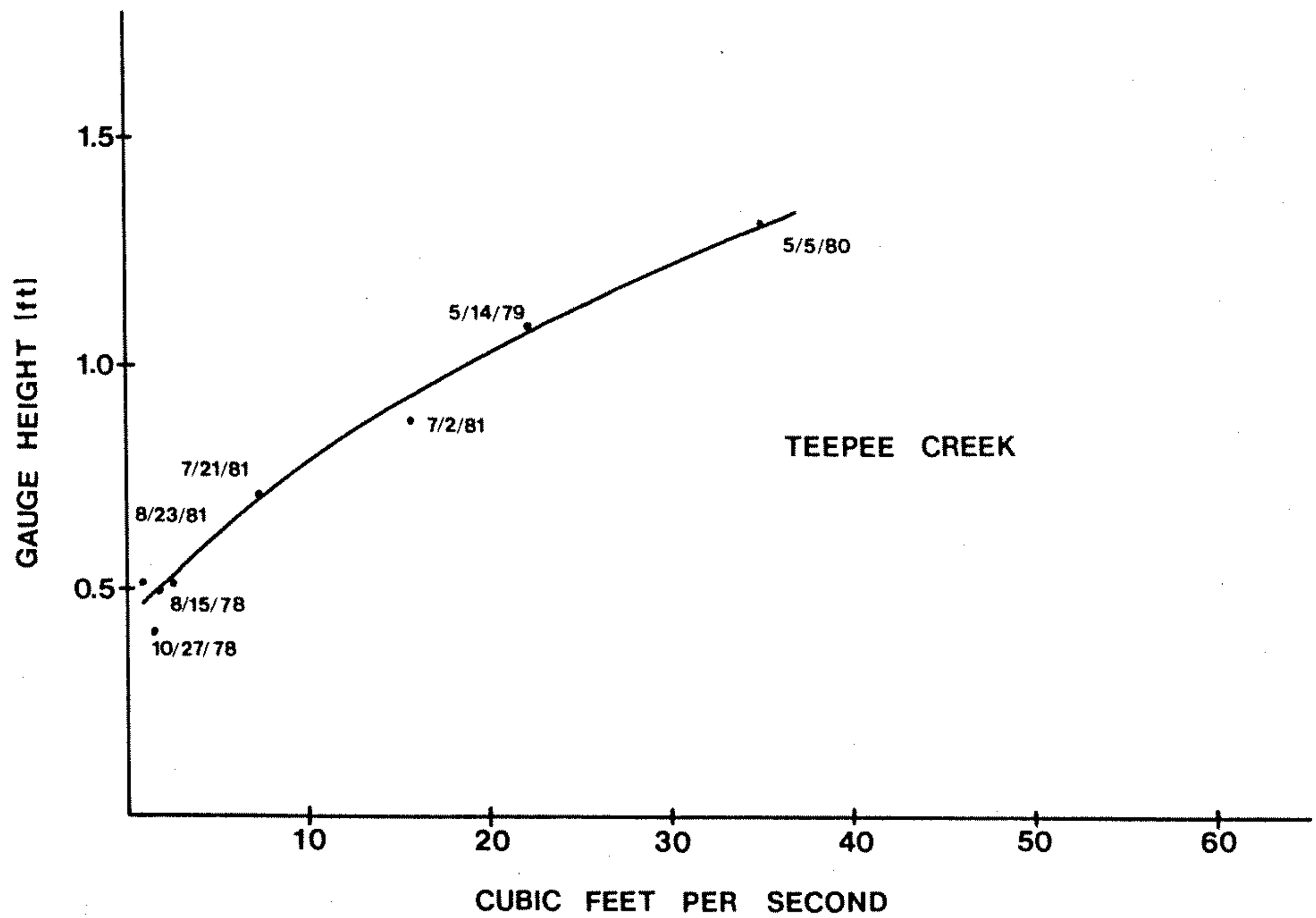

Figure 10. Gauge height and flow relationship for Teepee Creek. Dates of flow measurements are indicated along the discharge curve.

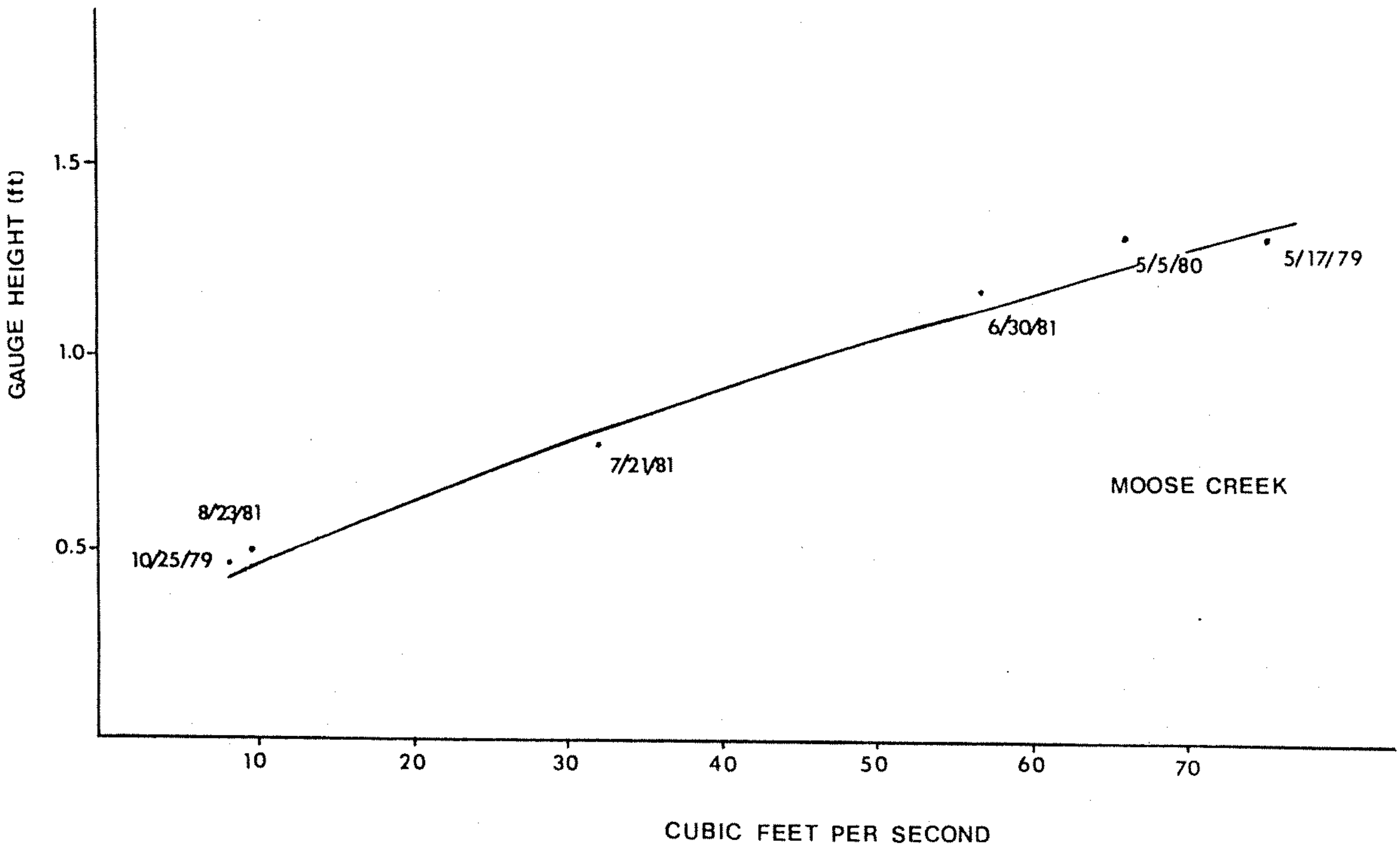

Figure 11. Gauge height and flow relationship for Moose Creek. Dates of flow measurements are indicated along the discharge curve.

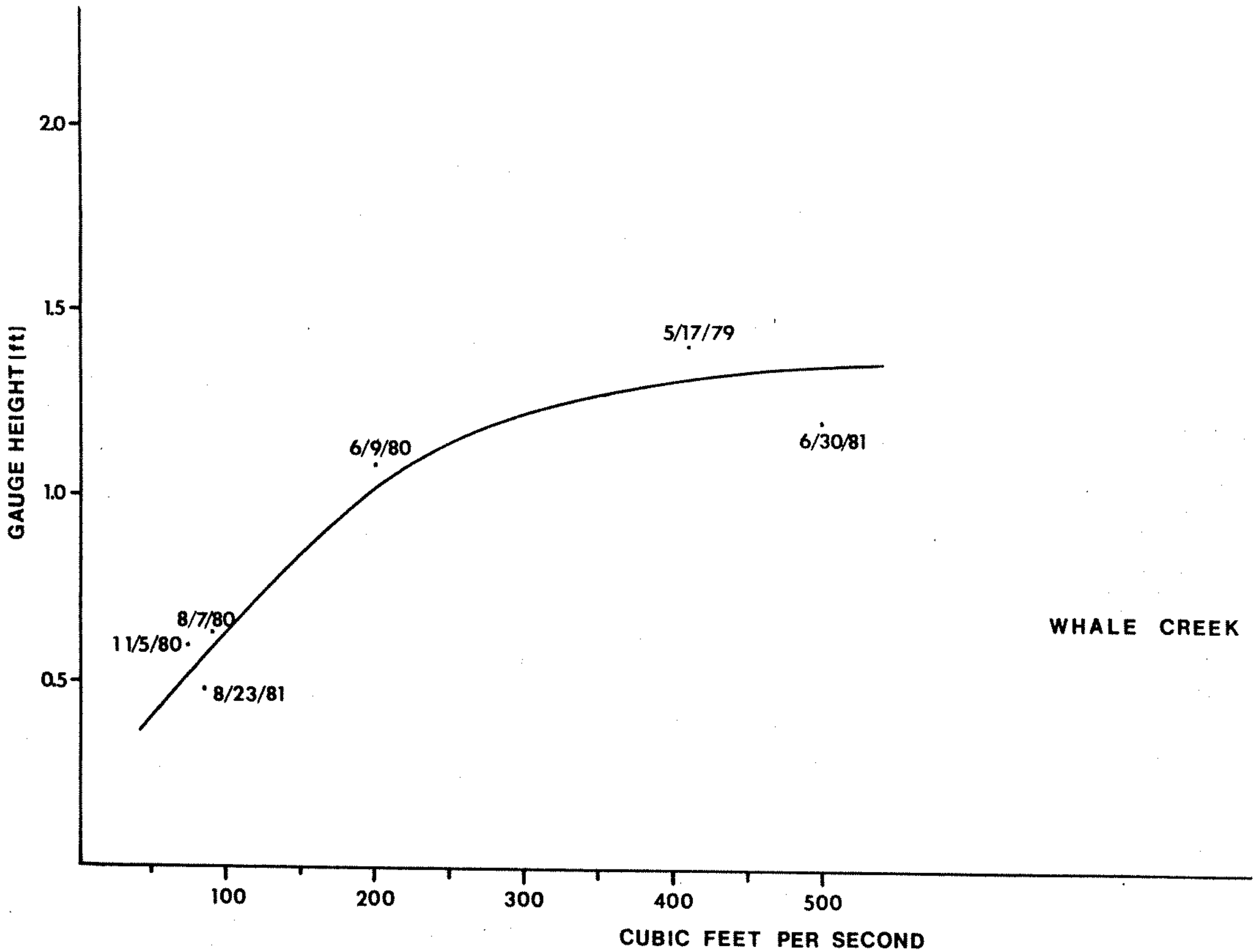

Figure 12. Gauge height and flow relationship for Whale Creek. Dates of flow measurements are indicated along the discharge curve.

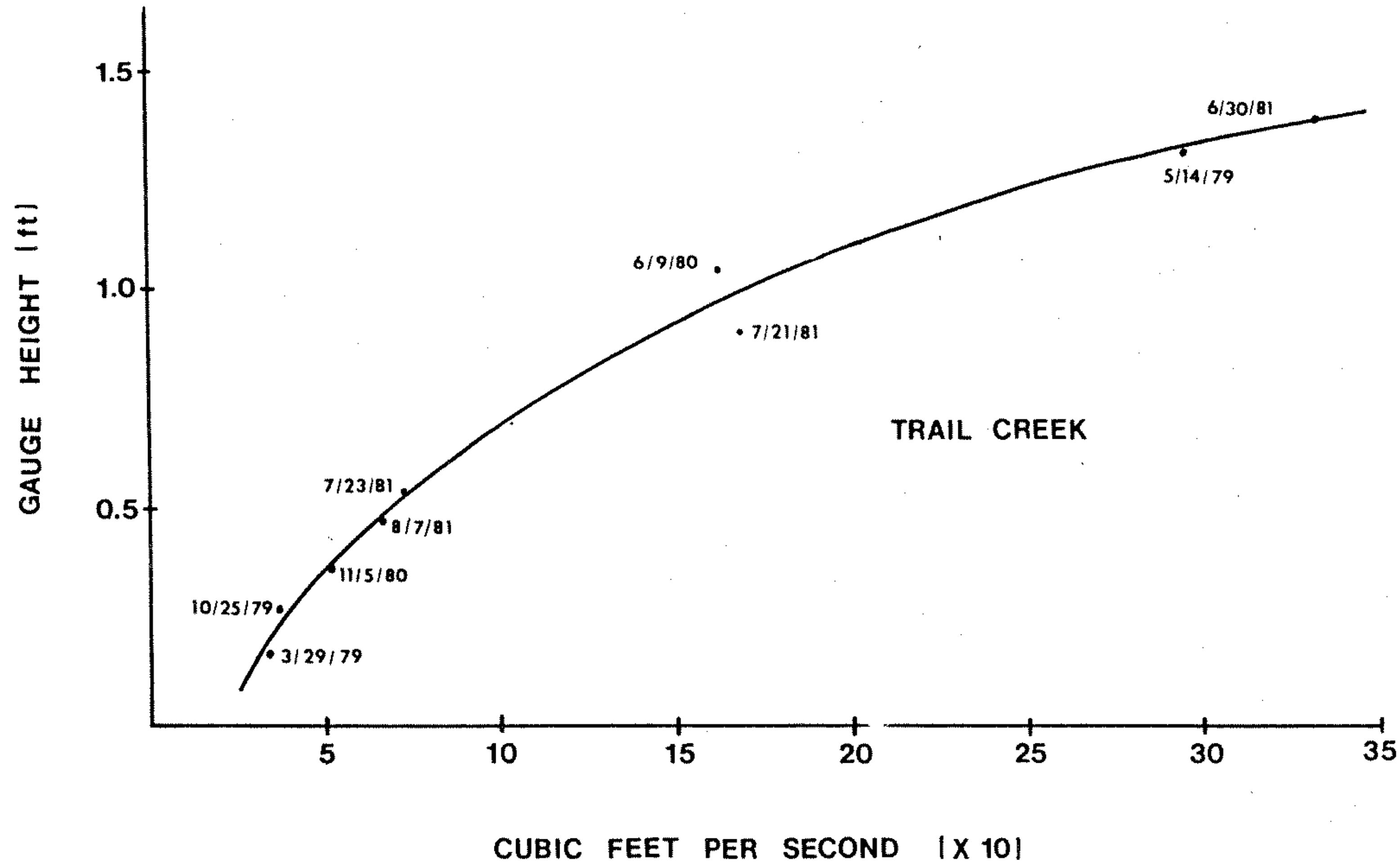

Figure 13. Gauge height and flow relationship for Trail Creek. Dates of flow measurements are indicated along the discharge curve.

Table 3. Alkalinity, conductivity and late summer flows for the lower reaches of major tributaries of the Middle Fork, 1981.

Stream name	Late summer flow(cfs)	Total Alkalinity	Total Conductivity (μohms)
McDonald Creek	*	50.6	105
Lincoln Creek	*	56.5	130
Deerlick Creek	*	117.9	225
Harrison Creek	*	46.1	105
Nyack Creek	*	110.7	220
Coal Creek	*	53.1	125
Stanton Creek	*	92.1	185
Tunnel Creek	*	89.3	160
Muir Creek	*	70.1	150
Paola Creek	*	91.0	170
Park Creek	*	66.7	150
Dickey Creek	*	115.8	200
Ole Creek	*	75.7	170
Bear Creek	*	130.7	240
Geifer Creek	*	133.3	240
Skyland Creek	*	98.3	305
Morrison Creek	*	150.3	250
Lodgepole Creek	*	133.9	340
Schafer Creek	4.5	8.6	160
Dolly Varden Creek	10.3	157.6	260
Clack Creek	8.2	146.9	200 1/
Bowl Creek	13.4	150.3	185 1/
Strawberry Creek	16.6	163.1	240 1/
Trail Creek	8.4	144.6	210 1/
Middle Fork above Bear Creek	*	116.4	210

* Flows measured with Marsh-McBirney current meter found to be inaccurate so not reported.
1/ Measurements made in 1980.

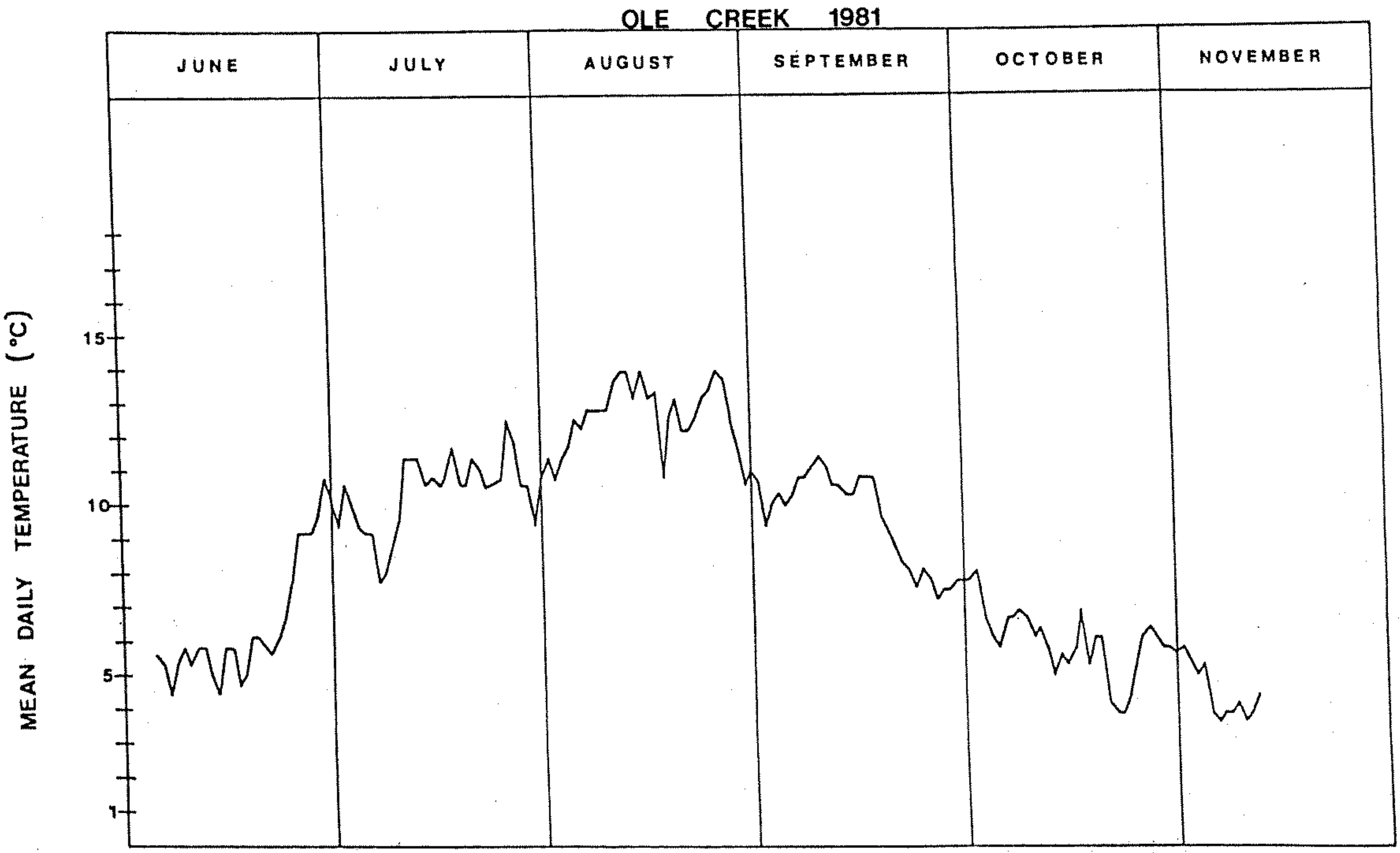

Figure 14. Mean daily temperatures from the thermograph installed in Ole Creek on 4 June and removed 13 November 1981.

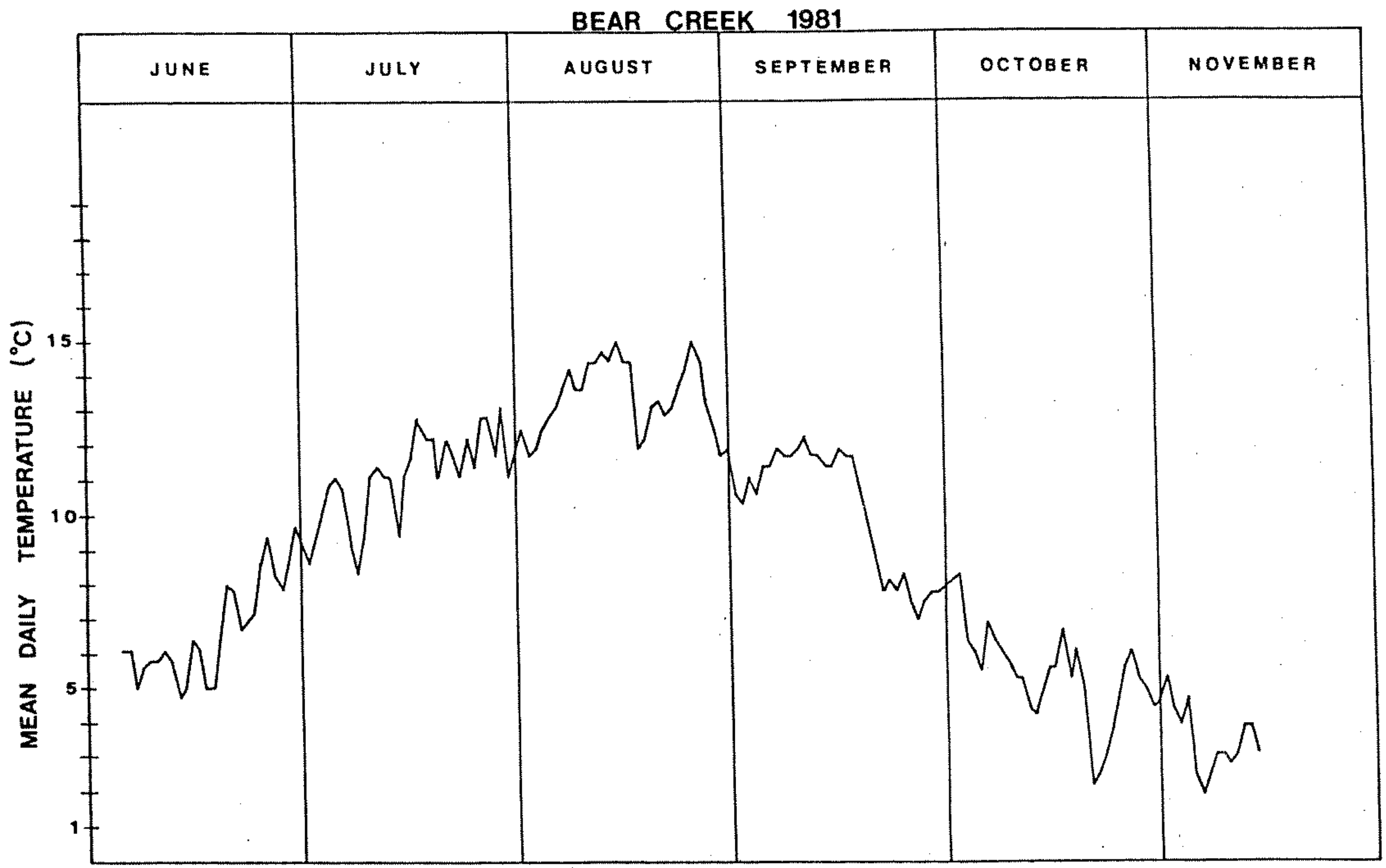

Figure 15. Mean daily temperatures from the thermograph installed in Bear Creek on 4 June and removed 15 November 1981.

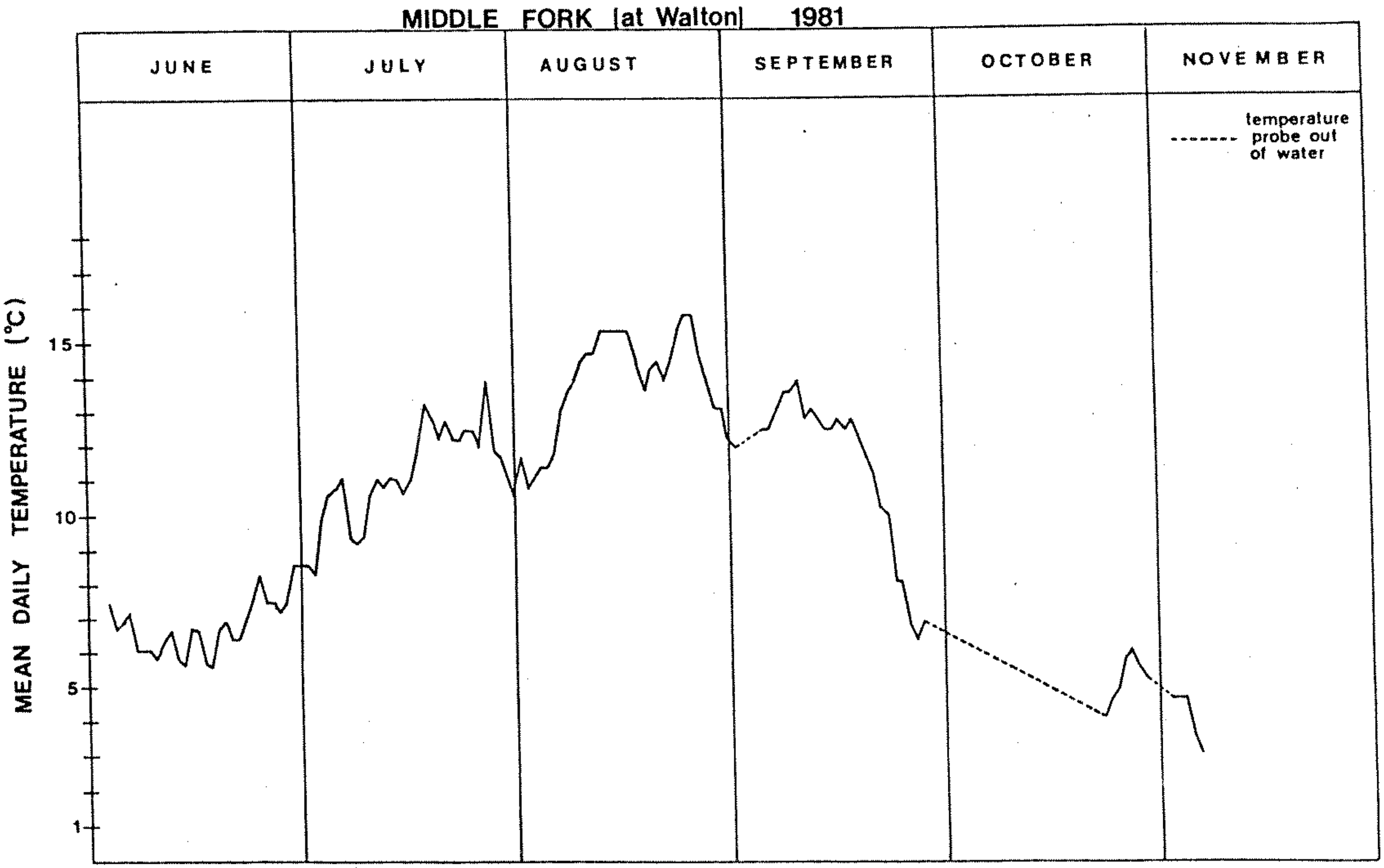

Figure 16. Mean daily temperatures from the thermograph installed in the Middle Fork at Walton on 2 June and removed 7 November 1981.

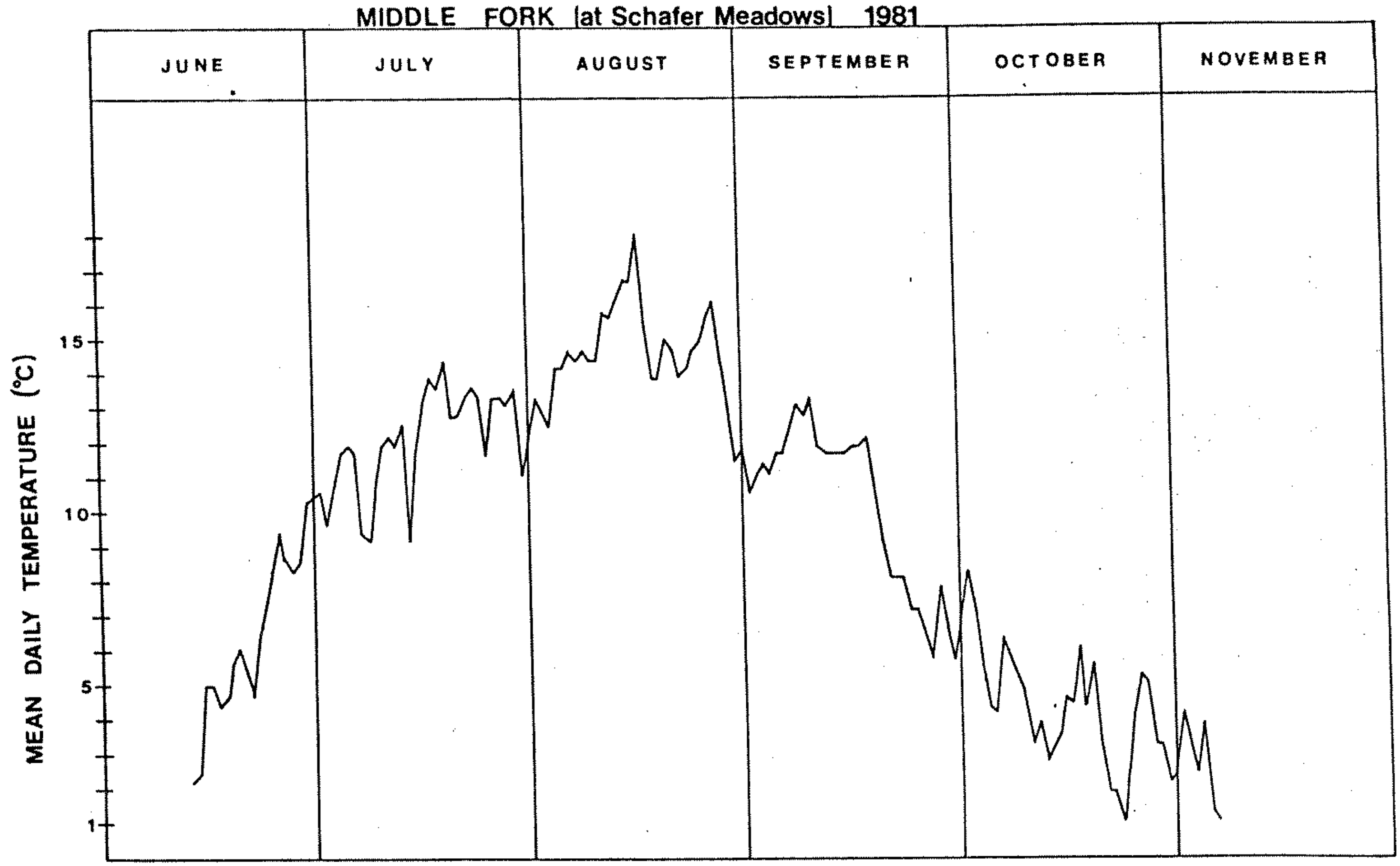

Figure 17. Mean daily temperatures from the thermograph installed in the Middle Fork at Schafer Meadows on 12 June and removed 7 November 1981.

are presented in Table 4. All streams reached maximum temperatures during August instead of July as reported for the previous year (Fraley et al. 1981). Bear Creek reached a maximum of 18.9°C while the summer maximum in Ole Creek was 16.7°C. The Middle Fork at Schafer Meadows reached a maximum of 20°C while downstream at Walton the maximum temperature was 17.2°C. Mean monthly maximum temperatures were greater than 10°C for all stations during July, August and September.

Minimum-maximum thermometers were placed in Essex, Tunnel, Park and Coal creeks to document summer maximum water temperatures. Summer maximums in tributaries entering the Middle Fork from the south averaged lower (14.4°C in both Essex and Tunnel creeks) than in those draining Glacier National Park (15.5 and 18.9°C in Park and Coal creeks). Minimum-maximum thermometers were also placed at fish trapping sites in Geifer, Challenge and Dodge creeks during June and July (Table 5).

Water Quality and Flows in the South Fork Drainage

Point measurements of alkalinity, conductivity and flow were made by department personnel during late summer in the South Fork River and the major tributaries surveyed (Table 6). Methods used for determination of alkalinity and conductivity were the same as described for the Middle Fork tributaries. The point measurements of flow were made using a Teledyne Gurley Current Meter.

Table 4. Monthly averages of minimum and maximum water temperatures (°C) at three locations in the Middle Fork River and two selected tributaries.

Month	Bear Creek[1/]	Ole Creek[2/]	Middle Fork at Schafer Meadows[3/]	Middle Fork at Walton[4/]	Middle Fork at West Glacier[5/]
June					
Mean minimum	5.1	5.3	4.2	5.9	
Mean maximum	8.2	7.5	8.3	7.6	
Range	3.3-13.3	3.3-13.3	0.6-13.9	4.4-10.0	
July					
Mean minimum	8.4	8.3	9.2	9.8	11.3
Mean maximum	13.8	12.5	14.9	12.4	13.2
Range	5.6-16.7	6.1-16.1	5.6-17.2	6.7-15.0	7.8-15.6
August					
Mean minimum	10.0	10.2	11.3	12.6	
Mean maximum	16.7	14.9	17.8	15.1	
Range	8.3-18.9	8.9-16.7	8.9-20.0	10.0-17.2	
September					
Mean minimum	7.8	8.2	7.4	10.4	
Mean maximum	12.6	11.0	12.9	12.3	
Range	5.0-16.7	6.1-13.3	4.4-16.7	6.1-15.0	
October					
Mean minimum	4.4	5.3	2.7	5.2	
Mean maximum	6.2	6.5	5.7	5.9	
Range	1.1-10.0	3.3-8.9	0.0-12.2	3.9-7.2	
November					
Mean minimum	2.8	3.9	1.3	3.9	
Mean maximum	4.0	4.9	4.2	4.4	
Range	1.7-6.1	3.3-6.7	0.0-5.6	2.8-5.0	

1/ Thermograph - in: June 4 - out: November 15.

2/ Thermograph - in: June 4 - out: November 13.

3/ Thermograph - in: June 12 - out: November 8.

4/ Thermograph - in: June 2 - out: November 7.

5/ Thermograph - in: July 2 - out: July 30.

Table 5.

Month	Water temperature		
	Geifer Creek 1/	Challenge Creek 2/	Dodge Creek 3/
June			
Mean minimum	4.2	4.6	3.9
Mean maximum	9.5	8.8	8.7
Range	2.2-13.9	5.6-16.7	4.4-17.2
July			
Mean minimum	6.9	7.3	3.8
Mean maximum	15.5	14.4	12.2
Range	4.4-22.8	5.6-16.7	4.4-17.2

1/ Thermometers installed 3 June and removed 21 July.
2/ Thermometers installed 28 May and removed 18 July.
3/ Thermometers installed 16 June and removed 13 July.

Table 6. Alkalinity, conductivity, and late summer flows for the lower reaches of five tributaries of the South Fork.

Stream name	Late summer flow (cfs)	Alkalinity	Total conductivity
Little Salmon Creek	38.7	---	115
White River	39.1	152.5	260
Gordon Creek	34.1	94.0	180
Danaher Creek	35.9	156.0	300
Young's Creek	50.7	95.0	160
South Fork at Big Creek	96.0	121.0	220

LITERATURE CITED

Orland, H.P. (ed). 1965. Standard Methods. Boyd Printing Co. Inc. Albany N.Y. 769 p.

APPENDIX B

Reach information for Middle and South Fork tributaries surveyed during 1981.

Table 1. Reach information for Middle Fork tributaries surveyed in 1981.

Drainage	Reach No.	Drainage area(km^2)	Length (km)	Gradient (%)
McDonald Creek	1	440.1	3.3	0.2
Lincoln Creek	1	93.5	8.0	2.0
	2	---	8.0	3.0
Walton	1	24.4	3.7	4.8
	2	---	3.2	2.5
Deerlick Creek	1	39.4	5.1	0.2
Harrison Creek	1	69.8	5.3	1.9
Nyack Creek	1	214.9	11.4	0.2
	2	---	1.9	2.5
Coal Creek	1	144.1	5.6	2.4
	2	---	12.5	0.7
	3	---	7.6	2.7
Pinchot	1	49.9	1.8	4.5
	2	---	3.7	2.6
Stanton Creek	1	33.5	2.4	3.5
Tunnel Creek	1	21.9	1.4	4.2
	2	---	4.3	0.9
Muir Creek	1	34.8	1.9	5.0
	2	---	2.4	3.8
	3	---	2.9	4.4
Paola Creek	1	16.9	1.2	9.6
Park Creek	1	101.6	3.5	1.7
	2	---	8.4	0.9
	3	---	7.6	2.2
	4	---	3.2	4.5
Dickey Creek	1	23.3	4.4	4.1
Ole Creek	1	119.5	7.4	1.6
	2	---	4.0	1.1
	3	---	15.6	2.0
Essex Creek	1	26.6	1.9	2.2
	2	---	1.6	8.3
Bear Creek	1	145.4	5.9	1.8
	2	---	7.7	0.7
	3	---	10.1	2.6
Geifer	1	---	3.7	2.5
Skyland	1	---	3.4	3.1

Table 2. Reach information for South Fork tributaries surveyed in 1981.

Drainage	Reach No.	Drainage area (km^2)	Length (km)	Gradient (%)	Late summer (cfs)
Little Salmon Creek	1	101.7	10.8	0.6	38.7
White River	1	226.6	8.8	1.1	39.1
	2	---	4.8	3.3	---
Gordon Creek	1	171.0	11.9	0.4	34.1
	3	---	4.7	0.5	---
	4	---	2.6	1.7	---
Danaher Creek	1	336.8	6.8	0.7	35.9
Young's Creek	1	310.3	5.8	0.8	50.7

APPENDIX C

Results of stream trapping activities conducted in Middle Fork tributaries during 1981.

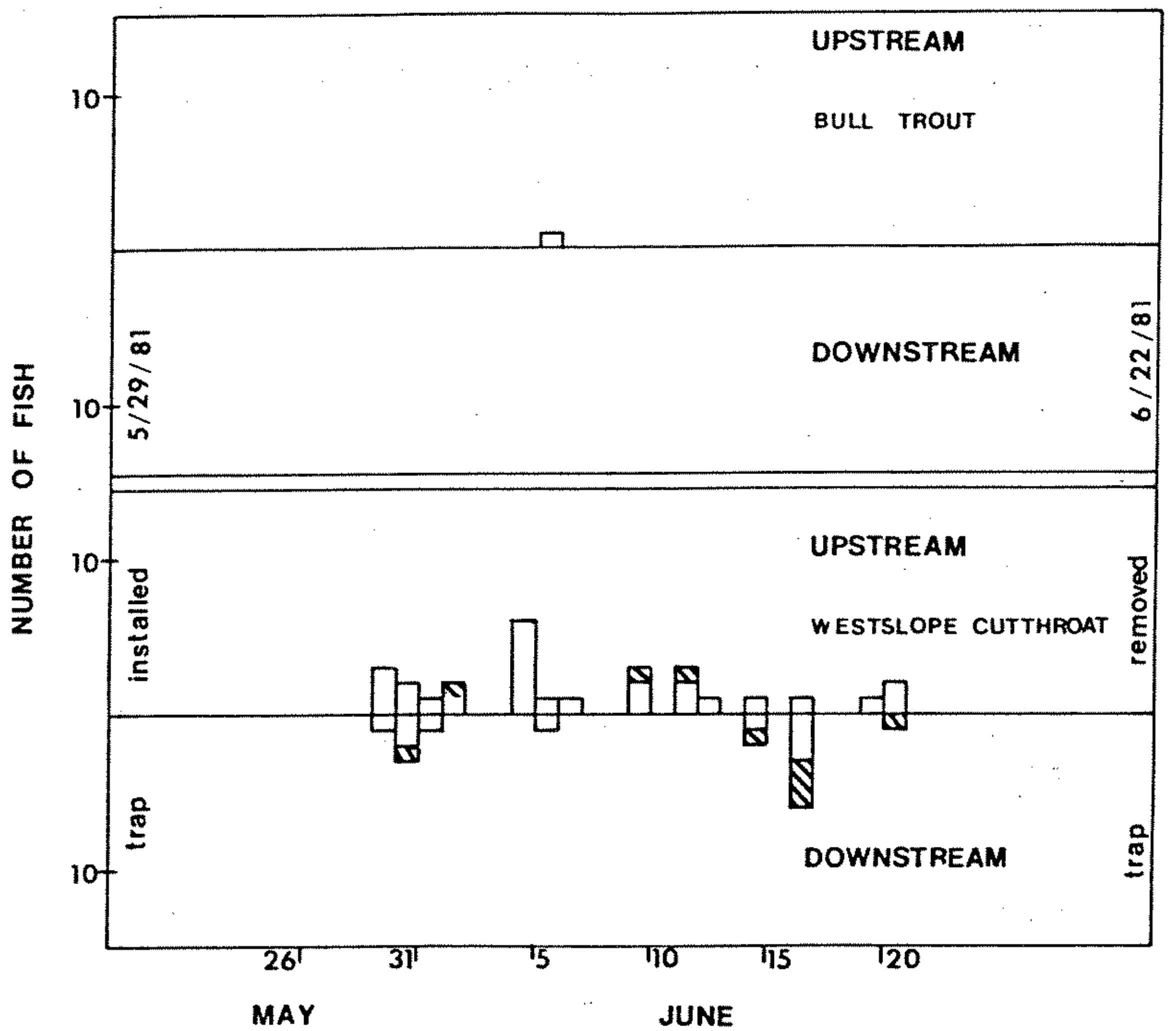

Figure 1. Upstream and downstream trap catches of westslope cutthroat and bull trout in Bear Creek at Site 1 for 1981. [hatched box] indicates recaptured fish.

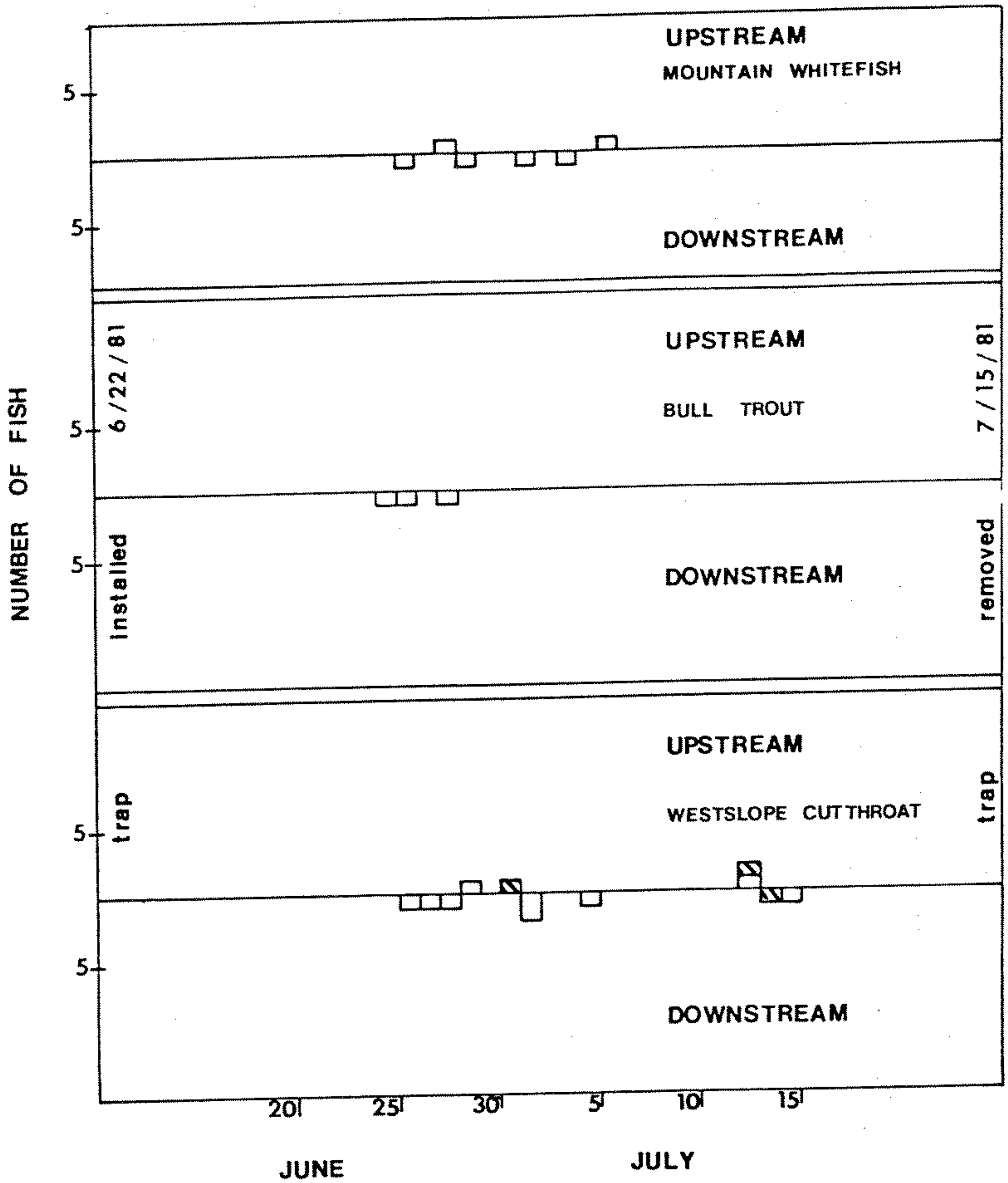

Figure 2. Upstream and downstream trap catches of mountain whitefish, bull trout and westslope cutthroat trout in Bear Creek at Site 2 for 1981. ⧅ indicates recaptured fish.

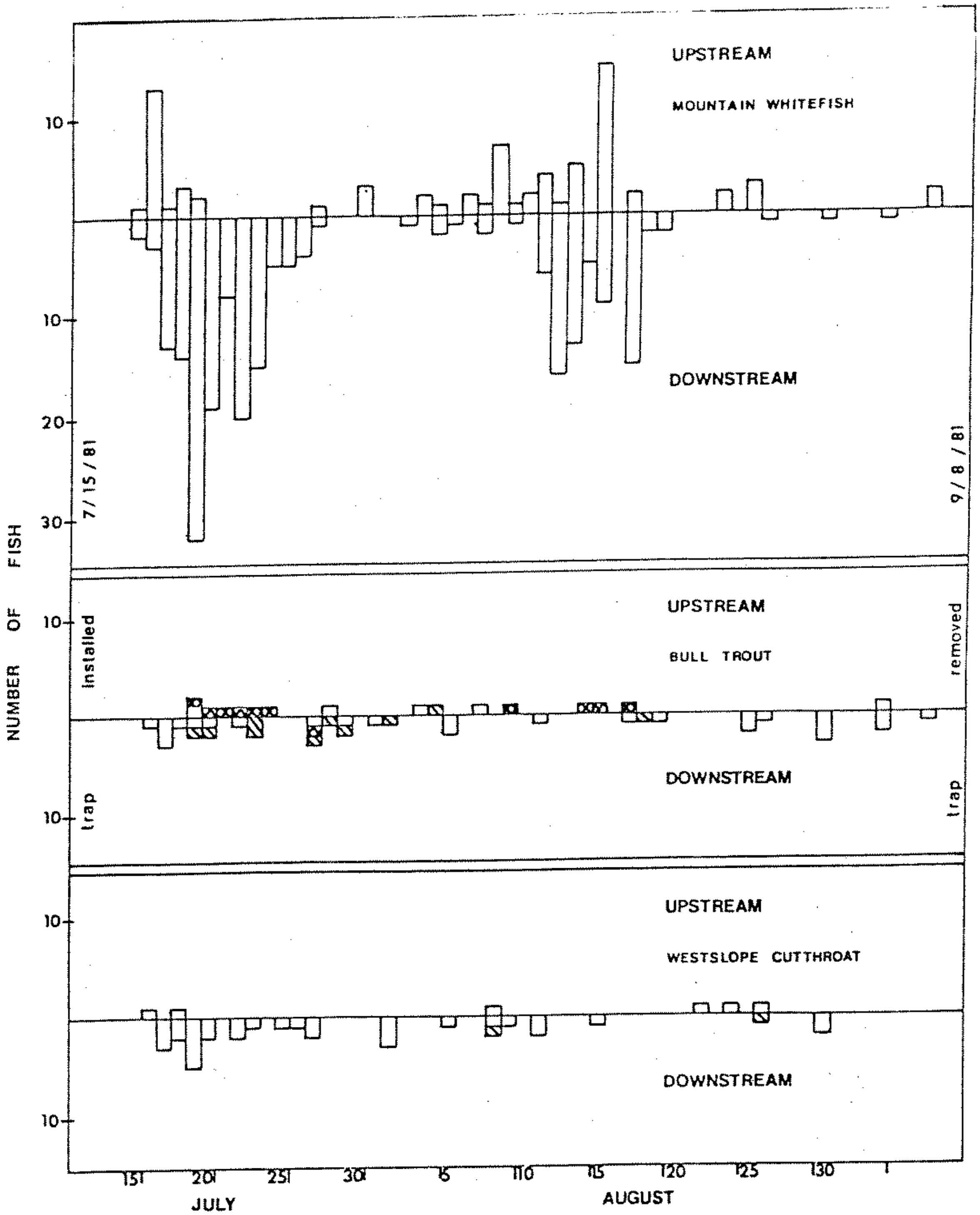

Figure 3. Upstream and downstream trap catches of mountain whitefish, bull trout and westslope cutthroat trout in Bear Creek at Site 3 for 1981. [hatched box] indicates recaptured fish and [crosshatched box] indicates mature fish.

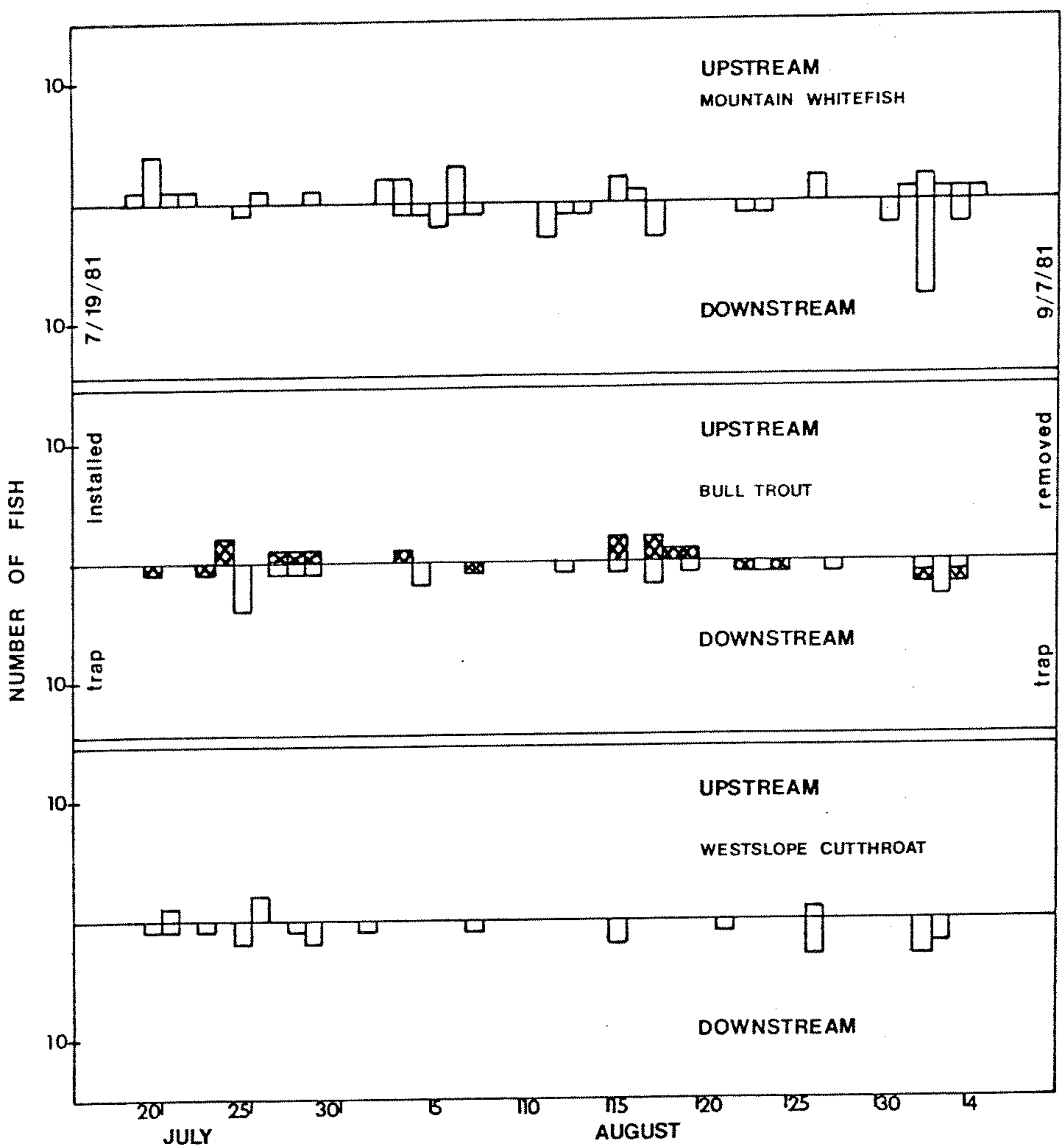

Figure 4. Upstream and downstream trap catches of mountain whitefish, bull trout and westslope cutthroat trout in Ole Creek for 1981. ▩ indicates mature fish.

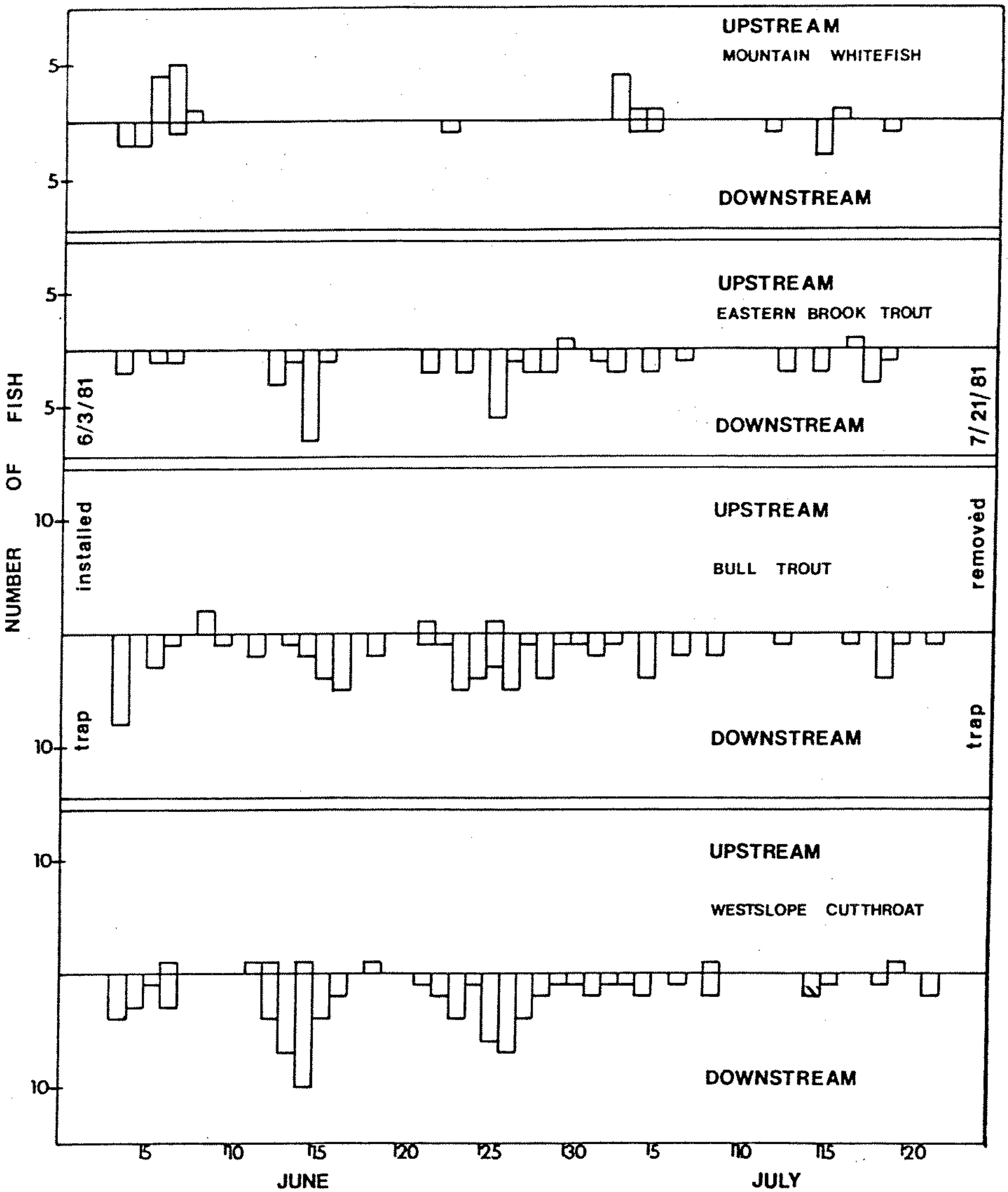

Figure 5. Upstream and downstream trap catches of mountain whitefish, eastern brook trout, bull trout and westslope cutthroat trout in Geifer Creek for 1981. ▨ indicates recaptured fish.

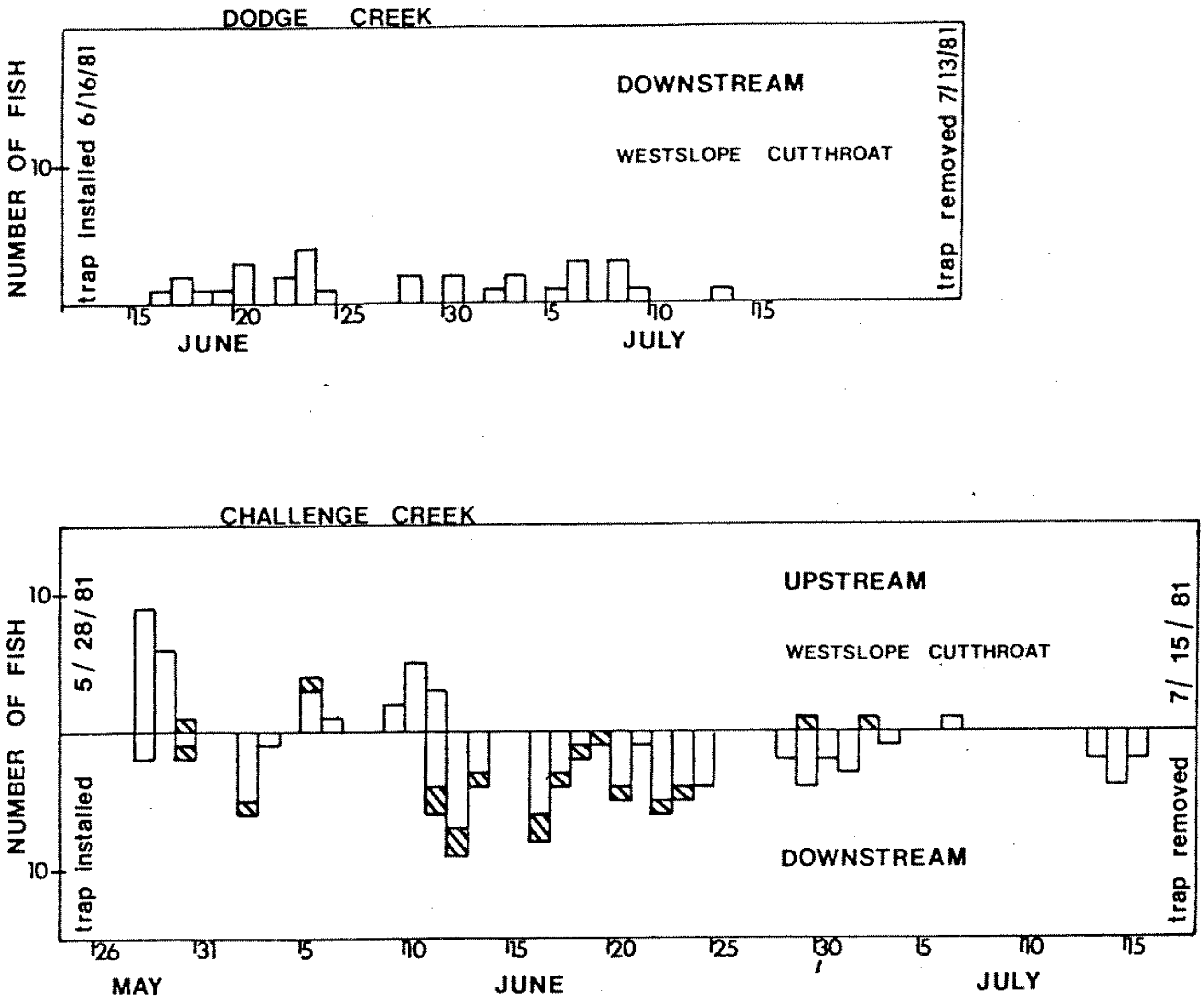

Figure 6. Downstream trap catch of westslope cutthroat trout in Dodge Creek (top) and upstream and downstream trap catches of westslope cutthroat trout in Challenge Creek (bottom) for 1981. ▨ indicates recaptured fish.

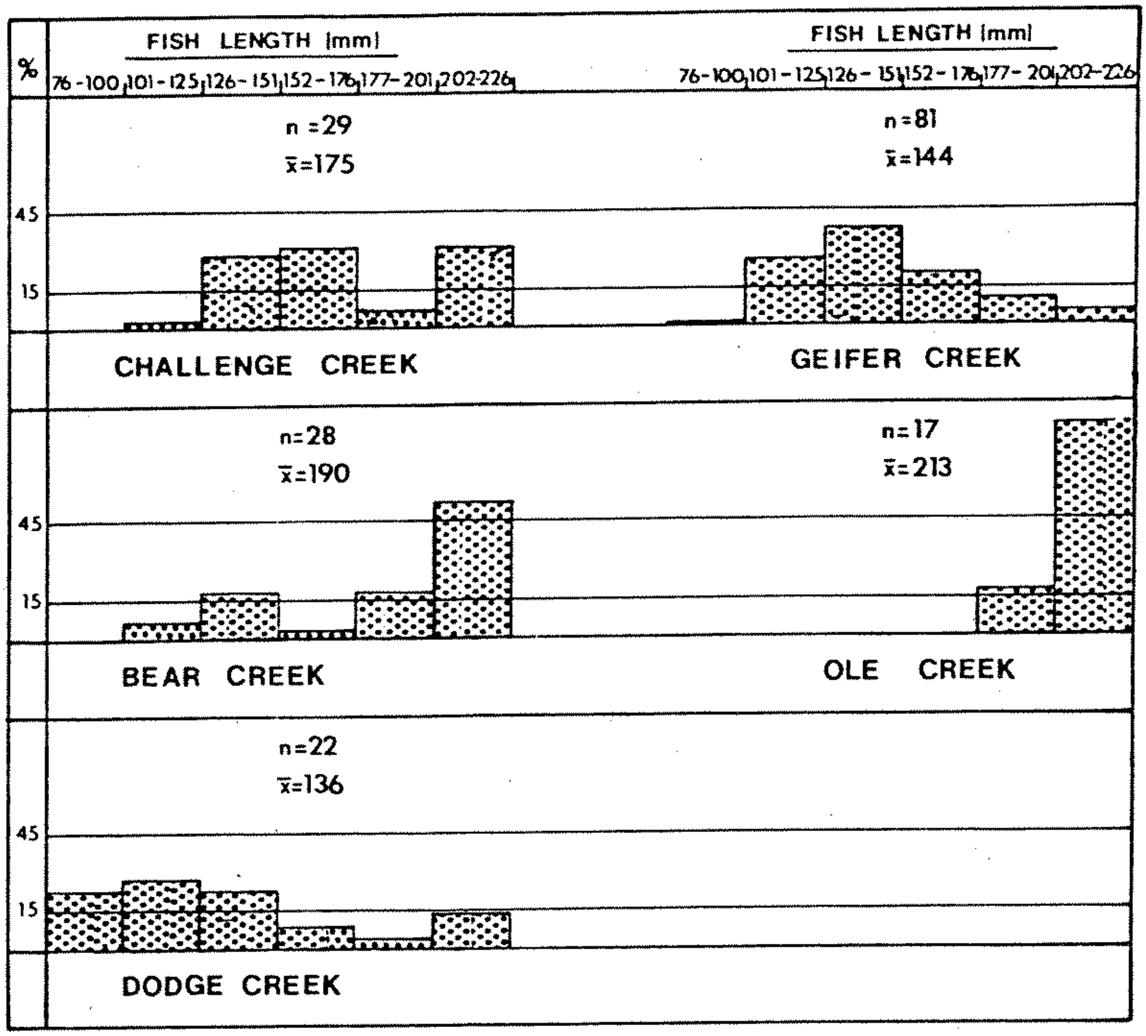

Figure 7. Percent abundance and lengths of westslope cutthroat trout emigrating downstream through Challenge, Geifer, Bear, Ole and Dodge creek traps in 1981.

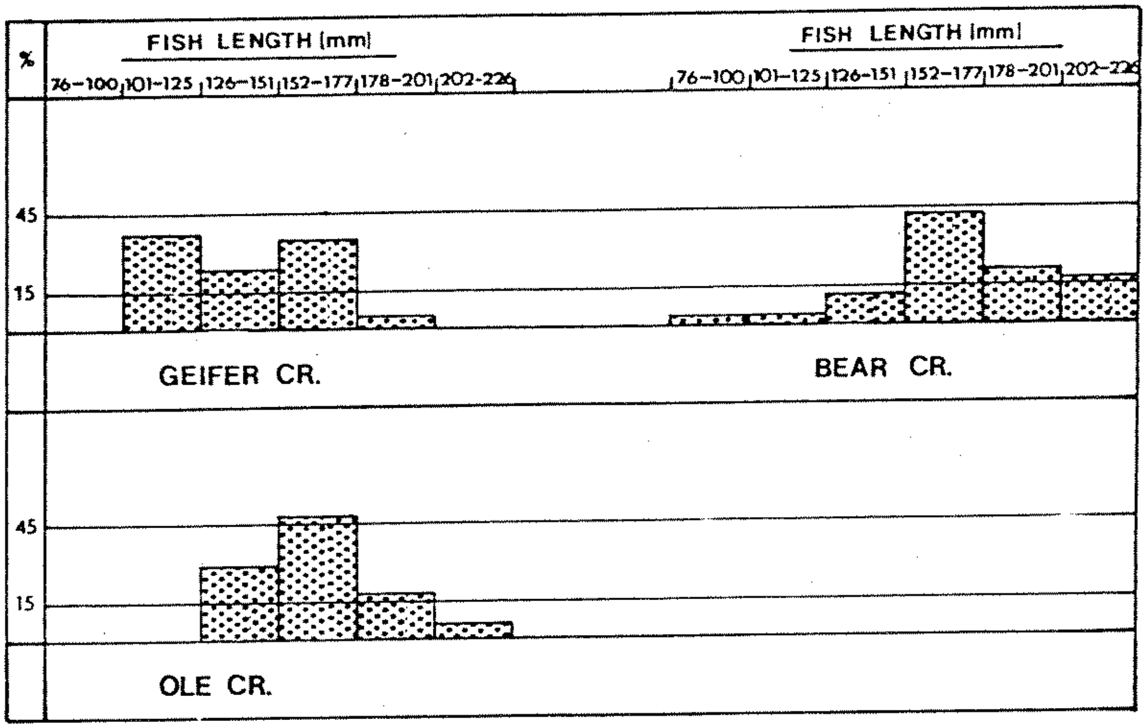

Figure 8. Percent abundance and lengths of juvenile bull trout emigrating downstream through Geifer, Bear and Ole creek traps in 1981.

APPENDIX D

Bull trout redd distributions in
North Fork tributaries in 1981 and
Middle Fork tributaries in 1980 and 1981.

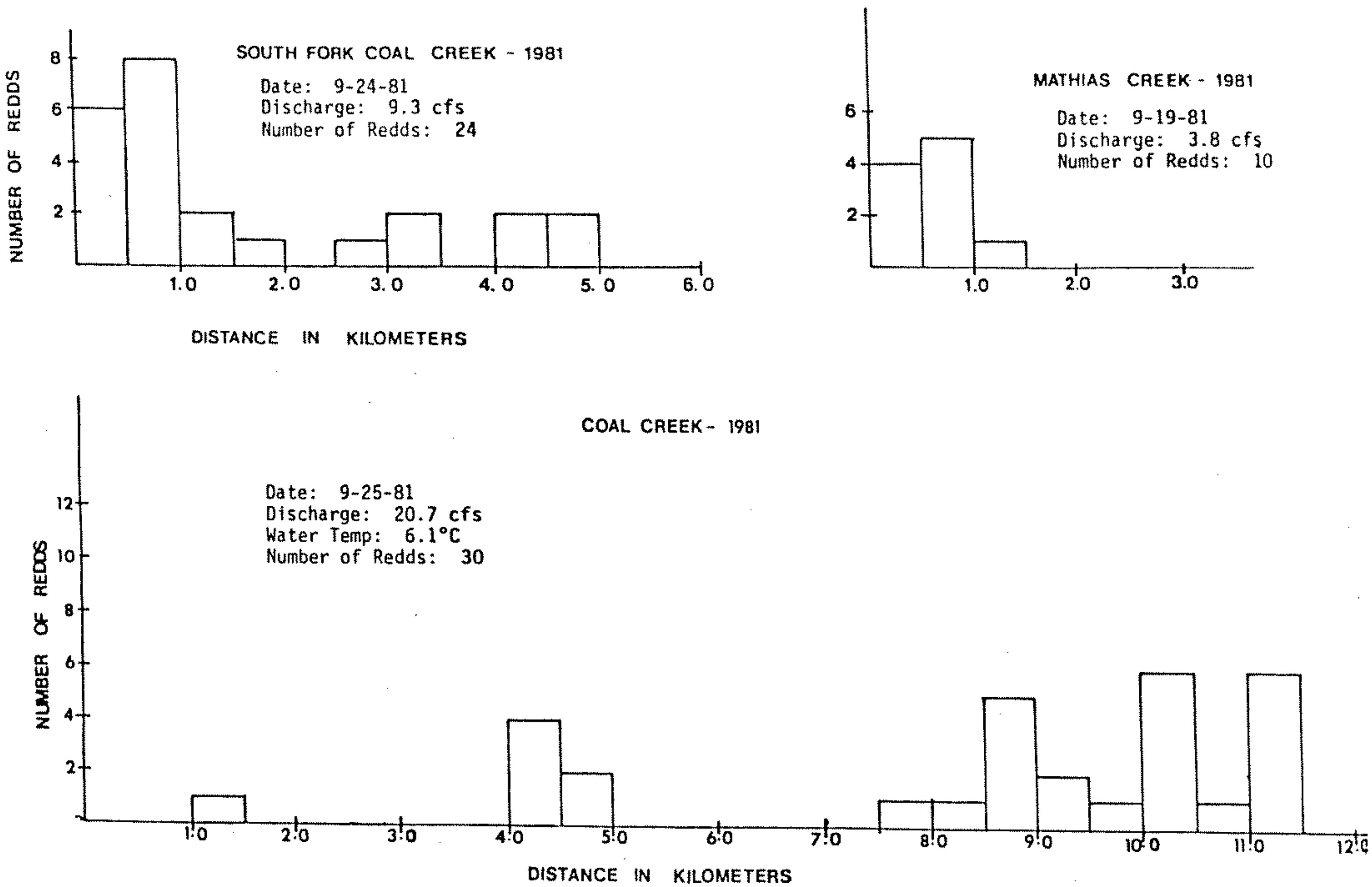

Figure 1. Bull trout redd distribution in the South Fork Coal Creek, Mathias Creek and Coal Creek. South Fork Coal survey in 1981 began below the upper boundry of Reach 1 (kilometer 0.0 on figure) and ended at the lower end of clearcut (kilometer 6.0 on figure). Mathias Creek survey in 1981 began at upper boundry of Reach 1 (kilometer 0.0 on figure) and ended at its mouth (kilometer 1.4 on figure). Coal Creek survey in 1981 began below Coal Ridge Lookout trail (kilometer 0.0 on figure) and ended above the mouth of Dead Horse Creek (kilometer 12.4 on figure. The South Fork Coal Creek joins Coal Creek at kilometer 5.8 on bottom figure.

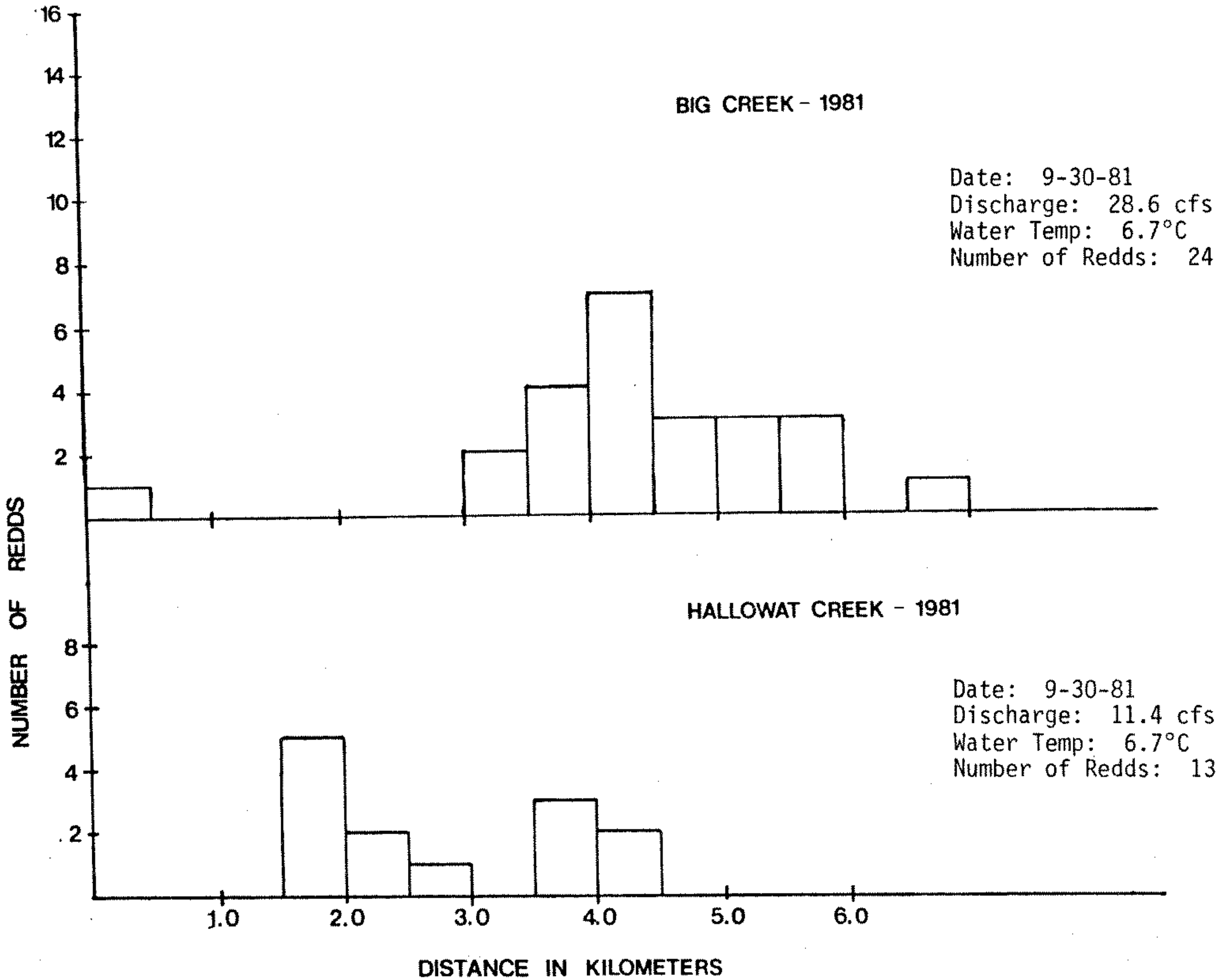

Figure 2. Bull trout redd distrubutions in Big Creek and Hallowat Creek. Big Creek survey began at the bridge above the mouth of Nicola Creek (kilometer 0.0 on figure) and ended just above the mouth of Eleleham Creek (kilometer 7.4 on figure). Hallowat survey began immediately below the mouth of Kletomus Creek (kilometer 0.0 on figure) and ended at Big Creek (kilometer 5.6 on figure).

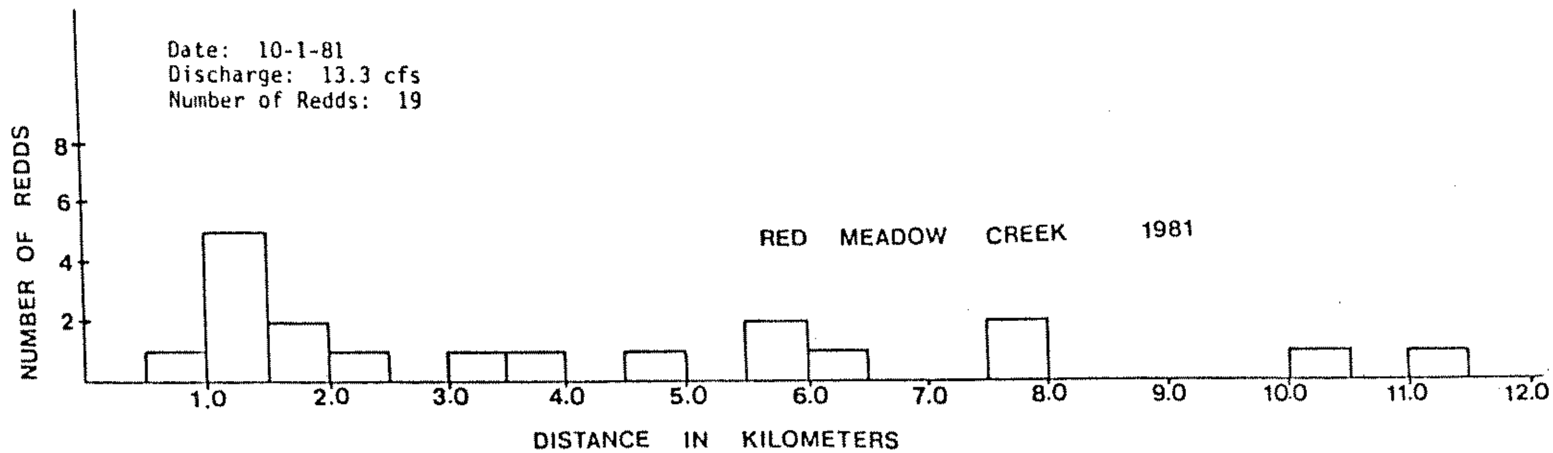

Figure 3. Bull trout redd distribution in Red Meadow Creek surveyed during 1981. Began survey at mouth of Chain Lakes Creek (kilometer 0.0 on figure) and ended 1.2 km above first bridge on Red Meadow road (kilometer 12.0 on figure).

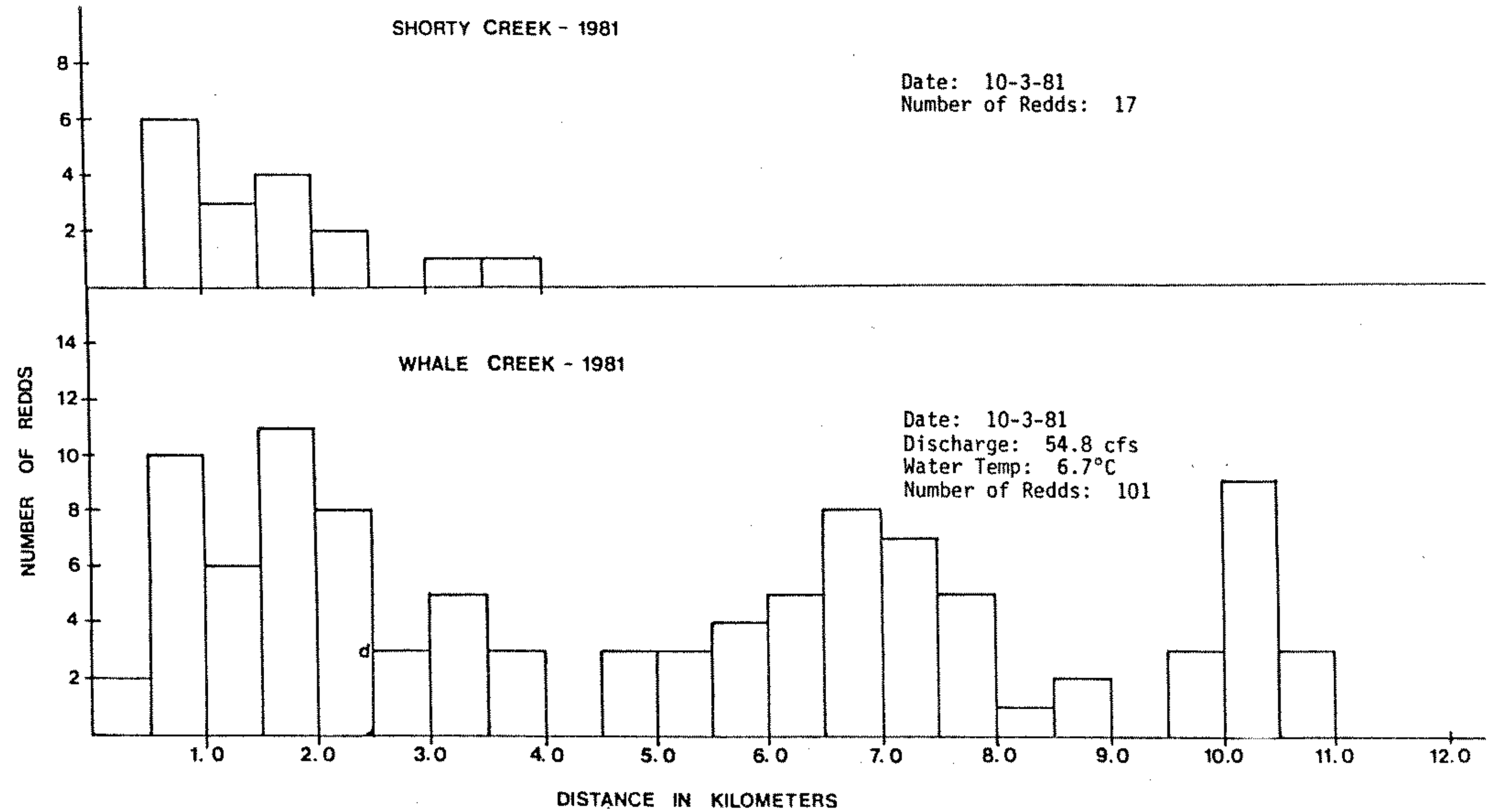

Figure 4. Bull trout redd distributions in Shorty Creek and Whale Creek surveyed during 1981. Shorty Creek survey began at the junction of the South Fork of Shorty Creek (kilometer 0.0 on figure) and ended at Whale Creek (kilometer 4.5 on figure. Whale Creek survey began at the mouth of Shorty Creek (kilometer 0.0 on figure) and ended below the road #1671 bridge (kilometer 11.1 on figure). Road #1672 bridge is at kilometer 3.8 and road #1671 bridge is at kilometer 10.5.

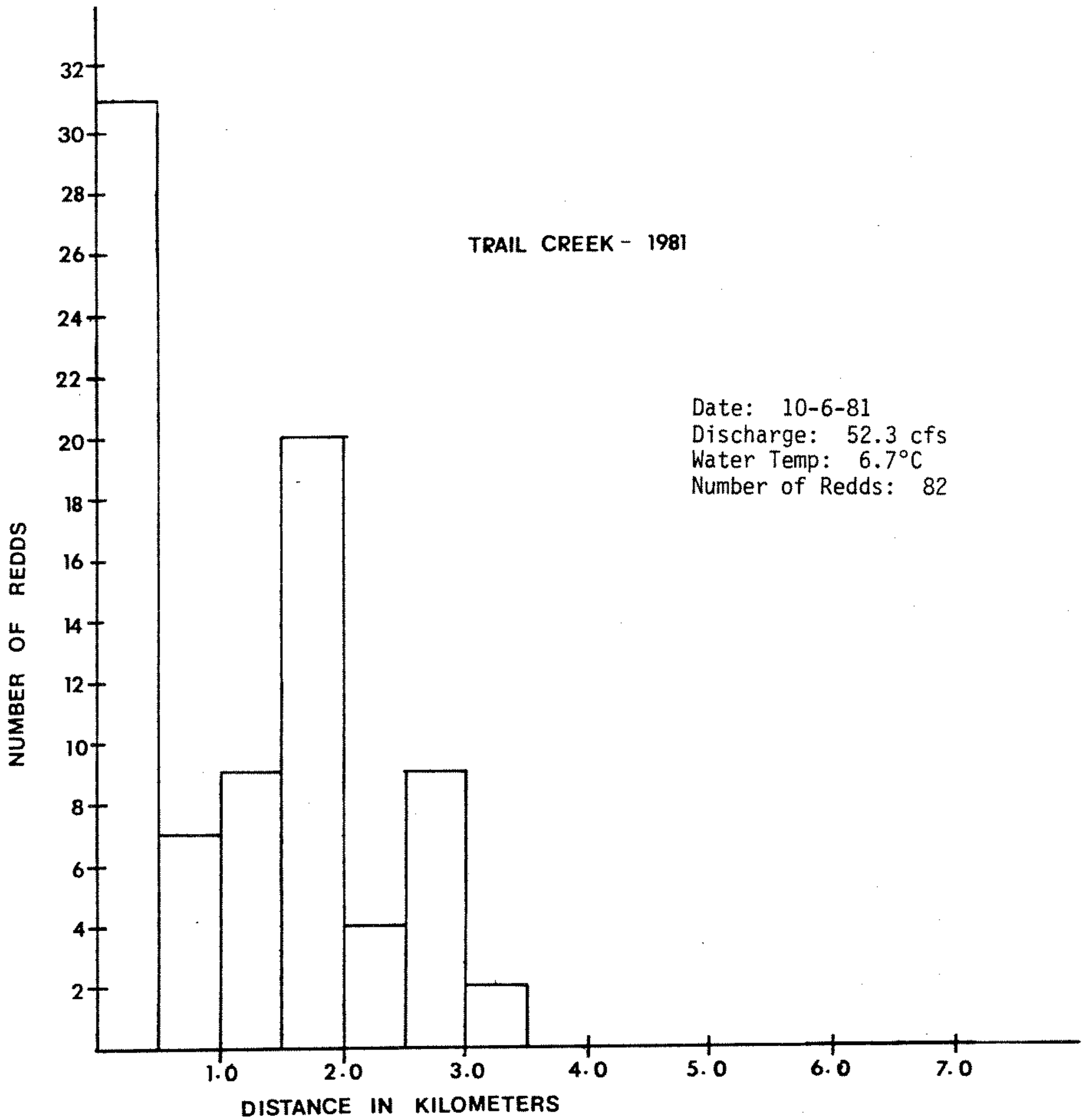

Figure 5. Bull trout redd distribution in Trail Creek surveyed during 1981. Began survey below canyon (kilometer 0.0 on figure), and ended at the Cleft Creek trail (kilometer 3.4 on figure).

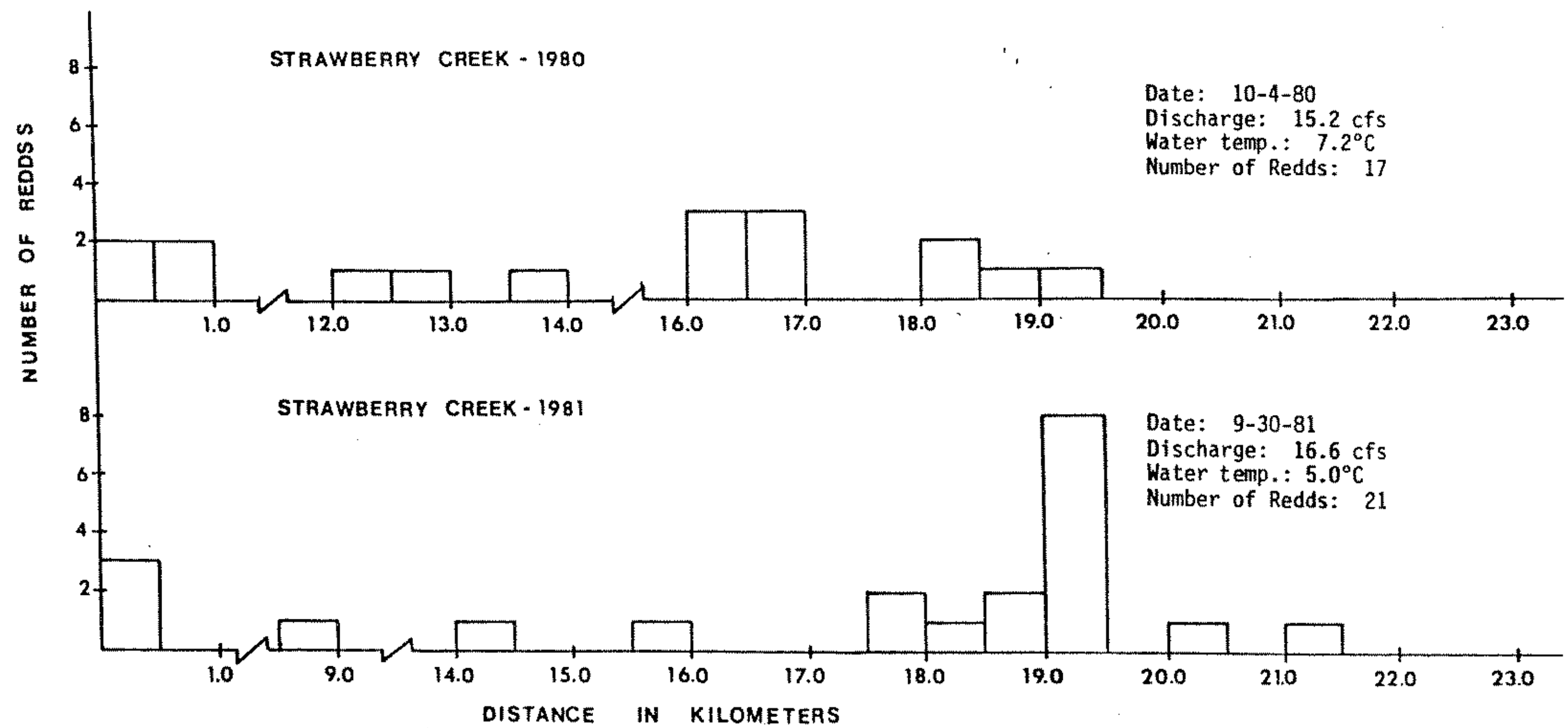

Figure 6. Bull trout redd densities in Strawberry Creek surveyed in 1980 and 1981. Survey began at the upper fork (kilometer 0.0 on figure) and ended at the junction with Bowl Creek (kilometer 22.5 on figure). Mouth of Gateway Creek is at kilometer 15.3 on figure.

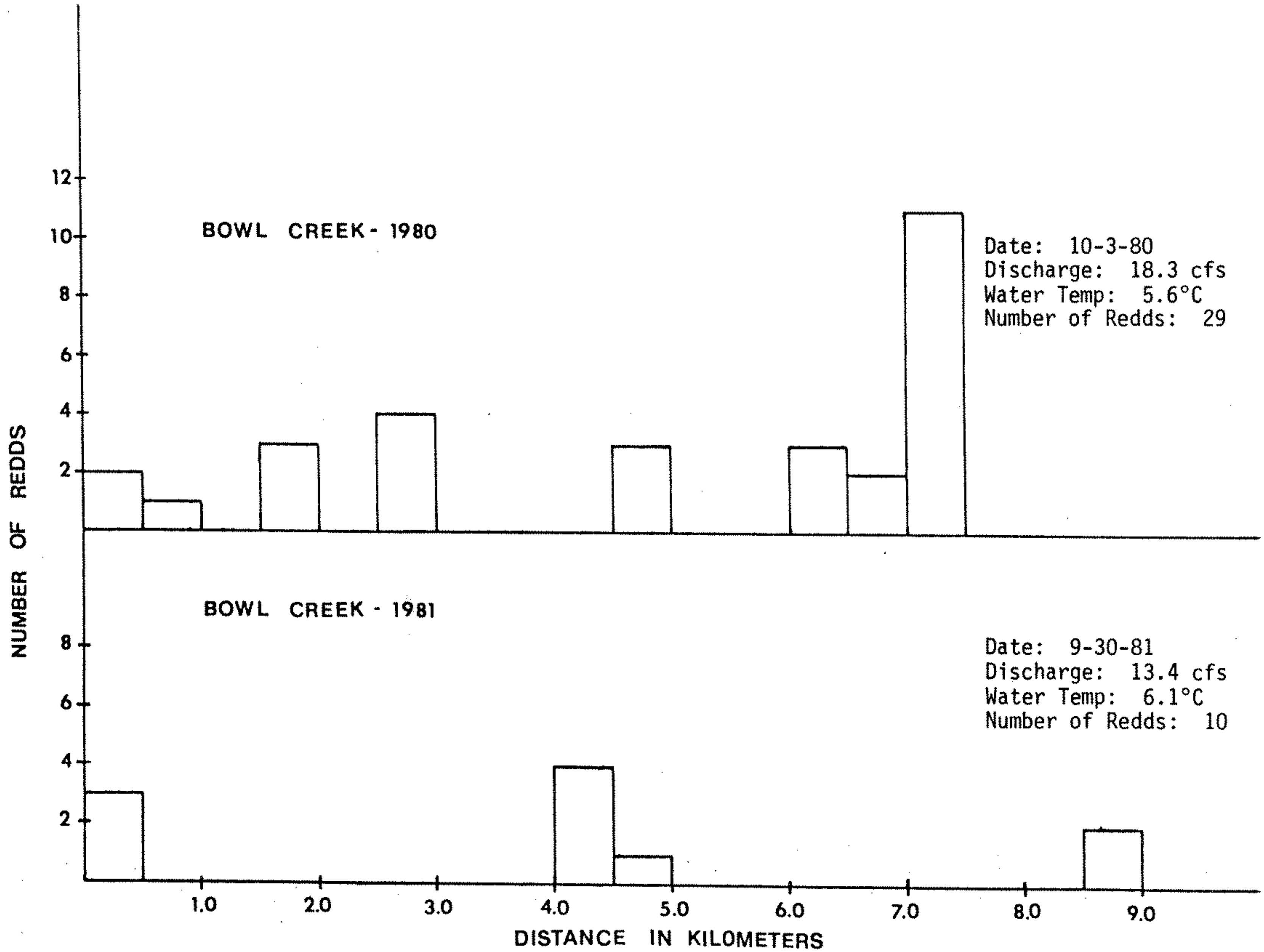

Figure 7. Bull trout redd distribution in Bowl Creek surveyed in 1980 and 1981. Survey began above the mouth of Basin Creek (kilometer 0.0 on figure), and ended at the junction of Strawberry Creek (kilometer 9.1 on figure). Mouth of Basin Creek is at kilometer 0.3 on figure.

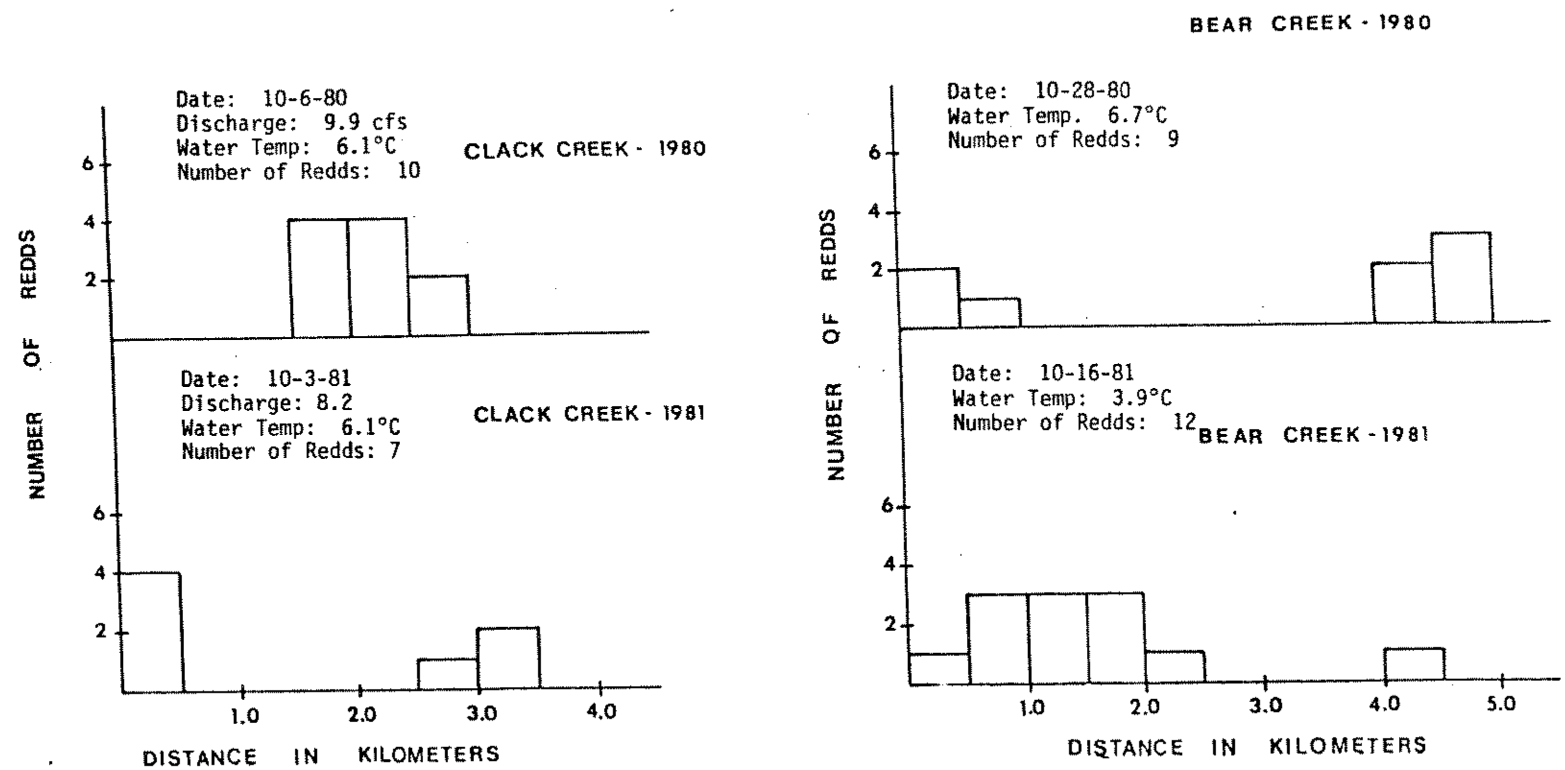

Figure 8. Bull trout redd distribution in Clack Creek and Bear Creek surveyed in 1980 and 1981. Clack Creek survey began at the lower end of the beaver dam section (kilometer 0.0 on figure) and ended at the junction with the Middle Fork (kilometer 4.1 on figure). Bear Creek survey began at Highway #2 bridge at Geifer Creek (kilometer 0.0 on figure) and ended at upper end of canyon (kilometer 5.0 on fiure). Mouth of Devils Creek is at kilometer 3.8 on figure.

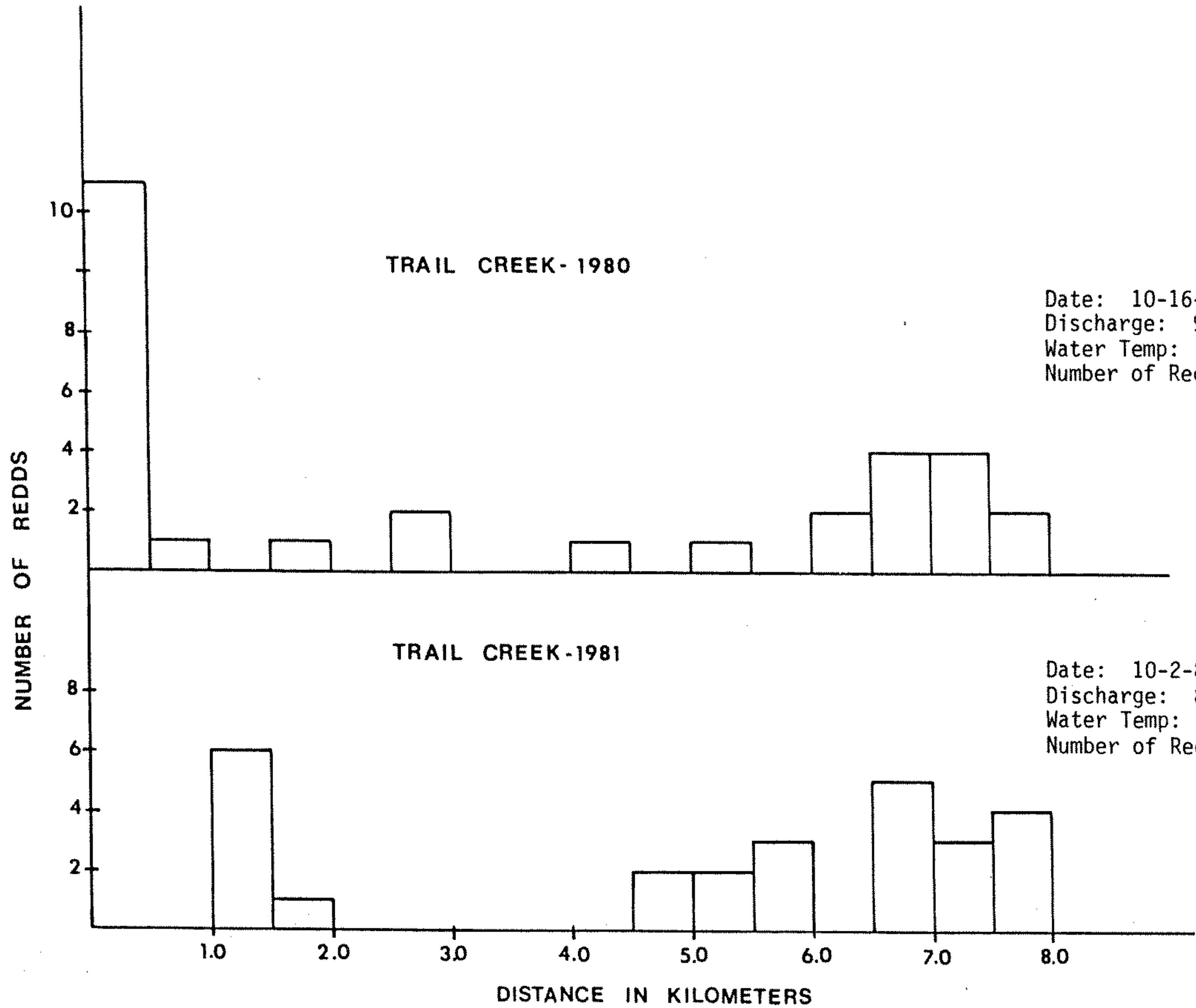

Figure 9. Bull trout redd distirbution in Trial Creek surveyed in 1980 and 1981. Survey began at mouth of Jeff Creek (kilometer 0.0 on figure) and ended at junction with Strawberry Creek (kilometer 7.8 on figure). Mouth of South Fork Trail Creek is at kilometer 6.5 on figure.

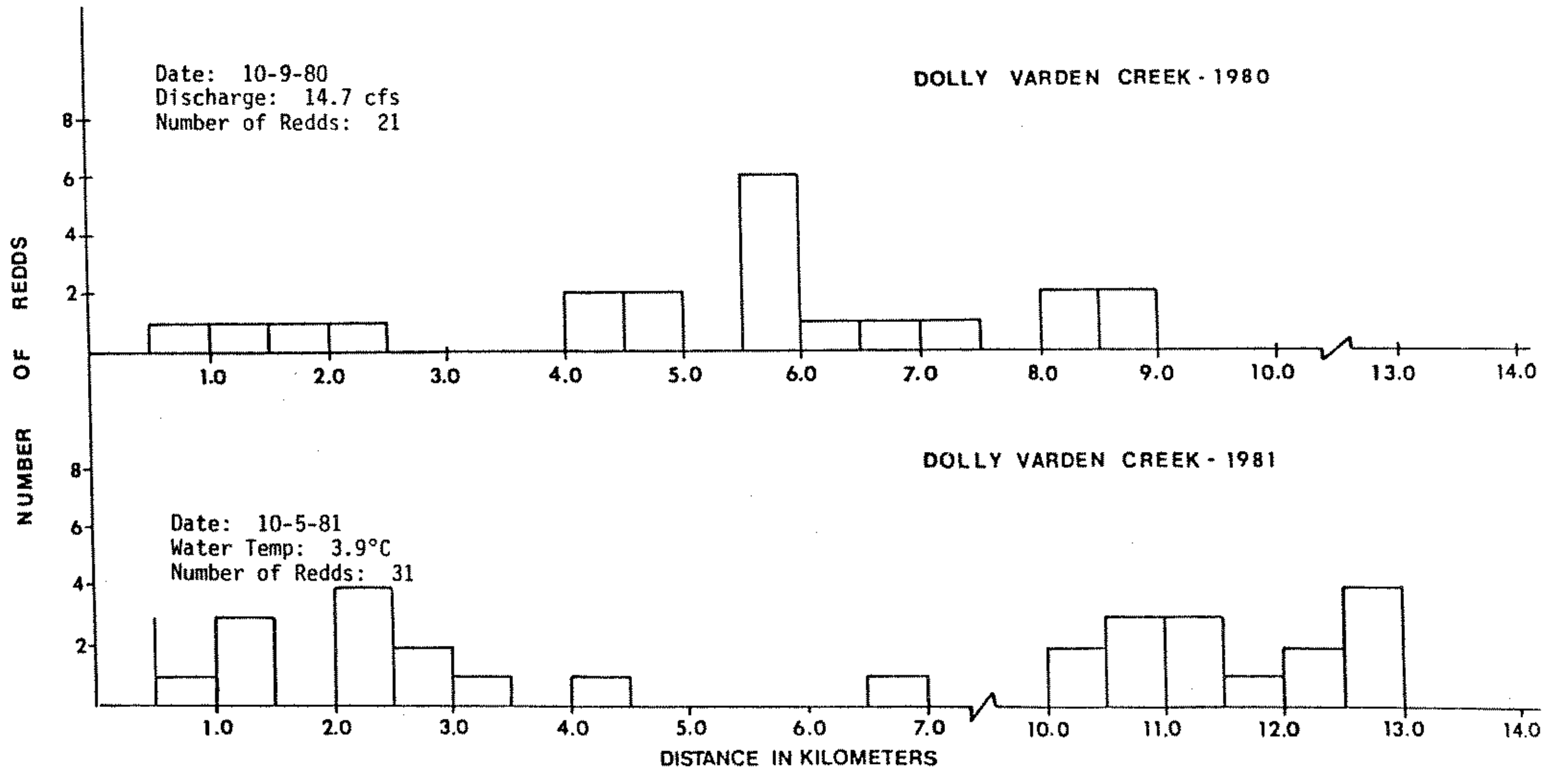

Figure 10. Bull trout redd distribution in Dolly Varden Creek surveyed in 1980 and 1981. Survey began at the falls (kilometer 0.0 on figure) and ended at junction with Schafer Creek (kilometer 14.2 on figure). Argosy Creek joins Dolly Varden Creek at kilometer 1.2 on figure.

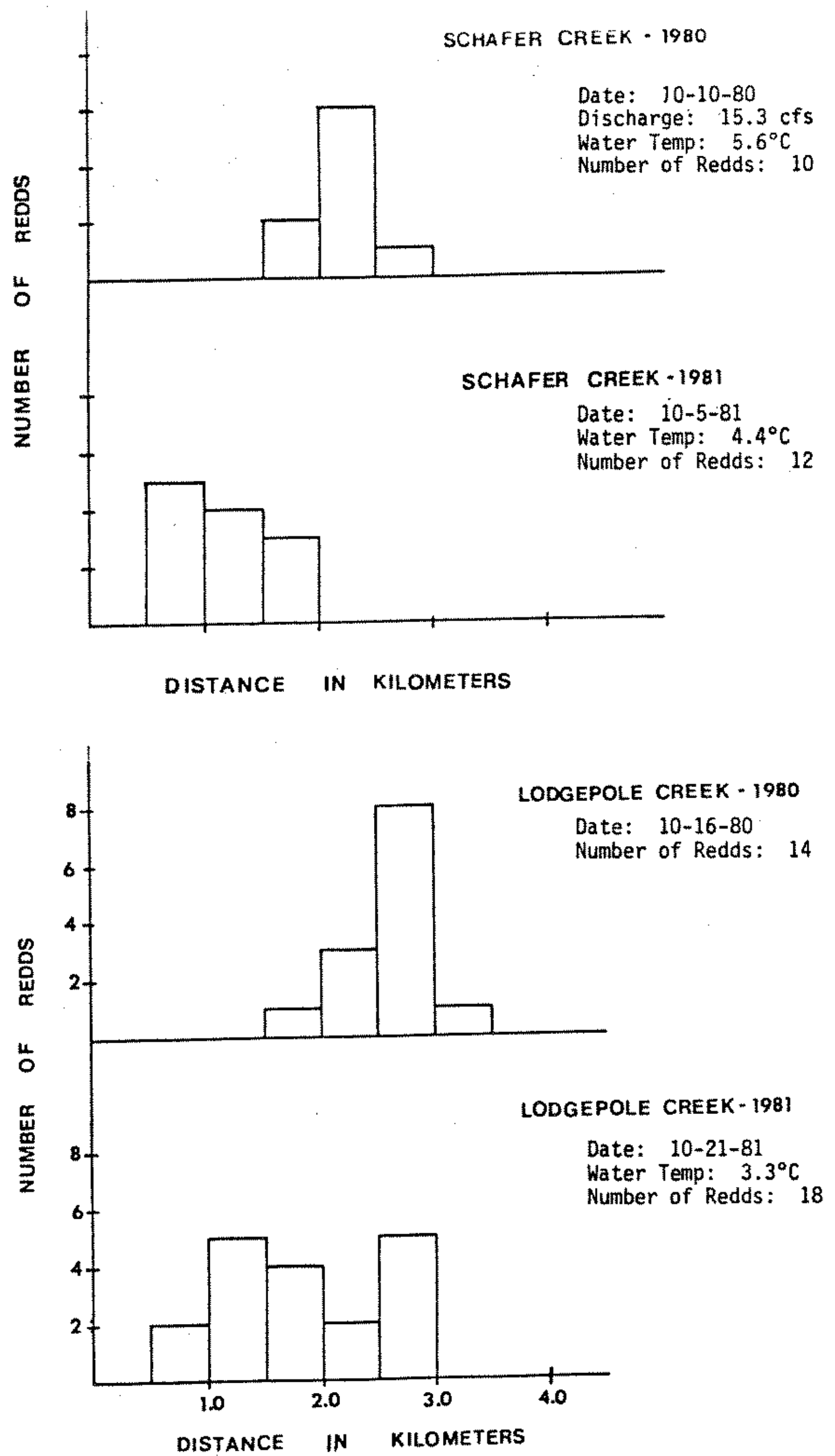

Figure 11. Bull trout redd distribution in Schafer Creek and Lodgepole Creek surveyed in 1980 and 1981. Schafer Creek survey began at lower end of dry section (kilometer 0.0 on figure) and ended at junction with Dolly Varden Creek (kilometer 4.2 on figure). Mouth of Roaring Creek is at kilometer 1.0 on top figure. Lodgepole Creek survey began at mouth of Whistler Creek (kilometer 0.0 on figure) and ended at junction of Morrison Creek (kilometer 3.3 on figure).

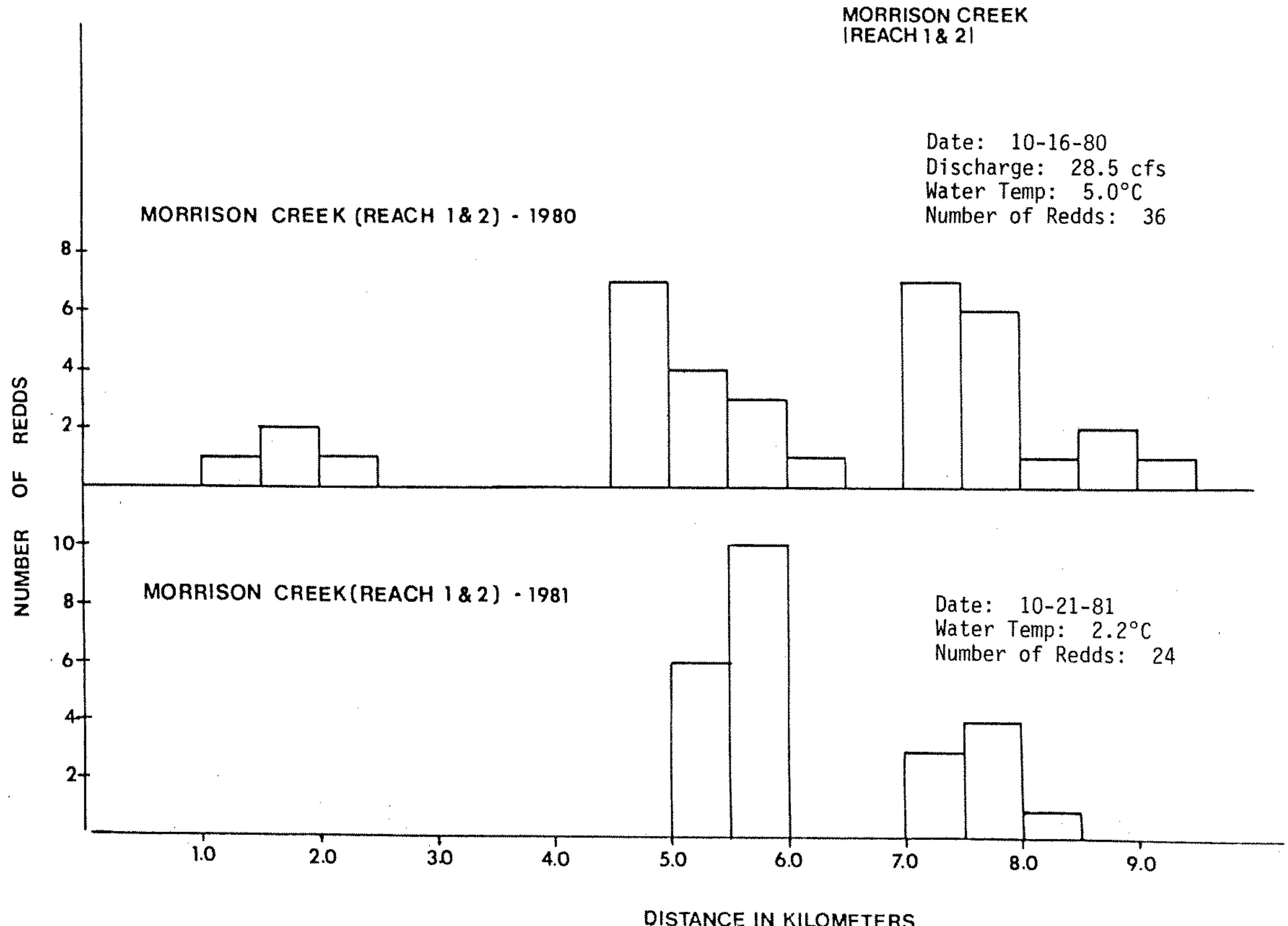

Figure 12. Bull trout redd distribution in Morrison Creek Reaches 1 and 2 surveyed in 1980 and 1981. Survey began at new trail crossing (kilometer 0.0 on figure) and ended below lower trail crossing (kilometer 8.8 on figure). Mouth of Star Creek is at kilometer 2.9 on figure, and the mouth of Lodgepole Creek is at kilometer 6.8 on figure.

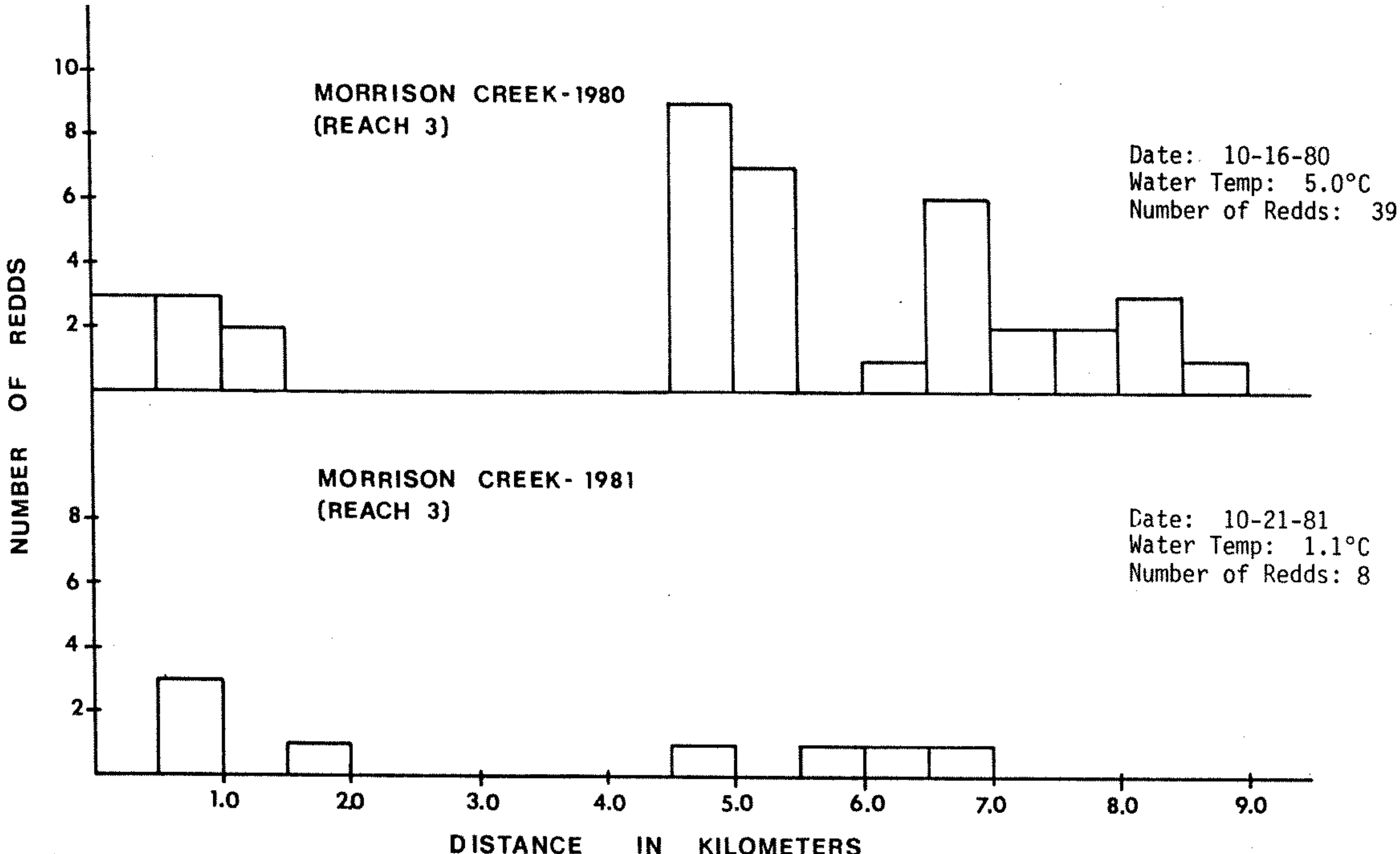

Figure 13: Bull trout redd distribution in Morrison Creek Reach 3 surveyed in 1980 and 1981. Survey began at mouth of Puzzle Creek (kilometer 0.0 on figure) and ended at New Trail crossing (kilometer 7.6 on figure).

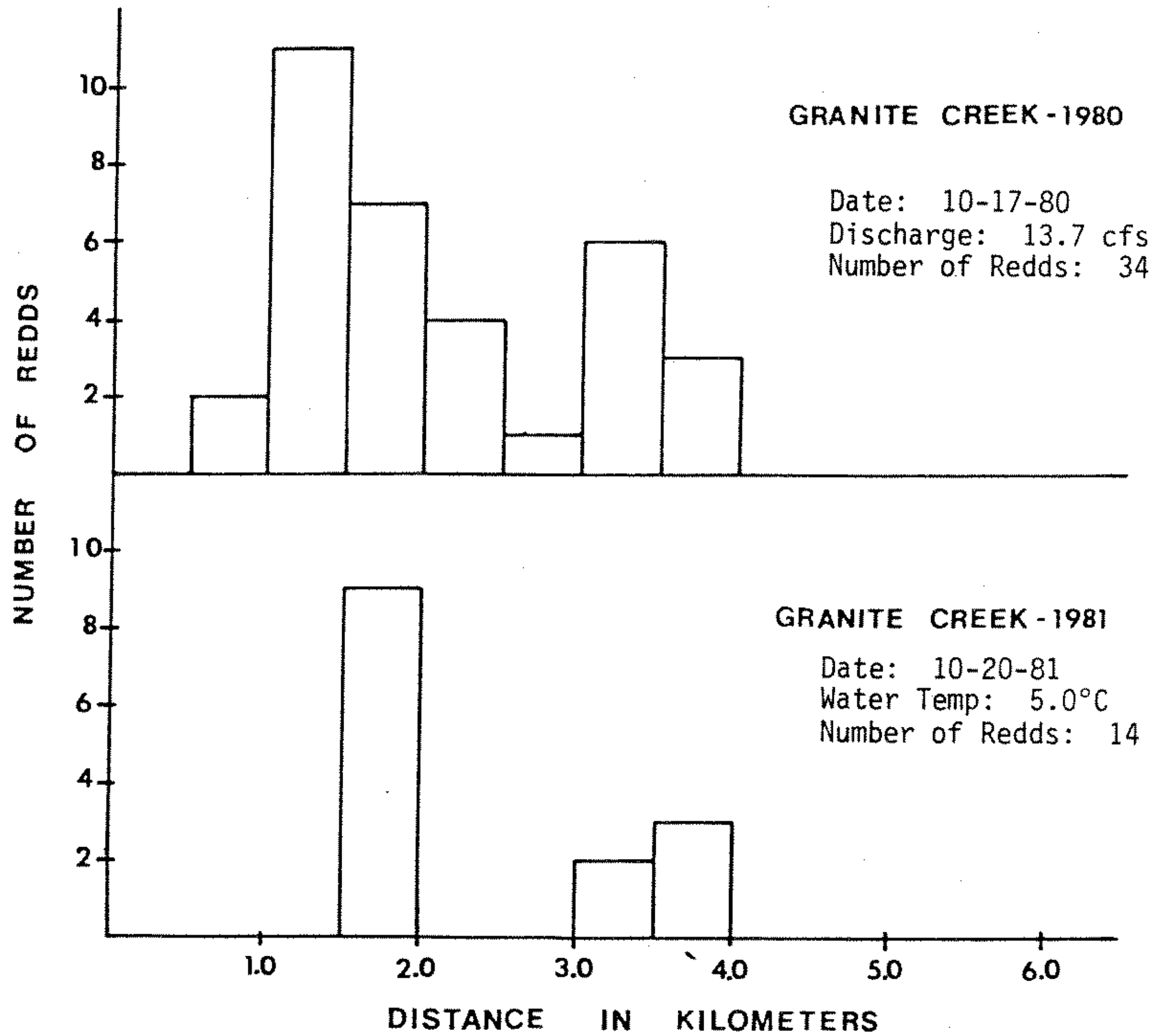

Figure 14. Bull trout redd distribution in Granite Creek surveyed in 1980 and 1981. Survey began at the mouth of Sign Creek (kilometer 0.0 on figure), and ended at the lower boundary of Reach 2 (kilometer 4.1 on figure).

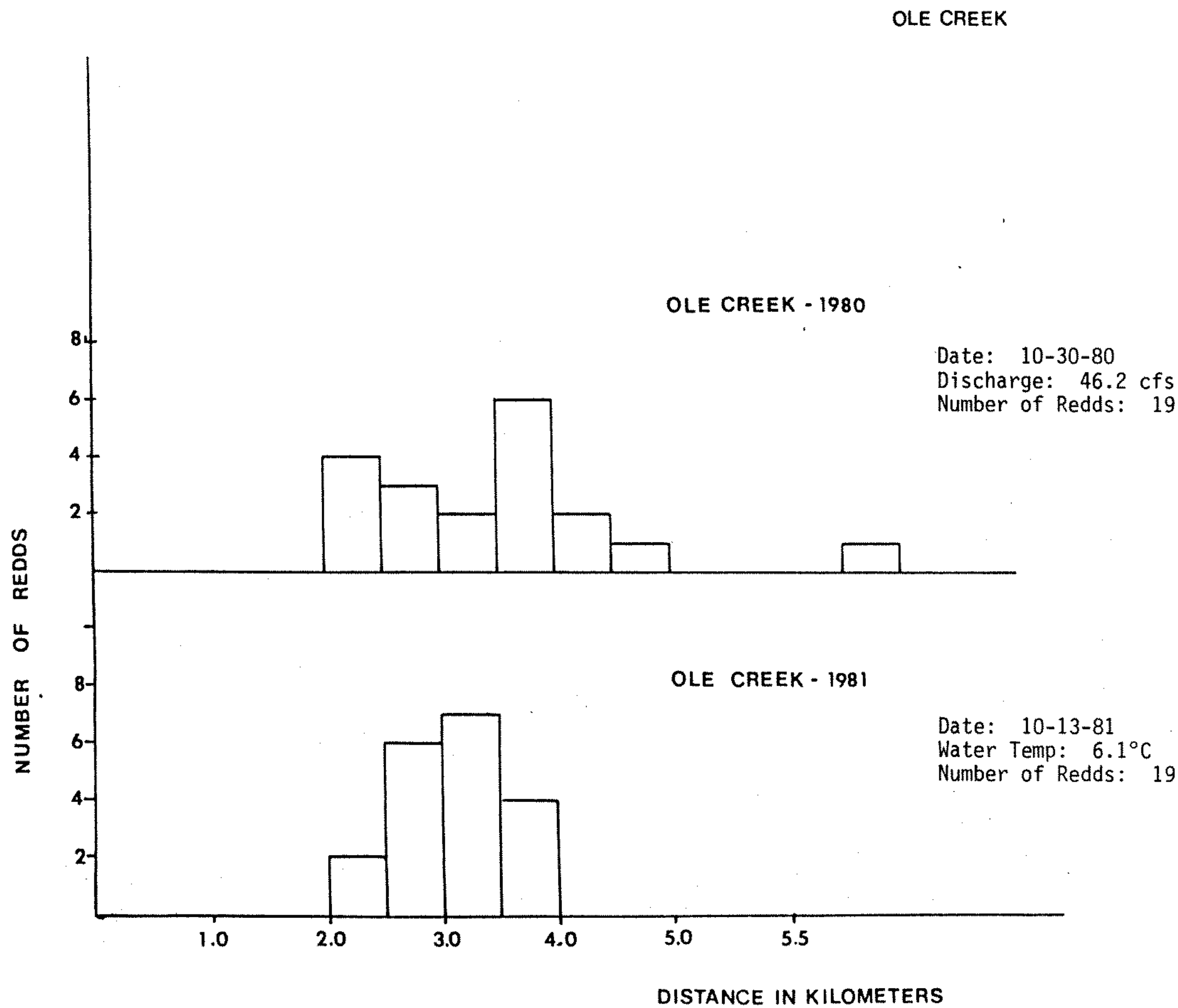

Figure 15. Bull trout redd distribution in Ole Creek surveyed in 1980 and 1981. Survey began at Fielding trail crossing (kilometer 0.0 on figure) and ended at upper end of canyon (kilometer 5.5 on figure).

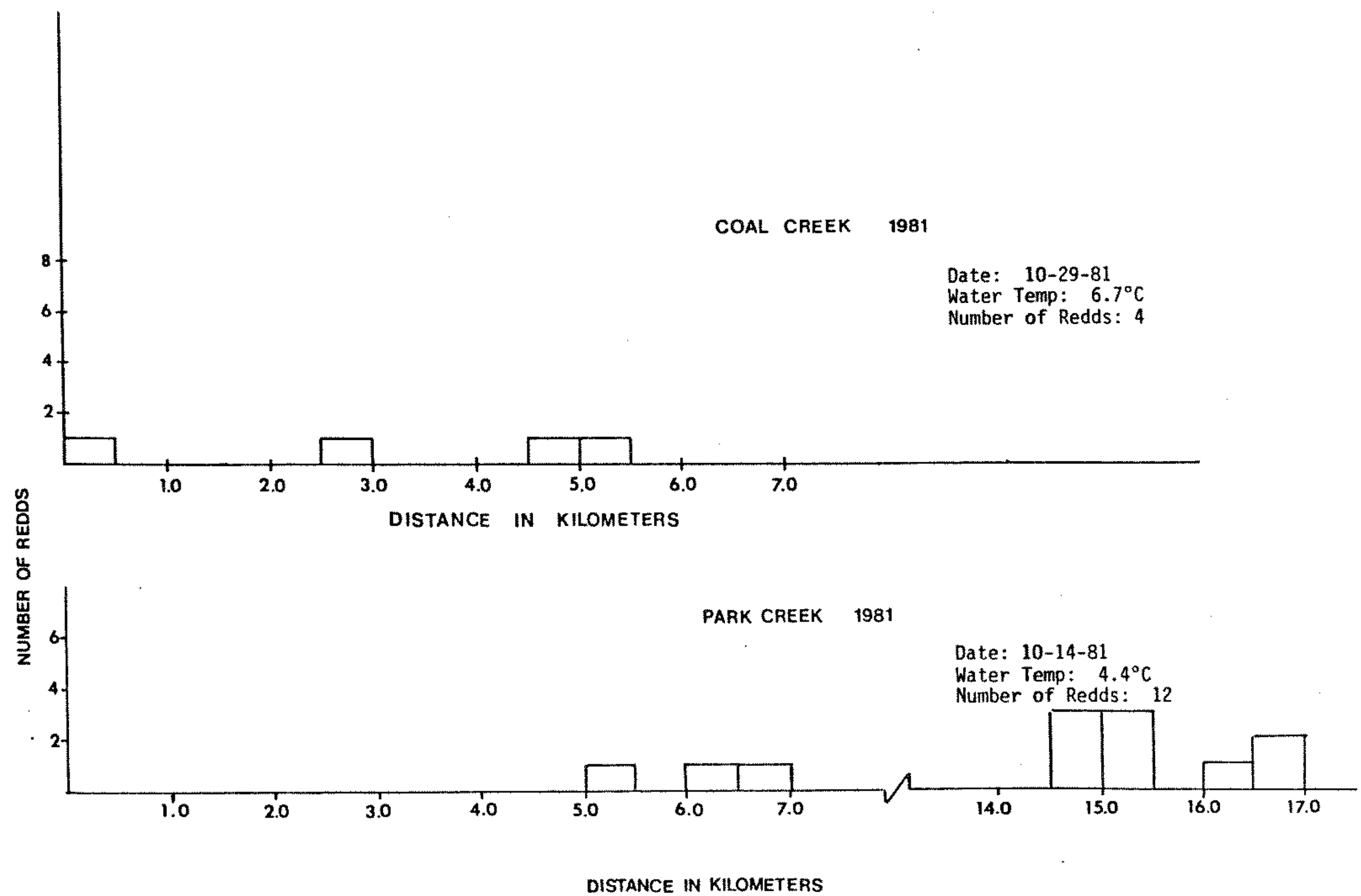

Figure 16. Bull trout redd distribution in Coal Creek and Park Creek surveyed in 1981. Coal Creek survey began at the mouth of Elk Creek (kilometer 0.0 on figure) and ended at the lower boundary of Reach 2(kilometer 7.0 on figure). Park Creek survey began at the upper fork (kilometer 0.0 on figure) and ended at the lower end of transition zone between Reaches 1 and 2 (kilometer 17.0 on figure).

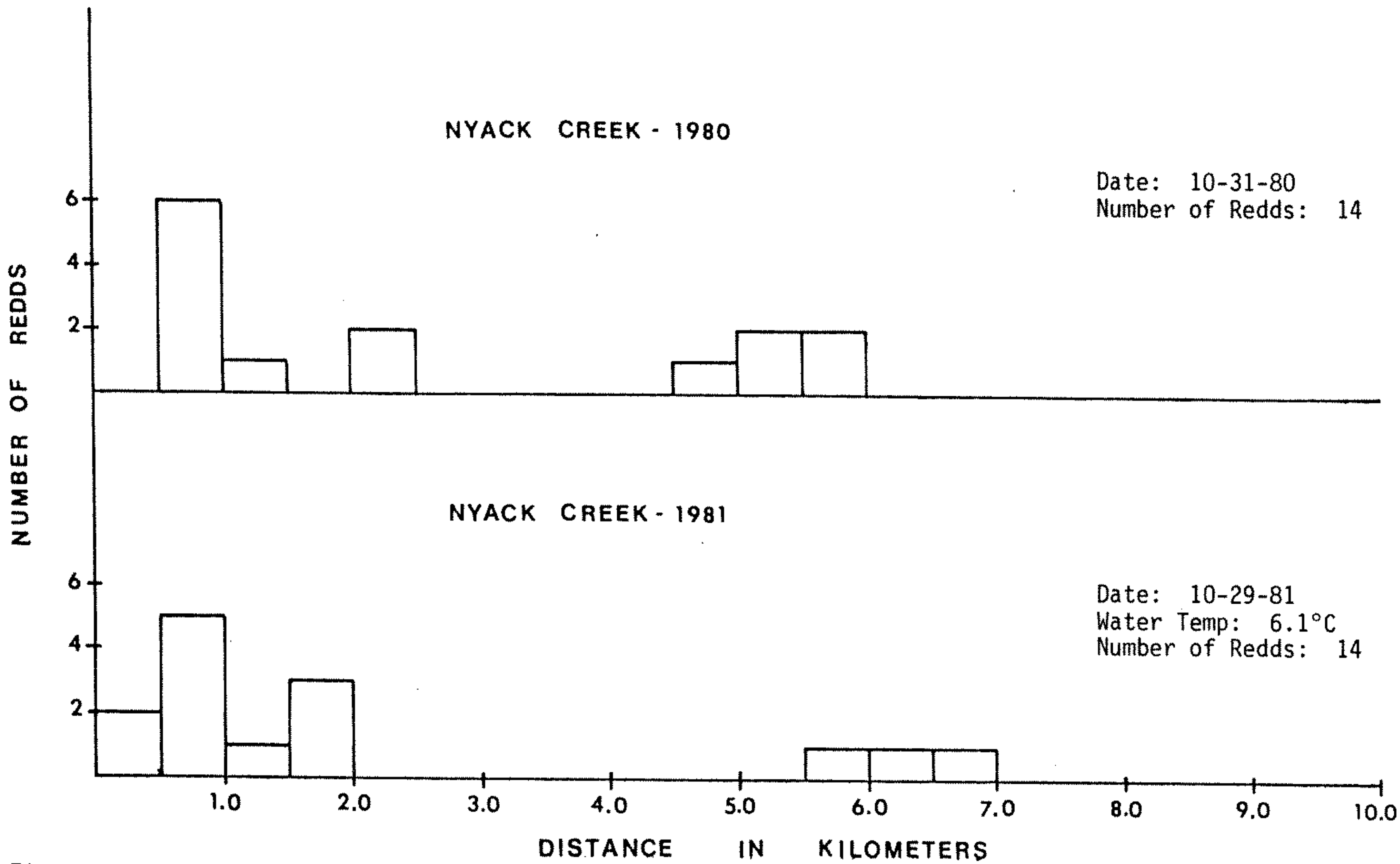

Figure 17. Bull trout redd densities in Nyack Creek surveyed in 1980 and 1981. Survey began at falls (kilometer 0.0 on figure), and ended at beginning of slough section (kilometer 10.0 on figure). Reach 2 begins at kilometer 1.0 on figure.

APPENDIX E

Number, occurrence, volume and IRI (Index of Relative Importance) of items in stomachs of westslope cutthroat and bull trout collected in Middle Fork tributaries during 1981.

Table 1. Number, occurrence volume and IRI (Index of Relative Importance) of items by order in stomachs of 30 westslope cutthroat Age I collected in Challenge Creek during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume (ml)			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Diptera	394	81.24	16.42	24	80	.80	25.16	.03	62.13
Ephemeroptera	73	15.05	3.48	21	70	1.61	50.63	.08	45.23
Trichoptera	6	1.24	1.0	6	20	.26	8.18	.04	9.81
Plecoptera	8	1.65	1.14	7	23	.40	12.58	.06	12.41
Coleoptera	1	.21	1	1	3.33	.05	1.57	.05	1.70
Hymenoptera	3	.62	1.5	2	6.66	.06	1.89	.03	3.06
TOTAL	485					3.18			

Table 2. Number, occurrence, volume and IRI (Index of Relative Importance) of items by order in stomachs of eight Age II westslope cutthroat collected in Challenge Creek during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume (ml)			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Diptera	17	23.94	8.50	2	25.0	0.12	6.03	.06	18.32
Ephemeroptera	37	52.11	6.17	6	75.0	1.02	51.25	.17	59.45
Trichoptera	10	14.08	2.00	5	62.5	0.46	23.12	.09	33.23
Plecoptera	2	2.82	1.00	2	25.0	0.31	15.58	.16	14.47
Coleoptera	--	---	---	---	---	---	---	---	---
Hymenoptera	5	7.04	1.67	3	37.5	0.08	4.02	.02	16.19
TOTAL	71					1.99			

Table 3. Number, occurrence, volume and IRI (Index of Relative Importance) of items by order in stomachs of 12 Age III westslope cutthroat collected in Challenge Creek during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume (ml)			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Arachnida	5	2.16	1.25	4	33.33	.65	4.33	.16	13.27
Diptera	56	24.24	8.00	7	58.33	2.59	17.26	.37	33.32
Ephemeroptera	59	25.54	7.38	8	66.67	7.32	48.76	.92	47.04
Trichoptera	69	29.87	5.75	12	100.00	2.27	15.12	.19	48.38
Plecoptera	11	4.76	1.83	6	50.00	1.20	7.99	.20	20.93
Coleoptera	13	5.63	1.44	5	41.67	.41	2.73	.08	16.68
Hymenoptera	18	7.79	1.50	7	58.33	.57	3.80	.08	23.31
TOTAL	231					15.01			

Table 4. Number, occurrence, volume and IRI (Index of Relative Importance) of items by order in stomachs of 62 westslope cutthroat ≤110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume (ml)			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Arachnida	1	.10	.02	1	1.61	.01	.01	.0002	.60
Coleoptera	2	.20	.03	2	3.22	.10	1.00	.002	1.50
Diptera	690	66.35	11.13	45	72.60	1.51	14.69	.02	51.21
Ephemeroptera	273	26.20	4.40	46	74.20	5.43	52.80	.08	51.00
Trichoptera	40	3.80	.64	21	33.90	1.54	15.00	.02	17.27
Plecoptera	26	2.50	.42	16	25.81	1.55	15.08	.02	14.46
Hymenoptera	8	.78	.13	5	8.10	.14	1.30	.002	3.40
TOTAL	1,040					10.28			

Table 5. Number, occurrence, volume and IRI (Index of Relative Importance) of items by order in stomachs of 28 westslope cutthroat >110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Hemiptera	1	.14	1	1	3.57	.05	.21	.05	1.31
Coleoptera	21	3.02	2.33	9	32.14	.75	2.97	.08	12.71
Diptera	221	31.75	10.52	21	75.00	4.50	17.83	.21	41.53
Ephemeroptera	196	28.16	10.89	18	64.28	11.32	44.84	.63	45.76
Trichoptera	207	29.74	7.39	28	100.00	5.18	20.53	.18	50.09
Plecoptera	17	2.45	1.89	9	32.14	2.03	8.03	.22	14.21
Hymenoptera	27	3.88	1.69	16	57.14	.66	2.62	.04	21.21
Arachnida	5	.72	1.25	4	14.28	.74	2.93	.18	5.98
Gastropoda	1	.14	1	1	3.57	.01	.04	.01	1.25
TOTAL	696					25.24			

Table 6. Number, occurrence, volume and IRI (Index of Relative Importance) of Trichoptera by family in stomachs of 62 westslope cutthroat ≤110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Brachycentridae	4	10.53	1.33	3	4.84	.15	10.20	.002	8.52
Hydropsychidae	5	13.16	1.00	5	8.06	.35	23.81	.56	15.01
Limnephilidae	12	31.57	2.40	5	8.06	.35	23.81	.56	21.15
Rhyacophilidae	17	44.74	1.89	9	14.52	.62	42.18	1.0	33.81
TOTAL	38					1.47			

Table 7 . Number, occurrence, volume and IRI (Index of Relative Importance) of Ephemeroptera by family in stomachs of 62 westslope cutthroat ≤110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Baetidae	133	47.84	3.41	39	69.90	1.38	25.36	.03	45.37
Heptageniidae	107	38.49	3.24	33	53.22	2.51	46.14	.07	45.95
Ephemerellidae	36	12.95	2.12	17	27.42	1.30	23.90	.08	21.42
Siphlonuridae	2	.72	1.00	2	3.22	.25	4.60	.12	2.85
TOTAL	278					5.44			

Table 8. Number, occurrence, volume and IRI (Index of Relative Importance) of Trichoptera by family in stomachs of 28 westslope cutthroat >110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Brachycentridae	22	11.34	2.75	8	28.57	.95	19.15	.12	19.69
Hydropsychidae	15	7.73	1.15	13	46.43	1.70	34.27	.13	29.48
Limnephilidae	119	61.34	13.2	9	32.14	1.22	24.60	.14	39.36
Rhyacophilidae	38	19.59	2.38	16	57.14	1.09	21.98	.07	32.90
TOTAL	194					4.96			

Table 9. Number, occurrence, volume and IRI (Index of Relative Importance) of Ephemeroptera by family in stomachs of 28 westslope cutthroat >110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Baetidae	86	43.88	6.6	13	46.43	1.81	15.85	.14	35.39
Heptageniidae	53	27.04	5.3	10	35.71	2.26	19.79	.23	27.51
Ephemerellidae	56	28.57	5.6	10	35.71	7.15	62.61	.72	42.30
Siphlonuridae	1	.51	1.0	1	3.57	.20	1.75	.20	1.94
TOTAL	196					11.42			

Table 10. Number, occurrence, volume and IRI (Index of Relative Importance) of items by order in stomachs of 10 bull trout ≤110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Coleoptera	---	---	---	---	---	---	---	---	---
Diptera	27	57.44	2.7	10	100	.10	27.02	.01	61.49
Ephemeroptera	15	31.92	3.0	5	50	.14	37.84	.03	39.92
Trichoptera	2	4.26	1.0	2	20	.06	16.22	.03	13.49
Plecoptera	3	6.38	1.5	2	20	.07	18.92	.04	15.10
TOTAL	47					.37			

Table 11. Number, occurrence, volume and IRI (Index of Relative Importance) of Ephemeroptera by family in stomachs of three bull trout >110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Coleoptera	---	---	---	---	---	---	---	---	---
Diptera	1	7.69	1.0	1	33.33	.05	3.16	.02	14.73
Ephemeroptera	8	61.53	2.67	3	100.00	.12	7.59	.04	56.37
Trichoptera	1	7.69	1.0	1	33.33	.05	3.16	.02	14.73
Plecoptera	2	15.38	2.0	1	33.33	.06	3.80	.02	17.50
Fish	1	7.69	1.0	1	33.33	1.30	82.28	.43	41.10
TOTAL	13					1.58			

Table 12. Number, occurrence, volume and IRI (Index of Relative Importance) of items by order in stomachs of three bull trout >110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Baetidae	4	50.00	2.0	2	66.67	.06	50.00	.02	55.56
Heptageniidae	2	25.00	2.0	1	33.33	.05	41.67	.02	33.33
Ephemerellidae	2	25.00	2.0	1	33.33	.01	8.33	.003	22.22
Siphlonuridae	---	---	---	---	---	---	---	---	---
TOTAL	8					.12			

Table 13. Number, occurrence, volume and IRI (Index of Relative Importance) of Ephemeroptera by family in stomachs of 10 bull trout ≤110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Baetidae	7	50.00	.70	1	10	.05	35.71	.005	31.90
Heptageniidae	5	35.72	.50	3	30	.07	50.00	.007	38.57
Ephemerellidae	1	7.14	.10	1	10	.01	7.14	.001	8.09
Siphlonuridae	1	7.14	.10	1	10	.01	7.14	.001	8.09
TOTAL	14					.14			

Table 14. Number, occurrence, volume and IRI (Index of Relative Importance) of items by order in stomachs of 20 eastern brook trout ≤110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Hymenoptera	1	.52	.03	1	5.0	.01	.50	.01	2.00
Diptera	30	15.23	1.50	10	50.00	.13	6.47	.006	23.90
Ephemeroptera	66	33.50	3.30	13	65.00	.92	45.77	.07	48.09
Trichoptera	84	42.64	4.20	11	55.00	.58	28.85	.05	42.16
Plecoptera	16	8.12	.80	5	25.00	.37	18.40	.07	17.17
TOTAL	197					2.01			

Table 15. Number, occurrence, volume and IRI (Index of Relative Importance) of Trichoptera by family in stomachs of 20 eastern brook trout ≤110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number Total	Number Percent	Number Mean	Occurrence	Frequency of occurrence	Volume Total	Volume Percent	Volume Mean	IRI
Hydropsychidae	1	1.20	1	1	5.0	.10	19.23	.1	8.48
Limnephilidae	2	2.41	2	1	5.0	.05	9.62	.05	5.68
Rhyacophilidae	4	4.82	1.33	3	15.0	.17	32.69	.06	17.50
Hydroptilidae	76	91.57	9.50	8	40.0	.20	38.46	.02	56.68
TOTAL	83					.52			

Table 16. Number, occurrence, volume and IRI (Index of Relative Importance) of Trichoptera by family in stomachs of seven eastern brook trout >110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number Total	Number Percent	Number Mean	Occurrence	Frequency of occurrence	Volume Total	Volume Percent	Volume Mean	IRI
Hydropsychidae	---	---	---	---	---	---	---	---	---
Limnephilidae	13	19.70	1.86	5	71.43	.31	59.61	.04	50.25
Rhyacophilidae	1	1.52	.14	1	14.28	.01	1.92	.001	5.91
Hydroptilidae	52	78.79	7.43	6	85.71	.20	38.46	.03	67.65
TOTAL	66					.52			

Table 17, Number, occurrence, volume and IRI (Index of Relative Importance) of items by order in stomachs of seven eastern brook trout >110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number Total	Number Percent	Number Mean	Occurrence	Frequency of occurrence	Volume Total	Volume Percent	Volume Mean	IRI
Diptera	19	14.28	6.30	3	42.85	.09	4.08	.01	21.08
Ephemeroptera	41	30.83	5.85	6	85.71	.74	50.34	.10	55.63
Trichoptera	70	52.63	10.00	6	85.71	.54	36.73	.08	58.35
Plecoptera	3	2.25	.43	1	14.28	.10	6.80	.01	7.78
TOTAL	133					1.47			

Table 18. Number, occurrence, volume and IRI (Index of Relative Importance) of Ephemeroptera by family in stomachs of 20 eastern brook trout ≤110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number Total	Number Percent	Number Mean	Occurrence	Frequency of occurrence	Volume Total	Volume Percent	Volume Mean	IRI
Baetidae	42	63.64	3.81	11	55.00	.50	54.35	.02	57.66
Heptageniidae	20	30.30	4.00	5	25.00	.26	28.26	.01	27.85
Ephemerellidae	4	6.06	1.33	3	15.00	.16	17.39	.008	12.82
TOTAL	66					.92			

Table 19. Number, occurrence, volume and IRI (Index of Relative Importance) of Ephemeroptera by family in stomachs of seven eastern brook trout >110 mm collected in Middle Fork tributaries during 1981.

Stomach contents	Number			Occurrence	Frequency of occurrence	Volume			IRI
	Total	Percent	Mean			Total	Percent	Mean	
Baetidae	20	48.78	2.86	6	85.71	.22	29.73	.03	54.74
Heptageniidae	11	26.83	1.57	2	28.57	.11	14.86	.02	23.42
Ephemerellidae	10	24.39	1.43	3	42.86	.41	55.40	.06	40.88
TOTAL	41					.74			