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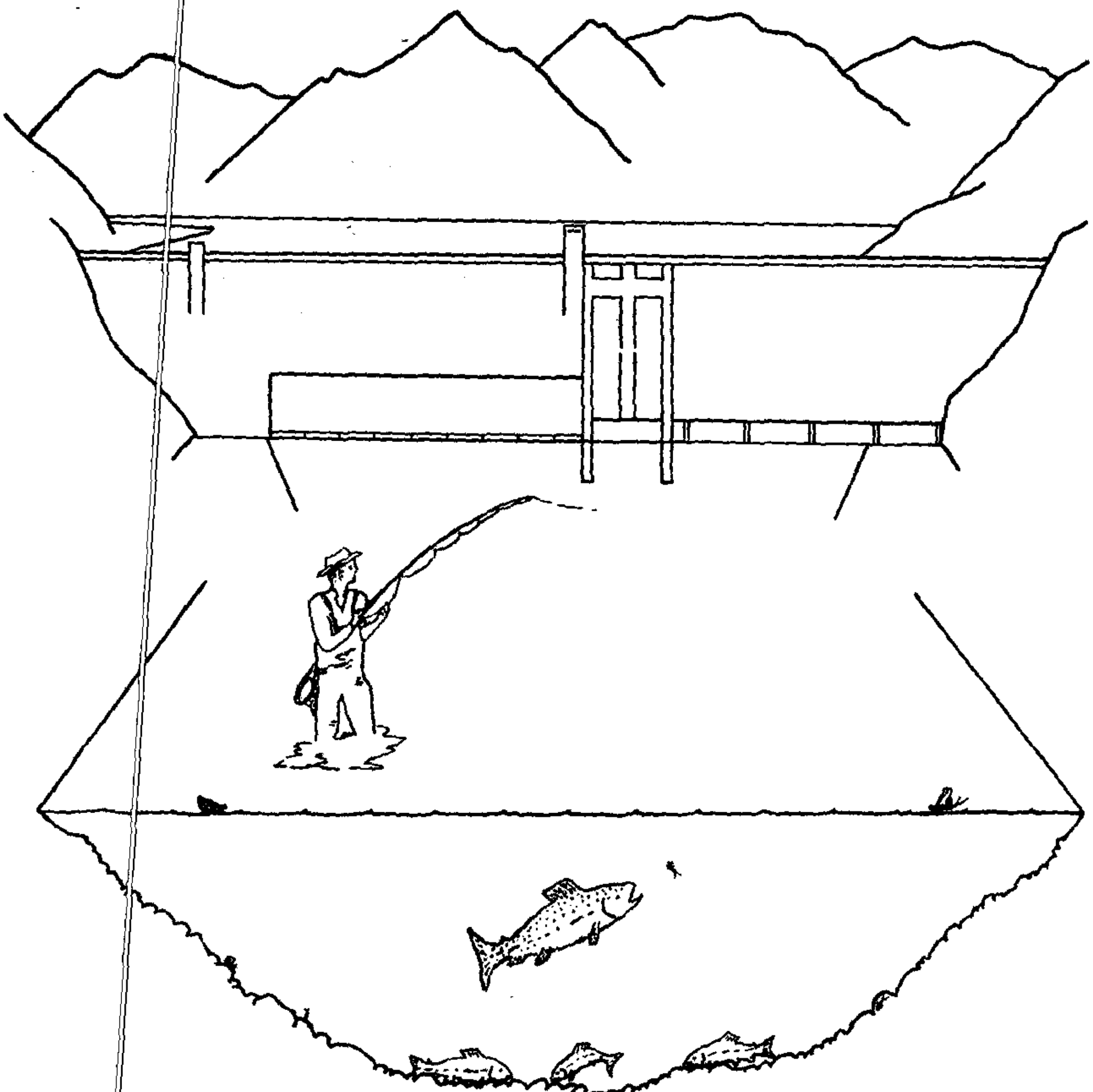
KOOTENAI RIVER FISHERIES INVESTIGATIONS

FINAL COMPLETION REPORT

1983



PREPARED BY:

MONTANA DEPT. FISH, WILDLIFE & PARKS

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THE U.S. ARMY CORPS OF ENGINEERS

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KOOTENAI RIVER INVESTIGATIONS FINAL REPORT
1972-1982

March, 1983

ABSTRACT

Impoundment of the Kootenai River in 1972 by Libby Dam altered the aquatic environment in the river downstream from the dam. Flow regimes, temperature patterns, sediment loads and water quality were markedly changed, resulting in changes in periphyton, aquatic insect, and fish populations. Periphyton biomass and productivity increased. Insect densities near the dam increased, but species diversity decreased. Insect diversity increased with increasing distance downstream from the dam, but species diversity was lower than would be expected in a free-flowing river. Biomass of aquatic insects was highest near the dam, but was not significantly different from the Fisher River at two downstream stations. Extensive recolonization of shoreline areas occurred above the 4,000 cfs level when discharge from Libby Dam was maintained at a higher level for two weeks or more. Reduction in the discharge following recolonization resulted in the stranding of large numbers of aquatic insects.

Considerable overlap occurs between the food habits of rainbow trout and mountain whitefish. Chironomidae were the most important food item of all sizes of mountain whitefish and for rainbow trout less than 20 centimeters long. Rainbow trout more than 20 cm long fed on Chironomidae, Trichoptera and Ephemeroptera.

Water released from the dam sluices and spillways caused gas supersaturation and appeared to limit fish populations in the Kootenai River from 1972 until 1975. From 1975-1981, water was released primarily through the penstocks and rainbow trout and mountain whitefish populations increased over 300 percent. The increased densities were associated with a marked decline in rainbow trout growth rates and a slight decline in mountain whitefish growth.

Significant spawning runs of rainbow trout have developed in four tributaries above Kootenai Falls and mainstem spawning activity was noted in 1981 and 1982. Mountain whitefish spawn primarily in the mainstem Kootenai, the Fisher River and Libby Creek. The lack of suitable spawning habitat and barrier problems in tributary streams downstream from Kootenai Falls are limiting trout populations.

Burbot populations have increased since impoundment, whereas white sturgeon numbers have declined. The rainbow trout fishery in the Kootenai River is comparable to some of Montana's more famous blue ribbon streams. Fishing pressure has increased markedly from 1968 to 1981. The current catch rate during the summer of 0.6 fish per hour of effort and average size of rainbow trout creeled (11.0 inches) make the Kootenai one of the better wild trout fisheries in western Montana.

The interaction of many environmental components have produced a favorable environment for rainbow trout downstream from Libby Dam. The single most important factor in maintaining the productivity of the Kootenai River has been the establishment of an adequate minimum flow. Other important environmental components include: 1) improved water temperatures for

growth in summer and fall and warm winter temperatures; 2) higher flows from September through March; 3) reduced sediment loads below Libby Dam; 4) curtailment of sediment pollution from a mine-mill operation on Rainy Creek; and 5) curtailment of heavy metals and chemical pollution from an industrial complex in British Columbia.

INTRODUCTION

The demand for electrical power, irrigation and flood control in the Pacific Northwest has resulted in the construction of dams on most major river systems. These developments provide the necessary water storage and produce major changes in the river downstream of the project. This report covers changes which have occurred in the aquatic environment, periphyton, benthos, and fish populations of the Kootenai River following impoundment by Libby Dam.

The Kootenai River (spelled Kootenay in Canada) is the second largest tributary of the Columbia River. Its drainage basin has an area of about 50,000 square kilometers (19,300 square miles) and includes parts of southeastern British Columbia, northern Idaho, and northwestern Montana. The river originates in Kootenay National Park, British Columbia, flows south into Montana, then northwest through Montana and Idaho and into Kootenay Lake in Canada; it then flows southwest from Kootenay Lake and joins the Columbia River at Castlegar, British Columbia (Figure A). The Kootenai River is approximately 780 km (485 miles) in length, of which 266 km (165 miles) is in the states of Montana and Idaho.

The basin ranges in elevation from about 418 m (1,370 feet) above mean sea level at Castlegar, British Columbia, to the 3,618 m (11,870 feet) peak of Mt. Assinibone on the Continental Divide in the northeastern part of the basin. The section of the river in the United States ranges from an elevation of about 704 m (2,310 feet) to 533 m (1,750 feet) above mean sea level. The gradient of the river in this section is 0.6 m/km (3.4 ft/mile).

Construction was begun on Libby Dam in 1966. In March, 1972, the river was impounded and its reservoir, Lake Koocanusa, was formed. Approximately 80 kilometers (48 miles) of the reservoir is in Montana with the remaining 70 km (42 miles) in British Columbia. Regulation has altered the flow regime, temperature patterns, sediment loads and water quality of the Kootenai River. These environmental changes have had profound effect on the biological communities living in the Kootenai River downstream from Libby Dam.

Libby Dam reversed the natural flow regime. Historically, the highest flows occurred from April through July, with the median peak flows being about 60,000 cfs during May and June, with low discharges of about 2,000 cfs occurring during the winter and early spring. The average annual discharge at Libby, Montana is 12,000 cfs. Since impoundment, low flows normally occur from April through July. During the remainder of the year, flows generally range from an operational minimum of 4,000 cfs to a maximum of 23,000 cfs. Maximum discharge prior to impoundment was 121,000 cfs as compared to 40,000 cfs following impoundment. An International Joint Commission order for Kootenai Lake requires that Lake Koocanusa be drawn down to elevation 2,412 feet msl to accommodate 2,000,000 acre-feet of storage by January 1 each year, which results in maximum power production in October through December each year.

The daily flow regime, which was relatively stable under natural conditions, now fluctuates due to the power peaking capability of Libby Dam. Daily flows can fluctuate a maximum of four vertical feet per day from April through September and six feet per day from October through March. Actual fluctuations have been less than the maximum criteria on most days.

From April, 1972 through June, 1975, water was released from either the dam sluices, the spillways or a combination of the two. The water falling into a 60-foot deep stilling basin resulted in gas supersaturation levels averaging 135 percent. Supersaturation persisted at somewhat lower levels downstream to Kootenai Falls, a distance of 29 miles. Beginning in July, 1975, increasing amounts of water began to be discharged via the penstocks as installation of the first four generators was completed. By the end of March, 1976, penstock discharges had reduced gas saturation levels to near 100 percent. Sluice and spillway discharges and associated gas supersaturation have been infrequent since this date.

The water temperature regime in the Kootenai River has been significantly altered by regulation. Sluiceway and spillway operation from 1972 through 1976 resulted in unusual temperature patterns. Discharge temperatures during the summer varied from about 8.2°C (47°F) to 18.3°C (65°F). These patterns were modified when the selective withdrawal system became operational in June, 1977. A temperature rule curve was developed for operating the system. Winter discharges are from deep within the reservoir and temperatures are generally near 4.0°C (39°F). As the reservoir fills, the selective withdrawal is operated to withdraw water no closer than 50 feet from pool surface (to reduce escapement of fish from the reservoir) and maintain a maximum temperature of 13.5°C (56°F). The operation of the system provides temperatures which are warmer than the natural regime from October to March, and cooler from April through September.

Flow regulation eliminated the spring flood flows which had maintained the river channel morphometry and resorted substrate materials. Decreased peak flows also allowed deltas to build around tributary stream mouths. The reservoir acts as a sediment and nutrient trap and reduces the concentrations of these water quality constituents in downstream water. Impoundment of the river has decreased available allochthonius materials, but sestonic drift from the reservoir area has increased.

A survey of the aquatic insects in the Kootenai River in Montana was done as part of the Corps of Engineers preimpoundment water quality study from 1967-1972 (Bonde and Bush 1975). Limited macroinvertebrate sampling done near Kootenai Falls 47 km (29 miles) downstream from Libby Dam (Graham 1979) indicated major changes in insect diversity and composition since impoundment.

Little fish data were collected on the Kootenai River prior to 1969 except for creel surveys conducted by game wardens. Testing of electro-fishing gear and development of sampling methodology began in 1969 and the first population estimates were obtained in 1971 in the Jennings Section, located 3.3 km (2.0 miles) downstream from Libby Dam. In 1972, Corps of Engineers funded a comprehensive biological study of Kootenai River. This report summarizes the data collected between 1972 and 1982.

SECTION A

Aquatic Insect Study
October, 1979 - June, 1982

By

Sue Appert Perry and Joe E. Huston

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ACKNOWLEDGEMENTS

The author wishes to acknowledge the efforts of several people and agencies without which this study would have been impossible. Dr. Jack Stanford, University of Montana Biological Station provided work space and specialized equipment. The U.S. Geological Service provided published and unpublished flow, temperature and chemical data. Tom Bonde, Seattle District, Corps of Engineers, provided his expertise, knowledge of pre-impoundment aquatic insect populations and some sampling equipment.

Dr. Loren Bahls, Montana Department of Health and Environmental Sciences, identified algal species and did the periphyton community structure analysis. Burwell Gooch, Montana Department of Administration, ran the computer program for species diversity indices. My husband, William Perry, assisted with field work, enumeration, and volumetric analysis of most insect samples. He also did much of the work on periphyton and particulate organic carbon analysis.

Thanks are also due the many employees of Montana Department of Fish, Wildlife and Parks who assisted in various tasks ranging from data collection to analysis to manuscript preparation. Special thanks are due to the federally-funded CETA and YACC programs for providing much labor for sorting and picking aquatic insect samples.

OBJECTIVES

The purpose of this aquatic insect study was to measure the quantity and quality of insects in the Kootenai River below Libby Dam. Specific objectives were: 1) determine standing crop, composition and specific diversity of aquatic insects at three locations in Kootenai River and a control in Fisher River; and 2) determine effects of river regulation on insect drift rates, stranding of insects on dewatered substrate and re-population of these dewatered areas.

These data were to be compared to applicable information collected by Bonde and Bush (1975) on pre-impoundment aquatic insect populations and to data collected by May (1972) at stations on the Fisher River.

METHODS

Sampling of benthic invertebrates was begun in October, 1979 at four sampling stations; three sites on the Kootenai River downstream from Libby Dam and a control site on the Fisher River (Figure 1). Locations of the four stations are shown on Figure 1 and were as follows:

Station name	Distance from Libby Dam	Location
Dunn Creek	3 km	Near the mouth of Dunn Creek
Elkhorn	18 km	Elkhorn Trailer Court - about 2 km below reregulation dam site.
Pipe Creek	35 km	Near the mouth of Pipe Creek
Fisher River	---	1 km upstream from mouth of Fisher River.

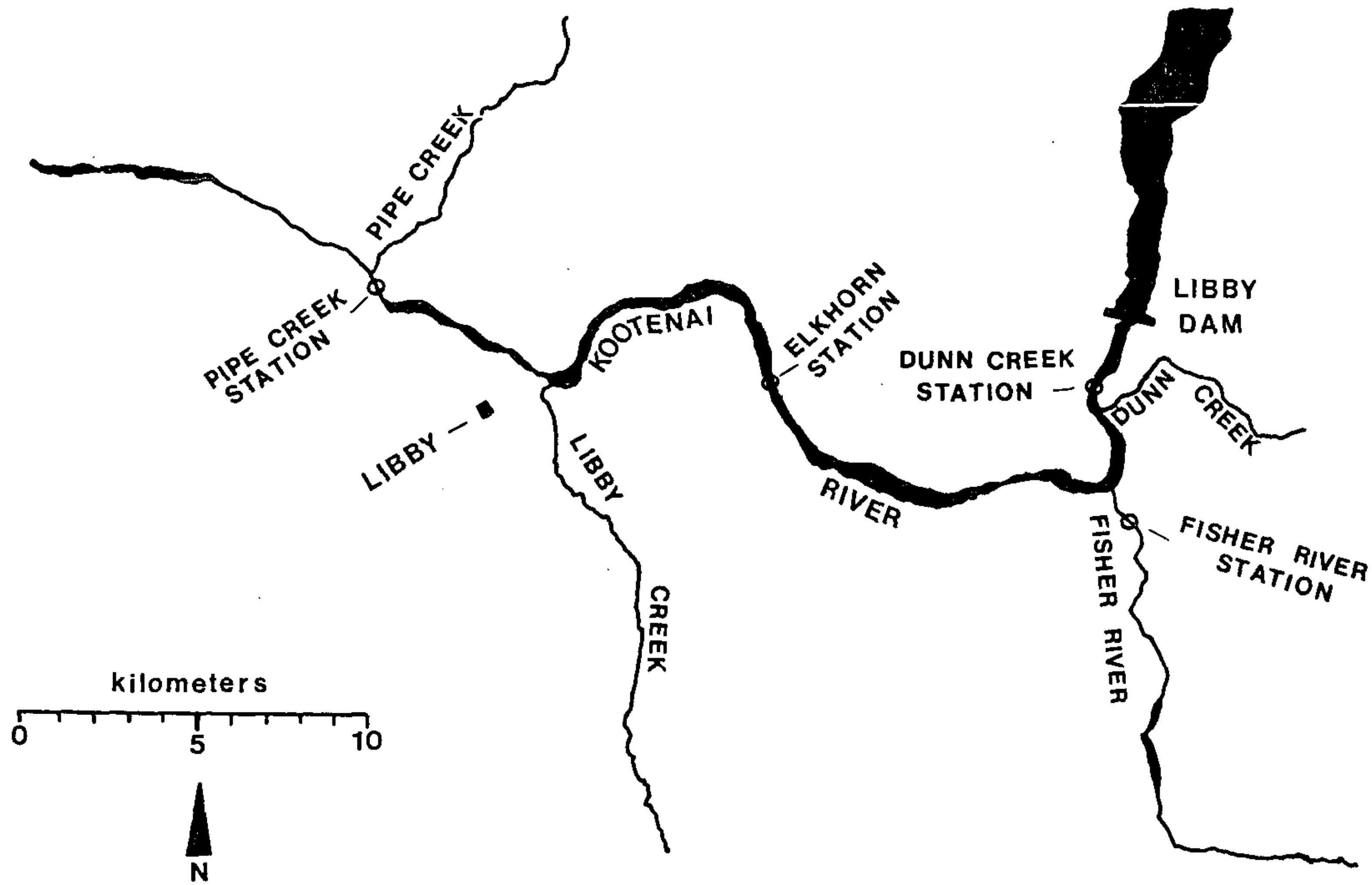


Figure 1. Location of macroinvertebrate sampling stations on the Kootenai and Fisher rivers.

The Dunn Creek site is at the same location as Station 3 in the pre-impoundment study (Bonde and Bush 1975).

Six benthic invertebrate samples were taken at each station each month (except December and February) for a one-year period. The sampling was done when releases from Libby Dam were at or near the operational minimum flow of 4,000 cfs. Water depths and mean current velocity measured at the 15.2 cm depth were taken just upstream from each benthic sample. During the first year (October 1979 - September 1980), 252 quantitative benthic samples were collected and analyzed numerically and volumetrically. An additional 36 quantitative benthic samples were collected during October, 1980 and January, March and May, 1981.

Three samples were taken at each station and three different samplers were used to reduce biomass. The modified Knapp-Waters sampler (Waters and Knapp 1961) which was used in preimpoundment studies (Bonde and Bush 1975) was used at the Dunn Creek, Elkhorn and Fisher River sites. It could not be effectively used at the Pipe Creek station due to the very large substrate size at that site. The other two samplers employed, a modified kick net and a circular depletion sampler (Carle 1976) were designed for use in large substrates. Both of these samplers enclosed a sample area of 0.33 m^2 and have a mesh size of 150 μm, compared with a sample area of 0.093 m^2 and a mesh size of 471 μm for the Knapp-Waters sampler. The circular sampler was used at the Pipe Creek site in place of the Knapp-Waters sampler and the kick net was used at all four sites.

After the sampler was placed over the substrate, rocks within the enclosed area were lifted and brushed free of insects by hand. After all rocks were cleaned and removed, the remaining substrate was disturbed by kicking for 15 seconds. Insects were collected in the cod end of each sampler. These insects were removed and placed in jars containing 10 percent formalin and Rose Bengal stain.

Laboratory analysis of each sample included placing the sample in a white porcelain tray and sorting out all insects larger than 2 mm in length. These larger insects were identified to order and preserved in separate vials. The remaining sample was divided into eight subsamples and all insects removed from one subsample. These insects were sorted to order and preserved in vials. Occasionally, a larger or smaller subsample was taken depending upon the mass of insects in the total sample.

All insects except dipterans were identified to the lowest taxonomic group possible and enumerated using a laboratory counter. Dipterans were sorted into Chironomidae and other taxonomic groups and counted. Biomass was measured by volume displacement, with any volume less than 0.1 ml assigned a trace value of 0.05 ml. Volumetric measurements were made with the use of a 50 milliliter burette and a graduated centrifuge tube.

Adult insects were collected at all four sample stations from rocks and vegetation with sweep nets or by hand. Pit traps (buried cans containing formalin covered with a thin film of diesel fuel to prevent evaporation) were utilized from March to June to collect stoneflies at the Pipe Creek and Fisher River sites. Light traps were operated nightly from June to October, 1980 at the Pipe Creek and Fisher River sites to collect caddisflies and dipterans. The light traps contained uv fluorescent lights powered by 110 volt A.C. current or by batteries controlled by a photocell which activated the lamp during the hours of darkness.

Insect drift nets had a rectangular opening measuring 45.7 by 30.5 cm and a Nitex bag 1.5 meters long made of 355 μm mesh. The frame was made of angle iron with holes for steel rods which were driven into the substrate. Samples were taken in duplicate; two nets were set parallel to each other and to the shoreline in water from 15 to 30 cm deep. Flow rates through the nets were monitored with a current meter. Generally the nets were set for a period of one hour.

Continuous recording thermograph data were obtained from the U.S. Army Corps of Engineers. Flow and chemical data were obtained from the U.S. Geological Survey (USGS) for the Kootenai River station below Libby Dam. Temperature and flow data from the Fisher River were obtained from USGS. Temperatures of Fisher River recorded in water year 1976 and Kootenai River in water year 1980 are shown in Figure 2.

Periphyton standing crop was quantified at the sampling stations on a seasonal basis (August, October and January) by measuring ash-free dry weights and chlorophyll a on material collected from natural substrates. For ash-free dry weight analyses, the Aufwuchs layer was removed from a randomly selected rock and the surface area was measured. Replicate samples were taken at two depths. Chlorophyll a samples were taken by scraping periphyton from a 6 cm^2 area using a flexible template. The sample for analysis of chlorophyll a was placed in an opaque, screw-cap centrifuge tube, and frozen until it was extracted. Methanol was used in the extraction process (Holm-Hansen and Riemann 1978); calculations were made according to Lorenzen (1967) using experimentally determined absorption coefficients (Riemann 1978).

Benthic community metabolism was measured at the Dunn Creek and Fisher River stations in September, 1981 by placing rocks from a circumscribed area of the riverbed in recirculating chambers used *in situ* and recording changes in oxygen evolution. Calculations were made of gross productivity, net community productivity, 24-hour respiration, net daily metabolism, and the productivity-respiration ratio.

Organic carbon in the seston was quantified as particulate (POC) and dissolved (DOC) on a monthly basis for the first year of the study. Analyses were conducted according to Menzel and Vaccaro (1964) in which organic carbon is oxidized and quantified in an infrared detector (Oceanography International, Inc.). In order to determine how the particle sizes which are available to insect filter feeders are altered by river regulation, the particle component of the seston was size-fractionated on a seasonal basis (September, November and February) at the control and regulated sites. A wet filtration method was used to size fractionate samples of the seston, and the organic carbon content of each size class

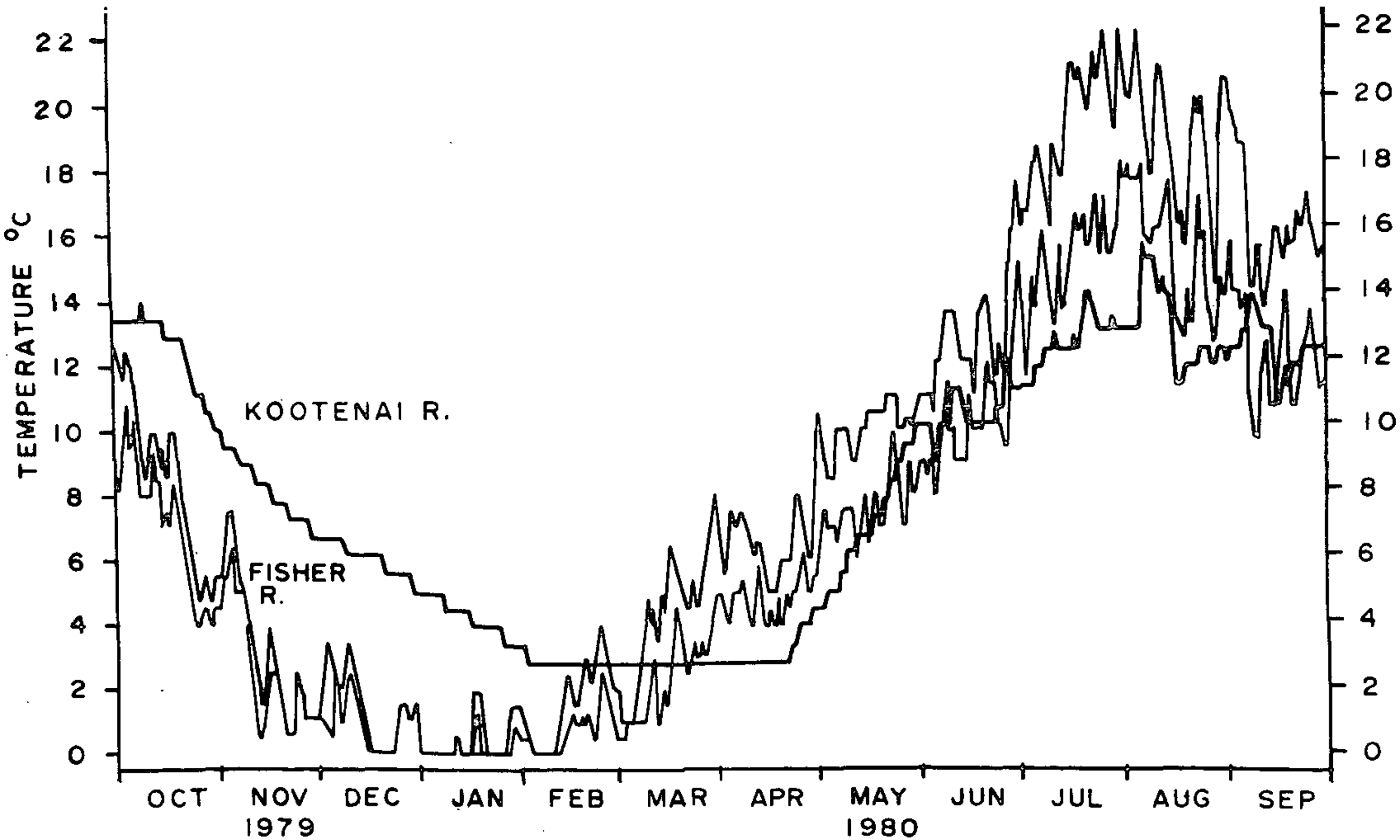


Figure 2. Mean daily temperatures for the Kootenai River for the 1980 water year and maximum and minimum daily temperatures for the Fisher River for the 1976 water year.

was determined with the use of a carbon analyzer. Particulates were sized into fractions (0.45-10 μm, 10-165 μm, and 355-1000 μm) by passing known volumes of water sequentially through the different mesh sizes. Particulate organic carbon from 355 μm to 1 cm was collected using insect drift nets. Nets were set in place for a timed interval at minimum discharge from Libby Dam and flow rate monitored to quantify the volume filtered. All insects and debris larger than 1 cm was removed prior to analysis for ash-free dry weight.

Periphyton species identifications were made by Dr. Loren Bahls of Montana Department of Environmental Sciences who analyzed periphyton community structure using methods described in Bahls, et al. (1979).

The substrate was characterized at each of the four sampling stations. The intermediate axis (the widest width) was measured on all surface rocks in an 0.33 m^2 area. Six replicate samples were taken at random from the zone flooded with flows of 20,000 cfs down to 4,000 cfs. Sampling was done at minimum discharge from Libby Dam. Replicate samples taken from subsurface rocks were fractionated into six size classes (>50, 50-19, 19-16, 16-2, 2-.063 and <.063 mm) using soil sieving techniques. A heterogeneity index (Schwoerbel 1961) was calculated for the subsurface samples. Heterogeneity (degree of particle size diversity) was calculated by making a plot of the cumulative percentage by weight against the particle size (mm); heterogeneity = particle size 60%/particle size 10%.

In order to determine the benthic community associations which have resulted from regulation of the Kootenai River, the biological data was reduced to fewer variables with the use of diversity indices and three ordination techniques. These methods were applied to data obtained from collections which were made in October, 1979 and January, March and July, 1980.

The Shannon diversity index was calculated after samples were pooled by sampler type at each sample station and date. The formula used for the Shannon function was $H' = \sum_{i}^{s} \left(\frac{N_i}{N}\right) \log_2 \left(\frac{N_i}{N}\right)$ where s = number of taxa in sample, N_i = number of individuals in taxon i, and $N = \sum_{i}^{s} N_i$. A value of zero is obtained when all individuals belong to the same species. The maximum value of H' depends on the number of individuals counted and is obtained when all individuals belong to different species. H' usually varies between three and four in natural stream areas and is usually less than one in polluted or stressed stream areas.

Evenness (E_v), as measured by Margalef (1957), is a ratio of the observed H' to a maximum theoretical diversity (H'_{max}), computed with all individuals equally distributed among the species. Maximum diversity (H'_{max}) was computed as $\log_2 s$; therefore evenness = $\frac{H'}{\log_2 s}$. Evenness generally ranges between 0 and 1. Perturbation reduces E_v below 0.5 and generally to a range of 0.0 to 0.3.

Ordination techniques were applied to the data with the use of two computer programs from the Cornell Ecology Program series. DECORANA, a Fortran program which was used for detrended correspondence analysis (Hill 1979) and ORDIFLEX, which was utilized for its programs for polar ordination and principal components analysis (Gauch 1977). DECORANA was performed with no transformation of the data and no downweighting of rare species. Polar ordination was run with both automatic and user selected samples as endpoints. Percentage distance was the measure used for the computation of similarity of species composition among the various samples, which is required for polar ordination. A major function of ordination is identification of groups of similar samples. The equation for the percentage distance (PD) similarity measure is:

$$PD_{jk} = IA - PS_{jk}, \text{ where } PS_{jk} = \frac{200 \cdot \sum_{i=1}^{I} \min(D_{ij}, D_{ik})}{\sum_{i=1}^{I} (D_{ij} + D_{ik})}$$

where IA is the internal association, PS is the percentage similarity, where the summations are over all species (I), D_{ij} and D_{ik} are the abundances of species i in samples j and k, and S_j and S_k are the numbers of species in samples j and k. The data were log transformed before principal components analysis was applied. The output from PCA was centered and standardized.

The reduced biological data were then related to environmental predictor variables using multiple regression and correlation analysis. These statistical methods were utilized to assess the importance of such factors as rates of flow change, temperature, substrate heterogeneity, and altered autochthonous (periphyton) and allochthonous (seston) carbon resources in determining the composition of benthic communities downstream from dams.

RESULTS

Density and Biomass Estimates

Data collected from October, 1979 to September, 1980 (1980 water year) were used for comparisons of insect densities (number/m^2) and biomass (cc/m^2) at the four sample stations. Accurate quantification of numbers and biomass in the Kootenai River was complicated by the fact that discharge from Libby Dam was reduced to 4,000 cfs just prior to invertebrate sampling. Insect drift is induced by reductions in flow and these flow reductions may have concentrated insects along the shoreline where samples were taken.

Annual mean densities (number/m^2) of all invertebrates ranged about 1.5 to 2.5 times greater in the Kootenai River than in the Fisher River (Table 1, Figure 3). Monthly mean densities for each insect order at each station are listed in Appendix 1.

A one-way analysis of variance (ANOVA) at the four stations was run on log transformed data of the monthly mean densities of all invertebrates. Densities were significantly different ($p<.05$) for pairwise comparisons

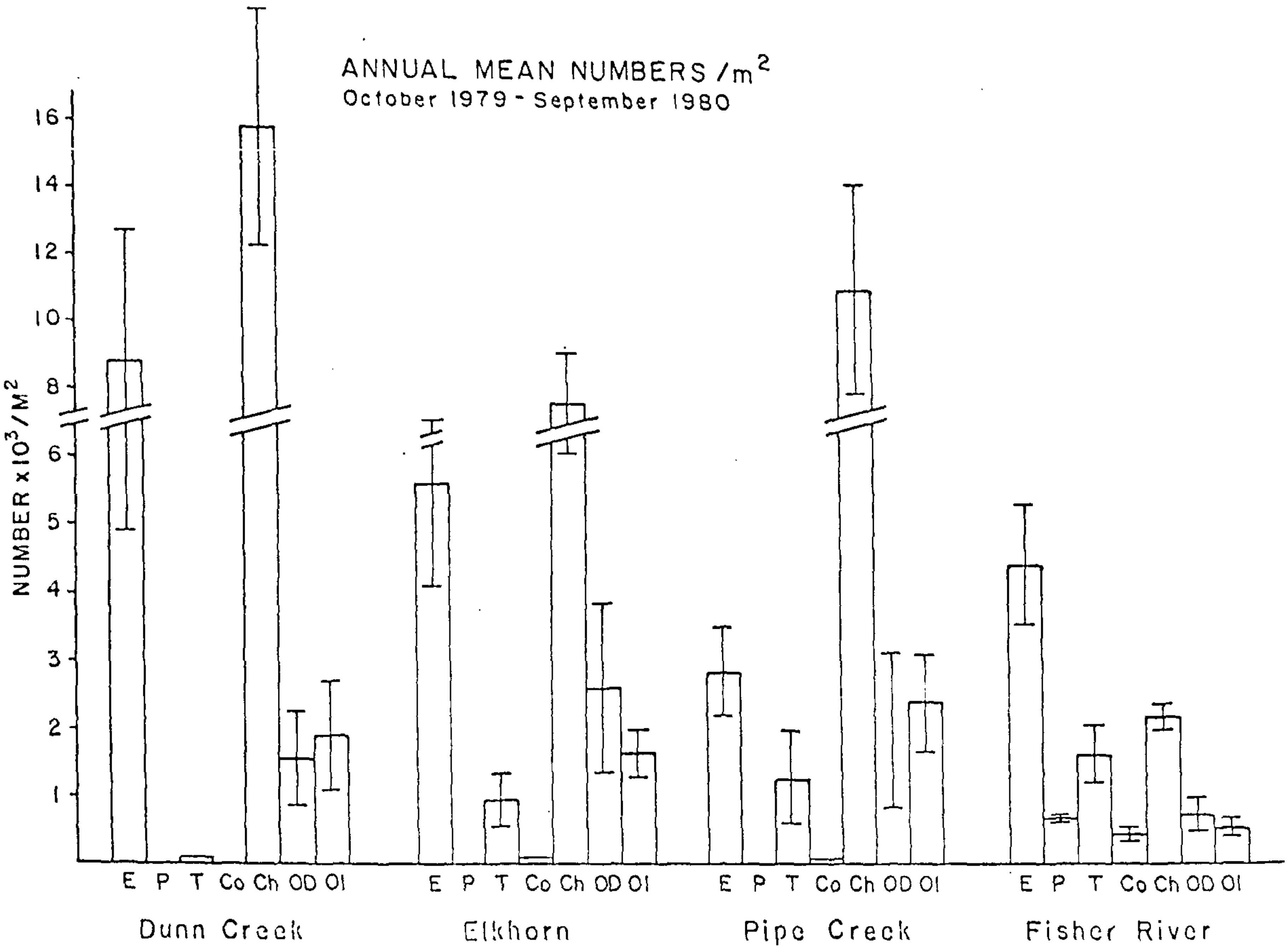


Figure 3. Annual mean number per square meter of Ephemeroptera (E), Plecoptera (P), Trichoptera (T), Coleoptera (Co), Chironomidae (Ch), Other Diptera (OD), and Other Invertebrates (OI). One standard deviation is shown by I on each bar.

of all sites but Elkhorn and Pipe Creek. There were distinctive differences in the abundance of insects by order at the regulated and control sites. In general, stoneflies, caddisflies and beetles were found in much higher numbers in the Fisher River. Mayflies were found in greater numbers in the Kootenai near the dam but the two downstream sites were more comparable to the Fisher River.

Annual mean biomass ($\bar{x}$ cc/m²) was not significantly different in the two rivers (Table 2, Figure 4). An ANOVA test of monthly biomass means at the four stations generally did not show significant differences. The only pairwise comparison of sites which was significantly different for monthly biomass mean was between the Elkhorn and Pipe Creek stations ($p<.05$). Monthly mean biomass for each insect order (cc/m²) at each station are given in Appendix 2.

A two-way ANOVA which incorporated both sites and sampler types was run using density and biomass data for four seasons (October, January, March and July). Density (number/m²) was significantly different between sampler types in all months. This may have been related to the difference in mesh size between the kick (150 μm) and Knapp-Waters (472 μm) samplers more than to the design of the samplers. Biomass (cc/m²) differences were not significant between sampler types in any month except July. These differences relate only to overall density and biomass. One might expect species differences in catchability between the different sampler types.

Percent composition was calculated from the annual density and biomass means (Tables 1 and 2). The annual percentages by numbers and volumes were averaged in the Density-Biomass Index (Table 3, Figure 5) to give an overall mean comparison of the sampling stations.

The percent composition of each insect order is presented for density (Table 4) and biomass (Table 5) data for each sample date. Samples for the Fisher River during May and June were not quantitative, since these collections were made during spring runoff conditions and were not included in the calculation of the annual means. A one-way ANOVA test was run on transformed (arcsin /% composition) data of the present composition by insect order at the four stations. Densities by insect order were significantly different ($P<0.05$) for the following pairwise comparisons between sampling sites:

Order	Paired Sampling Sites
Ephemeroptera (Mayflies)	Dunn vs Fisher, Elkhorn vs Fisher, Pipe vs Fisher, Dunn vs. Pipe, Elkhorn vs Pipe
Plecoptera (Stoneflies)	Dunn vs Fisher, Elkhorn vs Fisher, Pipe vs Fisher
Trichoptera (Caddisflies)	Dunn vs Fisher, Elkhorn vs Fisher, Pipe vs Fisher, Dunn vs Elkhorn, Dunn vs Pipe

Chironomidae (Midges)	All were significantly different
Other Diptera	None were significantly different
Other Invertebrates	Dunn vs Pipe, Pipe vs Fisher

These comparisons indicate: 1) densities of mayflies become comparable to those in Fisher River between Elkhorn and Pipe creeks; 2) caddisflies approach Fisher River densities between Dunn Creek and Elkhorn; and 3) stonefly densities do not approach Fisher River levels within the Kootenai River study area. Midge densities differ both between regulated sites and between regulated and control sites, while other dipterans and other invertebrate densities were not significantly different.

An ANOVA test was also run on percent composition by biomass. Biomass showed the same trends as density by insect order, but with fewer differences that were significant for the mayflies, stoneflies, caddisflies and midges. Other Diptera and Other Invertebrates were combined for volumetric analyses and showed significant biomass differences between the control and regulated sites. The comparisons that were significantly different ($P<0.05$) are listed below.

Order	Paired Sampling Sites
Ephemeroptera (Mayflies)	Dunn vs Pipe, Dunn vs Fisher
Plecoptera (Stoneflies)	Dunn vs Fisher, Elkhorn vs Fisher, Pipe vs Fisher
Trichoptera (Caddisflies)	Dunn vs Elkhorn, Dunn vs Pipe, Dunn vs Fisher
Chironomidae (Midges)	Dunn vs Elkhorn, Dunn vs Pipe, Dunn vs Fisher, Elkhorn vs Fisher, Pipe vs Fisher
Other Diptera	Dunn vs Fisher, Elkhorn vs Fisher, Pipe vs Fisher
Other Invertebrates	Dunn vs Fisher, Elkhorn vs Fisher, Pipe vs Fisher

Comparisons of Pre- and Post-Impoundment Densities and Biomass

Overall, post-impoundment densities were an order of a magnitude higher than those found at the Dunn Creek site in pre-impoundment studies (Table 6). This is due in part to the fact that some of our samples were taken with the kick sampler which collects many more of the small instars than the Knapp-Waters sampler used in pre-impoundment studies. Also, there is not a direct month-to-month correspondence in the sampling dates which could lead to differences. It does seem evident, however, that higher numbers of a few species of mayflies and dipterans projected

Table 1. Insect densities as annual mean of monthly means per square meter for Kick, Circular and Knapp Waters samples combined, October, 1979 through September, 1980.

	Dunn Creek n=10 $\bar{x}$(s.d.)	Elkhorn n=10 $\bar{x}$(s.d.)	Pipe Creek n=9 $\bar{x}$(s.d.)	Fisher River n=7 $\bar{x}$(s.d.)
Ephemeroptera	8,797(7,778)	5,627(3,079)	2,821(1,241)	4,443(1,784)
Plecoptera	6(6)	14(10)	15(11)	670(119)
Trichoptera	62(32)	953(799)	1,282(1,365)	1,657(944)
Coleoptera	7(6)	49(29)	34(28)	446(234)
Chironomidae	15,803(6,905)	7,587(3,047)	11,061(6,263)	2,207(395)
Other Diptera	1,560(1,417)	2,598(2,511)	1,970(2,309)	718(569)
Other Invertebrates	1,877(1,615)	1,658(698)	2,423(1,438)	535(251)
TOTAL	28,112(8,394)	18,486(7,919)	19,606(9,259)	10,676(3,325)
Percent Composition				
Ephemeroptera	31.3%*	30.4%	14.4%	41.6%
Plecoptera	0.1%	0.08%	0.08%	6.3%
Trichoptera	0.2%	5.2%	6.5%	15.5%
Coleoptera	0.02%	0.3%	0.2%	4.2%
Chironomidae	56.2%	41.0%	56.4%	20.7%
Other Diptera	5.5%	14.1%	10.0%	6.7%
Other Invertebrates	6.7%	9.0%	12.4%	5.0%

* Percentages do not always total 100% due to rounding.

Table 2. Insect biomass as annual mean of monthly means in cubic centimeters per square meter for Kick, Circular and Knapp Waters samples combined.

	Dunn Creek n=10 $\bar{x}$(s.d.)	Elkhorn n=10 $\bar{x}$(s.d.)	Pipe Creek n=9 $\bar{x}$(s.d.)	Fisher River n=7 $\bar{x}$(s.d.)
Ephemeroptera	16.4 (12.4)	11.0 (7.4)	5.8 (3.7)	6.2 (3.8)
Plecoptera	0.01(0.03)	0.5 (0.5)	0.5 (0.6)	4.0 (2.7)
Trichoptera	1.2 (0.7)	6.8 (3.6)	5.9 (4.8)	6.3 (4.5)
Chironomidae	9.6 (6.0)	5.5 (2.1)	4.0 (2.4)	2.2 (1.4)
Other	11.4 (4.4)	10.6 (4.4)	7.1 (4.4)	4.4 (2.5)
TOTAL	38.6 (20.6)	34.4 (15.0)	23.3 (12.1)	23.1 (14.0)
Percent Composition				
Ephemeroptera	42.5%	32.0%	24.9%	26.8%
Plecoptera	0.03	1.4	2.1	17.3
Trichoptera	3.1	19.8	25.3	27.3
Chironomidae	24.9	16.0	17.2	9.5
Other	29.5	30.8	30.5	19.0

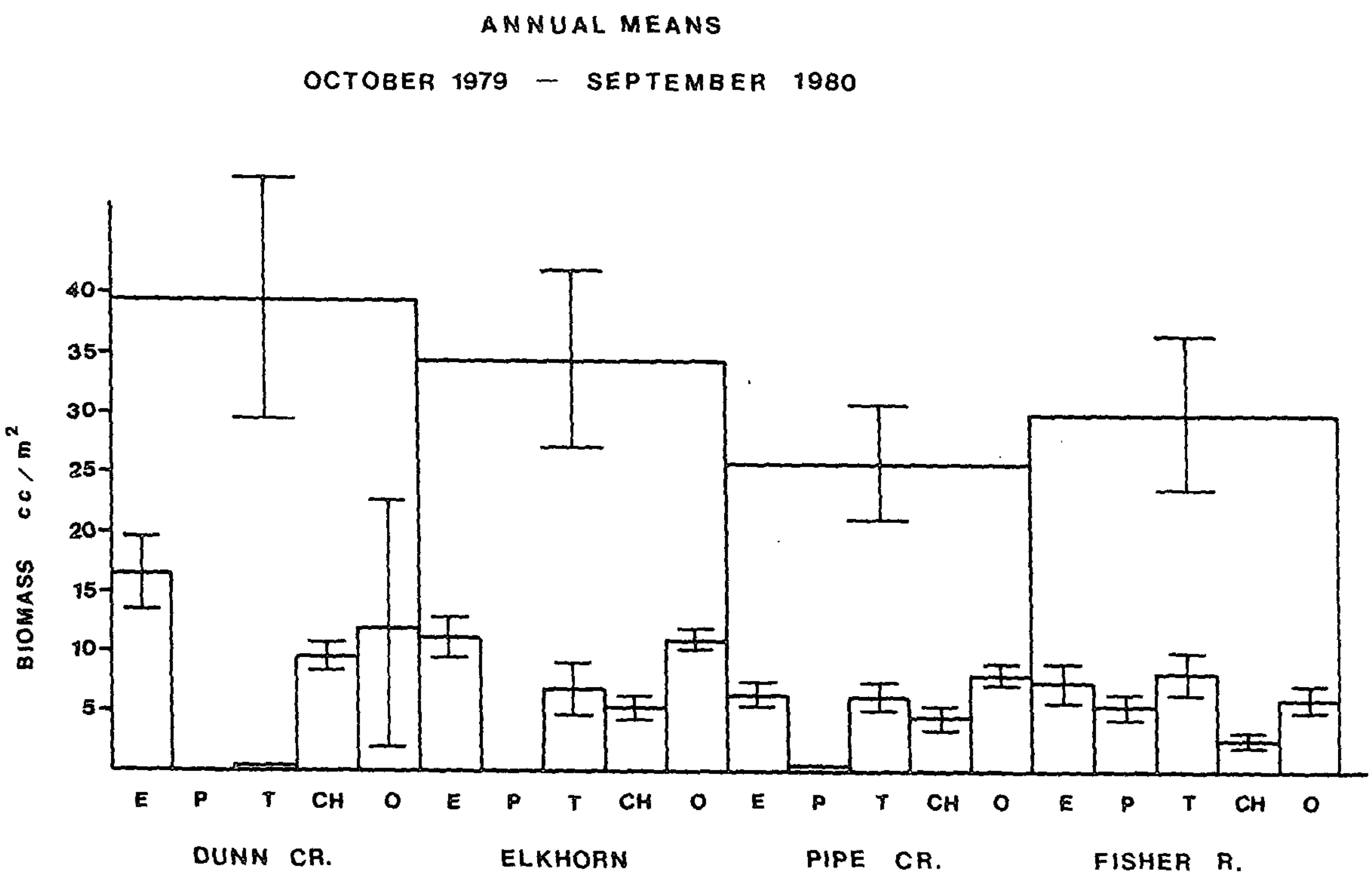


Figure 4. Annual means of monthly mean volumes in cubic centimeters per square meter of Ephemeroptera (E), Plecoptera (P), Trichoptera (T), Chironomidae (Ch), and other insects (O) by sampling site and combined by sampling sites. One standard deviation is shown by I on each bar.

Table 3. Density-Biomass Index (mean of annual percent composition of numbers and annual percent composition of volumes) for water year 1980.

Insect order	Dunn Creek n=10 $\bar{x}$ %	Elkhorn n=10 $\bar{x}$ %	Pipe Creek n=9 $\bar{x}$ %	Fisher River n=7 $\bar{x}$ %
Ephemeroptera	36.5	31.3	19.7	33.4
Plecoptera	0.1	0.7	1.0	12.3
Trichoptera	1.5	12.6	15.5	21.5
Chironomidae	40.3	28.1	36.8	14.8
Other	21.6	27.4	27.1	18.1

* Percentages do not always total 100% due to rounding.

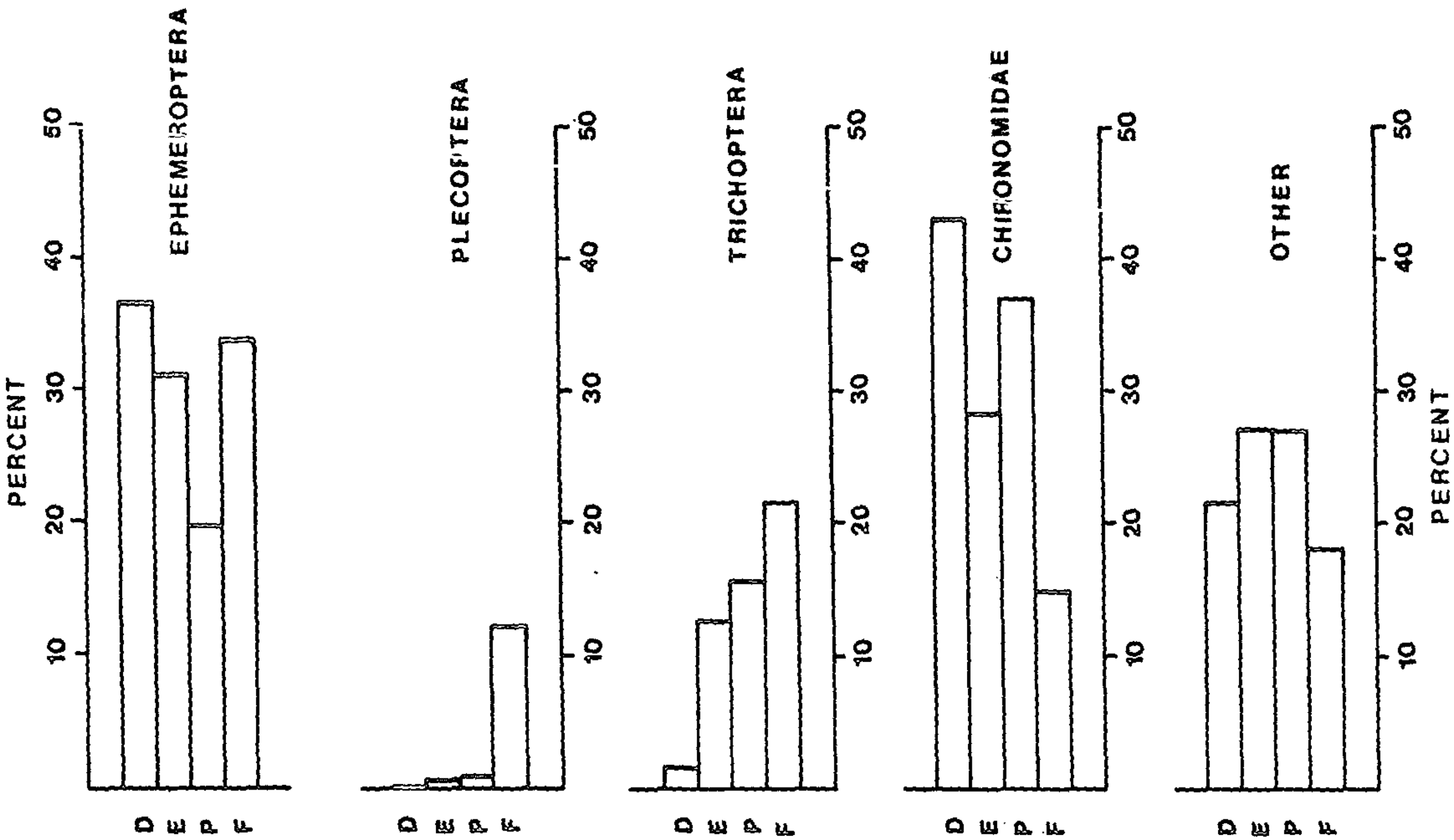


Figure 5. Density-Biomass Index; means of annual percent composition of numbers and annual percent composition of volumes for Dunn Creek (D), Elkhorn (E), Pipe Creek (P) and Fisher River (F).

Table 4. Percent of total number (no./m²) of invertebrates represented by insect order (Kick and Knapp-Waters samples combined).

	Ephemeroptera	Plecoptera	Trichoptera	Coleoptera	Chironomiade	Other Diptera	Other Invertebrates
Dunn Creek							
October	42.8	0.02	0.2	0.04	33.5	1.5	21.8
November	41.1	0.008	0.06	0.02	38.6	12.3	7.9
January	62.3	0.002	0.1	0.01	30.4	4.3	2.9
March	51.9	0.006	0.3	0.05	34.5	11.7	1.6
April	35.1	0.04	0.2	0.05	60.3	2.7	1.6
May	30.3	0.01	0.2	0.006	66.6	1.4	1.4
June	16.3	0.01	0.2	0	80.2	0.6	2.7
July	6.1	0.05	0.3	0.007	81.6	5.2	6.8
August	2.2	0.01	0.1	0.05	73.2	4.3	20.1
September	9.7	0.01	0.4	0.02	60.9	15.2	13.7
Elkhorn							
October	31.6	0.1	13.4	0.4	37.6	1.1	15.8
November	29.3	0.03	2.1	0.1	35.6	24.9	7.9
January	39.2	0.09	4.1	0.3	33.5	17.4	5.4
March	44.2	0.05	4.9	0.2	29.0	17.9	3.8
April	37.1	0.08	1.7	0.1	32.8	19.0	9.3
May	32.2	0.02	4.0	0.4	45.7	10.9	6.7
June	19.2	0.05	1.2	0.2	54.7	12.3	12.3
July	30.7	0.1	2.4	0.4	52.3	5.6	8.4
August	22.7	0.2	7.0	0.4	50.8	6.2	12.7
September	15.3	0.06	18.7	0.2	43.5	6.9	15.4

Table 4. (Continued).

	Ephemeroptera	Plecoptera	Trichoptera	Coleoptera	Chironomidae	Other Diptera	Other Invertebrates
Pipe Creek							
October	11.0	0.02	4.6	0.1	61.6	2.5	20.2
November	11.8	0.04	2.1	0.08	60.3	13.2	12.4
January	17.5	0.03	6.6	0.2	38.6	32.5	4.4
March	18.9	0.03	10.5	0.1	57.6	7.3	5.6
April	----	----	----	----	----	----	----
May	6.4	0.06	0.4	0.5	81.3	0.8	10.6
June	11.4	0.06	0.5	0.005	73.4	2.2	12.5
July	25.8	0.3	2.5	0.09	48.0	8.7	14.5
August	17.6	0.2	9.5	0.2	42.8	9.7	20.1
September	15.0	0.1	24.4	0.2	41.5	5.1	13.8
Fisher River							
October	35.8	6.9	19.3	8.6	16.4	5.2	7.8
November	42.1	7.3	18.7	2.6	18.4	5.2	5.8
January	51.0	3.8	12.4	2.7	20.2	8.4	1.4
March	40.9	7.6	8.7	2.9	25.5	5.7	8.7
April	----	----	----	----	----	----	----
May*	39.2	6.3	9.7	1.9	20.0	4.0	19.0
June*	43.9	6.6	2.9	8.7	23.0	6.9	7.9
July	38.7	10.4	5.5	4.8	32.5	5.1	3.0
August	42.9	4.7	19.5	3.7	13.9	10.8	4.5
September	34.7	6.3	20.0	4.4	26.8	2.3	5.4

Table 5. Percent of total biomass (cc/m²) of invertebrates represented by insect order (Kick and Knapp Waters samples combined).

	Ephemeroptera	Plecoptera	Trichoptera	Chironomidae	Total
Dunn Creek					
October	19.1	0.6	3.4	28.7	48.3
November	30.1	0	1.5	25.6	42.9
January	44.5	0	1.7	13.8	40.0
March	48.0	0	1.9	12.8	37.3
April	46.4	0	2.6	28.4	22.6
May	48.9	0	3.5	28.5	19.1
June	53.0	0	2.2	26.4	18.4
July	37.1	0	4.0	22.3	36.6
August	19.0	0	6.5	38.6	35.9
September	18.3	0	1.7	26.4	53.6
Elkhorn					
October	19.7	2.2	36.1	16.9	25.1
November	27.6	3.3	18.9	27.2	23.0
January	26.0	1.3	15.4	13.1	44.2
March	40.6	0.8	13.3	13.3	32.0
April	36.1	2.4	10.1	11.5	40.0
May	43.5	0.1	16.9	13.9	25.6
June	38.2	0	11.8	15.9	34.1
July	28.0	0.7	29.3	13.4	28.6
August	30.3	3.9	22.4	12.2	31.3
September	18.4	4.1	28.4	17.0	32.2
Pipe Creek					
October	14.6	7.3	42.7	8.5	26.8
November	18.1	2.7	24.9	25.3	29.0
January	23.8	2.0	19.0	10.3	44.8
March	29.2	4.0	28.7	16.5	21.6
April	----	----	----	----	----
May	25.6	0.5	6.4	32.0	35.6
June	27.8	0	8.3	26.0	37.9
July	27.1	0	40.7	8.8	23.4
August	28.6	3.0	15.8	14.1	38.5
September	19.6	1.3	31.0	15.7	32.4

Table 5. (Continued).

	Ephemeroptera	Plecoptera	Trichoptera	Chironomidae	Total
Fisher River					
October	19.4	23.9	29.9	7.5	19.4
November	27.8	17.3	26.2	11.0	17.7
January	18.2	22.0	31.0	11.9	16.8
March	33.1	18.9	17.1	5.6	25.3
April	----	----	----	----	----
May*	34.4	8.8	27.5	9.4	20.0
June*	34.9	9.6	2.4	14.5	38.6
July	26.2	16.3	29.2	8.2	20.2
August	27.2	13.0	29.8	8.7	21.4
September	22.3	17.9	31.4	9.5	18.9

* Not good quantitative data.

Table 6. A comparison of pre and post-impoundment aquatic insect data collected from Dunn Creek site. Preimpoundment data are four year averages from 1968 through 1971, while post-impoundment data are annual mean of monthly means from October 1979 through September, 1980.

Order	Pre-impoundment 1/ (n = 57 samples) 1/ Densities ($\bar{x}$ no/m²) x 2/ (s) 3/	Pre-impoundment Biomass (gm/m²) $\bar{x}$(s)	Post-impoundment (n = 63 samples) Densities ($\bar{x}$ no/m²) $\bar{x}$(s)	Post-impoundment Biomass (cc/m²) $\bar{x}$(s)
Ephemeroptera	539(434)	2.0(1.4)	8,797(7,778)	16.4(12.4)
Plecoptera	570(320)	5.8(3.5)	6(6)	0.01(0.03)
Trichoptera	732(215)	11.3(5.5)	62(32)	1.1(0.7)
Coleoptera	4(5)	trace	7(6)	trace
Diptera	1,030(466)	4.0(1.8)	17,363(8,322)	12.5(8.0)
TOTAL	2,876(1,197)	23.1(10.2)	26,235(6,779)	30.0(16.0)
Percent Composition				
Ephemeroptera	18.7	8.7	33.5	54.7
Plecoptera	19.8	25.1	0.02	.03
Trichoptera	25.5	48.9	0.2	3.7
Coleoptera	0.1	----	0.03	----
Diptera	35.8	17.3	66.2	41.7

1/ Bonde and Bush (1975)
2/ $\bar{x}$ is mean number of grams (pre-impoundment) or cubic centimeters (post-impoundment).
3/ S is one standard deviation.

an overall increase in the density of invertebrates. The number of stoneflies and caddisflies has decreased dramatically at this site since impoundment, while the densities of mayflies and dipterans appear to have increased substantially. Species collected in pre-impoundment studies, but not in this study, are listed in Table 7.

Biomass measurements are not directly comparable since we used volumetric analyses in order to preserve the specimens. The percent composition can be used for comparative purposes. The trend is the same as the density trend; a very marked decrease in stoneflies and caddisflies and a six-fold increase in mayflies and 2.5-fold increase in dipterans.

Comparisons of 1970 and 1980 Data on the Fisher River

Comparison of our data with a 1970 study of the Fisher River (May 1972) indicates that there have been similar changes in the relative percent composition by density and biomass of insect orders in the Fisher River in the last 10 years. A comparison of the percent composition of annual means in density and biomass at two stations from the 1970 study and from our study site on the Fisher River (Table 8) indicates a decrease in the importance of stoneflies and caddisflies and an increase in dipterans. This is likely due to long-term changes associated with channelization of the Fisher River at the time Libby Dam was constructed, and other changes associated with logging or agriculture in the Fisher River drainage.

Comparisons of Present Populations of Invertebrates in Kootenai and Fisher Rivers

A notable feature of the benthos in the Kootenai River was the paucity of stoneflies which generally comprise less than 0.1 percent of the density of benthic invertebrates (Table 4). There were no species of stonefly common in the Kootenai River as opposed to about 14 species which were common in the Fisher River. Seventeen species of stoneflies were collected in the Kootenai River compared to 23 species in the Fisher River and 42 species in the partially regulated Flathead River. Their absence may be related to changes in the substrate, to higher fall and winter water temperatures, or to availability of oxygen (see later section of possible problems with low dissolved oxygen).

Shifts in the species composition of mayflies were found with increasing distance downstream from the dam and between regulated and control sites (Tables 9 and 10). Two species of mayflies (*Ephemerella inermis* and *Baetis tricaudatus*) predominate near the dam. They are species with several generations per year, and apparently are prolific enough to withstand population losses due to frequent stranding and downstream drift caused by flow fluctuations. The heptageniid mayflies (*Epeorus*, *Rhithrogena*) were found in very low numbers near the dam, but increased at the downstream stations. They were far more abundant in the Fisher River than in the Kootenai River (Table 10). Rapid water fluctuations and increased algal growths probably impair the efficiency with which they can maintain their

Table 7. Genera collected in pre-impoundment studies of the Kootenai River, rarely or not collected in the present study.

<u>Genera not collected in present study</u>

<u>Ephemeroptera</u>
- Parameletus
- Leptophlebia

<u>Plecoptera</u>
- Arcynopteryx (Perlinodes, Setvena)
- Diura

<u>Trichoptera</u>
- Parapsyche
- Neothremma

<u>Megaloptera</u>
- Sialis

<u>Genera which are much reduced in abundance</u>

<u>Ephemeroptera</u>
- Heptagenia
- Callibaetis

<u>Plecoptera</u>
- Pteronarcella
- Capnia
- Isocapnia
- Brachyptera (Taenionema)
- Isogenus (Cultus, Isogenoides)
- Isoperla
- Acroneuria (Calineuria, Hesperoperla)
- Alloperla (Sweltsa, Suwallia)

<u>Trichoptera</u>
- Arctopsyche

Table 8. A comparison of data from a 1970 study (May 1972) of the Fisher River and the present study. Relative abundance of aquatic insect orders expressed as percent of annual density and biomass means.

	1970 Study Fisher River		Present Study
Aquatic Insect Order	Station 1 %	Station 3 %	Fisher River Station %
Ephemeroptera			
Density	17.7	15.9	6.3
Biomass	21.0	37.0	18.2
Plecoptera			
Density	41.5	26.8	41.6
Biomass	34.2	17.8	25.2
Trichoptera			
Density	1.3	18.5	4.2
Biomass	trace	3.1	1.0
Coleoptera			
Density	21.6	29.6	15.5
Biomass	20.0	24.8	27.5
Diptera			
Density	17.9	9.2	32.5
Biomass	24.8	17.3	20.1

Table 9. Aquatic insects with higher densities (no./m^2) in regulated areas. Kick, Circular and Knapp Waters samples are combined. Annual means of monthly means (October, 1979 - September, 1980).

	Kootenai River			
	Dunn Creek $\bar{x}$(s.d.)	Elkhorn $\bar{x}$(s.d.)	Pipe Creek $\bar{x}$(s.d.)	Fisher River $\bar{x}$(s.d.)
EPHEMEROPTERA				
Baetis tricaudatus	1,487(1,772)	3,422(3,594)	1,950(1,550)	866(1,247)
Ephemerella inermis	7,200(7,853)	1,346(1,231)	216(172)	521(603)
Ephemerella tibialis	14(15)	890(1,028)	319(321)	118(177)
TRICHOPTERA				
Symphitopsyche oslari	8(11)	227(229)	94(132)	5(8)
Ochrotrichia sp.	28(30)	89(102)	50(67)	3(6)
Brachycentrus sp.	6(9)	120(260)	77(71)	33(61)
DIPTERA				
Simulium sp.	1,489(1,500)	2,770(4,567)	1,808(2,796)	400(764)
Chironomidae	15,803(6,905)	7,587(3,047)	11,061(6,263)	2,207(395)

Table 10. Aquatic insects with higher densities (no./m^2) in the Kootenai and Fisher River. Kick, Circular and Knapp Waters samples are combined. Annual mean of monthly means, October, 1979 - September, 1980.

Taxa	Kootenai River: Dunn Creek $\bar{x}$(s.d.)	Kootenai River: Elkhorn $\bar{x}$(s.d.)	Kootenai River: Pipe Creek $\bar{x}$(s.d.)	Fisher River $\bar{x}$(s.d.)
EPHEMEROPTERA				
Baetis hageni	0.4(2)	1(3)	3(6)	218(379)
Epeorus sp.	0 (0)	6(22)	127(165)	639(1,202)
Rhithrogena hageni	5 (11)	35(32)	49(47)	640(422)
Ephemerella doddsi	0 (0)	0(0)	1(2)	38(45)
Paraleptophlebia heteronea	4 (9)	5(9)	16(22)	86(94)
TRICHOPTERA				
Arctopsyche grandis	0 (0)	0.7(3)	2(4)	21(34)
Hydropsyche occidentalis	2 (5)	92(193)	199(257)	347(526)
Cheumatopsyche sp.	0.1(0.6)	26(30)	22(21)	79(95)
Lepidostoma sp.	2 (5)	6(8)	7(19)	390(369)
COLEOPTERA				
Optioservus quadrimaculatus	5 (8)	37(37)	31(35)	131(111)
DIPTERA				
Hexatoma sp.	0.1(0.6)	3(7)	1(2)	97(137)

positions in the boundary layer on the surface of rocks as their gills form a suction cup which assists in maintaining their positions on rock surfaces.

Caddisflies (*Trichoptera*) often show compositional changes in regulated areas (Henricson and Müller 1979). The species present are often determined by the composition and particle sizes of the available food in the seston. The distribution of filter feeding caddisflies is often determined by the prevalence of food particle sizes. Various species spin nets of different mesh sizes and thus utilize only a specific range of particle size (Wallace and Merritt 1980). Seston from Lake Koocanusa is abundant in the Kootenai River and is utilized by certain filter feeding caddisflies and influences their abundance (*Hydropsyche oslari, Brachycentrus sp.*) (Table 9). Caddisflies which spin nets with larger mesh sizes (*Arctopsyche grandis*) and smaller mesh sizes (*Cheumatopsyche sp.*) than the medium sized mesh of *Hydropsyche* nets are more abundant in the Fisher River (Table 10). Periphyton biomass is high in the Kootenai River due to reduced turbidity and scouring. Caddisflies which graze on the periphyton (*Hydroptila sp.*) are found in higher densities in the Kootenai River than in the Fisher River (Table 10). Allochthonous material (leaves and woody material from the terrestrial sphere) are much more available in the Fisher River. Caddisflies which shred leaves (*Lepidostoma sp.*) are found in much higher densities in the Fisher River (Table 10).

Blackflies (Diptera) are also filter feeders which have much higher densities in the Kootenai River than in the Fisher River (Table 9). Midges, worms and snails are more abundant in the Kootenai River.

A species list (Table 11) was compiled from all of the insects collected during the study. The Odonata, Hemiptera, Chironomidae and some other groups of Diptera were identified only to family. Adult collections were likely incomplete for the Fisher River, so that the species list based on our samples is incomplete. Some of these species may have been incidental in the Kootenai River, arriving there in the drift from tributary streams. The relative abundance of species is indicated: rare = 1 or 2 specimens collected during the entire study; infrequent = less than $10/m^2$/year; common = >10 but <$1,000/m^2$/year; abundnt = >$1,000m^2$/year. A total of 53 species were collected at the Dunn Creek site, 73 at Elkhorn, 89 at Pipe Creek and 105 in the Fisher River.

A number of species were collected only in the Fisher River, while others only in the Kootenai River (Table 12). Many were collected rarely or only as adults, so may also occur in the other river. It is probable that a number of the stonefly species found in the Fisher River no longer occur in the Kootenai River. It is also possible that caddis species like *Brachycentrus americanus* have been eliminated in the Kootenai River, and that many of the leaf shredding species of caddis do not occur within the study area of the Kootenai River. Certain dipteran species were collected only in basket or drift samples in the Kootenai River, collection methods which were not used in the Fisher River. Some species differences would be expected based on the difference in the size of the river where

Table 11. A list of insect taxa collected from Dunn Creek, Elkhorn and Pipe Creek sites in Kootenai River and Fisher River site, 1979, 1980 and 1981. Frequency of occurrence is denoted as: rare (R), infrequent (I), common (C) and abundant (A).

	Sampling site			
	Kootenai River			
Taxa	Dunn Creek	Elkhorn	Pipe Creek	Fisher River
EPHEMEROPTERA				
Ameletus connectus	-	R	-	-
Ameletus cooki	R	-	I	I
Ameletus oregonensis	-	-	-	I
Ameletus sparsatus	-	-	-	I
Baetis tricaudatus	A	A	A	C
Baetis bicaudatus	-	-	-	I
Baetis hageni	R	I	I	C
Callibaetis sp.	-	R	-	R
Pseudocleon sp.	C	C	C	C
Cinygmula tarda	R	I	I	C
Epeorus albertae	-	I	I	C
Epeorus longimanus	-	I	C	C
Nixe criddlei	-	I	I	C
Rhithrogena hageni	I	C	C	C
Rhithrogena undulata	-	-	R	-
Rhithrogena robusta	-	-	-	R
Attenuatella margarita	-	R	R	C
Caudatella heterocaudata	I	C	C	C
Drunella doddsi	-	R	I	C
Drunella flavilinea	I	C	C	C
Drunella spinifera	R	R	I	I
Ephemeralla inermis	A	A	C	C
Serratella tibialis	I	C	C	C
Caenis sp.	-	I	C	C
Paraleptophlebia heteronea	I	I	C	C
Traverella albertana	-	-	-	R
ODONATA				
Coenagrionidae	I	I	I	I
PLECOPTERA				
Pteronarcella badia	-	R	R	I
Pteronarcys californica	-	I	I	C
Taenionema pacificum	-	R	I	C

Table 11. (Continued).

Taxa	Kootenai River: Dunn Creek	Kootenai River: Elkhorn	Kootenai River: Pipe Creek	Fisher River
PLECOPTERA (cont.)				
Zapada cinctipes	R	I	I	I
Zapada columbiana	-	-	-	R
Prostoia besametsa	-	-	I	-
Perlomyia utahensis	-	-	-	R
Capnia confusa	R	I	I	C
Eucapnopsis brevicauda	-	-	-	C
Utacapnia lemoniana	-	-	-	R
Isocapnia sp.	-	I	I	C
Calineuria californica	-	R	-	C
Classenia sabulosa	-	I	I	C
Hesperoperla pacifica	-	-	I	C
Cultus pilatus	-	-	-	I
Cultus sp.	I	-	-	I
Diura knowltoni	-	-	-	C
Perlinodes aurea	-	-	-	I
Skwala parallela	-	I	I	C
Isoperla fulva	-	R	I	C
Isoperla sp. A	R	-	-	-
Suwallia autumna	-	I	I	C
Suwallia pallidula	-	I	I	C
Sweltsa coloradensis	I	I	I	C
Utaperla sopladora	-	-	-	R
TRICHOPTERA				
Wormaldia gabriella	-	-	I	I
Tinodes sp.	-	R	I	-
Arctopsyche grandis	-	I	I	C
Cheumatopsyche campyla	R	C	C	C
Hydropsyche cockerelli	-	R	I	I
Hydropsyche occidentalis	I	C	C	C
Hydropsyche oslari	I	C	C	I
Rhyacophila angelita	-	-	R	C
Rhyacophila bifila	R	I	I	I
Rhyacophila vao	-	-	R	-

Table 11. (Continued).

Taxa	Sampling site			
	Kootenai River			
	Dunn Creek	Elkhorn	Pipe Creek	Fisher River
TRICHOPTERA (cont.)				
Glossosoma excitum	-	-	I	C
Glossosoma traviatum	-	-	-	R
Glossosoma velona	R	C	C	C
Hydroptila sp.	C	C	C	I
Brachycentrus americanus	-	-	-	C
Brachycentrus occidentalis	I	C	C	C
Lepidostoma sp.	I	I	I	C
Neophylax sp.	-	-	R	I
Dicosmoecus sp.	R	I	I	C
Onocosmoecus sp.	-	I	I	I
Chyranda sp.	-	-	-	I
Limnephilus cockerelli	-	-	-	R
Limnephilus sp. A	-	-	-	I
Limnephilus sp. B	-	-	-	I
Limnephilus sp. C	-	-	-	R
Psychoglypha sp.	-	-	I	I
Apatania sp.	-	-	R	-
Ceraclea	I	I	I	-
Oecetus sp.	-	-	-	R
HEMIPTERA				
Corixidae	-	I	I	I
COLEOPTERA				
Zaitzevia parvula	R	I	I	C
Optioservus quadrimaculatus	I	C	C	C
Lara avara	-	-	-	R
Narpus sp.	-	I	I	I
Helichus suturalis	-	-	-	R
Brychius sp.	I	I	I	-
Haliplus sp.	I	-	-	-
Dytiscidae	-	-	-	I

Table 11. (Continued).

Taxa	Sampling site			
	Kootenai River			
	Dunn Creek	Elkhorn	Pipe Creek	Fisher River
DIPTERA				
Antocha sp.	I	C	C	C
Dicranota sp.	-	-	R	R
Hexatoma sp.	R	I	I	C
Limonia sp.	-	R	-	-
Rhabdomastax sp.	-	-	R	-
Tipula spp.	-	-	R	I
Ceratopogonidae	I	I	I	C
Atrichopogon sp.	-	I	I	-
Simulium arcticum	C	C	A	C
Simulium vittatum	C	A	A	C
Simulium sp. A	-	-	-	I
Chironomidae	A	A	A	A
Protanyderus sp.	R	R	I	-
Deuterophlebiidae	-	-	-	I
Dixa sp.	-	-	R	-
Tabanidae	-	-	R	I
Atherix variegata	-	-	R	I
Dolichopodidae	I	I	I	R
Hemerodromia sp.	I	R	I	C
Chelifera sp.	-	-	-	R
Sciomyzidae	-	-	R	-
Euparyphus sp.	-	-	R	-
Pericoma sp.	-	-	-	R
COLLEMBOLA	I	I	C	I

Table 11. (Continued).

Taxa	Sampling site: Kootenai River: Dunn Creek	Elkhorn	Pipe Creek	Fisher River
OTHER INVERTEBRATES				
Turbellaria	C	C	C	C
Nematoda	C	C	C	C
Lumbriculidae	C	C	C	C
Naididae	C	C	C	C
Hirudinea	I	-	I	-
Piscicola sp.	R	I	R	-
Hydracarina	C	C	C	C
Lymnaea sp.	C	C	I	I
Gyraulus sp.	I	R	I	I
Physa sp.	R	R	R	I
TOTAL 124	53	73	89	105

Table 12. Aquatic insects collected only in regulated areas (Kootenai River) or only at the control site (Fisher River).

Colleted only in Fisher River	Collected only in Kootenai River
EPHEMEROPTERA	EPHEMEROPTERA
Ameletus oregonensis	Ameletus connectus
Ameletus sparsatus	
Rhithrogena robusta	
Traverella albertana	
PLECOPTERA	PLECOPTERA
Zapada columbiana	Prostoia besametsa
Perlomyia utahensis	Isoperla sp. A
Eucapnopsis brevicauda	
Utacapnia lemoniana	
Cultus pilatus	
Diura knowltoni	
Perlinodes aurea	
Utaperla sopladora	
TRICHOPTERA	TRICHOPTERA
Glossosoma traviatum	Rhyacophila vao
Brachycentrus americanus	Apatania sp.
Chyranda sp.	Ceraclea sp.
Limnephilus cockerelli	
Limnephilus sp. A	
Limnephilus sp. B	
Limnephilus sp. C	
Oecetus sp.	
COLEOPTERA	COLEOPTERA
Lara avara	Brychius sp.
Helichus suturalis	Haliplus sp.
Dytiscidae	
DIPTERA	DIPTERA
Simulium sp. A	Limonia sp.
Deuterophlebiidae	Euparyphus sp.
Chelifera sp.	Rhabdomastax sp.
Pericoma sp.	Atrichopogon sp.
	Protanyderus sp.
	Dixa sp.
	Sciomyzidae

mean discharge for the Kootenai River is 318.3 m^3 versus 14.2 m^3 for the Fisher River. A shift in abundance between the two rivers is a more frequent occurrence than the total elimination of a species in the Kootenai River (Tables 9 and 10).

Comparisons Between First and Second Years of the Study

An attempt was made to compare the relative abundance of common species collected during the first and second years of the study. This was complicated by the fact that samples were taken in only four months during the second year. Only marked changes in abundance were noted, since sample variation is large even within the same month at the same site. Generally, composition appeared to remain fairly constant during the two years (Appendix 3). Two more species of stoneflies were collected during the second year (*Isoperla fulva, Skwala parallela*). Higher densities of *Ephemerella inermis, Drunella flavilinea, Cinygmula, Hydroptila* and *Simulium* were found during January and March, 1981. This was very possibly due to the faster rate at which flows were reduced before sampling during those months. The faster rate of flow reduction may have concentrated higher numbers of certain species along the edge where samples were collected. More *Hydropsyche oslari* were collected at Dunn Creek during the second year, while fewer *Antocha* were collected at Elkhorn and Pipe Creek during the second year. Some changes in relative abundance would be expected from year to year under natural conditions, and especially in a newly developed regulated river where physical conditions (in particular flow and temperature regimes) have undergone changes since impoundment.

Comparative Insect Life Histories

Insect emergence times (Table 13) were monitored with the use of sweep nets, pit traps, and light traps at regulated and control sites. The amount of sampling effort expended on the Fisher River was much less than that spent on Kootenai River resulting in information on emergence times from control areas being less complete. Most mayfly adults were collected in drift nets, a method not used on the Fisher River. Adult caddisflies were collected in light traps operated from June to October on both rivers, but records were not as continuous as for the Kootenai River due to the fact that it was necessary to use a battery-powered light trap on the Fisher River. Emergence times were comparable for certain species, but were often prolonged in the Kootenai River. Particularly notable were *Hydropsyche oslari* which emerged from July to October in the Kootenai, but only in September and October in the Fisher River; *Glossosoma velona* emerged from May to September in the Kootenai, but only in June in the Fisher; and *Baetis tricaudatus* was collected in every month from the Kootenai River, but only in April in the Fisher. While the Fisher River records are probably not completed, it is highly probable that species like *Baetis tricaudatus* shift to a multivoltine (several generations per year) life cycle in the higher annual temperatures of the Kootenai River. Insect growth and emergence is greatly influenced by temperature patterns. Various researchers have documented the importance of temperature on larval development (Macon 1960; Becker 1973; Nebeker

Table 13. Adult insect emergence dates for the Kootenai and Fisher rivers.

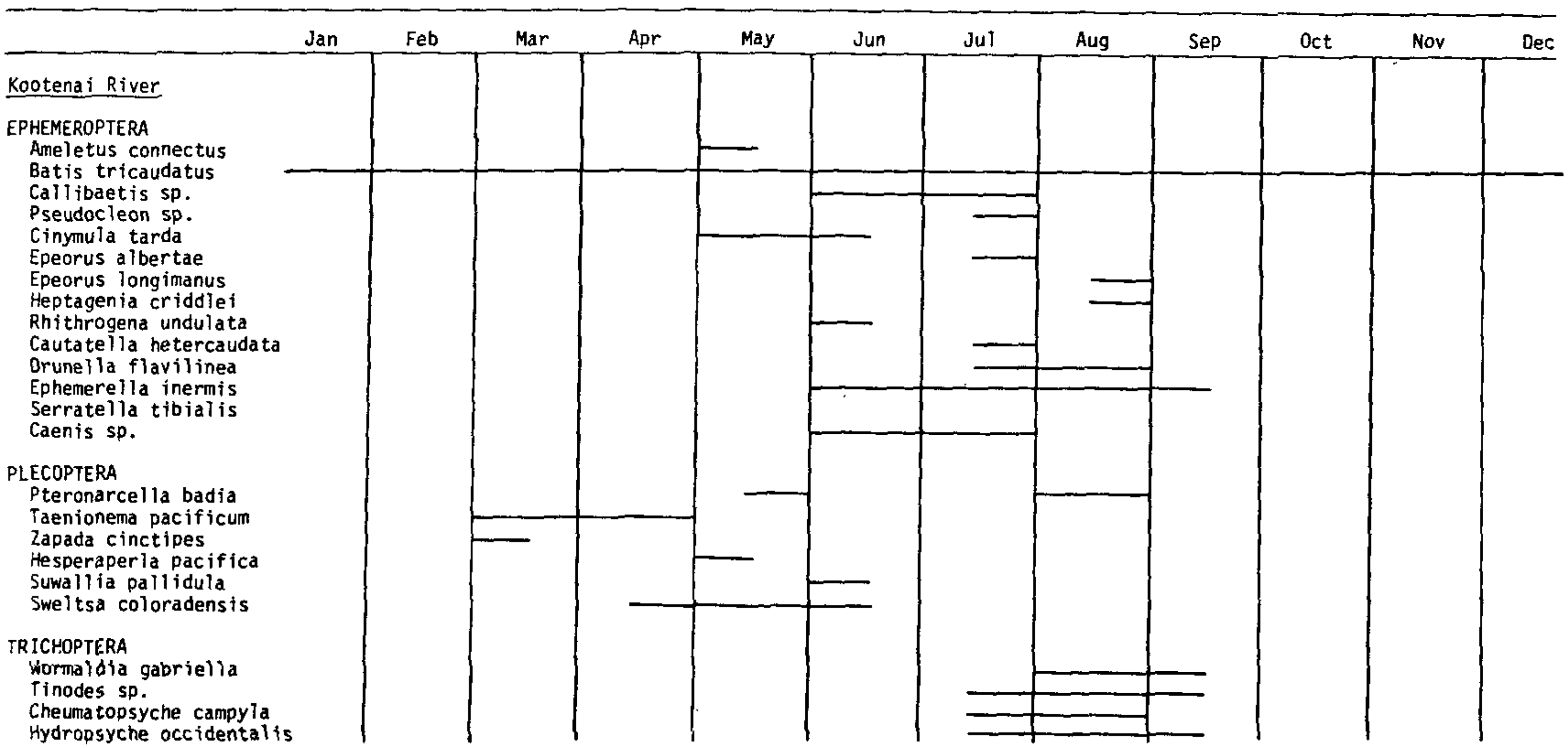


Table 13 (continued).

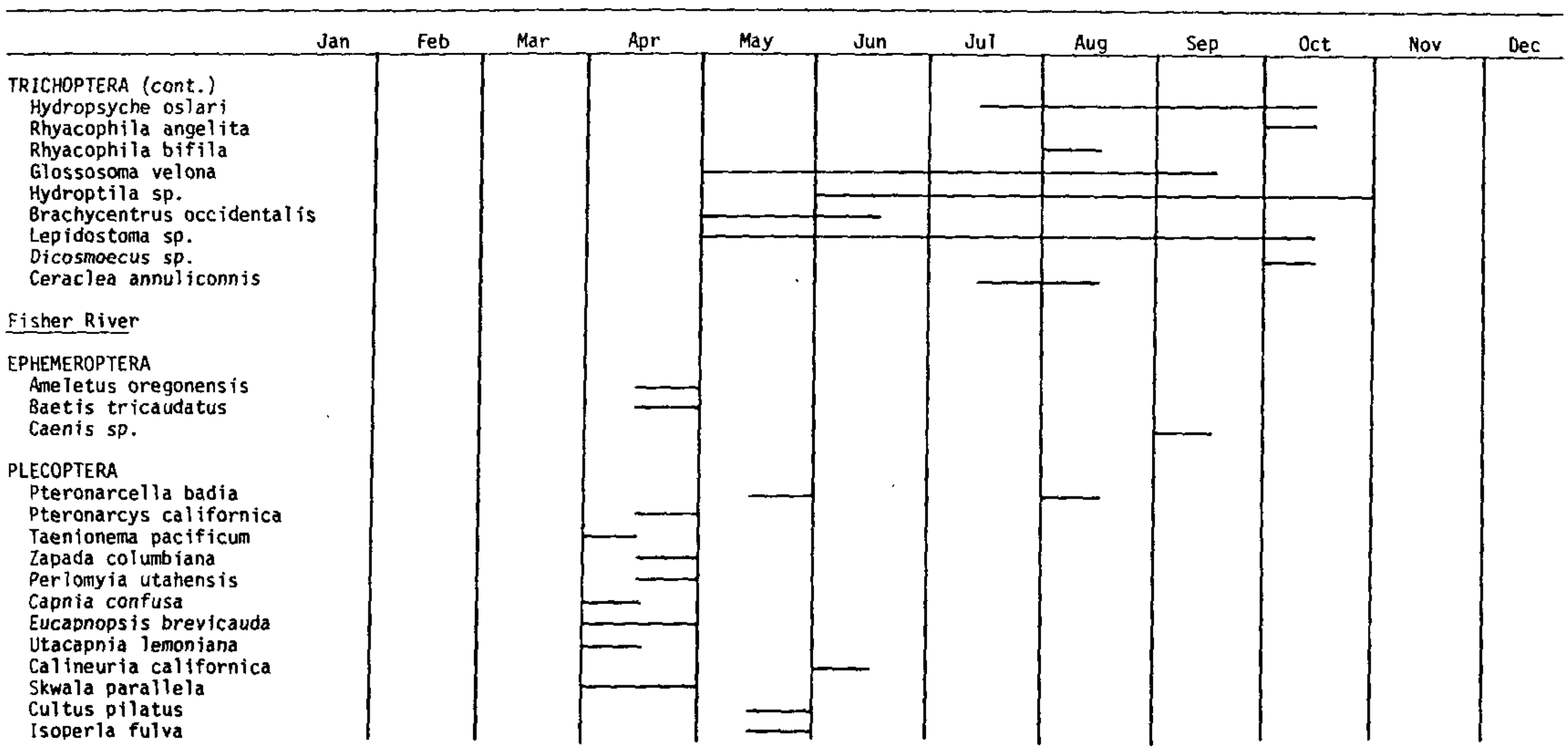
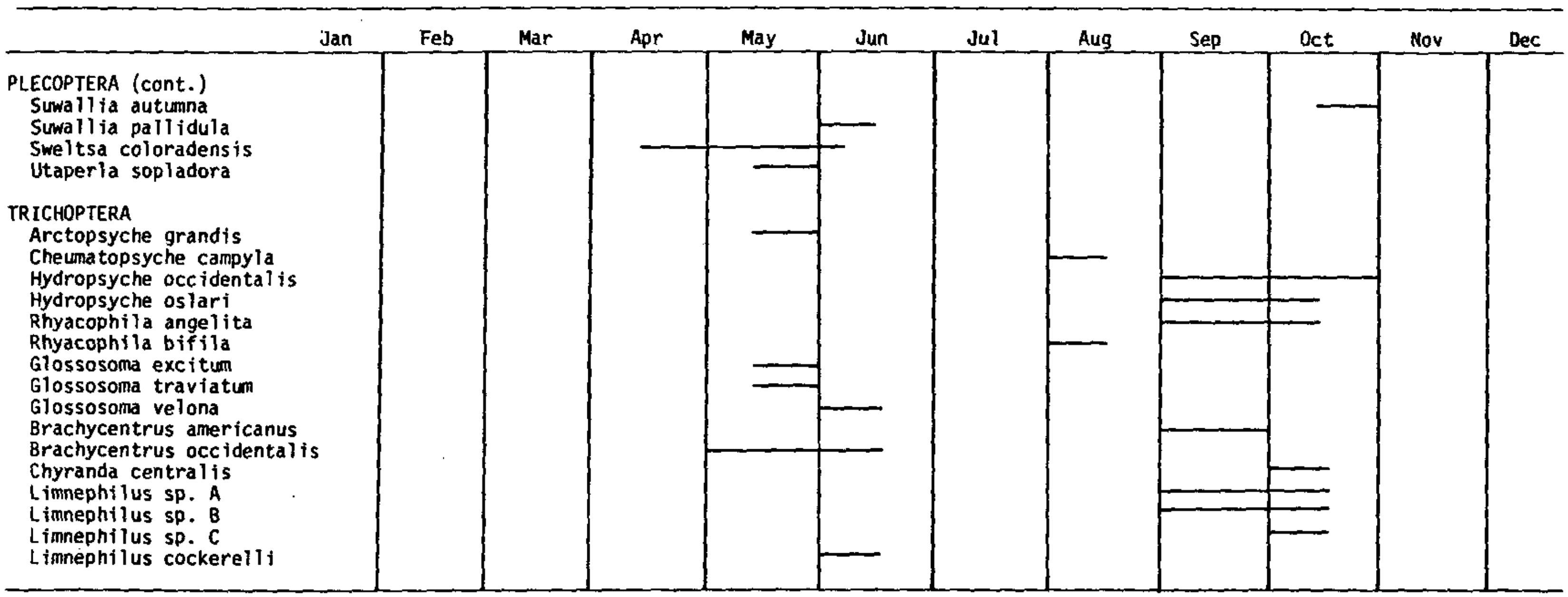


Table 13 (cont.).



1973; Stanford 1975; Corkum 1978) and on emergence (Macon 1958; Rupprecht 1975; Illies and Masteller 1977). Lehmkuhl (1979) concluded that relatively little information is available on the effects of environmental disturbances on insect life cycles.

The degree day concept has been used in the study of insect life histories. Mean daily temperatures can be summed for a given period of time (week, month, season) to give a comparison of the cumulative heat load in different areas. Mean daily temperatures were summed by the month, season and year for the Kootenai and Fisher rivers in water years 1979 and 1980 (Table 14). Use of the Libby selective withdrawal system provided a temperature regime more closely approximating pre-impoundment stream temperatures than were possible before its installation in 1977. Modified temperatures exist but to a much less extent than prior to 1977. Fall and winter temperatures are warmer than those in the Fisher River and spring and summer temperatures are cooler.

Some differences in insect life history and species composition in the two rivers would be expected on the basis of temperature alone. Some insect species show greater flexibility in the timing of life cycles, whereas the tolerance limits of other species may be exceeded and species replacement will result.

A seasonal temperature cycle is essential for the maintenance of most aquatic communities (Cairns 1971). Many insects have strict temperature requirements and minor alterations in temperature can have drastic effects. Constant temperatures are thought to eliminate many species which depend on temperature maxima or minima to break diapause or to stimulate hatching, growth and emergence (Ward 1976b). Life histories are often dimensioned by temperature summation criteria (Lehmkuhl 1972; Stanford 1975). Species for which the number of degree days is inadequate for larval maturation may be eliminated. It follows that cool summer conditions below dams may be a limiting factor in the number of species present (Ward 1976a). Reduced growth efficiency at low temperatures may eliminate species even though the temperature is within the tolerance range of the organism (Edington and Hildrew 1973), presumably by causing a competitive disadvantage. Certain species do appear to be capable of adapting metabolically to conditions found below dams. *Baetis rhodeni* exhibited similar growth in isothermic and normal streams in Ireland (Fahy 1973).

Higher winter water temperatures in regulated rivers may induce emergence into lethally cold air or during periods when mating is impossible (Nebeker 1971b). Elevated river water temperatures may disrupt mating behavior in some species by widening time lag between emergence of males and females (Nebeker 1971a). The precise relationship between water temperature and time of emergence of insects under field conditions has not been clearly explained for most species. Insects living in natural, constant temperature springs have either longer emergence periods or tend to emerge earlier than the same species living in rivers (Nebeker and Gaufin 1967; Smith 1968; Thorup and Lindegaard 1977). In the southern

Table 14. Sum of the mean daily temperatures in centigrade by month season and year for water years 1979 and 1980 in the Kootenai and Fisher Rivers.

	1979 Water Year		1980 Water Year	
	1 Oct 78-30 Sep 79	3 month subtotal	1 Oct 79-30 Sep 80	3 month subtotal
Kootenai River				
October	366.7		389.4	
November	275.7		256.6	
December	206.6		187.7	
		849		834
January	100.5		130.6	
February	86.7		78.9	
March	90.6		86.1	
		278		296
April	119.4		93.9	
May	144.4		221.1	
June	300.0		310.6	
		564		626
July	392.7		359.8	
August	420.6		396.7	
September	423.3		368.3	
		1,237		1,125
TOTAL	2,927.2		2,879.7	
Fisher River				
October	219		262.0	
November	32.5		64.5	
December	1.5		44.5	
		253		371
January	0		5.0	
February	0		4.0	
March	86		95.0	
		86		104
April	185		198.0	
May	278		307.0	
June	438		383.5	
		901		888.5
July	587		543.0	
August	587.5		500.0	
September	433		390.5	
		1,607.5		1,433.5
TOTAL	2,847.5		2,797	

United States, some species have been observed emerging year-round in power station outfalls (Nebeker 1971b), and midges have been observed to emerge year-round in regulated streams. Coutant (1967) has shown that a slight temperature increase (1°C) will cause hydropsychid caddisflies to emerge two weeks earlier downstream from the Hanford, Washington reactors than in upstream areas.

In experimental situations, it has been demonstrated that exposure of aquatic insect larvae to artifically high temperatures and stable flows can cause advances in the onset of adult emergence of up to five months in some species (Nebeker 1971b). On the other hand, Langford (1975) did not find evidence that temperature changes caused by the cooling-discharge below a power plant had any influence on the onset or progress of emergence of either Ephemeroptera or Trichoptera.

In order to assess the affects of regulation of insect growth rates, the head capsules of two species of mayfly and one species of caddisfly were measured each month during the 1980 water year in Kootenai River and Fisher River. The total head width through the eyes was measured for the two Ephemerellidae (Mayfly) species, while the interocular distance (between the eyes) was used for the hydropsychid caddisfly. The mayfly *Drunella flavilinea* emerges in July and lays its eggs which hatch in January. The mean head capsule width of this species was consistently larger in the Kootenai River than Fisher River, although the pattern of growth appears to be about the same (Table 15). *Serratella tibialis* also has an egg diapause; it was first collected in May and emerged in August and September. Both mayfly species emerged several weeks earlier in the Fisher River. However, *Serratella* showed no significant difference in the mean head capsule size in the two rivers.

Hydropsyche oslari, like *Drunella*, had consistently larger mean head capsule size in regulated areas. Hydropsychids emerged earlier in regulated areas; this may be related to the fact that their eggs hatch soon after being laid, rather than diapausing like the two mayfly species. This means that they are growing throughout the fall and winter months when temperatures in the Kootenai River are warmer and thus are able to complete their growth sooner. The mayfly species complete most of their growth during the spring and summer months when temperatures are cooler in the Kootenai and therefore require longer to complete their development and thus emerge later.

Certain changes in life history patterns associated with regulation may be an advantage to the fishery. Aquatic insects are often more available to fish when they are near emergence, because they often enter the drift more readily. Certain species, such as rainbow trout, feed extensively on insect drift and on emerging and oviposting adults. Extended emergence periods and an increase in the number of generations per year would increase their availability to fish. Reductions in the number of species would eliminate certain species which once provided a food source during their emergence periods (winter stoneflies).

Table 15. Mean head capsule widths of *Drunella flavilinea* in Kootenai and Fisher rivers. The standard deviation is in parentheses after the mean and the number of head capsules measured is given below the mean.

Date	Kootenai River: Elkhorn	Kootenai River: Pipe Creek	Fisher River
Oct - Dec 1979	egg diapause		egg diapause
January 1980	.59(.09) 4	.51(.06) 15	.39(.03) 4
March	.69(.11) 24	.70(.11) 18	.49(.06) 92
April	.97(.17) 48	run-off - no samples	
May	1.32(.22) 42	1.44(.21) 46	.96(.21) 58
June	1.85(.20) 92	1.69(.21) 32	1.29(.18) 3(runoff)
July	1.93(.15) 58	1.85(.19) 57	1.67(.11) 41
August	1.79(.04) 2	1.88(.09) 2	0
September	egg diapause		egg diapause

Species Diversity and Community Ordinations

Species diversity was lower in the Kootenai River than in the Fisher River, but diversity in the Kootenai River increased with distance downstream from the dam (Table 16). Shannon diversity indices were calculated using data from four seasons. The means of the diversity indices calculated using the kick samples taken during the months of October, 1979 and January, March and July, 1980 were 1.64 ± 0.4 at Dunn Creek, 2.38 ± 0.4 at Elkhorn, 2.44 ± 0.4 at Pipe Creek, and 3.60 ± 0.3 in the Fisher River.

Reduction in species diversity in the tailwater areas of hypolimnial release reservoirs have been found by a number of researchers (Pearson et al. 1968; Holsenhoff 1971; Hoffman and Kilambi 1971; Spence and Hynes 1971; Fisher and LaVoy 1972; Lehmkuhl 1972; Ward 1974, 1976; Young et al. 1976), but little information is available on the effects of selective withdrawal systems on the downstream benthic invertebrates (see Holden and Crist 1979). It appears that even though temperatures immediately below Libby Dam are more favorable for insect growth than those below hypolimnial release dams, the effects of flow fluctuations, the lack of drifing organisms from upstream, and other unknown factors still limit species diversity near the dam.

Although diversity has been considered an intrinsic property of insect communities, a recent view is that it is too vague (Hurlbert 1971) and that the two components (species richness and equitability) often vary independently (Moore 1975). Ordination and clustering methods are currently considered to be more informative methods for reducing biological data and arraying it spatially (Green 1979). Ordination techniques were applied to the data using two computer programs from the Cornell Ecology Program series. DECORANA was used for detrended correspondence analysis and ORDIFLEX was used for polar ordination and principal components analysis.

Ordination values were based on the similarity of the quantitative species composition at the sampling sites. The various ordination techniques use different mathematical methods to determine the compositional similarities between samples. Each of the samples (six at each station each month) was ordinated separately and then the output values for each sample were averaged to give a mean for each sample station. The mean values for the primary axis are presented in Table 17 for each of the ordination techniques. The values for each site are not to be looked at as absolutes, but rather the relative distance between sites is considered important. Values of the subsequent axes (not presented in table) can be used to array the samples in multi-dimensional space. The relationship between stations is best seen by arraying the values for the axes in two or three dimensional space. For purposes of brevity, only one example of the spatial relationships is presented in Figure 6, and values from the Flathead River are included for comparative purposes.

Environmental Variables

In an attempt to explain the differences in macroinvertebrate community structure in regulated and control areas, various environmental factors

Table 16. Shannon Diversity Indices, Kootenai River and Fisher River insect samples.

Sample location		Kick	Circular	Knapp Waters
October 1979				
Dunn	H'	1.70	1.92	1.98
	Ev	.42	.42	.49
Elkhorn	H'	2.93	2.43	2.19
	Ev	.59	.52	.51
Pipe Creek	H'	2.41	1.82	----
	Ev	.47	.35	----
Fisher River	H'	3.85	----	3.95
	Ev	.70	----	.75
January 1980				
Dunn Creek	H'	1.91	----	1.71
	Ev	.47	----	.40
Elkhorn	H'	2.33	----	2.87
	Ev	.43	----	.62
Pipe Creek	H'	2.25	1.94	----
	Ev	.42	.41	----
Fisher River	H'	3.27	----	3.50
	Ev	.58	----	.65
March 1980				
Dunn Creek	H'	1.94	----	1.93
	Ev	.45	----	.45
Elkhorn	H'	2.26	----	2.28
	Ev	.45	----	.50
Pipe Creek	H'	2.11	2.02	----
	Ev	.40	.40	----
Fisher River	H'	3.73	----	3.65
	Ev	.67	----	.71
July 1980				
Dunn Creek	H'	1.02	----	1.24
	Ev	.25	----	.32
Elkhorn	H'	2.0	----	2.81
	Ev	.40	----	.59
Pipe Creek	H'	2.98	2.40	----
	Ev	.58	.49	----
Fisher River	H'	3.53	----	----
	Ev	.61	----	----

Table 17. Values (mean and standard deviations of six samples) obtained on the primary axis using three community ordination techniques - detrended correspondence analysis (DECORANA), polar ordination (P.O.) and principal components analysis (P.C.A.) Eigenvalues (Eig. = amount of the variation explained by the first axis = % EV).

	Fall - October, 1979			Winter - January, 1980		
	DECORANA Eig. .410	P.O.	P.C.A. % EV 55	DECORANA Eig. .652	P.O.	P.C.A. % EV 22
Dunn Creek	115.0(60.7)	53.5(4.2)	20.7(5.7)	177.7(7.3)	32.9(5.7)	95.3(4.2)
Elkhorn	84.7(14.3)	48.6(4.4)	13.0(4.1)	178.8(19.5)	17.1(6.0)	63.0(7.1)
Pipe Creek	61.2(24.8)	43.1(2.3)	8.7(3.7)	141.2(13.7)	22.1(4.8)	58.1(4.2)
Fisher River	38.5(29.9)	10.9(9.5)	5.3(1.4)	39.8(31.0)	6.4(2.0)	27.1(3.2)
	Spring - March, 1980			**Summer - July, 1980**		
	DECORANA Eig. .367	P.O	P.C.A. % EV 24	DECORANA Eig. .327	P.O.	P.C.A. % EV
Dunn Creek	37.2(24.4)	89.0(5.8)	73.5(4.2)	2.2(2.0)	53.8(4.3)	78.9(3.8)
Elkhorn	74.7(25.2)	75.5(10.3)	58.5(7.6)	60.5(27.3)	52.8(5.0)	41.6(3.6)
Pipe Creek	115.8(8.7)	64.5(7.4)	51.8(4.2)	53.2(12.4)	59.7(2.8)	44.0(5.0)
Fisher River	194.5(28.3)	38.0(4.2)	25.1(1.5)	145.5(42.8)	24.0(13.3)	17.3(3.6)

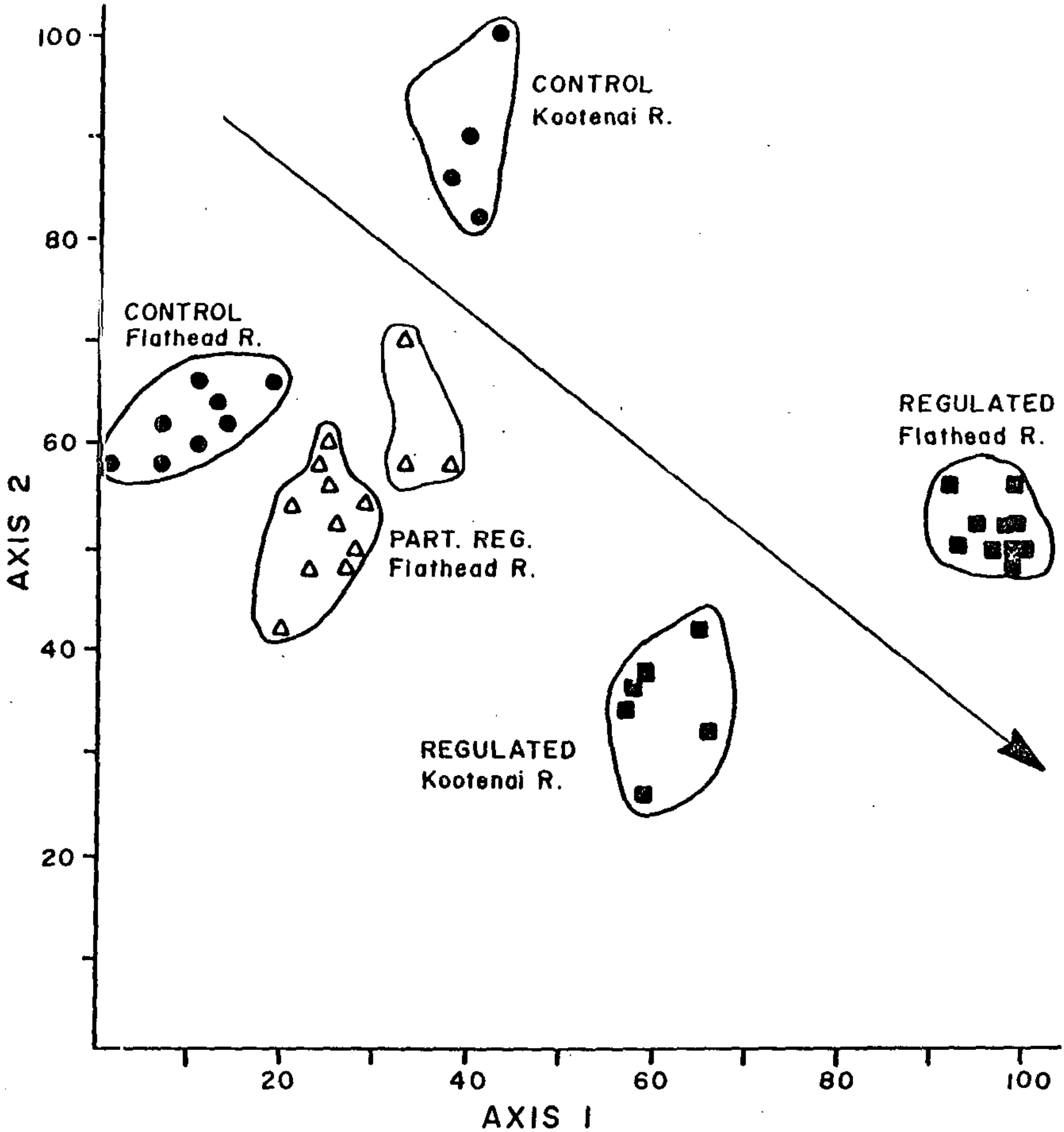


Figure 6. October 1979 values for axes 1 and 2 of polar ordination which show the spatial relationship between control, partially regulated and regulated aquatic insect sampling stations in Flathead River and Kootenai River.

were also measured. It has been found that other biotic factors better explain the variation in macroinvertebrate communities, than do factors such as the chemical composition of the water. Emphasis was placed on quantifying these factors. The altered food regime in regulated rivers leads to changes in the biota. Given suitable flow conditions, reduced turbidity and increased light penetration below dams often allow increased development of algae and macrophytes (Ward 1976c). Elevated winter water temperatures and the absence of ice may allow a high year-round production of periphyton in the comparatively nutrient-rich water below most deep-release dams. This may lead to increased numbers of scraper organisms which utilize the periphyton as a food source.

Periphyton was quantified during the summer, fall and winter by measuring ash free dry weight (AFDW) and chlorophyll a content of organisms scraped from natural substrates. Generally, biomass was much higher at the regulated sites (Table 18, Figure 7). An analysis of variance test showed significant differences between regulated and control site in all seasons. The only pairwise comparisons between rivers which were not significantly different were during the summer at Pipe Creek versus Fisher River for AFDW and Elkhorn versus Fisher River and Pipe Creek versus Fisher River for chlorophyll a. Biomass maxima were measured in September and October. During January, the substrate in the Fisher River had been scoured free of periphyton by winter flooding.

Periphyton productivity was measured in September, 1981 with the use of *in situ* recirculating chambers (Table 19, Figure 8). ANOVA tests showed all calculated parameters to be significantly different between the Kootenai and Fisher Rivers. Productivity levels were two to three times higher in the regulated Kootenai River. Due to very high respiration levels in the Kootenai River, productivity-respiration ratios were twice as high in the Fisher River. Warmer temperatures in the October to December period (approximately three times the accumulated seasonal head load of the Fisher River) would raise the respiration levels in the Kootenai River even higher than those measured in September.

Values obtained from the partially regulated Flathead River are included for comparative purposes. The Flathead River is generally less productive than Kootenai River. Lower respiration levels in the Flathead River resulted in higher productivity-respiration ratios than in the Kootenai River.

An analysis of the species composition of periphyton samples from the Kootenai and Fisher River was done by Dr. Loren Bahls of Montana Department of Health and Environmental Sciences (see Appendix 4). The samples were collected in September, 1981 when productivity analyses were made. *Nostac* and *Spirogyra* were abundant soft-bodied algae in the Fisher River, while *Chaetophora*, *Cladophora*, *Gongrosira*, *Phormidium*, and *Ulothrix* were very common in the Kootenai River.

Shannon diversity of diatom species was higher in the Fisher River (3.87) than in the Kootenai River (Dunn Creek - 2.17; Elkhorn - 1.39).

Table 18. Periphyton biomass measured as ash free dry weight (AFDW) and chlorophyll *a* (Chl *a*).

	$\bar{x}$ AFDW(s.d.) (g/m²)	$\bar{x}$ Chl *a* (s.d.) (g/m²)
August 16, 1980		
Dunn Creek	29.0(18)	0.258(0.149)
Elkhorn	68.0(18)	0.090(0.048)
Pipe Creek	20.0(16)	0.085(.058)
Fisher River	2.5(1.7)	0.0113(.008)
October 24, 1980		
Dunn Creek	61.0(11.0)	0.742(0.28)
Elkhorn	75.0(50.0)	0.236(0.050)
Pipe Creek	71.0(13.0)	0.331(0.15)
Fisher River	14.0(3.0)	0.027(0.015)
January 17, 1981		
Dunn Creek	29.0(18.0)	0.155(0.05)
Elkhorn	79.0(27.0)	0.147(0.03)
Pipe Creek	21.0(4.3)	0.119(0.14)
Fisher River	Not measureable	
September, 1981		
Dunn Creek	74.2(16.2)	.462(.131)
Elkhorn	-----	-----
Pipe Creek	-----	-----
Fisher River	17.0(5.8)	.065(.025)

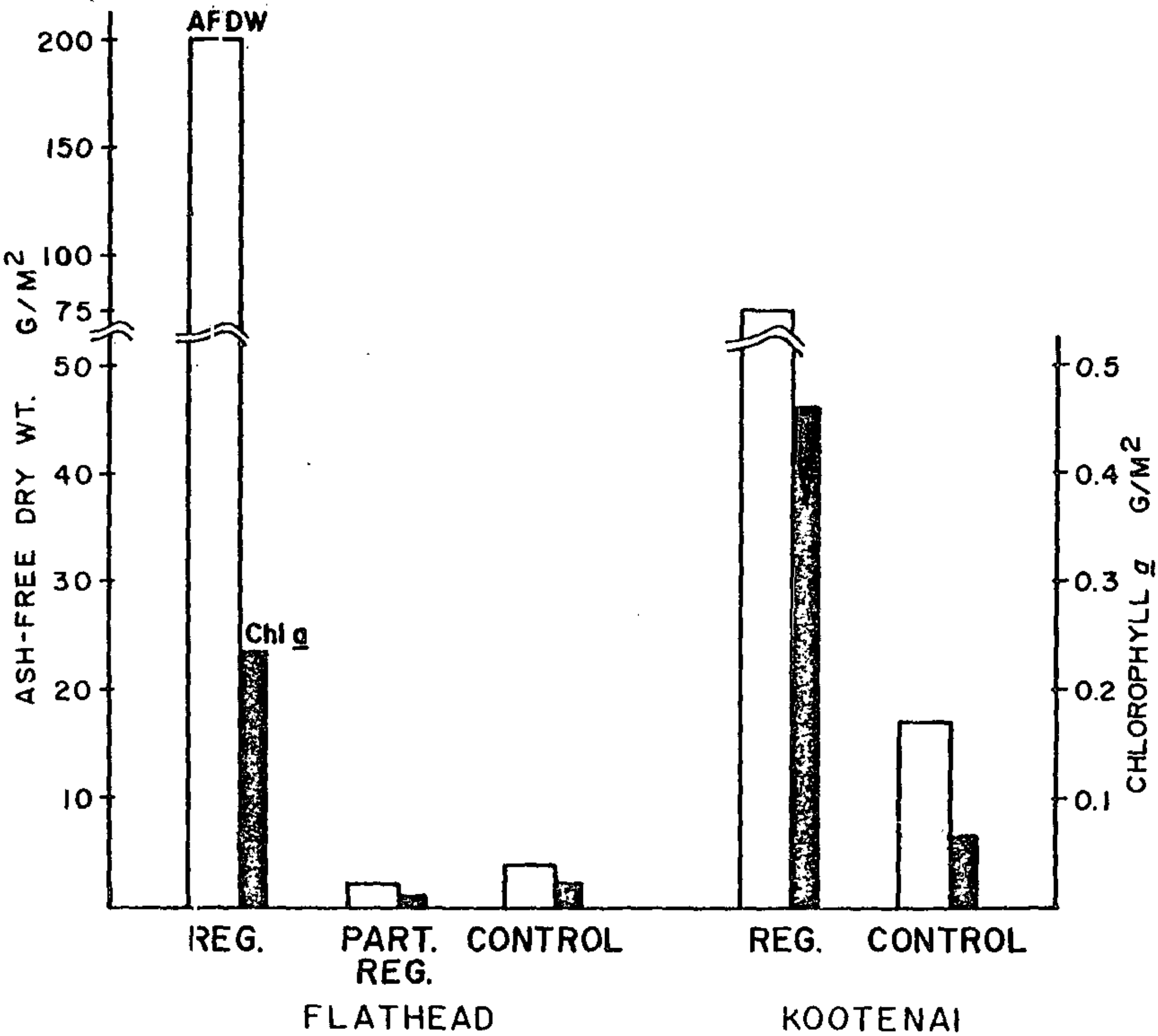


Figure 7. Periphyton biomass measured as ash free dry weight and chlorophyll *a*, September, 1981, Flathead River and Kootenai River at control sites, partially regulated site (Flathead River only) and regulated sites.

Table 19. Measurements of periphyton productivity in Kootenai, Fisher and Flathead rivers, September, 1981 in milligrams of oxygen per meter per day.

Location		Units in $mg\ O_2/m^2/day$				
		GP 1/	NCP 2/	R24 3/	NDM 4/	P/R 5/
Kootenai River						
Dunn Creek	$\bar{x}$	3273	2307	1792	1481	1.86
	s.d.	(283)	(108)	(363)	(143)	(0.26)
Fisher River	$\bar{x}$	1277	1086	372	895	3.5
	s.d.	(119)	(140)	(75)	(166)	(0.85)
Flathead River						
South Fork	$\bar{x}$	1428	1326	618	810	2.36
(regulated)	s.d.	(418)	(294)	(168)	(336)	(0.58)
Kokanee Bend	$\bar{x}$	664	519	269	396	2.69
(partially regulated)		(94)	(73)	(116)	(93)	(0.84)
Bible Camp	$\bar{x}$	493	362	242	252	2.05
(control)	s.d.	(30)	(23)	(27)	(24)	(0.18)

1/ GP = gross productivity = $\Sigma O_2 + R_{24}$

2/ NCP = net community productivity = GP - photoperiod respiration.

3/ R_{24} = respiration, 24 hr., as measured.

4/ NDM = net daily metabolism = GP - R_{24}.

5/ P/R = productivity - respiration ratio.

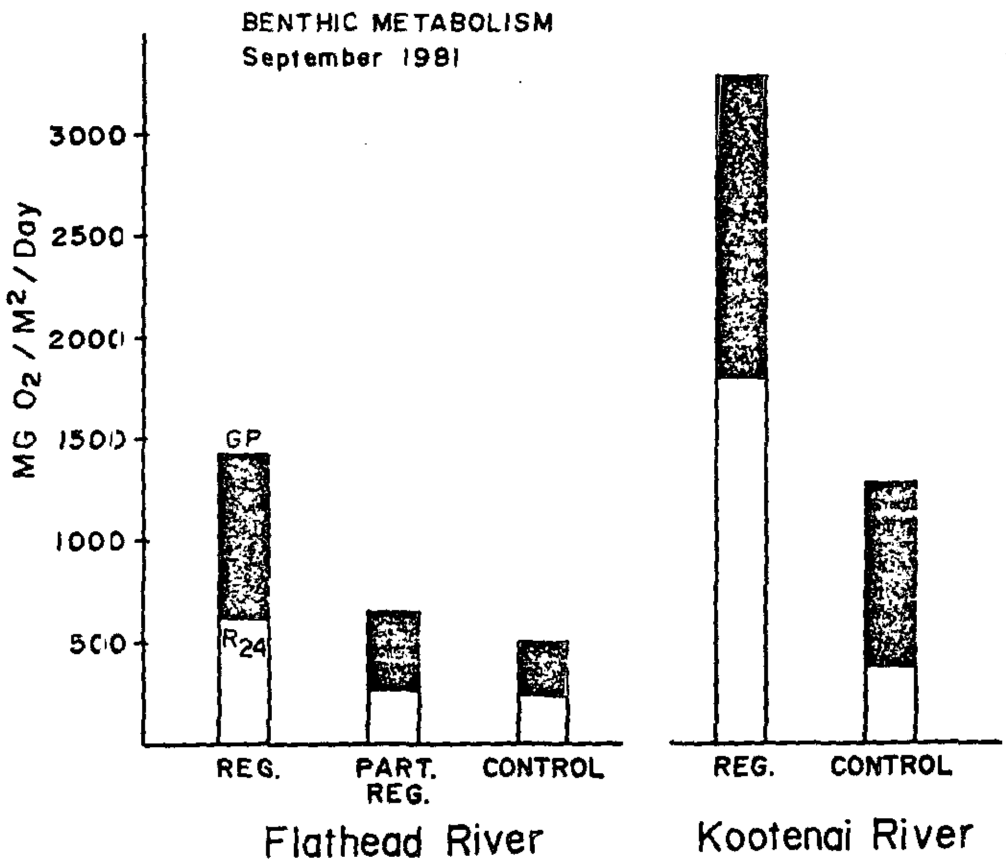


Figure 8. Gross productivity (entire bar) and respiration (lower part) measured in regulated Kootenai River and Fisher River (Kootenai River control) and Flathead River in September, 1981.

Planktonic diatoms (Centrales, Araphidae) made up a larger percentage of the periphyton in the Fisher River (9.5%) than in the Kootenai River (1.5-2.5%). The Biraphidae, which are benthic but motile, comprised 49.5 percent of the diatoms in the Fisher River, while the Monoraphidae, which are sessile and attached, made up 87 percent of the diatoms in the Kootenai River. *Cocconeis placentula* and *Epithemia sorex* were common diatom species in the Fisher River, while *Achnanthes minutissima* and *Achnanthes deflexa* were abundant in the Kootenai River.

The downstream transport of particulate organic matter (POM) in the seston is altered by reservoirs and dams. Dams act as barriers and settling traps which prevent the transport of certain categories of organic matter. There have been many recent investigations of particulate organic matter (POM) dynamics in natural streams, but little work has been done in regulated rivers. Limnetic production in reservoirs can have a positive influence downstream, when water is withdrawn from surface layers. Filter-feeding insects are usually not found below reservoirs in the concentrations found in the outlets of many natural lakes, unless they are supplied with plankton-rich surface water from above the dam (Müller 1962).

The particulate organic matter is also affected by the type of flow regime. The size distribution of drifting seston is a function of flow intensity. Algae and other POM may be sloughed and transported during high flows, and deposited during low flows. Studies done on the Flathead River showed large amounts of POM put into suspension as discharge was increased for hydropower generation (Perry and Graham 1982). This included sloughed algae, resuspended organic matter and debris collected from shoreline areas which were not wetted at lower discharges.

Particulate organic matter was fractionated into four size classes during operational minimum flow from Libby Dam (Table 20, Figures 9 and 10). The size classes measured in the Kootenai River therefore reflect the composition of particulate organic carbon (POC) in water discharged from the dam and include only a minimal component from sloughing which increases with discharge. Samples were taken in September and November before and after leaf fall and in February during a winter flood. The February samples reflect runoff conditions in both Kootenai and Fisher rivers. Total POC values were two to six times higher in the Fisher River than in the Kootenai River during these three sample months.

Eleven total POC values measured approximately monthly over the course of a year gave mean values (mg/l) of .14 ± .08 for Dunn Creek, .17 ± .13 for Pipe Creek, and .46 ± .66 for the Fisher River station. These gross POC values indicate Fisher River is much higher than Kootenai River.

The percentage of POC in each of the four size fractions is altered below Libby Dam. The largest percentage (85-93%) of POC was in the smallest size fraction (.45-10 μm) at the Dunn Creek site. Only 46-62% of the POC was in the smallest category in the Fisher River, with the lowest percentage occurring during runoff conditions. The Pipe Creek site (22

Table 20. Four size fractions of particulate organic carbon (POC) in the seston of three stations in Kootenai River.

	Total POC (mg/l)	355-1000um (%)	165-355um (%)	10-165um (%)	.45-10um (%)
September 13, 1980					
Dunn Creek	0.0705	1	4	10	85
Pipe Creek	0.0834	1	2	24	73
Fisher River	0.1480	2	3	41	54
November 10, 1980					
Dunn Creek	0.0652	2	3	2	93
Pipe Creek	0.0914	1	4	9	86
Fisher River	0.3258	1	2	35	62
February 19, 1981					
Dunn Creek	0.143	3	2	9	86
Pipe Creek	0.264	2	1	51	46
Fisher River	0.858	1	7	46	46

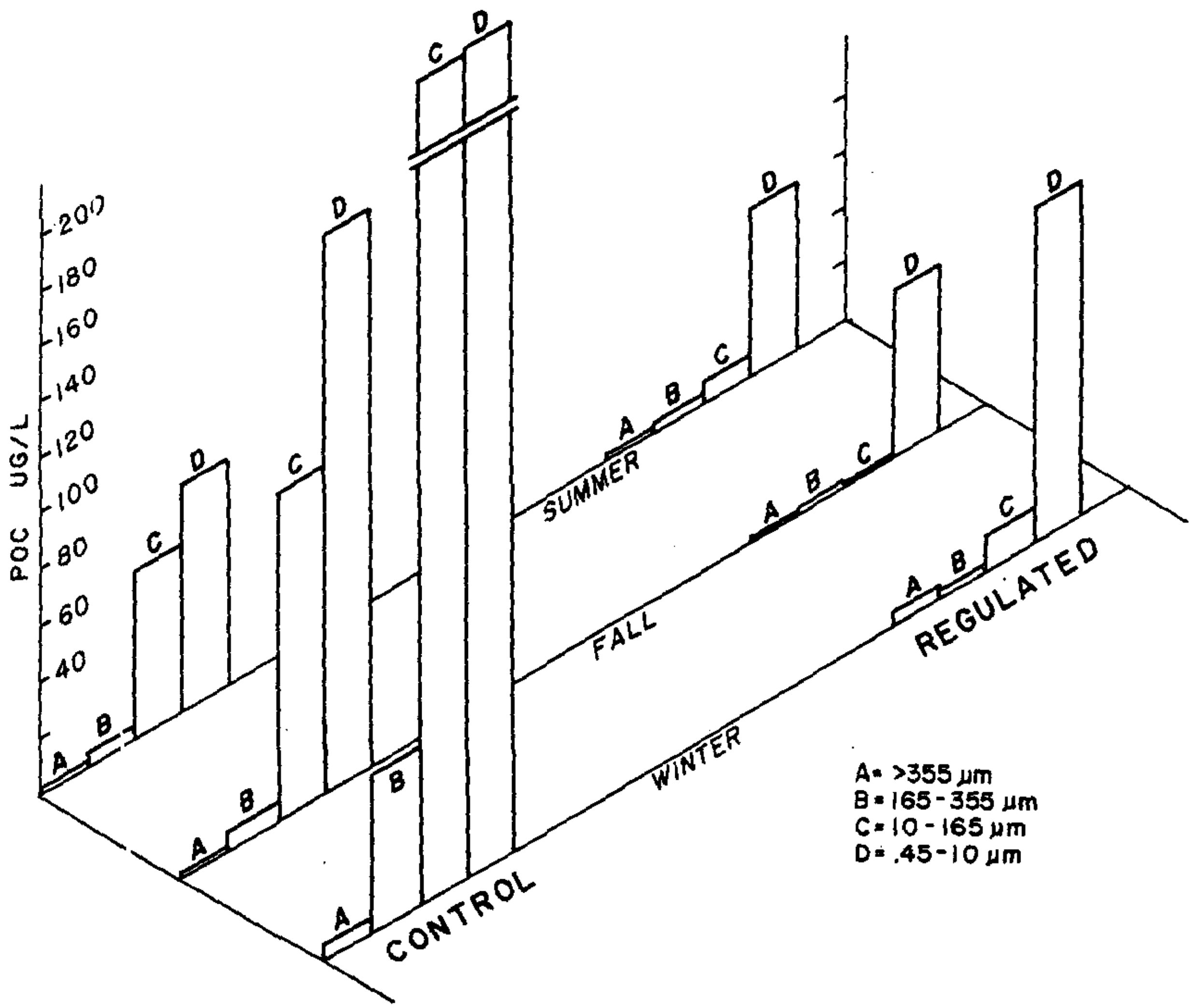


Figure 9. Four size fractions of particulate organic carbon in milligrams per liter in Fisher River (Kootenai River control) and Kootenai River, summer, fall and winter. Particle sizes are: A = >355 µm, B = 165-355 µm, C = 10-165 µm and D = .45-10 µm.

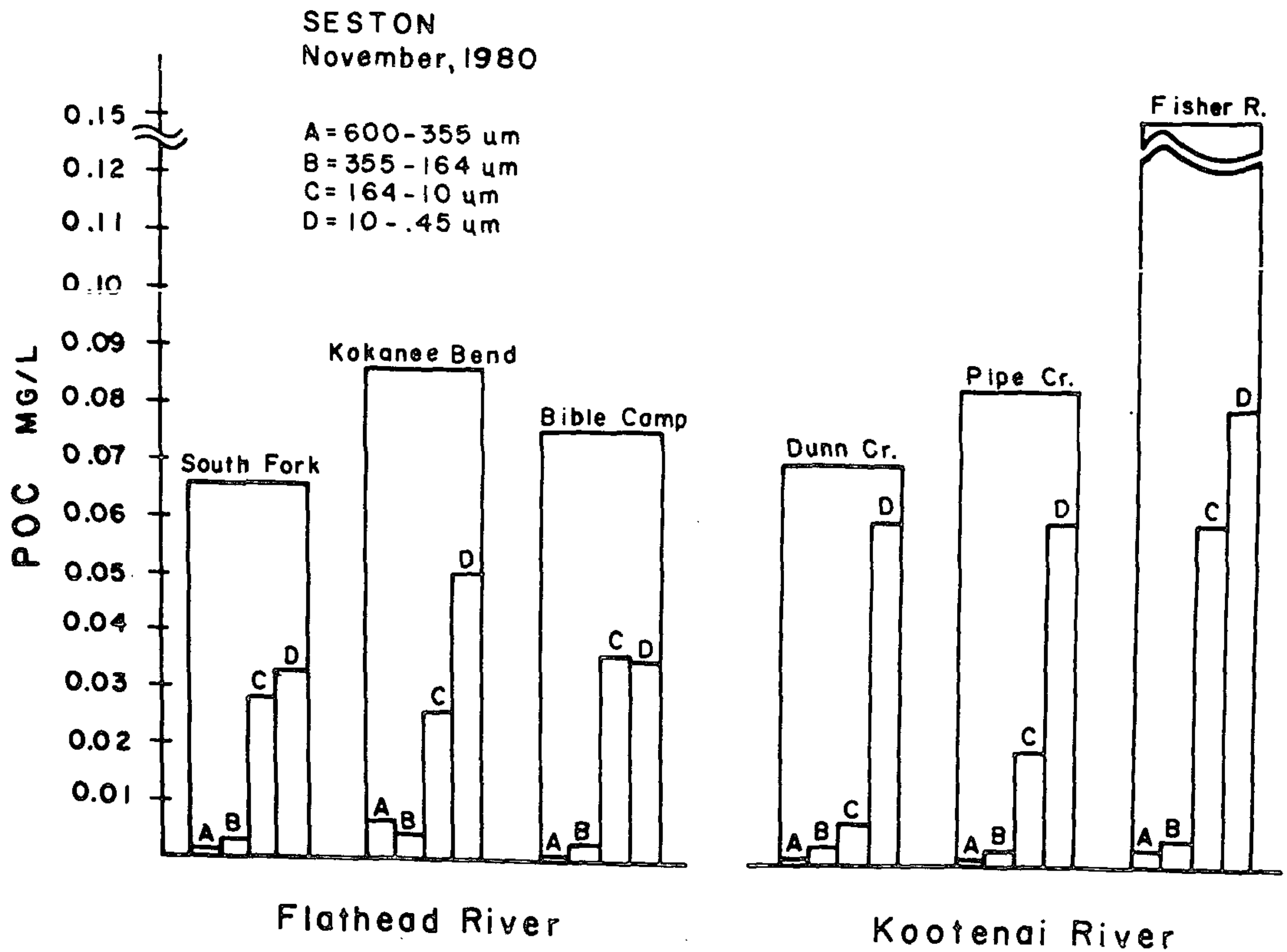


Figure 10. Four size fractions of seston particulate organic carbon in milligram per liter (DOC mg/l) in control, regulated and partially regulated sites in Flathead River and control site in Fisher River and regulated sites in Kootenai River, November, 1980.

miles from Libby Dam) was intermediate, reflecting some input of the larger size categories of POC from tributary streams, as well as sloughing, even at conditions of low discharge.

An ANOVA test of the log transformed POC size fractions showed significant differences (P<0.05) between all pairwise comparisons of Kootenai River stations with the Fisher River station for all size fractions in the fall and winter. There was not significant difference between Dunn Creek and Pipe Creek. The only pairwise comparisons between rivers which were not significant were during the summer for the largest and smallest size fractions.

The size of food particles is important to the filter feeding insects and to those that gather detritus. Blackflies can filter very small particles and were abundant at the Dunn Creek station. The hydropsychid caddisflies filter larger particles and were not common in the Kootenai River above the Elkhorn station. Only *Hydropsyche* and *Cheumatopsyche* were generally present throughout the Kootenai River. *Arctopsyche*, which spin nets with larger mesh sizes and feeds on larger sized particles, was found only in the Fisher River. Thus, certain of the compositional differences between the two rivers can be explained on the basis of the distribution of POC particle size.

Particulate organic carbon >355 μm was measured with the use of insect drift nets. Net POC was substantially higher in the Fisher River than Kootenai River under runoff conditions in February (Fisher River - .019 mg/l; Dunn Creek - .0025 mg/l; Pipe Creek - .0022 mg/l). Values for net seston were not significantly different between the two rivers in the summer and fall. Green filamentous algae and bits of leaves and needles composed much of the net POC in the Fisher River, while a large component of net POC in the Kootenai River was from insect exuvia, which have not been shown to be of great nutritional value.

Compositional changes in the POC altered carbon-nitrogen ratios in the two rivers. C:N ratios were: July - Kootenai River 5:1, Fisher 10:1; October - Kootenai River 7:1; Fisher 13.1. Lower carbon-nitrogen ratios in the Kootenai River were due to the greater amount of nitrogen in insect exuvia and probably also in plankton from Libby Reservoir.

Zooplankton from Libby Reservoir were frequently observed in insect drift net samples. Only the larger individuals would be retained by the 355 μm mesh. A count of Cladocera and Copepoda was made of February, 1981 samples. Count of Cladocera and Copepoda per cubic meter of water filtered were: Dunn Creek - 24 Cladocera and 73 Copepoda, and Pipe Creek - 6 Cladocera and 17 Copepoda. It is probable that zooplankton from Libby Reservoir provide a food source for filter feeding invertebrates at some times. Their availability in the river would depend upon whether selective withdrawal levels corresponded with their vertical distribution in the reservoir. It is not known whether zooplankton provide a constant food source.

Other environmental factors which are known to have important effects on aquatic insect distributions are river discharge, temperature and substrate. Flow, temperature and chemical data were obtained from the U.S. Geological Survey for the station just below Libby Dam and for the Fisher River. Rates of flow change were calculated from gauge height readings taken at the three sample stations as discharge was reduced.

Substrate measurements were taken in September, 1981. Surface rocks were measured in the field at the four sample stations and subsurface samples were taken back to the laboratory, dried and sieved. The mean size of surface rocks and the number/m^2 were calculated; the mean grain size and an index indicating the amount of heterogeneity were calculated for the subsurface samples (Table 21). Substrate size was not constant among the four sites; it ranged from small at Dunn Creek to large at the Fisher River and Pipe Creek stations. The substrate size was perhaps more related to the gradient at each of the sample sites than to regulation. The heterogeneity index shows some of the affects of regulations. The Fisher River substrate samples showed much higher heterogeneity. The study site on the Fisher River was not good for comparative purposes with Kootenai River sites due to its high gradient.

Downstream from a dam the small particles are typically washed out by fluctuating flows and are not replaced during runoff periods. Particles less than 2 mm are being removed from the Dunn Creek site. There is the possibility of some replacement of fine materials at the downriver sites on the Kootenai River due to the introduction of sediments from tributary streams. It is clear that the Dunn Creek site has not lost as large a proportion of the fine materials in 10 years since dam construction as the South Fork of the Flathead River has in 30 years and where armoring of the substrate has occurred.

Another environmental factor which probably affects macroinvertebrate composition is dissolved oxygen. Low dissolved oxygen levels in the Kootenai River may be limiting to certain species of aquatic insects. Our study was not designed to include water quality studies, so O_2 saturation levels were measured only on a few occasions. Our O_2 measurements were taken with a Yellow Springs Instruments oxygen meter which had been calibrated using the Winkler method. We measured O_2 saturation values on November 10, 1980 of 77% at Pipe Creek at 6:30 a.m. and 75% at Dunn Creek at 10:00 a.m. U.S.G.S. measurements of oxygen taken bimonthly below Libby Dam recorded percent saturation values in the 70 percentile range during November of 1976 and 1977 and January of 1978, 1979 and 1980. These readings were generally taken between 10:00 a.m. and 12:00 noon. Values taken during the night would be much lower and oxygen tensions in the substrate would be lower than in the water column. The decomposition and respiration load of organisms in the river would add to the load produced by decomposing phytoplankton passing out of Libby Reservoir.

Studies done on 24-hour community metabolism at the Dunn Creek site on September 26, 1982 show clearly the nocturnal depression and the high respiration in the Kootenai River as compared with the Fisher River.

Table 21. Measurements of surface rocks (number measured, mean size) and subsurface rocks (mean grain size, heterogeneity index (Schwoerbel 1961).

	Surface substrate			Subsurface substrate	
	N	$\bar{x}$(cm)	(s.d.)	$\bar{x}$ grain size(mm)	heterogeneity
Dunn Creek	278 (139/m^2)	6.66	(1.62)	9.5	14.8
Elkhorn	276 (138/m^2)	7.60	(2.51)	17.3	26.9
Pipe Creek	181 (90.5/m^2)	10.10	(4.33)	15.3	28.1
Fisher River	262 (131/m^2)	8.04	(3.25)	29.0	53.3

		Percent composition - subsurface substrate				
	Sample	50-19 (mm)	19-16 (mm)	16-2 (mm)	2-.063 (mm)	<.063 (mm)
Dunn Creek	1	33.2%	5.5%	42.6%	18.4%	0.2%
	2	28.2%	5.7%	46.7%	19.1%	0.3%
Elkhorn	1	35.4%	5.9%	36.1%	21.7%	0.9%
	2	36.6%	7.6%	35.4%	20.0%	0.4%
Pipe Creek	1	30.5%	6.3%	39.4%	23.2%	0.5%
	2	47.4%	4.0%	30.9%	17.0%	0.7%
Fisher River	1	59.5%	0.8%	14.9%	24.2%	0.6%
	2	45.2%	5.9%	18.9%	29.0%	0.9%

This work was done before oxygen levels become lowered, and since recirculating productivity chambers were used, our data account for only the respiration load of the riverbed periphyton, and not for the sestonic drift from the reservoir. A respiration value of 1,792 $mgO_2/m^2/day$ was obtained for the Kootenai River as opposed to 372 $mgO_2/m^2/day$ for the Fisher River.

Kootenai River oxygen readings outside the chambers taken September 26th were depressed from greater than 100 percent saturation during the day to a level of 83 percent saturation at night. A nocturnal depression of this magnitude when daytime readings were in the 70 percentile range could be very detrimental to invertebrates within the substrate.

Low oxygen values in the late fall and winter may be problematic for macroinvertebrates living within the substrate. Low oxygen tensions may be the cause of the current paucity of stoneflies and to the nymphs within the substrate which are particularly sensitive to O_2 levels. The sensitivity of stoneflies to lowering of the oxygen tension has been documented (Spence and Hynes 1971; Gaufin 1973; Hynes 1976). Noton and Chymko (1978) implicate the nocturnal oxygen depression in regulated Poplar Creek as a possible factor causing the absence of stoneflies.

Information concerning the oxygen requirements of aquatic insects is known for only a very few species, and these values are meaningful only for the particular conditions under which they were obtained. The rate of oxygen consumption of an animal is influenced by temperature, activity, nutritional state, body size, stage in life cycle, season, and time of day, as well as by previous oxygen experience. Gaufin (1971) found that, generally, coldwater mayflies and stoneflies cannot tolerate O_2 concentrations much below 5 mg/l for any extended period of time. Tests conducted at the University of Montana Biological Station gave an average LC_{50} (lethal concentration, 50% mortality) value of 4.9 mg/l for the stoneflies he tested, with an average survival of 62 days, and an LC_{50} of 4.6 mg/l for mayflies with an average survival of 30 days. The minimal dissolved oxygen level for 50% survival at 111 days was 5.8 mg/l for *Hesperoperla pacifica*, a stonefly which were collected in very low numbers in the Kootenai River. Gaufin found that stonefly groups with few or no external gills, such as the Perlodidae, were very sensitive. Species of this family have been almost totally eliminated from our study area.

Nebeker (1972) found that emergence of adult insects was inhibited at oxygen concentrations much higher than those of the 96-hour LC_{50} values he measured. He found only 20-30% emergence at concentrations of 6 to 7 mg/l of dissolved oxygen. Low dissolved oxygen levels at a sensitive point in an insect's life history could eliminate or severely reduce the numbers of that species.

There is need for further water quality studies on the possible oxygen limitation in the Kootenai River. The nocturnal oxygen depression should be measured on a number of occasions, measurements within the substrate should be taken, and the oxygen load should be modelled.

Correlation Analyses of Environmental and Macroinvertebrate Data

The composition of benthic communities downstream from dams may be largely regulated by the flow regime, temperature patterns, substrate composition and to altered autochthonous (periphyton) and allochthonous (POC in the seston) resources. To assess the importance of these factors in determining community associations, multiple regressions and correlations were run.

Environmental variables can also be ordinated to ascertain relationships between sites. Environmental data for temperature (degree days summed by season), flow (velocity rates of change), substrate heterogeneity, coarse (165-1000 μm) and fine (.45-165 μm) POC in the seston, AFDW and Chlorophyll a in the periphyton, and gross community productivity were ordinated for three seasons using detrended correspondence analysis (DECORANA). The sampling stations showed a gradient of values similar to that obtained from the macroinvertebrate ordinations. First axis values ranged from 43-54 at Dunn Creek, from 34-42 at Elkhorn, and were zero at the Fisher River station.

Correlation analyses included data from the three seasons in which environmental parameters were measured (summer, fall, and winter). Ash free dry weight (AFDW) and Chlorophyll a (Chl a) measurements of periphyton biomass were included as were particulate organic carbon (POC) measurements of the seston. The carbon fractions were combined into two groups; less than 165 μm and greater than 165 μm. The substrate heterogeneity index was used as the measure of substrate characteristics. The sum of the mean daily temperatures for the three months in each season was used as the measure of temperature. The rate of decrease of the water level on gauges was used as the indicator of rates of change in flows at the Kootenai River sites. These factors were used as the independent variables in the correlation analyses.

The dependent variables included the seasonal values obtained with the use of diversity indices and the three ordinations, detrended correspondence analysis (DECORANA), polar ordination (PO), and principal components analysis (PCA), on data collected during July, October and January. The mean monthly values for density (no./m^2) and biomass (cc/m^2) were averaged for the three months in each season.

A correlation matrix was obtained for the Dunn Creek and Pipe Creek sites on the Kootenai River and the Fisher River site (Table 22). Another correlation analysis was run which included three stations from the Flathead River (one control and two regulated as well as the Kootenai River stations (Table 23). A number of correlations between two independent variables and between independent and dependent variables were significant ($p<.05$) or highly significant ($p<.01$). The measurement of temperature did not give many correlations, primarily because temperatures did not change much between the Dunn and Pipe Creek sites. Invertebrate composition showed a considerable change.

Table 22. Pearson correlation matrix for seasonal data, Kootenai River stations.

	Velocity	Temperature	Substrate	POC >165	POC <165	AFDW	Chl *a*
Independent variables							
Velocity	1.0						
Temperature		1.0					
Substrate	-.952**		1.0				
Poc >165	-.697*	-.754**	.627	1.0			
POC <165	-.786*	-.758**	.726*	.965**	1.0		
AFDW	.815*		-.740**	-.838**	-.801**	1.0	
Chl *a*	.870**		-.819**	-.891**	-.891**	.973**	1.0
Dependent variables							
Numbers	.800**		-.849**				
Biomass							
Diversity	-.938**		.937**		.711*	-.690*	-.776*
DECORANA	-.927**		.937**	.805**	.862**	-.812**	-.880**
PO	.785*		-.759*				
PCA	.607		-.657				

* Significant at 0.05 level.
** Significant at 0.01 level.

Table 23. Pearson correlation matrix for seasonal data, Kootenai and Flathead rivers.

	Independent variables							Dependent variables					
	Veloc.	Temp.	Subst.	>165	<165	AFDW	Chl *a*	No's	Biomass	Diversity	DECORANA	PO	PCA
Independent variables													
Velocity	1.0												
Temperature		1.0											
Substrate			1.0										
POC >165			.727**	1.0									
POC <165	.492*		.734**		1.0								
AFDW	.741**			-.484*	.544*	1.0							
Chl *a*	.701**		-.626**	-.608**		.908**	1.0						
Dependent variables													
No's.								1.0					
Biomass								.593**	1.0				
Diversity	-.775**		.672**		.492*	-.720**	-.755**	-.489*		1.0			
DECORANA	-.656**					-.698**	-.753**			.670**	1.0		
PO	.767**		-.677*		-.486		.480*			-.780**	-.567*	1.0	
PCA	.598**					.529*							1.0

* Significant at 0.05 level.
** Significant at 0.01 level.

Among the dependent variables, numbers and biomass did not show many significant correlations. Although diversity indices have been somewhat out of favor for invertebrate analyses in recent years, their use appears quite adequate to elucidate differences in these regulated river environments. Principal components analysis (POC) was the least successful ordination technique used. Historically, it was one of the earlier ordination techniques developed and has since been shown to have problems with the mathematical assumptions not conforming to actual environmental differences.

Another correlation analysis (Table 24) was run which included annual means for total POC, gross productivity, degree days summed for the entire year, and annual mean numbers, biomass, and diversity. Fall values were used for periphyton, the two seston size fractions, and the ordinations. Yearly mean biomass was significantly correlated with temperature when daily mean temperatures were summed for the year. Gross productivity was significantly correlated with annual mean densities of invertebrates and with DECORANA.

Generally, velocity rates of change, substrate heterogeneity, POC in the seston, and AFDW and Chl a in the periphyton were environmental variables which were well correlated with measures of invertebrate diversity and composition. The characteristics of the seston and periphyton, as well as the invertebrate composition, appear to be determined by the type of regulation and exhibit similar variation.

Invertebrate Drift

Invertebrate drift samples were taken during eight months from June, 1980 to May, 1981 in conjunction with the fish food habits study (DosSantos Section B of this report). Two drift nets were set from one hour before dark to one hour after dark each month. These samples have been analyzed for this report for the purpose of examining the relationship between the discharge regime during sampling and the amount of insect drift. The insects in each drift sample were identified to species, but drift densities (number/100m^3) were calculated for each insect order rather than for each species.

Drift densities were highest during July and January and lowest during September (Appendix 5). There is an indication that drift rates were higher during months when discharges from Libby Dam were maintained at a high level for at least two weeks before sampling. It appears that high flows maintained for at least two weeks allowed insect recolonization to occur and that drift densities were higher as flows were reduced for invertebrate sampling.

Reduction in flows is a stimulus which initiates insect drift (Minshall and Winger 1968). Insect drift was increased during the day after flows were reduced, but the highest drift rates appeared to occur on the first night after the reduction in discharge. Insect drift rates in Kootenai River were normally highest just after dark. Drift rates were consistently higher at the Elkhorn than at the Pipe Creek sampling station. This is likely due to the fact that the Elkhorn station was sampled on the first

Table 24. Pearson correlation matrix for annual means and fall data, Kootenai and Flathead rivers.

	Veloc.	Temp.	Subst.	$\bar{x}$ POC	POC >165	POC <165	AFDW	Chl *a*	GP
Independent variables									
Velocity	1.0								
Annual temperature		1.0							
Substrate			1.0						
$\bar{x}$ Annual POC		.760	.811*	1.0					
Fall POC >165					1.0				
Fall POC <165			.910*	.930**		1.0			
Fall AFDW							1.0		
Fall Chl *a*					-.707		.749	1.0	
Fall GP								.907*	1.0
Dependent variables									
Annual $\bar{x}$ No's.								.890*	.969**
Annual $\bar{x}$ Biomass		.834*							.784
Annual $\bar{x}$ Diversity	-.821**						-.809	-.744	
Fall DECORANA							-.872*	-.934**	-.853*
Fall PO	.842*	-.745	-.761	-.879*		-.818*			
Fall PCA	.783						.902*	.854*	.757

* Significant at 0.05 level.
** Significant at 0.01 level.

night after flows were reduced and Pipe Creek was sampled on the second night after reduction. This hypothesis is further substantiated by the fact that the drift difference between sites was minimal during months when flows were generally low prior to sampling (e.g. June, 1980), and the difference between sites is maximal when flows were high prior to sampling (e.g. July, 1980).

The correlation between the mean discharge for the 14 days prior to sampling and the mean drift density for each month (Table 25) at the Elkhorn station was not significant, but it was high enough to perhaps substantiate the trend. The correlation coefficient for the mean drift density at Pipe Creek and the previous 14-day mean flow was not high enough to show any relationship.

There may be some differences between sites which are unrelated to discharge history, and there are seasonal differences in drift rates. Higher drift rates occur during months when common species are near emergence. Caddisflies, for example, were most abundant in the drift during July and October when many caddis species emerged. Caddisflies generally are not as predisposed to drift as certain species of mayflies and dipterans. More terrestrial insects were found in the drift during months when deciduous plants were leafed out. The nets set closest to the shore tended to collect more terrestrial insects.

In July and November, 1980 and January, February and March, 1981 discharge from Libby Dam was reduced to 4,000 cfs during daylight hours. Insect drift rates at the Dunn Creek site were 200,000-300,000/m³ at 11:00 a.m. in July, 1980 and January, 1981. River flow for the two weeks prior to flow reduction was above 15,000 cfs. Insect drift rates in March, 1981 were only 6,000/m³ following two weeks of variable discharge from Libby Dam.

Mid-water surface insect drift was sampled at the Montana Highway 37 bridge near Libby, Montana during a flow reduction in November, 1980. Drift nets were suspended from the sides of a boat tied to a bridge pier. Hourly drift samples were taken before, during and after flows were reduced from 20,000 cfs to 4,000 cfs. Total drift densities increased two to three times for the first several hours after water levels began to drop, then decreased as flows stabilized at 4,000 cfs discharge. Drift rates were lower than expected during the period of flow reduction averaging 200 insects per 100 m³ per sample period. The main component of the drift was adult midges. It was possible that some insect drift was lower in the water column than the surface which was sampled.

Recolonization of Zones of Fluctuating Flows

The amount of insect recolonization of riverbed above minimum flows was estimated by burying basket samplers just below the streambed surface at the 4,000, 6,000 and 10,000 cfs levels at the Elkhorn and Pipe Creek sites. The baskets were allowed to colonize for about a month at discharges above 10,000 cfs between sample periods during the months of October, 1980 and January, February and March, 1981. The samplers were removed after

Table 25. Mean monthly drift densities in number of insects per 100 cubic meters of flow at Elkhorn and Pipe Creek sites on Kootenai River compared to mean daily flow for 14 days prior to insect sampling.

	Mean drift density (no./100m³)		Prior 14 day mean flow
	Elkhorn $\bar{x}$(s.d.)	Pipe Creek $\bar{x}$(s.d.)	Below Libby Dam cfs
June, 1980	3,950(1,943)	2,692(276)	10,089
July, 1980	96,139(152,166)	33,670(24,552)	12,081
August, 1980	4,358(2,411)	1,715(303)	7,312
September, 1980	2,202(609)	1,834(875)	7,827
October, 1980	11,310(11,025)	1,106(1,068)	15,600
January	----	4,306(3,622)	18,200
May, 1981	9,540(4,197)	4,914(1,388)	3,000

discharge was reduced to the 4,000 cfs level.

Insect densities ranged from about 10,000/m² to over 100,000/m² recolonization in the zone previously dewatered. Colonization was higher at the 4,000 and 6,000 cfs levels during October and January, but by February and March, there appeared to be extensive recolonization at the 10,000 cfs level also (Appendix 6). After high flows had been in effect for long periods of time, the substrate was conditioned by microbes and algae. Recolonization was probably faster and densities were higher in the winter than when higher flows were first established in the fall.

Further evidence of the extensive recolonization was obtained from stranding samples (Appendix 7) taken by digging up the gravel in a circumscribed area and elutriating the invertebrates. These samples gave estimates of from 10,000 to over 100,000 individuals/m² during the winter months. Stranding samples were also taken during July, 1980 when there appeared to be stranding occurring, but these estimates were lower (4,000-7,000/m²) than in the winter.

CONCLUSIONS

Libby Dam has caused pronounced changes in the community structure of the benthos in the Kootenai River. There are large numbers of a few species near the dam and diversity increases with increasing distance downstream from the dam. Species diversity is lower than in a free-flowing river. A total of 53 species of macroinvertebrates were collected at the Kootenai River site two miles downstream from Libby Dam, while 105 species were collected at the Fisher River control site. Macroinvertebrate densities were highest near the dam and lowest in the Fisher River. Biomass was highest in the Kootenai River near the dam, but was not significantly different at the two downstream Kootenai stations from the Fisher River. Stoneflies were uncommon within the area of the Kootenai River under study, and caddisflies have also been reduced from their preimpoundment levels. There were compositional differences between Kootenai River sites and between Kootenai and Fisher rivers; these were reflected in the values obtained for the community ordinations. Differences were found in adult insect emergence times and in larval insect growth between the Kootenai and Fisher River.

Periphyton biomass and productivity were much higher at the Kootenai River sites. The percent composition of four size fractions of particulate organic carbon in the seston was altered at the regulated sites due to the presence of drift out of the reservoir. Ash free dry weight and chlorophyll <u>a</u> in the periphyton, particulate organic carbon in the seston, substrate heterogeneity and velocity rates of change showed high correlations with measures of invertebrate diversity and composition.

There was a relationship between the discharge regime prior to sampling and the amount of invertebrate drift and stranding. There was extensive recolonization of shoreline areas above the 4,000 cfs level during months when discharge from Libby Dam was maintained at a higher level.

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Appendix 1

Mean densities (no./m^2) of insects by order by month, October 1979 through September, 1980

Appendix 1. Mean densities (no./m^2) of insects by order by month, October 1979 through September, 1980.

	October $\bar{x}$(s.d.)	November $\bar{x}$(s.d.)	January $\bar{x}$(s.d.)	March $\bar{x}$(s.d.)	April $\bar{x}$(s.d.)
Dunn Creek					
Ephemeroptera	8,001(12,094)	5,077(1,837)	25,038(10,482)	17,833(9,901)	11,552(10,679)
Plecoptera	4(10)	1(2)	1(2)	2(4)	12(30)
Trichoptera	40(43)	7(8)	49(51)	106(55)	54(49)
Coleoptera	8(12)	2(3)	4(4)	16(30)	17(30)
Chironomidae	6,264(3,273)	4,765(1,908)	12,197(4,954)	11,844(3,591)	19,863(14,881)
Other Diptera	284(447)	1,523(1,225)	1,720(942)	4,005(1,422)	896(607)
Other Invertebrates	4,077(5,887)	978(389)	1,178(628)	543(435)	539(557)
TOTAL	18,678(14,630)	12,352(3,510)	40,186(15,697)	34,348(12,298)	32,928(25,201)
Elkhorn					
Ephemeroptera	2,262(2,018)	10,269(8,711)	10,950(4,764)	7,268(4,822)	4,325(4,121)
Plecoptera	7(10)	9(15)	26(18)	9(8)	9(12)
Trichoptera	963(1,362)	729(664)	1,148(938)	810(881)	196(99)
Coleoptera	26(26)	48(52)	92(73)	32(21)	12(20)
Chironomidae	2,689(1,225)	12,475(8,210)	9,368(7,349)	4,763(2,388)	3,825(2,229)
Other Diptera	81(101)	8,710(13,747)	4,869(6,993)	2,939(4,651)	2,216(3,649)
Other Invertebrates	1,134(844)	2,759(1,905)	1,510(627)	621(578)	1,088(576)
TOTAL	7,161(3,046)	35,000(28,737)	27,963(17,807)	16,441(6,697)	11,670(7,663)
Pipe Creek					
Ephemeroptera	2,061(867)	5,052(1,989)	3,367(1,902)	3,878(2,776)	----
Plecoptera	4(4)	19(15)	5(7)	7(2)	----
Trichoptera	857(707)	898(741)	1,275(1,318)	2,156(2,381)	----
Coleoptera	26(16)	35(30)	38(26)	25(36)	----
Chironomidae	11,538(7,186)	25,752(10,959)	7,412(2,508)	11,811(6,892)	----
Other Diptera	467(456)	5,638(3,197)	6,242(9,234)	1,492(971)	----
Other Invertebrates	3,785(2,812)	5,285(1,799)	847(590)	1,149(671)	----
TOTAL	18,738(8,955)	42,678(12,081)	19,184(12,647)	20,517(11,366)	----
Fisher River					
Ephemeroptera	3,683(1,776)	3,864(1,893)	6,656(3,108)	3,387(1,904)	----
Plecoptera	704(191)	666(292)	502(262)	626(385)	----
Trichoptera	1,985(375)	1,714(986)	1,618(810)	718(553)	----
Coleoptera	883(208)	238(126)	358(332)	238(194)	----
Chironomidae	1,681(1,842)	1,687(1,913)	2,632(1,909)	2,113(2,072)	----
Other Diptera	533(256)	476(486)	1,092(1,035)	470(369)	----
Other Invertebrates	806(437)	537(525)	187(185)	720(795)	----
TOTAL	10,274(4,129)	9,183(5,203)	13,044(4,947)	8,272(5,698)	----

Appendix 1. (Continued).

	May $\bar{x}$(s.d.)	June $\bar{x}$(s.d.)	July $\bar{x}$(s.d.)	August $\bar{x}$(s.d.)	September $\bar{x}$(s.d.)	Mean of means $\bar{x}$(s.d.)
Dunn Creek						
Ephemeroptera	10,775(8,504)	4,906(2,600)	1,643(584)	508(251)	2,633(407)	8,797(7,778)
Plecoptera	4(4)	4(10)	13(30)	3(4)	17(38)	6(6)
Trichoptera	76(55)	64(35)	76(60)	34(29)	109(131)	62(32)
Coleoptera	2(4)	0(0)	2(4)	11(14)	6(12)	7(6)
Chironomidae	23,681(10,797)	24,133(1,055)	21,982(3,005)	16,756(3,981)	16,543(6,871)	15,803(6,905)
Other Diptera	499(484)	171(176)	1,407(775)	975(1,035)	4,124(2,468)	1,560(1,417)
Other Invertebrates	508(501)	817(346)	1,824(724)	4,590(2,552)	3,720(3,666)	1,877(1,615)
TOTAL	35,543(20,019)	30,095(2,235)	26,945(4,588)	22,877(5,741)	27,150(12,271)	28,110(8,394)
Elkhorn						
Ephemeroptera	5,987(2,369)	2,823(1,495)	5,547(2,503)	4,418(1,199)	2,419(476)	5,627(3,079)
Plecoptera	3(4)	7(9)	24(38)	32(25)	9(10)	14(10)
Trichoptera	751(517)	183(78)	437(250)	1,363(713)	2,951(1,009)	953(799)
Coleoptera	79(72)	26(28)	72(71)	82(76)	24(26)	49(29)
Chironomidae	8,495(4,403)	8,038(5,163)	9,453(4,917)	9,894(5,318)	6,868(2,047)	7,587(3,047)
Other Diptera	2,032(1,349)	1,803(2,079)	1,021(391)	1,216(1,118)	1,088(587)	2,598(2,511)
Other Invertebrates	1,238(1,010)	1,803(830)	1,524(399)	2,472(949)	2,430(1,218)	1,658(698)
TOTAL	18,585(4,287)	14,682(8,694)	18,077(5,600)	19,477(7,703)	15,789(3,755)	18,485(7,919)
Pipe Creek						
Ephemeroptera	1,175(491)	1,229(748)	3,130(2,395)	2,779(921)	2,717(1,876)	2,821(1,241)
Plecoptera	11(15)	6(9)	31(41)	32(21)	23(27)	15(11)
Trichoptera	76(60)	53(42)	303(222)	1,498(998)	4,419(4,696)	1,282(1,365)
Coleoptera	99(63)	0.5(1)	11(15)	37(63)	37(50)	34(28)
Chironomidae	15,005(2,849)	7,918(4,505)	5,819(1,890)	6,766(3,361)	7,525(6,375)	11,061(6,263)
Other Diptera	145(108)	238(282)	1,058(613)	1,532(916)	921(1,051)	1,970(2,309)
Other Invertebrates	1,956(849)	1,347(780)	1,760(880)	3,174(1,544)	2,500(2,325)	2,423(1,438)
TOTAL	18,465(3,621)	10,789(6,192)	12,112(5,452)	15,816(4,200)	18,141(16,156)	19,604(9,259)
Fisher River						
Ephemeroptera	1,206(435)	317(146)	3,076(1,984)	7,351(4,516)	3,086(2,240)	4,443(1,784)
Plecoptera	194(130)	48(49)	824(716)	808(218)	563(337)	670(119)
Trichoptera	298(207)	21(19)	438(255)	3,346(2,039)	1,780(1,609)	1,657(944)
Coleoptera	57(45)	63(94)	379(338)	632(386)	392(157)	446(234)
Chironomidae	614(609)	166(74)	2,579(2,474)	2,376(1,730)	2,382(1,763)	2,207(395)
Other Diptera	122(147)	50(33)	405(530)	1,852(2,238)	201(162)	718(569)
Other Invertebrates	585(822)	57(57)	240(112)	776(405)	480(419)	535(251)
TOTAL	3,077(1,338)	721(297)	7,939(5,671)	17,145(9,635)	8,884(5,931)	10,677(3,325)

APPENDIX 2

Monthly mean biomass (cc/m^2) for each insect order at each sample station, October 1979 through September 1980. Data from the three types of samplers were analyzed for each month.

Appendix 2. Monthly mean biomass (cc/m^2) for each insect order at each sample station, October 1979 through September 1980. Data from the three types of samplers were analyzed for each month.

	October $\bar{x}$(s.d.)	November $\bar{x}$(s.d.)	January $\bar{x}$(s.d.)	March $\bar{x}$(s.d.)	April $\bar{x}$(s.d.)	May $\bar{x}$(s.d.)
Dunn Creek						
Ephemeroptera	3.4(3.8)	4.0(2.0)	20.7(6.3)	20.6(10.0)	25.0(23.9)	38.9(29.1)
Plecoptera	0.1(0.3)	0	0	0	0	0
Trichoptera	0.6(0.6)	0.2(0.5)	0.8(0.6)	0.8(0.6)	2.8(3.6)	2.8(2.7)
Chironomidae	5.1(3.7)	3.4(1.4)	6.4(3.4)	5.5(2.4)	15.3(10.5)	22.7(12.4)
Other	8.5(10.0)	5.7(3.6)	18.4(8.7)	8.0(2.5)	12.2(8.6)	15.2(14.8)
TOTAL	17.7	13.3	46.3	34.9	55.3	79.6
Elkhorn						
Ephemeroptera	3.6(2.6)	6.7(3.4)	9.7(3.6)	10.4(4.5)	7.5(2.9)	30.1(14.2)
Plecoptera	0.4(1.0)	0.8(2.4)	0.5(1.1)	0.2(0.5)	0.5(0.9)	0.1(0.2)
Trichoptera	6.2(5.4)	4.6(3.3)	6.0(2.4)	3.4(1.7)	2.1(0.5)	11.7(5.6)
Chironomidae	3.1(2.3)	6.6(4.1)	7.8(2.4)	3.4(1.7)	2.2(0.7)	9.6(2.5)
Other	4.6(2.5)	6.3(2.3)	17.2(7.5)	4.1(4.4)	8.3(4.2)	18.0(9.5)
TOTAL	17.9	25.0	41.2	21.5	20.6	69.5
Pipe Creek						
Ephemeroptera	1.2(0.5)	4.0(1.3)	6.6(3.7)	12.4(5.7)	0	5.7(1.9)
Plecoptera	0.6(0.9)	0.6(1.3)	0.5(1.2)	0.3(0.7)	0	0.1(0.1)
Trichoptera	3.5(2.1)	5.5(1.9)	7.0(7.7)	13.2(10.4)	0	1.4(1.1)
Chironomidae	0.7(0.3)	5.6(2.1)	3.1(1.3)	7.0(3.9)	0	7.0(2.9)
Other	2.2(1.2)	6.4(3.2)	14.9(20.2)	4.6(3.4)	0	7.5(3.3)
TOTAL	8.2	22.1	32.1	37.5		21.7
Fisher River						
Ephemeroptera	2.6(1.1)	6.6(2.2)	7.8(4.5)	12.4(3.6)	0	5.5(2.1)
Plecoptera	3.2(1.4)	4.1(3.2)	9.4(4.6)	7.1(3.7)	0	1.4(1.7)
Trichoptera	4.0(1.4)	6.2(3.9)	13.3(5.7)	6.4(3.0)	0	3.9(2.8)
Chironomidae	1.0(0.6)	2.6(1.3)	5.1(4.3)	2.1(0.7)	0	1.5(1.1)
Other	2.6(1.6)	4.2(3.4)	7.2(3.3)	4.8(5.2)	0	3.2(1.7)
TOTAL	13.4	23.7	42.8	32.8		15.5

Appendix 2. (Continued).

	June $\bar{x}$(s.d.)	July $\bar{x}$(s.d.)	August $\bar{x}$(s.d.)	September $\bar{x}$(s.d.)	Mean of means $\bar{x}$(s.d.)
Dunn Creek					
Ephemeroptera	28.3(15.7)	14.0(5.5)	3.5(1.6)	5.4(2.2)	16.4(12.4)
Plecoptera	0	0	0	0	.01(.03)
Trichoptera	1.2(1.3)	1.5(1.6)	1.2(1.7)	0.5(0.6)	1.2(0.7)
Chironomidae	14.1(7.4)	8.4(2.5)	7.1(2.8)	7.8(4.3)	9.6(6.0)
Other	9.8(8.8)	13.8(6.8)	6.6(2.0)	15.8(11.8)	11.4(4.4)
TOTAL	53.4	37.7	18.4	29.5	38.6
Elkhorn					
Ephemeroptera	14.2(5.9)	12.7(7.2)	9.2(5.2)	6.3(2.1)	11.0(7.4)
Plecoptera	0	0.3(0.8)	1.2(1.5)	1.4(1.8)	0.5(0.5)
Trichoptera	4.4(3.3)	13.3(5.5)	6.8(3.6)	9.7(5.5)	6.8(3.6)
Chironomidae	5.9(2.7)	6.1(1.6)	4.7(0.9)	5.8(1.4)	5.5(2.1)
Other	12.7(4.1)	13.0(5.6)	9.5(4.7)	11.0(7.1)	10.6(4.1)
TOTAL	37.2	45.4	31.4	34.2	34.4
Pipe Creek					
Ephemeroptera	4.7(2.6)	8.9(6.5)	8.7(4.9)	6.0(3.5)	5.8(3.7)
Plecoptera	0	0	2.1(2.3)	0.4(0.4)	0.5(0.6)
Trichoptera	1.4(1.3)	13.4(11.1)	4.8(1.3)	9.5(7.1)	5.9(4.8)
Chironomidae	4.4(2.6)	2.9(1.5)	4.3(1.3)	4.8(2.7)	4.0(2.4)
Other	6.4(3.3)	7.7(3.6)	11.7(7.5)	9.9(7.1)	7.1(4.4)
TOTAL	16.9	32.9	31.6	30.6	23.3
Fisher River					
Ephemeroptera	2.9(1.4)	6.1(2.6)	11.3(3.7)	6.6(1.2)	6.2(3.8)
Plecoptera	0.8(0.7)	3.8(1.9)	5.4(1.1)	5.3(2.5)	4.0(2.7)
Trichoptera	0.2(0.2)	6.8(4.7)	12.4(3.2)	9.3(7.0)	6.3(4.5)
Chironomidae	1.2(0.9)	1.9(0.8)	3.6(1.2)	2.8(0.7)	2.2(1.4)
Other	3.2(2.0)	4.7(1.4)	8.9(1.8)	5.6(2.0)	4.4(2.5)
TOTAL	8.3	23.3	41.6	29.6	23.1

APPENDIX 3

Insect species composition of samples collected in Kootenai and Fisher rivers, October 1979 through May 1981.

OCTOBER, 1979

	Dunn Creek		
	Kick n=2 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
PLECOPTERA			
Pteronarcidae			
Pteronarcys californica	0(0)	0(0)	0(0)
Chloroperlidae			
Sweltsa coloradensis	0(0)	1(2)	9(16)
Nemouridae			
Zapada cinctipes	0(0)	0(0)	0(0)
EPHEMEROPTERA			
Baetidae			
Baetis tricaudatus	1,080(1,527)	1,179(855)	102(177)
Baetis bicaudatus	0(0)	0(0)	0(0)
Baetis hageni	0(0)	0(0)	0(0)
Pseudocleon sp.	109(155)	1(2)	0(0)
Heptageniidae			
Epeorus sp.	0(0)	0(0)	0(0)
Rhithrogena hageni	0(0)	8(14)	0(0)
Cinygmula sp.	0(0)	0(0)	0(0)
Ephemerellidae			
Ephemerella inermis	18,094(23,103)	4,734(5,548)	2,406(2,720)
Drunella spinifera	0(0)	0(0)	0(0)
Leptophlebiidae			
Paraleptophlebia heteronea	3(4)	24(42)	25(19)
TRICHOPTERA			
Hydropsychidae			
Hydropsyche oslari	0(0)	27(26)	0(0)
Hydropsyche occidentalis	0(0)	0(0)	0(0)
Cheumatopsyche sp.	0(0)	0(0)	0(0)
small Hydropsychidae	0(0)	0(0)	0(0)

OCTOBER (Continued)

	Dunn Creek		
	Kick n=2 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Rhyacophilidae			
small Rhyacophila sp.	0(0)	8(14)	0(0)
Glossosomatidae			
Glossosoma sp.	12(17)	0(0)	0(0)
Hydroptilidae			
Hydroptila sp.	36(51)	1(2)	0(0)
Brachycentridae			
Brachycentrus sp.	0(0)	11(12)	3(5)
Lepidostomatidae			
Lepidostoma sp.	24(0)	9(16)	0(0)
COLEOPTERA			
Elmidae			
Zaitzevia parvula	13(19)	0(0)	0(0)
Optioservus quadrimaculatus	0(0)	0(0)	3(5)
Haliplidae			
Haliplus sp.	0(0)	8(14)	0(0)
DIPTERA			
Tipulidae			
Antocha sp.	0(0)	5(6)	3(5)
Simuliidae			
Simulium sp.	121(36)	615(619)	37(56)
Simulium vittatum pupae	0(0)	13(10)	3(5)
Chironomidae			
larvae	7,437(5,554)	7,211(1,680)	4,078(2,858)
pupae	171(123)	139(78)	161(28)
adults	48(68)	11(16)	0(0)

OCTOBER (Continued)

	Dunn Creek		
	Kick n=2 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
OTHER INVERTEBRATES			
Turbellaria	1(2)	12(16)	90(148)
Nematoda	181(172)	32(45)	217(157)
Oligochaeta			
Lumbriculidae	160(142)	51(63)	111(80)
Naididae	2,977(3,188)	742(590)	6,469(8,429)
Hydracarina	120(139)	4(7)	25(43)
Gastropoda			
Lymnaea sp.	190(184)	128(201)	542(465)
Gyraulic sp.	0(0)	1(2)	25(43)

OCTOBER, 1979

	Elkhorn		
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
PLECOPTERA			
Pteronarcidae			
Pteronarcys californica	1(2)	0(0)	0(0)
Chloroperlidae			
Sweltsa coloradensis	11(12)	6(8)	0(0)
Nemouridae			
Zapada cinctipes	1(2)	0(0)	0(0)
EPHEMEROPTERA			
Baetidae			
Baetis tricaudatus	3,115(1,445)	1,691(1,387)	403(221)
Baetis bicaudatus	1(2)	0(0)	0(0)
Baetis hageni	1(2)	4(7)	0(0)
Pseudocleon sp.	12(16)	18(8)	28(48)
Heptageniidae			
Epeorus sp.	10(12)	0(0)	0(0)
Rhithrogena hageni	36(47)	13(10)	56(48)
Cinygmula sp.	16(28)	2(2)	0(0)
Ephemerellidae			
Ephemerella inermis	1,059(412)	188(123)	99(86)
Drunella spinifera	1(2)	0(0)	0(0)
Leptophlebiidae			
Paraleptophlebia heteronea	17(12)	16(15)	0(0)
TRICHOPTERA			
Hydropsychidae			
Hydropsyche oslari	981(1,229)	316(368)	220(121)
Hydropsyche occidentalis	34(44)	18(13)	3(5)
Cheumatopsyche sp.	96(161)	26(26)	6(5)
small Hydropsychidae	583(709)	252(346)	102(58)

OCTOBER (Continued)

	Elkhorn		
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Rhyacophilidae			
small Rhyacophila sp.	8(14)	0(0)	0(0)
Glossosomatidae			
Glossosoma sp.	62(65)	31(25)	3(5)
Hydroptilidae			
Hydroptila sp.	20(12)	11(10)	46(40)
Brachycentridae			
Brachycentrus sp.	38(32)	17(24)	9(16)
Lepidostomatidae			
Lepidostoma sp.	2(2)	3(3)	0(0)
COLEOPTERA			
Elmidae			
Zaitzevia parvula	3(3)	2(2)	12(21)
Optioservus quadrimaculatus	33(24)	9(5)	0(0)
Haliplidae			
Haliplus sp.	0(0)	0(0)	0(0)
DIPTERA			
Tipulidae			
Antocha sp.	26(31)	4(2)	37(32)
Simuliidae			
Simulium sp.	140(158)	37(33)	0(0)
Simulium vittatum pupae	0(0)	0(0)	0(0)
Chironomidae			
larvae	2,176(1,509)	1,587(1,491)	3,354(1,205)
pupae	31(20)	35(33)	161(97)
adults	8(8)	2(2)	0(0)

OCTOBER (Continued)

	Elkhorn		
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
OTHER INVERTEBRATES			
Turbellaria	222(182)	115(71)	468(456)
Nematoda	265(134)	69(65)	152(70)
Oligochaeta			
Lumbriculidae	163(161)	13(18)	19(16)
Naididae	710(282)	152(106)	734(666)
Hydracarina	140(62)	32(37)	0(0)
Gastropoda			
Lymnaea sp.	30(26)	23(21)	96(106)
Gyraulis sp.	0(0)	0(0)	0(0)

OCTOBER, 1979

	Boothman's		Pipe Creek		Fisher River	
	Kick n-3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n-3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
PLECOPTERA						
Pteronarcidae						
Pteronarcys californica	0(0)	0(0)	0(0)	0(0)	2(2)	0(0)
Pteronarcella badia	0(0)	0(0)	0(0)	0(0)	1(2)	0(0)
Perlidae						
Classenia sabulosa	0(0)	0(0)	1(2)	0(0)	17(12)	19(16)
Calineuria californica	0(0)	0(0)	0(0)	0(0)	22(7)	49(28)
Hesperoperla pacifica	0(0)	0(0)	0(0)	0(0)	0(0)	6(11)
small Perlidae	0(0)	0(0)	0(0)	0(0)	8(14)	0(0)
Perlodidae						
Isoperla fulva	0(0)	0(0)	0(0)	0(0)	37(39)	22(23)
Skwala parallela	0(0)	0(0)	0(0)	0(0)	13(9)	6(11)
Diura sp.	0(0)	0(0)	0(0)	0(0)	26(32)	25(11)
Perlinodes aurea	0(0)	0(0)	0(0)	0(0)	10(6)	0(0)
Chloroperlidae						
Sweltsa coloradensis	12(3)	4(2)	2(2)	2(3)	242(145)	684(162)
small Chloroperlidae	0(0)	0(0)	0(0)	1(2)	84(51)	3(5)
Nemouridae						
Zapada cinctipes	1(2)	0(0)	0(0)	1(2)	0(0)	0(0)
Taeniopterygidae						
small Taeniopterygidae	0(0)	0(0)	0(0)	0(0)	101(18)	6(11)
Capniidae						
small Capniidae	2(2)	0(0)	1(2)	0(0)	22(38)	3(5)
EPHEMEROPTERA						
Siphlonuridae						
Ameletus sp.	0(0)	0(0)	0(0)	0(0)	5(9)	0(0)
Baetidae						
Baetis tricaudatus	2,749(1,056)	5,807(9,200)	846(587)	1,698(687)	1,535(645)	248(144)
Baetis bicaudatus	0(0)	1(2)	0(0)	0(0)	0(0)	0(0)
Baetis hageni	5(5)	3(3)	0(0)	8(14)	868(517)	3(5)
Pseudocleon sp.	9(11)	3(0)	69(39)	5(9)	21(21)	9(9)

OCTOBER (Continued)

	Boothman's		Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Heptageniidae						
Epeorus albertae	88(111)	73(126)	76(60)	257(290)	302(176)	62(71)
Rhithrogena hageni	47(30)	22(24)	99(104)	183(263)	490(110)	1,028(166)
Cinygmula sp.	35(38)	3(5)	11(14)	11(16)	110(48)	62(14)
Nixe criddlei	1(2)	0(0)	0(0)	0(0)	0(0)	0(0)
Ephemerellidae						
Drunella doddsi	0(0)	0(0)	0(0)	1(2)	7(3)	28(9)
Ephemerella inermis	265(55)	149(131)	230(84)	528(743)	1,681(295)	697(323)
small Ephemerella sp.	0(0)	0(0)	0(0)	16(28)	0(0)	0(0)
Leptophlebiidae						
Paraleptophlebia heteronea	92(53)	26(22)	55(7)	29(15)	98(87)	111(70)
TRICHOPTERA						
Hydropsychidae						
Arctopsyche grandis	0(0)	0(0)	1(2)	1(2)	9(8)	6(5)
Hydropsyche oslari	126(103)	152(106)	304(186)	181(176)	7(6)	102(177)
Hydropsyche cockerelli	0(0)	0(0)	0(0)	4(7)	4(2)	3(5)
Hydropsyche occidentalis	4(3)	4(7)	231(268)	91(142)	344(211)	313(326)
Cheumatopsyche sp.	6(6)	7(7)	31(30)	13(20)	79(83)	74(49)
small Hydropsychidae	26(3)	37(45)	393(374)	229(182)	800(301)	241(230)
Rhyacophilidae						
Rhyacophila bifila	35(30)	5(9)	10(12)	21(36)	24(27)	12(11)
Glossosomatidae						
Glossosoma sp.	3(0)	1(2)	9(13)	0(0)	139(178)	161(99)
Brachycentridae						
Brachycentrus sp.	30(42)	59(94)	45(24)	56(44)	27(24)	0(0)
Lepidostomatidae						
Lepidostoma sp.	1(2)	1(2)	13(7)	3(5)	741(253)	858(111)
Leptoceridae						
Ceraclea sp.	0(0)	0(0)	0(0)	1(2)	0(0)	0(0)
Hydroptilidae						
Hydroptila sp.	52(35)	70(78)	55(37)	22(23)	24(24)	0(0)

OCTOBER (Continued)

	Boothman's		Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
COLEOPTERA						
Elmidae						
Zaitzevia parvula	1(2)	8(14)	4(2)	1(2)	344(132)	653(366)
Zaitzevia parvula adults	0(0)	0(0)	0(0)	0(0)	76(22)	9(16)
Optioservus quadrimaculatus	11(14)	10(17)	34(10)	13(7)	416(73)	238(67)
Optioservus quadrimaculatus adults	0(0)	0(0)	0(0)	0(0)	13(20)	15(19)
DIPTERA						
Tipulidae						
Hexatoma sp.	5(6)	0(0)	10(15)	3(5)	554(338)	322(121)
Antocha sp.	263(228)	293(220)	335(429)	528(473)	78(53)	53(27)
Empidiidae						
Hemerodromia sp.	0(0)	0(0)	0(0)	0(0)	30(24)	3(5)
Tanyderidae						
Protanyderus sp.	0(0)	0(0)	1(2)	0(0)	0(0)	0(0)
Simuliidae						
Simulium sp.	133(115)	2,411(4,005)	54(86)	2(2)	9(6)	0(0)
Ceratopogonidae	0(0)	0(0)	0(0)	0(0)	18(26)	0(0)
Chironomidae						
larvae	8,730(8,369)	6,943(2,446)	6,850(4,354)	15,775(6,985)	3,212(1,158)	136(57)
pupae	114(108)	68(70)	200(140)	144(168)	0(0)	3(5)
adults	33(35)	0(0)	81(58)	26(21)	10(12)	0(0)
COLLEMBOLA	0(0)	0(0)	0(0)	8(14)	0(0)	0(0)
OTHER INVERTEBRATES						
Turbellaria	263(157)	218(209)	238(31)	147(39)	7(7)	3(5)
Nematoda	72(58)	19(20)	119(123)	18(26)	112(101)	43(59)

OCTOBER (Continued)

	Boothman's		Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
<u>Oligochaeta</u>						
Lumbriculidae	601(735)	103(67)	102(60)	23(17)	171(136)	71(44)
Naididae	814(548)	1,030(1,423)	3,018(3,548)	1,970(748)	68(80)	0(0)
Hirudinea	0(0)	0(0)	1(2)	0(0)	0(0)	0(0)
Hydracarina	124(204)	0(0)	488(686)	1,432(771)	764(323)	368(102)
<u>Gastropoda</u>						
Lymnaea sp.	31(28)	17(2)	1(2)	4(5)	0(0)	3(5)
Gyraulus sp.	5(6)	0(0)	8(14)	0(0)	0(0)	0(0)
Physa sp.	0(0)	0(0)	1(2)	0(0)	0(0)	0(0)

NOVEMBER, 1979

	Dunn Creek		
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
PLECOPTERA			
Pteronarcidae			
Pteronarcys californica	0(0)	0(0)	0(0)
Perlidae			
Calineuria californica	0(0)	0(0)	0(0)
Chloroperlidae			
Sweltsa coloradensis	0(0)	0(0)	0(0)
small Chloroperlidae	0(0)	1(2)	0(0)
Nemouridae			
Zapada cinctipes	0(0)	0(0)	0(0)
Taeniopterygidae			
Taenionema pacificum	0(0)	0(0)	0(0)
Capniidae			
small Capniidae	1(2)	1(2)	0(0)
EPHEMEROPTERA			
Baetidae			
Baetis tricaudatus	610(122)	552(392)	322(111)
Baetis bicaudatus	0(0)	0(0)	0(0)
Pseudocleon sp.	0(0)	0(0)	0(0)
Heptageniidae			
Epeorus sp.	0(0)	0(0)	0(0)
Rhithrogena hageni	41(71)	0(0)	3(5)
Cinygmula sp.	0(0)	0(0)	3(5)
Ephemerellidae			
Ephemerella inermis	6,336(599)	3,239(1,400)	4,115(955)
Leptophlebiidae			
Paraleptophlebia heteronea	0(0)	2(2)	6(5)

NOVEMBER (Cont.)

	Dunn Creek		
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
TRICHOPTERA			
Hydropsychidae			
Hydropsyche oslari	1(2)	0(0)	0(0)
Hydropsyche cockerelli	0(0)	0(0)	0(0)
Hydropsyche occidentalis	0(0)	0(0)	0(0)
Cheumatopsyche sp.	0(0)	0(0)	0(0)
small Hydropsychidae	3(5)	0(0)	0(0)
Glossosomatidae			
Glossosoma sp.	0(0)	0(0)	0(0)
Hydroptilidae			
Hydroptila sp.	2(2)	1(2)	6(5)
Brachycentridae			
Brachycentrus sp.	6(5)	0(0)	0(0)
Lepidostomatidae			
Lepidostoma sp.	2(3)	0(0)	0(0)
COLEOPTERA			
Elmidae			
Zaitzevia parvula	0(0)	0(0)	0(0)
Optioservus quadrimaculatus	0(0)	2(3)	3(5)
DIPTERA			
Tipulidae			
Antocha sp.	8(14)	0(0)	0(0)
Dolichopodidae	1(2)	1(2)	0(0)
Simuliidae			
Simulium sp.	2,235(1,481)	2,014(558)	294(133)
Chironomidae			
larvae	3,706(223)	5,711(2,307)	4,791(2,397)
pupae	16(15)	28(32)	31(54)
adults	1(2)	0(0)	12(14)

NOVEMBER (Cont.)

	Dunn Creek		
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Ceratopogonidae	8(14)	8(14)	0(0)
OTHER INVERTEBRATES			
Turbellaria	1(2)	12(14)	12(21)
Nematoda	112(95)	42(36)	118(42)
Oligochaeta			
Lumbriculidae	226(143)	34(18)	263(133)
Naididae	328(252)	1,018(573)	523(340)
Hydracarina	16(28)	0(0)	74(129)
Gastropoda			
Lymnaea sp.	69(74)	21(20)	62(27)
Gyraulus sp.	1(2)	0(0)	0(0)

NOVEMBER (CONT.)

	Elkhorn Kick n=3 $\bar{x}$(s.d.)	Elkhorn Circular n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
PLECOPTERA			
Pteronarcidae			
Pteronarcys californica	2(3)	0(0)	0(0)
Perlidae			
Calineuria californica	1(2)	0(0)	0(0)
Chloroperlidae			
Sweltsa coloradensis	8(3)	8(14)	0(0)
small Chloroperlidae	0(0)	0(0)	0(0)
Nemouridae			
Zapada cinctipes	1(2)	0(0)	0(0)
Taeniopterygidae			
Taenionema pacificum	1(2)	0(0)	0(0)
Capniidae			
small Capniidae	8(14)	0(0)	0(0)
EPHEMEROPTERA			
Baetidae			
Baetis tricaudatus	15,066(11,119)	5,093(2,533)	3,196(2,181)
Baetis bicaudatus	1(2)	0(0)	0(0)
Pseudocleon sp.	1(2)	2(3)	0(0)
Heptageniidae			
Epeorus sp.	9(16)	0(0)	0(0)
Rhithrogena hageni	42(42)	37(64)	34(44)
Cinygmula sp.	8(14)	0(0)	15(27)
Ephemerellidae			
Ephemerella inermis	3,191(687)	1,306(273)	2,778(1,674)
Leptophlebiidae			
Paraleptophlebia heteronea	27(42)	0(0)	0(0)
TRICHOPTERA			
Hydropsychidae			
Hydropsyche oslari	479(491)	74(107)	322(295)
Hydropsyche cockerelli	1(2)	0(0)	0(0)
Hydropsyche occidentalis	11(19)	10(17)	6(11)
Cheumatopsyche sp.	35(56)	2(2)	40(28)
small Hydropsychidae	285(240)	31(48)	186(89)
Glossosomatidae			
Glossosoma sp.	54(57)	11(19)	71(33)
Hydroptilidae			
Hydroptila sp.	126(120)	18(29)	347(205)
Brachycentridae			
Brachycentrus sp.	33(30)	1(2)	3(5)

NOVEMBER (CONT.)

	Elkhorn Kick n=3 x̄(s.d.)	Elkhorn Circular n=3 x̄(s.d.)	Knapp Waters n=3 x̄(s.d.)
Lepidostomatidae			
Lepidostoma sp.	11(14)	1(2)	28(25)
COLEOPTERA			
Elmidae			
Zaitzevia parvula	3(3)	8(14)	28(48)
Optioservus quadrimaculatus	48(68)	1(2)	56(49)
DIPTERA			
Tipulidae			
Antocha sp.	25(22)	27(29)	12(21)
Dolichopodidae	----	1(2)	----
Simuliidae			
Simulium sp.	20,765(19,865)	4,760(4,347)	533(440)
Chironimidae			
larvae	16,605(12,876)	8,935(2,689)	11,458(6,474)
pupae	70(49)	52(68)	9(9)
adults	242(154)	17(29)	43(42)
Ceratopogonidae	----	8(14)	----
OTHER INVERTEBRATES			
Turbellaria	335(434)	170(160)	474(411)
Nematoda	316(389)	67(62)	539(210)
Oligochaeta			
Lumbriculidae	539(788)	6(8)	59(39)
Naididae	2,192(1,289)	1,026(1,419)	1,028(633)
Hydracarina	1,064(977)	0(0)	285(176)
Gastropoda			
Lymnaea sp.	52(56)	36(35)	90(70)
Gyraulus sp.	0(0)	0(0)	0(0)

NOVEMBER 1979

	Boothman's		Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
PLECOPTERA						
Pteronarcidae						
Pteronarcys californica	0(0)	0(0)	1(2)	1(2)	0(0)	0(0)
Perlidae						
Classenia sabulosa	0(0)	0(0)	1(2)	0(0)	11(14)	25(11)
Hesperoperla pacifica	0(0)	0(0)	1(2)	0(0)	0(0)	0(0)
Calineuria californica	0(0)	0(0)	0(0)	0(0)	15(6)	71(39)
Perlodidae						
Isoperla fulva	0(0)	0(0)	0(0)	0(0)	6(3)	19(16)
Skwala parallela	0(0)	0(0)	0(0)	0(0)	8(5)	3(5)
Diura sp.	0(0)	0(0)	0(0)	0(0)	3(5)	12(14)
Chloroperlidae						
Sweltsa coloradensis	10(7)	0(0)	20(19)	2(2)	130(37)	409(190)
small Chloroperlidae	0(0)	0(0)	0(0)	8(14)	180(174)	0(0)
Nemouridae						
Zapada cinctipes	0(0)	0(0)	0(0)	1(2)	0(0)	0(0)
Taeniopterygidae						
Taenionema pacificum	0(0)	0(0)	1(2)	1(2)	98(47)	155(75)
small Taeniopterygidae	0(0)	0(0)	0(0)	0(0)	24(24)	68(60)
Capniidae						
small Capniidae	0(0)	0(0)	0(0)	0(0)	71(45)	25(21)
EPHEMEROPTERA						
Siphlonuridae						
Ameletus cooki	0(0)	0(0)	0(0)	0(0)	12(16)	3(5)

NOVEMBER (Cont.)

	Boothman's		Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Baetidae						
Baetis tricaudatus	2,129(2,053)	1,436(998)	3,632(1,245)	4,320(2,594)	926(800)	505(403)
Baetis hageni	26(45)	1(2)	8(14)	1(2)	519(177)	3(5)
Pseudocleon sp.	2(3)	1(2)	1(2)	1(2)	0(0)	12(21)
Heptageniidae						
Epeorus albertae	28(32)	21(36)	685(50)	243(218)	184(65)	830(332)
Rhithrogena hageni	16(5)	1(2)	97(10)	57(35)	449(209)	1,115(513)
Cinygmula sp.	3(5)	0(0)	4(3)	0(0)	53(55)	31(27)
Nixe criddlei	1(2)	0(0)	0(0)	0(0)	0(0)	0(0)
Ephemerellidae						
Drunella doddsi	0(0)	0(0)	0(0)	0(0)	8(9)	15(27)
Ephemerella inermis	212(269)	151(44)	602(153)	334(12)	1,931(2,066)	824(321)
Drunella flavilinea	0(0)	0(0)	16(28)	0(0)	0(0)	0(0)
Caudatella heterocaudata	0(0)	0(0)	0(0)	0(0)	8(14)	0(0)
Leptophlebiidae						
Paraleptophlebia heteronea	110(70)	10(2)	84(63)	29(26)	42(83)	74(74)
TRICHOPTERA						
Hydropsychidae						
Arctopsyche grandis	0(0)	0(0)	0(0)	0(0)	11(12)	15(19)
Hydropsyche oslari	84(64)	28(23)	131(62)	233(223)	3(5)	3(5)
Hydropsyche cockerelli	0(0)	0(0)	0(0)	0(0)	1(2)	0(0)
Hydropsyche occidentalis	13(18)	24(39)	21(19)	233(347)	216(190)	567(481)
Cheumatopsyche sp.	28(28)	4(7)	41(30)	42(23)	38(23)	136(77)
small Hydropsychidae	16(15)	47(35)	223(86)	366(390)	435(391)	263(215)
Rhyacophilidae						
Rhyacophila bifila	1(2)	17(15)	1(2)	5(5)	2(3)	0(0)

NOVEMBER (Cont.)

	Boothman's		Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Glossosomatidae						
Glossosoma sp.	1(2)	4(7)	9(13)	44(33)	66(23)	56(43)
Hydroptilidae						
Hydroptila sp.	62(84)	51(27)	47(36)	116(86)	0(0)	12(21)
Brachycentridae						
Brachycentrus americanus	53(68)	46(55)	92(70)	95(83)	14(14)	9(16)
Lepidostomatidae						
Lepidostoma sp.	0(0)	1(2)	82(70)	6(6)	546(517)	1,034(425)
Leptoceridae						
Ceraclea sp.	0(0)	4(7)	0(0)	8(14)	0(0)	0(0)
Limnephilidae						
Onocosmoecus sp.	3(5)	0(0)	0(0)	0(0)	0(0)	0(0)
COLEOPTERA						
Elmidae						
Zaitzevia parvula	0(0)	0(0)	2(2)	0(0)	72(59)	139(19)
Zaitzevia parvula adults	0(0)	0(0)	0(0)	0(0)	8(14)	9(16)
Optioservus quadrimaculatus	3(5)	6(8)	42(42)	18(13)	152(132)	74(9)
Optioservus quadrimaculatus adults	0(0)	0(0)	8(14)	0(0)	1(2)	19(9)
Carabidae adult	0(0)	0(0)	0(0)	0(0)	1(2)	0(0)
HEMIPTERA						
Corixidae	0(0)	0(0)	1(2)	0(0)	0(0)	0(0)

NOVEMBER (Cont.)

	Boothman's		Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
DIPTERA						
Tipulidae						
Hexatoma sp.	0(0)	0(0)	1(2)	0(0)	85(51)	170(153)
Antocha sp.	651(932)	236(370)	937(676)	138(117)	175(100)	28(19)
Tabanidae	0(0)	0(0)	0(0)	0(0)	0(0)	3(5)
Empididae						
Hemerodromia sp.	0(0)	0(0)	0(0)	0(0)	8(14)	0(0)
Simuliidae						
Simulium sp.	321(256)	157(83)	4,088(2,401)	5,982(4,480)	468(462)	6(5)
Ceratopogonidae	0(0)	0(0)	0(0)	0(0)	8(14)	0(0)
Chironomidae						
larvae	4,941(4,012)	6,872(3,463)	21,309(8,730)	29,963(12,759)	2,884(2,137)	468(322)
pupae	49(85)	22(20)	56(54)	0(0)	15(16)	3(5)
adults	14(9)	0(0)	40(35)	0(0)	5(6)	0(0)
COLLEMBOLA	0(0)	0(0)	0(0)	0(0)	3(5)	0(0)
OTHER INVERTEBRATES						
Turbellaria	292(179)	44(37)	261(221)	301(41)	2(3)	15(27)
Nematoda	35(30)	18(13)	338(303)	491(224)	32(55)	0(0)
Oligochaeta						
Lumbriculidae	217(68)	65(32)	432(189)	98(32)	65(27)	242(362)
Naididae	215(354)	445(195)	2,880(1,435)	2,600(2,035)	24(42)	0(0)
Hydracarina	9(16)	10(12)	1,272(1,084)	1,665(458)	428(431)	266(242)
Gastropoda						
Lymnaea sp.	32(34)	5(2)	21(15)	10(10)	0(0)	0(0)

JANUARY, 1980

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	0(0)	0(0)	1(2)	0(0)
Pteronarcella badia	0(0)	0(0)	0(0)	0(0)
Perlidae				
Classenia sabulosa	0(0)	0(0)	0(0)	0(0)
Hesperoperla pacifica	0(0)	0(0)	0(0)	0(0)
Calineuria californica	0(0)	0(0)	1(2)	0(0)
Perlodidae				
Isoperla fulva	0(0)	0(0)	0(0)	0(0)
Skwala parallela	0(0)	0(0)	1(2)	0(0)
Diura sp.	0(0)	0(0)	0(0)	0(0)
Chloroperlidae				
Sweltsa coloradensis	2(2)	0(0)	10(5)	3(5)
Suwallia sp.	0(0)	0(0)	10(15)	19(32)
small Chloroperlidae	0(0)	0(0)	1(2)	0(0)
Nemouridae				
Zapada cinctipes	0(0)	0(0)	0(0)	0(0)
Taeniopterygidae				
Taenionema pacificum	0(0)	0(0)	2(3)	0(0)
small Taeniopterygidae	0(0)	0(0)	0(0)	0(0)
Capniidae				
small Capniidae	0(0)	0(0)	1(2)	3(5)
EPHEMEROPTERA				
Siphlonuridae				
Ameletus cooki	0(0)	0(0)	0(0)	0(0)
Baetidae				
Baetis tricaudatus	6,065(1,572)	4,044(2,203)	10,463(2,077)	4,499(1,984)
Baetis hageni	8(14)	0(0)	8(14)	0(0)
Pseudocleon sp.	0(0)	0(0)	0(0)	0(0)

JANUARY (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Heptageniidae				
Epeorus sp.	0(0)	0(0)	102(108)	0(0)
Rhithrogena hageni	0(0)	0(0)	41(21)	111(98)
Cinygmula sp.	0(0)	0(0)	4(5)	3(5)
Ephemerellidae				
Drunella doddsi	0(0)	0(0)	0(0)	0(0)
Drunella spinifera	0(0)	0(0)	1(2)	0(0)
Ephemerella inermis	14,723(4,547)	25,204(11,430)	3,537(1,489)	2,539(2,299)
Drunella flavilinea	8(14)	0(0)	84(38)	257(421)
Caudatella heterocaudata	0(0)	3(5)	141(137)	77(79)
Leptophlebiidae				
Paraleptophlebia heteronea	0(0)	0(0)	31(25)	0(0)
TRICHOPTERA				
Hydropsychidae				
Arctopsyche grandis	0(0)	0(0)	2(2)	0(0)
Hydropsyche oslari	24(9)	12(14)	456(596)	207(227)
Hydropsyche cockerelli	0(0)	0(0)	0(0)	0(0)
Hydropsyche occidentalis	0(0)	0(0)	12(14)	46(72)
Cheumatopsyche sp.	0(0)	0(0)	80(69)	53(91)
small Hydropsychidae	0(0)	25(43)	544(729)	313(127)
Rhyacophilidae				
Rhyacophila bifila	0(0)	0(0)	2(3)	25(43)
Glossosomatidae				
Glossosoma sp.	0(0)	0(0)	64(80)	108(28)
Hydroptilidae				
Hydroptila sp.	0(0)	15(19)	150(183)	118(42)
Brachycentridae				
Brachycentrus sp.	10(7)	9(9)	75(91)	19(9)
Lepidostomatidae				
Lepidostoma sp.	2(2)	0(0)	10(12)	0(0)

JANUARY (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
<u>Leptoceridae</u>				
Ceraclea sp.	0(0)	0(0)	0(0)	0(0)
<u>Limnephilidae</u>				
Psychoglypha sp.	0(0)	0(0)	0(0)	0(0)
COLEOPTERA				
<u>Elmidae</u>				
Zaitzevia parvula	0(0)	0(0)	6(6)	0(0)
Zaitzevia parvula adults	0(0)	0(0)	0(0)	0(0)
Optioservus quadrimaculatus	0(0)	3(5)	48(18)	124(98)
Optioservus quadrimaculatus adults	0(0)	0(0)	1(2)	0(0)
Narpus sp.	0(0)	0(0)	1(2)	3(5)
Lara sp.	0(0)	0(0)	0(0)	0(0)
<u>Haliplidae</u>				
Haliplus sp.	1(2)	3(5)	0(0)	0(0)
HEMIPTERA				
<u>Corixidae</u>	0(0)	0(0)	1(2)	0(0)
DIPTERA				
<u>Tipulidae</u>				
Tipula sp.	0(0)	0(0)	0(0)	0(0)
Hexatoma sp.	0(0)	0(0)	3(5)	0(0)
Antocha sp.	0(0)	3(5)	81(50)	68(95)
<u>Athericidae</u>				
Atherix variegata	0(0)	0(0)	0(0)	0(0)
<u>Tabanidae</u>	0(0)	0(0)	0(0)	0(0)
<u>Empididae</u>				
Hemerodromia sp.	0(0)	3(5)	0(0)	0(0)

JANUARY (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Simuliidae				
Simulium sp.	1,650(1,431)	1,784(396)	8,682(8,712)	904(713)
Ceratopogonidae	0(0)	0(0)	0(0)	0(0)
Chironomidae				
Larvae	11,126(4,374)	13,842(6,357)	15,339(4,253)	3,369(3,008)
pupae	10(12)	105(142)	2(3)	3(5)
adults	10(17)	0(0)	23(10)	0(0)
OTHER INVERTEBRATES				
Turbellaria	23(9)	28(48)	1,069(797)	585(284)
Nematoda	216(203)	492(80)	126(141)	585(349)
Oligochaeta				
Lumbriculidae	13(20)	31(37)	62(52)	108(88)
Naididae	661(664)	424(182)	73(64)	0(0)
Hydracarina	0(0)	3(5)	33(36)	0(0)
Gastropoda				
Lymnaea sp.	85(59)	350(232)	129(116)	248(142)
Gyraulus	1(2)	28(48)	0(0)	0(0)
Rhysa sp.	0(0)	0(0)	0(0)	0(0)

JANUARY, 1980

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	2(3)	0(0)	11(9)	3(5)
Pteronarcella badia	1(2)	0(0)	2(2)	3(5)
Perlidae				
Classenia sabulosa	1(2)	0(0)	0(0)	3(5)
Hesperoperla pacifica	0(0)	0(0)	2(2)	6(11)
Calineuria californica	0(0)	0(0)	45(19)	77(71)
Perlodidae				
Isoperla fulva	0(0)	0(0)	23(21)	25(5)
Skwala parallela	0(0)	0(0)	5(3)	12(14)
Diura sp.	0(0)	0(0)	2(2)	3(5)
Chloroperlidae				
Sweltsa coloradensis	1(2)	3(3)	96(84)	263(86)
Suwallia sp.	1(2)	0(0)	0(0)	0(0)
small Chloroperlidae	0(0)	0(0)	8(14)	0(0)
Nemouridae				
Zapada cinctipes	0(0)	0(0)	1(2)	0(0)
Taeniopterygidae				
Taenionema pacificum	1(2)	0(0)	118(39)	285(334)
small Taeniopterygidae	0(0)	0(0)	3(5)	6(11)
Capniidae				
small Capniidae	0(0)	0(0)	16(14)	9(9)
EPHEMEROPTERA				
Siphlonuridae				
Ameletus cooki	0(0)	0(0)	8(11)	6(11)
Baetidae				
Baetis tricaudatus	4,414(764)	1,338(491)	288(363)	786(189)
Baetis hageni	*24(42)*	*1(2)*	*1,432(420)*	*207(280)*
Pseudocleon sp.	1(2)	0(0)	0(0)	0(0)

JANUARY (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Heptageniidae				
Epeorus sp.	98(74)	156(265)	4,222(2,458)	3,493(3,035
Rhithrogena hageni	83(57)	43(13)	333(212)	421(172)
Cinygmula sp.	2(3)	0(0)	72(70)	40(5)
Ephemerellidae				
Drunella doddsi	1(2)	0(0)	27(7)	0(0)
Drunella spinifera	2(3)	0(0)	1(2)	0(0)
Ephemerella inermis	285(47)	104(82)	371(259)	591(510)
Drunella flavilinea	50(41)	99(91)	80(69)	31(54)
Caudatella heterocaudata	8(14)	8(14)	16(14)	0(0)
Leptophlebiidae				
Paraleptophlebia heteronea	9(5)	8(14)	237(119)	350(353)
TRICHOPTERA				
Hydropsychidae				
Arctopsyche grandis	1(2)	0(0)	13(9)	6(11)
Hydropsyche oslari	405(307)	48(39)	8(14)	0(0)
Hydropsyche cockerelli	0(0)	1(2)	0(0)	0(0)
Hydropsyche occidentalis	421(369)	34(49)	147(35)	155(237)
Cheumatopsyche sp.	72(66)	9(9)	325(190)	248(284)
small Hydropsychidae	1,004(675)	196(146)	366(475)	149(179)
Rhyacophilidae				
Rhyacophila bifila	8(5)	2(2)	0(0)	0(0)
Glossosomatidae				
Glossosoma sp.	54(18)	55(51)	2(2)	0(0)
Hydroptilidae				
Hydroptila sp.	2(3)	41(35)	0(0)	0(0)
Brachycentridae				
Brachycentrus sp.	146(90)	31(36)	0(0)	0(15)

JANUARY (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Lepidostomatidae				
Lepidostoma sp.	11(16)	0(0)	676(560)	1,118(1,006)
Leptoceridae				
Ceraclea sp.	1(2)	8(14)	0(0)	0(0)
Limnephilidae				
Psychoglypha sp.	8(14)	0(0)	8(14)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	2(2)	10(17)	74(65)	183(196)
Zaitzevia parvula adults	0(0)	0(0)	0(0)	28(40)
Optioservus quadrimaculatus	52(12)	10(12)	160(163)	245(214)
Optioservus quadrimaculatus adults	0(0)	0(0)	17(15)	1(2)
Narpus sp.	1(2)	0(0)	2(2)	0(0)
Lara sp.	0(0)	0(0)	1(2)	1(2)
Haliplidae				
Haliplus sp.	0(0)	0(0)	0(0)	0(0)
HEMIPTERA				
Corixidae	0(0)	0(0)	0(0)	0(0)
DIPTERA				
Tipulidae				
Tipula sp.	0(0)	0(0)	0(0)	1(2)
Hexatoma sp.	0(0)	0(0)	41(35)	19(16)
Antocha sp.	170(130)	101(122)	238(37)	126(112)
Athericidae				
Atherix variegata	0(0)	0(0)	2(2)	0(0)
Tabanidae	0(0)	0(0)	2(3)	0(0)

JANUARY (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 x(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Empididae				
Hemerodromia sp.	0(0)	0(0)	1(2)	25(43)
Simuliidae				
Simulium sp.	11,088(11,789)	1,124(1,145)	1,268(1,470)	458(321)
Ceratopogonidae	0(0)	0(0)	1(2)	0(0)
Chironomidae				
larvae	7,460(596)	7,303(3,925)	3,390(2,020)	1,873(1,817)
pupae	3(3)	35(14)	0(0)	0(0)
adults	21(31)	1(2)	0(0)	0(0)
OTHER INVERTEBRATES				
Turbellaria	266(78)	110(185)	72(112)	15(19)
Nematoda	304(87)	158(75)	10(12)	3(5)
Oligochaeta				
Lumbriculidae	80(23)	18(16)	5(6)	71(115)
Naididae	281(262)	457(644)	129(145)	6(5)
Hydracarina	9(13)	0(0)	16(14)	3(5)
Gastropoda				
Lymnaea sp.	10(6)	0(0)	8(14)	25(43)
Gyraulus sp.	0(0)	0(0)	8(14)	0(0)
Physa sp.	0(0)	0(0)	2(3)	0(0)

MARCH, 1980

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
EPHEMEROPTERA				
Baetidae				
Baetis tricaudatus	2,993(684)	5,304(2,748)	2,484(711)	8,349(1,834)
Baetis hageni	0(0)	0(0)	8(14)	0(0)
Heptageniidae				
Rhithrogena hageni	0(0)	0(0)	13(5)	46(42)
Cinygmula sp.	1(2)	0(0)	1(2)	9(9)
Ephemerellidae				
Ephemerella inermis	7,018(4,371)	20,317(6,210)	802(451)	2,480(1,698)
Drunella flavilinea	0(0)	0(0)	12(10)	96(108)
Caudatella heterocaudata	8(14)	25(43)	89(93)	136(160)
Leptophlebiidae				
Paraleptophlebia heteronea	0(0)	0(0)	10(12)	0(0)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	0(0)	0(0)	0(0)	3(5)
Perlidae				
Classenia sabulosa	0(0)	0(0)	1(2)	0(0)
Perlodidae				
Cultus aestivalis	0(0)	3(5)	0(0)	0(0)
Chloroperlidae				
Sweltsa coloradensis	0(0)	0(0)	1(2)	3(5)
Suwallia pallidula	0(0)	0(0)	7(10)	3(5)
ODONATA				
Lestidae	1(2)	0(0)	0(0)	0(0)

MARCH (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
TRICHOPTERA				
Hydropsychidae				
Arctopsyche grandis	0(0)	0(0)	1(2)	0(0)
Hydropsyche cockerelli	0(0)	0(0)	0(0)	0(0)
Hydropsyche oslari	8(3)	0(0)	135(134)	325(301)
Hydropsyche occidentalis	0(0)	0(0)	25(24)	0(0)
Cheumatopsyche sp.	0(0)	0(0)	21(13)	6(11)
small Hydropsychidae	9(13)	0(0)	171(89)	433(584)
Rhyacophilidae				
Rhyacophila bifila	0(0)	0(0)	1(2)	0(0)
Glossosomatidae				
Glossosoma sp.	0(0)	0(0)	13(6)	40(35)
Glossosoma pupae	0(0)	0(0)	3(3)	0(0)
Hydroptilidae				
Hydroptila sp.	55(38)	80(28)	8(14)	378(359)
Brachycentridae				
Brachycentrus sp.	7(5)	40(27)	7(5)	9(9)
Lepidostomatidae				
Lepidostoma sp.	1(2)	0(0)	9(16)	28(48)
Limnephilidae				
Onocosmoecus sp.	0(0)	0(0)	1(2)	0(0)
Leptoceridae				
Ceraclea sp.	2(3)	9(9)	0(0)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	0(0)	0(0)	24(0)	0(0)
Optioservus quadrimaculatus	0(0)	28(40)	2(3)	37(32)

MARCH (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Haliplidae				
Haliplus sp.	0(0)	3(5)	0(0)	0(0)
DIPTERA				
Tipulidae				
Hexatoma sp.	0(0)	3(5)	0(0)	0(0)
Antocha sp.	4(2)	3(5)	19(20)	43(67)
Empididae				
Hemerodromia sp.	0(0)	9(16)	0(0)	0(0)
Simuliidae				
Simulium sp.	3,334(1,631)	4,506(1,099)	5,358(5,960)	424(275)
Simulium pupae	95(90)	0(0)	33(29)	0(0)
Chironomidae				
larvae	10,061(4,662)	11,897(2,897)	3,574(2,189)	25,497(36,088)
pupae	548(234)	1,099(251)	122(204)	337(423)
adults	83(81)	0(0)	92(116)	3(5)
OTHER INVERTEBRATES				
Turbellaria	98(128)	62(37)	477(515)	241(265)
Nematoda	69(80)	260(167)	63(35)	164(183)
Oligochaeta				
Lumbriculidae	4(5)	18(9)	14(14)	31(30)
Naididae	40(37)	272(343)	50(81)	0(0)
Hydracarina	24(42)	49(86)	0(0)	0(0)
Gastropoda				
Lymnaea sp.	31(2)	152(135)	37(31)	164(157)
Gyraulus sp.	5(9)	0(0)	0(0)	0(0)

MARCH, 1980

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
EPHEMEROPTERA				
Siphlonuridae				
Ameletus cooki	0(0)	0(0)	4(5)	0(0)
Baetidae				
Baetis tricaudatus	4,830(2,284)	1,676(139)	1,334(782)	319(371)
Baetis hageni	1(2)	0(0)	298(139)	0(0)
Heptageniidae				
Rhithrogena hageni	33(3)	9(3)	803(146)	749(291)
Cinygmula sp.	2(3)	1(2)	11(12)	0(0)
Epeorus sp.	246(363)	69(37)	765(90)	228(148)
Ephemerellidae				
Drunella doddsi	2(3)	0(0)	35(35)	19(24)
Ephemerella inermis	393(285)	155(15)	716(436)	328(193)
Drunella flavilinea	97(65)	72(60)	578(219)	307(216)
Caudatella heterocaudata	102(44)	33(24)	72(63)	0(0)
Drunella spinifera	0(0)	0(0)	1(2)	0(0)
Leptophlebiidae				
Paraleptophlebia heteronea	25(38)	10(12)	75(39)	130(158)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	0(0)	1(2)	2(2)	3(5)
Pteronarcella badia	0(0)	1(2)	0(0)	0(0)
Taeniopterygidae				
Taenionema pacificum	0(0)	1(2)	130(93)	111(98)
Capniidae				
Capnia sp.	0(0)	1(2)	0(0)	12(14)
Isocapnia sp.	0(0)	1(2)	20(18)	0(0)

MARCH (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Perlidae				
Classenia sabulosa	1(2)	0(0)	11(5)	0(0)
Calineuria californica	0(0)	0(0)	50(15)	43(39)
small Perlidae	0(0)	0(0)	8(14)	0(0)
Perlodidae				
Isoperla fulva	0(0)	0(0)	5(6)	3(5)
Diura sp.	0(0)	0(0)	1(2)	6(5)
Perlinoides aurea	0(0)	0(0)	1(2)	3(5)
Chloroperlidae				
Sweltsa coloradensis	4(3)	0(0)	382(257)	241(121)
Suwallia pallidula	1(2)	1(2)	0(0)	40(38)
small Chloroperlidae	0(0)	2(2)	168(168)	9(0)
TRICHOPTERA				
Hydropsychidae				
Arctopsyche grandis	1(2)	15(13)	0(0)	12(21)
Hydropsyche cockerelli	2(2)	2(2)	0(0)	0(0)
Hydropsyche oslari	365(456)	269(236)	0(0)	0(0)
Hydropsyche occidentalis	328(405)	391(348)	184(155)	133(125)
Cheumatopsyche sp.	34(27)	53(44)	71(33)	53(51)
small Hydropsychidae	1,628(2,551)	851(831)	241(415)	46(65)
Rhyacophilidae				
Rhyacophila bifila	4(3)	5(4)	1(2)	0(0)
Rhyacophila pupae	1(2)	0(0)	0(0)	0(0)
Glossosomatidae				
Glossosoma sp.	14(11)	37(56)	131(82)	121(169)
Hydroptilidae				
Hydroptila sp.	67(96)	38(66)	0(0)	0(0)

MARCH (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Brachycentridae				
Brachycentrus sp.	142(61)	58(37)	50(64)	12(11)
Brachycentrus pupae	2(3)	0(0)	0(0)	0(0)
Lepidostomatidae				
Lepidostoma sp.	6(10)	5(6)	247(157)	118(23)
Leptoceridae				
Ceraclea sp.	0(0)	9(13)	0(0)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	1(2)	0(0)	216(194)	77(38)
Zaitzevia parvula adults	0(0)	0(0)	22(26)	3(5)
Optioservus quadrimaculatus	42(42)	4(3)	92(33)	65(58)
Narpus sp.	0(0)	1(2)	1(2)	0(0)
Haliplidae				
Brychius sp.	2(2)	0(0)	0(0)	0(0)
DIPTERA				
Tipulidae				
Hexatoma sp.	2(3)	0(0)	73(25)	31(39)
Antocha sp.	144(68)	102(29)	80(92)	34(23)
Psychodidae				
Pericoma sp.	0(0)	0(0)	1(2)	0(0)
Athericidae				
Atherix variegata	0(0)	0(0)	1(2)	3(5)
Empididae				
Hemerodromia sp.	0(0)	0(0)	4(7)	28(48)
Simuliidae				
Simulium sp.	1,993(430)	602(437)	442(316)	241(274)
Simulium pupae	140(211)	0(0)	0(0)	0(0)

MARCH (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Chironomidae				
larvae	13,495(8,277)	8,545(3,165)	3,800(1,275)	347(169)
pupae	404(334)	107(128)	34(15)	28(24)
adults	1,014(488)	57(61)	18(17)	0(0)
Tabanidae	0(0)	0(0)	1(2)	0(0)
OTHER INVERTEBRATES				
Turbellaria	564(404)	201(134)	59(38)	3(5)
Nematoda	222(78)	128(51)	8(14)	0(0)
Oligochaeta				
Lumbriculidae	146(120)	55(30)	705(865)	604(903)
Naididae	385(410)	544(273)	0(0)	0(0)
Hydracarina	25(41)	0(0)	24(24)	37(37)
Gastropoda				
Lymnaea sp.	19(28)	8(4)	0(0)	0(0)
Gyraulus sp.	0(0)	0(0)	0(0)	0(0)

APRIL, 1980

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
COLLEMBOLA	8(14)	----	----	----
EPHEMEROPTERA				
Siphlonuridae				
small Siphlonuridae	8(14)	----	----	----
Baetidae				
Baetis tricaudatus	705(636)	2,892(1,819)	1,150(479)	3,286(4,692)
Baetis hageni			8(14)	
Heptageniidae				
Rhithrogena hageni	----	----	----	25(43)
Ephemerellidae				
Ephemerella inermis	1,963(694)	17,459(6,168)	741(439)	2,524(1,122)
Drunella flavilinea	8(14)	----	131(143)	161(135)
Caudatella heterocaudata	16(14)	50(43)	195(232)	415(355)
Leptophlebiidae				
Paraleptophlebia heteronea	----	----	----	3(5)
PLECOPTERA				
Pteronarcidae				
Pteronarcella badia	----	----	1(2)	----
Chloroperlidae				
Sweltsa coloradensis	----	----	1(2)	15(14)
small Chloroperlidae	----	25(43)	----	----
TRICHOPTERA				
Hydropsychidae				
Hydropsyche oslari	2(3)	22(14)	25(26)	34(21)
Hydropsyche occidentalis	----	3(5)	8(7)	37(43)
Cheumatopsyche sp.	----	----	2(2)	----
small Hydropsychidae	----	----	10(12)	12(14)

APRIL (Continued)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Glossosomatidae				
Glossosoma sp.	----	----	2(2)	6(11)
Glossosoma pupae	----	----	11(14)	19(16)
Hydroptilidae				
Aydroptila sp.	10(7)	46(64)	47(49)	164(88)
Brachycentridae				
Brachycentrus larvae	5(4)	6(11)	----	6(11)
Brachycentrus pupae	----	----	4(7)	----
Lepidostomatidae				
Lepidostoma sp.	----	----	1(2)	3(5)
Leptoceridae				
Ceraclea sp.	5(9)	----	----	----
COLEOPTERA				
Elmidae				
Zaitzevia parvula	1(2)	----	----	----
Optioservus quadrimaculatus	8(14)	25(43)	18(29)	6(11)
DIPTERA				
Tipulidae				
Hexatoma sp.	----	----	----	3(5)
Antocha sp. larvae	----	----	22(31)	50(78)
Antocha pupae	----	----	----	15(5)
Simuliidae				
Simulium sp.	304(106)	1,050(337)	921(662)	2,610(4,441)
Simulium pupae	88(37)	325(98)	104(72)	706(958)
Chironomidae				
Chironomidae larvae	12,513(5,758)	23,866(17,830)	4,708(2,696)	2,059(478)
Chironomidae pupae	519(307)	2,508(1,571)	268(130)	359(288)
Chironomidae adults	149(75)	177(177)	252(239)	3(5)

APRIL (Continued)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
OTHER INVERTEBRATES				
Turbellaria	6(8)	37(40)	380(72)	536(149)
Nematoda	13(12)	545(269)	126(120)	554(169)
Oligochaeta				
Lumbriculidae	----	----	27(25)	139(174)
Naididae	112(194)	173(239)	65(38)	204(338)
Mollusca				
Lymnaea sp.	16(12)	133(107)	16(12)	124(44)
Gyraulus sp.	2(3)	31(46)	----	3(5)

MAY, 1980

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
COLLEMBOLA	0(0)	0(0)	1(2)	0(0)
EPHEMEROPTERA				
Baetidae				
Baetis tricaudatus	298(215)	399(276)	2,125(942)	3,100(1,596)
Heptageniidae				
Rhithrogena hageni	0(0)	3(5)	39(32)	87(70)
Cinygmula sp.	0(0)	12(14)	2(2)	0(0)
Ephemerellidae				
Ephemerella inermis	2,904(810)	17,899(2,946)	1,501(161)	3,608(1,316)
Drunella flavilinea	0(0)	0(0)	182(94)	189(167)
Caudatella heterocaudata	10(15)	0(0)	389(135)	322(308)
Serratella tibialis	24(42)	0(0)	225(183)	46(33)
Leptophlebiidae				
Paraleptophlebia heteronea	0(0)	0(0)	8(14)	0(0)
PLECOPTERA				
Perlodidae				
Isoperla patricia	1(2)	0(0)	0(0)	0(0)
Chloroperlidae				
Sweltsa coloradensis	0(0)	3(5)	2(2)	0(0)
Suwallia pallidula	0(0)	0(0)	1(2)	3(5)
Small Chloroperlidae	0(0)	3(5)	0(0)	0(0)
TRICHOPTERA				
Hydropsychidae				
Arctopsyche grandis	0(0)	0(0)	0(0)	12(21)
Hydropsyche oslari	1(2)	34(44)	329(464)	294(115)
Hydropsyche occidentalis	1(2)	0(0)	169(269)	133(102)
Cheumatopsyche sp.	0(0)	0(0)	5(6)	40(54)
small Hydropsychidae	1(2)	3(5)	4(7)	99(19)

MAY (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Rhyacophilidae				
Rhyacophila bifila	0(0)	0(0)	2(2)	3(5)
Glossosomatidae				
Glossosoma sp.	0(0)	0(0)	59(29)	37(40)
Glossosoma sp. pupae	0(0)	0(0)	58(81)	62(67)
Hydroptilidae				
Hydroptila sp.	15(11)	68(51)	95(92)	115(121)
Brachycentridae				
Brachycentrus sp.	1(2)	12(5)	0(0)	6(5)
Brachycentrus pupae	1(2)	0(0)	3(5)	0(0)
Brachycentrus adults	0(0)	0(0)	6(10)	0(0)
Lepidostomatidae				
Lepidostoma sp.	0(0)	0(0)	5(6)	6(11)
Limnephilidae				
Psychoglypha sp.	0(0)	0(0)	1(2)	0(0)
Leptoceridae				
Ceraclea sp.	8(14)	6(5)	0(0)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	0(0)	0(0)	2(2)	0(0)
Optioservus quadrimaculatus	0(0)	0(0)	42(26)	99(81)
Narpus sp.	0(0)	0(0)	0(0)	15(19)
Haliplidae				
Haliplus sp.	0(0)	3(5)	0(0)	0(0)
DIPTERA				
Tipulidae				
Hexatoma sp.	0(0)	0(0)	1(2)	28(48)
Antocha sp.	0(0)	0(0)	52(80)	3(5)
Antocha adults	0(0)	0(0)	12(10)	3(5)

MAY, (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n-3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Ceratopogonidae	0(0)	0(0)	0(0)	34(59)
Simuliidae				
Simulium sp.	2(2)	105(103)	1,295(788)	201(230)
Simulium sp. pupae	93(151)	765(262)	2,241(2,083)	1,093(1,235)
Simulium sp. adults	4(5)	3(5)	86(58)	0(0)
Chironomidae				
larvae	11,906(2,780)	27,471(2,985)	8,232(1,692)	4,509(1,554)
pupae	2,027(1,449)	5,428(414)	1,124(94)	269(147)
adults	413(224)	118(131)	2,828(1,772)	28(40)
Tanyderidae				
Protanyderus sp.	0(0)	25(43)	1(2)	6(11)
OTHER INVERTEBRATES				
Turbellaria	26(24)	68(51)	196(113)	920(581)
Nematoda	17(29)	362(237)	276(174)	666(373)
Oligochaeta				
Lumbriculidae	0(0)	3(5)	16(7)	192(154)
Naididae	114(195)	74(129)	17(15)	115(67)
Hydracarina	0(0)	50(86)	1(2)	0(0)
Mollusca				
Lymnaea sp.	13(5)	251(168)	20(32)	56(9)
Gyraulus sp.	0(0)	34(35)	0(0)	0(0)
Physa sp.	0(0)	3(5)	0(0)	0(0)
Piscicola	0(0)	0(0)	1(2)	0(0)

MAY, 1980

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
EPHEMEROPTERA				
Baetidae				
Baetis tricaudatus	387(161)	244(127)	422(177)	189(48)
Baetis hageni	0(0)	8(14)	14(12)	12(21)
Pseudocleon sp.	96(87)	424(324)	148(143)	3(5)
Heptageniidae				
Epeorus sp.	44(43)	201(141)	119(104)	232(121)
Rhithrogena hageni	27(20)	13(12)	161(44)	300(139)
Cinygmula sp.	3(3)	1(2)	2(2)	0(0)
Ephemerellidae				
Drunella doddsi	0(0)	0(0)	1(2)	0(0)
Drunella spinifera	1(2)	0(0)	0(0)	0(0)
Ephemerella inermis	191(21)	205(37)	105(21)	74(81)
Drunella flavilinea	55(49)	27(18)	51(54)	130(85)
Caudatella heterocaudata	27(34)	63(56)	7(12)	12(21)
Serratella tibialis	129(68)	176(100)	341(287)	25(21)
small Ephemerella sp.	0(0)	1(2)	32(55)	0(0)
Leptophlebiidae				
Paraleptophlebia heteronea	13(5)	15(5)	5(6)	3(5)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	0(0)	0(0)	2(3)	0(0)
Pteronarcella badia	0(0)	0(0)	8(14)	0(0)
Nemouridae				
Prostoia besametsa	9(13)	0(0)	0(0)	0(0)
Perlidae				
Classenia sabulosa	0(0)	0(0)	1(2)	6(5)
Calineuria californica	0(0)	0(0)	6(3)	12(5)
small Perlidae	0(0)	0(0)	2(3)	12(21)

MAY (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Chloroperlidae				
Sweltsa coloradensis	4(2)	0(0)	1(2)	0(0)
Suwallia pallidula	0(0)	0(0)	5(9)	15(5)
small Chloroperlidae	8(14)	0(0)	181(151)	118(126)
TRICHOPTERA				
Hydropsychidae				
Hydropsyche oslari	10(15)	3(3)	1(2)	0(0)
Hydropsyche occidentalis	15(17)	13(11)	77(82)	65(33)
Cheumatopsyche sp.	4(2)	8(14)	8(6)	6(5)
small Hydropsychidae	11(19)	16(14)	12(21)	12(21)
Rhyacophilidae				
Rhyacophila bifila	4(3)	3(3)	4(7)	3(5)
Glossosomatidae				
Glossosoma sp.	3(5)	0(0)	0(0)	0(0)
Hydroptilidae				
Hydroptila sp.	2(3)	49(44)	0(0)	0(0)
Brachycentridae				
Brachycentrus sp.	0(0)	5(6)	40(38)	3(5)
Lepidostomatidae				
Lepidostoma sp.	1(2)	2(2)	180(75)	77(86)
Lepidostoma pupae	0(0)	0(0)	55(67)	34(30)
Limnephilidae				
Neophylax sp.	0(0)	0(0)	11(5)	6(5)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	8(14)	0(0)	16(18)	62(57)
Optioservus quadrimaculatus	143(32)	46(23)	12(12)	25(21)

MAY (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
DIPTERA				
Deuterophlebiidae	0(0)	0(0)	1(2)	12(21)
Tipulidae				
Hexatoma sp.	0(0)	1(2)	20(17)	12(14)
Antocha sp.	4(2)	76(32)	0(0)	0(0)
Antocha pupae	0(0)	90(53)	0(0)	0(0)
Antocha adults	6(6)	0(0)	0(0)	0(0)
Ceratopogonidae	0(0)	0(0)	41(52)	0(0)
Simuliidae				
Simulium sp.	24(32)	40(28)	132(195)	9(16)
Simulium sp. pupae	21(27)	26(35)	0(0)	0(0)
Simulium sp. adults	0(0)	0(0)	0(0)	0(0)
Chironomidae				
larvae	11,813(3,281)	15,317(3,205)	710(815)	399(314)
pupae	855(423)	471(162)	28(39)	81(84)
adults	1,668(1,207)	186(56)	4(7)	6(11)
Athericidae				
Atherix variegata	0(0)	0(0)	1(2)	0(0)
Dolichopodidae	0(0)	0(0)	0(0)	3(5)
Empididae				
Hemerodromia	0(0)	0(0)	0(0)	12(21)
OTHER INVERTEBRATES				
Turbellaria	353(321)	264(23)	12(5)	25(43)
Nematoda	161(55)	317(185)	8(7)	0(0)
Oligochaeta				
Lumbriculidae	688(590)	244(158)	130(186)	861(1,145)
Naididae	472(161)	1,371(878)	116(107)	3(5)
Hydracarina	1(2)	9(16)	12(12)	0(0)
Mollusca				
Lymnaea sp.	27(32)	5(2)	4(7)	0(0)

JUNE, 1980

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
COLLEMBOLA				
EPHEMEROPTERA				
Baetidae				
Baetis tricaudatus	5(5)	0(0)	317(333)	19(16)
Baetis hageni	0(0)	0(0)	1(2)	0(0)
Pseudocleon sp.	0(0)	0(0)	630(992)	81(99)
Heptageniidae				
Epeorus sp.	0(0)	0(0)	1(2)	0(0)
Rhithrogena hageni	2(2)	0(0)	26(40)	0(0)
Cinygmula sp.	0(0)	0(0)	2(3)	0(0)
Ephemerellidae				
Ephemerella inermis	2,567(595)	7,221(686)	1,384(599)	948(756)
Drunella flavilinea	1(2)	0(0)	76(67)	102(57)
Caudatella heterocaudata	0(0)	0(0)	24(18)	111(155)
Serratella tibialis	16(14)	0(0)	1,101(1,097)	811(492)
ODONATA				
Coenagrionidae	1(2)	0(0)	1(2)	0(0)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	0(0)	0(0)	9(13)	0(0)
Chloroperlidae				
Sweltsa coloradensis	8(14)	0(0)	0(0)	0(0)
Suwallia pallidula	0(0)	0(0)	1(2)	3(5)
HEMIPTERA				
Corixidae	0(0)	0(0)	1(2)	0(0)

JUNE (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
TRICHOPTERA				
Hydropsychidae				
Hydropsyche oslari	2(2)	12(14)	37(17)	37(40)
Hydropsyche occidentalis	0(0)	0(0)	15(14)	56(49)
Cheumatopsyche sp.	0(0)	0(0)	15(14)	19(25)
small Hydropsychidae	0(0)	0(0)	9(8)	3(5)
Rhyacophilidae				
Rhyacophila bifila	0(0)	0(0)	2(2)	0(0)
Glossosomatidae				
Glossosoma sp.	0(0)	0(0)	5(9)	25(14)
Glossosoma pupae	0(0)	0(0)	5(5)	0(0)
Hydroptilidae				
Hydroptila sp.	36(11)	68(39)	56(30)	19(32)
Brachycentridae				
Brachycentrus sp.	0(0)	3(6)	57(96)	3(5)
Lepidostomatidae				
Lepidostoma sp.	0(0)	3(6)	0(0)	0(0)
Lepidostoma pupae	0(0)	0(0)	0(0)	3(5)
Leptoceridae				
Ceraclea sp.	2(2)	0(0)	0(0)	0(0)
Ceraclea sp. pupae	1(2)	0(0)	0(0)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	0(0)	0(0)	1(2)	37(37)
Optioservus quadrimaculatus	0(0)	0(0)	10(15)	3(5)
DIPTERA				
Tipulidae				
Antocha sp.	0(0)	0(0)	0(0)	3(5)
Antocha sp. pupae	0(0)	0(0)	2(3)	0(0)

JUNE (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n-3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Simuliidae				
Simulium spp. larvae	310(124)	28(48)	3,559(1,198)	28(25)
Simulium spp. pupae	1(2)	3(6)	8(14)	0(0)
Chironomidae				
larvae	22,835(613)	21,476(284)	11,503(2,802)	3,236(2,040)
pupae	1,442(560)	1,814(668)	552(169)	653(557)
adults	582(211)	118(188)	119(54)	12(5)
Tanyderidae				
Protanyderus sp.	0(0)	0(0)	0(0)	6(5)
OTHER INVERTEBRATES				
Turbellaria	17(13)	62(54)	445(269)	889(836)
Nematoda	110(95)	313(42)	163(144)	142(88)
Oligochaeta				
Lumbriculidae	19(17)	59(44)	203(22)	111(81)
Naididae	449(398)	372(149)	1,315(1,007)	111(134)
Hirudinea				
Piscicola sp.	0(0)	3(6)	1(2)	0(0)
Hydracarina	8(14)	0(0)	17(29)	0(0)
Mollusca				
Lymnaea sp.	13(6)	202(117)	58(57)	149(121)
Gyraulus sp.	4(2)	3(6)	0(0)	0(0)

JUNE (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
EMPHEROPTERA				
Baetidae				
Baetis tricaudatus	104(61)	198(195)	24(21)	9(9)
Baetis hageni	1(2)	5(6)	17(27)	0(0)
Pseudocleon sp.	491(257)	349(304)	255(98)	102(67)
Heptageniidae				
Epeorus sp.	13(12)	70(61)	17(11)	34(59)
Rhithrogena hageni	59(28)	23(15)	23(10)	53(44)
Cinygmula sp.	14(17)	17(15)	4(7)	0(0)
Ephemerellidae				
Drunella doddsi	0(0)	0(0)	1(2)	0(0)
Ephemerella inermis	279(208)	66(48)	20(27)	6(11)
Drunella flavilinea	37(29)	20(3)	5(6)	3(5)
Caudatella heterocaudata	12(8)	31(29)	0(0)	0(0)
Serratella tibialis	447(291)	189(94)	24(24)	28(40)
small Ephemerella sp.	0(0)	4(7)	0(0)	0(0)
Leptophlebiidae				
Paraleptophlebia heteronea	2(2)	5(6)	2(3)	3(5)
ODONATA				
Coenagrionidae	1(2)	0(0)	0(0)	0(0)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	0(0)	0(0)	1(2)	0(0)
Pteronarcella badia	0(0)	0(0)	1(2)	0(0)
Chloroperlidae				
Sweltsa coloradensis	0(0)	0(0)	0(0)	12(21)
Suwallia pallidula	1(2)	1(2)	21(20)	50(78)
small Chloroperlidae	9(13)	0(0)	4(7)	0(0)

JUNE (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
HEMIPTERA				
Corixidae	1(2)	0(0)	0(0)	0(0)
TRICHOPTERA				
Hydropsychidae				
Arctopsyche grandis	0(0)	0(0)	9(8)	0(0)
Hydropsyche oslari	22(14)	8(6)	0(0)	0(0)
Hydropsyche occidentalis	21(18)	11(11)	0(0)	0(0)
Cheumatopsyche sp.	8(6)	3(3)	0(0)	3(5)
small Hydropsychidae	10(15)	1(2)	0(0)	0(0)
Hydropsychidae pupae	1(2)	0(0)	0(0)	0(0)
Hydroptilidae				
Hydroptila sp.	8(14)	6(3)	8(14)	0(0)
Brachycentridae				
Brachycentrus sp.	3(0)	2(3)	0(0)	0(0)
Brachycentrus pupae	0(0)	0(0)	1(2)	9(16)
Brachycentrus adults	0(0)	0(0)	3(5)	0(0)
Lepidostomatidae				
Lepidostoma sp.	0(0)	1(2)	8(6)	0(0)
Limnephilidae				
Neophylax sp.	0(0)	1(2)	0(0)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	0(0)	0(0)	28(14)	87(142)
Optioservus quadrimaculatus	1(2)	0(0)	12(0)	0(0)
DIPTERA				
Tipulidae				
Hexatoma sp.	1(2)	0(0)	15(11)	65(33)
Antocha sp.	0(0)	6(11)	0(0)	0(0)
Antocha pupae	0(0)	15(27)	0(0)	0(0)

JUNE (Cont.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Psychodidae				
Pericoma sp.	0(0)	0(0)	1(2)	0(0)
Ceratopogonidae	0(0)	5(6)	0(0)	0(0)
Simuliidae				
Simulium spp. larve	222(291)	238(341)	16(18)	0(0)
Chironomidae				
larvae	7,160(4,698)	7,407(4,921)	144(53)	121(46)
pupae	663(459)	174(27)	21(34)	37(37)
adults	379(109)	52(47)	8(14)	0(0)
Tanyderidae				
Protanyderus sp.	1(2)	0(0)	0(0)	0(0)
Dolichopodidae	0(0)	0(0)	0(0)	3(5)
OTHER INVERTEBRATES				
Turbellaria	132(59)	181(54)	0(0)	0(0)
Nematoda	1(2)	8(7)	38(14)	0(0)
Oligochaeta				
Lumbriculidae	357(362)	167(33)	60(0)	6(5)
Naididae	1,082(513)	663(547)	9(13)	0(0)
Mollusca				
Lymnaea sp.	47(74)	53(84)	0(0)	0(0)

JULY, 1980

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
EPHEMEROPTERA				
Baetidae				
Baetis tricaudatus	494(347)	765(239)	2,560(748)	1,982(1,247)
Pseudocleon sp.	0(0)	0(0)	662(338)	808(90)
Heptageniidae				
Epeorus sp.	0(0)	0(0)	0(0)	3(5)
Rhithrogena hageni	0(0)	0(0)	9(16)	0(0)
Cinygmula sp.	0(0)	0(0)	36(12)	0(0)
Ephemerellidae				
Ephemerella inermis	816(186)	1,136(294)	145(29)	71(33)
Drunella flavilinea	0(0)	0(0)	53(23)	108(98)
Caudatella heterocaudata	0(0)	0(0)	42(56)	37(37)
Serratella tibialis	27(29)	47(73)	1,099(260)	3,478(2,019)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	0(0)	0(0)	2(2)	3(5)
Chloroperlidae				
Sweltsa coloradensis	1(2)	0(0)	3(3)	0(0)
Suwallia pallidula	0(0)	25(43)	2(2)	37(48)
TRICHOPTERA				
Hydropsychidae				
Arctopsyche grandis	0(0)	0(0)	0(0)	0(0)
Hydropsyche oslari	1(2)	0(0)	45(23)	127(48)
Hydropsyche occidentalis	0(0)	0(0)	39(52)	93(83)
Cheumatopsyche sp.	0(0)	0(0)	16(12)	43(60)
small Hydropsychidae	0(0)	0(0)	8(14)	40(70)
Hydropsychidae pupae	0(0)	0(0)	23(23)	3(5)

JULY (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Glossosomatidae				
Glossosoma sp.	0(0)	0(0)	28(32)	77(86)
Hydroptilidae				
Hydroptila sp.	31(2)	99(84)	38(33)	40(54)
Brachycentridae				
Brachycentrus sp.	17(12)	3(6)	51(42)	198(224)
Lepidostomatidae				
Lepidostoma sp.	0(0)	0(0)	3(3)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	0(0)	0(0)	2(3)	0(0)
Optioservus quadrimaculatus	1(2)	3(6)	32(9)	105(94)
Narpus sp.	0(0)	0(0)	0(0)	3(5)
Haliplidae				
Brychius sp.	0(0)	1(2)	0(0)	0(0)
DIPTERA				
Tipulidae				
Hexatoma sp.	0(0)	0(0)	0(0)	15(19)
Antocha sp.	0(0)	0(0)	2(2)	3(5)
Ceratopogonidae	0(0)	0(0)	11(12)	0(0)
Simuliidae				
Simulium sp. larvae	822(232)	1,316(893)	1,060(367)	718(535)
Simulium sp. pupae	241(233)	421(111)	49(47)	180(115)
Chironomidae				
larvae	17,574(702)	22,906(1,709)	12,063(3,504)	4,958(1,322)
pupae	1,412(329)	1,607(202)	771(174)	505(293)
adults	430(187)	34(44)	556(450)	53(46)

JULY (Cont.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Tanyderidae				
Protanyderus sp.	0(0)	0(0)	1(2)	3(5)
OTHER INVERTEBRATES				
Turbellaria	16(12)	239(99)	458(144)	1,096(267)
Nematoda	43(47)	272(432)	262(107)	204(110)
Oligochaeta				
Lumbriculidae	11(14)	9(9)	7(5)	31(30)
Naididae	1,044(584)	1,709(609)	534(226)	319(71)
Hydracarina	8(14)	0(0)	35(12)	25(43)
Mollusca				
Lymnaea sp.	133(107)	151(199)	27(29)	50(51)
Gyraulus sp.	5(6)	7(6)	0(0)	0(0)

JULY, 1980

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
COLLEMBOLA	0(0)	0(0)	17(29)	8(14)
EPHEMEROPTERA				
Siphlonuridae				
small Siphlonuridae	0(0)	0(0)	16(28)	0(0)
Baetidae				
Baetis tricaudatus	2,790(2,528)	1,193(454)	1,181(640)	338(346)
Baetis bicaudatus	0(0)	0(0)	0(0)	3(5)
Baetis hageni	0(0)	0(0)	65(39)	0(0)
Pseudocleon sp.	220(215)	149(80)	1,329(278)	269(225)
Heptageniidae				
Epeorus sp.	74(105)	23(20)	187(35)	65(28)
Rhithrogena hageni	41(35)	10(6)	679(585)	499(445)
Cinygmula sp.	18(31)	1(2)	74(90)	0(0)
Nixe criddlei	0(0)	0(0)	210(179)	238(285)
Ephemerellidae				
Drunella doddsi	0(0)	8(14)	142(92)	62(77)
Ephemerella inermis	5(2)	2(3)	41(71)	0(0)
Drunella flavilinea	39(13)	33(14)	70(36)	19(16)
Caudatella heterocaudata	15(15)	3(5)	1(2)	0(0)
Serratella tibialis	1,091(316)	545(87)	537(153)	71(53)
Attenuatella margarita	0(0)	0(0)	33(29)	25(43)
Leptophlebiidae				
Paraleptophlebia heteronea	0(0)	0(0)	1(2)	0(0)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	1(2)	0(0)	28(26)	0(0)
Pteronarcella badia	0(0)	0(0)	16(14)	12(21)
Nemouridae				
Zapada cinctipes	0(0)	0(0)	12(12)	0(0)

JULY (CONT.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Perlidae				
Classenia sabulosa	0(0)	1(2)	5(3)	19(25)
Hesperoperla pacifica	1(2)	0(0)	18(16)	0(0)
Calineuria californica	0(0)	0(0)	13(3)	28(32)
small Perlidae	0(0)	17(27)	25(23)	12(21)
Perlodidae				
Skwala parallela	0(0)	0(0)	21(20)	0(0)
Diura sp.	0(0)	0(0)	4(7)	0(0)
small Perlodidae	0(0)	0(0)	78(57)	0(0)
Chloroperlidae				
Sweltsa coloradensis	6(8)	1(2)	758(848)	446(502)
Suwallia pallidula	10(17)	0(0)	13(8)	136(70)
small Chloroperlidae	25(43)	0(0)	4(7)	0(0)
HEMIPTERA				
Corixidae	0(0)	0(0)	1(2)	0(0)
TRICHOPTERA				
Philopotamidae				
Wormalidia sp.	0(0)	0(0)	17(22)	0(0)
Hydropsychidae				
Arctopsyche grandis	9(16)	0(0)	139(59)	12(11)
Hydropsyche oslari	20(17)	8(6)	0(0)	0(0)
Hydropsyche cockerelli	1(2)	0(0)	0(0)	0(0)
Hydropsyche occidentalis	183(129)	99(27)	65(29)	1(2)
Cheumatopsyche sp.	13(11)	7(10)	3(3)	0(0)
small Hydropsychidae	0(0)	0(0)	65(15)	50(21)
Hydropsychidae pupae	125(107)	47(20)	24(28)	9(9)
Rhyacophilidae				
Rhyacophila angelita	0(0)	0(0)	15(16)	3(5)

JULY (CONT.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Glossosomatidae				
Glossosoma sp.	0(0)	0(0)	51(51)	50(43)
Hydroptilidae				
Hydroptila sp.	3(3)	5(5)	1(2)	0(0)
Brachycentridae				
Brachycentrus sp.	50(65)	27(18)	264(183)	9(0)
Lepidostomatidae				
Lepidostoma sp.	1(2)	0(0)	7(10)	90(79)
Limnephilidae				
Onocosmoecus sp.	0(0)	0(0)	1(2)	0(0)
Leptoceridae				
Ceraclea sp.	8(14)	0(0)	0(0)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	9(13)	0(0)	130(178)	356(321)
Zaitzevia parvula adults	0(0)	0(0)	42(73)	28(48)
Optioservus quadrimaculatus	11(14)	1(2)	86(102)	37(34)
Optioservus quadrimaculatus adults	0(0)	0(0)	12(12)	0(0)
Narpus sp.	0(0)	0(0)	26(24)	37(64)
DIPTERA				
Tipulidae				
Hexatoma sp.	3(3)	1(2)	25(17)	15(19)
Antocha sp.	32(50)	19(17)	50(71)	6(5)
Ceratopogonidae	0(0)	0(0)	4(7)	12(21)

JULY (CONT.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Simuliidae				
Simulium sp. larvae	1,437(451)	563(367)	610(547)	62(43)
Simulium sp. pupae	27(9)	34(49)	19(28)	0(0)
Chironomidae				
larvae	6,355(1,693)	4,678(1,279)	3,999(2,536)	864(436)
pupae	270(306)	123(50)	109(38)	93(98)
adults	164(135)	48(29)	89(120)	3(5)
Tabanidae	0(0)	0(0)	2(3)	0(0)
Empididae				
Chelifera sp.	0(0)	0(0)	0(0)	3(5)
OTHER INVERTEBRATES				
Turbellaria	733(423)	486(617)	42(16)	22(23)
Nematoda	221(92)	133(101)	118(64)	34(33)
Oligochaeta				
Lumbriculidae	271(86)	106(63)	51(44)	77(97)
Naididae	815(745)	738(258)	12(12)	0(0)
Hydracarina	8(14)	0(0)	60(32)	62(57)
Mollusca				
Lymnaea sp.	8(14)	1(2)	0(0)	0(0)

AUGUST, 1980

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
COLLEMBOLA	16(28)	0(0)	0(0)	3(5)
EPHEMEROPTERA				
Baetidae				
Baetis tricaudatus	223(30)	56(48)	1,022(547)	1,805(353)
Baetis hageni	1(2)	0(0)	0(0)	0(0)
Pseudocleon sp.	267(148)	251(204)	2,331(668)	1,164(508)
Heptageniidae				
Rhithrogena hageni	24(42)	28(48)	10(15)	12(11)
Rhithrogena robusta	0(0)	0(0)	0(0)	0(0)
Cinygmula sp.	0(0)	0(0)	2(3)	0(0)
Nixe criddlei	0(0)	0(0)	63(82)	12(5)
Ephemerellidae				
Ephemerella inermis	53(51)	84(16)	127(94)	96(27)
Drunella flavilinea	0(0)	0(0)	171(231)	9(9)
Serratella tibialis	15(18)	7(11)	703(256)	1,301(1,076)
Caudatella heterocaudata	0(0)	3(5)	0(0)	0(0)
Leptophlebiidae				
Paraleptophlebia heteronea	0(0)	6(11)	0(0)	0(0)
ODONATA				
Zygoptera	0(0)	0(0)	1(2)	0(0)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	0(0)	0(0)	2(2)	6(11)
Pteronarcella badia	0(0)	0(0)	0(0)	3(5)
Nemouridae				
Zapada cinctipes	0(0)	0(0)	0(0)	0(0)
Capniidae				
small Capniidae	0(0)	0(0)	0(0)	0(0)

AUGUST (CONT.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Perlidae				
Classenia sabulosa	0(0)	0(0)	2(3)	0(0)
Chloroperlidae				
Sweltsa coloradensis	0(0)	3(5)	2(2)	0(0)
Suwallia sp.	2(4)	0(0)	26(22)	15(19)
TRICHOPTERA				
Hydropsychidae				
Hydropsyche oslari	0(0)	0(0)	16(28)	0(0)
Hydropsyche occidentalis	0(0)	0(0)	45(49)	9(16)
Cheumatopsyche sp.	0(0)	0(0)	10(17)	6(11)
small Hydropsychidae	16(28)	0(0)	409(215)	449(75)
Hydropsychidae pupae	0(0)	0(0)	2(3)	0(0)
Glossosomatidae				
Glossosoma sp.	0(0)	0(0)	1(2)	0(0)
Glossosoma pupae	0(0)	0(0)	12(18)	6(11)
Hydroptilidae				
Hydroptila sp.	7(10)	31(28)	34(23)	115(30)
Brachycentridae				
Brachycentrus sp.	2(2)	0(0)	460(259)	1,149(764)
Brachycentrus pupae	0(0)	0(0)	1(2)	0(0)
Lepidostomatidae				
Lepidostoma sp.	8(14)	0(0)	0(0)	0(0)
Leptoceridae				
Ceraclea sp.	1(2)	3(5)	1(2)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	0(0)	0(0)	2(2)	53(83)

AUGUST (CONT.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Elmidae				
Zaitzevia parvula adults	0(0)	0(0)	0(0)	0(0)
Optioservus quadrimaculatus	10(17)	12(14)	21(34)	87(84)
Narpus sp.	0(0)	0(0)	2(2)	0(0)
DIPTERA				
Tipulidae				
Hexatoma sp.	0(0)	0(0)	4(7)	0(0)
Antocha sp.	0(0)	0(0)	3(3)	25(43)
Antocha pupae	0(0)	0(0)	1(2)	0(0)
Simuliidae				
Simulium sp. larvae	1,671(1,008)	245(189)	1,914(1,183)	434(332)
Simulium sp. pupae	29(24)	3(5)	11(5)	31(38)
Simulium sp. adults	1(2)	0(0)	7(6)	1(2)
Chironomidae				
larvae	15,423(5,432)	16,428(2,744)	7,085(665)	8,810(8,009)
pupae	546(125)	1,059(293)	613(90)	198(38)
adults	57(28)	0(0)	3,053(2,220)	28(40)
OTHER INVERTEBRATES				
Turbellaria	71(50)	68(72)	986(481)	1,722(804)
Nematoda	135(65)	217(121)	188(80)	177(33)
Oligochaeta				
Lumbriculidae	408(291)	217(99)	118(97)	248(48)
Naididae	4,487(2,431)	2,818(2,416)	395(160)	632(418)
Hirudinea				
Piscicola	0(0)	0(0)	0(0)	3(5)
Mollusca				
Lymnaea sp.	270(207)	365(194)	145(139)	180(295)
Gyraulus sp.	5(5)	6(5)	0(0)	0(0)
Hydracarina	35(31)	77(79)	73(40)	74(0)

AUGUST, 1980

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
EPHEMEROPTERA				
Siphlonuridae				
small Siphlonuridae	1(2)	0(0)	32(37)	0(0)
Baetidae				
Baetis tricaudatus	1,760(747)	1,635(1,007)	5,467(2,011)	1,356(214)
Baetis hageni	0(0)	0(0)	145(17)	111(107)
Pseudocleon sp.	442(93)	1,026(411)	2,552(812)	886(127)
Heptageniidae				
Epeorus sp.	18(3)	6(8)	254(162)	1(2)
Rhithrogena hageni	0(0)	84(79)	1,429(447)	1,053(237)
Rhithrogena robusta	0(0)	0(0)	1(2)	0(0)
Cinygmula sp.	0(0)	0(0)	304(113)	12(21)
Nixe criddlei	0(0)	1(2)	11(6)	84(113)
Ephemerellidae				
Drunella doddsi	0(0)	2(2)	128(61)	50(14)
Ephemerella inermis	3(0)	56(50)	212(215)	12(21)
Drunella flavilinea	2(2)	0(0)	0(0)	0(0)
Serratella tibialis	393(204)	127(105)	80(60)	56(25)
Attenuatella margarita	0(0)	0(0)	240(416)	19(32)
Leptophlebiidae				
Paraleptophlebia heteronea	0(0)	0(0)	117(79)	84(61)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	3(3)	1(2)	7(3)	1(2)
Pteronarcella badia	1(2)	0(0)	4(2)	0(0)
Nemouridae				
Zapada cinctipes	0(0)	0(0)	8(14)	0(0)
Capniidae				
small Capniidae	0(0)	8(14)	24(42)	0(0)

AUGUST (CONT.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Perlidae				
Classenia sabulosa	0(0)	0(0)	19(14)	34(28)
Hesperoperla pacifica	1(2)	0(0)	5(5)	0(0)
Calineuria californica	0(0)	0(0)	34(15)	46(9)
small Perlidae	0(0)	8(14)	2(3)	12(21)
Perlodidae				
Isoperla fulva	0(0)	0(0)	66(57)	6(11)
Skwala parallela	0(0)	0(0)	29(23)	34(23)
Diura sp.	0(0)	0(0)	7(10)	6(5)
Perlinodes aurea	0(0)	0(0)	1(2)	9(9)
small Perlodidae	0(0)	0(0)	8(14)	0(0)
Chloroperlidae				
Sweltsa coloradensis	0(0)	0(0)	543(216)	653(263)
Suwallia sp.	14(3)	15(14)	20(21)	25(14)
small Chloroperlidae	4(5)	8(14)	18(26)	0(0)
TRICHOPTERA				
Philopotamidae				
Wormaldia sp.	0(0)	0(0)	8(6)	0(0)
Hydropsychidae				
Arctopsyche grandis	3(5)	0(0)	74(2)	25(23)
Hydropsyche oslari	16(14)	0(0)	0(0)	25(23)
Hydropsyche cockerelli	5(7)	0(0)	0(0)	3(5)
Hydropsyche occidentalis	1(2)	26(24)	1,745(1,243)	353(159)
Cheumatopsyche sp.	0(0)	1(2)	79(51)	87(77)
small Hydropsychidae	576(277)	1,937(1,075)	2,658(1,487)	263(38)
Hydropsychidae pupae	19(18)	4(5)	0(0)	0(0)
Rhyacophilidae				
Rhyacophila bifila	0(0)	0(0)	30(25)	15(27)
Rhyacophila angelita pupae	0(0)	0(0)	1(2)	0(0)

AUGUST (CONT.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Glossosomatidae				
Glossosoma sp.	0(0)	2(2)	308(233)	77(38)
Glossosoma pupae	7(8)	0(0)	5(6)	0(0)
Hydroptilidae				
Hydroptila sp.	16(18)	43(38)	0(0)	0(0)
Brachycentridae				
Brachycentrus sp.	215(174)	114(132)	52(56)	28(25)
Brachycentrus pupae	0(0)	3(3)	14(11)	25(35)
Lepidostomatidae				
Lepidostoma sp.	0(0)	0(0)	163(111)	653(494)
Leptoceridae				
Ceraclea sp.	0(0)	8(14)	0(0)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	1(2)	9(13)	467(312)	365(247)
Zaitzevia parvula adults	0(0)	1(2)	69(65)	12(5)
Optioservus quadrimaculatus	59(92)	4(5)	208(125)	102(40)
Optioservus quadrimaculatus adults	0(0)	0(0)	33(55)	3(5)
Narpus sp.	0(0)	0(0)	4(7)	0(0)
DIPTERA				
Tipulidae				
Hexatoma sp.	0(0)	0(0)	50(18)	59(14)
Antocha sp.	0(0)	19(33)	57(20)	12(14)
Antocha sp. pupae	0(0)	0(0)	4(3)	0(0)
Tipula sp.	0(0)	0(0)	0(0)	12(21)
Ceratopogonidae	0(0)	0(0)	8(14)	25(21)

AUGUST (CONT.)

	Pipe Creek		Fisher River	
	Kick *n*=3 $\bar{x}$(s.d.)	Circular *n*=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Simuliidae				
Simulium sp. larvae	2,050(881)	962(635)	3,147(2,512)	288(324)
Simulium sp. *pupae*	24(8)	7(8)	18(10)	12(21)
Simulium sp. adults	0(0)	0(0)	0(0)	0(0)
Chironomidae				
larvae	3,264(648)	6,211(2,461)	3,506(1,328)	827(137)
pupae	768(783)	435(112)	156(99)	127(78)
adults	1,365(1,983)	1,489(1,573)	108(53)	28(25)
Tabanidae	0(0)	0(0)	1(2)	6(11)
Athericidae				
Atherix variegata	1(2)	0(0)	0(0)	0(0)
Dolichopodidae	0(0)	0(0)	0(0)	3(5)
OTHER INVERTEBRATES				
Turbellaria	1,455(1,119)	266(202)	59(46)	19(16)
Nematoda	217(114)	340(205)	27(26)	0(0)
Oligochaeta				
Lumbriculidae	1,155(650)	63(42)	266(243)	40(11)
Naididae	0(0)	1,982(879)	176(169)	0(0)
Hirudinea				
Piscicola	1(2)	0(0)	0(0)	0(0)
Mollusca				
Lymnaea sp.	16(15)	1(2)	0(0)	0(0)
Gyraulus sp.	0(0)	0(0)	0(0)	0(0)
Hydracarina	8(14)	843(973)	349(286)	616(223)

SEPTEMBER, 1980

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
EPHEMEROPTERA				
Baetidae				
Baetis tricaudatus	1,880(209)	2,737(357)	1,757(576)	1,802(338)
Pseudocleon sp.	381(271)	105(118)	233(70)	273(176)
Heptageniidae				
Rhithrogena hageni	11(14)	0(0)	14(24)	111(94)
Cinygmula sp.	0(0)	0(0)	23(30)	6(11)
Ephemerellidae				
Ephemerella inermis	61(55)	50(51)	212(124)	273(76)
Drunella flavilinea	2(3)	6(11)	0(0)	0(0)
Serratella tibialis	0(0)	3(5)	32(27)	102(70)
Leptophlebiidae				
Paraleptophlebia heteronea	0(0)	28(40)	0(0)	0(0)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	1(2)	0(0)	0(0)	3(5)
Pteronarcella badia	0(0)	0(0)	0(0)	3(5)
Nemouridae				
Zapada cinctipes	0(0)	31(54)	0(0)	0(0)
Perlidae				
Classenia sabulosa	0(0)	0(0)	0(0)	3(5)
Chloroperlidae				
Sweltsa coloradensis	0(0)	0(0)	6(6)	0(0)
Suwallia sp.	0(0)	0(0)	1(2)	3(5)
Hydropsychidae				
Hydropsyche oslari	25(41)	6(5)	117(109)	424(224)
Hydropsyche occidentalis	9(13)	22(38)	377(158)	870(247)
Hydropsyche cockerelli	0(0)	0(0)	1(2)	0(0)
Cheumatopsyche sp.	0(0)	3(5)	92(129)	93(81)
small Hydropsychidae	112(132)	34(35)	1,665(923)	975(378)
Hydropsychidae pupae	0(0)	0(0)	1(2)	9(16)

SEPTEMBER (CONT.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Glossosomatidae				
Glossosoma sp. larvae	0(0)	0(0)	278(138)	486(71)
Hydroptilidae				
Hydroptila sp.	1(2)	0(0)	0(0)	3(5)
Brachycentridae				
Brachycentrus sp.	3(3)	0(0)	140(102)	359(150)
Lepidostomatidae				
Lepidostoma sp.	1(2)	0(0)	8(14)	0(0)
Leptoceridae				
Ceraclea sp.	1(2)	0(0)	0(0)	3(5)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	9(16)	0(0)	2(2)	6(5)
Optioservus quadrimaculatus	3(3)	0(0)	8(9)	25(35)
Narpus sp.	0(0)	0(0)	0(0)	6(5)
DIPTERA				
Tipulidae				
Antocha sp. larvae	0(0)	0(0)	6(3)	6(11)
Hexatoma sp.	0(0)	0(0)	1(2)	0(0)
Ceratopogonidae	0(0)	3(5)	0(0)	0(0)
Simuliidae				
Simulium sp. larvae	2,448(467)	4,868(2,246)	1,042(809)	892(293)
Simulium sp. pupae	146(41)	771(599)	40(32)	170(111)
Simulium sp. adults	8(5)	3(5)	10(17)	0(0)
Chironomidae				
larvae	10,460(3,970)	19,803(4,959)	6,979(385)	5,819(2,336)
pupae	747(193)	1,858(832)	187(104)	508(776)
adults	112(14)	105(134)	230(62)	12(21)

SEPTEMBER (CONT.)

	Dunn Creek		Elkhorn	
	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
OTHER INVERTEBRATES				
Turbellaria	43(36)	307(150)	765(441)	1,852(793)
Nematoda	8(14)	68(53)	20(30)	567(89)
Oligochaeta				
Lumbriculidae	80(73)	40(38)	28(10)	192(150)
Naididae	806(524)	5,881(3,213)	40(14)	263(223)
Hydracarina	32(37)	133(104)	808(612)	186(98)
Mollusca				
Lymnaea sp.	34(59)	0(0)	1(2)	133(89)
Gyraulus sp.	8(14)	0(0)	2(3)	3(5)

SEPTEMBER, 1980

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
EPHEMEROPTERA				
Siphlonuridae				
small Siphlonuridae	0(0)	0(0)	5(6)	6(11)
Baetidae				
Baetis tricaudatus	3,244(1,530)	783(260)	627(96)	40(46)
Baetis hageni	0(0)	0(0)	216(181)	6(11)
Pseudocleon sp.	517(330)	301(33)	598(100)	46(46)
Heptageniidae				
Epeorus sp.	8(14)	0(0)	459(216)	43(53)
Rhithrogena hageni	11(14)	1(2)	1,362(384)	570(301)
Cinygmula sp.	2(3)	0(0)	6(6)	12(11)
Nixe criddlei	0(0)	0(0)	2(3)	0(0)
Ephemerellidae				
Drunella doddsi	0(0)	1(2)	112(82)	43(23)
Ephemerella inermis	262(163)	180(138)	1,433(437)	331(204)
Caudatella heterocaudata	0(0)	2(3)	0(0)	0(0)
Serratella tibialis	78(60)	17(9)	13(15)	3(5)
Leptophlebiidae				
Paraleptophlebia heteronea	0(0)	0(0)	175(43)	46(19)
Traverella albertana	0(0)	0(0)	0(0)	6(5)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	1(2)	0(0)	10(12)	3(5)
Pteronarcella badia	2(2)	0(0)	2(3)	0(0)
Taeniopterygidae				
Taenionema pacificum	9(14)	8(14)	128(121)	6(5)
Nemouridae				
Zapada cinctipes	0(0)	0(0)	25(24)	0(0)

SEPTEMBER (CONT.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Capniidae				
small Capniidae	8(14)	0(0)	130(93)	0(0)
Perlidae				
Classenia sabulosa	0(0)	0(0)	34(31)	6(11)
Hesperoperla pacifica	0(0)	0(0)	0(0)	6(11)
Calineuria californica	0(0)	0(0)	30(11)	25(23)
Perlodidae				
Isoperla fulva	0(0)	0(0)	69(17)	6(11)
Skwala parallela	0(0)	0(0)	23(8)	9(9)
Diura sp.	0(0)	0(0)	7(2)	6(5)
Perlinodes aurea	0(0)	0(0)	1(2)	3(5)
Chloroperlidae				
Sweltsa coloradensis	16(20)	0(0)	361(170)	189(118)
Suwallia sp.	3(3)	0(0)	0(0)	6(5)
small Chloroperlidae	0(0)	0(0)	40(37)	0(0)
TRICHOPTERA				
Philopotamidae				
Philopotamidae pupae	0(0)	0(0)	1(2)	0(0)
Hydropsychidae				
Arctopsyche grandis	1(2)	1(2)	33(37)	9(16)
Hydropsyche oslari	69(68)	80(72)	2(3)	25(19)
Hydropsyche cockerelli	3(0)	0(0)	0(0)	0(0)
Hydropsyche occidentalis	1,019(299)	445(303)	1,724(1,009)	149(70)
Cheumatopsyche sp.	35(48)	27(39)	211(188)	0(0)
small Hydropsychidae	5,848(4,536)	600(265)	482(229)	177(237)
Hydropsychidae pupae	0(0)	1(2)	0(0)	0(0)
Rhyacophilidae				
Rhyacophila bifila	0(0)	0(0)	39(19)	3(5)
Rhyacophila angelita pupae	0(0)	0(0)	0(0)	3(5)

SEPTEMBER (CONT.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Glossosomatidae				
Glossosoma sp. larvae	26(20)	5(6)	235(203)	3(5)
Glossosoma sp. pupae	1(2)	0(0)	0(0)	0(0)
Hydroptilidae				
Hydroptila sp.	281(230)	101(110)	8(14)	0(0)
Brachycentridae				
Brachycentrus sp.	234(218)	58(51)	34(28)	6(5)
Lepidostomatidae				
Lepidostoma sp.	0(0)	0(0)	215(59)	201(84)
Leptoceridae				
Ceraclea sp.	0(0)	0(0)	0(0)	0(0)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	3(5)	1(2)	267(107)	84(105)
Zaitzevia parvula adults	0(0)	0(0)	76(45)	40(30)
Optioservus quadrimaculatus	47(69)	21(16)	128(29)	170(91)
Optioservus quadrimaculatus adults	0(0)	0(0)	16(28)	3(5)
Narpus sp.	0(0)	1(2)	0(0)	0(0)
DIPTERA				
Tipulidae				
Antocha sp. larvae	32(5)	11(19)	132(79)	3(5)
Antocha sp. pupae	1(2)	0(0)	0(0)	0(0)
Hexatoma sp.	0(0)	1(2)	147(129)	46(25)
Ceratopogonidae	0(0)	0(0)	2(3)	0(0)

SEPTEMBER (CONT.)

	Pipe Creek		Fisher River	
	Kick n=3 $\bar{x}$(s.d.)	Circular n=3 $\bar{x}$(s.d.)	Kick n=3 $\bar{x}$(s.d.)	Knapp Waters n=3 $\bar{x}$(s.d.)
Simuliidae				
Simulium sp. larvae	1,365(1,166)	295(208)	2(2)	0(0)
Simulium sp. pupae	106(144)	29(25)	1(2)	0(0)
Simulium sp. adults	1(2)	0(0)	0(0)	0(0)
Chironomidae				
larvae	11,394(6,409)	2,863(627)	3,542(1,359)	1,068(979)
pupae	252(50)	43(32)	93(47)	40(23)
adults	416(231)	82(50)	17(15)	3(5)
Tabanidae	0(0)	0(0)	3(3)	15(14)
Empididae				
Hemerodromia sp.	0(0)	0(0)	50(27)	0(0)
OTHER INVERTEBRATES				
Turbellaria	934(200)	220(103)	37(43)	0(0)
Nematoda	299(216)	186(95)	1(2)	0(0)
Oligochaeta				
Lumbriculidae	270(164)	45(20)	320(406)	22(23)
Naididae	1,489(1,182)	198(82)	8(14)	0(0)
Hydracarina	1,123(730)	236(358)	154(190)	418(126)

OCTOBER, 1980

	Dunn Creek Kick (n=3) $\bar{x}$(s.d.)	Elkhorn Kick (n-3) $\bar{x}$(s.d.)	Pipe Creek Kick (n-3) $\bar{x}$(s.d.)	Fisher River Kick (n=3) $\bar{x}$(s.d.)
EPHEMEROPTERA				
Siphlonuridae				
Ameletus cooki	----	----	----	6(6)
Ameletus sparsatus				
Baetidae				19(33)
Baetis tricaudatus	1,171(190)	2,902(1,860)	1,972(371)	3,055(744)
Baetis hageni	----	650(994)	----	505(278)
Pseudocleon sp.	----	24(20)	3(5)	33(13)
Heptageniidae				
Rhithrogena sp.	----	15(15)	70(27)	886(110)
Cinygmula sp.	15(19)	46(42)	120(112)	51(30)
Epeorus sp.	----	----	31(15)	1,037(291)
Ephemerellidae				
Drunella doddsi	----	----	1(2)	27(26)
Drunella spinifera	----	----	1(2)	1(2)
Ephemerella inermis	2,744(1,666)	1,966(1,023)	676(253)	1,390(265)
Leptophlebiidae				
Paraleptophlebia heteronea	----	----	13(20)	248(149)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	----	11(14)	----	1(2)
Pteronarcella badia	----	----	3(5)	5(9)
Taeniopterygidae				
Taenionema pacificum	----	----	1(2)	283(93)
Nemouridae				
Zapada cinctipes	----	----	1(2)	5(6)
Capniidae				
Capnia sp.	----	----	1(2)	199(180)
Isocapnia sp.	----	----	----	86(56)

OCTOBER, 1980 (Continued)

	Dunn Creek Kick (n=3) $\bar{x}$(s.d.)	Elkhorn Kick (n=3) $\bar{x}$(s.d.)	Pipe Creek Kick (n=3) $\bar{x}$(s.d.)	Fisher River Kick (n=3) $\bar{x}$(s.d.)
Perlidae				
Classenia sabulosa	----	2(3)	----	21(8)
Hesperoperla pacifica	----	----	----	1(2)
Calineuria californica	----	----	----	21(11)
Perlodidae				
Skwala parallela	----	----	1(2)	6(3)
Diura knowltoni	----	----	----	7(5)
Isoperla fulva	----	----	----	10(10)
Chloroperlidae				
Sweltsa coloradensis	28(40)	23(23)	12(21)	293(98)
small Chloroperlidae	----	----	----	58(78)
TRICHOPTERA				
Hydropsychidae				
Arctopsyche grandis	----	----	----	8(6)
Hydropsyche oslari	----	82(98)	458(117)	15(18)
Hydropsyche occidentalis	----	457(523)	1,684(180)	474(203)
Cheumatopsyche sp.	----	49(63)	66(60)	29(32)
small Hydropsychidae	----	227(173)	644(344)	474(216)
Rhyacophilidae				
Rhyacophila bifila	----	----	----	28(26)
Glossosomatidae				
Glossosoma sp. larvae	----	397(267)	23(2)	23(15)
Glossosoma sp. pupae	----	4(5)	1(2)	1(2)
Hydroptilidae				
Hydroptila sp.	263(154)	204(164)	32(14)	64(69)
Brachycentridae				
Brachycentrus sp.	3(5)	88(46)	199(113)	136(102)

OCTOBER, 1980 (Continued)

	Dunn Creek Kick (n=3) $\bar{x}$(s.d.)	Elkhorn Kick (n-3) $\bar{x}$(s.d.)	Pipe Creek Kick (n=3) $\bar{x}$(s.d.)	Fisher River Kick (n=3) $\bar{x}$(s.d.)
Lepidostomatidae				
Lepidostoma sp. larvae	3(5)	15(8)	1(2)	258(172)
Lepidostoma sp. pupae	----	----	----	3(3)
Leptoceridae				
Ceraclea sp.	3(5)	8(14)	----	----
COLEOPTERA				
Elmidae				
Zaitzevia parvula larvae	----	4(3)	1(2)	331(116)
Zaitzevia parvula adults	----	----	----	114(49)
Optioservus quadrimaculatus	----	37(39)	20(12)	66(52)
Optioseruvs quadrimaculatus adults	----	----	----	16(14)
Narpus sp.	----	2(2)	----	----
DIPTERA				
Tipulidae				
Hexatoma sp.	----	----	1(2)	511(81)
Antocha sp.	----	19(9)	30(18)	225(122)
Empididae				
Hemerodromia sp.	----	----	----	96(24)
Dolichopodidae	----	----	1(2)	----
Simuliidae				
Simulium sp. larvae	7,862(3,570)	15,760(8,181)	9,344(4,067)	175(113)
Simulium sp. pupae	15(19)	5(5)	2(3)	----
Ceratopogonidae	----	----	----	17(29)
Chironomidae				
larvae	24,767(6,687)	13,509(11,652)	20,052(1,388)	8,616(6,812)
pupae	282(23)	73(30)	26(30)	----
adults	19(16)	44(24)	12(10)	----

OCTOBER, 1980 (Continued)

	Dunn Creek Kick (n=3) $\bar{x}$(s.d.)	Elkhorn Kick (n=3) $\bar{x}$(s.d.)	Pipe Creek Kick (n=3) $\bar{x}$(s.d.)	Fisher River Kick (n=3) $\bar{x}$(s.d.)
OTHER INVERTEBRATES				
Turbellaria	347(264)	1,371(1,133)	1,159(599)	24(24)
Nematoda	338(44)	959(715)	270(78)	10(12)
Oligochaeta				
Lumbriculidae	87(94)	88(23)	219(211)	104(44)
Naididae	1,867(1,129)	579(144)	789(141)	8(14)
Hydracarina	74(74)	184(84)	80(60)	----
Mollusca				
Lymnaea sp.	81(54)	78(39)	28(23)	792(754)
Gyraulus sp.	15(5)	2(2)	3(3)	----

JANUARY, 1981

	Dunn Creek Kick n=3 $\bar{x}$(s.d.)	Elkhorn Kick n=2 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)	Fisher River Kick n=3 $\bar{x}$(s.d.)
EPHEMEROPTERA				
Siphlonuridae				
Ameletus cooki	----	----	----	2(2)
Ameletus sparsatus	----	----	----	1(2)
Baetidae				
Baetis tricaudatus	4,320(2,836)	37,752(27,208)	8,863(3,705)	2,717(1,136)
Baetis hageni	----	----	----	190(114)
Heptageniidae				
Epeorus sp.	----	96(136)	23(20)	365(116)
Rhithrogena hageni	----	2(2)	648(359)	1,050(88)
Cinygmula sp.	37(56)	2(2)	119(98)	96(21)
Ephemerellidae				
Drunella doddsi	----	----	----	25(6)
Drunella spinifera	----	----	----	3(3)
Drunella flavilinea	121(186)	1,154(817)	137(95)	46(72)
Ephemerella inermis	6,769(4,335)	48,267(58,625)	1,349(286)	2,438(664)
Caudatella heterocaudata	----	96(136)	286(270)	33(26)
Leptophlebiidae				
Paraleptophlebia heteronea	----	98(138)	----	200(70)
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	----	8(6)	2(3)	6(3)
Taeniopterygidae				
Taenionema pacificum	----	----	10(11)	75(15)
Nemouridae				
Zapada cinctipes	----	----	----	2(2)
Capniidae				
Capnia sp.	----	102(127)	2(2)	29(11)
Isocapnia sp.	----	96(136)	9(14)	39(22)

JANUARY, 1981

	Dunn Creek Kick n=3 $\bar{x}$(s.d.)	Elkhorn Kick n=2 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)	Fisher River Kick n=3 $\bar{x}$(s.d.)
Perlidae				
Classenia sabulosa	----	2(2)	3(3)	15(8)
Hesperoperla pacifica	----	----	2(3)	----
Calineuria californica	----	----	----	15(3)
Perlodidae				
Skwala parallela	----	1(0)	1(2)	8(3)
Diura knowltoni	----	----	----	3(3)
Isoperla fulva	----	----	2(3)	----
Chloroperlidae				
Sweltsa coloradensis	----	110(134)	26(14)	147(8)
small Chloroperlidae	----	----	----	127(32)
TRICHOPTERA				
Hydropsychidae				
Arctopsyche grandis	----	3(4)	----	----
Hydropsyche oslari	25(43)	6(8)	40(43)	1(0)
Hydropsyche occidentalis	3(5)	8(6)	197(194)	246(150)
Cheumatopsyche sp.	----	2(2)	41(38)	59(49)
small Hydropsychidae	----	291(407)	56(50)	8(14)
Rhyacophilidae				
Rhyacophila bifila	----	----	16(15)	14(17)
Rhyacophila vao	----	----	1(2)	----
Glossosomatidae				
Glossosoma sp.	----	77(83)	14(14)	203(120)
Hydroptilidae				
Hydroptila sp.	276(276)	390(547)	16(28)	----
Brachycentridae				
Brachycentrus sp.	----	12(17)	27(27)	87(77)
Lepidostomatidae				
Lepidostoma sp.	----	98(138)	25(33)	248(193)

JANUARY, 1981 (Continued)

	Dunn Creek Kick n=3 $\bar{x}$(s.d.)	Elkhorn Kick n=2 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)	Fisher River Kick n=3 $\bar{x}$(s.d.)
Limnephilidae				
Onocosmoecus sp.	----	----	1(2)	1(2)
Leptoceridae				
Ceraclea sp.	6(5)	----	----	----
Oecetis sp.	----	----	----	1(2)
COLEOPTERA				
Elmidae				
Zaitzevia parvula larvae	----	----	1(2)	13(15)
Zaitzevia parvula adults	----	----	----	18(16)
Optioservus quadrimaculatus	3(5)	----	----	46(36)
Optioservus quadrimaculatus adults	----	----	----	17(15)
Narpus sp.	----	----	1(2)	----
Dytiscidae	----	----	1(2)	3(5)
DIPTERA				
Tipulidae				
Hexatoma sp.	----	----	----	19(14)
Antocha sp.	----	1(0)	1(2)	80(85)
Tanyderidae				
Protanyderus sp.	----	----	106(46)	----
Empididae				
Hemerodromia sp.	----	----	1(2)	8(14)
Dolichopodidae	----	----	1(2)	----
Simuliidae				
Simulium sp. larvae	37,014(30,381)	75,527(94,448)	8,254(5,353)	162(107)
Simulium sp. pupae	----	98(138)	1(2)	----

JANUARY, 1981 (Continued)

	Dunn Creek Kick n=3 $\bar{x}$(s.d.)	Elkhorn Kick n=2 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)	Fisher River Kick n=3 $\bar{x}$(s.d.)
Chironomidae				
larvae	17,372(11,862)	55,076(9,344)	2,661(721)	403(383)
pupae	40(38)	----	----	----
adults	----	683(125)	----	----
Tabanidae	----	----	----	1(2)
Athericidae				
Atherix variegata	----	----	----	1(2)
COLLEMBOLA	1,607(1,475)	----	----	----
OTHER INVERTEBRATES				
Turbellaria	421(587)	1,548(806)	590(263)	55(62)
Nematoda	743(702)	198(4)	617(688)	9(16)
Oligochaeta				
Lumbriculidae	90(80)	113(121)	132(120)	490(117)
Naididae	56(89)	96(136)	257(295)	168(190)
Hydracarina	183(292)	----	72(63)	----
Mollusca				
Lymnaea sp.	77(33)	23(2)	11(11)	----
Gyraulus sp.	15(19)	----	----	----
Hirudinea				
Piscicola sp.	----	96(136)	----	----

MARCH and MAY, 1981

	Elkhorn Kick n=3 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)	Elkhorn Kick n=3 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)
EPHEMEROPTERA				
Baetidae				
Baetis tricaudatus	14,767(2,342)	6,446(2,671)	5,857(1,586)	3,851(1,506)
Baetis tricaudatus adults	208(30)	1(2)	2(2)	9(3)
Baetis hageni	----	----	68(118)	----
Heptageniidae				
Epeorus sp.	1(2)	121(105)	4(5)	262(291)
Rhithrogena sp.	659(573)	13(6)	86(103)	165(129)
Cinygmula sp.	5(9)	86(115)	64(111)	80(115)
Ephemerellidae				
Drunella doddsi	----	----	----	1(2)
Drunella spinifera	----	----	----	1(2)
Drunella flavilinea	644(294)	294(95)	94(96)	108(166)
Ephemerella inermis	3,513(1,220)	1,288(682)	5,576(4,768)	1,977(459)
Caudatella heterocaudata	7(10)	367(198)	256(126)	579(345)
Serratella tibialis	----	----	544(200)	128(222)
Leptophlebiidae				
Paraleptophlebia heteronea	1(2)	1(2)	----	----
PLECOPTERA				
Pteronarcidae				
Pteronarcys californica	2(3)	----	----	1(2)
Pteronarcella badia	----	2(2)	----	----
Taeniopterygidae				
Taenionema pacificum	1(2)	----	----	----
Capniidae				
Capnia sp.	1(2)	2(3)	----	----
Perlidae				
Classenia sabulosa	1(2)	1(2)	2(3)	1(2)
Calineuria californica	----	----	1(2)	----

MARCH and MAY, 1981 (continued)

	Elkhorn Kick n=3 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)	Elkhorn Kick n=3 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)
<u>Perlodidae</u>				
Skwala parallela	----	----	1(2)	----
Isoperla fulva	1(2)	----	----	1(2)
<u>Chloroperlidae</u>				
Sweltsa coloradensis	4(2)	32(55)	1(2)	3(3)
Suwallia sp.	----	1(2)	----	1(2)
TRICHOPTERA				
<u>Hydropsychidae</u>				
Arctopsyche grandis	----	2(3)	----	----
Hydropsyche oslari	185(261)	175(66)	336(169)	63(64)
Hydropsyche occidentalis	466(298)	452(330)	227(231)	795(344)
Hydropsyche cockerelli	----	1(2)	----	----
Cheumatopsyche sp.	74(118)	156(126)	319(289)	----
small Hydropsychidae	577(664)	376(268)	133(230)	64(55)
<u>Rhyacophilidae</u>				
Rhyacophila bifila	----	4(2)	2(3)	14(12)
Rhyacophila vao	----	3(3)	----	----
<u>Glossosomatidae</u>				
Glossosoma sp. larvae	317(323)	17(15)	160(168)	----
Glossosoma sp. pupae	16(20)	6(8)	85(32)	7(10)
<u>Hydroptilidae</u>				
Hydroptila sp.	599(323)	327(239)	162(55)	32(55)
<u>Brachycentridae</u>				
Brachycentrus sp.	106(119)	140(49)	11(9)	143(240)
Brachycentrus sp. pupae	----	----	8(8)	----
<u>Lepidostomatidae</u>				
Lepidostoma sp.	10(6)	139(218)	10(10)	11(14)
<u>Limnephilidae</u>				
Onocosmoecus sp.	64(111)	----	----	----
<u>Leptoceridae</u>				
Ceraclea sp.	----	33(55)	----	----

MARCH and MAY, 1981 (Continued)

	Elkhorn Kick n=3 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)	Elkhorn Kick n=3 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)
COLEOPTERA				
Elmidae				
Zaitzevia parvula	----	8(14)	----	----
Optioservus quadrimaculatus	2(2)	10(12)	32(55)	1(2)
Optioservus quadrimaculatus adults	----	----	----	1(2)
Narpus sp.	2(3)	33(55)	----	----
Haliplidae				
Brychius sp.	----	2(2)	----	----
DIPTERA				
Tipulidae				
Hexatoma sp.	----	1(2)	66(114)	4(5)
Antocha sp.	183(281)	136(21)	6(3)	76(119)
Dolichopodidae	----	1(2)	----	----
Tabanidae	----	1(2)	----	----
Simuliidae				
Simulium sp. larvae	27,265(31,557)	1,937(1,791)	2,093(488)	996(1,005)
Simulium sp. pupae	128(222)	115(96)	----	501(428)
Simulium vittatum pupae	2,552(3,435)	----	1,626(1,164)	1(2)
Chironomidae				
larvae	36,884(11,377)	20,607(3,661)	26,944(14,031)	27,380(7,700)
pupae	835(396)	620(158)	565(35)	1,137(1,017)
adults	1,251(242)	340(171)	518(401)	1,545(361)
OTHER INVERTEBRATES				
Turbellaria	1,637(1,010)	1,172(216)	1,763(415)	1,352(937)
Nematoda	27(22)	88(51)	104(104)	96(96)

MARCH and MAY, 1981 (Continued)

	Elkhorn Kick n=3 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)	Elkhorn Kick n=3 $\bar{x}$(s.d.)	Pipe Creek Kick n=3 $\bar{x}$(s.d.)
Oligochaeta				
Lumbriculidae	16(3)	97(50)	86(97)	14(9)
Naididae	----	144(127)	128(222)	320(474)
Hydracarina	64(111)	----	64(111)	64(111)
Mollusca				
Lymnaea sp.	24(23)	7(8)	13(11)	10(17)
Gyraulus sp.	1(2)	1(2)	1(2)	----
Hirudinea				
Piscicola sp.	2(3)	----	----	----

APPENDIX 4

Periphyton species collected in Kootenai River and Fisher River.

Appendix 4. Periphyton species collected in Kootenai River and Fisher River.

Species	Fisher River	Percent relative abundance* Dunn Creek	Elkhorn
Achnanthes affinis Grun.		0.3	
A. clevei Grun.		t	
A. deflexa Reim.		11.5	2.4
A. lanceolata (Breb.) Grun.		0.3	
A. lanceolata var. dubia Grun.	0.5	0.3	t
A. lapponica var. ninchei (Guerm. & Mang.) Reim.		t	
A. linearis (W. Sm.) Grun.	0.3	2.6	3.2
A. linearis f. curta H.L. Sm.	0.3	3.9	3.5
A. minutissima Kutz.	5.4	65.5	78.2
A. subrostrata Hust.		0.3	
Amphipleura pellucida Kutz.	1.1		
Amphora perpusilla (Grun.) Grun.		0.5	0.3
Caloneis bacillum (Grun.) Cl.			t
Cocconeis pediculus Ehr.	3.8	1.8	0.3
C. placentula var. euglypta (Ehr.) Cl.	24.4	t	0.3
C. placentula var. lineata (Ehr.) V. H.	6.4	0.3	0.3
Cyclotella bodanica Eulenstein		t	t
C. glomerata Bachman		0.3	t
Cymbella affinis Kutz.		0.3	0.8
C. brehmii Hust.		0.3	
C. cymbiformis Ag.	t		
C. lanceolata (Ag.) Ag.	0.3		
C. mexicana (Ehr.) Cl.		t	
C. microcephala Grun.	7.8	1.8	8.2
C. minuta Hilse ex Rabh.	1.9	0.5	0.5
C. muelleri Hust.	t		
C. prostrata (Berkeley) Cl.		0.3	t
Cymbella prostrata var. auerswaldii (Rabh.) Reim.	3.2	t	t
C. sinuata Greg.	3.2	t	0.3
C. tumida (Breb.) V. H.	t		

Appendix 4. (Continued)

Species	Percent relative abundance* Fisher River	Dunn Creek	Elkhorn
Denticula tenuis Kutz.		2.3	0.3
Diatoma hiemale var. mesodon (Ehr.) Grun.		t	
D. tenue Ag.		t	t
D. vulgare Bory		t	0.8
D. vulgare var. breve Grun.		t	
Didymosphenia geminata (Lyngb.) M. Schmidt		t	t
Epithemia argus var. protracta A. Mayer	0.5		
E. sorex Kutz.	16.6		t
E. turgida (Ehr.) Kutz.	2.1	t	
Fragilaria construens var. venter (Ehr.) Grun.	0.3		
F. crotonensis Kitton			0.3
F. leptostauron (Ehr.) Hust.	0.3	t	
F. leptostauron var. dubia (Grun.) Hust.	t		
F. pinnata Ehr.	0.3		
F. pinnata var. lancettula (Schm.) Hust.		t	
F. vaucheriae (Kutz.) Peters.		1.6	t
Gomphonema angustatum (Kutz.) Rabh.			t
G. bohemicum Reichelt et Fricke	0.3		
G. intricatum Kutz.	0.8		
G. intricatum var. pulvinatum (Braun) Grun.	2.7	t	
G. olivaceoides Hust.	0.5		
G. subclavatum (Grun.) Grun.		t	
G. tenellum Kutz.		1.8	t
G. truncatum Ehr.		0.3	
Melosira varians Ag.		0.3	t
Navicula bacillum Ehr.	0.3		
N. cryptocephala var. veneta (Kutz.) Rabh.	0.3	0.3	t
N. menisculus var. upsaliensis (Grun. in Cl. & Grun.) Grun.		t	

Appendix 4. (Continued).

Species	Percent relative abundance*		
	Fisher River	Dunn Creek	Elkhorn
N. minima Grun.		0.8	
N. minuscula Grun.			0.3
N. radiosa Kutz.	0.3		
N. radiosa var. parva Wallace		t	
N. radiosa var. tenella (Breb. & Kutz.) Grun.	1.6	1.3	t
N. salinarum var. intermedia (Grun.) Cl.	3.8	t	
N. tripunctata (O.F. Mull.) Bory	0.8	t	t
N. viridula (Kutz.) Kutz.	0.3		
Neidium productum (W. Sm.) Cl.	t		
Nitzschia fonticola Grun.		0.3	
N. kutzingiana Hilse		t	
N. linearis (Ag. ex. W. Sm.) W. Sm.	0.3		
N. palea (Kutz.) W. Sm.			t
N. sinuata (W. Sm.) Grun.		0.3	
Rhoicosphenia curvata (Kutz.) Grun.	t		
Rhopalodia gibba (Ehr.) O. Mull.	0.3	t	
R. gibba var. ventricosa (Kutz.) H. & M. Perag.	0.8		
Stephanodiscus hantzschii Grun.		t	
Synedra acus Kutz.	6.2		
S. famelica Kutz.			t
S. rumpens Kutz.			t
S. ulna (Nitz.) Ehr.		t	t
S. ulna var. contracta Ostra.	2.4		
Tabellaria quadrisepta Kunds.		0.3	0.3

Appendix 4. (Continued).

Species	Percent relative abundance* Fisher River	Dunn Creek	Elkhorn
Soft-bodied Algae			
Amphithrix sp.	Common		Rare
Batrachospermum sp.	Common	Common	
Calothrix sp.	Rare		
Chaetophora sp.		Common	V.common
Cladophora sp.		V.common	
Closterium sp.	Rare		
Cosmarium sp.	Rare		
Gongrosira sp.			V.common
Nostoc sp.	Abundant		
Oedogonium sp.		Rare	
Pediastrum sp.	Rare		
Phormidium sp.		V.common	
Rhizoclonium sp.		Common	
Scenedesmus sp.	Rare		
Spirogyra sp.	V.common		
Staurastrum sp.		Rare	
Stigeoclonium sp.			Rare
Tolypothrix sp.		Common	
Ulothrix sp.		Rare	Common
Zygnema sp.		Common	
Diatoms	Common	Abundant	Abundant
Frustules counted	373	383	376
Total Taxa	41	53	37
Taxa Counted	35	28	17
Diversity ($\bar{d}$)	3.87	2.17	1.39
Equitability (e)	0.60	0.21	0.18

Appendix 4. (Continued).

Species	Percent relative abundance*		
	Fisher River	Dunn Creek	Elkhorn
PRA Centrales	0	0.6	t
PRA Pennales	100.0	99.4	100.0
PRA Araphidae	9.5	1.9	1.4
PRA Monoraphidae	41.1	86.4	87.9
PRA Biraphidae	49.4	11.1	10.7

* Percentages are rounded, therefore totals do not equal 100%.

APPENDIX 5

Drift densities for each insect group at each site.

Appendix 5. Drift densities for each insect group at each site

	Elkhorn				Pipe Creek			
	Shallow1/	Deep1/	Shallow2/	Deep2/	Shallow1/	Deep1/	Shallow2/	Deep2/
June, 1980								
Ephemeroptera	78	68	1,117	585	25	61	241	237
Plecoptera	0	.3	27	6	0	0	1	0
Trichoptera	22	66	150	140	20	30	18	.7
Diptera	6,062	2,315	1,490	2,649	2,962	2,435	2,252	2,063
Other	23	3	4	3	30	7	34	2
Terrestrial	634	161	136	59	35	51	143	121
TOTAL	6,819	2,613	2,924	3,442	3,072	2,584	2,689	2,424
July, 1980								
Ephemeroptera	1,404	1,203	162,455	4,569	986	968	10,499	12,172
Plecoptera	0	0	1	5	0	0	.8	8
Trichoptera	172	234	6,484	602	232	82	237	912
Diptera	5,855	36,400	102,424	9,287	10,811	11,363	53,160	27,195
Other	32	555	2,837	3	827	779	1,443	66
Terrestrial	270	441	49,306	18	2,611	51	170	106
TOTAL	7,733	38,833	323,507	14,484	15,467	13,243	65,510	40,459
August, 1980								
Ephemeroptera	542	562	893	725	256	118	271	128
Plecoptera	.7	0	.7	0	2	.6	5	.6
Trichoptera	28	34	85	97	12	6	53	41
Diptera	1,740	2,292	2,748	6,482	1,713	1,009	1,294	1,498
Other	5	16	13	71	16	3	0	7
Terrestrial	74	85	535	402	59	186	73	106
TOTAL	2,390	2,989	4,275	7,777	2,058	1,323	1,696	1,781

Appendix 5. (Continued).

	Elkhorn				Pipe Creek			
	Shallow[1/]	Deep[1/]	Shallow[2/]	Deep[2/]	Shallow[1/]	Deep[1/]	Shallow[2/]	Deep[2/]
September, 1980								
Ephemeroptera	62	43	318	318	58	83	486	385
Plecoptera	0	0	1	0	0	0	.8	1
Trichoptera	35	6	55	98	8	21	136	48
Diptera	2,302	1,163	1,601	2,056	1,936	612	962	1,004
Other	3	6	3	2	264	39	36	27
Terrestrial	187	76	447	24	671	40	200	319
TOTAL	2,589	1,294	2,425	2,498	2,937	795	1,821	1,784
October, 1980								
Ephemeroptera	954	331	9,562	14,977	129	29	954	150
Plecoptera	0	0	4	26	0	.4	8	0
Trichoptera	341	119	1,693	2,614	151	52	845	251
Diptera	1,650	942	3,880	7,302	655	67	772	259
Other	352	92	195	117	17	11	21	18
Terrestrial	38	17	33	0	0	0	29	4
TOTAL	3,335	1,501	15,367	25,036	952	159	2,629	682
January, 1981								
Ephemeroptera	22,262	1,276	---[3/]	50,992	814	482	5,741	4,953
Plecoptera	0	0		5	0	3	19	6
Trichoptera	238	49		4	26	28	102	78
Diptera	3,006	402		152,033	659	335	2,077	1,702
Other	151	16		1	16	15	9	29
Terrestrial	26	19		0	20	15	56	37
TOTAL	25,683	1,762		203,035	1,535	878	8,004	6,805

Appendix 5. (Continued).

	Elkhorn				Pipe Creek			
	Shallow 1/	Deep 1/	Shallow 2/	Deep 2/	Shallow 1/	Deep 1/	Shallow 2/	Deep 2/
May, 1981								
Ephemeroptera	443	315	476	202	225	218	254	135
Plecoptera	.7	0	1	2	0	0	0	.7
Trichoptera	16	1	1	6	0	4	2	6
Diptera	7,901	4,583	2,323	3,555	3,569	4,949	4,933	2,877
Other	0	1	0	20	22	244	245	36
Terrestrial	6,849	3,698	2,298	5,467	880	176	859	22
TOTAL	15,210	8,598	5,099	9,252	4,696	5,591	6,293	3,077

1/ Samples taken before darkness.
2/ Samples taken during dark.
3/ Sample lost.

APPENDIX 6

Insect densities (no./m^2) in basket samples located at 4,000, 6,000 and 10,000 cfs levels retrieved after water level reductions.

Appendix 6.

	Elkhorn 10-24-80 4,000 cfs	Elkhorn 10-24-80 6,000 cfs	Elkhorn 10-24-80 10,000 cfs	Pipe Creek 10-25-80 4,000 cfs	Pipe Creek 10-25-80 6,000 cfs	Pipe Creek 10-25-80 10,000 cfs
Ephemeroptera	685	---	161	---	---	---
Plecoptera	40	---	---	---	---	---
Trichoptera	1,652	322	---	1,290	2,499	---
Diptera	13,339	2,337	1,975	4,111	1,773	363
Other Invertebrates	13,178	36,189	6,126	8,100	23,253	8,342
Terrestrial	---	322	---	---	---	---
TOTAL	28,895	39,172	8,262	13,501	27,525	8,705
Quick Drawdown	1-16-81 4,000 cfs	1-16-81 6,000 cfs	1-16-81 10,000 cfs	1-16-81 4,000 cfs	1-16-81 6,000 cfs	1-16-81 10,000 cfs
Ephemeroptera	20,956	6,891	---	81	7,133	161
Plecoptera	524	---	81	40	---	40
Trichoptera	1,290	2,982	11,042	1,491	1,491	161
Diptera	190,659	71,049	7,456	18,014	16,644	3,264
Other Invertebrates	3,143	12,050	10,680	10,196	7,133	9,350
Terrestrial	---	---	---	---	---	---
TOTAL	216,572	92,972	29,258	29,822	32,401	13,017
Normal Drawdown	2-19-81 4,000 cfs	2-19-81 6,000 cfs	2-19-81 10,000 cfs	2-19-81 4,000 cfs	2-19-81 6,000 cfs	2-19-81 10,000 cfs
Ephemeroptera	16,765	1,531	1,572	846	1,370	1,975
Plecoptera	443	---	40	---	---	161
Trichoptera	1,088	2,781	1,693	201	1,008	322
Diptera	98,856	25,671	37,237	6,770	24,825	57,871
Other Invertebrates	1,854	7,738	26,961	3,909	18,780	60,007
Terrestrial	---	---	---	---	---	---
TOTAL	119,006	37,721	67,503	11,727	45,982	120,336

Appendix 6. (Continued)

	Elkhorn 3-10-81 4,000 cfs	Elkhorn 3-10-81 6,000 cfs	Elkhorn 3-10-81 10,000 cfs	Pipe Creek 3-10-81 4,000 cfs	Pipe Creek 3-10-81 6,000 cfs	Pipe Creek 3-10-81 10,000 cfs
<u>Quick Drawdown</u>						
Ephemeroptera	27,888	7,214	4,272	6,569	6,045	887
Plecoptera	40	40	443	40	40	81
Trichoptera	806	846	2,096	242	1,934	363
Diptera	98,332	23,656	53,881	43,202	26,437	35,786
Other Invertebrates	725	1,693	19,586	242	8,866	9,309
Terrestrial	---	---	---	---	---	---
TOTAL	128,073	33,449	80,278	50,294	43,323	46,426

APPENDIX 7

Insect stranding (no./m^2) at normal and quick drawdown rates of river change.

Appendix 7.

	Normal drawdown		Quick drawdown		
	Dunn Creek 7-19-80	Dunn Creek 7-19-80	Dunn Creek 11-10-80	Pipe Creek 11-10-80	Pipe Creek 11-10-80
Ephemeroptera	4,896	585	---	37	---
Plecoptera	---	74	---	---	---
Trichoptera	---	---	---	---	---
Diptera	1,347	1,570	176	186	28
Other Invertebrates	390	1,477	84	149	1,524
Terrestrial	---	---	---	---	---
TOTAL	6,633	3,707	260	372	1,551

	Dunn Creek 1-16-81	Dunn Creek 1-16-81	Pipe Creek 1-16-81	Pipe Creek 1-16-81
Quick Drawdown - 20,000 cfs - 8,000 cfs in 10 min.				
Ephemeroptera	11,900	16,100	21,859	11,204
Plecoptera	28	---	195	325
Trichoptera	56	9	37	65
Diptera	33,035	38,470	1,486	2,741
Other Invertebrates	520	957	19	37
Terrestrial	---	---	---	---
TOTAL	45,540	55,536	23,606	14,372

	Dunn Creek 2-19-81	Dunn Creek 2-19-81	Pipe Creek 2-19-81	Pipe Creek 2-19-81
Normal Drawdown - 2 feet/hour				
Ephemeroptera	6,039	9,782	6,726	20,094
Plecoptera	---	---	102	111
Trichoptera	19	---	65	9
Diptera	17,502	15,895	2,787	3,029
Other Invertebrates	530	585	140	28
Terrestrial	---	---	---	---
TOTAL	24,089	26,263	9,820	23,271

Appendix 7. (Continued).

	Dunn Creek 3-10-81	Dunn Creek 3-10-81	Pipe Creek 3-10-81	Pipe Creek 3-10-81
Quick Drawdown				
Ephemeroptera	77,544	40,049	35,497	7,590
Plecoptera	---	---	46	47
Trichoptera	19	---	9	344
Diptera	31,883	26,542	37,717	59,484
Other Invertebrates	2,276	1,951	660	5,908
Terrestrial	---	---	---	---
TOTAL	111,722	68,542	73,939	73,372

Section B

Food Habits of Rainbow Trout and Mountain Whitefish in Kootenai River June, 1980 - October, 1981

By

Joe M. DosSantos and Joe E. Huston

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Data collected on food, feeding, and habitats of rainbow trout and mountain whitefish in Kootenai River are being analyzed by Joe DosSantos for fulfillment of thesis requirements for a Masters of Science degree, Montana State University, Bozeman, Montana. Aquatic insect data collected and analzyed by Sue Appert Perry and presented in Section A, Aquatic Insect Investigations, will be incorporated into this M.S. Thesis.

Mr. DosSantos is still in the process of analyzing data collected for this study and applicable information from the Aquatic Insect Investigation. It is regretable that all data and its analysis could not be available for inclusion in this report. Mr. DosSantos' Masters Degree Thesis is expected to be available by 31 March, 1983 from Montana Cooperative Fishery Research Unit, Montana State University, Bozeman, Montana 59717.

OBJECTIVES

Few studies have dealt with food habits, feeding habits, and habitat selection of sympatric fish populations in large regulated rivers (Dettman 1973). Mountain whitefish (*Prosopium williamsoni*) and rainbow trout (*Salmo gairdneri*) are the predominant gamefish species in Kootenai River below Libby Dam and abundance of these two species has increased since the dam was completed in 1972. Interaction between rainbow trout and whitefish for food and space may be occurring, but a thorough knowledge of food habits, feeding habits and habitats selected is required before assessments of competition can be judged.

This study provides information to explain the interactions between rainbow trout and mountain whitefish within the Kootenai River and the possible effects on one or both species caused by these species interaction. The principle objectives of this part of the Kootenai River biological investigation were:

1. Determine the food habits of mountain whitefish and rainbow trout and relate these food items to aquatic insects in the benthos and drift.

2. Compare the habitats selected by mountain whitefish and rainbow trout.

METHODS

Fish were collected from the Kootenai River monthly from June through October, 1980 and January, March, and May, 1981 in the Elkhorn and Pipe Creek stations (Figure 1) using boat mounted electrofishing gear. A total of 495 mountain whitefish and 399 rainbow trout were collected and stomachs removed for food habits analysis (Table 1). Fish less than 30 centimeters total length were killed, stomachs removed and contents preserved for later analysis. Stomach contents of rainbow trout greater than 20 centimeters total length were obtained using a stomach pump (Seaburgh

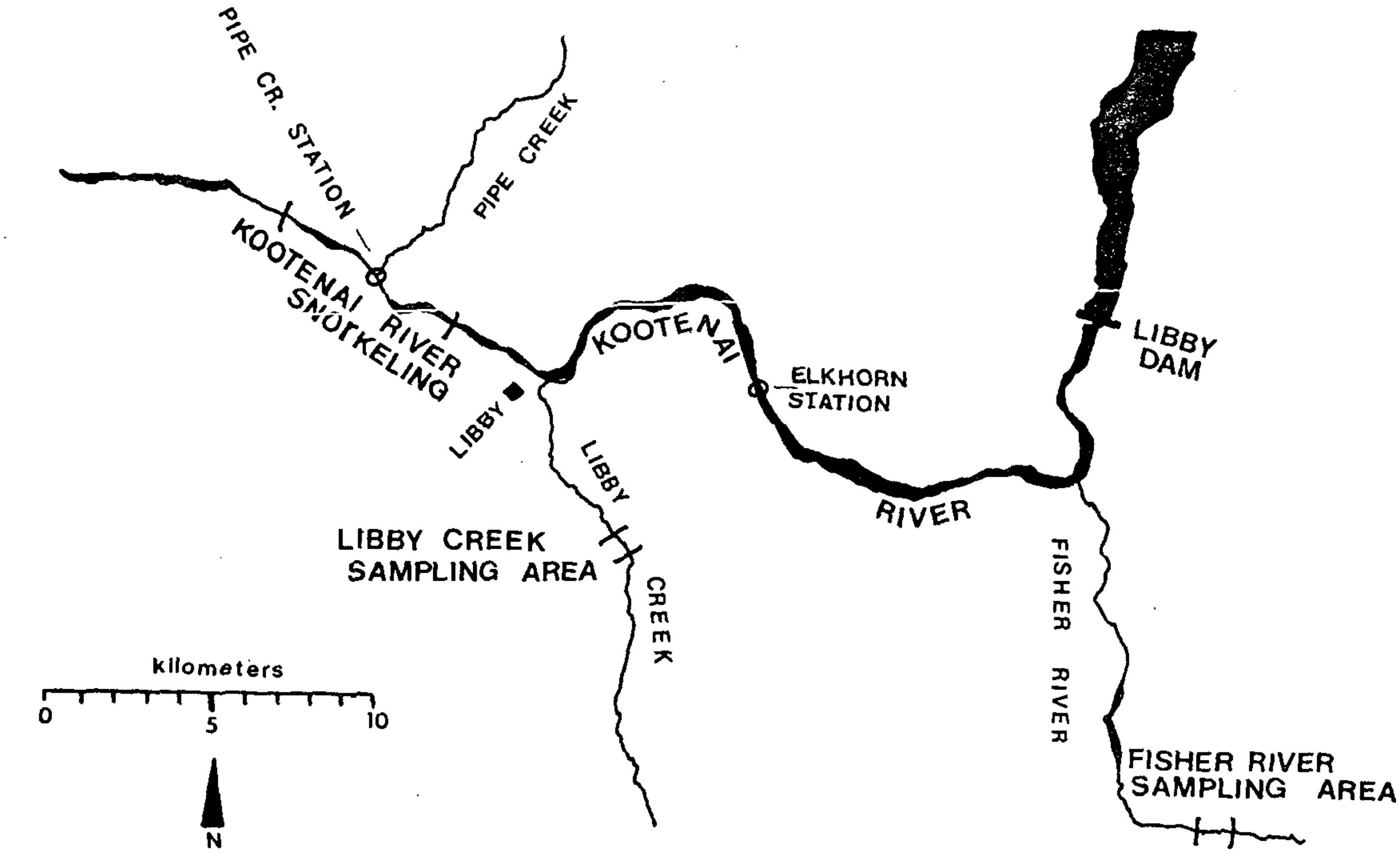

Figure 1. Map of Kootenai River, Fisher River, and Libby Creek showing fish collection stations and snorkeling areas.

Table 1. Total number of fish stomachs by size group in centimeters collected from the Elkhorn and Pipe Creek study sections of the Kootenai River, June 1980 through May 1981.

	Mountain whitefish				Rainbow trout			
	10.0 - 19.9 cm	20.0 - 27.7 cm	27.8 - 43.0 cm	Total	10.0 - 19.9 cm	20.0 - 27.7 cm	27.8 - 43.0 cm	Total
June 1980								
Elkhorn	21	5	8	34	7	3	8	18
Pipe Creek	22	9	8	39	20	9	7	36
July 1980								
Elkhorn	15	10	10	35	15	10	9	34
Pipe Creek	20	10	10	40	20	10	10	40
August 1980								
Elkhorn	1	5	5	11	10	5	6	21
Pipe Creek	8	5	4	17	10	5	5	20
September 1980								
Elkhorn	10	5	5	20	4	5	3	12
Pipe Creek	10	5	5	20	10	5	5	20
October 1980*								
Elkhorn	20	10	10	40	3	10	10	23
Pipe Creek	20	10	10	40	16	10	10	36
January 1981*								
Elkhorn	20	10	10	40	0	10	10	20
Pipe Creek	20	10	10	40	20	11	9	40
March 1981								
Elkhorn	10	5	5	20	0	7	3	10
Pipe Creek	12	4	3	19	11	6	4	21
May 1981*								
Elkhorn	20	10	10	40	4	8	10	22
Pipe Creek	20	10	10	40	16	10	10	36
Size Class Totals	249	123	123		166	114	119	
Grand Totals				495				399

* These months represent the four seasons of the year.

1957) during June, July and August, 1980. The efficiency of stomach pumping was considered too low for a quantitative study and its use was discontinued after August. Thereafter, this size group of rainbow trout were handled in the same manner as other fish. The stomach contents of rainbow trout and mountan whitefish were identified and measured volumetrically and numerically.

Insect drift samples were collected upstream from and immediately prior to and during capture of fish. Insect benthos samples were taken within 24 hours of the time fish were collected in the vicinity of fish collection sites.

Diet of rainbow trout and mountain whitefish as related to the available benthic and drifting aquatic insects were compared using a Chi-square statistic (Hunstberger and Billingsley 1977). Percent overlap in the diets of these two species were calculated using the Schoener (1970) overlap index.

$$\text{Percent overlap} = x = 1\text{-}0.5\ (\sum_{i=1}^{n} p_{xi} - p_{yi})$$

Where: p_{xi} = proportion of food category i in the diet of species x;

p_{xi} = proportion of food category i in the diet of species y;

n = number of food categories.

The selected size groups in which the fish species were divided for analysis were:

S = small: 10.0 - 19.9 centimeters
M = medium: 20.0 - 27.7 centimeters
L = large: 27.8 - 43+ centimeters

Total: S, M, L - combined

These size groupings represent age groups I, II and III and older trout and mountain whitefish adequately with some overlap (see Section C for Age and Growth data).

Stomach contents collected in June, August, September, 1980 and March, 1981 were identified to the ordinal level. Samples collected in July and October, 1980 and January and May, 1981 represent the four seasons of the year and were identified to the lowest possible taxonomic level, usually species.

Mountain whitefish and rainbow trout were observed feeding and interacting during daylight hours using snorkel gear from June through September, 1980 and 1981 in sections of the Kootenai River, Libby Creek and the Fisher River (Figure 1). Stream sections were surveyed to determine fish locations and stream characteristics by using the planimeter method and spot observations (Bovee 1977). Physical parameters included fish facing velocities, average velocities at 0.6 stream depth, total stream depth and composition of substrate types. Statistical comparisons were made using a simple t-test (Huntsberger and Billingsley 1977).

Sixty-seven meters of the Fisher River were mapped, including two different habitat types; a deep run-riffle area, and a run-pool-run area. Fifty-nine meters of stream were mapped in Libby Creek, and included two pool-riffle areas. About three miles of both Fisher River and Libby Creek were snorkeled several times to assess fish distribution patterns, make spot observations and to study behavioral interactions between rainbow trout and mountain whitefish. Approximately six miles of the Kootenai River were snorkeled to assess the above relationships.

FINDINGS

SEASONAL FOOD HABITS

Data presented in this section show deviations from the generalized seasonal food habit trends. Food preferences of individual fish result in variations that are clearly evident in any statistical analysis of the feeding habits of fish (Pontius and Parker 1973, Johnson 1981). Therefore, assigning confidence intervals to the selection of any insect group is relatively meaningless. The means for the three size groups and the group totals presented here should be taken at face value for the purposes of comparison.

The most important food item in the diet of all sizes of mountain whitefish were Chironomidae. This family of insects made up 43 to 62 percent of the total combined stomach volume (Tables 2 and 3; Figures 2 and 3). Ephemeroptera (mayflies) and Trichoptera (caddisflies) contributed to overall yearly means at 21 and 18 percent of total volume, respectively.

Whitefish from 10.0 to 19.9 cm (S) total length were the most consistent and greatest users of chironomids (Tables 2 and 3). Small whitefish collected at Elkhorn and Pipe Creek stations derived 60 percent of their total annual food bulk from chironomids. Whitefish, those 27.8 cm (L) long or longer, showed the largest deviation from heavy chironomid utilization. They ate significant quantities of Trichoptera larvae and adults and "other", mostly Gastropoda, during May and June through October (Tables 3 and 4).

Rainbow trout utilized more Ephemeroptera and Trichoptera than whitefish, ranging as high as a combined 95 percent total stomach volume (Tables 4 and 5; Figures 2 and 3). Rainbow trout showed a diverse food preference and fed on all the major invertebrate groups present in the Kootenai River. Utilization of other invertebrates (Nematoda, Coleoptera, Gastropoda, Annelidae, Hemiptera and Hirudinea) averaged 10 percent compared to only four percent for mountain whitefish.

PERCENT OVERLAP

Differences or similarities in food habits do not reflect the true relationship of overlap of the diet of mountain whitefish and rainbow

Table 2. Percent of total volume in milliliters of stomach contents of select size groups of *mountain whitefish* collected from the Elkhorn study section of the Kootenai River. June to October, 1980, January, March and May, 1981.

	Size group	Diptera	Chironomidae	Ephemeroptera	Trichoptera	Plecoptera	Terrestrial	Other*
June 1980	S	9.2	61.3	22.3	6.6	T**	0.0	0.6
	M	3.4	74.2	2.7	19.7	0.0	0.0	0.6
	L	3.1	41.5	5.4	30.0	0.0	T	6.5
	Total	6.9	58.5	15.5	14.0	T	T	1.9
July 1980	S	2.3	71.1	24.0	2.1	0.0	0.0	0.5
	M	0.2	67.9	18.6	13.2	0.0	T	0.0
	L	0.6	8.3	8.6	82.5	0.0	0.0	0.2
	Total	1.4	54.6	18.8	24.9	0.0	T	0.3
August 1980	S	0.0	60.4	9.4	30.2	0.0	0.0	0.0
	M	2.3	69.8	12.8	12.3	0.0	0.4	1.9
	L	0.3	17.3	9.4	40.2	0.0	0.3	27.6
	Total	1.2	45.1	10.9	26.6	0.0	0.3	13.4
September 1980	S	2.3	58.1	39.2	0.5	0.0	0.0	0.0
	M	2.3	6.9	47.9	22.9	0.0	0.0	0.0
	L	2.4	64.0	8.0	5.6	0.0	0.0	20.0
	Total	2.3	44.6	32.1	7.0	0.0	0.0	9.3
October 1980	S	12.3	44.3	31.3	11.7	T	0.0	0.1
	M	2.2	58.5	23.5	7.4	T	0.0	0.1
	L	2.2	66.5	5.2	25.4	0.0	0.0	0.8
	Total	9.3	53.4	24.0	14.1	0.2	0.0	0.3

Table 2. (Continued).

	Size group	Diptera	Chironomidae	Ephemeroptera	Trichoptera	Plecoptera	Terrestrial	Other*
January 1981	S	6.7	44.2	37.3	10.8	1.0	0.0	0.0
	M	18.8	56.1	8.1	16.9	0.1	0.0	T
	L	36.8	40.9	10.4	11.4	T	0.0	T
	Total	17.3	46.3	23.4	12.5	0.5	0.0	T
March 1981	S	10.9	76.2	3.5	9.4	0.0	0.0	0.0
	M	17.6	52.6	1.6	28.2	0.0	0.0	0.0
	L	9.6	54.6	13.7	22.0	0.0	0.0	0.0
	Total	12.2	64.9	5.6	17.3	0.0	0.0	0.0
May 1981	S	1.1	60.5	23.8	14.5	0.0	0.1	0.0
	M	0.5	59.1	7.0	33.4	0.0	0.0	0.0
	L	0.1	52.4	9.1	38.5	0.0	0.0	0.1
	Total	0.7	58.1	15.9	25.2	0.0	T	T
Eight month overall mean (S,M,L-combined)		6.4	53.2	18.3	17.7	T	T	3.2
Standard deviation		6.13	7.36	8.27	7.13			5.21

* Other includes Nemotoda, Coleoptera, Gastropoda, Annelida, Hemiptora and Hirudinea.
** Trace (T) is any percent less than 0.1.

Table 3. Percent of total volume in milliliters of stomach contents of select size groups of mountain whitefish collected from the Pipe Creek study section of the Kootenai River. June to October 1980, January, March and May, 1981.

	Size group	Diptera	Chironomidae	Ephemeroptera	Trichoptera	Plecoptera	Terrestrial	Other*
June 1980	S	8.6	59.9	20.5	1.8	0.0	0.1	2.2
	M	3.5	61.4	16.8	3.9	0.0	0.0	0.8
	L	1.6	4.7	17.6	60.0	0.0	0.0	1.7
	Total	6.0	50.8	19.1	14.2	0.0	T**	2.3
July 1980	S	0.4	68.8	27.0	3.7	0.0	T	0.1
	M	0.2	52.5	10.2	37.0	0.0	0.0	0.1
	L	3.7	9.4	5.2	81.6	0.0	0.0	0.1
	Total	1.2	49.9	17.4	31.5	0.0	0.0	0.1
August 1980	S	0.0	57.4	20.7	21.7	0.0	0.0	0.0
	M	0.6	64.5	18.2	15.4	0.0	0.0	0.0
	L	2.8	70.0	4.4	20.5	0.0	0.0	1.1
	Total	0.8	62.4	16.1	19.6	0.0	0.0	0.3
September 1980	S	2.3	50.9	45.7	2.2	0.0	0.0	0.0
	M	9.2	23.3	51.8	15.7	0.0	0.0	0.0
	L	0.0	45.7	5.8	8.4	0.0	0.0	20.1
	Total	3.3	42.7	37.3	7.1	0.0	0.0	5.0
October 1980	S	1.6	76.1	12.2	9.7	0.0	0.0	0.4
	M	7.7	69.2	2.3	20.4	0.0	0.0	0.4
	L	0.0	24.0	4.9	12.6	0.0	0.0	58.6
	Total	2.7	61.4	7.9	13.1	0.0	0.0	14.9

Table 3. (Continued).

	Size group	Diptera	Chironomidae	Ephemeroptera	Trichoptera	Plecoptera	Terrestrial	Other*
January 1981	S	1.5	59.4	27.9	10.8	0.5	0.0	T
	M	5.0	38.8	11.7	44.3	0.1	0.0	0.1
	L	5.7	35.7	26.2	31.9	0.2	0.0	0.3
	Total	3.4	48.3	23.4	24.4	0.3	0.0	0.1
March 1981	S	0.2	50.1	36.0	6.2	0.0	0.0	0.0
	M	2.3	75.6	2.1	19.5	0.0	0.0	0.0
	L	0.0	89.5	6.9	0.5	0.0	0.0	0.0
	Total	0.7	62.2	24.3	8.1	0.0	0.0	0.0
May 1981	S	1.8	64.0	28.0	5.8	T	0.3	T
	M	4.6	54.6	16.0	24.5	0.2	0.1	0.1
	L	0.2	45.6	8.2	6.1	0.0	0.0	39.8
	Total	2.1	57.1	20.1	10.6	T	0.2	10.0
Eight month overall mean (S,M,L-combined)		2.5	54.3	20.7	16.1	T	T	4.1
Standard deviation		1.75	7.44	8.41	8.50			5.59

* Other includes Nemotoda, Coleoptera, Gastropoda, Annelida, Hemiptora and Hirudinea.
** Trace (T) is any percent less than 0.1.

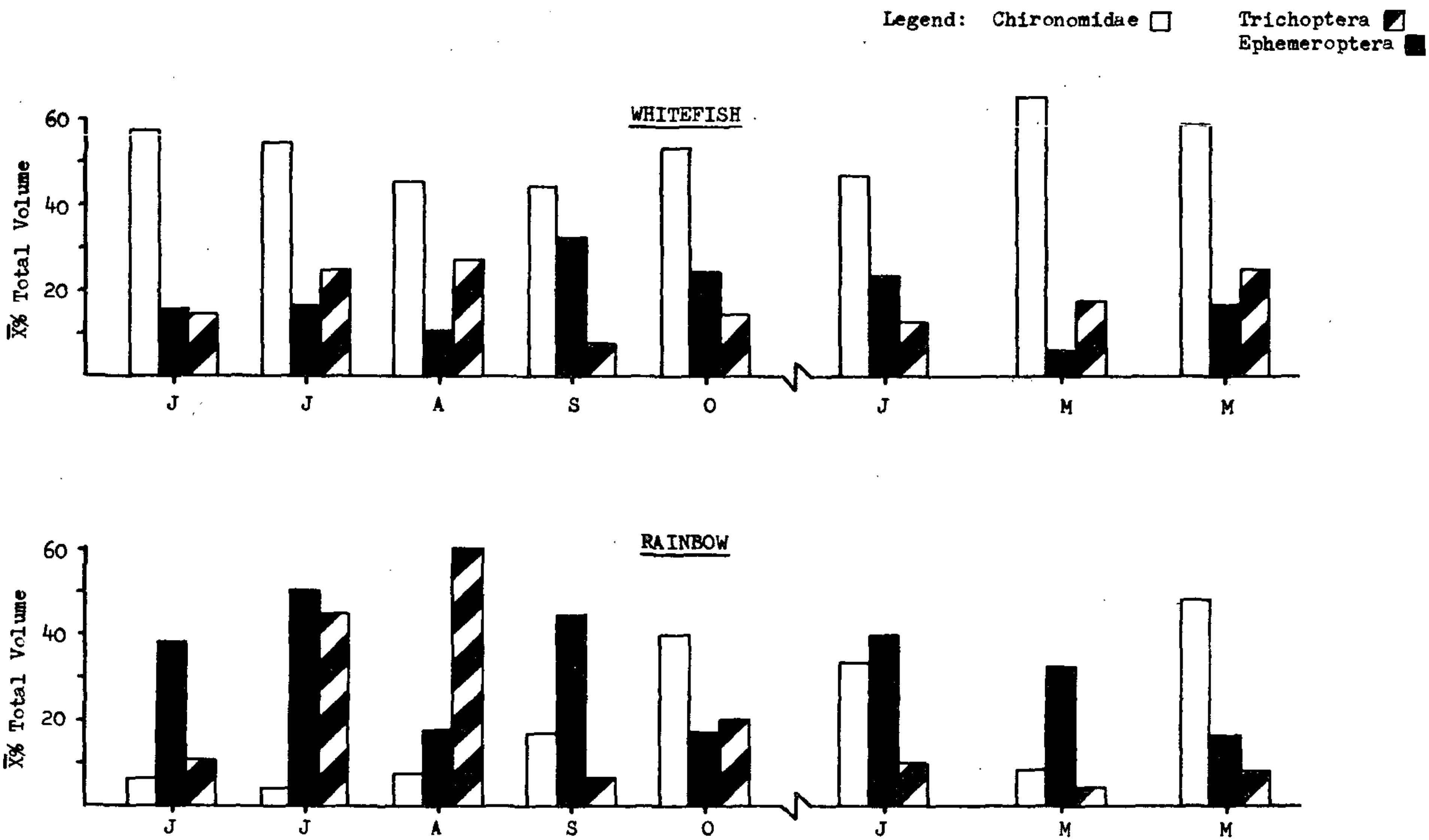

Figure 2. Monthly variation in the diets by percent of volume for mountain whitefish and rainbow trout collected from the Elkhorn study section of the Kootenai River during the sampling period June to October 1980, January, March and May 1981. Only the three major invertebrate groups are represented.

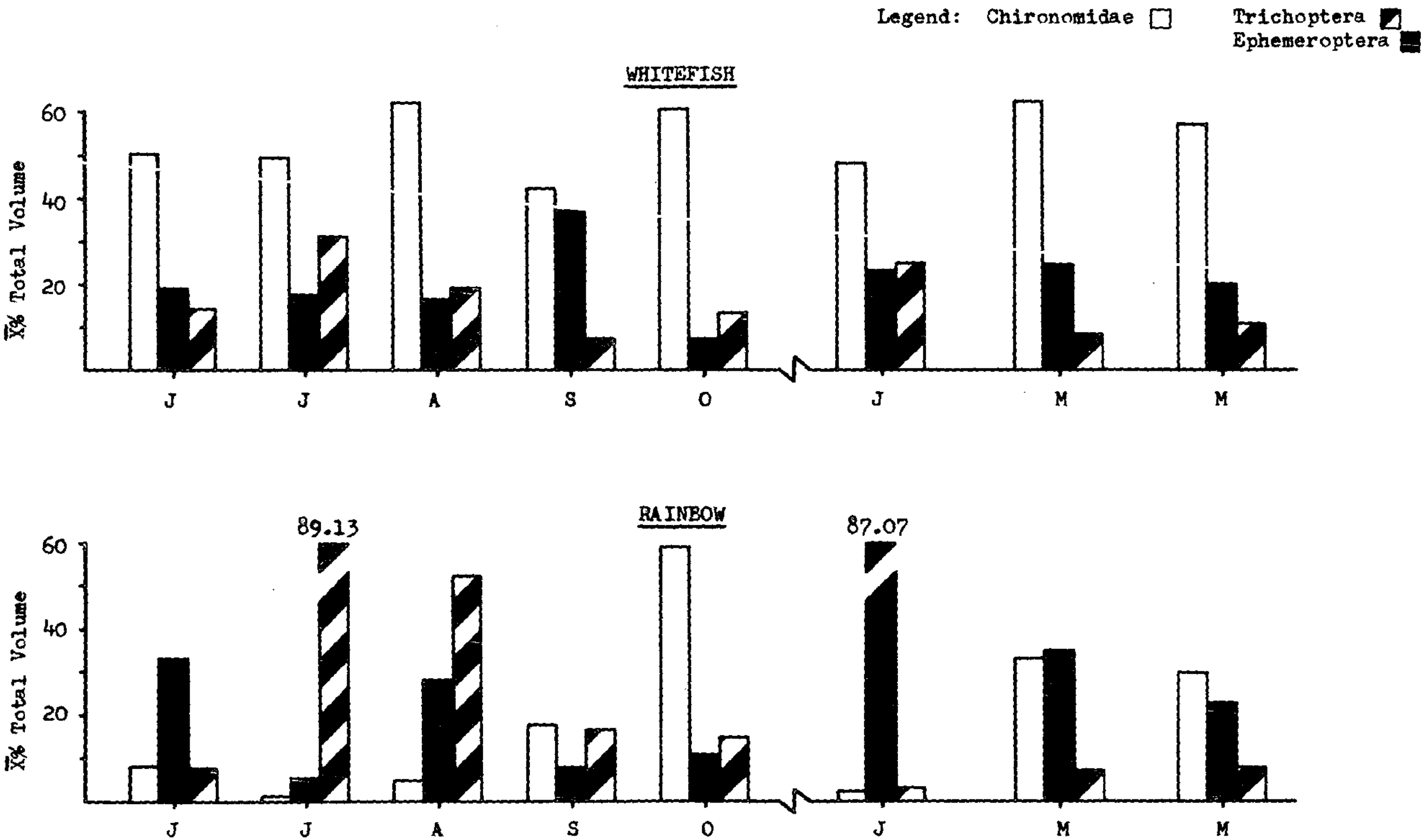

Figure 3. Monthly variation in the diets by percent of volume for mountain whitefish and rainbow trout collected from the Pipe Creek study section of the Kootenai River during the sampling period June to October 1980, January, March and May 1981. Only the three major invertebrate groups are represented.

Table 4. Percent of total volume in milliliters of stomach contents of select size groups of rainbow trout collected from the Elkhorn study section of the Kootenai River. June to October, 1980 and January, March and May, 1981.

	Size group	Diptera	Chironomidae	Ephemeroptera	Trichoptera	Plecoptera	Terrestrial	Other*
June 1980	S	12.6	10.7	48.0	7.2	0.0	4.2	17.3
	M	1.7	1.1	69.5	5.2	0.0	21.4	1.1
	L	10.6	3.4	17.4	16.4	0.1	5.5	13.6
	Total	9.9	5.8	38.0	11.0	T**	7.6	12.8
July 1980	S	0.1	7.4	62.8	39.6	T	T	T
	M	0.1	1.1	49.3	49.4	T	0.1	0.1
	L	0.1	1.1	36.9	61.7	0.0	0.1	0.1
	Total	0.1	4.2	50.6	45.2	T	0.1	0.1
August 1980	S	3.1	9.3	14.3	63.1	0.0	6.0	3.9
	M	5.4	3.0	5.7	52.1	0.0	2.4	16.9
	L	1.1	7.3	31.6	58.3	0.0	0.6	0.0
	Total	3.1	7.2	17.2	59.1	0.0	3.6	6.0
September 1980	S	8.4	30.1	53.9	7.7	0.0	0.0	0.0
	M	0.3	10.3	38.6	0.1	0.0	0.1	0.7
	L	0.4	11.1	41.7	14.6	0.0	0.0	32.3
	Total	3.0	17.1	44.4	6.3	0.0	0.1	20.9
October 1980	S	2.7	42.6	15.3	37.4	1.9	0.0	0.5
	M	0.7	54.7	24.4	11.8	0.0	T	8.1
	L	0.9	25.6	12.1	19.3	0.0	0.0	42.2
	Total	1.2	40.7	17.6	20.6	0.4	T	19.5

Table 4. (Continued).

	Size group	Diptera	Chironomidae	Ephemeroptera	Trichoptera	Plecoptera	Terrestrial	Other*
January 1981	S	4.8	85.7	0.0	8.9	0.0	0.0	0.6
	M	13.5	45.0	34.0	7.4	0.0	0.0	0.4
	L	3.6	10.0	52.3	14.6	0.1	0.0	19.3
	Total	8.2	32.9	39.2	10.0	0.1	0.0	9.0
March 1981	S			No Fish				
	M	35.1	11.3	34.1	6.2	0.0	0.0	0.0
	L	5.7	3.0	28.0	1.3	0.4	0.0	0.0
	Total	26.3	8.9	32.3	4.7	0.1	0.0	0.0
May 1981	S	2.0	34.4	29.7	0.0	0.0	0.6	33.3
	M	6.2	36.7	18.9	15.7	T	0.4	22.2
	L	1.4	69.3	6.1	3.6	0.1	19.0	0.6
	Total	4.8	48.7	16.5	7.4	0.1	7.6	16.4
Eight month overall mean (S,M,L-combined)		7.1	20.7	32.0	20.5	0.1	2.4	10.6
Standard deviation		8.43	17.55	13.40	20.44	0.15	3.46	8.19

* Other includes Nemotoda, Coleoptera, Gastropoda, Annelida, Hemiptora and Hirudinea.
** Trace (T) is any percent less than 0.1.

Table 5. Percent of total volume in milliliters of stomach contents of select size groups of rainbow trout collected from the Pipe Creek study section of the Kootenai River. June to October, 1980 and January, March and May, 1981.

	Size group	Diptera	Chironomidae	Ephemeroptera	Trichoptera	Plecoptera	Terrestrial	Other*
June 1980	S	17.6	7.5	31.6	10.1	0.1	2.3	7.2
	M	8.7	5.8	39.0	6.0	0.0	14.5	26.0
	L	15.0	16.3	32.6	7.0	0.0	0.3	35.4
	Total	14.9	8.8	33.6	8.5	T**	5.0	12.8
July 1980	S	0.2	2.1	10.7	86.6	0.0	0.1	0.1
	M	0.1	1.0	0.5	98.2	0.0	0.2	0.0
	L	T	0.4	1.4	84.6	T	T	13.6
	Total	0.1	1.4	5.8	89.1	0.0	0.1	3.4
August 1980	S	2.2	6.9	15.6	51.4	0.0	0.4	7.3
	M	2.0	1.4	27.9	68.7	0.0	0.0	0.0
	L	0.3	6.9	53.4	39.4	0.0	0.0	0.0
	Total	1.7	5.5	28.1	52.7	0.0	0.2	3.7
September 1980	S	6.6	18.0	16.2	18.6	0.0	0.0	4.4
	M	0.0	20.8	0.0	12.5	0.0	26.7	0.0
	L	20.1	6.0	0.1	14.9	0.0	0.0	39.0
	Total	8.3	17.2	8.1	16.2	0.0	6.7	12.0
October 1980	S	3.2	57.1	12.9	22.3	0.3	0.0	4.6
	M	2.2	62.7	15.7	9.9	0.2	0.0	9.5
	L	0.7	61.9	4.9	5.4	0.0	0.0	27.1
	Total	2.3	59.7	11.6	15.0	0.2	0.0	11.4

Table 5. (Continued).

	Size group	Diptera	Chironomidae	Ephemeroptera	Trichoptera	Plecoptera	Terrestrial	Other*
January 1981	S	3.9	3.0	87.3	0.7	5.0	T	T
	M	0.7	1.4	99.1	1.1	7.5	0.0	0.3
	L	0.6	0.6	84.6	9.6	3.4	0.0	1.3
	Total	2.3	2.0	87.1	3.0	5.2	0.0	0.4
March 1981	S	0.8	29.9	51.2	0.0	0.0	0.0	9.1
	M	4.7	51.5	13.4	14.0	0.0	0.0	2.6
	L	0.9	14.8	25.4	14.0	1.3	0.0	43.7
	Total	2.5	33.2	35.5	6.7	0.3	0.0	13.8
May 1981	S	2.2	41.1	30.6	7.3	4.5	0.6	13.3
	M	1.4	27.8	26.7	11.4	0.0	0.0	32.7
	L	13.6	13.2	3.5	7.1	15.2	11.1	36.4
	Total	4.7	30.8	23.0	8.2	6.1	3.1	23.9
Eight month overall mean (S,M,L-combined)		4.6	19.8	29.1	24.9	1.5	1.9	10.2
Standard deviation		4.84	20.28	26.04	30.32	2.58	2.68	7.42

* Other includes Nemotoda, Coleoptera, Gastropoda, Annelida, Hemiptora and Hirudinea.
** Trace (T) is any percent less than 0.1.

trout. There are three basic methods of food habit analysis; frequency of occurrence, percent of total numbers and percent of total volume (Bagenal 1978). Some investigators have used an index of relative importance (IRI) (George and Hadley 1979, McMullin 1979). This IRI is essentially a mean of the three dietary measures. Frequency of occurrence and percent of total numbers are heavily influenced by the smaller food items which may contribute little to the total volume of an individual stomach. For these reasons, the average of the volume percentages appears to be the least objectionable measure of the diet when calculating overlap (Wallace 1981).

Percent diet overlap between mountain whitefish and rainbow trout is given by month, size group and total in Table 6 for Elkhorn section and Table 7 for Pipe Creek section. The percent overlap in diet between mountain whitefish and rainbow trout in any one size group, month or section ranged from 11 percent in June, 1980 (at Elkhorn) to 91 percent in October, 1980 (also at Elkhorn section). Total overlap (for all size groups) for any one month ranged from 31 percent in January, 1981 at Pipe Creek section to 94 percent in October, 1980 also at Pipe Creek. Total percent overlaps in the Elkhorn section were more consistent than those for the Pipe Creek study section.

Percent overlap in the diets of small fish were the highest and were less variable than other size groups. Small fish are more restricted to smaller food items than larger fish and would be expected to have more diet overlap. Data described in Tables 3 through 6 indicates small whitefish feed heavily on chironomids and that small rainbow trout select more chironomids than other rainbow size groups. Therefore, if competition for food is occurring, it is most likely taking place among fish less than 19.9 cm long.

SELECTION VS AVAILABILITY

The measured or apparent availability of benthic insects may have little relationship to the actual ingestion of the item by a fish. Apparent abundant resources may be relatively inaccessible, less desirable, protectively camouflaged, or hard to catch (Wallace 1981). Not only must the behavioral habits and size of the particular fish be considered, but also the behavioral and drift habits of the insects and larval size before judgements about selectivity can be made.

Rainbow trout are primarily drift feeders (Bryan 1973, White 1973) while mountain whitefish are much more substrate oriented (May et al. 1981). Therefore feeding habits of mountain whitefish are not necessarily correlated to those invertebrates which have a high tendency to drift, but may be due to the inherent behavioral differences of the fish themselves. Fish develop and maintain definitive feeding images (Ivlev 1961). Regardless of the actual availability of a food item, some fish species may choose a particular food organism at a frequency well above its relative abundance. In other instances, selection is very strongly correlated to the actual availability.

Table 6. Percent overlap in the dietary composition of mountain whitefish and rainbow trout stomachs collected from the Elkhorn study section of the Kootenai River. Formula by Schoener (1970).

Month	Size group S	Size group M	Size group L	Total
June 1980	49.34	11.03	16.17	50.14
July 1980	28.61	32.98	71.47	48.00
August 1980	49.13	33.18	60.51	55.43
September 1980	71.98	65.82	45.07	73.52
October 1980	72.27	90.67	51.71	73.40
January 1981	57.88	73.88	35.85	74.85
March 1981	No fish	43.35	54.58	45.25
May 1981	59.42	59.92	62.16	72.04
Overall mean	55.52	51.35	49.69	61.58
Standard deviation	15.14	25.89	17.37	13.03

Table 7. Percent overlap in the dietary composition of mountain whitefish and rainbow trout stomachs collected from the Pipe Creek study section of the Kootenai River. Formula by Schoener (1970).

Month	Size group S	Size group M	Size group L	Total
June 1980	55.90	33.52	36.58	56.67
July 1980	16.80	38.56	83.46	38.93
August 1980	52.40	36.23	32.70	46.67
September 1980	56.28	53.30	54.50	58.83
October 1980	80.80	77.42	61.31	94.32
January 1981	33.58	15.06	37.47	31.11
March 1981	74.38	77.28	23.73	71.24
May 1981	77.03	56.69	59.29	71.54
Overall Mean	55.90	48.51	48.63	58.66
Standard deviation	22.19	21.87	19.51	20.33

At the present time, the drift data have not been compiled by mean percent total composition (biomass). However, the benthic data for summer 1980 have been analyzed and compared to food selection of rainbow trout and mountain whitefish. Rainbow trout usually selected Ephemeroptera and Trichoptera at or above their respective availability in the benthos. In June and September, 1980, they also selected "other" invertebrates in close correlation to their availability (Tables 8 and 9). Rainbow trout selection for chironomids was always well below their availability, except for the month of September, 1980 when they substituted chironomids and "others" for Trichoptera.

Mountain whitefish always selected chironomids above their apparent availability (Tables 10 and 11). Whitefish selection of "other" invertebrates was below availability, whereas their selectivity for Ephemeroptera and Trichoptera was variable.

These data support the seasonal food habit trends of mountain whitefish and rainbow trout food where Chironomidae were the principle food item for whitefish, while rainbow trout depend upon Ephemeroptera, Chironomidae and Trichoptera. The data also demonstrates that particular organisms are preyed on regardless of their degree of availability in the benthic insect community at any particular time in the Kootenai River.

MICROHABITAT COMPARISONS

High discharges from Libby Dam during June through September, 1981, rarely below 6,000 cubic feet per second, made habitat analysis in the Kootenai River operationally impossible. All habitat work was conducted in Fisher River and Libby Creek, the two largest tributaries to the Kootenai River above Kootenai Falls. The basic assumption is that habitat preferences of mountain whitefish and rainbow trout would be similar in these tributaries to those in the Kootenai River itself. Two basic justifications for this assumption are: both species move freely between these tributaries and the main river during certain times of the year, and on the basis of observations in Kootenai River, rainbow trout and mountain whitefish utilized relatively similar macrohabitat areas.

The author feels that data presented in this section can be extrapolated to the Kootenai River and that trends in microhabitat selection will likely hold true for fish residing in the river. Microhabitat preferences for 178 rainbow trout and 69 mountain whitefish were documented in Fisher River and Libby Creek. Velocity and depth measurements versus fish size data will be analyzed using single and multiple regression and discriminant and principle component techniques. Preliminary analysis indicate that as whitefish increase in size they choose habitats with slower water velocity. Conversely, as rainbow trout increased in size they chose habitats with increased velocities. Chapman and Bjornn (1969) noted that larger rainbow trout inhabited faster velocity water than small rainbow trout

Mountain whitefish chose deeper areas with higher average velocities than did rainbow trout (Table 12). However, due to their close association

Table 8. Comparison of percent of total volume of stomach contents (O-observed) of rainbow trout to that of percent total biomass (E-expected) of benthic samples collected from the Elkhorn study section of the Kootenai River during summer 1980.

Month	Value	Percent of				
		Ephemeroptera	Plecoptera	Tricoptera	Chironomidae	Other
June	Observed	37.99	0.03	10.97	5.84	30.35
	Expected	38.20	0.0	11.80	15.90	34.10
July	Observed	50.58	0.01	45.18	4.24	0.21
	Expected	28.00	0.70	27.30	13.40	28.60
August	Observed	17.19	0.0	59.10	7.24	12.70
	Expected	30.30	3.9	22.40	12.20	31.30
September	Observed	44.44	0.0	6.26	17.08	23.88
	Expected	18.40	4.1	28.40	17.00	32.20

Table 9. Comparison of percent of total volume of stomach contents (O-observed) of rainbow trout to that of percent total biomass (E-expected) of benthic samples collected from the Pipe Creek study section of the Kootenai River during the summer of 1980.

Month	Value	Percent of				
		Ephemeroptera	Plecoptera	Tricoptera	Chironomidae	Other
June	Observed	33.64	0.03	8.49	8.77	32.63
	Expected	27.80	0.0	8.30	26.00	37.90
July	Observed	5.84	0.0	89.13	1.40	3.63
	Expected	27.10	0.0	40.70	8.80	23.40
August	Observed	28.09	0.0	52.73	5.53	5.51
	Expected	28.06	3.0	15.80	14.10	8.05
September	Observed	8.30	0.0	16.15	17.20	26.94
	Expected	19.60	1.3	31.00	15.70	32.40

Table 10. Comparison of percent of total volume of stomach contents (O-observed) of mountain whitefish to that of percent total biomass (E-expected) of benthic samples collected from the Elkhorn section of the Kootenai River during the summer of 1980.

		Percent				
Month	Value	Ephemeroptera	Plecoptera	Tricoptera	Chironomidae	Other
June	Observed	15.46	0.03	14.02	58.51	8.86
	Expected	38.20	0.0	11.80	15.90	34.10
July	Observed	18.79	0.0	24.92	54.63	1.66
	Expected	28.00	0.7	29.30	13.40	28.60
August	Observed	10.91	0.0	26.62	45.06	14.87
	Expected	30.30	3.9	22.40	12.20	31.30
September	Observed	32.05	0.0	7.03	44.63	11.64
	Expected	18.40	4.1	28.40	17.00	32.20

Table 11. Comparison of percent of total volume of stomach contents (O-observed) of mountain whitefish to that of percent total biomass (E-expected) of benthic samples collected from the Pipe Creek section of the Kootenai River during the summer of 1980.

		Percent				
Month	Value	Ephemeroptera	Plecoptera	Tricoptera	Chironomidae	Other
June	Observed	19.07	0.0	14.21	50.77	8.29
	Expected	27.80	0.0	8.3	26.00	37.90
July	Observed	17.35	0.0	31.51	49.88	1.25
	Expected	27.10	0.0	40.70	8.80	23.40
August	Observed	16.12	0.0	19.55	62.44	1.08
	Expected	28.06	3.0	15.80	14.10	38.05
September	Observed	37.20	0.0	7.13	42.69	8.28
	Expected	19.60	1.3	31.00	15.70	32.40

Table 12. Comparison of microhabitat parameters associated with mountain whitefish and rainbow trout. Data collected from spot observations conducted in the Fisher River and Libby Creek.

	Rainbow trout			Mountain whitefish			Significant difference (95% level)
	Number of observations	Mean	Standard deviation	Number of observations	Mean	Standard deviation	
Velocities							
Facing	11	0.72	0.48	14	0.89	0.50	no
Average	22	1.22	1.05	14	1.85	1.04	yes
Surface	21	1.34	1.60	14	1.77	1.13	no
Depths							
Fish	21	0.47	0.25	14	0.20	0.10	yes
Total	22	2.18	0.83	14	2.97	1.06	yes
% Substrate Composition							
Sand	22	19.32	16.71	14	9.64	15.38	yes
Gravel	22	35.91	20.74	14	44.64	26.20	no
Cobble	22	30.91	19.19	14	38.21	21.63	no
Boulder	22	13.86	16.83	14	7.50	14.24	no

with the substrate (i.e. fish depth), they were actually occupying areas with lower velocities. Rainbow trout chose substrate areas with a higher percent sand composition than did mountain whitefish. Sand areas can only be deposited and maintained in areas with relatively low velocities (Chorley 1969). This corresponds to the slightly less facing velocities between the two species (Table 12).

Although there are not always statistically significant differences between all microhabitat parameters, the aspect of morphological adaptations should not be ignored. Mountain whitefish choose substrate areas with higher percent gravel and cobble composition. Because of their planing availity, they can maintain positions in these higher velocity areas. This type of substrate mixture may facilitate their benthic feeding habits (May et a˙. 1981). Rainbow trout occupied areas with a higher percent composition of boulders. They are not a planing fish, and use these boulders with reduced velocity areas. In this manner, they can occupy areas affording resting positions and still be near high velocity waters where drifting insects are available to them.

SUMMARY

Rainbow trout generally selected food items from the water column or near the water surface while mountain whitefish selected food items from near or on the substrate. Rainbow trout of all sizes generally fed on a wider range of food groups than did mountain whitefish. All sizes of mountain whitefish fed heavily on Chironomidae although whitefish larger than 27.8 cm total length often selected other food groups such as Trichoptera, Ephemeroptera and other Dipterans. Dietary overlap between rainbow trout and mountain whitefish was most noticeable for fish less than 19.9 cm total length and this overlap was confined to their utilization of Chironomidae.

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SECTION C

Fisheries Investigations
July 1972 - September 1982

By

Bruce May and Joe E. Huston

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OBJECTIVES

The objectives of this study were to determine the effects of operation of Libby Dam upon fish populations in the Kootenai River and to collect the data necessary for management of the sport fishery. The specific job objectives were:

1. Determine abundance of fish populations in the Kootenai River.

2. Determine growth rates and condition factors of gamefish in the Kootenai River.

3. Monitor spawning runs of rainbow trout and mountain whitefish from the Kootenai River into tributary streams and locate spawning areas in the mainstem Kootenai.

4. Determine angler catch rates and species composition of the catch.

METHODS

Water Quality and Flow Data

Water chemistry, flow and temperature data were collected by the USGS and Seattle District Corps of Engineers at a station just downstream from Libby Dam. Temperature degree days for each year from 1968-1978, and calculated degree days for the temperature rule curve developed for the selective withdrawal system were provided by Seattle District Corps of Engineers.

A Taylor recording thermograph was utilized to record water temperatures in Pipe Creek and maximum-minimum thermometers were utilized in Bobtail Creek. A Marsh-McBirney flow meter was used to determine velocities in tributary streams and Kootenai River.

Creel Census

Creel census information was collected from anglers fishing the Kootenai River between Libby Dam and Kootenai Falls in summers 1975 and 1980, and all four seasons in 1977 and 1978. Angling data were collected 12 weekdays and 12 weekend days during each three month season, spring, summer, fall and winter. Anglers interviewed included those that had completed their angling effort and those still fishing with the exception that interviews were not taken from anglers who had fished less than one hour.

Data collected from each angler included hours of fishing effort, time of day fished, number of fish caught by species and total length of each fish caught. Type of gear was recorded and included use of natural bait, artificial lures or flies or a combination and whether fishing was from a boat or shore. Residency of each angler was classified as resident of Lincoln County, other State of Montana residents, or non-resident.

Tag Returns

Rainbow trout more than 250 mm total length captured during electrofishing in Kootenai River or in spawning surveys were generally tagged with a numbered anchor tag and released. Return of these tags by anglers provided useful information on movements of individual fish and on fisherman harvest. Anglers were requested to return tags from tagged fish they had caught and to provide information about when the fish was caught, the size of the fish when caught, and where the fish was caught. Anglers were asked to return tags to either Department personnel or local sporting goods stores via newspaper articles and radio programs.

Fish Population Sampling

Fish were collected at night in the Kootenai River using an electrofishing boat. Pulsed direct current of approximately two amps and 150 volts was used. Fish caught were held overnight in cages and processed the next morning. Methods described by Vincent (1971) were followed for electrofishing operations and for analyzing mark and recapture data. Tributary streams were sampled with boat mounted electrofishing gear with mobile electrodes or a backpack electrofishing unit powered by a six volt motorcycle battery.

Fish population study sections, their lengths and locations, were: 1) Jennings Section, 4,117 m, three to eight km below Libby Dam; 2) Elkhorn Section, 6,100 m, 16 to 22.5 km downstream; 3) Flower-Pipe Section, 7,350 m, 27 to 35 km downstream; and 4) Troy Section, 3,843 m, 58 to 61 km downstream from Libby Dam (Figure 1).

Spawning fish entering tributary streams were captured in box traps with poultry netting leads and in fyke nets. The emigration of fry and juvenile fish was monitored using a fry trap designed by Northcote (1969a). The test leads were 6.4 mm square mesh hardware cloth.

Most fish collected during the study were anesthetized, measured, weighed, some scale samples taken, marked or tagged and released.

Age and Growth

Scale samples were taken from 20-30 fish per each 25.4 mm length group to determine growth and age structure of the population. Scales were collected from a small area below the origin of the dorsal fin and one scale row above the lateral line.

Cellulose acetate impressions of the scales were read at 106X and 40X magnification for rainbow trout and mountain whitefish, respectively. Measurements (mm) were made from the center of the focus to each annulus and to the anterior edge of the scale.

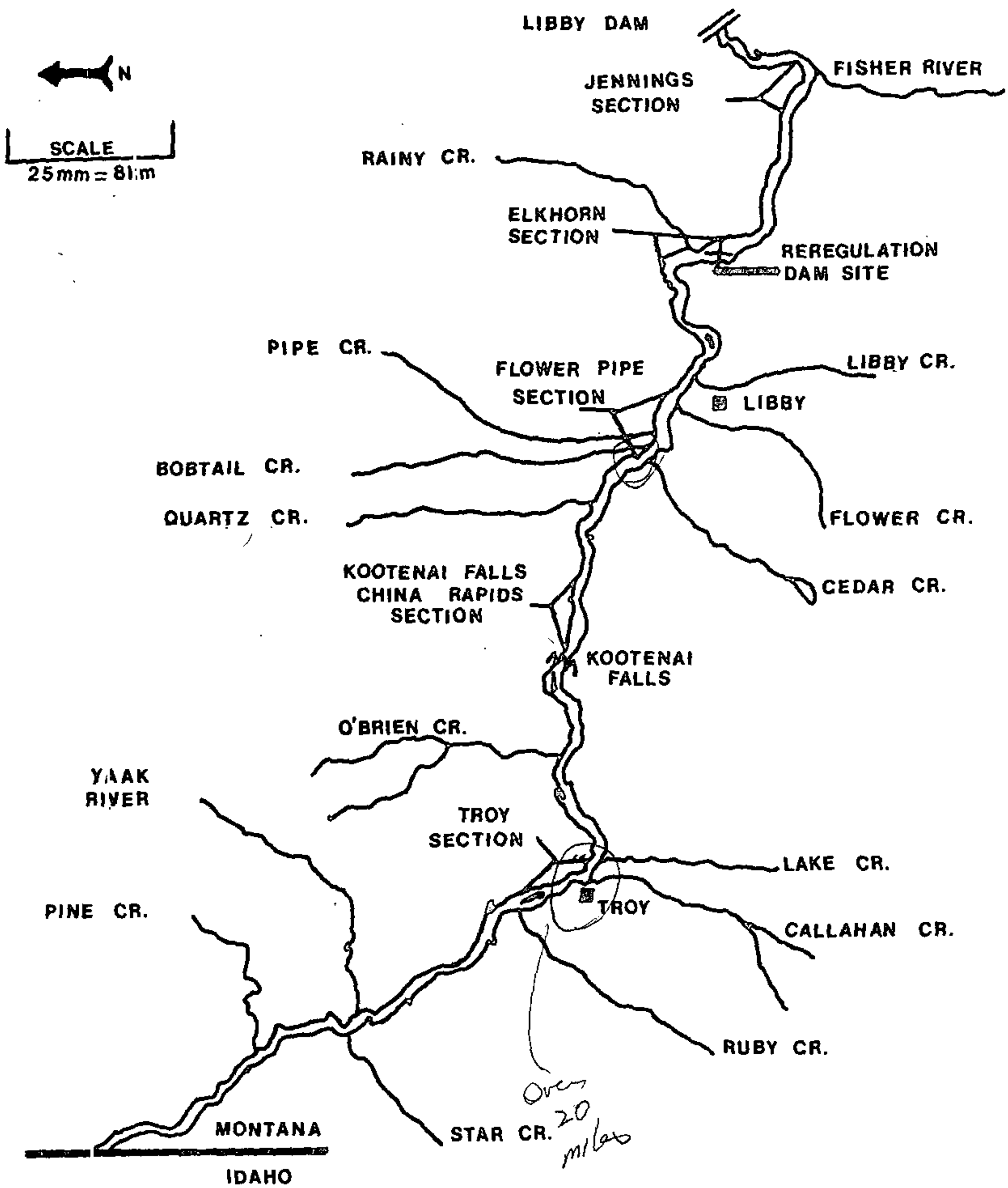

Figure 1. Map of Kootenai River and its tributaries below Libby Dam, showing electrofishing sections.

The Fire I computer program (Hesse 1977) was used to calculate the body-scale relationship. The relationship was most accurately described by the Monastrysky logrithmic method which is based on a log-log plot of fish length versus scale radius. Body-scale relationships for mountain whitefish and rainbow trout were calculated from pooled data (1972-1981) from the Flower-Pipe Section of the Kootenai River. Backcalculated lengths were determined using the Monastrysky relationship and a program, Age Mat, developed by Delano Hanzel and Bob McFarland of Montana Department of Fish, Wildlife and Parks.

The age at which juvenile rainbow trout emigrated from their natal stream into the Kootenai River varied from young-of-the-year to three years old. Fish that emigrated as young-of-the-year could not be reliably separated from those that emigrated at one year of age. Fish that emigrated at two years or three years of age were discrete. Age and growth data presented in this report combines rainbow trout that lived less than two years in the natal stream into classification X_1 and those that lived two or three years in the natal streams as X_2 and X_3. In this classification "X" represents the total age of the fish and the "sub" number represents the age at emigration from the natal stream, i.c., 5_2 is a fish with total age of five years which emigrated from the natal stream after rearing there two full years.

FINDINGS AND DISCUSSION

Pre-Impoundment Water Quality

Information concerning the water quality and fishery of the Kootenai River prior to 1967 is scarce. Bonde and Bush (1975) reported that prior to the late 1940's, cutthroat and burbot were the most abundant fish caught, while rainbow trout and mountain whitefish were less abundant. A decline in burbot and cutthroat populations and an increase in rainbow and mountain whitefish occurred in the 1950's. Fishermen reported that water quality deteriorated during this time period resulting in increased algae growth, silt and sediment becoming more noticeable. Sediment loads during the spring appeared larger and more persistent and on occasion the river seemed to develop an odd color.

Major point sources of pollution were mining operation, smelter and fertilizer plant on the St. Mary River, coal mines on Elk River, Kraft paper mill on the upper Kootenai, and a vermiculate mine and concentrator located 11 miles downstream from Libby Dam on Rainy Creek (Figure A). Sediment loaded discharge from thickening and concentration of the vermiculate and drainage from the tailings into Rainy Creek settled out in the Kootenai and adversely affected aquatic insect and fish production. This sediment source was cleaned up in 1972 by order of Montana Department of Health and Environmental Sciences.

Pollution in the St. Mary River resulted from effluents from a lead-zinc mine, a concentrator, a fertilizer plant and city sewage plant (Malick 1978). The mine began operation in 1900, the fertilizer plant in 1953 and the iron and steel plants operated from 1961 to 1972.

Water quality in the Kootenai River improved in 1968 following implementation of the first step of pollution control at the industrial complex on the St. Mary River. The improvement in water quality resulted in a marked increased in aquatic insect populations in the Kootenai River. The standing crop of aquatic insects increased from 1968 to 1971 by 273 percent above Libby Dam site and 392 percent downstream from Libby Dam site (Bonde and Bush 1975).

Significant improvements in water quality of the St. Mary River and Kootenai River were made in 1975 and 1977 largely by recycling effluents (Malick 1978). The concentrations of dissolved phosphorous, iron, zinc, lead and fluorides were reduced and pH increased. Rapid recovery of the stream biota occurred in conjunction with the reductions in levels of metals, suspended solids and phosphorous discharged into the St. Mary River. Cutthroat trout populations have increased and a good fishery now exists for this species in the St. Mary River (Jerry Oliver, personal communication).

In summary, water quality problems in the Kootenai River were limiting aquatic insect populations and may have caused a shift in the species composition of the fish population from cutthroat and burbot to rainbow trout and mountain whitefish.

Post-Impoundment Water Quality

Changes in water quality and discharge patterns occurred in the Kootenai River following impoundment in 1972. To illustrate these changes, comparisons are given of sediment loads in 1970 and 1975 and nutrient concentrations and specific conductance in 1970, 1975 and 1979. These were years of below normal flow, being 75, 83 and 75 percent of normal, respectively. Duration hydrographs were utilized to compare the median and 30th percentile flows prior to impoundment, 1925-1972 and post-impoundment, 1973-1981.

Sediment Loads

Suspended sediment loads in the Kootenai River downstream from Libby Dam and reservoir have dropped markedly since impoundment of the river. The sediment load in 1975 was approximately 15 percent of that found in 1970 (Figure 2). Prior to impoundment, peak sediment loads occurred from April to July in conjunction with peak flows. Following impoundment, peak loads took place during the high flow period from November to March when the reservoir was being drafted. In addition to reduced sediment load downstream from Libby Dam, a marked reduction in sediment pollution occurred in 1972 from Rainy Creek. An improved treatment facility removed most of the sediment from mine-mill effluents.

The reduction of large sediment loads has been an important factor in the high productivity of the river downstream from the dam. The adverse effects of sediment on the aquatic environment have been well documented in the literature by Cordone and Kelly (1961). Apman and Oates (1965), Peters (1967) and Hall and Lantz (1969). Phillips (1971) in reviewing

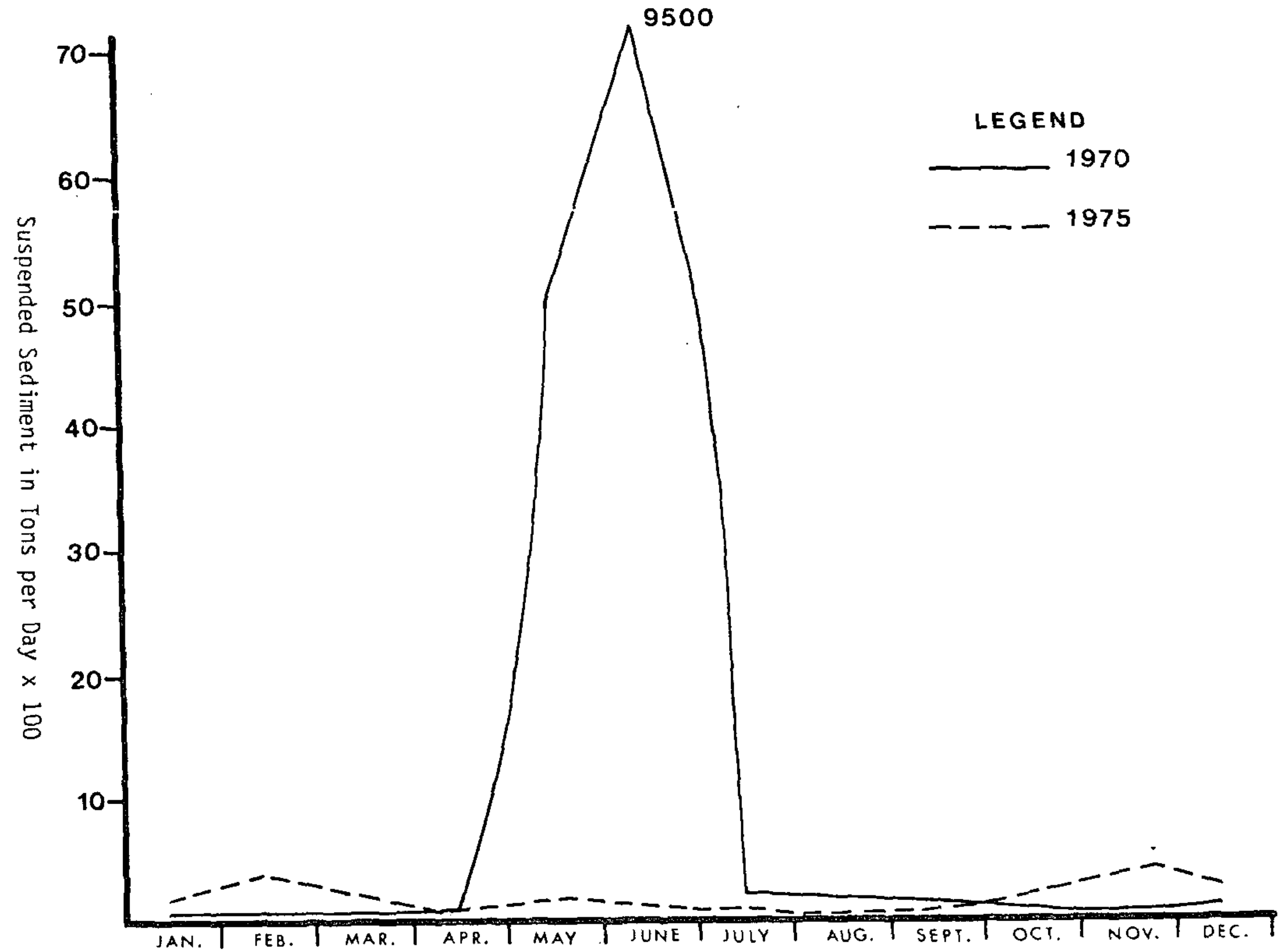

Figure 2. Average monthly suspended sediment loads in the Kootenai River prior to impoundment (1970) and three years after impoundment (1975).

research on the sediment problem concluded that sediment adversely affects fish by: 1) blocking transmission of light thereby reducing primary production; 2) reducing abundance and diversity of aquatic insects which are the primary food of stream salmonids; and 3) filling the interstices in the gravel which prevents successful incubation of eggs, escapement of fry from the gravels and eliminates escape cover for fry and fingerling.

Nutrient Concentrations

Nutrient concentrations in the Kootenai River downstream from Libby Dam have declined markedly since impoundment. Dissolved orthrophosphate concentrations averaged .383 ppm in 1970 as compared to .039 ppm in 1975 and only .002 ppm in 1979 (Figure 3 and Appendix A). A similar pattern was noted for concentrations of total phosphorous (Figure 4, Appendix A). This decline in nutrient concentrations was related to improved pollution control facilities at a fertilizer plant on the St. Mary River in British Columbia and trapping of nutrients in the reservoir. The operation of the selective withdrawal system was probably a factor in reduced nutrient levels after 1977 due to the shallow depth of water withdrawal from Lake Koocanusa. Deep release of water from reservoirs results in higher levels of nutrients than shallow releases (Ward and Stanford 1979).

Phosphorous is often considered the most critical single factor in the maintenance of biochemical cycles (Reid 1961). This extreme importance stems from the fact that phosphorous is vitally necessary in the operation of energy transfer systems in the cell and it normally occurs in very small amounts. The latter factor means that there is apt to be a deficiency of the nutrient which could lead to inhibition of primary productivity. It appears that the low phosphorous concentrations currently found in the Kootenai River could be limiting the production of periphyton.

Specific Conductance

Specific conductance was more stable following impoundment of the river in 1972 (Figure 5 and Appendix A) due to the lack of high spring flows and low winter flows. Specific conductance ranged between 190 and 373 μm in 1970 as compared to 235 and 298 μm in 1979. The mean conductance in 1970 of 295 μm was higher than the mean of 266 μm in 1979. Conductance is often used as a gross indication of potential productivity of aquatic systems (Ellis et al. 1946). The values for the Kootenai classify it as a medium to high productive system.

Water Temperature

The thermal regime was greatly modified in the Kootenai River downstream from Libby Dam following regulation in 1972. Temperature patterns were variable from 1972-1976 depending upon whether water was released via the sluices, spillways or penstocks (beginning June, 1975). Penstock inverts are at elevation 2,222 msl (237 feet below full pool), the sluices are at elevation 2,200 msl (259 feet below full pool), and the spillways are at elevation 2,405 msl (54 feet below full pool). Releases from

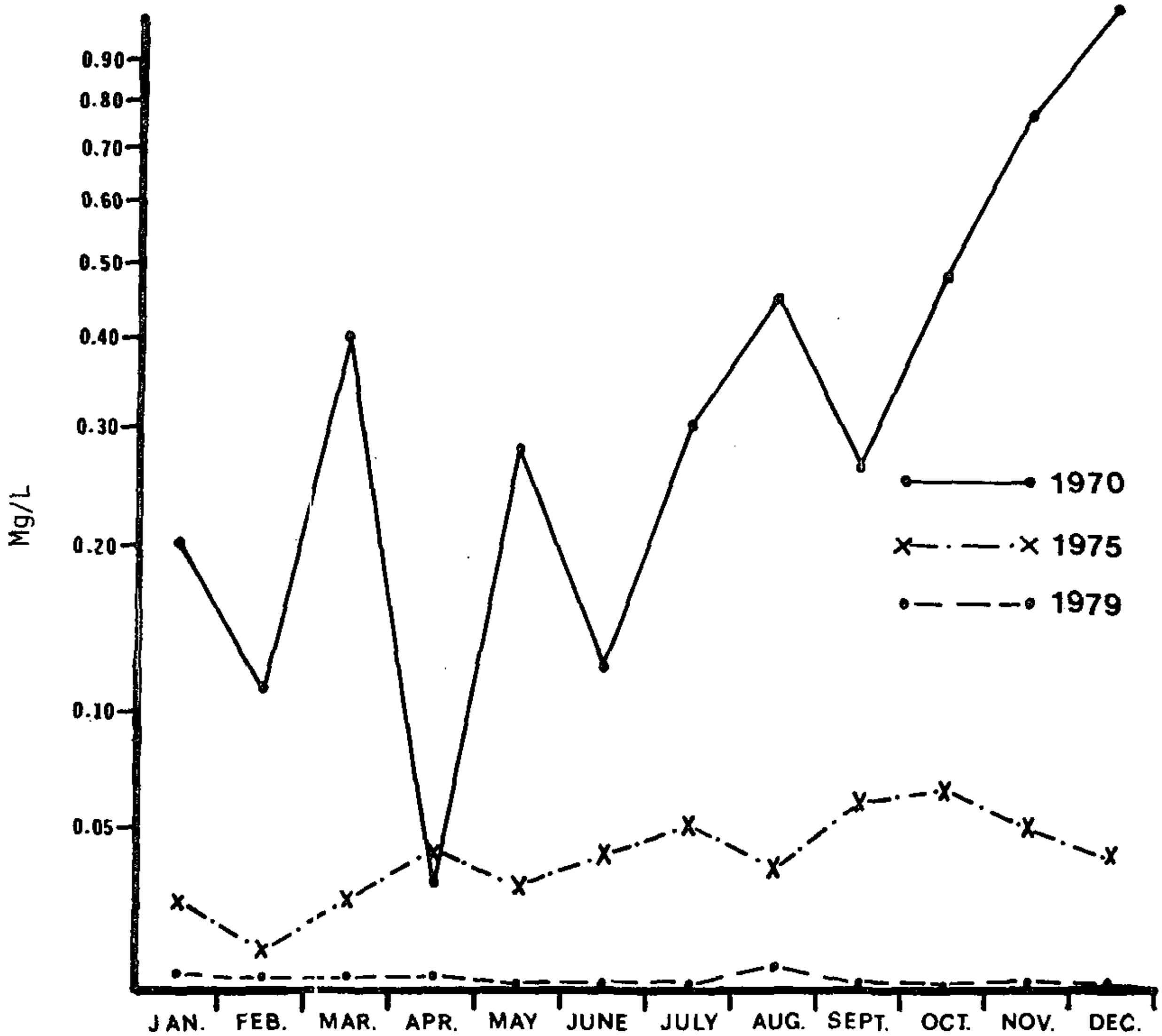

Figure 3. Total dissolved orthophosphate measured downstream from Libby Dam site prior to impoundment (1970), following impoundment (1975) and following operation of the selective withdrawal system (1979).

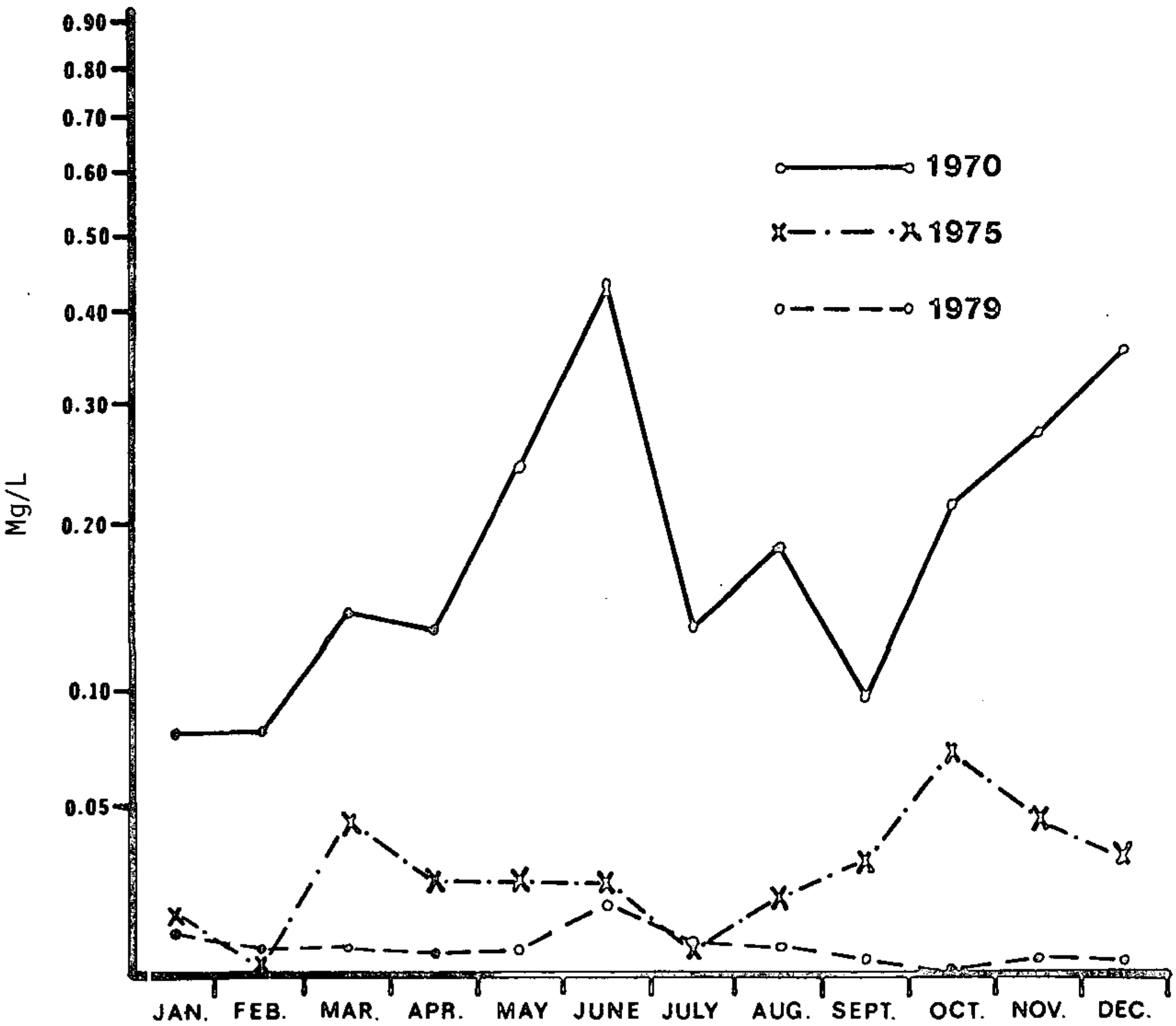

Figure 4. Total phosphorous measured downstream from Libby Dam site prior to impoundment (1970), following impoundment (1975), and following operation of the selective withdrawal system (1979).

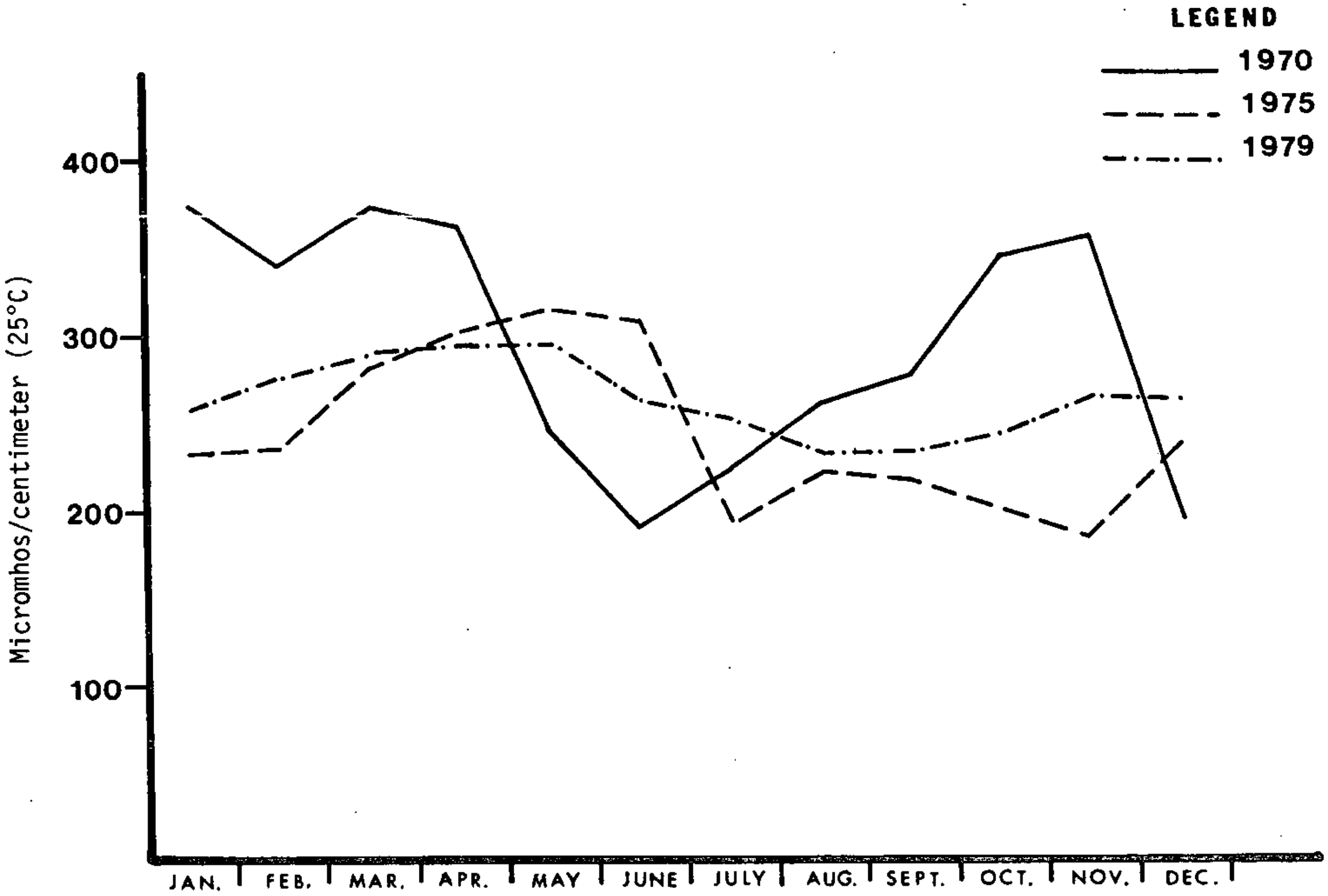

Figure 5. Specific conductance measured in Kootenai River downstream from Libby Dam site prior to impoundment (1970), following impoundment (1975) and following operation of the selective withdrawal system (1979).

the sluices and penstocks were hypolimnetic, whereas the spillway releases were epilimnetic. The mean daily temperatures in the Kootenai River prior to impoundment (1970), following impoundment (1975) and the first year the selected withdrawal system was operated (1977) are compared in Figure 6.

River temperatures were generally cooler in 1975 and 1977 than in 1970 from April to mid-September. Temperatures increased rapidly in 1975 the last week of June when the spillway was used to release water. Temperatures were warmer in 1975 and 1977 than 1970 from October through March.

The selective withdrawal system is operated under a temperature rule curve developed to control depth and temperature of water discharged from the dam. Discharges are from deep in the reservoir during the winter when the reservoir is isothermal with temperatures about 39°F. As temperatures increase in the spring, the selective withdrawal is operated to draw water from near the reservoir surface to increase the discharge temperature as rapidly as possible to a maximum temperature of 56°F. A temperature of 56°F is then maintained until reservoir temperatures decline to below 50°F. Selective withdrawal operation is regulated to draw water from 50 feet or more below the water surface to minimize gamefish escapement and turbine induced mortalities. The temperature regime was designed to provide near optimum temperatures for fish but still reduce escapement of fish from the reservoir.

The temperature patterns in the Kootenai River prior to impoundment (1962-1971), hypolimnetic release (1976) and the temperature rule curve are compared in Figure 7. The 1976 temperature pattern, in which releases were hypolimnetic, resulted in cooler water temperatures from mid-April to October than the preimpoundment temperatures. Water temperatures during the remainder of the year were higher than preimpoundment temperatures.

The temperature rule curve provides water temperatures that are cooler in the summer and warmer in the fall and winter than prior to impoundment with an overall increase in the number of degree days above the preimpoundment mean of approximately 30 percent (Table 1). However, the actual number of degree days from 1977-1980 has averaged only 115 percent of the preimpoundment mean. The highest number of degree days occurred in 1974 and 1975 when epilimnetic spillway releases were used.

Ward and Stanford (1979a) noted the extent to which impoundments modify the temperature of the receiving stream depends primarily upon the discharge depth, the thermal stratification of the reservoir, the retention time, and dam operation. Thermal modification of the Kootenai River has resulted in: 1) increased diurnal constancy; 2) increased seasonal constancy; 3) summer depression; and 4) winter elevation. The overall effect of these changes upon gamefish populations is not totally known, but some positive effects may have occurred for rainbow trout.

Numerous studies have been made on the temperature preferences of rainbow trout. These studies have shown that temperature preference

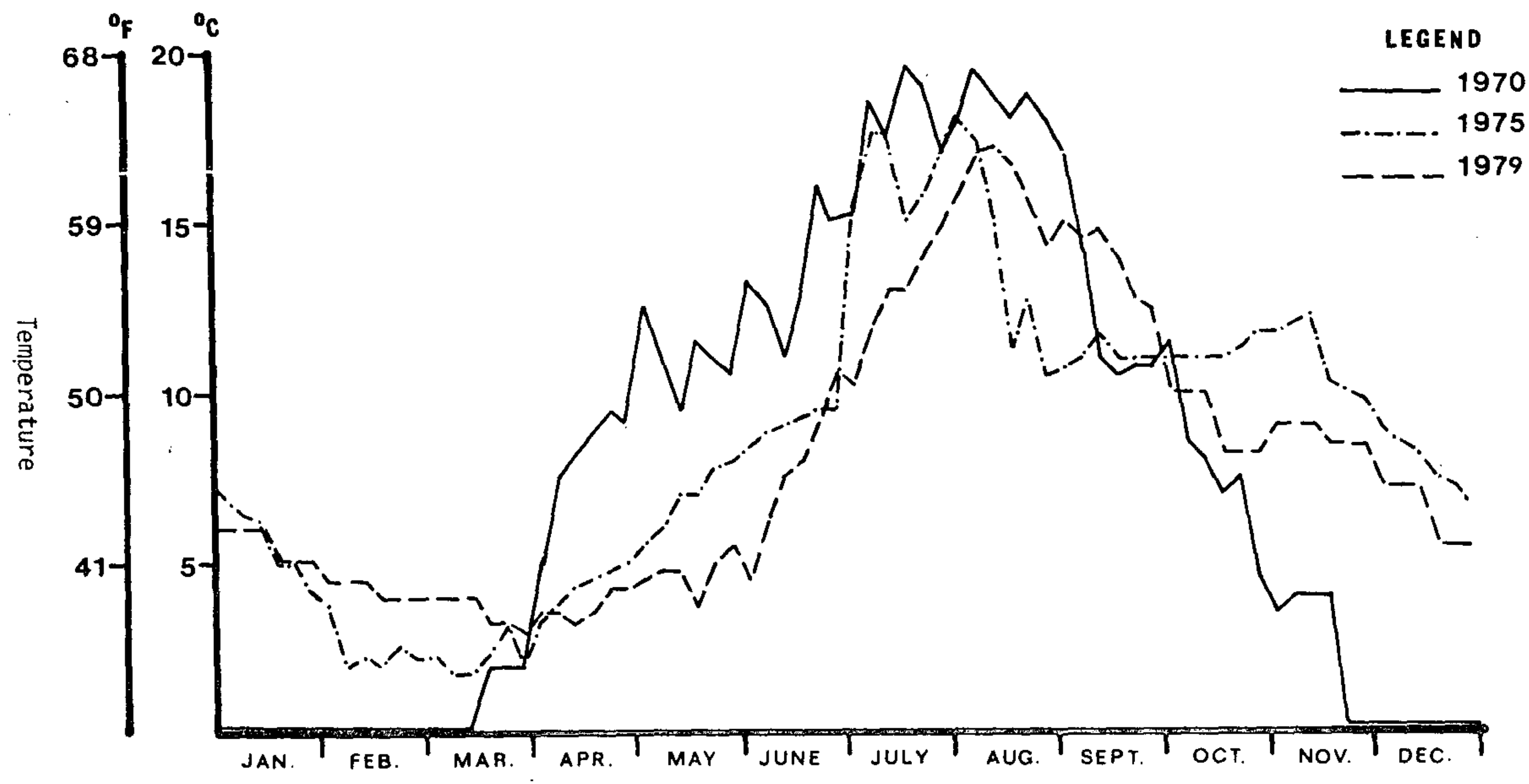

Figure 6. Mean daily water temperatures averaged for five day periods in the Kootenai River downstream from Libby Dam site prior to impoundment (1970), following impoundment (1975) and following operation of the selective withdrawal system (1979).

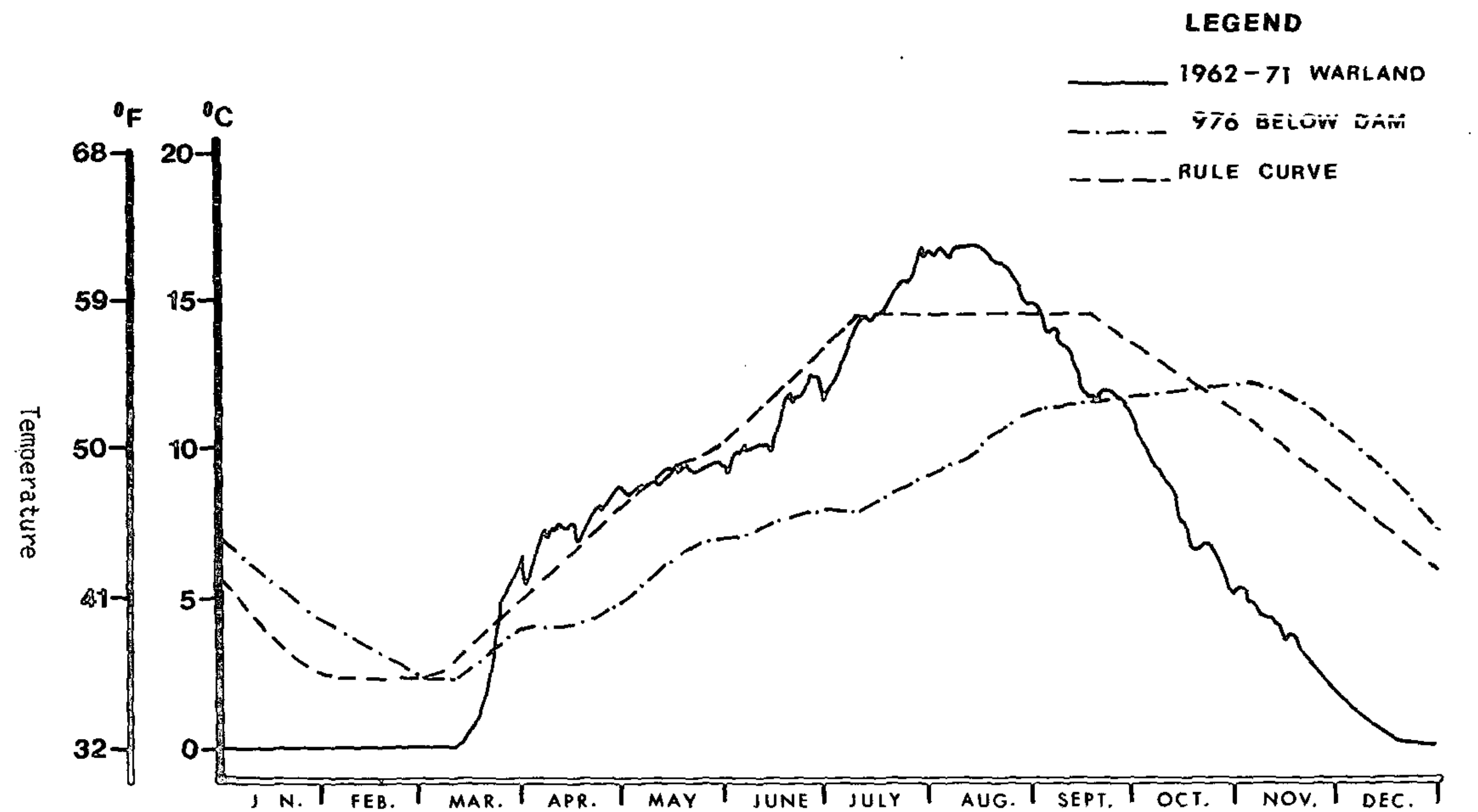

Figure 7. Mean daily water temperatures in the Kootenai River, 1962-1971 at Warland located seven miles upstream from Libby Dam, 1976 post-impoundment below Libby Dam and the temperature rule curve developed for the selective withdrawal system in 1978.

Table 1. Number of degree days (32°F base) in Kootenai River near Libby Dam before impoundment (1962-1971), after impoundment without selective withdrawal system (1972-1976) and with operation of selective withdrawal system (1977-1980).

Calendar year	Degree days	Percent of normal
Pre-impoundment mean[1/] 1962-1971)	4,573	100
Post-impoundment without selective withdrawal		
1972	4,827	106
1973	5,279	115
1974	5,519	121
1975	5,669	124
1976	4,940	108
1972-1976 mean	5,246	115
Post-impoundment with selective withdrawal		
1977	5,374	118
1978	5,220	114
1979	5,269	115
1980	5,183	113
1977-1980 mean	5,261	115
Operational plan	5,947	130

1/ Degree days data with the exception of 1979 and 1980 calendar years supplied by Tom Bonde, Seattle District Corps of Engineers.

is influenced primarily by the age of the fish and its recent thermal history or thermal acclimation. McCauley et al. (1977) found the calculated final preferred temperature of 15 month old rainbow trout was 52°F. In contrast, rainbow trout fingerlings had a preferred temperature of 63°F (McCauley and Pond 1971). Hokanson et al. (1977) found the maximum specific growth rate of juvenile rainbow trout fed excess rations occurred at a temperature of 63°F. A study by Atherton (1970) indicated that 54°F was the optimum temperature for rainbow trout growth. These studies show that young-of-the-year rainbow achieve their best growth at temperatures of about 60-63°F, whereas rainbow trout over one year old grow best when temperatures are about 50-54°F.

The Kootenai prior to impoundment averaged about 111 days each year above 50°F. The planned temperature regime should increase this to 168 days, but only 110 days were above 50°F in 1977 (Table 2). The number of days above 50°F increased to 140 in 1979 and 168 in 1980. The temperature pattern in 1980 followed the temperature rule curve closely, having temperatures above 50°F from May 30 to November 13.

Table 2. The number of days in which the mean daily water temperature was above 50°F in the Kootenai River near Libby Dam.

Calendar year	Period temperature above 50°F	Number days temperature above 50°F
Pre-impoundment (1962-1971)	6/15-10/4	111
1972	6/13-11/8	158
1973	5/12-11/18	191
1974	7/18-12/3	154
1975	6/24-12/2	162
1976	8/16-12/5	113
1977	6/23-10/15	115
1979	6/16-11/2	140
1980	5/30-11/13	168
Planned	6/1-11/15	168

Warmer water temperatures during the fall and winter following impoundment of the river have probably increased over-winter survival of trout. Severe winter conditions including the formation of anchor ice have been shown to cause high mortalities of trout (Needham and Slater 1945; Naciolek and Needham 1952; Nielson et al. 1957). Reimer (1957) found that excessive winter mortality rates are due more to adverse and exhaustive physical conditions than to food availability. Needham and Jones (1959) observed that rainbow trout fed actively as long as the water temperature was above 33°F.

Flows

The annual and daily flow regime of the Kootenai River was altered by river regulation. Prior to impoundment, high flows occurred from May through July. Following impoundment, high flows characteristically occurred from October through mid-February (Figure 8). The median peak flows prior to impoundment were about 60,000 cfs as compared to only 21,000 cfs following impoundment. In two of ten years, peak flows exceeded 60,000 cfs prior to impoundment as compared to a peak of 26,000 cfs following impoundment. The maximum discharge recorded prior to impoundment was 121,000 cfs on June 21, 1916, while the maximum following regulation was 40,000 cfs in June, 1981. The lack of high scouring spring flows has altered the habitat of the Kootenai River by allowing the formation of deltas at the mouths of tributaries and eliminating channel maintenance flows.

High spring flows determine the shape of the channel rather than the average or low flows. Lack of these high flows which are needed for scouring and channel maintenance may be especially important in maintaining fish and aquatic insect populations (Holden 1979). The Montana Department of Fish, Wildlife and Parks (1981) noted that the major function of the high spring flows in the maintenance of channel form are bedload movement and sediment transport. The movement of bed and bank material and subsequent deposition shapes the channel and forms islands and side channels. The flushing action of high flows removes deposited sediments and maintains suitable gravel conditions for aquatic insect production, fish spawning and egg incubation. A significantly altered channel configuration and armouring of the river bottom would affect both the abundance and species composition of the present aquatic populations by altering the existing habitat types through time.

An operational minimum flow of 4,000 cfs has been established in the Kootenai River downstream from Libby Dam, unless water is needed to refill the reservoir. In that case, a flow of 3,000 cfs is allowed during the period when water is being stored in the reservoir. The median flow in the Kootenai River was above 4,000 cfs from 1973-1981 (Figure 8). In contrast, the median flow from 1925-1972 was below 4,000 cfs from approximately the first week of December to the last week of March. A similar pattern was recorded for the 80th percentile flow or flow that is exceeded in eight of ten years (Figure 9).

The relationship of the wetted surface area to discharge is presented in Figure 10 for a 17.9 km section of the Kootenai River beginning 5.8 km below Libby Dam. This figure shows that the water surface area increases rapidly up to a discharge of about 5,000 cfs. Further increases in discharge results in a much smaller rate of increase in water surface area. The minimum flow of 4,000 cfs in conjunction with the higher flows in the winter have combined to produce good year-round flows for fish production. The establishment of a satisfactory minimum flow is probably the single most important factor in maintaining a high level of aquatic productivity downstream from dams. The primary impacts of increased minimum flow are an increase in the quantity and quality of living space. The detrimental effect of reduced flows on salmonid production has been well documented (Kraft 1968; Hazel 1976; Mulan et al. 1976; Bovee 1978; and McMullin and Graham 1981). The higher flows during the winter following impoundment

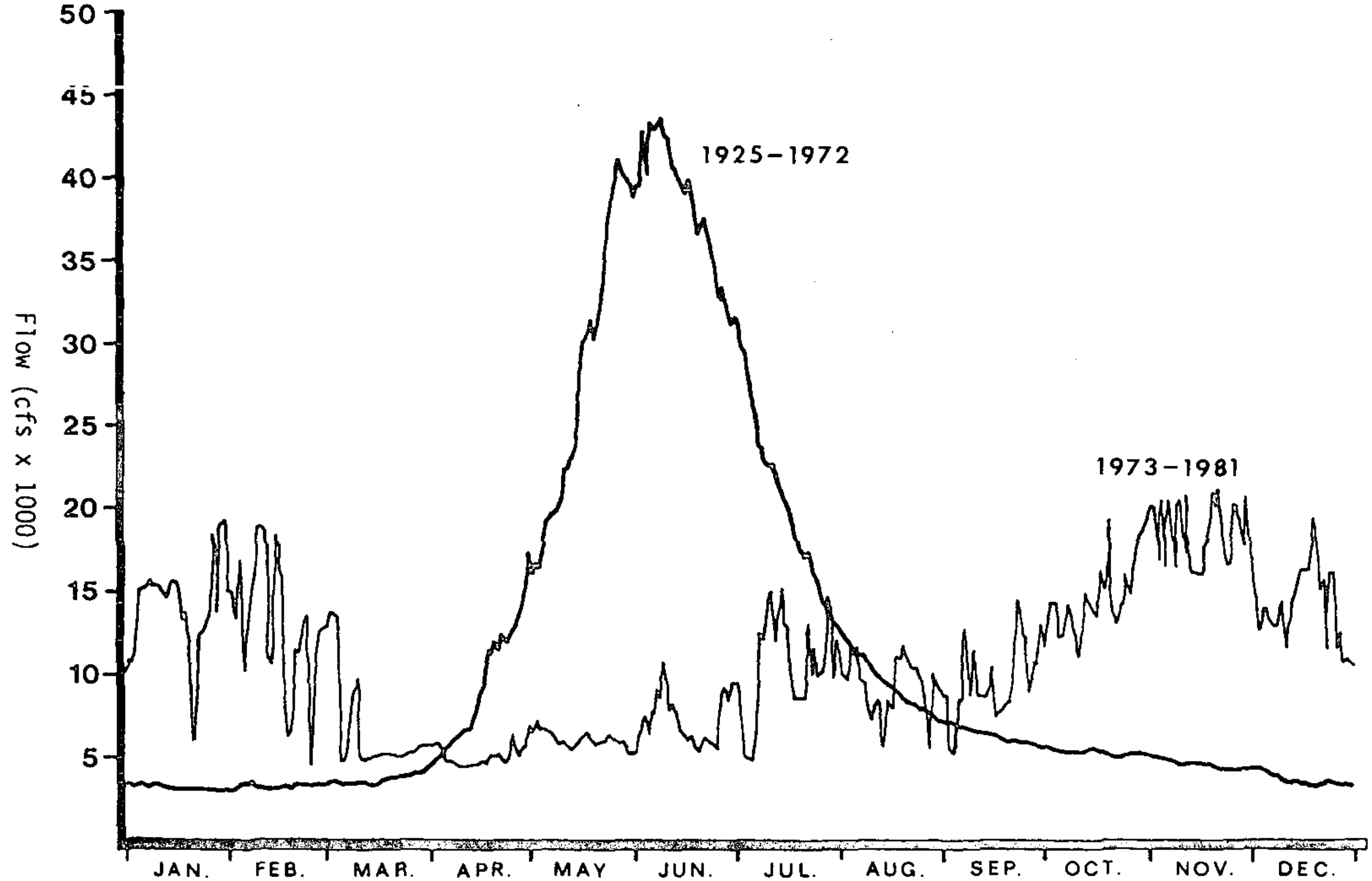

Figure 8. The median flows in the Kootenai River recorded downstream 17 miles from Libby Dam- The median percentile flow is the flow that is exceeded in five out of 10 years.

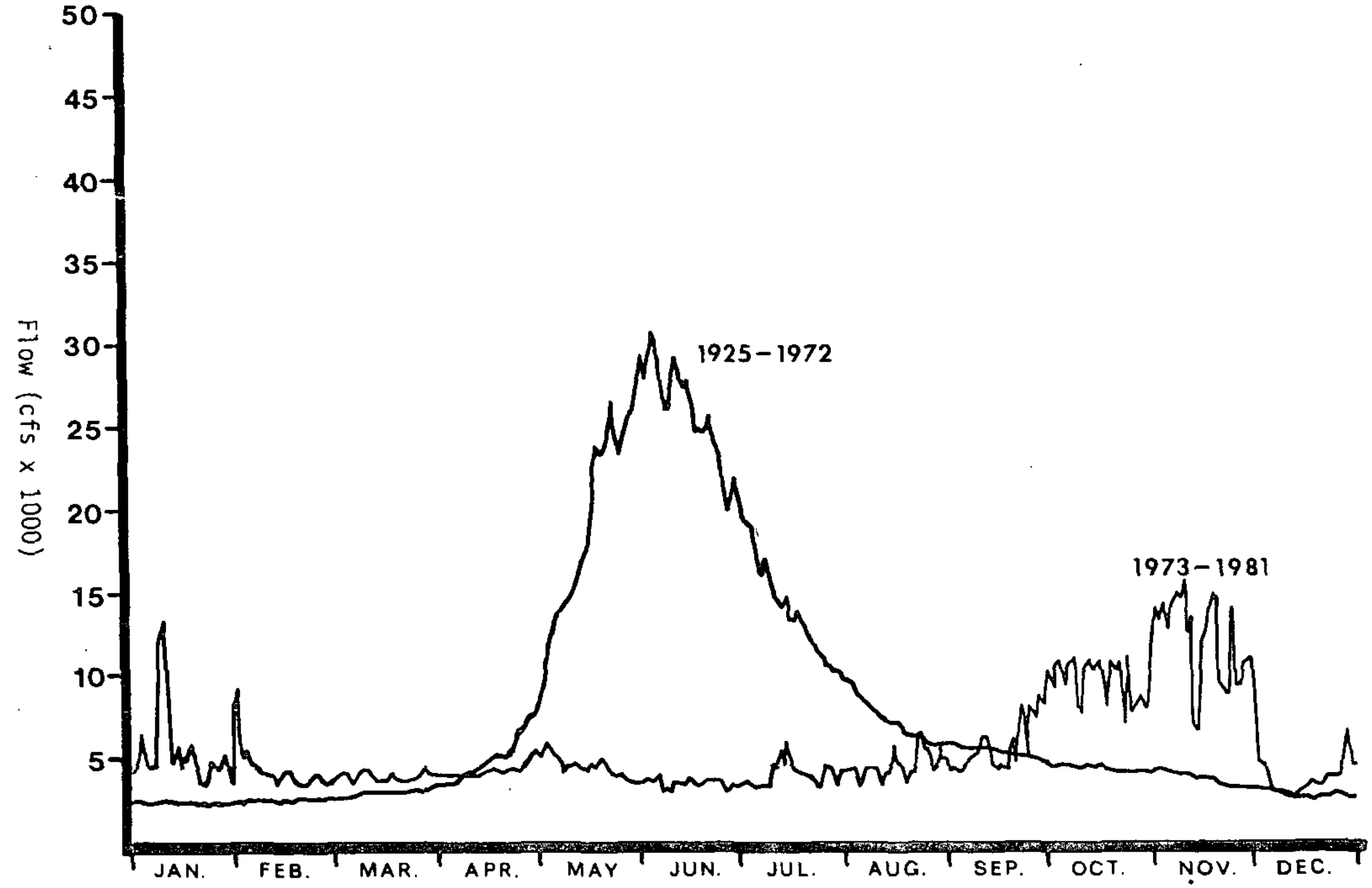

Figure 9. The 80th percentile flow in the Kootenai River recorded 17 miles downstream from Libby Dam. The 80th percentile flow is exceeded in eight out of 10 years.

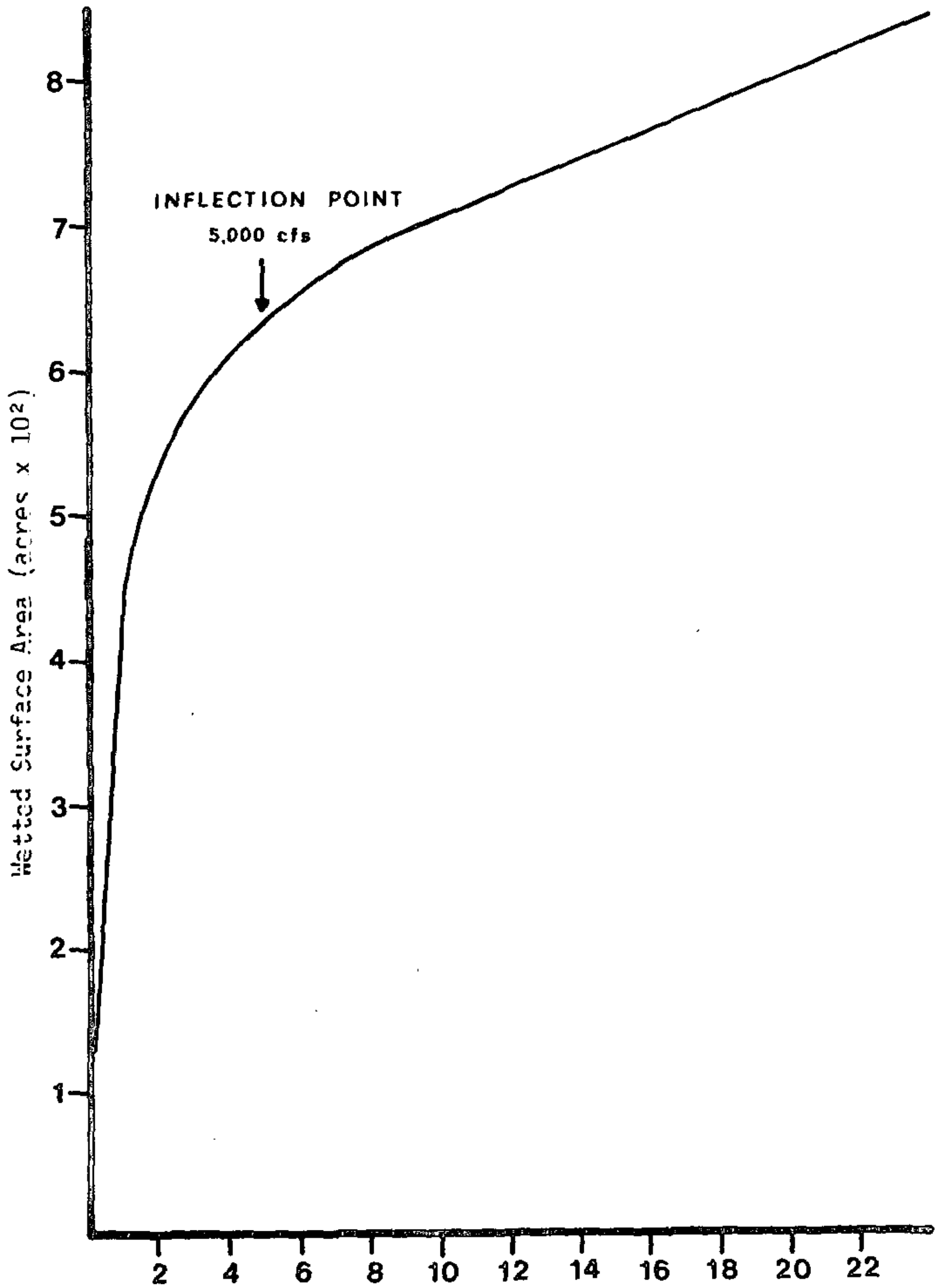

Figure 10. Wetted surface area vs. discharge for a 17.9 km section of the Kootenai River beginning 5.8 km below Libby Dam.

have undoubtedly increased over-winter survival of fish. The Montana Department of Fish, Wildlife and Parks (1981) pointed out that naturally occurring low flows in the winter coupled with the adverse affects of surface and anchor ice formation and the resulting scouring of the river channel at ice-out can adversely impact the fishery. Consequently, reduced flows during this crucial low flow period have the potential to be extremely harmful to trout populations. Needham (1959) noted that low winter flows and subsequent reduction of habitat was a factor limiting rainbow trout populations.

The daily flow pattern of the Kootenai River, which was stable under natural conditions, now fluctuates on most days due to the power-peaking operation of Libby Dam. Maximum fluctuations under discharge criteria are: 1) April through September, four vertical feet per day and one foot per hour; 2) October through March, six vertical feet per day and two feet per hour. The average daily fluctuation from 1976-1982 has been consistently less than the maximum criteria.

Fluctuating power dam releases have been shown to be detrimental to aquatic insect and fish populations below many dams. Corning (1969) found that stream fluctuations below dams on three Colorado trout streams reduced productive trout water to a non-productive series of intermittent pools. Aquatic insect diversity and abundance can be limited by slow currents resulting from low flows (Trotzby and Gregory 1974) or conversely by fast water releases (Powell 1958). Sudden decreases in flows exposes the streambed and destroys algae, aquatic insects and some fish (Kroger 1973; Brusven et al. 1974).

The magnitude of aquatic insect stranding in the Kootenai River is determined to a large degree by the flow regime prior to the flow reduction. Little stranding occurs when flows are fluctuated at least weekly from a high of 10,000-20,000 cfs to the minimum of 4,000 cfs. After higher flows have been in effect for several weeks, extensive colonization occurs above the 4,000 cfs perimeter and considerable stranding of aquatic insects occur when flows are reduced to 4,000 cfs (Section A, this report).

Stranding of fish has been limited to very small numbers of game and nongame fish in backwater areas and appears to have had little effect on any fish species population. The overall effect of flow fluctuations upon aquatic insect and salmonid production in the Kootenai River is not known, but it appears that the establishment of an adequate minimum flow has been an important factor in alleviating these effects. The minimum flow of 4,000 cfs provides a large amount of base habitat which is not dewatered when flow is fluctuated. The drastic effects of flow fluctuations upon the aquatic insects and fish populations in the studies previously noted occurred in streams without adequate minimum flows.

The alteration of flows has also influenced the fishability of the Kootenai River downstream from Libby Dam. Fishing appears to be best when the flows are less than 8,000 cfs (Graham 1981). Prior to flow regulation, the Kootenai River was "fishable" below 8,000 cfs an average of 225 days per year, about 62 percent of the time (Table 3, Figure 11). Following impoundment, the days the river has been below 8,000 cfs has varied from 45 days in 1974 to 261 days in 1973, with an average of 152 days per year or 42 percent of the time for the ten years from 1972 through 1981. On an annual basis, fishing opportunity has been reduced by 73 days since impoundment of the river.

The fishing opportunity is somewhat different if the period when most people desire to fish from April through September is considered. Prior to impoundment, the Kootenai River was below 8,000 cfs an average of 43 days or about 23 percent of the time. Following impoundment, the river was fishable an average of 94 days. Fishing opportunities during the summer season from April through September have increased by an average 51 days since construction of Libby Dam in 1972.

Species List

Sixteen species of fish have been documented in the Kootenai River below Libby Dam (Table 4). Westslope cutthroat trout (*Salmo clarki lewisi*), rainbow trout (*Salmo gairdneri*), mountain whitefish (*Prosopium williamsoni*), torrent sculpin (*Cottus rhotheus*), largescale sucker (*Catostomus macrocheilus*) and longnose dace (*Rhinichthys cataractae*) were considered abundant, whereas slimy sculpin (*Cottus cognatus*), northern squawfish (*Ptychocheilus oregonensis*) and peamouth chub (*Mylocheilus caurinus*) were seldom collected. Kokanee (*Oncorhynchus nerka*) were first collected in 1980. These fish emigrated from Lake Koocanusa through the turbines. Westslope cutthroat trout, torrent sculpins and longnose dace populations have declined in abundance following impoundment, whereas burbot (*Lota lota*), rainbow trout and mountain whitefish numbers increased. One largemouth bass (*Micropterus salmoides*) was collected but was not included in the species list.

Species found downstream from Kootenai Falls were identical to the upstream list except for white sturgeon (*Acipenser transmontanus*). A pure strain of native inland rainbow trout is found in Callahan Creek (Allendorf et al. 1980). Rainbow trout, mountain whitefish, largescale suckers and peamouth chub were considered abundant in both pre and post-impoundment periods.

White sturgeon populations appeared to decline following regulation of the river (Graham 1981). Moderate populations of white sturgeon still exist in the lower Kootenai River (Partridge 1981), but few fish move upstream into Montana.

Pre-impoundment Sport Fishery

Little data were collected on fish populations in Kootenai River prior to 1970, except for contact creel surveys conducted by game wardens. A summary of these surveys is given in Table 5. Cutthroat dominated the catch during the summer season comprising 46.2 percent of the fish creeled followed by mountain whitefish (38.7%), burbot (7.6%), rainbow

Table 3. A comparison of the number of days that the Kootenai River had good fishing flows (less than 8,000 cfs), pre-Libby Dam and post-Libby Dam.

	Number of days mean flow of 8,000 cfs or less										
	Pre-dam	Post-dam									
Month	1910-71	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1972-81
January	31	31	31	14	0	0	10	9	2	9	2	108
February	28	28	28	0	0	0	12	8	25	21	0	122
March	31	22	31	11	10	5	13	29	31	31	21	204
April	12	15	30	4	25	14	14	30	30	30	30	222
May	0	0	31	0	5	24	25	31	29	31	30	206
June	0	0	24	0	22	25	28	13	30	7	0	149
July	0	6	21	3	31	5	8	4	31	9	0	118
August	1	13	16	0	31	0	19	8	31	13	3	134
September	30	5	0	13	18	2	23	6	13	19	7	106
October	31	0	7	0	0	0	11	1	4	3	9	35
November	30	0	11	0	0	1	3	0	0	2	8	25
December	31	30	31	0	0	0	20	1	9	0	3	94
Total for year	225	150	261	45	142	76	186	140	235	175	113	1,523
Percent	62	41	72	12	39	21	51	38	64	48	21	42
April through September	43	39	122	20	132	70	117	12	164	109	70	935
Percent	23	21	67	11	72	38	64	50	90	60	38	51

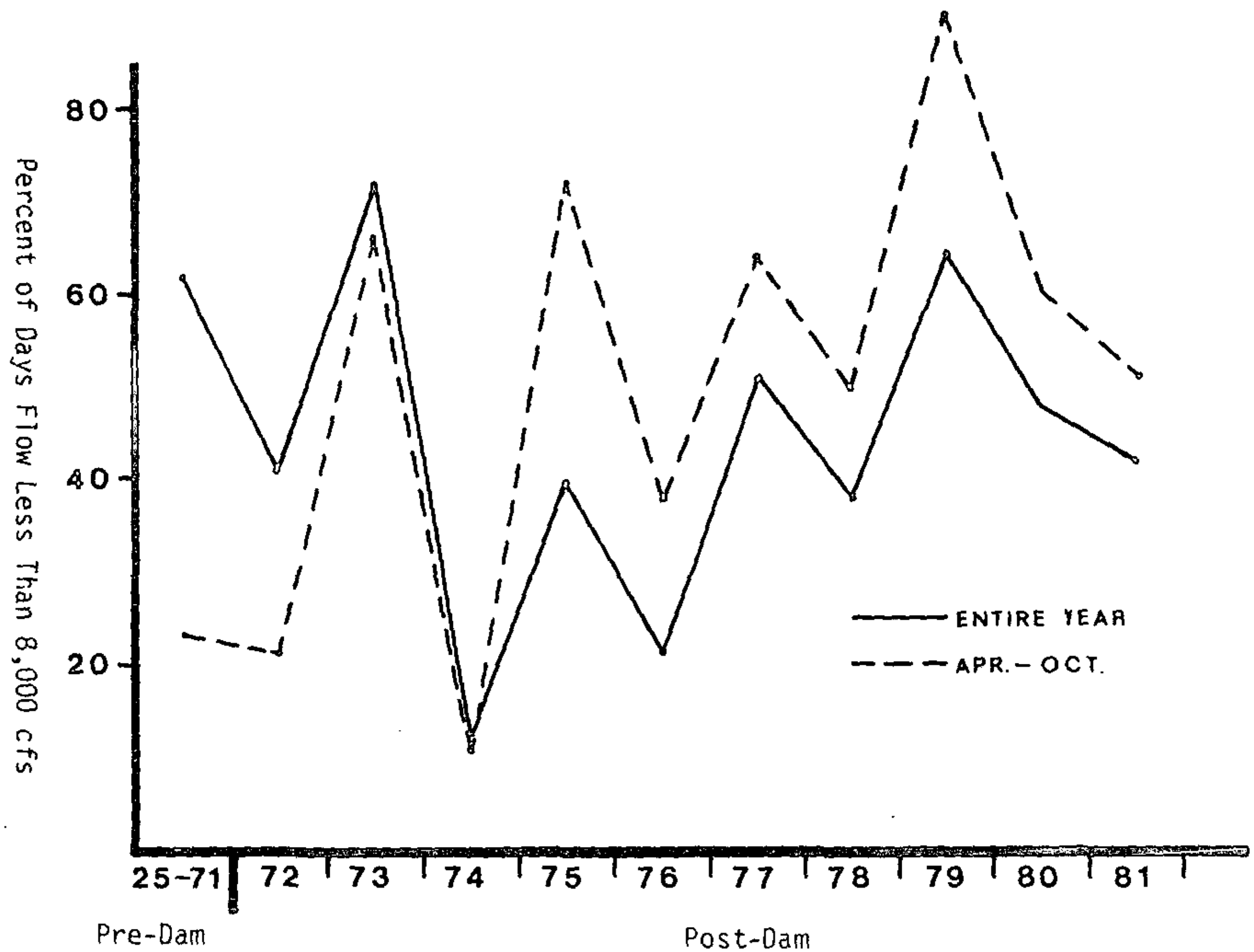

Figure 11. The percent of days in which the average flow of the Kootenai River was below 8,000 cfs.

Table 4. Relative abundance of fish species collected in the Kootenai River downstream from Libby Dam to Idaho.

Common name	Scientific name	Upstream of Kootneai Falls Pre-Impoundment	Upstream of Kootneai Falls Post-Impoundment	Downstream of Kootenai Falls Pre-Impoundment	Downstream of Kootenai Falls Post-Impoundment
Westslope cutthroat trout	*Salmo clarki lewisi*	A[1/]	U	U	U
Rainbow trout	*Salmo gairdneri*	A	A	A	A
Bull trout	*Salvelinus confluentus*	U	U	U	U
Brook trout	*Salvelinus fontinalis*	U	U	U	U
Mountain whitefish	*Prosopium williamsoni*	A	A	A	A
White sturgeon	*Acipenser transmontanus*	N	N	U	R
Burbot	*Lota lota*	U[2/]	C	U	U
Kokanee salmon	*Oncorhynchus nerka*	N	U[3/]	U[4/]	U
Torrent sculpin	*Cottus rhotheus*	A	C	U	U
Slimy sculpin	*Cuttus cognatus*	R	R	R	R
Largescale sucker	*Catostomus macrocheilus*	A	A	A	A
Longnose sucker	*Catostomus catostomus*	U	U	U	U
Northern squawfish	*Ptychocheilus oregonensis*	R	R	C	C
Peamouth chub	*Mylocheilus caurinus*	R	R	A	A
Redside shiner	*Richardsonius baltaetus*	C[5/]	C	C	C
Longnose dace	*Rhinichthys cataractae*	A	C	C	C

1/ A = abundant, U = uncommon, R = rare, N = not reported.
2/ Abundant until 1960, than declined in abundance.
3/ Drift from Lake Koocanusa.
4/ Spawning runs into Yaak River and Callahan Creek, origin is probably Kootenai Lake, B.C.
5/ Found in backwaters and sloughs.

Table 5. A summary of angler catch by season of creel census conducted by game wardens in the Kootenai River, 1949, 1951, 1952, 1954-1964.

Number of anglers	Catch per man hours of effort: Trout	Catch per man hours of effort: Game fish		Percent species composition of the catch and average total length in mm: RB	CT	DV	MWF	Burbot
315	.52	.97	Summer 1 May-31 Oct	6.5(307)	46.2(284)	1.0(323)	38.7(259)	7.6(434)
1,834	.06	1.53	Winter 1 Nov-30 Apr	0.2(290)	3.0(279)	0.6(290)	94.0(282)	2.2(470)

trout (6.5%) and bull trout (1.0%). The average length of cutthroat and rainbow trout creeled was 284 mm and 309 mm, respectively. The catch for gamefish was .97 fish per hour of effort, of which the catch for trout was .52 fish per hour of effort. Mountain whitefish made up 90 percent of the harvest during the winter and fish caught averaged 282 mm long.

Post-Impoundment Fisheries Investigations

Gamefish Reproduction

A detailed summary of data collected on the capabilities of streams tributary to Kootenai River to support spawning runs from the Kootenai for that section of river downstream from the Libby Reregulation Dam site (Figure 1) to the Idaho border was presented by May and Huston (1979). In summary, it was shown that adequate stream habitat was available from the reregulation damsite downstream to Kootenai Falls to maintain river populations of rainbow trout. About 219 kilometers of stream are accessible for spawning and rearing of rainbow trout. Only 34 kilometers of tributaries were accessible to spawning rainbow trout below Kootenai Falls to the Idaho border. Much of this stream length below Kootenai Falls was judged to be of poor quality. The quantity and quality of spawning and rearing area may be a factor limiting rainbow trout numbers in this section of the river. Natural falls or man-made barriers prevent fish access into major sections of all the Kootenai River tributaries below Kootenai Falls. O'Brien Creek, a tributary below Kootenai Falls, had a small wooden dam near its mouth which was removed in 1978. Rainbow trout eggs were taken from fish spawning in Bobtail Creek (Figure 1) and planted in O'Brien Creek in 1978 and 1980. Removal of this dam should provide access into about 25 km of fair to good spawning and rearing habitat for rainbow trout.

Mountain whitefish spawn both in tributary streams and in the mainstem Kootenai River. Spawning habitat for this species is considered excellent throughout the entire Kootenai River downstream from Libby Dam. May and Huston (1979) reported finding 17 whitefish spawning areas from the reregulation damsite downstream to Libby in 1979 compared to only five areas in 1973.

Spawning potential is considered to be more than adequate for rainbow trout and mountain whitefish above the site for the reregulation dam. Investigations have shown both species reproducing in Fisher River and mainstem Kootenai River between Fisher River and Libby Dam.

Kootenai National Forest funded a project to collect streamflow data needed to file on instream water reservations for Bobtail, Pipe, Libby and O'Brien creeks. The results of this study were presented by May (1982) and flow reservations requests have been filed with the Montana Department of Natural Resources and Conservation.

Rainbow Trout Spawning

Box traps utilized to capture spawning runs in Bobtail and Pipe creeks were located near the mouths, while the trap in Libby Creek was about six miles upstream from the mouth (Figure 1). Trapping success varied betweer streams and year as related to discharge and debris. Traps in Libby and Pipe Creek could only be maintained for short periods of time before high spring flows and captured a small part of the total spawning run.

Best trapping success was obtained in Bobtail Creek and was related to its small size and low peak discharges and less debris. The trap was inoperable only 10 days during the time fish were entering the creek from 1977 through 1979. The trap was removed before the end of the spawning run in 1978. The trap was inoperable for a total of 14 days during the spawning run in 1980 because of high water and large amounts of debris.

Rainbow trout spawners generally started entering Bobtail Creek near the last of March and new fish continued to enter the creek through early June (Table 6, Figure 12). Minimum and maximum temperatures in late March ranged from an average 35°F to 40°F (Table 7). Temperatures during the last of the spawning run varied from an average maximum of about 58°F to a minimum of 49°F. The peak of the spawning run in Bobtail Creek extended from mid-April through late May and average maximum and minimum water temperatures were from 44°F to 40°F in mid-April increasing to 58°F to 49°F in late May.

Stream gauge height listed in Table 7 is not related to a specific volume, but rather an illustration of changes in discharge. These data show that most spawning rainbow trout entered Bobtail Creek during noticeable increases in discharge. A similar temporal and temperature pattern was noted for spawning rainbow trout trapped in Libby and Pipe creeks.

Number of spawners caught in Bobtail Creek was 131 in 1977, 155 in 1978, 382 in 1979 and 205 in 1980. The reduced catch in 1980 is considered to be a function of poor trapping success, not a decreased spawning population (Table 8). Skewed distribution of sex ratios evident as many more males than females in 1978 and 1980 (Table 8) was undoubtedly related to trapping success. Males entered Bobtail Creek in greater numbers than females during the early part of the spawning run and in 1978 and 1980 trapping success was highest during the early part of the run.

Trap catches of spawning rainbow trout in Pipe and Libby creeks (Table 8) seem to indicate increased numbers of fish entering these creeks from 1976 to 1977 and 1981.

Examination of the average lengths of male and female rainbow trout captured in Bobtail, Pipe and Libby creeks (Table 8) clearly show two trends. These are: 1) females were larger than males in all creeks; and 2) average size of both males and females decreased from 1976-1977 to 1980-1981. Difference in sizes of males and females within the same year was a function of age composition differences while declining average size of fish between years was related to changes in growth rates while the fish were in Kootenai River (see Age and Growth Section).

Table 6. Number of rainbow trout spawners caught per week in the fish trap operated near the mouth of Bobtail Creek during the spring of 1977-1980.

Time period	Number of fish caught per week			
	1977	1978	1979	1980
March 18-March 24	0	0	0	0
March 25-March 31	7	leads down	1	6
April 1-April 7	8	12	8	7
April 8-April 14	27	21	10	8
April 15-April 21	10	9	23	26
April 22-April 28	36	40	102	leads down
April 29-May 5	6	73	84	24
May 6-May 12	19	trap removed	33	28
May 13-May 19	8		47	67
May 20-May 26	10		56	30
May 27-June 2	trap removed		15	9
June 3-June 9			3	trap removed
TOTAL	131	155	382	205

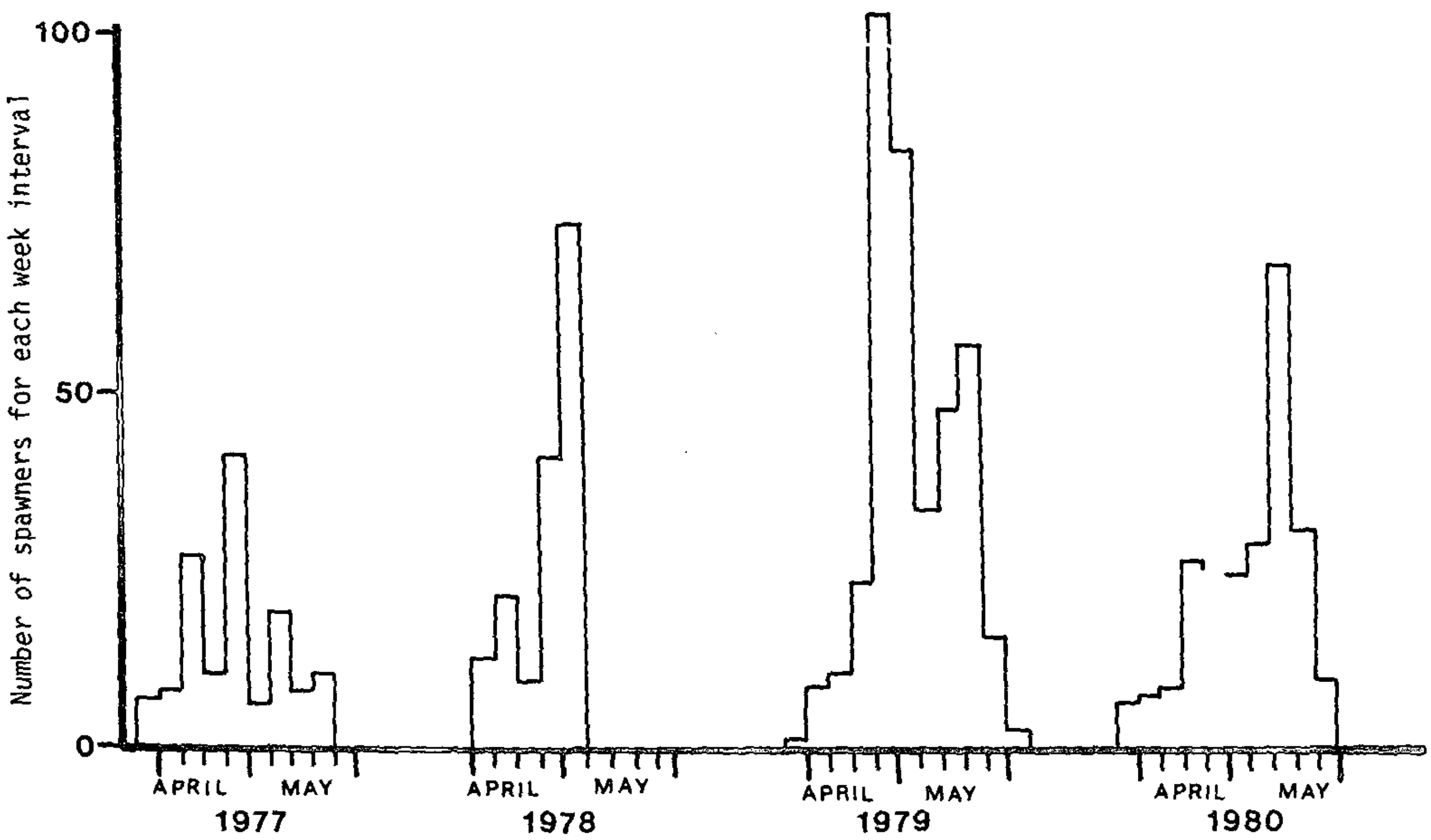

Figure 12. The number of rainbow trout spawners collected weekly in the fish trap in Bobtail Creek, 1977-1980.

Table 7. Average weekly maximum and minimum temperature (F°) and average stream gauge height recorded in Bobtail Creek in 1979 and 1980 during the rainbow trout spawning run. Average temperatures are given for 1978 based on a once daily instantaneous measurement taken about 1000 hours.

	1978	1979			1980		
Time period	Average	Max.	Min.	Height	Max.	Min.	Height
March 18-March 24	33.5	41.5	33.5	---	---	---	---
March 25-March 31	36.0	41.7	34.0	---	39.3	35.3	1.02
April 1-April 7	38.3	43.0	35.1	1.05	41.1	35.7	1.02
April 8-April 14	38.4	44.6	37.4	1.26	41.8	38.1	1.09
April 15-April 21	41.0	44.5	37.5	1.31	43.0	41.4	1.26
April 22-April 28	42.3	46.5	38.8	1.22	---	---	1.80
April 29-May 5	44.8	50.4	41.7	1.39	50.3	44.1	1.44
May 6-May 12	trap removed	50.7	41.4	1.28	55.4	47.3	1.30
May 13-May 19		54.8	43.0	1.13	57.5	49.3	1.18
May 20-May 26		59.5	48.2	1.00	57.0	49.7	1.03
May 27-June 2		59.0	47.7	.92	56.3	50.7	1.00
June 3-June 9		65.0	48.0	.90		trap removed	

Table 8. Summary of data from rainbow trout spawning runs from Kootenai River into Pipe Creek, Libby Creek, Fisher River and Bobtail Creek, 1976-1981. Box traps were fished in Pipe, Libby and Bobtail Creeks, four fyke traps were fished in the Fisher River.

Time trap in operation	Days trap in operation vs. length of run	Number of spawners	Average length in mm		Sex ratio Male-Female
			Male	Female	
Bobtail Creek					
Mar 25-May 25, 1977	51-57	131	350	437	0.7 : 1.0
Mar 21-May 8, 1978	33	155	297	414	3.1 : 1.0
Mar 22-Jun 4, 1979	70-74	382	287	356	1.0 : 1.0
Mar 26-Jun 1, 1980	54-68	205	262	345	2.3 : 1.0
Pipe Creek 1/					
Mar 18-Apr 5, 1976	18	54	361	465	3.5 : 1.0
Mar 3-May 20, 1977	46	78	358	442	0.8 : 1.0
Mar 17-Apr 20, 1981	22	85	287	335	1.4 : 1.0
Libby Creek 1/					
Mar 24-Apr 5, 1976	13	49	409	472	1.5 : 1.0
Mar 14-Apr 27, 1977	23	49	411	485	0.7 : 1.0
Apr 16-Apr 24, 1981	8	67	368	394	2.5 : 1.0

1/ Traps only fished during part of the spawning run.

Adequate numbers of scales for age analysis and lengths of fish were collected throughout the entire spawning run only from Bobtail Creek so analysis of differences between size of males and females will be limited to this creek. It may be assumed that what occurred in Bobtail Creek would also hold true for Pipe and Libby creeks.

Female fish averaged 89 mm longer than male fish in Bobtail Creek ranging from 117 m in 1978 to 69 mm in 1979. Age data presented in Table 9 indicates that most males were two year old fish in 1978, while most females were three and four year old fish. Data for 1979 shows that most males were two and three year olds, while most females were three year old fish.

Data shown in Table 8 for average sizes by year for Libby Creek and Pipe Creek show the same magnitude of differential sizes between males and females. It is suggested that most males in Pipe Creek were two and three year old fish, while most females were three and four year old fish. The greater average size of fish captured in Libby Creek suggests that most males were three and four years old, while most females were four and five years old.

Length frequency information presented in Table 10 for Bobtail Creek shows the yearly trend toward smaller fish. Figure 13 clearly shows the size differences between the 1977 spawning population and the 1980 spawning population by sex. Growth rates which reduced the size of fish spawning in Bobtail Creek will be discussed in Age and Growth of rainbow trout section of this report.

A substantial spawning run of rainbow trout appears to have developed in Quartz Creek. Personnel from the Kootenai National Forest counted 100 redds in 1980 and 83 in 1981 (personal communication, Alan Bratkovich).

Three fyke traps operated in the Fisher River in 1981 (Figure 1) caught six rainbow trout spawners ranging from 262 to 394 mm total length from the Kootenai River including one tagged in the Kootenai River near Flower Creek on May 28, 1980 and recaptured on May 15, 1981. This fish migrated 14 miles up the Kootenai to the Fisher River, then 12 miles up the Fisher River where it was captured. Other fish caught in the Fisher River included 28 largescale suckers and 58 resident rainbow trout ranging from 127 to 229 mm total length. A fyke net in Wolf Creek (Figure 1) caught 29 largescale suckers and one resident rainbow trout. Suckers collected in Fisher River and Wolf Creek were likely spawning fish from Kootenai River.

The first evidence of rainbow trout spawning in mainstem Kootenai River was found in 1981. Spawning activity was observed from mid-April to mid-May between the mouths of the Fisher River and Dunn Creek and 14 redds were identified. A SCUBA survey conducted in 1982 found 37 redds in the same area (Figure 14). Two rainbow trout observed spawning in 1981 appeared to be over 30 inches in total length. These fish were probably too large to have attained that length in the Kootenai River. They may have been rainbow trout from Kootenay Lake, British Columbia,

Table 9. Age composition by percent of male and female rainbow trout spawning in Bobtail Creek, 1978 and 1979.

Age class	1978		1979	
	Males	Females	Males	Females
II	67.5%	7.9%	42.0%	4.3%
III	28.2%	55.3%	51.3%	78.1%
IV	4.3%	36.8%	6.2%	14.4%
V and older	--	--	0.5%	3.2%
Size difference (from Table 10)	117mm		69mm	

Table 10. The percent length frequency distribution of rainbow trout spawning in Bobtail Creek from the Kootenai River, 1977-1980.

Length group in mm	Males				Females			
	1977	1978	1979	1980	1977	1978	1979	1980
178-202	--	--	--	10.5	--	--	--	--
203-228	--	8.5	14.6	9.0	--	--	--	--
229-253	--	17.8	17.6	30.0	--	--	1.1	--
254-278	5.1	19.4	17.6	25.6	--	--	1.1	9.8
279-304	10.3	21.7	15.0	9.8	--	--	10.7	23.5
305-329	12.8	14.0	9.8	3.0	--	5.6	18.2	13.7
330-355	28.2	11.6	8.8	3.8	8.2	16.6	20.2	15.7
356-380	23.1	0.8	5.2	3.0	4.1	8.3	22.5	9.8
381-405	7.7	--	4.1	2.3	12.2	13.9	12.3	7.8
406-431	7.7	2.3	4.7	2.3	18.4	16.6	5.9	5.9
432-456	5.1	1.6	1.6	0.7	24.5	11.1	4.3	13.8
457-482	--	0.8	0.5	--	10.2	5.6	0.5	--
483-507	--	--	0.5	--	16.3	8.3	1.1	--
508-532	--	0.8	--	--	4.1	5.6	--	--
533-558	--	0.8	--	--	2.0	2.8	1.6	--
559-582	--	--	--	--	--	5.6	0.5	--
Sample size	39	129	193	133	49	36	187	51

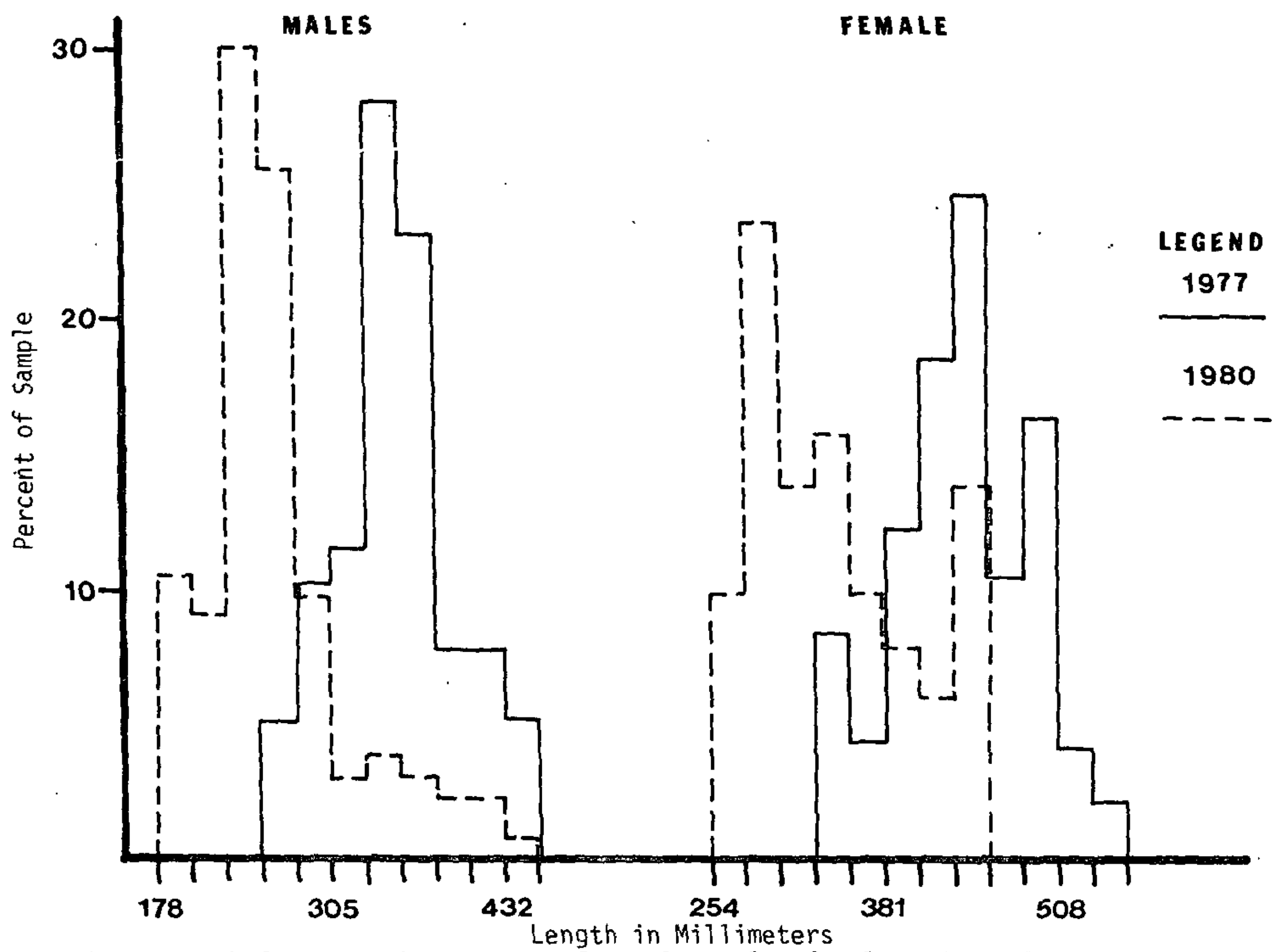

Figure 13. Length frequency by percent of total sample of male and female rainbow trout spawning in Bobtail Creek, 1977 and 1980.

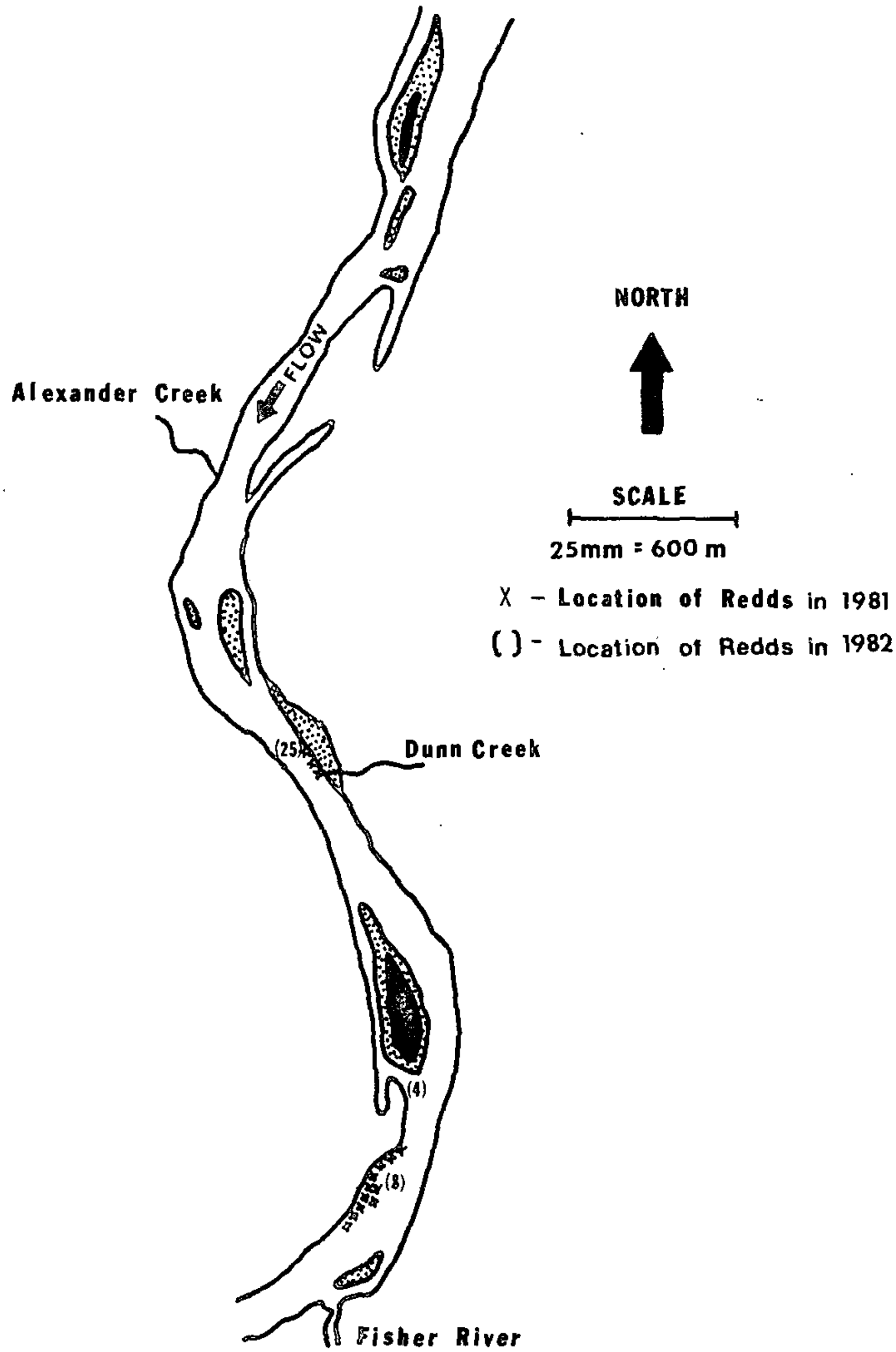

Figure 14. Location of rainbow trout redds in Kootenai River in 1981 and 1982.

which migrated up the Kootenai River or moved downstream from Loon Lake via the Fisher River or escaped from Lake Koocanusa.

Measurements were taken on eight redds in 1981 to determine characteristics of the spawning bed environment (Table 11). The substrate was comprised of gravel in the 13 to 76 mm range, the water velocities ranged from 0.40 to 0.88 meters per second, and the average depth was 0.58 meters. The distance from the waters edge varied from 1.37 to 10.95 meters. There was considerable variation in the size of redds which ranged in length from 0.79 to 6.28 meters and width from 0.43 to 2.35 meters. Several pairs of fish were observed spawning in the redd which was 6.28 meters in length.

Spawning runs of large rainbow trout weighing as much as 4 kilograms ascend Callahan Creek and the Yaak River from about April to mid-June. A specialized fishery for these fish has developed near the mouths of the two streams and in Kootenai River downstream from Kootenai Falls. These runs have not been quantified and little is known about them. The origin of these fish was thought to be Kootenay Lake, British Columbia, although this has not been verified.

Kokanee Spawning Runs

Small spawning runs of kokanee ascended the Yaak River, Callahan Creek and Lake Creek in September and Octiber, 1971 (May and Huston 1975). These runs have not been sampled and their current status is unknown. The origin of these fish was thought to be Kootenay Lake, British Columbia.

Smolting of Rainbow Trout

The emigration of juvenile rainbow trout from Bobtail Creek into Kootenai River was sampled in 1978 and 1979. In 1978, the downstream trap, located about 300 yards above the mouth, was installed July 28 and removed November 10 (Table 12). In 1979, the trap was fished from June 12 to July 13 (Table 13). Some numbers of juveniles emigrated prior to installation of the trap and after the trap was removed so trap catches represent an unknown percent of total annual emigration. Trap efficiencies shown in Tables 12 and 13 were determined by marking trapped fish, placing them some distance above the trap and calculating the percent that were trapped a second time.

Combining 1978 and 1979 trapping, young-of-the-year rainbow trout were first caught emigrating from Bobtail Creek during the last week of June and continued into November (Figure 15). A total of 1,479 young-of-the-year were captured from July 28 to November 10, 1978. The estimated number of emigrants during this period was 4,700. Large numbers of fish were still emigrating the first week of November when the trap was removed due to ice formation.

In 1979, the trap was installed before many young-of-the-year fish moved out of the creek (Table 13 footnote). The trap catch in July 1979 was 762 fish with the estimated number being 2,506 during this period.

Table 11. Characteristics of rainbow trout redds in mainstem Kootenai River.

Redds	Velocity 1/ meters/second	Water depth (meters)	Redd width (meters)	Redd length (meters)	Distance from shore (meters)	Substrate size (mm)
1	0.79	0.73	1.22	6.28	8.20	13 - 76
2	0.61	0.66	2.35	3.54	10.95	13 - 76
3	0.70	0.44	0.49	0.76	3.97	13 - 76
4	0.88	0.67	0.61	1.59	8.30	13 - 76
5	0.88	0.75	0.92	1.80	6.28	13 - 76
6	0.58	0.58	0.98	2.32	1.89	13 - 76
7	0.58	0.46	0.43	0.79	2.07	13 - 76
8	0.40	0.38	0.55	0.92	1.37	13 - 76
Average	0.70	0.58	0.95	2.26	5.37	

1/ Velocity taken at 0.6 depth in meters/second at 4,000 cfs discharge.

Table 12. A summary of the catch of young-of-the-year rainbow trout in a downstream fry trap in Bobtail Creek, 1978.

Parameter	Time period 7/28-8/31	9/1-9/30	10/1-11/10	Total
Number caught	369	469	641	1479
Size of fish (mm)	33<46>64	38<53>76	43<58>81	
Trap efficiency	35%	35%	36%	
Estimated total number	1054	1440	1831	4325

1/ Estimate based on trap efficiency in October.

Table 13. Catch of 0+, I+ and II+ age class juvenile rainbow trout in a downstream trap in Bobtail Creek, June 12 through July 31, 1979.

Parameter	Time period 6/12-6/30	7/1-7/31
0+ (young-of-the-year)		
Number caught	10	752
Size of fish (mm)	---	25<36>53
Trap efficiency	30%	30%
Estimated total number	33	2506
I+ (yearling)		
Number caught	343	40
Size of fish (mm)	64<89>109	---
Trap efficiency	23%	23%
Estimated total number	1491	174
II+ (2 year olds)		
Number caught	16	1
Size of fish (mm)	112<120>155	155
Trap efficiency	43%	50%
Estimated total number	37	2

1/ All 0+ fish were caught the last week of June.

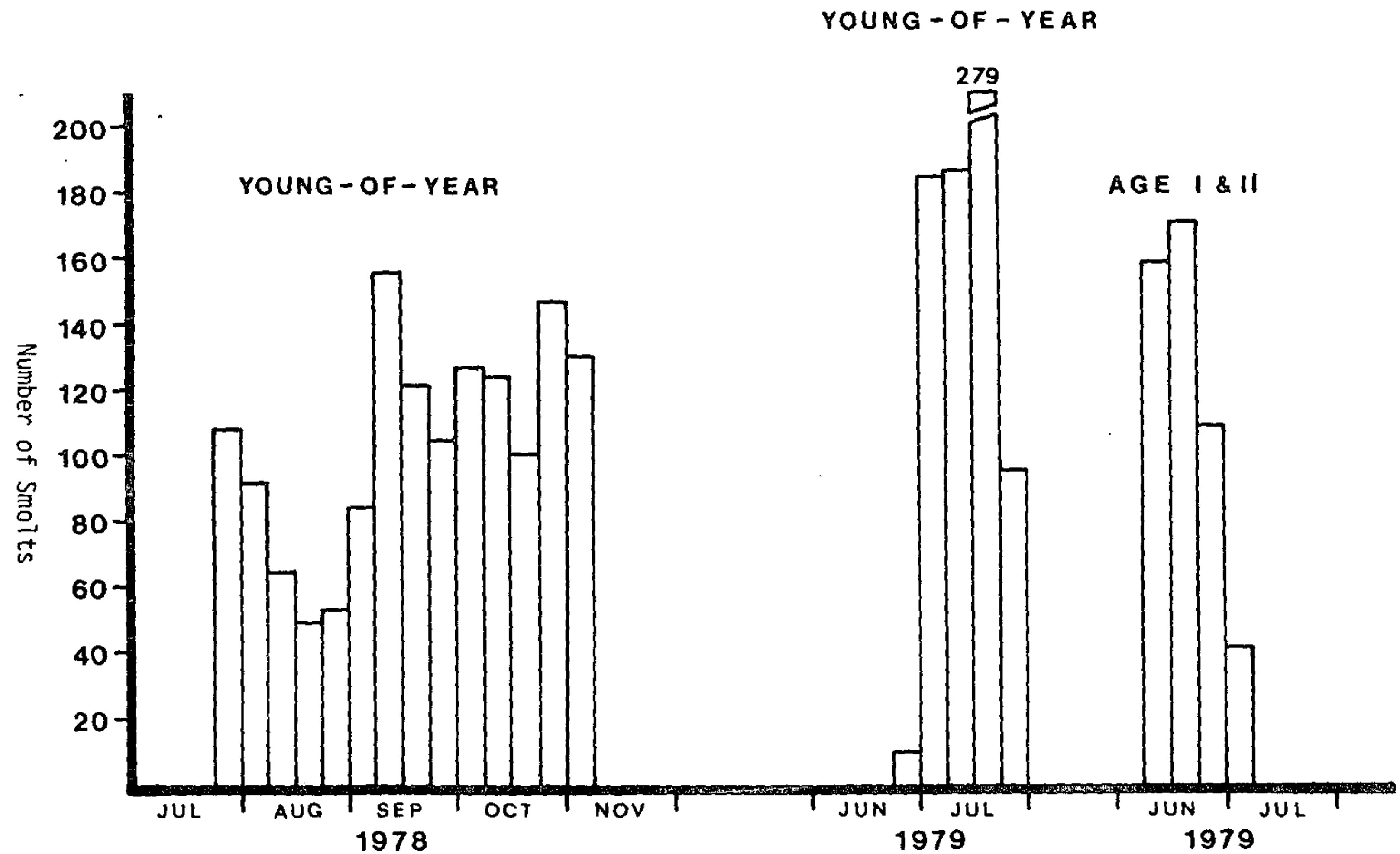

Figure 15. Number of juvenile rainbow trout caught by month emigrating from Bobtail Creek, 1978 and 1979.

The total number of young-of-the-year rainbow emigrating from Bobtail Creek is probably in excess of 7,000 fish per year.

Yearling and two year old rainbow trout were collected in 1979 from June 12 to July 8 (Figure 15). The large number of fish (158) collected the first week of trap operation indicated that considerable numbers had already left the stream prior to installation of the trap. The outmigration peaked the third quarter of June and was completed by July 8. A total of 383 age I and 17 age II fish were collected in the 26 day period. Estimated number of emigrants was 1,704. The total number of age I and II fish emigrating from Bobtail Creek in 1979 was probably in the 2,000-3,000 range.

The data collected in 1978 and 1979 indicated that most rainbow trout emigrated from Bobtail Creek as young-of-the-year from July into November. Age I fish migrated primarily in May and June along with a few age II fish. Numbers of juvenile rainbow trout emigrating from Bobtail Creek into Kootenai River included about 7,000 young-of-the-year and 3,000 yearlings and two year old fish.

Wagner et al. (1963) and Shapovalou and Taft (1954) reported that emigration of yearling and older rainbow trout from the natal stream generally occurred in late May to late July when flows were decreasing from the annual spring flood. Stauffer (1972) found that downstream movement of rainbow trout smolts occurred between May 21 and June 30 on subsiding water levels. The age composition of the migrants from a Lake Michigan tributary averaged 64% age I, 34% age II and 2% age III (Stauffer 1972). Van Velson (1974) noted that 92 percent of the rainbow trout in McConoughly Reservoir, Nebraska had spent one year in a tributary stream. In contrast, Erman and Hawthorne (1976) found that rainbow trout fry emigrated as young-of-the-year from a small stream which became dewatered in the late summer and fall. The age at migration for rainbow trout juvenile is quite variable from stream to stream, depending upon summer flows, water temperatures and fish densities (Northcote 1969b). Large numbers of rainbow would be expected to emigrate as young-of-the-year from streams like Bobtail Creek which have low summer flows and high fish densities. Conversely, most rainbow trout juveniles live one to two years before emigrating in streams with good summer flows and comparatively low fish densities.

Mountain Whitefish in Fisher River

Spawning runs of mountain whitefish ascending Fisher River were sampled from 1969-1975, 1978 and 1979 (Table 14). Trap efficiency varied depending primarily upon streamflows and was lowest in 1975, 1978 and 1979. In the other years, approximately 50 percent of the run was captured. Estimates of the 1978 and 1979 runs were made from mark and recapture data.

The number of fish captured varied among the years depending upon the magnitude of the run and trap efficiencies. The estimated run increased

Table 14. Summary of data from mountain whitefish spawning runs ascending the Fisher River from the Kootenai River, 1969-1975, 1978 and 1979. Estimates of the total run are given. The estimates from 1969-1975 are based on estimated trap efficiency, while the 1978 and 1979 estimates are based on mark and recapture data. The 80 percent confidence limits for the 1978 and 1979 estimates are given in parentheses.

Parameter	Year of spawning run 1969	1970	1971	1972	1973	1974	1975	1978	1979
Period trap operated	9/25-11/17	9/24-10/26	9/21-11/9	9/22-11/18	9/19-11/2	9/20-11/7	9/3-11/3	9/11-11/10	9/26-11/16
Peak of run	10/2-10/24	10/2-10/25	10/1-10/28	10/1-10/28	10/16-10/30	10/15-10/28		10/15-11/5	10/22-11/11
Days leads up	53	31	45	53	41	43	27	33	16
Number fish captured	1,131	2,641	2,015	1,220	1,506	3,702	512	1,166	1,400
Average daily catch	21.2	85.2	44.8	23.0	35.4	86.0	19.0	35.3	87.5
Estimated run	2,000	4,000	3,500	1,500	2,000	5,000	5,000	21,812 (±12.9)	30,972 (±11.6)
Average length males (mm)	295	269	279	262	287	302	302	315	307
Average length females (mm)	295	290	292	266	292	297	312	345	323
Sex ratio male:female	1.4:1.0	2.0:1.0	1.2:1.0	1.2:1.0	1.2:1.0	1.3:1.0	0.8:1.0	1.1:1.0	1.1:1.0

from about 2,000 fish in 1969 to 20,000 and 30,000 in 1978 and 1979. The increased spawning run since 1969 is primarily due to increased mountain whitefish populations in the Kootenai and improved water quality and spawning habitat in the Fisher River and Wolf Creek. Approximately 19 km of these two streams were rechanneled from 1965-1969 during construction of the Burlington Northern Railroad. The channelization caused excessive sediment loading and habitat destruction (May 1972).

The average length of fish collected from 295 mm in 1969 to 330 mm in 1978 (Table 14). This was primarily due to an increase in growth rates following impoundment which are presented in the age and growth section of this report.

Peak of the spawning run in 1969 through 1972 occurred in the first four weeks of October (Table 15). In 1973 and 1974 the largest numbers of fish entered Fisher River in late September and again in late October; a bimodal distribution. Trapping efficiency was too low in 1975 to estimate periods of peak upstream movement. In 1978 and 1979, greatest numbers of fish were captured in late October and early November.

These data indicate a shift in calendar timing of adult mountain whitefish and are likely related to method of water release from Libby Dam. Spawning runs in 1969 through 1971 were before any water was impounded, while the 1972 spawning run occurred during the time Lake Koocanusa discharge was kept at sluiceway elevations for construction purposes. Essentially the timing of the 1969-1972 spawning runs would have been indicative of pre-impoundment streamflow and temperature conditions. Spawning runs in 1973 through 1975 occurred during the time releases from Libby Dam were through sluiceways in the hypolimnion. Spawning runs in 1978 and 1979 were related to releases from Libby Dam controlled by the selective withdrawal system and were mostly from the epilimnion.

Kootenai River temperatures (Figure 6) show that in 1970 the river cooled from 20°C in early September to 10°C in mid-September and to 5°C in mid-October. In 1975, river temperatures were about 18°C in early August and dropped to about 10°C in mid-August. Discharge temperatures were about 10°C through late November and about 7°C in late December. After operation of the selective withdrawal system started in 1977, temperatures in early September were about 15°C and dropped to about 10°C in late September. Temperature slowly dropped to about 5°C in early December.

A review of temperature data (Figure 6) and spawning run data (Table 15) indicates that whitefish started entering Fisher River after the Kootenai River cooled to about 10°C. Rapid cooling of the river during pre-impoundment years resulted in peak numbers of fish entering Fisher River in October, while warmer temperatures extending later in the year after impoundment delayed the peak of the run two to three weeks. Rapid cooling of river temperatures in 1973, 1974 and 1975 likely caused the bimodal spawning run peaks.

Observations by Huston (unpublished data) and by Brown (1952) indicate that mountain whitefish do not spawn until water temperatures are about

Table 15. Number of mountain whitefish caught per week in the Fisher River, 1969-1975 and 1978 and 1979.

Time period	Number of fish caught per week								
	1969	1970	1971	1972	1973	1974	1975	1978	1979
9/2-9							0		
9/10-16							0	0	
9/17-23	15	0	21	10	223[a]	539[a]	52	58	
9/24-30	72	37	48	71	38[b]	209[a]	97	0	122
10/1-7	49	437[a]	454[a]	498[a]	21	81	2[b]	0	0[b]
10/8-14	170[a]	614[a]	186[a]	101[a]	6[b]	215	84[b]	2	0[b]
10/15-21	587[a]	823[a]	515[a]	222[a]	405[a]	897[a]	119	358[a]	79
10/22-28	100[a]	730[a]	749[a]	152[a]	737[a]	1,312[a]	158	293[a]	727[a]
10/29-11/4	38	Trap washed out	42	64	76	426[a]	Trap washed out	447[a]	176[a]
11/5-11	0		0	92		23		8	203[a]
11/12-18	0			10					93
TOTAL	1,131	2,641	2,015	1,220	1,506	3,702	512	1,166	1,400

a/ peak periods of spawning run.
b/ trap inoperative all or most of week.

5°C. Table 16 shows the average weekly maximum and minimum water temperatures in Fisher River for 1969 through 1975 and 1978. Whitefish started entering the Fisher River about a month before actual spawning may have occurred. Observations were not made on time of egg laying by whitefish in Fisher River, but spent fish started congregating near the trap leads one to two weeks before the trap was removed. This would indicate that egg deposition took place near the end of the upstream spawning run.

In 1969, upstream traps were fished at the mouth of Fisher River, in the mouth of Wolf Creek 10 miles upstream, and in Fisher River 14 miles upstream. All whitefish passed through the lower Fisher River trap were fin-clipped for future identification. No fish were recaptured in the Wolf Creek trap showing that few, if any, whitefish from Kootenai River spawn in Wolf Creek. The upper Fisher River trap caught 13 whitefish that had been marked at the lower Fisher trap. These data showed that the majority of whitefish spawned in the lower 14 miles of the Fisher River and that some whitefish moved at least 14 miles up the Fisher River to reach spawning areas.

Age composition of the spawning runs varied from year to year (Table 17) and may have been related to high levels of gas supersaturation in the Kootenai River from 1973 through 1975 and increased growth rates after 1975. Age class II and III fish made up the majority of both male and female fish in spawning years 1970, 1971 and 1972. Age class II fish decreased in abundance in 1973 (1971 year class) and 1975 (1973 year class) when gas supersaturation caused high mortalities of juvenile whitefish in the Kootenai River (May and Huston 1975). Age class II (1972 year class) spawning for the first time in 1974 appeared not to be severely affected by gas supersaturation. The spawning runs in 1973, 1974 and 1975 did contain more three and four year old fish than the 1970, 1971 and 1972 spawning runs.

The 1978 whitefish spawning run was comprised of mostly three year old and younger fish, similar to the 1970, 1971 and 1972 spawning runs. A considerable portion of the 1978 male spawning population were one year old fish compared to zero one year old fish in previous years. Yearling males averaged 252 mm in length and their presence in the spawning population is probably correlated with excellent growth in the Kootenai River. The average length of one year old males in 1978 was greater than two year old fish in 1969 through 1972 which ranged from 241 mm in 1971 to 246 mm in 1969 and 1970.

Mountain Whitefish in Libby Creek

Data were collected on mountain whitefish spawning runs ascending Libby Creek in 1976 through 1978 (Table 18 and 19). Trap efficiency was high in both 1976 and 1978 when the leads were down only six and three days, respectively, but low in 1977 when the leads were down for 15 days. The peak of the run varied but generally occurred from late October to mid-November.

An increase was noted in the spawning run from 1976 to 1978. A total of 3,403 spawners were trapped in 1976 as compared to 6,675 in

Table 16. Average weekly maximum and minimum temperatures (°C) in the Fisher River during mountain whitefish spawning run. Data published by U.S.G.S. in annual report, "Water Resources Data for Montana".

	1969		1970		1971		1972		1973		1974		1975		1978	
	Max	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Sep 17-Sep 23			11.3	9.1	12.6	7.9	13.6	13.2	13.7	11.1	14.4	9.6	14.8	10.7	11.6	8.0
Sep 24-Sep 30	12.9	9.8	11.6	7.4	10.7	6.7	10.3	8.1	13.6	9.9	12.8	9.1	14.9	10.4	13.9	9.9
Oct 1-Oct 7	10.6	9.4	11.5	8.6	11.9	8.2	11.5	8.1	10.5	7.3	9.1	6.1	12.0	9.6	11.1	6.7
Oct 8-Oct 14	8.1	6.8	8.5	7.1	9.3	8.0	9.1	6.6	8.1	5.9	9.3	5.9	9.2	8.1	10.2	6.4
Oct 15-Oct 21	6.4	4.4	7.4	5.4	6.3	4.9	8.0	6.5	9.4	7.0	8.3	5.5	8.9	7.4	9.3	5.3
Oct 22-Oct 28	7.0	6.1	6.1	4.8	5.7	4.0	6.6	5.6	8.5	7.1	6.0	3.9	5.5	4.6	6.4	3.8
Oct 29-Nov 4	6.9	6.1	3.0	1.6	1.9	0.9	4.6	3.6	5.3	3.9	6.0	4.6	5.9	5.1	4.6	2.4
Nov 5-Nov 11	5.4	4.6	4.7	3.7	2.1	1.1	4.9	3.9	2.2	1.7	5.7	4.8	4.3	3.4	3.6	2.7

Table 17. Percent age composition of mountain whitefish spawning in Fisher River, 1970-1975 and 1978.

Age class	1970	1971	1972	1973	1974	1975	1978
				Males			
I	--	--	--	--	--	--	28.2
II	54.3	37.6	62.4	1.9	20.8	9.5	17.5
III	32.7	43.9	30.7	65.8	39.5	64.3	51.0
IV and older	13.0	18.5	6.9	32.3	39.7	26.2	3.3
				Females			
I	--	--	--	--	--	--	--
II	22.3	22.8	55.4	2.0	21.6	7.0	25.1
III	44.5	52.7	34.4	65.5	38.9	57.3	70.6
IV and older	32.2	24.5	10.2	32.5	39.5	35.7	4.3

Table 18. Summary of data from mountain whitefish spawning in Libby Creek from the Kootenai River, 1976, 1977 and 1978.

Parameter	Results 1976	1977	1978
Period trap operated	9/18-11/29	9/20-11/20	10/15-11/15
Days trap in operation	51	54	31
Days lead up	45	39	28
Number fish captured	3,403	1,378	6,675
Estimated run	4,000-5,000	4,000-5,000	8,000-10,000
Ave. length male (mm)	259	305	328
Ave. length female (mm)	368	315	351
Sex ratio: male:female	5.5:1.0	1.1:1.0	1.1:1.0

Table 19. Number of mountain whitefish spawners caught per week in the fish trap operated near the mouth of Libby Creek, 1976, 1977 and 1978. The average weekly maximum and minimum temperature (°F) are given in parentheses for 1978.

Time period	Number of fish caught per week 1976	1977	1978
Sep 18-24	21	33	
Sep 25-30	1*	---*	
Oct 1-7	398	---*	
Oct 8-14	4*	0	
Oct 15-21	164	45	121 (53.0/42.0)
Oct 22-28	63	551	2,305 (48.7/37.1)
Oct 29-Nov 4	211	543	4,246 (45.4/41.0)
Nov 5-11	827	21*	3 (41.0/34.4)
Nov 12-18	1,565	178	0 (40.0/33.3)
Nov 19-25	144	7*	
Nov 26-Dec 2	5		
TOTAL	3,403	1,378	6,675

* Denotes trap leads down all or most of week.

☐ Spawning run peaks are boxed in.

1978. The estimated run of 10,000 fish in 1978 was twice as high as the 5,000 estimate in 1976. This substantial increase in numbers correlates with increased populations of mountain whitefish in the Kootenai River.

Length of whitefish spawning in Libby Creek varied by sex within the three years of trapping. Average length of males increased from 259 mm in 1976 to 328 mm in 1978, while average length of females declined from 368 mm in 1976 to 315 mm in 1977 then increased back to 351 mm in 1978 (Table 18). Variations in average length of spawning whitefish were related to year-class strengths (Table 20). Data listed in Table 20 show that the 1975 year-class made up 90 percent of the male fish in the 1976 run causing the small average length of males in that year's spawning population. The 1972 year-class was the predominant age female in the 1976 run resulting in the large average length for females. The paucity of the 1973 and 1974 year-classes in the 1976 spawning population was likely due to high mortalities related to gas supersaturation in Kootenai River which occurred from March 1972 through mid-year 1975.

The 1975 year-class comprised over 90 percent of both male and female fish in the 1977 spawning run which resulted in an increase in length of males and a decrease in average length of females. This same year class was the predominant fish in the 1978 spawning run as three year old fish resulting in increased average lengths for both sexes.

The low numbers of age III and older fish in the 1977 run was partially due to extensive mortalities of spent spawners in 1976. A gill bacteria disease (*Myobacteria sp*) was determined to be the cause of the epizootic by the U.S. Fish and Wildlife Services Disease Lab at Bozeman, Montana. The five fish examined had massive infections of the disease which resulted in extensive proliferation of the epithelium covering gill lamellae to the extent that the gill surface was rendered nonfunctional. *Mybacteria* is present in most waters, but only becomes virulent when the fish are stressed.

Other Whitefish Spawning

A substantial spawning run of whitefish has developed in Quartz Creek but has not been quantified. Spawning activity in the mainstem Kootenai River has increased since 1973. Seventeen spawning areas were found in 1979 from the "reregulation dam site" to Libby as compared to only five in 1973 (May et al. 1979).

Kootenai River Fish Populations

Four sections of the Kootenai River below Libby Dam were sampled between 1971 and 1981. Purpose and intensity of sampling varied between sampling sections and years, but was divided into two basic categories for analysis; population survey and population estimation. Sampling method was mainly an economic choice. Population estimation required an average expenditure of 400 man-hours of effort to collect field data per section while population survey required an expenditure of 80 man-hours.

Table 20. Year class, age class, composition of mountain whitefish spawning in Libby Creek, 1976, 1977 and 1978.

Spawning year	Year class	Age class	Percent composition Male	Female
1976	1975	I+	89.7	2.5
	1974	II+	3.2	18.5
	1973	III+	3.8	33.3
	1972	IV+ & older	3.3	45.7
1977	1976	I+	5.7	0.5
	1975	II+	92.5	97.0
	1974	III+	1.6	1.5
	1973	IV+ & older	0.1	1.0
1978	1977	I+	7.7	---
	1976	II+	37.6	29.5
	1975	III+	48.7	61.9
	1974	IV+ & older	6.0	8.6

Survey sampling in 1971 was to determine relative abundance of fish inhabiting Kootenai River before Libby Dam started storing water in 1972 and was funded by State of Montana. Work done in 1972 through 1981 was by contract with Corps of Engineers and was a combination of population survey and population estimation. Data are given by river sampling sections.

In the Jennings and Troy sections (Figure 1) work was limited to population survey measured by average catch-per-boat-hour of operation. A boat hour of operation was defined as one hour of actual fish catching. Data for the Elkhorn Section (Figure 1) was from catch-per-boat-hour data in 1971, 1973 and 1974, but a population estimate was made for this section in 1980. Fish samplings in the Jennings, Elkhorn and Troy sections were made in late summer.

Sampling of the Flower-Pipe Section (Figure 1) was by population estimation and was done in March or early April in 1973 through 1975 and 1977 through 1981.

Jennings Section

The section was sampled annually from 1971 through 1975 and in 1977 and 1981 (Table 21). Catch-per-boat-hour in 1971 (pre-impoundment) indicated a fish population of mostly mountain whitefish, suckers and few trout at 130,100 and one per boat-hour, respectively. Water was released from Libby Dam through sluiceways first in March, 1972 and created high levels of gas supersaturation which continued into 1975 (May and Huston 1975). River sampling done in the period of high gas levels (1972-1975) indicated a major decline in numbers of mountain whitefish, a less marked decline in suckers, and no change in trout. Sampling done in 1977 and 1981 indicated that catch of whitefish increased to near 1971 levels and by 1981 catch of trout had increased markedly above 1971 catch.

The length frequency distribution and age composition of the mountain whitefish population varied from year to year. The length mode of the 1972 catch was dominated by 203 mm fish, whereas the mode in 1974 was 457 mm fish (Figure 16 and Appendix B). The length frequency distribution showed a peak at 203 mm (I+) for 1972 and modes at 304 mm (II+) and 330 mm (III+) in 1977 and 1981, respectively.

Age II fish comprised 62.7 percent of the catch in 1971 as compared to only 1.0 to 9.4 percent of the catch from 1972-1975 (Table 22). Age I fish increased to 30.3 percent of the population in 1977 then declined to 12.7 percent in 1981. High mortalities from gas bubble disease were a major factor limiting the recruitment of age I fish into the population from 1972-1975 (May and Huston 1975). Whitefish fry and young-of-the-year inhabit shallow backwater areas (Libelt 1970) which make them more susceptible to gas bubble disease.

Largescale sucker populations remained high in 1972 and 1973, but declined sharply in abundance in 1974 and 1975 as the result of gas supersaturation affecting reprodutive success and recruitment. Suckers were present but not collected in 1977 and 1981. Observations indicated they were numerous in 1981.

Table 21. Catch per hour of boat operation for largescale suckers, mountain whitefish and trout larger than 178 mm in total length in Jennings Section of Kootenai River, 1971-1975, 1977 and 1981.

	Catch per boat hour			
	Largescale suckers	Mountain whitefish	Trout1/	Total
September 1971	100 (43)	130 (56)	1 (1)	231
August 1972	72 (89)	9 (11)	1 (1)	82
July 1973	143 (89)	16 (10)	2 (1)	171
September 1974	62 (62)	34 (34)	4 (4)	100
August 1975	38 (60)	24 (38)	1 (2)	63
August 1977	----2/	36 (90)	4 (10)	40
September 1981		97 (87)	14 (13)	111

1/ Trout includes rainbow, cutthroat and bull trout.
2/ Suckers were not collected in 1977 and 1981.

Table 22. Age composition of mountain whitefish electrofishing catches in the Jennings Section of the Kootenai River, 1971-1975, 1977 and 1981.

	Percent age composition of year class			
Year	I	II	III	IV and older
1971	62.7	25.4	3.7	8.2
1972	9.4	52.5	17.2	20.9
1973	6.7	34.6	47.1	11.6
1974	4.4	49.3	28.6	17.7
1975	1.0	21.2	43.6	34.2
1977	30.3	52.2	11.2	6.3
1981	12.7	32.0	41.0	14.3

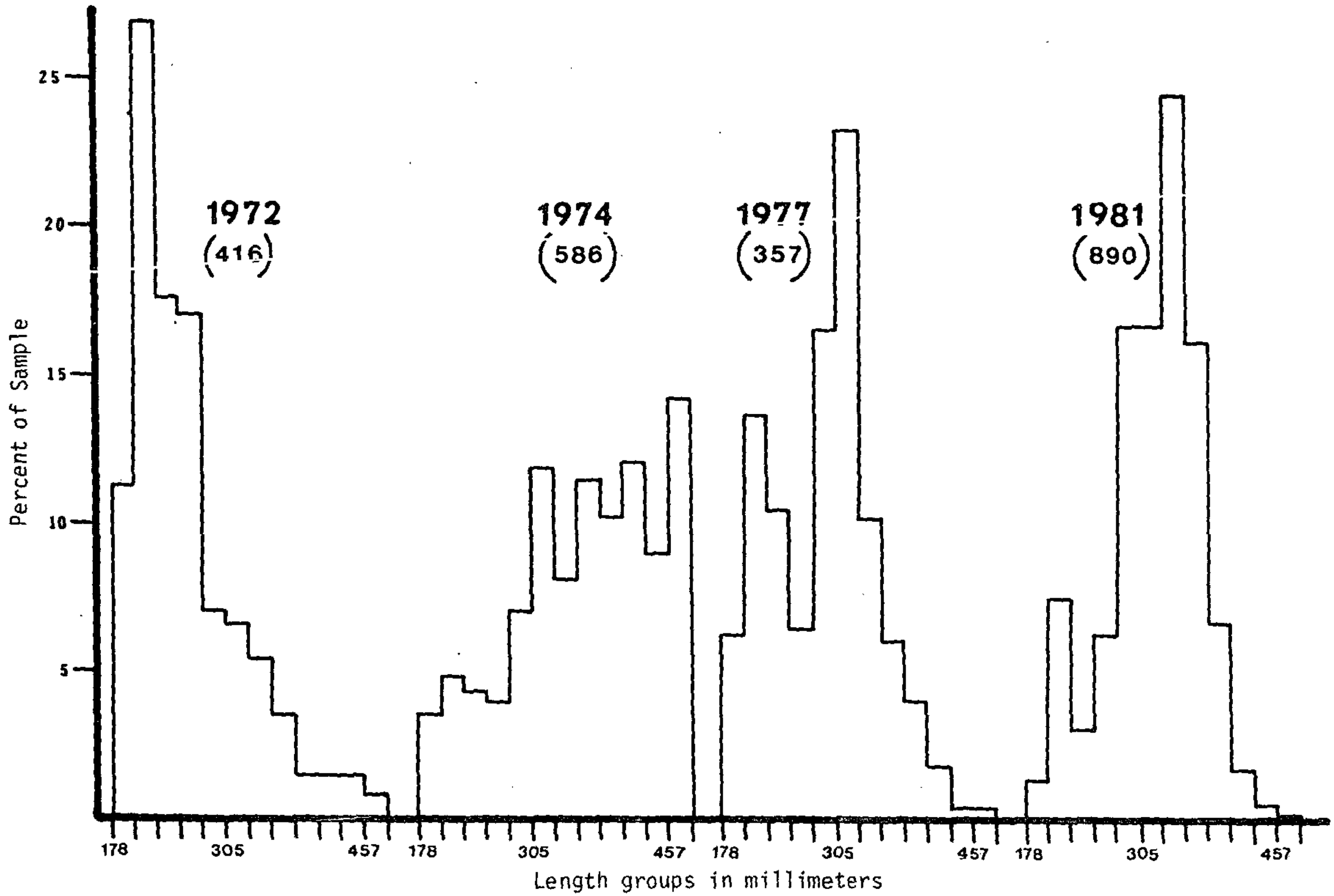

Figure 16. Length frequency distribution of mountain whitefish from Jennings Section of Kootenai River, 1972, 1974, 1977 and 1981. Sample size in parenthesis under year.

Trout populations in the Jennings Section were low from 1971 through 1977 but increased markedly in 1981. The catch-per-hour of boat operation increased from one in 1971 to 14 in 1981. The species composition of trout catch varied considerably among the years (Table 23). Rainbow trout appeared to increase in relative abundance from 1971 to 1981 whereas cutthroat trout and bull trout declined in relative abundance. Rainbow trout comprised 27 percent of the catch in 1971 as compared to 79 percent in 1981. Cutthroat catch declined from 50 percent in 1971 to 18 percent in 1981, but showed variability other years. Catch of trout, particularly cutthroat, was influenced by escapement out of Lake Koocanusa in 1972-1975 and 1981 when surface discharges were made.

Elkhorn Section

The Elkhorn Section located 16 to 23 km downstream from Libby Dam was sampled in 1971, 1973, 1974 and 1980 (Table 24). The mountain whitefish catch rate was 40 fish per hour of boat operation in 1971 prior to impoundment. The catch rate declined to 21 fish per hour in 1973 and 14 fish per hour in 1974. Catch increased to 56 fish per hour of boat operation in 1980. The 1980 population estimate was 1,059 whitefish per 300 meters of river (Table 25). The low catch rate in 1973 and 1974 was due to a marked reduction in the whitefish population from gas bubble disease following impoundment of the river in 1972 (May and Huston 1975). The high catch rate in 1980 shows that the whitefish population had recovered from the suppressing affects of gas supersaturation.

The 1974 length frequency distribution had only one mode at 279 mm with few fish under 203 mm or over 303 mm in length (Figure 17 and Appendix B). In contrast, the 1971 and 1980 distributions were bimodal with a good representation of fish less than 253 mm and fish over 303 mm in length.

Catch rate of rainbow trout (Table 24) was only 0.1 fish per hour in 1971 indicating a very low preimpoundment population. Catch increased to 1.1 fish per hour by 1974, probably not a significant change from 1971. The 1980 catch per boat hour increased markedly to 11.3 fish per hour while the population estimate (Table 25) was 123 rainbows per 300 meters of river. Yearling (I) fish averaging 221 mm total length were the most abundant age in the population estimate.

Flower-Pipe Section

The relative abundance of mountain whitefish increased from 1973-1975 to 1978-1981, whereas the relative abundance of rainbow trout, cutthroat trout and bull trout declined (Table 26 and Figure 18). Rainbow trout were more abundant in 1974 and 1975 when mountain whitefish were depressed. Cutthroat trout and bull trout comprised 6.5 percent and 0.9 percent of the catch, respectively, from 1973-1975 as compared to 0.3 percent and less than 0.1 percent, respectively from 1978-1981. The decline in cutthroat abundance after 1975 was primarily due to reduced escapement from Lake Koocanusa (May and Huston 1979).

Table 23. Electrofishing catch of trout from the Jennings Section of the Kootenai River, 1971-1975, 1977 and 1981. Percent is given in parentheses.

Year	Species		
	Rainbow	Cutthroat	Bull trout
1971	12(27)	22(50)	10(23)
1972	1(8)	4(31)	8(61)
1973	14(33)	15(36)	13(31)
1974	11(42)	15(58)	0
1975	5(45)	6(55)	0
1977	32(73)	8(18)	4(9)
1981	193(79)	43(18)	9(3)

Table 24. Catch per hour of boat operation for yearling and older mountain whitefish and rainbow trout from the Elkhorn Section of Kootenai River 1971, 1973, 1974 and 1980.

Year	Catch per hour boat operation		
	Rainbow trout	Mountain whitefish	Total
1971	0.1	40.4	40.5
1973	0.5	20.9	21.4
1974	1.1	14.3	15.3
1980	11.3	56.0	67.3

Table 25. Population estimate for rainbow trout and mountain whitefish per 300 meters from the Elkhorn Section of the Kootenai River September, 1980. The 80 percent confidence limits are given in parentheses. Lengths are in millimeters and weights in grams.

Age	Age composition of estimate	Average mm	Average grams	Number/ 300 meter	Kilograms 300 meter
Rainbow trout					
I+	77.6	221	123	95.3	11.6
II+	17.0	328	367	20.9	7.7
III+ and older	5.4	394	640	6.6	4.2
Totals				122.8 (±41.4%)	23.5 (±32.9%)
Mountain whitefish					
I+	22.0	224	127	233.2	29.7
II+	9.4	292	281	99.1	27.8
III+	50.3	340	445	533.0	237.5
IV+	14.8	386	603	156.7	94.5
V+ and older	3.5	424	699	37.4	26.2
Totals				1,059.4 (±21.7%)	415.7 (±21.3%)

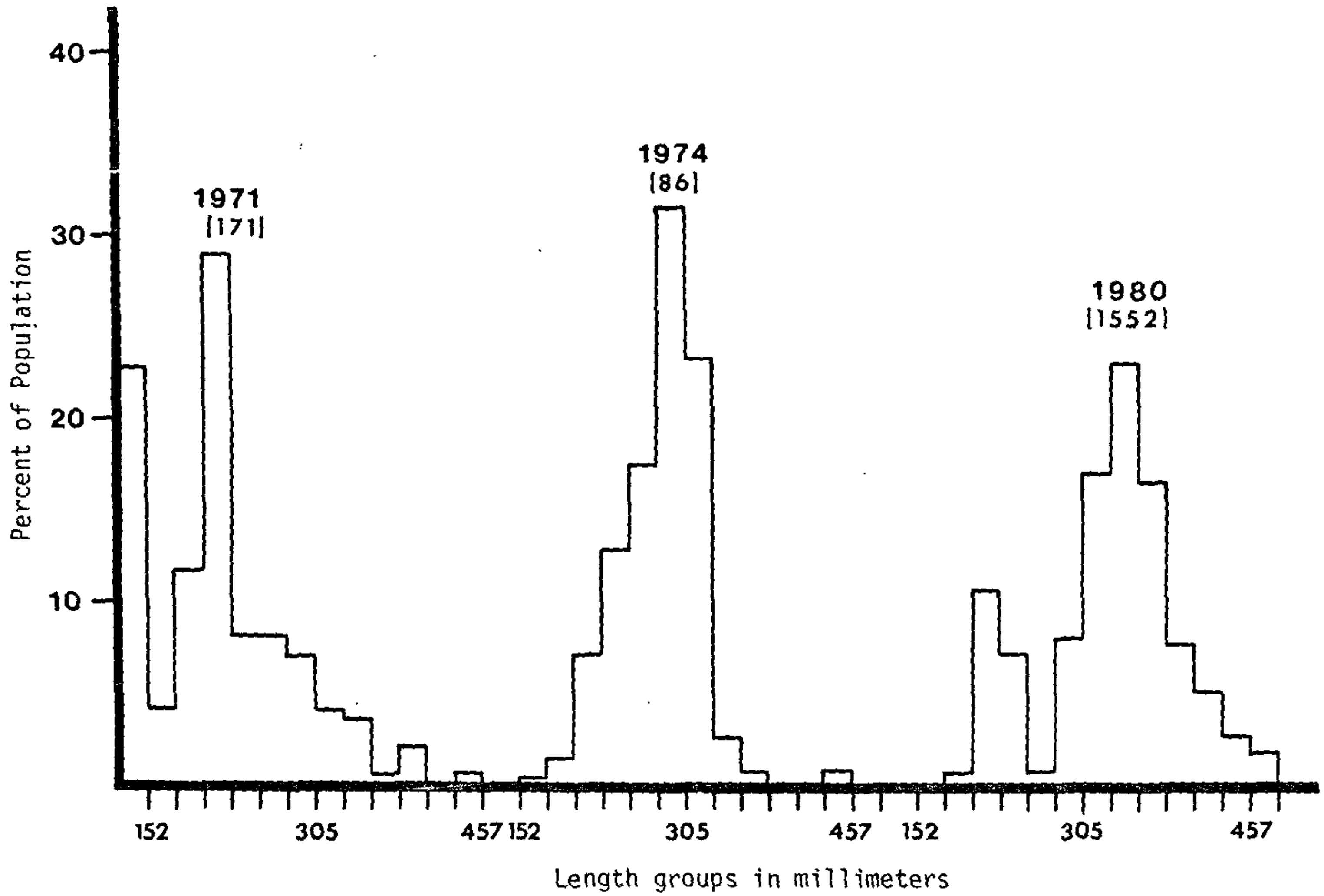

Figure 17. The length frequency distribution of mountain whitefish from the Elkhorn Section of the Kootenai River, 1971, 1974, and 1980. The sample size is given in parentheses below the year.

Table 26. Species composition of electrofishing catches in the Flower-Pipe Section of the Kootenai River, 1973-1981.

	Number and percent ( ) in catch			
Year	Rainbow trout	Cutthroat trout	Bull trout	Mountain whitefish
1973	210(12.9)	166(10.2)	12(0.7)	1,243(76.2)
1974	642(33.5)	39(2.0)	21(1.1)	1,217(63.4)
1975	848(39.2)	169(7.8)	17(0.8)	1,127(52.2)
1977	582(19.0)	93(3.0)	6(0.2)	2,376(77.8)
1978	680(15.6)	6(0.1)	2(<0.1)	3,683(84.3)
1979	855(17.5)	5(0.1)	2(<0.1)	4,020(82.3)
1980	868(16.5)	21(0.4)	1(<0.1)	4,386(83.1)
1981	1,305(19.4)	23(0.3)	5(0.1)	5,392(80.2)
1973-75	1,700(29.8)	374(6.5)	50(0.9)	3,587(62.8)
1978-81	3,708(17.4)	55(0.3)	10(<0.1)	17,481(82.3)

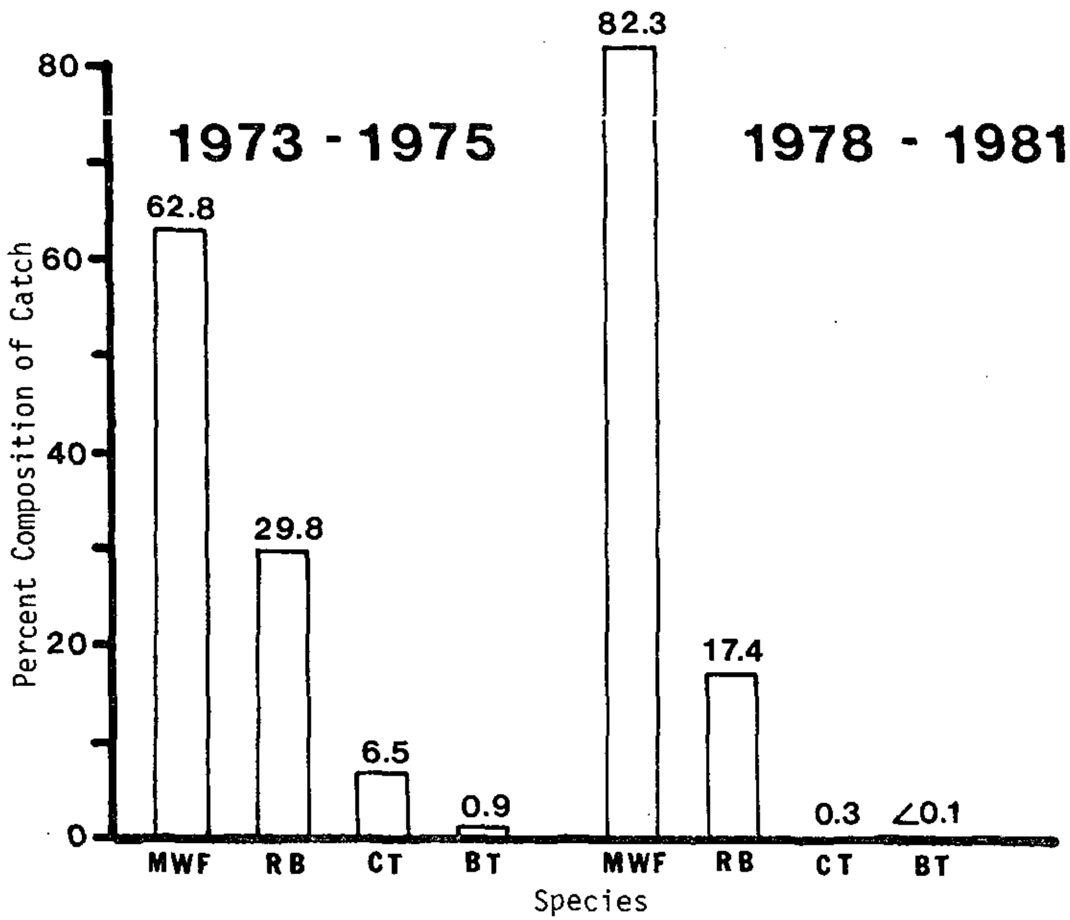

Figure 18. Percent species composition of electrofishing catches in the Flower-Pipe Section of the Kootenai River, 1973-1975 and 1978-1981. Abbreviations are rainbow (RB), mountain whitefish (MWF), cutthroat (CT) and bull trout (BT).

The population estimates for rainbow trout indicate an increase of nine-fold from 1973 to 1981 (Table 27, Figure 19). The trend estimate in 1973 was 24 two year old and older rainbow trout per 1,000 feet of stream compared to 212 in 1981. The weight estimate in 1981 of 37.7 kilograms per 300 meters was 478 percent higher than the estimate of 7.9 kilograms in 1973.

The large increases in rainbow trout numbers beginning in 1978 were due to strong 1976, 1978 and 1979 year classes (Figure 20) entering the catch as two year old fish. The number estimate for age II fish from the 1972 year class was 35 fish per 300 meters as compared to 90, 98 and 188 fish for 1976, 1978 and 1979 year classes, respectively. Percent contribution each year class made to the population estimates also showed a similar pattern with the 1976, 1978 and 1979 year classes appearing to be the strongest (Table 28). For example, the 1979 year class at age II comprised 88.7 percent of the 1981 estimate, while the 1972 year class at age II comprised only 49.3 percent in 1974. Although the 1976 and 1978 year classes were two to three times more numerous at age II than the 1972 and 1975 year classes, the numbers for all year classes were approximately equal at age III (Figure 20). This could be a result of high natural and angler mortality rates of strong year classes or reduced sampling efficiency for larger fish which tend to inhabit deeper water.

The increase in numbers of rainbow trout has been accompanied by a decrease in the size of the fish (Figure 21 and Appendix B). Approximately 50 percent of the 1977 electrofishing catch was 305 mm and longer, while only 13 percent of the 1981 catch was over 305 mm in length. The difference between 1977 and 1981 was even greater in fish over 356 mm in length. The percent of fish larger than 356 mm was 28 and 4 in 1977 and 1981, respectively. The marked reduction in the size of the fish resulted primarily from a decline in growth rates (see Age and Growth Section). increased angler harvest may have been a contributing factor (Graham 1979).

Age composition of the trend estimates showed 61.0 percent of the population was comprised of age II fish in 1977 as compared to 88.7 in 1981 (Table 28). The larger numbers of age II fish in 1981 resulted in higher numbers and percentages of smaller fish under 305 mm.

The trend population estimates for mountain whitefish from the Flower-Pipe Section of the Kootenai are given in Table 29 and Figure 22. The estimates show that the whitefish population was less in 1974 and 1975 than in 1973. The trend estimate increased from 240 fish per 300 meters in 1975 to 711 in 1978, and 783 in 1981. The weight of the population followed a similar pattern to that of the numbers. Condition factor of whitefish increased from 1973 to 1978, then declined thereafter to 1981.

The 1972, 1973 and 1974 year classes were weak due to high mortalities of fry and juveniles from gas bubble disease (Table 30, Figure 23).

Table 27. Trend population estimates, confidence limits, and condition factors for rainbow trout from the Flower-Pipe Section, Kootenai River 1973-1981. Weight is in kilograms. Estimates include age II and older fish.

Sample year	Number per 300 meters	80 percent confidence	Weight per 300 meters	Condition factors
1973	23.9	±23.2	7.9	38.99
1974	70.3	±13.3	19.9	35.81
1975	65.1	±12.6	20.0	36.78
1977	64.4	±15.9	31.4	38.82
1978	116.0	±19.6	32.5	38.76
1979	84.5	±12.7	22.3	34.98
1980	126.4	±16.1	33.2	36.55
1981	211.9	±13.9	37.7	35.08

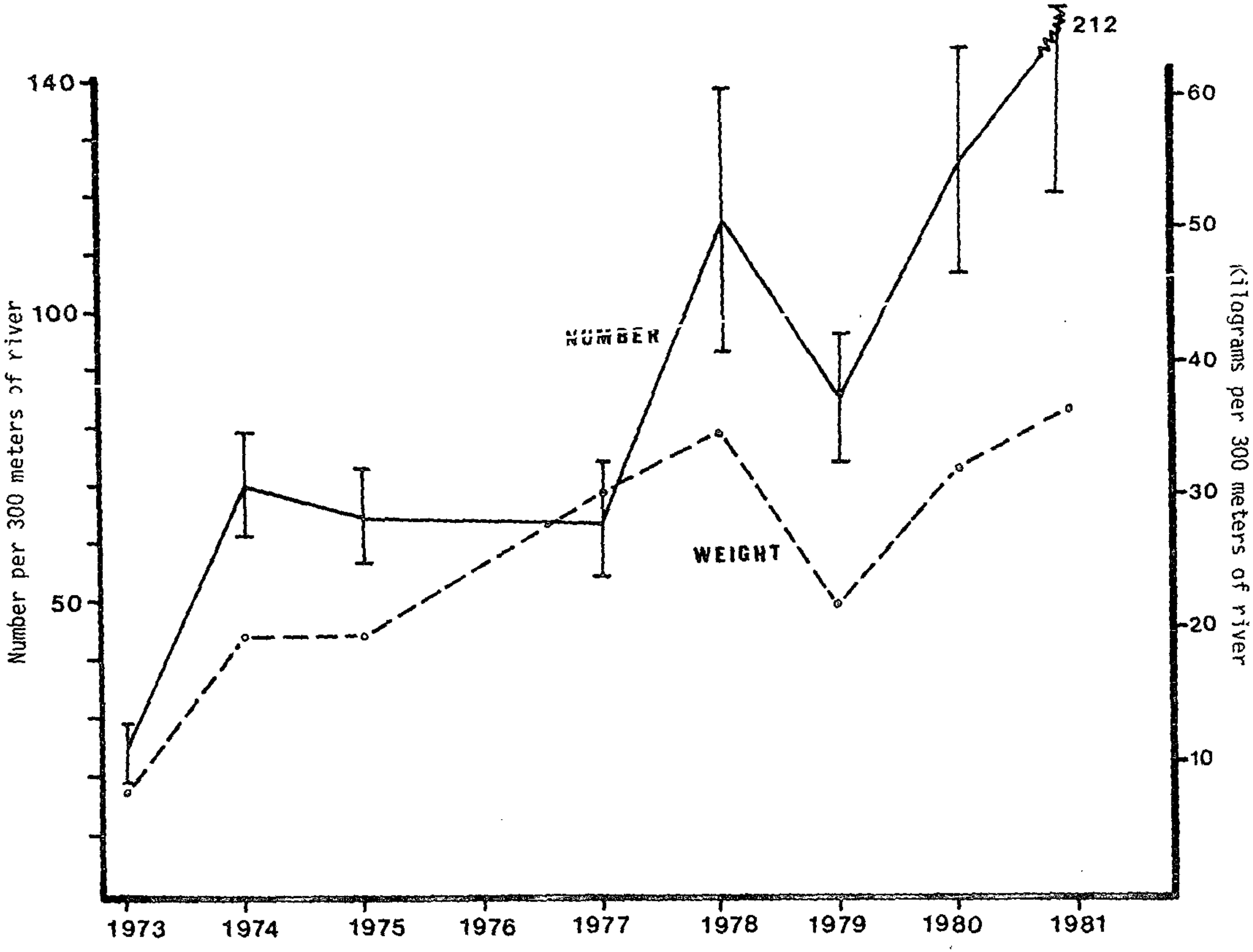

Figure 19. Number and weight of trend population estimates for rainbow trout from the Flower-Pipe Section of Kootenai River, spring 1973-1981. The 80 percent confidence limits are shown by the brackets.

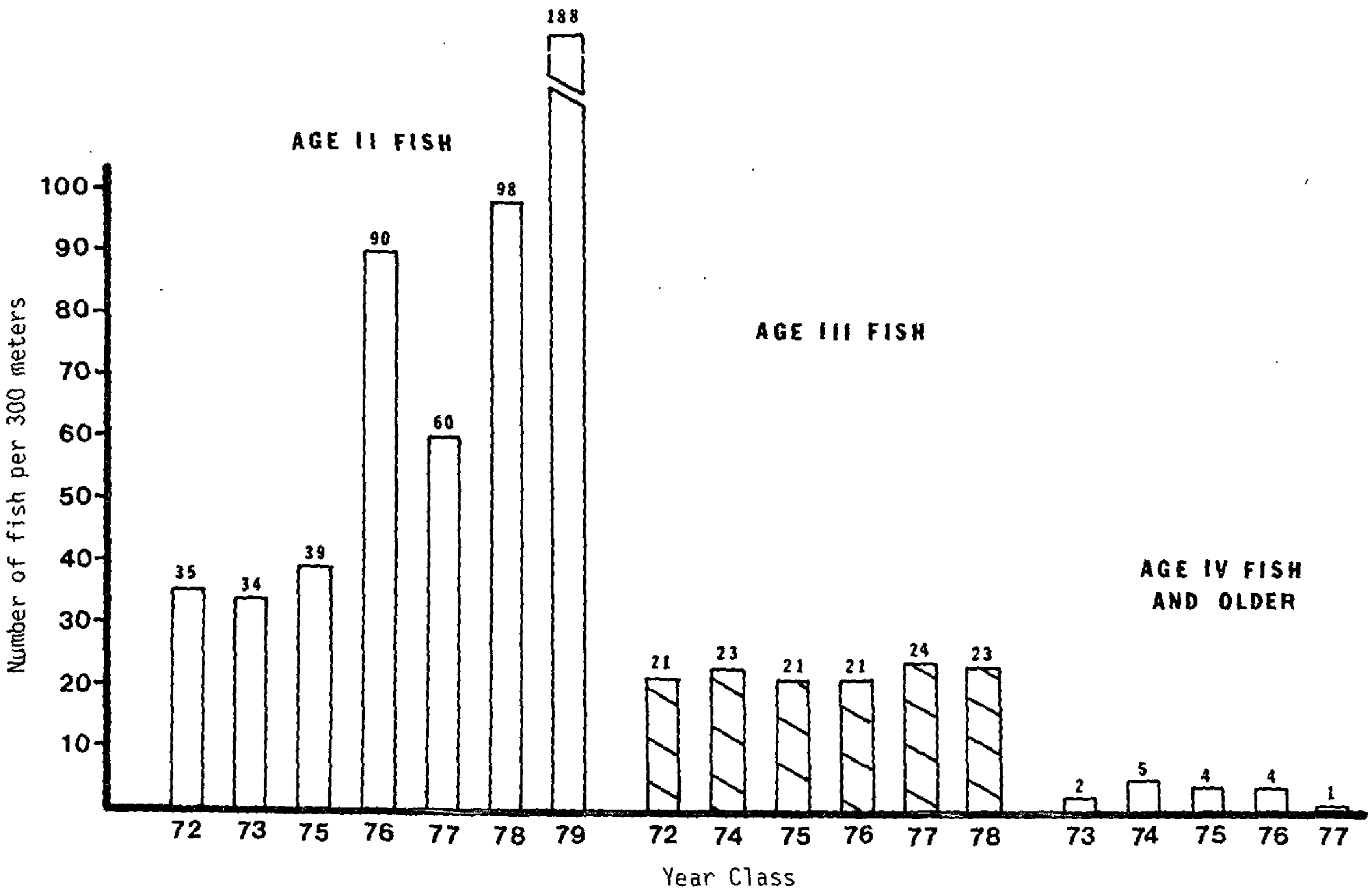

Figure 20. Year class distribution of rainbow trout in Flower-Pipe Section of Kootenai River.

Table 28. Percent age and year class composition of rainbow trout on Flower-Pipe population estimates, 1973-1982. No estimate was made in 1976.

Year class	Year of population estimate 1973	1974	1975	1976	1977	1978	1979	1980	1981
1969	32.4 1/								
1970	50.0 2/	7.0							
1971	17.6 3/	43.7	16.3						
1972		49.3	32.2	---					
1973			51.5	---	3.2				
1974				---	35.8	4.1			
1975					61.0	18.5	4.7		
1976						77.4	24.9	2.8	
1977							70.4	19.3	0.2
1978								77.9	11.1
1979									88.7

1/ First number in each column is percent of fish 4 years old or older.
2/ Second number in each column is percent of fish 3 years old.
3/ Third number in each column is percent of fish 2 years old.

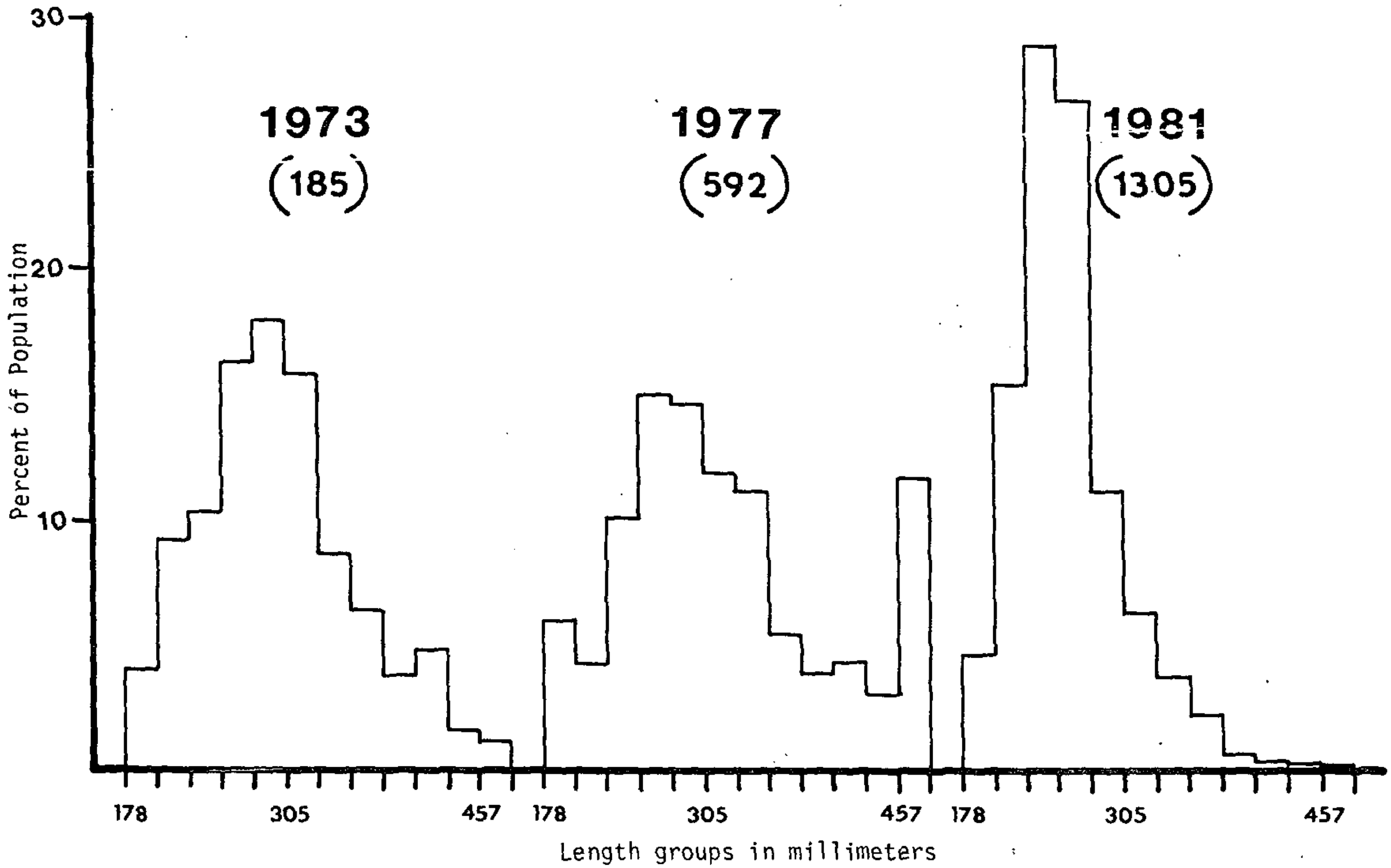

Figure 21. The length frequency of rainbow trout from the Flower-Pipe Section of the Kootenai River in 1973, 1977 and 1981. The sample size is given in parentheses.

Table 29. Trend population estimates, confidence limits and condition factors for mountain whitefish from the Flower-Pipe Section, Kootenai River 1973-1981. Weight is in kilograms and estimates include age II and older fish.

Sample	Number per 300 meters	80 percent confidence limit	Kilograms per 300 meters	Condition factors
1973	467.9	±20.0	66.6	32.87
1974	171.4	±22.4	39.9	32.42
1975	240.2	±21.5	57.3	35.09
1977	440.9	±12.8	125.3	36.30
1978	710.8	±10.5	248.9	37.41
1979	546.0	± 7.1	138.2	32.88
1980	559.5	± 6.7	174.4	33.18
1981	783.0	± 6.4	200.9	33.42

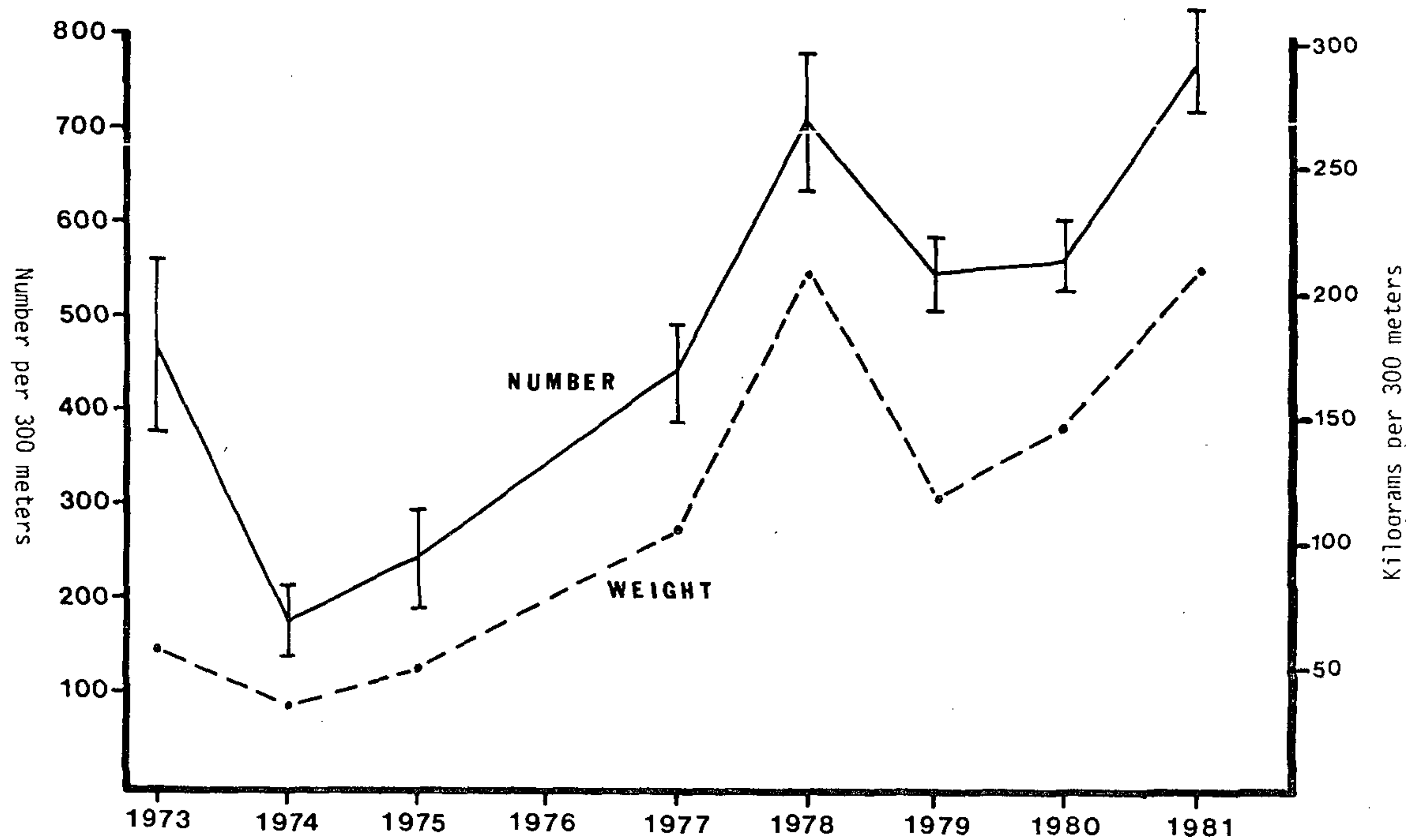

Figure 22. Number and weight of trend population estimates for mountain whitefish from the Flower-Pipe Section of the Kootenai River, 1973-1981. The 80 percent confidence limits are shown by the brackets.

Table 30. The percent contribution of year classes to the mountain whitefish population estimates in the Flower-Pipe Section of the Kootenai River, 1973-1981.

Year class	Percent of estimate at age			
	II	III	IV	V and older
1971	42.0	33.2	31.8	----
1972	29.8	29.3	----	3.6
1973	38.9	----	10.4	7.1
1974	----	5.3	2.2	5.2
1975	80.7	74.8	27.6	10.2
1976	15.9	16.2	32.5	8.0
1977	51.0	48.7	38.6	----
1978	8.6	11.4	----	----
1979	42.0	----	----	----

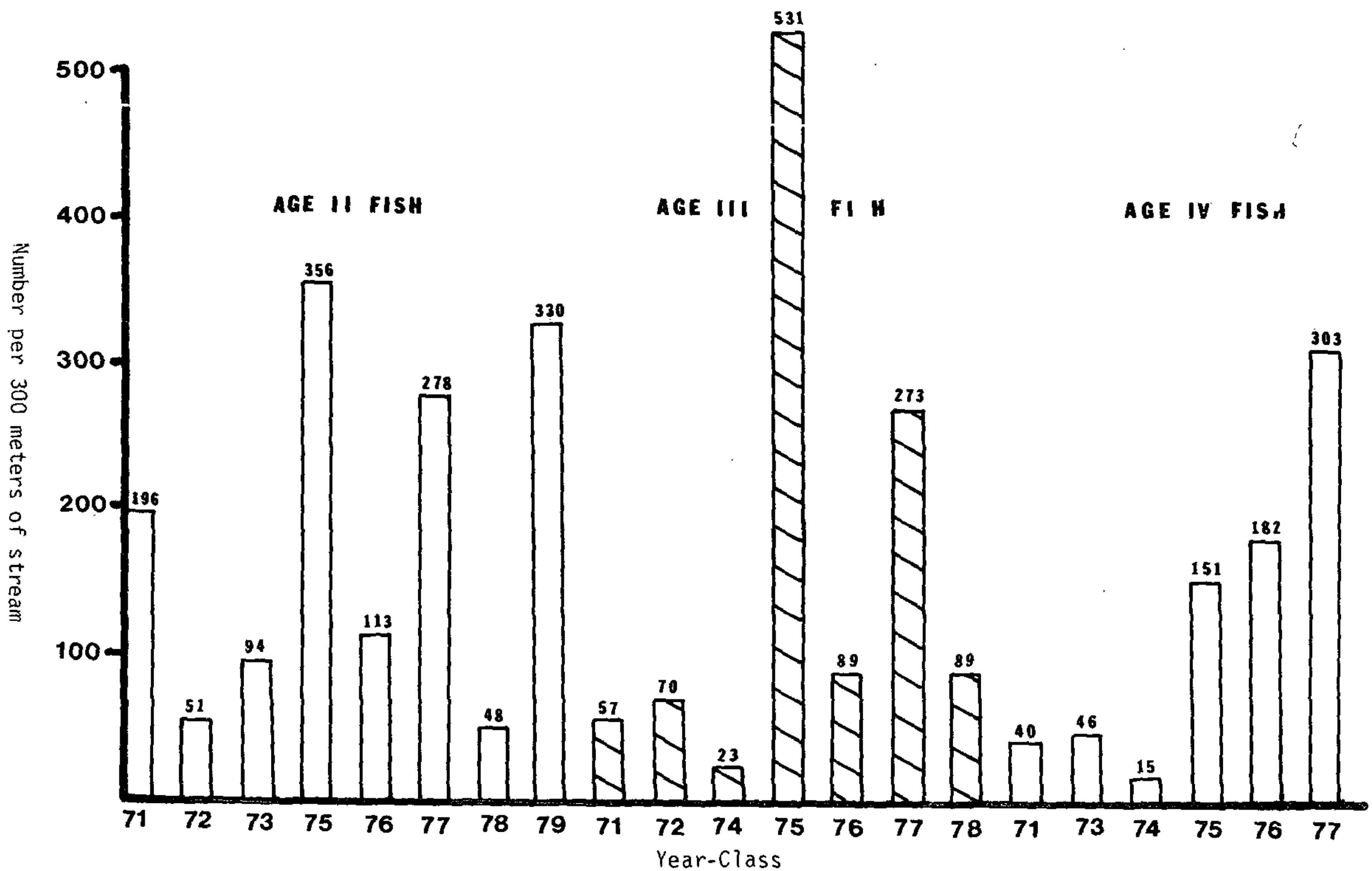

Figure 23. The number of age II, III`, and IV mountain whitefish by year class per 300 meters of stream in the Flower-Pipe Section, Kootenai River, 1973-1981. Age II fish from the 1974 year class, age III fish from 1973 year class, and age IV fish from the 1972 year class are missing because a population estimate was not made in 1976.

Following control of gas supersaturation in 1975, strong year classes were produced in 1975, 1977 and 1979. The 1975 year class appeared to be the strongest at age II with an estimate of 356 per 300 meters. The 1975 year class at age II comprised 80.7 percent of the 1977 population estimate. The 1975 and 1977 year classes at age III were also more numerous than the other year classes.

The frequency distribution in 1973 and 1977 were uni-model for mountain whitefish with fish under 280 mm in length comprising between 88 and 78 percent of the catch, respectively (Figure 24, Appendix B). The length frequency distribution in 1980 was more normal, having a bimodel distribution with peaks at 229 and 305 mm.

The difference in the length frequency distribution was due primarily to different age composition of the electrofishing catches (Table 31). Age II and III fish comprised 93.1 and 86.0 percent of the 1973 and 1977 samples, respectively, whereas these age groups made up only 53.4 percent of the 1981 catch. Changes in growth also influenced the length frequency distribution (see Age and Growth section).

Troy Section

The species composition in the Troy Section changed markedly from 1971 to 1981 (Table 32). Mountain whitefish comprised 15.8 percent of the catch in 1971 as compared to 60.7 in 1981. The catch per hour of boat operation increased from 8.5 fish to 122.3 fish during the same period. The catch rate of rainbow trout declined from 2.5 fish per hour in 1971 to 0.8 fish per hour in 1981. This decline may be due to sampling rather than an actual reduction in the rainbow population. Largescale sucker catch ratio varied considerably from year to year and it appears that 1981 population levels are comparable to 1972 levels. The catch rates of peamouth chub and northern squawfish decreased markedly from 1971 to 1981. This apparent decrease in numbers of peamouth and squawfish may be related to low water temperatures in spring and early summer adversely affecting reproductive success. Northern squawfish and peamouth spawn when water temperatures approach 55°F (Patten and Redman 1969; Brown 1971). From 1972-1977, this temperature was reached six to 12 weeks later than prior to impoundment. Spence and Hynes (1969) concluded that low spring and summer water temperatures were responsible for the absence of four species cyprinid fishes downstream of a flood control dam in Canada. In 1980, 55°F was achieved in the Kootenai River only about two to three weeks later than prior to impoundment.

Burbot

Burbot provided a popular early spring fishery in the Kootenai River prior to 1960. This species declined drastically in the early 1960's and burbot were rarely caught from 1965 to impoundment of the Kootenai in 1972. The exact reasons for the decline of this species are not known, but is probably related to chemical and sediment pollution. Burbot were collected in the Flower-Pipe Section during electrofishing surveys in March, 1979. Five fish ranging in total length from 340 to 495 mm were

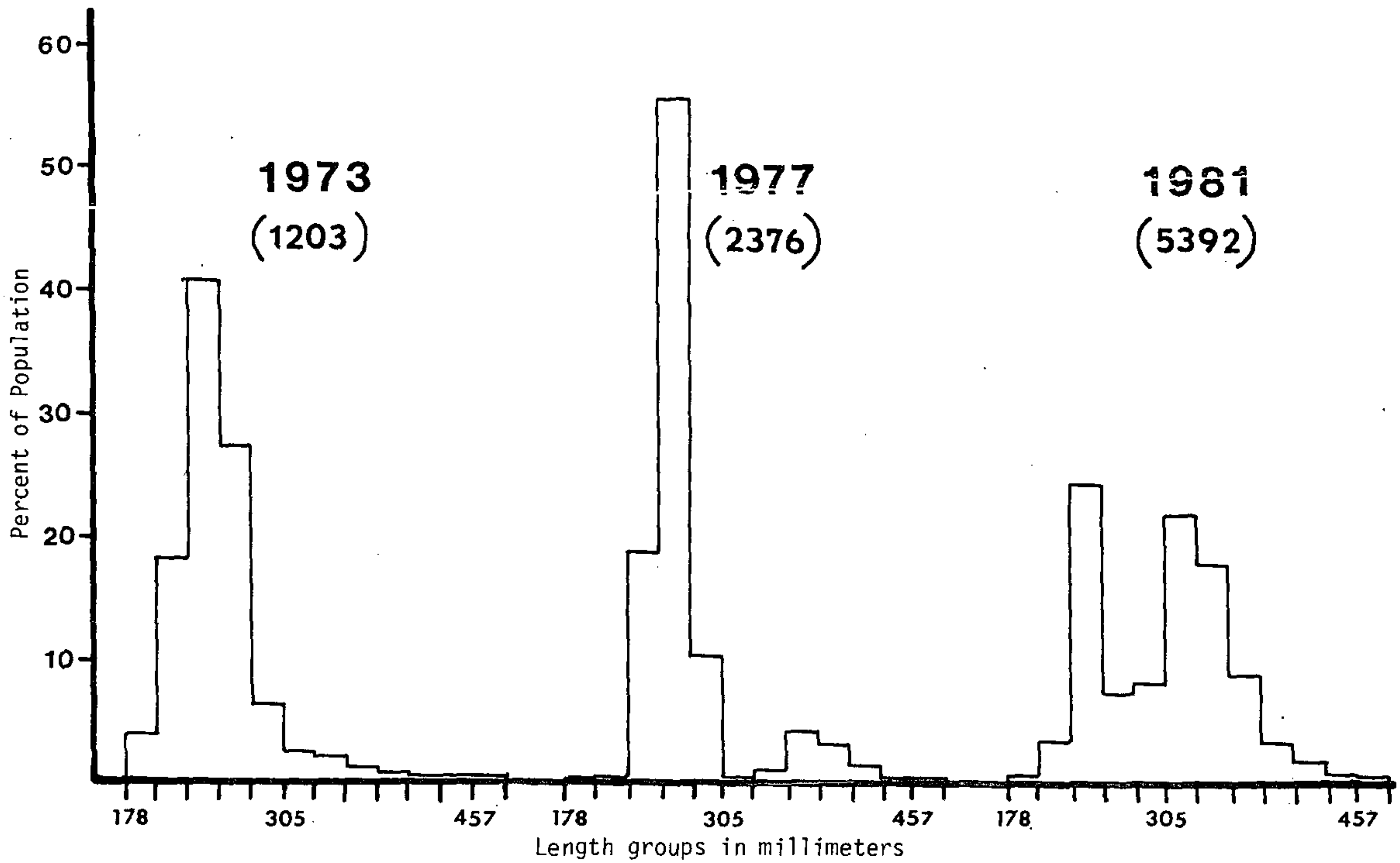

Figure 24. The length frequency of mountain whitefish from the Flower-Pipe Section of Kootenai River, 1973, 1977 and 1981. The data is presented as the percent each size group comprised of the population. The sample size is given in parentheses.

Table 31. Age composition of mountain whitefish in the trend population estimates from the Flower-Pipe Section of the Kootenai River, 1973-1981.

Sample year	Percent age composition in age group			
	II	III	IV	V and older
1973	42.0	51.1	6.9	----
1974	29.8	33.2	35.1	1.9
1975	38.9	29.3	31.8	----
1977	80.7	5.3	10.4	3.6
1978	15.9	74.8	2.2	7.1
1979	51.0	16.2	27.6	5.2
1980	8.6	48.7	32.5	10.2
1981	42.0	11.4	38.6	8.0

Table 32. Catch per hour of boat operation for rainbow trout (RB), mountain whitefish (MWF), largescale suckers (CSU), peamouth chub (CRC) and northern squawfish (NSQ) from the Troy Section of the Kootenai River. The species composition of the catch is given in parentheses.

Date	Catch per hour of boat operation					
	RB	MWF	CSU	CRC	NSQ	Total
9/29/71	2.5(4.6)	8.5(15.8)	23.5(43.5)	16.0(29.6)	3.5(6.5)	54.0
9/10/72	0.0	13.3(11.6)	73.5(64.0)	24.7(21.5)	3.3(2.9)	114.8
4/20/73	2.5(4.3)	4.1(7.1)	46.9(81.4)	3.8(6.6)	0.3(0.5)	57.6
9/19/74	2.9(4.1)	12.9(18.4)	41.4(59.1)	11.3(16.1)	1.6(2.3)	70.1
9/9/81	0.8(0.4)	122.3(60.7)	77.7(38.6)	0.5(0.2)	0.2(0.1)	201.5

captured. A few burbot have been collected each spring since 1979 in the Flower-Pipe Section and a popular fishery has developed for them in the Kootenai River immediately downstream from Libby Dam in the late winter and spring.

Age and Growth

Rainbow trout

A total of 1,276 scale samples collected from rainbow trout in the Flower-Pipe Section of the Kootenai River were utilized to determine ages, growth, migration class and body-scale relationships. The Monastyrsky body-scale relationship (Figure 25) was log TL+Log 9.170 + .739 Log SR ($r = .918$). This regression line described the body-scale relationship of rainbow trout in the Kootenai River.

Composition of the migration class for rainbow trout from the Flower-Pipe Section of the Kootenai River are given in Table 33. Migration class X_1 dominated from 1974-1981, when they comprised 64 to 94 percent for the rainbow population as compared to 36 to six percent for migration class $X_{2,3}$. The averages for the eight years of data were 83.5 percent X_1 and 16.5 percent $X_{2,3}$. Less than one percent were X_3.

The percent of X_1 migration class rainbow trout increased from 64 percent in 1974 to 92 percent in 1981. Northcote (1969) reported that juvenile rainbow trout emigrated from natal streams at an earlier age from densely populated streams than sparsely populated streams. Data presented in this report show that rainbow trout spawning populations increased markedly in Pipe, Libby and Bobtail creeks from 1976 to 1981 resulting in increased fish densities and earlier emigration of juveniles.

Data presented on growth rates of rainbow trout are limited to migration class X_1 fish only. Sample size of migration class X_2 and X_3 fish were too small for comparison between years. Growth of the 1969 through 1979 year class of rainbow trout by age group and total length is presented in Table 34 and Figure 26.

Growth of rainbow trout year classes varied considerably during the study. The 1969 year class grew the slowest attaining a length of 295 mm at age III. The 1974 year class had the fastest growth reaching 452 mm at age III. Growth declined appreciably in succeeding years with the 1978 year class averaging only 335 mm at age III. Growth continued to decline in the 1979 year class which averaged 244 mm at age II as compared to 264 mm for the 1978 year class.

The growth achieved by the 1978 and 1979 year classes in the Kootenai River was larger than attained by rainbow trout in other northwestern Montana streams. Rainbow trout in the Flathead River averaged 206 and 312 mm at ages II and III, respectively (McMullin and Graham 1981). The growth of rainbow in the Fisher River, Wolf Creek and Fortine Creek was markedly less than in the Kootenai (May 1972). Growth of rainbow trout was faster below impoundments on the Snake River in Idaho (Irving and

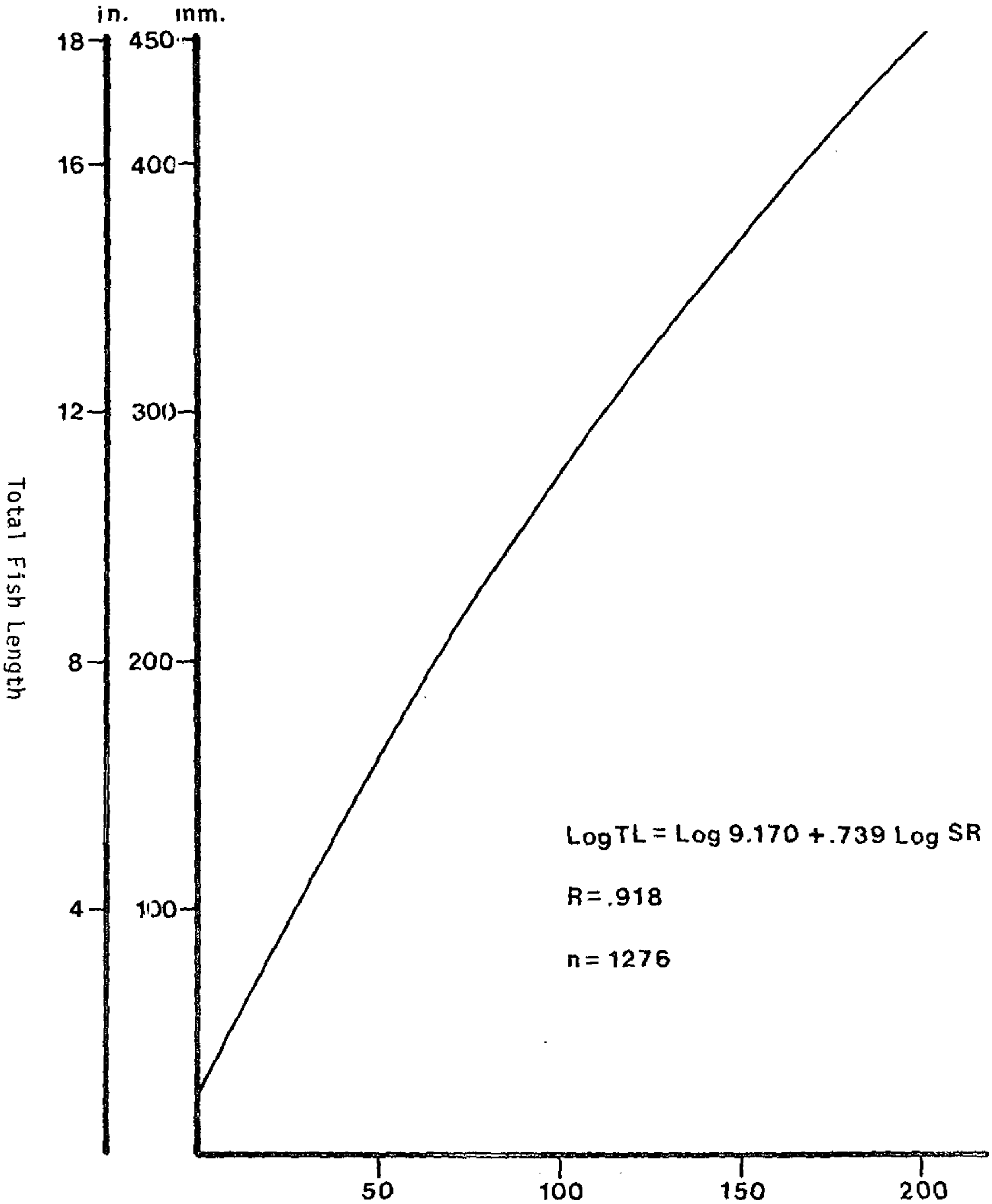

Figure 25. Monastyrsky body-scale relationship for rainbow trout from the Flower-Pipe Section of the Kootenai River. (106 x scale radius in mm).

Table 33. Percent of rainbow trout by migration class collected in the Flower-Pipe Section, 1974-1981.

Migration class	Year 1974	1975	1977	1978	1979	1980	1981	Average 1974-1981
X_1	63.8	83.8	73.7	79.8	90.8	94.0	91.9	83.5
$X_2 + X_3$	36.2	16.2	26.3	20.2	9.2	6.0	8.1	16.5

Table 34. Length of migration class X_1 rainbow trout by year class from the Flower-Pipe Section of the Kootenai River. Number of fish aged is given in parenthesis.

Year class	Back-calculated length in millimeters for age group I	II	III	IV
1969	107(19)	224(19)	295(19)	363(15)
1970	102(31)	208(31)	295(31)	401(4)
1971	102(26)	254(26)	358(15)	386(21)
1972	112(77)	279(77)	330(15)	----
1973	97(85)	269(85)	437(4)	493(4)
1974	99(18)	330(18)	452(18)	----
1975	97(65)	305(65)	383(26)	409(4)
1976	44(49)	277(49)	371(39)	409(15)
1977	104(93)	264(93)	358(55)	396(3)
1978	104(116)	264(116)	335(68)	
1979	76(128)	244(128)		
Preimpoundment averages				
1969-1971	104(76)	216(50)	295(19)	----
Postimpoundment averages				
1972-1976	104(294)	287(271)	373(83)	412(44)
1977-1979	97(337)	262(386)	353(188)	406(22)

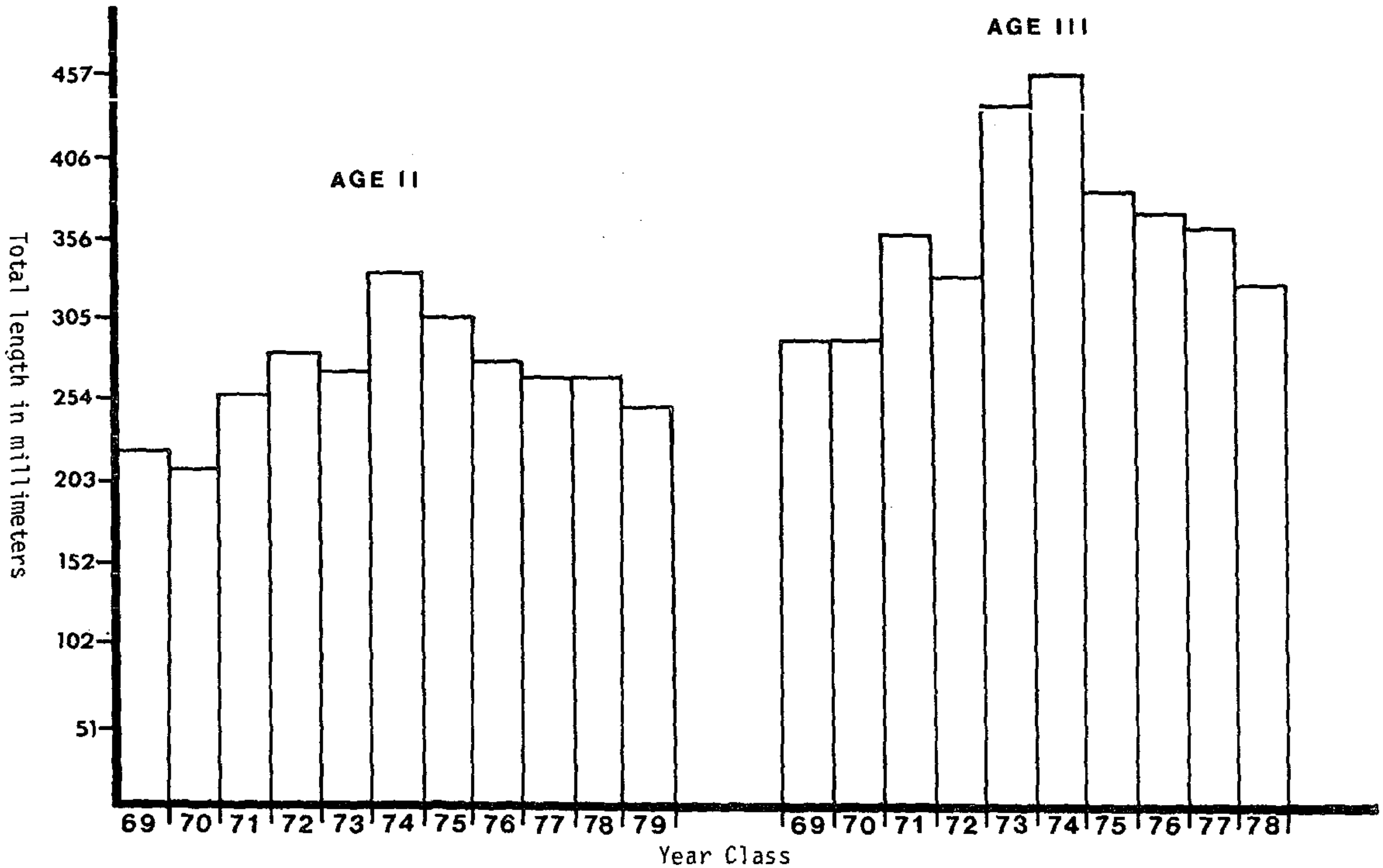

Figure 26. Length of age II and age III rainbow trout by year classes, Flower-Pipe Section of Kootenai River, 1969-1979.

Cuplin 1956) and Bighorn River in Montana (Stevenson 1975).

Annual growth increments by year for age groups 0 through III are given in Table 35 and for age I and II in Figure 27. The increments achieved during the first year of life in the natal stream varied little among the years. Growth was slowest in 1980 when an increment of 76 mm was achieved by young-of-the-year fish. Growth of fish in their second year of life, first year in Kootenai River, fluctuated considerably from 1970-1980. The smallest increment of 107 mm was registered in 1971, while the largest of 231 mm was recorded in 1975. The growth increments declined after 1975 with the increment in 1980 being 168 mm. A similar pattern was noted for fish in their third year of life.

Growth in fish is a complex process which is influenced by many factors (Everhart and Youngs 1981). Among the more important determinants are the amount and size of food available, the number of fish using the same food resource, temperature and other water quality factors, and the age and size of the fish. The most important factors influencing growth of rainbow trout in the Kootenai River appear to be density of bottom fauna, density of rainbow trout and mountain whitefish and water temperatures.

Temperatures of Kootenai River in 1979 and 1980 were comparable to the 1974-1975 temperatures. The number of days above 50°F in 1974 and 1975 was 154 and 162, respectively, as compared to 140 days in 1979 and 168 days in 1980. The densities of the aquatic insect populations in 1974-1975 are unknown, but they were probably comparable to the 1979-1980 densities. Allen (1969) noted that the density of bottom fauna may be controlled by the intraspecific predation or by fish species. Interspecific competition for food can occur between species which do not directly interact in their behavior. This appears to be the case for rainbow trout and mountain whitefish which feed in different levels of the water column, but utilize the same food resources (see Section B).

Intraspecific competition for food has been shown to reduce growth rates of trout (Allen, ibid). The increased densities of rainbow from 1977-1980 resulted in increased competition for food and space. Rainbow trout are territorial in streams (Stringer and Hoer 1955) and increased densities result in increased competition for suitable territories. Energy that could be spent in feeding activities is expended on establishing and defending territorial and social hierarchies. The dominant fish occupy the most desirable territories with regards to food availability. Symons (1971) found that subordinate atlantic salmon parr grew only two-thirds as fast as dominant parr. The large increase in mountain whitefish numbers have reduced trout growth by reducing the amount of habitat available, thereby increasing competition for territories. Chapman (1966) noted social control in salmonids is quite strong and increased aggression occurs between rainbow trout when living space is reduced.

The reduction in species diversity and loss of many of the larger species of Plecoptera, Ephemeroptera and Trichoptera may be a factor

Table 35. Growth increments of migration class X_1 rainbow trout from the Flower-Pipe Section of the Kootenai River.

Growth year	Length increments in (mm) for age group 0	I	II	III
1969[1/]	107	---	---	---
1970[1/]	102	117	---	---
1971[1/]	102	107	71	---
1972[2/]	112	152	86	69
1973[2/]	97	168	104	107
1974[2/]	99	173	51	28
1975[2/]	97	231	168	---
1976[2/]	114	208	147	56
1977[3/]	104	163	79	---
1978[3/]	104	160	94	25
1979[3/]	76	160	94	38
1980[3/]	---	168	71	---
Mean				
Preimpoundment	104	112	71	---
Postimpoundment				
1972-1976[1/]	104	185	112	66
1977-1980	94	163	84	33

1/ Growth years 1969-1971 was preimpoundment.
2/ Growth years 1972-1976 was postimpoundment prior to operation of selective withdrawal.
3/ Growth years 1977-1980 was postimpoundment with operation of selective withdrawal.

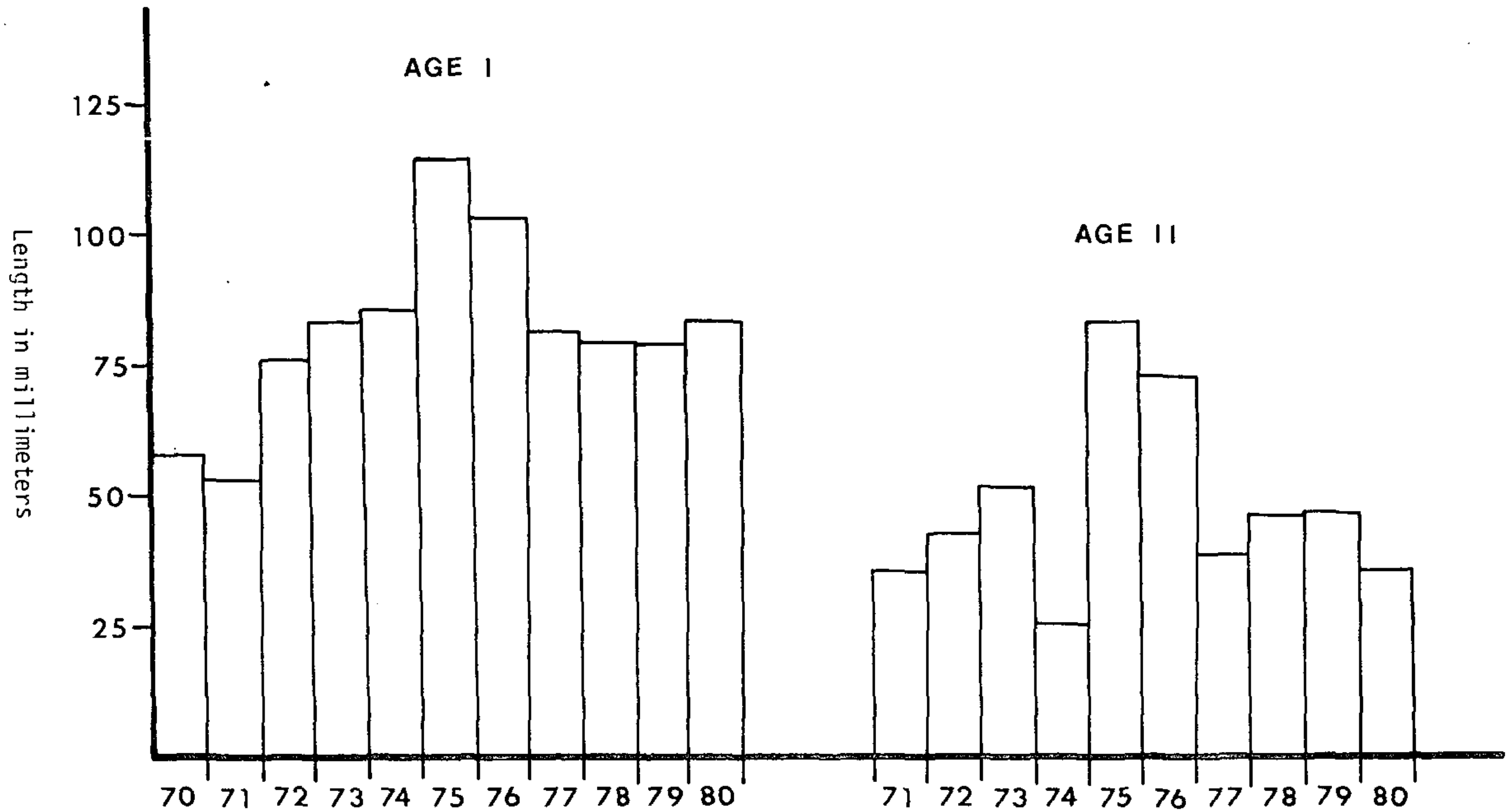

Figure 28. Growth increments achieved by age group I and II rainbow trout from the Flower-Pipe Section of the Kootenai River, 1969-1979.

in reducing the growth of larger trout. Larger fish tend to consume large food items if these are available. Thus the maximum size attained by trout may be determined by the lack of larger food items in the bottom fauna (Allen ibid and Section B).

The fast growth rates achieved by rainbow trout following impoundment of the Kootenai River in 1972 were primarily due to low fish densities, substantial numbers of aquatic insects and good water temperatures for growth especially in 1974 and 1975 when the largest growth increments were recorded. The reduction in gas supersaturation in 1975 resulted in large increases in rainbow trout and mountain whitefish populations in subsequent years and a decline in growth rates. The current growth rate of rainbow trout represents a more normal situation than in the first four years following impoundment when fish densities were low and the system responding to environmental changes.

Rainbow trout growth increased following impoundment due to an apparent increase in the density of bottom fauna, reduced densities of mountain whitefish and better temperatures for growth. The decline in rainbow trout growth after 1976 appears to be primarily due to increased densities of mountain whitefish and rainbow trout. Wells (1980) found that increased densities of trout in the Beaverhead River below Clark Canyon Dam caused a reduction in the size and weight of rainbow and brown trout.

Mountain Whitefish

A total of 1,216 mountain whitefish from the Flower-Pipe Section were used to determine the body-scale relationship (Figure 28). The Monastyrsky body-scale relationship was Log TL = Log 3.657 + .818 Log SR. The coefficient of correlation was .930. This relationship was comparable to the body-scale relationship for mountain whitefish from the Flathead River (McMullin and Graham 1981). Sufficient numbers of whitefish scales were collected and analyzed to present data on Jennings, Flower-Pipe and Troy sections and these data are presented below.

Jennings Section

The growth of the 1966-1979 mountain whitefish year classes was variable (Table 36, Figure 29). The 1966 year class recorded the slowest growth, achieving a length of 292 mm at age IV as compared to 376 mm for the 1973 year class. Preimpoundment growth was considerably less than post-impoundment. The mean length achieved by age III fish prior to impoundment was 252 mm, while age III fish averaged 282 mm from 1972-1976 and 312 mm from 1977-1980.

Growth increments of mountain whitefish age groups from the Jennings Section are displayed in Table 37, Figure 30. The mean length increments achieved by young-of-the-year and age I fish prior to impoundment were less than those attained following impoundment; while the mean increments for age II and III fish were slightly larger than following impoundment. The preimpoundment mean for age 0 size fish was 117 mm, whereas the post-impoundment means from 1972-1976 and 1977-1980 were 132 and 140 mm, re-

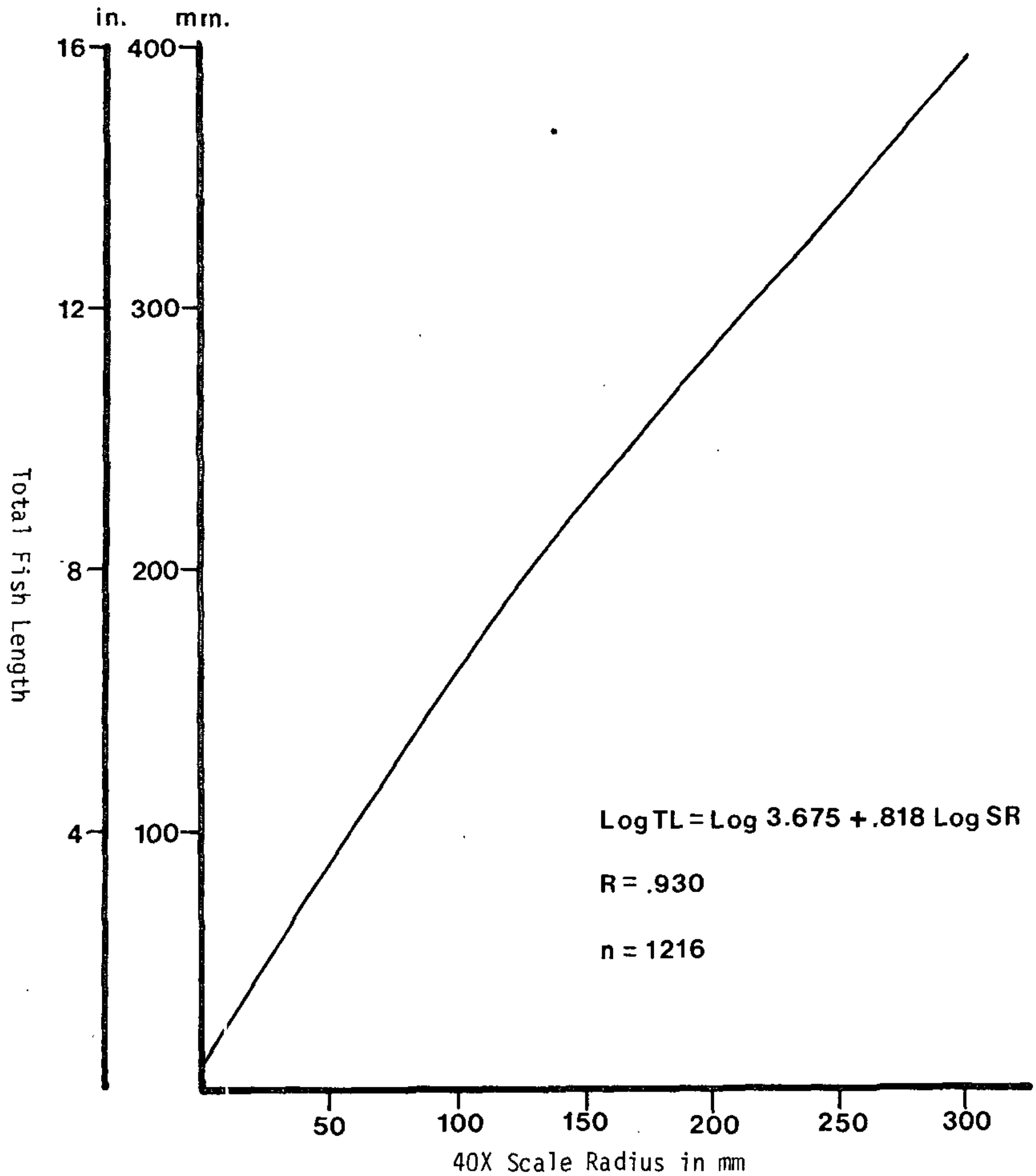

Figure 28. Monastyrsky body-scale relationship for mountain whitefish from the Flower-Pipe Section of the Kootenai River.

Table 36. The back-calculated growth of mountain whitefish year classes from the Jennings Section of the Kootenai River. Number of fish aged is given in parenthesis.

Year class	Back-calculated length in (mm) for age group				
1966	114(28)	193(28)	252(28)	292(28)	323(10)
1967	114(35)	193(35)	246(35)	297(12)	358(6)
1968	112(31)	193(31)	257(34)	310(18)	340(18)
1969	125(22)	203(22)	251(22)	285(22)	310(4)
1970	122(38)	198(38)	246(38)	302(18)	330(4)
1971	117(37)	198(37)	269(29)	307(28)	---
1972	119(29)	216(29)	254(42)	345(12)	386(12)
1973	117(22)	221(22)	338(6)	376(6)	---
1974	142(14)	244(14)	300(14)	---	---
1975	145(41)	246(41)	---	---	---
1976	---	---	---	---	---
1977	140(22)	262(22)	315(22)	351(22)	---
1978	142(57)	257(57)	307(57)	---	---
1979	135(48)	246(48)	---	---	---
Pre-impoundment averages					
1966-71	117(191)	196(154)	252(119)	300(58)	340(16)
Post-inpoundment averages					
1972-76	142(106)	226(143)	282(129)	323(86)	343(38)
1977-79	135(127)	254(127)	312(79)	351(22)	---

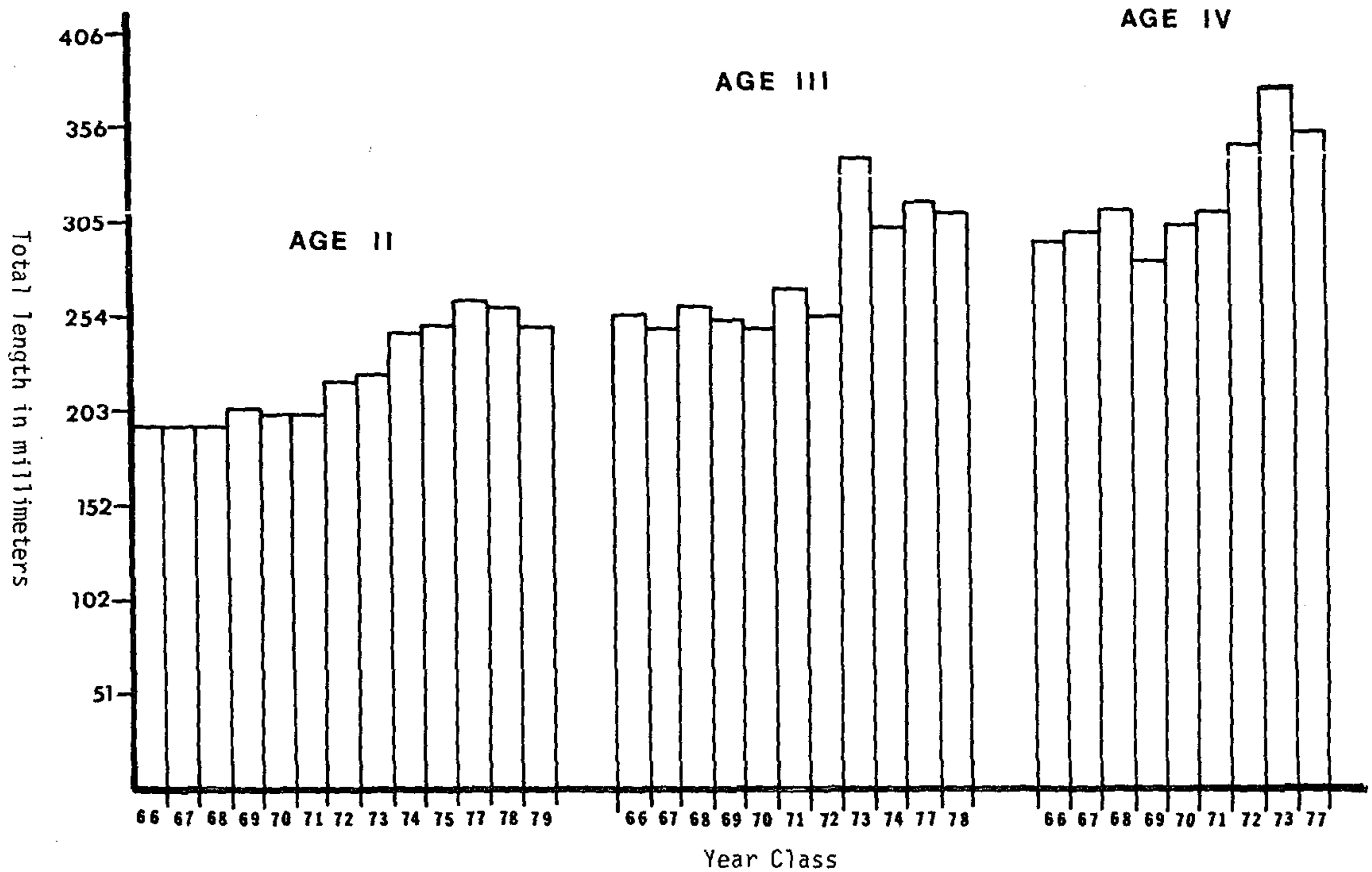

Figure 29. Length at age II, III, and IV by mountain whitefisy year classes from the Jennings Section of the Kootenai River.

Table 37. Growth increments of mountain whitefish from the Jennings Section of the Kootenai River.

Growth year	Length increments in mm for age group			
	0	I	II	III
1966 1/	114	---	---	---
1967	114	79	---	---
1968	112	79	58	---
1969	125	81	53	41
1970	122	79	64	51
1971	117	76	48	53
1972 2/	119	81	48	33
1973	117	97	71	56
1974	142	104	38	38
1975	145	102	---	41
1976	---	102	56	38
1977 3/	140	---	---	---
1978	142	122	---	---
1979	135	114	53	----
1980	---	112	51	36
Preimpoundment averages				
1966-71	117	79	56	48
Postimpoundment averages				
1972-76	132	94	53	41
1977-80	140	114	53	36

1/ Growth years 1966-1971 are preimpoundment.
2/ Growth years 1972-1976 are postimpoundment prior to operation of selective withdrawal system.
3/ Growth years 1977-1980 are postimpoundment with operation of selective withdrawal system.

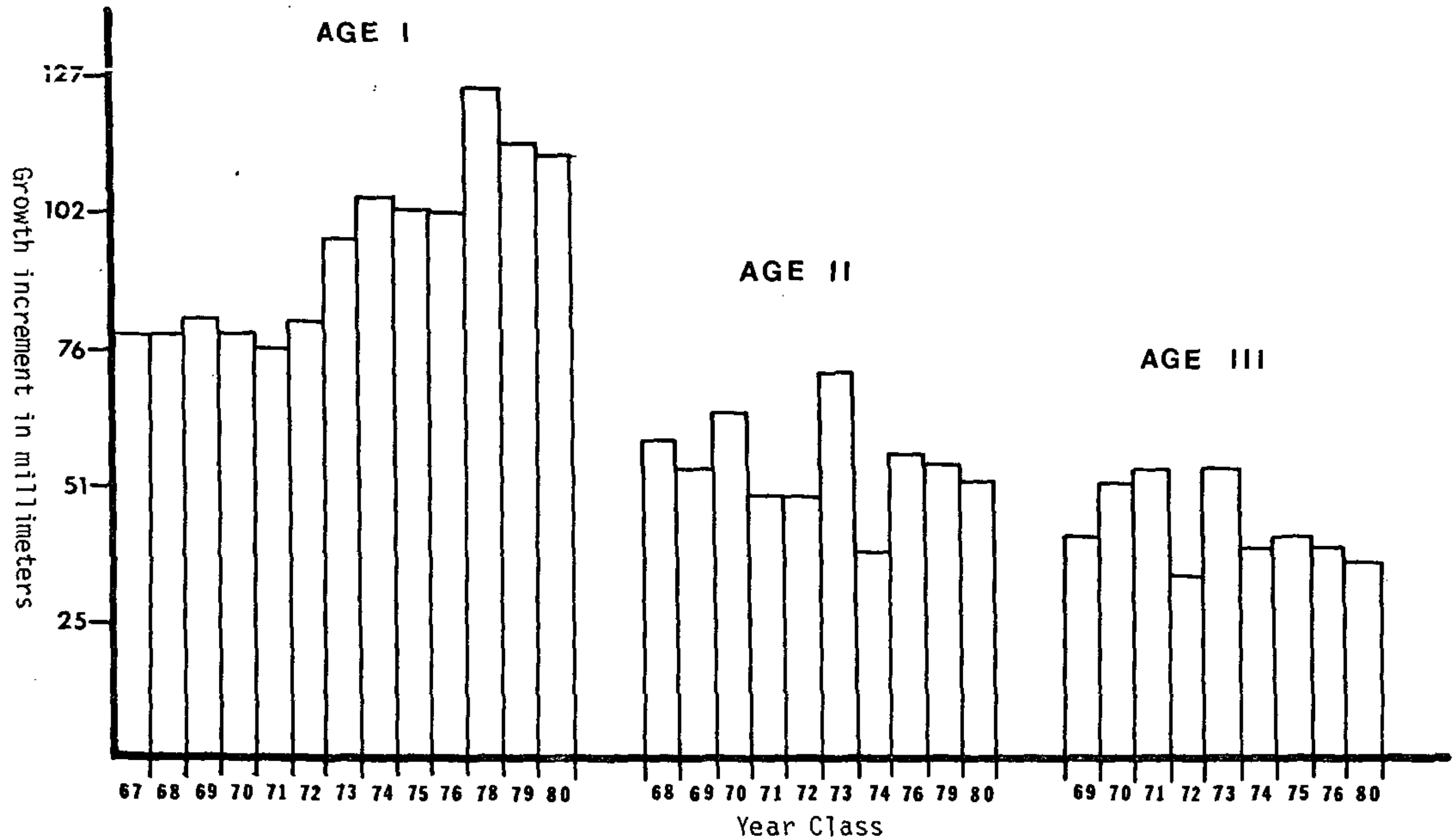

Figure 30. Growth increments of age groups I, II, and III mountain whitefish from the Jennings Section of the Kootenai River, 1967-1980.

spectively. Age II fish had a preimpoundment average of 56 mm as compared to 33 mm following impoundment. Growth increments declined slightly in 1979 and 1980 from the previous two years.

Flower-Pipe Section

The growth achieved by the 1968-1979 mountain whitefish year classes in the Flower-Pipe Section varied considerably (Table 38, Figure 31). The growth of the preimpoundment year classes was markedly less than post-impoundment year classes and growth of the 1977, 1978 and 1979 year classes was less than the 1973, 1974 and 1975 year classes. The 1970 year class achieved a length of 252 mm at age III, while the lengths attained by the 1974 and 1978 year classes at age III were 345 and 297 mm, respectively. The lengths achieved at age IV by the 1974 and 1975 year classes were 46 and 33 mm longer, respectively, than the 1977 year class. The 1973 year class attained the largest mean size of 378 mm at age IV, while the 1969 year class recorded the smallest mean size of 303 mm.

The growth increments achieved by mountain whitefish age groups from 1968-1980 are presented in Table 39, Figure 32. The increments of young-of-the-year fish and fish in their second year of life were less prior to impoundment than following impoundment. The average pre-impoundment increment for age 0 fish was 119 mm as compared to the 1977-1980 mean of 140 mm. In contrast, the length increments achieved by age II and III fish during preimpoundment years were larger than those recorded following impoundment. The mean increment of 33 mm for age III fish from 1977-1980 was less than the 1971 increment of 53 mm. The length increments attained in 1979 and 1980 were slightly less than recorded in 1975 and 1976, but the decline in growth increments appeared to have ceased by 1980.

The growth increments recorded in 1974 by age I, II and III fish were less than either the preceding or following year. Gas concentrations were much higher in the Flower-Pipe Section in 1974 than other years due to high flows (May and Huston 1975). These high gas concentrations appeared to have adversely affected whitefish growth. A similar decline in growth increments of age II rainbow trout occurred in 1974.

Troy Section

Age and growth data are presented on four year classes from the Troy Section of the Kootenai River (Table 40). Growth of the 1970 and 1971 year classes was less than that of the 1978 and 1979 year classes. The preimpoundment mean length for age III fish of 262 mm was 36 mm less than the post-impoundment mean of 297 mm. The increase in growth rate following impoundment occurred in age 0 and age I fish.

The growth of mountain whitefish from the Jennings, Flower-Pipe and Troy sections of the Kootenai is compared in Table 40, Figure 33. The growth pattern for the three areas of the Kootenai was comparable. Growth of young-of-the-year and age I fish was slower prior to impoundment

Table 38. The back-calculated length of mountain whitefish by year class from Flower-Pipe Section of Kootenai River. Number of fish is given in parenthesis.

Year class						
1968	112(18)	206(18)	257(18)	310(18)	340(18)	363(1)
1969	117(37)	196(37)	264(27)	300(27)	351(4)	361(2)
1970	125(36)	201(36)	252(36)	318(35)	340(24)	---
1971	122(31)	218(31)	285(24)	320(30)	391(6)	427(6)
1972	122(29)	249(29)	279(30)	376(8)	414(8)	---
1973	145(30)	257(30)	335(30)	379(30)	394(37)	434(20)
1974	170(20)	290(20)	345(20)	376(12)	386(8)	412(8)
1975	142(37)	259(37)	325(51)	363(18)	389(18)	412(81)
1976	147(60)	262(60)	302(60)	330(60)	389(18)	---
1977	145(27)	252(27)	297(27)	330(60)	---	---
1978	137(37)	246(37)	297(27)	---	---	---
1979	137(27)	246(27)	---	---	---	---
Pre-impoundment averages						
1968-1971	119(122)	201(91)	262(45)	310(18)	---	---
Post-impoundment averages						
1972-1976	145(176)	254(147)	300(140)	338(130)	368(60)	384(9)
1977-1979	140(91)	252(151)	305(165)	351(150)	389(81)	419(109)

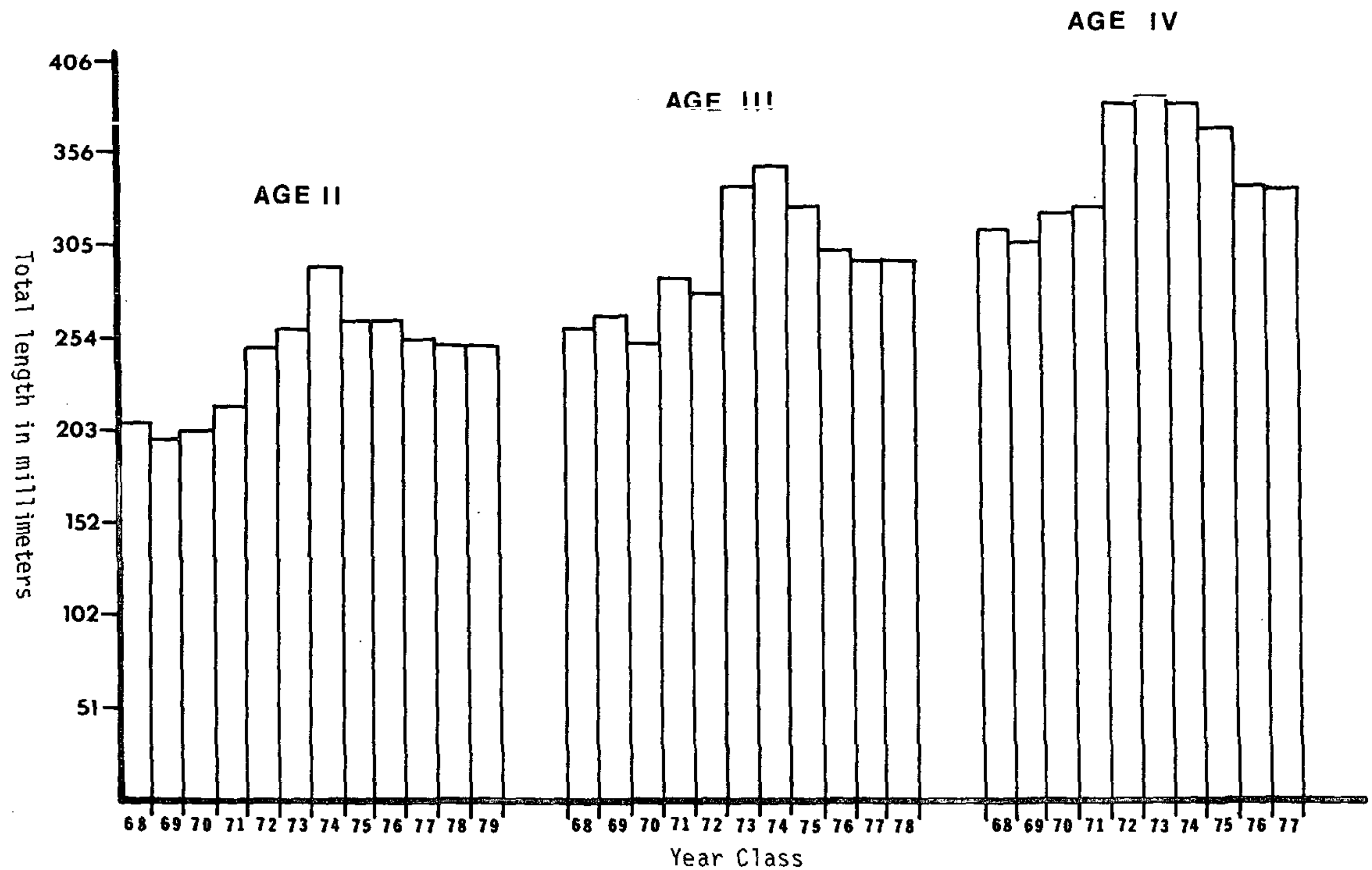

Figure 31. Length achieved at age II, III, and IV by mountain whitefish year classes from the Flower-Pipe Section of the Kootenai River.

Table 39. Growth increments of mountain whitefish from the Flower-Pipe Section of the Kootenai River.

Growth year	Length increment in millimeters for age group			
	0	I	II	III
1968[1/]	112	---	---	---
1969	117	94	---	---
1970	125	79	51	---
1971	122	76	69	53
1972[2/]	122	97	51	36
1973	145	127	66	66
1974	170	112	31	36
1975	142	119	79	97
1976	147	117	56	43
1977[3/]	145	114	66	31
1978	137	107	41	38
1979	137	109	46	28
1980	---	109	51	33
Pre-impoundment averages				
1968-1971	119	84	61	53
Post-impoundment averages				
1972-1976	145	114	56	56
1977-1980	140	109	51	33

1/ Growth year 1966-1971 are preimpoundment.
2/ Growth years 1972-1976 are postimpoundment prior to operation of selective withdrawal system.
3/ Growth years 1977-1980 are postimpoundment with operation of selective withdrawal system.

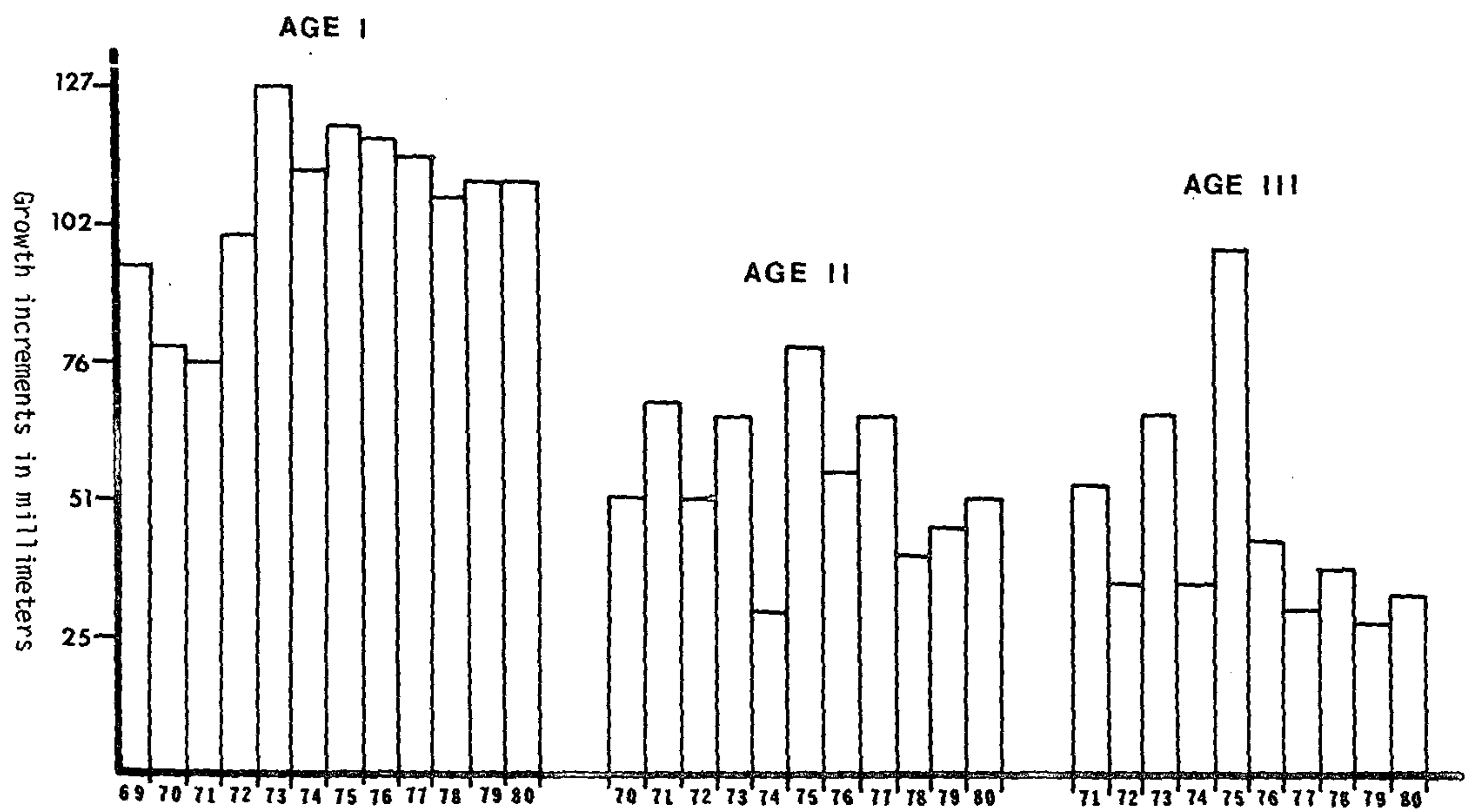

Figure 32. Growth increments achieved by age groups I, II, and III mountain whitefish from the Flower-Pipe Section of the Kootenai River, 1969-1980.

Table 40. The back-calculated growth of mountain whitefish year classes from the Troy Section of the Kootenai River. Number of fish aged is given in parenthesis.

Year class	Back-calculated length in millimeters for age group I	II	III
1970	127(13)	208(13)	262(13)
1971	104(16)	218(16)	---
1978	145(40)	257(40)	297(40)
1979	137(81)	249(81)	---
Pre-impoundment average			
1970-1971	117(29)	208(13)	---
Post-impoundment average			
1978-1979	142(121)	241(137)	297(53)

Table 41. Comparison of growth of mountain whitefish in the Jennings, Flower-Pipe and Troy sections of the Kootenai River.

Age group	River Section: Jennings	Flower-Pipe	Troy
	Pre-impoundment mean		
I	117	119	117
II	196	201	208
III	252	262	262
IV	300	310	---
	1972-1976 mean		
I	132	145	---
II	226	254	---
III	282	300	---
IV	323	338	---
	1977-1981 mean		
I	140	140	142
II	254	252	241
III	312	305	297
IV	351	351	---

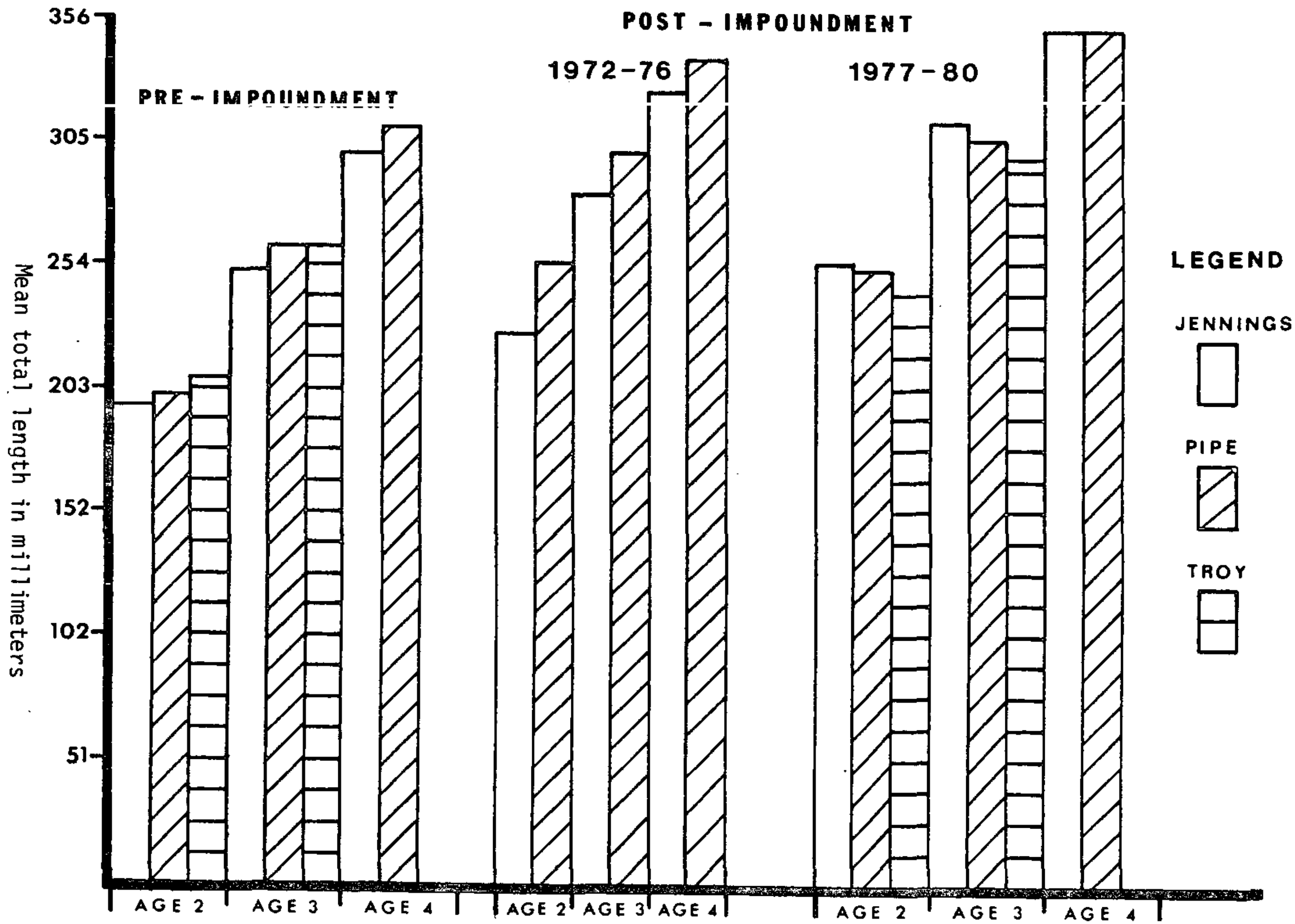

Figure 33. Comparison of growth achieved at age II, III, and IV by mountain whitefish from the Jennings, Flower-Pipe and Troy sections of the Kootenai River.

than after impoundment, but growth of age II and III fish was faster prior to impoundment than after impoundment. The increase in the growth of age 0 and I fish was primarily due to the increased populations of chironomids in the river following impoundment. The numbers and densities of chironomids were several times higher following impoundment than prior to impoundment (see Section A). Chironomids are the primary food source of small mountain whitefish in the Kootenai River (May and Huston 1975 and see Section B). Pontius and Parker (1973) and Thompson and Davis (1976) also found that small mountain whitefish feed primarily on chironomids.

The slower growth rate of age II and III fish following impoundment appears to be related to reduced insect diversity and less of the larger insect species of the order Ephemeroptera, Plecoptera and Trichoptera (see Section A). Large mountain whitefish tend to eat larger food items (Pontius and Parker 1973; Thompson and Davis 1976). Trichoptera were found to increase in importance in the diet as the size of the fish increased, but the number of species of Trichoptera has been reduced in the Kootenai River. Larger mountain whitefish in the Kootenai appeared to substitute snails and aquatic oligochaetes for the missing larger species of aquatic insects (See Section B).

It is perplexing that the growth of mountain whitefish in the Kootenai River declined only slightly in 1979 and 1980, even though fish densities were much higher than in previous years. The ability of whitefish to utilize a major part of their environment in the acquisition of the food resource probably accounts for their being able to maintain good growth rates in spite of increasing fish densities (see Section B). They actively feed from all levels in the water column, take insects from the surface film and engage in foraging through substrate.

The mean growth recorded in the Kootenai River from 1977-1980 is faster than that noted for other streams in Montana and other areas. Mountain whitefish from the Flathead River averaged only 282 mm in total length at age IV (McMullin and Graham 1981) as compared to 351 mm for fish from the Jennings and Flower-Pipe sections of the Kootenai River. The growth of mountain whitefish in the Fisher River (May and Huston 1972), Sheep River, Alberta, Canada (Thompson and Davis 1976) and North Fork Clearwater River, Idaho (Pettit and Wallace 1975) was less than growth in the Kootenai River from 1977-1980.

Creel Census

Fishing pressure has increased significantly on the Kootenai River since 1968. Fishing pressure on the 159 km of Kootenai in Montana was estimated at 11,549 man-days or about 73 man-days per km for the 1968-1969 season. A similar postal card survey for the 1975-1976 season produced an estimate of 20,352 man-days (254 per km) for the remaining 80 km of the Kootenai River. Graham (1979) estimated the fishing pressure in 1978 at 1,019 man-days per km for 6.4 km of river upstream from Kootenai Falls. Angler pressure on the Kootenai between Kootenai Falls and Libby Dam of 779 man-days per km in the summer was higher than recorded for

Yellowstone River, comparable to the Gallatin River and lower than the Madison River (Vincent and Clancey 1980).

Creel census data for all of 1977, 1978 and summer of 1980 are shown in Table 42. The percent of successful anglers varied between seasons and years. Fishing success was lowest in the spring and highest in the fall when 57-61 percent of the anglers creeled fish. The catch rate was highest in fall of 1978 when .87 fish were caught per hour of effort. The summer catch rate increased from .39 fish per hour of effort in 1977 to .58 fish in 1978 and 1980. Graham (1979) recorded a catch rate of .63 fish per hour during the summer of 1978 in the Kootenai Falls area. These catch rates were intermediate when compared to Montana's other Blue Ribbon trout streams. Catch rates in the catch and release section of the upper Madison River ranged from 1.5 to 2.8 fish/hour of effort (Vincent and Clancey 1980), as compared to 0.6-1.0 fish/hour in the Big Hole (Peterson 1973) and 0.7 to 0.8 fish/hour from 1976-1979 in the Yellowstone River (Vincent and Clancey 1980).

Rainbow trout dominated the catch comprising 89 percent in 1977, 86 percent in 1978 and 94 percent in summer 1980. Cutthroat catch was seven percent in 1977, four percent in 1978 and two percent in 1980.

Mountain whitefish comprised 11 percent and 16 percent of the catch in the 1977 and 1978 winter fishery, respectively. Prior to impoundment, mountain whitefish comprised 99 percent of the winter catch (May and Huston 1975). The altered flows in the Kootenai River since regulation has resulted in warmer winter temperatures, higher flows and a lack of ice formation in the winter. Trout feed more extensively during the winter and most anglers fish for trout rather than mountain whitefish. This has resulted in a marked reduction in whitefish harvest even though populations have increased three-fold since 1975.

The average size of rainbow trout creeled during the summer declined from 343 mm in total length in 1977 to 279 mm in 1980. This decline in size was due to a strong 1978 year class which entered the fishery at two years of age in 1980 and reduced growth rates. The average size of rainbow trout caught in the Kootenai was approximately 25 mm less than the average size creeled in the Yellowstone River (Vincent and Clancey 1980).

The fishing method used by anglers varied considerably from season to season. Natural bait was the predominate method during the winter and spring with from 50 to 99 percent of the anglers fishing with bait (Table 43). Natural bait was the most popular fishing method in the summer and fall except in the summer of 1977 when 47 percent of the anglers used flies. On an annual basis, the fishing method preferences in order of importance were natural bait both years, flies in 1977 versus combination in 1978, lures in 1977 versus combination in 1978, combination in 1977 versus flies in 1978. These results compare closely with those compiled by Graham (1979) in the Kootenai Falls section.

A large majority of anglers contacted were from Lincoln County (Table

Table 42. A summary by season of a contact creel survey in the Kootenai River from Libby Dam to Kootenai Falls. The average sizes of the rainbow creeled are given in parenthesis. The catch per man-hour of effort is for trout only.

Year/ month	Number of anglers	Percent successful anglers	Catch per man-hour of effort	Catch RB	CT	DV	MWF
1977							
Winter	76	32	.30	36(310)	15	--	6
Spring	26	15	.08	4(358)	--	--	3
Summer	197	37	.34	148(3 3)	5	2	1
Fall	53	57	.64	78(272)	1	--	--
Total	352	37	.36	266(310)	21	2	10
1978							
Winter 1/	95	53	.47	103(300)	1	1	20
Spring	123	35	.17	50(325)	6	1	24
Summer	275	46	.58	308(282)	10	3	8
Fall	56	61	.87	110(277)	7	2	11
Total	549	46	.48	571(290)	24	7	63
1980							
Summer 1/	146	48	.58	150(279)	3	5	2

1/ Does not include river from Kootenai Falls upstream four miles.

Table 43. Fishing method and residence of anglers contacted during the creel survey conducted on the Kootenai River in 1977, 1978 and 1980.

Season	Year	Percent anglers fishing with				Percent of anglers		
		Natural	Lures	Flies	Combination[1/]	Local resident	Montana resident	Non-resident
Winter	1977	60.5	31.6	7.9	---	97.4	2.6	---
Spring	1977	50.0	15.4	7.7	26.9	100.0	---	---
Summer	1977	18.8	18.3	46.7	16.2	65.5	13.7	20.8
Fall	1977	54.7	15.1	22.6	7.6	86.8	5.7	7.5
Total	1977	35.5	20.5	31.8	12.2	78.1	9.1	12.8
Winter	1978	99.0	---	---	1.0	100.0	---	---
Spring	1978	89.4	1.6	6.6	2.4	100.0	---	---
Summer	1978	41.4	4.0	21.2	33.4	81.5	6.2	12.3
Fall	1978	41.1	12.4	5.4	41.1	62.5	3.6	33.9
Total	1978	62.1	3.6	12.6	21.7	86.9	3.5	9.6
Summer	1980	30.1	14.4	28.8	26.7	80.8	8.2	11.0

1/ Combination usually included natural bait and lures.

43). The number of non-resident anglers was highest in the summer comprising 3.6 to 13.7 percent of angler population. Lincoln County residents accounted for between 78-87 percent of the anglers annually as compared to only 10-13 percent for nonresidents. The percent of out-of-state anglers in the Kootenai Falls section (20%) was larger probably due to good access from Highway No. 2 (Graham 1979).

Fish Movement

Rainbow trout

A total of 3,662 rainbow trout 250 mm and longer were tagged in the Flower-Pipe Section from 1971-1981 (Table 44). Anglers returned 269 tags with location of catch data. Seventy-seven percent (207) of the returned tags were from the Flower-Pipe Section, seven percent (18) were caught upstream, and 16 percent (44) were caught downstream from the Flower-Pipe Section (Figure 34). There was some variation in movement patterns between 1972-1975 and 1978-1981. Rainbow trout had a greater tendency to migrate downstream from 1972-1975 than from 1978-1981. Twenty-five percent of the fish tags returned from 1972-1975 exhibited downstream movement with 12 fish or 6.7 percent of the returns coming from below Kootenai Falls. In contrast, only one (0.7%) tag was returned from below Kootenai Falls from 1978-1981. The greater tendency towards downstream movement from 1972-1975 may be related to avoidance of high gas concentrations.

The percent return of tags ranged from 2.9 percent of fish tagged in 1981 to 16.0 percent of fish tagged in 1973 (Table 45). The small sample size of the 1972 collection precluded its use in the comparison among years. The low return in 1981 was influenced by the high flows generally over 8,000 cfs during most of the summer which limited fishing pressure and reduced angler catch. Graham (1979) found that angler catch rates were lower at flows above 10,000 cfs. The tag return rate from 1978-1981 was lower than prior to new generators going on-line and associated flow fluctuations, even though fishing pressure was greater from 1978-1981 than from 1972-1975. Overall, the mean return of 8.4 percent indicates the exploitation of rainbow was low or that tagged fish caught by many anglers were not reported.

The months in which the tagged rainbow were caught by anglers are given in Figure 35 and Appendix C. Approximately 83.4 percent of the rainbow trout were caught during April through September, as compared to only 16.6 percent during October through March.

Cutthroat trout

Angler returns from cutthroat trout tagged in the Flower-Pipe Section are given in Table 46. A total of 353 cutthroat were tagged from 1972-1981, but only 33 of these were tagged after 1978. Tags from 37 (60.7%) cutthroat trout were returned from the Flower-Pipe Section, 18 (29.5%) were caught downstream and five (9.8%) were caught upstream from the Flower-Pipe Section. Cutthroat trout exhibited more movement out of

Table 44. Movement of rainbow trout tagged in the Flower-Pipe Section of the Kootenai River as indicated by angler return of tags. Percent is based on the number of tags returned with location data (269) not the total number tagged.

Year tagged	Number tagged	Number and percent () of fish caught					
		Libby Dam Rereg Site	Rereg Site Hwy 37	Flower-Pipe Section	Cedar Creek Kootenai Falls	Kootenai Falls Yaak	Yaak - Idaho Line
1971	41	---	---	---	1(33.3)	2(66.7)	---
1972	8	---	---	2(10.0)	---	----	---
1973	181	---	---	23(79.3)	6(10.7)	----	---
1974	503	---	3(7.9)	25(65.8)	6(15.8)	4(10.5)	---
1975	646	1(1.5)	2(3.1)	46(70.8)	11(16.9)	5(7.7)	---
1978	536	4(9.3)	5(11.6)	33(76.7)	1(2.3)	----	---
1979	525	2(6.2)	---	26(81.3)	4(12.5)	----	---
1980	644	---	1(2.4)	38(92.7)	2(4.9)	----	---
1981	578	---	---	14(87.4)	1(6.3)	1(6.3)	---
Subtotal							
1972-75		1(0.8)	5(3.7)	96(71.6)	23(17.2)	9(6.7)	---
Subtotal							
1978-81		6(4.6)	6(4.6)	111(84.0)	8(6.1)	1(0.7)	---
TOTAL	3,662	7(2.6)	11(4.1)	207(77.0)	32(11.9)	12(4.4)	---

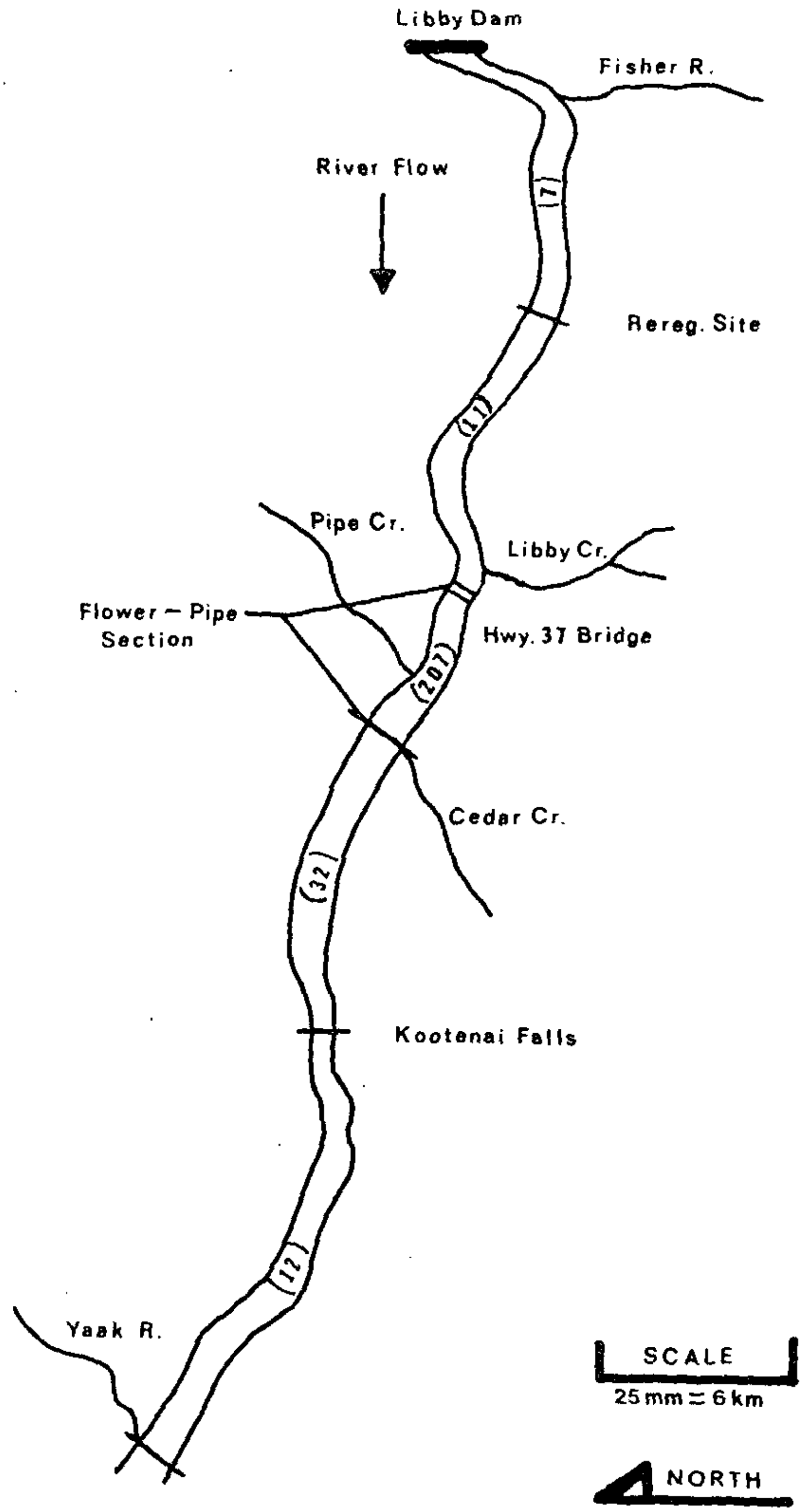

Figure 34. Movement of rainbow trout tagged in the Flower-Pipe Section of the Kootenai River as indicated by angler return of tags, 1971-1981. Numbers in parenthesis inside river channel are number of fish caught in that area.

Table 45. Angler return of rainbow trout tags from the Flower-Pipe Section of the Kootenai River, 1971-1981.

Year tagged	Number tagged	Number and percent ( ) of fish caught: First year	Second year	Third year	Total
1971	41	2(4.9)	----	1(2.4)	3(7.3)
1972	8	3(37.5)	----	----	3(37.5)
1973	181	25(13.8)	3(1.7)	1(0.5)	29(16.0)
1974	503	24(4.8)	21(4.2)	4(0.7)	49(9.7)
1975	646	58(9.0)	19(2.9)	4(0.6)	81(12.5)
1978	536	43(8.0)	2(0.4)	1(0.2)	46(8.6)
1979	525	25(4.8)	6(1.1)	2(0.4)	33(6.3)
1980	644	36(5.6)	9(1.4)	----	45(7.0)
1981	578	17(2.9)	----	----	17(2.9)
TOTAL	3,662	233(6.4)	60(1.6)	13(0.4)	306(8.4)

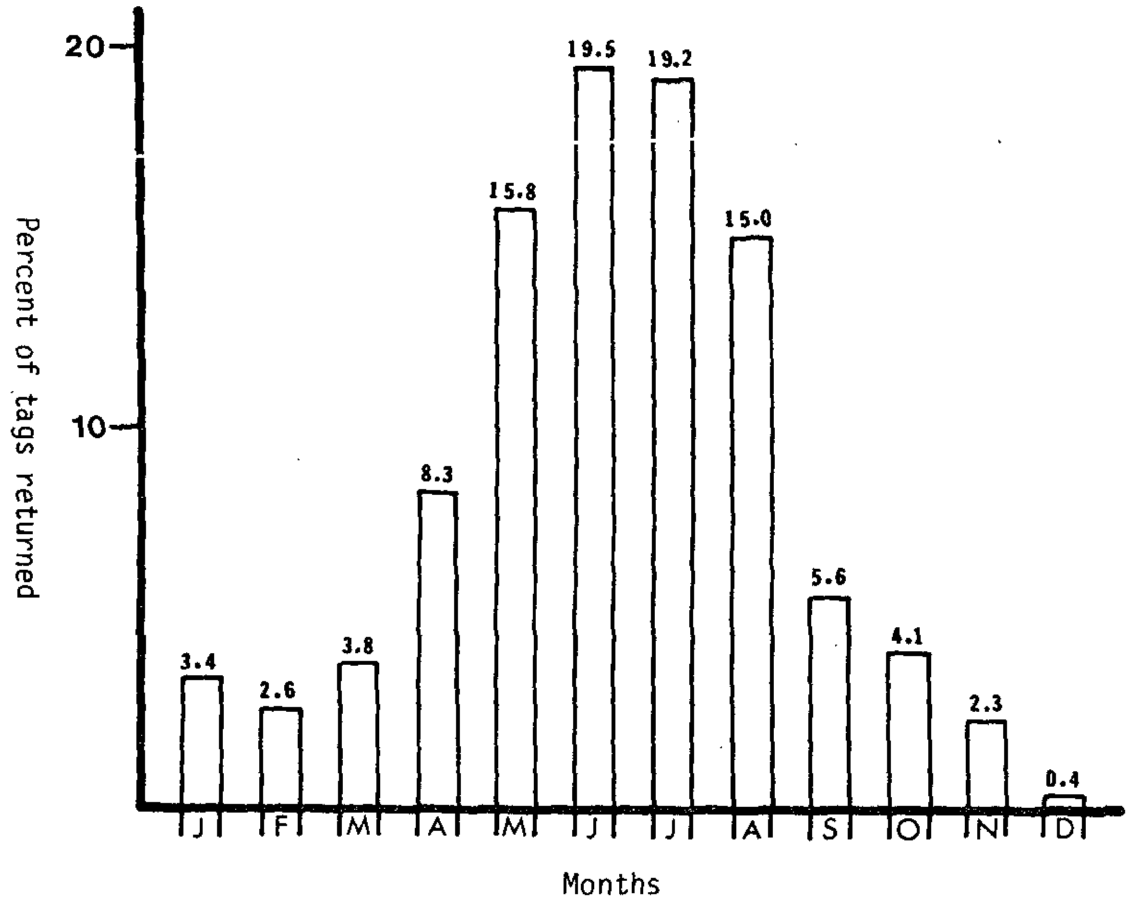

Figure 35. Month in which rainbow trout tagged in the Flower-Pipe Section of the Kootenai River were caught by anglers, 1971-1981.

Table 46. Movement of cutthroat trout tagged in the Flower-Pipe Section of the Kootenai River as indicated by angler return of tags. Percent is based on the number of tags returned with location data (61 total), not the total number tagged.

Year tagged	Number tagged	Number and percent ( ) fish caught: Libby Dam-Rereg site	Rereg site-Hwy 37 Bridge	Hwy 37 Bridge Cedar Creek	Cedar Creek-Kootenai Falls	Kootenai Falls Yaak
1972	5	----	----	2(100)	----	----
1973	145	2(5.6)	----	24(66.7)	10(27.7)	----
1974	30	----	----	----	----	----
1975	140	3(17.6)	1(5.9)	6(35.3)	4(23.6)	3(17.6)
1978	5	----	----	----	----	----
1979	5	----	----	----	----	----
1980	18	----	----	3(75.0)	1(25.0)	----
1981	5	----	----	2(100)	----	----
TOTAL	353	5(8.2)	1(1.6)	37(60.7)	15(24.6)	3(4.9)

the Flower-Pipe Section than did rainbow trout. Most of the cutthroat tagged were the adfluvial strain which escaped from Lake Koocanusa in the 1973 and 1975 reservoir spills and were not as well adapted to the river environment as rainbow trout.

Cutthroat trout tags were returned at a higher rate than rainbow with 19.3 percent of the tags returned (Table 47). The higher return rate for cutthroat tags indicate they were more vulverable to being caught by anglers than rainbow trout or were more available due to movement in seeking territory in a new environment. Approximately 87.7 percent of the cutthroat trout were caught from May through August with 40.0 percent of the catch occurring in July (Figure 36 and Appendix C). Only 7.7 percent of the tagged cutthroat were caught from October through March.

Bull trout

The number of bull trout tagged (50) was smaller than either rainbow or cutthroat trout. Ten bull trout tags were returned with seven from the Flower-Pipe Section, one upstream and two downstream from the Flower-Pipe Section. One of the downstream tags was returned from below Kootenai Falls. The small number of bull trout tagged and returned precludes any definite statements with regards to their movement patterns.

SUMMARY

The impoundment of the Kootenai River by Libby Dam in 1972 produced a number of environmental changes to the river downstream from the dam. Some of these changes have had beneficial affects on salmonid production, whereas other changes have been negative. Overall, the post-impoundment environment in the Kootenai River downstream from Libby Dam has been conducive to high production of rainbow trout and mountain whitefish.

Significant changes in the flow regime, temperature pattern, sediment load, and water quality have occurred. The establishment and maintenance of an adequate minimum flow has been the most important single environmental component in maintaining high level aquatic productivity in the Kootenai River. Other important factors include: 1) a reduction in sediment loads by 85 percent; 2) an increase in the number of days when the average water temperature was above 10°C by about 50 percent; 3) warmer water temperatures in the fall and winter; and 4) higher flows in fall and winter than prior to impoundment.

Severe water quality problems in the Kootenai River prior to impoundment limited the production of aquatic insects and fish. Solution of these problems has been an important factor contributing to the increased production of salmonids. Chemical and heavy metal pollution from an industrial complex on the St. Mary River in British Columbia has been greatly reduced since 1968. Sediment pollution from a mine-mill operation on Rainy Creek (11 miles downstream from Libby Dam) was almost eliminated in 1972.

Table 47. Angler return of cutthroat trout tags from the Flower-Pipe Section of the Kootenai River, 1972-1981.

Year tagged	Number tagged	Number and percent ( ) of fish caught: First year	Second year	Third year	Total
1972	5	1(20.0)	2(40.0)	----	3(60.0)
1973	145	34(23.4)	2(1.4)	----	36(24.8)
1974	30	----	1(3.3)	----	1(3.3)
1975	140	20(14.3)	1(0.7)	----	21(15.0)
1978	5	----	----	----	----
1979	5	----	1(20.0)	----	1(20.0)
1980	18	3(16.7)	1(5.6)	----	4(22.3)
1981	5	2(40.0)	----	----	2(40.0)
TOTAL	353	60(17.0)	8(2.3)		68(19.3)

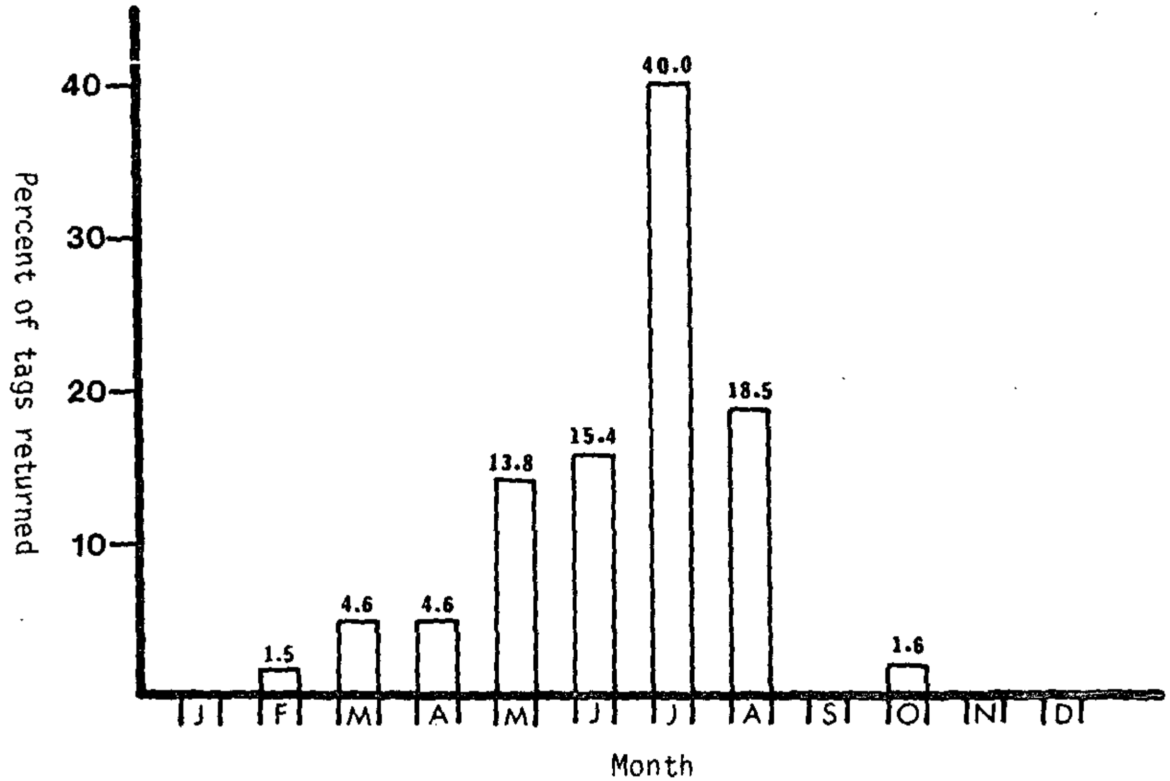

Figure 36. Month in which cutthroat trout tagged in the Flower-Pipe Section of the Kootenai River were caught by anglers, 1972-1981.

Aquatic insect populations are high in numbers near the dam, but species diversity is low. Diversity increased further downstream, but it is still less than in unregulated systems. The loss of many species of stoneflies, mayflies and caddisflies since the dam was completed appears to be limiting growth of larger rainbow trout and mountain whitefish.

The Kootenai River affords its best fishing when flows are less than 8,000 cfs. On an annual basis there has been a decline in the number of days flows are below this level. However, during the most popular fishing period (April through November) the number of days of suitably low flows has doubled since impoundment.

The spawning runs of rainbow trout and mountain whitefish into tributaries above Kootenai Falls have increased several fold since impoundment. A considerable amount of mountain whitefish spawning occurs in the mainstem Kootenai and spawning by rainbow trout may be increasing in the Kootenai River near Libby Dam. The lack of suitable spawning and nursery areas appear to be limiting rainbow trout populations in the Kootenai River downstream from Kootenai Falls.

Gas supersaturation limited rainbow trout and mountain whitefish populations in the Kootenai River from 1972-1975. Water was released via the penstocks after 1975 rather than through the sluice or spillway. Penstock releases resulted in total gas concentrations of approximately 100 percent as compared to 135 percent for sluice releases.

Rainbow trout and mountain whitefish numbers increased several fold in the Kootenai River from 1975-1981. This increase in number was associated with a marked decline in growth rates of rainbow trout and a slight decline in growth for mountain whitefish. Increased competition for food and space appears to be the primary cause for the decline in growth rates. Rainbow trout in streams are territorial and increased densities results in increased energy expenditures to occupy and defend territories. Even though growth has declined it is still faster than recorded for other streams in northwest Montana.

Burbot populations, rare in the river for several years prior to impoundment, have increased sufficiently to provide a fair fishery in the winter and spring downstream from Libby Dam. Curtailment of water pollution is believed to have been an important factor in the resurgence of the burbot population.

The number of white sturgeon in the Kootenai River downstream from Kootenai Falls has declined since impoundment. High spring flows and increasing water temperatures provide the stimulus which triggers the upstream spawning movements of sturgeon. The altered flow and temperature regimes in the Kootenai since impoundment may not provide the necessary conditions to induce the upstream movements of adult white sturgeon into Montana.

Peamouth chub and northern squawfish numbers have declined downstream from Kootenai Falls apparently as a result of limited reproductive success due to low spring water temperatures.

Largescale sucker populations have fluctuated since impoundment, but currently appear to be comparable to populations prior to impoundment.

This historical trout fishery in the Kootenai River was for native cutthroat trout. The catch rate of 0.5 fish per hour of effort recorded from 1949-1964 indicates that the quality of the fishery was good even though water quality problems were adversely affecting the river's biota.

Fishing pressure and angler harvest has increased on the Kootenai River since impoundment. The summer catch rate of 0.6 fish per man hour of effort compares favorably with Montana's more famous Blue Ribbon trout streams such as the Yellowstone and Big Hole rivers. The average size of rainbow trout creeled from the Kootenai is smaller.

Rainbow trout tagged in the Flower-Pipe Section showed a greater tendency to remain there than to move either upstream or downstream. Approximately 77 percent of the tags returned were from the Flower-Pipe Section. Downstream movement was more prevalent from 1972-1975 than from 1978-1981. Conversely, rainbow trout exhibited a greater tendency to move upstream from 1978-1981 than from 1972-1975. The harvest of rainbow trout was highest from April through September, when 84 percent of the tags returned were caught.

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APPENDIX A

Water Quality Parameters

Table 1. Total phosphorous (P) and dissolved orthophosphate (PO4) concentrations in the Kootenai River downstream from Libby Dam, 1970, 1975 and 1979. Concentrations are in milligrams per liter.

Month	1970		1975		1979	
	P	PO4	P	PO4	P	PO4
January	.080	.200	.016	.026	.010	.004
February	.080	.110	.001	.010	.007	.003
March	.140	.400	.045	.025	.007	.004
April	.130	.030	.025	.040	.005	.003
May	.240	.280	.026	.030	.007	.001
June	.430	.120	.025	.040	.018	.001
July	.130	.300	.005	.050	.006	.000
August	.180	.450	.020	.035	.006	.006
September	.090	.260	.030	.060	.003	.001
October	.210	.480	.070	.065	.000	.000
November	.270	.760	.045	.050	.004	.002
December	.350	1.200	.033	.040	.003	.000
Mean	.194	.383	.028	.039	.006	.002

Table 2. Specific conductance in micromhos per centimeter (25°C) measured in the Kootenai River downstream from Libby Dam site, 1970, 1975, and 1979.

Month	Year		
	1970	1975	1979
January	373	255	256
February	340	255	277
March	372	271	291
April	362	288	298
May	245	274	297
June	190	220	263
July	224	199	255
August	262	183	235
September	277	182	237
October	345	189	248
November	355	199	265
December	190	223	267
Mean	295	228	266

Table 3. Specific conductance in micromhos per centimeter (25°C) measured in the Kootenai River downstream from Libby Dam, 1970, 1975, and 1979.

Month	Year 1970	1975	1979
January	373	255	256
February	340	255	277
March	372	271	291
April	362	288	298
May	245	274	297
June	190	220	263
July	224	199	255
August	262	183	235
September	277	182	237
October	345	189	248
November	355	199	265
December	190	223	267
Mean	295	228	266

APPENDIX B

Fish Population Parameters

Table 1. The length frequency distribution of mountain whitefish collected in the Jennings Section of the Kootenai River in 1972, 1974, 1977, and 1981.

Total length in inches	1972		1974		1977		1981	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
178-202	47	11.3	20	3.4	22	6.2	12	1.3
203-227	112	26.9	28	4.8	49	13.7	66	7.4
228-253	73	17.6	26	4.4	37	10.4	26	2.9
254-278	71	17.1	23	3.9	23	6.4	55	6.2
279-303	29	7.0	41	7.0	64	17.8	148	16.6
304-329	27	6.5	69	11.8	83	23.3	148	16.6
330-354	22	5.3	47	8.0	36	10.1	217	24.4
355-380	15	3.6	67	11.4	21	5.9	142	16.0
381-405	6	1.4	60	10.2	14	3.9	57	6.4
406-431	6	1.4	70	12.0	6	1.7	14	1.6
432-456	6	1.4	51	8.8	1	0.3	4	0.5
457+	2	0.7	84	14.3	1	0.3	1	0.1
Total Sample	416		586		357		890	

Table 2. The length frequency of mountain whitefish electrofishing catches in the Elkhorn Section of the Kootenai River, 1971, 1974, and 1980.

Total length in mm	1971		1974		1980	
	Number	Percent	Number	Percent	Number	Percent
152-177	39	22.8	1	1.3	--	---
178-202	7	4.1	2	2.3	10	0.6
203-227	20	11.7	6	7.0	174	11.2
228-253	49	28.7	11	12.8	110	7.1
254-278	13	7.7	15	17.4	7	0.5
279-303	13	7.7	27	31.4	122	7.9
304-329	12	7.0	20	23.2	266	17.1
330-354	7	4.1	2	2.3	354	22.8
355-380	6	3.5	1	1.2	254	16.5
381-405	1	0.6	--	--	118	7.6
406-431	3	1.8	--	--	74	4.8
432-456	--	--	1	1.2	42	2.7
457+	1	0.6	--	--	21	1.4
TOTAL	171		86		1,552	

Table 3. The length frequency distribution of rainbow trout in the Flower-Pipe Section of the Kootenai River 1973, 1977, and 1981.

Total length in mm	1973 Number	1973 Percent	1977 Number	1977 Percent	1981 Number	1981 Percent
178-201	8	4.3	35	5.9	61	4.7
203-226	17	9.2	25	4.2	206	15.3
229-252	19	10.3	60	10.1	374	28.7
254-277	30	16.2	88	14.9	351	26.8
279-302	33	17.9	86	14.5	143	11.0
305-328	29	15.7	69	11.8	77	5.9
330-353	16	8.6	65	11.0	47	3.6
356-379	12	6.4	31	5.2	28	2.1
381-404	7	3.8	22	3.7	12	0.9
406-429	9	4.9	25	4.2	6	0.5
432-455	3	1.6	18	3.0	4	0.3
457+	2	1.1	68	11.5	2	0.2
TOTAL	185		592		1,302	

Table 4. The length frequency of mountain whitefish in the Flower-Pipe Section of the Kootenai River, 1973, 1977 and 1981.

Length group in mm	1973 Number	1973 Percent	1977 Number	1977 Percent	1981 Number	1981 Percent
178-201	39	3.2	4	0.2	28	0.5
203-226	208	17.3	14	0.6	197	3.7
229-252	486	40.3	455	19.1	1,319	24.4
254-277	325	27.0	1,376	57.9	393	7.3
279-302	76	6.3	252	10.6	452	8.3
305-328	27	2.2	10	0.4	1,179	21.9
330-353	23	1.9	30	1.3	965	18.0
356-379	11	0.9	99	4.2	475	8.8
381-404	6	0.5	81	3.4	194	3.6
406-429	1	0.1	38	1.6	104	1.9
432-455	1	0.1	12	0.5	55	1.0
457+	2	0.2	5	0.2	31	.06
TOTAL	1,205		2,376		5,392	

APPENDIX C

Catch of Tagged Fish

Table 1. Month in which rainbow trout tagged in the Flower-Pipe Section of the Kootenai River were caught by anglers (1971-1981).

Year	Number of fish caught											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971	--	--	--	--	--	--	1	--	--	--	--	--
1972	--	--	--	--	1	--	--	--	--	--	--	--
1973	--	--	--	3	4	4	9	6	1	--	--	--
1974	--	--	--	--	3	2	6	9	2	2	2	1
1975	1	2	1	5	8	13	9	20	4	4	1	--
1976	3	3	6	5	3	--	--	--	1	1	1	--
1977	1	1	1	--	1	--	--	--	--	--	--	--
1978	--	--	--	--	3	13	5	11	4	1	--	--
1979	--	1	--	1	3	12	6	1	2	--	--	--
1980	1	--	--	3	13	8	13	2	--	1	--	--
1981	3	--	2	5	3	--	3	1	1	2	2	--
TOTAL	9	7	10	22	4	52	51	40	15	11	6	1

SECTION D

Kootenai River Management Objectives

By

Bruce May, Robert Schumacher and Joe E. Huston

KOOTENAI RIVER MANAGEMENT OBJECTIVES

The Kootenai River downstream from Libby Dam currently produces an excellent rainbow trout fishery. Maintenance of this fishery and increasing the average size of fish creeled should be the primary long-term management objectives. Many environmental components have interacted to produce the rainbow trout fishery in the Kootenai River. The more important of these include flow regime, temperature regime, aquatic insect populations and spawning habitat in tributary streams. The fishery in the Kootenai River can only be maintained by keeping these necessary components in balance.

The flow regime has been an extremely important component in the production of the rainbow trout fishery. The normal minimum flow of 4,000 cfs appears to be the single most important factor influencing the high productivity of the river. The continuation of this minimum flow is of paramount importance in maintaining the current level of aquatic productivity.

The Kootenai River fluctuates daily throughout a large part of the year due to peaking power production at Libby Dam. Stable flows in excess of 10,000 cfs for three weeks or longer occur mostly in the fall and winter months. Stranding of fish during reduction of flows is minimal and does not significantly affect the numbers of any fish species. Reduction of flows causes increased insect drifting which does not appear to be deleterious to total insect populations. Reduction of discharge after flows have been maintained above the 4,000 cfs minimum for three weeks or longer strands large numbers of aquatic insects. At this time, it is not known whether this stranding is deleterious to the base aquatic insect population maintained by the 4,000 cfs minimum flow.

Providing good flows for angling in the Kootenai River should continue to be a management priority. The number of days when the Kootenai River has good flows for fishing of less than 8,000 cfs during the summer season is much larger now than prior to impoundment. An agreement between the Montana Department of Fish, Wildlife and Parks and the Corps of Engineers provides for stable flows for fishing on the weekends and holidays from 1 May through 15 September.

The spawning and rearing habitat in the tributary streams is a critical requirement of rainbow trout which needs to be protected and enhanced. The Kootenai National Forest (KNF) is the primary landowner in the Libby, Bobtail, Quartz, Pipe, O'Brien, Callahan and Yaak drainages. Close cooperation must be maintained between Montana Department of Fish, Wildlife and Parks (MDFWP) and KNF to ensure the protection of water quality, channel stability, riparian vegetation, fish passage and fish habitat in the above streams. The KNF is currently cognizant of the high fishery values of these streams and the protection and enhancement of these fish values is a high priority.

A stream protection law administered by the Lincoln County Conservation District with assistance from MDFWP is concerned with preserving channel stability and reducing sediment pollution on private land. Enforcement of this law will help protect spawning and nursery habitat in sections of streams which flow through private land.

Procurement of instream flow reservations should be a top priority for streams with important spawning and nursery habitat. The KNF funded a study in 1981 which collected data necessary to file for instream flows for Libby, Bobtail, Pipe and O'Brien creeks and the Yaak River. This data should be used to file for instream flows in these streams.

A spawning enhancement program for rainbow trout needs to be developed and executed in suitable tributaries to the Kootenai River downstream from Kootenai Falls. Low natural reproduction appears to be limiting rainbow populations in this section of the river. This program should involve barrier removal and reduction of resident stream fish stocks and imprint planting rainbow trout eggs on fish of the same genetic stock that inhabits the river.

An important factor in determining the quality of the fishery is the size of the fish creeled. Recent surveys conducted by the MDFWP showed that anglers would rather catch fewer larger fish than many smaller fish. Thus, a management objective which increases the average size of the rainbow trout in the creel is in accord with the values of anglers and would increase the overall quality of the Kootenai River fishery. The size of the rainbow trout can be increased by: 1) providing better temperatures for growth, 2) increasing the food supply for trout, 3) reducing competition for food and space from mountain whitefish, and 4) reducing the angling mortality of large rainbow trout.

Fish growth is a complex process and involves the interaction of many variables. Water temperatures, water quality and fish densities are variables that might be modified to improve conditions in Kootenai River. Each of these variables are discussed below.

Operation of the selective withdrawal system has improved annual heat budgets over those found in the Kootenai River prior to impoundment and those created from low-level penstock discharges. A thorough review of temperature and fish distribution profiles in the forebay area may reveal that further modification to the selective withdrawal operational criteria could be beneficial. An increased heat budget should increase biological productivity of the Kootenai River.

Water released from Libby Dam is less than 100 percent oxygen saturated. These subsaturated discharges may affect aquatic insect species diversity by reducing numbers of some groups of aquatic insects, primarily Plecopterans. Review of Libby Dam forebay temperature and oxygen profiles may allow discharge of saturated waters throughout the entire year which in turn should increase the numbers of Plecopteran insects in Kootenai River. Plecoptera are usually large insects unavailable to whitefish because of their size, but readily taken by trout.

High densities of mountain whitefish and rainbow trout appear to be competing for food and space. A reduction in the numbers of whitefish should result in more food and space being available for rainbow trout. Numbers of whitefish in the river might be reduced by either of two methods: 1) increasing the harvest by sport or commercial anglers, or by 2) interupting the reproductive cycle by trapping spawning fish or destroying their eggs.

Fishing regulations controlling the angler harvest of whitefish in the Kootenai River have been liberalized allowing anglers a daily limit of 100 fish and allowing these fish to be sold commercially. As yet, these regulations have not increased angler catch of whitefish materially. Further attempts to promote a commercial harvest of whitefish would require a change in state law to permit other methods of harvest.

Reduction of whitefish numbers through manipulation of spawning success appears to be the most efficient method of control at this time. Mountain whitefish spawn successfully both in mainstem Kootenai River and certain areas of its tributary streams. Spawning runs entering tributary streams would either have to be trapped and removed or blocked and forced to remain in mainstem Kootenai River. Whitefish spawn in Kootenai River in October and November when flows are generally above 10,000 cfs. Reducing the flows to 4,000 cfs in December or January for at least 48 hours during a time when air temperatures are below freezing should either desiccate or freeze large numbers of the eggs. Initial control of whitefish should be done for at least two consecutive years and thereafter as needed.

A reduction in angling mortality of rainbow trout over 35 cm in length should provide the opportunity to catch more larger fish. Several regulation options could be used to limit the harvest of the larger trout. These include: 1) fishing method, 2) bag limit, 3) size limits, and 4) season length. Maximum size limits coupled with the elimination of bait fishing has proven to be effective in increasing the number of larger trout in the Madison River, Big Hole River and Rock Creek in Montana. Clark et al. (1981) reviewed the effectiveness of various types of fishing regulations on trout in Michigan trout streams. They concluded that a minimum size limit was the most effective regulation for controlling exploitation of trout. A minimum size limit increased the number of larger trout harvested but decreased the total harvest. Hunt (1970) also found that a size limit was the single most effective method of preventing excessive harvest of brook trout populations.

A major obstacle to instituting a size limit in the Kootenai River is the high percentage of anglers fishing with natural bait. Mortality of trout caught and released is much higher with natural bait than with flies or lures. Before such a management program is instituted, the angling public should be informed of the reasons for the regulation changes through news releases and public hearings. The catch and release program for larger trout should increase their numbers in the river, but increased densities of larger fish may eventually result in a decline in growth.

The excellent wild trout fishery in the Kootenai River downstream from Libby Dam would be impacted if more of the river was impounded by dams. Dams would destroy the river fishery in the impoundment areas, reduce aquatic insect diversity and drift downstream from the dam and increase the fishing pressure and harvest on the remaining riverine part of the Kootenai. Therefore, an important fisheries management priority should be to keep the Kootenai River downstream from Libby Dam in a free-flowing condition.

Monitoring of fish populations and angler harvest should be done in the Kootenai River to determine the effects of management changes upon fish populations, angler catch rates and size of fish creeled. Population estimates should be made for rainbow trout and mountain whitefish annually in late winter in the Flower-Pipe Section and every other year in the Troy Section. Information on the length frequency distribution, age structure and condition factor of the rainbow trout and mountain whitefish populations should be determined. The spawning run of rainbow trout ascending Bobtail Creek and Libby Creek should be monitored biannually. A creel census should be conducted on the Flower-Pipe Section every other year from July through August. Data should be collected on catch rates, species composition of the catch, average size of trout creeled, and total fishing pressure and harvest. Standing crops of major groups of aquatic insects should be determined biannually in the spring and fall at the station located above the mouth of Pipe Creek.

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