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PRELIMINARY DATA ON THE AQUATIC RESOURCES OF THREE MACKENZIE RIVER TRIBUTARIES TO BE CROSSED DURING HIGHWAY CONSTRUCTION, 1975-76

by

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ABSTRACT

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During 1975 an investigation of the effects of culvert construction on streams crossed by the Mackenzie Highway, Northwest Territories was initiated. Three streams were chosen for study; Creek Mile 422.7, Creek Mile 426.5 and Smith Creek (Mile 430).

Preliminary data was collected on selected water quality parameters, stream hydraulics, the diversity and standing crop of benthic invertebrates, and the species composition of fish and their utilization of the stream systems.

Fish were found to be utilizing the streams as nursery and feeding areas during the summer and fall of 1975. Smith Creek provided overwintering habitat for Arctic grayling. Benthic organisms were an important constituent in the diet of fish.

The three streams chosen for study are considered typical of numerous small Mackenzie River tributaries crossed by the Mackenzie Highway right-of-way.

Key words: Arctic zone; highway construction; environmental impact; aquatic environment; fishery resources; fishery biology; benthos; stream flow; chemical analysis; monitoring.

RESUME

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En 1975, on a entrepris une étude visant les effets de la construction de canaux sur trois cours d'eau que traverse l'autoroute Mackenzie, dans les Territoires du Nord-Ouest: le Creek Mile 422.7, le Creek Mile 426.5 et le Smith Creek (borne 430).

On a d'abord recueilli des données préliminaires sur certains paramètres de la qualité de l'eau, l'hydrologie des cours d'eau, la diversité et la population exploitable des invertébrés benthiques, la composition des espèces de poisson et leur utilisation des cours d'eau.

L'étude a montre que le poisson a utilisé les cours d'eau comme aires d'élevage et d'alimentation pendant l'été et l'automne 1975. L'Ombre de l'Arctique a passé l'hiver dans le Smith Creek. Les organismes benthiques ont constitué un élément important du régime alimentaire du poisson.

Les trois cours d'eau choisis sont représentatifs des nombreux petits tributaires du Mackenzie River traversés par l'emprise de l'autoroute Mackenzie.

Mots-clés: zone Arctique; construction d'autoroutes; conséquences environmentales; environnent aquatique; ressources halieutiques; biologie du poisson; benthos; débit des cours d'eau; analyse chimique; contrôle.

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INTRODUCTION

Road construction in or near streams and rivers can affect aquatic resources in several ways including disruption of fish migrations, destruction or siltation of vital habitats and alteration of water quality parameters. Increased suspended or deposited sediments in streams can reduce light penetration, cause mechanical abrasion of fish gills and produce changes in substrate. A review of recent literature on the effects of increased sedimentation on aquatic biota is presented in Brunskill et al. (1973) and Rosenberg and Snow (1975). The long-term effects of culvert stream crossings are of particular concern. Studies have shown that small northern tributaries can provide important spawning, nursery and over-wintering areas for indigenous fish (Jessop et al. 1974; Slaney and Co. 1974). Brunskill et al. (1975) have determined that small streams and rivers will be more affected by terrain disturbance than larger streams since construction will affect a larger proportion of drainage area.

In order to limit the impact of highway construction in the Northwest Territories, it is necessary to have an understanding of the natural state of representative streams as well as the short and long-term effects of disturbance. The long-term effects must be considered the most important and critical. A number of workers have stressed the need for further study to delineate long-term impacts including Brunskill et al. (1973), Rosenberg and Snow (1975), Dryden and Jessop (1974), Porter et al. (1974) and Brunskill et al. (1975).

The present study is designed to study the effects of culvert construction on streams crossed by the Mackenzie Highway, Northwest Territories. In order to carry the study through pre- and post-construction phases, the choice of feasible streams was narrow. Based on construction schedules available in the spring of 1975, three creeks along a section of the highway route were chosen for study; Creek Mile 422.7, Creek Mile 426.5 and Smith Creek (Mile 430). While these streams differ substantially in drainage areas, all are destined for culvert structures.

The objectives of the study are to obtain data on the diversity and standing crop of invertebrate communities, to determine the species composition of fish and their utilization of the stream systems and to study changes in selected water quality parameters and stream hydraulics. As highway construction proceeds past each stream, the short-term effects of construction on stream water quality and the ecosystem will be investigated. The field program will continue after completion of construction in order to study long-term effects, if any. Results of this study will contribute to the defining of highway routes, construction schedules and techniques, stream crossing designs and the formulation and updating of guidelines for the protection of aquatic environments as proposed by Dryden and Stein (1975).

DESCRIPTION OF THE STUDY AREA

Three streams were chosen for study along the proposed Mackenzie Highway south of Wrigley, N.W.T. (Figs. 1 and 2). These streams (Mile 422.7, Mile 426.5 and Smith Creek (Mile 430) provide drainage for a 225 km^2 area comprised of both mountain and lowland terrain. The lowland area is covered with a continuous mantle of glacial and post-glacial deposits overlaying Devonian shale and limestone. Smith Creek forms a boundary between a glacial outwash plain to the north and a glaciolacustrine plain to the south. The mountain areas (McConnell Range) are composed of thrust masses of Silurian-Ordovician dolomites, limestones and shales overlain for the most part with a shallow veneer of glacial drift deposits.

The climate of the region is semi-arid and subarctic to cold temperate in type. The mean annual precipitation is close to 33 cm, 18 to 20 cm of which fall as rain in the summer months. Mean annual temperature is approximately -5°C.

The study area is located in the Boreal forest region; vegetation is mainly white and black spruce, balsam poplar, pine and aspen on degraded eutric brunisal soil. Undergrowth ranges from grasses, sedges and *Sphagnum* moss on low-lying areas, to lichen and rock flora on mountain terrain. The area is one of discontinuous permafrost.

Creek Mile 422.7 (63°06’N, 123°16’W) is a cobble bottom, clear stream with alternating riffles and pools draining a generally low relief spruce forest. It is well contained within a deep gorge from the highway right-of-way to its confluence with the Mackenzie River, a distance of 2.9 km. The drainage area is approximately 75 km^2 of which one-third is mountainous terrain.

Creek Mile 426.5 (63°09’N, 123°18’W) has a boulder and gravel bottom, clear water and flows through a gully between sloping moss-covered hills. The channel is not well defined above the highway right-of-way and is overgrown with stands of black spruce and tamarack. The drainage area is approximately 20 km^2 of generally lowland area and the highway right-of-way is located 3.1 km upstream from the confluence with the Mackenzie River. This creek drains a number of small lakes, the largest being approximately 22 hectares in area.

Smith Creek Mile 430 (63°10’N, 123°20’W) drains an area of approximately 130 kin^2, one-half of which is mountainous terrain and one-half glaciolacustrine plain with bogs and lakes. The channel is generally well defined with large riffle areas of rock and gravel. A series of waterfalls are located approximately 5 km upstream from the mouth. Groundwater flow into Smith Creek is substantial throughout the year and is responsible for keeping portions of the stream open during the winter. The highway right-of-way is located 0.76 km from the confluence with the Mackenzie River and is characterized by a very large ancient bi-modal land flow on the south bank of the creek. This landslide is now inactive and the head scarp is heavily vegetated (McRoberts and Morgenstern 1973).

METHODS AND MATERIALS

PHYSICAL AND CHEMICAL STUDIES

Hydraulics

Hydraulic cross-section stations were established on both Creek Mile 422.7 and Smith Creek on August 14, 1975 (Fig. 2). Measurements of water level, velocity and discharge were made at each site until October 23, 1975. Water level readings only were taken at Location 11 on Creek Mile 426.5. The cross-section stations were selected to allow accurate discharge measurements or to represent natural pool-riffle hydraulic conditions. Water velocities measured during low flows at riffle sections generally produced unreliable discharge calculations.

Levels were run to the stream from temporary benchmarks near each station to determine water levels, using a Kern GK1 level. Water velocity measurements were made using a full-sized OTT current meter, handheld on a wading rod. Thirty-second readings were taken. Discharges were calculated using the mid-section method (U.S. Dept. of The Interior 1967). All hydraulic data were recorded in English units and later converted into Metric units.

Water chemistry

Water temperature, dissolved oxygen and pH measurements were made on site at each location using a Hach water analysis kit (Model AL36WR). Water samples for analysis of ions, nutrients and suspended sediments were collected by filling one litre polyethlene bottles directly from the surface of the water. Water samples collected August 14 were analysed by the Fisheries and Marine Service chemistry laboratory in Yellowknife. All subsequent samples were analysed by the Freshwater Institute, Water Chemistry Laboratory, Analytical Chemistry Unit in Winnipeg. Methods used followed those of Stainton et al. (1974).

BIOLOGICAL STUDIES

Biological sampling locations were chosen to coincide with hydraulic stations. In addition, locations 9 and 10 were established downstream of the proposed highway crossing on Creek Mile 426.5 on September 25, 1975 (Fig. 2). All biological sampling locations were sampled once every two weeks in conjunction with hydraulic station metering. Open water on Smith Creek on February 4, 1976 permitted the collection of additional biological data.

Benthos

Invertebrate communities were sampled by means of Surber and artificial substrate samplers. Two surber samples of benthos were taken every two weeks at each sampling location on Creek Mile 422.7 and Smith Creek. Surber samples collected on August 28 utilized a 950 micron mesh opening; all subsequent samples were collected using a 200 micron mesh opening. Contents were preserved in 70% ethyl alcohol for later laboratory analysis.

Stainless steel conical cages 43 cm in height and 24 cm in bottom diameter were used as artificial substrate samplers. Two of these were placed at each location in Creek Mile 422.7 and Smith Creek and one at each location in Creek Mile 426.5. The cages were filled with cleaned rocks so as to duplicate as closely as possible the natural stream bottom, and left undisturbed for one month. A dip net of 200 micron mesh was placed under the substrate sampler at the time of lifting to capture organisms displaced by movement. Attached materials were scrubbed from the rocks and preserved in 70% ethyl alcohol for subsequent laboratory analysis.

Preserved benthic samples were stained with a solution of rose bengal (100 mg rose bengal per litre of 95% ethanol diluted to 70%) then sorted, identified to family and enumerated.

Fish

Fish were collected in a variety of ways depending on the nature of the stream at each location. Gill net gangs (two 3.0 m sections of 3.8 cm and 5.1 cm stretched mesh, 1.5 m deep) were used at Location 1 on Creek Mile 422.7 and Location 5 on Smith Creek. A 9.2 m beach seine of either 0.6 cm or 0.3 cm mesh was utilized at Location 3 on Creek Mile 422.7 and at sampling locations on Smith Creek. Fry drift nets were employed at Locations 9 and 11 on Creek Mile 426.5 to monitor fry movements (1 m long apex of 0.6 cm mesh and attached to a 20 cm x 50 cm wooden frame). These nets were set in riffle areas with the entrance funnel facing upstream. At all locations on Creek Mile 422.7 and Smith Creek, fry holding boxes similar to Porter's (1973) design were attached to the netting material. Angling was conducted on both Creek Mile 422.7 and Smith Creek.

All fish captured were enumerated by species. Those with a fork length greater than 200 mm were measured to the nearest 1 mm, a scale sample taken and the stomach removed and preserved in 10% formalin; subsequent laboratory analyses consisted of measuring all fish to the nearest 1 mm, weighing to the nearest 0.1 gin, aging by means of scales or otoliths and examining stomach contents. Stomach content organisms were enumerated and identified to family where possible.

RESULTS AND DISCUSSION

PHYSICAL AND CHEMICAL CONDITIONS

Creek Mile 422.7

A summary of physical and chemical baseline findings for Creek Mile 422.7 is presented in Table 1 and includes data on stream velocity, discharge, pH, dissolved oxygen and temperature. Water levels from Creek Mile 422.7 are presented in Appendix 1.

Hydraulics: Variations in discharge calculations are due in large part to the nature of the stream bed at each location and to the low flows experienced. Station 1, located at a narrow gravel riffle section downstream of the proposed highway crossing, gave consistently higher velocities than any other station, possibly due to the addition of groundwater flow between Stations 1 and 2. Station 2 located in a wide riffle section, immediately downstream of the crossing site, did not produce meaningful velocity measurements. Most of the flow at this location occurred under or around large cobbles and was difficult to measure. The stream bottom at Station 3, upstream of the proposed crossing consisted of large rocks intersticed with organic debris. Station 4, located at a narrow pool section immediately upstream of the CNT crossing, produced consistently low velocity readings. Discharge calculations from Stations 1, 3 and 4 are considered the most accurate. All hydraulic stations were frozen to stream bed on February 4, 1976, although there were some short open stretches of water upstream of the CNT crossing, probably due to local groundwater flow. Ice levels for February 4, 1976, presented in Table 1 indicate a buildup of ice in and around the stream channel at Locations 1, 2 and 3 presumably due to groundwater flow.

Water chemistry: Dissolved oxygen values ranged between 10 and 13 mg/L for all locations on Creek Mile 422.7 during the study period while pH values ranged from 8.0 to 9.0. Water temperatures steadily declined from 14 August to 23 October at which time ice had begun to form on the water surface. Dissolved oxygen levels were at or near saturation until mid-September. Values presented for February 4, 1976 were taken from groundwater flow at the ice surface.

Analyses results from water samples collected on August 14 and October 8, 1975 and February 4, 1976 are presented in Appendix II. The marked difference in some parameters from fall to winter appears to be due to the increased proportion of groundwater in the water sample. There appears to be no major differences between locations for each sampling date with the exception of some parameters for Locations 1 and 2 on February 4, 1976. Water samples on this date were obtained directly from groundwater sources and did not represent stream flow.

Creek Mile 426.5

Hydraulics: Water level readings from Station 11 on Creek Mile 426.5 are presented in Appendix I. The recorded range in water level was 0.375 in from August 15 until October 23, 1975. No evidence of flow was found at Station 11 on February 4, 1976, however, stretches of open water were noticed approximately 1 km upstream from the highway crossing site. These were apparently due to groundwater activity and probably did not indicate actual stream flow.

Water chemistry: Between August 14 and October 23 dissolved oxygen values ranged from 8 mg/L to 13 mg/L for all locations and pH varied from 8.0 to 8.5 (Table 1). Dissolved oxygen levels were generally from 1 to 3 mg/L below saturation. Water temperatures declined steadily from August 14 until October 23, 1975, at which time ice began to form.

Results of analyses on water samples collected August 14 and October 8, 1975 are presented in Appendix III. The water sample obtained at Location 9 on October 8, 1975 differs substantially from those taken at Locations 10 and 11. The stream is extremely turbid at this location possibly due to the influence of small tributaries increase in concentrations of major cations and anions (particularly Na and Cl) suggests that there is a substantial subsurface flow into Creek Mile 426.5 below Location 10. Analyses of water samples taken on August 14 and October 8, 1975 from Location 11 are very similar except for a large decrease in Susp. P which cannot be explained at present.

Smith Creek

A summary of physical and chemical baseline findings for Smith Creek is presented in Table 1 and includes data on stream velocity, discharge, pH, dissolved oxygen and temperature. Water levels from Smith Creek are presented in Appendix 1.

Hydraulics: The higher flows experienced in Smith Creek permitted more accurate determinations of discharge than was possible in Creek Mile 422.7. Station 5, situated at a wide pool section downstream of the proposed crossing site, allowed accurate discharge measurements to be made. Station 6, located at a gravel riffle section immediately downstream of the proposed highway, is the same as that used by Jasper (1976) in conjunction with hydrologic studies. Station 7, upstream of the highway crossing, was located at a steep riffle section. It was selected primarily as a maximum velocity station. Station 8 was located in a pool similar to Station 5. The increase in discharge between Station 8 and Station 5 is primarily due to groundwater inflow between Stations 7 and 8.

The 1975 spring, summer and fall hydrograph for Smith Creek are presented in Figs. 3, 4 and 5. Mean velocity versus discharge is plotted in Fig. 6. These are based on data collected at Station 6 by Jasper (1976) and this study.

Reconnaissance on February 4, 1976 revealed that Smith Creek was open intermittently from the CNT crossing above Station 8, downstream to a point between Stations 5 and 6. At this point the stream began to flow under the ice. Groundwater flow into the stream channel was evident especially in the immediate vicinity of Station 8. No velocity and discharge measurements were taken.

Water chemistry: Dissolved oxygen values generally increased with time for all sampling locations on Smith Creek during the study period in response to lowering water temperatures. August values were at or near the saturation level of oxygen in water in all cases. Dissolved oxygen values increased to 13 mg/L in October from 10 mg/L in August, but remained below the saturation level. The pH ranged from 8.0 to 9.0. Water temperatures steadily declined at all sampling locations from August 14 until October 23, 1975. Water temperatures were found to increase from station to station downstream from August 14 to September 25, 1975 and to decrease downstream on February 4, 1976. This is believed to be due to the inflow of groundwater at Location 8 which remains at a relatively constant temperature throughout the year. Water temperatures of springs in the vicinity of Location 8 ranged from 6°C to 15°C over the period of study. The temperature of one spring in this area was 15°C on February 4, 1976.

Water samples were collected on August 14 and October 8, 1975 and February 4, 1976 at all sampling locations on Smith Creek. Subsequent analyses results are presented in Appendix IV. Analysis of water samples taken on August 14 and October 8, 1975 are similar for all locations sampled, although concentrations of total suspended solids, major cations and anions generally increased downstream. Water samples taken on February 4, 1976 revealed much higher concentrations of most parameters than did the fall samples.

BIOLOGICAL CHARACTERISTICS

Creek Mile 422.7

A summary of biological findings from Creek Mile 422.7 is presented in Table 2.

Benthos: Results of Surber samples collected from sampling locations in Creek Mile 422.7 during 1975 are shown in Fig. 7. The size of each circle is proportional to the value of the standing crop (number of invertebrates m^2) which appears below each circle. Standing crop appears to be similar at all locations sampled. A greater percent occurrence of Plecoptera was found in locations upstream of the proposed highway crossing and Ephemeroptera occurred more frequently at downstream locations. Location 1 had a consistently lower percent occurrence of Chironomidae than other locations sampled.

Detailed results of benthic invertebrate samples taken by means of artificial substrates are presented in Fig. 9. In general, artificial substrates above the proposed highway crossing produced a relatively higher percent occurrence of Ephemeroptera than did Surber samples and a relatively lower percent occurrence of Chironomidae. Mean numbers of major taxa were similar for all locations on Creek Mile 422.7 and any differences that occur can probably be attributed to the choice of specific sampling site at each location.

Fish: Three fish species were collected from Creek Mile 422.7 during 1975. Slimy sculpins *(Cottus cognatus)* were by far the most abundant fish caught. Arctic grayling *(Thymallus arcticus)* and lake chub *(Couesius plumbeus)* were also collected. Slimy sculpins were caught throughout the entire sampling period until the 23rd of October, while no Arctic grayling were caught after the 29th of September. Lake chub were not caught after the 10th of October.

SLIMY SCULPINS: A total of 203 slimy sculpins were captured from all sampling locations on Creek Mile 422.7. The length-weight relationship for slimy sculpins from Creek Mile 422.7 is presented in Fig. 12a. The linear regression is expressed by the equation:

$$\log(\text{Weight}) = -5.376 + 3.245 \log(\text{Length}); \quad \text{C.I.} = 3.163 - 3.328$$

where C.I. = 95% confidence interval of b.

Length frequency is given in Fig. 12b. The dominant fork length classes at 30.0 to 39.9 mm and 50 to 59.9 mm corresponded to ages of 1 and 2 years respectively as shown in Table 5. Ages of 83 slimy sculpins in Creek Mile 422.7 were determined from otoliths and ranged from 0 to 4 years.

Detailed analyses of stomach contents of 114 slimy sculpins taken from Creek Mile 422.7 are presented in Appendix V. The sculpins were placed in five arbitrarily chosen groups on the basis of fork length. Diet of the smaller fish (F.L. 26 to 50 mm) consisted mainly of chironomids, ostracods and ephemeropterans. As fork length increased, these organisms became less important in the diet and trichopterans, plecopterans and fish, more important.

Creek Mile 422.7 apparently provides a nursery and summer feeding area for slimy sculpins. Although overwintering in Creek Mile 422.7 may be possible in some areas, it is probable that the majority of slimy sculpins migrate downstream in the fall to overwintering areas in the Mackenzie River. Emigration of slimy sculpins peaked in late September in conjunction with a drop in water temperature to 4°C. Jessop et al. (1974) and Jessop and Lilley (1975) reported similar emigrations of slimy sculpins from small Mackenzie River tributaries in the Fort Simpson area between late August and late September.

ARCTIC GRAYLING: A total of 15 Arctic grayling were captured from all sampling locations on Creek Mile 422.7. Of these, 14 were sampled for weight, length and age. The length-weight relationship for Arctic grayling from Creek Mile 422.7 is presented in Fig. 13a. The linear regression is expressed by the equation:

$$\log(\text{Weight}) = -4.222 + 2.686 \log(\text{Length}); \quad \text{C.I.} = 2.284 - 3.088$$

where C.I. = 95% confidence interval of b.

Length frequency is presented in Fig. 13b. A summary of growth in length and weight is presented in Table 6. The ages of Arctic grayling from Creek Mile 422.7, determined from scales ranged from 0 to 2 years.

Detailed results from stomach content analyses for 15 Arctic grayling from Creek Mile 422.7 are presented in Appendix VII. Grayling were placed in three groups on the basis of fork length prior to analysis. The stomachs were found to contain a wide variety of insects and arachnids both aquatic and terrestrial. Trichopterans were the most abundant food for all length classes and occurred more frequently as fork length increased. Adult dipterans and corixids were important food items for small grayling (100 to 140 mm in fork length) and chironomid larvae were abundant in larger grayling. A mean number of 41.5 organisms per stomach over all length classes was found and there were no empty stomachs.

Creek Mile 422.7 provides a nursery and summer feeding area for Arctic grayling. While only grayling ranging in length from 120 mm to 216 mm were caught during this study, Slaney and Co. (1974) report catches ranging in fork length from 60 to 65 mm on September 28, 1973. The growth rate reported here for the 0 year age class is much greater than that reported for Mackenzie River grayling at either Fort Simpson or Norman Wells by Stein et al. (1973). It is not yet clear whether this is indicative of habitat quality or due to difficulties in aging this particular year class. No grayling were caught after September 29 and it is probable that most had emigrated out of the stream by this date.

LAKE CHUB: A total of 9 lake chubs were collected from two sampling locations on Creek Mile 422.7. The length-weight relationship for lake chubs from Creek Mile 422.7 is presented in Fig. 14a. Insufficient data were available to calculate a meaningful regression line. Length frequency is presented in Fig. 14b. The ages of 8 lake chubs from Creek Mile 422.7 ranged from 0 to 1 year as determined from otoliths (Table 7).

Only 2 of the 8 lake chub stomachs analyzed from Creek Mile 422.7 contained food items. A total of 2 trichopterans and 1 chironomid were identified from these stomachs. Stein et al. (1973) found lake chubs in the Mackenzie River system to be feeding predominantly on insects, including plecopterans, dipterans, hymenopterans and coleopterans.

Creek Mile 422.7 probably serves as a nursery and feeding area for juvenile lake chubs. However, feeding was apparently light at the time of sampling as 75% of the lake chubs analyzed had empty stomachs. Growth of this species in Creek Mile 422.7 is slower than that reported by Porter et al. (1974) for three specimens from the Martin River. Martin River fish ranged in length from 37 to 42 mm and were found to be 0 years old based on otolith annuli counts. Lake chubs were not caught after October 10 and it is probable that this species, along with slimy sculpins and Arctic grayling, emigrates from Creek Mile 422.7 in the fall.

Creek Mile 426. 5

A summary of biological findings from Creek Mile 426.5 is presented in Table 3.

Benthos: Detailed results of benthic invertebrate samples taken by means of artificial substrates in Creek Mile 426.5 during 1975 are presented in Fig. 10. Numbers of major taxa colonizing artificial substrates were similar for the two locations sampled with Copepoda being the dominant group numerically. Chironomidae and Plecoptera were also abundant.

Fish: Two species of fish were collected from Creek Mile 426.5 during 1975. Lake chubs comprised 97% of the total catch with longnose suckers *(Catostomus catostomus)* accounting for the other 3%. All fish were caught on or after the 26th of September.

LAKE CHUB: A total of 142 lake chubs were captured from the three locations on Creek Mile 426.5. The length-weight relationship for 33 lake chubs from Creek Mile 426.5 is presented in Fig. 14a. The linear regression is expressed by the equation:

$$\log(\text{Weight}) = -4.214 + 2.585 \log(\text{Length}); \quad \text{C.I.} = 2.313 - 2.856$$

where C.I. = 95% confidence interval of b.

Length frequency is given in Fig. 14b. Ages of 23 lake chubs from Creek Mile 426.5 ranged from 0 to 1 year (Table 7).

Of 34 lake chubs from Creek Mile 426.5 analyzed for stomach contents, only two contained food items. A total of one amphipod and one coleopteran were found in the two stomachs.

Creek Mile 426.5 probably provides nursery and feeding areas for lake chubs, however, it is doubtful that it is capable of overwintering large numbers of fish due to icing conditions. Some lakes for which Creek Mile 426.5 provides drainage may support resident populations of this species. As was the case in Creek Mile 422.7, lake chubs in Creek Mile 426.5 were found to be feeding lightly or not at all (94% of lake chubs caught in Creek Mile 426.5 had empty stomachs). Lake chubs were caught for the duration of the study period even as water temperatures dropped to 0.5°C.

LONGNOSE SUCKER: A total of four longnose suckers were collected from sampling locations on Creek Mile 426.5. All specimens were sampled for length and weight. Length ranged from 29 mm to 40 mm and weight ranged from 0.3 g to 0.9 g. No analysis of stomach contents was performed.

Creek Mile 426.5 apparently provides nursery areas for longnose suckers. Although no ages were determined for longnose suckers taken from Creek Mile 426.5, these were probably 0 years of age on the basis of fork length. Longnose suckers aged as 0 years in Norman Wells region had a mean fork length of 57 mm (Stein et al. 1973).

No other species have been reported from Creek Mile 426.5, however, Slaney and Co. (1974) report taking slimy sculpin from Creek Mile 427.5, a tributary of Creek Mile 426.5.

Smith Creek

A summary of biological findings from Smith Creek is presented in Table 4.

Benthos: Detailed results of Surber samples collected from sampling locations in Smith Creek during 1975-1976 are presented in Fig. 8. The size of each circle is proportional to the value of the standing crop (number of invertebrates^{-2}) which appears below each circle. Locations 7 and 8 above the proposed highway crossing produced consistently higher estimates of standing crop than did locations 5 and 6 below the proposed crossing site. For all locations, Chironomidae and Ephemeroptera were the dominant groups of invertebrates numerically.

Detailed results of benthic invertebrate samples taken by means of artificial substrates are presented in Fig. 11. No major differences are apparent between mean number of organisms per artificial substrate upstream of the proposed highway crossing and those downstream. As in the case of Surber samples, Chironomidae and Ephemeroptera were the numerically dominant groups at all sampling locations.

Fish: A total of eight species of fish were collected from Smith Creek during 1975. Slimy sculpins were the most abundant fish caught, comprising 60% of the total catch. Arctic grayling comprised 19% of the total catch and lake chubs, 11%. The remaining 10% was comprised of longnose dace *(Rhinichthys cataractae),* longnose suckers, northern pike *(Esox lucius),* burbot *(Lota lota),* and a whitefish *(Coregonus* sp.). Abundant species (i.e. those comprising 10% or more of total catch) were caught at locations both upstream and downstream of the proposed highway crossing. Both Arctic grayling and burbot were observed at Location 8 on Smith Creek on February 4, 1976, however, none were collected.

SLIMY SCULPINS: A total of 57 slimy sculpins were captured from all sampling locations on Smith Creek. The length-weight relationship for 36 slimy sculpins from Smith Creek is presented in Fig. 12a. The linear regression is expressed by the equation:

$$\log(\text{Weight}) = -5.549 + 3.337 \log(\text{Length}); \quad \text{C.I.} = 3.013 - 3.661$$

where C.I. = 95% confidence interval of b.

The dominant fork length class for 37 slimy sculpins from Smith Creek was from 20.0 mm to 29.9 mm (Fig 12b). This fork length class corresponds to an age of 0 years as shown in Table 5. Ages of 21 slimy sculpins in Smith Creek ranged from 0 to 2 years.

Detailed analysis of the stomach contents of 49 slimy sculpins taken from Smith Creek are presented in Appendix VI. The slimy sculpins were placed into four arbitrarily chosen groups on the basis of fork length prior to analysis. Percent occurrence of empty stomachs decreased as fork length increased. The smaller groups of sculpins (0 to 25 mm and 26 to 50 mm) fed predominantly on chironomids, ostracods and trichopterans. As fork length increased, chironomids and ostracods decreased in importance as food items while trichopterans increased in importance.

Smith Creek provides a nursery and feeding area for slimy sculpins. Growth rates are similar to those in Creek Mile 422.7 except for the 2 year age class which apparently attain a greater fork length in Smith Creek. It is probable that slimy sculpins overwinter in Smith Creek although none were observed on February 4. Specimens were collected throughout the entire sampling period until October 23 when sampling ended. Analysis of the stomach contents of slimy sculpins showed that diets were similar in Creek Mile 422.7 and Smith Creek. In both creeks, chironomids and ostracods made up a large portion of the diet of smaller sculpins and decreased in importance as fork length increased. Trichopterans were an important food item in the diet of larger slimy sculpins, (fork length 51 to 100 mm) from both creeks. Results of Surber and artificial substrate sampling revealed that slimy sculpins were not necessarily feeding on the most abundant benthic organisms available to them. This is contrary to findings reported for the Martin River by Porter et al. (1974).

ARCTIC GRAYLING: A total of 18 Arctic grayling were collected from all sampling locations on Smith Creek. The length-weight relationship for 9 to these is presented in Fig. 13a. The linear regression is expressed by the equation:

$$\log(\text{Weight}) = -5.001 + 3.015 \log(\text{Length}); \quad \text{C.I.} = 2.747 - 3.283$$

where C.I. = 95% confidence interval of b.

Length frequency of 16 Arctic grayling from Smith Creek is presented in Fig. 13b. Grayling in the larger length classes did not appear in the length-weight relationship.

The dominant fork length class was 50.0 mm to 79.9 mm which corresponds closely to an age of 0 years as shown in Table 6. Scale ages ranged from 0 to 6 years.

Detailed results from stomach content analyses on 16 Arctic grayling from Smith Creek are presented in Appendix VIII. All of the stomachs analyzed contained food items. The grayling were placed into two arbitrarily chosen groups on the basis of fork length. The larger grayling (F.L. 280 mm to 330 mm) fed almost exclusively on trichopterans. Trichipterans also comprised the major part of the diet for smaller grayling (F.L. 40 mm to 90 mm) however, dipteran adults and chirmid larvae were also important as food items in this group.

Smith Creek apparently provides year-round habitat for Arctic grayling. Approximately 5 Arctic grayling were observed at Location 8 on February 4, 1976. Grayling ranging in age from 0 to 6 years were captured. It is noteworthy that the 1 and 2 year age classes are not represented in the sample, however, this is likely due to the selectivity of catch methods in employed. Small grayling (fork length 48 mm to 78 mm) were captured by means of fry traps and seines, while the larger graylings were caught by angling. Fork lengths at age are similar to those reported by Stein et al. (1973) for the Mackenzie River system at Norman wells. Trichopterans were by far the most abundant food item in grayling stomachs. Feeding was generally lighter in Smith Creek than in Mile 422.7 during this study; the mean number of organisms per stomach overall was 8.0 as compared to 41.5 in Creek Mile 422.7.

LAKE CHUB: A total of 10 lake chubs were caught at Locations 6, 7 and 8 on Smith Creek. Length versus weight is plotted for 8 of these fish, in Fig. 14a. Insufficient data were available to calculate a meaningful regression line for these fish. Length frequency is presented in Fig. 14b. The dominant fork length class (n = 4) was from 50.0 mm to 54.9 mm. Ages of lake chubs taken from Smith Creek ranged from 1 to 2 years (Table 7).

Analysis of the stomach contents of 10 lake chubs revealed a 90% occurrence of empty stomachs. A single trichopteran was found in the one stomach with contents.

Growth rates for one year old lake chubs from Smith Creek are similar to those from Creek Mile 426.5. As was the case with both Creek Mile 422.7 and Creek Mile 426.5, lake chubs were found to be feeding lightly or not at all.

OTHER SPECIES: Three longnose dace were caught at Location 7 and 8 on Smith Creek. Fork length ranged from 21 mm to 26 mm with a mean of 23 mm. No weights or ages were recorded. Analysis of stomach contents revealed two empty stomachs. The remaining stomach contained two chironomids, one trichopteran and two dipteran adults.

Three longnose suckers were caught, one each at Locations 6, 7 and 8. Fork length ranged from 28 mm to 75 mm with a mean on 49.7 mm. One longnose sucker with a fork length of 28 mm and a weight of 0.2 g gas aged as 0 years. No analysis of stomach contents was performed.

Two northern pike (F.L. 296 mm and 318 mm) were caught at Locations 5 and 8. No weights were recorded. The scale age of the pike with fork length of 318 cm was 4 years. Analysis of the stomach contents revealed one empty stomach and one containing fish remains.

One whitefish sp. was collected at Location 5 of Smith Creek. No analyses were performed on this specimen.

One burbot with fork length of 197 mm was captured at Location 6 on October 24, 1975. The weight was 52 g and age was recorded as 2 years. Analysis of the stomach contents revealed one lake chub.

Smith Creek is characterized by a high diversity of fish species. In addition to the species collected as a result of this study, Slaney and Co. (1974) have identified six species.
These are white suckers *(Catostomus commersoni),* Arctic cisco *(Coregonus autumnalis),* spottail shiners *(Notropis hudsonius),* flathead chubs *(Platygobio gracilis),* trout perch *(Percopsis omiscomaycus)* and peamouth *(Mylocheilus caurinus).*

GENERAL DISCUSSION

The streams under study are deeply incised into high ice content terrain; consequently erosion, resulting from slope instability may be a major problem. Brunskill et al. (1973) concluded that the magnitude of physical, chemical and biological consequences of increased rates of supply of watershed soils and plant material to aquatic ecosystems is likely to be more deleterious and irreversible in smaller watersheds compared to larger watersheds. Creek Mile 426.5 will be particularly susceptible since the low discharges present are not capable of transporting large amounts of deposited materials from the stream bed.

Groundwater flow during the winter produces a buildup of ice in some areas and maintains open water in others. The proposed crossing of Creek Mile 422.7 is located in an area of severe winter icing which may be aggravated by culvert installation. The crossing of Smith Creek, on the other hand, is to be constructed in an area which is flowing and free of ice in winter. Installation of a culvert in this instance may initiate a buildup of ice within the culvert leading to blockage and upstream ponding. Subsequent erosion of the crossing embankment may occur.

Creek Mile 422.7 and Creek Mile 426.5 were each found to contain one of the twelve species of fish which are considered by Dryden and Stein (1975) to be numerically significant in the Mackenzie Valley, or form the basis of existing or potential domestic, sport or commercial fisheries. Smith Creek is characterized by a high diversity of fish species and of the eight species collected as a result of this study, five are considered significant by Dryden and Stein (1975). Fish were found to be utilizing the streams as nursery and feeding areas during the summer and fall of 1975 and spring spawning is suspected. Smith Creek was found to provide overwintering habitat for Arctic grayling.

Benthic organisms played an important role in the diet of fish. Previous studies including Brunskill et al. (1973) have shown that silt loads increase during and after construction activities in watersheds and that increased siltation generally results in decreased abundance and diversity of aquatic organisms. The rate of recovery of benthic organisms from the effects of highway construction activities is of fundamental importance with respect to the food-chain inter-relationships of aquatic ecosystems.

CONCLUSIONS

The three streams chosen for the monitoring study are typical of numerous small Mackenzie River tributaries crossed by the Mackenzie Highway right-of-way. They are likely to be highly susceptible to many of the problems associated with highway construction as described by Dryden and Stein (1975).

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TABLE 1. SUMMARY TABLE OF PHYSICAL AND CHEMICAL BASELINE FINDINGS FOR CREEK MILE 422.7, CREEK MILE 426.5, AND SMITH CREEK.

Date	Creek Mile 422.7						Creek Mile 426.5				Smith Creek					
	Location	$\overline{V}$ (m/sec)	Q (m^3/sec)	pH	D.O. (mg/ℓ)	Temp. (°C)	Location	pH	D.O. (mg/ℓ)	Temp. (°C)	Location	$\overline{V}$ (m/sec)	Q (m^3/sec)	pH	D.O. (mg/ℓ)	Temp. (°C)
14/08/75*	1	0.37	0.10	9.0	11	10.0	9	-	-	-	5	0.23	0.48	8.5	10	15.0
	2	0.30	0.13	8.0	11	8.0	10	-	-	-	6	0.34	0.45	8.5	10	14.0
	3	0.28	0.20	8.5	11	8.0	11	8.0	8	14.0	7	0.58	0.59	8.5	10	13.5
	4	0.27	0.13	8.5	11	8.5					8	0.22	0.47	8.0	10	13.0
28/08/75*	1	0.61	0.08	8.5	11	10.0	9	-	-	-	5	0.19	0.34	8.5	10	12.5
	2	0.59	n/a	9.0	12	8.0	10	-	-	-	6	0.26	0.31	8.5	10	12.5
	3	0.23	0.13	8.5	10	7.5	11	8.5	10	10.5	7	0.52	0.39	8.5	10	12.0
	4	0.30	0.10	8.5	11	7.0					8	0.15	0.33	9.0	10	11.5
12/09/75	1	0.79	0.12	8.5	12	5.0	9	-	-	-	5	0.24	0.44	8.5	11	8.0
	2	0.39	n/a	8.5	11	4.0	10	-	-	-	6	0.29	0.42	8.5	11	7.0
	3	0.28	0.15	8.5	12	4.0	11	8.0	10	8.0	7	0.54	0.52	8.5	11	7.0
	4	0.24	0.17	8.5	11.5	4.5					8	0.16	0.34	8.5	11	7.0
25/09/75	1	0.55	0.07	8.5	12	4.0	9	8.5	12	5.0	5	0.21	0.43	8.5	11	5.5
	2	0.33	n/a	8.5	12	4.0	10	8.0	10	7.0	6	0.30	0.41	8.5	11	5.5
	3	0.23	0.11	8.5	12	4.0	11	8.0	10	7.0	7	0.51	0.45	8.5	11	5.5
	4	0.27	0.14	8.5	12	3.5					8	0.20	0.38	8.5	11	5.0
08/10/75*	1	0.45	0.34	8.5	12	1.0	9	8.5	12	2.0	5	0.36	1.04	8.5	12	2.0
	2	0.33	0.26	8.5	12	1.0	10	8.0	11	2.0	6	0.47	1.09	8.5	12	2.0
	3	0.34	0.27	8.5	12	1.0	11	8.0	12	2.0	7	0.78	1.23	8.5	13	2.0
	4	0.32	0.25	8.5	13	1.0					8	0.34	0.90	8.5	13	2.0
23/10/75	1	0.52	0.10	8.5	11	0.0	9	8.5	13	0.0	5	0.19	0.37	8.5	12	1.0
	2	0.53	0.05	8.0	12	-0.5	10	8.0	11	0.5	6	0.31	0.44	8.5	12	1.0
	3	0.25	0.11	8.0	11	-0.5	11	8.0	11	0.5	7	0.53	0.44	8.5	12	1.0
	4	0.24	0.12	8.0	12	-0.5					8	0.18	0.33	8.0	12	1.0
04/02/76*	1	-	-	8.0	10	0.0					5	-	-	8.5	11	0.0
	2	-	-	8.5	12	0.0					6	-	-	8.5	11	1.0
	3	-	-	-	-	-					7	-	-	8.5	10	3.0
	4	-	-	-	-	-					8	-	-	8.0	12	3.0

*Velocity and discharge measurements were taken on day following date indicated.
$\overline{V}$ = mean velocity over cross-section.
Q = calculated discharge from velocity and cross-sectional area measurements.
n/a = not applicable.

TABLE 2. SUMMARY TABLE OF BIOLOGICAL FINDINGS FROM CREEK MILE 422.7

BENTHOS

Taxa	% occurrence (over all sampling dates and locations except where noted) S_1	S_2
Diptera		
Chironomidae	27.6	10.5
Simulidae	0.2	1.0
Tipulidae	0.1	0.1
Empididae	0.5	0.1
Ephemeroptera		
Baetidae	36.3	47.6
Heptagenidae	5.5	7.8
Trichoptera		
Brachycentridae	3.5	6.6
Hydropsychidae	0.3	0.1
Limnephilidae	<0.05	0.2
Plecoptera	23.6	23.7
Hemiptera	<0.05	<0.05
Hydracarina	1.1	1.0
Oligochaeta	0.1	0.0
Nematoda	0.1	0.0
Gastropoda	0.1	0.9
Pelecypoda	0.0	<0.05
Copepoda	0.4	0.3
Ostacoda	<0.05	0.1
Cladocera	0.5	0.0
Amphipoda	0.2	0.0

S_1 = Collected by means of Surber sampler omitting sampling date 28/8/75.

S_2 = Collected by means of artificial substrate sampler.

FISH

Species	# Taken	L. W. Relationships	C.I.
Cottus cognatus	203	log W = -5.376 + 3.245 log L	3.163-3.328
Thymallus arcticus	15	log W = -4.222 + 2.686 log L	3.284-3.088
Couesius plumbeus	9	N/A	N/A

Food Item	Stomach Contents by Fish Species* *Cottus cognatus* n = 114	*Thymallus arcticus* n = 15	*Couesius plumbeus* n = 8
Gastropoda	7.8		
Arachnida		3.5	
Insecta			
Hymenoptera		4.8	
Diptera	35.2	11.9	33.3
Hemiptera		6.1	
Trichoptera	19.6	72.0	66.7
Coleoptera		1.3	
Ephemeroptera	21.1	0.4	
Plecoptera	7.0	0.2	
Fish	9.3		

*Food items as percent by number of diet over all length classes by species.

TABLE 3. SUMMARY TABLE OF BIOLOGICAL FINDINGS FROM CREEK MILE 426.5.

BENTHOS

Taxa	% occurrence (over all sampling dates and locations as collected by artificial substrate sampler)
Diptera	
Chironomidae	20.9
Tipulidae	0.1
Empididae	0.1
Ceratopogonidae	0.3
Other	0.2
Ephemeroptera	
Baetidae	1.2
Heptagenidae	0.0
Trichoptera	
Brachycentridae	0.3
Glossosomatidae	0.1
Plecoptera	3.2
Hydracarina	2.1
Oligochaeta	1.0
Nematoda	0.4
Gastropoda	0.9
Pelecypoda	0.1
Copepoda	61.2
Ostracoda	2.9
Cladocera	4.5
Amphipoda	0.1
Collembola	0.6

FISH

Species	# Taken	L. W. Relationships	C.I.
Couesius plumbeus	142	log W = -4.214 + 2.585 log L	2.313-2.856
Catostomus catostomus	4	N/A	

Food Item	Stomach Content by Fish Species* *Couesius plumbeus* n = 34	*Catostomus catostomus*
Coleoptera	50	No analysis performed
Amphipoda	50	

*Food items as percent by number of diet over all length classes by species.

TABLE 4. SUMMARY TABLE OF BIOLOGICAL FINDINGS FROM SMITH CREEK.

BENTHOS

Taxa	% occurrence (over all sampling dates and locations except where noted) S_1	S_2
Diptera		
Chironomidae	62.2	39.5
Simulidae	0.1	0.4
Tipulidae	<0.05	<0.1
Empididae	0.3	0.2
Ceratopogonidae	<0.05	<0.05
Other	0.1	0.1
Ephemeroptera		
Baetidae	30.9	43.7
Heptagenidae	0.5	0.2
Trichoptera		
Brachycentridae	0.5	1.0
Hydropsychidae	0.9	1.9
Glossosomatidae	0.2	<0.05
Hydroptilidae	<0.05	0.0
Limnephilidae	<0.05	0.3
Plecoptera	2.0	6.3
Hemiptera	0.0	<0.05
Hydracarina	0.5	0.4
Oligochaeta	0.1	0.1
Nematoda	0.3	0.1
Gastropoda	0.2	0.6
Copepoda	1.0	0.7
Ostracoda	0.1	0.1
Cladocera	<0.05	<0.05
Amphipoda	<0.05	0.0
Collembola	<0.05	0.0

S_1 = Collected by means of Surber sampler omitting sampling date 28/8/75.

S_2 = Collected by means of artificial substrate sampler.

FISH

Species	# Taken	L. W. Relationships	C.I.
Cottus cognatus (1)	57	log W = -5.549 + 3.337 log L	3.013 - 3.661
Thymallus arcticus (2)	18	log W = -5.001 + 3.015 log L	2.747 - 3.283
Couesius plumbeus (3)	10	N/A	N/A
Rhinichthys cataractae (4)	3	N/A	N/A
Catostomus catostomus (5)	3	N/A	N/A
Esox lucius (6)	2	N/A	N/A
Lota lota (7)	1	N/A	N/A
Coregonus sp. (8)	1	N/A	N/A

Food Item	Stomach Contents by Fish Species* (1) n=49	(2) n=16	(3) n=10	(4) n=3	(5)	(6) n=2	(7) n=1	(8)
Gastropoda		0.3			No Analysis			No Analysis
Arachnida		1.2						
Ostracoda	17.4							
Insecta								
Hymenoptera		7.8						
Diptera	48.8	23.8		80.0				
Hemiptera		0.6						
Trichoptera	21.3	52.6	100	20.0				
Coleoptera		2.7						
Ephemeroptera	7.8	8.3						
Plecoptera	4.6	1.2						
Odonata		1.2						
Orthoptera		0.3						
Fish						100	100	

*Food items as percent by number of diet over all length classes by species.

TABLE 5. SUMMARY OF GROWTH IN LENGTH AND WEIGHT FOR SLIMY SCULPING FROM CREEK MILE 422.7 AND SMITH CREEK.

Age	No.	Length (mm)				Weight (gm)			
		Range	Mean	S.D.	S.E.	Range	Mean	S.D.	S.E.
CREEK MILE 422.7									
0	7	17-31	26.3	5.5	2.1	.05-.3	.19	.10	.04
1	29	28-45	36.5	5.0	0.9	.2-1.8	.56	.33	.06
2	25	47-68	55.7	5.2	1.0	1.0-4.0	1.95	.69	.14
3	13	64-89	75.4	7.2	2.0	3.5-10.1	5.62	1.96	.54
4	9	79-107	92.7	8.1	2.7	5.1-17.4	10.39	3.39	1.13
SMITH CREEK									
0	8	22-31	26.9	3.4	1.2	.05-.4	.21	.11	.04
1	5	27-32	28.8	1.9	0.9	.1-.3	.18	.08	.04
2	8	47-86	61.5	4.6	3.0	3.7-8.2*	5.00*	2.14*	1.07*

* based on n=4

TABLE 6. SUMMARY OF GROWTH IN LENGTH AND WEIGHT FOR ARCTIC GRAYLING FROM CREEK MILE 422.7 AND SMITH CREEK.

Age	No.	Length (mm)				Weight (gm)			
		Range	Mean	S.D.	S.E.	Range	Mean	S.D.	S.E.
CREEK MILE 422.7									
0	3	120-122	120.7	1.2	0.7	22.0-28.0	24.43	3.16	1.82
1	8	123-191	161.0	27.9	9.8	20.5-91.2	52.80	24.50	8.66
2	4	146-216	178.3	29.1	14.6	46.5-68.8*	58.17*	11.19*	6.46*
SMITH CREEK									
0	8	48-78	63.8	11.1	3.9	1.2-5.0	3.67	1.50	0.50
3	1	---	283.0	-	-	---	-	-	-
4	1	---	305.0	-	-	---	-	-	-
5	1	---	308.0	-	-	---	-	-	-
6	1	---	326.0	-	-	---	-	-	-

* based on n=3

TABLE 7. SUMMARY OF GROWTH IN LENGTH AND WEIGHT FOR LAKE CHUB FROM CREEK MILE 422.7, CREEK MILE 426.5 AND SMITH CREEK.

Age	No.	Length (mm)				Weight (gm)			
		Range	Mean	S.D.	S.E.	Range	Mean	S.D.	S.E.
Creek Mile 422.7									
0	4	17-30	24.5	5.4	2.7	.05-.5	.19	1.0	.05
1	4	31-33	32.3	0.4	1.0	.2-.5	.50	.08	.04
Creek Mile 426.5									
0	2	28-34	31.0	4.2	3.0	.3-.6	.45	.21	.15
1	21	37-58	45.4	5.8	1.3	.6-2.3	1.20	.43	.09
Smith Creek									
1	3	44-59	51.3	7.5	4.3	1.0-2.3	1.63	.65	.38
2	1		58				1.9		

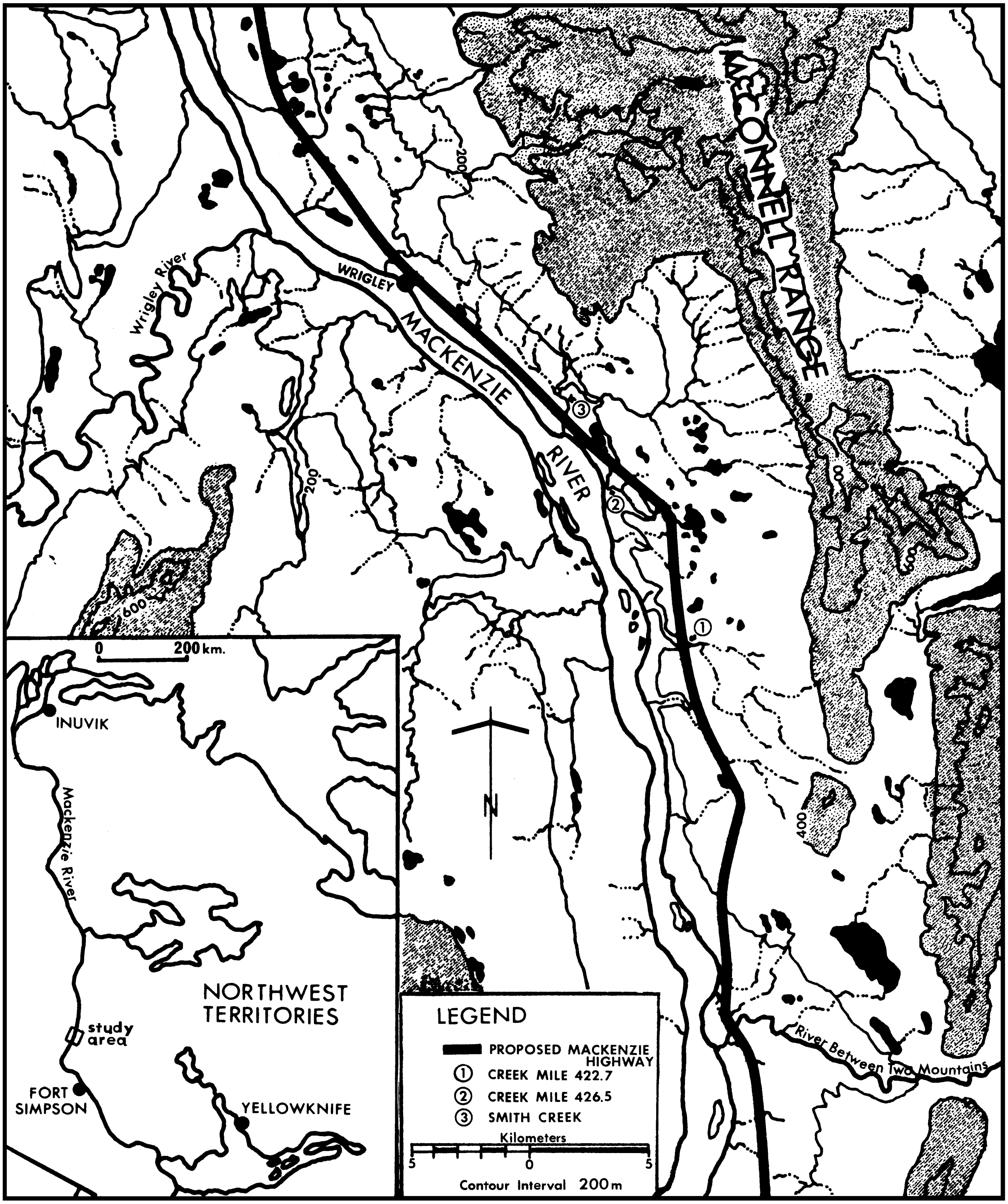


Figure 1. Map of study area showing proposed Mackenzie highway route.

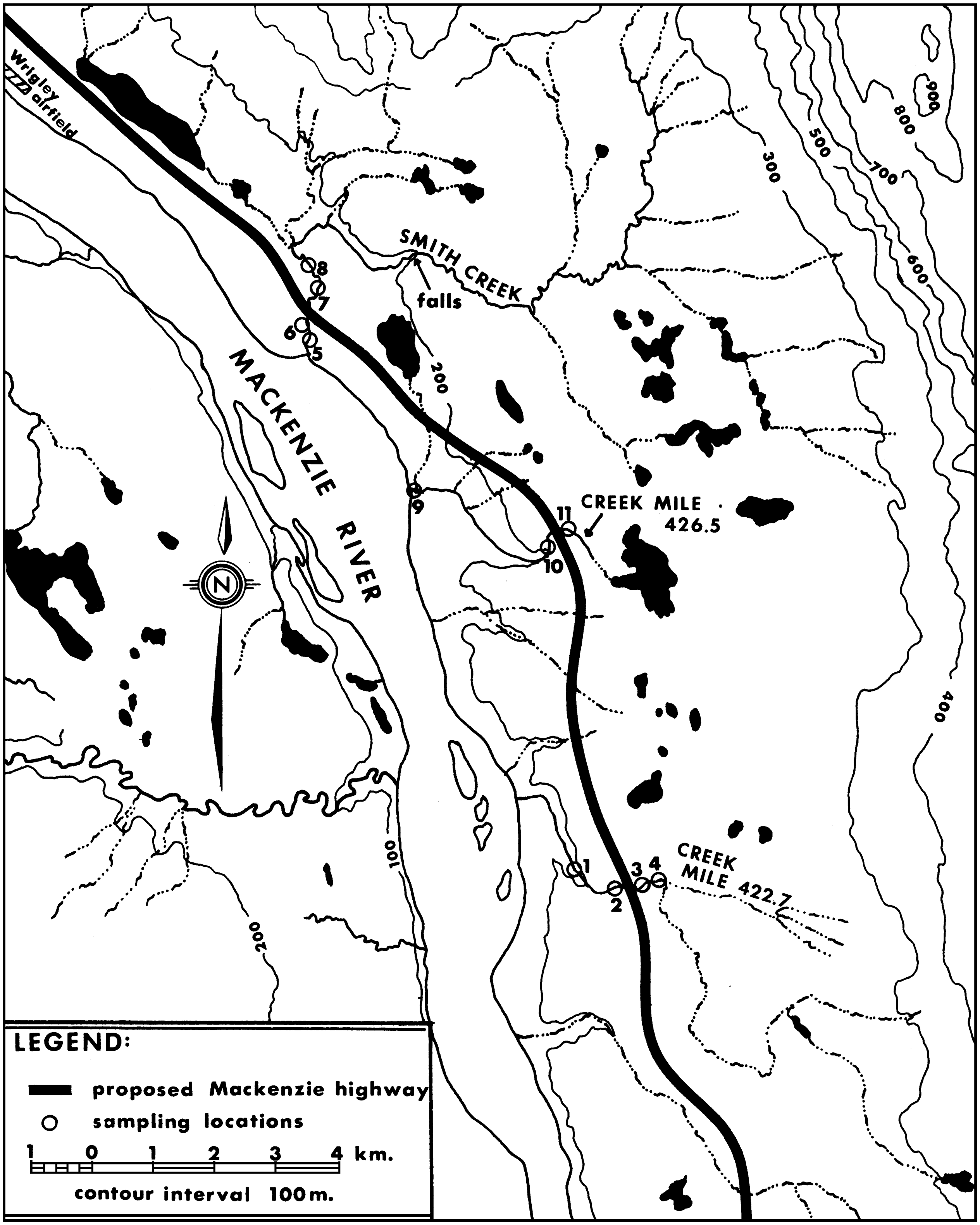


Figure 2 . Map of study area showing sampling locations.

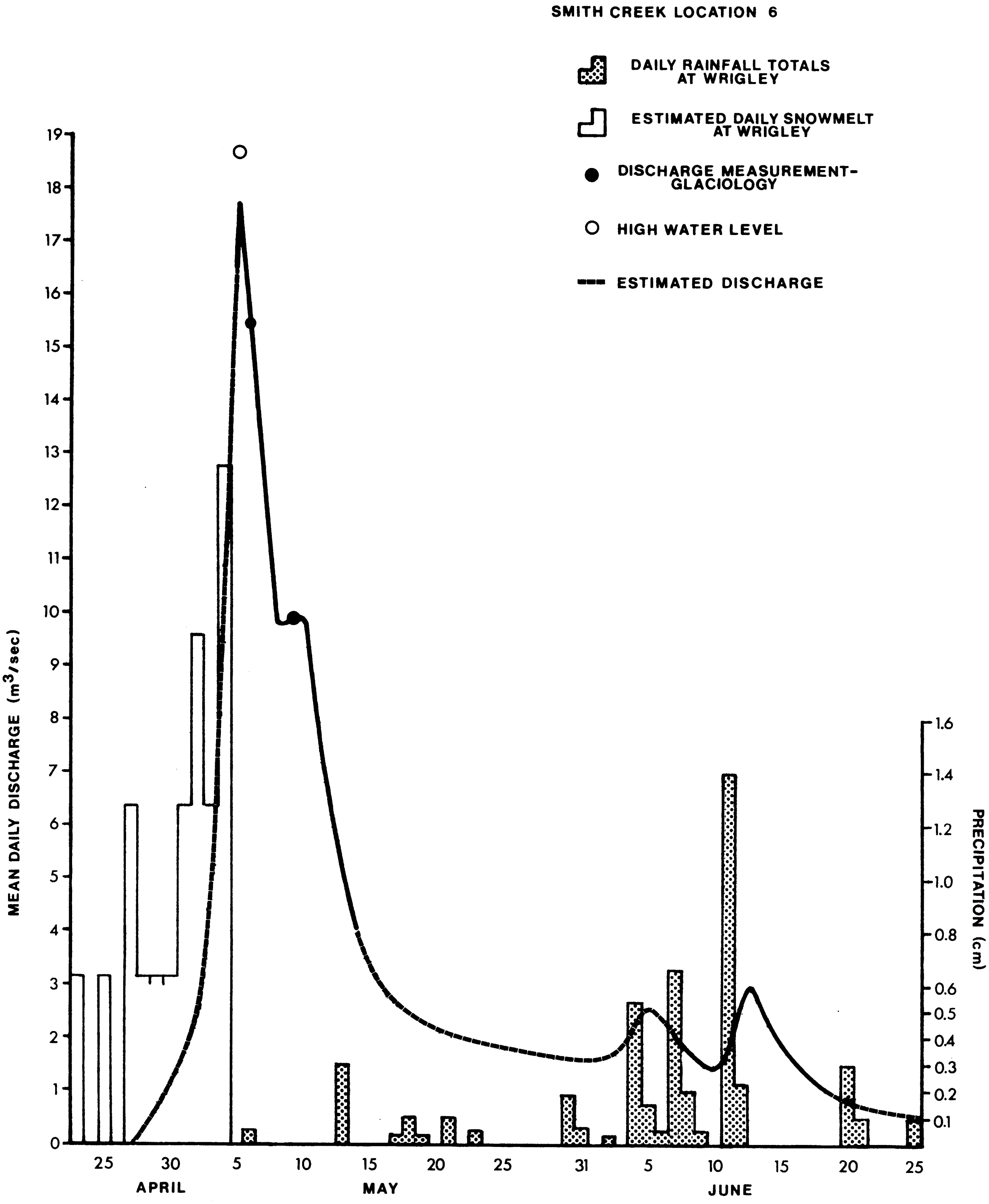


Figure 3 . Spring hydrograph for Smith Creek, 1975.

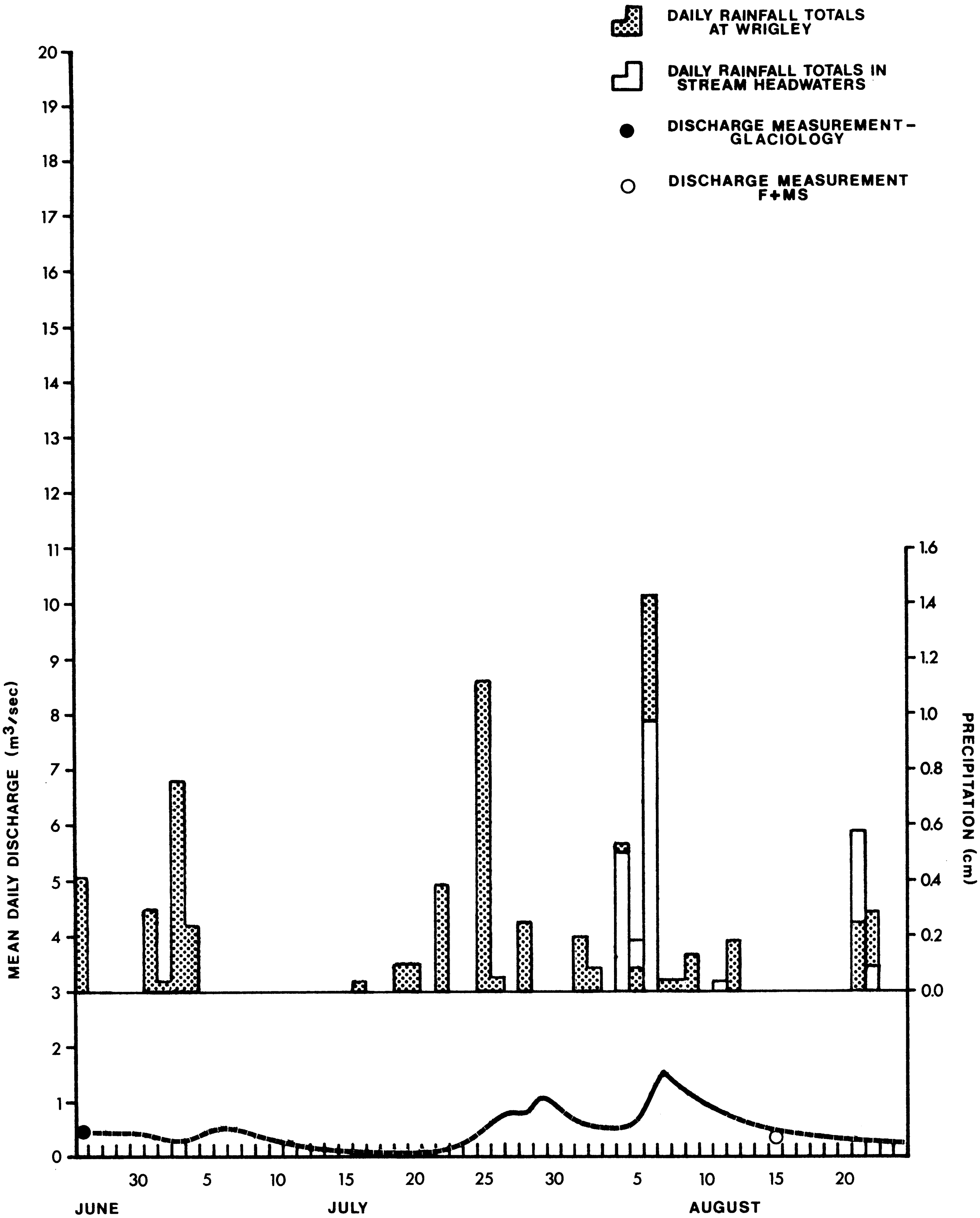


Figure 4 . Summer hydrograph for Smith Creek, 1975.

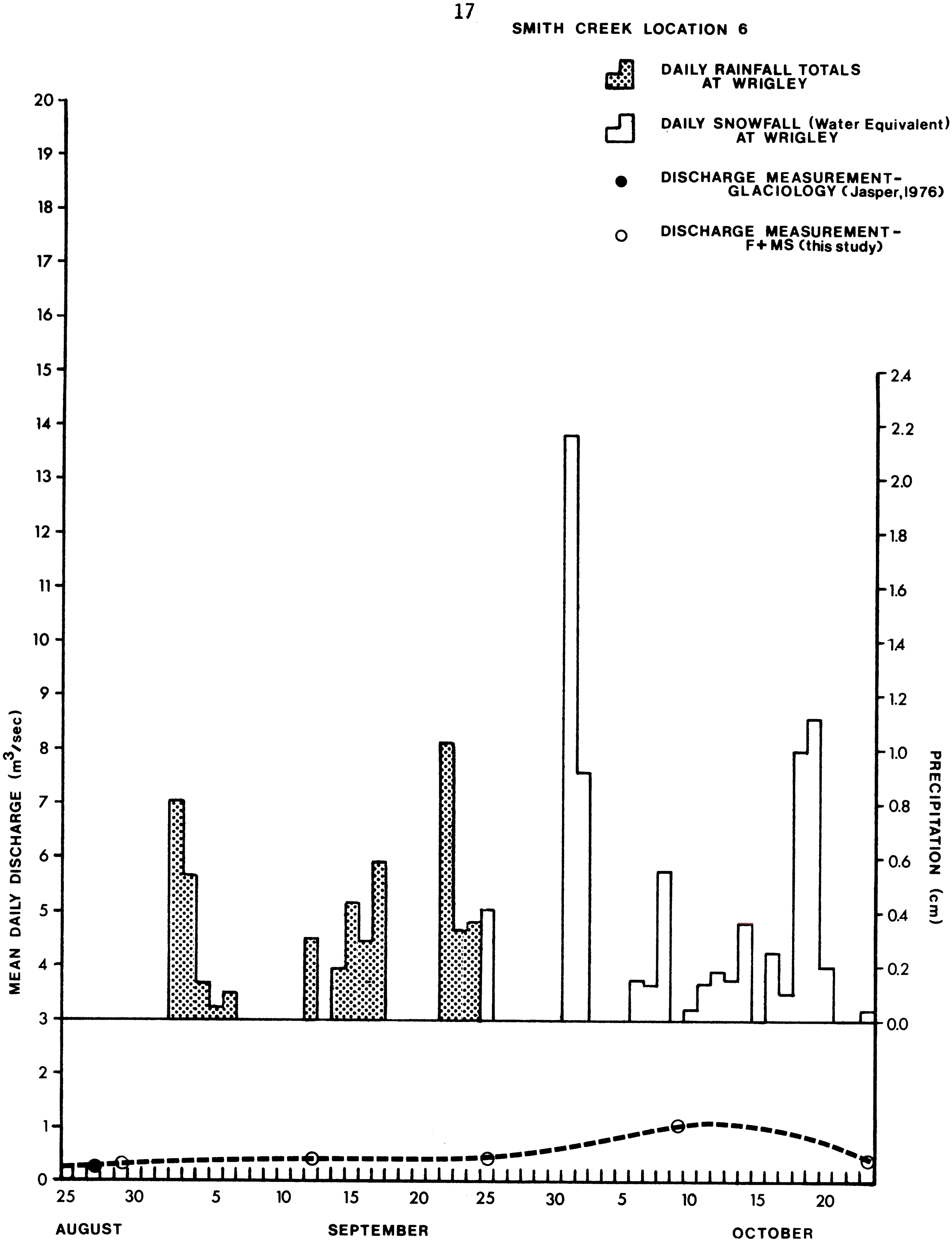


Figure 5 . Fall hydrograph for Smith Creek, 1975.

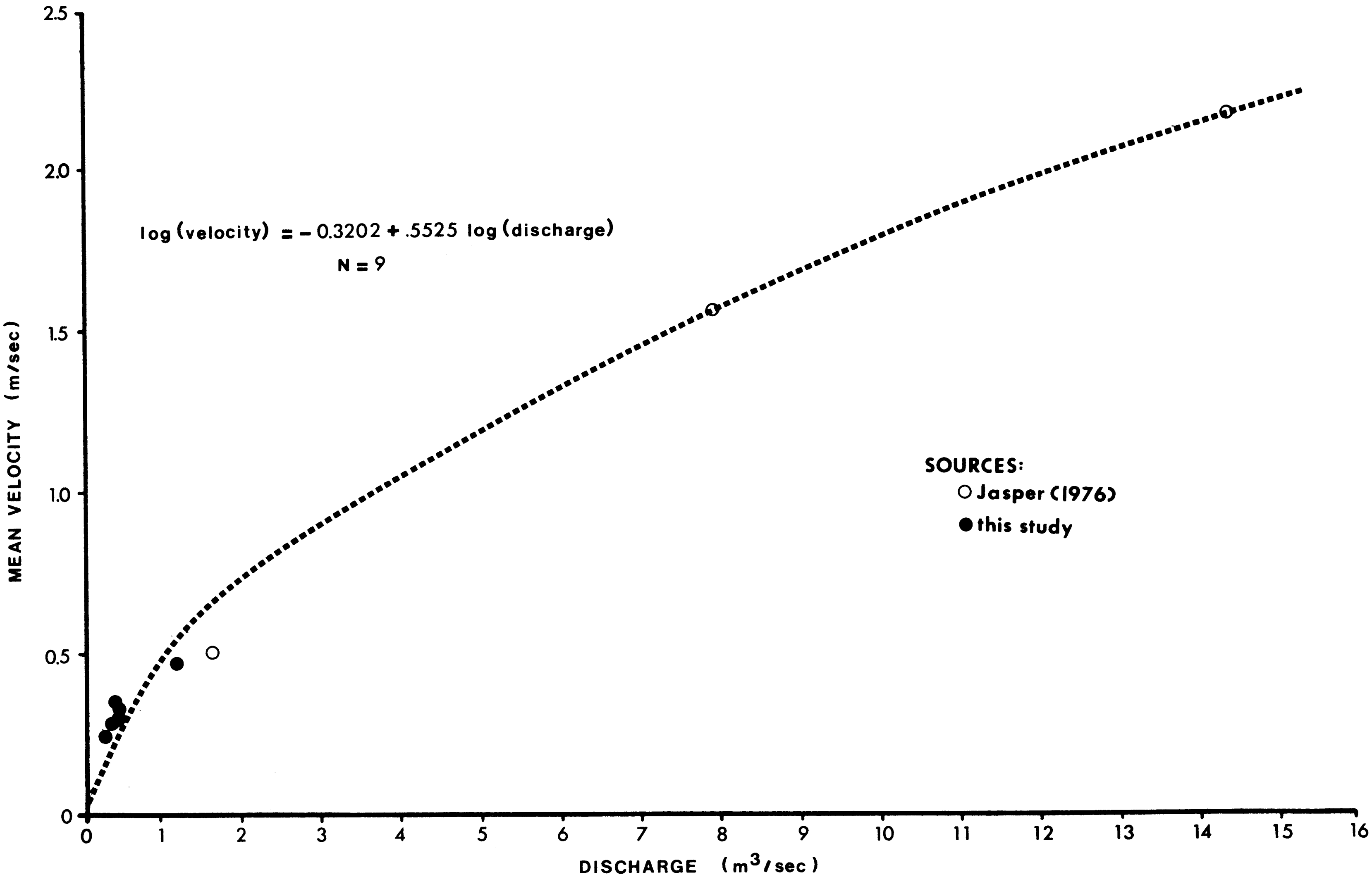


Figure 6 . Mean velocity versus discharge for Smith Creek, 1975.

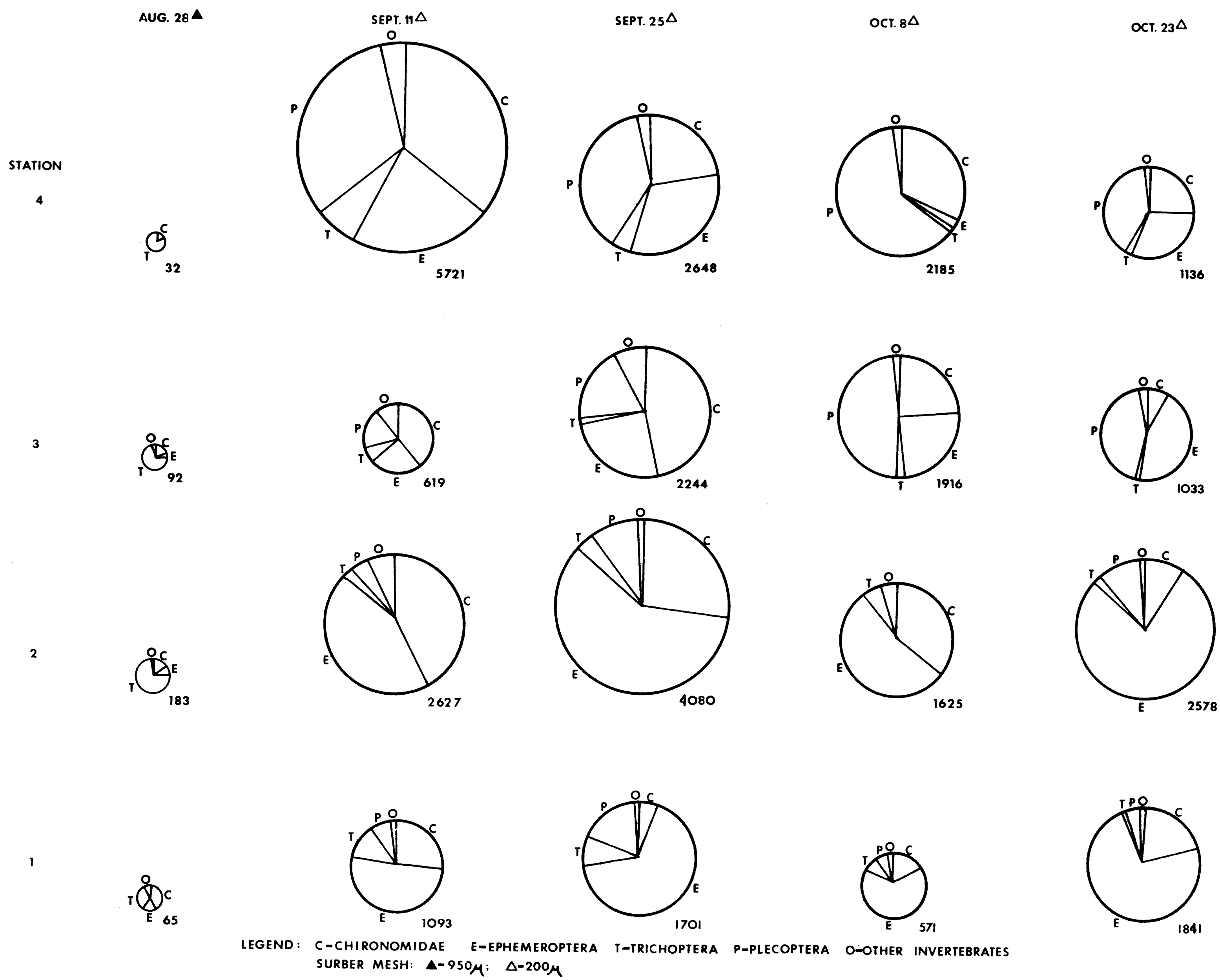


Figure 7. Standing crops (number m^{-2}) and percent occurrence of major taxa of invertebrates in Creek Mile 422.7, 1975. (A major taxon occurred as 4% or more of total abundance.)

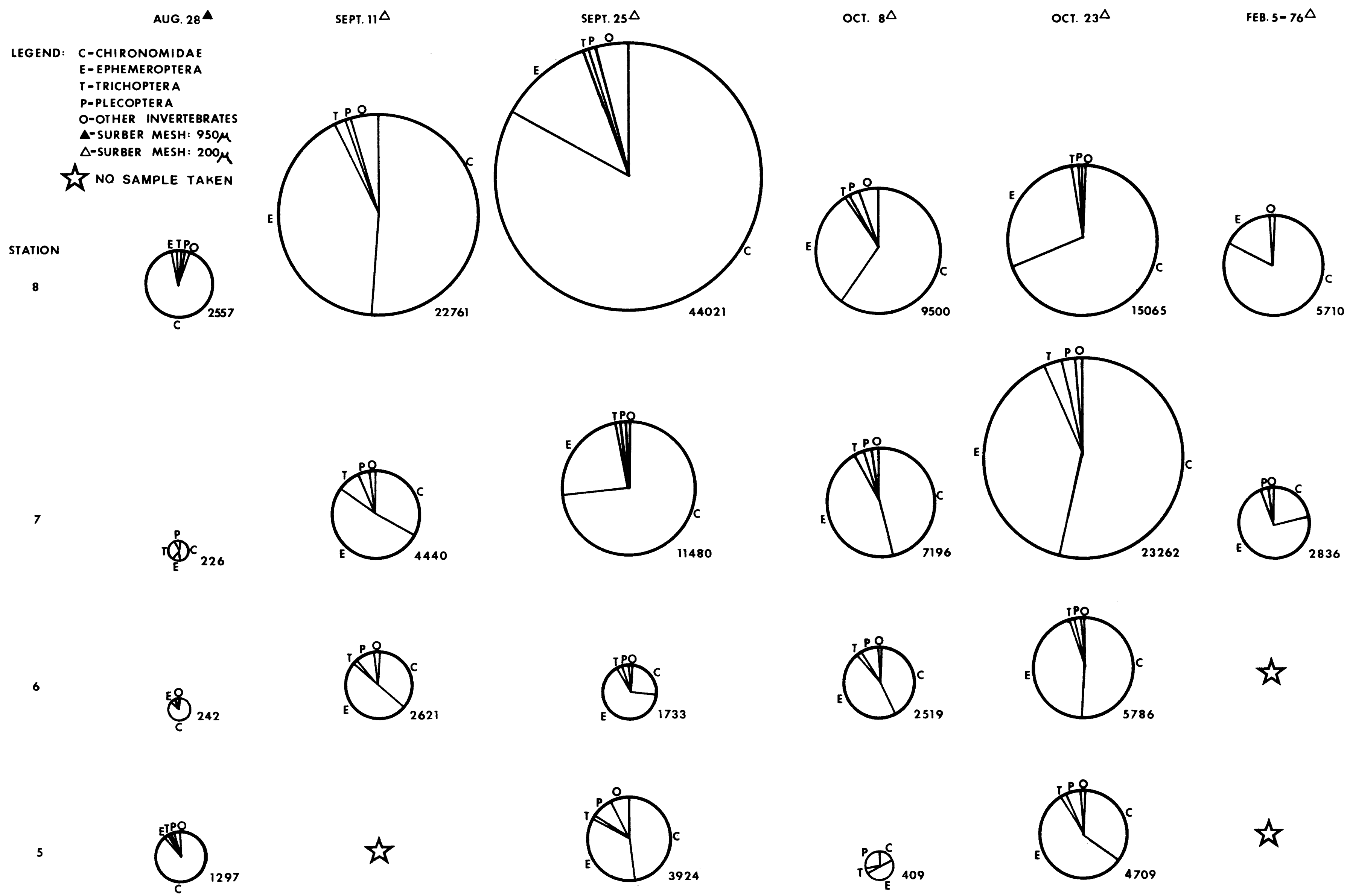


Figure 8. Standing crops (number m^{-2}) and percent occurrence of major taxa of invertebrates in Smith Creek, 1975. (A major taxon occurred as 1% or more of total abundance.)

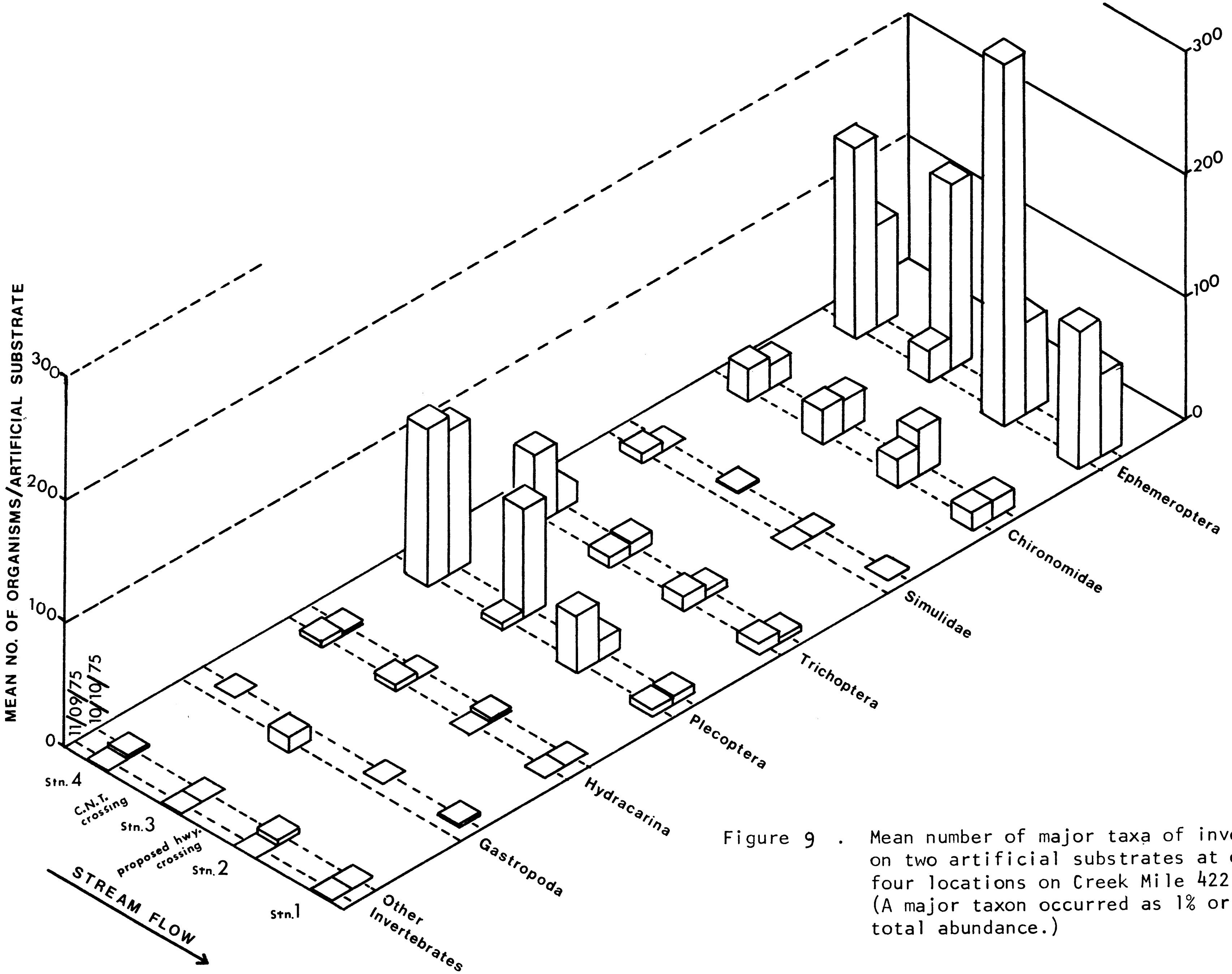


Figure 9 . Mean number of major taxa of invertebrates on two artificial substrates at each of four locations on Creek Mile 422.7, 1975. (A major taxon occurred as 1% or more of total abundance.)

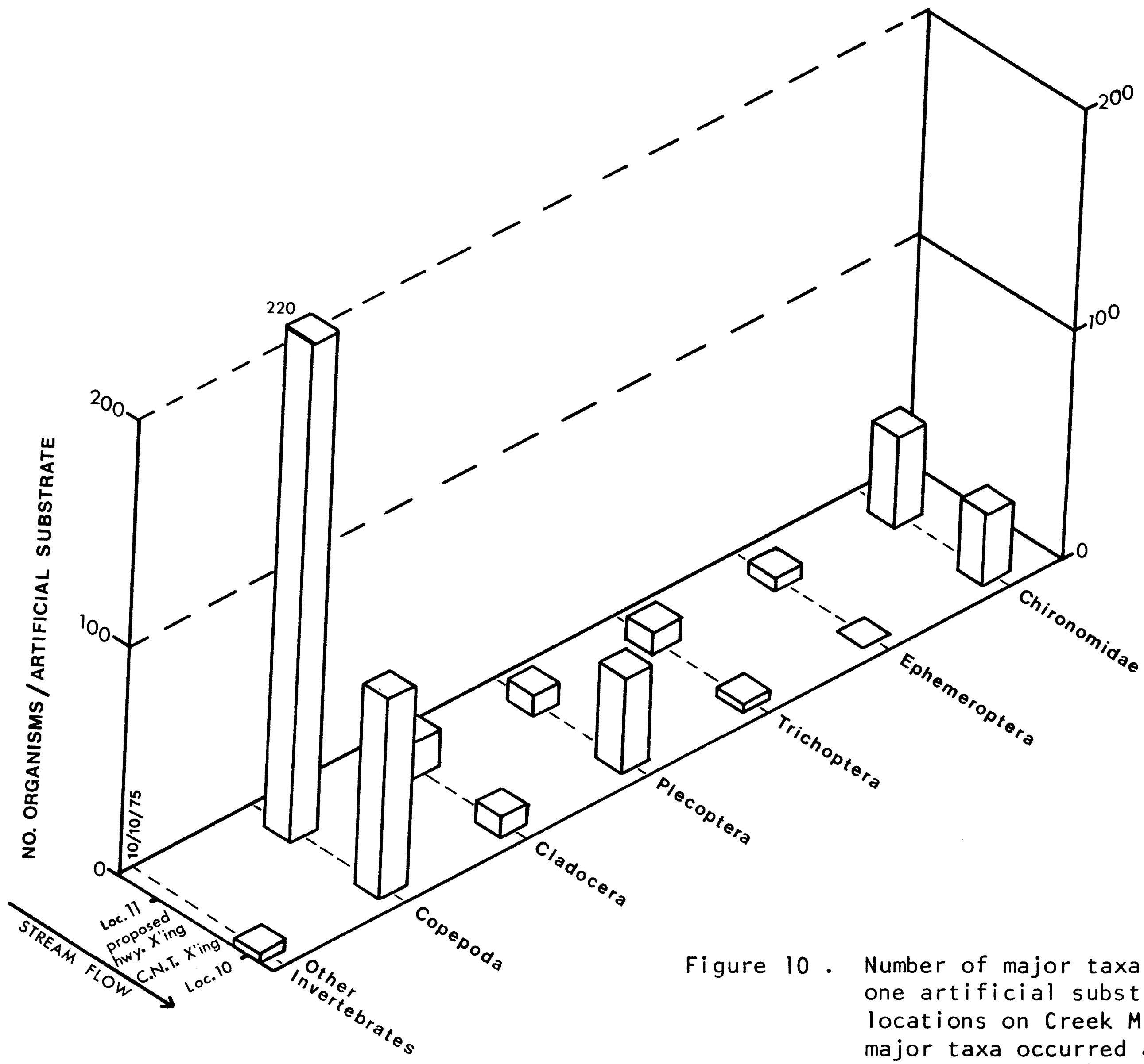


Figure 10 . Number of major taxa of invertebrates on one artificial substrate at each of two locations on Creek Mile 426.5, 1975. (A major taxa occurred as 1% or more of total abundance.)

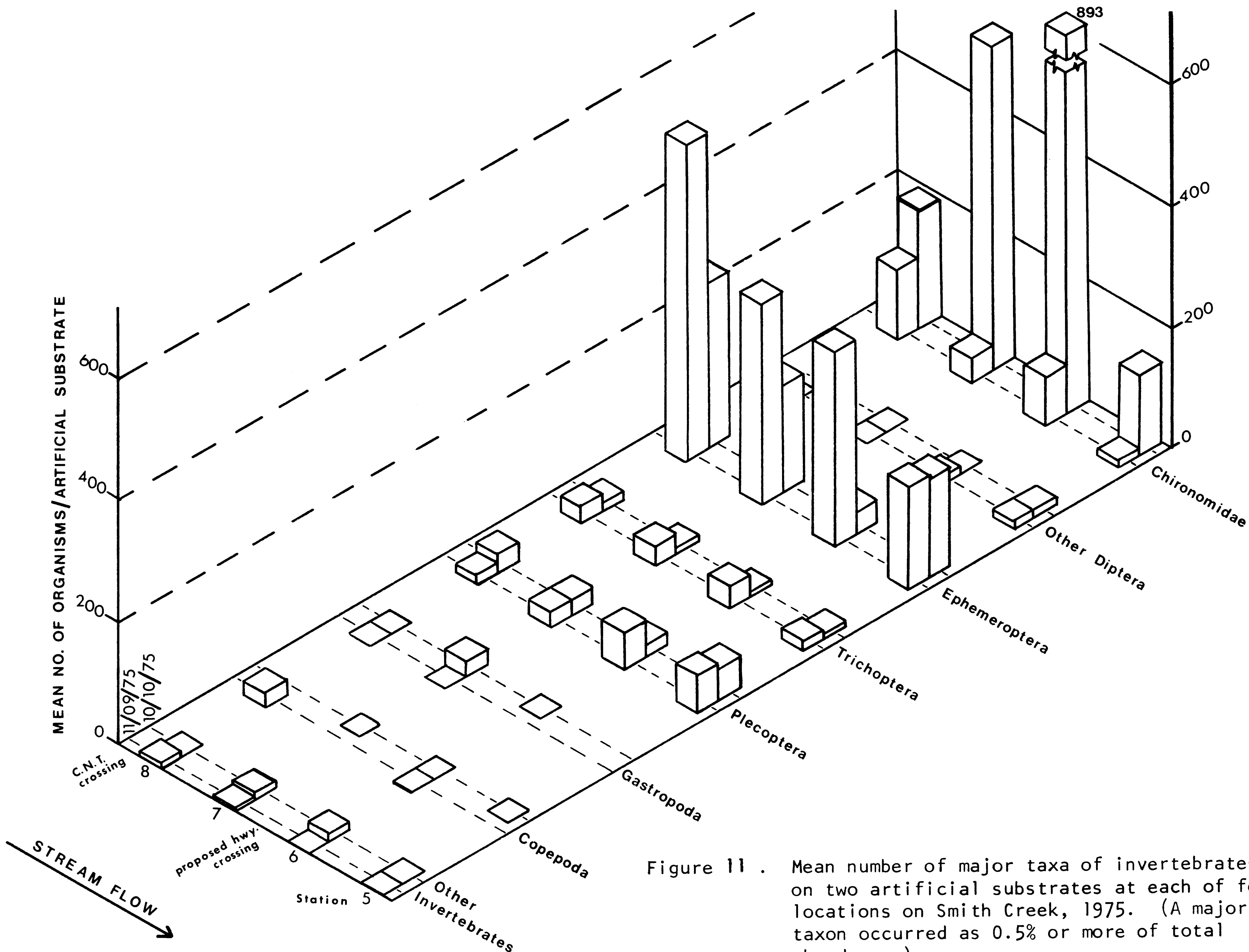
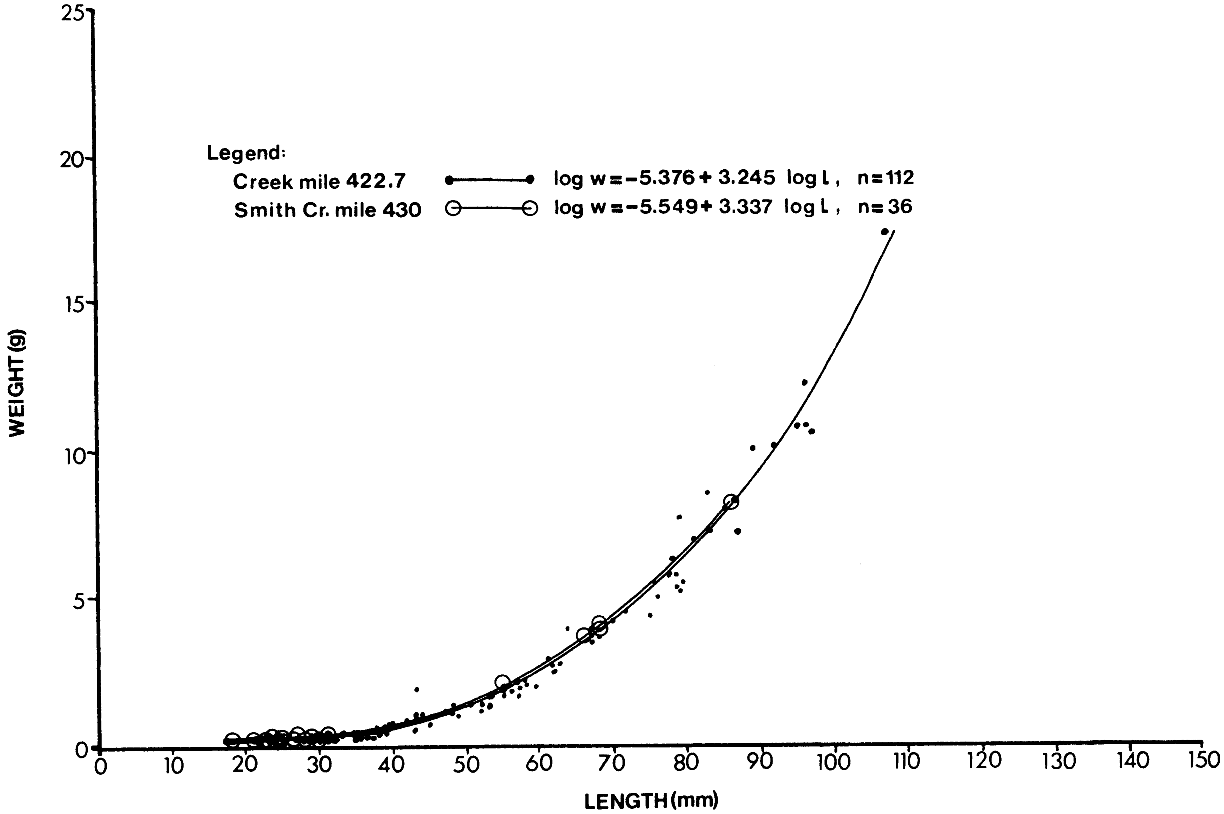


Figure 11 . Mean number of major taxa of invertebrates on two artificial substrates at each of four locations on Smith Creek, 1975. (A major taxon occurred as 0.5% or more of total abundance.)



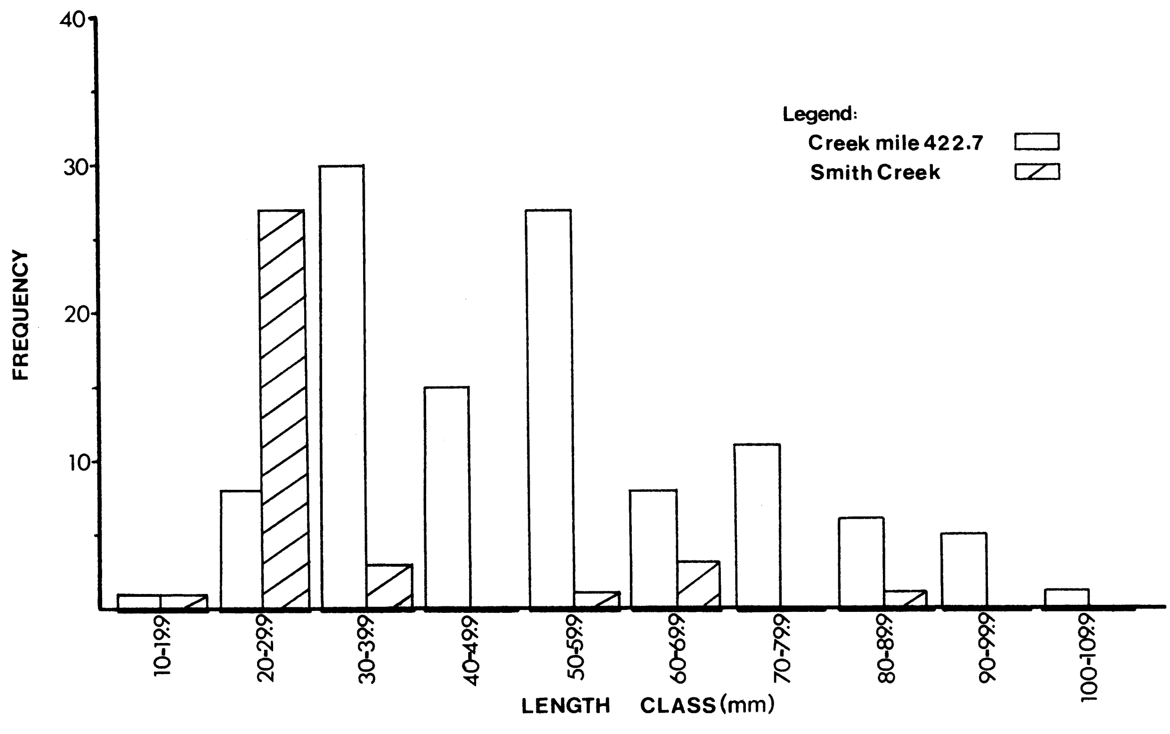


Figure 12. (a) Length-weight relationships for slimy sculpins from Creek Mile 422.7 and Smith Creek, 1975.

(b) Length frequency of slimy sculpins from Creek Mile 422.7 and Smith Creek, 1975.

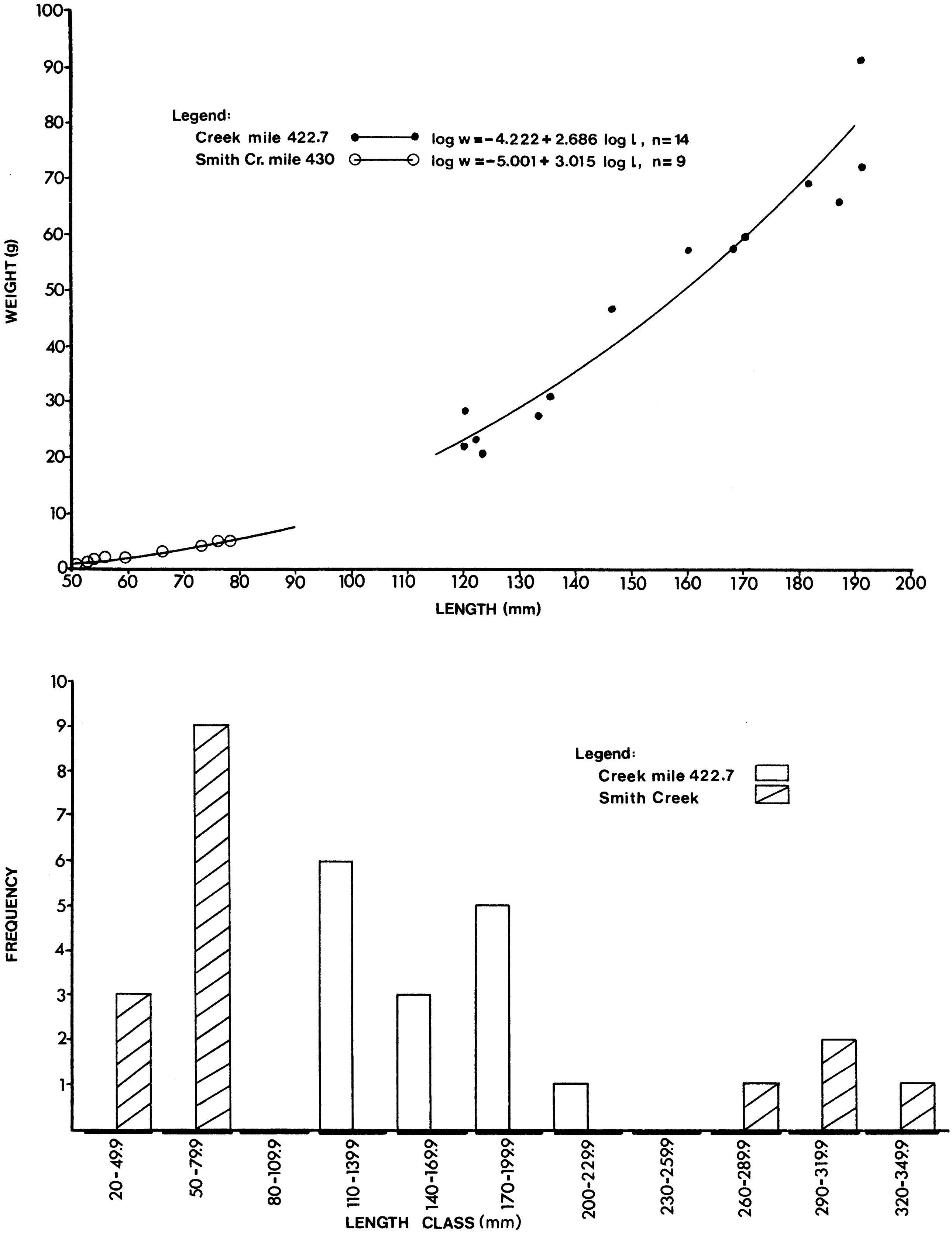


Figure 13. (a) Length-weight relationships for arctic grayling from Creek Mile 422.7 and Smith Creek, 1975.

(b) Length frequency of arctic grayling from Creek Mile 422.7 and Smith Creek, 1975.

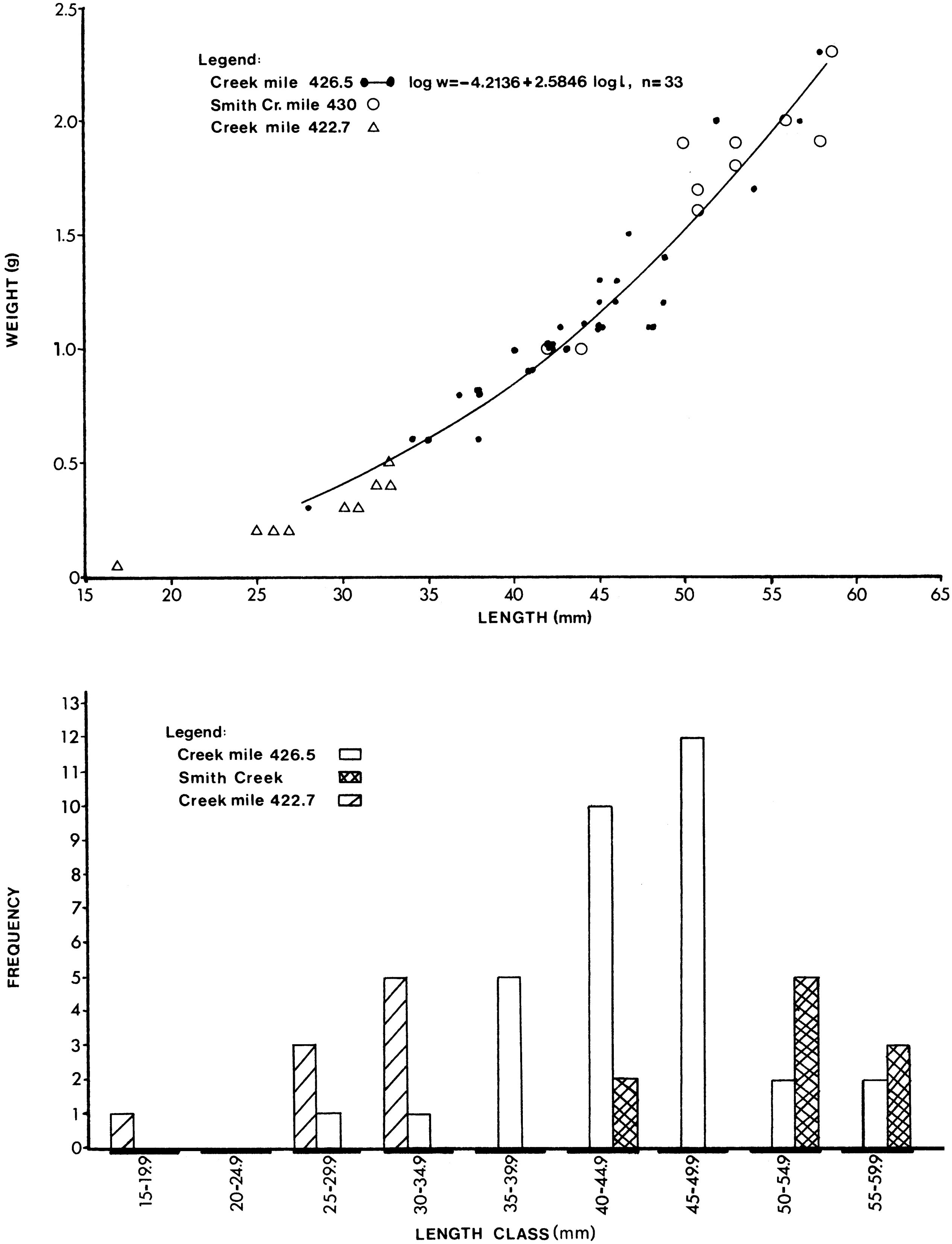


Figure 14. (a) Length-weight relationships for lake chub from Creek Mile 422.7, Creek Mile 426.5 and Smith Creek, 1975.

(b) Length frequency of lake chub from Creek Mile 422.7, Creek Mile 426.5 and Smith Creek, 1975.

APPENDIX I. WATER LEVELS FOR CREEK MILE 422.7, CREEK MILE 426.5 AND SMITH CREEK

Sampling Station Number	BM elevation in meters	August 15	August 29	Sept. 12	Sept. 25	Oct. 9	Oct. 23	Feb. 4
1	BM = 30.480	29.730	29.720	29.765	29.745	29.810	29.725	30.96†
2	BM = 25.450		24.460	24.470	24.430	24.49	24.42*	26.22†
Highway Crossing	DPW Staff Gauge Zero Equal 24.650	25.695	25.745					27.23†
3	BM = 27.955	27.480	27.485	27.495	27.495	27.580	27.500	28.62†
4	BM = 30.480	30.040	30.040	30.085	30.080	30.195	30.085	
5	BM = 30.480	29.410	29.365	29.410	29.360	29.485	29.345	29.85† 29.155
6	BM = 31.990	31.980*	31.940*	31.990	31.950*	32.110	31.950	31.86*
7	BM = 28.440	27.575	27.515	27.570	27.540	27.670	27.535	27.460
8	BM = 30.480	29.780	29.775	29.795	29.795	29.890	29.750	29.625
11	BM = 30.480	30.574	30.446	30.370	30.587	30.745	30.593	

*extrapolated from cross-section depth measurement.
†ice level.

APPENDIX II. DETAILED WATER CHEMISTRY OF CREEK MILE 422.7

PARAMETER	14 AUGUST 1975 LOCATION				8 OCTOBER 1975 LOCATION				4 FEBRUARY 1975 LOCATION			
	1	2	3	4	1	2	3	4	1	2	3	4
Temperature (°C)	10.0*	8.0*	8.0*	8.5*	1.0*	1.0*	1.0*	1.0*	0.0*	0.0*		
O_2 (mg/ℓ)	11*	11*	11*	11*	12*	12*	12*	13*	10*	12*		
pH	9.0*	8.0*	8.5*	8.5*	8.12 (8.5)*	8.02 (8.5)*	7.98 (8.5)*	7.98 (8.5)*	8.16 (8.0)*	8.33 (8.5)*		
Conductivity (μmho/cm at 25°C)					320	310	300	300	435	465		
T.S.S. (mg/ℓ)	<1	6		5					18	10		
Hardness (mg/ℓ as CaCO)	201	200		199	174	169	179	172	253	268		
Si (mg/ℓ)	2.62	2.67		2.61	2.52	2.51	2.53	2.51	3.23	3.66		
Ca (mg/ℓ)	55.7	56.5		56.1	49.1	48.0	50.9	49.1	69.5	73.6		
Na (mg/ℓ)	0.89	0.74		0.67	1.01	0.92	0.92	0.96	3.09	1.36		
Mg (mg/ℓ)	15.1	14.7		14.4	12.5	12.0	12.5	12.1	19.4	20.4		
K (mg/ℓ)	0.31	0.31		0.31	0.61	0.56	0.57	0.60	0.94	0.98		
Cl (mg/ℓ)					0.8	0.6	1.2	0.8	4.0	1.4		
SO_4 (mg/ℓ)					8.2	8.2	8.0	8.0	11.4	5.6		
NO_3 - N (μg/ℓ)					17	15	18	17	90	105		
T.D.N. (μg/ℓ)	360	350		330	420	400	430	450	330	450		
Susp. N (μg/ℓ)	86	6		3	43	17	54	42	40	34		
NH_3 - N (μg/ℓ)					10	10	10	10	20	30		
Susp. C (μg/ℓ)	740	410		290	570	460	390	400	1360	1170		
CO (μmole/ℓ)					2700	2680	2690	2670	4470	5520		
Susp. P (μg/ℓ)	24	12		12	<1	1	<1	<1	5	1		
PO_4 - P (μg/ℓ)					1	1	1	1	4	3		
T.D.P. (μg/ℓ)					9	8	8	7	6	7		

* Measurements taken on site at time of sampling.

T.S.S. Total suspended solids.

T.D.N. Total dissolved nitrogen.

T.D.P. Total dissolved phosphorus.

APPENDIX III. DETAILED WATER CHEMISTRY OF CREEK MILE 426.5

PARAMETER	14 AUGUST 1975 LOCATION 11	LOCATION 9	8 OCTOBER 1975 LOCATION 10	LOCATION 11
Temperature (°C)	14.0*	2.0	2.0*	2.0*
O_2 (mg/ℓ)	8*	12*	11*	12*
pH	8.0*	8.29 (8.5)*	8.01 (8.0)*	7.95 (8.0)*
Conductivity (μmho/cm at 25°C)		370	250	250
T.S.S. (mg/ℓ)	1	69	9	2
Hardness (mg/ℓ as $CaCO_3$)	143	173	140	139
Si (mg/ℓ)	2.40	2.72	2.17	2.20
Ca (mg/ℓ)	41.7	48.5	41.7	41.1
Na (mg/ℓ)	0.59	11.9	1.01	0.92
Mg (mg/ℓ)	9.34	12.5	8.7	8.9
K (mg/ℓ)	0.10	0.71	0.30	0.32
Cl (mg/ℓ)		19.4	0.6	1.0
SO_4 (mg/ℓ)		23.4	6.0	6.4
NO_3 - N (μg/ℓ)		22	15	14
T.D.N. (μg/ℓ)	570	510	590	620
Susp. N (μg/ℓ)	57	84	63	48
NH_3 - N (μg/ℓ)		10	10	20
Susp. C. (μg/ℓ)	610	1670	1040	680
CO_2 (μmole/ℓ)		2610	2230	2230
Susp. P. (μg/ℓ)	21	36	8	1
PO_4 - P (μg/ℓ)		2	1	1
T.D.P. (μg/ℓ)		8	9	8

* Measurements taken on site at time of sampling.

T.S.S. Total suspended solids.

T.D.N. Total dissolved nitrogen.

T.D.P. Total dissolved phosphorus.

APPENDIX IV. DETAILED WATER CHEMISTRY OF SMITH CREEK.

PARAMETER	14 AUGUST 1975 LOCATION				8 OCTOBER 1975 LOCATION				4 FEBRUARY 1976 LOCATION			
	5	6	7	8	5	6	7	8	5	6	7	8
Temperature (°C)	15.0*	13.0*	13.5*	13.0*	2.0*	2.0*	2.0*	2.0*	0.0*	1.0*	3.0*	3.0*
O_2 (mg/ℓ)	10*	10*	10*	10*	12*	12*	13*	13*	11*	11*	10*	12*
pH	8.5*	8.5*	8.5*	8.5*	8.20 (8.5)*	8.24 (8.5)*	8.25 (8.5)*	8.28 (8.5)*	8.24 (8.5)*	8.20 (8.5)*	8.19 (8.5)*	8.18 (8.0)*
Conductivity (µmho/cm at 25°C)					450	460	440	400	2150	2170	2160	1975
T.S.S. (mg/ℓ)	8	6	2	1	23	10	9	5	18	24	39	10
Hardness (mg/ℓ as $CaCO_3$)	260	263	278	255	217	223	216	209	656	624	656	682
Si (mg/ℓ)	2.65	2.76	2.73	2.63	2.72	2.70	2.70	2.63	5.26	5.32	5.36	5.25
Ca (mg/ℓ)	70.9	70.9	78.2	70.9	61.1	62.3	61.1	59.4	173	167	175	181
Na (mg/ℓ)	23.68	24.60	20.00	10.99	14.6	15.1	11.9	7.25	216	228	211	191
Mg (mg/ℓ)	20.1	20.8	20.1	19.0	15.6	16.3	15.4	14.7	54.5	50.3	53.2	56.0
K (mg/ℓ)	0.82	0.82	0.72	0.62	0.84	0.84	0.81	0.70	4.14	4.24	4.28	4.17
Cl (mg/ℓ)					25.0	26.0	20.2	11.6	355	328	358	327
SO_4 (mg/ℓ)					41.5	38.5	34.5	26.0	442	465	465	480
NO_3 - N (µg/ℓ)					15	12	16	12	85	80	75	90
T.D.N. (µg/ℓ)	320	410	410	410	470	530	490	530	170	180	160	170
Susp. N (µg/ℓ)	39	13	11	16	83	52	14	71	32	2	83	39
NH_3 - N (µg/ℓ)					20	10	10	10	30	30	30	30
Susp. C (µg/ℓ)	550	960	560	390	920	540	250	710	570	730	1570	360
CO_2 (µmole/ℓ)					2850	2850	2790	2820	4250	4200	4200	4360
Susp. P (µg/ℓ)	19	37	15	15	6	4	3	3	8	12	19	3
PO_4 - P (µg/ℓ)					1	1	1	1	4	4	4	3
T.D.P.					11	11	9	9	6	6	6	10

* Measurements taken on site at time of sampling.

T.S.S. Total suspended solids.

T.D.N. Total dissolved nitrogen.

T.D.P. Total dissolved phosphorus.

APPENDIX V. FOOD ITEMS AS PERCENT BY NUMBER, OF DIET IN SLIMY SCULPIN STOMACHS FROM CREEK MILE 422.7

Fork length range (mm)	0 - 25	26 - 50	51 - 75	76 - 100	101 - 125	0 - 125
Numbers of stomachs analysed	2	52	40	19	1	114
Number of empty stomachs (%)	2 (100.0)	23 (44.2)	8 (20.0)	6 (31.6)	0 (0.0)	39 (34.2)
Mean numbers of organisms/stomach	0.0	1.8	2.2	1.5	1.0	1.9
Food Item % of Diet						
Ostracoda	0.0	17.6	2.3	0.0	0.0	7.8
Diptera						
Chironomidae	0.0	46.2	23.3	7.1	0.0	29.0
Other	0.0	5.5	8.1	3.6	0.0	6.2
Ephemeroptera	0.0	16.5	30.2	10.7	0.0	21.1
Trichoptera	0.0	7.7	24.4	35.7	0.0	19.6
Plecoptera	0.0	6.6	4.7	14.3	0.0	7.0
Fish	0.0	0.0	7.0	28.6	100.0	9.3

APPENDIX VI. FOOD ITEMS AS PERCENT BY NUMBER, OF DIET IN SLIMY SCULPIN STOMACHS FROM SMITH CREEK

Fork length range (mm)	0 - 25	26 - 50	51 - 75	76 - 100	0 - 100
Number of stomachs analysed	17	25	6	1	49
Number of empty stomachs (%)	4 (23.5)	6 (24.0)	0 (0.0)	0 (0.0)	10 (20.4)
Mean number of organisms/stomach	1.7	4.8	1.7	2.0	3.3
Food Item % of Diet					
Ostracoda	34.5	12.2	0.0	0.0	17.4
Insecta					
Diptera					
Chironomidae	41.4	56.6	10.0	0.0	42.9
Others	3.4	3.4	20.0	0.0	5.9
Trichoptera	10.3	15.7	50.0	100.0	21.3
Ephemeroptera	6.9	11.3	0.0	0.0	7.8
Plecoptera	3.4	0.8	20.0	0.0	4.6

APPENDIX VII. FOOD ITEMS AS PERCENT BY NUMBER, OF DIET IN ARCTIC GRAYLING STOMACHS FROM CREEK MILE 422.7.

Fork Length Range (mm)	100 - 140	141 - 180	181 - 220	100 - 220
Number of stomachs analysed	6	4	5	15
Number of empty stomachs (%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Mean number of organisms/stomach	37.2	29.3	56.4	41.5
Food Item % of Diet				
Arachnida				
Araneida	3.1	0.9	0.7	1.7
Hydracarina	4.5	0.0	0.0	1.8
Insecta				
Hymenoptera				
Formicidae	0.4	0.9	1.4	0.9
Other	2.2	7.8	2.8	3.9
Diptera				
Adult	10.8	0.0	2.1	5.0
Larvae				
Chironomidae	1.3	19.7	0.0	5.8
Other	1.8	0.9	0.4	1.1
Hemiptera				
Corixidae	7.6	5.1	4.6	5.9
Other	0.0	0.9	0.0	0.2
Plecoptera	0.4	0.0	0.0	0.2
Ephemeroptera	0.9	0.0	0.0	0.4
Trichoptera	65.5	63.2	86.9	72.0
Coleoptera	1.3	1.7	1.1	1.3

APPENDIX VIII. FOOD ITEMS AS PERCENT BY NUMBER, OF DIET IN ARCTIC GRAYLING STOMACHS FROM SMITH CREEK.

Fork Length Range (mm)	40 - 90	280 - 330	40 - 330
Number of stomachs analysed	12	4	16
Number of empty stomachs (%)	0 (0.0)	0 (0.0)	0 (0.0)
Mean number of organisms/stomach	5.3	19.8	8.9
Food Item % of Diet			
Gastropoda	0.0	1.3	0.3
Arachnida			
Araneida	1.6	0.0	1.2
Insecta			
Hymenoptera			
Formicidae	3.2	1.3	2.7
Others	6.3	1.3	5.1
Diptera			
Adult	14.3	0.0	10.7
Larvae			
Chironomidae	15.9	0.0	11.9
Other	1.6	0.0	1.2
Hemiptera			
Corixidae	0.0	1.3	0.3
Notonectidae	0.0	1.3	0.3
Trichoptera	39.7	91.1	52.6
Coleoptera	3.2	1.3	2.7
Ephemeroptera	11.1	0.0	8.3
Plecoptera	1.6	0.0	1.2
Odonata	1.6	0.0	1.2
Orthoptera	0.0	1.3	0.3