SEASONAL CHANGES OF BENTHIC MACROINVERTEBRATE COMMUNITIES IN SOUTHWESTERN BRITISH COLUMBIA

Prepared for:

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FRAP Report Number: DOE- FRAP1998-33

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September 1998

Funding for the study was provided by Environment Canada through the Fraser River Action Plan's Environmental Quality Program.

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Abstract

Two main goals of community ecology are to recognize patterns in species composition and to understand the processes affecting those patterns. The first goal of this study was to identify patterns of benthic macroinvertebrate composition between both different classes of streams and seasons in southwestern British Columbia. Insect life cycles and environmental conditions were examined to determine which processes were associated with patterns of community composition.

To address the goals of this study, benthic macroinvertebrate samples and associated environmental data were collected over five sampling dates during the course of one year, 1995-1996 (late spring, summer, autumn, winter, early spring). The samples were collected from eight streams that comprised three different classes of streams: 1) coastal streams, 2) interior plateau streams, and 3) large rivers. Each of the stream classes has a different climate, elevation, riparian vegetation, and discharge regime.

Seasonal change of the benthic invertebrate community was small relative to the spatial change, i.e., between the three stream classes. Correlation analysis indicated that spatial change of the invertebrate community in southwestern British Columbia was related to the environmental factors channel width, mean depth, maximum depth, maximum velocity, discharge, conductivity, alkalinity, nitrite and nitrate nitrogen, and total Kjeldahl nitrogen. Seasonal change of the community was not directly related to the seasonal change of any of the individual environmental variables measured. It was however, related to changes in the environment through effects of the environment on invertebrate life cycles. Of the environmental conditions measured, temperature had the greatest influence on the timing of insect life cycles. Abundance patterns in the small coastal and interior streams were related to the timing of invertebrate life cycles whereas abundance was related to life cycles and the spring freshet in the large rivers.

Résumé

Les deux grands objectifs de l’écologie des communautés sont de repérer les variations régulières de la composition en espèces et de comprendre les processus qui les régissent. Le premier but de la présente étude était de déterminer les fluctuations de la composition en macro-invertébrés benthiques dans le sud-ouest de la Colombie-Britannique en fonction, d’une part, de la catégorie de cours d’eau et, d’autre part, de la saison. On a examiné les cycles biologiques des insectes et les conditions environnementales pour déterminer quels processus étaient associés aux caractéristiques de la composition des communautés.

Pour ce faire, on a recueilli des échantillons de macro-invertébrés benthiques et des données environnementales connexes à cinq occasions sur l’espace d’un an, soit en 1995-1996 (fin du printemps, été, automne, hiver, début du printemps). Les échantillons ont été prélevés dans huit cours d’eau représentant trois catégories différentes : 1) fleuves côtiers, 2) cours d’eau des plateaux de l’intérieur et 3) cours d’eau importants. Chaque catégorie présente des caractéristiques différentes pour ce qui est du climat, de l’altitude, de la végétation riveraine et du débit.

Les variations intersaisonnières de la communauté d’invertébrés benthiques étaient relativement faibles par rapport aux variations spatiales, c.-à-d. entre les trois catégories de cours d’eau. L’analyse de corrélation a mis en évidence que les variations spatiales de la communauté d’invertébrés dans le sud-ouest de la Colombie-Britannique étaient liées aux facteurs environnementaux : largeur du chenal, profondeur moyenne, profondeur maximale, vitesse maximale, débit, conductivité, alcalinité, teneur en azote sous forme de nitrite et de nitrate, et azote total Kjeldahl. Les fluctuations saisonnières n’étaient directement liées aux variations saisonnières d’aucun des paramètres environnementaux mesurés. Elles étaient par contre liées à des changements de l’environnement, via les effets de ce dernier sur les cycles biologiques des invertébrés. Parmi les variables environnementales mesurées, c’est la température qui avait le plus d’influence sur la survenue des étapes du cycle biologique des insectes. Les abondances étaient liées au moment de survenue des stades biologiques des invertébrés dans les petits cours d’eau côtiers et ceux de l’intérieur, mais liées aux cycles biologiques et à la crue printanière dans les cours d’eau plus importants.

Acknowledgments

Many thanks go to the people who helped with my sampling, sample processing and invertebrate identification: Jeremy Detman, Jessica Kaman, Craig Logan, and Jill Melody. Thanks also go to the people who generously donated their time and effort to verify my invertebrate identifications: Art Borkent, Jeff Cumming, Doug Currie, Boris Kondratieff, and Rob Roughly. The text benefited from the comments of Bill Neill, Trefor Reynoldson and Dave Rosenberg on an earlier draft. This project was funded by Environment Canada's Fraser River Action Plan and NSERC.

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Chapter One

INTRODUCTION

1.1.0 *The Benthic Community*

The benthic community is the assemblage of species populations which occur and interact together in space and time on the bottom of streams and rivers (Begon *et al*. 1990). Community composition or structure is described by the number of coexisting species and their relative abundance. Benthic macroinvertebrate communities of streams and rivers change both spatially and temporally (Hynes 1970), largely in relation to environmental factors. Three theoretical frameworks predict the relationship between environmental factors and community structure. The habitat templet concept holds that "…habitats provide the framework on which evolution forges characteristic species traits…"(page 3) and influences community composition (Southwood 1977, 1988; Townsend and Hildrew 1994). The river continuum concept (RCC) describes the changing structure and function of communities along a river system in response to the changing abiotic environment and upstream processes (Vannote et al. 1980; Minshall *et al*. 1985). The patch dynamics concept examines the importance of temporal phenomena, history, and chance in organizing communities (Townsend 1989).

Field studies and the use of predictive models have provided support and evidence that abiotic factors influence community composition. Community structure is known to be related to environmental factors (e.g., Corkum 1990; Richards *et al*. 1993; Tate and Heiny 1995). As well, models have been used for the successful prediction of community structure based on physical and chemical features of the environment (e.g. Wright 1995; Reynoldson *et al.* 1995). However, the most influential abiotic factors vary from system to system and with the spatial scale of the study (Corkum 1990; Cobb *et al*. 1992; Tate and Heiny 1995). Abiotic factors that are related to community structure include discharge, substrate, dissolved substances, turbidity, riparian vegetation, land use, temperature, altitude, and latitude (Hynes 1970).

Many of the environmental conditions that are related to community structure change seasonally. Yet, surprisingly, few studies have related the seasonal change in community structure with changes in the environment (Giller and Twomey 1993). The benthic invertebrate community could change seasonally in association with changes in the environment and as invertebrates move through their life cycles (Hynes 1970). Previous studies have related the timing of life cycle events and size at emergence with temperature, photoperiod, food resources, and discharge (see review by Sweeney 1984; Poff 1989). Seasonal patterns of invertebrate abundance have been proposed and monitored (Hynes 1970; Boulton and Lake 1992; Bothwell and Culp 1993). Studies on the seasonal changes that occur in benthic communities and how they relate to the seasonal change of environmental conditions are needed.

1.1.2 *Purpose*

This study addresses how the benthic macroinvertebrate community changes seasonally both taxonomically and functionally, and the role of life cycles and environmental conditions in the seasonal change of community composition. Benthic community structure and associated environmental conditions were monitored in eight streams from three different classes of streams (large rivers, coastal, and interior streams) each having different climate, riparian vegetation, land use, and discharge regime. For the purpose of this study, the benthic macroinvertebrate community is defined as the assemblage of invertebrate species collected in the benthic samples. Although this may not be the full community of interacting organisms as seen from an invertebrate's point of view, it does include species populations which occur together in space and time and interact across trophic levels (Begon *et al.* 1990).

The findings of this study are presented in two main chapters. The first of which - Chapter 2 - examines the life cycles of three invertebrates found in the different classes of streams. Seasonal changes in benthic communities and invertebrate abundance are attributed in part to invertebrate life cycles. The potential for life cycles to differ in the three types of streams because of different environmental conditions means that faunal communities may have different seasonal patterns. The influence on invertebrate life cycles of discharge regime, food resources, and temperatures is determined.

Chapter 3 considers how the community changes seasonally and whether the seasonal changes can be attributed to life cycles and/or particular environmental conditions. The chapter also examines how the community differs between the three classes of streams, and which environmental factors are related to the spatial change in community structure. Finally, the relative importance of spatial versus temporal change is considered. Both taxonomic and functional classifications are analyzed.

Chapter Two-LIFE CYCLES OF THREE LOTIC INSECTS LIVING UNDER THREE DIFFERENT DISCHARGE REGIMES

2.1.0 Introduction

Ecology attempts to understand the relationship between the complex array of organisms and the environment (Begon *et al*. 1990), and it has been theorized that the physical environment provides a templet on which evolution forges characteristic life history strategies (Southwood 1977 1988; Chesson 1986; Townsend and Hildrew 1994). Environmental characteristics involved in habitat templets and thus related to life histories, include 1) habitat favorableness and disturbance frequency and intensity (Southwood 1977,1988), 2) the relative importance of stress, disturbance and competition (Grime 1977), and 3) temporal and spatial variation (Townsend 1989; Townsend and Hildrew 1994). Life history characteristics such as life cycle length, time to first reproduction, number of reproductive events, and number and size of offspring adapted to environmental conditions constitute appropriate ecological strategies for persistence in a habitat. For benthic macroinvertebrates environmental conditions influence life history parameters such as rate of larval growth, size of maturation, and the timing of life cycle events (review by Sweeney 1984).

Stream discharge influences many important structural attributes in streams (e.g., channel geomorphology and substrate stability) and varies temporally and spatially within and between lotic systems. Both unusually high and low levels of discharge constitute sources of disturbances in streams. Bankfull discharge is the level of discharge required to move dominant substrates and shape the stream channel (Newbury 1984), creating disturbances in streams (Poff 1992). Bankfull discharges and associated disturbances have a return time of 1-2 years (Newbury 1984). The return time of seasonal flooding and bankfull discharge, the associated disturbances, and discharge variability have the potential to influence benthic invertebrate life cycles.

The predictability and variability of discharge, and resulting disturbances, may influence the timing of benthic invertebrate life cycle events (Resh *et al.* 1988; Poff and Ward 1989). Resh *et al.* (1988) proposed that benthic invertebrates are adapted to predictable seasonal changes in discharge, but data are still needed to determine whether this is true (Poff and Ward 1989; Poff 1992; Robinson *et al*. 1992). Poff (1989) identified potential biological and life cycle attributes of lotic invertebrates under different levels of discharge variability and predictability. Adaptations to minimize exposure to predictable seasonal scour associated with bankfull discharge include modifications to life cycles, behavioral responses, or both. Life cycle tactics to avoid the seasonal scour may include alterations to the timing or duration of resting, egg, or adult life cycle stages. Modifications to life cycle timing will vary depending on the intensity, frequency and predictability of hydrologic disturbance events (Resh *et al*. 1988; Poff and Ward 1989). As a result, there is the potential for invertebrate life cycles to differ, within a species, when populations inhabit streams with different discharge regimes.

A few studies have looked at the influence of discharge regime on invertebrate life histories and characteristics. For example, life history traits of the snail *Juga plicifera* are influenced by stream size (Diamond 1982), and thus habitat predictability (Leopold 1962; Ward and Stanford 1980). Snail populations from large streams with less variable discharge, had low individual fecundity, high individual survivorship, and high individual biomass. In contrast, snail populations from small unpredictable streams had high individual fecundity, low survivorship, and low individual biomass (Diamond 1982). Greater genetic variability occurs in invertebrates living in streams with more variable discharge regimes (Robinson *et al*. 1992).

In southwestern British Columbia (Fig. 2.1) there are three different classes of streams with discharge regimes of different predictability. In the interior streams, bankfull discharge occurs with snowmelt in the spring (see Fig. 2.2A). The discharge level achieved and the duration depends on the depth of the snow pack and the speed of melting. The second characteristic discharge regime, found in coastal streams, is characterized by high and variable winter discharge caused by heavy winter rains (Fig. 2.2B). The winter rains begin in late September and last through January and February; bankfull discharge is typically achieved during this period. The third discharge regime, found in large rivers, is quite predictable and is characterized by a unimodal freshet that lasts from early April until late August

(Fig. 2.2C). The long freshet of large rivers is a result of the slightly different timing of snowmelt in subdrainage basins. The life cycles of benthic invertebrates common to these three classes of streams may differ if the invertebrates have adapted their life cycles to the seasonal change in discharge.

The three stream classes used in this study also have different climates, geology, and riparian vegetation. As a result, the streams differ in water temperature, chemistry, nutrients, primary production, and the type and amount of organic matter inputs. Environmental variables such as temperatures, in-stream primary production, and allochthonous inputs influence life cycle timing, survival rates, and growth rates of benthic invertebrates (review by Sweeney 1984). Temperature may be the single most important factor influencing egg development, growth rates, and timing of emergence (Corkum 1978; Vannote and Sweeney 1980; Sweeney 1984). The quality and quantity of food resources also affects growth rates and size at maturation (Anderson and Cummins 1979). In natural systems, it can be difficult to distinguish between the relative importance of temperature and food resources on growth rates (Sweeney and Vannote 1981; Hawkins 1986).

The purpose of this study was to examine the timing of benthic invertebrate life cycles in the three different classes of streams southwestern British Columbia. According to the classification scheme developed by Poff and Ward (1989), the three classes of streams are all perennial and have high flood predictability and low flood frequency. As such, the invertebrates should have synchronous development, and emergence and reproduction should be temporally cued to floods for a given stream type (Poff and Ward 1989). There are two potential strategies the invertebrates may adopt to cope with the seasonal flooding and associated disturbances. First, invertebrates could use emergence periods, or egg stages to avoid seasonal flooding, i.e., they would be absent from the stream during seasonal flooding (Gray 1981). Second, invertebrates may be mobile larvae using behavioural tactics to deal with the scour (Gray 1981).

The timing of invertebrate life cycles could also differ between stream classes given the different climates, water chemistry, allochthonous and autochthonous inputs. Invertebrate abundance and growth rates should be greatest in the summer and autumn because warm temperatures, high primary production, and the greatest input of organic matter should occur at this time.

2.2.0 Study Sites

Benthic invertebrate samples and associated environmental data were collected from three interior streams (Mellin Creek, Glimpse Creek, and Beak Creek), three coastal streams (Spring Creek, Mayfly Creek, and the North Alouette River), and two large rivers (Fraser and Thompson Rivers) all located in southwestern British Columbia (B.C.) (Fig. 2.1). One riffle was sampled in each river. Each study site was chosen because it was the site of previous research, (Spring Creek, Mayfly Creek, Fraser River, Thompson River) or the site was accessible and the stream maintained flow year round, (North Alouette River, and the interior streams). See Table 2.1 for the environmental characteristics of each stream.

2.2.1 *Interior Streams:*

The interior streams are located in the Nicola River watershed. The climate of the Nicola drainage basin is arid with an average annual rainfall of 223 mm and snowfall of 88 cm at Merritt (Environment Canada, Historical and Statistical Climate Information). Summer temperatures reach 35C and winter temperatures dip to -30C. Beak Creek was inaccessible in the winter, and could not be sampled. Highest discharge occurs in the spring as a result of snow melt (Fig. 2.2A). Through the summer, there is very little precipitation and many streams in the area become intermittent. The three streams chosen for this study maintained some flow throughout the entire year. The interior streams have the highest elevations of all the streams sampled (Table 2.1).

Agriculture is the dominant land use in the Nicola Drainage Basin and most streams, including those sampled for this study, are impacted by cattle. Glimpse Creek is less impacted by cattle than Mellin and Beak Creek. The riparian vegetation for all three interior streams consists of *Pseudotsuga menziesii* (Douglas fir), *Picea glauca* (white spruce), and *Picea engelmanii* (Engelmann spruce). Deciduous vegetation at Mellin Creek consists of *Salix* spp. (willow) along with abundant grasses and herbs, and at Beak Creek it consists of *Alnus* spp. (alder) and very few grasses or herbs. At Glimpse Creek there is almost no deciduous riparian vegetation. Parent rock surrounding the interior streams consists of sedimentary rocks, in particular limestone (Geological Survey of Canada, 1969). The extreme temperatures in the interior increase the rate of weathering of the sedimentary rocks and result in hardwater streams with high alkalinity, high conductivity, and a slightly basic pH (Table 2.1).

2.2.2 *Coastal Streams:*

The three coastal streams sampled are located in the Malcolm Knapp Research Forest in the Pitt River catchment. This area is a second growth forest with a closed canopy and some logging in the watersheds. The coastal climate consists of heavy winter rains and correspondingly high and variable winter discharges (Fig. 2.2B). Reduced levels of precipitation through the summer result in lower and less variable discharge. Average annual precipitation at the entrance to the research forest consists of 2016.6 mm rain and 73 cm snow (Environment Canada, Historical and Statistical Climate Information). Air temperatures can range from 30C in the summer to -10C in the winter. The dominant vegetation in the area consists of *Tsuga heterophylla* (western hemlock), *Thuja plicata* (western red cedar), and Douglas fir. Red alder (*Alnus rubra*), *Oplopanax horridum* (Devil’s club), and a variety of ferns can be found along the stream banks and in the understory. These streams have the highest gradients of the three classes of streams and are at intermediate elevations (Table 2.1). The parent rock surrounding the coastal sites consists of quartzite (Geological Survey of Canada, 1957 and 1969). The hard rocks and temperate coastal climate result in very slow weathering of the parent material, so the streams have soft water, low alkalinity, low conductivity, and are slightly acidic (Table 2.1).

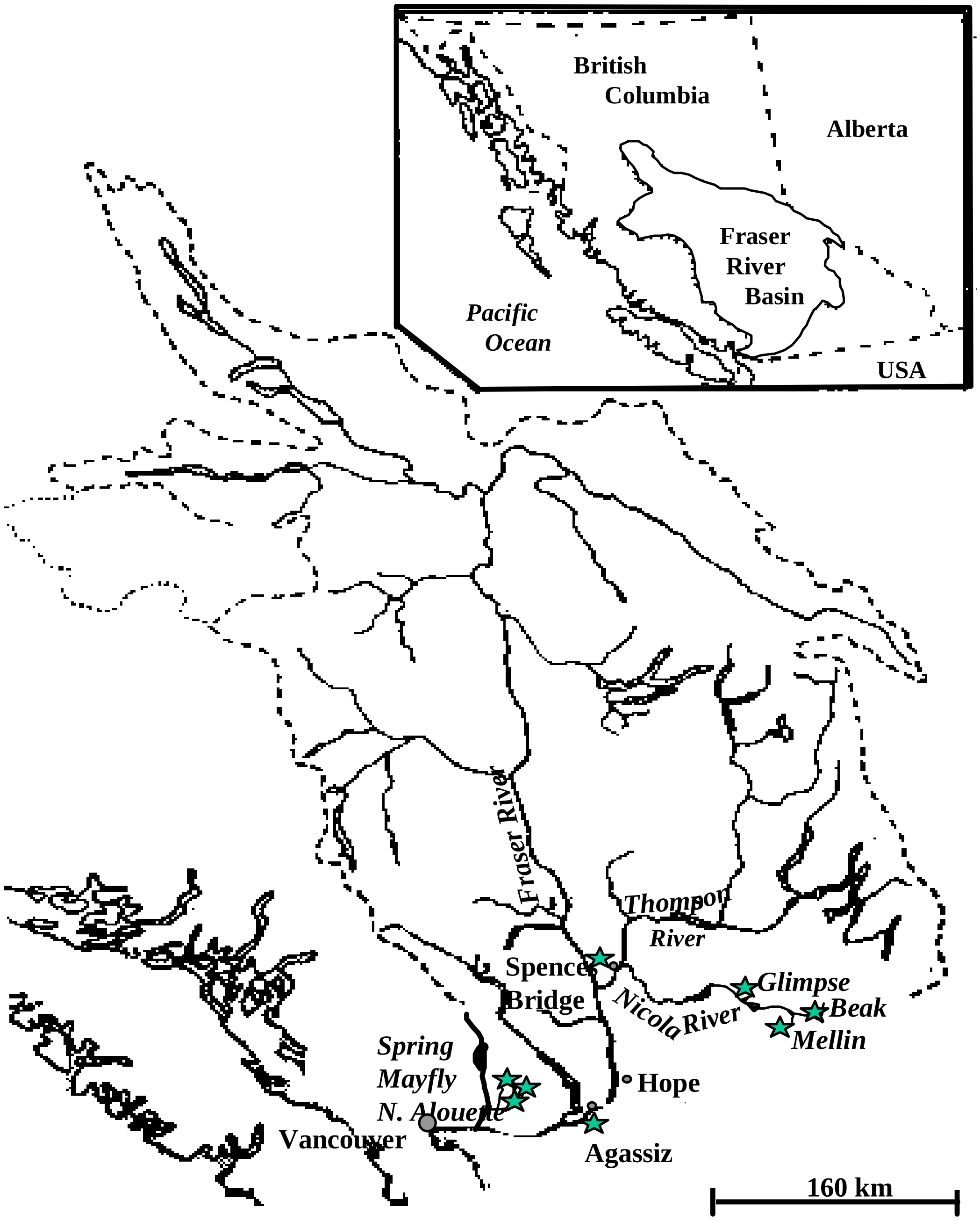

Figure 2.1: Location of seasonal test sites in southwestern British Columbia (★). All eight sampling sites are located in the Fraser River Drainage Basin.

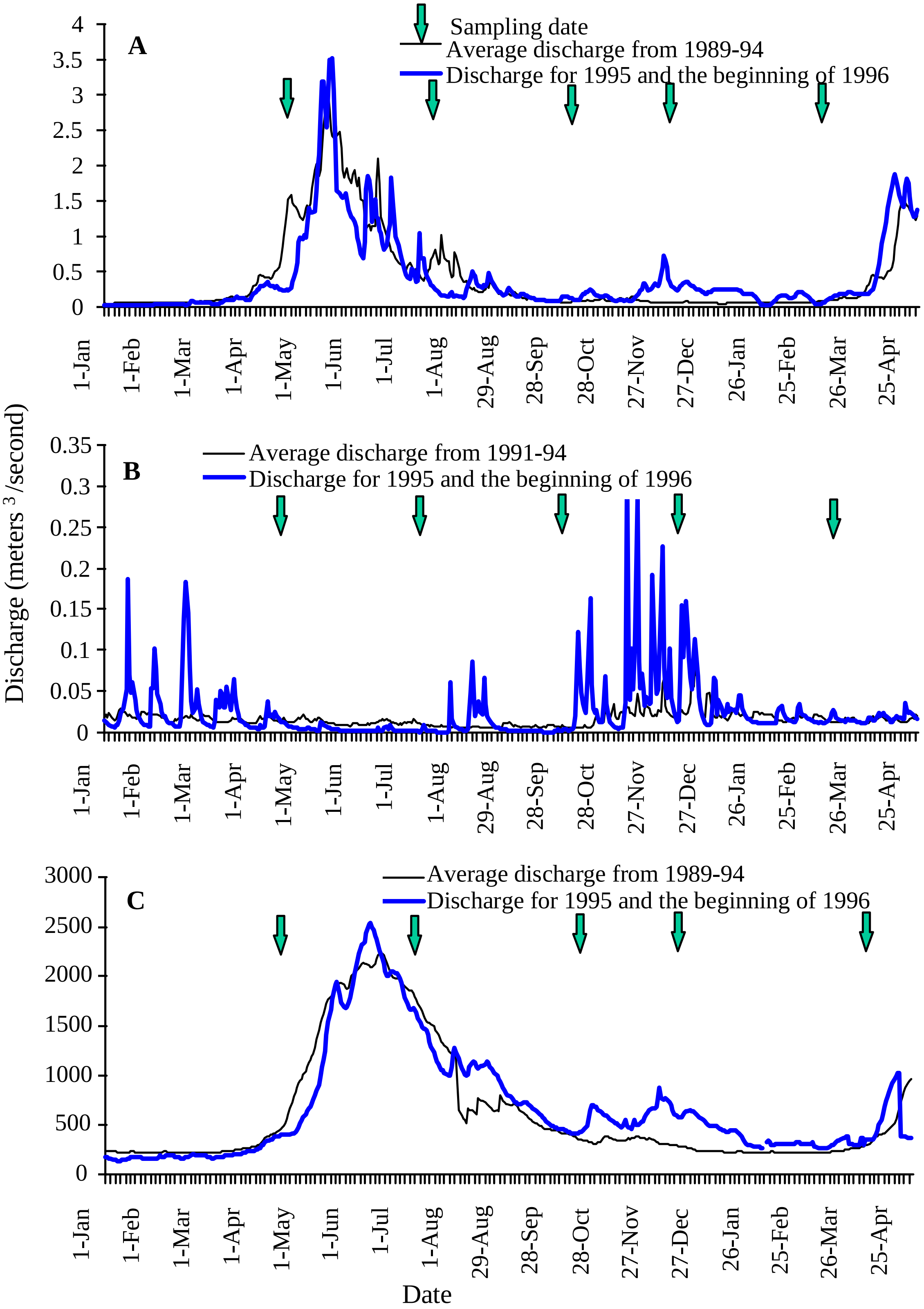

Figure 2.2: Typical hydrographs for interior streams (Beak Creek - A) (source: Environment Canada, Water Survey), coastal streams (East Creek - B) (source: Dr.M. Feller, Forest Sciences, UBC), and large rivers (Thompson River at Spences Bridge - C) (source: Environment Canada, Water Survey). The dates the streams were sampled are indicated by the arrows. Note the scales differ.

Table 2.1 Physical and environmental characteristics for each seasonal test site stream. Ranges are given for variables that changed seasonally. Stream order is based on a 1:250 000 scale map.

	Interior			*Coastal*			*Large Rivers*	
	Mellin	Glimpse	Beak	Spring	Mayfly	N. Alouette	Fraser	Thompson
Latitude	50° 7’ 1.1	50° 15’ 2	50° 6’ 45.4	49° 16’ 0.3	49° 19’ 2	49° 17’ 0.8	49° 12’ 20.2	50° 25’ 28
Longitude	120° 6’ 28.8	120° 14’ 9	119° 58’ 51	122° 34’ 0.4	122° 32’ 0.4	122° 32’ 0.6	121° 46’ 7.2	121° 19’ 35
Elevation (m a.s.l.)	1123.1	1171.1	1003	132.9	413.5	315	68.7	204.2
Order	2	1	2	1	1	2	8	6
Drainage basin (km^2)	52.35	10.18	86.41	1.99	2.14	9.58	217000	54900
Channel slope	0.0204	0.0025	0.0170	0.0319	0.0020	0.0400	0.0002	0.0102
Channel width (m)	0.15 - 5.8	1.3 - 2.8	6.8 - 13.42	3.1 - 8.7	2.9 - 3.84	3.8 - 15	300 - 400.9	70 - 235.7
Mean depth (m)	0.07 - 0.41	0.08 - 0.22	0.106 - 0.27	0.03 - 0.99	0.11 - 0.88	0.21 - 0.38	0.4 - 1	0.3 - 0.5
Max. velocity (m^2/sec)	0.09 - 0.93	0.07 - 1.18	0.15 - 1.06	0.23 - 0.29	0.08 - 0.67	0.43 - 1.01	0.225- 1.72	0.152 - 1.41
Discharge (m^3/sec)	0.006 - 1.44	0.004-0.31	0.047-1.405	0.04 - 0.3	0.04 - 0.52	0.436 - 1.14	1060- 4480	409 - 1630
Temperature (^{o}C)	0.1 - 14.5	0.1 - 8.5	0.1 - 11.5	3.8 - 10	2 - 10	2 - 11	0 - 17.5	0.5 - 18
pH	7.21 - 8.1	7.69 - 8.25	7.44 - 8.45	6.37 - 6.73	5.71 - 7.68	5.65 - 6.68	6.94 - 8.08	7.58 - 8.65
Conductivity (*u*holm at 25 ^{o}C)	72.1-262.7	234.4-534.9	75.7 - 234.2	16.4 - 30	15.22 - 24.2	13 - 21.23	95.6 - 218	78.5 - 110.6
Alkalinity ($CaCO_3$) (mg/l)	40.2 - 97.6	123 - 201	30.2 - 86	4.9 - 12.1	2.4 - 10.2	0.1 - 4.5	39.2 - 56.9	29.2 - 42.2
NO_3NO_2 - N (mg/l)	0.005-0.071	0.005-0.057	0.005-0.06	0.032-0.199	0.036-0.1	0.096-0.147	0.005-0.156	0.032-0.148
TKN (mg/l)	0.487-0.674	0.286-0.34	0.21-0.48	0.03-0.19	0.04-0.092	0.037-0.075	0.118-0.39	0.069-0.127
Total phosphorus (mg/l)	0.045-0.089	0.007-0.016	0.028-0.034	0.001-0.005	0.002-0.006	0.000-0.004	0.028-0.101	0.006-0.017
Total suspended solids (mg/l)	4.33 - 32.9	1.35 - 3.05	1.56 - 3.56	0.38 - 2.2	0.29 - 1.76	0.06 - 1.2	9.46 - 62.51	0.96 - 3.41

2.2.3 *Large Rivers:*

The two large-river sampling sites were the Thompson River at Spences Bridge, and the Fraser River at Agassiz. Air temperatures at these sites range from 30C in the summer to -20C in the winter. Land use around Spences Bridge and Agassiz consists of agriculture, some rural development, and forested areas. There are major urban centers and pulp mills upstream of both sampling sites. The geology surrounding the Thompson River sampling site consists of undivided sedimentary and volcanic rocks (Geological Survey of Canada, 1969). The geology surrounding the Fraser River sampling site consists of recently deposited alluvium and glacial deposits (Geological Survey of Canada, 1969). The water at these two large river sites is probably influenced more by the various parent materials and land uses in their whole drainage basins than by the immediate surrounding area. The Fraser and the Thompson have an intermediate alkalinity, and a conductivity and pH similar to the interior streams (Table 2.1).

2.3.0 Methods

Benthic invertebrate samples and environmental data were collected from all eight streams. The samples were collected over 5 sampling dates spread between April 1995 and April 1996 (Fig. 2.2). The sampling dates were chosen to bracket the major discharge periods.

2.3.1 *Benthic Invertebrate Life Cycle and Abundance Data*

Benthic invertebrate samples were collected using triangular kicknets (38.5 cm for each side and 400-*u*m mesh). Five one-minute kicknet samples were collected at each site and date, in the large rivers, this meant starting at the river edge and moving into the river channel for one minute. In the small streams however, sample collection was achieved by kicking from stream bank to stream bank and then back until one minute had passed. Efforts were made to keep sampling intensity consistent between sites and sampling dates. Samples were taken at least three days after a high discharge event to avoid redistribution of animals and changes in sampling efficiency. The samples were preserved in 4% formaldehyde and then taken to the lab for sorting and identification. Three randomly chosen samples per site per date were processed.

If a sample contained less than 500 invertebrates the entire sample was sorted and all the invertebrates were identified. Samples containing more than 500 invertebrates were subsampled (Marchant 1989). The sample was poured into a 35x35x10cm box divided into 100 equal cells. A lid was placed onto the box, and the box was shaken to distribute the sample evenly among the cells. Cells were randomly emptied and the contents were sorted until 200 invertebrates were collected. The cell containing the 200th invertebrate was completed. Organisms in the subsample were identified to the lowest possible taxonomic level, numbers were extrapolated to a full sample.

Rosenberg *et al.* (in prep.) compared the results of subsampling 100, 200, and 300 invertebrates to sorting entire samples, and found no significant difference between the total number of invertebrates estimated and the actual numbers in the whole sample. Rosenberg *et al.* (in prep.) found no significant difference in the number of families estimated between the subsamples, but observed that fewer families were estimated by the subsamples than were in the entire sample. However, subsampling only missed rare families. Subsampling 200 invertebrates captured all the families that represented >5% of a sample and collected 46 % (± 36%) of the families that represented <1% of the sample (Rosenberg *et al.* in prep.). Because only taxa common in at least two stream classes were useful for this study, the loss of the rare taxa from the data set was not considered to be a problem.

Material not used in the subsample was split into two size fractions (greater and less than 2 mm) and any invertebrates greater than 2 mm long were collected to aid in identification of the smaller invertebrates. Quality assurance /quality control was maintained by resorting and reidentifying invertebrates from the first 20 samples processed, and then randomly selecting 10% of the remaining samples for reexamination. The resorting of the QA/QC samples was carried out by a different person than first sorted the sample. Sample specimens of almost all invertebrates identified were verified by experts (when possible), and a voucher collection was given to the Royal British Columbia Museum, Victoria.

Kicknet samples of organic matter permitted an estimate of the type and quantity of food resources available for detritivores. Organic material from the subsamples was split into two size fractions - <1mm (fine particulate organic matter [FPOM]), and >2mm (coarse particulate organic matter [CPOM]). The organic matter content of each size fraction was determined by drying it to a constant weight, weighing it, ashing it at 540C for one hour, and weighing it again.

The length of each invertebrate was determined using a dissecting microscope, digitizing tablet, and the Zoobenthos Biomass Digitizing Program (Hopcroft 1995). Weights were estimated using the length/weight regression slopes and intercepts, for the respective families included in the Zoobenthos Biomass Digitizing Program. Growth rates between sampling dates were calculated using (from Hawkins 1986):

$$G = \frac{\ln (W_t / W_o)}{t}$$

Where: G = growth rate (day^{-1})
W_t = weight at time t (mg)
W_o = weight at time 0 (mg)
t = time interval (number of days).

Invertebrate size, growth pattern, and wing pad development were used to determine invertebrate life cycles. Growth rates were used to determine the maximal growth period for each invertebrate in relation to the different environmental parameters. Correlation analysis (Proc Corr; SAS Institute 1996) was used to determine if invertebrate growth varied with allochthonous or autochthonous resources or water temperatures.

The invertebrates included in this study had to meet a number of criteria: 1) taxa had to be found in at least two of the three classes of streams; 2) they had to be identifiable to the species level; 3) they had to be abundant enough to determine what their life cycle was; and 4) univoltine taxa were preferred to facilitate identification of the life cycle. Only three taxa fulfilled the criteria: *Drunella doddsi* and *D. spinifera* (Ephemerellidae: Ephemeroptera) and *Zapada cinctipes* (Nemouridae: Plecoptera).

2.3.2 *Environmental Conditions*

Environmental variables were either measured when the benthic samples were collected or were determined from maps (Table 2.2). Measurement procedures for hydraulic variables such as drainage basin area, distance from source, stream order, stream channel slope, bankfull width, stream width, and discharge, were taken from Newbury (1984) and Newbury and Gaboury (1993). Drainage basin area and distance from source were calculated from 1:50000 scale maps by digitizing. Stream order was determined from 1:250000 scale maps. Slope, bankfull width and channel width were measured at each site. Discharge (m^3/s) for the small streams was determined by multiplying current velocity (m/s) with area (m^2). Current velocity was measured at regular intervals along the channel width and at 60% of the depth (site of average velocity for a given area) with a Marsh-McBirney electromagnetic current velocity meter. Discharge measurements for the Fraser and Thompson rivers and the annual discharge hydrograph for Beak Creek were supplied by the Water Survey Branch of Environment Canada. Environment Canada has gauging stations at the mouth of Beak Creek (200 m downstream of the sampling site used here) on the Thompson River at Spences Bridge, and on the Fraser River at Hope. There are no major tributaries to the Fraser River between Hope and Agassiz (Fig. 2.1), so there is less than 2% difference in discharge between Hope and Agassiz (Environment Canada, Water Survey). The discharge of a tributary of Spring Creek, East Creek, is continuously recorded, and was used to represent the coastal stream hydrograph (Michael Feller, Forest Sciences, UBC, unpublished data) (Fig. 2.2).

Periphyton samples were collected for chlorophyll-*a* content and periphyton biomass using the protocol adapted by Environment Canada (Rosenberg *et al.* in prep.). Three rocks from the stream

Table 2.2: Environmental variables measured and the respective abbreviations (adapted from Rosenberg et al. in prep.)

Geographic	*Site Characteristics*	*Channel Characteristics*	*Water Chemistry*
ecoregion (eco)	sampling date (julday)	bankfull width (bnkfl)	pH
latitude (lat)	flow state1 (riffle to pool) (flw1)	wetted width (width)	dissolved O2 (DO)
longitude (long)	canopy coverage (cpy)	mean depth (menD)	conductivity (cond)
elevation (elev)	macrophyte coverage (macro)	maximum depth (maxD)	temperature (temp)
stream order (order)	logging in riparian zone (log)	discharge (Q)	total P (totlP)
drainage basin area (DBA)	shrubs in riparian zone (shrub)	mean velocity (menV)	alkalinity (alkal)
distance from source (dist)	grass in riparian zone (grass)	maximum velocity (maxV)	ammonuim - N (NH4-N)
	coniferous vegetation (conif)	flow state2 (flw2)	nitrate and nitrite - N (NO3-N)
	deciduous vegetation (decid)	(slow subcritical to hydraulic jump)	suspended N (suspN)
		substrate framework (frmwrk)	suspended C (suspC)
		substrate matrix (matrx)	total Kjeldahl nitrogen (TKN)
		substrate embededness (embd)	total suspended solids (TSS)
		channel gadient (slope)	% carbon in suspended solids
			(% CTSS)

channel were selected at each sampling site. In small streams, one rock was selected from each of the right side of the stream, the left side, and the center while proceeding in an upstream direction. At large river sampling sites, the rocks were selected from the shallow, intermediate, and arms-length depths while proceeding in an upstream direction. Thus, bank-to-bank and upstream-downstream differences were accounted for. The rocks selected were representative of the channel substrate. Rocks selected were larger than base stream flow could move, so they were stable. Periphyton samples from the three rocks at a site were combined into one sample, which was taken to represent the primary production for that site and sampling date.

The periphyton sample was collected by placing a cylindrical template (11.3 cm^2) on the rock and removing the periphyton from within the template boundaries using a toothbrush attached to a drill bit and an electric drill. The composite sample from the three rocks represents a periphyton sample from 34 cm^2 of rock surface. Stream water was added to the periphyton sample to bring the volume up to 680 ml. This solution was blended to create a homogenous mixture. Twenty milliliter subsamples of the solution (1 cm^2 of rock surface area) were then filtered for chlorophyll-*a* and periphyton biomass analysis. The periphyton samples were dried, and frozen until analysis. Chlorophyll-*a* and biomass samples were analyzed according to Stainton *et al.* (1977).

2.4.0 Results

2.4.1 *Invertebrate Life Cycles, Abundance and Growth Rates*

Drunella doddsi, D. spinifera, and *Zapada cinctipes* were not equally abundant in each stream or between the different stream classes. *Drunella doddsi* was most abundant in Beak Creek and was found only occasionally in the North Alouette River, Spring Creek, and in the Thompson River (Fig. 2.3). *Drunella spinifera* was most abundant in Mayfly Creek and a few specimens were found in the Thompson River and in Beak Creek (Fig. 2.4). *Zapada cinctipes* occurred in all six small streams, but was only abundant enough for analysis in four of them, and was not found in any of the large river samples. The limited data from the other two streams (Beak Creek and the North Alouette River) were consistent with the data in Figures 2.5A and 2.5B.

In the interior streams, *Drunella. doddsi* emerged in early July, had begun hatching by early July, and had its greatest growth rate between July and October (Fig. 2.3 and Table 2.3). In the Thompson River, *D. doddsi* appeared in July and was not collected again. In the coastal streams, *Drunella doddsi* most likely emerged a little earlier and hatched a little earlier than in the interior streams, so *D. doddsi* in the coastal streams were slightly larger at each sampling date (Fig. 2.3).

In the coastal streams, *Drunella spinifera* was both emerging and hatching in July (Fig. 2.4). Its greatest growth rate was during the period between July and October (Table 2.3). The size *of D. spinifera* was similar in the large rivers, interior streams, and the coastal streams at each of the sampling dates (Fig. 2.4), so it appears that the life cycle and its timing of *D. spinifera* is similar in all three classes of streams.

In the coastal streams, *Zapada cinctipes* began emergence in December, and had begun hatching prior to late March/early April (Fig 2.5A), and had their highest growth rate between October and December (Table 2.3). In the interior streams, *Zapada cinctipes* did not emerge until late March/early April, hatching was concurrent (Fig. 2.5B), and they had their highest growth rates between July and October (Table 2.3).

Table 2.3: Growth rates between sampling dates for each taxa. For *Drunella doddsi*, 0.0191 day^{-1} is the growth rate for the period between October 1995 and April 1996. N/S indicates no sample

Taxa	*Site*	*Growth Rate (day^{-1})*			
		May - July	July - October	October - December	December - April
Drunella doddsi	Beak	0.0163	0.0416	0.0191	
D. spinifera	Mayfly	0.0172	0.0238	0.0067	0.008
Zapada cinctipes	Mayfly	-0.0018	0.0295	0.0405	N/S
Z.cinctipes	Mellin	N/S	0.0424	0.0187	0.0057

The abundance of each taxon varied with stream, sampling date, and life cycle stage. Abundance was greatest during the July sampling for all three taxa and in all three classes of streams (Fig. 2.6). Abundance of *Drunella doddsi* and *D. spinifera* was greatest during the period when emergence and hatching coincided (Fig 2.6A and B). Abundance of *Zapada cinctipes* was greatest after most of the eggs had hatched (Fig. 2.6C).

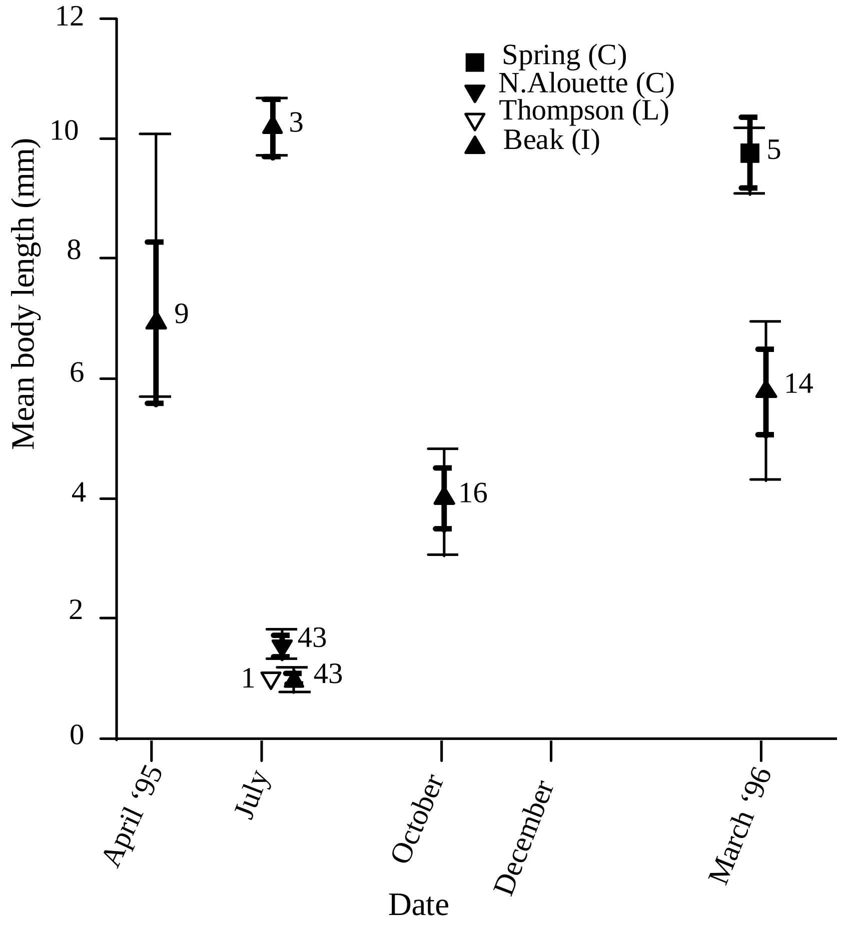

Figure 2.3: Size distribution of *Drunella doddsi* at each sampling date. Number of individuals measured is indicated. Thick bars represent standard deviation and thin bars represent upper and lower size ranges. C = coastal, I = interior, and L = large rivers.

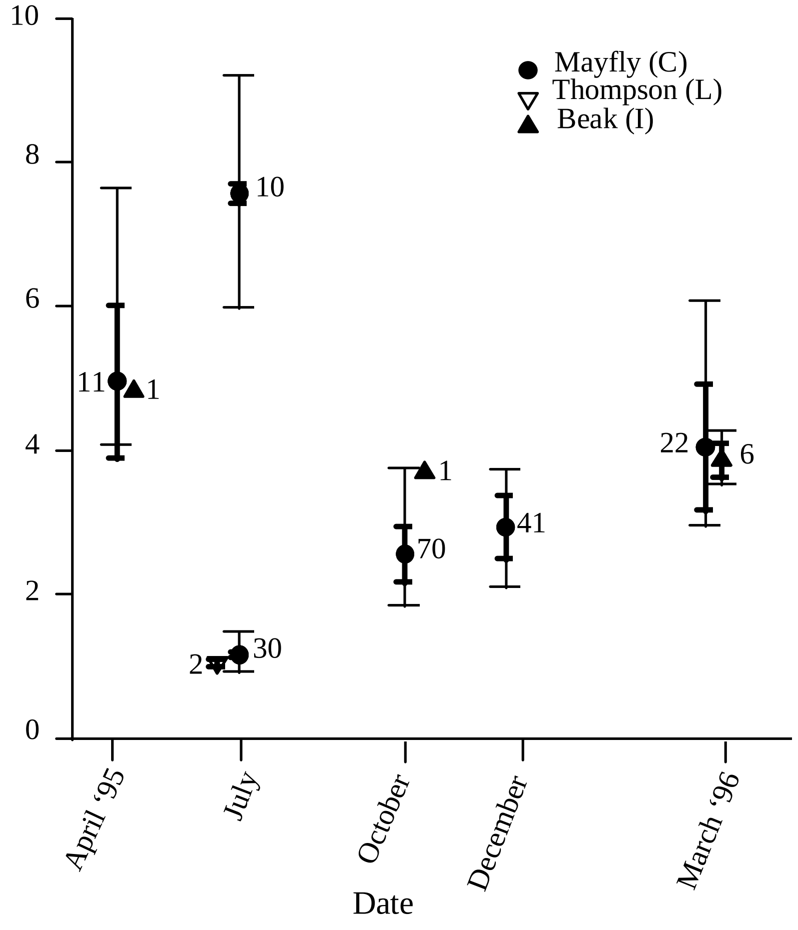

Figure 2.4: Size distribution of *Drunella spinifera* at each sampling date. Number of individuals measured is indicated. Thick bars represent standard deviation and thin bars represent upper and lower size ranges. C = coastal, I = interior, and L = large rivers.

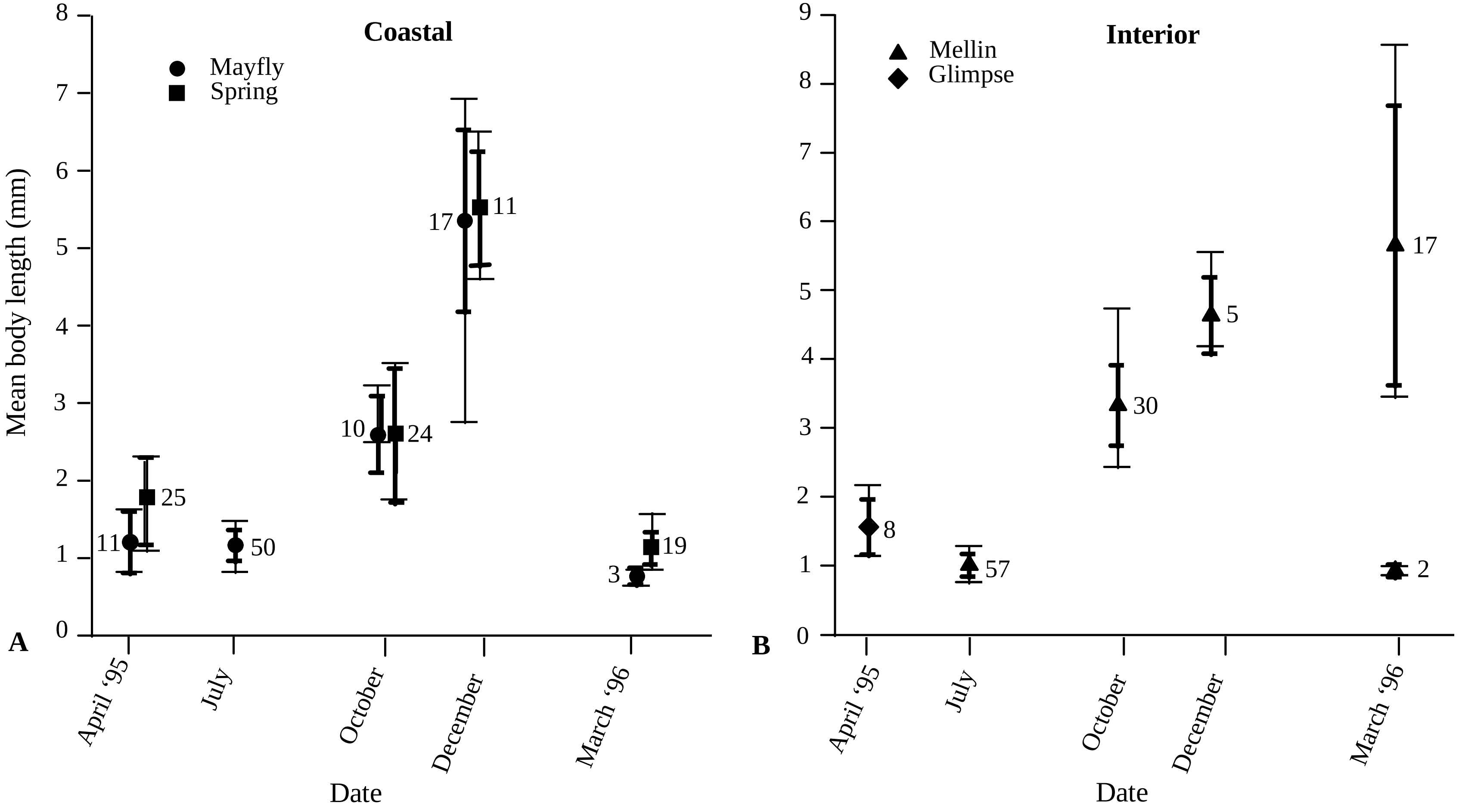

Figure 2.5: Size distribution of *Zapada cinctipes* from coastal (A) and interior (B) streams. The number of individuals measured is indicated. Thick bars represent standard deviation and thin bars represent the size range. *Zapada cinctipes* body lengths Mayfly and Spring Creek are off-set for each season to aid interpretation.

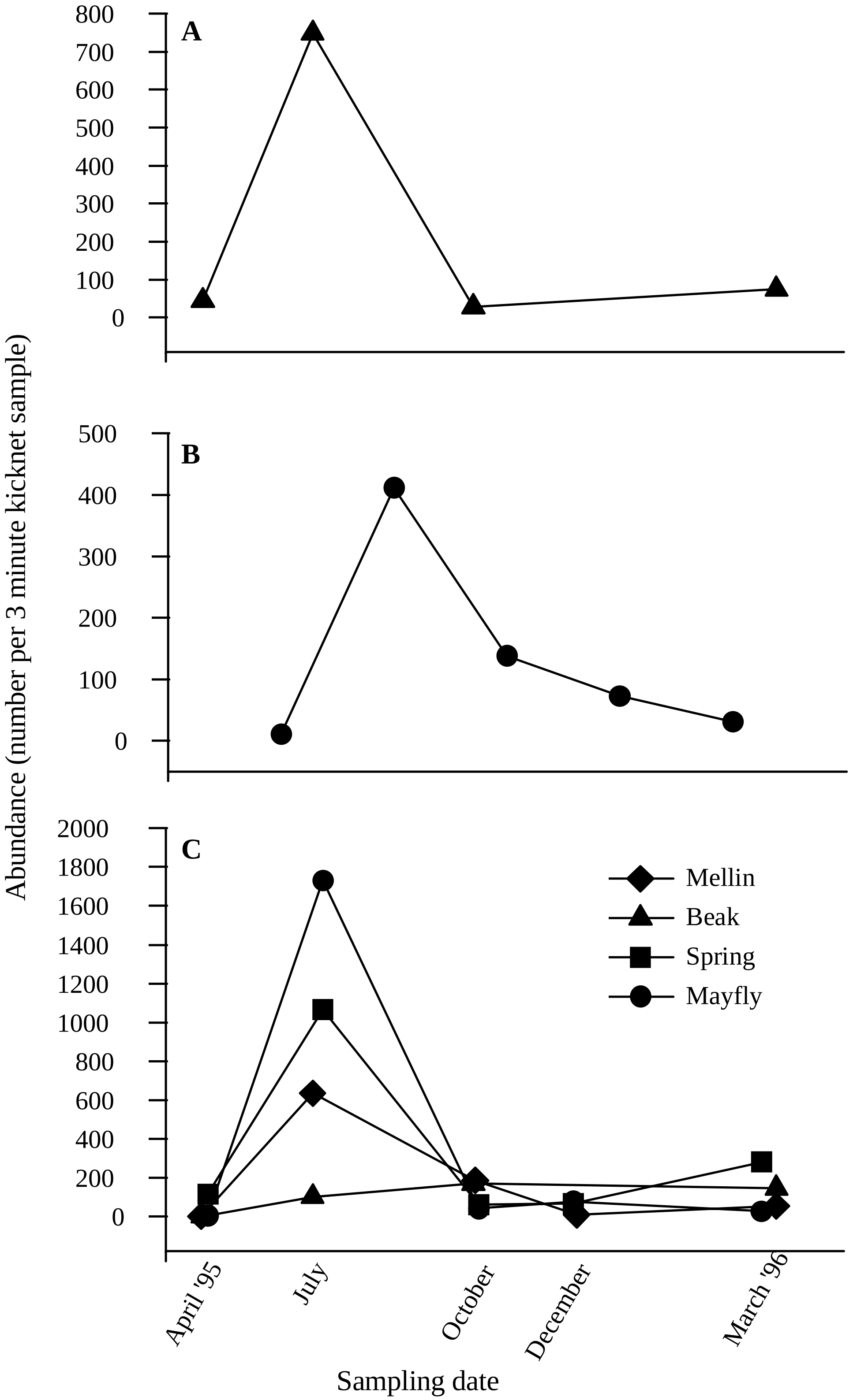

Figure 2.6: Relative abundance of *Drunella doddsi* in Beak Creek (A), *D. spinifera* in Mayfly Creek (B), and *Zapada cinctipes* (C) at each sampling date. Points for each season are slightly off-set because of the slightly different sampling dates.

2.4.2 *Environmental Conditions*

The timing and amount of discharge during the study year were consistent with the average discharge for the previous four - five years (Fig. 2.2); slight differences are a result of year to year variation. Discharge for the fall and winter months (October to January) in the coastal streams appears to be quite different between 1995 and the 4 previous years because of how the data are presented (Fig. 2.2B). The discharge is quite low when the slightly different timing of the spates during the variable fall/winter discharge is averaged out. However, the timing and the magnitude of the variable fall/winter discharge in 1995 is typical of previous years (Michael Feller, Forest Sciences, UBC, unpublished data).

The higher-elevation interior streams were generally cooler than the coastal streams and large rivers (Fig. 2.7). The interior streams were frozen over by November and retained some ice cover until mid-April. Although neither chlorophyll-*a* content or biomass was significantly correlated with water temperatures, for most streams, the greatest amount of biomass and chlorophyll-*a* coincided with the warmest water temperatures and the greatest amount of light. Both periphyton biomass and chlorophyll-*a* were greatest in July and October in all streams, except in the Thompson River and Mayfly Creek (Fig. 2.8). The large amount of algae in Mayfly Creek in the April 1995 sample is probably sampling error caused by inclusion of moss in the sample. In the Thompson River, algal biomass and chlorophyll-*a* were greatest in the early spring (March 1996) - just before the predictable seasonal increase in discharge, which scours the channel bottom.

Typically, the interior streams had the highest amount of both CPOM and FPOM (Fig. 2.9) and the large rivers had the least organic matter. The winter sampling generally produced the least amount of organic matter and spring samplings generally produced the most (Fig. 2.9).

Growth rates for each taxon were not significantly correlated with allochthonous food resources (CPOM or FPOM), autochthonous food resources (chlorophyll-*a* or periphyton biomass), or temperatures ($\alpha_c = 0.05$).

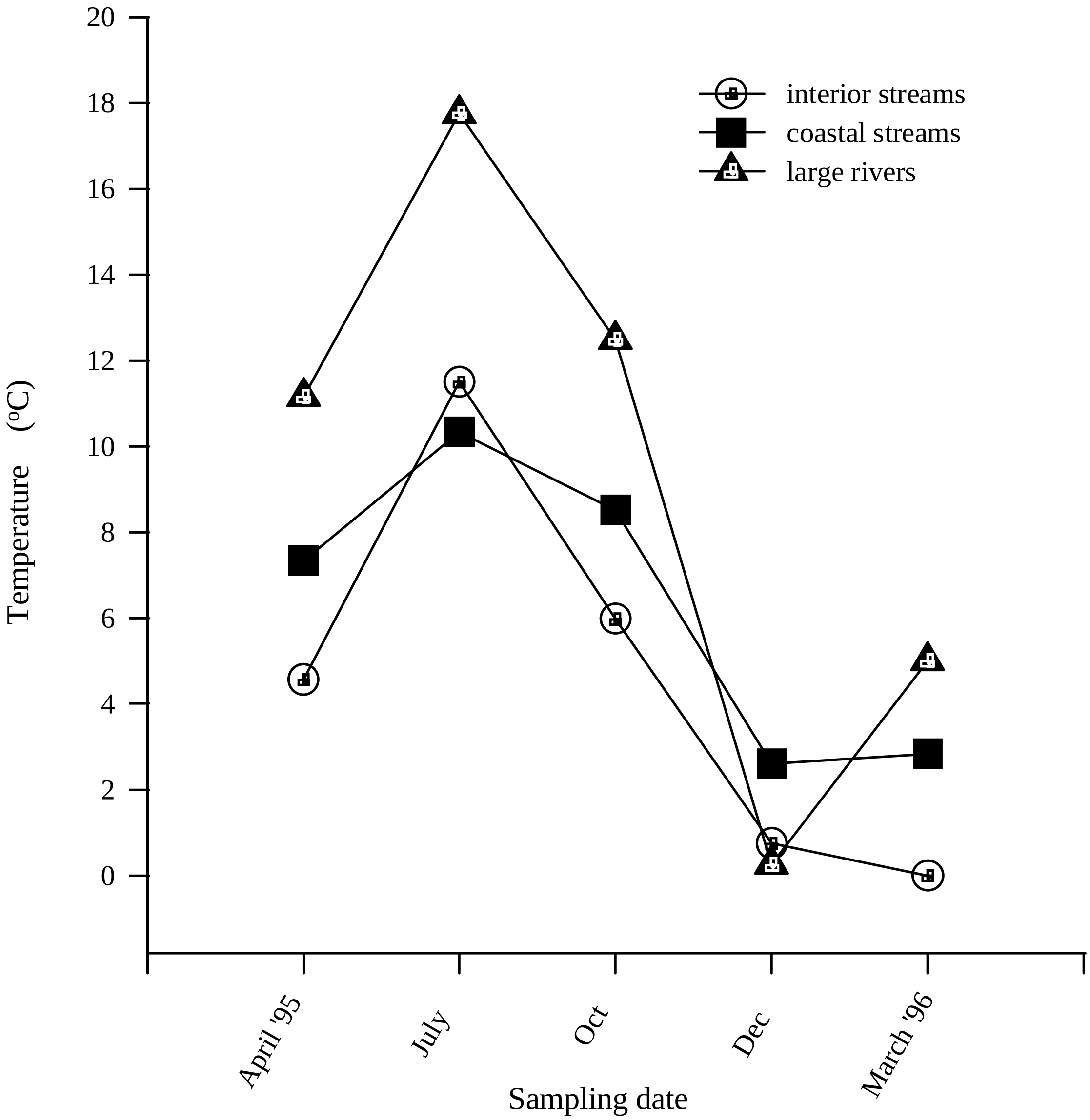

Figure 2.7: Average water temperatures for each of the three classes of streams (interior, coastal, and large rivers) at each sampling date.

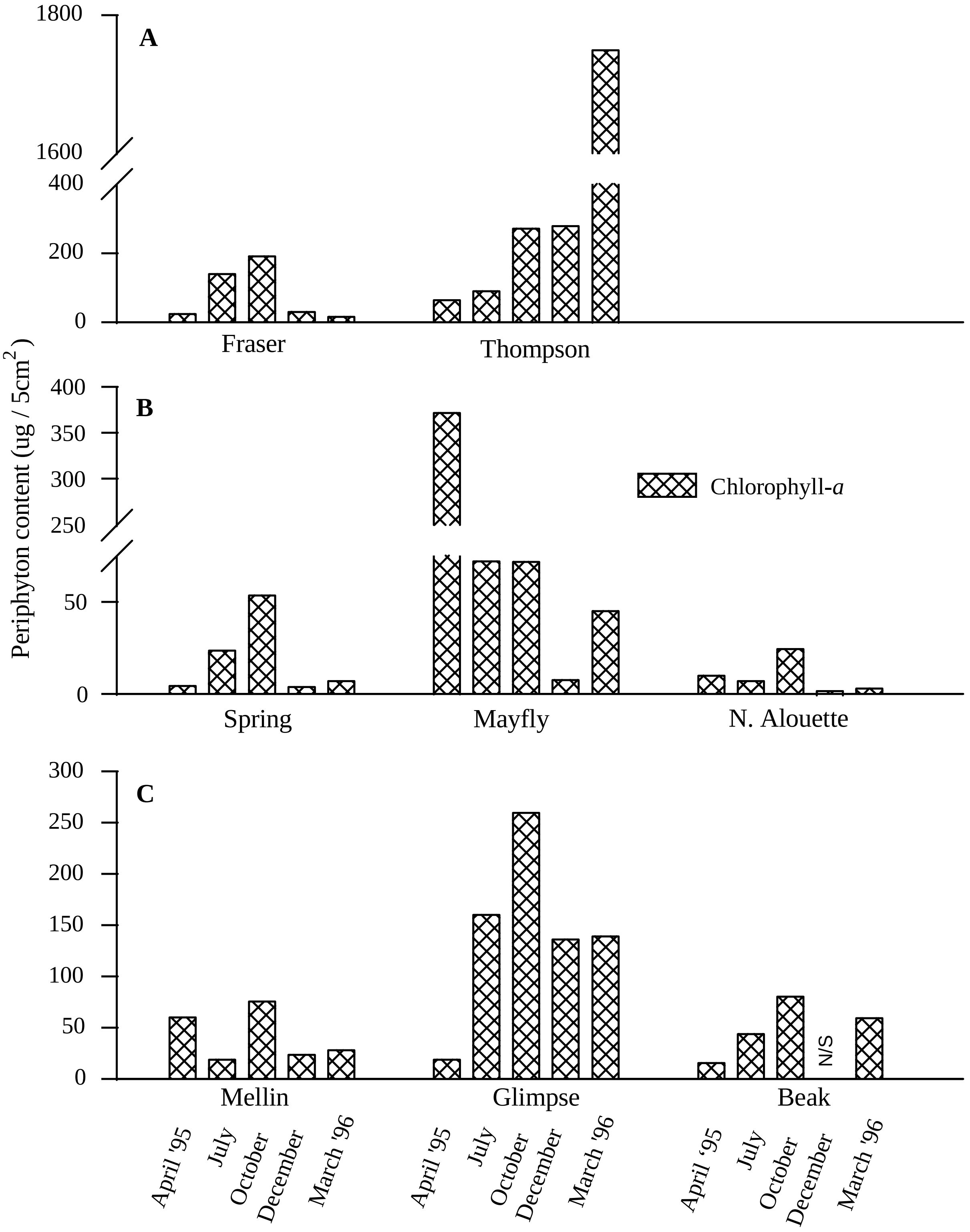

Figure 2.8: Periphyton chlorophyll-*a* content for each stream at each sampling date. A = Large rivers, B = coastal streams, and C = interior streams. Chlorophyll-*a* content is presented as *u*m / 5 cm^2 of rock surface area

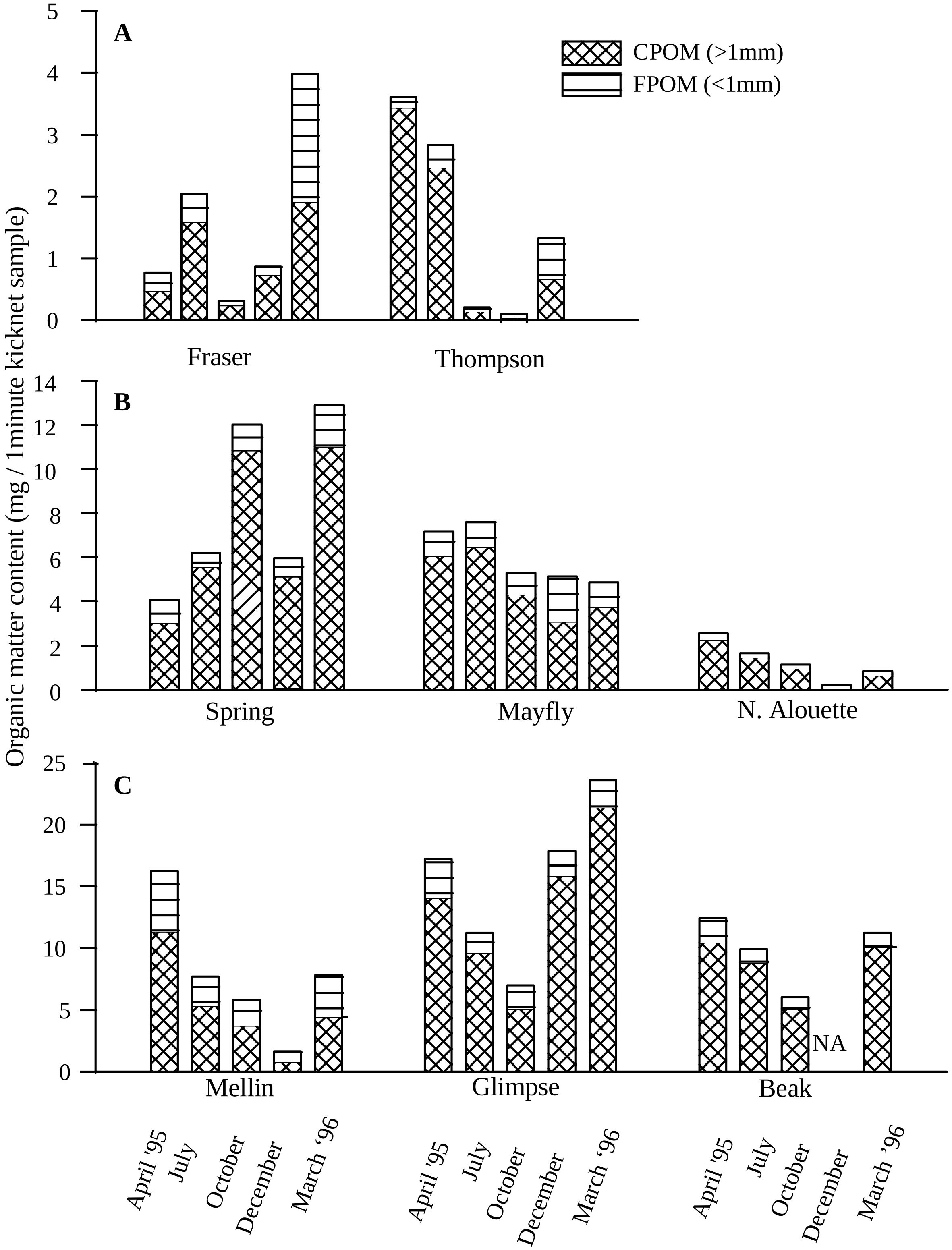

Figure 2.9: Average coarse (CPOM) and fine particulate organic matter (FPOM) content at each site and date. The avergae organic matter content was determined from the 3, one-minute kicknet samples collected at each sampling. A = large rivers, B = coastal streams, and C = interior streams.

2.5.0 Discussion

2.5.1 *Influence of Discharge Regime on Life Cycles*

Differences in the timing of emergence, egg hatching, and growth rates appeared to be unrelated to discharge regimes and therefore cannot be explained by the different regimes. Both *Drunella doddsi* and *D. spinifera* emerged and hatched in the summer regardless of the discharge regime of the stream they were inhabiting. *Zapada cinctipes* emerged either during or prior to peak discharge depending on whether they were from coastal or interior streams. The timing of emergence for all three taxa was similar to the range of emergence periods found in other studies regardless of the discharge regime (Allen and Edmonds 1962; Bradford and Hartland-Rowe 1971; Hawkins 1986). There are five potential reasons why *D. doddsi, D. spinifera,* and *Z. cinctipes* do not have life cycles adapted to the three discharge regimes in this study. First, there is the potential that the predictability and frequency of the seasonal flood events are not sufficient to promote local adaptation (Poff 1992). Second, other environmental constraints may limit life cycle adaptations (Poff and Ward 1989). Third, these three invertebrates may be generalists - they are able to colonize and survive in any environment. Fourth, the invertebrates may be using behavioural adaptations rather than life cycle ones to avoid the seasonal scouring. Finally, bankfull discharge associated with seasonal flooding may not accurately represent disturbance events at a level meaningful to benthic invertebrates (Townsend *et al*. 1997).

The three discharge regimes included in this study occur naturally in southwestern British Columbia. The timing of seasonal floods caused by snow melt is predictable, although the magnitude and duration of flooding will depend on the depth of the snow pack and the timing of spring rains. The months in which seasonal floods caused by winter rains occur are also predictable. However, the exact timing of flood events within those months cannot be predicted. Seasonal flood events occur once per year or once per generation for *D. doddsi, D. spinifera,* and *Z. cinctipes*, and they occur over a 2-4 month period. The frequency and the duration of these presumably harsh conditions should create an environment in which life cycle adaptations would be beneficial. Because life cycle timing was not adapted to the discharge regimes, there must be constraints on the ability to shift timing, or the invertebrates must be using other strategies to deal with the seasonal scour.

Environmental conditions such as photoperiod and temperature may regulate the timing of life cycle events including hatching and emergence. Seasonal environmental conditions such as ice, low oxygen levels or food shortages may constrain life cycle adaptations. Thus, adaptations to other environmental signals such as the discharge regime could be limited. This is a plausible explanation for the lack of adaptation in southwestern B.C. The invertebrates included in this study and in other life cycle studies of the same taxa, all have similar emergence and hatching periods (Allen and Edmonds 1962; Radford and Hartland-Rowe 1971; Hawkins 1986; Richardson 1989) despite discharge regimes that differed from those described in this study. Only minor changes occur in the timing of emergence periods and growth rates primarily due to temperatures, food resources, or both (Radford and Hartland-Rowe 1971; Hawkins 1986).

The three invertebrate taxa may be able to exist under a wide variety of environmental conditions and possible discharge regimes, i.e., they may be habitat generalists. *Zapada cinctipes* was found in all streams except the large rivers. *Z. cinctipes* is a shredder/detritivore (Short and Ward 1981; Merritt and Cummins 1996) and its absence from the large rivers may be simply a result of the lack of CPOM in the large rivers. *Drunella doddsi* and *D. spinifera*, however, are less habitat generalists than *Z. cinctipes*, because they were not common to as many streams. *Drunella doddsi* have particular habitat requirements such as coarse substrates, steep gradient streams, and dense riparian vegetation (Mangum and Winget 1991). Although the invertebrates used in this study may not be generalists for all environmental conditions, they may use behaviours that allow them to cope with different discharge regimes.

Invertebrates may use behavioural adaptations rather than life cycle adaptations to avoid seasonal scouring. These behavioural adaptations could include movement to margins or flood plains, movement down into the substrate, or movements into areas of downwelling. Rempel (1997) found invertebrates in large rivers use the flood plain as a refuge during the annual freshet. It has been demonstrated that areas of the substrate act as flow refugia (Lancaster and Hildrew 1993a), particularly where there are patches of flow downwelling (Dole-Olivier *et al.* 1997). Invertebrates move into these refugia during periods of high flow. These behavioural adaptations may provide the invertebrates with sufficient protection from the seasonal scour so that changes to the timing of life cycle events are not required.

Life cycle adaptations to bankfull discharge associated with seasonal flooding may not be necessary for benthic invertebrates. Researchers have defined bankfull discharge as an event that scours, disturbs stream channel substrate, and disrupts and removes benthic invertebrates (Newbury 1984; Poff 1992). However, measures of bed movement may be better related to species traits and richness than measures of discharge (Townsend *et al.* 1997).

2.5.2 ***Influence of Temperatures and Food Resources on Life Cycles***

Interior streams were generally cooler than the coastal streams and large rivers. These cooler temperatures were a result of a combination of the high elevations and cooler air temperatures in the spring, autumn and winter. By November, the interior streams were frozen over, and they retained some ice cover until mid April. Coastal streams were generally warmer than the interior streams because the coastal climate is moderated by the Pacific Ocean, and the streams are at intermediate elevations. As a result, the streams did not freeze over in the winter. Water temperatures in the large rivers were warm in the spring, summer, and autumn because of the large surface area of water exposed to the sun and air.

Water temperatures influenced the timing of insect life cycles in the coastal and interior streams. The greatest growth rate for *D. doddsi* and *D. spinifera* occurred between July and October when stream temperatures were the warmest. Warm coastal stream temperatures also resulted in *D. doddsi* reaching their final instar and emerging earlier than individuals living in the cooler interior streams (Sweeney 1984). *Drunella doddsi* from the coastal streams were slightly larger at each sampling date than *D. doddsi* from interior streams, probably because *D. doddsi* emerged, laid eggs, and hatched a little earlier in coastal streams than in the interior.

The greatest growth rate of *Zapada cinctipes* from interior streams also occurred between July and October when stream temperatures were the warmest. These *Z. cinctipes* continued to grow through the winter at a reduced rate but sufficient for them to achieve the size required for emergence by late March/early April, after the ice cover had broken up.

The greatest growth rate of *Z. cinctipes* in coastal streams occurred between October and December. Although temperatures are cooler between October and December than between July and October, they are not too cool for the invertebrates to take advantage of the seasonal input of CPOM. In fact, the combination of ‘warm’ temperatures and abundant food through October and December allowed *Z. cinctipes* to attain a size large enough for emergence by mid-December. Ice did not form over the coastal streams in the winter and emergence of *Z. cinctipes* was not delayed. *Zapada cinctipes* in coastal streams of British Columbia emerge from January to March (Richardson 1989).

The quantity and quality of food resources also influences growth rates and life cycles. In temperate streams, the majority of leaf litter falls between September and November (Richardson 1992). In this study, major inputs into the stream channel were not limited to the period of leaf fall. For the interior streams and large rivers, the relatively large amount of CPOM and FPOM in spring and summer coincided with the annual increase in discharge, which can remove organic matter from the stream banks and flood plain bringing it into the channel (Ractliffe *et al.* 1995; Rempel 1997). For the coastal streams, the majority of the leaf litter input coincided with leaf fall (Richardson 1992) and discharge high enough to entrain the majority of the accessible material.

Leaf fall between September and October provided food resources during the major growth period of coastal stream *Z. cinctipes.* It also provided food resources for over-wintering detritus shredders such as *D. spinifera* (Hawkins 1984) and interior stream *Z. cinctipes* (Short and Ward 1981). The major influx of organic matter in the spring, provided a flush of resources for shredders through spring and summer.

Periphyton biomass and chlorophyll-*a* levels were highest in spring and summer for all streams except the Thompson River and Mayfly Creek. In the Thompson River, algal biomass and chlorophyll-*a* were greatest in spring - just before the predictable seasonal increase in discharge scours the channel bottom. Bothwell and Culp (1993) concluded that the scouring of the channel bottom at the same site in the Thompson River, removed most of the periphyton. Post scouring, the periphyton community rebuilds itself until the next scouring event. This trend, however, was not seen at the Fraser River sampling site, perhaps because of the large amount of suspended particulates in the water column (Table 2.1). As discharge decreases, sediments fall out of suspension, coating the substrate and covering any periphyton growth. As a result, primary production was highest in the summer during high levels of discharge when the sediments were removed from the rock surfaces.

Invertebrate abundance varied with stream, sampling date, and life cycle stage. In general, the highest abundance of each taxon was related to the hatching of the new generation. Some of the changes in abundance between sampling dates may have been a result of different sampling intensities at each date, although efforts were made to keep sampling intensity consistent. *Drunella doddsi* are diatom scrapers and predators (Hawkins 1984), their highest growth rates and abundance occurred during the spring and summer, the interior and coastal streams, and corresponded with high levels of periphyton. In July, the abundance of *Zapada cinctipes* was lower in the interior streams than in coastal streams, this may be a result of the timing of hatching and the discharge regime.

In summary, the timing of *D. doddsi, D. spinifera*, and *Z. cinctipes* life cycle events do not appear to be altered with different discharge regimes. The invertebrates may be unable to adapt to the discharge regimes. Conversely, these invertebrates may not need to adapt if behavioural tactics are sufficient to avoid the seasonal scour. Invertebrate growth rates and the timing of emergence are influenced by temperatures and food resources, but it was not possible to separate these effects.

Chapter Three

SEASONAL AND SPATIAL CHANGES OF BENTHIC INVERTEBRATE COMMUNITIES AND ASSOCIATED ENVIRONMENTAL CONDITIONS IN SOUTHWESTERN BRITISH COLUMBIA

3.1.0 Introduction

The relationship between environmental conditions and benthic invertebrates has been a dominant theme in stream ecology. Combinations of geographic factors, water chemistry, habitat stability, and/or land use influence stream community structure (Wright *et al.* 1984; Ormerod and Edwards 1987; Corkum 1989; Richards *et al*. 1993; Death 1995; Tate and Heiny 1995 and others). Many environmental factors change seasonally and there is the potential for the structure of invertebrate communities to change with them. Environmental factors which change seasonally include those which have been shown to have a direct influence on invertebrate life cycles, population dynamics, trophic interactions, etc., e.g., temperature, resource abundance, photoperiod, and discharge (Sweeney and Vannote 1981; Sweeney 1984; Hawkins 1986; Robinson *et al*. 1992; Chapter 2).

Studies have related seasonal change of community structure to a limited number of environmental conditions. For example, Hawkins and Sedell (1981) related functional composition to longitudinal and seasonal changes of food resources. Boulton and Lake (1992) and Closs and Lake (1994) related changes in faunal and functional composition to seasonal changes of flow regime and food resources in intermittent streams. Hynes (1970) proposed a pattern of seasonal change in abundance and biomass in small streams based on a review of several studies that sampled benthic communities in small temperate streams through the year, and the life histories of invertebrates. Hynes predicted that with recruitment, total invertebrate abundance would increase from the late spring through the summer, and highest abundance would be achieved in late autumn (Fig 3.1). Abundance would decrease through the winter as a result of deaths and predation, and lowest abundance would occur in the early spring (Fig 3.1). In lotic systems, many environmental factors may change simultaneously. The relationship between seasonal change of invertebrate community structure and changes of co-occurring environmental variables should be determined to facilitate identification of environmental factors that have the greatest influence on the seasonal change of community structure or that interact with other variables to influence community structure.

The purpose of this chapter is to examine how benthic invertebrate community composition changes spatially, between streams classes and streams nested within classes, and seasonally in southwestern British Columbia. The three stream classes include coastal streams, interior streams and large rivers. Changes to community composition were assessed at 1) the lowest possible taxonomic level, 2) family level, and 3) functional level. Environmental variables were monitored along with the invertebrate communities. Relationships between invertebrate community structure and environmental characteristics were first determined, followed by ways in which the benthic community changes seasonally, and then whether community changes are related to seasonal changes in the environment.

3.2.0 Methods

Spatial and temporal changes of benthic macroinvertebrate community structure were assessed for eight rivers in three stream classes in southwestern British Columbia (Fig. 2.1, 2.2). Samples were collected from the eight streams over five sampling dates between April 1995 and April 1996 (Figs. 2.2a,b and c). The sampling dates were selected to bracket seasonal changes in temperature, food resources, and discharge.

3.2.1 *Invertebrate Samples*

Benthic invertebrate were collected using kicknets, a detailed description of sample collection and processing was presented in Chapter 2. Three samples per site per date were randomly selected from the five collected, processed, and the data were combined. The loss of rare taxa from the data set as a result of subsampling was not considered to be a problem. Rare taxa create a large number of zero values, noise in the data set, and are therefore typically excluded when multivariate analyses are used.

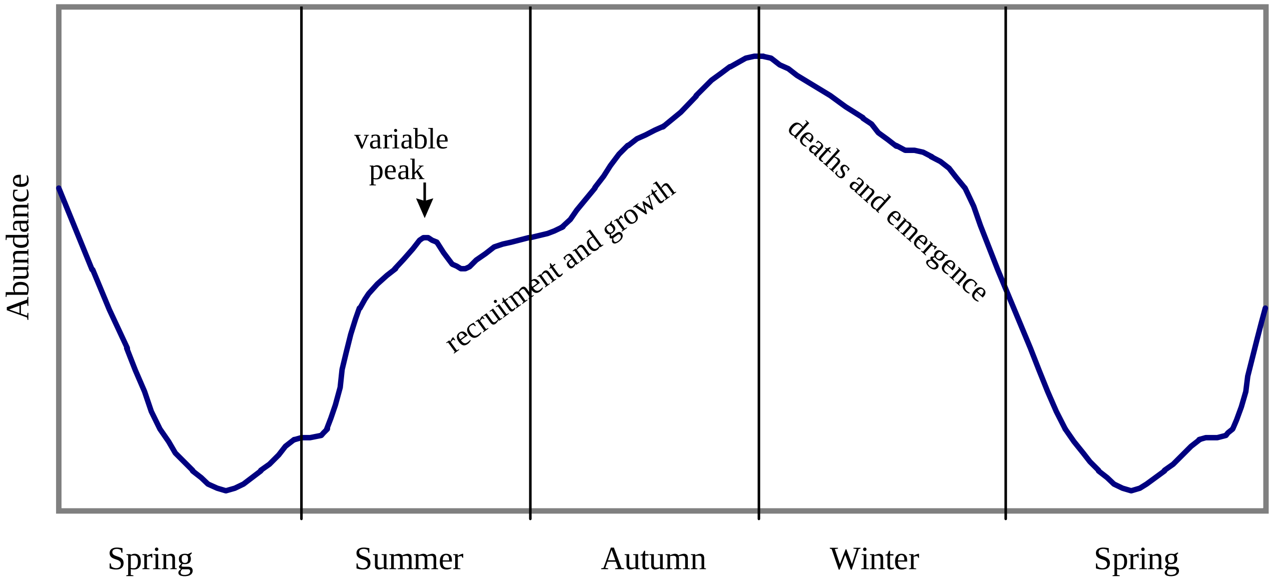

Figure 3.1: Seasonal pattern of insect abundance in small undisturbed streams as proposed by Hynes (1970).

Invertebrates were identified to the lowest practical taxonomic level, usually species and genus levels. However, Ostracoda, Turbellaria, and Copepoda were not identified beyond class, and the Chironomidae were identified to the subfamily level. The resulting data set will hereafter be referred to as the **genus/species data set**. Family level and functional groups data sets were generated from the genus/species data set. Insects were placed into functional groups based on Pennak (1978) and Merritt and Cummins (1996). Invertebrates using more than one food source were divided equally into each of the appropriate functional groups.

3.2.2 *Environmental Conditions*

Environmental variables were measured either when the benthic samples were collected or were determined from maps (Table 2.2). Variables having an association with benthic invertebrate community composition were included (Wright *et al.* 1984; Corkum and Currie 1987; Ormerod and Edwards 1987; Corkum 1989). The measurement of hydraulic variables and the collection of periphyton samples are described in Chapter 2. Conductivity, pH, dissolved oxygen, temperature, depth, and velocity were all measured at each sampling site with the respective meters. Current velocity was determined by measuring velocity with a Marsh-McBirney electromagnetic current velocity meter at regular intervals along the stream and at 60% of the depth. From those measurements, average velocity was determined by averaging the velocities and maximum velocity was the highest velocity measured.

Water chemistry samples (alkalinity, TKN, $NO_3 NO_2$-N, NH_3-N and total phosphorous) were collected, sent to the National Water Research Institute (NWRI) for analysis, and analyzed following the methods described in Cancilla (1994). One milliliter of 30% H_2SO_4 was used to preserve the water sample for the phosphorous analysis, and all samples were stored at 4 -5C until analyzed. Samples of total suspended solids and sediment particle size were also sent to the NWRI for analysis. Sediment particle size was determined by sieving the sample, drying and weighing the sand and gravel portion (>0.063mm), and then running the <0.063mm portion through a Sedigraph analyzer to determine silt and clay content (Duncan and LaHaie 1979)

Channel bottom substrates were described using a classification system that involved three descriptors: framework, matrix, and embeddedness (Rosenberg *et al.* In prep). Framework represented the size of dominant substrate on the channel bottom; matrix represented the size of substrate surrounding the framework; and embeddedness represented the depth at which dominant substrates were embedded in the surrounding material. Each of these substrate characteristics was assigned a score depending on the size and class of the substrate. The scoring system for framework and matrix based on the substrate particle size was: 1 = organic cover over 50% of the bottom, 2 = <0.1-0.2cm, 3 = 0.2-0.5cm, 4 = 0.5-2.5cm, 5 = 2.5-5cm, 6 = 5-10cm, 7 = 10-25cm, and 8 = >25cm. For embeddedness, 1 = totally embedded, 2 = ¾ embedded, 3 = ½ embedded, 4 = ¼ embedded, and 5 = unembedded.

Vegetation in and around the stream was also described in the data set by categories. Macrophyte categories were assigned based on the percent area covered by macrophytes: 1 = 0%, 2 = 0-25%, 3 = 25-50%, 4 = 50-75%, 5 = 75-100%. Each type of riparian vegetation was assigned a number based on whether the different vegetation types (grasses, shrubs, deciduous, coniferous) were present (1) or absent (0). Percent canopy cover for a reach was estimated based on the area covered by a canopy along a transect on one side of the stream channel.

3.2.3 *Data Analysis*

Principal Components Analysis (PCA) (Proc Princomp; SAS Institute 1996), an indirect ordination technique, was used to summarize the variation and identify major gradients in both the invertebrate and environmental data sets. Both the invertebrate and environmental data sets used in the PCA contained the seasonal information as well as the spatial information. Ordinations were run for three invertebrate classification levels: genus/species, family, and functional group. PCA assumes a linear response curve (Gauch 1982) and a large number of zero values will create a non-linear response curve, so rare taxa were removed from the data set. Taxa that occurred < 1% of the time were removed from the genus/species data set, and taxa with < 0.5 % occurrence were removed from the family data set (a 1 % cut-off for the family data left too few taxa for the analysis and a 0.5% cut-off for the genus/species data added only 5 taxa). Patterns of composition (rather than just numeric differences) were important, so the faunal data were log transformed ($\log_{10}(x+1)$), which reduced the influence of the more abundant taxa. A correlation matrix was used because it standardizes the data, thus altering the relative weight of each variable and allowing relative abundance to be examined (Jackson 1993).

Two ordinations were run for the environmental data - one on the 33 environmental variables listed in Table 3.1 and one for 21 of the environmental variables that changed seasonally. The correlation matrix was used because it standardizes the data and minimized variation caused by different scales of the environmental variables.

Correlation analysis (Proc Corr; SAS Institute 1996) was used to determine which taxa and environmental variables had significant loadings for their respective ordinations. Significance was determined by comparing probability values with a Bonferroni-corrected probability value (p = 0.05/number of comparisons made). This step reduced the likelihood of a correlation being significant simply due to chance, and reduced over-interpretation of the data (Rice 1989). Correlation analysis was also used to determine if and how eigenvectors from the invertebrate and environmental ordinations were related.

Two different analysis techniques were used to determine how much variation in the ordinations could be explained by season, site, and stream class. Multiple analysis of variance (MANOVA) (Proc GLM; SAS Institute, 1996) of the axis 1 and 2 principal component (PC) scores was used to determine if the ordination scores for the seasons, sites nested within stream class, and stream class were significantly different, and how much variation each spatial and temporal level explained. Coefficient of variation (CV = standard deviation of seasonal PC scores for a site/average seasonal PC scores for a site) was used to determine how much seasonal variation existed for each stream (Zar 1984).

PCA assumes that the distance between a given pair of ordination points is proportional to the measure of similarity between the pair of samples those points represent (Gauch 1992). Thus, the distance in ordination space between seasonal samples for a site represents the (dis)similarity in the communities between seasons. This magnitude of invertebrate seasonal change in ordination space was

Table 3.1: Environmental variables used in the analyses.

Environmental variables	*Abbreviation*	*Variables which change seasonally*
Stream order	order	
Drainage basin area	DBA	
Distance from source	dist	
Elevation	elev	
Channel gradient	slope	
Flow state1 (riffle to pool)	flw1	
Flow state2 (slow subcritical to hydraulic jump)	flw2	
Bankfull width	bnkfl	
Wetted width	width	*
Mean depth	menD	*
Maximum depth	maxD	*
Discharge at sampling	Q	*
Peak discharge	peakQ	*
Cumulative discharge	cummQ	*
Mean velocity	menV	*
Maximum velocity	maxV	*
Temperature	temp	*
pH	pH	*
Conductivity	cond	*
Total suspended solids	TSS	*
Percent carbon in TSS	%CTSS	*
Alkalinity	alkal	*
Nitrate and nitrite - nitrogen	NO3-N	*
Ammonia - nitrogen	NH3-N	*
Total Kjeldahl nitrogen	TKN	*
Total phosphorus	totlP	*
Suspended N	suspN	*
Suspended C	suspC	*
Chlorophyll-a	chla	*
Coarse particulate organic matter	CPOM	*
Fine particulate organic matter	FPOM	*
Canopy coverage	%cover	
Substrate framework	frmwrk	
Substrate matrix	matrx	
Substrate embedbedness	embd	

tested for correlation with those environmental variables that change seasonally to determine whether seasonal changes in the invertebrate community were related to seasonal changes in the environment. The distance between seasonal coordinates for a site was calculated using:

$$Z^2 = X\,(a_2 - a_1)^2 + Y\,(b_2 - b_1)^2$$

Where: Z = Distance in ordination space between seasons (seasonal change)
a_1 = PC axis 1 coordinate at season 1
a_2 = PC axis 1 coordinate at season 2
X = Proportion of variance explained by axis 1
b_1 = PC axis 2 coordinate at season 1
b_2 = PC axis 2 coordinate at season 2
Y = Proportion of variance explained by axis 2

Two measures of discharge were used (Table3.1): peak discharge and total cumulative discharge during the month prior to sampling. Total cumulative discharge was determined from guaging station measurements collected by Environment Canada and Dr. Michael Feller, (Department of Forest Sciences, UBC). Discharge (peak and cumulative), wetted width, mean depth, maximum depth, and mean and maximum velocity were standardized (e.g., $Q_{max}/Q_{\text{average for the year}}$) so that the change was relative and inter-system comparisons could therefore be made. Correlation analysis assumes that the variables have a bivariate normal distribution. To meet this assumption, seasonal changes of the environmental variables were tested for normality (Shapiro-wilk test; Statsoft Inc. 1994), and transformations were tested and applied as required. No transformations were required for the distance between the PC scores or the standardized variables because both were already standardized. Transformations were also not required for pH, temperature, and NO_3NO_2- N. All other variables were $\log_e$ -transformed.

The magnitude of change in stream communities between seasons and their relations with environmental variables, or the seasonal difference in those variables, were tested with analysis of covariance (ANCOVA) (Proc GLM; SAS Institute, 1996). ANCOVA was first used to determine the relationship between the change in invertebrate PC scores between seasons and the change in environmental variables (regression). It was then used to test for a difference between the slopes for streams nested within stream class and stream class (treatments) while controlling for an environmental variable (covariate). Variables used in this analysis were the same as those used in the correlation analysis above. The same transformations were applied to the environmental variables to meet the assumptions of normality, homogenous variances, and distributions of the residuals. Least square means were used to determine which means differed for the various streams and stream classes. Alpha critical for the least square means was Bonferroni-corrected because all possible pairwise comparisons were used, thus controlling for Type I errors.

3.3.0 Results

3.3.1 *Invertebrate Composition*

A total of 152 taxa was identified, mostly to genus. Forty-nine of the taxa were found in all three classes of streams, 20 only in the interior streams, 36 only in coastal streams, and 20 only in large rivers (Appendix 1). Many of the invertebrates specific to a stream class were found in low numbers and only on one or two occasions. Taxa common to a stream class are defined as those found in > 25 % of the samples. There were nine taxa specific to and common in interior streams, and they are listed in Table 3.2, which also lists the 16 taxa specific to and common in coastal streams and the three taxa specific to and common in the large rivers. The lack of common occurrence by more taxa in the large rivers may have been simply a result of the generally low abundance of most taxa. A few of the exclusive taxa were only specific to a stream class because identifications were made to the genus or species level.

Taxon richness, abundance, and diversity changed among stream class, sites, and sampling dates. The large rivers generally had the lowest taxon richness and abundance, whereas the coastal streams had the highest richness and interior streams had the greatest abundance (Figs. 3.2 and 3.3). Simpson’s index, of diversity (Krebs 1989) was generally high (Table 3.3), which may have been partly caused by the removal of rare taxa with subsampling. Streams and seasons with the highest diversity typically had the greatest number of taxa (Fig 3.2) or, to a lesser extent, a more even distribution of abundance. Across all eight streams there was no consistency as to which season had either the highest or lowest taxon richness, invertebrate abundance, or diversity.

Table 3.2: Taxa found in > 25% of the samples from a specific stream class (interior streams, coastal streams, or large rivers). See Appendix 1 for a listing of all taxa found in each stream class.

	Taxonomic Group	*Interior*	*Coastal*	*Large*
Gastropoda	*Pisidium casertanum*	+		
Plecoptera	*Amphinemura* spp.	+		
Plecoptera	*Megarcys* spp.	+		
Trichoptera	*Brachycentrus americanus*	+		
Trichoptera	*Hesperophylax* spp.	+		
Trichoptera	*Allomyia* spp.	+		
Trichoptera	*Neophlax* spp.	+		
Diptera	*Pericoma* spp. / *Thelmatoscopu*s spp	+		
Diptera	*Hexatoma* sp. A	+		
Ephemeroptera	*Epeorus* (*Ironopsis*) spp.		+	
Ephemeroptera	*Ironodes* spp.		+	
Plecoptera	*Malenka* spp.		+	
Plecoptera	*Yoraperla brevis*		+	
Plecoptera	*Hesperoperla pacifica*		+	
Plecoptera	*Setvena bradley*		+	
Plecoptera	*Pteronarcys princeps*		+	
Trichoptera	*Micrasema* sp. A		+	
Trichoptera	*Agraylea* spp.		+	
Trichoptera	*Onocosmoecus unicolor*		+	
Trichoptera	*Wormaldia* spp.		+	
Trichoptera	*Polycentropus* spp.		+	
Trichoptera	*Rhyacophila chilsia* grp.		+	
Coleoptera	*Cleptelmis* spp.		+	
Coleoptera	*Lara* spp.		+	
Coleoptera	*Hexatoma* sp. B		+	
Ephemeroptera	*Stenonema* spp.			+
Trichoptera	*Brachycentrus occidentalis*			+
Diptera	*Robackia* spp.			+

Through all seasons, the large river samples were composed primarily of Diptera (up to 93 %). In the large rivers, combined abundance of Ephemeroptera, Plecoptera, and Trichoptera ranged from 4.7 % in the Thompson River spring 1996 sampling to 66.8% in the winter sampling of the Fraser River. Coleoptera and other invertebrates made up only a small proportion of the total (Fig. 3.4). Naididae

(Oligochaeta) were abundant in seasons in which other invertebrates had relatively high abundances in the Fraser River. In contrast, in both the coastal and interior streams Ephemeroptera, Plecoptera, and Trichoptera were typically more abundant than the Diptera (Fig. 3.4). Again, Coleoptera and other invertebrates made up only a small proportion of the interior and coastal benthic communities, except in Mellin Creek in the 1995 spring and summer samplings when tubificids were abundant.

Deposit FPOM collectors were the most abundant functional group in the large rivers and across all seasons, making up to 94.8 % of community composition (Fig. 3.5). The second most abundant functional group was herbivores (up to 53 % of the composition). All other functional groups combined made up a maximum of 29.2 % of the composition. The most abundant functional groups in the coastal and interior streams were also the deposit FPOM collectors and herbivores. However, predators and shredders made up larger proportions of the community than in the large rivers (Fig. 3.5). Predators and shredders composed ~32 % of the community in coastal streams, and 13.6 and 63.6 % of the community, respectively, in interior streams.

Of the 153 taxa identified, 23 represented > 1% of the total organisms collected when identification was to the genus/species level (Appendix 2). When identification was to the family level, 24 taxa represented > 0.5% of the total organisms collected (Appendix 2). These taxa were used in the PC analyses. Many of the rare taxa exclusive to the three stream classes were thus removed from the data set. The absence of rare taxa did not result in less discrimination between sites in the PCA because results of a PCA of presence/absence data were similar.

The first three axes for the PCA done on abundances of genus/species taxa explained 58.7 % of the variation in the data set. Each of the sampling dates for a site clustered together (Fig 3.6a). Large river sites occupy one end of the ordination and the other six sites are spread across the ordination plot. Fourteen taxa were significantly positively correlated with the first axis ($p < 0.002$). Invertebrate abundance rather than composition dominated the first axis even though the data were $\log_{10}(x+1)$

transformed and the correlation matrix was used. Taxa had both significant positive and negative correlations with axes 2 and 3 indicating that composition was more important along these axes.

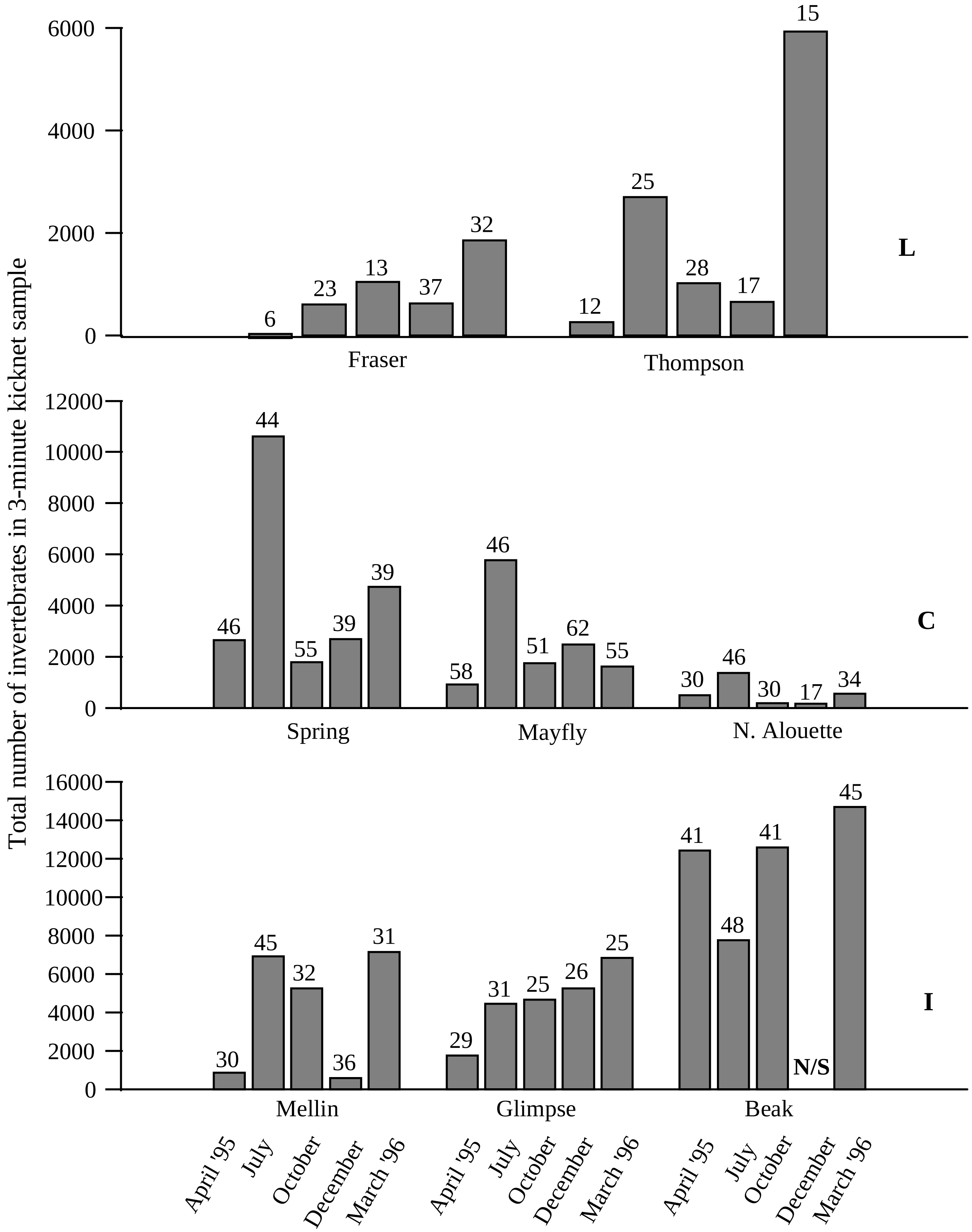

Figure 3.2: Invertebrate abundance at each sampling site and date based on three one-minute kicknet samples. The number of taxa found at that site and sampling date is above the bars. All eight sampling sites are located in southwestern British Columbia. Note the scales differ. N/S = no sample. L = large rivers, C = coastal streams, and I = interior streams.

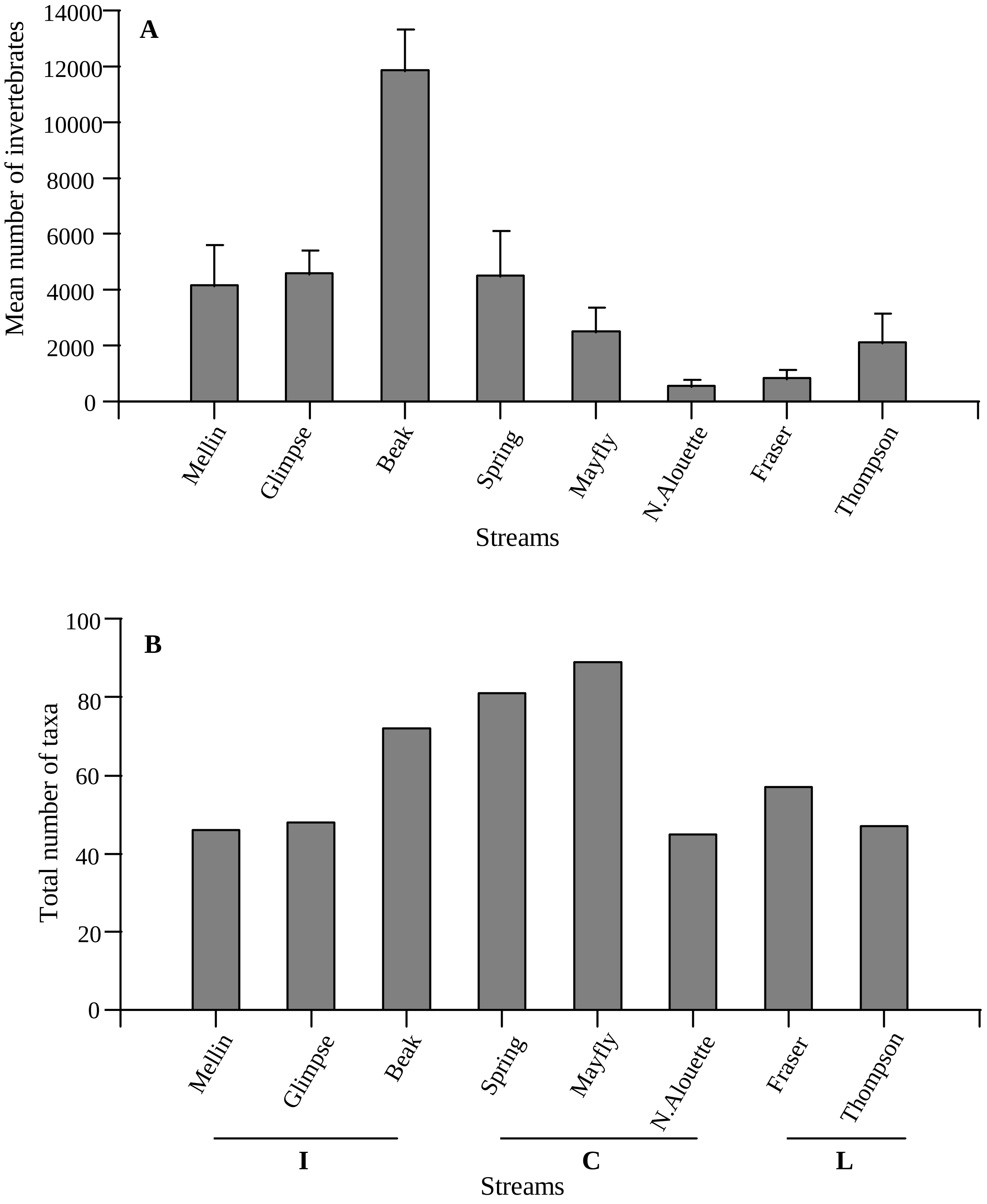

Figure 3.3: (A) Average number of invertebrates collected in the composite three one-minute kicknet samples over all sampling dates. Bars represent + 1 SE. (B) Total number of invertebrate taxa in the three one-minute kicknet samples at each sampling site over all sampling dates. I = interior streams, C = coastal streams, and L = large rivers.

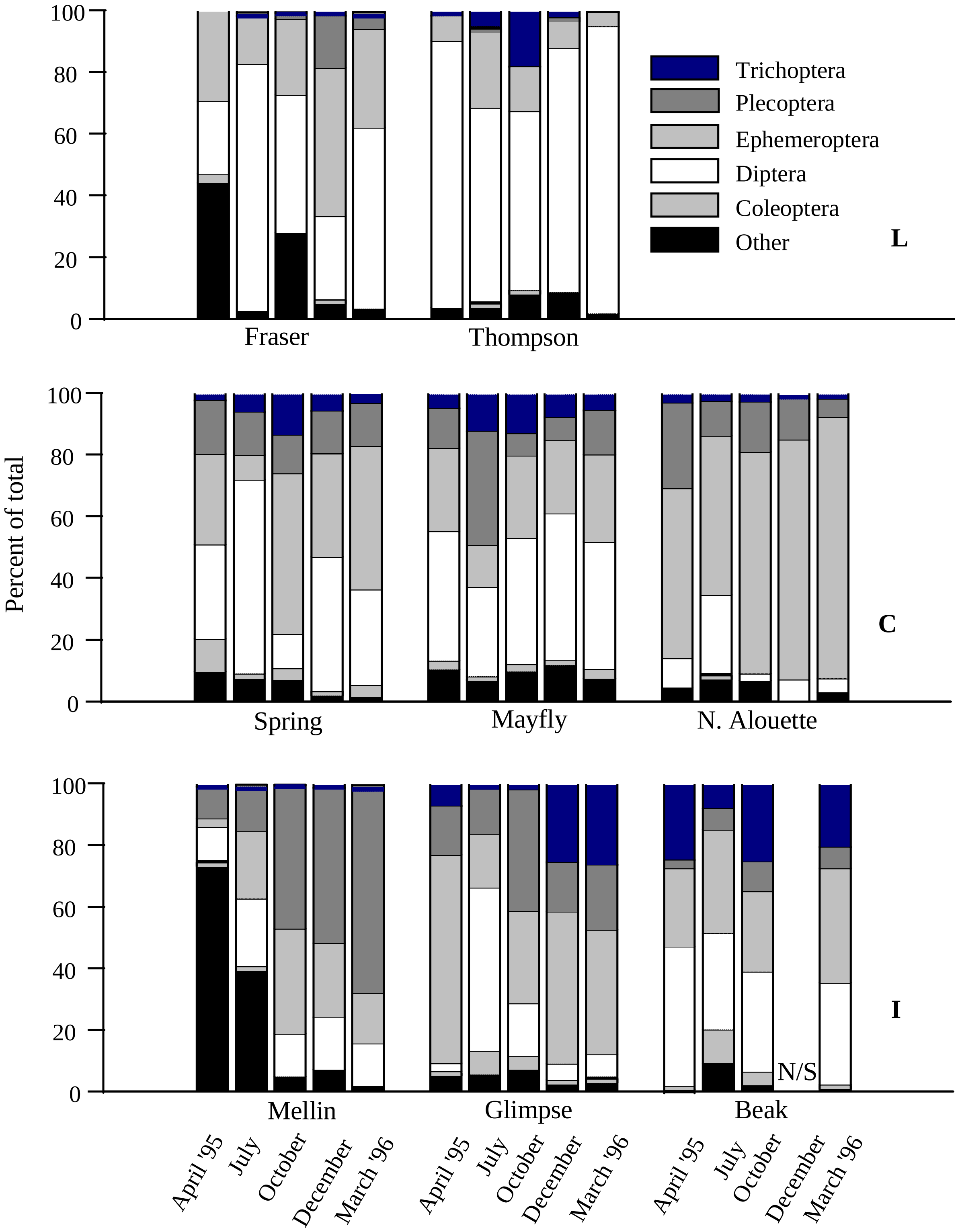

Figure 3.4: Relative abundance of the major insect orders and other invertebrates in the composite 3 X 1- minute kicknet samples collected at each sampling site and date. L = large rivers, C = coastal streams, I = interior streams, and N/S = no sample.

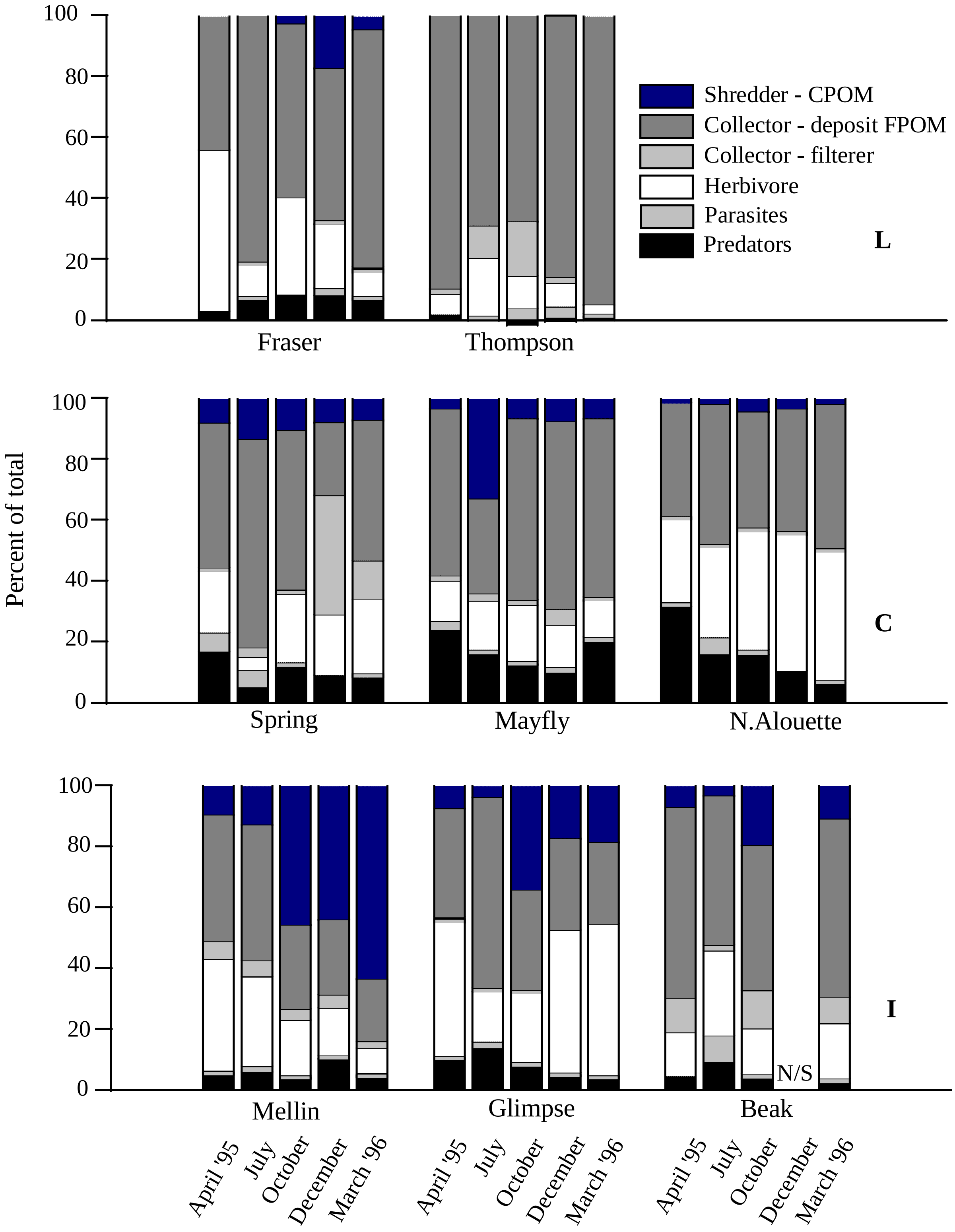

Figure 3.5: Relative abundance of functional groups in each composite 3 X 1-minute kicknet sample collected from each stream and sampling date. Functional groups are as defined by Merritt and Cummins (1996) and Pennak (1978). L = large rivers, C = coastal streams, I = interior streams, and N/S = no sample.

Tubificidae and *Prosimulium* sp. were positively correlated with the second axis and *Neophylax* sp., *Zapada oregonensis* group, *Sweltsa* sp., and *Cinygmula* sp. were negatively correlated with the second axis. The direction and magnitude of invertebrate loadings for taxa with significant correlations are illustrated in Fig 3.6b.

The MANOVA indicated that seasonal variation within a site accounted for < 5 % of the explained variance expressed in the ordination space, whereas the stream accounted for 47.9 and 37.6 % of the variation along axes 1 and 2, respectively, and the stream class accounted for 47.4 and 57.5 % of the variation along axes 1 and 2 (Table 3.4). Coefficient of variation analyses indicated that the benthic community in each stream varied different amounts between seasons. The communities in Mellin and Glimpse creeks varied the most along axis 1 (changes in abundance) and changed very little along axis 2 (change in composition) (Table 3.5). All other sampling sites vary more along axis 2 (change in composition) than along axis one (change in abundance) (see Table 3.5).

PCA results were similar for analysis at the genus/species and family levels. For the family level data, the first three axes explained 61.5 % of the variation. Most of the seasons for a site and the sites within the large river and coastal stream classes clustered together (Fig. 3.7a). As in the genus\species ordination, 16 of the 17 taxa with significant correlations ($p < 0.002$) were positively correlated with the first axis. Naididae were included at this level of analysis, however, and were negatively correlated with the first axis because of their increased abundance in large rivers. Naididae, Psychodidae, Ephemerellidae, Brachycentridae, and Hydropsychidae were positively correlated with the second axis, whereas Glossosomatidae were negatively correlated with the second axis ($p < 0.002$). The direction and magnitude of loadings for taxa with significant correlations are illustrated in Fig. 3.7b.

Seasonal variation in the family data set only explained 5% of the variation in the ordination, similar to MANOVA analysis at the genus/species level. The stream explained 39 and 75 % of the variation along axes 1 and 2, respectively, and the stream class accounted for 56 and 19.6 % of the variation along axis 1 and 2 (Table 3.4). The coefficient of variation analyses indicated lower seasonal variation at each site when family level data were used than when the genus/species level data were used.

At the family level of analysis, Mellin Creek still varied the most along axis 1, followed by the North Alouette River and Glimpse Creek. Mayfly Creek, Mellin Creek, and the Fraser River varied the most along axis 2 (Table 3.5).

When functional groups were used in the PCA, the first three axes explained 67.7, 11.4, and 10.2 % of the variation respectively. Certain communities were functionally distinct between sites or regions such as Glimpse Creek versus the Thompson River or the interior streams versus the large rivers (Fig3.8a). All functional groups had significant positive correlations with the first axis ($p < 0.008$). Only filter feeders were significantly correlated with the second axis (Fig. 3.8b).

Seasonal variation in the functional group data set explained 17.9 and 7.4 % of the variation along axes 1 and 2 respectively. The stream explained 26.9 and 85.1% and the stream class accounted for 55.2 and 7.5 % of the variation along axes 1 and 2 (Table 3.4). Results from the coefficient of variation analyses indicated that Mellin and Mayfly creeks varied the most along the first axis or, abundance changed seasonally the most in these streams. The Fraser River and Mayfly Creek varied the most along the second axis, indicating that abundance of filter-feeders changed seasonally the most (Table 3.5).

3.3.2 *Environmental Conditions*

Principal component analyses were similar for all the environmental variables measured and just those that varied seasonally. Therefore, only results from the latter ordination are presented. The first three axes explained 66.4 % of the variation in the data set. The coastal sites occupied the left side of the ordination space, the interior streams occupied the lower right corner, and the large rivers occupied the upper right corner (Fig. 3.9a). Fourteen of the environmental variables were significantly correlated with axis 1 and/or axis 2 ($p < 0.0024$). The direction and magnitude of the loadings are illustrated in Fig 3.9a. Variables such as pH, conductivity, alkalinity, and TKN were high in the interior streams. Wetted width, maximum depth, and discharge were high in the large rivers. Percent carbon of suspended solids were high in the coastal streams.

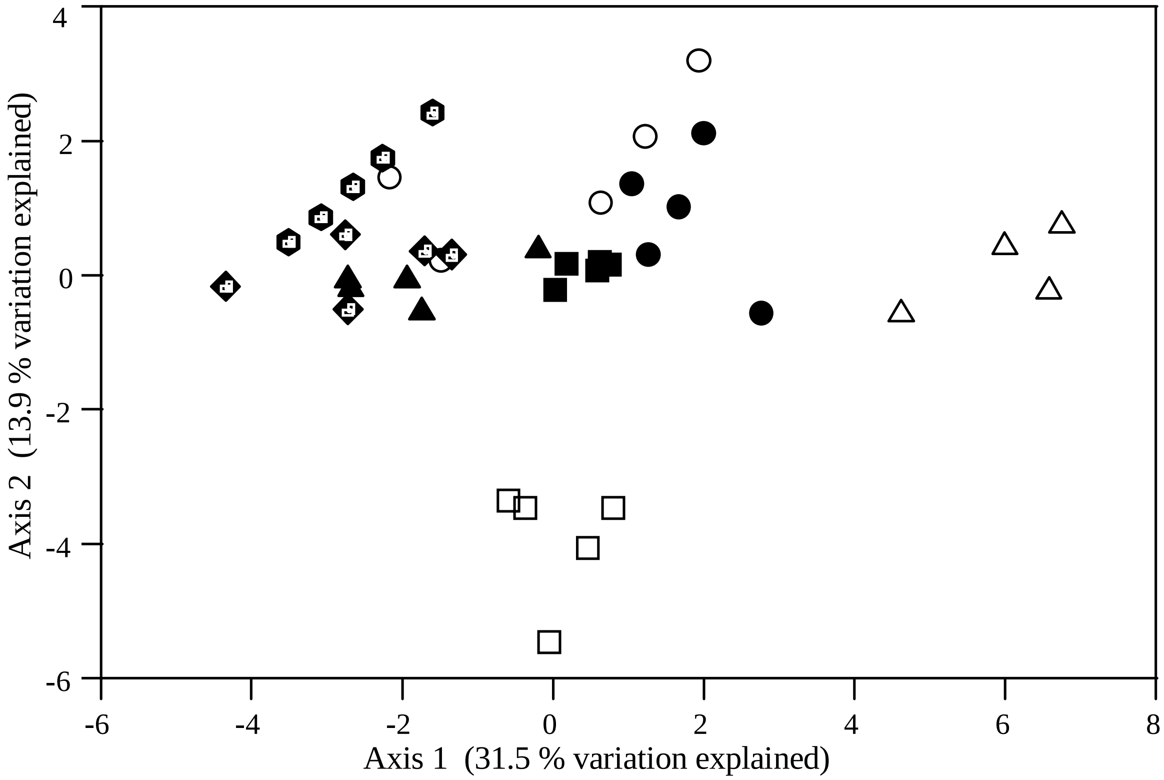

Figure 3.6a: Ordination plot of the seasonal samples for each site along principal component axes 1 and 2 based on log-transformed invertebrate data identified to genus/species, 1% censorship level.
○Mellin □Glimpse △ Beak ● Spring ■ Mayfly ▲ N.Alouette ◈Fraser ⬢ Thompson

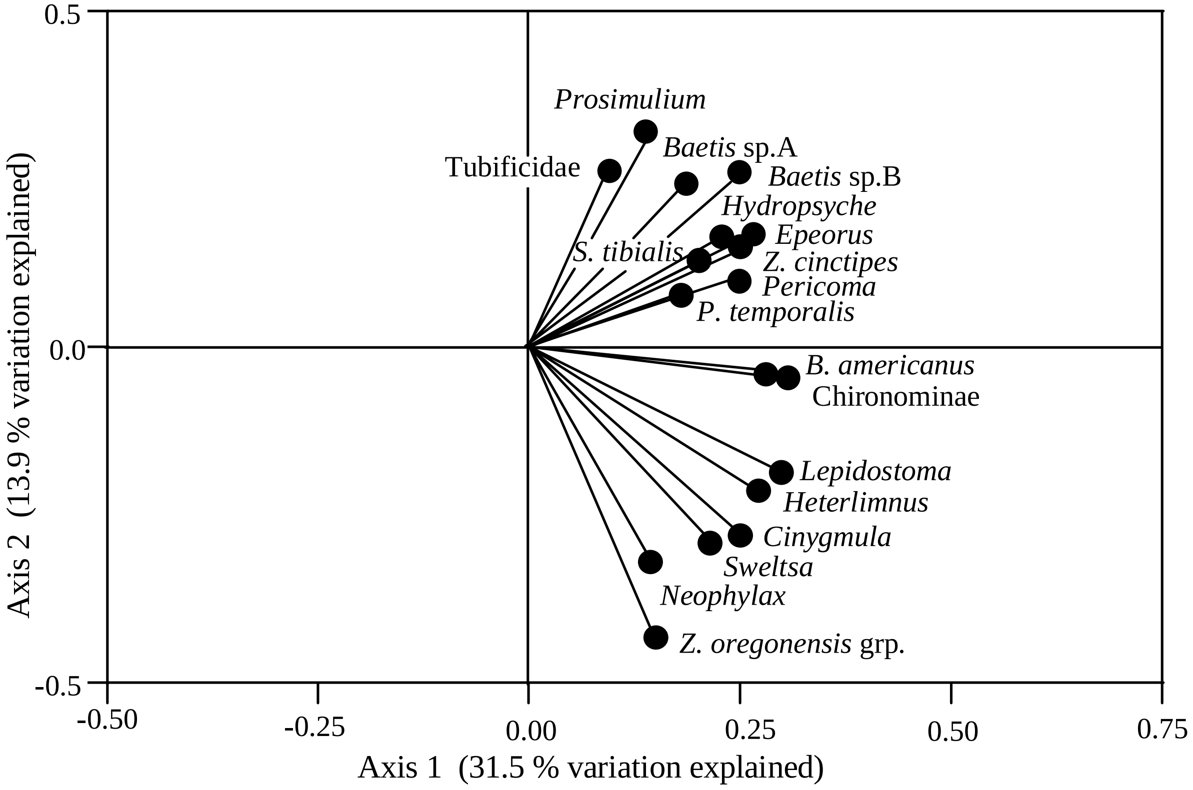

Figure 3.6b: Direction and magnitude of loadings for taxa with significant loadings along axis 1 and 2 of the ordination shown in Fig 3.6a..

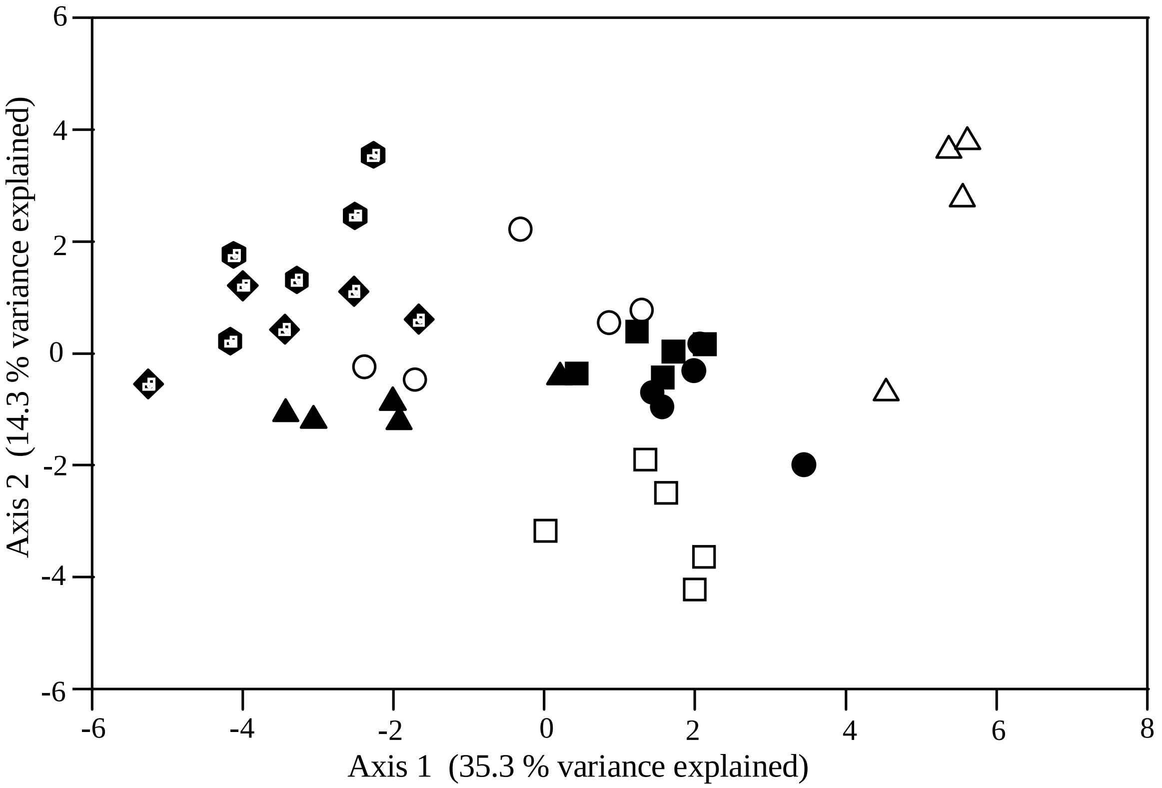

Figure 3.7a: Ordination plot of the seasonal samples for each site along principal component axes 1 and 2 based on log-transformed invertebrate data identified to family, 0.5% censorship level.
○Mellin □Glimpse △ Beak ● Spring ■ Mayfly ▲ N.Alouette ◈ Fraser ⬢ Thompson

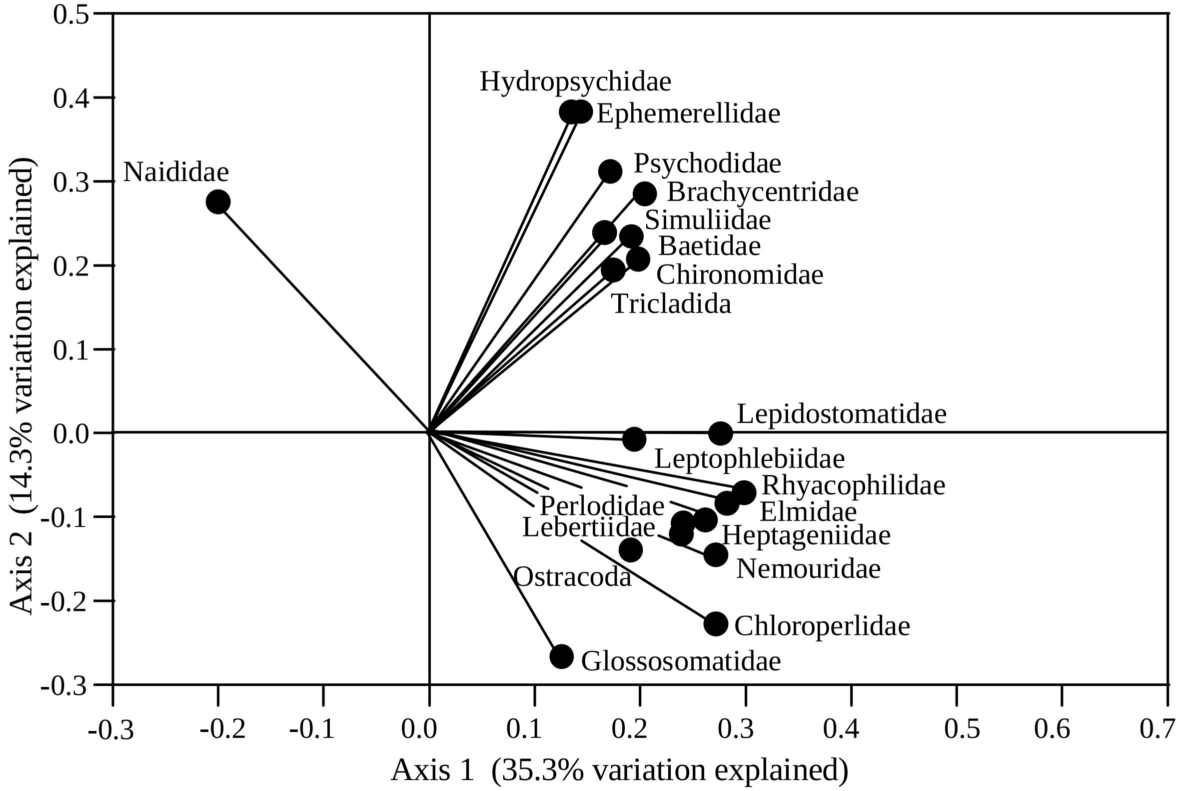

Figure 3.7b: Direction and magnitude of loadings for families with significant loadings along axis 1 and/or axis 2 of the ordination illustrated in Fig 3.7a.

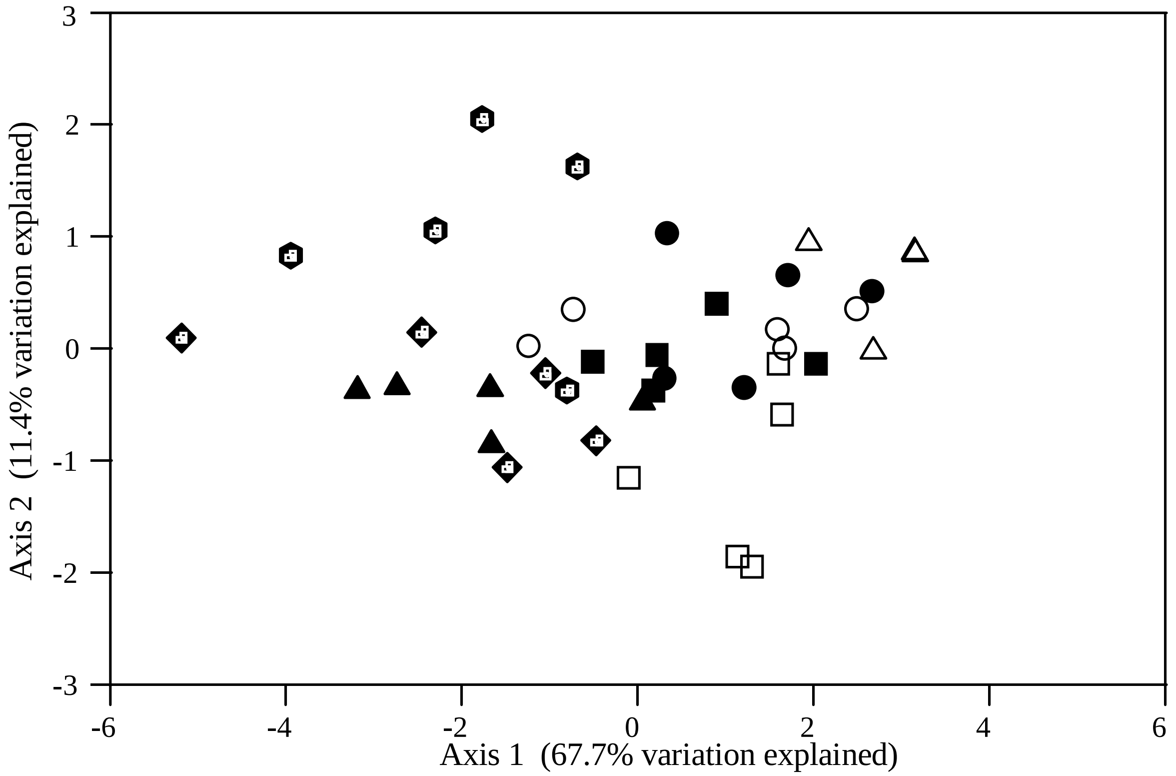

Figure 3.8a: Ordination plot of the seasonal samples for each site along principal component axes 1 and 2 based on invertebrate data classified by functional group.

○Mellin □Glimpse △Beak ● Spring ■ Mayfly ▲ N.Alouette ◆Fraser ⬢ Thompson

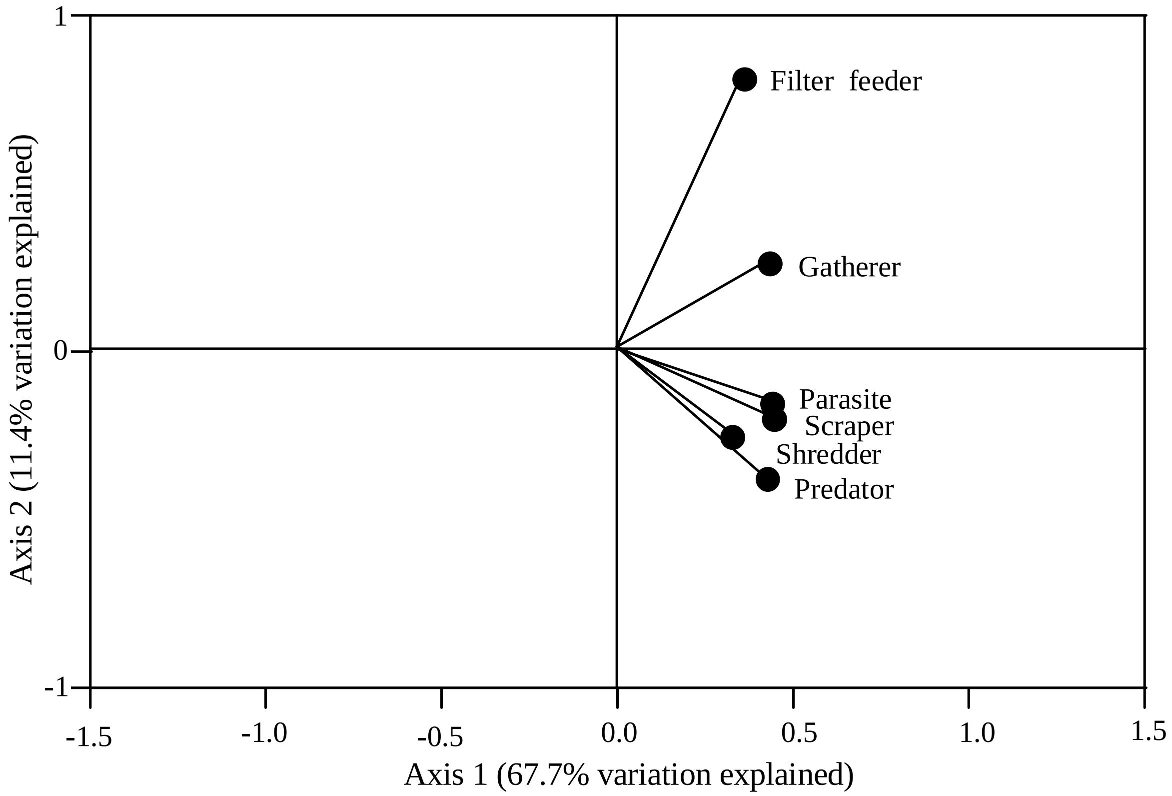

Figure 3.8b: Direction and magnitude of significant loadings for functional groups.

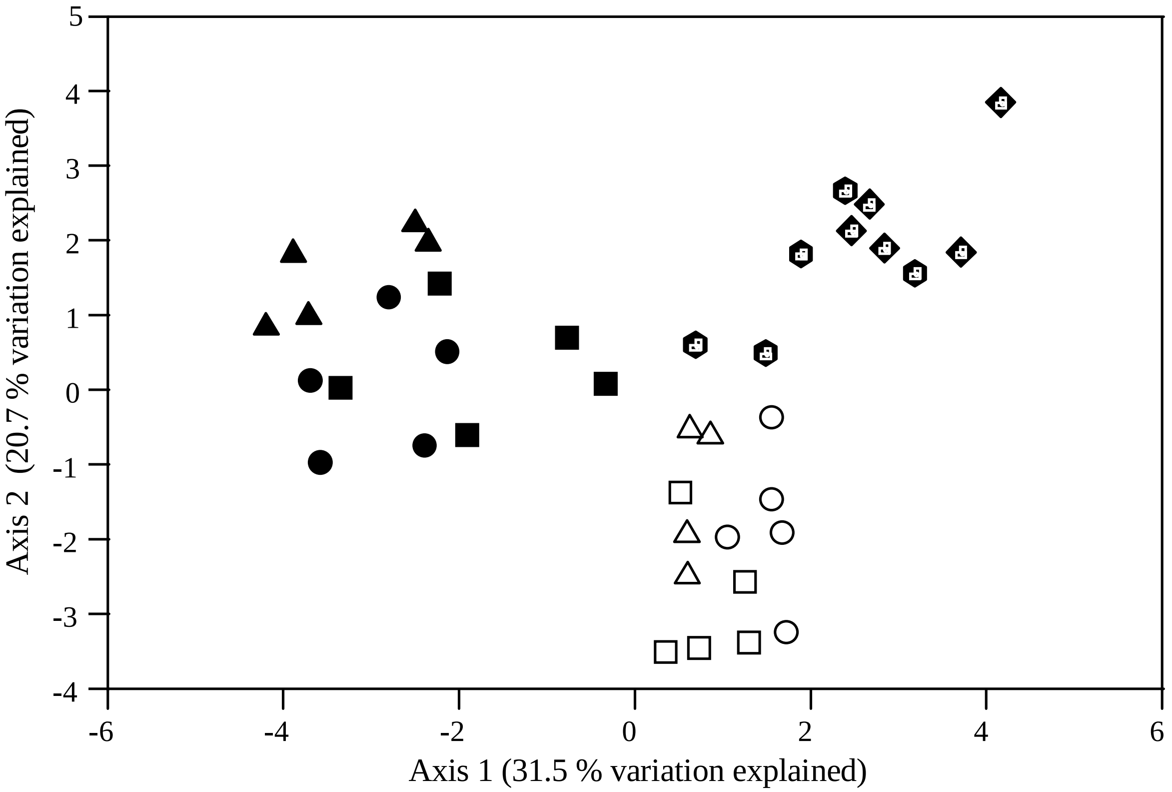

Figure 3.9a: Ordination plot of the sampling dates and sites along principal component axes 1 and 2 based on environmental conditions that change seasonally (Table 3.1).

○Mellin □Glimpse △ Beak ● Spring ■ Mayfly ▲ N.Alouette ◈ Fraser ⬢ Thompson

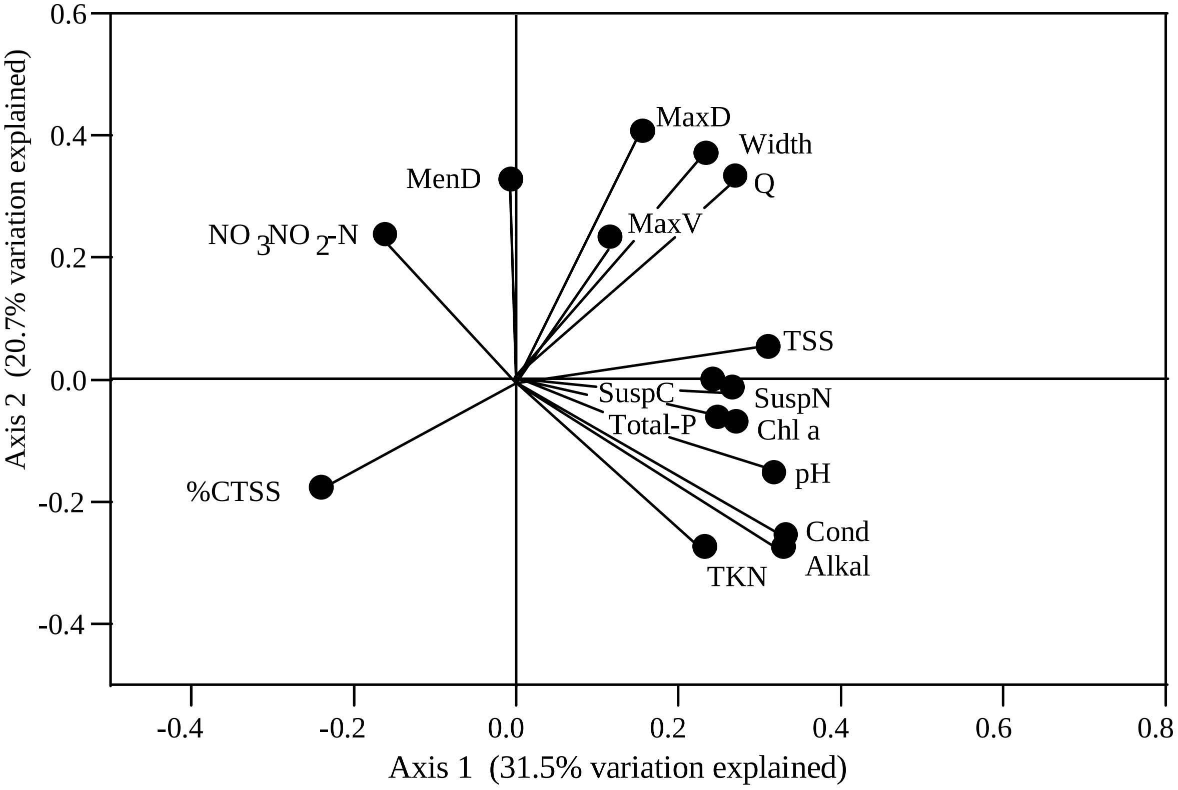

Figure 3.9b: Direction and magnitude of significant environmental loadings along axis 1 and 2 of the PCA. Abbreviations are listed in Table 3.1

Table 3.3: Invertebrate diversity at each sampling site and date based on Simpson’s index of diversity (1-D). Index ranges from a low diversity value of near 0 to almost 1.

Stream			*Season*		
	Spring 1995	*Summer*	*Autumn*	*Winter*	*Spring 1996*
Mellin	0.4874	0.8019	0.8123	0.8722	0.4985
Glimpse	0.5307	0.9153	0.843	0.6419	0.7493
Beak	0.8553	0.9172	0.8722	N/S	0.8972
Spring	0.9254	0.6867	0.9235	0.79	0.9126
Mayfly	0.9251	0.8078	0.8021	0.8106	0.9313
N. Alouette	0.8863	0.9017	0.9029	0.7968	0.5382
Fraser	0.7264	0.5183	0.8149	0.9053	0.8541
Thompson	0.4121	0.8709	0.6586	0.8389	0.2299

Table 3.4: Percent variance (of explained variance) explained by season, site, and stream class in the PCA ordinations as determined by MANOVA. The environmental data used in the ordination consisted of environmental variables that changed seasonally.

Data Analyzed	*PCA Axis*	*Season*	*Site*	*Stream Class*
Genus / Species	1	4.7	47.9	47.4
	2	4.9	37.6	57.5
Family	1	5	39	56
	2	5.3	75.1	19.6
Functional Groups	1	17.9	26.9	55.2
	2	7.4	85.1	7.5
Environmental	1	3	6.6	90.4
	2	3.6	11.7	84.7

Table 3.5: Coefficient of variation used to summarize the seasonal variation in ordination space for each site. Coefficients of variation were determined for the ordinations of the genus/species, family, and functional data, and for the ordination of the environmental variables that change seasonally. The rank order of the first axis coefficients of variation for the genus/species and family data are correlated (Spearman’s rank order correlation, r_s= 0.9286, $p < 0.005$), but the rank order of the second axis is not correlated (Spearman’s rank order correlation, r_s = 0.2857, $p > 0.5$).

	Genus / Species		*Family*		*Functional*		*Environmental*	
Site	*Axis 1*	*Axis 2*	*Axis 1*	*Axis 2*	*Axis 1*	*Axis 2*	*Axis 1*	*Axis 2*
Mellin	70.87	0.69	3.49	1.88	2.17	0.95	0.18	0.58
Glimpse	11.24	0.22	0.59	0.3	0.64	0.69	0.52	0.32
Beak	0.16	7.26	0.09	0.89	0.21	0.7	0.19	0.7
Spring	0.39	1.21	0.38	1.07	0.8	1.9	0.24	29.47
Mayfly	0.72	2.43	0.45	7.2	1.69	4.75	0.7	2.38

N.Alouette	0.55	3.08	0.69	0.34	0.68	0.45	0.25	0.4
Fraser	0.45	3.77	0.41	1.26	0.87	1.46	0.23	0.34
Thompson	0.28	0.55	0.27	0.67	0.7	0.89	0.49	0.63

Seasonal variation explained < 4 % of the variation in the ordination space and stream explained only slightly more (MANOVA, Table 3.4). Stream class explained most of the variation (85 - 90 %). Coefficient of variation analyses indicated that seasonal variation at each site was minor. Most of the variation occurred along the second axis (Table 3.5).

3.3.3 *How Changes in the Benthic Community are Related to Changes in the Environment*

The first and second PCA axes from the genus/species ordination were significantly correlated with the second axis of the ordination of environmental variables that change seasonally ($p < 0.0125$) (Table 3.6). The taxa *Baetisi* sp.A, *Baetis* sp.B, *Hydropsyche* sp., *Epeorus* sp., *Zapada cinctipes*, *Serratella tibialis*, *Pericoma* sp., *Paraleptophlebia temporalis*, *Brachycentrus americanus*, Chironominae, *Lepidostoma* sp., and *Heterlimnus* sp. from axis 1, and the taxa *Cinygmula* sp., *Sweltsa* sp., *Neophylax* sp., and *Zapada oregonensis* group from axis 2 all increased in abundance in streams with small channel widths, small discharge levels, low maximum and mean depths, low levels of NO_3NO_2-N, and a high conductivity, alkalinity and TKN level (small interior streams). Tubificidae and *Prosimulium* sp. decreased in abundance in rivers which *Cinygmula* sp., *Sweltsa* sp., *Neophylax* sp., and *Zapada oregonensis* increased in abundance. The first and second PCA axes from the family ordination were also significantly correlated with the second axis from the environmental ordination (Table 3.6). The families Simuliidae, Baetidae, Chironomidae, Tricladida, Lepidostomatidae, Leptophlebiidae, Rhyacophilidae, Elmidae, Perlodidae, Lebertiidae, Heptageniidae, Nemouridae, and Chloroperlidae from axis 1 and Glossosomatidae from axis 2 all increased in abundance in streams with small channel widths, small discharge levels, low maximum and mean depths, and low levels of NO_3NO_2-N, and a high conductivity, alkalinity, and TKN level (small interior streams). Hydropsychidae, Ephemerellidae, Psychodidae, Brachycentridae, and Naididae were most abundant in rivers with some combination of great widths, depth and discharge, and/or low alkalinity, conductivity, and TKN levels. The first PCA axes from the ordination of functional group data was significantly correlated ($p < 0.0125$) with the first and second

axes from the environmental ordination (Table 3.6). All functional groups were least abundant in rivers with the greatest depths, widths, and discharges and were most abundant in the smaller streams.

Table 3.6: Correlation coefficients (r) and significance values (p) for correlation of PCA axes from the invertebrate ordination with the PCA axes from the ordination of environmental variables that changed seasonally ($\alpha_c = 0.0125$). Bold type indicates significant correlations.

		Genus / Species		*Family*		*Functional Groups*	
Environment		*Axis 1*	*Axis 2*	*Axis 1*	*Axis 2*	*Axis 1*	*Axis 2*
Axis 1	r	-0.1981	0.0019	-0.245	0.2285	**-0.4233**	0.1655
	p	0.2267	0.9910	0.132	0.1617	**0.0072**	0.3141
Axis 2	r	**-0.5386**	**0.4477**	**-0.538**	**0.4903**	**-**	0.1841
	p	**0.0004**	**0.0043**	**0.0004**	**0.0015**	**0.5784**	0.2620
						0.0001	

Seasonal changes in the benthic community at each site were significantly correlated with the seasonal changes of some environmental conditions. The relationship between changes in community structure with environmental variables differed between streams and between invertebrate classification level. A summary of the significant correlations can be found in Table 3.7. For this analysis, probability values were compared to an uncorrected alpha critical value (0.05) because patterns were sought and thus the problem of type I error was not so critical (Rice 1989). To test a common hypothesis, the Bonferroni-corrected alpha value would be $\alpha_c = 0.0023$, resulting in only one significant correlation (Table 3.7).

Mellin Creek was the only interior stream that had significant correlations ($p<0.05$); seasonal change of the invertebrate communities was positively correlated with seasonal change in temperature, and seasonal change of the functional community was positively correlated with the change in cumulative discharge (Table 3.7). Changes in the benthic community in Spring Creek were positively correlated with channel width and suspended carbon with identification to the genus/species level. When identification was to the family level, community change was positively correlated with suspended nitrogen and negatively correlated with peak discharge. Functional community changes were positively correlated with channel width. The benthic community in Mayfly Creek (genus/species level) was positively correlated with suspended nitrogen and negatively correlated with suspended carbon and CPOM. In the North Alouette River, changes in the benthic community (family level), were positively correlated with suspended nitrogen. At the functional level, changes to the community were correlated with changes in suspended nitrogen and carbon. In the Fraser River, changes in the benthic community (family level) were positively correlated with change in peak discharge and negatively correlated with conductivity.

ANCOVAs were run for the 3 invertebrate classification levels and 22 environmental variables to determine whether the benthic communities from the different streams and classes of streams changed seasonally with the same magnitude for a given environmental variable and how change in community was related to seasonal change in the environmental variable. While stream and stream class had significant effects there were no significant effects of the environmental variables or of the interaction between the environmental variables and streams or stream classes ($\alpha_c = 0.05$) The seasonal change of benthic community structure was not related to the rate of seasonal change of the environmental variables measured in this study regardless of the invertebrate classification level used.

Table 3.7: Summary of the significant correlations between the seasonal change of the invertebrate community PCA scores and the seasonal change of environmental variables ($\alpha_c = 0.05$). For abbreviations see Table 3.1. Asterisk represent probability values, *$p \leq 0.05$, ** $p \leq 0.01$, *** $p < 0.001$.

Site	*Invertebrate Classification*	*Environmental Variables*	*Correlation Coefficient p - value*
Mellin	genus/species	temp	0.990 *
	family	temp	0.986 *
	functional	cumulative Q	0.989 *
Glimpse	no significant correlations		
Beak	no significant correlations		
Spring	genus/species	width; suspC	0.960 *; 0.952 *
	family	suspN; Peak Q	0.976 *; -0.944 *
	functional	width	0.992 **
Mayfly	genus/species	suspN; suspC; CPOM	-0.978 *; -0.998 ***; -0.957 *
N.Alouette	family	suspN	0.948 *
	functional	suspN; suspC	0.969 *; 0.953 *
Fraser	family	Peak Q, cond	0.950 *; -0.963 *
Thompson	no significant correlations		

3.4.0 Discussion

3.4.1 *Spatial Patterns of Benthic Communities*

Benthic invertebrate species composition, diversity, and abundance can vary along environmental gradients (e.g. biogeographical features, altitude). The particular gradients of environmental conditions correlated with patterns of community composition can be hierarchically nested across spatial scales of the study and environmental gradients present in the study area. Many of the environmental variables related to community composition in this study are the same as those related to community composition in previous studies (Table 3.8). Environmental variables related to invertebrate composition in this study were channel width, mean depth, maximum depth, maximum velocity, discharge, conductivity, alkalinity, nitrite and nitrate nitrogen, and TKN.

Invertebrate abundance was high in the small streams and was low in the large river sites. This pattern of abundance related to stream size dominated the PCA results at all levels of invertebrate classification. Nutrients, autochthonous and allochthonous inputs, and canopy coverage were high in the small streams, presumably providing resources for the invertebrates. Within the small streams *Zapada oregonensis* group, *Sweltsa* sp., *Cinygmula* sp., and *Neophylax* sp. were most abundant in Glimpse Creek, which had the highest elevation, alkalinity, and conductivity of all the streams; and conifers dominated the riparian vegetation. Ward (1986) found *Z. oregonensis,* and *Sweltsa coloradensis* to be euryzonal, although *Z. oregonensis* was most abundant in high elevation streams with a combination of coniferous and deciduous riparian vegetation. *Zapada oregonensis* grp. are shredders and Glimpse Creek typically had the highest amounts of CPOM. *Cinygmula* sp. and *Neophylax* sp. are scrapers and Glimpse Creek also had one of the highest amounts of periphyton. *Cinygmula* sp. are dominant taxa in high elevation streams with both open and closed canopies of coniferous and deciduous vegetation (Ward 1986). *Prosimulium sp.* and Tubificidae were not very abundant in the large river samples as suggested by the correlation analysis however, they were never found in the samples from streams that *Z. oregonensis* group, *Sweltsa* sp., *Cinygmula* sp., and *Neophylax* sp. were most abundant in.

Hydropsychidae, Ephemerellidae, Brachycentridae, and Naididae were found in all stream classes but increased in abundance in rivers with low conductivity, alkalinity and TKN levels. In previous studies, Hydropsychidae were most abundant at deciduous sites (Corkum 1990) or in 4*th* and 5*th* order streams with deciduous trees and grasses in the riparian vegetation (Ward 1986). Ephemerellid genera were diverse in both the interior streams and large rivers, however *Ephemerella inermis/infrequens* dominated at the large river sites. Brachycentridae are ubiquitous and can be found throughout the Holarctic region from cold mountain springs to marshy rivers (Wiggins 1996). The genera *Brachycentrus occidentalis* occurred at the large river sites while *B. americanus* occurred at the interior stream sites.

The River Continuum Concept (RCC) proposed some general characteristics of "the structure and function of communities along a river system" in relation to the abiotic environment (Vannote *et al*. 1980). Community composition in pristine river systems should shift from one dominated by shredders (CPOM) and collectors (FPOM) in upstream reaches, to one dominated by collectors and grazers in intermediate reaches, and then to communities primarily composed of collectors in downstream reaches (Vannote *et al*. 1980; Hawkins and Sedell 1981; Cummins 1988). This change should occur as the relative contribution and sources of autochthonous and allochthonous inputs change. Our study supports the RCC in that CPOM shredders were relatively more abundant in the headwaters than downstream in the large rivers. As well, collector-gatherers made up a larger proportion of the community in the large rivers than in the small streams. Contrary to predictions made by the RCC, our study found shredders and grazers on average made up 20 % of the functional composition of the large river communities. The large river samples were collected from the river margins, which could bias composition. However, Rempel (1997) found consistent proportions of functional groups up to 3 m in depth in the Fraser. As well, the river margins are the habitat used primarily by invertebrates (Rempel 1997).

Both the RCC and food web theory predict that predator/prey ratios should remain constant. Freshwater invertebrate predator/prey ratios range between a mean of 0.29 in large (species- rich) collections to 0.48 in small (species-poor) collections (Jeffries and Lawton 1985). In our study,

Table 3.8: Summary of the environmental variables correlated with benthic community composition from this and previous studies. For abbreviations see Table 2.2.

Reference	*Geographic Region*	*Environmental Variables*
Furse *et al.*, 1984	Great Britain	alkal, NO_3NO_2-N, substrate, slope, elev, Q, dist, width, and depth
Ormerod and Edwards, 1987	River Wye	pH, total hardness, associated geology, slope and dist.
Corkum, 1989	northwestern North America	Biogeographical features: latitude, elev, slope Hydrological variables: meanV, meanD
Corkum, 1990	eastern deciduous forest biome, southwestern Ontario, Canada	land use/riparian vegetation
Richards *et al.*, 1993	Saginaw Bay catchment, Michigan, USA	habitat/channel morphology (substrate composition and riparian vegetation).
Tate and Heiny, 1995	South Platte River basin, Southern Rocky Mountains to the Great Plains, USA	temp, cond, organic nitrogen, NH_4-N, totalP, NO_3NO_2-N, slope, and width
Dymond, 1998 (this study)	southwestern British Columbia, Canada	cond, alkal, TKN, NO_3NO_2-N, width, meanD, maxD, maxV, Q.

invertebrate predator/prey ratios ranged between 0.01 in the Thompson River and 0.46 in the North Alouette River. These ratios were fairly consistent within a site although they were not constant between study sites or stream classes, and they were consistently less than those previously found in the literature (Jeffries and Lawton 1985). There are two possible explanations for this discrepancy. First, vertebrate predators were not considered in this study and they may account for a larger proportion of the predators than in other systems. Second, it is difficult to accurately classify invertebrates into functional groups. Merritt and Cummins' (1996) functional group classifications are only defined for some genera; however, species within a genus may have different food resources (e.g. Hawkins 1984), and taxa may change food sources between sites and seasons, or with life cycle stage (e.g. Chapman and Demory 1963; Fuller and Stewart 1977; Martinson and Ward 1982).

Shifts in functional group composition between the various stream classes shown in Fig. 3.4 may be obscured in the ordination (Fig. 3.8a) because of differences in abundance between large rivers and small streams. Abundance of invertebrates in all functional groups increases from the large river sites to the small streams; greatest abundance was attained in Beak Creek.

3.4.2 *Seasonal Patterns of Benthic Communities*

Seasonal variation in community composition was less than between-site variation and the variation between stream classes in this study. The relatively small amount of seasonal variation in community composition compared to spatial variation is also common to other studies over a range of spatial scales. Both Hawkins and Sedell (1981) and Corkum (1990) found less seasonal variation than spatial variation when samples were collected from 1st to 7th order streams or when samples were collected over a large area within a biome. In those studies, the relatively small amount of seasonal variation may have been a result of large spatial differences. However, Matthews *et al*. (1991) and Death (1995) also found only small amounts of seasonal variation relative to spatial variation when samples were collected within a 4-km stretch of a stream or from streams with similar physical and chemical characteristics.

Studies documenting that seasonal variation of the benthic community was greater than spatial variation were conducted in either intermittent streams in Australia (Boulton and Lake 1992; Closs and Lake 1994), or in a Mediterranean stream with distinctly unfavorable seasons (Doledec 1989). In intermittent streams, seasonal change was related to time since drought or flooding; the number of taxa and/or number of individuals increase as the period of constant streamflow increases (Harrel and Dorris 1968; Boulton and Lake 1992; Closs and Lake 1994). In the Mediterranean stream, seasonal changes of benthic composition resulted from taxa able to tolerate strong, sudden spates in the winter, to those able to tolerate elevated water temperatures in the summer, with a transition period between (Doledec 1989). Extreme conditions such as those mentioned above were not found in the streams included in this study, resulting in no drastic changes in composition. In addition, the extent to which the communities in our study can change seasonally may be limited by the short period of warmer temperatures.

Within a study site there were seasonal changes in community composition and invertebrate abundance. The variation resulted from changes in relative and absolute abundances as invertebrates moved through their life cycles (see also Giberson and Hall 1988). Hynes (1970) proposed a general pattern of annual insect abundance in small temperate streams (Fig. 3.1). The mechanism of seasonal change in the small streams of our study was similar to that established by Hynes (1970); however, the pattern of abundance differed slightly probably because of local environmental conditions and the fauna specific to each site.

According to Hynes (1970), invertebrate abundance should decrease during the spring season with the emergence of many taxa. This loss of numbers may be offset as the eggs of summer species hatch. In the interior streams, however, greatest abundance was achieved in the early spring. This early spring peak corresponded with overlapping generations of ready-to-emerge winter stoneflies and the beginning of recruitment of the next generation (e.g. *Zapada cinctipes*, Chap. 2). Abundance then decreased later in the spring only to increase again in the summer with recruitment. The difference between Hynes's predictions and the results from the interior streams may be a result of temperatures. Thus, it may be more productive to compare the timing of annual temperature cycles rather than specific seasons. In the coastal streams, abundance was low in the spring samples. Summer was the season of greatest abundance and coincided with a variable peak predicted by Hynes (1970). This peak in abundance was a result of the hatching of eggs of both summer and univoltine taxa (Chap. 2). In the coastal streams, late spring through summer were more important seasons for invertebrate recruitment than was suggested by Hynes (1970).

Macroinvertebrate abundance in the large rivers, increased from the late spring through summer and autumn and was maximum in the early spring. This pattern in the large rivers was different from that predicted for small streams by Hynes (1970), but was very similar to that found by Bothwell and Culp (1993) in the Thompson River. Bothwell and Culp (1993) found that many taxa emerged in the spring prior to the onset of the annual freshet and density remained low until after the freshet. Following the freshet, abundance then increased to a secondary annual peak in the autumn, during a period of lower, stable flows and high water temperatures. Annual peak abundance was reached late in the winter, and the insects were large and close to emergence.

The seasonal change of the invertebrate community was not directly related to the seasonal change of environmental conditions in this study. The seasonal change of the faunal community was however, indirectly related to environmental conditions such as temperatures and food resources through the influence of the environment on invertebrate life cycles (Chap. 2). Many of the changes in composition observed are a result of increases and decreases in abundance that corresponded to timing of invertebrate life cycles. Mellin Creek provides an example of the relationship between environmental conditions, life cycles, abundance, and community compositon. Changes in community composition in Mellin Creek were positively correlated with changes in temperatures. The largest change in community composition at both the genus/species and family levels occurred between the late spring (1995) and summer samples at a time of maximum increase in water temperatures (Fig 2.7). Most taxa increased in abundance between these dates, especially the tubificids, *Prosimulium* sp., *Serratella tibialis,* and *Cinygmula* sp. Increases in abundance were primarily a result of the hatching of eggs of summer species and summer generations of multivoltine taxa (Hynes 1970). Changes in composition between autumn and winter were slight because of a decline in recruitment and emergence rates.

The RCC predicts that functional group composition should remain consistant through the year. (Vannote *et al*. 1980). Studies have found the functional composition of stream communities change seasonally. Seasonal change of the functional composition would allow the community to take advantage of the change in energy input sources over time (Statzner and Higler 1985). In small streams with open canopies and deciduous riparian vegetation, shredders should increase in the autumn and winter when CPOM resources are at their greatest. In the summer, the communities in these streams should have the greatest abundance of herbivores because of the high primary production accompanying warm temperatures and high light availability. Shredder abundance in the interior streams did increase in the autumn, however, herbivore abundance was not greatest in the summer. Perhaps the riparian vegetation along the interior streams reduced light penetration to the stream channel. The riparian vegetation along the coastal streams was primarily coniferous, resulting in reduced seasonality of influx rate of CPOM and a fairly consistent abundance of shredders.

Our study demonstrated that the amount of seasonal variation changed between each site. Differences in the seasonal variation between each site are a result of the different taxa composing each community and differences in environmental conditions. Environmental conditions that influence the timing of life cycles, change seasonally, and differ among the three stream classes include discharge, water temperature, and food resources. The seasonal change in assemblage structure at each site was correlated with changes of few, if any, environmental variables. However, discharge seems to influence invertebrate abundance in the large rivers. The difference in the winter temperatures between the coastal and interior streams influences invertebrate life cycles (Chap.2) and patterns of abundance. The level of each food resource changes seasonally and abundance of each functional group follows the seasonal flux.

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Appendix 1: List of taxa identified, functional group classification, and the class(es) of streams in which they were found. CPOM shredder (SH), herbivore shredder (HE), deposit collector (DE), filter collector (FI), grazer (GR), wood gouger (GO), parasite (PA), and predator (PR)
* = taxon found in > 25% of the samples from a specific stream class (i.e, common taxa).
! = taxon in less than 25% of the samples collected from a specific class of stream (i.e., rare taxa).

	TAXONOMIC GROUP		**FUNCTIONAL GRP**	**INTERIOR**	**COASTAL**	**LARGE**
Coelentrata	Hydra polyps !		PR	-	-	+
Turbellaria	Tricladida		PR	+	+	+
Nematoda			PA	+	+	+
Gastropoda	Valvatidae	*Valvata sincera* !	GR	-	+	-
Plecypoda	Sphaeriidae	*Psidium cassertanum* *	FI	+	-	-
Crustacea	Amphipoda	*Hyalella azteca* !	GR	-	-	+
		Stygobromus sp. !	GR	+	-	-
Ostracoda			GR	+	+	-
Oligochaeta	Lumbriculidae		GR	+	+	-
	Naididae		GR	+	-	+
	Tubificidae		GR/DE	+	+	+
Arachnida	Araneae !		PR	-	+	-
	Anisitsiellidae		PA	+	+	+
	Ataridae	Albiinae !	PA	-	+	-
		Axonopsinae !	PA	+	-	-
	Aturidae	*Frontipodopsis* sp. !	PA	-	+	-
	Hydryphantidae	*Prozia* sp. !	PA	-	+	-
	Lebertiidae	*Lebertia* sp.	PA	+	+	+
	Limnesiidae	*Limnesia* sp.	PA	+	+	+
		Tyrreliinae	PA	+	+	+
	Sperchonidae	*Sperchon* sp.	PA	+	+	+
	Torrenticolidae	*Torrenticola* sp.	PA	+	+	+
	Unidentified mite !		PA	+	-	-
Pseudoscorpiones	!		PR	-	+	-
Insecta	Collembola		DE	+	+	+
Ephemeroptera	Ameletidae	*Ameletus* sp.	HE/DE	+	+	+
	Baetidae	*Baetis* sp. A	HE/DE	+	+	+
	Baetidae	*Baetis* sp.B	HE/DE	+	+	+
	Baetidae	*Callibaetis* sp. !		+	-	-
	Ephemerellidae	*Caudatella* sp.	HE/DE	+	-	+
	Ephemerellidae	*Drunella doddsi*	HE/DE	+	+	+
	Ephemerellidae	*Drunella flavilinea*	HE/DE	+	+	+

	Ephemerellidae	*Drunella grandis ingens*	HE/DE	+	-	+
	Ephemerellidae	*Drunella spinifera*	HE/DE	+	+	+
	Ephemerellidae	*Ephemerella inermis/infrequens*	DE	+	+	+
	Ephemerellidae	*Serratella tibialis*	DE	+	+	-
	Heptageniidae	*Cinygma* sp.	HE/DE	+	+	-
	Heptageniidae	*Cinygmula* sp.	HE/DE	+	+	+
	Heptageniidae	*Epeorus* (*Ironopsis*) sp. *	HE/DE	-	+	-
	Heptageniidae	*Epeorus* (*Iron*) sp.	HE/DE	+	+	+
	Heptageniidae	*Ironodes* sp. *	HE/DE	-	+	-
	Heptageniidae	*Rhithrogena* sp.	HE/DE	+	+	+
	Heptageniidae	*Stenonema* sp. *	HE/DE	-	-	+
	Leptophlebiidae	*Paraleptophlebia temporalis*	DE	+	+	+
	Tricorythidae	*Tricorythodes minutes* !	DE	-	-	+
Plecoptera	Capniidae	*Capnia* sp	SH	+	+	+
	Capniidae	*Eucapnopsis brevicauda* !	SH	-	+	-
	Capniidae	*Mesocapnia* sp. !	SH	-	-	+
	Chloroperlidae	*Haploperla* sp.	PR	+	+	-
	Chloroperlidae	*Kathroperla* sp. !	DE	-	+	-
	Chloroperlidae	*Plumiperla* sp.		+	+	-
	Chloroperlidae	*Suwallia* sp.	PR	+	+	+
	Chloroperlidae	*Sweltsa* sp.	PR	+	+	+
	Leuctridae	*Despaxia augusta*	SH	+	+	+
	Leuctridae	*Perlomyia collaris*	SH	+	+	-
	Nemouridae	*Amphinemura* sp. *	SH	+	-	-
	Nemouridae	*Malenka* sp. *	SH	-	+	-
	Nemouridae	*Ostrocerca* sp. !	SH	-	+	-
	Nemouridae	*Podmosta* sp.	SH	+	+	+
	Nemouridae	*Visoka cataractae*		+	+	+
	Nemouridae	*Zapada cinctipes*	SH	+	+	+
	Nemouridae	*Zapada oregonensis*	SH	+	+	+
	Peltoperlidae	*Yoraperla brevis* *	SH	-	+	-
	Perlidae	*Calineuria californica*	PR	+	+	-
	Perlidae	*Doroneuria baumanni*	PR	+	+	-
	Perlidae	*Hesperoperla pacifica* *	PR	-	+	-
	Perlodidae	*Isogenoides* sp. !	PR	-	-	+
	Perlodidae	*Isoperla* sp.	PR	+	+	+
	Perlodidae	*Kogotus* sp. !	PR	-	-	+
	Perlodidae	*Megarcys* sp. *	PR	+	-	-
	Perlodidae	*Setvena bradley* *	PR	-	+	-
	Perlodidae	*Skwala* sp.	PR	+	+	+
	Pteronarcyidae	*Pteronarcys princeps* *	SH	-	+	-
	Taeniopterygidae	*Taenionema* sp.	SH	+	+	+
Trichoptera	Apataniidae	*Apatania zonella*	HE/DE	+	+	-
	Brachycentridae	*Amiocentrus aspilus* !	DE	+	-	-

	Brachycentridae	*Brachycentrus americanus* *	FI	+	-	-
	Brachycentridae	*Brachycentrus occidentalis* *	FI	-	-	+
	Brachycentridae	*Micrasema* sp. A *	SH	-	+	-
	Glossosomatidae	*Glossosoma* sp.	HE	+	+	+
	Hydropsychidae	*Parapsyche elsis*	FI	+	+	+
	Hydropsychidae	*Hydropsyche* sp.	FI	+	+	+
	Hydropsychidae	*Hydropsyche* "British Columbia"	FI	+	-	+
	Hydropsychidae	*Hydropsyche centra* !	FI	-	-	+
	Hydropsychidae	*Hydropsyche oslari* !	FI	-	-	+
	Hydroptilidae	Hydroptilidae	HE	+	+	+
	Hydroptilidae	*Agraylea* sp. *	HE	-	+	-
	Hydroptilidae	*Hydroptila* sp. !	HE	-	-	+
	Leptoceridae	*Ceraclea* sp. !	HE	-	-	+
	Lepidostomatidae	*Lepidostoma* sp.	SH	+	+	+
	Limnephilidae	Limnephilidae	SH	+	+	-
	Limnephilidae	*Chyranda centralis* !	SH	+	-	-
	Limnephilidae	*Clostoeca* sp. !	SH	-	+	-
	Limnephilidae	*Ecclisomyia* sp.	HE/DE	+	+	-
	Limnephilidae	*Hesperophylax* sp. *	SH/HE	+	-	-
	Limnephilidae	*Onocosmoecus unicolor* *	SH	-	+	-
	Limnephilidae	*Allomyia* sp. *	SH/DE	+	-	-
	Philopotamidae	*Wormaldia* sp. *	FI	-	+	-
	Philopotamidae	*Dolophilodes* sp. !	FI	-	+	-
	Polycentropodidae	*Polycentropus* sp. *	PR	-	+	-
	Rhyacophilidae	*Rhyacophila* sp.	PR	+	+	+
	Rhyacophilidae	*Rhyacophila acropedes* grp.	PR	+	+	+
	Rhyacophilidae	*Rhyacophila angelita* grp.	PR	+	+	-
	Rhyacophilidae	*Rhyacophila chilsia* grp. *	PR	-	+	-
	Rhyacophilidae	*Rhyacophila grandis* !	PR	-	+	-
	Rhyacophilidae	*Rhyacophila narvae*	PR	+	+	-
	Rhyacophilidae	*Rhyacophila norcuta* grp. !	PR	-	+	-
	Rhyacophilidae	*Rhyacophila vagrita*	PR	+	+	-
	Uenoidae	*Neophylax* sp. *	SH/HE	+	-	-
Coleoptera	Amphizoidae	*Amphizoa* sp. !	PR	+	-	-
	Dytiscidae	*Agabus* sp. !	PR	+	-	-
	Dytiscidae	Dytiscidae (adult) !	PR	+	-	-
	Dytiscidae	*Brachyvatus* sp. !	PR	-	-	+
	Dytiscidae	*Desmopachria* sp. (adult)	PR	-	+	-
	Dytiscidae	*Laccornis* sp. !	PR	-	-	+
	Elmidae	*Ancronyx* sp. (adult)	HE/DE	+	+	-
	Elmidae	*Cleptelmis* sp. *	HE/DE	-	+	-
	Elmidae	*Dubiraphia* sp. !	HE/DE	-	+	-
	Elmidae	*Heterlimnius* sp.	HE/DE	+	+	+
	Elmidae	*Narpus* sp. (adult) !	DE	-	+	-

	Elmidae	*Lara* sp. *	GO	-	+	-
	Elmidae	*Ordobrevia* sp. (adult)	HE/DE	+	+	-
	Elmidae	*Optioservus* sp. (adult) *	DE	-	+	-
	Elmidae	*Zaitzevia* sp. (adult) !	HE/DE	-	-	+
	Tenebrionidae !			-	-	+
Hemiptera	Corixidae !			-	-	+
Odonata	Coenargrionidae !			-	-	+
Diptera	Athericidae	*Atherix* sp. !	PR	-	-	+
	Blephariceridae	*Blepharicera* sp. !	HE/DE	-	+	-
	Ceratopogonidae	Ceratopogoninae	PR	+	+	+
	Ceratopogonidae	*Atrichopogon* sp. !	HE/DE	-	+	-
	Chironomidae	Chironominae	HE/DE	+	+	+
		Constempellina sp.	DE/FI	+	+	+
		Robackia sp. *		-	-	+
		Tanytarsus sp.	DE/FI	+	+	+
	Chironomidae	Orthocladiinae	HE/DE	+	+	+
		Corynoneura sp.	HE/DE	+	+	+
	Chironomidae	Prodiamesinae !	HE/DE	+	-	-
	Chironomidae	Tanypodinae	PR/DE/F	+	+	+
	Dixidae	*Dixa* sp. !	DE	-	+	-
	Dolichopodidae	*Hydrophorus* sp. !	PR	+	-	-
	Empididae	*Chelifera* sp.	PR	+	+	-
	Empididae	*Hemerodromia* sp.	PR/DE/F	-	+	+
	Empididae	*Oreogeton* sp.	PR	+	+	-
	Psychodidae	*Pericoma* sp./*Thelmatoscopus* sp. *	DE	+	-	-
	Simuliidae	*Prosimulium* sp.	FI	+	+	+
	Simuliidae	*Simulium* sp.	FI	+	+	+
	Tipulidae	*Antocha monticola*	DE	+	+	+
	Tipulidae	*Dicranota* sp.	PR	+	+	+
	Tipulidae	*Hexatoma* sp. A *	PR	+	-	-
	Tipulidae	*Hexatoma* sp. B *	PR	-	+	-
	Tipulidae	*Rhabdomastix* sp.		-	+	+
	Tipulidae	*Tipula* sp. !	SH/DE	+	-	-

Appendix 2: Invertebrate taxa included in genus/species and family level analyses and their respective class, order, and family.

TAXONOMIC CLASSIFICATIONS			GROUPS IN EACH ANALYSIS	
CLASS	**ORDER**	**FAMILY**	**GENUS/SPECIES**	**FAMILY**
Turbellaria	Tricladida			Tricladida
Ostracoda				Ostracoda
Oligochaeta		Naididae		Naididae
		Tubificidae	Tubificidae	Tubificidae
Arachnida	Acari	Lebertiidae		Lebertiidae
		Torrenticolidae	*Torrenticola* sp.	Torrenticolidae
		Baetidae	*Baetis* sp.A	Baetidae
Insecta	Ephemeroptera	Baetidae	*Baetis* sp.B	
		Ephemerellidae	*Ephemerella inermis/infrequens*	Ephemerellidae
		Ephemerellidae	*Serratella tibialis*	
		Heptageniidae	*Cinygmula* sp.	Heptageniidae
		Heptageniidae	*Epeorus* (Iron) sp.	
		Leptophlebiidae	*Paraleptophlebia temporalis*	Leptophlebiidae
		Capniidae	*Capnia* sp.	Capniidae
	Plecoptera	Chloroperlidae	*Sweltsa* sp.	Chloroperlidae
		Nemouridae	*Podmosta* sp.	Nemouridae
		Nemouridae	*Zapada cinctipes*	
		Nemouridae	*Zapada oregonensis*	
		Perlodidae		Perlodidae
	Trichoptera	Brachycentridae	*Brachycentrus americanus*	Brachycentridae
		Glossosomatidae		Glossosomatidae
		Hydropsychidae	*Hydropsyche* sp.	Hydropsychidae
		Lepidostomatidae	*Lepidostoma* sp.	Lepidostomatidae
		Rhyacophilidae		Rhyacophilidae
		Uenoidae	*Neophylax* sp.	Uenoidae
	Coleoptera	Elmidae	*Heterlimnius* sp.	Elmidae
	Diptera	Chironomidae	Chironominae	Chironomidae
		Chironomidae	Orthocladiinae	
		Psychodidae	*Pericoma* sp. / *Thelmatoscopus* sp.	Psychodidae
		Simuliidae	*Prosimulium* sp.	Simuliidae

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Hydra polyps	Nematoda	Valvata	Psidium	Lumbriculidae	Naididae	Tubificidae	Araneae	A6	Torrenticola sp.	Frontipodopsis sp.	Lebertia sp.	Limnesia sp.	Tyrreliinae	Sperchon sp.	Anisitsellidae
					sincera	cassertanum												
Mellin	1-May-95	spr	0	4	0	32	0	0	612	0	0	0	0	0	0	0	0	0
Mellin	6-Jul-95	smr	0	89.652	0	72.33	0	16.66	2568.636	0	8.33	0	0	6.667	0	0	29.994	0
Mellin	10-Oct-95	fll	0	9.09	0	32.466	0	29.392	168.88	0	0	0	0	0	0	0	18.831	0
Mellin	9-Dec-95	wtr	0	0	0	2	0	1	25	0	0	0	0	1	0	1	3	0
Mellin	5-Apr-96	spr	0	0	0	28.448	0	6.896	62.501	0	0	0	0	16.667	0	0	16.667	0
Glimpse	2-May-95	spr	0	0	0	0	59.04	0	0	0	0	6.25	0	1.786	0	0	0	0
Glimpse	5-Jul-95	smr	0	0	0	0	94.618	0	0	0	0	5.882	0	39.382	0	0	0	51.173
Glimpse	9-Oct-95	fll	0	0	0	0	21.9776	0	0	0	0	0	0	15.384	7.692	0	0	48.4726
Glimpse	9-Dec-95	wtr	0	0	0	0	5.263	0	0	0	0	0	0	37.5	0	0	0	0
Glimpse	4-Apr-96	spr	0	0	0	0	16.667	0	0	0	0	0	0	24.286	0	0	0	0
Beak	2-May-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Beak	6-Jul-95	smr	0	12.5	0	0	0	0	16.667	0	0	467.504	0	72.501	0	0	25	85.001
Beak	9-Oct-95	fll	0	0	0	0	0	0	14.286	0	0	0	0	153.572	0	0	0	50
Beak	5-Apr-96	spr	0	0	0	0	0	0	0	0	0	0	0	70	120	0	20	0
Spring	5-May-95	spr	0	0	0	0	0	0	59.939	7.142	0	124.772	0	0	0	0	0	38.513
Spring	12-Jul-95	smr	0	0	0	0	11.111	0	122.222	0	0	362.221	0	60	0	0	40	135.555
Spring	12-Oct-95	fll	0	1	0	0	0	0	98.074	7.408	0	0	0	11.999	0	0	0	3.704
Spring	7-Dec-95	wtr	0	0	0	0	0	0	78.448	0	0	0	0	0	0	0	0	0
Spring	27-Mar-96	spr	0	10	0	0	0	0	43.33	0	0	6.25	0	0	0	0	0	0
Mayfly	5-May-95	spr	0	0	0	1	0	0	12.887	0	0	2	0	13.435	6	1	0	4.887
Mayfly	12-Jul-95	smr	0	7.692	0	0	0	0	10	0	0	15.384	0	17.692	0	0	33.076	0
Mayfly	12-Oct-95	fll	0	0	2	0	0	0	59.55	0	0	3	0	10.555	0	0	0	0
Mayfly	7-Dec-95	wtr	0	3	1	0	0	0	41.665	0	0	0	1	12.11	6	0	0	20.665
Mayfly	27-Mar-96	spr	0	4.76	0	0	0	0	30.81	0	0	0	0	16.286	2	0	0	5.762
N.Alouette	25-Apr-95	spr	0	0	0	0	0	0	3	0	0	3	0	3	0	0	0	0
N.Alouette	11-Jul-95	smr	0	0	0	0	0	0	2	0	0	67	0	4	0	0	3	1
N.Alouette	12-Oct-95	fll	0	0	0	0	0	0	3	4	0	1	0	2	0	0	0	0
N.Alouette	7-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N.Alouette	27-Mar-96	spr	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Fraser	27-Apr-95	spr	0	0	0	0	0	11	4	0	0	0	0	0	0	0	0	0
Fraser	4-Jul-95	smr	0	0	0	0	0	12	1	0	0	0	0	0	0	0	2	0
Fraser	11-Oct-95	fll	0	0	0	0	0	289	0	0	0	0	0	0	0	0	0	0
Fraser	8-Dec-95	wtr	0	1	0	0	1	21	0	0	0	2	0	4	1	1	6	0
Fraser	27-Mar-96	spr	0	3	0	0	2	35.048	9	0	0	0	0	2	0	0	7.762	0
Thompson	3-May-95	spr	4	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0
Thompson	5-Jul-95	smr	0	4	0	0	0	141.009	0	0	0	0	0	0	0	0	0	0
Thompson	10-Oct-95	fll	0	1	0	0	0	57	0	0	0	0	0	3	4	3	25	0
Thompson	9-Dec-95	wtr	0	7	0	0	0	33	0	0	0	0	0	0	2	4	10	0
Thompson	4-Apr-95	spr	0	12.5	0	0	0	36.111	11.111	0	0	0	0	0	11.111	0	0	25
		TOTAL	4	170.19	3	168.244	211.6766	694.116	4058.006	18.55	8.33	1066.263	1	602.822	159.803	10	240.33	469.7326

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Albiinae	Axonopsinae	Prozia sp.	Pseudoscorpiones	Tricladida	Hyalella azteca	Stygobromus sp.	Ostracoda	Amphizoa sp.	Agabus sp.	Dytiscidae	Brachyvatus sp.	Desmopachria sp.	Laccornis sp.	Ancronyx Sp.
													adult		adult		adult
Mellin	1-May-95	spr	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Mellin	6-Jul-95	smr	0	6.667	0	0	0	0	0	8.33	8.33	13.334	2	0	0	0	0
Mellin	10-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mellin	9-Dec-95	wtr	0	1	0	0	0	0	0	7	0	0	0	0	0	0	0
Mellin	5-Apr-96	spr	0	0	0	0	0	0	3.448	3.448	0	0	0	0	0	0	0
Glimpse	2-May-95	spr	0	0	0	0	0	0	0	32.25	0	0	0	0	0	0	0
Glimpse	5-Jul-95	smr	0	0	0	0	0	0	0	51.93	0	0	0	0	0	0	0
Glimpse	9-Oct-95	fll	0	0	0	0	0	0	0	237.2964	0	0	0	0	0	0	0
Glimpse	9-Dec-95	wtr	0	0	0	0	0	0	0	71.927	0	0	0	0	0	0	8.333
Glimpse	4-Apr-96	spr	0	0	0	0	0	0	0	282.385	0	0	0	0	0	0	0
Beak	2-May-95	spr	0	0	0	0	25	0	0	90.001	0	0	0	0	0	0	0
Beak	6-Jul-95	smr	0	0	0	0	39.167	0	0	0	0	0	0	0	0	0	0
Beak	9-Oct-95	fll	0	0	0	0	0	0	0	39.286	0	0	0	0	0	0	0
Beak	5-Apr-96	spr	0	0	0	0	40	0	0	20	0	0	0	0	25	0	0
Spring	5-May-95	spr	0	0	0	0	26.013	0	0	0	0	0	0	0	0	0	0
Spring	12-Jul-95	smr	0	0	0	0	33.333	0	0	0	0	0	0	0	0	0	0
Spring	12-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.333
Spring	7-Dec-95	wtr	0	0	0	0	0	0	0	7.143	0	0	0	0	0	0	0
Spring	27-Mar-96	spr	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0
Mayfly	5-May-95	spr	0	0	0	0	51.983	0	0	1	0	0	0	0	0	0	0
Mayfly	12-Jul-95	smr	0	0	15.384	0	306.15	0	0	0	0	0	0	0	0	0	0
Mayfly	12-Oct-95	fll	1	0	0	0	81.55	0	0	11.555	0	0	0	0	0	0	0
Mayfly	7-Dec-95	wtr	0	0	0	0	74.775	0	0	120.22	0	0	0	0	0	0	0
Mayfly	27-Mar-96	spr	0	0	0	0	41.81	0	0	14.286	0	0	0	0	0	0	0
N.Alouette	25-Apr-95	spr	0	0	0	0	13	0	0	0	0	0	0	0	0	0	0
N.Alouette	11-Jul-95	smr	0	0	0	0	46	0	0	2	0	0	0	0	0	0	0
N.Alouette	12-Oct-95	fll	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0
N.Alouette	7-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N.Alouette	27-Mar-96	spr	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0
Fraser	27-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Fraser	4-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	11-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	8-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0
Fraser	27-Mar-96	spr	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Thompson	3-May-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	5-Jul-95	smr	0	0	0	0	5.263	0	0	0	0	0	0	0	0	0	0
Thompson	10-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	9-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	4-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1	7.667	15.384	1	802.04	1	3.448	1001.057	8.33	13.334	5	1	25	1	11.666

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Cleptelmis sp.	Dubiraphia sp.	Heterlimnius sp.	Narpus sp.	Lara sp.	Ordobrevia sp	Optoiservus sp.	Zaitzrvia sp.	Corixidae	Coenargrionidae	Tenebrionidae	Collumbolla	Atherix sp.	Blephariceras sp.	Ceratopogoninae
						adult		adult	adult	adult	(hemiptera	(odonata)					
Mellin	1-May-95	spr	0	0	0	0	0	0	0	0	0	0	0	1	0	0	24
Mellin	6-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	2	0	0	77.994
Mellin	10-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.635
Mellin	9-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Mellin	5-Apr-96	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.5
Glimpse	2-May-95	spr	0	0	12.5	0	0	0	0	0	0	0	0	3.572	0	0	0
Glimpse	5-Jul-95	smr	0	0	339.797	0	0	0	0	0	0	0	0	0	0	0	0
Glimpse	9-Oct-95	fll	0	0	211.3506	0	0	0	0	0	0	0	0	0	0	0	0
Glimpse	9-Dec-95	wtr	0	0	76.095	0	0	0	0	0	0	0	0	0	0	0	0
Glimpse	4-Apr-96	spr	0	0	7.143	0	0	0	0	0	0	0	0	0	0	0	7.143
Beak	2-May-95	spr	0	0	131.668	0	0	0	0	0	0	0	0	0	0	0	20
Beak	6-Jul-95	smr	0	0	831.674	0	0	10	0	0	0	0	0	0	0	0	66.667
Beak	9-Oct-95	fll	0	0	521.43	25	0	0	0	0	0	0	0	0	0	0	25
Beak	5-Apr-96	spr	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0
Spring	5-May-95	spr	0	0	264.318	3.571	9.821	0	0	0	0	0	6.25	0	0	0	15.3
Spring	12-Jul-95	smr	30	0	84.444	60	10	0	0	0	0	0	0	0	0	0	51.111
Spring	12-Oct-95	fll	16.665	0	42.815	0	3.704	1	0	0	0	0	0	2	0	0	8.704
Spring	7-Dec-95	wtr	0	0	7.143	0	0	0	0	0	0	0	0	0	0	0	0
Spring	27-Mar-96	spr	0	0	182.04	0	0	0	0	0	0	0	0	0	0	0	52.91
Mayfly	5-May-95	spr	0	0	24.548	0	1	0	0	0	0	0	0	0	0	0	15.887
Mayfly	12-Jul-95	smr	15.384	0	38.46	0	10	0	0	0	0	0	0	0	0	0	60.768
Mayfly	12-Oct-95	fll	0	0	25.665	0	8.555	0	5.555	0	0	0	0	0	0	0	23.665
Mayfly	7-Dec-95	wtr	8	1	8.555	0	14.11	5	5.555	0	0	0	0	10	0	0	9.555
Mayfly	27-Mar-96	spr	1	0	11.524	0	20.048	6.762	14.286	0	0	0	0	4	0	0	27.048
N.Alouette	25-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N.Alouette	11-Jul-95	smr	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
N.Alouette	12-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
N.Alouette	7-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
N.Alouette	27-Mar-96	spr	0	0	0	0	0	0	0	0	0	0	0	4	0	1	0
Fraser	27-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	4-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	11-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	8-Dec-95	wtr	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Fraser	27-Mar-96	spr	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
Thompson	3-May-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	5-Jul-95	smr	0	0	4	0	0	0	0	0	0	0	0	0	0	0	8
Thompson	10-Oct-95	fll	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Thompson	9-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	4-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	71.049	1	2866.1696	88.571	77.238	22.762	26.396	1	1	1	6.25	26.572	1	12	526.887

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Atrichopogon sp.	Chironominae	Orthocladiinae	Prodiamesinae	Tanypodinae	Diptera pupae	Dixa sp.	Hydrophorus sp.	Chelifera sp.	Hemerodromia sp.	Oreogeton sp.	Glutops sp.	Pericoma sp./ Thelmatoscopus sp.	Prosimulium sp.
Mellin	1-May-95	spr	0	7	27	0	7	2	0	2	0	0	0	0	1	11
Mellin	6-Jul-95	smr	0	172.285	773.796	0	30.66	53.98	0	17.334	0	0	0	0	2	138.62
Mellin	10-Oct-95	fll	0	174.712	166.273	0	50.345	4.545	0	0	28.572	0	0	0	57.964	100.002
Mellin	9-Dec-95	wtr	0	33	24	0	3	0	0	0	1	0	0	0	1	6
Mellin	5-Apr-96	spr	0	378.309	396.984	0	0	0	0	0	6.896	0	0	0	20.688	71.407
Glimpse	2-May-95	spr	0	8.93	10.716	0	1	1	0	0	0	0	0	0	0	0
Glimpse	5-Jul-95	smr	0	99.102	2045.812	0	0	110.001	0	0	0	0	0	0	0	0
Glimpse	9-Oct-95	fll	0	265.62	445.599	15.384	61.536	0	0	0	0	0	0	0	0	0
Glimpse	9-Dec-95	wtr	0	141.665	84.427	0	5.263	0	0	0	0	0	0	0	0	0
Glimpse	4-Apr-96	spr	0	50.953	403.339	0	0	0	0	0	0	0	10	0	0	0
Beak	2-May-95	spr	0	3675.017	823.336	0	40	20	0	0	0	0	0	20	725.006	208.334
Beak	6-Jul-95	smr	0	990.01	1129.178	0	74.167	80	0	0	0	0	0	0	0	0
Beak	9-Oct-95	fll	0	2785.722	750.004	0	25	14.286	0	0	25	0	0	0	350.002	0
Beak	5-Apr-96	spr	0	2970	1295	0	50	20	0	0	25	0	0	0	305	120
Spring	5-May-95	spr	0	233.999	390.387	0	47.439	70.835	0	0	6.25	0	3.571	0	0	4.525
Spring	12-Jul-95	smr	31.111	4899.992	1382.219	0	41.111	182.222	20	0	0	0	0	0	0	0
Spring	12-Oct-95	fll	0	90.554	61.74	0	6.666	23.482	0	0	3.704	0	0	0	0	1
Spring	7-Dec-95	wtr	0	27.795	96.529	0	0	0	0	0	0	0	0	0	0	997.665
Spring	27-Mar-96	spr	0	257.05	558.25	0	38.75	14.58	0	0	0	6.25	0	0	0	531.54
Mayfly	5-May-95	spr	0	154.367	160.706	0	22.209	5	0	0	2	0	5.774	0	0	9.661
Mayfly	12-Jul-95	smr	0	414.608	1022.284	0	99.996	15.384	0	0	0	0	0	0	0	0
Mayfly	12-Oct-95	fll	0	617.51	27	0	5	7.555	0	0	3	5.555	5.555	0	0	0
Mayfly	7-Dec-95	wtr	1	928.065	125.55	0	33.665	0	0	0	11.11	0	0	0	0	22.555
Mayfly	27-Mar-96	spr	0	405.146	177.478	0	35.524	2	0	0	1	0	1	0	0	4.762
N.Alouette	25-Apr-95	spr	0	14	34	0	0	0	0	0	0	0	0	0	0	0
N.Alouette	11-Jul-95	smr	0	42	253	0	5	40	0	0	0	0	4	0	0	2
N.Alouette	12-Oct-95	fll	0	0	1	0	0	0	0	0	0	0	1	0	0	0
N.Alouette	7-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	1	1
N.Alouette	27-Mar-96	spr	0	1	19	0	1	1	0	0	0	0	1	0	0	0
Fraser	27-Apr-95	spr	0	4	4	0	0	0	0	0	0	0	0	0	0	0
Fraser	4-Jul-95	smr	0	14	388	0	36	44	0	0	0	1	0	0	0	0
Fraser	11-Oct-95	fll	0	175	179	0	62	24	0	0	0	24	0	0	0	0
Fraser	8-Dec-95	wtr	0	68	50	0	34	1	0	0	0	11	0	0	0	1
Fraser	27-Mar-96	spr	0	237.048	730.53	0	75.096	12.524	0	0	0	27.524	0	0	0	0
Thompson	3-May-95	spr	0	1	191	0	0	23	0	0	0	0	0	0	0	3
Thompson	5-Jul-95	smr	0	10.526	1430.273	0	15.846	83.552	0	0	0	0	0	0	0	116.595
Thompson	10-Oct-95	fll	0	3	551	0	2	22	0	0	0	0	0	0	0	10
Thompson	9-Dec-95	wtr	0	5	504	0	5	2	0	0	0	0	0	0	0	0
Thompson	4-Apr-95	spr	0	0	5186.081	0	44.444	283.331	0	0	0	0	0	0	0	0
		TOTAL	32.111	20355.99	21898.491	15.384	958.717	1163.277	20	19.334	113.532	75.329	31.9	20	1463.66	2360.666

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Simulium sp.	Antocha	Dicranota sp.	Hexatoma .	Hexatoma	Rhabdomastix	Tipula sp.	Unidentified	Ameletus sp.	Baetis sp. A	Baetis sp.B	Callibaetis	Caudatella sp.	Drunella	Drunella	Drunella
				monticola		sp A	sp.B	sp.						sp.		doddsi	flavilinea	grandis ingens
Mellin	1-May-95	spr	7	0	3	1	0	0	0	0	0	1	9	1	0	0	0	0
Mellin	6-Jul-95	smr	163.94	0	70.977	2	0	0	0	0	0	205.291	862.761	2	0	0	0	0
Mellin	10-Oct-95	fll	52.117	0	39.133	24.847	0	0	13.33	0	6.667	0	415.151	0	0	0	0	0
Mellin	9-Dec-95	wtr	17	0	8	1	0	0	0	0	0	4	19	0	0	0	0	0
Mellin	5-Apr-96	spr	54.74	0	26.292	3.448	0	0	0	6.896	0	0	570.403	0	0	0	0	0
Glimpse	2-May-95	spr	0	0	20.536	3.572	0	0	0	0	2.786	0	13.5	0	0	0	0	0
Glimpse	5-Jul-95	smr	56.271	0	44.453	0	0	0	0	0	35.238	0	3.333	0	0	0	0	0
Glimpse	9-Oct-95	fll	0	0	7.692	0	0	0	0	0	7.1428	0	21.9776	0	0	0	0	0
Glimpse	9-Dec-95	wtr	0	0	33.333	12.5	0	0	0	0	8.333	0	0	0	0	0	0	0
Glimpse	4-Apr-96	spr	0	0	26.667	0	0	0	0	0	0	30	258.573	0	0	0	0	0
Beak	2-May-95	spr	40	16.667	20	0	0	0	0	0	0	178.334	831.672	0	0	0	0	25
Beak	6-Jul-95	smr	12.5	16.667	0	0	0	0	0	50.001	0	266.668	137.501	0	0	748.339	22.5	0
Beak	9-Oct-95	fll	39.286	39.286	0	0	0	0	0	50	78.572	64.286	1557.154	0	0	28.572	0	0
Beak	5-Apr-96	spr	0	60	0	0	0	0	0	0	60	300	1240	0	50	75	0	0
Spring	5-May-95	spr	10.713	0	6.25	0	10.775	0	0	0	41.251	75.242	345.804	0	0	3.571	13.575	0
Spring	12-Jul-95	smr	0	0	20	0	10	0	0	40	11.111	50	373.332	0	0	0	10	0
Spring	12-Oct-95	fll	0	0	3	0	0	0	0	0	6	175.659	23.665	0	0	0	0	0
Spring	7-Dec-95	wtr	37.429	0	9.469	0	0	0	0	0	14.121	42.938	528.056	0	0	0	0	0
Spring	27-Mar-96	spr	8.33	0	0	0	0	0	0	0	32.5	221.63	1040.29	0	0	8.33	0	0
Mayfly	5-May-95	spr	1	0	6.887	0	3	0	0	0	5	11.548	92.384	0	0	0	0	0
Mayfly	12-Jul-95	smr	25.384	0	33.076	0	0	0	0	0	40.768	0	118.46	0	0	0	0	0
Mayfly	12-Oct-95	fll	8.555	0	0	0	6.555	1	0	0	7	87.215	6	0	0	0	0	0
Mayfly	7-Dec-95	wtr	40.665	0	5	0	0	0	0	0	6	49.22	76.44	0	0	0	0	0
Mayfly	27-Mar-96	spr	9.524	0	0	0	9.524	0	0	0	55.524	21	91.716	0	0	0	0	0
N.Alouette	25-Apr-95	spr	0	0	0	0	0	0	0	0	31	1	39	0	0	0	2	0
N.Alouette	11-Jul-95	smr	1	0	3	0	0	0	0	0	34	113	253	0	0	78	3	0
N.Alouette	12-Oct-95	fll	0	1	0	0	0	0	0	0	12	7	16	0	0	0	0	0
N.Alouette	7-Dec-95	wtr	0	0	0	0	0	0	0	0	10	28	56	0	0	0	0	0
N.Alouette	27-Mar-96	spr	0	1	0	0	0	0	0	0	15	2	336	0	0	0	0	0
Fraser	27-Apr-95	spr	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0
Fraser	4-Jul-95	smr	0	0	0	0	0	1	0	0	0	12	40	0	0	0	1	0
Fraser	11-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Fraser	8-Dec-95	wtr	0	0	0	0	0	0	0	0	41	6	73	0	1	0	0	0
Fraser	27-Mar-96	spr	0	0	0	0	0	0	0	0	4.762	3	11.524	0	19.048	0	0	0
Thompson	3-May-95	spr	0	0	0	0	0	0	0	0	2	2	16	0	0	0	0	0
Thompson	5-Jul-95	smr	26.218	0	0	0	0	0	0	0	0	336.574	262.505	0	4	4	19.692	0
Thompson	10-Oct-95	fll	0	1	0	0	0	0	0	0	0	26	20	0	0	0	0	1
Thompson	9-Dec-95	wtr	0	0	0	0	0	0	0	0	1	4	27	0	0	0	0	0
Thompson	4-Apr-95	spr	0	0	0	0	0	0	0	0	0	197.222	25	0	11.111	0	0	0
		TOTAL	611.672	135.62	386.765	48.367	39.854	2	13.33	146.897	578.7758	2521.827	9812.202	3	85.159	945.812	71.767	26

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Drunella	Ephemerella	Serratella	Cinygma sp.	Cinygmula sp.	Epeorus sp.	Epeorus sp.	Ironodes sp.	Rhithrogena sp.	Stenonema sp.	Paraleptop hlebia	Tricorythodes	Capnia sp	Eucapnopsis
			spinifera	inermis/infrequens	tibialis			(Ironopsis)	(Iron)				temporalis	minutes		brevicauda
Mellin	1-May-95	spr	0	0	9	0	1	0	4	0	0	0	0	0	0	0
Mellin	6-Jul-95	smr	0	0	131.294	0	215.284	0	106.297	0	0	0	0	0	51.658	0
Mellin	10-Oct-95	fll	0	0	137.664	0	1228.51	0	0	0	0	0	0	0	2170.717	0
Mellin	9-Dec-95	wtr	0	0	4	0	111	0	1	0	0	0	0	0	200	0
Mellin	5-Apr-96	spr	0	0	93.678	0	428.879	0	75.001	0	3.448	0	0	0	0	0
Glimpse	2-May-95	spr	0	0	0	0	1154.282	0	0	0	0	0	0	0	0	0
Glimpse	5-Jul-95	smr	0	0	0	16.665	710.263	0	3.333	0	0	0	0	0	6.666	0
Glimpse	9-Oct-95	fll	0	0	0	45.6028	1325.991	0	0	0	0	0	0	0	787.4692	0
Glimpse	9-Dec-95	wtr	0	0	0	12.5	2568.802	0	0	0	0	0	0	0	104.603	0
Glimpse	4-Apr-96	spr	0	0	0	10	2458.135	0	0	0	0	0	0	0	0	0
Beak	2-May-95	spr	0	0	505.003	0	751.672	0	820.003	0	0	0	20	0	0	0
Beak	6-Jul-95	smr	0	33.334	336.67	0	520.006	0	471.67	0	16.667	0	51.667	0	0	0
Beak	9-Oct-95	fll	0	175	25	0	975.004	0	335.716	0	0	0	25	0	403.572	0
Beak	5-Apr-96	spr	20	45	1145	0	1145	0	1305	0	65	0	0	0	0	135
Spring	5-May-95	spr	0	9.821	0	0	22.321	0	141.614	32.446	0	0	88.569	0	0	0
Spring	12-Jul-95	smr	0	0	0	0	92.222	0	53.333	0	0	0	266.666	0	0	0
Spring	12-Oct-95	fll	3.333	118.626	0	0	124.808	0	19.112	168.773	0	0	295.223	0	1	0
Spring	7-Dec-95	wtr	0	8	0	0	180.276	0	58.198	36.447	0	0	31.143	0	48.689	0
Spring	27-Mar-96	spr	0	36.66	0	0	194.55	0	259.14	230.81	0	0	179.15	0	0	0
Mayfly	5-May-95	spr	10.774	0	46.418	0	22.661	1.887	14.661	13.435	1	0	26.774	0	0	0
Mayfly	12-Jul-95	smr	411.53	0	25.384	0	30.768	0	0	0	10	0	152.304	0	0	0
Mayfly	12-Oct-95	fll	138.33	11.11	0	0	104.33	0	0	0	0	0	113.215	0	1	0
Mayfly	7-Dec-95	wtr	72.885	0	0	11.11	77.665	0	0	16.665	0	0	284.655	0	3	0
Mayfly	27-Mar-96	spr	31.048	0	19.048	3	61.096	0	8.762	0	0	0	173.288	0	0	1
N.Alouette	25-Apr-95	spr	0	0	0	0	91	0	68	39	4	0	1	0	0	0
N.Alouette	11-Jul-95	smr	1	0	0	0	81	11	47	2	86	0	4	0	0	0
N.Alouette	12-Oct-95	fll	1	0	0	0	33	5	30	7	17	0	0	0	2	0
N.Alouette	7-Dec-95	wtr	0	0	0	0	24	6	3	0	7	0	0	0	0	0
N.Alouette	27-Mar-96	spr	0	0	0	0	37	9	60	9	1	0	1	0	0	0
Fraser	27-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	4-Jul-95	smr	0	4	0	0	4	0	0	0	33	2	0	0	0	0
Fraser	11-Oct-95	fll	0	193	0	0	23	0	0	0	9	30	0	1	21	0
Fraser	8-Dec-95	wtr	0	81	0	0	48	0	1	0	4	44	1	0	78	0
Fraser	27-Mar-96	spr	0	324.1	0	0	50.096	0	15.286	0	87.192	75.382	0	0	28.81	0
Thompson	3-May-95	spr	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Thompson	5-Jul-95	smr	7.692	46.007	0	0	0	0	0	0	19.538	8	0	0	0	0
Thompson	10-Oct-95	fll	0	82	0	0	0	0	2	0	9	8	1	0	0	0
Thompson	9-Dec-95	wtr	0	31	0	0	0	0	0	0	0	0	0	0	1	0
Thompson	4-Apr-95	spr	0	36.111	0	0	11.111	0	0	0	0	0	0	0	0	0
		TOTAL	697.59	1234.769	2478.159	98.8778	14907.73	32.887	3903.126	555.576	372.845	167.382	1715.654	1	3909.184	136

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Mesocapnia sp.	Chloroperlidae	Haploperla sp.	Kathroperla sp.	Plumiperla sp.	Suwallia sp.	Sweltsa sp.	Despaxia augusta	Perlomyia collaris	Amphinemura s	Malenka sp.	Ostroderca sp.	Podmosta sp.	Viskoa cataractae	Zapada cinctipes
Mellin	1-May-95	spr	0	0	0	0	9	1	0	0	0	0	0	0	78	0	0
Mellin	6-Jul-95	smr	0	0	0	0	18	25.327	0	0	0	16.66	0	0	164.33	0	634.818
Mellin	10-Oct-95	fll	0	0	13.334	0	28.572	0	0	4.545	0	14.286	0	0	0	0	185.285
Mellin	9-Dec-95	wtr	0	0	36	0	6	0	0	2	0	1	0	0	38	0	7
Mellin	5-Apr-96	spr	0	0	230.443	0	37.5	12.5	0	0	0	0	0	0	4469.149	0	53.449
Glimpse	2-May-95	spr	0	0	0	0	6.25	0	141.254	0	0	6.25	0	0	43.18	0	12.716
Glimpse	5-Jul-95	smr	0	0	0	0	19.998	9.999	263.412	0	0	3.333	0	0	0	0	0
Glimpse	9-Oct-95	fll	0	0	0	0	0	0	211.8394	0	0	0	0	0	0	0	0
Glimpse	9-Dec-95	wtr	0	0	0	0	0	0	127.628	0	0	0	0	0	0	0	0
Glimpse	4-Apr-96	spr	0	0	28.572	0	0	20	151.431	0	0	20	0	0	832.865	0	0
Beak	2-May-95	spr	0	0	0	0	0	60	100.001	16.667	0	20	0	0	16.667	20	0
Beak	6-Jul-95	smr	0	0	0	0	0	0	145.834	25	33.334	0	0	0	0	0	100.002
Beak	9-Oct-95	fll	0	0	0	0	0	0	153.572	25	0	0	0	0	200.002	0	167.858
Beak	5-Apr-96	spr	0	0	0	0	0	0	45	0	0	0	0	0	370	45	145
Spring	5-May-95	spr	0	0	25	0	0	0	196.564	31.43	0	0	29.463	0	0	4.525	113.51
Spring	12-Jul-95	smr	0	0	0	0	0	0	144.444	0	0	0	142.222	0	0	11.111	1065.55
Spring	12-Oct-95	fll	0	0	24	1	0	5	78.553	12.704	0	0	0	0	4	13.408	60.331
Spring	7-Dec-95	wtr	0	0	42.858	0	6.978	0	97.096	23.755	0	0	0	0	16.612	21.429	65.876
Spring	27-Mar-96	spr	0	0	24.99	0	30	0	227.07	16.66	0	0	24.99	0	0	8.33	279.13
Mayfly	5-May-95	spr	0	0	18	0	15.096	1	23.661	4	0	0	3.774	0	1	1	3.774
Mayfly	12-Jul-95	smr	0	0	0	0	0	0	187.688	0	0	0	37.692	0	61.536	0	1729.97
Mayfly	12-Oct-95	fll	0	0	0	0	0	0	51.33	6.555	1	0	0	0	5.555	5.555	40.33
Mayfly	7-Dec-95	wtr	0	2	0	0	0	0	52.22	6	0	0	0	0	4	13	74.995
Mayfly	27-Mar-96	spr	0	0	0	0	0	0	58.81	5.762	0	0	1	0	1	5.762	25.81
N.Alouette	25-Apr-95	spr	0	0	13	0	12	2	98	0	1	0	3	0	0	0	0
N.Alouette	11-Jul-95	smr	0	0	47	0	15	4	43	0	0	0	3	0	0	5	6
N.Alouette	12-Oct-95	fll	0	0	7	0	0	0	14	1	0	0	0	2	0	0	2
N.Alouette	7-Dec-95	wtr	0	0	2	0	0	0	14	0	0	0	0	0	0	0	4
N.Alouette	27-Mar-96	spr	0	0	0	0	0	0	15	0	0	0	1	0	1	1	4
Fraser	27-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	4-Jul-95	smr	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0
Fraser	11-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	8-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	10	1	1
Fraser	27-Mar-96	spr	1	0	0	0	0	5.762	4.762	0	0	0	0	0	53.382	0	0
Thompson	3-May-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	5-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	10-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	9-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	4-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	1	2	512.197	1	204.394	147.588	2647.169	181.078	35.334	81.529	246.141	2	6370.278	156.12	4782.41

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Zapada	Taenionema sp.	Yoraperla	Calineuria	Doroneuria	Hesperoperla	Isogenoides sp.	Isoperla sp.	Kogotus sp.	Megarcys sp.	Setvena	Skwala sp.	Pteronarcys	Apatania	Amiocentrus	Brachycentrus
			oregonensis		brevis	californica	bamanni	pacifica					bradley		princeps	zonella	aspilus	americanus
Mellin	1-May-95	spr	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	1
Mellin	6-Jul-95	smr	0	0	0	0	0	0	0	12.33	0	71.644	0	40.002	0	0	0	2
Mellin	10-Oct-95	fll	14.286	0	0	0	0	0	0	28.572	0	0	0	0	0	0	0	0
Mellin	9-Dec-95	wtr	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Mellin	5-Apr-96	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Glimpse	2-May-95	spr	59.25	0	0	0	0	0	0	8.036	0	0	0	0	0	0	0	1.786
Glimpse	5-Jul-95	smr	113.218	17.646	0	0	0	0	0	156.3	0	57.144	0	0	0	0	0	0
Glimpse	9-Oct-95	fll	766.104	0	0	0	0	0	0	66.666	0	11.111	0	0	0	0	0	30.2188
Glimpse	9-Dec-95	wtr	546.699	0	0	0	0	0	0	5.263	0	64.691	0	0	0	0	0	0
Glimpse	4-Apr-96	spr	388.575	0	0	0	0	0	0	0	0	14.286	0	0	0	0	0	0
Beak	2-May-95	spr	0	25	0	25	40	0	0	0	0	0	0	20	0	150.003	60	916.67
Beak	6-Jul-95	smr	25	0	0	25	79.168	0	0	40	0	25	0	33.334	0	0	37.5	107.501
Beak	9-Oct-95	fll	100	0	0	28.572	114.286	0	0	0	0	14.286	0	25	0	0	0	1010.718
Beak	5-Apr-96	spr	20	200	0	0	50	0	0	0	0	0	0	25	0	300	40	645
Spring	5-May-95	spr	0	0	0	7.142	0	6.25	0	0	0	0	0	39.65	12.5	0	0	0
Spring	12-Jul-95	smr	66.666	0	0	11.111	0	0	0	0	0	0	32.222	20	0	0	0	0
Spring	12-Oct-95	fll	7.704	0	0	9.037	0	5.333	0	0	0	0	3.704	1	0	0	0	0
Spring	7-Dec-95	wtr	4	4	0	0	0	0	0	0	0	0	7.143	20.612	16.612	0	0	0
Spring	27-Mar-96	spr	0	0	0	0	0	8.33	0	0	0	0	0	20.83	14.58	31.25	0	0
Mayfly	5-May-95	spr	13	0	0	0	2.887	0	0	0	0	0	0	31.548	1	3	0	0
Mayfly	12-Jul-95	smr	0	0	0	7.692	0	20	0	0	0	0	10	79.228	7.692	10	0	0
Mayfly	12-Oct-95	fll	0	0	1	0	12.11	3	0	0	0	0	0	0	1	0	0	0
Mayfly	7-Dec-95	wtr	10.555	0	14.11	1	0	1	0	0	0	0	0	2	1	0	0	0
Mayfly	27-Mar-96	spr	6.762	0	0	1	2	0	0	1	0	0	0	114.526	9.524	3	0	0
N.Alouette	25-Apr-95	spr	0	0	0	6	3	0	0	0	0	0	0	1	0	0	0	0
N.Alouette	11-Jul-95	smr	0	0	0	8	3	0	0	8	0	0	0	13	0	0	0	0
N.Alouette	12-Oct-95	fll	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
N.Alouette	7-Dec-95	wtr	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
N.Alouette	27-Mar-96	spr	2	1	0	0	2	0	0	2	0	0	0	3	0	0	0	0
Fraser	27-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	4-Jul-95	smr	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
Fraser	11-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	8-Dec-95	wtr	0	15	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Fraser	27-Mar-96	spr	0	0	0	0	0	0	0	1	0	0	0	9.524	0	0	0	0
Thompson	3-May-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	5-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0
Thompson	10-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	9-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	4-Apr-95	spr	0	0	0	0	22.222	0	0	11.111	0	0	0	0	0	0	0	0
		TOTAL	2145.819	262.646	15.11	129.554	333.673	43.913	1	345.278	1	258.162	53.069	503.254	63.908	497.253	137.5	2715.8938

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Brachycentrus	Micrasema	Glossosoma sp.	Glossoma	Parapsyche elsis	Cheumatopsyche sp.	Hydropsyche	Hydropsyche sp.	Hydroptilidae	Agraylea sp.	Hydroptila sp.	Ceraclea sp.	Lepidostoma sp.	Limniphilidae
			occidentalis	sp. A		pupae			recurvata							
Mellin	1-May-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Mellin	6-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	0	14.33	0
Mellin	10-Oct-95	fll	0	0	0	0	0	0	0	6.667	0	0	0	0	0	4.545
Mellin	9-Dec-95	wtr	0	0	0	0	0	0	0	0	1	0	0	0	5	0
Mellin	5-Apr-96	spr	0	0	0	0	0	0	0	0	0	0	0	0	10.344	0
Glimpse	2-May-95	spr	0	0	13.5	0	0	0	0	0	0	0	0	0	11.036	0
Glimpse	5-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	0	3.333	0
Glimpse	9-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	36.5076	0
Glimpse	9-Dec-95	wtr	0	0	226.096	0	0	0	0	0	0	0	0	0	245.831	0
Glimpse	4-Apr-96	spr	0	0	140.479	0	0	0	0	0	0	0	0	0	30.953	0
Beak	2-May-95	spr	0	0	0	0	20	0	0	111.667	0	0	0	0	746.674	0
Beak	6-Jul-95	smr	0	0	179.17	0	0	0	0	16.667	12.5	0	0	0	66.668	0
Beak	9-Oct-95	fll	0	14.286	0	0	0	0	0	525.002	0	0	0	0	1571.434	0
Beak	5-Apr-96	spr	0	105	0	0	0	0	0	425	0	0	0	0	645	0
Spring	5-May-95	spr	0	0	4.525	0	0	0	0	4.525	0	0	0	0	7.142	0
Spring	12-Jul-95	smr	0	0	21.111	11.111	0	0	0	0	0	0	0	0	110	0
Spring	12-Oct-95	fll	0	0	49.556	0	4.704	0	0	15.999	0	0	0	0	79.152	0
Spring	7-Dec-95	wtr	0	8	51.385	0	0	0	0	0	0	0	0	0	8.652	7.143
Spring	27-Mar-96	spr	0	27.08	28.33	0	10	0	0	0	0	0	0	0	0	0
Mayfly	5-May-95	spr	0	7	0	0	0	0	0	0	0	5	0	0	3.887	0
Mayfly	12-Jul-95	smr	0	23.076	0	0	10	0	0	0	68.46	276.916	0	0	0	50
Mayfly	12-Oct-95	fll	0	110.325	0	0	3	0	0	0	0	15.11	0	0	33.775	2
Mayfly	7-Dec-95	wtr	0	21.11	0	0	1	0	0	0	0	0	0	0	18.555	26
Mayfly	27-Mar-96	spr	0	23.81	0	0	0	0	0	0	0	0	0	0	23.286	6
N.Alouette	25-Apr-95	spr	0	0	0	0	1	0	0	0	0	0	0	0	3	0
N.Alouette	11-Jul-95	smr	0	0	0	0	6	0	0	0	0	1	0	0	13	0
N.Alouette	12-Oct-95	fll	0	0	0	0	1	0	0	0	0	0	0	0	1	0
N.Alouette	7-Dec-95	wtr	0	1	1	0	0	0	0	0	0	0	0	0	1	0
N.Alouette	27-Mar-96	spr	0	0	0	0	3	0	0	0	0	0	0	0	2	0
Fraser	27-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	4-Jul-95	smr	0	0	1	0	0	1	0	2	0	0	0	0	0	0
Fraser	11-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	1	7	0
Fraser	8-Dec-95	wtr	0	0	0	0	0	0	4	3	0	0	0	0	3	0
Fraser	27-Mar-96	spr	0	0	0	0	0	0	1	0	0	0	0	0	3	0
Thompson	3-May-95	spr	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Thompson	5-Jul-95	smr	58.152	0	0	0	46.768	0	0	31.578	3.846	0	0	0	0	0
Thompson	10-Oct-95	fll	36	0	8	0	0	0	0	133	2	0	4	0	1	0
Thompson	9-Dec-95	wtr	6	0	0	0	0	0	0	8	0	0	0	1	0	0
Thompson	4-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	100.152	340.687	724.152	11.111	106.472	1	5	1284.105	87.806	298.026	4	2	3708.5596	95.688

Appendix 3. Data for the first 200 invertebrates, 1995-1996 seasonal sampling.
Data lumped into one 3 minute sample.

Site	Date	Season	Limniphilidae pupae	Chyranda centralis	Clostoeca sp.	Ecclisomyia sp.	Hesperophylax sp.	Lenarchus sp.	Onocosmoecus unicolor	Pseudostenophylax edwardsi	Wormaldia sp.	Polycentropus sp.	Rhyacophila sp.	Rhyacophila pupae	Rhyacophila acropedes grp.	Rhyacophila angelita grp.
Mellin	1-May-95	spr	0	0	0	0	3	0	0	0	0	0	0	0	0	0
Mellin	6-Jul-95	smr	0	0	0	0	6	0	0	0	0	0	0	0	0	8.33
Mellin	10-Oct-95	fll	0	0	0	0	9.09	0	0	0	0	0	0	0	0	0
Mellin	9-Dec-95	wtr	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Mellin	5-Apr-96	spr	0	0	0	0	6.896	0	0	0	0	0	0	0	0	6.896
Glimpse	2-May-95	spr	1.786	0	0	0	0	0	0	0	0	0	0	0	1	0
Glimpse	5-Jul-95	smr	3.333	0	0	6.666	0	0	0	28.572	0	0	0	0	37.787	0
Glimpse	9-Oct-95	fll	0	0	0	14.8348	0	0	0	14.2856	0	0	0	0	0	0
Glimpse	9-Dec-95	wtr	0	12.5	0	26.096	0	0	0	8.333	0	0	0	0	8.333	0
Glimpse	4-Apr-96	spr	0	0	0	10	0	0	0	0	0	0	30	0	17.143	0
Beak	2-May-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	81.667	0
Beak	6-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	29.167	85.001	33.334
Beak	9-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	25	0
Beak	5-Apr-96	spr	0	0	0	0	0	0	0	0	0	0	20	0	40	0
Spring	5-May-95	spr	0	0	0	0	0	0	0	0	11.667	0	0	0	0	0
Spring	12-Jul-95	smr	0	0	0	0	0	0	0	0	321.11	0	80	0	0	0
Spring	12-Oct-95	fll	0	0	0	3.333	0	0	0	0	1	4	0	0	3.704	0
Spring	7-Dec-95	wtr	0	0	0	0	0	0	0	0	15.795	0	0	0	0	2.326
Spring	27-Mar-96	spr	0	0	0	0	0	0	0	0	47.08	0	0	0	0	10
Mayfly	5-May-95	spr	0	0	0	2	0	0	0	0	4.887	0	3.774	0	4.887	0
Mayfly	12-Jul-95	smr	0	0	0	53.844	0	0	0	0	106.92	7.692	23.076	0	0	0
Mayfly	12-Oct-95	fll	0	0	0	5	0	0	11.11	0	20.11	0	13.11	0	1	0
Mayfly	7-Dec-95	wtr	0	0	1	5.555	0	0	5	0	62.22	5	11	0	6.555	0
Mayfly	27-Mar-96	spr	0	0	3	0	0	0	1	0	0	4	0	0	4.762	0
N.Alouette	25-Apr-95	spr	0	0	0	1	0	0	0	0	0	7	4	0	0	0
N.Alouette	11-Jul-95	smr	0	0	0	4	0	0	0	0	0	0	4	0	5	4
N.Alouette	12-Oct-95	fll	0	0	0	2	0	0	0	0	0	0	0	0	0	0
N.Alouette	7-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N.Alouette	27-Mar-96	spr	0	0	0	0	0	0	0	0	0	0	4	0	1	0
Fraser	27-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	4-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	11-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	8-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fraser	27-Mar-96	spr	0	0	0	0	0	0	0	0	0	0	0	0	4.762	0
Thompson	3-May-95	spr	0	0	0	0	0	0	0	0	0	0	0	3	0	0
Thompson	5-Jul-95	smr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	10-Oct-95	fll	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	9-Dec-95	wtr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thompson	4-Apr-95	spr	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		TOTAL	5.119	12.5	4	134.3288	24.986	1	17.11	51.1906	590.789	27.692	192.96	32.167	327.601	64.886

Appendix 4. Environmental data for all sampling sites and dates. * int R means that the analysis was interrupted and that there are no data points.

Sample Site	Sample Date	Lat.	Long.	Ecoregion	Order	DB area (km^2)	Dist. fr. Source (Km)	Elevation (Ft)	Slope		Flow state (2)	Bankful width (m)	Wetted width (m)	Mean depth (m)	Max. depth (m)	Mean velocity (m^2/s)	Max Vel (m^2/s)	Discharge (m^3/s)	Temperature	pH	D.O.	Spec. Cond. @ 25*C	T.S.S. (/L)	% C in T.S.S.	Substrate score
Mellin	1/5/95	50 7 01.1	120 06 28.8	T-op	2	52.35	8.6	3740	0.0204		rapid	5.8	5.8	0.41	0.55	0.4117	0.93	1.4377	5.9	7.21		72.1	10.83	20.56	16
Mellin	6/7/95	50 7 01.1	120 06 28.8	T-op	2	52.35	8.6	3740	0.0204		rapid	5.8	4.3	0.207	0.35	0.286	0.76	0.232	14.5	7.82		117.515	4.33	23.56	16
Mellin	10/10/95	50 7 01.1	120 06 28.8	T-op	2	52.35	8.6	3740	0.0204		rapid	5.8	0.6	0.0725	0.08	0.0771	0.0972	0.00642	8.06	7.22	9.22 (78%)	262.71	22.16	21.44	16
Mellin	9/12/95	50 7 01.1	120 06 28.8	T-op	2	52.35	8.6	3740	0.0204		rapid	5.8	0.6	0.15	0.15	0.35	0.75	0.1	1	7.29		140.3	32.9	14.12	16
Mellin	5/4/96	50 7 01.1	120 06 28.8	T-op	2	52.35	8.6	3740	0.0204		rapid	5.8	1.4	0.197	0.23	0.4388	0.863	0.1217	0	8.1	.	136.17	17.45	20.23	16
Glimpse	2/5/95	50 15 02	120 14 9	T-op	1	10.18	5.4	3900	0.0025		rapid	2.8	2.8	0.22	0.24	0.5575	1.18	0.3139	4.9	7.69		234.4	3.045	42.18	17
Glimpse	6/7/95	50 15 02	120 14 9	T-op	1	10.18	5.4	3900	0.0025		rapid	2.8	1.3	0.09	0.1	0.433	0.55	0.0446	8.5	8.22		338.1	2.36	52.97	17
Glimpse	9/10/95	50 15 02	120 14 9	T-op	1	10.18	5.4	3900	0.0025		rapid	2.8	2.6	0.08	0.08	0.078	0.078	0.00375	4.9	7.93		534.89	1.54	33.91	17
Glimpse	16/12/95	50 15 02	120 14 9	T-op	1	10.18	5.4	3900	0.0025		rapid	2.8	1.3	0.09	0.1	0.1345	0.1345	0.1	0.5	7.95		337.02	1.35	43.12	17
Glimpse	4/4/96	50 15 02	120 14 9	T-op	1	10.18	5.4	3900	0.0025		rapid	2.8	1.6	0.1	0.11	0.191	0.193	0.1238	0	8.25	.	327.6	1.38	80.43	17
Beak	2/5/95	50 6 45.4	119 58 50.8	T-op	2	86.41	15.3	3340	0.0170		rapid	13.42	7.9	0.267	0.32	0.7643	1.06	1.405	2.9	7.44		75.65	3.56	42.48	19
Beak	6/7/95	50 6 45.4	119 58 50.8	T-op	2	86.41	15.3	3340	0.0170		rapid	13.42	6.8	0.223	0.37	0.638	0.74	0.7622	11.5	7.7		117.72	1.56	40.84	19
Beak	9/10/95	50 6 45.4	119 58 50.8	T-op	2	86.41	15.3	3340	0.0170		rapid	13.42	7	0.106	0.16	0.0938	0.1519	0.04718	4.98	7.71	11.52 (90%)	234.17	1.78	31.24	19
Beak	5/4/96	50 6 45.4	119 58 50.8	T-op	2	86.41	15.3	3340	0.0170		rapid	13.42	8.05	0.17	0.21	0.178	0.52	0.298	0	8.45	.	138.06	2.08	28.43	19
Spring	25/4/95	49 16 0.3	122 34 0.4	lm	1	1.99	2.5	442.6	0.0319		rapid	8.7	3.1	0.073	0.115	0.2075	0.29	0.0604	9	6..5		25.992	0.42	145.2	19
Spring	12/7/95	49 16 0.3	122 34 0.4	lm	1	1.99	2.5	442.6	0.0319		rapid	8.7	3.6	0.035	0.07	0.2125	0.27	0.0363	10	6.48		32.4	2.2	65.31	19
Spring	12/10/95	49 16 0.3	122 34 0.4	lm	1	1.99	2.5	442.6	0.0319		rapid	8.7	6.5	0.145	0.3	0.1542	0.2255	0.0766	9.81	6.37	11.08 (98%)	20.23	1.94	36.96	19
Spring	7/12/95	49 16 0.3	122 34 0.4	lm	1	1.99	2.5	442.6	0.0319		rapid	8.7	3.96	0.193	0.2	0.1807	0.233	0.1261	3.8	6.45		16.408	0.38	54.67	19
Spring	27/3/96	49 16 0.3	122 34 0.4	lm	1	1.99	2.5	442.6	0.0319		rapid	8.7	3.45	0.986	0.15	0.1223	0.24	0.2962	4.5	6.73	12.8 (100.4%)	29.98	1.04	8.61	19
Mayfly	5/5/95	49 19 02	122 32 0.4	lm	1	2.14	1.8	1377	0.0020		rapid	3.84	3.5	0.883	0.15	0.266	0.59	0.1039	7	6.7		21.225	1.06	83.41	16
Mayfly	12/7/95	49 19 02	122 32 0.4	lm	1	2.14	1.8	1377	0.0020		rapid	3.84	2.9	0.106	0.15	0.225	0.41	0.0416	10	6.36		24.192	1.76	3.4	16
Mayfly	12/10/95	49 19 02	122 32 0.4	lm	1	2.14	1.8	1377	0.0020		rapid	3.84	3.7	0.422	0.48	0.5177	0.6794	0.5221	8.48	5.71		15.59	0.46	68.73	16
Mayfly	7/12/95	49 19 02	122 32 0.4	lm	1	2.14	1.8	1377	0.0020		rapid	3.84	3.84	0.327	0.4	0.0576	0.157	0.0764	2.5	6.68		15.22	0.29	40.68	16
Mayfly	27/3/96	49 19 02	122 32 0.4	lm	1	2.14	1.8	1377	0.0020		rapid	3.84	3.6	0.197	0.25	0.125	0.087	0.0379	2	7.68	25.77 (181.6%)	23.73	0.34	29.41	16
N.Alouette	25/4/95	49 17 0.8	122 32 0.6	lm	2	9.58	7.7	1049	0.0400		supercritical	15	7.2	0.358	0.6	0.4008	0.93	1.1401	6	6.6		12.951	0.98	11.2	24
N.Alouette	11/7/95	49 17 0.8	122 32 0.6	lm	2	9.58	7.7	1049	0.0400		supercritical	15	8	0.213	0.4	0.2417	0.43	0.6919	11	6.67		13.2	0.06	554.6	24
N.Alouette	12/10/95	49 17 0.8	122 32 0.6	lm	2	9.58	7.7	1049	0.0400		supercritical	15	10	0.27	0.36	0.5871	1.0061	0.9725	7.25	5.65	11.62 (98%)	14.095	1.2	27.03	24
N.Alouette	7/12/95	49 17 0.8	122 32 0.6	lm	2	9.58	7.7	1049	0.0400		supercritical	15	3.97	0.3633	0.48	0.319	0.47	0.4356	1.5	6.68		13.81	0.24	57.14	24
N. Alouette	27/3/96	49 17 0.8	122 32 0.6	lm	2	9.58	7.7	1049	0.0400		supercritical	15	3.8	0.383	0.58	0.28	0.95	0.4359	2	6.25	23.98 (165%)	21.23	0.38	57.89	24
Fraser	27/4/95	49 12 20.2	121 46 07.2	pacr	8	217000		229	0.0002		rapid	400.86	320	0.4	1	0.326	0.5759	2320	13.3	7.73		185	23.45	10.46	16
Fraser	4/7/95	49 12 20.2	121 46 07.2	pacr	8	217000		229	0.0002		rapid	400.86	350	0.4	1	0.9429	1.72	4480	17.5	8.08		95.612	30.59	6.45	16
Fraser	11/10/95	49 12 20.2	121 46 07.2	pacr	8	217000		229	0.0002		rapid	400.86	300	0.4	1	0.162	0.225	1420	11.28	7.59	10.35 (95%)	141.804	9.46	9.14	16
Fraser	8/12/95	49 12 20.2	121 46 07.2	pacr	8	217000		229	0.0002		rapid	400.86	300	0.4	1	0.162	0.225	1660	0	6.94		127.67	62.51	6.02	16
Fraser	27/3/96	49 12 20.2	121 46 07.2	pacr	8	217000		229	0.0002		rapid	400.86	300	0.4	1	0.162	0.225	1060	6	7.96	13.93 (111%)	218.05	23.05	6.42	16
Thompson	3/5/95	50 25 28	121 19 35.3	itr	6	54900		680	0.0102		rapid	235.7	90	0.3	0.5	0.7998	1.408	664	9	7.58		108.072	3.41	21.8	25
Thompson	5/7/95	50 25 28	121 19 35.3	itr	6	54900		680	0.0102		rapid	235.7	150	0.3	0.5	0.8522	1.39	1630	18	8.05		78.472	2.97	8.42	25
Thompson	10/10/95	50 25 28	121 19 35.3	itr	6	54900		680	0.0102		rapid	235.7	70	0.3	0.5	0.1305	0.1519	409	13.68	8	10.21 (98.7%)	110.573	1.59	39.58	25
Thompson	10/12/95	50 25 28	121 19 35.3	itr	6	54900		680	0.0102		rapid	235.7	70	0.3	0.5	0.1305	0.1519	575	0.5	7.71		99.682	0.96	35.6	25
Thompson	4/4/96	50 25 28	121 19 35.3	itr	6	54900		680	0.0102		rapid	235.7	70	0.3	0.5	0.1305	0.1519	354	4	8.65	18.9 (148%)	94.53	2.64	25.33	25

Appendix 4. Environmental data for all sampling sites and dates. * int R means that the analysis was interrupted and that there are no data points.

Sample Site	Sample Date	% gravel	% sand	% silt & clay	Folk	Alkal. (CaCO3) (mg/l)	NH3- (mg/l)	NO3NO2-N (mg/l)	TKN-N (mg/l)	Total P (mg/l)	susp. N (ug/l)	susp C (ug/l) (biomass)	Chlor. a (ug/l)	HPLC Chlor. (ug/l)	Riparian veg	% logging	% canopy cover	Macropohytes	grasses	decidious	shrubs	conifers	framework	matrix	embeddedness
Mellin	1/5/95	25.45	71.79	2.76	gs	40.2	0.025	0.005	0.674	0.0454	1000	10000	60	33.5	willow,spruce	0	0	1	1	0	1	1	4	2	5
Mellin	6/7/95	25.18	74.21	0.61	gs	58.7	0.018	0.024	0.664	0.0727	1100	14500	18.5	13	willow,spruce	0	0	1	1	0	1	1	4	2	5
Mellin	10/10/95	57.01	42.4	0.59	sg	97.6	0.014	0.013	0.489	0.0702	2433.5	22166.5	75.5	56	willow,spruce	0	0	1	1	0	1	1	4	2	5
Mellin	9/12/95	0	0	0	p	64.3	0.014	0.07	0.572	0.0456	750	7750	23	.	willow,spruce	0	0	1	1	0	1	1	4	2	5
Mellin	5/4/96	34.89	64.35	0.77	sg	71.8	0.013	0.071	0.487	0.0886	750	8500	28	18	willow,spruce	0	0	1	1	0	1	1	4	2	5
Glimpse	2/5/95	53.65	45.5	0.85	sg	123	int R	0.005	0.342	0.0161	450	5500	18.5	13.5	spruce	0	50	1	0	0	0	1	6	2	4
Glimpse	6/7/95	56.23	43.43	0.34	sg	189	0.018	0.038	0.314	0.0135	1950	18500	160	103.5	spruce	0	50	1	0	0	0	1	6	2	4
Glimpse	9/10/95	37.69	61.95	0.36	sg	201	0.015	0.019	0.286	0.007	3325	42750	259.5	214.5	spruce	0	50	1	0	0	0	1	6	2	4
Glimpse	16/12/95	0	0	0	p	177	0.007	0.021	0.314	0.008	950	9000	136	.	spruce	0	50	1	0	0	0	1	6	2	4
Glimpse	4/4/96	31.58	68.27	0.15	sg	180	0.013	0.057	0.32	0.014	2400	21500	139.5	76.5	spruce	0	50	1	0	0	0	1	6	2	4
Beak	2/5/95	30.23	69	0.77	sg	30.2	int R	0.005	0.481	0.0344	900	8500	15.5	9	spruce,fir,alde	0	5	1	0	1	0	1	7	2	4
Beak	6/7/95	32.76	66.06	1.18	sg	55.2	0.008	0.01	0.28	0.0291	1550	15500	43.5	38	spruce,fir,alde	0	5	1	0	1	0	1	7	2	4
Beak	9/10/95	.	.	.	.	84.9	0.019	0.005	0.247	0.0276	1575	14000	80	56.5	spruce,fir,alde	0	5	1	0	1	0	1	7	2	4
Beak	5/4/96	100	0	0	g	86	0.009	0.06	0.209	0.0299	1050	11000	59	44	spruce,fir,alde	0	5	1	0	1	0	1	7	2	4
Spring	25/4/95	38.37	61.53	0.1	sg	4.9	int R	0.032	0.112	0.0012	150	3000	4.5	2.5	ceader, alder	0	60	1	0	1	0	1	6	4	4
Spring	12/7/95	.	.	.	.	12.1	0.008	0.171	0.191	0.0054	700	7000	23.5	12	ceader, alder	0	80	1	0	1	0	1	6	4	4
Spring	12/10/95	90.46	9.53	0.01	g	5.4	0.005	0.199	0.1	0.0042	1683.5	18000	53.5	.	ceader, alder	0	80	1	0	1	0	1	6	4	5
Spring	7/12/95	76.77	23.22	0	sg	5.9	0.002	0.135	0.03	0.0023	325	3500	3.75	.	ceader, alder	0	60	1	0	1	0	1	6	4	4
Spring	27/3/96	63.62	36.16	0.22	sg	7.8	0.012	0.129	0.051	0.0023	200	4000	7	4.5	ceader, alder	0	60	1	0	1	0	1	6	4	4
Mayfly	5/5/95	21.9	72.94	5.16	gs	2.4	int R	0.036	0.092	0.0057	9050	170500	371.5	270.5	ceader, alder	0	15	1	0	0	1	1	5	2	3
Mayfly	12/7/95	40.94	58.9	0.16	sg	10.2	0.01	0.1	0.079	0.0041	13850	132000	72	46	ceader, alder	0	30	1	0	0	1	1	5	2	3
Mayfly	12/10/95	15.43	84.52	0.05	gs	4.2	0.005	0.069	0.07	0.0042	1075	14750	71.5	.	ceader, alder	0	30	1	0	0	1	1	5	2	3
Mayfly	7/12/95	24.2	75.27	0.23	gs	5.3	0.002	0.047	0.044	0.0016	200	3000	7.5	0	ceader, alder	0	30	1	0	0	1	1	5	2	3
Mayfly	27/3/96	25.71	74.14	0.15	gs	6.2	0.007	0.097	0.042	0.0018	1100	14000	45	36.5	ceader, alder	0	15	1	0	0	1	1	5	2	3
N.Alouette	25/4/95	36.53	63.75	0	mg	1	int R	0.096	0.065	0.0002	250	4000	10	5.5	ceader, alder	0	10	1	0	0	1	1	8	5	4
N.Alouette	11/7/95	.	.	.	.	0.1	0.007	0.116	0.04	0.0044	300	3500	7	4.5	ceader, alder	0	20	1	0	0	1	1	8	5	4
N.Alouette	12/10/95	66.71	25.81	7.49	msg	3.4	0.005	0.135	0.075	0.0037	750	8833.5	24.5	.	ceader, alder	0	20	1	0	0	1	1	8	5	4
N.Alouette	7/12/95	45	54.98	0.01	sg	4.5	0.005	0.101	0.037	0.0018	150	2000	1.5	.	ceader, alder	0	20	1	0	0	1	1	8	5	4
N. Alouette	27/3/96	100	0	0	g	0.1	0.008	0.147	0.062	0.004	150	2500	3	1.5	ceader, alder	0	10	1	0	0	1	1	8	5	4
Fraser	27/4/95	28.08	67.1	4.83	gs	51.6	int R	0.005	0.39	0.0356	450	5500	23	16	decidious	0	0	1	1	1	1	0	6	4	4
Fraser	4/7/95	13.6	79.1	7.3	gs	39.2	0.013	0.064	0.118	0.0358	3450	37000	139.5	101.5	decidious	0	0	1	1	1	1	0	6	2	5
Fraser	11/10/95	.	.	.	.	43	0.111	0.066	0.269	0.0276	32500	125000	191	120	decidious	0	0	1	1	1	1	0	6	2	4
Fraser	8/12/95	0	0	0	p	44.8	0.002	0.156	0.169	0.101	700	6500	29.5	.	decidious	0	0	1	1	1	1	0	6	2	4
Fraser	27/3/96	6.62	36.89	56.49	gm	56.9	0.011	0.145	0.213	0.0543	700	9000	16	13	decidious	0	0	1	1	1	1	0	6	2	4
Thompson	3/5/95	30.92	68.97	0.11	sg	42.2	0.006	0.032	0.167	0.0174	1400	14500	64	42.5	grass	0	0	1	1	1	1	0	8	5	2
Thompson	5/7/95	.	.	.	.	29.2	0.016	0.076	0.128	0.0107	2550	31500	89.5	34	grass	0	0	1	1	1	1	0	8	6	4
Thompson	10/10/95	.	.	.	.	35.4	0.026	0.064	0.127	0.0095	5175	39750	271	158.25	grass	0	0	1	1	1	1	0	8	6	4
Thompson	10/12/95	0	0	0	p	36	0.003	0.148	0.069	0.0061	3175	26750	278	.	grass	0	0	1	1	1	1	0	8	6	4
Thompson	4/4/96	47.97	51.38	0.65	sg	39.4	0.011	0.096	0.116	0.0074	12500	96000	1751		grass	0	0	1	1	1	1	0	8	6	4