Benthic Community of Shuswap Lake's Foreshore

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THE BENTHIC COMMUNITY OF SHUSWAP LAKE'S FORESHORE

by

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ABSTRACT

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Substrate trays and a benthic pump were employed to collect samples of the benthic community from the foreshore of Shuswap Lake, British Columbia. The majority of samples were collected in June and July (1999-2001) from depths of less than two meters. The most numerous benthic invertebrates were; Cladocera, Chironomidae (larvae), Ostracods, Oligochaeta, Calanoida and Nematoda. Although there was no significant diurnal difference in total invertebrate numbers, a greater number and weight of insects ($P < .05$) was measured from the samples taken at night in 2001. The cobble/rocky shores supported significantly more Cladocera ($P < .05$) especially chydorids and *Sida crystalline* than the sandy/mud locations. Slightly more chironomid larva were recovered from the sandy/mud foreshore locations, however this result was not significant.

RESUME

Brown, T.G., Winchell, P., and Postans, N. 2004. Benthic community of Shuswap Lake's foreshore.
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Des échantillons de la communauté benthique de la zone intertidale du lac Shuswap en Colombie Britannique ont été recueillis en utilisant des plateaux de substrat et une pompe benthique. La plupart des échantillons ont été recueillis en juin et en juillet (1998-2001) à une profondeur de moins de 2 mètres Les invertébrés benthiques les plus nombreux étaient : Cladocères, Chironomes (larve), Ostracode**,** Oligochète, Calanoïdes et Nématodes**.** Malgré que l'effet des variations diurnes sur le nombre total des invertébrés n'était pas significatif, un plus grand nombre d'insectes ayant un poids plus élevé ($P > .05$) a été mesuré à partir des échantillons prélevés la nuit en 2001. Les rives rocheuses/rocailleuses accueillent un plus grand nombre de cladocères ($P < .05$) surtout les espèces chydoridae et Sida crystallina que les endroits sableux/boueux. Un nombre légèrement supérieur de larves de chironomes a été recueilli dans la zone intertidale aux endroits sableux/boueux, cependant ce résultat n'est pas significatif.

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INTRODUCTION

Shuswap Lake is an important source of Thompson River sockeye (*Oncorhynchus nerka*), chinook (*O. tshawytscha*), and coho (*O. kisutch*) salmon. Juvenile salmon utilized the foreshore areas of Shuswap Lake for rearing and migration (Fedorenko and Pearce 1982; Graham and Russell 1979; Russell et al. 1980). Juvenile salmonids can exploit previously dry lake margins (Figure 1) from April to July, as the lake water levels rise. Fish can also access alcoves, channels, and bordering wetlands previously isolated from the lake. A large portion of the diet of juvenile coho and chinook salmon captured from the foreshore of Shuswap Lake consisted of benthic invertebrates (Brown and Winchell 2002).

The foreshore (littoral zone) of large lakes such as Shuswap Lake is under considerable pressure from urbanization. Some beaches are naturally sandy (Figure 1), but cobble and boulder substrates cover much of the foreshore (Figure 2). Cobble substrate is removed for private beach creation and collected in rows, riparian vegetation is cut, protective walls are built, emergent vegetation is removed, and small marshy bays are altered. We studied the littoral zone associated with the main arm of Shuswap Lake for 3 years (Figure 3). Field-work was conducted during spring and summer (April to August) as lake water levels rose and fell. This study was designed to define the role of Shuswap Lake's littoral zone as juvenile salmon fish habitat and assess the potential impacts of foreshore and riparian development.

This paper examines the benthic community of Shuswap Lake's seasonally flooded foreshore. An examination of the benthic community is only a small component of the overall ecology of juvenile salmonids rearing along the foreshore of a large lake. Fish diets and distribution will be examined in a later paper.

STUDY AREA

Shuswap Lake is located in the southern interior of British Columbia within the South Thompson River drainage. The South Thompson River drains an area of approximately 16,200 km^2 (Fedorenko and Pearce 1982). Shuswap Lake is a multibasin lake consisting of four arms or five reaches (Salmon, Sicamous, Anstey, Seymour, and Main), has a surface area of 310 km^2, has a maximum depth of 162 m, and is considered to be oligotrophic (Williams et al. 1989). Lake transparency as measured mid-lake near Sorrento can range from 2.0 m during the period of peak runoff to 12 m in winter or early spring (Williams et al. 1989). The Main Arm of Shuswap Lake was the only area examined during the three years of study (Figure 3).

Shuswap Lake water levels were monitored at Sicamous B.C. by Kramer (2003) and were recorded as meters above sea level. The lowest Shuswap Lake water levels occur in March (e.g. March 22, 2001 at 344.8 m elevation) and the highest lake levels have historically occurred in June or July (e.g. June 14, 1972 at 349.66 m elevation). Lake levels annually rise from 3 to 4.5 m freshly flooding a considerable portion of the lake margins and occasionally inundating surrounding riparian vegetation (e.g. 1997 and 1999). The largest single day increase in lake level was 24 cm on May 28, 1972. During the three years of study the largest single day increases in lake levels occurred on; May 26, 1999 at 16.0 cm, May 22, 2000 at 12.6 cm, and May 28, 2001 at 16.1 cm. The maximum recorded lake level for each of the three years of study were; 349.22 m on July 15, 1999, 348.33 m on July 1, 2000, and 347.92 m on June 11, 2001 (Kramer 2003). Davies et al. (1996) reported an average annual difference in water levels of 3.3 m, with a mean high water of 348.3 m above the geodetic chart datum and a mean low water level of 345.0 m.

METHODS

Benthic samples were collected from the littoral zone of Shuswap Lake for three years. Different methods and study design were employed each year and it is likely that each sampling method was biased towards the collection of different invertebrate groups. The difficulty of sampling cobble bottoms with the same efficiency as sand/mud bottoms excluded the use of “dredges and grabs” (Southwood 1966) and led to the planting of removable portions of the substrate within plastic trays in 1999 and 2000. Attempts to measure the types and production levels associated with different substrates, using plastic trays were unsuccessful during the first two years. In 2000, the majority of substrate baskets and the invertebrates that had colonized them were never recovered. A benthic sampler was used to vacuum invertebrates from the shallow lake foreshore during the last year of study. This benthic pump could only sample shallow depths (< 0.4 m). Thus, as different methods were used each year, it is difficult to compare years.

In 1999, three plastic benthic trays were placed at each of 16 locations (Appendix 1, Table 1-2). Eight locations were characterized as having sand/mud beaches and eight had cobble beaches. Each tray (23 x 15 x 5 cm) covered an area of 345 cm^2 and contained approximately 1725 cm^3 of substrate collected from the immediate foreshore (Figure 4). All larger cobbles and rocks were removed (> 8 cm) and the trays were buried 15 cm into the foreshore (level to the top of the tray). Trays were installed on June 8-10 at a depth of 50-70 cm and at 75-90 cm on June 17-20 as lake levels rose. After lake levels had peaked and fallen the trays were recovered on July 28-30 from a depth of 50-95 cm. Three trays from Location 8 could not be found and 3 grab samples of a similar size were substituted for the missing tray samples at the time of recovery.

In 2000, two locations were chosen for benthic collection (Appendix 1, Table 3). Thirty of the same benthic trays used in 1999 were used in 2000; however, all trays contained a uniform 1725 cm^2 of sieved gravel 3.2 – 6.3 mm (1/8 to 1/4 inch). Both locations had been altered by the clearing of boulder/cobble material from portions of the foreshore and placement of these rocks into rows (Figure 5). Each location was divided into 3 substrate types; natural cobble/rock, sand/fine-gravel following cobble removal, and windrowed cobble. At each location 5 trays were placed within each of the three substrate types. This study design allowed the comparison of windrowed cobble and natural foreshore. The trays were placed on June 4 at a depth of 60-80 cm and after lake levels peaked the trays were recovered on July 31 from 40-60 cm depth. Unfortunately only 10 of the 30 trays were recovered.

The trays and contents were separated from the surrounding bottom materials, placed in a bucket under water, and hauled to the water surface. All fine materials and invertebrates held within the bucket were then washed and sieved in a fine mesh net (200 micron nitex) to reduce water volume. Concentrated materials were emptied into a 1 liter jar and preserved with formaldehyde. To estimate the number and type of invertebrates that could potentially be added to the sample by this removal method, a series of six bucket hauls with an empty tray were completed.

In 2001, a total of 37 samples were taken by a customized benthic pump sampler (Appendix 1, Tables 4-6). The first test sample was taken on April 26. To compare night and day benthic activity a series of 3 night and 3 day samples (30 samples total) were taken at 5 locations from May 10 to August 28. Six additional daylight samples were taken from two locations during peak flooding (June 19 to July 11).

The benthic pump sampler vacuumed benthic organisms and fine materials from the shallow edge of Shuswap Lake (Figure 6). This apparatus consisted of a bilge pump and associated hoses, a portable power supply, a modified circular “Hess” type benthic frame sampler with fine-mesh screening (300 micron), and fine mesh collecting net (200 micron) with screw sieve collecting container (200 micron). The frame of the sampler was 40 cm deep and 43 cm in diameter. The area sampled was 1450 cm^2 and during sampling the bottom was turned over to a depth of 3-4 cm. This equates to a substrate volume of approximately 5000 cm^3. Water depth ranged from 10 to 27 cm and mean water depth sampled was 17.8 cm (± 1.2 cm, 95% Confidence Limits or C.L.).

The benthic pump sampler was designed to sample both cobble and fine substrates in a similar manner. However, when the sampling frame is being placed on cobble beaches, larger stones will lie partly inside and partly outside the metal frame and selection and rejection of these materials is a matter of judgment. The larger rocks considered inside the frame were rubbed with gloves (inside of frame) and removed from the sampling area. Following removal of all larger rocks, the top 3-4 cm of the remaining finer substrate was stirred by hand and the materials and water within the frame was vacuumed for 10 min. The collecting net (200 micron) was washed (filtered water) and benthic invertebrates and fines were concentrated in the removable plastic sieve end of the net (200 micron). The concentrated materials were emptied into a 1 liter jar and preserved with formaldehyde. All invertebrates were identified and counted and all insects in 2001 were weighed (Appendix 1, 2).

Location 7 was sampled both day and night in early spring 2001 as the lake level rose and again in August 2001 as lake level fell. The riparian zone at this location consisted of a grove of cottonwoods and willows and the substrate consisted primarily of sand and muck. The foreshore had a gentle slope and in June/July the lake flooded into this riparian vegetation as well as covered small patches of emergent vegetation (mainly grasses and sedges). We considered this location to be undisturbed by lake front development.

RESULTS

DIFFERENCES IN METHODS AND YEARS

The method of benthic sampling was different during each of the three years. In 1999, substrate trays were filled at each location with unwashed foreshore substrate materials representative of that location. Samples obtained in this manner would approximate samples obtained with a benthic grab. Invertebrates, invertebrate eggs, fines, and detritus present at the location would be added to the tray at the time of filling. That portion of the invertebrate community that utilized fines and detritus and is slow to colonize new areas, should be present in greater relative numbers (Figure 7).

In 2000 all fines, organic materials, and invertebrates were washed from the sorted gravel used to fill the trays. Every tray held the same gravel mix. This was considered to be an “artificial” substrate as it was not representative of the foreshore substrates upon which it was placed. Those invertebrates that could rapidly colonize the trays and that preferred cleaner substrates should dominate (Figure 8).

In 2001 a benthic pump was used to sample the shallow (<40 cm) freshly flooded portion of the foreshore. This method should be biased towards two types of invertebrates; those that rapidly colonize the flooded foreshore in May and June and those that remain in the shallow waters as the lake levels drop in July and August (Figure 9). In 2001, sampling commenced in early May instead of June-July as in 1999-2000 and 15 night samples were taken. Thus, those invertebrates more prevalent on the shallow lake margins at night and in early spring would be relatively more numerous in the 2001 samples.

During the three years of study a total of 114,574 invertebrates were classified (Appendix 1; Figure 10). The most numerically abundant benthic invertebrate group was Cladocera 27,212 and it was also the least variable, annually averaging 23.8% of the invertebrates identified (Figure 11). The other dominant invertebrate groups included; Chironomidae (19.1%), Ostracoda (17.5%), Calanoida (11.0%), Oligochaeta (13.6%), and Nematoda (8.7%). These six groups represented 94% of the total benthic numbers (Figures 10-11).

Differences in the relative composition of the benthic community were noted for each year of the study (Figure 11). In 1999, Oligochaeta and Nematoda were 10x more common than in 2000. These worms utilize fines and detritial material and we suspect they were placed in the trays with the unwashed substrate, but were slow to colonize the cleaned substrate used in 2000. Calanoida and Chironomidae larvae were twice as prevalent in the community structure in 1999 as in 2000. These invertebrates also rely on detritus and may have been reluctant to colonize the cleaned substrates. Ephemeroptera (mayflies) and Trichoptera (caddis flies) dominated the clean gravel trays used in 2000 compared to the unwashed substrate used in 1999.

The benthic pump samples did appear biased towards Ostracoda, capturing 30 times more in 2001 than the benthic trays in 1999 or 2000. We observed large numbers of very small highly mobile invertebrates in very shallow water at night in April-May. Thus the higher numbers noted in 2001 are likely due to when the samples were taken and not necessarily due to the efficiency of the pump sampler compared to tray samples. Nematodes were also relatively more abundant in 2001 samples. Although nematode food and feeding habits vary among freshwater groups, many of the nematodes we captured could be considered to be microbiotrophic (feeding on bacteria, algae, fungi, and protozoa). Decaying vegetative material, concentrated along the shallow lake edge (wrack), may have provided a good food source for both Ostracoda and Nematoda.

INVERTEBRATE NUMBERS AND SEDIMENT

The volume of fine material remaining (< 200 microns) after the samples were sieved was measured for each sample in 1999. This volume of fines can be compared to the total number of invertebrates (Figure 12) and to the number of non-insecta invertebrates (Figure 13). There was a positive correlation) between the volume of fines and the total number of invertebrates (Petersons $P < .05$). There was also a positive correlation between the volume of fines and the number of non-insecta invertebrates (Petersons $P < .05$). Although the number of each non-insect invertebrate group was not significantly correlated to volume of fines, the actual number of ostracods, oligochaetes and nematodes increased with the volume of sediment.

INVERTEBRATE NUMBERS VS SUBSTRATE AND RIPARIAN TYPES

In 1999, three trays were placed on each of 8 cobble/rock foreshore locations and 8 sand/mud locations. A difference between the total number of invertebrates and substrate type was not apparent. The total number of benthic organisms was similar under the two treatments (Figure 14). In 2000, not enough trays were recovered to reasonably analyze the data. However, it appears the number of organisms was similar on both of the substrate types (Figure 15).

In 1999, the riparian zones of 8 locations were considered to be natural or treed (supported well established natural trees and brush) and 8 locations were considered to be cleared (majority of riparian zone consisted of lawns, riprap, retaining walls, roadways, and developed lands). There was no apparent difference in total invertebrate numbers when the two riparian types are compared. Possible differences in the abundance of invertebrate families relative to habitat types will be examined below.

NON-INSECTA GROUPS

Ostracoda

The relative number of each invertebrate group changed over the season. In temperate lakes, many of the Ostracoda occupy the shallow edge of the lake (<30 cm depth) as the water level rises in May (Figure 16). These benthic invertebrates reside on the sediment-water interface of the substratum feeding on small pieces of detritus and algae (Delorme 1991). They are very small (< 1.5 mm) and the majority of the body is contained within a solid carapace (Walter 2002). These Ostracoda species are not tolerant of warm summer temperatures (Delorme 1991) and few were collected in July and August from the warm foreshore.

Three Ostracoda genera dominated the foreshore of Shuswap Lake. *Cypria* sp and *Cypris* sp. were significantly more numerous in May than in August (Two-Way ANOVA, $P < .05$) and significantly more numerous at night (Two Way ANOVA, $P < .05$). The spring numbers of these two genera represented 92% of the total number of Ostracoda captured from all locations during 2001 (Appendix 1, Table 4). In 1999, *Candona* was the more numerous genera captured (Appendix 1, Table 1); while in 2001 they were the third most common genera. In 2001, *Candona* sp. were more numerous during the day but not significantly.

Acari

Among the Acari, the Hydracarina are commonly referred to as “water mites” (Ward and Whipple 1966) and most have three life stages; larvae, deutonymph, and adult (Clifford 1991). The larval stage is parasitic, commonly as an ectoparisite on immature aquatic insects (Smith and Cook 1991). Only free-living adults were enumerated during this study. Hydracarina were more numerous on rocky shores than on sandy/mud shores in 1999 (t-test P <.01), 2000 (t-test P <.05), and from the samples collected in June and July 2001 (t-test, P < .01). The family Oribatidae includes the genus, *Hydrozetes*. These adult mites are herbaceous, feeding on fungi and green plant material (Ward and Whipple 1966). Location 7 supported beds of aquatic vegetation. This location (Figure 16) also supported the most Oribatidae (100/283 in 1999 and 230/284 in 2001).

Copepoda

Copepods are common in a wide variety of aquatic habitats (benthic, littoral and pelagic) and most species are omnivorous (Williamson 1991). They may feed on detritus, pollen, plankton, other invertebrates and even larval fish. Williamson (1991) described the calanoids as primarily planktonic and the cyclopoids as primarily littoral and benthic. Adams et al. (1990) noted that the most dominant epibenthic species in Shuswap Lake were Copepoda (Calanoida and Cyclopidae).

Although Copepoda were found at all locations, the majority (1055/1729) in 2001 were found at sites supporting aquatic vegetation (location 7; Figure 16). In 2001, they were more abundant later in the year (80/sample) compared to early in the year (25/sample) but not significantly so (t-test). The most numerous Copepoda suborder was Cyclopoida (6642/10755 in 1999, 91/169 in 2000, and 1565/1729 in 2001).

Cladocera

The Cladocera (water fleas) are a group of small (range from 0.2 to 18 mm) meiobenthic crustaceans (Dodson and Frey 1991) and are a common item in Shuswap Lake fish diets (Russell et al. 1980). The Cladocera consume a variety of small particles ranging from bacteria, through algae to rotifers and copepod nauplii. We identified six families of Cladocera of which the Chydoridae and Sididae were by far the most numerous (Appendix 1, Tables 1,3,4). The Cladocera were more abundant on rocky foreshore than on sand sites in 1999 (Mann-Witney P < .05). Cobble/rocky locations averaged 432 ± 95 (95% C.L.) cladocerns / sample while sandy/mud locations averaged 194 ± 45 (95% C.L.) cladocerns / sample.

The Daphnidae (*Scapholeberis rammneri* and *S. mucronata*) are primarily limnetic (Edmondson 1966). The species in the genus *Daphnia* are limnetic zooplankton but may be encountered in the littoral zone (Chengalath 1982). *Ceriodaphnia* are small in size but were common in littoral samples collected across Canada (Chengalath 1982). They range in size from 0.2 to 3.0 mm and most are filter feeders using setae on 5 pairs of legs to capture small particles (Holmes 2001). Very few Daphnidae were captured in the substrate trays used in 1999 and 2000. In 2000, more Daphnidae were found in the six water column samples than in the 10 substrate samples. This indicates they reside in the water column not on the bottom. In 2001, three of seven samples taken in April and May had 95% (770/807) of the total number of Daphnidae. This indicates a highly gregarious distribution and possible higher spring abundance of Daphnidae on the lake foreshore. Their occurrence on the lake foreshore is likely related to winds and lake currents rather than habitat preference.

The Chydoridae (family of Cladocera) are typically littoral (Chengalath 1982). In 1999, three chydorids dominated the foreshore in July. These included; *Acroperus harpae*, *Alona* spp., and *Chydorus sphaericus* (Appendix 1, Table1). *A. harpae* were significantly more numerous on rocky foreshore than on sandy/mud foreshore in 1999 (Mann-Whitney P < .0001). Chengalath (1982) reported that *A. harpae* was common to all lake habitats. Edmondson (1966) reported that it prefer shallow, weedy habitats and was rare in open waters. *Pleuroxus procurvatus* and *P. denticulatus* were found at only a few locations but these were sand/mud bottomed. *Alonella* spp. were more numerous at two cobble/rock locations

(610/721) and *Camptocercus rectorostris* was more abundant at cobble/rock locations (496/640). In 2000, the chydorids were more numerous within samples obtained from cobble/rock sites than from sand/mud sites (t-test, P < .05).

The chydorids were significantly more abundant along the shallow foreshore as lake levels dropped in August 2001 than in May (t-test, P < .01; Figure 16). *Alonella excisa* and *Chydorus sphaericus* were 100 times more numerous in August than in May. *Acroperus harpae* was more prevalent in June and slightly more were captured during the day than at night (Appendix 1, Table 4).

Polyphemidae (*Polyphemus pediculus*) is common in marshes and weedy ponds (Edmondson 1966). In 1999, it was found only at location 7. This location contains considerable emergent vegetation (reeds and sedges).

Sida crystallina were more numerous on rocky-cobble foreshore in July 1999. (Mann-Whitney P < .0001). In 2000*, Sida crystallina* dominated the Cladocera (541/604) and were more numerous at the cobble/rock locations than at the sand/mud locations (Mann-Whitney, P < .05). A few *Sida crystallina* were captured during the control sampling in 2000. This indicates they were common in the water column as well as on the lakeshore bottom. These organisms should be readily available to juvenile fish feeding in the littoral zone. In 2001 during June and July, significantly more *Sida crystallina* were captured in benthos samples obtained from cobble/rocky shores than from sandy/mud sites (Mann-Whitney, P < .001).

Nematoda

Nematoda are more likely to be captured through the use of a Galen type sampler (samples substrate) than by a benthic sled (Adams et al. 1990). They tend to occupy the interstitial spaces in the substratum rather than the surface. It is doubtful that they are available as juvenile salmonid food. The Nematoda (Figure 17) were more abundant in May than in August 2001 (t-test P < .01). Nematoda were also more numerous in the 1999 benthic samples with a greater volume of fines; although the correlation between sediment and numbers was positive, it was not significant (Peterson, P = .09).

Mollusca

The bivalves (Pelecypoda) are filter feeders, consuming plankton, detritus and bacteria. They are called “fingernail clams” (Soil and Water Conservation Society of Metro Halifax 2002). The freshwater Sphaeriidae are often abundant in profundal areas, residing in the sandy substrate. Two genera were noted (*Sphaerium* and *Pisidium*). *Sphaerim* sp range in size from 8-20 mm, while *Pisidium* sp are smaller, ranging in size from 2-6 mm. It appears the bivalves were highly gregarious in distribution. In 2001, all 209 of the bivalves identified were obtained from location 7. No bivalves were recovered from the plastic substrate trays in 1999 or 2000.

The freshwater Gastropoda (snails) are primarily herbivores and detritovores. They use a rasping radula to scrape periphyton from substrate and epiphytic algae from macrophytes (e.g. *Gyraulus*), or consume macrophytes (e.g. Lymnaeidae). The genera we captured have been described as small, lentic, thin shelled, and preferring sandy to muddy substrates (Schuster 2002).

Gyraulus spp. were present each year and were the dominant gastropod (134 of the 166 characterized to genus). *Stagnicola* and *Physa* spp. were also found, but in fewer numbers. In 1999, significantly more gastropods were found on the cobble-rocky shores than the sand/mud beaches (t-test P < .05). In 2000, *Gyraulus* sp. was more abundant in the 2 samples taken from sandy substrate (36/sample) than in the 5 samples taken from cobble substrate (7.2/sample) at location 14. However, as few samples were recovered, statistical analysis is impossible. In 2001, more gastropods were collected on the sandy shores (1.2/sample) than on rocky locations (0.67/sample) although this result was not significant (t-test, P = 0.28).

Amphipoda

The Amphipod, *Hyalella azteca* is a relatively large laterally compressed invertebrate (> 6 mm), easily seen in the shallow lake waters and is commonly referred to as a “scud.” It is an omnivorous scavenger, feeding mainly on dead animals and plant matter (Clifford 1991). *Hyalella* requires well oxygenated water, resides in water less than 1 meter deep, and often hides under plant mats. In 1999, 200 of 223 *Hyalella* were captured from rocky foreshore sites. In 2000, 8 of 10 were from the trays placed on cobble foreshore. In 2001, more than half (589/983) were recovered from location 7 and an additional 230 were enumerated from the single sample taken at location 2 in April. At the time of sampling location 2, wave action had covered the foreshore with a blanket of fine decaying organic materials (leaf litter and wood chips).

Oligochaeta

Another common group of invertebrates identified within the benthic samples from Shuswap Lake was Oligochaeta (Figures 11, 17, 18). Three families dominated, these were Naididae, Enchytraeidae, and Tubificidae (Appendix 1. Tables 1,3,4). The freshwater oligochaetes are primarily burrowing worms, feeding by passing mud and debris through the gut and extracting organic matter (Clifford 1991). It is doubtful that oligochaetes are available to juvenile salmon. These worms are generally found in soft sediments rich in organic matter and they can tolerate low oxygen levels (Fox 2000). In Shuswap Lake, some naidids and tubificids are epiphetic (Hatfield 1996). *Nais* sp. feeds on heterotrophic aerobic bacteria, while *Chaetogaster* spp. are carnivorous, actively hunting and consuming smaller organisms such as ostracods (Nikon Microscopy 2003). The enchytraeids are common in marginal aquatic habitats such as marshes, small streams and interstitial waters along the margins of lakes (Soil and Water Conservation Society of Metro Halifax 2002).

In both 1999 and 2001, the naidids dominated the counts of identified aquatic oligochaetes, representing 91% and 74% of the oligochaetes. In 2000, only 13 worms were obtained from the cleaned substrate trays (Appendix 1, Table 3). The most commonly identified species of naidids were; *Chaetogaster* spp., *Nais* spp*.* *Stylaria lacustris* and *Pristina foreli* (Appendix 1, Table 1, 4).

The distribution of oligochaetes was location specific in 2001 (Figure 18). The sites with the most flooded aquatic vegetation (locations 2 and 7) had the highest densities of oligochaetes, mainly naidids. However, high densities of tubificids were noted in August at location 7. Location 10 also had a high density of enchytraeids. There was not a significant correlation between the volume of sediment/sample and the number of oligochaetes/sample in 1999 (Linear Regression P = .15). In 1999, there was no significant difference between the number of oligochaetes within cobble/rock and sandy foreshores (t-test, P = .72).

INSECT NUMBER VS WEIGHT (2001)

An assessment of the number of insects without consideration of their relative size is misleading. The midges (Chironomidae) represented 59.1% of the total number of insects in the 2001 benthic pump samples (Figure 19). The combined numbers of caddisflies (Trichoptera), beetles (Coleoptera) and true bugs (Hemiptera) represented only 9.4% of the total number of insects. When the weight of the individual insects is examined (Figure 20), the latter group represented 50% of the total insect weight and the midges only 20.8%. In terms of numbers, the midges and mayflies (Ephemeroptera) dominate. However, four groups (caddisflies, mayflies, midges, and true bugs) were similar in relative group weight and cumulatively represented 86% of the total insect weight.

NIGHT VS DAY FOR INSECTS

There were significantly more (2 Way ANOVA $P < .05$) insects at night (139.8/sample ± 18.0 1SE) versus day (94.0/sample ± 13.1 1SE) in 2001 (Appendix 1, Table 5). The insects were more numerous at two locations in 2001 (2 Way ANOVA $P < .001$). Locations 10 and 7 supported higher numbers of insects than the other sites, mainly due to the high numbers of Chironomidae recovered at those two locations. Location 7 was sampled both day and night (Figure 21), while location 10 was not sampled at night.

The weight of insects / sample was greater at night (87.4 mg/sample ± 33.18 1SE) than during the day (26.4 mg/sample ± 8.65 1SE), but not significantly so (Mann-Whitney P = 0.15). Location 7 represented 94% of insect weight from comparable night/day samples in 2001 (Figure 22). If we compare the day/night insect weights from only location 7, then a significantly greater weight of insects was obtained from the night samples (Mann-Whitney P < .01). This apparent weight difference is due to a few large Trichoptera, Corixidae, and Coleoptera captured at night (Appendix 1, Table 6).

INSECTA GROUPS

The midges (Chironomids) were the most numerous insect group identified during this study (Figure 11; Appendix 1, Tables 2, 3, 5). They represented 87% of the total insect number and annually represented; 96.7% in 1999, 40.4% in 2000, and 59.1% in 2001. The next most numeric group of insects were the mayflies (Ephemeroptera). They represented 8.1% of the total insects (1999, 1.6%; 2000, 51.3%; 2001, 25.5%). Together the midges and mayflies represented 95% of the insects recovered from the foreshore of Shuswap Lake during the three years of study. The relative numbers of the remaining Insecta groups changed slightly during each of the three years (Figure 11) with Diptera other than Chironomids (1.8%), Trichoptera (1.6%), Coleoptera (0.5%) and Collembola (0.3%) the next most abundant groups.

In examination of the foreshore invertebrates, two groups of Insecta common to freshwater were not found. These are Culicidae (mosquitoes) and Plecoptera (stoneflies). This is not surprising as mosquito larva must obtain oxygen at the lake surface and large lakes have considerable wave action making this difficult or impossible. Stonefly nymphs require well oxygenated water. Consequently they are found in flowing rivers and streams amongst the rocks and bottom debris. A few species of stoneflies can also be found in the rocky shoals of cold lakes.

Diptera

Four families (Chironomidae, Ceratopogonidae, Dolichopodidae, and Empididae) were numerically the most dominate of the “true flies.” The Chironomids were the most numerous and were found at all sites. All non-chironomidae were captured as larvae and appeared to be very location specific rather than spread uniformly around the lakeshore.

Chironomidae

The Chironomidae are one of the most important food sources for salmonids (Newman 2003). The pupae are the most vulnerable to fish predation as they must secure oxygen from the water surface through an anterior respiratory horn. The larvae dominate the benthos within the littoral zones of a lake and their faecal pellets are an important component of the food chain. The larvae are primarily herbivores or detritovores, consuming fine particles and blue green algae. Many of the larvae construct sediment tubes in the substrate and are filter feeders. The pupae and adults do not feed. The adults fly over the water and may temporarily land on the surface.

In 1999, we estimated the density of chironomid larvae to be greater than 1/cm^2 (Figure 23). In later years the density was substantially less. It is possible this difference was due to annual changes in sampling procedures as described earlier. However, it could also be due to differences in sampling locations or seasonal flooding.

Considerable variation exists between sampling locations for any given year (Appendix 1, Tables 2, 5). There is too much variation between locations to clearly show differences in larval densities relative to the physical nature of the foreshore. Slightly more chironomid larva were recovered from the sandy foreshore locations (414/sample ± 121, 1SE) than from the cobble beaches (379/sample ± 121

1SE) in 1999. However, one sandy location (location 8, grab samples) strongly biases this result. If location 8 is excluded from the analysis then the cobble locations have significantly (Two Way ANOVA, P < .05) more larvae than the remaining sandy locations (150/sample ± 60 1SE). The treed foreshore locations (281/sample ± 60 1SE) had a similar number of chironomid larvae to the cleared locations (249/sample ± 63 1SE) in 1999. In 2000, more chironomids were recovered from the trays placed on cobble substrate (42/sample ± 10 1SE) than from trays placed on sandy substrate (18/sample ± 6 1SE). This result was not significant (t-test, P = .11). In 2001, cobble locations supported 15 larvae / sample (± 7 1SE) versus 102 larvae / sample (± 22 1SE) on sandy foreshore locations. This result is also strongly biased by the high density noted for sandy location 7 (195 ± 22 1SE or 0.13 / cm^2).

More chironomid larvae were captured at night than during the day (Figure 24). However, there was not a significant difference between day and night larval densities (Two-Way ANOVA P = .15), while there was a significant difference between larval densities at location #7 compared to the other three locations (P < .001).

A portion of the Chironomidae captured during the three years of study (15,793 of 21,894) was classified further. Three subfamilies dominated the Chironomidae found along Shuswap Lake's foreshore. The most numerous were Chironominae of which 6,980 were of the tribe Tanytarsini and 1,828 were of the tribe Chironomini. Orthocladiinae numbered 5,448, Tanypodinae numbered 518 and 18 Diamesinae were identified.

Ceratopogonidae

Some adult ceratopogonidae bite warm blooded animals and these are commonly called "biting midges" or "no-see-ums." Others such as Bezzia and Probezzia feed on small insects (i.e. Chironomidae). As larvae they are small, elongate, carnivores, and swim with a serpentine motion (Hilsenhoff 1991). They burrow head first into larger insect larvae. They hang to the surface film as pupae and may emerge in large numbers.

In 1999, the ceratopogonidae larvae were the second most abundant dipterans after the chironomids. They represented 189 of the 221 non-chironomid Diptera. All were of the genus *Bezzia* and *Probezzia*. The majority of the biting midges (111/189) were captured at location 8 in October.

Empididae

Empididae adults are known as "dance flies" and are small (<7mm) as larvae (Hilsenhoff 1991). The larvae are predaceous. The majority of Empididae larvae were recovered from location 7. In 1999, 11/12 and in 2001, 10/10 were recovered from this location. Only two were captured from location 12 in 2000. All were captured late in the summer (July 28 to August 28).

Dolichopodidae

These dipterans are commonly named, "long-legged flies." They are predaceous as both larvae and adults. Only one genus, *Rhaphium*, represented the 11 Dolichopodidae we captured. All of the *Rhaphium* were found at location 5 in 1999 and location 2 in 2001. Both of these sites could be considered to be fine sand beaches.

Coleoptera

The Coleoptera are commonly known as water beetles (Hilsenhoff 1991). In their larval phase they can swim, but commonly crawl along the bottom and respire cutaneously. As adults they have appendages adapted for swimming, eat with chewing mouthparts, and must surface to breathe. The requirement to surface generally restricts them to the shallow lake margins. A beetle generation takes one year of which approximately a month in spring is larval. They often use shoreline litter to pupate.

The use of substrate trays did not appear to be an effective way to capture aquatic beetles when compared to the benthic pump. In 1999, 14 beetles were recovered at five locations from 36 samples (Appendix 1, Table 2). Thirteen were from rocky sites and thirteen were larvae. In 2000, only four beetles were recovered from the 10 trays (Appendix 1, Table 3). The benthic pump in 2001 captured 96 beetles from 37 samples and a greater number of taxa (Appendix 1, Table 5).

Two genera of Dytiscidae dominated numerically in 2001, *Hydroporus* spp. (76/114) and *Brachyvatus* spp. (28/114). They are predaceous diving beetles as adults and range in size from 2-40 mm. The adults of these two genera were more abundant at night (64/65) where comparable day/night sampling was completed. The larvae of *Hydroporus* spp. were recovered from day samples collected at location 10.

Collembola

The adult Collembola (springtails) are considered to be semiaquatic, wingless arthropods, usually less than 3 mm long. They may reside on the surface of lotic waters and don't break through the surface film due to their small size and hydrophobic body surface. Thus, they are not benthic organisms. They specialize in items of food available on the water surface such as algae, detritus, and bacteria. The young springtails (nymphs) look similar to adults and we did not differentiate stages (Appendix 1, Tables 2-5).

Each year of sampling produced a different numerically dominant genus of springtail. In 1999, all 20 of the springtails recovered were *Anurida* sp. In 2000, 25 of 26 were *Isotoma* sp. In 2001, the majority (12/15) were *Sminthurus* sp.

Trichoptera

Trichoptera (caddisflies) construct portable cases out of plant material or sand. The larvae crawl along the bottom and are generally omnivorous or herbivorous. Most caddisflies pupate in their case. The adults feed on liquids and are attracted to lights at night (Clifford 1991; Wiggins et al. 1985).

Two families of Trichoptera dominated our catches during the three years of study. In 2001, Leptoceridae were the most numerically abundant (259/311) and were represented by two genera (*Mystacides* and *Nectopsyche*). Hydroptilidae were the next most abundant (41/311). In 2001, the majority of the caddisflies (309/311) were obtained from location 7 and location 2. In 1999, 24/50 caddisflies were obtained from location 7.

More caddisfly larvae were captured in August (240) than in May (43) from location 7 (Figure 21). However, this result was not significant (t-test, P = .09). All Hydroptilidae larvae were captured during the day, while more Leptoceridae larvae were captured at night (195) than during the day (47). However, this result was also not significant (Mann Whitney P=.18).

Heteroptera

The most numerous aquatic Heteroptera were the Corixidae. These “water boatmen” feed primarily on detritus, algae, protozoan, and very small invertebrates (Hilsenhoff 1991). The adults can fly and are common along the littoral zones of lakes. In 2001, fifty-six *Corisella* sp. adults were recovered. The majority (55/56) were recovered in May and August from location 7.

Hemiptera (Aphididae)

The aphids encountered during this study were of terrestrial origin. Although they were not identified to species, it is likely they were falling from riparian zone cottonwood trees (*Populus trichocarpa*) onto the water surface and onto our equipment and were thus included in our benthic samples. The majority of aphids (7/9 in 1999 and 25/28 in 2001) were recovered from locations 7 and 2. The riparian zones of these two locations consisted of stands of cottonwood trees.

A considerable number of aphids must have entered the lake foreshore from June to August. If we consider the total lake shore sampled, we estimated an aphid density of 1/1840 cm^2 in 1999 and 1/1550 cm^2 in 2001. These estimates equated to approximately 6 aphids per square meter of water surface. If we consider only the surface area sampled at the two cottonwood locations in 2001, than a density of 19 aphids per square meter of water surface can be estimated.

Ephemeroptera

The Insecta order Ephemeroptera are commonly called mayflies (Mounce 1973). The aquatic larvae occur among vegetation in littoral areas and sometimes along wave–swept beaches (Hilsenhoff 1991). The larva stage emerges from the water as a subimago and molts quickly into an adult. The adult and subimago stages of mayflies do not feed and are short-lived. Larval mayflies are mainly herbivore-detritivores.

The ecological characteristics and habitat preferences of the various families of Ephemeroptera identified in Shuswap Lake have been described by Thorp and Covich (1991), Mounce (1973) and Clifford (1991). The Baetidae are relatively small mayflies and are active swimmers, residing on the substratum. They tend to consume algae and detritus. Heptageniidae are relatively large and flat and are often found clinging to rocks. They feed on algae they scrape from the surface of rocks. Leptophlebiidae are medium sized invertebrates which and may be found within the gravel, in quiet waters. These mayflies were described as detritus feeders by Mounce (1973). Ephemeridae are relatively large filter-feeders that burrow into sand or silt, and may emerge in large numbers. Caenidae are small, can occupy bottom sediments, and emerge at the water surface. Surrounding vegetation and support is necessary for completion of their life cycle. Ephemerellidae may be found along wave-swept shores often within leaf litter. They crawl up on protruding substrate to emerge. Ameletidae (or Siphlonuridae) larvae are relatively large and mainly herbivores and detritivores.

In 1999, 311 mayfly nymphs were captured of which 50% were identified to species or genus (*Procloeon* sp. 104; *Ephemera simulans* 12; *Caenis simulans* 39). An average of 6.5/location (± 1.4 1SE) were counted. There was no significant difference between the numbers of mayfly nymph captured on cobble and sand/mud beaches (t-test, P = 0.11), although 226/311 mayflies were obtained from the rocky foreshore sites.

In 2000, Leptophlebiidae dominated and comprised 374 of 422 mayflies captured. An average of 42.4 mayflies/sample (± 6.3 1SE), were captured from the trays. Significantly more mayflies were captured in 2000 than in 1999 (Mann-Whitney Rank Sum P<.001). This may indicate they preferred the cleaner substrate used in 2000.

In 2001, 4 groups of mayflies dominated. Baetidae (603), Heptageneiidae (303), Caenidae (58), and Ameletidae (188) represented 89% of the 1289 mayflies recovered in 2001. *Ameletus* sp was most numerous in May, *Caenis simulans* and Heptageneiidae in June, and Baetids were common from June to late August (Appendix 1, Table 5).

DISCUSSION

The benthic species that dominated the foreshore from mid-May to mid-July varied each year, likely due to differences in sampling methods and differences in annual flooding characteristics. Cladocera, Chironomidae and Calanoida were the most numerous and most available to near-shore juvenile fish. Sididae were significantly more abundant in early spring. Oligochaeta and Nematoda were also abundant but occupied the interstitial spaces in the substrate and would not be readily available to juvenile salmonids. Ostracoda were abundant along the foreshore in May. However, the consumption of freshwater ostracods by juvenile salmon was not noted during preliminary analysis of Shuswap Lake chinook stomach samples (Brown and Winchell 2002). Ephemeroptera were common in 2000 and are considered excellent fish food (Newman 2003). They are much larger than chironomids and although fewer in number, they represent an important item in the salmonids diet.

Many of B.C.'s lakes support rearing sockeye juveniles throughout the year (Stockner and Shortreed 1978; McDonald 1973). Although, we were sampling the benthic community while salmon fry appear to be surface oriented. It is possible that the large numbers of juvenile salmonids associated with the lake foreshore in spring may have influenced the number and type of benthic invertebrates we captured. In Quesnel Lake from mid-May until mid-June high densities of migrating sockeye fry were observed within 5 m of shore and these juvenile sockeye shifted their diet from *Leptodiaptomus* (near shore, water column) to pelagic Daphnia (limnetic) as the fish become more pelagic (Morton and Williams 1990).

The slightly higher numbers of Insecta noted on the lake foreshore at night can not be attributed to predator avoidance. The density of juvenile salmonids along the shallow lake margins was substantially higher in spring during the night than during the day (Brown and Winchell 2002). Thus, we might assume that nocturnal predation rates of invertebrates by fish would be higher at night than during the day. It is possible invertebrates may avoid shallow waters during the day to limit their exposure to UV light (Kelly and Bothwell 2002; Bothwell et al. 1994). The diurnal difference in invertebrate numbers was examined for only one sampling year (2001). There was no significant diurnal difference in total invertebrate numbers, or non-insecta numbers. The ostracods *Cypria* and *Cypris* were more numerous at night, while *Candona* were numerous during the day. Insecta were significantly more numerous at night and a significantly greater weight of insects was measured from the samples taken at night. Although slightly more Coleoptera, Trichoptera, Chironomidae, and Corixidae were noted from the night samples, there was no significant diurnal difference when each of the insect groups was examined separately.

There was no apparent difference in benthic communities between foreshore locations bordered by natural vegetation versus those areas cleared of trees. Our sampling design was not sophisticated enough to evaluate litter deposition rates or transport associated with lake wave actions. In the spring prior to maximum lake level, the unconsolidated foreshore separates the riparian vegetation from the water's edge. On beaches with a shallow gradient this distance can be over 100 meters. It is likely materials originating from the riparian zone are transported along the shore edge by wave action and are deposited upon certain shores and removed from others. Thus, the volume and type of litter that accumulates on the foreshore may not be related to the condition of the immediate uplands.

It did not appear that there was a relationship between the total number of invertebrates and substrate type. However, differences in the abundance of specific invertebrate families and species relative to habitat types were apparent. The cobble shores supported more Cladocera, especially the chydorids; *Acroperus harpae*, *Camptocerus rectorostris*, and *Alonella* spp. *Sida crystallina,* the most numerically abundant Cladocera, was also significantly associated with cobble sites. *Pleuroxus procurvatus* and *P. denticulatus* were associated with sand/mud substrate. More amphipods were captured from cobble/rocky foreshores. Slightly more chironomid larva were recovered from the sandy/mud foreshore locations in 1999 and 2001.

Location did appear to influence the number of invertebrates. We observed that certain locations produced greater numbers of invertebrates and supported differences in invertebrate community structure. Terrestrial aphids were consistently captured in greater numbers in benthic samples from two sites (location 7 and 2) where the upland areas were dominated by cottonwood trees. These two locations are also near the outlet of the Adams River and may be influenced by suspended materials washed down the river in the spring. Location 7 was associated with small beds of aquatic vegetation and was considered undisturbed. In 2001, location 7 supported a greater diversity of invertebrates and supported greater numbers of Oribatidae, Copepoda, Amphipoda, tubificids, chironomid larvae, Corixidae, Trichoptera, and bivalves.

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LIST OF FIGURES

14. Total number of benthic invertebrates (sum of 3 samples) at each of 16 locations in 1999. Substrate (cobble or sand/mud) and status of riparian fringe (cleared or treed) is indicated.

15. Total number of benthic invertebrates per sample taken in 2000.

16. Numbers of Hydracarina, Ostracoda, Copepoda, and three families of Cladocera per benthic pump sample. Foreshore samples were taken in May and August 2001 at location 7 during day and night.

17. Numbers of bivalves, amphipods, nematodes, and Oligochaeta (Tubificidae, Enchytraeidae, and Naididae) per benthic pump sample. Foreshore samples taken in May and August 2001 at location 7 during both day and night.

18. Numbers of 3 Oligochaeta families from all samples taken in 2001.

19. Relative numbers of Insecta from all samples taken in 2001.

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21. Numbers of Insecta (Orders) per benthic pump sample. Foreshore samples were taken in May and August 2001 at location 7 during both day and night.

22. Weight of insects / benthic pump sample. Foreshore samples taken during both day and night. Location 7 is represented by samples 1-6 (May) and 25-30 (August).

23. Density of chironomid larvae and pupae captured during each of three years.

24. Number of chironomid larvae/benthic pump sample. Foreshore samples taken during both day and night. Location 7 is represented by samples 1-6 (May) and 15-30 (August).

FIGURES

Figure 1. Extent of Shuswap Lake foreshore in early spring prior to rise in lake level. Photo was taken looking towards Location 2.

Figure 2. A cobble beach (location 18).

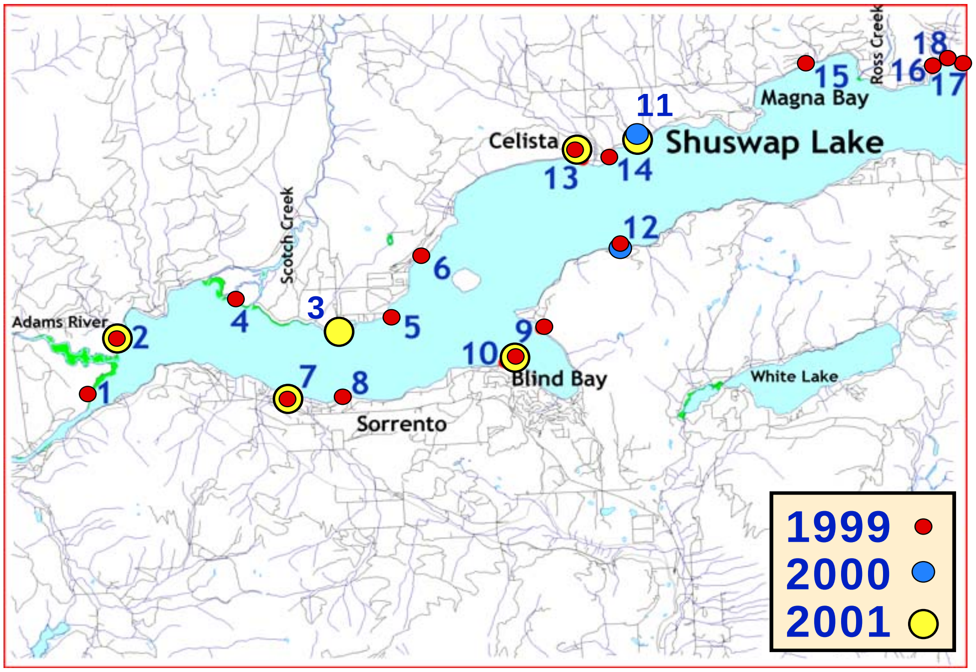

Figure 3. Main Arm of Shuswap Lake, illustrating the benthic sampling locations for three years of study.

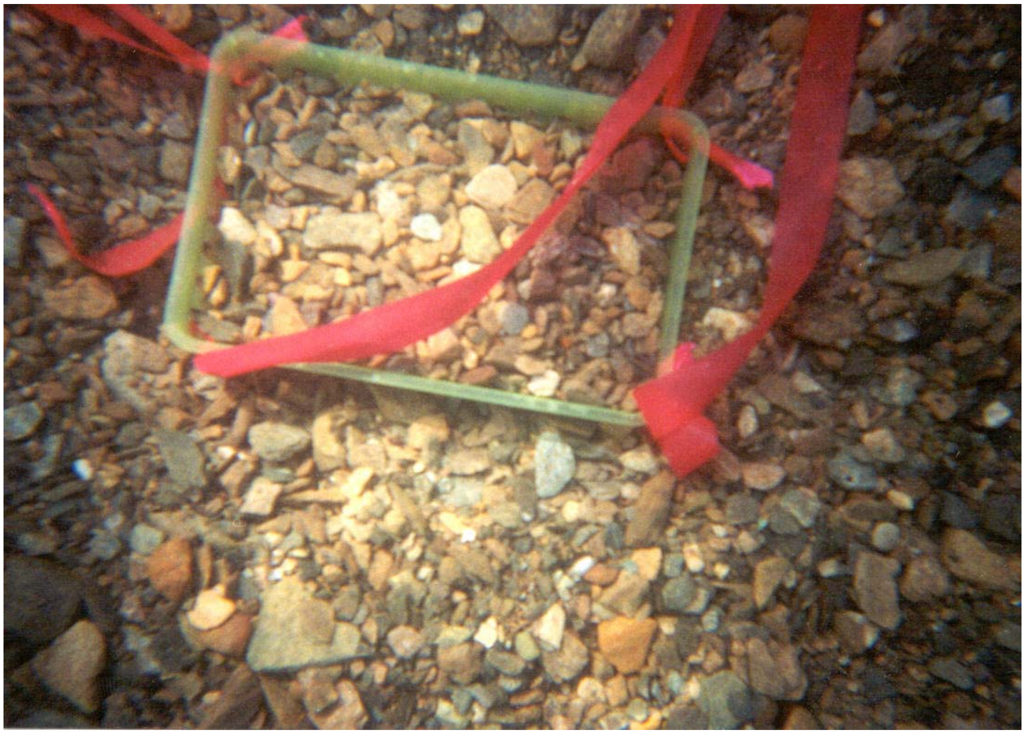

Figure 4. Plastic benthic trays used in 1999-2000.

Figure 5. Placement of cobble and rock into rows at location 12.

Figure 6. Benthic pump used in 2001.

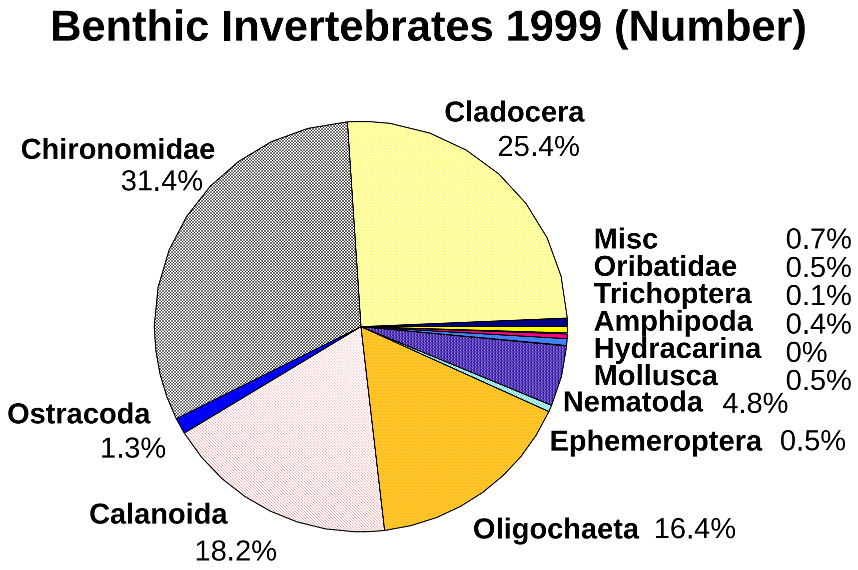

Figure 7. Relative benthic invertebrate composition of benthic substrate trays collected in spring 1999.

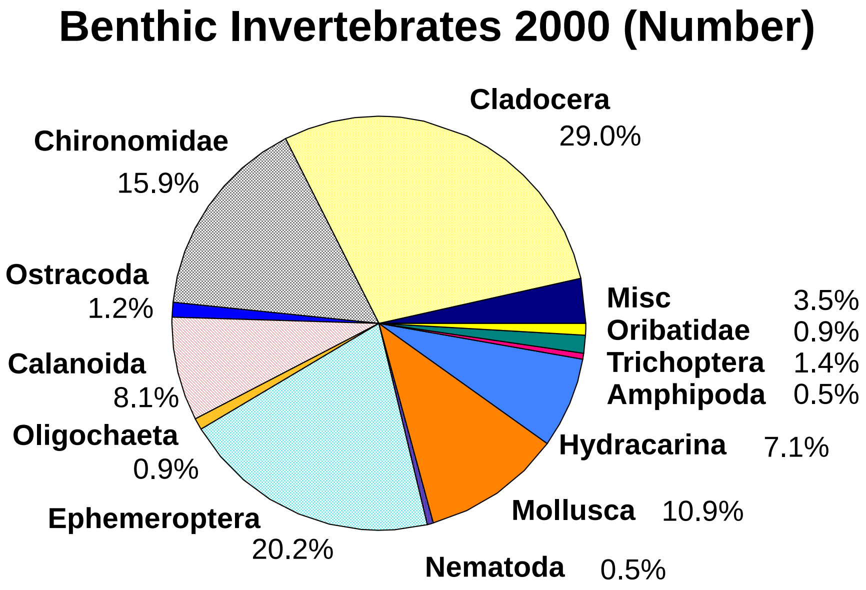

Figure 8. Relative benthic invertebrate composition of benthic substrate trays collected in spring 2000. Substrate consisted of washed and sorted fine gravel.

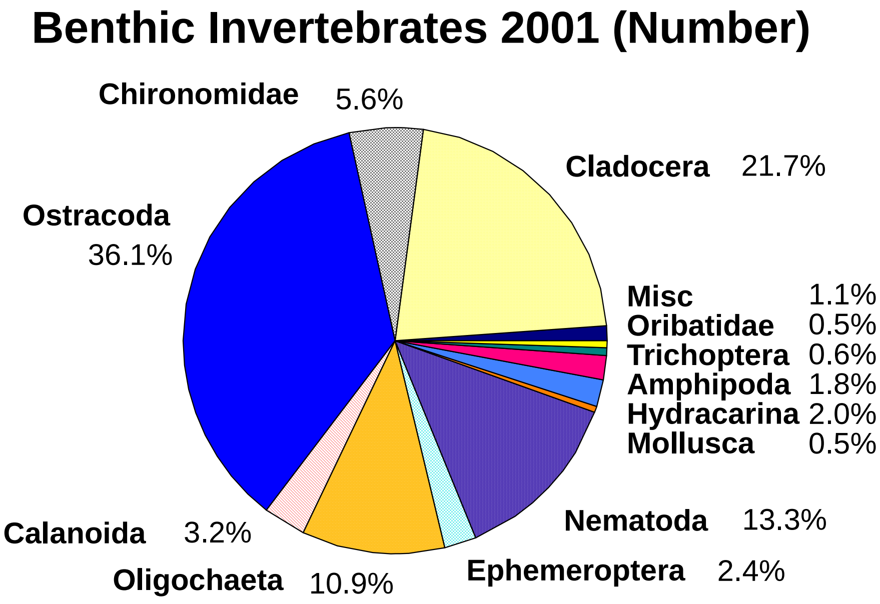

Figure 9. Relative benthic invertebrate composition of samples collected in spring and summer 2001 with a benthic pump sampler.

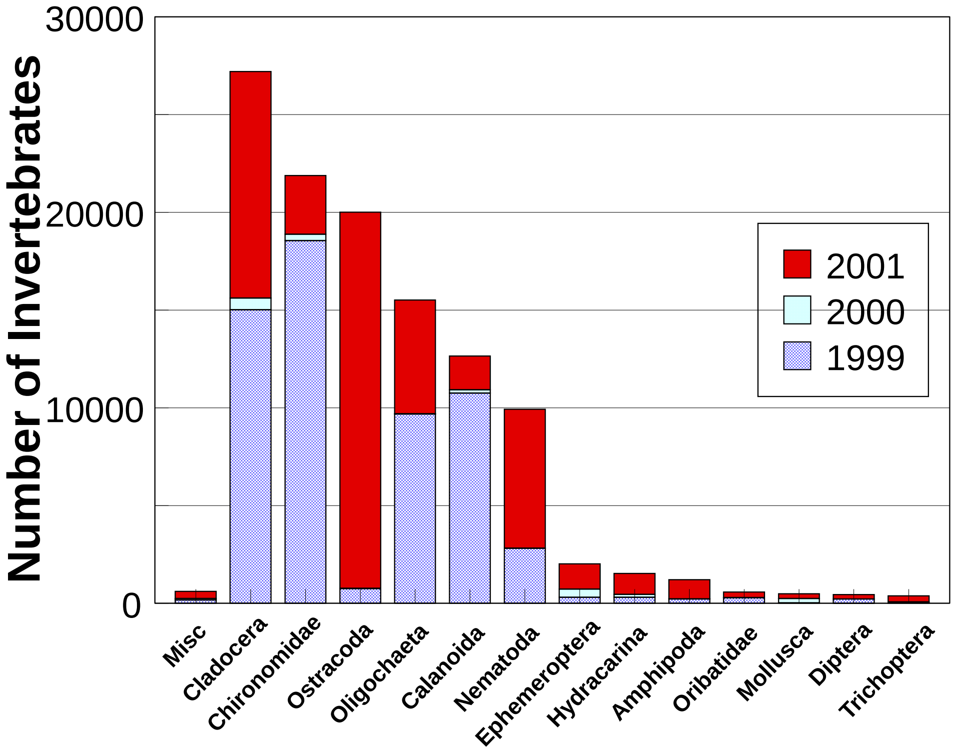

Figure 10. Number of benthic invertebrates for each of three springs (1999-2001).

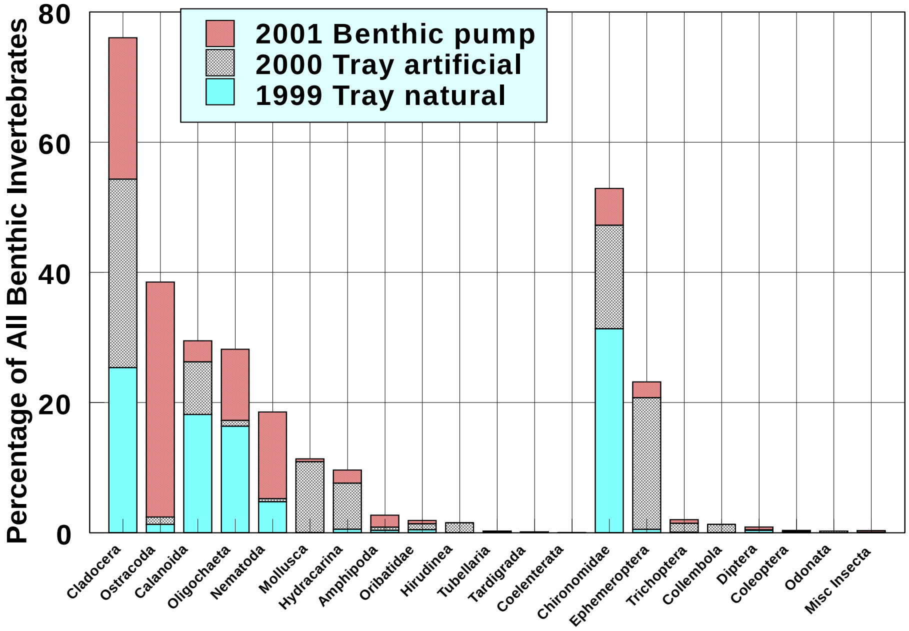

Figure 11. Relative composition of benthic samples for each of three springs (1999-2001). Major invertebrate groups are illustrated and differences between their relative numeric compositions are likely due to different sampling methods.

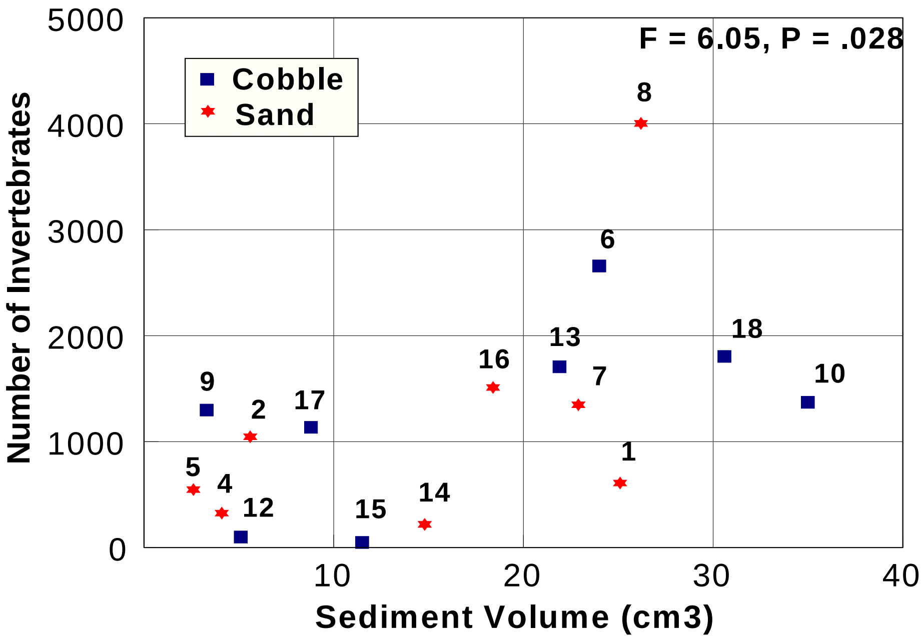

Figure 12. The relationship between the average volume of sediment (3 samples per location) and average number of organisms. Each sample represents 1725 cm^3 of substrate. Cobble/rock and sandy foreshore locations are indicated by data-labels.

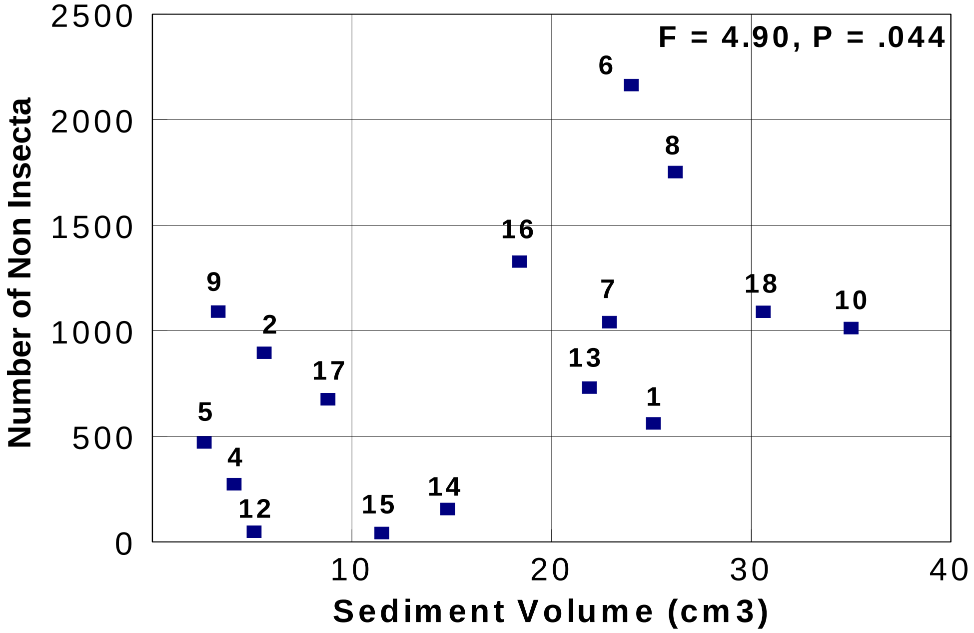

Figure 13. Relationship between the average volume of sediment at each location (3 samples per location) and average number of non-insecta organisms. A sample represents 1725 cm^3 of substrate. Location numbers are indicated by data-labels.

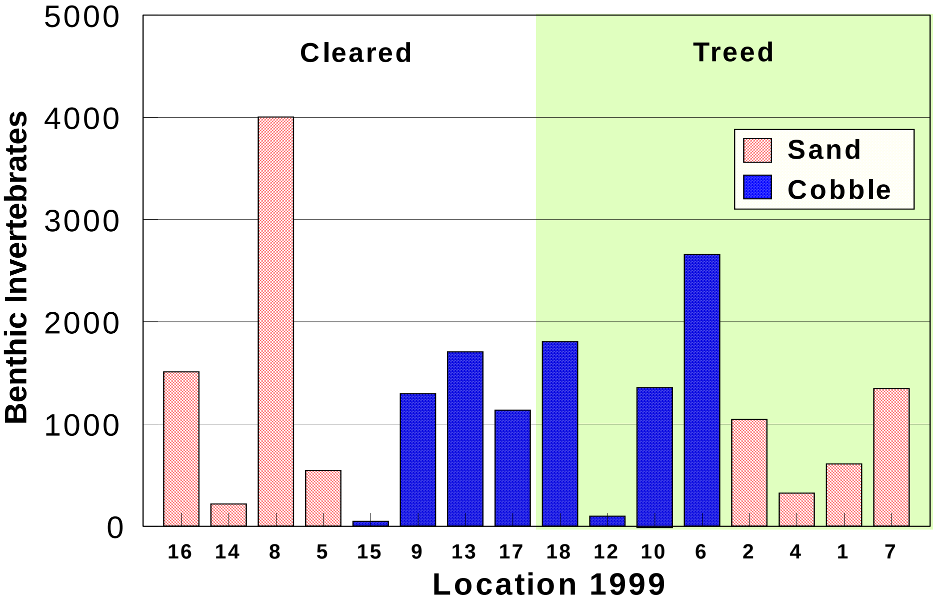

Figure 14. Total number of benthic invertebrates (sum of 3 samples) at each of 16 locations in 1999. Substrate (cobble or sand/mud) and status of riparian fringe (cleared or treed) is indicated.

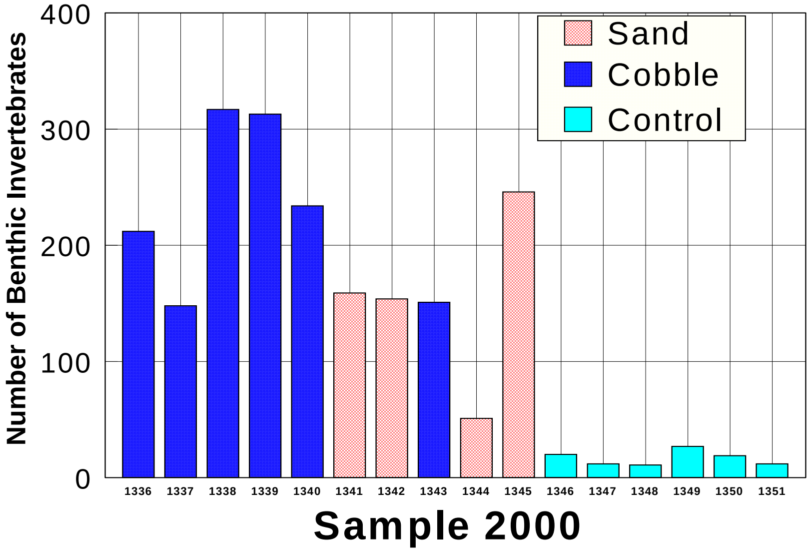

Figure 15. Total number of benthic invertebrates per tray sample . Samples were taken on sandy/mud or cobble/rock foreshore. Control samples consisted of bucket hauls with empty trays (indicates invertebrates in water column).

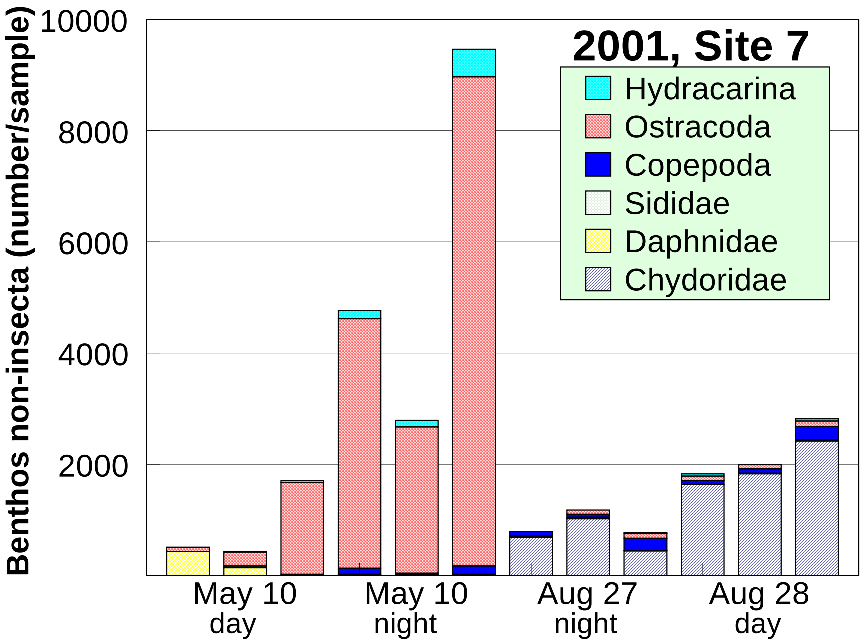

Figure 16. Numbers of Hydracarina, Copepoda, Ostracoda, and Cladocera per benthic pump sample. Foreshore samples were taken in May and August 2001 at location 7 during both day and night.

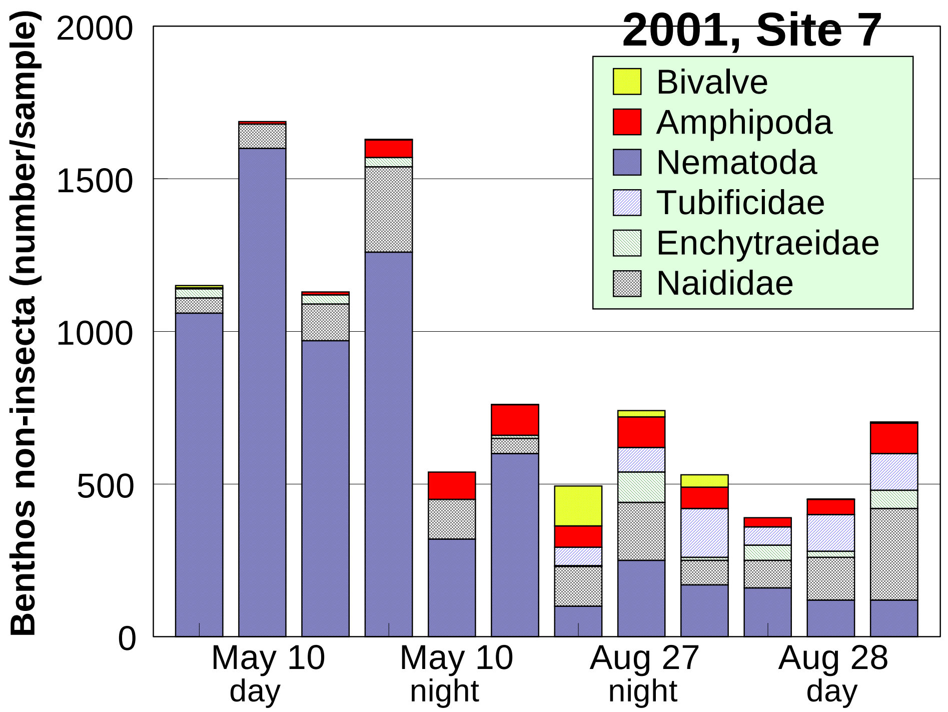

Figure 17. Numbers of bivalves, amphipods, nematodes, and Oligochaeta (Tubificidae, Enchytraeidae, and Naididae) per benthic pump sample. Foreshore samples taken in May and August 2001 at location 7 during both day and night.

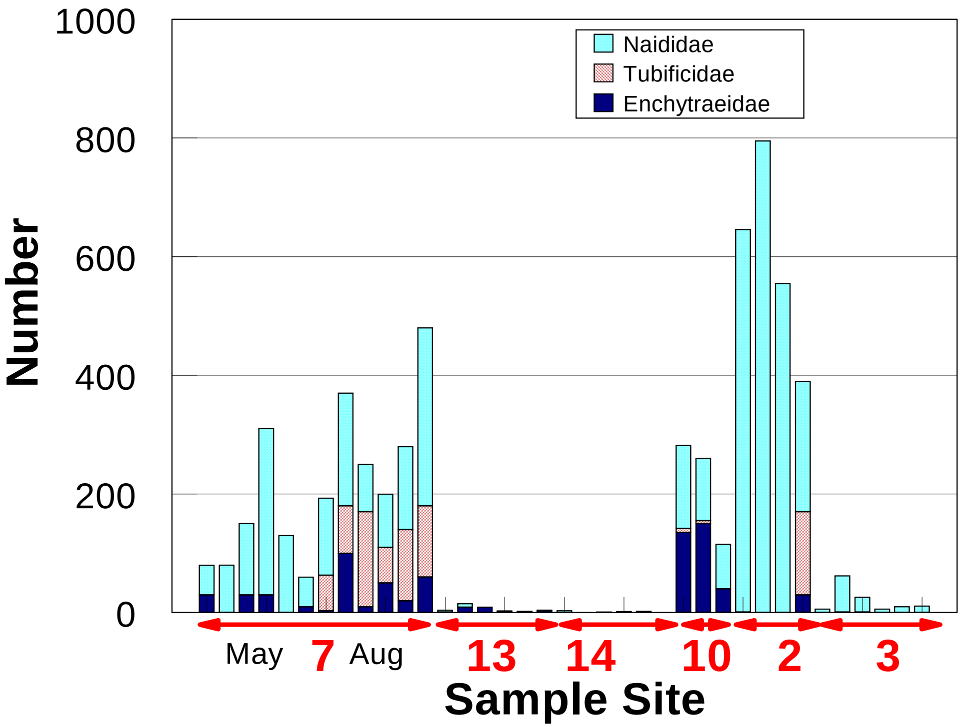

Figure 18. Numbers of 3 Oligochaeta families from all samples taken in 2001.

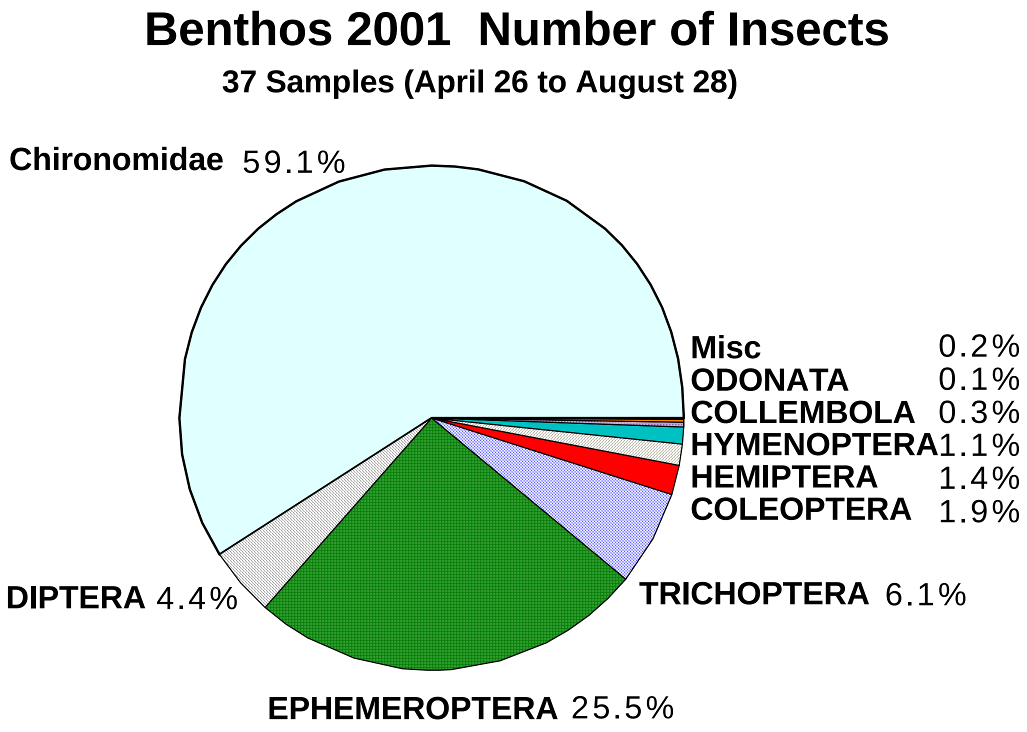

Figure 19. Relative numbers of Insecta from all samples taken in 2001.

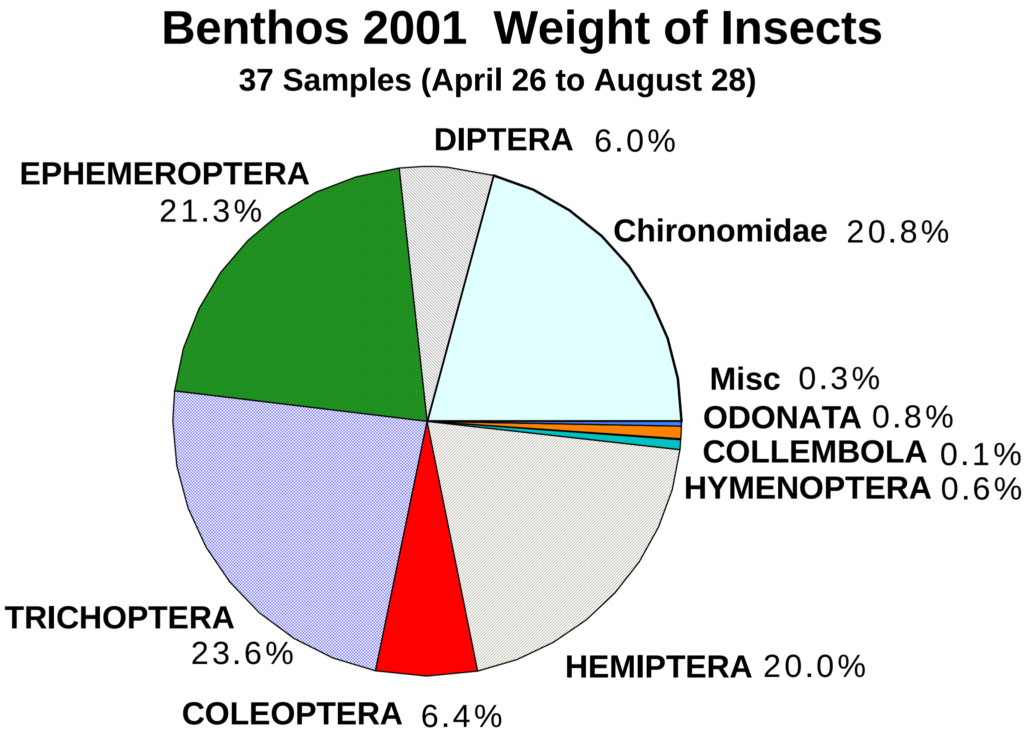

Figure 20. Relative weight of Insecta from all samples taken in 2001.

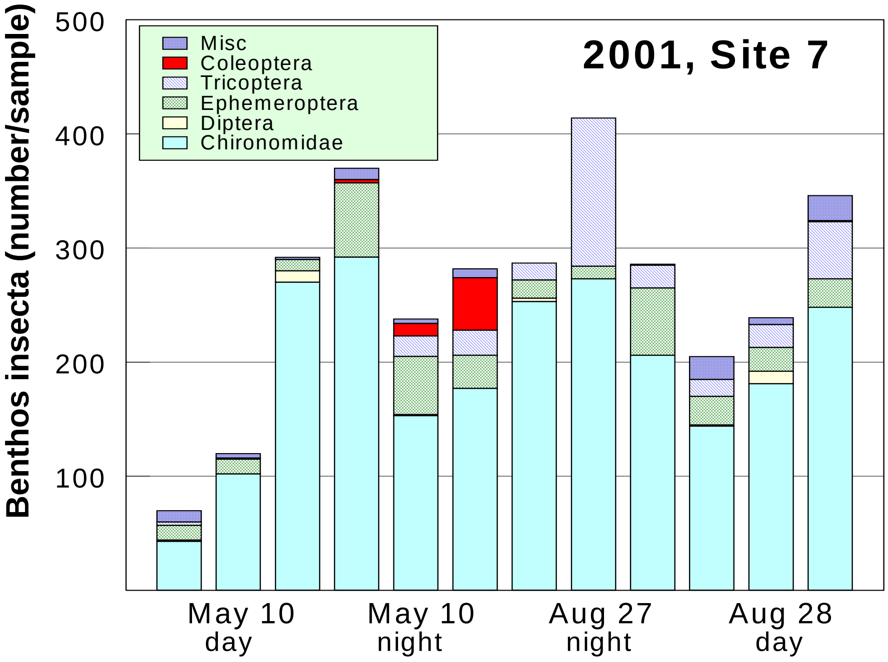

Figure 21. Number of Insecta (Orders) per benthic pump sample. Foreshore samples taken in May and August 2001 at location 7 during both day and night.

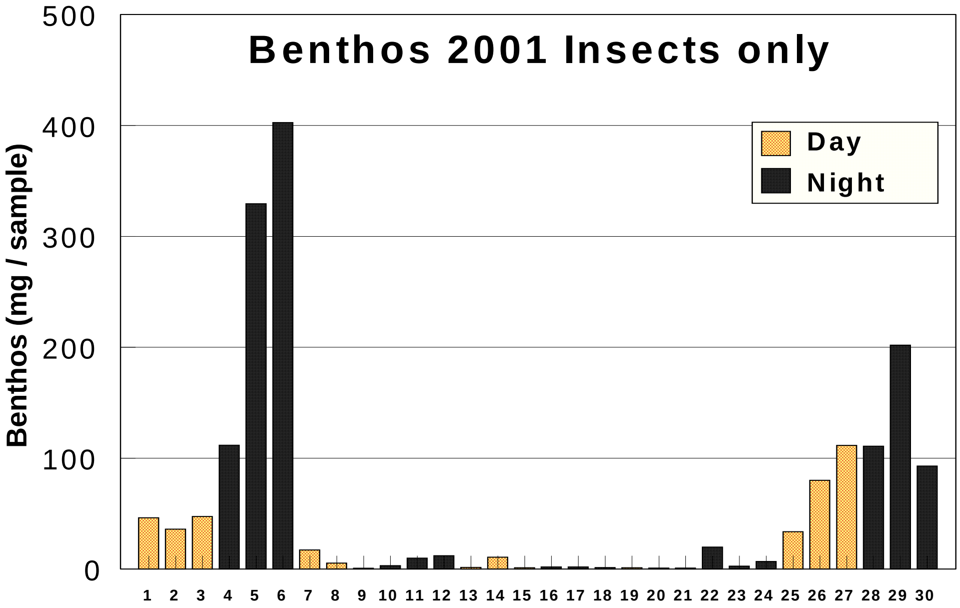

Figure 22. Weight of insects / benthic pump sample. Foreshore samples taken during both day and night. Location 7 is represented by samples 1-6 (May) and 25-30 (August).

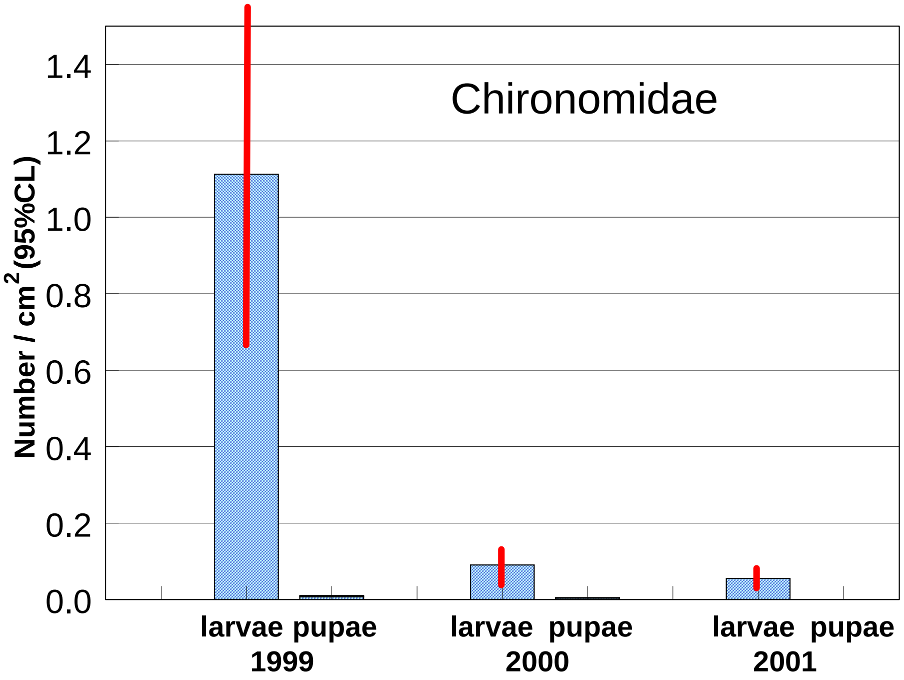

Figure 23. Density of chironomid larvae and pupae captured during each of three years with 95% confidence limits (CL).

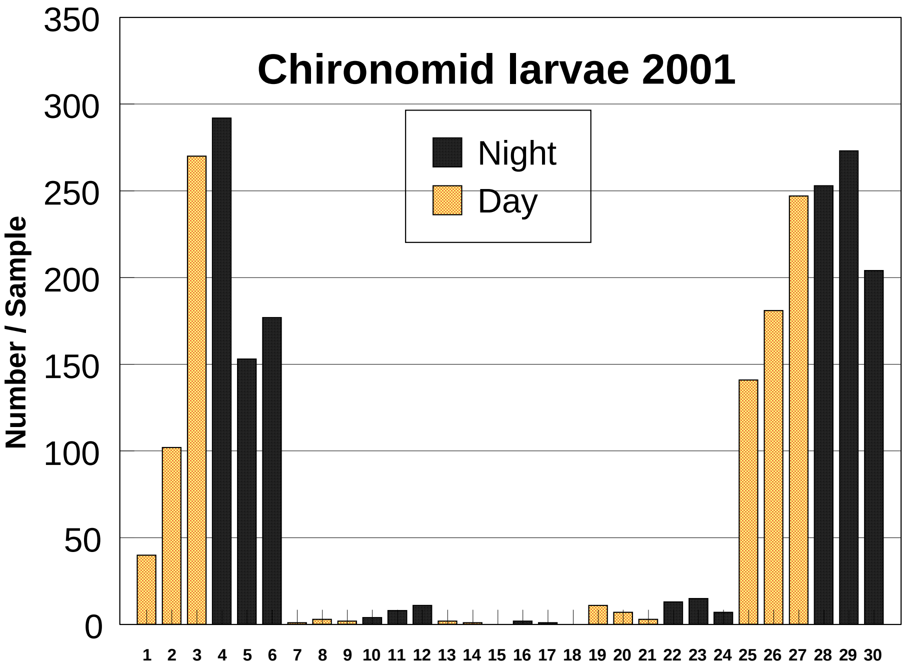

Figure 24. Number of chironomid larvae/benthic pump sample. Foreshore samples taken during both day and night. Location 7 is represented by samples 1-6 (May) and 15-30 (August).

APPENDIX 1. BENTHIC SPECIES LIST; SHUSWAP LAKE FORESHORE

Group	Family	Genus
COELENTERATA		
		Hydra
TURBELLARIA		
NEMATODA		
BRYOZOA		
OLIGOCHAETA		
	Enchytraeidae	
	Naididae	
		Chaetogaster
		Nais
		Pristina foreli
		Stylaria lacustris
		Vejdovskyella
		Slavinia appendicularia
	Tubificidae	
	Lumbriculidae	
	Lumbricidae	
HIRUDINEA		
		Piscicola salmositica
		Dina parva
		Helobdella stagnalis
TARDIGRADA		
ARACHNIDA		
HYDRACHNIDIA(Hydracarina)		
		Hydracarina #1
		Frontipoda
		Torrenticola
		Forellia
	Oribatidae	
		Hydrozetes
OSTRACODA		
		Candona
		Cyclocypris
		Limnocythere
		Cypria
		Cypris
		Cypricercus elongata
COPEPODA		
Calanoida		
		Cyclops scutifer
		Eucyclops agilis
		Leptodiaptomus
		Epsichura nevadensis
		Macrocycops ater
Cyclopoida		
		Cyclops capillatus
Harpacticoida		
	Canthocamptidae	
CLADOCERA		
	Daphnidae	
		Daphnia
		Ceriodaphnia

- *Scapholeberis mucronata*
- *Scapholeberis rammneri*

Leptodoridae
- *Leptodora kindti*

Macrothricidae
- *Ilyocryptus spinifer*

Chydoridae
- *Acroperus harpae*
- *Alona costata*
- *Alona guttata*
- *Alonella excisa*
- *Camptocercus rectorostris*
- *Chydorus sphaericus*
- *Eurycercus lamellatus*
- *Pleuroxus denticulatus*
- *Pleuroxus procurvatus*
- *Graptoleberis testudinaria*

Sididae
- *Sida crystallina*

Polyphemidae
- *Polyphemus pediculus*

AMPHIPODA
- *Hyalella azteca*

INSECTA
DIPTERA

Chironomidae
- Tanypodinae
    - *Paramerina*
    - *Procladius*
    - *Thiennemannimyia*
- Chironominae
    - Tanytarsini
        - *Micropsectra*
        - *Cladotanytarsus*
        - *Paratanytarsus*
        - *Rheotanytarsus*
        - *Stempellina*
        - *Tanytarsus*
        - *Stempellinella*
    - Chironomini
        - *Chironomus*
        - *Demicryptochironomus*
        - *Paratendipes*
        - *Microtendipes*
        - *Paracladopelma*
        - *Stictochironomus*
        - *Phaenopsectra*
        - *Polypedilum (pentapedilum)*
- Orthocladiinae
    - *Corynoneura*
    - *Cardiocladius*
    - *Cricotopus*
    - *Epoicocladius*
    - *Orthocladius*
    - *Eukiefferiella*

			Heterotrissocladius
			Paracladius
			Psectrocladius
			Thienemanniella
		Diamesinae	
			Potthastia
	Podonomidae		
			Trichotanypus
	Ceratopogonidae		
			Bezzia
			Probezzia
	Muscidae		
			Limnophora
	Tabanidae		
			Tabanus
	Cecidomyidae		
	Empididae		
			Phyllodromia
	Phoridae		
			Megaselia
	Sciomyzidae		
	Dolichopodidae		
			Rhaphium
HYMENOPTERA			
	Chalcoidea		
	Formicidae		
	Tenthredinidae		
	Encyrtidae		
HOMOPTERA			
	Aphididae		
COLEOPTERA			
	Haliplidae		
			Haliplus
	Dytiscidae		
			Brachyvatus
			Hydroporus
			Oreodytes
	Curculionidae		
	Staphylinidae		
	Phalactidae		
	Gyrinidae		
			Gyrinus
LEPIDOPTERA			
EPHEMEROPTERA			
	Baetidae		
			Baetis tricaudatus
			Procloeon
	Heptageneiidae		
			Heptageneia
			Cinygmula
			Heptagenia solitaria
	Leptophlebiidae		
			Choroterpes albiannulata
			Paraleptophlebia bicornuta
			Paraleptophlebia temporalis

			Leptophlebia
		Ephemeridae	
			Ephemera simulans
			Hexagenia limbata
		Caenidae	
			Caenis simulans
		Ephemerellidae	
			Ephemerella inermis
		Tricorythidae	
			Tricorythodes minutus
		Ameletidae	
			Ameletus
PLECOPTERA			
		Chloroperlidae	
		Perlodidae	
			Suwallia
TRICHOPTERA			
		Hydroptilidae	
			Agraylea
		Lepidostomatidae	
			Hydroptila
			Lepidostoma
		Leptoceridae	
			Mystacides
			Nectopsyche
		Brachycentridae	
		Limnephilidae	
			Onocosmoecus
			Brachycentrus
HEMIPTERA			
		Corixidae	
			Corisella
THYSANOPTERA			
COLLEMBOLA			
		Hypogasturidae	
			Anurida
		Isotomidae	
			Isotoma
		Sminthuridae	
			Sminthurus
ODONATA			
	Anisoptera		
		Aeschnidae	
			Aeschna umbrata
		Coenagridae	
	Zygoptera		
			Enallagma sp.
			Enallagma cythigerum
MOLLUSCA			
	Gastropoda		
		Planorbidae	
			Gyraulus
		Lymnaeidae	
			Stagnicola
			Lymnaea
		Physidae	

		Physa
	Valvatidae	
		Valvata sincera sincera
Pelecypoda		
	Sphaeriidae	
		Sphaerium
		Pisidium

APPENDIX 2. SHUSWAP LAKE BENTHIC SAMPLES (1999-2001)

Table 1. Number of Non-Insecta Benthic Invertebrates from Shuswap Lake Foreshore in 1999

Location		12			17			18			16			13			15			6			14			10			5			9			4			2			1			7			8				
Date		July 28			July 28			July 29			July 29			July 29			July 29			July 29			July 29			July 30			July 30			July 30			July 30			July 30			July 30			July 30			Oct 04				
Replicate		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		
Benthos #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48		
Sample #		514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	Total	Sub
Species	Stage																																																		
COELENTERA																																																			
Hydra									1						1	1				2			1																											6	6
Turbellaria												11		24	1							1				2	3	11						1		4														58	58
Nematoda		1	3	1	70	50	50	21	2	71	298	74	188	72	40	41	1		1	13	1	96		1	4	51	82	43	18		3		5		20	24	55	76	31	19	180	120	94	56	128	17	162	91	443	2817	2817
Tardigrada											10				10								1							2	5					1				1				10		10	10			60	
Bryozoa						1																																												1	61
Oligochaeta	egg																									3																								3	
Oligochaeta	juv	1	4	4	100	90	60	120	60	90	150	60	60	90	160	90	2	14	9	180	50	150	9	37	32	100	60	20	47	29	130	50	50	65	70	92	40	180	30	5	70	50		100	70	70	566	464	1790	5770	
Naididae		20	18	34	50	27	7	7	25	68	19	26	25	9	7	4		1	5	32	11	30	1	2	3	5	10	30			5	1		1	3	1		7	4			7	1	34	24	15	14		9	602	
Chaetogaster		5	3	3	49	36	12	3	14	35	2	5	16	43	33	33			2	8	4	9	6	11	4	3	12		21	16	80	15	22	56	40	29	12	10	1	3	26	10		18	1	10		121	143	974	
Nais				2	32	17	8	11	19	27	21	158	55			2	1	1	1	31	10	3	1			2	1			1	2	2	4	8	7	7	1	58		3	5	5	1	20	198	130	12	1	28	896	
Stylaria lacustris				5	31	55	61	11	13	14	3		1		2	2				1		1				7	2	1			1	1	2	1				1	1	1		1			7	3				224	
Pristina foreli								7	4	4	46	63	50		1	1				37	60	23		2	4	3	13	21	9	13	16	14	46	90	5	3	2	93	10	5	90	50	3	1			11	4	39	843	
Slavinia appendiculata								1	1		3		1	4						4	1	2																								2	1			20	
Tubificidae												1																																			15	34	55	105	
Lumbriculidae				1																	4						1																							6	
Lumbricidae				1																					1																					1				3	
Enchytraeidae				2	1			10	2	4	5		1		1					3	8	6				3	11	60	7	2	1	1			1	6	2	10		1	1	12		22	3	7	12	2	29	236	9684
Hirudinea																																																		0	
Piscicola salmositica																					1																													1	1
Hydracarina				1	8	16	20	3	16	22				29	12	12		1		33	2	1		1		5	14	23				1	30	4	6		1	4	1			10							1	277	
Hydracarina #1	(parasitic)				10			10	10					10																																				40	317
Oribatidae												10									20			1		20				2					5	1	2		10		10			60	10	10				161	
Hydrozetes				1	11			10	10	20		10		20					1					3			10	2	1	1						1									10	10			1	122	283
Ostracoda									20	10																													5											35	
Candona				1				10						10						60	240	110				51	10	60												1						1	1	21	1	577	
Cyclocypris				1																																									1		1		6	9	
Cypria									20		10		1																														10							41	
Cypris								31		1				11						11	10						1								1				1									23		90	752
Calanoida	nauplius						10				20				10								1	4	1		10		3	4	1	10	40	10	20	5	6	20	15	1										191	
Calanoida	copepodite																							1																										1	
Cyclops scutifer																													1																					1	
Eucyclops agilis		1			6	34	28	45	8	45	163	63	236	42	32	16	1	3	5	27	50	7		20	6	2	21	60	9	12	30	5	8	8	5	13		245	65	23	90	10	4	3	23	39		42	63	1618	
Leptodiaptomus					1							1	2		10	1				10	1	1		1	3				131	113	135	5			15	10	8	1	12	4	10		1	10	2	1				489	
Epischura											1		1	2	1			1					37	9	16	4	3	1					1																	77	
Macrocyclops ater					3				20	33	7	1	3	3	2	5		6		18	15	10		1		4	1			1		4	1	4				1	1		5				1	3				153	
Cyclopoida	copepodite		2		170	71	140	240	315	312	165	92	208	111	218	152	1	18	12	134	210	128	5	96	17	102	131	350	26	33	35	70	165	70	40	20	12	610	83	17	90		80	141	258	202	11	267	169	5801	
Cyclopoida	nauplius				10					10			10		30	10		5	2	90	140	40		5		20	50	20	3			10	120	20		6	4	30	15	1	30	70	10		40				40	841	
Harpacticoida	copepodite																													3																				3	
Harpacticoida																													1																					1	
Harpacticoida	nauplius						20			40	20	40	190	20	20	20		2	4	20	20	40	3	8	3	10			2	2		60	60	25		3	2	230	45	14	110	70	10	10	10	30		60	20	1243	
Canthocamptidae					20		10												1	30	30	1							4	2	5					2					20	20				10		100	81	336	10755
Cladocera		1																																																1	
Daphnidae																																																		0	
Daphnia														1				1		2	1		1		3		1												1											11	
Ceriodaphnia																																									5		2							7	
Scapholeberis mucronata						10																				10												10	3	1				14	32	7				87	
Macrothricidae																																																		0	
Ilyocryptus spinifer																																		1																1	
Chydoridae								70	60	200	160	70	140	30	30	50	2			270	460	310	3	18	8	100	220	100	82	43	50	110	20	5	80	21	4	310	60	3		40		70	150	90		20	20	3679	
Acroperus harpae					11	42	20	71	16	212		10		13	31	14		1	1	295	80	74	1	20	1	53	81	50	1		1		110	40		1		6			15	10			33	1				1313	
Alona costata?1		2	1		50	10	30	20	22	2		80	11	10	32	10				56	10	102				14	32	20	1	1	1				10	1		8	6	1	53	11				12		20	1	640	
Alona sp. 2					20	10	70	10	50	171	141	40	100	10	10	40		6	4	160	260	190	1	4	4	140	120	80	46	75	100		10	15	35	15	5	100	30	1		20				20			60	2153	
Camptocercus rectirostris														21						30				3		3	21	20					217	165		1					1			25	82	32				623	
Chydorus sphaericus			1		40	70	70	93	104	96	131	90	190	100	21	101		3		257	600	121	3	10	5		60		16	7	5	25	60	25	3	2	2	51	16	7	40	20		31	483	55		100	60	3163	
Eurycercus lamellatus							1							2	7	6				10		10		1													1	2	1											41	
Pleuroxus denticulatus																								1		20				2									20		17	31	20							111	
Alonella																				30	190	230		4	1		100	60	19							9	3	23												669	
Pleuroxus procurvatus																																						20		1	10				20	1				52	
Sididae																																																		0	
Sida crystallina			12	15	45	53	69	9	49	46	5	2	4	15	36	75	1	5		284	83	67		11	3	41	109	3			1	298	243	761	7	1	4					1		15	67	16				2456	
Polyphemidae																																																		0	
Polyphemus pediculus																																												1	10	1				12	15019
Amphipoda																						5																												5	
Hyalella azteca					2	6	4	12	35	37		2	1	17	21	7					13					17	11	11				2							1					2	5	5			7	218	223
Gastropoda																						3		1																									1	5	
Stagnicola														1					1	1																														3	
Physa						1		3	1	4				1								1				1																								12	
Gyraulus																																																	1	1	21
Bivalve																																																		0	
Sphaerium																																																	1	1	1
Fish																																																		0	
Cottus asper	1																			1																														1	1
TOTAL		31	44	70	739	599	690	828	879	1564	1580	911	1494	721	779	693	9	68	49	2135	2585	1772	74	276	119	791	1201	1046	442	364	607	684	1214	1375	373	279	166	2106	470	113	878	568	236	643	1668	811	816	1370	3069	39999	39999

Table 2. Number of Benthic Insecta from Shuswap Lake Foreshore in 1999

Location		12			17			18			16			11			15			6			14			10			5			9			4			2			1			7			8			[illegible]	[illegible]
Date		July 28			July 28			July 29			July 29			July 29			July 29			July 29			July 29			July 30			July 30			July 30			July 30			July 30			July 30			July 30			Oct 04				
Replicate		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3		
Station #		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48		
Sample #		314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361		
Species	Stage																																																		
Insecta																																																			
Chironomidae	L	17	18	8	233	128	58	262	190	727	100	16	41	322	466	384	2	2	2	143	70	94		35	2	40	140	20	26		15	15	120	175	5	14	4	63	15	9		1		21	136	43	245	672	978	[illegible]	
Chironomidae	P															2																																				[illegible]	
Tanypodinae	L										10			25	67	6		1		2	1	5	1	2	1	23	2	1	5			1	5	1				5	2	7		1		29	12	15	1	1	7	[illegible]	
Paramerina	L			1										10	7	8				2	2	3				1	5	1			1	1	3	1	1												1				[illegible]	
Paramerina	P													3		1								1		2	1						1																				[illegible]	
Procladius	L							1																																								1		1	39	31	[illegible]	
Thienemannimyia	P				1																																																[illegible]	
Thienemannimyia	L	1	6	3	5	6	9	2	4	8				5	4	2	1			2	1	6		1	3	6	7	6		1								5			1		3		1				[illegible]	
Tanytarsini	L	5	10	7	55	31	23	40	40	98	22	11	61	126	251	152	1			156	50	130	1	3	1	93	98	20	17	5	12	18	46	17	12	6	2	120	7	16		34		10	68	120	257	606	1096	[illegible]	
Tanytarsinae	P																					1																												[illegible]	
Micropsectra	L			1	1		1	1	4	5				2	1				1	5	5	9				1	5	1				1						4			1	12		3	3	1				[illegible]	
Paratanytarsus	L		5	1	2				4	2	10	10	29	7	13	2				8	1	26						1	19	1	7				7	3	1	17		1	9	8		2	38	31	5	4	19	[illegible]	
Paratanytarsus	P											1																																						[illegible]	
Stempellina	P							1								1											1																									[illegible]	
Stempellina	L		1	1						1	3						1							2					4	1	1						1									1									[illegible]	
Tanytarsus	L	5	18	18	2	1	1	2	15	16	4	6	5	27	11	8				10	2	31				2	6	2				2		2	2		1	4	1	5		12		14	23	25	2		3	[illegible]	
Tanytarsus	P	1		2		2				1									3	3			1			1					1										1		1						[illegible]	
Stempellinella	P																																																	47	[illegible]	
Chironomini	L							22	4	1			10	45	12	30	1			2	1	5				25			5							9	5	6	2		1			3	3	12	287	286	430	[illegible]	
Chironomini	P																																																			[illegible]	
Chironomus	P																																											1	1							[illegible]	
Chironomus	L	1								1	1	1																														3	2		3	2	8				[illegible]	
Demicryptochironomus	L			1	2		3		2	1		2	1	7	5	4				6	1	4				3	1	1	2	3	3				4	2	2	1	1			1		3	1	2	16	15	31	[illegible]	
Demicryptochironomus	P																																																			[illegible]	
Paratendipes	P							1						1														1																							[illegible]	
Paratendipes	L				2	1		23	11	3				9		1				2		5					2	2																			1			26	[illegible]	
Phaenopsectra	L																					1				4																				4	7	5	6	5	8	[illegible]	
Polypedilum ([illegible])	L																																															279	63	164	[illegible]	
Polypedilum ([illegible])	L																													7	1																1	1		1	[illegible]	
Orthocladiinae	P																1															1																1		[illegible]	
Orthocladiinae	L		1	2	11	16	43	34	36	118	11	2	5	40	81	179				43	17	36	2	7		10	1		2		1	1	20	12	2	3		8	8		2	2		3	46	5	1	67	57	[illegible]	
Corynoneura	L	1	1	2	368	217	135	129	76	168	133	20	59	123	102	261	2			99	112	182		64	24	89	193	140	29	8	36	18	19	36	41	14	1	85	25	11	4	13		11	76	50			1	[illegible]	
Corynoneura	P				7	1		1		1										23	1							15							1								1	1								[illegible]	
Cricotopus	L																			1		5																														[illegible]	
Eukiefferiella	L																												2																						[illegible]	
Heterotrissocladius	L		1																		1	3																							1						[illegible]	
Orthocladius	L																																			1								1					4	1				[illegible]	
Paracladius	L				7	1		1		1							2																																			[illegible]	
Psectrocladius	P		1																																																[illegible]	
Psectrocladius	L			1	7	6	1	4	8	8		2	1	6	4	19				3									3	1	2	1	2	1												3					[illegible]	
Thienemanniella	L		1			7		1	1	4					11					23	12	78	16			1	10							5	1	1									1	22	8			1	[illegible]	
Diamesinae	L																																																			[illegible]	
Protanypus	L																																																4			[illegible]	
Diptera																				10																																	
Ceratopogonidae							10							20																												1	10						26	19	50	[illegible]	
Bezzia	L				1																											11				5	5	1	5			2								[illegible]	
Probezzia	L				1						1				1		1	1	1							1																						9	2	5	[illegible]	
Empididae	L									1																																				10		1				[illegible]	
Phylidorea	L																																					1	1	1	1								[illegible]	
Phoridae	L																																									1							[illegible]	
Megaselia	L																														1																		[illegible]	
Sciomyzidae	P													1																																					[illegible]	
Dolichopodidae	L																																																			[illegible]	
Rhagionidae	L																													1	1	1																		[illegible]	
Homoptera																																																			
Aphididae	A																																	1				2	1						4				1		[illegible]	
Coleoptera																																																			
Dytiscidae																																																			
Hydroporus	L	1		2		1					1			1												2	2	1																						[illegible]	
Hydroporus	A	1																																																	[illegible]	
Gyrinidae																																																			
Gyrinus	L				1																						1																						[illegible]	
Ephemeroptera	N		1			20	10		1						20										2		21				1	1	10					3	3	1				10		1				[illegible]	
Baetidae	N						10												1			10	12	2	2	12																								[illegible]	
Procloeon	N				6	6	1	1						2	5						1			10	5	5	10	25	2				7	14	15													1				[illegible]	
Heptageniidae	N																																																			[illegible]	
Heptagenia [illegible]	N					1																																												[illegible]	
Ephemeridae	N																																																			[illegible]	
Ephemera simulans	N																			1		1							1																				2	3	4	[illegible]	
Caenidae	N																																																			[illegible]	
Caenis simulans	N			3	2	7				1				1	1					4	1	1			1	6		8														6	7					1			1	[illegible]	
Plecoptera	N																																																				
Perlodidae	N					1																																												[illegible]	
Trichoptera	L				7		1		10					1	2							1	1						1																			20					[illegible]	
Hydroptilidae	L																																													4				2	[illegible]	
Hydroptila	L														7																																			[illegible]	
Leptoceridae	P				1																																														[illegible]	
Mystacides	L																										2																						[illegible]	
Brachycentridae	L																																																			[illegible]	
Brachycentrus	L																									1																							[illegible]	
Hemiptera	A	1																																								1							[illegible]	
Collembola																																																			
Hypogastruridae																																																			
Anurida																						1						10	1									1		5		2									[illegible]	
Odonata																																																			
Anisoptera	N					1																																												[illegible]	
Coenagrionidae																																																			
Enallagma cyathigerum	N									1																		1																						[illegible]	
TOTAL		34	64	35	600	442	326	546	477	1167	275	87	208	780	1090	1009	9	4	5	348	284	433	41	39	46	573	546	210	111	23	9	98	217	266	31	57	18	326	30	14	41	98	8	136	471	314	1142	1777	1842	[illegible]	[illegible]

Table 3. Number of Benthic Invertebrates from Shuswap Lake Foreshore in 2000

Location		12	12	12	12	12	12	12	11	11	11	12	12	12	11	11	11		
Date		July 31	July 31	July 31	July 31	July 31	July 31	July 31	Aug 01	Aug 01	Aug 01	July 31	July 31	July 31	Aug 01	Aug 01	Aug 01		
Sample No.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
ATS no.		1336	1337	1338	1339	1340	1341	1342	1343	1344	1345	1346	1347	1348	1349	1350	1351		
Substrate		cobble	cobble	cobble	cobble	cobble	sand	sand	sand	sand	cobble	water	water	water	water	water	water	Tota	Sub
Recovery Depth (cm)		70	77	68	68	62	69	60	40	31	46								
Species	Stage																		
Turbellaria						1												1	1
Nematoda		1	3		1	1		2	1		1							10	10
Tardigrada											1							1	1
Oligochaeta	egg	5		1														6	
Oligochaeta	juv	3			1			1			3							8	
Lumbriculidae			1		1	1		1										4	
Lumbricidae		1																1	19
Hirudinea																		0	
Piscicola salmositica	juv						10	5										15	
Piscicola salmositica		1	1	2		2	2		2	3	4							17	32
Hydracarina		19	10	26	15	28	7	9	4	6	22	1		1				148	148
Oribatidae		1		1		1	3	9		1			1		1			18	
Forellia		1																1	19
Ostracoda																		0	
Candona		1		2	1				1		1	1						7	
Cyclocypris		2		1	1		5	4			1							14	
Cypricercus elongata				1			2											3	24
Calanoida																		0	
Cyclops scutifer				2	3			1										6	
Eucyclops agilis		2		2	1													5	
Leptodiaptomus		5		1	5	1	3		7	2	1	5	4	1	7	12	10	64	
Epischura nevadensis				1			1											2	
Cyclopoida	cop	7	2	9	6	4	4	5	9	9	27	2	1	1	5			91	
Harpacticoida																		0	
Canthocamptidae			1															1	169
Cladocera																		0	
Daphnidae																		0	
Daphniasp.												2				1		3	
Scapholeberis mucronata				1					3	1	1				4	4		14	
Macrothricidae																		0	
Ilyocryptus spinifer			3	2	1													6	
Chydoridae																		0	
Acroperus harpae					1													1	
Alona (costata?)		5	2	1	1	1					1		1			1		13	
Chydorus sphaericus		1	2	7	2	1	2	1	1		1		1	1	1		1	23	
Graptoleberis testudinaria			1	1			1								1			4	
Sididae																		0	
Sida crystallina		38	26	141	116	98	8	7	34	3	46	8	3	4	8	1		541	604
Amphipoda																		0	
Hyalella azteca		3		1	1		1			1	3							10	10
Gastropoda	juv/dm	4		6	17	7	9	14	41		10							108	
Stagnicola		3	2	2	1			1										9	
Physa										1	1							2	
Gyraulus		7	1	2	14	12	24	48										108	227
																		0	
Insecta																		0	
Chironomidae	L*	2	4	5	4	3			1	2	1							22	
Chironomidae	P	1					1											2	
Tanypodinae	P						1											1	
Paramerina	L			2														2	
Thienemannimyia	L	10	4		8	2	6	2	1									33	
Tanytarsini	L*	6	16	4	13	2	3		3	2	16							67	
Micropsectra	L	6	3		6	2	1		1		7							26	
Paratanytarsus	L		1		2	1	1				3							8	
Rheotanytarsus	P										1							1	
Stempellina	L		1	1	4				7		9							22	
Stempellina	P			1					2		4							7	
Tanytarsus	P				1													1	
Tanytarsus	L				2						2							4	
Chironomini/	L*		1				2			1	5							9	
Chironomini	P									1								1	
Demicryptochironomus	L						1		1	2	1			1			1	7	
Microtendipes	L		1	1					2		11							15	
Phaenopsectra	L								1		1							2	
Orthocladiinae	L*	1			4				1	1	1							8	
Orthocladiinae	P				1	1												2	
Corynoneura	L	6	3	9		10	2	4	10	4	17			2				67	
Corynoneura	A	1							1									2	
Heterotrissocladius	L	1	2		2				2	2	4	1						14	
Orthocladius	L																	0	
Psectrocladius	L	1							1		2							4	
Thienemanniella	L		2		1	1					1							5	532
Diptera																		0	
Empididae	A	2																2	2
Coleoptera																		0	
Dytiscidae																		0	
Hydroporus	L									1								1	
Hydroporus	A			1						1	1							3	4
Ephemeroptera	N*			2		2	1		4		7							16	
Baetidae	N*			1	2	1			4	1	13							22	
Leptophlebiidae	N*	23	25	29	35	19	12	30	1									174	
Choroterpes albiannulata	N	19	11	27	27	29	23	4	4	3	5							152	
Paraleptophlebia bicornut	N	3	12	4	2		15	3										39	
Paraleptophlebia tempora	N	2	2	4	1													9	
Ephemeridae	N																	0	
Hexagenia limbata	N									1	2							3	
Caenidae	N																	0	
Caenis sp.	N						2			1	4							7	422
Trichoptera	L*	2	1	1	7	2	3	1			1		1					19	
Trichoptera	A																	0	
Leptoceridae	L*	1			1	1	1	2		1								7	
Mystacides	L		1						1		1							3	29
Thysanoptera	N						1											1	
Thysanoptera	A						1											1	2
Collembola																		0	
Isotoma		14	3	8														25	
Sminthurus		1																1	26
Odonata																		0	
Aeschnidae																		0	
Aeschna umbrata	N			4	1													5	
Zygoptera																		0	
Enallagma cythigerum	N																	0	5
		212	148	317	313	234	159	154	151	51	246	20	12	11	27	19	12	2086	2086

Table 4. Number of Non-Insecta Benthic Invertebrates Shuswap Lake 2001

Location Code Name		7	7	7	7	7	7	13	13	13	13	13	13	14	14	14	14	14	14	10	10	10	2	2	2	3	3	3	3	3	3	7	7	7	7	7	7	2		
Date		May 10 day			May 10 night			June 7 day			June 7 night			June 8 night			June 8 day			June 19 day		June 20	July 1 day			July 31 night			July31 day			Aug 27 night			Aug 28 day			Apr 26 day		
Replicate No.		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
Depth (cm)		10	14	27	N/A	N/A	N/A	20	21	19	20	21	19	21	19	19	20	22	18	24	21	17	15	19	15	16	10	12	15	16	14	14	19	20	19	17	17	20		
Volume (mL)		30	30	500	150	150	140	5	5	5	10	5	5	1	1	1	1	1	1	115	30	35	15	10	7	1	1	1	25	10	10	140	160	175	150	250	275	100		
Sample No.		30227	30228	30229	30230	30231	30232	30233	30234	30235	30236	30237	30238	30239	30240	30241	30242	30243	30244	30245	30246	30247	30248	30249	30250	30251	30252	30253	30254	30255	30256	30257	30258	30259	30260	30261	30262	30263	Total	Sub
Species/Group	Stage																																							
COELENTERATA																																								
Hydra												3	1							5		20																	29	29
TURBELLARIA														4	11	20		1		20	6														10				72	72
NEMATODA		1060	1600	970	1260	320	600	29	3	9	8	6	7	3		2	2	5		15		15	12	115	15	3	2	1	3	2	1	100	250	170	160	120	120	120	7108	7108
TARDIGRADA																							2															10	12	12
OLIGOCHAETA																																							0	
Enchytraeidae		30		30	30		10	1	9	9	2	2	3				1			135	150	40	1			1	1					3	100	10	50	20	60	30	728	
Naididae	juv	50	80	120	280	130	50	2	6		1						1			60	50	40	255	470	370	36	11	2	4	4	8	80	160	80	70	80	100	110	2710	
Chaetogaster								1					1	3		1		2		50	25	35	170	100	120	22	13	4	2	6	3	10	20			50	80	80	798	
Pristina foreli																				30	30		220	225	65		1					40	10		20	10	120	30	801	
Stylaria lacustris																										2													2	
Vejdovskyella																										1													1	
Tubificidae	juv																			7	5											60	80	160	60	120	120	140	752	
Lumbriculidae				10	1	3	2													1	1					1												10	29	
Lumbricidae						1																																	1	5822
Hirudinea																																							0	
Dina parva																																						1	1	
Helobdella stagnalis																																1	3	1	3				8	9
Hydracarina	A	9	16	40	150	120	500	11		3	8	7	9	1	6	2	2	2	2	40	3	20	3	1		4			1	1		3		10	40		40	20	1074	
Frontipoda	A																	1		5																			6	
Torrenticola	A												1																										1	1081
Oribatidae	A			20	50	10		1	2		1	2	3	2	3		2	2	2	10	15	5		2		2							40	20	10		80		284	284
OSTRACODA	juv																				5	10																	15	
Candona		30	50	380	10	20		2	1											20	30	10					1						10	10	40	30	80		724	
Cyclocypris				400																	5												10		1	40	20		476	
Limnocythere				100	20	3																							1										124	
Cypria		40	180	500	3500	2010	7200	31	1		7			2			1																					620	14092	
Cypris		1	20	270	960	600	1600	14	2	2										10		10											60	80	40	10		140	3819	19250
COPEPODA																																							0	
Cyclopoida		3	2	10	110	30	150	11	4	13	12	14	13	17	30	40	28	25	12	15	10	35	25	110	60	6	7	7	2	2	2	50	40	200	50	70	200	150	1565	
Cyclops capillatus																																30							30	
Harpacticoida																																							0	
Canthocamptidae				10																	5	5			10	1	1	1		1			10	20	20	10	40		134	1729
CLADOCERA																																							0	
Daphnidae																																							0	
Scapholeberis rammneri		430	140					2	3	1								1						10									10			10		200	807	
Leptodoridae																																							0	
Leptodora kindti																						2						1											3	
Chydoridae																																							0	
Acroperus harpae								10	1	8	11	18	36	275	165	245	40	32	33		10	5			15								10	1	20	10	40	10	995	
Alona costata																										4	1		1		1					20			27	
Alonella excisa							10										1	5	2		5		235	270	180	15	2		1	1		50	90	60	310	500	320	10	2067	
Alona guttata																				5	5											40							50	
Chydorus sphaericus					20	10	10	5	4	3	2	4	9	20	3	6	13	32	9			5	2	5	30		1	1	4		1	600	920	380	1310	1300	2000		6769	
Sididae																																							0	
Sida crystallina		1	30					68	23	29	72	146	97	27	13	9	14	14	14	70	70	30		5	5	19	22	20	2			20	20	10			20		870	
Polyphemidae																																							0	
Polyphemus pediculus																		1																					1	11589
AMPHIPODA																																							0	
Hyalella azteca		3	8	10	58	90	100	2		2		2	2							22	8	15				4	1	3	2		1	70	100	70	30	50	100	230	983	983
Gastropoda	juv							1																									10						11	
Lymnaea							1																													1			2	
Gyraulus					2	1	1							4	2	4	1	2	2	5																		1	25	
Lymneidae				1																																			1	
Planorbidae		2																																					2	
Valvata sincera sincera																													1										1	42
Bivalve																																							0	
Sphaeriidae	juv	8			1		1																									130	20	40			3		203	
Sphaerium																																	1	1					2	
Pisidium					1																											1				1	1		4	209
FISH																																							0	
Cottus asper	juv																												1			1							2	2
TOTAL		1667	2126	2871	6453	3348	10235	191	59	79	124	204	182	358	233	329	106	125	76	525	435	302	925	1313	870	121	64	40	25	17	17	1289	1974	1323	2244	2452	3604	1912	48221	

Table 5. Number of Benthic Insecta from Shuswap Lake Foreshore in 2001 Method Benthic Pump

Location Code Name		7	7	7	7	7	7	13	13	13	13	13	13	14	14	14	14	14	14	10	10	10	2	2	2	3	3	3	3	3	3	7	7	7	7	7	7	2		
Date		May 10 day			May 10 night			June 7 day			June 7 night			June 8 night			June 8 day			June 19 day		June 20	July 1 day			July 31 night			July31 day			Aug 27 night			Aug 28 day			Apr 26 day		
Replicate No.		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
Depth (cm)		10	14	27	N/A	N/A	N/A	20	21	19	20	21	19	21	19	19	20	22	18	24	21	17	15	19	15	16	10	12	15	16	14	14	19	20	19	17	17	20		
Volume (mL)		30	30	500	150	150	140	5	5	5	10	5	5	1	1	1	1	1	1	115	30	35	15	10	7	1	1	1	25	10	10	140	160	175	150	250	275	100		
Sample No.		30227	30228	30229	30230	30231	30232	30233	30234	30235	30236	30237	30238	30239	30240	30241	30242	30243	30244	30245	30246	30247	30248	30249	30250	30251	30252	30253	30254	30255	30256	30257	30258	30259	30260	30261	30262	30263	Total	Sub
Species/Group	Stage																																							
Chironomidae	P	3										1														1	1												6	
Chironomidae	L*															1								10	5														16	
Tanypodinae	L*																			5																			5	
Procladius	L																							1															1	
Thienemannimyia	L							1	2				1							5							1											1	11	
Tanytarsini	L*	13	60	100	240	120	160													10				4	5	1	3		1			20	20	20	30	20	40	250	1117	
Cladotanytarsus	L																									1	1	1				8		4	2		40	10	67	
Cladotanytarsus	P																																				1		1	
Stempellina	L																										1												1	
Tanytarsus	L	1	3			2	5			2											1	1	1											1				20	37	
Chironomini	L*	5		60	6	1	2				1	1	3	1							10			4									10			10			114	
Demicryptochironomus	L					1																	1									1	1	1	1	1			7	
Microtendipes	L			40	3	1	6																																50	
Paracladopelma	L																							22	3	1	2			1								20	49	
Paracladopelma	P																							1															1	
Stictochironomus	L	13	9	20	7	5	2																1	1		1						150	70	140	18	60	7	70	574	
Stictochironomus	P																																	1					1	
Orthocladiinae	L*	8	30	50	30	20	2				3	5	5	1						5	15	3	2	5	2	3	2						30	20	10	10	20	20	301	
Orthocladiinae	P																																		2				2	
Corynoneura	L				1				1			2	2		1		2	1		10	30	1	2		1	6	3	5	10	6	3	50	30	5	50	30	40		292	
Corynoneura	P																														1			1	1				3	
Epoicocladius	L																				1																		1	
Cardiocladius	L																			1													5						6	
Orthocladius	L				5	2															1		1									2	7	4					22	
Eukiefferiella	L																			1																			1	
Paracladius	L																															1							1	
Psectrocladius	L																						1											1					2	
Thienemanniella	L																										2	1				20	90	8	30	50	100		301	
Diamesinae																																							0	
Potthastia	L					1																	2									1	10						14	3004
DIPTERA	L			10																	1																		11	
Ceratopogonidae																																							0	
Bezzia	L												1													1													2	
Probezzia	L							9			1		2		1					75	80	15	1		1					1	1	3			1				191	
Muscidae																																							0	
Limnophora	L					1																																	1	
Tabanidae																																							0	
Tabanus	L																																			1			1	
Cecidomyidae	A	1																																					1	
Empididae	L*																																			10			10	
Podonomidae																																							0	
Trichotanypus	L																					1																	1	
Dolichopodidae	A																							1															1	
Rhaphium	L																						2	5															7	226
HYMENOPTERA																																							0	
Chalcoidea	A																					1													20	2	1		24	
Formicidae	A																					1																	1	
Tenthredinidae	A								1							1																							2	27
Aphididae	A									1	1	1											2	2												1	20		28	28
COLEOPTERA																																							0	
Haliplidae																																							0	
Haliplus	L						1																																1	
Dytiscidae																																							0	
Brachyvatus	A				1	4	18					2	2													1													28	
Hydroporus	A		1		2	7	27														2																		39	
Hydroporus	L																			15	1	5																	21	
Oreodytes	L																												1										1	
Curculionidae	A																					1																	1	
Staphylinidae	A							1	1											1							1												4	
Phalacridae	L																																				1		1	96
LEPIDOPTERA	L																							1															1	1
TOTAL		44	103	280	295	165	223	11	5	3	6	12	16	2	2	2	2	1	0	128	142	29	16	57	17	16	17	7	12	8	5	256	273	206	165	195	270	391	3382	

Table 5. continued

Location Code Name		7	7	7	7	7	7	13	13	13	13	13	13	14	14	14	14	14	14	10	10	10	2	2	2	3	3	3	3	3	3	7	7	7	7	7	7	2		
Date		May 10 day			May 10 night			June 7 day			June 7 night			June 8 night			June 8 day			June 19 day		June 20	July 1 day			July 31 night			July31 day			Aug 27 night			Aug 28 day			Apr 26 day		
Replicate No.		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
Depth (cm)		10	14	27	N/A	N/A	N/A	20	21	19	20	21	19	21	19	19	20	22	18	24	21	17	15	19	15	16	10	12	15	16	14	14	19	20	19	17	17	20		
Volume (mL)		30	30	500	150	150	140	5	5	5	10	5	5	1	1	1	1	1	1	115	30	35	15	10	7	1	1	1	25	10	10	140	160	175	150	230	275	100		
Sample No.		30227	30228	30229	30230	30231	30232	30233	30234	30235	30236	30237	30238	30239	30240	30241	30242	30243	30244	30245	30246	30247	30248	30249	30250	30251	30252	30253	30254	30255	30256	30257	30258	30259	30260	30261	30262	30263	Total	Sub
Species/Group	Stage																																							
EPHEMEROPTERA	N*		1								5	3	1	1			10	5		10	10					2	1								20				69	
Thysanoptera	A	1												1									1	2															5	
Baetidae								11		6	6	6	4	6	3	3	3	2	2	80	60	155				14	13	3	1	1	2	12	1	30	1	20	20	130	599	
Baetis tricaudatus	N																					2												1				1	4	
Heptageniidae	N*							3	3	2		1	3	8	7	2	4	11	6	50	115	75																	290	
Cinygmula	N																				10																		10	
Heptagenia	N																				3																		3	
Leptophlebiidae																																		21					21	
Leptophlebia	N				1	1	3	1																														5	11	
Ephemeridae																																							0	
Ephemera simulans	N																				2					2						1	10	4	4	1	3		27	
Caenidae																																							0	
Caenis simulans	N							3	2	3	3	5	4	3	2	4	4	11	3	1		6																	58	
Ephemerellidae																																							0	
Ephemerella inermis	N																	1																					1	
Tricorythidae																																							0	
Tricorythodes minutus	N																															3		3			2		8	
Ameletidae																																							0	
Ameletus	N	12	12	10	64	50	26	3	1		1		3	1		1		1			2			1															188	1294
PLECOPTERA																																							0	
Suwallia	N																				1																		1	1
TRICHOPTERA	L*																												1										1	
Ecnomidae	A																																				1		1	
Hydroptilidae	L*																																		10	10	20		40	
Agraylea	P					1																																	1	
Lepidostomatidae																																							0	
Lepidostoma	L						1																																1	
Leptoceridae	L*	1																														4	70	5	3	1	20	10	114	
Mystacides	L	2				10	18																			1												3	34	
Nectopsyche	L					2																										11	60	15	2	9	9	3	111	
Limnephilidae																																							0	
Onocosmoecus	L					3	1																																8	311
HEMIPTERA	N																						1		1											1			3	
Corixidae	N*																									4	1	2						1		1	1		10	
Corisella	A	3	1		2	8	31															1														1		9	56	69
THYSANOPTERA	N														1								1		1														3	3
COLLEMBOLA																																							0	
Sminthurus	A			10										2																									12	
Isotomidae			1		1											1																							3	15
ODONATA																																							0	
Anisoptera	N*																			5																			5	
Enallagma	N	1			1																	1																1	4	9
TOTAL		64	118	300	364	242	305	34	11	14	21	27	31	24	15	13	23	32	17	274	345	269	19	60	19	39	34	16	14	9	7	287	414	286	305	239	346	553	5084	

Table 6. Weight (mg) of Benthic Insecta from Shuswap Lake Foreshore in 2001

Location	7	7	7	7	7	7	13	13	13	13	13	13	14	14	14	14	14	14	10	10	10	2	2	2	3	3	3	3	3	3	7	7	7	7	7	7	2		
Date	May 10 day			May 10 night			June 7 day			June 7 night			June 8 night			June 8 day			June 19 day		June 20	July 1 day			July 31 night			July31 day			Aug 27 night			Aug 28 day			Apr 26 day		
Replicate No.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
Depth (cm)	10	14	27	N/A	N/A	N/A	20	21	19	20	21	19	21	19	19	20	22	18	24	21	17	15	19	15	16	10	12	15	16	14	14	19	20	19	17	17	N/A		
Volume (mL)	30	30	500	150	150	140	5	5	5	10	5	5	1	1	1	1	1	1	115	30	35	15	10	7	1	1	1	25	10	10	140	160	175	150	250	275	100		
Sample No.	30227	30228	30229	30230	30231	30232	30233	30234	30235	30236	30237	30238	30239	30240	30241	30242	30243	30244	30245	30246	30247	30248	30249	30250	30251	30252	30253	30254	30255	30256	30257	30258	30259	30260	30261	30262	30263		
Family/Group																																						Total	Sub-Tot
Chironomidae	1										0.5												0.1	0.5	0.5	0.01												2.6	
Tanypodinae							0.1	0.1				0.1							5.5				0.5			0.2											0.5	7.0	
Tanytarsini	1	6.5	10	24	12	0.5			0.2										0.1	0.1	0.5	0.5	0.4	0.1	0.5	0.5	0.2	0.01			4	2	1	1		2	10	77.1	
Chironomini	15	12	25	12	7	4				0.1	0.1	0.3	0.1							0.1		1	7	1	0.5	0.5			0.2		50	21	7	8	20	40	80	311.9	
Orthocladiinae	1	3	5	5	3	0.2		0.01		0.3	0.4	0.7	0.1	0.1		0.2	0.1		2	1	0.1	1	0.5	0.3	0.5	0.5	0.3	0.5	0.3	0.4	7	14	2	5	5	8	2	69.5	
Diamesinae					0.5																	0.1									0.1	1						1.7	
Podonomidae																					0.5																	0.5	470.3
DIPTERA	0.2		5		1					0.5		1		0.5					50	50	4	0.5	8	0.5	0.1				0.5	0.7	0.6			0.5	11.5			135.1	135.1
HYMENOPTERA							6	0.01							0.01						2													2	2	2		14.0	14.0
COLEOPTERA																																						0.0	
Curculionidae																					2																	2.0	
Dytiscidae		6		22	73	7					7	8							2	8	0.5				4			0.2										137.7	
Haliplidae																																						0.0	
Phalactidae																																				0.1		0.1	
Staphylinidae							0.1	5											0.5							0.2												5.8	145.6
LEPIDOPTERA																							0.2															0.2	0.2
EPHEMEROPTERA		0.1								0.5	0.3	0.05	0.01			0.1	0.1		0.1						0.1	0.01								0.2				1.6	
Ameletidae	2	3	2	14.5	12.5	8	0.1	0.05		0.1		0.3	0.1		0.1		0.1			1			0.2															44.0	
Baetidae							0.5		0.3	0.6	0.6	0.4	0.3	0.3	0.2	0.1	0.1	0.1	8	5	20				0.7	0.3	0.5	0.1	0.01	0.02	0.2	0.1	4	0.2	1	1	2	46.6	
Caenidae							0.5	0.2	0.3	1	1	1	1	0.5	1	1	3	1	0.5	0.5	2																	14.5	
Ephemerellidae																	7			9																		16.0	
Ephemeridae																				56					1						3	44	22	12	1	23		162.0	
Heptageneiidae							0.1	0.1	0.01		0.1	0.3	0.4	0.7	0.1	0.2	0.5	0.3	5	17	10																	34.8	
Leptophlebiidae				14	13	44	10																										2				53	136.0	
Tricorhythidae																															10		9			8		27.0	482.6
PLECOPTERA																																						0.0	
Chloroperlidae																				6																		6.0	6.0
TRICHOPTERA																												0.5										0.5	
Hydroptilidae					0.5																													1	1	0.5		3.0	
Lepidostomatidae						5																																5.0	
Leptoceridae	2				40	21																			0.1						36	120	40	4	29	20	28	340.1	
Limnephilidae					105	81																																186.0	534.6
HEMIPTERA																																			0.5			0.5	
Aphididae etc.									0.1	0.1	0.01											0.3	0.2	0.5											0.2	2		3.4	
Corixidae	20	5		16	62	232															7				12	0.5	6						6		9	5	69	449.5	453.4
THYSANOPTERA	0.1												0.1	0.01								0.2	0.2	0.05														0.7	0.7
COLLEMBOLA		0.5	0.5	0.2									0.02		0.1																							1.3	1.3
ODONATA	4			4															1		1																8	18.0	18.0
TOTAL	46.3	36.1	47.5	111.7	329.5	402.7	17.4	5.5	0.9	3.2	10.0	12.2	2.1	2.1	1.5	1.6	10.9	1.4	74.7	153.7	49.6	3.6	17.3	3.0	20.0	2.7	7.0	1.3	1.0	1.1	110.9	202.1	93.0	33.9	80.2	111.6	252.5	2261.8	2261.8