The Freshwater Macroinvertebrate Species Composition of Big Spring Creek, Calvert Island BC

By

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At

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Abstract:

Big Spring Creek is a salmon-bearing stream on Calvert Island at the edge of the Great Bear Rainforest region on British Columbia's central coast. This study investigated the freshwater macroinvertebrate community composition of two study reaches based on distance away from the lake outflows at the head of each reach. In conjunction with macroinvertebrate diversity, water quality parameters including pH, temperature, specific conductance, and dissolved oxygen were measured. The results of our data analyses show that there is a significant difference in macroinvertebrate community structure between our two study reaches. However, macroinvertebrate community structure changed according to distance from lake outlet only in one of our study reaches (the lowest reach near the mouth of the creek). The differences in community composition between the two reaches may be attributable to reach scale differences in pH, specific conductance, temperature, or habitat. The changes in community composition according to distance from the lake outlet in the lower reach (but not in the upper) may be related to sub-reach scale temperature trends.

Keywords: benthic, aquatic, freshwater macroinvertebrate, community structure, biodiversity, lake outflow, creek, water quality

1. Introduction

Waterways such as Big Spring Creek are the site of transition between marine, freshwater, and terrestrial ecosystems, where energy and materials among these different ecosystems can cycle through. Big Spring Creek is a salmon-bearing body of water, with marine nutrient input coming in the form of spawning adult Coho (*Oncorhynchus kisutch*) whose bodies provide nutrients for terrestrial predators and scavengers. Salmon also leave behind nutrients in both terrestrial and freshwater ecosystems for plants (Christie and Reimchen, 2009). These plants can provide shelter and sustenance for macroinvertebrates, and in turn, the macroinvertebrates provide the salmon and other fish, such as sculpins, in Big Spring Creek with fodder (Krieger, 1992). The macroinvertebrates also provide nutrients for passerine birds (Krieger, 1992) and in their adult stages pollinate plants (Adams, 2004), contributing once again to diversity across freshwater and terrestrial ecosystems. The healthy functioning of macroinvertebrate communities

within Big Spring Creek contributes to the overall functioning and diversity of nearby terrestrial ecosystems.

Considering the important roles played by macroinvertebrates in cycling energy and materials, and providing a food source for fish and birds, it is worthwhile to study their community composition as a means to understanding the diversity of freshwater ecosystems on Calvert Island. Freshwater macroinvertebrates are often studied in creeks and streams to measure the level of pollution in degraded freshwater habitats, based on the known habitat preferences of macroinvertebrates collected within the particular body of water (Water Watch Biological Monitoring Procedures). Big Spring Creek and Calvert Island are located at the southern edge of the Great Bear Rainforest, home to some of the last remaining intact temperate rainforest of British Columbia (Howells, 2013). As such, the creek remains currently unpolluted and undisturbed. With natural stochastic events, climate change and perhaps other forms of human influence, the creek will experience disturbance in the future. Therefore, it is useful to document and understand the creek, its macroinvertebrate community composition, and water quality components as they are in their current undisturbed state to create a baseline to study future changes and perturbation effects on this system, and to understand the system better as a whole.

Our study investigated the freshwater macroinvertebrate distribution and community structure in a previously unstudied, salmon-bearing creek within the Hakai Luxvbalis Conservancy Area, in watershed 708, Calvert Island, British Columbia. Our goal was to identify patterns in the distribution of aquatic macroinvertebrate diversity between the first two reaches of Big Spring Creek and along the gradient of distance away from the lakes at the top of each of the reaches. We also sought to examine the relationship between macroinvertebrate diversity and fluctuations in water quality throughout the reaches. Embedded within these goals is the desire to

establish a baseline of data on the macroinvertebrate species present and the water quality conditions within the system. Along with this, we intended to create a resource to inform and inspire future more in depth studies of Big Spring Creek and the macroinvertebrate communities within it. Our guiding hypotheses were: (a) that the freshwater macroinvertebrate community composition in Reach 1 would be different from that in Reach 2; and (b) that the macroinvertebrate community composition would be different between distance groups (moving away from lake outlets) within each of the reaches.

2. Study Area

The study area we chose is Big Spring Creek, approximately 4km from the Hakai Beach Institute on Calvert Island, BC. The Big Spring Creek watershed is 780 hectares and drains Hakai watershed number 708. According to local knowledge, adult salmon have been observed staging at the mouth of the creek during the spawning season. University of Northern British Columbia Professor Farid Rahemtullo also informed us that there are remnants of fish traps created by local First Nations by rearranging boulders near the mouth of Big Spring Creek and the outflow of its first lake. During a reconnaissance visit to the site, we observed and photographed multiple juvenile Coho salmon (*Oncorhynchus kisutch*) and two sculpins (*Cottus sp.*) within the lower reach of the creek (Figures 1 and 2). Macroinvertebrates are a key food source for fish in running-water (Wallace and Webster, 1996). The presence of salmon led us to consider the macroinvertebrates that the fish feed on and the composition of those macroinvertebrate communities.

Figure 1. Juvenile Coho Salmon found in Big Spring Creek. **Figure 2.** Sculpin collected in Big Spring Creek.

The lower reach is just over 120m and is bounded at the upstream end by a lake. The second reach is approximately another 120 m long and bounded at the upstream end by another lake (Figure 3). At the top of the second reach, just below the second lake, there is also a small (<1m high) beaver dam across its width. Our study area is bounded by the mouth of Big Spring Creek at its northern terminus (51º 38' 57.2" N, 128º 04' 07.92"W) and the beaver dam at its southern terminus (51º 38' 44.11"N, 128º 04' 00.88"W). We chose this creek as our site because of its accessibility from the Hakai Beach Institute and because its species composition had not yet been studied. We also chose this site because we hoped that our project could serve as a useful contribution to knowledge of the local area and future research. Hakai staff (Ian Giesbrecht) had also expressed a common interest with us in testing the creek's conductivity and other water quality parameters. Although Big Spring Creek has several reaches further up the watershed, before reaching the headwaters, we chose to focus our study on the first two reaches due to the inaccessibility of upper reaches and because of the unique lake features at the upstream end of the first two reaches. We labelled the lowest reach "Reach 1" (between Lake 1 and the creek mouth) and the upper reach "Reach 2" (between Lake 1 and the beaver dam at

Lake 2) (Figure 3). Lakes affect various components of macroinvertebrate habitat including temperature, water flow, primary productivity, and nutrient cycling (Gustafson, 2008). Therefore, these locations offered us an opportunity to measure and compare the macroinvertebrate community structure and water quality between two different reaches within our limited time period.

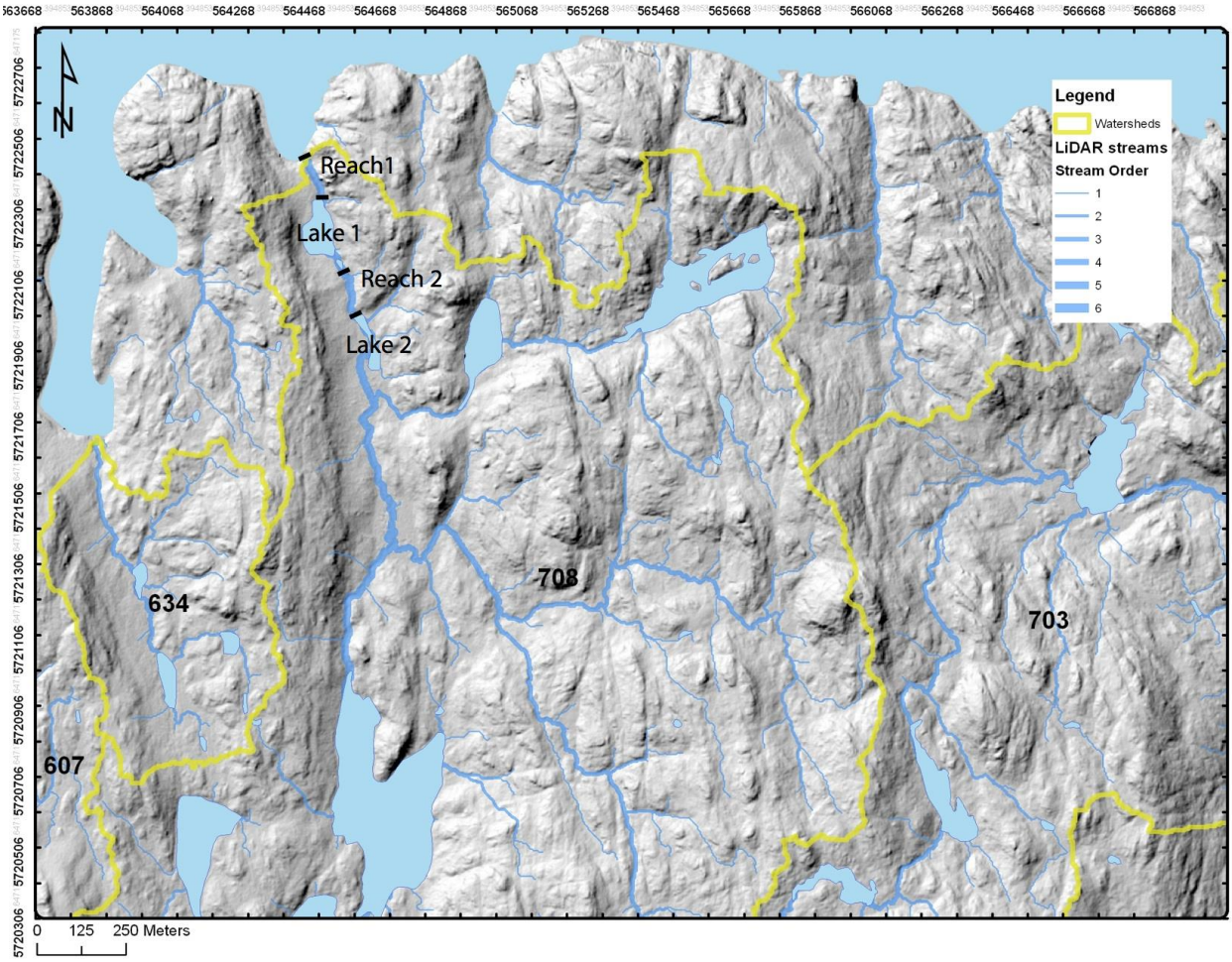

Figure 3. LiDAR map displaying some of Calvert Island's watersheds including 708, the watershed containing Big Spring Creek. This map shows Reach 1 between the first two black lines along Big Spring Creek and Reach 2 between the second pair of black lines.

3. Methods

3.1 Field Methods

Twenty-four transects were established along two reaches of Big Spring Creek, with 12 transects per each reach. Using the Hakai GIS we determined that the first reach from the mouth of the creek to the outfall of the first lake was approximately 120 meters, and the second reach from the other end of the same lake to the next lake's outfall was a little over 120 meters as well. Due to the nearly even match of the two reach's lengths, sampling transects were marked at 10-meter intervals using flagging tape and a tape measure along the shores of both reaches. While marking off the sample transects, we also measured the width of the creek at each of the 24 transects. The decision to sample from the first two reaches was based on the time constraints for the course and the time required for sampling and processing samples.

At each of the 24 transects, we measured water quality parameters using the YSI meter. Water quality and water depth were measured near the left bank, in the thalweg, and near the right bank along each of the 24 transects at 10m intervals. Water quality parameters included temperature, pH, dissolved oxygen, and specific conductance. Along with measuring water quality, depth, and width at each of the 24 transects, we took pictures of the creek at each of the 10-meter markers to document the variation in habitat characteristics along the creek (Appendix III).

Macroinvertebrate sampling was conducted based on Barbour et al.'s (1999) Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers and tailored to the scope of our project. One macroinvertebrate sample was collected along each of the 24 ten meter transects. Based on Barbour et al.'s (1999) protocols, which suggest dividing samples between representative areas of habitat within the creek, we chose to do selective rather than random sampling. The locations along each transect from which samples were taken were chosen based on the overall existing habitat structure within each reach to get samples representing the

proportion of various habitats within each reach. For example, Reach 1 was characterized by approximately 70% cobble to large boulder habitat, 10% woody debris and logs, 10% overhanging and submerged banks, and 10% smaller cobble and gravel. Using this assessment of the habitat composition of the creek, we divided our 12 samples accordingly to ensure the ratio of habitat variation matched the habitat in points of the creek sampled. This method is called the multiple habitat approach and was developed to collect samples that are more representative of habitat across varying stream types (Blocksom, 2008). In our case, we used this method to collect samples representative of the different habitat across the two reaches at every 10-meter transect.

To collect the macroinvertebrate samples we used a dip net, and to transport and store the samples we used yogurt containers and whirl packs. Barbour et al.'s (1999) protocol calls for 20 jabs or kicks per 100 meter reach of stream. A jab refers to thrusting the net with force into the selected habitat along a 0.5 m straight line (Barbour et al., 1999). The kick method involves a sampler using the toe or heel of their shoe to disturb the top layer of cobble or gravel and to scrape the substrate beneath within 1 meter squared in front of a net (Barbour et al., 1999). We modified this to one jab, kick, or scrub at each 10-meter transect for a total of 24 macroinvertebrate samples to suit our time constraints. Where substrate was too large for a kick or jab, we employed a "scrub" which involved scrubbing and flipping an area of rocks and other surfaces within an area of 0.5 meters squared in front of the dip net to disturb the substrate and loosen any macroinvertebrates that might be in the area. We decided on this method to account for the profusion of large cobble and boulders within the two reaches, particularly Reach 1, that could not be properly sampled using the standard jab and kick methods. By choosing to do one jab, kick, or scrub per sample we also sought to keep an equal sampling effort throughout both

reaches. Li (2001) indicates that species richness is highly dependent on sampling effort and that without maintaining a standard sampling effort throughout a stream survey, the number of species collected will fluctuate depending on the size of area sampled and yield a greater amount of species in larger, more heavily sampled transects. Thus, to avoid a bias in sampling of certain areas of the creek, we sought to normalize the sampling effort.

The samples were labeled with numbers based on the number of their corresponding 10 m sampling transect. Samples 1 through 5, and 7 through 10 were collected from Reach 1 on June 23rd. Samples 6, 11, and 12 from Reach 1 were collected on June 26th along with samples 1 through 12 from Reach 2.

3.2 Lab Methods

After collection of samples from Big Spring Creek, the samples were transported to the lab for examination, identification of species, and determination of the numbers of each species. Files from The Xerces Society for Invertebrate Conservation's Guide to Pacific Northwest Macroinvertebrate Monitoring and Identification **(**Adams, 2004) supplied by TA Martina Beck were key resources for learning to identify freshwater macroinvertebrates. Each sample was divided up into petri dishes and examined under a microscope to distinguish living specimens from debris. After separating specimens from debris, they were then identified by comparing features to those listed in the keys contained in the Xerces Guide (Adams, 2004) and other online macroinvertebrate species identification resources (Water Watch Biological Monitoring Procedures; Iowa State University BugGuide) (See Appendix III). Due to the difficulty of identifying macroinvertebrate, species to a finer scale without stronger microscopes it was decided to identify species down to family. Barbour et al. (1999) also suggest identifying to family or genus and species if possible, while keeping consistent throughout. It was also decided

to prevent counting the same individual twice by recording only specimens with intact heads and enough intact body to determine other necessary identifying features.

After samples were identified, specimens were placed in a petri dish, labelled with the sample number, and covered with alcohol preservative. We preserved these specimens to enable us and others to look back at the species samples collected. Simuliidae species were not separated into petri dishes and preserved with the other species because of the profusion of Simuliidae specimens encountered, the time involved in picking out each of these hundreds of individuals, and the relative ease of identifying members of that particular family.

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counting the same individual twice that only specimens with intact heads and bodies with other necessary identifying features intact would be recorded.

After species were identified, specimens were placed in a petri dish, labeled with the sample number, and covered with alcohol preservative. We preserved these specimens to enable future reference. Simuliidae species were not separated into petri dishes and preserved with the other species because of the profusion of Simuliidae specimens encountered, the time involved in picking out each of these hundreds of individuals, and the relative ease of identifying members of that particular family.

3.3 Analytical Methods

In order to answer our questions regarding macroinvertebrate community composition, we formulated the following hypotheses: (a) that the freshwater macroinvertebrate community composition in Reach 1 would be different from that in Reach 2; and (b) that the macroinvertebrate community composition would be different between distance groups within each of the reaches. In order to test our first hypothesis (a) we compared the community structure between Reach 1 and Reach by analyzing the 12 samples collected within each reach at 10 m transect intervals (Figure 4). In order to test our second hypothesis (b) we created 4 distance groups within each reach composed of 3 samples each. These distance groups were labeled A, B, C and D: where group A was furthest upstream and closest to the contributing lake outlet, and D was furthest downstream and away from the respective lake outflow (Figure 4).

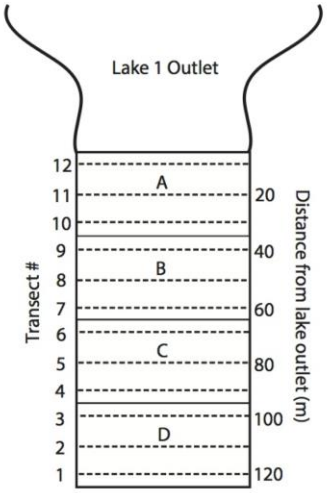

Figure 4. Schematic showing the distribution and labeling of sample transects along a study reach. Distance groups A, B, C and D are also shown.

PRIMER-E, a multivariate statistical software package designed for ecological datasets, was used to run all multivariate statistical analyses. First, a Bray Curtis similarity matrix was generated from square root transformed data. With this matrix we ran the following analyses: nonmetric multidimensional scaling (nMDS) techniques generated ordination maps, one-way Analyses of Similarities (ANOSIM) generated Global R sample statistics and significance levels, and finally relative family-level contributions to observed differences were determined using a Similarity of Percentages (SIMPER) analyses with a 90.00% cut off for low contributions. All additional analyses were performed using Excel.

4. Results

4.1 Water Quality Parameters

Most measured water quality parameters (dissolved oxygen, pH, temperature and specific conductance) were fairly uniform within and throughout each study reach (Figure 5). The only noticeable within-reach trend appeared along the longitudinal stream temperature profile for Reach 1, where temperatures steadily decreased away from the lake outlet, dropping from 20°C at the upstream end down to 16°C at the downstream end (Figure 5, transect C).

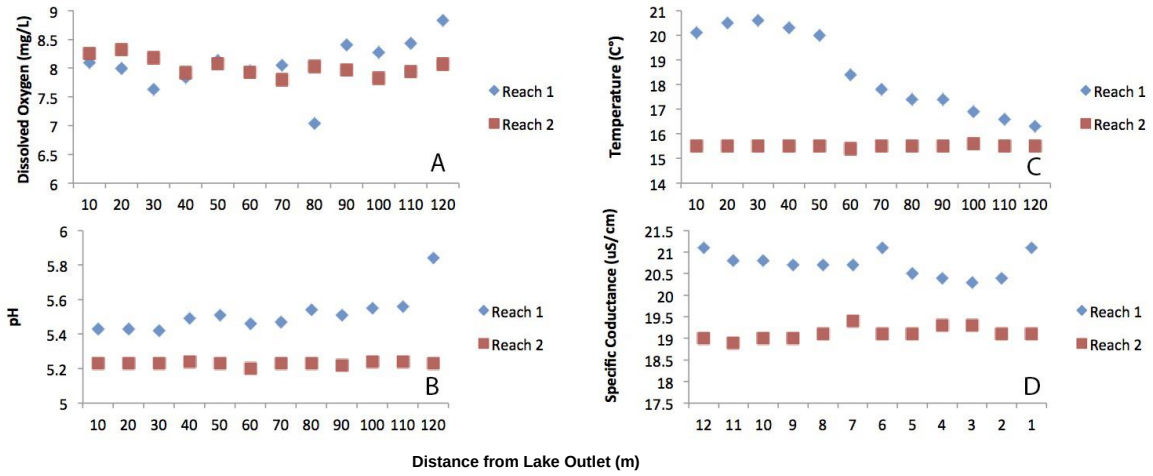

Figure 5. Stream profiles showing water quality measurements recorded on June 23 and 26, 2013 from upstream (lake outlets) to downstream ends in both Reach 1 and Reach 2.

Despite the general uniformity of water quality parameters within each reach, Figure 5 also illustrates that certain parameters were markedly and consistently different between the two study reaches. For example, the mean pH in Reach 1 was 5.5 ±0.11 while the mean pH in Reach 2 was 5.2 ±0.01 (Figure 6, transect B). Similarly, the mean specific conductance for Reach 1 was 20.7 ±0.28 μS/cm and in Reach 2 it was 19.1 ±0.14 μS/cm (Figure 6, transect D). Dissolved oxygen exhibited the least distinguishable differences both within and between Reach 1 and 2 (Figures 5 and 6, transect A). Finally, as described above, temperature remained essentially unchanged throughout Reach 2 (with a mean value of 15.5 ±0.04°C), compared with a marked decreasing trend in Reach 1 (where the mean was 18.5 ±1.7°C).

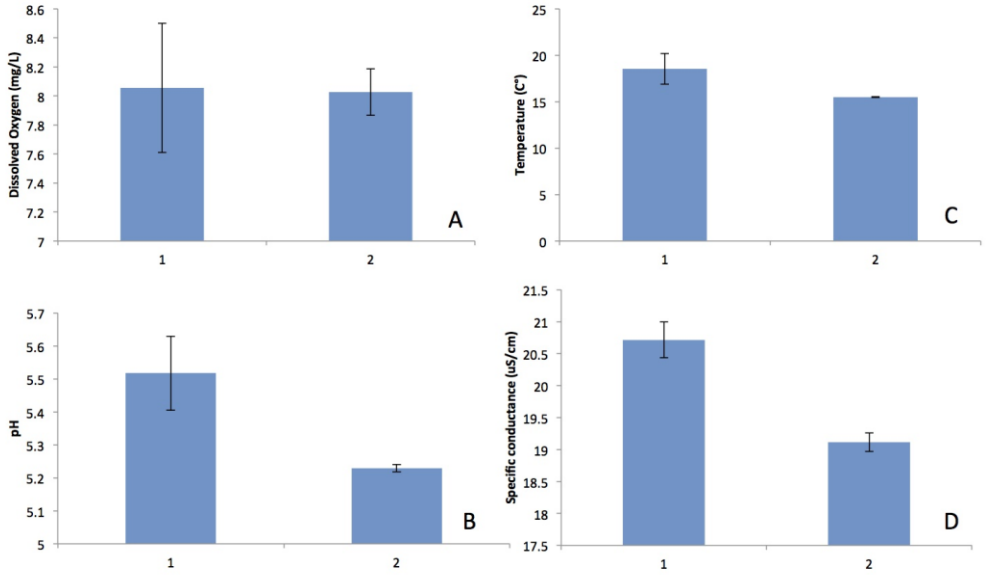

Figure 6. Mean water quality measurements from Reach 1 and Reach 2 collected on June 23 and 26, 2013.

4.2 Macroinvertebrate Community Composition

Hypothesis (a): The freshwater macroinvertebrate community composition in Reach 1 is different from that in Reach 2.

The results of our data analyses confirmed our first hypothesis, showing that there is indeed a statistically significant difference between the macroinvertebrate community structures sampled in Reach 1 compared with Reach 2 (global R= 0.31, significance level of sample statistic= 0.3%). This difference between macroinvertebrate communities in our two sample reaches is clearly visualized by the two distinct clusters shown in the ordination map below (Figure 7).

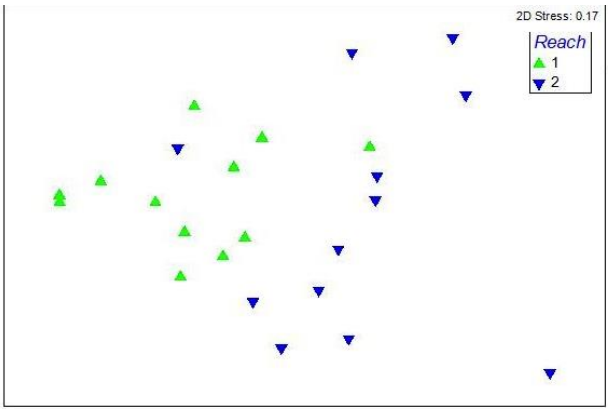

Figure 7. Ordination map (nMDS) showing similarity relationships of family-level macroinvertebrate community composition between Reach 1 and Reach 2.

However, it is important to note that most of the similarity within our study reaches resulted from the extreme abundance of order Diptera (True Flies) and especially the family Simuliidae (black flies). Tables 1, 2, and 3 show SIMPER results with a 90.00% cut off for low contributions. Within Reach 1, Simuliidae (black flies) accounted for 75% of the similarity and Chironomidae (midges) for 3%, while Baetidae (may flies) made up the remaining 13%. Within Reach 2, Simuliidae (black flies) contributed less to the similarity than in Reach 1, but still ranked highest among the contributing families at 44%, with Chironomidae (midges) being a close secondary contributor at 28%. The remaining similarity in Reach 2 was made up of Brachycentridae (order Trichoptera, caddisflies) Baetidae (order Ephemeroptera, mayflies) and Libellulidae (order Odonata, dragonflies). The overall average similarities of Reach 1 and Reach 2 were 35% and 21%, respectively (Tables 1 and 2). As expected, the dissimilarity between the two reaches was driven by a wider diversity of less abundant taxa and averaged 81% (Table 3).

Tables 1 and 2. SIMPER similarity results for within Reach 1 (Table 1) and within Reach 2 (Table 2).

Reach 1
Average similarity: 35.24

Order	Family	Contribution %
Diptera (True Flies)	Simuliidae	75.03
Ephemeroptera (May flies)	Baetidae	13.3
Diptera (True Flies)	Chironomidae	3.45

Reach 2
Average similarity: 21.36

Order	Family	Contribution %
Diptera (True Flies)	Simuliidae	43.97
Diptera (True Flies)	Chironomidae	27.71
Trichoptera (Caddisflies)	Brachycentridae	10.82
Ephemeroptera (May flies)	Baetidae	6.89
Odonata (Dragonflies)	Libellulidae	5.3

Table 3. SIMPER dissimilarity results between Reach 1 and Reach 2.

Reaches 1 & 2
Average dissimilarity: 81.21

Order	Family	Reach 1 Average Abundance	Reach 2 Average Abundance	Contribution %
Diptera (True Flies)	Simuliidae	9.66	1.59	45
Ephemeroptera (May flies)	Baetidae	1.56	0.39	9.82
Diptera (True Flies)	Chironomidae	0.65	0.53	7.31
Ephemeroptera (May flies)	Leptophlebiidae	0.37	0.25	4.73
Trichoptera (Caddisflies)	Brachycentridae	0.28	0.46	4.42
Trichoptera (Caddisflies)	Rhyacophilidae	0.53	0	3.79
Trichoptera (Caddisflies)	Hydropsychidae	0.4	0	3.57
Nematoda (Nematodes)	Nematoda	0.47	0.17	3.1
Odonata (Dragonflies)	Libellulidae	0	0.41	2.89
Plecoptera (Stoneflies)	Nemouridae	0.2	0	2.71
Haplotaxida (Oligochaete worm)	Naididae	0.08	0.12	1.88
Hirudinea (Leeches)	Hirudinea	0.08	0.12	1.66

Hypothesis (b): The macroinvertebrate community composition is different between distance groups (corresponding to progressive distances away from the lake outlets) within each of the reaches.

Our second hypothesis, however, proved to be true for Reach 1 but not Reach 2. A one-way Analysis of Similarities (ANOSIM) composed of 6 pair-wise tests between distance groups (A, B, C and D) within Reach 1 confirmed our hypothesis that there would be a difference from upstream to downstream, moving away from the outflow of Lake 1 (global R= 0.259, significance level of sample statistic= 0.7%). On the other hand, the identical analyses performed on distance groups within Reach 2 showed no significant difference between the macroinvertebrate communities (global R= -0.076, significance level of sample statistic= 67%). In the ordination maps presented by Figure 8, clear data clusters are evident within Reach 1, but not Reach 2.

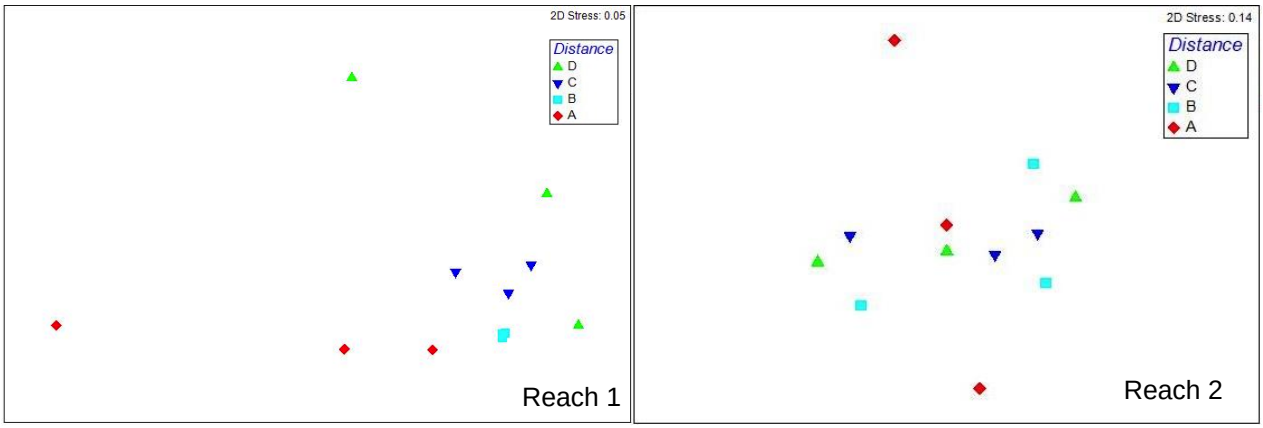

Figure 8. Ordination maps (nMDS) showing similarity relationships of family-level macroinvertebrate community composition between samples in distance groups A, B, C, and D.

4.3 Exploratory Results

After initial processing of our water quality and community composition data, we sought additional insight into the patterns observed. Depth measurements collected at each water quality point (right bank, left bank and thalweg) were transectted in a bubble chart to provide contextual information regarding habitat differences between the two study reaches. Figure 9 shows that depth was variable within each reach, and also between the two reaches, with Reach 1 being shallower overall.

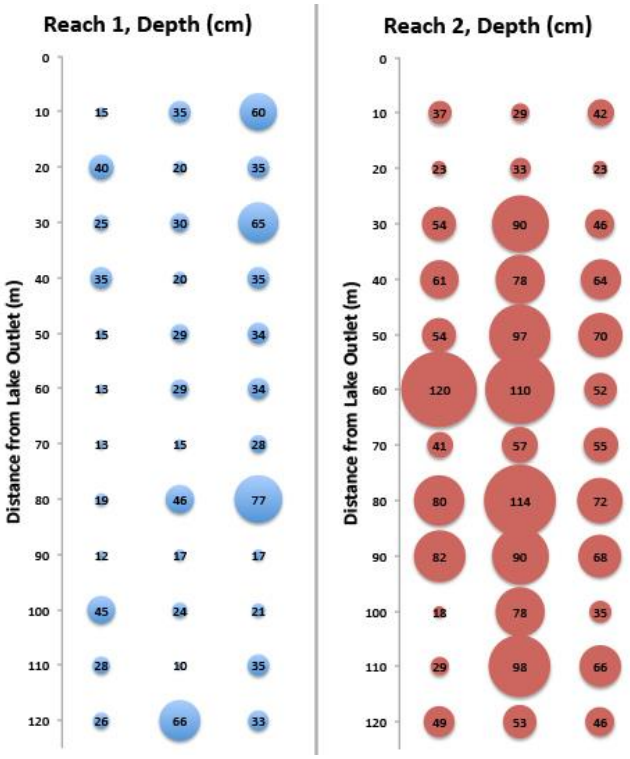

Figure 9. Depth measurements recorded at the left bank, right bank and thalweg across each transect. Bubble diameters correspond to depth and are comparably scaled.

Bar graphs showing both the total number of taxa per transect as well as the total number of individuals per transect were generated, showing that although macroinvertebrate abundances were exceptionally high in the middle of Reach 1 (with a hyper abundance of Simuliidae), the mean diversity of taxa encountered per transect across both study reaches ranged from 1 to 9 different taxa (Figure 10) with a mean of 3.8 ±2.1.

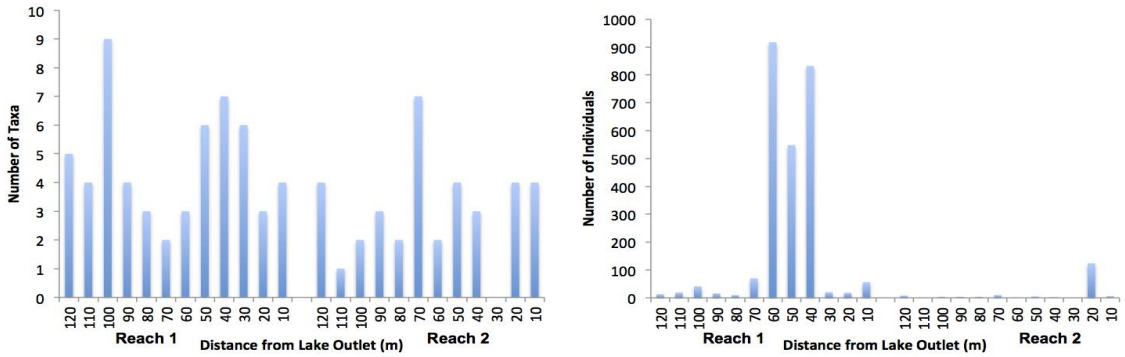

Figure 10. Bar graphs showing both the total number of taxa per transect as well as the total numbers of individuals per transect.

We also became interested in the feeding niches of observed taxa, and categorized them according to the Xerces *Guide to Pacific Northwest Macroinvertebrate Monitoring and Identification* (Adams et al, 2004) (Table 4). However, because most specimens were only identified down to the family level, and some families are composed of multiple species with a variety of feeding strategies at different instar growth stages (e.g. Ceratopogonidae, Tabanidae, Leptophlebiidae), these functional feeding group (FFG) assignments are only best approximations.

Table 4. Functional Feeding Groups assigned to each observed taxa (Adams et al, 2004).

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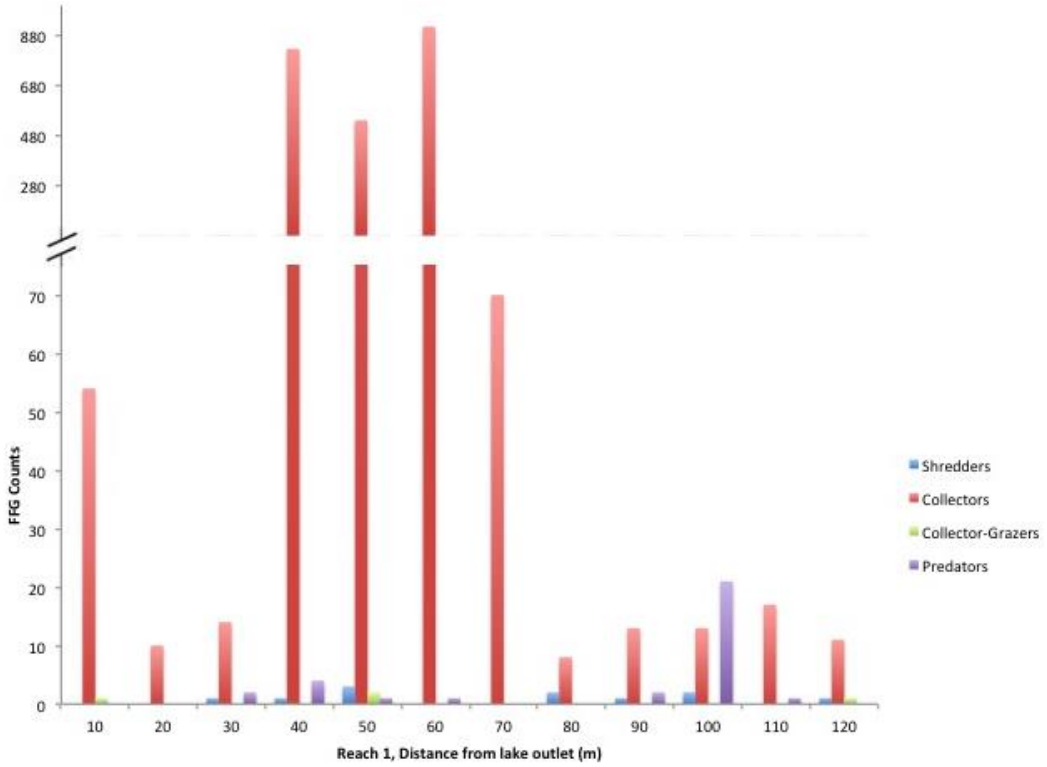
Family	Functional Feeding Group	Family	Functional Feeding Group	Family	Functional Feeding Group
Ceratopogonidae (Biting Midges)	Predator, Collector-gatherers, Shredders, Grazers/scrapers	Hydropsychidae (Net-spinning Caddisflies)	Shredders	Caecidota (Cress Bugs, Freshwater Sow or Pill Bugs)	Collector-gatherers
Chironomidae (Midges)	Predator	Lepidostomatidae (Case Maker Caddisflies)	Predator	Naididae (Aquatic Earthworms)	Predator
Simuliidae (Black Flies)	Predator	Rhyacophilidae (Free-living Caddisflies or Green Rock Worms)	Predator	Nematoda (Nematodes or Roundworms)	Predator
Tabanidae (Horse-flies)	Shredders, Grazers/scrapers, Predator	Coenagrionidae (Narrow-winged Damselflies)	Predator	Hydracarina (Aquatic Mites)	Predator
Tipulidae (Crane Flies)	Collector-gatherers	Perlidae (Common Stoneflies)	Shredders	Hemiptera (True Bugs)	Collector-gatherers
Baetidae (Small Minnow Mayflies)	Collector-gatherers	Nemouridae (Forestflies or Little Brown Stoneflies)	Predator	Pisidiidae (Fingernail Clams)	Predator
Leptophlebiidae (Prong-gilled Mayflies)	Collector-gatherers, Grazers/scrapers	Libellulidae (Skimmer Dragonflies)	Shredders	Hirudinea (Leeches)	Predator
Brachycentridae (Humpless Casemaker Caddisflies)	Collector-gatherers	Sphaeromatidae (Freshwater Sow or Pill Bugs)	Shredders		

Based on the functional feeding group assignments in Table 4, the number of shredders, collector/gatherers, predators, and collector-grazers (a joint assignment) were transectted by transect for each study reach (Figures 11 and 12). (Note that no collected specimens could be assigned to a pure "grazer" category, however taxa representing a mix of collector and grazer strategies were categorized as "collector-grazers.")



Figures 11. Taxa grouped according to functional feeding groups (FFG) per transect in Reach 1.

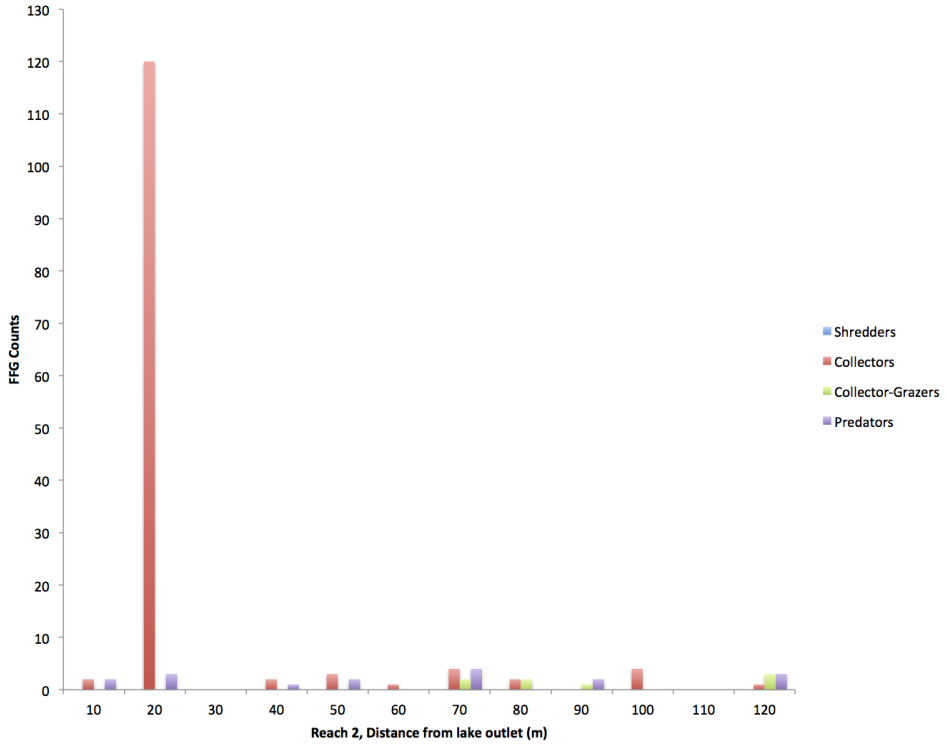


Figure 12. Taxa grouped according to functional feeding groups (FFG) per transect in Reach 2.

Collectors clearly dominate the FFG counts across the study reaches, composing 97% of the total individuals. Predators compose 2%, and then shredders and collector-grazers make up the remaining one percent. Notably, no shredders were collected from Reach 2-- all shredder specimens were found evenly distributed over the length of Reach 1.

5. Discussion

5.1 Hypothesis (a)

Our first hypothesis was that the freshwater macroinvertebrate community composition in Reach 1 would be different from that in Reach 2. Based on our analysis of collected data, there was indeed a significant difference between the macroinvertebrate communities in Reach 1 compared with Reach 2 (Figure 7). The largest contributors to the overall difference between reaches were members of the order Diptera, and especially the family Simuliidae (black flies) (Tables 1 and 2). However it is unclear what conditions are driving the differences between these communities. Water quality measurements suggest that while dissolved oxygen levels were virtually indistinguishable between reaches, pH and specific conductance values were consistently different. Overall, Reach 1 exhibited a higher concentration of total dissolved solids (TDS) (20.7 ±0.28 μS/cm) compared with Reach 2 (19.1 ±0.14 μS/cm); and Reach 1 was also slightly less acidic (pH of 5.5 ±0.11) compared with Reach 2 (5.2 ±0.01) (Figure V). Temperature in Reach 1 was also slightly higher than Reach 2 (with a mean value of 18.5 ±1.7°C in Reach 1 compared with a mean of 15.5 ±0.04°C in Reach 2).

Geomorphic attributes and habitat type also varied between Reach 1 and 2. Reach 1 exhibited a steeper stream gradient with a substrate dominated by large boulders that created shallow pocket pools linked by short cascade segments. The steep gradient, very coarse substrate, and cascade-pool complex at Reach 1 made it look very much like the headwaters of a first order mountain stream, despite the fact that Reach 1 is the terminal reach of Big Spring Creek bounded at the downstream end by outflow into the marine environment at the creek mouth. Figure 9 illustrates how depth varied across the study reaches, showing the shallow pocket pools in Reach 1 compared with the more variable depths across Reach 2. Reach 2 exhibited a deeper and more confined channel dominated by coarse cobble to coarse sand substrate. Immediately below the beaver dam at the upstream end of Reach 2 there is an approximately 25 m long section of classic riffle habitat, however the remainder of the reach is essentially one long, and periodically deep glide.

Therefore, considering the distinct habitat and water quality conditions in Reach 1 and 2, observed differences in macroinvertebrate community composition may be attributable to reach scale differences in pH, specific conductance, temperature, habitat, or some other unknown variable.

5.1 Hypothesis (b)

Our second hypothesis was that macroinvertebrate community composition would be different between distance groups within each of the reaches. This turned out to be true for Reach 1 but not for Reach 2 (Figure 8). Most water quality characteristics, with the exception of temperature, were fairly uniform within each study reach (Figures 5 and 6), suggesting that the creek is well-mixed at the reach scale. Therefore, pH, specific conductance and dissolved oxygen

levels are unlikely to be driving the macroinvertebrate community differences observed within Reach 1. Temperature, however, was the only measured parameter exhibiting a clear within-reach trend, decreasing steadily from 20°C at the upstream end to 16°C at the downstream end. This temperature trend was observed in Reach 1 only, strengthening the possibility that temperature could be a driver of the observed differences between macroinvertebrate communities according to distance groups within Reach 1.

5.3 Functional Feeding Groups/ Ecological models

After investigating our preliminary hypotheses, we sought further insight into observed patterns by shifting our research lens from taxa-level relationships to functional feeding groups (FFG) (Barbour et al., 1996) (Table 4). Figures 11 and 12 show FFG categories per transect for both study reaches. Aside from the anticipated hyper abundance of collectors (represented by the Simuliidae), the most remarkable pattern is the notable presence of shredders in the lower reach (Reach 1) and total absence of shredders in the upper reach (Reach 2). This is contrary to what would be expected based on the widely accepted River Continuum Concept (RCC) described by Vannote and colleagues in their seminal publication (Vannote et al, 1980). RCC theory predicts that shredders will be most abundant in the upper headwater reaches of a stream system where most nutrients are largely allochthonous and particulate organic matter is coarser and requires "shredding" before it can be consumed (Figure 13).

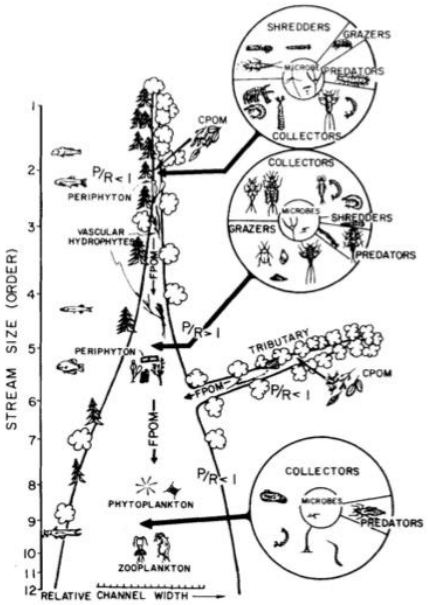


Figure 13. Schematic showing relative proportion of FFG's across stream order according to the River Continuum Concept (taken directly, without permission, from Vannote et al, 1980).

Conversely, the RCC predicts a dominance of collectors in the higher order reaches where particulate organic matter becomes increasingly fine (Figure 13). Additionally, the Serial Discontinuity Concept of Lotic Ecosystems, another formative model first proposed by Ward and Stanford in 1983, predicts that the ratio of coarse particulate organic matter (CPOM) to fine particulate organic matter (FPOM) will drop downstream from a dam or lake impoundment, resulting in a decrease in shredding organisms (Figure O).

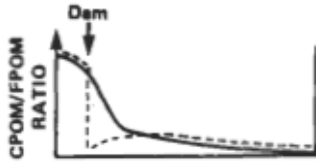


Figure O. Schematic showing a drop in the ratio of coarse to fine particulate organic matter (CPOM/FPOM) downstream from a dam impoundment according to the
Serial Discontinuity Concept of Lotic Ecosystems (taken directly, without permission, from Ward and Stanford, 1983).

Neither of these models explains the presence of shredders in our lower reach (6^{th} order segment) at the mouth of Big Spring Creek. Interestingly, RCC theory does characterize natural first order streams as heavily canopied and light-limited systems with course substrate— a characterization that matches Reach 1 extremely well, despite the fact that it is not actually a headwater reach. The atypical geomorphic and biological character of this lower reach combined with notable presence of shredders represents an ecological curiosity worthy of future study.

6. Potential Errors and Bias

The factor that likely contributed the most to error and bias in this study is the collection of only a few samples without duplicates. The small sampling size for our study and lack of duplication meant that when we found no macroinvertebrates in sample 10 from reach 2 we could only accept that this means there were no macroinvertebrates in that section of stream, which may have skewed our results. Barbour et al. (1999) call for the collection of at least 20 samples in a 100-meter reach. We were unable to meet this standard based on our time constraints. As well, our water quality and macroinvertebrate samples were collected once on only two separate days, rather than repeatedly collected over a longer stretch of time. This means that our information is specific to these localized sections of the reach and a very specific time. Therefore, they cannot accurately be extrapolated to make inferences on a larger time or spatial scale. Further surveys, with more in depth collection of macroinvertebrate samples over a longer period, are recommended to create greater knowledge of the species composition of macroinvertebrates in Big Spring Creek.

Other potential sources of uncertainty and error may be the result of our transportation and identification of the macroinvertebrate samples. Due to the minuscule nature of macroinvertebrates it is possible that some individuals were lost during transport from the

containers we used in the field to petri dishes in the lab, and that while sifting through the debris remaining in the petri dishes some specimens were lost. Although we took great care to identify species based on their distinguishing characteristics, using the Xerces Society for Invertebrate Conservation's Guide to Pacific Northwest Macroinvertebrate Monitoring and Identification **(**Adams, 2004), our inexperience with identifying macroinvertebrates may have led to misidentification (Baldaccini et al., 2009). As well, the use of forceps to pick up and move species from one container to the next and decomposition that occurred in spite of the use of alcohol as a preservative occasionally resulted in disfigured, difficult to identify specimens. Inexperience with handling and identifying macroinvertebrate samples may have influenced the volume of each species collected and the number of different species identified.

7. Conclusions

Despite project constraints, (Section 6. *Potential Errors and Bias*) our limited data suggests that, as hypothesized, there is indeed a significant difference in the macroinvertebrate community structure between Reach 1 and Reach 2 of Big Spring Creek on Calvert Island, BC. These differences in community composition may be attributable to reach scale differences in pH, specific conductance, temperature, habitat, or some other unknown variable.

However, our secondary hypothesis that the community structure would change according to distance from lake outlets, proved true only for Reach 1 and not Reach 2. Notably, the only recognizable sub-reach scale trend in water quality conditions also occurred within Reach 1, where water temperatures showed a steady decrease moving downstream, away from the lake outlet.

Finally, contrary to widely accepted ecological models for lotic ecosystems (Vannote et al, 1980; Ward and Stanford, 1983), all of the macroinvertebrate taxa classified as shredders occur only in the lower reach. These results combined with the atypical physical, chemical and biological conditions at Big Spring Creek make it a unique study site that cannot be easily understood within current ecological frameworks.

In light of these preliminary data, it may prove worthwhile for future researchers to further investigate the potential link between water temperature and macroinvertebrate community structure in Big Spring Creek. Additionally, the unusual pattern of colonization by functional feeding groups within the system warrants further investigation, and could provide valuable insight into the ecological functioning of the broader bog ecosystems on Calvert Island.

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Appendix I

Raw Data

Table 1: Raw freshwater macroinvertebrate sample data collected from Reach 1 and Reach 2 of Big Spring Creek, including numbers of individuals collected for each family. This table also includes the distance of each sample from the lake outlet. Samples labeled under the "Distance Bins" category go from A, which is closest to the lake and D, which is furthers away from the lake outlet.

Date	Reach	Transect	Distance Bins	Ceratopogonidae	Chironomidae	Simuliidae	Tabanidae	Tipulidae	Baetidae	Leptophlebiidae	Brachycentridae	Hydropsychidae	Lepidostomatidae	Rhyacophilidae	Coenagrionidae	Perlidae	Nemouridae	Libellulidae	Sphaeromatidae	Caecidota	Naididae	Nematoda	Hydracarina	Hemiptera	Pisididae	Unk. Hirudinea	Erpobdellidae
23/6/13	1	1	D	0	0	9	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0
23/6/13	1	2	D	0	0	9	0	1	8	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
23/6/13	1	3	D	0	5	6	1	0	6	0	0	1	2	4	0	0	0	0	0	0	0	13	3	0	0	0	0
23/6/13	1	4	C	0	0	12	0	0	0	0	0	1	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0
26/6/13	1	5	C	0	0	7	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
23/6/13	1	6	C	0	0	62	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23/6/13	1	7	B	0	0	905	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
23/6/13	1	8	B	0	0	534	0	0	6	2	2	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
23/6/13	1	9	B	1	0	819	0	0	8	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	0	0	0
23/6/13	1	10	A	0	3	12	0	0	0	0	0	2	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0
26/6/13	1	11	A	0	8	1	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26/6/13	1	12	A	0	1	52	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26/6/13	2	1	D	0	1	1	0	0	0	0	3	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
26/6/13	2	2	D	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26/6/13	2	3	D	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0
26/6/13	2	4	C	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
26/6/13	2	5	C	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26/6/13	2	6	C	0	0	1	0	0	1	1	2	0	0	0	0	0	0	3	0	0	0	1	0	0	1	0	0
26/6/13	2	7	B	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26/6/13	2	8	B	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
26/6/13	2	9	B	0	0	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
26/6/13	2	10	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26/6/13	2	11	A	0	1	117	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
26/6/13	2	12	A	0	2	1	0	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0

Table 2: Raw water quality data collected from Reach 1.

Reach	Transect	Location	Distance	Depth	SpC (uS/cm)	DO (mg/L)	pH	Temperature (C)	Width (cm)
1	1	3	120	33	24.7	8.40	7.85	16.2	670
1	1	2	120	66	21.1	8.83	5.84	16.3	670
1	1	1	120	26	20.7	8.77	5.57	16.3	670
1	2	3	110	35	20.3	8.58	5.58	16.7	710
1	2	2	110	10	20.4	8.52	5.57	16.7	710
1	2	1	110	28	20.4	8.43	5.56	16.6	710
1	3	3	100	21	20.3	8.27	5.55	16.9	750
1	3	2	100	24	20.3	8.43	5.5	17.1	750
1	3	1	100	45	20.4	8.11	5.56	17.2	750
1	4	3	90	17	20.3	7.78	5.58	17.3	990
1	4	2	90	17	20.4	8.34	5.53	17.4	990
1	4	1	90	12	20.4	8.40	5.51	17.4	990
1	5	3	80	77	20.5	7.04	5.54	17.4	935
1	5	2	80	46	20.4	8.11	5.51	17.5	935
1	5	1	80	19	20.5	7.82	5.53	17.3	935
1	6	3	70	28	20.6	8.04	5.45	17.6	790
1	6	2	70	15	20.6	8.14	5.46	17.9	790
1	6	1	70	13	21.1	8.05	5.47	17.8	790
1	7	3	60	34	20.7	7.52	5.47	18.1	710
1	7	2	60	29	20.6	7.95	5.49	18.3	710
1	7	1	60	13	20.7	7.95	5.46	18.4	710
1	8	3	50	34	20.6	8.07	5.78	20	660
1	8	2	50	29	20.7	8.13	5.51	20	660
1	8	1	50	15	20.7	6.80	5.52	20	660
1	9	3	40	35	20.7	7.84	5.49	20.3	770
1	9	2	40	20	20.8	7.93	5.45	20.3	770
1	9	1	40	35	20.7	7.81	5.46	20.3	770
1	10	3	30	65	21	7.95	5.46	20.6	630
1	10	2	30	30	20.8	7.63	5.42	20.6	630
1	10	1	30	25	20.9	7.43	5.43	20.2	630
1	11	3	20	35	21.1	7.80	5.45	20.8	620
1	11	2	20	20	20.8	7.99	5.43	20.5	620
1	11	1	20	40	21	7.75	5.45	20.5	620
1	12	3	10	60	20.9	7.46	5.43	21.5	550
1	12	2	10	35	21	7.80	5.44	21	550
1	12	1	10	15	21.1	8.10	5.43	20.1	550

Table 3: Raw water quality data collected from Reach 2.

Reach	Transect	Location	Distance	Depth	SpC (uS/cm)	DO (mg/L)	pH	Temperature (C)	Width (cm)
2	1	3	120	46	19.1	8.00	5.25	15.5	640
2	1	2	120	53	19.1	8.07	5.23	15.5	640
2	1	1	120	49	19.1	8.09	5.25	15.5	640
2	2	3	110	66	19.1	7.94	5.24	15.5	620
2	2	2	110	98	19.2	8.00	5.23	15.5	620
2	2	1	110	29	19.1	7.96	5.23	15.5	620
2	3	3	100	35	19.3	7.83	5.24	15.6	560
2	3	2	100	78	19.1	8.01	5.23	15.5	560
2	3	1	100	18	19.2	8.03	5.23	15.5	560
2	4	3	90	68	19.2	7.66	5.22	15.6	1220
2	4	2	90	90	19.1	7.92	5.24	15.5	1220
2	4	1	90	82	19.3	7.97	5.22	15.5	1220
2	5	3	80	72	19.2	7.43	5.23	15.5	950
2	5	2	80	114	19.2	8.05	5.23	15.5	950
2	5	1	80	80	19.1	8.03	5.23	15.5	950
2	6	3	70	55	19.1	7.80	5.23	15.5	860
2	6	2	70	57	19.1	8.05	5.23	15.5	860
2	6	1	70	41	19.1	8.00	5.23	15.5	860
2	7	3	60	52	19.4	7.93	5.2	15.4	570
2	7	2	60	110	19.2	7.68	5.23	15.4	570
2	7	1	60	120	19.1	8.01	5.23	15.5	570
2	8	3	50	70	19.1	8.08	5.23	15.5	810
2	8	2	50	97	19.1	8.03	5.23	15.5	810
2	8	1	50	54	19.1	8.01	5.23	15.5	810
2	9	3	40	64	19.1	8.10	5.23	15.5	760
2	9	2	40	78	19	7.92	5.24	15.5	760
2	9	1	40	61	18.8	7.80	5.28	15.5	760
2	10	3	30	46	19.1	7.96	5.24	15.5	840
2	10	2	30	90	19	8.09	5.24	15.5	840
2	10	1	30	54	19	8.18	5.23	15.5	840
2	11	3	20	23	19.1	8.23	5.22	15.5	780
2	11	2	20	33	18.9	8.32	5.23	15.5	780
2	11	1	20	23	19	8.07	5.24	15.5	780
2	12	3	10	42	19	8.19	5.23	15.5	570
2	12	2	10	29	19	8.25	5.23	15.5	570
2	12	1	10	37	19	7.87	5.23	15.5	570

Appendix II

Macroinvertebrate Families Sampled and Habitat Preference Table

Table 4: Displays the macroinvertebrate families collected, the number of individuals in each reach, their documented habitat preferences, and the sample transects members of each family were collected from.

Family	Total Number of Individuals in R1	Total Number of Individuals in R2	Known Habitat Preference	Transects Observed In
Ceratopogonidae (Biting Midges)	1	0	Moist or wet sand, mud, decaying vegetation, salt tolerant, freshwater marshes [1]	**R1**: S9
Chironomidae (Midges)	17	7	Riffles, pollution tolerant [2]	**R1**: S3, S10 – S12 **R2**: S1, S2, S4, S7, S11, S12
Simuliidae (Black Flies)	2428	127	quickly flowing, riffle, on stones and leaves, pollution tolerant[3]	**R1**: S1 – S12 **R2**: S1, S3, S5, S6, S8, S9, S11, S12
Tabanidae (Horse-flies)	1	0	wet soils of streams and ponds, sands and gravels of fast, cold streams[2]	**R1**: S3
Tipulidae (Crane Flies)	1	0	most aquatic habitats from small clear streams to woodland bogs[2]	**R1**: S2
Baetidae (Small Minnow Mayflies)	49	6	found in almost any freshwater habitat,[2] pollution sensitive[3]	**R1:** S1 – S3, S5 – S9 **R2**: S6 – S8, S11
Leptophlebiidae (Prong-gilled Mayflies)	11	3	most streams and rivers across the Northwest,[2] pollution sensitive[3]	**R1**: S7, S11 **R2**: S6, S9, S12
Brachycentridae (Humpless Casemaker Caddisflies)	4	8	wide range of stream and river types, moderate to fast currents,[2] pollution sensitive[3]	**R1**: S1, S8, S12 **R2:** S1, S4 – S6
Hydropsychidae (Net-spinning Caddisflies)	6	0	Most streams and rivers ranging from lowland streams to higher mountain streams,[2] pollution sensitive[3]	**R1**: S3, S4, S10, S12
Lepidostomatidae (Case Maker Caddisflies)	6	0	cold, headwater streams, slower areas of larger rivers, edges of lakes,[2] pollution sensitive[3]	**R1**: S3, S8, S9
Rhyacophilidae (Free-living Caddisflies or Green Rock Worms)	9	0	only in fast flowing water, mostly under rocks,[2] pollution sensitive[3]	**R1**: S2 – S4, S8, S9
Coenagrionidae (Narrow-winged	1	0	Riffles, warmer still waters,[2] pollution	**R1**: S10

[1] Bugguide: Iowa State University. Retrieved from: http://bugguide.net/node/view/15740. July 3 2013.

[2] Adams, J. (2004). Stream Bugs as Biomonitors: Guide to Pacific Northwest Macroinvertebrate Monitoring and Identification. The Xerces Society for Invertebrate Conservation.

[3] Water Watch Biological Monitoring Procedures. Biological Stream Assessment. Retrieved from: http://www.state.ky.us/nrepc/water/introtxt.htm. July 3 2013.

Damselflies)			intermediate[3]	
Perlidae (Common Stoneflies)	0	1	cold, high elevation streams or low elevation, rocky bottom rivers,[2] pollution sensitive[3]	**R2**: S9
Nemouridae (Forestflies or Little Brown Stoneflies)	3	0	Pollution sensitive,[3] small cold-water streams, larger rivers, lake edges[4]	**R1**: S4, S5
Libellulidae (Skimmer Dragonflies)	0	8	streams and rivers (only in the pools and edges), more common in ponds and marshes, springs, ditches,[2] pollution intermediate[3]	**R2**: S1, S6, S12
Sphaeromatidae (Freshwater Sow or Pill Bugs)	1	0	lower reaches of streams, rivers that drain directly into the ocean, primarily marine, common near the estuarine/freshwater boundaries,[2] pollution intermediate[3]	**R1**: S1
Caecidota (Cress Bugs, Freshwater Sow or Pill Bugs)	1	0	abundant in small streams, seeps, and springs,[2] pollution intermediate[3]	**R1**: S10
Naididae (Aquatic Earthworms)	1	2	riffle samples, large Northwest rivers,[2] pollution tolerant[3]	**R1**: S1 **R2**: S3
Nematoda (Nematodes or Roundworms)	15	2	nearly everywhere on land and water,[2] pollution tolerant[3]	**R1**: S3, S7, S9 **R2**: S6, S8
Hydracarina (Aquatic Mites)	3	3	Almost any freshwater habitat[2]	**R1**: S3 **R1**: S11
Hemiptera (True Bugs)	1	0	Slow or still waters[3]	**R1**: S9
Pisidiidae (Fingernail Clams)	0	1	ubiquitous in many aquatic habitats,[2] pollution intermediate[3]	**R2**: S6
Unknown Hirudinea (Leeches)	1	2	solid substrates, slack water, some riffles,[2] pollution tolerant[3]	**R1**: S10 **R2**: S4
Erpobdellidae (Leeches)	0	1	solid substrates, slack water, some riffles,[2] pollution tolerant[3]	**R2**: S8

[4] Bouchard, R.W. (2004) Guide to Aquatic Macroinvertebrates of the Upper Midwest. Retrieved from: http://wrc.umn.edu/prod/groups/cfans/@pub/@cfans/@wrc/documents/asset/cfans_asset_115807.pdf. July 3 2013.

Appendix III

Sampling transect pictures

Figure 1: Reach 1, sampling transect 1.

Figure 2: Reach 1, sampling transect 2.

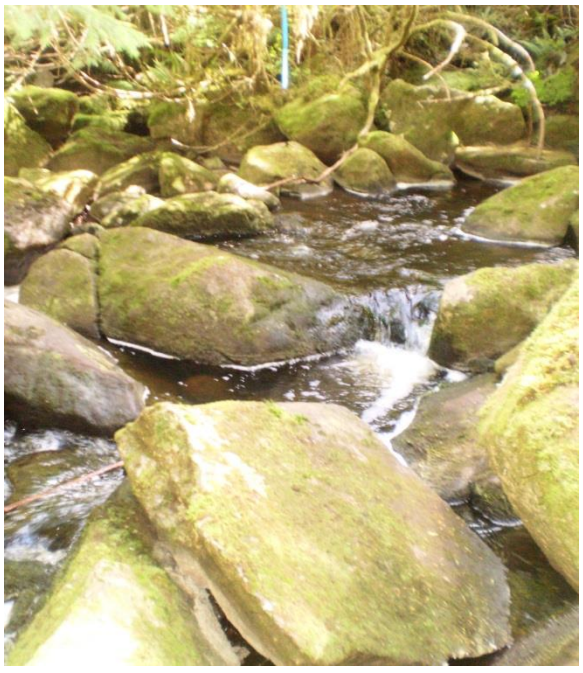


Figure 3: Reach 1, sampling transect 3.

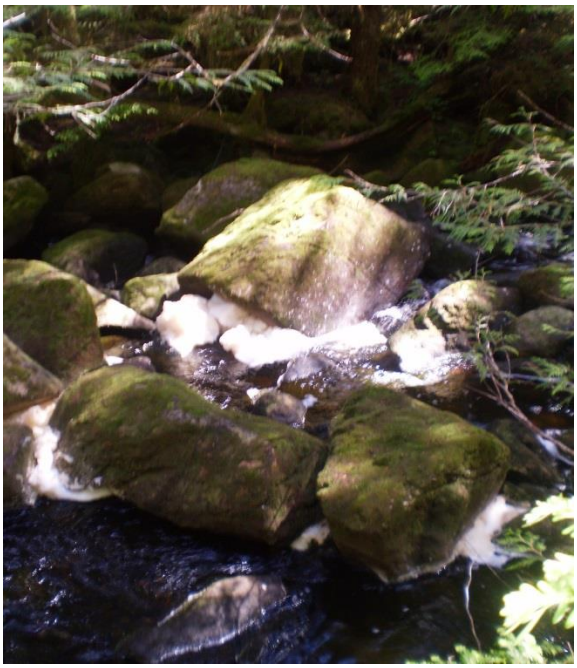


Figure 4: Reach 1, sampling transect 4.

Figure 5: Reach 1, sampling transect 5.

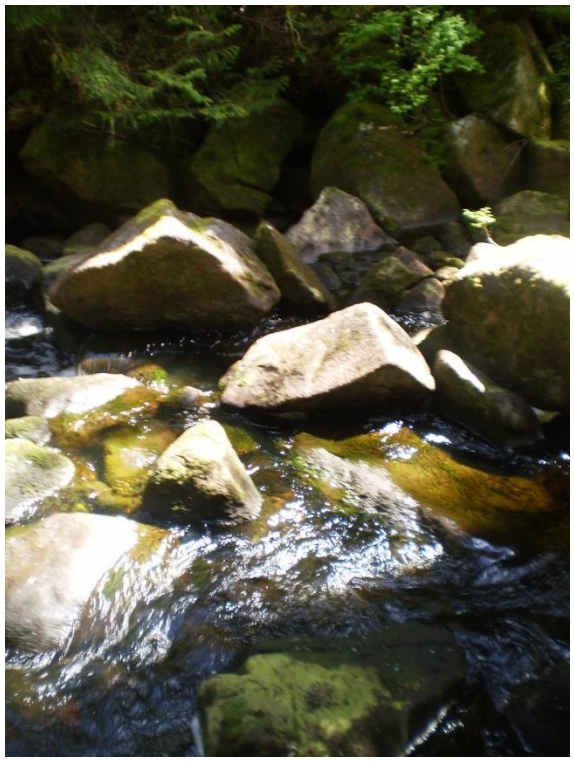


Figure 6: Reach 1, sampling transect 6.

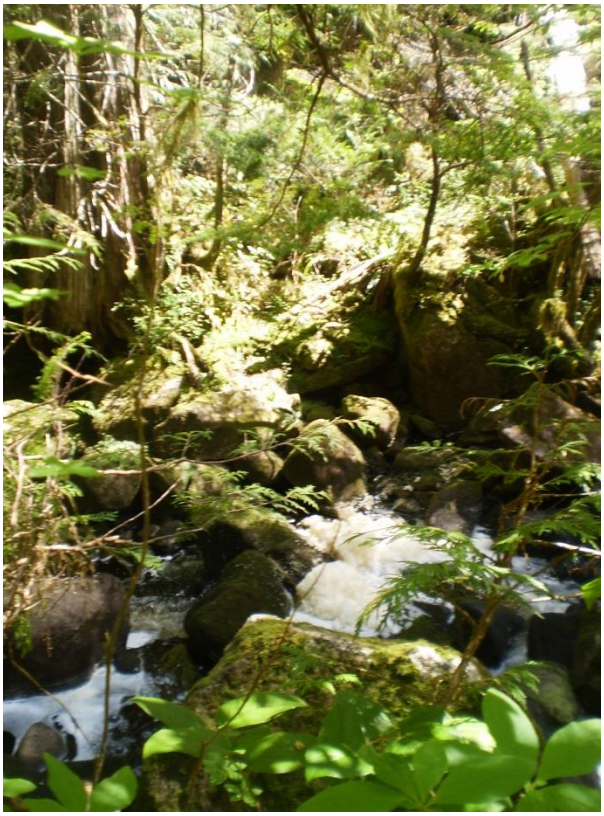


Figure 7: Reach 1, sampling transect 7.

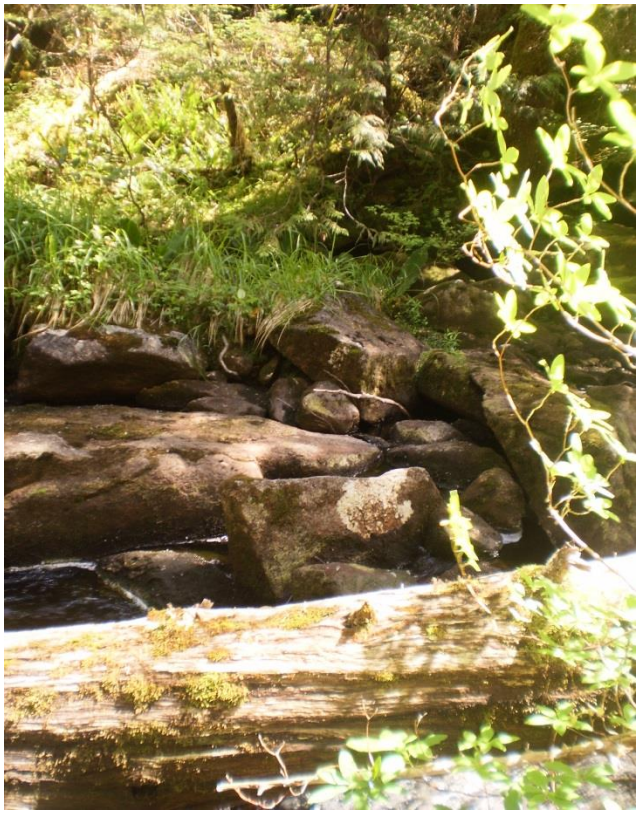


Figure 8: Reach 1, sampling transect 8.

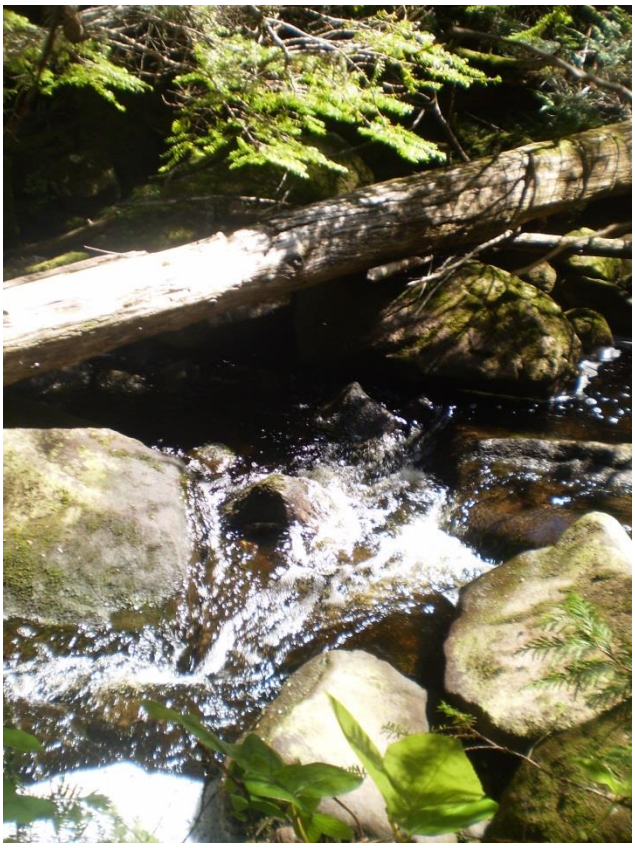


Figure 9: Reach 1, sampling transect 9.

Figure 10: Reach 1, sampling transect 10.

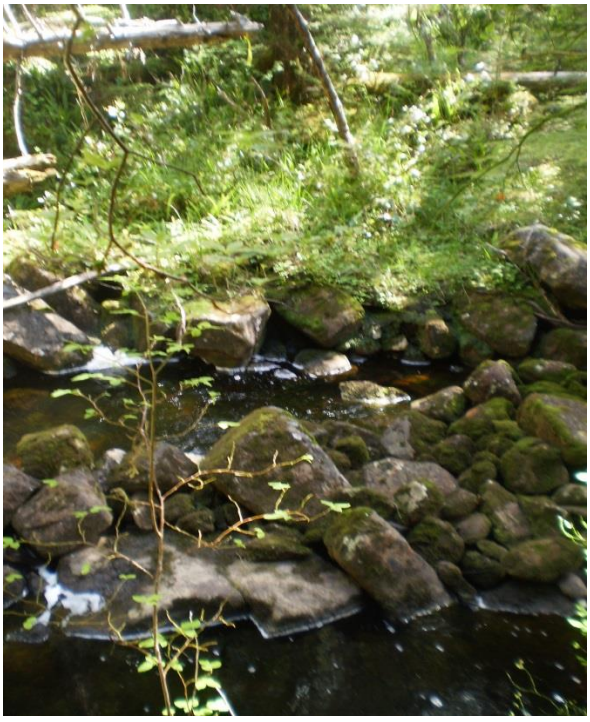


Figure 11: Reach 1, sampling transect 11.

Figure 12: Reach 1, sampling transect 12.

Figure 13: Reach 2, sampling transect 1.

Figure 14: Reach 2, sampling transect 2.

Figure 15: Reach 2, sampling transect 3.

Figure 16: Reach 2, sampling transect 4.

Figure 17: Reach 2, sampling transect 5.

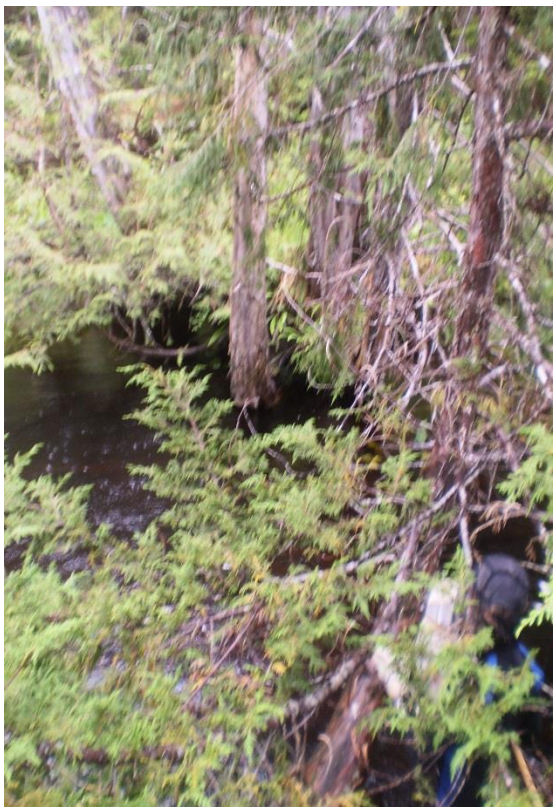


Figure 18: Reach 2, sampling transect 6.

Figure 19: Reach 2, sampling transect 7.

Figure 20: Reach 2, sampling transect 8.

Figure 21: Reach 2, sampling transect 9.

Figure 22: Reach 2, sampling transect 10.

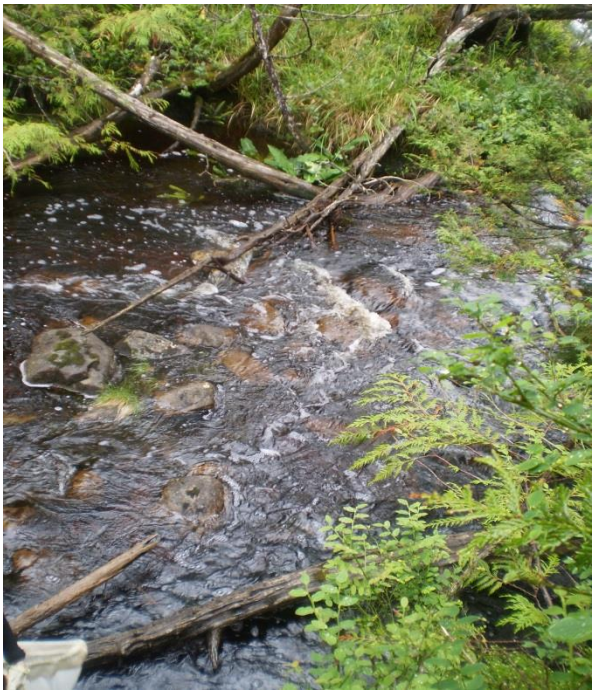


Figure 23: Reach 2, sampling transect 11.

Figure 24: Reach 2, sampling transect 12.

Appendix IV

Macroinvertebrate Specimens

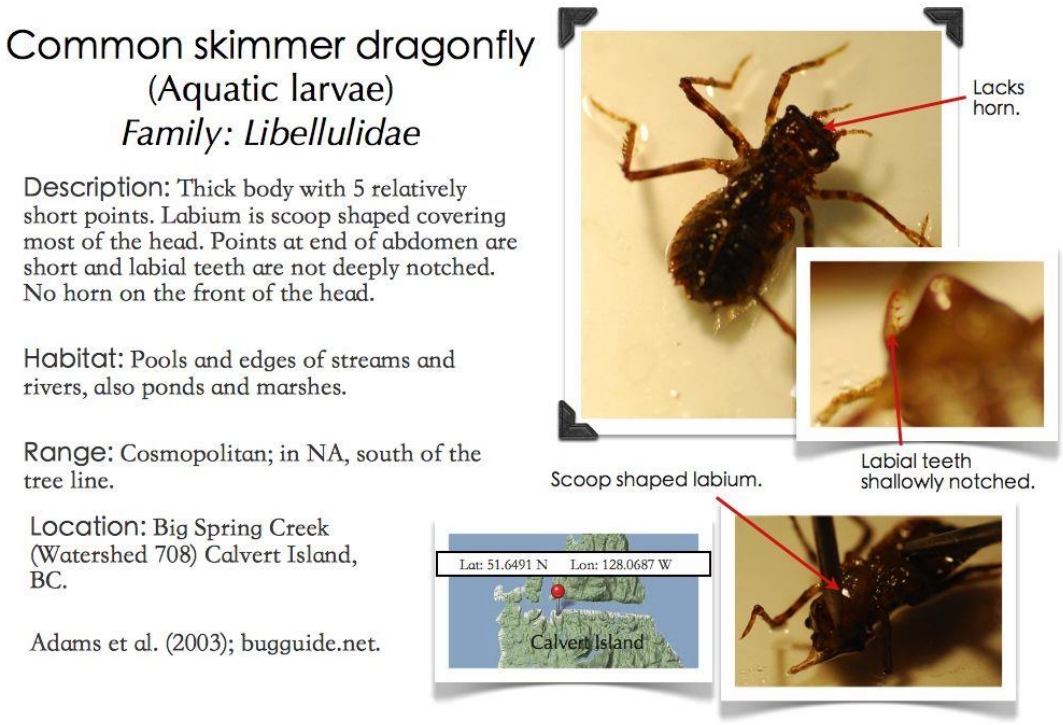


Figure 1: Information and photographs of one of the species we collected and identified to family: *Libellulidae*.

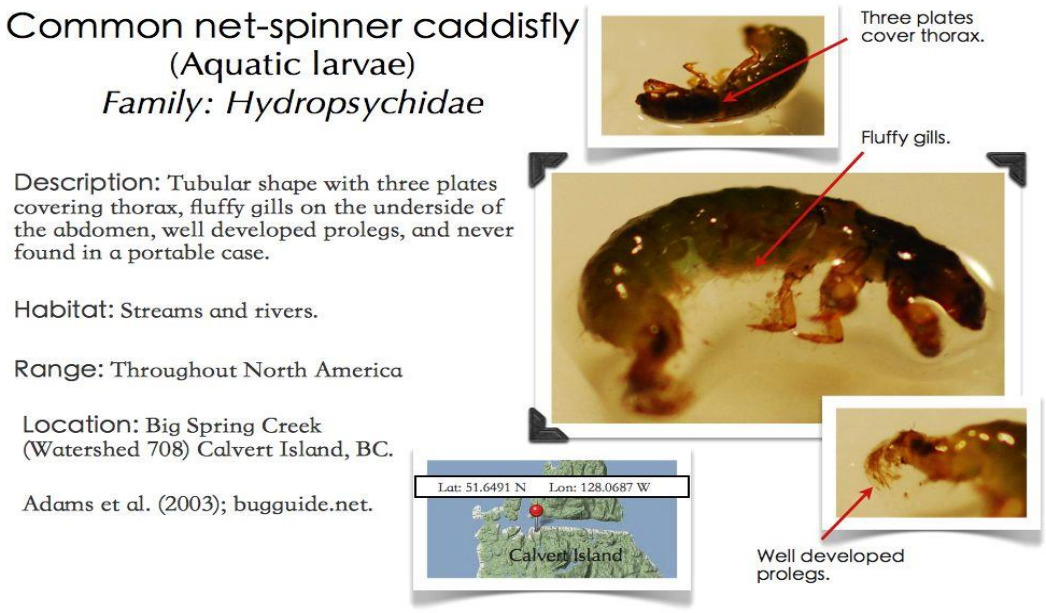


Figure 2: Information and photographs of one of the species we collected and identified to family: *Hydropsychidae*.

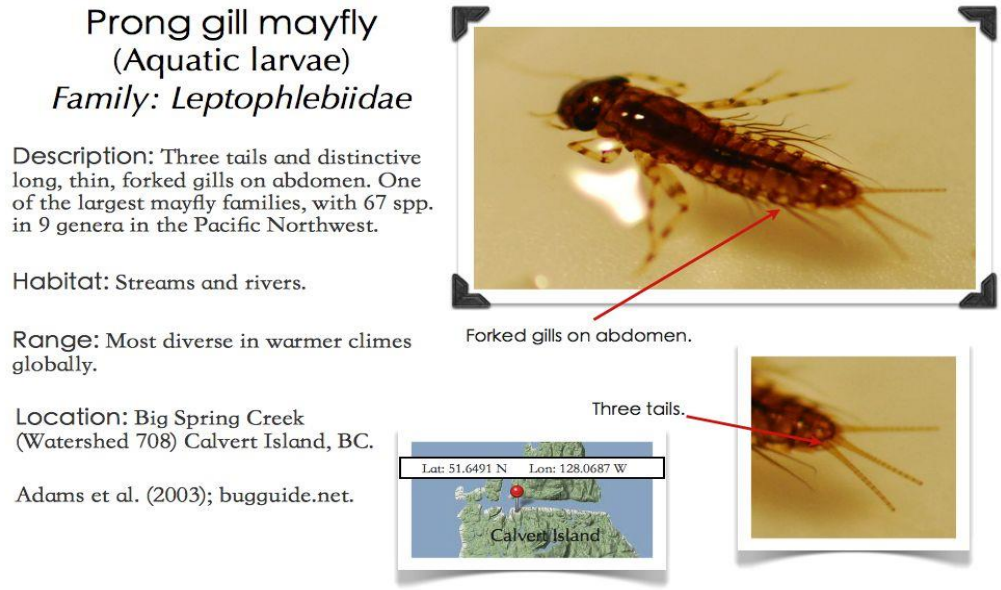


Figure 3: Information and photographs of one of the species we collected and identified to family: *Leptophlebiidae*.

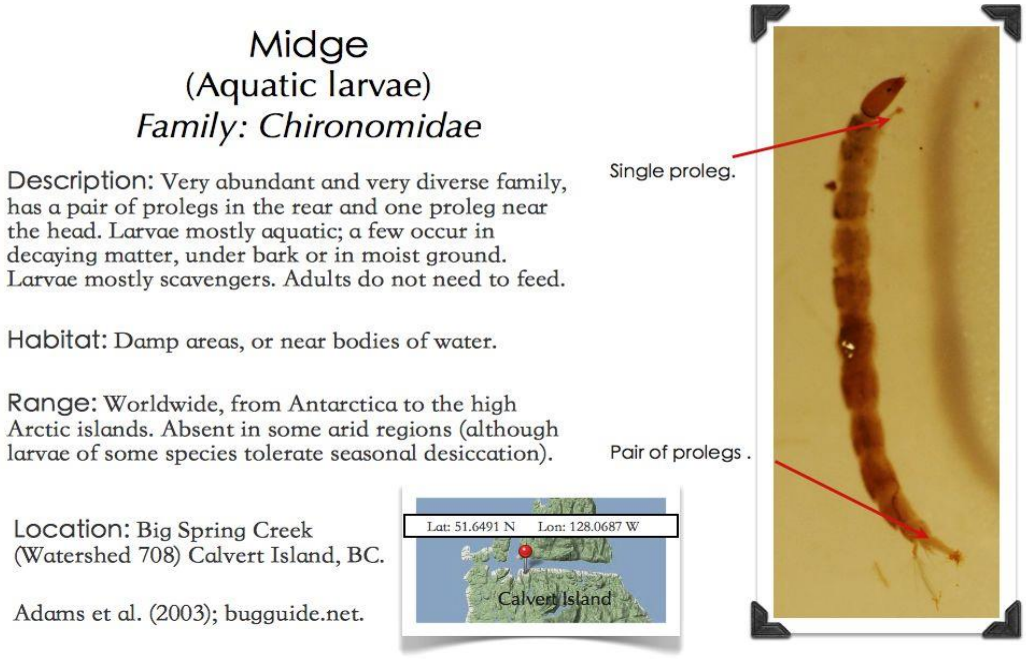


Figure 4: Information and photographs of one of the species we collected and identified to family: *Chironomidae*.

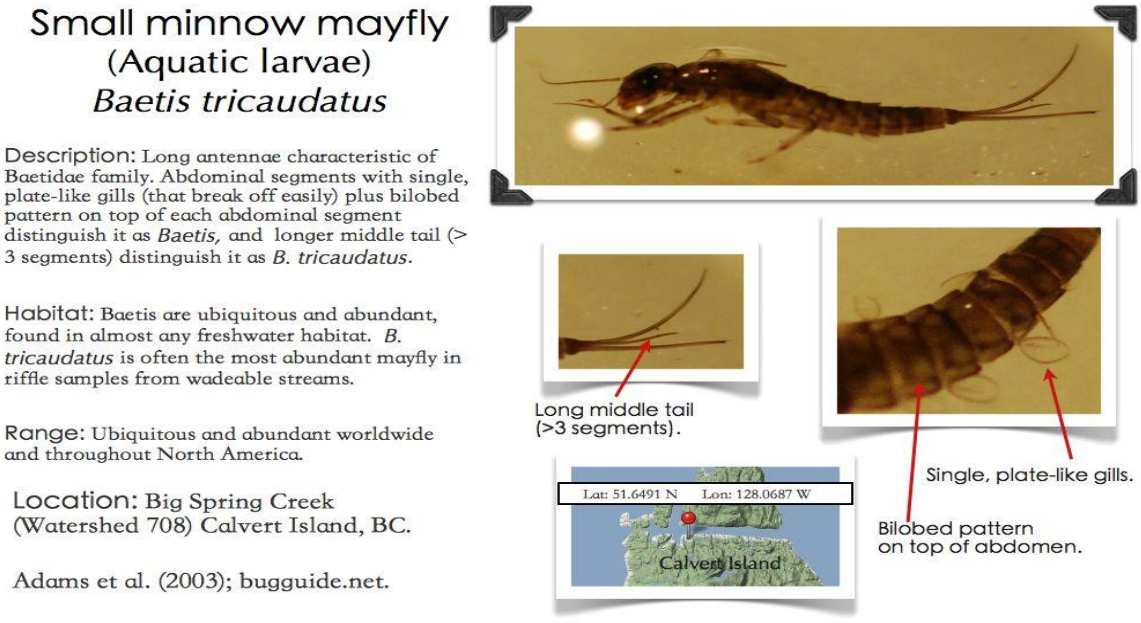


Figure 5: Information and photographs of one of the species we collected and identified to genus and species: *Baetis tricaudatus*.

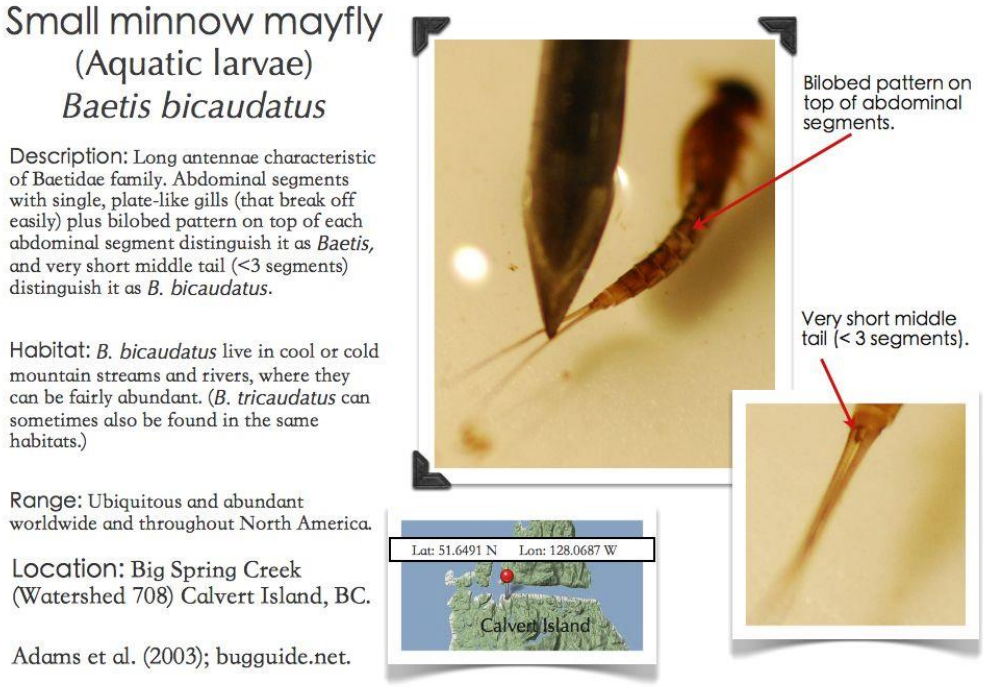
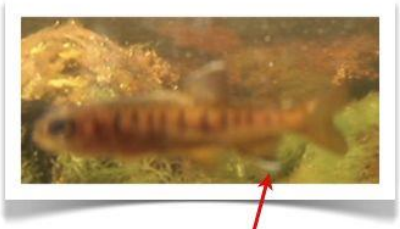


Figure 6: Information and photographs of one of the species we collected and identified to genus and species: *Baetis bicaudatus*.

Coho salmon*
(Juvenile)
Oncorhynchus kisutch

*Movie clip included separately:
Juv Coho Big Spring Crk.AVI or .MOV

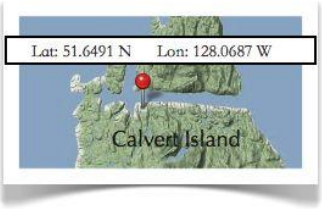
Description: Parr marks narrower than distance between them. Sickle-shaped anal fin with white leading edge. Hakai staff have observed adult coho staging at the mouth of Big Spring Creek in the fall, and remnant fish trap structures indicate presence of historic runs and correspondent use by local First Nations.



Habitat: Spawning habitats are small streams with stable gravel substrates and rearing habitats include small streams and off-channel ponds and wetlands.

Historic Range: North Pacific rim (Japan, eastern Russian, Bering Sea, Alaska, and south to Monterey Bay, California).

Location: Big Spring Creek (Watershed 708) Calvert Island, BC.



Pollard et al. (1997); Hakai staff (pers. comm).

Figure 7: Information and photographs of one of the species we collected and identified *Oncorhynchus kisutch*.