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Benthic macroinvertebrate community comparison of four streams in the Juneau, Alaska, area

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Abstract

A benthic macroinvertebrate bioassessment was completed in 1995 for Steep, Salmon, Gold and Sheep creeks in Juneau, Alaska. This survey was completed to examine any differences in stream benthic communities. Prior benthic surveys were done in areas of logging activity and hardrock mining in Southeast Alaska, but there were no data on local Juneau streams. The four similarly sized creeks selected were located in areas with varying levels of past and present human activities. Benthic samples were collected from five riffle habitats in each creek using a modified Hess stream bottom sampler with a 500-micron mesh net. Sampling was conducted in spring and fall for each creek. Ephemeroptera, Plecoptera, and Tricoptera (EPT) specimens were identified to genera. Specimens from other taxa were identified to at least family level for community similarity indices. Benthic communities of these four streams were compared through quantitative analyses. Data summary included the total EPT genera, total EPT number, EPT/total individual ratio, percent dominant taxa, and a family biotic index (FBI) for taxa tolerance indices. Water quality metrics showed some differences among streams. Steep, Gold and Sheep Creeks are healthy waterbodies with good representation of EPT taxa, a general absence of pollution-tolerant species such as chironomids and oligochates, and overall high taxa richness. Only Salmon Creek has a benthic community that indicates a degree of impairment based on various measures of Ephemeroptera, Plecoptera, and Tricoptera taxa.

Key words: Benthic macroinvertebrates, biomonitoring, Alaska streams, benthic survey, EPT, stream bioassessment, water quality, stream condition

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Acknowledgments

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Introduction

Benthic macroinvertebrate communities are commonly used to evaluate water quality of streams (Fore et. al. 1996). Freshwater benthic investigations are well-suited to assess site-specific effects because many species have limited migration patterns or are sessile. Benthic invertebrate communities will exhibit shifts in species composition over time, reflecting species tolerances of environmental perturbations (Resh and Rosenberg 1984). Stream invertebrates respond to a wide range of disturbances including chemical inputs, temperature changes, sedimentation and organic loading. Unimpaired streams typically support a wide variety of species, particularly from the three taxa that are important indicators of water quality, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies). These three taxa are referred to as EPT, and various metrics of EPT are used to evaluate stream health. Waterbody impairment may be indicated by the absence of these generally pollution-sensitive taxa, or low benthic abundance or limited taxa richness. Diptera (true flies), particularly Chironomids (midges), are commonly more abundant in streams with degraded water quality.

Macroinvertebrate surveys have been applied to bioassessments for creeks in Southeast Alaska including Greens Creek on Admiralty Island (Gabrielson and Milner 1994), the Keta and Blossom Rivers near Ketchikan (Elliott 1980) and five streams on Prince of Wales Island (Milner 1994, Hock and Milner 1997). In 1994, an evaluation of macroinvertebrate assemblages in Gold Creek was conducted after a fish kill (PTI Environmental Services 1994). Macroinvertebrate surveys have also been conducted in Southeast Alaska to assess creek productivity (Wipfli and Gregovich 2002, Wipfli et al. 1999).

Benthic invertebrates are the single most important food source for rearing juvenile salmon and resident salmonids. Pollution that reduces the abundance and diversity of these organisms can also limit salmonid carrying capacity (Elliott 1980). All of the creeks in this study support salmon populations in varying degrees. Rearing and resident salmonids were not assessed in this study.

Macroinvertebrate surveys were conducted during spring and fall of 1995 in four creeks in Juneau, Alaska. Steep, Salmon, Gold and Sheep Creeks selected for this study, were located in areas with different development influences (Fig.1). Of these four creeks, a prior benthic survey had been conducted only in Gold Creek. No other seasonal data on benthic macroinvertebrates for any of these creeks is available.

Steep Creek is located in the Mendenhall Valley and is within the Tongass National Forest. Steep forested mountainsides, such as Thunder Mountain, are in the watershed of Steep Creek. Lower sections of this creek have compaction and creek bank erosion from visitor use, occurring primarily during the late summer and fall to observe spawning salmon. A well-used paved road traverses Steep Creek and parallels a portion of the creek. Bottom substrate was primarily gravel with patches of cobble and sand. The surrounding vegetation for all four creeks is primarily forested, with Sitka spruce and western hemlock as overstory species. Red alder, willows and viburnums are dominant species of the riparian understory. Large woody debris was occasionally found in all of these creeks. Fish species found in Steep Creek are Dolly Varden char, *Salvelinus malma*, and sockeye salmon, *Oncorhynchus nerka* (ADF&G, unpubl. report).

Salmon Creek, located approximately 10 km south of Steep Creek, has adjacent residential and commercial development and is crossed by a heavily used paved road. Bottom substrate was mixed gravel and cobble with smaller sections of sand and boulders. Silt was present at the first station. The surrounding vegetation is forest, with the exception of the lower portion of Salmon Creek; that area is flanked by open grassy vegetation. Chum salmon, *Oncorhynchus keta*, and pink salmon, *Oncorhynchus*

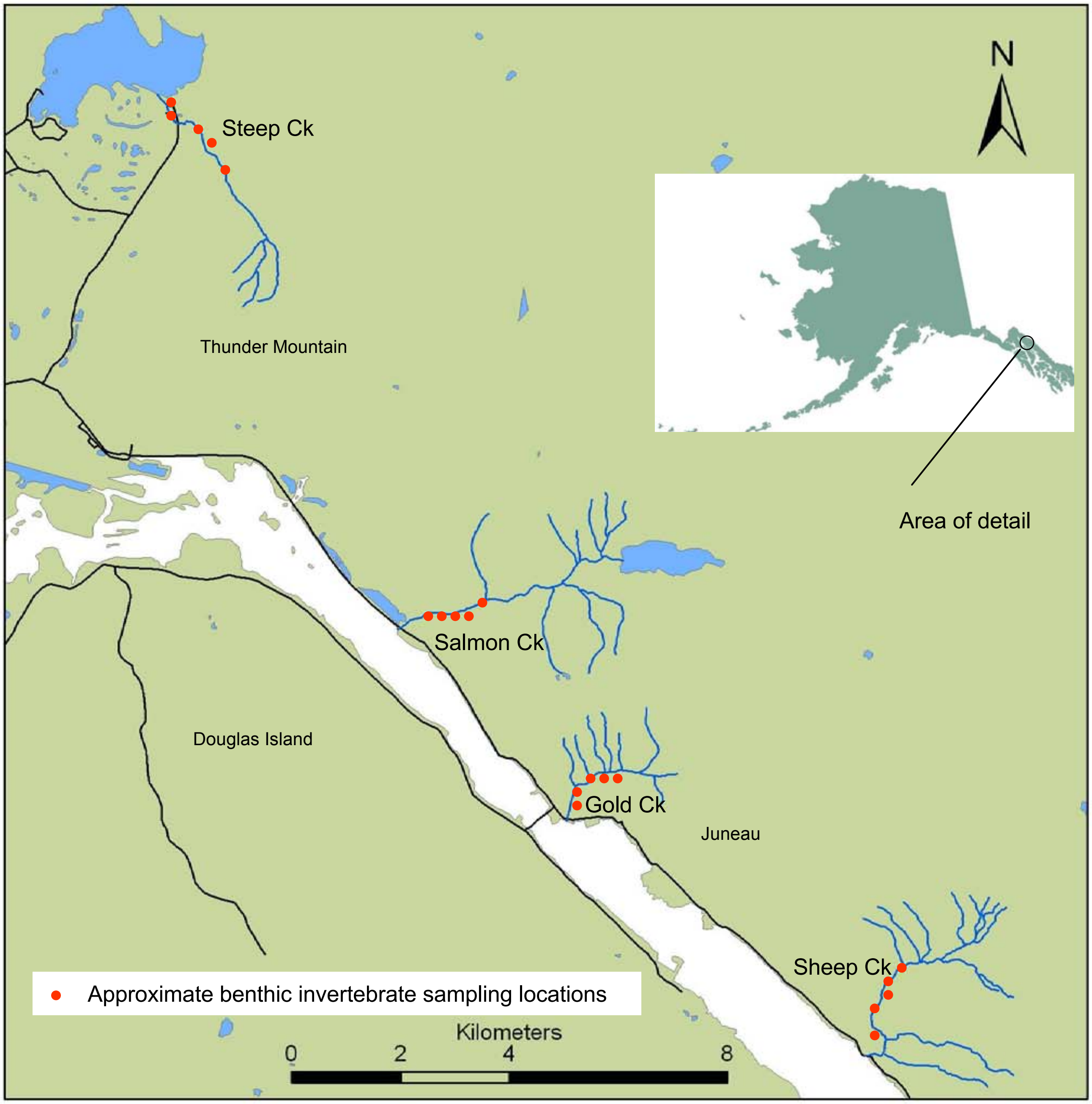

Figure 1. Location map of Steep, Salmon, Gold and Sheep Creeks, Juneau, Alaska.

gorbuscha, are in Salmon Creek. Brook trout, *Salvelinus fontinalis*, are also found in Salmon Creek, originating from early State of Alaska stocking efforts.

Gold Creek is located above downtown Juneau and provides the city's drinking water. There is a dirt road that parallels part of the creek which allows both vehicle and pedestrian use. The road is closed to vehicular traffic during the winter months. Gold mining activity occurred in this area from 1881 to 1912 (Roppel 1983). Only recreational gold panning continues today. Cobble was the primary substrate with gravel and boulders as lesser components. Silt was present at one station. Dolly Varden char, *Salvelinus malma*, and pink salmon, *Oncorhynchus gorbuscha*,are found in Gold Creek (ADF&G, unpubl. report).

Sheep Creek, located approximately 6 km farther south, has a summer season use only dirt road above the lower reaches. A hiking trail parallels part of the creek and the area is primarily undeveloped. Cobble was the dominant substrate at all stations, with gravel as the secondary component. Boulders and sand were present at two stations. Black cottonwood is the dominant overstory riparian species at Sheep Creek. Chum salmon, *Oncorhynchus keta*, pink salmon, *Oncorhynchus gorbuscha*, and Dolly Varden char, *Salvelinus malma*, are found in Sheep Creek (ADF&G, unpubl. report). This area was also the site of gold mining activity, which continued until the early 1940s.

All four creeks support several species of both fresh and saltwater sculpin, *Cottus* spp. Cutthroat trout, *Salmo clarki* are present only below the barriers in Sheep and Gold creeks (D. Gregovich, pers. comm.).

Potential increase in non-point source pollution affecting these creeks could come from a number of sources. The Juneau population continues to grow, creating the need for additional housing, vehicle use, and other associated development. The tourism market is also expanding, and with it there is an increase in the development of scenic use areas. All of these factors may contribute to non-point source pollution to both fresh and marine waters and habitat degradation.

Objectives

1. Characterize the benthic macroinvertebrate community in four local streams to provide baseline data

2. Determine if there are seasonal differences in the benthic macroinvertebrate community by comparing the community structure of these four creeks between spring and fall sampling periods.

3. Determine if there are differences in stream water quality or impairment using macroinvertebrate bioassessment techniques and creek water quality metrics.

4. Provide macroinvertebrate bioassessment information that can be used to determine future stream water and/or habitat quality changes.

Methods

Sample collection

Guidance developed by the EPA for collecting benthic macroinvertebrate samples is discussed in, "Rapid Bioassessment Protocols (RBP) for Use in Rivers and Streams" (Plafkin, et al. 1989). A modification of RBP (Protocol I) was used to collect samples in this study. Samples were collected during late May and late September – early October of 1995. All creeks were accessible from roads and/or trails. Benthic samples were collected from stream riffle habitats by USFWS personnel using a modified Hess stream bottom sampler with a 500-micron mesh net (see photos in Appendix C). Sampling was focused on riffle/run habitat with gravel and cobble substrate because it is generally the habitat with maximum macroinvertebrate diversity (Plafkin et al.1989).

Similar riffle habitats were sampled from each creek (see photos in Appendix C). Substrate for these areas was predominantly a mix of coarse gravel and cobble. We did not quantify streambed substrate composition, but used visual habitat assessment for substrate, vegetation, large woody debris and disturbance estimation. Five stations were sampled in each creek. A station sample was a composite of three grabs randomly selected from a 9-block grid. The sampler was rapidly thrust down and turned into the substrate, imbedding it 5 to 10 cm. The substrate within the sampler was agitated by gloved hands for at least one minute. When they occurred within sampling stations, large rocks or debris were scrubbed with a brush to dislodge specimens into the sampler. All invertebrates and organic material were directed into the collection container of the sampler. Specimens and other collected material were removed from the sampler, put into plastic trays for preliminary debris removal and transferred into sample jars containing a preservative of 70 percent ethyl alcohol. Some coarse organic material was included when it was collected in the sampler.

Water quality data was collected at each sampling grid location during benthic sampling activities using a Hydrolab, Surveyor 3 model. Data collected included water depth (m), temperature (^{o}C), percent dissolved oxygen, specific conductivity (milliSiemens/cm), pH, percent salinity and redox potential. Current was measured at these locations using a Marsh-McBirney flow meter. Stream width was measured with a surveyor's tape. Sample site descriptions included riparian vegetation species present, aquatic vegetation, and creek bottom substrate. Fish species present were noted. All site data were recorded in a waterproof field notebook. Sampling sites were marked with flagging for relocation during the fall sampling period.

Specimen identification

Specimen sorting, identification and counting were completed by a contractor at the University of Alaska, Fairbanks. Ephemeroptera, Plecoptera, and Tricoptera (EPT) specimens were identified to genera. Specimens from other taxa were identified to at least family level for community similarity indices. Benthic communities of these four streams were compared through quantitative analyses. Data summary included the total EPT genera, total EPT number, EPT number/total individual ratio, percent dominant taxa, and a family biotic index (FBI) for taxa tolerance indices based on Hilsenhoff (1988) and E. Major (pers. comm.). A one-way analysis of variance (ANOVA) was used to statistically evaluate differences in benthic metrics among streams.   Stream health was based on these results. The raw invertebrate counts for each creek are attached as Appendix A.

QA/QC

Quality assurance and control was implemented throughout the investigation. Sampling crews used standard protocols. The principal investigator was the primary sample collector during all field efforts. Sampling events at each creek were initiated in the downstream sites, working upstream to avoid substrate disturbance. Sampling locations were marked to allow repeat sampling during the next season. The Hydrolab was calibrated before each sampling effort. All sample identification was completed by the same contract individual and ten percent of the samples were treated as duplicates.

Results and Discussion

Four major invertebrate metrics can be linked with water quality and other stream conditions (Gabrielson and Milner 1994; Table 1). Collectively these metrics characterize a creek's benthic macroinvertebrate community and can be used as a monitoring tool to assess creek conditions over time. Multimetric indices are resistant to natural variability and thus more accurately depict a creek's biological condition, versus use of a single metric, which may be sensitive to slight microhabitat changes (Fore et al. 1996). When comparing streams, these data can be used to rank sites as to their degree of impairment, reflecting potential need for improved management or restoration activities. Fish communities can also be used to look at biotic creek integrity, either alone or in combination with invertebrate metrics, but we chose to only look at invertebrate metrics in this investigation.

Table 1. Range of biotic metrics and their relationship to water quality (Gabrielson and Milner 1994).

Metric	**Range**	**Water Quality**
Number of EPT Genera	0 to ~22	Increasing
EPT/Total Individuals	0 to 1.0	Increasing
% Dominant Taxa	0 to 100	Decreasing
Family Biotic Index	0 to 10	Decreasing

Resident creek biota are sensitive to a range of pollution sources, and some species are tolerant of various perturbations. Invertebrate family tolerances adapted from Hilsenhof, 1988 (Table 2) were used to calculate Family Biotic Index (FBIs), displayed in Table 3, for estimates of pollution tolerance for each creek's benthic community. FBI values of >6.0 identified only Salmon Creek having less than good water quality for both spring and fall periods. Sampling between spring and fall showed differences in species distribution among streams (percent dominant taxa), but this was not necessarily reflected in the other biotic metrics (Table 3). The three numerically most common taxa in all creeks during spring sampling were Heptageniidae, Baetidae and Chironomids, except in Sheep Creek where Ephemerellidae were more numerous than Chironomids (Appendix A). These results are similar to those reported by Wipfli and Gregovich (2002), in their study of 52 small streams in southeast Alaska.

Table 2. Tolerances of invertebrate families to water quality changes on a scale of 0 to 10 [0 = least tolerant, 10 = most tolerant] (Adapted from Hilsenhoff 1988).

Scale	Plecoptera	Ephemeroptera	Tricoptera	Diptera
0	Leuctridae		Glossosomatidae Rhyacophilidae	Blephariceridae
1	Capniidae Chloroperlidae	Ephemerellidae	Brachycentridae	
2	Nemouridae Perlodidae Taeniopterygidae	Leptophlebiidae		
3			Philopotamidae	Tipulidae
4		Baetidae Heptageniidae	Hydropsychidae Limnephilidae	
5				
6			Polycentropodidae	Simuliidae Ampididae Empididae Ceratopogonidae Stratiomyidae
7		Ameletidae		
8				Chironomidae (blood-red) Oligochaeta (not Diptera)
9				
10				Psychodidae

Table 3. Summary of average biotic measures for five sites in each of four creeks in Juneau, Alaska, 1995.

Creek	Site	**Total EPT Genera**		**Total Number EPT**		**EPT/Total Ratio**		**% Dominant Taxa**		**Family Biotic Index**	
		SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL	SPRING	FALL
Steep Creek	1	9	3	61	6	0.71	0.75	31	50	3.66	2.25
	2	11	9	314	94	0.88	0.61	58	28	4.16	4.45
	3	13	16	250	124	0.95	0.90	64	38	3.76	2.88
	4	9	9	173	61	0.64	0.44	40	48	4.85	5.61
	5	11	8	173	24	0.91	0.57	56	29	3.89	4.52
	Creek Aver.	19 (total)	21 (total)	184	67	0.78	0.68	52	39	4.15	4.26
Salmon Creek	1	10	4	61	9	0.07	0.04	81	91	7.45	7.54
	2	10	5	158	8	0.76	0.67	16	17	3.76	2.82
	3	11	4	174	13	0.67	0.68	28	37	4.59	3.33
	4	8	1	24	1	0.38	0.11	36	56	4.90	4.56
	5	9	3	106	3	0.31	0.07	50	62	6.52	6.47
	Creek Aver.	19 (total)	13 (total)	105	7	0.30	0.11	42	53	6.31	6.96
Gold Creek	1	11	4	140	26	0.77	0.74	34	31	4.23	3.17
	2	9	14	70	70	0.80	0.79	42	42	4.27	3.04
	3	7	7	205	26	0.80	0.84	41	35	4.71	2.90
	4	7	7	92	34	0.84	0.92	34	35	4.26	2.65
	5	11	6	95	26	0.81	0.81	36	28	4.55	3.03
	Creek Aver.	21 (total)	16 (total)	122	40	0.80	0.83	37	34	4.52	2.95
Sheep Creek	1	7	9	196	21	0.94	0.72	47	24	4.44	3.69
	2	10	9	160	40	0.96	0.91	56	34	3.72	3.11
	3	12	8	262	33	0.94	0.87	45	21	3.56	3.0
	4	14	16	421	108	0.91	0.92	45	24	3.95	2.58
	5	13	8	485	39	0.97	0.98	57	38	3.65	2.28
	Creek Aver.	18 (total)	22 (total)	306	48	0.94	0.90	50	28	3.73	2.82

Diversity and abundance of EPT genera was high for all creeks, except during fall for Salmon Creek, dropping from a spring total of 105 to 7 EPT (Table 3). Both Steep and Sheep Creek had percent dominant taxa at 50 percent or greater for the spring sampling period. This metric usually indicates more creek impairment with values closer to 100 (Table 1). Upon examining the dominant taxa for these two creeks, mayflies, the most sensitive taxa to water quality degradation, made up 75 and 84 percent, respectively, of each creek's invertebrate assemblage. This indicates excellent water quality. Average percent dominant taxa were lower for Salmon and Gold Creeks. Steep, Gold and Sheep Creeks also had low FBI values (≤ 4.3) indicative of high water quality.

Steep, Sheep and Gold Creeks had the highest EPT/Total ratios, calculated at 7.8 and above. It is unusual for EPT/Total ratios to be close to one, even in the most pristine streams (Gabrielson and Milner 1994). Salmon Creek had the highest Dipteran count (App. A), represented in the low EPT/Total ratio of 0.30, which indicates diminished water quality. Relative abundance of Diptera increased in Virginia streams where watershed urbanization occurred (Jones and Clark 1987). Differences in percent dominant taxa among stations at each creek between spring and fall sampling seasons varied by creek (Figure 2). Percent dominant taxa for Salmon Creek were not significantly different from other creeks, but over 50 percent of the organisms sampled in this creek were Oligochaeta (bristle worms), which are most common in mud of stagnant waters (Klots 1966). In this study, Salmon Creek was the most disturbed by human activity, including removal of riparian vegetation from some areas, and had the greatest likelihood for impairment of the four creeks surveyed. Field notes on physical habitat indicate that more silt, algae and trash was present in Salmon Creek; these variables were not quantified. Salmon Creek's degradation from human activities is reflected in three of its biotic metrics. Many of the water quality metrics were significantly different among these four creeks, but Salmon Creek was not always the most different creek (Table 4). One major perturbation in Salmon Creek is the upstream impoundment, which certainly affects stream temperature, flow regime, and the normal stream food web.

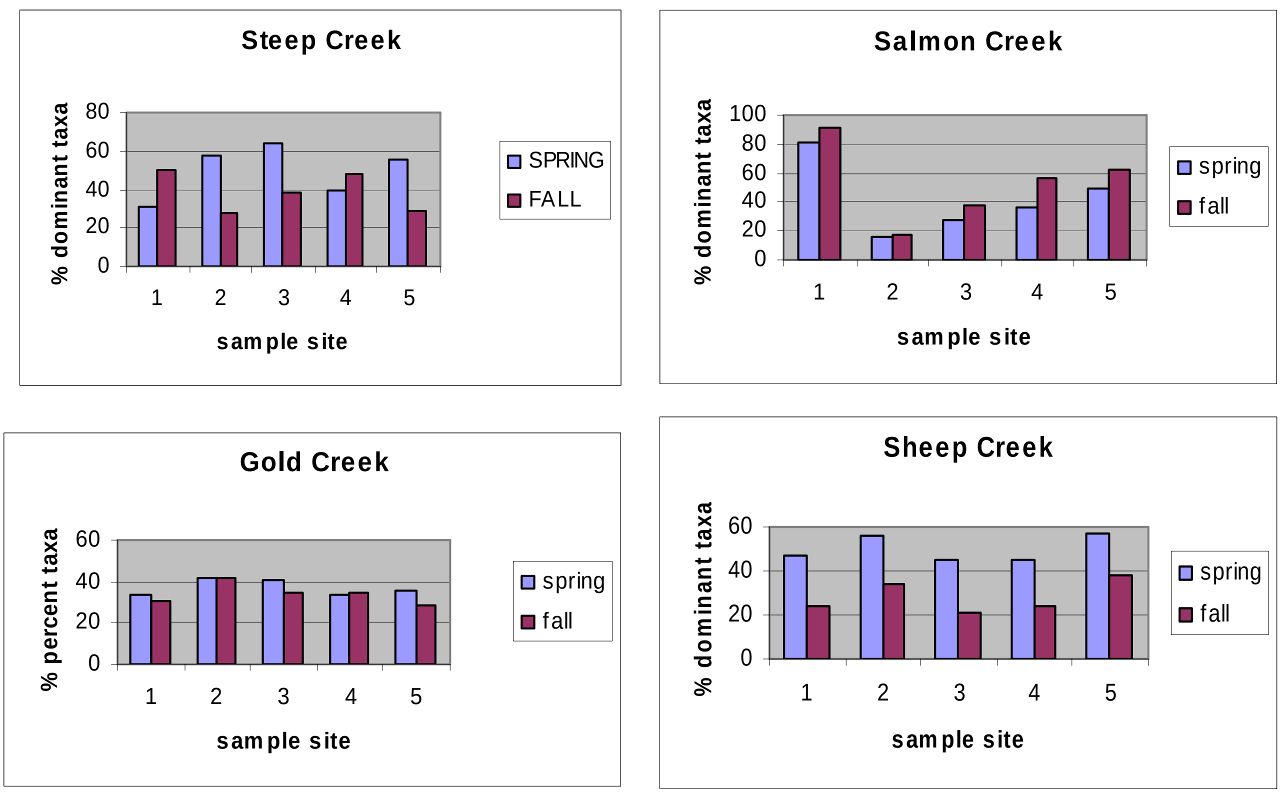

Fig. 2. EPT / Total ratio for Steep, Salmon, Gold and Sheep Creeks, Juneau, Alaska, spring and fall 1995.

Although Gold Creek was severely degraded by placer mining activities from the 1880s, the macroinvertebrate community present indicates recovery to a healthy water body. Photos of Silverbow Basin, the location of Gold Creek, show large hydraulic hoses washing away creek gravel into sluice boxes for gold recovery in the early 1880s (Roppel 1983, Stone and Stone 1980). Sheep Creek Valley was clearcut during mining activities that continued to the 1940s. Forest vegetation has reestablished. This area differs from other creeks in this study in that deciduous trees compose the dominant overstory. If before/after impact (eg. mining, dam construction) data were available for these creeks, those data would have provided a better means of gauging changes in stream health.

Table 4. Invertebrate total counts for four creeks in Juneau, Alaska, in spring (S) and fall (F), 1995.

Steep	Salmon	Gold	Sheep
S 1168 F 483	S 1766 F 301	S 755 F 243	S 1622 F 269

Invertebrate totals (all individuals) for each creek, including EPT, Diptera and other species, were two to six times higher during the spring sampling period. This would be expected due to summer emergence of adults, particularly Ephemeroptera and Diptera, transforming from the aquatic nymph stages found during spring sampling. Salmon and Sheep Creeks had the highest spring invertebrate totals (Table 4), but did not have corresponding higher fall numbers. Biotic measurements from the spring sampling period showed more differentiation among creeks than data from the fall sampling period (Table 5). The explanation for this difference can only be speculative that heterogeneity in the streams' environmental conditions, such as amount of organic material, number of downed logs, etc., which were noted but not quantified, was also large. A study by Benke et al. 1984, found snags supported more biomass of invertebrates than did mud or sand habitats. A number of studies have demonstrated the importance of detritus (Egglishaw 1964, Reice 1980, Rabeni and Minshall 1977) to the aquatic invertebrate community.

Table 5. Summary of average stream measures for four creeks in Juneau, Alaska, in spring (S) and fall (F), 1995.

	width (m)	depth (m)	% DO	Temp C	conduct.	pH	redox	current	% salinity
Steep Ck S	6.3	0.37	97.87	4.9	0.13	9.13	14.52	1.33	0
Steep Ck F	4.2	0.23	97.85	9.6	0.10	8.62	14.07	0.31	0
Salmon Ck S	11.8	0.40	94.03	5.2	0.09	8.31	14.47	1.96	0
Salmon Ck F	11.0	0.32	97.92	9.4	0.10	9.05	13.83	0.34	0
Gold Ck S	10.0	0.41	92.35	5.2	0.16	8.44	14.46	2.71	0.08
Gold Ck F	12.0	0.21	97.68	7.0	0.12	8.79	13.73	0.52	0.05
Sheep Ck S	7.4	0.21	88.35	4.1	0.10	8.47	14.49	2.39	0
Sheep Ck F	8.7	0.12	97.75	7.1	0.08	8.66	11.26	0.61	0

Although all four creeks support salmonids, barriers to upstream salmon movement are present below our sampling locations at both Gold and Sheep Creeks. Based on work by Wipfli *et al.* (1998, 1999), we could expect higher invertebrate density in streams with salmon carcasses. This was not the case here as invertebrate and EPT totals were not significantly greater in Steep and Salmon Creeks. However, chironomid numbers were greater in Steep and Salmon Creeks during the spring sampling period. Wipfli *et al.* (1999) reported chironomids increased in streams with greater numbers of salmon carcasses.

The most significant metrics were related to EPT numbers. The ratio of EPT species to total number of organisms was the most significant metric during both spring and fall sampling periods ($p = 0.001$), showing that benthic communities differed among streams (Table 6). Percent dominant taxa was not a suitable biometric to distinguish differences in creek benthic macroinvertebrate communities.

Comparison with biotic measures from three creeks on Prince of Wales Island (POW) (Hock and Milner 1997), showed some differences between these two locations in Southeast Alaska. The Juneau creeks in our study had almost double the number of EPT genera but had similar EPT/Total ratios, excepting Salmon Creek which was much lower. Percent dominant taxa were in similar ranges at 32 – 55 (POW) versus 37 – 52 (Juneau) for both locations, while FBI was generally higher in the Juneau creeks. The Prince of Wales Island creeks were similar in water quality metrics to the Juneau creeks, but one POW creek had a history of timber harvest. That creek did have two metrics that indicated a degree of impairment (Hock and Milner 1997).

Table 6. F and p values for a one-way ANOVA to test for significant differences for a number of biotic measures among five sites each at four Juneau, Alaska creeks during spring and fall sampling periods 1995.

Metric	F Value - spring	p Value - spring	F Value - fall	p Value - fall
Total No. of EPT	4.168	0.016**	2.796	0.074
EPT/Total Ratio	9.752	0.001**	8.360	0.001***
% Dominant Taxa	0.877	0.474	2.025	0.122
FBI	4.304	0.021*	2.927	0.066
No. of EPT Genera	3.305	0.047*	3.403	0.043*

* significant at $p \leq 0.05$; ** significant at $p \leq 0.01$; ** *significant at $p \leq 0.001$

Major *et al.* (2003) examined benthic communities in 51 Southeast Alaska streams; 14 of these were in the Juneau area. Some streams in that study were considered stressed while the majority were reference streams. In the Juneau area reference streams, the EPT total genera ranged from 11 to 21, while the stressed streams ranged from 3 to 13. Our Juneau streams had 18 to 21 EPT total genera, comparable to their reference streams. Our percent dominant taxa for each creek (37 to 52), was also in the range of that study's reference streams of 19 to 55. Comparing these two studies, our Juneau streams match the metrics of reference streams in that study, with only Salmon Creek's 30 percent EPT comparable to that study's stressed streams (range of 1 to 35). Percent EPT in our other three creeks was 78 to 94, matching the range of 40 to 95 that Major *et al*. (2003) found in their reference streams.

There were no apparent trends in invertebrate species richness either increasing or decreasing in an upstream pattern (Fig. 2). Downstream invertebrate populations are often found to be greater in abundance (Allen 1996).

Conclusions and Recommendations

Steep, Gold and Sheep Creeks are healthy waterbodies based on the biological data collected in this study. Benthic invertebrate metrics show minor differences among these three creeks. These three creeks had good representation of EPT taxa, a general absence of pollution-tolerant species such as chironomids and oligochates, and overall high taxa richness. Steep, Gold and Sheep Creeks' benthic invertebrate metrics were comparable to reference streams from other Southeast Alaska studies (Hock and Milner 1997, Major *et al*. 2003, Wipfli and Gregovich 2002). Only Salmon Creek had a benthic community that indicated a degree of impairment. Higher chironomid numbers in Steep and Salmon Creeks may represent greater salmon carcass nutrient loading in these creeks. Salmon can travel further upstream in both of these creeks than in Gold and Sheep Creeks. Water quality metrics were different among creeks, but did not indicate any water quality problems. Data from this study document 1995 stream conditions and they can be used for comparative purposes with benthic data from future sampling.

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Appendix A.

Benthic macroinvertebrate species data for Steep, Salmon, Gold and Sheep Creeks, Juneau, Alaska, 1995

Steep Creek macroinvertebrates 15 - 16 May 1995									
Order	Family	Tolerance Value	Taxa	Steep Ck 1	Steep Ck 2	Steep Ck 3	Steep Ck 4	Steep Ck 5	Total
EPHEMEROPTERA									
	Baetidae	4	Baetis	10	64	43	15	39	171
	Ephemerellidae	1	Drunella	1		1			2
		1	Serratella		20	8	10	1	39
	Heptageniidae	4	Cinygmula	27	206	167	109	107	616
		4	Epeorus		7	6	6	4	23
		4	Rithrogena	3	6	5		3	17
	Leptophlebiidae	2	Paraleptophlebia	1					1
	Total								869
PLECOPTERA								2 un.	2
	Capniidae	1	Capnia				1		1
		1	Paracapnia	1					1
	Chloroperlidae	1	Paraperla	6	2	2	1	5	16
		1	Utaperla	11	2	2	21	3	39
	Leutridae	1	Megaleutra					1	1
		1	Periomyia			1		2	3
	Nemouridae	2	Podmosta			1			1
		2	Zapada	1	3	3	7		14
	Taeniopterygidae	2	Taenionema		2				2
	Total								80
TRICOPTERA									
	Limnephilidae	4	Apatania			1			1
	Polycentropodida	6	Polycentropus		1				1
	Rhyacophilidae		Rhyacophila		1	10	3	8	22
	Total								24
DIPTERA									
	Chironomidae	8		9	30	2	84	7	132
	Empididae	6		1	9	3	2	2	17
	Simuliidae	6			1			1	2
	Tipulidae	3		13	2	3	6	4	28
	Total								179
ANNELIDA	Oligochaetae	8		2	1	4	5	4	16
	Total								16
Total EPT				61	314	250	173	173	920
Total organisms				86	357	262	270	191	1168
EPT/Total				0.71	0.88	0.95	0.6	0.9	0.78
% Dominant Taxa				31	58	64	40	56	52
FBI value									4.15

Steep Creek macroinvertebrates 28 September 1995

Order	Family	Toler. Value	Taxa	Steep Ck 1	Steep Ck 2	Steep Ck 3	Steep Ck 4	Steep Ck 5	Total
Ephemeroptera			unknown		7	1			8
	Ameletidae	7	*Ameletus*				2		2
	Baetidae	4	*Baetis*	1	3	2			6
	Ephemerellidae	1	*Drunella*		2				2
	Ephemerellidae	1	*Eurylophella*				3		3
	Heptagenlidae	4	*Cinygmula*		43	22	26	5	96
	Heptageniidae	4	*Epeorus*			5		1	6
	Leptophlebiidae	2	*Paraleptophlebia*			2			2
	Siphlonuridae	7	*Parameletus*			2		1	3
Total									128
Plecoptera			unknown			6			6
	Capniidae	1	*Capnia*				6		6
	Capniidae	1	*Paracapnia*				7		7
	Chloroperlidae	1	*Kathroperla*			1			1
	Chloroperlidae	1	*Plumiperia*		1				1
	Chloroperlidae	1	*Utaperia*		11	16	1	5	33
	Leuctridae	0	*Perlomyia*			2			2
	Nemouridae	2	*Zapada*	4	22	53	12	7	98
	Perlodidae	2	*Perlinodes*			1			1
Total									155
Trichoptera			unknown			3			3
	Hydropsychidae	4	*Parapsyche*		1				1
	Linmephilidae	4	*Ecclisomyia*			4	3	1	8
	Polycentropodidae	6	*Polycentropus*		4		1		5
	Rhyacophilidae	0	*Himalopsyche*			1		1	2
	Rhyacophilidae	0	*Rhyacophila*	1		3		3	7
Total									26
Diptera	Chironomidae	8			38	8	67	12	125
	Chironomidae (pupae	8						1	1
	Empididae	6			3	2	1		6
	Simuliidae	6				1			1
	Tipulidae	3		2	10	1	1		15
Total									148
Annelida	Oligochaetae	8			4	1	8	4	17
Total									17
Mollusca					4	1	1		6
Total									6
Nematoda					1				1
Total									1
Arthropoda	Arachnida						1		1
Total									1
Hemiptera								1	1
Total									1
Total EPT				6	94	124	61	24	329
Total Organisms				8	154	138	140	42	483
EPT/Total				0.75	0.61	0.9	0.44	0.57	0.68
% Dominant Taxa				50	28	38	48	29	39
FBI Value									4.31

Salmon Creek macroinvertebrates 16, 17, 23 May 1995									
Order	Family	Tolerance Value	Taxa	Salmon Creek 1	Salmon Creek 2	Salmon Creek 3	Salmon Creek 4	Salmon Creek 5	Total
EPHEMEROPTERA									
	Baetidae	4	*Baetis*	10	30	47	7	32	126
	Ephemerellidae	1	*Drunella*		1	1			2
		1	*Seffatelia*		9	15		6	30
	Heptageniidae	4	*Cinygmula*	6	32	28	4	25	95
		4	*Epeorus*	9	34	55	2	36	136
		4	*Rithrogena*			2	5		7
	Leptophlebiidae	2	*Paraleptophlebia*				1		1
Total									397
PLECOPTERA							1 adult	3 un.	4
	Capniidae	1	*Capnia*	4	28		1		33
	Chloroperlidae	1	*Plumiperla*	2	6		3		11
		1	*Utapeila*	2	5	17	1	1	26
	Leuctridae		*Leutra*		12				12
			Megaleutra	24				4	28
			Perlomyia			3			3
	Nemouridae	2	*Zapada*			2		1	3
Total									120
TRICOPTERA									
	Glossomatidae		*Glossosoma*			3			3
	Hydropsychidae	4	*Parapsyche*	1		1			2
	Philopotamidae	3	*Wormaldia*					1	1
	Polycentropodidae	6	*Polycentropus*	1					1
	Rhyacophilidae		*Rhyacophila*	2	1				3
Total									10
DIPTERA									
	Blephariceridae					1			1
	Chironomidae	8		77	13	73	23	52	238
	Empididae	6		8	1	1		1	11
	Tipulidae	3		24	9	12	16	12	73
Total									323
ANNELID/	Oligochaeta	8		718	27			169	914
Total									914
COLLEMBOLA				1					1
Total									1
MILLIPEDIA					1				1
Total									1
Total EPT				61	158	174	24	106	527
Total Organisms				889	209	261	63	340	1766
EPT/Total				0.07	0.76	0.67	0.38	0.31	0.3
% Dominant Taxa				81	16	28	36	50	42
FBI value (creek)									6.31

Salmon Creek macroinvertebrates 28 September 1995									
Order	Family	Tolerance Value	Taxa	Salmon Creek 1	Salmon Creek 2	Salmon Creek 3	Salmon Creek 4	Salmon Creek 5	Total
Ephemeroptera	unknown				1				1
	Heptageniidae	4	*Cinygmula*	1					1
	Heptageniidae	4	*Rithrogena*		2	7	1	1	11
Total									13
Plecoptera	Capniidae	1	*Paracapnia*		2				2
	Chloroperlidae	1	*Plumiperla*		1				1
	Chloroperlidae	1	*Utapeda*	1	2				3
	Nemouridae	2	*Zapada*	6		4		1	11
Total									17
Trichoptera			unknown	1					1
	Brachycentridae	1	*Micrasema*					1	1
	Glossosomatidae		*Glossosoma*			1			1
	Polycentropodidae	6	*Polycentropus*			1			1
Total									4
Diptera	Ceratopogonidae	6				1			1
	Ceratopogonidae (adu	6				1			1
	Chironomidae	6		2	1	1		6	10
	Chironomidae (pupae)	6					1		1
	Empididae	6		1	1			1	3
	Tipulidae	3		6	2	1	5	6	20
	Tipulidae (adult)	3				1			1
Total									37
Annelida	Oligochaetae	8		197			2	28	227
Total									227
Arthropoda	Amphipoda (adult)			1					1
	Arachnida					1			1
	Crustacea							1	1
Total									3
Total EPT				9	8	13	1	3	34
Total Organisms				216	12	19	9	45	301
EPT/Total				0.04	0.67	0.68	0.11	0.07	0.11
% Dominant Taxa				91	17	37	56	62	53
FBI value (creek)									6.96

Gold Creek macroinvertebrates 17 - 18 May 1995									
Order	Family	Tolerance Value	Taxa	Gold Ck 1	Gold Ck 2	Gold Ck 3	Gold Ck 4	Gold Ck 5	Total
Ephemeroptera	Ameletidae	7	Ameletus		1				1
	Baetidae	4	Baetis	53	37	106	37	42	275
	Ephemerellidae	1	Serratella					6	6
	Heptageniidae	4	Cinygma		2				2
	Heptageniidae	4	Cinygmula	62	17	83	37	23	222
	Heptageniidae	4	Epeorus	3	2	5	6	9	25
	Heptageniidae	4	Ironodes	1					1
	Heptageniidae	4	Rhithrogena	10	2		2	1	15
	Siphloneuridae	7	Parameletus			3		4	7
Total									554
Plecoptera	Capniidae	1	Paracapnia		1		8	3	11
	Chloroperlidae	1	Haploperia			5			5
	Chloroperlidae	1	Plumiperia		7				7
	Chloroperlidae	1	Utaperla			2			2
	Leuctridae	0	Megaleutra	4			1	4	9
	Nemouridae	2	Zapada	3				1	4
	Perlodidae	2	Megarcys	1					1
	Taeniopterygidae	2	Taenionema	1					1
Total									40
Trichoptera	Brachycentridae	1	Micrasema	1	1		1		3
	Limnephilidae	4	Ecocosmoec	1					1
	Polycentropodidae	6	Polycentropus			1			1
	Rhyacophilidae	0	Rhyacophila					1	1
	unknown							1	1
Total									7
Diptera	Chironomidae	8		3 +2 adult	6	14	5	18 +1 adult	49
	Empididae	6		4	6	1			12
	Simuliidae	6		27	1	1		1	30
	Tipulidae	3		3	2	1			11
Total								3	105
Annelida	Oligochaetae	8		2	3	35	10		50
Coleoptera				1					1
Nematoda				1					1
Total									
Total EPT				140	70	205	92	95	601
Total Organisms				181	88	257	110	117	758
EPT/Total				0.77	0.8	0.8	0.84	0.81	0.8
% Dominant Taxa				34	42	41	34	36	37
FBI value (creek)									4.52

Gold Creek macroinvertebrates 2 October 1995									
Order	Family	Tolerance Value	Taxa	Gold Ck 1	Gold Ck 2	Gold Ck 3	Gold Ck 4	Gold Ck 5	Total
Ephemeroptera	Ameletidae		Ameletus		1	1			2
	Baetidae	4	Baetis		3		1		4
	Ephemerellidae	1	Drunella	1	7	2	4	1	15
	Heptageniidae	4	Cinygmula		1	1			2
	Heptageniidae	4	Rhithrogena	8	8	9	13	8	46
Total									69
Plecoptera	Capniidae	1	Capnia	11	37	11	13	9	81
	Chloroperlidae	1	Utaperla		1	1	1	2	5
	Nemouddae	2	Zapada		4			2	6
	Perlodidae	2	Megarcys			1	1		21
Total									113
Trichoptera	Brachycentridae	1	Micrasema		1				1
	Linmephilidae	4	Ecclisomyia		1			4	5
	Linmephilidae	4	Moselyana		2				2
	Philopotamidae	3	Wormaldia		2				2
	Polycentropodidae	6	Polycentropus		1				1
	Psychomyiidae	2	Psychomyia		1				1
	Rhyacophilidae	0	Rhyacophila	6			1		7
Total									19
Diptera	Chironomidae	8		5	17	3	2	3	30
	Empididae	6				1	1		2
	Tipulidae	3		1	2	1		3	7
Total									39
Annelida	Oligochaetae	8		3					3
Total									3
Total EPT				26	70	26	34	26	201
Total Organisms				35	89	31	37	32	243
EPT/Total				0.74	0.79	0.84	0.92	0.81	0.83
% Dominant Taxa				31	42	35	35	28	34
FBI value									2.95

Sheep Creek macroinvertebrates 22 May 1995									
Order	Family	Tolerance Value	Taxa	Sheep Ck 1	Sheep Ck 2	Sheep Ck 3	Sheep Ck 4	Sheep Ck 5	Total
EPHEMEROPTERA									
	Baetidae	4	*Baetis*	98	93	126	209	102	628
	Ephemerellidae	1	*Drunella*	9	7	14	16	23	69
	Heptageniidae	4	*Cinygmula*	75	44	68	139	285	611
		4	*Epeorus*	2		2	3	17	24
		4	*Ironodes*				1		1
		4	*Rithrogena*	3	1	10	12	7	33
	Siphioneuridae	7	*Parameletus*					1	1
Total									1367
PLECOPTERA							2 un.		2
	Capniidae	1	*Capnia*					1	1
	Chloroperlidae	1	*Katroperia*		6	20			26
		1	*Paraperia*				9	21	30
		1	*Suwalia*				2		2
		1	*Utaperla*		2	5	13	7	27
	Leuctridae	0	*Megaleutra*		1				1
	Nemouridae	2	*Zapada*	3	1	1	1	3	9
Total									98
TRICOPTERA							1 un.	2 un.	3
	Brachycentridae	1	*Micrasema*		2	10	1	3	16
	Lepidostomatidae	1	*Lepidostoma*			1			1
	Limnephilidae	4	*Apatania*			1			1
	Rhyacophilidae	0	*Rhyacophila*	6	3	4	15	15	43
Total									64
DIPTERA							2 un.		2
	Chironomidae	8		2	4	11	27	10	54
	Empididae	6		1	1	1	2	3	8
	Simuliidae	6				1	1		2
	Tipulidae	3		8		4	2	2	16
Total									82
OLIGOCHAETA				2	1		8		11
Total									11
Total EPT				196	160	262	421	485	1529
Total Organisms				209	166	279	461	500	1622
EPT/Total				0.94	0.96	0.94	0.91	1	0.94
% Dominant Taxa				47	56	45	45	57	50
FBI value (creek)									3.73

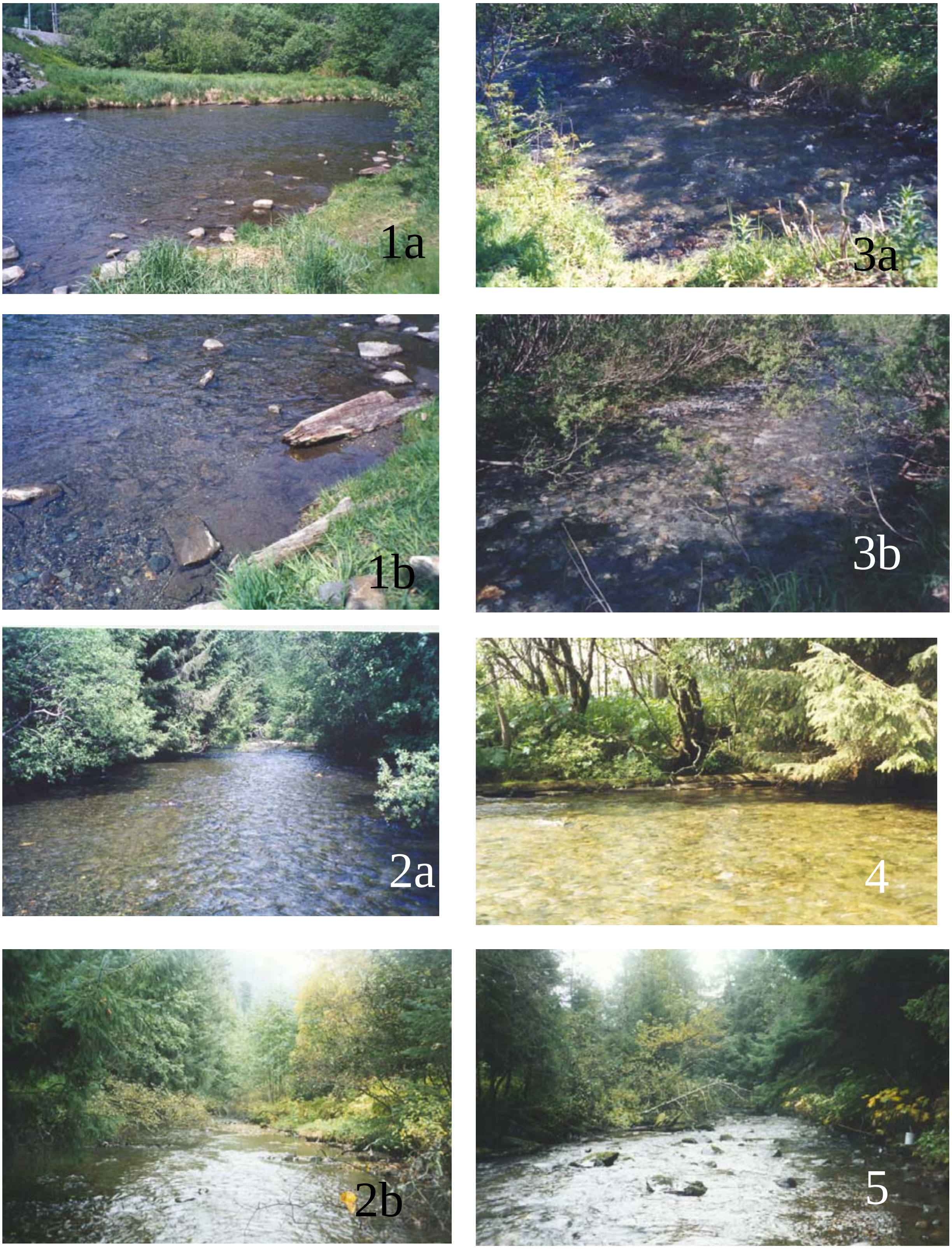
Sheep Creek macroinvertebrates 3 October 1995									
Order	Family	Tolerance Value	Taxa	Sheep Creek 1	Sheep Creek 2	Sheep Creek 3	Sheep Creek 4	Sheep Creek 5	Total
Ephemeroptera	unknown						1		1
	Ameletidae	7	*Ameletus*	2	1		2		5
	Baetidae	4	*Baetis*				1		1
	Ephemerellidae	1	*Caudatella*				3		3
	Ephemerellidae	1	*Drunella*			3	22	2	27
	Ephemerellidae	1	*Eurylophelia*			1			1
	Heptageniidae	4	*Cinygmula*				2		2
	Heptageniidae	4	*Rithrogena*	4	13	8	28	15	68
Total									108
Plecoptera	Capniidae	1	*Capnia*	2	15	6	21	10	54
	Capniidae	1	*Paracapnia*	1					1
	Chloroperlidae	1	*Utapeda*	6		6	4	6	22
	Chloroperlidae	1	*Suwallia*		2		3	1	6
	Nemouridae	2	*Zapada*	1	3		2	1	7
	Perlodidae	2	*Megarcys*		1		1		2
	Perlodidae	2	*Skwala*					2	2
Total									94
Trichoptera	Brachycentridae	1	*Micrasema*		1				1
	Hydroptilidae	4	*Neotrichia*	1					1
	Limnephilidae	4	*Ecclisomyia*		2		1		3
	Limnephilidae	4	*Moselyana*			6			6
	Limnephilidae	4	*pupae*			1			1
	Polycentropodidae	6	*Polycentropus*	1	2		5		8
	Rhyacophilidae	0	*Himalopsyche*				10		10
	Rhyacophilidae	0	*Rhyacophila*	3		2	2	2	9
Total									39
Diptera	Chironomidae	8		7	3	2	3	1	16
	Empididae	6				1			1
	Stratiomyidae	6					3		3
Total									20
Annelida	Oligochaetae	8			1	2	4		7
Total									7
Coleoptera				1					1
Total									1
Total EPT				21	40	33	108	39	241
Total Organisms				29	44	38	118	40	269
EPT/Total				0.72	0.91	0.87	0.92	0.98	0.9
% Dominant Taxa				24	34	21	24	3705	28
FBI value (creek)									2.66

Appendix B.

Photos of sampling locations in Juneau, Alaska creeks

Sampling methods; 1-flow meter, 2- Hydrolab, 3a,b Modified Hess creek bottom sampler, 4- gross sorting, 5- organic debris in sample

Steep Creek sampling locations, Sept. 27 & 28, 1995.



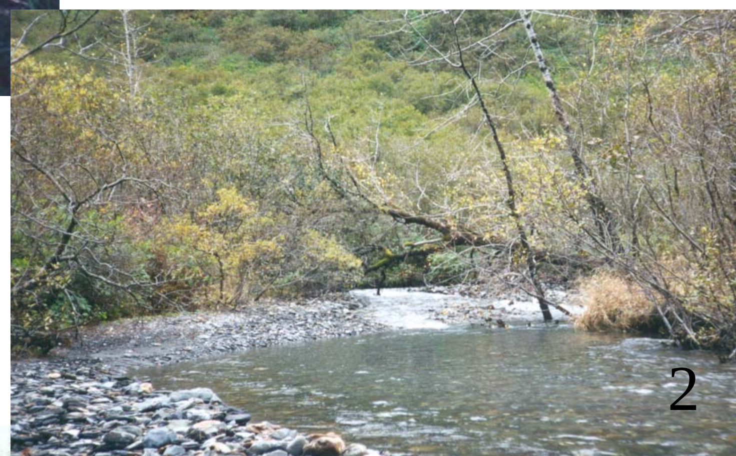
Salmon Creek sampling locations 1995 (a & b are different views of same location).

Salmon Creek; 1- falls at creek head; 2- creek mouth flowing into Gastineau Channel.

Gold Creek macroinvertebrate sampling sites No.1 – May 17&19,1995; No.2-5 Oct.2, 1995

Gold Creek sampling locations, Oct.2, 1995

Sheep Creek sampling locations, fall (1-3), spring (4)



Sheep Creek sampling areas, spring (1) and fall (2-4)