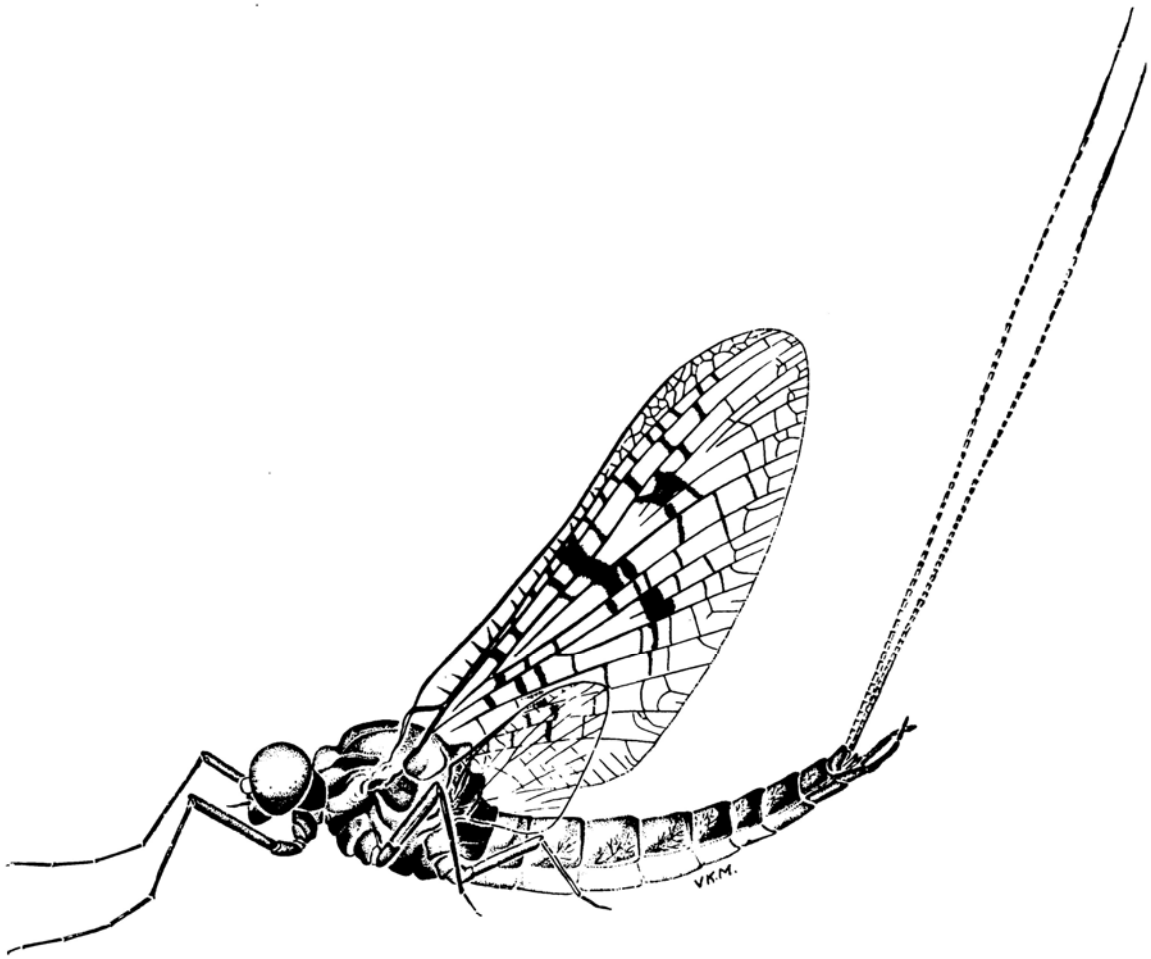
Technical Report No. 03-05

Aquatic Baselines Sampling, Wulik River Drainage. Volume I: Summary of Biological and Water Quality Information

by Phyllis Weber Scannell and Alvin G. Ott



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Office of Habitat Management and Permitting

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Acknowledgments

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Executive Summary

This report summarizes data collected on water quality, periphyton, benthic invertebrates, and fish in streams located in the vicinity of the Anarraaq Prospect. All major stream systems potentially affected by development of the Anarraaq Prospect were sampled.

The report is divided into two sections: Tributaries to the Ikalukrok Creek Drainage and tributaries to the Wulik River drainage. Tabulated data for each stream sampled are presented in the appendices.

Ikalukrok Creek Drainage

Overall water quality was highest in Grayling Junior Creek, followed by East Fork Ikalukrok Creek, Sled Creek, North Fork Red Dog Creek, and Ikalukrok Creek upstream of the West Fork. Sites with the most degraded water quality (ordered from highest concentrations of metals) were Ikalukrok Creek at Cub Creek, Moil and Noa creeks, and West Fork of Ikalukrok Creek.

In general, sites with the highest concentrations of chlorophyll-a also had the best water quality: highest concentrations of chlorophyll-a were found in East Fork Ikalukrok Creek, Ott Creek, North Fork Red Dog Creek, Sled Creek, and Grayling Junior Creek (ordered from highest to lowest). Chlorophyll-a concentrations were near zero at Stations 207, 211, and 210 and increased slightly at Stations 206 and 205.

Invertebrate abundance (as drift, Figure 5) was highest in clear water Stations 206 and 208 and impaired Station 207 (downstream of Station 206). When counts are adjusted for volumes of water, Station 206 had substantially higher invertebrate densities than any of the other sites.

No fish were found in Ikalukrok Creek upstream of West Fork, West Fork of Ikalukrok Creek, Noa Creek, Moil Creek, Sled Creek or Ott Creek. Fish were excluded from Sled

Creek and Ott Creek because both creeks flowed underground before connecting to downstream Ikalukrok Creek. We believe that fish were excluded from West Fork Ikalukrok Creek, Noa Creek and Moil Creek by poor water quality and from Ikalukrok Creek upstream of West Fork by poor downstream water quality near the Cub Creek seep. Only 1 fish was found in Ikalukrok Creek at Station 207, this Arctic grayling appeared stressed and in poor condition.

Wulik River Drainage

Overall, Square Creek (Sta. 214), Sunday Creek (Sta. 215), and Oak Creek (Sta. 216) had the lowest concentrations of metals and the best water quality for aquatic life. Sourdock Creek (Sta. 214) also had good water quality, but a few samples had slightly elevated Cd. Ferric Creek (Sta. 213) contained elevated concentrations of Al and Fe; otherwise the water quality was good. Water quality was most degraded in Competition Creek, upstream of Sourdock Creek.

Primary production, as estimated by concentrations of chlorophyll-a was near detection at Competition Creek, upstream of Sourdock Creek and low in Sunday Creek. Chlorophyll-a concentrations were highest in Sourdock Creek and Ferric Creek.

Aquatic invertebrate abundance as drift was highest in Ferric Creek and Competition Creek upstream of Sourdock Creek. When invertebrate counts are adjusted for volume of water flowing through drift nets, invertebrate density in Square Creek is similar to Ferric Creek and Competition Creek upstream of Sourdock Creek. Numbers of distinct taxa groups were similar among sites.

Juvenile Dolly Varden were found in all sampling sites in the Wulik River drainage, although more fish were trapped in Sourdock Creek than the other sites. Larval Dolly Varden were found in invertebrate drift nets in Ferric, Square, and Sunday creeks. The presence of larval fish is evidence of Dolly Varden spawning in these systems.

Introduction

TeckCominco Alaska Inc. (TCAK) has conducted geotechnical work in uplands in the Ikalukrok Creek and Wulik River drainages for a number of years. Drilling during summer 2000 focused on the Anarraaq Prospect located in Section 23, T32N, R19W (De Long Mountains A-2), and some drilling was done to the west of the Wulik River.

Working in cooperation with TCAK, the Alaska Department of Fish and Game (now Alaska Department of Natural Resources, Office of Habitat Management and Permitting) identified sample sites for collection of baseline data in areas with possible mineral prospects and in control areas where mineral development is not expected to occur. Our objective was to collect environmental data on stream hydrology, water quality, periphyton, benthic invertebrates, and fish to describe conditions before any substantial land surface activities.

Locations of Sample Sites

Biomonitoring began in early July 2000 at nine sites in streams adjacent to and downstream of the Anarraaq Prospect (Table 1 and Figure 1). In late July/early August, sites in Ikalukrok Creek, upstream of the West Fork and Competition Creek upstream of Sourdock were added. Four sample sites were added in summer 2001: Ferric, Square, Sunday, and Oak creeks. These four streams were located in the vicinity of the Lik Deposit and the TCAK shallow gas exploration program.

Eight streams are tributary to Ikalukrok Creek and seven to the Wulik River. Except for Square Creek, all of the sites had been minimally disturbed. Considerable exploratory work, predating the Red Dog Mine, had been done at the Lik Deposit in the upper portions of Square Creek. Disturbances included a road from the airstrip to the camp site that crosses several branches of Square Creek.

Table 1. Locations of Biomonitoring Sample Sites.

Station Number	Stream or Site Name	Year Sampled
Ikalukrok Creek Drainage		
Station 207	Ikalukrok Creek (upstream of confluence with East Fork Ikalukrok Creek)	2000-01
Station 205	West Fork Ikalukrok Creek	2000-01
Station 206	Ikalukrok Creek (upstream of West Fork Ikalukrok Creek)	2000-01
Station 208	East Fork Ikalukrok Creek	2000-01
Station 209	Grayling Junior Creek	2000-01
Station 210	Noa Creek	2000-01
Station 211	Moil Creek	2000-01
Station 212	Sled Creek	2000-01
Wulik River Drainage		2000-01
Station 202	Competition Creek (lower portion)	2000-01
Station 203	Competition Creek (upstream of Sourdock Creek)	2000-01
Station 204	Sourdock Creek	2000-01
Station 213	Ferric Creek	2001
Station 214	Square Creek	2001
Station 215	Sunday Creek	2001
Station 216	Oak Creek	2001

The baseline sampling at all sites included periphyton standing crop (as Chlorophyll-a concentrations), aquatic invertebrates abundance and community structure, fish presence and use, water quality, and hydrology. We conducted mark-recapture sampling of Arctic graying in 2000 and 2001 in East Fork Ikalukrok Creek, Station 208 and Grayling Junior Creek, Station 209. Juvenile Dolly Varden were collected for whole body concentrations of select metals in 2001 from East Fork Ikalukrok Creek, Grayling Junior Creek Ferric Creek.

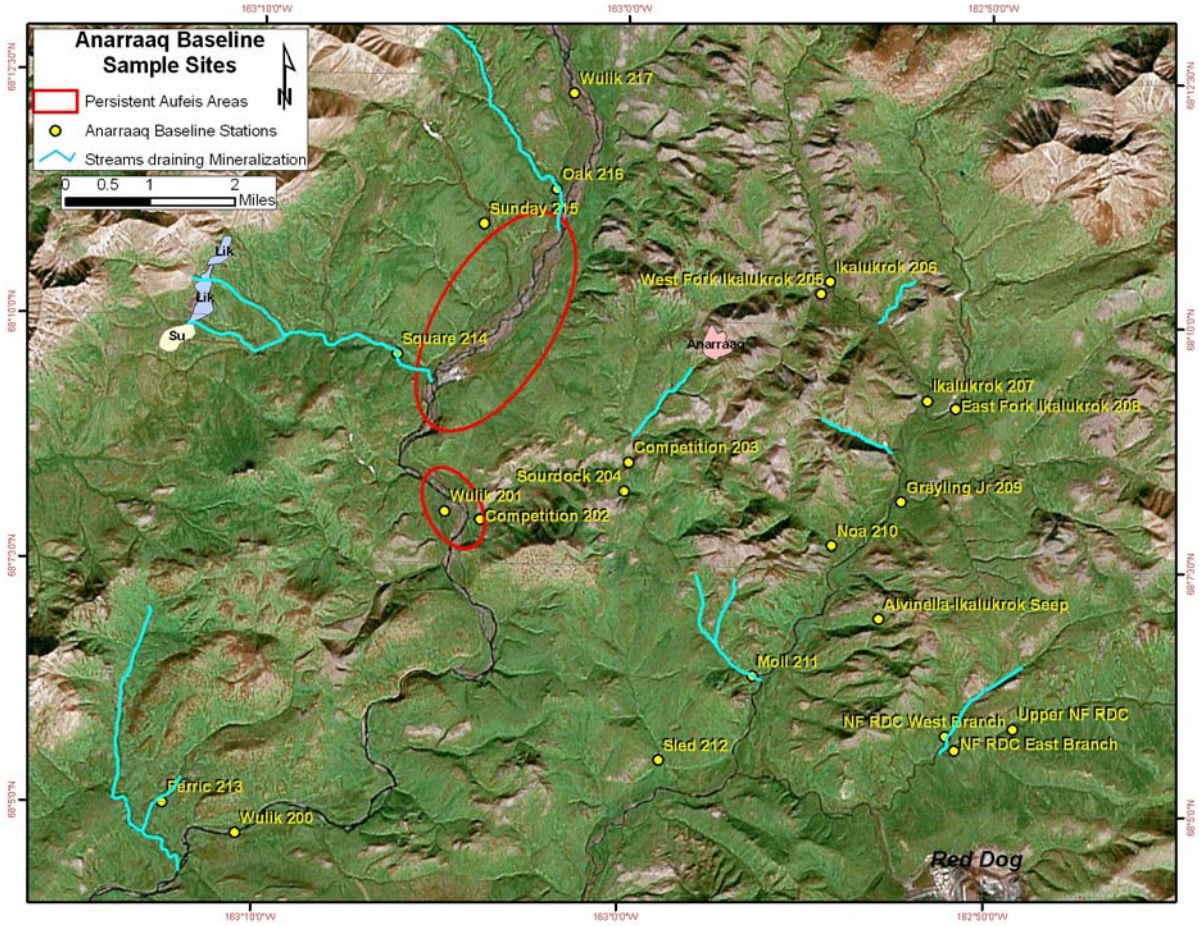


Figure 1. Locations of sample sites in the Ikalukrok Creek and Wulik River drainages for biomonitoring. Map provided by TCAK.

Two water quality sample sites were established in the Wulik River (Stations 200 and 201) and the US Geological Survey (USGS) established a stream gauging station in the Wulik River upstream of Ferric Creek. Biological samples were not collected from the Wulik River.

Methods

Water Quality

Water samples were collected from each of the sample sites twice monthly. Water samples were analyzed at a commercial analytical laboratory for Ag, Al, As, Cd, Cr, Cu, Fe, Mn, Ni, NO2+NO3, Pb, Se, TOC, Tot P, Zn, Hardness, Alkalinity, Ca, Cl, K, Mg, Na, SO4, and TDS. Field measurements of temperature, conductivity, pH, and flow were made at the same time water samples were collected.

Periphyton

Periphyton, or attached micro-algae, is sensitive to changes in water quality and is often used to document in-situ productivity. Periphyton standing crop was sampled over a three-year period to account for natural variations.

Ten rocks randomly selected from each sample site were collected. Sample protocol followed methods and procedures described in the report by ADF&G (1998), based upon US EPA method 446.0 (1997). In 2001, we modified the procedure to include acidification of all chlorophyll samples with 0.1 ml 0.1 N hydrochloric acid to estimate concentrations of phaeophytin. Low phaeophytin concentrations demonstrate that periphyton samples were taken and preserved to minimize decomposition of chlorophyll pigments and that sampled chlorophyll is from live algae. Comparisons of acidified samples to pre-acidified samples showed no significant degradation of pigments (Wilcoxon rank Sum Test, $p = 0.486$).

The concentrations of chlorophyll-a were displayed graphically for each site. Concentrations among the sites ranged from less than 1 mg/m^2 to nearly 25 mg/m^2; this wide range among sites made it impossible to scale all of the chlorophyll-a graphs to the same scale. Therefore, data was graphed on one of three scales: 0 to 1 mg/m^2, 0 to 10 m^2, and 0 to 25 m^2. In comparing among sites, it is important to observe which scale was used to graph the chlorophyll-a data for a particular site.

Aquatic Invertebrates

OBJECTIVES

The aquatic invertebrate community was sampled at all sites to estimate in-situ productivity (by abundance and density) and community complexity (by taxa richness and community composition). Five aquatic invertebrate samples were collected once during summers 2000 and 2001 at each site with drift nets, according to ADF&G (1997). In 2001, we used an invertebrate subsampler (a gridded tray) to more accurately divide samples. Analysis of sample partitions showed variability within subsamples to be within acceptable ranges (Chi-square test, p=0.05). Quality control checks on invertebrate sorting (based on four samples) showed that less than 2% of the invertebrates were missed at sorting.

Metals Concentrations in Juvenile Dolly Varden

We collected juvenile Dolly Varden from Grayling Junior Creek and Ferric Creek to be analyzed for whole body concentrations of Cd, Pb, Se, and Zn. Fish were collected and handled according to the methods specified in ADF&G (1997). Fish were analyzed on a dry weight basis with the percent moisture reported.

Quality assurance and quality control (QA/QC) were conducted by the laboratory on all samples. QA/QC procedures included field blanks (of reagent water), laboratory blanks, spike recoveries, and recovery of criteria reference materials.

Fish Presence and Use in Tributary Streams

Fish monitoring focused on the distribution and relative abundance of juvenile Dolly Varden and Arctic grayling in Ikalukrok Creek and Wulik River to describe annual variations in distribution and abundance. Field sampling methods and gear included visual observations, fyke-nets, minnow traps, and aerial surveys. Aerial surveys were made using an A-Star helicopter. Arctic grayling >200 mm fork length were measured and marked with numbered Floy® internal anchor tags.

The fyke-net used in Competition Creek was 0.9 m^2 or 1.2 m^2 or 0.69 m by 0.99 m (mini-fyke). The mini-fyke nets were 3.7 m long, had four hoops, a 1.8 m cod end, and two 0.91 m by 4.6m wing nets. All netting was 10 mm square mesh. Center leads varied from 7.6 m to 30.4 m and were deployed to the maximum extent possible without submerging the top of the entrance frame. Nets were set with the center lead either perpendicular to or at an angle to the shore. Unbaited fyke-nets were fished 24 hrs and either reset or removed.

Ten minnow traps baited with salmon roe treated with a 1% betadine solution were fished for 24 to 48 hours at all sample sites. Traps were used twice per summer, in late June/early July and in late July-early August.

Angling with barbless flies was used to capture adult and juvenile Arctic grayling. All fish were identified to species, measured, and released. Arctic grayling >200 mm fork length were marked with numbered Floy-tags.

Results and Discussion

Tributaries in the Ikalukrok Creek Drainage

Data on the biota and water quality conditions in the Ikalukrok Creek Drainage are presented first as a summary of comparisons among sites, then as a more detailed description of each site. Tabulated data for individual sites are presented in the Appendix. Graphs of biological and water quality factors to compare sites are ordered by the algal standing crop, from lowest to highest. This ordering was done to aid in comparisons among sites.

Water Quality

Overall water quality was highest in Grayling Junior Creek, followed by East Fork Ikalukrok Creek, Sled Creek, North Fork Red Dog Creek, and Ikalukrok Creek upstream of the West Fork. Sites with the most degraded water quality were Ikalukrok Creek at Cub Creek, Moil and Noa creeks, and West Fork of Ikalukrok Creek. The pH was lower than the limit (6.5) for aquatic life in more than 50% of the samples from Stations 207, 211, 210, and 205 (Figure 2). Station 212 had one early spring sample with low pH.

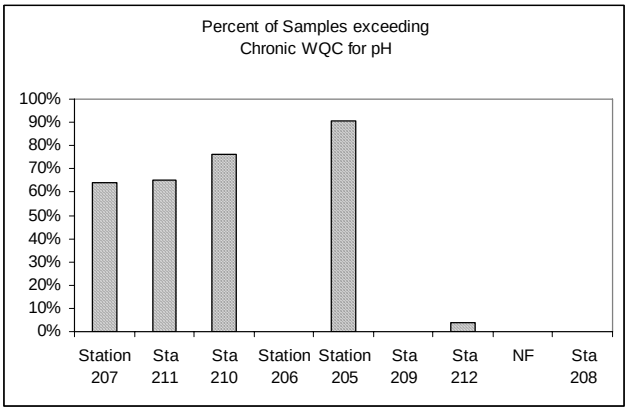


Figure 2. Percent of water samples outside of the pH range (6.5 to 9) for aquatic life.

The same sites, Stations 207, 211, 210, and 205 also had elevated concentrations of Cd and Zn (Figure 3). See discussions of individual sampling sites for more detailed water quality information.

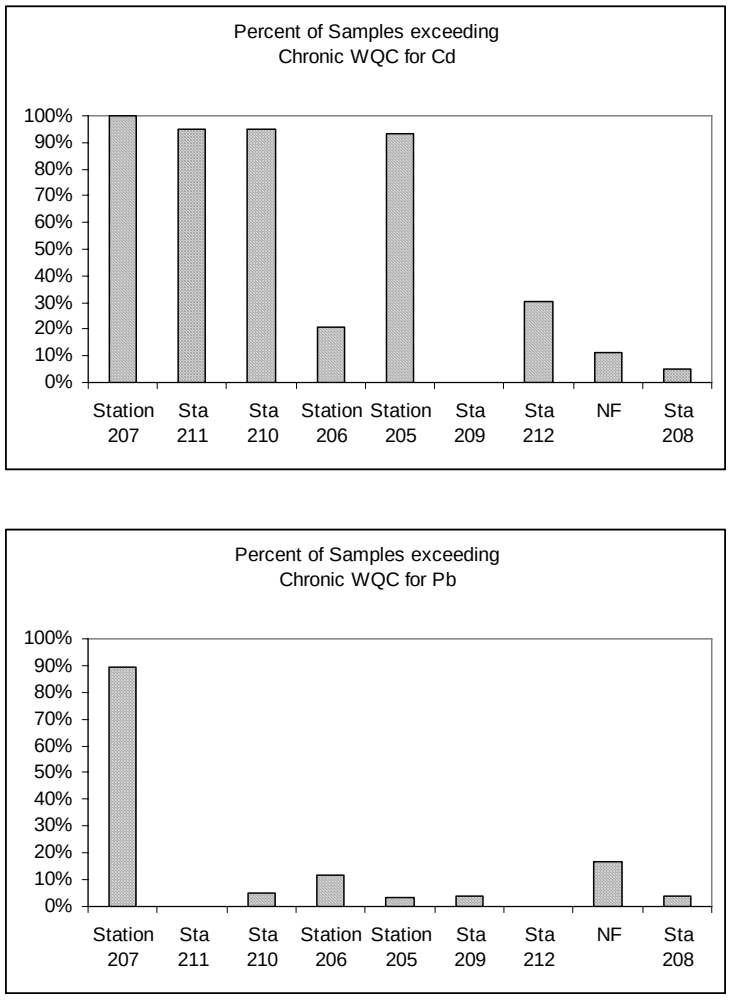


Figure 3. Percent of water samples exceeding chronic aquatic life criteria for Cd, Pb, and Zn, Ikalukrok Creek drainage.

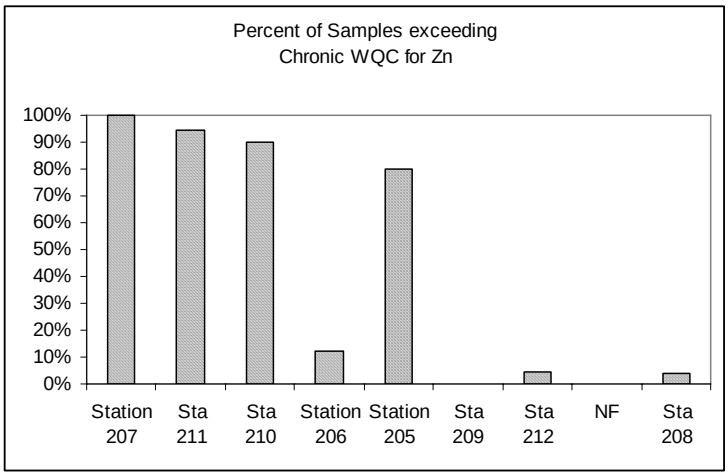


Figure 3. Continued.

Periphyton

Primary production, as estimated by concentrations of chlorophyll-a was near zero at Stations 207, 211, and 210 and increased slightly at Stations 206 and 205 (Figure 4). In general, sites with the highest concentrations of chlorophyll-a also had the best water quality.

Aquatic Invertebrates

Invertebrate abundance (as drift, Figure 5) was highest in clear water Stations 206 and 208 and impaired Station 207 (downstream of Station 206). When counts are adjusted for volumes of water, Station 206 had substantially higher invertebrate densities than any of the other sites (Figure 6).

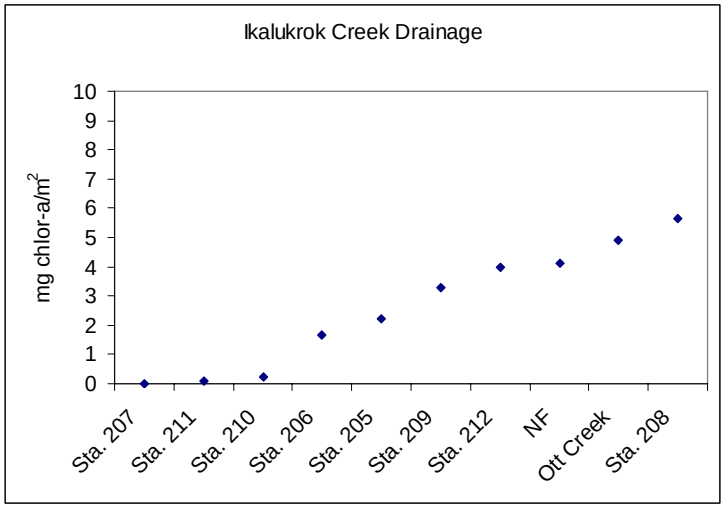


Figure 4. Concentrations of chlorophyll *a* (mg/m^2) from baseline sites in the Ikalukrok Creek drainage. The points on the graph represent the average for all years sampled at a given site.

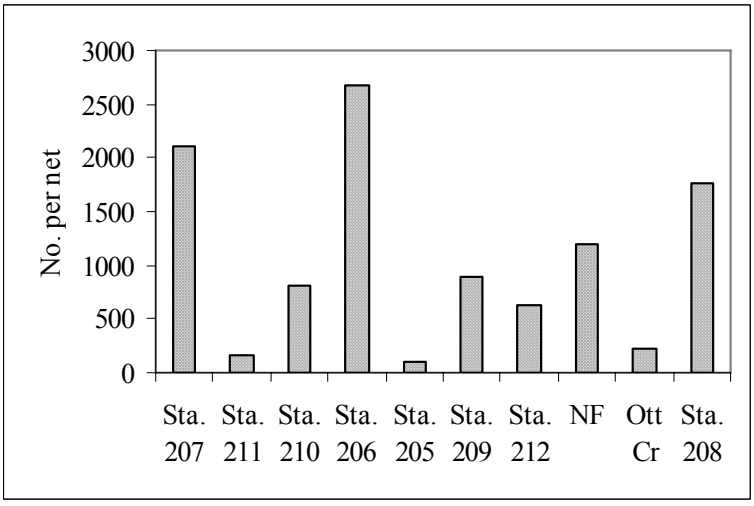


Figure 5. Abundance of aquatic invertebrates from baseline sites in the Ikalukrok Creek drainage. The points on the graph represent the average for late June – early July for all years sampled at a given site.

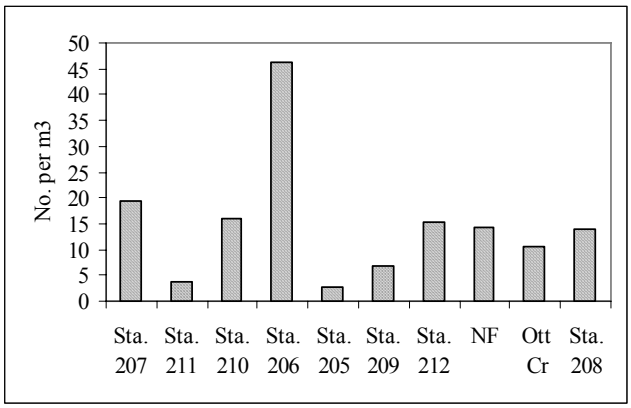


Figure 6. Density of aquatic invertebrates from baseline sites in the Ikalukrok Creek drainage. The points on the graph represent the average for all years sampled at a given site; 1997 and 1998 data include only late June to minimize seasonal variability.

Sites with the highest number of different taxa were not necessarily the same as sites with the highest abundance or density. The North Fork of Red Dog Creek, Station 212, and Station 205 had the greatest numbers of different aquatic taxa (Figure 7). The composition of the community, in terms of relative abundance of the different invertebrate orders (Figure 8) also places North Fork Red Dog Creek, Station 205, and Station 212 as having the most diverse and complex invertebrate community. The category "miscellaneous" is mostly Collembola and aquatic mites (Acari).

Chironomidae (Order Diptera) was by far the most prevalent group in any of the sites (Figure 9). EPT (Ephemeroptera/Plecoptera/Trichoptera) were a minor component at all sites, but most abundant at Stations 206 and 212.

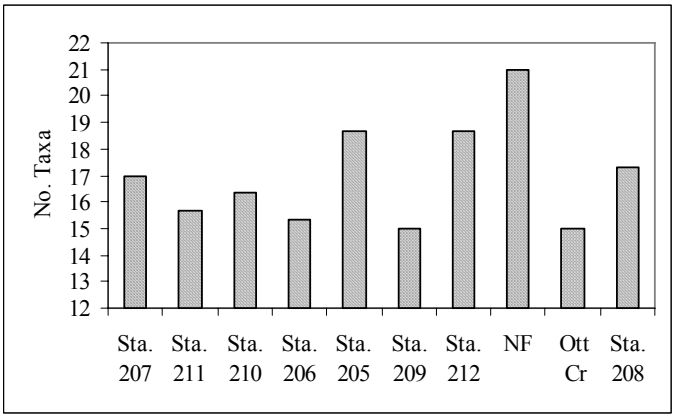


Figure 7. Taxa richness, as total number of aquatic taxa collected, from baseline sites in the Ikalukrok Creek drainage. The points on the graph represent the average for all years sampled at a given site; note the scale (from 12 to 22) to better show differences among sites.

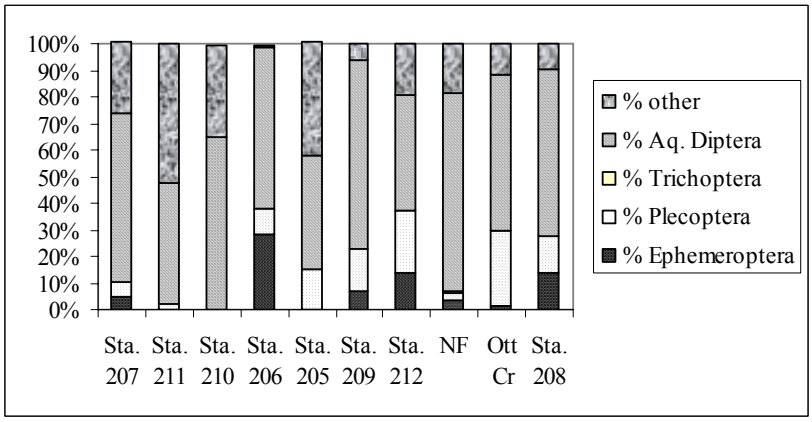


Figure 8. Relative abundance (as percent of total samples) of aquatic insect orders found in each of the sample sites, Ikalukrok Creek Drainage.

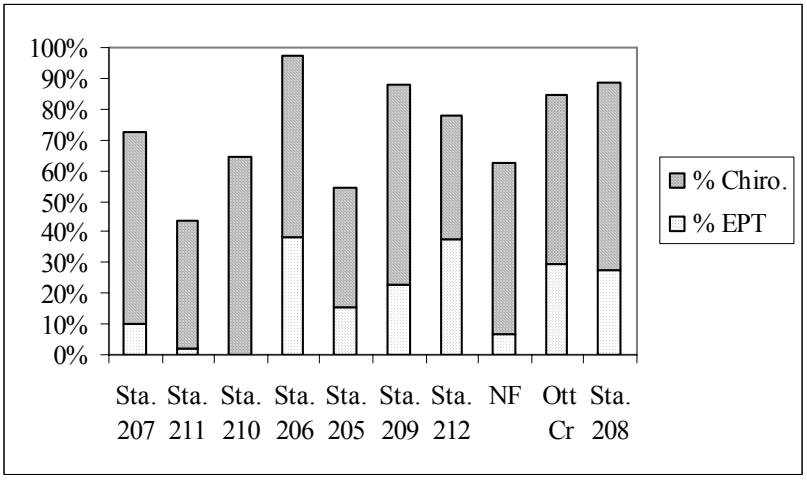


Figure 9. Percent Chironomidae and Percent EPT taxa, Ikalukrok Creek drainage.

Fish Populations

No fish were found at Stations 205, 206, 210, 211, 212 or Ott Creek (Table 2). Fish were excluded from Station 212 (Sled Creek) and Ott Creek because both creeks flowed underground before connecting to downstream Ikalukrok Creek. We believe that fish were excluded from Stations 205, 210, and 211 by poor water quality and from Station 206 by downstream water quality near the Cub Creek seep. Only 1 fish was found in Ikalukrok Creek at Station 207, this Arctic grayling appeared stressed and in poor condition.

Table 2. Fish Collected in Ikalukrok Creek Drainage.

Station	Dolly Varden Juveniles No./Trap	Dolly Varden Age 0+ Present	Other Species Observed
Station 208	0.03	0	Arctic grayling
Station 209	0.98	0	Numerous Arctic Grayling, several slimy sculpin age 0+ Arctic grayling collected.
Station 206	0	0	
Station 207	0	0	1 Arctic grayling observed
Station 211	0	0	
Station 210	0	0	
Station 212	0	0	No surface connection
Station 205	0	0	
North Fork Red Dog Cr	0.9	0	Arctic grayling, slimy sculpin
Ott Creek	0	0	No surface connection

Appendices 1 through 10 contain tabulated data for each sampling site; Appendix 12 contains miscellaneous mark re-capture fisheries data.

Descriptions of Individual Creeks

Ikalukrok Creek near Cub Creek, Station 207

PHYSICAL FEATURES

- Drainage size: 13.77 square miles
- Average July water temperature: 9°C
- 2001 average stream flow, 7/15-9/23 = 47.8 cfs
- 2002 average flow, 5/31 - 9/23 = 43 cfs
- Elevated Al, Cd, Cu, Fe, Ni, Pb, and Zn
- Low pH

SUMMARY OF BIOLOGICAL PRODUCTIVITY

- Low chlorophyll-a, no detectable chlorophyll-b, or –c
- High aquatic invertebrate abundance and density
- Most aquatic invertebrates were Diptera, Acari common in 2000
- Few EPT invertebrates
- No fish

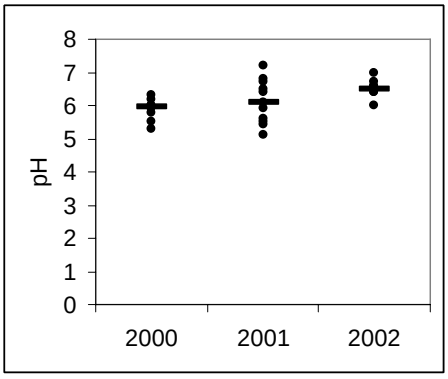
Water Quality

Ikalukrok Creek near Station 207 is stained red in most years, especially downstream of the heavily mineralized Cub Creek seep. In early July 2005, the iron floc in Ikalukrok Creek below the Cub Creek seep appeared substantially greater than previously observed (Ott and Townsend 2005a). TCAK collected water quality samples from Cub Creek and the pH was 3.3.

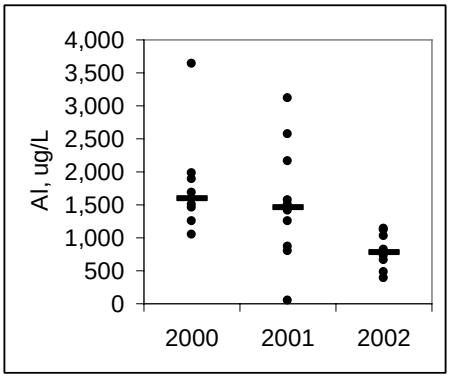
The red stain and iron floc often extends downstream below the confluence with East Fork Ikalukrok Creek; however, in early July 2004, Ikalukrok Creek below this confluence was clear below the confluence with East Fork Ikalukrok Creek (Ott et al. 2000). Water clarity in Ikalukrok Creek below the Cub Creek seep was the clearest it has been since 1997.

The relatively high hardness (2000-2001 average = 122 mg/L) combined with low alkalinity (2000-2001 average = 4 mg/L) and high concentrations of sulfate (2000-2001 average = 169 mg/L) in Ikalukrok Creek at Station 207 suggest that this system is dominated by calcium sulfate rather than calcium bicarbonate.

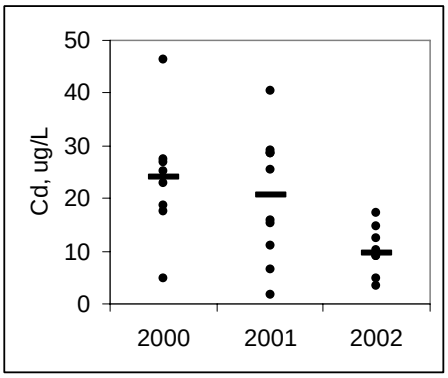
Metals concentrations in Ikalukrok Creek at Cub Creek (Station 207) were high (Figure 10). Concentrations of Al exceeded the US EPA chronic criterion for aquatic life (US EPA 2004) in 96% of the samples, cadmium in 100% of the samples, Cu in 84%, iron in 92%, Ni in 73%, lead in 90%, and zinc in 100% of the samples. The pH was below the range for aquatic life in 64% of the water samples (Table 3).



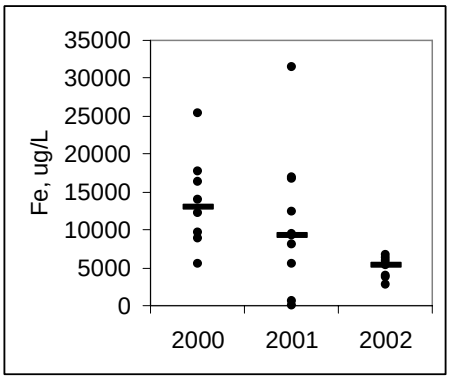
pH, standard units



Concentration of Aluminum

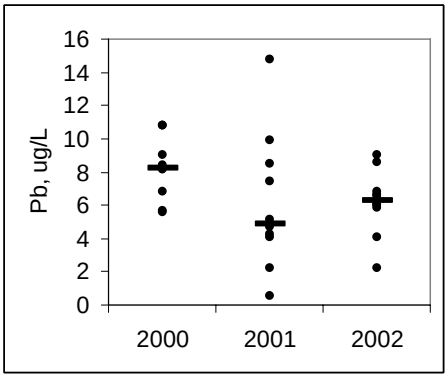


Concentration of Cadmium

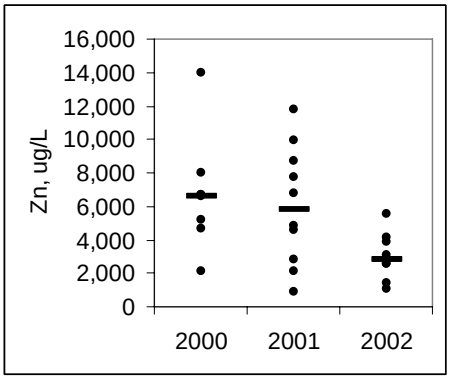


Concentration of Iron

Figure 10. Concentrations of select metals and pH at Station 207: Ikalukrok Creek upstream of Cub Creek, 2000 - 2002. Graph shows median as bar and all data values as points, for most metals, n=8, 10, and 8 in 2000, 2001, and 2002, respectively. For pH, n= 8, 11, and 9 in 2000, 2001, and 2002, respectively.



Concentration of Lead



Concentration of Zinc

Figure 10, continued.

Table 3. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 207. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	1245	3640	53.3	26	81%	96%
Cd, µg/L	16.45	46.3	1.7	26	96%	100%
Cu, µg/L	19.1	66.7	6.3	25	68%	84%
Fe, µg/L	8535	31400	90.1	26		92%
Ni, µg/L	78.6	242	17	26	0%	73%
Pb, µg/L	6.8	97.8	0.5	29	3%	90%
PH	6.25	7.2	5.1	28	64%	
Se, µg/L	1	5	1	30	0%	0%
Zn, µg/L	4765	14000	856	26	100%	100%

Periphyton

Periphyton, or algal, standing crop, was measured 7 times from 1997 through 2002 at Station 207. In all years, except 2001, concentrations of chlorophyll *a* were below the detection limit of 0.05 mg/m2 (n = 10 for each sample time, Figure 11). In 2001, two samples contained chlorophyll *a* concentrations that were slightly above the limit of detection. No samples contained sufficient chlorophyll to estimate other pigments.

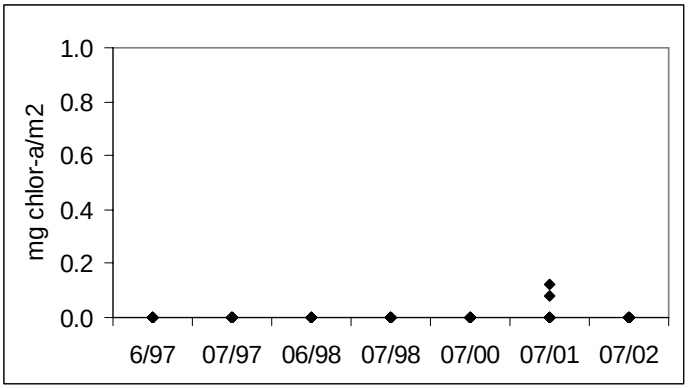


Figure 11. Concentration of chlorophyll-a in Ikalukrok Creek at Station 207.

Invertebrate Communities

Invertebrate samples contained both high abundance and density, in contrast to low periphyton growth. Both abundance and density were lowest in 2000 (Figures 12 and 13) when metals concentrations were highest. We found an average invertebrate abundance of 1648 aquatic invertebrates/net and an average aquatic invertebrate density of 14.9/m^3 water over the 1997-2002 sampling period.

We identified a total of 21 taxonomic groups (usually genus) at Station 207.from 1997 through 2002 (Figure 14). From 60% to 80% of samples are aquatic forms (Figure 15). The communities are mostly Diptera, with few Ephemeroptera (Figure 16). The proportion of Diptera: Chironomidae greatly exceeds the proportion of Ephemeroptera-

Plecoptera-Trichopera (EPT) taxa (Figure 17). The dominance by a few taxonomic groups suggests a depaurate invertebrate community compared to other baseline sites.

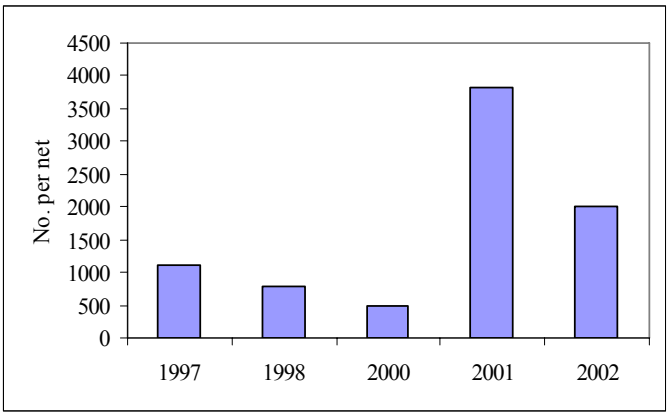


Figure 12. Abundance of aquatic invertebrates at Station 207.

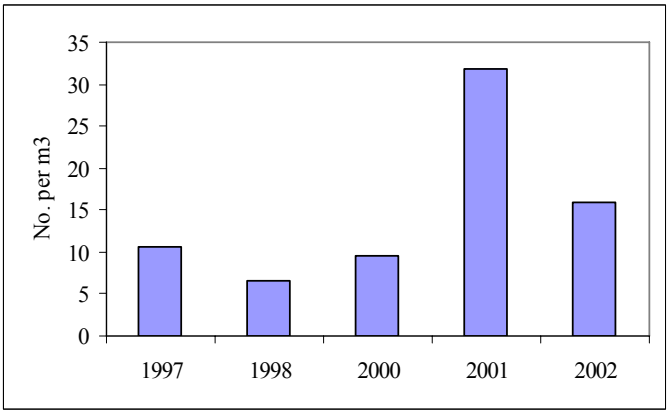


Figure 13. Density of aquatic invertebrates at Station 207.

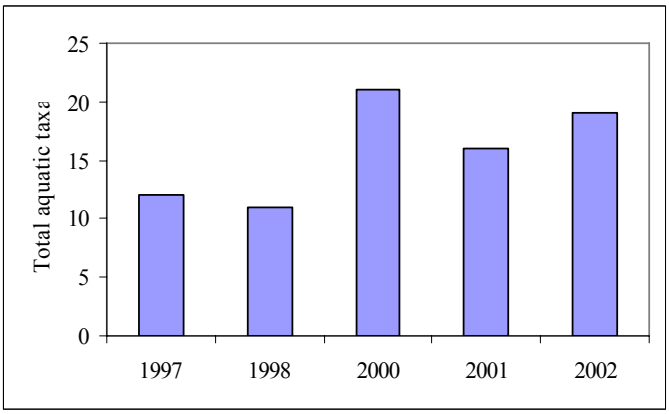


Figure 14. Total aquatic taxa at Station 207.

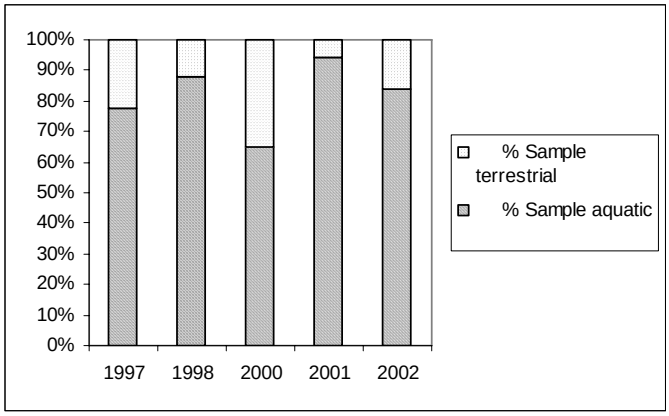


Figure 15. Proportion of terrestrial and aquatic invertebrates in drift samples at Station 207.

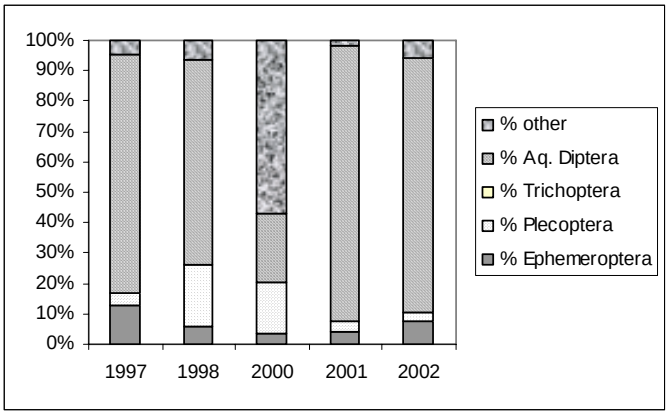


Figure 16. Proportion of aquatic insect orders in drift samples at Station 207.

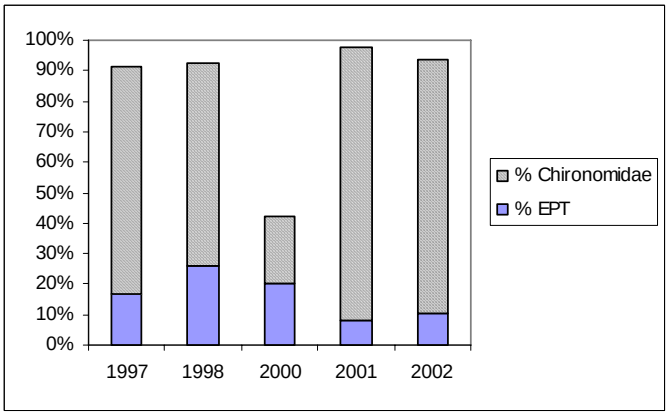


Figure 17. Proportion of Chironomidae and EPT taxa at Station 207.

Fish Communities

No fish were seen in Ikalukrok Creek upstream of Cub Creek during an aerial survey on July 10, 2000 or July 30, 2005 (Ott et al 2000, Ott and Townsend 2005b). In 2000, 2001, and 2002, we set minnow buckets twice each summer downstream of Cub Creek. No fish were caught in any of the traps; in three years of sampling, only one Arctic grayling adult was seen. When we observed the Arctic grayling, the water was turbid with

substantial red flocculant in the water column and on the streambed. The Arctic grayling appeared lethargic and was almost picked from the water by hand.

Turbidity, resulting from precipitation of metals from the Cub Creek seep, limit visibility at this site; however, because minnow traps failed to collect fish, it is unlikely that this system supports a viable fish population.

Fish Tissues

No fish were collected from this site for tissue analysis.

Appendix 1 contains the water quality and biological data from Ikalukrok Creek at Cub Creek, Station 207.

Ikalukrok Creek upstream of the confluence with the West Fork of Ikalukrok Creek, Station 206.

PHYSICAL FEATURES

- Drainage size: 8.47 square miles
- Average July water temperature: 9.6°C
- 28% of samples with elevated Al, 12% elevated Zn
- neutral pH

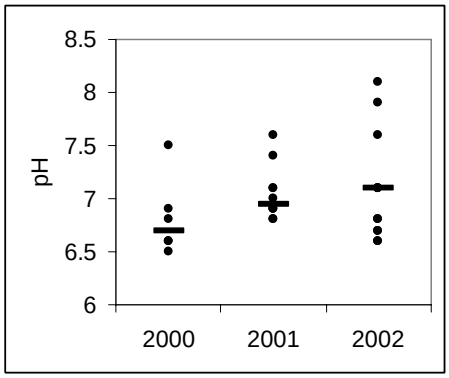
SUMMARY OF BIOLOGICAL PRODUCTIVITY

- Low periphyton standing crop
- Highest invertebrate abundance and density of Ikalukrok Cr. sites
- High proportion of EPT taxa
- Abundant Ephemeroptera
- No fish; likely excluded by impaired water quality downstream

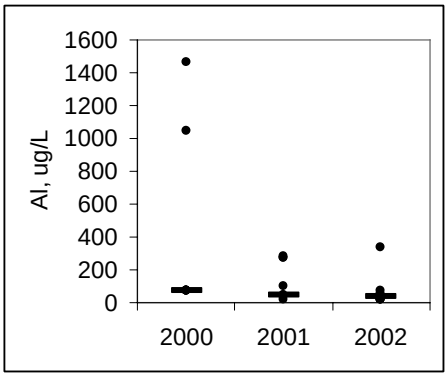
Water Quality

Ikalukrok Creek, from the headwaters downstream to the West Fork is a clear water system with fairly good water quality. The water is moderately hard (average hardness = 110 mg/L) with an average alkalinity of 40 mg/L. The pH is near neutral (Figure 18) and ranges from 6.5 to 8.1. Concentrations of all metals are substantially lower than at downstream Station 207 (Figure 18). In 2000-2002, 28% of the samples exceeded the US EPA water quality criterion for aquatic life (US EPA 2004), and less than 15% of the samples exceeded the other analytes (Table 4). Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 6 samples were reported at <1 ug/L. When these six values are ignored, 17% of the water samples exceeded the chronic criterion for Cd.

The pH of the water was within acceptable ranges in all samples.

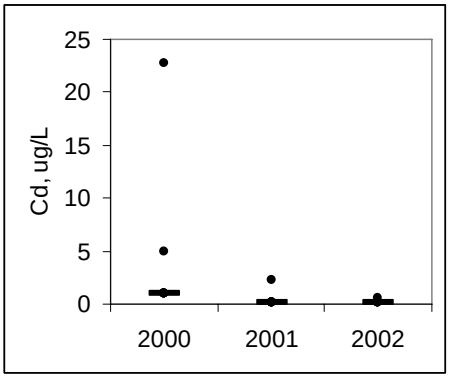


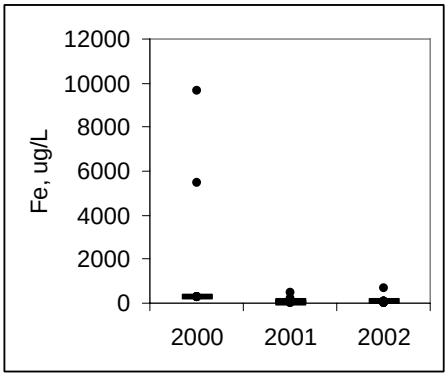
pH, standard units

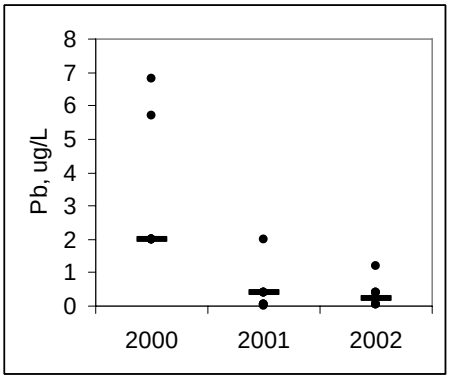


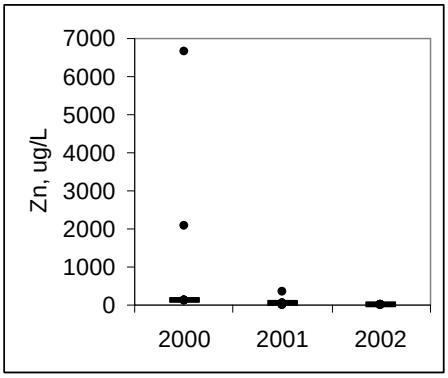
Concentration of Aluminum

Figure 18. Concentrations of pH and select metals at Station 206: Ikalukrok Creek upstream of the West Fork, 2000 - 2002. Graph shows median as bar and all data values as points, for metals, n=8, 9, and 8 in 2000, 2001, and 2002, respectively. For pH, n= 6. 10, and 13 in 2000, 2001, and 2002, respectively.









Concentration of Lead

Concentration of Zinc

Figure 18, continued.

Table 4. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 206. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample. Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	75	1460	20	25	8%	28%
Cd, µg/L	0.1	22.8	0.1	24	13%	*17%
Cu, µg/L	3	24.6	1	24	13%	13%
Fe, µg/L	63.15	9620	0.1	26	no acute	8%
Ni, µg/L	17	208	3	24	0%	8%
Pb, µg/L	2	6.8	0.02	17	0%	12%
pH	6.9	8.1	6.5	29	0%	
Se, µg/L	1	5	1	26	0%	0%
Zn, µg/L	20.2	6660	4.5	25	12%	12%

*Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 6 samples were reported at <1 ug/L, these six values were ignored to calculate the percent of samples exceeding the chronic criterion for Cd.

Periphyton

Periphyton, or algal, standing crop, was measured 3 times in Ikalukrok Creek upstream of the West Fork, from 2000 through 2002. Concentrations of chlorophyll-a ranged from the lowest amounts in 2001 of 0.13 mg/m2 to 5.8 mg/m2 in 2002 (Figure 19). The average amount of chlorophyll-a for all years was 1.64 mg/m2. There were higher amounts of chlorophyll-c than chlorophyll-b (Figure 20), indicating a community that is dominated by photosynthetic Chromista and dinoflagellates, rather than green algae and

euglenophytes. As with all of the other Ikalukrok Creek drainage sites (except the North Fork of Red Dog Creek), concentrations of chlorophyll-c were higher than concentrations of chlorophyll-b.

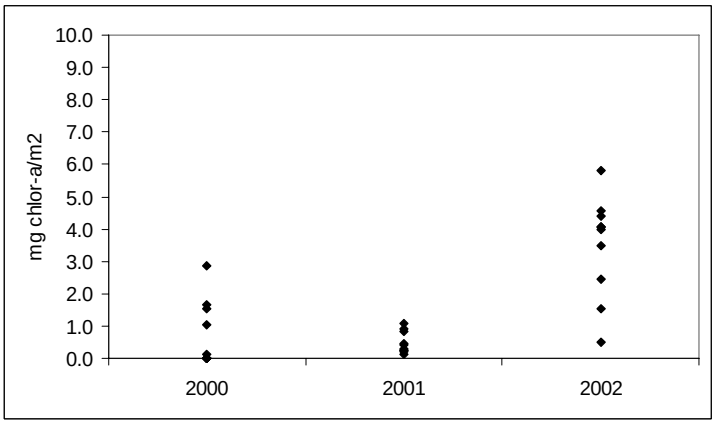


Figure 19. Concentration of chlorophyll-a in Ikalukrok Creek at Station 206.

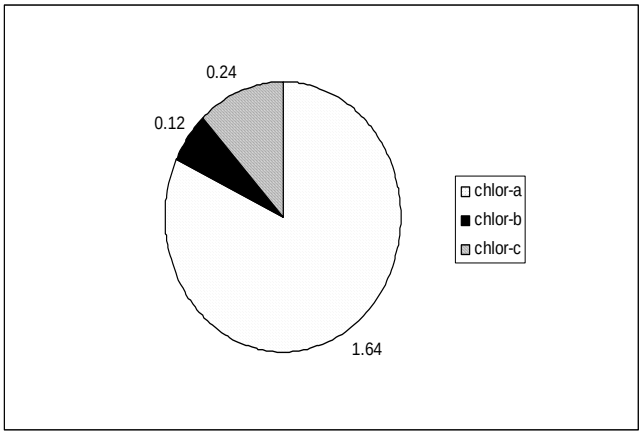


Figure 20. Proportions of chlorophyll-a, -b, and -c in Ikalukrok Creek at Station 206.

Invertebrate Communities

Aquatic invertebrate samples contained both higher abundance (average 2679/net) and density (21.2/m^3 water) than in the downstream site at Station 207. Invertebrate abundance was highest in 2001 (Figure 21) and density (Figure 21) was slightly higher in 2000. The higher density in 2000 correlates with lower flow rates: we estimated an average 106 m^3 water flowing through nets in 2000, 135 m^3 in 2001, and 168 m^3 in 2002.

We found from 14 to 18 distinct taxonomic invertebrate groups in Ikalukrok Creek at Station 206 from 2000 through 2002 (Figure 23). Nearly all of the invertebrates collected in samples from 2000 through 2002 were aquatic forms; the proportion of terrestrial insects was low all years (Figure 24). Invertebrate communities at Station 206 in 2000 were mostly Ephemeroptera (with an average of 580 Baetidae: *Baetis* per net). In 2000, the mayfly Heptageniidae: *Cingymula* and Plecoptera: *Capnia* also were common. In 2001 and 2002, aquatic Diptera dominated samples (Figure 25); however, Plecoptera, *Capnia* was common in 2001 samples. The Diptera were mostly Chironomidae larvae, although Tipuliidae and Simuliidae were common. Trichoptera, although rare, were found at this site. The prevalence of Ephemeroptera in 2000 and Plecoptera in 2001 are reflected in the high proportions of EPT taxa in samples from those years, especially in 2000 samples (Figure 26).

Ikalukrok Creek at Station 206 supports a rich community of aquatic invertebrates. Year to year variations in the proportions of different groups, especially genera of Ephemeroptera and Plecoptera, likely reflect sampling times with respect to emergence of adult insects because most species are commonly found in drift as they reach final instars before emergence

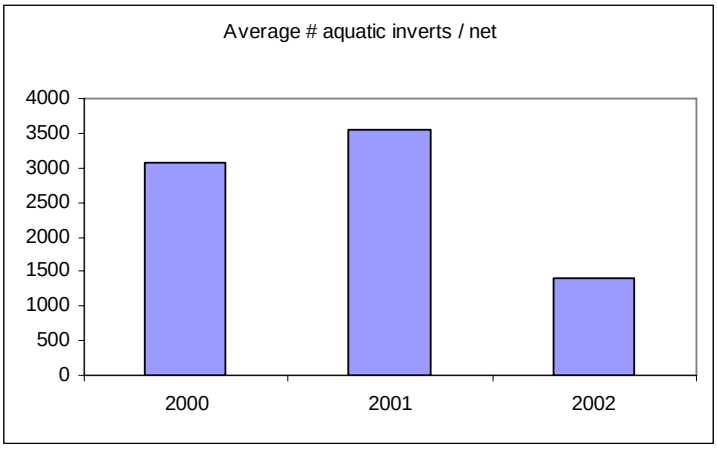


Figure 21. Abundance of aquatic invertebrates (average number per net) at Station 206.

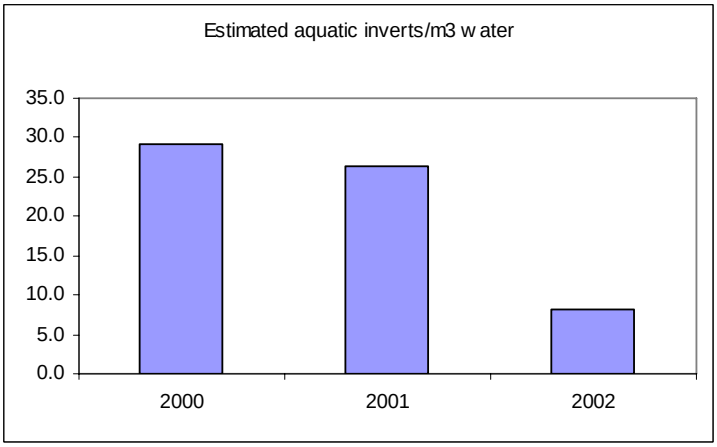


Figure 22. Density of aquatic invertebrates (average number per m3 water flowing through drift nets) at Station 206.

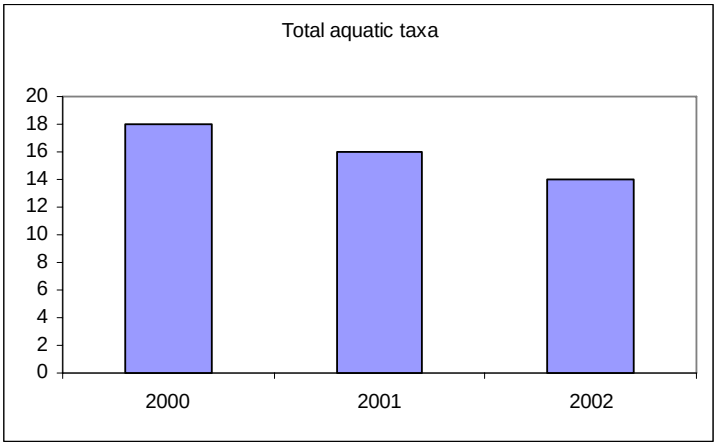


Figure 23. Total aquatic taxa at Station 206.

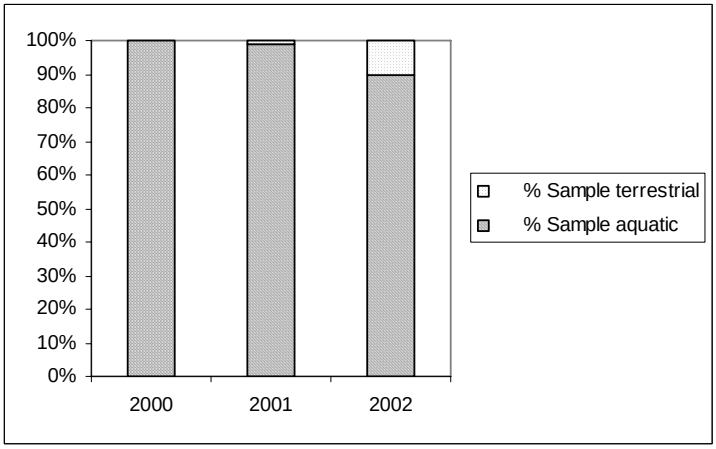


Figure 24. Proportion of terrestrial and aquatic invertebrates in drift samples at Station 206.

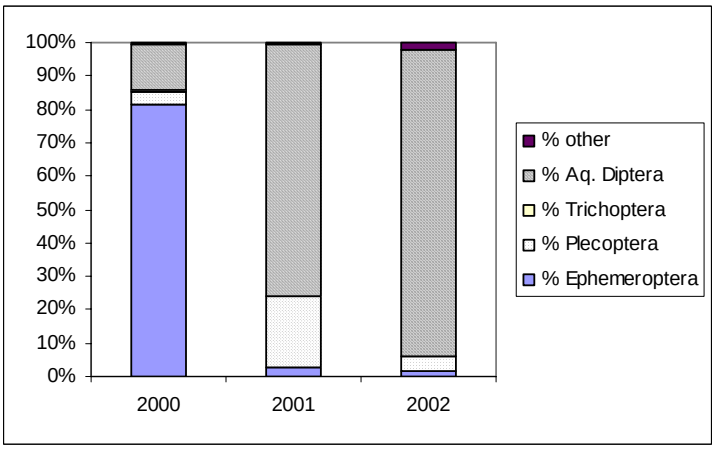


Figure 25. Proportion of aquatic insect orders in drift samples at Station 206.

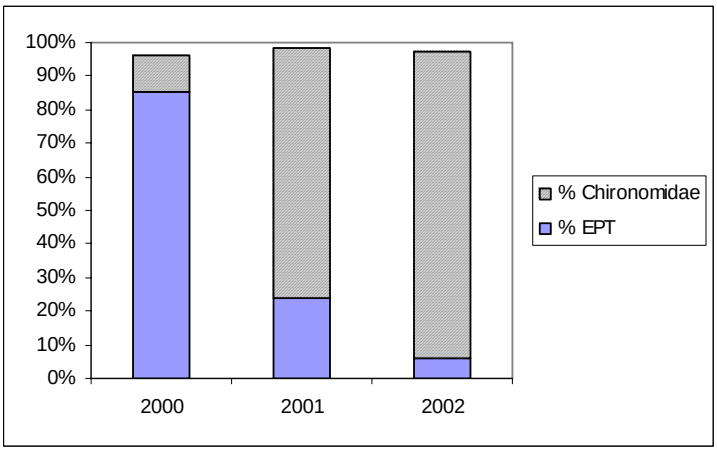


Figure 26. Proportion of Chironomidae and EPT taxa at Station 206.

Fish Populations

On July 10, 2000, we flew Ikalukrok Creek upstream to its headwaters and observed no fish in the entire system above its confluence with East Fork Ikalukrok Creek (Ott et al 2000). In 2000, 2001, and 2002, we set minnow buckets twice each summer. No fish were caught in any of the traps.

Fish Tissues

No fish occur at this site; therefore, fish were not collected for tissue analysis.

Baseline data for Ikalukrok Creek upstream of the West Fork, Station 206, is included in Appendix 2.

West Fork of Ikalukrok Creek, Station 205.

PHYSICAL FEATURES

- Drainage size: 3.07 square miles
- Average July water temperature: 7.7C
- 2001 average stream flow, 7/15-9/23 = 14.09 cfs
- 2002 average flow, 5/31 - 9/23 = 10.3 cfs
- Degraded water quality: 93% of samples exceed chronic aquatic life criteria for Al and Cd, 80% exceed for Cu and Zn, 79% for Ni, and 91% below pH criterion.

SUMMARY OF BIOLOGICAL PRODUCTIVITY

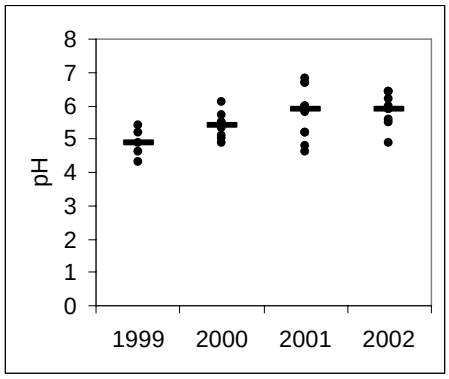
- Moderately low periphyton standing crop
- Lowest abundance and density of aquatic invertebrates
- Invertebrate communities mostly Diptera, Acari, Collembola, and Copepoda
- Ephemeroptera rare, Trichoptera absent

Water Quality

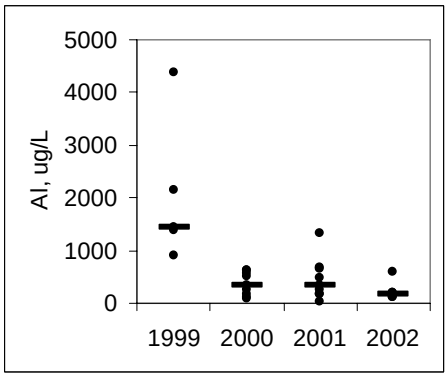
The relatively high hardness (average = 195 mg/L as $CaCO_3$) combined with low alkalinity (average = 4 mg/L as $CaCO_3$) and higher concentrations of sulfate (average =

223 mg/L) in West Fork of Ikalukrok Creek indicate that this system is dominated by calcium sulfate rather than calcium bicarbonate. The pH in this creek is low and ranges from 4.3 to 6.8 (Figure 27).

The West Fork of Ikalukrok Creek has high concentrations of most elements (Figure 27), especially Al, Cd, Cu, Ni, and Zn. During the three years of sampling, the US EPA water quality chronic criterion for aquatic life was exceeded for Al in 93% of the samples, Cd in 90% of the samples (disregarding one sample with a method reporting limit higher than the chronic life criterion), Cu in 80% of the samples, Ni in 79% of the samples, and Zn in 80% of the samples (Table 5). The pH was lower than the water quality criterion in 91% of the samples. A white precipitate of metals (predominantly Zn and Al) forms at the mouth of the West Fork of Ikalukrok Creek as the waters mix with Ikalukrok Creek (Figure 28).

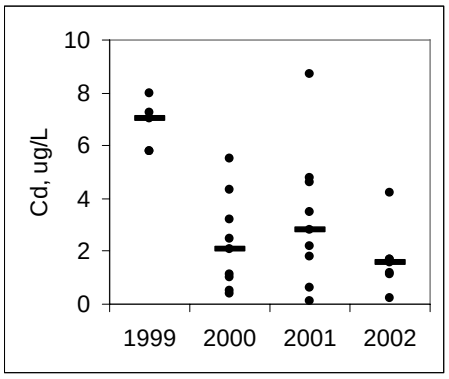


pH, standard units

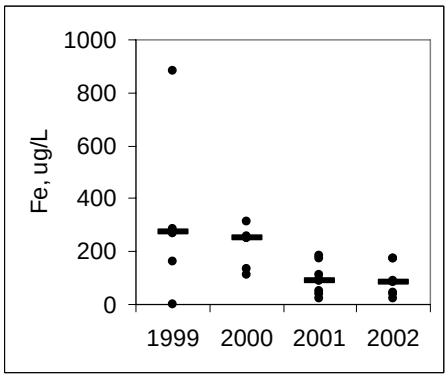


Concentration of Aluminum

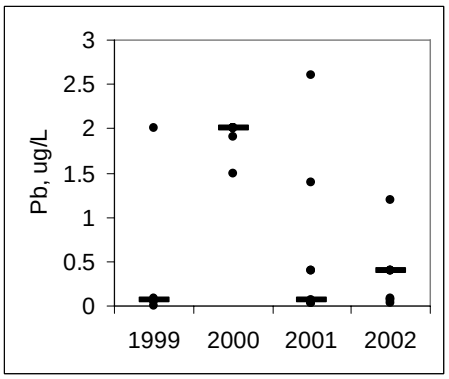
Figure 27. Concentrations of pH and select metals at Station 205, 1999 - 2002. Graph shows median as bar and all data values as points, for metals, n=8, 9, and 8 in 2000, 2001, and 2002, respectively. For pH, n= 6. 10, and 13 in 2000, 2001, and 2002, respectively.



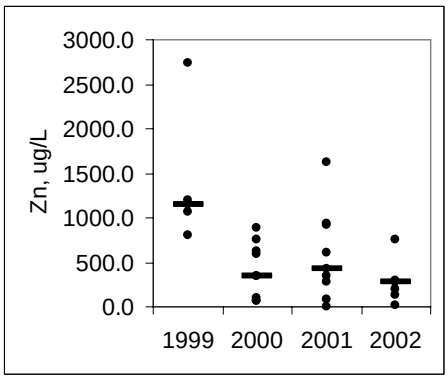
Concentration of Cadmium



Concentration of Iron



Concentration of Lead



Concentration of Zinc

Figure 27, continued.

Figure 28. Confluence of West Fork with Ikalukrok Creek, showing precipitation of metals.

Table 5. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 205. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample. Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	338.5	4380	20	30	20%	93%
Cd, µg/L	2.35	8.7	0.1	29	57%	93%*
Cu, µg/L	25.6	178	2.3	30	77%	80%
Fe, µg/L	160	881	20	29		0%
Ni, µg/L	247	1180	2.2	29	34%	79%
Pb, µg/L	0.4	2.6	0.04	30	0%	3%
pH	5.5	6.8	4.3	32	91%	
Se, µg/L	1.3	5	1	32	0%	0%
Zn, µg/L	391.5	2740	2	30	80%	80%

*Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 1 sample was reported at <1 ug/L; this sample was disregarded in the above table.

Periphyton

Given the overall poor water quality and high concentrations of metals in West Fork Ikalukrok Creek, the concentrations of chlorophyll-a were surprisingly high (Figure 29). The average chlorophyll-a for the sample period 2000 – 2002 was slightly higher than Ikalukrok Creek upstream of the West Fork (Station 206). Concentrations of chlorophyll-b were at the limit of detection (Figure 30), although chlorophyll-c was higher than expected.

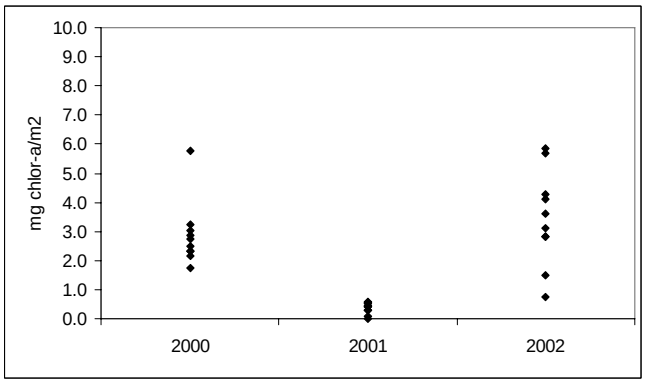


Figure 29**.** Concentration of chlorophyll-a in West Fork Ikalukrok Creek, Station 205.

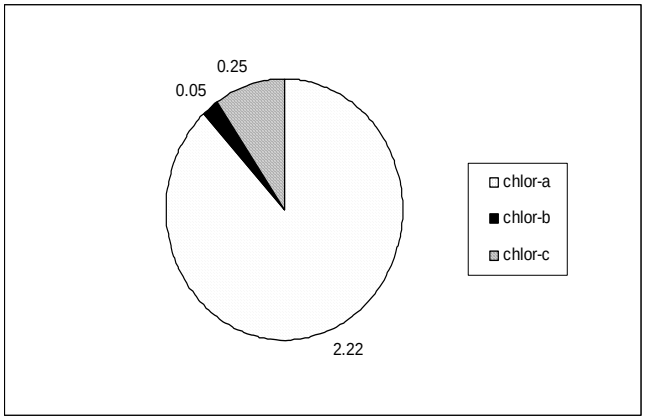


Figure 30. Proportions of chlorophyll-a, -b, and -c in West Fork Ikalukrok Creek at Station 205.

Invertebrate Communities

Both invertebrate abundance (Figure 31) and density (Figure 32) were considerably lower than the nearby Ikalukrok Creek sites at Stations 206 and 207. Abundance and density were among the lowest found in any of the Ikalukrok Creek drainage sites. Taxonomic richness in the West Fork of Ikalukrok Creek was comparable to nearby Stations 206 and 207 sites (Figure 33), although the communities were different. Drift samples from the West Fork of Ikalukrok Creek contained many aquatic mites (Acari), springtails (Collembola), and Copepoda. These groups are usually associated with lentic systems and may have entered the creek from adjacent wetlands. Samples in 2001 contained high proportions of the stonefly, *Capnia*, and Chironomidae larvae. The high proportion of terrestrial invertebrates (which are not included in aquatic invertebrate density or abundance) suggests that terrestrial inputs are possibly a more important part of this system than instream production (Figure 34). Plecoptera were rare, and Ephemeroptera and Trichoptera absent (Figure 35), signifying a depauperate invertebrate community. Overall, the proportion of EPT taxa was low (Figure 36)

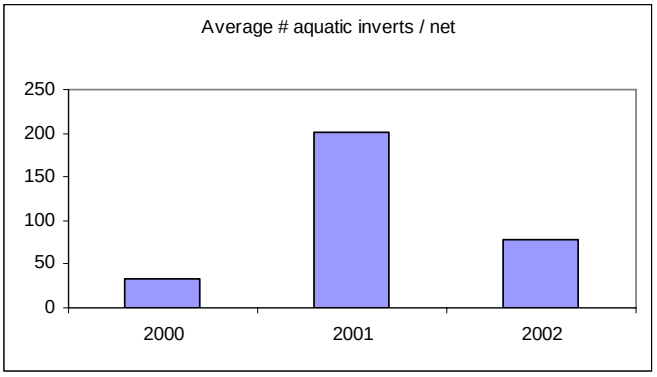


Figure 31. Abundance of aquatic invertebrates (average number per net) in West Fork Ikalukrok Creek, Station 205.

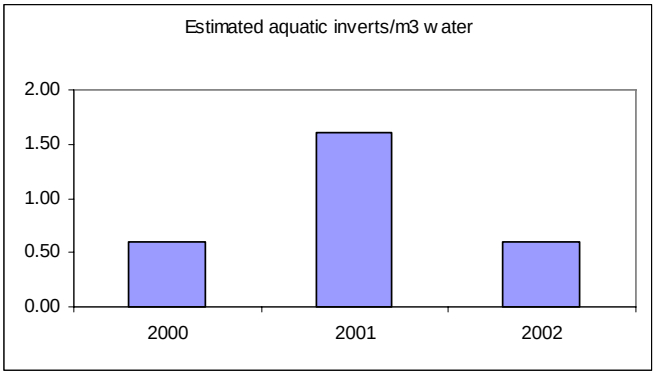


Figure 32. Density of aquatic invertebrates (average number per m3 water flowing through drift nets) in West Fork Ikalukrok Creek, Station 205.

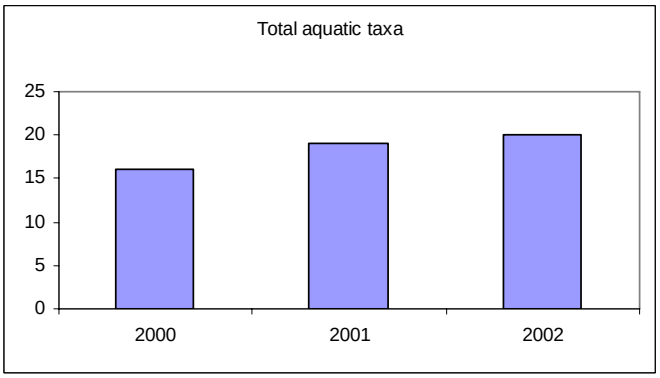


Figure 33. Total aquatic taxa in West Fork Ikalukrok Creek, Station 205.

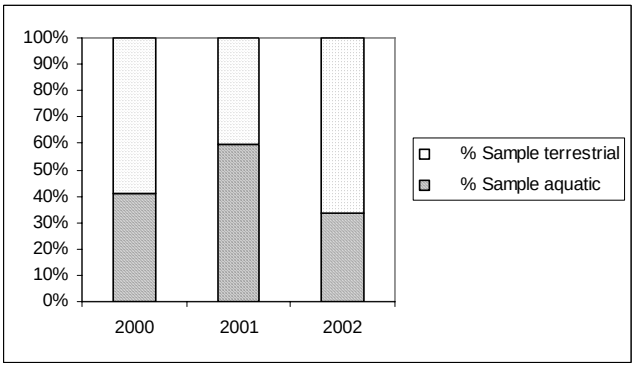


Figure 34. Proportion of terrestrial and aquatic invertebrates in drift samples in West Fork Ikalukrok Creek, Station 205.

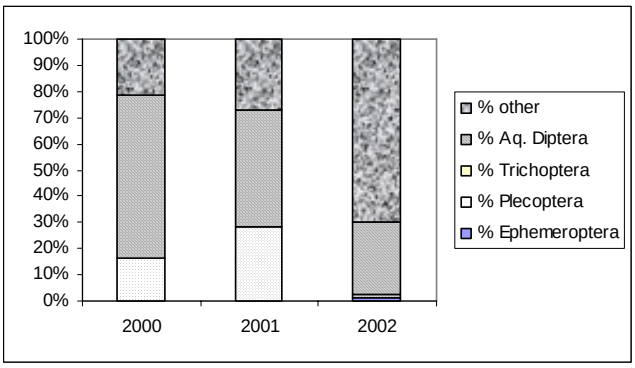


Figure 35. Proportion of aquatic insect orders in drift samples in West Fork Ikalukrok Creek, Station 205.

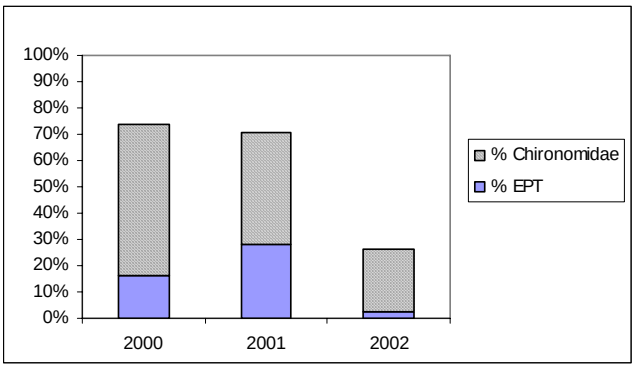


Figure 36. Proportion of Chironomidae and EPT taxa in West Fork Ikalukrok Creek, Station 205.

Fish Populations

No fish have been found at this site.

Fish Tissues

No fish occur at this site; therefore, fish were not collected for tissue analysis.

Baseline data for West Fork of Ikalukrok Creek, Station 205, is included in Appendix 3.

East Fork of Ikalukrok Creek, Station 208.

PHYSICAL FEATURES

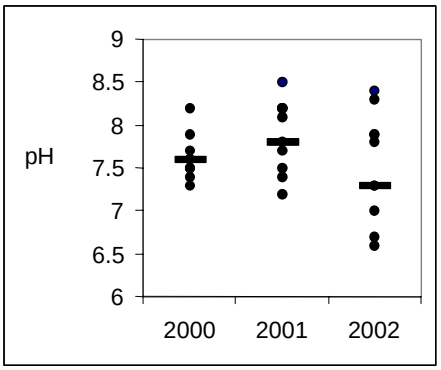
- Drainage size: 22.35 square miles
- Average July water temperature: 8.9°C
- Persistent aufeis into July
- Summer flow ranged from 309 cfs on June 11, 2000 (likely high break-up flow) to 40.7 cfs in late September 2000. Mid-summer flow was 44.6 on June 22, 2000.
- Only one early spring water sample exceed acute chronic criteria for Cd, Pb, and Zn.

SUMMARY OF BIOLOGICAL PRODUCTIVITY

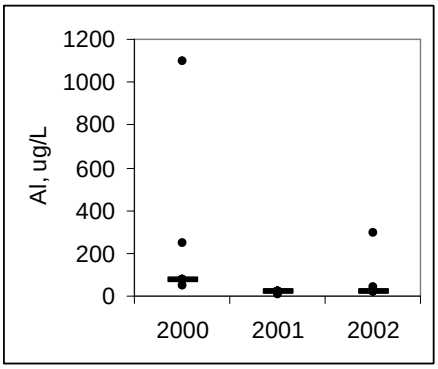
- Highest periphyton standing crop of any of the Ikalukrok Creek sites
- High invertebrate abundance, lower density (likely a function of high stream flows)
- Ephemeroptera and Plecoptera common
- Important summer rearing habitat for Arctic grayling

Water Quality

The water in East Fork Ikalukrok Creek has moderately high hardness (median = 130 mg/L) and alkalinity (median = 117 mg/L), which is typical of a calcium-bicarbonate dominated system. The pH of this creek is near neutral and ranges from 6.6 to 8.5, with lower pH values in early spring during snowmelt. Metals concentrations are low (Figure .37). In the three years of water sampling, only one sample exceeded the US EPA chronic criteria for aquatic life for Cd, Cu, Fe, Pb, and Zn and 3 samples (12%) exceeded the chronic life criterion for Al (Table 6). Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 7 samples were reported at <1 ug/L. Samples reported as <1 ug/L were ignored to calculate the summary data on Table 6.

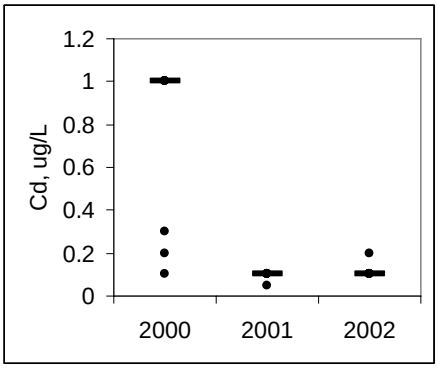


pH, standard units

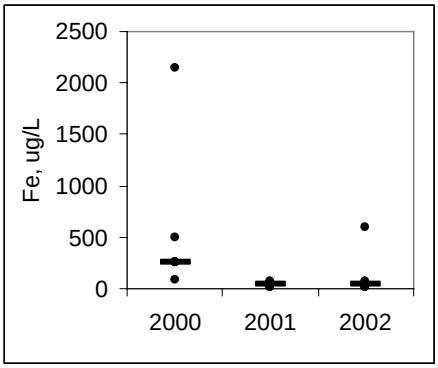


Concentration of Aluminum

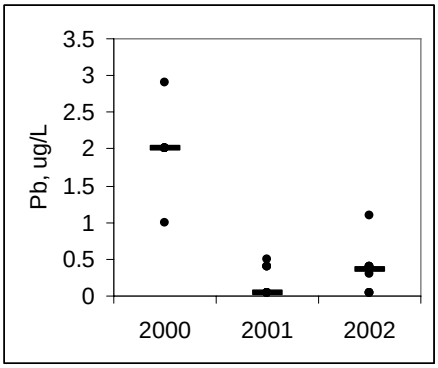
Figure 37. Concentrations of select metals at Station 208: East Fork Ikalukrok Creek, 2000 - 2002. Graph shows median as bar and all data values as points, n=9 for 2000, n=9 for 2001, and n=8 for 2002.



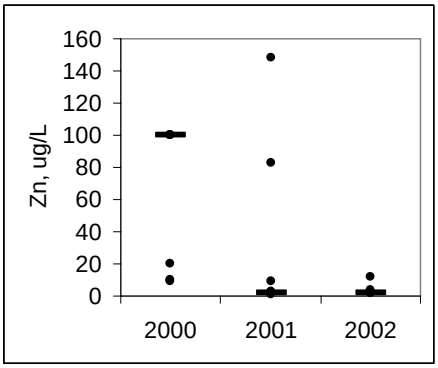
Concentration of Cadmium



Concentration of Iron



Concentration of Lead



Concentration of Zinc

Figure 37, continued.

Table 6. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 208. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	21.05	1100	10	26	4%	12%
Cd, µg/L	0.1	1	0.05	20	0%	5*%
Cu, µg/L	1	10	0.8	24	0%	4%
Fe, µg/L	50	2140	20	26		4%
Ni, µg/L	4.65	50	0.8	26	0%	0%
Pb, µg/L	0.4	2.9	0.04	26	0%	4%
pH	7.7	8.5	6.6	29	0%	
Se, µg/L	1	5	1	25	0%	0%
Zn, µg/L	6.25	148	1	26	4%	4%

*Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 6 samples were reported at <1 ug/L. These samples were disregarded in the above table.

Periphyton

Chlorophyll-a concentrations at Station 208 were the highest measured in any sites in the Ikalukrok Creek drainage (Figure 38, note the larger graph scale). In 2002, we estimated an average of 7.36 mg chlorophyll-a /m^2. Although chlorophyll-a concentrations were lower in 2001, they remained among the highest measured in this drainage. Periphyton communities in East Fork Ikalukrok Creek are dominated by Chromista, or diatoms, as indicated by the high proportions of chlorophyll-c (Figure 39).

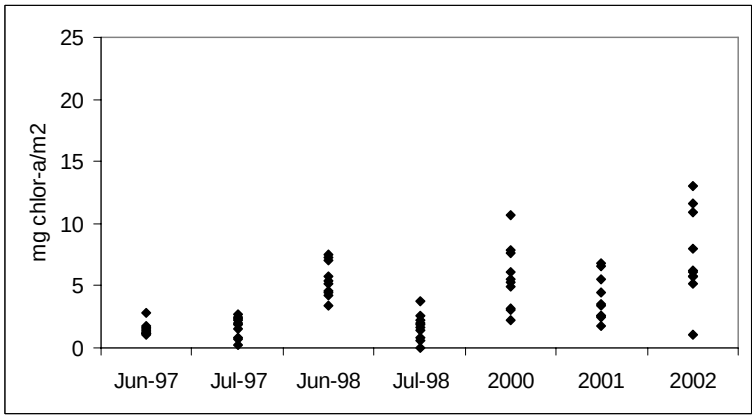


Figure 38**.** Concentration of chlorophyll-a in East Fork Ikalukrok Creek, Station 208.

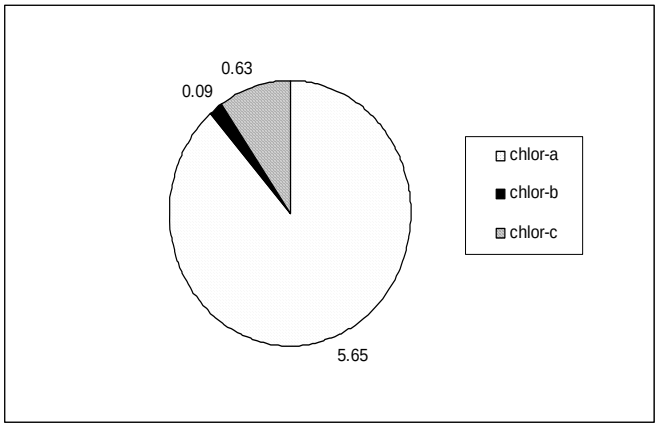


Figure 39**.** Proportions of chlorophyll-a, -b, and -c in Fork Ikalukrok Creek, Station 208.

Invertebrates

Both abundance and density of aquatic invertebrate communities were high in 1997 through 2001; abundance was the third highest found in the Ikalukrok Creek drainage; following Stations 206 and 207 (Figures 40 and 41). Numbers in 2002 were low and we believe that this was due to sorting errors in the lab in training new technicians and do not

adequately represent communities. Because we do not believe these numbers are meaningful, the 2002 data are not included in comparisons among sites.

We collected from 13 to 20 distinct taxonomic groups from drift nets in the East Fork of Ikalukrok Creek (Figure 42). Most of the invertebrates were aquatic forms, signifying a greater dependence on instream productivity than terrestrial inputs (Figure 43). Invertebrate communities in the East Fork of Ikalukrok Creek are dominated by aquatic Diptera, although other orders are well represented (Figure 44). The percent EPT taxa were among the highest measured at any of the sites (Figure 45). There were few Trichoptera, which is typical of northern latitude systems.

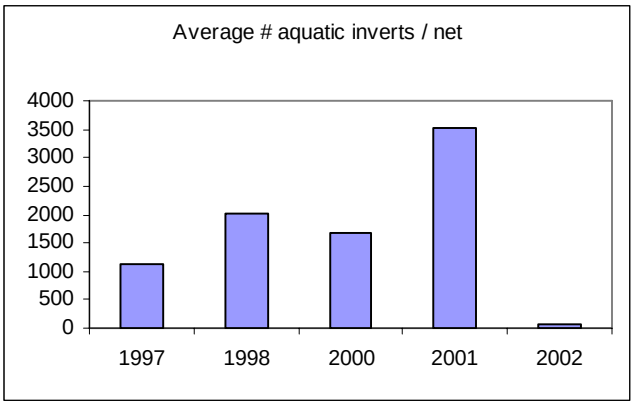


Figure 40. Abundance of aquatic invertebrates (average number per net) in East Fork Ikalukrok Creek, Station 208.

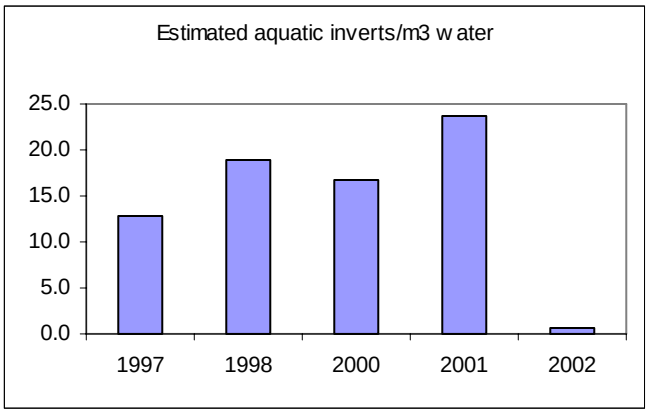


Figure 41. Density of aquatic invertebrates (average number per m3 water flowing through drift nets) in East Fork Ikalukrok Creek, Station 208.

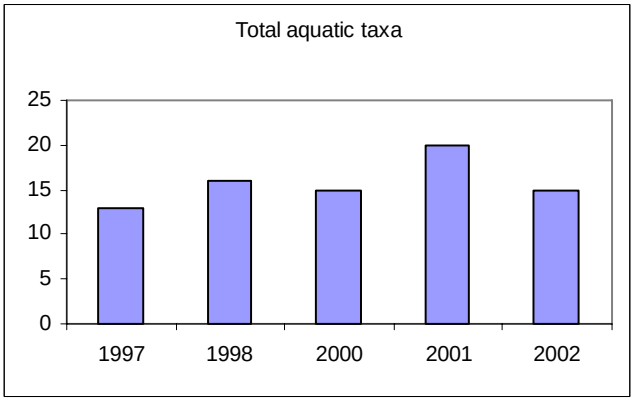


Figure 42. Total aquatic taxa in East Fork Ikalukrok Creek, Station 208.

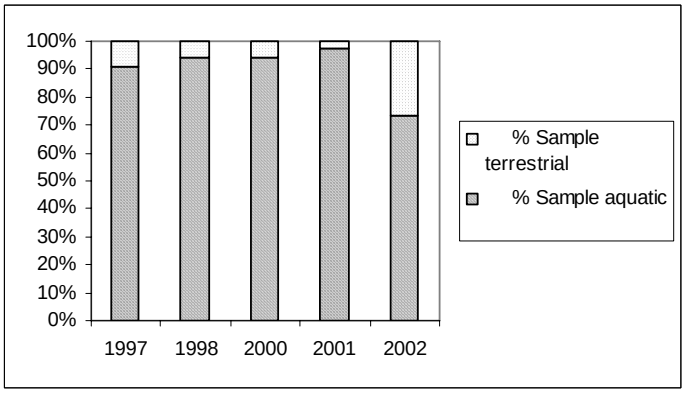


Figure 43. Proportion of terrestrial and aquatic invertebrates in drift samples in East Fork Ikalukrok Creek, Station 208.

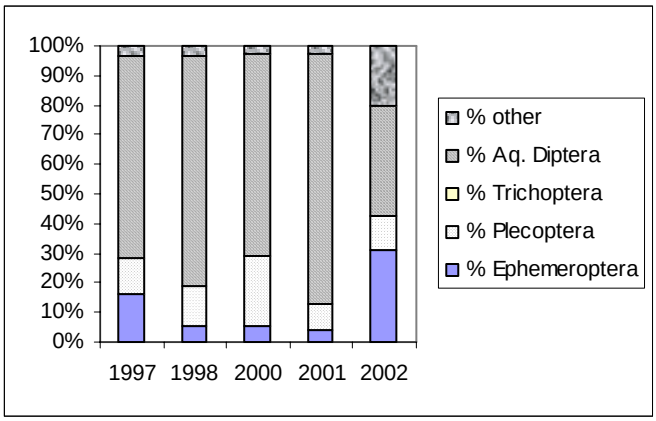


Figure 44. Proportion of aquatic insect orders in drift samples in East Fork Ikalukrok Creek, Station 208.

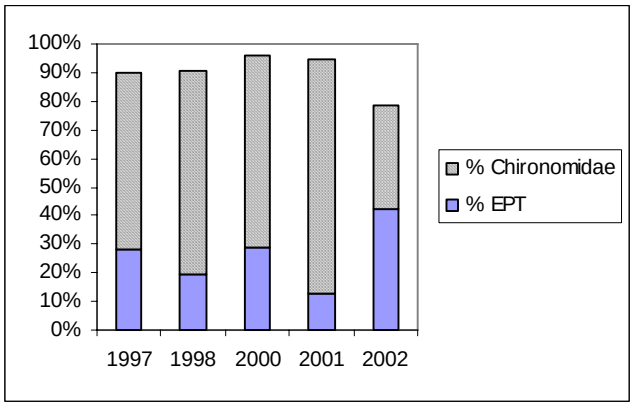


Figure 45. Proportion of Chironomidae and EPT taxa in East Fork Ikalukrok Creek, Station 208.

Fish Populations

Aerial and ground surveys of East Fork Ikalukrok Creek have shown this headwater stream to be important for summer rearing of adult Arctic grayling (Table 7), and to a lesser extent, juvenile Dolly Varden (Table 8). Several Arctic grayling collected by angling at the mouth of East Fork Ikalukrok Creek had been previously tagged in either Mainstem Red Dog or North Fork Red Dog creeks. The collection of fish tagged in downstream areas supports the importance of the system for summer feeding following spawning in downstream Mainstem Red Dog and North Fork Red Dog creeks.

Table 7. Numbers of adult Arctic grayling observed in East Fork Ikalukrok Creek.

Date of Survey	Number of Arctic grayling counted	Location in River	Reference
Late June 1997		Lower 11 km	Ott 1997
July 1999	200		Ott and Morris 1999a
July 2000	258	up to the falls located in Section 34, T33N, R18W	Ott et al 2000
August 2000	None observed	up to the falls located in Section 34, T33N, R18W	Weber Scannell et al. 2001
July 2001	<10		
Late July 2002	≥ 200		
August 2003	None observed		Townsend and Ingalls 2003
August 2005	≥70		Ott and Townsend 2005

Table 8. Dolly Varden caught in minnow traps, East Fork Ikalukrok Creek, Station 208.

7/8/00	7/29/00	7/8/01	8/3/01	7/12/02	8/1/02
FL (mm)	FL (mm)	FL (mm)	FL (mm)	FL (mm)	FL (mm)
10 traps	10 traps	10 traps	10 traps	10 traps	10 traps
no DV	113	no DV	no DV	no DV	110
					89
					112

The following observations of Arctic grayling in East Fork Ikalukrok Creek were made by ADNR/ADFG:

June 26, 1997. Adult Arctic grayling were observed in pools in the lower 11 km of East Fork Ikalukrok Creek (Ott 1997).

July 29, 1997. Adult Arctic grayling also were seen in East Fork Ikalukrok Creek (Weber Scannell 1997).

July 12, 1999. An aerial helicopter survey was conducted and we estimated 200 adult Arctic grayling in East Fork Ikalukrok Creek (Ott and Morris 1999a).

Early spring, 2000. We flew along East Fork Ikalukrok Creek up to and above the canyon containing two waterfalls. Extensive bottom founded ice with substantial overflow persisted in this region (Section 34, T33N, R18W).

July 9, 2000. East Fork Ikalukrok Creek was clear during early July surveys, but aufeis was still present along the edges of the floodplain. We counted 258 adult Arctic grayling in East Fork Ikalukrok Creek (Ott et al 2000). Arctic grayling adults were evenly distributed throughout East Fork Ikalukrok Creek up to the falls.

August 2, 2000. Water in East Fork Ikalukrok Creek was clear, but high with turbulent flow and no fish were observed during an aerial survey (Morris 2000).

Early July 2001. An aerial survey was made along East Fork Ikalukrok Creek and we counted less than 10 Arctic grayling adults (Weber Scannell et al. 2001).

July 31, 2002. We estimated at least 200 Arctic grayling adults in East Fork Ikalukrok Creek (Ott and Townsend 2002). Fish were counted during an aerial survey and they were scattered throughout East Fork Ikalukrok Creek from its mouth to the two waterfalls (about 11 km from the mouth).

August 2003. An aerial survey in early resulted in less than 50 Arctic grayling in Ikalukrok Creek from the mouth of Dudd Creek to the headwaters. Concentrations of Arctic grayling in East Fork Ikalukrok Creek were not observed (Townsend and Ingalls 2003).

August 2004. A large number of Arctic grayling (adults and juveniles) were present in East Fork Ikalukrok Creek.

July 30, 2005. An aerial survey of East Fork Ikalukrok Creek resulted in an estimated 70 adult Arctic grayling in the creek (Ott and Townsend 2005).

August 2, 2005. We used angling to capture 13 Arctic grayling from a deep pool/run near the mouth of East Fork Ikalukrok Creek. We observed several juvenile fish. Three of the Arctic grayling caught were recaptured fish that had been tagged in either Mainstem Red Dog or North Fork Red Dog creeks.

Based on our surveys, we believe that fish move into Ikalukrok Creek and then upstream for summer feeding e following spawning in Mainstem Red Dog and North Fork Red Dog creeks. Adult Arctic grayling concentrate in East Fork Ikalukrok Creek and in Ikalukrok Creek at the mouth of Grayling Junior Creek during the summer months following spring spawning.

Fish Tissues

Fish were not collected for tissue analysis.

Baseline data for East Fork of Ikalukrok Creek, Station 208, is included in Appendix 4.

Grayling Junior Creek, Station 209.

PHYSICAL FEATURES

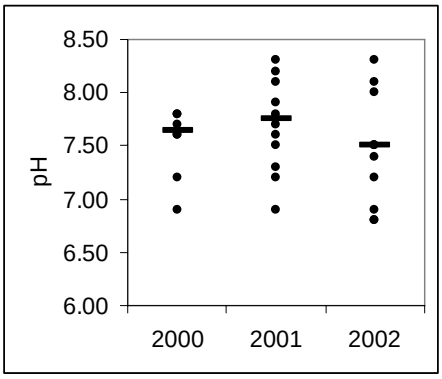
- Drainage size: 13.21 square miles
- Average July water temperature: 9.2°C
- Stream flow was measured only 7 times in 2000-01. June high flow was 119 cfs, July and August flows were around 19 to 20 cfs, and fall low flows were 14 cfs.
- Excellent water quality, 3 samples with elevated Al

SUMMARY OF BIOLOGICAL PRODUCTIVITY

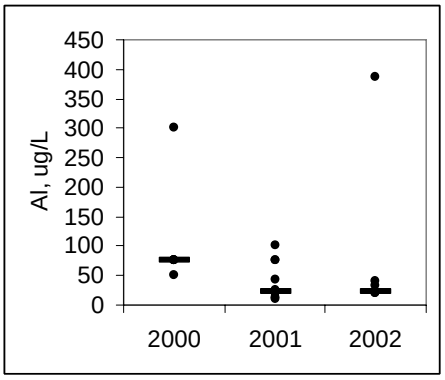
- Fairly high periphyton standing crop
- Low invertebrate abundance and density
- EPT taxa important: Ephemeroptera and Plecoptera common
- Numerous Arctic grayling collect at mouth of creek
- Fairly abundant Dolly Varden juveniles (mostly age 2 and 3) migrate into creek for summer rearing

Water Quality

Water quality in Grayling Junior Creek was similar to East Fork Ikalukrok Creek with neutral to slightly basic pH and low concentrations of metals (Figure 46). Concentrations of Zn were slightly elevated, and ranged from detection to 106 ug/L. Eight percent of the 2000-2002 water samples exceeded the US EPA chronic aquatic life criterion for Al, 1 sample (7%) exceeded the chronic criterion for Fe (Table 9) .No samples exceeded the acute criterion for aquatic life for any analytes. Water samples with MRLs greater than the acute or chronic criteria were disregarded in these calculations.

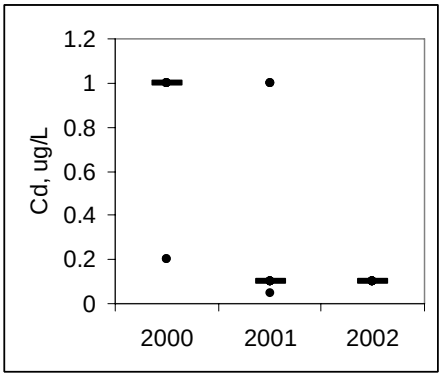


pH, standard units

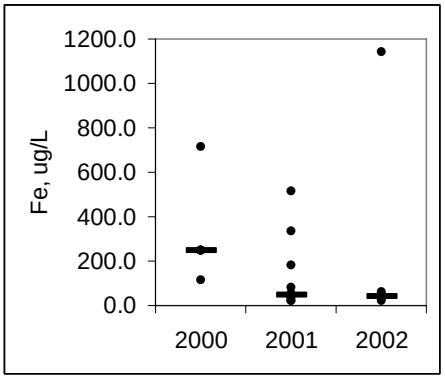


Concentration of Aluminum

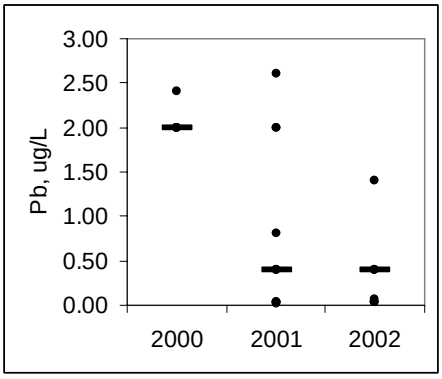
Figure 46. Concentrations of select metals at Station 209: Grayling Junior Creek, 2000 - 2002. Graph shows median as bar, all data values as points, n=7 for 2000, n=11 for 2001, and n=8 for 2002.



Concentration of Cadmium



Concentration of Iron



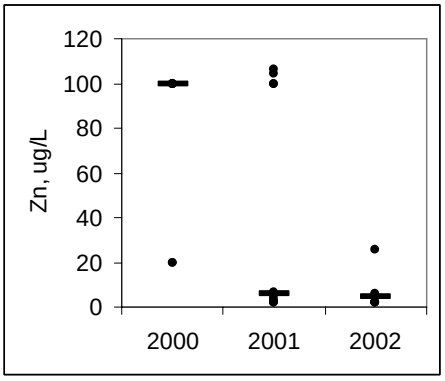


Figure 46, continued.

Table 9. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 209. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	36.4	388	10	26	0%	8%
Cd, µg/L	0.1	1	0.05	26	0%	0%*
Cu, µg/L	1.05	10	0.8	26	0%	0%
Fe, µg/L	56.7	1140	20	26		7%
Ni, µg/L	5	50	1.1	26	0%	0%
Pb, µg/L	0.4	2.6	0.02	26	0%	0%
pH	7.6	8.3	6.8	29	0%	
Se, µg/L	1	5	1	27	0%	0%
Zn, µg/L	6.1	106	2	26	0%	0%

*Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 8 samples were reported at <1 ug/L. These samples were disregarded in the above table.

Periphyton

Chlorophyll-a concentrations were similar among the years sampled (Figure 47) and considerably lower than measured in the East Fork of Ikalukrok Creek. In 2002, we estimated an average of 4.6 mg chlorophyll-a /m^2, compared to 7.36 mg chlorophyll-a/m^2 in East Fork of Ikalukrok Creek. Periphyton communities in Grayling Junior Creek are dominated by Chromista, or diatoms, as indicated by the high proportions of chlor-c (Figure 48).

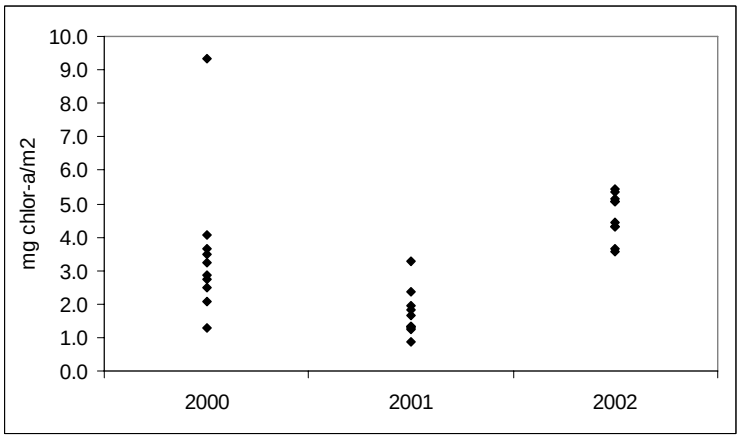


Figure 47. Concentration of chlorophyll-a at Station 209: Grayling Junior Creek.

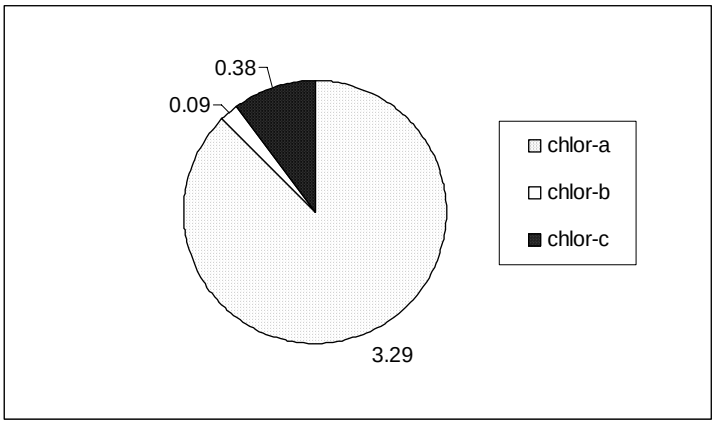


Figure 48. Proportions of chlorophyll-*a*, -*b*, *and* -*c* at Station 209: Grayling Junior Creek.

Invertebrates

When compared with all other sites in the Ikalukrok Creek drainage, samples from Grayling Junior Creek had among the lowest invertebrate abundance and density (Figures 49 and 50). Low abundance and density in 2002 may have been due to inexperienced technicians sorting samples.

We collected from 11 to 17 distinct taxonomic groups from drift nets in Grayling Junior Creek (Figure 51). Most of the invertebrates were aquatic forms, signifying a greater dependence on instream productivity than terrestrial inputs (Figure 52). Invertebrate communities in Grayling Junior Creek are dominated by Diptera larvae, and to lesser proportions, by Ephemeroptera and Plecoptera nymphs(Figure 53); Trichoptera were absent. EPT taxa accounted for less than 30% of samples (Figure 54).

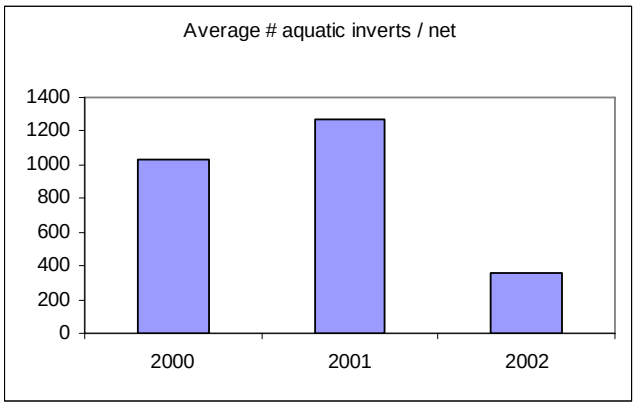


Figure 49. Abundance of aquatic invertebrates (average number per net) at Station 209: Grayling Junior Creek**.**

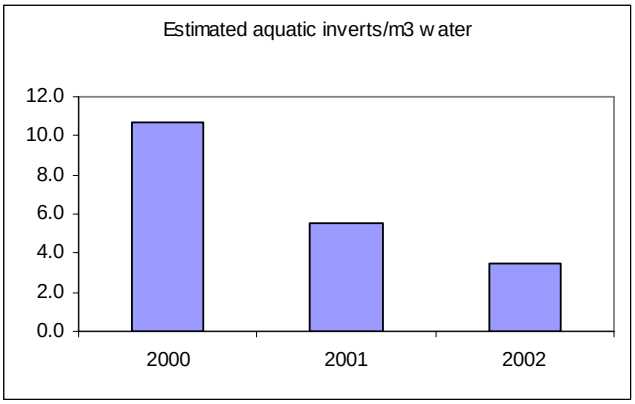


Figure 50. Density of aquatic invertebrates (average number per m3 water flowing through drift nets) at Station 209: Grayling Junior Creek.

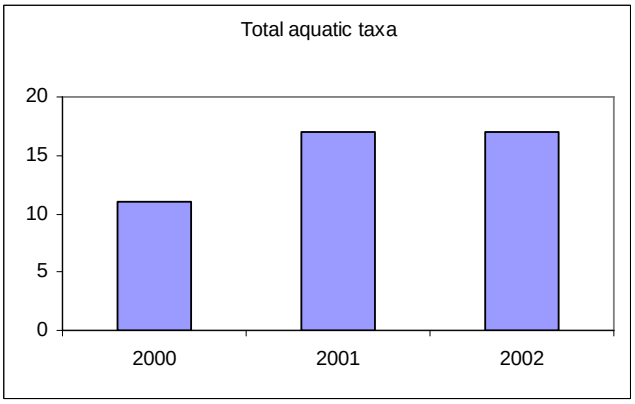


Figure 51. Total aquatic taxa at Station 209: Grayling Junior Creek.

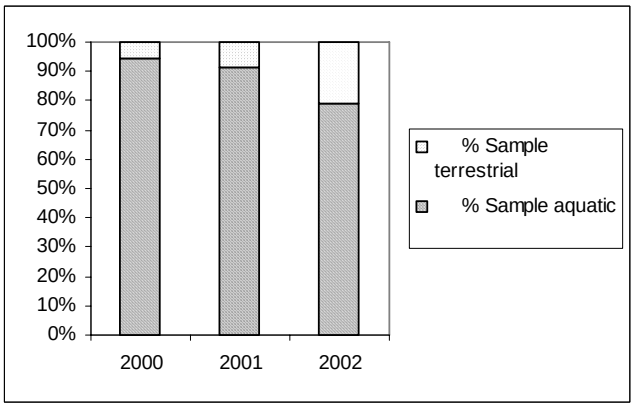


Figure 52. Proportion of terrestrial and aquatic invertebrates in drift samples at Station 209: Grayling Junior Creek**.**

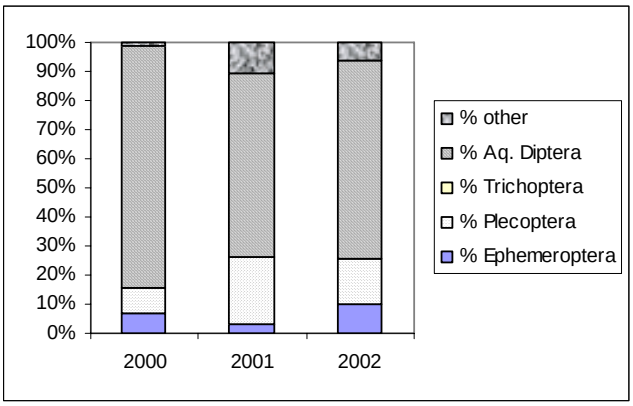


Figure 53. Proportion of aquatic insect orders in drift samples at Station 209: Grayling Junior Creek.

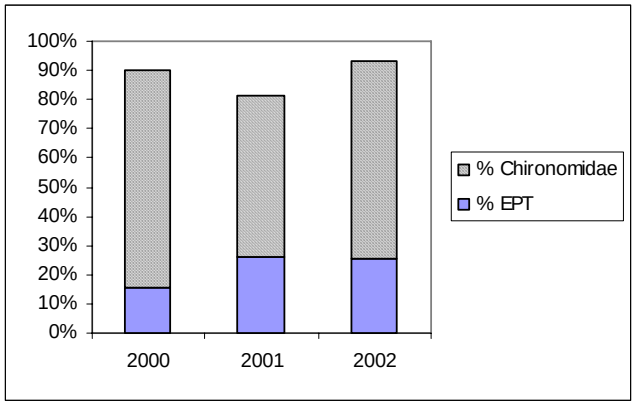


Figure 54. Proportion of Chironomidae and EPT taxa at Station 209: Grayling Junior Creek.

Fish Populations

Fish populations in Grayling Junior Creek were sampled by periodic helicopter surveys, angling, and mark-recapture. Aerial surveys included the confluence of Grayling Junior Creek with Ikalukrok Creek. In mark-re-capture sampling, only fish over 200 mm are marked

Mark-recapture sampling and aerial surveys indicated that Arctic grayling spawn in North Fork Red Dog Creek in spring, and then migrate up Ikalukrok Creek to rear in Grayling Junior Creek. Based on aerial and ground surveys in Ikalukrok Creek drainage, a substantial portion of the Arctic grayling were in Grayling Junior Creek or in Ikalukrok Creek in the mixing zone of these two systems (Figure 55). Less than 50 adult Arctic grayling were observed in Ikalukrok Creek upstream of Dudd Creek. All evidence collected to date indicates that Arctic grayling do not spawn in Grayling Junior Creek, but that this system is important for summer rearing of adult Arctic grayling and juvenile

Dolly Varden (Figure 56, Townsend and Ingalls 2003). Grayling Junior Creek, as judged by presence of algae, fish, and invertebrates is one of the most productive stream systems in the Ikalukrok Creek drainage (Ott et al. 2000b).

Figure 55. Arctic grayling at the mouth of Grayling Junior Creek.

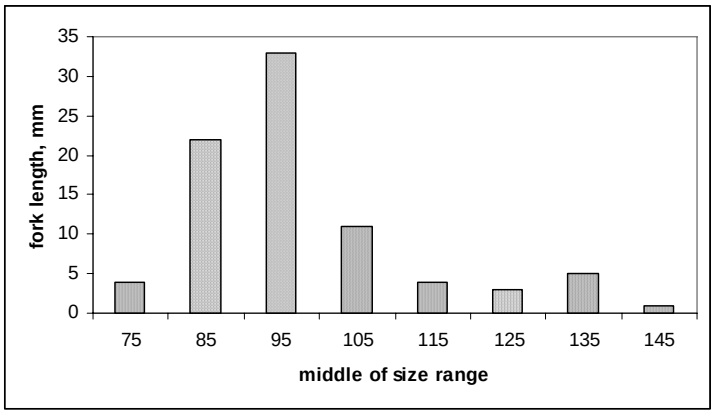


Figure 56. Size distribution of Dolly Varden juvenile fish collected at Station 209, Grayling Junior Creek.

ADFG/ADNR provided the following summary of observations of fish in Grayling Junior Creek:

July, 1999. Large numbers of Arctic grayling <200 mm were observed in many of the streams in the Ikalukrok Creek drainage in July of 1999 (Ott and Morris 1999a). Observations of large numbers of juvenile Arctic grayling distributed throughout many of the streams in the Ikalukrok Creek drainage has only occurred once since work began in 1990. We estimated 300 adult Arctic grayling in Ikalukrok Creek at the mouth of Grayling Junior Creek (Ott and Morris 1999a).

August 7, 1999. Numerous adult Arctic grayling were observed at the confluence with Ikalukrok Creek (Ott and Morris 1999b).

July 10 -11, 2000. 53 adult and juvenile Arctic grayling in Grayling Junior Creek (Ott et al. 2000b). Thirty-eight of the Arctic grayling were marked with individual floy-tags and one fish was a recapture that had been tagged in North Fork Red Dog Creek in July 1995.

July 28, 2000. Nine Arctic grayling were captured in Grayling Junior Creek. Six were greater than 200 mm long and were marked (Ott et al. 2000c).

August 2, 2000. Only a few Arctic grayling were seen during an aerial survey in the lower 3 km of Grayling Junior Creek (Morris 2000).

Early June 2001. We recaptured one Arctic grayling previously tagged in North Fork Red Dog Creek during the spawning run (Morris et al. 2001). This re-

capture documents the upstream migration of Arctic grayling after spawning in the North Fork of Red Dog Creek.

Early July 2001. We estimated that at least 300 adult Arctic grayling at the mouth of Grayling Junior Creek (Weber Scannell et al. 2001). We marked 73 Arctic grayling and had 8 recaptures. Three of the recaptures were fish that had been marked in spring 2001 in North Fork Red Dog Creek. One fish was marked in fall 2000 in East Fork Ikalukrok Creek and then recaptured in spring in North Fork Red Dog Creek and again in Grayling Junior Creek in July 2001. In late July, an aerial survey at the mouth was made in late July, only about 100 Arctic grayling were observed (Morris and Ott 2001).

Late July, 2001. An aerial survey of Grayling Junior Creek at its mouth was made in late July, only about 100 Arctic grayling were observed (Morris and Ott 2001).

Early July 2002. No Arctic grayling were observed at the mouth of Grayling Junior Creek (Ott et al. 2002).

July 31, 2002. We saw about 20 adult Arctic grayling at the mouth of Grayling Junior Creek (Ott and Townsend 2002).

August 1, 2002. Seven fish were caught by angling on and three of these were recaptures. Two of the recaptured fish had been tagged during the spring spawning migration in North Fork and Mainstem Red Dog creeks (Ott and Townsend 2002).

June 12, 2003. No adult Arctic grayling were seen in Grayling Junior Creek – water was fairly clear (Morris and Townsend 2003). During this time period, adult Arctic grayling were seen in both Mainstem Red Dog and North Fork Red Dog creeks during the spring spawning period.

Early July 2004. We surveyed the mouth of Grayling Junior Creek and found no Arctic grayling (Ott et al. 2004).

Late August 2004. We sampled Grayling Junior Creek with minnow traps and for the first time captured age-0 Arctic grayling (Townsend and Conley 2004). Five age-0 Arctic grayling (64 to 79 mm) were caught (Townsend and Conley 2004). Previous work (minnow traps in early July and early August) in Grayling Junior Creek in 2000, 2001, and 2002 had only resulted in the capture of juvenile Dolly Varden.

August 27, 2004. In fall, 2004 we also caught several slimy sculpin in Grayling Junior Creek. We noted a waterfall in Grayling Junior Creek that would be

impassable to fish migrating upstream under most, if not all, flow conditions. The waterfall is located in Section 29, T32N, R18W.

July August 2005. Two aerial surveys were conducted to assess the number of fish at the mouth of Grayling Junior Creek (Ott and Townsend 2005a and 2005b). Few adult Arctic grayling were found in Grayling Junior Creek in early July or early August. As noted in the late July – early August trip report, a large number of Arctic grayling (adults and juveniles) were present in East Fork Ikalukrok Creek. We also noted a waterfall in Grayling Junior Creek that would be impassable to upstream moving fish under most, if not all, flow conditions. The waterfall is located in Section 29, T32N, R18W.

Early July 2005. Few adult Arctic grayling were found in Grayling Junior Creek in early July or early August.

Fish Tissues

Fish collected from Grayling Junior Creek for whole body analysis of tissues were selected within a narrow age/size range to minimize variability due to length of exposure (Fig.57)

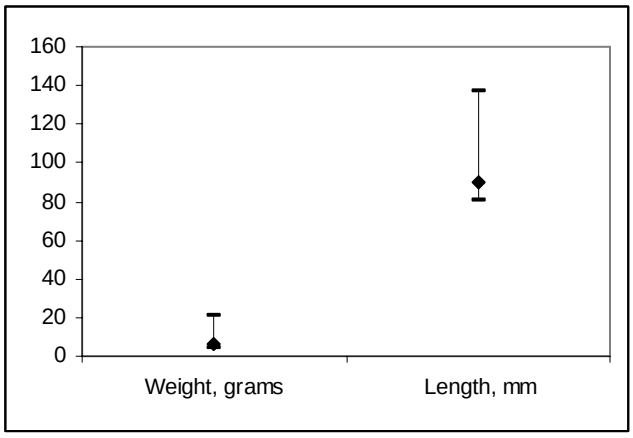


Figure 57. Median, maximum, and minimum length and weight of juvenile Dolly Varden collected in Grayling Junior Creek for whole body metals analysis.

Juvenile Dolly Varden from Grayling Junior Creek contained surprisingly high concentrations of metals (Figure 58), especially compared to similarly sized Dolly Varden from Anxiety Ridge, Ferric, Red Dog, and North Fork of Red Dog creeks (ADNR OHMP data files). The juvenile fish in Grayling Junior Creek contained higher concentrations of Cd than fish in Anxiety Ridge Creek, Ferric Creek and North Fork; higher concentrations of Pb than fish in Ferric Creek; higher concentrations of Se than all other four sites; and higher concentrations of Zn than Red Dog and North Fork of Red Dog Creeks. Fish from Anxiety Ridge and Ferric Creeks were not sampled for Zn.

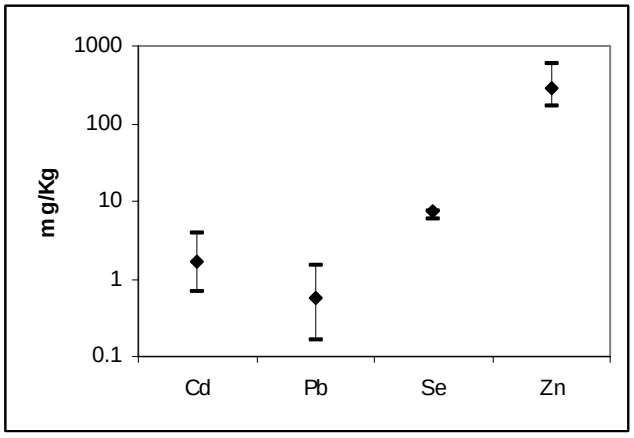


Figure 58. Median, maximum, and minimum concentrations of Cd, Pb, Se, Zn (logarithmic scale) of juvenile Dolly Varden collected in Grayling Junior Creek.

All baseline data collected from Grayling Junior Creek are listed in Appendix 5.

Noa Creek, Station 210.

PHYSICAL FEATURES

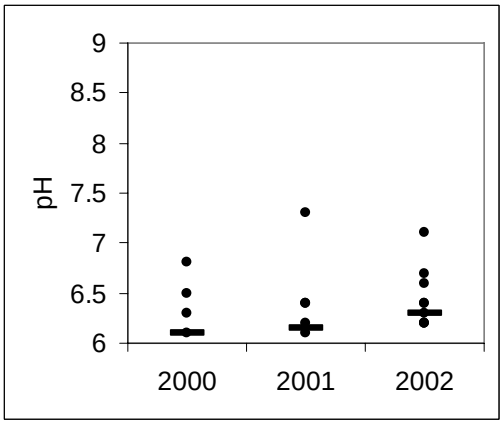
- Drainage size: 1.57 square miles
- Average July water temperature: 3.6°C
- Break-up flows about 20 cfs
- Average summer flow, mid-June – August 4.5 cfs
- Degraded water quality: 95% of water samples exceed chronic aquatic life criteria for Al and Cd, 90% exceed for Ni and Zn, and 76% have pH below water quality criterion for aquatic life
- Small creek, dense riparian vegetation

SUMMARY OF BIOLOGICAL PRODUCTIVITY

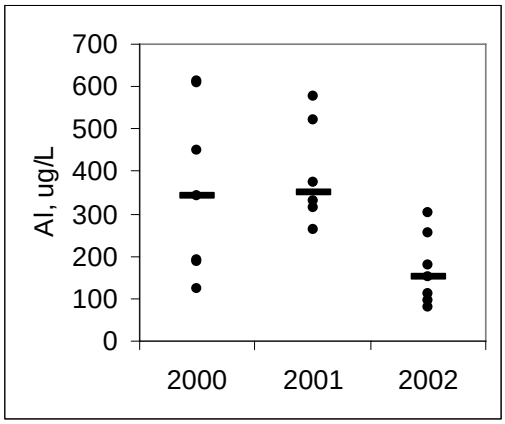
- Periphyton standing crop (chlor-a) near Method Reporting Limit
- Moderately low invertebrate abundance and density
- No EPT taxa
- Invertebrate community primarily aquatic Diptera, Acari, and Collembola
- No fish

Water Quality

The relatively high hardness (median = 217 mg /L) combined with low alkalinity (median = 2.6 mg/L) and higher concentrations of sulfate (median = 224 mg/L) in Noa Creek indicate that this system is dominated by calcium sulfate rather than calcium bicarbonate. The pH of the water is low, with most samples below 6.5, the lower limit for aquatic life. The water in Noa Creek is of poor water quality with high concentrations of Al, Cd, Cu, Ni, and Zn (Figure 59, Table 10). Of samples collected from 2000 through 2002, 95% exceeded the chronic criterion for Al, 95% exceeded for Cd, 60% exceeded for Cu, 90% exceeded for Ni, and 90% for Zn. Seventy six percent of the water samples were below the pH range for aquatic life (Table 10).

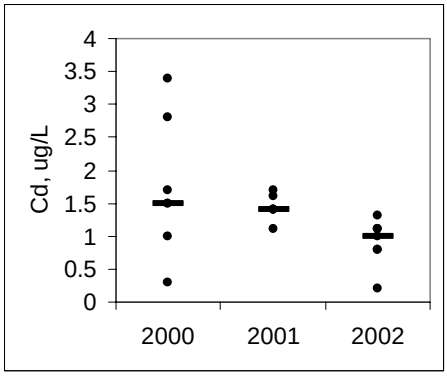


pH, standard units

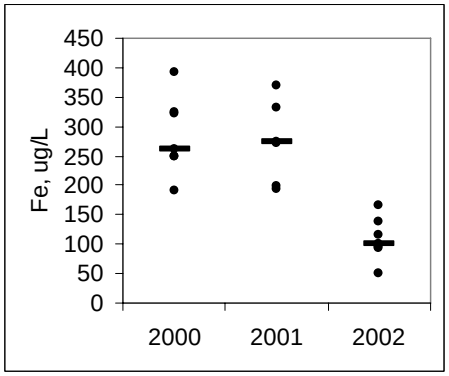


Concentration of Aluminum

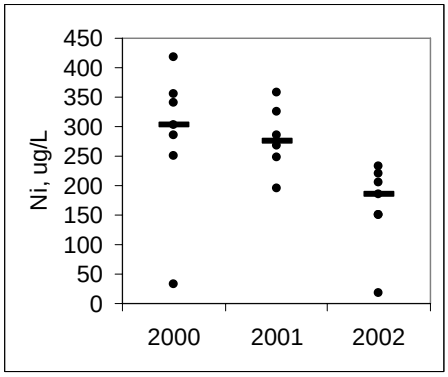
Figure 59. Concentrations of select metals at Station 210: Noa Creek, 2000 - 2002. Graph shows median as bar, all data values as points, n=7, 6, and 7 for metals and n= 7, 8, and 9 for pH in 2000, 2001, and 2002, respectively.



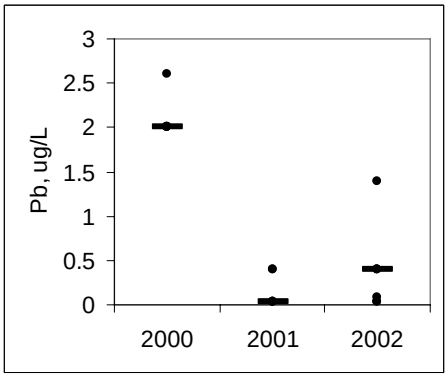
Concentration of Cadmium



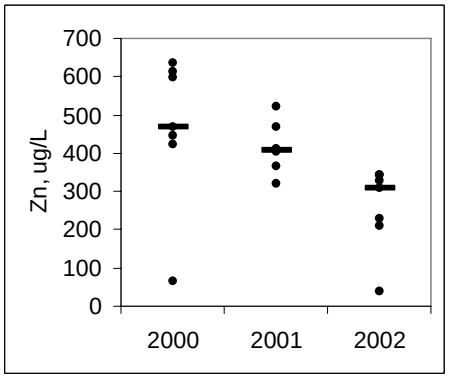
Concentration of Iron



Concentration of Nickel



Concentration of Lead



Concentration of Zinc

Figure 59, continued.

In 2002, Noa Creek appeared to have lower concentrations of metals than the previous two years, although sample sizes were too small to allow statistical analysis. Lower concentrations of Al, Ni, and Zn in 2002 are most notable; changes in Cd are largely due to improved Method Detection Limits in 2001 and 2002.

Table 10. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 210. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	282.5	613	79.9	20	0%	95%
Cd, µg/L	1.35	3.4	0.2	20	10%	95%
Cu, µg/L	10.5	23.8	3.5	20	30%	60%
Fe, µg/L	224	391	51	20		0%
Ni, µg/L	249	418	17.8	20	0%	90%
Pb, µg/L	0.4	2.6	0.04	20	0%	5%
pH	6.2	7.3	5.5	25	76%	
Se, µg/L	3.3	5.1	1	22	0%	5%
Zn, µg/L	384.5	635	38.1	20	90%	90%

Periphyton

Periphyton biomass, as estimated by concentrations of chlorophyll *a*, was low in Noa Creek in all years (Fig. 60, note the change in scale from previous graphs of similar data). The concentrations of chlorophyll *b* and *c* in most of the samples (for all years) were below the detection limit; therefore, these we were unable to estimate concentrations of these pigments.

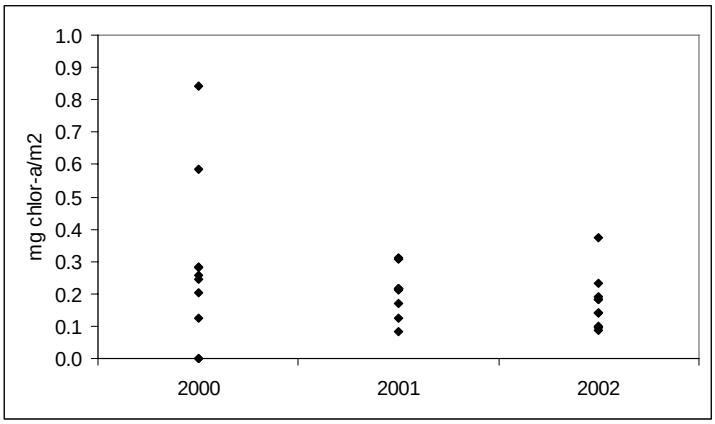


Figure 60. Concentration of chlorophyll *a* in Noa Creek, Station 210.

Invertebrate Communities

Both abundance and density of aquatic invertebrates increased from 2000 to 2001 and from 2001 to 2002 (Figs. 61 and 62); the changes in invertebrate populations may be due to decreases in metals and improved water quality found in 2002. The invertebrate abundance in Noa Creek was similar to Grayling Junior Creek and the East Fork of Ikalukrok Creek; invertebrate density was higher in Noa Creek than in Grayling Junior Creek.

Although numbers of aquatic taxa found in Noa Creek (Fig. 63) were similar that found in Grayling Junior and East Fork Ikalukrok Creeks, the communities are different. Noa Creek had high proportions of terrestrial invertebrates in drift samples (Fig. 64). In 2001 and 2002, most of the aquatic invertebrates found in Noa Creek were Diptera: Chironomidae with few, or no, Trichoptera, Ephemeroptera, or Plecoptera (EPT taxa, Figure 65). In 2000, samples contained high proportions of aquatic mites (Acari) and springtails (Collembola). The absence of EPT taxa (Fig. 66) signifies a depauperate

community and is likely a reflection of higher concentrations of metals and lower pH than found at most of the other sites.

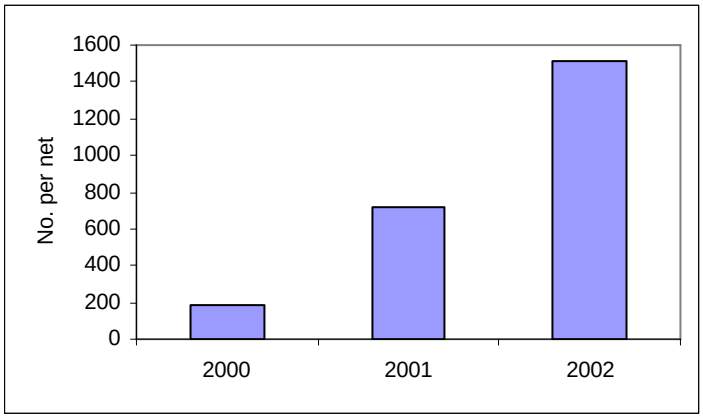


Figure 61. Abundance of aquatic invertebrates in Noa Creek, Station 210.

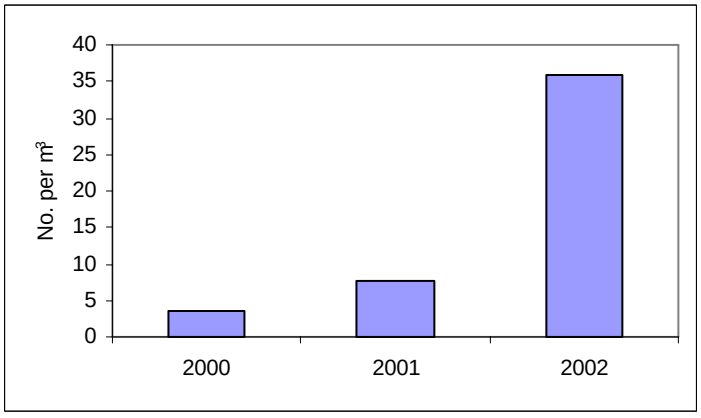


Figure 62. Density of aquatic invertebrates in Noa Creek, Station 210.

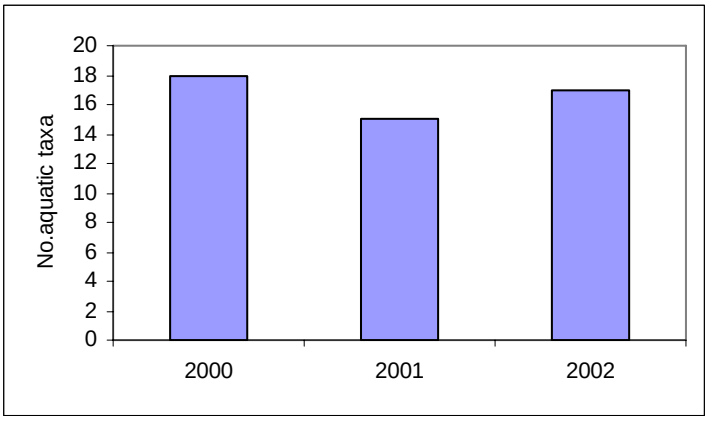


Figure 63. Total aquatic taxa in Noa Creek, Station 210.

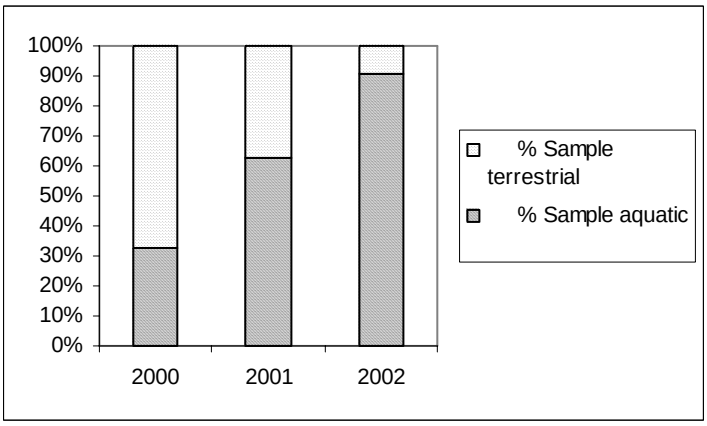


Figure 64. Proportion of terrestrial and aquatic invertebrates in drift samples in Noa Creek, Station 210.

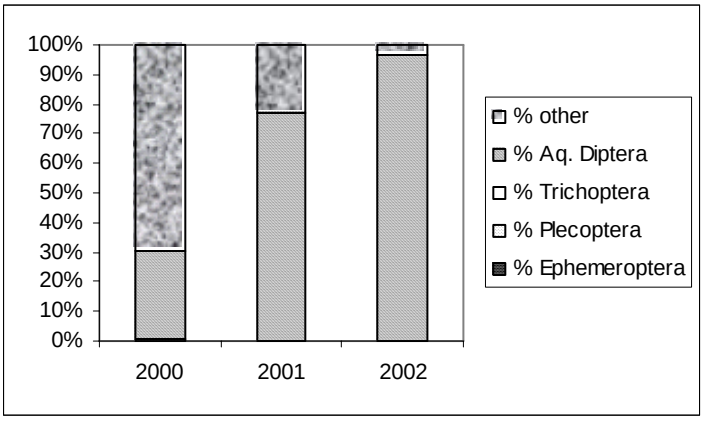


Figure 65. Proportion of aquatic insect orders in drift samples in Noa Creek, Station 210.

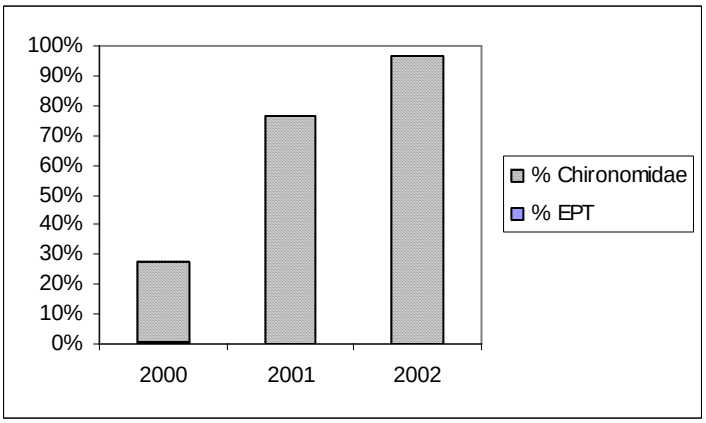


Figure 66. Proportion of Chironomidae and EPT taxa in Noa Creek, Station 210.

Fish Communities

No fish have been found in Noa Creek.

Fish Tissues

No fish have been found in Noa Creek; therefore, no fish tissue samples have been collected.

Water quality and Biological data for Noa Creek are listed in Appendix 6.

Moil Creek, Station 211.

PHYSICAL FEATURES

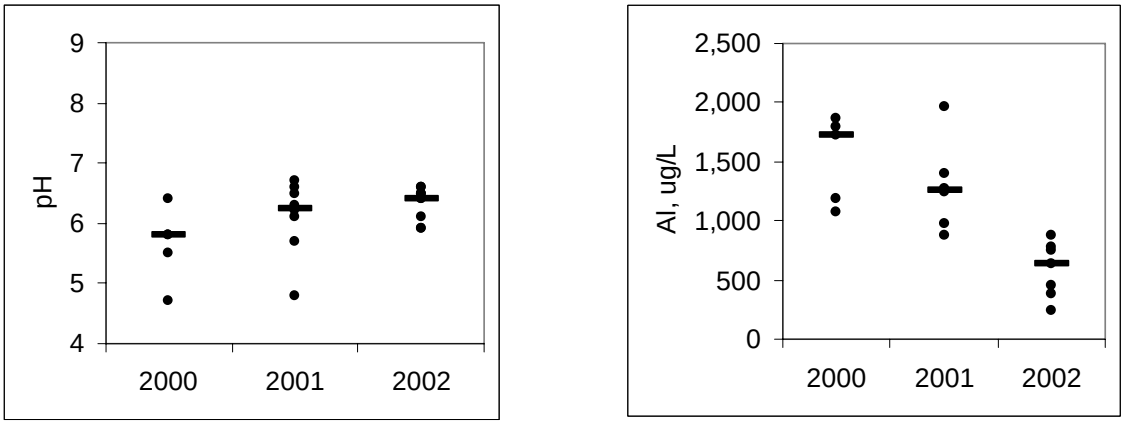
- Drainage size: 1.34 square miles
- Average July water temperature: 4.8°C
- Stream flows ranged from 2.2 to 11 cfs, July through mid-August flows were 3 to 5 cfs
- Degraded water quality: 100% of water samples exceed chronic criteria for aquatic life, 95% exceed for Cd, Cu, Ni, and Zn, and 65% have pH below chronic criterion

SUMMARY OF BIOLOGICAL PRODUCTIVITY

- Periphyton standing crop below Method Reporting Limit
- Extremely low aquatic invertebrate abundance and density
- EPT taxa rare: few Plecoptera, no Ephemeroptera or Trichoptera
- No fish

Water Quality

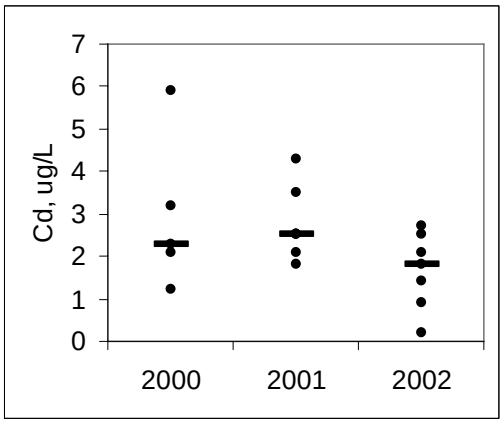
The relatively high hardness (median = 218 mg/L) combined with low alkalinity (median <2/0 mg/L) and higher concentrations of sulfate (median = 203.5 mg/L) in Moil Creek indicate that this system is dominated by calcium sulfate rather than calcium bicarbonate. Metals concentrations in Moil Creek are high, especially Cu, Fe, Al, and Zn, and the pH is low (Figure67, Table 11). From 2000 through 2002, 100% of the water samples exceeded the chronic aquatic life criteria for Al and Fe, 95% of the samples exceeded for Cd, and 94% exceeded for Cu, Ni, and Zn (Table 11). Sixty five percent of the samples had pH levels that were below the aquatic life criteria.



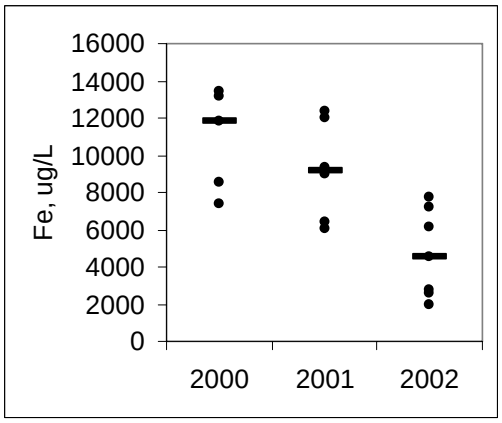
pH, standard units

Concentration of Aluminum

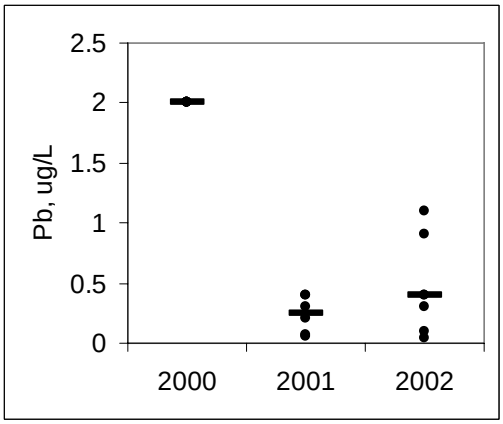
Figure 67. Concentrations of select metals at Station 211: Moil Creek, 2000 - 2002. Graph shows median as bar, all data values as points, n=75, 6, and 7 for metals and 5, 8, and 9 for pH in 2000, 2001, and 2002, respectively.



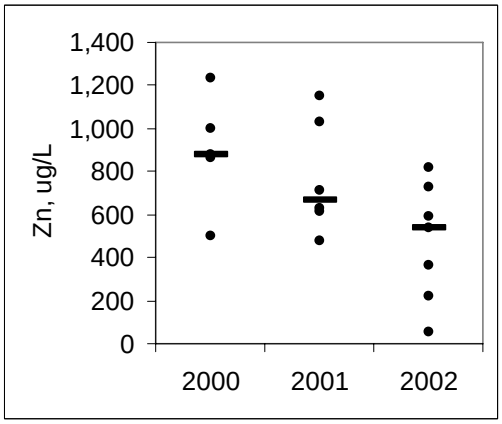
Concentration of Cadmium



Concentration of Iron



Concentration of Lead
Note high MRL in 2000 = 2 ug/L



Concentration of Zinc

Figure 67, continued.

Table 11. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 211. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample. Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	1024	1960	235	18	78%	100%
Cd, µg/L	2.3	5.9	0.2	19	68%	95%
Cu, µg/L	25.2	46	7.7	18	83%	95%
Fe, µg/L	7560	13400	1950	18		100%
Ni, µg/L	226	418	20.6	18	0%	95%
Pb, µg/L	0.4	2	0.04	18	0%	0%
pH	6.3	6.7	4.7	23	65%	
Se, µg/L	3.6	7	1	19	0%	16%
Zn, µg/L	668	1230	56.2	18	94%	95%

Periphyton

Periphyton biomass in Moil Creek was near or below levels of detection in all years (Figure 68). Low concentrations of chlorophyll *a* likely reflect the overall poor water quality with high concentrations of metals.

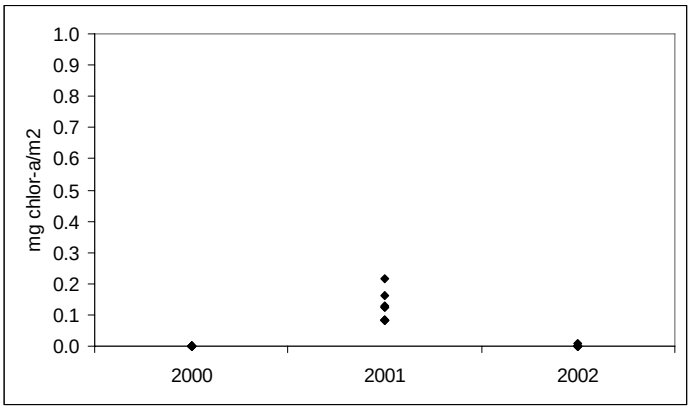


Figure 68. Concentration of chlorophyll *a* in Moil Creek, Station 211.

None of the periphyton samples had sufficient amounts of chlorophyll to distinguish chlorophyll–*a*, –*b*, and –c.

Invertebrate Communities

Both abundance and density of aquatic invertebrates were higher in 2001 and 2002 (Figs. 69 and 70) than in 2000. Water quality was somewhat improved in 2001 and 2002 with lower concentrations of Al and Fe and higher pH.

The invertebrate abundance in Moil Creek was among the lowest found in any of the Ikalukrok Creek drainage sites and similar to abundance and density found in West Fork of Ikalukrok Creek (Station 205). Although numbers of aquatic taxa (Fig. 71) found in Moil Creek were similar to many of the other sites, the community was substantially different than other sites: 64% of the invertebrates collected in 2000-2002 were terrestrial (Fig 72). As in Noa Creek, aquatic mites (Acari, 6% of total samples) and Collembola (6% of total samples) were among the most common taxa. There were no

aquatic Ephemeroptera or Trichoptera and only 1 Plecoptera (Fig. 73). Five percent of the total samples were Ephemeroptera adults of the family Baetidae. The absence of EPT taxa (Fig. 74) signifies a depauperate community and is likely a reflection of higher concentrations of metals and lower pH than found at most of the other sites.

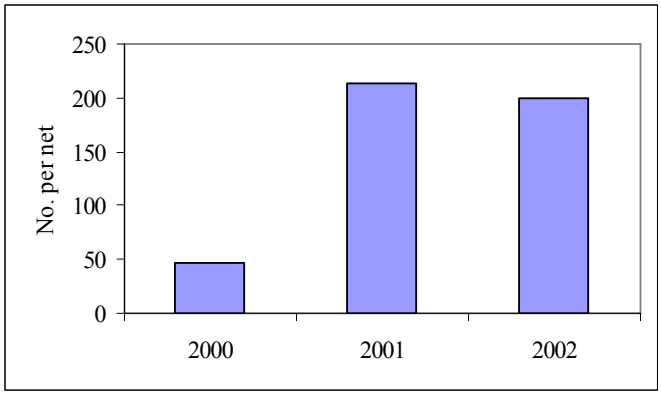


Figure 69. Abundance of aquatic invertebrates in Moil Creek, Station 211.

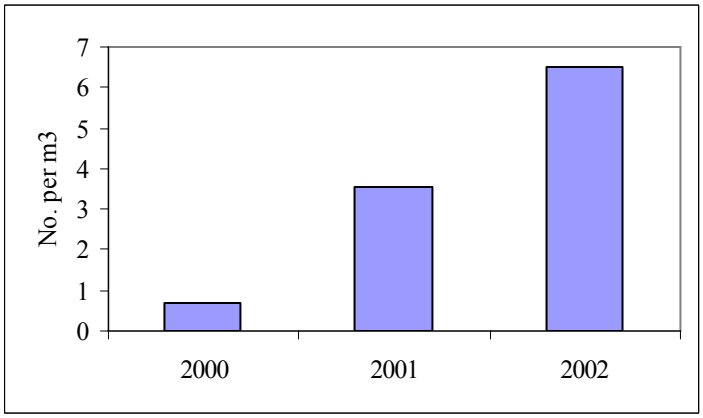


Figure 70. Density of aquatic invertebrates in Moil Creek, Station 211.

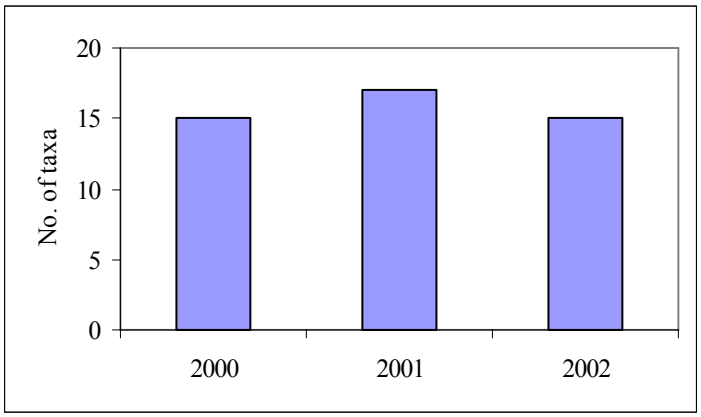


Figure 71. Total aquatic taxa in Moil Creek, Station 211.

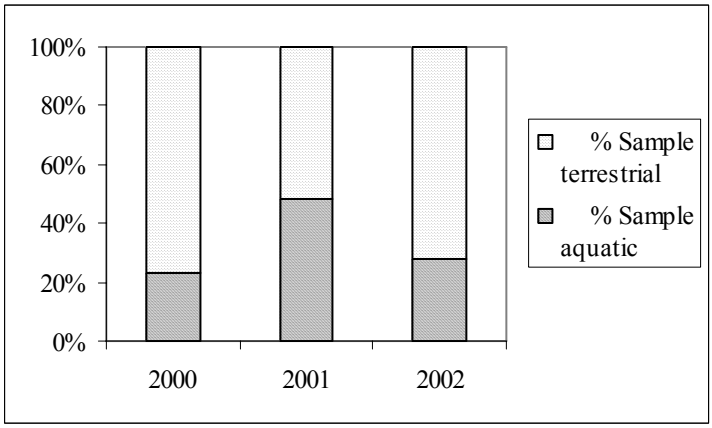


Figure 72. Proportion of terrestrial and aquatic invertebrates in drift samples in Moil Creek, Station 211.

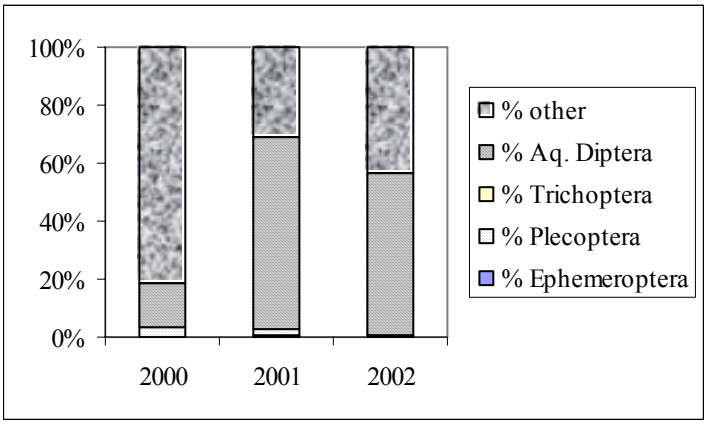


Figure 73. Proportion of aquatic insect orders in drift samples in Moil Creek, Station 211.

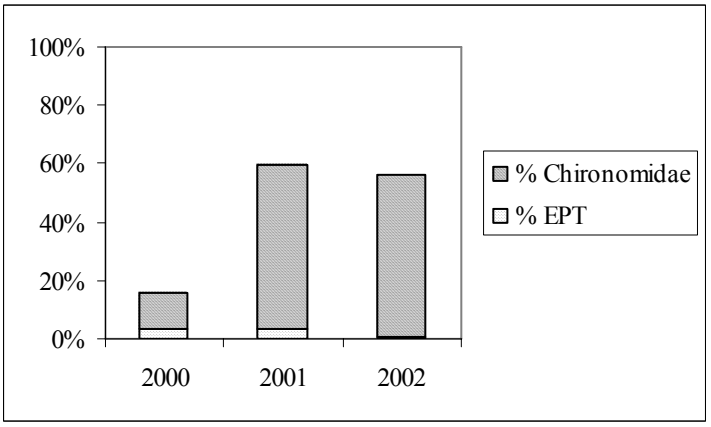


Figure 74. Proportion of Chironomidae and EPT taxa in Moil Creek, Station 211.

Fish Communities

No fish were found in Moil Creek.

Fish Tissues

The absence of fish prevented sampling fish tissues for metals.

Water quality and biological data for Moil Creek are presented in Appendix 7.

Sled Creek, Station 212.

PHYSICAL FEATURES

- Drainage size: 2.51 square miles
- Average July water temperature: 6.9°C
- 2000-02 summer flow from <1 cfs to 10 cfs
- One flow measurement at breakup (June 5, 2000) was 45.7 cfs
- Excellent water quality. 2 samples exceeded chronic aquatic life criterion for Al, 1 sample exceeded criteria for Cd, Cu, and Zn, and 1 sample with pH slightly below aquatic life criterion
- Flows underground before reaching Ikalukrok Creek; there is no surface water connection.
- Dense riparian vegetation

SUMMARY OF BIOLOGICAL PRODUCTIVITY

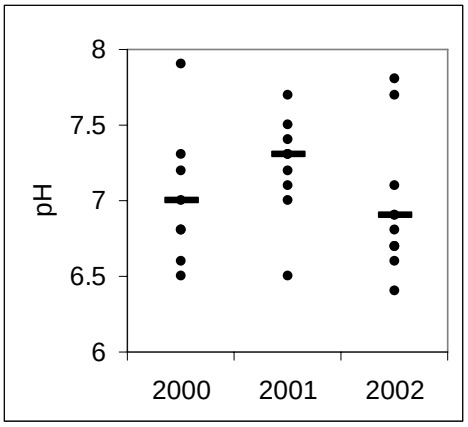
- High level of periphyton standing crop
- Moderately high invertebrate abundance and density
- Proportion of EPT taxa high, both Ephemeroptera and Plecoptera abundant
- No fish because of lack of surface connection to Ikalukrok Creek

Water Quality

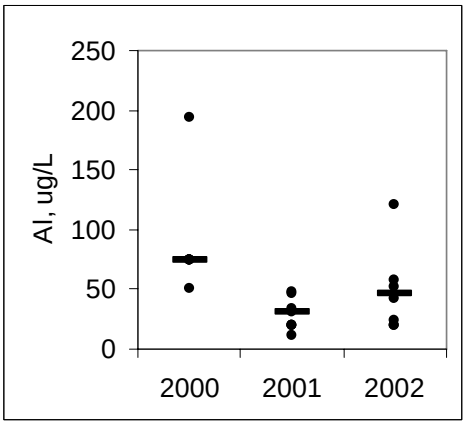
The moderate hardness (median = 98 mg /L) combined with moderate alkalinity (median = 53 mg/L) and median sulfate concentrations of 43 mg/L suggest that Sled Creek is dominated by calcium bicarbonate with lesser amounts of calcium sulfate. The pH was circumneutral over the years sampled and in the range of a minimum of 6.4 to a high of 7.9. Bicarbonate is the dominate for of alkalinity in the pH range of 6.8 to 8.4, and most of the pH measurements in Sled Creek were within this range.

Water quality in Sled Creek is excellent with low concentrations of metals (Fig. 75, Table 12). One water sample collected on September 9, 2002 exceeded the US EPA acute and chronic aquatic life criteria for Cd, Zn, and pH (Table 12). Two water samples, collected on June 5, 2000 (during break-up flows) and on September 9, 2002 exceeded the chronic aquatic life criterion. Water samples collected in 2000 with Method Reporting Limits of <1 ug/L for Cd (higher than the aquatic life criterion) were disregarded in the summary table.

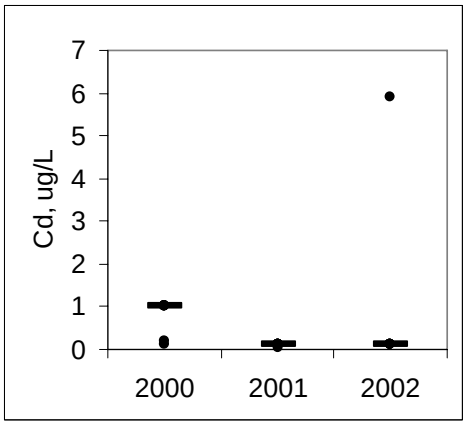
Stream flows in Sled Creek range from 3 to 45 cfs during summer months. The creek is of low gradient, has ample overhanging vegetation, and suitable habitat for fish. Although water quality and habitat conditions in Sled Creek is of sufficient quality to support fish, the creek does not have a direct connection to Ikalukrok Creek and fish are without access.



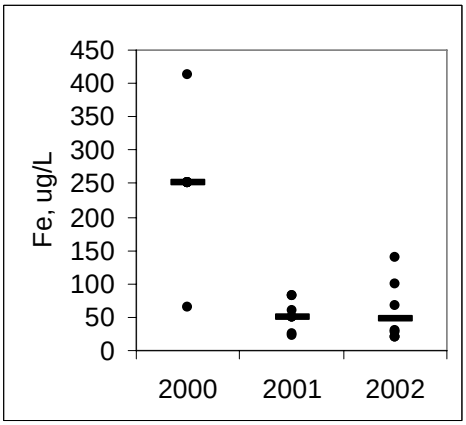
pH, standard units



Concentration of Aluminum

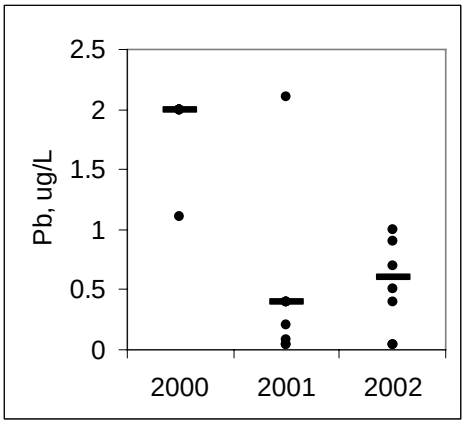


Concentration of Cadmium

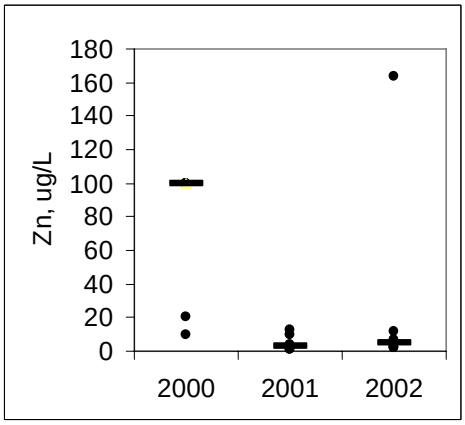


Concentration of Iron

Figure 75. Concentrations of select metals at Station 212: Sled Creek, 2000 - 2002. Graph shows median as bar, all data values as points, n=9 for 2000, n=9 for 2001, and n=8 (n=9 for pH) for 2002.



Concentration of Lead



Concentration of Zinc

Figure 75, continued.

Table 12. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 212. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample. Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	47.7	194	11.7	23	0%	9%
Cd, µg/L	0.1	5.9	0.05	23	4%	4%*
Cu, µg/L	1.5	10	0.8	23	0%	4%
Fe, µg/L	66.9	412	20	23	No Acute	0%
Ni, µg/L	5	50	1	23	0%	0%
Pb, µg/L	0.7	2.1	0.04	23	0%	0%
pH	7	7.9	6.4	27	4%	
Se, µg/L	1	5	1	24	0%	0%
Zn, µg/L	9.6	164	1.1	23	4%	4%

*Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 6 samples were reported at <1 ug/L. These samples were disregarded in the above table.

Periphyton

Periphyton biomass, as estimated by chlorophyll a concentrations, was high in Sled Creek (Fig. 76) especially in 2000 and 2001. Proportions of chlorophylls b and c were similar (Fig. 77) and suggest that both Chromista, or diatoms and dinoflagellates (chlorophyll *c*) and green algae and plants (chlorophyll *b*) are important to the periphyton community. Chlorophyll *a* concentrations in Sled Creek were among the highest measured in any of the Ikalukrok Creek drainages (Fig. --); only the North Fork of Red Dog Creek, Ott Creek, and East Fork of Ikalukrok Creek had higher concentrations.

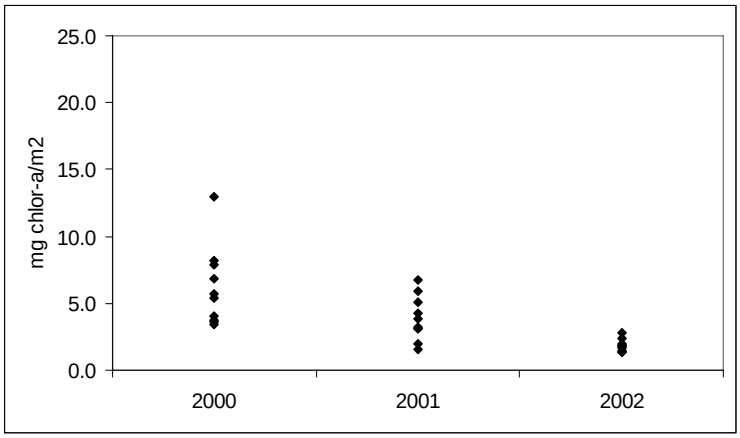


Figure 76. Concentration of chlorophyll *a* in Sled Creek, Station 212. .

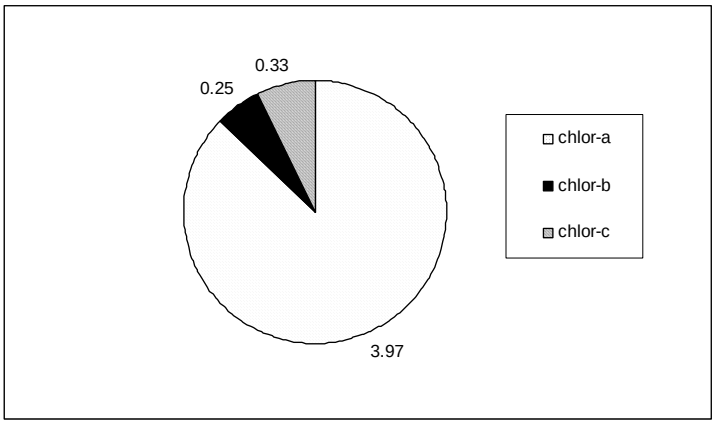


Figure 77. Proportions of chlorophyll *a*, *b*, and *c* in Sled Creek, Station 212.

Invertebrates

Both abundance and density of aquatic invertebrate communities were lower in 2002 than the previous years, similar to findings at most other sites. When compared with all other sites in the Ikalukrok Creek drainage, samples from Sled Creek had among the lowest abundance (Figure 78) but when invertebrate numbers are adjusted for amounts of water flowing through the nets (density), results are similar to other sites in the Ikalukrok Creek drainage (Figure 79).

We collected from 15 to 20 distinct taxonomic groups from drift nets in Sled Creek (Figure 80). Most of the invertebrates were aquatic forms, signifying a greater dependence on instream productivity than terrestrial inputs (Figure 81). Invertebrate communities in Sled Creek are dominated by aquatic Diptera, but also contain high proportions of Ephemeroptera and Plecoptera (Figure 82). There were no Trichoptera. The proportions of EPT taxa was higher than the proportion of Chironomidae (Figure 83)

and similar to the community found in Ikalukrok Creek upstream of West Fork of Ikalukrok Creek.

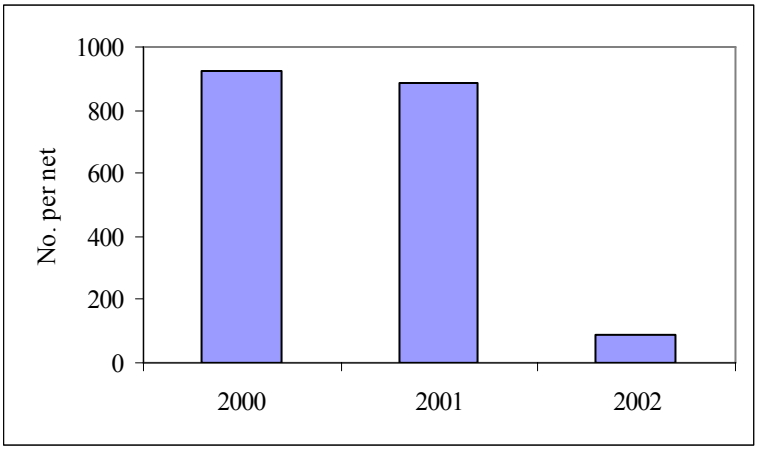


Figure 78. Abundance of aquatic invertebrates in Sled Creek, Station 212.

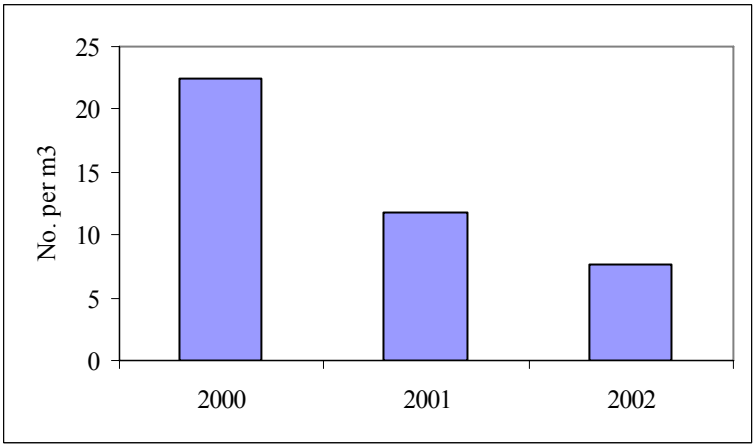


Figure 79. Density of aquatic invertebrates in Sled Creek, Station 212.

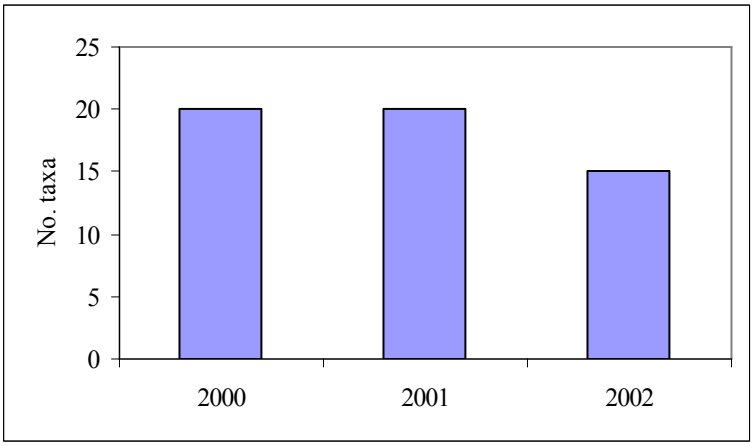


Figure 80. Total aquatic taxa in Sled Creek, Station 212.

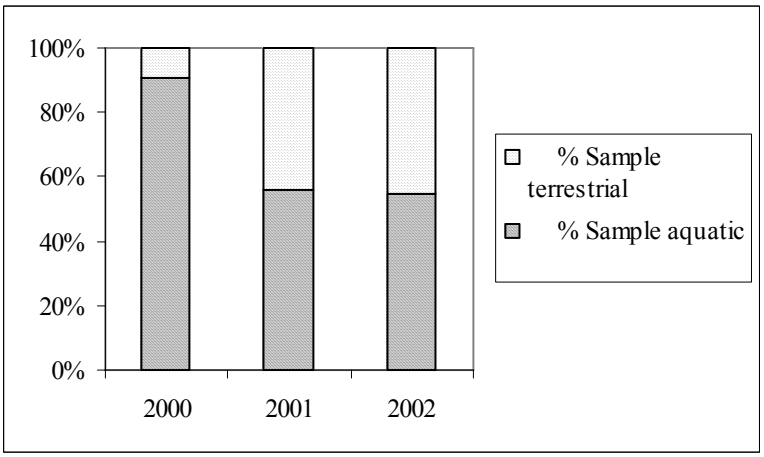


Figure 81. Proportion of terrestrial and aquatic invertebrates in drift samples in Sled Creek, Station 212.

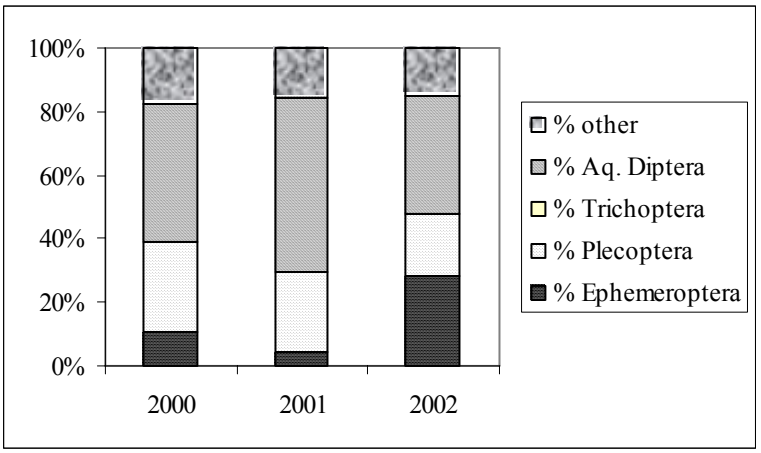


Figure 82. Proportion of aquatic insect orders in drift samples in Sled Creek, Station 212.

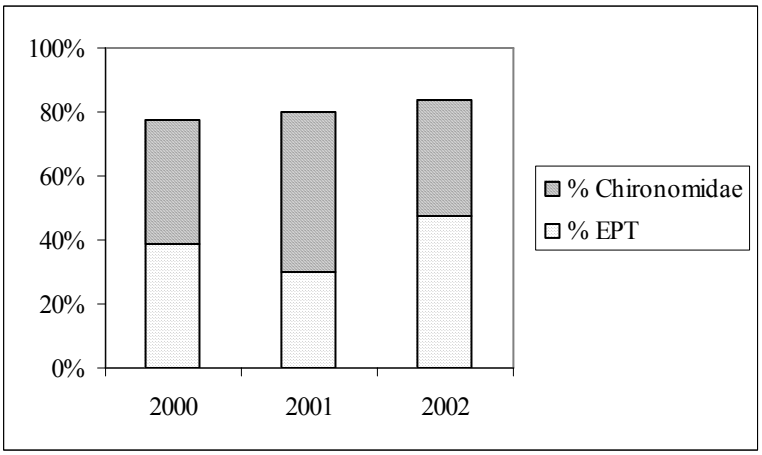


Figure 83. Proportion of Chironomidae and EPT taxa in Sled Creek, Station 212.

Fish Communities

Sled Creek flows underground before joining Ikalukrok Creek; therefore, fish do not have access to this system.

Fish Tissues

No fish were collected for tissue analysis.

Water quality and biological data for Sled Creek are presented in Appendix 8.

Ott Creek

No station number.

Ott Creek is a small tributary that flows underground before its confluence with Ikalukrok Creek, downstream of Sled Creek. Biological data were collected in 2002 only; there are no stream flow, temperature, or water quality or hydrology data for this site.

SUMMARY OF BIOLOGICAL PRODUCTIVITY

- Periphyton levels highest measured in Ikalukrok Creek drainage
- Invertebrate abundance low, density moderately low
- Few Ephemeroptera, Plecoptera common

Periphyton

Concentrations of chlorophyll a and c in Ott Creek were among the highest measured in any tributaries in the Ikalukrok Creek drainage (Figs.85 and 86). Chlorophyll-a ranged from 3 mg/m^2 to 7.4 mg/m^2 and chlor-c ranged from 0.13 mg/m^2 to 0.82 mg/m^2. Concentrations of chlor-b were near the detection limit.

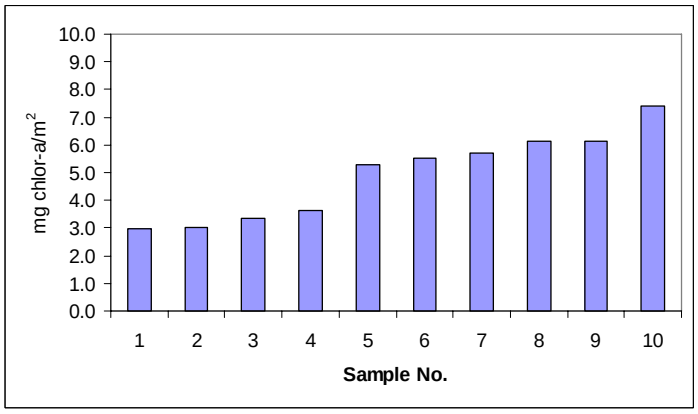


Figure 84. Concentration of chlorophyll *a* in Ott Creek, sampled only in 2002.

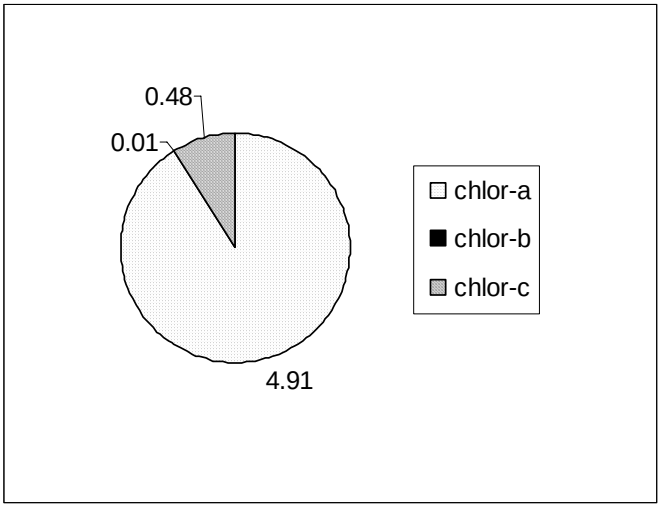


Figure 85. Proportions of chlorophyll *a*, *b*, and *c* in Ott Creek.

Invertebrates

When compared to other sites in the Ikalukrok Creek drainage, invertebrate abundance was lower in Ott Creek than any other sites sampled, except West Fork Ikalukrok and Moil Creeks (Table 13). Invertebrate density and number of taxa were comparable to most of the other sites. Seventy three percent of invertebrates collected in drift nets were aquatic species (Fig. 86), and the majority of invertebrates were Diptera and Plecoptera (Fig. 87). The proportion of Chironomidae was slightly higher than the combined proportion of Plecoptera and Ephemeroptera (Fig. 88).

Table 13. Summary of drift net samples, Ott Creek, 2002.

Factor Measured	Units	Average of Samples
Total aquatic taxa		15
Abundance of aquatic inverts.	no. per net	229
Density of aquatic inverts.	no. per m^2	7.6
% Dominant taxon	Chironomidae	55%

Fish Populations

Although biological samples suggest that Ott Creek would provide suitable rearing habitat for juvenile fish, access to this creek is blocked near the mouth where the creek flows underground.

Biological data for Ott Creek are listed in Appendix 9.

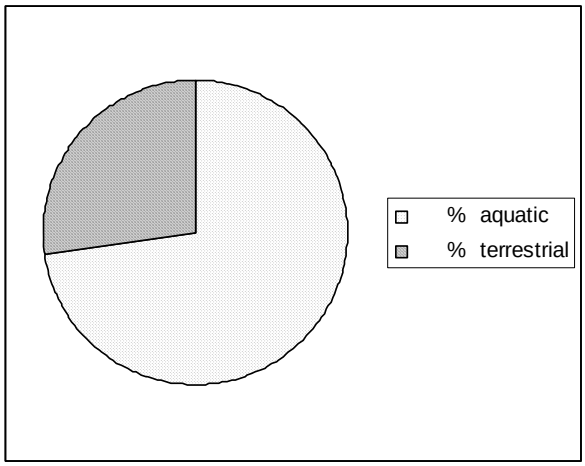


Figure 86. Proportion of terrestrial and aquatic invertebrates in drift samples in Ott Creek.

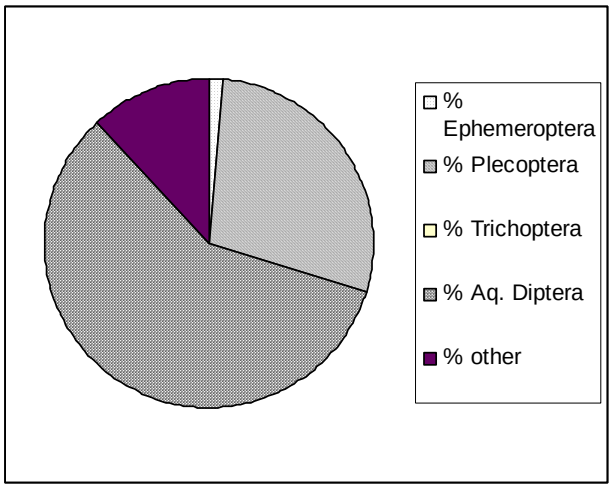


Figure 87. Proportion of aquatic insect orders in drift samples in Ott Creek.

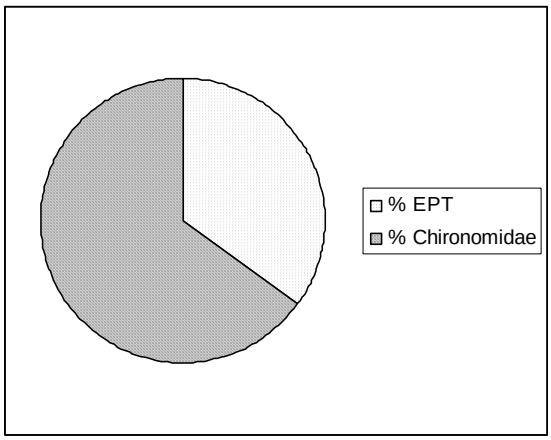


Figure 88. Percent EPT taxa and Chironomidae in Ott Creek, 2002.

North Fork Red Dog Creek

Upstream Site below East and West branches

PHYSICAL FEATURES

- Total Drainage Area: 13.94 square miles (to the mouth)
- Average July water temperature: 12.6°C
- Water quality generally good, West Branch with elevated Cd, East Branch had a few water samples with elevated Fe and Pb
- Water usually clear, occasional melting ice lens cause erosion and turbidity.

SUMMARY OF BIOLOGICAL PRODUCTIVITY

- Periphyton standing crop high
- Fairly high invertebrate abundance and density
- EPT taxa present, not common
- Arctic grayling spawning and rearing, Dolly Varden summer rearing, slimy sculpin rearing

Water Quality

Stream water in North Fork Red Dog Creek below the two forks is low in metals with no samples in 2002 exceeding US EPA Aquatic Life Criteria for Cd, Cu, Fe, Ni, Pb, Se, or Zn (Table 14). Alkalinity is moderately high after breakup, with a median value of 108 mg/L. The pH is similarly favorable for aquatic life and ranges from 6.6 to 8.1; the lowest values occur during spring runoff. Because metals concentrations were consistently low, the data are not displayed on individual graphs.

Table 14. Summary of water quality and % of samples exceeding aquatic life criteria (EPA 2004) in North Fork Red Dog Creek, 3 sites. *Samples with high Cd detection limits 2000 were disregarded.

		Median	Maximum	Minimum	Sample Size	% WQS acute	% WQS chronic
Al	upstream	28.7	1020	13.4	12	8%	17%
	E Branch	37	1,160	16	18	11%	22%
	W Branch	61.5	157	20	18	0%	22%
Cd	upstream	0.1	0.1	0.1	12	0%	0%*
	E Branch	0.1	0.4	0.1	13	6%	15%*
	W Branch	0.4	2.3	0.1	12	11%	75%*
Cu	upstream	2.5	7.5	0.8	12	0%	0%
	E Branch	3	10	1	18	0%	6%
	W Branch	5.25	10	1	18	0%	6%
Fe	upstream	204	3000	50	12		8%
	E Branch	98	3,480	25	12		17%
	W Branch	60.5	613	28.8	10		0%
Ni	upstream	4.45	50	1.4	12	0%	0%
	E Branch	8	57	1	18	0%	6%
	W Branch	25.7	56.1	1	18	0%	6%
Pb	upstream	1.15	2.4	0.06	12	0%	0%
	E Branch	1	10	0	18	0%	17%
	W Branch	0.4	5.6	0.04	18	0%	6%

Table 14, continued.

pH	upstream	7.75	8.3	6.9	12	0%	
	E Branch	8	8	7	13	0%	
	W Branch	7.2	7.9	6.4	11	9%	
Se	upstream	1.6	3	1	13	0%	0%
	E Branch	1	4	1	19	0%	0%
	W Branch	2.6	4	1	18	0%	0%
Zn	upstream	7.1	100	1.8	12	0%	0%
	E Branch	27	104	2	18	0%	0%
	W Branch	64.9	123	3	17	6%	6%

North Fork Red Dog Creek usually has clear water with little sediment, except occasionally when an ice lens melts and erodes. Aerial surveys of the drainage have documented several areas of thermal/hydraulic erosion with substantial sediment input to the creek (Ott and Morris 2000). In June 2000, two point sources of sediment were identified in the headwaters – these areas had water flowing up and under pressure through the organic mat and underlying ice-rich soils (Ott and Morris 2000). Areas of thermal/hydraulic erosion have been found in the lower portion of the creek and in the upper areas in the vicinity of our sample station. Sources and amount of turbidity observed in the water varies from year to year – generally the system is clear, but sediment loading is substantial in some years.

Periphyton

Periphyton biomass, as estimated by chlorophyll a concentrations, was consistently high in North Fork Red Dog Creek during all years sampled (Fig.89). Proportions of chlorophylls *b* and *c* were similar (Fig. 90), with slightly more chlorophyll *b*. The proportions of these two pigments suggests that the North Fork Red Dog Creek supports

a complex periphyton community of Chromista, dinoflagellates, green algae and plants. The proportions of these two pigments were similar to those found in Sled Creek.

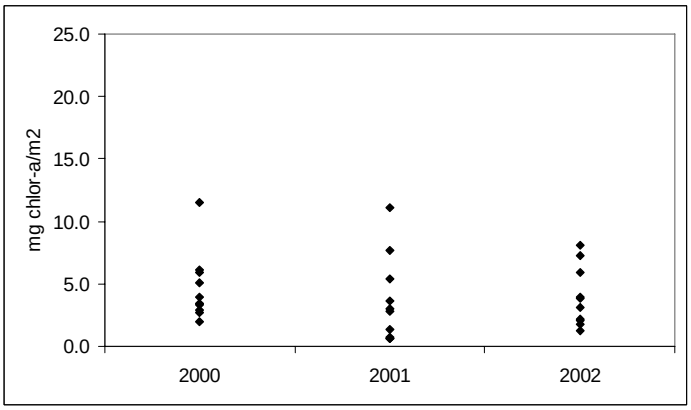


Figure 89. Concentration of chlorophyll *a* in North Fork Red Dog Creek, upstream site.

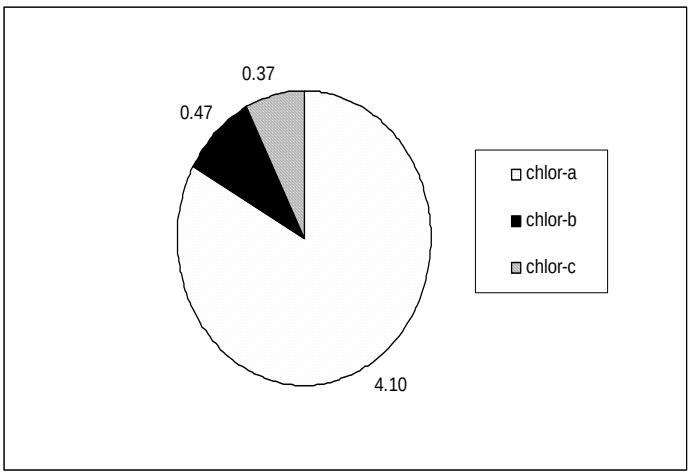


Figure 90. Proportions of chlorophyll *a*, *b*, and *c* North Fork Red Dog Creek, upstream site.

Chlorophyll *a* concentrations in North Fork Red Dog Creek were among the highest measured in any of the Ikalukrok Creek drainages, only Ott Creek, and East Fork of Ikalukrok Creek had higher concentrations. The complex and abundant periphyton community in this site reflects the habitat and water quality conditions.

Invertebrates

Invertebrate abundance was highest in 2001 when we estimated 1,860 invertebrates per net (Fig. 91). Invertebrate abundance was slightly lower in 2002; however, invertebrate density was substantially higher (Fig. 92). When compared with all other sites in the Ikalukrok Creek drainage, samples from North Fork Red Dog Creek had higher abundance than Sled Creek and similar densities.

We collected from 20 to 22 distinct taxonomic groups from drift nets in North Fork Red Dog Creek (Figure 93), which was among the highest found in any of the Ikalukrok Creek drainage sites. Most of the invertebrates were aquatic forms, signifying a greater dependence on instream productivity than terrestrial inputs (Figure 94). Invertebrate communities in North Fork Red Dog Creek are dominated by aquatic Diptera, and contain low proportions of Ephemeroptera and Plecoptera (Figure 95), especially compared to Sled Creek.. Trichoptera were more common than at any of the other sites, especially in 2000. The proportions of EPT taxa were substantially lower than the proportion of Chironomidae (Figure 96) and similar to the communities found in Moil Creek and Ikalukrok Creek at Cub Creek. North Fork Red Dog Creek contains diverse invertebrate communities dominated by Baetis, Capniidae, Chironomidae, Simuliidae, aquatic mites, parasitic Hymenoptera, Ostracoda, Collembola and Copepoda (all often associated with wetland complexes), and Simuliidae.

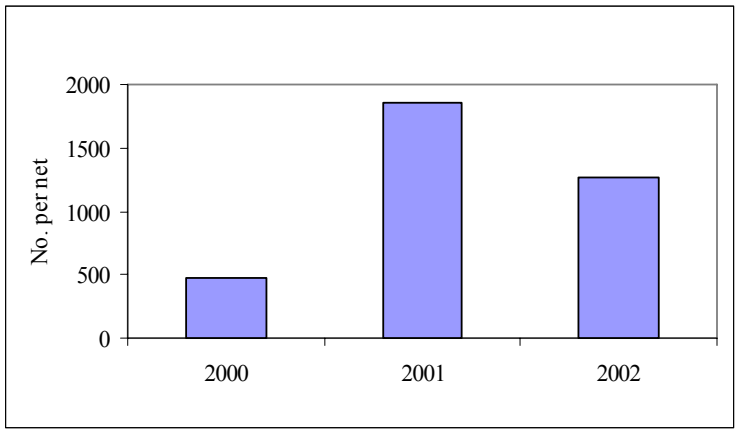


Figure 91. Abundance of aquatic invertebrates in North Fork Red Dog Creek, upstream site.

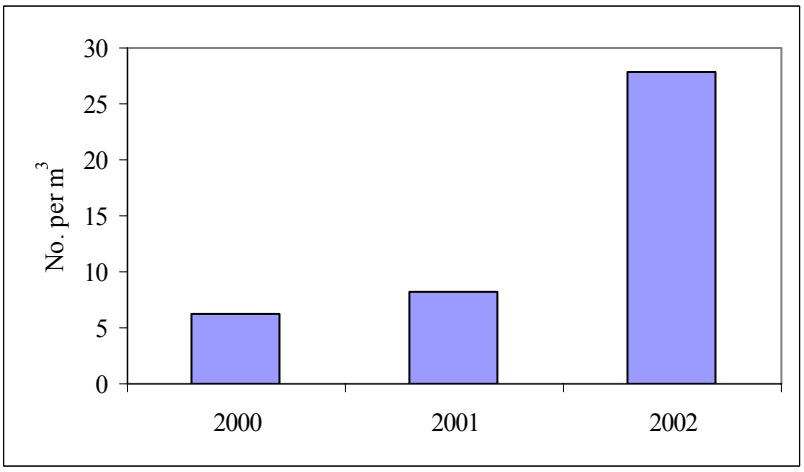


Figure 92. Density of aquatic invertebrates in North Fork Red Dog Creek, upstream site.

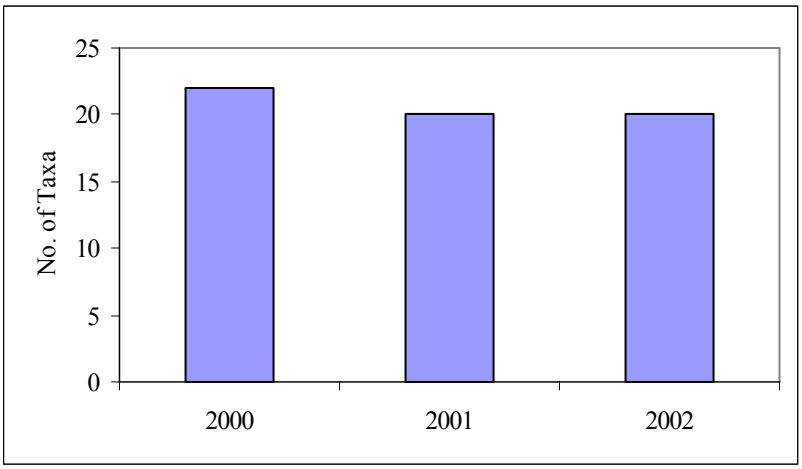


Figure 93. Total aquatic taxa in North Fork Red Dog Creek, upstream site.

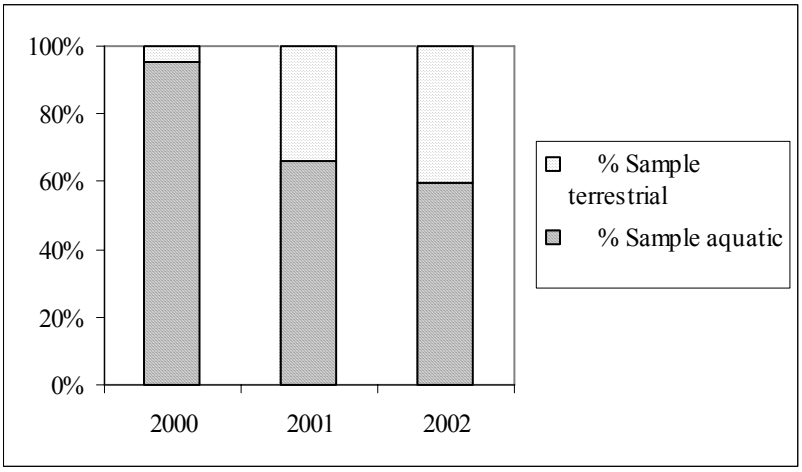


Figure 94. Proportion of terrestrial and aquatic invertebrates in drift samples in North Fork Red Dog Creek, upstream site.

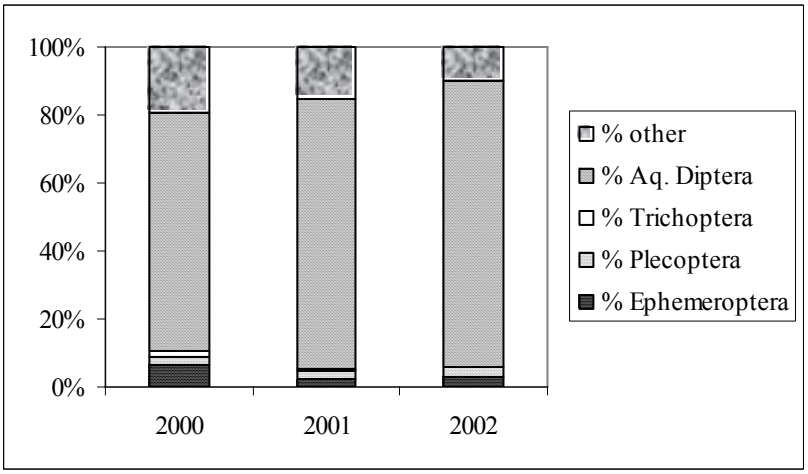


Figure 95. Proportion of aquatic insect orders in drift samples in North Fork Red Dog Creek, upstream site.

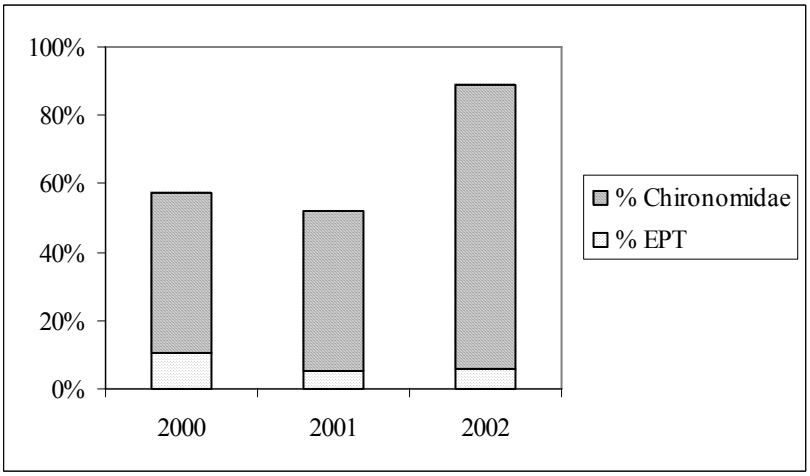


Figure 96. Proportion of Chironomidae and EPT taxa in North Fork Red Dog Creek, upstream site.

Fish Communities

Fish sampling (observations, fyke-nets, angling, and minnow traps) has been conducted in North Fork Red Dog Creek since summer 1992. Most of our fieldwork focused on the lower 3 km of the creek, but upper reaches of the drainage also have been sampled.

North Fork Red Dog Creek is the most important system in the Ikalukrok Creek drainage for Arctic grayling spawning and production of age-0 fish. The creek also supports populations of Dolly Varden and slimy sculpin for summer rearing. There is no indication of winter use by fish of North Fork Red Dog Creek.

Observations on the life history and abundance of fish in North Fork Red Dog Creek from ADNR/ADFG sampling are summarized below:

ARCTIC GRAYLING

The beginning of the Arctic grayling spawning run is predominately males (>80%), adult females migrate upstream a few days later (Morris and Winters 2002). In most years, adult fish remain in the creek for a short period of time after spawning, then move downstream to Ikalukrok Creek. In summers 1995, 2000, and 2002 many adult Arctic grayling stayed in North Fork Red Dog Creek throughout the summer (Townsend and Lunderstadt 1995; Ott and Morris 2000; Ott and Townsend 2002).

Juvenile Arctic grayling enter North Fork Red Dog Creek near the end of the spawning run. In most years, numbers of juvenile Arctic grayling are low, although in fall 2000, we observed schools of 10 to 12 juvenile Arctic grayling per pool or run in the Upper North Fork sample area (Ott and Morris 2000).

Observations of age-0 Arctic grayling in North Fork Red Dog Creek confirm that spawning occurs throughout the drainage, from above the upstream sample site almost to the mouth. Numbers of fry observed each year in July vary

considerably, but in those years with abundant age-0 fish, they are present from the lower end of the creek to upstream of our sample station.

Mark/recapture sampling throughout the Ikalukrok Creek drainage has shown:

Arctic grayling adults marked during the spring spawning migration into North Fork Red Dog Creek are most frequently recaptured in North Fork Red Dog Creek during following springs.

In most years, adult Arctic grayling leave North Fork Red Dog Creek and are recaptured in Ikalukrok Creek upstream of Mainstem Red Dog Creek.

Arctic grayling marked in Grayling Junior Creek during the summer often are recaptured back in North Fork Red Dog Creek in subsequent springs.

Mark-recapture data indicate that North Fork Red Dog Creek is the primary spawning stream in the Ikalukrok Creek drainage for Arctic grayling.

ANADROMOUS AND RESIDENT DOLLY VARDEN

North Fork Red Dog Creek provides habitat for both resident and anadromous Dolly Varden, including Dolly Varden that have spent some time in the ocean. In early June 2000, we caught 18 Dolly Varden (148 to 250 mm long, average size 200 mm, SD = 28.1) in fyke-nets fished to catch fish moving upstream (Ott and Morris 2000). These Dolly Varden had visible parr marks with orange dots along the sides and were much larger than Dolly Varden caught previously in minnow traps. We believe the larger Dolly Varden are resident fish moving upstream to rear in the upper portion of North Fork Red Dog Creek.

In early July 2000, fyke-nets caught smaller Dolly Varden than in June. These fish were of similar size to those caught in minnow traps (n = 76, 85 to 278 mm, average size 76 mm, SD = 30.6) (Ott et al. 2000a). Most of these fish were juveniles before smolt out migration to the ocean. Catches in fyke nets show

that resident and larger Dolly Varden migrate upstream in the spring at the same time as adult Arctic grayling.

From 2001 to 2005, fyke nets have continued to catch larger Dolly Varden moving upstream each spring.

In August 1995, we documented use of North Fork Red Dog Creek by Dolly Varden that had been to the ocean at least once. Four Dolly Varden (169, 182, 219, and 247 mm long) were caught by angling (Townsend and Lunderstadt 1995). These fish had no parr marks, were silvery in color, and probably had spent a short time in marine waters during summer 1995 before returning to freshwater to winter. This is the only time we have caught Dolly Varden of this type in North Fork Red Dog Creek.

SLIMY SCULPIN

Catches in fyke-nets and minnow traps also have produced small catches of slimy sculpin.

Fish Tissues

We collected three juvenile Dolly Varden from the upstream site in North Fork Red Dog Creek and analyzed them for whole body concentrations of Cd, Pb, Se, and Zn (Table 15). The small sample size limits statistical analysis of this data; however, comparisons with other Ikalukrok Creek baseline sites indicate that fish from this site contain concentrations of Cd that were similar to fish in Grayling Junior Creek and substantially higher than fish in Ferric Creek. Concentrations of Pb were higher than either Grayling Junior or Ferric Creek and concentrations of Se were similar among fish from the three creeks.

Table 15. Metals concentrations in juvenile Dolly Varden from North Fork Red dog Creek, upstream site.

Date Collected	Weight grams	Length mm	Cd mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
8/1/2001	11.39	113	1.21	1.27	7.7	183	24.0
8/1/2001	15.87	130	1.45	2.37	8.0	154	23.7
8/1/2001	25.42	138	2.28	4.41	11.4	236	22.9

Appendix 10 contains the water quality and biological data for North Fork Red Dog Creek.

Tributaries in Wulik River Drainage

Comparisons among Sites

Water QuAlity

Of the sites sampled in the Wulik River Drainage, Square Creek (Sta. 214), Sunday Creek (Sta. 215), and Oak Creek (Sta. 216) had the lowest concentrations of metals and the best water quality for aquatic life. Sourdock Creek (Sta. 214) also had good water quality, but a few samples had slightly elevated Cd. Ferric Creek (Sta. 213) contained elevated concentrations of Al and Fe, otherwise the water quality was good.

The pH was lower than the limit (6.5) for aquatic life in only one water sample in Stations 203, 215, 202, and 204 (Fig. 97). Lower pH occurred in June 2001 at Stations 215 and 204 with pH values of 6.4 and 6.3, respectively; in August at Station 202 with pH of 6.3; and in early October 2000 at Station 203, with pH = 6.4. Sites on the graphs are listed in the same order as concentrations of chlorophyll-a (from lowest to highest) to facilitate comparisons.

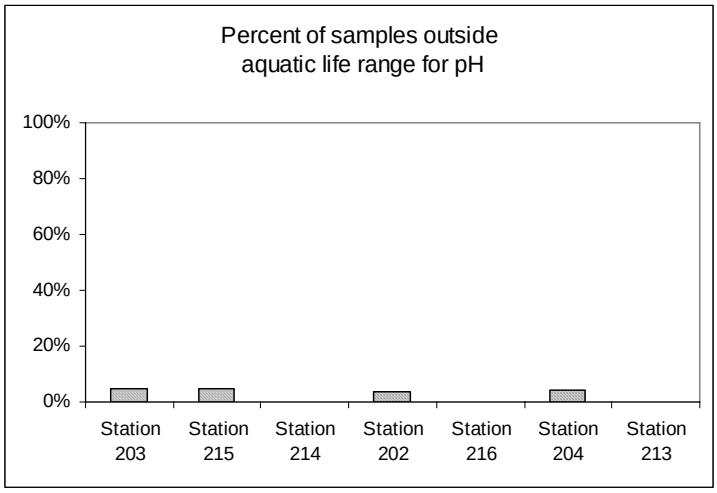


Figure 97. Percent of water samples below the pH range for aquatic life in the Wulik River Drainage.

Competition Creek upstream of Sourdock Creek (Station 203) had the highest concentrations of metals: 86% of the water samples exceeded the chronic aquatic life criterion for Al, 95% exceeded Cd, and 82% exceeded Ni and Zn (Figure 98). Concentrations of Fe were low at this site, although elevated in more than 75% of the samples from Ferric Creek and Oak Creek. Concentrations of Pb were low in all of the Wulik River drainage sites; one sample from Sourdock Creek exceeded the chronic aquatic life criterion for Pb.

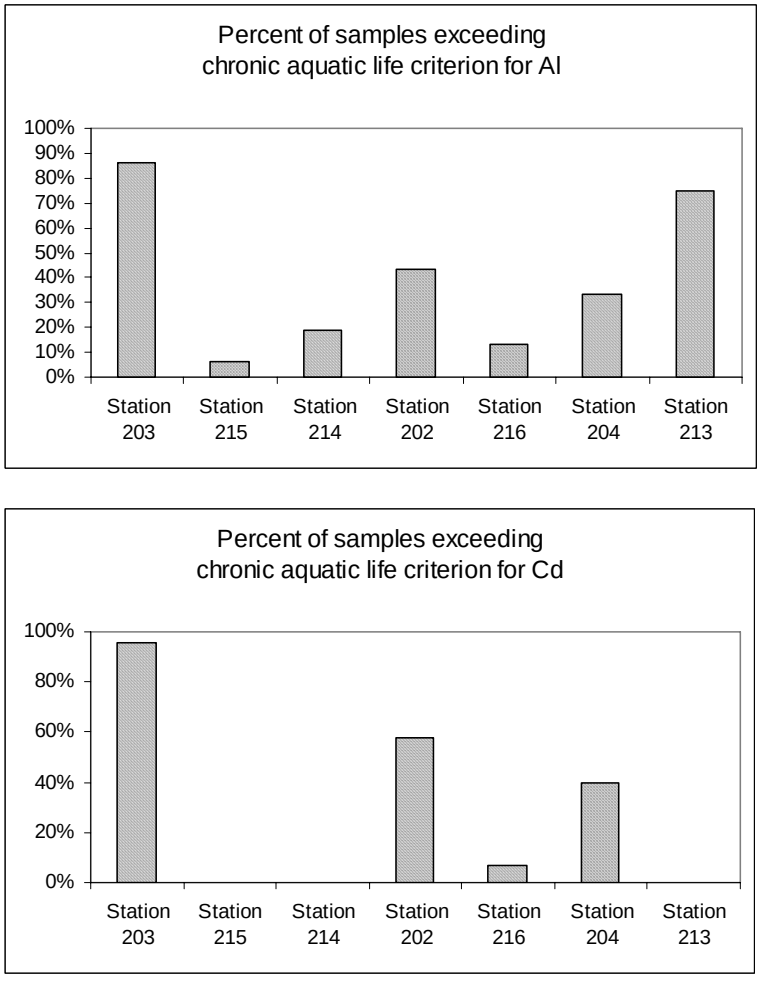
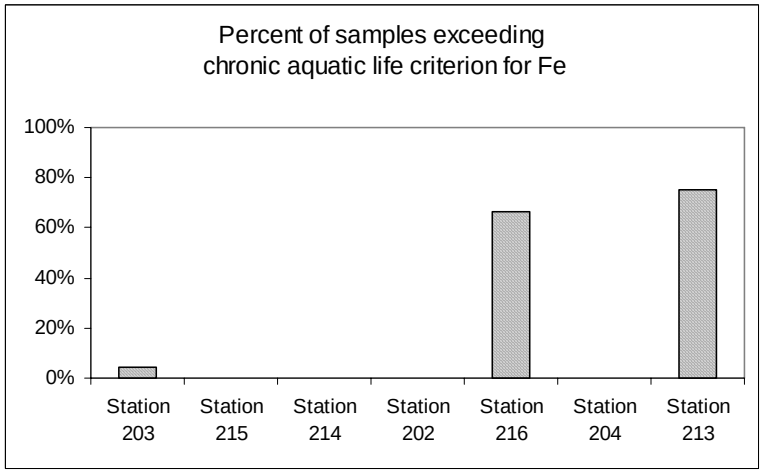


Figure 98. Percent of samples exceeding chronic aquatic life criterion for various metals, Wulik River drainage.



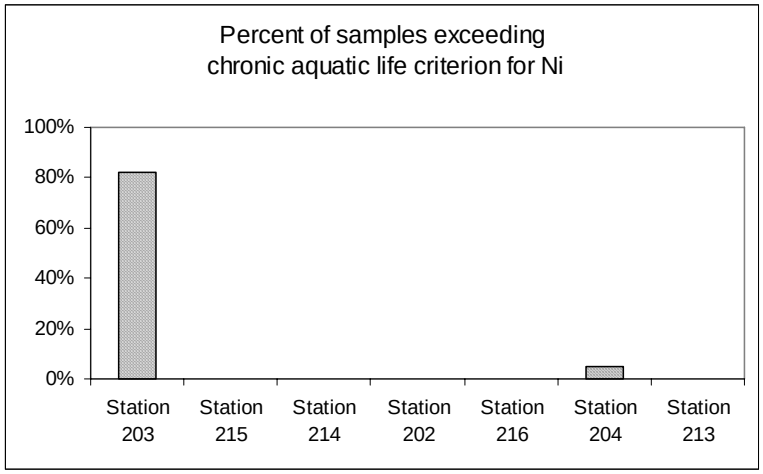


Figure 98, continued

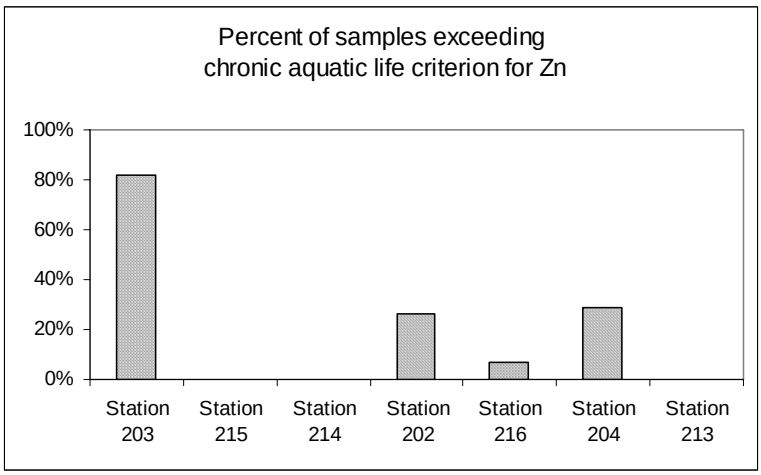


Figure 98, continued

Periphyton

Sampling sites for all graphs of biological factors are presented in the same order to aid in comparisons among sites. The order of the sites is based on primary productivity, from lowest to highest.

Primary production, as estimated by concentrations of chlorophyll-a was near detection at Station 203 and low at Station 215 (Figure 99). Low concentrations at Station 203 are likely a result of poorer water quality; however, water quality was likely not the influencing factor at Station 215. Station 215 (Sunday Creek) has a gravel substrate, with a stream channel that extends into shallow, vegetated areas. It is possible that physical characteristics of substrate size limit algal standing crop at this site. Chlorophyll-a concentrations were highest at Stations 204 and 213.

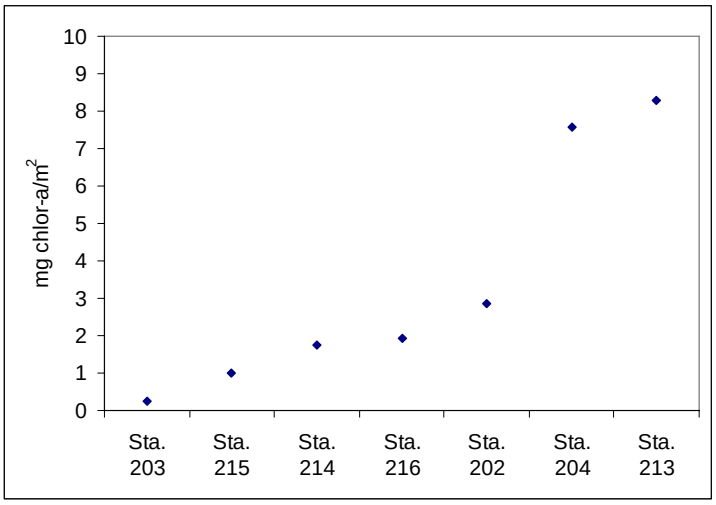


Figure 99. Estimates of primary production (as concentrations of chlorophyll-a) at each sampling site in the Wulik River Drainage. Each data point represents the average of all samples collected at that site.

Periphyton communities appear similar among all sites except Stations 204 and 213 (Figure 100). Concentrations of chlorophyll-b are similar among all sites, except Station 204, where it is substantially higher. Concentrations of chlorophyll-c increase with increasing chlorophyll-a, except at Station 213, where it is low.

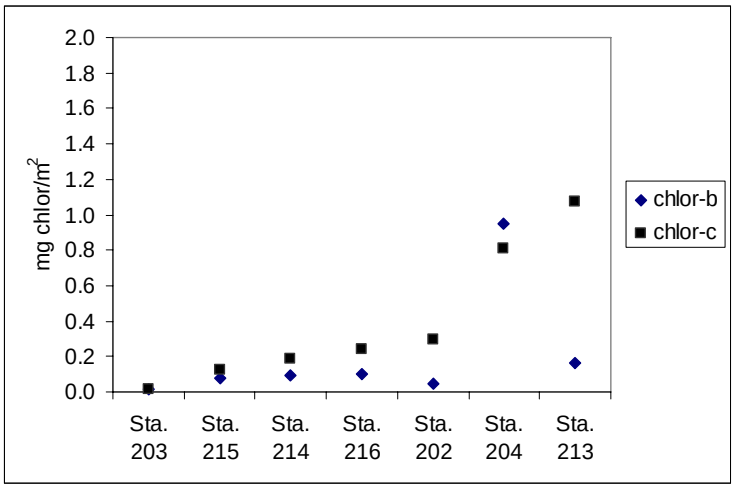


Figure 100. Concentrations of chlorophyll-b and –c at baseline sites in the Wulik River drainage.

Aquatic Invertebrates

Invertebrate abundance as drift was highest in Ferric Creek (Figure 101) and Competition Creek upstream of Sourdock Creek (Station 202). When invertebrate counts are adjusted for volume of water flowing through drift nets, invertebrate density in Square Creek is similar to Stations 202 and 213 (Figure 102). Numbers of distinct taxa groups were similar among sites, but somewhat higher at Stations 213, 215, and 216 (Figure 103). Terrestrial inputs were a higher component of the total invertebrate communities at Station 203 and 216 (Figure 104). The composition of the community, in terms of relative abundance of the different invertebrate orders (Figure 105) shows an expected dominance by Diptera species, but includes substantial Plecoptera (especially Station 204) and Ephemeroptera (especially Station 214). The category "miscellaneous" is mostly Collembola and aquatic mites (Acari).

Chironomidae (Order Diptera) was by far the most prevalent group in any of the sites (Figure 106). EPT taxa (Ephemeroptera/Plecoptera/Trichoptera) were a minor component at Station 213, but well represented at the other sites. Trichoptera were rare at all sites, which is usual for many high latitude environments. Invertebrate samples did not suggest impaired communities in any of the streams sampled in the Wulik River Drainage, except Station 213 where EPT taxa were rare.

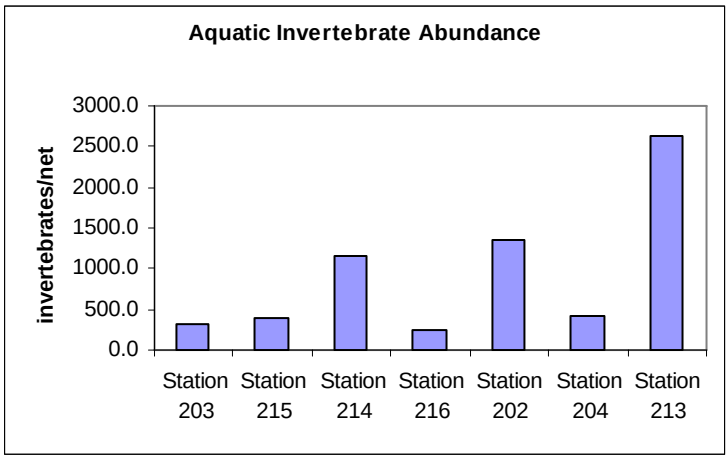


Figure 101. Abundance of aquatic invertebrates (average of all years sampled), Wulik River drainage.

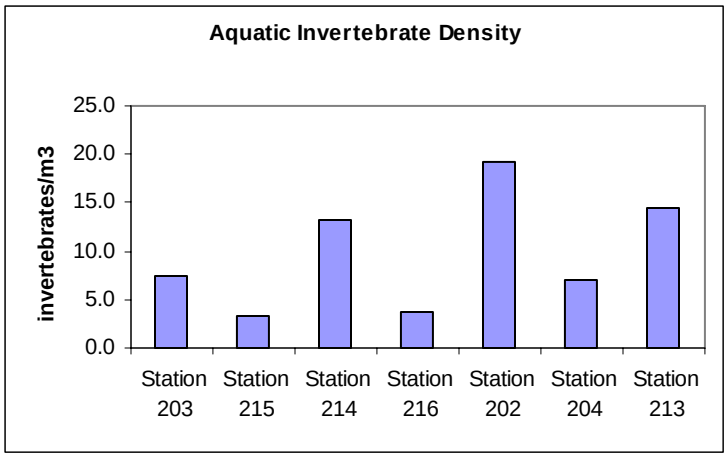


Figure 102. Density of aquatic invertebrates, Wulik River drainage. The graph shows the average for all years sampled at a given site.

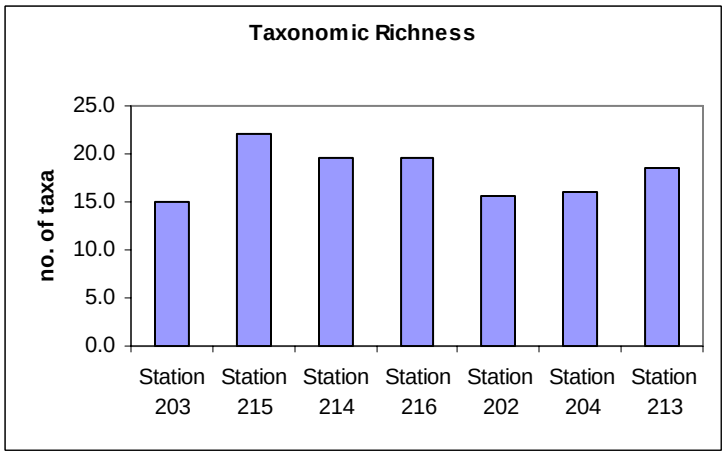


Figure 103. Taxonomic richness, as total number of aquatic taxa collected, Wulik River Drainage. The graph shows the average for all years sampled at a given site.

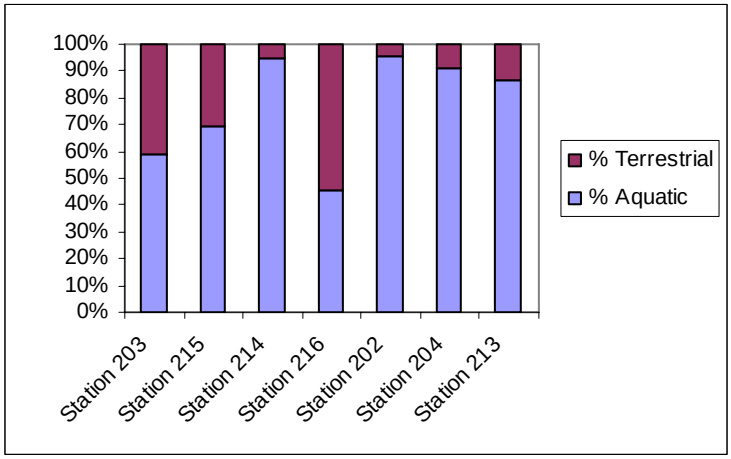


Figure 104. Proportion of terrestrial and aquatic invertebrates, Wulik River Drainage.

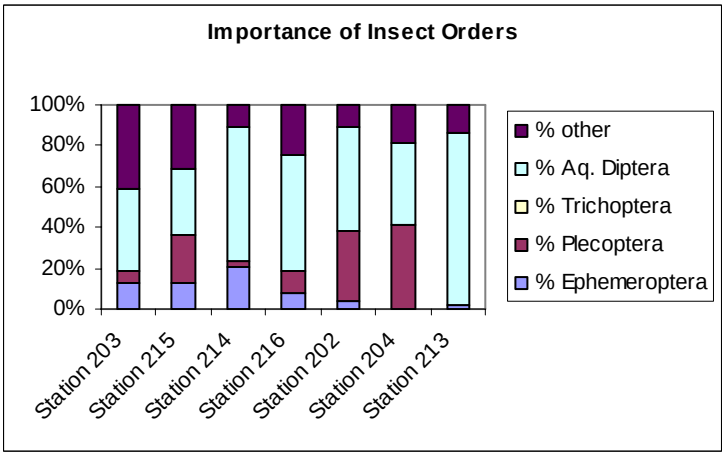


Figure 105. Proportion of aquatic insect orders (average of all years sampled), Wulik River drainage.

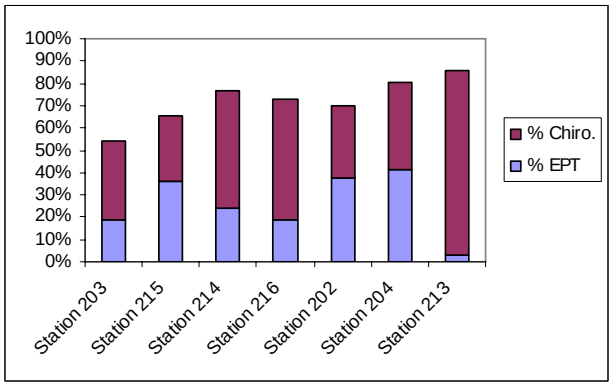


Figure 106. Proportion of Chironomidae and EPT taxa (average of all years sampled), Wulik River drainage.

Fish Presence

Juvenile Dolly Varden were found in all sampling sites in the Wulik River drainage, although more fish were trapped in Sourdock Creek (Station 204) than the other sites (Table 16). Larval Dolly Varden were found in invertebrate drift nets at Stations 213, 214 and 215. The presence of larval fish is evidence of Dolly Varden spawning in these systems.

Table 16. Occurrence of fish, Wulik River Drainage.

Station	Dolly Varden		Other Species
	Juveniles No./Trap	Age 0+ Present	Observed
Station 202	0.87		
Station 203	0.16		
Station 204	2.2		
Station 213	1.1	yes	slimy sculpin, Arctic grayling
Station 214	0.5	yes	
Station 215	2.6	yes	
Station 216	0.4		

Descriptions of Individual Creeks

Competition Creek upstream of Sourdock Creek, Station 203

PHYSICAL FEATURES

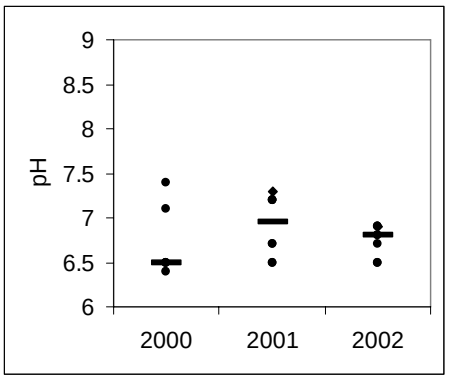
- Drainage size: 3.18 square miles
- Average July water temperature: 6.6°C

SUMMARY OF BIOLOGICAL PRODUCTIVITY

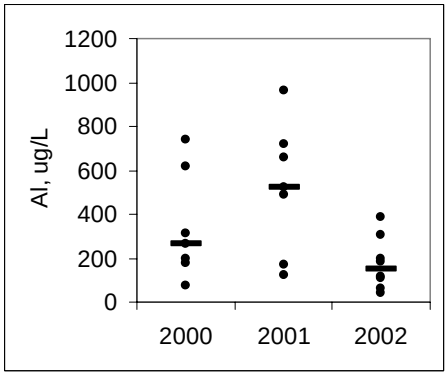
- Low chlorophyll-a, no detectable chlorophyll-b, or -c.
- Low invertebrate abundance and density.
- ≈25% of total invertebrates were terrestrial.
- Few juvenile Dolly Varden present.

Water Quality

Water in Competition Creek upstream of Sourdock Creek (Figure 107) had relatively low alkalinity (as $CaCO_3$) (2000-2002 median = 29.5 mg/L), high concentrations of sulfate (2000-2002 median = 220 mg/L) and median hardness of 300 mg/L (range 129 to 421 mg/L). Conductivity ranged from 78.8 to 535 µSi/cm (median for 2000-2002 was 302 µSi/cm). These water quality factors suggest that this system is dominated by sulfate, not bicarbonate. Station 203 had moderately low pH and elevated concentrations of Al, Cd, Ni, and Zn.. The substrate at Station 203 had a grayish-yellow precipitate (Figure 108). Concentrations of Al exceeded the US EPA chronic criterion for aquatic life (US EPA 2004) in 86% of the samples, Cd in 95% of the samples, Cu in 41%, Ni in 82%, and Zn in 100% of the samples (Table 17). Concentrations of Fe and Pb were relatively low (Table 17).

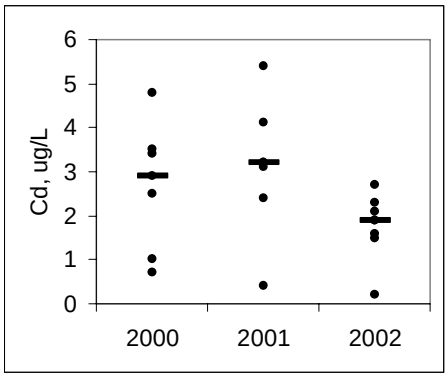


pH, standard units

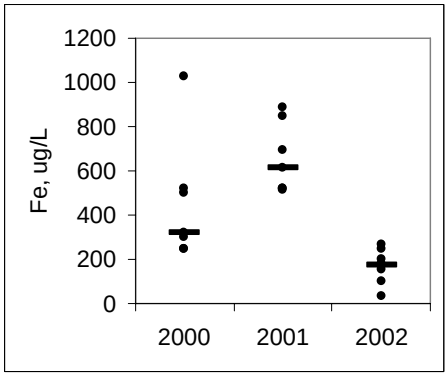


Concentration of Aluminum

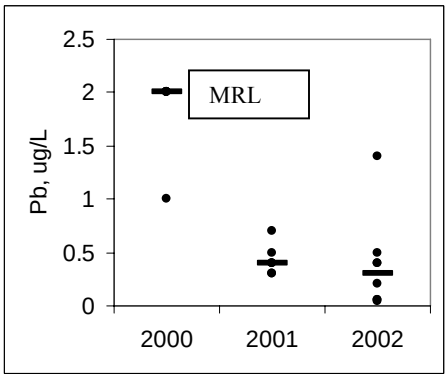
Figure 107. Concentrations of select metals and pH at Station 203: Competition Creek upstream of Sourdock Creek, 2000 - 2002. Graph shows median as bar and all data values as points, for most metals, n=7, 7, and 8 in 2000, 2001, and 2002, respectively. For pH, n= 6, 8, and 8 in 2000, 2001, and 2002, respectively.



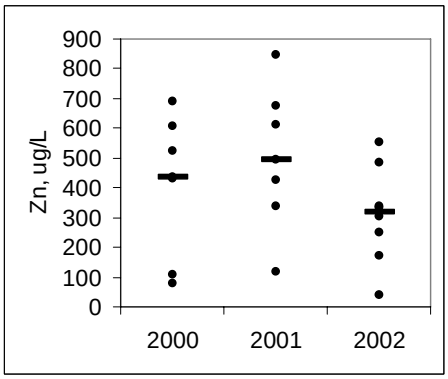
Concentration of Cadmium



Concentration of Iron



Concentration of Lead
note high MRL in 2000



Concentration of Zinc

Figure 107, continued.

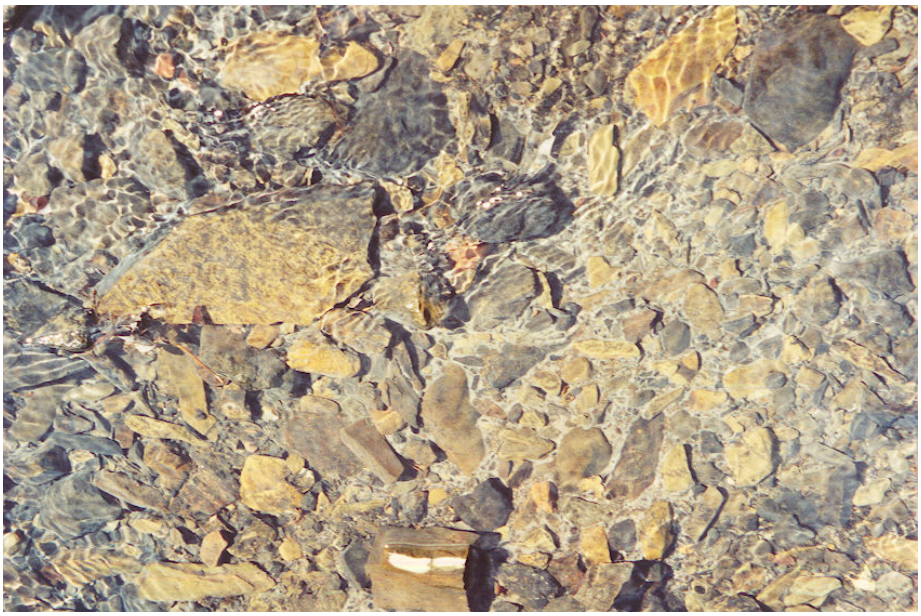


Figure 108. Substrate of Competition Creek at Station 203, showing grayish-yellow precipitate.

Table 17. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 203. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample. Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	230	963	39.4	22	5%	86%
Cd, µg/L	2.45	5.4	0.2	22	64%	95%
Cu, µg/L	7.5	27	2.2	22	32%	41%
Fe, µg/L	310	1030	33.3	22		5%
Ni, µg/L	123.5	268	7.6	22	0%	82%
Pb, µg/L	0.45	2	0.04	22	0%	0%
pH	6.75	7.4	6.4	22	5%	
Se, µg/L	3.15	6	1	24	0%	13%
Zn, µg/L	426.5	845	38.8	22	82%	82%

Periphyton

Chlorophyll-a concentrations at Station 203 were the lowest measured at any of the Wulik River Drainage sites (Figure 109, note scale of graph). Most of the chlorophyll-a measurements were at or below the MRL of 0.5 mg/L. Concentrations of chlorophyll-b and –c were too low to measure. Low levels of algal standing crop at this site are likely a reflection of poor water quality, especially elevated concentrations of Al, Cd, Cu, Ni, and Zn.

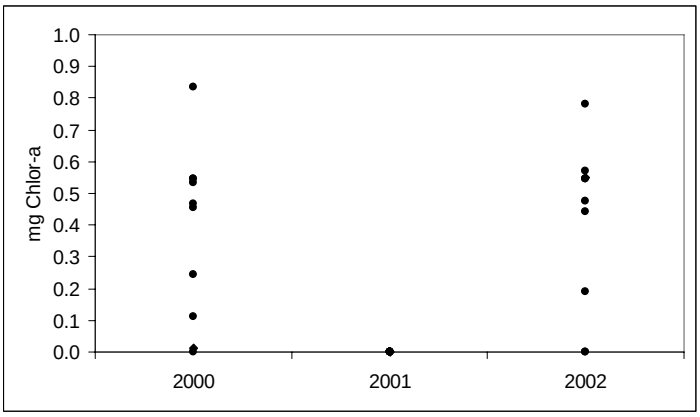


Figure 109. Concentration of chlorophyll *a* in Competition Creek at Station 203.

Invertebrates

Both abundance and density of aquatic invertebrate communities were among the lowest found in any of the Wulik River sites; the 2000-2002 average number of aquatic invertebrates per net was only 313, although 2001 numbers were higher (Fig. 110). The density of aquatic invertebrates also was substantially higher in 2001 than the other years sampled (Fig. 111), although density was among the lowest of any of the Wulik River sites. We found from 13 to 19 distinct aquatic taxa groups at Station 203 (Fig. 112); the

highest number of taxa corresponds to the higher abundance in 2001. Most of the total invertebrates collected were aquatic forms, signifying a somewhat greater dependence on instream productivity than terrestrial inputs (Figure 113). Invertebrate communities in Competition Creek upstream of Sourdock Creek are dominated by aquatic mites (Acari), Collembola (mites and Collembola fall to the category "Miscellaneous aquatic species" on the graph), and Diptera, although Plecoptera (*Capnia*) was fairly common in 2001 and 2002 (Fig. 114). Ephemeroptera (*Baetis*) was fairly common in 2000. The percent EPT taxa was low in 2001 and 2002 (Figure 115). No Trichoptera were found.

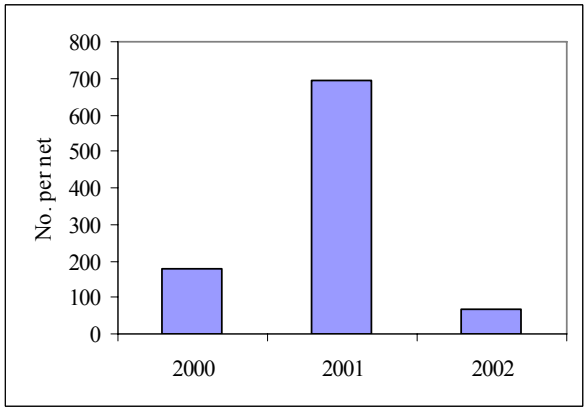


Figure 110. Abundance of aquatic invertebrates at Station 203.

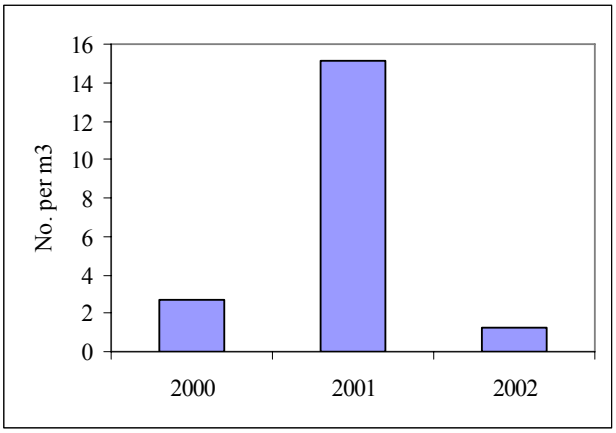


Figure 111. Density of aquatic invertebrates at Station 203.

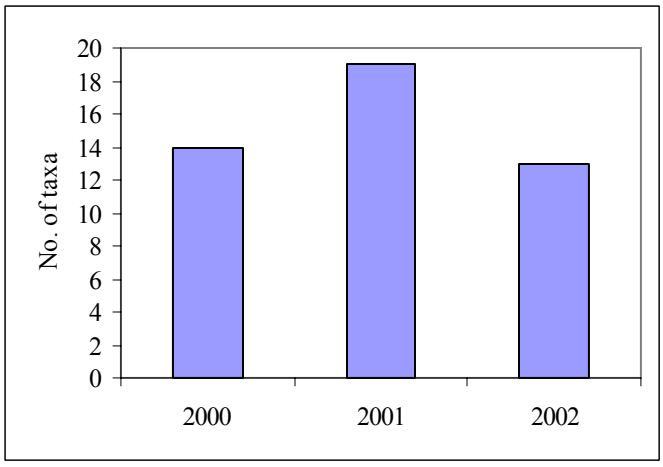


Figure 112. Total aquatic taxa at Station 203.

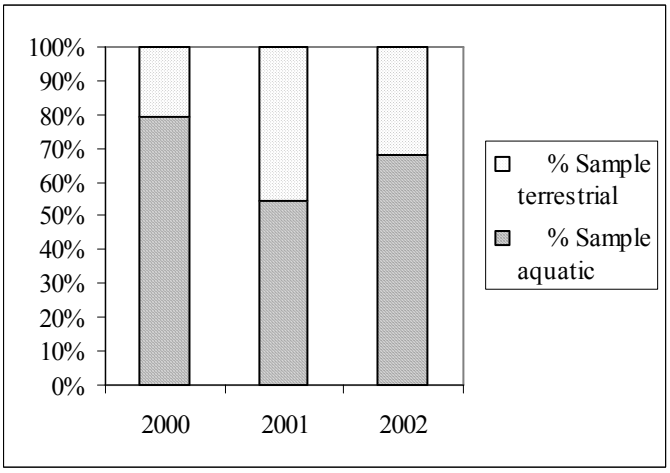


Figure 113. Proportion of terrestrial and aquatic invertebrates at Station 203.

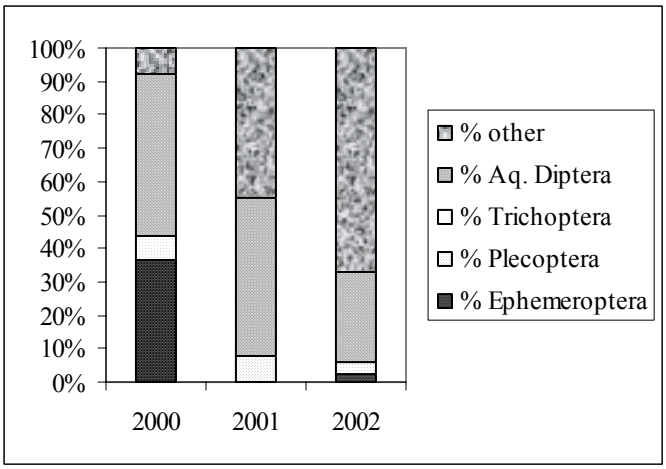


Figure 114**.** Proportion of aquatic insect orders in each order at Station 203.

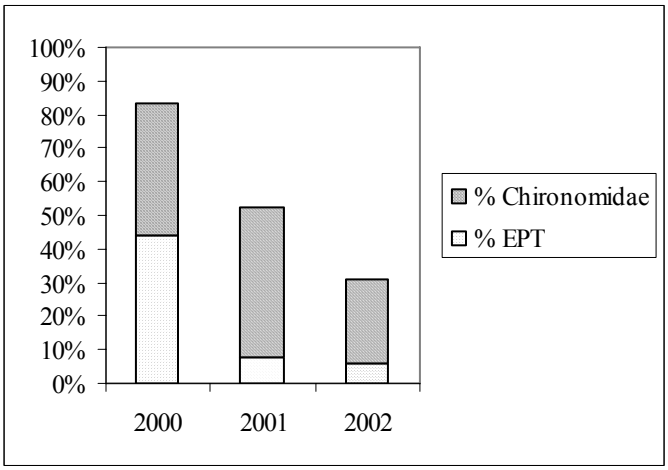


Figure 115. Proportion of Chironomidae and EPT taxa at Station 203.

Fish Communities

Juvenile Dolly Varden were found in Competition Creek upstream of Sourdock Creek, although the average number per trap (0.16) was the lowest of any of the sites. No larval fish were found and there is no indication of fish spawning at this site.

Fish Tissues

No fish were collected for tissue analysis.

Appendix 12 contains the water quality and biological data for Competition Creek upstream of Sourdock Creek, Station 203.

Competition Creek downstream of Sourdock Creek, Station 202

PHYSICAL FEATURES

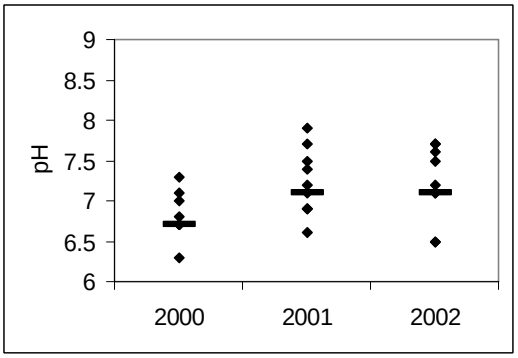
- Drainage size: 7.13 square miles
- Average July water temperature: 8.0°C
- 2001 average stream flow, 7/15-9/23 = 14.4 cfs
- 2002 average flow, 5/31 - 9/23 = 24.8 cfs

SUMMARY OF BIOLOGICAL PRODUCTIVITY

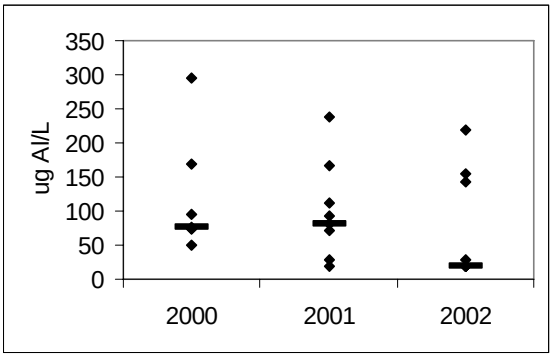
- Moderate amounts of chlorophyll-a, low concentrations of b and c..
- High invertebrate abundance.
- <10% of total invertebrates were terrestrial.
- Juvenile Dolly Varden rearing habitat, no indication of spawning.

Water Quality

Water in Competition Creek at Station 202 was moderated from upstream Station 202 by the inflow of Sourdock Creek. Compared to the upstream Station 203 site, the alkalinity (as $CaCO_3$) was higher (2000-2002 median = 39.8 mg/L), sulfate concentrations lower (2000-2002 median = 163 mg/L) and hardness lower (2000-2002 median = 212 mg/L). Conductivity ranged from 39 to 413 µSi/cm (median for 2000-2002 was 243 µSi/cm). Station 202 had circumneutral pH; metals concentrations were substantially lower than at the upstream Competition Creek site (Figure 116). Concentrations of Al exceeded the US EPA chronic criterion for aquatic life (US EPA 2004) in 43% of the samples (compared to 86% upstream), Cu in 4% (compared to 41% upstream), and Zn in 26% (compared to 100% upstream). Unlike the upstream site, no samples contained concentrations of Fe, Ni, or Pb that exceeded the chronic criteria for aquatic life (Table 18). The number of samples exceeding the chronic aquatic life criterion for Cd was estimated at 48%. The MRL of 4 samples was higher than the chronic aquatic life criterion and these samples were disregarded in Table 18.

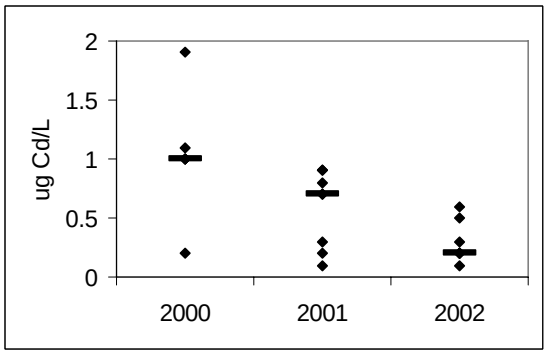


pH, standard units

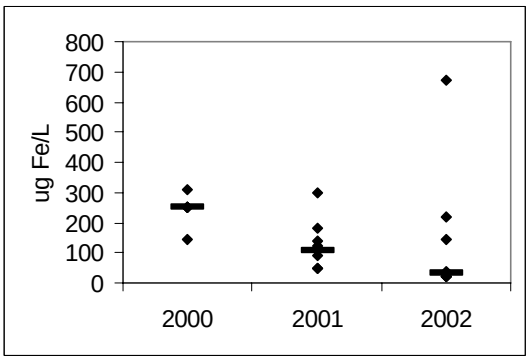


Concentration of Aluminum

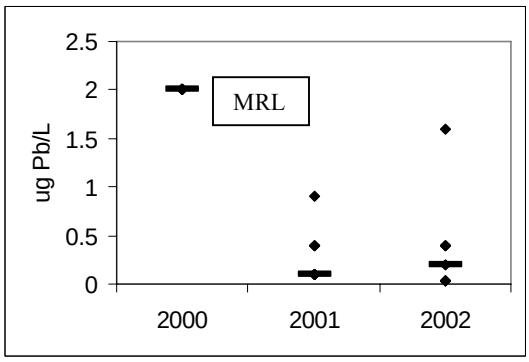
Figure 116. Concentrations of select metals and pH at Station 202: Competition Creek downstream of Sourdock Creek, 2000 - 2002. Graph shows median as bar and all data values as points, for pH and metals, n=7, 7, and 7 in 2000, 2001, and 2002, respectively.



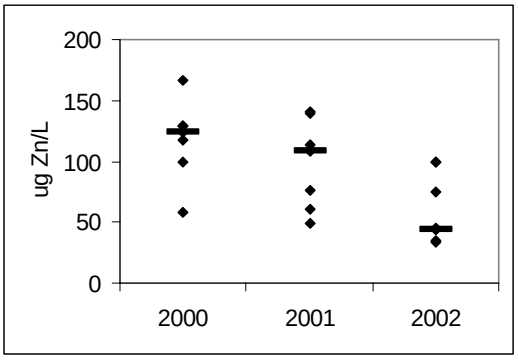
Concentration of Cadmium



Concentration of Iron



Concentration of Lead
Note high MRL



Concentration of Zinc

Figure 116, continued.

Table 18. Summary of water quality and % of samples exceeding aquatic life criteria at Station 202. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample. Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	76.5	295	20	23	0%	43%
Cd, µg/L	0.6	1.9	0.1	19*	0%	58%*
Cu, µg/L	4.1	10	1	23	0%	4%
Fe, µg/L	142	673	20	23		0%
Ni, µg/L	30.4	50	10.5	22	0%	0%
Pb, µg/L	0.4	2	0.04	23	0%	0%
pH	7.1	7.9	6.3	26	4%	
Se, µg/L	2.6	5	1	23	0%	0%
Zn, µg/L	100	166	33.5	23	26%	26%

*Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 4 samples were reported at <1 ug/L, they were disregarded in the above table.

Periphyton

Chlorophyll-a concentrations at Station 202 were higher than Stations 203, 215, and 214, but substantially lower than Stations 204 and 213. All samples from Station 213 were less than 10 mg/m^2 (Fig. 117). Chlorophyll-a concentrations were highest in 2002. Periphyton communities in Competition Creek downstream of Sourdock Creek contain higher concentrations of chlor-a than chlor-b, signifying the importance of Chromista, or diatoms (Figure 118).

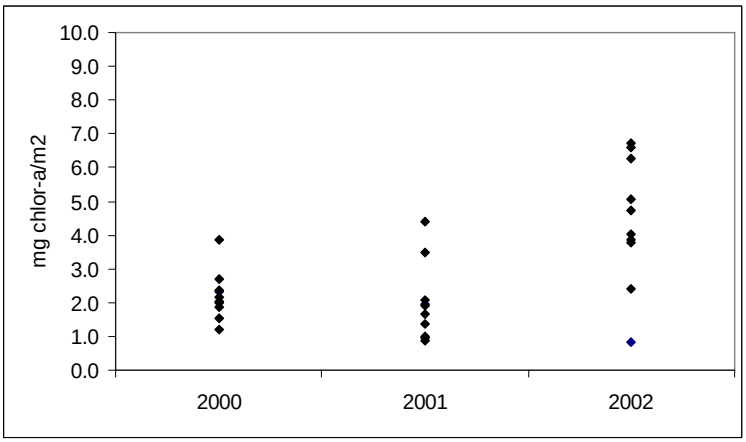


Figure 117. Concentration of chlorophyll *a* in Competition Creek at Station 202.

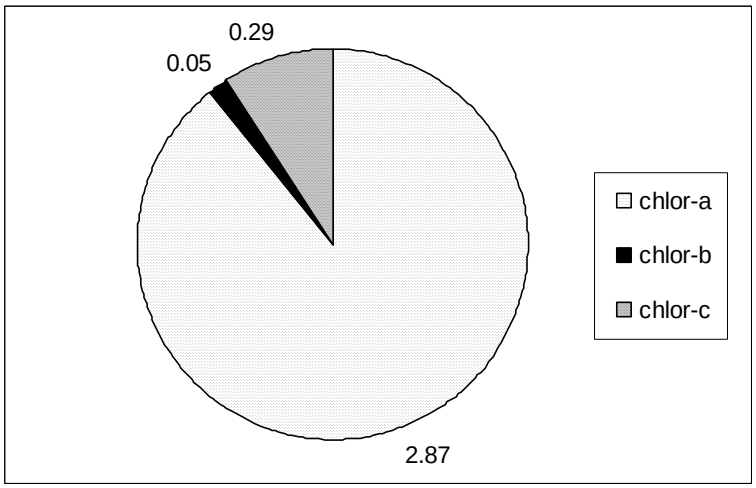


Figure 118. Proportions of chlorophyll *a*, *b*, and *c* in Competition Creek at Station 202.

Invertebrate Communities

Aquatic invertebrate abundance was highest in 2001 (Fig.119); however, when samples are adjusted for volumes of water flowing through drift nets, the highest density was

found in 2000 (Fig. 120). Aquatic invertebrate abundance was among the highest of any Wulik River sites, second only To Ferric Creek (Station 213).

We collected from 14 to 17 distinct taxonomic groups from drift nets in Competition Creek at Station 202 (Figure 121). More than 90% of the total invertebrates were aquatic, signifying a greater dependence on instream productivity than terrestrial inputs (Figure 122). Plecoptera (*Capnia*) and aquatic Diptera (mostly Simulidae and Chironomidae) were the most commonly found groups in Competition Creek at Station 202, although Ephemeroptera (*Baetis*) were common in 2002 (Figure 123). Unlike the upstream site (Station 203), aquatic mites and Collembola were not numerous. The percent EPT taxa was among the highest measured at any of the sites (Figure 124). No Trichoptera were found.

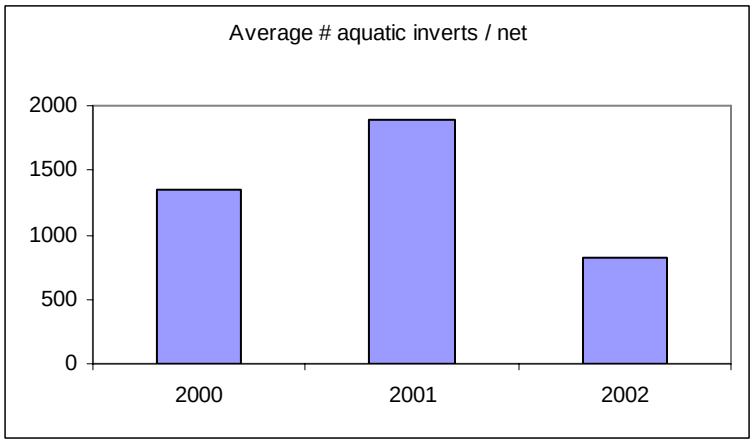


Figure 119. Abundance of aquatic invertebrates in Competition Creek, Station 202.

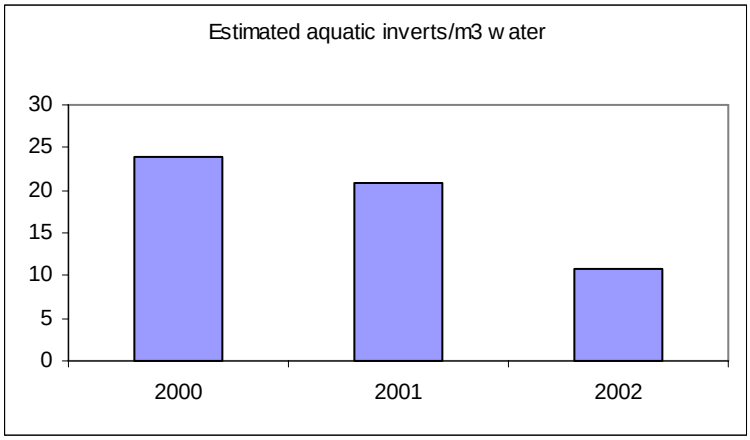


Figure 120. Density of aquatic invertebrates in Competition Creek, Station 202.

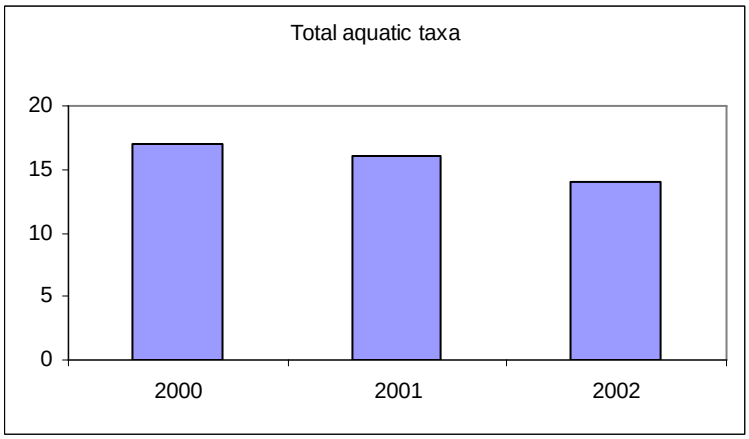


Figure 121. Total aquatic taxa in Competition Creek, Station 202.

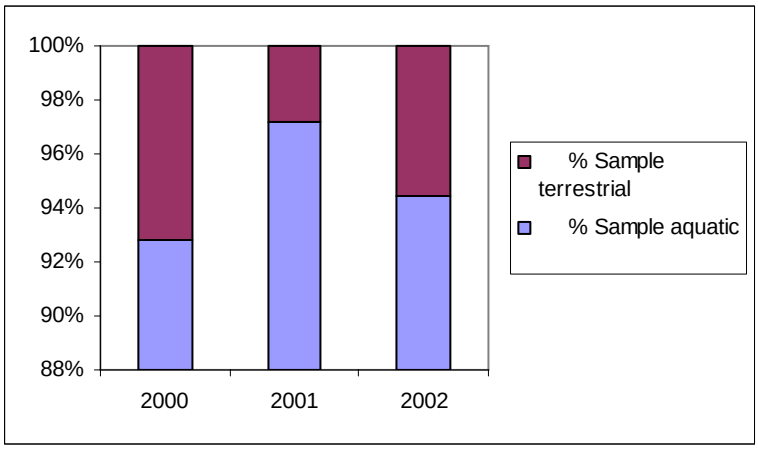


Figure 122. Proportion of terrestrial and aquatic invertebrates in Competition Creek, Station 202.

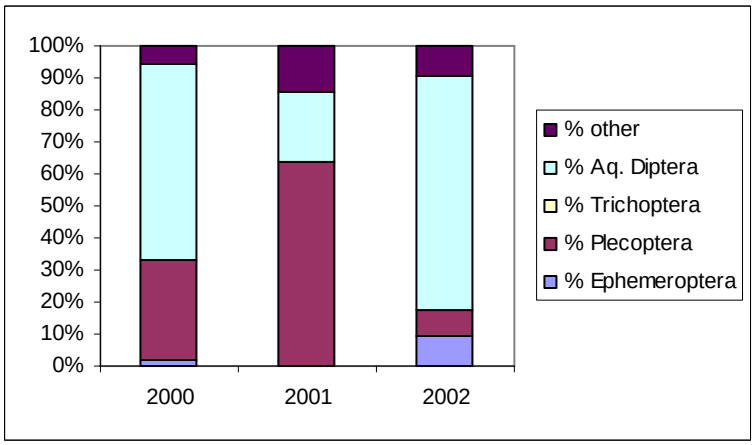


Figure 123. Proportion of aquatic insect orders in Competition Creek, Station 202.

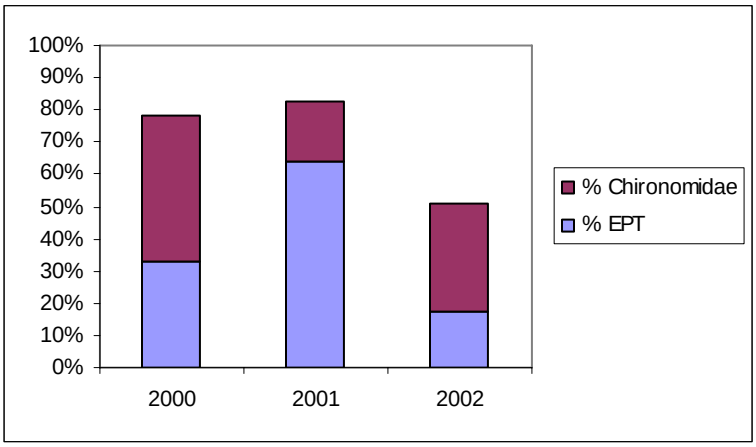


Figure 124. Proportion of Chironomidae and EPT taxa in Competition Creek, Station 202.

Fish Communities

A fyke net set in Competition Creek near Station 202 sampled fish for 24 hours. Fifty one juvenile Dolly Varden were caught in the net (Fig. 125); the fish were mostly 80 – 95 mm fork length. Although fish were not numerous at Station 202, the size distribution signifies the importance of this site for summer rearing of Dolly Varden juveniles. An average of 0.4 Dolly Varden juveniles per trap were collected in lower Competition Creek. The catch rate is similar to Station 214 and 216 and higher than Station 203.

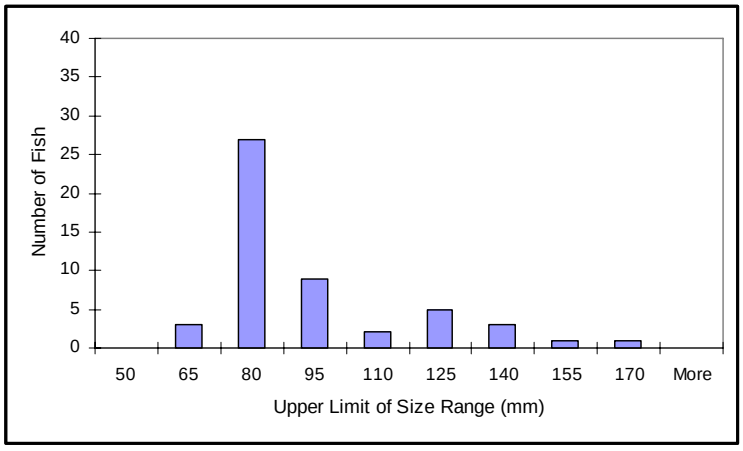


Figure 125. Juvenile Dolly Varden collected in a fyke net from Competition Creek at Station 202. The graph shows the number of fish in each size range.

FISH TISSUES

No fish were collected from this site for tissue analysis.

Appendix 13 contains all of the water and biological data for Competition Creek at Station 202.

Sourdock Creek, Station 204

Sourdock Creek is unlike any of the other streams that we have sampled in the Red Dog area: the stream cascades around and over large boulders that are covered with a thick layer of moss. The creek is heavily shaded, shallow with a few deeper pools, and small.

PHYSICAL FEATURES

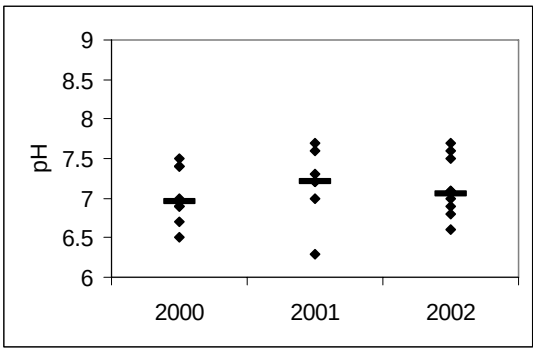
- Drainage size: 1.98 square miles
- Average July water temperature: 6.2°C

SUMMARY OF BIOLOGICAL PRODUCTIVITY

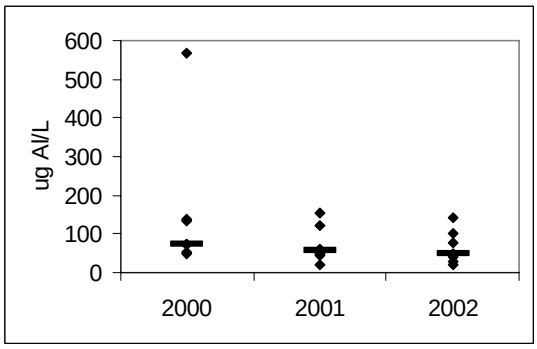
- Second highest amounts of chlorophyll-a.
- Highest concentration of chlorophyll-b measured at any of the sites
- Among the highest concentrations of chlorophyll-c, indicating a strong diatom community.
- Moderately low invertebrate abundance and density.
- <10% of total invertebrates were terrestrial, high proportion of EPT taxa.
- Highest abundance of Dolly Varden juvenile fish.

Water Quality

Water in Sourdock Creek had moderate alkalinity (as $CaCO_3$) (2000-2002 median = 46 mg/L), sulfate concentrations that were lower than Competition Creek (2000-2002 median = 116 mg/L) and median hardness of 170 mg/L (range 129 to 421 mg/L). Conductivity ranged from 15.4 to 344 µSi/cm (median for 2000-2002 was 194 µSi/cm), which is considerably lower than downstream Competition Creek (Station 202). Station 204 had neutral pH and slightly elevated concentrations of Al, Cd, and Zn (Figure 126). Concentrations of Al exceeded the US EPA chronic criterion for aquatic life (US EPA 2004) in 33% of the samples, Cd in 40% of the samples, Cu in 10%, Ni and Pb in 5% (1 sample in 3 years), and Zn in 29% of the samples (Table 19). Concentrations of Fe and Se were relatively low. Nine water samples had a MRL greater than the chronic criteria; these samples were disregarded in Table 19.

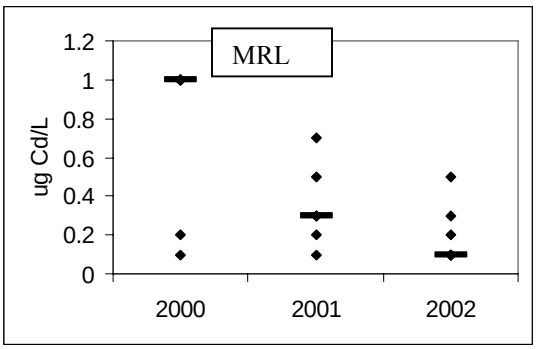


pH, standard units

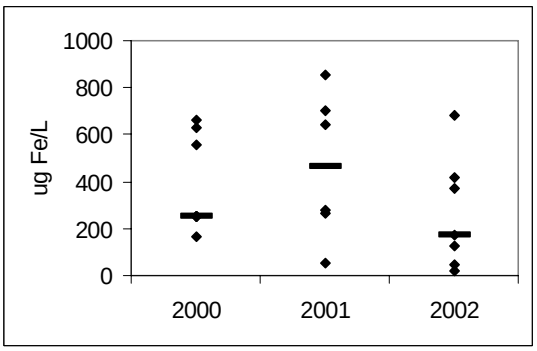


Concentration of Aluminum

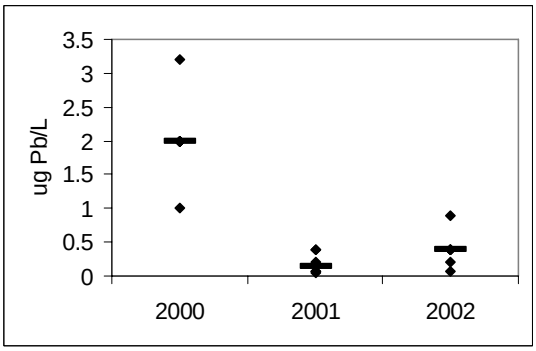
Figure 126. Concentrations of select metals and pH at Station 204: Sourdock Creek, 2000 - 2002. Graph shows median as bar and all data values as points, for most metals, n=8, 6, and 7 in 2000, 2001, and 2002, respectively. For pH, n= 8, 7, and 8 in 2000, 2001, and 2002, respectively.



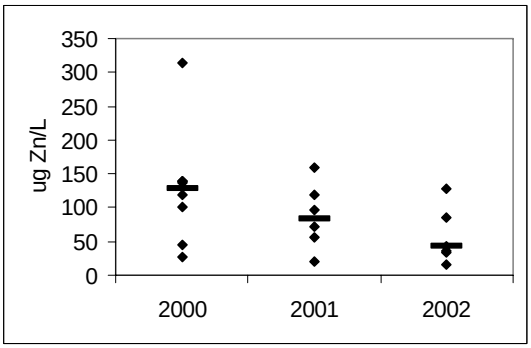
Concentration of Cadmium
note high MRL for 2000



Concentration of Iron



Concentration of Lead



Concentration of Zinc

Figure 126, continued.

Table 19. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 204. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample. Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	75	569	20	21	0%	33%
Cd, µg/L	0.2	0.7	0.1	15*	0%	40%*
Cu, µg/L	3.6	20.5	1	21	5%	10%
Fe, µg/L	266	852	20	21		0%
Ni, µg/L	30.3	107	5	21	0%	5%
Pb, µg/L	0.4	3.2	0.04	21	0%	5%
pH	7.1	7.7	6.3	24	4%	
Se, µg/L	2.7	5	1	23	0%	0%
Zn, µg/L	86.3	315	16.4	21	29%	29%

*Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 6 samples were reported at <1 ug/L, they were disregarded in the above table.

Periphyton

Chlorophyll-a concentrations at Station 204 were among the highest measured in any sites in the Wulik Creek Drainage, second only to Ferric Creek (Figure 127, note the larger graph scale). In the three years of sampling, we found from 0.5 to 20 mg/m^2 chlorophyll-a in Sourdock Creek. Periphyton communities in Sourdock Creek have high, and nearly equal concentrations of chlorophyll-b and chlorophyll-c (Figure 128). Concentrations of chlorophyll-b were the highest of any sites sampled in the Wulik River or Ikalukrok Creek drainages. Nearly equal proportions of chlorophylls b and c suggest that both Chromista, or diatoms and dinoflagellates (chlorophyll *c*) and green algae and plants (chlorophyll *b*) are important to the periphyton community.

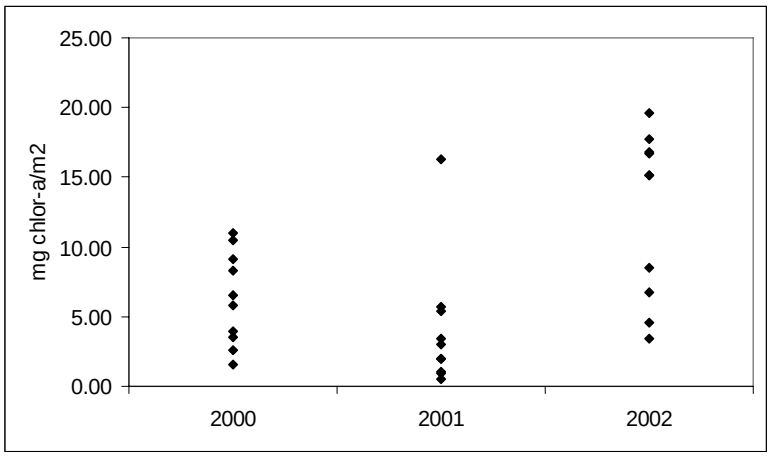


Figure 127. Concentration of chlorophyll *a* in Sourdock Creek, Station 204.

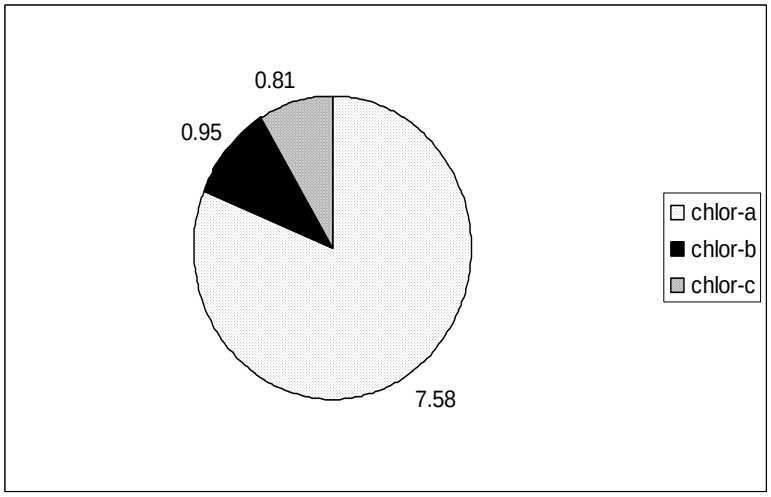


Figure 128. Proportions of chlorophyll *a*, *b*, and *c* in. Sourdock Creek, Station 204

Invertebrate Communities

Both abundance and density of aquatic invertebrate communities were lower than in this site (Figs.129 and 130); both abundance and density were similar to those found in Competition Creek at Station 203 and lower than Competition Creek at Station 202. We collected from 13 to 19 distinct aquatic invertebrate taxa (Fig. 131). Most of the invertebrates were aquatic forms, signifying a greater dependence on instream productivity than terrestrial inputs (Figure 132). Invertebrate communities in Sourdock Creek are dominated by Plecoptera (from 27% to 46%, nearly all *Nemoura* and *Capnia*), and aquatic Diptera ((24% to 50% Chironomidae) (Figure 133). There were few Ephemeroptera and no Trichoptera and fewer Acari and Collembola than found in upstream Competition Creek. From 27% to 53% of samples were EPT taxa, which is the highest percentage found in Wulik River sites (Figure 134).

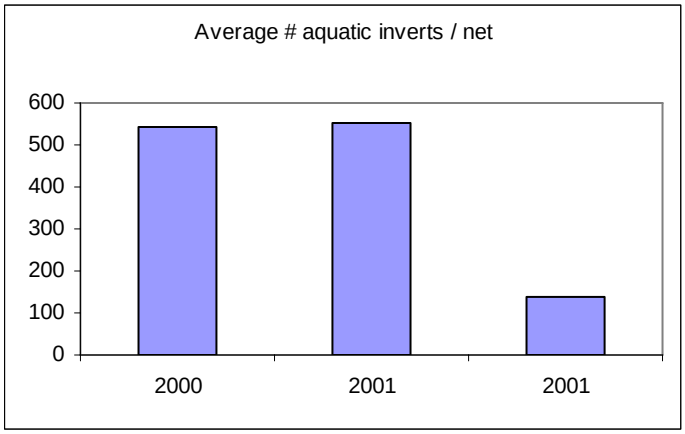


Figure 129. Abundance of aquatic invertebrates in Sourdock Creek, Station 204.

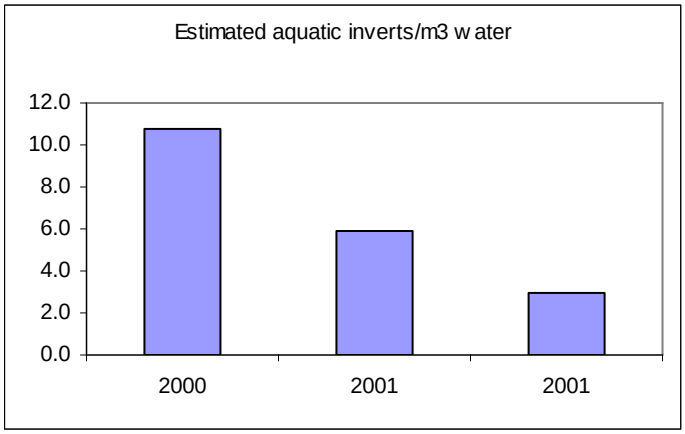


Figure 130. Density of aquatic invertebrates in Sourdock Creek, Station 204.

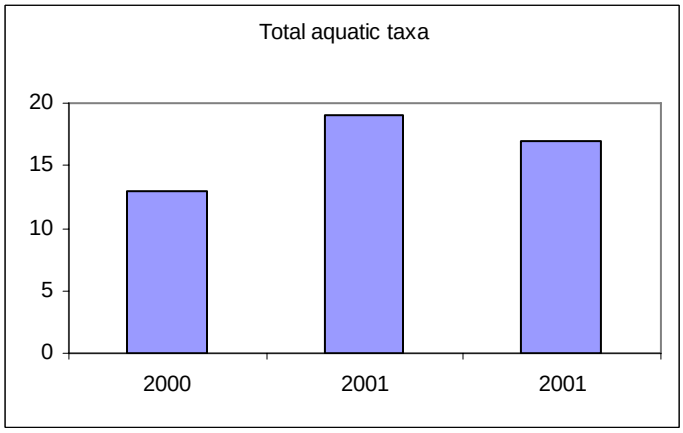


Figure 131. Total aquatic taxa in Sourdock Creek, Station 204.

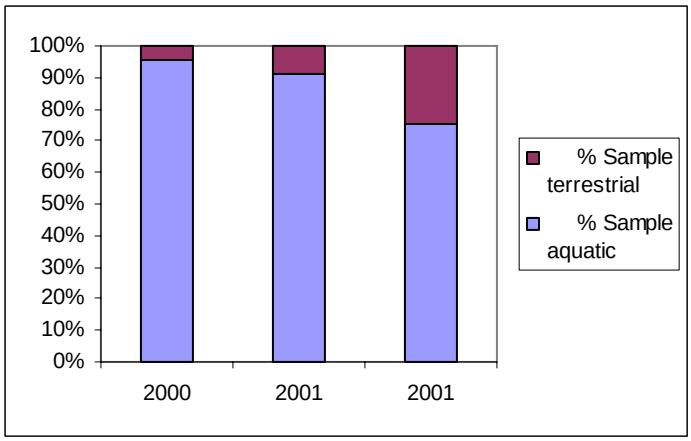


Figure 132. Proportion of terrestrial and aquatic invertebrates in Sourdock Creek, Station 204.

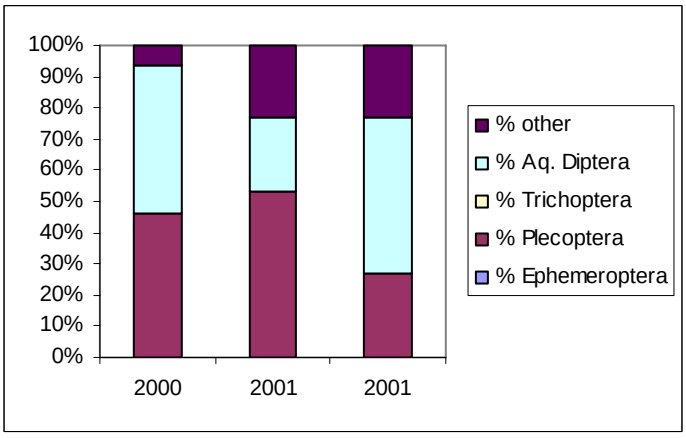


Figure 133. Proportion of aquatic insect orders in Sourdock Creek, Station 204.

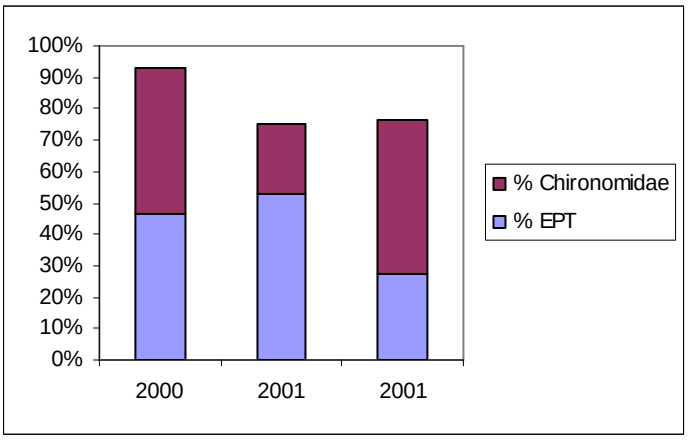


Figure 134. Proportion of Chironomidae and EPT taxa in Sourdock Creek, Station 204.

Fish Communities

The abundance of juvenile Dolly Varden was higher than in any of the sites in this study. We collected an average of 2.2 fish per trap, compared to the next most abundant site, Ferric Creek, where we found an average of 1.1 fish per trap. Most of Dolly Varden collected in the traps were 80 to 120 mm fork length (Figure 135). Fish trap information suggests that Sourdock Creek is among the most important sites for summer rearing of juvenile Dolly Varden in the Wulik River drainage.

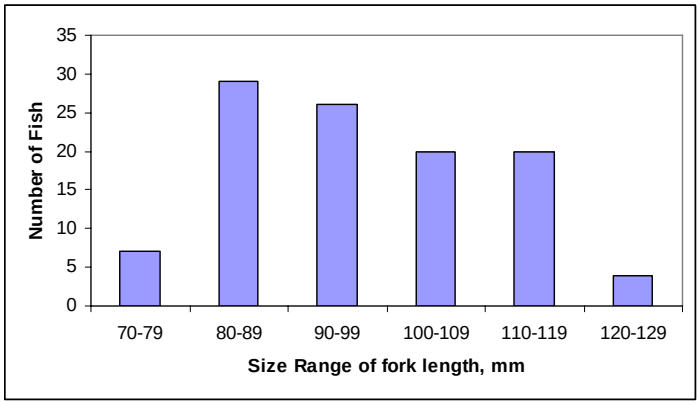


Figure 135. Number of juvenile Dolly Varden, by size, collected in Sourdock Creek.

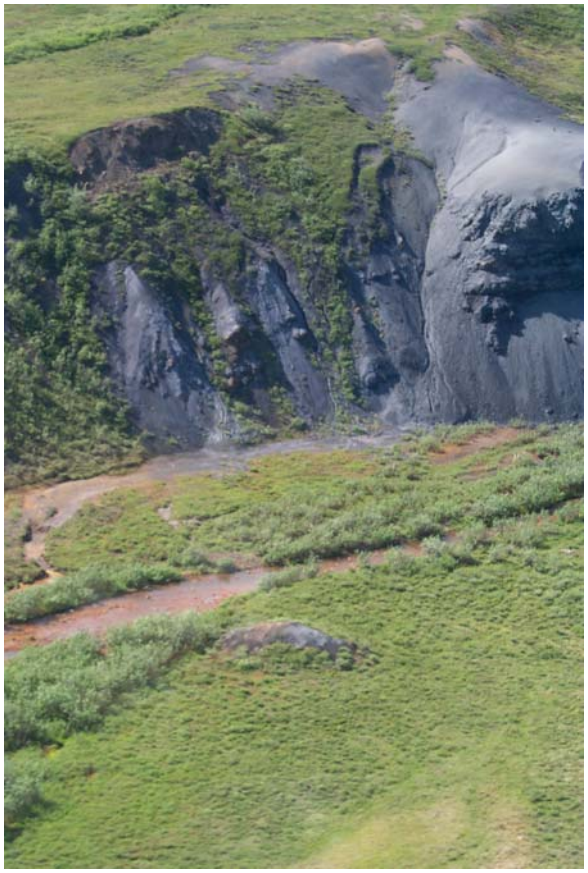
Fish Tissues

Analysis of fish tissues was not done at this site

.

Appendix 14 contains the water quality and biological data for Sourdock Creek, Station 204.

Ferric Creek, Station 213



PHYSICAL FEATURES

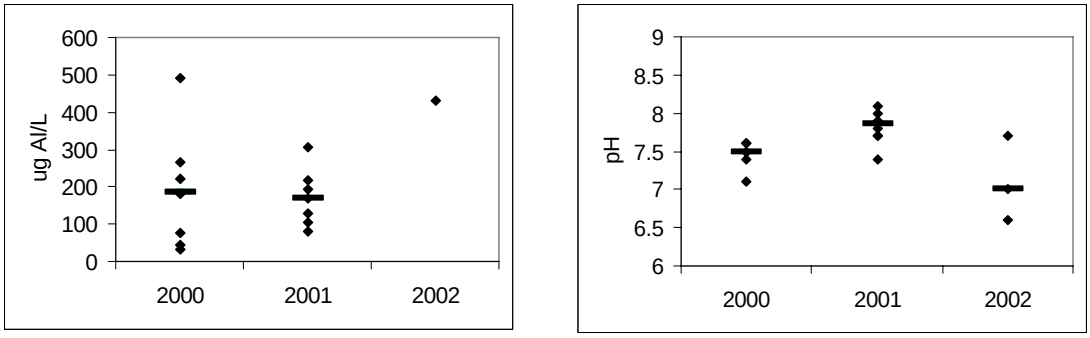
- Drainage size: 9.91 square miles
- Average July water temperature: 7°C
- Elevated Al and Fe, other metals low.

SUMMARY OF BIOLOGICAL PRODUCTIVITY

- Chlorophyll-a highest of any Wulik River sites
- High aquatic invertebrate abundance and density
- EPT taxa rare, most invertebrates were Chironomidae and Collembola
- Dolly Varden, Arctic grayling, and slimy sculpin inhabit Ferric Creek
- Presence of larval Dolly Varden evidence of spawning
- Juvenile fish contain low concentrations of Cd and Pb. Se concentrations similar to other sites.

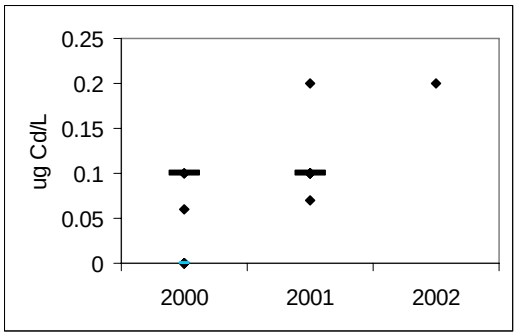
Water Quality

Water in Ferric Creek has elevated concentrations of Al and Fe (Figure 136). Alkalinity and hardness were higher than in most other sites (2000-2002 median alkalinity = 138 mg/L as $CaCO_3$ and median hardness = 186 mg/L as $CaCO_3$) and sulfate was lower (2000-2002 median = 64 mg/L). Conductivity ranged from 32 to 323 µSi/cm (median for 2000-2002 was 224 µSi/cm). The stream bottom is stained with iron throughout. Station 213 had neutral to slightly basic pH (Figure --). Concentrations of Al and Fe exceeded the US EPA chronic criterion for aquatic life (US EPA 2004) in 75% (Table 20). Concentrations of all other metals were relatively low (Figure 136 and Table 20).

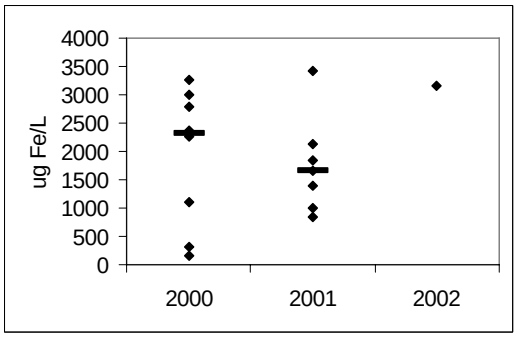


pH, standard units Concentration of Aluminum

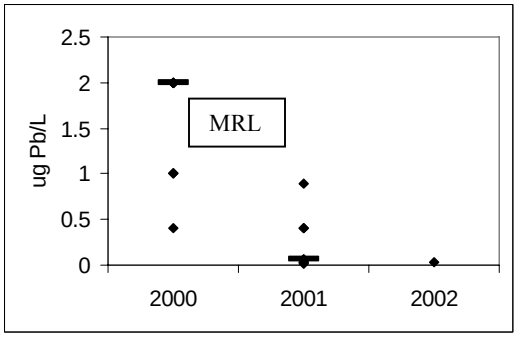
Figure 136. Concentrations of select metals and pH at Station 213, Ferric Creek, 2000 - 2002. Graph shows median as bar and all data values as points, for most metals and pH, n=8, 7, and 5 in 2000, 2001, and 2002, respectively.



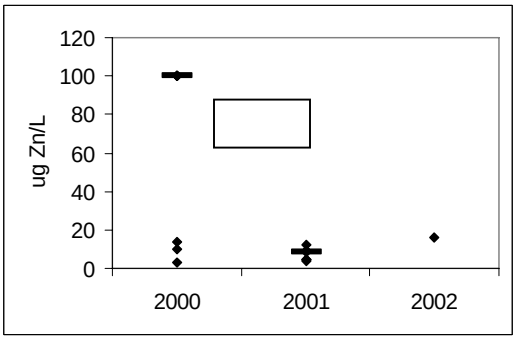
Concentration of Cadmium



Concentration of Iron



Concentration of Lead
Note high MRL in 2000



Concentration of Zinc
Note high MRL in 2000

Figure 136, continued.

Table 20. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 213. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample. Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	185	492	33	16	0%	75%
Cd, µg/L	0.1	<1	0.06	11*	0%	0*
Cu, µg/L	1.75	7.5	0.8	16	0%	0%
Fe, µg/L	1975	3420	145	16		75%
Ni, µg/L	4.4	<50	1	16	0%	0%
Pb, µg/L	0.65	2	0.02	16	0%	0%
pH	7.6	8.1	6.6	18	0%	
Se, µg/L	2.4	4	1	18	0%	0%
Zn, µg/L	11.25	<100	3	16	0%	0%

*Detection limits for Cd in 2000 were 1 ug/L, which is higher than the chronic life criterion; 5 samples were reported at <1 ug/L, these samples were disregarded in the above table.

Periphyton

Chlorophyll-a concentrations at Station 213, Ferric Creek were the highest measured in any sites in the Wulik River Drainage (Figure 137, note the larger graph scale). In 2001-02, we estimated an average of 14.9 mg chlorophyll-a /m^2. Periphyton communities at Station 212 contain higher proportions of chlor-c than chlor-a; the higher proportion of chlor-c indicates that Chromista, or diatoms, are more important to the community than green algae (Figure 138).

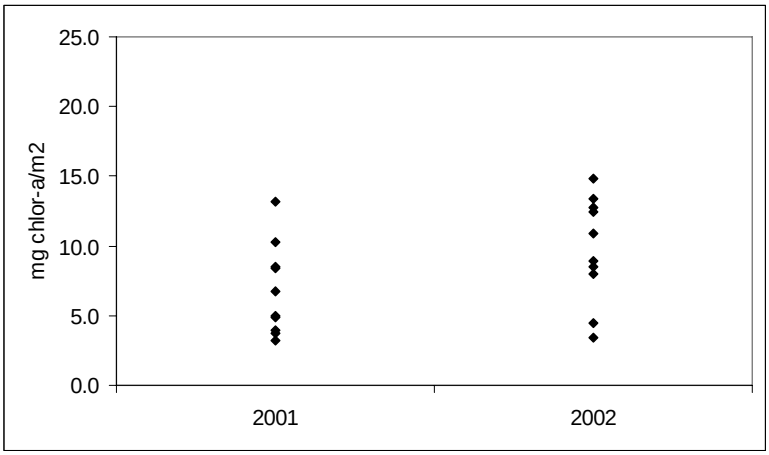


Figure 137. Concentration of chlorophyll *a* in Ferric Creek.

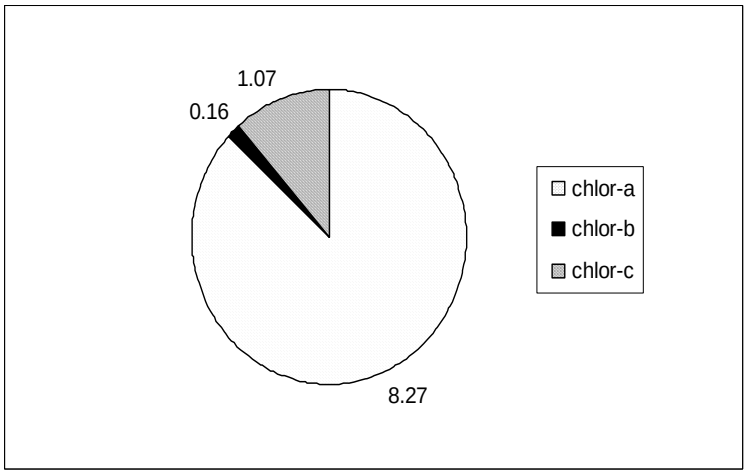


Figure 138. Proportions of chlorophyll *a*, *b*, and *c* in Ferric Creek.

Invertebrate Communities

Aquatic invertebrate abundance and density was high at Station 213 (Figs. 139 and 140); abundance was higher than any of the other Wulik River sites.

We collected 21 distinct aquatic invertebrate taxa in 2001 and 17 in 2002 (Fig. 141). Most of the total invertebrates were aquatic forms (90% in 2001 and 68% in 2002, Fig. 142), signifying a greater dependence on instream productivity than terrestrial inputs. Invertebrate communities in Ferric Creek are dominated by aquatic Diptera (Fig. 143). Seventy percent of the aquatic invertebrates in 2001 and 49% in 2002 were Chironomidae larvae and pupae. The second most common group of aquatic species was Collembola (17% in 2001 and 12% in 2002). Ephemeroptera and Plecoptera were rare; Trichoptera were absent (Fig. 144).

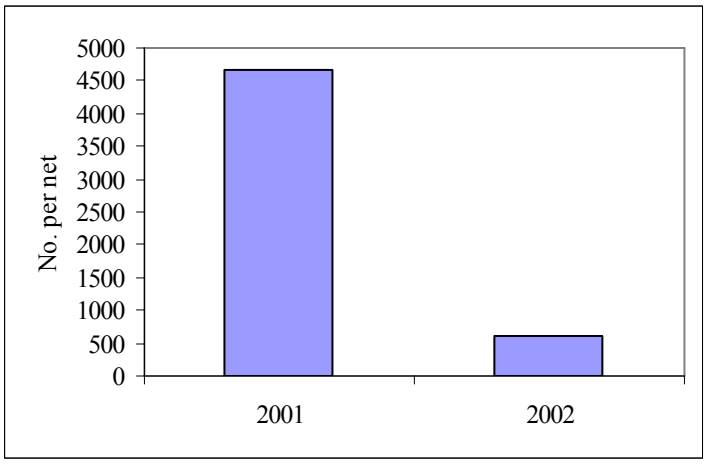


Figure 139. Abundance of aquatic invertebrates in Ferric Creek.

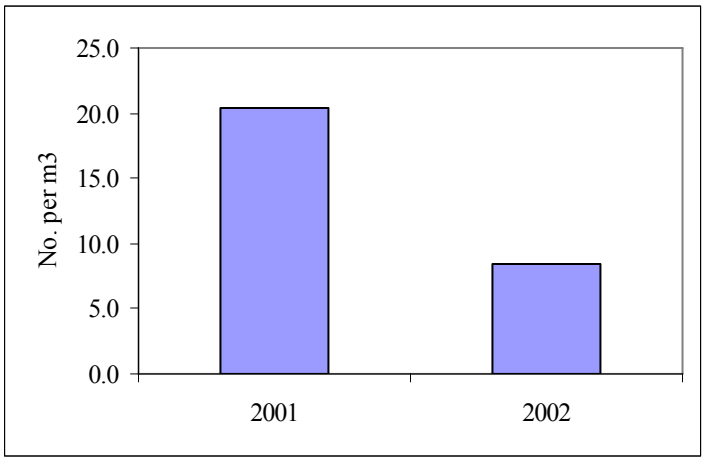


Figure 140. Density of aquatic invertebrates in Ferric Creek.

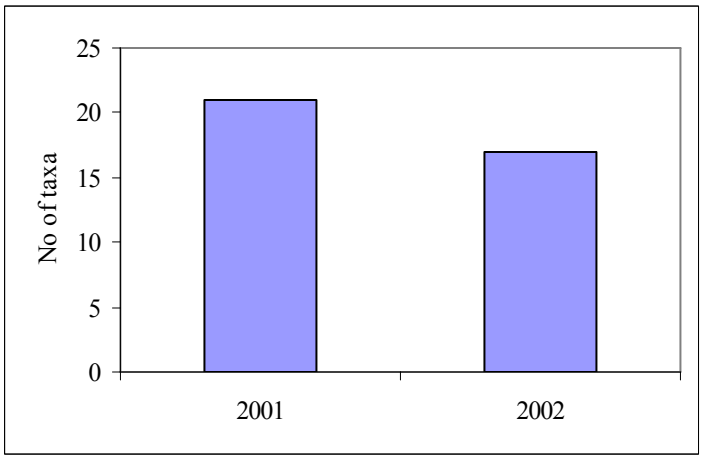


Figure 141. Total aquatic taxa in Ferric Creek.

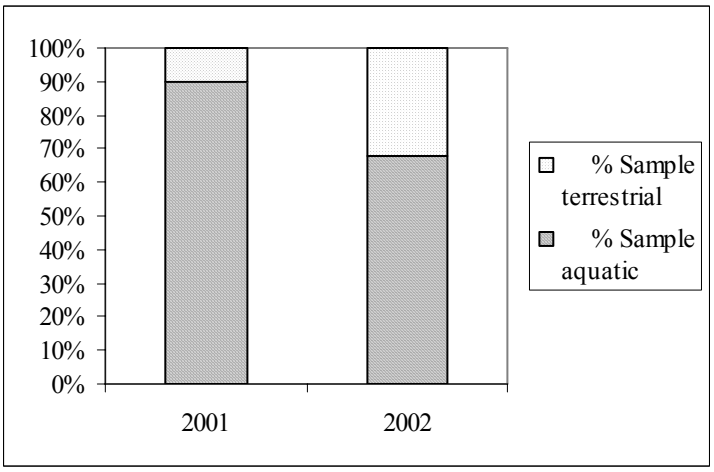


Figure 142. Proportion of terrestrial and aquatic invertebrates in Ferric Creek.

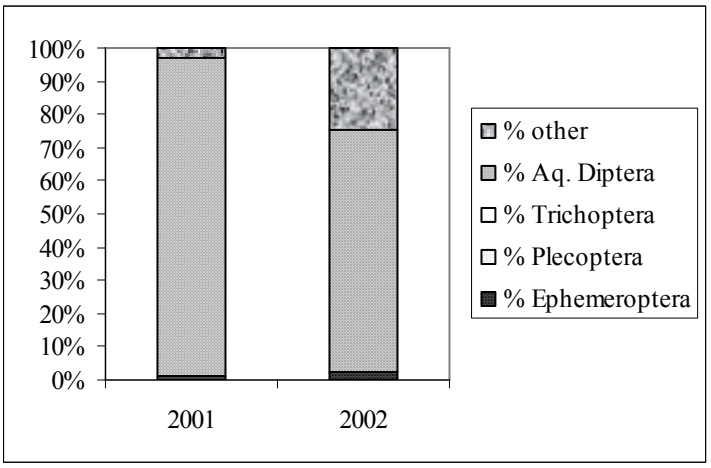


Figure 143. Proportion of aquatic insect orders in Ferric Creek.

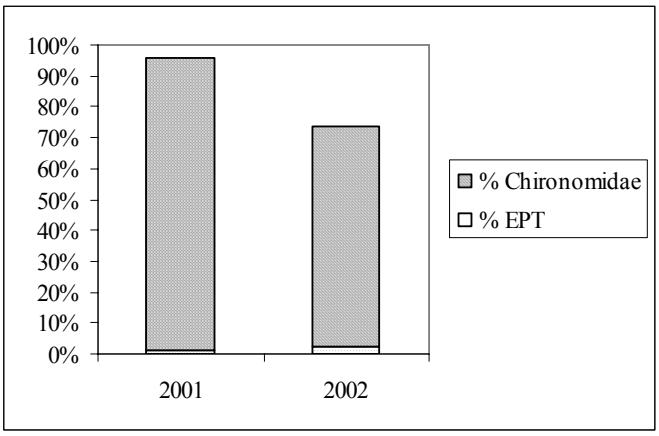


Figure 144. Proportion of Chironomidae and EPT taxa in Ferric Creek.

Fish Communities

Ferric Creek supports populations of juvenile Dolly Varden, Arctic grayling, and slimy sculpin. We collected an average of 1.1 juvenile Dolly Varden per trap, Stations 204 and 215 were the only other sites in the Wulik River Drainage with higher trap rates. Fish catches included age 0+ Dolly Varden, which is evidence that spawning occurred in Ferric Creek. The size distribution of Dolly Varden collected in Ferric Creek (Fig. 145) suggests that the fish are age 0+ to age 3.

Fish Tissues

Nine Dolly Varden, between 107 mm and 149 mm fork length were collected and analyzed for whole body concentrations of Cd, Pb, and Se (Fig. 146). Juvenile Dolly Varden contained lower concentrations of Cd and Pb than fish from Grayling Junior Creek or North Fork of Red Dog Creek. Cd and Pb concentrations in fish from North Fork Red Dog Creek were substantially higher than in the other sites. Se concentrations were similar among the three sites: median concentrations of Se were 5.69 mg/kg in Ferric Creek, 7.2 mg/kg in Grayling Junior Creek, and 8 mg/kg in North Fork.

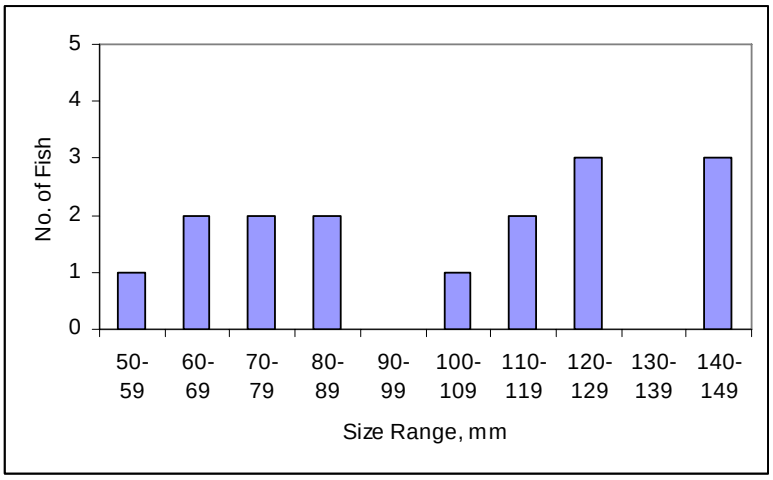


Figure 145. Fork length of juvenile Dolly Varden collected in Ferric Creek.

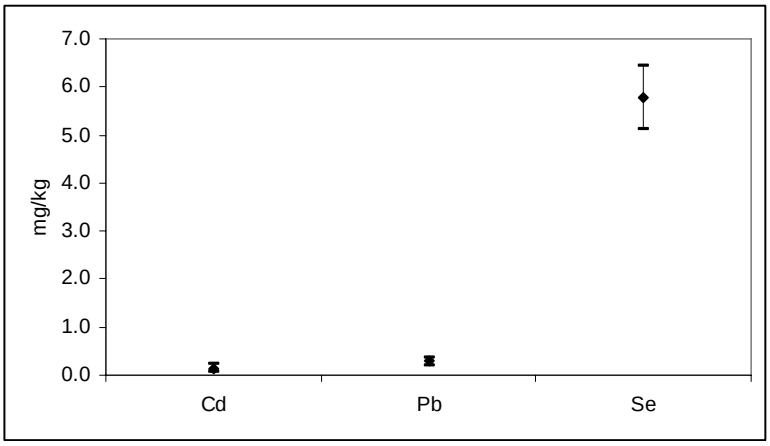


Figure 146. Average concentration (plus and minus one criteria deviation) of Cd, Pb, and Se in juvenile Dolly Varden from Ferric Creek.

Appendix 15 contains the water quality and biological data for Ferric Creek, Station 213.

Square Creek, Station 214

PHYSICAL FEATURES

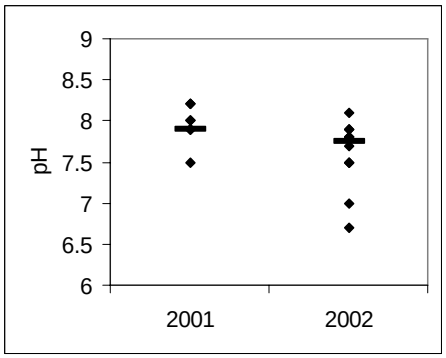
- Drainage size: 10.19 square miles
- Average July water temperature: 11.1°C
- Contains aufeis that persists into mid-summer
- Water low in metals; only 3 samples exceed chronic aquatic life criterion for Al

SUMMARY OF BIOLOGICAL PRODUCTIVITY

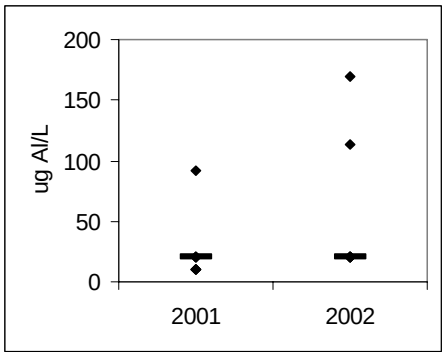
- Algal standing crop was low
- Aquatic invertebrate abundance and density among highest in Wulik River sites
- Ephemeroptera were abundant, especially in 2002.
- Few juvenile Dolly Varden collected in minnow traps; all were from 89 to 105 mm fork length.
- Presence of age 0+ Dolly Varden in invertebrate drift nets is evidence of spawning

Water Quality

Square Creek is characterized by high alkalinity (2001-2002 median = 168 mg/L as $CaCO_3$), moderate sulfate (2001-2002 median = 97 mg/L) and high hardness (2001-2002 median = 273 mg/L as $CaCO_3$). Conductivity ranged from 86 to 421 µSi/cm (median for 2001-2002 was 301 µSi/cm). The pH was higher than most other sites; median pH for 2001-2002 was 7.9. Square Creek has exceptionally good water quality with low concentrations of metals; however, three early spring samples contained slightly elevated Al (Figure 147); these samples exceeded the US EPA chronic criterion for aquatic life (US EPA 2004) for Al. No other metals exceeded the chronic or acute criteria for aquatic life (Table 21).

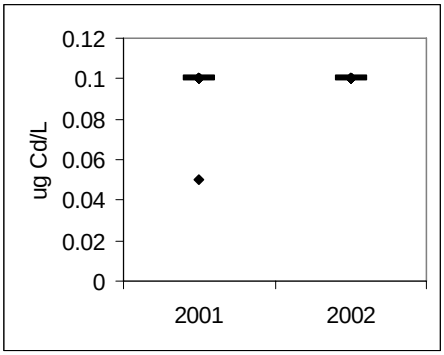


pH, standard units

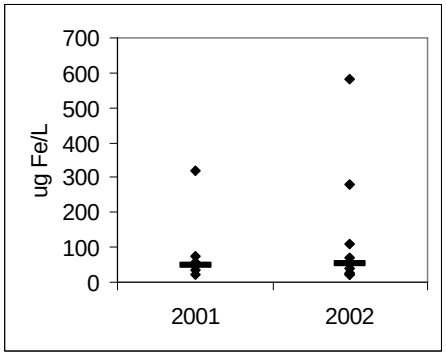


Concentration of Aluminum

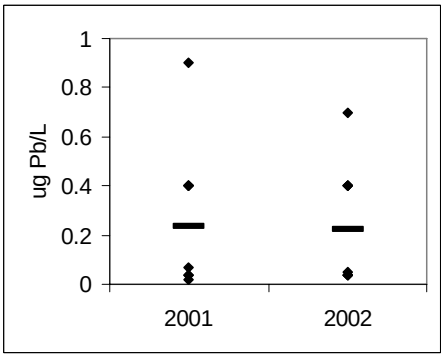
Figure 147. Concentrations of select metals and pH at Station 214: Square Creek. 2001 - 2002. Graph shows median as bar and all data values as points, for most metals, n=8 and 8 in 2001 and 2002, respectively. For pH, n= 9 and 10 in 2001 and 2002, respectively.



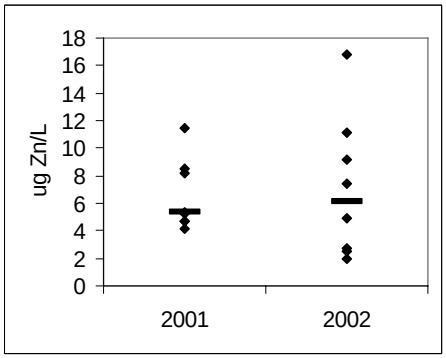
Concentration of Cadmium



Concentration of Iron



Concentration of Lead



Concentration of Zinc

Figure 147, continued.

Table 21. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 214. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample. Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	20	169	10	16	0%	19%
Cd, µg/L	0.1	0.1	0.05	16	0%	0%
Cu, µg/L	1	2	0.8	16	0%	0%
Fe, µg/L	50	584	20	16		0%
Ni, µg/L	3.15	10	1	16	0%	0%
Pb, µg/L	0.235	0.9	0.02	16	0%	0%
pH	7.9	8.2	6.7	19	0%	
Se, µg/L	1.1	2.6	1	17	0%	0%
Zn, µg/L	5.3	16.8	2	16	0%	0%

Periphyton

Chlorophyll-a concentrations at Station 214 were low (Fig. 148) and among the lowest measured in the Wulik River sites. Concentrations of chlor-b and chlor-c were both low in Square Creek, although chlor-c was slightly higher (Fig. 149). Chromista, or diatoms, are commonly found in cold, clear water systems such as Square Creek.

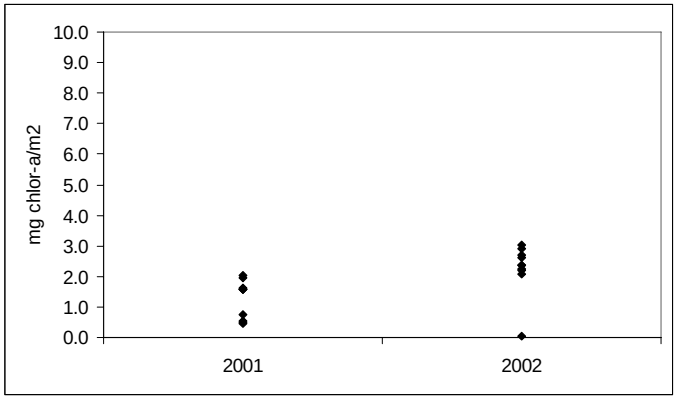


Figure 148. Concentration of chlorophyll *a* in Square Creek at Station 214.

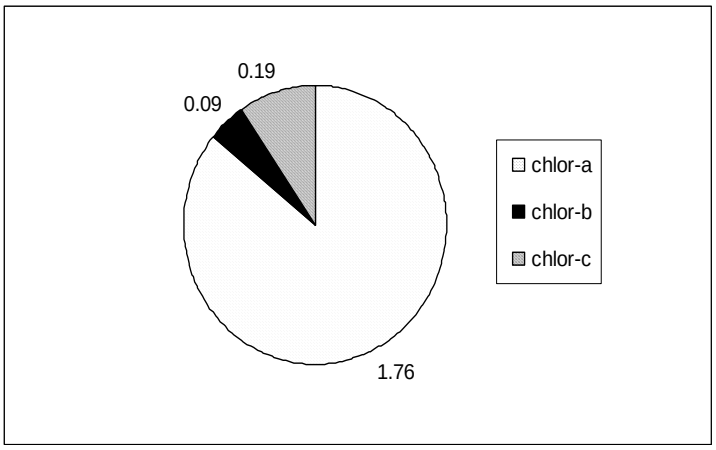


Figure 149. Proportions of chlorophyll *a*, *b*, and *c* in Square Creek at Station 214.

Invertebrate Communities

Both abundance and density of aquatic invertebrate communities were among the highest found in any of the Wulik River sites: only Stations 202 and 213 contained higher numbers of aquatic invertebrates. We found an average of nearly 2000 aquatic invertebrates per net in 2001 and 400 per net in 2002 (Fig. 150), and densities of 19 and 8 aquatic invertebrates per m^2 in 2001 and 2002, respectively (Fig. 151).

We collected 21 distinct taxonomic groups in 2001 and 18 distinct taxa in 2002 (Fig.152). More than 90% of the total invertebrates were aquatic forms in both 2001 and 2002 (Fig. 153), signifying a greater dependence on instream productivity than terrestrial inputs. Aquatic Diptera dominated invertebrate communities in Square Creek in 2001 (Fig. 154), although in 2002, Ephemeroptera were nearly as common. Plecoptera were rare (3% in 2001 and 2% in 2002) and Trichoptera were absent. The percent EPT taxa was low in 2001 (9%), but higher than the percent Chironomidae in 2002 (Fig. 155).

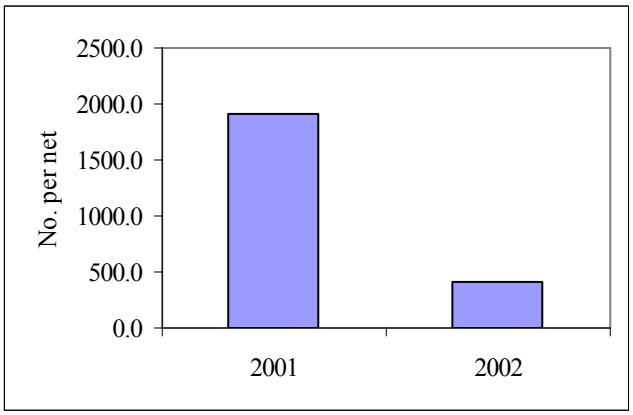


Figure 150. Abundance of aquatic invertebrates in Square Creek at Station 214.

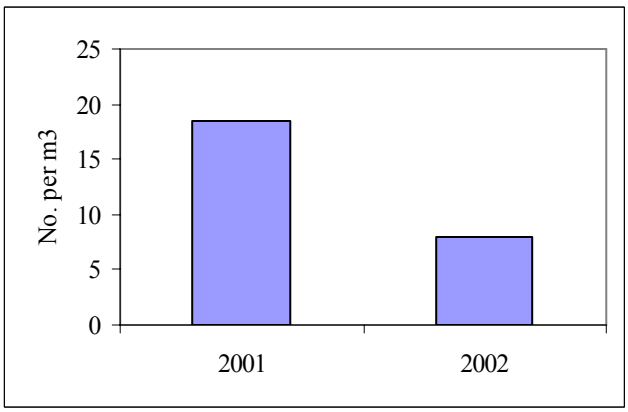


Figure 151. Density of aquatic invertebrates in Square Creek at Station 214.

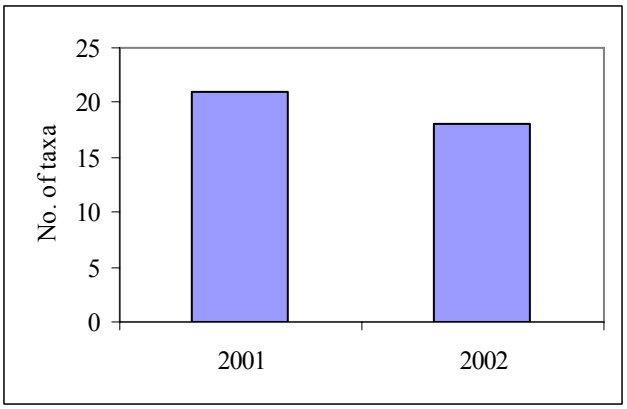


Figure 152. Total aquatic taxa in Square Creek at Station 214.

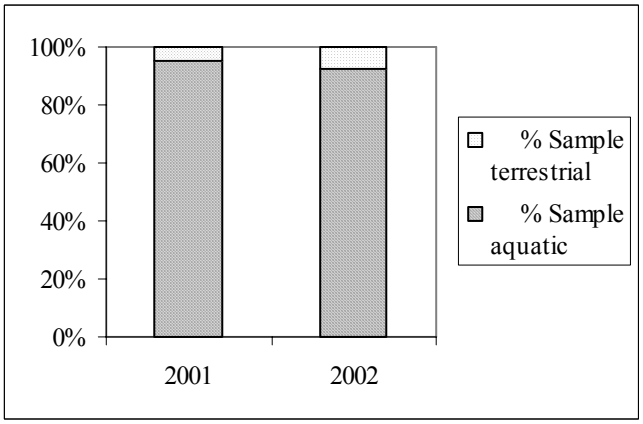


Figure 153. Proportion of terrestrial and aquatic invertebrates in Square Creek at Station 214.

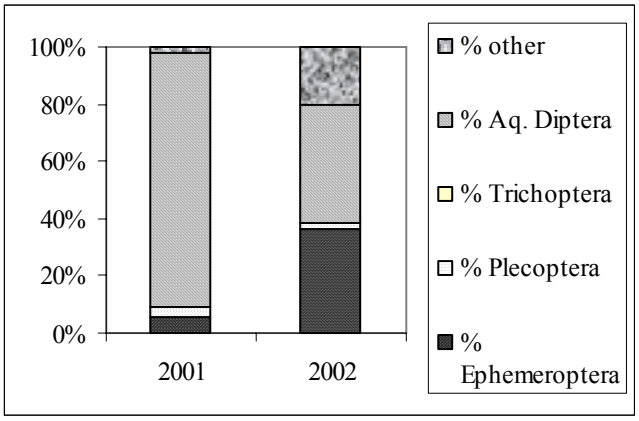


Figure 154**.** Proportion of aquatic insect orders in Square Creek at Station 214.

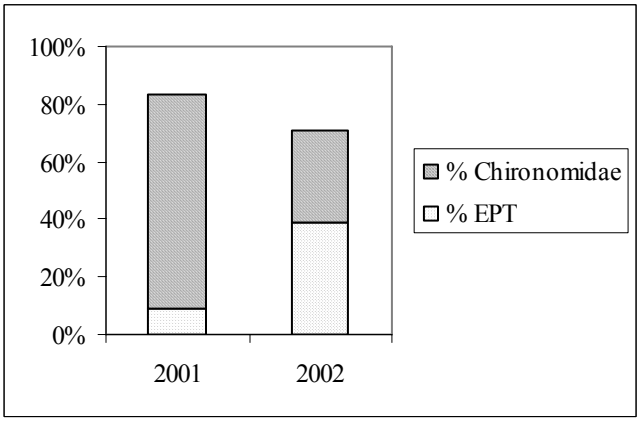


Figure 155. Proportion of Chironomidae and EPT taxa in Square Creek at Station 214.

Fish Communities

The number of juvenile Dolly Varden collected in Square Creek was low (0.5 per trap) when compared to the other sites. The Dolly Varden in Square Creek were of similar size and age: all fish collected in the minnow traps were from 89 to 105 mm fork length, or about age 2.

We found larval (age 0+) Dolly Varden in the aquatic invertebrate drift nets. The presence of these small fish is evidence that spawning occurs in Square Creek.

Fish Tissues

No fish were collected from this site to analyze for metals concentrations.

Appendix 16 contains the water quality and biological data for Square Creek.

Sunday Creek, Station 215

PHYSICAL FEATURES

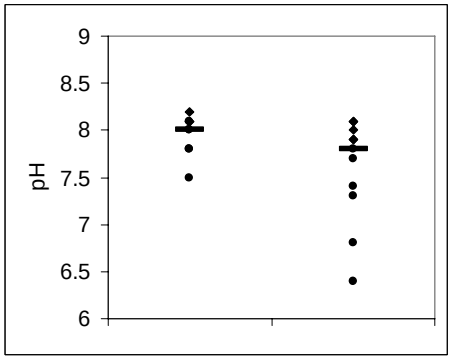
- Drainage size: 5.76 square miles
- Average July water temperature: 10.2°C
- Most of drainage basin lies in areas of limestone or limey shale
- Water is low in metals, pH is slightly basic (median = 7.9)
- Stream bottom substrate of fine gravel

SUMMARY OF BIOLOGICAL PRODUCTIVITY

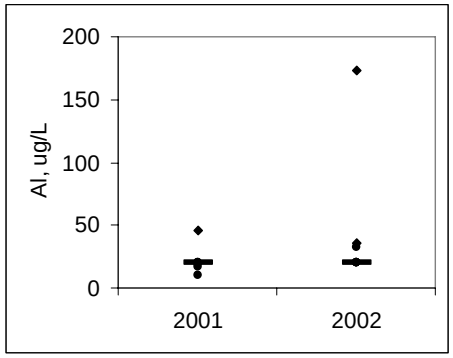
- Periphyton standing crop low
- Low abundance and density of aquatic invertebrates
- Highest number of distinct taxonomic groups found in any Wulik River site
- EPT taxa more abundant than Chironomidae
- *Capnia*, *Baetis*, *Cinygmula*, and *Epeorus* were common.
- Second highest number of juvenile Dolly Varden caught in traps
- Age 0+ Dolly Varden present, evidence of spawning in Sunday Creek

Water Quality

Water quality in Sunday Creek is exceptionally good with low concentrations of metals (Figure 156). The alkalinity was higher than in many of the other sites, with a median value of 129 mg/L as $CaCO_3$. Conductivity ranged from 94 to 393 µSi/cm, the median hardness was 223 mg/L as $CaCO_3$, and the median concentration of SO_4 was 94 mg/L. Station 215 had slightly basic pH. One sample, collected in late May 2002, contained slightly elevated concentrations of Al; no other samples contained elevated metals. Except for the May 2002 sample, no water samples exceeded the acute or chronic life criteria for any of the metals (Table 22).

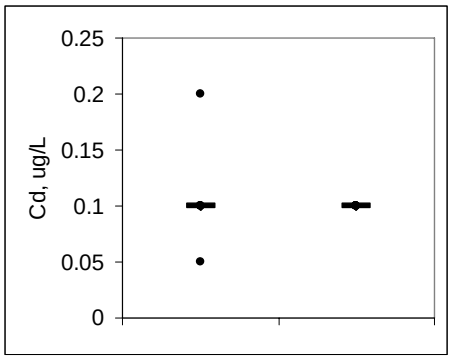


pH, standard units

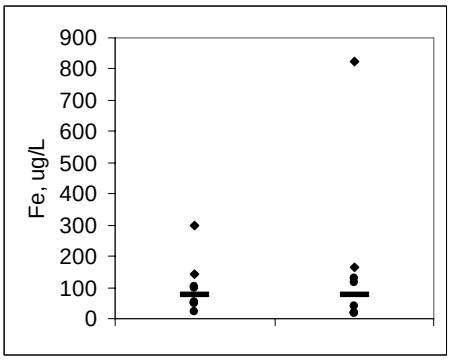


Concentration of Aluminum

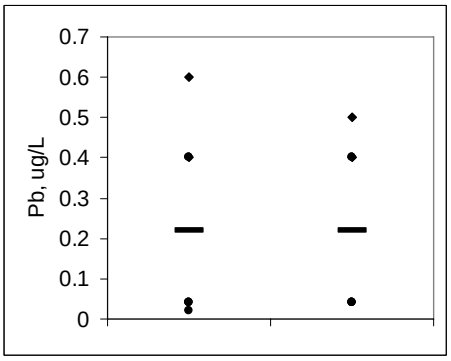
Figure 156. Concentrations of select metals and pH at Station 215: Sunday Creek, 2001 - 2002. Graph shows median as bar and all data values as points, for most metals, n=8 and 8 in 2001 and 2002, respectively. For pH, n= 9 and 11 in 2001 and 2002, respectively.



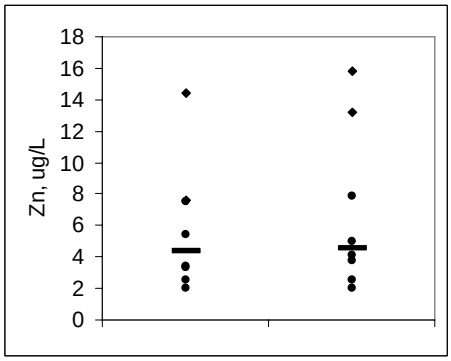
Concentration of Cadmium



Concentration of Iron



Concentration of Lead



Concentration of Zinc

Figure 156, continued.

Table 22. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 215. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample Size	% >WQC Acute	% >WQC Chronic
Al, µg/L	20	173	10	16	0%	6%
Cd, µg/L	0.1	0.2	0.05	16	0%	0%
Cu, µg/L	1	3.4	0.8	16	0%	0%
Fe, µg/L	75.4	824	20	16		0%
Ni, µg/L	5.05	9.5	1.9	16	0%	0%
Pb, µg/L	0.22	0.6	0.02	16	0%	0%
pH	7.9	8.2	6.4	20	5%	
Se, µg/L	1	1	1	17	0%	0%
Zn, µg/L	4.55	15.8	2	16	0%	0%

Periphyton

Chlorophyll-a concentrations at Sunday Creek were low (Fig. 157) and among the lowest measured in the Wulik River sites. (Only Station 203 had lower chlorophyll-a concentrations). Concentrations of chlor-b and chlor-c were both low in Sunday Creek, (Fig. 158): concentrations of chlor-b were near the limit of detection and concentrations of chlor-c were slightly higher.

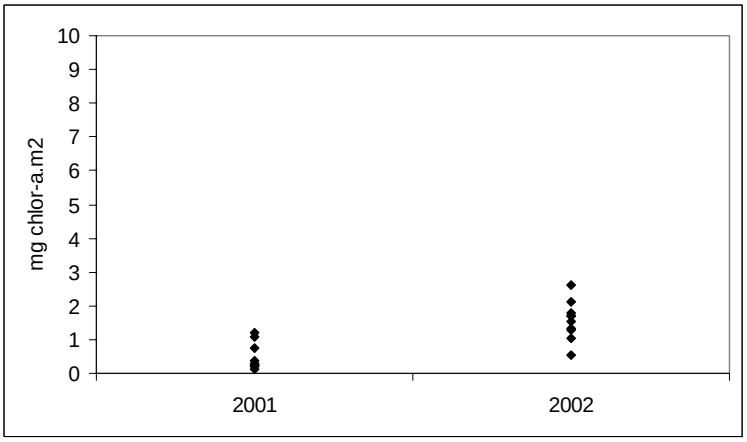


Figure 157. Concentration of chlorophyll *a* in Sunday Creek, Station 215.

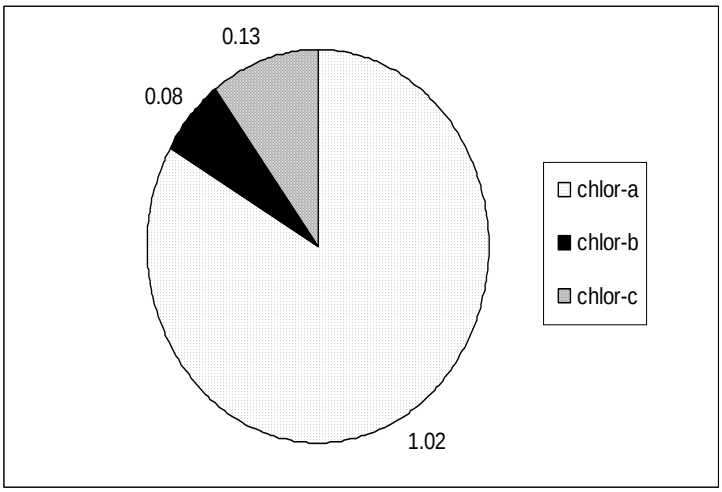


Figure 158. Proportions of chlorophyll *a*, *b*, and *c* in Sunday Creek, Station 215.

Invertebrate Communities

Both abundance and density of aquatic invertebrate communities were low in Sunday Creek (Figs. 159 and 160), especially when compared to the other Wulik River sites. We identified 23 distinct aquatic taxa groups in 2001 and 22 in 2002 (Fig. 161). The majority of the total invertebrates were aquatic (Fig. 162), although the proportion of aquatic to terrestrial was not as high as other sites in the Wulik River drainage. In 2001 and 2002, most of the aquatic invertebrates were Diptera species (Fig. 163). The second most common order in 2001 was Plecoptera; most of the stoneflies were *Capnia*. Mayflies also were common, especially *Baetis*, *Cinygmula*, and *Epeorus*. The proportion of EPT taxa was higher than the proportion of Chironomidae (Fig. 164), unlike any of the other sites in the Wulik River drainage. No Trichoptera were found.

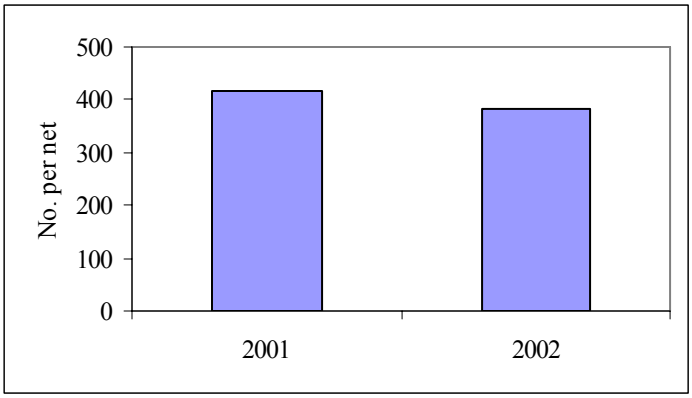


Figure 159. Abundance of aquatic invertebrates in Sunday Creek, Station 215.

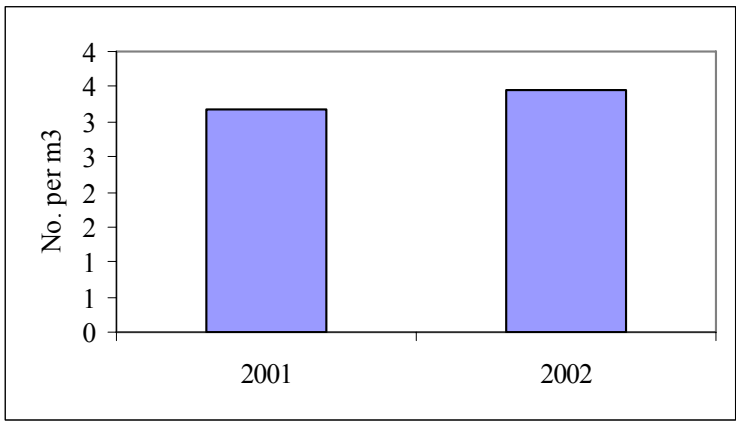


Figure 160. Density of aquatic invertebrates in Sunday Creek, Station 215.

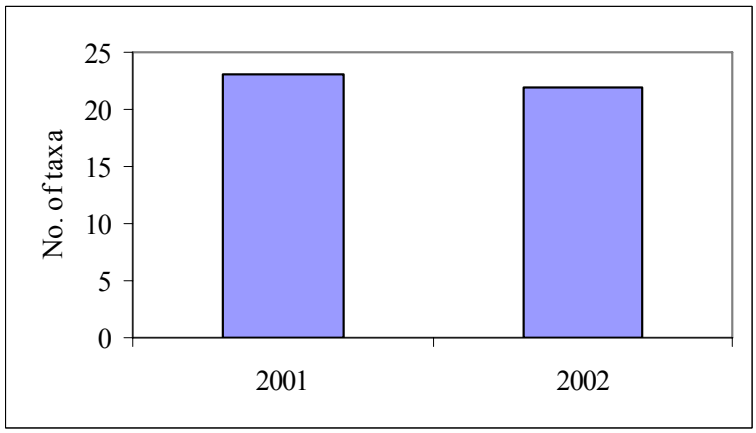


Figure 161. Total aquatic taxa in Sunday Creek, Station 215.

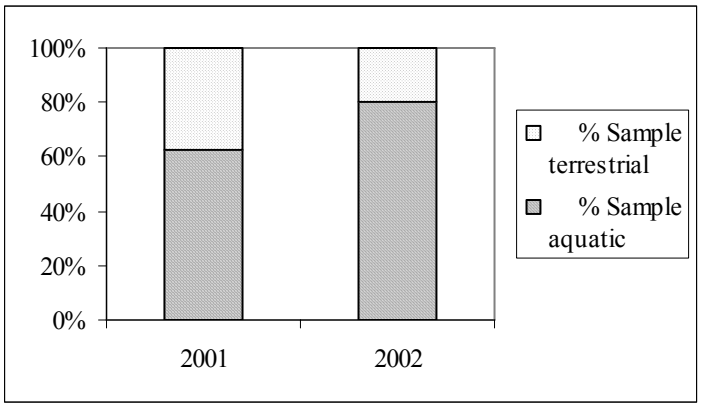


Figure 162. Proportion of terrestrial and aquatic invertebrates in Sunday Creek, Station 215.

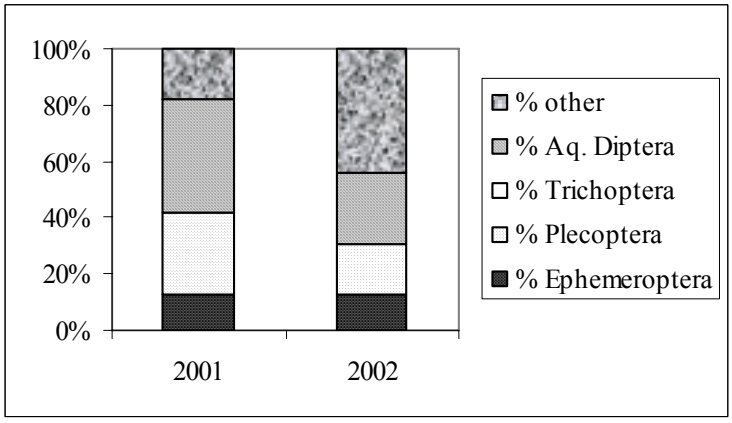


Figure 163. Proportion of aquatic insect orders in Sunday Creek, Station 215.

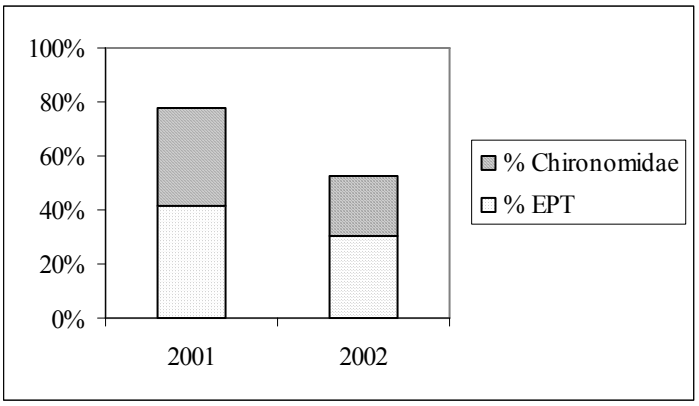


Figure 164. Proportion of Chironomidae and EPT taxa in Sunday Creek, Station 215.

Fish Communities

More Dolly Varden juvenile fish were collected in Sunday Creek than any other site in the Wulik River drainage, except Sourdock Creek. We collected an average of 2.6 fish per trap and fish ranged in fork length from 50 to 162 mm (Fig. --), or approximately age 0+ to age 4.

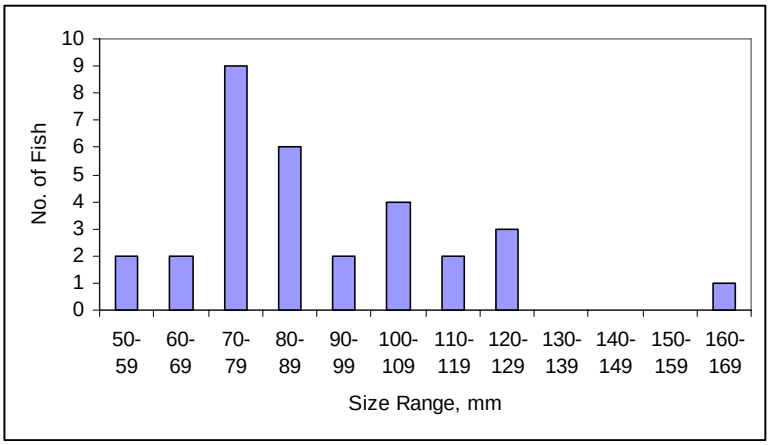


Figure 165. Size range of Dolly Varden juveniles collected in Sunday Creek, Station 215.

Age 0+ Dolly Varden were found in Sunday Creek; the presence of these small fish is evidence of spawning in the site.

Fish Tissues

Fish were not collected for tissue analysis from Sunday Creek.

Appendix 17 contains the water quality and biological data for Sunday Creek, Station 215.

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Oak Creek, Station 216

PHYSICAL FEATURES

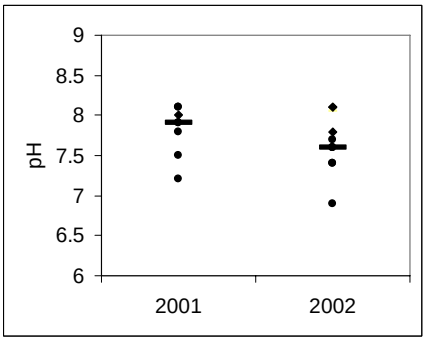
- Drainage size: 4.39 square miles
- Average July water temperature: 10.5°C
- Oak Creek drainage flows over mineralized formations
- Stream bed contains aufeis that persists into mid-summer
- Stream water is high in Fe, 67% of samples exceeded chronic aquatic life criterion for Fe.

SUMMARY OF BIOLOGICAL PRODUCTIVITY

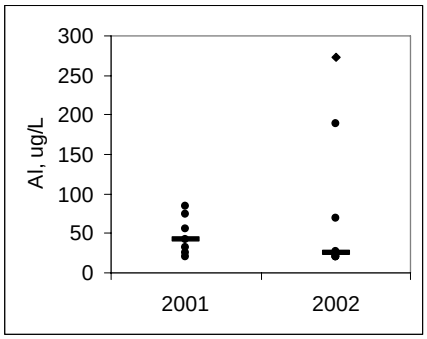
- Periphyton standing crop was at moderate levels and higher than at Stations 203, 215, or 214.
- Aquatic invertebrate abundance and density were lower than any other site, except Sunday Creek.
- Proportions of aquatic and terrestrial inputs were nearly equal
- Proportion of EPT taxa was fairly low: 25% of aquatic invertebrates in 2001 and 10% in 2002.
- Catch of juvenile Dolly Varden lower than all other sites, except Station 203.
- No age 0+ fish were found, no evidence of spawning.

Water Quality

Water in Oak Creek had median alkalinity of 106 mg/L as CaCO3, median concentrations of sulfate of 107 mg/L and median hardness of 231.6 mg/L as CaCO3. Conductivity ranged from 108 to 420 µSi/cm (median for 2000-2002 was 279.5 µSi/cm). Station 216 had neutral to basic pH (median = 7.8). Except for Fe, concentrations of metals were low (Figure --). Concentrations of Al exceeded the US EPA chronic criterion for aquatic life (US EPA 2004) in 13% of the samples, Cd in 7% of the samples, Fe in 67%, and Zn in 7% of the samples (Table --). Concentrations of Cu, Ni, Pb, and Se were below the chronic criteria in all samples.

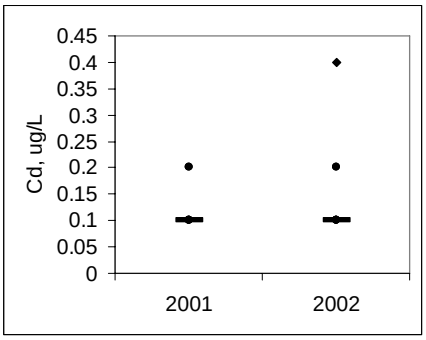


pH, standard units

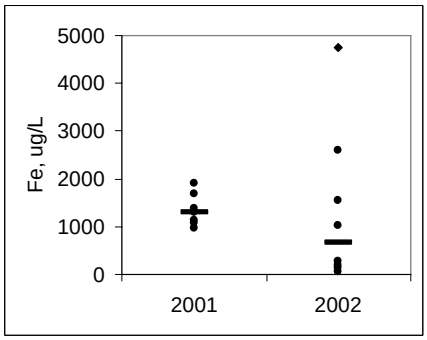


Concentration of Aluminum

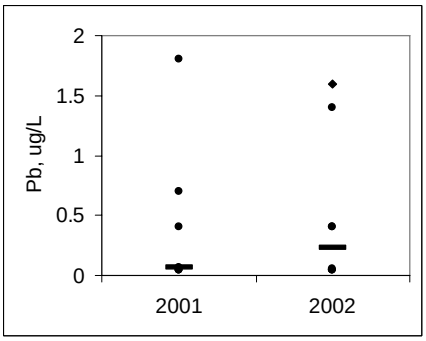
Figure 166. Concentrations of select metals and pH at Station 216: Oak Creek, 2001 - 2002. Graph shows median as bar and all data values as points, for most metals, n= 7 and 8 in 2001 and 2002, respectively. For pH, n= 8 and 11 in 2001 and 2002, respectively.



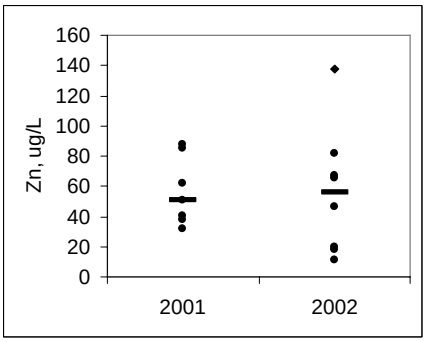
Concentration of Cadmium



Concentration of Iron



Concentration of Lead



Concentration of Zinc

Figure 166, continued.

Table 23. Summary of water quality characteristics and percent of samples exceeding aquatic life criteria at Station 216. Samples were compared to values presented by US EPA (2004).

Analyte	Median	Maximum	Minimum	Sample	% >WQC Acute	% >WQC Chronic
Al, µg/L	31.6	273	20	15	0%	13%
Cd, µg/L	0.1	0.4	0.1	15	0%	7%
Cu, µg/L	1.6	4.9	1	15	0%	0%
Fe, µg/L	1130	4750	68.6	15		67%
Ni, µg/L	29.8	45.7	7.8	15	0%	0%
Pb, µg/L	0.07	1.8	0.04	15	0%	0%
pH	7.8	8.1	6.9	19	0%	
Se, µg/L	1.2	2.6	1	16	0%	0%
Zn, µg/L	50.9	138	10.9	15	7%	7%

Periphyton

Chlorophyll-a concentrations at Station 216 were at detection in 2001 and fairly low in 2002 (Figure 167). In 2002, we estimated an average of 3.9 mg chlorophyll-a /m^2. Although chlorophyll-a concentrations were somewhat higher in 2002, concentrations were lower than all sites except Competition Creek upstream of Sourdock Creek (Station 203). Periphyton communities in Sunday Creek, Station 215 have higher proportions of chlorophyll-c than –b, which indicates that Chromista, or diatoms, are more prevalent than dinoflagellates and green algae (Figure 168).

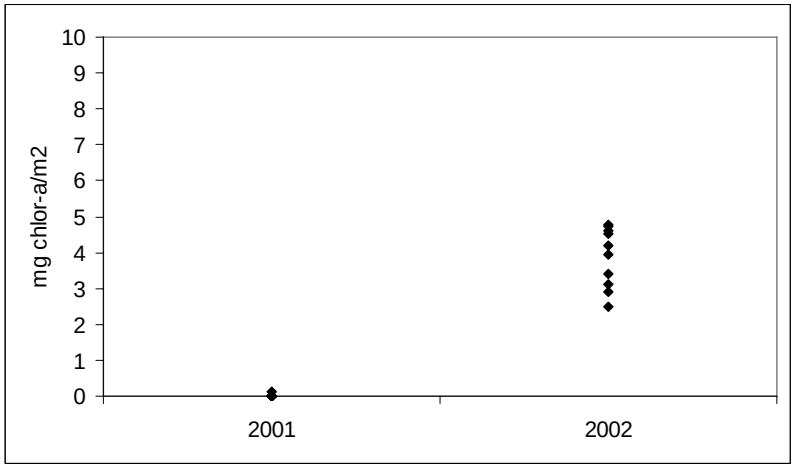


Figure 167. Concentration of chlorophyll *a* in Oak Creek, Station 216.

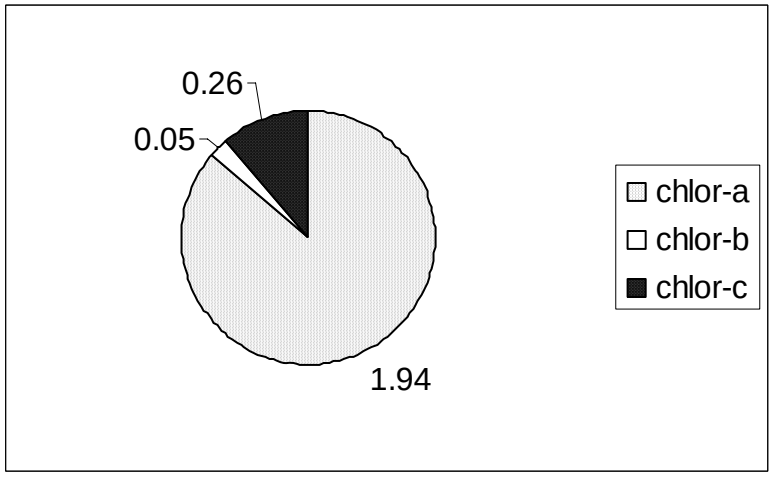


Figure 168. Proportions of chlorophyll *a*, *b*, and *c* in Oak Creek, Station 216.

Invertebrate Communities

Both abundance and density of aquatic invertebrate communities were higher in 2001 than 2002 in Oak Creek (Figures 169 and 170). Abundance was the lowest at any of the sites and density was lower than all sites except Sunday Creek.

We collected 22 distinct aquatic taxa in 2001 and 18 in 2002 (Figure 171). From 45% to 55% of the total samples were aquatic species; instream productivity and terrestrial inputs were of nearly equal importance (Figure 172). Aquatic Diptera dominate invertebrate communities in Oak Creek, although Plecoptera and Ephemeroptera are represented (Figure 173). Nearly 30% of the aquatic invertebrates were EPT taxa (Figure 174) in 2001, and only about 10% in 2002. As with most of the Wulik River sites, Chironomidae were overwhelmingly predominant. No Trichoptera were found.

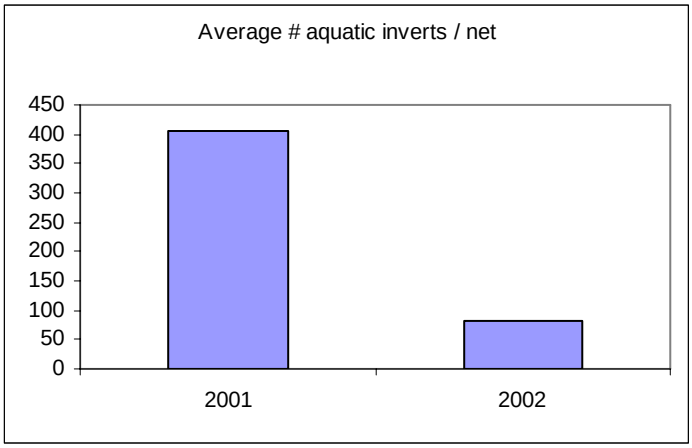


Figure 169. Abundance of aquatic invertebrates in Oak Creek, Station 216.

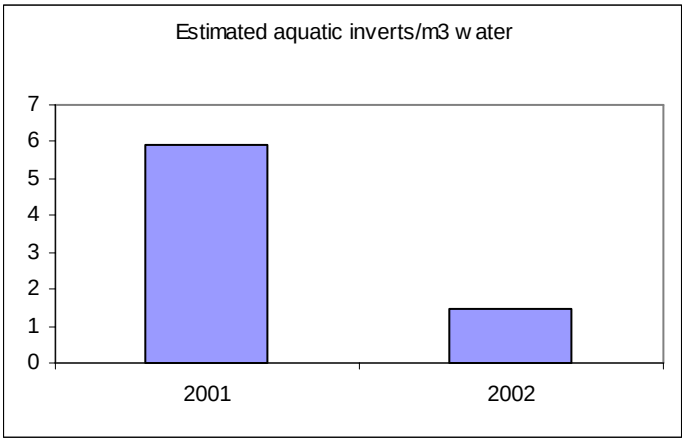


Figure 170. Density of aquatic invertebrates in Oak Creek, Station 216.

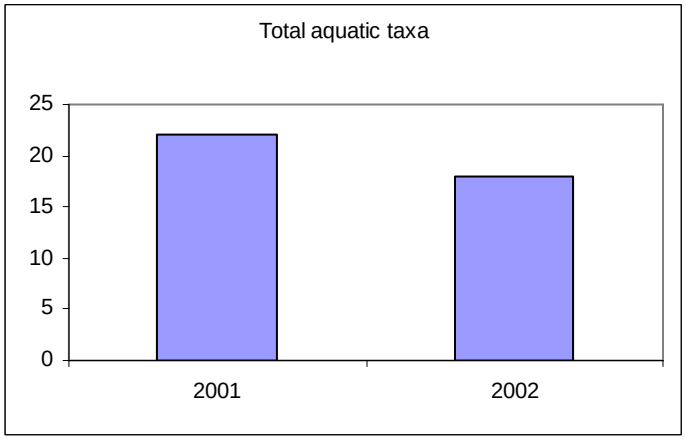


Figure 171. Total aquatic taxa at in Oak Creek, Station 216.

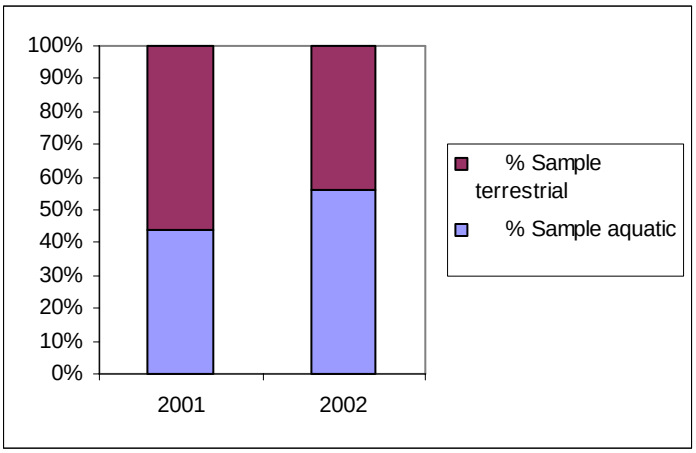


Figure 172. Proportion of terrestrial and aquatic invertebrates in Oak Creek, Station 216.

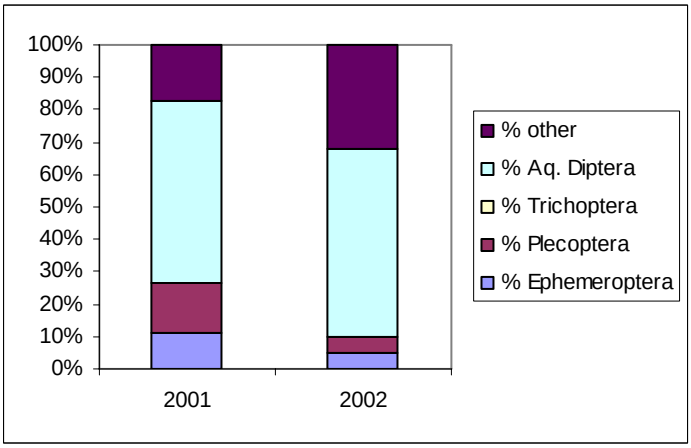


Figure 173. Proportion of aquatic insect orders in Oak Creek, Station 216.

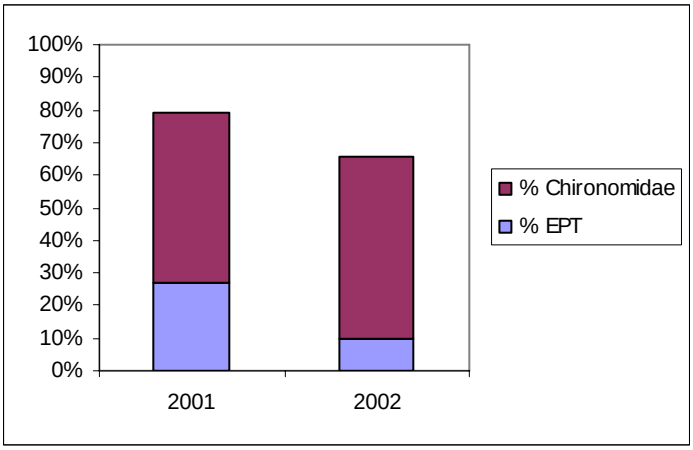


Figure 174. Proportion of Chironomidae and EPT taxa in Oak Creek, Station 216.

Fish Communities

Fewer juvenile Dolly Varden were collected in Oak Creek than in any of the other Wulik River drainage sites, except Competition Creek upstream of Sourdock Creek. We collected only 0.4 fish per minnow trap and the fish ranged from 90 to 130 mm fork length (Figure 175). No larval fish were found in fish traps or in the invertebrate drift nets; therefore, there is no indication that Dolly Varden spawning occurs in this creek. We found no other fish species.

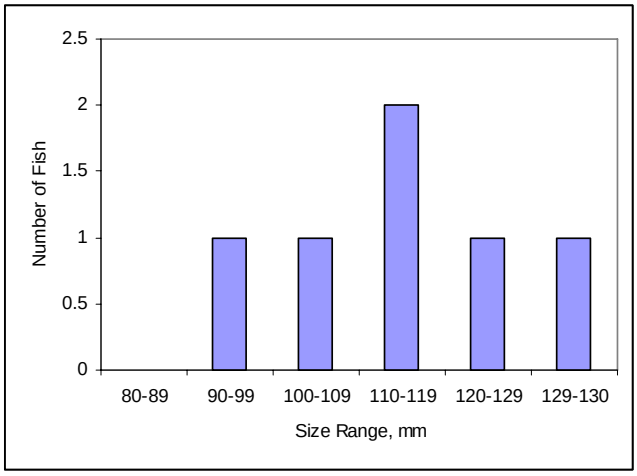


Figure 175. Size distribution of juvenile Dolly Varden collected in Oak Creek, Station 216.

FISH TISSUES

No fish were collected for tissue analysis from Oak Creek.

Appendix 18 contains the water quality and biological data for Oak Creek, Station 216.

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