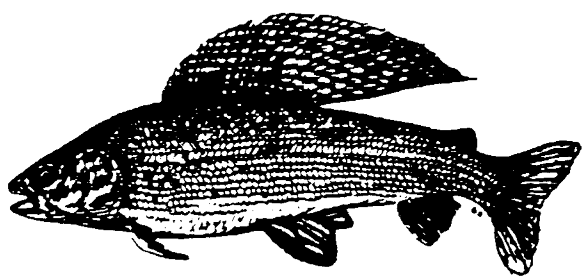
Aquatic Habitat Study, upper Fish Creek drainage, with an emphasis on Arctic grayling (*Thymallus arcticus*): Baseline Studies 1992

by:
Phyllis Weber Scannell and Alvin G. Ott

Technical Report No. 93-4



Alaska Department Of Fish And Game
Habitat and Restoration Division

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ACKNOWLEDGEMENTS

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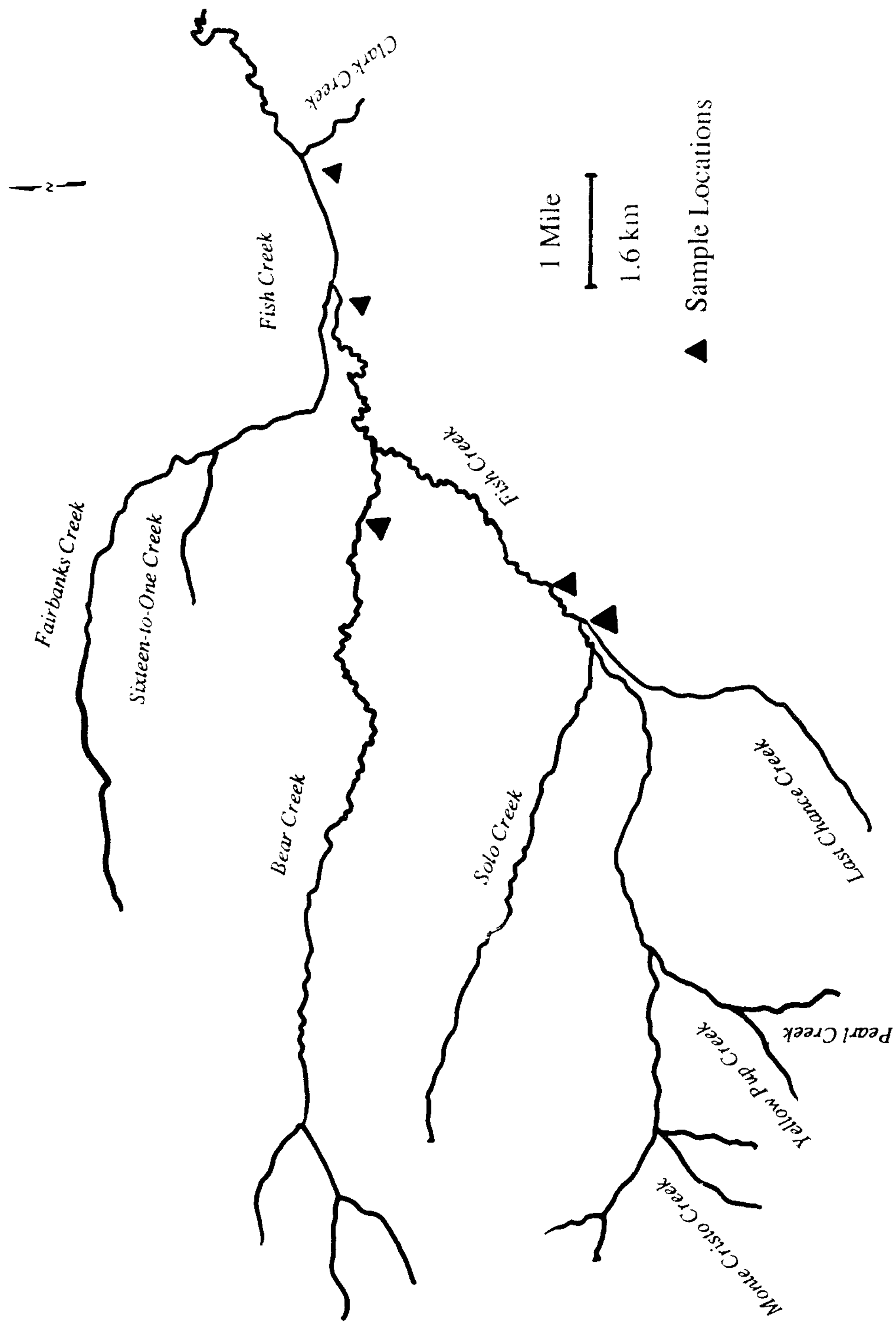
INTRODUCTION

The headwaters of the Fish Creek drainage, located about 25 km northeast of Fairbanks, Alaska, is the site of the proposed Fort Knox open pit gold mine (Figure 1). This drainage supports Arctic grayling, longnose sucker, round whitefish, burbot, and slimy sculpin. Downstream in the Chena River are chum and chinook salmon. Aquatic habitat in the Fish Creek and Fairbanks Creek drainages has been altered extensively by gold mining since the early 1900s.

As proposed, development of the Fort Knox gold mine would create a freshwater impoundment dam in Fish Creek below Solo and Last Chance creeks, a tailings impoundment in the upper portion of the Fish Creek drainage, and controlled stream flows below the freshwater dam. Fish access to Solo Creek, Last Chance Creek, and Fish Creek upstream of Bear Creek from areas downstream of the freshwater impoundment dam will be eliminated. Development of the Fort Knox gold deposit probably will produce considerable changes in flow conditions and water quality in Fish Creek, in flow conditions in Fish Creek from the freshwater dam to Bear Creek, and in the water quality of Fish Creek. These changes probably will alter the temporal and spatial use of Fish Creek by fish.

In 1992, Fairbanks Gold Mining, Inc. contracted with Alaska Department of Fish and Game (ADF&G) to conduct a 2-year fisheries habitat assessment of the Fish Creek drainage, including tributary streams that may be affected by development of the Fort Knox gold mine. The goal of this habitat assessment was to establish baseline data for fish and aquatic invertebrates in the Fish Creek drainage before development of a hard rock mine and associated facilities. These fish and aquatic invertebrate data can be used in the development of an Environmental Assessment (or other appropriate document) and to provide a data base for comparing changes, if any, that might occur from development of a hard rock mine and associated facilities.

Figure 1. Fish Creek drainage, showing locations of ADF&G sampling sites, 1992.



The objectives of the study were to:

(1) determine the temporal and spatial use of Fish Creek by fish;

(2) estimate the number of fish in discrete sample areas in the Fish Creek drainage;

(3) determine aquatic invertebrates present in the Fish Creek drainage;

(4) identify potential mitigation options in the Fish Creek drainage; and

(5) determine concentrations of select metals in Arctic grayling tissues (muscle, liver, kidney, gill) collected in Fish Creek in 1992 and 1993.

This report presents findings of the first year of the fisheries habitat assessment.

HISTORICAL FISHERIES INFORMATION

Arctic grayling juveniles were reported previously from Fish Creek in the vicinity of Last Chance Creek. Preliminary studies on fish distribution made during the summer of 1991 by Dames and Moore documented the presence of adult and young-of-the-year Arctic grayling in Last Chance and Solo creeks.

Surveys of the Little Chena River between Sorrels Creek and the Chena Hot Springs Road crossing were conducted by ADF&G from August 13 to 15, 1971. Upstream of the mouth of Fish Creek, Arctic grayling and round whitefish were present and young-of-the-year Arctic grayling were observed in pools (Tack 1972). Between the mouth of Fish Creek and the Chena Hot Springs Road crossing, angling produced no fish, but Arctic grayling and round whitefish were captured with gill nets and young-of-the-year Arctic grayling fry were observed in backwater areas (Tack 1972). The character of the Little Chena River above the mouth of Fish Creek was described as swift, with large cobbles and few pools. Below the mouth of Fish Creek, the Little Chena River channel meanders extensively with silt covering the gravel substrate in all quiet water (Tack 1972).

Fish surveys of the Little Chena River below the Chena Hot Springs Road crossing were conducted in June 1984 by ADF&G. The lower 10 km of the Little Chena River was highly turbid (with a reported Secchi disk reading of 10 cm) and 40 Arctic grayling were captured in 6 net-nights (Holmes 1985). According to Holmes (1985), none of the fish sampled were of spawning size and length-at-age values for Little Chena River Arctic grayling were consistently smaller than for Chena River fish.

Turbid water conditions attributed to upstream placer-mine operations located on Fairbanks and Fish creeks were reported by Tack (1972) and Holmes (1985). The Alaska Department of Natural Resources (ADNR) has operated an automated water sampler on the Little Chena River from June through September since 1989. The seasonal average turbidity level in the Little Chena River was 8.5 NTU in 1990 and 7.2 NTU in 1989. More complete data from the Little Chena River are available from the ADNR (Public Data File 91-19 by Scott R. Ray).

METHODS

Sampling Sites

Habitat surveys of the Fish Creek drainage, including the lower portion of Bear Creek, were conducted to establish permanent fish and invertebrate sample locations at Fish Creek downstream of Last Chance Creek, Bear Creek, Fish Creek upstream of Fairbanks Creek, and Fish Creek downstream of Fairbanks Creek (Figure 1).

Water Quality

Temperature was measured at each site with a hand-held thermometer or a digital electronic thermometer. Settleable solids were measured with an Imhoff Cone, according to standard methods (American Public Health Association 1985). Water samples were collected in clean 1-liter containers and refrigerated until analyzed for turbidity and total suspended solids. All analyses were done by the Alaska Department of Natural Resources, Division of Water, Water Quality Laboratory. U.S. Environmental Protection Agency (USEPA) method 180.1 was used for turbidity and USEPA method 160.2 for total suspended solids.

Fish Population Sampling

Six reaches, each consisting of one pool-riffle section, were marked and labeled with survey flagging at each stream site. When stream flows permitted, each reach was blocked both upstream and downstream with seines, and four passes with an electrofisher were made to collect fish. Water levels were too high to allow use of block nets at any sample sites in June and in Fish Creek above and below Fairbanks Creek at any of the times sampled. In July and August, Bear Creek, Fish Creek below Last Chance Creek, and Last Chance Creek were sampled by blocking pool-riffle sequences with blocknets and electrofishing. Only three pool-riffle sections remained in Last Chance Creek following failure of upstream settling ponds.

All fish collected were identified, measured (fork length), and released. Arctic grayling greater than 150 mm were tagged before release.

Aquatic Invertebrate Communities

We collected benthic invertebrates three times in 1992 (June, July, and August) at four sample sites: Fish Creek immediately downstream of recent mining disturbance below the confluence of Fish and Last Chance creeks; Bear Creek approximately 1 km upstream of the confluence with Fish Creek; Fish Creek upstream of the confluence of Fairbanks and Fish creeks, and Last Chance Creek immediately upstream of the confluence with Fish Creek. Ten benthic samples were collected with a Hess sampler from riffle sections of each stream. Pools were not sampled. Invertebrates were preserved with ethanol, sorted from organic and inorganic debris, counted, and identified to family. Too few invertebrates were found in any of the sample sites to analyze these samples for metals.

Metals Concentrations in Fish

Three Arctic grayling (236 to 245 mm) were collected in late June to analyze their tissues for metals. All three fish were collected in Fish Creek near Fairbanks Creek. The fish were packed in clean plastic bags, transported to Fairbanks, and frozen. Dissection of fish tissues was done in the ADF&G laboratory in Fairbanks, using standard procedures to minimize contamination. All dissection instruments were cleaned with concentrated ultra-pure nitric acid (Ultrex®) and rinsed with double distilled, deionized water before dissecting any of the tissues. Samples of liver, muscle, gill, and kidney were removed from each fish, packed in pre-cleaned jars (EPA protocol C, Series 300), and frozen. Tissue samples were submitted to a private analytical laboratory where they were digested and analyzed for Al, Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Ti, V, and Zn using inductively coupled plasma emission spectroscopy (ICP-MS), flame atomic absorption spectrophotometry (Zn), and cold vapor atomic absorption spectrophotometry (Hg). Because of the small amounts of tissue, only muscle tissue could be analyzed for Hg.

Twelve Arctic grayling and twelve round whitefish were collected from Fish Creek upstream of Fairbanks Creek in October to analyze for whole body content of Al, As, Cd, Pb, and Hg. Three Arctic grayling were collected on October 5, placed in a clean plastic bucket with clear water and held for approximately 3 hrs before sacrificing. The remainder of the fish were collected on October 28, placed in clear water in a clean, plastic bucket, and held for about 1 hr.

RESULTS

WATER QUALITY OF FISH CREEK DRAINAGE

Fish Creek had elevated turbidity and total suspended solids during most of the sample times (Table 1, Figures 2 and 3). Settleable solids were especially high during break-up flows; the settleable solids level in Fish Creek below Last Chance Creek was 5 ml/L, 25 times higher than the Alaska water quality criterion for aquatic life. Water temperatures increased throughout June and July, then cooled in August.

Table 1. Water quality and temperature measured in the Fish Creek drainage, 1992.

	Date Sampled	Temperature °C	Settleable Solids ml/L	Turbidity NTU	TSS mg/L
Fish Creek below Last Chance Creek	6/16/92	8	5	600	3330
	6/25/92	11	0.9	--	--
	7/20/92	10	0.4	65	119
	8/24/92	--	<0.1	180	120
Fish Creek u/s Fairbanks Creek	5/28/92	--	--	360	--
	6/17/92	5	4.5	500	3680
	6/25/92	8	0.5	--	--
	7/22/92	11	trace	13	20.6
	8/26/92	6.2	trace	130	52.2
Fish Creek d/s Fairbanks Creek	5/28/92	--	--	360	--
	6/17/92	6	3	370	2340
	7/22/92	--	trace	--	--
	8/25/92	8.5	trace	100	29.0
Last Chance Creek	6/16/92	6	trace	5.9	11.9
	6/25/92	10	trace	--	--
	7/20/92	11	ND	3.7	19.6
	8/24/92	--	ND	130	53.4
Bear Creek	6/18/92	3	0.1	--	--
	7/21/92	7	<0.1	14	--
	8/25/92	4.7	trace	2.0	5.05

ND = not detected

Bear Creek had the lowest water temperatures of any of the streams sampled (Table 1). Water temperatures in July, the highest measured during the season, were equivalent to June temperatures in Fish Creek. Bear Creek has high water quality with low turbidity and low concentrations of total suspended solids. The stream is downcut about 3 to 4 meters with eroding banks. The ice-rich banks contribute small amounts of organic and inorganic sediments while melting.

Last Chance Creek is a clearwater tributary to Fish Creek. In June and July, turbidity was low (Table 1), but elevated in August. Stream water temperatures are comparable to temperatures in Fish Creek.

Turbidity and total suspended solids in Fish Creek above Fairbanks Creek remained high throughout the period of record, June 4 - August 28, 1992 (Figures 2 and 3). The total sediment load for Fish Creek (measured upstream of Fairbanks Creek) for the period June 4 - August 28, 1992 was 10,200 tons. The peak daily-average turbidity of 2,900 NTU occurred on July 9 when upstream placer-mine settling ponds failed. Only 25% of the composite sample was collected during the resulting flood event: the estimated turbidity of water from the pond failure was 11,300 NTU (Ray pers. comm.).

Figure 2. Daily average turbidity in Fish Creek upstream of Fairbanks Creek. Data from Alaska Department of Natural Resources, Division of Water (Ray and Vohden 1992).

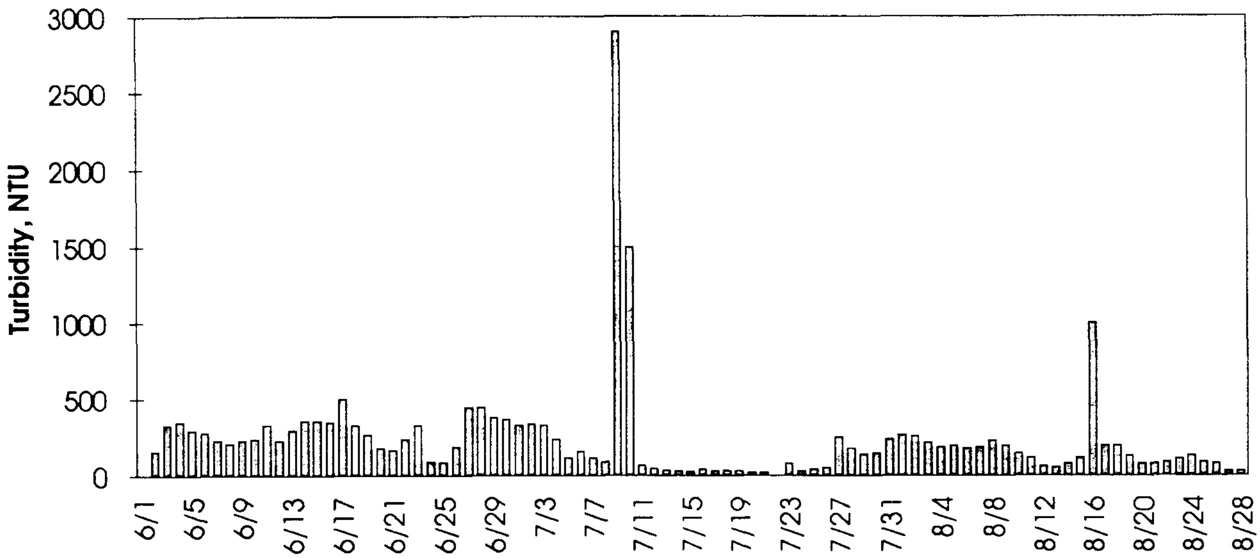
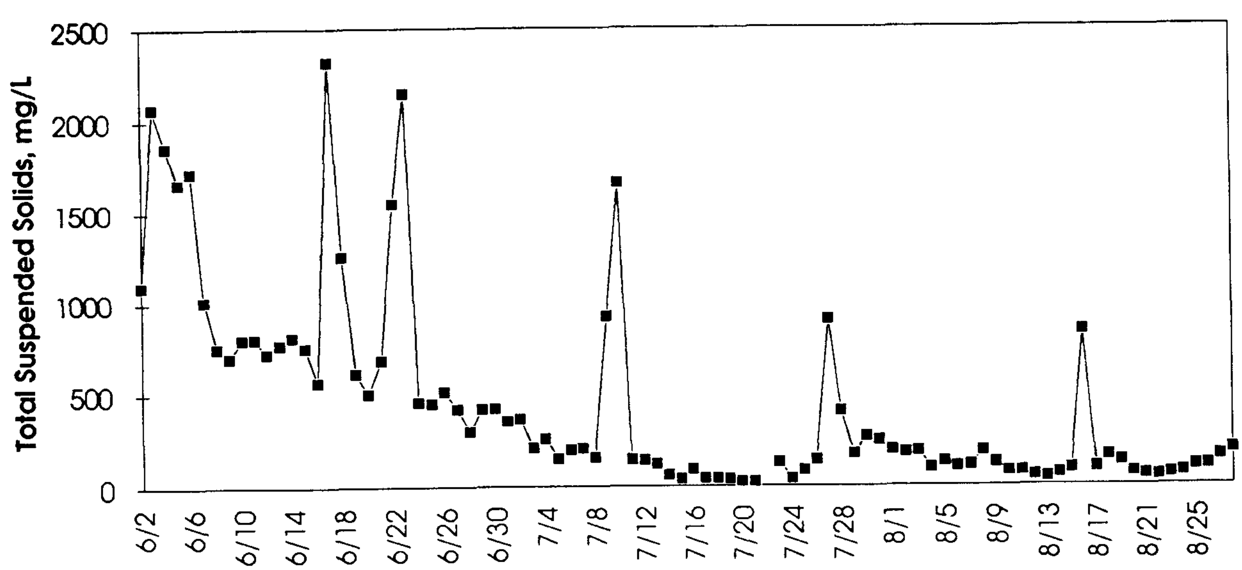


Figure 3. Daily average total suspended solids in Fish Creek upstream of Fairbanks Creek. Data from Alaska Department of Natural Resources, Division of Water (Ray and Vohden 1992).



Fish Populations in Fish Creek Drainage

Fish were sampled in June, July, and August in Bear and Last Chance Creek, Fish Creek below Last Chance Creek, Fish Creek upstream of Fairbanks Creek, and Fish Creek downstream of Fairbanks Creek. In October, fish were sampled in Fish Creek upstream and downstream of Fairbanks Creek. Fish densities in all sites of Fish Creek are underestimated because turbid water conditions prevented biologists from seeing many fish that were stunned by the electrofisher.

Arctic grayling, slimy sculpin, longnose sucker, burbot, and round whitefish are distributed throughout Fish Creek near Fairbanks Creek (Figure 4). Arctic grayling, slimy sculpin, and burbot were found in Last Chance Creek and the upper site of Fish Creek; Arctic grayling, slimy sculpin, and round whitefish were found in Bear Creek. Fork length of each fish, by species, is listed in Appendix I.

Bear Creek: Overall, Bear Creek had the highest density of fish per pool-riffle section (Table 2). Fish migrated into Bear Creek between late June and late July when the water temperature warmed from 3°C to 7°C. Both the number of species and the number of fish increased in Bear Creek between June and July. By August, we collected Arctic grayling, round whitefish, and slimy sculpin, and fish densities were considerably higher than in June.

The size distribution of Arctic grayling caught in Bear Creek remained the same from June to August (Figure 5). Most of the Arctic grayling collected in Bear Creek ranged from 100 mm to 255 mm. Although Arctic grayling of spawning size were collected in Bear Creek, no young-of-the-year fish were collected. Therefore, there is no evidence that Arctic grayling spawned in Bear Creek.

Last Chance Creek: In June Last Chance Creek had the highest density of fish of any of the sites sampled. The numbers of fish caught in Last Chance Creek decreased between June and July when upstream placer mining ponds failed in early July. In June there was an average of 16 fish (all Arctic grayling) per pool-riffle section; in July we caught only 1.3 fish per pool-riffle and in August, the average number of fish was 1.7 (Table 2). Only one slimy sculpin and no burbot, round whitefish, or longnose sucker were found in Last Chance Creek.

Figure 4. Distribution of fish in the Fish Creek drainage, 1992.

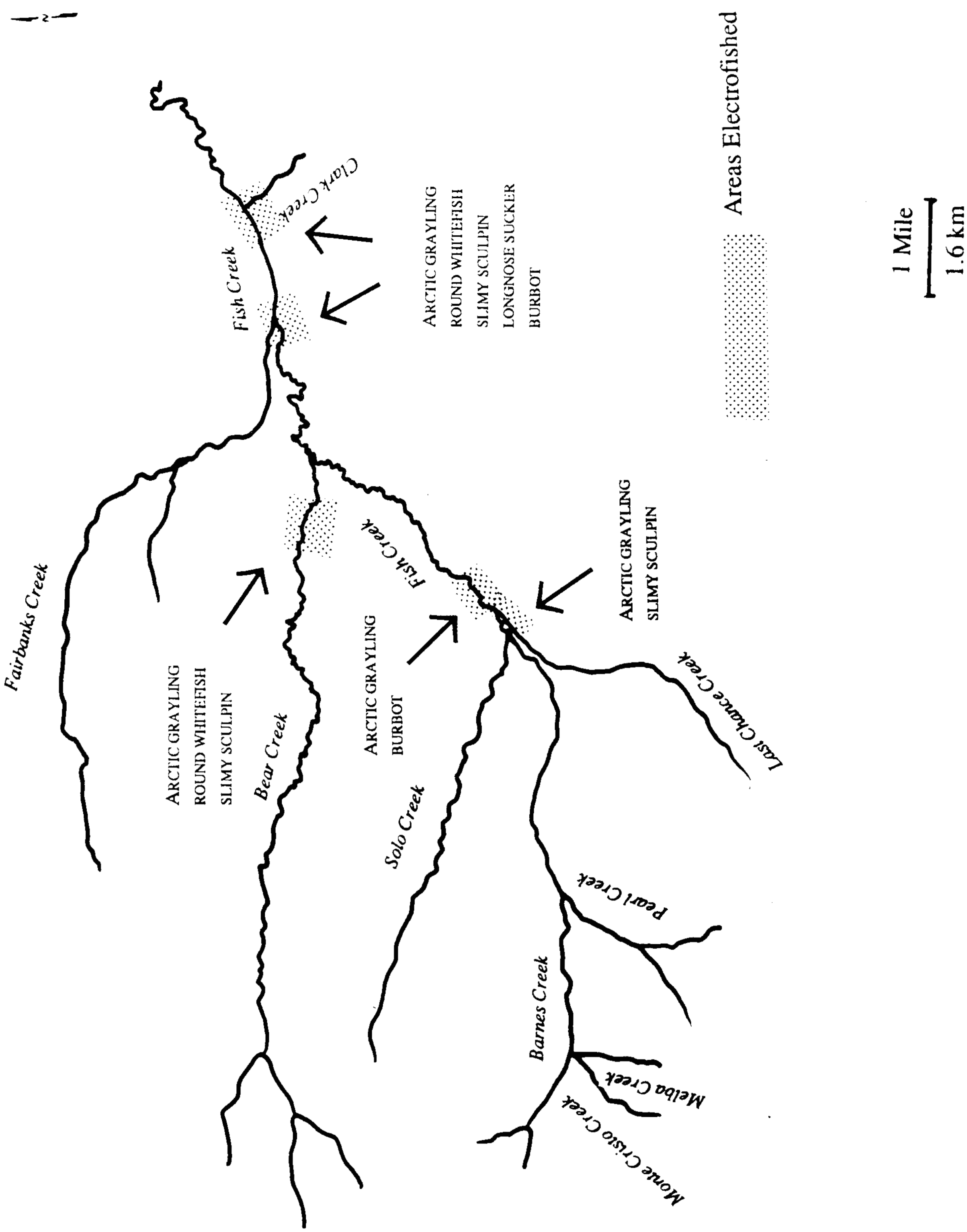
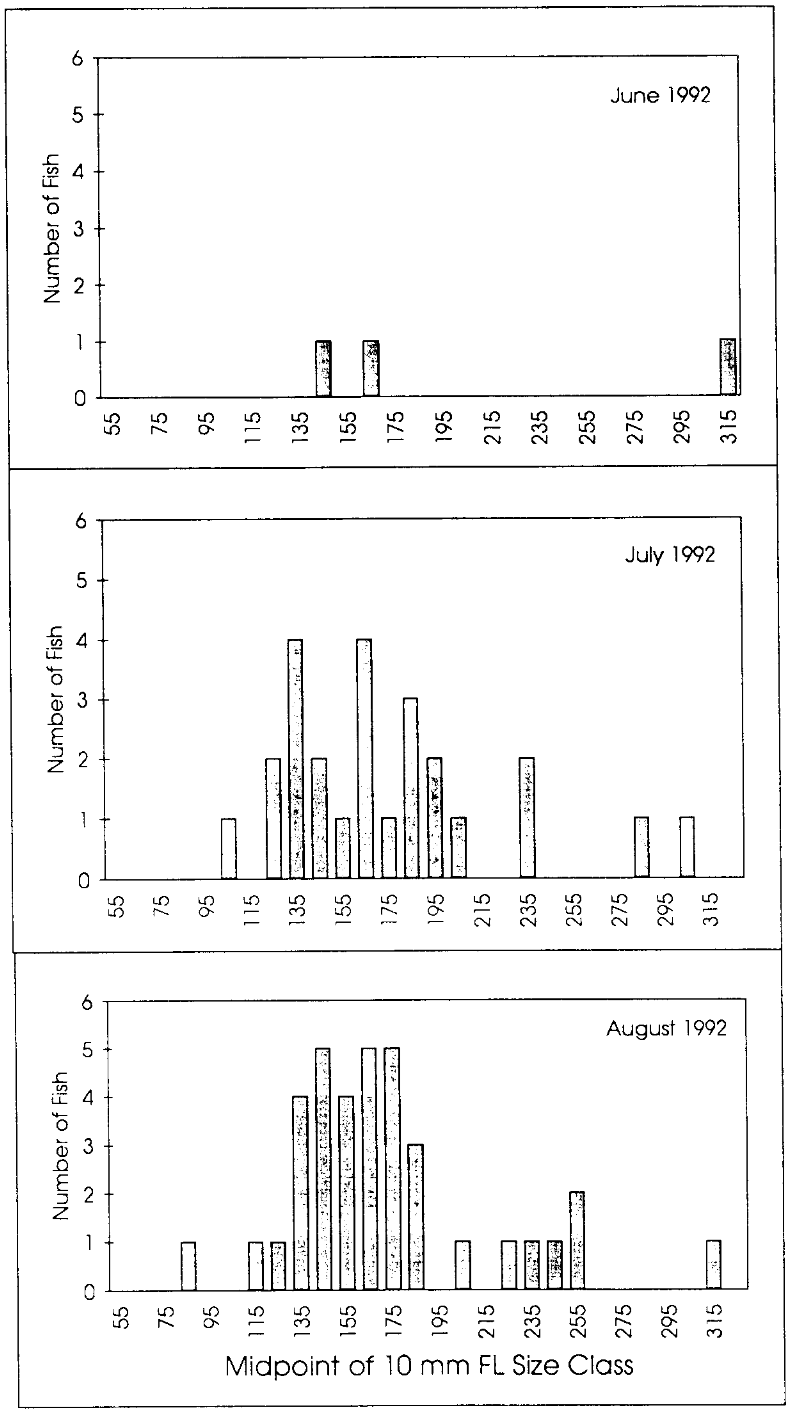


Table 2. Numbers of fish caught, by species, and average number of fish per pool-riffle section from sites in the Fish Creek drainage, 1992.

	Date Sampled	AG	SC	LNS	BB	RWF	Total Fish	Average per pool-riffle
Bear Creek	6/18/92	3	0	0	0	0	3	--*
	7/21/92	26	0	0	0	6	32	5.3
	8/25/92	36	4	0	0	24	64	10.7
Last Chance Creek	6/18/92	48	0	0	0	0	48	16
	6/25/92	13	0	0	0	0	13	4.3
	7/20/92	4	0	0	0	0	4	1.3
	8/24/92	4	1	0	0	0	5	1.7
Fish Creek below Last Chance Cr.	6/16/92	23	0	0	0	0	23	3.8
	6/25/92	9	0	0	0	0	9	1.5
	7/20/92	11	0	0	0	0	11	1.8
	8/24/92	4	0	0	1	0	5	0.8
Fish Creek above Fairbanks Cr.	6/17/92	2	1	0	0	0	3	--*
	6/24/92	3	0	0	1	1	5	--*
	7/22/92	9	1	4	1	7	22	3.7
	8/26/92	14	4	0	2	4	24	4
	10/5/92	7	0	0	0	8	15	--*
	10/28/92	10	2	0	0	12	24	--*
Fish Creek below Fairbanks Cr.	6/17/92	5	1	0	0	1	7	--*
	7/22/92	1	10	2	0	1	14	4.7
	8/25/92	7	19	2	1	9	38	9.5
	10/5/92	4	4	0	1	8	17	--*

AG = Arctic grayling, SC = slimy sculpin, LNS = longnose sucker, BB = burbot, RWF = round whitefish.
*High water in June and ice in October prevented identification and block-netting of discrete pool-riffle sections.

Figure 5. Size distribution of Arctic grayling collected in Bear Creek in 1992.



Failure of upstream placer-mine settling ponds resulted in a considerable decrease in the numbers of fish in Last Chance Creek. Therefore, we were not able to determine if this creek is used by different size classes and species of fish at different times of the year. The size distribution of Arctic grayling (Figure 6) suggests that Last Chance Creek is inhabited by young of the year through juvenile (or sub-spawning size) fish.

Fish Creek: Few Arctic grayling and burbot and no longnose sucker, round whitefish, or slimy sculpin were found in Fish Creek below Last Chance Creek (Table 2). Like Last Chance Creek, this sample site was immediately below the placer mining ponds that failed in early July. The high volume of water and sediments resulted in a severe decline in fish density. In June, we collected an average of 3.8 fish per pool/riffle sequence, but in July, only 1.5 fish per pool-riffle were collected. Densities in August remained low.

In June, Arctic grayling in Fish Creek below Last Chance Creek ranged from 55 mm to 165 mm (Figure 7). In July and August, no Arctic grayling less than 115 mm were found in this site.

Fish Creek below Fairbanks Creek had the highest density of fish per pool-riffle section of any of the sites sampled in Fish Creek (Table 2), followed by Fish Creek above Fairbanks Creek. These two sites contained Arctic grayling, burbot, longnose sucker, round whitefish, and slimy sculpin.

The size distribution of Arctic grayling in Fish Creek above and below Fairbanks Creek did not change greatly throughout the summer (Figures 8 and 9). Most of the Arctic grayling collected at these two sites were immature fish ranging from 115 to 245 mm.

Figure 6. Size distribution of Arctic grayling collected in Last Chance Creek in 1992.

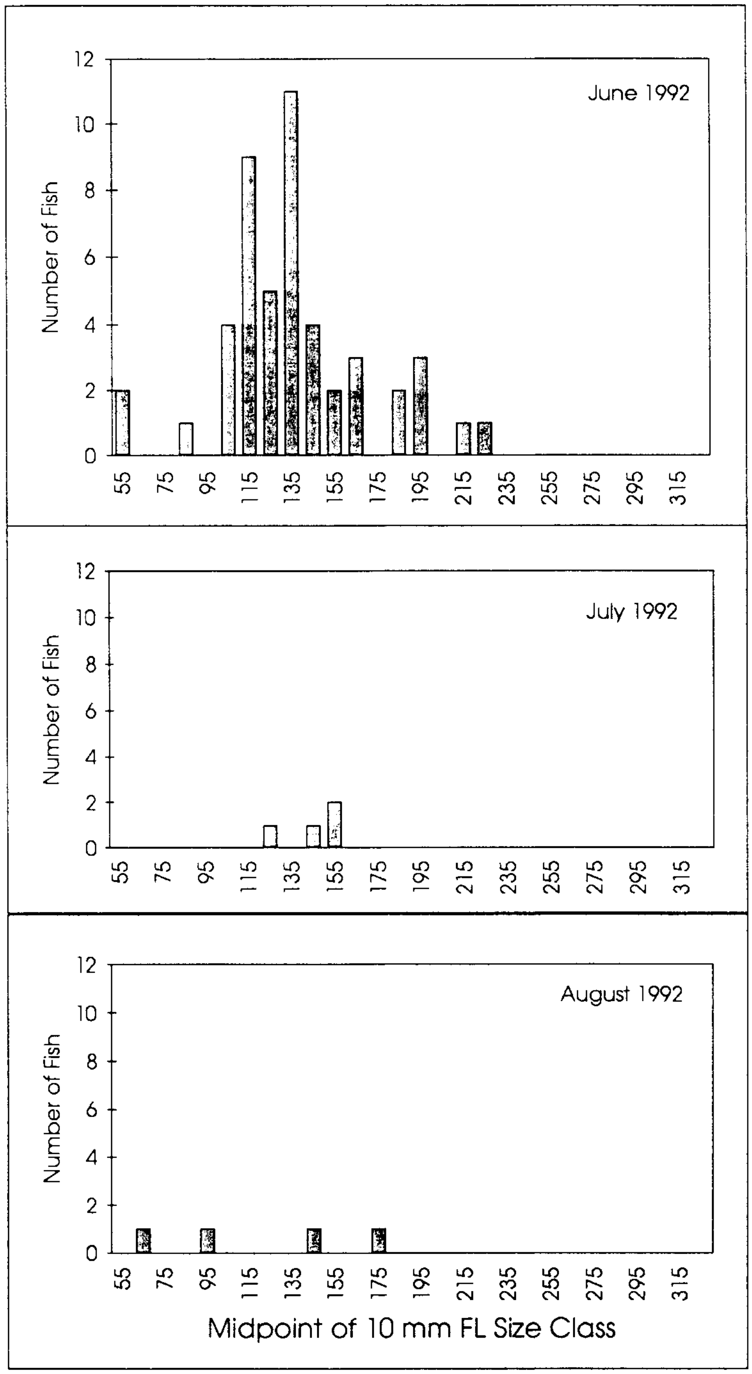


Figure 7. Size distribution of Arctic grayling collected in Fish Creek downstream of Last Chance Creek in 1992.

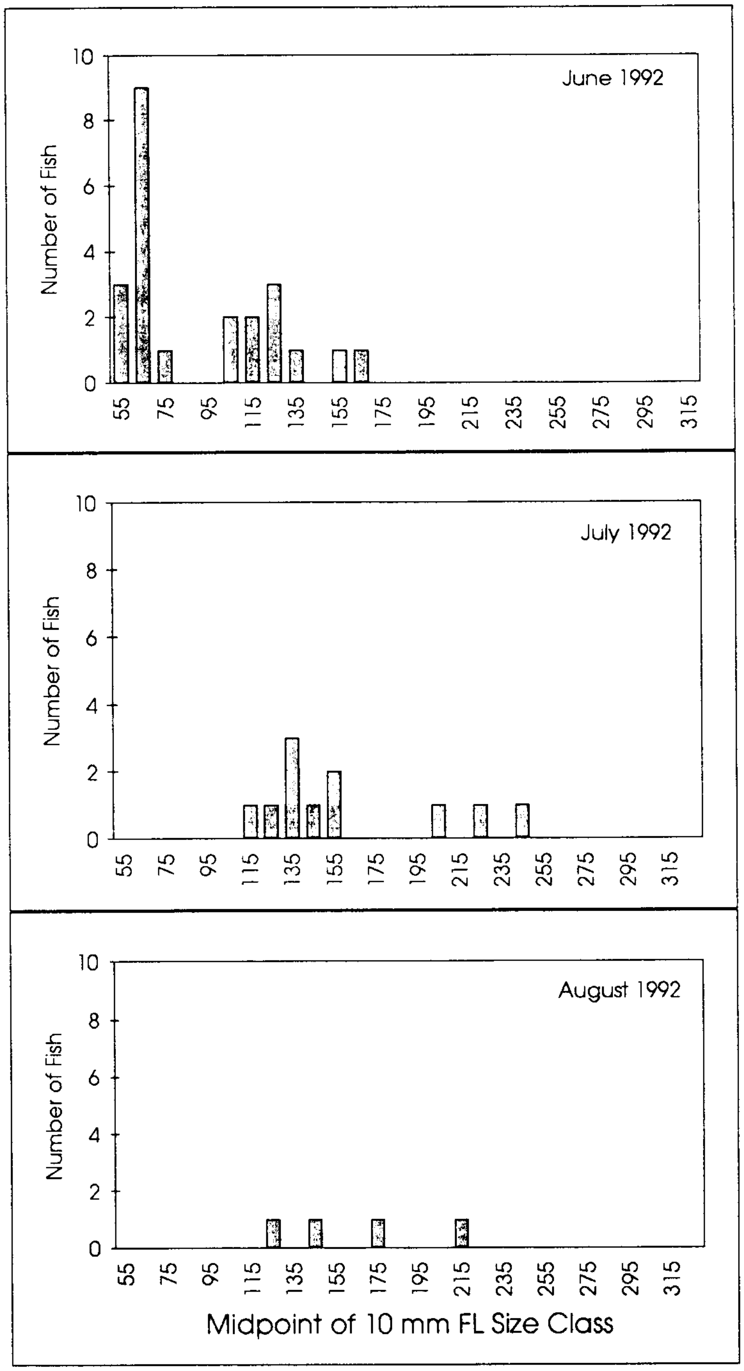


Figure 8. Size distribution of Arctic grayling collected in Fish Creek upstream of Fairbanks Creek in 1992.

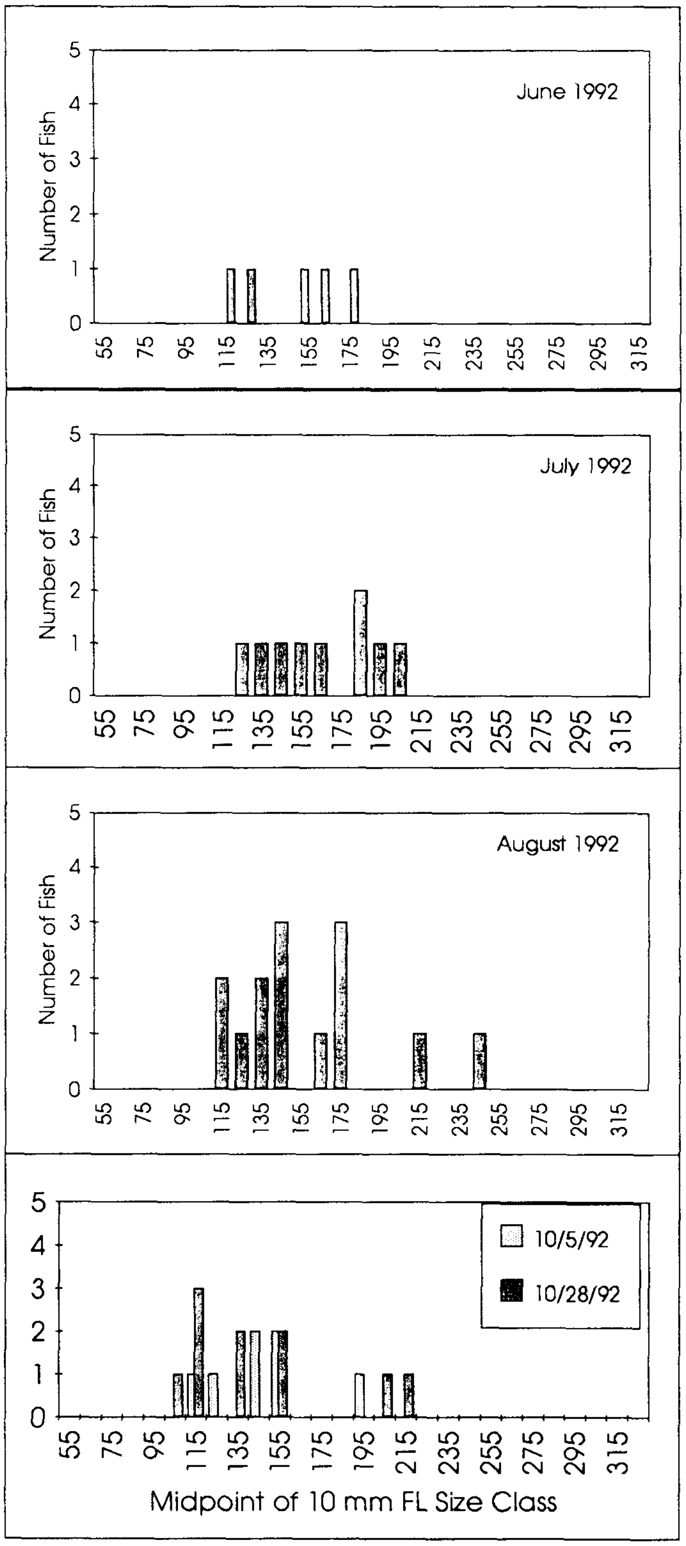
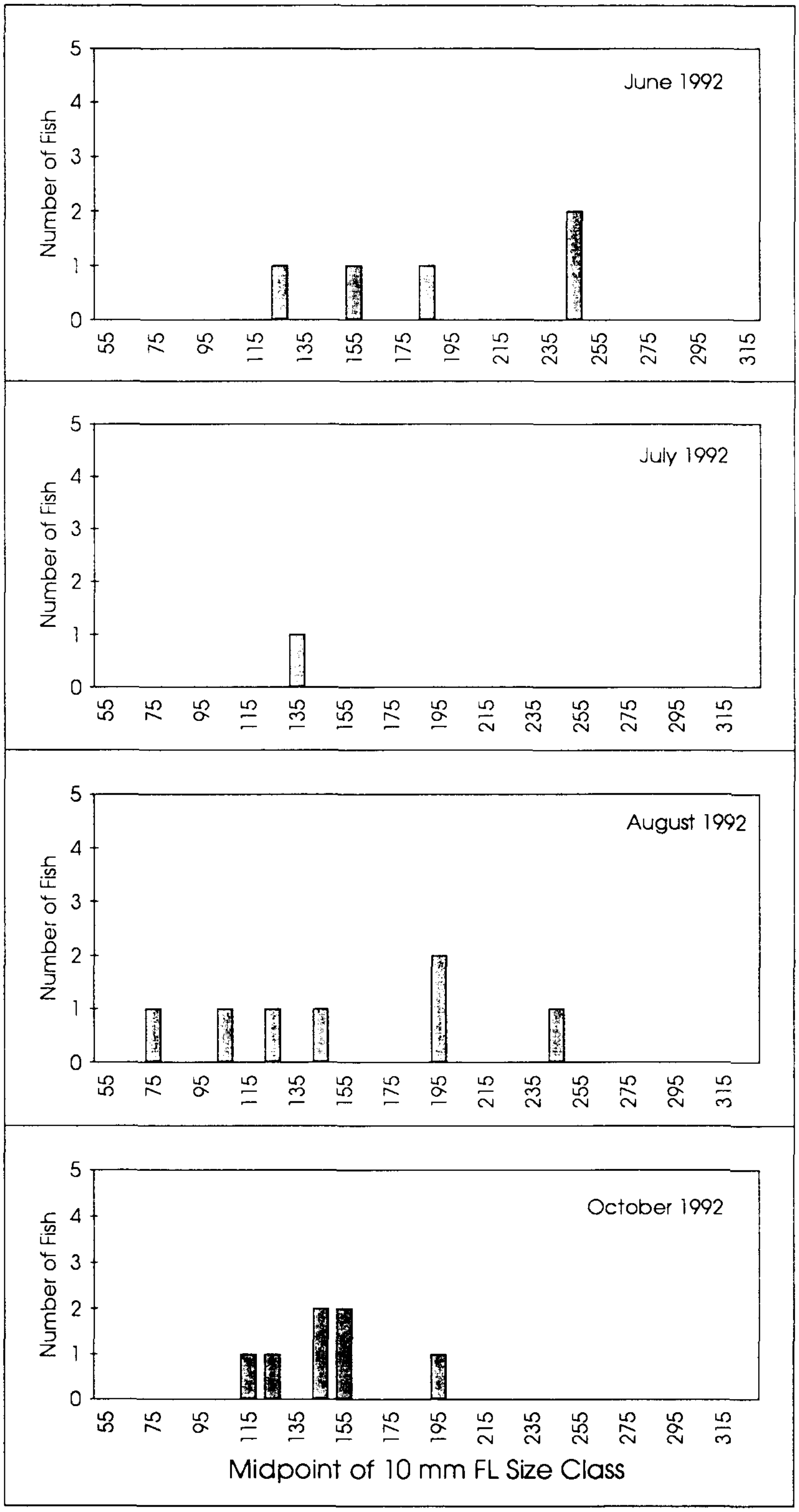


Figure 9. Size distribution of Arctic grayling collected in Fish Creek downstream of Fairbanks Creek in 1992.



Aquatic Invertebrate Communities in Fish Creek Drainage

Ten aquatic invertebrate samples were collected from Last Chance Creek, Bear Creek, Fish Creek below Last Chance Creek, and Fish Creek above Fairbanks Creek in June, July, and August (Appendix II).

Last Chance Creek: The highest density of aquatic invertebrates in June was found in Last Chance Creek (Figure 10). The density of invertebrates declined to about 10% of June levels in July, following failure of the settling ponds at an upstream placer-mine. Invertebrate densities remained low in Last Chance Creek in August. The taxonomic richness (number of taxa per 0.1 m^2 of stream bottom) also was lower in July and August than in June (Figure 11).

Aquatic invertebrate communities in Last Chance Creek shifted from an even distribution of Plecoptera, Chironomidae, Nematoda, and Simulidae, with a few Ephemeroptera (Table 3) to a community dominated by Nematoda (82% of total invertebrates collected in July and 70% in August).

Fish Creek downstream of Last Chance Creek: Although the densities of aquatic invertebrates remained similar, the invertebrate community in Fish Creek downstream of Last Chance Creek changed considerably after failure of the upstream settling ponds (Table 3). In June, the community contained similar proportions of Ephemeroptera, Chironomidae, Simulidae, and Nematoda. In July, 87% of the community was *Daphnia*, a genus that is usually confined to ponds. Few Ephemeroptera, Chironomidae, Simulidae, or Nematoda were found. The community in August was similar to July, with *Daphnia* comprising 65% of the community.

Fish Creek upstream of Fairbanks Creek: Invertebrate densities were lowest in Fish Creek upstream of Fairbanks Creek in June and July (Figure 10). Densities increased slightly in August. Taxonomic richness was low in June and July, but by August the taxonomic richness was nearly equal to that found in Bear Creek (Figure 11). The invertebrate community in this site was dominated by Ephemeroptera and Nematodes, with few Plecoptera (Table 3). Trichoptera (Phryganeidae) were found in August, but they comprised only 1% of the community.

Bear Creek: Invertebrate densities and taxonomic richness increased in Bear Creek between June (Figures 10 and 11) and July and remained higher in August than in Last Chance Creek or Fish Creek near Last Chance Creek.

The invertebrate community in Bear Creek contained different aquatic invertebrates than found in Fish Creek or Last Chance Creek. In Bear Creek there was a high proportion of Ephemeroptera in June and July (Table 3) when they comprised 71% and 53% of the community. The proportion of Ephemeroptera declined in August following the emergence of two species (one species of Baetidae and one species of Heptagenidae). Plecoptera were more common in Bear Creek than in any of the other sites sampled, Nematoda were uncommon, and Daphnia were not found. One Trichoptera family, Phryganeidae, was found in Bear Creek; however, this family was not common.

Figure 10. Average, minimum, and maximum density of aquatic invertebrates from Fish Creek drainage, 1992.

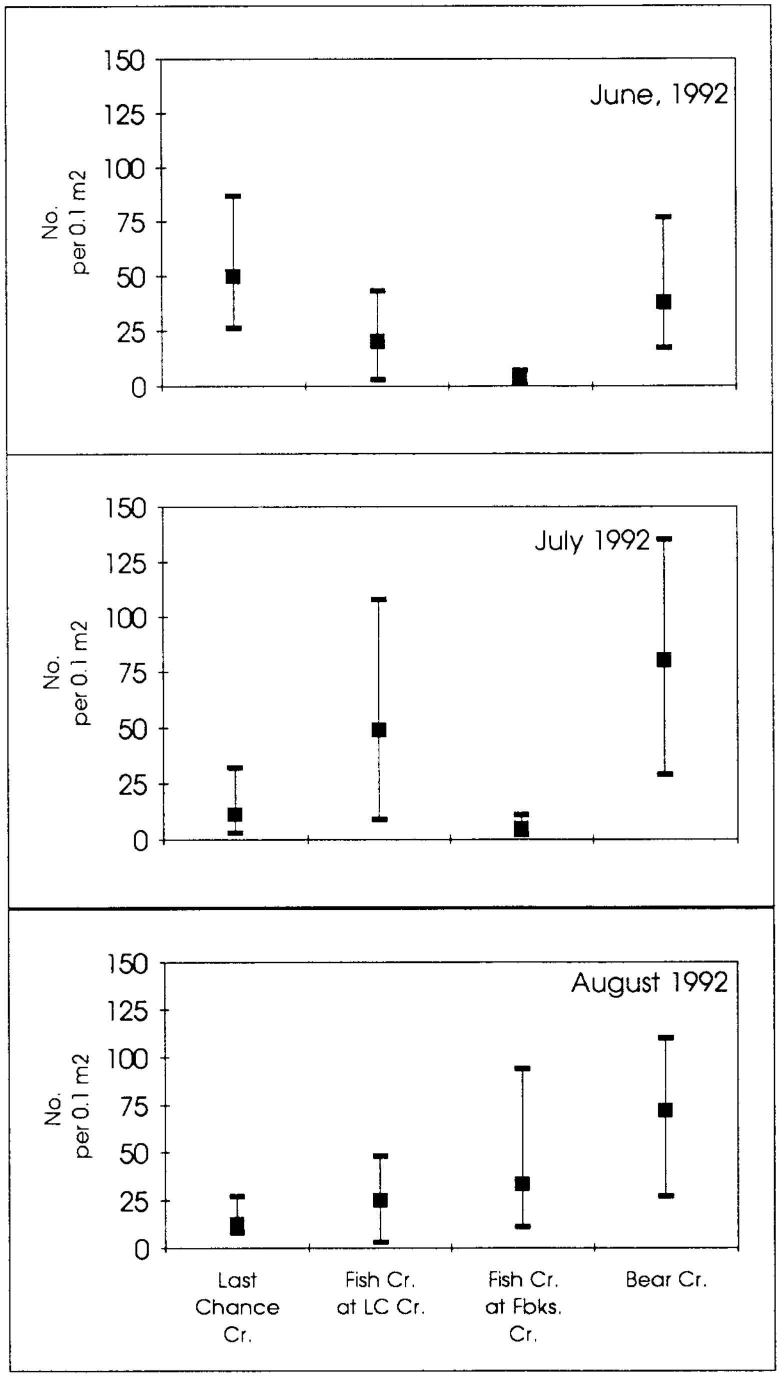


Figure 11. Average, minimum, and maximum number of taxa (taxonomic richness) of aquatic invertebrates from Fish Creek drainage, 1992. Taxonomic groups are family, except Nematoda, which is phylum and *Daphnia*, which is genus.

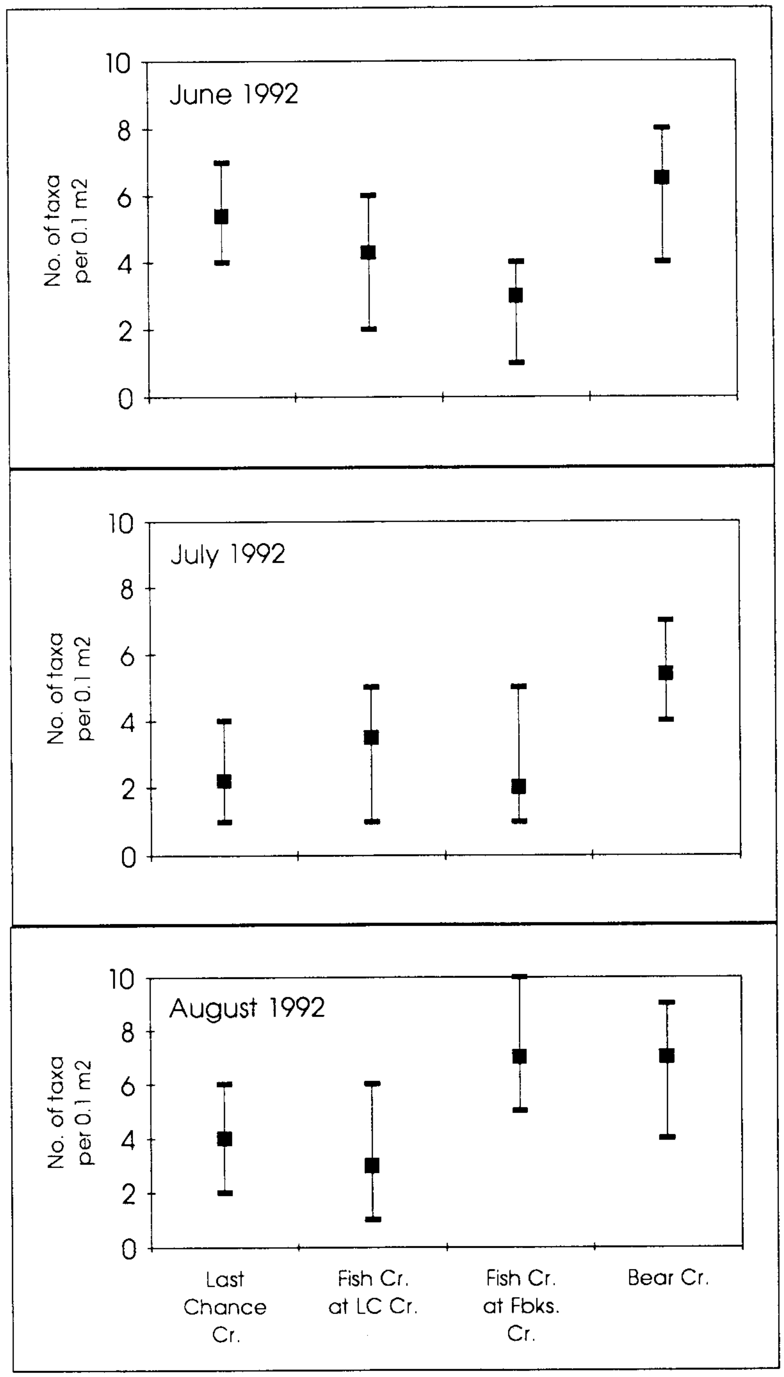


Table 3. Proportion of insects by order from each stream site.

	Ephemeroptera	Plecoptera	Chironomidae	Other Diptera	Nematoda	*Daphnia*	Trichoptera
Bear Creek							
June	0.71	0.05	0.16	0.069	0.016	0	0
July	0.53	0.03	0.31	0.123	04	0	0
August	0.19	0.17	0.05	.011	0	0	
Last Chance Creek							
June	0.07	0.21	0.30	0.19	0.23	0	0
July	0.01	0	0.04	0.12	0.82	0	0
August	0.01	0.04	0.19	0.05	0.70	0.01	0
Fish Creek below Last Chance Creek							
June	0.44	0	0.22	0.13	0.21	0	0
July	0.03	0	0.07	0.01	0.02	0.87	0
August	0	0	0.27	0.02	0.06	0.65	0
Fish Creek above Fairbanks Creek							
June	0.40	0.10	0.13	0.03	0.35	0	0
July	0.33	0.07	0.04	0.04	0.53	0	0
August	0.13	0.11	0.52	0.04	0.13	0.05	0.01

METALS CONCENTRATIONS IN FISH

In late June, we collected three adult Arctic grayling from Fish Creek; one fish was collected near the dredge pond and two from upstream reaches (Table 4).

Table 4. Arctic grayling collected for tissue analyses.

Laboratory Number	Sample Site	Weight grams	Length mm	Sex	Spawning Condition
062592FCAGA1	Fish Creek near dredge	150	245	F	pre-spawner
062592FCAGA2	Fish Creek u/s Fairbanks Creek	143	236	F	pre-spawner
062592FCAGA3	Fish Creek u/s Fairbanks Creek	147	239	F	pre-spawner

Stomachs of the three fish were examined to identify prey items (Table 5). The three Arctic grayling contained a combination of invertebrates from lotic and lentic water and a few terrestrial species. The Corixidae, or water boatman, typically occurs in ponds. Arctic grayling may have entered the dredge pond located at the confluence of Fish and Fairbanks creeks to feed or the invertebrates may have drifted into Fish Creek from the dredge pond. The Trichoptera family (Limnephilidae) has not been found in invertebrate samples collected from the Fish Creek drainage in 1992. This family may occur in either lotic or lentic habitats; we speculate that these invertebrates originated in the dredge pond.

Table 5. Stomach contents of Arctic grayling from Fish Creek collected for tissue analyses, June 1992.

Fish Laboratory Number	Order	Family	Number of Organisms
0626FCAGA1	Diptera	Chironomidae (l)	5
		Tipulidae	1
		Ceratopogonidae(?)	1
	Hemiptera	Pentamidae	1
		Corixidae	1
	Hymenoptera	Formicidae	2
	Trichoptera	Limnephilidae	6
0626FCAGA2	Diptera	Chironomidae (l)	2
		Chironomidae (a)	1
	Trichoptera	Limnephilidae	7
0626FCAGA3	Trichiptera	Limnephilidae	6
	Hymenoptera	Formicidae	1

(l) = larvae, (a) = adult, (?) = uncertain identity

Arctic grayling gill tissue contained higher concentrations of Al, Ni, and Ti than any of the other tissues (Table 6). Concentrations of Cu were highest in liver tissue, and Cd, Cr, and V in liver. Concentrations of As were highest in gill and kidney tissue and Zn concentrations were similar in liver, gill, and kidney, and lower in muscle. Overall, muscle tissues contained the lowest concentrations of metals.

Because of limited sizes of organ tissues, only muscle tissue could be analyzed for Hg. Concentrations of muscle Hg were similar in the three fish: from 0.27 to 0.35 mg/kg.

Table 6. Metals concentrations in select tissues of Arctic grayling collected in Fish Creek.

Sample No. (MRL)	tissue	Al PPM (0.1)	As PPM (1)	Be PPM (0.01)	Cd PPM (0.02)	Cr PPM (0.05)	Cu PPM (0.05)
0626FCAGA1	liver	12.1	1	<0.01	0.87	1.19	9.44
0626FCAGA2	liver	5.4	1	<0.01	0.61	1.18	6.06
0626FCAGA3	liver	8.2	1	<0.01	0.26	1.21	4.94
Average		8.5	1	<0.01	0.58	1.19	6.81
0626FCAGA1	gill	189.0	2	<0.01	0.08	1.61	2.29
0626FCAGA2	gill	53.9	1	<0.01	0.09	1.15	5.83
0626FCAGA3	gill	268.0	2	<0.01	0.09	1.81	2.74
Average		170.3	2	<0.01	0.09	1.52	3.62
0626FCAGA1	muscle	6.3	1	<0.01	0.03	1.32	1.01
0626FCAGA2	muscle	6.4	1	<0.01	<0.02	1.25	1.24
0626FCAGA3	muscle	5.8	1	<0.01	<0.02	1.18	1.10
Average		6.2	1	<0.01	0.02	1.25	1.12
0626FCAGA1	kidney	15.9	2	<0.01	1.26	2.53	6.13
0626FCAGA2	kidney	9.4	1	<0.01	0.73	1.26	3.43
0626FCAGA3	kidney	15.0	2	<0.01	0.89	1.30	4.55
Average		13.4	2	<0.01	0.96	1.70	4.70

Table 6. Continued.

Sample No. (MRL)	Tissue	Pb PPM (0.02)	Hg PPM (0.05)	Ni PPM (0.1)	Ag PPM (0.02)	V PPM (0.05)	Zn PPM (5)	Ti PPM (0.1)
0626FCAGA1	liver	0.10	--	1.3	0.13	0.83	86	1.3
0626FCAGA2	liver	0.09	--	1.0	0.03	0.85	80	1.9
0626FCAGA3	liver	0.04	--	0.3	<0.02	0.55	55	1.1
Average		0.08	--	0.9	0.06	0.74	74	1.4
0626FCAGA1	gill	0.75	--	2.7	<0.02	1.17	77	10.6
0626FCAGA2	gill	0.17	--	1.1	<0.02	0.62	72	3.7
0626FCAGA3	gill	1.08	--	2.1	<0.02	1.25	80	14.5
Average		0.67	--	2.0	<0.02	1.01	76	9.6
0626FCAGA1	Muscle	0.14	0.35	0.7	<0.02	0.28	23	6.5
0626FCAGA2	Muscle	0.06	0.37	0.5	<0.02	0.25	22	1.2
0626FCAGA3	Muscle	0.06	0.27	0.4	0.02	0.26	20	1.3
Average		0.09	0.33	0.5	0.02	0.26	22	3.0
0626FCAGA1	Kidney	0.12	--	1.6	0.18	6.08	80	1.8
0626FCAGA2	Kidney	0.09	--	1.0	0.08	4.76	75	1.9
0626FCAGA3	Kidney	0.09	--	2.0	0.08	3.77	82	2.3
Average		0.10	--	1.5	0.11	4.87	79	2.0

Standard quality control/quality assurance procedures were followed by the analytical laboratory. Contamination was minimal for all metals except aluminum (Appendix III); although the method blank showed Al concentrations of 3.51 mg/kg, this concentration is lower than the lowest concentration found in any of the tissues analyzed. Duplicate samples and standard additions resulted in concentrations that were within acceptable ranges for all metals in this analysis.

Initial fish tissue sampling suggested that Al, As, Cd, Pb, and Hg probably occurred in Fish Creek fish at concentrations above the method reporting limit and that these metals would most likely provide baseline information on metals concentrations. Therefore, subsequent fish tissue samples were analyzed for concentrations of Al, As, Cd, Pb, and Hg. In October we collected 12 Arctic grayling and 12 round whitefish. These fish were too small to analyze for metals concentrations in discrete tissues, so the fish were analyzed for whole body concentrations. Analysis of whole body concentrations allowed us to compare concentrations found in Fish Creek fish with concentrations reported in the U.S. Fish and Wildlife Contaminant Biomonitoring Program (Lowe et al. 1985, Schmitt and Brumbaugh 1990).

Both Arctic grayling and round whitefish contained high concentrations of Al: in Arctic grayling we found an average of 111.4 mg Al/kg (n=12, sd = 54.3) and in round whitefish we found an average of 115 mg Al/kg (n=12, sd = 55.2) (Table 7). There was no correlation with size of the fish and Al concentrations for either Arctic grayling or round whitefish. Whole body concentrations of Al were higher than found in any of the tissues analyzed in July, except gill.

As, Cd, Pb, and Hg were detected in all fish sampled (Table 7). Whole body concentrations of As were comparable to amounts found in individual tissues; concentrations of Cd were higher in liver and kidney, concentrations of Pb were highest in gill tissue, and concentrations of Hg were higher in muscle than whole body samples. We found no correlation of fish species, size of fish, or date captured (Oct. 5 versus Oct. 28) with metals concentrations.

Quality control/quality assurance data provided by the analytical laboratory (Appendix IV) showed no contamination of any of the metals and recovery of all metals within acceptable limits.

Table 7. Concentration of Al, As, Cd, Pb, and Hg in whole body fish tissues collected from Fish Creek near Fairbanks Creek, October 1992. All analyses are on a dry weight basis.

date collected (MRL)	species	length mm	weight grams	Al mg/kg (0.4)	As mg/kg (0.5)	Cd mg/kg (0.02)	Pb mg/kg (0.02)	Hg mg/kg (0.01)	% Solids
10/28/92	AG	126	21.0	38.2	1.4	0.06	0.48	0.14	26.6
10/28/92	AG	116	17.5	82.0	1.3	0.04	0.13	0.14	28.0
10/28/92	AG	127	20.5	118.0	2.4	0.07	0.15	0.15	24.9
10/28/92	AG	114	15.0	217.0	2.6	0.07	0.15	0.14	20.3
10/28/92	AG	113	14.5	127.0	1.8	0.06	0.15	0.10	24.6
10/28/92	AG	145	31.5	54.3	2.1	0.05	0.08	0.08	30.5
10/28/92	AG	142	28.5	198.0	2.1	0.10	0.24	0.26	21.7
10/28/92	AG	200	77.5	145.0	2.8	0.05	0.23	0.04	28.5
10/28/92	AG	202	78.0	84.6	1.6	0.05	0.14	0.16	26.5
10/05/92	AG	195	87.0	115.0	2.2	0.08	0.13	0.04	25.4
10/05/92	AG	156	38.5	76.7	1.9	0.09	0.15	0.05	24.3
10/05/92	AG	140	29.5	81.2	2.0	0.05	0.08	0.14	23.0
10/28/92	RWF	184	57.5	152.0	2.1	0.05	0.11	0.13	22.2
10/28/92	RWF	176	50.0	62.6	1.9	0.03	0.07	0.04	26.0
10/28/92	RWF	172	50.0	147.0	2.0	0.07	0.10	0.08	16.4
10/28/92	RWF	180	57.5	45.0	1.7	0.03	0.05	0.06	26.0
10/28/92	RWF	146	35.0	105.0	2.1	0.05	0.08	0.04	26.5
10/28/92	RWF	162	36.0	71.0	1.8	0.03	0.10	0.14	23.7
10/28/92	RWF	152	39.0	225.0	3.7	0.06	0.56	0.05	25.9
10/28/92	RWF	150	33.0	65.3	1.7	0.03	0.07	0.07	25.5
10/28/92	RWF	192	60.5	134.0	3.7	0.05	0.16	0.07	23.0
10/28/92	RWF	184	55.0	77.1	2.0	0.05	0.09	0.04	23.1
10/28/92	RWF	180	53.5	186.0	2.0	0.04	0.11	0.06	24.9
10/28/92	RWF	175	51.0	119.0	2.0	0.08	0.15	0.08	25.2
Average AG		148.00	38.3	111.4	2.0	0.06	0.18	0.12	25.4
SD		33.48	26.7	54.3	0.5	0.02	0.11	0.06	2.9
Average RW		171.08	48.2	115.8	2.2	0.05	0.14	0.07	24.0
SD		15.05	9.8	55.2	0.7	0.02	0.14	0.03	2.8
Average all fish		159.54	43.2	113.6	2.1	0.06	0.16	0.10	24.7
SD		27.99	20.3	53.6	0.6	0.02	0.12	0.05	2.9

MRL = method reporting limit
AG = Arctic grayling
SD = standard deviation
RW = round whitefish

DISCUSSION

Aquatic Invertebrate Communities in Fish Creek Drainage

The densities of aquatic invertebrates in Last Chance and Bear creeks were somewhat lower than densities found in similar-sized clearwater creeks in Interior Alaska. For example, Weber (1986) reported average densities of 96.8 invertebrates/0.1 m^2 in Porcupine Creek above mining, and of 60.2 invertebrates/0.1 m^2 in Boulder Creek, both clearwater streams. Wagener and LaPerriere (1985) reported invertebrate densities from 37 to 68 invertebrates/0.1 m^2 from clearwater tributaries to the Chatanika River and Birch Creek.

Aquatic invertebrate densities from placer-mined sites in the Fish Creek drainage were comparable to those reported for similar mining-disturbed sites in the Birch Creek and Chatanika River drainages. Weber (1986) reported invertebrate densities ranging from 4 to 32 invertebrates/0.1 m^2 in 8 tributary streams below mining. Wagener and LaPerriere (1985) found average invertebrate densities in 5 placer-mined tributaries to Birch Creek and the Chatanika River ranging from 3 to 25 invertebrates/0.1 m^2.

Samples from Bear Creek contained the highest proportion of Ephemeroptera (mayflies). Families within this order typically inhabit rocky-bottomed, second- and third-order, clear, fast-flowing streams and rely upon algal production as a food base.

Plecoptera were not common at any of the sites in June. This order is associated primarily with clean, cool running waters. Stonefly nymphs tend to have specific water temperature, substrate type, and stream size requirements (Harper and Stewart 1984).

Diptera (true flies) are a widely diverse group; the families found in the Fish Creek drainage occur worldwide in both erosional and depositional habitats, from slow, silt-laden rivers to torrential mountain streams.

Failure of upstream settling ponds in early July had profound effects on invertebrate communities in Last Chance Creek and Fish Creek downstream of Last Chance Creek. In June Fish Creek contained primarily Ephemeroptera; however, by July the community was comprised of 82% *Daphnia* and few Ephemeroptera, Nematoda, or Diptera (including Chironomidae). *Daphnia* are a pond-dwelling species that usually does not occur in flowing water; a likely source of *Daphnia* was the upstream settling ponds.

Samples collected in August were similar to those collected in July, except there was a higher proportion of Chironomidae in August (27% in August compared with 7% in July).

Invertebrate communities in Last Chance Creek responded differently to the failure of the settling ponds and subsequent input of sediments than did communities in Fish Creek. In Last Chance Creek the communities changed from a dominance of Diptera (including Chironomidae) and Plecoptera with few Ephemeroptera to a community dominated by Nematoda, or roundworms. Nematoda are typical of a depositional environment of fine sands and sediments.

METALS CONCENTRATIONS IN FISH

Metals concentrations of Arctic grayling collected in Fish Creek were compared with baseline studies of Arctic grayling from other areas in Alaska (U.S. Fish and Wildlife Service, 1992, Dames and Moore 1983) and with the National Contaminants Biomonitoring Data (Lowe et al. 1985, Schmitt and Brumbaugh 1990). Only limited data for kidney and gill tissues are available. In comparing these data, note that method reporting limits (MRL) from different data sets are often different and concentrations at the MRL should be treated as not detected. For example, concentrations of <0.5 mg Cd/kg are not higher than concentrations of <0.02 mg Cd/kg.

Arctic grayling in Fish Creek had higher muscle concentrations of Al than at any of the other sites reported (Table 8) and higher concentrations of muscle chromium than that found in Arctic grayling in the Koyukuk River drainage. Muscle concentrations of all other metals were comparable to those reported from Selawik National Wildlife Refuge, Koyukuk River drainage, and Tetlin National Wildlife Refuge. Metal concentrations of most metals in Arctic grayling were either comparable to or lower than concentrations reported from the Wulik River drainage.

Liver concentrations of As in Arctic grayling from Fish Creek were higher than those found in Arctic grayling from the Koyukuk River drainage, Tetlin National Wildlife Refuge, or the Wulik River (Table 9). Gill and kidney concentrations of As also were higher in Arctic grayling from Fish Creek than from the Wulik River (Table 10). Concentrations of Be, Cd, Cr, Cu, Pb, Ni, Ag, V, and Zn in Arctic grayling liver tissues from Fish Creek were similar or lower than concentrations of these metals reported in fish from the Koyukuk River and Tetlin NWR (Table 9). Gill and kidney concentrations of Cd, Cu, Pb, and Zn were similar in Arctic grayling from Fish Creek and the Wulik River (Table 10).

Liver, gill, and kidney concentrations in fish from Fish Creek were similar or lower than concentrations found at the other sites.

Table 8. Average metals concentrations in Arctic grayling muscle tissues from Fish Creek and other sites in Alaska. All concentrations are as mg/kg, dry weight basis. Comparison data are from US Fish and Wildlife Service (1992) and Dames and Moore (1983).

Metal	Fish Creek	Selawik NWR	Koyukuk R.	Tetlin NWR	Wulik River
Al	6.2	3.5	2.15	4.8	--
As	1	0.5	<0.5	<0.48	<0.39
Be	<0.01	<0.2	0.098	<0.24	--
Cd	0.02	<0.5	0.49	<0.24	0.26
Cr	1.25	<2.0	0.295	1.25	--
Cu	1.12	3.8	2.15	2.02	2.40
Pb	0.09	<4.0	2.75	<1.14	<0.05
Hg	0.33	0.7	0.455	0.9	<0.05
Ni	0.53	4.42	0.983	<1.95	--
Ag	0.02	--	0.393	<2.4	--
V	0.26	--	0.295	<2.4	--
Zn	21.67	23.1	13.6	15.24	24.3

Table 9. Average metals concentrations in Arctic grayling liver tissues from Fish Creek and other sites in Alaska. All concentrations are as mg/kg, dry weight basis. Comparison data are from US Fish and Wildlife Service (1992) and Dames and Moore (1983).

Metal	Fish Creek	Koyukuk R.	Tetlin NWR	Wulik River
Al	8.5	20.5	11.17	--
As	1	ND	<0.35	<0.49
Be	<0.01	0.125	<0.18	--
Cd	0.58	0.715	1.22	9.25
Cr	1.19	0.56	1.40	--
Cu	6.81	11.075	10.32	9.07
Pb	0.08	3.5	<1.2	<1.99
Hg	no data			
Ni	0.78	1.25	<1.62	--
Ag	0.06	0.5	<1.98	--
V	0.74	0.85	3.83	--
Zn	73.67	67.175	81.53	98.2

ND = not detected

Table 10. Average metals concentrations in Arctic grayling gill and kidney tissues from Fish Creek and the Wulik River. All concentrations are as mg/kg, dry weight basis. Data from the Wulik River drainage are from Dames and Moore (1983).

	Gill Tissue		Kidney Tissue	
	Fish Creek	Wulik River	Fish Creek	Wulik River
As	2	<0.33	2	<0.74
Cd	0.09	1.28	0.96	38.5
Cu	3.62	2.86	1.70	14.8
Pb	0.67	<0.89	0.10	<0.48
Zn	76.33	100.1	79.0	150.7

Arctic grayling and round whitefish collected in October in Fish Creek had higher whole body concentrations of Al than found in any other fish reported for Alaska. Three Arctic grayling collected in Tetlin National Wildlife Refuge contained 26.8, 16.3, and 10.0 mg Al/kg (dry weight basis) (USFWS 1992). In contrast, Arctic grayling from Fish Creek had an average of 111.4 mg Al/kg and round whitefish had an average of 115.8 mg Al/kg. Metals analyses of discrete fish tissues from fish collected in July show gill tissue to contain the highest concentrations of Al; however, the relatively small proportion of gill contained in whole body fish suggests that other tissues also contain elevated concentrations of Al. Although whole body concentrations of Al were high, similar concentrations have been reported from fish in other natural, non-polluted systems (Phillips pers. comm. 1992). The high turbidity of Fish Creek resulted from fine clays, a primary source of aluminum silicate; these fine sediment particles may have been a major source of Al in Fish Creek fish. Although the fish were held in clear water for 1-3 hrs before sacrificing, it is unlikely that all sediment particles were removed from gill, gut, or skin tissue.

Aluminum accumulates primarily in the gills of fish (Moore and Ramamoorthy 1984); gill concentrations of Al from Fish Creek were higher than concentrations found in any of the other tissues tested. We found concentrations of Al in Arctic grayling gills from Fish Creek to range from 54 to 268 mg Al/kg by dry wt.; liver tissue contained the second highest concentration with 5.4 to 12.1 mg Al/kg. We were unable to find comparable Arctic grayling gill tissue data from other regions of Alaska for comparison. However, when gill tissue concentrations from Fish Creek are compared with Arctic char gill tissue concentrations from the Wulik River (Ott, et al. 1991), Arctic grayling gills contained an average of 170.3 mg Al/kg compared to an average of 14 mg Al/kg for Wulik River Arctic char gill tissue. This is a relative comparison because uptake and depuration rates may be different for these two species. ADF&G recommends that future water quality sampling include Al.

Whole body concentrations of As, Cd, Pb, and Hg in Arctic grayling and round whitefish from Fish Creek were compared with Arctic grayling, burbot, longnose sucker, and northern pike sampled from the Chena River under the National Contaminant Biomonitoring Program (NCBP) (Lowe, et al. 1985, Schmitt and Brumbaugh 1990) (Table 11). Arctic grayling and round whitefish from Fish Creek had higher concentrations of As and Cd than any of the fish species from the Chena River.

Concentrations of Pb were highest in fish from Fish Creek and burbot from the Chena River. Concentrations of Hg were comparable among all fish species.

Arctic grayling are a highly migratory species and the amount of time spent in the Fish Creek drainage is not known. The presence of Arctic grayling, round whitefish and sculpin in Fish Creek below Fairbanks Creek in late October suggests overwintering in this area. It is likely that juvenile Arctic grayling and round whitefish spend most or all of the time in the Fish Creek drainage without migrating downstream to the Chena River.

In 1992 we tagged all Arctic grayling of 150 mm or greater. We intend to continue monitoring fish populations within Fish Creek and ADF&G Division of Sport Fish will continue their active sampling program of the Chena River. Recapture of tagged fish within the Fish Creek drainage or the Chena River will lend an understanding to migratory patterns of these fish.

Table 11. Whole body concentrations of As, Cd, Pb, and Hg in Arctic grayling, round whitefish, burbot, longnose sucker, and northern pike from the Chena River drainage. (Chena River data from Lowe, et al. 1985 and Schmitt and Brumbaugh 1990).

Fish Species	As mg/kg	Cd mg/kg	Pb mg/kg	Hg mg/kg
Round whitefish Fish Creek	2.2	0.05	0.18	0.12
Arctic grayling Fish Creek	2.0	0.06	0.14	0.07
Arctic grayling Chena River	0.02	0.01	0.04	0.06
Burbot	0.38	0.01	0.10	0.21
Longnose sucker	0.11	0.01	0.06	0.06
	0.19	0.03	0.15	0.12
	0.18	0.03	0.10	0.09
	0.22	0.02	0.10	0.07
Northern pike	0.05	0.01	0.10	0.14

Stream Habitats in Fish Creek Drainage

The upper part of the Fish Creek drainage, upstream of its confluence with Last Chance Creek, is characterized by high turbidity and settleable solids, low benthic invertebrate densities, a compacted stream substrate covered with organics and silts, a low fish density (seasonal average of two fish per pool-riffle section), and fish barriers from perched culverts and beaver dams. The upper watershed has been mined extensively, the stream channel altered by diversion and channelization, and riparian habitat has been removed. Both non-point and point sources of sediment enter Fish Creek. Substantial habitat alteration to the stream channel, stream banks, stream substrate, and riparian zone since the early 1900s, combined with degraded water quality, create an aquatic habitat in the upper portion of the drainage that is suboptimal for fish and aquatic invertebrates. Several tributaries (Last Chance, Barnes, Pearl, and Solo creeks) in the headwaters of Fish Creek also have been affected by past mining activities. Fish access to Barnes and

Pearl creeks probably has not existed for at least ten years. Fish use of Fish Creek above its confluence with Last Chance Creek, Last Chance, and Solo creeks probably has been limited due to instream obstructions from beaver dams, perched culverts, and sedimentation and poor water quality.

Dames and Moore (1991) did not find fish in the following tributaries to Fish Creek: Upper Barnes, Monte Cristo, Melba, Lower Barnes, Pearl, and Yellow Pup creeks. Densities in Solo Creek were reported to be "low" (the actual fish density was not reported). Solo Creek has had relatively minor disturbance to the stream bed and riparian habitat; this creek contains adequate fish habitat but use probably is curtailed due to water quality conditions and physical barriers to fish movement.

In June 1992, Last Chance Creek was a small, narrow creek with numerous pool-riffle sections. Pools were formed either by logs and branches deposited on the streambed or by erosion at stream meanders. In July, the failure of placer mining settling ponds upstream caused large amounts of silt, sand, and small gravel to be deposited in Last Chance Creek. Pools previously sampled for fish in June were filled with sediments and few pools and little fish habitat remained in the creek. Fish densities declined from 16 fish per pool-riffle before failure of the settling ponds to 1.5 fish per pool-riffle (the average for July and August).

Adverse impacts are not limited to the areal extent of the surface disturbance in the Fish Creek drainage. Fish Creek between the proposed freshwater dam and its confluence with Bear Creek (approximately 5 km) is characterized by well defined pool-riffle sections in the first kilometer. Stream characteristics for the remainder of Fish Creek to Bear Creek and for a distance of approximately 2.8 km below Bear Creek change. In this reach, the creek is deeply incised (from 3 to 5 m), banks are vegetated (some containing exposed ice-rich soils), pools are deep (approximately 1 to 1.5 m), and organic debris covers portions of the stream bottom. Aquatic habitat is adversely affected by poor water quality with elevated concentrations of suspended and resuspended sediments originating from placer mining in the upper watershed.

Fish Creek returns to a well-defined pool-riffle habitat for the last 1 km immediately above its confluence with Fairbanks Creek. One exposed ice lens along a cut bank was observed. Water quality in this reach is degraded, benthic invertebrate numbers are low (an average of 4 invertebrates per 0.1 m^2 and an average of 2.6 taxa per 0.1 m^2), accumulated sediments and organics are evident along the stream bottom, and fish numbers are low (an average of 3.8 fish per pool-riffle). However, fish species diversity was higher than in upper Fish, Last Chance, or Bear creeks. Five species were found in Fish Creek above Fairbanks Creek: burbot, Arctic grayling, round whitefish, slimy sculpin, and longnose sucker. Fish use and increased species diversity may be directly associated with clear surface and subsurface flow from Fairbanks Creek. At the confluence with Fish Creek, water from Fairbanks Creek is clear with low suspended sediments, as the entire flow of Fairbanks Creek drains though several kilometers of abandoned dredge tailings.

Fairbanks Creek enters Fish Creek as surface water through the outlet from an old dredge pond and as subsurface water percolating through abandoned dredge tailings. Fish access into and use of Fairbanks Creek is precluded due to subsurface flow of water with the exception of the old dredge pond and outlet. Although Arctic grayling were observed in the old dredge pond, fish movement into and out of the pond was limited by a beaver dam.

Fish Creek below Fairbanks Creek (near the confluence with Clark Creek, Figure 1) is in a stream diversion channel that was created during recent placer mining. The stream channel is about 50% shorter than the original channel and is cut through overburden and eroding bluffs. The stream bed is embedded and pools contain large amounts of fine silt and sand. Fish densities were higher in Fish Creek below Fairbanks Creek than in any other site in Fish Creek (average of 4.7 fish per pool-riffle in July and 9.5 fish per pool-riffle in August). Fish densities were probably higher than our sampling indicates because high flows prevented the use of block nets and high turbidity made it difficult to see and catch fish. Arctic grayling, slimy sculpin, longnose sucker, burbot, and round whitefish were found in this section of Fish Creek.

Bear Creek is clear, slightly stained, and contains abundant pool-riffle habitat at its confluence with Fish Creek. Fish were observed in the first pool-riffle section in Bear Creek above the mouth. Upstream in the region of fish sampling (approximately 1 km above the mouth) Bear Creek contains extensive pool-riffle habitat. Pools are typically deep (up to 1 m) with substrata of coarse sand and gravel. Eroding banks have contributed some sediment to the stream substrate. Riffles are of medium to small gravel. Overhanging vegetation is prevalent and organic debris is deposited throughout on the stream bed. The debris, in the form of tree boles and branches, form some of the pools. Other pools are formed by erosion and deposition on stream meanders.

Arctic grayling in Bear Creek are more numerous than in any of the other sample areas in the Fish Creek drainage (the seasonal average of fish for Bear Creek was 8 fish per pool-riffle). Fish use of Bear Creek appears to be seasonal, with fish migrating into Bear Creek in June and July after breakup and leaving the creek in the fall. Although some mining exploration work probably has occurred in and adjacent to Bear Creek, the drainage is unmined with little apparent surface disturbance. Fish use of Bear Creek did not appear to be affected by instream physical barriers and no intact beaver dams were found in Fish Creek downstream of Bear Creek; however, fish use may be altered by water quality conditions in Fish Creek.

Studies of the effects of elevated sediment concentrations on Arctic grayling have shown that Arctic grayling were excluded from heavily mined streams in Interior Alaska (Simmons 1984, Weber and Post 1985, Weber Scannell 1992), and population levels remained low until water quality conditions improved and stream channel reclamation had been completed (Townsend 1991). Research conducted since 1984 has identified both direct (e.g. mortality, avoidance) and indirect (e.g. loss of habitat, restricted prey, decreased sight feeding ability) effects of sediment on Arctic grayling (Simmons 1984, Scannell 1988, Weber and Post 1985, Weber 1986, Townsend 1991). Fish moving within the Fish Creek system downstream of Bear Creek may avoid high concentrations of sediment or be delayed in migrating upstream with resulting impacts on numbers of fish using the system and associated tributaries.

EXPECTED CHANGES TO STREAM HABITAT FROM FORT KNOX

Development of the Ft. Knox hard-rock gold mine and associated facilities, including the freshwater dam and impoundment, wetland and riparian habitat rehabilitation between the tailings dam and freshwater impoundment, and the tailings dam and associated impoundment, in the upper part of the Fish Creek drainage will change aquatic habitats, alter the movement patterns of freshwater resident fish species, and alter potential rehabilitation options for the system. Projected changes from the Ft. Knox project are based on the assumption that the headwaters portion of the Fish Creek drainage would be rehabilitated if the Fort Knox project is not constructed. We assume that with adequate rehabilitation and improved water quality that fish (primarily Arctic grayling) would inhabit Fish, Last Chance, Barnes, Pearl, and Solo creeks. Anticipated changes to the aquatic habitats in the drainage, using the assumption stated above, are summarized below:

(1) Upstream of the freshwater dam and impoundment, there will be changes in approximately 17 km of habitat useable to fish, provided the drainage was completely reclaimed or had never been mined. We estimate about 5 km of riverine habitat in Fish Creek, 4.5 km in Solo Creek, 3.5 km in Last Chance Creek, 2.5 km in Barnes Creek, and 1.25 km in Pearl Creek provided suitable and accessible fish habitat before mining. Changes to fluvial habitats are listed below:

  (a) Fish habitat in Barnes and Pearl creeks will be covered permanently with the tailings impoundment, a loss of 3.75 km of stream habitat;

  (b) Portions of Solo (1 km), Last Chance (1.8 km), and Fish (1.8 km) creeks will be changed from riverine to lentic habitat by the freshwater lake upstream of the dam;

  (c) Portions of Solo (3.5 km) and Last Chance (1.5 km) creeks will remain riverine habitat accessible to fish from the freshwater impoundment, if a fish population is able to establish and maintain itself within the freshwater impoundment;

  (d) Fish Creek (3.2 km) between the freshwater pool created by the freshwater dam and the tailings impoundment seepage collection system will be changed from a riverine habitat to a wetland complex; and

  (e) Fish Creek (0.4 km) immediately downstream of the tailings impoundment will contain the seepage collection system consisting of several subsurface dewatering wells and a stilling basin.

(2) Upstream movement of fish in Fish Creek will be blocked by the 70-foot high freshwater dam. Access to approximately 17 km of riverine habitat in Fish, Solo, Last Chance, Pearl, and Barnes creeks will be blocked to use by fish using portions of Fish Creek below the freshwater dam. Past and present placer mining and existing beaver dams in the Fish Creek drainage currently limit fish use of Last Chance, Solo, Pearl, and Barnes creeks and the headwaters of Fish Creek. Extensive stream channel rehabilitation would be required to reestablish fish

passage in these areas if the project is not built. Creation of the freshwater impoundment and proposed wetlands upstream of the impoundment in the Fish Creek valley probably will remove, by flooding, fish barriers, thus allowing fish access to wetlands in Fish Creek and riverine habitats in Solo and Last Chance creeks.

(3) Water flows in the Fish Creek drainage below the freshwater dam will decrease during the time period that the freshwater reservoir is filling with water. During the estimated two years to fill the reservoir, surface flow from Fish, Solo, or Last Chance creeks probably will not pass through the spillway. Some subsurface flow probably will occur in Fish Creek below the freshwater dam. Although the volume of subsurface flow is unknown, estimates of 100 gallons per minute have been made. If subsurface flows continue throughout the year, fairly extensive *aufeis* accumulations (11.0 hectares one meter deep - 89.5 acre/feet) could occur within the Fish Creek system below the freshwater dam. Effects of an *aufeis* field, as observed in other stream systems, probably would include increased erosion, changes in stream channel location, changes in vegetation, and a lowering of instream water temperature.

(4) Surface discharges in Fish Creek below the freshwater dam may only occur during periods of high flow during the summer months. Flow patterns from any discharge over the freshwater dam will be relatively stable without peak flood events. Breakup flows will be moderated by the impoundment. Most, if not all, breakup waters may be used to replace water used during the winter by the mining operation. Actual fluctuations in water levels within the freshwater pool are directly related to the operational plans for water makeup to the mill and tailings impoundments. Details regarding water operational plans are not yet available. If water levels fluctuate widely during the ice free season, effects could include dewatering of areas used by spring spawning fish (e.g., Arctic grayling) and changes in vegetation along the edges of the impoundment. Design, installation, and operations of a control structure within the proposed spillway over the freshwater dam and operational plans for water use can be used to mitigate these changes during the mining phase of the project. Winter water withdrawals from the freshwater pond, depending upon volumes used, could affect water quality and fish survival.

(5) Flows in Fish Creek below the freshwater reservoir are projected to be relatively stable after the impoundment fills with water. Discharge from the dam is estimated to be low and periodic. Surface water inputs to Fish Creek are limited to seeps until Bear Creek enters the system about 5.2 km below the freshwater dam. The next major tributary to Fish Creek is Fairbanks Creek located about 3.7 km below Bear Creek. Several other small streams enter Fish Creek but surface discharges during the summer months are not substantial (less than 0.25 cfs).

(6) Abandoned and active beaver dams exist within the Fish Creek drainage from the freshwater reservoir to the confluence of Fish and Fairbanks creeks. With peak flows eliminated from Fish Creek above Bear Creek, we anticipate that the number of beaver dams may increase and established beaver dams will remain in place longer. Upstream movement of fish in the drainage, including use of Bear Creek, may be altered or entirely blocked by beaver dams. Therefore, we predict that little fish use will occur in Fish Creek between the freshwater dam and its confluence with Bear Creek, a distance of 5.2 km. Displacement of fish from the freshwater impoundment over the spillway during the open water season also may occur. Fish displaced over the freshwater dam probably will be trapped within Fish Creek by physical barriers such as beaver dams and depending upon winter water flows may not survive.

(7) Arctic grayling and slimy sculpin were found in the Fish Creek drainage upstream of the proposed freshwater dam site. Data on fish presence and size distributions indicate that some overwintering, spawning, and rearing occur in the Fish Creek drainage upstream of the proposed freshwater dam. The presence of age 1+ Arctic grayling in Last Chance and Fish creeks during June 1992 immediately following breakup, suggests that these fish likely overwintered in this drainage upstream of the proposed freshwater dam site. Documentation of adult and young-of-the-year Arctic grayling in Last Chance Creek suggests that these fish spawn here. Rearing fish were found at all sample times during the summer of 1992. Therefore, when the freshwater dam is constructed, a portion of the fish using the upper Fish Creek drainage will be trapped in the impoundment when it fills with water. Natural establishment of a viable fish (e.g., Arctic grayling) population in the freshwater impoundment may occur with fish using the littoral zone of the reservoir for spawning and rearing and deeper water for overwintering and rearing. Spawning and rearing also are predicted to occur in portions of Solo

and Last Chance creeks not covered by the freshwater reservoir. If access via a continuous surface water connection to the proposed wetland complex is available to fish, we predict that fish, primarily Arctic grayling, would spawn and rear in this area. Natural wetland complexes associated with streams are extensively used by Arctic grayling for spawning and juvenile rearing (e.g., Poplar Grove Creek, Pamplin's Potholes, Shaw Creek, Steitz Lake Outlet, Mary Angel Creek). Factors affecting the establishment of a fish population in the freshwater reservoir include water quality within the reservoir, fish impingement/entrapment at the water intake site, water use during the winter months, and the number and age-classes of fish trapped when the freshwater dam is constructed.

There is potential for enhancing lentic fish populations, provided water quality in the reservoir will support fish during both winter and summer, and habitats for spawning, rearing, and overwintering exist. One option is to introduce Arctic grayling to the freshwater reservoir after it has filled with water. Creations of wetlands upstream of the freshwater pond should increase nutrient input, improve water quality, and provide aquatic invertebrate drift.

(8) Water quality conditions in the Fish Creek drainage were highly degraded as a result of both non-point and point source pollution associated with several active placer-mines and historic mining. Mean turbidities during June and July 1992 in Fish Creek (sample site located immediately upstream of Fairbanks Creek) were 286 and 380 NTU (Figure 2, Ray and Vohden 1992). Arsenic and lead also were detected at significant concentrations at or below the ADEC maximum contaminant concentration for drinking water in Fish Creek in 1990 below active placer mining (CH^2M Hill 1992). Most of the area currently affected by active placer mining will be affected by development of the Ft. Knox hard-rock mine (e.g., portions of the Fish Creek valley will be inundated by the freshwater reservoir). Sources of sediment and associated heavy metals in Fish Creek should be reduced due to a cessation in active placer mining, rehabilitation, and by containment within the freshwater reservoir and the tailings impoundment.

The major source of sediment input to Fish Creek and the Little Chena River is the placer-mined areas of Fish Creek upstream of the confluence of Fish and Last Chance creeks. Therefore, degraded water quality from current sediment pollution and associated heavy metals should improve considerably in the Fish Creek drainage in the short and mid-term. Substantial improvements in water quality also should be experienced in Fish Creek below the freshwater dam and therefore within the Little Chena River drainage. Increased fishing opportunities in the Little Chena River should be experienced with improved water quality.

Long-term effects of the project to Fish Creek will need to be assessed to determine whether the absence of high-water events downstream of the freshwater dam will delay recovery of stream habitat by eliminating scouring flows and whether altered stream flows enable beavers to construct additional dams in Fish Creek. Researchers from the U.S. Geological Survey (LaPerriere pers. comm.) predicted that a series of 20-year flood events would be required to scour placer-mined Birch Creek. A succession of 20-year flood events or greater flood events in Bear Creek may be required to scour Fish Creek. Long-term, or post-project, effects will be determined by post-mining uses and reclamation (e.g., permanent versus temporary freshwater dam).

(9) After completion of mining, there is a potential to reclaim the mine pit for fish habitat and stock the pit providing water levels are adequate. Stocking can be done only if there is guaranteed public access to the flooded mine pit. Final rehabilitation of the tailings impoundment, including reestablishment of a stream channel, will affect both water quantity and quality into the freshwater impoundment. Provisions to monitor effectiveness of rehabilitation and implement corrective actions, if needed, must be incorporated into the project plans. Development of a recreational use area and fishery also are possible within the freshwater reservoir provided provisions are incorporated to ensure proper maintenance.

Based on the existing degraded conditions in Fish Creek above the proposed freshwater dam (e.g., extensive past-mining activities within the drainage, degraded water quality associated with point and non-point source pollution), we believe that construction of the Ft. Knox project will have a net overall benefit to fisheries resources in the Little Chena River drainage. Limited fishery enhancement options appear to be viable for the freshwater reservoir contiguous with the development of the project. Enhancement options for fisheries exist for both the freshwater reservoir and the open pit upon completion of mining at the Ft. Knox site. Improved water quality in Fish Creek downstream of the freshwater dam will occur with eventual positive effects in the lower Little Chena River system which is capable of supporting a recreational fishery. Benthic invertebrate densities are expected to increase in Fish Creek downstream of the freshwater dam after water quality improves and there are sufficient flood events to scour the streambed. With the exception of the reach of Fish Creek between the freshwater dam and Bear Creek, increased fish use is anticipated in Fish Creek. Bear Creek may have increased fish use, provided fish access to this creek is not limited by low flows and beaver dams. In addition, potential options for on-site and off-site mitigation are being pursued as part of the process to obtain a Fish Habitat Permit (A.S. 16.05.840) for the freshwater dam.

Without the Ft. Knox hard-rock mine, we speculate that rehabilitation of the headwaters of Fish Creek (including Fish, Last Chance, Barnes, Pearl, and Solo creeks) to pre-mining conditions may not be feasible. The extent of the disturbance to stream channels, banks, and riparian habitat, the cost of rehabilitation, the potential for on-going active placer mining, and the current limited fish use of the this portion of the Fish Creek drainage make complete reclamation appear impractical.

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Appendix I. Fork length, in mm, of fish collected in the Fish Creek drainage, 1992.

BEAR CREEK, JUNE 1992

	mm
Arctic Grayling	163 319 145
Round Whitefish	0
Burbot	0
Slimy Sculpin	0

Note: High water conditions prevented identifying discrete pool/riffle sections and use of block nets in Bear Creek in June.

Appendix I, continued.

BEAR CREEK, JULY 1992

Arctic Grayling

Reach1 mm	Reach2 mm	Reach3 mm	Reach4 mm	Reach5 mm	Reach6 mm
103	131	148	127	145	186
124	150	163	135	193	280
135	164	165	139	194	
166	301	187	201		
177		189			
239		236			

Round Whitefish

Reach1 mm	Reach2 mm	Reach3 mm	Reach4 mm	Reach5 mm	Reach6 mm
190	174	212	209	0	0
	190				
	288				

Summary of Species Collected:

	Total AG	Total RWF	Total BB	Total SC	Total Fish
Reach1	6	1	0	0	7
Reach2	4	3	0	0	7
Reach3	7	1	0	0	8
Reach4	4	1	0	0	5
Reach5	3	0	0	0	3
Reach6	2	0	0	0	2
Total Fish Collected					32
Average No. of Fish per Pool/Riffle Reach					5

Appendix I, continued.

BEAR CREEK, AUGUST 1992

Reach1 mm	Reach2 mm	Reach3 mm	Reach4 mm	Reach5 mm	Reach6 mm
Arctic Grayling					
126	84	139	243	116	139
139	137	158		148	144
140	156	162		152	145
143	162	164		153	171
184	180	170		162	174
210	231	223		164	175
230	254			185	178
				314	
Round Whitefish					
151	152	156	156	154	203
207	188	183	180	204	215
218	191	190	232		227
218	224	193			
219		208			
		224			
		228			
Slimy Sculpin					
116	115	0	106	90	0

<u>Summary of Species Collected:</u>

	Total AG	Total RWF	Total BB	Total SC	Total Fish
Reach1	7	5	0	1	13
Reach2	8	4	0	1	13
Reach3	6	7	0	0	13
Reach4	1	3	0	1	5
Reach5	9	2	0	1	12
Reach6	8	3	0	0	11
Total Fish Collected					67
Average No. of Fish per Pool/Riffle Reach					11

Appendix I, continued.

LAST CHANCE CREEK, JUNE 1992.

Arctic grayling

mm	mm	mm	mm	mm
56	114	129	138	168
57	114	130	139	182
88	114	131	141	183
106	115	132	143	192
108	116	133	144	195
109	116	133	147	196
109	123	134	152	215
110	124	136	154	222
112	126	136	162	
114	126	136	163	

Summary of Species Collected:

	Total AG	Total RWF	Total BB	Total SC	Total Fish
	48	0	0	0	48
Average No. of Fish per Pool/Riffle Reach					16

Note: Approximately 100 m of stream was electrofished, no block nets were used. Sampling area encompassed three pool/riffle reaches.

Appendix I, continued.

LAST CHANCE CREEK, JULY, 1992

	Reach1 mm	Reach2 mm	Reach3 mm
Arctic grayling			
	0	0	159
			151

Summary of Species Collected:

	Total AG	Total RWF	Total BB	Total SC	Total Fish
Reach1	0	0	0	0	0
Reach2	0	0	0	0	0
Reach3	2	0	0	0	2

Total Fish Collected	2
Average No. of Fish per Pool/Riffle Reach	0

Appendix I, continued.

LAST CHANCE CREEK, AUGUST 1992

	Reach1 mm	Reach2 mm	Reach3 mm
Arctic grayling			
	97	147	170
	63		
Slimy sculpin			
	85		

Summary of Species Collected:

	Total AG	Total RWF	Total BB	Total SC	Total Fish
Reach1	2	0	0	1	3
Reach2	1	0	0	0	1
Reach3	1	0	0	0	1

Total Fish Collected	5
Average No. of Fish per Pool/Riffle Reach	2

Appendix I, continued.

FISH CREEK DOWNSTREAM OF LAST CHANCE CREEK, JUNE 1992.

Arctic Grayling mm	Arctic Grayling mm	Round Whitefish
66	63	0
56	72	
64	63	Burbot
65	61	0
139	55	
64	125	Slimy Sculpin
54	110	0
62	100	

Note: Water levels were too high to identify discrete pool/riffle sections or to use block nets in Fish Creek during June.

Appendix I, continued.

Fish Creek downstream of Last Chance Creek, July 1992

Reach 1 mm	Reach 2 mm	Reach 3 mm	Reach 4 mm	Reach 5 mm	Reach 6 mm
Arctic Grayling					
124	112	0	0	0	132
139	139				147
205					151
					152
					227
					241

Summary of Species Collected:

	Total AG	Total RW	Total BB	Total SC	Total fish
Reach1	3	0	0	0	3
Reach2	2	0	0	0	2
Reach3	0	0	0	0	0
Reach4	0	0	0	0	0
Reach5	0	0	0	0	0
Reach6	6	0	0	0	6

Total Fish Collected	11
Average No. of Fish per Pool/Riffle Reach	2

Appendix I, continued.

FISH CREEK DOWNSTREAM OF LAST CHANCE CREEK, AUGUST 1992

Reach1 mm	Reach2 mm	Reach3 mm	Reach4 mm	Reach5 mm	Reach6 mm
Arctic grayling					
205	112	0	0	0	227
124	139				241
139					147
					151
					152
					132

<u>Summary of Species Collected:</u>

	Total AG	Total RWF	Total BB	Total SC	Total Fish
Reach1	3	0	0	0	3
Reach2	2	0	0	0	2
Reach3	0	0	0	0	0
Reach4	0	0	0	0	0
Reach5	0	0	0	0	0
Reach6	6	0	0	0	6
Total Fish Collected					11
Average No. of Fish per Pool/Riffle Reach					2

Appendix I, continued.

FISH CREEK UPSTREAM OF FAIRBANKS CREEK, JUNE 1992

	6/17/92 mm	6/24/92 mm
Arctic grayling		
	165	172
	157	110
		122
Burbot	270	
Slimy Sculpin		100

Summary of Species Collected:

	Total AG	Total RWF	Total BB	Total SC	Total Fish
6/17/92	2	0	0	1	3
6/24/92	3	0	1	0	4

Appendix I, continued.

FISH CREEK UPSTREAM OF FAIRBANKS CREEK, JULY 1992

	Reach1 mm	Reach2 mm	Reach3 mm	Reach4 mm	Reach5 mm
Arctic Grayling	167	198	184	204	0
	143	187	151		
		138			
		123			
Burbot	250				
Round Whitefish	205	267	0	0	205
		262			
		269			
		223			
		191			
Longnose Sucker	550	370	260		
	560				
Slimy Sculpin		115			

Summary of Species Collected:

	Total AG	Total RWF	Total BB	Total Sc	Total LNS	Total Fish
Reach1	2	1	1		2	6
Reach2	4	51	10			
Reach3	2	0	0	1	1	4
Reach4	1	0	0	0	0	1
Reach5	0	1	0	0	0	1

Total Fish Collected	22
Average No. of Fish per Pool/Riffle Reach	4

NOTE: Because of high stream flows, we were not able to block net stream reach 3, 4, or 5. Therefore, data were not summarized as catch per pass.

Appendix I, continued.

FISH CREEK UPSTREAM OF FAIRBANKS CREEK, AUGUST 1992

	Reach1 mm	Reach2 mm	Reach3 mm	Reach4 mm	Reach5 mm	Reach6 mm
Arctic Grayling	163	138 130	148 141 127 112 116	214 146	173 177	175 240
Burbot	240					384
Round whitefish				210 213	170	157
Slimy Sculpin	37 79 108					

Summary of Species Collected:

	Total AG	Total RWF	Total BB	Total Sc	Total LNS	Total Fish
Reach1	1	0	3	1	0	5
Reach2	2	0	0	0	0	2
Reach3	5	0	0	0	0	5
Reach4	2	2	0	0	0	4
Reach5	2	1	0	0	0	3
Reach 6	2	1	0	1	0	4
Total Fish						23
Average No. of Fish per Pool/Riffle Reach						3.8

NOTE: Because of high stream flows, we were not able to use block nets in this site.

Appendix I, continued.

FISH CREEK AT FAIRBANKS CREEK (NEAR THE DREDGE), OCTOBER 1992

	Arctic grayling mm	Arctic grayling mm	Round whitefish mm	Round whitefish mm	Slimy sculpin mm
Oct. 5, 1992					
	119	158	144	170	
	125	158	162	190	
	142	198	162	199	
	144		163	200	
Oct. 28, 1992					
	101	134	152	183	122
	116	152	155	184	92
	117	152	157	187	
	119	207	169	190	
	132	210	181	192	
			182	195	

Summary of Species Collected:

	Total AG	Total RWF	Total BB	Total Sc	Total LNS	Total Fish
Oct. 5, 1992	7	8	0	0	0	15
Oct. 28, 1992	10	2	0	2	0	24

Note: This section of stream was electrofished from the dredge upstream to the confluence of Fairbanks Creek. Ice on the creek prevented further sampling. On October 5, Arctic grayling were retained for metals analyses, and on October 28, both Arctic grayling and round whitefish were collected for metals analyses.

Ice cover on Fish Creek prevented sampling discrete pool\riffle reaches or using block nets.

Appendix I, continued.

FISH CREEK BELOW FAIRBANKS CREEK, JUNE 17, 1992

	Arctic grayling mm	Round whitefish mm	Burbot mm	Slimy Sculpin mm	Longnose Sucker mm
	247 186 151 122 185	193	0	45	0
Total	5	1	0	1	0

Total fish = 17

JULY 22, 1992

	Arctic grayling mm	Round whitefish mm	Burbot mm	Slimy Sculpin mm	Longnose Sucker mm
	138	200	0	46 54 46 55 47 64 50 70 52100	365 360
Total	1	1	1	10	2

Total fish = 14

Appendix I, concluded.

FISH CREEK BELOW FAIRBANKS CREEK

AUGUST 25, 1992

	Arctic grayling mm	Round whitefish mm	Burbot mm	Slimy Sculpin mm	Longnose Sucker mm
	243	204	287	47 73	320
	191	245		54 75	328
	192	195		57 84	
	104	182		57 92	
	72	203		59 96	
	141	187		60 96	
	126	163		66 99	
		144		67 101	
		189		70 109	
				72	
Total	7	9	1	19	2

Total fish = 38

OCTOBER 5, 1992

	Arctic grayling mm	Round whitefish mm	Burbot mm	Slimy Sculpin mm	Longnose Sucker mm
	113	152	366	57	0
	138	165		60	
	240	168		61	
	295	186		89	
	190				
	195				
	218				
	220				
Total	8	4	1	4	0

Total fish = 17

Appendix II. Number of invertebrates, by family, collected in the Fish Creek drainage, 1992.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.											
Bear Creek											
June 18, 1992											
	Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera											
	Baetidae	7	13	23	11	6	8	15	14	20	6
	Heptagenidae	14	12	4	8	8	5	19	22	28	7
	Siphlonuridae	1	3	1	2			1	4	6	
	Ephemerellidae	1									
Plecoptera											
	Leuctradae							1			
	Perlodidae		1		2	3		1	1	3	1
	Nemouridae			1	1	1			1		
Diptera											
	Chironomidae L	3	4	9	1	7	7	9	8	8	2
	Chironomidae P						1				
	Tipulidae	1	7	1		1	1		3	9	
	Simulidae			1	1	1					
Miscellaneous											
	Nematoda				1			1	1	3	
	Snail										1
Trichoptera											
Total Invertebrates		27	40	40	27	27	22	47	54	77	17
Total Taxa		6	6	7	8	7	4	7	8	7	5

Appendix II, continued.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.											
Bear Creek											
July 1992											
	Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera											
	Baetidae	6	11	34	2	8	20	18	14	23	29
	Heptagenidae	41	21	35	16	22	28	17	23	30	25
	Siphlonuridae										
	Ephemerellidae						1	1			
Plecoptera											
	Leuctradae										
	Perlodidae	2				2					
	Nemouridae	3		2	1			8	1	2	5
Diptera											
	Chironomidae L	13	23	46	8	12	18	35	25	35	32
	Chironomidae P		1		1						
	Tipulidae							2	1		
	Simulidae	2	8	18	1	5	1	8	12	29	12
Miscellaneous											
	Nematoda	1					1		1		
	Snail										
Trichoptera											
Total Invertebrates		68	64	135	29	49	69	89	77	119	103
Total Taxa		7	4	5	5	5	4	7	7	5	5

Appendix II, continued.

		1	2	3	4	5	6	7	8	9	10
Number of invertebrates, by family, collected in 0.1 m2											
	of stream substrate.										
Bear Creek											
August 25, 1992											
	Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera											
	Baetidae				2			1	1		
	Heptagenidae	11	24	7	17	1	5	23	19	9	
	Siphlonuridae	1	2						2		
	Ephemerellidae		1								
Plecoptera											
	Leuctradae			1	1						
	Perlodidae	1	2		1		1	4	1		
	Nemouridae	10	17	3	14	1	12	24	15		8
Diptera											
	Chironomidae L	52	21	14	53	23	66	47	27	15	20
	Chironomidae P										
	Tipulidae	4	3	6	8	1	8	8	4	2	4
	Simulidae		2	3	9	1		1	2	2	
	Dixidae			1	1		2	1			1
Miscellaneous											
	Nematoda	2									
	Collembola										
	Daphnia										
	Oligichaeta							1			
Trichoptera											
	Phryganeidae								1		
Coleoptera											
	Dytiscidae										
Total Invertebrates		81	72	35	106	27	94	110	72	28	33
Total Taxa		7	8	7	9	5	6	9	9	4	4

Appendix II, continued.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.										
Last Chance Creek										
June 19, 1992										
Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera										
Baetidae	8	1	2	2	4	4	5	5		1
Heptagenidae		1			2					
Siphlonuridae							1			
Ephemerellidae	1									
Plecoptera										
Leuctradae	4			4						
Perlodidae										
Nemouridae		7	11	10	14	17	5	15	7	11
Diptera										
Chironomidae L	4	8	6	17	12	37	8	18	12	17
Chironomidae P		2	1	1		4		1		
Tipulidae	1				1		2			
Simulidae			5	8	19	15	17	16	9	3
Miscellaneous										
Nematoda	8	20	5	30		10	12	4	5	19
Trichoptera										
Total Invertebrates	26	39	30	72	52	87	50	59	33	51
Total Taxa	6	5	5	6	6	5	7	5	4	5

Appendix II, continued.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.										
Last Chance Creek										
July 1992										
Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera										
Baetidae									1	
Heptagenidae										
Siphlonuridae										
Ephemerellidae										
Plecoptera										
Leuctradae										
Perlodidae										
Nemouridae										
Diptera										
Chironomidae L		1						1	2	1
Chironomidae P										
Tipulidae			1					1		
Simulidae	2	5				3			1	1
Miscellaneous										
Nematoda	9	4	8	15	7	12	5	4	28	1
Trichoptera										
Total Invertebrates	11	10	9	15	7	15	5	6	32	3
Total Taxa	2	3	2	1	1	2	1	3	4	3

Appendix II, continued.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.										
Last Chance Creek										
August 24, 1992										
Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera										
Baetidae										
Heptagenidae										
Siphlonuridae	1									
Ephemerellidae										
Plecoptera										
Leuctradae										
Perlodidae		1		1				1		
Nemouridae		1					2			
Diptera										
Chironomidae L	2	3	5		2	1	2	6	2	3
Chironomidae P	2						1			
Tipulidae					1	1	1	1		
Simulidae				1	1			2		
Miscellaneous										
Nematoda	7	8	13	5	23	6	15	17	6	7
Collembola										
Daphnia				1		1				
Oligichaeta							1			
Trichoptera										
Limnephilidae										
Coleoptera										
Dytiscidae										
Total Invertebrates	12	13	18	8	27	9	22	27	8	10
Total Taxa	4	4	2	4	4	4	6	5	2	2

Appendix II, continued.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.										
Fish Creek downstream of Last Chance Creek.										
June 19, 1992										
Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera										
Baetidae	6	1	18	4	2	10	10	3	14	9
Heptagenidae						1		1	1	4
Siphlonuridae										
Ephemerellidae										
Plecoptera										
Leuctradae										
Perlodidae										
Nemouridae	2				2		3	2	1	2
Diptera										
Chironomidae L	2		14		3	6	7	2		2
Chironomidae P	1	1	1				1			2
Tipulidae										
Simulidae			7	2	1	5		3	4	2
Miscellaneous										
Nematoda	4	1	3	7	6	6	6			7
Collembola						1				
Trichoptera										
Total Invertebrates	15	3	43	13	14	29	27	11	20	28
Total Taxa	4	2	4	3	5	6	4	5	4	6

Appendix II, continued.

	Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.										
Fish Creek downstream of Last Chance Creek.											
July 20, 1992											
	Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera											
	Baetidae	3	1			2	2	3		1	2
	Heptagenidae										
	Siphlonuridae										
	Ephemerellidae										
Plecoptera											
	Leuctradae										
	Perlodidae										
	Nemouridae										
Diptera											
	Chironomidae L	8			1	3	5	2	4		9
	Chironomidae P										
	Tipulidae										
	Simulidae				1	2	1	2			1
Miscellaneous											
	Nematoda				1		1	5	1		4
	Collembola									1	
	Daphnia	40	18	9	105	22	47	48	50	52	30
Trichoptera											
Total Invertebrates		51	19	9	108	29	56	60	55	54	46
Total Taxa		3	2	1	4	4	5	5	3	3	5

Appendix II, continued.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.

Fish Creek downstream of Last Chance Creek
August 24, 1992

	Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera											
	Baetidae								1		
	Heptagenidae										
	Siphlonuridae										
	Ephemerellidae										
Plecoptera											
	Leuctradae										
	Perlodidae										
	Nemouridae									1	
Diptera											
	Chironomidae L	6	3	2	10	21	2		10	4	2
	Chironomidae P				3	1					
	Tipulidae								1	1	2
	Simulidae									1	
Miscellaneous											
	Nematoda				1		4		5	5	
	Collembola										
	Daphnia	7		26	20	26	16	16	21	19	4
Trichoptera											
Coleoptera											
	Dytiscidae				1						
Total Invertebrates		13	3	28	35	48	22	16	38	31	8
Total Taxa		2	1	2	5	3	3	1	5	6	3

Appendix II, continued.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.											
Fish Creek above Fairbanks Creek											
June 17, 1992											
	Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera											
	Baetidae		3	1		1	1	1		1	1
	Heptagenidae							1			
	Siphlonuridae	1					1		2		2
	Ephemerellidae										
Plecoptera											
	Leuctradae							1			
	Perlodidae				1	1				1	
	Nemouridae										
Diptera											
	Chironomidae L	1	1						1		
	Chironomidae P					2					
	Tipulidae									1	
	Simulidae										
Miscellaneous											
	Nematoda		1				5	3	2		3
Trichoptera											
Total Invertebrates		2	5	1	1	4	7	6	5	3	6
Total Taxa		2	3	1	1	3	3	4	3	3	3

Appendix II, continued.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.											
Fish Creek above Fairbanks Creek											
July 1992											
	Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera											
	Baetidae										
	Heptagenidae	2		1	2	2	2		3	4	2
	Siphlonuridae										
	Ephemerellidae										
Plecoptera											
	Leuctradae										
	Perlodidae				1				2	1	
	Nemouridae										
Diptera											
	Chironomidae L	1			1						
	Chironomidae P										
	Tipulidae										
	Simulidae				1					1	
Miscellaneous											
	Nematoda		4	5	2	2	2	2	6	2	4
Trichoptera											
Total Invertebrates		3	4	6	7	4	4	2	11	8	6
Total Taxa		2	1	2	5	2	2	1	3	4	2

Appendix II, concluded.

Number of invertebrates, by family, collected in 0.1 m2 of stream substrate.										
Fish Creek upstream of Fairbanks Creek										
August 24, 1992										
Sample Number	1	2	3	4	5	6	7	8	9	10
Ephemeroptera										
Baetidae	3	3	14	2	7	6	5	4	2	1
Heptagenidae			1				1		1	1
Siphlonuridae						1				
Ephemerellidae										
Plecoptera										
Leuctradae						1				
Perlodidae	7	8	3	2	5	1	1	2	5	1
Nemouridae		4	2					5		
Diptera										
Chironomidae L	74	33	22	5	5	18	4	20	6	6
Chironomidae P	4	7	1	1		1		1		
Tipulidae	1	3	1		1	4		1	2	3
Simulidae		1	1							
Miscellaneous										
Nematoda	1		2		3	5	5	15	6	15
Collembola										
Daphnia	4	3	2		5			5		2
Oligichaeta								1		
Trichoptera										
Phryganeidae		1		1		1			1	
Coleoptera										
Dytiscidae										
Total Invertebrates	94	63	49	11	26	38	16	54	23	29
Total Taxa	7	9	10	5	6	9	5	9	7	7

Appendix III. Quality control and quality assurance data for tissue samples collected in Fish Creek, July 1992. All concentrations are as mg/kg, dry weight basis.

				Duplicate Summary				Matrix Spike Summary			
Analyte	EPA Method	MRL	Method Blank	Sample Result	Duplicate Sample Result	Average	Relative Percent Difference	Spike Level	Sample Result	Spiked Sample Result	Percent Recovery
Al	200.8	0.05	3.51	5.77	5.43	5.6	6	21	5.77	25.7	95
As	200.8	1	ND	1	1	1	<1	8	1	10	112
Be	200.8	0.01	ND	ND	ND	ND	--	4.2		4.13	98
Cd	200.8	0.02	ND	ND	ND	ND	--	4.2		4.4	105
Cr	200.8	0.05	ND	1.18	1.14	1.16	3	8.5	1.18	9.35	96
Cu	200.8	0.05	0.05	1.1	1.3	1.2	17	21	1.1	21.3	96
Pb	200.8	0.02	0.08	0.06	0.05	0.06	17	4.2	0.06	5.08	120
Hg	7471	0.05	ND	0.27	0.3	0.28	11	0.37	0.27	0.57	81
Ni	200.8	0.1	ND	0.4	0.5	0.4	25	8.5	0.4	8.6	96
Ag	200.8	0.02	ND	0.02		NC	NC	4.2	0.02	4.24	100
V	200.8	0.05	ND	0.26	0.24	0.25	8	8.5	0.26	8.64	99
Zn	7950	5	ND	20	19	20	5	42	20	62	100
Ti	200.8	0.1	ND	1.3	1.2	1.2	8	4.2	1.3	5.2	93

ND = not detected at or above the method reporting limit.
NC = not calculated.
MRL = method reporting limit.

Appendix IV. Quality control and quality assurance data for Arctic grayling collected in Fish Creek, October 1992. All concentrations are as mg/kg, dry weight basis.

				Duplicate Summary				Matrix Spike Summary			
Analyte	EPA Method	MRL	Method Blank	Sample Result	Duplicate Sample Result	Average	Relative Percent Difference	Spike Level	Sample Result	Spiked Sample Result	Percent Recovery
Al	200.8	0.4	ND	84.6	80.9	82.8	4	4.9	84.6	87.1	NA
As	200.8	0.5	ND	1.6	1.8	1.7	12	9.7	1.6	11.7	104
Cd	200.8	0.02	ND	0.05	0.05	0.05	<1	0.97	0.05	1.04	102
Pb	200.8	0.02	ND	0.14	0.12	0.13	15	4.9	0.14	5.3	105
Hg	7471	0.01	ND	0.04	0.04	0.04	<1	0.35	0.04	0.34	86
Ai	200.8	0.4		119	117	118	2	4.6	119	120	NA
As	200.8	0.5		2	2.2	2.1	10	9.2	2	11.5	103
Cd	200.8	0.02		0.08	0.08	0.08	<1	0.92	0.08	1.02	102
Pb	200.8	0.02		0.15	0.16	0.16	6	4.6	0.15	5.03	106
Hg	7471	0.01		0.04	0.05	0.04	25	0.42	0.04	0.43	93