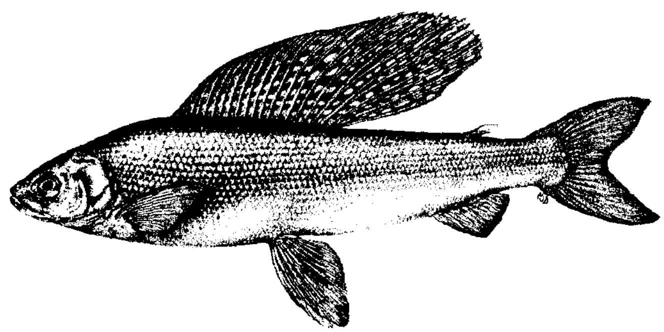
AQUATIC HABITAT OF FISH CREEK BEFORE DEVELOPMENT OF THE FORT KNOX GOLD MINE 1992-1993

By

Phyllis Weber Scannell and Alvin G. Ott

Technical Report 94-5



Alaska Department of Fish & Game
Habitat and Restoration Division
June 1994

AQUATIC HABITAT OF FISH CREEK

BEFORE DEVELOPMENT OF THE FORT KNOX GOLD MINE

1992-1993

By

Phyllis Weber Scannel and Alvin G. Ott

Technical Report 94-5

Frank Rue
Director
Habitat and Restoration
P.O. Box 25526
Juneau, Alaska 99802-55265

June 1994

TABLE OF CONTENTS

List of Tables

List of Figures

ACKNOWLEDGEMENTS

Mr. Alan Townsend of Alaska Department of Fish and Game, Habitat Division led fish sampling efforts for this project and arranged all logistic support. Additional assistance was provided by Mr. Jack Winters and Mr. Carl Hemming of Habitat Division. Mr. Scott Ray and Mr. Jim Vohden, Alaska Department of Natural Resources, Division of Water operated the automated water sampler and flow recorder on Fish Creek and analyzed water samples for sediment content. Mr. Fred Andersen, ADF&G Division of Sport Fish, provided technicians to sort aquatic invertebrate samples. Ms. Sheree Warner provided final editing of this report.

Funding for this project and for all laboratory analyses was provided by a grant from Fairbanks Gold Mining Inc.

INTRODUCTION

The upper Fish Creek drainage, located about 25 km northeast of Fairbanks, Alaska at the headwaters of the Little Chena River, is the site of the proposed Fort Knox open pit gold mine (Figure 1). This drainage supports Arctic grayling (*Thymallus arcticus*), longnose sucker, round whitefish (*Prosopium cylindraceum*), burbot (*Lota lota*), and slimy sculpin (*Cottus cognatus*). Downstream in the Chena River are chum salmon (*Oncorhynchus keta*) and chinook salmon (*O. tshawytscha*). Aquatic habitat in Fish Creek and Fairbanks Creek drainages has been altered extensively by gold mining since the early 1900s.

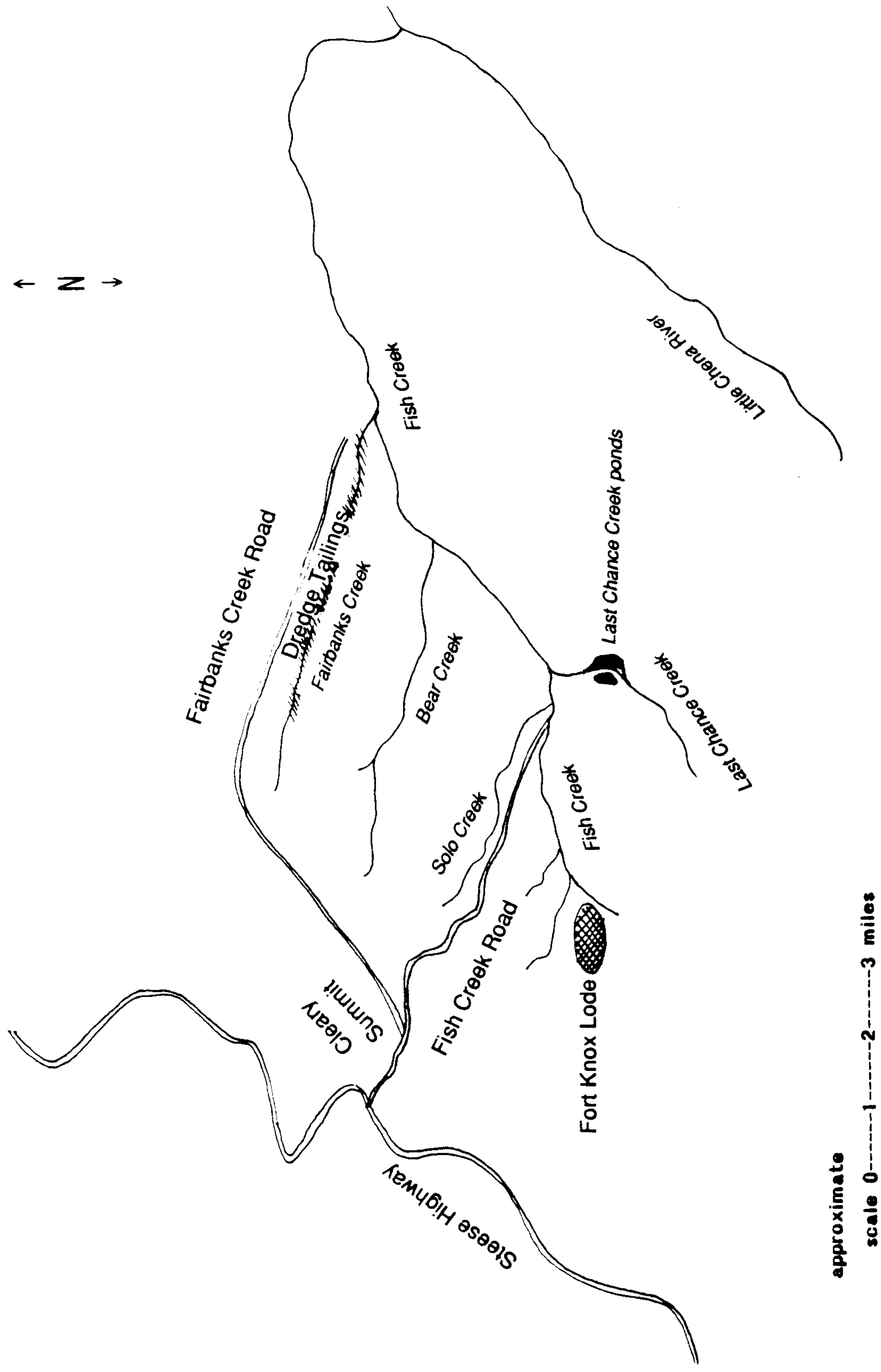
As proposed, the Fort Knox gold mine will process 35,000 to 50,000 tons of ore per day. The mill will require approximately 0.6 m^3s^{-1} process water; approximately 0.4 m^3s^{-1} will be supplied by recycling from the tailings pond and 0.2 m^3s^{-1} will be from runoff, drainage, or from water stored in the reservoir. The freshwater reservoir will provide water during initial years of operation, during years of low precipitation, and during winter months. Fairbanks Gold Mining Inc. estimates the freshwater reservoir will impound or regulate approximately 30% of the downstream flow in Fish Creek (Fairbanks Gold Mining Inc. 1992).

Development and operation of the Fort Knox gold deposit probably will produce considerable changes in flow conditions in Fish Creek from the tailings impoundment to Bear Creek. Diminished stream flow may limit fish migration into upstream areas. Water quality in Fish Creek and its receiving waters may improve when the freshwater dam is constructed and when sufficient reclamation occurs to stabilize abandoned placer mining areas. Improved water quality should result in changes in fish use of this drainage.

In 1992, Fairbanks Gold Mining Inc. (FGMI) contracted with Alaska Department of Fish and Game (ADF&G) to conduct a 2-year fisheries habitat assessment of Fish Creek, including tributary streams that may be affected by development of the Fort Knox gold mine.

The goal of this habitat assessment was to determine baseline conditions of Fish Creek and its suitability for fish before development of a hard rock mine and associated facilities. In addition, habitat assessment data were used to develop an environmental assessment, assess both negative and positive environmental changes, to develop a future monitoring program, and to provide a basis for permit decisions and mitigation. Results from the first year of baseline studies are reported in Weber Scannell and Ott (1993). In 1993 the fisheries component of the study was expanded to include abandoned settling ponds connected to Last Chance Creek.

Figure 1. Fish Creek drainage, showing locations of ADF&G sampling sites, 1993.



Objectives

The objectives of the 1993 study were:

(1) to determine use of Fish Creek by fish, including identification of spawning and rearing areas, abundance of fish, and species present;

(2) to determine the importance of small ponds connected to flowing water for rearing Arctic grayling;

(3) to monitor the water quality and quantity of Fish Creek upstream of the confluence with Fairbanks Creek;

(4) to compare benthic invertebrate populations between undisturbed Bear Creek and disturbed Fish Creek; and

(5) to determine concentrations of select metals in Arctic grayling that inhabit the Fish Creek drainage above the site of the proposed impoundment.

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

Historical Fisheries Information

ADF&G surveyed the Little Chena River between Sorrels Creek and the Chena Hot Springs Road crossing in August 1971. Tack (1972) found Arctic grayling and round whitefish upstream of the mouth of Fish Creek and young-of-the-year Arctic grayling in pools. 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). Tack described the Little Chena River above the mouth of Fish Creek 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.

Holmes (1985) surveyed the Little Chena River below the Chena Hot Springs Road crossing in June 1984. 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. According to Holmes, none of the fish sampled was of spawning size and length-at-age values for Little Chena River Arctic grayling were consistently smaller than for Chena River fish.

Dames and Moore (1991) documented the presence of adult and young-of-the-year Arctic grayling in Last Chance and Solo creeks in summer 1991. In 1992, ADF&G found burbot, Arctic grayling, longnose sucker, round whitefish, and slimy sculpin in Fish Creek near Fairbanks Creek. Arctic grayling and burbot were found in the upstream reaches of Fish Creek, and round whitefish and Arctic grayling were found in Bear Creek (Weber Scannell and Ott 1993).

Turbid water conditions attributed to upstream placer mine operations located on Fairbanks and Fish creeks were reported by Tack (1972), Holmes (1985), and Weber Scannell and Ott (1993). 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 in the Little Chena River was between 7 and 9 NTU from 1989 through 1993, except in 1992 when the average was 31 NTU (Table 1).

Table 1. Average turbidity and total suspended solids at the Little Chena River gauging station between 1989 and 1992. Seasonal averages were calculated from four composite samples per day. Data courtesy of J. Vohden, Department of Natural Resources.

Year	Turbidity NTU	Total Suspended Solids, mg/L	No. of Samples
1989	7.2	59.3	62
1990	8.5	48.6	94
1991	9.1	71.9	111
1992	31	61.4	88
1993	9.1	56.6	136

METHODS

Sampling Sites

ADF&G established 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 in 1992 (Weber Scannell and Ott 1993). Sampling sites established in 1992 were continued in 1993. The number of pool/riffle sequences in Bear Creek and Fish Creek (near Last Chance Creek) were increased. Benthic invertebrate sampling was limited to Fish Creek near Fairbanks Creek, Bear Creek, and Last Chance Creek. In addition, we sampled Solo Creek, all outlets from settling ponds and side channels in Last Chance Creek and Fish Creek near the Polar Mining Operation, and two abandoned settling ponds in Last Chance 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 1000 ml Nalgene® cubitainers and kept refrigerated until analyzed for turbidity and total suspended solids. The Alaska Department of Natural Resources, Division of Water, Water Quality Laboratory conducted all water quality analyses. U.S. Environmental Protection Agency (USEPA) method 180.1 was used for turbidity and USEPA method 160.2 for total suspended solids.

Temperature, flow, turbidity, and total suspended solids were measured in Fish Creek upstream of Fairbanks Creek. Water level was measured with a pressure transducer and automated recorder, calibrated with stream flow measurements taken throughout the year.

Water was sampled for turbidity and total suspended solids four times daily with an automated water sampler. Daily water samples were composited into one sample to give an average amount for the day. Temperature was recorded by an automated temperature recorder.

Water samples were collected from the Last Chance Creek ponds in July with a VanDorn water sample bottle. In November, we collected water samples with a peristaltic pump. Dissolved oxygen was measured with a Corning Checkmate® dissolved oxygen meter calibrated in air and with zero oxygen standard, or with Winkler titrations.

Fish Population Sampling

We sampled Last Chance, Solo, Fish, and Bear creeks to estimate fish abundance. In each creek we made one pass upstream through each pool-riffle sequence with an electrofisher. Fish were sampled in the Last Chance Creek ponds by angling and with a fyke-net.

Fish collected in May, June, and July were identified, measured to fork length, and released. Arctic grayling greater than 150 mm were marked with numbered Floy tags and adipose fin clips before release. Arctic grayling smaller than 150 mm were marked with an adipose clip.

Aquatic Invertebrate Communities

We collected benthic invertebrates in June and August from Fish Creek upstream of Fairbanks Creek and from Bear Creek, and in late June from Last Chance Creek. Ten 0.1 m^2 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 lowest practical taxonomic level.

METALS CONTENT IN FISH TISSUES

Twenty four Arctic grayling (150 to -180 mm) were collected in August from the ponds in Last Chance Creek to analyze for whole body concentrations of Al, As, Cd, Pb, and Hg. The fish were weighed, measured, and packed in pre-cleaned jars (EPA protocol C, Series 300), and frozen. Fish samples were submitted to a private analytical laboratory where they were digested and analyzed for As, Al, Cd, Pb using inductively coupled plasma emission spectroscopy (ICP-MS) and for Hg with cold vapor atomic absorption spectrophotometry.

RESULTS

Fish Creek and Tributaries

Water quality

The water stage recorder operated continuously from May 19 through September 19, water and air temperatures were monitored from July 14 through November 19, and turbidity and total suspended solids were sampled from May 19 through September 18. No water samples were collected from June 17 through July 12; a high water event buried the intake hose with sediment.

Fish Creek continued to have high sediment loads and high turbidity throughout most of 1993 (Table 2). Water quality in Fish Creek near Last Chance Creek was poorest in July when exposed ice lenses melted and eroded into the creek. At this time, we measured settleable solids contents of 7.5 mg/L.

The total sediment load for Fish Creek (measured upstream of Fairbanks Creek) for the period May 20 through September 19 was 5435 tons, and the average sediment loading for the time period was 57 tons per day.

Fish Creek had elevated turbidity and suspended solids during most of the sample times from May through September. Turbidity levels exceeded the State Water Quality Criterion of 25 NTU for aquatic life on all days sampled in May, June, and September (Figure 2). Turbidity was less than or equal to 25 NTU on 11 of the 19 days sampled in July and on 1 of the 31 days sampled in August (Appendix I). Except during breakup, both turbidity and sediment loading increased with increases in stream flow (Figure 2).

All study sites had cold water, although Bear and Solo creeks have the lowest water temperatures of any of the streams sampled (Table 3). Water temperatures in July, the highest measured during the season, were only 7.9°C in Bear Creek and 9°C in Solo Creek. Water quality in both of these creeks is good with low turbidity and low concentrations of total suspended solids. Both creeks are incised, mostly shaded, and flow from north-facing slopes. Stream water at all sites was of low alkalinity and low hardness (Table 3).

Table 2. Water quality and temperature measured in the Fish Creek at Fairbanks Creek, 1993. Data from Ray and Vohden 1993.

		Water temp,˚C	Air temp, ˚C	Flow CFS	Turbidity NTU	TSS mg/L	Sediment Load tons/day
May	avg.			54.6	74.1	1184.8	201.5
	max.			75.0	100.0	1790.0	304.0
	min.			41.9	39.0	801.0	139.0
	n			13	12	12	12
June	avg.			39.9	85.6	883.8	105.5
	max.			74.7	100.0	1240.0	149.0
	min.			29.1	70.0	563.0	58.8
	n			30	16	16	16
July	avg.	12.0	17.0	28.6	23.7	50.2	4.0
	max.	13.1	21.0	59.6	38.0	122.0	9.5
	min.	11.0	14.7	21.5	9.4	22.6	1.6
	n	18	18	31	19	19	19
Aug.	avg.	8.3	10.8	31.6	80.0	143.9	16.8
	max.	12.4	18.5	55.9	290.0	774.0	114.0
	min.	5.3	6.0	20.3	25.0	26.8	2.2
	n	31	31	31	30	30	30
Sept.	avg.	3.7	4.2	50.6	145.2	354.3	312.0
	max.	7.7	14.1	76.7	270.0	1760.0	5435.1
	min.	-0.3	-6.7	36.5	34.0	138.0	16.9
	n	30	30	19	23	23	20
Oct.	avg.	0.0	-4.0				
	max.	1.3	8.1				
	min.	-0.3	-17.3				
	n	29	29				
Nov.	avg.	-0.3	-11.9				
	max.	-0.3	-1.2				
	min.	-0.3	-36.2				
	n	19	19				

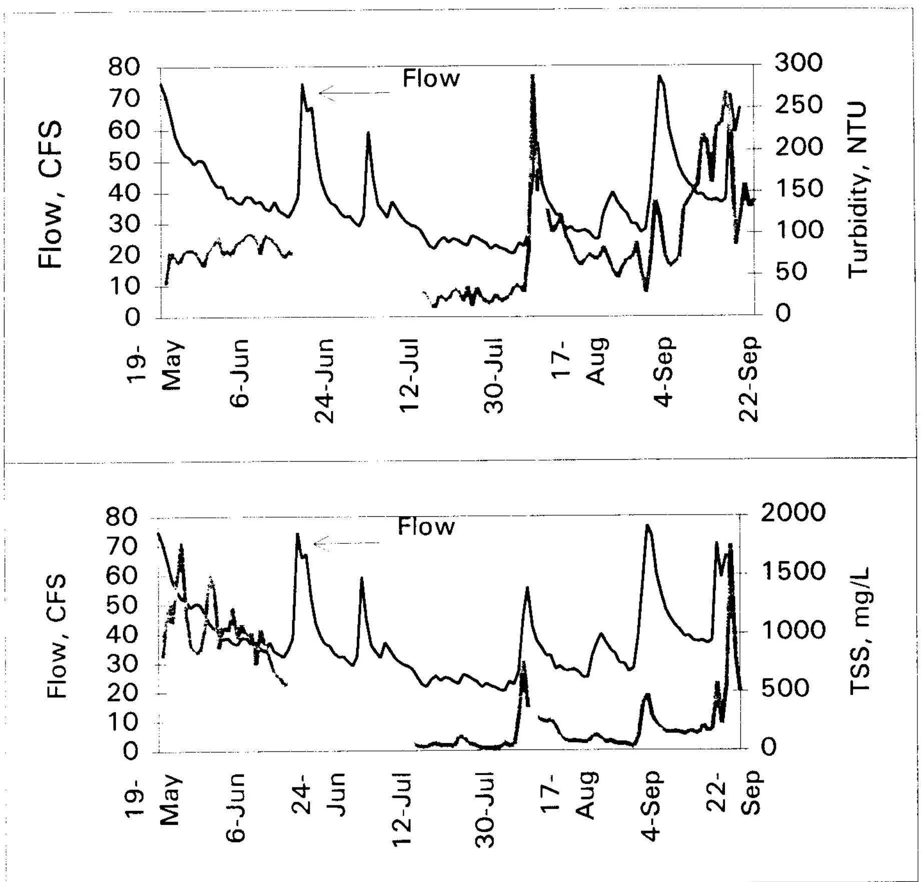
ND = not detected
Data from Ray and Vohden 1994.

Table 3. Water quality conditions at sample sites in the Fish Creek drainage, 1993.

	Date Sampled	Temp. °C	Settleable Solids ml/L	Turbidity NTU	TSS mg/L	Alkalinity mg/L	Hardness mg/L
Fish Creek	5/18/93				17.9	30***	
below	5/25/93	6.9	0.2	110	418	24.1	39.2
Last Chance	5/27/93	6.9					
Creek	6/18/93	8.8	tr			35	47
	7/13/93	13	tr				
	7/14/93	13	tr			45	59
	8/9/93	10	7.5			51.5	80
Fish Creek	5/18/93	6.4	tr	55	199	17.9	30
above	6/17/93	9.8	tr			41	53
Fairbanks	7/13/93	12	tr				
Creek	7/14/93		tr			48	63
	8/10/93	9.8	<0.2			40.6	58
Last Chance	5/17/93	0.2					
Creek	5/25/93					23.2	36.4
	5/27/93	6.3					
	6/18/93	11	tr			40.8	55
	7/14/93	17	tr			53	67.2
	8/9/93	10	nd			41	55
Bear Creek	5/19/93	3.1	tr	5.7	51.4	18	29.5
	7/12/93	7.9	nd			57.5	7.9
	8/11/93	5				37.5	52
Solo Creek	5/25/93	6.3		1.6	9.05	22	36
	5/27/93	3.8					
	6/18/93	6.9	tr			22.6	35.2
	7/14/93	9	nd			51	66.8
	8/9/93	7.3	nd			41	55

nd = not detected, tr = trace

Figure 2. Comparison of turbidity and total suspended solids with stream flow in Fish Creek at Fairbanks Creek. Data from Alaska Department of Natural Resources, Division of Water (Vohden 1994).



Abundance of Fish

Fish were sampled throughout the summer (May through August) in Bear, Solo, Last Chance creeks and Fish Creek near Last Chance Creek and near Fairbanks Creek. Arctic grayling was the most abundant fish species in all sample sites. Young-of-the-year Arctic grayling were collected in all sample sites except Solo Creek. Fry were most numerous in turbid water effluent from settling ponds located in the Fish Creek floodplain. These ponds were used for placer mining through 1993. Fry also were abundant in Last Chance and Fish creeks downstream of the settling ponds.

In all sites, the number of fish caught increased between May and August (Table 4). The abundance of all species of fish increased in all sites sampled from May to August. In May, only 3 Arctic grayling and 2 round whitefish were captured in Bear Creek. By August, we captured 24 Arctic grayling, 1 round whitefish, and 2 slimy sculpin. In Fish Creek at Fairbanks Creek, we captured 9 Arctic grayling in May and 41 in August.

Eighteen juvenile burbot were collected in a turbid water seep emerging from a Fish Creek settling pond during August. All of these fish were collected near the road crossing and the outlet from the Fish Creek settling ponds. These burbot ranged from 80 to 110 mm length. Although not collected, more burbot in the same size range were observed. The most fish were found in Fish Creek at Fairbanks Creek. We estimated fish density from the average number of fish collected per pool/riffle sequence (Table 5). The highest density of fish were found in Fish Creek near Fairbanks Creek and in Last Chance Creek and the lowest fish density in Bear Creek. Solo Creek is a deeply incised creek with dense willow brush. We were not able to identify and sample discrete pool/riffle sections of Solo Creek.

Table 4. Number of fish, by species, collected from each tributary stream.

	Date	Arctic Grayling	Burbot	Round Whitefish	Slimy Sculpin
Fish Creek at Last Chance Creek	5/17/93	12	0	0	0
	6/18/93	13	1	2	0
	7/14/93	28	1	4	0
	8/9/93	29	18	1	0
Fish Creek at Fairbanks Creek	5/18/93	9	0	0	1
	6/17/93	22	0	9	3
	7/13/93	40	2	26	37
	8/10/93	41	2	10	29
Last Chance Creek	5/17/93	11	1	0	0
	5/27/93	12	0	0	0
	6/4/93	16	0	0	0
	6/18/93	53	1	0	0
	7/14/93	66	0	0	0
	8/9/93	71	3	0	0
Bear Creek	5/19/93	3	0	2	0
	7/12/93	17	0	0	3
	8/11/93	24	0	1	2
Solo Creek	5/17/93	6	0	0	0
	6/18/93	1	0	0	0
	7/14/93	10	0	0	0
	8/9/93	29	0	0	0

Table 5. Total fish and average fish per pool/riffle section collected in the Fish Creek drainage, 1993. Only data from sampling discrete pool/riffle sections are included.

Stream Site	Date Sampled	Total Fish	Average fish per pool/riffle
Fish Creek at Last Chance Creek	6/18/93	16	3
	7/14/93	33	6
	8/9/93	48	8
Fish Creek at Fairbanks Creek	6/17/93	34	7
	7/13/93	105	21
	8/10/93	82	16
Bear Creek	5/19/93	5	<1
	7/12/93	20	3
	8/11/93	27	3
Last Chance Creek	6/18/93	54	14
	7/14/93	66	17
	8/9/93	74	19

Size Distribution of Arctic grayling

Arctic grayling in Last Chance Creek ranged from 110 to 220 mm (Figure 3); there was no consistent change in the size distribution of these fish throughout the summer.

Arctic grayling collected in Fish Creek near Last Chance Creek were divided into two groups: those collected below the confluence with Last Chance Creek (Figure 4) and those collected upstream of the confluence with Last Chance Creek (Figure 5). Fish from both areas ranged from 40 mm to 280 mm. Juvenile fish (<100 mm) were more common in August than in earlier months and most of the small Arctic grayling were collected in the upper section of Fish Creek.

Arctic grayling in Fish Creek at Fairbanks Creek (Figure 6) and Bear Creek (Figure 7) showed similar age structure as fish collected in the upper reaches of Fish Creek. The majority of fish were from 140 mm to 200 mm until August when small (50-60 mm) fish were collected. Arctic grayling in Solo Creek ranged from 150 mm to 180 mm in May; by June we found larger fish from 230 to 270 mm. Few fish in the 150-170 size range were found in August. No young-of-the-year Arctic grayling were found in Solo Creek (Figure 8) in May through August.

Figure 3. Size distribution of Arctic grayling collected in Last Chance Creek in 1993.

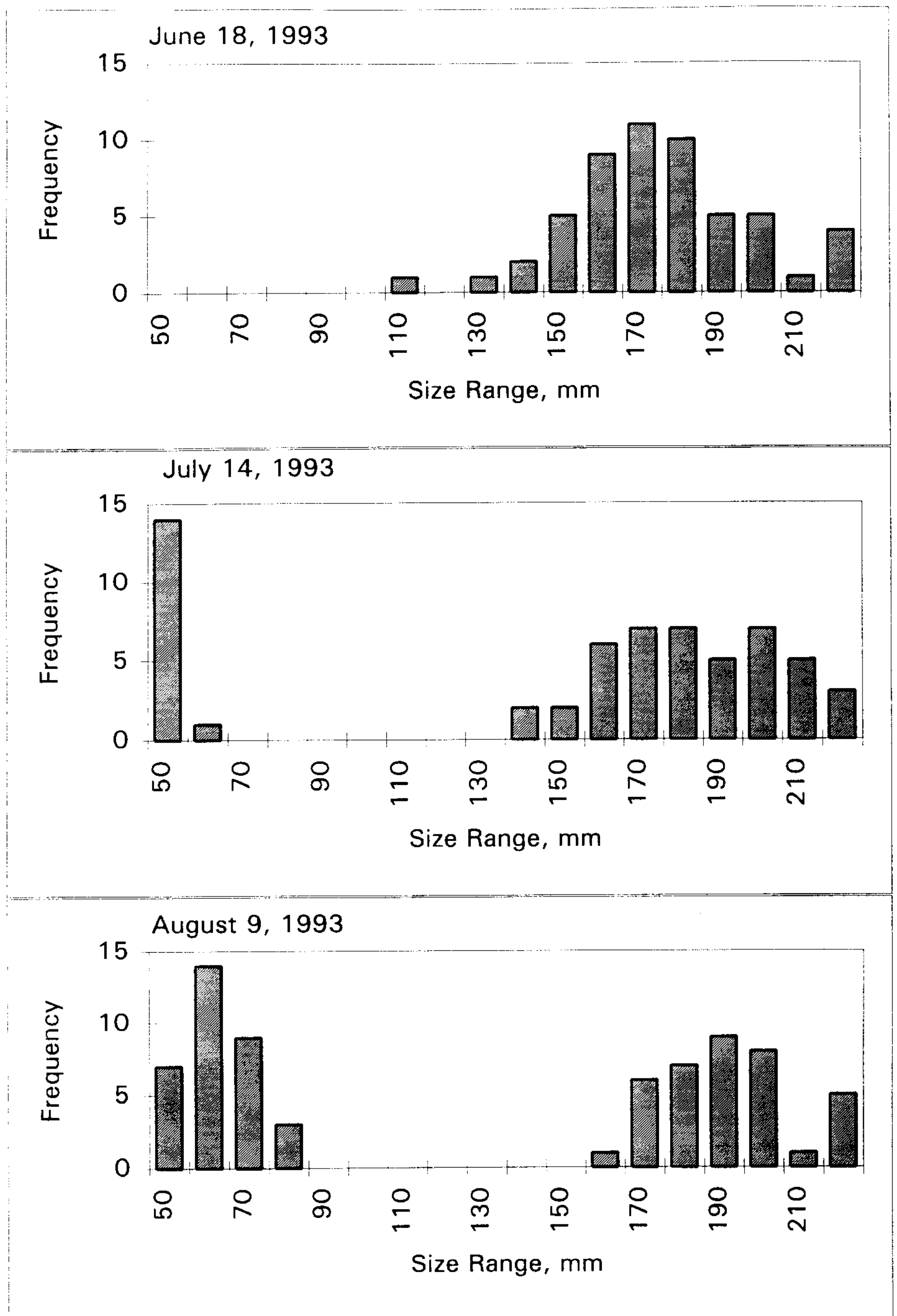


Figure 4. Size distribution of Arctic grayling collected in Fish Creek downstream of Last Chance Creek in 1993.

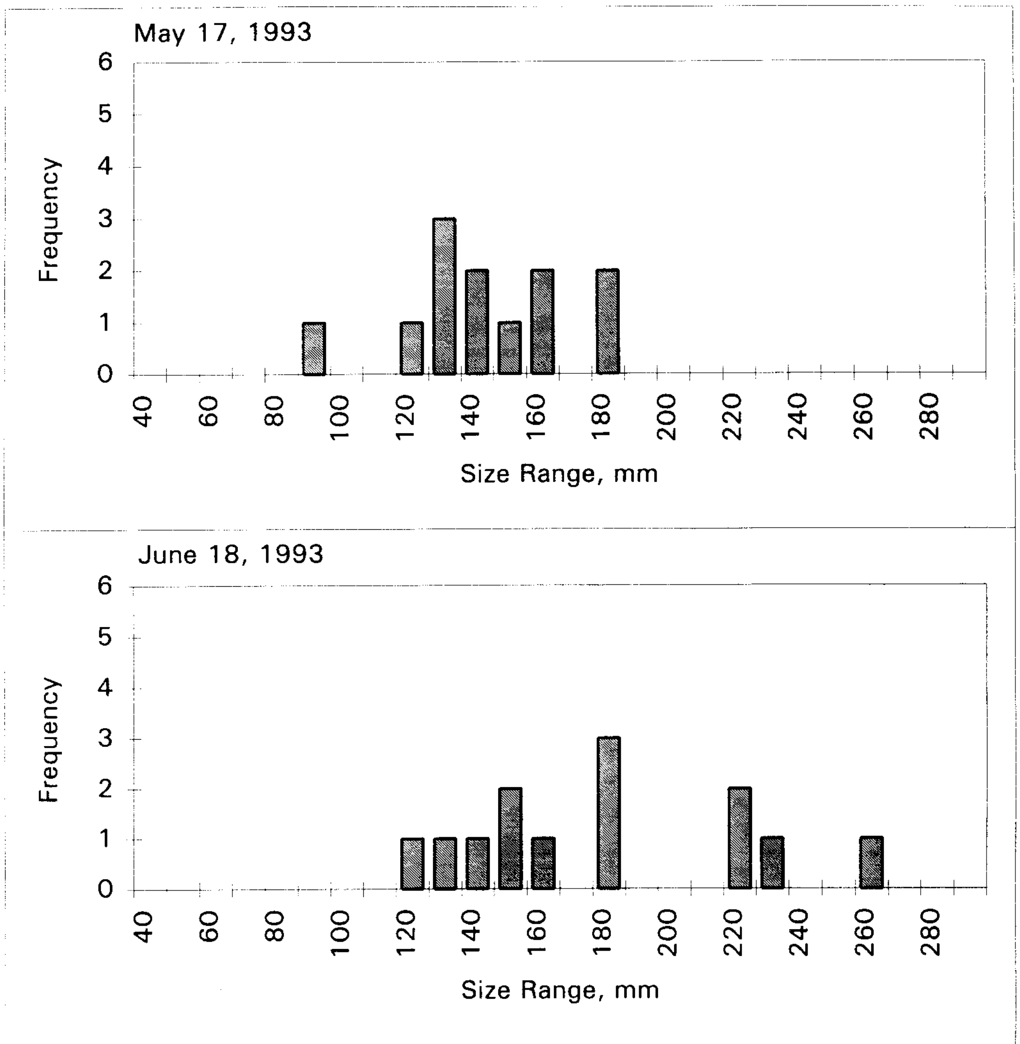
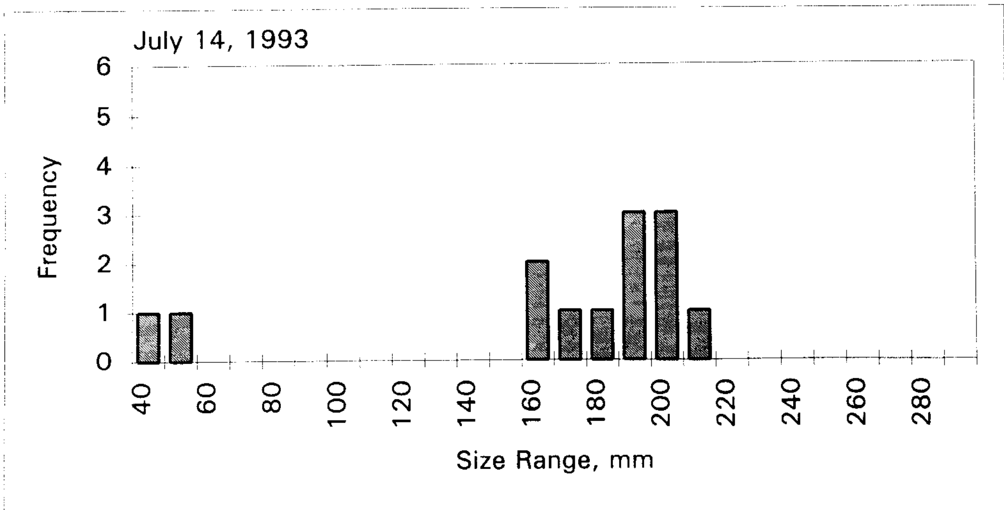


Figure 4, continued.



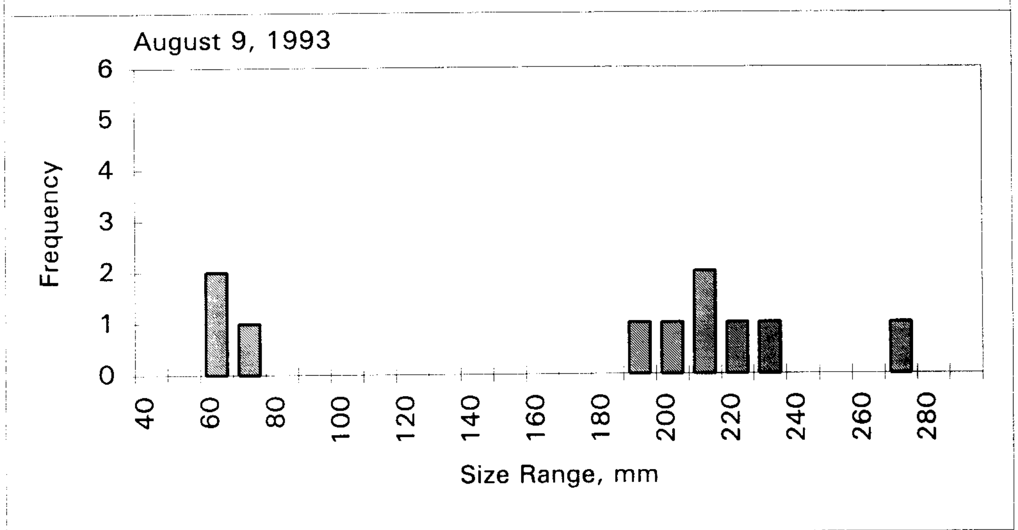


Figure 5. Size distribution of Arctic grayling collected in Fish Creek upstream of Last Chance Creek in 1993.

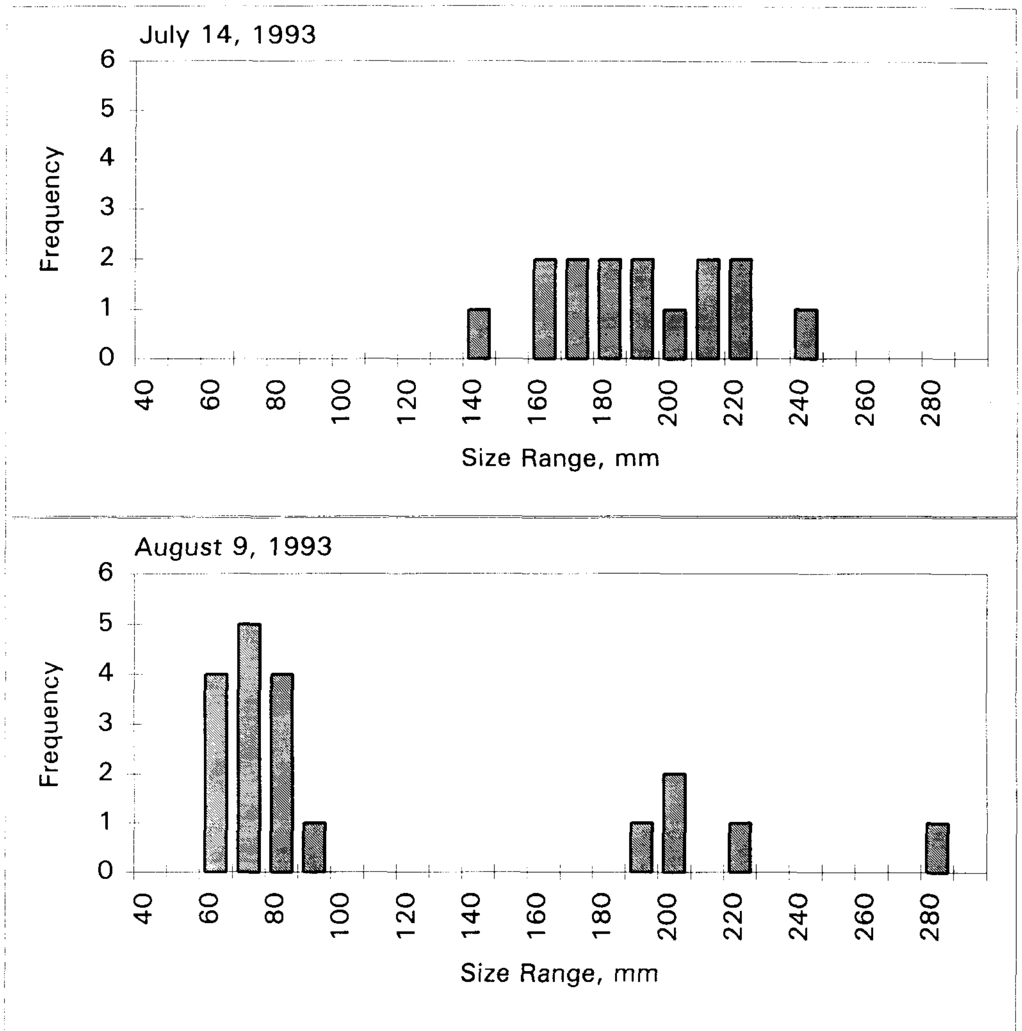


Figure 5, continued.

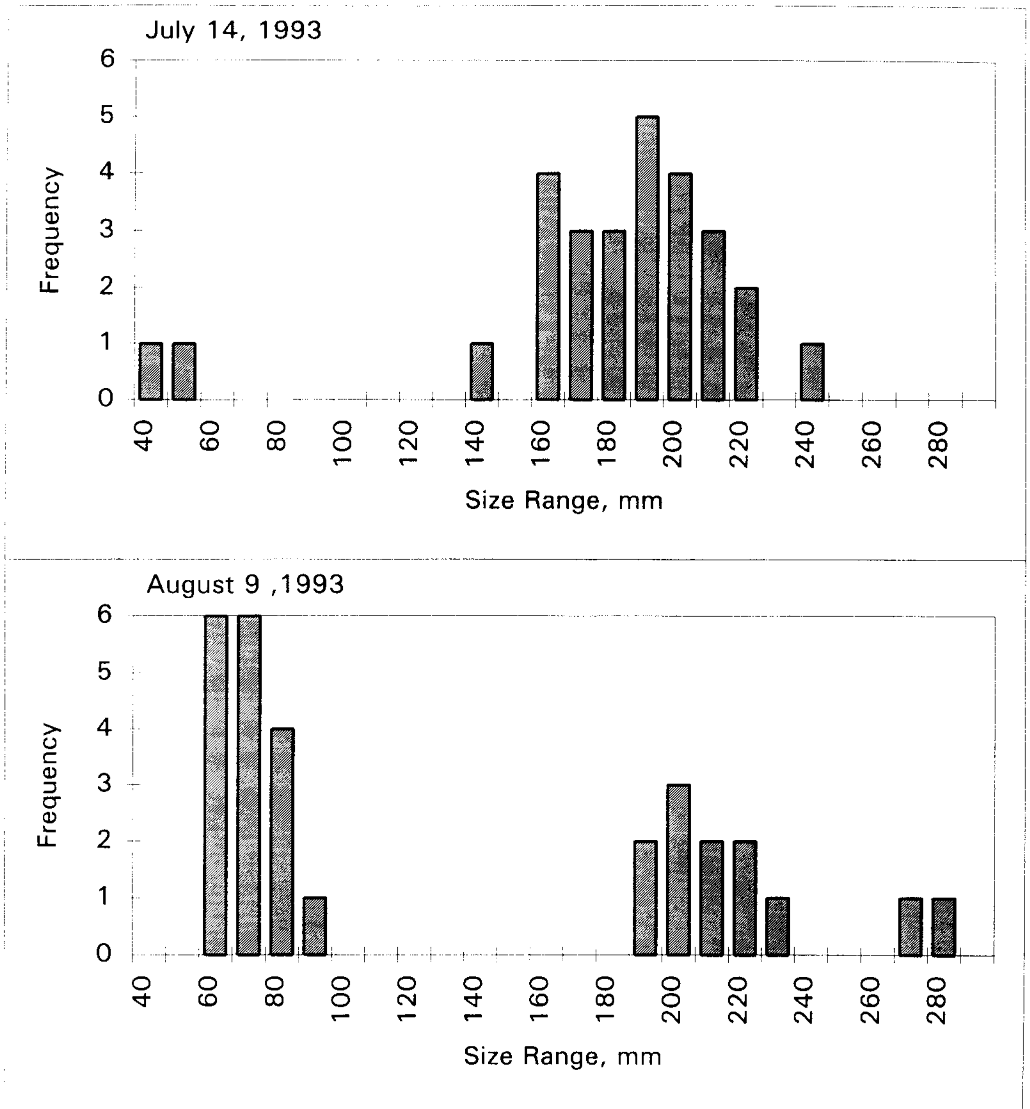


Figure 6. Size distribution of Arctic grayling collected in Fish Creek upstream of Fairbanks Creek in 1993.

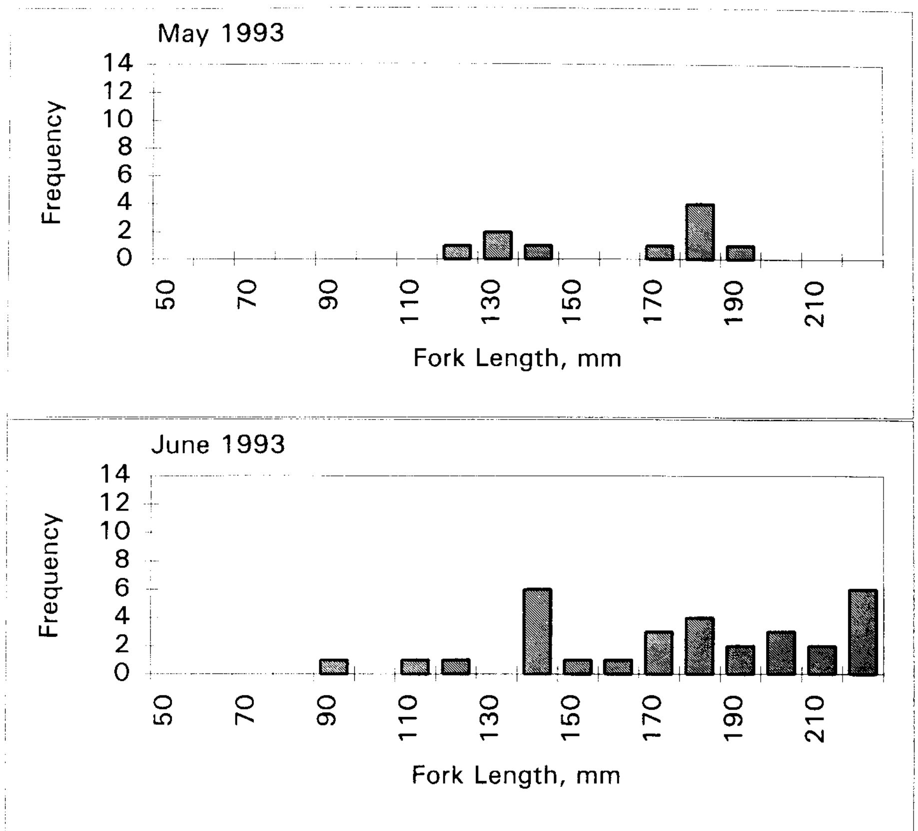


Figure 6, continued.

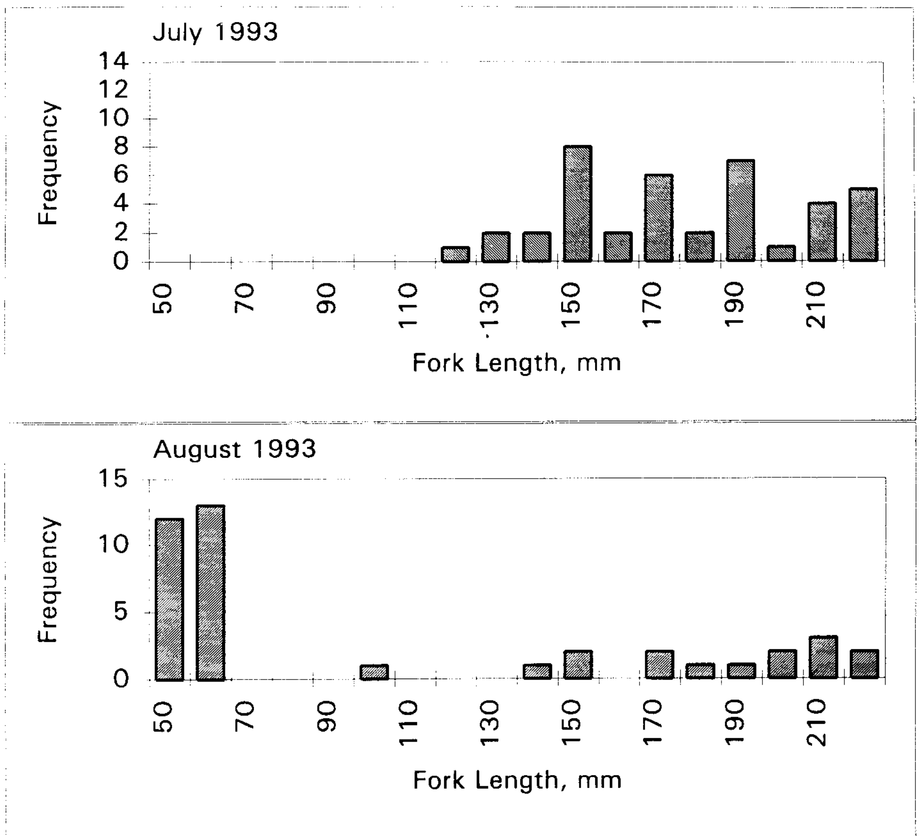


Figure 7. Size distribution of Arctic grayling collected in Bear Creek in 1993.

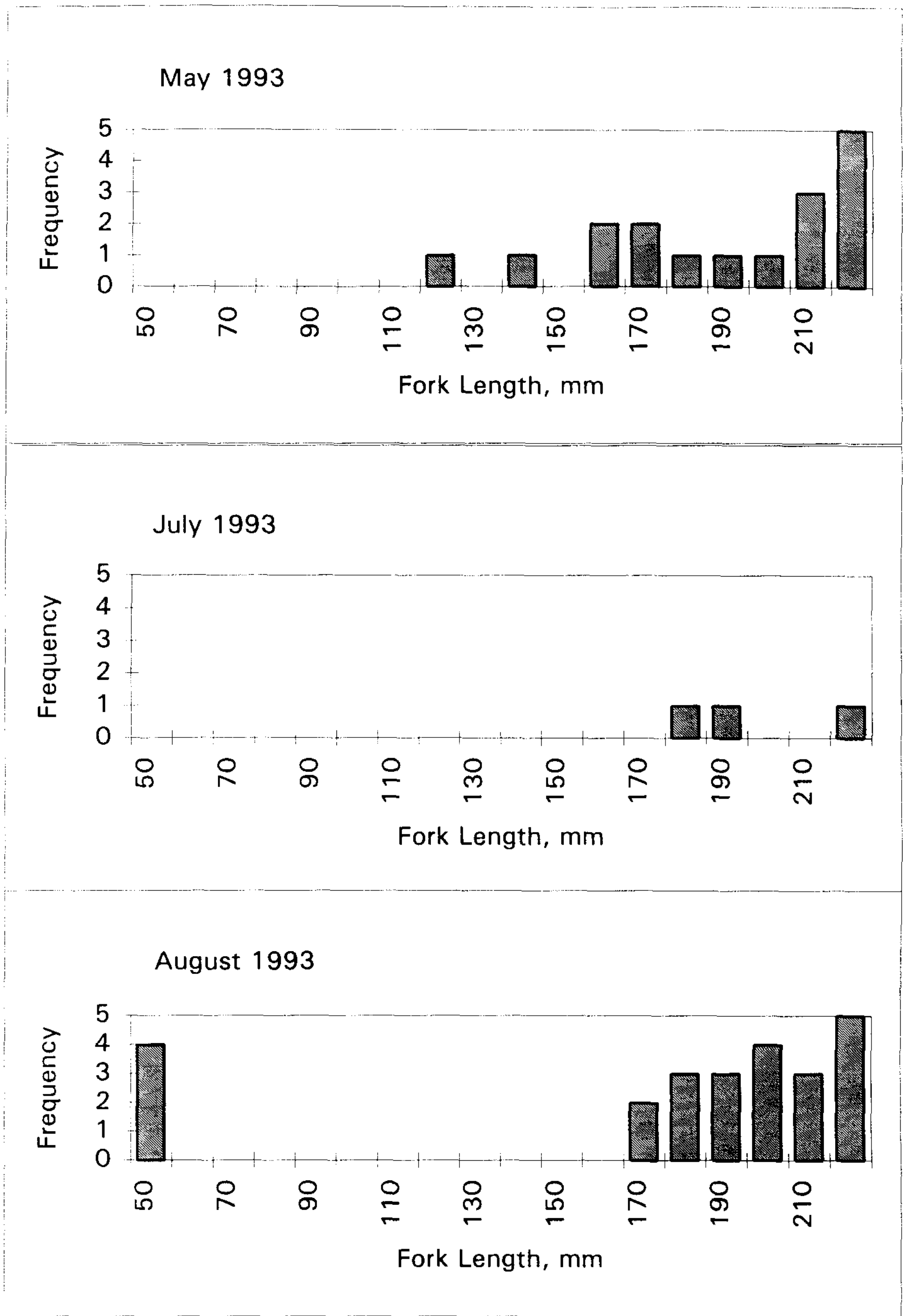
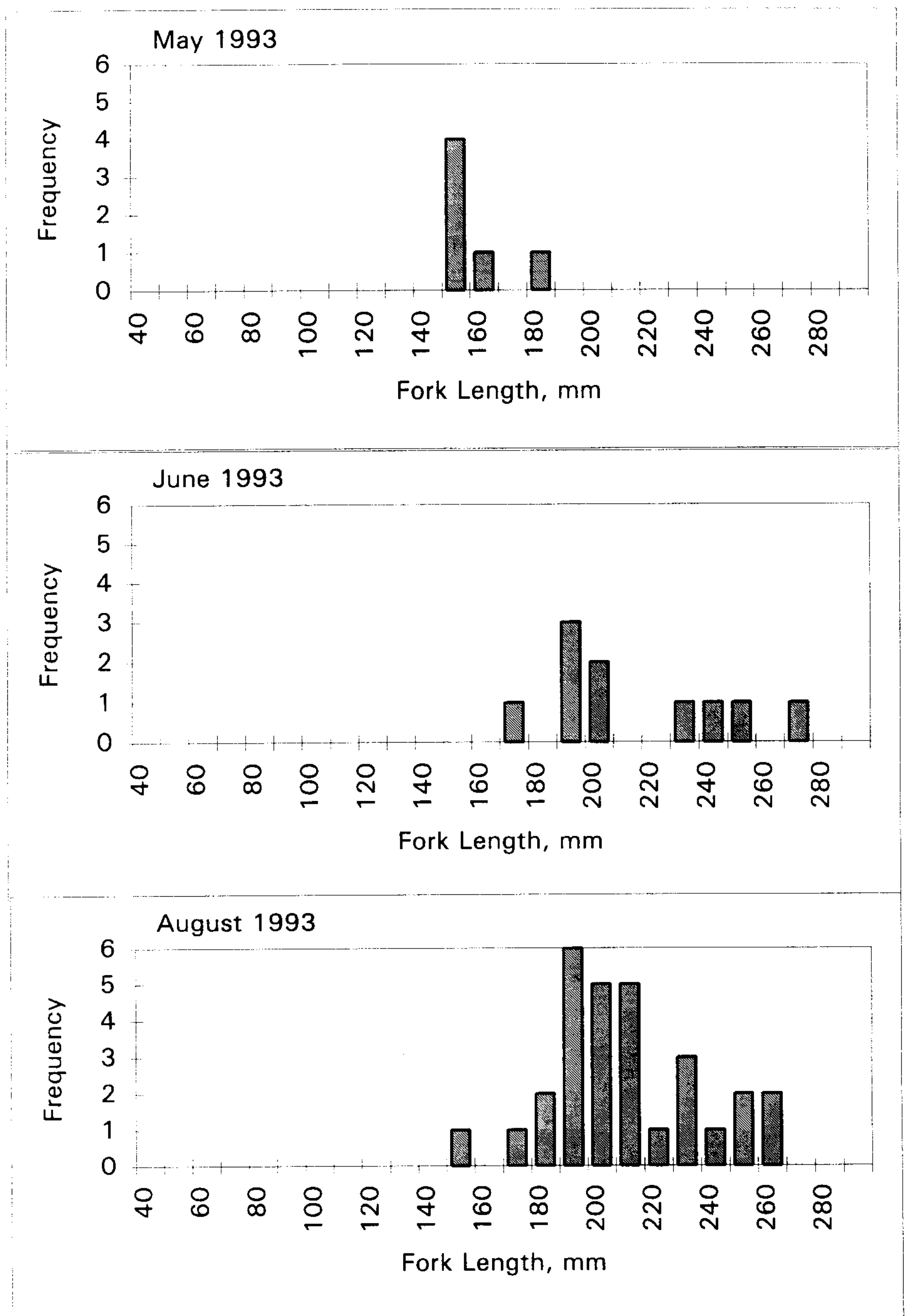


Figure 8. Size distribution of Arctic grayling collected in Solo Creek in 1993.



Movement of Fish

In 1992 and 1993 we tagged 541 Arctic grayling in Fish, Last Chance, Solo, and Bear creeks. Sixty-three of the 541 fish were tagged in 1992. We recaptured 102 of the tagged Arctic grayling at least once. Arctic grayling movement between sample areas was minimal with most recaptures made in the same area as the original capture, except for fish tagged in Fish Creek at Last Chance Creek. Of the twelve fish recaptured from fish tagged in this site, 10 were captured in a different location. In contrast, of the 26 recaptures of fish tagged in the upper Last Chance Creek pond, 25 were originally tagged in the same location. Long-range movements were found for only three fish:

1. A 244 mm Arctic grayling tagged on 7/22/92 in Fish Creek near Fairbanks Creek was recaptured at the same location on 8/25/92 and recaptured again in the Chena River near Nordale Road on 7/7/93.

2. A 210 mm Arctic grayling tagged on 8/25/92 in Bear Creek was recaptured in Solo Creek on 8/9/93; and

3. A fin-clipped juvenile Arctic grayling stocked in the Chena River during the summer of 1993 was collected in Bear Creek in 1993.

LAST CHANCE CREEK PONDS

The Last Chance Creek ponds were formed from abandoned placer mining settling ponds and most likely an old mine cut (Figure 9). The surrounding riparian areas have revegetated with shrubs and herbaceous plants; the shrubs are primarily willow (*Salix* spp.). Smaller ponds adjacent to the Last Chance Creek ponds have since filled in with sediments and are revegetated with wetland plant species (Figure 10); the most common plant appears to be cotton grass (*Eriophorum* spp.). Berms along the ponds (Figure 11) contain ancient organic mucks that are gradually eroding into the ponds, contributing both coarse and fine organic matter. Littoral areas contain abundant emergent vegetation (Figure 12).

Water Quality

We measured water quality conditions in the Last Chance Creek Ponds in July and November. In July, both the upper and the lower ponds at Last Chance Creek contained high concentrations of dissolved oxygen.

Water depth in the upper pond dropped quickly and reached maximum depth near the center, where it was approximately 4 meters. In the upper pond, concentrations ranged from 11 to 11.7 mg/L at all sites (Table 6). The small, shallow extension of the upper pond contained lower concentrations of oxygen; we measured concentrations of 6.2 to 7.6 mg/L at the surface. This section of the pond also had somewhat lower pH values (from 6 to 6.2). Water temperatures were similar in both sections of the pond, from 19.5 to 21°C.

In November, water temperatures in the upper pond were 2.4°C at the surface and at 2.5 m, water temperature in the lower pond was -0.6° C. The upper pond contained from 5.9 mg/L dissolved oxygen at the surface to 8 mg/L at 1.5 m. We were unable to pump water from the lower pond; the cold water froze in the intake hose.

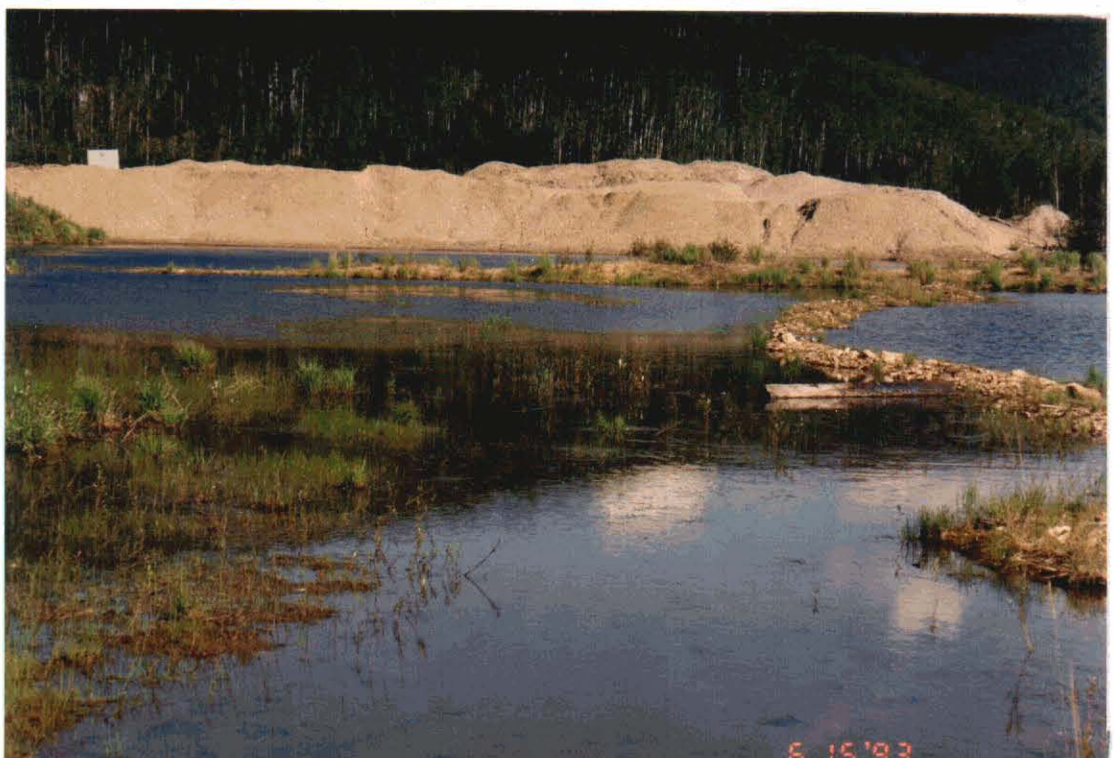
Water in the lower pond on Last Chance Creek was consistently colder in May though November than the upper pond (Table 7). The upper pond is fed entirely by groundwater and contains a larger surface area of shallow water and the lower pond is fed by

Figure 9. Last Chance Creek ponds showing riparian vegetation.

Figure 10. Wetland complexes adjacent to Last Chance Creek ponds.

Figure 11. Sediments and organic mucks on far shore of Last Chance Creek ponds.

Figure 12. Emergent aquatic vegetation in littoral areas of Last Chance Creek ponds.



groundwater from the upper pond and by Last Chance Creek. Maximum depth in both ponds is 4 m.

Table 6. Water quality conditions in Last Chance Creek ponds, July 19, 1993.

Site	Temp. °C	Oxygen mg/L	pH	Alkalinity mg/L	Hardness mg/L
Upper pond 1					
surface	19.1	11.0	6.7	60	71
2 m	20.7	11.1		59.5	75
4 m	16.8	10.1		56.7	69
Upper Pond 2	19.5	7.6	6.1	65	71
Lower Pond	14.9	8.8	7.0	44.6	59

Table 7. Water temperature in the Last Chance Creek ponds.

Date	Upper Pond Temp.°C	Lower Pond Temp.°C
5/28/93	15	6.3
6/4/93	18	8.7
6/11/93	15	10
6/13/93	16	7
6/15/93	16	
8/12/93		9
11/24/93	2.4	-0.6

Abundance of Fish

Arctic grayling were collected by angling in both the upper and lower ponds in late May and June, 1993. We sampled fish for recapture in the lower pond in mid-August and in the upper ponds in late August (Table 8). Using the adjusted Peterson estimate (Ricker 1975), we estimated 2013 Arctic grayling in the lower pond (95% confidence interval = 1513 - 2739 fish) and 2289 Arctic grayling in the upper pond (95% confidence limit = 1800-2817 fish).

Table 8. Arctic grayling collected and tagged in Last Chance Creek ponds, 1993.

	Date	Number of Fish Marked	Number Recaptured	Number of Fish >150 mm
Lower Pond	5/28/93	62		42
	6/4/93	85	3	20
	6/11/93	52	7	18
	6/13/93	93	10	24
Recapture Event	8/12,13/93	270	45	218
Upper Pond	5/28/93	50		29
	6/4/93	75	1	45
	6/11/93	99	5	39
	6/13/93	112	9	49
	6/15/93	117	20	59
Recapture Event	8/25,26/93	295	72	346

Arctic grayling in the Last Chance Creek ponds were of similar size: in both the upper and lower ponds the majority of fish were from 120 to 170 mm fork length (Figures 13 and 14) and the size of fish in the ponds did not change appreciably throughout the summer. Only one Arctic grayling greater than 250 mm was found in the lower pond and none of that size in the upper pond. No young-of-the-year fish were found in the ponds, however we did observe some young-of-the-year (50-60 mm) fish in the stream connecting the two ponds.

Figure 13. Size distribution of Arctic grayling collected in the upper pond in Last Chance Creek, 1993.

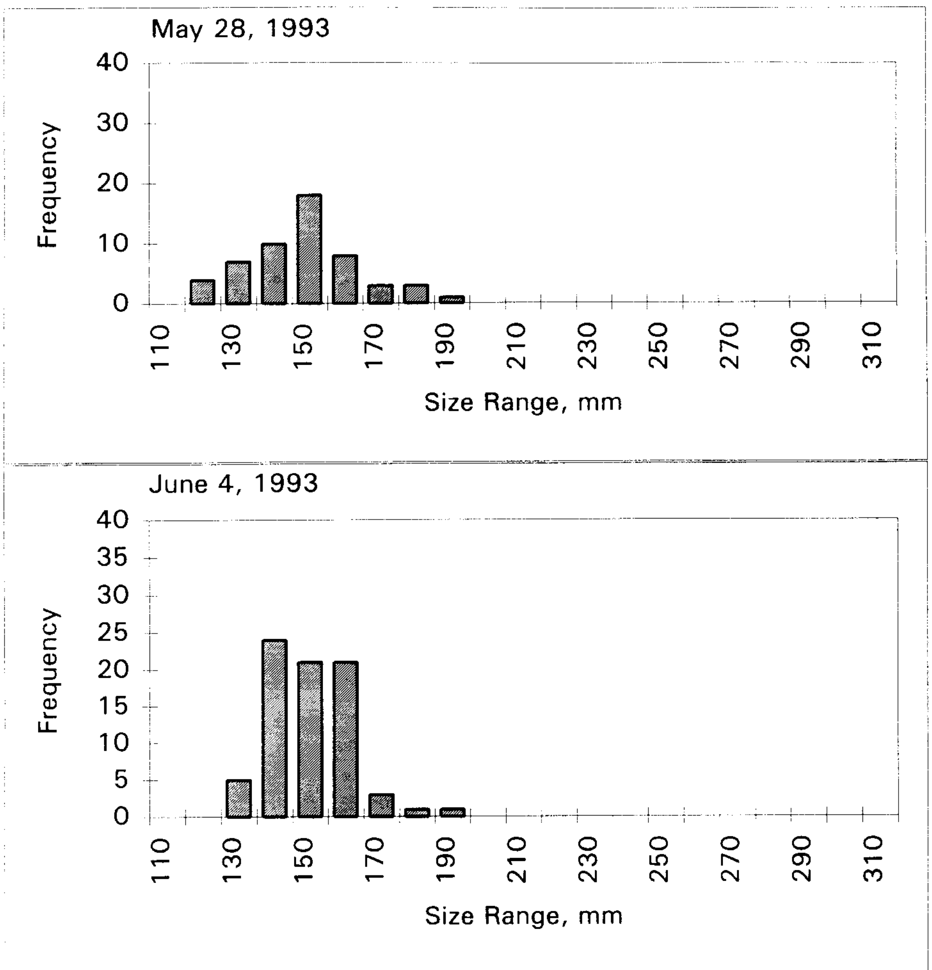


Figure 13, continued.

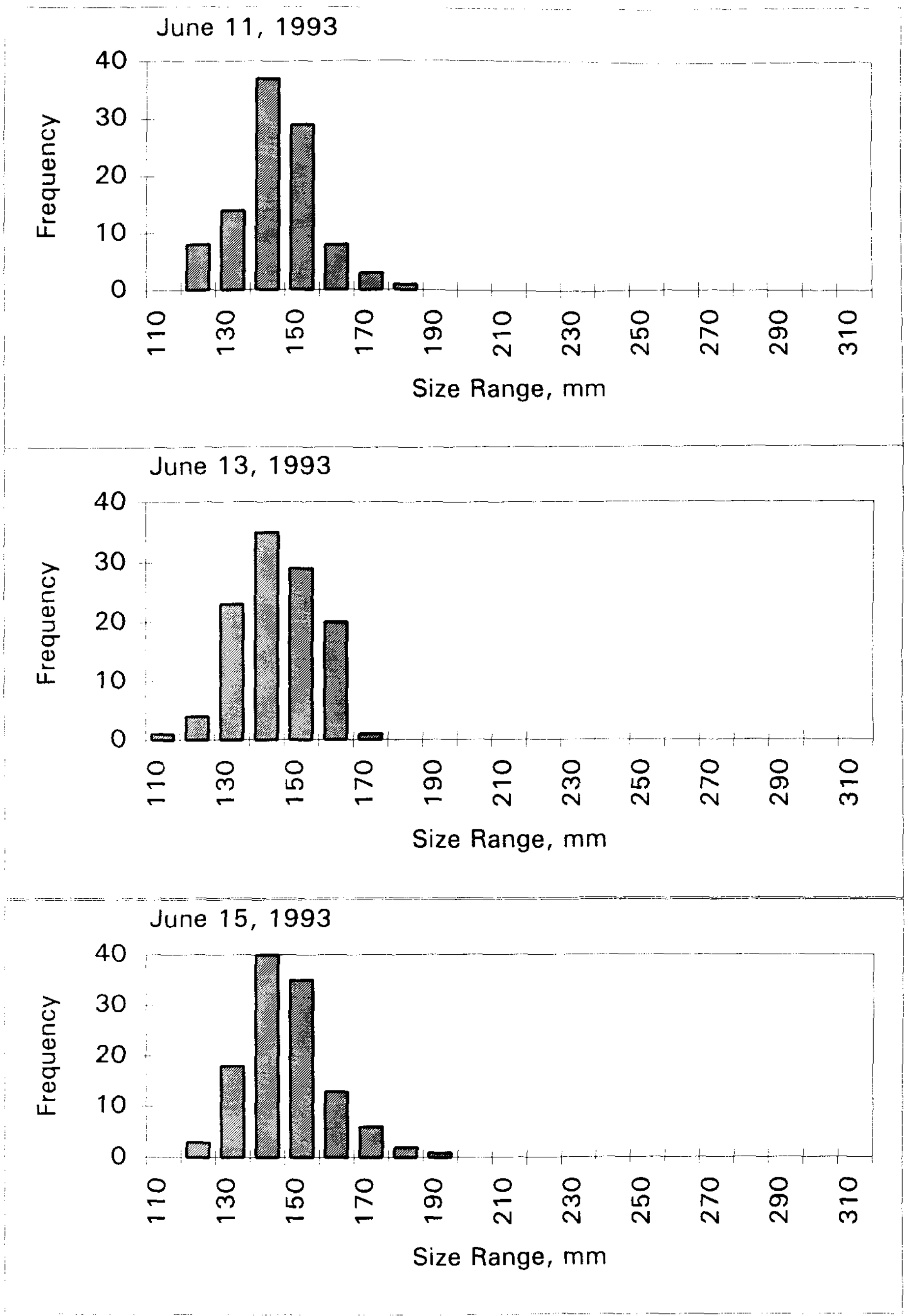


Figure 13, continued.

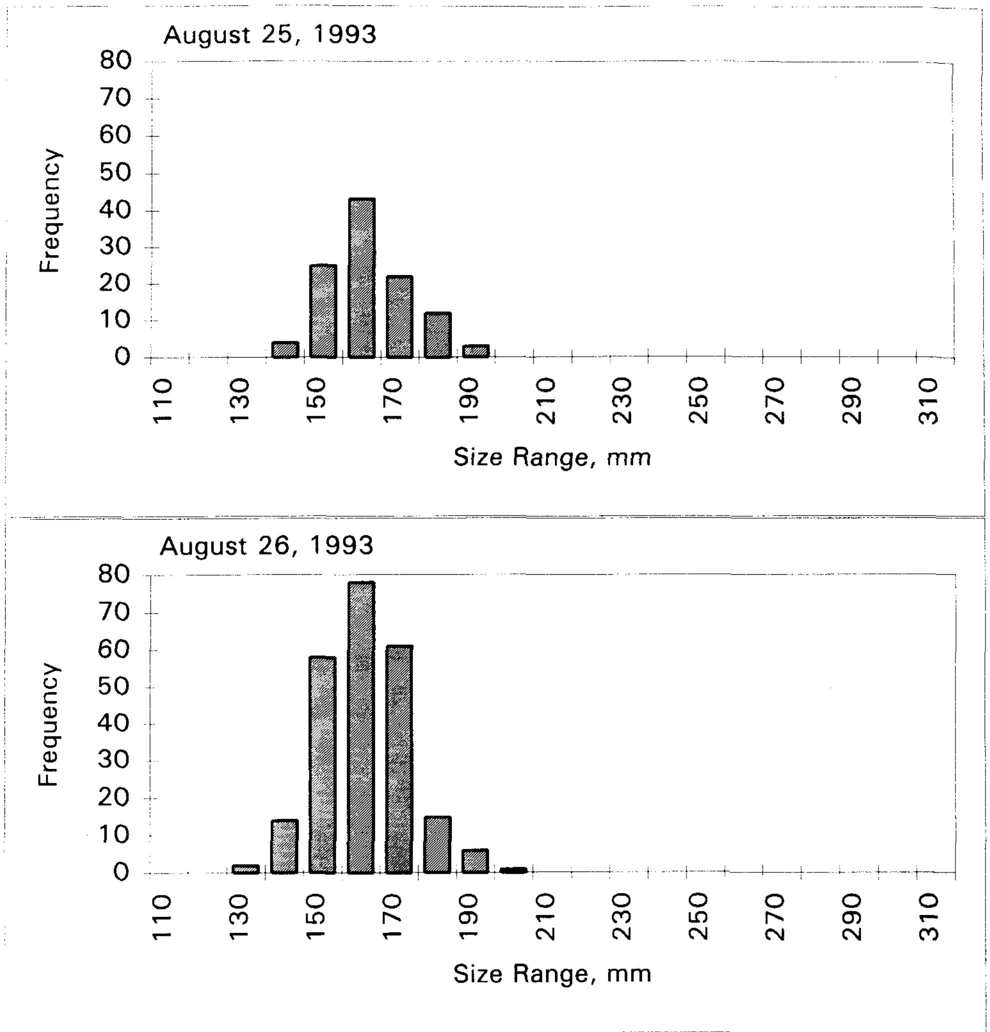


Figure 14. Size distribution of Arctic grayling collected in the lower pond in Last Chance Creek, 1993.

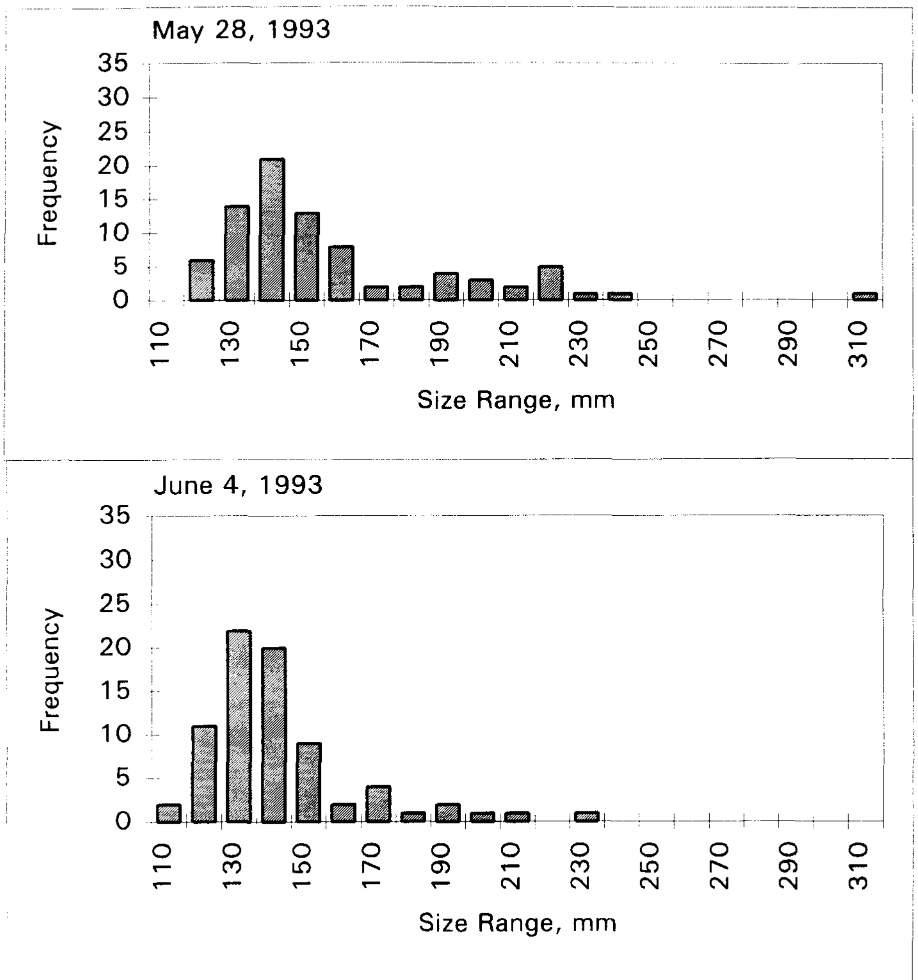


Figure 14, continued.

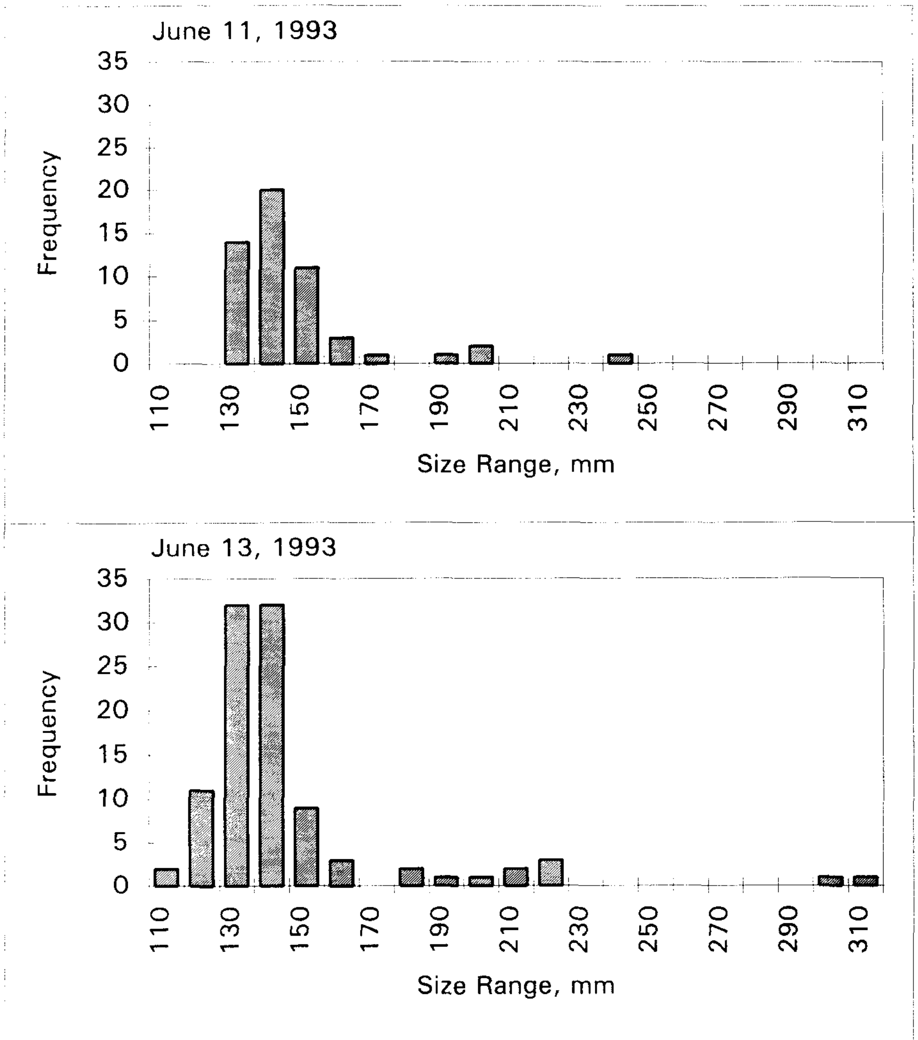
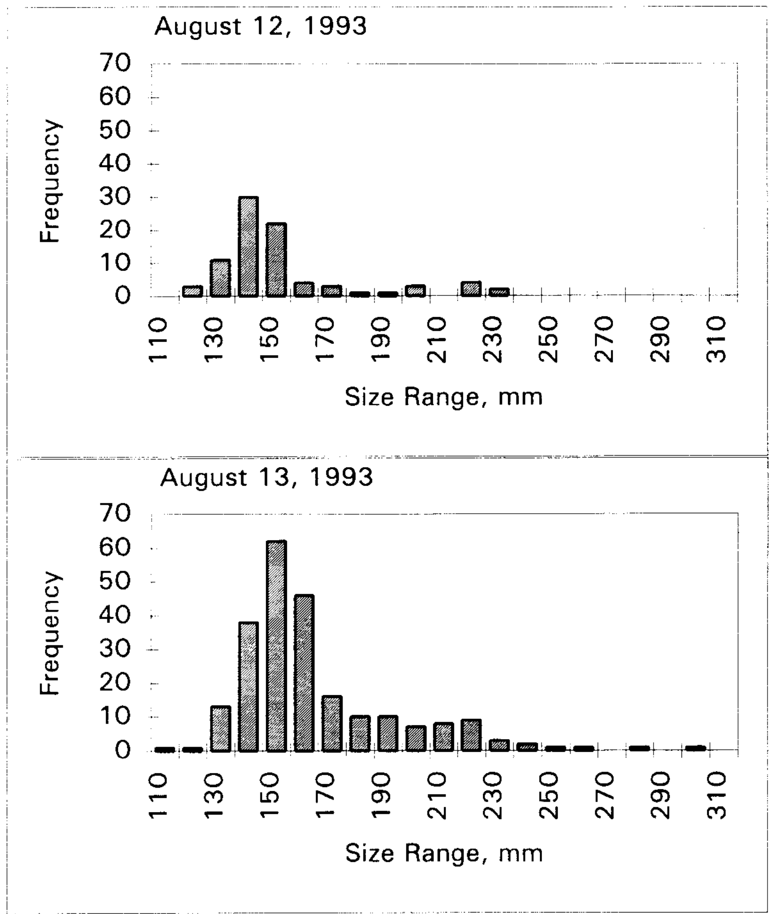


Figure 14, continued.



Overwintering by Arctic Grayling

Ponds in Last Chance Creek were sampled in November to determine if Arctic grayling used them for overwintering. We collected 10 fish from the lower pond and 11 from the upper pond to determine size and body condition. Most of the fish had been actively feeding (Table 9) and the upper pond had sufficient dissolved oxygen for fish.

Arctic grayling were using both ponds for overwintering. The fish were in good condition with ample fat reserves surrounding their internal organs. Of the 20 fish examined, 11 were in mature spawning condition and would have spawned in the spring. The sexually mature fish ranged from 160 to 233 mm fork length.

Table 9. Arctic grayling collected in Last Chance Creek Ponds, November 1993.

Lower Pond Length	Age	Sex	Stomach Contents
158	3+	immature	Chironomidae, Plecoptera.
233	3+	mature male	3+ Trichoptera
160	2+	immature	empty
193	3+	mature female	Corixidae
142	2+	immature	1 Trichoptera
174	3+	mature female	many small Chironomidae.
167	3+	immature	detritus
169	3+	immat. female	2+ Trichoptera
151	2+	immature	many Chironomidae, 1 Plecoptera.
156	2+	immature	detritus

Table 9, continued.

Upper Pond Length	Age	Sex	Stomach Contents
171	3+	mature male	Ephemeroptera, detritus
180	2+	mature female	Ephemeroptera, detritus
161	3+	immature	Tipulidae, Chironomidae., detritus
179	3+	mature male	Corixidae, detritus
173	2+	mature female	mostly empty, detritus
166	4+	mature female	Ephemeroptera, Chironomidae,detritus
180	3+	mature female	8+ Corixidae
160	3+	mature female	Chironomidae, detritus
160	3+	immature	10+ Chironomidae, Corixidae, detritus
180	3+	mature female	few Chironomidae, detritus
134	3+	immature	Corixidae, detritus

Aquatic Invertebrate Communities in Fish Creek Drainage

Ten aquatic invertebrate samples were collected from Fish Creek near Fairbanks Creek in both June and August. Ten invertebrate samples were collected from Bear Creek in August. Last Chance Creek was sampled in late June.

Invertebrate densities were highest in Fish Creek upstream of Fairbanks Creek in June, then declined in August. Although there were fewer invertebrates, more taxonomic groups were found in the August samples than in June (Table 10) The predominate taxonomic groups in Fish Creek were Diptera: Chironomidae (53% of the total insects) and Plecoptera: Perlodidae (18% of total) (Table 11).

Bear Creek was sampled only in August. At that time, the density of aquatic invertebrates was higher than in Fish Creek near Fairbanks Creek. In Bear Creek, samples were comprised mostly of Chironomidae (71% of total) and Plecoptera: Nemouridae (15% of total).

Table 10. Average, minimum, and maximum density and taxonomic richness of aquatic invertebrates from Fish Creek drainage, 1993. Taxonomic groups are family, except Nematoda, which is phylum.

Number of Invertebrates		Average	Minimum	Maximum
Fish Creek	June	154	62	210
Fish Creek	August	358	193	519
Bear Creek	August	95	38	156

Number of Taxa		Average	Minimum	Maximum
Fish Creek	June	6	4	9
Fish Creek	August	4	2	5
Bear Creek	August	7	5	10

Table 11. Invertebrate taxa, as percent of total invertebrates, collected in Fish Creek and Bear Creek, 1993.

	Bear Creek	Fish Creek	
	August	June	August
Ephemeroptera			
Baetidae	0.1	0.1	3
Heptagenidae	0.3	0.2	1
Siphlonuridae	0	0	<0.1
Ephemerelidae	0.2	0	<0.1
Plecoptera			
Perlodidae	4	0.4	18
Nemouridae	15	<0.1	3
Diptera			
Chironomidae	71	96	53
Tipulidae	7	0	14
Simulidae	<0.1	3	4
Psychodidae	2	0	0.5
Trichoptera			
Limnephilidae	0.7	0	0.5
Nematoda	0	0.1	4

Aquatic invertebrates were sampled in Last Chance Creek in late June. At the time of sampling, most of the rocks in the creek were almost entirely covered with Simulidae larvae and pupae. The pupae were cemented to the rock and not collected. We estimated that less than 50% of the invertebrates were collected; therefore, the samples are not considered quantitative. Each invertebrate sample collected from 0.1 m^2 stream substrate contained Chironomidae and Tipulidae larvae and Baetidae nymphs. The majority of invertebrates were Simulidae, which were too numerous to count. We estimated several thousand Simulidae in each 0.1 m^2 sample.

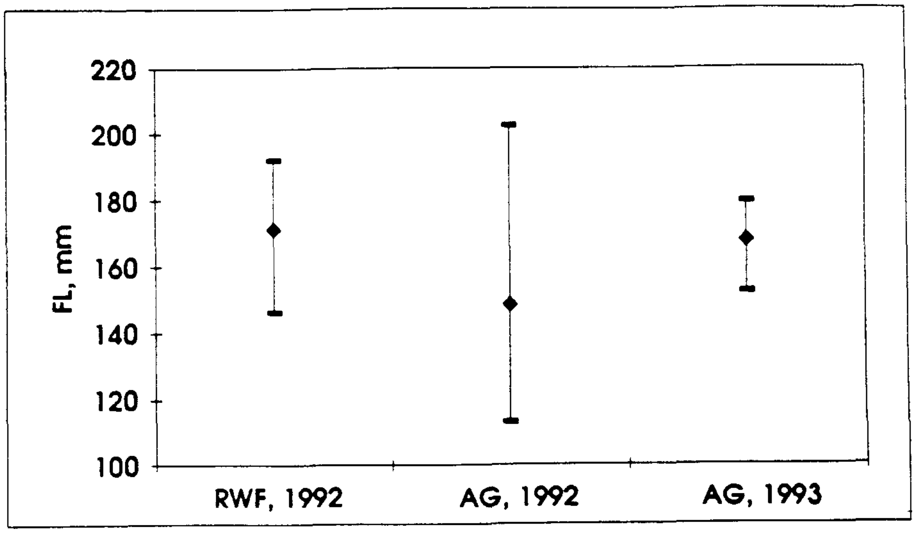
Metals concentrations in Arctic Grayling

In August 1993 we collected 24 Arctic grayling from abandoned settling ponds in Last Chance Creek; 12 fish were collected from the lower pond and 12 from the upper pond. We selected fish from the ponds because our information of the Arctic grayling communities of this area indicate that these fish are most likely to inhabit the freshwater reservoir that will be constructed with development of the Ft. Knox gold mine.

Fish were selected within a narrow size range: from 150 to 180 mm fork length and 34 to 55 grams in weight. The fish were similar in length to Arctic grayling and round whitefish tested in 1992 for metals (Figure 15).

The fish were analyzed for whole body concentrations of Al, As, Cd, Pb, and Hg (Appendix II). Metals concentrations in the two groups of fish were compared to determine differences that might be related to the ponds (Two Sample T-test, assuming unequal variances, $p<0.05$). There were no significant differences between the two groups for any of the metals; therefore, we combined the fish into one sample group representing the Last Chance Creek ponds.

Figure 15. Average, minimum, and maximum length of Arctic grayling and round whitefish collected in 1992 and 1993 for metals tissue analyses.



In all fish concentrations of arsenic were below 1.0, the detection limit. There was a wide range of aluminum concentrations found in these fish: from 2.2 to 168 mg Al/kg (Table 12). The 24 Arctic grayling contained an average concentration of 0.8 mg Cd/kg, 0.1 mg Pb/kg, and 0.21 mg Hg/kg.

Table 12. Average, maximum, and minimum concentrations of Al, As, Cd, Pb, and Hg in Arctic grayling from Last Chance Creek ponds.

Analyte	Average mg/kg	Maximum mg/kg	Minimum mg/kg	n
Al	43.2	2.2	168	24
As	<1	<1	<1	24
Cd	0.08	0.04	0.15	24
Pb	0.1	0.03	0.47	24
Hg	0.21	0.13	0.29	24

Arctic grayling from the Last Chance Creek ponds were compared with Arctic grayling and round whitefish from Fish Creek near Fairbanks Creek (Weber Scannell and Ott 1993). The two fish species collected in Fish Creek were first compared to determine differences in metals concentrations that may be associated with fish species. We found no difference in any of the metals concentrations between round whitefish and Arctic graying collected in Fish Creek in 1992 (Two sample T-test, assuming unequal variances, $p<0.05$); therefore, these fish were treated as one sample.

Fish collected in Fish Creek contained significantly higher concentrations of Al, As, and Pb than fish collected in the Last Chance Creek ponds (Two-sample T-test, assuming unequal variances, $p<0.05$, Table 13, Figure 16). Fish from Last Chance Creek ponds contained significantly higher concentrations of Cd and Hg than fish collected in Fish Creek ($p<0.05$, Table 13).

Figure 16. Concentrations of Al, As, Cd, Pb, and Hg in Arctic grayling and round whitefish from Fish Creek (1992) and Arctic grayling from Last Chance Creek ponds (1993).

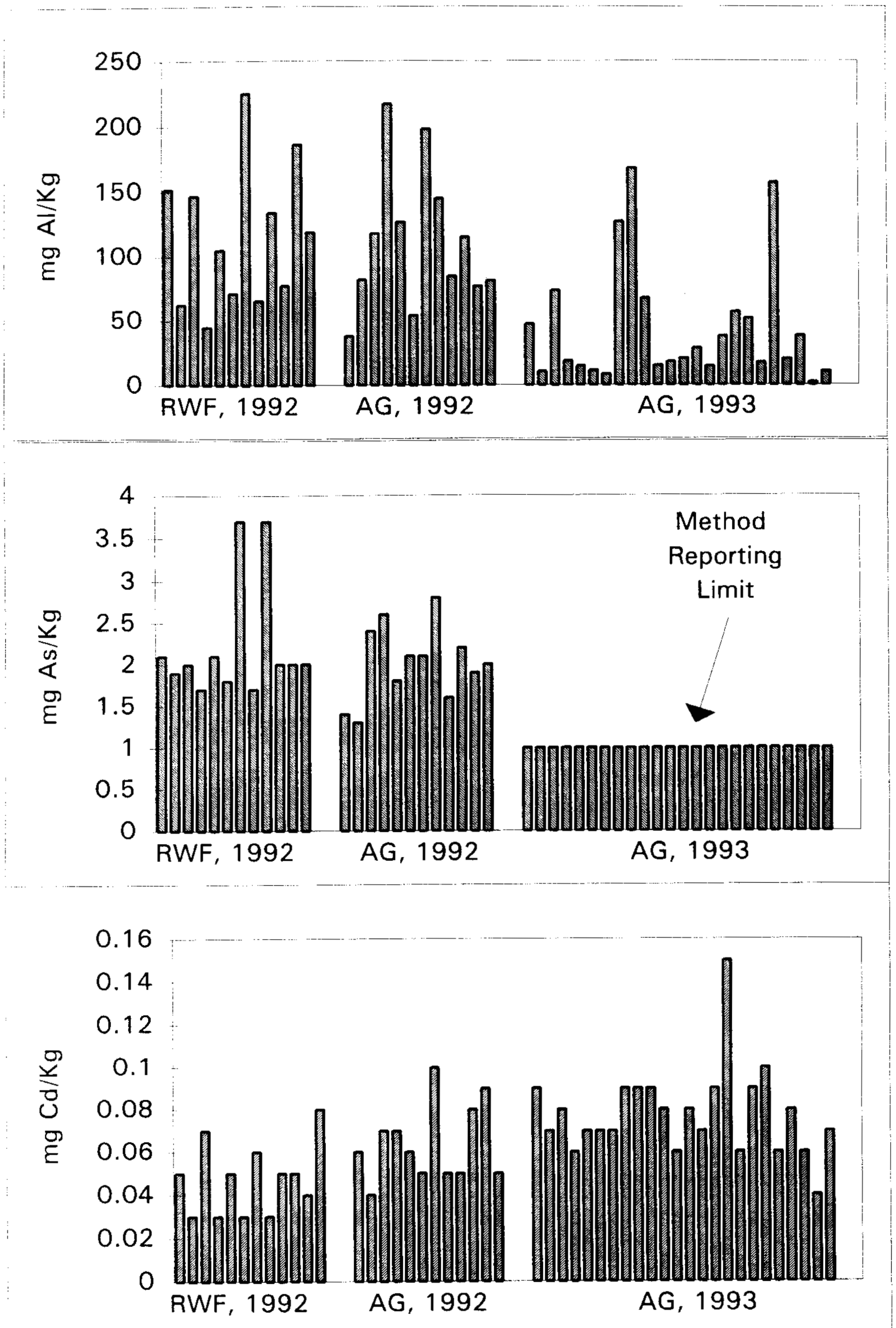


Figure 16, continued.

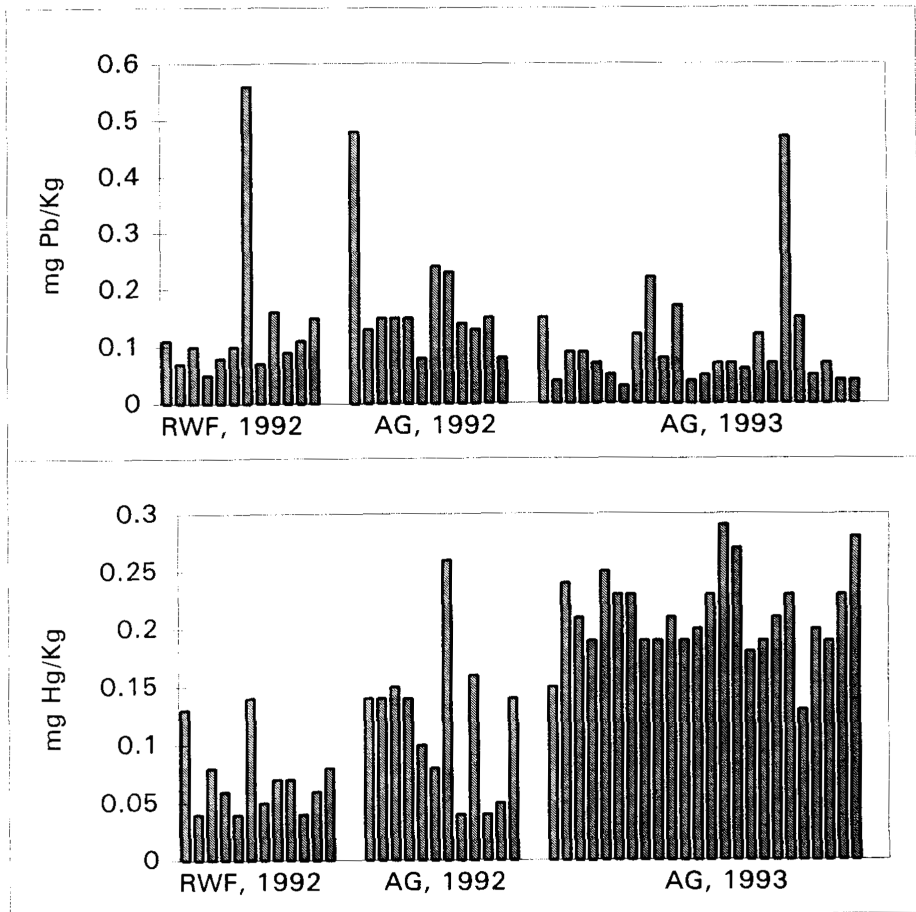


Table 13. Average concentrations of metals in fish from Last Chance Creek ponds and in Fish Creek. All concentrations are dry-weight basis.

Metal	Last Chance Creek Ponds Average Concentration mg/kg	n	Fish Creek Average Concentration mg/kg	n
Al	43.21	24	113.6	24
As	<1	24	2.1	24
Cd	0.078	24	0.056	24
Pb	0.10	24	0.157	24
Hg	0.21	24	0.096	24

Standard quality control/quality assurance procedures were followed by the analytical laboratory (Appendix III). Contamination was minimal for all metals except aluminum; although the method blank showed Al concentrations of 0.7 and 0.5 mg Al/kg, these concentrations are less than 33% of the lowest concentration found in any of the tissues analyzed and less than 2% of the average concentration. The percent relative difference between duplicate samples was low (less than 10%) except for Pb (17% and 17%) and Hg (19% and 5%). The matrix spikes had acceptable recovery for all metals except Al (87% and 31% recovery) and Hg (68% and 67% recovery). Quality control information for fish tissues analyzed in 1992 are presented in Weber Scannell and Ott (1993).

DISCUSSION

WATER QUALITY

Water quality in Fish Creek downstream of placer mining continued to be degraded by high sediment loads throughout 1993. A melting ice-lens in the upper portion of the drainage contributed high concentrations of total suspended solids and elevated settleable solids. Fairbanks Gold Mining, Inc. constructed stream diversion channels to pond the sediment-laden water and allow settling. Water quality in Fish Creek upstream of Bear Creek improved after the diversion.

High sediment loads in Fish Creek near Fairbanks Creek correlated with stream flows, except at break-up. The flow-related increases in sediment suggest that degraded water quality is primarily due to re-suspension of sediments from the streambed and not from other point or non-point sources. We anticipate the sediment loads observed in this section of Fish Creek will decrease after several flood events.

The ponds in Last Chance Creek exhibit qualities for successful fish rearing and overwintering: good water quality, high productivity, and high dissolved oxygen concentrations throughout the year.

Water temperatures in the lower pond were lower than those in the upper pond. We believe that this may be due to Last Chance Creek flowing through the pond. The upper pond is fed entirely by groundwater which initially enters a small pond with over 50% of the surface area less than 0.5 m depth. Approximately 15% of the surface area of the upper pond is shallow water habitat. This pond probably has a long retention time since discharge is less than 0.006 $m^3 s^{-1}$.

Abundance and Distribution of Fish

Environmental Baseline Studies (Dames and Moore 1991) found only Arctic grayling in the Fort Knox Project area. Our studies extend the species present to include burbot, slimy sculpin, round whitefish, and Arctic grayling.

The abandoned settling ponds adjacent to Last Chance Creek appear to be heavily used by juvenile fish for rearing. Fish in these ponds fall within a narrow size range, with most of the fish from 110 mm to 160 mm fork length. Larger Arctic grayling (>180 mm fork length) appear to migrate into the lower pond from Last Chance Creek; however, the use of this pond by large Arctic grayling appears to be limited. Large Arctic grayling are probably not able to access the upper pond because the outlet connecting the two ponds is shallow (<10 cm) during most of the summer.

Young-of-the-year fish were never observed in the Last Chance Creek ponds except in the small stream connecting the upper and lower ponds. We speculate that any young-of-the-year Arctic grayling inhabiting the ponds were subject to predation by larger Arctic grayling.

The high densities of fish in these ponds suggest that this type of rearing and overwintering habitat may be an important factor enhancing Arctic grayling populations in Fish Creek. The size distribution suggests that sub-adult and small adult fish move into ponds for rearing, then migrate out of the drainage after growing to 180+ mm fork length.

Arctic grayling in the Last Chance Creek ponds attained sexual maturity at a small size (from 160 to 233 mm) and younger age (3+ years) than has been found for other Arctic grayling populations in the Chena River drainage (pers. comm. R. Clark, Sport Fish Biologist, ADF&G). Tack (1972) reported that Arctic grayling in the Chena River system reach sexual maturity at approximately 270 mm, more than 100 mm larger than the smallest sexually mature fish in the Last Chance Creek ponds. Early maturity may result from abundant food in the ponds.

Arctic grayling overwinter in the ponds and in Fish Creek and Last Chance Creek. It is possible that some Arctic grayling migrate downstream to overwinter, but a large number of fish remain in this portion of the drainage throughout the year.

In August 18 juvenile burbot (from 80 to 110 mm) and numerous young-of-the-year Arctic grayling were collected in Fish Creek near the road crossing and the outlet from the placer mine settling ponds. The presence of young-of-the-year fish suggests that spawning occurred in or near the Fork Knox project area. Although young-of-the-year fish were not found until August, this is probably a function of gear selectivity.

The abundance of Arctic grayling in Last Chance Creek was similar to the number found in early 1992 before the Fish Creek settling ponds failed and flushed most fish out of the system (rf. Weber Scannell and Ott 1993). Aquatic invertebrate populations recovered in abundance, although taxonomic richness remained low.

In Bear Creek, more slimy sculpin and fewer round whitefish were collected in 1993 than in 1992; abundance of Arctic grayling was similar in 1992 and 1993.

AQUATIC INVERTEBRATE COMMUNITIES

Densities of aquatic invertebrates were higher in Fish Creek in 1993 than in 1992. In June 1992 we collected an average of 4 invertebrates per 0.1 m^2 compared to an average of 154 invertebrates per 0.1 m^2 in 1993. In August 1992, there was an average of 40.3 compared with a 1993 average of 358 invertebrates per 0.1 m^2. There are several factors contributing to lower invertebrate abundance in 1992. Ice-off in 1992 was delayed by a prolonged cold spring with abnormally low temperatures, therefore the June sample occurred only a few weeks after the ice melted. Spring 1993 was warm with early ice-off.

Samples collected in August 1992 were depleted by the failure of the Fish Creek settling ponds and subsequent flooding with water and sediment. Water quality in 1992 was poorer than in 1993: in 1992 we measured an average turbidity of 290 NTU in June and 161 NTU in August. In 1993 the average June turbidity was 85.6 NTU and in August, 80 NTU.

Sampling in Bear Creek during 1993 was limited to August. During this time, invertebrate densities were somewhat higher than in 1992: in 1992 we collected an average of 66 invertebrates per 0.1 m^2 compared to 95 in 1993. Taxonomic richness was the same (7 taxa per sample) in both years.

METALS CONTENT IN ARCTIC GRAYLING

The higher concentrations of Al, As, and Pb found in round whitefish and Arctic grayling from Fish Creek probably result from metals associated with placer mine sediments. LaPerriere, et al. (1985) reported elevated stream water concentrations of both Pb and As associated with placer mining. They did not find Cd or Hg to be elevated below placer mined sites. Although LaPerriere et al. did not measure concentrations of Al, this metal is closely associated with fine clays which are prevalent in the Fish Creek valley. We speculate that higher concentrations of Al found in Fish Creek fish resulted from fine clays suspended in placer mine discharge water.

Jackson (1991) found an approximate three-fold increase in concentrations of fish muscle mercury (wet weight basis) following expansion of lake reservoirs in Manitoba, Canada. The increase in fish tissue Hg resulted from stimulation of Hg methylating microbes by submerged terrestrial organic matter. It is possible that higher Hg concentrations found in fish inhabiting the Last Chance Creek ponds resulted from gradual decomposition of organic mucks in the ponds.

Although the concentration of Cd in fish from Last Chance Creek ponds was significantly higher than in fish from Fish Creek, the differences are not substantial. Concentrations in fish from the ponds averaged 0.08 mg Cd/kg and in fish from Fish Creek, 0.055 mg Cd/kg.

Although metals were detected in Arctic grayling from the Last Chance Creek ponds, ADF&G does not consider any of the concentrations found in these fish to be unusually high, particularly for a disturbed system (U.S. Fish and Wildlife Service, 1992, Dames and Moore 1983).

Arctic grayling, burbot, longnose sucker, and northern pike have been sampled from the Chena River under the National Contaminant Biomonitoring Program (NCBP) (Lowe, et al. 1985, Schmitt and Brumbaugh 1990) (Table 14) for whole body concentrations of As, Cd, Pb, and Hg. Arctic grayling from Last Chance Creek ponds had higher concentrations of Cd, Pb, and Hg than Arctic grayling from the Chena River. Burbot concentrations of Hg were similar to Arctic grayling from Last Chance Creek ponds. The higher concentrations found in Arctic grayling from Last Chance Creek ponds is likely due to the mineralized character of this area and sedimentation from disturbance.

Table 14. 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 LC Creek Ponds	<1	0.08	0.1	0.21
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 0.19 0.18 0.22	0.01 0.03 0.03 0.02	0.06 0.15 0.10 0.10	0.06 0.12 0.09 0.07
Northern pike	0.05	0.01	0.10	0.14

EXPECTED CHANGES TO STREAM HABITAT FROM FORT KNOX

Predicted changes in the aquatic habitats of Fish Creek drainage were described by Weber Scannell and Ott (1993). Studies conducted in 1993 support earlier predictions with several additions.

The large Arctic grayling population currently rearing in the Last Chance Creek ponds will probably expand with increased habitat in the freshwater reservoir. Provided access is maintained, fish from Solo Creek will move freely between the reservoir and Solo Creek. We hypothesize that the freshwater reservoir will provide habitat of similar quality as the Last Chance Creek ponds. The larger area of the reservoir will probably support a larger population of Arctic grayling than found in the ponds. Burbot probably will inhabit the freshwater reservoir.

ADF&G has proposed a five-year fish biomonitoring study to assess changes in aquatic habitat resulting from development of the Fort Knox gold mine. The intent of this study is to monitor the abundance and distribution of fish in the reservoir and in tributary creeks, to monitor changes in water quality and quantity, and to determine changes in concentrations of Al, As, Cd, Pb, and Hg in Arctic grayling inhabiting the reservoir. The study proposal for the fish biomonitoring study is included in Appendix IV.

LITERATURE CITED

American Public Health Association. 1985. Standard methods for the examination of water and wastewater. Sixteenth Edition.

Dames and Moore. 1991. Fort Knox Project: Fish and terrestrial wildlife reconnaissance surveys. in Fort Knox Project: Environmental baseline report. Vol. 1. May 1992.

Dames and Moore. 1983. Aquatic biology. Chap. II. in Environmental Baseline Studies: Red Dog Project. for Cominco Alaska, Inc.

Fairbanks Gold Mining, Inc. 1992. Fort Knox Project: Water Resources Management Plan. Draft report. December 1992.

Holmes, R. 1985. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. AK Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1984-1985, Project F-9-17, 26(R-I): pp. 60-102.

Jackson, T.A. 1991. Biological and environmental control of mercury accumulation by fish in lakes and reservoirs of northern Manitoba, Canada. Can. J. Fish. Aquat. Sci. 48:2449-2470.

LaPerriere, J.D., S.M. Wagener, and D.M. Bjerklie. 1985. Gold-mining effects on heavy metals in streams, Circle Quadrangle, Alaska. Water Res.. Bull. 21:245-252.

Lowe, T.P., T.W. May, W.G. Brumbaugh, and D.A. Kane. 1985. National contaminant biomonitoring program: Concentrations of seven elements in freshwater fish, 1978-1981. Arch. Environ. Contam. Toxicol. 14:363-388.

Ray, S., and J. Vohden. 1992. Alaska Department of Natural Resources, Division of Water, unpublished data.

Ray, S., and J. Vohden. 1994. Alaska Department of Natural Resources, Division of Water, unpublished data.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin 191. Department of the Environment, Fisheries and Marine Service. Ottawa, Canada.

Schmitt, C.J. and W.G. Brumbaugh. 1990. National contaminant biomonitoring program: Concentrations of arsenic, cadmium, copper, lead, mercury, selenium, and zinc in U.S. freshwater fish, 1976-1984. Arch. Environ. Contam. Toxicol. 19:731-747.

Tack, S.L. 1972. Distribution, abundance and natural history of the Arctic grayling in the Tanana River drainage. AK Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1971-1972, Project F-9-4, 13(R-I): 36 pp.

U.S. Fish and Wildlife Service, Ecological Services. 1992. Unpublished data reports.

Weber Scannell, P., and A.G. Ott. 1993. Aquatic Habitat Study, upper Fish Creek drainage, with an emphasis on arctic grayling (*Thymallus arcticus*): Baseline Studies 1992. Alaska Dept. Fish and Game Tech. Rept. 93-4. Habitat Division. Juneau. 76 pp.

APPENDIX I. Water quality in Fish Creek at Fairbanks Creek. Data from Alaska Department of Natural Resources (Ray and Vohden 1993).

Date	Water Temp ˚C	Air Temp ˚C	Q (cfs)	Turbidity (NTU)	TSS (mg/L)	Sediment Load (tons/day)
19-May-93			75.0			
20-May-93			70.9	39	801	184
21-May-93			64.8	80	1310	276
22-May-93			58.5	70	1090	207
23-May-93			54.7	65	1470	261
24-May-93			52.2	80	1790	304
25-May-93			51.3	80	1160	193
26-May-93			49.2	80	888	142
27-May-93			50.5	70	847	139
28-May-93			50.1	60	851	139
29-May-93			47.0	80	1060	162
30-May-93			43.8	85	1530	218
31-May-93			41.9	100	1420	193
1-Jun-93			42.1	75	872	119
2-Jun-93			38.3	80	1070	133
3-Jun-93			38.6	75	1020	128
4-Jun-93			37.0	90	1240	149
5-Jun-93			36.4	90	954	113
6-Jun-93			38.7	100	1090	137
7-Jun-93			38.5	100	970	121
8-Jun-93			36.6	95	1020	121
9-Jun-93			37.3	75	731	88.5
10-Jun-93			35.0	100	1050	119
11-Jun-93			34.1	95	902	100
12-Jun-93			37.2	90	779	94.1
13-Jun-93			34.1	80	663	73.5
14-Jun-93			33.1	70	635	68.2
15-Jun-93			32.1	80	563	58.8
16-Jun-93			34.8	75	581	65.6
17-Jun-93			38.7			
18-Jun-93			74.7			
19-Jun-93			65.9			
20-Jun-93			67.3			
21-Jun-93			52.6			
22-Jun-93			43.9			
23-Jun-93			39.4			
24-Jun-93			36.7			
25-Jun-93			35.9			
26-Jun-93			33.4			
27-Jun-93			32.1			
28-Jun-93			32.4			
29-Jun-93			30.5			
30-Jun-93			29.1			
1-Jul-93			32.5			
2-Jul-93			59.6			

APPENDIX I, CONTINUED.

Date	Water Temp °C	Air Temp °C	Q (cfs)	Turbidity (NTU)	TSS (mg/L)	Sediment Load (tons/day)
3-Jul-93			44.8			
4-Jul-93			36.1			
5-Jul-93			34.0			
6-Jul-93			31.8			
7-Jul-93			37.1			
8-Jul-93			34.6			
9-Jul-93			32.1			
10-Jul-93			30.5			
11-Jul-93			29.4			
12-Jul-93			29.0			
13-Jul-93			27.8	30	66.1	5.97
14-Jul-93	12.6	21.0	25.2	30	43.9	3.60
15-Jul-93	13.0	20.7	22.6	17	34.2	2.51
16-Jul-93	13.1	18.4	21.8	9.4	36.9	2.62
17-Jul-93	12.0	15.8	24.2	28	53.7	4.22
18-Jul-93	11.5	16.9	25.6	20	62.6	5.20
19-Jul-93	11.0	15.5	23.8	21	46.2	3.57
20-Jul-93	11.2	17.0	25.1	33	46.3	3.78
21-Jul-93	12.0	17.0	24.5	33	48.3	3.84
22-Jul-93	11.5	16.2	23.4	17	33.8	2.57
23-Jul-93	11.7	16.0	22.8	38	122	9.04
24-Jul-93	11.7	14.7	26.0	12	113	9.54
25-Jul-93	11.4	17.4	25.4	36	58.6	4.84
26-Jul-93	11.8	17.6	24.3	22	51.1	4.04
27-Jul-93	12.2	17.5	23.5	19	37.2	2.85
28-Jul-93	12.2	17.1	21.6	16	22.6	1.59
29-Jul-93	12.8	16.6	22.9	28	24.3	1.81
30-Jul-93	12.4	15.0	21.9	18	25.4	1.81
31-Jul-93	11.6	16.4	21.5	22	27.1	1.90
1-Aug-93	12.4	18.5	20.5	25	32.8	2.18
2-Aug-93	12.1	15.9	20.3	37	64.5	4.25
3-Aug-93	11.1	13.9	23.6	38	42.1	3.23
4-Aug-93	10.6	12.8	22.5	28	46.8	3.42
5-Aug-93	10.5	11.7	26.9	80	291	25.4
6-Aug-93	9.9	12.1	45.4	290	774	114
7-Aug-93	9.7	13.7	55.9	150	359	65.2
8-Aug-93	9.0	10.2	42.4			
9-Aug-93	8.9	11.9	37.5	130	285	32.5
10-Aug-93	9.4	12.4	35.1	100	255	26.9
11-Aug-93	9.1	11.8	32.5	110	243	25.8
12-Aug-93	8.5	10.5	32.6	120	260	23.6
13-Aug-93	7.8	9.0	27.9	95	201	18.8
14-Aug-93	8.3	13.4	28.8	85	123	10.9
15-Aug-93	8.7	12.6	27.3	70	89.2	7.92
16-Aug-93	8.2	8.1	27.3	60	75.4	6.82
17-Aug-93	7.2	8.7	27.8	70	82.1	7.14

APPENDIX I, CONTINUED.

Date	Water Temp °C	Air Temp °C	Q (cfs)	Turbidity (NTU)	TSS (mg/L)	Sediment Load (tons/day)
18-Aug-93	7.8	11.7	26.8	75	72.7	5.89
19-Aug-93	8.4	14.4	24.9	70	72.7	5.89
20-Aug-93	7.9	10.7	25.0	70	67.5	7.20
21-Aug-93	8.2	9.3	32.8	85	132	15.8
22-Aug-93	7.2	6.9	36.8	70	129	16.7
23-Aug-93	6.1	6.0	39.9	55	105	12.6
24-Aug-93	5.8	6.9	36.9	45	68.7	7.69
25-Aug-93	5.3	7.0	34.5	60	81.3	8.70
26-Aug-93	5.9	7.7	33.0	70	59.6	5.75
27-Aug-93	5.8	7.7	29.7	70	53.3	5.15
28-Aug-93	6.0	8.8	29.7	90	55.8	4.87
29-Aug-93	6.2	7.3	26.9	55	45.3	4.14
30-Aug-93	6.7	11.8	28.1	27	26.8	3.41
31-Aug-93	7.9	12.8	39.2	70	123	23.3
1-Sep-93	7.7	10.3	58.2	140	418	104
2-Sep-93	6.8	9.3	76.7	120	482	115
3-Sep-93	6.2	10.0	73.4	75	284	55.4
4-Sep-93	6.1	8.4	60.1	60	219	38.4
5-Sep-93	6.5	12.7	53.9	65	181	28.3
6-Sep-93	7.0	14.1	48.2	70	161	23.6
7-Sep-93	6.3	7.6	45.2	130	154	21.4
8-Sep-93	5.8	6.9	42.8	140	160	21.5
9-Sep-93	5.3	6.9	41.3	150	153	19.4
10-Sep-93	5.7	7.2	39.0	160	139	17.7
11-Sep-93	5.3	4.9	39.3	220	165	20.0
12-Sep-93	4.9	6.2	37.4	210	160	19.3
13-Sep-93	5.8	9.0	37.2	160	138	16.9
14-Sep-93	6.1	10.0	37.6	230	222	26.4
15-Sep-93	6.0	9.1	36.5	230	150	18.4
16-Sep-93	6.0	6.4	37.7	270	187	43.1
17-Sep-93	4.0	1.1	70.9	240	582	112
18-Sep-93	1.9	-0.5	59.0	85	217	47.1
19-Sep-93	1.8	2.8	66.8	120	558	
\20-Sep-93	2.5	7.1		160	1760	
21-Sep-93	2.9	3.6		130	787	
22-Sep-93	1.6	-0.5		140	492	
23-Sep-93	0.5	-3.2				
24-Sep-93	1.0	-0.2		34	381	
25-Sep-93	0.1	-3.1				
26-Sep-93	-0.3	-3.9				
27-Sep-93	-0.3	-6.7				
28-Sep-93	-0.3	-3.7				
29-Sep-93	-0.3	-2.6				
30-Sep-93	-0.3	-1.6				
1-Oct-93	-0.3	2.8				
2-Oct-93						
3-Oct-93						

APPENDIX I, CONTINUED.

Date	Water Temp °C	Air Temp °C	Q (cfs)	Turbidity (NTU)	TSS (mg/L)	Sediment Load (tons/day)
4-Oct-93	-0.3	1.5				
5-Oct-93	-0.3	-1.9				
6-Oct-93	-0.3	1.8				
7-Oct-93	0.0	4.9				
8-Oct-93	0.9	3.6				
9-Oct-93	1.3	8.1				
10-Oct-93	1.2	1.6				
11-Oct-93	0.7	-0.9				
12-Oct-93	-0.3	-3.3				
13-Oct-93	0.2	1.4				
14-Oct-93	1.1	2.2				
15-Oct-93	1.3	1.3				
16-Oct-93	0.0	-1.9				
17-Oct-93	-0.3	-3.3				
18-Oct-93	-0.3	-1.5				
19-Oct-93	-0.3	-10.8				
20-Oct-93	-0.3	-14.5				
21-Oct-93	-0.3	-15.3				
22-Oct-93	-0.3	-12.7				
23-Oct-93	-0.3	-10.6				
24-Oct-93	-0.3	-17.3				
25-Oct-93	-0.3	-9.5				
26-Oct-93	-0.3	-7.1				
27-Oct-93	-0.3	-10.3				
28-Oct-93	-0.3	-9.1				
29-Oct-93	-0.3	-3.3				
30-Oct-93	-0.3	-5.0				
31-Oct-93	-0.3	-7.2				
1-Nov-93	-0.3	-13.7				
2-Nov-93	-0.3	-9.1				
3-Nov-93	-0.3	-12.7				
4-Nov-93	-0.3	-14.1				
5-Nov-93	-0.3	-9.2				
6-Nov-93	-0.3	-6.7				
7-Nov-93	-0.3	-10.0				
8-Nov-93	-0.3	-10.2				
9-Nov-93	-0.3	-8.9				
10-Nov-93	-0.3	-1.2				
11-Nov-93	-0.3	-5.3				
12-Nov-93	-0.3	-3.7				
13-Nov-93	-0.3	-5.3				
14-Nov-93	-0.3	-5.8				
15-Nov-93	-0.3	-9.4				
16-Nov-93	-0.3	-9.6				

APPENDIX II. Metals concentrations in Whole Body fish Collected in Last Chance Creek Ponds, 1993.

Length mm	Weight grams	Al mg/kg	As mg/kg	Cd mg/kg	Pb mg/kg	Hg mg/kg	% Solids
175	53.4	47.5	<1	0.09	0.15	0.15	24.6
172	50.2	10.8	<1	0.07	0.04	0.24	25.8
171	48.0	73.3	<1	0.08	0.09	0.21	25
155	36.0	18.8	<1	0.06	0.09	0.19	23.8
168	46.3	15.0	<1	0.07	0.07	0.25	25.7
158	39.0	11.4	<1	0.07	0.05	0.23	24.3
168	43.8	8.6	<1	0.07	0.03	0.23	24
170	50.5	127.0	<1	0.09	0.12	0.19	25
171	54.8	168.0	<1	0.09	0.22	0.19	26.8
171	49.6	67.3	<1	0.09	0.08	0.21	25.2
165	45.0	15.2	<1	0.08	0.17	0.19	23.9
156	38.8	18.2	<1	0.06	0.04	0.20	25
169	42.8	20.7	<1	0.08	0.05	0.23	23.1
175	54.8	28.6	<1	0.07	0.07	0.29	25.2
176	53.4	14.7	<1	0.09	0.07	0.27	22.9
152	34.0	38.0	<1	0.15	0.06	0.18	23.4
155	37.9	56.6	<1	0.06	0.12	0.19	23
179	55.0	51.6	<1	0.09	0.07	0.21	24
164	40.6	17.4	<1	0.10	0.47	0.23	23.2
172	52.0	157.0	<1	0.06	0.15	0.13	24.1
158	38.8	20.2	<1	0.08	0.05	0.20	23.3
174	47.0	38.1	<1	0.06	0.07	0.19	22.3
178	55.0	2.2	<1	0.04	0.04	0.23	22.5
162	43.8	10.8	<1	0.07	0.04	0.28	24.9

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

Metal	Method	Blank1 MRL	Method Result	Duplicate Samples: Sample Difference	Duplicate	Percent
Al	200.8	0.1	0.7	15.2	13.9	9
As	7060	1	ND	ND	ND	--
Cd	200.8	0.02	ND	0.08	0.08	<1
Pb	200.8	0.02	ND	0.17	0.20	17
Hg	7471	0.02	ND	0.19	0.21	5

Metal	Method	Blank MRL Result	Method Result	Duplicate Samples: Sample Difference	Duplicate	Percent
Al	200.8	0.1	0.5	28.6	30.2	5
As	7060	1	ND	ND	ND	--
Cd	200.8	0.02	ND	0.07	0.07	<1
Pb	200.8	0.02	0.07	0.06	17	
Hg	7471	0.02	0.29	0.24	19	

Matrix Spike Summary

Metal	Method Level Result	MRL Result	Spike Sample	Sample Recovery	Spiked	Percent
Al	200.8	0.1	8.7	15.2	22.8	87
As	7060	1	4	ND	4	100
Cd	200.8	0.02	4.3	0.08	4.68	107
Pb	200.8	0.02	4.3	0.17	4.97	112
Hg	7471	0.02	0.4	0.20	0.47	68

Matrix Spike Summary

Metal	Method Level Result	MRL Result	Spike Sample	Sample Recovery	Spiked	Percent
Al	200.8	0.1	9.8	28.6	31.6	31
As	7060	1	5	ND	5	100
Cd	200.8	0.02	4.9	0.07	4.44	89
Pb	200.8	0.02	4.9	0.07	4.49	90
Hg	7471	0.02	0.49	0.27	0.60	67

Appendix IV. Fort Knox Biomonitoring Study

Fort Knox Biomonitoring Study, Fish Creek Drainage, Emphasis on Arctic Grayling

SUBMITTED BY:
Alaska Department of Fish and Game
Habitat and Restoration Division, Fairbanks

APPROVED BY:

Frank Rue, Director
Habitat and Restoration Division

TITLE

Fort Knox Biomonitoring Study, Fish Creek Drainage, Emphasis on Arctic Grayling (*Thymallus arcticus*).

PRINCIPAL INVESTIGATOR

Dr. Alvin G. Ott, Project Personnel: Dr. Phyllis Weber Scannell, Mr. Bob Clark, and Mr. Alan Townsend.

BACKGROUND STATEMENT

The Fort Knox hard-rock gold mine is located in the upper portion of Fish Creek in the Chena River drainage (Figure A-1). The proposed development of the hard-rock mine will include the construction of a tailings impoundment, 18.2 hectares of wetlands below the tailings impoundment, a freshwater reservoir, a causeway/utility road crossing of Solo Creek, and associated facilities (Figure A-2). The freshwater dam will be constructed across Fish Creek immediately downstream of the confluence of Solo and Last Chance creeks with Fish Creek. Distances to receiving waterbodies from the Fish Creek freshwater dam site to the Little Chena River, Chena Hot Springs road crossing of the Little Chena River, Chena River, and Tanana River are 20, 60, 81, and 112 km, respectively.

Habitat modifications from placer mining have been extensive in the upper Fish Creek drainage upstream of the confluence of Last Chance and Fish creeks. Areas to be flooded by the freshwater reservoir in Fish, Solo, and Last Chance creeks have been altered by placer mine activities (e.g., stream diversions, settling ponds, mine cuts). Fish Creek contains multiple beaver dams and water quality (suspended sediments) is degraded. Some minor surface disturbance of habitat adjacent to Solo Creek has occurred and the thalweg of Solo Creek appears to have undergone substantial downcutting. Last Chance Creek has been diverted into a man-made channel, contains multiple beaver dams, and flows through a 1.8 hectare pond complex (probably an old mine cut and abandoned settling ponds). The age of the ponds and associated mine cut probably exceeds ten years.

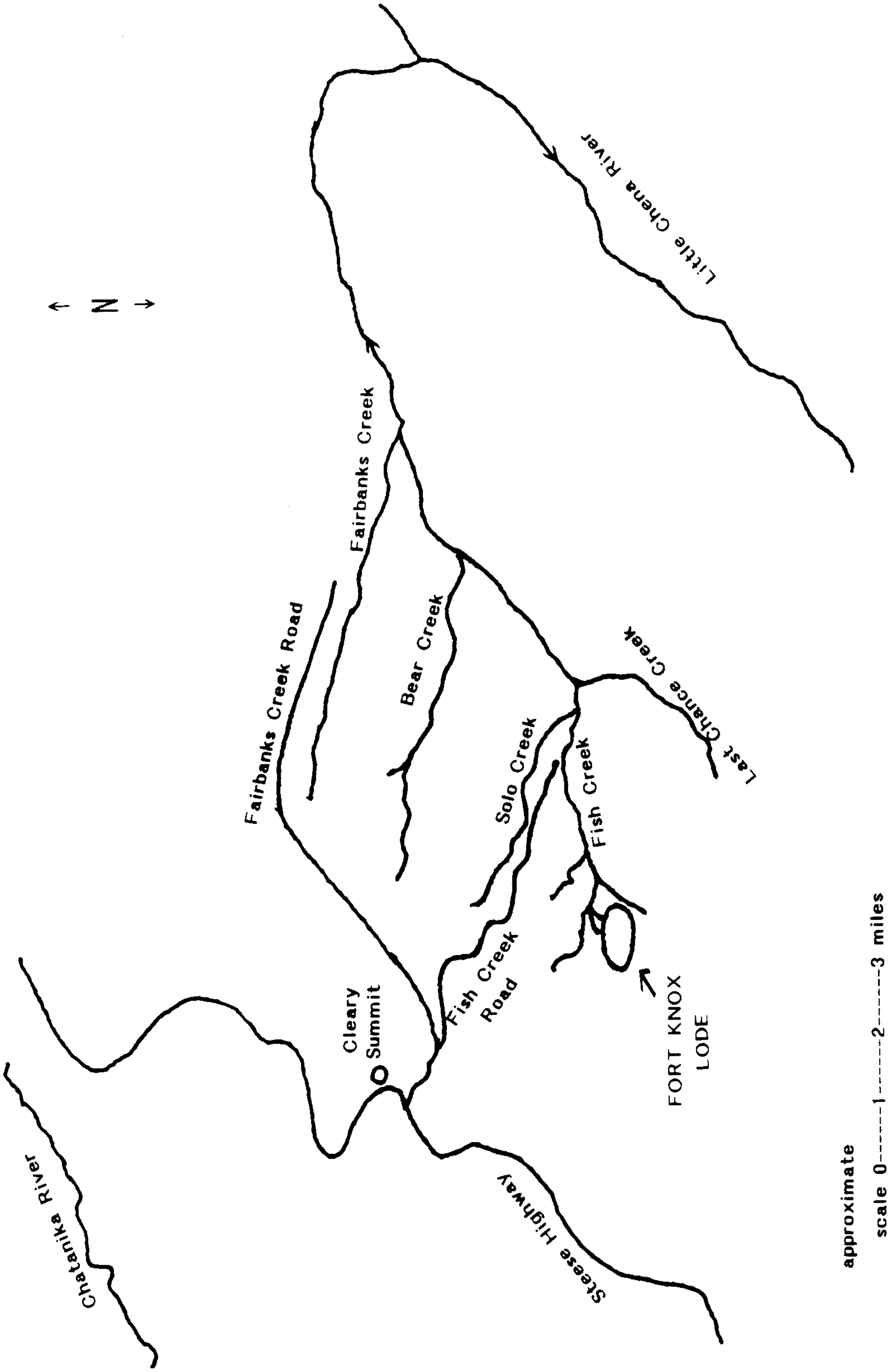


Figure A-1. Map of Fort Knox hard-rock gold mine located in interior Alaska on Fish Creek in the Chena River drainage.

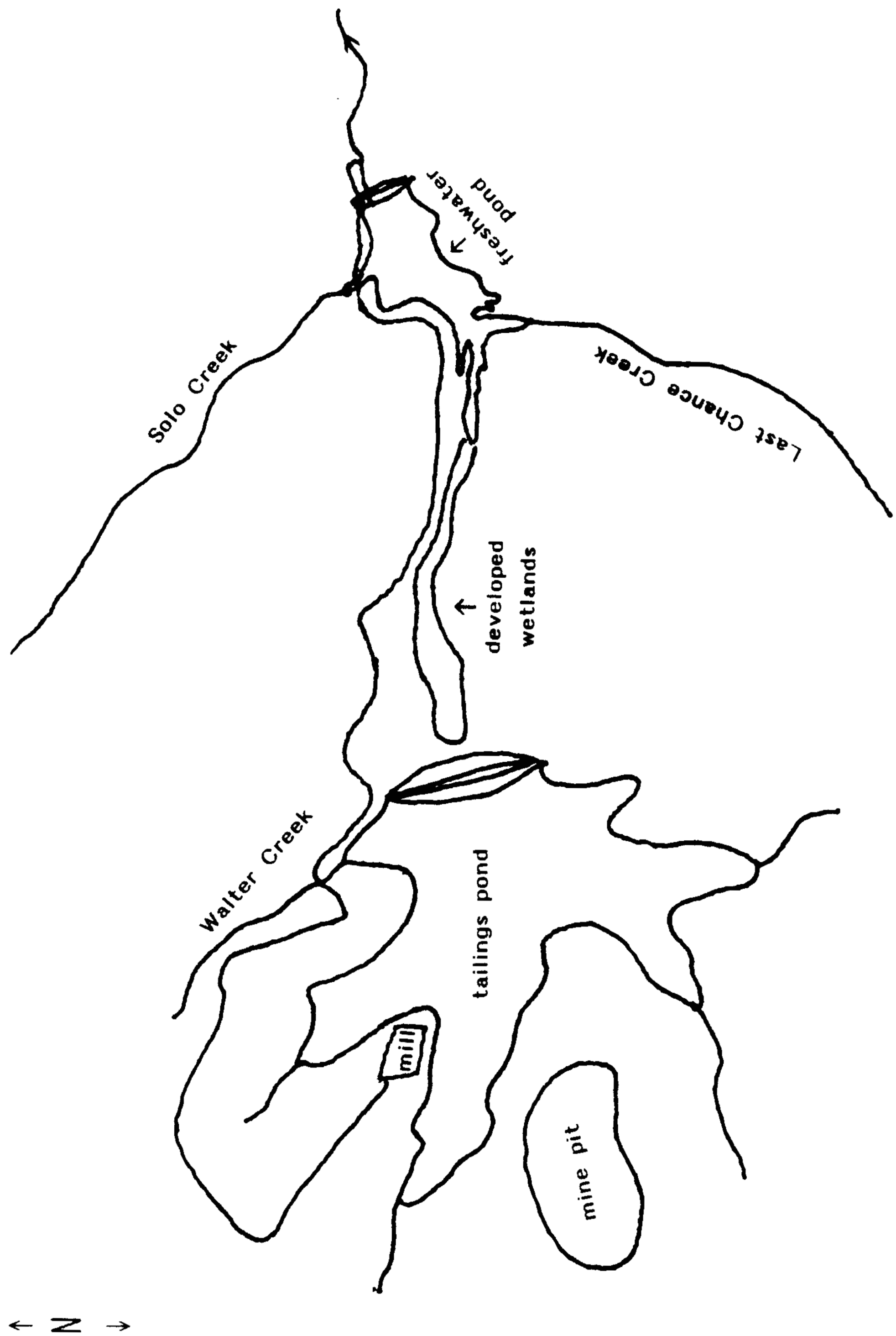


Figure A-2. Major facilities, including the proposed mill site, tailings impoundment, developed wetlands, freshwater reservoir, and causeway/utility crossing of Solo Creek at the Fort Knox Mine.

Fish surveys (by visual observation and sampling with gill nets) of the Little Chena River below the confluence of the Little Chena River and Fish Creek were made in 1971 (August) and 1984 (June) by the ADF&G. Tack (1972) found Arctic grayling (*Thymallus arcticus*) and round whitefish (*Prosopium cylindraceum*) and observed young-of-the-year Arctic grayling in backwater areas and Holmes (1985) collected Arctic grayling. Tack (1972) and Holmes (1985) attributed turbid water conditions in the Little Chena River to placer-mine operations on Fish and Fairbanks creeks.

Preliminary fish surveys of Fish Creek in the vicinity of Last Chance and Solo creeks were conducted in 1991 by Dames and Moore. Dames and Moore (1991) documented the presence of adult and young-of-the-year Arctic grayling in Last Chance and Solo creeks. Fish surveys in 1992 and 1993 by the ADF&G resulted in the capture of Arctic grayling, round whitefish, slimy sculpin (*Cottus cognatus*), and burbot (*Lota lota*) in Fish Creek in the area to be inundated by the freshwater reservoir (Weber Scannell and Ott 1992). Arctic grayling adults, juveniles, and young-of-the-year are present and juvenile and young-of-the-year burbot occur, although adult burbot were not found. The most common species present in Fish, Last Chance, and Solo creeks is Arctic grayling, with the highest density recorded in the Last Chance Creek pond complex where several thousand fish were present. Water quality was degraded by high turbidity in Fish Creek and lower Last Chance Creek during most of the open water season in 1992 and 1993. However, the Last Chance Creek pond complex had good water quality in 1992 and 1993.

Construction of the Fort Knox project will result in the formation of a 64.8 hectare freshwater lake with 18.2 hectares of wetlands upstream of the lake. Two clear water tributaries (Last Chance and Solo Creek) will flow into the lake. Habitats suitable to support rearing, spawning, and overwintering for the various fish species using Fish Creek should result from construction of the freshwater reservoir and wetlands. We hypothesize that the freshwater lake complex will support an Arctic grayling and burbot population. Slimy sculpin and round whitefish also may inhabit the freshwater reservoir but due to low numbers existing in Fish Creek it is unknown whether these species will successfully establish a population in the freshwater reservoir.

Installation of the freshwater dam will significantly alter flows downstream of the dam particularly during the first several years of operation. Once the freshwater reservoir fills with water, a surface discharge will be present through the spillway. Flows downstream of the dam will be moderated due to the presence of the dam and flows will be affected by the mine's water use and precipitation in the valley. Previously disturbed habitat in Fish, Solo, and Last Chance creeks will be inundated by the freshwater reservoir and developed wetlands. One of the major sources of sediment (e.g., nonpoint erosion, discharge from settling ponds from active placer operations) in Fish Creek will be substantially decreased or eliminated, but resuspension of sediments will occur until accumulated fines have been flushed from the system.

Bear Creek (located about 7.2 km downstream of the freshwater dam) is the first main tributary entering Fish Creek. Arctic grayling, round whitefish, and slimy sculpin use Bear Creek seasonally (Weber Scannell and Ott 1992). Arctic grayling, round whitefish, burbot, longnose sucker (*Catostomus catostomus*), and slimy sculpin are present in Fish Creek near the mouth of Fairbanks Creek (Weber Scannell and Ott 1992). Decreased and/or moderated flows and decreased suspended sediments are anticipated in Fish Creek with resultant changes in fish distribution and use. Additional beaver dams due to reduced flows also may alter fish use and distribution in Fish Creek.

OBJECTIVES

Objectives of the five-year Fort Knox fish biomonitoring study, including the stated hypothesis for each objective, follow: (Note: Changes to sample design, analyses, and frequency may be required based on results obtained.)

(1) Determine relative abundance (catch per unit of effort) of Arctic grayling (greater than 125 mm) in the freshwater reservoir during the ice-free season. We hypothesize that the number of Arctic grayling in the freshwater reservoir will increase during the five years following construction of the freshwater dam. Based on initial population estimates of several thousand Arctic grayling in the Last Chance Creek complex, we predict significant numbers of Arctic grayling will use lentic habitat created by the freshwater reservoir for rearing and overwintering. A substantial increase in the amount of lentic and overwintering habitat should result in an increase in Arctic grayling populations.

H: The number of Arctic grayling (>125 mm) in the upper Fish Creek drainage will increase after the freshwater dam is constructed and the reservoir fills with water.

(2) Estimate the number of Arctic grayling (greater than 200 mm) in the freshwater reservoir annually beginning in year three following construction of the freshwater dam. The stated goal of the rehabilitation plan for the Fort Knox project is an Arctic grayling population in the freshwater reservoir of between 800 and 1,600 fish. An Arctic grayling population of 800 to 1,600 would make the waterbody comparable to existing sport fisheries in other Alaska waterbodies, such as Fielding Lake.

H: The Arctic grayling population in the Fish Creek freshwater reservoir will be between 800 and 1,600 fish over 200 mm fork length five years after construction of the freshwater dam.

(3) Determine Arctic grayling use of Solo Creek upstream of the freshwater impoundment. Adult and juvenile Arctic grayling use Solo Creek for rearing during the ice-free season but young-of-the-year fish have not been observed. The causeway/utility crossing of Solo Creek is designed to provide for the free passage of fish.

H: Arctic grayling juveniles and adults continue to use Solo Creek upstream of the causeway/utility crossing.

(4) Determine Arctic grayling use of Bear Creek. A baseline sampling reach consisting of nine (9) pool/riffle sequences was established in Bear Creek about 1.6 km upstream from its confluence with Fish Creek. Fish use of Bear Creek appears to be seasonal with Arctic grayling entering the system during the ice-free season and outmigrating prior to breakup. In 1992 and 1993, juvenile and adult Arctic grayling were documented in Bear Creek. In 1993, two young-of-the-year Arctic grayling were collected indicating that spawning does occur in Bear Creek. Reduced and moderated flows in Fish Creek downstream of the freshwater reservoir and resulting beaver dams could alter fish movement into and from Bear Creek.

H: Arctic grayling juveniles and adults continue to use Bear Creek during the ice free season.

(5) Determine Arctic grayling use of Fish Creek immediately upstream of Fairbanks Creek. A baseline sampling reach consisting of five (5) pool/riffle sequences was established in Fish Creek immediately upstream of its confluence with Fairbanks Creek. Arctic grayling appear to use Fish Creek at Fairbanks Creek throughout the year. Sampling in October when the creek was partially ice-covered resulted in the collection of Arctic grayling. Water flow under the ice was documented in the winter of 1992/1993. Young-of-the-year Arctic grayling were common in mid-summer of 1993; however, we believe these fish originated from upper Fish and Last Chance creeks. We predict that fish use in this reach of Fish Creek will increase due to improved water quality with lower total suspended solids.

H: The relative abundance of Arctic grayling in Fish Creek at Fairbanks Creek will increase due to improved water quality.

(6) Determine heavy metal concentrations (Pb, Cd, Hg, As, Al) in whole body samples of Arctic grayling (130 to 180 mm) taken in the summer from waters in the freshwater reservoir. Baseline heavy metals concentrations in whole body samples of Arctic grayling (N = 24) from the Last Chance Creek pond complex were collected in August 1993 (Weber Scannell 1993). Pb, Cd, Hg, As, and Al were selected for long-term monitoring based on an initial test of three Arctic grayling for Al, Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Ti, V, and Zn (Weber Scannell and Ott 1992). Trends in heavy metals concentrations in juvenile Arctic grayling will be monitored in the freshwater reservoir approximately every third year. (NOTE: A sample of adult Arctic grayling may be collected and analyzed during the summer of 1994.)

H: Heavy metal concentrations (Pb, Cd, Hg, As, Al) in juvenile Arctic grayling will not be substantially different from baseline data collected Arctic grayling from the Last Chance Creek pond complex.

(7) Monitor water quality (pH, alkalinity, hardness, temperature, settleable solids, turbidity) in Solo and Last Chance creeks (upstream of the influence of the freshwater impoundment), Bear Creek, and Fish Creek (immediately upstream of Fairbanks Creek). Monitor water quality (pH, alkalinity, hardness, temperature, settleable solids, turbidity, and dissolved oxygen) in the freshwater impoundment during the ice-free season and during late winter. Water quality in Solo and Last Chance creeks is not affected by activities associated with the Fort Knox mine. Water quality data from Solo and Last Chance creeks would be used to track changes in these creeks due to other activities unrelated to Fort Knox but which could impact the freshwater impoundment. Water quality data in the reservoir would be used to evaluate changes over time and to provide information regarding suitability of aquatic habitat for fish spawning, rearing, and overwintering. Data on water quality in Bear Creek should remain unchanged whereas water quality changes are anticipated in Fish Creek at the Fairbanks Creek site.

H: Water quality conditions in the freshwater reservoir will be sufficient to support spawning, rearing, and overwintering fish.

H: Settleable solids and turbidity will decrease in Fish Creek near Fairbanks Creek.

METHODS

Juvenile and adult Arctic grayling will be sampled during the ice-free season using fyke-nets, seines, electroshocker, and angling. We plan to sample the following locations: (a) Solo Creek upstream of the freshwater impoundment; (b) Last Chance Creek upstream of the freshwater impoundment; (c) the freshwater impoundment; (d) Bear Creek about 1.6 km upstream from the confluence of Bear and Fish creeks; and (e) Fish Creek immediately upstream of Fairbanks Creek. The Bear and Fish Creek (at Fairbanks Creek) sites are baseline sample locations. Stream sample reaches (individual pool/riffle combinations) have been established at each sample location. Each sample reach will be electrofished using one pass upstream. All fish collected will be identified, measured to fork length, and released. Fish sampling will be conducted five times each year. Each sample reach has been marked in the field.

All Arctic grayling greater than 125 mm will be marked with an adipose clip or caudal punch). Arctic grayling greater than 149 mm fork length will be marked with floy tags and an adipose clip. All fish data will be reported to Sport Fish Division (ADF&G). Sport Fish Division has an active stock assessment program for Arctic grayling in the Chena River upstream and downstream of confluence of the Chena and Little Chena Rivers. The Chena River supports one of the largest Arctic grayling fisheries in North America (Clark 1990). Recapture of fish marked in upper Fish Creek in the Chena River fishery would provide some indication of the importance of the headwaters of the Little Chena to the fishery. In 1993, an Arctic grayling tagged in Fish Creek was recaptured in the Chena River by the ADF&G and an Arctic grayling released in the Chena River was collected in Bear Creek.

We propose to sample juvenile Arctic grayling (whole body analyses) to document changes in concentrations of heavy metals that may occur concurrent with mining of the Fort Knox ore deposit. A minimum of 24 Arctic grayling (130 to 180 mm) will be collected with fyke-nets and angling during the ice-free season from the freshwater reservoir. Arctic grayling retained for heavy metals analyses will be placed in individual clean plastic containers, transported to Fairbanks, and frozen. Whole body tissue samples will be shipped frozen to a laboratory for analyses. Samples will be freeze-dried and analyzed for Pb, Cd, Hg, As, and Al using Inductively Coupled Plasma Emission Spectroscopy (ICP) or graphite furnace atomic absorption spectroscopy (AA), depending upon availability of and desired detection limits. Analyses will be done by a private analytical laboratory according to the following methods (method reporting limit is ug/g equals parts per million):

Analyte	EPA Method	Method Reporting Limit
Aluminum	200.8	0.1
Arsenic	7060	1
Cadmium	200.8	0.02
Lead	200.8	0.02
Mercury	7471	0.02

Alkalinity will be measured using sulfuric acid titration to a color endpoint (Bromcresol green-Methyl Red) or a pH endpoint, according to Standard Methods (American Public Health Assoc. 1985). Total calcium and magnesium hardness will be measured with an EDTA titration according to Standard Methods (American Public Health Assoc. 1985). Dissolved oxygen will be measured with a Winkler titration according to Standards Methods (American Public Health Assoc. 1985) and with a Corning Checkmate dissolved oxygen meter, calibrated in air at 100% saturation and in a zero oxygen standard. A Corning Checkmate meter calibrated with two standards will be used to determine pH. Temperature will be measured with an electronic temperature probe. Settleable solids will be determined using an Imhoff Cone according to Standard Methods (American Public Health Assoc. 1985). Water samples will be collected from each site in a clean 1-liter container and refrigerated until analyzed for turbidity and total suspended solids. Turbidity and total suspended solids analyzes will be done by the Alaska Department of Natural Resources, Division of Water, Water Quality Laboratory (USEPA method 180.1 for turbidity and USEPA method 160.2 for total suspended solids).

PRODUCTS

The ADF&G will prepare trip reports for each sampling period. An annual progress report summarizing results of field and laboratory data will be completed by May 1. A final report summarizing the first five years of the mine project also will be prepared. The final five-year report will address the need for continued monitoring of the project. All reports will be distributed to appropriate state and federal agency personnel and other interested parties.

LITERATURE CITED

American Public Health Assoc. 1985. Standard methods for the examination of water and wastewater. 16th Edition.

Clark, R.A. 1990. Stock status of Chena River Arctic grayling. AK Dept. of Fish and Game. Federal Aid in Fish Restoration. Project F-10-5, G-8-1a. 52 pp.

Dames and Moore. 1991. Fort Knox Project: fish and terrestrial wildlife reconnaissance surveys. In Fort Knox Project: Environmental baseline report. Vol. 1. May 1992.

Holmes, R. 1985. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. AK Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1984-1985, Project F-9-17, 26(R-I): pp 60-102.

Tack, S.L. 1972. Distribution, abundance, and natural history of the Arctic grayling in the Tanana River drainage. AK Dept. of Fish and Game. Federal Aid in Fish Restoration, Annual Report of Progress, 1971-1972, Project F-9-4, 23(R-I): 36 pp.

Weber Scannell, P. and A.G. Ott. 1993. Aquatic habitat study, upper Fish Creek drainage, with an emphasis on Arctic grayling (*Thymallus arcticus*): Baseline Studies 1992. Technical Report No. 93-4. AK Dept. of Fish and Game, Habitat and Restoration Division. 76 pp.