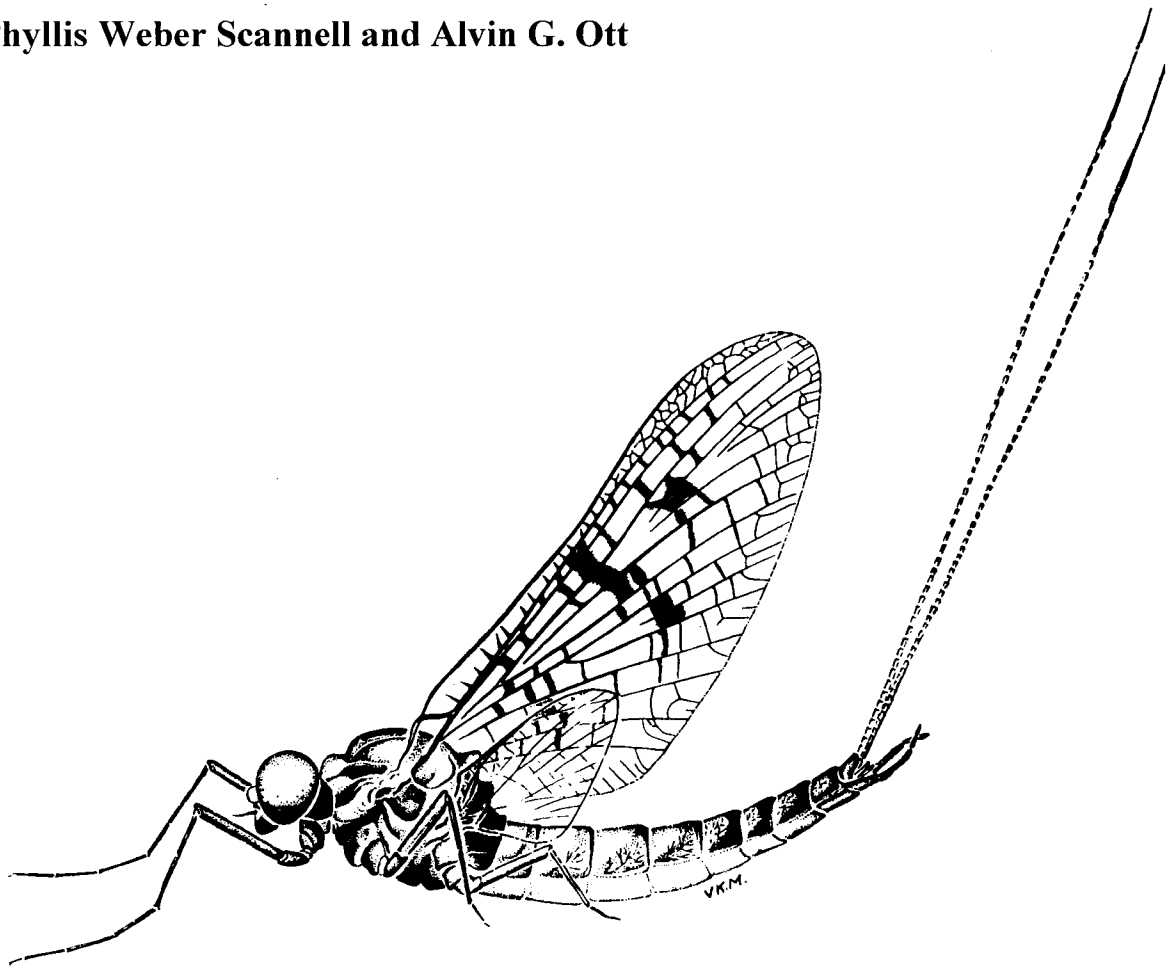
Technical Report No. 98-2

Fisheries Resources and Water Quality, Red Dog Mine

by Phyllis Weber Scannell and Alvin G. Ott



March 1998

Alaska Department of Fish and Game

Habitat and Restoration Division

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FISHERIES RESOURCES and WATER QUALITY, RED DOG MINE

By

Phyllis Weber Scannell and Alvin G. Ott

Technical Report No. 98-2

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INTRODUCTION

The Red Dog zinc and lead deposit is located in northwest Alaska, approximately 130 km north of Kotzebue and 75 km inland from the coast of the Chukchi Sea (Figure 1). The mine site is located on Red Dog Creek in the DeLong Mountains of the western Brooks Range. The Red Dog Mine is in a remote area with no previous development. The project consists of an open pit zinc and lead mine, with smaller amounts of silver. The mill and housing are located about 90 km inland from the Chukchi Sea. The port facility, located at the coast, is accessed by an interconnecting road. The mine, mill, tailing pond, housing, water treatment facilities, and port facility are described by Ott and Weber Scannell (1996).

Vegetation ranges from open tall scrub along stream margins to open low scrub on the hillsides. The entire area is underlain by permafrost. Waterfowl and shorebirds frequent the coast during spring and fall migrations. The Western Arctic caribou herd migrates through the region of the Red Dog Mine. Other large mammals found near the mine site are muskoxen, moose, Dall sheep, wolf, and brown bear.

Red Dog Creek runs through the mine deposit, emptying into Ikalukrok Creek, which then drains into the Wulik River. Pink salmon (*Oncorhynchus gorbuscha*), chum (*O. keta*), coho (*O. kisutch*), sockeye (*O. nerka*), and chinook salmon (*O. tshawytscha*), Dolly Varden (*Salvelinus malma*), burbot (*Lota lota*), slimy sculpin (*Cottus cognatus*), humpback (*Coregonus pidschian*) and round whitefish (*Prosopium cylindraceum*), least (*Coregonus sardinella*) and Bering (*C. laurettae*) cisco, Alaska blackfish (*Dallia pectoralis*), ninespine stickleback (*Pungitius pungitius*) and Arctic grayling (*Thymallus arcticus*) occur in the Wulik River. Arctic grayling, slimy sculpin, and juvenile Dolly Varden migrate upstream in Ikalukrok Creek, through the mainstem Red Dog Creek, and into North Fork Red Dog Creek in early summer and return to the Wulik River in fall to winter. Chum salmon spawn in the lower reaches of Ikalukrok Creek in late July and in August. Dolly Varden spawn in Ikalukrok Creek during late August through September.

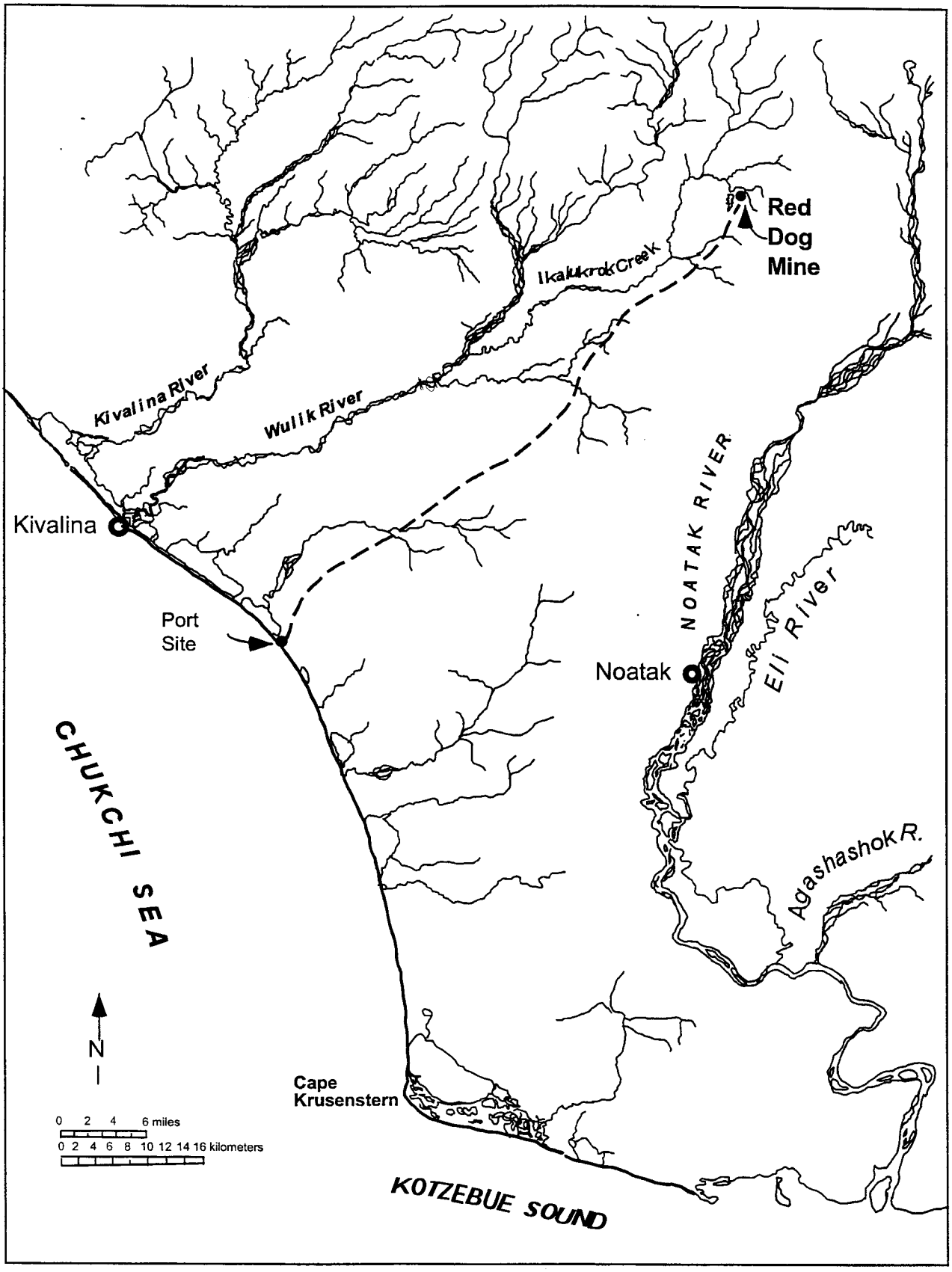

Figure 1. Location of the Red Dog Mine in northwest Alaska.

The Inupiaq village of Kivalina is located at the mouth of the Wulik River. Residents of Kivalina use water from the Wulik River for drinking and depend on fish from the river as a major source of food.

The Red Dog Mine began operation in 1989, about 10 years after baseline studies were conducted. Soon after startup, water running through the exposed ore body caused increased metals concentrations in Red Dog Creek. The cause of the metals increase was described by Ott and Weber Scannell (1993): "The acidic metal-laden surface and subsurface waters emerging from the ore body were a major source of metals contamination to Red Dog Creek in 1989 and 1990." Impaired water quality caused concern to the resource agencies and downstream users. Cominco Alaska Inc. constructed an elevated channel to carry unpolluted waters of upper Red Dog Creek around the mining operation to a point downstream of the mine and a channel to collect surface water runoff and intercepted ground water. Water in the mine seep channel is pumped to the tailing impoundment for storage until it is treated and discharged. Cominco also increased monitoring of downstream water quality and fishery resources. (A summary of mine development and changes in water quality treatment is presented in Appendix 1.)

In 1991, the Alaska Department of Fish and Game (ADF&G) began a 3-year study in the Wulik River drainage to document short-term changes in fish distribution during mine development and operation, following construction of the water bypass and collection system. Our study focused on distribution and relative abundance of juvenile Dolly Varden, Arctic grayling use of North Fork Red Dog Creek, metals concentrations in adult Dolly Varden tissues, and the number of adult Dolly Varden wintering in the Wulik River. Results and conclusions of the 3-year study were reported in Ott and Weber Scannell (1994).

In 1994, a 5-year study was developed to document changes in fish distribution, relative abundance, fish species composition, and metals concentrations in adult Dolly Varden

tissues. Results and conclusions for year 1 were reported in Weber Scannell and Ott (1995), and for year 2 in Ott and Weber Scannell (1996.).

In 1996 we expanded the scope to include a chum salmon survey in Ikalukrok Creek and a study of aquatic invertebrates and periphyton. In 1997, selenium was added to the laboratory tissue analyses. The objective of this expanded scope of work was to monitor and document changes that may occur in stream systems of the Wulik River drainage either naturally or as a result of mining activity. Aquatic invertebrates and periphyton represent communities that are continually exposed to water quality conditions present in a given tributary or section of stream. Specifically, we addressed how aquatic communities were affected by the Red Dog Mine effluent and naturally occurring changes in water quality. Since fish are a migratory group, their presence gives only limited information about in-situ productivity.

Objectives of the 5-Year Study

1. To document changes in mining activity, water treatment, and water quality in the Wulik River drainage;
2. To document in-situ standing crop of periphyton in waters downstream of the mine effluent;
3. To estimate abundance and assess distribution of overwintering Dolly Varden in the Wulik River;
4. To determine relative abundance of rearing juvenile Dolly Varden in Ikalukrok, Anxiety Ridge, Evaingiknuk, Middle Fork Red Dog, Mainstem Red Dog, and North Fork Red Dog Creeks;
5. To determine concentrations of aluminum, cadmium, copper, lead, selenium, and zinc in Dolly Varden muscle, gill, liver, and kidney; and
6. To determine the number of adult chum salmon spawning in Ikalukrok Creek.

I: WATER QUALITY CONDITIONS

Red Dog Creek flows through an orebody containing Al, Cd, Cu, Fe, Pb, Zn, Ag, and Se. Red Dog and Ikalukrok Creeks periodically experienced naturally occurring, high concentrations of metals before development of the mine. Causes of periodic increases in metals were not investigated, but may have been related to high rainfall remobilizing metals in the soils. Local residents also attributed periods of high metals to low flow conditions, when metals may have been more concentrated.

Few water quality data were collected in Red Dog Creek before mining or during the early years of mine operation, especially in 1989 and 1990. Following construction of the stream bypass, mine seepage collection ditch, and expanded water treatment facility (1994), water quality and contaminants data collection increased in both frequency and number of stations monitored (Figure 2). Pre-mining metals concentrations were reported as dissolved or total; since 1989 metals are usually reported as total recoverable. Because suspended sediment concentrations are low in Red Dog and Ikalukrok Creeks, we assumed that samples before mining and after 1989 were sufficiently comparable to document general trends in water quality.

Since 1986, samples for water quality and metals concentrations have been collected by Cominco at stations identified during baseline studies. All samples are collected in pre-cleaned Nalgene bottles (cleaned by US EPA Series 300, Protocol C specifications). Samples for metals are acidified with ultra-pure nitric acid to pH 2 or less, and shipped to an analytical laboratory. Standard quality control and quality assurance procedures, including method blanks, matrix spikes, and duplicate recoveries are done by the laboratory. QA/QC data for water samples are available.

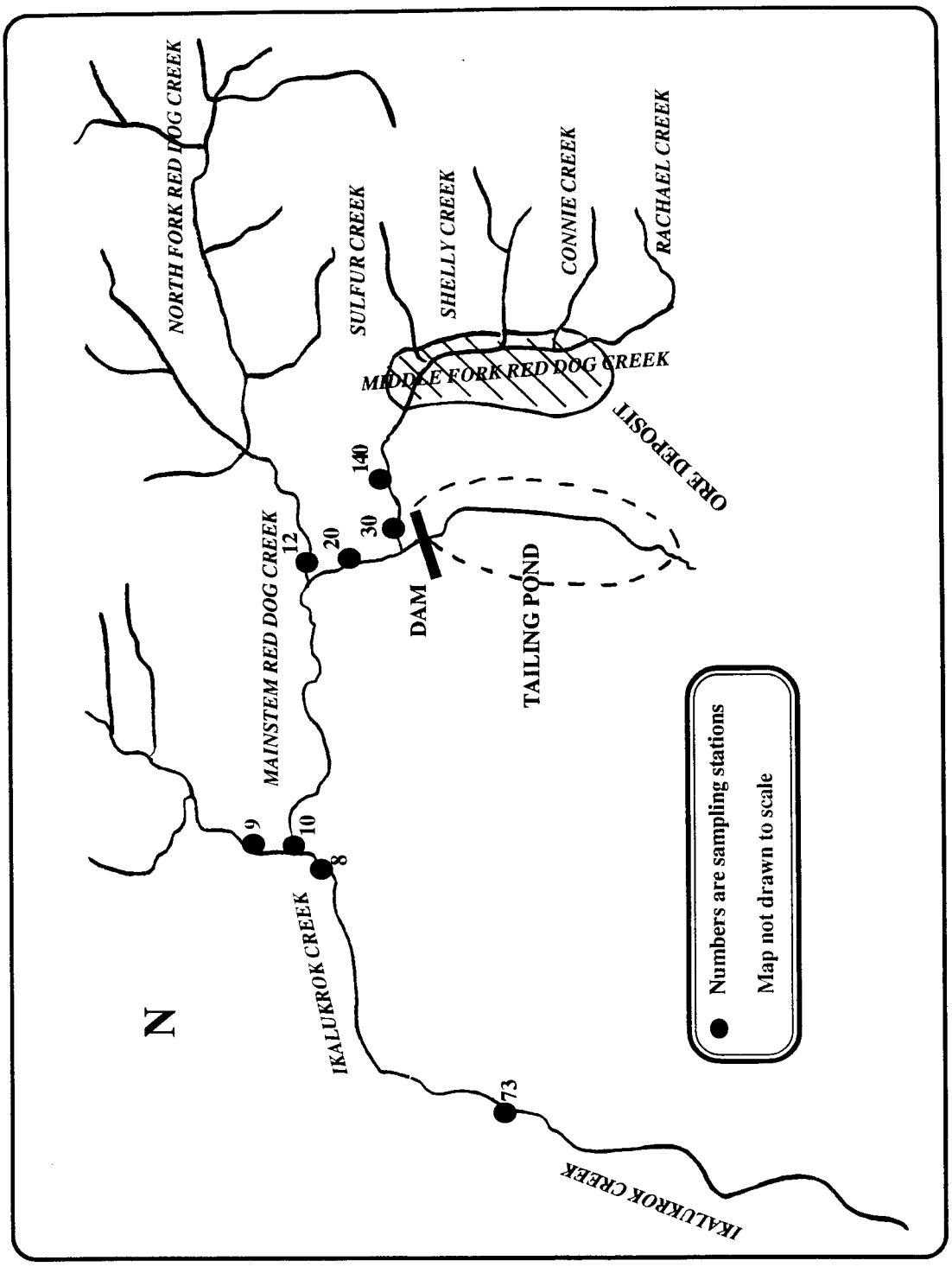

Figure 2. Locations of water quality sampling stations.

Water quality degradation experienced in 1989 and 1990 during startup of the mine resulted in lower pH (especially in 1990, Figure 3) and in higher concentrations of Al, Cd, Pb, and Zn (Figure 4) in Red Dog Creek (Station 10, near the mouth) than measured during baseline. High metals and low pH persisted in Red Dog Creek through 1990.

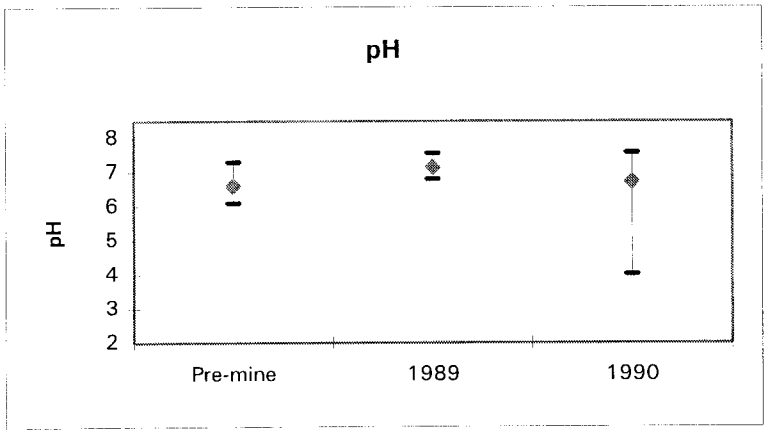

Figure 3. pH in Mainstem Red Dog Creek (Station 10), pre-mining, 1989 , and 1990. Samples are from the open water period only.

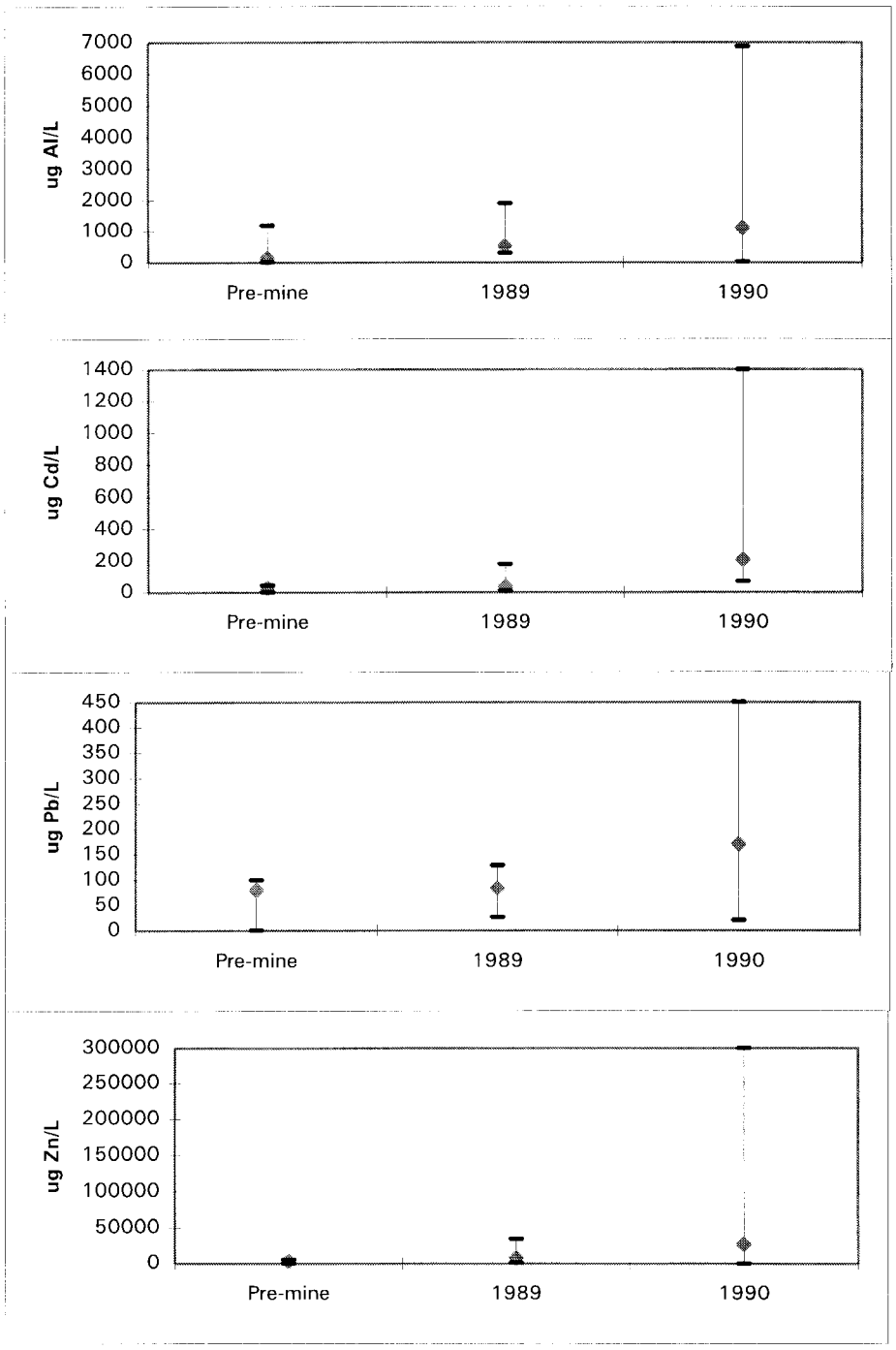

Figure 4. Median, maximum, and minimum concentrations of metals in Red Dog Creek (Station 10), pre-mining, 1989, and 1990, open water period.

Water quality in Red Dog Creek improved in 1991 with construction of the water bypass and mine sump collection ditch. The mine sump ditch was designed to collect mineralized water draining from the ore body and pump it to the tailing pond, where it is stored until later treatment and discharge to Red Dog Creek. The bypass ditch routes less-mineralized Red Dog Creek and tributaries (Sulfur, Shelly, Connie, and Rachael Creeks, Appendix 2) through a perched channel that does not intercept water draining the ore body.

Cominco has continued to expand and improve the wastewater treatment system. In 1993, sand filters were added to remove fine particulate metals and in 1994 they constructed a larger capacity wastewater treatment facility to treat additional water collected in the mine seepage ditch. In September 1995, the water collection ditch was extended to capture water from Hilltop Creek.

Since construction of the mine seepage ditch and improvements in water treatment, median concentrations of Cd, Pb, and Zn in Middle Fork Red Dog Creek at Station 20 (below the mine effluent and upstream of North Fork Red Dog Creek) have generally decreased (Figure 5). Extremes of Cd and Zn measured during baseline did not occur in 1993 through 1996, although maximum concentrations of Al were highest in 1994 and maximum concentrations of Pb were high through 1994, then decreased. Median and maximum concentrations of Al and Pb were lower at Station 20 in 1995, 1996, and 1997 than during baseline. Concentrations of all metals were lower in 1997 than in any of the previous years.

Variations in concentrations of metals in Middle Fork Red Dog Creek are usually attributable to changes in metals inputs from tributary streams. Water quality and metals concentrations have been sampled in Hilltop, Rachel, Connie, Shelly, and Sulfur Creeks and in the bypass ditch above the mine effluent. Summaries of metals data for these sites are presented in Appendix 2.

Rachael Creek, a tributary to Red Dog Creek upstream of the ore body, is a major source of Al. In 1995 and 1996, Rachael Creek contained extremely high concentrations of Al

(from 1170 to 3270 ug/L) and Cu (from 40 to 60 ug/L) and low pH (from 4.7 to 5.9) (Appendix 2). Increases in metals concentrations from baseline conditions followed high rainfall and flood events during late summer 1994; Rachael Creek lies upstream of the ore body and has not been altered by mining. Al precipitate on the substrate was prevalent in 1995 and 1996 and to a lesser extent in 1997 (Figure 6). The combination of high concentrations of Al and low pH would exclude most, if not all, aquatic species from Rachael Creek (Canadian Water Quality Guidelines 1995).

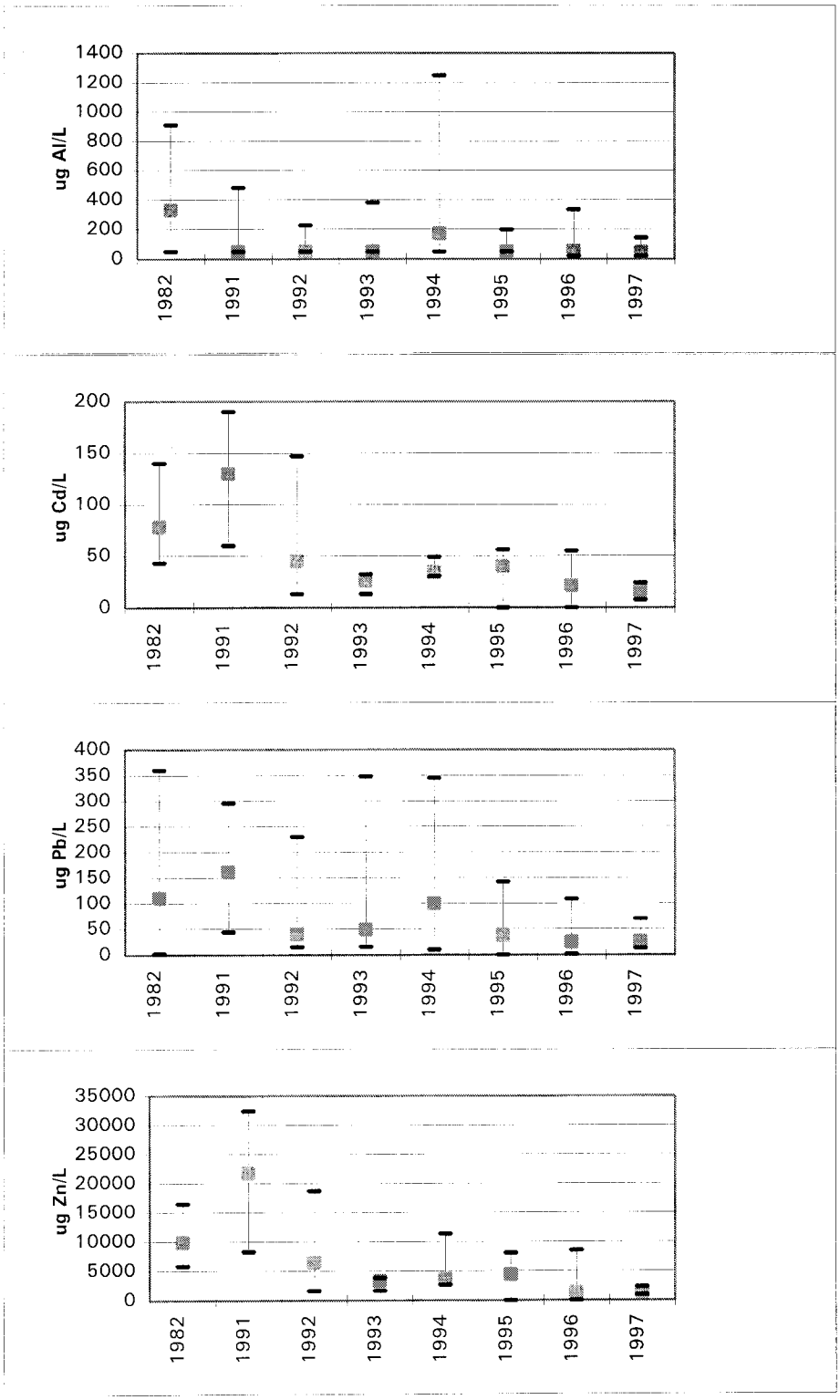

Figure 5. Median, maximum, and minimum metals concentrations in Middle Fork Red Dog Creek (Station 20), 1982-1997. All data are from open water periods.

Figure 6. Rachael Creek, a tributary to Red Dog Creek upstream of mining activity. White precipitate is Al, which began flowing into the creek after high rainfall events in 1994.

Variations in water quality downstream in Red Dog Creek below the confluence with North Fork (Station 10, Figure 7) and in Ikalukrok Creek downstream of Red Dog Creek (Station 73, Figure 8) are similar, but of lesser magnitude, than Middle Fork Red Dog Creek (Station 20, Figure 5).

Metals in Ikalukrok Creek below Red Dog Creek are from several sources, including Red Dog Creek and upper Ikalukrok Creek. The headwaters of Ikalukrok Creek appear highly mineralized (Figure 9), with elevated iron and other metals. Median metals concentrations in Ikalukrok Creek at Station 73 in 1994 through 1997 are lower than 1989-1990 concentrations (Figure 8) and similar to baseline. The 1994-1996 maximum concentrations of aluminum and lead are higher than or similar to baseline.

Collection of mine seepage water has decreased the amount of metals in Red Dog Creek over 1989 and 1990 amounts, but has resulted in an increase in total dissolved solids. Effluent from the water treatment plant generally has low concentrations of metals, high pH, and high total dissolved solids (Table 1). Total dissolved solids in the effluent were analyzed by two different analytical laboratories to identify major ions and found to contain primarily calcium and sulfate (Table 2) These analyses should be regarded as preliminary because QA/QC data were not made available, methods were not specified, and only one of three samples included carbonate; none included hydroxide. The average volume of treated wastewater discharged from 1994 through 1996 (for open water periods only) was 20.3 cfs (for a total of 322 discharge days, SD = 5.0).

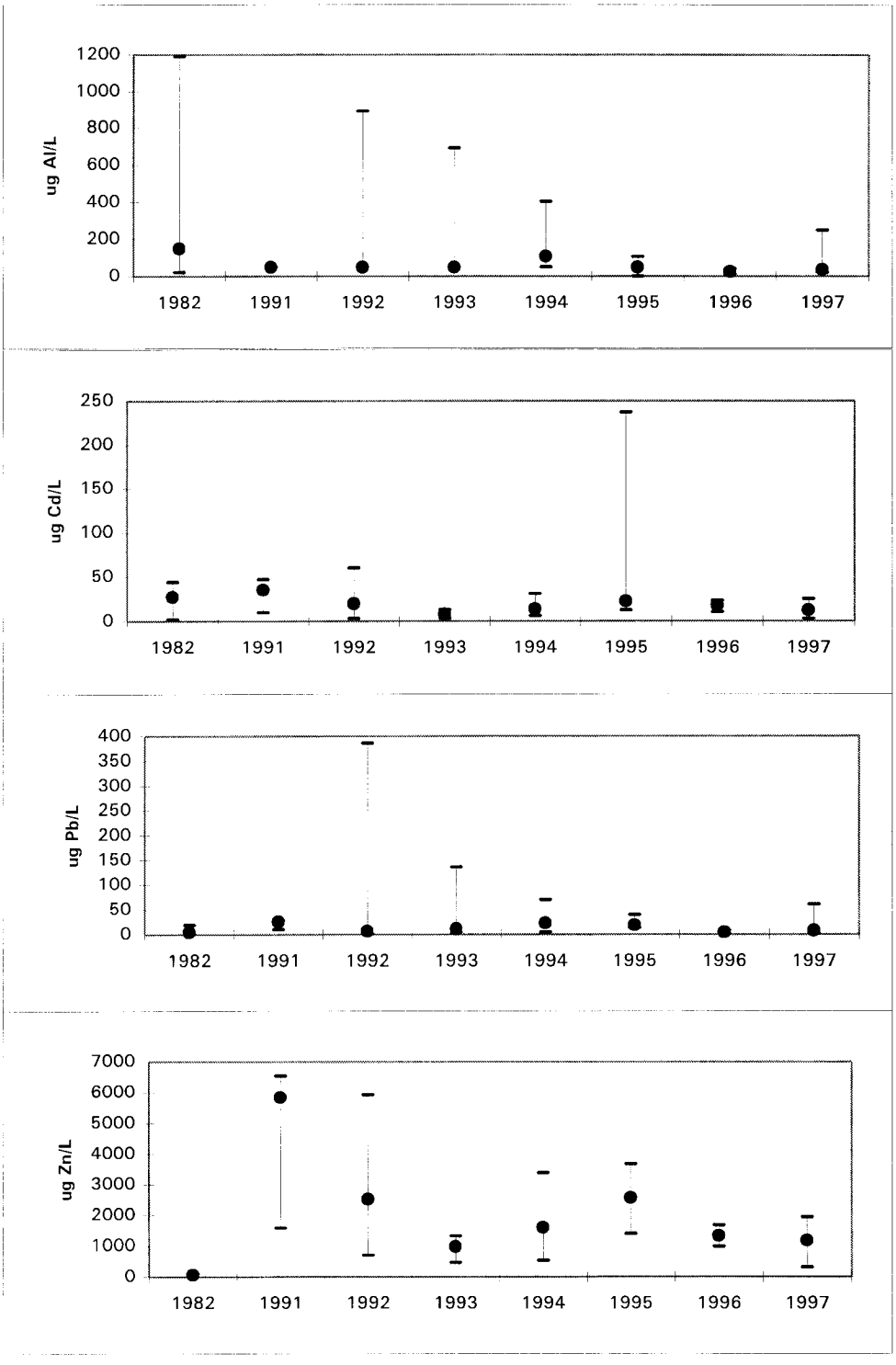

Figure 7. Median, maximum, and minimum concentrations of metals in Mainstem Red Dog Creek (Station 10), 1982 and 1991 - 1997.

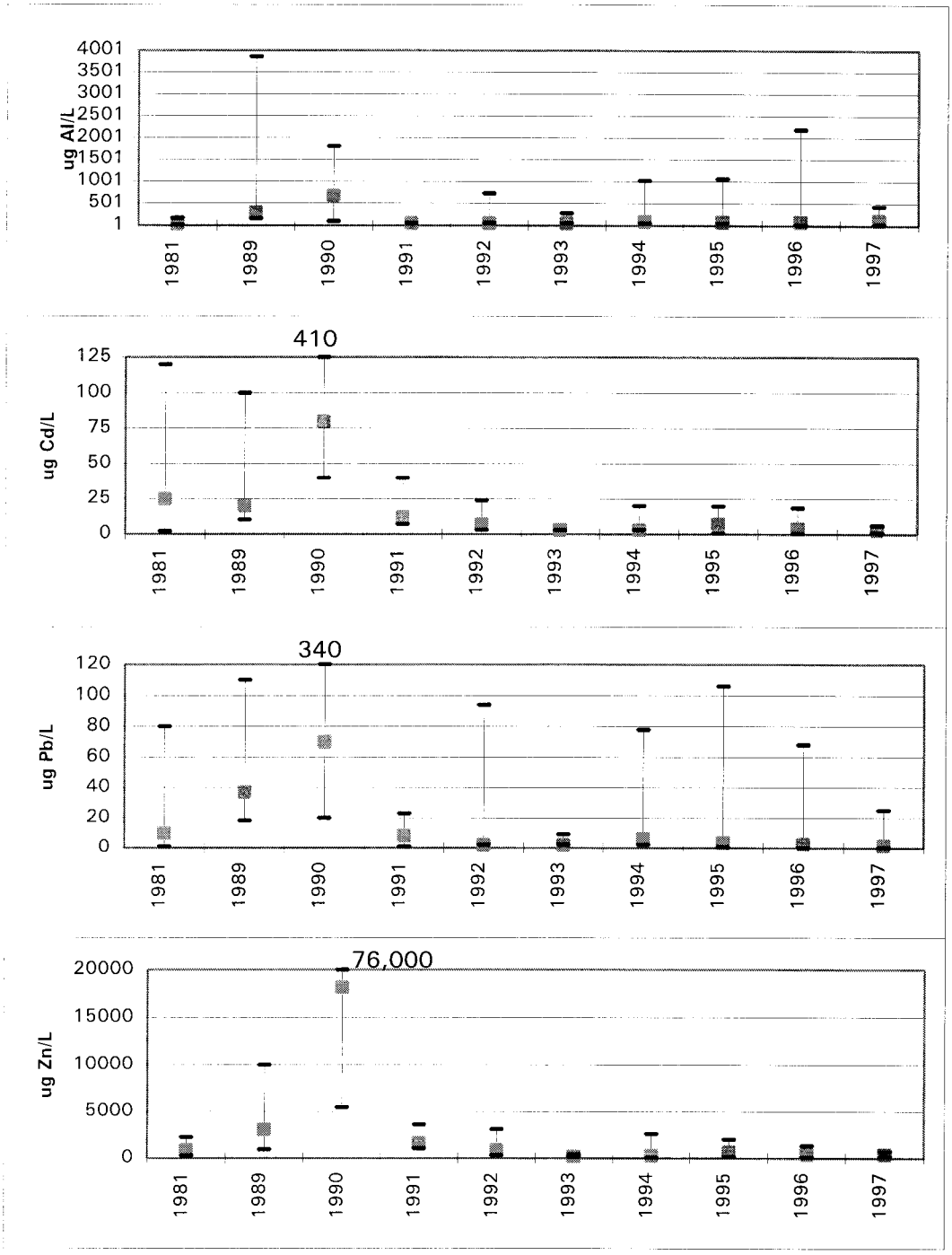

Figure 8. Median, maximum, and minimum concentrations of metals in Ikalukrok Creek (Station 73 or 8), 1981 through 1997.

Figure 9. Mineralization in the headwaters of Ikalukrok Creek, July 1997.

Table 1. Concentrations of metals, total dissolved solids, sulfate, and pH in effluent from the Red Dog Mine wastewater treatment facility, 1994-1996.

	Analyte (Year)	Median	Max	Min	n
1994	TDS, mg/L	2420	2810	352	63
	Sulfate, mg/L	1600	2000	200	41
	pH	9.6	10.3	6.8	73
	Cd, ug/L	<LOD[1]	55	<LOD	71
	Pb, ug/L	<LOD	<LOD	<LOD	71
	Zn, ug/L	46	299	18	71
	total cyanide, mg/L	<0.01	0.13	<0.01	73
1995	TDS, mg/L	2465	2700	1040	134
	Sulfate, mg/L	1700	1900	690	53
	pH	9.6	10.5	9.1	150
	Cd, ug/L	14.9	67.5	0.4	134
	Pb, ug/L	0.97	12	0.12	136
	Zn, ug/L	36	34	23	134
	total cyanide, mg/L	<0.01	0.06	<0.01	60
1996	TDS, mg/L	2760	2960	1360	136
	Sulfate, mg/L	1800	6500	170	136
	pH	9.6	10.13	8.6	131
	Cd, ug/L	19.2	30.1	10	48
	Pb, ug/L	1.52	8.83	0.43	45
	Zn, ug/L	40	258	21	47
	total cyanide, mg/L	<0.01	0.02	<0.01	46
1997	TDS, mg/L	2865	3360	753	20
	Sulfate, mg/L	1800	2400	560	20
	pH	10.2	10.4	9.7	10
	Cd, ug/L	5	58	3	28
	Pb, ug/L	5.3	25.9	1.1	23
	Zn, ug/L	87	209	26	27
	total cyanide, mg/L	0.007	0.288	0.003	29

[1]LOD=Limit of Detection, in 1995 the LOD was lowered leading to detectable limits although actual concentrations may not have changed

Table 2. Major ions identified in mine effluent by two private analytical laboratories, 1996. Data from Cominco.

Analyte	Laboratory 1 June 6, 1996 mg/L	Laboratory 1 June 27, 1996 mg/L	Laboratory 2 June 27, 1996 mg/L
Calcium	498	665	590
Carbonate	NA	NA	9.1
Chloride	7.7	10	15
Fluoride	NA	<1.0	0.7
Magnesium	39.3	40.6	37
Potassium	15	19.4	17
Sodium	20.6	30.8	28
Sulfate	1400	1900	1800
TDS	NA	2740	2700
Ion Balance (% difference)	0.25	3.3	10.7

Total dissolved solids concentrations at Station 20 approach 3000 mg/L and are controlled by mine effluent volume and quality. pH has not increased at Station 20 with increases in discharge following installation of the expanded water treatment plant in 1994 (Figure 10); since improvements in water treatment and control of mine seepage water, extreme low pH, such as those reported in 1990 (Figure 3) have not been observed.

Total dissolved solids (TDS), sulfate, and pH have been monitored at Station 8 and 73 since 1981, and flow and conductivity (used to estimate TDS) continuously at Station 73 in 1995 and 1996 (Figure 11). Continuous monitoring of stream discharge and conductivity show an inverse correlation between total dissolved solids and stream discharge.

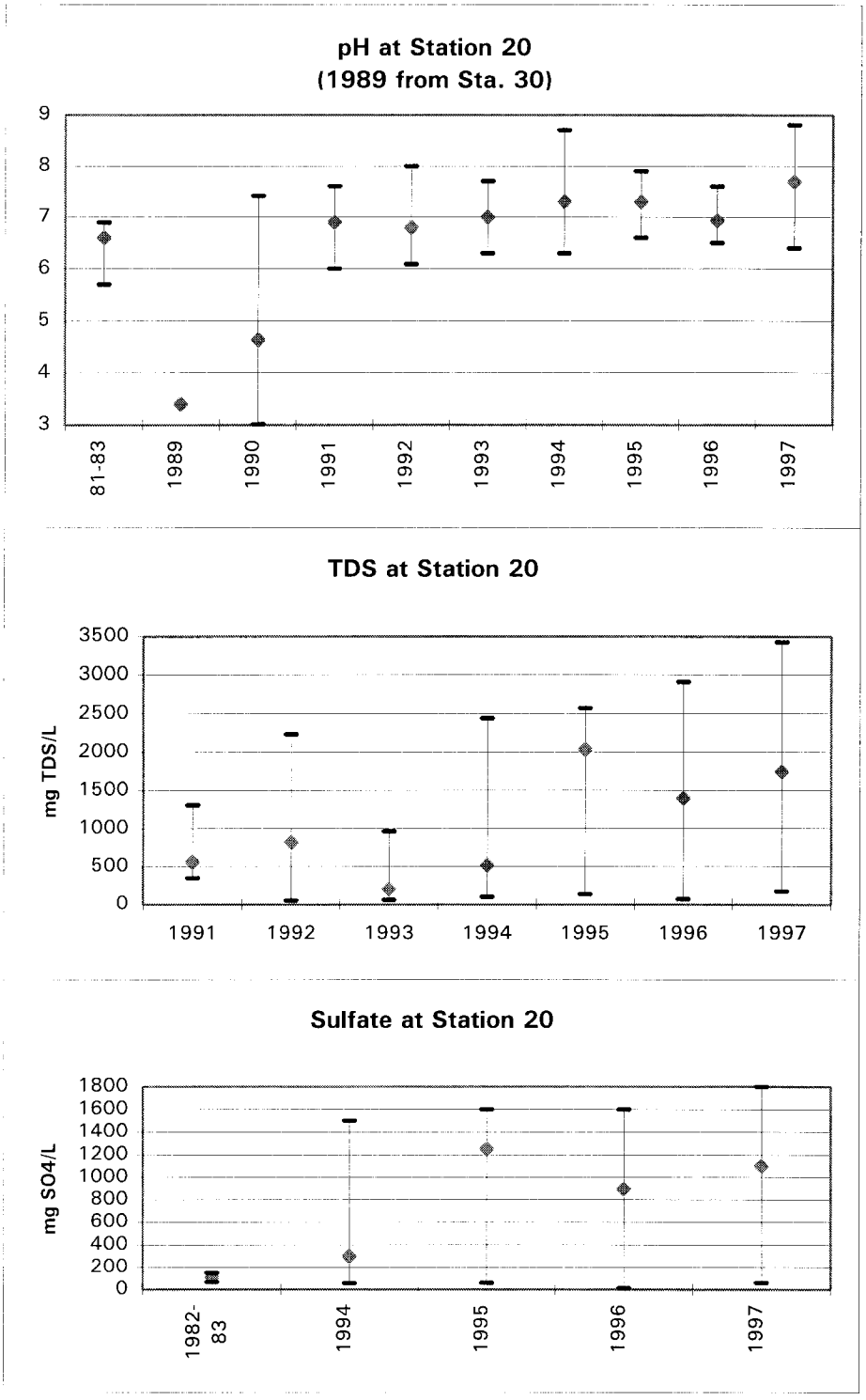

Figure 10. Median, maximum, and minimum pH, and concentrations of total dissolved solids and sulfate in Middle Fork Red Dog Creek (Station 20).

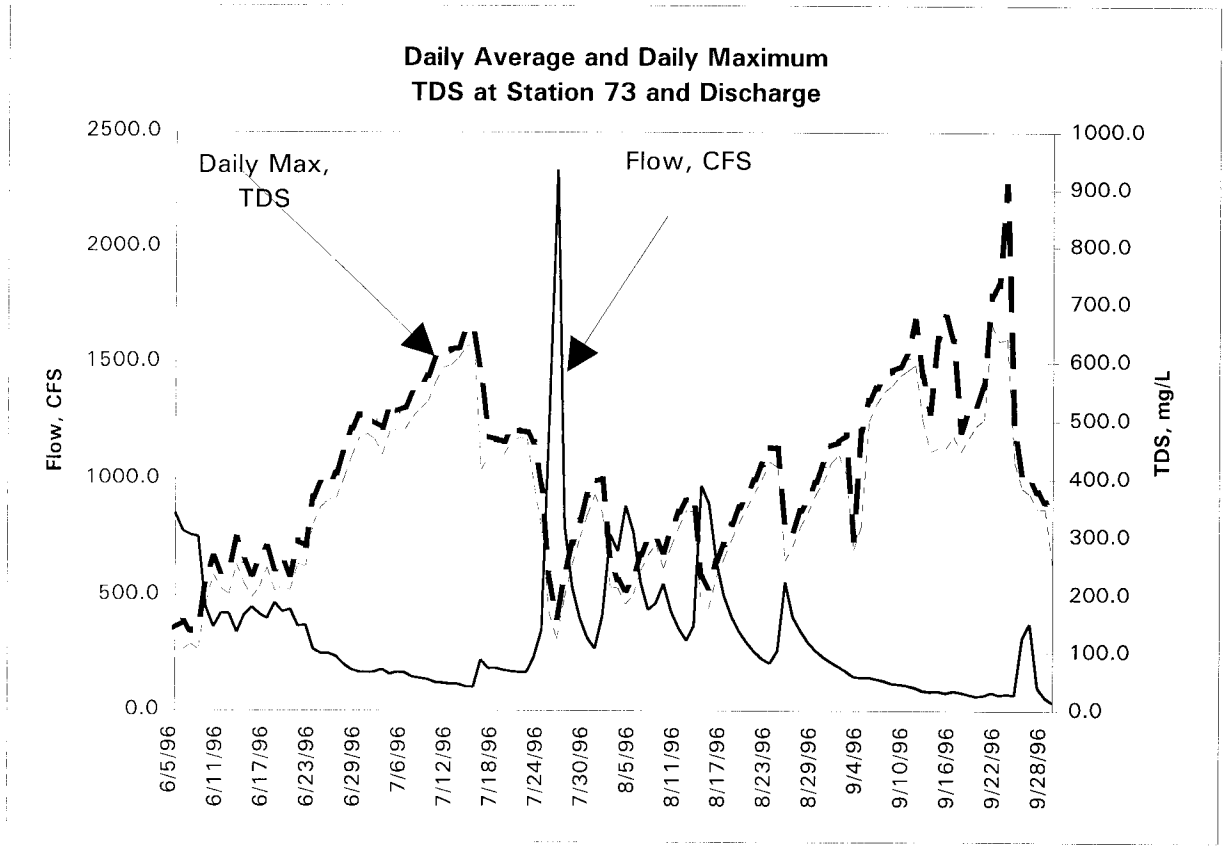

Figure 11. Total dissolved solids and stream discharge in Ikalukrok Creek (Station 73), 1996. TDS is estimated from measurements of conductivity.

II: AQUATIC INVERTEBRATE COMMUNITIES

Methods

Aquatic invertebrate communities were sampled in 1995 and 1996 to determine abundance and taxonomic richness of communities in Ikalukrok and Red Dog Creeks below the mine effluent. The objective was to detect continued productivity of stream reaches along a continuum from areas containing maximum concentrations of metals to sites that were diluted by downstream tributaries. Sites unaffected by the mine also were sampled: Ikalukrok Creek upstream of Red Dog Creek (1996 only), North Fork Red Dog Creek (1995 only) and tributaries to Red Dog Creek upstream of the ore body. Communities were sampled in July 1995 and in mid-July and early August 1996. In 1995, we collected five semi-quantitative samples with a kick net in each of the creeks. In 1996 we set three drift nets in each creek. Drift nets from July 1996 samples from small tributaries (Shelly, Rachel, and Connie Creeks) were left overnight because flows were sufficiently low that nets did not seal with debris. In August 1996, during high flows, nets were left in each creek for approximately 2 hr; nets became clogged and stopped flowing water after two hours. Benthic kick samples also were collected in 1996, but the method did not provide a sufficient representation of aquatic communities, so data were not used. Because different sampling methods were used (kick net samples in 1995 and drift samples in 1996) and sampling efforts changed (because of low flow in July 1996 and flood flows in August 1996), only relative comparisons are made among sample periods. Sampling sites and frequency of sampling are listed in Table 3.

Samples were washed through a plankton bucket into whirl-pack bags, preserved in 70% ethanol (ETOH), and labeled. Samples were sorted from rocks and organic debris, identified to lowest practical taxonomic level, (usually genus) and counted. A taxonomic list is presented in Appendix 3.

Table 3. Sites in the Wulik River drainage sampled for aquatic invertebrates and number of replicates for a given event.

Station No. (or stream name)	July 1995	July 1996	August 1996
Rachel Creek	5		
Rachel Creek (RF*)		3	
Connie Creek	5	3	3
Shelly Creek	5	3	3
Sulfur Creek	5	(dry in 1996)	
Red Dog Creek (140)	5		
Red Dog Creek (20)	5	3	3
Red Dog Creek (11)	5		
Red Dog Creek (10)	5	3	3
North Fork (12)	5		
Ikalukrok Creek (9)		3	3
Ikalukrok Creek (8)	5	3	3
Ikalukrok Creek (7)		3	3
Ikalukrok Creek (6)		3	3

*RF = right fork

Results

Substantial differences occurred between benthic kick and drift samples. Drift sampling was far more effective in collecting larger numbers of insects and more genera (Tables 4, 5, and 6). Terrestrial insects were not represented in kick samples, so their importance as potential fish food could not be determined with this sampling method.

The largest numbers of insects in the aquatic stages (excluding terrestrial forms) were usually collected in the tributary streams: North Fork Red Dog, Connie, and Shelly Creeks in 1995 (Table 4), and Connie and Shelly Creeks in both July and August 1996 (Tables 5 and 6). No correlation was found with invertebrate density and distance downstream from the mine, except in July 1996. During this sample period, densities were highest at Station 6, followed by Station 7, then by Station 8. Station 20 (the

middlefork Red Dog Creek) had the lowest invertebrate density. Station 10 had the highest invertebrate density of all sites, except the tributaries Connie and Shelly Creeks.

Differences in invertebrate densities among the sample sites did not follow the same pattern in August as in July, with the exception that highest densities were found in tributaries Shelly and Connie Creeks.

Drift samples collected in 1996 indicated that benthic sample methods used in 1995 did not provide a sufficient representation of taxonomic richness. Numbers of taxa from benthic samples were low at all sites, except North Fork Red Dog Creek (Table 4). Drift nets collected more taxa from all sites, especially genera of Ephemeroptera and Plecoptera (Tables 4 and 5).

In July 1996, the highest taxonomic richness was found in the right fork of Rachel Creek, upstream of the inflow of aluminum-stained water, where an average of 6.7 different taxonomic groups were found. The majority of invertebrates were Diptera, and no Ephemeroptera was found. Most of the Diptera were Chironomidae and Simulidae (*Simulium*) with a few Tipulidae (*Tipula*). Common Plecoptera genera found in this study were *Allocapnia* and *Alloperla*. Stations 8, 9, and 20 each had an average of 4 taxa per sample, and Station 9 had a higher proportion of Ephemeroptera and Plecoptera than the other two sites.

Differences between July and August samples are notable: Station 8 had the lowest taxonomic richness in July 1996 and highest in August 1996 (Rachel Creek was not sampled in August).

Table 4. Proportion of Ephemeroptera, Plecoptera, and Diptera and the average number of invertebrates collected in July 1995. Samples were collected with kick nets.

Sample Site	Percent Ephemeroptera	Percent Plecoptera	Percent Diptera	Average no. per sample immature	Average No. of Taxa
Station 8	3	3	13	7.4	1.4
Station 10	0	0	15	4	1
Station 11	0	0	100	0.4	0.4
Station 20	0	0	0	1	0.6
Station 140	0	0	100	0.2	0.2
Sulfur Cr.	0	0	5	36.6	1.8
Shelly Cr.	0	10	30	4.2	1.6
Connie Cr.	3	1	96	40.6	2.6
Rachel Cr.	0	0	100	0.6	0.2
North Fork	35	2	55	26	5.4

Non-insect invertebrates, including Nematoda, were collected in some of the samples.

Table 5. Proportion of Ephemeroptera, Plecoptera, and Diptera and the average number of invertebrates collected in July 1996. Samples were collected with drift nets.

Sample Site	Percent Ephemeroptera	Percent Plecoptera	Percent Diptera	Average/ sample adults	immature	Average no. Taxa*
Station 6	1	2	98	28	237	4.3
Station 7	6	11	82	1	210	5.3
Station 8	0	4	94	23	170	4
Station 9	6	15	77	138	57	4
Station 10	1	7	92	99	629	5.7
Station 20	3	0	95	299	81	4
Shelly Cr.	0	2	98	262	2842	4.7
Connie Cr.	1	3	94	675	700	5
Rachel Cr.	0	10	89	1	610	6.7

*Only aquatic taxa and aquatic life stages were counted.

Table 6. Proportion of Ephemeroptera, Plecoptera, and Diptera and average number of invertebrates, August 1996. Samples were collected with drift nets.

Sample Site	Percent Ephemeroptera	Percent Plecoptera	Percent Diptera	Average/ sample adults	immature	Average no. Taxa*
Station 6	10	2	86	7	49	4
Station 7	87	4	9	0	805	5.7
Station 8	56	10	33	2	263	8.7
Station 9	77	5	18	3	905	6.3
Station 10	38	11	51	0	704	6
Station 20	68	2	28	50	737	5
Shelly Cr.	33	54	13	9	1246	4
Connie Cr.	67	4	28	14	1479	6.7

*Only aquatic taxa and aquatic life stages were counted.

The highest proportion of terrestrial insects (adult stage of aquatic taxa) were found in July at Stations 9 and 20 (Table 7). Seasonal differences in timing of emergence account for differences between July and August samples. The emerging and flying insects are an important prey for surface feeding fish, such as Arctic grayling. In August, many of the *Alloperla* and *Capnia* nymphs appeared to be in final aquatic life stages with darkened and well developed wing pads; these genera were within 1-2 weeks of emergence. Adult insects were less common in August than in July and comprised less than 1% of August samples at all sites except Station 6 (12.5 %) and Station 20 (6.4 %).

Table 7. Proportion of terrestrial (adult) forms of aquatic taxa found in study sites, 1996.

	July % of total	August % of total
Station 6	10.6	12.5
Station 7	0.5	0.0
Station 8	11.9	0.8
Station 9	70.8	0.3
Station 10	13.6	0.0
Station 20	78.7	6.4
Shelly Creek	8.4	0.7
Connie Creek	49.1	0.9
Rachel Creek	0.2	

III: PERIPHYTON STANDING CROP

Methods

In 1995, we collected five rocks at each sample site within a riffle section to sample for periphyton. In 1996, we sampled at least 5 and up to 10 rocks within the same study sites sampled for aquatic invertebrates (Table 3). A 5 cm x 5 cm square of high density foam was placed on the rock. Using a small tooth brush, all material around the foam square was removed and rinsed away with clean water. The foam was removed from the rock and the rock was brushed with a clean tooth brush and rinsed onto a 0.45 *u*m glass fiber filter, held by a magnetic filter holder connected to a hand vacuum pump. Excess water was pumped through the filter, and approximately 1 ml saturated $MgCO_3$ was added to the filter to prevent acidification. The dry filter was wrapped in a large filter (to absorb any additional water), labeled, placed in a sealable plastic bag, and packed over desiccant. Filters were frozen in a light-proof container with desiccant.

Filters were cut into small pieces and placed in an extraction tube with 10 ml of 90% buffered acetone. Extraction tubes were covered with aluminum foil and were held in a dark refrigerator for 24 hrs. After extraction, samples were read on a Shimadzu UV-1601 Spectrophotometer (1995) and a Turner Model 10 Fluorometer (1996). Trichromatic equations (according to Standard Methods, APHA 1992) were used to convert spectrophotometric optical densities to total chlorophyll-a. The Turner Fluorometer was calibrated with US EPA standards according to Standard Methods (APHA 1992). A calibration curve was developed with chlorophyll-a standards using a spectrophotometer.

Results and Discussion

In 1995, periphyton standing crop (as measured by concentrations of chlorophyll-a) was higher in North Fork Red Dog Creek than at any of the other sites (Figure 12). Concentrations in Sulfur Creek and one sample at Station 11 (immediately below the

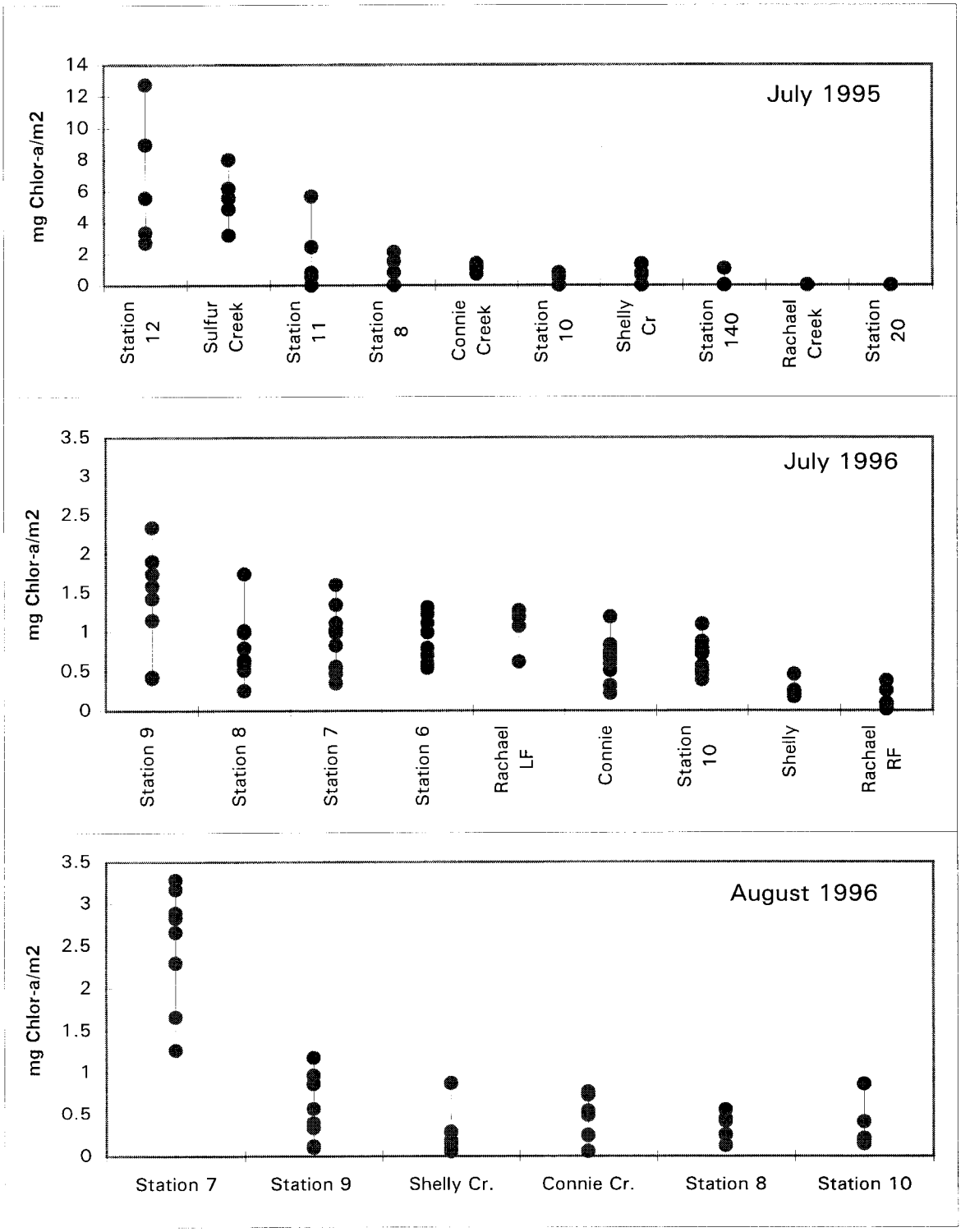

Figure 12. Periphyton standing crop (concentration of chlorophyll-a) in the Wulik River drainage, 1995 and 1996.

confluence of North Fork Red Dog Creek) also were high. The greater concentration measured at Station 11 was believed to be within the influence of the North Fork, before complete mixing with Red Dog Creek.

Periphyton standing crop measured in 1996 varied between sample dates, but standing crop in Ikalukrok Creek (Stations 6, 7, 8, and 9) was always higher than in Red Dog Creek at Station 10 (near the mouth). Among the tributaries, the left fork of Rachel Creek and Connie Creek had highest standing crop, and right fork Rachel Creek (below the input of Al) the lowest. As with invertebrate samples, there appeared to be no correlation in periphyton standing crop in Ikalukrok Creek with distance from the mine. Standing crop in this creek is probably influenced more directly by stream velocity, exposure to sunlight, and substrate particle size. Samples taken in August were collected during seasonal high flows following several days of heavy precipitation. We sampled areas of Ikalukrok Creek that were dry in July and, because of high flows and water depth, we were not able to sample toward the center of the creek as in July.

Periphyton standing crop in Ikalukrok Creek and tributaries to Red Dog Creek were comparable to periphyton standing crop reported for the upper Chena River drainage in interior Alaska (LaPerriere, Van Nieuwenhuyse, and Anderson 1989) but lower than values reported in baseline studies for the Red Dog area (EVS and Ott Water Engineers 1983). Chlorophyll-a concentrations reported in baseline studies were approximately 100 times greater than measured in our study; we believe that baseline studies either concentrated in areas of dense filamentous algae or that the units were erroneously reported. Because of the 100-fold discrepancy in chlorophyll-a values, no further comparisons with baseline chlorophyll-a data are made.

Samples were not collected in Sulfur Creek in 1996 because the creek was dry.

IV. METALS CONCENTRATIONS IN DOLLY VARDEN

Methods

Dolly Varden in the Wulik River are highly migratory. Tagged fish have been caught as far away as Russia and fish returning to the Wulik River are a mixed stock from drainages throughout western Alaska. Therefore, it is difficult to correlate tissue metals concentrations with sources of metals. However, because of the importance of Wulik River Dolly Varden as a subsistence and sport fish, the adult fish are regularly sampled for metals concentrations in fall after they return from the ocean and in spring, after spending the winter in the Wulik River.

ADF&G Division of Sport Fish collected the fish sample in fall 1996, spring 1997, and fall 1997 and Division of Habitat and Restoration collected fish in spring 1996. Since 1990, adult fish were taken in the Wulik River below the mouth of Ikalukrok Creek. Individual Dolly Varden were placed in clean plastic containers and labeled with sample date and location. Fish were frozen and shipped to ADF&G in Fairbanks, Alaska. We removed Dolly Varden from the freezer, measured, weighed, recorded sex and spawning condition, and removed otiliths to determine age. Tissue samples from muscle (muscle was removed below the dorsal fin and above the lateral line), gill, kidney, and liver were removed from partially thawed fish using standard procedures to minimize contamination (Crawford and Luoma 1993). About 10 g of each tissue was placed a in pre-cleaned jar (EPA Series 300, Protocol C) and refrozen. We cleaned each dissection instrument in ultra-pure nitric acid with two rinses in double distilled water before we began to work on a new tissue. Tissue samples were submitted to a private analytical laboratory. Samples were digested, freeze-dried, and analyzed for Al, Cu, Cd, Pb, and Zn using U.S.

Environmental Protection Agency standard methods (Table 8); beginning in spring 1997, tissues also were analyzed for selenium.

Table 8. Method and method detection limit used to analyze fish tissues for various metals. All samples were reported as mg/Kg, dry weight basis.

Metal	Method[1]	Limit of Detection
Al	200.8	0.2
Cd	200.8	0.02
Cu	200.8	0.05
Pb	200.8	0.02
Zn	200.8	0.5
Se	7740	0.5

[1]Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-020

Quality Control / Quality Assurance

In addition to results, the laboratory provided quality assurance/quality control information for each analyte. Beginning in fall 1994, we required the following quality assurance procedures: matrix spikes, standard reference materials, laboratory calibration data, sample blanks, and sample duplicates. The laboratory submits copies of all raw data, including laboratory calibration curves and internal quality control.

Beginning in spring 1997 samples, we have submitted blind duplicate tissues to the laboratory.

We compared the 1990 through 1997 data on concentrations of Al, Cu, Cd, Pb, and Zn in adult Dolly Varden with baseline data collected by Dames and Moore (1983) and with water quality conditions in the Wulik River.

Results and Discussion

Since 1990, ADF&G has sampled adult Dolly Varden from the Wulik River for metals concentrations (Al, Cd, Cu, Pb, and Zn) in gill, kidney, liver, and muscle (Weber Scannell and Ott 1995) (Appendix 4, a description of fish sampled). Laboratory Quality Assurance data are on file with ADF&G, Division of Habitat and Restoration.

Since beginning this sampling, we have compared tissue metals concentrations in adult Dolly Varden with baseline data collected by Dames and Moore (1983) and with water quality conditions in the Wulik River to show long-term trends and to identify any changes in tissue concentrations that may be related to operation of the Red Dog Mine. The metals monitored in the Dolly Varden tend to concentrate in specific tissues: Al, Se, and Zn are most prevalent in gill tissue, Cd and Cu in liver, Pb in both liver and kidney. Although certain tissues may have the highest concentrations, especially during periods when metals concentrations are high in the stream water, they are not necessarily the best indicators of metals accumulation for long-term monitoring.

To determine long-term trends in metals accumulation, we focus on Al and Cd in kidney tissue, and Cu, Pb, and Zn in liver. Se has not been monitored for sufficient time to identify the most representative tissue; data for Se in both kidney and liver are presented. None of the metals being monitored tend to accumulate in muscle tissue.

Data for concentrations of Al, Cd, Cu, Pb, Se, and Zn for all tissues monitored are contained in Appendix 5.

Aluminum

Al in kidney tissues reached highest concentrations in spring 1991, spring 1994, and fall 1995 (Figure 13). In fall 1994 and spring 1995, Al concentrations in gill tissue were the highest ever measured (Appendix 5), when maximum amounts were more than 400 times

baseline amounts. High Al tissue concentrations during 1994 and 1995 correlate to increased Al input from Rachael Creek after 1994 flood events.

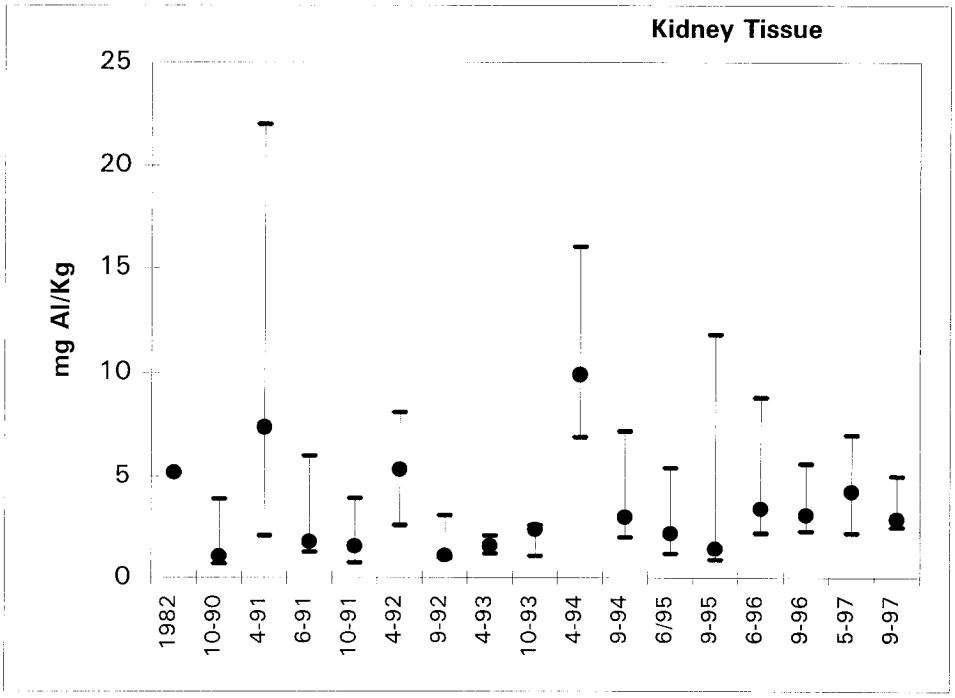

Figure 13. Concentrations of aluminum (dry weight basis) in adult Dolly Varden kidney tissue, Wulik River, 1982 and 1990-1997. 1982 data are expressed as mean concentration.

Cadmium

Maximum Cd concentrations were highest in Dolly Varden kidney tissue in June 1991, then decreased to the lowest amounts in September 1994 (Figure 14). Median concentrations gradually increased from June 1992 until September 1997. Kidney tissue in September 1997 had the lowest amounts recorded since we began tissue monitoring in 1991. No increase in Cd was observed in the other three tissues sampled (Appendix 5). The only time kidney tissue was found to contain median Cd concentrations above baseline was June 1991. This sample was collected before the mine seepage ditch and bypass of Red Dog Creek were completed.

Copper

Liver concentrations of Cu have varied from 20 mg/Kg to about 60 mg/Kg, with no pattern that could be related to differences between spring and fall caught fish, completion of the mine diversion and collection system, or any changes in any of the other metals that were monitored (Figure 15). No notable change (either an increase or decrease) was observed in copper concentrations in any of the other tissues sampled (Appendix 5).

Lead

Median concentrations of lead have remained at low amounts throughout our study. On two occasions, June 1991 and September 1995, maximum Pb concentrations exceeded 0.4 mg/Kg (Figure 16). Concentrations of Pb were similarly elevated in gill, kidney, and muscle tissues in the same samples (Appendix 5). Hilltop Creek was identified as a substantial source of Pb and Zn. The mine sump collection ditch was extended in September 1995 to capture water from Hilltop Creek for treatment.

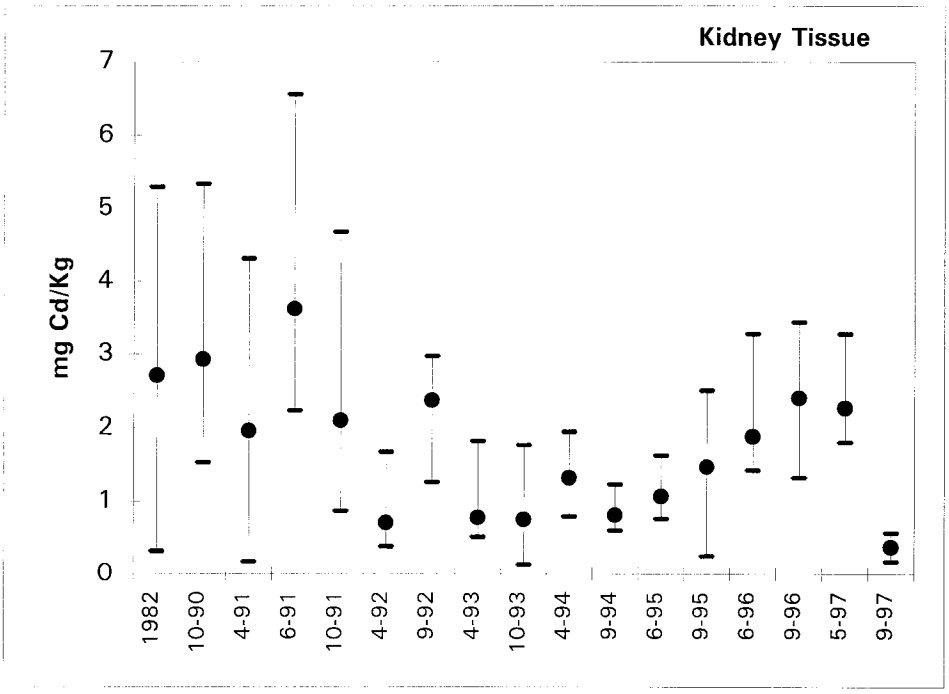

Figure 14. Concentrations of cadmium (dry weight basis) in adult Dolly Varden kidney tissue, Wulik River, 1982 and 1990-1997. 1982 data are expressed as mean concentration.

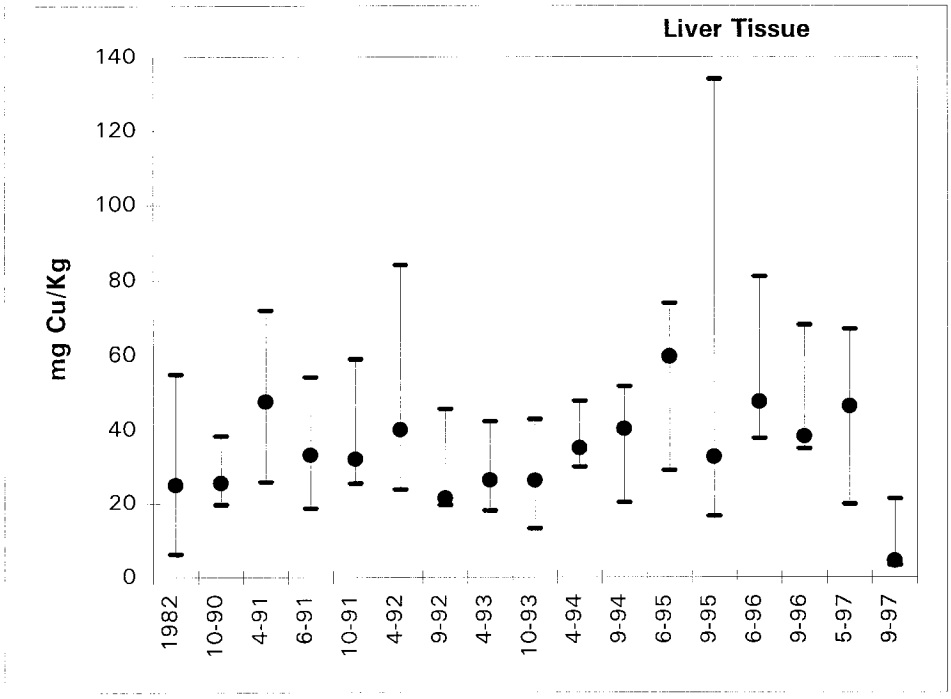

Figure 15. Concentrations of copper (dry weight basis) in adult Dolly Varden liver tissue, Wulik River, 1982 and 1990-1997. 1982 data are expressed as mean concentration.

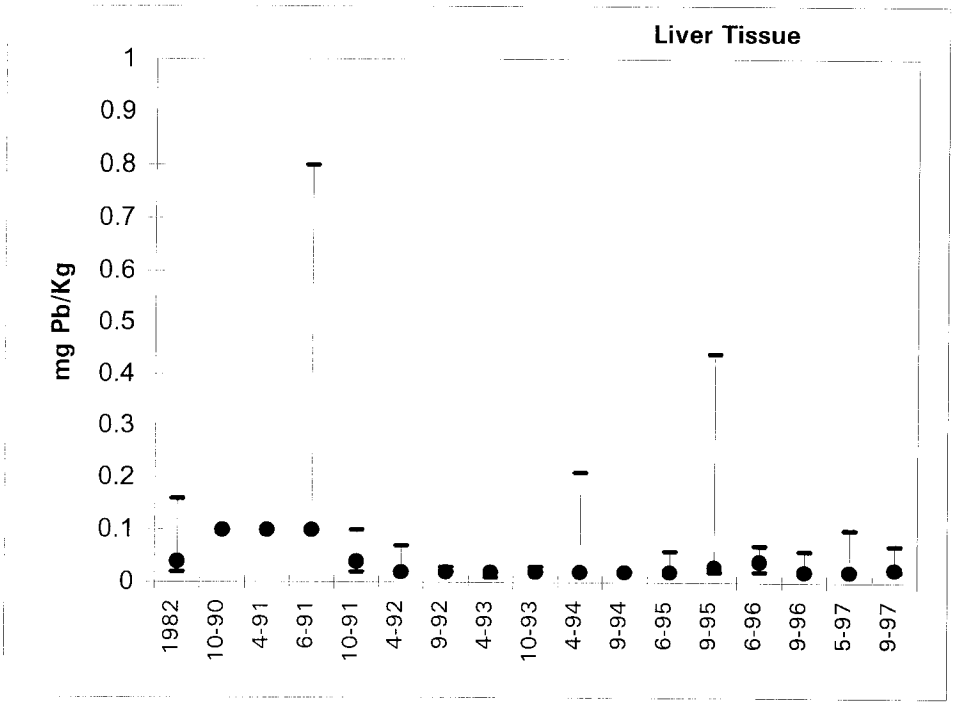

Figure 16. Concentrations of lead (dry weight basis) in adult Dolly Varden tissues, Wulik River, 1982 and 1990-1997. 1982 data are expressed as mean concentration.

Zinc

Zn concentrations in Dolly Varden liver were similar to Pb in September 1995, when high maximum concentrations were found. Median concentrations were not different from previous sampling periods. Concentrations of Zn were similarly elevated in gill, kidney, and muscle tissue in September 1995 (Appendix 5). Zn concentrations were low in all tissues for all sampling times after September 1995 (Figure 17, Appendix 5).

Selenium

In spring 1997, we began analyzing Dolly Varden tissues for selenium (Figure 18). Because there are no baseline data for Se, we compared Wulik River fish to fish collected from refuges in interior Alaska by the US Fish and Wildlife Service.

Of 22 fish tested from the Koyukuk, Northern Unit of Innoko, and Nowitna National Wildlife Refuges, Mueller et al (1996) reported median Se concentrations in 22 fish livers of 5.6 mg/Kg, with a maximum reported amount of 22 mg/Kg. (The tested fish were a combination of Arctic grayling, northern pike, and Alaska blackfish.) Median values from these three refuges are similar to the median amounts found in Wulik River fish and the maximum amount from the refuges is considerably higher.

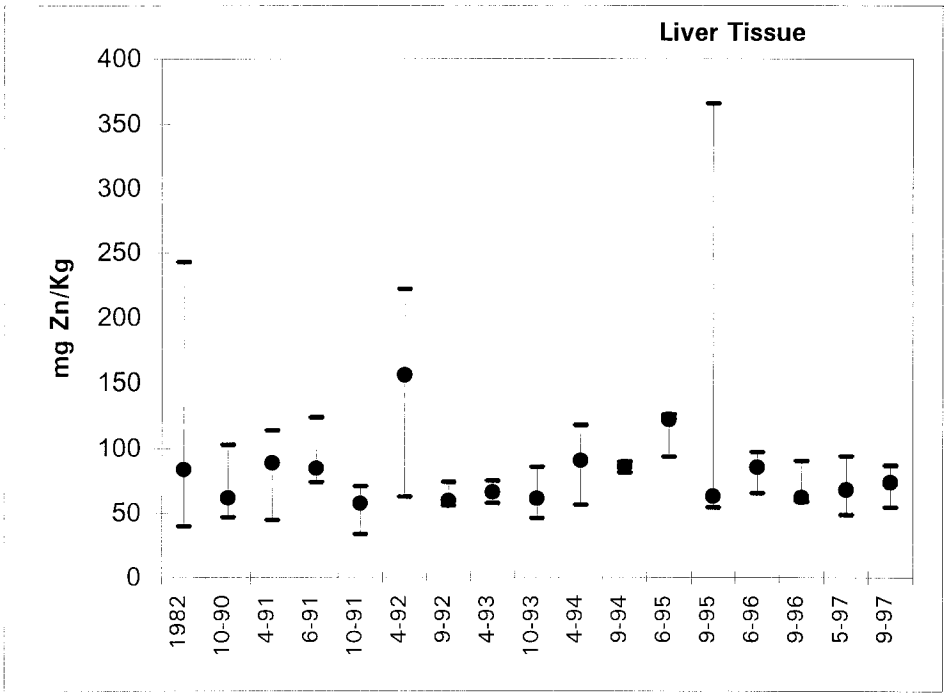

Figure 17. Concentrations of zinc (dry weight basis) in adult Dolly Varden liver, Wulik River, 1982 and 1990-1997. 1982 data are expressed as mean concentration

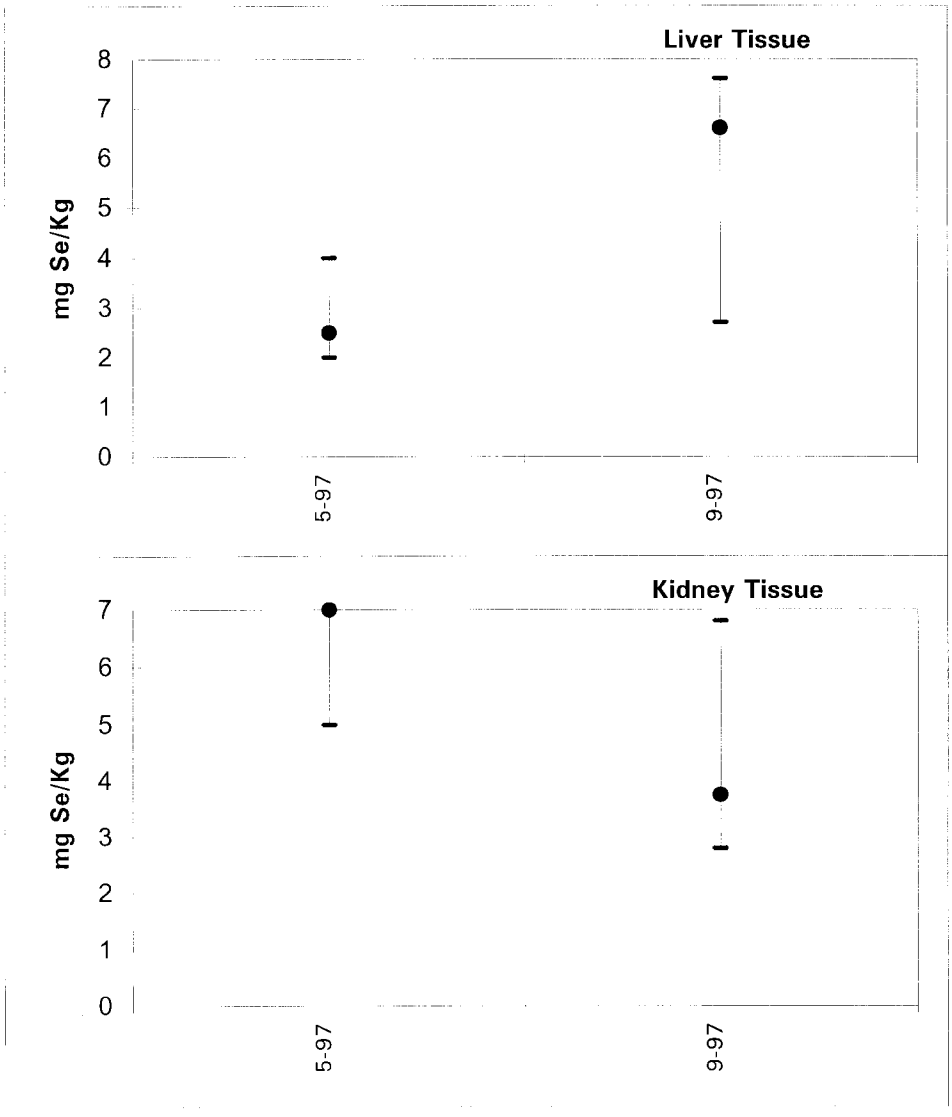

Figure 18. Concentration of Se in adult Dolly Varden liver and kidney tissues, Wulik River, 1997.

We compared total age of fish (including time in salt water) with Cd, Pb, and Zn concentrations in liver (Figure 19) and kidney tissues (Figure 20) to detect any increases in metals with duration of exposure (measured by total age of the fish) to Wulik River water. Eighty three percent of fish collected since 1991 were age 5, 6, and 7. The range of metals in these fish spanned the range of the entire sample; therefore, we could detect no correlation between age and metals concentrations.

We further compared size of fish (determined by weight in grams) to concentrations of Cd, Pb, and Zn in kidney (Figure 21) and liver (Figure 22) to detect increases or decreases of metals with size of fish. As with age comparisons, we found no correlation between concentration of metal and size of fish. Most fish sampled since 1990 weighed from 500 grams to 1500 grams; metals concentrations in fish within this weight range spanned the range of the entire sample.

Concentrations of metals in Dolly Varden tissues in the Wulik River do not appear to correlate with either age of fish or size of fish. Rather, it appears that metals concentrations are a response to metals in the water, and the response can be immediate. For example, increases in Al, measured at Station 73, in August 1995 were followed by increases in tissue Al in the September 1995 fish sample.

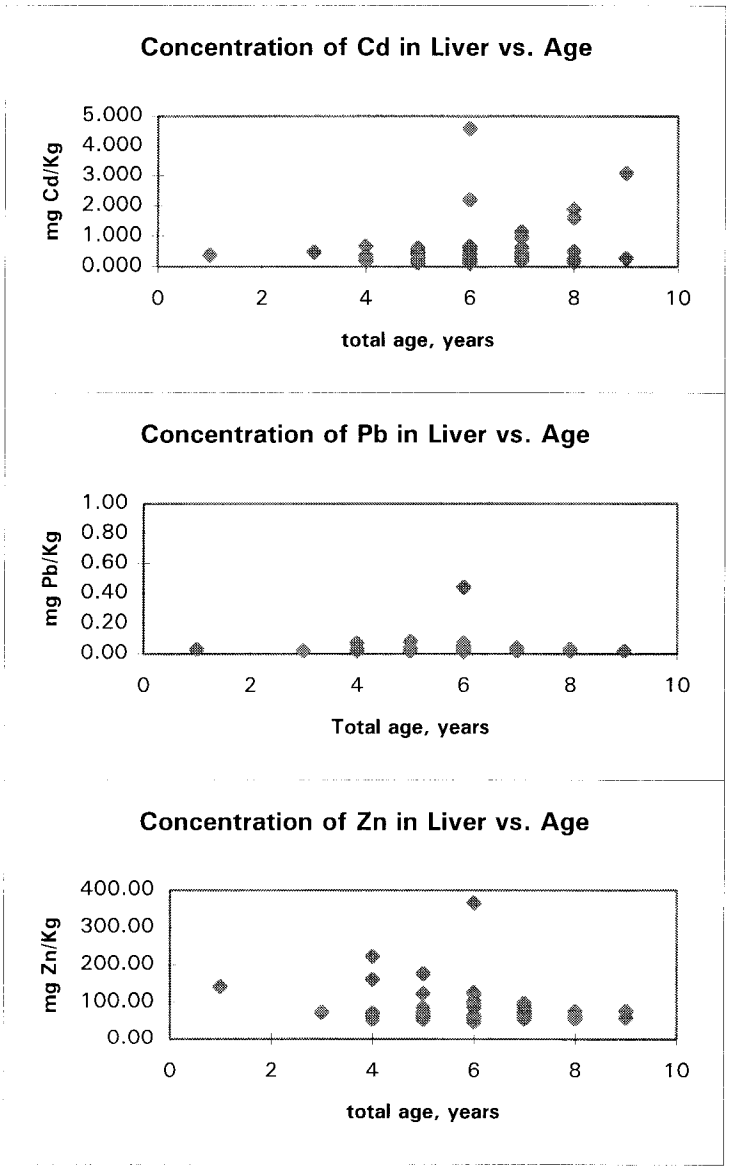

Figure 19. Concentration of Cd, Pb, and Zn in Dolly Varden liver by total age. Each point on the graph represents one sample.

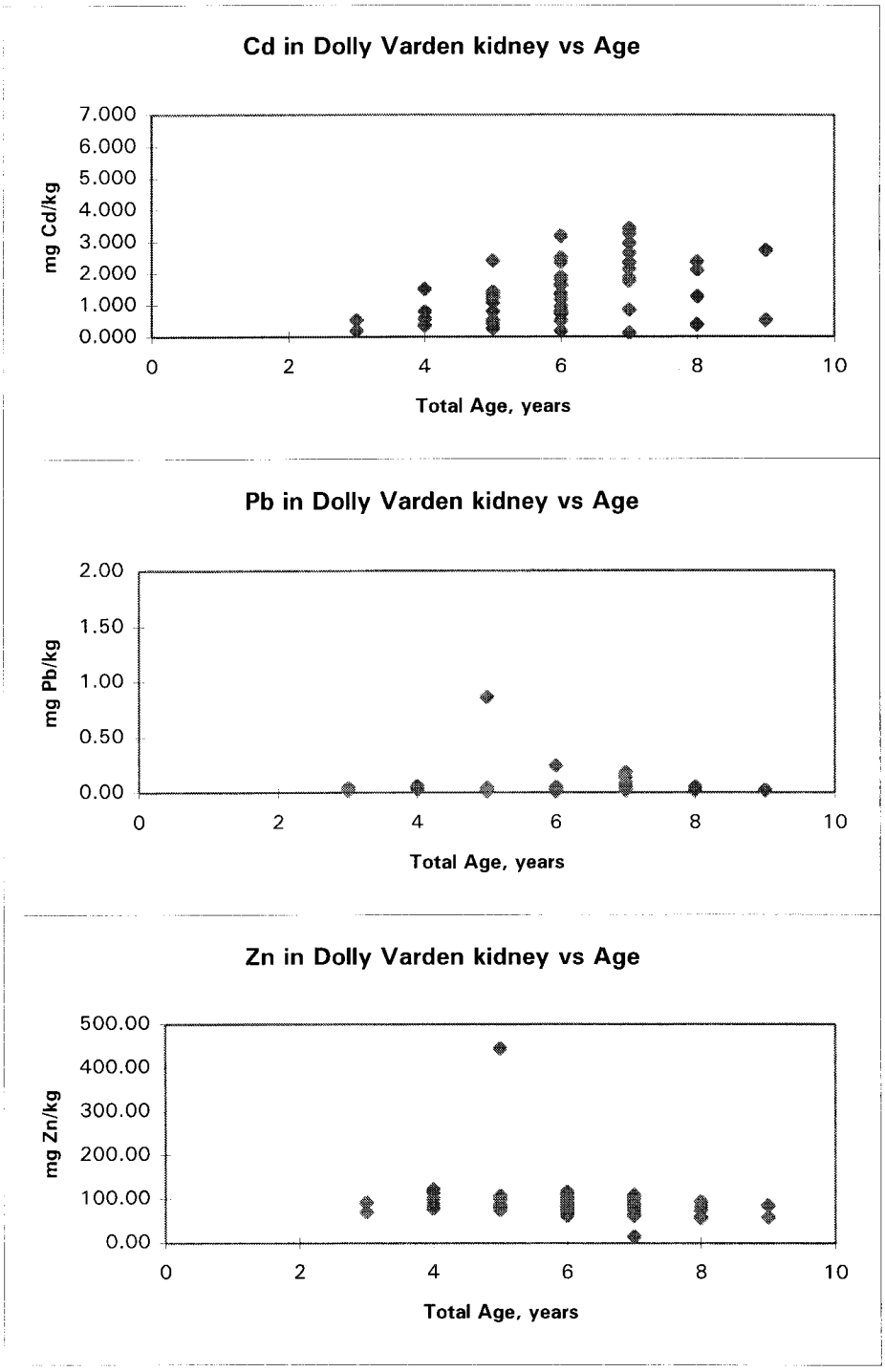

Figure 20. Concentration of Cd, Pb, and Zn in Dolly Varden kidney by total age. Each point on the graph represents one sample.

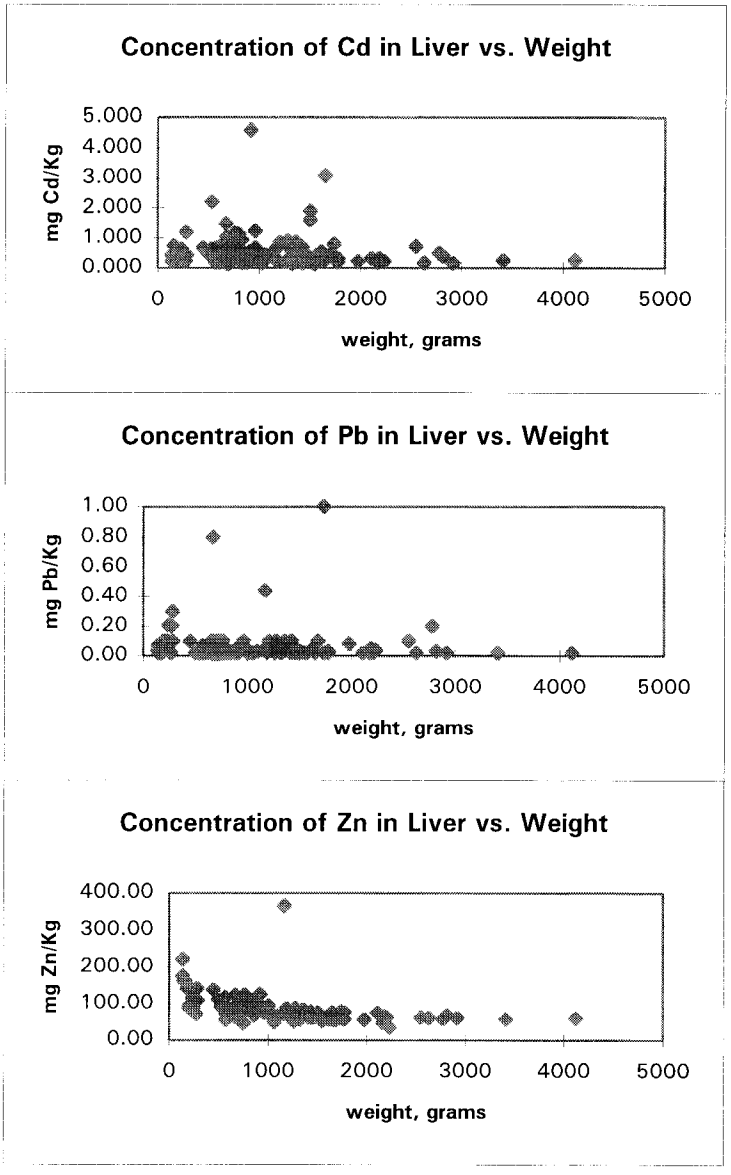

Figure 21. Concentration of cadmium, lead, and zinc in Dolly Varden liver by weight of fish. Each point on the graph represents one sample.

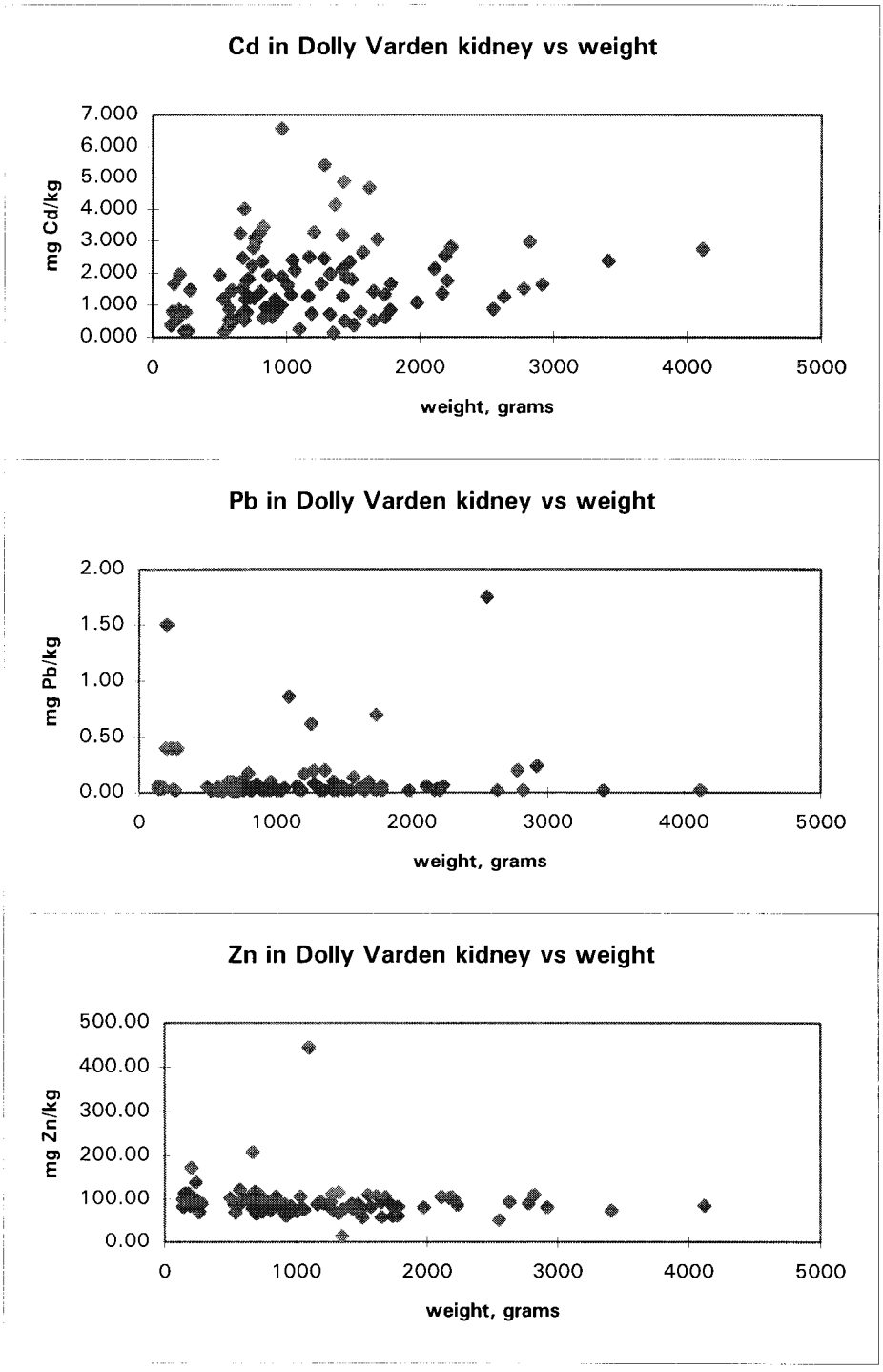

Figure 22. Concentration of cadmium, lead, and zinc in Dolly Varden kidney by weight of fish. Each point on the graph represents one sample.

V: OVERWINTERING DOLLY VARDEN

ADF&G has continued a fall survey of overwintering Dolly Varden in the Wulik River since 1979, except in 1983, 1985, 1986, and 1990 when weather conditions did not permit aerial surveys. More than 90% of Dolly Varden were observed in the Wulik River downstream of the mouth of Ikalukrok Creek during fall surveys (Table 9), except in 1980, when 89% were found downstream. A population estimate for Dolly Varden >400 mm was made by DeCicco (1995) for the 1994-1995 overwintering population in the Wulik River. Fish were marked in fall 1994 and recaptured during the 1995 spring subsistence fishery in Kivalina. An estimated 361,599 Dolly Varden used the Wulik River in winter 1994-1995. The 1994-1995 population estimate exceeded the aerial count because Dolly Varden entered the Wulik River late in fall 1994 after the aerial survey was done.

The number of Dolly Varden counted in fall 1996 was 61,005 (DeCicco 1996) and in fall 1997 was 95,412 (DeCicco 1997). Numbers of Dolly Varden counted in the Wulik River during fall surveys have ranged from a low of 30,853 in 1984 to a high of 144,138 in 1993. Fluctuations in numbers appear to be related to weather conditions during the survey and, especially, to the time these fish enter the Wulik River for overwintering. In some years, most of the fish appear to enter the river late in the fall and may be missed during the annual survey. We found no increase or decrease in numbers of Dolly Varden that correspond to development and production at the Red Dog Mine. Over 90% of Dolly Varden continue to occur in the Wulik River below the mouth of Ikalukrok Creek in late September and early October (Table 9).

Table 9. Number of overwintering adult Dolly Varden in the Wulik River before freezeup. Surveys conducted by ADF&G (DeCicco 1989, 1991, 1992, 1993, 1994, 1995, 1996, and 1997).

Year	Wulik River upstream of Ikalukrok Creek	Wulik River downstream of Ikalukrok Creek	Total Fish	Percent of Fish downstream of Ikalukrok Creek
Pre-Mining, including Mine Construction				
1979	3,305	51,725	55,030	94
1980	12,486	101,067	113,553	89
1981	4,125	97,136	101,261	96
1982	2,300	63,197	65,497	97
1984	370	30,483	30,853	99
1987	893	60,397	61,290	99
1988	1,500	78,644	[1]80,144	98
Mine Production				
1989	2,110	54,274	56,384	96
1991	7,930	119,055	126,985	94
1992	750	134,385	135,135	99
1993	7,650	136,488	144,138	95
1994	415	66,337	[2]66,752	99
1995	240	128,465	128,705	99
1996	1,010	59,995	61,005	98
1997	2,295	93,117	95,412	98

[1]The population estimate (mark/recapture) for winter 1988/1989 for fish >400 mm was 76,892 (DeCicco 1990a).

[2]The population estimate (mark/recapture) for winter 1994/1995 for fish >400 mm was 361,599.

VI: CHUM SALMON SPAWNING

Our objective was to count and assess distribution of adult chum salmon in Ikalukrok Creek downstream of Dudd Creek using aerial surveys (Table 10, Figure 23). The estimated number of chum salmon in September 1981 ranged from 3,520 to 6,960 (Houghton and Hilgert 1983). Houghton and Hilgert estimated 353 chum salmon in August 1982 and 1400 chum salmon in September 1982. DeCicco (1990b) documented 994 adult chum salmon in Ikalukrok Creek in August 1984 and 1,975 in August 1986. In 1990 and 1991, less than 70 chum salmon were seen (Ott et al. 1992). Surveys were not done from 1992 to 1994. Two separate aerial surveys were done in 1995 with 49 chum salmon observed during the first flight and 300 to 400 estimated during the second survey.

Helicopter surveys were done on August 11, 1996 and August 12, 1997. Visibility of the river in 1996 was excellent and two observations were made. One biologist counted 180 chum salmon and the second biologist counted 162 live and 20 dead chum salmon. In 1997 we estimated between 730 and 780 chum salmon, but visibility was limited by overcast skies and rain. Numbers of chum salmon observed in Ikalukrok Creek in 1995, 1996, and 1997 were higher than in 1990 and 1992, although in 1996 we counted only 50% of the chum salmon observed in 1995 (Table 10). Our highest count since opening the Red Dog Mine was in August 1997. During the August 1997 flight, we also observed ten sockeye salmon in Ikalukrok Creek.

Counts of chum salmon made after mine development are lower than during baseline fisheries work conducted by ADF&G and by Dames and Moore (1983). Chum salmon in 1996 were actively spawning with all redds observed in the lower 8 km of Ikalukrok Creek. In 1997 chum salmon, while concentrated in the lower portion of Ikalukrok Creek, were seen spawning in Ikalukrok Creek from the lower part to the mouth of Dudd Creek. Most chum salmon observed in 1996 and 1997 were spawning adjacent to cut banks. Although numbers of chum salmon spawning in Ikalukrok Creek remain lower

than before mining, the chum salmon spawning population appears to be recovering from the water quality degradation experienced in 1990.

Table 10. Number of adult chum salmon in Ikalukrok Creek downstream of Dudd Creek.

Survey Time	Number of Chum Salmon	Reference
September 1981	3,520 to 6,960	Houghton and Hilgert 1983
August/September 1982	353 and 1,400	Houghton and Hilgert 1983
August 1984	994	DeCicco 1990b
August 1986	1,985	DeCicco 1990b
August 1990	<70	Ott et al. 1992
August 1991	<70	Ott et al. 1992
August 1995	49	Townsend and Lunderstadt 1995
August 1995	300 to 400	DeCicco 1995
August 1996	180	Townsend and Hemming 1996
August 1997	730 to 780	Ott and Simpers 1997

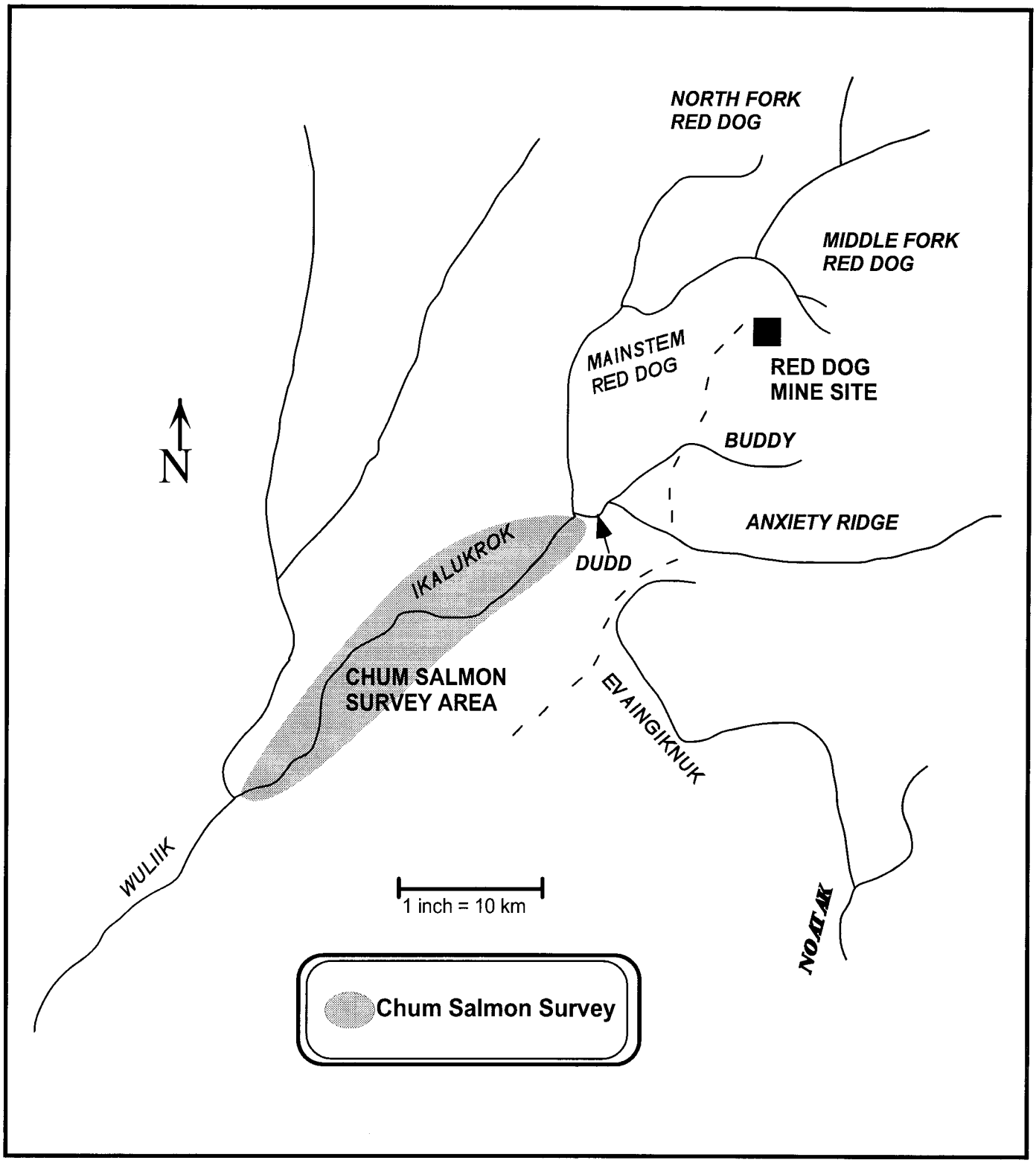

Figure 23. Chum salmon survey area in Ikalukrok Creek.

VII: FISH DISTRIBUTION

Fish monitoring conducted by ADF&G focused on distribution and relative abundance of juvenile Dolly Varden and Arctic grayling downstream of the Red Dog Mine and Arctic grayling use of North Fork Red Dog Creek. The purpose of this monitoring is to ensure that these waterways continue to be used by juvenile fish for rearing, that fish access to North Fork Red Dog Creek is maintained and to document changes in fish distribution and use in relation to the development and operations of the Red Dog Mine. Since beginning operation of the Red Dog Mine, Cominco has continued to refine water treatment and improve control of seepage water. Changes in fish distribution and habitat use first were documented in 1992 when juvenile Dolly Varden were observed and collected in North Fork Red Dog Creek. Beginning in 1995 and continuing in 1996 and 1997, juvenile Dolly Varden were caught with minnow traps in Mainstem Red Dog Creek below North Fork Red Dog Creek. Slimy sculpin were caught for the first time in Mainstem Red Dog Creek in 1995 and again in 1996 and 1997. Slimy sculpin also were found in North Fork Red Dog Creek in 1995. In 1997, young-of-the-year Arctic grayling were seen and collected in Mainstem Red Dog Creek beginning in late June within several days of hatching. DeCicco (ADF&G), working with Cominco, found slimy sculpin, juvenile Dolly Varden, and young-of-the-year Arctic grayling in Mainstem Red Dog Creek in late September 1997 (Dusenbury 1997). Presence of these fish species coincides with general improvements in water quality (Figure 7, Mainstem Red Dog Creek at Station 10; Figure 8, Ikalukrok Creek at Station 8 or 73).

Methods for Sampling Juvenile Fish

In 1996 and 1997, we fished minnow traps in Anxiety Ridge, Evaingiknuk, Ikalukrok, Middle Fork Red Dog, Mainstem Red Dog, Buddy, and North Fork Red Dog Creeks (Figure 24). Evaingiknuk Creek, a Noatak River tributary, was a control stream unaffected by the mine. Identification markers and flagging on stream bank vegetation were used to designate trap sites.

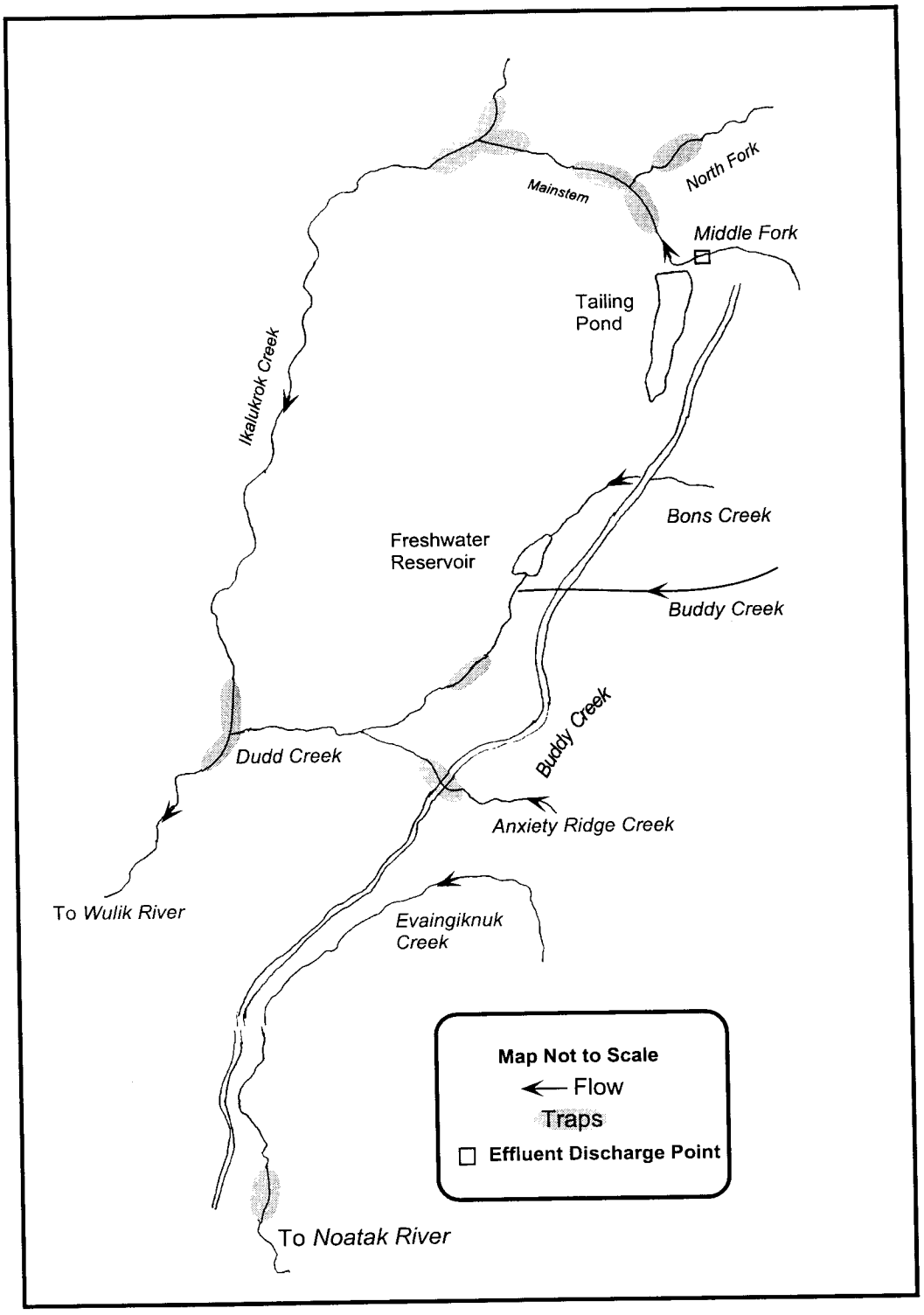

Figure 24. Minnow trap sampling areas.

Minnow traps were fished in mid-June, mid-July, and mid-August, in 1996 and in late June and early August 1997. All trap sites were sampled in 1997. In 1996, trap sites in Ikalukrok Creek and lower Mainstem Red Dog Creek could not be sampled in August because of high water. Visual surveys of all creeks were made at the same time fish traps were used. Fish collected in each trap were measured to the nearest mm and the total number of fish per trap was recorded. Numbers of Dolly Varden per trap (catch) were compared among sample areas and times.

Angling was used to collect Arctic grayling in Buddy, North Fork Red Dog, Ikalukrok, and Mainstem Red Dog Creeks. Arctic grayling were marked with an adipose fin clip and those greater than 150 mm were tagged with numbered *Fine Fabric Floy-tags*.

Results: Juvenile Dolly Varden

Tributary Streams

Total Dolly Varden captured in minnow traps were compared among tributary creeks and among sample years. The greatest number of Dolly Varden juvenile fish were found in tributary streams Anxiety Ridge, Evaingiknuk, and Buddy Creeks (Appendices 6 through 16 and Table 11). No Dolly Varden were found in North Fork Red Dog Creek in 1994 and 1996; samples show consistently low use of this stream by juvenile Dolly Varden except in 1993 when high use also was seen in Anxiety Ridge Creek and in 1995 when we caught five Dolly Varden (169-247 mm) by angling (Ott and Weber Scannell 1996).

Four of the five Dolly Varden caught in 1995 were silvery without parr marks (Figure 25) and we believe these fish spent the summer in saltwater and returned to freshwater to rear. Hougton and Hilgert (1983) observed a large school of several hundred Dolly Varden (235-257 mm) in Dudd Creek in September 1982. Moulton (1997) observed similar fish use in the Colville River drainage when he captured similar size rearing Dolly Varden in the Miluveach River, a Colville River tributary, in July.

Table 11. Highest catch of Dolly Varden per trap by year in Mainstem Red Dog Creek (below North Fork Red Dog Creek), Anxiety Ridge, Evaingiknuk, North Fork Red Dog, and Buddy Creeks, 1990 - 1997.

Year	Mainstem Red Dog Creek	Anxiety Ridge Creek	Evaingiknuk Creek	North Fork Red Dog Creek	Buddy Creek
1990		3.5	7.6		
1991		16.2	8.0		
1992		33.4	11.1	0.4	
1993		29.5	2.9	3.1	
1994	0.0	2.6	3.7	0.0	
1995	0.7	15.4	3.8	0.1	
1996	0.3	3.8	0.7	0.0	1.8
1997	1.3	6.8	5.4	0.2	4.8

Dolly Varden use of tributary creeks is substantial and highly variable. Depending on environmental conditions (stream flows and water temperature), peak use of these creeks occurs from late July through mid-August, with lesser use occurring early in the spring and late in the fall. Juvenile Dolly Varden use of Mainstem Red Dog Creek was first found in 1995 and use continued to be documented in summers 1996 and 1997 (Table 11). Although juvenile Dolly Varden continue to migrate into North Fork Red Dog Creek for summer rearing, its importance as a rearing stream for these fish is minor compared with other tributary streams like Anxiety Ridge and Buddy Creeks. However, in late September 1997, seven juvenile Dolly Varden were caught in 3 minnow traps in

North Fork Red Dog Creek (Dusenbury 1997) even though we caught no fish in our August 1997 sample. Ambient air temperatures in September 1997 remained high throughout much of Alaska and we believe that the juvenile fish caught were outmigrating from the upper reaches of North Fork Red Dog Creek where they had spent the summer rearing. Thus, summer rearing by Dolly Varden in the upper reaches of North Fork Red Dog Creek might be higher than estimated by our samples near the mouth of the creek.

The highest catch per trap of juvenile Dolly Varden in Evaingiknuk Creek and Anxiety Ridge Creek occurred in 1992 (Table 11). The Dolly Varden catch was low in all tributary streams in 1994 and 1996; no Dolly Varden were caught in North Fork Red Dog Creek during those years. The overall low catch in all tributaries, including Evaingiknuk Creek which is unaffected by the mine, suggest that natural environmental conditions in the region and numbers of adult spawners in previous years influence juvenile fish numbers and distribution. Most of the juvenile Dolly Varden collected are ages 0, 1, 2, and 3.

In spring 1996 and 1997, we caught juvenile Dolly Varden smolts in Anxiety Ridge Creek. Juveniles turn a characteristic silver color during outmigration to salt water. Presence of smolts in Anxiety Ridge Creek would indicate that a portion of the small Dolly Varden using this system for summer rearing also overwinter in the creek (Figure 25).

Length-frequency distribution for juvenile Dolly Varden for August 1997 shows a substantial difference among Anxiety Ridge, Mainstem Red Dog, and Buddy Creeks. Young-of-the-year Dolly Varden (60-80 mm) were present in all three creeks but were most abundant in Buddy Creek (Figure 26). Buddy Creek was first determined to support adult Dolly Varden spawners in 1996. Proximity of spawning areas to the Buddy Creek sample reach probably explains the higher use by young-of-the-year fish. A similar distribution of size classes occurred in Mainstem Red Dog Creek and Anxiety Ridge

Creek (Figure 26) and we noted during sampling that larger Dolly Varden (120-160 mm) from both creeks were in excellent condition: deep bodied and robust.

Figure 25. Smolt-colored juvenile Dolly Varden caught in Anxiety Ridge Creek in June 1997.

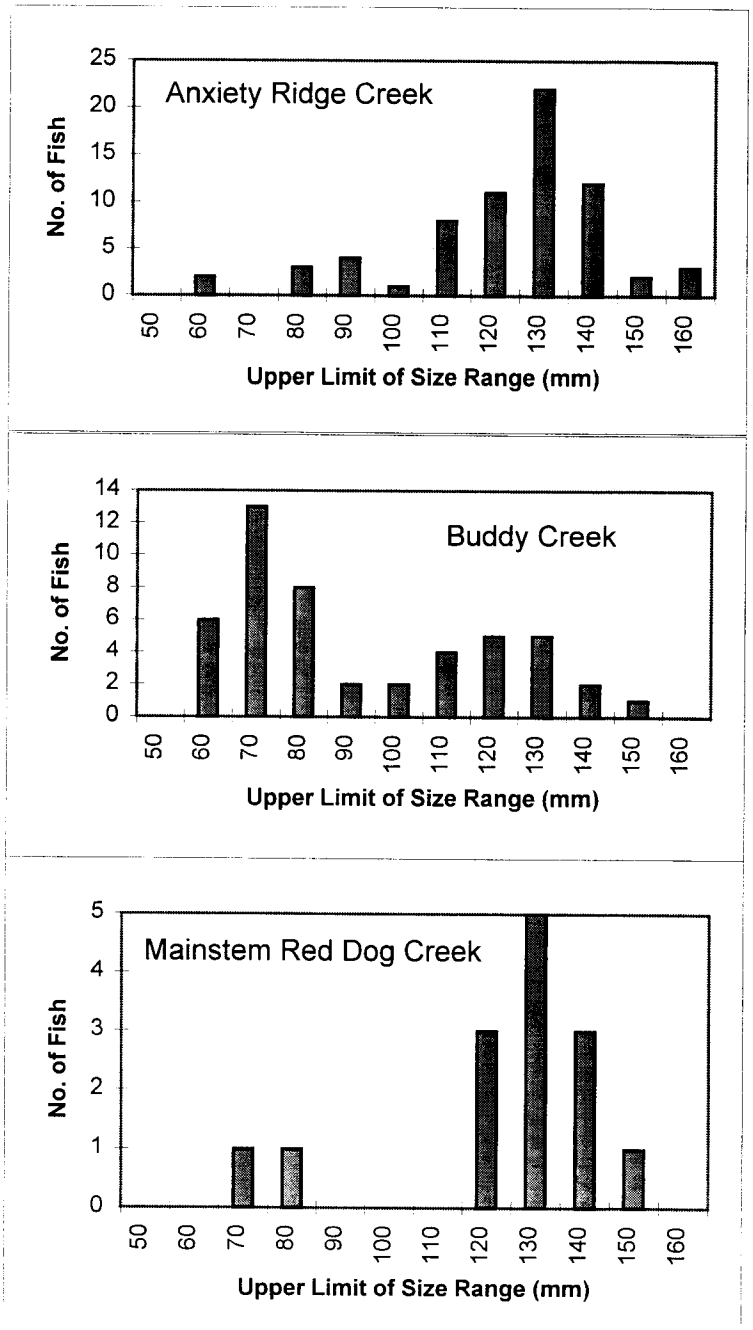

Figure 26. Length-frequency distribution of Dolly Varden juveniles from Anxiety Ridge, Buddy, and Mainstem Red Dog Creeks in August, 1997.

Ikalukrok Creek

The highest catch rates in Ikalukrok Creek since sampling began occurred in 1992 and 1993 (Table 12), the same years that catch rates peaked in Anxiety Ridge Creek. Generally, catch rates are lower in Ikalukrok Creek than Anxiety Ridge, Evaingiknuk, and Buddy Creeks but comparable to Mainstem and North Fork Red Dog Creeks. We believe that the juvenile Dolly Varden found in the tributary creeks migrate through Ikalukrok Creek from overwintering habitats in lower Ikalukrok Creek and the Wulik River. Juvenile Dolly Varden appear to be selecting the smaller, more productive tributary streams over larger systems like Ikalukrok Creek. Estimates of relative productivity for these streams were provided by Houghton and Hilgert 1983. Possible predation by large post-spawning Arctic grayling in Ikalukrok Creek also may limit the distribution of small Dolly Varden.

We also compared catches in Ikalukrok Creek among the 1992 through 1997 samples (Table 12). The lowest catches were recorded in 1994 and 1996, the same year catches were low in Evaingiknuk and Anxiety Ridge Creeks, suggesting that area-wide environmental conditions likely influence juvenile fish distribution.

Table 12. Highest catch of Dolly Varden per trap by year in Ikalukrok Creek, 1990-1997.

Year	Above and Below Dudd Creek	Below Red Dog Creek	Above Red Dog Creek
1990	0.0		0.0
1991	2.0		
1992	5.8		
1993	3.8		
1994	1.0		
1995	1.4		
1996	0.05	0.1	0.0
1997	0.8	0.4	0.3

Red Dog Creek

Minnow traps, visual surveys, and angling were used to assess fish presence in Mainstem and Middle Fork Red Dog Creeks. Visual surveys were made since sampling began in 1990, minnow traps were first fished in 1994, and angling was started in 1995. Juvenile Dolly Varden have never been caught in Middle Fork Red Dog Creek. The fish barrier was constructed across Middle Fork Red Dog Creek just above its confluence with North Fork Red Dog Creek in April 1997 to prevent migration of fish into the mine area. Juvenile Dolly Varden were first found and have been consistently caught in Mainstem Red Dog Creek each year since 1995 (Table 13). Highest catches occurred in 1997 during the August sample event. Juvenile Dolly Varden were not caught in lower Mainstem Red Dog Creek in 1996 but were found there in 1997. In September 1997, Dusenbury captured Dolly Varden juveniles in lower Mainstem Red Dog Creek indicating that these fish remained in the creek to rear much longer than previously documented.

Table 13. Total catch of Dolly Varden in Red Dog Creek, 1994-1997.

Year	Month	Middle Fork above North Fork (Traps 6-10)	Mainstem below North Fork (Traps 1-5)	Mainstem below North Fork (Traps 20-29)	Mainstem above Ikalukrok (Traps 30-39)
1994	June	0	0		
	July	0	0		
	August	0	0		
1995	June	0	0	5	
	July	0	0	10	
	August	0	4	3	
1996	June	0	0	0	0
	July	0	1	3	0
	August	0	1	1	
1997	June	0	0	13	1
	August	0	5	14	10

Results: Arctic Grayling

North Fork Red Dog Creek

Our objective was to determine Arctic grayling use of North Fork Red Dog Creek. Baseline studies reported abundant spawned-out Arctic grayling in June 1982 and numerous young-of-the-year Arctic grayling in July 1982 (Dames and Moore 1983). Age 1 and 2 Arctic grayling were rarely found and only one juvenile Dolly Varden, assumed to be a resident fish, was found in the headwaters of North Fork Red Dog Creek (Houghton and Hilgert 1983).

Large Arctic grayling (>200 mm) were captured or seen in North Fork Red Dog Creek in all sample years beginning in 1991. Collection of Arctic grayling using angling started in 1993. The highest catch was in 1995 when about 100 Arctic grayling were collected in June, July, and August (Table 14). The average size of fish captured in the creek increased each year since 1993, and in 1997 the average size was 318 mm (Table 14, Figure 27). In 1993, several of the Arctic grayling caught were less than 150 mm, but in 1994 all fish exceeded 200 mm (Figure 27). Although we did capture several fish smaller than 200 mm in 1995, in 1996 and 1997 the average size of fish continued to increase. It would appear that recruitment of age 1+ fish to the population has not occurred in the last four years (Figure 27).

In 1995, mature Arctic grayling were present in late June, young-of-the-year (<25 mm) were observed on July 17, and in mid-August, fry (40 - 47 mm) were present but not numerous (Ott and Weber Scannell 1996). In previous sample years (1991 to 1994), we found mature fish in late June and young-of-the-year in July (Ott et al. 1992; Ott and Weber Scannell 1993; Ott and Weber Scannell 1994; Weber Scannell and Ott 1995). Fry were numerous in backwater areas and along stream margins in 1991, 1992, and 1993. Fry were not abundant in 1994; high-water events following spawning likely reduced spawning success.

Table 14. Average size of Arctic grayling collected, by angling, in North Fork Red Dog Creek (1993-1997).

Sample Period	Number of Fish	Average Length (mm)	Range (mm)	Standard Deviation
6/28-7/2/93	25	214	130-410	68.2
6/27-29/94	48	257	194-325	31.2
7/25-30/94	54	216	158-269	23.0
8/30/94	0[1]			
6/26-30/95	95	257	180-395	36.3
7/17-21/95	100	263	171-377	32.6
8/11-15/95	107	264	147-383	35.2
6/13-21/96	1[2]	330		
7/13-14/96	36	281	209-412	36.3
6/24-27/97	36	318	251-398	35.2

[1]Arctic grayling juveniles and adults were not observed or collected. We assume fish had outmigrated to overwintering habitat.
[2]Arctic grayling adults had not reached North Fork Red Dog Creek.

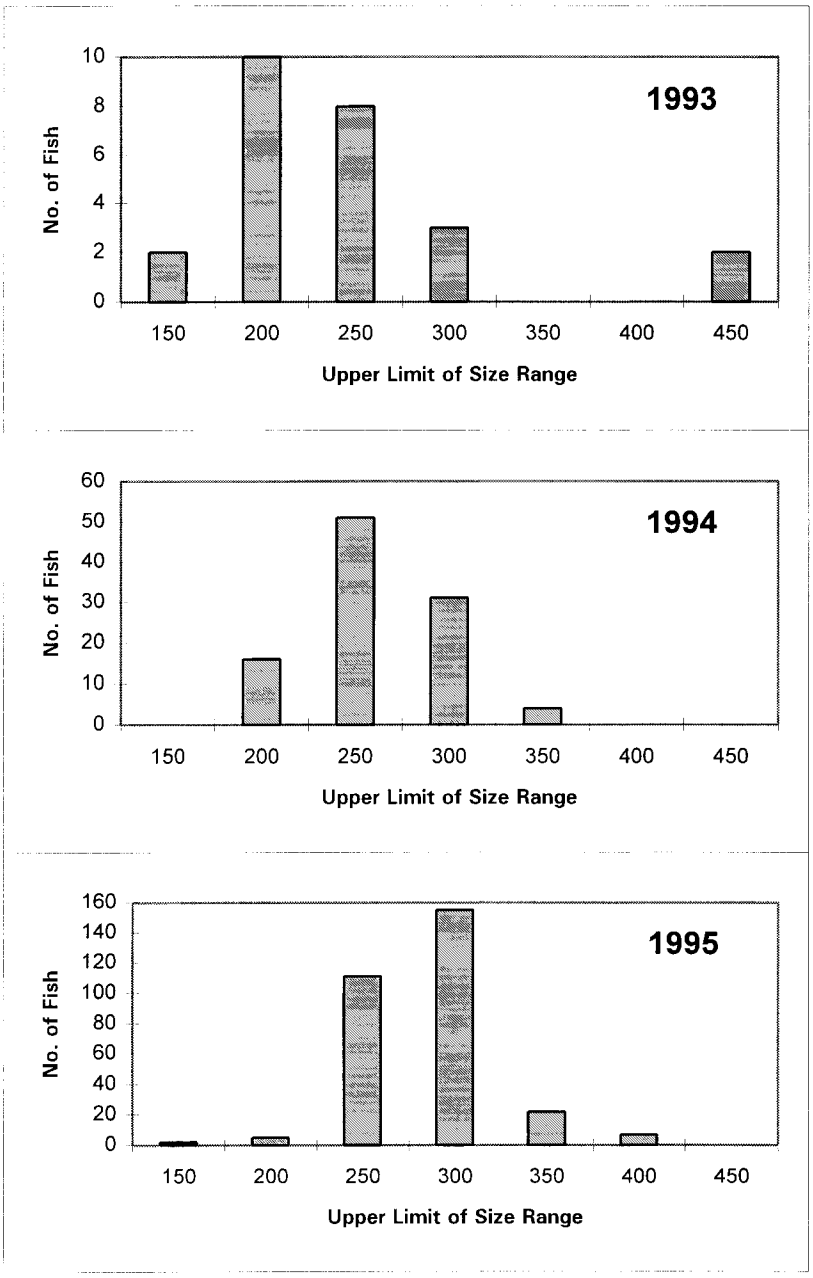

Figure 27. Length frequency distribution of Arctic grayling in North Fork Red Dog Creek (1993-1997). Note scale changes in the five graphs.

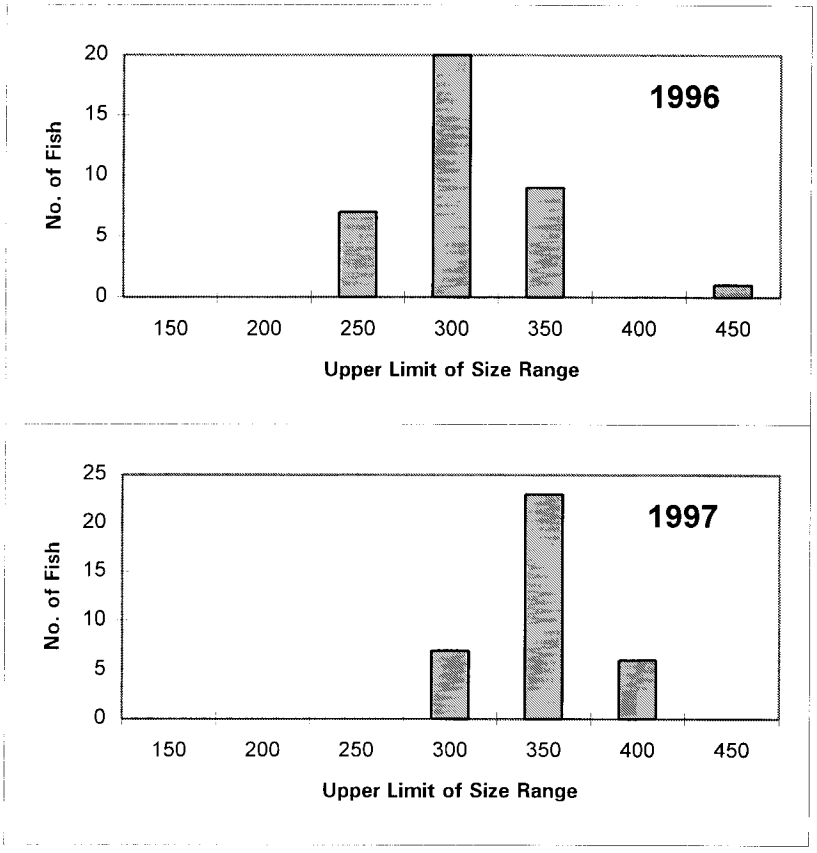

Figure 27. Arctic grayling, concluded.

Total rainfall in 1995 was similar to 1994, but more evenly distributed throughout the summer and fry were abundant. Young-of-the-year Arctic grayling were numerous in 1996, and more abundant in 1997, when stream flows were moderate from after breakup until mid-July. We caught 13 young-of-the-year Arctic grayling (average length 54 mm, 50-57 mm long) in mid-August 1997. In late September, Dunsenbury (1997) caught 7 (average length 75 mm, 70-83 mm long). Spawning success and early survival of Arctic grayling appeared strong in 1997 and the average size of fry in August was about 10 mm greater than in 1995.

Even though we observed spawning success each year in North Fork Red Dog Creek and in most years we saw abundant fry in the creek, recruitment to the adult population has been low to zero for the past four years. DeCicco et al. (1997) reported that the Arctic grayling population in the Sinuk River, Seward Peninsula, Alaska, is static with low recruitment. They describe the Sinuk River population as unexploited, dominated by large fish with a mean fork length of 450 mm, and with few small fish present. North Fork Red Dog Creek also is an unexploited population and with the exception of 1993 and 1994, juvenile Arctic grayling have been rarely caught or observed.

Arctic grayling use of North Fork Red Dog Creek varies among years. In 1994, adult fish left North Fork Red Dog Creek shortly after spawning. Out-migration of adult fish was observed in mid-August 1995 when large aggregations of fish moved downstream. Observations in 1996 were similar to 1994. In mid-August 1997, only one Arctic grayling was seen in North Fork Red Dog Creek. Adult spawners usually enter the system in early to mid-June, spawn, and outmigrate by mid-July. By early August, most Arctic grayling in North Fork Red Dog Creek are young-of-the-year.

Sampling for Arctic grayling in North Fork Red Dog Creek began in 1993 and tagging began in 1994. Data on size at tagging, recapture date, and size and location at recapture from 1994-1997 are given in Appendix 17. A reach in North Fork Red Dog Creek was sampled by angling in 1994 and expanded in 1995. Sampling by angling continued in 1996 and 1997 (Figure 28).

Changes in fork length were determined to determine average annual growth. Eleven Arctic grayling tagged in summer 1994 were recaptured in summer 1995, five tagged in 1995 were caught in 1996, and one marked in 1996 was recaptured in 1997 (Table 15). Growth between 1994 and 1995 ranged from 37 to 66 mm per year (Table 15), and growth between 1995 and 1996 ranged from 19 to 48 mm per year.

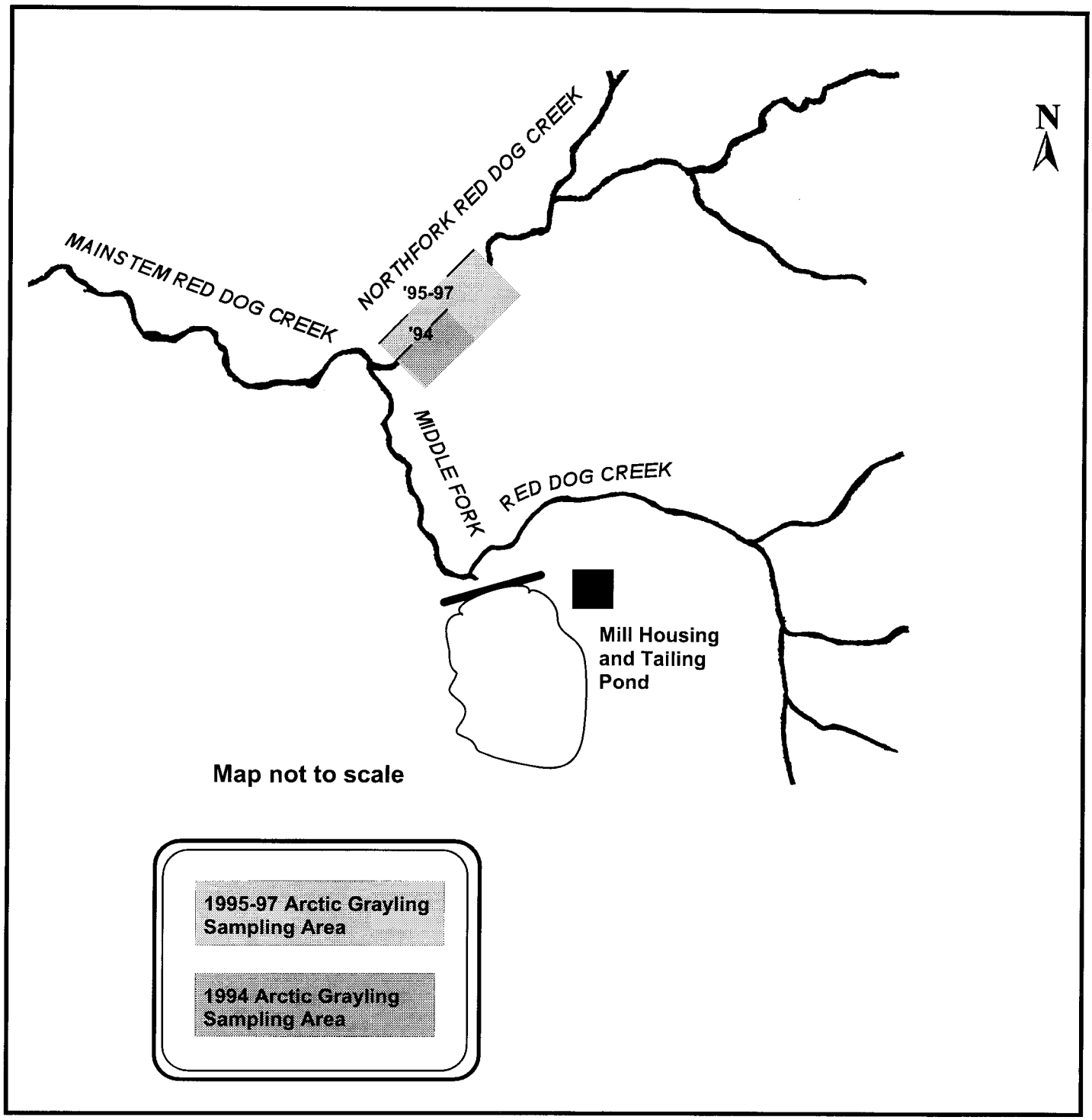

Figure 28. Arctic grayling sample area where angling was used to capture fish in North Fork Red Dog Creek.

Table 15. Growth of Arctic grayling collected in North Fork Red Dog Creek (1994-1997).

Tag Number Color	Length at Marking (mm)	Time at Large (days)	Growth (mm)	Estimated Growth mm/year
Tagged in 1994, Recaptured in 1995				
3114 Y[1]	200	359	36	37
3124 Y	200	338	37	40
3137 Y	203	384	69	66
3426 Y	205	364	60	60
3411 Y	210	384	68	65
3122 Y	211	385	55	52
3110 Y	222	356	43	44
3449 Y	235	366	53	53
3417 Y	238	363	52	52
3107 Y	255	384	47	45
3419 Y	270	384	44	42
Tagged in June 1995, Recaptured in August 1995				
1588 W	227	47	23	
1579 W	228	43	29	
1573 W	241	46	34	
1565 W	243	47	28	
1539 W	270	46	20	
1507 W[1]	320	46	12	
Tagged in 1995, Recaptured in 1996				
1745 W	238	359	34	35
1874 W	240	334	23	25
1758 W	247	359	45	46
1718 W	258	359	47	48
1818 W	260	334	17	19
Tagged in 1996, Recaptured in 1997				
10527O[1]	412	398	0	0

[1]W=White, [1]Y=Yellow, [1]O=Orange

Middle Fork and Mainstem Red Dog Creek

Before mine development, Arctic grayling were rarely seen in Mainstem Red Dog Creek and were not reported in Middle Fork Red Dog Creek (Hougton and Hilgert 1983). Fish were observed in Mainstem Red Dog Creek within the influence of the North Fork Red Dog Creek (Dames and Moore 1983) and fish mortalities were documented in the Mainstem Red Dog Creek (EVS and Ott Water Engineers 1983). Before mine development, Arctic grayling adults were assumed to migrate through Mainstem Red Dog Creek in early spring when discharges were high and metals concentrations low. Outmigration of adults probably occurred during high-water events and the young-of-the-year Arctic grayling left as water temperatures cooled in the fall or were displaced by high-water events. In some years the young-of-the-year Arctic grayling would be exposed to lower flows with high metals concentrations. These conditions likely resulted in mortality of young Arctic grayling and loss of a year's Arctic grayling production.

No fish were observed in Middle Fork Red Dog Creek in 1992 and 1993. In 1994, we began sampling Middle Fork and Mainstem Red Dog Creek with minnow traps and our visual survey effort was substantially increased. In 1995, we sampled an 0.8 km reach in Mainstem Red Dog Creek below the mouth of North Fork Red Dog Creek. A third sample area about 1.2 km long in lower Mainstem Red Dog Creek just above Ikalukrok Creek was sampled beginning in 1996. Since 1992, we have never observed Arctic grayling in Middle Fork Red Dog Creek. We first saw adult Arctic grayling in Mainstem Red Dog Creek in 1994 (Table 16). In 1995, young-of-the-year Arctic grayling were observed in Mainstem Red Dog Creek and adult fish were seen or captured and tagged in June, July, and August (Table 16). Adult and young-of-the-year Arctic grayling were found in summer 1995 and 1996 and all fish observed appeared to be unstressed. Young-of-the-year Arctic grayling 13-15 mm long were caught in drift nets late June 1997 near Station 10 and they were still present in August and September (Table 16). Based on the

Table 16. Arctic grayling visual observations and capture in Mainstem Red Dog Creek below confluence of North Fork and Middle Fork Red Dog Creeks since 1994. Note, surveys limited until 1994 when minnow trap sample areas were established.

Sample Date	Sample Method	Comments on Arctic grayling (YOY = young-of-the-year Arctic grayling)
7/27/94	visual	2 adults just below North Fork
6/29/95	angling	one adult (368 mm) just below North Fork
7/17/95	angling	2 adults (296, 323 mm) near rock bluff about 0.8 km below North Fork
7/20/95	visual	one adult near rock bluff about 0.8 km below North Fork
8/11/95	visual	YOY (about 30) below North Fork
8/11/95	visual	one adult near rock bluff about 0.8 km below North Fork
8/14/95	angling	tagged/recaptured 11 (range 290-340 mm, average 319 mm), near rock bluff about 0.8 km below North Fork
6/19/96	visual	one adult near Station 10
7/15/96	angling	tagged 7 fish (range 274-382 mm, average 330 mm), about 2 km above mouth
8/11/96	visual	YOY in shallow eddies at mouth
8/12/96	visual	YOY near rock bluff about 0.8 km below North Fork
6/25/97	drift net	YOY present near Station 10, 13-15 mm long
6/25/97	visual	2 adults near rock bluff about 0.8 km below North Fork
6/26/97	angling	tagged 15 fish (range 300-416 mm, average 364 mm) in scour pool at mouth of Mainstem, 8 were spawned out
6/27/97	visual	YOY numerous near Station 10
8/10/97	visual	YOY present in backwater areas
9/29/97	traps	seven YOY caught near Station 10

size of fry caught (probably lessthan two to three days since hatching), we believe that Arctic grayling spawned in Mainstem Red Dog Creek in June 1997. Total dissolved solids at Station 10 as reported by Cominco during June 1997 varied from 300 to 650 mg/L. One sample on the last estimated day of Arctic grayling egg incubation had a TDS concentration of 870 mg/L.

Use of Mainstem Red Dog Creek by Arctic grayling adults and young-of-the-year in 1995, 1996, and 1997 is much higher than that reported during baseline studies in the early 1980s. Stressed or dead fish were not observed. In many cases, adult fish were observed actively feeding on drift and terrestrial insects.

Results: Slimy Sculpin

Anxiety Ridge, Ikalukrok, and Red Dog Creek

Houghton and Hilgert (1983) found slimy sculpin in all of the regularly sampled stations on Ikalukrok Creek and in Dudd Creek but none were collected in the Red Dog Creek drainage. ADF&G started sampling with minnow traps in North Fork Red Dog Creek in 1992 and in Middle Fork and Mainstem Red Dog Creek in 1994. Slimy sculpin were never caught in Middle Fork Red Dog Creek (Table 17) and were first captured in Mainstem and North Fork Red Dog Creeks in 1995. The number of slimy sculpin using the Red Dog Creek drainage is extremely low and is similar to Anxiety Ridge Creek. The largest catches of slimy sculpin occurred in Ikalukrok Creek where the traps were fished just above and below the mouth of Dudd Creek. It is generally accepted that slimy sculpin do not distribute long distances from suitable overwintering habitats. We believe slimy sculpin overwinter in lower Ikalukrok Creek and the Wulik River, and probably do not migrate long distances to spring spawning or summer rearing habitats.

Table 17. Slimy sculpin collected in Anxiety Ridge, Ikalukrok (at mouth of Dudd Creek and at mouth of Mainstem Red Dog), Mainstem Fork Red Dog, Middle Fork Red Dog, and North Fork Red Dog Creeks, 1990-1997.

Creek	Year	No. Sample Periods	No. Traps Deployed	No. Slimy Sculpin
Anxiety Ridge	1990	3	5	0
	1991	6	5	0
	1992	3	10	0
	1993	2	10	0
	1994	3	10	1
	1995	3	10	2
	1996	3	10	0
	1997	2	10	1
Ikalukrok (at Dudd Cr.)	1990	3	5	0
	1991	4	5	3
	1992	3	10	3
	1993	2	10	2
	1994	1	20	8
	1995	3	20	8
	1996	2	20	2
	1997	2	20	11
Ikalukrok (at Red Dog)	1996	2	20	0
	1997	2	20	1
Lower Mainstem Red Dog[a]	1996	2	10	1
	1997	2	10	0
Mainstem Red Dog[b]	1994	3	5	0
	1995	3	15	1
	1996	3	15	1
	1997	2	15	0
North Fork Red Dog	1992	2	5	0
	1993	2	10	0
	1994	3	10	0
	1995	3	10	1
	1996	3	10	0
	1997	2	10	0

Table 17. Slimy sculpin, concluded.

Creek	Year	No. Sample Periods	No. Traps Deployed	No. Slimy Sculpin
Middle Fork Red Dog[c]	1994	3	5	0
	1995	3	5	0
	1996	3	5	0
	1997	2	5	0

[a]Lower Mainstem Red Dog Creek - sample area immediately upstream of Ikalukrok Creek

[b]Mainstem Red Dog Creek - sample area downstream of North Fork Red Dog Creek

[c]Middle Fork Red Dog Creek - sample area upstream of North Fork Red Dog Creek

CONCLUSIONS

I. Water Quality

Station 20
Reference Figure 5

Concentrations of Al, Cd, Pb, and Zn in Middle Fork Red Dog Creek have varied each year since development of the Red Dog Mine, with no consistent increase or decrease over baseline of the metals that were monitored. Al was highest in 1994, Cd, Pb, and Zn were highest in 1991. Median concentrations in 1996 and 1997 were generally lower than baseline concentrations.

Reference Figure 10.

Total dissolved solids increased in fall 1994 at Station 20 over concentrations reported in 1991 and 1992. TDS from fall 1994 through 1996 varied, but there was no consistent increase in TDS.

Station 73: Ikalukrok Creek
Reference Figure 8.

Concentrations of Al, Cd, Pb, and Zn were highest in 1989 and 1990. After construction of the seepage water collection ditch, concentrations of most metals decreased. Maximum amounts of Al were higher in 1996 than 1990-95; and concentrations of Pb varied each year, with no consistent increase or decrease. Concentrations of all metals in 1996 dropped to near baseline following extension of the mine sump ditch to capture Hilltop Creek. Concentrations of all metals monitored were lower in 1997. Cd appears lower in 1996 than baseline; but differences cannot be determined because of lower detection limits in 1996.

II. Aquatic Invertebrates

Reference Tables 5 and 6.

In July 1996 there was a higher invertebrate density in Ikalukrok Creek with distance downstream from Red Dog Creek. This correlation may be coincidental, because

densities at Station 10, in Red Dog Creek, were higher than any of the other sites, except tributary streams Shelly and Connie Creeks.

Reference Table 7.

In July 1996, adult forms of aquatic insects were an important component of invertebrate drift in many of the sites sampled. Adults comprised up to 78.7 % of samples (Station 20). Adult forms were substantially more rare in August, and comprised less than 1% of samples at most sites. Differences are due to timing of emergence.

III. Periphyton Standing Crop

Reference Figure 12.

Periphyton standing crop, estimated by chlorophyll-a concentrations, was generally higher in Ikalukrok Creek (Stations 6, 7, and 8) than in Red Dog Creek (Station 10). Highest concentrations were measured in North Fork (Station 12) in 1995.

IV. Metals Concentrations in Overwintering Dolly Varden

Reference Figures 13 through 22.

Gill, muscle, liver, and kidney tissues were sampled from adult Dolly Varden collected in the Wulik River in spring and fall. ADF&G has done similar sampling every spring and fall since October 1990. Monitoring of fish tissues is done to detect any changes in concentrations of Al, Cd, Cu, Pb, and Zn that may be associated with changes in water quality.

In fall 1997, fish had lowest tissue Al concentrations of any years monitored. Cd increased slightly in kidney tissues since 1993, then dropped in fall 1997. Maximum Cd concentrations remained substantially lower than reported for baseline. No increase in Cd was observed in other tissues sampled. Median Pb concentrations in fish liver remained low since 1991 and liver concentrations of Zn changed little since fall 1992, except during spring 1995.

We could detect no correlation between age or size of fish and concentrations of metals: there was no identifiable increase or decrease in tissue metals concentrations in larger or smaller fish. Metals concentrations appear to be related to concentrations of metals in water.

V. Overwintering Dolly Varden

Reference Table 9.

Populations of overwintering Dolly Varden fluctuate from year to year. Changes in population size seen are related to: (a) weather conditions during the fall survey; (b) natural annual variation in numbers of returning fish; and (c) the mixed stock of fish in the Wulik River. We found no increase or decrease in numbers of Dolly Varden that correspond to development and production at the Red Dog Mine. Use of the Wulik River with Dolly Varden concentrated in the reach below the mouth of Ikalukrok Creek remains high. Over 90% of the overwintering Dolly Varden use the reach below Ikalukrok Creek and this pattern of habitat selection has not changed from pre-mining.

VI. Chum Salmon Spawning

Reference Table 10.

Chum salmon surveys have been conducted in 1990, 1991, 1995, 1996, and 1997. The number of returning adult chum salmon spawners in Ikalukrok Creek remains lower than pre-mining. The highest count recorded since 1990 was in 1997 when 730 to 780 adults were observed. Distribution of spawning adults in 1997 was similar to pre-mining. Adults were concentrated in lower Ikalukrok Creek but were present throughout the creek from its mouth to the large pool located immediately below the mouth of Dudd Creek.

VII. Fish Distribution

1. Juvenile Dolly Varden

Reference Tables 11, 12, and 13.

Except for Middle Fork Red Dog Creek, juvenile Dolly Varden were found in all sample reaches in 1997 (Anxiety Ridge, Evaingiknuk, Ikalukrok, North Fork Red Dog Creek, Mainstem Red Dog Creek, and Buddy Creeks). Highest use continues to occur in Anxiety Ridge Creek which was identified as the most productive stream system in the project area by Houghton and Hilgert (1983). Pre-mining fisheries work indicated that Mainstem Red Dog Creek did not provide suitable rearing habitat for juvenile Dolly Varden. Since 1995, we have documented juvenile Dolly Varden rearing in Mainstem Red Dog Creek and fish collected in 1997 were in excellent condition. Numbers of juvenile Dolly Varden in tributary streams varies annually, but relative use remains fairly consistent with highest catches, even during years of low use, occurring in Anxiety Ridge Creek. Juvenile rearing in mainstem Ikalukrok Creek for all sample years has remained low in comparison to tributary streams like Anxiety Ridge and Buddy Creeks. Juvenile Dolly Varden appear to be preferentially selecting the small, more productive streams and avoiding areas inhabited by adult Arctic grayling and large Dolly Varden. Smolt-colored Dolly Varden were found in Anxiety Ridge Creek upstream of the haul road indicating that a portion of the population overwinters in Anxiety Ridge Creek.

2. Arctic grayling in Mainstem and North Fork Red Dog Creeks

Reference Table 14 and Figure 27.

Arctic grayling use of North Fork Red Dog Creek varies among years, with highest use occurring in 1995. Successful spawning, judged by presence of young-of-the-year fish, has been observed each year in North Fork Red Dog Creek. Relative abundance and growth of young-of-the-year Arctic grayling varies annually, but recruitment to the population has not been documented the past four years. The 1997 spawning success and growth of young-of-the-year fish was the highest recorded since our sampling began in 1991.

Houghton and Hilgert (1983) concluded that Arctic grayling only used Mainstem Red Dog Creek as a migratory corridor to access suitable habitat in North Fork Red Dog Creek. Both adult and young-of-the-year Arctic grayling have used Mainstem Red Dog Creek for summer rearing since 1995 and in 1997 spawning occurred in Mainstem Red Dog Creek near Station 10. The highest recorded numbers of adult fish was in 1995, the same year high numbers were found in North Fork Red Dog Creek and the only year adult fish remained in the Red Dog Creek drainage for an entire summer.

3. Slimy Sculpin

Reference Table 17.

Baseline studies reported slimy sculpin occurred in all regularly sampled sites in Ikalukrok Creek and Dudd Creek, and none were collected in the Red Dog Creek drainage. ADF&G reported a few (1-2) slimy sculpin in Mainstem Red Dog Creek in 1995, 1996, and 1997; no slimy sculpin were collected in Middle Fork Red Dog Creek (upstream of the confluence with North Fork Red Dog Creek).

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Appendix 1

A Summary of the History of Mine Development and Operation, 1982 through 1996.

1982 baseline data, Cominco/Nana agreement

1983 EIS process, alternatives, road to port site

1984 consultant surveys streams along proposed road

1985 permit applications prepared for ADF&G, NPDES, ADEC, etc.
ADF&G defers to ADEC on the wastewater treatment plant
summer discharge only of wastewater
extent of potential acid rock generation not recognized

1986 permits issued
permits preceded ADNR reclamation standards
permits preceded ADEC solid waste permit and bonding
AIDEA bonds issued to build road and port by state

1987 construction of road starts, ADF&G prepares budget request to AIDEA
AIDEA agrees to reimburse ADF&G only for logistics to monitor construction

1988 development of ore body starts
road and port site construction begin
road crossing by-passes fail and Notice of Violation issued to AIDEA
Uniform Summons and Complaint issued for illegal water removal
AIDEA requests an ADF&G budget and provides funds (salary)
rehabilitation plans for streams developed and implemented

1989 close-out of old solid waste site agreement reached with Cominco
civil work on ore body, drainage control surface water
complaints on water quality in Ikalukrok Creek are received (fall 1989)
tailing dam full, need approval for siphoning untreated water over the dam, state denies request
Ikalukrok Creek below Red Dog heavily stained with red precipitate from elevated metals concentrations
State authorizes a winter discharge of treated water
disagreement on whether metals exceed background, baseline

1990 ADF&G develops a fish study proposal and initiates fish sampling
dead fish being turned into ADF&G from Ikalukrok Creek by the public
sampling indicates virtually no fish left in Ikalukrok Creek
sumps and pumps placed to intercept metal laden seeps in Red Dog Creek
ADF&G reviews baseline and current water quality data

ADF&G notifies Cominco to bypass clean water
Zn levels in Ikalukrok Creek greater than 40 mg/L
disagreement on whether there is a water quality problem continues
ADEC issues compliance order by consent (late August 1990) for water quality violations
ADF&G issues Notice of Violation (late August 1990) for water quality violations affecting anadromous fish
Cominco directed to design and construct clean water bypass
Kivalina involvement begins, subsistence fishery being affected

1991 Clean water bypass system designed by Cominco and approved by State agencies
Cominco agrees to fund ADF&G fisheries study
clean water bypass system built in March/April 1991
repairs made to clean water bypass system
improvements in water quality seen by mid-summer

1992 fish study continues
water quality improvements to downstream receiving waters continue
volume of water in tailing impoundment continues to increase
water from dirty water collection system increases volume of tailing pond
water treatment plant modifications made

1993 fish study continues
sand filters installed to remove particulate zinc

1994 fish study continues
work begins on stream reclassification
thickening tank converted to increase water treatment capacity
wastewater discharge increased to 23 cfs from 7.5 cfs
Cominco expands ore processing capability

1995 fish study continues and is expanded to add aquatic taxa survey
work continues on stream reclassification and site-specific criteria
metals begin to rise again in clean water bypass system
source identified as Hilltop Creek (Zn), Shelly Creek (Cd) and Rachel Creek (Al)
clean water bypass system extended in fall 1995 to collect Hilltop Creek
drilling locates more ore, doubling the reserves
possible heavy metal contamination in Bons Creek identified by ADF&G

1996 stream reclassification out for public notice
Bons Creek water quality samples collected above and below Kivalina shale dump

1997 stream reclassification becomes incorporated into regulation (18 AAC 70.050)

April, 1997. fish barrier constructed across Mainstem Red Dog Creek to prevent possible migration of fish upstream.

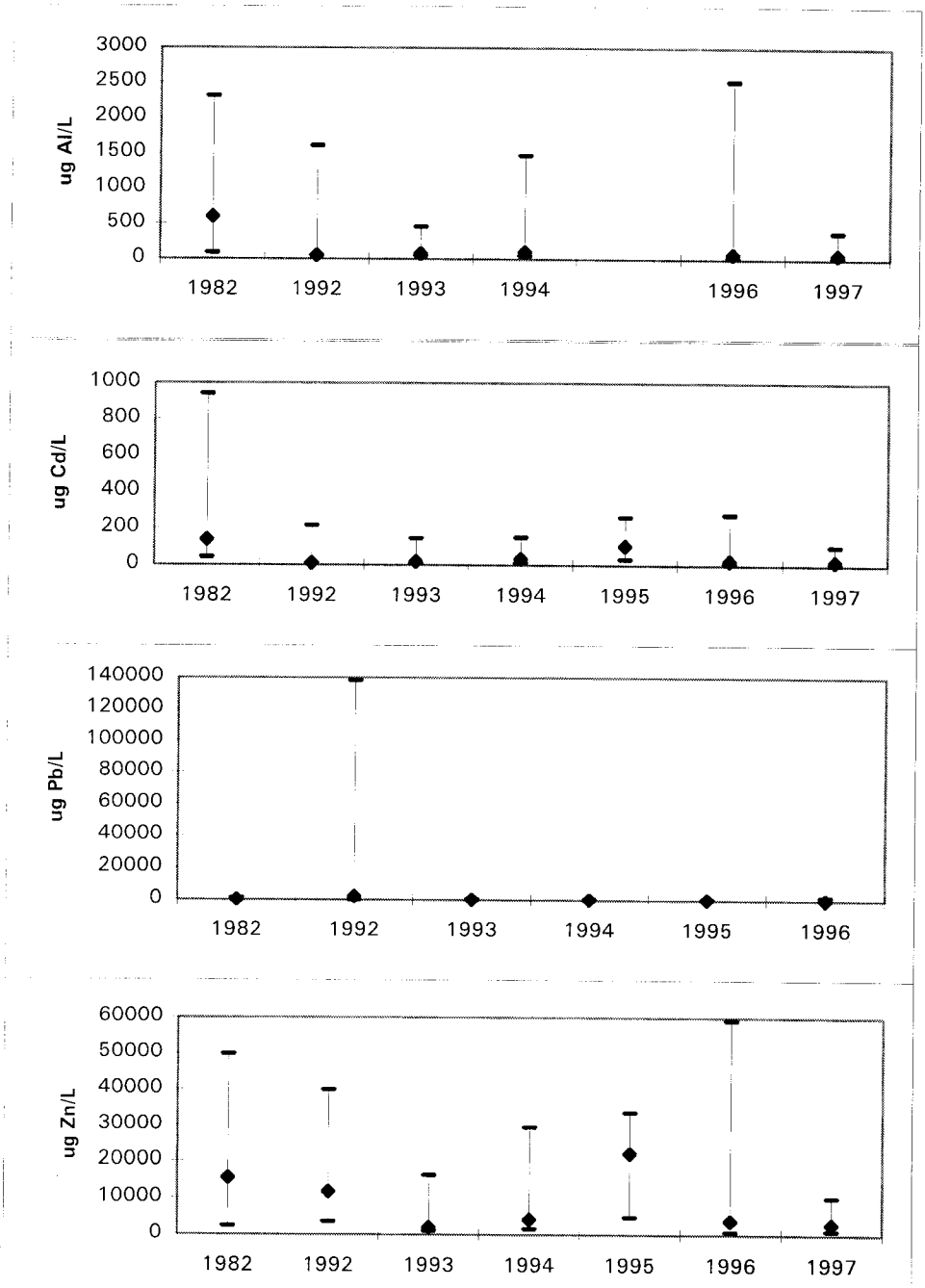
March, April. bypass built to carry water around the Kivalina shale dump.

interceptor trench with submerged pumps constructed on south side of Kivalina shale dump

Appendix II. Metals concentrations in tributary streams.

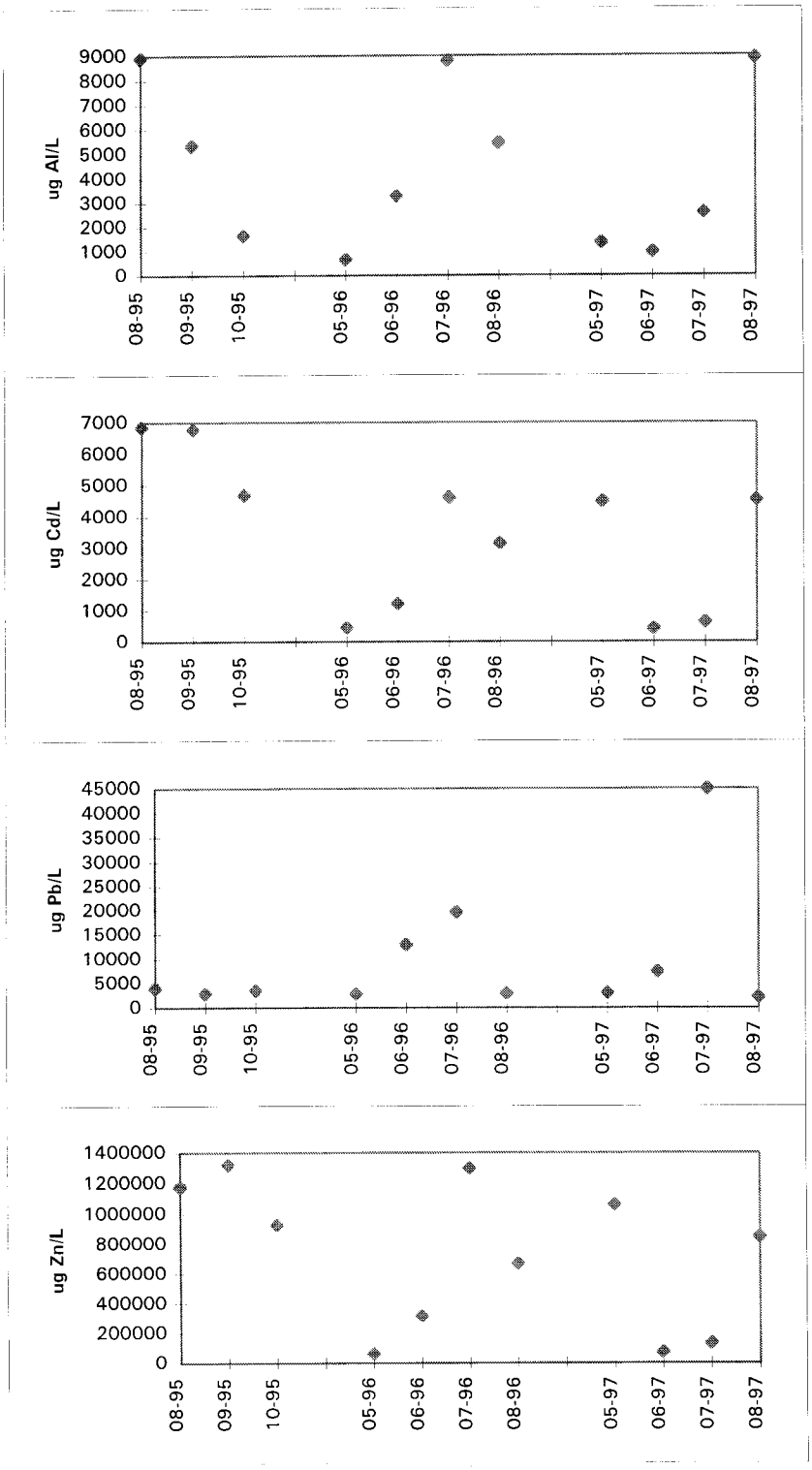
Middle Fork Red Dog Creek

Concentrations of metals in Middle Fork Red Dog Creek upstream of the mine effluent. Baseline data were collected at Station 30, post mining data were collected at Station 140.



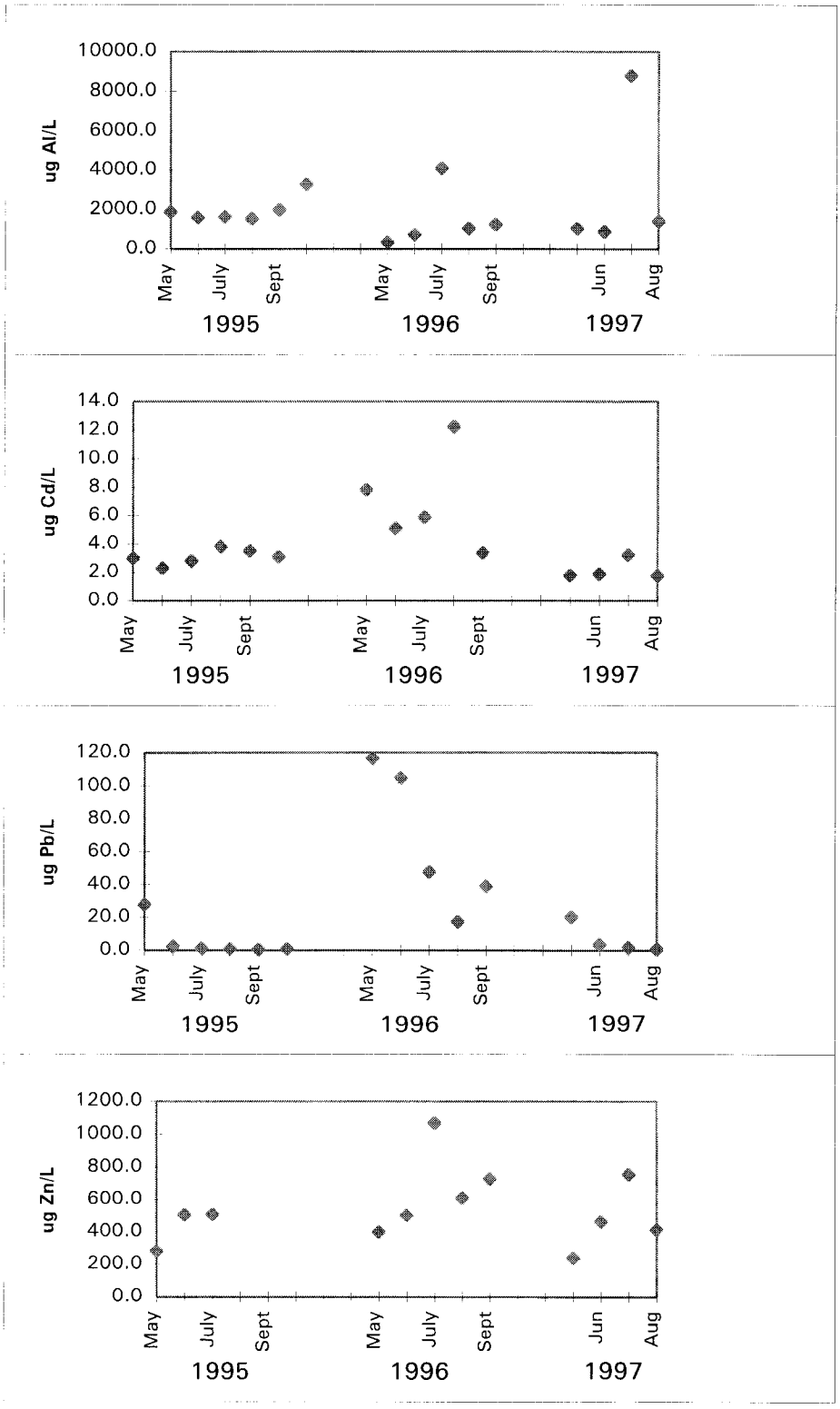
Hilltop Creek

Monthly average concentrations of metals in Hilltop Creek, 1995 and 1996.



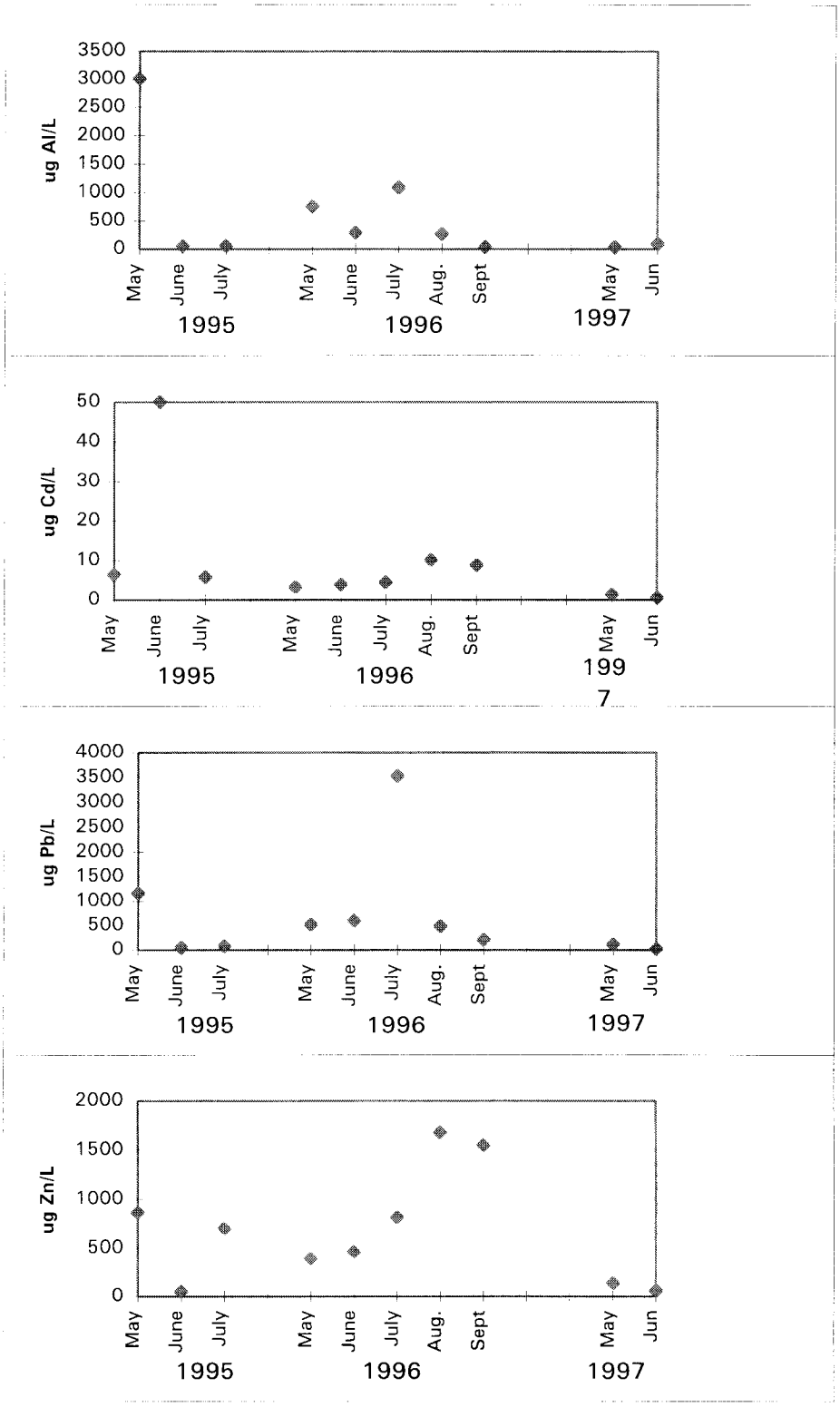
Rachel Creek

Average monthly concentrations of metals in Rachel Creek, 1995 and 1996.



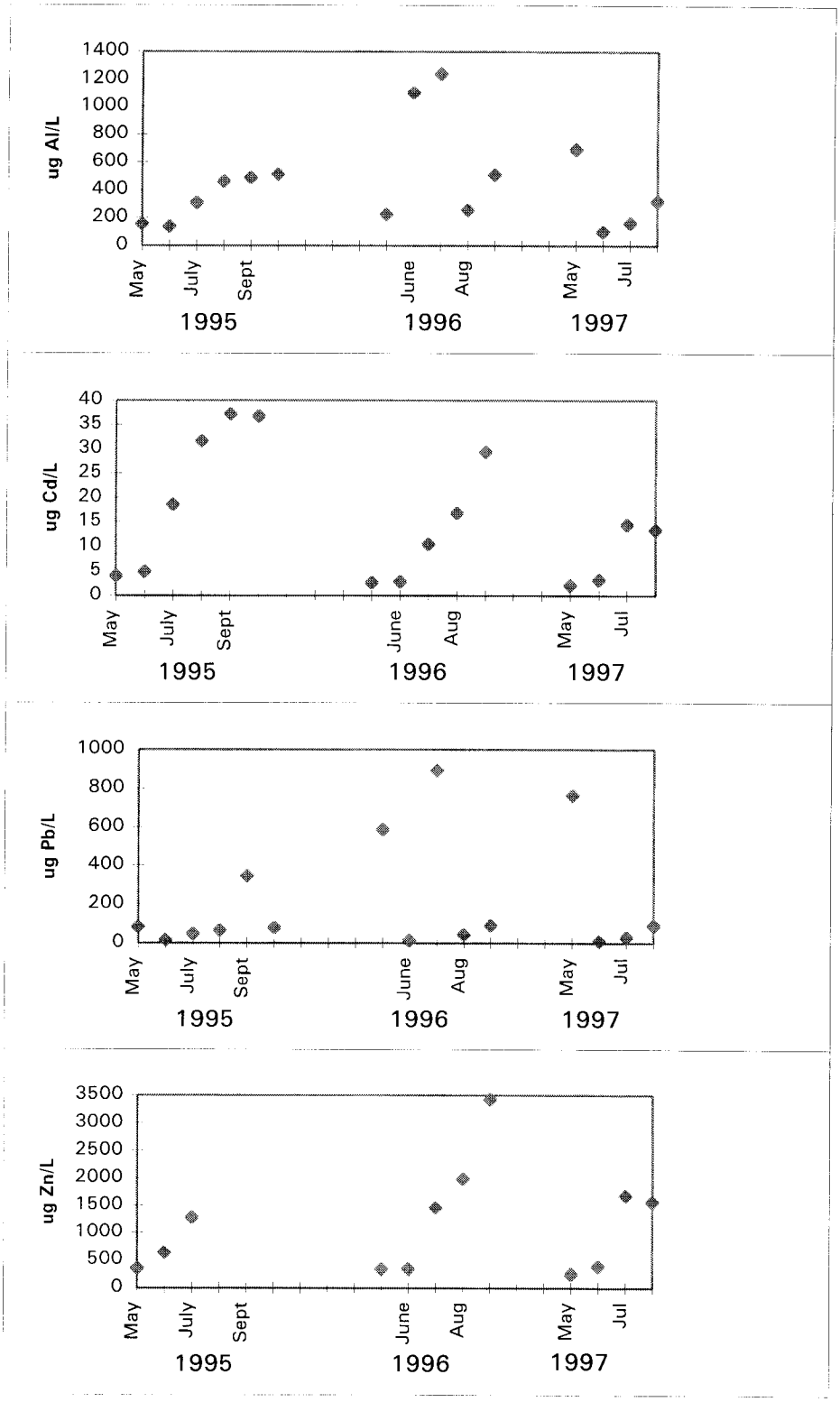
Sulfur Creek

Monthly average concentrations of metals in Sulfur Creek.



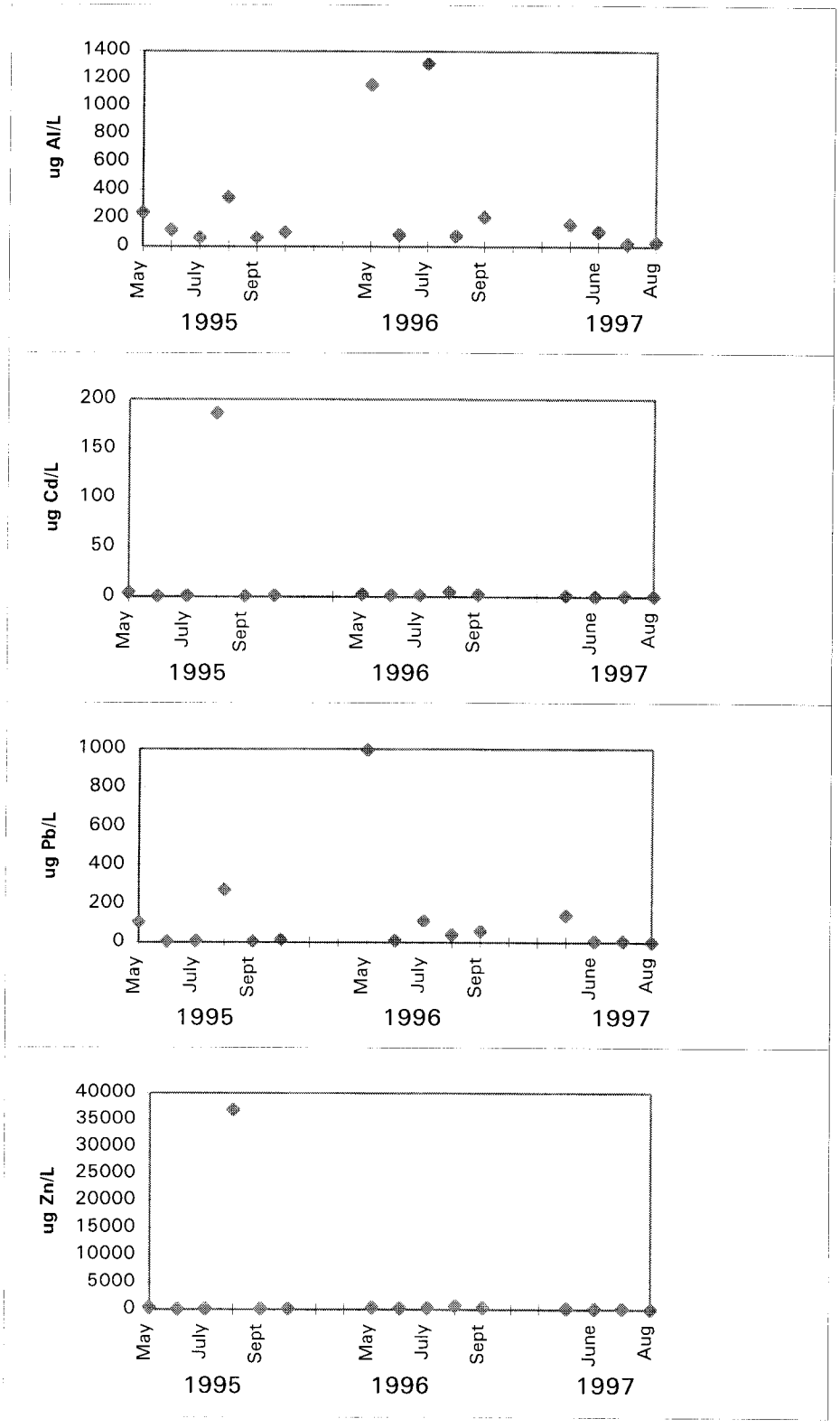
Shelly Creek

Monthly average concentrations of metals in Shelly Creek.



Connie Creek

Average monthly concentrations of metals in Connie Creek.



Appendix 3.

Taxonomic list of invertebrates collected in Wulik River drainage, 1995 and 1996.

Ephemeroptera	
Baetidae	*Baetis*
Heptagenidae	*Cyngmula*
Plecoptera	
Perlodidae	*Alloperla*
Nemouridae	*Nemoura*
Capnidae	*Capnia*
Diptera	
Chironomidae L	
Chironomidae P	
Tipulidae	*Tipula*
Tipulidae	*Limonia*
Simulidae	*Simula*
Coleoptera	
Staphylinidae L	*Stenus*
Hydrophilidae L	*Hydrochus*
Miscellaneous	
Nematoda	
Collembola	*Podura*

Appendix 4.

Description of sample groups for determinations of fish tissue metals concentrations.

Fall 1990. Six adult Dolly Varden collected from the Wulik River (downstream of the mouth of Ikalukrok Creek) by Fred DeCicco (ADF&G) on October 3, 1990, before freezeup.

Late Winter, 1991. Nine adult Dolly Varden collected from the Wulik River (three by Cominco on 3/9/91, five by Kivalina on 4/6/91, one by Cominco on 4/26/91) between Driver's Camp (Station 2) and Umiivaq (lower Wulik River) during late winter before breakup.

Winter 1990-91. Five adult Dolly Varden collected from the Noatak River by local residents during winter 1990/1991. Date and exact location in the Noatak River are unknown.

Spring 1991. Eight adult Dolly Varden collected from the Wulik River (lower Wulik River immediately upstream of Kivalina) by Cominco and local residents from Kivalina on 6/16/91, immediately following breakup.

Fall 1991. Six adult Dolly Varden collected from the Wulik River (Station 2) by Matt Robus (ADF&G) and Hank Brown and John Martinesko (Cominco) on 10/5/91, before freezeup.

Spring 1992. Eight adult Dolly Varden collected from the Wulik River (about 5 miles upstream of Kivalina) between 4/28 and 4/30/92, by Al Townsend (ADF&G) and Hank Brown (Cominco) during late winter before breakup.

Fall 1992. Six adult Dolly Varden collected from the Wulik River (Station 2) by Al Townsend (ADF&G) on 9/29/92, before freezeup.

Spring 1993. Six adult Dolly Varden collected from the Wulik River (about five miles upstream of Kivalina) between 4/19 and 4/23/93, by Al Townsend (ADF&G) and Jake Wells (Cominco) during late winter before breakup.

Fall 1993. Six adult Dolly Varden collected from the Wulik River (Station 2) by Al Townsend (ADF&G) on 10/20/93, before freezeup.

Spring 1994. Six adult Dolly Varden collected from the Wulik River (Station 2) by Al Townsend (ADF&G) on 4/7/94, during late winter before breakup.

Fall 1994. Six adult Dolly Varden collected from the Wulik River (Station 2) by Fred DeCicco (ADF&G) on 9/23/94, before freezeup.

Spring 1995. Six adult Dolly Varden collected from the Wulik River (lower Wulik River near Kivalina) by Fred DeCicco (ADF&G) on 6/10/95 after breakup.

Fall 995. Six adult Dolly Varden collected from the Wulik River (Station 2) by Randy Zarnke (ADF&G) on 9/9/95, before freezeup.

Spring 1996. Five Dolly Varden collected by Al Townsend from the Wulik River near Station 2 on 6/16/96. Only five fish were collected.

Fall 1996. Six Dolly Varden collected by Fred DeCicco from the Wulik River upstream of Kivalina. Tissue from fish #5 was split into two samples, to constitute a blind duplicate for the analytical laboratory. The duplicate sample is listed as fish #7. Tissues from these fish also were sent to Washington state for histological analysis.

Spring 1997. Six Dolly Varden collected by Fred DeCicco from the Wulik River on May 22, 1997.

Fall 1997. Six Dolly Varden collected by Fred DeCicco from the Wulik River on September 27, 1997. Samples 6 and 7 are duplicates of the same fish.

Appendix 5.

Concentrations of Al, Cd, Cu, Pb, and Zn in adult Dolly Varden tissues, 1990 through 1997, from the Wulik River and Se from spring 1997. Baseline fish tissue data from Dames and Moore (1983) are included. All concentrations expressed as mg/Kg, dry weight basis. See Appendix 4 for explanation of the sample groups.

				Gill Tissue												
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh	Al		Cd		Cu		Pb		Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	Solids
D&M	6/1/81	Sta 1	A						0.770		3.00	<	0.03			67.20	
D&M	6/1/81	Sta 2	A						1.200		3.20	<	0.02			68.60	
D&M	8/1/81	Sta 1	A						0.360		3.20	<	0.04			34.10	
D&M	9/1/81	Sta 1	A						0.790		3.10	<	0.04			67.40	
D&M	9/1/81	Mid-Ikaluk	A						1.400		3.10	<	0.03			52.70	
D&M	6/1/82		A						5.750		0.75		3.18			0.03	24.8
ADF&G	10/5/90	Wulik	F		538		1.8		1.630		2.20		0.20			90.40	22.3
ADF&G	10/5/90	Wulik	F		615		1.3		0.680		3.10	<	0.10			70.90	25.8
ADF&G	10/5/90	Wulik	M		608		1.4		1.440		2.60	<	0.10			68.70	24.0
ADF&G	10/5/90	Wulik	F		430		2.0		1.200		3.30		0.10			70.50	26.2
ADF&G	10/5/90	Wulik	F		452		0.6		1.220		2.10	<	0.10			70.20	21.6
Cominco	10/5/90	Wulik	F		528		2.2		2.440		2.60		0.20			96.60	24.1
Cominco	3/9/91	Wulik	F		560	7(3+4)	6.1		0.390		2.30	<	0.10			87.40	19.2
Cominco	3/9/91	Wulik	F		380	5(3+2)	7.8		0.660		2.30	<	0.10			87.60	22.0
Cominco	3/9/91	Wulik	F		387	4(2+2)	10.8		1.020		2.30	<	0.10			77.80	22.1
KIVALINA	4/6/91	WULIK	M		300		5.0		0.450		2.60	<	0.10			94.80	19.5
KIVALINA	4/6/91	WULIK	M	197	294		13.9		0.360		1.90	<	0.10			74.40	18.6
KIVALINA	4/6/91	WULIK	F	201	303		3.4		0.820		2.20	<	0.10			88.40	19.3
KIVALINA	4/6/91	WULIK	F	237	355		4.2		0.330		2.50		0.20			70.30	19.0
KIVALINA	4/6/91	WULIK	F	751	434		16.1		0.850		1.90	<	0.10			83.00	19.8
Cominco	4/26/91	Wulik	F	1279	518		3.2		0.790		1.7		1.10			79.80	20.4
Noatak	4/15/91	Noatak	F	274	323		27.6		0.050		1.80		0.20			105.00	20.3
Noatak	4/15/91	Noatak	F	283	324		15.6		0.060		1.60		0.10			79.80	22.3
Noatak	4/15/91	Noatak	M	714	416		3.5		0.070		2.20		0.10			81.20	20.5
Noatak	4/15/91	Noatak	F	730	443		6.7		0.100		1.50	<	0.10			76.60	21.3
Noatak	4/15/91	Noatak	F	449	401		10.5		0.040		2.20	<	0.10			84.00	20.3
Cominco	6/16/91	Wulik	M	962	489		36.6		1.510		3.10		1.00			75.60	18.2
Cominco	6/16/91	Wulik	F	1426	538		56.3		0.780		3.00		3.00			79.30	21.1
Cominco	6/16/91	Wulik	M	1361	541		21.2		1.150		2.70		0.60			75.50	18.8
Cominco	6/16/91	Wulik	F	762	461		18.4		2.000		3.10		1.50			89.60	22.2
Cominco	6/16/91	Wulik	F	672	417		20.5		0.640		2.10		0.80			64.70	21.4
Cominco	6/16/91	Wulik	F	745	430		33.3		0.830		2.80		1.50			75.30	20.8
Cominco	6/16/91	Wulik	F	680	443		60.2		0.850		2.90		2.40			67.70	21.5
Cominco	6/16/91	Wulik	F	654	430		1.2		1.820		3.10		1.20			78.50	20.2

Appendix 5, continued.

				Gill Tissue												
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh	Al		Cd		Cu		Pb	Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	mg/kg	Solids
Cominco	10/5/91	Wulik	F	1162	480		1.6		0.550		3.39		0.10		70.80	21.0
Cominco	10/5/91	Wulik	M	1262	480		23.4		0.300		2.92		0.16		75.20	19.3
Cominco	10/5/91	Wulik	M	2551	614		10.6		0.630		2.82		0.29		71.40	20.3
Cominco	10/5/91	Wulik	F	2188	589		2.1		0.540		3.64		0.23		72.30	23.0
Cominco	10/5/91	Wulik	F	1616	525		22.1		0.500		4.23		1.26		73.60	19.8
Cominco	10/5/91	Wulik	M	2233	563		31.7		0.710		5.10		0.33		84.10	21.7
ADF&G	4/29/92	Wulik	F	180	291		3.1		0.130		3.34		0.18		93.30	20.8
ADF&G	4/29/92	Wulik	F	670	424	(2+2)	2.1		0.160		1.780		0.07		65.50	25.9
ADF&G	4/29/92	Wulik	F	1420	530	(2+3)?	9.0		0.070		1.79		0.11		65.70	27.8
ADF&G	4/29/92	Wulik	U	180	294	(2+1)?	2.3		0.130		1.92		0.07		84.20	21.0
ADF&G	4/29/92	Wulik	F	140	275	(3+1)	2.7		0.120		3.73		0.04		93.70	19.9
ADF&G	4/29/92	Wulik	M	160	276		4.4		0.140		2.21		0.02		81.30	19.2
ADF&G	4/29/92	Wulik	M	140	264	(4+1)	5.9		0.080		2.24		0.06		80.20	20.3
ADF&G	4/29/92	Wulik	F	150	259	(3+1)	1.7		0.090		2.13		0.03		77.70	19.9
ADF&G	9/30/92	Wulik	F	4120	706	9	2.8		0.240		3.22		0.04		76.00	21.2
ADF&G	9/30/92	Wulik	M	2820	620	(3+4)	2.3		0.420		8.50		0.16		90.00	18.8
ADF&G	9/30/92	Wulik	F	3410	674	(3+5)	1.3		0.410		2.92	<	0.02		86.00	19.8
ADF&G	9/30/92	Wulik	M	2630	600	(4+4)	1.3		0.330		2.90		0.04		91.00	20.3
ADF&G	9/30/92	Wulik	F	2110	564	(3+4)	1.4		0.330		2.92	<	0.02		94.00	19.8
ADF&G	9/30/92	Wulik	M	2920	595	(2+4)	1.0		0.360		2.34		0.04		73.00	21.6
ADF&G	4/21/93	Wulik R.		673	407		1.8		0.240		2.420		0.36		87.00	20.2
ADF&G	4/21/93	Wulik R.		1032	480	(2+3)	1.6		0.150		2.500		0.03		97.00	20.7
ADF&G	4/21/93	Wulik R.		717	414	(4+2)	2.5		0.180		2.350		0.43		84.00	20.8
ADF&G	4/21/93	Wulik R.		701	421	(3+2)	3.7		0.140		2.330		0.04		74.00	21.7
ADF&G	4/21/93	Wulik R.		685	398	6	3.1		0.160		2.190		0.04		75.00	22.4
ADF&G	4/21/93	Wulik R.		611	407	(2+3)	1.4		0.170		2.310		0.03		77.00	22.8
ADF&G	10/20/93	Wulik R.	F	2168	575	(3+3)	42.4		0.180		2.680		0.06		101.00	25.5
ADF&G	10/20/93	Wulik R.	M	1352	491	(4+3)	3.9		0.260		12.800		0.20		88.50	24.8
ADF&G	10/20/93	Wulik R.	M	1551	498	(3+3)	3.7		0.310		3.930	<	0.02		80.10	22.2
ADF&G	10/20/93	Wulik R.	F	1188	456	(3+3)	66.7		0.280		2.900		0.08		88.50	25.8
ADF&G	10/20/93	Wulik R.	M	1324	473	(3+3)	2.9		0.160		2.640		0.03		81.20	21.7
ADF&G	10/20/93	Wulik R.	M	2204	556	(3+4)	4.3		0.230		2.020		0.02		64.70	24.8
ADF&G	4/7/94	Wulik R.	M	245	297		15.9		0.110		2.150		0.04		83.10	20.8
ADF&G	4/7/94	Wulik R.	F	572	380		14.5		0.160		16.300		0.81		78.30	25.1
ADF&G	4/7/94	Wulik R.	M	526	390		5.2		0.170		23.100		0.43		66.00	21.2
ADF&G	4/7/94	Wulik R.	M	499	385		3.5		0.120		2.910		0.04		111.00	15.2
ADF&G	4/7/94	Wulik R.	M	590	386		3.9		0.160		3.640	<	0.02		103.00	19.1
ADF&G	4/7/94	Wulik R.	F	1651	521		5.5		0.150		27.400		0.38		88.50	19.0

Appendix 5, continued.

Gill Tissue

Collector	Date	Location	Sex	Weight grams	Length mm	age (fresh salt)	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	9/23/94	Wulik R.	F	844	420		487.0	0.25	3.41	0.65		99.10	27.3
ADF&G	9/23/94	Wulik R.	M	690	420		379.0	0.21	2.95	0.55		99.40	25.8
ADF&G	9/23/94	Wulik R.	M	826	425		452.0	0.25	2.52	0.70		94.60	26.3
ADF&G	9/23/94	Wulik R.	M	890	435		184.0	0.25	2.09	0.32		83.5	27.5
ADF&G	9/23/94	Wulik R.	F	681	405		308.0	0.26	25	0.46		87.2	25.9
ADF&G	9/23/94	Wulik R.	F	726	420		212.0	0.32	2.35	0.31		91.4	24.6
ADF&G	6/14/95	Wulik R.	M	916.25	443	3/3	4.4	0.26	2.37	0.04		68.8	21.6
ADF&G	6/14/95	Wulik R.	F	1007	454	3/3	2.3	0.1	2.3 <	0.02		53	23.8
ADF&G	6/14/95	Wulik R.	M	762.03	419	3/2	441	0.23	3.26	0.67		70.3	19.6
ADF&G	6/14/95	Wulik R.	F	907.18	455	3/3	5.4	0.24	3.05 <	0.02		83.5	19.5
ADF&G	6/14/95	Wulik R.	F	925.32	462	3/3	294	0.29	7.51	0.5		74.7	20.0
ADF&G	6/14/95	Wulik R.	F	916.25	448	3/3	388	0.38	2.95	0.56		78.9	18.9
ADF&G	9/9/95	Wulik R.	F	816.46	434	3/3	11.8	0.43	3.71	1.5		362	7.9
ADF&G	9/9/95	Wulik R.	M	1170.3	482	3/3	7.1	0.3	2.47	1.08		527	8.5
ADF&G	9/9/95	Wulik R.	F	1451.5	475	4/3	11.1	0.23	2.43	0.63		351	8.0
ADF&G	9/9/95	Wulik R.	M	1097.7	457	2/3	0.9	1.2	3.29	0.02		70.3	7.8
ADF&G	9/9/95	Wulik R.	F	1977.7	530	2/3	24.6	0.25	2.34	0.73		375	8.0
ADF&G	9/9/95	Wulik R.	U	1778.1	555	7	12.1	0.3	2.25	0.58		315	8.2
ADF&G	6/16/96	Wulik R.	F	699.2	424	4/3	4.7	1.76	4.55	0.09		64.6	17.1
ADF&G	6/16/96	Wulik R.	F	808.1	450	2/3	3.4	1.42	3.56	0.04		74.5	22
ADF&G	6/16/96	Wulik R.	M	799	432	2/4	8.8	3.27	3.6	0.18		85.3	23.7
ADF&G	6/16/96	Wulik R.	M	962.5	468	2/4	2.2	1.88	3.95	0.05		71.1	21.7
ADF&G	6/16/96	Wulik R.	F	1416	505	3/5	3.1	2.1	4.68	0.05		83.7	23.5
ADF&G	9/19/96	Wulik R.	F	826.3	430	4+3	3.3	3.43	7.83	0.02		88.1	21
ADF&G	9/19/96	Wulik R.	F	1044	455	5	5.6	2.4	5.62	0.02		81	23.2
ADF&G	9/19/96	Wulik R.	F	1471	475	2+5	3.1	2.34	6.56	0.04		88.8	23.4
ADF&G	9/19/96	Wulik R.	F	1416	485	2+4	3.4	3.18	6.01	0.04		84.5	23.9
ADF&G	9/19/96	Wulik R.	F	1734	520	2+4	2.3	1.32	3.92 <	0.02		84.1	23.6
ADF&G	9/19/96	Wulik R.	F	1571	525	2+5	2.4	2.64	6.75	0.14		81.2	23.2
ADF&G	9/19/96	Wulik R.	duplicate fish of #5				2.7	1.85	4.84 <	0.02		94.4	55.8
ADF&G	5/22/97	Wulik R.	F	1207	499		104	0.2	2.91	0.25	2	58.6	22.9
ADF&G	5/22/97	Wulik R.	F	1061	478		45.7	0.14	2.58	0.17	3	55.5	23.2
ADF&G	5/22/97	Wulik R.	F	1279	488		58.4	0.14	2.16	0.15	2	56.3	22.9
ADF&G	5/22/97	Wulik R.	M	1325	485		88.9	0.11	2.76	0.19	3	56.9	23.3
ADF&G	5/22/97	Wulik R.	M	1488	531		12.7	0.21	2.25	0.05	2	61.4	23.3
ADF&G	5/22/97	Wulik R.	F	771.1	450		17.5	0.18	2.27	0.05	2	59	22.4

Appendix 5, continued.

				Gill Tissue												
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh	Al		Cd		Cu		Pb		Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	Solids
ADF&G	9/27/97	Wulik R.	F	572	383	4	72.7		0.13		2.06		0.2		2.7	54.6	24.3
ADF&G	9/27/97	Wulik R.	M	535.7	392	3/3	136		0.21		2.4		0.27		2.4	68.4	24.6
ADF&G	9/27/97	Wulik R.	M	572	397	2/2	7.8		0.1		1.62		0.09		2.3	46.3	23.8
ADF&G	9/27/97	Wulik R.	F	263.3	299	2/1	66.4		0.16		2.16		0.18		2.8	58.4	23.8
ADF&G	9/27/97	Wulik R.	F	1653	555	3/6	90		0.21		2.6		0.26		2.9	73.4	24.6
ADF&G	9/27/97	Wulik R.	M	1507	520	3/5	112		0.14		2.28		0.31		2.1	79.5	25.3
ADF&G	9/27/97	Wulik R.	Duplicate of #6				60.6		0.1		1.9		0.21		1.8	64.6	22.9

Appendix 5, continued.

Kidney Tissue																
Collector	Date	Location	Sex	Weight	Length	age			Cd		Cu		Pb		Se	Zn	%
				grams	mm	(fresh/	Al										
						salt)	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	Solids
D&M	6/1/81	Sta 1	A						0.32		4.90		0.02			80.10	
D&M	6/1/81	Sta 2	A						5.30		4.00	<	0.02			75.90	
D&M	8/1/81	Sta 1	A						2.90		5.20	<	0.05			74.60	
D&M	9/1/81	Sta 1	A						3.00		5.80	<	0.03			109.00	
D&M	6/1/82		A				3.0		2.53		5.28		0.03			94.43	
ADF&G	10/5/90	Wulik R.	F		538		1.5		5.34		3.30		0.20			117.00	21.4
ADF&G	10/5/90	Wulik R.	F		615		1.1		2.22		4.80	<	0.10			96.40	21.9
ADF&G	10/5/90	Wulik R.	M		608		0.7		1.53		4.80	<	0.10			79.30	24.0
ADF&G	10/5/90	Wulik R.	F		430		3.0		2.93		5.20	<	0.10			100.00	23.7
ADF&G	10/5/90	Wulik R.	F		452		0.9		3.30		5.00	<	0.10			106.00	21.9
ADF&G	10/5/90	Wulik R.	F		528		1.1		2.63		5.30	<	0.10			103.00	18.5
Cominco	3/9/91	Wulik R.	F		560	7(3+4)	2.3		3.59		4.80	<	0.10			143.00	23.1
Cominco	3/9/91	Wulik R.	F		380	5(3+2)	4.7		3.48		5.20	<	0.10			103.00	22.9
Cominco	3/9/91	Wulik R.	F		387	4(2+2)	2.1		3.20		4.90	<	0.10			118.00	23.6
KIVALINA	4/6/91	Wulik R.	M		300		2.4		4.31		3.70	<	0.20			127.00	20.3
KIVALINA	4/6/91	Wulik R.	M	197	294		8.8		0.85		2.70	<	0.40			85.60	23.4
KIVALINA	4/6/91	Wulik R.	F	201	303		22.0		1.96		4.10		1.50			173.00	23.7
KIVALINA	4/6/91	Wulik R.	F	237	355		7.4		0.17		9.00		0.40			139.00	21.8
KIVALINA	4/6/91	Wulik R.	F	751	434		2.1		2.79		3.50	<	0.10			102.00	22.4
Cominco	4/26/91	Wulik R.	F	1279	518		1.0		5.40		6.20		0.20			112.00	21.0
Noatak	4/15/91	Noatak R.	F	274	323		2.1		0.93		3.20	<	0.10			112.00	23.1
Noatak	4/15/91	Noatak R.	F	283	324		4.6		0.57		2.90	<	0.10			79.80	22.0
Noatak	4/15/91	Noatak R.	M	714	416		2.2		2.01		3.20	<	0.10			93.40	26.5
Noatak	4/15/91	Noatak R.	F	730	443		4.1		2.06		3.30	<	0.10			106.00	23.2
Noatak	4/15/91	Noatak R.	F	449	401		5.0		1.82		3.70		0.10			108.00	18.0
Cominco	6/16/91	Wulik R.	M	962	489		6.0		6.56		6.00		0.10			83.30	18.3
Cominco	6/16/91	Wulik R.	F	1426	538		2.4		4.87		4.10	<	0.10			89.20	23.0
Cominco	6/16/91	Wulik R.	M	1361	541		1.7		4.14		4.00		0.20			76.60	22.3
Cominco	6/16/91	Wulik R.	F	762	461		2.1		3.09		4.50	<	0.10			94.50	22.4
Cominco	6/16/91	Wulik R.	F	672	417		1.5		2.47		3.50	<	0.10			208.00	15.2
Cominco	6/16/91	Wulik R.	F	745	430		1.6		2.23		4.20	<	0.10			71.10	21.9
Cominco	6/16/91	Wulik R.	F	680	443		1.9		4.01		4.90	<	0.10			108.00	22.5
Cominco	6/16/91	Wulik R.	F	654	430		1.3		3.23		4.10	<	0.10			95.90	21.2

Appendix 5, continued.

Kidney Tissue																
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh/	Al		Cd		Cu		Pb	Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	mg/kg	Solids
Cominco	10/5/91	Wulik R.	F	1162	480		1.0		1.27		4.54		0.06		87.10	22.7
Cominco	10/5/91	Wulik R.	M	1262	480		1.9		1.66		4.89		0.62		92.40	22.8
Cominco	10/5/91	Wulik R.	M	2551	614		3.9		0.87		17.70		1.75		51.20	23.0
Cominco	10/5/91	Wulik R.	F	2188	589		1.3		2.54		6.18		0.03		104.00	22.3
Cominco	10/5/91	Wulik R.	F	1616	525		1.9		4.68		5.94		0.04		107.00	21.5
Cominco	10/5/91	Wulik R.	M	2233	563		0.8		2.81		4.37		0.06		86.40	22.9
ADF&G	4/29/92	Wulik R.	F	180	291		6.6		0.62		5.04		0.04		114.00	36.4
ADF&G	4/29/92	Wulik R.	F	670	424	(2+2)	5.0		1.51		3.570		0.04		78.10	24.2
ADF&G	4/29/92	Wulik R.	F	1420	530	(2+3)?	5.7		1.28		3.43		0.02		86.60	24.5
ADF&G	4/29/92	Wulik R.	U	180	294	(2+1)?	4.7		0.53		3.83		0.04		91.70	20.8
ADF&G	4/29/92	Wulik R.	F	140	275	(3+1)	4.3		0.38		6.43		0.06		99.70	21.4
ADF&G	4/29/92	Wulik R.	M	160	276		8.1		1.67		3.88		0.05		95.50	19.8
ADF&G	4/29/92	Wulik R.	M	140	264	(4+1)	2.6		0.40		3.50		0.04		82.20	17.4
ADF&G	4/29/92	Wulik R.	F	150	259	(3+1)	5.9		0.80		4.22		0.03		114.00	21.3
ADF&G	9/30/92	Wulik R.	F	4120	706	9	3.1		2.74		4.49	<	0.02		85.00	22.5
ADF&G	9/30/92	Wulik R.	M	2820	620	(3+4)	2.3		2.97		5.00	<	0.02		110.00	22.6
ADF&G	9/30/92	Wulik R.	F	3410	674	(3+5)	1.1		2.37		4.09	<	0.02		74.00	28.0
ADF&G	9/30/92	Wulik R.	M	2630	600	(4+4)	1.0		1.26		5.64	<	0.02		93.00	24.2
ADF&G	9/30/92	Wulik R.	F	2110	564	(3+4)	1.0		2.14		5.24		0.06		105.00	24.3
ADF&G	9/30/92	Wulik R.	M	2920	595	(2+4)	1.7		1.64		3.69		0.24		81.00	24.1
ADF&G	4/21/93	Wulik R.	F	673	407		1.4		0.76		3.850		0.02		88.00	23.8
ADF&G	4/21/93	Wulik R.		1032	480	(2+3)	1.7		1.33		4.530		0.02		106.00	23.5
ADF&G	4/21/93	Wulik R.		717	414	(4+2)	1.5		1.82		4.440		0.01		112.00	24.8
ADF&G	4/21/93	Wulik R.		701	421	(3+2)	1.2		0.79		3.660		0.01		84.00	26.9
ADF&G	4/21/93	Wulik R.		685	398	6	2.1		0.51		4.050	<	0.01		100.00	22.9
ADF&G	4/21/93	Wulik R.		611	407	(2+3)	4.1		0.53		3.610	<	0.01		99.00	22.3
ADF&G	10/20/93	Wulik R.		2168	575	(3+3)	2.3		1.37		4.67	<	0.02		103	25.6
ADF&G	10/20/93	Wulik R.		1352	491	(4+3)	1.1		0.13		0.54	<	0.02		13.8	24.6
ADF&G	10/20/93	Wulik R.		1551	498	(3+3)	2.3		0.77		4.51	<	0.02		110	23.0
ADF&G	10/20/93	Wulik R.		1188	456	(3+3)	2.6		0.73		4.01	<	0.02		95.5	24.0
ADF&G	10/20/93	Wulik R.		1324	473	(3+3)	2.6		0.71		3.93	<	0.02		116	23.5
ADF&G	10/20/93	Wulik R.		2204	556	(3+4)	2.5		1.76		5.45	<	0.02		98.9	22.7

Appendix 5, continued.

Kidney Tissue																
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh/	Al		Cd		Cu		Pb		Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	Solids
ADF&G	4/7/94	Wulik R.	M	245	297		16.0		0.79		4.660		0.03			97.60	25.7
ADF&G	4/7/94	Wulik R.	F	572	380		10.2		0.88		3.280	<	0.02			88.50	23.1
ADF&G	4/7/94	Wulik R.	M	526	390		6.9		1.20		3.300	<	0.02			87.40	21.2
ADF&G	4/7/94	Wulik R.	M	499	385		9.6		1.94		4.190		0.05			102.00	20.7
ADF&G	4/7/94	Wulik R.	M	590	386		8.9		1.47		4.190		0.02			98.20	20.6
ADF&G	4/7/94	Wulik R.	F	1651	521		10.4		1.43		4.370	<	0.02			92.40	21.3
ADF&G	9/23/94	Wulik R.	F	844	420		5.7		0.92		4.34		0.04			106.00	23.0
ADF&G	9/23/94	Wulik R.	M	690	420		3.1		1.17		6.93		0.03			117.00	22.9
ADF&G	9/23/94	Wulik R.	M	826	425		2.9		0.60		3.70	<	0.02			101.00	23.6
ADF&G	9/23/94	Wulik R.	M	890	435		7.2		0.63		3.69		0.03			86.6	25.9
ADF&G	9/23/94	Wulik R.	F	681	405		2.6		0.71		4.37	<	0.02			114	24.7
ADF&G	9/23/94	Wulik R.	F	726	420		2.0		1.23		3.83		0.02			91.3	25.7
ADF&G	6/14/95	Wulik R.	M	916.25	443	3/3	3.5		1.18		4.58	<	0.02			88	22.1
ADF&G	6/14/95	Wulik R.	F	1007	454	3/3	5.4		1.62		4.31	<	0.02			71.8	24.4
ADF&G	6/14/95	Wulik R.	M	762.03	419	3/2	2.5		1.22		4.59	<	0.02			83.5	22.6
ADF&G	6/14/95	Wulik R.	F	907.18	455	3/3	1.2		0.95		4.28	<	0.02			74.3	23.5
ADF&G	6/14/95	Wulik R.	F	925.32	462	3/3	1.9		0.8		3.59	<	0.02			61.2	22.9
ADF&G	6/14/95	Wulik R.	F	916.25	448	3/3	1.3		0.76		3.58	<	0.02			65.9	22.1
ADF&G	9/9/95	Wulik R.	F	816.46	434	3/3	1.3		2.36		4.94	<	0.02			89.4	5.4
ADF&G	9/9/95	Wulik R.	M	1170.3	482	3/3	1		2.5		13.4	<	0.02			89.6	6.4
ADF&G	9/9/95	Wulik R.	F	1451.5	475	4/3	1.6		1.86		4.47	<	0.02			75.1	6.9
ADF&G	9/9/95	Wulik R.	M	1097.7	457	2/3	11.8		0.25		2.27		0.86			444	5.8
ADF&G	9/9/95	Wulik R.	F	1977.7	530	2/3	3.4		1.08		3.88	<	0.02			80.5	8.9
ADF&G	9/9/95	Wulik R.	U	1778.1	555	7	0.9		0.85		3.98		0.06			61.4	9.6
ADF&G	6/16/96	Wulik R.	F	699.2	424	4/3	4.7		1.76		4.55		0.09			64.6	17.1
ADF&G	6/16/96	Wulik R.	F	808.1	450	2/3	3.4		1.42		3.56		0.04			74.5	22
ADF&G	6/16/96	Wulik R.	M	799	432	2/4	8.8		3.27		3.6		0.18			85.3	23.7
ADF&G	6/16/96	Wulik R.	M	962.5	468	2/4	2.2		1.88		3.95		0.05			71.1	21.7
ADF&G	6/16/96	Wulik R.	F	1416	505	3/5	3.1		2.1		4.68		0.05			83.7	23.5
ADF&G	9/19/96	Wulik R.	F	826.3	430	4+3	3.3		3.43		7.83		0.02			88.1	21
ADF&G	9/19/96	Wulik R.	F	1044	455	5	5.6		2.4		5.62		0.02			81	23.2
ADF&G	9/19/96	Wulik R.	F	1471	475	2+5	3.1		2.34		6.56		0.04			88.8	23.4
ADF&G	9/19/96	Wulik R.	F	1416	485	2+4	3.4		3.18		6.01		0.04			84.5	23.9
ADF&G	9/19/96	Wulik R.	F	1734	520	2+4	2.3		1.32		3.92	<	0.02			84.1	23.6
ADF&G	9/19/96	Wulik R.	F	1571	525	2+5	2.4		2.64		6.75		0.14			81.2	23.2
ADF&G	9/19/96	Wulik R.	duplicate fish of #5				2.7		1.85		4.84	<	0.02			94.4	55.8

Appendix 5, continued.

Kidney Tissue																
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh/	Al		Cd		Cu		Pb		Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	Solids
ADF&G	5/22/97	Wulik R.	F	1207	499		4.1		3.27		5.15		0.17		7	89.9	22.8
ADF&G	5/22/97	Wulik R.	F	1061	478		4.4		2.08		3.7		0.04		7	76.2	21.9
ADF&G	5/22/97	Wulik R.	F	1279	488		2.2		2.45		4.2		0.08		7	74.4	22.1
ADF&G	5/22/97	Wulik R.	M	1325	485		3.3		1.97		6.49		0.04		7	66.7	23.1
ADF&G	5/22/97	Wulik R.	M	1488	531		7		1.8		7.88		0.06		6	73.5	24.4
ADF&G	5/22/97	Wulik R.	F	771.1	450		4.6		2.96		6.31		0.04		5	87.1	22.6
ADF&G	9/27/97	Wulik R.	F	572	383	4	5		0.57		3.82		0.05		6.8	87.4	23
ADF&G	9/27/97	Wulik R.	M	535.7	392	3/3	3.1		0.17		36.8		0.02		3.7	69.1	42.6
ADF&G	9/27/97	Wulik R.	M	572	397	2/2	2.7		0.36		60.8		0.03		3.8	122.0	40.2
ADF&G	9/27/97	Wulik R.	F	263.3	299	2/1	2.7		0.19		54.4	<	0.02		4.4	70.2	37.0
ADF&G	9/27/97	Wulik R.	F	1653	555	3/6	2.5		0.52		43.4		0.02		2.9	58.2	42.9
ADF&G	9/27/97	Wulik R.	M	1507	520	3/5	3.1		0.39		63.2	<	0.02		2.8	56.8	44.8
ADF&G	9/27/97	Wulik R.	Duplicate of #6				2.9		0.37		68.9	<	0.02		3.0	58.5	49.1

Appendix 5, continued.

Liver Tissue																
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh	Al		Cd		Cu		Pb	Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg	mg/Kg	mg/kg	Solids
D&M	6/1/81	Sta 1	A						0.580		33.00	<	0.02		72.3	
D&M	6/1/81	Sta 1	A						0.540		16.50	<	0.02		50.8	
D&M	8/1/81	Sta 1	A						0.770		11.00	<	0.02		91.0	
D&M	9/1/81	Sta 1	A						0.970		18.00		0.02		78.2	
D&M	9/1/81	Mid-Ikaluk	A						1.200		7.90	<	0.03		243.0	
D&M	6/1/82		A				2.50		0.670		27.75		0.03		69.6	
ADF&G	10/5/90	Wulik R.	F		538		1.50		1.110		25.60		0.10		103.0	26.1
ADF&G	10/5/90	Wulik R.	F		615		0.70		0.250		19.70	<	0.10		46.6	46.6
ADF&G	10/5/90	Wulik R.	M		608		0.70		0.190		38.40	<	0.10		58.7	50.9
ADF&G	10/5/90	Wulik R.	F		430		0.80		0.460		22.60	<	0.10		79.3	29.0
ADF&G	10/5/90	Wulik R.	F		452		0.70		0.400		24.20	<	0.10		74.6	34.6
ADF&G	10/5/90	Wulik R.	F		528		0.40		0.370		29.90	<	0.10		61.8	55.9
Cominco	3/9/91	Wulik R.	F		560	7(3+4)	1.50		1.810		40.30	<	0.10		164.0	27.1
Cominco	3/9/91	Wulik R.	F		380	5(3+2)	3.10		0.530		30.70	<	0.10		65.8	44.4
Cominco	3/9/91	Wulik R.	F		387	4(2+2)	2.00		0.730		46.60	<	0.10		84.8	38.8
Kivalina	4/6/91	Wulik R.	M		300		4.80		1.730		51.90	<	0.10		88.8	33.8
Kivalina	4/6/91	Wulik R.	M	197	294		1.50		0.290		47.70	<	0.10		87.2	34.9
Kivalina	4/6/91	Wulik R.	F	201	303		1.80		0.450		41.10	<	0.10		95.8	33.1
Kivalina	4/6/91	Wulik R.	F	237	355		2.20		0.630		72.00	<	0.10		114.0	25.2
Kivalina	4/6/91	Wulik R.	F	751	434		2.90		0.380		25.90		0.10		44.6	35.0
Cominco	4/26/91	Wulik R.	F	1279	518		1.30		0.760		25.40	<	0.10		56.1	38.2
Noatak	4/15/91	Noatak R.	F	274	323		10.00		0.210		26.90		0.20		70.3	36.3
Noatak	4/15/91	Noatak R.	F	283	324		2.60		0.430		44.40	<	0.10		110.0	28.5
Noatak	4/15/91	Noatak R.	M	714	416		6.70		0.270		29.80	<	0.10		88.1	44.3
Noatak	4/15/91	Noatak R.	F	730	443		1.20		0.270		26.80	<	0.10		49.0	44.2
Noatak	4/15/91	Noatak R.	F	449	401		3.70		0.680		65.10	<	0.10		137.0	28.3
Cominco	6/16/91	Wulik R.	M	962	489		1.30		1.250		32.40	<	0.10		74.0	31.9
Cominco	6/16/91	Wulik R.	F	1426	538		1.80		0.710		18.70	<	0.10		75.2	30.8
Cominco	6/16/91	Wulik R.	M	1361	541		3.60		0.860		37.50	<	0.10		83.2	33.7
Cominco	6/16/91	Wulik R.	F	762	461		2.00		1.180		34.10	<	0.10		96.6	27.4
Cominco	6/16/91	Wulik R.	F	672	417		1.80		1.480		38.30		0.80		124.0	24.0
Cominco	6/16/91	Wulik R.	F	745	430		1.20		0.690		54.20	<	0.10		85.4	28.9
Cominco	6/16/91	Wulik R.	F	680	443		1.20		1.040		26.00	<	0.10		84.3	33.3
Cominco	6/16/91	Wulik R.	F	654	430		0.90		0.840		31.00	<	0.10		88.0	30.1

Appendix 5, continued.

Liver Tissue																
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh	Al		Cd		Cu		Pb		Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg		mg/Kg	mg/kg	Solids
Cominco	10/5/91	Wulik R.	F	1162	480		0.94		0.290		33.60		0.04			70.8	45.6
Cominco	10/5/91	Wulik R.	M	1262	480		0.34		0.210		27.40		0.02			50.2	43.1
Cominco	10/5/91	Wulik R.	M	2551	614		0.44		0.720		39.00		0.10			61.7	37.7
Cominco	10/5/91	Wulik R.	F	2188	589		0.87		0.320		59.00		0.05			65.6	45.7
Cominco	10/5/91	Wulik R.	F	1616	525		0.40		0.530		25.40		0.04			55.1	41.5
Cominco	10/5/91	Wulik R.	M	2233	563		0.70		0.210		30.60		0.04			33.8	47.6
ADF&G	4/29/92	Wulik R.	F	180	291		3.20		0.410		40.30	<	0.02			152.0	27.0
ADF&G	4/29/92	Wulik R.	F	670	424	(2+2)	7.20		0.310		23.80	<	0.02			62.8	46.7
ADF&G	4/29/92	Wulik R.	F	1420	530	(2+3)?	4.70		0.260		47.80		0.02			66.2	39.6
ADF&G	4/29/92	Wulik R.	U	180	294	(2+1)?	7.60		0.370		32.40		0.03			142.0	27.7
ADF&G	4/29/92	Wulik R.	F	140	275	(3+1)	7.80		0.210		71.80		0.07			222.0	26.4
ADF&G	4/29/92	Wulik R.	M	160	276		2.30		0.740		39.90	<	0.02			162.0	26.5
ADF&G	4/29/92	Wulik R.	M	140	264	(4+1)	5.50		0.450		84.10		0.04			176.0	27.0
ADF&G	4/29/92	Wulik R.	F	150	259	(3+1)	4.50		0.350		36.20		0.02			160.0	25.3
ADF&G	9/30/92	Wulik R.	F	4120	706	9	1.64		0.270		21.50		0.02			60.0	45.0
ADF&G	9/30/92	Wulik R.	M	2820	620	(3+4)	3.07		0.370		19.50		0.03			67.0	41.8
ADF&G	9/30/92	Wulik R.	F	3410	674	(3+5)	0.92		0.240		19.70		0.02			56.0	50.1
ADF&G	9/30/92	Wulik R.	M	2630	600	(4+4)	0.51		0.160		40.20	<	0.02			60.0	48.1
ADF&G	9/30/92	Wulik R.	F	2110	564	(3+4)	0.61		0.320		45.60		0.02			74.0	41.4
ADF&G	9/30/92	Wulik R.	M	2920	595	(2+4)	0.55		0.150		20.00	<	0.02			59.0	41.4
ADF&G	4/21/93	Wulik R.		673	407		1.200		0.2400		29.80	<	0.01			75.0	39.5
ADF&G	4/21/93	Wulik R.		1032	480	(2+3)	1.400		0.1600		37.30		0.02			73.0	37.4
ADF&G	4/21/93	Wulik R.		717	414	(4+2)	1.400		0.1900		42.30	<	0.01			63.0	46.0
ADF&G	4/21/93	Wulik R.		701	421	(3+2)	1.400		0.1300		23.00		0.02			58.0	42.2
ADF&G	4/21/93	Wulik R.		685	398	6	1.400		0.1500		21.00		0.01			66.0	38.7
ADF&G	4/21/93	Wulik R.		611	407	(2+3)	1.100		0.1800		18.10		0.02			67.0	36.8
ADF&G	10/20/93	Wulik R.		2168	575	(3+3)	2.800		0.1800		23.60	<	0.02			46.5	48.4
ADF&G	10/20/93	Wulik R.		1352	491	(4+3)	2.800		0.2300		22.10		0.03			67.6	41.4
ADF&G	10/20/93	Wulik R.		1551	498	(3+3)	2.000		0.1200		13.20	<	0.02			51.0	46.3
ADF&G	10/20/93	Wulik R.		1188	456	(3+3)	2.300		0.2300		42.90	<	0.02			86.0	37.4
ADF&G	10/20/93	Wulik R.		1324	473	(3+3)	2.600		0.1400		28.90	<	0.02			60.9	44.4
ADF&G	10/20/93	Wulik R.		2204	556	(3+4)	2.400		0.2700		35.20	<	0.02			62.4	35.6

Appendix 5, continued.

Liver Tissue																
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh	Al		Cd		Cu		Pb	Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg	mg/Kg	mg/kg	Solids
ADF&G	4/7/94	Wulik R.	M	245	297		24.40		0.270		34.50		0.21		88.5	35.0
ADF&G	4/7/94	Wulik R.	F	572	380		10.10		0.550		42.80	<	0.02		118.0	32.4
ADF&G	4/7/94	Wulik R.	M	526	390		4.70		0.630		47.80	<	0.02		93.3	32.9
ADF&G	4/7/94	Wulik R.	M	499	385		7.80		0.480		35.00	<	0.02		110.0	30.1
ADF&G	4/7/94	Wulik R.	M	590	386		2.20		0.400		35.20	<	0.02		86.0	35.4
ADF&G	4/7/94	Wulik R.	F	1651	521		10.20		0.270		30.00		0.02		56.5	37.6
ADF&G	9/23/94	Wulik R.	F	844	420		0.70		0.17		20.30	<	0.02		85.3	44.7
ADF&G	9/23/94	Wulik R.	M	690	420		0.80		0.20		41.10	<	0.02		87.0	42.1
ADF&G	9/23/94	Wulik R.	M	826	425		1.10		0.18		51.70	<	0.02		87.2	45.8
ADF&G	9/23/94	Wulik R.	M	890	435		0.9		0.18		39.60	<	0.02		81.4	46.4
ADF&G	9/23/94	Wulik R.	F	681	405		0.9		0.17		48.00	<	0.02		82.0	50.5
ADF&G	9/23/94	Wulik R.	F	726	420		0.9		0.34		28.90	<	0.02		89.9	43.1
ADF&G	6/14/95	Wulik R.	M	916.25	443	3/3	7.4		4.58		61.7	<	0.02		125	25.5
ADF&G	6/14/95	Wulik R.	F	1007	454	3/3	3.2		0.32		53	<	0.02		93.6	33.6
ADF&G	6/14/95	Wulik R.	M	762.03	419	3/2	0.8		0.52		57.6	<	0.02		124	25.6
ADF&G	6/14/95	Wulik R.	F	907.18	455	3/3	1.4		0.54		65.7	<	0.02		121	24.4
ADF&G	6/14/95	Wulik R.	F	925.32	462	3/3	2.8		0.44		73.9		0.04		126	25.3
ADF&G	6/14/95	Wulik R.	F	916.25	448	3/3	18.2		0.24		29		0.06		98.9	29.9
ADF&G	9/9/95	Wulik R.	F	816.46	434	3/3	2.1		0.62		34.5		0.02		103.0	14.5
ADF&G	9/9/95	Wulik R.	M	1170.3	482	3/3	4.5		0.65		134		0.44		366	13.1
ADF&G	9/9/95	Wulik R.	F	1451.5	475	4/3	0.6		0.4		16.6	<	0.02		61	13.8
ADF&G	9/9/95	Wulik R.	M	1097.7	457	2/3	1		0.4		27.3		0.03		65.8	13.6
ADF&G	9/9/95	Wulik R.	F	1977.7	530	2/3	0.6		0.21		31		0.08		54.6	15.2
ADF&G	9/9/95	Wulik R.	U	1778.1	555	7	0.9		0.19		39.4	<	0.02		55.4	15.0
ADF&G	6/16/96	Wulik R.	F	699.2	424	4/3	3		0.64		50.1		0.04		97.1	27.7
ADF&G	6/16/96	Wulik R.	F	808.1	450	2/3	1.9		0.61		37.7		0.02		85.7	30
ADF&G	6/16/96	Wulik R.	M	799	432	2/4	2.1		1.14		46.3		0.04		82.3	31.7
ADF&G	6/16/96	Wulik R.	M	962.5	468	2/4	1.9		0.67		80.9		0.07		87.2	30.3
ADF&G	6/16/96	Wulik R.	F	1416	505	3/5	4.1		0.51		47.6		0.03		65.6	41.4

Appendix 5, continued.

Liver Tissue																
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh	Al		Cd		Cu		Pb	Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg	mg/Kg	mg/kg	Solids
ADF&G	9/19/96	Wulik R.	F	826.3	430	4+3	2.4		0.95		38.3		0.03		90.2	32.5
ADF&G	9/19/96	Wulik R.	F	1044	455	5	2.5		0.44		68.1	<	0.02		63.3	46
ADF&G	9/19/96	Wulik R.	F	1471	475	2+5	3.2		0.4		34.9	<	0.02		62.4	39.8
ADF&G	9/19/96	Wulik R.	F	1416	485	2+4	2.3		0.6		43.6		0.06		60.8	51.4
ADF&G	9/19/96	Wulik R.	F	1734	520	2+4	1.9		0.43		37.2	<	0.02		60	44
ADF&G	9/19/96	Wulik R.	F	1571	525	2+5	2.3		0.44		37.9	<	0.02		59.2	45
ADF&G	9/19/96	Wulik R.	duplicate fish of #5				2.8		0.52		41.7	<	0.02		65.3	42
ADF&G	5/22/97	Wulik R.	F	1207	499		5.5		0.85		44.9		0.1	4	72.5	33.1
ADF&G	5/22/97	Wulik R.	F	1061	478		2.6		0.44		19.9		0.02	2	48.8	37.7
ADF&G	5/22/97	Wulik R.	F	1279	488		1.9		0.9		48		0.05	3	87.7	29.7
ADF&G	5/22/97	Wulik R.	M	1325	485		2.1		0.55		41.3	<	0.02	2	56.4	39.1
ADF&G	5/22/97	Wulik R.	M	1488	531		1.3		0.31		67		0.02	2	63.9	43.2
ADF&G	5/22/97	Wulik R.	F	771.1	450		2		0.83		57.8	<	0.02	3	93.9	31.7
ADF&G	9/27/97	Wulik R.	F	572	383	4	6.3		0.18		21.3		0.07	2.7	54.5	42.6
ADF&G	9/27/97	Wulik R.	M	535.7	392	3/3	4.2		2.2		4.61	<	0.02	6.6	86.9	22.9
ADF&G	9/27/97	Wulik R.	M	572	397	2/2	3.1		0.67		3.22		0.03	7.1	71.9	25.2
ADF&G	9/27/97	Wulik R.	F	263.3	299	2/1	4.6		0.47		4.37		0.02	5.9	73.2	23.7
ADF&G	9/27/97	Wulik R.	F	1653	555	3/6	3.5		3.09		4.48		0.02	7.6	76.5	23.5
ADF&G	9/27/97	Wulik R.	M	1507	520	3/5	4.5		1.61		4.04		0.03	6.6	74.7	25.0
ADF&G	9/27/97	Wulik R.	Duplicate of #6				2.7		1.89		4.36	<	0.02	6.4	75.0	23.1

Appendix 5, continued.

			Muscle Tissue														
Collector	Date	Location	Sex	Weight	Length	age											
				grams	mm	(fresh	Al		Cd		Cu		Pb		Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	Solids
D&M	6/1/81	Sta 1	A						0.160		1.30	<	0.02			9.89	
D&M	6/1/81	Sta 2	A						0.200		2.00	<	0.02			9.16	
D&M	7/1/81	Sta 6	A						0.210		2.50	<	0.04			13.90	
D&M	8/1/81	Sta 1	A						0.190		2.00		0.03			13.60	
D&M	9/1/81	Sta 1	A						0.120		2.10	<	0.02			16.80	
D&M	9/1/81	Mid-Ikaluk	A						0.170		2.90		0.02			10.90	
D&M	6/1/82	Sta 1	A				3.40		0.170		1.56		0.02			12.07	
ADF&G	10/5/90	Wulik	F		538		1.60	<	0.010		2.50	<	0.10			18.10	24.90
ADF&G	10/5/90	Wulik	F		615		0.40	<	0.010		1.00	<	0.10			7.60	42.40
ADF&G	10/5/90	Wulik	M		608		0.80	<	0.010		1.80	<	0.10			11.50	38.10
ADF&G	10/5/90	Wulik	F		430		0.50	<	0.010		1.90	<	0.10			12.90	32.50
ADF&G	10/5/90	Wulik	F		452		0.50	<	0.010		1.70	<	0.10			15.30	30.10
ADF&G	10/5/90	Wulik	F		528		0.90	<	0.010		1.70	<	0.10			12.10	39.50
KIVALINA	10/19/90	Wulik	F	1680	535		2.30	<	0.010		2.40	<	0.10			12.90	27.90
Cominco	3/9/91	Wulik	F		560	7(3+4)	2.20	<	0.010		3.50	<	0.10			18.60	24.70
Cominco	3/9/91	Wulik	F		380	5(3+2)	2.80	<	0.010		2.40	<	0.10			14.50	27.00
Cominco	3/9/91	Wulik	F		387	4(2+2)	1.60	<	0.010		2.50	<	0.10			15.50	26.80
KIVALINA	4/6/91	WULIK	M		300		1.60		0.010		2.00		0.10			17.40	24.90
KIVALINA	4/6/91	WULIK	M	197	294		6.10	<	0.010		2.20	<	0.10			15.00	23.60
KIVALINA	4/6/91	WULIK	F	201	303		11.60	<	0.010		3.10		0.60			15.50	24.70
KIVALINA	4/6/91	WULIK	F	237	355		3.20	<	0.010		1.90	<	0.10			18.80	19.30
KIVALINA	4/6/91	WULIK	F	751	434		1.90	<	0.010		2.20	<	0.10			14.20	28.40
Noatak	4/15/91	Noatak	F	274	323		6.40		0.040		2.40	<	0.10			16.10	24.10
Noatak	4/15/91	Noatak	F	283	324		1.50	<	0.010		2.00	<	0.10			14.60	24.40
Noatak	4/15/91	Noatak	M	714	416		3.70		0.010		2.90	<	0.10			14.10	28.60
Noatak	4/15/91	Noatak	F	730	443		0.60	<	0.010		1.40	<	0.10			13.80	26.40
Noatak	4/15/91	Noatak	F	449	401		4.10		0.010		1.20	<	0.10			17.00	23.60
Cominco	4/26/91	Wulik	F	1279	518		1.20	<	0.010		1.70	<	0.10			14.10	29.10
Cominco	6/16/91	Wulik	M	962	489		1.40		0.010		3.30	<	0.10			16.00	29.70
Cominco	6/16/91	Wulik	F	1426	538		1.80	<	0.010		2.20		0.10			15.30	26.40
Cominco	6/16/91	Wulik	M	1361	541		3.00	<	0.010		2.60	<	0.10			15.60	25.40
Cominco	6/16/91	Wulik	F	762	461		0.80	<	0.010		2.40	<	0.10			16.00	23.70
Cominco	6/16/91	Wulik	F	672	417		0.90	<	0.010		1.20	<	0.10			16.40	22.40
Cominco	6/16/91	Wulik	F	745	430		1.10	<	0.010		1.50	<	0.10			15.10	23.60
Cominco	6/16/91	Wulik	F	680	443		1.20		0.030		1.50	<	0.10			18.90	23.00
Cominco	6/16/91	Wulik	F	654	430		1.20	<	0.010		2.00	<	0.10			16.60	24.00

Appendix 5, continued.

			Muscle Tissue														
Collector	Date	Location	Sex	Weight	Length	age											
				grams	mm	(fresh	Al		Cd		Cu		Pb		Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	Solids
Cominco	10/5/91	Wulik	F	1162	480		0.55	<	0.020		2.55		0.03			14.90	27.70
Cominco	10/5/91	Wulik	M	1262	480		0.66	<	0.020		2.85		0.03			13.90	26.90
Cominco	10/5/91	Wulik	M	2551	614		0.43	<	0.020		2.02		0.04			14.50	27.40
Cominco	10/5/91	Wulik	F	2188	589		0.13		0.030		2.68		0.04			13.10	30.40
Cominco	10/5/91	Wulik	F	1616	525		0.22	<	0.020		2.03		0.03			12.80	27.50
Cominco	10/5/91	Wulik	M	2233	563		0.32	<	0.020		2.42		0.05			12.20	29.10
ADF&G	4/29/92	Wulik	F	180	291		2.50	<	0.020		2.27	<	0.05			16.50	24.70
ADF&G	4/29/92	Wulik	F	670	424	(2+2)	2.20	<	0.020		1.460		0.02			14.60	24.40
ADF&G	4/29/92	Wulik	F	1420	530	(2+3)?	1.80	<	0.020		1.35	<	0.02			14.10	25.90
ADF&G	4/29/92	Wulik	U	180	294	(2+1)?	2.60	<	0.020		2.12		0.03			25.90	23.60
ADF&G	4/29/92	Wulik	F	140	275	(3+1)	1.50	<	0.020		2.08	<	0.02			28.70	20.50
ADF&G	4/29/92	Wulik	M	160	276		2.60	<	0.020		2.38		0.02			22.90	22.60
ADF&G	4/29/92	Wulik	M	140	264	(4+1)	3.00	<	0.020		2.57	<	0.02			24.30	21.80
ADF&G	4/29/92	Wulik	F	150	259	(3+1)	3.90	<	0.020		1.99		0.02			26.10	22.80
ADF&G	9/30/92	Wulik	F	2820	620	9	1.35	<	0.020		1.74	<	0.02			14.00	23.50
ADF&G	9/30/92	Wulik	M	3410	674	(3+4)	0.47	<	0.020		1.27	<	0.02			11.00	31.70
ADF&G	9/30/92	Wulik	F	2630	600	(3+5)	0.72	<	0.020		1.27	<	0.02			13.00	34.40
ADF&G	9/30/92	Wulik	M	2110	564	(4+4)	0.74	<	0.020		1.26		0.03			13.00	26.20
ADF&G	9/30/92	Wulik	F	2920	595	(3+4)	0.42	<	0.020		1.59	<	0.02			14.00	30.70
ADF&G	9/30/92	Wulik	M	673	407	(2+4)	1.26	<	0.020		2.08		0.17			14.00	35.50
ADF&G	4/21/93	Wulik R.		1032	480		1.000	<	0.0100		1.380		0.02			16.000	25.400
ADF&G	4/21/93	Wulik R.		717	414	(2+3)	1.400	<	0.0100		1.450		0.03			18.000	27.400
ADF&G	4/21/93	Wulik R.		701	421	(4+2)	1.300	<	0.0100		1.490		0.02			20.000	27.400
ADF&G	4/21/93	Wulik R.		685	398	(3+2)	1.300	<	0.0100		1.380		0.02			16.000	26.500
ADF&G	4/21/93	Wulik R.		611	407	6	1.200	<	0.0100		1.230		0.02			18.000	24.800
ADF&G	4/21/93	Wulik R.		2168	575	(2+3)	1.300	<	0.0100		1.270		0.07			15.000	25.800
ADF&G	10/20/93	Wulik R.		2168	575	(3+3)	2.70	<	0.020		16.700		0.22			14.60	36.700
ADF&G	10/20/93	Wulik R.		1352	491	(4+3)	2.60	<	0.020		1.570	<	0.01			14.50	29.600
ADF&G	10/20/93	Wulik R.		1551	498	(3+3)	2.10	<	0.020		1.510	<	0.01			14.00	31.100
ADF&G	10/20/93	Wulik R.		1188	456	(3+3)	1.90	<	0.020		1.910	<	0.01			16.10	31.300
ADF&G	10/20/93	Wulik R.		1324	473	(3+3)	2.10	<	0.020		1.370	<	0.01			14.70	31.400
ADF&G	10/20/93	Wulik R.		2204	556	(3+4)	1.80	<	0.020		1.000	<	0.01			11.70	33.100

Appendix 5, continued.

			Muscle Tissue													
Collector	Date	Location	Sex	Weight	Length	age										
				grams	mm	(fresh	Al		Cd	Cu		Pb		Se	Zn	%
						salt)	mg/kg		mg/kg	mg/kg		mg/kg		mg/kg	mg/kg	Solids
ADF&G	4/7/94	Wulik R.	M	245	297		7.80	<	0.020	1.380	<	0.02			16.70	23.000
ADF&G	4/7/94	Wulik R.	F	572	380		8.80	<	0.020	1.350		0.02			15.80	25.800
ADF&G	4/7/94	Wulik R.	M	526	390		6.60	<	0.020	1.480		0.03			16.50	24.300
ADF&G	4/7/94	Wulik R.	M	499	385		5.70	<	0.020	1.090	<	0.02			17.00	22.800
ADF&G	4/7/94	Wulik R.	M	590	386		8.20	<	0.020	1.390		0.02			16.40	24.300
ADF&G	4/7/94	Wulik R.	F	1651	521		15.00	<	0.020	1.250		0.02			12.90	28.000
ADF&G	9/23/94	Wulik R.	F	844	420		3.10	<	0.02	1.74		0.04			16.90	29.1
ADF&G	9/23/94	Wulik R.	M	690	420		0.90	<	0.02	1.53	<	0.02			23.70	31.3
ADF&G	9/23/94	Wulik R.	M	826	425		1.00	<	0.02	1.64	<	0.02			19.60	30.5
ADF&G	9/23/94	Wulik R.	M	890	435		1.2	<	0.02	1.73	<	0.02			21.4	31
ADF&G	9/23/94	Wulik R.	F	681	405		1.4	<	0.02	1.48	<	0.02			20.3	30
ADF&G	9/23/94	Wulik R.	F	726	420		2.1	<	0.02	1.7	<	0.02			20.8	27.6
ADF&G	6/14/95	Wulik R.	M	916.25	443	3/3	31.8	<	0.02	1.82		0.03			21.3	25.2
ADF&G	6/14/95	Wulik R.	F	1007	454	3/3	12.8	<	0.02	1.49	<	0.02			16.4	25.2
ADF&G	6/14/95	Wulik R.	M	762.03	419	3/2	2.2	<	0.02	1.9	<	0.02			20.5	25.2
ADF&G	6/14/95	Wulik R.	F	907.18	455	3/3	2.2	<	0.02	1.21	<	0.02			14.6	24.5
ADF&G	6/14/95	Wulik R.	F	925.32	462	3/3	2.4	<	0.02	1.76	<	0.02			19.5	25.2
ADF&G	6/14/95	Wulik R.	F	916.25	448	3/3	3.3	<	0.02	1.44	<	0.02			17.4	27.7
ADF&G	9/9/95	Wulik R.	F	816.46	434	3/3	5.9	<	0.04	2.43	<	0.56			264	8.6
ADF&G	9/9/95	Wulik R.	M	1170.3	482	3/3	4.2	<	0.02	1.66	<	0.42			160	10.8
ADF&G	9/9/95	Wulik R.	F	1451.5	475	4/3	1.8	<	0.02	1.23		0.18			88.5	12.3
ADF&G	9/9/95	Wulik R.	M	1097.7	457	2/3	2.2	<	0.02	1.52		0.16			67.1	11.4
ADF&G	9/9/95	Wulik R.	F	1977.7	530	2/3	2.3	<	0.02	1.34		0.19			64.7	12.5
ADF&G	9/9/95	Wulik R.	U	1778.1	555	7	1.3	<	0.02	0.97		0.06			28.5	15.8
ADF&G	6/16/96	Wulik R.	F	699.2	424	4/3	3.9		0.02	3.05		0.06			14.8	24
ADF&G	6/16/96	Wulik R.	F	808.1	450	2/3	2.4		0.04	1.99		0.03			21.3	
ADF&G	6/16/96	Wulik R.	M	799	432	2/4	2	<	0.02	1.3		0.03			22.8	27.6
ADF&G	6/16/96	Wulik R.	M	962.5	468	2/4	3.4	<	0.02	1.44	<	0.02			19.7	26.2
ADF&G	6/16/96	Wulik R.	F	1416	505	3/5	2.1	<	0.02	0.99		0.02			12.5	27.4
ADF&G	9/19/96	Wulik R.	F	826.3	430	4+3	4.1	<	0.02	1.49		0.07			13.9	26.0
ADF&G	9/19/96	Wulik R.	F	1044	455	5	2.2	<	0.02	1.08	<	0.02			12.1	30.0
ADF&G	9/19/96	Wulik R.	F	1471	475	2+5	2.4		0.02	1.26	<	0.02			17.9	31.7
ADF&G	9/19/96	Wulik R.	F	1416	485	2+4	2.4	<	0.02	1.7	<	0.02			15.4	32.1
ADF&G	9/19/96	Wulik R.	F	1734	520	2+4	2.9	<	0.02	0.88	<	0.02			12.2	41.6
ADF&G	9/19/96	Wulik R.	F	1571	525	2+5	2.8	<	0.02	1.55		0.03			13.6	21.3
ADF&G	9/19/96	Wulik R.	duplicate fish of #5				1.8	<	0.02	1.45	<	0.02			14.3	32.6

Appendix 5, concluded.

			Muscle Tissue														
Collector	Date	Location	Sex	Weight	Length	age											
				grams	mm	(fresh	Al		Cd		Cu		Pb		Se	Zn	%
						salt)	mg/kg		mg/kg		mg/kg		mg/kg		mg/kg	mg/kg	Solids
ADF&G	5/22/97	Wulik R.	F	1207	499		2.7	<	0.02		1.43		0.08	<	1	14.3	27.5
ADF&G	5/22/97	Wulik R.	F	1061	478		5.1	<	0.02		1.44		0.02	<	1	14.2	28.6
ADF&G	5/22/97	Wulik R.	F	1279	488		7.7	<	0.02		1.36		0.04	<	1	12.6	25.1
ADF&G	5/22/97	Wulik R.	M	1325	485		3.7	<	0.02		1.16		0.04	<	1	11.5	27.4
ADF&G	5/22/97	Wulik R.	M	1488	531		1.4	<	0.02		1.41	<	0.02	<	1	10.7	28.1
ADF&G	5/22/97	Wulik R.	F	772	450		1.2	<	0.02		1.87	<	0.02	<	1	15.8	24.8
ADF&G	9/27/97	Wulik R.	F	572	383	4	3.6	<	0.02		1.21		0.03		0.9	12	34.2
ADF&G	9/27/97	Wulik R.	M	535.7	392	3/3	3.3	<	0.02		1.36		0.15		1.6	12.9	25.4
ADF&G	9/27/97	Wulik R.	M	572	397	2/2	4.5	<	0.02		2.38		0.04		0.9	16.5	26.8
ADF&G	9/27/97	Wulik R.	F	263.3	299	2/1	2.7	<	0.02		2.32	<	0.02		1.1	18.9	26.2
ADF&G	9/27/97	Wulik R.	F	1653	555	3/6	3.2	<	0.02		1.25		0.02		1.2	9.7	30.6
ADF&G	9/27/97	Wulik R.	M	1507	520	3/5	3.8	<	0.02		1.03	<	0.02		0.9	12.1	36
ADF&G	9/27/97	Wulik R.	Duplicate of #6				3	<	0.02		1.67	<	0.02		0.9	12.1	28.7

Appendix 6

Dolly Varden collected in Evaingiknuk Creek using minnow traps baited with salmon roe, 1990-1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
7/27-28/90	5	30	38	58-153(99)	7.6±7.2
8/23-24/90	5	24	23	56-174(101)	4.6±5.9
6/17-18/91	5	24	27	69-129(80)	5.4±8.2
6/18-19/91	5	25	34	66-110(77)	6.8±6.4
6/19-20/91	5	23	25	69-127(77)	5.0±3.6
7/20-21/91	2	24	15	90-107(98)	7.5±10.7
7/21-22/91	2	23	16	83-115(96)	8.0±1.4
8/5-6/91	5	18	34	62-136(97)	6.8±3.5
8/27-28/91	5	20	16	64-135(96)	3.2±2.3
8/28-29/91	5	25	14	59-113(88)	2.8±1.8
8/29-30/91	5	18	20	54-116(93)	4.0±3.4
10/2-3/91	5	24	0		0.0
10/3-4/91	5	24	1	64	0.2±0.4
10/4-5/91	5	26	1	62	0.2±0.4
6/30-7/1/92	10	24	39	64-112(80)	3.9±3.7
7/28-29/92	10	24	63	70-125(90)	6.3±3.2
8/25-26/92	10	24	111	73-143(90)	11.1±9.0
6/29-30/93	10	24	29	70-114(94)	2.9±2.1
8/24-25/93	10	22	26	59-118(93)	2.6±3.1
6/27-28/94	10	24	11	79-110(96)	1.1±0.7
7/25-26/94	10	29	37	78-121(95)	3.7±2.7

Appendix 6, concluded.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
8/30-31/94	10	25	3	94-118(107)	0.3±0.5
6/27-29/95	10	48	28	79-123(97)	2.8±2.3
7/18-20/95	10	48	35	76-129(102)	3.5±3.2
8/12-14/95	10	50	38	54-138(100)	3.8±3.6
6/14-16/96	10	47	7	103-117(108)	0.7±1.9
7/12-13/96	10	27	3	117-127(124)	0.3±0.5
8/9-10/96	10	24	2	92-103(98)	0.2±0.4
6/24-25/97	10	24	7	72-132(100)	0.7±0.9
8/12-13/97	10	27	54	54-136(81)	5.4±4.5

Appendix 7

Dolly Varden collected in Anxiety Ridge Creek using minnow traps baited with salmon roe, 1990-1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
7/27-28/90	5	27.5	7	104-152(133)	1.4±2.1
7/28-29/90	5	23	3	89-128(108)	0.6±0.9
7/29-30/90	5	16.5	9	107-146(132)	1.8±2.0
8/24-25/90	5	17	14	78-166(135)	3.5±1.9
8/25-26/90	5	22	10	75-160(140)	2.0±3.5
9/14-15/90	3	22	1	82	0.3±0.6
5/23-24/91	5	18	0		0.0
6/17-18/91	5	24	2	90,95	0.4±0.6
6/18-19/91	5	25	0		0.0
6/19-20/91	5	22	2	85,137	0.4±0.6
7/20-21/91	5	24	25	99-153(114)	5.0±8.0
7/21-22/91	5	24	18	60-131(100)	3.6±5.9
7/22-23/91	5	13	11	62-155(109)	2.2±3.8
8/5-6/91	5	19	75	88-147(118)	15.0±15.3
8/6-7/91	5	24	79	88-148(118)	15.8±11.3
8/7-8/91	5	20	81	99-147(117)	16.2±10.6
8/27-28/91	5	24	34	71-143(111)	6.8±8.8
8/28-29/91	5	25	3	71-126(90)	0.6±0.9
8/29-30/91	5	17	27	68-135(115)	5.4±4.8
10/2-3/91	4	24	6	108-137(121)	1.5±0.6
10/3-4/91	5	21	7	87-136(123)	1.4±2.6
10/4-5/91	5	26	4	78-133(117)	0.8±0.8

Appendix 7, concluded.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
10/4-5/91	5	26	4	78-133(117)	0.8±0.8
6/30-7/1/92	10	23	11	89-131(113)	1.1±1.7
7/28-29/92	10	24	223	82-144(101)	22.3±13.4
8/25-26/92	10	24	334	60-162(102)	33.4±17.4
6/29-30/93	10	24	55	74-161(109)	5.5±6.8
8/24-25/93	10	22	295	58-159(113)	29.5±8.5
6/27-28/94	10	24	9	72-124(104)	0.9±1.9
7/25-26/94	10	29	22	74-138(108)	2.2±1.6
8/30-31/94	10	25	26	61-146(113)	2.6±3.0
6/27-29/95	10	48	17	76-118(95)	1.7±1.7
7/18-20/95	10	48	27	62-141(96)	2.7±2.9
8/12-14/95	10	51	154	60-135(101)	15.4±9.8
6/14-16/96	10	48	17	65-132(100)	1.7±1.9
7/12-13/96	10	25	12	70-115(93)	1.2±2.1
8/9-10/96	10	24	32	79-133(103)	3.8±2.5
6/24-25/97	10	24	10	80-137(107)	1.0±1.4
8/12-13/97	10	28	68	59-156(118)	6.8±5.5

Appendix 8

Dolly Varden collected in Buddy Creek using minnow traps baited with salmon roe, 1996-1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
6/14-16/96	10	49	0		
7/12-13/96	10	26	18	82-118(100)	1.8±3.1
8/9-10/96	10	24	1	132	0.1±0.3
6/24-25/97	10	24	5	113-137(127)	0.5±0.7
8/12-13/97	10	27	48	57-143(87)	4.8±3.1

Appendix 9

Dolly Varden collected in Middle Fork Red Dog Creek immediately upstream of North Fork Red Dog Creek using minnow traps baited with salmon roe, 1994-1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
6/27-28/94	5	23	0		
7/26-27/94	5	22	0		
8/30-31/94	5	25	0		
6/26-29/95	5	72	0		
7/17-20/95	5	63	0		
8/11-14/95	5	68	0		
6/13-16/96	5	58	0		
7/13-14/96	5	24	0		
8/10-12/96	5	48	0		
6/25-26/97	5	34	0		
8/9-10/97	5	23	0		

Appendix 10

Dolly Varden collected in the North Fork Red Dog Creek using minnow traps baited with salmon roe, 1992-1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
7/27-30/92	5	72	2	124-133(129)	0.4±0.9
8/24-25/92	5	22	1	168	0.2±0.4
6/28-29/93	10	24	0		0.0
8/23-25/93	10	48	31	74-148(113)	3.1±3.1
6/27-28/94	10	23	0		
7/26-27/94	10	22	0		
8/30-31/94	10	25	0		
6/26-29/95	10	72	1	136	0.1±0.3
7/17-20/95	10	64	1	85	0.1±0.3
8/11-14/95	10	67	1	116	0.1±0.3
6/13-16/96	10	62.5	0		
7/13-14/96	10	24	0		
8/10-12/96	10	24	0		
6/25-27/97	10	56	2	89-92	0.2±0.6
8/9-10/97	10	24	0		

Appendix 11.

Dolly Varden collected in Mainstem Red Dog Creek downstream of North Fork Red Dog Creek using minnow traps baited with salmon roe, 1994-1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
6/27-28/94	5	23	0		
7/26-27/94	5	22	0		
8/30-31/94	5	25	0		
6/26-29/95	15	72	5	111-132(120)	0.3±0.8
7/17-20/95	15	63	10	77-114(88)	0.7±1.3
8/11-14/95	15	68	7	85-144(107)	0.3±0.7
6/13-16/96	15	58	0		
7/13-14/96	15	24	4	117-137(123)	0.3±0.8
8/10-12/96	15	48	2	111-137(124)	0.1±0.4
6/25-26/97	15	34	13	87-128(103)	0.9±2.1
8/9-10/97	15	23	19	70-143(122)	1.3±1.5

Appendix 12.

Dolly Varden collected in the lower Mainstem Red Dog Creek (immediately upstream of confluence with Ikalukrok Creek) using minnow traps baited with salmon roe, 1996-1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
6/19-20/96	10	29	0		
7/15-17/96	10	46.5	0		
6/26-27/97	10	22	1	120	0.1±0.3
8/10-11/97	10	25	10	78-152(119)	1.0±2.5

Appendix 13.

Dolly Varden collected in Ikalukrok Creek using minnow traps baited with salmon roe, 1990-1997. Minnow trap sample sites included Ikalukrok Creek from upstream of the mouth of Red Dog Creek to the lower portion of Ikalukrok Creek about 20 km downstream of the mouth of Dudd Creek. Sample stations (#1 - #5) in Ikalukrok Creek at Dudd Creek were the same with five additional sites established and run in 1992, 1993, 1994, 1995, 1996, and 1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
[a]7/27-28/90	5	19	0		0.0
[b]7/27-28/90	5	23	1	107	0.2±0.4
[c]7/28-29/90	5	23	0		0.0
[d]7/28-29/90	5	22	0		0.0
[d]8/23-24/90	5	24	0		0.0
[e]8/23-24/90	5	24	0		0.0
[e]8/24-26/90	5	48	0		0.0
[f]8/24-29/90	5	120	0		0.0
[d]9/12-13/90	4	24	0		0.0
[d]9/13-14/90	4	20	0		0.0
[d]9/14-15/90	4	23	0		0.0
[f]9/13-14/90	5	24	0		0.0
[f]9/14-15/90	4	25	0		0.0
[e]9/13-14/90	5	22	0		0.0
[e]9/14-15/90	5	23	0		0.0

Appendix 13, continued.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
[e]7/17-18/91	5	23	6	53-61(57)	1.2±1.1
[e]7/18-19/91	5	23	4	52-109(72)	0.8±0.8
[e]7/19-20/91	5	21	9	82-140(112)	1.8±1.9
[e]8/5-8/91	5	65	10	60-105(66)	2.0±2.5
[e]8/27-30/91	5	65	0		0.0
[e]10/2-5/91	5	73	0		0.0
[g]6/30-7/1/92	10	24	0		
[g]7/28-29/92	10	24	6	56-104(76)	0.6±1.3
[g]8/25-26/92	10	24	58	60-155(102)	5.8±5.8
[g]6/29-30/93	10	24	8	76-93(83)	0.8±1.0
[g]8/24-25/93	10	22	38	62-137(82)	3.8±3.8
[g]7/27-28/94	10	20	12	56-97(81)	1.2±2.3
[g]6/27-28/95	10	24	0		
[g]7/18-19/95	10	21	8	68-114(88)	0.8±1.3
[g]8/12-13/95	10	21	21	63-135(107)	2.1±3.5
[g]6/17-18/96	10	24	0		
[g]7/17-18/96	10	27	0		

Appendix 13, concluded.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
[g]6/26-27/97	10	23	1	79	0.1±0.3
[g]8/10-11/97	10	24	9	58-130(88)	0.9±1.6

[a]Ikalukrok Creek - 7 km upstream of Dudd Creek
[b]Ikalukrok Creek - 10 km downstream of Dudd Creek
[c]Ikalukrok Creek - 10 km downstream of Dudd Creek, clear back-water
[d]Ikalukrok Creek - 20 km downstream of Dudd Creek
[e]Ikalukrok Creek - Immediately upstream of Dudd Creek
[f]Ikalukrok Creek - Immediately upstream of Red Dog Creek
[g]Ikalukrok Creek - Immediately upstream and downstream of Dudd Creek

Appendix 14.

Dolly Varden collected in Ikalukrok Creek using minnow traps baited with salmon roe using 20 traps, 1994-1997. Sample stations (#1 - #10) in Ikalukrok Creek at Dudd Creek were the same with 10 sites added in 1994.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
7/27-28/94	20	20	20	53-97(80)	1.0±2.0
6/27-28/95	20	24	3	46-99(75)	0.15±0.5
7/18-19/95	20	21	16	68-114(83)	0.8±1.2
8/12-13/95	20	21	28	64-135(106)	1.4±2.5
6/17-18/96	20	24	0		
7/17-18/96	20	24	1	93	
6/26-27/97	20	23	4	79-113(95)	0.2±0.4
8/10-11/97	20	24	16	58-137(100)	0.8±1.3

Appendix 15.

Dolly Varden collected in Ikalukrok Creek, immediately downstream of Mainstem Red Dog Creek, using minnow traps baited with salmon roe, 1996-1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
6/19-20/96	10	27.5	0		
7/15-17/96	10	47	1	113	0.1±0.3
6/26-27/97	10	23	3	81-109(91)	0.3±0.9
8/10-11/97	10	25	4	59-123(80)	0.4±1.0

Appendix 16.

Dolly Varden collected in Ikalukrok Creek, immediately upstream of Mainstem Red Dog Creek, using minnow traps baited with salmon roe, 1996-1997.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
6/19-20/96	10	26	0		
7/15-17/96	10	46	0		
6/26-27/97	10	23	0		
8/10-11/97	10	25	3	77-145(103)	0.3±0.9

Appendix 17.

Arctic grayling collected, tagged, released, and recaptured in North Fork Red Dog, Mainstem Red Dog, Anxiety Ridge, Buddy, and Ikalukrok Creeks (1994 - 1997).

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
		130	6/29/93	North Fork			
		140	6/29/93	North Fork			
		152	6/29/93	North Fork			
		152	6/29/93	North Fork			
		159	6/29/93	North Fork			
		162	6/29/93	North Fork			
		180	6/29/93	North Fork			
		186	6/29/93	North Fork			
		188	6/29/93	North Fork			
		194	6/29/93	North Fork			
		195	6/29/93	North Fork			
		197	6/29/93	North Fork			
		204	6/29/93	North Fork			
		205	6/29/93	North Fork			
		214	6/29/93	North Fork			
		215	6/29/93	North Fork			
		218	6/29/93	North Fork			
		218	6/29/93	North Fork			
		222	6/29/93	North Fork			
		228	6/29/93	North Fork			
		255	6/29/93	North Fork			
		264	6/29/93	North Fork			
		265	6/29/93	North Fork			
		405	6/29/93	North Fork			
		410	6/29/93	North Fork			
3401	Y	248	6/28/94	North Fork			
3402	Y	270	6/28/94	North Fork			
3403	Y	281	6/28/94	North Fork			
3404	Y	268	6/28/94	North Fork			
3405	Y	248	6/28/94	North Fork			
3406	Y	245	6/28/94	North Fork			
3407	Y	263	6/28/94	North Fork			
3408	Y	270	6/28/94	North Fork			
3409	Y	248	6/28/94	North Fork			
3411	Y	210	6/28/94	North Fork	7/17/95	North Fork	278
3413	Y	270	6/28/94	North Fork			
3414	Y	295	6/28/94	North Fork			
3415	Y	280	6/28/94	North Fork			
3416	Y	325	6/28/94	North Fork			
3417	Y	238	6/28/94	North Fork	6/26/95	North Fork	290

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
3418	Y	257	6/28/94	North Fork			
3419	Y	270	6/28/94	North Fork	7/17/95	North Fork	314
3420	Y	275	6/28/94	North Fork			
3421	Y	316	6/28/94	North Fork			
3422	Y	260	6/28/94	North Fork			
3423	Y	230	6/28/94	North Fork			
3424	Y	241	6/28/94	North Fork			
3425	Y	258	6/28/94	North Fork			
3426	Y	205	6/27/94	North Fork	6/26/95	North Fork	265
					6/27/97	North Fork	336
3427	Y	227	6/27/94	North Fork			
3428	Y	205	6/27/94	North Fork			
3429	Y	194	6/27/94	North Fork			
3430	Y	245	6/27/94	North Fork			
3431	Y	200	6/27/94	North Fork			
3432	Y	243	6/27/94	North Fork			
3433	Y	238	6/27/94	North Fork			
3434	Y	207	6/27/94	North Fork			
3435	Y	221	6/27/94	North Fork			
3436	Y	265	6/28/94	North Fork			
3437	Y	295	6/28/94	North Fork			
3438	Y	320	6/28/94	North Fork			
3439	Y	295	6/28/94	North Fork			
3440	Y	260	6/28/94	North Fork			
3441	Y	262	6/28/94	North Fork			
3442	Y	273	6/28/94	North Fork			
3443	Y	240	6/28/94	North Fork			
3444	Y	247	6/28/94	North Fork			
3445	Y	271	6/28/94	North Fork			
3446	Y	268	6/28/94	North Fork			
3447	Y	255	6/28/94	North Fork			
3448	Y	317	6/28/94	North Fork			
3449	Y	235	6/28/94	North Fork	6/29/95	North Fork	288
3450	Y	260	6/28/94	North Fork			
3101	Y	238	7/26/94	North Fork			
3102	Y	228	7/26/94	North Fork			
3103	Y	215	7/26/94	North Fork			
3104	Y	204	7/26/94	North Fork			
3105	Y	254	7/26/94	North Fork			
3106	Y	268	7/26/94	North Fork			

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
3107	Y	255	7/26/94	North Fork	8/14/95	Mainstem	302
3108	Y	183	7/26/94	North Fork			
3109	Y	255	7/26/94	North Fork			
3110	Y	222	7/26/94	North Fork	7/17/95	North Fork	265
3111	Y	220	7/26/94	North Fork			
3112	Y	213	7/26/94	North Fork			
3113	Y	190	7/26/94	North Fork			
3114	Y	200	7/26/94	North Fork	7/20/95	North Fork	236
3115	Y	198	7/26/94	North Fork			
3116	Y	255	7/26/94	North Fork			
3117	Y	210	7/26/94	North Fork			
3118	Y	198	7/26/94	North Fork			
3119	Y	209	7/26/94	North Fork	7/14/96	North Fork	285
3120	Y	214	7/26/94	North Fork			
3121	Y	218	7/26/94	North Fork			
3122	Y	211	7/26/94	North Fork	6/29/95	North Fork	248
					8/15/95	North Fork	266
3123	Y	196	7/26/94	North Fork			
3124	Y	200	7/26/94	North Fork	6/29/95	North Fork	237
3125	Y	206	7/26/94	North Fork			
3126	Y	205	7/26/94	North Fork			
3127	Y	200	7/26/94	North Fork			
3128	Y	256	7/26/94	North Fork			
3129	Y	207	7/26/94	North Fork			
3130	Y	217	7/27/94	North Fork			
3131	Y	190	7/27/94	North Fork			
3132	Y	220	7/27/94	North Fork			
3133	Y	210	7/27/94	North Fork			
3134	Y	200	7/27/94	North Fork			
3135	Y	212	7/27/94	North Fork			
3136	Y	214	7/27/94	North Fork			
3137	Y	203	7/27/94	North Fork	8/15/95	North Fork	272
3138	Y	260	7/27/94	North Fork			
3139	Y	210	7/27/94	North Fork			
3140	Y	227	7/27/94	North Fork			
3141	Y	201	7/27/94	North Fork			
3142	Y	248	7/27/94	North Fork			
3143	Y	269	7/27/94	North Fork			
3144	Y	218	7/27/94	North Fork			
3145	Y	217	7/27/94	North Fork			
3146	Y	211	7/27/94	North Fork			

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
3147	Y	158	7/27/94	North Fork			
3148	Y	215	7/27/94	North Fork			
3149	Y	196	7/27/94	North Fork			
3150	Y	225	7/27/94	North Fork			
		225	7/27/94	North Fork			
		183	7/27/94	North Fork			
		196	7/27/94	North Fork			
		210	7/27/94	North Fork			
1501	W	390	6/26/95	North Fork			
1502	W	315	6/26/95	North Fork			
1503	W	265	6/26/95	North Fork	7/17/95	North Fork	279
1504	W	254	6/26/95	North Fork	7/17/95	North Fork	265
1505	W	240	6/26/95	North Fork			
1506	W	237	6/26/95	North Fork			
1507	W	320	6/26/95	North Fork	7/17/95	North Fork	324
					8/11/95	North Fork	332
1508	W	281	6/26/95	North Fork			
1509	W	229	6/26/95	North Fork	7/17/95	North Fork	237
1510	W	262	6/26/95	North Fork			
1511	W	323	6/26/95	North Fork			
1512	W	297	6/26/95	North Fork	7/20/95	North Fork	309
1513	W	220	6/26/95	North Fork			
1514	W	259	6/26/95	North Fork			
1515	W	278	6/26/95	North Fork			
1516	W	283	6/26/95	North Fork	7/20/95	North Fork	291
1517	W	237	6/26/95	North Fork	7/17/95	North Fork	245
1518	W	240	6/26/95	North Fork			
1519	W	218	6/26/95	North Fork			
1520	W	223	6/26/95	North Fork			
1527	W	395	6/29/95	North Fork			
1528	W	266	6/29/95	North Fork			
1529	W	274	6/29/95	North Fork	7/20/95	North Fork	281
1530	W	254	6/29/95	North Fork	7/20/95	North Fork	261
1531	W	241	6/29/95	North Fork			
1532	W	251	6/29/95	North Fork			
1533	W	232	6/29/95	North Fork			
1534	W	291	6/29/95	North Fork			
1535	W	240	6/29/95	North Fork			
1536	W	236	6/29/95	North Fork			
1537	W	230	6/29/95	North Fork	6/27/97	North Fork	310

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1538	W	242	6/29/95	North Fork	6/27/97	North Fork	310
1539	W	270	6/29/95	North Fork	8/14/95	Mainstem	290
1540	W	304	6/29/95	North Fork			
1541	W	289	6/29/95	North Fork	7/17/95	North Fork	298
1542	W	273	6/29/95	North Fork			
1543	W	263	6/29/95	North Fork			
1544	W	228	6/29/95	North Fork	7/20/95	North Fork	240
1545	W	228	6/29/95	North Fork			
1546	W	227	6/29/95	North Fork			
1547	W	254	6/29/95	North Fork			
1548	W	236	6/29/95	North Fork			
1549	W	256	6/29/95	North Fork	7/17/95	North Fork	268
1550	W	270	6/29/95	North Fork	7/20/95	North Fork	276
1551	W	253	6/29/95	North Fork			
1552	W	270	6/29/95	North Fork			
1553	W	249	6/29/95	North Fork			
1554	W	315	6/29/95	North Fork			
1555	W	264	6/29/95	North Fork	7/20/95	North Fork	278
1556	W	233	6/29/95	North Fork			
1557	W	280	6/29/95	North Fork			
1558	W	261	6/29/95	North Fork			
1559	W	251	6/29/95	North Fork			
1560	W	235	6/29/95	North Fork			
1561	W	232	6/29/95	North Fork			
1562	W	234	6/29/95	North Fork	7/17/95	North Fork	244
1563	W	275	6/29/95	North Fork			
1564	W	228	6/29/95	North Fork			
1565	W	243	6/29/95	North Fork	8/15/95	North Fork	271
1566	W	296	6/29/95	North Fork			
1567	W	244	6/29/95	North Fork	7/20/95	North Fork	255
1568	W	255	6/29/95	North Fork			
1569	W	234	6/29/95	North Fork			
1570	W	232	6/29/95	North Fork			
1571	W	211	6/29/95	North Fork			
1572	W	225	6/29/95	North Fork			
1573	W	241	6/29/95	North Fork	7/20/95	North Fork	257
					8/14/95	North Fork	275
1574	W	226	6/29/95	North Fork			
1575	W	255	6/29/95	North Fork			
1576	W	234	6/29/95	North Fork			
1577	W	253	6/29/95	North Fork			

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1578	W	293	6/29/95	North Fork			
1579	W	228	6/29/95	North Fork	8/11/95	North Fork	257
1580	W	240	6/29/95	North Fork			
1581	W	253	6/29/95	North Fork	7/17/95	North Fork	266
1582	W	222	6/29/95	North Fork			
1583	W	224	6/29/95	North Fork			
1584	W	226	6/29/95	North Fork			
1585	W	235	6/29/95	North Fork			
1586	W	228	6/29/95	North Fork	7/20/95	North Fork	243
1587	W	180	6/29/95	North Fork			
1588	W	227	6/29/95	North Fork	8/15/95	North Fork	250
1589	W	322	6/29/95	North Fork			
1590	W	276	6/29/95	North Fork	7/20/95	North Fork	280
1591	W	252	6/29/95	North Fork	6/27/97	North Fork	318
1592	W	235	6/29/95	North Fork	7/20/95	North Fork	248
1593	W	232	6/29/95	North Fork			
1594	W	237	6/29/95	North Fork			
1595	W	228	6/29/95	North Fork			
1596	W	383	6/29/95	North Fork			
3122	Y	248	6/29/95	North Fork			
3124	Y	237	6/29/95	North Fork			
3417	Y	290	6/26/95	North Fork			
3426	Y	265	6/26/95	North Fork			
3449	Y	288	6/29/95	North Fork			
1521	W	298	6/28/95	Anxiety			
1522	W	298	6/28/95	Anxiety			
1523	W	267	6/28/95	Anxiety			
1524	W	306	6/28/95	Anxiety			
1525	W	251	6/28/95	Anxiety			
1503	W	279	7/17/95	North Fork			
1504	W	265	7/17/95	North Fork			
1507	W	324	7/17/95	North Fork			
1509	W	237	7/17/95	North Fork			
1516	W	291	7/20/95	North Fork			
1517	W	245	7/17/95	North Fork			
1529	W	281	7/20/95	North Fork			
1530	W	261	7/20/95	North Fork			
1541	W	298	7/17/95	North Fork			
1544	W	240	7/20/95	North Fork			

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1549	W	268	7/17/95	North Fork			
1550	W	276	7/20/95	North Fork			
1555	W	278	7/20/95	North Fork			
1562	W	244	7/17/95	North Fork			
1567	W	255	7/20/95	North Fork			
1573	W	257	7/20/95	North Fork			
1581	W	266	7/17/95	North Fork			
1586	W	243	7/20/95	North Fork			
1590	W	280	7/20/95	North Fork			
1592	W	248	7/20/95	North Fork			
1599	W	377	7/17/95	North Fork	8/11/95	North Fork	383
1600	W	238	7/17/95	North Fork			
1701	W	249	7/17/95	North Fork			
1702	W	264	7/17/95	North Fork	8/14/95	North Fork	280
1703	W	240	7/17/95	North Fork			
1704	W	256	7/17/95	North Fork	8/14/95	North Fork	269
1705	W	250	7/20/95	North Fork			
1706	W	241	7/17/95	North Fork			
1707	W	233	7/17/95	North Fork			
1708	W	348	7/17/95	North Fork			
1709	W	297	7/17/95	North Fork			
1710	W	296	7/17/95	North Fork	6/24/97	North Fork	358
1711	W	222	7/17/95	North Fork			
1712	W	171	7/17/95	North Fork			
1713	W	262	7/17/95	North Fork			
1714	W	235	7/17/95	North Fork			
1715	W	253	7/17/95	North Fork			
1716	W	241	7/17/95	North Fork			
1717	W	234	7/17/95	North Fork			
1719	W	290	7/20/95	North Fork			
1720	W	269	7/20/95	North Fork			
1721	W	284	7/20/95	North Fork			
1722	W	236	7/20/95	North Fork			
1723	W	251	7/20/95	North Fork			
1724	W	254	7/20/95	North Fork			
1726	W	248	7/20/95	North Fork			
1727	W	247	7/20/95	North Fork			
1728	W	265	7/20/95	North Fork			
1729	W	267	7/20/95	North Fork			
1730	W	294	7/20/95	North Fork			
1731	W	244	7/20/95	North Fork			

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1732	W	240	7/20/95	North Fork			
1733	W	247	7/20/95	North Fork			
1734	W	262	7/20/95	North Fork			
1735	W	262	7/20/95	North Fork			
1736	W	241	7/20/95	North Fork			
1737	W	235	7/20/95	North Fork			
1738	W	295	7/20/95	North Fork			
1739	W	252	7/20/95	North Fork			
1740	W	241	7/20/95	North Fork			
1741	W	267	7/20/95	North Fork	8/14/95	North Fork	282
1742	W	234	7/20/95	North Fork			
1743	W	235	7/20/95	North Fork			
1744	W	216	7/20/95	North Fork	8/15/95	North Fork	233
1745	W	238	7/20/95	North Fork	7/13/96	North Fork	272
1746	W	280	7/20/95	North Fork			
1747	W	295	7/20/95	North Fork			
1748	W	242	7/20/95	North Fork			
1749	W	225	7/20/95	North Fork	8/14/95	North Fork	246
1750	W	255	7/20/95	North Fork			
1751	W	231	7/20/95	North Fork			
1752	W	242	7/20/95	North Fork	8/14/95	North Fork	258
1753	W	366	7/20/95	North Fork			
1754	W	291	7/20/95	North Fork			
1755	W	257	7/20/95	North Fork			
1756	W	238	7/20/95	North Fork	8/15/95	North Fork	260
1757	W	225	7/20/95	North Fork			
1758	W	247	7/20/95	North Fork	7/13/96	North Fork	292
					6/27/97	North Fork	306
1759	W	261	7/20/95	North Fork			
1760	W	267	7/20/95	North Fork			
1761	W	272	7/20/95	North Fork			
1762	W	277	7/20/95	North Fork			
1763	W	373	7/20/95	North Fork			
1764	W	301	7/20/95	North Fork			
1765	W	253	7/20/95	North Fork			
1766	W	246	7/20/95	North Fork	8/14/95	North Fork	262
1767	W	240	7/20/95	North Fork			
1768	W	294	7/20/95	North Fork			
1769	W	259	7/20/95	North Fork			
1770	W	280	7/20/95	North Fork			
1771	W	302	7/20/95	North Fork	8/11/95	North Fork	307

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1772	W	282	7/20/95	North Fork			
1773	W	321	7/20/95	North Fork			
1774	W	240	7/20/95	North Fork			
1775	W	231	7/20/95	North Fork			
1776	W	240	7/20/95	North Fork			
3110	Y	265	7/17/95	North Fork			
3114	Y	236	7/20/95	North Fork			
3411	Y	278	7/17/95	North Fork			
3419	Y	314	7/17/95	North Fork			
1718	W	258	7/20/95	North Fork	7/13/96	North Fork	305
1507	W	332	8/11/95	North Fork			
1565	W	271	8/15/95	North Fork			
1573	W	275	8/14/95	North Fork			
1579	W	257	8/11/95	North Fork			
1588	W	250	8/15/95	North Fork			
1599	W	383	8/11/95	North Fork	6/27/97	North Fork	385
1702	W	280	8/14/95	North Fork			
1704	W	269	8/14/95	North Fork			
1741	W	282	8/14/95	North Fork			
1744	W	233	8/15/95	North Fork			
1749	W	246	8/14/95	North Fork			
1752	W	258	8/14/95	North Fork			
1756	W	260	8/15/95	North Fork			
1766	W	262	8/14/95	North Fork			
1771	W	307	8/11/95	North Fork			
1777	W	300	8/11/95	North Fork			
1778	W	275	8/11/95	North Fork			
1779	W	250	8/11/95	North Fork			
1781	W	286	8/11/95	North Fork			
1782	W	293	8/11/95	North Fork			
1783	W	336	8/11/95	North Fork			
1784	W	233	8/11/95	North Fork			
1785	W	246	8/11/95	North Fork			
1786	W	246	8/11/95	North Fork			
1787	W	318	8/11/95	North Fork			
1788	W	278	8/11/95	North Fork			
1789	W	275	8/11/95	North Fork			
1790	W	210	8/11/95	North Fork			
1791	W	270	8/11/95	North Fork			

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1792	W	237	8/11/95	North Fork			
1793	W	271	8/11/95	North Fork			
1794	W	269	8/11/95	North Fork			
1807	W	274	8/14/95	North Fork			
1808	W	241	8/14/95	North Fork			
1809	W	261	8/14/95	North Fork			
1810	W	274	8/14/95	North Fork			
1811	W	292	8/14/95	North Fork			
1812	W	252	8/14/95	North Fork			
1813	W	264	8/14/95	North Fork			
1814	W	265	8/14/95	North Fork			
1815	W	242	8/14/95	North Fork			
1816	W	255	8/14/95	North Fork			
1817	W	265	8/14/95	North Fork			
1818	W	260	8/14/95	North Fork	7/13/96	North Fork	277
1819	W	261	8/14/95	North Fork			
1820	W	237	8/14/95	North Fork			
1821	W	236	8/14/95	North Fork			
1822	W	152	8/14/95	North Fork			
1826	W	237	8/14/95	North Fork			
1827	W	236	8/14/95	North Fork			
1828	W	263	8/14/95	North Fork			
1829	W	253	8/14/95	North Fork			
1830	W	149	8/14/95	North Fork			
1831	W	154	8/14/95	North Fork			
1833	W	282	8/14/95	North Fork			
1834	W	249	8/14/95	North Fork			
1835	W	243	8/14/95	North Fork			
1836	W	314	8/14/95	North Fork			
1837	W	300	8/14/95	North Fork			
1838	W	256	8/14/95	North Fork			
1839	W	260	8/14/95	North Fork			
1840	W	300	8/14/95	North Fork			
1841	W	268	8/14/95	North Fork			
1842	W	258	8/14/95	North Fork			
1843	W	286	8/14/95	North Fork			
1844	W	262	8/14/95	North Fork			
1845	W	236	8/15/95	North Fork			
1846	W	147	8/15/95	North Fork			
1847	W	293	8/15/95	North Fork			
1848	W	291	8/15/95	North Fork			

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1849	W	234	8/15/95	North Fork			
1850	W	277	8/15/95	North Fork			
1851	W	318	8/15/95	North Fork			
1852	W	260	8/15/95	North Fork			
1853	W	260	8/15/95	North Fork			
1854	W	292	8/15/95	North Fork			
1855	W	272	8/15/95	North Fork			
1856	W	280	8/15/95	North Fork			
1857	W	280	8/15/95	North Fork			
1858	W	259	8/15/95	North Fork			
1859	W	325	8/15/95	North Fork			
1860	W	255	8/15/95	North Fork			
1861	W	301	8/15/95	North Fork			
1862	W	262	8/15/95	North Fork			
1863	W	264	8/15/95	North Fork			
1864	W	274	8/15/95	North Fork			
1865	W	278	8/15/95	North Fork			
1866	W	261	8/15/95	North Fork			
1867	W	275	8/15/95	North Fork			
1868	W	280	8/15/95	North Fork			
1869	W	280	8/15/95	North Fork			
1870	W	264	8/15/95	North Fork			
1871	W	260	8/15/95	North Fork			
1872	W	193	8/15/95	North Fork			
1873	W	205	8/15/95	North Fork			
1874	W	240	8/15/95	North Fork	7/14/96	North Fork	263
1875	W	254	8/15/95	North Fork			
1876	W	277	8/15/95	North Fork			
1877	W	303	8/15/95	North Fork			
1878	W	310	8/15/95	North Fork			
1879	W	262	8/15/95	North Fork			
1880	W	276	8/15/95	North Fork			
1881	W	269	8/15/95	North Fork			
1882	W	284	8/15/95	North Fork			
1883	W	242	8/15/95	North Fork			
3122	Y	266	8/15/95	North Fork			
3137	Y	272	8/15/95	North Fork			
1795	W	373	8/12/95	Ikalukrok	7/12/96	Buddy	380
1796	W	356	8/12/95	Ikalukrok			
1797	W	318	8/12/95	Ikalukrok			

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1798	W	337	8/12/95	Ikalukrok			
1539	W	290	8/14/95	Main Stem			
1783	W	335	8/14/95	Main Stem			
1799	W	335	8/14/95	Main Stem			
1800	W	330	8/14/95	Main Stem			
1801	W	340	8/14/95	Main Stem			
1802	W	290	8/14/95	Main Stem			
1803	W	327	8/14/95	Main Stem			
1804	W	319	8/14/95	Main Stem			
1805	W	336	8/14/95	Main Stem			
1806	W	300	8/14/95	Main Stem			
3107	Y	302	8/14/95	Main Stem			
10500	OR	387	6/17/96	Ikalukrok (Dudd)			
10501	OR	376	6/17/96	Ikalukrok (Dudd)			
10502	OR	415	6/17/96	Ikalukrok (Dudd)			
10503	OR	409	6/17/96	Ikalukrok (Dudd)	6/26/97	Ikalukrok (Dudd)	413
10504	OR	374	6/17/96	Ikalukrok (Dudd)			
10505	OR	380	6/17/96	Ikalukrok (Dudd)			
10506	OR	427	6/17/96	Ikalukrok (Dudd)			
10507	OR	424	6/17/96	Ikalukrok (Dudd)			
10508	OR	330	6/21/96	North Fork			
10510	OR	300	7/12/96	Buddy			
10511	OR	285	7/12/96	Buddy			
10512	OR	300	7/12/96	Buddy			
10513	OR	265	7/12/96	Buddy			
10514	OR	269	7/12/96	Buddy			
10515	OR	328	7/12/96	Buddy			
10516	OR	321	7/12/96	Buddy			
10517	OR	430	7/12/96	Buddy			
10518	OR	420	7/12/96	Buddy			
10519	OR	376	7/12/96	Buddy			
10520	OR	318	7/12/96	Buddy			
10521	OR	321	7/12/96	Buddy			
10522	OR	383	7/12/96	Buddy			
10523	OR	320	7/12/96	Buddy			
10524	OR	265	7/12/96	Buddy			
10525	OR	364	7/12/96	Buddy			

Appendix 17, continued.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
10526	OR	336	7/12/96	Buddy			
1795	W	380	7/12/96	Buddy			
10600	OR	324	7/13/96	North Fork			
		209	7/13/96	North Fork			
10601	OR	222	7/13/96	North Fork			
10603	OR	277	7/13/96	North Fork			
1745	W	272	7/13/96	North Fork			
10604	OR	311	7/13/96	North Fork			
1992	W	314	7/13/96	North Fork			
10605	OR	286	7/13/96	North Fork			
10606	OR	268	7/13/96	North Fork			
10607	OR	305	7/13/96	North Fork			
10608	OR	281	7/13/96	North Fork			
1758	W	292	7/13/96	North Fork	6/27/97	North Fork	306
10609	OR	223	7/13/96	North Fork			
10610	OR	248	7/13/96	North Fork			
1818	W	277	7/13/96	North Fork			
10611	OR	268	7/13/96	North Fork			
10612	OR	309	7/13/96	North Fork			
10613	OR	290	7/13/96	North Fork			
10614	OR	293	7/13/96	North Fork			
10615	OR	284	7/13/96	North Fork			
1718	W	305	7/13/96	North Fork			
10616	OR	247	7/13/96	North Fork			
10618	OR	296	7/13/96	North Fork			
10527	OR	412	7/14/96	North Fork	6/24/97	North Fork	398
10528	OR	274	7/14/96	North Fork			
10529	OR	306	7/14/96	North Fork			
10530	OR	293	7/14/96	North Fork			
10531	OR	310	7/14/96	North Fork			
10532	OR	280	7/14/96	North Fork			
10533	OR	271	7/14/96	North Fork			
10534	OR	260	7/14/96	North Fork			
3119	Y	285	7/14/96	North Fork			
10535	OR	222	7/14/96	North Fork	6/24/97	North Fork	251
10536	OR	238	7/14/96	North Fork			
10537	OR	291	7/14/96	North Fork			
1874	W	263	7/14/96	North Fork			
10538	OR	332	7/15/96	Mainstem			

Appendix 17, concluded.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
10539	OR	324	7/15/96	Mainstem			
10540	OR	382	7/15/96	Mainstem			
10541	OR	274	7/15/96	Mainstem			
10542	OR	345	7/15/96	Mainstem			
10543	OR	326	7/15/96	Mainstem			
10548	OR	330	7/15/96	Mainstem			
996	W	410	7/15/96	Ikalukrok (Red)			
10544	W	412	7/15/96	Ikalukrok (Red)			
10545	OR	445	7/15/96	Ikalukrok (Red)			
10546	OR	425	7/15/96	Ikalukrok (Red)			
10547	OR	430	7/15/96	Ikalukrok (Red)			
10549	OR	444	7/15/96	Ikalukrok (Red)			
10619	OR	415	7/18/96	Ikalukrok (Dudd)			
10638	OR	432	7/18/96	Ikalukrok (Dudd)			
10640	OR	423	7/18/96	Ikalukrok (Dudd)			
10641	OR	402	7/18/96	Ikalukrok (Dudd)			
10642	OR	390	7/18/96	Ikalukrok (Dudd)			
10643	OR	450	7/18/96	Ikalukrok (Dudd)			
10644	OR	421	7/18/96	Ikalukrok (Dudd)			
10646	OR	400	7/18/96	Ikalukrok (Dudd)			