FISH MONITORING STUDY, RED DOG MINE IN THE WULIK RIVER DRAINAGE, EMPHASIS ON DOLLY VARDEN (*SALVENIUS MALMA*), 1992 PROGRESS REPORT

By

Alvin G. Ott and Phyllis Weber-Scannell

Technical Report 93-10

Alaska Department of Fish & Game
Habitat and Restortion Division

Alaska Department of Fish and Game

Habitat and Restoration Division
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ACKNOWLEDGEMENTS

We extend our appreciation to Cominco Alaska, Inc. for their logistical and financial support to the fish study in the Wulik River drainage. Mr. Ralph hargrave (President, Cominco Alaska Inc.) and Ms. Charlotte MacCay (Manager, Environmental Affairs, Cominco Alaska Inc.) continued to support our study efforts and Mr. John Martinisko and Mr. Jake Wells assisted with field work.

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INTRODUCTION

The Red Dog Mine operated by Cominco Alaska Inc. is located in northwestern Alaska near the headwaters of Red Dog Creek in the Wulik River drainage (Figure 1). Major facilities include a tailings impoundment, freshwater reservoir, airstrip, mill, living quarters, and a solid waste site (Figure 2). Background information on mine operations, streams, fisheries resources, and water quality conditions in Red Dog and Ikalukrok Creeks, between 1988 and 1991, were summarized by Ott et al. (1992).

The acidic metal-laden surface and subsurface waters emerging from the ore body were a major source of heavy metals contamination to Red Dog Creek in 1989 and 1990. The input of this water to Red Dog Creek was successfully controlled by installation of a clean water/dirty water bypass system in 1991 prior to breakup. Acidic waters from the ore body are collected in an excavated trench located adjacent to the ore body. The contaminated water is contained in a sump then pumped to the tailings impoundment. The clean water channel intercepts surface water low in heavy metals from Red Dog Creek above the ore body and from three tributaries located along the north side of Red Dog Creek. The clean water channel is lined to prevent water loss and was designed and constructed with a bottom elevation higher than the dirty water collection channel. A layer of permeable rock was placed under the clean water ditch to allow subsurface seepage to reach the dirty water ditch from the north side of the valley. The clean water/dirty water bypass system was functional throughout the summers of 1991 and 1992.

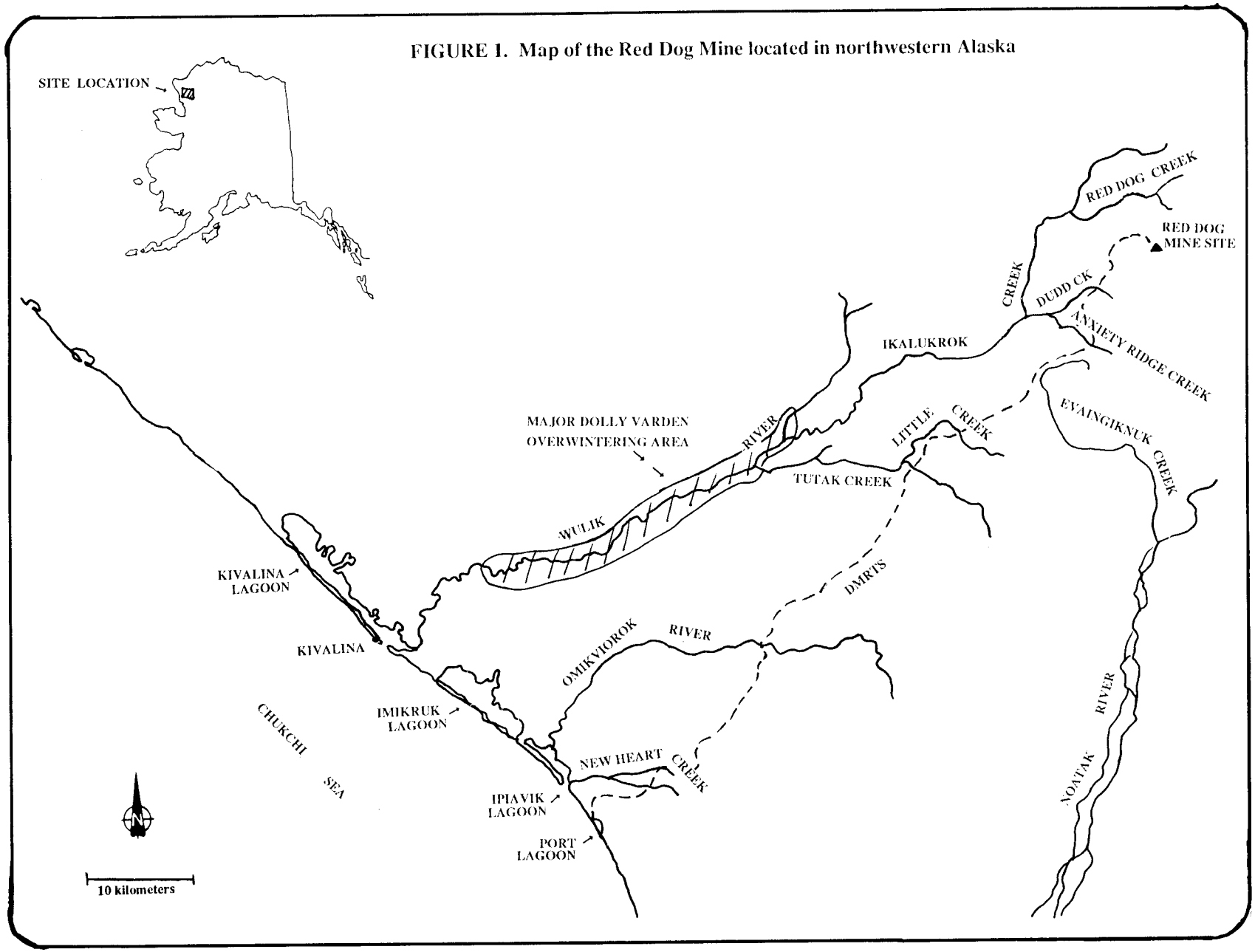
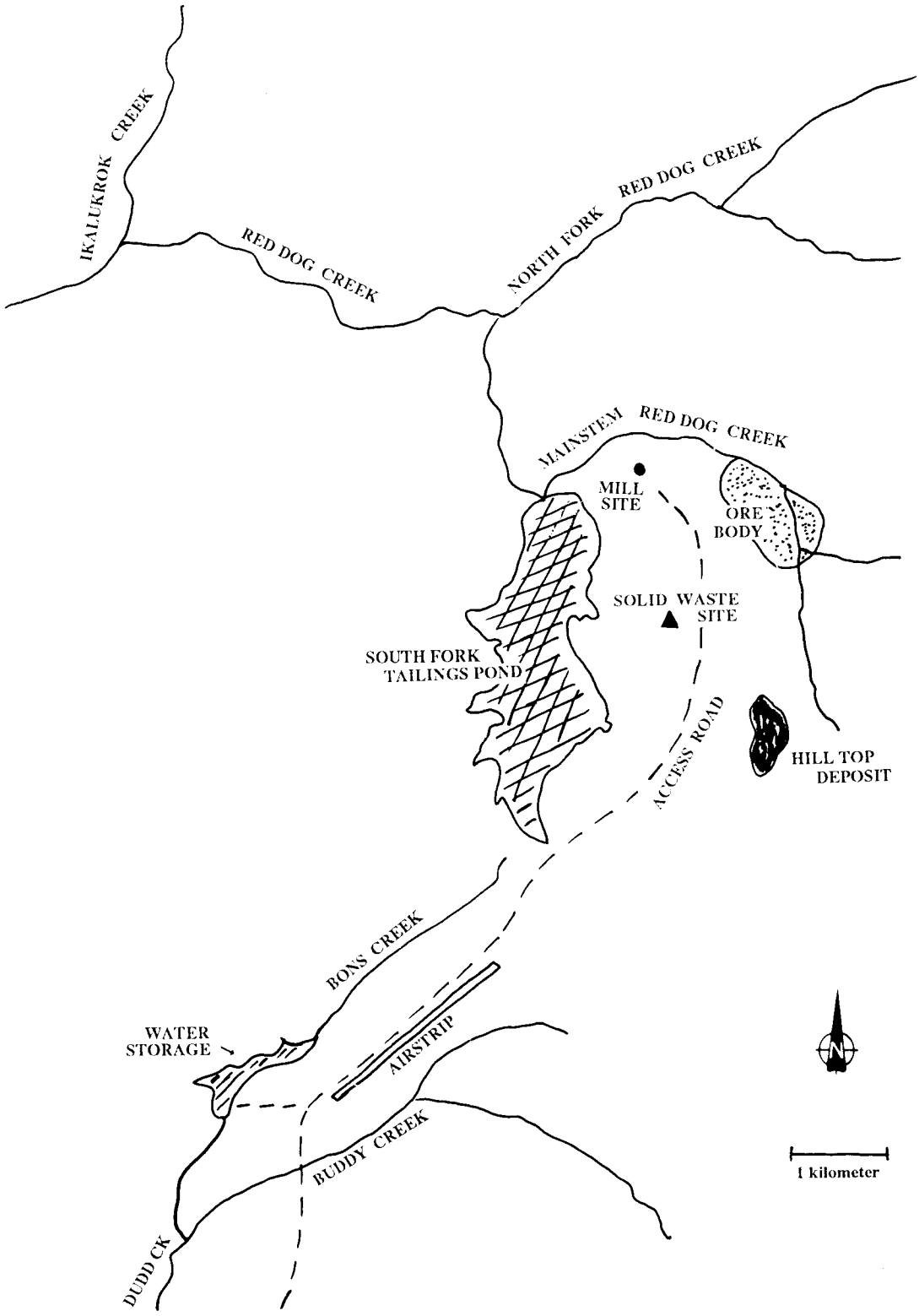


FIGURE 1. Map of the Red Dog Mine located in northwestern Alaska

FIGURE 2. Major facilities, including the mill, airstrip, tailings impoundment, solid waste site, and freshwater impoundment at the Red Dog Mine.



Fisheries investigations of streams directly affected by waters from the mine operation were started in 1990 because of observed degraded water quality conditions in Ikalukrok Creek. Discoloration of receiving waters was documented fall 1989 and during summer 1990. Orange, green, and white colored water was observed throughout Ikalukrok Creek below the confluence with Red Dog Creek with effects visible in the Wulik River.

Concentrations of Zn were as high as 1510 mg/L in Red Dog Creek below the mine effluent (Station 21) in 1990 (Table 1) and 76 mg/L in Ikalukrok Creek below the confluence with Red Dog Creek (Station 8) (Table 2). Concentrations of Zn reached high levels in 1991 and 1992; however, these levels were limited to periods before break-up. Overall, water quality improved in 1991 and 1992 at both sampling stations: the median concentration of Zn at Station 21 was 12.6 mg/L in 1991 and 7.28 mg/L in 1992, compared to a median concentration of 166 mg/L in 1990. At Station 8 the median concentration of Zn was 1.67 mg/L in 1991 and 1.39 mg/L in 1992, compared with a median concentration of 11 mg/L in 1990. Median concentrations of other analytes (Al, Cd, Cu, and Pb) showed similar decreases in 1991 and 1992.

The three-year fisheries investigation was designed to monitor and evaluate project impacts to fisheries resources. Funding was provided by Cominco Alaska, Inc. The study commenced in 1991 and results of work conducted in both 1990 and 1991 were reported by Ott et al. (1992). We report herein results from year two of the study. Recommendations regarding the need for continued fisheries work associated with the Red Dog Mine will be contained in the final report to be completed in early 1994.

Table 1. Median, maximum, and minimum concentrations of Al, Cd, Cu, Pb, and Zn in Red Dog Creek below the mine discharge (Station 21). No data are available for concentrations of Cu in 1990.

Year	Analyte	Median mg/L	maximum mg/L	minimum mg/L	n
1990	Al	2.3	20.8	<0.01	69
	Cd	0.91	7.5	<0.05	69
	Pb	0.73	6.51	<0.01	69
	Zn	166	1510	6.3	69
1991	Al	0.1	3.2	<0.01	228
	Cd	0.079	0.87	<0.005	228
	Cu	0.05	0.05	<0.01	228
	Pb	0.09	7.08	<0.003	228
	Zn	12.6	161	0.73	228
1992	Al	0.05	1.17	<0.05	54
	Cd	0.046	0.206	0.013	54
	Cu	0.01	0.051	<0.01	54
	Pb	0.057	12.2	0.011	54
	Zn	7.28	116	0.726	54

Table 2. Median, maximum, and minimum concentrations of Al, Cd, Cu, Pb, and Zn in Ikalukrok Creek below the confluence of Red Dog Creek (at Station 8).

Year	Analyte	median mg/L	maximum mg/L	minimum mg/L	n
1989	Al	0.3	3.86	0.16	17
	Cd	0.016	0.1	0.006	17
	Cu	0.013	0.048	<0.01	17
	Pb	0.037	0.11	0.018	17
	Zn	3.1	10	0.94	17
1990	Al	0.54	1.8	<0.01	38
	Cd	0.071	0.41	<0.003	38
	Cu	0.013	0.033	<0.01	38
	Pb	0.057	0.34	<0.005	38
	Zn	11	76	0.45	38
1991	Al	<0.03	1.54	<0.03	105
	Cd	0.012	0.75	<0.001	105
	Cu	<0.01	0.03	<0.01	105
	Pb	0.009	0.408	<0.001	105
	Zn	1.67	90.8	<0.05	105
1992	Al	0.05	3.26	<0.05	46
	Cd	0.011	1.97	<0.003	46
	Cu	<0.01	0.38	<0.01	46
	Pb	0.004	0.266	<0.002	46
	Zn	1.39	259	0.305	46

OBJECTIVES

We initiated a three-year study in the Wulik River drainage in 1991 to document whether short-term and long-term changes in fish distribution, species composition, or heavy metal concentrations of select fish tissues would result from changes in water quality at the Red Dog Mine. Objectives of the three-year study including the stated null hypothesis for each objective follow:

Objective 1 - Estimate heavy metal concentrations (Zn, Cu, Pb, Al, and Cd) in gill, liver, muscle, and kidney tissue of adult Dolly Varden (*Salvelinus malma*) taken in the fall and spring from the Wulik River.

H_o: Heavy metal concentrations in adult Dolly Varden tissues are not substantially different from baseline concentrations measured in 1982 and 1983.

Objective 2 - Count and assess distribution of overwintering adult Dolly Varden in late September/early October using aerial surveys of the Wulik River from the mouth to approximately five river miles upstream of the confluence of the Wulik River and Ikalukrok Creek.

H_o: Ninety percent of overwintering adult Dolly Varden continue to use the Wulik River downstream of the mouth of Ikalukrok Creek and abundance is not substantially different from prior year estimates.

Objective 3 - Count and assess distribution of adult chum salmon (*Oncorhynchus keta*) during mid-August in Ikalukrok Creek using aerial surveys from the mouth of Ikalukrok Creek to Dudd Creek.

H_O: Chum salmon continue to spawn in the lower 24 km of Ikalukrok Creek in numbers comparable to numbers reported by Dames and Moore and the ADF&G in baseline data.

Objective 4 - Measure relative abundance (catch) and seasonal use patterns of juvenile Dolly Varden during the ice-free season in Ikalukrok, Dudd, Anxiety Ridge, Evaingiknuk, and Little Creeks.

H_O: Relative abundance (catch) and seasonal use patterns of juvenile Dolly Varden are not substantially different in Ikalukrok, Dudd, Anxiety Ridge, Evaingiknuk, and Little Creeks.

Objective 5 - Determine Arctic grayling (*Thymallus arcticus*) use of North Fork of Red Dog Creek.

H_O: Arctic grayling continue to spawn in the North Fork of Red Dog Creek and young-of-the-year Arctic grayling are present.

METHODS

With assistance from Cominco Alaska, Inc. and residents of Kivalina, we collected adult Dolly Varden by angling in the Wulik River during 1992. Wulik River Dolly Varden were collected in the lower river during late winter before breakup and in the fall before freezeup. Each Dolly Varden was placed in a clean plastic container which was labeled with sample date and location. Fish were frozen and shipped to ADF&G in Fairbanks, Alaska. We collected a minimum of six adult fish per sample period.

We removed the adult Dolly Varden from the freezer and measured and weighed each fish. 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 and placed in pre-cleaned jars (EPA protocol C, Series 300) and refrozen. We attempted to remove at least 10 g of each tissue. We cleaned each dissection instrument (i.e., tweezers, knives) in ultra-pure nitric acid with a rinse in double-distilled water before we began work on a new tissue. We also recorded sex and removed both otiliths from each fish. Tissue samples were submitted to a private analytical laboratory. Samples were freeze-dried and analyzed for Al, Cu, Cd, Pb, and Zn using U.S. Environmental Protection Agency standard methods (Table 3.

Results from the analytical laboratory were sent to us and the laboratory provided Quality Assurance/Quality Control information pertinent to each sample set. Statistical analyses of heavy metals data were not performed due to a small sample size (n = 5 to 9). We elected to display the median and range for each sample set. We qualitatively compared the 1990, 1991, and 1992 heavy metal concentrations in adult Dolly Varden with baseline data collected by Dames and Moore (1983).

Table 3. 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[1,2]	MRL
Al	202.2	0.1
Cd	7131.0	0.01
Cu	6010.0	0.5
Pb	7421.0	0.1
Zn	6010.0	0.5

[1]EPA Method 202.2 - "Methods for Chemical Analysis of Water and Wastes" EPA 600/4-79-020

[2]EPA Methods 7131, 7421, 6010 - "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW-846, 3rd Edition, 1986

We flew aerial surveys using fixed-wing aircraft in August and September 1992 in the Wulik River. The September survey covered the Wulik River from its mouth near the village of Kivalina to a point approximately five river miles above its confluence with Ikalukrok Creek. No aerial overflights were made of Ikalukrok Creek in 1992 and therefore an estimate of adult chum salmon was not made. From the Wulik River September flight, we estimated the number of overwintering Dolly Varden in the Wulik River.

We collected juvenile Dolly Varden and other fish species (e.g., Arctic grayling) in Ikalukrok, Dudd, Anxiety Ridge, North Fork of Red Dog, Evaingiknuk, and Little Creeks with minnow traps baited with salmon roe contained in perforated plastic containers. We allowed the minnow traps to actively fish for approximately 24 hours for each sample period. Each time traps were checked fish were identified, measured, and released. In August 1992, 50 Dolly Varden juveniles from Anxiety Ridge Creek were retained for genetic studies being conducted by Sport Fish Division. We established sample areas in each creek system and fixed the location of each minnow trap for the 1992 sample season. The number of minnow traps per sample area was increased from five to ten and minnow traps #1 through #5 were at the same locations in 1991 and 1992. We flagged and placed identification markers in streambank vegetation for permanent minnow trap fish sites. Number of fish captured, fork length of fish (mm), and time fished were recorded for- each minnow trap. Number of fish per trap (catch) was compared among sample areas and times (One-Way Analysis of Variance, $p<0.05$).

We conducted visual stream surveys for Arctic grayling in the North Fork of Red Dog, Dudd, Ikalukrok, and Anxiety Ridge Creeks. Angling was used to sample fish in the North Fork of Red Dog, Ikalukrok, and Dudd Creeks.

RESULTS

Dolly Varden Tissue Heavy Metals Concentrations

Since 1990 ADF&G has sampled Dolly Varden from the Wulik River for concentrations of select metals (Ott et al. 1992) (Table 4). Metal concentrations in muscle, liver, gill, and kidney were compared to pre-mining concentrations reported by Dames and Moore (1983). Metals concentrations expressed in mg/kg dry weight in the liver, gill, muscle, and kidney of adult Dolly Varden are presented in Appendix 1 and quality control/quality assurance data are presented in Appendix 2.

Table 4. Fish samples tested for concentrations of select metals by Dames and Moore and ADF&G, 1982 to 1992. All fish collected from 1990 were dissected by ADF&G and analyzed by a private analytical laboratory according to the methods listed in Table 3.

Date Collected	Site	No. of Fish	Collector
1982	Wulik River	Varies with tissue	
October 1990	Wulik River	6	ADF&G
April 1991	Wulik River	4	Cominco Alaska, Inc.
April 1991	Wulik River	5	Kivalina
April 1991	Noatak River	5	ADF&G
June 1991	Wulik River	8	Cominco Alaska, Inc.
October 1991	Wulik River	6	Cominco Alaska, Inc.
April 1992	Wulik River	6	Cominco and ADF&G
September 1992	Wulik River	6	ADF&G

Concentrations of Zn, Cu, Al, Pb, and Cd in adult Dolly Varden tissues collected in 1992 do not appear to be substantially different from either pre-mining fish samples collected in 1982 and 1983 or from fish sampled in 1990 and 1991 (Figures 3 through 7). Except for fish sampled in June 1991, Dolly Varden sampled after startup of the Red Dog mine did not contain consistently higher concentrations of metals than fish sampled before development of the mine. Dolly Varden collected in June 1991 contained elevated Al and Pb concentrations in gill tissue; these concentrations were higher than found at any other sampling time in either the Wulik or the Noatak Rivers (Figures 5 and 6).

Dolly Varden from the Wulik River sampled since 1989 show highest concentrations of Al and Pb in gill tissue, Cu in liver tissue, and Cd and Zn in kidney, liver, and gill tissues. Muscle tissue generally contained the lowest concentrations of metals in all sample groups.

Of the five metals tested, results for Pb are probably the least reliable. Concentrations of Pb were equal to or near the method reporting limit in 80% of the muscle samples, 68% of the liver samples, and 57% of the kidney samples. Gills, however, contained higher concentrations of Pb: concentrations were at or less than the method reporting limit in only 32% of the samples and 42% of the samples contained at least 10 times more Pb than the method reporting limit.

Figure 3. Median, maximum, and minimum concentration of Zinc (mg/kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Noatak (N) and Wulik Rivers in 1982, 1990, 1991, and 1992. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.

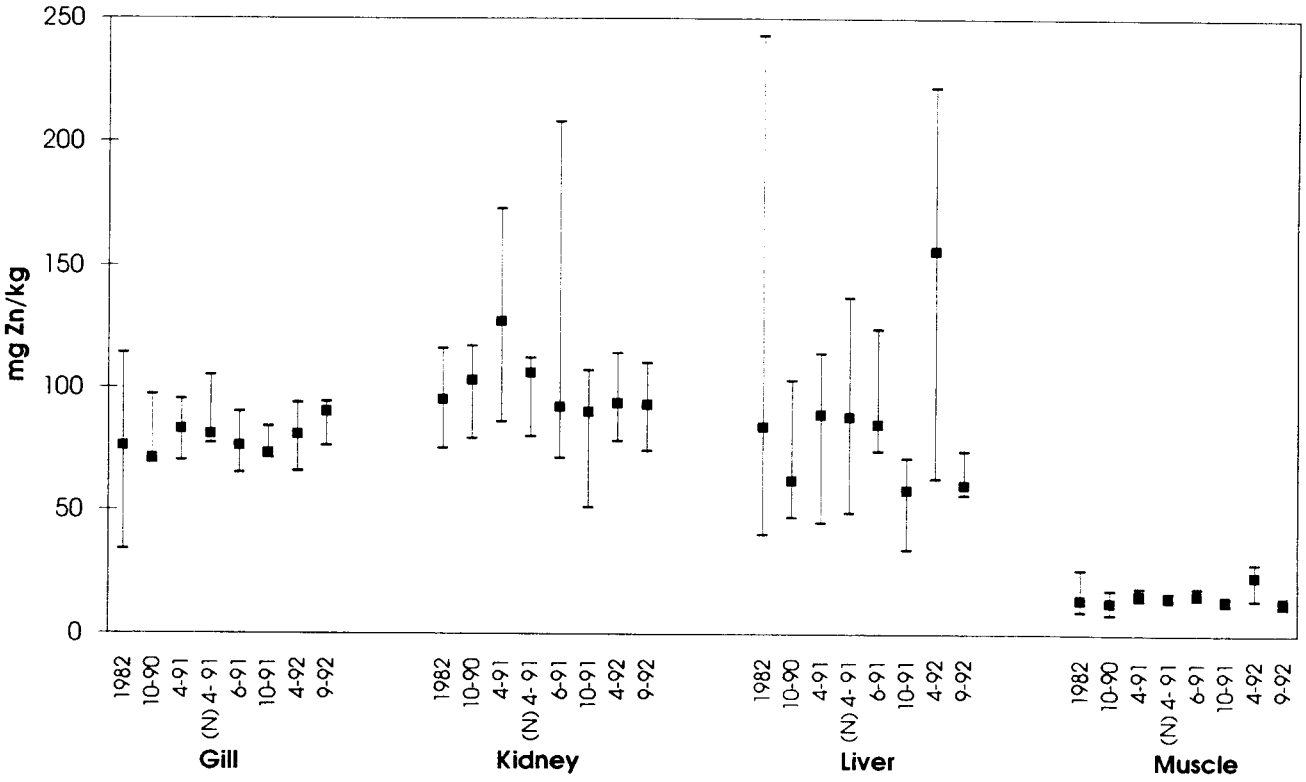


Figure 4. Median, maximum, and minimum concentration of Copper (mg/kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Noatak (N) and Wulik Rivers in 1982, 1990, 1991, and 1992. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.

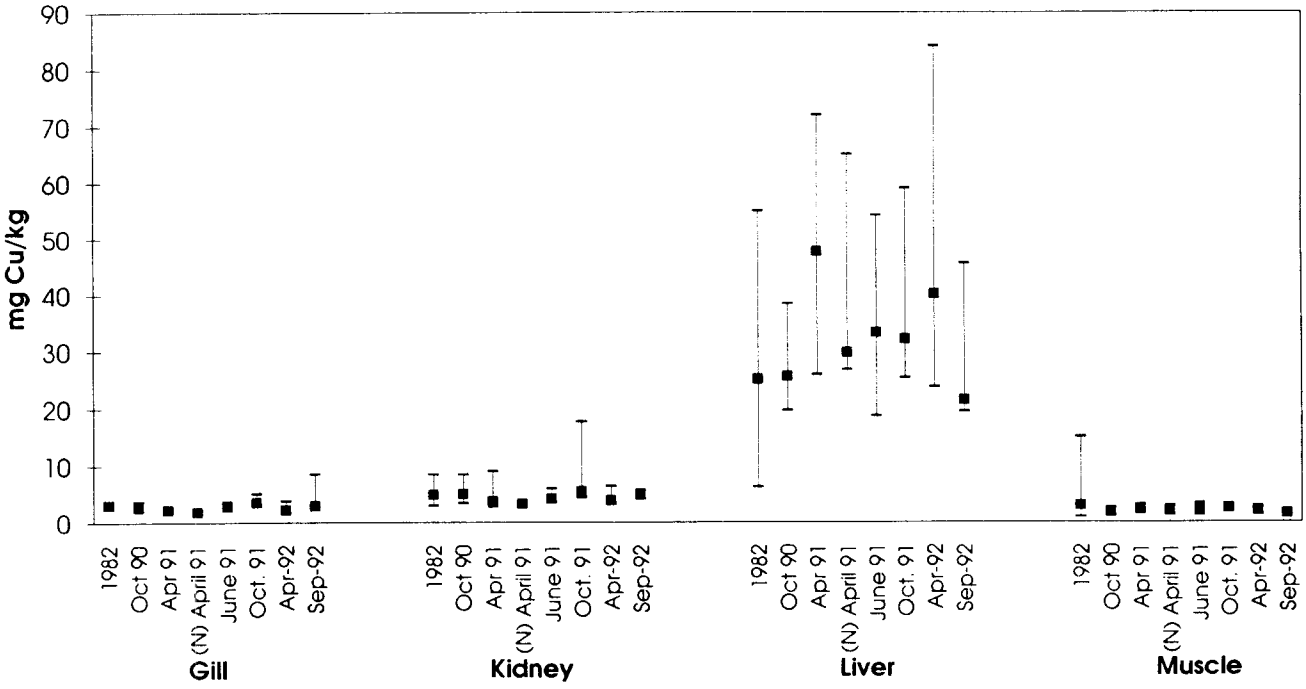


Figure 5. Median, maximum, and minimum concentration of Aluminum (mg/kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Noatak (N) and Wulik Rivers in 1982, 1990, 1991, and 1992. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.

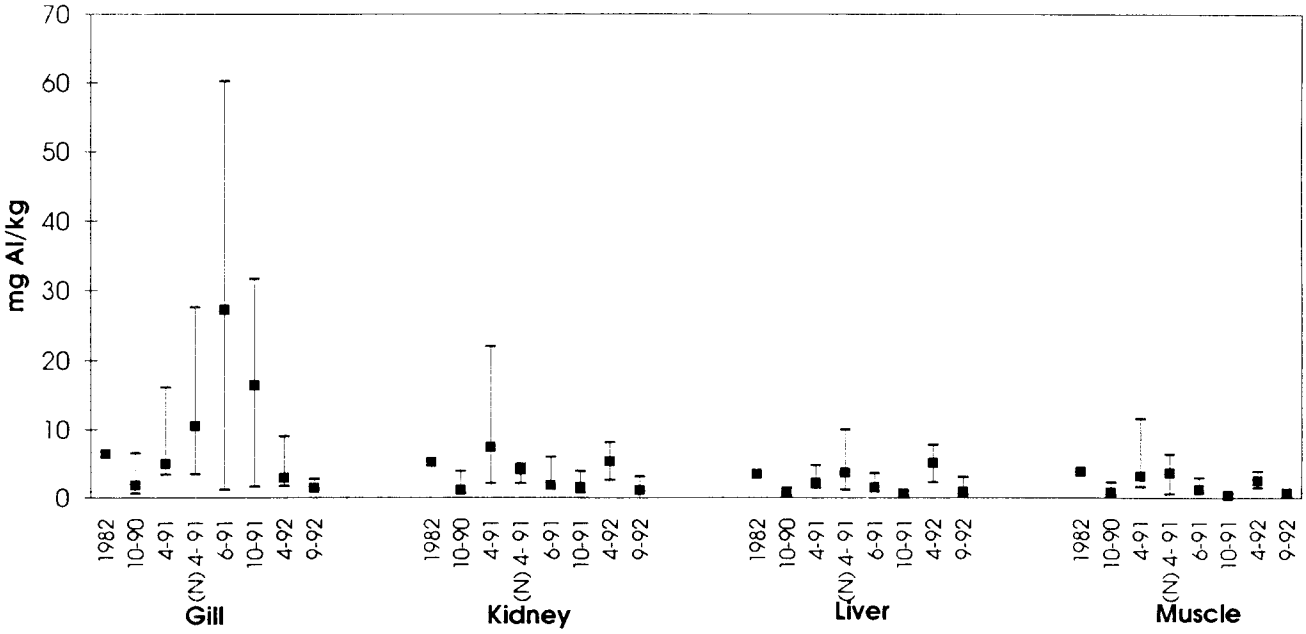


Figure 6. Median, maximum, and minimum concentration of Lead (mg/kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Noatak (N) and Wulik Rivers in 1982, 1990, 1991, and 1992. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.

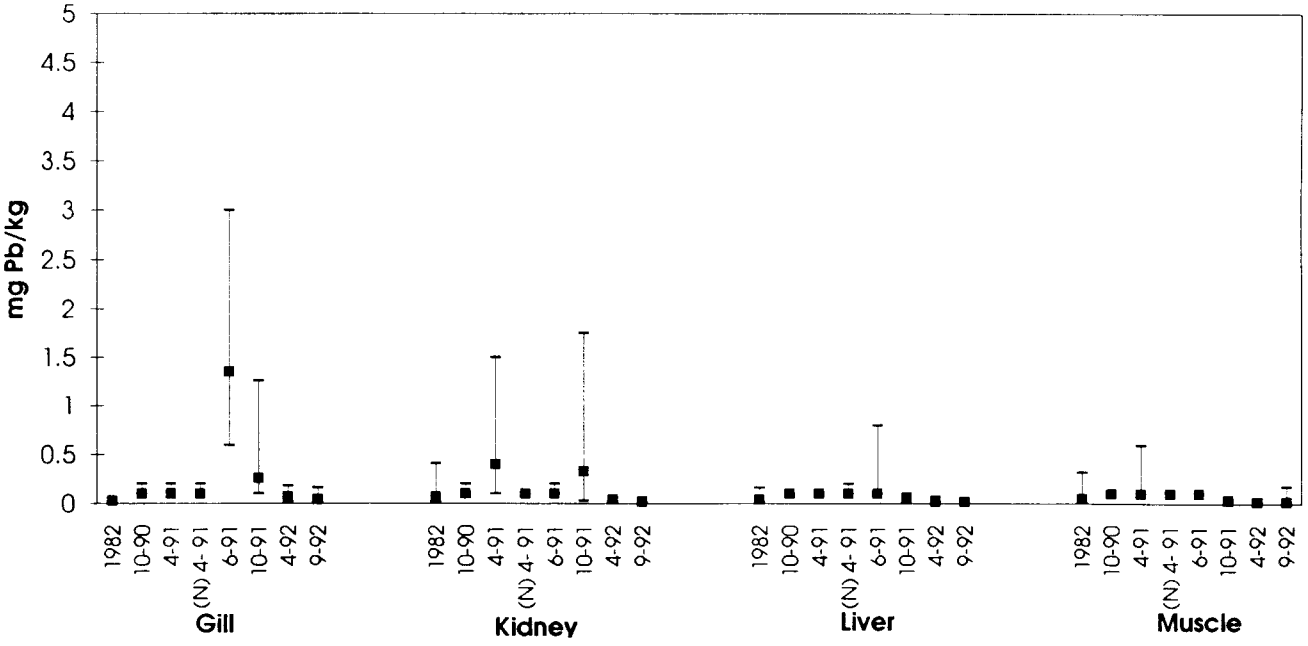
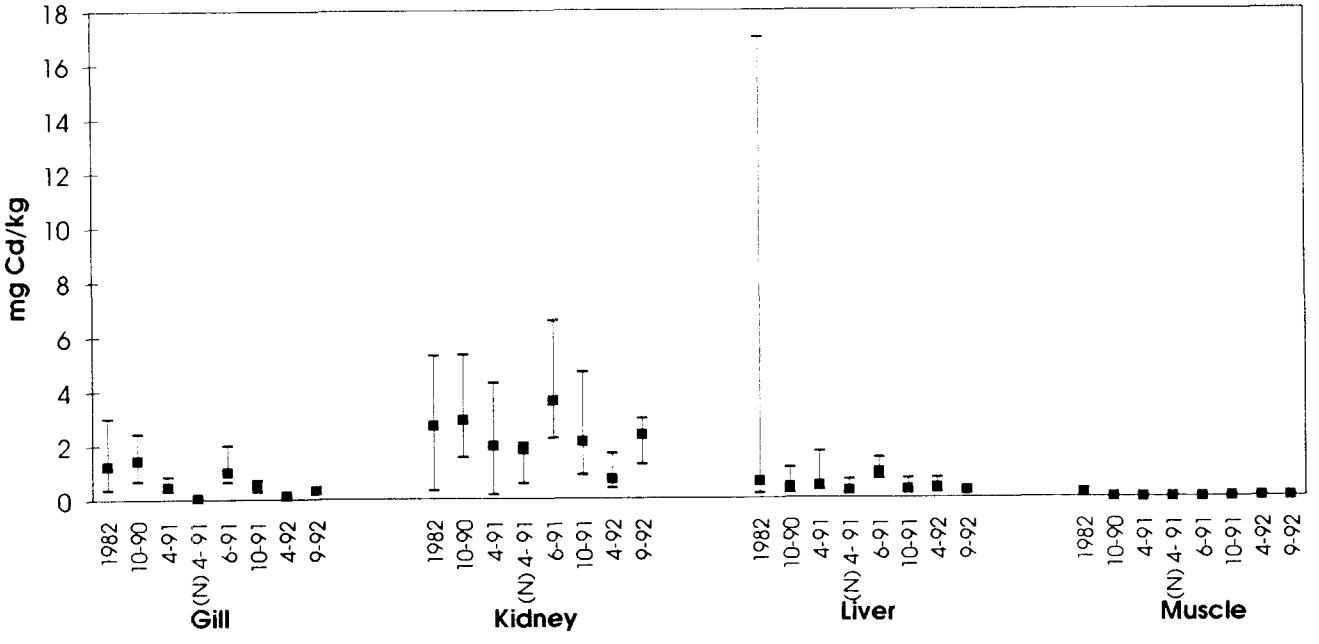


Figure 7. Median, maximum, and minimum concentration of Cadmium (mg/kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Noatak (N) and Wulik Rivers in 1982, 1990, 1991, and 1992. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.



Dolly Varden collected in the fall after they had spent the summer in salt water were compared with Dolly Varden collected in spring after overwintering in the Wulik River to determine differences in tissue metals concentrations. A two- sample T-test, assuming unequal sample variances was used to compare concentrations of each metal by tissue with $p < 0.05$. The method reporting limit was used for censored data.

Overall, concentrations of Al and Zn were significantly higher (two sample T-test, $p < 0.05$, Table 5) in all tissues from spring-caught fish except gill tissue, where there was no significant difference between spring- and fall-caught fish. Concentrations of Cd and Cu were significantly higher (two sample T-test, $p < 0.05$, Table 5) in liver tissue from spring-caught fish and significantly higher in gill tissue from fall-caught fish. Concentrations of Pb were at or near the method reporting limit in all tissues from both sample groups, and no significant differences (Table 5) could be shown between spring- and fall-caught fish.

Overwintering Dolly Varden Surveys, Wulik River

Aerial surveys to count the number of overwintering Dolly Varden in the Wulik River were made periodically from fall 1979 to present. In 1992 two aerial surveys were conducted. On August 19, 1992, adult Dolly Varden were present in the lower Wulik River downstream of Driver's Camp indicating that movement into the system for spawning and overwintering had started (Lean 1992). DeCicco (1992) counted 135,135 Dolly Varden in the Wulik River on September 8, 1992, the most Dolly Varden observed in the Wulik River upstream and downstream of the confluence of Ikalukrok Creek since 1979 (Table 6).

Table 5. Comparisons of metals concentrations in tissues of Dolly Varden collected from the Wulik River in the fall and in the spring. Comparisons were made with a two sample T-test, assuming unequal variances, with $p < 0.05$.

Analyte	Tissue	Fall Caught Fish mg/Kg	Spring Caught Fish mg/Kg	Significantly Different $p < 0.05$
Al	Muscle	0.83	2.92	yes
	Liver	0.95	3.86	yes
	Gill	18.72	13.59	no
	Kidney	1.71	4.95	yes
Cd	Muscle	0.02	0.01	no
	Liver	0.35	0.55	yes
	Gill	0.73	0.31	yes*
	Kidney	2.21	1.82	no
Cu	Muscle	2.09	2.47	no
	Liver	28.12	42.64	yes
	Gill	3.39	2.39	yes*
	Kidney	5.54	5.30	no
Pb	Muscle	0.11	0.09	no
	Liver	0.06	0.08	no
	Gill	0.219	0.17	no
	Kidney	0.17	0.17	no
Zn	Muscle	13.9	18.4	yes
	Liver	67.1	107.2	yes
	Gill	75.2	82.5	no
	Kidney	91.9	106.8	yes
n		25	23	

*The mean concentration in fall-caught fish is higher than in spring-caught fish.

Table 6. Number of overwintering adult Dolly Varden in the Wulik River, including percent of total count located in the Wulik River downstream of Ikalukrok Creek during late-fall (prior to freezeup). Surveys conducted by the ADF&G (DeCicco 1989, 1990, 1991, and 1992).

Year	Wulik River upstream of Ikalukrok Creek	Wulik River downstream of Ikalukrok Creek	Percent of Fish downstream of Ikalukrok Creek
1979	3,305	51,725	94
1980	12,486	101,067	89
1981	4,125	97,136	96
1982	2,300	63,197	97
1984	370	30,483	99
1987	893	60,397	99
1988	1500	78,644	98
1989	3,500	50,050	93
1989	2,110	54,274	96
1991	7,930	119,055	94
1992	750	134,385	99

Chum Salmon Surveys, Ikalukrok Creek

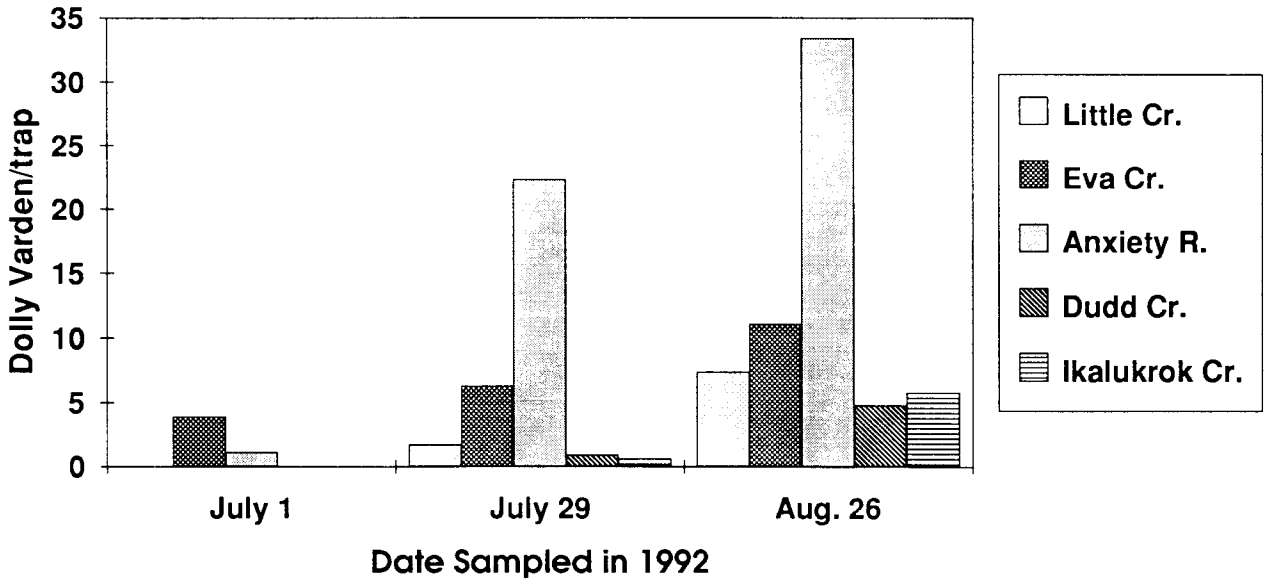
Aerial surveys for adult chum salmon in Ikalukrok Creek were not conducted in 1992. We observed Ikalukrok Creek immediately above and below the confluence of Dudd Creek. Chum salmon adults were not observed, but at least 12 adult Dolly Varden were present in Ikalukrok Creek in the first pool/riffle below Dudd Creek on July 28, 1992. Three adult Dolly Varden were observed in Dudd Creek on August 27, 1992, in the first pool below the confluence of Buddy/Bonns and Anxiety Ridge Creeks. Active spawning behavior was not documented.

Juvenile Dolly Varden, Relative Abundance and Distribution

In 1992, minnow traps were set in Evaingiknuk, Dudd, Anxiety Ridge, Little, and Ikalukrok Creeks. Sample effort, number of Dolly Varden captured, their length (range and average), and the number of fish (average, standard deviation) per trap were recorded (Appendices 3 through 7).

In 1992, the catch of Dolly Varden increased in sample creeks from early July through late August (Figure 8). The number of Dolly Varden captured per minnow trap was compared for sample creeks. Comparisons in catch/trap were made for each sample period (June 30/July 1, July 28/29, and August 26/27). Significant differences among the creeks in total catch per trap of juvenile Dolly Varden were determined for the early July ($F = 8.70$; $df = 4,45$; $P < 0.05$), late July ($F = 20.50$; $df = 4,45$; $P < 0.05$), and late August ($F = 15.20$; $df = 4,45$; $P < 0.05$) sample periods. Highest catches were recorded in Evaingiknuk Creek during early July and in Anxiety Ridge Creek for both the late July and late August samples. The average number of juvenile Dolly Varden per minnow trap in Anxiety Ridge Creek on August 26 was 33.4.

Figure 8. Catch of Dolly Varden per minnow trap in Evaingiknuk, Dudd, Anxiety Ridge, Little, and Ikalukrok Creeks, 1992.



Arctic Grayling Surveys, North Fork of Red Dog Creek

Fisheries surveys were conducted along the lower 1.2 km of the North Fork of Red Dog Creek on July 2, July 27, and August 24, 1992. In early July, turbidity in the North Fork of Red Dog Creek was measured at 5.1 NTU, water temperature was 12°C, angling (i.e., fly fishing) was unproductive, and only several small Arctic grayling (140 to 180 mm) were observed. The nonpoint source of sediment in the North Fork of Red Dog Creek was a tributary stream (e.g., probably an exposed ice lens and/or channel change in the unnamed tributary) located approximately two miles upstream from its confluence with Red Dog Creek (Martinisko 1992).

During the late July sample period water in the North Fork of Red Dog Creek was clear with a temperature of 15.5°C. Thousands of young-of-the-year Arctic grayling were observed (i.e., one collected was 27 mm). Nine Arctic grayling were captured by fly fishing, measured, and released in a two-hour period (388, 100, 407, 400, 145, 218, 375, 215, and 250 mm). Small juvenile fish were observed in riffle areas and based on their behavior, we assumed they were Dolly Varden. We set five minnow traps in the North Fork of Red Dog Creek and captured two juvenile Dolly Varden (124 and 133 mm).

In late August water in the North Fork of Red Dog Creek was clear with a temperature of 11°C. We fished five minnow buckets for one day (August 24 to 25) with a catch of two Arctic grayling (48 and 53 mm) and one Dolly Varden (168 mm). Arctic grayling young-of-the-year were present in backwater habitats although numbers appeared to be less than in late July.

DISCUSSION AND CONCLUSIONS

Dolly Varden Tissue Heavy Metals Concentrations

Comparisons of metal concentrations in fish tissues that were reported as less than the method reporting limit were set at the method reporting limit for comparison purposes. Using the method reporting limit for censored data is the most conservative approach for censored data and is more likely to indicate higher levels than actually occur than to indicate no metal accumulation where it has occurred.

Concentrations of Al, Cd, Cu, Pb, and Zn in muscle tissue were approximately equal to or lower than concentrations found in liver, kidney, or gill tissues during all of the times sampled. This result is not surprising because muscle tissue is not known to accumulate any of the metals tested (Sorensen 1991, Ott et al. 1992).

The Al and Pb concentrations in gill tissue were higher in the June 1991 sample from the Wulik River than in any previous set of samples from either the Wulik or Noatak drainages. However, gill concentrations of both Al and Pb were lower in subsequent samples (October 1991, April 1992, and September 1992). The apparent decrease in both Al and Pb in gill tissue from June 1991 through September 1992 (four sample groups) coincides with the installation and proper functioning of the clean water/dirty water bypass system installed by Cominco Alaska, Inc. in March/April 1991. The clean water/dirty water bypass system began to function efficiently during July 1991 following initial flushing of the work area and minor repairs and modifications to the bypass system. Fish collected after July 1991 contained lower concentrations of Al and Pb.

Based on the 1992 results and qualitative comparisons with baseline data and heavy metals concentrations from the 1990 and 1991 Dolly Varden tissue samples we concluded:

(1) There is no consistent increase or decrease in Al, Cd, Cu, Pb, or Zn concentrations in Dolly Varden tissues in the Wulik River drainage following startup of the Red Dog Mine. Increases in tissue concentrations of Pb and Al in 1991 appeared to decrease to background levels after construction of the clean water/dirty water bypass system.

(2) We could demonstrate no consistent difference in the concentration of Cd, Cu, or Pb that could be correlated with fish caught in the fall after returning from salt water and fish that had overwintered in the Wulik River and were collected in the spring. Concentrations of Al and Zn were higher in muscle, liver, and kidney tissues in fish caught in the spring than in fish caught in the fall.

Overwintering Dolly Varden Surveys, Wulik River

Objective #2 of our study was to estimate the number of overwintering Dolly Varden in the Wulik River from its mouth to a point five miles upstream of the confluence of the Wulik River and Ikalukrok Creek. Our null hypothesis was that 90% of the overwintering Dolly Varden continue to use the Wulik River downstream of the mouth of Ikalukrok Creek and abundance is not substantially different from prior year estimates. In both 1991 and 1992 over 90% of the Dolly Varden were observed in the Wulik River downstream of Ikalukrok Creek.

Chum Salmon Surveys, Ikalukrok Creek

Objective #3 of our study was to count and assess distribution of adult chum salmon during mid-August in Ikalukrok Creek using aerial surveys from the mouth of Ikalukrok Creek to Dudd Creek. Surveys were not conducted in 1992.

Juvenile Dolly Varden, Relative Abundance and Distribution

Our objective was to measure relative abundance (catch) and seasonal use patterns of juvenile Dolly Varden during the ice free season in Evaingiknuk, Dudd, Anxiety Ridge, Little, and Ikalukrok Creeks. Our null hypothesis that the relative abundance of juvenile Dolly Varden are not significantly different in sample creeks was rejected for all 1992 summer sample periods.

Our highest catch rates in 1992 excluding the early July period were in Anxiety Ridge Creek. Similar results were obtained in 1990 and 1991 (Ott et al. 1992). Researchers conducting baseline studies also reported that the most productive creek for juvenile Dolly Varden was Anxiety Ridge Creek (Dames and Moore 1984). Our 1992 results continue to confirm work conducted by Dames and Moore prior to development of the Red Dog Mine. Catch rates recorded in Evaingiknuk, Dudd, Anxiety Ridge, Little, and Ikalukrok Creeks in 1992 consistently exceeded those reported for either 1990 or 1991 indicating an overall increase in abundance of fish in our sample reaches.

Patterns of juvenile Dolly Varden use of Evaingiknuk, Dudd, Anxiety Ridge, Little, and Ikalukrok Creeks during the summer months remained similar to those reported in 1990 and 1991 (Ott et al. 1992). Catch rates for juvenile Dolly Varden are low early in the summer with peak catches occurring from late July to late August. We believe that the increased fish use later in the summer represents a gradual dispersal of the juveniles from overwintering to rearing habitats.

Dolly Varden use of Ikalukrok Creek was virtually non-existent in the summer 1990 but increased in 1991 (Ott et al. 1992). The clean water/dirty water bypass system was constructed during March/April 1991 and was functional from mid-July 1991 to present. Water quality improved in Red Dog Creek below the confluence of the North Fork (Station 10) and in Ikalukrok Creek below the confluence of Red Dog Creek (Station 8)

during late summer 1991 and throughout summer 1992 (Appendix 8 and Water Quality Data Files, Cominco Alaska Inc.). Concentrations of Cd and Zn were considerably lower after completion of the clean water/dirty water ditch system in late summer 1991; however, concentrations of Pb were elevated above the method detection limit in 42 of the 44 water samples collected between June 1 and September 1, 1991 (Appendix 8). One Dolly Varden was captured and released in Ikalukrok Creek in 1990, 29 in 1991, and 64 in 1992 (Appendix 7). Since numbers of juvenile fish per minnow trap increased in all sample creeks including Evaingiknuk Creek (a Noatak River tributary), it is not known to what extent the increased use is related to overall improvements in water quality.

The first documentation of juvenile Dolly Varden use of the North Fork of Red Dog Creek was obtained in 1992. Three juveniles were collected and several (i.e., 20) were observed in shallow-riffle areas. It is postulated that these fish had moved from overwintering habitats in lower Ikalukrok Creek and/or the Wulik River. Therefore, the Dolly Varden had moved up the Ikalukrok Creek and through the lower portion of Red Dog Creek in order to access the North Fork of Red Dog Creek.

Arctic Grayling Surveys, North Fork of Red Dog Creek

Our objective in 1992 was to continue to evaluate Arctic grayling use of the North Fork of Red Dog Creek. In 1991 we found that Arctic grayling continued to spawn in the North Fork of Red Dog Creek and young-of-the-year Arctic grayling were present (Ott et al. 1992); we found no change in Arctic grayling spawning patterns from baseline reports. Adult Arctic grayling also were captured in late July 1992 and thousands of young-of-the-year Arctic grayling were observed in the lower 1.2 km of the creek.

Surveys for adult and young-of-the-year Arctic grayling were deemed necessary to evaluate potential effects of high heavy metals in Red Dog Creek during fall 1989 and

throughout summer 1990. Adult Arctic grayling migrate from overwintering areas believed to exist in lower Ikalukrok Creek and/or the Wulik River through Red Dog Creek to reach spawning and rearing habitat in the North Fork of Red Dog Creek. If significant mortalities occurred to adult Arctic grayling in both 1989 and 1990, use of the North Fork of Red Dog Creek could have been substantially decreased. Documentation of adult and young-of-the-year Arctic grayling in the North Fork of Red Dog Creek in 1991 and 1992 indicate that use is similar to that reported by Houghton and Hilgert (1983).

Visual observations indicating the presence of Dolly Varden juveniles in the North Fork of Red Dog Creek were confirmed with actual catches made in minnow traps in late July and August 1992. Presence of age 1+ (i.e., 100 mm) and 2+ (i.e., 145 mm) Arctic grayling also was documented. Houghton and Hilgert (1983) conducted fisheries surveys in the North Fork of Red Dog Creek and documented only Arctic grayling with no age 1+ and few, if any, age 2+ fish present. Houghton and Hilgert (1983) hypothesized that access by fish to the North Fork of Red Dog Creek was limited to periods of high water (i.e., spring breakup) when heavy metals concentrations were lower. Because adult Arctic grayling migrate to spawning areas in the spring during high flows they were able to access and use habitats in the North Fork of Red Dog Creek. During low flow periods following breakup when metals concentrations are higher, juvenile Arctic grayling and other fish species have limited movement through Red Dog Creek. Our results in 1992 indicate that the number of species (Arctic grayling and Dolly Varden) and age classes (1+ and 2+) of Arctic grayling using the North Fork of Red Dog Creek has changed. We believe that fish access to the North Fork of Red Dog Creek is now possible under various flow events, particularly low flow conditions. The clean water/dirty water bypass system installed adjacent to the Red Dog Mine ore body in late winter 1991 contributed to improved water quality during low flow periods thus providing an opportunity for

juvenile Dolly Varden and age 1+ Arctic grayling to reach raring habitats in the North Fork of Red Dog Creek (Appendix 8 and Water Quality Data Files, Cominco Alaska Inc).

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Appendix 1. Concentrations of Al, Cd, Cu, Pb, and Zn in adult Dolly Varden muscle, liver, gill, and kidney tissues, 1990, 1991, and 1992 from the Wulik and Noatak Rivers. Baseline fish tissue data from Dames and Moore (1983) are included. All concentrations are expressed as mg/kg, dry weight basis.

Muscle Tissue

Collected By	Date	Location	Sex	Length mm	Weight grams (fresh+salt)	Age	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Zn mg/kg	% Solids
D&M	1-Jun-81	Wulik R.	a					0.160	1.30	< 0.02	9.89	
D&M	1-Aug-81	Wulik R.	a					0.190	2.00	0.03	13.60	
D&M	1-Sep-81	Wulik R.	a					0.120	2.10	< 0.02	16.80	
D&M	1-Jun-81	Wulik R.	a					0.200	2.00	< 0.02	9.16	
D&M	1-Jul-81	Wulik R.	a					0.210	2.50	< 0.04	13.90	
D&M	1-Sep-81	Ikalukrok	a					0.170	2.90	0.02	10.90	
D&M	*1982	Wulik R.	a				3.40	0.170	1.56	0.02	12.07	
ADF&G	5-Oct-90	Wulik R.	f	538			1.60	< 0.010	2.50	< 0.10	18.10	24.90
ADF&G	5-Oct-90	Wulik R.	f	615			0.40	< 0.010	1.00	< 0.10	7.60	42.40
ADF&G	5-Oct-90	Wulik R.	m	608			0.80	< 0.010	1.80	< 0.10	11.50	38.10
ADF&G	5-Oct-90	Wulik R.	f	430			0.50	< 0.010	1.90	< 0.10	12.90	32.50
ADF&G	5-Oct-90	Wulik R.	f	452			0.50	< 0.010	1.70	< 0.10	15.30	30.10
ADF&G	5-Oct-90	Wulik R.	f	528			0.90	< 0.010	1.70	< 0.10	12.10	39.50
Cominco	9-Mar-91	Wulik R.					2.20	< 0.010	3.50	< 0.10	18.60	24.70
Cominco	9-Mar-91	Wulik R.					2.80	< 0.010	2.40	< 0.10	14.50	27.00
Cominco	9-Mar-91	Wulik R.					1.60	< 0.010	2.50	< 0.10	15.50	26.80
KIVALINA	6-Apr-91	Wulik R.		300	1279		1.60	0.010	2.00	0.10	17.40	24.90
KIVALINA	6-Apr-91	Wulik R.		294	197		6.10	< 0.010	2.20	< 0.10	15.00	23.60
KIVALINA	6-Apr-91	Wulik R.		303	201		11.60	< 0.010	3.10	0.60	15.50	24.70
KIVALINA	6-Apr-91	Wulik R.		355	237		3.20	< 0.010	1.90	< 0.10	18.80	19.30
KIVALINA	6-Apr-91	Wulik R.		434	751		1.90	< 0.010	2.20	< 0.10	14.20	28.40
Cominco	26-Apr-91	Wulik R.		518	1279		1.20	< 0.010	1.70	< 0.10	14.10	29.10
ADF&G	15-Apr-91	Noatak		323	274		6.40	0.040	2.40	< 0.10	16.10	24.10
ADF&G	15-Apr-91	Noatak		324	283		1.50	< 0.010	2.00	< 0.10	14.60	24.40
ADF&G	15-Apr-91	Noatak		416	714		3.70	0.010	2.90	< 0.10	14.10	28.60
ADF&G	15-Apr-91	Noatak		443	730		0.60	< 0.010	1.40	< 0.10	13.80	26.40
ADF&G	15-Apr-91	Noatak		401	449		4.10	0.010	1.20	< 0.10	17.00	23.60
Cominco	6/16/91	Wulik R.	m	489	962		1.40	0.010	3.30	< 0.10	16.00	29.70
Cominco	6/16/91	Wulik R.	f	538	1426		1.80	< 0.010	2.20	0.10	15.30	26.40
Cominco	6/16/91	Wulik R.	m	541	1361		3.00	< 0.010	2.60	< 0.10	15.60	25.40
Cominco	6/16/91	Wulik R.	f	461	762		0.80	< 0.010	2.40	< 0.10	16.00	23.70
Cominco	6/16/91	Wulik R.	f	417	672		0.90	< 0.010	1.20	< 0.10	16.40	22.40
Cominco	6/16/91	Wulik R.	f	430	745		1.10	< 0.010	1.50	< 0.10	15.10	23.60
Cominco	6/16/91	Wulik R.	f	443	680		1.20	0.030	1.50	< 0.10	18.90	23.00
Cominco	6/16/91	Wulik R.	f	430	654		1.20	< 0.010	2.00	< 0.10	16.60	24.00
Cominco	10/5/91	Wulik R.	F	480	1162		0.55	< 0.020	2.55	0.03	14.90	27.70
Cominco	10/5/91	Wulik R.	M	480	1262		0.66	< 0.020	2.85	0.03	13.90	26.90
Cominco	10/5/91	Wulik R.	M	614	2551		0.43	< 0.020	2.02	0.04	14.50	27.40
Cominco	10/5/91	Wulik R.	F	589	2188		0.13	0.030	2.68	0.04	13.10	30.40
Cominco	10/5/91	Wulik R.	F	525	1616		0.22	< 0.020	2.03	0.03	12.80	27.50
Cominco	10/5/91	Wulik R.	M	563	2233		0.32	< 0.020	2.42	0.05	12.20	29.10

Appendix 1, continued.

Collected By	Date	Location	Sex	Length mm	Weight grams (fresh+salt)	Age	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Zn mg/kg	% Solids
ADF&G	4/29/92	Wulik R.	F	291	1800		2.50	< 0.020	2.27	< 0.05	16.50	24.70
ADF&G	4/29/92	Wulik R.	F	424	670	(2+2)	2.20	< 0.020	1.460	0.02	14.60	24.40
ADF&G	4/29/92	Wulik R.	F	530	1420	(2+3)?	1.80	< 0.020	1.35	< 0.02	14.10	25.90
ADF&G	4/29/92	Wulik R.	undet	294	180	(2+1)?	2.60	< 0.020	2.12	0.03	25.90	23.60
ADF&G	4/29/92	Wulik R.	F	275	140	(3+1)	1.50	< 0.020	2.08	< 0.02	28.70	20.50
ADF&G	4/29/92	Wulik R.	M	276	160		2.60	< 0.020	2.38	0.02	22.90	22.60
ADF&G	4/29/92	Wulik R.	M	264	140	(4+1)	3.00	< 0.020	2.57	< 0.02	24.30	21.80
ADF&G	4/29/92	Wulik R.	F	259	150	(3+1)	3.90	< 0.020	1.99	0.02	26.10	22.80
ADF&G	9/30/92	Wulik R.	F	620	2820	9	1.35	< 0.020	1.74	< 0.02	14.00	23.50
ADF&G	9/30/92	Wulik R.	M	674	3410	(3+4)	0.47	< 0.020	1.27	< 0.02	11.00	31.70
ADF&G	9/30/92	Wulik R.	F	600	2630	(3+5)	0.72	< 0.020	1.27	< 0.02	13.00	34.40
ADF&G	9/30/92	Wulik R.	M	564	2110	(4+4)	0.74	< 0.020	1.26	0.03	13.00	26.20
ADF&G	9/30/92	Wulik R.	F	595	2920	(3+4)	0.42	< 0.020	1.59	< 0.02	14.00	30.70
ADF&G	9/30/92	Wulik R.	M	407	673	(2+4)	1.26	< 0.020	2.08	0.17	14.00	35.50

Appendix 1, continued.

Liver Tissue

Collected By	Date	Location	Sex	Length mm	Weight grams (fresh+salt)	Age	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Zn mg/kg	% Solids
D&M	1-Jun-81	Wulik R.	a					0.580	33.00	< 0.02	72.30	
D&M	1-Jun-81	Wulik R.	a					0.540	16.50	< 0.02	50.80	
D&M	1-Aug-81	Wulik R.	a					0.770	11.00	< 0.02	91.00	
D&M	1-Sep-81	Wulik R.	a					0.970	18.00	0.02	78.20	
D&M	1-Sep-81	Mid-Ikaluk	a					1.200	7.90	< 0.03	243.00	
D&M	*1982	Wulik R.	a				2.50	0.670	27.75	0.03	69.63	
ADF&G	5-Oct-90	Wulik R.	f	538			1.50	1.110	25.60	0.10	103.00	26.10
ADF&G	5-Oct-90	Wulik R.	f	615			0.70	0.250	19.70	< 0.10	46.60	46.60
ADF&G	5-Oct-90	Wulik R.	m	608			0.70	0.190	38.40	< 0.10	58.70	50.90
ADF&G	5-Oct-90	Wulik R.	f	430			0.80	0.460	22.60	< 0.10	79.30	29.00
ADF&G	5-Oct-90	Wulik R.	f	452			0.70	0.400	24.20	< 0.10	74.60	34.60
ADF&G	5-Oct-90	Wulik R.	f	528			0.40	0.370	29.90	< 0.10	61.80	55.90
Cominco	9-Mar-91	Wulik R.					1.5	1.81	40.3	< 0.10	164	27.1
Cominco	9-Mar-91	Wulik R.					3.10	0.530	30.70	< 0.10	65.80	44.40
Cominco	9-Mar-91	Wulik R.					2.00	0.730	46.60	< 0.10	84.80	38.80
KIVALINA	6-Apr-91	Wulik R.		300	1279		4.80	1.730	51.90	< 0.10	88.80	33.80
KIVALINA	6-Apr-91	Wulik R.		294	197		1.50	0.290	47.70	< 0.10	87.20	34.90
KIVALINA	6-Apr-91	Wulik R.		303	201		1.80	0.450	41.10	< 0.10	95.80	33.10
KIVALINA	6-Apr-91	Wulik R.		355	237		2.20	0.630	72.00	< 0.10	114.00	25.20
KIVALINA	6-Apr-91	Wulik R.		434	751		2.90	0.380	25.90	0.10	44.60	35.00
Cominco	26-Apr-91	Wulik R.		518	1279		1.30	0.760	25.40	< 0.10	56.10	38.20
ADF&G	15-Apr-91	Noatak		323	274		10.00	0.210	26.90	0.20	70.30	36.30
ADF&G	15-Apr-91	Noatak		324	283		2.60	0.430	44.40	< 0.10	110.00	28.50
ADF&G	15-Apr-91	Noatak		416	714		6.70	0.270	29.80	< 0.10	88.10	44.30
ADF&G	15-Apr-91	Noatak		443	730		1.20	0.270	26.80	< 0.10	49.00	44.20
ADF&G	15-Apr-91	Noatak		401	449		3.70	0.680	65.10	< 0.10	137.00	28.30
Cominco	6/16/91	Wulik R.	m	489	962		1.30	1.250	32.40	< 0.10	74.00	31.90
Cominco	6/16/91	Wulik R.	f	538	1426		1.80	0.710	18.70	< 0.10	75.20	30.80
Cominco	6/16/91	Wulik R.	m	541	1361		3.60	0.860	37.50	< 0.10	83.20	33.70
Cominco	6/16/91	Wulik R.	f	461	762		2.00	1.180	34.10	< 0.10	96.60	27.40
Cominco	6/16/91	Wulik R.	f	417	672		1.80	1.480	38.30	0.80	124.00	24.00
Cominco	6/16/91	Wulik R.	f	430	745		1.20	0.690	54.20	< 0.10	85.40	28.90
Cominco	6/16/91	Wulik R.	f	443	680		1.20	1.040	26.00	< 0.10	84.30	33.30
Cominco	6/16/91	Wulik R.	f	430	654		0.90	0.840	31.00	< 0.10	88.00	30.10
Cominco	10/5/91	Wulik R.	F	480	1162		0.94	0.290	33.60	0.04	70.80	45.60
Cominco	10/5/91	Wulik R.	M	480	1262		0.34	0.210	27.40	0.02	50.20	43.10
Cominco	10/5/91	Wulik R.	M	614	2551		0.44	0.720	39.00	0.10	61.70	37.70
Cominco	10/5/91	Wulik R.	F	589	2188		0.87	0.320	59.00	0.05	65.60	45.70
Cominco	10/5/91	Wulik R.	F	525	1616		0.40	0.530	25.40	0.04	55.10	41.50
Cominco	10/5/91	Wulik R.	M	563	2233		0.70	0.210	30.60	0.04	33.80	47.60

Appendix 1, continued.

Collected By	Date	Location	Sex	Length mm	Weight grams	Age (fresh+salt)	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Zn mg/kg	% Solids
ADF&G	4/29/92	Wulik R.	F	291	1800		3.20	0.410	40.30	< 0.02	152.00	27.00
ADF&G	4/29/92	Wulik R.	F	424	670	(2+2)	7.20	0.310	23.800	< 0.02	62.80	46.70
ADF&G	4/29/92	Wulik R.	F	530	1420	(2+3)?	4.70	0.260	47.80	0.02	66.20	39.60
ADF&G	4/29/92	Wulik R.	undet	294	180	(2+1)?	7.60	0.370	32.40	0.03	142.00	27.70
ADF&G	4/29/92	Wulik R.	F	275	140	(3+1)	7.80	0.210	71.80	0.07	222.00	26.40
ADF&G	4/29/92	Wulik R.	M	276	160		2.30	0.740	39.90	< 0.02	162.00	26.50
ADF&G	4/29/92	Wulik R.	M	264	140	(4+1)	5.50	0.450	84.10	0.04	176.00	27
ADF&G	4/29/92	Wulik R.	F	259	150	(3+1)	4.50	0.350	36.20	0.02	160.00	25.30
ADF&G	9/30/92	Wulik R.	F	706	4120	9	1.64	0.270	21.50	0.02	60.00	45.00
ADF&G	9/30/92	Wulik R.	M	620	2820	(3+4)	3.07	0.370	19.50	0.03	67.00	41.80
ADF&G	9/30/92	Wulik R.	F	674	3410	(3+5)	0.92	0.240	19.70	0.02	56.00	50.10
ADF&G	9/30/92	Wulik R.	M	600	2630	(4+4)	0.51	0.160	40.20	< 0.02	60.00	48.10
ADF&G	9/30/92	Wulik R.	F	564	2110	(3+4)	0.61	0.320	45.60	0.02	74.00	41.40
ADF&G	9/30/92	Wulik R.	M	595	2920	(2+4)	0.55	0.150	20.00	< 0.02	59.00	41.40

Appendix 1, continued.

Gill Tissue

Collected By	Date	Location	Sex	Length mm	Weight grams (fresh+salt)	Age	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Zn mg/kg	% Solids
D&M	1-Jun-81	Wulik R.	a					0.770	3.00	< 0.03	67.20	
D&M	1-Aug-81	Wulik R.	a					0.360	3.20	< 0.04	34.10	
D&M	1-Sep-81	Wulik R.	a					0.790	3.10	< 0.04	67.40	
D&M	1-Jun-81	Wulik R.	a					1.200	3.20	< 0.02	68.60	
D&M	1-Sep-81	Mid-Ikaluk	a					1.400	3.10	< 0.03	52.70	
D&M	*1982	Wulik R.	a					5.750	0.75	3.18	0.03	24.76
ADF&G	5-Oct-90	Wulik R.	f	538			1.80	1.630	2.20	0.20	90.40	22.30
ADF&G	5-Oct-90	Wulik R.	f	615			1.30	0.680	3.10	< 0.10	70.90	25.80
ADF&G	5-Oct-90	Wulik R.	m	608			1.40	1.440	2.60	< 0.10	68.70	24.00
ADF&G	5-Oct-90	Wulik R.	f	430			2.00	1.200	3.30	0.10	70.50	26.20
ADF&G	5-Oct-90	Wulik R.	f	452			0.60	1.220	2.10	< 0.10	70.20	21.60
ADF&G	5-Oct-90	Wulik R.	f	528			2.20	2.440	2.60	0.20	96.60	24.10
Cominco	9-Mar-91	Wulik R.					6.10	0.390	2.30	< 0.10	87.40	19.20
Cominco	9-Mar-91	Wulik R.					7.80	0.660	2.30	< 0.10	87.60	22.00
Cominco	9-Mar-91	Wulik R.					10.80	1.020	2.30	< 0.10	77.80	22.10
KIVALINA	6-Apr-91	Wulik R.	m	300	1279		5.00	0.450	2.60	< 0.10	94.80	19.50
KIVALINA	6-Apr-91	Wulik R.	m	294	197		13.90	0.360	1.90	< 0.10	74.40	18.60
KIVALINA	6-Apr-91	Wulik R.	f	303	201		3.40	0.820	2.20	< 0.10	88.40	19.30
KIVALINA	6-Apr-91	Wulik R.	f	355	237		4.20	0.330	2.50	0.20	70.30	19.00
KIVALINA	6-Apr-91	Wulik R.	f	434	751		16.10	0.850	1.90	< 0.10	83.00	19.80
Cominco	26-Apr-91	Wulik R.	f	518	1279		3.2	0.79	1.7	1.1	79.8	20.4
ADF&G	15-Apr-91	Noatak	f	323	274		27.60	0.050	1.80	0.20	105.00	20.30
ADF&G	15-Apr-91	Noatak	f	324	283		15.60	0.060	1.60	0.10	79.80	22.30
ADF&G	15-Apr-91	Noatak	m	416	714		3.50	0.070	2.20	0.10	81.20	20.50
ADF&G	15-Apr-91	Noatak	f	443	730		6.70	0.100	1.50	< 0.10	76.60	21.30
ADF&G	15-Apr-91	Noatak	f	401	449		10.50	0.040	2.20	< 0.10	84.00	20.30
Cominco	6/16/91	Wulik R.	m	489	962		36.60	1.510	3.10	1.00	75.60	18.20
Cominco	6/16/91	Wulik R.	f	538	1426		56.30	0.780	3.00	3.00	79.30	21.10
Cominco	6/16/91	Wulik R.	m	541	1361		21.20	1.150	2.70	0.60	75.50	18.80
Cominco	6/16/91	Wulik R.	f	461	762		18.40	2.000	3.10	1.50	89.60	22.20
Cominco	6/16/91	Wulik R.	f	417	672		20.50	0.640	2.10	0.80	64.70	21.40
Cominco	6/16/91	Wulik R.	f	430	745		33.30	0.830	2.80	1.50	75.30	20.80
Cominco	6/16/91	Wulik R.	f	443	680		60.20	0.850	2.90	2.40	67.70	21.50
Cominco	6/16/91	Wulik R.	f	430	654		1.20	1.820	3.10	1.20	78.50	20.20
Cominco	10/5/91	Wulik R.	F	480	1162		1.61	0.550	3.39	0.10	70.80	21.00
Cominco	10/5/91	Wulik R.	M	480	1262		23.40	0.300	2.92	0.16	75.20	19.30
Cominco	10/5/91	Wulik R.	M	614	2551		10.60	0.630	2.82	0.29	71.40	20.30
Cominco	10/5/91	Wulik R.	F	589	2188		2.08	0.540	3.64	0.23	72.30	23.00
Cominco	10/5/91	Wulik R.	F	525	1616		22.10	0.500	4.23	1.26	73.60	19.80
Cominco	10/5/91	Wulik R.	M	563	2233		31.70	0.710	5.10	0.33	84.10	21.70

Appendix 1, continued.

Collected By	Date	Location	Sex	Length mm	Weight grams (fresh+salt)	Age	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Zn mg/kg	% Solids
ADF&G	4/29/92	Wulik R.	F	291	1800		3.10	0.130	3.34	0.18	93.30	20.80
ADF&G	4/29/92	Wulik R.	F	424	670	(2+2)	2.10	0.160	1.780	0.07	65.50	25.90
ADF&G	4/29/92	Wulik R.	F	530	1420	(2+3)?	9.00	0.070	1.79	0.11	65.70	27.80
ADF&G	4/29/92	Wulik R.	undet	294	180	(2+1)?	2.30	0.130	1.92	0.07	84.20	21.00
ADF&G	4/29/92	Wulik R.	F	275	140	(3+1)	2.70	0.120	3.73	0.04	93.70	19.90
ADF&G	4/29/92	Wulik R.	M	276	160		4.40	0.140	2.21	0.02	81.30	19.20
ADF&G	4/29/92	Wulik R.	M	264	140	(4+1)	5.90	0.080	2.24	0.06	80.20	20.30
ADF&G	4/29/92	Wulik R.	F	259	150	(3+1)	1.70	0.090	2.13	0.03	77.70	19.90
ADF&G	9/30/92	Wulik R.	F	706	4120	9	2.79	0.240	3.22	0.04	76.00	21.20
ADF&G	9/30/92	Wulik R.	M	620	2820	(3+4)	2.29	0.420	8.50	0.16	90.00	18.80
ADF&G	9/30/92	Wulik R.	F	674	3410	(3+5)	1.25	0.410	2.92	< 0.02	86.00	19.80
ADF&G	9/30/92	Wulik R.	M	600	2630	(4+4)	1.28	0.330	2.90	0.04	91.00	20.30
ADF&G	9/30/92	Wulik R.	F	564	2110	(3+4)	1.39	0.330	2.92	< 0.02	94.00	19.80
ADF&G	9/30/92	Wulik R.	M	595	2920	(2+4)	1.02	0.360	2.34	0.04	73.00	21.60

Appendix 1, continued.

Kidney Tissue

Collected By	Date	Location	Sex	Length mm	Weight grams (fresh+salt)	Age	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Zn mg/kg	% Solids
D&M	1-Jun-81	Wulik R.	a					0.320	4.90	0.02	80.10	
D&M	1-Aug-81	Wulik R.	a					2.900	5.20	< 0.05	74.60	
D&M	1-Sep-81	Wulik R.	a					3.000	5.80	< 0.03	109.00	
D&M	1-Jun-81	Wulik R.	a					5.300	4.00	< 0.02	75.90	
D&M	*1982	Wulik R.	a				3.00	2.530	5.28	0.03	94.43	
ADF&G	5-Oct-90	Wulik R.	f	538			1.50	5.340	3.30	0.20	117.00	21.40
ADF&G	5-Oct-90	Wulik R.	f	615			1.10	2.220	4.80	< 0.10	96.40	21.90
ADF&G	5-Oct-90	Wulik R.	m	608			0.70	1.530	4.80	< 0.10	79.30	24.00
ADF&G	5-Oct-90	Wulik R.	f	430			3.00	2.930	5.20	< 0.10	100.00	23.70
ADF&G	5-Oct-90	Wulik R.	f	452			0.90	3.300	5.00	< 0.10	106.00	21.90
ADF&G	5-Oct-90	Wulik R.	f	528			1.10	2.630	5.30	< 0.10	103.00	18.50
Cominco	9-Mar-91	Wulik R.					2.30	3.590	4.80	< 0.10	143.00	23.10
Cominco	9-Mar-91	Wulik R.					4.70	3.480	5.20	< 0.10	103.00	22.90
Cominco	9-Mar-91	Wulik R.					2.10	3.200	4.90	< 0.10	118.00	23.60
KIVALINA	6-Apr-91	Wulik R.		300	1279		2.40	4.310	3.70	< 0.20	127.00	20.30
KIVALINA	6-Apr-91	Wulik R.		294	197		8.80	0.850	2.70	< 0.40	85.60	23.40
KIVALINA	6-Apr-91	Wulik R.		303	201		22.00	1.960	4.10	1.50	173.00	23.70
KIVALINA	6-Apr-91	Wulik R.		355	237		7.40	0.170	9.00	0.40	139.00	21.80
KIVALINA	6-Apr-91	Wulik R.		434	751		2.10	2.790	3.50	< 0.10	102.00	22.40
Cominco	26-Apr-91	Wulik R.		518	1279		1.00	5.400	6.20	0.20	112.00	21.00
ADF&G	15-Apr-91	Noatak		323	274		2.10	0.930	3.20	< 0.10	112.00	23.10
ADF&G	15-Apr-91	Noatak		324	283		4.60	0.570	2.90	< 0.10	79.80	22.00
ADF&G	15-Apr-91	Noatak		416	714		2.20	2.010	3.20	< 0.10	93.40	26.50
ADF&G	15-Apr-91	Noatak		443	730		4.10	2.060	3.30	< 0.10	106.00	23.20
ADF&G	15-Apr-91	Noatak		401	449		5.00	1.820	3.70	0.10	108.00	18.00
Cominco	6/16/91	Wulik R.	m	489	962		6.00	6.560	6.00	0.10	83.30	18.30
Cominco	6/16/91	Wulik R.	f	538	1426		2.40	4.870	4.10	< 0.10	89.20	23.00
Cominco	6/16/91	Wulik R.	m	541	1361		1.70	4.140	4.00	0.20	76.60	22.30
Cominco	6/16/91	Wulik R.	f	461	762		2.10	3.090	4.50	< 0.10	94.50	22.40
Cominco	6/16/91	Wulik R.	f	417	672		1.50	2.470	3.50	< 0.10	208.00	15.20
Cominco	6/16/91	Wulik R.	f	430	745		1.60	2.230	4.20	< 0.10	71.10	21.90
Cominco	6/16/91	Wulik R.	f	443	680		1.90	4.010	4.90	< 0.10	108.00	22.50
Cominco	6/16/91	Wulik R.	f	430	654		1.30	3.230	4.10	< 0.10	95.90	21.20
Cominco	10/5/91	Wulik R.	F	480	1162		0.96	1.270	4.54	0.06	87.10	22.70
Cominco	10/5/91	Wulik R.	M	480	1262		1.86	1.660	4.89	0.62	92.40	22.80
Cominco	10/5/91	Wulik R.	M	614	2551		3.93	0.870	17.70	1.75	51.20	23.00
Cominco	10/5/91	Wulik R.	F	589	2188		1.30	2.540	6.18	0.03	104.00	22.30
Cominco	10/5/91	Wulik R.	F	525	1616		1.86	4.680	5.94	0.04	107.00	21.50
Cominco	10/5/91	Wulik R.	M	563	2233		0.75	2.810	4.37	0.06	86.40	22.90

Appendix 1, continued.

Collected By	Date	Location	Sex	Length mm	Weight grams (fresh+salt)	Age	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Zn mg/kg	% Solids
ADF&G	4/29/92	Wulik R.	F	291	1800		6.60	0.620	5.04	0.04	114.00	36.40
ADF&G	4/29/92	Wulik R.	F	424	670	(2+2)	5.00	1.510	3.570	0.04	78.10	24.20
ADF&G	4/29/92	Wulik R.	F	530	1420	(2+3)?	5.70	1.280	3.43	0.02	86.60	24.50
ADF&G	4/29/92	Wulik R.	undet	294	180	(2+1)?	4.70	0.530	3.83	0.04	91.70	20.80
ADF&G	4/29/92	Wulik R.	F	275	140	(3+1)	4.30	0.380	6.43	0.06	99.70	21.40
ADF&G	4/29/92	Wulik R.	M	276	160		8.10	1.670	3.88	0.05	95.50	19.80
ADF&G	4/29/92	Wulik R.	M	264	140	(4+1)	2.60	0.400	3.50	0.04	82.20	17.40
ADF&G	4/29/92	Wulik R.	F	259	150	(3+1)	5.90	0.800	4.22	0.03	114.00	21.30
ADF&G	9/30/92	Wulik R.	F	706	4120	9	3.08	2.740	4.49	< 0.02	85.00	22.50
ADF&G	9/30/92	Wulik R.	M	620	2820	(3+4)	2.30	2.970	5.00	< 0.02	110.00	22.60
ADF&G	9/30/92	Wulik R.	F	674	3410	(3+5)	1.13	2.370	4.09	< 0.02	74.00	28.00
ADF&G	9/30/92	Wulik R.	M	600	2630	(4+4)	0.97	1.260	5.64	< 0.02	93.00	24.20
ADF&G	9/30/92	Wulik R.	F	564	2110	(3+4)	1.00	2.140	5.24	0.06	105.00	24.30
ADF&G	9/30/92	Wulik R.	M	595	2920	(2+4)	1.66	1.640	3.69	0.24	81.00	24.10

m=male, f=female, a=adult fish, sex not specified

*1982 data from Dames and Moore is an average of several fish. Data on exact numbers are not available.

Please refer to file QAQC for information on the quality control/ quality assurance data for these samples

Appendix 2. Quality control/quality assurance data for concentrations of metals in Dolly Varden tissues. (Metals concentrations data presented in Appendix 1.)

Duplicate Samples

Dates of Samples QA/QC applies to	Metal	Method	Method Reporting Limit	Sample A	Sample B	%Relative Difference
10/5/90	Al	202.2	0.10	1.50	1.00	38
	Cd	7131	0.01	1.11	1.14	3
	Cu	6010	0.40	25.60	27.00	5
	Pb	7412	0.10	0.10	ND	
	Zn	6010	0.40	103.00	105.00	2
10/19/90	Al	202.2	0.10	2.30	4.30	61
	Cd	7131	0.01	0.01	0.01	0
	Cu	6010	0.50	2.40	3.50	37
	Pb	7412	0.10	0.10	0.10	0
	Zn	6010	0.50	12.90	13.80	7
3/9/91	Al	202.2	0.10	2.20	2.30	4
	Cd	7131	0.01	nd	nd	
	Cu	6010	0.50	3.50	3.70	6
	Pb	7412	0.10	nd	nd	
	Zn	6010	0.50	18.60	17.60	6
4/6/91	Al	202.2	0.10	6.40	6.80	6
4/15/91	Cd	7131	0.01	0.04	0.04	<1
	Cu	6010	0.50	2.40	2.20	9
	Pb	7412	0.10	nd	nd	
	Zn	6010	0.50	16.10	16.40	2
4/6/91	Al	202.2	0.10	4.10	3.80	8
4/15/91	Cd	7131	0.01	0.01	nd	
continued	Cu	6010	0.50	1.20	1.20	<1
	Pb	7412	0.10	nd	nd	
	Zn	6010	0.50	17.00	16.90	<1
4/26/91	Al	202.2	0.10	1.20	1.30	8
6/16/91	Cd	7131	0.01	ND	ND	
	Cu	6010	0.50	1.70	1.50	12
	Pb	7412	0.10	ND	ND	
	Zn	6010	0.50	13.60	13.80	4
4/26/91	Al	202.2	0.10	2.10	2.20	4
6/16/91	Cd	7131	0.01	3.09	3.12	<1
continued	Cu	6010	0.50	4.50	4.30	5
	Pb	7412	0.10	ND	ND	
	Zn	6010	0.50	94.50	90.70	4
10/5/91	Al	200.8	0.05	0.55	0.59	7
	Cd	200.8	0.02	ND	ND	--
	Cu	200.8	0.05	2.55	2.15	17
	Pb	200.8	0.02	0.03	0.04	25
	Zn	200.8	0.05	14.90	14.00	6
10/5/91	Al	200.8	0.05	0.32	0.28	13
Continued	Cd	200.8	0.02	ND	ND	--
	Cu	200.8	0.05	2.42	2.35	3
	Pb	200.8	0.02	0.05	0.03	50
	Zn	200.8	0.05	12.20	12.20	<1

Appendix 2, continued.

Duplicate Samples

Dates of Samples QA/QC applies to	Metal	Method	Method Reporting Limit	Sample A	Sample B	%Relative Difference
4/29/92	Al	200.8	0.5	2.5	6.9	94
	Cd	7131	0.02	ND	ND	---
	Cu	200.8	0.05	2.27	2.51	10
	Pb	200.8	0.02	ND	0.08	NC
	Zn	200.8	0.2	16.5	16.5	<1
4/29/92 (continued)	Al	200.8	0.5	2.6	2.4	8
	Cd	7131	0.02	ND	ND	---
	Cu	200.8	0.05	2.38	2.27	5
	Pb	200.8	0.02	0.02	ND	---
	Zn	200.8	0.2	22.9	22.3	3
9/30/92	Al	200.8	0.05	0.47	0.47	<1
	Cd	200.8	0.02	ND	ND	---
	Cu	200.8	0.05	1.27	1.23	3
	Pb	200.8	0.02	ND	ND	---
	Zn	7950	1	11	12	8
9/30/92 continued	Al	200.8	0.05	0.42	0.56	29
	Cd	200.8	0.02	ND	ND	---
	Cu	200.8	0.05	1.59	1.42	11
	Pb	200.8	0.02	ND	0.02	NC
	Zn	7950	1	14	13	7

Appendix 2, continued.

			Matrix Spike Results				Method Blank Summary		
	Metal	Method	Spike Level	Sample Result	Spiked Sample Result	% Recovery	MB1	MB2	MB3
10/5/90	Al	202.2	4.70	1.50	6.80	113	ND		
	Cd	7131	0.95	1.11	1.93	86	ND		
	Cu	6010	4.70	25.60	32.60	NC	ND		
	Pb	7412	0.90	0.10	0.90	89	ND		
	Zn	6010	23.70	103.00	129.00	NC	ND		
10/19/90	Al	202.2	47.70	2.30	76.40	155	ND		
	Cd	7131	1.20	0.01	1.34	112	ND		
	Cu	6010	47.70	2.40	59.80	120	ND		
	Pb	7412	4.80	0.10	5.10	106	ND		
	Zn	6010	119.00	12.90	135.00	103	ND		
3/9/91	Al	202.2	10.40	2.20	10.20	77	0.2		
	Cd	7131	1.04	nd	1.14	110	nd		
	Cu	6010	41.50	3.50	47.30	106	nd		
	Pb	7412	4.20	nd	4.30	102	nd		
	Zn	6010	104.00	18.60	126.00	103	nd		
4/6/91	Al	202.2	9.60	6.40	16.10	101	0.2	0.2	0.2
4/15/91	Cd	7131	0.96	0.04	1.10	110	nd	nd	nd
	Cu	6010	38.50	2.40	43.40	106	nd	nd	nd
	Pb	7412	3.90	nd	4.10	105	nd	nd	nd
	Zn	6010	96.30	16.10	113.00	101	nd	nd	nd
4/6/91	Al	202.2	9.70	4.10	14.70	109			
4/15/91	Cd	7131	0.97	0.01	1.07	109			
continued	Cu	6010	38.40	1.20	42.70	108			
	Pb	7412	3.90	nd	4.00	103			
	Zn	6010	96.00	17.00	116.00	103			
4/26/91	Al	202.2	6.70	1.20	6.40	78	0.3	0.3	
6/16/91	Cd	7131	0.67	ND	0.67	100	ND	ND	
	Cu	6010	26.90	1.70	28.80	101	ND	ND	
	Pb	7412	2.70	ND	2.70	100	ND	ND	
	Zn	6010	67.30	14.10	78.40	96	ND	ND	
4/26/91	Al	202.2	9.20	2.10	12.20	110	0.4	0.2	
6/16/91	Cd	7131	0.92	3.09	4.01	100	ND	ND	
continued	Cu	6010	36.70	4.50	39.70	96	ND	ND	
	Pb	7412	3.70	ND	3.90	105	ND	ND	
	Zn	6010	91.70	94.50	178.00	91	ND	ND	
10/5/91	Al	200.8	4.06	0.55	3.97	84	0.5	0.6	0.51
	Cd	200.8	0.81	ND	0.88	109	ND	ND	ND
	Cu	200.8	16.20	2.55	18.20	97	0.08	ND	ND
	Pb	200.8	1.62	0.03	1.81	110	0.04	ND	ND
	Zn	200.8	40.60	14.90	51.60	90	0.9	0.4	0.31
10/5/91	Al	200.8	4.48	0.32	5.42	114			
Continued	Cd	200.8	0.90	ND	0.97	108			
	Cu	200.8	17.90	2.42	21.40	106			
	Pb	200.8	1.79	0.05	2.13	116			
	Zn	200.8	44.80	12.20	56.40	99			

Appendix 2, continued.

			Matrix Spike Results				Method Blank Summary		
	Metal	Method	Spike Level	Sample Result	Spiked Sample Result	% Recovery	MB1	MB2	MB3
4/29/92	Al	200.8	4.8	2.5	8	115	ND	ND	
	Cd	7131	4.8	ND	5.08	106	ND	ND	
	Cu	200.8	19	2.27	20.5	96	ND	ND	
	Pb	200.8	4.8	ND	4.83	101	ND	ND	
	Zn	200.8	48	16.5	63.3	98	ND	ND	
4/29/92	Al	200.8	4.6	2.6	5.5	63			
(continued)	Cd	7131	4.6	ND	4.58	100			
	Cu	200.8	18	2.38	19.4	95			
	Pb	200.8	4.6	0.02	4.57	99			
	Zn	200.8	46	22.9	66.5	95			
9/30/92	Al	200.8	4.6	0.47	4.9	96	0.36	0.2	
	Cd	200.8	0.92	ND	0.89	97	ND	ND	
	Cu	200.8	18	1.27	18.3	95	ND	ND	
	Pb	200.8	1.8	ND	1.93	107	ND	ND	
	Zn	7950	46	11	59	104	ND	ND	
9/30/92	Al	200.8	4.8	0.42	5.2	100			
continued	Cd	200.8	0.95	ND	0.94	99			
	Cu	200.8	19	1.59	19.3	93			
	Pb	200.8	1.9	ND	1.97	104			
	Zn	7950	48	14	63	102			

ND = not detected at MRL
NC = not calculated due to sample concentration greater than 4 times the spike level

Appendix 3. Dolly Varden collected in Evaingiknuk Creek using minnow traps baited with salmon roe.

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

Appendix 4. Dolly Varden collected in Dudd Creek using minnow traps baited with salmon roe.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
8/23-24/90	5	22	2	80,127	0.4±0.5
8/24-26/90	5	41	8	89-133(115)	1.6±3.6
9/12-13/90	5	15	1	125	0.2±0.4
9/13-14/90	5	25	0		0.0
9/14-15/90	5	23	2		0.4±0.9
7/17-18/91	5	23	8	55-118(82)	1.6±1.8
7/18-19/91	5	23	10	55-134(101)	2.0±1.6
7/19-20/91	5	21	9	59-133(84)	1.8±2.2
8/5-8/91	5	65	36	53-161(92)	7.2±5.7
8/27-30/91	5	64	8	68-136(101)	1.6±2.1
10/2-5/91	5	72	35	69-145(89)	7.0±12.0
6/30-7/1/92	10	23	0		
7/28-29/92	10	24	9	54-110(89)	0.9±1.3
8/25-26/92	10	24	48	57-138(116)	4.8±4.8

Appendix 5. Dolly Varden collected in Anxiety Ridge Creek using minnow traps baited with salmon roe.

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

Appendix 5 continued.

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

Appendix 6. Dolly Varden collected in Little Creek using minnow traps baited with salmon roe.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
7/29-30/90	5	17	7	97-127(107)	1.4±1.5
6/17-18/91	5	24	4	131-163(145)	0.8±1.3
6/18-19/91	5	25	0		0.0
6/19-20/91	5	22	0		0.0
7/20-21/91	5	24	2	112,113	0.4±0.9
7/21-22/91	5	24	4	99-114(107)	0.8±1.3
7/22-23/91	5	14	4	92-114(107)	0.8±1.8
8/5-6/91	5	21	7	104-142(120)	1.4±1.1
8/6-7/91	5	25	8	54-140(116)	1.6±1.1
8/7-8/91	5	19	8	54-142(116)	1.6±1.1
8/27-28/91	5	22	1	51	0.2±0.4
8/28-29/91	5	25	1	126	0.2±0.4
8/29-30/91	5	19	1	58	0.2±0.4
10/2-3/91	4	24	2	61,78	0.5±1.0
10/3-4/91	5	21	1	60	0.2±0.4
10/4-5/91	5	26	1	102	0.2±0.4
6/30-7/1/92	10	23	0		
7/28-29/92	10	24	17	88-136(100)	1.7±3.7
8/25-26/92	10	24	74	60-145(105)	7.4±5.3

Appendix 7. Dolly Varden collected in Ikalukrok Creek using minnow traps baited with salmon roe. 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 mouth of Dudd Creek. Sample stations (#1 - #5) in Ikalukrok Creek at Dudd Creek were the same in 1990, 1991, and 1992; however, five additional sites were established in 1992.

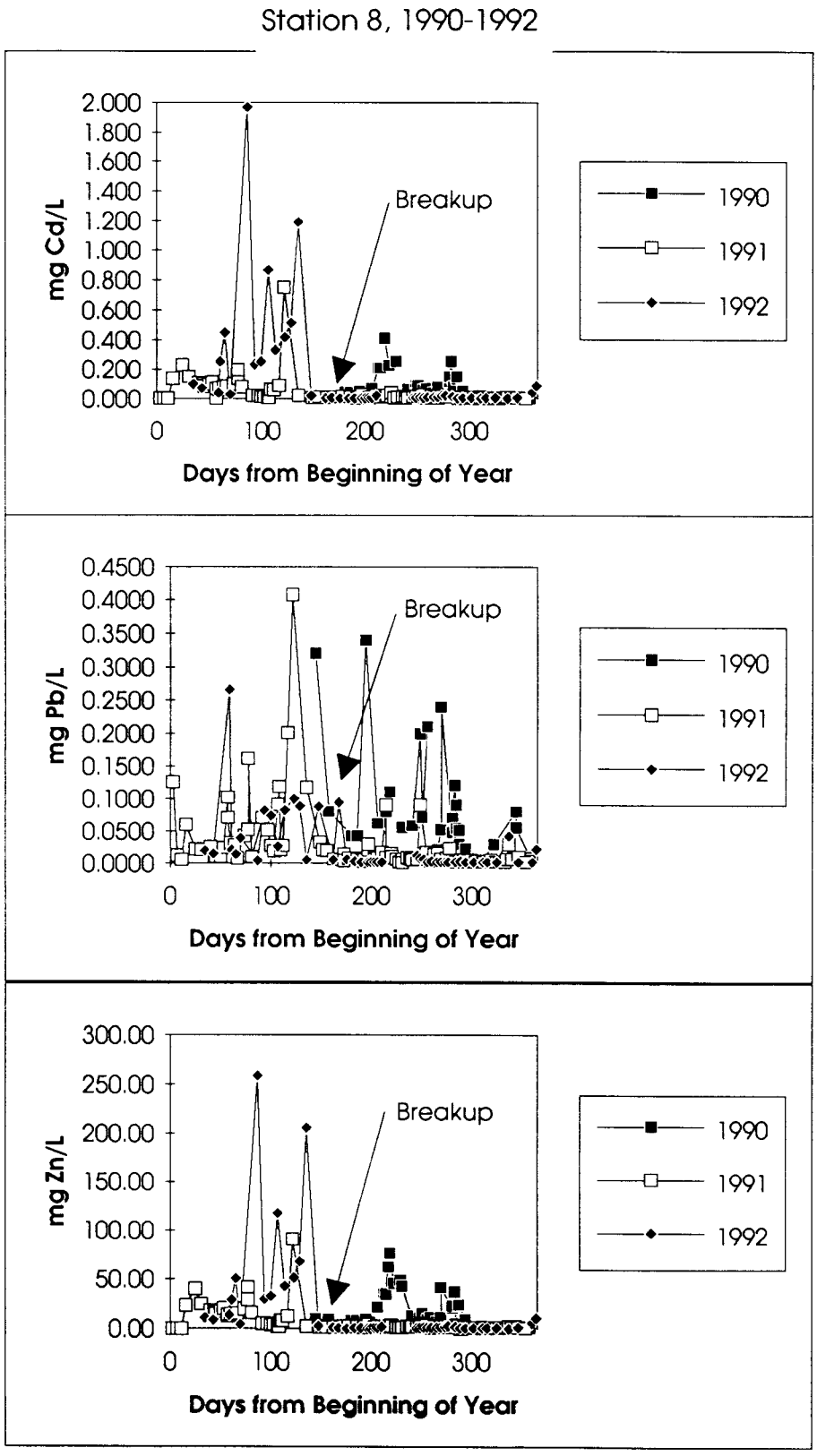
Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
[a]7/27-28/90	5	19	0		0.0
[b]7/27-28/90	5	23	1	107	0.2±0.4
[c]7/28-29/90	5	23	0		0.0
[d]7/28-29/90	5	22	0		0.0
[d]8/23-24/90	5	24	0		0.0
[e]8/23-24/90	5	24	0		0.0
[e]8/24-26/90	5	48	0		0.0
[f]8/24-29/90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

Appendix 7 continued.

Sample Time	Number of Traps	Hours Fished/ Trap	Total Number DV	Length Range (mm), (Average)	DV/Trap ±SD
[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

[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 8. Concentrations of Cd, Pb, and Zn at Station 8 and Station 10, 1990-1992.



Appendix 8. Continued.