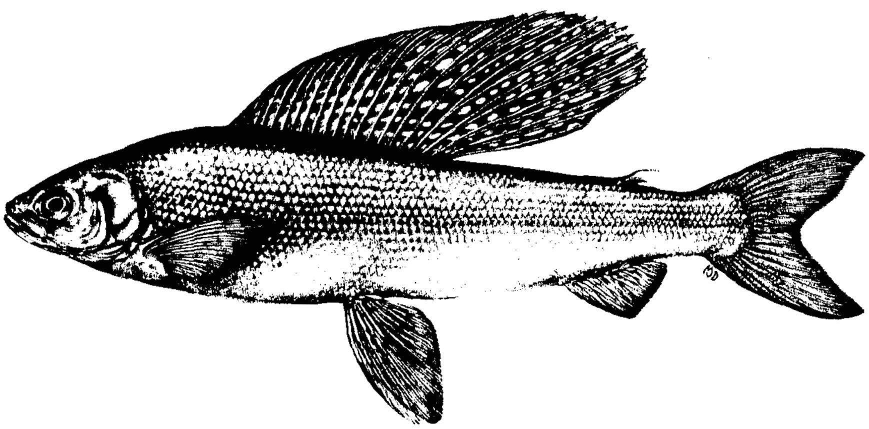
# FISHERY RESOURCES BELOW THE RED DOG MINE NORTHWEST ALASKA

By

Phyllis Weber Scannell and Alvin G. Ott

Technical Report No. 95-5



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August 1995

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# NORTHWEST ALASKA
# 1990-1994

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ACKNOWLEDGEMENTS

We thank Cominco Alaska Inc. for the logistical and financial support they have provided for the fish monitoring study since 1991. Without their assistance, the fish study would not have been possible. Mr. Ralph Hargrave (President, Cominco Alaska Inc.) and Ms. Charlotte MacCay (Manager, Environmental Affairs, Cominco Alaska Inc.) have been especially supportive of our studies.

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# INTRODUCTION

The Red Dog Mine, operated by Cominco Alaska Inc., is in remote northwestern Alaska in the Wulik River drainage, approximately 95 km north of Kotzebue (Figure 1). The mine facility includes a tailing impoundment, freshwater reservoir, airstrip, mill, living quarters, a solid waste site, and an open pit lead-zinc mine (Figure 2).

In 1991, ADF&G began a three-year study in the Wulik River drainage to document short-term changes in fish distribution occurring during mine development. Our study focused on distribution and relative abundance of juvenile Dolly Varden and Arctic grayling in the Wulik River drainage and changes in concentrations of metals in adult Dolly Varden. Additional information on fish use of the Wulik River has been provided by ADF&G's aerial surveys of overwintering Dolly Varden and adult chum salmon since 1966. Results and conclusions of the three-year monitoring study were reported in Ott and Weber Scannell (1994).

The ADF&G initiated a 5-year study in 1994 to document long-term changes in fish distribution, relative abundance, fish species composition, and metal concentrations in Dolly Varden tissues. This report is divided into two parts; Part 1 presents a summary of water quality and fisheries in the Wulik River drainage before 1994 and Part 2 presents results from the first year of the 5-year fisheries study.

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

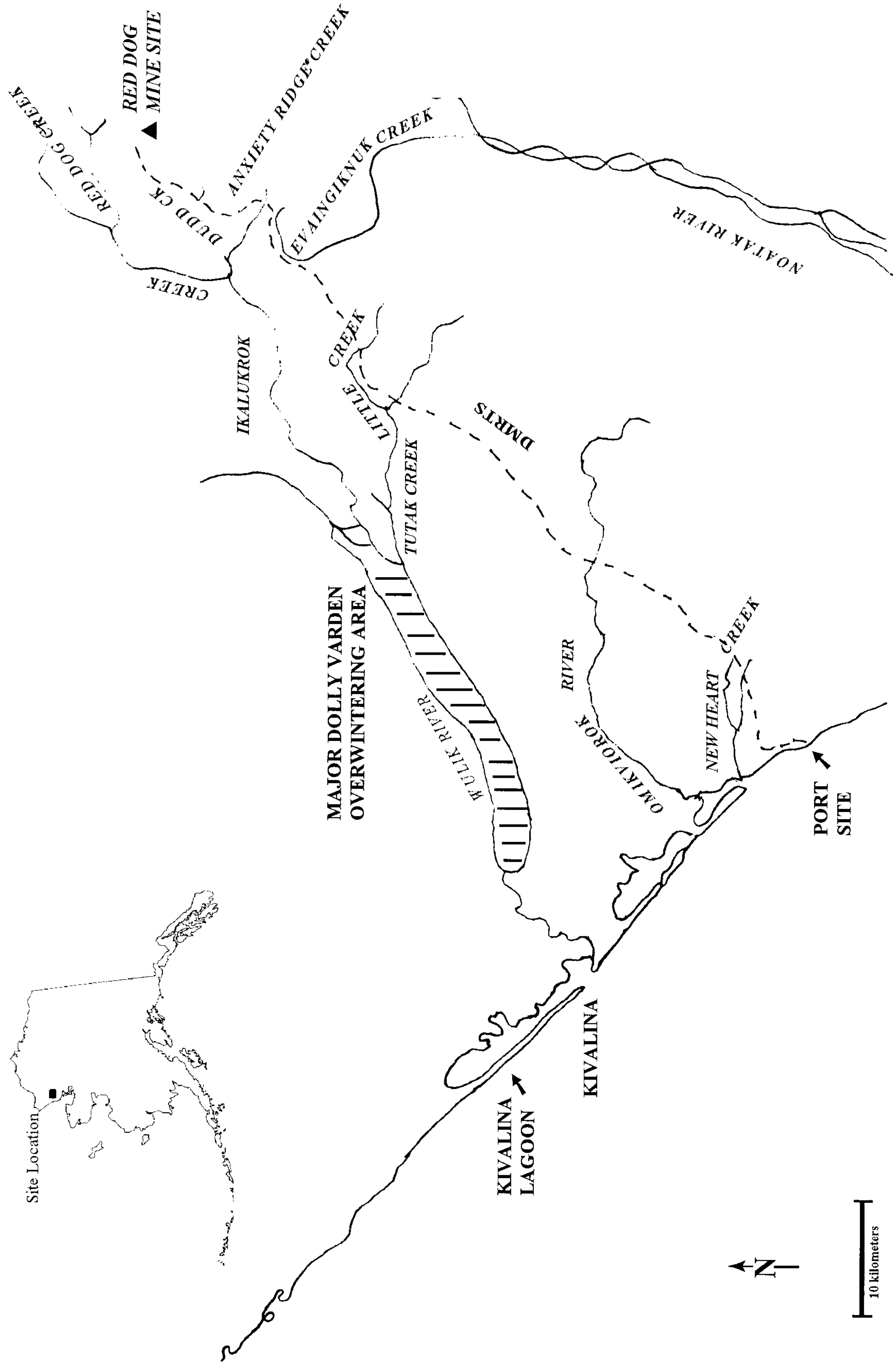
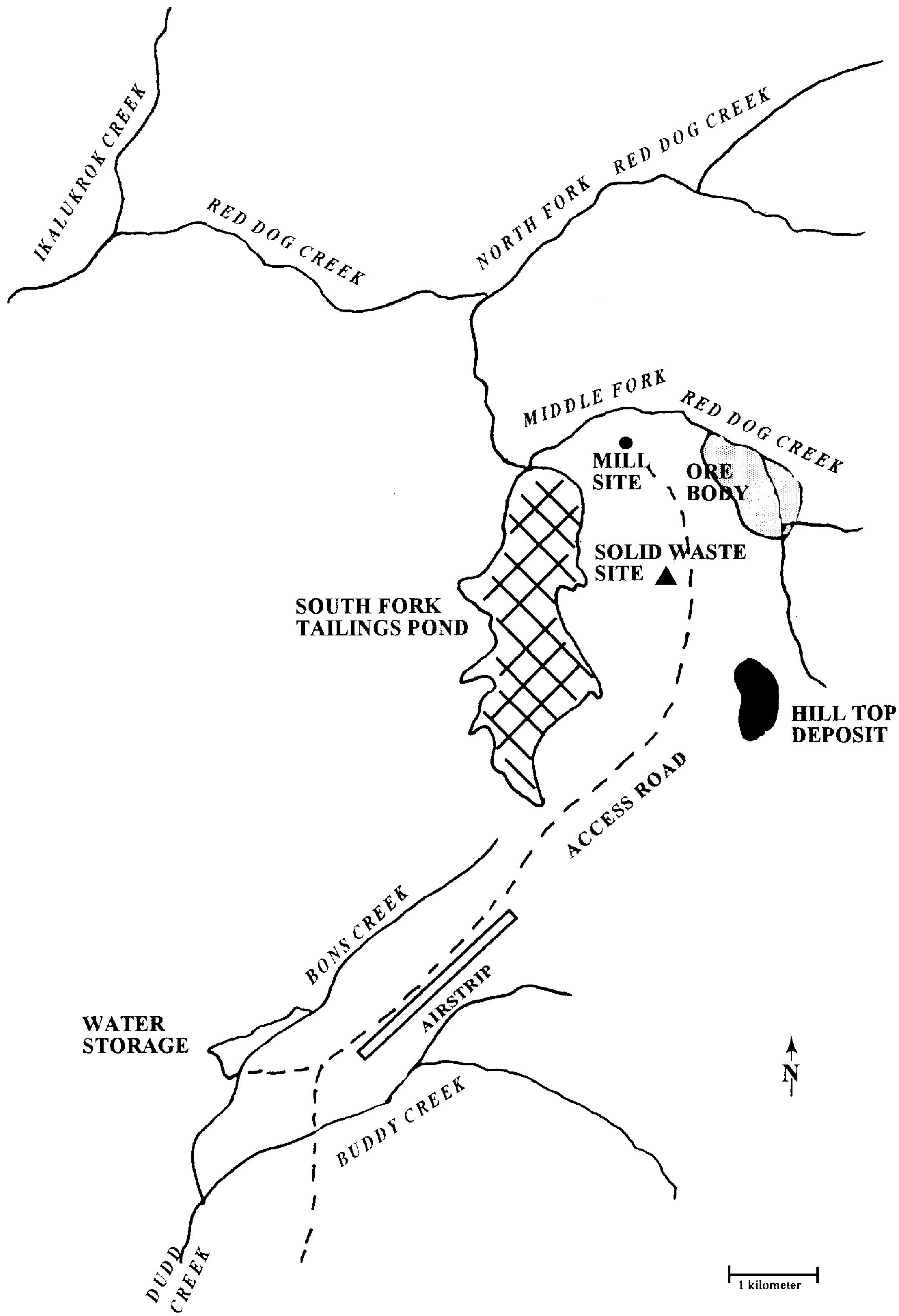


Figure 2. Major facilities, including the mill, airstrip, tailing impoundment, solid waste site, and freshwater impoundment at the Red Dog Mine.



# PART 1: WATER QUALITY AND FISHERIES: A SUMMARY OF HISTORICAL INFORMATION

## WATER QUALITY

Planning and baseline data collection for the Red Dog Mine began in late 1979 and extended through 1982. The Environmental Impact Statement for the project was completed in 1983. Cominco Alaska Inc. began processing ore in 1989. Immediate changes in water quality occurred in receiving waters after opening the mine pit. Concentrations of metals in Red Dog and Ikalukrok Creeks increased considerably in 1989 and 1990 compared to baseline conditions. In 1990, concentrations of Zn reached 1510 mg/L in Red Dog Creek below the mine effluent (Station 21). The median Zn concentration in Ikalukrok Creek (Station 8) in 1990 was 18.5 mg/L, with a maximum of 76 mg/L. In comparison, the median baseline concentration of Zn at Station 8 in 1982-83 was 1.1 mg/L, with a maximum of 3 mg/L. Similar comparisons of baseline and 1989-90 concentrations cannot be made for Station 20 because of insufficient baseline data.

Early attempts to control mine seepage water in 1990 had only limited success. In 1991, Cominco Alaska Inc. constructed a lined channel to bypass stream water around the ore body and a pump back system to collect mine seepage water and pump it to the tailing pond for later treatment. Background information on mine operations, streams, fisheries resources, and water quality conditions in Red Dog and Ikalukrok Creeks between 1988 and 1993 were summarized by Ott et al. (1992) and Ott and Weber Scannell (1993, 1994).

Cominco Alaska Inc. added sand filters in 1993 to remove remaining particulate metals from the effluent, and in 1994 a new water treatment system was constructed to increase treatment capacity from about 9 to 22.6 cfs.

Efforts by Cominco Alaska Inc. resulted in improved water quality of downstream waters. Metals concentrations decreased downstream at Station 20 (downstream of the mine effluent in Red Dog Creek) and Station 73 (in Ikalukrok Creek) every year since 1991, with the exception of slight increases in 1994 during periods of high rainfall (Tables 1 and 2).

Table 1. Concentrations of Al, Cd, Pb, and Zn (median, maximum, and minimum) in Red Dog Creek at Station 20 (below the mine discharge) during the ice-free season (June 1 through October 15). 1982 data are from Dames and Moore (1983); remaining data are from Cominco Alaska Inc.

| Year | | Al mg/L | Cd mg/L | Pb mg/L | Zn mg/L |
|---|---|---|---|---|---|
| 1982 | median | 0.33 | 0.078 | 0.11 | 9.91 |
| | maximum | 0.91 | 0.14 | 0.36 | 16.5 |
| | minimum | 0.05 | 0.043 | 0.002 | 5.88 |
| | n | 28 | 33 | 33 | 33 |
| 1991 | median | <0.05 | 0.13 | 0.161 | 21.75 |
| | maximum | 0.48 | 0.19 | 0.295 | 32.40 |
| | minimum | <0.05 | 0.06 | 0.044 | 8.28 |
| | n | 12 | 12 | 12 | 12 |
| 1992 | median | <0.05 | 0.045 | 0.0405 | 6.38 |
| | maximum | 0.226 | 0.147 | 0.23 | 18.7 |
| | minimum | <0.05 | 0.013 | 0.015 | 1.6 |
| | n | 30 | 30 | 30 | 30 |
| 1993 | median | <0.05 | 0.026 | 0.049 | 3.29 |
| | maximum | 0.38 | 0.032 | 0.348 | 3.83 |
| | minimum | <0.05 | 0.013 | 0.016 | 1.64 |
| | n | 17 | 17 | 17 | 17 |
| 1994 | median | 0.086 | 0.029 | 0.095 | 3.57 |
| | maximum | 1.25 | 0.52 | 0.345 | 11.3 |
| | minimum | 0.05 | 0.016 | 0.01 | 2.1 |
| | n | 23 | 23 | 23 | 23 |

Table 2. Median, maximum, and minimum concentrations of Al, Cd, Pb, and Zn in Ikalukrok Creek (Station 8) during the ice-free season (June 1 through October 15). Data for 1993-94 were collected at Station 73 on Ikalukrok Creek (about one mile downstream from Station 8).

| Year | | Al mg/L | Cd mg/L | Pb mg/L | Zn mg/L |
|---|---|---|---|---|---|
| 1981-83 | median | 0.04 | 0.12 | 0.017 | 1.100 |
| | maximum | 0.17 | <0.025 | 0.080 | 3.00 |
| | minimum | 0.02 | <0.004 | <0.003 | 0.349 |
| | n | 13 | 13 | 13 | 13 |
| 1989 | median | 0.30 | 0.02 | 0.037 | 3.10 |
| | maximum | 3.86 | 0.10 | 0.110 | 10.00 |
| | minimum | 0.16 | <0.01 | 0.018 | 0.94 |
| | n | 16 | 17 | 17 | 17 |
| 1990 | median | 0.67 | 0.080 | 0.070 | 18.15 |
| | maximum | 1.80 | 0.410 | 0.340 | 76.00 |
| | minimum | 0.10 | 0.040 | <0.02 | 5.46 |
| | n | 24 | 26 | 23 | 28 |
| 1991 | median | <0.05 | 0.012 | 0.008 | 1.62 |
| | maximum | <0.05 | 0.040 | 0.023 | 3.61 |
| | minimum | <0.05 | 0.007 | <0.001 | 1.07 |
| | n | 12 | 12 | 12 | 12 |
| 1992 | median | <0.05 | 0.007 | <0.002 | 0.865 |
| | maximum | 0.73 | 0.024 | 0.094 | 3.120 |
| | minimum | <0.05 | <0.003 | <0.002 | 0.305 |
| | n | 28 | 28 | 28 | 28 |
| 1993 | median | <0.05 | <0.003 | <0.002 | 0.203 |
| | maximum | 0.28 | <0.003 | 0.009 | 0.389 |
| | minimum | <0.05 | <0.003 | <0.002 | 0.143 |
| | n | 17 | 17 | 17 | 17 |
| 1994 | median | 0.085 | 0.003 | 0.006 | 0.282 |
| | maximum | 1.02 | 0.02 | 0.078 | 2.62 |
| | minimum | 0.05 | 0.003 | 0.002 | 0.098 |
| | n | 23 | 23 | 23 | 23 |

*Limits of Detection vary among 1981-83 data for specific analytes.

Red Dog received unusually high rainfall in summer 1994. Total precipitation between June 1 and September 30 was 47 cm; the water level in the tailing dam increased 2.4 m. In cooperation with Cominco Alaska Inc., ADF&G sampled the tailing pond water for temperature, conductivity, pH, and concentrations of Al, Fe, Cd, Pb, and Zn. The tailing pond contains mine spoils and untreated water that is not discharged to any waterway before treatment. Given high water levels in the pond and the possibility, however remote, that untreated water would be discharged to prevent overtopping, we wanted to determine water quality in the tailing pond water.

In August 1994 water in the tailing pond was completely mixed (Table 3). We found only slight differences in conductivity, pH, temperature, and concentrations of metals at each of three sites along four transects and at each of three depths (surface, 6 m, and 10 m) at each site (a total of 36 locations were sampled).

Table 3. Water quality of the mine tailing pond, August 1994.

| Analyte | median | maximum | minimum | n |
|---|---|---|---|---|
| Temperature, °C | 10.0 | 10.3 | 10.0 | 36 |
| Hardness, mg/L | 1560 | 1690 | 1510 | 36 |
| pH | 3.7 | 3.7 | 3.7 | 36 |
| Conductivity, *u*Si/cm | 2425 | 2468 | 2397 | 36 |
| Al, mg/L | 3.31 | 3.8 | 2.58 | 36 |
| Cd, mg/L | 1.32 | 1.5 | 1.25 | 36 |
| Fe, mg/L | 8.8 | 11.1 | 7.99 | 36 |
| Pb, mg/L | 2.7 | 2.9 | 2.64 | 36 |
| Zn, mg/L | 257 | 259 | 251 | 36 |

In September and October 1994, 734.11 million gallons of water from the tailing dam were treated and discharged. This large discharge lowered water levels in the tailing impoundment by 0.7 m, and reduced the possibility of an untreated discharge. All discharge water met state and federal limits for metals (Table 4). Water was discharged until October 30; then discharge was discontinued for the winter months.

Table 4. Concentrations of metals, total dissolved solids, sulfate, and pH in effluent from the Red Dog Mine wastewater treatment facility, 1994.

| | median mg/L | maximum mg/L | minimum mg/L | n | Limit mg/L |
|---|---|---|---|---|---|
| Hardness | 1660 | 1950 | 714 | 49 | |
| Total Dissolved Solids | 2420 | 2810 | 352 | 63 | |
| Sulfate | 1600 | 2000 | 200 | 41 | |
| pH | 9.6 | 10.3 | 6.8 | 73 | |
| Cd | <LOD | 0.055 | <LOD | 71 | 0.1 |
| Cu | <LOD | <LOD | <LOD | 71 | 0.3 |
| Hg | <LOD | <LOD | <LOD | 45 | |
| Pb | <LOD | <LOD | <LOD | 71 | 0.6 |
| Zn | 0.046 | 0.299 | 0.018 | 71 | 1.5 |
| total cyanide | <LOD | 0.13 | <LOD | 73 | 0.1 |

LOD=Limit of Detection, Maximum Daily Limits for Cd, Cu, Pb, Zn, and total CN are from Wastewater Disposal Permit 9332-DB007.

Concentrations of metals did not increase in Ikalukrok Creek during the high volume effluent discharge in 1994. However, the concentration of total dissolved solids (TDS) reached a maximum of 658 mg/L at Station 73 (Table 5), compared to a maximum baseline concentration of 174 mg/L (Station 8, 1981-82). There are insufficient background data on TDS and sulfate at Station 20 to make similar comparisons (Table 6).

Table 5. Total dissolved solids, sulfate, and pH at Station 8 (Station 73 in 1994).

| | | TDS mg/L | Sulfate mg/L | pH |
|---|---|---|---|---|
| 1981 | median | | | |
| | maximum | 174 | | |
| | minimum | 124 | | |
| | n | 2 | | |
| 1982 | median | | 62 | |
| | maximum | | 72 | |
| | minimum | | 36 | |
| | n | | 3 | |
| 1989 | median | | | 7.3 |
| | maximum | | | 7.9 |
| | minimum | | | 6.8 |
| | n | | | 16 |
| 1990 | median | | | 7.1 |
| | maximum | | | 7.8 |
| | minimum | | | 6.5 |
| | n | | | 18 |
| 1991 | median | 271 | | 7.2 |
| | maximum | 406 | | 7.5 |
| | minimum | 174 | | 6.8 |
| | n | 12 | | 12 |
| 1992 | median | 209 | | 7.47 |
| | maximum | 548 | | 8.20 |
| | minimum | 64 | | 6.15 |
| | n | 21 | | 28 |
| 1993 | median | 181 | | 7.7 |
| | maximum | 229 | | 8.2 |
| | minimum | 68 | | 6.7 |
| | n | 17 | | 17 |
| 1994 | median | 166 | 58 | 7.7 |
| (Station 73) | maximum | 658 | 400 | 8.2 |
| | minimum | 72 | 21 | 7.2 |
| | n | 23 | 23 | 23 |

Table 6. Total dissolved solids, sulfate, and pH at Station 20.

| | | TDS mg/L | Sulfate mg/L | pH |
|---|---|---|---|---|
| 1982 | median | | | |
| | maximum | | 108 | |
| | minimum | | 66 | |
| | n | | 2 | |
| 1991 | median | 598 | | |
| | maximum | 1310 | | |
| | minimum | 346 | | |
| | n | 12 | | |
| 1992 | median | 815 | | |
| | maximum | 2230 | | |
| | minimum | 50 | | |
| | n | 31 | | |
| 1993 | median | 235 | | |
| | maximum | 961 | | |
| | minimum | 57 | | |
| | n | 17 | | |
| 1994 | median | 509 | 300 | 7.3 |
| | maximum | 2440 | 1500 | 8.7 |
| | minimum | 97 | 55 | 6.3 |
| | n | 18 | 18 | 17 |

## Fish Population Studies

In 1993, ADF&G completed a three-year monitoring study to identify changes to fish populations downstream of the Red Dog Mine associated with the mine (Ott and Weber Scannell 1994). ADF&G's study focused on distribution and abundance of juvenile Dolly Varden in the Wulik River drainage, concentrations of Al, Cu, Cd, Pb, and Zn in Dolly Varden tissues, and Arctic grayling use of the North Fork of Red Dog Creek.

After 4 years of sampling (1990-1993), we found the greatest reduction in metals concentrations in adult Dolly Varden followed construction of the clean water bypass system (1991). Concentrations of Cd in liver, gill, and kidney; lead in muscle, liver, and gill; and zinc in kidney were reduced significantly (Ott and Weber Scannell 1994).

We found some differences between Dolly Varden collected in the fall, shortly after returning from the ocean, and Dolly Varden collected in the spring, after spending the winter in the Wulik River. Fall-caught Dolly Varden and spring-caught Dolly Varden showed no significant difference in the concentration of Pb. Spring-caught fish had significantly higher concentrations of Al and Zn in muscle, liver, and kidney tissues and Cu in liver than fall-caught fish. In contrast, Cd and Cu in gill tissue were significantly higher in fall-caught fish (Ott and Weber Scannell 1994).

The number and distribution of overwintering adult Dolly Varden has not decreased since the opening of the Red Dog Mine. Prior to development of the mine, overwintering Dolly Varden in the Wulik River ranged from 30,853 to 113,553 fish in 1979 through 1984, with an average of 72,518. Dolly Varden from 1989 to 1993 ranged from 56,384 to 144,138, with an average of 115,661.

Anxiety Ridge Creek had high densities of juvenile Dolly Varden in 1990, 1991 (Ott et al. 1992) and 1993 (Ott and Weber Scannell 1994) and during baseline studies (Dames and Moore 1984). Baseline studies (Hougton and Hilgert 1983) reported only one Dolly Varden in the North Fork of Red Dog Creek. In 1992, ADF&G confirmed juvenile Dolly Varden rearing in the North Fork of Red Dog Creek (Ott et al. 1993). Seasonal abundance of juvenile Dolly Varden was similar in Evaingiknuk, Dud, Anxiety Ridge, Little, Ikalukrok, and the North Fork of Red Dog Creeks in summer 1991 through 1993 (Ott and Weber Scannell 1993, 1994). Juvenile Dolly Varden are sparse in early summer, peak from late July to late August, and are not found in late fall. Dolly Varden were virtually absent from Ikalukrok Creek in summer 1990 during poor water quality conditions (Ott et al. 1992).

Overwintering habitat probably is restricted to the lower portion of Ikalukrok Creek, the Wulik River immediately upstream and downstream of its confluence with Ikalukrok Creek, and to spring-fed areas in tributaries.

## PART 2: YEAR 1 OF THE 5-YEAR FISH MONITORING STUDY

Past studies conducted by ADF&G focused on the distribution and relative abundance of juvenile Dolly Varden, heavy metals concentrations in selected tissues of adult Dolly Varden, and Arctic grayling use of the North Fork of Red Dog Creek. Since beginning operation of the Red Dog Mine, Cominco Alaska Inc. has continued to add facilities that reduced the concentrations of metals in Red Dog Creek, treated higher volumes of metal-laden water to cleaner conditions, and controlled seepage water from the ore body. Changes in fish distribution and habitat have been documented and appeared to coincide with changes in water quality conditions downstream of the Red Dog Mine.

To determine the effectiveness of facilities such as the clean-water bypass, the sand filters, and the new water treatment plant it is essential to continue fisheries studies to document changes in fish distribution, relative abundance, and metals content of fish tissues. The 5-Year monitoring project was based upon the following objectives.

### Objectives of The 5-Year Fish Monitoring Study

1. Summarize changes in water quality and fisheries distribution at the Red Dog Mine from 1981 to 1994;
2. Determine concentrations of aluminum, cadmium, copper, lead, and zinc in Dolly Varden muscle, gill, liver, and kidney tissue.
3. Estimate abundance and assess distribution of overwintering adult Dolly Varden in late September - early October using aerial surveys of the Wulik River from its mouth to approximately five river miles upstream of the confluence of Ikalukrok Creek.
4. Determine relative abundance (catch per unit effort) of juvenile Dolly Varden during the ice-free season in Ikalukrok, Anxiety Ridge, Evaingiknuk, Red Dog, and North Fork of Red Dog Creeks. Evaingiknuk Creek, tributary to the Noatak River, is a reference stream unaffected by the Red Dog Mine.
5. Determine Arctic grayling and juvenile Dolly Varden use of the North Fork of Red Dog Creek.
6. Determine fish use of Red Dog Creek between its mouth and the Red Dog Mine site.

## METHODS

ADF&G Divisions of Habitat and Restoration and Division of Sport Fish collected adult Dolly Varden from the Wulik River by angling in spring 1994 (before break-up) and by seining in fall 1994 (before freeze-up). Each Dolly Varden was placed in a clean plastic container which was labeled with the 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 using standard procedures to minimize contamination (Crawford and Luoma 1993). Tissue was 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 in ultra-pure nitric acid with a rinse in double-distilled water before we began work on a new tissue. We recorded sex and spawning condition and removed otiliths to determine age. Tissue and whole body 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 7).

Table 7. 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] | MDL |
|---|---|---|
| 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 |

[1]EPA Method 200.8 - "Methods for Chemical Analysis of Water and Wastes" EPA 600/4-79-020

Results from the analytical laboratory were sent to us and the laboratory provided Quality Assurance/Quality Control information for each analyte. Beginning with fall 1994, we required the following quality assurance procedures: matrix spikes, standard reference materials, laboratory calibration data, sample blanks, and sample duplicates. We compared the 1990, 1991, 1992, 1993, and 1994 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.

We flew an aerial survey using fixed-wing aircraft in September 1994 over 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. From the Wulik River September flight, we estimated the number of overwintering Dolly Varden and spawning salmon in the Wulik River.

In 1994, minnow traps were set in Evaingiknuk, Anxiety Ridge, Ikalukrok, Red Dog (Middle Fork and Mainstem), and the North Fork of Red Dog Creeks. Minnow traps were located at the same sites within Anxiety Ridge, Evaingiknuk, and Ikalukrok Creeks in 1991, 1992, 1993, and 1994, and at the same sites in the North Fork of Red Dog Creek in 1993 and 1994. Identification markers and flagging on stream bank vegetation were used to designate permanent minnow trap fish sites. Ten traps were fished for 24 hour periods in each creek. Numbers of Dolly Varden captured and fork length (to nearest mm) were recorded. Numbers of fish per trap (catch) were compared among sample areas and times (Analysis of Variance, $p<0.05$).

Five minnow traps were placed in the Middle Fork of Red Dog Creek (upstream of the North Fork of Red Dog Creek) and five in the Mainstem Red Dog Creek (downstream of the North Fork of Red Dog Creek). Minnow traps were fished during late June, late July, and late August. Visual surveys of the Middle Fork of Red Dog Creek were made in late June, late July, and late August 1994, and in the Mainstem of Red Dog Creek for a distance of about 0.4 km below the North Fork of Red Dog Creek.

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

Water samples were collected from Anxiety Ridge Creek with pre-cleaned plastic bottles and analyzed by a commercial laboratory for concentrations of Al, Cd, Cu, Pb, and Zn. Metals concentrations in Anxiety Ridge Creek were compared with juvenile Dolly Varden tissue concentrations measured in 1993 (Ott and Weber Scannell 1994).

## Results and Discussion

### *Metals in Dolly Varden Tissues*

Since 1990, ADF&G has sampled adult Dolly Varden from the Wulik River for concentrations of Al, Cd, Cu, Pb and Zn (Ott et al. 1992, Ott and Weber Scannell 1993, 1994) (Appendix 1 and quality control/quality assurance data, Appendix 2).

Dolly Varden collected in spring and fall 1994 showed some increases in concentrations of Al, Cu, and Zn over previously collected fish. Fall-caught fish had higher concentrations of gill Al than previously reported, and spring-caught fish showed slight Al elevations in kidney, liver, and muscle (Figure 3). Concentrations of Cd in fish collected in 1994 were unchanged from previous samples (Figure 4). Maximum concentrations of Cu were somewhat higher in gills and liver of both spring- and fall-caught fish than in fish collected in 1993 (Figure 5). Median concentrations of Pb in gills of fall-caught fish were somewhat higher than reported in 1992 through spring 1994 (Figure 6). Median concentrations of Zn in muscle of fall-caught fish were somewhat higher than concentrations measured in 1992 through spring 1994 (Figure 7).

Figure 3. Median, maximum, and minimum concentration of aluminum (mg/Kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Wulik River in 1982 and 1990-1994. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.

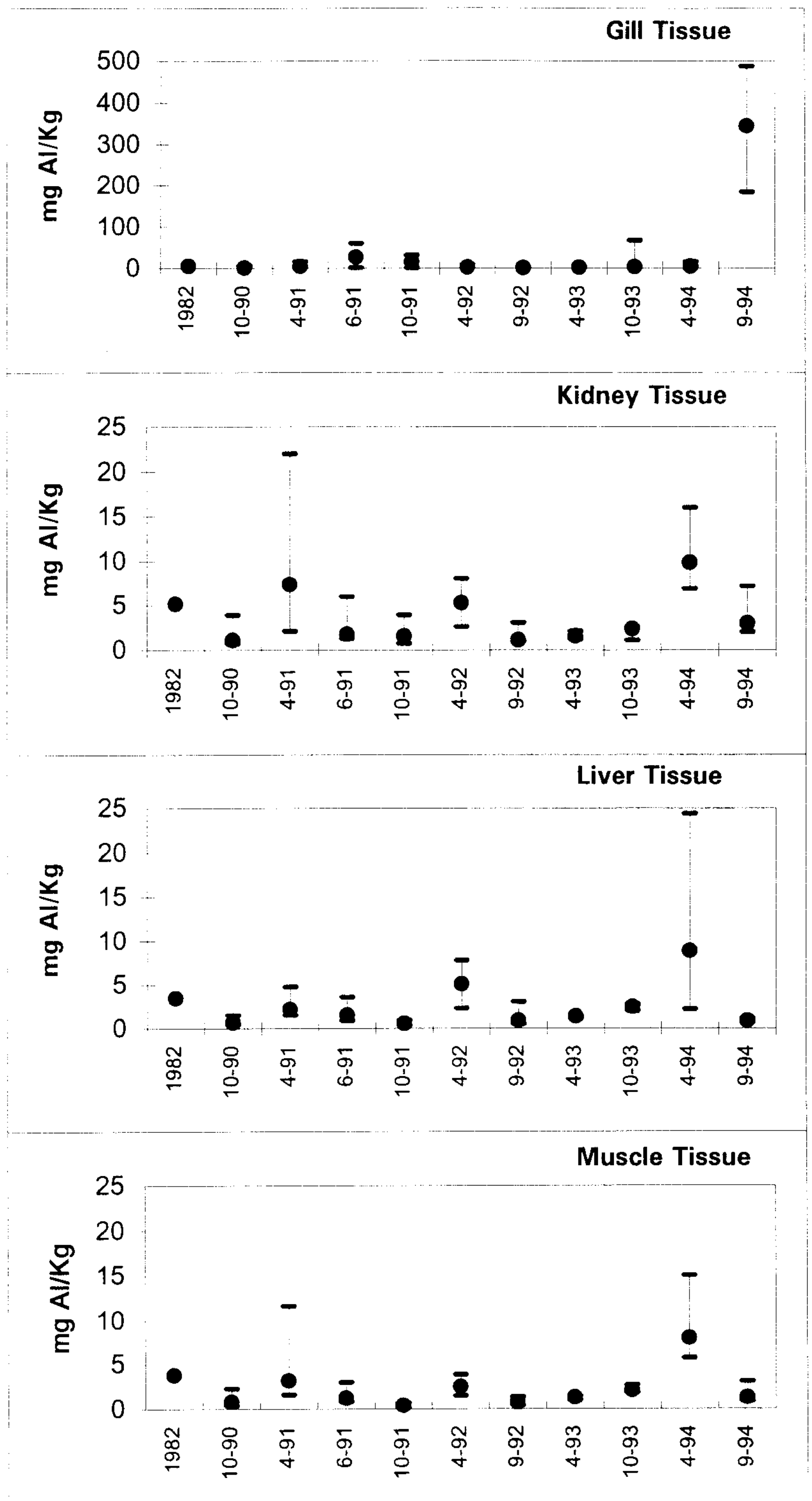


Figure 4. Median, maximum, and minimum concentration of cadmium (mg/Kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Wulik River in 1982 and 1990-1994. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.

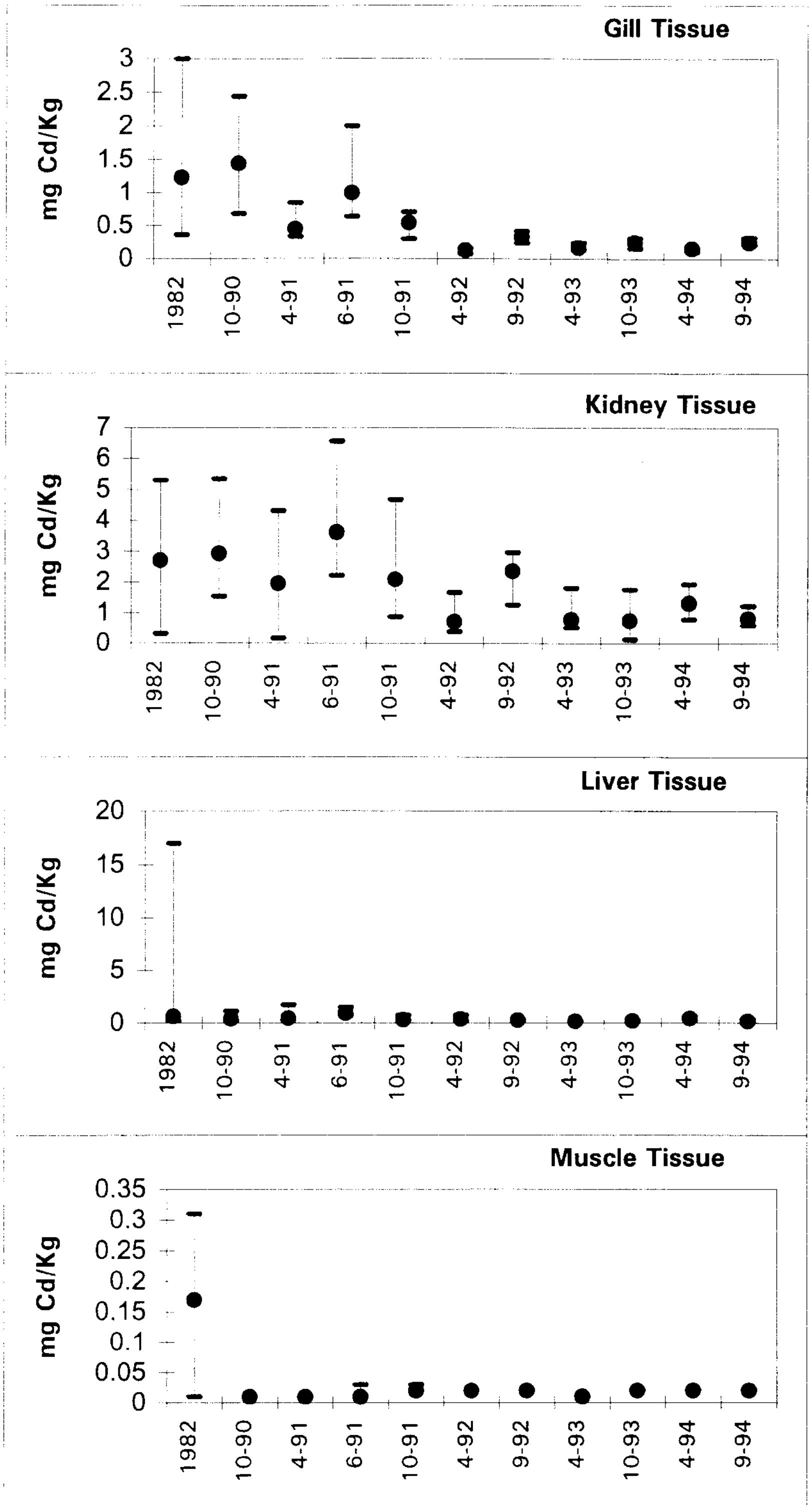


Figure 5. Median, maximum, and minimum concentration of copper (mg/Kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Wulik River in 1982, and 1990-1994. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.

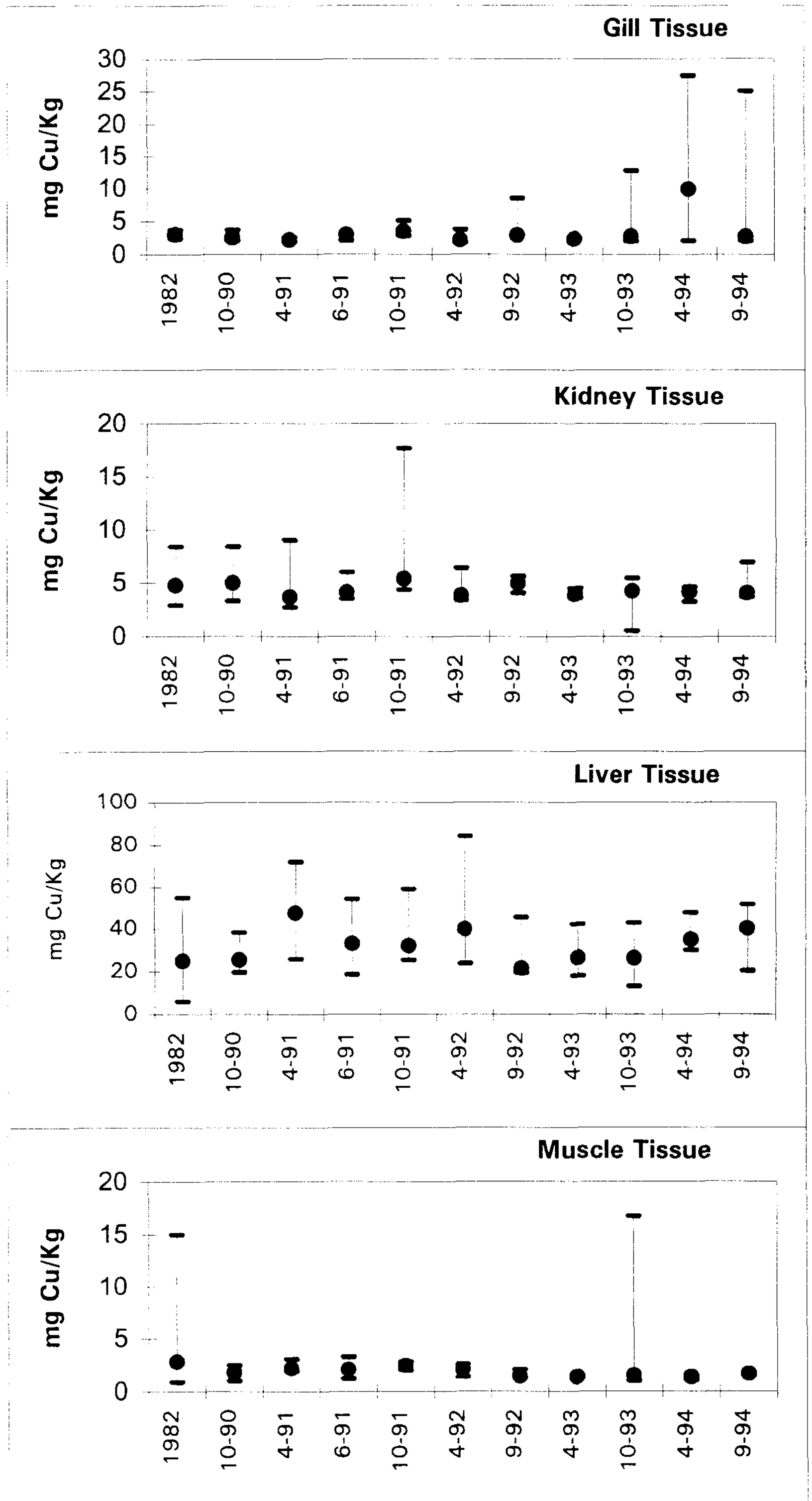


Figure 6. Median, maximum, and minimum concentration of lead (mg/Kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Wulik River in 1982 and 1990-1994. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.

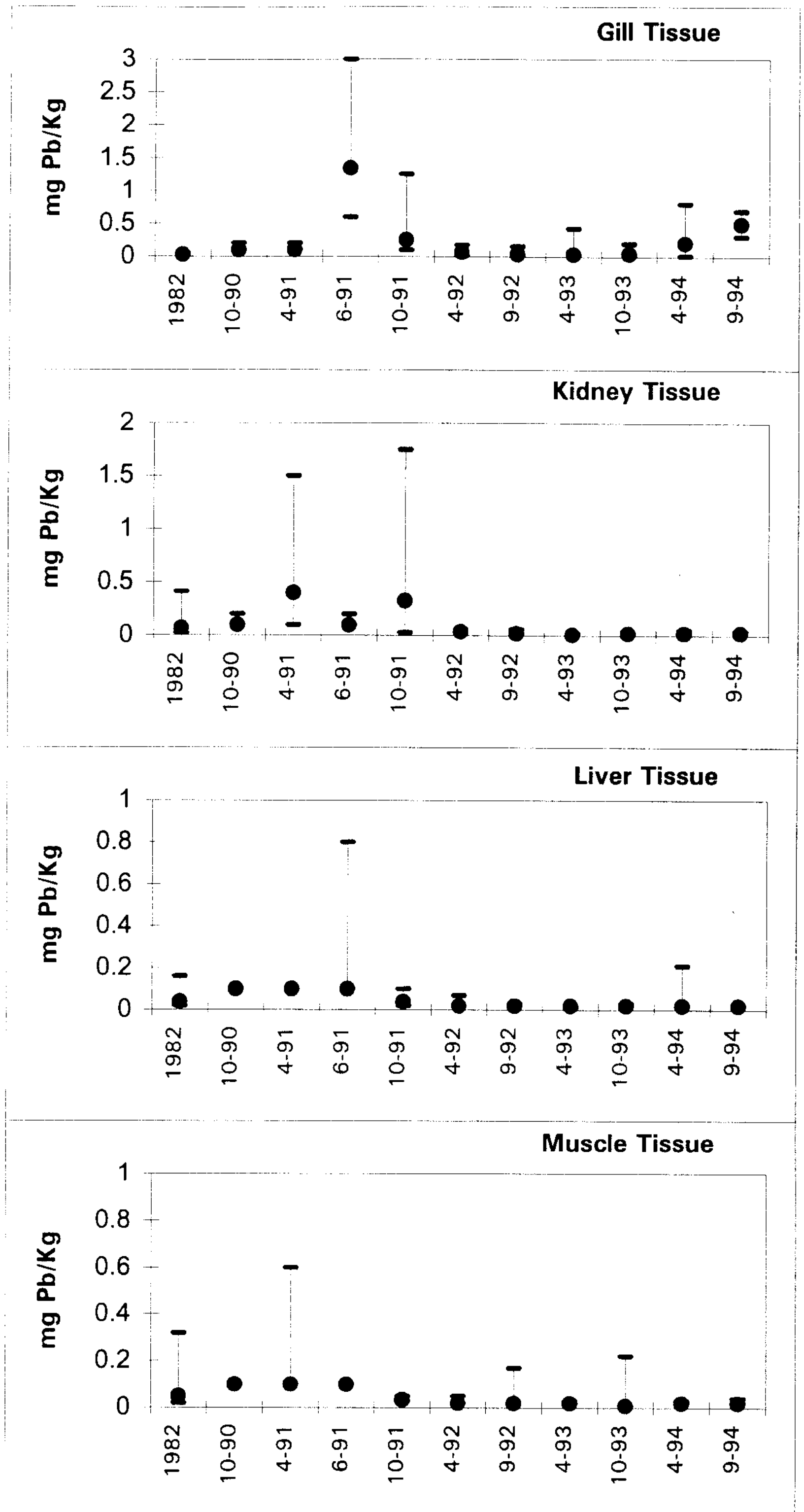
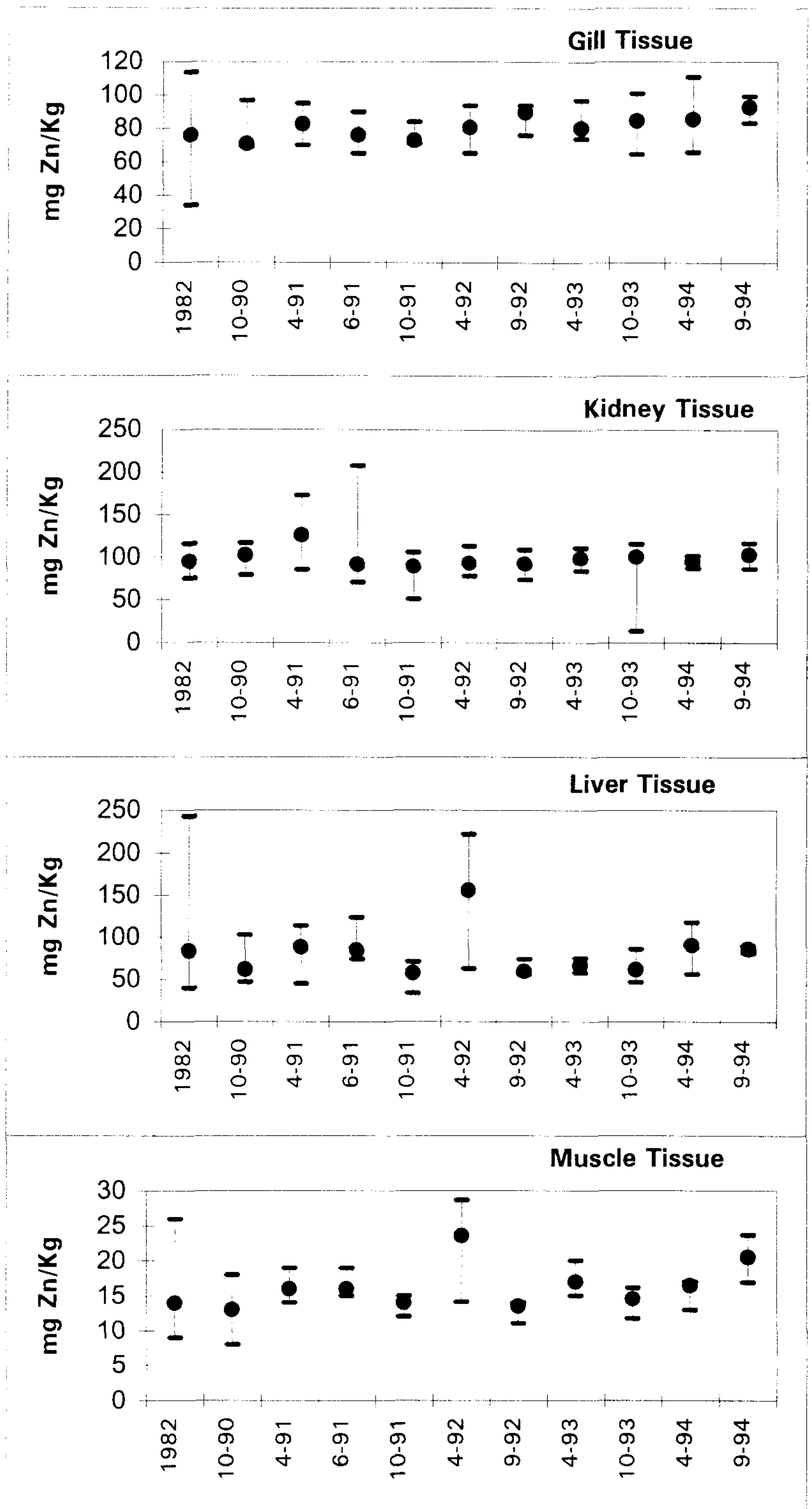


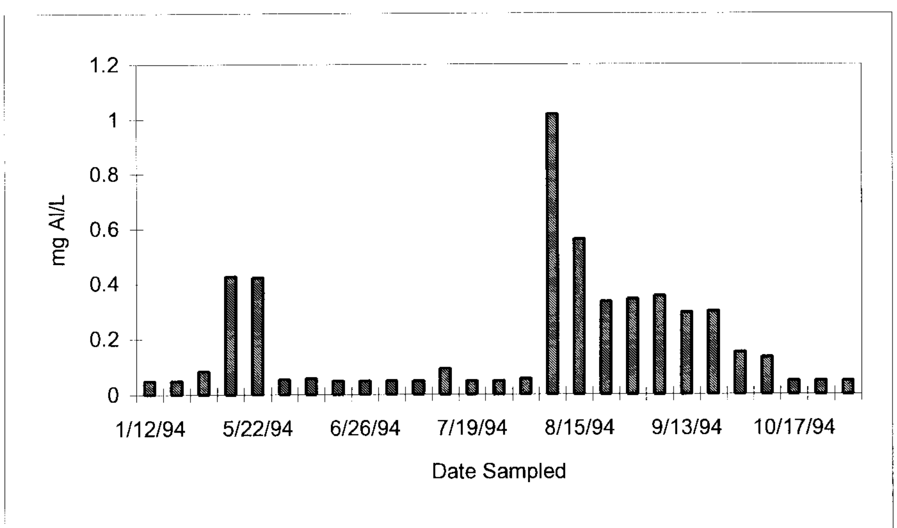
Figure 7. Median, maximum, and minimum concentration of zinc (mg/Kg dry weight) in adult Dolly Varden tissues (gill, kidney, liver, and muscle) collected in the Wulik River in 1982 and 1990-1994. Median values for 1982 fish were not available; 1982 data are expressed as mean concentration.



Increases in Al concentrations in Dolly Varden gill tissue probably resulted from Al released from tributary streams during periods of high rainfall. ADF&G observed whitish flocculant on the stream bottom in Shelly Creek and in Red Dog Creek upstream of the ore body. Neither of these sites are affected by the Red Dog Mine. Laboratory analysis found the flocculant to be Al. Water samples from these two tributaries also contained high concentrations of Al.

Water samples collected at Station 73 contained slightly higher concentrations of Al in August and September than in previous months (Figure 8); however, concentrations after August 15 (approximately the earliest date fish would be expected to enter the Wulik River) did not exceed 0.5 mg/L. Water samples from the Wulik River at Station 2 were not taken with sufficient frequency to relate metals to increased Al in gill tissues.

Figure 8. Concentrations of total recoverable Al in Ikalukrok Creek at Station 73, 1994.



*Overwintering Dolly Varden, Wulik River*

In late September 1994, ADF&G conducted our annual aerial survey to count overwintering Dolly Varden in the Wulik River. Similar surveys have been made annually since 1979 except in 1983, 1985-86 and 1990 when conditions were not favorable for aerial surveys (Table 8).

The number of Dolly Varden counted in 1994 was lower than the previous three years but similar to that found from 1982 to 1989. Lower numbers of fish may be due to fish entering the river for overwintering later in the season and to natural fluctuations in fish populations.

Table 8. Number of overwintering adult Dolly Varden in the Wulik River before freeze-up. Surveys conducted by the ADF&G (DeCicco 1989, 1991, 1993, and 1994.)

| Year | Wulik River upstream of Ikalukrok Creek | Wulik River downstream of Ikalukrok Creek | Total Fish | Percent of Fish downstream of Ikalukrok Creek |
|---|---|---|---|---|
| 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 | 1500 | 78,644 | 80,144 | 98 |
| 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 | 66,752 | 99 |

*Juvenile Dolly Varden, Metals Concentrations*

In 1993, ADF&G collected 6 juvenile Dolly Varden from Anxiety Ridge Creek and 6 from the North Fork of Red Dog Creek to compare concentrations of Cd and Pb (Ott and Weber Scannell 1994). Pb concentrations in Dolly Varden from Anxiety Ridge Creek were significantly higher than concentrations in Dolly Varden from the North Fork of Red Dog Creek. In August 1994, we collected water samples from Anxiety Ridge Creek at the road crossing (near where the fish were collected in 1993), 1000 m below the road crossing, and 1000 m above the road crossing. We found 3 ug/L total recoverable Pb above and below the bridge crossing at Anxiety Ridge Creek and Pb concentrations below the limit of detection (1 ug/L) at the bridge. Quality assurance results were within acceptable limits (Appendix 3).

*Juvenile Dolly Varden, Relative Abundance and Distribution*

Our objective was to determine if relative abundance (catch per trap) of juvenile Dolly Varden was similar among Ikalukrok, Anxiety Ridge, Evaingiknuk, Red Dog (Middle Fork and Mainstem), and the North Fork of Red Dog Creeks during the ice-free season. The most productive creek for juvenile Dolly Varden during baseline surveys in 1983 was Anxiety Ridge Creek in the vicinity of the proposed Haul Road crossing (Dames and Moore 1984).

In 1994, catches of Dolly Varden increased between late June and late July in both Evaingiknuk and Anxiety Ridge Creeks (Appendices 5 and 6). Catches remained similar in Anxiety Ridge Creek in late August but decreased in Evaingiknuk Creek. Because of several rain storm events in 1994, Ikalukrok Creek was sampled only once, in late July. The juvenile Dolly Varden catch in late July in Ikalukrok Creek averaged 1.2 fish per trap (SD = 2.3) (Appendix 8). In 1992 Ikalukrok Creek was sampled in late July and the average catch of juvenile Dolly Varden per trap was 0.6 (SD = 1.3) (Appendix 8).

Dolly Varden captured per minnow trap were compared for sample creeks. Comparisons in catch per trap were made for each 1994 sample period (June 27-28, July 25-28, and

August 30-31). Significant differences among the creeks in total catch per trap of juvenile Dolly Varden were determined for late June ($F = 3.43$; $df = 3,36$; $P < 0.05$), late July ($F = 8.23$; $df = 4,45$; $P < 0.05$), and late August ($F = 6.87$; $df = 3,36$; $P < 0.05$).

The number of Dolly Varden captured in Anxiety Ridge and Evaingiknuk Creeks in late August 1992, 1993, and 1994 were compared. Significant differences were noted among sample years for Anxiety Ridge Creek ($F = 21.9$; $df = 2,27$; $P < 0.05$) and Evaingiknuk Creek ($F = 10.7$; $df = 2,27$; $P < 0.05$). Total catch of juvenile Dolly Varden in Evaingiknuk Creek was 111, 26, and 3 in 1992, 1993, and 1994. Total catch of juvenile Dolly Varden in Anxiety Ridge Creek was 334, 295, and 26 in 1992, 1993, and 1994. Catches of juvenile Dolly Varden decreased to zero in the North Fork of Red Dog Creek in 1994. Reduced catches in 1994, particularly the late August sample, probably were due to high water events in mid-August and an early 1994 freeze-up which triggered outmigration of fish to overwintering habitats. In August 1994, 11.29 inches of rain fell at Red Dog, with 4.5 inches falling between August 14 and 18. High stream discharges probably caused downstream displacement of some juvenile Dolly Varden. Decreased abundance of juvenile Dolly Varden in Evaingiknuk Creek (Noatak River tributary) and Anxiety Ridge Creek (Ikalukrok Creek tributary) may reflect an overall reduction of fish due to environmental conditions unrelated to the Red Dog Mine. Significant differences may simply reflect natural year to year variability.

*Arctic Grayling Surveys, North Fork of Red Dog Creek*

On June 6, 1982, spawned-out Arctic grayling were abundant in the North Fork of Red Dog Creek and on July 9, 1982, numerous young-of-the-year Arctic grayling were observed (Dames and Moore 1983). The objective of this survey was to determine if adult Arctic grayling spawn and young-of-the-year Arctic grayling rear in the North Fork of Red Dog Creek after development of the Red Dog Mine.

We evaluated Arctic grayling use of the North Fork of Red Dog Creek from 1991 through 1994. Arctic grayling spawned in the North Fork of Red Dog Creek and young-of-the-year Arctic grayling were present in 1991 through 1993 (Ott et al. 1992; Ott and Weber Scannell 1993; 1994). In 1994, adult Arctic grayling in good post-spawning condition were collected by angling and released in the North Fork of Red Dog Creek in late June.

We observed young-of-the-year Arctic grayling (20 - 25 mm long) in late July 1994; however, fry were not numerous. In our previous sampling (1991 through 1993), we documented numerous young-of-the-year Arctic grayling in the North Fork of Red Dog Creek. Five inches of rain fell in the Red Dog area in early July and high stream discharges occurred when newly hatched alevins were present. We believe the absence of numerous Arctic grayling fry in the creek in late July 1994 was due to high water in early July.

Clark (1992) reviewed stream flow data in relation to recruitment of Arctic grayling in the Chena River system and concluded that stream flow during spawning, emergence, and larval stage was a significant descriptor of variability in recruitment. We documented a loss of young-of-the-year Arctic grayling in summer 1994 in Last Chance Creek, in the Chena River system, where several hundred Arctic grayling spawned but after high water following spawning, young-of-the-year fish were absent for the remainder of the year (Ott et al. 1995).

In 1992 through 1994, we collected by angling, measured, and released Arctic grayling in the North Fork of Red Dog Creek. In late June 1994, we caught and released 48 fish with an average length of 256.5 mm (range 194 to 325 mm, SD = 31.2). In late July 1994, we caught and released 54 fish with an average length of 216.0 mm (range 158 to 269 mm, SD = 23.0). Most of the large adult Arctic grayling outmigrate following spawning and smaller fish continue to move into the North Fork of Red Dog Creek. Movement of adult Arctic grayling into spawning streams before juvenile movement has been observed in North Slope streams (McCart et al. 1972; Craig and Poulin 1975). The same general movement pattern has been observed in all sample years.

In late June 1993, we measured 25 Arctic grayling with an average length of 214 mm (SD = 68); 6 of these fish were less than 170 mm. In late June 1994, we collected and released 48 fish with an average length of 256.5 mm (SD = 31.2); none of the fish were less than 170 mm. In July 1994, we collected 54 Arctic grayling in the North Fork of Red Dog Creek; only 1 fish was less than 170 mm.

Summer 1994 had unusually high rainfall; large storms and high stream flows occurred shortly after Arctic grayling spawned, and above average rainfalls continued throughout the summer. High stream flows probably caused physical displacement of Arctic grayling fry. Increases in metals concentrations were found in Red Dog and Ikalukrok Creeks (rf. Tables 1 and 2) in 1994. The clean water bypass system was functioning throughout the summer; however, high concentrations of metals (especially Al) were originating from undisturbed sites along Red Dog Creek. The combination of physical displacement of fry and higher concentrations of metals probably contributed to the decreased use of the North Fork of Red Dog Creek by smaller Arctic grayling.

*Juvenile Dolly Varden Use of the North Fork of Red Dog Creek*

Our objective was to determine if juvenile Dolly Varden continue to rear in the North Fork of Red Dog Creek during the ice-free season. Hougton and Hilgert (1983) repeatedly sampled the North Fork of Red Dog Creek in 1981 and 1982 and reported finding only one Dolly Varden near the headwaters of the creek. They assumed the Dolly Varden was a non-migratory resident. Juvenile Dolly Varden were first documented in the North Fork of Red Dog Creek during the ice-free season in 1992 (Ott and Weber Scannell 1993). Juvenile Dolly Varden use of the North Fork of Red Dog Creek also occurred in summer 1993 (Ott and Weber Scannell 1994).

In 1994, we fished ten minnow traps in the North Fork of Red Dog Creek in late June, late July, and late August. We did not capture any juvenile Dolly Varden (Appendix 9); however, we did observe juvenile Dolly Varden in high water channels in late July. Our results show that juvenile Dolly Varden are rearing in the North Fork of Red Dog Creek, although numbers of fish present in 1994 were lower in the North Fork of Red Dog Creek than in previous years.

*Dolly Varden and Arctic Grayling Use of the Middle Fork and Mainstem of Red Dog Creek*

Our objective was to determine Dolly Varden and Arctic grayling use of the Mainstem (downstream of the North Fork of Red Dog Creek) and Middle Fork of Red Dog Creeks (from the confluence of the North Fork of Red Dog Creek upstream to the discharge point from the wastewater treatment facility). Historical data indicate that fish use was limited to migration in the Mainstem of Red Dog Creek and that fish did not use the Middle Fork of Red Dog Creek. However, fish were observed in the Mainstem of Red Dog Creek within the influence of the North Fork of Red Dog Creek (Dames and Moore 1983) and fish mortalities were documented in the Mainstem of Red Dog Creek (E.V.S. Consultants 1983).

Water quality in Red Dog Creek has improved with development of the Red Dog Mine and construction of the water bypass system. The intent of our studies was to determine if Dolly Varden and Arctic grayling continue to use the Mainstem of Red Dog Creek as a migratory corridor but remain excluded from the Middle Fork of Red Dog Creek.

Visual and minnow trap surveys of the Middle Fork and the Mainstem of Red Dog Creek yielded few fish (Appendix 7). One Dolly Varden (about 200 mm) was observed in the Mainstem of Red Dog Creek immediately below the North Fork of Red Dog Creek in late August 1994. Two large adult Arctic grayling were present in the Mainstem of Red Dog Creek along the right bank and in the influence of the North Fork of Red Dog Creek in late June 1994.

Fish were not observed in the Middle Fork of Red Dog Creek in 1994. The Middle Fork of Red Dog Creek also was surveyed visually in 1992 and 1993 during sampling trips to the North Fork of Red Dog Creek and fish were not observed. Water in the Middle Fork of Red Dog Creek is clear, pools are less than 1 m deep, and visibility is high. It is likely that any Arctic grayling or juvenile Dolly Varden present in the Middle Fork would have been observed as we walked the stream channel. No fish were collected in minnow traps in either the Middle Fork or the Mainstem of Red Dog Creek.

## Conclusions

Fish surveys conducted in 1994 show an expansion of the distribution of fish into the North Fork of Red Dog Creek over pre-mining conditions. Improved water quality in Red Dog Creek with operation of the clean water bypass system did not result in increased fish use of Red Dog Creek above the North Fork. The stream bypass system and other measures taken by Cominco Alaska Inc. appeared to contribute to a decrease in concentrations of Al, Cd, Cu, Pb, and Zn in adult Dolly Varden in the Wulik River.

After extensive sampling, we found no fish in the Middle Fork of Red Dog Creek, from the confluence of the North Fork upstream to the mine effluent. We conclude that fish do not use this portion of Red Dog Creek. Arctic grayling use of the Mainstem of Red Dog Creek appears to be limited to migration to the North Fork of Red Dog Creek. Juvenile Dolly Varden use the Mainstem of Red Dog Creek to access rearing habitat in the North Fork of Red Dog Creek. Our findings in 1992, 1993, and 1994, with the exception of juvenile Dolly Varden use of the North Fork, support the pre-mining findings of Hougton and Hilgert (1983) and E.V.S. Consultants Ltd. (1983).

Age 1+ and 2+ Arctic grayling were not found in the North Fork of Red Dog Creek before development of the Red Dog Mine (Houghton and Hilgert 1983). Improved water quality in the Mainstem of Red Dog Creek is now allowing access of young fish to the North Fork, although numbers of fish were lower in 1994 than in 1993. A combination of physical displacement and higher concentrations of metals in Red Dog Creek due to high water events probably contributed to the decrease in numbers of smaller fish in the North Fork of Red Dog Creek. Physical displacement from unusually high rainfall probably contributed to the decreased densities of fish in all streams sampled by ADF&G in 1994.

Juvenile Dolly Varden sampled for Cd and Pb in 1993 showed higher concentrations of Pb in fish from Anxiety Ridge Creek than in fish from the North Fork of Red Dog Creek. We hypothesize that air-borne sediments from the road may have contributed to elevated Pb concentrations. Water sampling above the bridge (outside of the dust shadow), at the bridge, and below the bridge did not confirm the road as a source of Pb. It is possible that Dolly Varden accumulated Pb from a different source or that increased dust control on the road by Cominco Alaska Inc. eliminated a source of air-borne Pb. With our limited sampling, it is not possible to determine the Pb source or if juvenile Dolly Varden in Anxiety Ridge Creek continue to have higher Pb concentrations than fish in the North Fork of Red Dog Creek.

The number of adult Dolly Varden in the Wulik River was low in 1994 but higher than 5 of the 12 years surveys have been conducted. In 1994 we found fewer fish in the Wulik River upstream of Ikalukrok Creek than in all previous years except 1984.

Sampling of the mine tailing pond showed that it was completely mixed in late August and that the water temperature was about 8°C higher than the water temperature in the freshwater reservoir.

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Appendix 1. Concentrations of Al, Cd, Cu, Pb, and Zn in adult Dolly Varden tissues, 1990 through 1994 from the Wulik River. Baseline fish tissue data from Dames and Moore (1983) are included. All concentrations are expressed as mg/Kg, dry weight basis. See Appendix 3 for an explanation of the sample groups.

## Gill Tissue

| Sample Group* | Date | Location | Sex | Weight grams | Length mm | age (fresh/ salt) | Al mg/kg | Cd mg/kg | Cu mg/kg | | Pb mg/kg | Zn mg/kg | % Solids |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DM | 6/1/81 | Sta 1 | A | | | | | 0.770 | 3.00 | < | 0.03 | 67.20 | |
| DM | 6/1/81 | Sta 2 | A | | | | | 1.200 | 3.20 | < | 0.02 | 68.60 | |
| DM | 8/1/81 | Sta 1 | A | | | | | 0.360 | 3.20 | < | 0.04 | 34.10 | |
| DM | 9/1/81 | Sta 1 | A | | | | | 0.790 | 3.10 | < | 0.04 | 67.40 | |
| DM | 9/1/81 | Mid-Ikaluk | A | | | | | 1.400 | 3.10 | < | 0.03 | 52.70 | |
| DM | 6/1/82 | | A | | | | | 5.750 | 0.75 | | 3.18 | 0.03 | 24.8 |
| A | 10/5/90 | Wulik | F | | 538 | | 1.8 | 1.630 | 2.20 | | 0.20 | 90.40 | 22.3 |
| A | 10/5/90 | Wulik | F | | 615 | | 1.3 | 0.680 | 3.10 | < | 0.10 | 70.90 | 25.8 |
| A | 10/5/90 | Wulik | M | | 608 | | 1.4 | 1.440 | 2.60 | < | 0.10 | 68.70 | 24.0 |
| A | 10/5/90 | Wulik | F | | 430 | | 2.0 | 1.200 | 3.30 | | 0.10 | 70.50 | 26.2 |
| A | 10/5/90 | Wulik | F | | 452 | | 0.6 | 1.220 | 2.10 | < | 0.10 | 70.20 | 21.6 |
| A | 10/5/90 | Wulik | F | | 528 | | 2.2 | 2.440 | 2.60 | | 0.20 | 96.60 | 24.1 |
| B | 3/9/91 | Wulik | | | | | 6.1 | 0.390 | 2.30 | < | 0.10 | 87.40 | 19.2 |
| B | 3/9/91 | Wulik | | | | | 7.8 | 0.660 | 2.30 | < | 0.10 | 87.60 | 22.0 |
| B | 3/9/91 | Wulik | | | | | 10.8 | 1.020 | 2.30 | < | 0.10 | 77.80 | 22.1 |
| B | 4/6/91 | WULIK | M | | 300 | | 5.0 | 0.450 | 2.60 | < | 0.10 | 94.80 | 19.5 |
| B | 4/6/91 | WULIK | M | 197 | 294 | | 13.9 | 0.360 | 1.90 | < | 0.10 | 74.40 | 18.6 |
| B | 4/6/91 | WULIK | F | 201 | 303 | | 3.4 | 0.820 | 2.20 | < | 0.10 | 88.40 | 19.3 |
| B | 4/6/91 | WULIK | F | 237 | 355 | | 4.2 | 0.330 | 2.50 | | 0.20 | 70.30 | 19.0 |
| B | 4/6/91 | WULIK | F | 751 | 434 | | 16.1 | 0.850 | 1.90 | < | 0.10 | 83.00 | 19.8 |
| C | 4/15/91 | Noatak | F | 274 | 323 | | 27.6 | 0.050 | 1.80 | | 0.20 | 105.00 | 20.3 |
| C | 4/15/91 | Noatak | F | 283 | 324 | | 15.6 | 0.060 | 1.60 | | 0.10 | 79.80 | 22.3 |
| C | 4/15/91 | Noatak | M | 714 | 416 | | 3.5 | 0.070 | 2.20 | | 0.10 | 81.20 | 20.5 |
| C | 4/15/91 | Noatak | F | 730 | 443 | | 6.7 | 0.100 | 1.50 | < | 0.10 | 76.60 | 21.3 |
| C | 4/15/91 | Noatak | F | 449 | 401 | | 10.5 | 0.040 | 2.20 | < | 0.10 | 84.00 | 20.3 |
| B | 4/26/91 | Wulik | F | 1279 | 518 | | 3.2 | 0.790 | 1.7 | | 1.10 | 79.80 | 20.4 |
| D | 6/16/91 | Wulik | M | 962 | 489 | | 36.6 | 1.510 | 3.10 | | 1.00 | 75.60 | 18.2 |
| D | 6/16/91 | Wulik | F | 1426 | 538 | | 56.3 | 0.780 | 3.00 | | 3.00 | 79.30 | 21.1 |
| D | 6/16/91 | Wulik | M | 1361 | 541 | | 21.2 | 1.150 | 2.70 | | 0.60 | 75.50 | 18.8 |
| D | 6/16/91 | Wulik | F | 762 | 461 | | 18.4 | 2.000 | 3.10 | | 1.50 | 89.60 | 22.2 |
| D | 6/16/91 | Wulik | F | 672 | 417 | | 20.5 | 0.640 | 2.10 | | 0.80 | 64.70 | 21.4 |
| D | 6/16/91 | Wulik | F | 745 | 430 | | 33.3 | 0.830 | 2.80 | | 1.50 | 75.30 | 20.8 |
| D | 6/16/91 | Wulik | F | 680 | 443 | | 60.2 | 0.850 | 2.90 | | 2.40 | 67.70 | 21.5 |
| D | 6/16/91 | Wulik | F | 654 | 430 | | 1.2 | 1.820 | 3.10 | | 1.20 | 78.50 | 20.2 |
| E | 10/5/91 | Wulik | F | 1162 | 480 | | 1.6 | 0.550 | 3.39 | | 0.10 | 70.80 | 21.0 |
| E | 10/5/91 | Wulik | M | 1262 | 480 | | 23.4 | 0.300 | 2.92 | | 0.16 | 75.20 | 19.3 |
| E | 10/5/91 | Wulik | M | 2551 | 614 | | 10.6 | 0.630 | 2.82 | | 0.29 | 71.40 | 20.3 |
| E | 10/5/91 | Wulik | F | 2188 | 589 | | 2.1 | 0.540 | 3.64 | | 0.23 | 72.30 | 23.0 |
| E | 10/5/91 | Wulik | F | 1616 | 525 | | 22.1 | 0.500 | 4.23 | | 1.26 | 73.60 | 19.8 |
| E | 10/5/91 | Wulik | M | 2233 | 563 | | 31.7 | 0.710 | 5.10 | | 0.33 | 84.10 | 21.7 |
| F | 4/29/92 | Wulik | F | 180 | 291 | | 3.1 | 0.130 | 3.34 | | 0.18 | 93.30 | 20.8 |
| F | 4/29/92 | Wulik | F | 670 | 424 | (2+2) | 2.1 | 0.160 | 1.780 | | 0.07 | 65.50 | 25.9 |
| F | 4/29/92 | Wulik | F | 1420 | 530 | (2+3)? | 9.0 | 0.070 | 1.79 | | 0.11 | 65.70 | 27.8 |
| F | 4/29/92 | Wulik | U | 180 | 294 | (2+1)? | 2.3 | 0.130 | 1.92 | | 0.07 | 84.20 | 21.0 |
| F | 4/29/92 | Wulik | F | 140 | 275 | (3+1) | 2.7 | 0.120 | 3.73 | | 0.04 | 93.70 | 19.9 |

Appendix 1, continued.

| | | | | Gill Tissue | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Group* | Date | Location | Sex | Weight grams | Length mm | age (fresh/ salt) | Al mg/kg | Cd mg/kg | Cu mg/kg | | Pb mg/kg | Zn mg/kg | % Solids |
| F | 4/29/92 | Wulik | M | 140 | 264 | (4+1) | 5.9 | 0.080 | 2.24 | | 0.06 | 80.20 | 20.3 |
| F | 4/29/92 | Wulik | F | 150 | 259 | (3+1) | 1.7 | 0.090 | 2.13 | | 0.03 | 77.70 | 19.9 |
| G | 9/30/92 | Wulik | F | 4120 | 706 | 9 | 2.8 | 0.240 | 3.22 | | 0.04 | 76.00 | 21.2 |
| G | 9/30/92 | Wulik | M | 2820 | 620 | (3+4) | 2.3 | 0.420 | 8.50 | | 0.16 | 90.00 | 18.8 |
| G | 9/30/92 | Wulik | F | 3410 | 674 | (3+5) | 1.3 | 0.410 | 2.92 | < | 0.02 | 86.00 | 19.8 |
| G | 9/30/92 | Wulik | M | 2630 | 600 | (4+4) | 1.3 | 0.330 | 2.90 | | 0.04 | 91.00 | 20.3 |
| G | 9/30/92 | Wulik | F | 2110 | 564 | (3+4) | 1.4 | 0.330 | 2.92 | < | 0.02 | 94.00 | 19.8 |
| G | 9/30/92 | Wulik | M | 2920 | 595 | (2+4) | 1.0 | 0.360 | 2.34 | | 0.04 | 73.00 | 21.6 |
| H | 4/21/93 | Wulik R. | | 673 | 407 | | 1.8 | 0.240 | 2.420 | | 0.36 | 87.00 | 20.2 |
| H | 4/21/93 | Wulik R. | | 1032 | 480 | (2+3) | 1.6 | 0.150 | 2.500 | | 0.03 | 97.00 | 20.7 |
| H | 4/21/93 | Wulik R. | | 717 | 414 | (4+2) | 2.5 | 0.180 | 2.350 | | 0.43 | 84.00 | 20.8 |
| H | 4/21/93 | Wulik R. | | 701 | 421 | (3+2) | 3.7 | 0.140 | 2.330 | | 0.04 | 74.00 | 21.7 |
| H | 4/21/93 | Wulik R. | | 685 | 398 | 6 | 3.1 | 0.160 | 2.190 | | 0.04 | 75.00 | 22.4 |
| H | 4/21/93 | Wulik R. | | 611 | 407 | (2+3) | 1.4 | 0.170 | 2.310 | | 0.03 | 77.00 | 22.8 |
| I | 10/20/93 | Wulik R. | F | 2168 | 575 | (3+3) | 42.4 | 0.180 | 2.680 | | 0.06 | 101.00 | 25.5 |
| I | 10/20/93 | Wulik R. | M | 1352 | 491 | (4+3) | 3.9 | 0.260 | 12.800 | | 0.20 | 88.50 | 24.8 |
| I | 10/20/93 | Wulik R. | M | 1551 | 498 | (3+3) | 3.7 | 0.310 | 3.930 | < | 0.02 | 80.10 | 22.2 |
| I | 10/20/93 | Wulik R. | F | 1188 | 456 | (3+3) | 66.7 | 0.280 | 2.900 | | 0.08 | 88.50 | 25.8 |
| I | 10/20/93 | Wulik R. | M | 1324 | 473 | (3+3) | 2.9 | 0.160 | 2.640 | | 0.03 | 81.20 | 21.7 |
| I | 10/20/93 | Wulik R. | M | 2204 | 556 | (3+4) | 4.3 | 0.230 | 2.020 | | 0.02 | 64.70 | 24.8 |
| J | 4/7/94 | Wulik R. | M | 245 | 297 | | 15.9 | 0.110 | 2.150 | | 0.04 | 83.10 | 20.8 |
| J | 4/7/94 | Wulik R. | F | 572 | 380 | | 14.5 | 0.160 | 16.300 | | 0.81 | 78.30 | 25.1 |
| J | 4/7/94 | Wulik R. | M | 526 | 390 | | 5.2 | 0.170 | 23.100 | | 0.43 | 66.00 | 21.2 |
| J | 4/7/94 | Wulik R. | M | 499 | 385 | | 3.5 | 0.120 | 2.910 | | 0.04 | 111.00 | 15.2 |
| J | 4/7/94 | Wulik R. | M | 590 | 386 | | 3.9 | 0.160 | 3.640 | < | 0.02 | 103.00 | 19.1 |
| J | 4/7/94 | Wulik R. | F | 1651 | 521 | | 5.5 | 0.150 | 27.400 | | 0.38 | 88.50 | 19.0 |
| k | 9/23/94 | Wulik R. | F | 844 | 420 | | 487.0 | 0.25 | 3.41 | | 0.65 | 99.10 | 27.3 |
| k | 9/23/94 | Wulik R. | M | 690 | 420 | | 379.0 | 0.21 | 2.95 | | 0.55 | 99.40 | 25.8 |
| k | 9/23/94 | Wulik R. | M | 826 | 425 | | 452.0 | 0.25 | 2.52 | | 0.70 | 94.60 | 26.3 |
| k | 9/23/94 | Wulik R. | M | 890 | 435 | | 184.0 | 0.25 | 2.09 | | 0.32 | 83.5 | 27.5 |
| k | 9/23/94 | Wulik R. | F | 681 | 405 | | 308.0 | 0.26 | 25 | | 0.46 | 87.2 | 25.9 |
| k | 9/23/94 | Wulik R. | F | 726 | 420 | | 212.0 | 0.32 | 2.35 | | 0.31 | 91.4 | 24.6 |

A=Adult, U= undetermined, F=female, M=male.

Appendix 1, continued.

## Kidney Tissue

| Sample Group* | Collector | Date | Location | Sex | Weight grams | Length mm | age (fresh/ salt) | Al mg/kg | | Cd mg/kg | | Cu mg/kg | | Pb mg/kg | Zn mg/kg | % Solids |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DM | D&M | 6/1/81 | Sta 1 | A | | | | | | 0.32 | | 4.90 | | 0.02 | 80.10 | |
| DM | D&M | 6/1/81 | Sta 2 | A | | | | | | 5.30 | | 4.00 | < | 0.02 | 75.90 | |
| DM | D&M | 8/1/81 | Sta 1 | A | | | | | | 2.90 | | 5.20 | < | 0.05 | 74.60 | |
| DM | D&M | 9/1/81 | Sta 1 | A | | | | | | 3.00 | | 5.80 | < | 0.03 | 109.00 | |
| DM | D&M | 6/1/82 | | A | | | | 3.0 | | 2.53 | | 5.28 | | 0.03 | 94.43 | |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 538 | | 1.5 | | 5.34 | | 3.30 | | 0.20 | 117.00 | 21.4 |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 615 | | 1.1 | | 2.22 | | 4.80 | < | 0.10 | 96.40 | 21.9 |
| A | ADF&G | 10/5/90 | Wulik R. | M | | 608 | | 0.7 | | 1.53 | | 4.80 | < | 0.10 | 79.30 | 24.0 |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 430 | | 3.0 | | 2.93 | | 5.20 | < | 0.10 | 100.00 | 23.7 |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 452 | | 0.9 | | 3.30 | | 5.00 | < | 0.10 | 106.00 | 21.9 |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 528 | | 1.1 | | 2.63 | | 5.30 | < | 0.10 | 103.00 | 18.5 |
| B | Cominco | 3/9/91 | Wulik R. | | | | | 2.3 | | 3.59 | | 4.80 | < | 0.10 | 143.00 | 23.1 |
| B | Cominco | 3/9/91 | Wulik R. | | | | | 4.7 | | 3.48 | | 5.20 | < | 0.10 | 103.00 | 22.9 |
| B | Cominco | 3/9/91 | Wulik R. | | | | | 2.1 | | 3.20 | | 4.90 | < | 0.10 | 118.00 | 23.6 |
| B | KIVALINA | 4/6/91 | Wulik R. | M | | 300 | | 2.4 | | 4.31 | | 3.70 | < | 0.20 | 127.00 | 20.3 |
| B | KIVALINA | 4/6/91 | Wulik R. | M | 197 | 294 | | 8.8 | | 0.85 | | 2.70 | < | 0.40 | 85.60 | 23.4 |
| B | KIVALINA | 4/6/91 | Wulik R. | F | 201 | 303 | | 22.0 | | 1.96 | | 4.10 | | 1.50 | 173.00 | 23.7 |
| B | KIVALINA | 4/6/91 | Wulik R. | F | 237 | 355 | | 7.4 | | 0.17 | | 9.00 | | 0.40 | 139.00 | 21.8 |
| B | KIVALINA | 4/6/91 | Wulik R. | F | 751 | 434 | | 2.1 | | 2.79 | | 3.50 | < | 0.10 | 102.00 | 22.4 |
| C | Noatak | 4/15/91 | Noatak R. | F | 274 | 323 | | 2.1 | | 0.93 | | 3.20 | < | 0.10 | 112.00 | 23.1 |
| C | Noatak | 4/15/91 | Noatak R. | F | 283 | 324 | | 4.6 | | 0.57 | | 2.90 | < | 0.10 | 79.80 | 22.0 |
| C | Noatak | 4/15/91 | Noatak R. | M | 714 | 416 | | 2.2 | | 2.01 | | 3.20 | < | 0.10 | 93.40 | 26.5 |
| C | Noatak | 4/15/91 | Noatak R. | F | 730 | 443 | | 4.1 | | 2.06 | | 3.30 | < | 0.10 | 106.00 | 23.2 |
| C | Noatak | 4/15/91 | Noatak R. | F | 449 | 401 | | 5.0 | | 1.82 | | 3.70 | | 0.10 | 108.00 | 18.0 |
| B | Cominco | 4/26/91 | Wulik R. | F | 1279 | 518 | | 1.0 | | 5.40 | | 6.20 | | 0.20 | 112.00 | 21.0 |
| D | Cominco | 6/16/91 | Wulik R. | M | 962 | 489 | | 6.0 | | 6.56 | | 6.00 | | 0.10 | 83.30 | 18.3 |
| D | Cominco | 6/16/91 | Wulik R. | F | 1426 | 538 | | 2.4 | | 4.87 | | 4.10 | < | 0.10 | 89.20 | 23.0 |
| D | Cominco | 6/16/91 | Wulik R. | M | 1361 | 541 | | 1.7 | | 4.14 | | 4.00 | | 0.20 | 76.60 | 22.3 |
| D | Cominco | 6/16/91 | Wulik R. | F | 762 | 461 | | 2.1 | | 3.09 | | 4.50 | < | 0.10 | 94.50 | 22.4 |
| D | Cominco | 6/16/91 | Wulik R. | F | 672 | 417 | | 1.5 | | 2.47 | | 3.50 | < | 0.10 | 208.00 | 15.2 |
| D | Cominco | 6/16/91 | Wulik R. | F | 745 | 430 | | 1.6 | | 2.23 | | 4.20 | < | 0.10 | 71.10 | 21.9 |
| D | Cominco | 6/16/91 | Wulik R. | F | 680 | 443 | | 1.9 | | 4.01 | | 4.90 | < | 0.10 | 108.00 | 22.5 |
| D | Cominco | 6/16/91 | Wulik R. | F | 654 | 430 | | 1.3 | | 3.23 | | 4.10 | < | 0.10 | 95.90 | 21.2 |
| E | Cominco | 10/5/91 | Wulik R. | F | 1162 | 480 | | 1.0 | | 1.27 | | 4.54 | | 0.06 | 87.10 | 22.7 |
| E | Cominco | 10/5/91 | Wulik R. | M | 1262 | 480 | | 1.9 | | 1.66 | | 4.89 | | 0.62 | 92.40 | 22.8 |
| E | Cominco | 10/5/91 | Wulik R. | M | 2551 | 614 | | 3.9 | | 0.87 | | 17.70 | | 1.75 | 51.20 | 23.0 |
| E | Cominco | 10/5/91 | Wulik R. | F | 2188 | 589 | | 1.3 | | 2.54 | | 6.18 | | 0.03 | 104.00 | 22.3 |
| E | Cominco | 10/5/91 | Wulik R. | F | 1616 | 525 | | 1.9 | | 4.68 | | 5.94 | | 0.04 | 107.00 | 21.5 |
| E | Cominco | 10/5/91 | Wulik R. | M | 2233 | 563 | | 0.8 | | 2.81 | | 4.37 | | 0.06 | 86.40 | 22.9 |
| F | ADF&G | 4/29/92 | Wulik R. | F | 180 | 291 | | 6.6 | | 0.62 | | 5.04 | | 0.04 | 114.00 | 36.4 |
| F | ADF&G | 4/29/92 | Wulik R. | F | 670 | 424 | (2+2) | 5.0 | | 1.51 | | 3.570 | | 0.04 | 78.10 | 24.2 |
| F | ADF&G | 4/29/92 | Wulik R. | F | 1420 | 530 | (2+3)? | 5.7 | | 1.28 | | 3.43 | | 0.02 | 86.60 | 24.5 |
| F | ADF&G | 4/29/92 | Wulik R. | U | 180 | 294 | (2+1)? | 4.7 | | 0.53 | | 3.83 | | 0.04 | 91.70 | 20.8 |
| F | ADF&G | 4/29/92 | Wulik R. | F | 140 | 275 | (3+1) | 4.3 | | 0.38 | | 6.43 | | 0.06 | 99.70 | 21.4 |
| F | ADF&G | 4/29/92 | Wulik R. | M | 160 | 276 | | 8.1 | | 1.67 | | 3.88 | | 0.05 | 95.50 | 19.8 |
| F | ADF&G | 4/29/92 | Wulik R. | M | 140 | 264 | (4+1) | 2.6 | | 0.40 | | 3.50 | | 0.04 | 82.20 | 17.4 |

Appendix 1, continued.

| Kidney Tissue | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | Collector | Date | Location | Sex | Weight | Length | age | | | | | | | | | |
| Group* | | | | | grams | mm | (fresh/ | Al | | Cd | | Cu | | Pb | Zn | % |
| | | | | | | | salt) | mg/kg | | mg/kg | | mg/kg | | mg/kg | mg/kg | Solids |
| | | | | | | | | | | | | | | | | |
| F | ADF&G | 4/29/92 | Wulik R. | F | 150 | 259 | (3+1) | 5.9 | | 0.80 | | 4.22 | | 0.03 | 114.00 | 21.3 |
| G | ADF&G | 9/30/92 | Wulik R. | F | 4120 | 706 | 9 | 3.1 | | 2.74 | | 4.49 | < | 0.02 | 85.00 | 22.5 |
| G | ADF&G | 9/30/92 | Wulik R. | M | 2820 | 620 | (3+4) | 2.3 | | 2.97 | | 5.00 | < | 0.02 | 110.00 | 22.6 |
| G | ADF&G | 9/30/92 | Wulik R. | F | 3410 | 674 | (3+5) | 1.1 | | 2.37 | | 4.09 | < | 0.02 | 74.00 | 28.0 |
| G | ADF&G | 9/30/92 | Wulik R. | M | 2630 | 600 | (4+4) | 1.0 | | 1.26 | | 5.64 | < | 0.02 | 93.00 | 24.2 |
| G | ADF&G | 9/30/92 | Wulik R. | F | 2110 | 564 | (3+4) | 1.0 | | 2.14 | | 5.24 | | 0.06 | 105.00 | 24.3 |
| G | ADF&G | 9/30/92 | Wulik R. | M | 2920 | 595 | (2+4) | 1.7 | | 1.64 | | 3.69 | | 0.24 | 81.00 | 24.1 |
| H | ADF&G | 4/21/93 | Wulik R. | F | 673 | 407 | | 1.4 | | 0.76 | | 3.850 | | 0.02 | 88.00 | 23.8 |
| H | ADF&G | 4/21/93 | Wulik R. | | 1032 | 480 | (2+3) | 1.7 | | 1.33 | | 4.530 | | 0.02 | 106.00 | 23.5 |
| H | ADF&G | 4/21/93 | Wulik R. | | 717 | 414 | (4+2) | 1.5 | | 1.82 | | 4.440 | | 0.01 | 112.00 | 24.8 |
| H | ADF&G | 4/21/93 | Wulik R. | | 701 | 421 | (3+2) | 1.2 | | 0.79 | | 3.660 | | 0.01 | 84.00 | 26.9 |
| H | ADF&G | 4/21/93 | Wulik R. | | 685 | 398 | 6 | 2.1 | | 0.51 | | 4.050 | < | 0.01 | 100.00 | 22.9 |
| H | ADF&G | 4/21/93 | Wulik R. | | 611 | 407 | (2+3) | 4.1 | | 0.53 | | 3.610 | < | 0.01 | 99.00 | 22.3 |
| I | ADF&G | 10/20/93 | Wulik R. | | 2168 | 575 | (3+3) | 2.3 | | 1.37 | | 4.67 | < | 0.02 | 103 | 25.6 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1352 | 491 | (4+3) | 1.1 | | 0.13 | | 0.54 | < | 0.02 | 13.8 | 24.6 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1551 | 498 | (3+3) | 2.3 | | 0.77 | | 4.51 | < | 0.02 | 110 | 23.0 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1188 | 456 | (3+3) | 2.6 | | 0.73 | | 4.01 | < | 0.02 | 95.5 | 24.0 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1324 | 473 | (3+3) | 2.6 | | 0.71 | | 3.93 | < | 0.02 | 116 | 23.5 |
| I | ADF&G | 10/20/93 | Wulik R. | | 2204 | 556 | (3+4) | 2.5 | | 1.76 | | 5.45 | < | 0.02 | 98.9 | 22.7 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 245 | 297 | | 16.0 | | 0.79 | | 4.660 | | 0.03 | 97.60 | 25.7 |
| J | ADF&G | 4/7/94 | Wulik R. | F | 572 | 380 | | 10.2 | | 0.88 | | 3.280 | < | 0.02 | 88.50 | 23.1 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 526 | 390 | | 6.9 | | 1.20 | | 3.300 | < | 0.02 | 87.40 | 21.2 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 499 | 385 | | 9.6 | | 1.94 | | 4.190 | | 0.05 | 102.00 | 20.7 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 590 | 386 | | 8.9 | | 1.47 | | 4.190 | | 0.02 | 98.20 | 20.6 |
| J | ADF&G | 4/7/94 | Wulik R. | F | 1651 | 521 | | 10.4 | | 1.43 | | 4.370 | < | 0.02 | 92.40 | 21.3 |
| k | ADF&G | 9/23/94 | Wulik R. | F | 844 | 420 | | 5.7 | | 0.92 | | 4.34 | | 0.04 | 106.00 | 23.0 |
| k | ADF&G | 9/23/94 | Wulik R. | M | 690 | 420 | | 3.1 | | 1.17 | | 6.93 | | 0.03 | 117.00 | 22.9 |
| k | ADF&G | 9/23/94 | Wulik R. | M | 826 | 425 | | 2.9 | | 0.60 | | 3.70 | < | 0.02 | 101.00 | 23.6 |
| k | ADF&G | 9/23/94 | Wulik R. | M | 890 | 435 | | 7.2 | | 0.63 | | 3.69 | | 0.03 | 86.6 | 25.9 |
| k | ADF&G | 9/23/94 | Wulik R. | F | 681 | 405 | | 2.6 | | 0.71 | | 4.37 | < | 0.02 | 114 | 24.7 |
| k | ADF&G | 9/23/94 | Wulik R. | F | 726 | 420 | | 2.0 | | 1.23 | | 3.83 | | 0.02 | 91.3 | 25.7 |
| | | | | | | | | | | | | | | | | |
| A=Adult, U= undetermined, F=female, M=male. | | | | | | | | | | | | | | | | |

Appendix 1, continued.

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

Appendix 1, continued.

| | | | | Muscle Tissue | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | Collector | Date | Location | Sex | Weight | Length | age | | | | | | | | | |
| Group | | | | | grams | mm | (fresh/ | Al | | Cd | | Cu | | Pb | Zn | % |
| | | | | | | | salt) | mg/kg | | mg/kg | | mg/kg | | mg/kg | mg/kg | Solids |
| E | Cominco | 10/5/91 | Wulik | F | 1162 | 480 | | 0.55 | < | 0.020 | | 2.55 | | 0.03 | 14.90 | 27.70 |
| E | Cominco | 10/5/91 | Wulik | M | 1262 | 480 | | 0.66 | < | 0.020 | | 2.85 | | 0.03 | 13.90 | 26.90 |
| E | Cominco | 10/5/91 | Wulik | M | 2551 | 614 | | 0.43 | < | 0.020 | | 2.02 | | 0.04 | 14.50 | 27.40 |
| E | Cominco | 10/5/91 | Wulik | F | 2188 | 589 | | 0.13 | | 0.030 | | 2.68 | | 0.04 | 13.10 | 30.40 |
| E | Cominco | 10/5/91 | Wulik | F | 1616 | 525 | | 0.22 | < | 0.020 | | 2.03 | | 0.03 | 12.80 | 27.50 |
| E | Cominco | 10/5/91 | Wulik | M | 2233 | 563 | | 0.32 | < | 0.020 | | 2.42 | | 0.05 | 12.20 | 29.10 |
| F | ADF&G | 4/29/92 | Wulik | F | 180 | 291 | | 2.50 | < | 0.020 | | 2.27 | < | 0.05 | 16.50 | 24.70 |
| F | ADF&G | 4/29/92 | Wulik | F | 670 | 424 | (2+2) | 2.20 | < | 0.020 | | 1.460 | | 0.02 | 14.60 | 24.40 |
| F | ADF&G | 4/29/92 | Wulik | F | 1420 | 530 | (2+3)? | 1.80 | < | 0.020 | | 1.35 | < | 0.02 | 14.10 | 25.90 |
| F | ADF&G | 4/29/92 | Wulik | U | 180 | 294 | (2+1)? | 2.60 | < | 0.020 | | 2.12 | | 0.03 | 25.90 | 23.60 |
| F | ADF&G | 4/29/92 | Wulik | F | 140 | 275 | (3+1) | 1.50 | < | 0.020 | | 2.08 | < | 0.02 | 28.70 | 20.50 |
| F | ADF&G | 4/29/92 | Wulik | M | 160 | 276 | | 2.60 | < | 0.020 | | 2.38 | | 0.02 | 22.90 | 22.60 |
| F | ADF&G | 4/29/92 | Wulik | M | 140 | 264 | (4+1) | 3.00 | < | 0.020 | | 2.57 | < | 0.02 | 24.30 | 21.80 |
| F | ADF&G | 4/29/92 | Wulik | F | 150 | 259 | (3+1) | 3.90 | < | 0.020 | | 1.99 | | 0.02 | 26.10 | 22.80 |
| G | ADF&G | 9/30/92 | Wulik | F | 2820 | 620 | 9 | 1.35 | < | 0.020 | | 1.74 | < | 0.02 | 14.00 | 23.50 |
| G | ADF&G | 9/30/92 | Wulik | M | 3410 | 674 | (3+4) | 0.47 | < | 0.020 | | 1.27 | < | 0.02 | 11.00 | 31.70 |
| G | ADF&G | 9/30/92 | Wulik | F | 2630 | 600 | (3+5) | 0.72 | < | 0.020 | | 1.27 | < | 0.02 | 13.00 | 34.40 |
| G | ADF&G | 9/30/92 | Wulik | M | 2110 | 564 | (4+4) | 0.74 | < | 0.020 | | 1.26 | | 0.03 | 13.00 | 26.20 |
| G | ADF&G | 9/30/92 | Wulik | F | 2920 | 595 | (3+4) | 0.42 | < | 0.020 | | 1.59 | < | 0.02 | 14.00 | 30.70 |
| G | ADF&G | 9/30/92 | Wulik | M | 673 | 407 | (2+4) | 1.26 | < | 0.020 | | 2.08 | | 0.17 | 14.00 | 35.50 |
| H | ADF&G | 4/21/93 | Wulik R. | | 1032 | 480 | | 1.000 | < | 0.0100 | | 1.380 | | 0.02 | 16.000 | 25.400 |
| H | ADF&G | 4/21/93 | Wulik R. | | 717 | 414 | (2+3) | 1.400 | < | 0.0100 | | 1.450 | | 0.03 | 18.000 | 27.400 |
| H | ADF&G | 4/21/93 | Wulik R. | | 701 | 421 | (4+2) | 1.300 | < | 0.0100 | | 1.490 | | 0.02 | 20.000 | 27.400 |
| H | ADF&G | 4/21/93 | Wulik R. | | 685 | 398 | (3+2) | 1.300 | < | 0.0100 | | 1.380 | | 0.02 | 16.000 | 26.500 |
| H | ADF&G | 4/21/93 | Wulik R. | | 611 | 407 | 6 | 1.200 | < | 0.0100 | | 1.230 | | 0.02 | 18.000 | 24.800 |
| H | ADF&G | 4/21/93 | Wulik R. | | 2168 | 575 | (2+3) | 1.300 | < | 0.0100 | | 1.270 | | 0.07 | 15.000 | 25.800 |
| I | ADF&G | 10/20/93 | Wulik R. | | 2168 | 575 | (3+3) | 2.70 | < | 0.020 | | 16.700 | | 0.22 | 14.60 | 36.700 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1352 | 491 | (4+3) | 2.60 | < | 0.020 | | 1.570 | < | 0.01 | 14.50 | 29.600 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1551 | 498 | (3+3) | 2.10 | < | 0.020 | | 1.510 | < | 0.01 | 14.00 | 31.100 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1188 | 456 | (3+3) | 1.90 | < | 0.020 | | 1.910 | < | 0.01 | 16.10 | 31.300 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1324 | 473 | (3+3) | 2.10 | < | 0.020 | | 1.370 | < | 0.01 | 14.70 | 31.400 |
| I | ADF&G | 10/20/93 | Wulik R. | | 2204 | 556 | (3+4) | 1.80 | < | 0.020 | | 1.000 | < | 0.01 | 11.70 | 33.100 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 245 | 297 | | 7.80 | < | 0.020 | | 1.380 | < | 0.02 | 16.70 | 23.000 |
| J | ADF&G | 4/7/94 | Wulik R. | F | 572 | 380 | | 8.80 | < | 0.020 | | 1.350 | | 0.02 | 15.80 | 25.800 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 526 | 390 | | 6.60 | < | 0.020 | | 1.480 | | 0.03 | 16.50 | 24.300 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 499 | 385 | | 5.70 | < | 0.020 | | 1.090 | < | 0.02 | 17.00 | 22.800 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 590 | 386 | | 8.20 | < | 0.020 | | 1.390 | | 0.02 | 16.40 | 24.300 |
| J | ADF&G | 4/7/94 | Wulik R. | F | 1651 | 521 | | 15.00 | < | 0.020 | | 1.250 | | 0.02 | 12.90 | 28.000 |

Appendix 1, continued.

| | | | | Muscle Tissue | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | Collector | Date | Location | Sex | Weight | Length | age | | | | | | | | | |
| Group | | | | | grams | mm | (fresh/ | Al | | Cd | | Cu | | Pb | Zn | % |
| | | | | | | | salt) | mg/kg | | mg/kg | | mg/kg | | mg/kg | mg/kg | Solids |
| | | | | | | | | | | | | | | | | |
| k | ADF&G | 9/23/94 | Wulik R. | F | 844 | 420 | | 3.10 | < | 0.02 | | 1.74 | | 0.04 | 16.90 | 29.1 |
| k | ADF&G | 9/23/94 | Wulik R. | M | 690 | 420 | | 0.90 | < | 0.02 | | 1.53 | < | 0.02 | 23.70 | 31.3 |
| k | ADF&G | 9/23/94 | Wulik R. | M | 826 | 425 | | 1.00 | < | 0.02 | | 1.64 | < | 0.02 | 19.60 | 30.5 |
| k | ADF&G | 9/23/94 | Wulik R. | M | 890 | 435 | | 1.2 | < | 0.02 | | 1.73 | < | 0.02 | 21.4 | 31 |
| k | ADF&G | 9/23/94 | Wulik R. | F | 681 | 405 | | 1.4 | < | 0.02 | | 1.48 | < | 0.02 | 20.3 | 30 |
| k | ADF&G | 9/23/94 | Wulik R. | F | 726 | 420 | | 2.1 | < | 0.02 | | 1.7 | < | 0.02 | 20.8 | 27.6 |

A=Adult, U= undetermined, F=female, M=male.

Appendix 1, continued.

**Liver Tissue**

| Sample | Collector | Date | Location | Sex | Weight | Length | age | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group* | | | | | grams | mm | (fresh/ | Al | | Cd | | Cu | | Pb | Zn | % |
| | | | | | | | salt) | mg/kg | | mg/kg | | mg/kg | | mg/kg | mg/kg | Solids |
| | | | | | | | | | | | | | | | | |
| DM | D&M | 6/1/81 | Sta 1 | A | | | | | | 0.580 | | 33.00 | < | 0.02 | 72.3 | |
| DM | D&M | 6/1/81 | Sta 1 | A | | | | | | 0.540 | | 16.50 | < | 0.02 | 50.8 | |
| DM | D&M | 8/1/81 | Sta 1 | A | | | | | | 0.770 | | 11.00 | < | 0.02 | 91.0 | |
| DM | D&M | 9/1/81 | Sta 1 | A | | | | | | 0.970 | | 18.00 | | 0.02 | 78.2 | |
| DM | D&M | 9/1/81 | Mid-Ikaluk | A | | | | | | 1.200 | | 7.90 | < | 0.03 | 243.0 | |
| DM | D&M | 6/1/82 | | A | | | | 2.50 | | 0.670 | | 27.75 | | 0.03 | 69.6 | |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 538 | | 1.50 | | 1.110 | | 25.60 | | 0.10 | 103.0 | 26.1 |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 615 | | 0.70 | | 0.250 | | 19.70 | < | 0.10 | 46.6 | 46.6 |
| A | ADF&G | 10/5/90 | Wulik R. | M | | 608 | | 0.70 | | 0.190 | | 38.40 | < | 0.10 | 58.7 | 50.9 |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 430 | | 0.80 | | 0.460 | | 22.60 | < | 0.10 | 79.3 | 29.0 |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 452 | | 0.70 | | 0.400 | | 24.20 | < | 0.10 | 74.6 | 34.6 |
| A | ADF&G | 10/5/90 | Wulik R. | F | | 528 | | 0.40 | | 0.370 | | 29.90 | < | 0.10 | 61.8 | 55.9 |
| B | Cominco | 3/9/91 | Wulik R. | | | | | 1.50 | | 1.810 | | 40.30 | < | 0.10 | 164.0 | 27.1 |
| B | Cominco | 3/9/91 | Wulik R. | | | | | 3.10 | | 0.530 | | 30.70 | < | 0.10 | 65.8 | 44.4 |
| B | Cominco | 3/9/91 | Wulik R. | | | | | 2.00 | | 0.730 | | 46.60 | < | 0.10 | 84.8 | 38.8 |
| B | KIVALINA | 4/6/91 | Wulik R. | M | | 300 | | 4.80 | | 1.730 | | 51.90 | < | 0.10 | 88.8 | 33.8 |
| B | KIVALINA | 4/6/91 | Wulik R. | M | 197 | 294 | | 1.50 | | 0.290 | | 47.70 | < | 0.10 | 87.2 | 34.9 |
| B | KIVALINA | 4/6/91 | Wulik R. | F | 201 | 303 | | 1.80 | | 0.450 | | 41.10 | < | 0.10 | 95.8 | 33.1 |
| B | KIVALINA | 4/6/91 | Wulik R. | F | 237 | 355 | | 2.20 | | 0.630 | | 72.00 | < | 0.10 | 114.0 | 25.2 |
| B | KIVALINA | 4/6/91 | Wulik R. | F | 751 | 434 | | 2.90 | | 0.380 | | 25.90 | | 0.10 | 44.6 | 35.0 |
| B | Cominco | 4/26/91 | Wulik R. | F | 1279 | 518 | | 1.30 | | 0.760 | | 25.40 | < | 0.10 | 56.1 | 38.2 |
| C | Noatak | 4/15/91 | Noatak R. | F | 274 | 323 | | 10.00 | | 0.210 | | 26.90 | | 0.20 | 70.3 | 36.3 |
| C | Noatak | 4/15/91 | Noatak R. | F | 283 | 324 | | 2.60 | | 0.430 | | 44.40 | < | 0.10 | 110.0 | 28.5 |
| C | Noatak | 4/15/91 | Noatak R. | M | 714 | 416 | | 6.70 | | 0.270 | | 29.80 | < | 0.10 | 88.1 | 44.3 |
| C | Noatak | 4/15/91 | Noatak R. | F | 730 | 443 | | 1.20 | | 0.270 | | 26.80 | < | 0.10 | 49.0 | 44.2 |
| C | Noatak | 4/15/91 | Noatak R. | F | 449 | 401 | | 3.70 | | 0.680 | | 65.10 | < | 0.10 | 137.0 | 28.3 |
| D | Cominco | 6/16/91 | Wulik R. | M | 962 | 489 | | 1.30 | | 1.250 | | 32.40 | < | 0.10 | 74.0 | 31.9 |
| D | Cominco | 6/16/91 | Wulik R. | F | 1426 | 538 | | 1.80 | | 0.710 | | 18.70 | < | 0.10 | 75.2 | 30.8 |
| D | Cominco | 6/16/91 | Wulik R. | M | 1361 | 541 | | 3.60 | | 0.860 | | 37.50 | < | 0.10 | 83.2 | 33.7 |
| D | Cominco | 6/16/91 | Wulik R. | F | 762 | 461 | | 2.00 | | 1.180 | | 34.10 | < | 0.10 | 96.6 | 27.4 |
| D | Cominco | 6/16/91 | Wulik R. | F | 672 | 417 | | 1.80 | | 1.480 | | 38.30 | | 0.80 | 124.0 | 24.0 |
| D | Cominco | 6/16/91 | Wulik R. | F | 745 | 430 | | 1.20 | | 0.690 | | 54.20 | < | 0.10 | 85.4 | 28.9 |
| D | Cominco | 6/16/91 | Wulik R. | F | 680 | 443 | | 1.20 | | 1.040 | | 26.00 | < | 0.10 | 84.3 | 33.3 |
| D | Cominco | 6/16/91 | Wulik R. | F | 654 | 430 | | 0.90 | | 0.840 | | 31.00 | < | 0.10 | 88.0 | 30.1 |
| E | Cominco | 10/5/91 | Wulik R. | F | 1162 | 480 | | 0.94 | | 0.290 | | 33.60 | | 0.04 | 70.8 | 45.6 |
| E | Cominco | 10/5/91 | Wulik R. | M | 1262 | 480 | | 0.34 | | 0.210 | | 27.40 | | 0.02 | 50.2 | 43.1 |
| E | Cominco | 10/5/91 | Wulik R. | M | 2551 | 614 | | 0.44 | | 0.720 | | 39.00 | | 0.10 | 61.7 | 37.7 |
| E | Cominco | 10/5/91 | Wulik R. | F | 2188 | 589 | | 0.87 | | 0.320 | | 59.00 | | 0.05 | 65.6 | 45.7 |
| E | Cominco | 10/5/91 | Wulik R. | F | 1616 | 525 | | 0.40 | | 0.530 | | 25.40 | | 0.04 | 55.1 | 41.5 |
| E | Cominco | 10/5/91 | Wulik R. | M | 2233 | 563 | | 0.70 | | 0.210 | | 30.60 | | 0.04 | 33.8 | 47.6 |
| F | ADF&G | 4/29/92 | Wulik R. | F | 180 | 291 | | 3.20 | | 0.410 | | 40.30 | < | 0.02 | 152.0 | 27.0 |
| F | ADF&G | 4/29/92 | Wulik R. | F | 670 | 424 | (2+2) | 7.20 | | 0.310 | | 23.80 | < | 0.02 | 62.8 | 46.7 |
| F | ADF&G | 4/29/92 | Wulik R. | F | 1420 | 530 | (2+3)? | 4.70 | | 0.260 | | 47.80 | | 0.02 | 66.2 | 39.6 |
| F | ADF&G | 4/29/92 | Wulik R. | U | 180 | 294 | (2+1)? | 7.60 | | 0.370 | | 32.40 | | 0.03 | 142.0 | 27.7 |
| F | ADF&G | 4/29/92 | Wulik R. | F | 140 | 275 | (3+1) | 7.80 | | 0.210 | | 71.80 | | 0.07 | 222.0 | 26.4 |
| F | ADF&G | 4/29/92 | Wulik R. | M | 160 | 276 | | 2.30 | | 0.740 | | 39.90 | < | 0.02 | 162.0 | 26.5 |

Appendix 1, concluded.

**Liver Tissue**

| Sample Group* | Collector | Date | Location | Sex | Weight grams | Length mm | age (fresh/ salt) | Al mg/kg | Cd mg/kg | Cu mg/kg | | Pb mg/kg | Zn mg/kg | % Solids |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F | ADF&G | 4/29/92 | Wulik R. | M | 140 | 264 | (4+1) | 5.50 | 0.450 | 84.10 | | 0.04 | 176.0 | 27.0 |
| F | ADF&G | 4/29/92 | Wulik R. | F | 150 | 259 | (3+1) | 4.50 | 0.350 | 36.20 | | 0.02 | 160.0 | 25.3 |
| G | ADF&G | 9/30/92 | Wulik R. | F | 4120 | 706 | 9 | 1.64 | 0.270 | 21.50 | | 0.02 | 60.0 | 45.0 |
| G | ADF&G | 9/30/92 | Wulik R. | M | 2820 | 620 | (3+4) | 3.07 | 0.370 | 19.50 | | 0.03 | 67.0 | 41.8 |
| G | ADF&G | 9/30/92 | Wulik R. | F | 3410 | 674 | (3+5) | 0.92 | 0.240 | 19.70 | | 0.02 | 56.0 | 50.1 |
| G | ADF&G | 9/30/92 | Wulik R. | M | 2630 | 600 | (4+4) | 0.51 | 0.160 | 40.20 | < | 0.02 | 60.0 | 48.1 |
| G | ADF&G | 9/30/92 | Wulik R. | F | 2110 | 564 | (3+4) | 0.61 | 0.320 | 45.60 | | 0.02 | 74.0 | 41.4 |
| G | ADF&G | 9/30/92 | Wulik R. | M | 2920 | 595 | (2+4) | 0.55 | 0.150 | 20.00 | < | 0.02 | 59.0 | 41.4 |
| H | ADF&G | 4/21/93 | Wulik R. | | 673 | 407 | | 1.200 | 0.2400 | 29.80 | < | 0.01 | 75.0 | 39.5 |
| H | ADF&G | 4/21/93 | Wulik R. | | 1032 | 480 | (2+3) | 1.400 | 0.1600 | 37.30 | | 0.02 | 73.0 | 37.4 |
| H | ADF&G | 4/21/93 | Wulik R. | | 717 | 414 | (4+2) | 1.400 | 0.1900 | 42.30 | < | 0.01 | 63.0 | 46.0 |
| H | ADF&G | 4/21/93 | Wulik R. | | 701 | 421 | (3+2) | 1.400 | 0.1300 | 23.00 | | 0.02 | 58.0 | 42.2 |
| H | ADF&G | 4/21/93 | Wulik R. | | 685 | 398 | 6 | 1.400 | 0.1500 | 21.00 | | 0.01 | 66.0 | 38.7 |
| H | ADF&G | 4/21/93 | Wulik R. | | 611 | 407 | (2+3) | 1.100 | 0.1800 | 18.10 | | 0.02 | 67.0 | 36.8 |
| I | ADF&G | 10/20/93 | Wulik R. | | 2168 | 575 | (3+3) | 2.800 | 0.1800 | 23.60 | < | 0.02 | 46.5 | 48.4 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1352 | 491 | (4+3) | 2.800 | 0.2300 | 22.10 | | 0.03 | 67.6 | 41.4 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1551 | 498 | (3+3) | 2.000 | 0.1200 | 13.20 | < | 0.02 | 51.0 | 46.3 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1188 | 456 | (3+3) | 2.300 | 0.2300 | 42.90 | < | 0.02 | 86.0 | 37.4 |
| I | ADF&G | 10/20/93 | Wulik R. | | 1324 | 473 | (3+3) | 2.600 | 0.1400 | 28.90 | < | 0.02 | 60.9 | 44.4 |
| I | ADF&G | 10/20/93 | Wulik R. | | 2204 | 556 | (3+4) | 2.400 | 0.2700 | 35.20 | < | 0.02 | 62.4 | 35.6 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 245 | 297 | | 24.40 | 0.270 | 34.50 | | 0.21 | 88.5 | 35.0 |
| J | ADF&G | 4/7/94 | Wulik R. | F | 572 | 380 | | 10.10 | 0.550 | 42.80 | < | 0.02 | 118.0 | 32.4 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 526 | 390 | | 4.70 | 0.630 | 47.80 | < | 0.02 | 93.3 | 32.9 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 499 | 385 | | 7.80 | 0.480 | 35.00 | < | 0.02 | 110.0 | 30.1 |
| J | ADF&G | 4/7/94 | Wulik R. | M | 590 | 386 | | 2.20 | 0.400 | 35.20 | < | 0.02 | 86.0 | 35.4 |
| J | ADF&G | 4/7/94 | Wulik R. | F | 1651 | 521 | | 10.20 | 0.270 | 30.00 | | 0.02 | 56.5 | 37.6 |
| k | ADF&G | 9/23/94 | Wulik R. | F | 844 | 420 | | 0.70 | 0.17 | 20.30 | < | 0.02 | 85.3 | 44.7 |
| k | ADF&G | 9/23/94 | Wulik R. | M | 690 | 420 | | 0.80 | 0.20 | 41.10 | < | 0.02 | 87.0 | 42.1 |
| k | ADF&G | 9/23/94 | Wulik R. | M | 826 | 425 | | 1.10 | 0.18 | 51.70 | < | 0.02 | 87.2 | 45.8 |
| k | ADF&G | 9/23/94 | Wulik R. | M | 890 | 435 | | 0.9 | 0.18 | 39.60 | < | 0.02 | 81.4 | 46.4 |
| k | ADF&G | 9/23/94 | Wulik R. | F | 681 | 405 | | 0.9 | 0.17 | 48.00 | < | 0.02 | 82.0 | 50.5 |
| k | ADF&G | 9/23/94 | Wulik R. | F | 726 | 420 | | 0.9 | 0.34 | 28.90 | < | 0.02 | 89.9 | 43.1 |

A=Adult, U= undetermined, F=female, M=male.

Appendix 2. Quality control/quality assurance data for concentrations of metals in Dolly Varden tissues collected from 1989 through 1994. (Metals concentrations data presented in Appendix 1.)

## Duplicate Samples

| Dates of Samples QA/QC applies to | Metal | Method | MRL | Sample A | Sample B | %Relative Difference |
|---|---|---|---|---|---|---|
| 10/1/89 | Al | 202.2 | 0.1 | 2.8 | 2.8 | <1 |
| | Cd | 213.2 | 0.01 | 0.03 | 0.01 | 100 |
| | Cu | 200.7 | 0.4 | 1.2 | 1.6 | 28 |
| | Pb | 239.2 | 0.1 | 0.1 | 0.2 | 50 |
| | Zn | 200.7 | 0.3 | 14.7 | 14.5 | 1 |
| 5/1/90 | Al | 202.2 | 0.1 | 0.6 | 0.2 | 100 |
| | Cd | 213.2 | 0.01 | 0.48 | 0.52 | 8 |
| | Cu | 200.7 | 0.4 | 29.8 | 30.5 | 2 |
| | Pb | 239.2 | 0.1 | ND | ND | |
| | Zn | 200.7 | 0.3 | 68.1 | 70 | 3 |
| 8/6/90 | Al | 202.2 | 0.1 | 8.7 | 18.1 | 70 |
| | Cd | 213.2 | 0.01 | 0.14 | 0.14 | <1 |
| | Cu | 200.7 | 0.4 | 3.8 | 3.5 | 8 |
| | Pb | 239.2 | 0.1 | 0.9 | 1 | 10 |
| | Zn | 200.7 | 0.3 | 128 | 133 | 4 |
| 8/30/90 | Al | 202.2 | 0.1 | 0.7 | 0.8 | 12 |
| 8/24/90 | Cd | 7131 | 0.01 | 0.02 | ND | |
| 9/15/90 | Cu | 6010 | 0.4 | 1.7 | 2.4 | 33 |
| 8/24/90 | Pb | 7412 | 0.1 | ND | ND | |
| 8/26/90 | Zn | 6010 | 0.4 | 12.9 | 12.7 | 2 |
| 8/25/90 | Al | 202.2 | 0.1 | 20.6 | 19.2 | 7 |
| 8/19/90 | Cd | 7131 | 0.01 | 0.3 | 0.29 | 3 |
| (all | Cu | 6010 | 0.4 | 2.9 | 2.8 | 3 |
| Juveniles, | Pb | 7412 | 0.1 | 0.3 | 0.4 | 25 |
| whole | Zn | 6010 | 0.4 | 102 | 123 | 19 |
| body) | | | | | | |
| 10/5/90 | Al | 202.2 | 0.1 | 1.5 | 1 | 38 |
| | Cd | 7131 | 0.01 | 1.11 | 1.14 | 3 |
| | Cu | 6010 | 0.4 | 25.6 | 27 | 5 |
| | Pb | 7412 | 0.1 | 0.1 | ND | |
| | Zn | 6010 | 0.4 | 103 | 105 | 2 |

Appendix 2, continued.

## Duplicate Samples

| Dates of Samples QA/QC applies to | Metal | Method | MRL | Sample A | Sample B | %Relative Difference |
|---|---|---|---|---|---|---|
| 10/19/90 | Al | 202.2 | 0.1 | 2.3 | 4.3 | 61 |
| | Cd | 7131 | 0.01 | 0.01 | 0.01 | 0 |
| | Cu | 6010 | 0.5 | 2.4 | 3.5 | 37 |
| | Pb | 7412 | 0.1 | 0.1 | 0.1 | 0 |
| | Zn | 6010 | 0.5 | 12.9 | 13.8 | 7 |
| 3/9/91 | Al | 202.2 | 0.1 | 2.2 | 2.3 | 4 |
| | Cd | 7131 | 0.01 | nd | nd | |
| | Cu | 6010 | 0.5 | 3.5 | 3.7 | 6 |
| | Pb | 7412 | 0.1 | nd | nd | |
| | Zn | 6010 | 0.5 | 18.6 | 17.6 | 6 |
| 4/6/91 | Al | 202.2 | 0.1 | 6.4 | 6.8 | 6 |
| 4/15/91 | Cd | 7131 | 0.01 | 0.04 | 0.04 | <1 |
| | Cu | 6010 | 0.5 | 2.4 | 2.2 | 9 |
| | Pb | 7412 | 0.1 | nd | nd | |
| | Zn | 6010 | 0.5 | 16.1 | 16.4 | 2 |
| 4/6/91 | Al | 202.2 | 0.1 | 4.1 | 3.8 | 8 |
| 4/15/91 | Cd | 7131 | 0.01 | 0.01 | nd | |
| continued | Cu | 6010 | 0.5 | 1.2 | 1.2 | <1 |
| | Pb | 7412 | 0.1 | nd | nd | |
| | Zn | 6010 | 0.5 | 17 | 16.9 | <1 |
| 4/26/91 | Al | 202.2 | 0.1 | 1.2 | 1.3 | 8 |
| 6/16/91 | Cd | 7131 | 0.01 | ND | ND | |
| | Cu | 6010 | 0.5 | 1.7 | 1.5 | 12 |
| | Pb | 7412 | 0.1 | ND | ND | |
| | Zn | 6010 | 0.5 | 13.6 | 13.8 | 4 |
| 4/26/91 | Al | 202.2 | 0.1 | 2.1 | 2.2 | 4 |
| 6/16/91 | Cd | 7131 | 0.01 | 3.09 | 3.12 | <1 |
| continued | Cu | 6010 | 0.5 | 4.5 | 4.3 | 5 |
| | Pb | 7412 | 0.1 | ND | ND | |
| | Zn | 6010 | 0.5 | 94.5 | 90.7 | 4 |
| 7/10/91 | Al | 202.2 | 0.1 | 11.2 | 10.1 | 10 |
| | Cd | 7131 | 0.01 | ND | ND | |
| | Cu | 6010 | 0.5 | 3.7 | 3.9 | 3 |
| | Pb | 7412 | 0.1 | 0.1 | 0.1 | <1 |
| | Zn | 6010 | 0.5 | 13.8 | 13.4 | 3 |
| 4/29/92 | Al | 200.8 | 0.5 | 2.5 | 6.9 | 94 |

Appendix 2, continued.

## Duplicate Samples

| Dates of Samples QA/QC applies to | Metal | Method | MRL | Sample A | Sample B | %Relative Difference |
|---|---|---|---|---|---|---|
| | 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 | Al | 200.8 | 0.5 | 2.6 | 2.4 | 8 |
| (continued) | 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 | 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 |
| 4/21/93 | Al | 200.8 | 0.2 | 1.4 | 1.6 | 13 |
| | Cd | 200.8 | 0.01 | ND | ND | <1 |
| | Cu | 200.8 | 0.05 | 1.45 | 1.47 | 1 |
| | Pb | 200.8 | 0.01 | 0.03 | 0.01 | 100 |
| | Zn | 7950 | 1 | 18 | 18 | <1 |
| 4/21/93 | Al | 200.8 | 0.2 | 1.3 | 1 | 25 |
| | Cd | 200.8 | 0.01 | ND | ND | <1 |
| | Cu | 200.8 | 0.05 | 1.24 | 1.3 | 5 |
| | Pb | 200.8 | 0.01 | 0.07 | 0.02 | 125 |
| | Zn | 7950 | 1 | 15 | 15 | <1 |
| 10/20/93 | Al | 200.8 | 0.2 | 2.6 | 2.2 | 17 |
| | Cd | 200.8 | 0.02 | ND | ND | <1 |
| | Cu | 200.8 | 0.05 | 1.57 | 1.78 | 12 |
| | Pb | 200.8 | 0.02 | ND | 0.3 | -- |
| | Zn | 200.8 | 0.5 | 14.5 | 13.2 | 9 |

Appendix 2, continued.

## Duplicate Samples

| Dates of Samples QA/QC applies to | Metal | Method | MRL | Sample A | Sample B | %Relative Difference |
|---|---|---|---|---|---|---|
| 10/20/93 | Al | 200.8 | 0.2 | 1.8 | 1.5 | 19 |
| | Cd | 200.8 | 0.02 | ND | ND | -- |
| | Cu | 200.8 | 0.05 | 1 | 1.12 | 11 |
| | Pb | 200.8 | 0.02 | ND | ND | -- |
| | Zn | 200.8 | 0.5 | 11.7 | 12.9 | 10 |
| 4/7/94 | Al | 200.8 | 0.2 | 7.8 | 8.6 | 10 |
| | Cd | 200.8 | 0.02 | ND | ND | |
| | Cu | 200.8 | 0.05 | 1.38 | 1.4 | 1 |
| | Pb | 200.8 | 0.02 | ND | ND | |
| | Zn | 200.8 | 0.5 | 17.4 | 17 | 4 |
| 4/7/94 | Al | 200.8 | 0.2 | 15 | 13.4 | 14.2 |
| | Cd | 200.8 | 0.02 | ND | ND | NC |
| | Cu | 200.8 | 0.05 | 1.25 | 1.21 | 1.23 |
| | Pb | 200.8 | 0.02 | 0.02 | ND | NC |
| | Zn | 200.8 | 0.5 | 12.9 | 12.5 | 12.7 |
| 9/23/94 | Al | 200.8 | 0.2 | 3.1 | 3.3 | 6 |
| | Cd | 200.8 | 0.02 | ND | ND | NC |
| | Cu | 200.8 | 0.05 | 1.74 | 1.68 | 4 |
| | Pb | 200.8 | 0.02 | 0.04 | 0.04 | <1 |
| | Zn | 200.8 | 0.5 | 16.9 | 16.1 | 5 |
| 9/23/94 | Al | 200.8 | 0.2 | 2.1 | 1.4 | 39 |
| | Cd | 200.8 | 0.02 | ND | ND | NC |
| | Cu | 200.8 | 0.05 | 1.7 | 1.68 | 1 |
| | Pb | 200.8 | 0.02 | ND | ND | NC |
| | Zn | 200.8 | 0.5 | 20.8 | 20.6 | 1 |

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

| Dates of Samples QA/QC applies to | Metal | Method | MRL | Matrix Spike Results: Spike Level | Sample Result | Spike Result | % Recovery | Method Blank: MB1 | MB2 | MB3 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10/1/89 | Al | 202.2 | 0.1 | 267 | 2.8 | 283 | 105 | ND | | |
| | Cd | 213.2 | 0.01 | 6.68 | 0.03 | 6.78 | 101 | ND | | |
| | Cu | 200.7 | 0.4 | 33.4 | 1.2 | 33.9 | 98 | ND | | |
| | Pb | 239.2 | 0.1 | 2.4 | 0.1 | 2.9 | 117 | ND | | |
| | Zn | 200.7 | 0.3 | 66.8 | 14.7 | 74.7 | 90 | ND | | |
| 5/1/90 | Al | 202.2 | 0.1 | 2.9 | 0.6 | 4.2 | 124 | ND | | |
| | Cd | 213.2 | 0.01 | 0.58 | 0.48 | 1 | 90 | ND | | |
| | Cu | 200.7 | 0.4 | 2.9 | 29.8 | 34.1 | NC | ND | | |
| | Pb | 239.2 | 0.1 | 0.6 | ND | 0.6 | 100 | ND | | |
| | Zn | 200.7 | 0.3 | 14.4 | 68.1 | 80.4 | NC | ND | | |
| 8/6/90 | Al | 202.2 | 0.1 | 5 | 8.7 | 14 | 106 | 0.3 | 0.2 | |
| | Cd | 213.2 | 0.01 | 1 | 0.14 | 1.15 | 101 | ND | ND | |
| | Cu | 200.7 | 0.4 | 5 | 3.8 | 8.2 | 88 | ND | ND | |
| | Pb | 239.2 | 0.1 | 1 | 0.9 | 2 | 110 | ND | ND | |
| | Zn | 200.7 | 0.3 | 24.8 | 128 | 143 | NC | ND | ND | |
| 8/30/90 | Al | 202.2 | 0.1 | 4.9 | 0.7 | 6.3 | 114 | ND | | |
| 8/24/90 | Cd | 7131 | 0.01 | 0.99 | 0.02 | 1.01 | 100 | ND | | |
| 9/15/90 | Cu | 6010 | 0.4 | 4.9 | 1.7 | 7.6 | 120 | ND | | |
| 8/24/90 | Pb | 7412 | 0.1 | 1 | ND | 1 | 100 | ND | | |
| 8/26/90 | Zn | 6010 | 0.4 | 24.6 | 12.9 | 39.2 | 107 | | | |
| 8/25/90 | Al | 202.2 | 0.1 | 5.1 | 20.6 | 30.9 | NC | ND | | |
| 8/19/90 | Cd | 7131 | 0.01 | 1 | 0.3 | 1.42 | 112 | ND | | |
| (all | Cu | 6010 | 0.4 | 5.1 | 2.9 | 8.7 | 114 | ND | | |
| Juveniles, | Pb | 7412 | 0.1 | 1 | 0.3 | 1.6 | 130 | ND | | |
| whole | Zn | 6010 | 0.4 | 25.5 | 102 | 139 | 145 | ND | | |
| body) | | | | | | | | | | |
| 10/5/90 | Al | 202.2 | 0.1 | 4.7 | 1.5 | 6.8 | 113 | ND | | |
| | Cd | 7131 | 0.01 | 0.95 | 1.11 | 1.93 | 86 | ND | | |
| | Cu | 6010 | 0.4 | 4.7 | 25.6 | 32.6 | NC | ND | | |
| | Pb | 7412 | 0.1 | 0.9 | 0.1 | 0.9 | 89 | ND | | |
| | Zn | 6010 | 0.4 | 23.7 | 103 | 129 | NC | ND | | |

Appendix 2, continued.

| Dates of Samples QA/QC applies to | Metal | Method | MRL | Matrix Spike Results: Spike Level | Sample Result | Spike Result | % Recovery | Method Blank: MB1 | MB2 | MB3 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10/19/90 | Al | 202.2 | 0.1 | 47.7 | 2.3 | 76.4 | 155 | ND | | |
| | Cd | 7131 | 0.01 | 1.2 | 0.01 | 1.34 | 112 | ND | | |
| | Cu | 6010 | 0.5 | 47.7 | 2.4 | 59.8 | 120 | ND | | |
| | Pb | 7412 | 0.1 | 4.8 | 0.1 | 5.1 | 106 | ND | | |
| | Zn | 6010 | 0.5 | 119 | 12.9 | 135 | 103 | ND | | |
| 3/9/91 | Al | 202.2 | 0.1 | 10.4 | 2.2 | 10.2 | 77 | 0.2 | | |
| | Cd | 7131 | 0.01 | 1.04 | nd | 1.14 | 110 | nd | | |
| | Cu | 6010 | 0.5 | 41.5 | 3.5 | 47.3 | 106 | nd | | |
| | Pb | 7412 | 0.1 | 4.2 | nd | 4.3 | 102 | nd | | |
| | Zn | 6010 | 0.5 | 104 | 18.6 | 126 | 103 | nd | | |
| 4/6/91 | Al | 202.2 | 0.1 | 9.6 | 6.4 | 16.1 | 101 | 0.2 | 0.2 | 0.2 |
| 4/15/91 | Cd | 7131 | 0.01 | 0.96 | 0.04 | 1.1 | 110 | nd | nd | nd |
| | Cu | 6010 | 0.5 | 38.5 | 2.4 | 43.4 | 106 | nd | nd | nd |
| | Pb | 7412 | 0.1 | 3.9 | nd | 4.1 | 105 | nd | nd | nd |
| | Zn | 6010 | 0.5 | 96.3 | 16.1 | 113 | 101 | nd | nd | nd |
| 4/6/91 | Al | 202.2 | 0.1 | 9.7 | 4.1 | 14.7 | 109 | | | |
| 4/15/91 | Cd | 7131 | 0.01 | 0.97 | 0.01 | 1.07 | 109 | | | |
| continued | Cu | 6010 | 0.5 | 38.4 | 1.2 | 42.7 | 108 | | | |
| | Pb | 7412 | 0.1 | 3.9 | nd | 4 | 103 | | | |
| | Zn | 6010 | 0.5 | 96 | 17 | 116 | 103 | | | |
| 4/26/91 | Al | 202.2 | 0.1 | 6.7 | 1.2 | 6.4 | 78 | 0.3 | 0.3 | |
| 6/16/91 | Cd | 7131 | 0.01 | 0.67 | ND | 0.67 | 100 | ND | ND | |
| | Cu | 6010 | 0.5 | 26.9 | 1.7 | 28.8 | 101 | ND | ND | |
| | Pb | 7412 | 0.1 | 2.7 | ND | 2.7 | 100 | ND | ND | |
| | Zn | 6010 | 0.5 | 67.3 | 14.1 | 78.4 | 96 | ND | ND | |
| 4/26/91 | Al | 202.2 | 0.1 | 9.2 | 2.1 | 12.2 | 110 | 0.4 | 0.2 | |
| 6/16/91 | Cd | 7131 | 0.01 | 0.92 | 3.09 | 4.01 | 100 | ND | ND | |
| continued | Cu | 6010 | 0.5 | 36.7 | 4.5 | 39.7 | 96 | ND | ND | |
| | Pb | 7412 | 0.1 | 3.7 | ND | 3.9 | 105 | ND | ND | |
| | Zn | 6010 | 0.5 | 91.7 | 94.5 | 178 | 91 | ND | ND | |
| 7/10/91 | Al | 202.2 | 0.1 | 9 | 11.2 | 21.2 | 110 | 0.3 | | |
| | Cd | 7131 | 0.01 | 0.9 | ND | 0.92 | 102 | ND | | |
| | Cu | 6010 | 0.5 | 36 | 3.7 | 39.5 | 99 | ND | | |
| | Pb | 7412 | 0.1 | 3.6 | 0.1 | 4.1 | 111 | ND | | |
| | Zn | 6010 | 0.5 | 90.3 | 13.8 | 105 | 101 | ND | | |
| 4/29/92 | Al | 200.8 | 0.5 | 4.8 | 2.5 | 8 | 115 | ND | ND | |

Appendix 2, continued.

| Dates of Samples QA/QC applies to | Metal | Method | MRL | Matrix Spike Results<br>Spike Level | Sample Result | Spike Result | % Recovery | Method Blank<br>MB1 | MB2 | MB3 |
|---|---|---|---|---|---|---|---|---|---|---|
| | Cd | 7131 | 0.02 | 4.8 | ND | 5.08 | 106 | ND | ND | |
| | Cu | 200.8 | 0.05 | 19 | 2.27 | 20.5 | 96 | ND | ND | |
| | Pb | 200.8 | 0.02 | 4.8 | ND | 4.83 | 101 | ND | ND | |
| | Zn | 200.8 | 0.2 | 48 | 16.5 | 63.3 | 98 | ND | ND | |
| 4/29/92 | Al | 200.8 | 0.5 | 4.6 | 2.6 | 5.5 | 63 | | | |
| (continued) | Cd | 7131 | 0.02 | 4.6 | ND | 4.58 | 100 | | | |
| | Cu | 200.8 | 0.05 | 18 | 2.38 | 19.4 | 95 | | | |
| | Pb | 200.8 | 0.02 | 4.6 | 0.02 | 4.57 | 99 | | | |
| | Zn | 200.8 | 0.2 | 46 | 22.9 | 66.5 | 95 | | | |
| 9/30/92 | Al | 200.8 | 0.05 | 4.6 | 0.47 | 4.9 | 96 | 0.36 | 0.227 | |
| | Cd | 200.8 | 0.02 | 0.92 | ND | 0.89 | 97 | ND | ND | |
| | Cu | 200.8 | 0.05 | 18 | 1.27 | 18.3 | 95 | ND | ND | |
| | Pb | 200.8 | 0.02 | 1.8 | ND | 1.93 | 107 | ND | ND | |
| | Zn | 7950 | 1 | 46 | 11 | 59 | 104 | ND | ND | |
| 9/30/92 | Al | 200.8 | 0.05 | 4.8 | 0.42 | 5.2 | 100 | | | |
| | Cd | 200.8 | 0.02 | 0.95 | ND | 0.94 | 99 | | | |
| | Cu | 200.8 | 0.05 | 19 | 1.59 | 19.3 | 93 | | | |
| | Pb | 200.8 | 0.02 | 1.9 | ND | 1.97 | 104 | | | |
| | Zn | 7950 | 1 | 48 | 14 | 63 | 102 | | | |
| 4/21/93 | Al | 200.8 | 0.2 | 8.6 | 1.4 | 12.9 | 134 | 0.8 | 0.6 | |
| | Cd | 200.8 | 0.01 | 4.3 | ND | 4.28 | 100 | ND | ND | |
| | Cu | 200.8 | 0.05 | 8.6 | 1.45 | 9.76 | 97 | ND | ND | |
| | Pb | 200.8 | 0.01 | 4.4 | 0.03 | 4.26 | 96 | ND | ND | |
| | Zn | 7950 | 1 | 43 | 18 | 59 | 95 | ND | ND | |
| 4/21/93 | Al | 200.8 | 0.2 | 8.4 | 1.3 | 9.1 | 93 | | | |
| | Cd | 200.8 | 0.01 | 4.2 | ND | 4.17 | 99 | | | |
| | Cu | 200.8 | 0.05 | 8.4 | 1.24 | 9.46 | 98 | | | |
| | Pb | 200.8 | 0.01 | 4.2 | 0.07 | 4.35 | 105 | | | |
| | Zn | 7950 | 1 | 42 | 15 | 58 | 102 | | | |
| 10/20/93 | Al | 200.8 | 0.2 | 9.4 | 2.6 | 11 | 89 | 0.7 | 0.7 | |
| | Cd | 200.8 | 0.02 | 4.7 | ND | 4.41 | 94 | ND | ND | |
| | Cu | 200.8 | 0.05 | 9.4 | 1.57 | 10.3 | 93 | ND | ND | |
| | Pb | 200.8 | 0.02 | 4.7 | ND | 4.43 | 94 | ND | ND | |
| | Zn | 200.8 | 0.5 | 47 | 14.5 | 56.8 | 90 | ND | 0.6 | |

Appendix 2, continued.

| Dates of Samples QA/QC applies to | Metal | Method | MRL | Matrix Spike Results: Spike Level | Sample Result | Spike Result | % Recovery | Method Blank: MB1 | MB2 | MB3 |
|---|---|---|---|---|---|---|---|---|---|---|
| 10/20/93 | Al | 200.8 | 0.2 | 10 | 1.8 | 10.9 | 91 | | | |
| | Cd | 200.8 | 0.02 | 5 | ND | 4.89 | 98 | | | |
| | Cu | 200.8 | 0.05 | 10 | 1 | 10.1 | 91 | | | |
| | Pb | 200.8 | 0.02 | 5 | ND | 4.72 | 94 | | | |
| | Zn | 200.8 | 0.5 | 50 | 11.7 | 60.1 | 97 | | | |
| 4/7/94 | Al | 200.8 | 0.2 | 4.9 | 7.8 | 13 | 106 | 0.7 | ND | |
| | Cd | 200.8 | 0.02 | 0.98 | ND | 0.99 | 101 | ND | ND | |
| | Cu | 200.8 | 0.05 | 20 | 1.38 | 19 | 88 | ND | ND | |
| | Pb | 200.8 | 0.02 | 2 | ND | 1.99 | 100 | ND | ND | |
| | Zn | 200.8 | 0.5 | 49 | 16.7 | 65.8 | 100 | ND | ND | |
| 4/7/94 | Al | 200.8 | 0.2 | 4.7 | 15 | 20.9 | 126 | | | |
| | Cd | 200.8 | 0.02 | 0.94 | ND | 0.97 | 103 | | | |
| | Cu | 200.8 | 0.05 | 19 | 1.25 | 18.4 | 90 | | | |
| | Pb | 200.8 | 0.02 | 1.9 | 0.02 | 1.91 | 99 | | | |
| | Zn | 200.8 | 0.5 | 47 | 12.9 | 60.5 | 101 | | | |
| 9/23/94 | Al | 200.8 | 0.2 | 200 | 3.1 | 206 | 101 | ND | | |
| | Cd | 200.8 | 0.02 | 4.9 | ND | 5.16 | 105 | ND | | |
| | Cu | 200.8 | 0.05 | 24 | 1.74 | 27.6 | 108 | ND | | |
| | Pb | 200.8 | 0.02 | 49 | 0.04 | 47.5 | 97 | ND | | |
| | Zn | 200.8 | 0.5 | 49 | 16.9 | 72.9 | 114 | ND | | |
| 9/23/94 | Al | 200.8 | 0.2 | 200 | 2.1 | 197 | 97 | | | |
| | Cd | 200.8 | 0.02 | 4.9 | ND | 4.89 | 100 | | | |
| | Cu | 200.8 | 0.05 | 24 | 1.7 | 26.1 | 98 | | | |
| | Pb | 200.8 | 0.02 | 49 | ND | 46.6 | 95 | | | |
| | Zn | 200.8 | 0.5 | 49 | 20.8 | 70.8 | 102 | | | |

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

Appendix 2, concluded.

## Recovery of Standard Reference Material

| Dates of Samples QA/QC applies to | Metal | Method | MRL | TRUE Value mg/kg | Laboratory Result mg/kg | TRUE Value mg/kg | Laboratory Result mg/kg |
|---|---|---|---|---|---|---|---|
| 4/7/94 | Al | 200.8 | 0.2 | | | | |
| | Cd | 200.8 | 0.02 | 26.3 | 24.8 | 26.3 | 25 |
| | Cu | 200.8 | 0.05 | 439 | 414 | 439 | 422 |
| | Pb | 200.8 | 0.02 | 10.4 | 9.6 | 10.4 | 10.8 |
| | Zn | 200.8 | 0.5 | 177 | 155 | 177 | 157 |
| 9/23/94 | Al | 200.8 | 0.2 | 10.9 ± 1.7 | 8.1 | 10.9 ± 1.7 | 9 |
| | Cd | 200.8 | 0.02 | 0.043 ± 0.008 | 0.047 | 0.043 ± 0.008 | 0.049 |
| | Cu | 200.8 | 0.05 | 2.34 ± 0.16 | 3.02 | 2.34 ± 0.16 | 2.51 |
| | Pb | 200.8 | 0.02 | 0.065 ± 0.007 | 0.074 | 0.065 ± 0.007 | 0.062 |
| | Zn | 200.8 | 0.5 | 25.6 ± 2.3 | 27 | 25.6 ± 2.3 | 27.3 |
| 9/23/94 | Al | 200.8 | 0.2 | | | | |
| | Cd | 200.8 | 0.02 | 26.3 ± 2.1 | 25.4 | 26.3 ± 2.1 | 24.9 |
| | Cu | 200.8 | 0.05 | 439 ± 22 | 466 | 439 ± 22 | 466 |
| | Pb | 200.8 | 0.02 | 10.4 ± 2.0 | 10.1 | 10.4 ± 2.0 | 10 |
| | Zn | 200.8 | 0.5 | 177 ± 10 | 206 | 177 ± 10 | 204 |

Appendix 3. Description of fish sample groups for determinations of concentrations of Al, Cd, Cu, Pb, and Zn.

| Date Collected | Site | No. of Fish | Collector |
|---|---|---|---|
| 1982 | Wulik River | Varies with tissue | Dames and Moore |
| [1]October 1990 | Wulik River | 6 | ADF&G |
| [2]April 1991 | Wulik River | 4 | Cominco |
| [2]April 1991 | Wulik River | 5 | Kivalina |
| [3]April 1991 | Noatak River | 5 | ADF&G |
| [4]June 1991 | Wulik River | 8 | Cominco |
| [5]October 1991 | Wulik River | 6 | Cominco and ADF&G |
| [6]April 1992 | Wulik River | 8 | Cominco and ADF&G |
| [7]September 1992 | Wulik River | 6 | ADF&G |
| [8]April 1993 | Wulik River | 6 | Cominco and ADF&G |
| [9]October 1993 | Wulik River | 6 | ADF&G |
| [10]April 1994 | Wulik River | 6 | ADF&G |
| [11]October 1994 | Wulik River | 6 | ADF&G |

[1]Sample Group A - 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.

[2]Sample Group B - Nine adult Dolly Varden collected from the Wulik River (three by Cominco Alaska Inc. on 3/9/91, five by Kivalina on 4/6/91, one by Cominco Alaska Inc. on 4/26/91) between Driver's Camp (Station 2) and Umiivaq (lower Wulik River) during late winter before breakup.

[3]Sample Group C - 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.

[4]Sample Group D - Eight adult Dolly Varden collected from the Wulik River (lower Wulik River immediately upstream of Kivalina) by Cominco Alaska Inc. and local residents from Kivalina on June 16, 1991, immediately following breakup.

[5]Sample Group E - Six adult Dolly Varden collected from the Wulik River (Station 2) by Matt Robus (ADF&G) and Hank Brown and John Martinesko (Cominco Alaska Inc.) on October 5, 1991, before freezeup.

[6]Sample Group F - Eight adult Dolly Varden collected from the Wulik River (about five miles upstream of Kivalina) between April 28 and 30, 1992, by Al Townsend (ADF&G) and Hank Brown (Cominco Alaska Inc.) during late winter before breakup.

[7]Sample Group G - Six adult Dolly Varden collected from the Wulik River (Station 2) by Al Townsend (ADF&G) on September 29, 1992, before freezeup.

[8]Sample Group H - Six adult Dolly Varden collected from the Wulik River (about five miles upstream of Kivalina) between April 19 and 23 by 1993, by Al Townsend (ADF&G) and Jake Wells (Cominco Alaska Inc.) during late winter before breakup.

[9]Sample Group I - Six adult Dolly Varden collected from the Wulik River (Station 2) by Al Townsend (ADF&G) on October 20, 1993, before freezeup.

[10]Sample Group J - Six adult Dolly Varden collected from the Wulik River (Station 2) by Al Townsend (ADF&G) on April 7, 1994 before breakup.

[11]Sample Group K - Six adult Dolly Varden collected from the Wulik River (Station 2) by Al Townsend (ADF&G) on September 23, 1994, before freezeup.

Appendix 4. Laboratory Quality Control Results for Pb samples from Anxiety Ridge Creek. All concentrations are reported as ug/L, EPA method 7421. Note: These samples were part of a larger catalog of samples submitted to an analytical laboratory.

| Limit of Detection ug/L | Sample Result ug/L | Duplicate Sample Result ug/L | Average ug/L | Relative Percent Difference |
|---|---|---|---|---|
| 1 | 35 | 34 | 34 | 3 |

| Method Blank ug/L | Spike Level ug/L | Spiked Sample Result ug/L | Sample Result ug/L | Percent Recovery |
|---|---|---|---|---|
| <LOD | 20 | 35 | 54 | 95 |

Appendix 5. Dolly Varden collected in Evaingiknuk Creek using minnow traps baited with salmon roe, 1990-1994.

| 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 |

Appendix 5, continued.

| Sample Time | Number of Traps | Hours Fished/ Trap | Total Number DV | Length Range (mm), (Average) | DV/Trap ±SD |
|---|---|---|---|---|---|
| 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 |
| 8/30-31/94 | 10 | 25 | 3 | 94-118(107) | 0.3±0.5 |

Appendix 6. Dolly Varden collected in Anxiety Ridge Creek using minnow traps baited with salmon roe, 1990-1994.

| 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 6, 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 |
| 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 |

Appendix 7. Dolly Varden collected in Middle Fork and Mainstem Red Dog Creek using minnow traps baited with salmon roe, 1994.

| Sample Time | Number of Traps | Hours Fished/ Trap | Total Number DV | Length Range (mm), (Average) | DV/Trap ±SD |
|---|---|---|---|---|---|
| 6/27-28/94 | 10 | 23 | 0 | | |
| 7/26-27/94 | 10 | 22 | 0 | | |
| 8/30-31/94 | 10 | 25 | 0 | | |

Appendix 8. Dolly Varden collected in Ikalukrok Creek using minnow traps baited with salmon roe, 1990-1994. 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 Dud Creek. Sample stations (#1 - #5) in Ikalukrok Creek at Dud Creek were the same in 1990, 1991, 1992, and 1993; however, five additional sites were established and run in 1992, 1993, and 1994.

| 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 |
| [c]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 |
| [c]9/13-14/90 | 5 | 22 | 0 | | 0.0 |
| [c]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 |
| [c]8/5-8/91 | 5 | 65 | 10 | 60-105(66) | 2.0±2.5 |

Appendix 8, continued.

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

[a]Ikalukrok Creek - 7 km upstream of Dud Creek
[b]Ikalukrok Creek - 10 km downstream of Dud Creek

[c]Ikalukrok Creek - 10 km downstream of Dud Creek, clear back-water

[d]Ikalukrok Creek - 20 km downstream of Dud Creek

[e]Ikalukrok Creek - Immediately upstream of Dud Creek

[f]Ikalukrok Creek - Immediately upstream of Red Dog Creek

[g]Ikalukrok Creek - Immediately upstream and downstream of Dud Creek

Appendix 9. Dolly Varden collected in the North Fork of Red Dog Creek using minnow traps baited with salmon roe, 1992-1994.

| 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 | 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 | | |