Technical Report No. 01-04

Aquatic Biomonitoring At Red Dog Mine, 2000

National Pollution Discharge Elimination System
Permit No. AK-003865-2

by Phyllis Weber Scannell
and Alvin G. Ott

Photo by Alvin G. Ott, Alaska Dept. of Fish and Game

May 15, 2001

Alaska Department of Fish and Game **Habitat and Restoration Division**

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Acknowledgements

We thank Cominco Alaska Inc. for the extensive financial and logistical support that allowed us to conduct this biomonitoring project. In particular, we acknowledge the support given by Mr. John Key, Mr. Jim Kulas, Mr. Mark Thompson, Mr. Wayne Hall, Mr. John Martinisko, and Mr. Austin Swan of Cominco Alaska. We also thank members of ADF&G for their help with laboratory analysis, sampling adult fish, preparing and reviewing this report, and conducting field work. In particular, we thank Mr. Fred DeCicco, Mr. Bill Morris, Mr. Jack Winters, Mr. Bruce McIntosh, Ms. Laura Jacobs, and Ms. Nancy Ihlenfeldt. The University of Alaska, Cooperative Fish and Wildlife Research Unit, allowed us to use their laboratory facilities for chlorophyll analysis.

Executive Summary

The Alaska Department of Fish and Game conducted biomonitoring from late May through freeze-up in mid-September in tributaries below the Red Dog Mine. We also sampled tributaries that were not affected by the mining activity to detect natural fluctuations in the fish populations that might result from climatic conditions. Based upon our observations on invertebrate communities, periphyton standing crop, and the distribution and abundance of fish, we present the following overall observations of the biotic conditions in streams adjacent to and downstream of the Red Dog Mine.

Aquatic Invertebrates and Periphyton

Station 12, the North Fork of Red Dog Creek, had the highest invertebrate density and taxon richness, highest percent of aquatic invertebrates (compared to terrestrial drift), and highest concentrations of chlorophyll-a. Ikalukrok Creek at Station 7 had similar, but slightly lower, abundance and complexity in aquatic communities. The percent of EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa was highest at Station 9.

The density of aquatic invertebrates collected at Station 10 was lower in 2000 than during any of the other sample times, except July 1997. Invertebrate density has steadily declined since July 1998.

Invertebrate communities in Stations 8, 7, and Ikalukrok Creek upstream of Dudd Creek were dominated by larval Chironomidae. Communities in Station 10, 20, and 12 were dominated by Plecoptera: Capniidae. Communities in Station 9 were dominated by Ephemeroptera: Heptageniidae – *Cinygmula*.

Periphyton standing crop, measured as concentration of chlorophyll-a, was lowest at Station 20 and Station 10. The highest periphyton standing crop was measured at Stations 12 and 7, where we found the highest invertebrate abundance and taxon richness.

Water Quality and Concentrations of Metals

In summer 2000, the North Fork of Red Dog Creek contained the lowest median concentrations of Cd, Pb, and Zn. Median Cd concentrations also were low in Ikalukrok Creek upstream of Dudd Creek, and Stations 7 and 9. Median concentrations of Cd, Pb, and Zn were highest at Station 20.

Distribution of Fish

Populations of juvenile Dolly Varden were lower in all tributaries downstream of the mine and in tributaries unaffected by the mine. The low population numbers likely resulted from early freeze-up and exceptionally thick ice on the overwintering areas. Recruitment of young of the year Arctic grayling was the highest measured since sampling began in the early 1990s, suggesting successful spawning of this fish species during spring.

Juvenile Dolly Varden Tissues

We found increased maximum (although not median) concentrations of cadmium, lead, and selenium in juvenile Dolly Varden collected from Mainstem Red Dog Creek below the mine increased from 1999 to 2000 samples.

Adult Dolly Varden Tissues

We found no changes over previous years in concentrations of aluminum, cadmium, lead, or zinc in any of the tissues from adult Dolly Varden. Median concentrations of selenium have slowly increased in liver tissues since 1998. Selenium concentrations are higher in reproductive tissues from fall-caught fish than spring-caught fish, suggesting marine sources.

INTRODUCTION

The Red Dog zinc and lead deposit is located in northwest Alaska, approximately 130 km north of Kotzebue and 75 km inland from the coast of the Chukchi Sea (Figure 1). The mine operation and facilities and the surrounding vegetation and wildlife are described in Weber Scannell and Ott (1998). A chronicle of development and operation of the Red Dog Mine is contained in Appendix 1.

In July 1998, the US Environmental Protection Agency (US EPA) issued National Pollution Discharge Elimination System (NPDES) Permit No. AK-003865-2 to Cominco Alaska Inc. to allow discharge of up to 2.418 billion gallons of treated effluent per year. The Alaska Department of Environmental Conservation (ADEC) issued a Certificate of Reasonable Assurance and the NPDES permit became effective August 28, 1998. The NPDES permit required biomonitoring of fish, aquatic invertebrates, and periphyton in streams downstream and adjacent to the Red Dog Mine. This report contains the results of the year 2000 biomonitoring studies conducted by the Alaska Department of Fish and Game (ADF&G).

Receiving waters below the mine, including Ikalukrok Creek and the Wulik River, support important subsistence and sport fisheries. Pink salmon (*Oncorhynchus gorbuscha*), chum (*O. keta*), coho (*O. kisutch*), sockeye (*O. nerka*), and chinook salmon (*O. tshawytscha*), Dolly Varden (*Salvelinus malma*), burbot (*Lota lota*), slimy sculpin (*Cottus cognatus*), humpback (*Coregonus pidschian*) and round whitefish (*Prosopium cylindraceum*), least (*Coregonus sardinella*) and Bering (*C. laurettae*) cisco, Alaska blackfish (*Dallia pectoralis*), ninespine stickleback (*Pungitius pungitius*) and Arctic grayling (*Thymallus arcticus*) occur in the Wulik River.

In early summer, Arctic grayling, slimy sculpin, and juvenile Dolly Varden disperse upstream into Ikalukrok Creek and its tributaries. In late summer, usually around July 25, chum salmon and adult Dolly Varden spawn throughout the Wulik River and in Ikalukrok Creek up to the confluence of Dudd Creek. Spawning usually continues through mid-September.

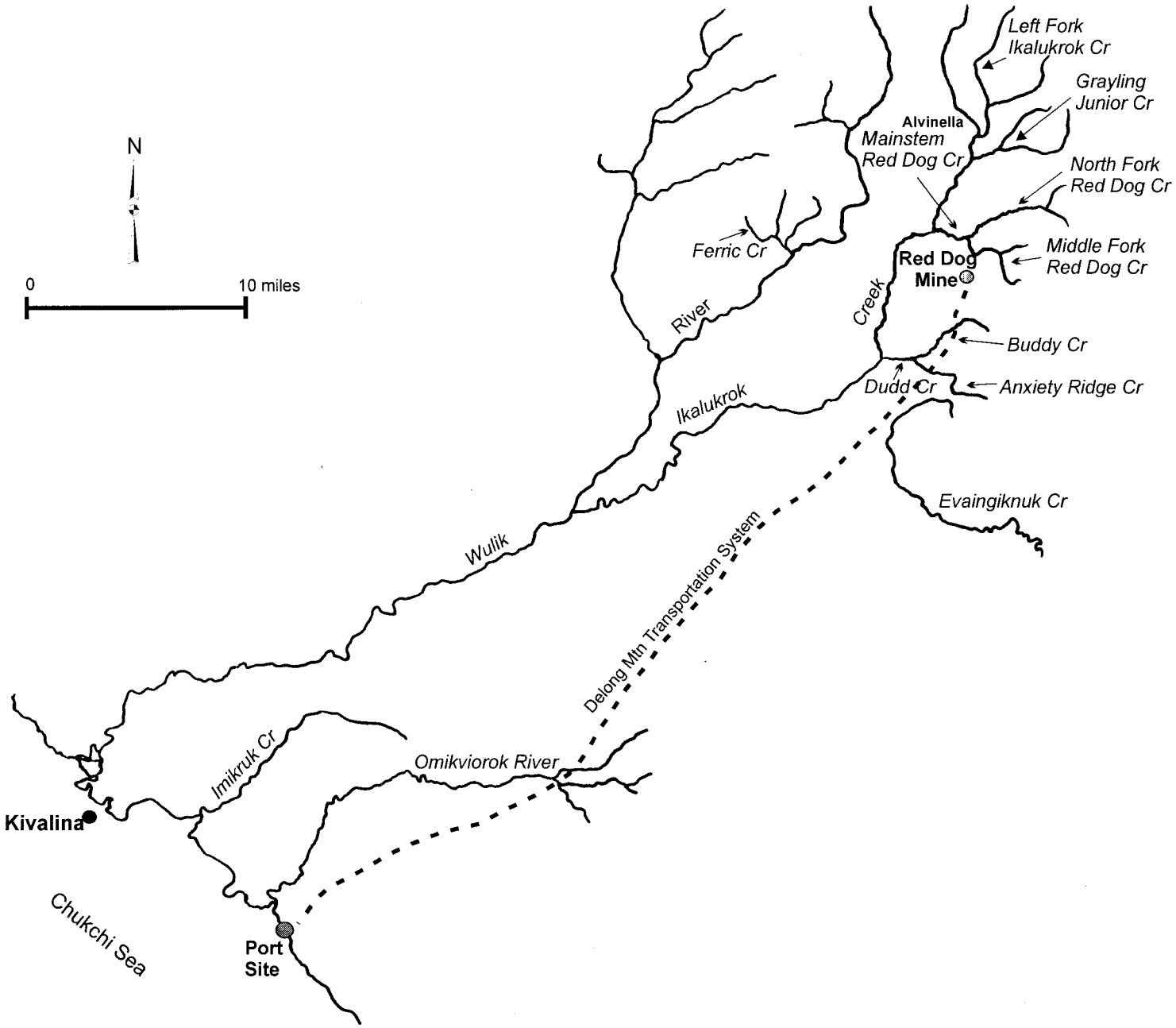


Figure 1. Location of the Red Dog Mine in northwest Alaska.

ADFG has conducted numerous biomonitoring studies of fish, invertebrates, and stream periphyton since the mine began operation in 1989. In 1991, ADF&G began a three-year study in the Wulik River drainage to document short-term changes in fish distribution during mine development and operation, and following construction of the water bypass and collection system. We focused on the distribution and relative abundance of juvenile Dolly Varden, use of North Fork Red Dog Creek by Arctic grayling, metals concentrations in adult Dolly Varden tissues, and the population size of adult Dolly Varden in the Wulik River (Ott and Weber Scannell 1994).

In 1994, we developed a five-year study to document changes in fish distribution, relative abundance, fish species composition, and metals concentrations in adult Dolly Varden tissues. Results and conclusions for the first year were reported in Weber Scannell and Ott (1995), and for the second year in Ott and Weber Scannell (1996.). The scope of the five-year study was expanded in 1996 to include aerial counts of chum salmon in Ikalukrok Creek and biomonitoring of aquatic invertebrate abundance and community composition and periphyton standing crop. In 1997, we added selenium to the laboratory tissue analyses.

The objective of our expanded scope of work was to monitor and document changes that may occur in stream systems of the Wulik River drainage either naturally or as a result of mining activity. Specifically, we addressed how aquatic communities were affected by the red Dog Mine effluent and naturally occurring changes in water quality. Since fish are a migratory group, their presence gives only limited information about in-situ productivity. Aquatic invertebrates and periphyton represent communities that are continually exposed to water quality conditions present in a given tributary or section of stream.

ADF&G conducted in-depth biomonitoring of benthic macroinvertebrates and periphyton from selected sites downstream from the Red Dog Mine water treatment plant in 1997 and 1998 (Weber Scannell and Andersen 1999). Information was compared with historical data and other data from sites unaffected by the mine. The study focused on stream habitats that were directly exposed to mining activity or treated mine effluent and

mineralization. This information, with existing fish and water quality information, was used as the basis for evaluating whether observed changes, if any, occurred in aquatic communities that may be due to natural or mining related conditions or events.

Weber Scannell, et al. (2000) summarized results from biomonitoring studies conducted at the Red Dog Mine through 1999. Their study compared the then current conditions with baseline and early mining conditions in the Red Dog and Wulik River drainage.

Structure of this Report

Results of water quality monitoring, aquatic invertebrate sampling, and estimates of periphyton standing crop are given for each site for the years sampled (usually 1996-2000). Following presentation of these results is a table summarizing changes in biotic communities and water quality conditions since pre-mining. Biomonitoring results for juvenile and adult fish are presented after discussions of the sample sites.

LOCATIONS OF SAMPLE SITES

Biomonitoring was conducted in streams adjacent to and downstream of the Red Dog Mine as required under US EPA NPDES Permit No. AK-003865-2 (Figure 2). A description of the sites included in this study is listed below, followed by the station number.

Stream or Site Name	Station Number	Photo
Ikalukrok Creek upstream of Red Dog Creek	Station 9	Photo 1
Ikalukrok Creek downstream of Red Dog Creek	Station 8	Photo 2
Ikalukrok Creek upstream of Dudd Creek		Photo 3
Ikalukrok Creek downstream of Dudd Creek	Station 7	Photo 4
Mainstem Red Dog Creek	Station 10	Photo 5
Middle Fork Red Dog Creek	Station 20	Photo 6
North Fork of Red Dog Creek	Station 12	Photo 7

Description of Streams

All of the streams in this study are in the Wulik River watershed. Station numbers correspond to the numbers used by Dames and Moore (1983) during their baseline studies and the current water sampling program being conducted by Cominco Alaska. Water quality and fisheries data collected during baseline studies (1979-1982) represent pre-mining conditions because no disturbance had occurred in this drainage at that time. Each sample component and location listed in Table 1 is required in NPDES Permit No. AK-003865-2. ADF&G conducts additional sampling that is supplemental to the requirements under the NPDES permit to further our understanding of the aquatic communities at this site (Table 2).

Table 1. Locations and components of studies required under NPDES Permit No. AK-003865-2, Wulik River drainage, Red Dog, Alaska, 2000.

Middle Fork Red Dog Creek	Periphyton (as Chlorophyll-a concentrations) Aquatic invertebrates: taxon richness and abundance
North Fork Red Dog Creek	Periphyton (as Chlorophyll-a concentrations) Aquatic invertebrates: taxon richness and abundance Fish presence and use
Mainstem Red Dog Creek	Periphyton (as Chlorophyll-a concentrations) Aquatic invertebrates: taxon richness and abundance Fish presence and use
Ikalukrok Creek, Stations 9, 7; and upstream of Dudd Creek	Periphyton (as Chlorophyll-a concentrations) Aquatic invertebrates: taxon richness and abundance Fish presence and use.
Ikalukrok Creek	Fall aerial survey of returning chum salmon
Wulik River	Metals concentrations in Dolly Varden gill, liver, muscle, and kidney Fall aerial survey of overwintering Dolly Varden
Anxiety Ridge Creek	Fish presence and use
Evaingiknuk Creek	Fish presence and use
Buddy Creek	Fish presence and use

Table 2. Locations and components of supplemental biomonitoring studies supported by Cominco Alaska Inc., but not required under NPDES Permit No. AK-003865-2.

North Fork Red Dog Creek, near mouth	Collected juvenile fish for whole body concentrations of Cd, Pb, and Zn. Collected adult arctic grayling, analyze liver and reproductive tissues for Se Determine fish movement with fyke net traps
North Fork Red Dog Creek near headwaters	Presence of juvenile fish
Mainstem Red Dog Creek	Collected juvenile fish for whole body concentrations of Cd, Pb, and Zn Determine fish movement with fyke net traps
Ikalukrok Creek: Stations 9, 7; and upstream of Dudd Creek	Fish presence and use
Ikalukrok Creek upstream of Red Dog Creek	Aerial surveys to determine distribution of adult Arctic grayling
Wulik River	Fish presence and use
Ferric Creek	Collected juvenile fish for whole body concentrations of Cd, Pb, and Zn (1999)
Anxiety Ridge Creek	Collected juvenile fish for whole body concentrations of Cd, Pb, and Zn
Evaingiknuk Creek	Fish presence and use
Buddy Creek	Fish presence and use
Graying Creek Jr.	mark-recapture Arctic grayling (2000)

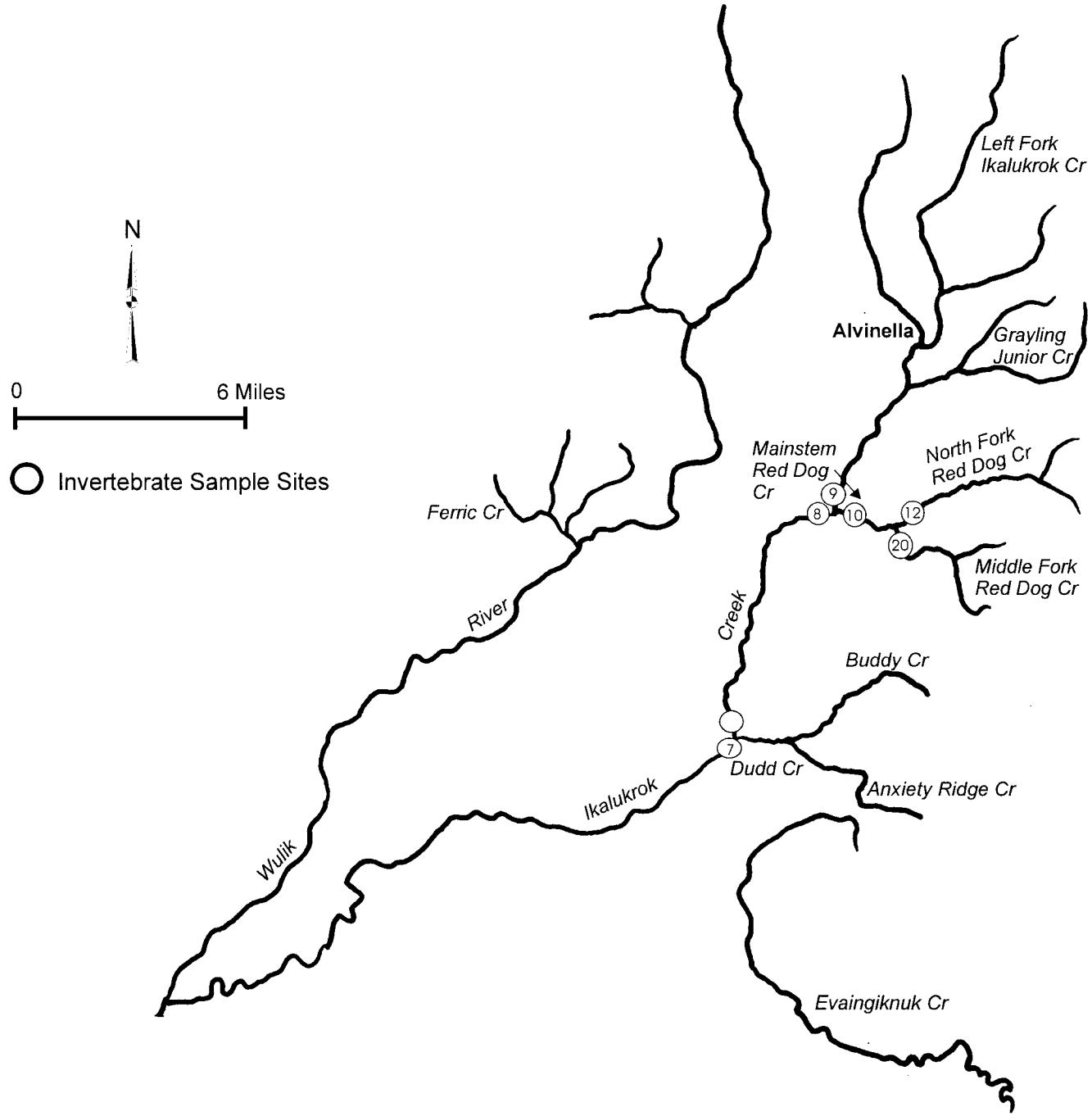
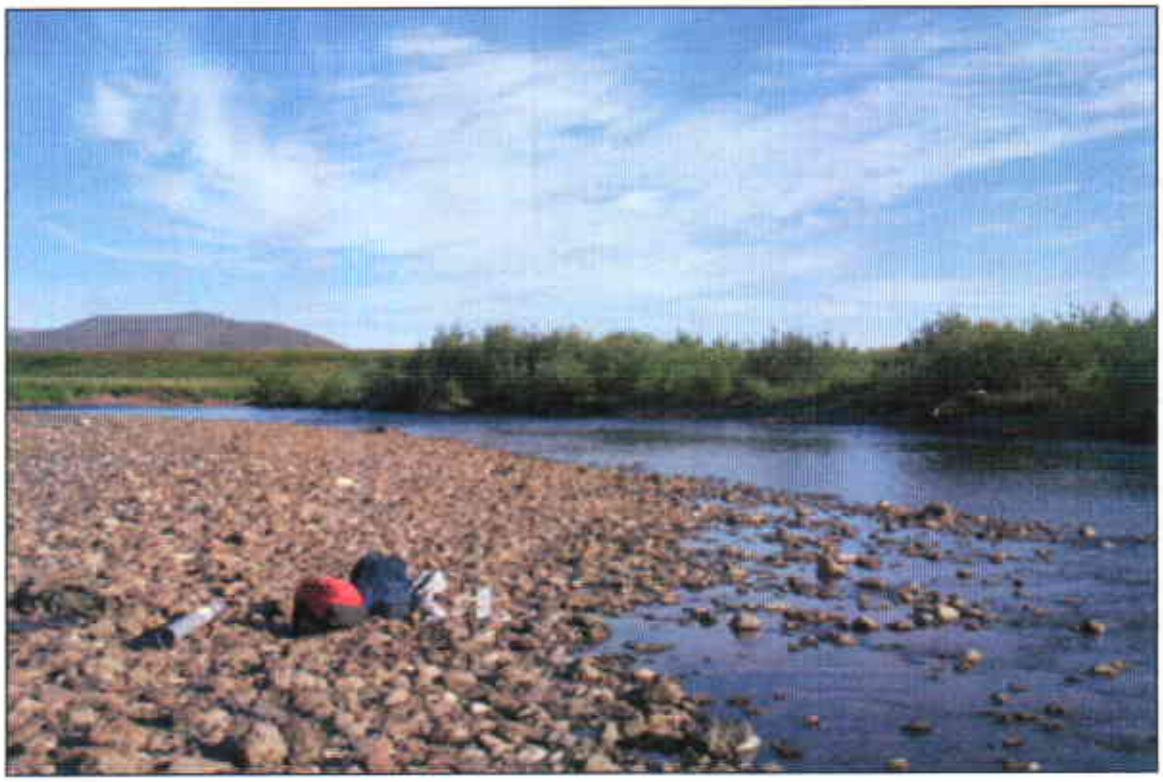


Figure 2. Locations of sites in the Red Dog Creek drainage for aquatic sampling.

Photograph 1. Ikalukrok Creek upstream of Red Dog Creek, Station 9.

Photograph 2. Ikalukrok Creek downstream of Red Dog Creek, Station 8.



Photograph 3. Ikalukrok Creek upstream of Dudd Creek.

Photograph 4. Ikalukrok Creek downstream of Dudd Creek, Station 7.

Photograph 5. Mainstem Red Dog Creek, Station 10.

Photograph 6. Middle Fork Red Dog Creek, Station 20.

Photograph 7. North Fork of Red Dog Creek, Station 12

METHODS USED FOR NPDES MONITORING

All methods used for the NPDES Biomonitoring Study were described by ADF&G (1998) and submitted to US EPA for their approval and comment. No changes have been made to the biomonitoring program since its inception.

Periphyton Standing Crop

OBJECTIVES

Periphyton, or attached micro-algae, is sensitive to changes in water quality and is often used in monitoring studies to detect early changes in aquatic communities. The presence of periphyton in a stream system documents continued in-situ productivity. Periphyton standing crop was monitored to detect changes to in-situ productivity in receiving waters of the Red Dog Mine effluent. Reference sites were sampled to detect variations due to other factors, such as climate.

Periphyton is sampled directly from cobble on the stream bottom. The periphyton was collected, following the rapid bioassessment techniques of Barbour et al (1997), and augmented with more replicates per site to increase sample precision. The concentrations of chlorophyll-a were determined to estimate periphyton standing crop.

Sampling was conducted once per year, in late June through mid-July during a period of low water.

METHODS FOR FIELD COLLECTION OF SAMPLES:

Ten rocks were collected from the stream benthos in each study reach. A 5-cm x 5-cm square of high density foam was placed on the rock. Using a small toothbrush, all material around the foam square was removed and rinsed away with clean water. The foam was removed from the rock and the rock brushed with a clean tooth brush and rinsed onto a 0.45 *u*m glass fiber filter, attached to a hand vacuum pump. After extracting as much water as possible, approximately 1 ml saturated $MgCO_3$ was added to the filter to prevent acidification and conversion of chlorophyll-a to phaeophytin. The dry filter was wrapped in a large filter (to absorb any additional water), labeled, placed in

a sealable plastic bag, and packed over silicon gel desiccant. Filters were frozen in a light-proof container with desiccant.

LABORATORY ANALYSIS

Filters were cut into small pieces and placed in a centrifuge tube with 10 ml of 90% buffered acetone. Extraction tubes were placed in a metal rack, covered with aluminum foil and held in a dark refrigerator for 24 hrs. After extraction, samples were read on a Shimadzu UV-1601 Spectrophotometer (1995) and a Turner Model 10 Fluorometer (1996). Trichromatic equations (according to Standard Methods, APHA 1992) are used to convert spectrophotometric optical densities to total chlorophylls-a, b, and c. The Turner Fluorometer was calibrated with primary and secondary chlorophyll standards, according to Standard Methods (APHA 1992).

QUALITY CONTROL OF FIELD SAMPLING

Samples were placed in pre-labeled bags, placed over fresh silica gel desiccant, and frozen until chlorophylls were extracted.

QUALITY CONTROL FOR CHLOROPHYLL-A DETERMINATIONS

Fresh chlorophyll-a standards were used to calibrate the Fluorometer. Samples containing sufficient chlorophyll-a were read on both the Fluorometer and the Spectrophotometer to check calibration curves. Samples with chlorophyll-a concentrations below the calibration point were reported as "non-detectable."

Aquatic Invertebrates: Taxon Richness and Abundance

OBJECTIVES

Aquatic invertebrate communities were sampled below the Red Dog Mine effluent to document the continued biological integrity of these communities and to detect changes to in-situ productivity. Reference sites were used to detect variations due to other factors, such as climate.

METHODS

We modified the rapid bioassessment techniques developed by USEPA (Barbour et al 1997) to retain more quantitative features of sampling. Benthic invertebrates were

collected in drift nets set within riffle habitats to standardize assessments among streams. Five drift nets were installed at random locations in riffle habitat and left to collect invertebrates for one hour . Water velocity and depth were measured at the mouth of each net to standardize numbers of insects by volume of water and to compare relative biomass of invertebrates among sites. Invertebrates were transferred to individually labeled bags and preserved in 70% ETOH.

Invertebrate samples were taken back to the laboratory and sorted. Samples were first washed with tap water into an enamel pan and the sample container examined for remaining invertebrates. Then samples were strained through a 90 *u*m mesh to remove water and placed in a glass dish.

Samples were sorted from other detritus, placed in fresh 70% ETOH and identified to the lowest practical taxon level. Mature larvae and nymphs and adult forms of aquatic species usually could be identified to genus; immature larvae and nymphs were usually identified to family. Chironomidae larvae was be identified to family and adult forms identified to genus.

QUALITY ASSURANCE IN THE FIELD

Sample containers were pre-labeled with stream site name and date. Samples were assigned a discrete number that matched a particular net with measurements of stream velocity and flow. Nets were positioned to prevent interception of flow into downstream nets by staggering nets across the stream width. Where stream sites are too narrow to allow staggering, nets were distributed along the stream length, each net placed below a different riffle habitat.

Contents of the drift nets were washed with ETOH into sample containers. The end buckets of the drift nets were examined for remaining invertebrates.

Five replicate samples were collected from each site. A log was maintained of all invertebrate samples and volumes of water flowing into each net.

QUALITY ASSURANCE IN THE LABORATORY

Quality Control for Sorting

Ten percent of the sorted samples were examined by a senior biologist to determine the number of organisms missed by the sorter. If the QC sorter found less than 10% of the total sample organisms remaining in the tray, the sample passed.

Quality Control for Taxonomy

A technician with training in entomology identified the invertebrates; a senior biologist with extensive experience identifying invertebrates in Alaska checked the identification of at least 10% of the samples. A reference collection of identified taxa is maintained. Because many of the aquatic insects in Alaska have not been identified to species, identification will be done to the family or genus level. Family level is used when insects are too immature to see identifying characteristics.

Metals Concentrations in Dolly Varden Tissues

OBJECTIVE

Since 1990, ADF&G has sampled adult Dolly Varden from the Wulik River to determine the concentrations of Al, Cd, Cu, Pb, and Zn in muscle, gill, liver, and kidney tissue. Beginning in 1996, tissue samples also were analyzed for selenium. The objective of this sampling effort was to compare metals concentrations of fish tissues to concentrations found since beginning of operation of the Red Dog Mine and to detect any changes in concentrations of fish tissues that can be related to changes in metals concentrations in receiving waters below the mine. Sampling under the current NPDES permit for the Red Dog Mine effluent is a continuation of this effort.

METHODS

Individual Dolly Varden were caught by hook and line and placed in clean plastic containers and labeled with sample date and location. Six fish were collected from the Wulik River below Tutak Creek in fall before freeze-up and in spring after break-up. Fish were measured to fork length, weighed, sex and spawning condition recorded, and otiliths removed to determine age. Tissue samples from muscle (from below the dorsal

fin and above the lateral line), gill, kidney, and liver (excluding bile tissue) were removed from partially thawed fish using standard procedures to minimize contamination (Crawford and Luoma 1993). About 10 g of each tissue will be placed in pre-cleaned jars (EPA Series 300, Protocol C) and refrozen. Tissue samples will be submitted to a private analytical laboratory. Samples were digested, freeze-dried, and analyzed for Al, Cu, Cd, Pb, Zn and Se using U.S. Environmental Protection Agency standard methods.

Quality Control for Collecting Fish Samples

Each fish was immediately placed in a clean plastic bag after being caught. Fish were labeled with time and location of collection and frozen as soon as possible.

Quality Control in Preparing Fish Tissues

Each dissection instrument was cleaned in ultra-pure nitric acid with two rinses in double distilled water before beginning dissection of a new tissue. No instruments were used on successive tissues without cleaning. Fish were dissected in a partially frozen condition to allow removal of discrete tissues without contamination by other tissues. Liver bile ducts were included in liver samples. Kidney tissues were removed in a frozen condition to allow extraction of intact samples.

Only pre-cleaned bottles (USEPA Series 300, Protocol C) were used for fish tissues. After preparation of samples, fish tissues were re-frozen in an ultra-cool (-30°C) freezer until shipment to the analytical laboratory. Shipments were not made after mid-week to prevent samples arriving during week-end days. The analytical laboratory was notified of any incoming shipments.

Chain of custody forms will be prepared for each sample catalogue. Samples will be numbered following the convention used by ADF&G since 1990:

Date/Stream Code/Species Code/Age Code/Sample Number/Tissue Code

Quality Control / Quality Assurance of Laboratory Analysis

The analytical laboratory provided quality assurance/quality control information for each analyte, including matrix spikes, standard reference materials, laboratory calibration data,

sample blanks, and sample duplicates. All raw data, including laboratory calibration curves and internal quality control will be included in the laboratory report.

Tissues from one fish from each sample was divided to provide blind duplicate tissues that were submitted to the laboratory with each sample catalogue. The blind duplicate was labeled in the same way as the other tissue samples.

Fish Presence and Use in Tributary Streams

OBJECTIVES

Fish monitoring focused on the distribution and relative abundance of juvenile Dolly Varden and Arctic grayling downstream of the Red Dog Mine and in tributaries to waters potentially affected by the mine. Reference streams were monitored to detect annual variations in distribution and abundance that are independent of mine operation.

METHODS

Fish were sampled two times per summer; early July and early August, using visual surveys, angling, and minnow traps. Juvenile fish were collected with minnow traps. baited with fresh or preserved salmon eggs, contained in perforated plastic bags. Traps were placed at numbered sites established and used by ADF&G since 1992. Traps were placed in areas of moderate current to prevent traps from dislodging, and left to fish for about 24 hrs. All fish were counted, identified, and measured to the nearest mm fork length . Numbers of fish were compared within and among sample years.

Angling was used to determine the presence of adult Arctic grayling throughout the drainage. Visual surveys aided in documenting the presence of young-of-the-year Arctic grayling and Dolly Varden within the sample reaches. Recently emerged larval Arctic graying were opportunistically collected in invertebrate drift nets and their presence was recorded.

QUALITY CONTROL OF FISH SAMPLING

ADF&G established specific trap locations in 1992 to capture juvenile fish; the same locations have been used each year since, with minor modifications for channel

migration. The numbers of traps and trap locations have been kept constant to allow comparisons among years.

Fall Aerial Survey of Overwintering Dolly Varden

OBJECTIVE

Aerial surveys for adult Dolly Varden are conducted each year if weather permits. The objective of aerial surveys is to estimate the abundance and assess the distribution of overwintering adult Dolly in the Wulik River. Changes in the use of this river system (for example, relative proportion of fish upstream and downstream of Ikalukrok Creek) are documented.

ADF&G has conducted a fall survey of overwintering Dolly Varden in the Wulik River since 1979, except in 1983, 1985, 1986, and 1990 when weather conditions did not permit aerial surveys (DeCicco 1997; Weber Scannell and Ott 1998).

METHODS

We were unable to conduct fish surveys in 2000 because of storms and poor visibility.

Chum Salmon Spawning

OBJECTIVES

The abundance and distribution of adult chum salmon spawning in Ikalukrok Creek downstream of Dudd Creek will be assessed using aerial surveys to document any changes in the use of this spawning area. These aerial surveys are conducted each fall unless poor weather conditions limit visibility and increase safety concerns.

METHODS

We were unable to conduct aerial chum salmon surveys in 2000 because of storms and poor visibility.

DATA REPORTING

Reports of data included trip reports summarizing field sampling efforts and preliminary findings summarizing fish, invertebrate, and periphyton data and relating these data to

water quality conditions. An annual report is prepared and submitted to US EPA, ADEC, and other interested federal, state and private individuals.

Water Quality and Metals Concentrations

Water quality and metals concentrations are sampled by Cominco Alaska Inc. according the specifications of NPDES Permit AK-003865-2. Data are presented in this biomonitoring report to complement information on aquatic populations and to aid in identification of long-term trends.

Water quality monitoring has been conducted throughout the Wulik River drainage since 1979, ten years before initial operations development of the Red Dog Mine; sampling is done at many of the same stations, using the same station numbers, as baseline monitoring conducted by Dames and Moore.

RESULTS

Ikalukrok Creek

Four segments of Ikalukrok Creek are monitored under the NPDES Permit: Ikalukrok Creek upstream of Red Dog Creek (Station 9), Ikalukrok Creek below the confluence with Red Dog Creek (Station 8), and Ikalukrok Creek above (no station number) and below (Station 7) Dudd Creek

STATION 9

SITE DESCRIPTION

Ikalukrok Creek above the confluence with Red Dog Creek has a drainage area of 150 km^2 (59.2 mi^2) (Photograph 1). The creek flows through naturally mineralized zones and red iron flocculent is prevalent in side channels, smaller tributaries, and backwater areas. Stream bottom substrates frequently are stained orange from iron precipitate. Summer flows range from 15 cfs to 1545 cfs, highest flows occur during breakup and seasonal rains in late July through August. At Station 9, stream width ranges from 2 to 7 m (7 to 24 ft) (up to 21 m or 68 feet in high flow years), with depths ranging from 0.15 to 1.2 m (0.5 to 4 feet). The streambed at Station 9 consists of gravel, cobbles, and rocks. Mining or other human activity has not disturbed this section of Ikalukrok Creek.

WATER QUALITY

The water quality at Station 9 is characterized as having moderate hardness (approximately 150 mg/L as CaCO3, Figure 3) and neutral to slightly basic pH. The median pH of the water at Station 9 was lower in 2000 than in previous years . Sulfate concentrations are relatively low (median concentrations for each year range from 40 mg/L to nearly 130 mg/L. The conductance ranged from 10 uSi/cm to 700 uSi/cm. Higher values occur in fall (September and October) during low flow periods and low levels occur during periods of high flows.

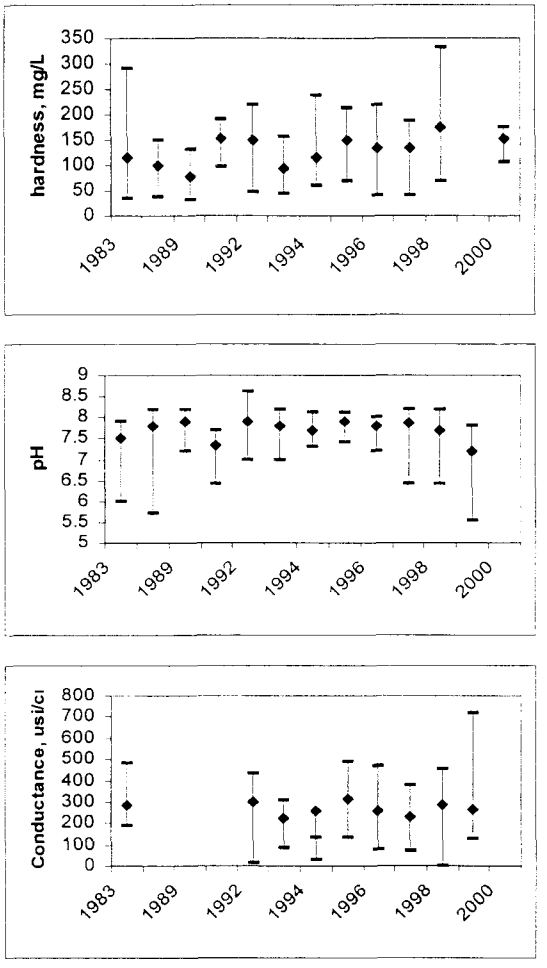


Figure 3. Water quality in Ikalukrok Creek at Station 9. Concentrations of Heavy Elements

Metals concentrations increased visibly in Ikalukrok Creek at Station 9 after 1996 when iron-laden water began seeping into Ikalukrok Creek near the headwaters. Water samples show increases in both median and maximum concentrations of Al, Fe, and Zn (Figure 4) in 1998 through 2000. No similar increases were detected in median concentrations of Cd, Cu, or Pb. There are insufficient data from years before 1996 to detect changes in median concentrations of Se or Ni; however, median concentrations of these two elements were not substantially higher in 1998-2000 (over 1996 values).

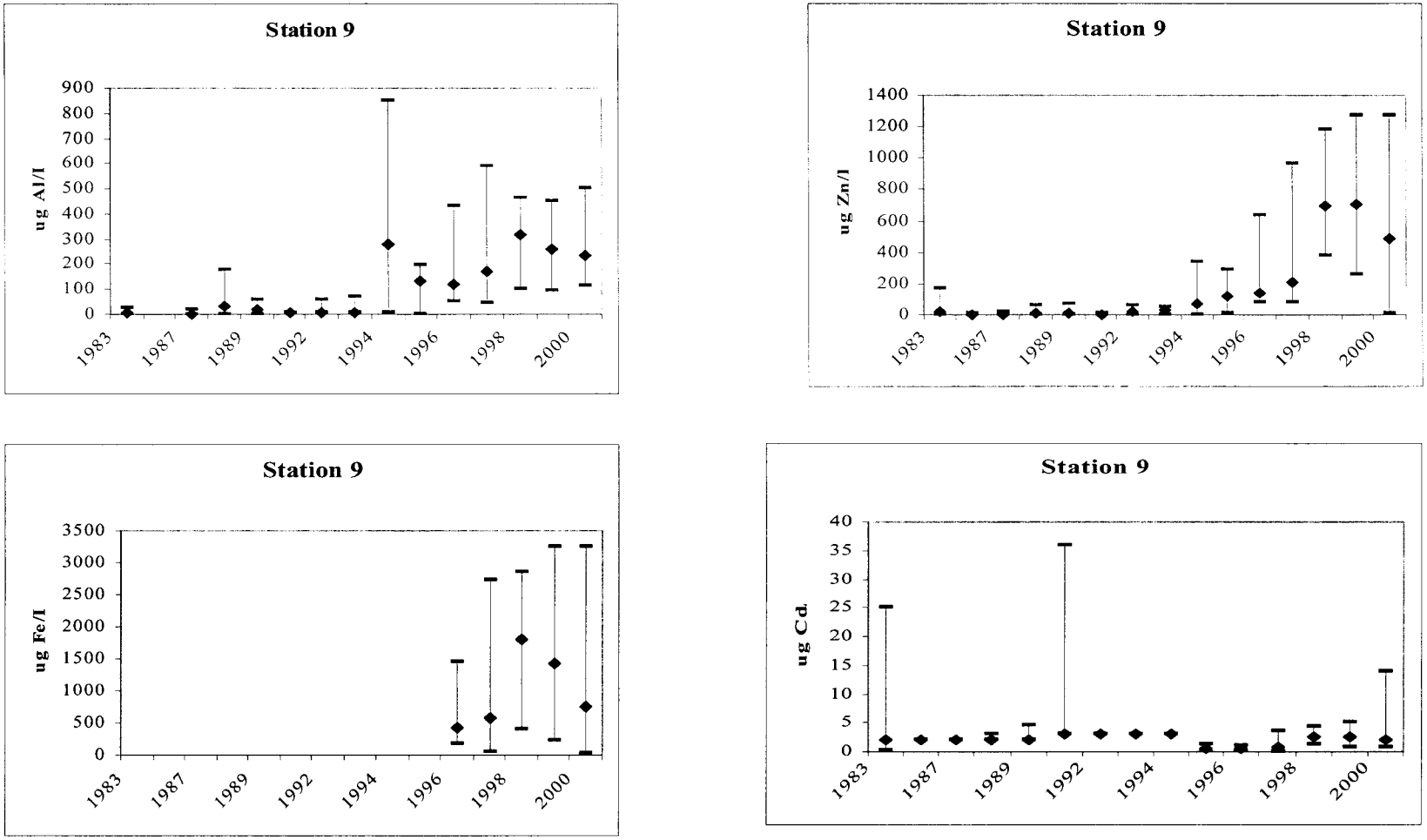
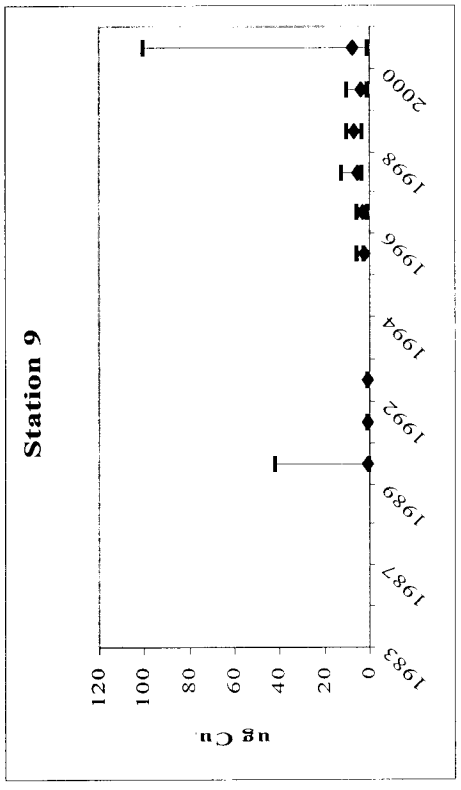
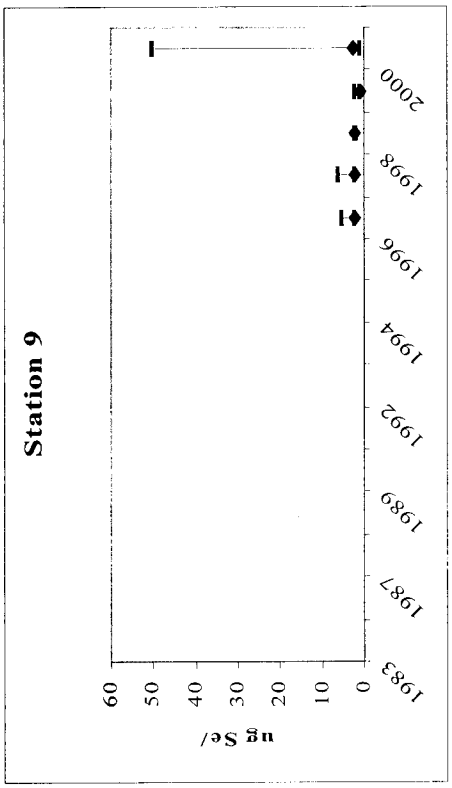
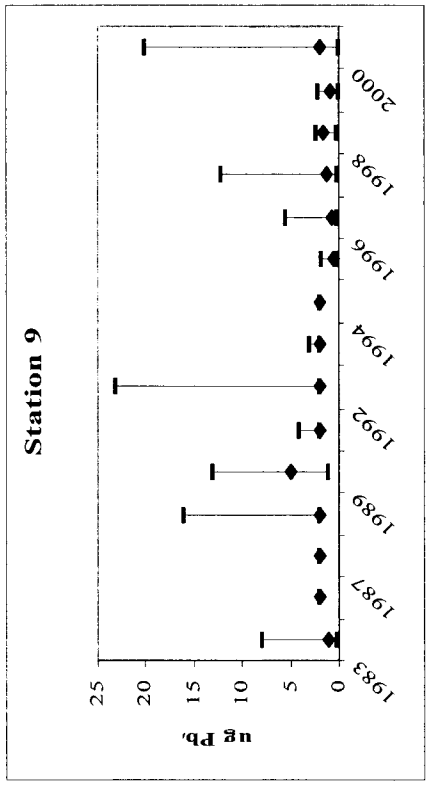


Figure 4. Median, maximum, and minimum concentrations of select metals measured during the open water periods in Ikalukrok Creek at Station 9. Data from Cominco Alaska Inc.







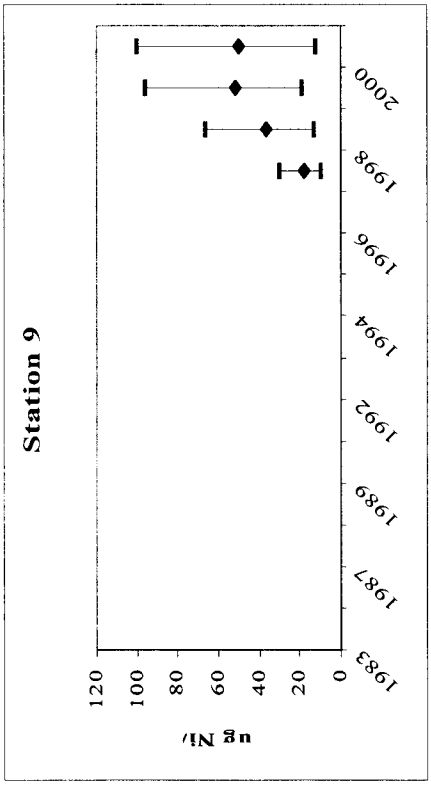


Figure 4, continued.

INVERTEBRATE COMMUNITIES

Abundance, density, and taxon richness

Invertebrate communities in Ikalukrok Creek at Station 9 appeared to respond to the increases in metals concentrations in 1999 and 2000. The abundance of invertebrates (average number of aquatic invertebrates per net, Figure 5) was lower in 1999 and 2000 than any of the other years measured, except July 1996. The density of invertebrates (average number of aquatic invertebrates/m3 of water, Figure 6) was lowest in June and July 1999 and July 2000 than during any of the other sample times, including the 1996 samples.

The taxon richness, as numbers of aquatic taxa collected, was similar for all years, except 1996 when few different taxa were found (Figure 7).

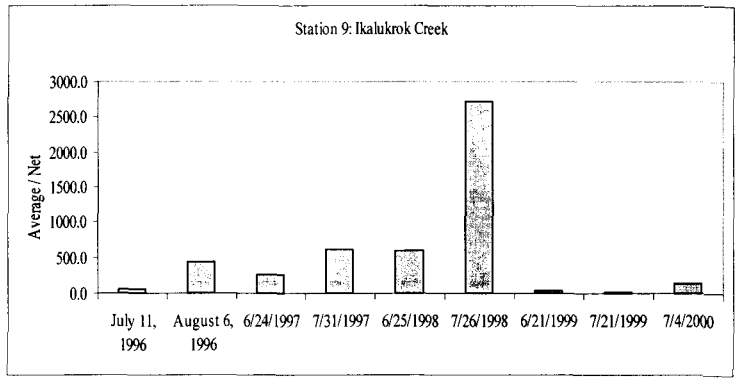


Figure 5. Abundance of aquatic invertebrates collected in Ikalukrok Creek at Station 9.

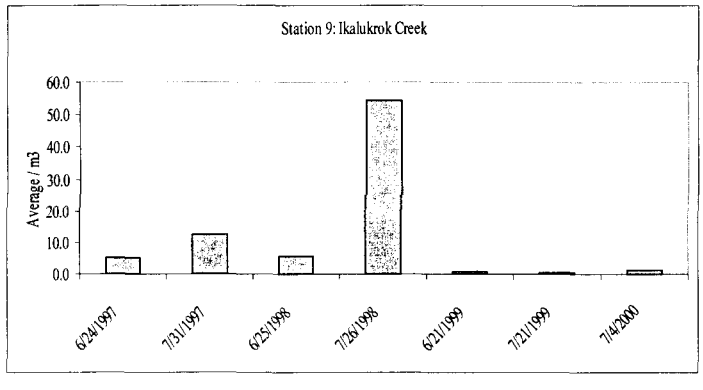


Figure 6. Density of aquatic invertebrates collected in Ikalukrok Creek at Station 9.

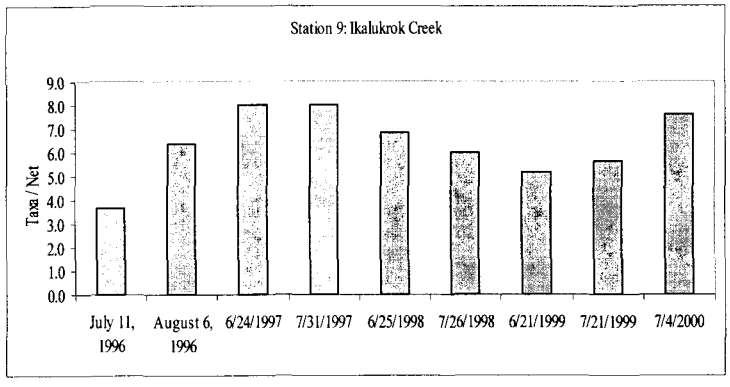


Figure 7. Taxon richness of aquatic invertebrates collected in Ikalukrok Creek at Station 9.

STRUCTURE OF COMMUNITY

Invertebrate samples contained a high proportion of Ephemeroptera, Plecoptera, and Trichoptera (EPT) in most of the sample events, except in late July 1997 (Figure 8). The abundance of EPT (mostly Ephemeroptera: Baetidae and Plecoptera: Capniidae) corresponded with their emergence; these taxa are especially abundant when they reach maturity and are ready to emerge as adults. Chironomidae larvae were most common in only two of the sample events: July 31, 1997 and July 1999.

The dominant taxon groups (comparisons of proportions of Ephemeroptera, Plecoptera, and Diptera) changed with year and with sample event (Appendix 2). Diptera were the most prevalent group in four of the nine sample events; Ephemeroptera were dominant in three events, and Plecoptera were dominant in one event. The prevalence of a particular invertebrate group is often influenced by one species at emergence; Ephemeroptera were primarily Baetidae: *Baetis* and Plecoptera were Capniidae. Trichoptera were rare or absent in all samples. Miscellaneous includes Ostracoda, Nematoda, Oligachaeta, Acarii, and aquatic Coleoptera.

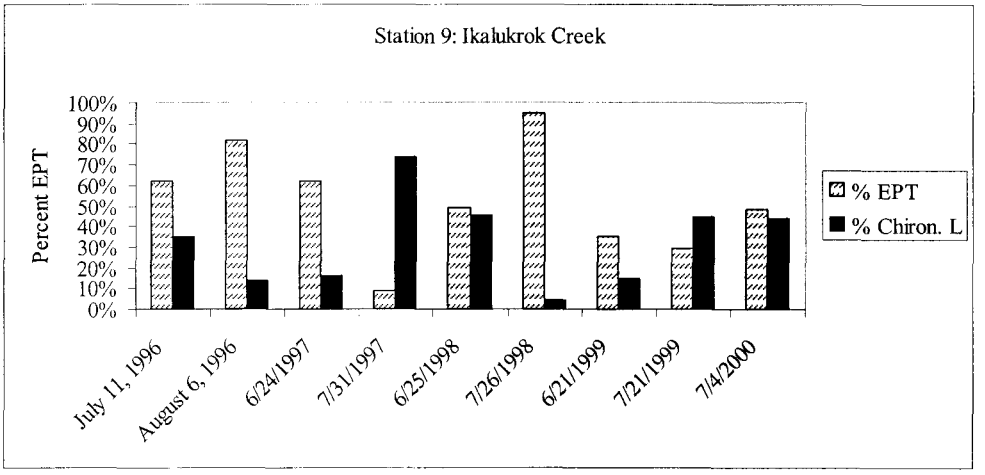


Figure 8. Relative proportions of EPT and Chironomidae larvae in invertebrate samples from Ikalukrok Creek at Station 9, 1996 – 2000.

The results of invertebrate biomonitoring data collected at Station 9 are summarized in Appendix 2.

PERIPHYTON STANDING CROP

Concentrations of chlorophyll-a were low in all samples and ranged from 0 to 3 mg/m2 (Figure 9). No substantial changes have occurred within this community among the years sampled.

COMPOSITION OF ALGAL COMMUNITIES

The algal community at Station 9 consists of a mixture of green algae and diatoms; the proportions of chlorophyll b and c are similar at this site (Figure 10). Because few samples contained sufficient chlorophyll to distinguish pigments, all years were combined to determine the proportions of chlorophylls a, b, and c.

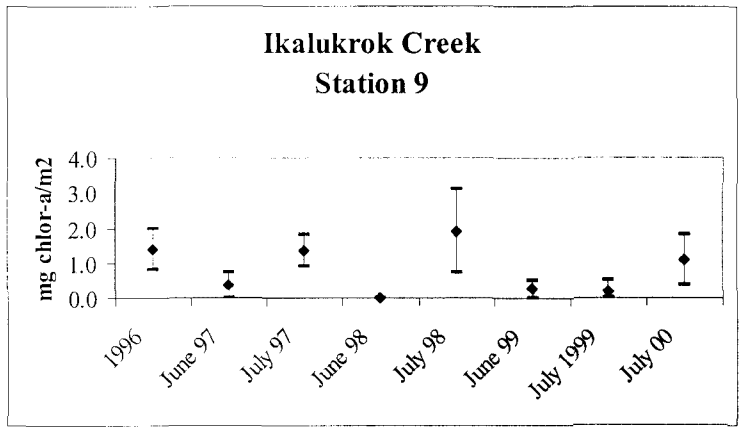


Figure 9. Median, maximum, and minimum concentrations of chlorophyll-a measured in Ikalukrok Creek at Station 9.

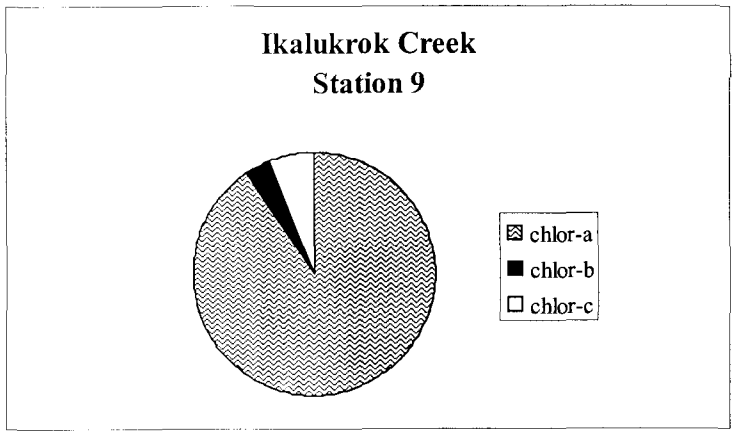


Figure 10. Proportions of chlorophylls a, b, and c measured in Ikalukrok Creek at Station 9.

SUMMARY OF BIOMONITORING, STATION 9

Changes in water quality, periphyton and invertebrate communities that have been documented over time are summarized in Table 3.

Table 3. Summary of biomonitoring, Station 9, 1996 through 2000.

Factor	Changes Observed
Water Quality	Increase in Al, Fe, and Zn since 1996.
Periphyton Communities	No change detected.
Invertebrates Communities:	Abundance lowest in 1996, and 1999-2000. Density lowest in 1999 and 2000. No change in Taxon Richness.

STATION 8

DESCRIPTION OF SITE

Ikalukrok Creek below Red Dog Creek is a relatively fast flowing stream with medium sized gravel to small cobble substrate (Photograph 2). Stream banks are covered with various species of willows and gravel bars are exposed at lower flows. For the first time since our monitoring began, the stream bottom was covered with a dense growth of filamentous algae and iron precipitate in July 1998. We located the source of iron precipitate in seeps flowing into Ikalukrok Creek near the headwaters; iron staining has been visible each summer since 1998.

WATER QUALITY

Water quality and metals sampling were done intermittently at Stations 8 and more consistently at Station 73, downstream. In summer 1999, we sampled conductivity across transects at Station 8 and verified that Ikalukrok Creek and Red Dog Creek are not mixed at this site. The water from Red Dog Creek flows against the left side, where most of the biomonitoring is done. The right side, containing water from Ikalukrok Creek, is too deep to sample. The degree of mixing is a function of stream flows and velocities and is different at each sample event. There are no water quality or metals data that reliably characterize this site.

WATER QUALITY CONDITIONS
CONCENTRATIONS OF HEAVY ELEMENTS

Because the water is not mixed at this site, earlier data on water quality and metals concentrations are not reliable. Water samples have not been collected from this site in recent years.

INVERTEBRATE COMMUNITIES

ABUNDANCE, DENSITY, AND TAXON RICHNESS

The abundance of aquatic invertebrates found in Ikalukrok Creek at Station 8 was highest in June and July 1998 (Figure 11), then declined sharply in 1999 and 2000. Invertebrate abundance was lowest in late July 1997. Invertebrate densities followed a similar pattern as abundance (Figure 12); therefore, stream flows do not appear to be a biasing factor for

density. Highest densities do not occur in the same sample events as highest taxon richness (Figure 13). Taxon richness ranged from 2 to 8 distinct taxa per sample event.

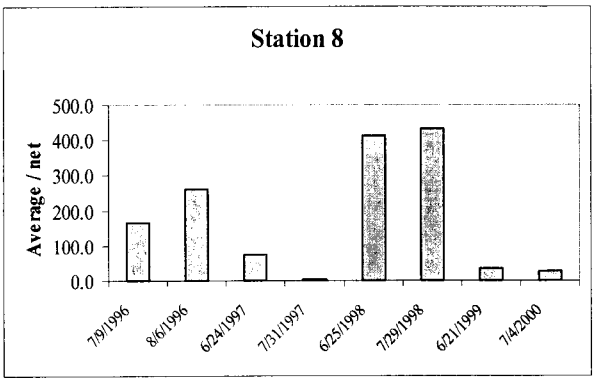


Figure 11. Abundance of aquatic invertebrates in Ikalukrok Creek at Station 8.

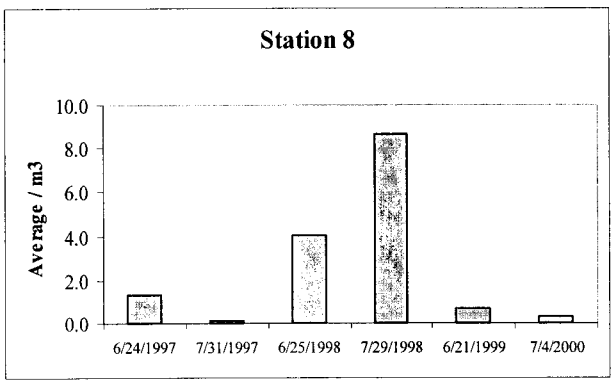


Figure 12. Density of aquatic invertebrates in Ikalukrok Creek at Station 8.

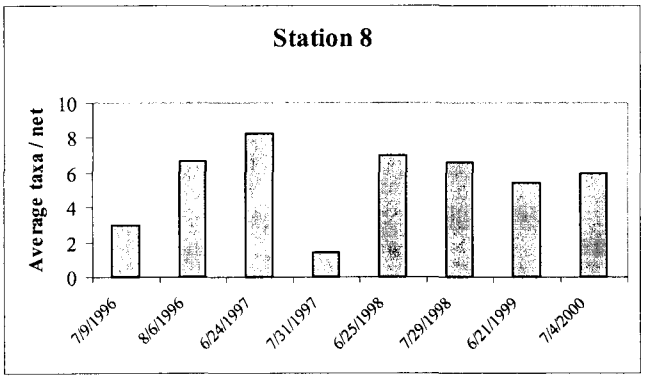


Figure 13. Taxon richness of aquatic invertebrate communities in Ikalukrok Creek at Station 8.

STRUCTURE OF INVERTEBRATE COMMUNITIES

Invertebrate communities contained a large proportion of EPT taxa (>50%) in August 1996, and in both June and July 1998 (Figure 14). Samples collected later in the summer (early August 1996 and late July 1998) were dominated by Ephemeroptera: Baetidae and the earlier sample taken in June 1998, was dominated by the Plecoptera: Capniidae. Both of these genera were in later instar stages and ready to emerge. More recent samples (1999 and 2000) show a lower proportion of EPT taxa and higher proportions of Chironomidae larvae.

Analysis of the community structure in invertebrate samples from Ikalukrok Creek at Station 8 show strong shifts from a dominance by Diptera, to Plecoptera or Ephemeroptera (Appendix 2). Trichoptera, although rare, were most plentiful in samples collected in 1999 and 2000. Most of the Trichoptera were *Brachycentrus*, a case-building caddisfly common in northern streams.

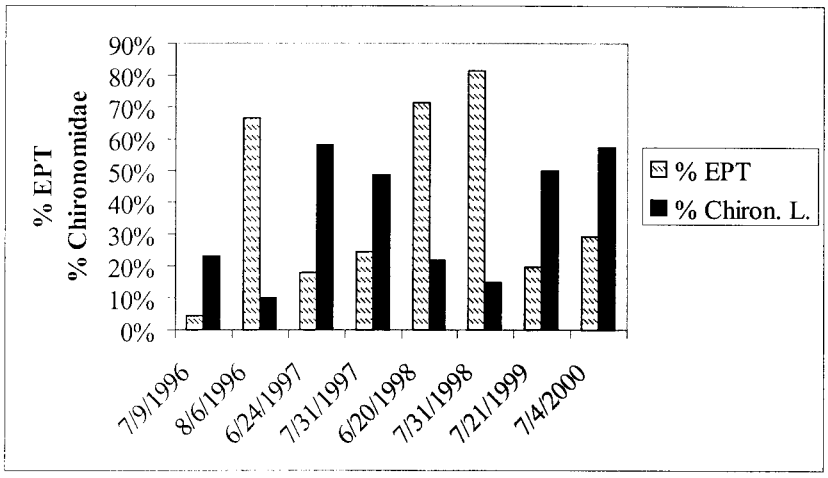


Figure 14. Proportion of EPT taxa and Chironomidae larvae in aquatic invertebrate samples collected in Ikalukrok Creek at Station 8.

The results of invertebrate biomonitoring conducted at Station 8 from 1996-2000 are summarized in Appendix 2. The table contains a summary of invertebrate abundance, community metrics, and estimates of invertebrate densities.

Periphyton Standing Crop

The abundance of attached algae, estimated by chlorophyll-a concentrations, was low in 1995 and June 1997, then increased by July 1997. The highest concentrations were found in June 1999 when we measured 7 mg chlorophyll-a per m2 of stream substrate (Figure 15). The algal standing crop declined by July 1999 and remained low in July 2000. The chlorophyll-a concentrations measured in 2000 were similar to values found in 1995 and 1997.

The lower concentrations of chlorophyll-a measured in 1999 and 2000 may be related to increases in metals concentrations from upstream Ikalukrok Creek and correlate to the low invertebrate abundances and densities measured during these same sample periods.

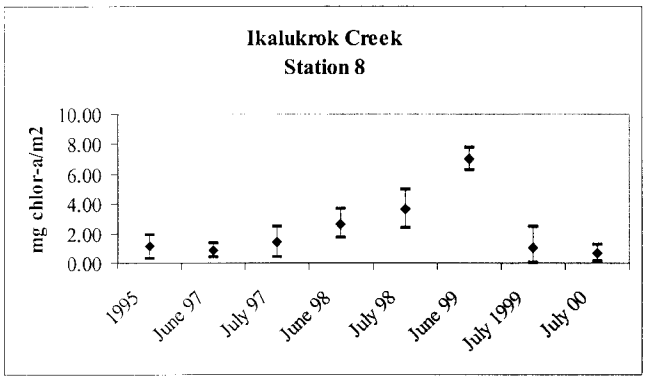


Figure 15. Concentrations of chlorophyll-a measured in Ikalukrok Creek at Station 8.

COMPOSITION OF ALGAL COMMUNITIES

Seventy seven periphyton samples have been collected and analyzed from Ikalukrok Creek since 1995; of these, only 9 samples has sufficiently high concentrations to determine chlorophyll-b and only 7 had sufficient concentrations to determine chlorophyll-c.

The algal communities in Ikalukrok Creek at Station 8 are dominated by chlorophyll-a, with 11% of total chlorophylls as chlorophyll-b and 7% as chlorophyll-c (Figure 16). Green algae, including filamentous algae, are more abundant than diatoms.

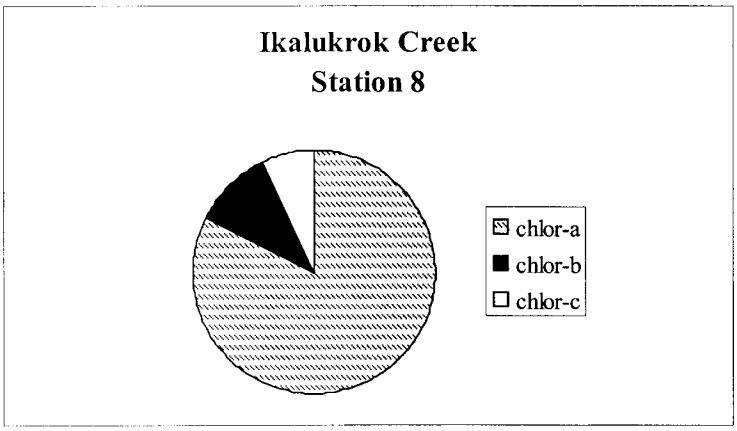


Figure 16. Relative proportions of chlorophylls a, b, and c measured in Ikalukrok Creek at Station 8, all years combined.

SUMMARY OF BIOMONITORING, STATION 8

Changes in water quality, invertebrate and periphyton communities, and fish populations documented over the biomonitoring period are summarized in Table 4.

Table 4. Summary of biomonitoring, Station 8, 1995-2000

Water Quality	Ikalukrok Creek and Red Dog Creek not mixed, data unreliable.
Concentration of Toxic elements	Ikalukrok Creek and Red Dog Creek not mixed, data unreliable.
Invertebrate Communities	Abundance low in 1999 and 2000.
	Densities low in 1999 and 2000.
	Trichoptera most common in 1999 and 2000.
Algal Communities	Chlorophyll-a concentrations low in 1995, 1997, 1999, and 2000.

Ikalukrok Creek upstream of Dudd Creek

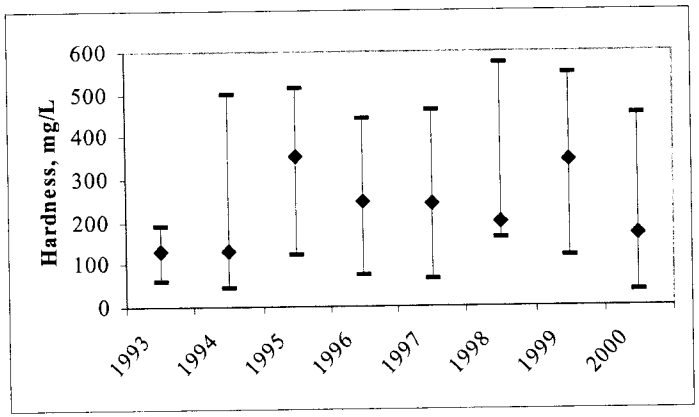
SITE DESCRIPTION

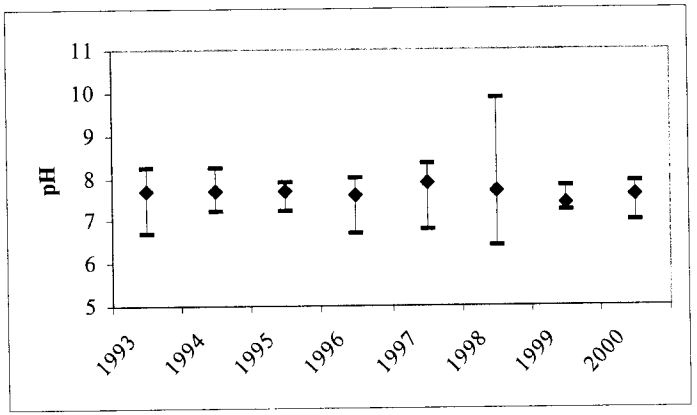
Ikalukrok Creek upstream of Dudd Creek is a wide, fairly shallow channel of from 10 to 40 m width and 0.5 to 1.5 m deep during summer low flows (Photograph 3). The substrate contains mostly small cobble with medium-sized gravel. The banks are thickly vegetated with willows and herbaceous plants and grasses.

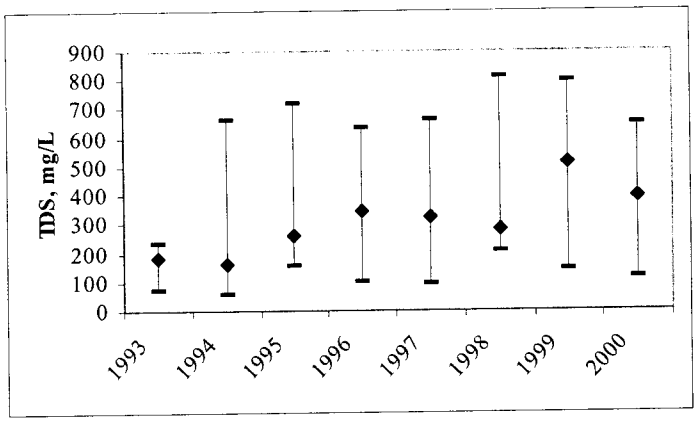
WATER QUALITY

Water is not sampled in Ikalukrok Creek upstream of Dudd Creek; however, samples collected upstream at Station 73 are a good representation of the water quality at this site. There are no Creeks between these two sites that provide sufficient amounts of water to alter the water quality or concentrations of heavy elements.

Ikalukrok Creek at Station 73 during mine operation (data for 1993 to present) has hard water (Figure 17) with circumneutral to basic pH. The lowest pH (6.4) was measured in June 1998. The mine effluent influences water quality conditions, especially hardness, total dissolved solids, and sulfate. During periods of maximum discharge of treated mine effluent, water hardness reached concentrations of 569 mg/L, sulfate was reported up to 410 mg/L, and total dissolved solids up to 810 mg/L. High conductivity (maximum = 919 *u*Si/cm) results from high total dissolved solids from the mine effluent. Low concentrations of total dissolved solids, hardness, and sulfate were found during breakup, high rainfall events, or during periods when the mine was not discharging Figure 18).







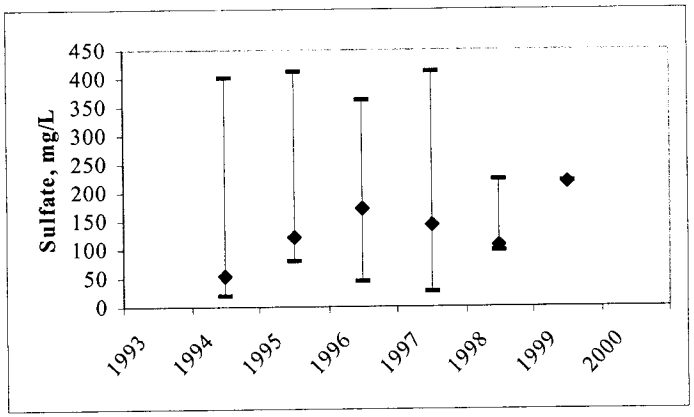


Figure 17. Water quality conditions in Ikalukrok Creek at Station 73, 1993-2000.

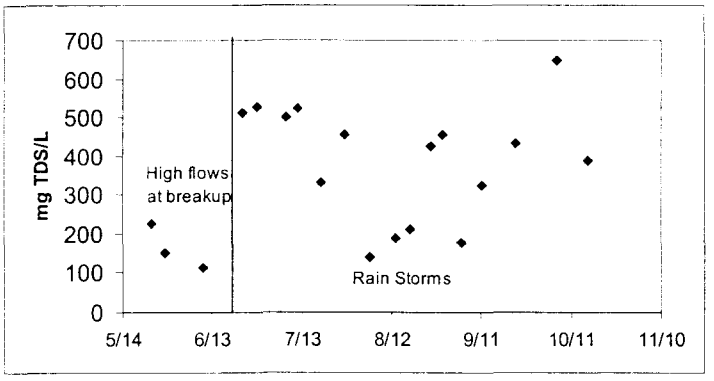
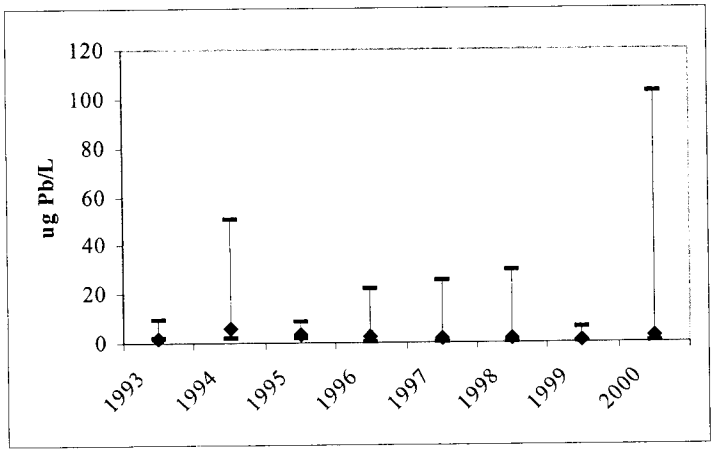


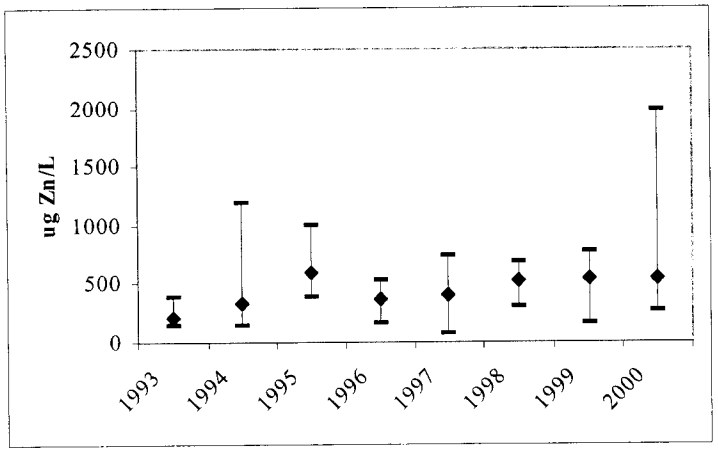
Figure 18. Seasonal changes in TDS concentrations measured in Ikalukrok Creek at Station 73, June through September 2000.

Concentrations of Heavy Elements

Water samples analyzed in 2000 had higher detection limits than previous samples, making comparisons among years difficult. Samples collected later in the season were analyzed with lower limits of detection than samples from earlier years. Therefore, the maximum concentrations recorded in 2000 may reflect the limits of detection rather than actual increases at the site.

The concentrations of Al, Cd, Cu, Fe, Pb, and Zn have remained relatively unchanged since 1993, when consistent sampling at this site was initiated (Figure 19). Water samples were first analyzed for Se in 1996 (Figure 20); median concentrations have remained at or near the limit of detection for all years sampled. Concentrations of Ni and Cr have increased since 1997, when these elements were first added to the analytes (Figure 20).





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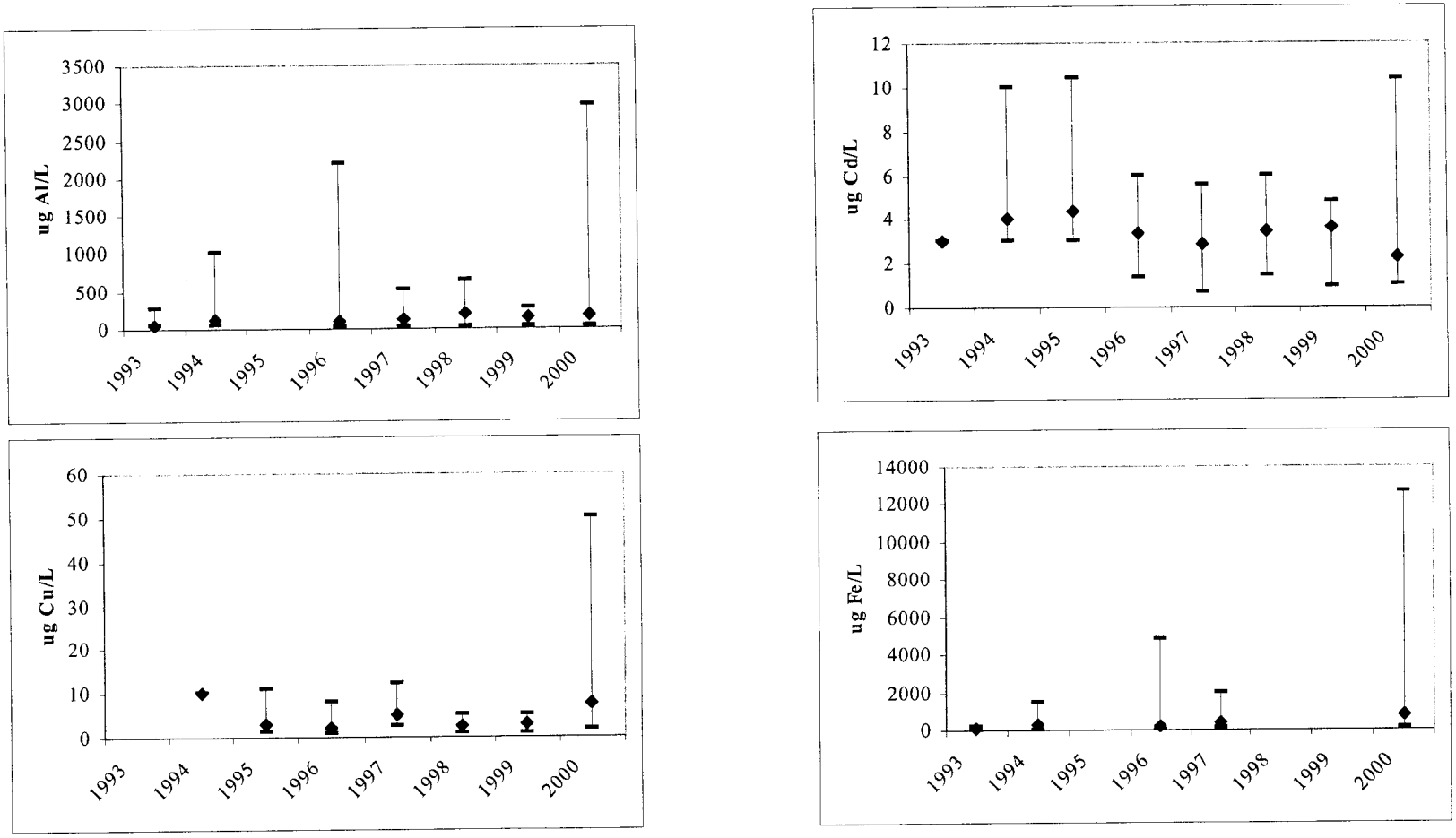
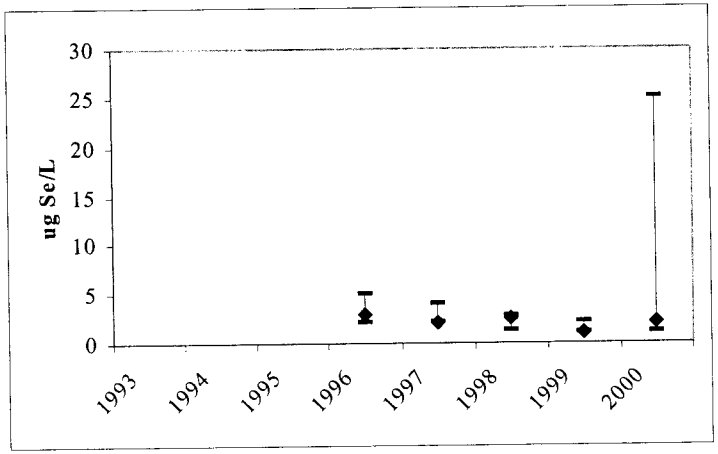
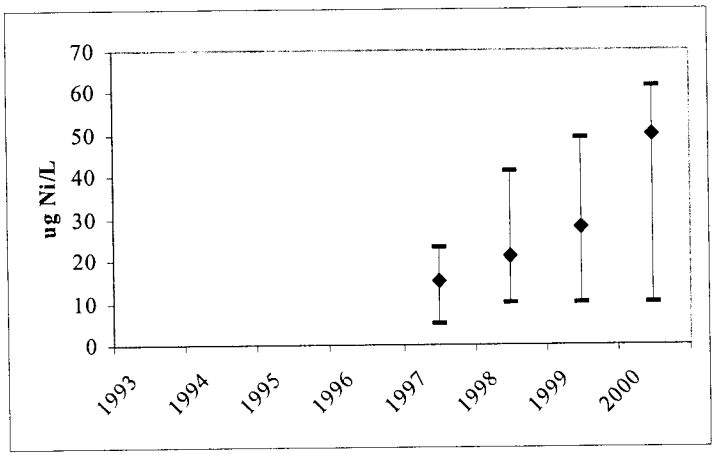


Figure 19. Median, maximum, and minimum concentrations of Al, Cd, Cu, Fe, Pb, and Zn in Ikalukrok Creek at Station 73, 1993 through 2000.





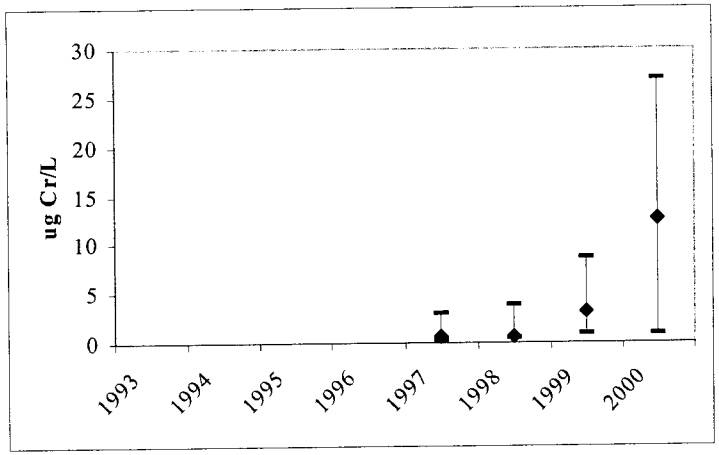


Figure 20. Median, maximum, and minimum concentrations of Se (1996-2000), Cr (1997-2000) and Ni (1997-2000) in Ikalukrok Creek at Station 73.

INVERTEBRATE COMMUNITIES, IKALUKROK CREEK UPSTREAM OF DUDD CREEK

ABUNDANCE, DENSITY, AND TAXON RICHNESS

Invertebrate abundance and density have fluctuated since June 1997, when this site was first sampled. Both abundance and density were lowest in June 1998 (Figures 21 and 22), and then increased in July 1998. Declines in the populations were not found in 1999 and 2000 as they were at Station 8 or Station 9.

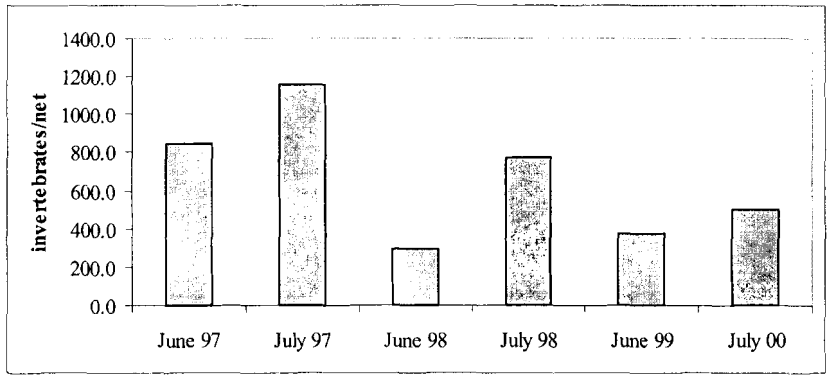


Figure 21. Abundance of aquatic invertebrates collected in Ikalukrok Creek upstream of Dudd Creek.

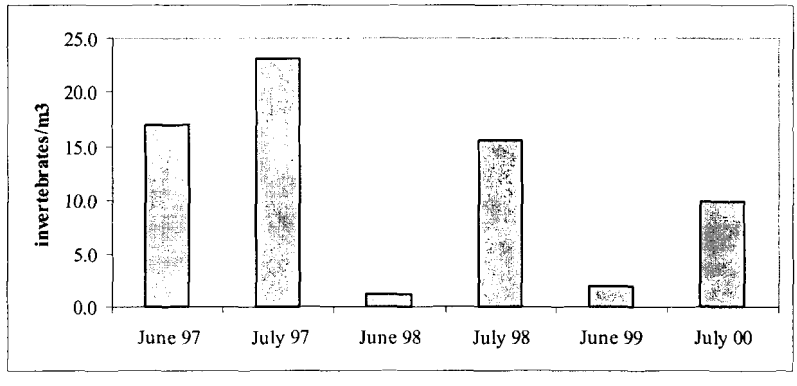


Figure 22. Density of aquatic invertebrates collected in Ikalukrok Creek upstream of Dudd Creek.

Taxon richness was similar during all sample periods, except June and July 1998 samples, when fewer taxa were found (Figure 23). Samples collected in 2000 contained the highest numbers of taxa found and were comparable to samples in 1997.

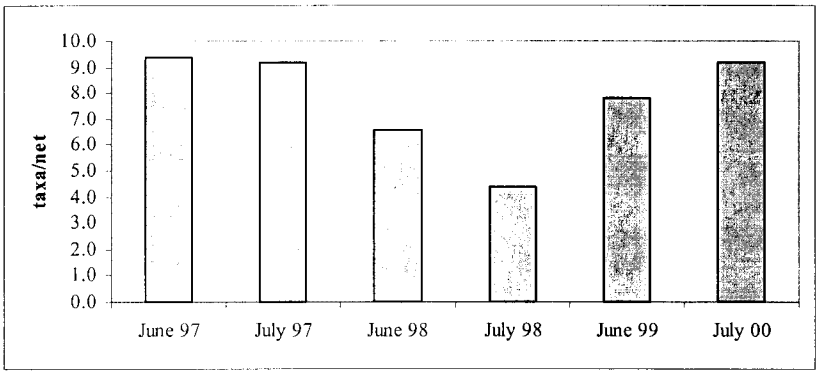


Figure 23. Taxon richness of invertebrate samples collected in Ikalukrok Creek upstream of Dudd Creek.

STRUCTURE OF COMMUNITY

Aquatic invertebrate communities contained a low proportion of EPT taxa compared to the proportions of Chironomidae (Figure 24). Only samples collected in June 1998 showed a dominance of EPT taxa. The presence of large proportions of Ephemeroptera or Plecoptera usually occur just before emergence as the adult stage.

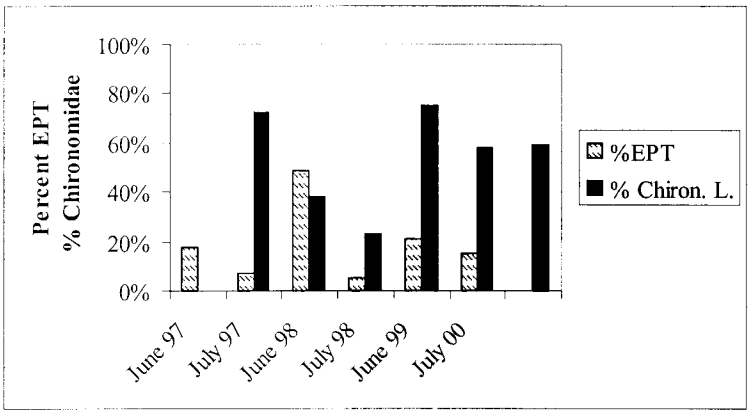


Figure 24. Proportions of EPT taxa and Chironomidae collected from Ikalukrok Creek upstream of Dudd Creek.

Comparisons of community structure in invertebrate samples from Ikalukrok Creek at Station 8 show strong shifts from a dominance by Diptera, to Plecoptera or Ephemeroptera (Appendix 2). Trichoptera, although rare, were most plentiful in samples collected in 1999 and 2000. Most of the Trichoptera were *Brachycentrus,* a case-building caddisfly common in northern streams.

The results of the invertebrate biomonitoring conducted by ADF&G from 1997 - 2000 are summarized in Appendix 2.

PERIPHYTON STANDING CROP

Periphyton was sampled from benthic substrates in Ikalukrok Creek upstream of Dudd Creek in late June and late July 1997 and 1998, in late June 1999, and in early July 2000. Concentrations of periphyton were highest in June and July 1998 (Figure 25) when they the median concentrations were 6 mg/m^2 (June 1998) and 4 mg/m^2 (July 1998). Samples collected in 1997, 1999, and 2000 were similar, with median concentrations ranging from 2.3 to 3.1 mg/m^2.

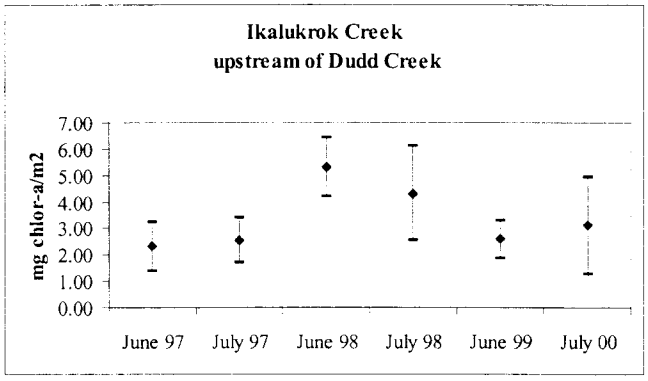


Figure 25. Median, maximum, and minimum concentrations of chlorophyll-a measured in Ikalukrok Creek upstream of Dudd Creek, 1997-2000.

COMPOSITION OF ALGAL COMMUNITIES

All periphyton samples collected in Ikalukrok Creek upstream of Dudd Creek contained sufficient concentrations of chlorophyll-a to analyze with a spectrophotometer. In 2000, the periphyton samples from this site contained slightly more chlorophyll-c than chlorophyll-b, indicating a predominance of diatoms over green algae (Figure 26).

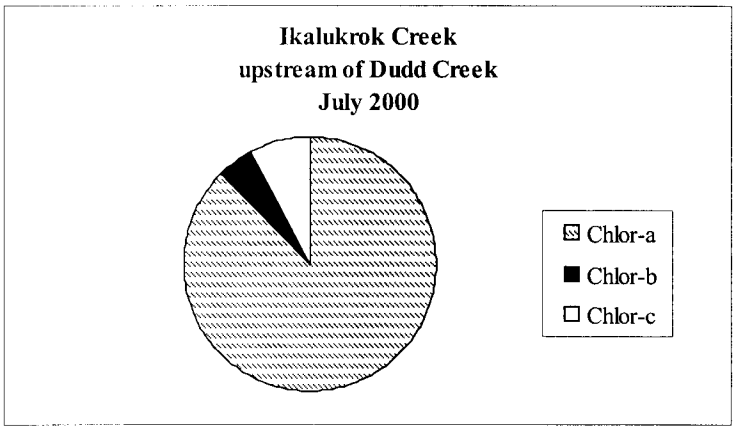


Figure 26. Average concentrations of chlorophylls a, b, and c in Ikalukrok Creek upstream of Dudd Creek, 2000.

SUMMARY OF BIOMONITORING, IKALUKROK CREEK UPSTREAM OF DUDD CREEK

Changes in water quality, invertebrate and periphyton communities, and fish populations documented over the biomonitoring period are summarized in Table 5.

Table 5. Summary of biomonitoring, Ikalukrok Creek upstream of Dudd Creek, 1996-2000.

Water Quality	No pre-mining data. Median concentrations of TDS highest in 1999 and 2000.
Concentrations of metallic elements.	Concentrations of Al, Cd, Cu, Fe, Pb, Se, and Zn relatively unchanged since 1996
	Median Concentrations of Ni and Cr increased since 1997
Invertebrate Communities	Trichoptera found only in June 1998 samples. Community dominated by Diptera: Chironomidae (nearly 60% in 2000). Low EPT, less than 10%
Algal Communities	Predominance of diatoms in periphyton communities.

Station 7

SITE DESCRIPTION

Ikalukrok Creek below Dudd Creek (Station 7) has stream widths from approximately 10 to 40 m (30 to 130 feet) and depths from 0.3 to 1.2 m (1 to 4 ft) (Photograph 4). The substrate consists of small to medium sized gravel with prevalent gravel bars exposed at lower flow rates. Streamside vegetation consists of willow shrubs.

WATER QUALITY

Minimal water quality and stream flow sampling have been done at this site. Total dissolved solids and sulfate concentrations are primarily influenced by discharge of treated effluent from the mine (Figure 27). The median pH is near 7.5 for all years recorded; low pH values occur in early spring before high breakup flows. In 2000, Cominco Alaska regulated their discharge of treated effluent to limit the concentration of TDS to less than 500 mg/L at Station 7 during the chum salmon and Dolly Varden spawning period, July 25 through August 31 (Figure 28). Higher concentrations of total dissolved solids occurred during periods of low flow in July and late fall.

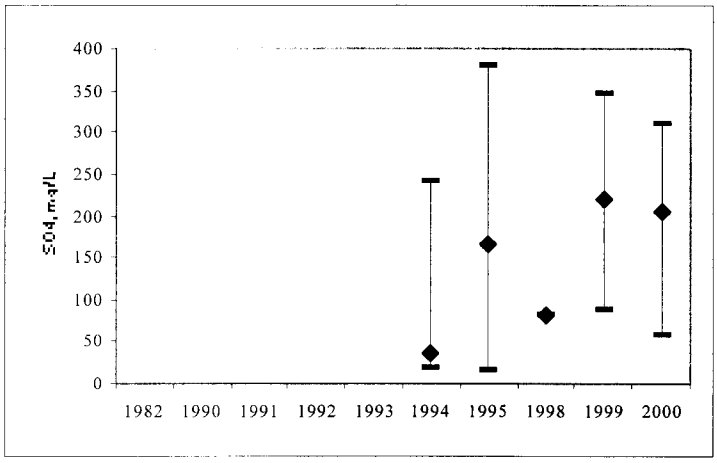
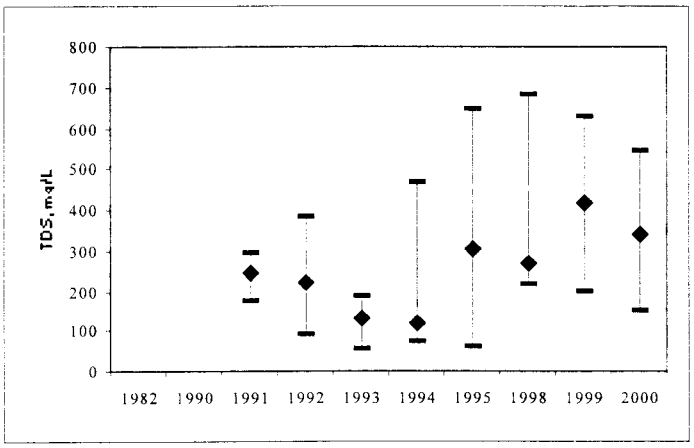


Figure 27. Water quality (TDS, SO_4, and pH) of water at Station 7, 1982 through 2000.



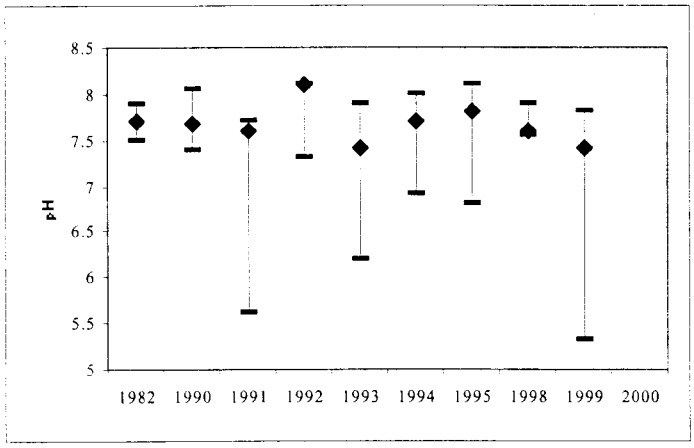


Figure 27, continued.

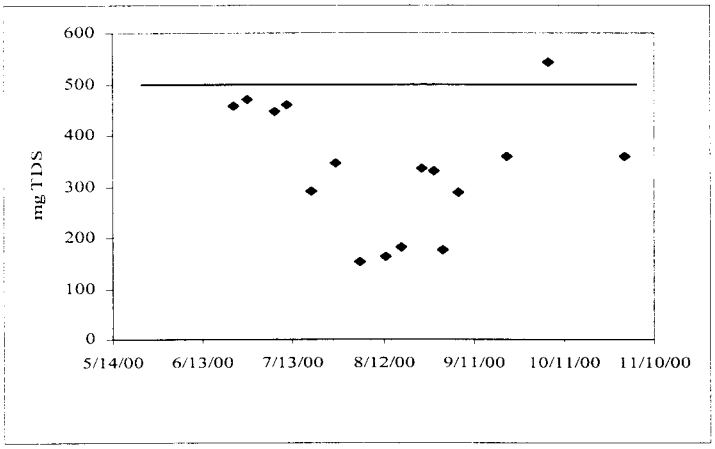


Figure 28. Seasonal variability in TDS at Station 7, 2000.

Concentrations of Heavy Elements

Baseline sampling for heavy elements was limited to Cd, Pb, and Zn; concentrations of these three elements were low at Station 7 before development of the Red Dog Mine. Metals concentrations were substantially higher in 1990 and decreased following construction of the stream bypass system at the mine. Concentrations of Cd remained low following 1990 (Figure 29). Maximum concentrations of Al and Zn fluctuate from near detection to 1.0 mg Al/L and 3.0 mg Zn/L; however, median concentrations have remained below 0.2 mg Al/L and 0.5 mg Zn/L since 1990. The method reporting limit for Se in 2000 was 50 *u*g/L for samples collected early in the summer; these samples do not necessarily contain higher concentrations of Se, but they cannot be compared with samples of lower (1-2 *u*g/L) detection limits.

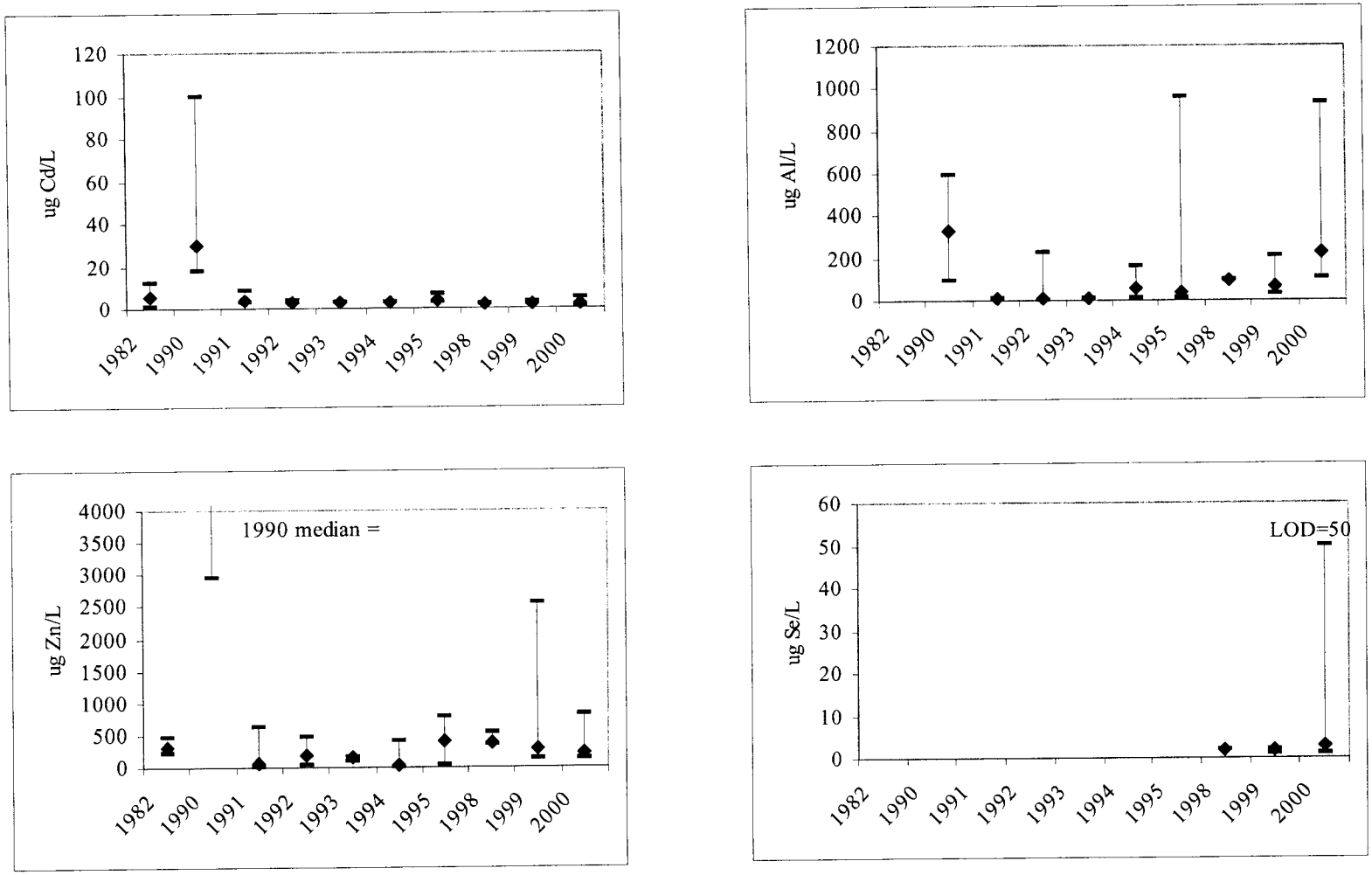


Figure 29. Median, maximum, and minimum concentrations of Cd, Al, Zn, and Se in Ikalukrok Creek at Station 7, below Dudd Creek, 1990-2000. Data from Cominco Alaska.

INVERTEBRATE COMMUNITIES

ABUNDANCE, DENSITY, AND TAXON RICHNESS

Invertebrate abundance and density were highest in late June 1997 and early July 1998 and lowest in June 1999 (Figures 30 and 31), and then increased in July 1998. Abundance and density was not at lowest levels in 2000 as they were at Stations 8 and Station 9.

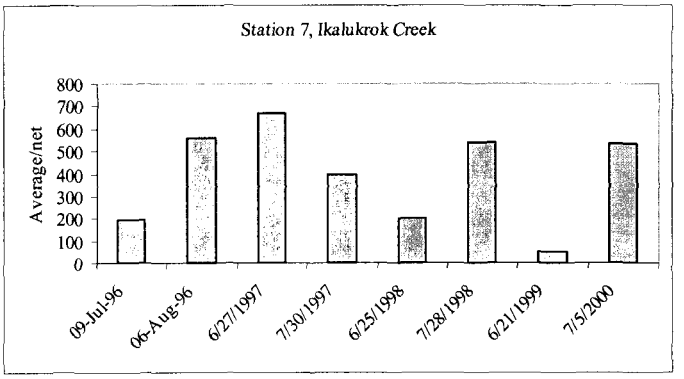


Figure 30. Abundance of aquatic invertebrates collected in Ikalukrok Creek, Station 7.

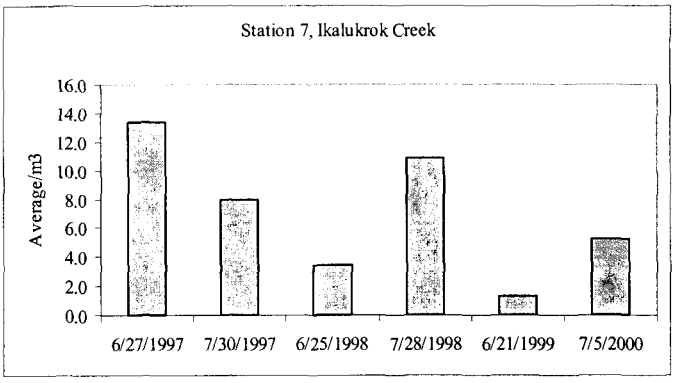


Figure 31. Density of aquatic invertebrates collected in Ikalukrok Creek, Station 7.

Taxon richness ranged from 4 to 11 taxa per sample; the most invertebrate taxa were found in late June 1997 and early July 2000 (Figure 32).

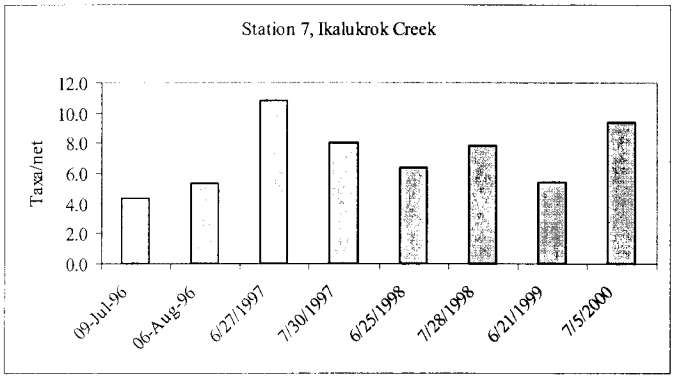


Figure 32. Taxon richness of invertebrate samples from Ikalukrok Creek, Station 7.

STRUCTURE OF COMMUNITY

Invertebrate samples contained an EPT ratio of less than 50% in most sample events. Samples collected in August 1996 contained numerous Baetidae that were about to emerge. Samples collected in June 1998 contained numerous Capniidae, also in the later stages of development. The proportions of Chironomidae larvae usually exceeded the proportions of EPT taxa. In July 1996, both EPT and Chironomidae ratios were relatively low; these samples contained numerous other Diptera, including Simuliidae (black fly larvae) (Figure 33, Appendix 2).

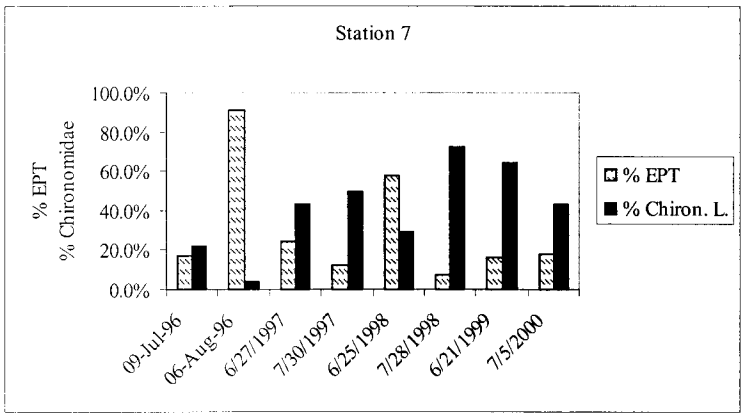


Figure 33. Proportions of EPT and Chironomidae in samples from Station 7, Ikalukrok Creek.

Invertebrate communities from Ikalukrok Creek at Station 7 show a predominance of Diptera larvae for most of the sample events; Diptera: Simuliidae were most common in

July 1996, Ephemeroptera: Baetidae in August 1996, and Plecoptera: Capniidae in June 1998. Trichoptera were rare in all samples. The community at this site exhibits the diversity and mixture of taxa commonly found in these northern streams (Appendix 2).

The results of the invertebrate biomonitoring conducted by ADF&G from 1996 - 2000 are summarized in Appendix 2.

PERIPHYTON STANDING CROP

Stream periphyton has been sampled in Ikalukrok Creek at Station 7 since 1996. Concentrations of periphyton were highest in June and July 1998 and July 2000 (Figure 34) when the median concentrations were 5 mg/m2 (July 1998, July 2000) and 4 mg/m2 (June 1998).

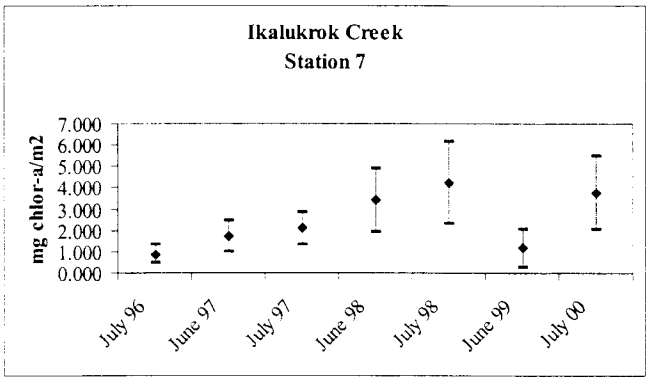


Figure 34. Median, maximum, and minimum concentrations of chlorophyll-a measured in Ikalukrok Creek, Station 7, 1996-2000.

COMPOSITION OF ALGAL COMMUNITIES

All periphyton samples collected in Ikalukrok Creek at Station 7 contained sufficient concentrations of chlorophyll-a to analyze with a spectrophotometer. In 2000, the periphyton samples from this site were mostly chlorophyll-a with small amount of Chlorophyll-b and no chlorophyll-c (Figure 35). The absence of chlorophyll-c suggests an absence of diatom species during the time that this creek was sampled. In 1998, chlorophyll-c was present in samples, suggesting the existence of a diatom community.

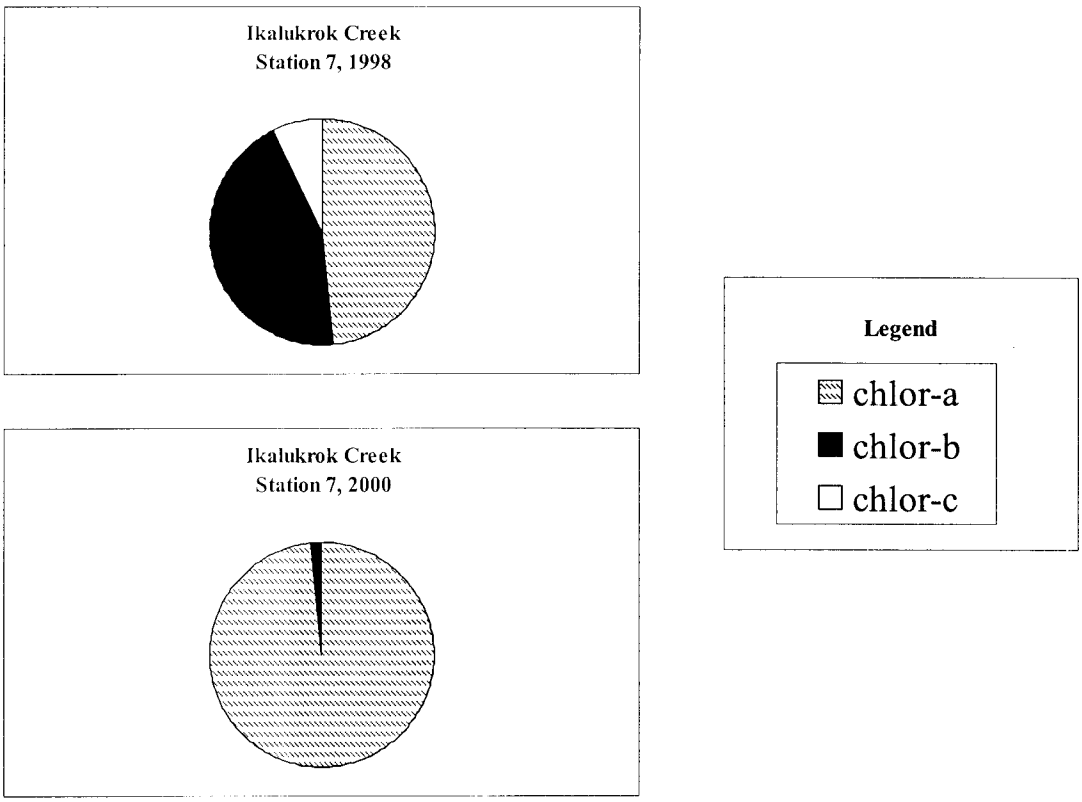


Figure 35. Average concentrations of chlorophylls a, b, and c in Ikalukrok Creek, Station 7, 1998 and 2000

SUMMARY OF BIOMONITORING, STATION 7

Changes in water quality, invertebrate and periphyton communities, and fish populations documented over the biomonitoring period are summarized in Table 6.

Table 6. Summary of biomonitoring, Ikalukrok Creek at Station 7, 1996-2000.

Water Quality	Concentrations of sulfate and TDS are higher since 1992, pH levels are unchanged
Concentrations of metallic elements.	Concentrations of Al, Cd, and Zn were highest in 1990, then dropped to low levels. Median concentrations remained low in 2000
Invertebrate Communities	The abundance and taxon richness of aquatic invertebrates was relatively high in 2000; among the highest in the years sampled. The percent of EPT taxa was low in 1999 and 2000.
Algal Communities	Concentrations of chlorophyll-a in 2000 were among the highest measured; proportions of Chlorophylls b and c declined sharply over previous years

Mainstem of Red Dog Creek: Station 10

Description of Site

The Mainstem of Red Dog Creek (Photograph 5) drains an area of 64 km^2 (24.6 mi^2. Widths of the creek range from 3.5 to 18 m (12 to 60 ft), with depths ranging from 0.06 to 0.5 m (0.2 to 1.7 feet) (R. Kemnitz, pers. comm., USGS Water Resources Division, Fairbanks). The stream bed consists mostly of gravel, small cobble, with a few small boulders. The creek has some meander and areas where it has shifted locations.

Water Quality

Median pH levels have not changed substantially since pre-mining (Figure 36); however, minimum levels have increased since 1990. The pH in Mainstem Red Dog Creek is near neutral for the open water season in 2000.

Concentrations of TDS in Mainstem Red Dog Creek are controlled by the volume of effluent from the mine. In 2000 Cominco limited the volume of discharge of treated water to maintain TDS concentrations below 1500 mg/L in Mainstem Red Dog Creek. During periods of no discharge from the mine, the TDS in the creek quickly reaches background concentrations of 150 mg/L or less.

Both hardness and concentrations of sulfate are controlled by the volume of water discharged from the mine, high concentrations occur during maximum effluent discharge. Median hardness and sulfate concentrations were lower in 2000 than in 1996-1999 because the volume of discharge from the mine was limited.

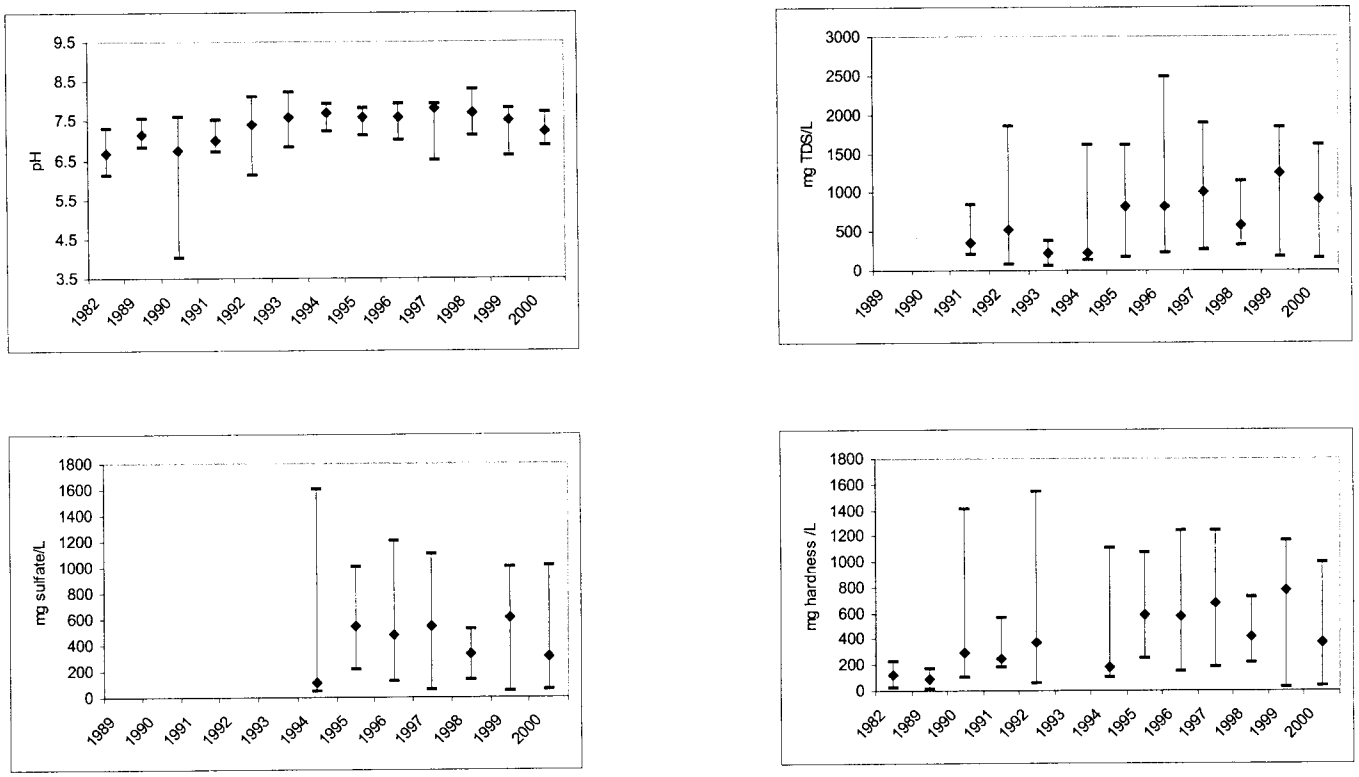


Figure 36. Water quality conditions (pH, TDS, and sulfate) in Mainstem Red Dog Creek at Station 10.

CONCENTRATIONS OF HEAVY ELEMENTS

Baseline concentrations of Zn were elevated above the reported chronic/acute toxic concentrations of 2 mg/L for salmonid fish and often contained elevated concentrations of Al and Cd (Weber Scannell and Andersen 1999). Median concentrations of Pb were below the limit of detection. Baseline studies (Dames and Moore 1983) reported that Arctic graying migrated through the Mainstem of Red Dog Creek to the North Fork of Red Dog Creek during spring high flows when metals concentrations were lower. Concentrations of metals at this site decreased after construction of the stream bypass and mine sump.

The higher method reporting limits in 2000 data limit comparisons of this year with previous years. Maximum concentrations of Al and Pb appear to have substantially increased in 2000 (Figure 37 for all metals). Median concentrations of Cu and Se appear higher in 2000 than in previous years, and minimum concentrations of Ni appear higher in 2000. It is not possible to determine if median and maximum Ni concentrations also are elevated in 2000 because reporting limits are substantially higher than in previous years. Concentrations of Cd and Zn appear unchanged in 2000 over amounts reported in previous years.

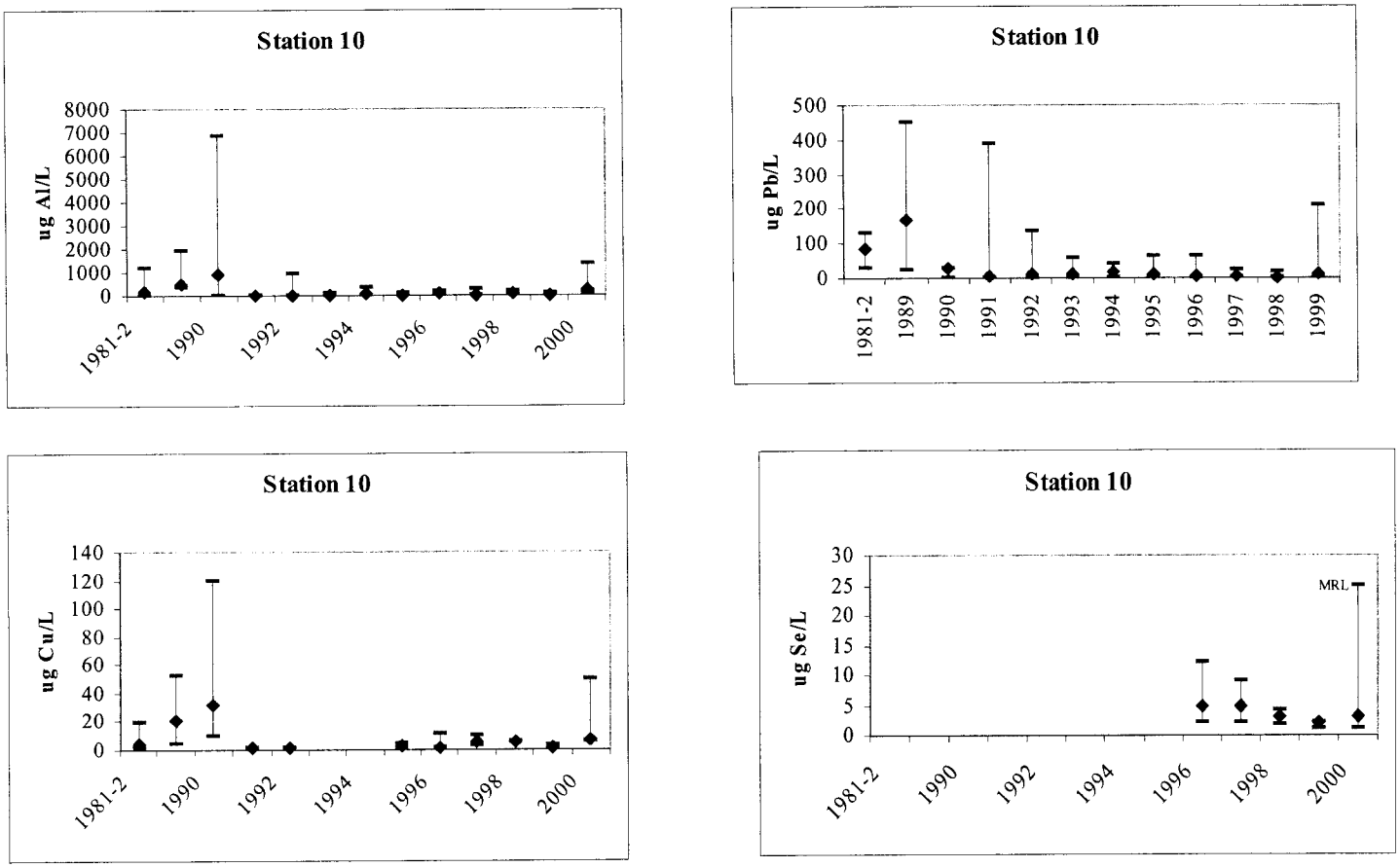
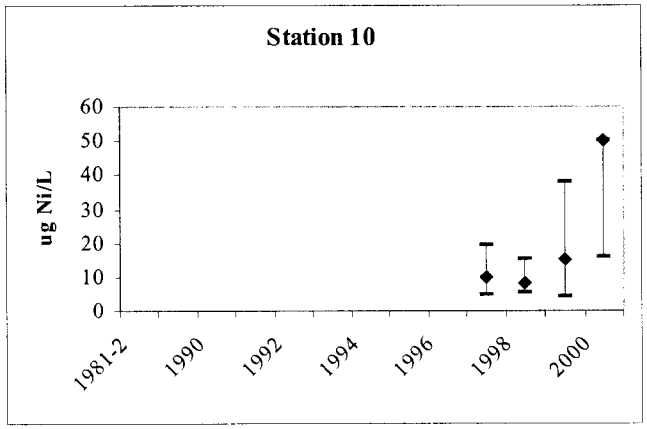
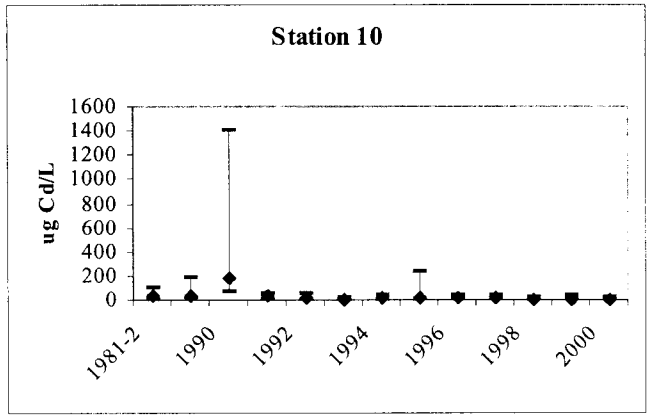


Figure 37. Median, maximum, and minimum concentrations of select elements in Mainstem Red Dog Creek, 1981-2000.





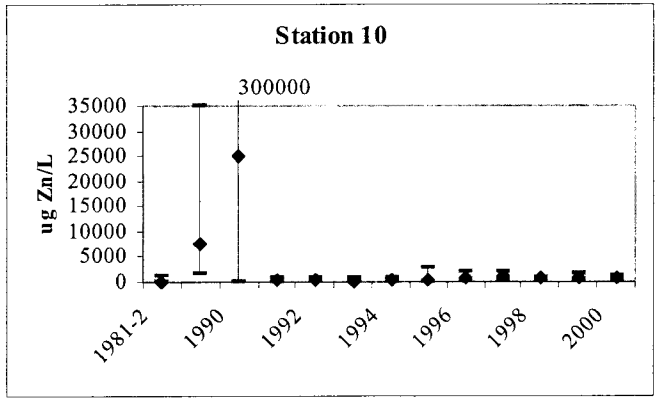


Figure 37, continued.

INVERTEBRATE COMMUNITIES

ABUNDANCE, DENSITY, AND TAXON RICHNESS

Both abundance and density of aquatic invertebrate populations were lower in Mainstem Red Dog Creek in 2000 than any year measured (Figures 38 and 39). Similar declines in both invertebrate abundance and invertebrate densities were found at Stations 8 and 9 in both 1999 and 2000.

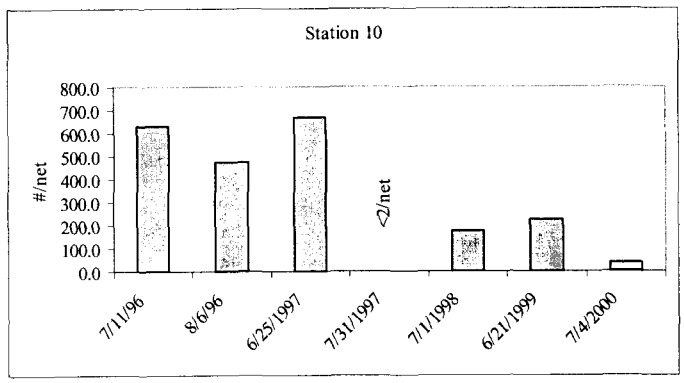


Figure 38. Abundance of aquatic invertebrates collected in Mainstem Red Dog Creek, Station 10.

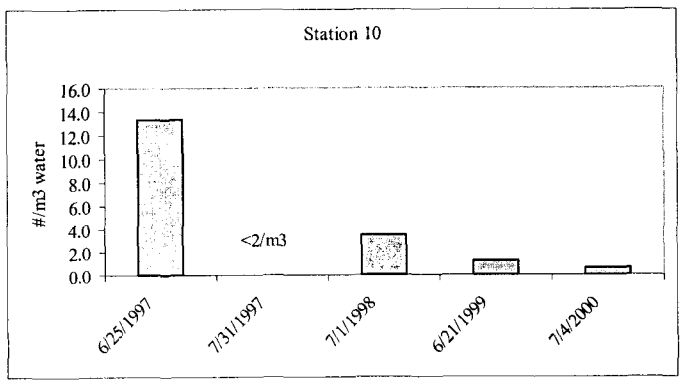


Figure 39. Density of aquatic invertebrates collected in Mainstem Red Dog Creek, Station 10.

Taxon richness was highest in June 1997 and lowest in July 1997, when few taxa were found. (Figure 40).

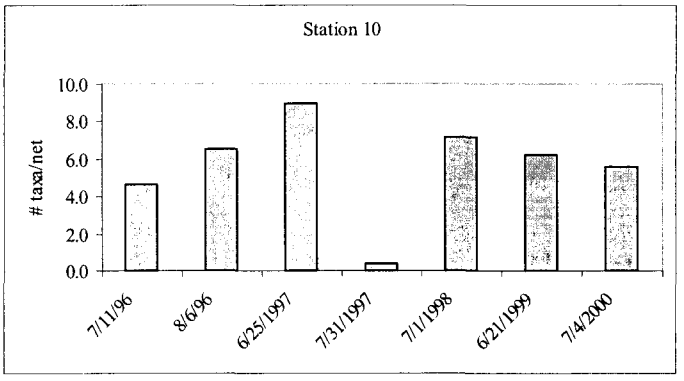


Figure 40. Taxon richness of invertebrate samples collected in Mainstem Red Dog Creek, Station 10.

STRUCTURE OF COMMUNITY

Less than 50% of the invertebrate communities included EPT taxa in all sample events, except June 1998 (Figure 41). Four of the eight sample periods contained less than 10% EPT taxa, these samples contained large proportions of Simuliidae and Chironomidae. Chironomidae were among the most commonly found taxa in most sample events.

Invertebrate communities in Mainstem Red Dog Creek are dominated by Diptera in most months sampled (Appendix 2). Proportions of Ephemeroptera, although not dominant, were highest in August 1996 samples and proportions of Plecoptera were highest in July 2000 samples. Trichoptera, although rare, were most plentiful in samples collected in July 2000.

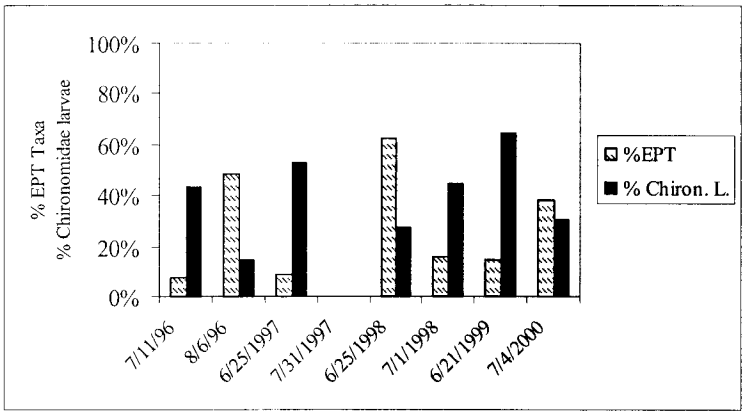


Figure 41. Percent EPT taxa and percent Chironomidae in Mainstem Red Dog Creek.

The results of the invertebrate biomonitoring conducted by ADF&G from 1996 - 2000 are summarized in Appendix 2.

Periphyton Standing Crop

The abundance of attached algae, estimated by chlorophyll-a concentrations, was substantially lower in 2000 than in 1998 or 1999 (Figure 42). The lowest concentrations were found in samples collected in June 1997 and June 1998, when all replicates were below the detection limit. The chlorophyll-a concentrations measured in 2000 were similar to values found in 1995 and 1996. The lower concentrations of chlorophyll-a measured in 2000 correspond to low invertebrate densities found during the same sampling period.

Composition of Algal Communities

No measurable amounts of chlorophyll-b or c were found in samples from Station 10; most of the samples contained concentrations that were too low to analyze for distinct pigments.

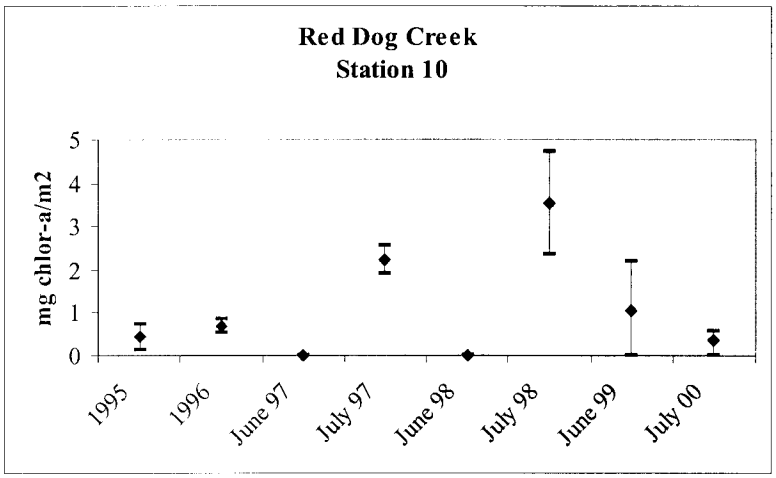


Figure 42. Concentrations of chlorophyll-a measured in Mainstem Red Dog Creek, Station 10.

SUMMARY OF BIOMONITORING, MAINSTEM RED DOG CREEK

Changes in water quality, invertebrate and periphyton communities, and fish populations documented over the biomonitoring period are summarized in Table 7.

Table 7. Summary of Biomonitoring, Mainstem Red Dog Creek, 1995-2000.

Water Quality	Median concentrations of TDS and SO_4 increased since 1994.
Concentration of Toxic elements	Median concentrations of Al, Pb, Cu, Se, Cd, and Zn low in 2000, MRL for Ni high in 2000 (comparisons with previous years not possible).
Invertebrate Communities	Abundance declined since 1996. Densities declined since 1997 (when first estimated). Communities dominated by Diptera during all years sampled
Algal Communities	Chlorophyll-a concentrations low in 2000, predominance of chlorophyll-a for all years, no detectable chlorophyll-b or c.

Middle Fork Red Dog Creek, Station 20

Description of Site

Middle Fork Red Dog Creek has a drainage area of 12 km^2 (4.74 mi^2), the flow comes from the clean water bypass ditch (Station 140) and treated mine effluent. Upper Red Dog Creek, and tributaries Rachael, Connie, and Shelly Creeks flow into the bypass channel, Sulfur Creek flows intermittently. The creek has wide meanders with average channel widths from 3 to 10 m (10 to 30 ft), and depths from 0.03 to 0.45 m (0.1 and 1.5 feet) (Photograph 6). Stream flows range from approximately 1500 cfs at break-up to less than 1 cfs during summer low flows. Extreme low flows occur when the mine is not discharging. Upstream migration to Middle Fork Red Dog Creek is blocked by a gravel weir at the mouth of the North Fork of Red Dog Creek.

Water Quality

Station 20 was not sampled regularly for water quality. The available data suggests that the pH, hardness, and TDS concentrations are controlled by discharge from the mine (Figure 43). During periods of maximum discharge, the pH is above neutral and as high as 8.8 . Low pH occurs during periods of low flow when the mine is not discharging or discharging limited volumes of water. Hardness also is highest during periods of maximum discharge from the mine, and low during periods of no or limited discharge. Concentrations of sulfate and TDS, reported through 1997, are high at this site. Sulfate ranged from 58 to 1800 mg/L and TDS from 173 to 3420 mg/L. Higher concentrations results from effluent discharged from the mine water treatment system.

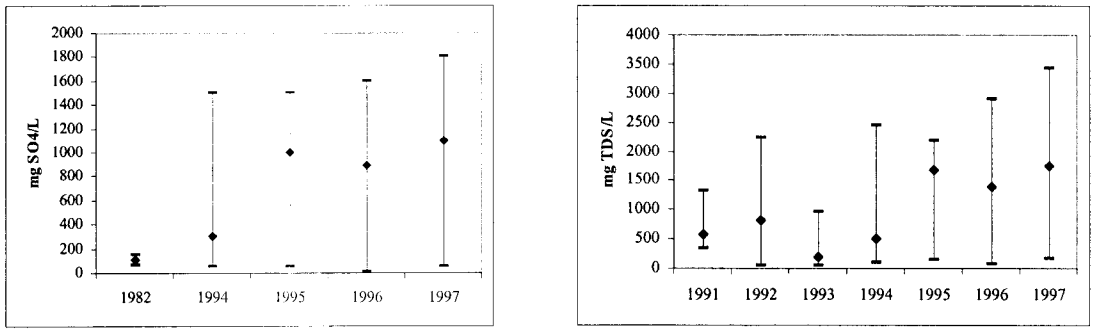


Figure 43. Water quality at Station 20, Middlefork Red Dog Creek.

CONCENTRATIONS OF TOXIC ELEMENTS

Concentrations of Al, Cd, Pb, and Zn at Station 20 are higher than in any of the other sites monitored; however, the concentrations of these metals are lower than baseline, or pre-mining, concentrations (Figure 44).

Median concentrations of Cd, Pb, and Zn in the mine effluent are lower than at Station 20; median concentrations of Cd, Pb, and Zn at Station 140, upstream of the mine effluent, are higher (Table 8). Median concentrations of Al, Cu, and Se are similar at all three sites.

Table 8. Median concentrations of Al, Cd, Cu, Pb, Se, and Zn (*u*g/L) at the mine effluent (outfall), Station 140 upstream of Station 20, and Station 20 in 2000. A sign of < is used if the metal was not detected at the specified concentration.

Metal	Outfall *u*g/L	Station 140 *u*g/L	Station 20 *u*g/L
Al	<75	<75	<75
Cd	<1	22.9	11.2
Cu	<7.5	<7.5	<7.5
Pb	<2	65.2	30.6
Se	4	3	3
Zn	<100	3670	1390

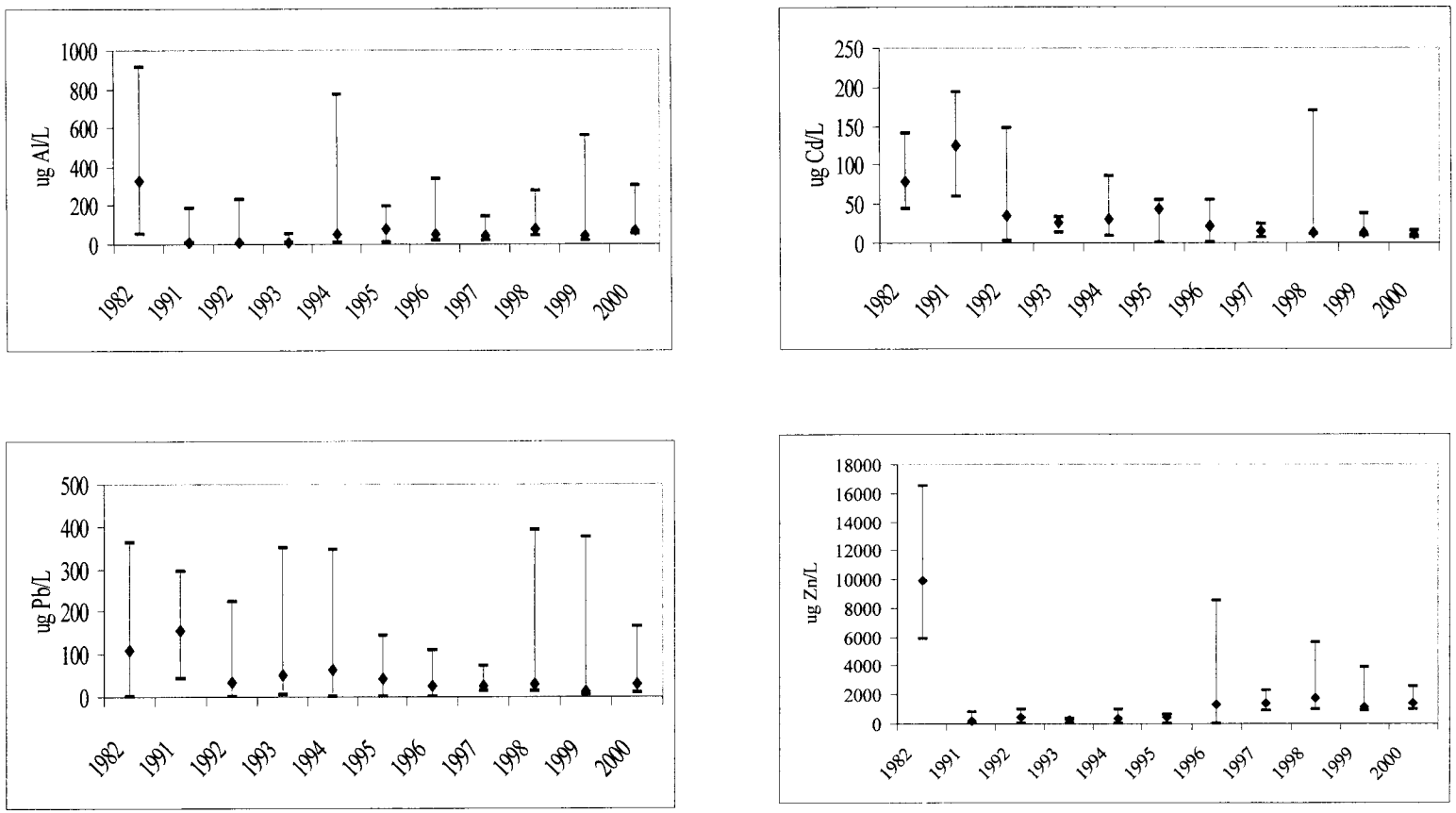


Figure 44. Median, maximum, and minimum concentrations of select metals at Station 20.

INVERTEBRATE COMMUNITIES

ABUNDANCE, DENSITY, AND TAXON RICHNESS

Invertebrate abundance was low at Station 20 during all sample periods except August 1996 and June 1998 (Figure 45). Samples collected in August 1996 contained numerous emerging Baetidae (Ephemeroptera). Samples collected in June 1998 also contained many mature Baetidae (average 52/net) and numerous Chironomidae pupae (average 440/net).

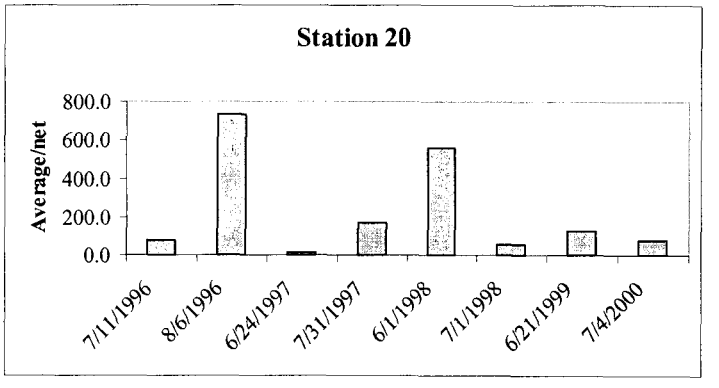


Figure 45. Abundance of aquatic invertebrates (average/net) in Middle Fork Red Dog Creek, Station 20.

Invertebrate densities also were low at Station 20 (Figure 46) where the highest density sampled was only 4 organisms per m^3 water. Conversely, taxon richness was comparable to other sites (Figure 47).

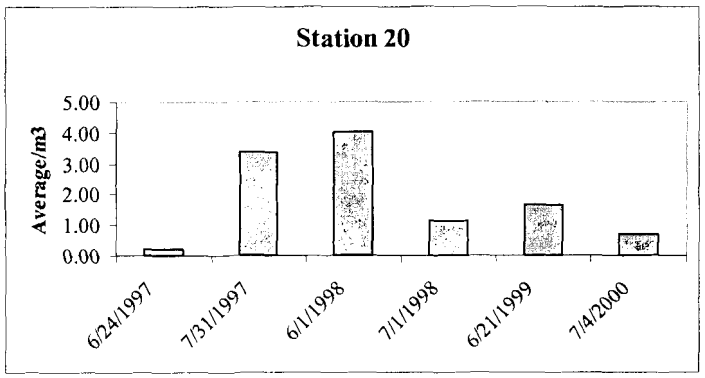


Figure 46. Density of aquatic invertebrates in Middlefork Red Dog Creek at Station 20.

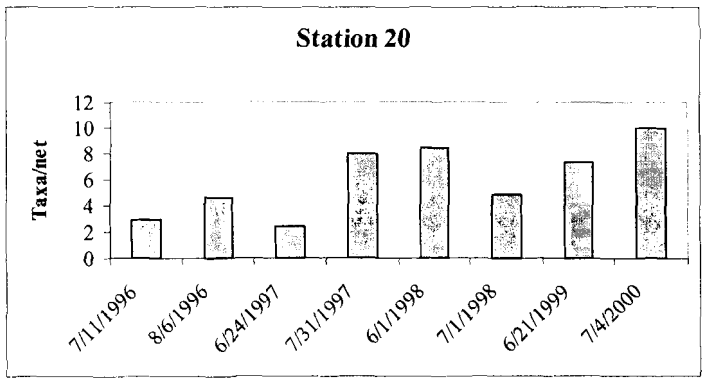


Figure 47. Taxon richness of aquatic invertebrate communities in Middlefork Red Dog Creek at Station 20.

STRUCTURE OF COMMUNITY

Less than 20% of invertebrate communities were EPT taxa in 6 of the 8 sample periods (Figure 48). Five of the eight sample periods contained less than 10% EPT, these samples contained large proportions of Simuliidae and Chironomidae. Chironomidae were among the most commonly found taxa in most sample events.

Invertebrate communities in Middlefork Red Dog Creek are dominated by Diptera in most months sampled (Appendix 2). Proportions of Ephemeroptera, although not dominant, were highest in August 1996 samples (when they also were most common at Station 10) and proportions of Plecoptera were highest in July 2000 samples (also most common at Station 10) (Appendix 2). Trichoptera were rarely collected. Samples with high numbers of Plecoptera (usually Capniidae) or Ephemeroptera (usually Baetidae) contained drifting insects that were fully mature and ready to emerge.

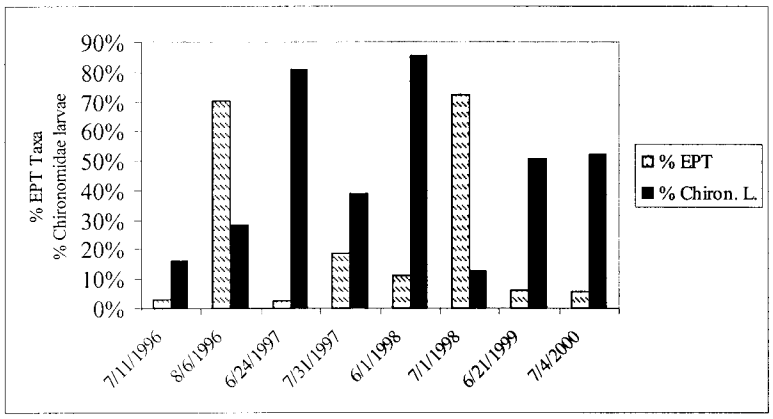


Figure 48. Percent EPT and percent Chironomidae larvae in aquatic invertebrate communities in Middlefork Red Dog Creek at Station 20.

PERIPHYTON STANDING CROP

The concentration of chlorophyll-a in Middlefork Red Dog Creek at Station 20 was consistently lower of any of the sites sampled; during most sample events the concentrations were below the limit of detection, 0.01 mg/m^2 (Figure 49) . No samples from this site contained sufficient amounts of chlorophyll to determine concentrations of chlorophylls b or c.

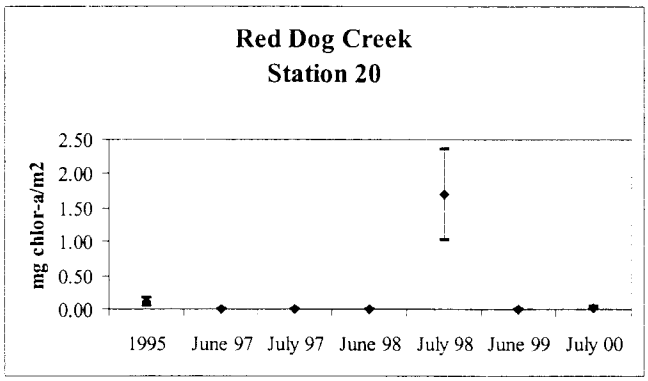


Figure 49. Concentration of chlorophyll-a in Middlefork Red Dog Creek Station 20, 1995-2000.

SUMMARY OF BIOMONITORING

The changes observed in the water quality conditions and aquatic communities are summarized in Table 9. Overall, this site has the lowest productivity (as estimated by invertebrate abundance and concentrations of chlorophyll) of any of the sites sampled. We found no consistent pattern in abundance or density of aquatic invertebrates or in taxon richness that could be related to operations of the Red Dog Mine since 1995.

Table 9. Summary of Biomonitoring, Station 20, 1995-2000

Water Quality	Insufficient baseline data to make comparisons. Median pH somewhat higher than pre-mining.
Concentration of Toxic elements	Decrease in median concentrations of Al, Cd, Pb, and Zn.
Invertebrate Communities	Abundance and density usually low at this site. No consistent pattern of change in abundance, density, or taxon richness . Communities dominated by Diptera at most times, Ephemeroptera and Plecoptera occasionally common.
Algal Communities	Chlorophyll-a concentrations low in all years, samples to low to determine concentrations of chlorophyll-b and c.

North Fork of Red Dog Creek, Station 12

Description of Site

The North Fork of Red Dog Creek is a tributary to the Mainstem of Red Dog Creek. The North Fork has some mineralization in the left fork, but the concentrations of metals are consistently below the USEPA standard for aquatic life (Weber Scannell and Andersen 1999). The North Fork of Red Dog Creek has a drainage area of 41 km^2 (15.9 mi^2), abundant streamside vegetation, deep pools, and wide riffle areas. Widths range from 7 to 15 m (24 to 50 ft) and depths from 0.09 to 2 m (0.3 to 6 ft). Mineral staining is not evident in the North Fork of Red Dog Creek (Photograph 12). Arctic grayling spawn in the North Fork of Red Dog Creek and both Arctic grayling and Dolly Varden juveniles rear in this creek. During the open water period in 1998, the North Fork of Red Dog Creek had seasonal high flows up to 487 cfs in mid-August and seasonal low flows of 14 cfs in mid-July.

Water Quality

The creek is a clear water stream with high dissolved oxygen concentrations during summer and moderate hardness and total dissolved solids (Figure 50) and low sulfate. The median pH is neutral to slightly basic; low pH levels were recorded in early summer, during snow melt, and in late fall during periods of low flow when the creek was freezing (Cominco Alaska unpublished data files).

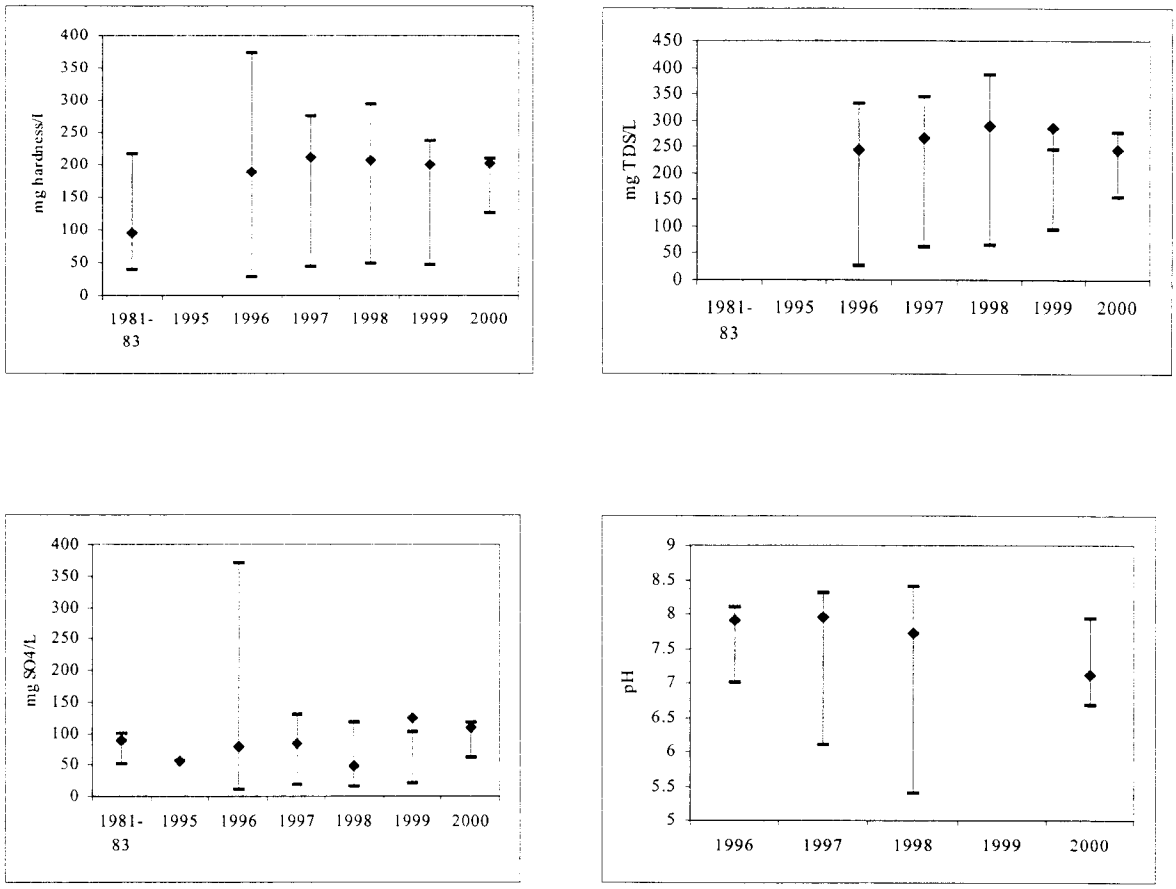


Figure 50. Water quality in the North Fork of Red Dog Creek, Station 12.

CONCENTRATIONS OF HEAVY ELEMENTS

Median concentrations of metals in the North Fork of Red Dog Creek were low, although occasional samples show elevated concentrations (Figure 51). In 2000, the concentrations of Cd, Pb, and Zn were lower in the North Fork of Red Dog Creek than any other creeks sampled. The method reporting limits for Cu, Ni, and Se were too high in 2000 to make similar comparisons.

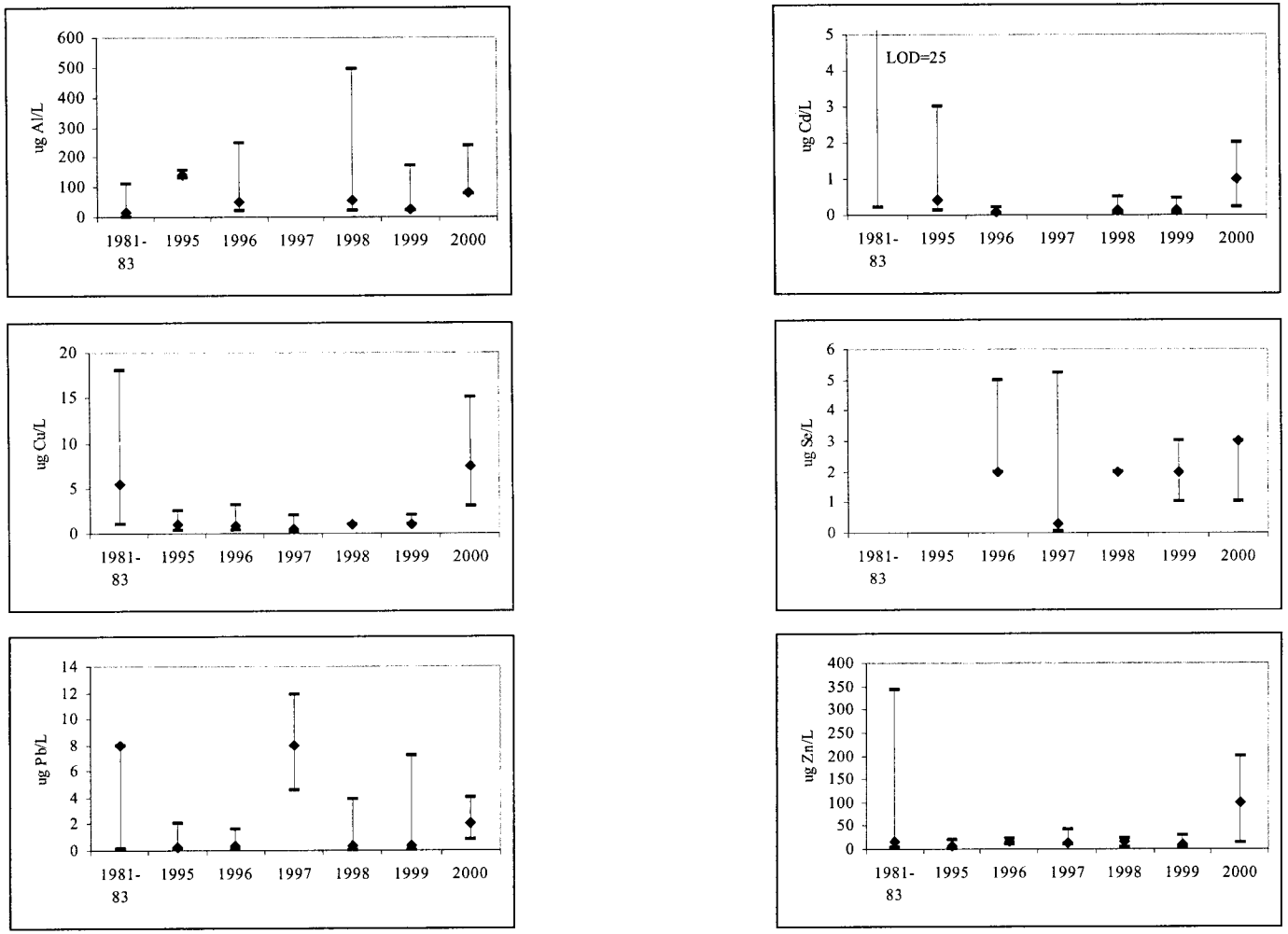


Figure 51. Concentration of select metals in North Fork of Red Dog Creek, Station 12, 1981-2000. .

INVERTEBRATE COMMUNITIES

ABUNDANCE, DENSITY, AND TAXON RICHNESS

Invertebrate abundance in the North Fork of Red Dog Creek at Station 12 ranged from a maximum count of 1500 invertebrates per net to a low of about 100 per net (Figure 52). The highest abundance occurs when different taxa reach final developmental stages and enter the drift just before hatch. As with samples collected in Ikalukrok Creek at Stations 8 and 9, the numbers were lowest in June 1997 and July 1999. Invertebrate abundance was highest at all three sites in June 1997, June 1998, and June 1999. Invertebrate densities showed similar fluctuations among the years sampled (Figure 53), except the density was higher in July 2000 than in June 1999.

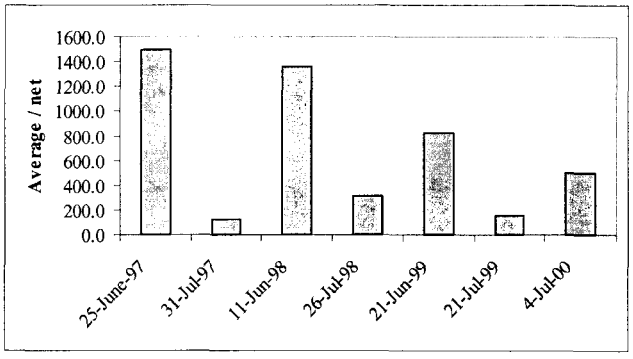


Figure 52. Abundance of aquatic invertebrates (number/net) collected in the North Fork of Red Dog Creek, 1997-2000.

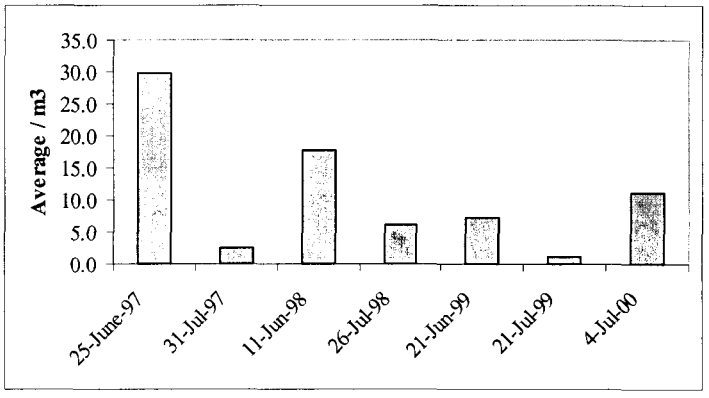


Figure 53. Density of aquatic invertebrates (number/m^3 water) collected in the North Fork of Red Dog Creek, 1997-2000.

Taxon richness in aquatic invertebrate samples from the North Fork of Red Dog Creek showed little fluctuation among the years sampled (Figure 54). The average taxon richness ranged from 6.5 to 9.7 taxa per sample; the lowest numbers of taxa do not correspond to lowest abundance or lowest density.

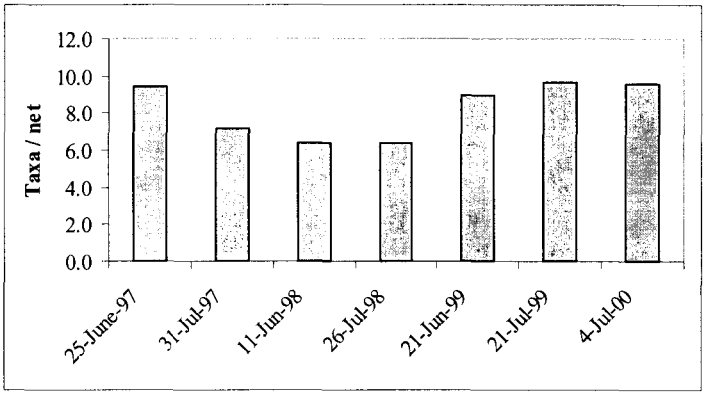


Figure 54. Taxon richness of aquatic invertebrate samples from North Fork of Red Dog Creek.

STRUCTURE OF COMMUNITY

Invertebrate samples contained low proportions (usually less than 20%) of Ephemeroptera, Plecoptera, and Trichoptera (EPT) in most of the sample events (Figure 55); the percentage of EPT taxa was in 2000 North Fork samples was lower than at Stations 8, 9, or 10 for the same sample period. Chironomidae larvae were the most abundant taxa in North Fork samples in all years. In 2000, we found an average 134 Chironomidae larvae/net. Also common in 2000 samples were Simuliidae (Diptera, average 133/net) and Ephemeroptera (average 15 Baetidae/net and 14 Heptageniidae/net). Ostracoda, though not found in samples from previous years, was prevalent in 2000 samples, where we found an average of 55.8 Ostracoda/ net. A summary of invertebrate data for all years sampled is included in Appendix 2.

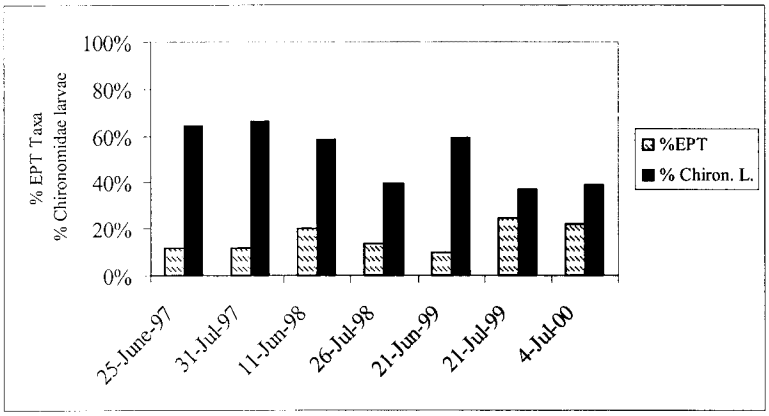


Figure 55. The proportions of EPT taxa and Chironomidae larvae in aquatic invertebrate samples from the North Fork of Red Dog Creek.

PERIPHYTON STANDING CROP

The North Fork of Red Dog Creek at Station 12 contained abundant attached algae (Figure 56). Concentrations of chlorophyll-a at this site are high than, but similar to, concentrations found in Ikalukrok Creek upstream of Dudd Creek and at Station 7.

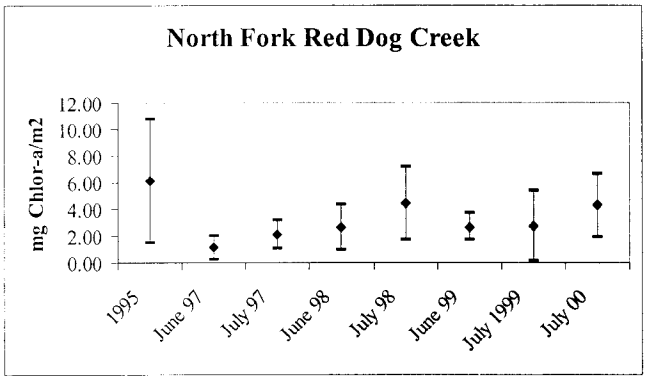


Figure 56. Concentration of chlorophyll-a (mg/m^2) from attached algae collected in the North Fork of Red Dog Creek.

COMPOSITION OF ALGAL COMMUNITIES

Algal communities in the North Fork of Red Dog Creek are a mixture of diatoms and green algae, as indicated by the proportions of chlorophyll-c (diatoms) and chlorophyll-b (green algae) (Figure 57). The proportions of chlorophyll-b and c are higher at this site in 2000 than in any of the other sites sampled under the NPDES biomonitoring program.

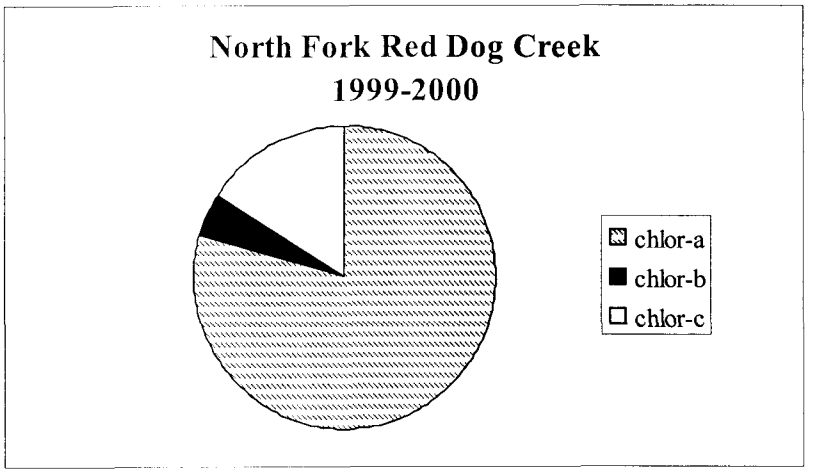


Figure 57. Proportions of chlorophyll-a, b, and c in samples of stream periphyton collected from the North Fork of Red Dog Creek, all years combined.

SUMMARY OF BIOMONITORING, NORTH FORK RED DOG CREEK

Although no mining has not occurred in this drainage, ADF&G conducts biomonitoring in this site to provide a comparison of an unaffected site with sites potentially affected by mining or mine discharge. The North Fork of Red Dog Creek is a productive site for aquatic invertebrates and periphyton, and contains low concentrations of metals (Table 10).

Table 10. Summary of biomonitoring, North Fork Red Dog Creek, 1995-2000.

Water Quality	Water is contains neutral pH, low TDS, and low sulfate.
Concentration of Toxic elements	Concentrations of Al, Cd, Pb, and Zn are low. Higher reported values usually reflect higher method reporting limits.
Invertebrate Communities	Abundance and density are high at this site; however, proportions of EPT taxa are low. Year to year variability is high.
Algal Communities	Chlorophyll-a concentrations high. Periphyton community contains abundant diatoms (Chlor-c).

Metals Concentrations in Adult Dolly Varden, Wulik River

Since 1990, ADF&G has sampled adult Dolly Varden from the Wulik River for metals concentrations (Al, Cd, Cu, Pb, and Zn) in gill, kidney, liver, and muscle (Weber Scannell, et al. 2000). In 1997, we included Se analysis and in 1998 we started sampling reproductive tissues. The purpose of sampling adult Dolly Varden for metals concentrations is both to monitor their long-term condition over the operation of the Red Dog Mine and to identify any changes in tissue concentrations that may be related to mining operations.

Metals tend to concentrate in specific tissues: Al, Se, and Zn are most prevalent in gill tissue, Cd and Cu in liver, Se in reproductive tissues, and Pb in both liver and kidney. Adult Dolly Varden have a complex life history that includes moving between fresh water and ocean environments; metals can be accumulated and depurated in either fresh or salt water. Therefore, it is not possible to determine accumulation rates.

To determine long-term trends in metals concentrations, we focused on Al and Cd in kidney tissue, Cu, Pb, and Zn in liver tissue, and Se in kidney, liver, and reproductive tissues. Concentrations of all metals tested are low in muscle tissue (Appendix 4)

ALUMINUM

Median concentrations of Al in kidney tissues were highest in spring 1991, spring 1994, and spring 1998 (Figure 58). Concentrations of Al in kidney tissues from Dolly Varden collected in spring and fall 2000 were among the lowest concentrations found.

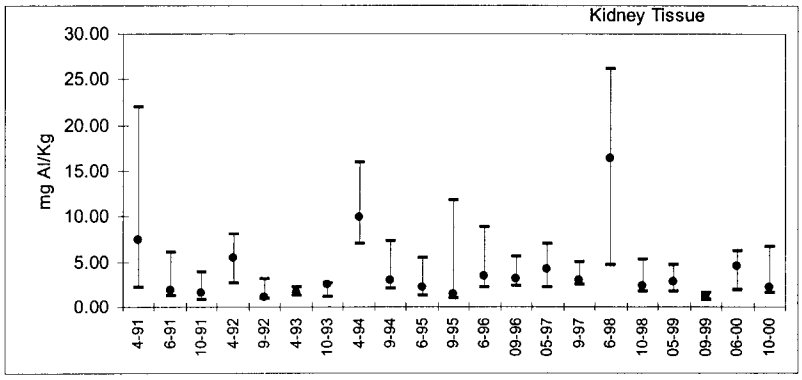


Figure 58. Median, maximum, and minimum concentrations of aluminum (dry weight basis) in adult Dolly Varden kidney tissue, Wulik River, 1990-2000. There are no baseline data for Al.

CADMIUM

Maximum Cd concentrations in Dolly Varden kidney tissue have fluctuated since fall 1991 (Figure 59). The median Cd kidney concentrations were lower in samples taken after 1991 (when median = 3.62 mg/kg) and have fluctuated between 2.4 and 0.38 mg/kg over time. Since fall 1997, median concentrations of Cd in kidney tissues have remained below 2 mg/kg. No increase in Cd was observed in the other tissues sampled (Appendix 4). Higher method reporting limits in fall 2000 samples limit comparisons to earlier data, especially in muscle tissues with low concentrations near the MRL.

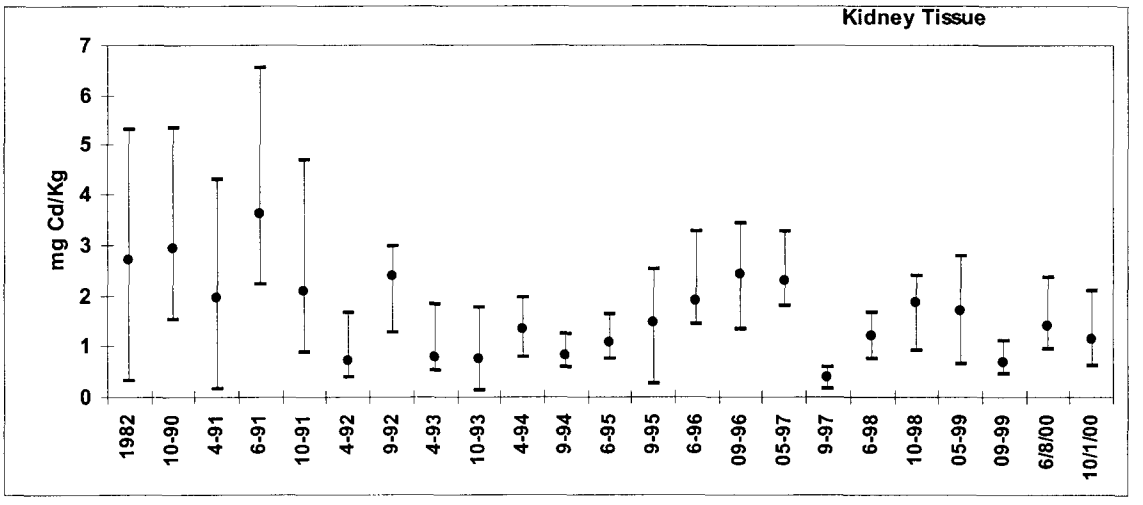


Figure 59. Median, maximum, and minimum concentrations of cadmium (dry weight basis) in adult Dolly Varden kidney tissue, Wulik River, 1982 and 1990-2000. 1982 data are expressed as mean concentration.

COPPER

Liver concentrations of Cu have varied from 20 mg/Kg to about 60 mg/Kg, with no pattern that could be related to completion of the mine diversion and collection system, or any changes in any of the other metals that were monitored (Figure 60). Cu concentrations in Dolly Varden liver were significantly higher in spring-caught fish (two-sample T-test, $p<0.02$) while Cd concentrations in kidney tissues were significantly higher in fall-caught fish (two-sample T-test, $p<0.02$, Weber Scannell, et al. 2000) No notable change (either an increase or decrease) was observed in copper concentrations in any of the other tissues sampled (Appendix 4).

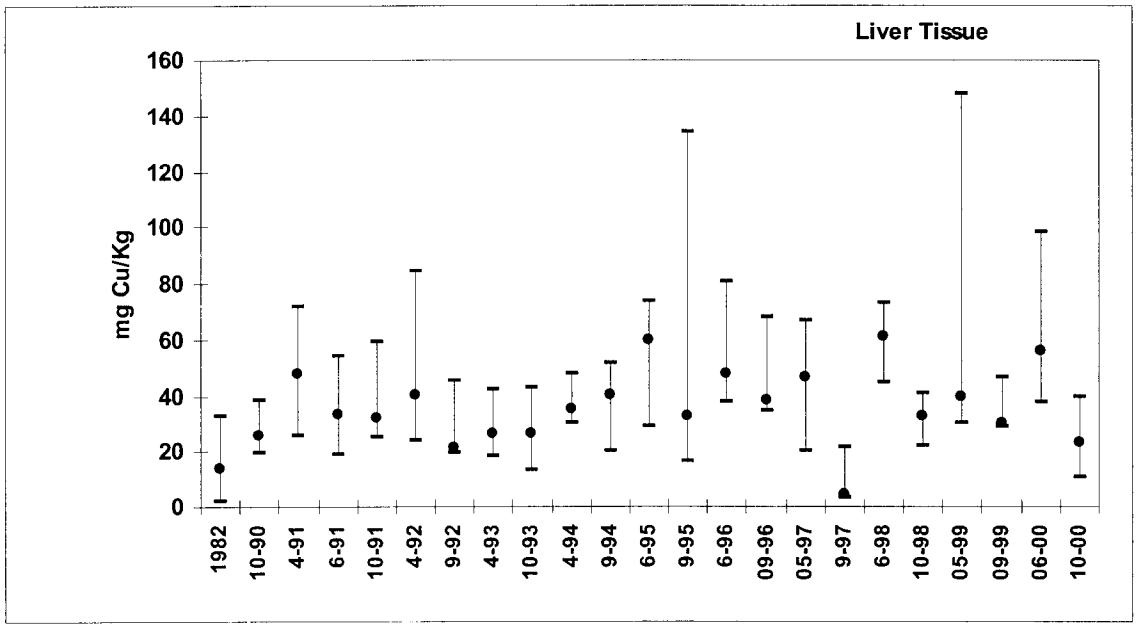


Figure 60. Median, maximum, and minimum concentrations of copper (dry weight basis) in adult Dolly Varden liver tissue, Wulik River, 1982 and 1990-2000. 1982 data are expressed as mean concentration.

LEAD

Median concentrations of lead have generally remained at low concentrations from 1990 through fall 1998, with the exception of elevated Pb in Dolly Varden muscle tissue in the fall 1995 sample (Figure 61). Higher Pb concentrations during 1995 were attributed to Hilltop Creek, a substantial source of Pb and Zn. This tributary to Red Dog Creek has since been diverted to the mine sump collection ditch (September 1995) and subsequent Pb concentrations declined until spring 1999. In spring 1999, median Pb concentrations rose in liver and muscle (Figure 62) tissues, and slightly in kidney tissues (Figure 63). Pb concentrations in these tissues were lower in 2000 fish than in the previous year.

There was no significant difference in Pb concentrations between spring-caught and fall-caught Dolly Varden (two-sample T-test, $p>0.10$ for gill tissue, >0.50 for kidney, liver, and muscle tissues).

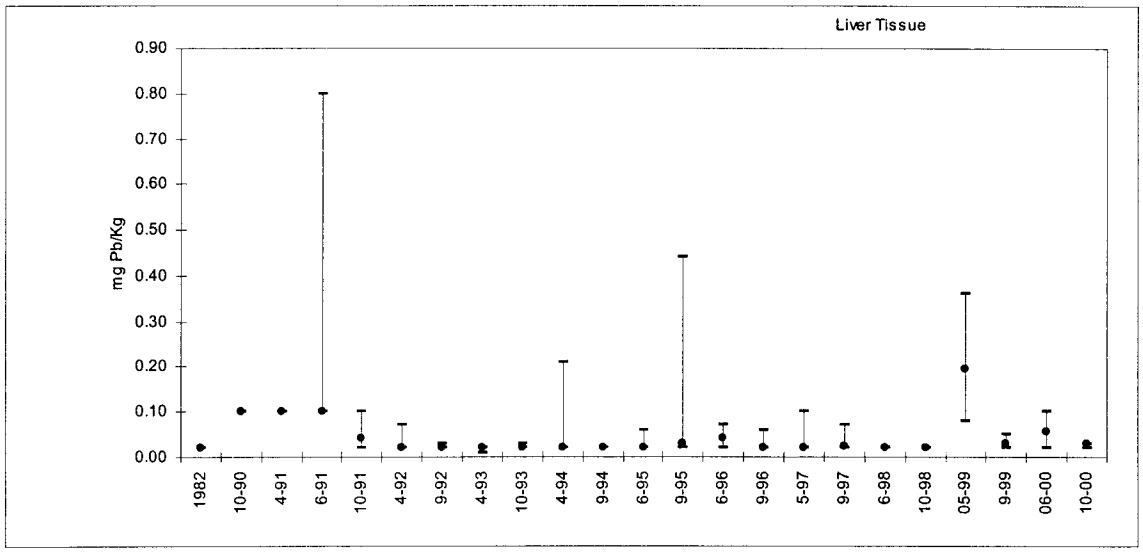


Figure 61. Median, maximum, and minimum concentrations of lead (dry weight basis) in adult Dolly Varden liver tissues, Wulik River, 1982 and 1990-2000. 1982 data are expressed as mean concentration.

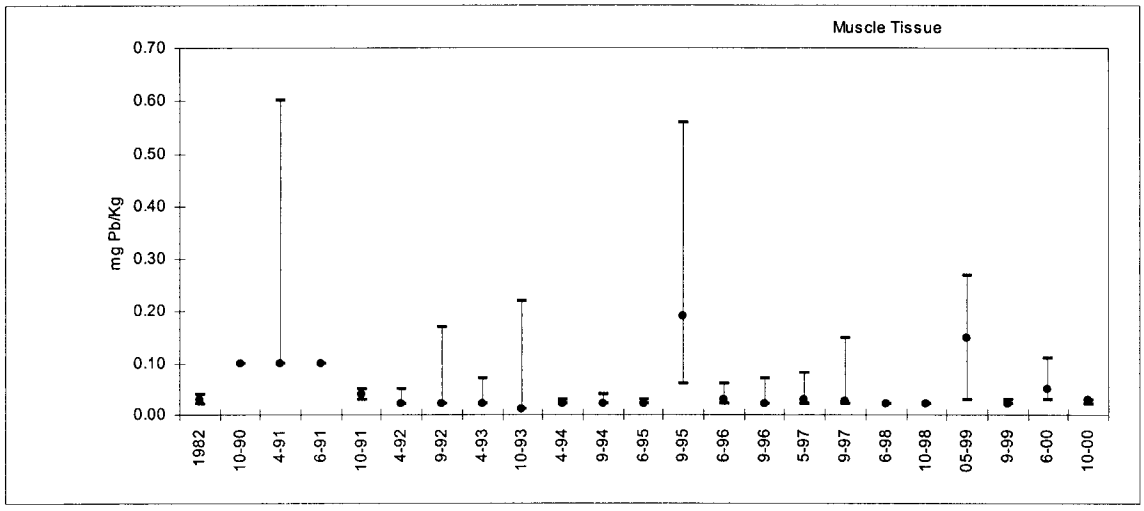


Figure 62. Median, maximum, and minimum concentrations of lead (dry weight basis) in adult Dolly Varden muscle tissues, Wulik River, 1982 and 1990-2000. 1982 data are expressed as mean concentration.

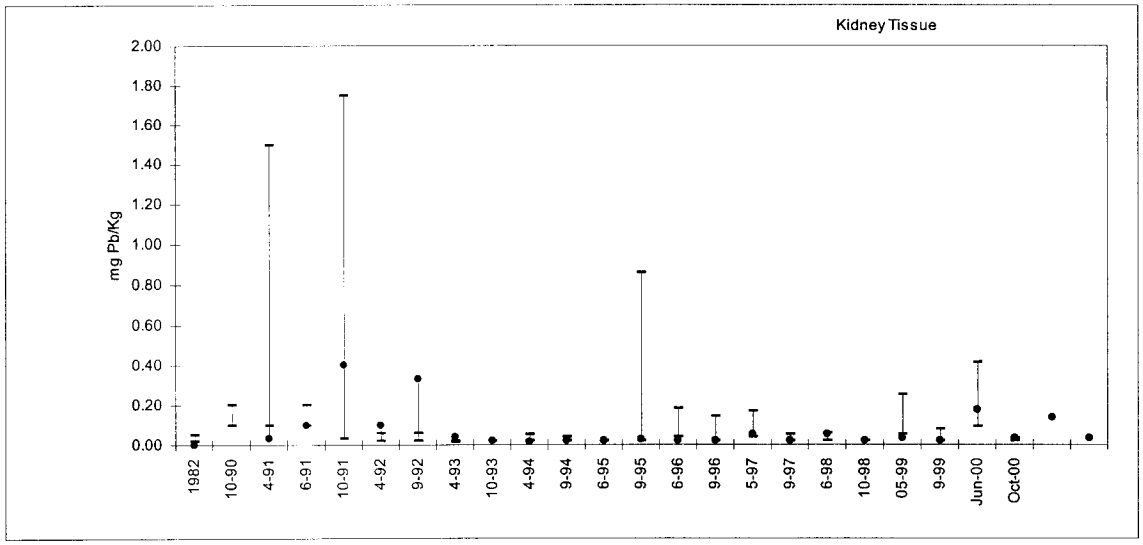


Figure 63. Median, maximum, and minimum concentrations of lead (dry weight basis) in adult Dolly Varden kidney tissues, Wulik River, 1982 and 1990-2000. 1982 data are expressed as mean concentration.

ZINC

Maximum zinc concentrations in Dolly Varden liver (Figure 64) were elevated in September 1995 and median concentrations rose in gill and muscle tissues (Appendix 4). As with lead, higher Zn concentrations measured in September 1995 are believed to result from metals input from Hill Top Creek. Median concentrations from fish collected in spring and fall 2000 were among the lowest measured.

Results of tissue concentrations were combined for all years for fish caught in the fall and for fish caught in the spring to detect differences that may result after overwintering in the Wulik River. Concentrations of Zn were significantly higher in gills of fall-caught fish than in fish caught in the spring (two-sample T-test, $p<0.02$, Weber Scannell, et al. 2000). However, Zn concentrations in livers were significantly higher spring-caught fish than fall-caught fish ($p=0.009$). We found no consistent increase or decrease in metals in adult Dolly Varden that could be attributed to residence time in the Wulik River.

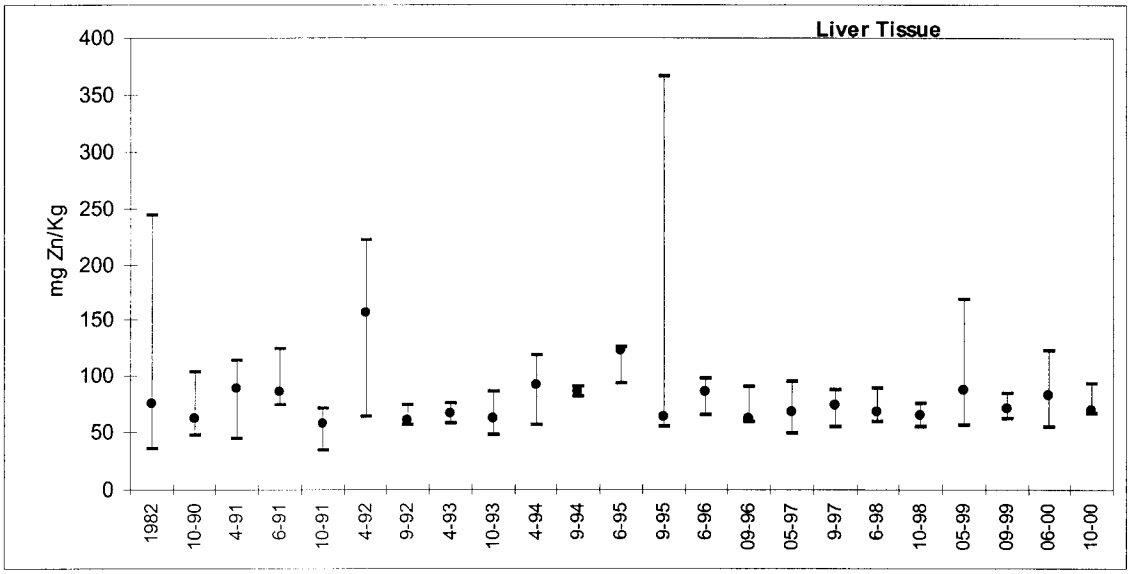


Figure 64. Median, maximum, and minimum concentrations of zinc (dry weight basis) in adult Dolly Varden liver, Wulik River, 1982 and 1990-2000. 1982 data are expressed as mean concentration

SELENIUM

Median Se concentrations in Dolly Varden liver were highest in fall 1997, then dropped to near detection in spring 1998. The median concentrations have steadily risen since spring 1998, but remain considerably lower than measured in fall 1997 (Figure 65). Se tissues in Dolly Varden kidney also increased from fall 1997 through spring 1999 (Figure 66). Median Se concentrations in kidney tissue were similar in the spring and fall of 1999, and the spring and fall of 2000.

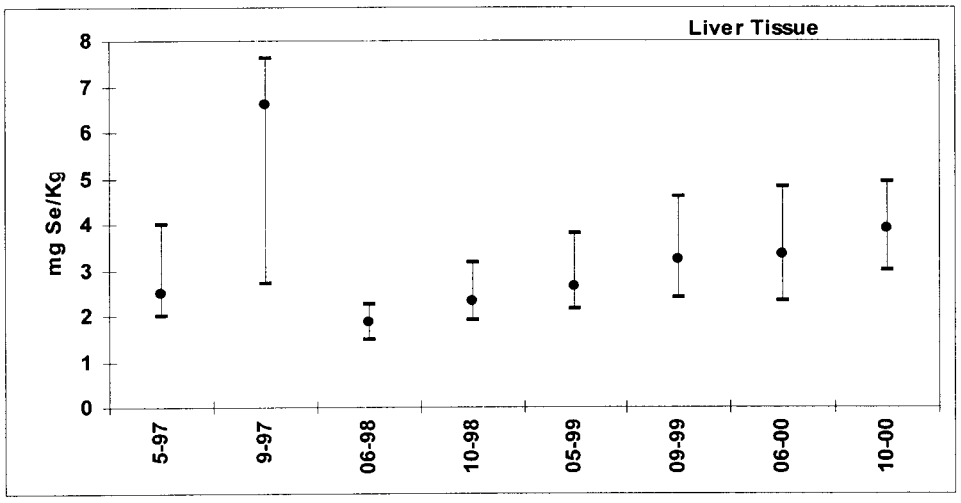


Figure 65. Concentration of Se in adult Dolly Varden liver tissues, Wulik River, 1997-2000.

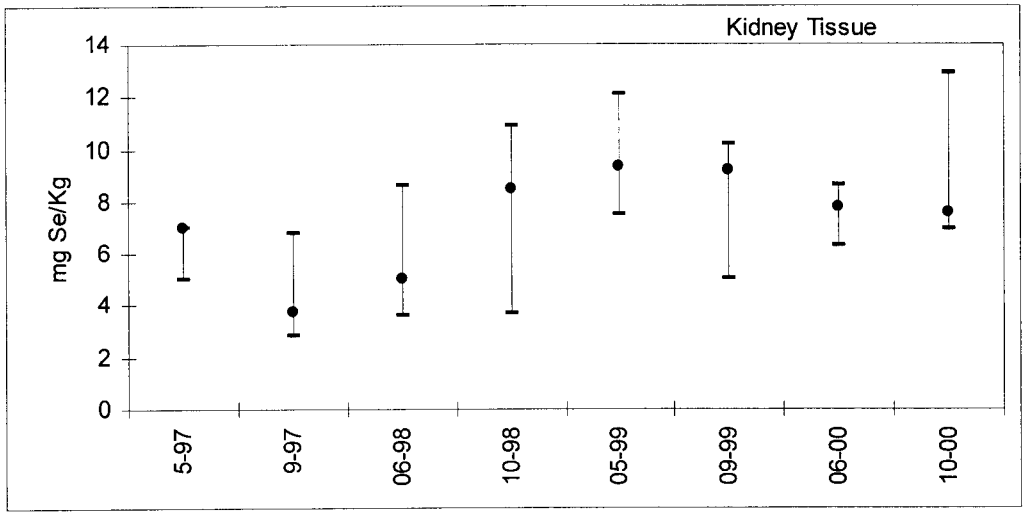


Figure 66. Concentration of Se in adult Dolly Varden kidney tissues, Wulik River, 1997-2000.

Median, maximum, and minimum Se concentrations in reproductive tissues were higher in fall-caught fish (returning from the ocean) than in spring-caught fish (after spending the winter in fresh water) (Figure 67).

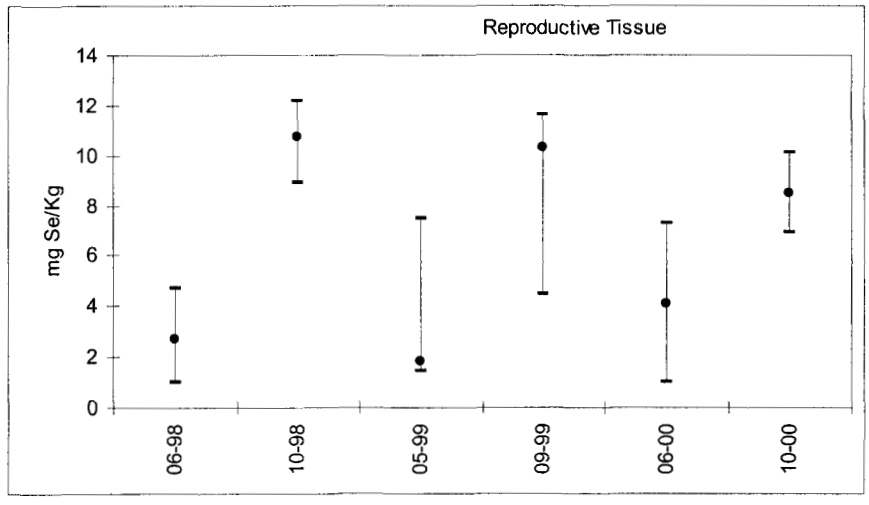


Figure 67. Concentration of Se in adult Dolly Varden reproductive tissues, Wulik River, 1997-2000.

Concentrations of metals in Dolly Varden tissues in the Wulik River do not appear to correlate with age of fish nor do older fish appear to be accumulating higher concentrations of metals (Weber Scannell, et al. 2000).

Metals Concentrations in Juvenile Dolly Varden

Juvenile Dolly Varden overwintering habitats are limited. Based on field observations and the presence of adult spawning fish, some of the overwintering areas have been identified. Most, if not all, juvenile Dolly Varden that use Mainstem Red Dog and North Fork Red Dog Creeks during summer for rearing, migrate to overwintering habitats in Ikalukrok Creek downstream of the mouth of Dudd Creek. In Anxiety Ridge Creek some of the juveniles over winter in the system, but most leave to winter in Ikalukrok Creek. Some of the juvenile Dolly Varden probably move through Ikalukrok Creek to overwintering areas in the Wulik River.

Concentrations of metals in juvenile Dolly Varden likely represent differences in the amount of metals accumulated from summer rearing areas, particularly North Fork and Mainstem Red Dog Creeks where juveniles migrate before freeze-up. Cadmium, Pb, and Se concentrations were, as would be expected, highest for juvenile fish collected from Mainstem Red Dog Creek (Figures 68 to 70, Appendix 5).

Median Cd concentrations in juvenile Dolly Varden from all sample areas did not change substantially from 1998 to 2000, although maximum concentrations in fish from Mainstem Red Dog Creek increased from 1998 to 1999 and from 1999 to 2000 (Figure 68). Median Pb concentrations in juvenile Dolly Varden increased from 1999 to 2000 in all three sites we sampled (Figure 69). Selenium concentrations were similar at all sample sites with some increases in Mainstem and North Fork Red Dog Creeks (Figure 70).

All fish handled from North Fork Red Dog, Mainstem Red Dog, and Anxiety Ridge Creeks appeared to be healthy with no apparent abnormalities. We calculated the condition factor (using Fulson's Condition Factor: weight/length^3) and found no significant difference in condition of these fish among the three sites (one-factor ANOVA, $p=0.365$).

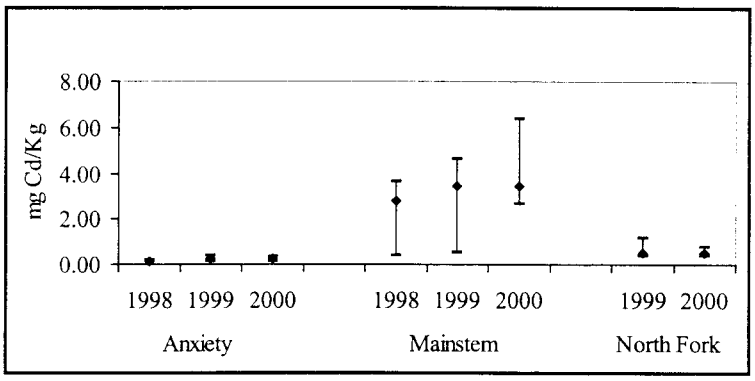


Figure 68. Median, maximum, and minimum concentrations of Cd (mg/Kg dry weight, whole body) in juvenile Dolly Varden, Red Dog Mine, 1998-2000.

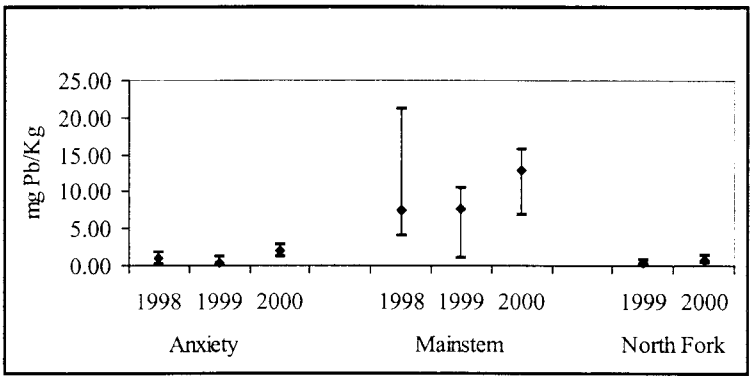


Figure 69. Median, maximum, and minimum concentrations of Pb (mg/Kg dry weight, whole body) in juvenile Dolly Varden, Red Dog Mine, 1998-2000.

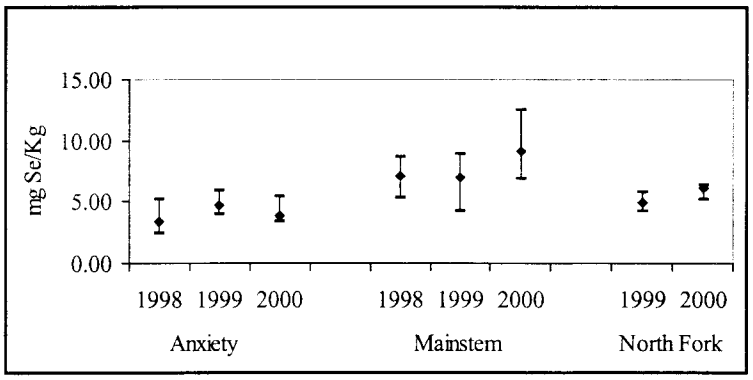


Figure 70. Median, maximum, and minimum concentrations of Se (mg/Kg dry weight, whole body) in juvenile Dolly Varden, Red Dog Mine, 1998-2000.

Distribution of Fish throughout Drainage

OVERWINTERING DOLLY VARDEN

The Dolly Varden fall aerial survey in the Wulik River was not made in 2000 because of persistent fog and rain in late September/early October.

The number of Dolly Varden counted in fall 1998 and 1999 was 104,043 and 70,704 (DeCicco 1998, 1999) (Figure 71, Appendix 6). Numbers of Dolly Varden counted in the Wulik River during fall surveys have ranged from a low of 30,853 in 1984 to a high of 144,138 in 1993. Fluctuations in numbers appear to be related to weather conditions during the survey and to the time these fish enter the Wulik River for overwintering. In some years, most of the fish appear to enter the river late in the fall and may be missed during the annual survey. We found no increase or decrease in numbers of Dolly Varden that correspond to development and production at the Red Dog Mine. Surveys conducted through fall 1999 suggest that over 90% of Dolly Varden in the Wulik River remain below the mouth of Ikalukrok Creek in late September and early October. Aerial survey areas are shown in Appendix 7.

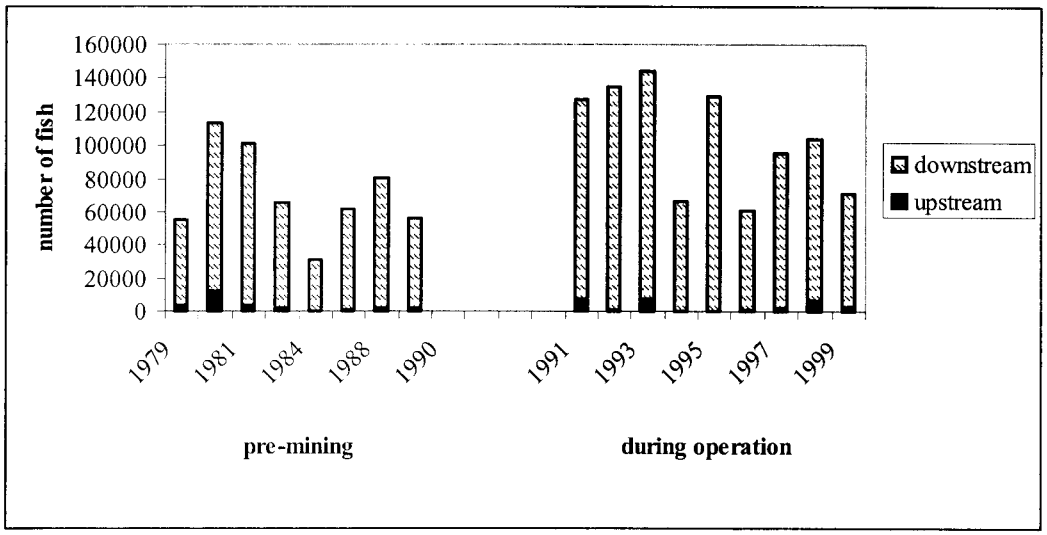


Figure 71. The number of adult Dolly Varden counted in aerial surveys in the Wulik River upstream and downstream of Ikalukrok Creek.

CHUM SALMON SPAWNING

ADF&G plans annual surveys to assess the distribution of adult chum salmon in Ikalukrok Creek downstream of Dudd Creek (Table 11, Appendix 7); however, these surveys often are prevented by poor weather conditions. On August 3, 2000, we attempted an aerial survey, but high water levels and turbidity limited our visibility and we could not see chum salmon in the river. Periodic rain storms prohibited two later surveys scheduled in August 2000. Mr. Phil Driver (resident guide, pers. comm. 2001) indicated that in late-September there were chum salmon present in lower Ikalukrok Creek. Although fish were not counted, Mr. Driver estimated hundreds of fish in the river.

A helicopter survey on August 9, 1999 resulted in a count of 75 chum salmon in lower Ikalukrok Creek. Visibility in August 1999 was poor and numbers of chum salmon probably were substantially higher than reported. DeCicco (1999) conducted a fixed-wing survey of Ikalukrok Creek on September 28, 1999, and reported seeing 145 chum salmon. DeCicco's 1999 survey was conducted after the peak spawning period for chum

salmon and our August 9 survey results were limited due to poor visibility, thus numbers of chum salmon in Ikalukrok Creek in fall 1999 probably were higher than reported.

Numbers of chum salmon observed in Ikalukrok Creek in 1995, 1996, 1997, and 1999 were higher than in 1990 and 1992, although in 1996 we counted only 50% of the chum salmon observed in 1995 (Table 11). Our highest count since the opening of the Red Dog Mine was in August 1997 (730 - 780 fish). During the August 1997 flight, we also observed ten sockeye salmon in Ikalukrok Creek.

Counts of chum salmon made after mine development are lower than reported in baseline studies of ADF&G and Dames and Moore (1983). Chum salmon in 1996 and 1999 were actively spawning in the lower 8 km of Ikalukrok Creek. In 1997, chum salmon, while concentrated in the lower portion of Ikalukrok Creek, were seen spawning in Ikalukrok Creek from the Wulik River to the mouth of Dudd Creek. Most chum salmon observed in 1996 and 1997 were spawning adjacent to cut banks. Although numbers of chum salmon spawning in Ikalukrok Creek remain lower than before mining, the chum salmon spawning population appears to be increasing over low numbers reported in 1990 and 1991.

Table 11. Number of adult chum salmon in Ikalukrok Creek downstream of Dudd Creek.

Survey Time	Number of Chum Salmon	Reference
September 1981	3,520 to 6,960	Houghton and Hilgert 1983
August/September 1982	353 and 1,400	Houghton and Hilgert 1983
August 1984	994	DeCicco 1990b
August 1986	1,985	DeCicco 1990b
August 1990	<70	Ott et al. 1992
August 1991	<70	Ott et al. 1992
August 1995	49	Townsend and Lunderstadt 1995
August 1995	300 to 400	DeCicco 1995
August 1996	180	Townsend and Hemming 1996
August 1997	730 to 780	Ott and Simpers 1997
August-September 1998	No survey	
August 1999	75	Ott and Morris 1999
September 1999	145	DeCicco 1999
August 2000	No survey	

JUVENILE DOLLY VARDEN

Limited pre-mining data for juvenile Dolly Varden distribution and use were available for Evaingiknuk, Buddy, and Ikalukrok Creeks. Highest use by juvenile Dolly Varden was found in Anxiety Ridge Creek, also identified as the most productive stream system in the project area by Houghton and Hilgert (1983). Houghton and Hilgert (1983) found only one juvenile Dolly Varden, assumed to be a resident fish, in the headwaters of North Fork Red Dog Creek. Fish were observed in Mainstem Red Dog Creek within the influence of the North Fork Red Dog Creek (Dames and Moore 1983) and fish mortalities were documented in Mainstem Red Dog Creek (EVS and Ott Water Engineers 1983, Ward and Olson 1980).

Patterns of juvenile Dolly Varden use of Evaingiknuk, Anxiety Ridge, and Ikalukrok Creeks have been studied by the ADF&G annually since summer 1990. In 1992 we increased fishing effort from five to ten traps per creek. Since 1990, we have added additional sample sites (Table 12).

Table 12. Locations of juvenile fish monitoring and year the site was first sampled.

Site Name	Station No.	Year First Sampled
Evaingiknuk Cr.		1990
Anxiety Ridge Cr.		1990
Ikalukrok Cr. above Dudd Cr.		1990
Ikalukrok Cr. below Dudd Creek	7	1990
North Fork RDC	12	1993
Mainstem RDC, below North Fork	11	1995
Buddy Creek		1996
Mainstem RDC, above Ikalukrok Creek	10	1996
Ikalukrok Cr. Above Mainstem RDC	9	1996
Ikalukrok Cr. Below Mainstem RDC	8	1996

Relative numbers of Dolly Varden vary considerably among years, due in large part to natural environmental variables, including time of break-up, patterns and magnitude of rainfall events, and how rapidly the water warms (Weber Scannell et al. 2000, Weber Scannell and Ott 1998; Ott and Weber Scannell 1996; Weber Scannell and Ott, 1995; Ott and Weber Scannell 1994; Ott and Weber Scannell 1993, Ott et al. 1992). Peak use of tributary streams (i.e., Anxiety Ridge, Buddy, North Fork Red Dog, Mainstem Red Dog, and Ikalukrok Creeks) by juvenile Dolly Varden occurs from late July to mid-August.

Catches of juvenile Dolly Varden at all sample sites in late summer (late July to early August) 2000 were low compared with previous years. We caught a total of 111 Dolly Varden in late July 2000, compared with a catch of 945 in early August 1999 (Table 13). Catch data for late summer 1997 through 2000 show that the number of fish present in various sample reaches follows a similar pattern. Highest use by juvenile Dolly Varden was documented in 2000 at almost all sample sites (Figure 72). When numbers are high in the reference streams, Anxiety Ridge and Buddy Creeks, they also are high in sample reaches directly effected by the mine drainage and the effluent outfall. Appendix 8 shows the locations of the juvenile fish sampling sites.

Table 13. The number of juvenile Dolly Varden caught in minnow traps (10 traps per sample reach) from 1997 through 2000.

	Dates Sampled			
Sample Location	7/28-8/1/00	8/9-10/99	8/7-10/98	8/10-13/97
Evaingiknuk Creek	2	38	27	54
Anxiety Ridge Creek	27	271	94	68
Buddy Creek	11	306	154	48
North Fork Red Dog Creek (Station 12)	1	17	12	0
Mainstem Red Dog Creek below North Fork	13	86	70	14
Mainstem Red Dog Creek (Station 10)	1	66	21	10
Ikalukrok Creek below Dudd Creek (Station 7)	31	55	51	13
Ikalukrok Creek above Dudd Creek	14	37	53	3
Ikalukrok Creek below Mainstem (Station 8)	6	28	19	4
Ikalukrok Creek above Mainstem (Station 9)	5	41	44	3
Total Catch of Dolly Varden for All Sites	111	945	545	217

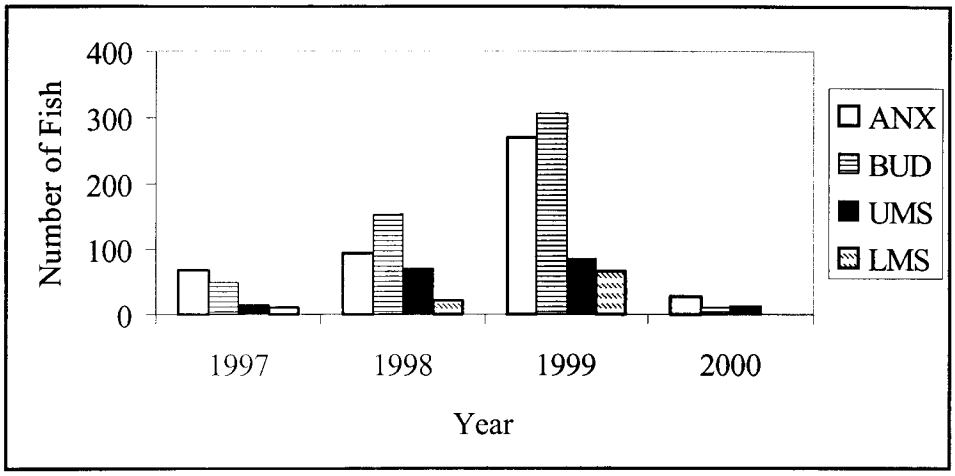


Figure 72. Juvenile Dolly Varden caught in minnow traps in late July – early August, 1997-2000. ANX =Anxiety Ridge Cr. BUD = Buddy Cr. UMS = Upper Mainstem Red Dog Cr. And LMS =Lower Mainstem Red Dog Cr.

Length frequency distribution of fish captured from 1997 through 2000 is presented in Figure 73. The number of age-0 Dolly Varden was higher in both 1997 and 1998 and likely explains the higher catches in 1999. DeCicco (ADF&G Sport Fish Biologist, pers. Comm. 2000) noted that most of these Dolly Varden are age-1 and –2. Also, a few older fish and a few age-0 fish started to appear in the catch. Overall abundance of juvenile Dolly Varden increased substantially from 1997 to 1998 and from 1998 to 1999. Numbers doubled with strong age-0 recruitment in both 1997 and 1998; age-0 recruitment was less in 1999. Again, we collected few age-0 fish in fish traps during summer 2000.

The substantial decrease in numbers caught in 2000 likely resulted when larger fish reached smolt size and migrated to marine water. Juvenile Dolly Varden smolt as early as age-2, but most leave at age-3 with some staying in fresh water up to five years before becoming smolt.

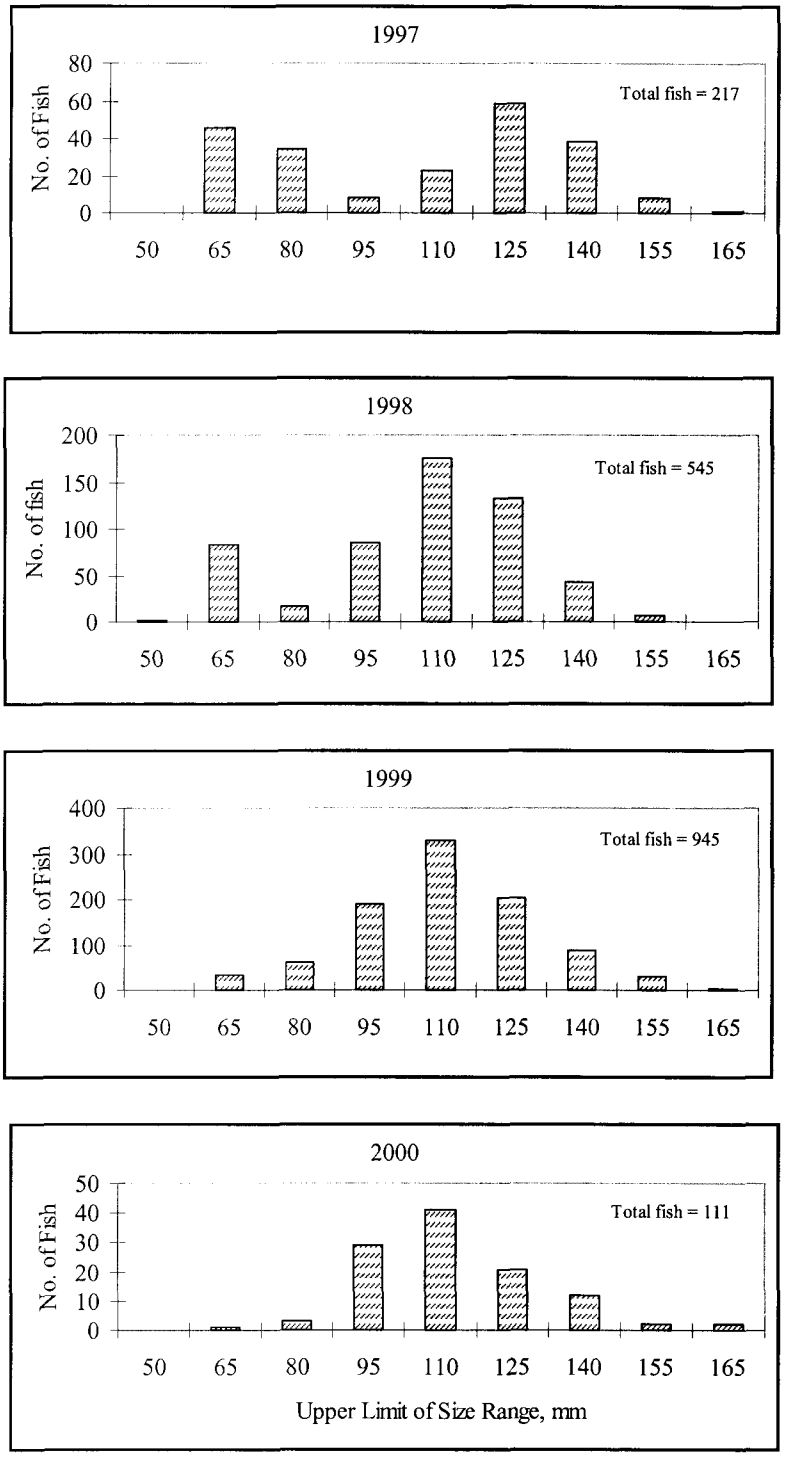


Figure 73. Length frequency of juvenile Dolly Varden captured from 1997 through 2000, all sites combined.

In early June, 2000, we captured 18 juvenile Dolly Varden, 76 in early July, and 3 in late July. Dolly Varden captured in early June ranged from 148 to 250 mm fork length (n = 18, average = 200, SD = 28.1) and were moving upstream. Dolly Varden in this size range have not been captured during previous sampling with minnow traps and angling. These larger Dolly Varden, with visible parr marks and orange dots along the sides, probably are resident fish moving to the upper portions of North Fork Red Dog Creek for summer rearing. The only juvenile Dolly Varden found during baseline studies by Houghton and Hilgert (1983) were found in the headwaters of North Fork Red Dog Creek. Juvenile Dolly Varden caught in early July ranged from 85 to 278 mm (n = 76, average = 117 mm, SD = 30.6). Length frequency distribution for the early June and July sample period shows a clear difference in the length of fish collected (Figure 74). Although several larger Dolly Varden (>200 mm) were caught in early July, most of the fish were small and similar in size to fish normally caught in minnow traps. During the late July sample period, only three Dolly Varden (95 to 112 mm) were caught.

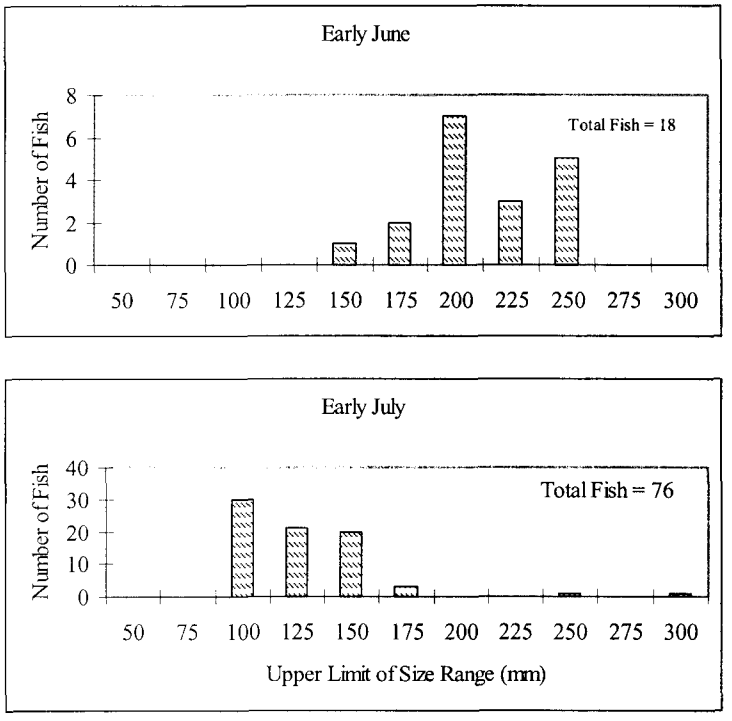


Figure 74. Length-frequency distribution of Dolly Varden captured in North Fork and Mainstem Red Dog Creeks using fyke-nets in summer 2000.

ARCTIC GRAYLING

Baseline studies reported abundant spawned-out Arctic grayling in North Fork Red Dog Creek in June 1982, and numerous age-0 Arctic grayling in July 1982 (Dames and Moore 1983). Age-1 and 2 Arctic grayling were rarely found (Houghton and Hilgert 1983). Ward and Olson (1980) reported some use of the lower 1.6 km of Mainstem Red Dog Creek by Arctic grayling but numbers were less than in adjacent streams. Arctic grayling were rarely seen in Mainstem Red Dog Creek and were not reported in Middle Fork Red Dog Creek (upstream of the mouth of North Fork Red Dog Creek) by Houghton and Hilgert (1983). Fish were observed in Mainstem Red Dog Creek within the influence of the North Fork Red Dog Creek (Dames and Moore 1983) and dead fish (Arctic grayling and Dolly Varden) were seen in Mainstem Red Dog Creek (EVS and Ott Water Engineers 1983, Ward and Olson 1980).

Before mine development, Arctic grayling adults were thought to migrate through Mainstem Red Dog Creek in early spring when discharges were high and metals concentrations were low. Migration of adults probably occurred during high-water events, while age-0 Arctic grayling left as water temperatures cooled in the fall or as high-water events displaced them.

Since 1993, we have found embryonic (approximately 3-4 day-old) fish in the North Fork of Red Dog Creek. The presence of these young fish confirms spawning.

Water temperatures in the North Fork of Red Dog Creek were substantially warmer during spring 1999 fyke net sampling than during 2000 fyke net sampling (Figure 75). Fyke-nets were set as early as ice conditions and flow allowed. In spring 1999, fyke-nets were set on May 28 and the first adult Arctic grayling were caught on May 30 when the water temperature peaked at 4.1°C. Fyke-nets in spring 2000 were set on June 8 and the first Arctic grayling were captured on June 10 when the water temperature peaked at 4.8°C. The majority of the Arctic grayling collected on June 13 had already spawned. Peak water temperatures in North Fork Red Dog Creek from June 10 to 13 were greater than 4°C.

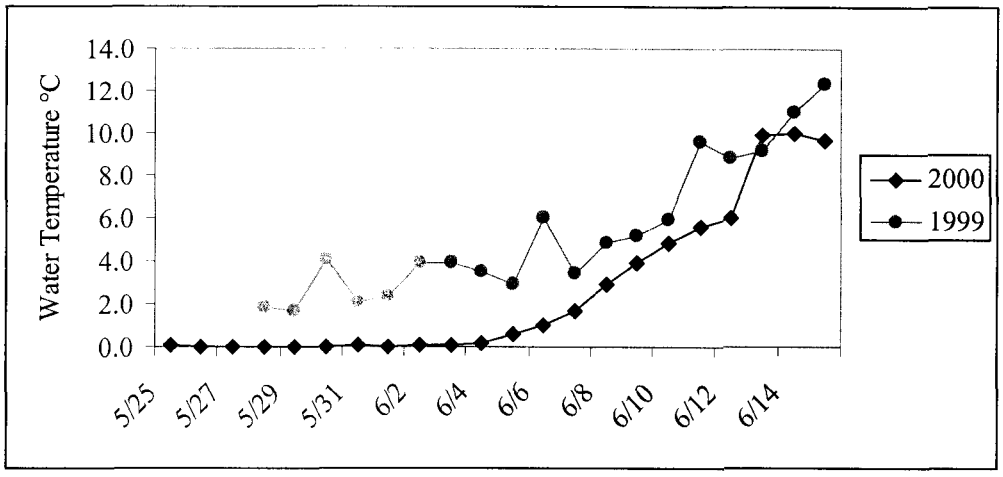


Figure 75. Water temperature (°C) in North Fork Red Dog Creek during spring breakup in 1999 and 2000.

We caught 55 Arctic grayling in the North Fork and Mainstem Red Dog Creek in early June (Appendix 9, Figure 76). Of the fish collected, the majority (49) were adult fish. In early and late July, we collected 361 fish in the North Fork fyke-net, nearly all of these fish were juveniles. The large catches of small Arctic grayling indicate that young fish hatched in 1996, 1997, and 1999 constitute a considerable proportion of the catchable population. Small Arctic grayling (75 to 120 mm) caught in late July were full-bodied and in good condition.

In 1995 and 2000, Arctic grayling remained in the North Fork Red Dog Creek for most of the summer months (Figure 77). The substantial difference in numbers of fish by size class between samples from 1995 and samples from 2000 shows three strong cohorts of small fish. The only other year in which small Arctic grayling were documented in North Fork Red Dog Creek was in 1993.

In 2000, we caught and tagged 185 Arctic grayling in North Fork Red Dog, Grayling Junior, Ikalukrok, East Fork Ikalukrok, and Mainstem Red Dog Creeks. Arctic grayling moved downstream through Mainstem Red Dog, and both upstream and downstream in Ikalukrok Creek. Recaptured fish (Appendix 10) show that numerous adult Arctic grayling remained in North Fork Red Dog Creek and concentrations of fish also were observed during in Grayling Junior Creek and in the East Fork of Ikalukrok Creek and in Ikalukrok Creek at the mouth of Dudd and Grayling Junior Creeks.

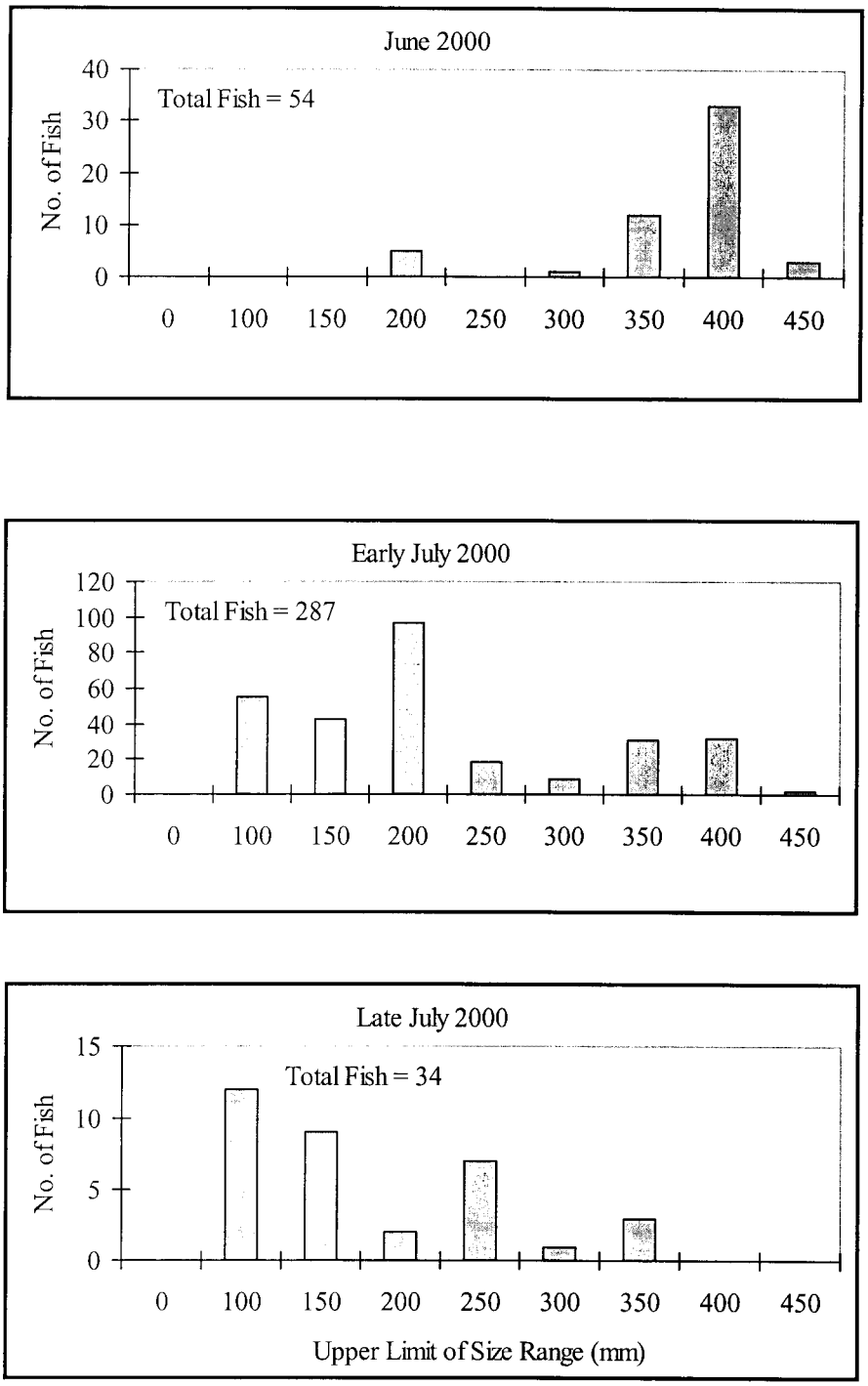


Figure 76. Length-frequency distribution of Arctic grayling caught in fyke-nets fished in Mainstem and North Fork Red Dog Creeks during summer 2000.

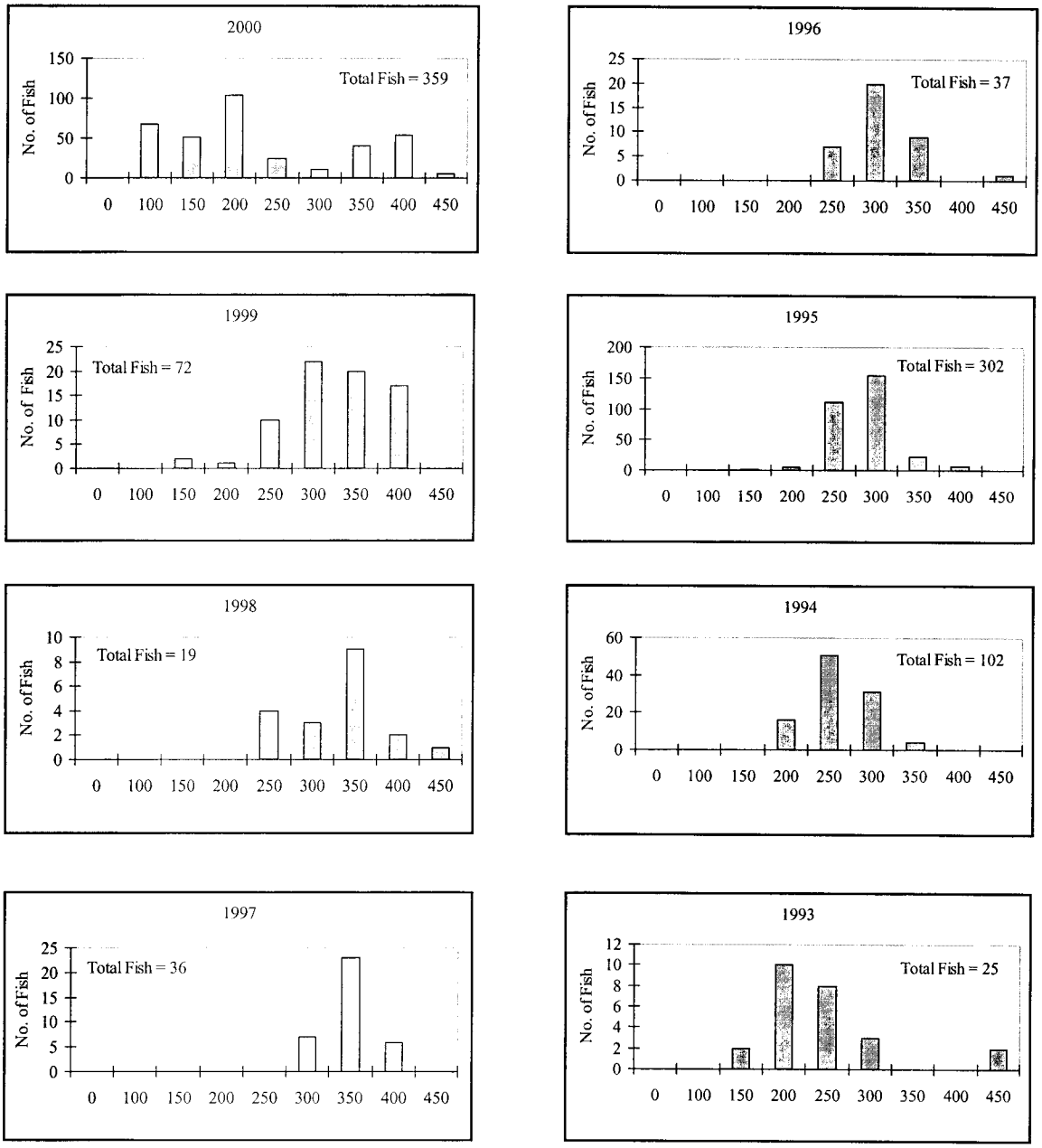


Figure 77. Length-frequency distribution of Arctic grayling caught in summer 1993 through 2000 in North Fork Red Dog Creek.

Eleven Arctic grayling marked in previous years were recaptured (Table 14). With one exception, all of the fish had been marked in North Fork Red Dog Creek and had been recaptured in the same creek. One of the North Fork Red Dog Creek fish was recaptured in Grayling Junior Creek. Five of the recaptured fish were marked in 1995. The number of fish marked each year has varied with the most marks put out in summer 1995.

Table 14. Arctic grayling recaptures during summer 2000.

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
1520	W	223	6/26/95	North Fork	6/14/00	North Fork	398
1567	W	244	6/29/95	North Fork	7/20/95	North Fork	255
1702	W	264	7/17/95	North Fork	8/14/95	North Fork	280
					6/11/00	North Fork	371
1703	W	240	7/17/95	North Fork	7/10/00	Grayling Jr.	351
1849	W	234	8/15/95	North Fork	7/1/98	North Fork	300
					7/5/00	North Fork	319
10940	OR	278	6/27/97	North Fork	7/5/00	North Fork	354
1605	W	312	7/1/98	North Fork	6/14/00	North Fork	360
1608	W	352	7/1/98	North Fork	6/14/00	North Fork	360
8077	OR	262	7/8/99	North Fork	6/14/00	North Fork	330
8035	OR	330	7/12/99	North Fork	6/13/00	North Fork	352
8046	OR	338	7/12/99	North Fork	6/14/00	North Fork	345

We again conducted visual surveys of Mainstem Red Dog Creek to document use by Arctic grayling. These surveys, which have been done annually since 1994, are summarized in Appendix 11. Arctic grayling adults were present throughout Mainstem Red Dog Creek in summer 2000 with most pools holding one to three fish. Age-0 Arctic grayling were seen, but were not abundant.

SLIMY SCULPIN

Houghton and Hilgert (1983) found slimy sculpin in all of the regularly sampled stations on Ikalukrok Creek and in Dudd Creek, but none were collected in the Red Dog Creek drainage. We started sampling with minnow traps in North Fork Red Dog Creek in 1992 and in Middle Fork and Mainstem Red Dog Creeks in 1994. Slimy sculpin were never caught in Middle Fork Red Dog Creek, but were captured in Mainstem and North Fork Red Dog Creeks in 1995 (Weber Scannell and Ott 1998). Few slimy sculpin use the Red Dog Creek drainage and the population levels are similar to Anxiety Ridge Creek (Weber Scannell and Ott 1998). The greatest number of slimy sculpin were caught in Ikalukrok Creek just above and below the mouth of Dudd Creek (Figure 78, Appendix 12). We believe slimy sculpin over winter in lower Ikalukrok Creek and the Wulik River, and probably do not migrate long distances from suitable overwintering habitats to spring spawning or summer rearing areas.

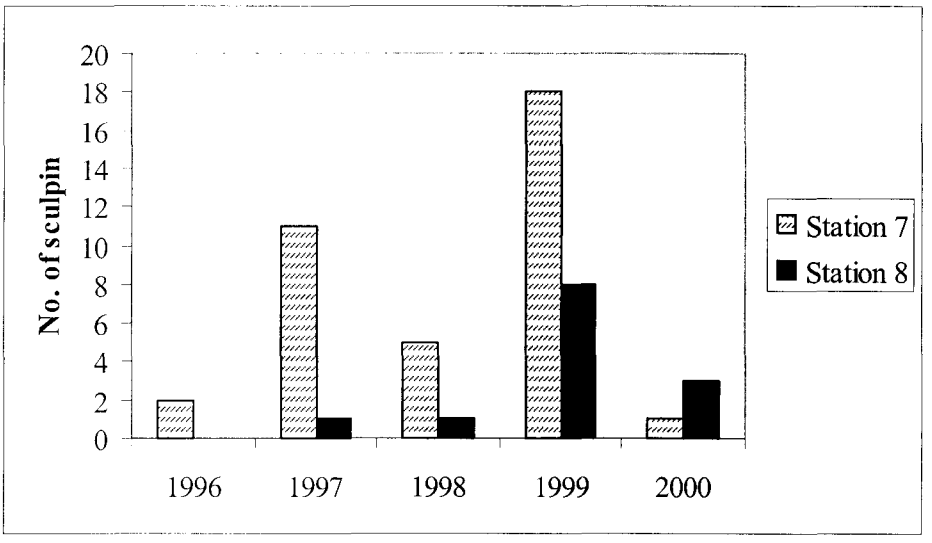


Figure 78. Numbers of slimy sculpin collected in Ikalukrok Creek near Dudd Creek (Station 7) and near Red Dog Creek (Station 8).

SUMMARY AND CONCLUSIONS

We summarized average (or median for metals) results to compare water quality conditions and community metrics among sites (Table 15), then ranked the sites from 1 through 7 for each metric. We assigned 7 to the "best" conditions, for example, the highest invertebrate abundance or the lowest concentrations of metals (Table 16). The metals were Cd, Pb, and Zn. We did not include Ni, Cu, or Se in this ranking because most of the values were at or near the method reporting limit at most sites.

Table 15. Comparisons of biomonitoring in all sites, 2000.

	Station 9	Station 8	Ikaluk. u/s Dudd Cr.	Station 7	Station 10	Station 20	Station 12
Abundance	157.4	31	503.0	589.6	44.8	94	523
Taxa Richness	7.6	6	9.2	9.4	5.6	8.8	9.6
Density	1.5	0.3	7.4	5.2	0.6	0.7	11.2
%EPT Taxa	48.5	29.0	15.1	18.2	37.9	5	21.9
% Ephemeroptera	39.1	11.9	0.1	0.8	0.4	0.0	2.3
% Plecoptera	9.0	14.3	15.0	17.6	35.9	5.8	13.7
% Chironomidae	43.8	57.4	59.3	43.3	30.8	52	39.2
% Aquatic	91.6	83.2	74.6	90.9	90.0	82.8	95.1
% Terrestrial	8.4	16.8	25.4	9.1	10.0	17.2	4.9
Mg Chlor-a/m^2	0.96	0.55	2.7	3.3	0.37	0.02	3.3
*u*g Cd/L	2.15		2	1.5	6.2	11.2	1.0
*u*g Pb/L	2		3	6.35	10	30.6	2
*u*g Zn/L	488.5		534	227.5	712	1390	100

Table 16. Ranks (1 is lowest or "worst" and 7 is highest or "best" for each community metric and selected elements, 2000 data.

	Station 9	Station 8	Ikaluk. Cr. u/s Dudd Cr.	Station 7	Station 10	Station 20	Station 12
Abundance	4	1	5	7	2	3	6
Taxa Richness	3	2	5	6	1	4	7
Density	4	1	6	5	2	3	7
%EPT Taxa	7	5	2	3	6	1	4
% Chironomidae	4	2	1	5	7	3	6
% Aquatic	6	3	1	5	4	2	7
Mg Chlor-a/m^2	4	3	5	6	2	1	7
Sum of Biotic Ranks	32	17	25	37	24	17	44
Cd	4		3	5	2	1	6
Pb	5		4	3	2	1	6
Zn	4		3	5	2	1	6
Sum of Water Quality Ranks	13	no data	10	13	6	3	18

The metrics for many of the community features are strongly linked; for example, high ranks for percent EPT correspond to high ranks for lower percentages of Chironomidae. Therefore, the ranking system should be used in the context of the results presented for this study. However, some useful patterns can be identified.

The North Fork of Red Dog Creek at Station 12 has the highest overall ranking for biotic abundance and water quality. Station 12 had the highest taxon richness, highest invertebrate density, highest proportion of aquatic taxa, and highest concentrations of chlorophyll-a. Station 12 also had the highest proportions of chlorophylls b and c, an

indicator of a diverse algal community. The results for this site confirm its usefulness as a reference site that exhibits the biotic abundance and community complexity of high latitude streams in this area.

Water quality and biotic community ranks at Station 7 were similar to Station 9. Station 9 exemplifies a site with some effects of upstream mineralization, but no effects of mining. Station 7 is the farthest downstream from mining operations and from identified zones of mineralization.

Station 8, 10, and 20 contained biotic conditions that were similar to each other and the lowest of any of the sites. The water quality (estimated by median amounts of Cd, Pb, and Zn) received the lowest ranking of all sites. There are no metals data for Station 8, but this site is sampled in water that is primarily from Red Dog Creek and can be expected to be of similar water quality to Station 10. Conductivity measurements across the stream width at Station 8 (ADNR and ADF&G, field data, 1999) show that this sample station is located in slightly mixed water that is mostly from Red Dog Creek.

Invertebrate communities in Stations 8, 7, and Ikalukrok Creek upstream of Dudd Creek were dominated by larval Chironomidae. Communities in Station 10, 20, and 12 were dominated by Plecoptera: Capniidae. Communities in Station 9 were dominated by Ephemeroptera: Heptageniidae – *Cinygmula*.

Concentrations of Se and Ni measured in 2000 cannot be directly compared with previous years data because many of the method reporting limits were higher in 2000 than in previous years. Maximum concentrations of Al, Cd, and Cu were slightly higher at Station 10 in 2000 than in previous years.

The high median and maximum concentrations in 2000 are a reflection of the higher method reporting limits for that year rather than actual increases in selenium.

Metals Concentrations in Juvenile Fish

Metals concentrations in juvenile fish were highest in fish from Station 10, a reflection of the higher metals concentrations in water at this site.

We found increased maximum (although not median) concentrations of cadmium, lead, and selenium in juvenile Dolly Varden collected from Mainstem Red Dog Creek in 2000 than in previous years.

Distribution of Fish

We found no changes in fish migration to and use of North Fork Red Dog Creek that could be related to conditions at the mine. We did not observe fish kills in Mainstem Red Dog or Ikalukrok Creeks.

Overall, we found that populations of juvenile Dolly Varden were decreased in all tributaries below the mine and in tributaries that were not affected by the mine. We believe the low population numbers resulted from early freeze-up and exceptionally thick ice on the overwintering areas. We believe the fish experienced high winter mortalities. Recruitment of young of the year Arctic grayling was the highest measured since sampling began in the early 1990s, suggesting successful spawning of this fish species during spring.

Adult Dolly Varden Tissues

We found no changes over previous years in concentrations of aluminum, cadmium, lead, or zinc in any of the tissues. Median concentrations of selenium have slowly increased in liver tissues since 1998. Selenium concentrations are higher in reproductive tissues from fall-caught fish than spring-caught fish, suggesting marine sources.

Plans for Future Sampling

The biomonitoring required under NPDES Permit No. AK-003865-2 will be continued each year. In addition, we plan to continue sampling juvenile fish for whole body concentrations of metals to document changes over time.

LITERATURE CITED

ADF&G. 1998. Methods for aquatic life monitoring to satisfy requirements under NPDES permit. NPDES AK-003865-2, Red Dog Mine Site. AK Dept. of Fish and Game. 23 pp.

American Public Health Association. 1992. Standard Methods for the Examination of Water and Wastewater. Section 10300.B.2. 18th Edition. American Public Health Association, Washington, D.C.

Azur Environmental. 1999. Microtox Test Manual, 3rd Revision. Azur Environmental Document, available in electronic format by request from the company.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1997. Revision to Rapid Bioassessment Protocols For Use in Streams and Rivers: Periphyton, Benthic, Macroinvertebrates,and Fish. EPA-841-D-97-002.

Crawford, J.K. and S.N. Luoma. 1993. Guidelines for studies of contaminants in biological tissues for the National Water-Quality Assessment Program. U.S. Geological Survey Open File Report 92-494. Lemoyne, Pa. 69 pp.

Dames and Moore. 1983. Environmental baseline studies, Red Dog Project.

DeCicco, A.L. 1989. Memorandum, Wulik River char distribution. AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 3 pp.

DeCicco, A.L. 1990a. Northwest Alaska Dolly Varden study 1989. Federal Aid in Sport Fish Restoration Act. AK. Dept. of Fish and Game. Fishery Data Series No. 90-8. Fairbanks, AK. 42 pp.

DeCicco, A.L. 1990b. Trip report, Red Dog October 3 to 6, 1990. AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 2 pp.

DeCicco, A.L. 1991. Kotzebue trip report, August 16 to 27, 1991. AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 5 pp.

DeCicco, A.L. 1992. Memorandum, Char surveys. AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 2 pp.

DeCicco, A.L. 1993. Memorandum, Wulik River survey. AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 1 p.

DeCicco, A.L. 1994. Memorandum, Wulik River survey. AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 1 p.

DeCicco, A.L. 1995. Personal communication. AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK.

DeCicco, A.L. 1996a. Memorandum, Wulik River survey. AK Dept. of Fish and Game, Sport Fish Division. 1 p.

DeCicco, A.L. 1996b. Abundance of Dolly Varden overwintering in the Wulik River, Northwestern Alaska during 1994/1995. AK Dept. of Fish and Game, Sport Fish Fishery Data Series No. 96-3. Anchorage, AK.

DeCicco, A.L. 1997. Memorandum, Wulik River survey. AK Dept. of Fish and Game, Sport Fish Division. 1 p.

DeCicco, A.L. 1998. Memorandum, Wulik River survey. AK Dept. of Fish and Game, Sport Fish Division. 1 p.

DeCicco, A.L. 1999. Memorandum, 1999 Wulik River survey. AK Dept. of Fish and Game, Sport Fish Division. 1 p.

EVS Consultants Ltd and Ott Water Engineers. 1983. Toxicological, biophysical and chemical assessment of Red Dog, Delong Mountains, Alaska, 1982. Prepared for Alaska Department of Environmental Conservation, Juneau, by G. Vigers, J. Barrett, R. Hoffman, J. Humphrey, D. Kathman, D. Konasewich, R. Olmsted, and B. Reid. 245 pp.

Houghton, J.P. and P.J. Hilgert. 1983. In Environmental baseline studies Red Dog project. Dames and Moore. 82 pp.

Ott, A.G. and P. Weber Scannell. 1993. Fish monitoring study, Red Dog Mine in the Wulik River drainage, emphasis on Dolly Varden (*Salvelinus malma*), 1992 progress report. Technical Report No. 93-10. AK Dept. of Fish and Game, Habitat and Restoration Division. Juneau, AK. 52 pp.

Ott, A.G. and P. Weber Scannell. 1994. Fish monitoring study, Red Dog Mine in the Wulik River drainage, emphasis on Dolly Varden (*Salvelinus malma*), summary report 1990-1993. Technical Report No. 94-1. AK Dept. of Fish and Game, Habitat and Restoration Division. Juneau, AK. 63 pp.

Ott, A.G. and P. Weber Scannell. 1995. Baseline fish and aquatic habitat data for Fort Knox Mine, 1992 to 1995. Technical Report No. 96-5. AK Dept. of Fish and Game, Habitat and Restoration Division. Juneau, AK. 165 pp.

Ott, A.G. and P. Weber Scannell. 1996. Fishery resources below the Red Dog Mine northwest Alaska, 1990-1995. Technical Report No. 96-2. AK Dept. of Fish and Game, Habitat and Restoration Division. 89 pp.

Ott, A.G. and S. Simpers. 1997. Red Dog Mine Field Trip Report. August 9 - August 15, 1997. AK Department of Fish and Game, Div. Habitat and Restoration, Fairbanks, AK. 9 pp.

Ott, A.G. and W.A. Morris. 1999. Red Dog Mine Field Trip Report. August 7 - August 13, 1999. AK Department of Fish and Game, Div. Habitat and Restoration, Fairbanks, AK. 5 pp.

Ott, A.G., P.K. Weber Scannell, and M.H. Robus. 1992. Fish monitoring study, Red Dog Mine in the Wulik River drainage, emphasis on Dolly Varden (*Salvelinus* malma). Technical Report No. 91-4. AK Dept. of Fish and Game, Habitat Division. Juneau, AK. 67 pp.

Townsend, A.H. and C. Hemming. 1996. Red Dog Field Trip Report. August 9 - August 15, 1996. Alaska Department of Fish and Game, Habitat and Restoration Division, Fairbanks, AK.

Townsend, A.H., and C. Lunderstadt. 1995. Trip report, August 11 to 16, 1995. AK Dept. of Fish and Game, Habitat and Restoration Division, Fairbanks, AK. 7 pp.

Ward, D.L. and T.J. Olson. 1980. Baseline aquatic investigations of fishes and heavy metal concentrations in the Kivalina and Wulik Rivers, 1978-79. LGL Ecological Research Associates, Inc. Prepared for GCO Minerals Company. 89 pp.

Weber Scannell, P, A. Ott, and W. Morris. 2000. Fish and Aquatic Taxa Report at Red dog Mine, 1998-1999. Technical Report No. 00-3. AK Dept. of Fish and Game, Habitat and Restoration Division

Weber Scannell, P. and A.G. Ott. 1995. Fishery resources below the Red Dog Mine northwestern Alaska. Technical Report No. 95-5. AK Dept. of Fish and Game, Habitat and Restoration Division. Juneau, AK. 61 pp.

Weber Scannell, P. and A.G. Ott. 1998. Fisheries resources and water quality, Red Dog Mine. Technical Report No. 98-2. AK Dept. of Fish and Game, Habitat and Restoration Division. Juneau, AK. 136 pp.

Weber Scannell, P. and S. Andersen. 1999. Aquatic taxa monitoring study at Red dog Mine, 1997-1998. Technical Report No. 00-2. AK Dept. of Fish and Game, Habitat and Restoration Division

APPENDIX 1.

A Summary of Mine Development and Operations
with Emphasis on Biological Factors

1982

- Baseline studied initiated, Cominco agreement with Nana finalized

1983

- EIS process initiated, alternatives for mine and road to port site identified

1984

- Stream surveys conducted along proposed road by private consultant

1985

- Permit applications prepared for regulatory agencies
- Implementation of wastewater treatment plant deferred to ADEC by ADF&G
- Wastewater discharge limited to summer
- Potential for acid rock drainage and metals mobilization not recognized

1986

- ADEC solid waste permit and bonding not required
- ADEC permit preceded solid waste regulations
- AIDEA bonds to build road and port site issued

1987

- Construction of road began, budget request to AIDEA prepared by ADF&G
- Reimbursement agreement for logistics with ADF&G to monitor construction made by AIDEA

1988

- Ore body developed
- Road and port site construction began
- Notice of Violation issued to AIDEA by ADF&G for failed road crossing by-passes
- Uniform Summons and Complaint issued for illegal water removal
- AIDEA provided funding to ADF&G for monitoring
- Rehabilitation plans for streams developed and implemented

1989

- Agreement to close-out old solid waste site finalized with Cominco
- Civil work on ore body and surface water drainage control begun
- Complaints about water quality in Ikalukrok Creek received
- Tailing dam becomes full, Cominco's request to siphon untreated water over the dam denied by State
- Elevated metals concentrations identified by red precipitation, were observed in Ikalukrok Creek below the mine
- Winter discharge of treated water authorized by State
- State regulatory agencies and Cominco in disagreement over whether metals exceeded background conditions

1990

- Biomonitoring of fish populations proposed and initiated by ADF&G
- Dead fish from the Wulik River were discovered by the public
- ADF&G sampling indicated very few fish remaining in Ikalukrok Creek
- Installation of sumps and pumps by Cominco prevented metals-laden water from entering Red Dog Creek
- Baseline and current water quality data reviewed by ADF&G
- Clean water bypass system requested by ADF&G
- Zinc levels in Ikalukrok Creek exceeded 40 mg/L
- State regulatory agencies and Cominco in disagreement over cause and extent of water quality problems
- Compliance Order by Consent for water quality violations affecting anadromous fish issued by ADEC
- Notice of Violation for water quality violations affecting anadromous fish issued by ADF&G
- Cominco directed to design and construct a clean water bypass system
- Perceived impairment to the subsistence fishery initiated involvement by the community of Kivalina

1991

- Clean water bypass system designed by Cominco, approved by state agencies
- ADF&G fisheries study funded by Cominco
- Clean water bypass system built
- Clean water bypass system repaired
- Improvements to water quality measured

1992

- Fish study continued
- Water quality improvements to downstream receiving water continued
- Increasing water volume in tailing impoundment continued
- Water from dirty water collection system entering tailing impoundment increased volume
- Water treatment plant modifications made

1993

- Fish study continued
- Sand filters to remove particulate zinc installed

1994

- Fish study continued
- Use attainablility studies of several streams initiated for reclassification
- Water treatment capacity increased by thickening tank conversion
- Wastewater discharge increased from 7.5 cfs to 23 cfs
- Ore processing capability expanded by Cominco

1995

- Fish study expanded to include other aquatic biota
- Work on stream reclassification and site-specific criteria continued by ADF&G
- Metals concentrations in the clean water bypass system increased; contributing sources were identified: Hilltop Creek (Zn), Shelly Creek (Cd), and Rachel Creek (Al)
- Clean water bypass system extended to collect water from Hilltop Creek
- Reserves were doubled after exploration drilling located more ore
- Possible metals contamination in Bons Creek identified by ADF&G

1996

- Public notice for stream reclassification sent out
- Bons Creek water samples from above and below the Kivalina shale dump collected
- Fish and aquatic biota study continued

1997

- Stream reclassification incorporated into regulation (18 AAC 70.50)
- Fish barrier constructed across Middle Fork Red Dog Creek
- Water bypass around the Kivalina shale dump and interceptor trench at the head of the tailing impoundment built
- Gray-white precipitate observed in Middle Fork Red Dog Creek

- Heavy red staining and precipitate seen in Ikalukrok Creek; originated from seep near headwaters of Ikalukrok Creek, located upstream of mining activity
- Laboratory experiments of TDS on egg fertilization and early egg development initiated
- Fish and aquatic biota studies continue
- US EPA brings enforcement action for water quality violations; Cominco initiates Supplemental Environmental Projects
- Two-year aquatic community study in upper Ikalukrok Creek, above and below the Red Dog Mine discharge initiated by ADF&G
- Ground water monitoring wells installed and monitored below tailing dam by Cominco

1998

- Wet fertilization studies to test effects of TDS on fish embryos continued
- Draft 401 certification for a new NPDES permit prepared by ADEC and reviewed by ADF&G
- Discussed extension of the clean water bypass system up Shelly and Connie Creeks to ensure bypass of clean water and collection of seepage water from newly disturbed areas
- Heavy red staining in headwaters of Ikalukrok Creek, originating from seep in headwaters of Ikalukrok Creek, upstream of mining activity, staning extends downstream about 30 km
- Site-specific criteria for Zn in Mainstem Red Dog and Ikalukrok Creeks approved by EPA
- Heavy rains cause an unanticipated release of water into Bons Creek from the Kivalina stockpile
- Plans to increase port site capacity for direct loading of ships released to public
- NPDES permit reissued by US EPA
- Two-year aquatic community study completed
- Biomonitoring, including studies of fish and aquatic biota, required under 1998 NPDES permit

1999

- Two-year drilling program (Shelly and Connie Creeks) proposed
- New station 7 on Ikalukrok Creek established by Cominco, USGS, and ADF&G
- Fish and aquatic biota study expanded to upper North Fork Red Dog, Ikalukrok, and Ferric Creeks
- Biomonitoring and USGS gauging work proposals submitted to Cominco
- Study of periphyton communities exposed to different concentrations of TDS in Mainstem Red Dog Creek done by ADF&G and Cominco Alaska Inc.
- Request to increase TDS for periphyton colonization experiment not approved
- Effects to Ikalukrok Creek from Alvinella Creek seepage water continued to below Dudd Creek mouth
- Arctic grayling females in ripe spawning condition collected from North Fork Red Dog Creek for selenium analysis of livers and ovaries

2000

- Effects to Ikalukrok Creek from Alvinella seepage continued; red stain and precipitate observed several km below mouth of Mainstem Red Dog Creek
- North Fork Red Dog Creek silty at breakup, previously not observed
- Minimal precipitate in Middle Fork Red Dog Creek below effluent outfall observed
- Civil work performed in Connie Creek to isolate surface from subsurface flows and bypass flow through disturbed areas
- Effectiveness of pump back system at the Kivalina rock dump verified by presence of juvenile Arctic grayling in creek immediately north of dump
- Site-specific criteria for TDS requested by Cominco
- Biomonitorig study continued
- Baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect begun

Appendix 2. Summary of invertebrate samples collected during biomonitoring studies.

Ikalukrok Creek, Station 9

Date Sampled	07/11/96	08/06/96	06/24/97	07/31/97	06/25/98	07/29/98	06/21/99	07/21/99	07/04/00
Invertebrate	**Abundance**								
No. aquatic inverts / net	56.7	434.0	262.6	618.8	582.8	2722.4	46.4	21.0	144.2
No. terresterial inverts / net	138.7	0.0	114.6	214.0	10.4	8.8	32.4	4.3	13.2
Total inverts / net	195.3	434.0	377.2	832.8	593.2	2731.2	78.8	25.3	157.4
No. of taxa / net	3.7	6.3	8.0	8.0	6.8	6.0	5.2	5.7	7.6
Community	Features								
% Ephemeroptera	15.9	75.7	43.1	2.2	23.4	92.1	14.4	10.1	39
% Plecoptera	56.1	4.4	19.9	5.8	24.0	0.9	23.2	17.9	9
% Trichoptera	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0
% Aq. Diptera	28.0	19.5	23.1	77.0	48.1	5.9	45.1	61.6	45
% other	0.0	0.3	13.8	14.8	4.5	1.0	17.3	10.4	6
% EPT	62.2	81.6	62.3	8.5	48.7	94.8	35.4	28.9	49
% Chironomidae	35.3	13.7	16.3	74.0	45.2	4.1	14.5	44.7	44
% Dominant Taxon	47.6	76.0	44.8	44.0	42.2	93.6	32.3	31.7	44
	Capniidae	Baetidae	Cinygmula	Chiron. L	Chiron. L	Baetidae	Capniidae	Chiron. L	*Cinygmula*
% sample aquatic	29.0	100.0	69.6	74.3	98.2	99.7	58.9	82.9	92
% sample terrestrial	71.0	0.0	30.4	25.7	1.8	0.3	41.1	17.1	8
Invertebrate	Density								
Invertebrates/m3 water			7.6	16.7	5.9	54.7	1.5	0.3	1.6
Aquatic invertebrates/m3 water			5.3	12.4	5.8	54.5	0.9	0.2	1.5

Chiron. L. = Chironomidae (Diptera) larvae

Ikalukrok Creek, Station 8

Date Sampled	09-Jul-96	06-Aug-96	24-Jun-97	31-Jul-97	25-Jun-98	28-Jul-98	21-Jun-99	04-Jul-00
Abundance								
aquatic inverts / net	166.7	263.3	74.25	5	414.2	433.4	37	25.8
terr. inverts / net	25.3	0.0	112	1.6	16.6	2.4	8.8	5.2
Total / net	192.0	263.3	186.25	6.6	430.8	435.8	45.8	31
Community Structure								
% aquatic	86.8	100.0	39.9	75.8	96.1	99.4	80.8	83.2
% terrestrial	13.2	0.0	60.1	24.2	3.9	0.6	19.2	16.8
# taxa / net	3	6.7	8.25	1.4	7	6.6	5.4	6
% Ephemeroptera	0.0	56.2	12.5	0.0	3.5	74.3	3.6	11.9
Plecoptera	5.0	9.9	8.3	20.0	64.0	5.1	14.9	14.3
Trichoptera	0.0	0.0	0.0	0.0	0.2	0.0	0.8	1.5
Aq. Diptera	92.4	33.2	69.5	75.0	29.7	19.1	75.6	68.1
% EPT	4.2	66.3	17.7	24.2	71.2	81.1	19.5	29.0
% Chironomidae	22.9	10.1	58.3	48.5	21.9	14.8	50.0	57.4
% other	2.6	0.8	9.7	5.0	2.6	1.5	5.1	4.2
% Dominant Taxon	68.8	54.7	35.7	52	69.5	76	55.7	34.1
Taxon	Simuliidae	Baetidae	Chiron. L	Chiron. L	Capniidae	Baetidae	Chiron. L	Chiron. L
Invertebrate Density								
Invertebrates per m3 water			3.4	0.1	4.2	8.7	0.8	0.4
Aquatic invertebrates per m3 water			1.4	0.1	4.0	8.7	0.7	0.3

Chiron. L. = Chironomidae (Diptera) larvae

Ikalukrok Creek, upstream of Dudd Creek

Date Samples Collected	27-Jun-97	30-Jul-97	25-Jun-98	24-Jul-98	21-Jun-99	5-Jul-00
Invertebrate Abundance						
Average # aquatic inverts / net	623.8	377.8	269.2	471.2	254.2	375.2
Average # terr. inverts / net	224.0	776.0	25.6	304.0	122.4	127.8
Average # inverts / net	847.8	1153.8	294.8	775.2	376.6	503.0
Average # taxa / net	9.4	9.2	6.6	4.4	7.8	9.2
Invertebrate Community						
% Ephemeroptera	10.4	4.1	12.7	0.2	2.3	0.1
% Plecoptera	7.4	3.3	35.1	5.3	18.3	15.0
% Trichoptera	0.0	0.0	0.8	0.0	0.2	0.0
% Aq. Diptera	77.9	44.0	34.7	78.3	59.8	73.2
% other	4.3	48.6	16.7	16.2	19.4	11.7
%EPT	17.7	7.4	48.6	5.5	20.8	15.1
% Chironomidae	72.2	38.0	23.1	75.1	58.0	59.3
% Dominant Taxon	58.2	34.7	38.8	42.8	48.7	47.2
	Chiron. L.	Chiron. L.	Chiron. L.	Chiron. L.	Chiron. L.	Chiron. L.
% sample aquatic	73.6	32.7	91.3	60.8	67.5	74.6
% sample terrestrial	26.4	67.3	8.7	39.2	32.5	25.4
Invertebrate Density						
Average invertebrates/m3 water	17.0	23.1	1.2	15.5	2.0	9.9
Average aq. invertebrates/m3 water	12.5	7.6	1.1	9.4	1.3	7.4

Chiron. L. = Chironomidae (Diptera) larvae

Summary of Invertebrate biomonitoring from Ikalukrok Creek, Station 7. 1996-2000.

Station 7								
Date Samples Collected	July 9 1996	August 6 1996	June 27 1997	July 30 1997	June 28 1998	July 20 1998	June 21 1999	July 5 2000
Invertebrate Abundance								
aquatic inverts / net	192	558.7	666.8	394.4	198.8	542.8	50.8	535.8
Terrestrial inverts / net	17.3	0	94.6	138.4	3.2	57.6	17.8	53.8
Total inverts / net	209.3	558.7	761.4	532.8	202	600.4	68.6	589.6
No. of Taxa/net	4.3	5.3	10.8	8	6.4	7.8	5.4	9.4
Community Features								
% Ephemeroptera	7.2	85.7	15.8	8.0	7.1	3.3	1.0	0.8
% Plecoptera	10.8	4.8	9.2	3.1	48.6	4.9	15.4	17.6
% Trichoptera	0.0	0.0	0.0	0.6	0.0	0.2	0.0	0.2
% Aq. Diptera	81.3	9.3	63.3	58.3	40.6	75.6	72.0	62.1
% other	0.8	0.2	11.7	30.0	3.6	16.0	11.6	19.3
% EPT	17.2	91.2	24.1	12.6	57.5	7.6	16.0	18.2
% Chironomidae	21.7	3.8	43.1	49.2	29.5	72.1	64.1	43.3
% Dominant Taxon	57.6	87.1	36.4	40.8	50.7	60.3	62.6	39.0
Dominant Taxon	Simuliidae	Baetidae	Chiron. L	Chiron. L	Capniidae	Chiron. L	Chiron. L	Chiron. L
% sample aquatic	91.7	100.0	87.6	74.0	98.4	90.4	74.1	90.9
% sample terrestrial	8.3	0.0	12.4	26.0	1.6	9.6	25.9	9.1
Invertebrate Density								
Volume of water (m3)	not measured	not measured	249.63	249.63	291.14	249.63	189.6	513.45
Average invertebrates/m3 water		15.3	10.7	3.5	12.0	1.8	5.7	
Average aq. invertebrates/m3 water			13.4	7.9	3.4	10.9	1.3	5.2

Chiron. L. = Chironomidae (Diptera) larvae

Mainstem Red Dog Creek, Station 10. 1996-2000

Date Sampled	July 7, 1996	August 4, 1996	June 25, 97	July 31, 97	June 25, 98	July 24, 98	June 21, 99	July 4, 00
Invertebrate Abundance								
Aquatic / net	629.3	472.0	668.4	1.0		176.4	222.0	40.4
Terrestrial / net	98.7	1.3	1122.4	4.2		49.2	27.8	4.4
Totals / net	728.0	473.3	1790.8	5.2		225.6	249.8	44.8
taxa / net	4.7	6.5	9	0.4	5	7.2	6.2	5.6
Community Features								
% Ephemeroptera	1.1	40.1	2.0	8.3	1.5	4.8	0.4	0.4
% Plecoptera	6.6	10.2	7.3	6.7	58.8	12.0	12.5	35.9
% Trichoptera	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.5
% Aq. Diptera	92.0	49.2	81.4	68.3	39.2	76.7	84.8	52.3
% other	0.4	0.6	9.3	16.7	0.5	6.6	2.3	9.9
% Chironomidae	43.2	14.9	52.8	NC	27.3	44.6	64.5	30.8
%EPT	7.7	48.7	8.6		62.4	16.2	14.8	37.9
% Dominant Taxa	39.6	38.6	13.8		60.0	34.7	54.5	35.7
	Chiron. L	Baetidae	Chiron. L.		Capniidae	Chiron. L	Chiron. L	Capniidae
% aquatic	86.4	99.7	37.3	19.2	94.5	78.2	88.9	90.2
% terrestrial	13.6	0.3	62.7	80.8	5.5	21.8	11.1	9.8
Invertebrate Density								
total/m3 water			35.9	0.1		4.5	1.4	0.63
Aquatic/m3 water			13.4	0.0		3.5	1.3	0.57

Chiron. L. = Chironomidae (Diptera) larvae
NC = not calculated, too few individuals in sample

Middlefork Red Dog Creek, Station 20

Date Sampled	11-Jul-96	6-Aug-96	24-Jun-97	31-Jul-97	25-Jun-98	25-Jul-98	21-Jun-99	4-Jul-00
Invertebrate Abundance								
No. aquatic inverts / net	81.3	733.3	10.8	167.5	559.6	56.6	125.8	77.8
No. terresterial inverts / net	298.7	53.3	39.0	181.8	104.0	4.8	95.4	16.2
Total inverts / net	380.0	786.7	49.8	349.3	663.6	61.4	221.2	94.0
No. of taxa / net	3	4.7	2.4	8	8.4	4.8	7.4	10
Community Features								
% Ephemeroptera	2.9	65.9	1.6	17.6	9.5	71.0	5.3	0.0
% Plecoptera	0.0	1.7	1.2	1.0	2.3	1.0	1.8	5.8
% Trichoptera	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.4
% Aq. Diptera	94.6	30.9	87.5	52.7	87.1	20.1	81.9	73.7
% other	2.5	1.5	9.7	28.3	1.1	7.9	11.0	20.2
% EPT	3	70	2	19	11	72	6	5
% Chironomidae	16	28	81	39	85	13	51	52
% Dominant Taxon	48	73	67	55	79	72	46	29
	Chiron. L.	Baetidae	Chiron. L	Chiron. L	Chiron. L	Chiron. L	Chiron. L	Chiron. L
% sample aquatic	21.4	93.2	21.7	48.0	84.3	92.2	56.9	82.8
% sample terrestrial	78.6	6.8	78.3	52.0	15.7	7.8	43.1	17.2
Invertebrate Density								
Invertebrates/m3 water			1.00	7.00	4.78	1.23	2.93	0.85
Aquatic invertebrates/m3 water			0.22	3.36	4.03	1.13	1.66	0.71

Chiron. L. = Chironomidae (Diptera) larvae

North Fork of Red Dog Creek, Station 12

Date Sampled	25-Jun-97	31-Jul-97	25-Jun-98	25-Jul-98	21-Jun-99	21-Jul-99	4-Jul-00
Invertebrate Abundance							
No. aquatic inverts / net	1490.4	128.6	1362.4	310.0	824.0	153.0	497.2
No. terresterial inverts / net	386	82.6	243.2	196.4	208.8	59.7	25.8
Total inverts / net	1877	211.2	1605.6	506.4	1032.8	212.7	523.0
No. of taxa / net	9.4	7.2	6.4	6.4	9.0	9.7	9.6
Community Features							
% Ephemeroptera	9.7	10.3	1.8	7.5	7.3	13.2	2.3
% Plecoptera	1.4	1.6	18.4	5.8	2.5	9.3	13.7
% Trichoptera	0.8	0.3	0.0	0.0	0.4	0.0	1.1
% Aq. Diptera	82.3	74.1	74.9	53.0	85.2	60.1	67.8
% other	5.7	13.6	4.9	33.7	4.5	17.4	15.0
% EPT	12	12	20	14	10	25	22
% Chironomidae	65	66	59	40	59	37	39
% Dominant Taxon	53	45	32	30	45	28	32
	Chiron. L	Chiron. L.	Chiron. L.	Chiron. P.	Chiron. L.	Simuliidae	Chiron. L.
% sample aquatic	79	61	85	61	80	72	95
% sample terrestrial	21	39	15	39	20	28	5
Invertebrate Density							
Invertebrates/m3 water	37.6	4.2	21.0	10.1	9.2	1.7	11.8
Aquatic invertebrates/m3 water	29.9	2.6	17.8	6.2	7.4	1.2	11.2

Chiron. L. = Chironomidae (Diptera) larvae, Chiron. P. = Chironomidae pupae

Appendix 3. Summary Water Quality, 2000

	Analyte	Median ug/L	Maximum ug/L	Minimum ug/L	Highest Median Value ug/L	Recorded at Station	Lowest Median Value ug/L	Recorded at Station
North Fork	Al	80.4	238.0	75.0	250	at MRL	75.0	at MRL
Station 7	Al	228	924	102				
Ikalukrok Cr u/s Dudd Cr.	Al	168	2950	15				
Station 9	Al	234	500	115				
Station 20	Al	75	301	50				
Station 10	Al	250	1360	75				
North Fork	Cd	1.00	1.00	0.20	11	Station 20	1.0	NF, Sta7, IK u/s
Station 7	Cd	1.5	4.2	1				
Ikalukrok Cr u/s Dudd Cr.	Cd	2	10.3	1				
Station 9	Cd	2.15	14	0.85				
Station 20	Cd	11.2	15.9	6.8				
Station 10	Cd	6.2	13	1.4				
North Fork	Cu	7.50	7.50	3.00	8	at MRL	7.5	at MRL
Station 7	Cu	8	50	7.5				
Ikalukrok Cr u/s Dudd Cr.	Cu	8	50	1.5				
Station 9	Cu	7.5	100	1				
Station 20	Cu	7.5	10	6				
Station 10	Cu	7.5	50	6				

	Analyte	Median ug/L	Maximum ug/L	Minimum ug/L	Highest Median Value ug/L	Recorded at Station	Lowest Median Value ug/L	Recorded at Station
North Fork	Fe	250.00	749.00	250.00	767	Ik, u/s Dudd	250.0	North Fork
Ikalukrok Cr u/s Dudd Cr.	Fe	767	12600	50				
Station 9	Fe	748.5	3250	13				
Station 20	Fe	403	1840	250				
North Fork	Ni	50.00	50.00	12.00	50	at MRL	50.0	at MRL
Ikalukrok Cr u/s Dudd Cr.	Ni	50	61	10				
Station 9	Ni	50	100	12				
Station 10	Ni	50	50	16				
North Fork	Pb	2.00	4.00	0.80	31	Station 20	2.0	NF, Sta 9, Ik u/s
Station 7	Pb	6.35	25.2	2				
Ikalukrok Cr u/s Dudd Cr.	Pb	3	102	0.4				
Station 9	Pb	2	20	0.05				
Station 20	Pb	30.6	165	9.5				
Station 10	Pb	10	207	2				
North Fork	Se	2.00	3.00	1.00	3	at MRL	2.0	at MRL
Station 7	Se	3	50	1				
Ikalukrok Cr u/s Dudd Cr.	Se	2	25	1				
Station 20	Se	3	5.7	2				
Station 10	Se	3	25	1				
Station 9	Se	2.5	50	1				

	Analyte	Median ug/L	Maximum ug/L	Minimum ug/L	Highest Median Value ug/L	Recorded at Station	Lowest Median Value ug/L	Recorded at Station
Station 9	Zn	488.5	1270	14	1390	Station 20	100	North Fork
North Fork	Zn	100.00	100.00	13.00				
Station 7	Zn	227.5	813	110				
Ikalukrok Cr u/s Dudd Cr.	Zn	534	1970	256				
Station 20	Zn	1390	2510	959				
Station 10	Zn	712	1280	358				

at MRL = value is reported at the Method Reporting Limit for the Analytical Laboratory

Appendix 4. Summary of metals concentrations in adult Dolly Varden tissues.

Liver Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

U = undetermined sex, F = female, M = male.

Collector	Date Collected	Sex	Weight grams	Length mm	Age fresh	Age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
D&M	6/1/81	u						0.6	33.0	<	0.02		72.3	
D&M	6/1/81	u						0.5	16.5	<	0.02		50.8	
D&M	8/1/81	u						0.8	11.0	<	0.02		91.0	
D&M	9/1/81	u						1.0	18.0		0.02		78.2	
EVS	7/3/82	u	1350	559			n.d.	0.1	1.6		n.d.		35.8	
ADF&G	10/5/90	f		538			1.50	1.1	25.6		0.10		103	26.1
ADF&G	10/5/90	f		615			0.70	0.3	19.7	<	0.10		46.6	46.6
ADF&G	10/5/90	m		608			0.70	0.2	38.4	<	0.10		58.7	50.9
ADF&G	10/5/90	f		430			0.80	0.5	22.6	<	0.10		79.3	29.0
ADF&G	10/5/90	f		452			0.70	0.4	24.2	<	0.10		74.6	34.6
ADF&G	10/5/90	f		528			0.40	0.4	29.9	<	0.10		61.8	55.9
Kivalina	10/19/90	f	1680	535			1.40	0.4	35.5	<	0.10		52.5	44.6
Cominco	3/9/91	u		387	2	2	1.50	1.8	40.3	<	0.10		164	27.1
Cominco	3/9/91	u		380	3	2	3.10	0.5	30.7	<	0.10		65.8	44.4
Cominco	3/9/91	u		560	3	4	2.00	0.7	46.6	<	0.10		84.8	38.8
Kivalina	4/6/91	m		300			4.80	1.7	51.9	<	0.10		88.8	33.8
Kivalina	4/6/91	m	197	294			1.50	0.3	47.7	<	0.10		87.2	34.9
Kivalina	4/6/91	f	201	303			1.80	0.5	41.1	<	0.10		95.8	33.1
Kivalina	4/6/91	f	237	355			2.20	0.6	72.0	<	0.10		114	25.2
Kivalina	4/6/91	f	751	434			2.90	0.4	25.9		0.10		44.6	35.0
Cominco	4/26/91	f	1279	518			1.30	0.8	25.4	<	0.10		56.1	38.2
Cominco	6/16/91	m	962	489			1.30	1.3	32.4	<	0.10		74.0	31.9
Cominco	6/16/91	f	1426	538			1.80	0.7	18.7	<	0.10		75.2	30.8
Cominco	6/16/91	m	1361	541			3.60	0.9	37.5	<	0.10		83.2	33.7
Cominco	6/16/91	f	762	461			2.00	1.2	34.1	<	0.10		96.6	27.4
Cominco	6/16/91	f	672	417			1.80	1.5	38.3		0.80		124	24.0

Liver Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	Age fresh	Age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
Cominco	6/16/91	f	745	430			1.2	0.7	54.2		0.10		85.4	28.9
Cominco	6/16/91	f	680	443			1.20	1.0	26.0	<	0.10		84.3	33.3
Cominco	6/16/91	f	654	430			0.90	0.8	31.0	<	0.10		88.0	30.1
Kivalina	7/10/91	F	2778	627			6.50	0.5	22.3		0.20		57.7	40.2
Kivalina	7/10/91	F	1738	550			3.40	0.8	72.2		1.00		78.6	35.1
Kivalina	7/10/91	F	280	280			7.80	1.2	27.3		0.30		141	22.8
Kivalina	8/6/91	F	1434	480			2.03	0.2	20.3		0.07		78.2	37.6
Kivalina	8/6/91	M	962	417			0.82	0.3	24.7		0.06		78.2	43.7
Kivalina	8/6/91	F	863	405			0.44	0.3	11.1		0.03		66.6	40.7
Kivalina	8/6/91	F	1780	512			0.56	0.3	15.8		0.03		76.2	45.1
Cominco	10/5/91	F	1162	480			0.94	0.3	33.6		0.04		70.8	45.6
Cominco	10/5/91	M	1262	480			0.34	0.2	27.4		0.02		50.2	43.1
Cominco	10/5/91	M	2551	614			0.44	0.7	39.0		0.10		61.7	37.7
Cominco	10/5/91	F	2188	589			0.87	0.3	59.0		0.05		65.6	45.7
Cominco	10/5/91	F	1616	525			0.40	0.5	25.4		0.04		55.1	41.5
Cominco	10/5/91	M	2233	563			0.70	0.2	30.6		0.04		34	47.6
ADF&G	4/29/92	F	180	291			3.20	0.4	40.3	<	0.02		152	27.0
ADF&G	4/29/92	F	670	424	2	2	7.20	0.3	23.8	<	0.02		63	46.7
ADF&G	4/29/92	F	1420	530	2	3	4.70	0.3	47.8		0.02		66	39.6
ADF&G	4/29/92	undet	180	294	2	1	7.60	0.4	32.4		0.03		142	27.7
ADF&G	4/29/92	F	140	275	3	1	7.80	0.2	71.8		0.07		222	26.4
ADF&G	4/29/92	M	160	276			2.30	0.7	39.9	<	0.02		162	26.5
ADF&G	4/29/92	M	140	264	4	1	5.50	0.5	84.1		0.04		176	27.0
ADF&G	4/29/92	F	150	259	3	1	4.50	0.4	36.2		0.02		160	25.3
ADF&G	9/30/92	F	4120	706	9	9	1.64	0.3	21.5		0.02		60	45.0
ADF&G	9/30/92	M	2820	620	3	4	3.07	0.4	19.5		0.03		67	41.8

Liver Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	Age fresh	Age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	9/30/92	F	3410	674	3	5	0.92	0.2	19.7		0.02		56	50.1
ADF&G	9/30/92	M	2630	600	4	4	0.51	0.2	40.2	<	0.02		60	48.1
ADF&G	9/30/92	F	2110	564	3	4	0.61	0.3	45.6		0.02		74	41.4
ADF&G	9/30/92	M	2920	595	2	4	0.55	0.2	20.0	<	0.02		59	41.4
ADF&G	4/21/93	u	673	407			1.200	0.2	29.8	<	0.01		75	39.5
ADF&G	4/21/93	u	1032	480	2	3	1.400	0.2	37.3		0.02		73	37.4
ADF&G	4/21/93	u	717	414	4	2	1.400	0.2	42.3	<	0.01		63	46.0
ADF&G	4/21/93	u	701	421	3	2	1.400	0.1	23.0		0.02		58	42.2
ADF&G	4/21/93	u	685	398	6	6	1.400	0.2	21.0		0.01		66	38.7
ADF&G	4/21/93	u	611	407	2	3	1.100	0.2	18.1		0.02		67	36.8
ADF&G	10/20/93	u	2168	575	3	3	2.800	0.2	23.6	<	0.02		47	48.4
ADF&G	10/20/93	u	1352	491	4	3	2.800	0.2	22.1		0.03		68	41.4
ADF&G	10/20/93	u	1551	498	3	3	2.000	0.1	13.2	<	0.02		51	46.3
ADF&G	10/20/93	u	1188	456	3	3	2.300	0.2	42.9	<	0.02		86	37.4
ADF&G	10/20/93	u	1324	473	3	3	2.600	0.1	28.9	<	0.02		60.9	44.4
ADF&G	10/20/93	u	2204	556	3	4	2.400	0.3	35.2	<	0.02		62.4	35.6
ADF&G	4/7/94	m	245	297			24.40	0.3	34.5		0.21		88.5	35.0
ADF&G	4/7/94	f	572	380			10.10	0.6	42.8	<	0.02		118	32.4
ADF&G	4/7/94	m	526	390			4.70	0.6	47.8	<	0.02		93.3	32.9
ADF&G	4/7/94	m	499	385			7.80	0.5	35.0	<	0.02		110	30.1
ADF&G	4/7/94	m	590	386			2.20	0.4	35.2	<	0.02		86	35.4
ADF&G	4/7/94	f	1651	521			10.20	0.3	30.0		0.02		56.5	37.6
ADF&G	9/23/94	F	844	420			0.70	0.2	20.3	<	0.02		85.3	44.7
ADF&G	9/23/94	M	690	420			0.80	0.2	41.1	<	0.02		87	42.1
ADF&G	9/23/94	M	826	425			1.10	0.2	51.7	<	0.02		87.2	45.8
ADF&G	9/23/94	M	890	435			0.9	0.2	39.6	<	0.02		81.4	46.4

Liver Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	Age fresh	Age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	9/23/94	F	681	405			0.9	0.2	48.0	<	0.02		82	50.5
ADF&G	9/23/94	F	726	420			0.9	0.3	28.9	<	0.02		89.9	43.1
ADF&G	6/14/95	M	916.3	443	3	3	7.4	4.6	61.7	<	0.02		125	25.5
ADF&G	6/14/95	F	1007	454	3	3	3.2	0.3	53.0	<	0.02		93.6	33.6
ADF&G	6/14/95	M	762	419	3	2	0.8	0.5	57.6	<	0.02		124	25.6
ADF&G	6/14/95	F	907.2	455	3	3	1.4	0.5	65.7	<	0.02		121	24.4
ADF&G	6/14/95	F	925.3	462	3	3	2.8	0.4	73.9		0.04		126	25.3
ADF&G	6/14/95	F	916.3	448	3	3	18.2	0.2	29.0		0.06		98.9	29.9
ADF&G	9/9/95	F	816.5	434	3	3	2.1	0.6	34.5		0.02		103	14.5
ADF&G	9/9/95	M	1170	482	3	3	4.5	0.7	134.0		0.44		366	13.1
ADF&G	9/9/95	F	1451	475	4	3	0.6	0.4	16.6	<	0.02		61	13.8
ADF&G	9/9/95	M	1098	457	2	3	1	0.4	27.3		0.03		65.8	13.6
ADF&G	9/9/95	F	1978	530	2	3	0.6	0.2	31.0		0.08		54.6	15.2
ADF&G	9/9/95	U	1778	555	7	7	0.9	0.2	39.4	<	0.02		55.4	15.0
ADF&G	6/16/96	F	699.2	424	4	3	3	0.6	50.1		0.04		97.1	27.7
ADF&G	6/16/96	F	808.1	450	2	3	1.9	0.6	37.7		0.02		85.7	30.0
ADF&G	6/16/96	M	799	432	2	4	2.1	1.1	46.3		0.04		82.3	31.7
ADF&G	6/16/96	M	962.5	468	2	4	1.9	0.7	80.9		0.07		87.2	30.3
ADF&G	6/16/96	F	1416	505	3	5	4.1	0.5	47.6		0.03		65.6	41.4
ADF&G	9/19/96	F	826.3	430	4	3	2.4	1.0	38.3		0.03		90.2	32.5
ADF&G	9/19/96	F	1044	455	5	5	2.5	0.4	68.1	<	0.02		63.3	46.0
ADF&G	9/19/96	F	1471	475	2	5	3.2	0.4	34.9	<	0.02		62.4	39.8
ADF&G	9/19/96	F	1416	485	2	4	2.3	0.6	43.6		0.06		60.8	51.4
ADF&G	9/19/96	F	1734	520	2	4	1.9	0.4	37.2	<	0.02		60	44.0
ADF&G	9/19/96	F	1571	525	2	5	2.3	0.4	37.9	<	0.02		59.2	45.0
ADF&G	9/19/96	D#5					2.8	0.5	41.7	<	0.02		65.3	42.0

Liver Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	Age fresh	Age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	5/22/97	F	1207	499			5.5	0.9	44.9		0.1	4	72.5	33.1
ADF&G	5/22/97	F	1061	478			2.6	0.4	19.9		0.02	2	48.8	37.7
ADF&G	5/22/97	F	1279	488			1.9	0.9	48.0		0.05	3	87.7	29.7
ADF&G	5/22/97	M	1325	485			2.1	0.6	41.3	<	0.02	2	56.4	39.1
ADF&G	5/22/97	M	1488	531			1.3	0.3	67.0		0.02	2	63.9	43.2
ADF&G	5/22/97	F	771.1	450			2	0.8	57.8	<	0.02	3	93.9	31.7
ADF&G	9/27/97	F	572	383	4	4	6.3	0.2	21.3		0.07	2.7	54.5	42.6
ADF&G	9/27/97	M	535.7	392	3	3	4.2	2.2	4.6	<	0.02	6.6	86.9	22.9
ADF&G	9/27/97	M	572	397	2	2	3.1	0.7	3.2		0.03	7.1	71.9	25.2
ADF&G	9/27/97	F	263.3	299	2	1	4.6	0.5	4.4		0.02	5.9	73.2	23.7
ADF&G	9/27/97	F	1653	555	3	6	3.5	3.1	4.5		0.02	7.6	76.5	23.5
ADF&G	9/27/97	M	1507	520	3	5	4.5	1.6	4.0		0.03	6.6	74.7	25.0
ADF&G	9/27/97	D#6					2.7	1.9	4.4	<	0.02	6.4	75.0	23.1
ADF&G	6/1/98	F	1889	530	3	4	2.3	0.3	44.6	<	0.02	1.67	65.9	39.3
ADF&G	6/1/98	M	2334	575	4	5	2.2	0.5	73.0	<	0.02	2.25	59.5	41.1
ADF&G	6/1/98	M	1880	553	2	5	4.1	0.3	72.4	<	0.02	1.48	60.2	45.0
ADF&G	6/1/98	F	1961	550	3	5	3.2	0.4	67.5	<	0.02	1.88	73.9	36.9
ADF&G	6/1/98	F	1471	514	3	4	2.4	0.4	53.1	<	0.02	2.03	88.4	35.6
ADF&G	6/1/98	M	1244	500	5	5	8.6	0.4	54.9		0.02	1.81	69.6	40.9
ADF&G	6/1/98	D#2					3.2	0.5	49.9	<	0.02	2.01	56.1	43.7
ADF&G	10/6/98	F	2830	626	2	8	2.6	0.3	25.9	<	0.02	3.17	63.5	46.7
ADF&G	10/6/98	M	2304	560	2	4	1.3	0.2	22.0	<	0.02	2.39	60.7	42.1
ADF&G	10/6/98	F	2713	578	3	6	2.8	0.2	41.2	<	0.02	2.14	65.9	42.0
ADF&G	10/6/98	F	1914	528	3	5	2.2	0.1	39.7	<	0.02	2.84	70.1	43.2

Liver Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	Age fresh	Age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	10/6/98	M	1343	475	3	3	1.3	0.1	24.2	<	0.02	1.89	54.3	46.3
ADF&G	10/6/98	F	1161	467	3	3	1.5	0.3	40.4	<	0.02	2.26	74.7	43.2
ADF&G	10/6/98	D#3					2	0.2	31.8	<	0.02		57.1	41.5
ADF&G	5/15/99	M	1235	491	3	3	1.3	0.1	30.5		0.15	2.42	60.6	46.0
ADF&G	5/15/99	F	1943	625	3	6	1.4	1.0	148.0		0.24	2.14	168	21.6
ADF&G	5/15/99	M	1898	605	3	7	2.1	0.9	104.0		0.26	2.26	141	21.9
ADF&G	5/15/99	M	2225	595	4	4	1.4	0.2	45.4		0.08	3.79	97.6	36.1
ADF&G	5/15/99	F	2760	620	3	7	1.3	0.2	31.3		0.13	3.24	76	37.0
ADF&G	5/15/99	M	4831	720	3	6	1.2	0.3	34.5		0.36	2.83	56.7	36.8
ADF&G	5/15/99	D#6					1.1	0.3	37.5		0.05		54.9	41.8
ADF&G	9/8/99	M	681	392	2	3	0.8	0.3	28.8	<	0.02	4.61	64.2	78.0
ADF&G	9/8/99	F	1344	490	3	4	0.9	0.3	30.3	<	0.02	4.05	84.2	35.2
ADF&G	9/8/99	F	1616	510	2	4	0.7	0.2	29.3		0.05	2.4	68	40.9
ADF&G	9/8/99	F	1144	455	3	3	0.8	0.2	34.9		0.03	2.41	62.5	52.4
ADF&G	9/8/99	M	1734	540	3	1	0.6	0.2	46.5		0.03	2.96	77.9	43.0
ADF&G	9/8/99	M	1752	520	3	4	1.4	0.1	30.5	<	0.02	3.47	74.6	41.2
ADF&G	6/8/00	M	2447	603			1.4	0.2	57.6		0.1	3.1	75.1	36.1
ADF&G	6/8/00	M	5539	769			1.5	0.2	37.5	<	0.02	2.3	53.9	47.4
ADF&G	6/8/00	M	2561	621			2.1	0.5	87.4		0.1	3.7	113	31.7
ADF&G	6/8/00	M	2461	613			1	0.4	54.8		0.05	3.4	85.4	31.0
ADF&G	6/8/00	M	5230	832			2.8	0.8	98.3		0.06	4.8	123	20.3
ADF&G	6/8/00	M	5198	635			1	0.3	45.1	<	0.02	3.3	81	31.0
ADF&G	6/8/00	D#5					1	0.8	83.5	<	0.02	4.8	122	19.9
ADF&G	10/20/00	M	929.4	455			1.4	0.4	27.1	<	0.03	4.8	92.4	
ADF&G	10/20/00	F	1336	482			1	0.2	23.5	<	0.03	3	65.8	
ADF&G	10/20/00	F	921.5	438			1.2	0.3	25.7	<	0.03	3.9	77.9	
ADF&G	10/20/00	F	2502	616			1.2	0.4	10.7	<	0.03	4	66.5	
ADF&G	10/20/00	F	1321	496			1.1	0.2	40.0	<	0.02	3.2	65.7	
ADF&G	10/20/00	M	1188	465			1.1	0.3	19.8	<	0.02	3.7	78.7	
ADF&G	10/20/00	D#4					1.1	0.4	13.7	<	0.02	4.9	68.7	

MuscleTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg		Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
D&M	6/1/81	u							0.16	1.3	<	0.0		9.89	
D&M	6/1/81	u							0.20	2.0	<	0.0		9.16	
D&M	7/1/81	u							0.21	2.5	<	0.0		13.9	
D&M	8/1/81	u							0.19	2.0		0.0		13.6	
D&M	9/1/81	u							0.12	2.1	<	0.0		16.8	
EVS	7/3/82	u	1350	559			n.d.		n.d.	2.3		n.d.		16.2	25.4
ADFG	10/5/90	f		538			1.6	<	0.01	2.5	<	0.1		18.1	24.9
ADFG	10/5/90	f		615			0.4	<	0.01	1.0	<	0.1		7.6	42.4
ADFG	10/5/90	m		608			0.8	<	0.01	1.8	<	0.1		11.5	38.1
ADFG	10/5/90	f		430			0.5	<	0.01	1.9	<	0.1		12.9	32.5
ADFG	10/5/90	f		452			0.5	<	0.01	1.7	<	0.1		15.3	30.1
ADFG	10/5/90	f		528			0.9	<	0.01	1.7	<	0.1		12.1	39.5
Cominco	3/9/91	f		560	3	4	2.2	<	0.01	3.5	<	0.1		18.6	24.7
Cominco	3/9/91	f		380	3	2	2.8	<	0.01	2.4	<	0.1		14.5	27.0
Cominco	3/9/91	f		387	2	2	1.6	<	0.01	2.5	<	0.1		15.5	26.8
KIVALINA	4/6/91	m		300			1.6		0.01	2.0		0.1		17.4	24.9
KIVALINA	4/6/91	m	197	294			6.1	<	0.01	2.2	<	0.1		15.0	23.6
KIVALINA	4/6/91	f	201	303			11.6	<	0.01	3.1		0.6		15.5	24.7
KIVALINA	4/6/91	f	237	355			3.2	<	0.01	1.9	<	0.1		18.8	19.3
KIVALINA	4/6/91	f	751	434			1.9	<	0.01	2.2	<	0.1		14.2	28.4
Cominco	4/26/91	f	1279	518			1.2	<	0.01	1.7	<	0.1		14.1	29.1
Cominco	6/16/91	m	962	489			1.4		0.01	3.3	<	0.1		16.0	29.7
Cominco	6/16/91	f	1426	538			1.8	<	0.01	2.2		0.1		15.3	26.4
Cominco	6/16/91	m	1361	541			3.0	<	0.01	2.6	<	0.1		15.6	25.4
Cominco	6/16/91	f	762	461			0.8	<	0.01	2.4	<	0.1		16.0	23.7
Cominco	6/16/91	f	672	417			0.9	<	0.01	1.2	<	0.1		16.4	22.4
Cominco	6/16/91	f	745	430			1.1	<	0.01	1.5	<	0.1		15.1	23.6
Cominco	6/16/91	f	680	443			1.2		0.03	1.5	<	0.1		18.9	23.0
Cominco	6/16/91	f	654	430			1.2	<	0.01	2.0	<	0.1		16.6	24.0

MuscleTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg		Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
Kivalina	7/10/91	F	2778	627			11.2	<	0.01	3.7		0.1		13.8	29.6
Kivalina	7/10/91	F	1738	550			2.5	<	0.01	5.0	<	0.1		13.4	31.9
Kivalina	7/10/91	F	280	280			8.7		0.03	5.4		0.4		29.3	20.9
Kivalina	8/6/91	F	1434	480			0.2	<	0.02	2.4		0.0		14.7	28.2
Kivalina	8/6/91	M	962	417			1.1		0.02	4.7		1.4		17.6	27.6
Kivalina	8/6/91	F	863	405			0.4	<	0.02	2.0	<	0.0		17.6	27.3
Kivalina	8/6/91	F	1780	512			2.1	<	0.02	2.0		0.1		14.0	29.1
Cominco	10/5/91	F	1162	480			0.6	<	0.02	2.6		0.0		14.9	27.7
Cominco	10/5/91	M	1262	480			0.7	<	0.02	2.9		0.0		13.9	26.9
Cominco	10/5/91	M	2551	614			0.4	<	0.02	2.0		0.0		14.5	27.4
Cominco	10/5/91	F	2188	589			0.1		0.03	2.7		0.0		13.1	30.4
Cominco	10/5/91	F	1616	525			0.2	<	0.02	2.0		0.0		12.8	27.5
Cominco	10/5/91	M	2233	563			0.3	<	0.02	2.4		0.1		12.2	29.1
ADFG	4/29/92	F	180	291			2.5	<	0.02	2.3	<	0.1		16.5	24.7
ADFG	4/29/92	F	670	424	2	2	2.2	<	0.02	1.5		0.0		14.6	24.4
ADFG	4/29/92	F	1420	530	2	3	1.8	<	0.02	1.4	<	0.0		14.1	25.9
ADFG	4/29/92	U	180	294	2	1	2.6	<	0.02	2.1		0.0		25.9	23.6
ADFG	4/29/92	F	140	275	3	1	1.5	<	0.02	2.1	<	0.0		28.7	20.5
ADFG	4/29/92	M	160	276			2.6	<	0.02	2.4		0.0		22.9	22.6
ADFG	4/29/92	M	140	264	4	1	3.0	<	0.02	2.6	<	0.0		24.3	21.8
ADFG	4/29/92	F	150	259	3	1	3.9	<	0.02	2.0		0.0		26.1	22.8
ADFG	9/30/92	F	2820	620			1.4	<	0.02	1.7	<	0.0		14.0	23.5
ADFG	9/30/92	M	3410	674	3	4	0.5	<	0.02	1.3	<	0.0		11.0	31.7
ADFG	9/30/92	F	2630	600	3	5	0.7	<	0.02	1.3	<	0.0		13.0	34.4
ADFG	9/30/92	M	2110	564	4	4	0.7	<	0.02	1.3		0.0		13.0	26.2
ADFG	9/30/92	F	2920	595	3	4	0.4	<	0.02	1.6	<	0.0		14.0	30.7
ADFG	9/30/92	M	673	407	2	4	1.3	<	0.02	2.1		0.2		14.0	35.5

MuscleTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg		Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADFG	4/21/93	u	1032	480			1.0	<	0.01	1.4		0.0		16.0	25.4
ADFG	4/21/93	u	717	414	2	3	1.4	<	0.01	1.5		0.0		18.0	27.4
ADFG	4/21/93	u	701	421	4	2	1.3	<	0.01	1.5		0.0		20.0	27.4
ADFG	4/21/93	u	685	398	3	2	1.3	<	0.01	1.4		0.0		16.0	26.5
ADFG	4/21/93	u	611	407			1.2	<	0.01	1.2		0.0		18.0	24.8
ADFG	4/21/93	u	2168	575	2	3	1.3	<	0.01	1.3		0.1		15.0	25.8
ADFG	10/20/93	u	2168	575	3	3	2.7	<	0.02	16.7		0.2		14.6	36.7
ADFG	10/20/93	u	1352	491	4	3	2.6	<	0.02	1.6	<	0.0		14.5	29.6
ADFG	10/20/93	u	1551	498	3	3	2.1	<	0.02	1.5	<	0.0		14.0	31.1
ADFG	10/20/93	u	1188	456	3	3	1.9	<	0.02	1.9	<	0.0		16.1	31.3
ADFG	10/20/93	u	1324	473	3	3	2.1	<	0.02	1.4	<	0.0		14.7	31.4
ADFG	10/20/93	u	2204	556	3	4	1.8	<	0.02	1.0	<	0.0		11.7	33.1
ADFG	4/7/94	m	245	297			7.8	<	0.02	1.4	<	0.0		16.7	23.0
ADFG	4/7/94	f	572	380			8.8	<	0.02	1.4		0.0		15.8	25.8
ADFG	4/7/94	m	526	390			6.6	<	0.02	1.5		0.0		16.5	24.3
ADFG	4/7/94	m	499	385			5.7	<	0.02	1.1	<	0.0		17.0	22.8
ADFG	4/7/94	m	590	386			8.2	<	0.02	1.4		0.0		16.4	24.3
ADFG	4/7/94	f	1651	521			15.0	<	0.02	1.3		0.0		12.9	28.0
ADFG	9/23/94	F	844	420			3.1	<	0.02	1.7		0.0		16.9	29.1
ADFG	9/23/94	M	690	420			0.9	<	0.02	1.5	<	0.0		23.7	31.3
ADFG	9/23/94	M	826	425			1.0	<	0.02	1.6	<	0.0		19.6	30.5
ADFG	9/23/94	M	890	435			1.2	<	0.02	1.7	<	0.0		21.4	31.0
ADFG	9/23/94	F	681	405			1.4	<	0.02	1.5	<	0.0		20.3	30.0
ADFG	9/23/94	F	726	420			2.1	<	0.02	1.7	<	0.0		20.8	27.6
ADFG	6/14/95	M	916.3	443	3	3	31.8	<	0.02	1.8		0.0		21.3	25.2
ADFG	6/14/95	F	1007	454	3	3	12.8	<	0.02	1.5	<	0.0		16.4	25.2
ADFG	6/14/95	M	762	419	3	2	2.2	<	0.02	1.9	<	0.0		20.5	25.2
ADFG	6/14/95	F	907.2	455	3	3	2.2	<	0.02	1.2	<	0.0		14.6	24.5
ADFG	6/14/95	F	925.3	462	3	3	2.4	<	0.02	1.8	<	0.0		19.5	25.2

MuscleTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg		Cd mg/kg	Cu mg/kg		Pb mg/kg		Se mg/kg		Zn mg/kg	% Solids
ADFG	6/14/95	F	916.3	448	3	3	3.3	<	0.02	1.4	<	0.0				17.4	27.7
ADFG	9/9/95	F	816.5	434	3	3	5.9	<	0.04	2.4		0.6				264.0	8.6
ADFG	9/9/95	M	1170	482	3	3	4.2	<	0.02	1.7		0.4				160.0	10.8
ADFG	9/9/95	F	1451	475	4	3	1.8	<	0.02	1.2		0.2				88.5	12.3
ADFG	9/9/95	M	1098	457	2	3	2.2	<	0.02	1.5		0.2				67.1	11.4
ADFG	9/9/95	F	1978	530	2	3	2.3	<	0.02	1.3		0.2				64.7	12.5
ADFG	9/9/95	U	1778	555			1.3	<	0.02	1.0		0.1				28.5	15.8
ADFG	6/16/96	F	699.2	424	4	3	3.9		0.02	3.1		0.1				14.8	24
ADFG	6/16/96	F	808.1	450	2	3	2.4		0.04	2.0		0.0				21.3	25.2
ADFG	6/16/96	M	799	432	2	4	2.0	<	0.02	1.3		0.0				22.8	27.6
ADFG	6/16/96	M	962.5	468	2	4	3.4	<	0.02	1.4	<	0.0				19.7	26.2
ADFG	6/16/96	F	1416	505	3	5	2.1	<	0.02	1.0		0.0				12.5	27.4
ADFG	9/19/96	F	826.3	430	4	3	4.1	<	0.02	1.5		0.1				13.9	26.0
ADFG	9/19/96	F	1044	455			2.2	<	0.02	1.1	<	0.0				12.1	30.0
ADFG	9/19/96	F	1471	475	2	5	2.4		0.02	1.3	<	0.0				17.9	31.7
ADFG	9/19/96	F	1416	485	2	4	2.4	<	0.02	1.7	<	0.0				15.4	32.1
ADFG	9/19/96	F	1734	520	2	4	2.9	<	0.02	0.9	<	0.0				12.2	41.6
ADFG	9/19/96	F	1571	525	2	5	2.8	<	0.02	1.6		0.0				13.6	21.3
ADFG	9/19/96	F#5					1.8	<	0.02	1.5	<	0.0				14.3	32.6
ADFG	5/22/97	F	1207	499			2.7	<	0.02	1.4		0.1	<	1		14.3	27.5
ADFG	5/22/97	F	1061	478			5.1	<	0.02	1.4		0.0	<	1		14.2	28.6
ADFG	5/22/97	F	1279	488			7.7	<	0.02	1.4		0.0	<	1		12.6	25.1
ADFG	5/22/97	M	1325	485			3.7	<	0.02	1.2		0.0	<	1		11.5	27.4
ADFG	5/22/97	M	1488	531			1.4	<	0.02	1.4	<	0.0	<	1		10.7	28.1
ADFG	5/22/97	F	772	450			1.2	<	0.02	1.9	<	0.0	<	1		15.8	24.8
ADFG	9/27/97	F	572	383			3.6	<	0.02	1.2		0.0		0.9		12	34.2
ADFG	9/27/97	M	535.7	392	3	3	3.3	<	0.02	1.4		0.2		1.6		12.9	25.4
ADFG	9/27/97	M	572	397	2	2	4.5	<	0.02	2.4		0.0		0.9		16.5	26.8

MuscleTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg		Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADFG	9/27/97	F	263.3	299	2	1	2.7	<	0.02	2.3	<	0.0	1.1	18.9	26.2
ADFG	9/27/97	F	1653	555	3	6	3.2	<	0.02	1.3		0.0	1.2	9.7	30.6
ADFG	9/27/97	M	1507	520	3	5	3.8	<	0.02	1.0	<	0.0	0.9	12.1	36
ADFG	9/27/97	D#6					3.0	<	0.02	1.7	<	0.0	0.9	12.1	28.7
ADF&G	6/1/98	F	1889	530	3	4	2.4	<	0.02	2.3	<	0.0	0.738	15.1	27.4
ADF&G	6/1/98	M	2334	575	4	5	2.4	<	0.02	2.1	<	0.0	0.596	13.2	29.3
ADF&G	6/1/98	M	1880	553	2	5	2.7	<	0.02	2.7	<	0.0	0.742	13.7	30.8
ADF&G	6/1/98	F	1961	550	3	5	2.9	<	0.02	2.6	<	0.0	0.46	14	27.5
ADF&G	6/1/98	F	1471	514	3	4	2.5	<	0.02	1.9	<	0.0	0.518	14.2	28.1
ADF&G	6/1/98	M	1244	500	5	5	2.3	<	0.02	2.2	<	0.0	0.546	13.8	29.1
ADF&G	6/1/98						1.6	<	0.02	1.3	<	0.0	0.382	11.6	24.5
ADF&G	10/6/98	F	2830	626	2	8	5.2	<	0.02	2.0	<	0.0	0.7	12.4	33.0
ADF&G	10/6/98	M	2304	560	2	4	1.1	<	0.02	1.5	<	0.0	0.7	10.9	41.2
ADF&G	10/6/98	F	2713	578	3	6	2.5	<	0.02	2.3	<	0.0	0.5	12.3	41.9
ADF&G	10/6/98	F	1914	528	3	5	2.8	<	0.02	1.8	<	0.0	0.4	12.4	39.0
ADF&G	10/6/98	M	1343	475	3	3	1.7	<	0.02	1.7	<	0.0	0.8	11.9	34.8
ADF&G	10/6/98	F	1161	467	3	3	1.2	<	0.02	1.8	<	0.0	0.8	13.6	30.9
ADF&G	10/6/98	D#3					1.2	<	0.02	1.3	<	0.0		12.2	42.8
ADF&G	5/15/99	M	1235	491	3	3	1.2	<	0.02	1.6		0.2	0.4	12.5	34
ADF&G	5/15/99	F	1943	625	3	6	2.2	<	0.02	2.3		0.2	0.5	20.8	22.8
ADF&G	5/15/99	M	1898	605	3	7	1.1	<	0.02	2.9		0.0	0.7	21.2	24.4
ADF&G	5/15/99	M	2225	595	4	4	1.0	<	0.02	2.3		0.3	0.6	15.5	29.8
ADF&G	5/15/99	F	2760	620	3	7	0.9	<	0.02	1.6		0.0	0.5	12.3	31.8
ADF&G	5/15/99	M	4831	720	3	6	2.4	<	0.02	1.5		0.1	0.6	15.5	28
ADF&G	5/15/99	D#6					1.2	<	0.02	1.2		0.1		12.4	30
ADF&G	9/8/99	M	681	392	2	3	0.8	<	0.02	1.2	<	0.0	0.7	13.1	26.8
ADF&G	9/8/99	F	1344	490	3	4	0.6	<	0.02	1.2	<	0.0	1.0	13.1	15.6
ADF&G	9/8/99	F	1616	510	2	4	0.7	<	0.02	1.0		0.0	0.5	12.2	33.1
ADF&G	9/8/99	F	1144	455	3	3	0.7	<	0.02	1.4	<	0.0	0.5	14.0	33.1

MuscleTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg		Cd mg/kg	Cu mg/kg		Pb mg/kg		Se mg/kg	Zn mg/kg	% Solids
ADF&G	9/8/99	M	1734	540	3	1	0.7	<	0.02	1.5	<	0.0		0.8	16.1	32.7
ADF&G	9/8/99	M	1752	520	3	4	0.5	<	0.02	1.4	<	0.0		0.6	14.0	31.2
ADF&G	6/8/00	M	2447	603			1.8	<	0.05	5.2		0.1		1.0	14.1	31.1
ADF&G	6/8/00	M	5539	769			1.1	<	0.05	4.5		0.1		1.0	13.4	34.5
ADF&G	6/8/00	M	2561	621			1.8	<	0.05	3.0		0.1		1.0	15.2	28.7
ADF&G	6/8/00	M	2461	613			1.3	<	0.05	4.3		0.1		1.0	16.0	28.5
ADF&G	6/8/00	M	5230	832			1.1	<	0.05	3.6		0.0		1.3	21.8	25.0
ADF&G	6/8/00	M	5198	635			1.0	<	0.05	3.1		0.0		1.3	14.2	29.8
ADF&G	6/8/00	D#5					1.0	<	0.05	3.2	<	0.0		1.5	20.5	25.0
ADF&G	10/20/00	M	929.4	455			1.0	<	0.05	2.1	<	0.0	<	1.0	17.0	
ADF&G	10/20/00	F	1336	482			1.0	<	0.05	1.7	<	0.0	<	1.0	16.9	
ADF&G	10/20/00	F	921.5	438			1.4	<	0.05	1.7	<	0.0	<	1.0	16.5	
ADF&G	10/20/00	F	2502	616			1.5	<	0.05	2.0	<	0.0		1.1	14.8	
ADF&G	10/20/00	F	1321	496			1.1	<	0.05	2.9	<	0.0	<	1.0	18.1	
ADF&G	10/20/00	M	1188	465			1.0	<	0.05	2.4	<	0.0	<	1.0	18.6	
ADF&G	10/20/00	D#4					1.1	<	0.05	1.7	<	0.0	<	1.0	14.0	

F = female, M = male

D# = Fish is a duplicate of specified sample number

U = sex was not reported

KidneyTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Zn mg/kg	% Solids
D&M	6/1/81	a						0.3	4.9		0.02	80.1	
D&M	6/1/81	a						5.3	4.0	<	0.02	75.9	
D&M	8/1/81	a						2.9	5.2	<	0.05	74.6	
D&M	9/1/81	a						3.0	5.8	<	0.03	109	
ADF&G	10/5/90	f		538			1.50	5.3	3.3		0.20	117	21.4
ADF&G	10/5/90	f		615			1.10	2.2	4.8	<	0.10	96.4	21.9
ADF&G	10/5/90	m		608			0.70	1.5	4.8	<	0.10	79.3	24.0
ADF&G	10/5/90	f		430			3.00	2.9	5.2	<	0.10	100	23.7
ADF&G	10/5/90	f		452			0.90	3.3	5.0	<	0.10	106	21.9
ADF&G	10/5/90	f		528			1.10	2.6	5.3	<	0.10	103	18.5
KIVALINA	10/19/90	f	1680	535			3.90	3.1	8.4	<	0.10	105	20.3
Cominco	3/9/91	F		387	2	2	2.3	3.6	4.8	<	0.10	143	23.1
Cominco	3/9/91	F		380	2	3	4.7	3.5	5.2	<	0.10	103	22.9
Cominco	3/9/91	F		560	4	3	2.1	3.2	4.9	<	0.10	118	23.6
KIVALINA	4/6/91	m		300			2.4	4.3	3.7	<	0.20	127	20.3
KIVALINA	4/6/91	f	197	294			8.8	0.9	2.7	<	0.40	85.6	23.4
KIVALINA	4/6/91	f	201	303			22.0	2.0	4.1		1.50	173	23.7
KIVALINA	4/6/91	f	237	355			7.4	0.2	9.0		0.40	139	21.8
KIVALINA	4/6/91	f	751	434			2.1	2.8	3.5	<	0.10	102	22.4
Cominco	4/26/91	f	1279	518			1.0	5.4	6.2		0.20	112	21.0
Cominco	6/16/91	m	962	489			6.0	6.6	6.0		0.10	83.3	18.3
Cominco	6/16/91	f	1426	538			2.4	4.9	4.1	<	0.10	89.2	23.0
Cominco	6/16/91	m	1361	541			1.7	4.1	4.0		0.20	76.6	22.3
Cominco	6/16/91	f	762	461			2.1	3.1	4.5	<	0.10	94.5	22.4
Cominco	6/16/91	f	672	417			1.5	2.5	3.5	<	0.10	208	15.2
Cominco	6/16/91	f	745	430			1.6	2.2	4.2	<	0.10	71.1	21.9
Cominco	6/16/91	f	680	443			1.9	4.0	4.9	<	0.10	108.0	22.5
Cominco	6/16/91	f	654	430			1.3	3.2	4.1	<	0.10	95.9	21.2

KidneyTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Zn mg/kg	% Solids
Kivalina	7/10/91	F	280	280			28.5	1.5	2.6		0.40	90.2	19.5
Kivalina	8/6/91	F	1434	480			1.3	0.5	5.5		0.03	77.2	23.1
Kivalina	8/6/91	M	962	417			0.6	1.0	5.6		0.02	82.8	26.3
Kivalina	8/6/91	F	863	405			3.0	1.9	5.7		0.08	86.6	24.6
Kivalina	8/6/91	F	1780	512			0.8	1.7	4.7	<	0.02	82.4	26.1
Cominco	10/5/91	F	1162	480			1.0	1.3	4.5		0.06	87.1	22.7
Cominco	10/5/91	M	1262	480			1.9	1.7	4.9		0.62	92.4	22.8
Cominco	10/5/91	M	2551	614			3.9	0.9	17.7		1.75	51.2	23.0
Cominco	10/5/91	F	2188	589			1.3	2.5	6.2		0.03	104	22.3
Cominco	10/5/91	F	1616	525			1.9	4.7	5.9		0.04	107	21.5
Cominco	10/5/91	M	2233	563			0.8	2.8	4.4		0.06	86.4	22.9
ADF&G	4/29/92	F	180	291			6.6	0.6	5.0		0.04	114	36.4
ADF&G	4/29/92	F	670	424	2	2	5.0	1.5	3.6		0.04	78.1	24.2
ADF&G	4/29/92	F	1420	530	3?	2	5.7	1.3	3.4		0.02	86.6	24.5
ADF&G	4/29/92	U	180	294	1?	2	4.7	0.5	3.8		0.04	91.7	20.8
ADF&G	4/29/92	F	140	275	1	3	4.3	0.4	6.4		0.06	99.7	21.4
ADF&G	4/29/92	M	160	276			8.1	1.7	3.9		0.05	95.5	19.8
ADF&G	4/29/92	M	140	264	1	4	2.6	0.4	3.5		0.04	82.2	17.4
ADF&G	4/29/92	F	150	259	1	3	5.9	0.8	4.2		0.03	114	21.3
ADF&G	9/30/92	F	4120	706	9	9	3.1	2.7	4.5	<	0.02	85	22.5
ADF&G	9/30/92	M	2820	620	4	3	2.3	3.0	5.0	<	0.02	110	22.6
ADF&G	9/30/92	F	3410	674	5	3	1.1	2.4	4.1	<	0.02	74	28.0
ADF&G	9/30/92	M	2630	600	4	4	1.0	1.3	5.6	<	0.02	93	24.2
ADF&G	9/30/92	F	2110	564	4	3	1.0	2.1	5.2		0.06	105	24.3
ADF&G	9/30/92	M	2920	595	4	2	1.7	1.6	3.7		0.24	81	24.1
ADF&G	4/21/93	F	673	407			1.4	0.8	3.9		0.02	88	23.8
ADF&G	4/21/93	u	1032	480	3	2	1.7	1.3	4.5		0.02	106	23.5
ADF&G	4/21/93	u	717	414	2	4	1.5	1.8	4.4		0.01	112	24.8

KidneyTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Zn mg/kg	% Solids
ADF&G	4/21/93	u	701	421	2	3	1.2	0.8	3.7		0.01	84	26.9
ADF&G	4/21/93	u	685	398	6	6	2.1	0.5	4.1	<	0.01	100	22.9
ADF&G	4/21/93	u	611	407	3	2	4.1	0.5	3.6	<	0.01	99	22.3
ADF&G	10/20/93	u	2168	575	3	3	2.3	1.4	4.7	<	0.02	103	25.6
ADF&G	10/20/93	u	1352	491	3	4	1.1	0.1	0.5	<	0.02	13.8	24.6
ADF&G	10/20/93	u	1551	498	3	3	2.3	0.8	4.5	<	0.02	110	23.0
ADF&G	10/20/93	u	1188	456	3	3	2.6	0.7	4.0	<	0.02	95.5	24.0
ADF&G	10/20/93	u	1324	473	3	3	2.6	0.7	3.9	<	0.02	116	23.5
ADF&G	10/20/93	u	2204	556	4	3	2.5	1.8	5.5	<	0.02	98.9	22.7
ADF&G	4/7/94	m	245	297			16.0	0.8	4.7		0.03	97.6	25.7
ADF&G	4/7/94	f	572	380			10.2	0.9	3.3	<	0.02	88.5	23.1
ADF&G	4/7/94	m	526	390			6.9	1.2	3.3	<	0.02	87.4	21.2
ADF&G	4/7/94	m	499	385			9.6	1.9	4.2		0.05	102	20.7
ADF&G	4/7/94	m	590	386			8.9	1.5	4.2		0.02	98.2	20.6
ADF&G	4/7/94	f	1651	521			10.4	1.4	4.4	<	0.02	92.4	21.3
ADF&G	9/23/94	F	844	420			5.7	0.9	4.3		0.04	106	23.0
ADF&G	9/23/94	M	690	420			3.1	1.2	6.9		0.03	117	22.9
ADF&G	9/23/94	M	826	425			2.9	0.6	3.7	<	0.02	101	23.6
ADF&G	9/23/94	M	890	435			7.2	0.6	3.7		0.03	86.6	25.9
ADF&G	9/23/94	F	681	405			2.6	0.7	4.4	<	0.02	114	24.7
ADF&G	9/23/94	F	726	420			2.0	1.2	3.8		0.02	91.3	25.7
ADF&G	6/14/95	M	916.3	443	3	3	3.5	1.2	4.6	<	0.02	88	22.1
ADF&G	6/14/95	F	1007	454	3	3	5.4	1.6	4.3	<	0.02	71.8	24.4
ADF&G	6/14/95	M	762	419	3	2	2.5	1.2	4.6	<	0.02	83.5	22.6
ADF&G	6/14/95	F	907.2	455	3	3	1.2	1.0	4.3	<	0.02	74.3	23.5
ADF&G	6/14/95	F	925.3	462	3	3	1.9	0.8	3.6	<	0.02	61.2	22.9
ADF&G	6/14/95	F	916.3	448	3	3	1.3	0.8	3.6	<	0.02	65.9	22.1

KidneyTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Zn mg/kg	% Solids
ADF&G	9/9/95	F	816.5	434	3	3	1.3	2.4	4.9	<	0.02	89.4	5.4
ADF&G	9/9/95	M	1170	482	3	3	1	2.5	13.4	<	0.02	89.6	6.4
ADF&G	9/9/95	F	1451	475	4	3	1.6	1.9	4.5	<	0.02	75.1	6.9
ADF&G	9/9/95	M	1098	457	2	3	11.8	0.3	2.3		0.86	444	5.8
ADF&G	9/9/95	F	1978	530	2	3	3.4	1.1	3.9	<	0.02	80.5	8.9
ADF&G	9/9/95	U	1778	555	7	7	0.9	0.9	4.0		0.06	61.4	9.6
ADF&G	6/16/96	F	699.2	424	4	3	4.7	1.8	4.6		0.09	64.6	17.1
ADF&G	6/16/96	F	808.1	450	2	3	3.4	1.4	3.6		0.04	74.5	22.0
ADF&G	6/16/96	M	799	432	2	4	8.8	3.3	3.6		0.18	85.3	23.7
ADF&G	6/16/96	M	962.5	468	2	4	2.2	1.9	4.0		0.05	71.1	21.7
ADF&G	6/16/96	F	1416	505	3	5	3.1	2.1	4.7		0.05	83.7	23.5
ADF&G	9/19/96	F	826.3	430	3	4	3.3	3.4	7.8		0.02	88.1	21.0
ADF&G	9/19/96	F	1044	455	5	5	5.6	2.4	5.6		0.02	81	23.2
ADF&G	9/19/96	F	1471	475	5	2	3.1	2.3	6.6		0.04	88.8	23.4
ADF&G	9/19/96	F	1416	485	4	2	3.4	3.2	6.0		0.04	84.5	23.9
ADF&G	9/19/96	F	1734	520	4	2	2.3	1.3	3.9	<	0.02	84.1	23.6
ADF&G	9/19/96	F	1571	525	5	2	2.4	2.6	6.8		0.14	81.2	23.2
ADF&G	9/19/96	D#5					2.7	1.9	4.8	<	0.02	94.4	55.8
ADF&G	5/22/97	F	1207	499			4.1	3.3	5.2		0.17	89.9	22.8
ADF&G	5/22/97	F	1061	478			4.4	2.1	3.7		0.04	76.2	21.9
ADF&G	5/22/97	F	1279	488			2.2	2.5	4.2		0.08	74.4	22.1
ADF&G	5/22/97	M	1325	485			3.3	2.0	6.5		0.04	66.7	23.1
ADF&G	5/22/97	M	1488	531			7	1.8	7.9		0.06	73.5	24.4
ADF&G	5/22/97	F	771.1	450			4.6	3.0	6.3		0.04	87.1	22.6
ADF&G	9/27/97	F	572	383	4	4	5	0.6	3.8		0.05	87.4	23.0
ADF&G	9/27/97	M	535.7	392	3	3	3.1	0.2	36.8		0.02	69.1	42.6
ADF&G	9/27/97	M	572	397	2	2	2.7	0.4	60.8		0.03	122	40.2

KidneyTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Zn mg/kg	% Solids
ADF&G	9/27/97	F	263.3	299	2	1	2.7	0.2	54.4	<	0.02	70.2	37.0
ADF&G	9/27/97	F	1653	555	3	6	2.5	0.5	43.4		0.02	58.2	42.9
ADF&G	9/27/97	M	1507	520	3	5	3.1	0.4	63.2	<	0.02	56.8	44.8
ADF&G	9/27/97	D#6					2.9	0.4	68.9	<	0.02	58.5	49.1
ADF&G	6/1/98	F	1889	530	4	3	4.7	1.2	4.8	<	0.02	75.5	24.1
ADF&G	6/1/98	M	2334	575	5	4	16.5	1.2	4.6		0.05	87.5	24.5
ADF&G	6/1/98	M	1880	553	5	2	26.2	1.7	6.6		0.06	68.5	23.3
ADF&G	6/1/98	F	1961	550	5	3	17.8	1.6	5.6		0.04	78.5	25.9
ADF&G	6/1/98	F	1471	514	4	3	5.6	0.7	3.4	<	0.02	65.2	24.0
ADF&G	6/1/98	M	1244	500	5	5	16.3	1.2	21.2	<	0.03	77	25.0
ADF&G	6/1/98	D#2					7.7	1.0	3.6	<	0.02	71.5	24.6
ADF&G	10/6/98	F	2830	626	8	2	5.2	2.1	4.2	<	0.02	94.7	23.6
ADF&G	10/6/98	M	2304	560	4	2	2.3	2.1	5.9	<	0.02	121	21.7
ADF&G	10/6/98	F	2713	578	6	3	2.2	1.6	5.1	<	0.02	118	22.7
ADF&G	10/6/98	F	1914	528	5	3	1.8	1.3	6.1	<	0.02	119	20.6
ADF&G	10/6/98	M	1343	475	3	3	3.6	0.9	4.5	<	0.02	111	25.0
ADF&G	10/6/98	F	1161	467	3	3	1.7	2.4	6.4	<	0.02	123	25.6
ADF&G	10/6/98	D#3					1.9	1.6	4.9	<	0.02	109	23.9
ADF&G	5/15/99	M	1235	491	3	3	2.4	1.0	4.6		0.22	98.1	27.4
ADF&G	5/15/99	F	1943	625	3	6	4.7	1.6	4.3		0.23	109	20.7
ADF&G	5/15/99	M	1898	605	3	7	2.7	2.6	4.4		0.25	113	24.1
ADF&G	5/15/99	M	2225	595	4	4	1.7	0.6	3.0		0.13	70.2	24.5
ADF&G	5/15/99	F	2760	620	3	7	3.1	1.8	3.8		0.13	79.2	25.7
ADF&G	5/15/99	M	4831	720	3	6	2.8	2.8	4.5		0.05	106	19.8
ADF&G	5/15/99	D#6					2.4	3.6	5.2		0.08	98.6	22.9
ADF&G	9/8/99	M	681	392	2	3	1.3	1.1	4.6		0.02	91.4	15.4
ADF&G	9/8/99	F	1344	490	3	4	1.2	0.6	3.0		0.03	88.3	21.8
ADF&G	9/8/99	F	1616	510	2	4	1.3	0.8	4.1		0.02	88.2	23.4

KidneyTissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Zn mg/kg	% Solids
ADF&G	9/8/99	F	1144	455	3	3	1.6	0.5	3.7		0.04	95.5	19.7
ADF&G	9/8/99	M	1734	540	3	1	1.2	1.1	4.6		0.08	96.9	22.9
ADF&G	9/8/99	M	1752	520	3	4	0.7	0.6	4.7		0.02	92	21.1
ADF&G	6/8/00	M	2447	603			3	0.9	38.5		0.34	78	25.3
ADF&G	6/8/00	M	5539	769			1.9	1.3	16.5		0.09	116	20.3
ADF&G	6/8/00	M	2561	621			6	1.7	20.9		0.41	111	19.2
ADF&G	6/8/00	M	2461	613			3.2	1.5	8.1		0.12	76.3	21.9
ADF&G	6/8/00	M	5230	832			5.7	1.0	9.7		0.09	75.8	17.1
ADF&G	6/8/00	M	5198	635			6.2	2.3	12.1		0.15	91.2	20.4
ADF&G	6/8/00	D#5					1.4	2.3	8.5		0.04	80.5	16.6
ADF&G	10/20/00	M	929.4	455			1.5	1.3	4.9	<	0.03	110	
ADF&G	10/20/00	F	1336	482			6.7	1.1	4.4	<	0.03	95	
ADF&G	10/20/00	F	921.5	438			2.2	1.4	4.0	<	0.03	85.3	
ADF&G	10/20/00	F	2502	616			1.7	0.6	3.2	<	0.03	82.1	
ADF&G	10/20/00	F	1321	496			1.8	1.1	7.5	<	0.03	91.7	
ADF&G	10/20/00	M	1188	465			2.5	1.0	5.1	<	0.03	89.6	
ADF&G	10/20/00	D#4					2.2	2.1	4.0	<	0.02	89.1	

F = female, M = male
D# = Fish is a duplicate of specified sample number
U = sex was not reported

Gill Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
D&M	6/1/81	u						0.770	3.00	<	0.03		67.2	
D&M	6/1/81	u						1.200	3.20	<	0.02		68.6	
D&M	8/1/81	u						0.360	3.20	<	0.04		34.1	
D&M	9/1/81	u						0.790	3.10	<	0.04		67.4	
EVS	7/3/82	u	1350	559			35.30	0.050	0.68		n.d.		23.3	25.4
ADF&G	10/1/89	u					7.60	0.500	1.90		0.20		71.0	17.7
ADF&G	5/1/90	u					147.00	0.320	6.90		0.70		85.4	19.8
ADF&G	8/30/90	f		500			13.70	0.160	3.10		0.30		94.1	23.7
ADF&G	10/5/90	f		538			1.80	1.630	2.20		0.20		90.4	22.3
ADF&G	10/5/90	f		615			1.30	0.680	3.10	<	0.10		70.9	25.8
ADF&G	10/5/90	m		608			1.40	1.440	2.60	<	0.10		68.7	24.0
ADF&G	10/5/90	f		430			2.00	1.200	3.30		0.10		70.5	26.2
ADF&G	10/5/90	f		452			0.60	1.220	2.10	<	0.10		70.2	21.6
ADF&G	10/5/90	f		528			2.20	2.440	2.60		0.20		96.6	24.1
Cominco	3/9/91	u		387	2	2	6.10	0.390	2.30	<	0.10		87.4	19.2
Cominco	3/9/91	u		380	3	2	7.80	0.660	2.30	<	0.10		87.6	22.0
Cominco	3/9/91	u		560	3	4	10.80	1.020	2.30	<	0.10		77.8	22.1
KIVALINA	4/6/91	m		300			5.00	0.450	2.60	<	0.10		94.8	19.5
KIVALINA	4/6/91	m	197	294			13.90	0.360	1.90	<	0.10		74.4	18.6
KIVALINA	4/6/91	f	201	303			3.40	0.820	2.20	<	0.10		88.4	19.3
KIVALINA	4/6/91	f	237	355			4.20	0.330	2.50		0.20		70.3	19.0
KIVALINA	4/6/91	f	751	434			16.10	0.850	1.90	<	0.10		83.0	19.8
Cominco	4/26/91	f	1279	518			3.20	0.790	1.70		1.10		79.8	20.4
Cominco	6/16/91	m	962	489			36.60	1.510	3.10		1.00		75.6	18.2
Cominco	6/16/91	f	1426	538			56.30	0.780	3.00		3.00		79.3	21.1
Cominco	6/16/91	m	1361	541			21.20	1.150	2.70		0.60		75.5	18.8
Cominco	6/16/91	f	762	461			18.40	2.000	3.10		1.50		89.6	22.2
Cominco	6/16/91	f	672	417			20.50	0.640	2.10		0.80		64.7	21.4
Cominco	6/16/91	f	745	430			33.30	0.830	2.80		1.50		75.3	20.8

Gill Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
Cominco	6/16/91	f	680	443			60.20	0.850	2.90	2.40		67.7	21.5
Cominco	6/16/91	f	654	430			1.20	1.820	3.10	1.20		78.5	20.2
Kivalina	7/10/91	F	2778	627			16.10	0.480	3.00	0.50		91.3	19.6
Kivalina	7/10/91	F	1738	550			194.00	0.630	7.30	0.70		59.0	24.6
Kivalina	7/10/91	F	280	280			28.50	1.480	2.60	0.40		90.2	19.5
Kivalina	8/6/91	F	1434	480			46.00	0.130	2.93	0.23		5.5	20.9
Kivalina	8/6/91	M	962	417			12.40	0.220	3.21	0.12		64.3	23.6
Kivalina	8/6/91	F	863	405			37.80	0.480	3.57	0.16		70.0	22.4
Kivalina	8/6/91	F	1780	512			222.00	0.340	3.93	0.62		62.2	23.0
Cominco	10/5/91	F	1162	480			1.61	0.550	3.39	0.10		70.8	21.0
Cominco	10/5/91	M	1262	480			23.40	0.300	2.92	0.16		75.2	19.3
Cominco	10/5/91	M	2551	614			10.60	0.630	2.82	0.29		71.4	20.3
Cominco	10/5/91	F	2188	589			2.08	0.540	3.64	0.23		72.3	23.0
Cominco	10/5/91	F	1616	525			22.10	0.500	4.23	1.26		73.6	19.8
Cominco	10/5/91	M	2233	563			31.70	0.710	5.10	0.33		84.1	21.7
ADF&G	4/29/92	F	180	291			3.10	0.130	3.34	0.18		93.3	20.8
ADF&G	4/29/92	F	670	424	2	2	2.10	0.160	1.78	0.07		65.5	25.9
ADF&G	4/29/92	F	1420	530	2	3	9.00	0.070	1.79	0.11		65.7	27.8
ADF&G	4/29/92	U	180	294	2	1	2.30	0.130	1.92	0.07		84.2	21.0
ADF&G	4/29/92	F	140	275	3	1	2.70	0.120	3.73	0.04		93.7	19.9
ADF&G	4/29/92	M	160	276			4.40	0.140	2.21	0.02		81.3	19.2
ADF&G	4/29/92	M	140	264	4	1	5.90	0.080	2.24	0.06		80.2	20.3
ADF&G	4/29/92	F	150	259	3	1	1.70	0.090	2.13	0.03		77.7	19.9
ADF&G	9/30/92	F	4120	706	9	9	2.79	0.240	3.22	0.04		76.0	21.2
ADF&G	9/30/92	M	2820	620	3	4	2.29	0.420	8.50	0.16		90.0	18.8
ADF&G	9/30/92	F	3410	674	3	5	1.25	0.410	2.92	< 0.02		86.0	19.8
ADF&G	9/30/92	M	2630	600	4	4	1.28	0.330	2.90	0.04		91.0	20.3

Gill Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	9/30/92	F	2110	564	3	4	1.39	0.330	2.92	<	0.02		94.0	19.8
ADF&G	9/30/92	M	2920	595	2	4	1.02	0.360	2.34		0.04		73.0	21.6
ADF&G	4/21/93	U	673	407			1.80	0.240	2.42		0.36		87.0	20.2
ADF&G	4/21/93	U	1032	480	2	3	1.60	0.150	2.50		0.03		97.0	20.7
ADF&G	4/21/93	U	717	414	4	2	2.50	0.180	2.35		0.43		84.0	20.8
ADF&G	4/21/93	U	701	421	3	2	3.70	0.140	2.33		0.04		74.0	21.7
ADF&G	4/21/93	U	685	398	6	6	3.10	0.160	2.19		0.04		75.0	22.4
ADF&G	4/21/93	U	611	407	2	3	1.40	0.170	2.31		0.03		77.0	22.8
ADF&G	10/20/93	F	2168	575	3	3	42.40	0.180	2.68		0.06		101.0	25.5
ADF&G	10/20/93	M	1352	491	4	3	3.90	0.260	12.80		0.20		88.5	24.8
ADF&G	10/20/93	M	1551	498	3	3	3.70	0.310	3.93	<	0.02		80.1	22.2
ADF&G	10/20/93	F	1188	456	3	3	66.70	0.280	2.90		0.08		88.5	25.8
ADF&G	10/20/93	M	1324	473	3	3	2.90	0.160	2.64		0.03		81.2	21.7
ADF&G	10/20/93	M	2204	556	3	4	4.30	0.230	2.02		0.02		64.7	24.8
ADF&G	4/7/94	m	245	297			15.90	0.110	2.15		0.04		83.1	20.8
ADF&G	4/7/94	f	572	380			14.50	0.160	16.30		0.81		78.3	25.1
ADF&G	4/7/94	m	526	390			5.20	0.170	23.10		0.43		66.0	21.2
ADF&G	4/7/94	m	499	385			3.50	0.120	2.91		0.04		111.0	15.2
ADF&G	4/7/94	m	590	386			3.90	0.160	3.64	<	0.02		103.0	19.1
ADF&G	4/7/94	f	1651	521			5.50	0.150	27.40		0.38		88.5	19.0
ADF&G	9/23/94	F	844	420			487.0	0.25	3.41		0.65		99.1	27.3
ADF&G	9/23/94	M	690	420			379.0	0.21	2.95		0.55		99.4	25.8
ADF&G	9/23/94	M	826	425			452.0	0.25	2.52		0.70		94.6	26.3
ADF&G	9/23/94	M	890	435			184.0	0.25	2.09		0.32		83.5	27.5
ADF&G	9/23/94	F	681	405			308.0	0.26	25.00		0.46		87.2	25.9
ADF&G	9/23/94	F	726	420			212.0	0.32	2.35		0.31		91.4	24.6

Gill Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg		Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	6/14/95	M	916.3	443	3	3	4.4	0.26	2.37		0.04		68.8	21.6
ADF&G	6/14/95	F	1007	454	3	3	2.3	0.1	2.30	<	0.02		53.0	23.8
ADF&G	6/14/95	M	762	419	3	2	441	0.23	3.26		0.67		70.3	19.6
ADF&G	6/14/95	F	907.2	455	3	3	5.4	0.24	3.05	<	0.02		83.5	19.5
ADF&G	6/14/95	F	925.3	462	3	3	294	0.29	7.51		0.5		74.7	20.0
ADF&G	6/14/95	F	916.3	448	3	3	388	0.38	2.95		0.56		78.9	18.9
ADF&G	9/9/95	F	816.5	434	3	3	11.8	0.43	3.71		1.5		362.0	7.9
ADF&G	9/9/95	M	1170	482	3	3	7.1	0.3	2.47		1.08		527.0	8.5
ADF&G	9/9/95	F	1451	475	4	3	11.1	0.23	2.43		0.63		351.0	8.0
ADF&G	9/9/95	M	1098	457	2	3	0.9	1.2	3.29		0.02		70.3	7.8
ADF&G	9/9/95	F	1978	530	2	3	24.6	0.25	2.34		0.73		375.0	8.0
ADF&G	9/9/95	U	1778	555	7	7	12.1	0.3	2.25		0.58		315.0	8.2
ADF&G	6/16/96	F	699.2	424	4	3	25.5	0.17	3.23		0.15		56.4	21.7
ADF&G	6/16/96	F	808.1	450	2	3	18.8	0.43	2.10		0.37		52.7	24.0
ADF&G	6/16/96	M	799	432	2	4	14.8	0.24	2.32		0.08		61.2	22.9
ADF&G	6/16/96	M	962.5	468	2	4	26.2	0.29	1.78		0.1		61.1	20.7
ADF&G	6/16/96	F	1416	505	3	5	38.9	0.41	2.52		0.5		62.0	21.2
ADF&G	9/19/96	F	826.3	430	4	3	21	0.17	1.99		0.05		54.2	23.2
ADF&G	9/19/96	F	1044	455	5	5	22.9	0.15	2.55		0.03		49.9	26.6
ADF&G	9/19/96	F	1471	475	2	5	14.9	0.18	4.07		0.06		58.4	23.1
ADF&G	9/19/96	F	1416	485	2	4	31.8	0.25	2.43		0.08		64.8	23.2
ADF&G	9/19/96	F	1734	520	2	4	9.4	0.13	2.06		0.03		59.2	25.0
ADF&G	9/19/96	F	1571	525	2	5	64	0.18	2.02		0.08		55.1	31.2
ADF&G	9/19/96	D#5					11.3	0.17	1.81		0.02		61.6	24.9
ADF&G	5/22/97	F	1207	499			104	0.2	2.91		0.25	2	58.6	22.9
ADF&G	5/22/97	F	1061	478			45.7	0.14	2.58		0.17	3	55.5	23.2
ADF&G	5/22/97	F	1279	488			58.4	0.14	2.16		0.15	2	56.3	22.9
ADF&G	5/22/97	M	1325	485			88.9	0.11	2.76		0.19	3	56.9	23.3

Gill Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	5/22/97	M	1488	531			12.7	0.21	2.25	0.05	2	61.4	23.3
ADF&G	5/22/97	F	771.1	450			17.5	0.18	2.27	0.05	2	59.0	22.4
ADF&G	9/27/97	F	572	383	4	4	72.7	0.13	2.06	0.2	2.7	54.6	24.3
ADF&G	9/27/97	M	535.7	392	3	3	136	0.21	2.40	0.27	2.4	68.4	24.6
ADF&G	9/27/97	M	572	397	2	2	7.8	0.1	1.62	0.09	2.3	46.3	23.8
ADF&G	9/27/97	F	263.3	299	2	1	66.4	0.16	2.16	0.18	2.8	58.4	23.8
ADF&G	9/27/97	F	1653	555	3	6	90	0.21	2.60	0.26	2.9	73.4	24.6
ADF&G	9/27/97	M	1507	520	3	5	112	0.14	2.28	0.31	2.1	79.5	25.3
ADF&G	9/27/97	D#6					60.6	0.1	1.90	0.21	1.8	64.6	22.9
ADF&G	6/1/98	F	1889	530	4	3	24	0.16	2.79	0.04	2.23	68.1	19.5
ADF&G	6/1/98	M	2334	575	5	4	39.7	0.16	2.42	0.08	1.73	62.8	25.2
ADF&G	6/1/98	M	1880	553	5	2	125	0.19	3.08	0.32	1.65	64.1	24.2
ADF&G	6/1/98	F	1961	550	5	3	115	0.12	2.34	0.19	1.6	56.9	24.5
ADF&G	6/1/98	F	1471	514	4	3	14.7	0.1	1.79	0.04	1.21	52.8	27.0
ADF&G	6/1/98	M	1244	500	5	5	73.9	0.11	1.74	0.14	1.97	48.6	26.0
ADF&G	6/1/98	D#2					15.6	0.1	1.97	0.03	1.9	50.5	26.3
ADF&G	10/6/98	F	2830	626	2	8	4.8	0.17	5.97	0.06	3.2	65.8	27.0
ADF&G	10/6/98	M	2304	560	2	4	7.5	0.18	8.38	0.08	3.71	83.1	24.5
ADF&G	10/6/98	F	2713	578	3	6	31.7	0.14	6.82	0.1	1.98	62.2	26.9
ADF&G	10/6/98	F	1914	528	3	5	21.5	0.26	4.36	0.04	2.05	72.2	26.0
ADF&G	10/6/98	M	1343	475	3	3	7.7	0.2	5.15	0.03	3.54	62.4	26.5
ADF&G	10/6/98	F	1161	467	3	3	7	0.16	5.09	0.05	2.97	75.6	25.8
ADF&G	10/6/98	D#3					26.8	0.15	4.42	0.06		69.7	26.8
ADF&G	5/15/99	M	1235	491	3	3	44.3	0.16	2.46	0.21	2.89	76.4	21.9
ADF&G	5/15/99	F	1943	625	3	6	30.4	0.05	1.83	0.29	0.36	66.7	23.3
ADF&G	5/15/99	M	1898	605	3	7	51	0.12	2.99	0.22	0.63	94.8	18.2
ADF&G	5/15/99	M	2225	595	4	4	34.4	0.13	2.86	0.27	2.45	59.2	24.4
ADF&G	5/15/99	F	2760	620	3	7	66.4	0.1	1.71	0.29	1.74	66.2	21.6

Gill Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Sex	Weight grams	Length mm	age fresh	age salt	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	5/15/99	M	4831	720	3	6	21.9	0.11	1.87	0.21	2.12	65.1	23.3
ADF&G	5/15/99	D#6					59.7	0.14	2.09	0.11		65.7	21.6
ADF&G	9/8/99	M	681	392	2	3	34.3	0.15	2.16	0.05	4.54	81.5	26.1
ADF&G	9/8/99	F	1344	490	3	4	10.1	0.13	1.92	0.05	2.67	73.6	24.8
ADF&G	9/8/99	F	1616	510	2	4	32.3	0.17	2.36	0.07	1.54	73.5	20.2
ADF&G	9/8/99	F	1144	455	3	3	45	0.1	1.37	0.11	6.5	51.4	26.3
ADF&G	9/8/99	M	1734	540	3	1	164	0.15	1.76	0.18	3.53	67.9	29.5
ADF&G	9/8/99	M	1752	520	3	4	9.2	0.13	1.27	0.02	3.09	52.5	26.2
ADF&G	6/8/00	M	2447	603			11.7	0.16	7.80	0.07	3.6	71.8	21.4
ADF&G	6/8/00	M	5539	769			24.2	0.17	12.60	0.34	3.9	92.6	18.6
ADF&G	6/8/00	M	2561	621			90.6	0.15	6.10	0.18	2.8	94.7	16.3
ADF&G	6/8/00	M	2461	613			66.3	0.11	5.30	0.26	2.9	78.3	17.8
ADF&G	6/8/00	M	5230	832			39.9	0.16	5.30	0.13	2.3	99.6	17.5
ADF&G	6/8/00	M	5198	635			16.7	0.15	3.85	0.11	2.7	89.5	24.1
ADF&G	6/8/00	D#5					30	0.11	3.68	0.06	2.6	70.5	27.0
ADF&G	10/20/00	M	929.4	455			8.5	0.2	3.60	< 0.03	4.5	82.7	20.3
ADF&G	10/20/00	F	1336	482			6.4	0.31	3.20	0.04	3.2	79.9	19.5
ADF&G	10/20/00	F	921.5	438			3.3	0.26	3.10	0.05	3.4	74.1	19.0
ADF&G	10/20/00	F	2502	616			121	0.18	2.80	0.09	3.2	69.3	18.7
ADF&G	10/20/00	F	1321	496			220	0.26	4.70	0.2	3.1	95.1	20.0
ADF&G	10/20/00	F					73.3	0.24	3.80	0.1	3.5	85.2	20.4
ADF&G	10/20/00	M	1188	465			250	0.3	3.90	0.27	4.6	83.4	19.8
ADF&G	10/20/00	D#4					238	0.19	4.20	0.44	4.4	75.8	18.9

D# = Fish is a duplicate of specified sample number
U = sex was not reported
F = female, M = male

Reproductive Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Fish #	Sex	Weight grams	Length mm	age fresh	age salt	total age	Al mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	% Solids
ADF&G	6/1/98	1	F	1888.64	530	3	4	7		0.0101		< 0.034	4.72		20.7
ADF&G	6/1/98	2	M	2333.56	575	4	5	9		0.0358		0.054	1.85		18.4
ADF&G	6/1/98	3	M	1879.56	553	2	5	7		0.0259		< 0.034	2.02		17.8
ADF&G	6/1/98	4	F	1961.28	550	3	5	8		0.0147		< 0.034	3.38		27.2
ADF&G	6/1/98	5	F	1470.96	514	3	4	7		0.0104		< 0.034	3.61		20.3
ADF&G	6/1/98	6	M	1243.96	500	5	5	10		0.034		0.034	0.982		32.9
ADF&G	10/6/98	1	F	2830	626	2	8	10					8.91		19.3
ADF&G	10/6/98	2	F	2713	578	3	6	9					12.2		24.9
ADF&G	10/6/98	3	F	1161	467	3	3	6					10.2		19.7
ADF&G	10/6/98	D#3											11.3		25.1
ADF&G	5/15/99	D#6	M										2.74		17.8
ADF&G	5/15/99	2	F	1943.12	625								1.44		20.2
ADF&G	5/15/99	3	M	1897.72	605								1.47		15.6
ADF&G	5/15/99	4	M	2224.6	595								1.8		18.2
ADF&G	5/15/99	5	F	2760.32	620								7.48		31.5
ADF&G	5/15/99	6	M	4830.56	720								2.86		17.1
ADF&G	9/8/99	2	F	1343.84	490								7.68		18.6
ADF&G	9/8/99	3	F	1616.24	510								11		20.2
ADF&G	9/8/99	4	F	1144.08	455								10.3		23.2
ADF&G	9/8/99	5	M	1734.28	540								4.43		16.5
ADF&G	9/8/99	6	M	1752.44	520								11.6		7.5

Reproductive Tissues from adult Dolly Varden collected from the Wulik River, 1981-2000

Collector	Date Collected	Fish #	Sex	Weight grams	Length mm	age fresh	age salt	total age		Al mg/kg		Cd mg/kg	Cu mg/kg		Pb mg/kg		Se mg/kg	Zn mg/kg	% Solids
ADF&G	6/8/00	1	M	2446.6	603				<	1	<	0.05	21.7	<	0.02		7.3	387	25.5
ADF&G	6/8/00	2	M	5539	769					1.3	<	0.05	16.5		0.2	<	1	109	18.1
ADF&G	6/8/00	3	M	2561	621				<	1	<	0.05	26.3		0.04		5.2	353	24.1
ADF&G	6/8/00	4	M	2461	613				<	1	<	0.05	16.4	<	0.02		5	104	26.6
ADF&G	6/8/00	5	M	5230	832					2.3		0.08	14.2		0.08		3.1	159	14.4
ADF&G	6/8/00	6	M	5198	635					2.2	<	0.05	5.95	<	0.02		3.2	125	16.5
ADF&G	6/8/00	D#5								4.9	<	0.05	8.53		0.03		4	142	17.2
ADF&G	10/20/00	2	F	1335.5	482					1.3	<	0.05	33.2	<	0.023		8	533	
ADF&G	10/20/00	3	F	921.5	438					1.7		0.13	24.7				8.3	260	
ADF&G	10/20/00	4	F	2502.2	616					1.2		0.08	18.4				6.9	214	
ADF&G	10/20/00	5	F	1320.9	496					2.2	<	0.05	34.3				10.1	407	

Appendix 5. Metals concentrations in juvenile Dolly Varden

All fish were collected by ADF&G and analyzed as whole body samples, dry weight basis.

Sample Name	Location	Length mm	Cd mg/Kg	Pb mg/Kg	Se mg/Kg
080798MSDVJ01	Mainstem	132	1.97	5.04	6.46
080798MSDVJ02	Mainstem	145	3.62	15.00	7.27
080798MSDVJ03	Mainstem	124	3.62	16.20	6.40
080798MSDVJ04	Mainstem	124	3.04	10.60	5.23
080798MSDVJ05	Mainstem	110	3.07	6.97	5.73
080798MSDVJ06	Mainstem	130	1.89	4.17	7.29
080798MSDVJ07	Mainstem	143	0.42	3.95	6.88
080798MSDVJ08	Mainstem	130	2.54	21.20	8.68
080798MSDVJ09	Mainstem	115	3.08	6.48	7.26
080798MSDVJ10	Mainstem	132	1.04	7.97	7.62
081098AXDVJ11	Anxiety	120	0.14	1.03	2.89
081098AXDVJ12	Anxiety	120	0.10	0.72	2.45
081098AXDVJ13	Anxiety	118	0.18	1.33	5.19
081098AXDVJ14	Anxiety	133	0.21	1.45	2.83
081098AXDVJ15	Anxiety	142	0.15	1.77	3.12
081098AXDVJ16	Anxiety	126	0.16	0.62	3.03
081098AXDVJ17	Anxiety	140	0.11	0.17	5.12
081098AXDVJ18	Anxiety	128	0.11	1.07	3.51
081098AXDVJ19	Anxiety	132	0.15	0.41	3.64
081098AXDVJ20	Anxiety	111	0.13	1.15	4.26
081299AXDVJ01	Anxiety	125	0.22	0.42	5.63
081299AXDVJ02	Anxiety	134	0.39	0.51	5.87
081299AXDVJ03	Anxiety	135	0.18	0.48	4.55
081299AXDVJ04	Anxiety	131	0.37	1.20	4.17
081299AXDVJ05	Anxiety	137	0.13	0.27	3.96
081299AXDVJ06	Anxiety	130	0.26	0.36	4.31
081299AXDVJ07	Anxiety	123	0.34	1.10	5.24
081299AXDVJ08	Anxiety	127	0.14	0.43	4.89
081299AXDVJ09	Anxiety	123	0.23	0.68	4.48
081299AXDVJ10	Anxiety	126	0.27	0.56	5.46
081299FEDVJ01	Ferric	123	0.09	0.36	5.27
081299FEDVJ02	Ferric	125	0.21	0.37	5.20
081299FEDVJ03	Ferric	149	0.06	0.22	6.32
081299FEDVJ04	Ferric	141	0.06	0.33	5.58
081299FEDVJ05	Ferric	123	0.26	0.42	6.19
081299FEDVJ06	Ferric	141	0.11	0.18	6.46
081299FEDVJ07	Ferric	115	0.27	0.30	6.64
081299FEDVJ08	Ferric	116	0.16	0.22	5.69
081299FEDVJ09	Ferric	107	0.07	0.21	4.66

Sample Name	Location	Length (mm)	Cd mg/Kg	Pb mg/Kg	Se mg/Kg
081299MSDVJ01	Mainstem	140	4.62	8.91	6.89
081299MSDVJ02	Mainstem	121	3.90	8.78	7.13
081299MSDVJ03	Mainstem	125	3.75	8.68	8.90
081299MSDVJ04	Mainstem	127	4.14	3.11	7.26
081299MSDVJ05	Mainstem	130	3.19	4.97	6.87
081299MSDVJ06	Mainstem	134	1.28	3.18	7.30
081299MSDVJ07	Mainstem	139	3.84	6.52	8.89
081299MSDVJ08	Mainstem	145	3.17	10.40	6.30
081299MSDVJ09	Mainstem	143	0.54	1.09	5.66
081299MSDVJ10	Mainstem	120	2.47	9.94	4.24
081299NFDVJ01	North Fork	140	0.42	0.52	4.71
081299NFDVJ02	North Fork	123	0.88	0.86	5.22
081299NFDVJ03	North Fork	128	0.56	0.22	4.40
081299NFDVJ04	North Fork	128	0.58	0.57	4.20
081299NFDVJ05	North Fork	125	0.43	0.31	5.46
081299NFDVJ06	North Fork	134	0.42	0.28	5.81
081299NFDVJ07	North Fork	146	0.52	0.57	4.28
081299NFDVJ08	North Fork	119	0.50	0.30	4.61
081299NFDVJ09	North Fork	126	1.15	0.29	5.72
081299NFDVJ10	North Fork	126	0.38	0.32	5.13
072800MSDVJ01	Mainstem	131	2.69	6.80	6.8
072800MSDVJ02	Mainstem	117	3.45	13.0	10.8
072800MSDVJ03	Mainstem	140	4.75	9.75	9.1
072800MSDVJ04	Mainstem	110	2.91	13.4	12.5
072800MSDVJ05	Mainstem	125	6.40	15.8	8.9
072800NFDV01	North Fork	136	0.78	1.38	6.4
072800NFDV02	North Fork	142	0.37	0.36	5.2
072800NFDV03	North Fork	132	0.73	0.99	6.2
072800NFDV04	North Fork	132	0.54	0.90	5.7
072800NFDV05	North Fork	137	0.43	0.89	6.1
080100AXDV01	Anxiety	125	0.21	1.36	3.4
080100AXDV02	Anxiety	117	0.31	2.86	5.4
080100AXDV03	Anxiety	124	0.31	2.09	3.9
080100AXDV04	Anxiety	133	0.11	2.30	3.9
080100AXDV05	Anxiety	134	0.27	1.20	4.1

Sample Name 080798MSDVJ01 represents the date of collection (August 7, 1998), location (MS = Mainstem Red Dog Creek), species (DV = Dolly Varden), age (J = juvenile), and individual sample number (01).

Appendix 6. Dolly Varden aerial surveys

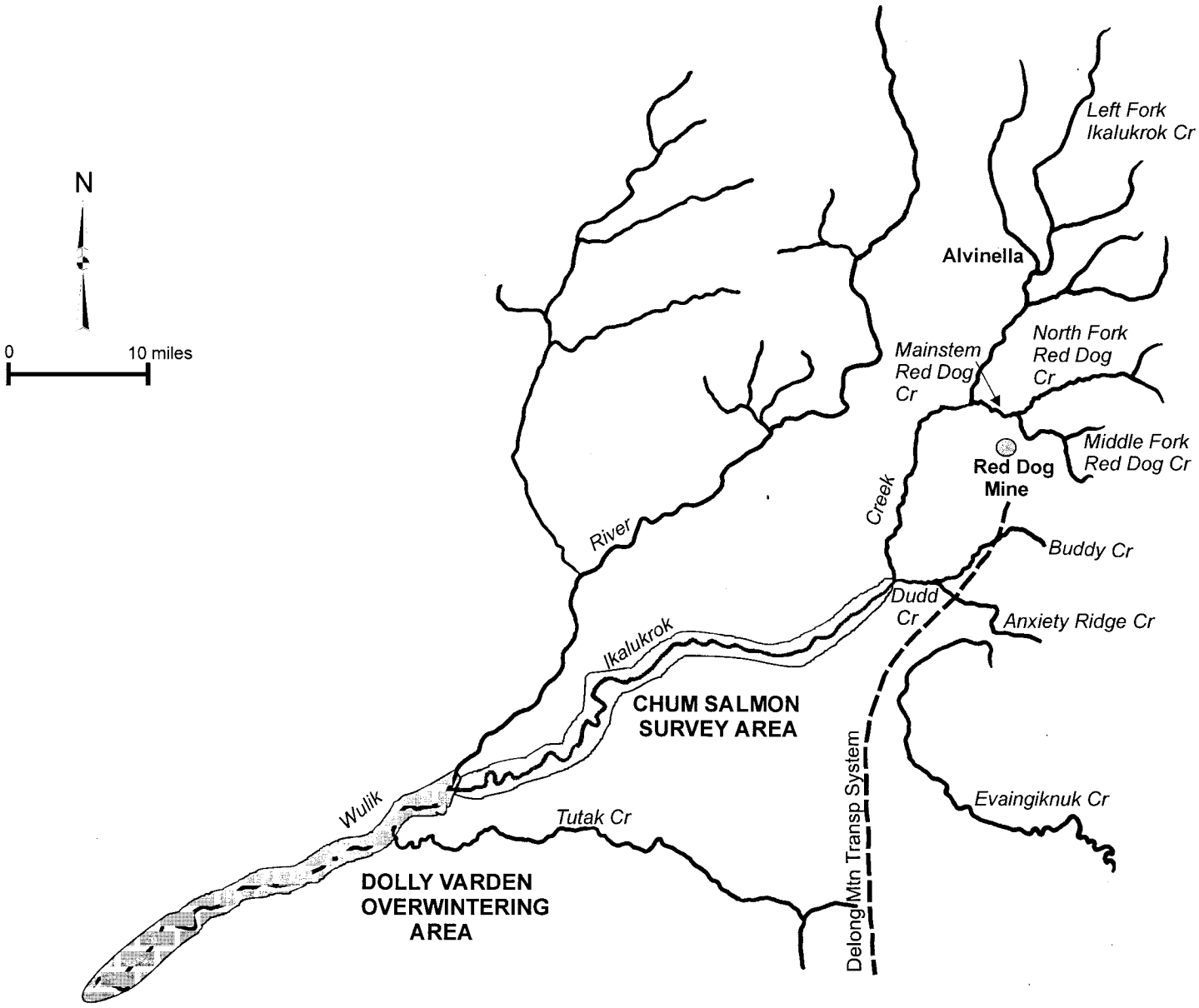
Number of overwintering adult Dolly Varden in the Wulik River before freezeup. Surveys conducted by ADF&G (DeCicco 1989 and 1991-1999).

Year	Wulik River upstream of Ikalukrok Creek	Wulik River downstream of Ikalukrok Creek	Total Fish	Percent of Fish downstream of Ikalukrok Creek
Pre-Mining, including Mine Construction				
1979	3,305	51,725	55,030	94
1980	12,486	101,067	113,553	89
1981	4,125	97,136	101,261	96
1982	2,300	63,197	65,497	97
1984	370	30,483	30,853	99
1987	893	60,397	61,290	99
1988	1,500	78,644	[1]80,144	98
Mine Production				
1989	2,110	54,274	56,384	96
1991	7,930	119,055	126,985	94
1992	750	134,385	135,135	99
1993	7,650	136,488	144,138	95
1994	415	66,337	[2]66,752	99
1995	240	128,465	128,705	99
1996	1,010	59,995	61,005	98
1997	2,295	93,117	95,412	98
1998	6,350	97,693	104,043	94
1999	2,750	67,954	70,704	96
2000[3]	-	-	-	

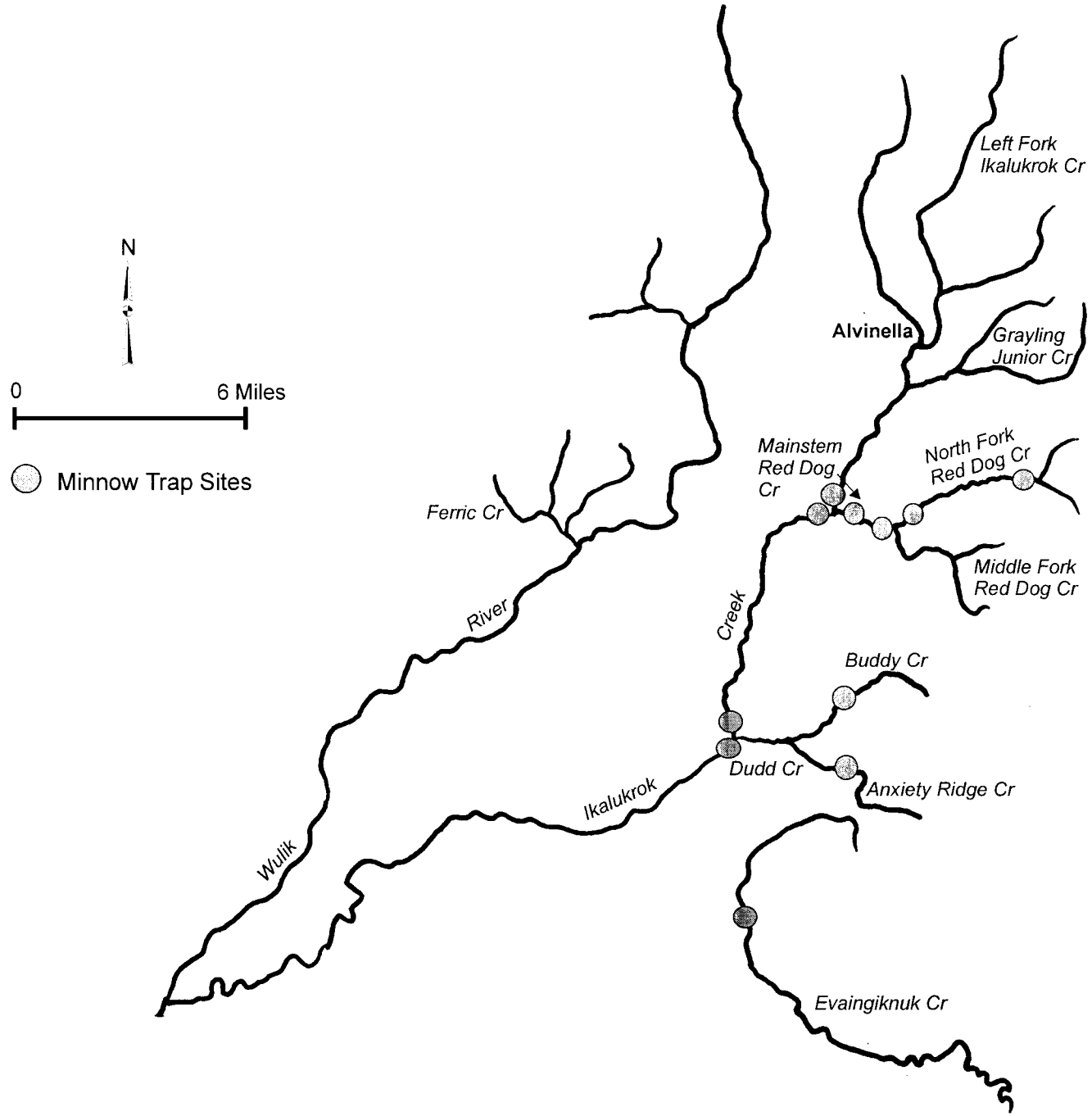
[1]The population estimate (mark/recapture) for winter 1988/1989 for fish >400 mm was 76,892 (DeCicco 1990a).

[2]The population estimate (mark/recapture) for winter 1994/1995 for fish >400 mm was 361,599 (DeCicco 1996b).

[3]Fall 2000 aerial survey was not made due to weather.



Appendix 7. Adult Dolly Varden survey areas.



Appendix 8. Juvenile Dolly Varden sampling areas.

Appendix 9. Fyke net sampling

in North Fork and Mainstem Red Dog Creeks in 2000.

Date	Sample Site	Time	Water Temperature °C	Number of Arctic Grayling
6/8/00	North Fork	1700	0.0	
6/9/00	North Fork	0900	0.0	0
6/9/00	North Fork	1300	0.3	0
6/9/00	North Fork	1800	2.1	0
6/10/00	North Fork	0900	0.7	0
6/10/00	North Fork	1400	3.0	3
6/10/00	North Fork	1500	3.0	2
6/10/00	North Fork	2100	2.1	4
6/11/00	North Fork	1100	2.7	5
6/11/00	North Fork	1800	4.1	1
6/12/00	North Fork	0830	0.0	2
6/12/00	North Fork	1800	4.6	1
6/13/00	North Fork	1000	2.5	4
6/13/00	North Fork	1730	9.2	2
6/14/00	North Fork	0800	1.0	15
6/10/00	Mainstem	1200		
6/11/00	Mainstem	0900		0
6/11/00	Mainstem	1100		5
6/11/00	Mainstem	1830		3
6/12/00	Mainstem	0800		0
6/13/00	Mainstem	1530		9
7/4//00	North Fork	1100	7.8	
7/5/00	North Fork	1130	--	17
7/6/00	North Fork	1100	--	31
7/7/00	North Fork	1300	--	15
7/8/00	North Fork	1130	--	21
7/9/00	North Fork	1100	--	100
7/10/00	North Fork	1500	--	74
7/11/00	North Fork	0830	--	50
7/12/00	North Fork	0900	--	13
7/27/00	North Fork	1700	4.4	
7/28/00	North Fork	1800	8.9	7
7/29/00	North Fork	2000	8.7	4
7/30/00	North Fork	1600	8.6	5
7/31/00	North Fork	1600	9.9	10
8/1/00	North Fork	1800	5.0	14

Appendix 10. Arctic grayling recaptured in 2000.

Summary of fish tagged in 2000

Site	Total Fish Tagged
EF Ikalukrok	1
Grayling Jr.	44
Ikalukrok (Red)	2
Mainstem	17
North Fork	121

Recaptures in 2000

Tag Number	Color	Length (mm)	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
13139	GRN	425	7/11/00	Grayling Jr.	7/29/00	Grayling Jr.	425
13067	GRN	371	7/6/00	Mainstem	7/31/00	Ikalukrok Cr at (Dudd)	375
13064	GRN	268	7/8/00	North Fork	8/1/00	North Fork	283
10940	OR	278	6/27/97	North Fork	7/5/00	North Fork	354
8077	OR	262	7/8/99	North Fork	6/14/00	North Fork	330
8035	OR	330	7/12/99	North Fork	6/13/00	North Fork	352
8046	OR	338	7/12/99	North Fork	6/14/00	North Fork	345
10959	OR	355	7/13/99	North Fork	7/10/00	North Fork	371
8076	OR	276	7/8/99	North Fork	7/10/00	North Fork	310
1520	W	223	6/26/95	North Fork	6/14/00	North Fork	398
1567	W	244	6/29/95	North Fork	7/20/95	North Fork	255
1702	W	264	7/17/95	North Fork	8/14/95	North Fork	280
1703	W	240	7/17/95	North Fork	7/10/00	Grayling Jr.	351
1849	W	234	8/15/95	North Fork	7/1/98	North Fork	300
1605	W	312	7/1/98	North Fork	6/14/00	North Fork	360
1608	W	352	7/1/98	North Fork	6/14/00	North Fork	360
1606	W	309	7/1/98	North Fork	7/11/00	North Fork	354

Appendix 11. Arctic grayling visual observations

Observations and captures in Mainstem Red Dog Creek below confluence of North Fork and Middle Fork Red Dog Creeks since 1994.

Sample Date	Sample Method	Comments on Arctic grayling (YOY = young-of-the-year Arctic grayling)
6/11-12/00	fyke-net	adults captured, marked, and released
7/5/00	visual	two adults feeding at rock bluff (0.8 km below North Fork), juvenile observed
7/6/00	visual	walked most of Mainstem Red Dog Creek, tagged three adults just above dog-leg airstrip, most pools held one to three adults
7/28/00	visual	several age-0 in backwaters and along stream margins in Mainstem Red Dog Creek, not numerous
5/29/99	angling	three adult Arctic grayling caught just below North Fork Mainstem Red Dog Creek mouth
5/30/99	fyke-net	32 adult grayling, about 100 m below North Fork mouth
7/8-9/99	angling	two Arctic grayling marked in lower Mainstem Red Dog
7/8-9/99	visual	12 grayling and some fry in lower Mainstem
7/8-9/99	visual	two adult grayling at rock bluff (0.8 km below North Fork)
7/8-9/99	visual	two adult grayling at rock bluff (0.1 km below North Fork)
8/9-10/99	visual	numerous YOY in backwaters and along stream margins in Mainstem Red Dog Creek
6/10/98	visual	no fish seen in Mainstem, North Fork mouth to rock bluff
6/28/98	visual	one adult feeding (rock bluff 0.8 km below North Fork)
6/25/97	drift net	YOY present near Station 10, 13-15 mm long
6/25/97	visual	two adults near rock bluff about 0.8 km below North Fork
6/26/97	angling	15 tagged fish (range 300-416 mm, average 364 mm) in scour pool at mouth of Mainstem, eight were spawned out
6/27/97	visual	YOY numerous near Station 10
8/10/97	visual	YOY present in backwater areas
9/29/97	traps	seven YOY caught near Station 10

Appendix 10, concluded.

Sample Date	Sample Method	Comments on Arctic grayling (YOY = young-of-the-year Arctic grayling)
6/19/96	visual	one adult near Station 10
7/15/96	angling	seven tagged fish (range 274-382 mm, average 330 mm), 2 km above mouth
8/11/96	visual	YOY in shallow eddies at mouth
8/12/96	visual	YOY near rock bluff about 0.8 km below North Fork
6/29/95	angling	one adult (368 mm) just below North Fork
7/17/95	angling	two adults (296, 323 mm) near rock bluff about 0.8 km below North Fork
7/20/95	visual	one adult near rock bluff about 0.8 km below North Fork
8/11/95	visual	YOY (about 30) below North Fork
8/11/95	visual	one adult near rock bluff about 0.8 km below North Fork
8/14/95	angling	11 tagged/recaptured (range 290-340 mm, average 319 mm), near rock bluff about 0.8 km below North Fork
7/27/94	visual	two adults just below North Fork

Appendix 12. Slimy sculpin

Collected in Ikalukrok Creek at the mouth of Dudd and Mainstem Red Dog Creeks.

Creek	Year	No. Sample Periods	No. Traps Deployed	No. Slimy Sculpin
Ikalukrok (at Dudd Cr.)	2000	2	20	1
	1999	2	20	18
	1998	2	20	5
	1997	2	20	11
	1996	2	20	2
	1995	3	20	8
	1994	1	20	8
	1993	2	10	2
	1992	3	10	3
	1991	4	5	3
	1990	3	5	0
Ikalukrok (at Red Dog)	2000	2	20	3
	1999	2	20	8
	1998	2	20	1
	1997	2	20	1
	1996	2	20	0