Technical Report No. 09-03

Aquatic Biomonitoring at Red Dog Mine, 2008
National Pollution Discharge Elimination System
Permit No. AK-003865-2

by Alvin G. Ott and William A. Morris

North Fork Red Dog Creek, Spring Breakup, Arctic Grayling Sampling
Photograph by Bill Morris 2008

May 2009

Alaska Department of Fish and Game
Division of Habitat

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Director
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Acknowledgements

We thank Teck Alaska Incorporated (Teck) for their financial and logistical support that enabled us to conduct aquatic biomonitoring work at the Red Dog Mine. We specifically acknowledge the support provided by Mr. Jim Kulas, Mr. Wayne Hall, Mr. Devin Harbke, Mr. Jeff Clark, Mr. Chris Eckert, Mr. Andy Willman, and Mr. John Martinisko of Teck. Ms. Tiffany Scott (Teck) assisted with spring field sampling of Arctic grayling in North Fork Red Dog Creek.

Ms. Laura Jacobs with the Division of Habitat, Alaska Department of Fish and Game (ADF&G), provided assistance with field and laboratory work. Mr. Fred DeCicco (Fisheries Services and Supplies) and Mr. Brendan Scanlon (Sport Fish Division, ADF&G) conducted the fall Dolly Varden (*Salvelinus malma*) aerial surveys and collected the fall sample of adult Dolly Varden from the Wulik River. The University of Alaska Fairbanks allowed us to use their equipment for chlorophyll analyses.

Dr. Phyllis Weber Scannell (Scannell Technical Services) updated our long-term water quality data base with 2008 information. Ms. Nora Foster (NRF Taxonomic Services) was responsible for sorting and identification of aquatic invertebrates collected with drift nets.

Executive Summary

●Metals concentrations (Cd, Pb, and Zn) in Mainstem Red Dog Creek exceed those found in North Fork Red Dog, Ikalukrok, and Buddy creeks. There are no apparent trends for increasing metal concentrations in Mainstem Red Dog Creek, except for an increase in Ni that is coming from Rachael Creek. Cd, Pb, and Zn are now lower in Mainstem Red Dog Creek than they were pre-mining, but total dissolved solids (TDS), conductivity, and sulfate are higher than baseline data and are directly related to the higher TDS associated with the waste water treatment effluent.

●Algal biomass, as measured by chlorophyll-a concentration, is sampled each year at a number of sites in the Red Dog Creek and Bons/Buddy Creek drainages. Generally, chlorophyll-a concentrations are highest in North Fork Red Dog, Bons, and Buddy creeks compared to Middle Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks. Chlorophyll-a concentrations track with changes in metals concentrations in Ikalukrok Creek at Station 9, a site that is not affected by wastewater discharge or drainage from the Red Dog Mine. Fish use is higher in those systems exhibiting higher chlorophyll-a concentrations.

●Aquatic invertebrate densities appear to be a relatively good measure of stream productivity. Higher densities were found in the Bons and Buddy Creek and North Fork Red Dog Creek sites. Lower densities are found in sample sites with the higher metals concentrations (Middle Fork Red Dog Creek). The percentage of Ephemeroptera, Plecoptera, and Tricoptera (EPT) which normally would be higher in cleaner water does not reflect this pattern for the Red Dog sites. No apparent differences are seen in taxa richness for all sites among sample years.

●Juvenile Dolly Varden are collected each year from selected sites and are analyzed for whole body metal concentrations. Based on our results to date, we believe that whole body concentrations of selected metals in juvenile Dolly Varden do reflect water quality differences among sample sites (fish from Mainstem Red Dog have higher metal concentrations) and are useful in tracking change over time. Fish body condition was similar among the creeks from 2005 to 2008, with the notable exception that juvenile Dolly Varden in Mainstem Red Dog Creek in 2008 were in better condition than fish from the Buddy and Anxiety Ridge creeks. Arctic grayling juveniles from Bons Pond did not differ in Se or Pb concentrations between the 2004 and 2007 samples, but Cd concentrations in 2007 were significantly lower and Zn was significantly higher, as compared to the 2004 sample.

●Adult Dolly Varden from the Wulik River have been sampled for Al, Cd, Cu, Pb, and Zn concentrations in gill, kidney, liver, muscle, and reproductive tissue since 1990. Se was added in 1997 and in 2003 Hg was included in the analyte matrix. None of the analytes measured have been found to concentrate in muscle tissue. Various metals do concentrate in specific tissues: Al in gill, Cd in kidney, Cu in liver, Pb in gill, Se in kidney and ovary, Zn in ovary, and Hg in kidney.

●The number of Dolly Varden is estimated each fall in the Wulik River. Estimates vary annually. There is no indication, based on surveys conducted before and after mining, that the estimated number of fish overwintering in the Wulik River has exhibited a trend of increasing or decreasing numbers. Aerial surveys prior to mine development found that 90% of the Dolly Varden in the Wulik River are located below the mouth of Ikalukrok Creek. Surveys post mining continue to find that 90% of the fish counted in the fall are found downstream of the mouth of Ikalukrok Creek.

●Annual aerial surveys are made to assess the distribution of chum salmon in Ikalukrok Creek. Aerial counts of adult chum salmon after mine development in 1990 and 1991 were much lower than reported in baseline studies. The highest estimated number of chum salmon was 4,185 in 2006. Fairly large returns of chum salmon have been seen in 2001, 2002, 2006, 2007, and 2008.

●Catch of juvenile Dolly Varden varies considerably among sample sites and years. Catches peak in late summer/early fall as fish move to rearing habitats. While most Dolly Varden are believed to be from anadromous parents, a resident component exists in North Fork Red Dog Creek. The two most productive sample sites for juvenile Dolly Varden continue to be Anxiety Ridge and Buddy creeks. Juvenile Dolly Varden use Mainstem Red Dog Creek for rearing, but catches from 2000 through 2008 have been low.

●The Arctic grayling spring migration of fish into North Fork Red Dog Creek was strong in spring 2008 with at least three age classes of immature fish present in the catches. Part of the recruitment seen is due to fish leaving Bons Pond and returning to North Fork Red Dog Creek. Breakup was a little later in 2008, but spawning was judged to be essentially completed by June 9. Arctic grayling fry were common in Mainstem Red Dog Creek where the majority of fish spawned in 2008 and none were seen in North Fork Red Dog Creek.

●Premining slimy sculpin abundance is unknown, but baseline data reports indicated that this species was numerous in the Ikalukrok Creek drainage. Highest catches of slimy sculpin occur in Ikalukrok Creek near Dudd Creek. Increasing numbers of slimy sculpin from 2000 to 2005 seemed to track with improved water quality due to natural decreases in the Cub Creek seep located upstream of Mainstem Red Dog Creek.

Introduction

The Red Dog zinc (Zn) and lead (Pb) deposit is located in northwestern Alaska, about 130 km north of Kotzebue and 75 km inland from the Chukchi Sea coast (Figure 1). Mine operations and facilities and surrounding vegetation and wildlife are described in Weber Scannell and Ott (1998). A chronology of development and operations at the Red Dog Mine is presented in Appendix 1. Aquatic resources in the Wulik River drainage are described in Weber Scannell et al. 2000.

In July 1998, the US Environmental Protection Agency (EPA) issued a draft National Pollution Discharge Elimination System Permit No. AK-003865-2 (NPDES Permit) to Teck Cominco Alaska Inc. (now officially referred to as Teck Alaska Incorporated) 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 became effective August 28, 1998. The NPDES Permit was modified effective August 23, 2003, to include ADEC's authorization of two mixing zones for total dissolved solids in Mainstem Red Dog and Ikalukrok creeks.

The NPDES Permit requires biomonitoring of fish, aquatic invertebrates, and periphyton in streams downstream of and adjacent to the Red Dog Mine. Although the NPDES Permit expired August 28, 2003, it was administratively extended until such time as a new permit is issued. Aquatic biomonitoring has continued annually as required by the NPDES Permit. Our report contains results of studies undertaken by the Alaska Department of Fish and Game (ADF&G) in 2008 and comparisons of the 2008 data set with previous years.

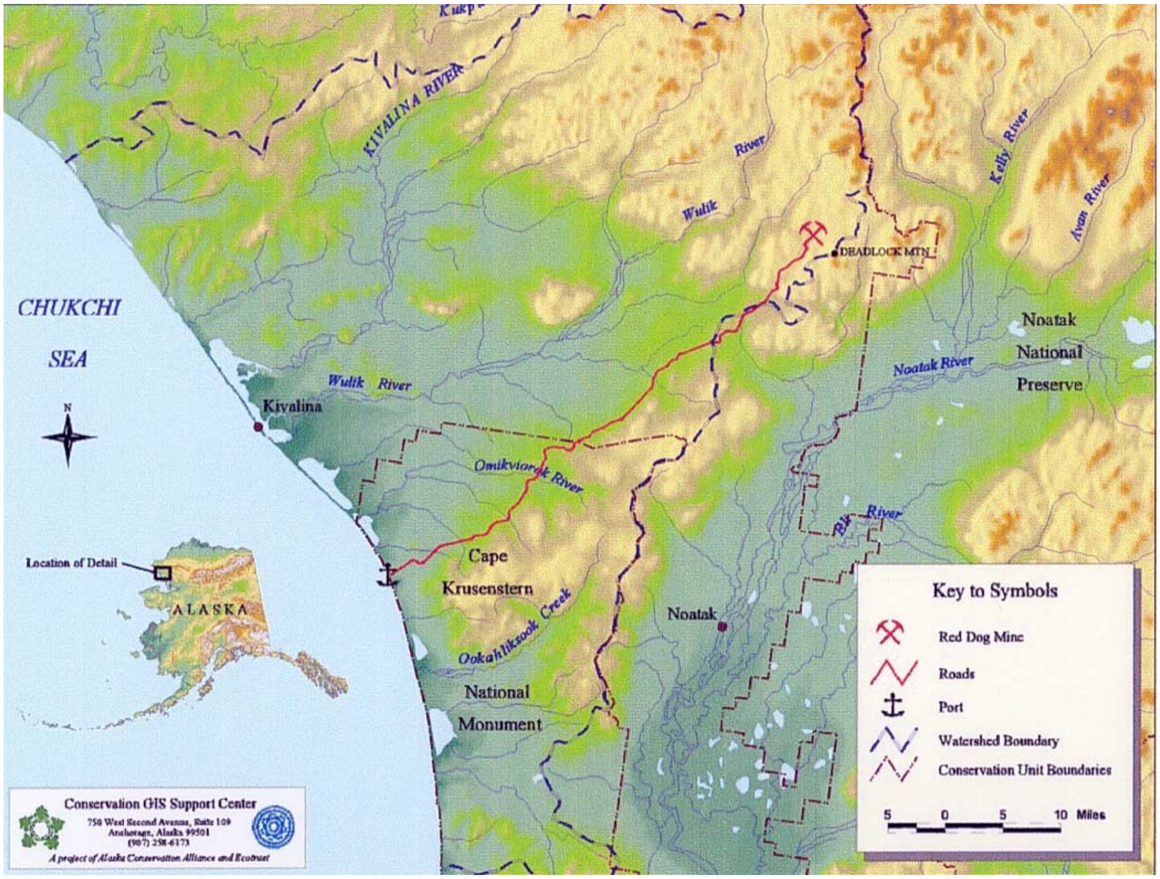


Figure 1. Location of the Red Dog Mine in northwestern Alaska. Map used with permission of Conservation GIS Support Center, Anchorage, Alaska.

Structure of Report

Water quality, periphyton standing crop, and aquatic invertebrate data are presented in the first three sections of our report. Metals concentration data for juvenile Dolly Varden (*Salvelinus malma*) collected from small streams near the mine and for adult Dolly Varden collected from the Wulik River are then presented. Aerial survey estimates of overwintering Dolly Varden in the Wulik River and chum salmon (*Oncorhynchus keta*) spawners in Ikalukrok Creek are covered next. Finally, biological monitoring data for Dolly Varden juveniles, Arctic grayling (*Thymallus arcticus*), and slimy sculpin (*Cottus cognatus*) are discussed.

Location of Sample Sites

Biomonitoring is conducted in streams adjacent to and downstream of the Red Dog Mine as required under the EPA NPDES Permit No. AK-003865-2 (Table 1, Figure 2). A description of the site location and Station Number is presented in Table 1. A site map of the Red Dog Creek drainage with sample locations shown is presented in Figure 3.

Table 1. Sample site locations for NPDES biomonitoring.

Stream of Site Name	Station Number
Ikalukrok Creek downstream of Dudd Creek	Station 7
Ikalukrok Creek upstream of Dudd Creek	no station #
Ikalukrok Creek downstream of Mainstem Red Dog Creek	Station 8
Ikalukrok Creek upstream of Mainstem Red Dog Creek	Station 9
Mainstem Red Dog Creek	Station 10
North Fork Red Dog Creek	Station 12
Middle Fork Red Dog Creek	Station 20

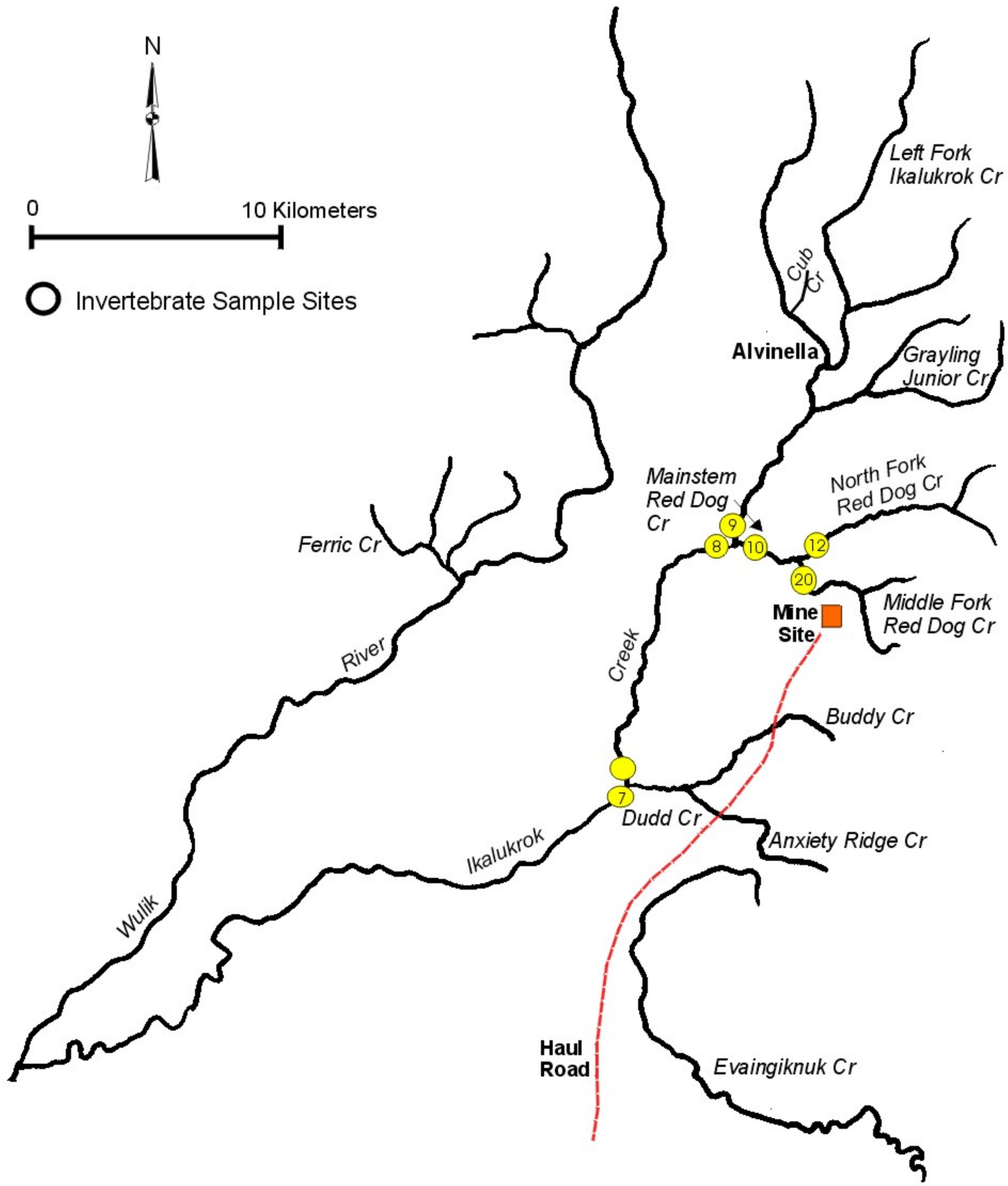


Figure 2. Location of sample sites in the Ikalukrok Creek drainage for aquatic invertebrate and periphyton sampling. The site in Ikalukrok Creek immediately upstream of Dudd Creek does not have a numerical designation.

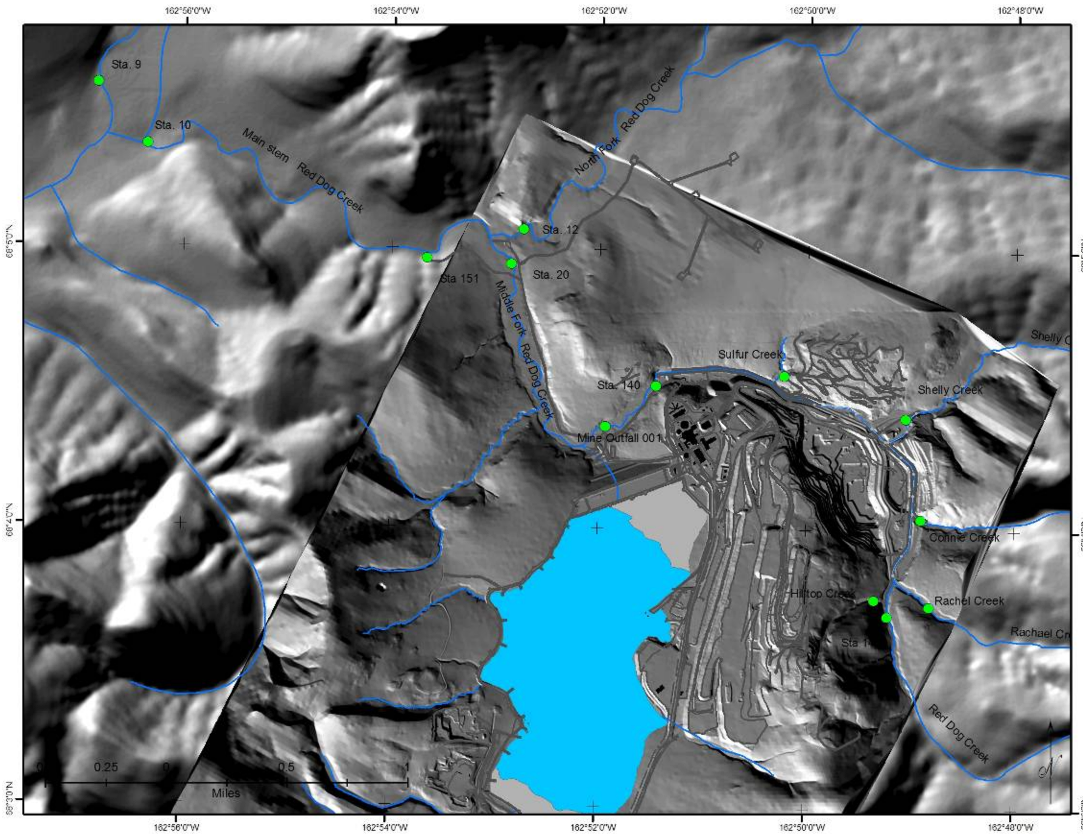


Figure 3. Location of sample sites in the Red Dog Creek drainage (map provided by Teck).

Supplemental biomonitoring in the Bons and Buddy Creek drainages is conducted under a voluntary agreement between Teck Alaska Incorporated (Teck) and the ADEC. Water quality data are collected at sites in these drainages by Teck and the ADF&G conducts biological sampling at four sites in the Bons and Buddy Creek drainages (Figure 4).

- Bons Creek, about 200 m upstream of Bons Pond;
- Bons Creek, downstream of Bons Pond and about 50 m upstream from its confluence with Buddy Creek (Station 220);
- Buddy Creek, about 50 m upstream of the Haul Road (Station 221); and
- Buddy Creek, below the waterfall that is a barrier to upstream movement of fish.

Arctic grayling were transplanted into Bons Pond in 1994 and 1995. In 1994, 107 juvenile and adult Arctic grayling were moved from North Fork Red Dog Creek to Bons Pond. In 1995, about 200 Arctic grayling fry were transported from North Fork Red Dog Creek to Bons Pond. In summer 2003, Ott and Townsend (2003) reported that an Arctic grayling population had been established in Bons Pond. Prior to the fish transplant, fish were absent from the Bons and Buddy Creek drainages by an impassable waterfall located about 1.6 km below Bons Pond.

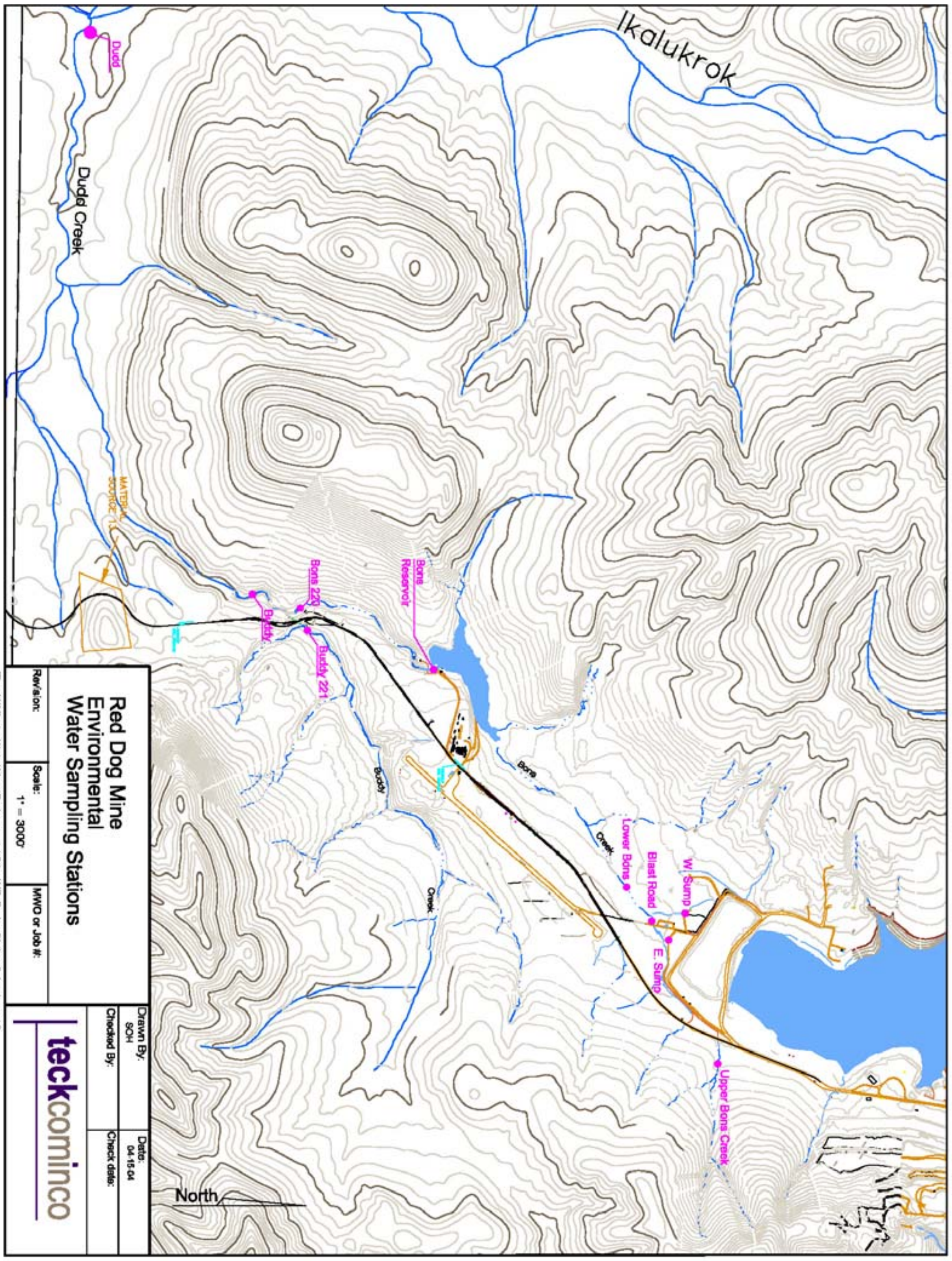


Figure 4. Bons and Buddy creeks and Bons Pond (map provided by Teck).

Description of Streams

All streams in the study area are in the Wulik River drainage, except for Evaingiknuk Creek, which is in the Noatak River drainage. Station numbers correspond either to those used by Dames and Moore (1983) during baseline work or to the current water quality program being conducted by Teck. Water quality and fish data collected during baseline studies (1979 to 1982) represent pre-mining conditions. Each monitoring component and sample site listed in Table 2 is required by either the NPDES Permit No. AK-003865-2 or the ADEC Certificate of Reasonable Assurance. Supplemental sampling not required by permits also is conducted to further our understanding of aquatic communities (Table 3). Ott and Morris (2007) summarized aquatic biomonitoring in Bons Pond and Bons and Buddy Creeks from 2004 through 2006. Aquatic biomonitoring in the Bons and Buddy Creek drainages continued in summer 2008.

Table 2. Study sites and components required by NPDES Permit and ADEC Certificate of Reasonable Assurance.

Ikalukrok Creek Stations 7, 8, 9, and upstream of Dudd Creek Creek	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use
Mainstem Red Dog (10), North Fork Red Dog (12) Creeks	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use
Middle Fork Red Dog Creek (20)	periphyton (as chlorophyll-a, mg/2) aquatic invertebrates (taxa richness, density)
Ikalukrok Creek	chum salmon aerial survey
Wulik River	Dolly Varden fall aerial survey
Anxiety Ridge, Evaingiknuk, and Buddy Creeks	fish presence and use

Table 3. Study sites and components of supplemental biomonitoring in 2008.

Ikalukrok Creek, upstream of Mainstem Red Dog Creek	aerial Arctic grayling surveys
Mainstem Red Dog Creek	juvenile Dolly Varden, whole body metal analyses fish presence and use downstream of North Fork spawning condition of Arctic grayling (spent, ripe) mark-recapture of Arctic grayling
North Fork Red Dog Creek	spawning condition of Arctic grayling (spent, ripe) mark-recapture of Arctic grayling
Buddy Creek, below waterfalls	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) juvenile Dolly Varden, whole body metal analyses
Buddy Creek, above Haul Road	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use
Bons Creek, below Bons Pond	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use
Bons Pond	fish presence and use mark-recapture of Arctic grayling Arctic grayling population estimate
Bons Creek, above Bons Pond	periphyton (as chlorophyll-a, mg/m^2) aquatic invertebrates (taxa richness, density) fish presence and use spawning condition of Arctic grayling (spent, ripe) mark-recapture of Arctic grayling

Methods Used for NPDES Biomonitoring

All methods used for the NPDES biomonitoring study are described by ADF&G (1998) and submitted to EPA for their approval and comment. Only minor modifications, as described by Ott and Weber Scannell (2003), have been made.

The method detection limit (MDL) in 2000 for copper (Cu), Pb, and selenium (Se) was 50, 20, and 50 *u*g/L, respectively, for a portion of the samples early in the ice-free season. MDL's were changed part way through summer 2000 for Cu, Pb, and Se to 1, 2, and 1 *u*g/L respectively. Because of the high MDLs used in early 2000, water quality data for these samples are not presented.

Water quality data presented in our report are for "total recoverable." All water quality data are provided by Teck. The number of water quality samples taken each year varies with the permit condition requirements, but for most analytes samples are collected twice each month with a sample size of 9 to 13 for each ice-free season.

Results and Discussion

Water Quality

Water samples are collected each year by Teck at a number of sites, including those required under the NPDES Permit. Sampling occurs twice each month during the open water season. As we did in last years report, we focus on several key sites that depict whether water quality conditions are changing. Key sites include Mainstem Red Dog Creek (Stations 151 and 10), North Fork Red Dog Creek (Station 12), Ikalukrok Creek upstream of Red Dog Creek (Station 9), and Buddy Creek (below confluence with Bons Creek) (Appendix 2). North Fork Red Dog Creek, Ikalukrok Creek at Station 9, and Buddy Creek are not directly affected by the mine wastewater discharge. Mainstem Red Dog Creek is sampled for periphyton, aquatic invertebrates, and fish (Figure 5).

Figure 5. Mainstem Red Dog Creek at Station 10 on July 3, 2008 (Arctic grayling fry were seen along margins and in backwaters).

Teck continued to maintain the mine's clean water bypass system which picks up water from Sulfur, Shelly, Connie, Rachael, and Middle Fork Red Dog creeks and moves the water through the active pit area via a combination of culverts and lined open ditch. Pb and Zn concentrations at Station 10, downstream of the clean water bypass system, indicate that both of these elements are lower now than they were pre-mining, with the exception of several maximum Pb concentrations (Figures 6 and 7, Appendix 2). Median Pb concentrations remain consistently lower than pre-mining (Figure 6).

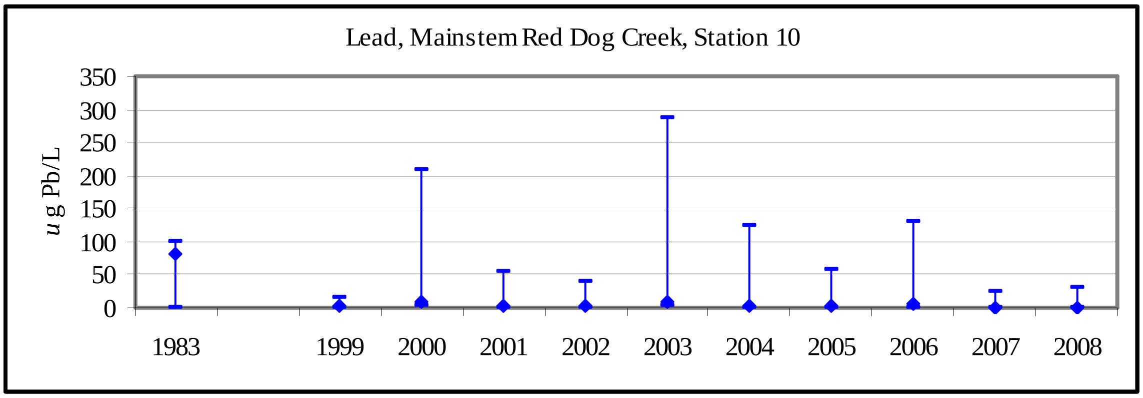


Figure 6. Median, maximum, and minimum Pb concentrations at Station 10.

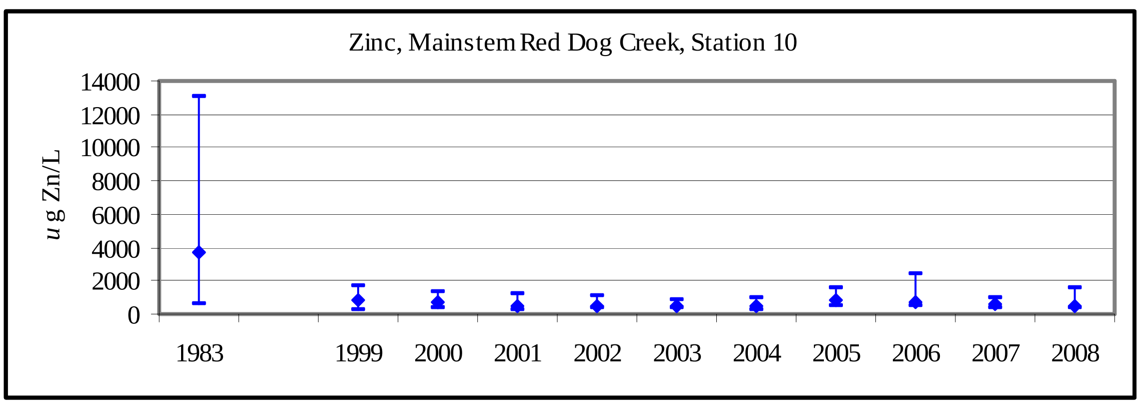


Figure 7. Median, maximum, and minimum Zn concentrations at Station 10.

We continued to evaluate water quality data being collected in Mainstem Red Dog Creek at Station 10 as part of the ongoing biomonitoring program. Median Al concentrations were lower than pre-mining, and the 2008 concentrations were some of the lowest measured during the ice free season since 1999 (Figure 8). Cd concentrations at Station 10 have been consistently lower than pre-mining conditions and in 2008 were the lowest seen since 1999 (Figure 9).

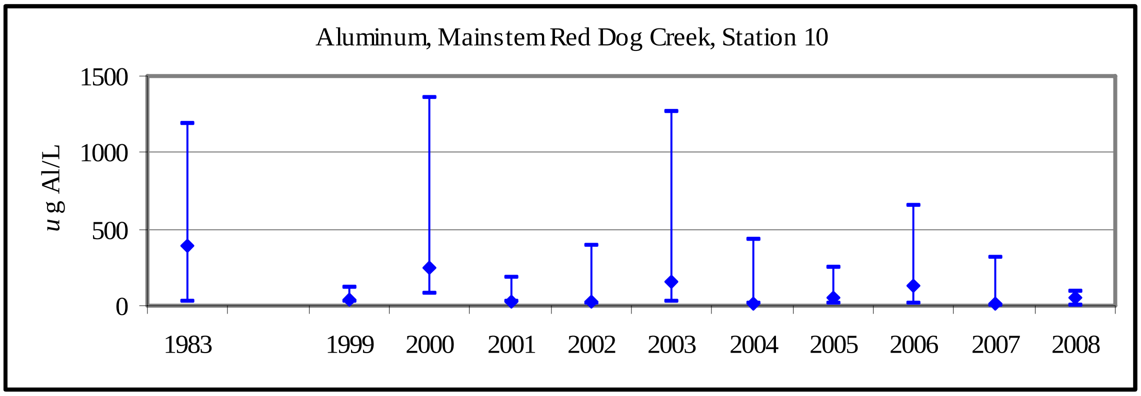


Figure 8. Median, maximum, and minimum Al concentrations at Station 10.

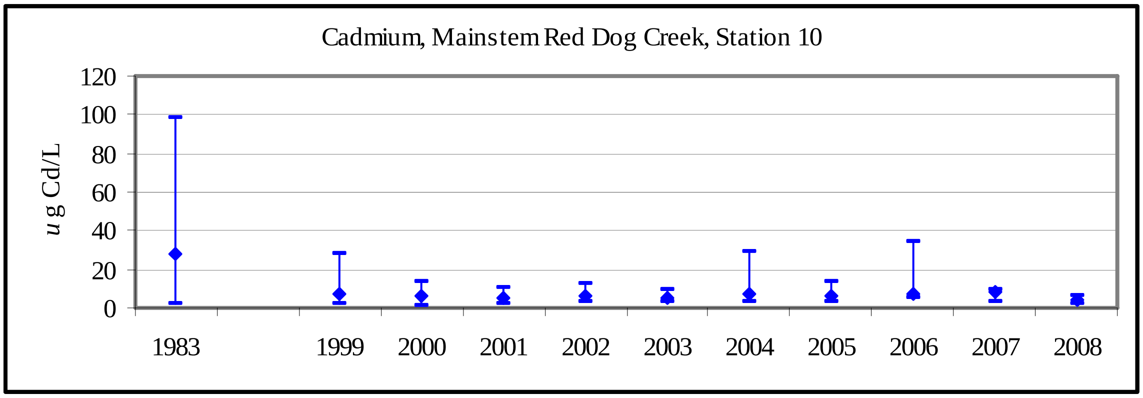


Figure 9. Median, maximum, and minimum Cd concentrations at Station 10.

Specific conductance at Station 10 is higher than pre-mining. Higher specific conductance is directly related to higher TDS associated with the treated wastewater discharge at Station 001 (Figure 10). Specific conductance has remained relatively stable since 1999.

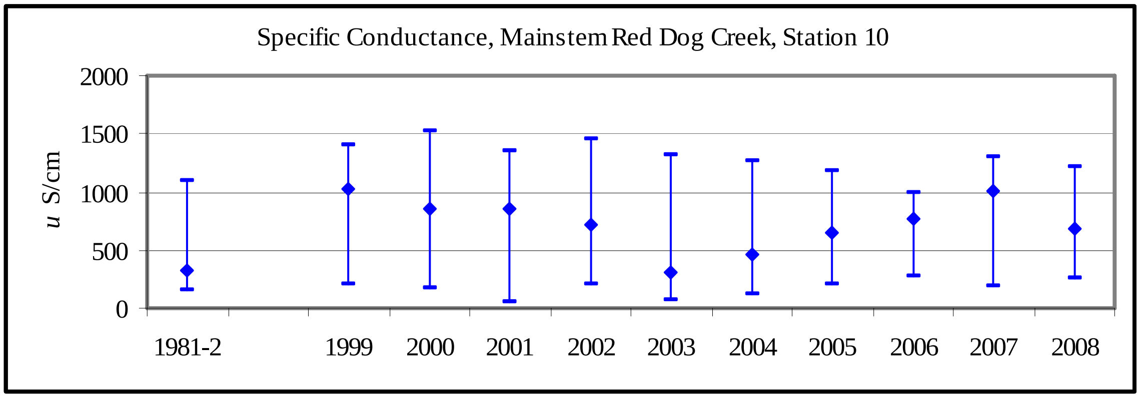


Figure 10. Median, maximum, and minimum specific conductance at Station 10.

Cu concentrations for baseline conditions and from 1999 through 2008 are presented in Figure 11. Data for 2000 are not presented for reasons stated in the methods section of this report. Median Cu concentrations except for 2003 are lower than baseline data.

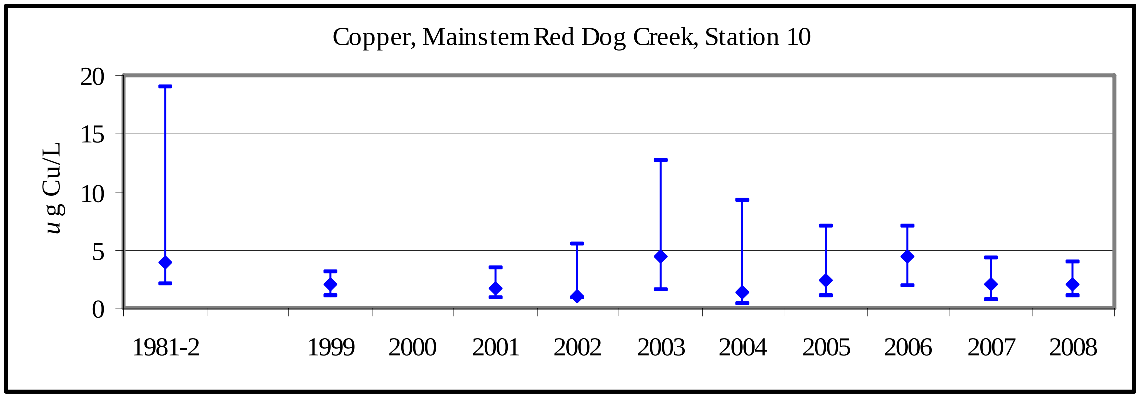


Figure 11. Median, maximum, and minimum Cu concentrations at Station 10.

Baseline data for Fe are not available. There has been no apparent increase or decrease in Fe concentrations at Station 10 from 1999 through 2008 (Figure 12). Median concentrations of Fe were highest in 2000 (827 *u*g/L) and 2006 (326 *u*g/L).

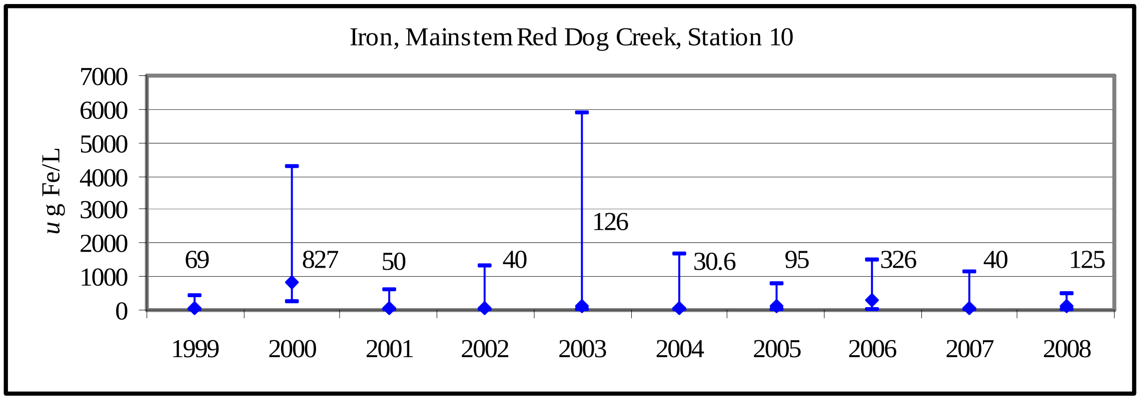


Figure 12. Median, maximum, and minimum Fe concentrations at Station 10. The values shown are the median Fe concentration.

Baseline data for Ni are not available. Ni concentrations at Station 10 have increased in recent years (Figure 13). Higher Ni concentrations were observed first in 2006 and also in both 2007 and 2008.

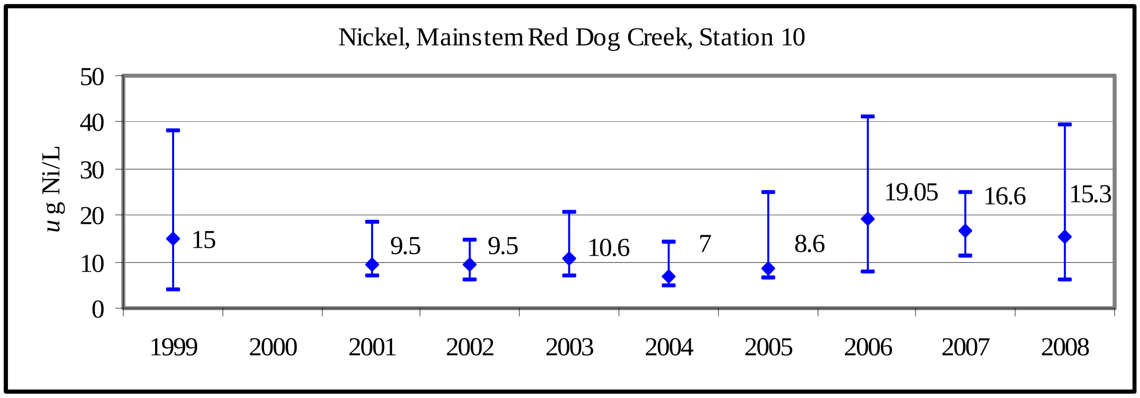


Figure 13. Median, maximum, and minimum Ni concentrations at Station 10. The values shown are the median Ni concentration.

Water quality data are collected by TCAK in tributaries to the clean water bypass. In past years, when metals concentrations have increased in the bypass system, they generally have originated from either Connie or Rachael creeks. Ni concentrations at various sites upstream (Station 145), in bypass tributaries, and downstream (Stations 20 and 10) are presented in Figure 14. The major source of Ni continues to be Rachael Creek and it is clear that the outfall input (i.e., wastewater discharge) substantially decreases Ni concentrations immediately downstream at Station 20 (Middle Fork Red Dog Creek) and that input from North Fork Red Dog Creek reduces it further at Station 10.

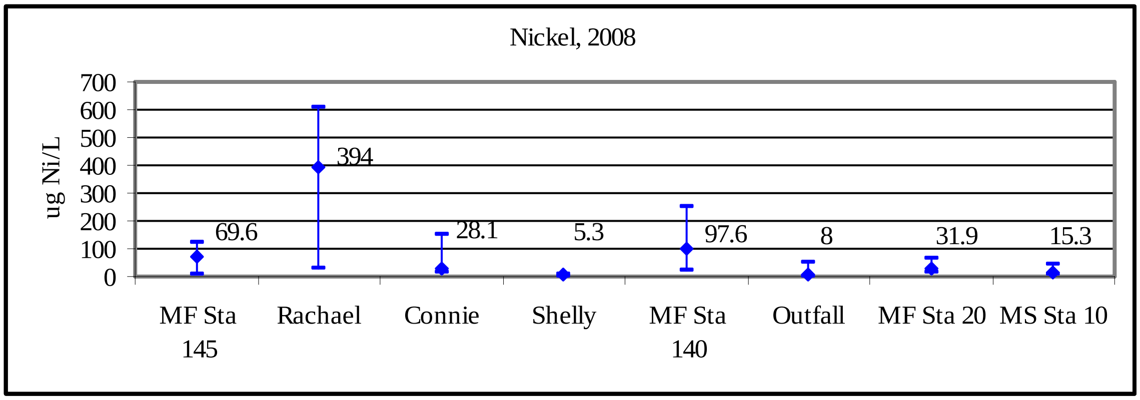


Figure 14. Median, maximum, and minimum Ni concentrations at various sites along and downstream of the clean water bypass. The values shown are the median Ni concentration.

The pH at Station 10 has been fairly consistent since 1999 (Figure 15). Generally, the pH is slightly more basic than pre-mining and has not dropped below 6 as seen in 1990. The 1990 data set is during mining, but prior to construction of the clean water bypass. The bypass system was constructed in late winter prior to spring breakup 1991. Numerous modifications and improvements to the clean water bypass system have been made since the initial construction (key construction and maintenance events are included in Appendix 1).

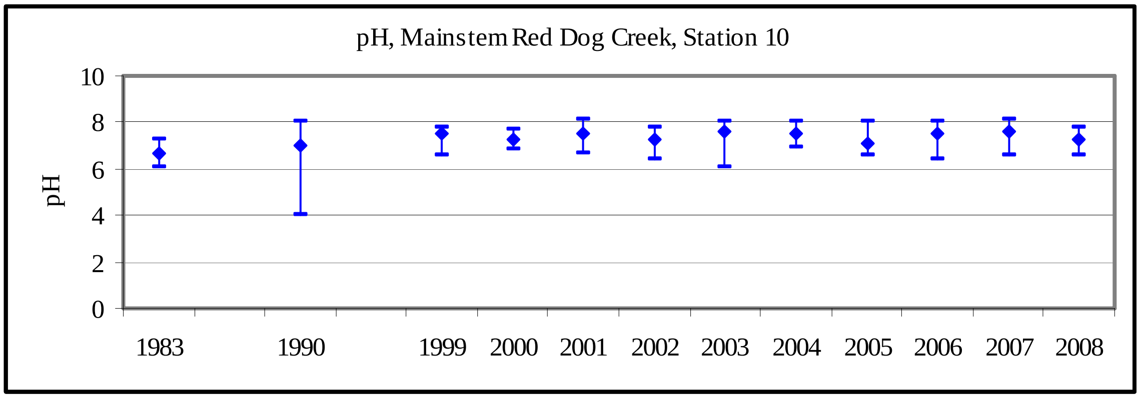


Figure 15. Median, maximum, and minimum pH values at Station 10.

Pre-mining Se data are not available. Median Se concentrations have been similar since 1999 (Figure 16). Sulfate concentrations at Station 10 have varied among the sample years and are higher compared to baseline data (Figure 17). The higher sulfate concentrations are directly associated with the higher TDS concentrations in the treated water effluent (Figure 18). The majority of TDS in the water consists of $CaSO_4$.

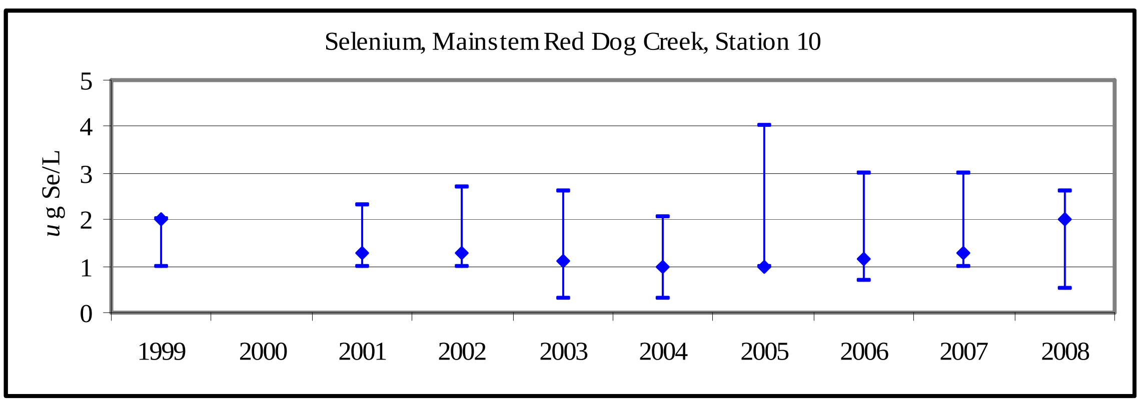


Figure 16. Median, maximum, and minimum Se concentrations at Station 10.

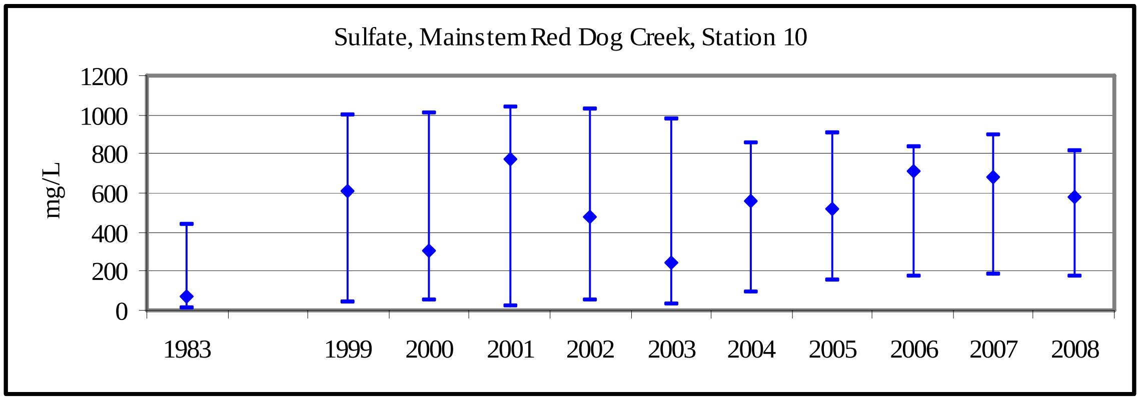


Figure 17. Median, maximum, and minimum sulfate concentrations at Station 10.

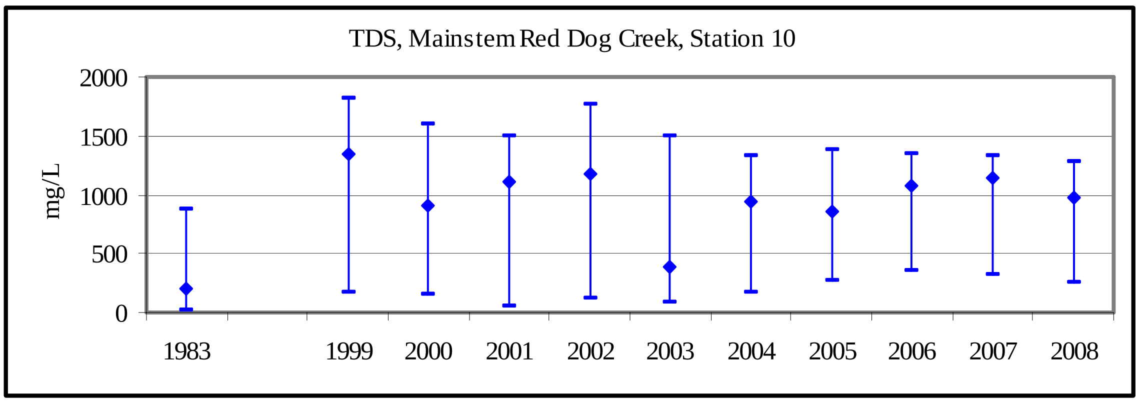


Figure 18. Median, maximum, and minimum TDS concentrations at Station 10.

We next compare cadmium, lead, selenium, and zinc concentrations in Mainstem Red Dog Creek (Station 10) with those found in North Fork Red Dog Creek (Station 12), Ikalukrok Creek (Station 9), and Buddy Creek (below the confluence of Bons and Buddy creeks) (Appendix 2). Cadmium concentrations are higher in Mainstem Red Dog Creek and lowest in Buddy and North Fork Red Dog creeks. Lead concentrations also are highest in Mainstem Red Dog Creek, but are fairly low in the three other sample sites. There is not much difference in selenium concentrations among the sample creeks. Zinc follows the same pattern as cadmium being highest in Mainstem Red Dog Creek.

As we will discuss in subsequent sections of our report, overall biological productivity in the Red Dog Mine area is highest in those creeks where the metals concentrations are lower. We also looked at the seasonality of metals concentrations (Zn, Cd, Pb, and Se) in Bons Pond. Although these metals are present at low concentrations, Cd, Pb, and Zn show a definite trend of peaking during spring breakup (Figures 19, 20, and 21). Zn also appears to have a small increase in early August and again in the fall. Se concentrations are fairly consistent throughout the ice-free season with some indication of a slight increase with time (Figure 22).

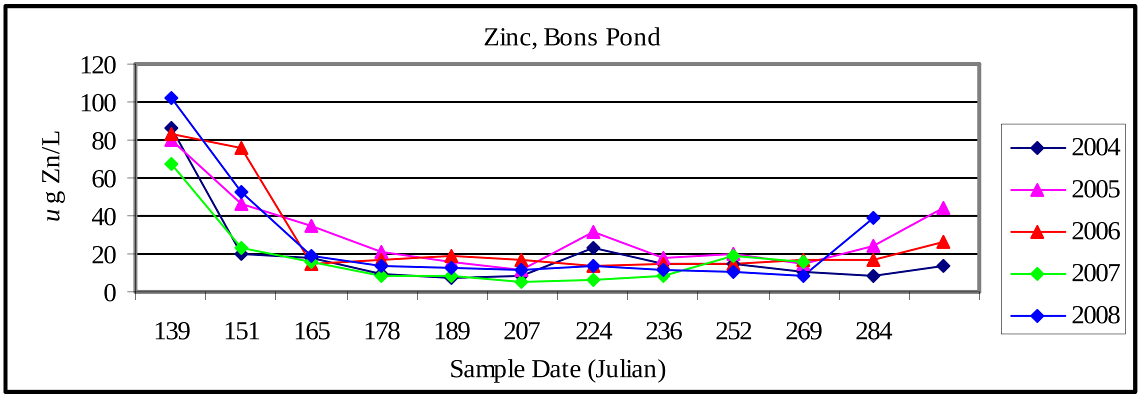


Figure 19. Zn concentrations in Bons Pond (2004 to 2008).

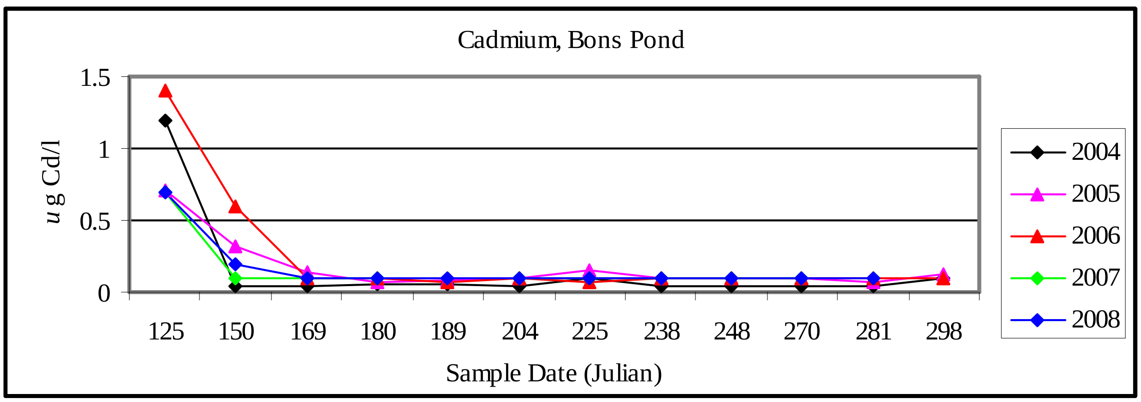


Figure 20. Cd concentrations in Bons Pond (2004 to 2008).

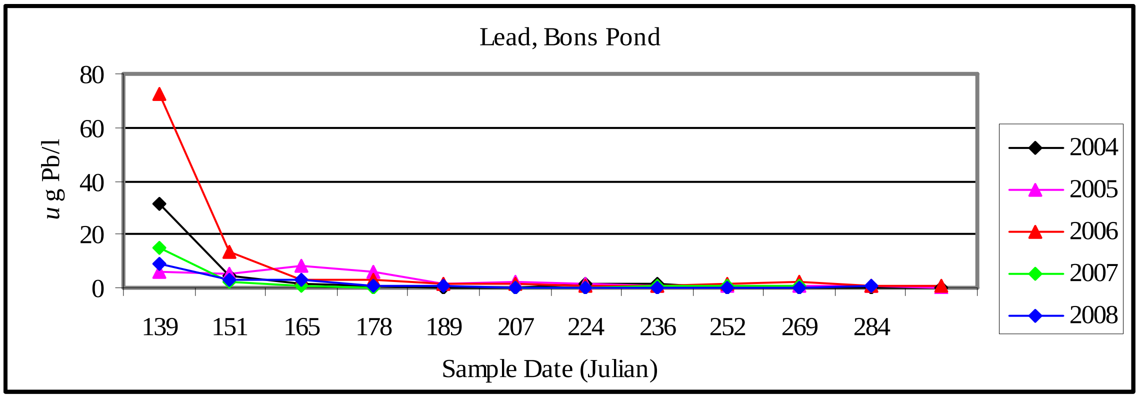


Figure 21. Pb concentrations in Bons Pond (2004 to 2008).

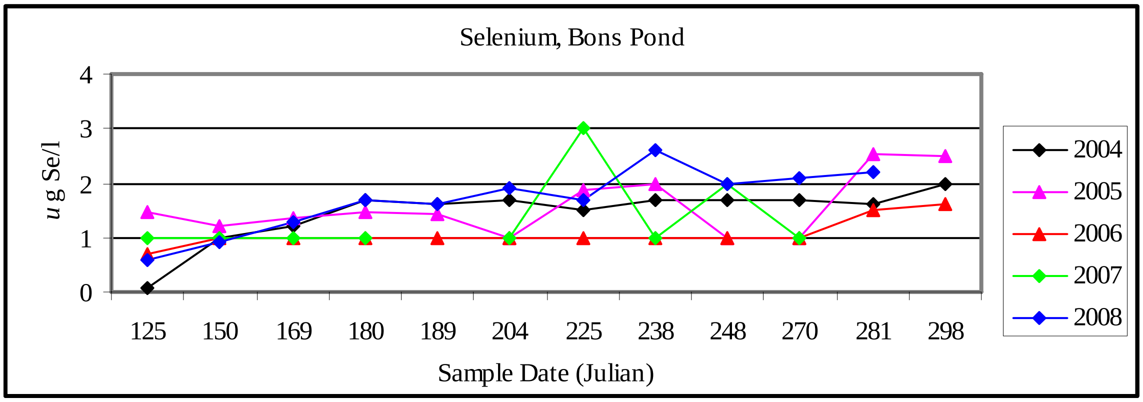


Figure 22. Se concentrations in Bons Pond (2004 to 2008).

We believe that there many be several reasons for the peak concentrations of Zn, Cd, and Pb occurring in early spring. These include the flushing of fugitive dust accumulations from the prior winter, sediment input from the creeks due to erosion, and the possibility that the interceptor system downstream of the Kivalina Waste Dump does not function effectively until the ground has thawed. Several projects are underway and have been for some time to mitigate fugitive dust. Natural stream erosion and sediment input are something that will continue to occur, but thought should be given to evaluating the long-term effectiveness of the interceptor system downstream of the Kivalina Waste Dump.

Periphyton Standing Crop

Algal biomass samples, as estimated by chlorophyll-a concentrations (mg/m^2), are collected each year at seven NPDES sites. We have now collected these samples for 10 years (1999 to 2008). In 2004, we added four new sites in the Bons and Buddy Creek drainages. In all years except 2006, these samples were collected in early July. The lowest chlorophyll-a concentrations in 2008 were seen in Middle Fork Red Dog Creek (Station 20) and some of the highest occurred in the Bons and Buddy Creek sites (Figure 23 and Appendix 3). Similar patterns were seen in 2007 (Figure 24).

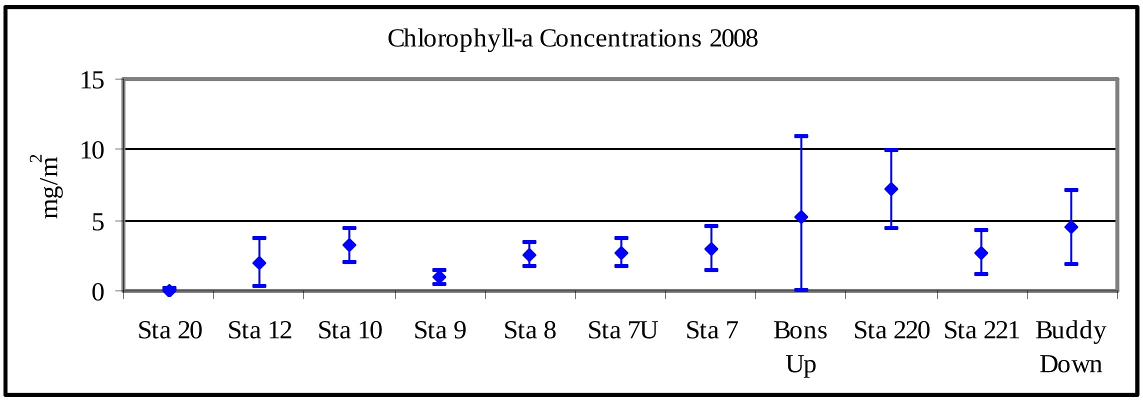


Figure 23. Average concentration of chlorophyll-a, plus and minus one standard deviation, at the NPDES sample sites and in the Bons and Buddy Creek drainages.

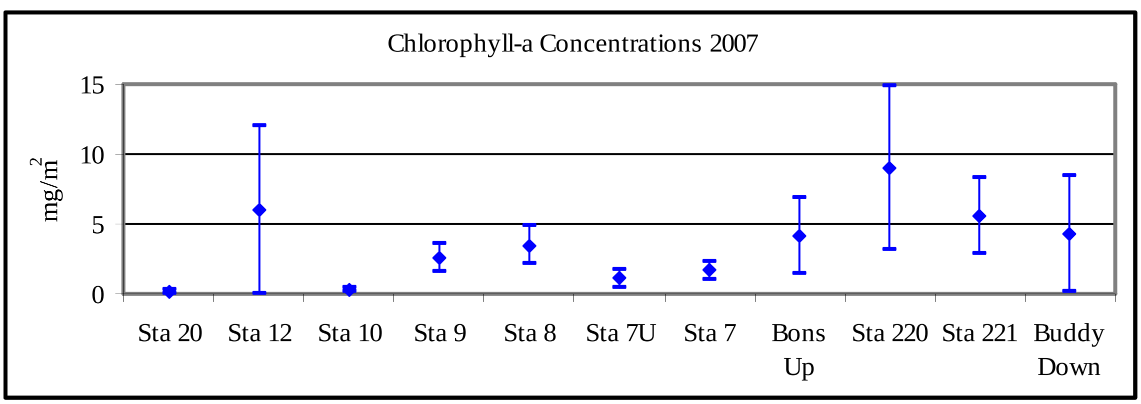


Figure 24. Average concentration of chlorophyll-a, plus and minus one standard deviation, at the NPDES sample sites and in the Bons and Buddy Creek drainages.

Average chlorophyll-a concentrations in North Fork Red Dog Creek from 1999 through 2008 varied from a low of .97 to a high of 6.39 mg/m^2 (Figure 25). Generally, chlorophyll-a concentrations in North Fork Red Dog Creek were higher than in Mainstem Red Dog Creek (Figure 26). In 7 out of 10 years, higher concentrations were found in North Fork Red Dog Creek. Except for 2004, chlorophyll-a concentrations were greater than 2 mg/m^2 in North Fork Red Dog Creek. In contrast, the average chlorophyll-a concentrations in Middle Fork Red Dog Creek ranged from a low of 0 to a high of 0.28 mg/m^2 (Figure 27). The lower periphyton standing crop in Middle Fork Red Dog Creek is likely related to higher metals concentrations from the clean water bypass.

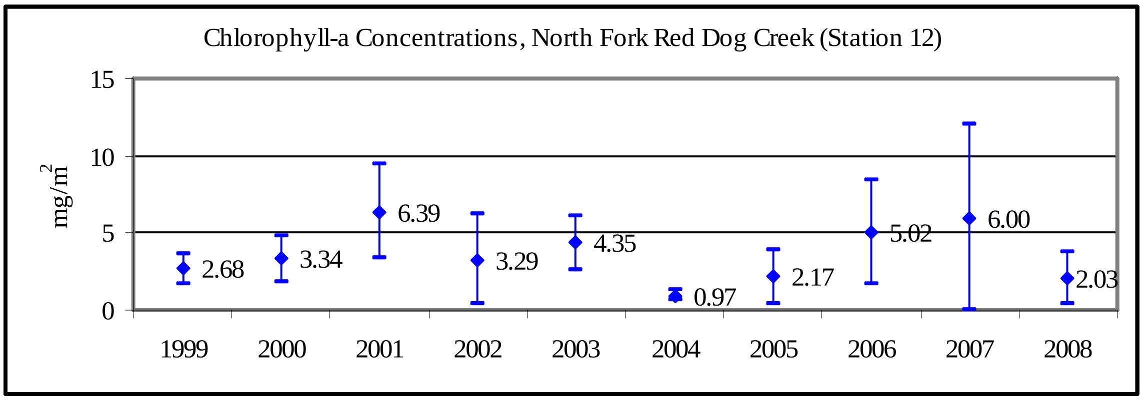


Figure 25. Average concentration of chlorophyll-a, plus and minus one standard deviation, in North Fork Red Dog Creek.

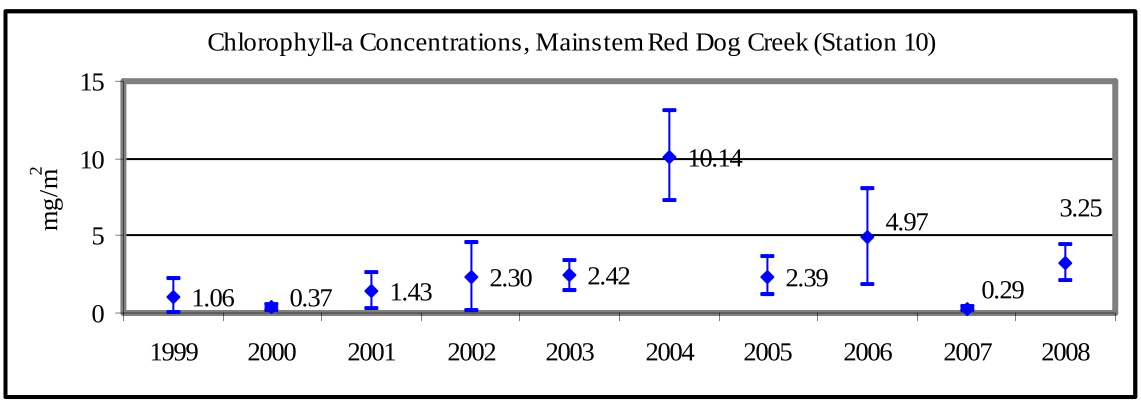


Figure 26. Average concentration of chlorophyll-a, plus and minus one standard deviation, in Mainstem Red Dog Creek.

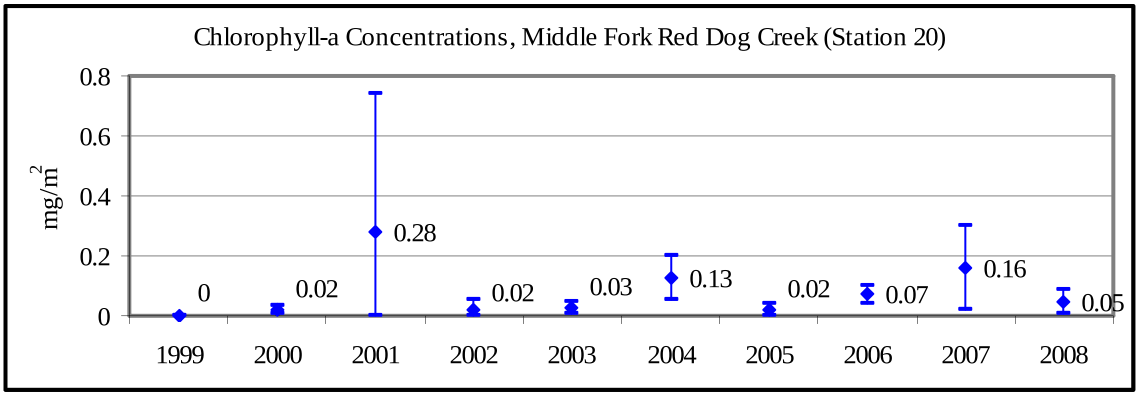


Figure 27. Average concentration of chlorophyll-a, plus and minus one standard deviation, in Middle Fork Red Dog Creek.

Periphyton standing crop also tracks very closely with elevated metals (Zn and Cd) in Ikalukrok Creek at Station 9. Water quality at Station 9 is not affected by water from the Red Dog Mine facility, but is affected by natural mineral seeps located upstream and along Ikalukrok Creek (Ott and Morris, 2007) (Figure 28). Chlorophyll-a concentrations are higher when the Zn and Cd concentrations are lower (Figures 29, 30, and 31).

Figure 28. Cub Creek seep is located about 10 km upstream of Station 9.

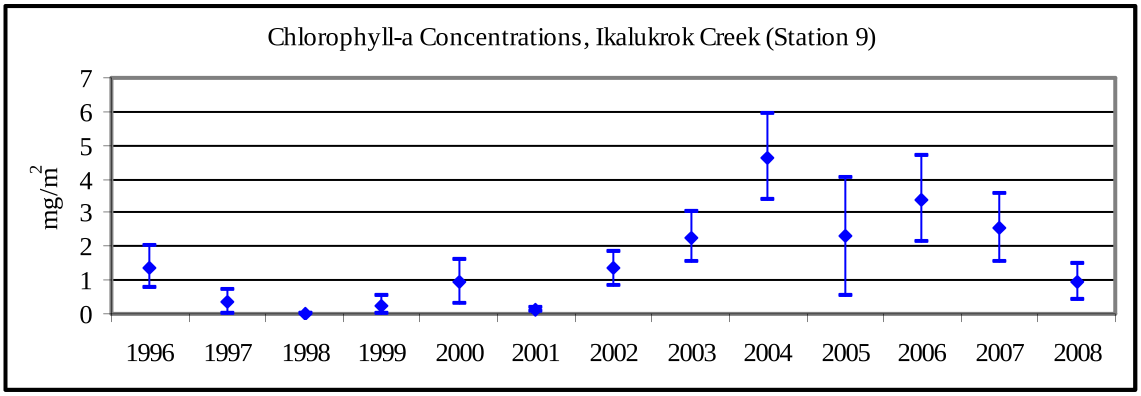


Figure 29. Average concentration of chlorophyll-a, plus and minus one standard deviation, in Ikalukrok Creek.

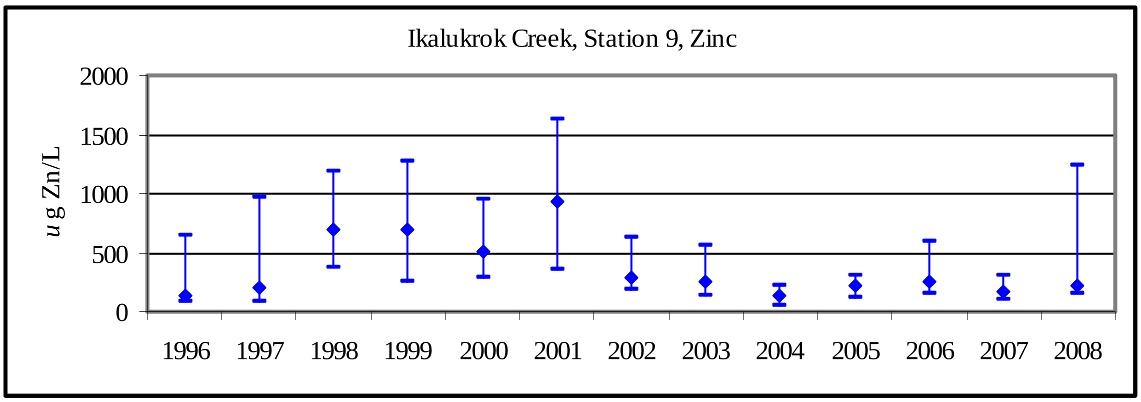


Figure 30. Median, maximum, and minimum Zn concentrations at Station 9.

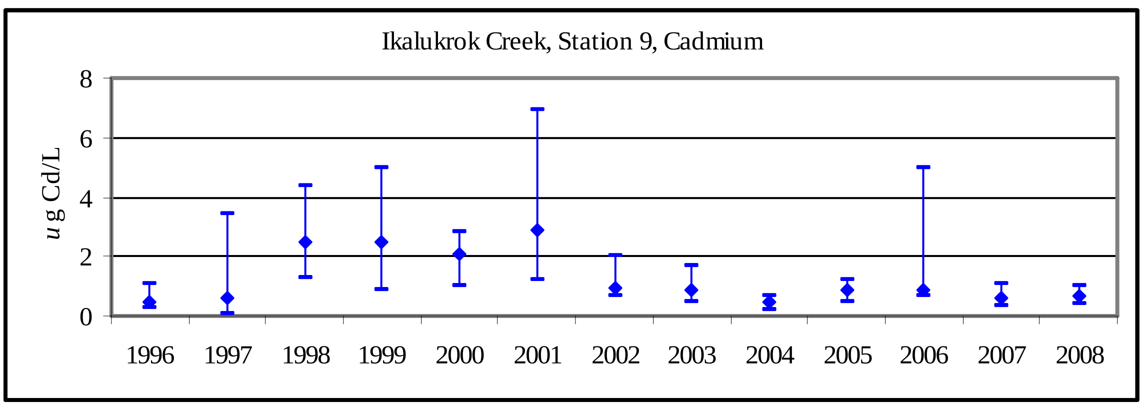


Figure 31. Median, maximum, and minimum Cd concentrations at Station 9.

Aquatic Invertebrates

Aquatic invertebrate samples are collected annually using drift nets at seven NPDES sample sites. The NPDES sites have been sampled since 1999 with all sampling done in late-June/early-July, except in 2006 when, due to rainfall events, samples were collected in August. In 2004, we added four new sites in the Buddy and Bons Creek drainages and employed the same methods/protocols as the NPDES sites. Summary data for these sites are presented in Appendix 4.

In 2008, the density of aquatic invertebrates was highest in Bons Creek (Station 220) downstream of Bons Pond (Figure 32). Higher densities in Bons Creek (Station 220) are due, in part, to the presence of Ostracods coming from Bons Pond. Aquatic invertebrate densities were lowest in Ikalukrok Creek and in Middle Fork Red Dog Creek (Station 20) and, by comparison, higher in the Bons and Buddy Creek drainages and in North Fork and Mainstem Red Dog creeks. The lowest density found was 3.39 in Middle Fork Red Dog Creek. The Middle Fork Red Dog Creek site (Station 20) also has the lowest periphyton standing crop and the highest metals concentrations. Generally, the higher densities of aquatic invertebrates track closely with the periphyton standing crop data.

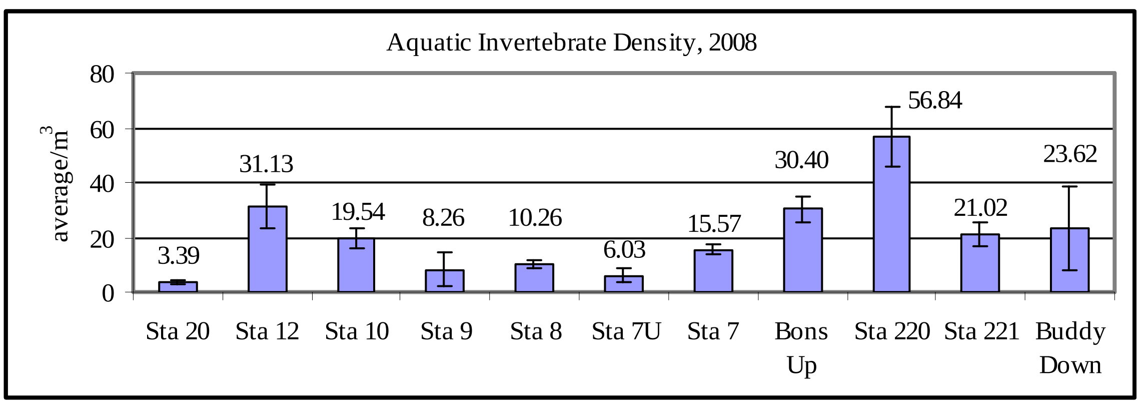


Figure 32. Aquatic invertebrate densities (average plus and minus one SD).

Aquatic invertebrate densities for North Fork Red Dog Creek, Mainstem Red Dog Creek, and Ikalukrok creeks from 1999 through 2008 are presented in Figures 33, 34, and 35. The highest density recorded in Mainstem Red Dog and North Fork Red Dog creeks occurred in 2008. The lowest density recorded at all three sites was in 2004. Generally, aquatic invertebrate densities are consistently higher in North Fork Red Dog Creek. North Fork Red Dog Creek is the most productive of these three sites. Lower productivity in Mainstem Red Dog and Ikalukrok creeks probably is related to higher metals concentrations from natural mineral seeps that occur upstream. Mineral seeps are not apparent in the North Fork Red Dog Creek drainage.

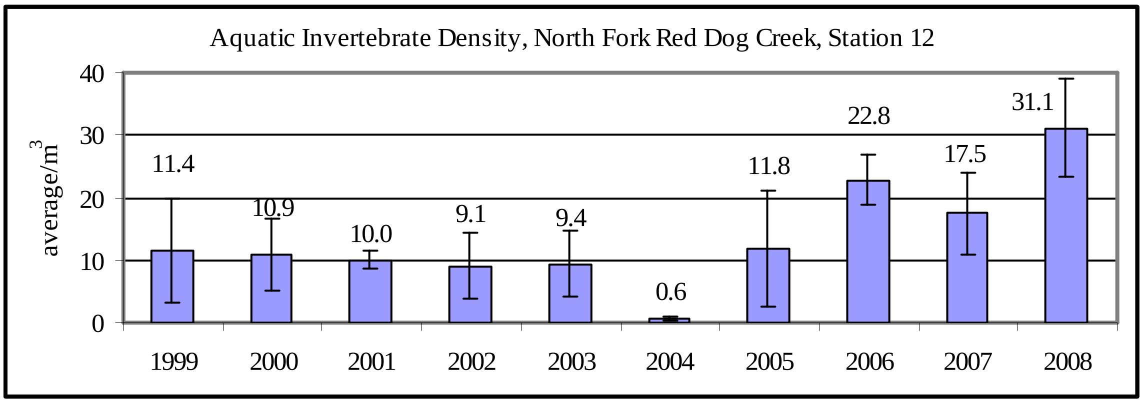


Figure 33. Aquatic invertebrate density (average plus and minus one SD) in North Fork Red Dog Creek.

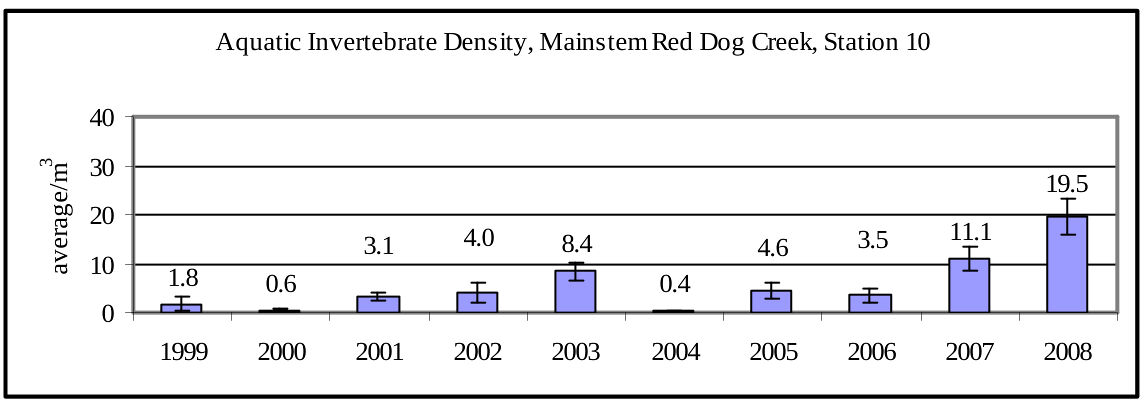


Figure 34. Aquatic invertebrate density (average plus and minus one SD) in North Mainstem Red Dog Creek.

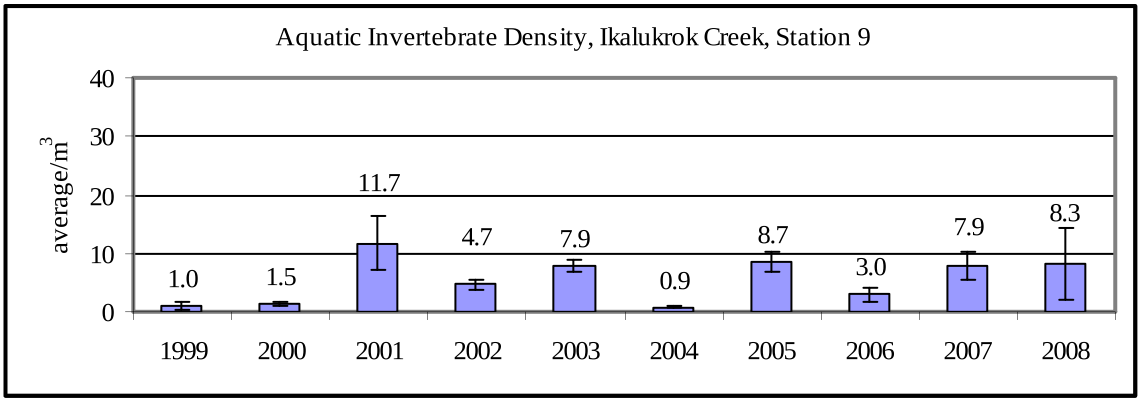


Figure 35. Aquatic invertebrate density (average plus and minus one SD) in Ikalukrok Creek.

The percent Ephemeroptera, Plecoptera, and Tricoptera (EPT) in North Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks from 1999 through 2008 are presented in Figures 36, 37, and 38. The percent EPT varied from a low of 7% to a high of 57% in North Fork Red Dog Creek. In Mainstem Red Dog Creek the highest EPT was 55% and the lowest was 5%. The percent EPT in Ikalukrok Creek also varied among sample years, but in general it was higher than the other two sites – ranging from 25% to 79%. In 8 out of 10 years the EPT was higher in Ikalukrok Creek at Station 9. Caddisflies were an insignificant contributor to the EPT at all three sites. Generally, higher EPT percentages reflect better overall water quality, but this obviously is not the case for sample sites at the Red Dog Mine.

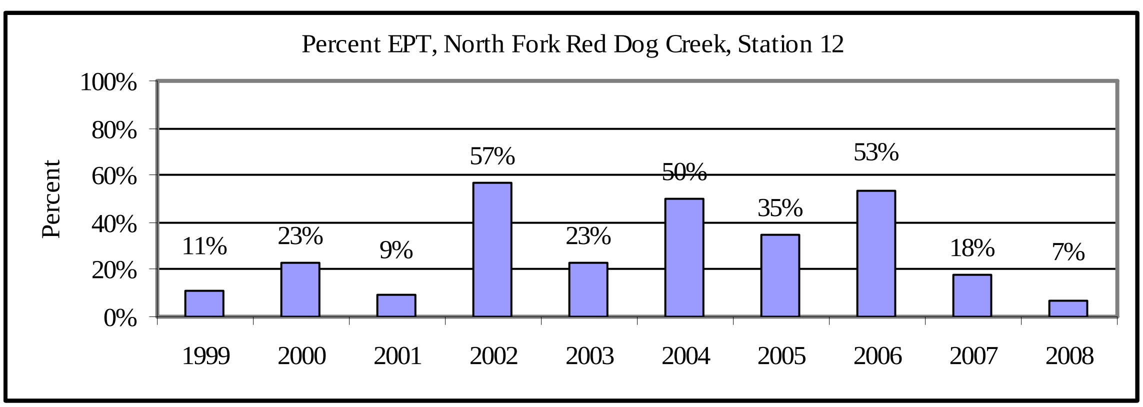


Figure 36. Percent EPT in North Fork Red Dog Creek.

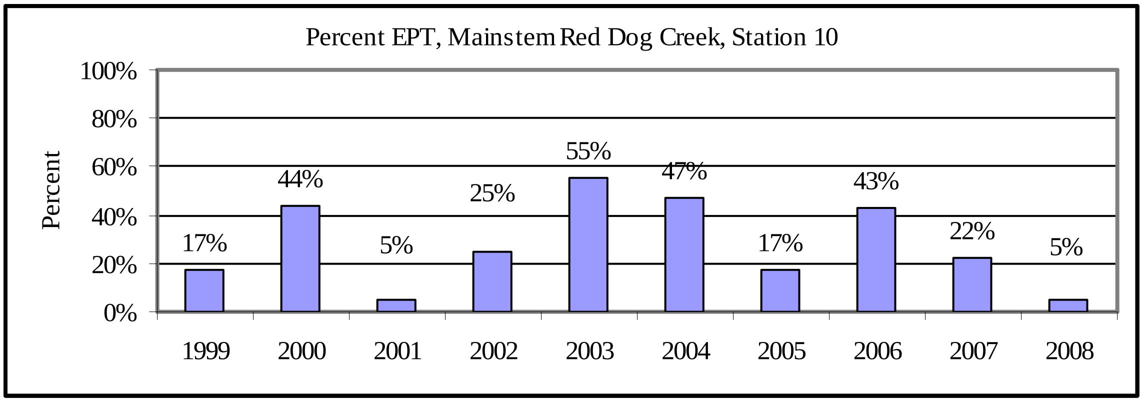


Figure 37. Percent EPT in Mainstem Red Dog Creek.

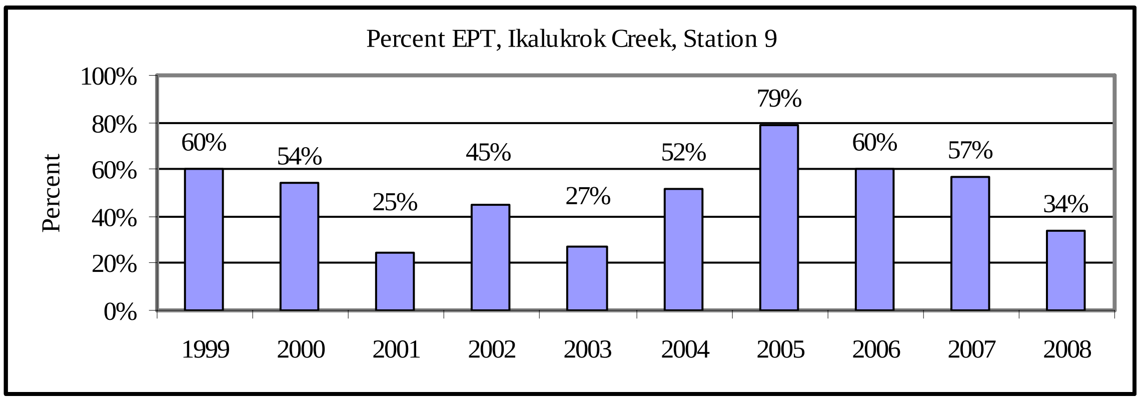


Figure 38. Percent EPT in Ikalukrok Creek.

We looked at taxa richness for all current sample sites from 2004 through 2008. There is virtually no difference over time at either the NPDES sites or at the Bons and Buddy Creek sites (Figures 39 and 40). These data would indicate that aquatic conditions at these sites (11 total sites) have been stable over the past 5 years. There also is no difference among the Red Dog drainage sites and those in the Bons and Buddy Creek drainages.

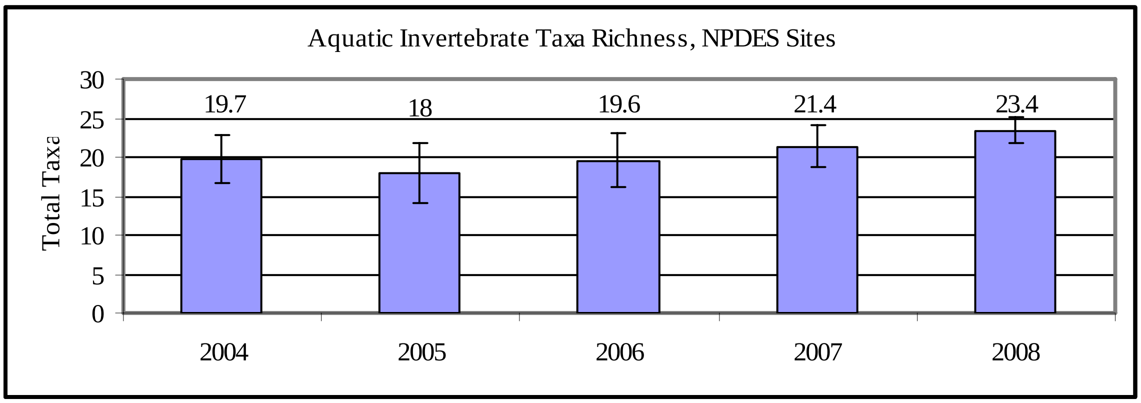


Figure 39. Aquatic invertebrate taxa richness at NPDES sample sites (average plus and minus one SD).

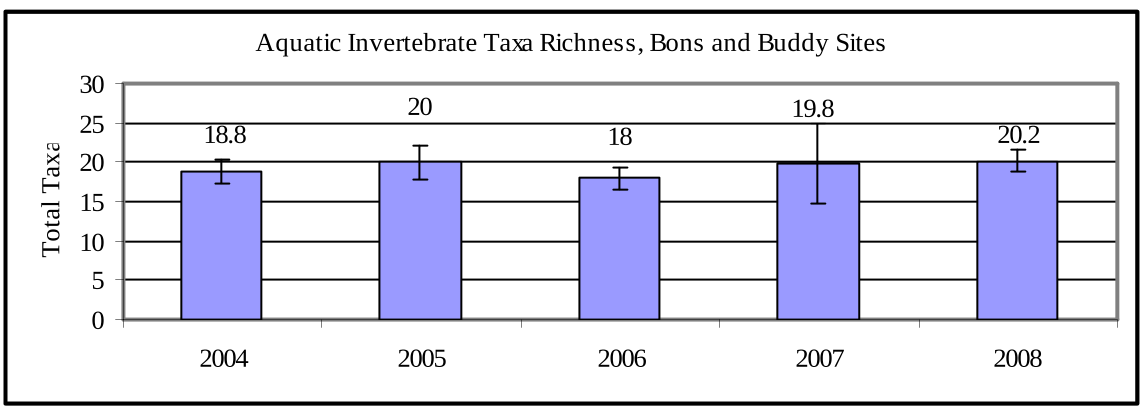


Figure 40. Aquatic invertebrate taxa richness at the Bons and Buddy Creek sample sites (average plus and minus one SD).

Metals Concentrations in Juvenile Dolly Varden

Although not required by permit condition, we have sampled juvenile Dolly Varden to determine whole body concentrations of selected metals. The purposes of this effort are: (1) to determine if differences exist among the sample sites that can be linked with background water quality; and (2) to track change over time. Juvenile Dolly Varden were selected as the target species because of their wide distribution in the Red Dog area streams, their presence in Mainstem Red Dog Creek, their residence in freshwater for 2 to 4 years before smolting, and their rearing in the sample sites only during the ice-free season. Juvenile Arctic grayling were added for monitoring after we had successfully established a self-sustaining population in Bons Pond. Arctic grayling captured in Bons Pond have been in the pond upstream of the freshwater dam their entire life and therefore serve as a good indicator of year round water quality conditions and change over time.

Ott and Morris (2004) found no relationship between fish length and whole body concentrations of selected metals for pre-smolt sized Dolly Varden. To minimize variability associated with fish being collected, we targeted juvenile Dolly Varden from 90 to 140 mm (basically 2 and 3 year old fish), and collected all samples in August after fish have spent time rearing in the sample reach. Fish larger than 140 mm are excluded because they could be resident fish and may be much older than the fish from 90 to 140 mm. In a similar manner, we selected juvenile Arctic grayling that were between 140 and 220 mm long (predominately 2 or 3 year old fish).

We collected our first Dolly Varden in 1993, and in 1998 began a more systematic program focused on Mainstem Red Dog Creek. Our selected sample size for each stream was initially set at 10 fish, but in 2002 we increased the sample size to 15 fish to better define variability in sample results (Ott and Morris 2004). Even though we have set our sample size at 15 fish, there are years when numbers of fish are low and the desired sample is not achieved.

Cd, Pb, Se, and Zn concentrations (mg/Kg dry weight) for fish collected from Anxiety Ridge, Buddy, and Mainstem Red Dog creeks were compared for the period from 2005 to

2008 (Appendix 5). Condition factor (CF = weight/length^3) X Constant also was calculated for each fish and compared by stream and year. All statistical analyses and condition factor figures are presented in Appendix 6.

Fish condition was similar among the creeks in 2005 to 2008, with the notable exception that juvenile Dolly Varden in Mainstem Red Dog Creek were in better condition than fish from the other two creeks and in significantly better condition than fish from Anxiety Ridge Creek. Closer analysis indicates that two distinct groups of fish were captured in August 2008 in Mainstem Red Dog Creek; one group with more typical condition for the area and one group with exceptional condition (Appendix 6). Fish with exceptionally high condition factors were distributed throughout the size range of the sample suggesting that length/age differences were not the cause of the higher condition. It is possible that exceptionally high condition fish were out-migrants from North Fork Red Dog Creek, but we have no condition data for fish from North Fork Red Dog Creek to verify this assumption. Productivity is higher in North Fork Red Dog Creek and in some years receives high use by rearing juvenile Dolly Varden in the upper portion of the drainage.

Whole body Cd concentrations were consistently higher in fish collected from Mainstem Red Dog Creek and consistently lowest in Anxiety Ridge Creek (Appendix 6, Figures 41, 42, and 43 – note y-axis scales differ among graphs). The higher Cd concentrations in Buddy and Anxiety Ridge creeks both occurred in 2006. Although Cd concentrations were highest in Buddy Creek Dolly Varden in 2006, concentrations were statistically similar to 2008 concentrations (Appendix 6).

Whole body Pb concentrations also were consistently higher in fish collected from Mainstem Red Dog Creek (Appendix 6, Figures 44, 45, and 46 – note y-axis scales differ among graphs) and generally lowest in fish taken from Anxiety Ridge Creek. As was the case with Cd, Pb concentrations were higher in 2006 than in the other years for both Buddy and Anxiety Ridge creeks. However, pairwise comparison tests indicate that Pb concentrations in Buddy Creek Dolly Varden were statistically similar in 2006, 2007, and 2008 (Appendix 6).

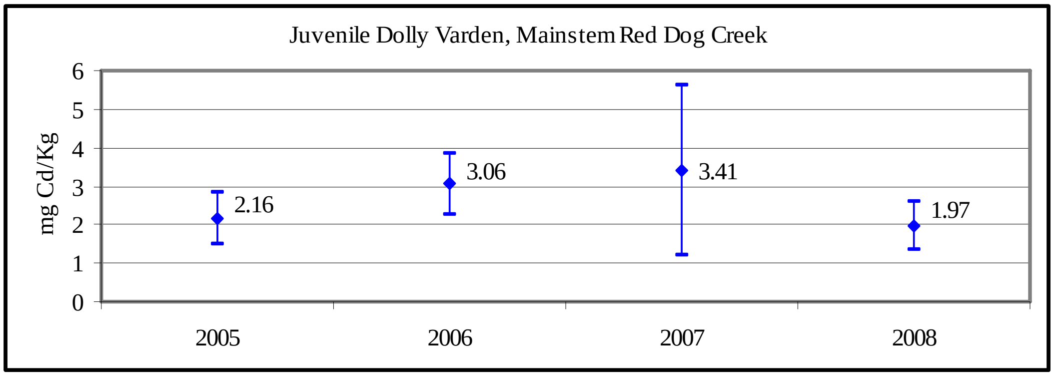


Figure 41. Average (plus and minus 1 SD) Cd concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek.

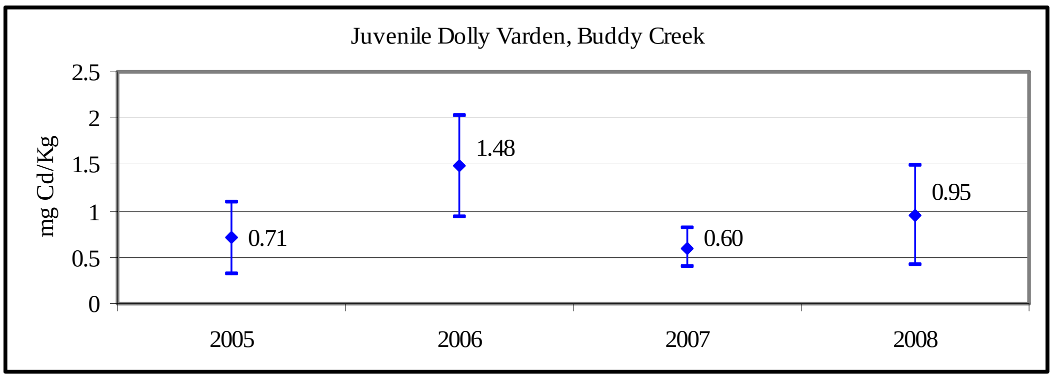


Figure 42. Average (plus and minus 1 SD) Cd concentrations in juvenile Dolly Varden from Buddy Creek.

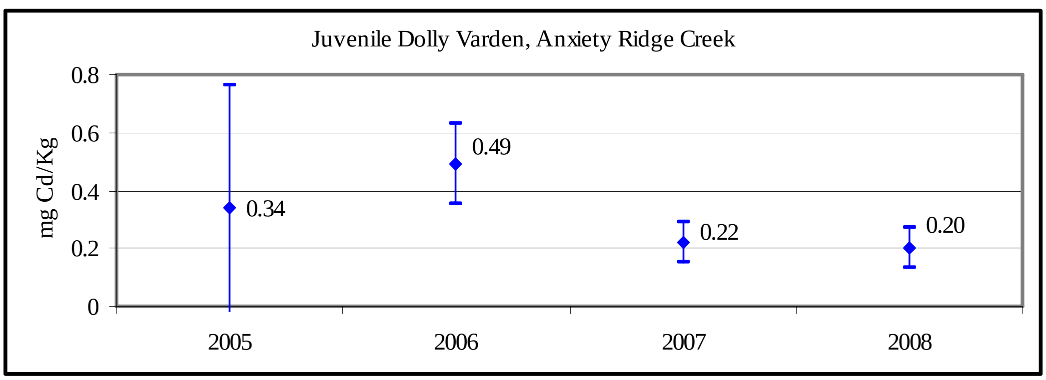


Figure 43. Average (plus and minus 1 SD) Cd concentrations in juvenile Dolly Varden from Anxiety Ridge Creek.

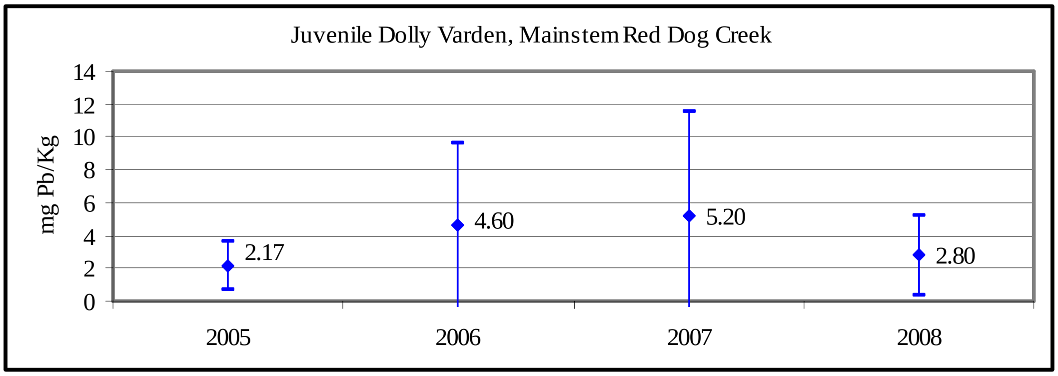


Figure 44. Average (plus and minus 1 SD) Pb concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek.

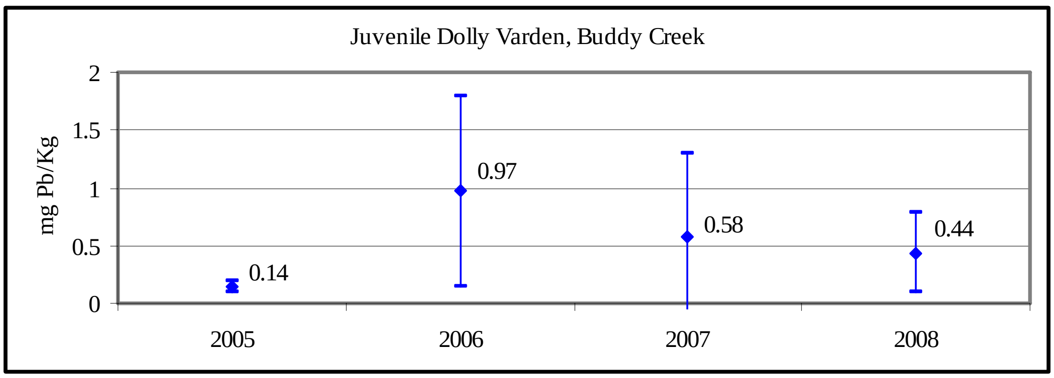


Figure 45. Average (plus and minus 1 SD) Pb concentrations in juvenile Dolly Varden from Buddy Creek.

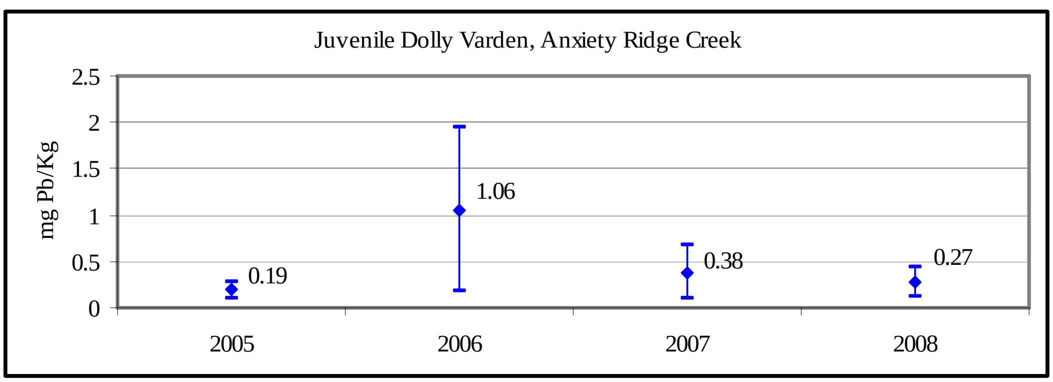


Figure 46. Average (plus and minus 1 SD) Pb concentrations in juvenile Dolly Varden from Anxiety Ridge Creek.

Average whole body Se concentrations were slightly higher in Mainstem Red Dog Creek (Appendix 6, Figures 47, 48, and 49 – note y-axis scales differ among graphs). Se concentrations appeared to decrease slightly from 2005 to 2007 and then increase slightly in 2008. However, there is a significant decreasing trend with time for Se whole body concentrations for Dolly Varden juveniles captured in Mainstem Red Dog Creek (Appendix 6). But, time only accounts for about 50% of the variability observed in Se concentrations in Mainstem Red Dog Creek. Of the metals discussed, there is less difference among the three sample sites for Se than for the other metals.

Zn whole body concentrations were highest in Mainstem Red Dog Creek fish and lower in both Buddy and Anxiety Ridge creek fish (Appendix 6, Figures 50, 51, and 52 – note y-axis scales differ among graphs). Whole body Zn concentrations were highest in fish in Mainstem Red Dog Creek and generally, were higher in Buddy Creek juvenile Dolly Varden than in Anxiety Ridge Creek fish (Appendix 6). Again, as with Cd and Pb, the highest magnitude Zn concentrations were found in 2006 in each of the three sample creeks. However, Zn concentrations in Anxiety Ridge Creek were lowest in 2007, but statistically similar in 2005, 2006 and 2008 (Appendix 6). Similarly, Buddy Creek Dolly Varden Zn concentrations were statistically similar in 2006 and 2008. The lowest Zn concentrations were recorded in 2005 and 2007. Mainstem Red Dog Creek juvenile Dolly Varden Zn concentrations comparisons are more complex; however, for the period 2005 – 2008, the lowest concentrations were recorded in 2005, the highest concentrations were recorded in 2006, but concentrations were statistically similar from 2006 through 2008.

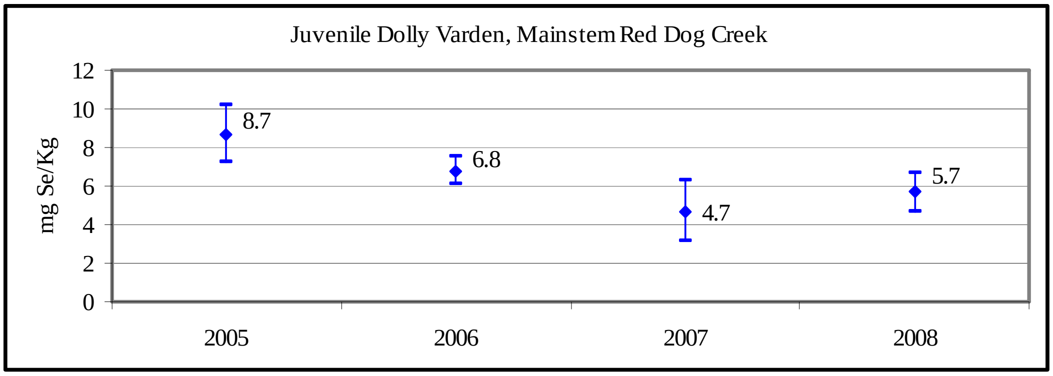


Figure 47. Average (plus and minus 1 SD) Se concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek.

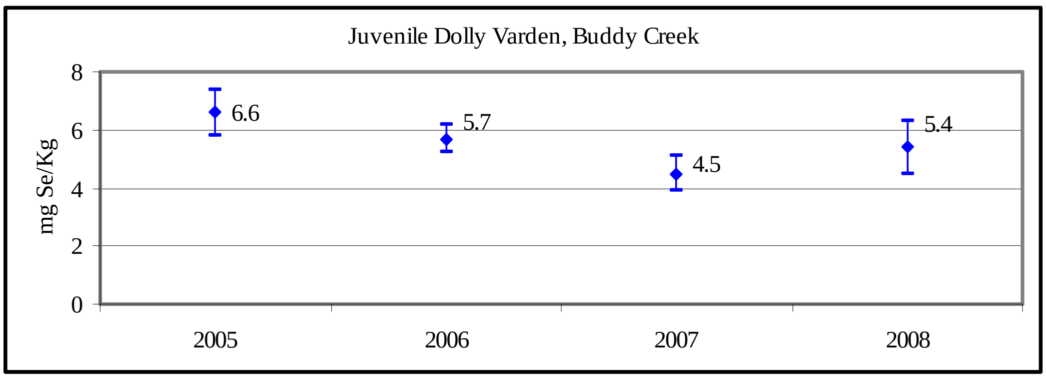


Figure 48. Average (plus and minus 1 SD) Se concentrations in juvenile Dolly Varden from Buddy Creek.

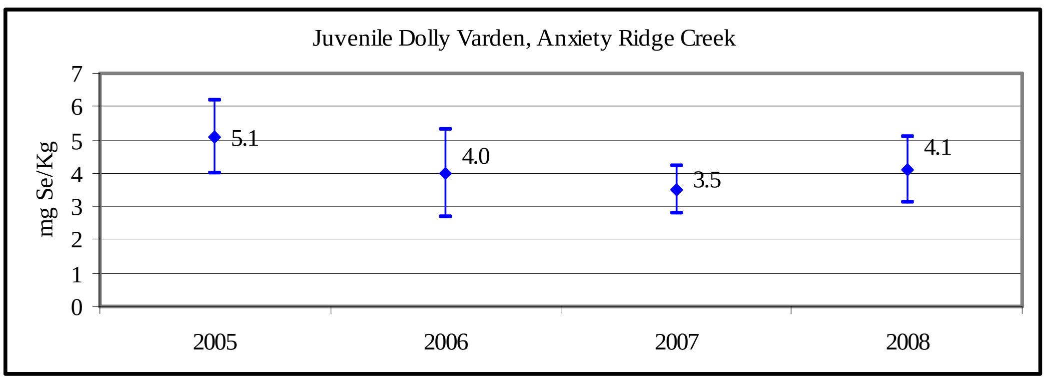


Figure 49. Average (plus and minus 1 SD) Se concentrations in juvenile Dolly Varden from Anxiety Ridge Creek.

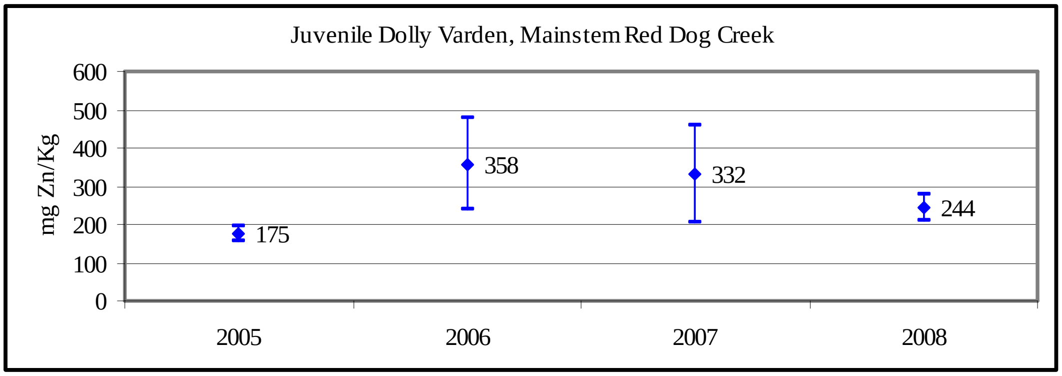


Figure 50. Average (plus and minus 1 SD) Zn concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek.

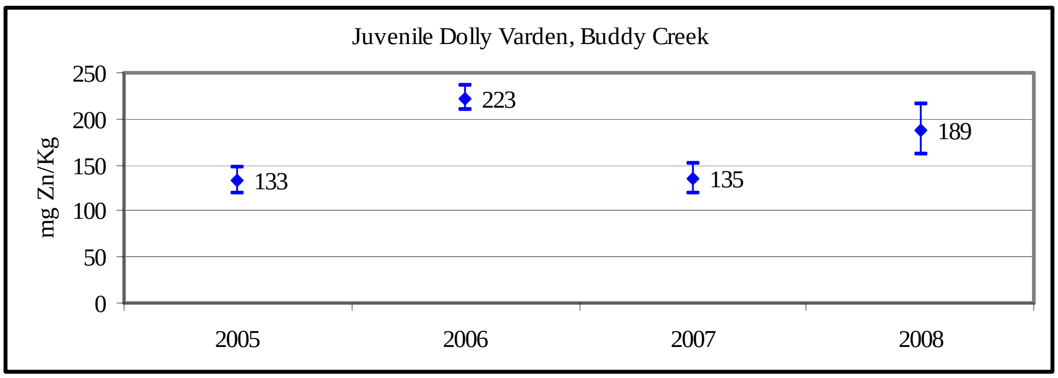


Figure 51. Average (plus and minus 1 SD) Zn concentrations in juvenile Dolly Varden from Buddy Creek.

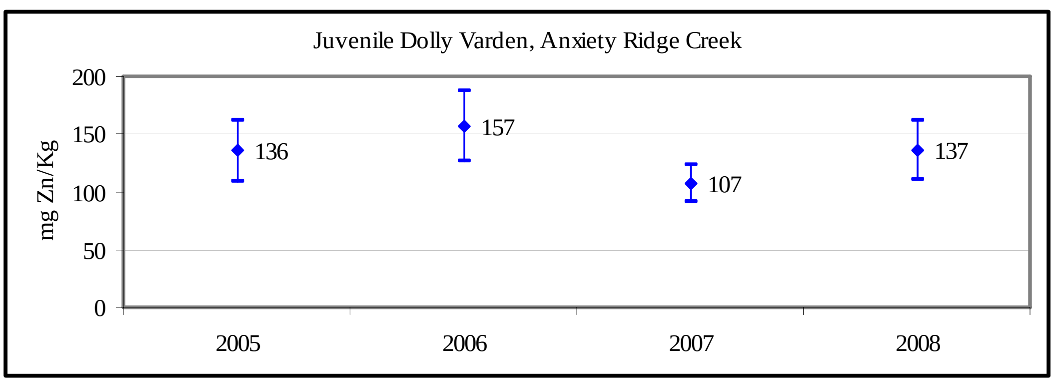


Figure 52. Average (plus and minus 1 SD) Zn concentrations in juvenile Dolly Varden from Anxiety Ridge Creek.

Our second objective was to determine if changes in tissue metals concentrations were occurring over time. In Mainstem Red Dog Creek, we have seen no obvious pattern of change in Cd concentrations from 1998 through 2008 (Figure 53). Linear regression analysis provided no support for a trend in Cd concentrations in fish over time with a resulting non-significant regression (Appendix 6 – Statistical Analyses).

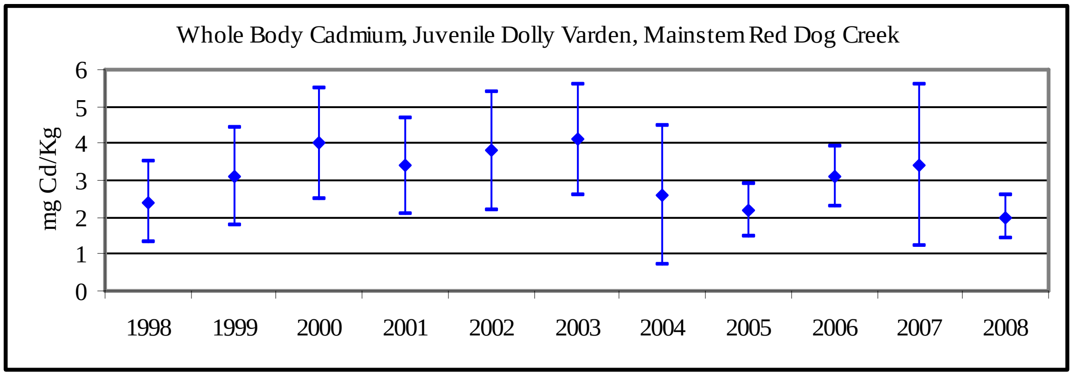


Figure 53. Average (plus and minus 1 SD) Cd concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek.

Average Pb concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek appear to have decreased slightly with time (Figure 54). However, linear regression analysis of Pb concentrations in fish collected from 1998 to 2008 provides no support for a relationship with time (Appendix 6 – Statistical Analyses).

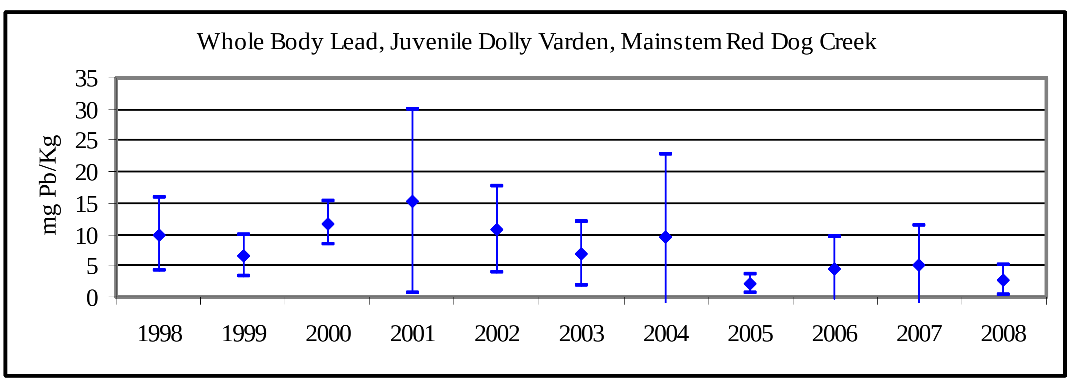


Figure 54. Average (plus and minus 1 SD) Pb concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek.

Juvenile Dolly Varden were analyzed for Zn from 2001 through 2008 (Figure 55). There was an increase in Zn whole body concentrations in 2006 and 2007, but no apparent trend.

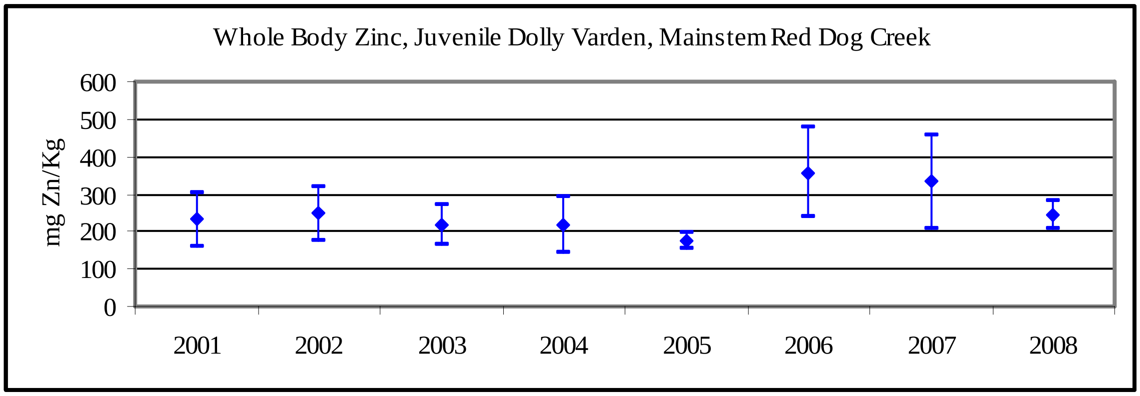


Figure 55. Average (plus and minus 1 SD) Zn concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek.

Arctic grayling juveniles have been sampled twice in Bons Pond (2004 and 2007). In 2004, the average size of the fish collected was 178 mm (range 163 to 190, SD = 7.8). The average size was 186 mm (range 140 to 212, SD = 22.4) for the 2007 sample. Fish conditions, Se and Pb concentrations were similar in both years (Appendix 6). However, Cd concentrations were significantly lower in 2007 than in 2004 whereas Zn was significantly higher in 2007 than in 2004 (Appendix 6, Figures 56 and 57).

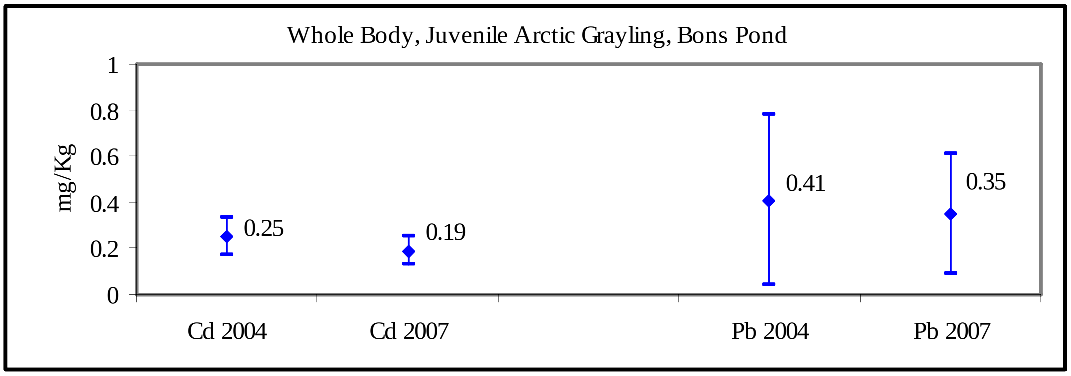


Figure 56. Average (plus and minus 1 SD) Zn concentrations in juvenile Arctic grayling from Bons Pond.

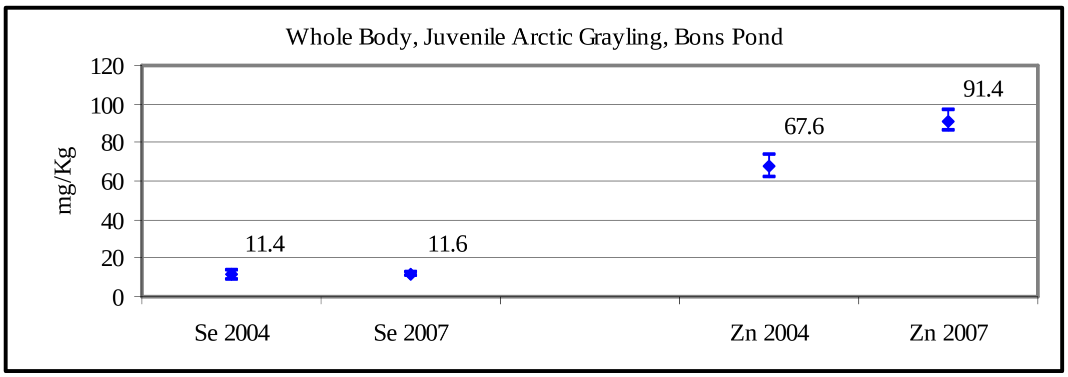


Figure 57. Average (plus and minus 1 SD) Zn concentrations in juvenile Arctic grayling from Bons Pond.

Metals Concentrations in Adult Dolly Varden

Since 1990, we have sampled adult Dolly Varden from the Wulik River (Station 2) near Tutak Creek for metals concentrations (Al, Cd, Cu, Pb, and Zn) in gill, kidney, liver, and muscle tissue (Weber Scannell et al. 2000). In 1997, we added Se and in 1998 we started sampling reproductive tissue, when available. In 2003, we added Hg and Ca to the analytes being tested. In 2004, 2005, 2006, 2007, and 2008, Dolly Varden tissues were analyzed for Al, Cd, Cu, Pb, Se, Zn, and Hg. The sample size for each spring and fall sample period has been 6 fish, except for the fall 2002 sample, when only 5 fish were collected.

The purpose of sampling adult Dolly Varden for metals concentrations is to monitor the long-term condition of fish over the life of the mine, to identify changes in tissue metals concentrations that may be related to mine activities and to provide a data base for use by other professionals. The most likely benefits of this sampling program are long-term monitoring and use of these data by other professionals. It is highly unlikely that tissue metals concentrations changes could be related to event at the Red Dog Mine. All laboratory work has been done with Level III Quality Assurance.

Metals are known to concentrate preferentially in certain organs; however, the relationship of organ concentration to ambient environmental concentrations is unknown. Concentrations of metals vary with season, age, size, weight, and feeding habits of fish (Jenkins 1980) and in the case of anadromous Dolly Varden, the metals concentrations vary with exposure to freshwater and marine environments. None of the analytes we measure concentrate in muscle tissue, but they do in other tissues, as listed below:

- Al concentrates in gill tissue (Figure 58);
- Cd concentrates in kidney tissue (Figure 59);
- Cu concentrates in liver tissue (Figure 60);
- Pb concentrates in gill tissue (Figure 61);
- Se concentrates in kidney and ovarian tissue (Figure 62);
- Zn concentrates in ovarian tissue (Figure 63); and
- Hg concentrates in kidney tissue (Figure 64).

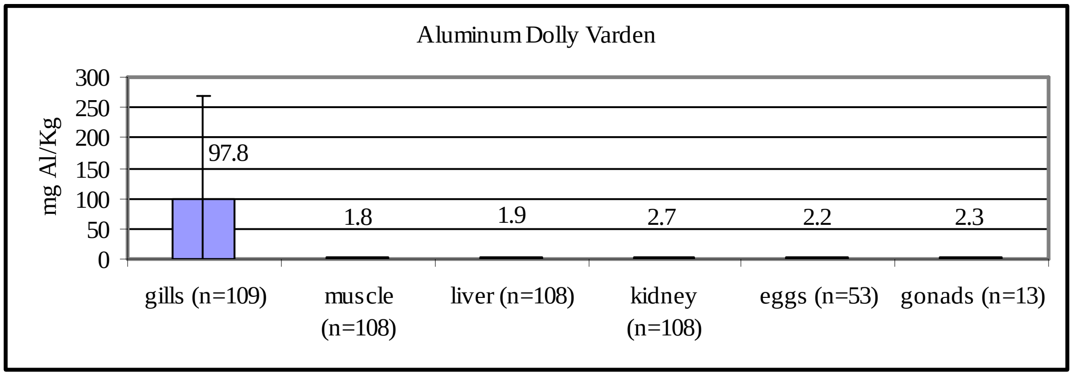


Figure 58. Average (plus and minus 1 SD) Al concentrations in Dolly Varden tissues (1999 to 2008).

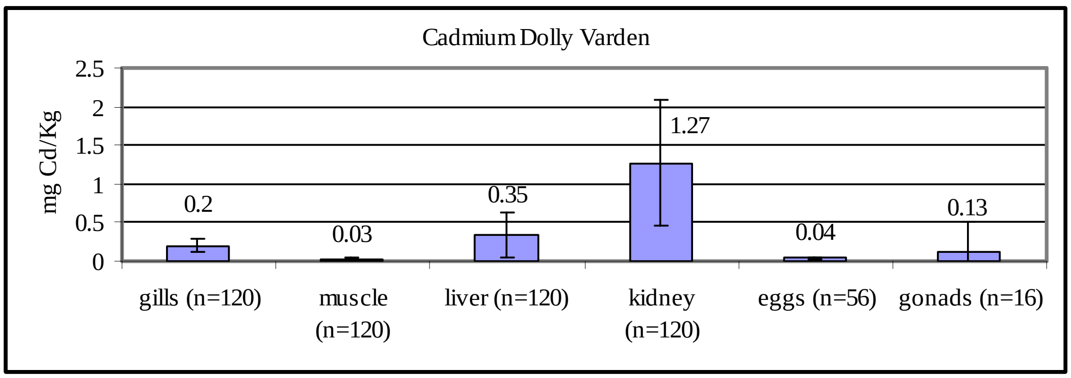


Figure 59. Average (plus and minus 1 SD) Cd concentrations in Dolly Varden tissues (1999 to 2008).

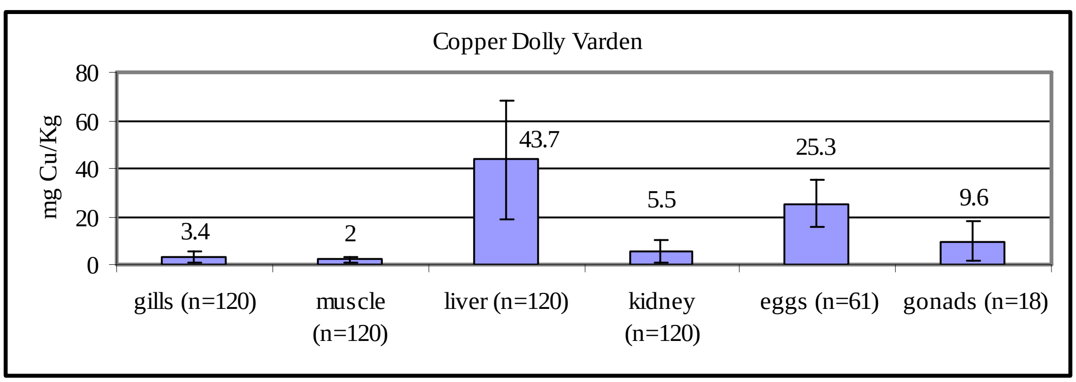


Figure 60. Average (plus and minus 1 SD) Cu concentrations in Dolly Varden tissues (1999 to 2008).

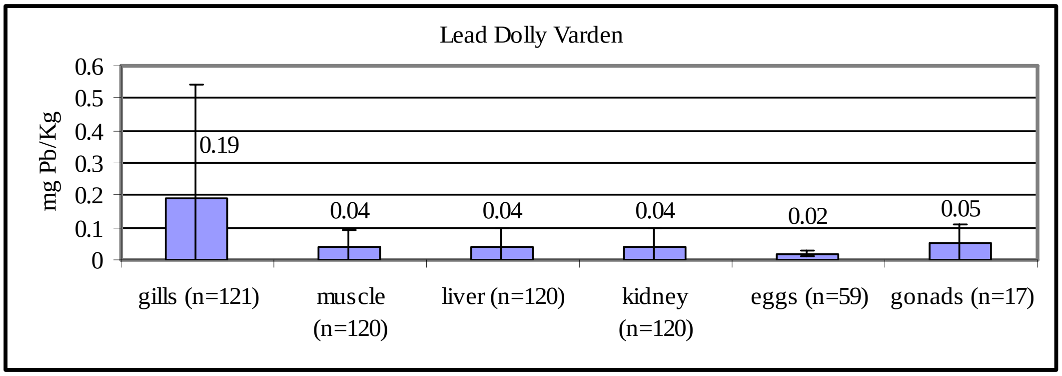


Figure 61. Average (plus and minus 1 SD) Pb concentrations in Dolly Varden tissues (1999 to 2008).

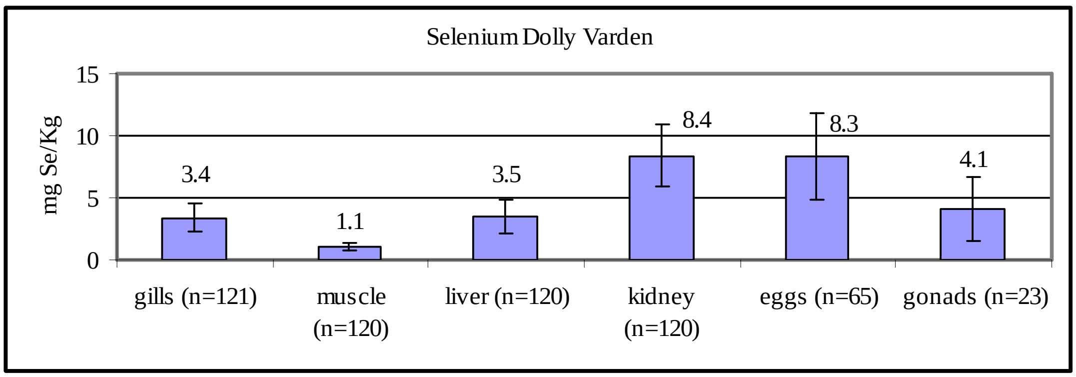


Figure 62. Average (plus and minus 1 SD) Se concentrations in Dolly Varden tissues (1999 to 2008).

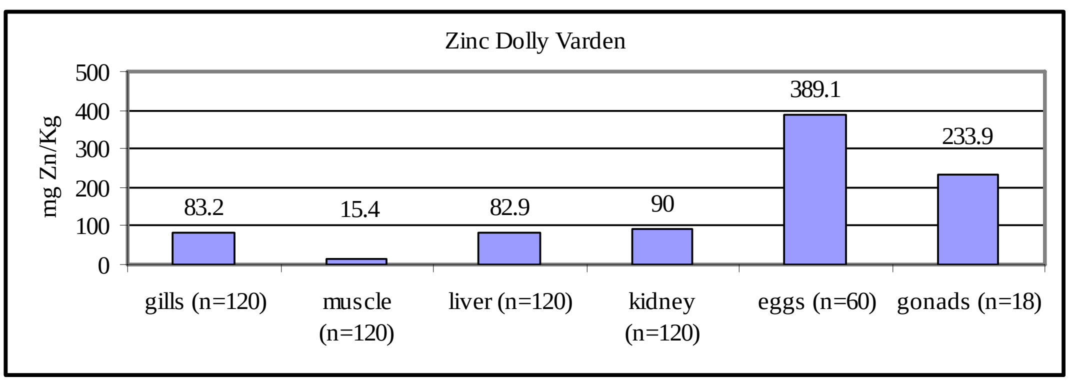


Figure 63. Average (plus and minus 1 SD) Zn concentrations in Dolly Varden tissues (1999 to 2008).

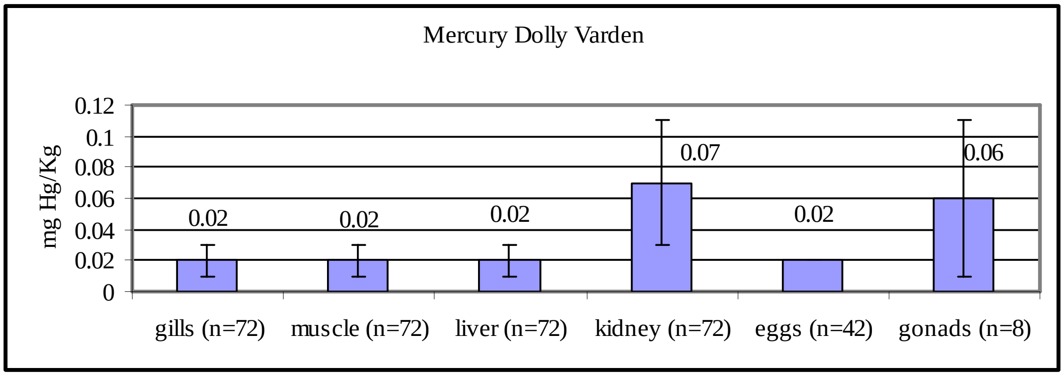


Figure 64. Average (plus and minus 1 SD) Hg concentrations in Dolly Varden tissues (1999 to 2008).

Included in Appendix 7 are figures showing the median, maximum, and minimum concentrations of Al in gill, Cd in kidney, Cu in liver, Pb in gill, Se in ovary, Zn in ovary, and Hg in kidney tissues. Al concentrations are highly variable within samples and among sample events, but a trend up or down is not apparent. Median Cd concentrations in kidney tissue, both spring and fall, are lower than baseline data. Over the last five years, Cd concentrations have been stable and lower than those previously reported. Median Cu concentrations in liver tissue are higher than baseline data, and generally, Cu concentrations in spring-caught fish are higher than in fall-caught fish. Median concentrations of Pb in gill tissue are slightly higher than those reported in baseline reports. Median Se concentrations in ovarian tissue consistently are higher in fall-caught fish. Zn concentrations (median) in ovarian tissue have remained fairly consistent during the sample period. Generally, Zn concentrations are higher in fall-caught fish. Generally, the concentrations of Hg in all tissues, except kidney, are at or below the detection limit.

Dolly Varden, Overwintering

An aerial survey to estimate the number of overwintering Dolly Varden in the Wulik River was flown on September 14, 2008, with a R-44 helicopter provided by Teck (DeCicco 2008). The survey was flown in late afternoon to take advantage of the highest sun angle. The weather was clear and the wind was light out of the east; overall, conditions were nearly ideal. Counts began about 0.8 km upstream of Kivalina Lagoon and fish were distributed nearly to the lagoon and were likely still entering from the sea. The total count was 71,493 (Figure 65). Overall the count was lower than in the recent past. However, DeCicco indicated that this may have been due to the fact that very few small fish (first year migrants) were present and that small fish often enter later in the fall. Low numbers of first year migrants (250 to 325 mm long) have been reported during the last two surveys and may indicate reduced reproduction.

The number of Dolly Varden estimated in the fall in the Wulik River varies annually (Figure 65 and Appendices 8 and 9). Survey results in 2008 found that about 99% of the fish seen were downstream of the mouth of Ikalukrok Creek. Only in 2004 has the percentage of fish below Ikalukrok Creek been less than 90%. Continued use of this section of the Wulik River by the majority of overwintering Dolly Varden suggests that conditions have not changed to affect the distribution of these fish.

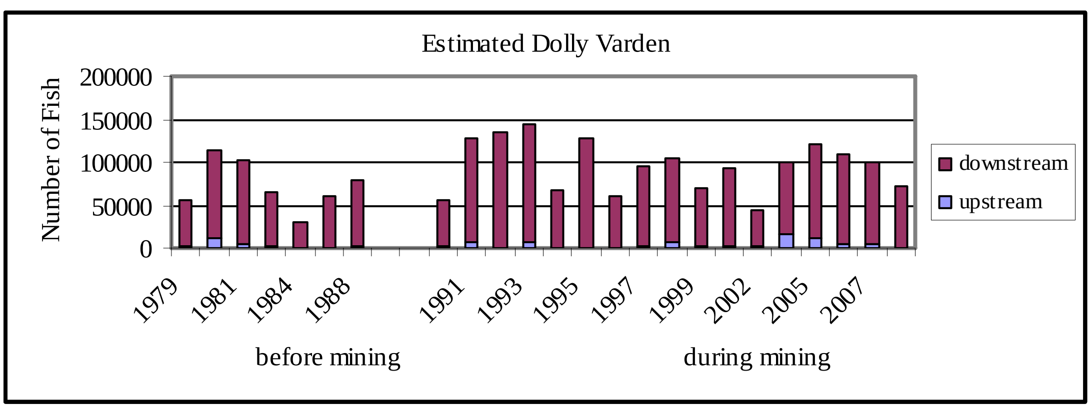


Figure 65. Estimated count of Dolly Varden in the Wulik River in fall just prior to freezeup.

Chum Salmon, Spawning

ADF&G conducts annual aerial surveys to assess the distribution of adult chum salmon in Ikalukrok Creek from its confluence with the Wulik River upstream to Dudd Creek (Table 4, Appendix 9). In fall 2008, we flew a R-44 helicopter survey along Ikalukrok Creek. Survey conditions were good with clear skies and very little wind, but in deep water areas visibility was limited. We estimated 3,820 chum salmon – the second highest count made since post-mining surveys began in 1990. Most of the chum salmon were seen in the lower 20 km of Ikalukrok Creek. Large numbers were seen in several backwater areas and in areas normally not containing adult spawners. In years of high escapements, the adults spread over a much larger area of lower Ikalukrok Creek. This is only the second year where we have seen active spawning in backwater sloughs.

All chum salmon observed were below Station 160 on Ikalukrok Creek, - the downstream limit of the mixing zone. Counts of chum salmon in Ikalukrok Creek after mine development in 1990 and 1991 were lower than reported in baseline studies. Surveys began again in 1995, with the highest count made in fall 2006. Large returns of chum salmon in recent years are good indications that the population has recovered from the early 1990s.

Table 4. Number of chum salmon adults in Ikalukrok Creek.

Survey Date	Number of Chum Salmon	Reference
September 1981	3,520 to 6,960	Houghton and Hilgert 1983
August September 1982	353 to 1,400	Houghton and Hilgert 1983
August 1984	994	DeCicco 1990c
August 1986	1,985	DeCicco 1990c
August 1990	<70	Ott et al. 1992
August 1991	<70	Ott et al. 1992
August 16, 1995	49	Townsend and Lunderstadt 1995
August 1995	300 to 400	DeCicco 1995
August 11, 1996	180	Townsend and Hemming 1996
August 12, 1997	730 to 780	Ott and Simpers 1997
1998	no survey	
August 9, 1999	75	Ott and Morris 1999
2000	no survey	
August 7, 2001	850	Morris and Ott 2001
August 28, 2001	2,250	DeCicco 2001b
August 29, 2001	1,836	DeCicco 2001b
September 23, 2001	500	DeCicco 2001c
October 8, 2001	232	DeCicco 2001a
August 5, 2002	890	Ott and Townsend 2002
August 11, 2003	218	Townsend and Ingalls 2003
August 26, 2004	405	Townsend and Conley 2004
August 29, 2005	350	Thompson 2005
August 14, 2006	4,185	Ott and Timothy 2006
August 11, 2007	1,408 and 1,998	Ott and Townsend 2007
August 6, 2008	3,820	Ott and Jacobs 2008

Dolly Varden, Juveniles

Limited pre-mining juvenile Dolly Varden distribution and use data are available for streams in the Red Dog Mine area. Houghton and Hilgert (1983) identified Anxiety Ridge Creek as the most productive system in the project area. They also reported finding only one Dolly Varden in the North Fork Red Dog Creek drainage and presumed that it was a resident fish. Surveys along Mainstem Red Dog Creek reported either a few fish or the absence of fish, and in some cases mortalities were noted for small juvenile Dolly Varden and Arctic grayling fry (EVS Consultants Ltd and Ott Water Engineers 1983, Ward and Olson 1980).

We have targeted juvenile Dolly Varden in streams in the Red Dog Mine area since 1990. We added new sample sites and increased the number of minnow traps per sample reach in 1992. Currently, we sample 10 sites, as listed in Table 5 (Appendix 10), with 10 minnow traps per sample reach, a fishing effort of about 24 hr, and two sample events each summer (one in late June/early July and one in early to mid-August).

Table 5. Location of juvenile Dolly Varden sample sites.

Site Name	Station No.	Year Sampling Started
Evaingiknuk Creek		1990
Anxiety Ridge Creek		1990
Buddy Creek		1996
North Fork Red Dog Creek	12	1993
Mainstem Red Dog Creek	11	1995
Mainstem Red Dog Creek	10	1996
Ikalukrok Creek above Mainstem	9	1996
Ikalukrok Creek below Mainstem	8	1996
Ikalukrok Creek above Dudd		1990
Ikalukrok Creek below Dudd	7	1990

Minnow traps are the preferred sampling gear for juvenile Dolly Varden because they are very effective for this species and age classes, the gear is suitable for all sample areas (i.e., large to small streams), the effort is uniform across sample sites, variability due to sampler-induced bias is reduced, and there is virtually no mortality to fish. Juvenile Dolly Varden generally are the most numerous fish species present and are distributed most widely in all the sample sites. Our objectives are to assess seasonal patterns of use, to quantitatively assess numbers of fish using streams over time, and to sample juvenile Dolly Varden for whole body metal analyses from selected streams. Data relevant to whole body metal analyses was presented in a previous section of this report.

Relative abundance of juvenile Dolly Varden varies considerably among sample years (Figure 66); however, the relative catches among the sample sites follow similar patterns. Natural environmental conditions such as the duration of breakup, patterns and magnitude of rainfall events, ambient air temperatures, and the strength of the age 1 cohort affect distribution of juveniles and relative abundance. We believe that the most important factor is the strength of the age 1 cohort which is directly related to numbers of spawners and spawning success and survival the previous winter.

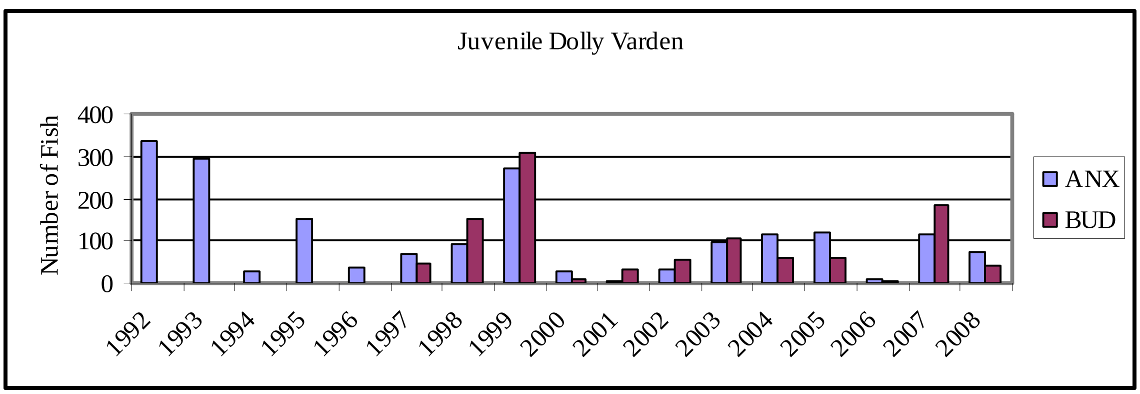


Figure 66. Catch of juvenile Dolly Varden in Anxiety Ridge (ANX) and Buddy (BUD) creeks in late July to early August.

With almost 20 years of sampling for juvenile Dolly Varden in streams near the Red Dog Mine, we have developed the following conclusions: abundance is higher in the upper reaches of each sample stream; peak use occurs from late July to late August depending upon freezeup timing; and although catches vary annually, juvenile Dolly Varden are most abundant in Anxiety Ridge and Buddy creeks.

Catches of juvenile Dolly Varden from 1997 through 2008 in Anxiety Ridge (ANX), Mainstem Red Dog (MS), and North Fork Red Dog creeks are shown in Figure 67 and Appendix 11. Both Anxiety Ridge and North Fork Red Dog creeks are considered reference streams with no direct affects from the wastewater discharge. Catches, although variable among years, are consistently higher in Anxiety Ridge Creek.

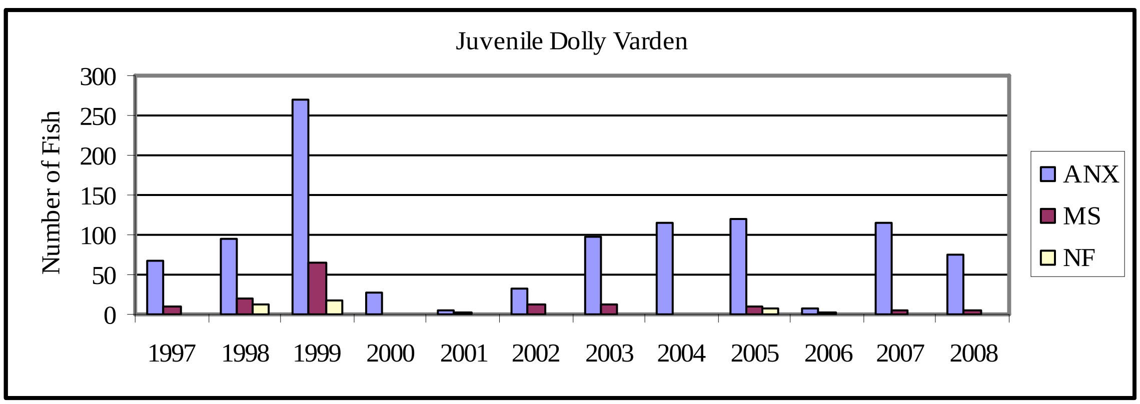


Figure 67. Catches of juvenile Dolly Varden in Anxiety Ridge (ANX), Mainstem Red Dog (MS), and North Fork Red Dog (NF) creeks in late July to early August.

Juvenile Dolly Varden sampling in both upper and lower Mainstem Red Dog Creek has taken place each year since 1997. Sampling is conducted twice each summer with catches always higher later in the summer. Catches were highest in 1998 and 1999, but have been low every year since 2000 (Figure 68).

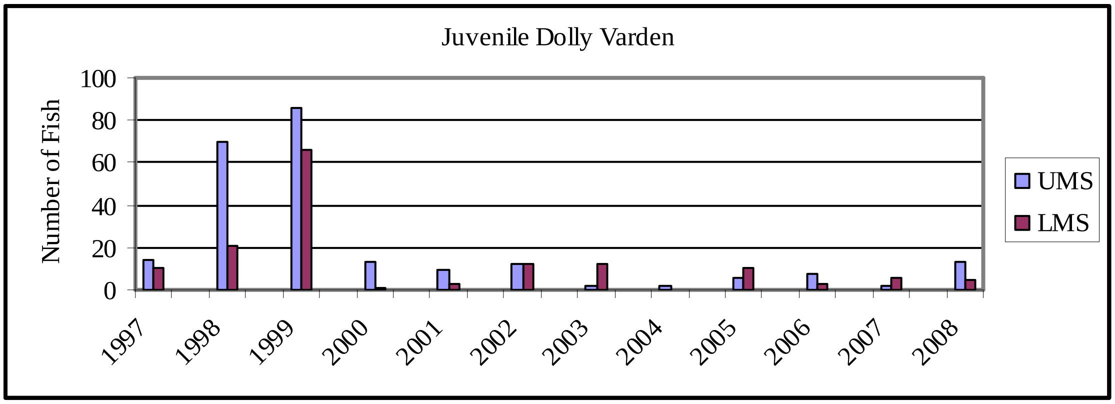


Figure 68. Catches of juvenile Dolly Varden in upper Mainstem Red Dog (UMS) and lower Mainstem Red Dog (LMS) creeks, in late July to early August.

Each spring (2000 through 2008), we catch resident Dolly Varden moving upstream with the Arctic grayling in fyke nets fished in North Fork Red Dog Creek. In spring 2008, we caught 11 Dolly Varden (Figure 69). Most of these fish were presumed to be resident fish due to size (larger than smolts), obvious parr marks, and distinct orange/pink dots. It is unknown whether this consistent change in fish use compared with baseline data is related to water quality improvements in Mainstem Red Dog Creek or simply due to increased sampling effort and the use of fyke nets. It is highly probable that these resident Dolly Varden are following Arctic grayling to feed on Arctic grayling eggs.

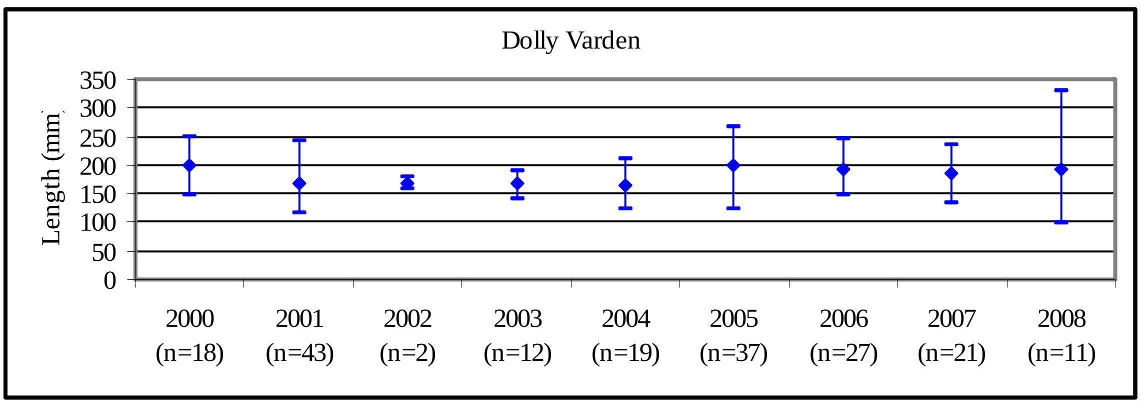


Figure 69. Dolly Varden caught in fyke nets fished in North Fork Red Dog Creek in spring during the Arctic grayling spawning run.

The length frequency distribution of juvenile Dolly Varden, especially the presence of fry, indicates successful reproduction and survival. Dolly Varden less than 60 mm long in late July and early August probably are age 0 (Houghton and Hilgert 1983, DeCicco 1985). Age 0 fish caught in drift nets in Wulik River tributaries in early July were less than 30 mm long. Smolting can occur as early as age 2, but more commonly at age 3 (DeCicco 1990a). Our catch in 2007 in mid-August was 415 fish and in early August 2008 it was 178 fish. The larger sized fish seen in 2007 likely smolted in spring 2008 and the dominant grouping of fish from 85 to 105 mm long is survival of this strong age group from the previous year (Figures 70 and 71).

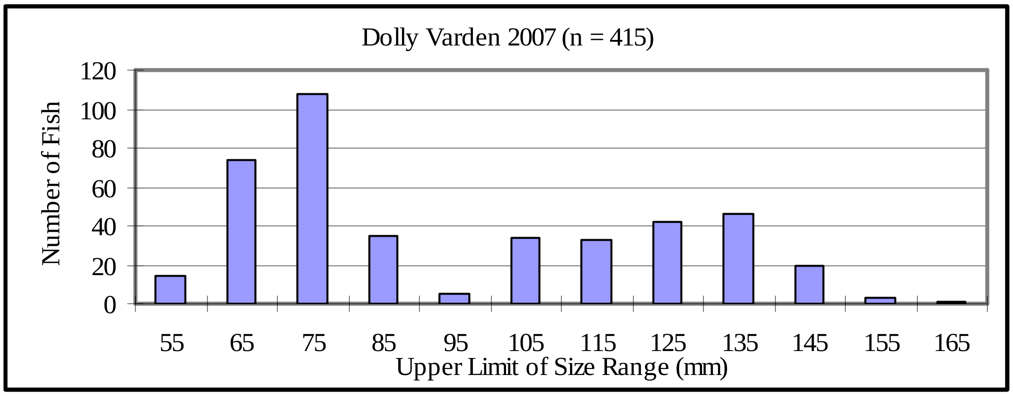


Figure 70. Length frequency distribution of Dolly Varden caught in minnow traps in mid-August 2007 (includes all the NPDES sample sites).

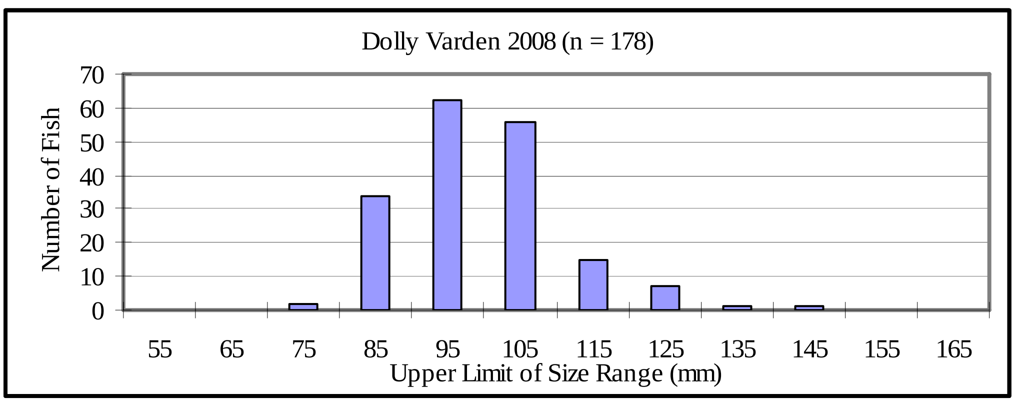


Figure 71. Length frequency distribution of Dolly Varden caught in minnow traps in early August 2008 (includes all the NPDES sample sites).

Arctic Grayling

Before mine development, Arctic grayling adults migrated through Mainstem Red Dog Creek in spring when flows were high and metals concentrations were low (Ward and Olsen 1980, EVS and Ott Water Engineers 1983, and Houghton and Hilgert 1983). Arctic grayling moved through Mainstem Red Dog Creek to spawn in North Fork Red Dog Creek. None of these reports stated or indicated that any Arctic grayling spawned in Mainstem Red Dog Creek. Arctic grayling fry reared in North Fork Red Dog Creek and were displaced downstream by high-water events or outmigrated as water temperatures cooled in fall. Before Red Dog Mine operations, very few, if any, juvenile Arctic grayling were found rearing in North Fork Red Dog Creek. Mortalities of fry were reported in Mainstem Red Dog Creek by EVS Consultants and Ott Water Engineers (1983) and Ward and Olsen (198). Since 1994, we have consistently documented Arctic grayling use (migration, spawning, and rearing) of Mainstem Red Dog Creek (Appendix 12).

Arctic Grayling Spawning

We have monitored Arctic grayling spawning during spring in North Fork Red Dog and Mainstem Red Dog creeks since 2001. The purpose of this sampling effort is to document when spawning has been substantially completed in Mainstem Red Dog Creek. Water temperature is the most likely factor determining spawning time, emergence of fry, first year growth, and survival. High flows during or immediately following spawning have a substantial negative effect on fry survival.

Discharge volume and quality from the wastewater treatment facility at Red Dog are regulated to meet permit conditions (NPDES Permit AK-003865-2, dated August 28, 1998, as modified on August 22, 2003). Total dissolved solids (TDS) concentrations are limited to 500 mg/L at Station 151 (Station 10) during Arctic grayling spawning. Upon completion of spawning in Mainstem Red Dog Creek, TDS concentrations are not to exceed 1,500 mg/L for the remainder of the discharge season.

A TDS site-specific criterion (SSC) of 1,500 mg/L during Arctic grayling spawning was issued by ADEC and became effective on February 15, 2006. The US Environmental Protection Agency (EPA) approved the 1,500 mg/L TDS SSC on April 21, 2006. The SSC as developed by ADEC was based on field and laboratory studies conducted with Arctic grayling at the Red Dog Mine site (Brix and Grosell 2005).

Due to third party appeals and other circumstances, it is unclear which permit version TDS provisions are in effect. Nevertheless, in spring 2008 Teck regulated the wastewater discharge to ensure that TDS concentrations did not exceed the ADEC and EPA approved 1,500 mg/L at Station 151. Spawning based on water temperature could have begun as early as June 1 (Julian Date 153) and was determined to be substantially complete by the evening of June 9 (Julian Date 161). TDS concentrations as required by permit condition did not exceed 1,500 mg/L for the entire 2008 discharge season (Figure 72). TDS concentration averaged 1,089 (n = 4, SD = 176) during Arctic grayling spawning. In 2008 the majority of the fish spawned in Mainstem Red Dog Creek and spawning was successful based on presence of fry during our July sample event.

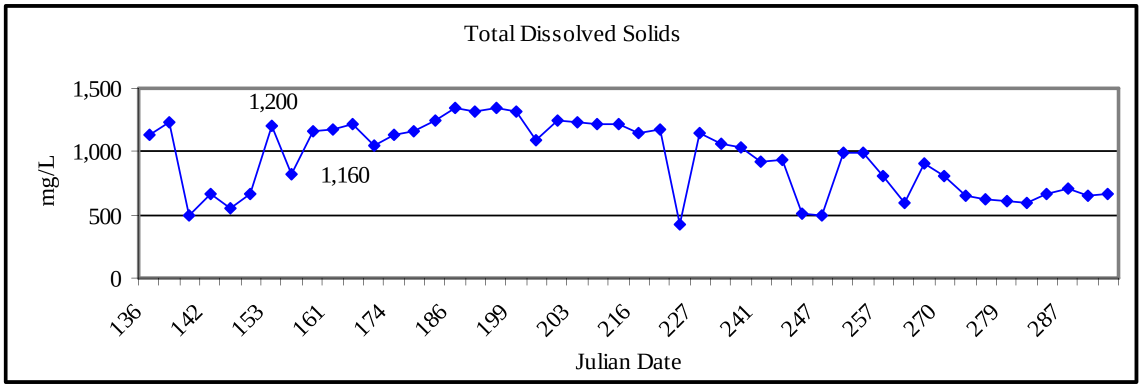


Figure 72. TDS concentrations at Station 151 during 2007. Station 151 is located immediately below the mixing zone in upper Mainstem Red Dog Creek just downstream of the mouth of North Fork Red Dog Creek.

On June 5, 2008, two fyke nets were set in North Fork Red Dog Creek immediately upstream from its confluence with Middle Fork Red Dog Creek. The nets were fished and checked twice daily from June 5 through the morning of June 11. A small fyke net was placed along the east side of North Fork Red Dog Creek and was set to capture upstream moving fish along the thalweg only – the creek was not blocked. The large fyke net was set just upstream of the small net in a backwater area on the west side of the creek with a wing on the east side extending completely across the main current (Figure 73).

Figure 73. North Fork Red Dog Creek, large fyke net in spring 2008.

These two fyke nets capture Arctic grayling moving upstream for spawning and rearing, but we also catch Arctic grayling that have completed their spawning activity in Mainstem Red Dog Creek that have continued to move upstream. The fyke nets provide catch data that help characterize the spawning event in Mainstem Red Dog Creek.

Fyke net catches on June 5 indicated that some spawning had already occurred in Mainstem Red Dog Creek, but it was not until June 9 that catches of fish increased (Figure 74). Our highest catches of female Arctic grayling occurred on June 9 and 10 and by June 10 over 90% of the females were spent. We walked the reach of Mainstem Red Dog Creek, immediately downstream of North Fork Red Dog Creek, on June 6 and 9. We saw one Arctic grayling on June 6 and caught a spent female on June 9. On June 10, we walked about 1.0 km of Mainstem Red Dog Creek just upstream of Station 10 and caught 5 Arctic grayling (4 males, 1 spent female). Active spawning was observed in spring 2007 in Mainstem Red Dog Creek downstream of Station 151 and in a reach upstream of Station 10. In both of these specific runs we did not observe spawning in 2008, but adults were present and feeding although numbers were much lower than those observed in spring 2007. In early July 2008, we noted Arctic grayling fry along stream margins and in backwaters in the vicinity of Station 10 and we caught 45 fry in drift nets on July 4. Successful spawning had occurred in Mainstem Red Dog Creek near Station 10.

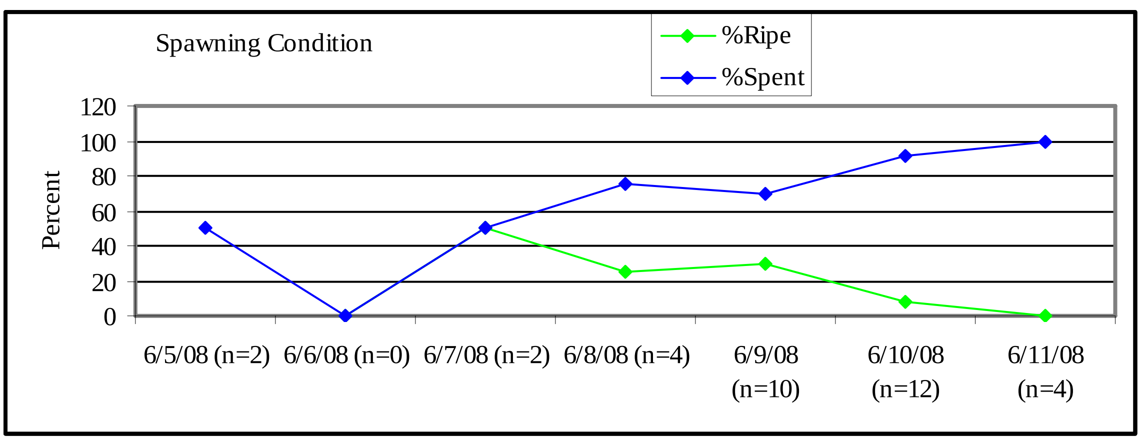


Figure 74. Spawning condition of female Arctic grayling, North Fork Red Dog Creek, June 2008. Total count of females each day, with the net being checked twice daily from June 6 to 10 (around 1000 and 1800 hours).

Our catches in North Fork Red Dog Creek peaked on June 9 and then decreased the next two days. The percentage of males and females versus immature fish remained fairly consistent from June 7 through June 11 (Figure 75). Based on observations made during our visual surveys of the creek and our fyke net catches, we believe that spent fish moved upstream after spawning and immature fish entering the system were also moving through upstream to North Fork Red Dog Creek. In contrast, Arctic grayling were observed leaving Mainstem Red Dog Creek after spawning in spring 2007.

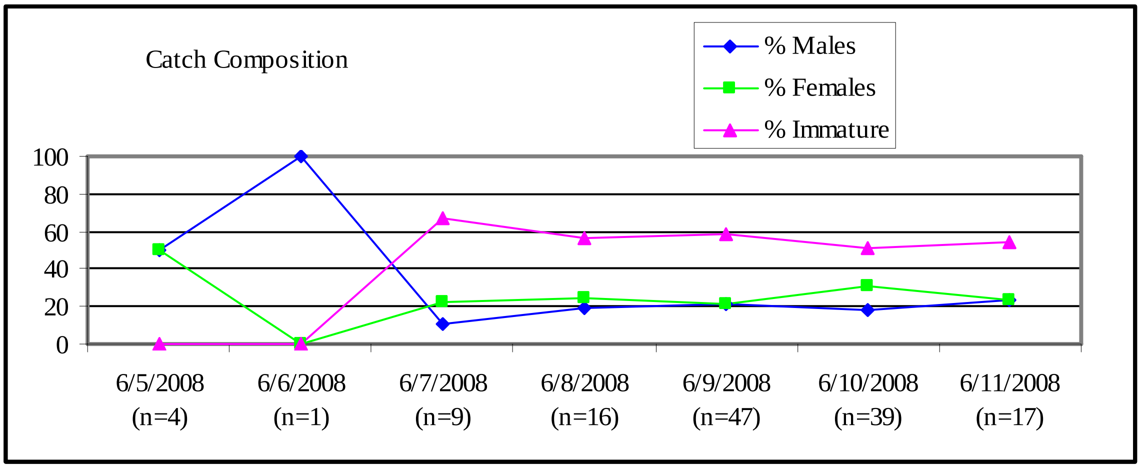


Figure 75. Catch composition of Arctic grayling caught in two fyke nets in North Fork Red Dog Creek in spring 2008.

By the afternoon of June 9, water temperatures at Station 10 in lower Mainstem Red Dog Creek exceeded 4.0°C for 7 days (Figure 76). Temperatures first exceeded 3.0°C on June 1, when they reached 4.6°C. Based on the daily catch compositions in North Fork Red Dog Creek and our observations on June 10 in Mainstem Red Dog Creek, Arctic grayling spawning in Mainstem Red Dog Creek was substantially complete by the evening of June 9.

Peak water temperatures in North Fork Red Dog Creek closely track with those seen in Mainstem Red Dog Creek (Figure 76), but temperatures in Mainstem Red Dog Creek were above 4°C much earlier in the season. As Arctic grayling spawning is keyed to water temperature, this probably explains why most of the spawning occurred in Mainstem Red Dog Creek in spring 2008.

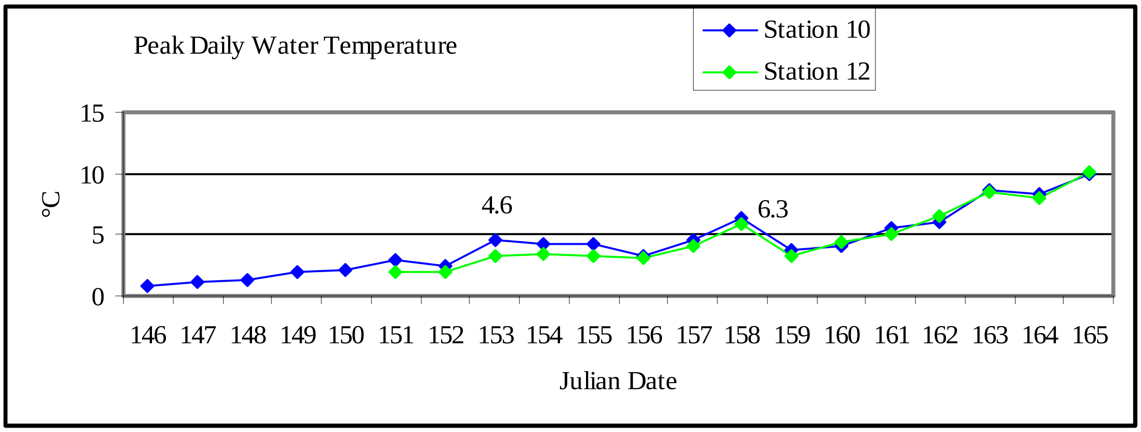


Figure 76. Peak daily water temperature in Mainstem Red Dog Creek at Station 10.

A summary of Arctic grayling spawning in Mainstem Red Dog Creek from spring 2001 to 2008 is presented in Table 6. The earliest spawning that was judged to be substantially complete was on May 31 in 2004. The latest spawning was judged to be substantially complete was June 15 in both 2001 and 2006. A complete description of each year's work with Arctic grayling spawning is available from our office in Fairbanks.

Table 6. Summary of Arctic grayling spawning in Mainstem Red Dog Creek.

Year	Date When Limited Spawning Started (3°C)	Date When Spawning Complete (Condition of Females)	Number of Days Peak Temperatures Exceeded 4°C[1]
2001	June 6	June 15	6
2002	May 29	June 8	8
2003	June 7	June 14	6
2004	May 25	May 31	4
2005	May 27	June 6	9
2006	May 30	June 15	10
2007	May 26	June 3	8
2008	June 1	June 9	9

[1]Does not include the day spawning was judged to be complete since the fyke net is worked in the early morning prior to peak temperatures on that day.

We also monitored Arctic grayling spawning in Bons Pond and its tributaries. Typically, Arctic grayling spawn in the outlet of Bons Pond and in Bons Creek. There are two major tributaries that enter Bons Pond from the north, but only Bons Creek is available to fish due to a beaver dam blocking fish passage in the other stream. A fyke net was set in Bons Creek about 0.2 km upstream of Bons Pond on June 5 (Figure 77). The fyke net was set to capture fish moving upstream and the net was checked once each day until removed on June 10. When the fyke net was set on June 5, there were about 10 to 20 fish present in the tail of the run. We caught 11 Arctic grayling using angling as the capture method – all of the fish were mature males.

Figure 77. Fyke net in Bons Creek, spring 2008.

Bons Pond was 90% ice covered throughout the sample event and was not moated along the shoreline. Water temperatures were taken in Bons Creek from June 6 through 10 with a HOBO® water temp pro V2 at the fyke net (Figure 78). Peak water temperatures never exceeded 4.0°C, but males were defending territories.

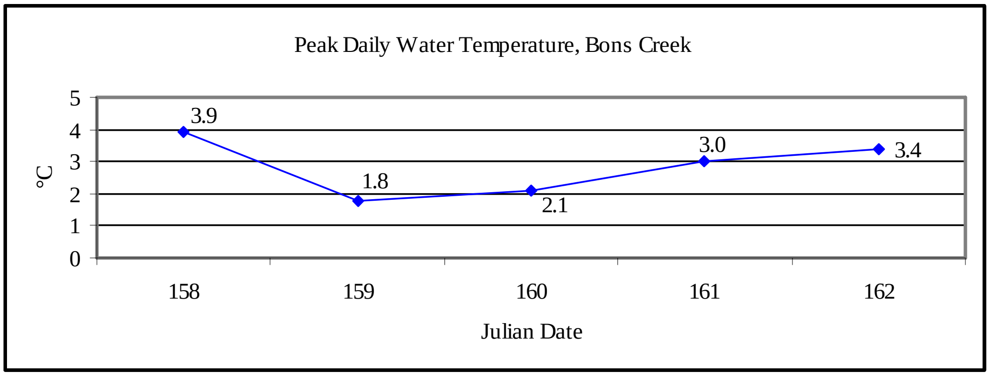


Figure 78. Peak daily water temperatures in Bons Creek just upstream of Bons Pond.

Our catches of fish in the Bons Creek fyke net were low from June 6 through the 10th, probably because the continued cold water temperatures limited upstream movement of fish (Table 7). We did observe Arctic grayling spawning activity in Bons Pond on several afternoons in shallow water habitat near the mouth of Bons Creek. In early July, we did not catch any Arctic grayling fry in drift nets fished in Bons Creek and we did not observe any fry. We believe that little, if any, successful spawning occurred in 2008 in Bons Creek.

Table 7. Fyke net catches of Arctic grayling in Bons Creek, spring 2008.

Date	Method	Male	Female	Immature
6/5/2008	angling	11	0	0
6/6/2008	fyke net	2	6	39
6/7/2008	fyke net	0	0	16
6/8/2008	fyke net	7	6	0
6/9/2008	fyke net	7	10	1
6/10/2008	fyke net	6	3	4

Arctic Grayling Catches and Metrics

In North Fork Red Dog Creek, most of the Arctic grayling were caught in the large fyke net. We caught 61 mature and 70 immature Arctic grayling (Figure 79). All Arctic grayling >350 mm fork length were mature. Length frequency distributions for Arctic grayling from 2000 to 2008 are presented in Appendix 13.

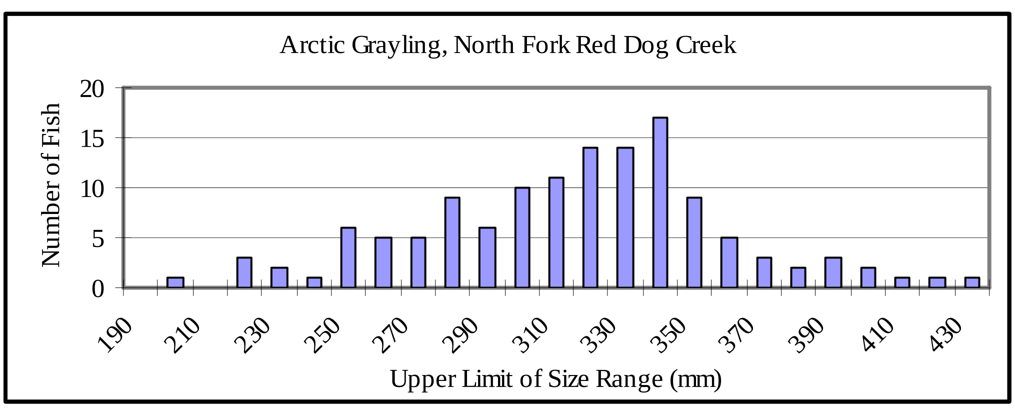


Figure 79. Length frequency distribution of Arctic grayling in North Fork Red Dog Creek, spring 2008.

Morris and Jacobs (2007) reported a bimodal distribution showing two strong age classes of immature fish in spring 2007. The bimodal distribution was not seen in spring 2008. However, we probably have at least three age classes of immature fish present in our 2008 sample, and we would expect to see good recruitment to the spawning population for the next several years.

Strong recruitment to the North Fork Red Dog Creek Arctic grayling population has been seen in both 2007 and 2008. A portion of this recruitment is from Arctic grayling leaving Bons Pond. Arctic grayling that leave Bons Pond go through the bypass channel around the dam and over a substantial waterfall (i.e., a one way trip) (Ott and Morris 2007). In spring 2007, Morris and Jacobs reported 7 recaptured fish (12% of the number caught) that were tagged originally in Bons Pond. We caught 5 Arctic grayling (18% of the recaptured fish caught) in spring 2008 that had been tagged in Bons Pond. Two of the recaptured fish from Bons Pond were caught in North Fork Red Dog Creek in 2007 and 2008 (Table 8).

In spring 2008, we captured Arctic grayling in Bons Pond and Bons Creek by angling and with fyke nets. The length frequency distribution of these captured fish is shown in Figure 80. Fish from 80 to 110 mm long are most likely age 1, indicating some level of spawning success in spring 2007.

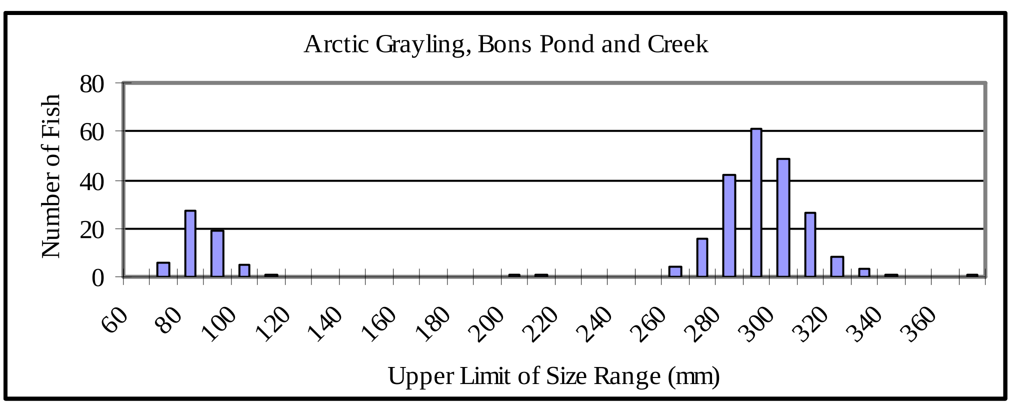


Figure 80. Length frequency distribution of Arctic grayling in Bons Pond and Bons Creek, spring 2008.

Table 8. Arctic grayling recaptures in 2008 in North Fork Red Dog Creek.

Tag Number	Color	Gear Type	Length (mm)	Sex	Date Captured	Site Captured	Recapture Date	Recapture Site	Length (mm)
17980	Gray	Fyke Net	316	Male	6/1/2007	North Fork Big Net	6/5/2008	North Fork Big Net	335
17974	Gray	Fyke Net	420	Male	5/31/2007	North Fork Big Net	6/9/2008	North Fork Big Net	422
12480	Gray	Fyke Net	300	Immature/Male	6/3/2007	North Fork Big Net	6/9/2008	North Fork Big Net	340
12405	Gray	Fyke Net	298	Male	6/2/2007	North Fork Big Net	6/9/2008	North Fork Big Net	323
12481	Gray	Fyke Net	303	Immature/Male	6/3/2007	North Fork Big Net	6/9/2008	North Fork Big Net	335
12521	Gray	Fyke Net	259	Immature	6/3/2007	North Fork Big Net	6/9/2008	North Fork Big Net	298
12442	Gray	Fyke Net	274	Male	6/2/2007	North Fork Big Net	6/9/2008	North Fork Big Net	322
12528	Gray	Fyke Net	266	Immature	6/3/2007	North Fork Small Net	6/9/2008	North Fork Big Net	315
12400	Gray	Fyke Net	296	Immature	6/2/2007	North Fork Big Net	6/10/2008	North Fork Big Net	331
17984	Gray	Fyke Net	263	Immature	6/1/2007	North Fork Big Net	6/10/2008	North Fork Big Net	317
9746	Orange	Fyke Net	201	Immature	6/16/2003	Bons Pond	6/1/2007	North Fork	305
							6/11/2008	North Fork	331
15862	White	Fyke Net	376	Male	6/4/2005	North Fork	6/1/2007	North Fork	380
							6/11/2008	North Fork	384
16059	White	Fyke Net	247	Immature	8/2/2005	Bons Pond	6/3/2007	North Fork	279
							6/11/2008	North Fork	305
15612	White	Angling	336		5/29/2004	North Fork	6/25/2005	Mainstem	360
							7/8/2008	North Fork	380
15738	White	Angling	325	Female	7/13/2004	North Fork	6/1/2007	North Fork	351
							7/8/2008	North Fork	350
12826	Gray	Fyke Net	294	Immature	6/8/2008	North Fork Big Net	7/8/2008	North Fork	295
27019	Gray	Angling	230		6/17/2003	North Fork	8/5/2008	North Fork	370
13129	Green	Fyke Net	351	Female	7/11/2000	North Fork	6/4/2005	North Fork	366
							6/15/2006	North Fork	368
							6/6/2008	North Fork	386
15731	White	Fyke Net	280	Female	7/13/2004	North Fork	6/8/2008	North Fork	359
17679	Gray	Fyke Net	255	Female	6/12/2006	North Fork	6/8/2008	North Fork	318
17812	Gray	Fyke Net	251	Immature/Female	6/15/2006	North Fork	6/9/2008	North Fork	325
17809	Gray	Angling	279	Immature	6/15/2006	North Fork	6/9/2008	North Fork	342
17864	Gray	Angling	278	Female	6/16/2006	Mainstem	6/10/2008	North Fork	313
15647	White	Fyke Net	350		5/31/2004	North Fork	6/10/2008	North Fork	369
15778	White	Fyke Net	264	Male	6/1/2005	Bons Pond	6/9/2008	North Fork Big Net	303
14739	White	Fyke Net	220	Female	6/7/2004	Bons Pond	6/10/2008	North Fork Big Net	329
15776	White	Angling	244		6/1/2005	Bons Pond	8/5/2008	North Fork	345

The absence of Arctic grayling from 120 to 260 mm in spring 2008 may reflect spawning failures for several years. Data from spring 2006 and 2007 (Figures 81 and 82) would support our hypothesis that spawning success was very poor in spring 2005 and spring 2006. Fish from those year classes are missing from the current Arctic grayling Bons Pond population.

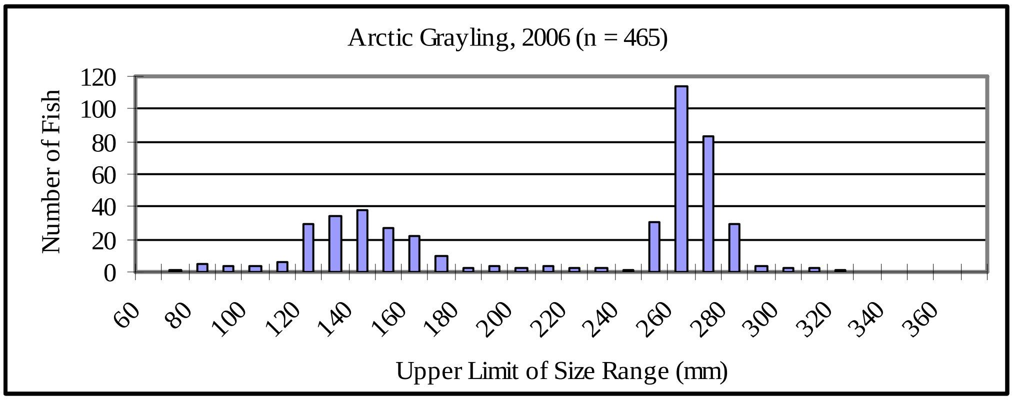


Figure 81. Length frequency distribution of Arctic grayling in Bons Pond and Bons Creek, spring 2006.

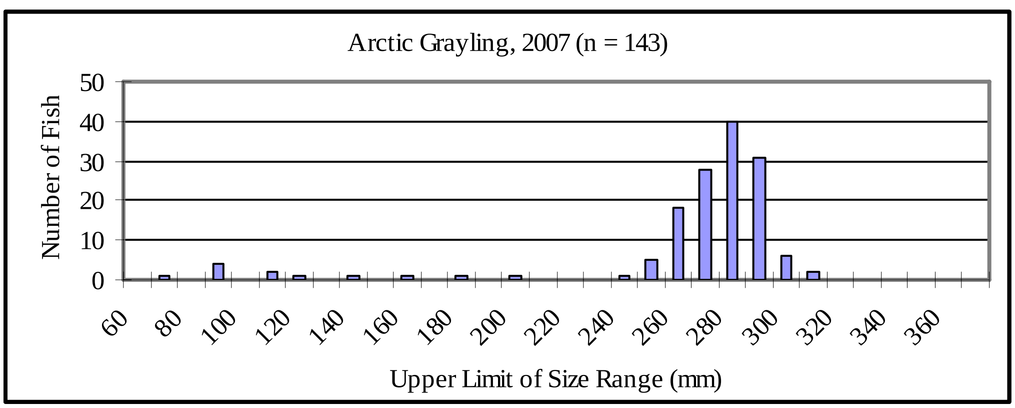


Figure 82. Length frequency distribution of Arctic grayling in Bons Pond and Bons Creek, spring 2007.

Arctic Grayling Mark/Recapture

We were able to estimate the Bons Pond Arctic grayling population for fish >200 mm fork length using the summer of 2007 as the mark event (n_1 = 596) and spring 2008 as the recapture event (n_2 = 211). In spring 2008 we had 28 recaptures (m_2) of fish seen in summer 2007. Our estimated population using Chapman's modification of the Lincoln-Petersen two-sample mark-recapture model (Chapman 1951) for summer 2007 was 4,363 fish (Figure 83). Seber (1982) was used for our calculation of the 95% confidence interval. With the expected lack of recruitment to the population of fish >200 mm, we would expect the population to continue to decline for at least two more years.

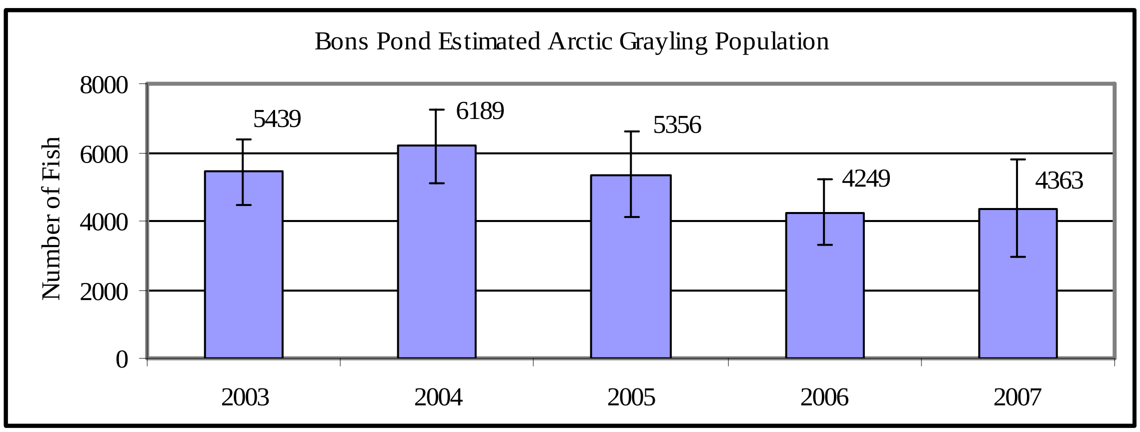


Figure 83. Estimated Arctic grayling population in Bons Pond.

Arctic Grayling Fry

Since 1992, we have conducted visual surveys for adult and fry Arctic grayling in North Fork Red Dog Creek. We have observed Arctic grayling spawning in North Fork Red Dog Creek and have captured fry (12 to 15 mm long) in drift nets at Station 10 in Mainstem Red Dog Creek and at Station 12 in North Fork Red Dog Creek. No fry were observed during our survey work in early July in North Fork Red Dog Creek (Table 9).

Table 9. Relative abundance of Arctic grayling fry in North Fork Red Dog Creek (1992 to 2008).

Year	Relative Abundance of Fry	Comments
1992	high	100's of fry, late July
1993	low	Few fry in early August, high water
1994	low	High water after spawning probably displaced fry
1995	low	Fry small (<25 mm) in mid-July
1996	high	Schools of 50 to 200 fry common
1997	high	Average size of fry was 10 mm greater than in 1996
1998	low	Cold water, late breakup, high water after spawning
1999	high	Low flows, warm water after spawning, schools of 50 to 100 fry common
2000	low	Cold water, late breakup, spawning 90% done June 13/14, fry small (<25 mm) and rare in mid-July
2001	low	Cold water, late breakup, spawning 90% done June 19, fry small (<25 mm) and rare in mid-July
2002	low	High flows, spawning 90% done June 8, fry small (<35 mm) in early August and rare, more fry seen in Ikalukrok Creek in early July, probably displaced by high water
2003	low	Cold water, late breakup, spawning 90% done June 14, fry small (<25 mm) and rare in early August
2004	low	Early breakup, spawning 90% done by May 31, fry (<30 mm) on July 10
2005	low	Spawning 90% done by June 7, fry present in early July, several groups of 25 to 30 observed
2006	low	Spawning partially abandoned due to cold water temperatures, no fry observed in early August, July surveys not possible due to high water
2007	high	Spawning 90% done by June 3, followed by low water with very little rainfall until mid-August, fry numerous, hundreds seen in shallow water along stream margin, fry averaged 64 mm in early August
2008	low	Spawning 90% done by June 9, most fish probably spawned in Mainstem Red Dog Creek, no fry seen along stream margins

Slimy Sculpin

Houghton and Hilgert (1983) found slimy sculpin in Ikalukrok Creek and Dudd Creeks, but none were seen or caught in the Red Dog Creek drainage. In 1995, we caught slimy sculpin in Mainstem Red Dog and North Fork Red Dog creeks (Weber Scannell and Ott 1998). Slimy sculpin are infrequently caught in the Red Dog Creek drainage and in Anxiety Ridge Creek; however, we did catch three large slimy sculpin (133, 129, and 132 mm) in spring 2008 in the North Fork Red Dog Creek fyke net. Catches of slimy sculpin generally have been highest in the two sample reaches in Ikalukrok Creek at the mouth of Dudd Creek. Catch per unit of effort (CPUE = 20 traps for 24 hr) for slimy sculpin for the two sites in Ikalukrok Creek is presented in Figure 84. The overall trend appears to be for an increasing presence of slimy sculpin – slimy sculpin were assumed to be the most likely impacted species in the Ikalukrok Creek drainage in the early days of Red Dog prior to the construction of the clean water bypass system.

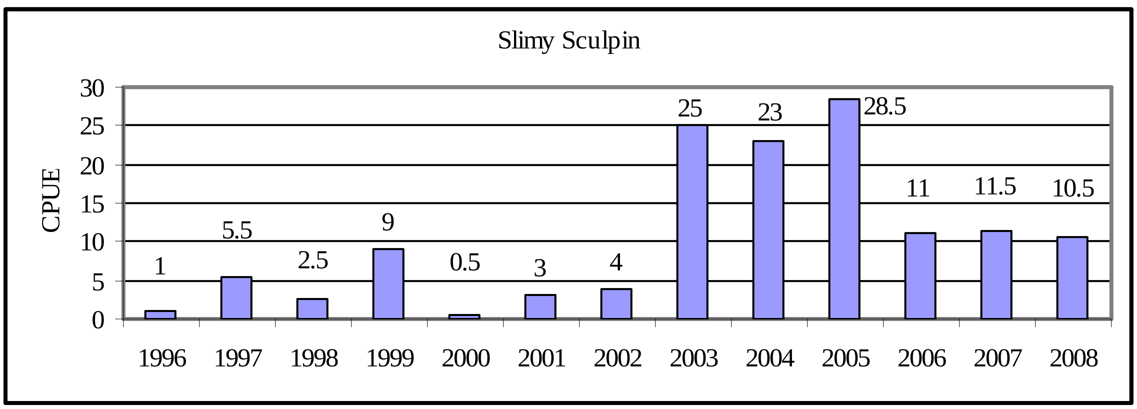


Figure 84. Slimy sculpin caught in Ikalukrok Creek at two sample reaches – one upstream of Dudd Creek and one downstream of Dudd Creek.

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, Habitat and Restoration Division. 23 pp.

Brix, K.V. and M. Grosell. 2005. Report on the effects of total dissolved solids on Arctic grayling and Dolly Varden fertilization success. Prepared for Teck Cominco. 23 pp.

Dames and Moore. 1983. Environmental baseline studies Red Dog project.

Chapman, D.G. 1951. Some practices of the hypergeometric distribution with applications to zoological censuses. University of California Publications in Statistics. 1:131-60.

DeCicco, A.L. 2008. Wulik River aerial survey 2008. Letter to Division of Habitat dated September 20, 2008. Fisheries Services and Supplies. Fairbanks, AK. 2 p.

DeCicco, A.L. 2007. Wulik River aerial survey 2007. Letter to Office of Habitat Management and Permitting dated October 18, 2007. Fisheries Services and Supplies. Fairbanks, AK. 2 p.

DeCicco, A.L. 2006. Wulik River aerial survey 2006. Letter to Office of Habitat Management and Permitting dated October 9, 2006. Fisheries Services and Supplies. Fairbanks, AK. 1 p.

DeCicco, A.L. 2005. Memorandum, 2005 Wulik River survey. AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 1 p.

DeCicco, A.L. 2004. Red Dog trip report, September 11 to 15, 2004. Memorandum, AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 2 pp.

DeCicco, A.L. 2002. 2002 Wulik River survey. October 14, 2002. Memorandum, AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 1 p.

DeCicco, A.L. 2001a. Wulik River survey and Ikalukrok Creek, October 8, 2001. Memorandum, AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 1 p.

DeCicco, A.L. 2001b. Ikalukrok Creek salmon, September 3, 2001. Memorandum, AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 2 p.

DeCicco, A.L. 2001c. Ikalukrok Creek salmon, September 28, 2001. Memorandum, AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 2 p.

DeCicco, A.L. 2000. Personal communication to Habitat and Restoration Division. November, 2000.

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

Literature Cited (continued)

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

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

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

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

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

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

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

DeCicco, A.L. 1992. Memorandum, char surveys. 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. 1990a. Life history of anadromous Dolly Varden (*S. malma*) in Northwestern Alaska. AK Dept. of Fish and Game, Sport Fish Division. Prepared for the 1990 meeting of the International Society of Arctic char fanatics in Murmansk, USSR. September 1990. 19 pp.

DeCicco, A.L. 1990b. 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. 1990c. 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. 1989. Memorandum, Wulik River char distribution. AK Dept. of Fish and Game, Sport Fish Division. Fairbanks, AK. 3 pp.

DeCicco, A.L. 1985. Inventory and cataloging of sport fish and sport fish waters of Western Alaska with emphasis on Arctic char life history studies. AK Dept. of Fish and Game. Federal-Aid Fish Rest. Annual Performance Report, 1984-1985, Project F-9-17, Volume 26. 41-134.

Literature Cited (continued)

EVS Consultants Ltd and Ott Water Engineers. 1983. Toxicological, biophysical and chemical assessment of Red Dog, Delong Mountains, Alaska, 1982. Prepared for the 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.F. and P.J. Hilgert. 1983. In Environmental baseline studies Red Dog project. Dames and Moore. 82 pp.

Jenkins, D.W. 1980. Biological monitoring of toxic trace metals. Vol. 1. Biological Monitoring and Surveillance. J EPA-600/3-80-089. 215 pp.

Morris, W.A. and L. Jacobs. 2007. Red Dog mine spring 2007 NPDES fish sampling trip report (May 30 to June 3, 2007). AK Dept. of Natural Resources, Office of Habitat Management and Permitting. Juneau, AK. 8 pp.

Morris, W.A. and A.G. Ott. 2001. Red Dog trip report (July 28 to August 9, 2001). AK. Dept. of Fish and Game. 9 pp.

Ott, A.G. and L. Jacobs. 2008. Red Dog trip report, August 2 to 9, 2008. AK. Dept. of Fish and Game. Division of Habitat. Juneau, AK. 4 pp.

Ott, A.G. and W.A. Morris. 2007. Aquatic biomonitoring in Bons Pond, and Bons and Buddy Creeks, 2004 to 2006, at Red Dog Mine. Technical Report No. 07-04. AK Dept. of Natural Resources, Office of Habitat Management and Permitting. Juneau, AK. 92 pp.

Ott, A.G. and A.H. Townsend. 2007. Red Dog trip report, August 8 to 15, 2007. AK Dept. of Natural Resources, Office of Habitat Management and Permitting. Juneau, AK. 4 pp.

Ott, A.G. and J.L. Timothy. 2006. Red Dog trip report, August 9 to 16, 2006. AK Dept. of Natural Resources, Office of Habitat Management and Permitting. Juneau, AK. 3 pp.

Ott, A.G. and W.A. Morris. 2004. Juvenile Dolly Varden whole body metals analyses, Red Dog Mine (2002). Technical Report No. 04-01. AK Dept. of Natural Resources, Office of Habitat Management and Permitting. Juneau, AK. 71 pp.

Ott, A.G. and P.W. Scannell. 2003. Aquatic biomonitoring at Red Dog Mine, 2002. Technical Report No. 03-03. AK Dept. of Fish and Game, Habitat and Restoration Division. Juneau, AK. 116 pp.

Ott, A.G. and A.H. Townsend. 2003. A transplant of Arctic grayling to Bons Pond at the Red Dog Mine. AK Department of Natural Resources, Office of Habitat Management and Permitting. Juneau, AK. 36 pp.

Literature Cited (concluded)

Ott, A.G. and A.H. Townsend. 2002. Red Dog trip report (July 27 to August 7, 2002). AK Department of Fish and Game, Div. Habitat and Restoration, Fairbanks, AK. 7 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.

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. 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.

Seber, G.A.F. 1982. The estimation of abundance. Charles Griffin & Company LTD.

Thompson, M. 2005. Electronic mail report to A.G. Ott on August 29, 2005. Teck-Cominco Alaska Inc. Red Dog Mine.

Townsend, A.H. and L. Conley. 2004. Red Dog field trip report, August 18 to 28, 2004. AK Dept. of Natural Resources, Office of Habitat Management and Permitting. Fairbanks, AK. 2 pp.

Townsend, A.H. and L. Ingalls. 2003. Red Dog Field Trip Report. August 6 to 13, 2003. Alaska Department of Natural Resources, Office of Habitat Management and Permitting, Fairbanks, AK. 3 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.G. Ott, and W.A. Morris. 2000. Fish and aquatic taxa report at Red Dog Mine, 1998-1999. Technical Report No. 00-03. AK Dept. of Fish and Game, Habitat and Restoration Division. Juneau, AK. 136 pp.

Weber Scannell P. and A.G. Ott. 1998. Fisheries resources and water quality, Red Dog Mine. Technical Report No. 98-02. AK Dept. of Fish and Game, Habitat and Restoration Division. Juneau, AK. 136 pp.

Appendix 1. Summary of Mine Development and Operations

1982

- ●Baseline studies 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 bypasses
- ●Uniform Summons and Complaint issued for illegal water removal
- ●AIDEA provided funding to ADF&G for monitoring
- ●Rehabilitation plans for streams developed and implemented

Appendix 1 (continued)

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 were documented

Appendix 1 (continued)

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 attainability 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
- ●107 juvenile and adult Arctic grayling transplanted from North Fork Red Dog Creek to Bons Pond in late June
- ●79 juvenile Dolly Varden transplanted from Anxiety Ridge Creek to Bons Pond in late June

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
- ●About 200 Arctic grayling fry (40 to 45 mm) were moved from North Fork Red Dog Creek to Bons Pond in August

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

Appendix 1 (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, staining 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 (AK-003865-2) issued by US EPA became effective August 28, 1998 and was certified by ADEC (Certificate of Reasonable Assurance)
- ●Two-year aquatic community study completed
- ●Biomonitoring, including studies of fish and aquatic biota, required under 1998 NPDES permit

Appendix 1 (continued)

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 Cub Creek seep 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 south of dump
- ●Site-specific criteria for TDS requested by Cominco
- ●Biomonitoring study continued
- ●Baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect begun

Appendix 1 (continued)

2001

●Effects to Ikalukrok Creek from Cub Creek seep continued, red stain and precipitate observed in Ikalukrok Creek to Station 8 below Mainstem Red Dog Creek, affects minor near mouth of Dudd Creek
●North Fork Red Dog Creek, siltation (natural) less than in summer 2000
●Minimal precipitate in Middle Fork Red Dog Creek below effluent outfall
●Water quality was monitored in Shelley, Rachel, Connie, and Middle Fork Red Dog creeks upstream and downstream of surface disturbance, catch-box and pipeline (about 430 m) placed in Shelley Creek to move water pass disturbance
●Juvenile Arctic grayling observed in Bons Creek just south of the Kivalina rock dump, pump-back system working based on fish use
●Fish weir repairs made during 2000, no problems observed in 2001
●Stream survey of cross drainage structures made along the Delong Mountains Transportation System, some minor work at some crossings identified
●Site-specific criteria for TDS still being worked, data on Arctic grayling spawning/water temperature collected in North Fork Red Dog and Mainstem Red Dog creeks, supplemental data gathered at the Ft. Knox mine
●Studies expanded to include the Delong Mountains Transportation System based on a National Park Service report that metals concentrations adjacent to road were elevated, water sites established upstream and downstream of road and sampled by Teck Cominco, juvenile Dolly Varden samples collected in Omikviorok River and Aufeis Creek, vegetation sampling started by Teck Cominco
●New haul trucks brought on site, hard-covered trucks to minimize loss of zinc and lead concentrates during transport
●Exploratory drilling (ore and shallow gas) continued, focus on North Fork Red Dog Creek and Wulik River basins near Anarraaq and Lik, including west of the Wulik River, another ore prospect found northwest of Anarraaq, shallow gas results promising
●State and Teck Cominco agree to start the state’s large mine team to work on issues, key issue identified was development of a solid waste permit with bonding for the tailing dam, other issues include site-specific criterion for total dissolved solids, clean-water bypass system, waste rock dumps (acid-rock drainage, and truck wash to minimize metal transport)
●Biomonitoring study continued, baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect continued for the second field season, four new sites added (tributaries on west side of Wulik in the area of the Lik Deposit and potential shallow gas development)

Appendix 1 (continued)

2002

●Effects to Ikalukrok Creek from Cub Creek seep continued, red stain and precipitate observed in Ikalukrok Creek to Station 8 below Mainstem Red Dog Creek, affects minor near mouth of Dudd Creek

●North Fork Red Dog Creek, siltation minor during summer 2002

●Minor precipitate in Middle Fork Red Dog Creek below effluent outfall

●Fish weir operating as designed

●Data on Arctic grayling spawning/water temperature collected in North Fork Red Dog Creek, supplemental data gathered at Ft. Knox

●Pit expansion continues to the north of the clean-water bypass system, road crossing added for access

●A bypass was installed for Connie Creek during winter 2001/2002. The bypass captures the upstream creek and carries the water in a pipe to the clean-water bypass system

●The bypass system for Shelly Creek was modified during summer 2002 to correct an overflow problem that occurred during breakup (the overflow water was captured in the pit and did not affect downstream waters). The modification involved adding a lined ditch to contain overflowing clean water and direct the water to the clean-water bypass system

●Juvenile Dolly Varden collected at eight sites located upstream and downstream of the Delong Mountains Regional Transportation System, whole body metals analyses for Cd, Pb, Se, and Zn

●Site-specific criteria for total dissolved solids is still being worked

●State and Teck Cominco continue to work on key issues, e.g., solid waste permit with bonding for the tailing dam, site-specific criterion for total dissolved solids, clean-water bypass system, waste rock dumps (acid-rock drainage, and truck wash to minimize metal transport)

●Biomonitoring study continued, baseline fish and aquatic biota studies in streams located in the vicinity of the Anarraaq Prospect and shallow gas exploration

●Arctic grayling adults remained in North Fork Red Dog Creek through early August, only the second time since 1992 that most of the adults stayed in the creek during summer, most years adults outmigrate shortly after spawning in spring

●Arctic grayling adults present in Buddy Creek just below the falls, about 50 adult fish in sample reach (0.3 km) in early July, all gone by early August

●About 50 to 60 adult Dolly Varden in Ikalukrok Creek at mouth of Dudd Creek from early July through late August

●Effluent discharge ceased on October 5, 2002, to allow time to winterize the water treatment plant

Appendix 1 (continued)

2003

- ●Effects to Ikalukrok Creek from Cub Creek seep continued but were much less than seen in the last two to three years
- ●North Fork Red Dog Creek, natural siltation throughout most of the summer was minor in summer 2003
- ●Minor precipitate in Middle Fork Red Dog Creek below effluent outfall
- ●Fish weir operating as designed
- ●Data on Arctic grayling spawning/water temperature collected in North Fork Red Dog Creek, supplemental data gathered at Ft. Knox
- ●Site-specific criteria for total dissolved solids was finalized
- ●USEPA modified the NPDES effective August 22, 2003, to incorporate the ADEC Site Specific Criteria and mixing zones for total dissolved solids in Mainstem Red Dog and Ikalukrok creeks with conditions that ensure total dissolved solids are at or below 500 mg/L during Arctic grayling spawning in Mainstem Red Dog Creek and during chum salmon and Dolly Varden spawning in Ikalukrok Creek, the modified permit was appealed by the Kivalina Relocation Planning Committee
- ●State and Teck Cominco continue to work on key issues, e.g., solid waste permit with financial assurance for the tailing dam, site-specific criterion for total dissolved solids, clean-water bypass system, waste rock dumps (acid-rock drainage, and truck wash to minimize metal transport)
- ●Arctic grayling adult returns to North Fork Red Dog Creek were low, number of adult Arctic grayling seen in the Ikalukrok Creek drainage was the lowest seen since aerial surveys were begun in the late 1990s
- ●Arctic grayling population estimate was completed for Bons Pond the site of a fish transplant made in 1994 and 1995, estimated population in the reservoir was 6,773
- ●Modification to Shelly Creek bypass ditch completed, a better designed and constructed lined ditch was built and commissioned in August, 2003
- ●A permanent lined ditch was constructed parallel to the Connie Creek diversion pipeline to avoid spring freeze-up issues
- ●A permanent monitoring station was established at the end of the mixing zone in Mainstem Red Dog Creek, the location designation is Station 151, and is fitted with real time total dissolved solids and flow determination equipment and telemetry to link the station directly into the mill process control system
- ●Station 150, at the end of the mixing zone in Ikalukrok Creek, was fitted with real time total dissolved solids and flow determination equipment and telemetry to link the station directly into the mill process control system

Appendix 1 (continued)

2004

●Wastewater discharge began on May 20, ended on September 26, total discharge about one billion gallons

●Effects to Ikalukrok Creek from Cub Creek seep continued but were minor

●North Fork Red Dog Creek, natural siltation minor during ice-free season

●Minor precipitate in Middle Fork Red Dog Creek below effluent outfall

●Fish weir operating as designed

●Arctic grayling spawning/water temperature data collected, Arctic grayling from North Fork Red Dog Creek used for TDS fertilization experiment

●State and Teck Cominco continued to work on key issues associated with the solid waste permit and closure plan for the mine

●Arctic grayling adult returns to North Fork Red Dog Creek were low, number of adults seen in Ikalukrok Creek drainage remained low as in summer 2003

●Bons Pond (the site of a fish transplant made in 1994 and 1995), estimated Arctic grayling population for summer 2003 was 6,773 and for summer 2004 was 5,739

●Chinook salmon juveniles were documented for the first time in Ikalukrok Creek, near Dudd Creek, and in Anxiety Ridge Creek

●Age-1 Arctic grayling were caught in minnow traps fished in Ikalukrok, Mainstem, and Buddy creeks, since age-1 fish are seldom captured in minnow traps this may indicate good survival of fry spawned in spring 2003

●Red Dog Creek diversion (clean water ditch) was realigned to the west side of the pit. Realigned configuration is a combination of large diameter culvert and open lined ditch

2005

●Wastewater discharge began on May 10, 2005, ended on October 6, 2005, total discharge about 1.501 billion gallons

●Major precipitate observed on streambed in Middle Fork Red Dog Creek below effluent outfall in July and August, precipitates (gray colored) evident for at least 1 km downstream of effluent outfall

●Fish weir operating as designed

●Effects to Ikalukrok Creek from Cub Creek seep substantially greater than seen for past several years, water opaque and streambed coated with red precipitate at confluence with Mainstem Red Dog Creek, TCAK water sample from Cub Creek seep with a pH of 3.3

●Arctic grayling spawning/water temperature data collected, Arctic grayling from North Fork Red Dog Creek used for TDS fertilization experiment

●Attended and participated in a NPDES permit renewal meeting in Seattle with EPA, TCAK, and NANA, identified and discussed key issues

Appendix 1 (continued)

2005

●Red Dog Creek diversion (clean water ditch) mine engineering drawings (r4) were provided by TCAK showing the culverts and lined ditch that carry water from tributaries and Middle Fork Red Dog Creek through the pit area

●Recommendations for changes to the Red Dog biomonitoring program based on field data collection and analyses since 1999 were made for possible incorporation into the renewed NPDES permit or ADEC's solid waste permit for the tailing impoundment

●TCAK distributed the 2005 draft report on Arctic grayling fertilization studies that concluded TDS concentrations at or below 1,500 mg/L at Station 10 in Mainstem Red Dog Creek would provide for proper protection of Arctic grayling in the Red Dog Creek drainage, OHMP supported these findings in a letter to Pete McGee (ADEC) dated August 17, 2005

●Dr. Weber Scannell prepared comments on fish tissue data (Dolly Varden from Wulik and Kivalina rivers) collected by Maniilaq Association and compared these data with existing information from other sources in both Alaska and nationwide

●OHMP prepared a summary report (letter to Jim Kulas dated August 23, 2005) on temperature/spawning data collected for Arctic grayling in Mainstem Red Dog and North Fork Red Dog creeks from 2001 through 2005, a recommendation for determining start and completion of spawning based on temperature was developed for Mainstem Red Dog Creek

●State and TCAK continued to work on key issues associated with the solid waste permit and closure plan for the mine ADEC

●Wastewater Treatment Plant (WTP) #3 began operations in late summer 2005 to treat mine sump water and drainage from waste rock dumps prior to placement of these waters into the tailing impoundment, purpose is to improve water quality in tailing impoundment over time

●Exploratory drilling and flow testing for gas in North Fork Red Dog Creek basin was conducted, access road and pads inspected, corrugated pipes installed to provide cross drainage, no evidence of erosion noted along road to and connecting the drill pads

●A road was constructed to Station 151 (end of mixing zone in Mainstem Red Dog Creek

●Work to expand and relocate the water treatment plant sand filters was initiated

●Bons Pond (the site of a fish transplant made in 1994 and 1995), estimated Arctic grayling population for summer 2003 was 6,773 - for summer 2004 was 5,739 – and for summer 2005 was 5,356

Appendix 1 (continued)

2006

●ADEC amended the site-specific criteria (SSC) for TDS in Mainstem Red Dog Creek, the 500 mg/L limit during Arctic grayling spawning was removed and replaced with a 1,500 mg/L limit on February 15, 2006, and EPA approved the new SSC in April 2006

●North Fork Red Dog Creek, extensive areas of aufeis existed, turbidity and organic debris high due to erosion and thermal degradation, in several reaches flow was not in stream channel due to aufeis

●Arctic grayling spawning/water temperature data collected, early spring warming followed by cold weather, adult Arctic grayling entered North Fork Red Dog Creek in late May and due to cold water temperatures abandoned spawning and outmigrated from the creek in mid-June

●Four Arctic grayling captured in North Fork Red Dog Creek in spring 2006 were fish that had been marked in Bons Pond

●Review of ADEC's draft 401 certification to the renewal of the NPDES was completed and we provided a letter of support (March 10, 2006) to ADEC, including our concurrence with ADEC's decision to not require Whole Effluent Toxicity (WET) limits

●Effects to Ikalukrok Creek from Cub Creek seep continued, but were minor

●Major precipitate observed on streambed in Middle Fork Red Dog Creek below effluent outfall in August, precipitates (orange colored) evident for at least 1 km downstream of effluent outfall and precipitates continued upstream through the clean water bypass to Connie and Rachel creeks

●Fish weir operating as designed

●Work continued on the design for the Red Dog tailing backdam, the dam will be located on the south side of the tailing pond and will be constructed of earth fill with a concrete/soil aggregate/bentonite cutoff wall, the dam will be constructed to a final height of 986 ft., construction anticipated during 2006 and 2007

●In July, windrows of dead capelin were documented at the Port Site, die off after spawning is normal, only a small percentage survive spawning

●Total count of chum salmon in Ikalukrok Creek on August 16 was 4,185, the highest number reported since 1990

●In 2006, slightly elevated Zn concentrations persisted and TCAK initiated a field investigation comprised of sampling along the clean water bypass, although not definitive, results indicated that the Mine Sump might have been the source of increased Zn concentrations, modifications were made in operational procedures to ensure containment of contaminated waters in the Mine Sump

●Bons Pond (the site of a fish transplant made in 1994 and 1995), estimated Arctic grayling population for summer 2006 was 4,249

Appendix 1 (continued)

2007

●ADEC issued the Certificate of Reasonable Assurance for NPDES Permit AK-003865-2 on February 12, 2007. EPA issued the proposed NPDES permit for the Red Dog Mine discharge on March 7, 2007. Both actions were appealed and on September 28, 2007, EPA signed the NPDES Permit withdrawal. EPA intends to reissue the NPDES Permit upon completion of the Supplemental EIS for Aqqaluk Extension. In the interim, TCAK will operate under the 1998 NPDES Permit
●OHMP completed Technical Report No. 07-04 which summarized aquatic biomonitoring in Bons and Buddy creeks from 2004 to 2006. OHMP recommended that aquatic biomonitoring at four sites in Bons and Buddy Creeks and field work to estimate the Arctic grayling population in Bons Pond continue
●On May 17, 2007, ADNR issued the Certificate of Approval to Construct a Dam Red Dog Back Dam (AK00303)
●On May 24, we notified EPA that open flow existed in North Fork and Mainstem Red Dog creeks. TCAK received written permission from EPA to begin discharge from Outfall 001 and discharge was initiated on May 25
●Two fyke nets were fished in North Fork Red Dog Creek in spring 2007 to determine when Arctic grayling spawning was finished. Based on net catches, observed spawning activity in Mainstem Red Dog Creek, outmigration of mature fish from Mainstem Red Dog Creek as observed on June 3, and the lack of any spawning activity in Mainstem Red Dog Creek on June 3, OHMP determined that spawning was completed on June 2
●On June 6, EPA notified TCAK that the TDS load in Mainstem Red Dog Creek could be increased to 1,500 mg/L due to the fact that Arctic grayling spawning was complete
●Seven Arctic grayling captured in North Fork Red Dog Creek in spring 2007 were fish that had been marked in Bons Pond. Recruitment of Arctic grayling to North Fork Red Dog Creek from the Bons Pond population is occurring
●Fish weir, on Middle Fork Red Dog Creek, is operating as designed
●Arctic grayling spawning success, as determined by presence of fry, was very good in 2007 due to early spawning, low water following spawning for most of the summer, and warm water temperatures. Numerous fry were seen in North Fork Red Dog, Mainstem Red Dog, Ikalukrok, and Bons creeks. Arctic grayling fry in mid-August average 64 mm long (n = 26, 58 to 71 mm, SD = 3.1)
●Middle Fork Red Dog Creek contained an orange, tan colored precipitate that extended both above and below the waste water discharge point and was visible downstream to the fish weir

Appendix 1 (continued)

2007

- ●Our two estimates for adult chum salmon in Ikalukrok Creek (downstream of Station 160) were 1,408 and 1,998 along with about 100 adult Dolly Varden and 8 chinook salmon
- ●Work on a Supplemental EIS for the Aqqaluk Extension project began with a draft scoping document in August, public meetings in early October, and draft alternatives scoping in December
- ●TCAK continued to make improvements to the mine's clean water bypass system. In October, galvanized culvert was installed replacing sections of HDPE lined ditch in Middle Fork Red Dog Creek upstream of Shelly Creek and continued upstream to the Rachel Creek confluence. In addition, the section of HDPE lined ditch in Connie Creek was converted to culvert as well

Appendix 1 (continued)

2008

●Work on the SEIS for the Aqqaluk Extension continued during 2008. Input via the State's LMPT coordinator was made periodically with emphasis on the alternatives being considered, the aquatic biology background section, and the monitoring plan for both the Red Dog and Bons/Buddy Creek drainages
●On May 5, 2008, we distributed copies of our technical report titled "Aquatic biomonitoring at Red Dog Mine, 2007 National Pollution Discharge Elimination System Permit No. AK-003865-2" covering work done in summer 2007
●On May 13, 2008, we notified ADEC that based on information provided by TCAK that open water flow existed in North Fork Red Dog, Mainstem Red Dog, and Ikalukrok creeks and that wastewater discharge could commence under the conditions of state and federal permits
●On May 28, 2008, TCAK reported to EPA that TDS on May 16 exceeded the permit limits in effect at the time of the discharge
●In spring 2008, Kivalina residents and NANA collected a number of adult Dolly Varden in the Wulik River and planned to have the fish analyzed for metals by Columbia Analytical Lab. Input regarding sampling protocol for adult Dolly Varden was provided to TCAK and NANA on June 6
●June 24, 2008, we reported to TCAK the successful completion of spring work on Arctic grayling in North Fork Red Dog and Mainstem Red Dog creeks and Bons Creek/Bons Pond. In spring 2008, we had at least three age classes of immature fish present in our North Fork Red Dog Creek sample and 18% of these recaptures were fish originally marked in Bons Pond. Our estimated population of Arctic grayling in Bons Pond for summer 2007 was 4,363 fish ≥ 200 mm
●On July 9, 2008, we participated in a teleconference with TCAK and Tetra Tech (contractor for the Aqqaluk SEIS) to discuss the potential impacts to Mainstem Red Dog Creek if the wastewater discharge was moved to the ocean. A short narrative describing possible changes to Mainstem Red Dog Creek was prepared and distributed
●On July 16, 2008, ADF&G sent a letter to TCAK that summarized results of our early July field work when we sampled periphyton, aquatic invertebrates, and fish at the NPDES and ADEC sample sites
●In early August, 2008, ADF&G Commissioner Denby Lloyd spent several days at Red Dog that included a briefing, tour of mine facilities, and an overflight of the project area including Ikalukrok Creek, Wulik River, Port Site, and the haul road from the port to the mine

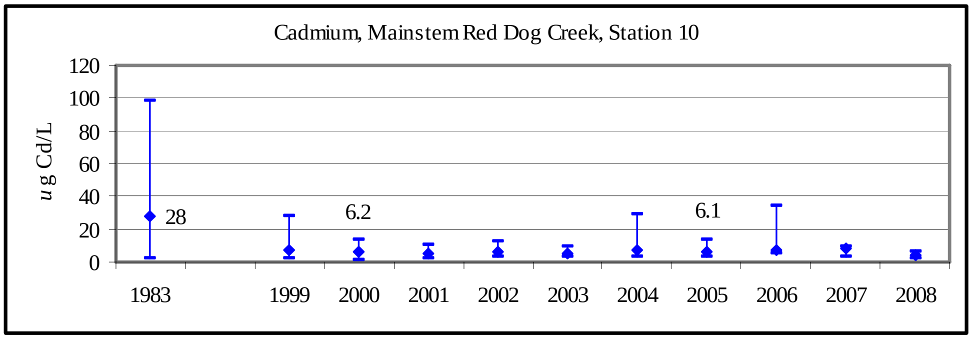
Appendix 1 (concluded)

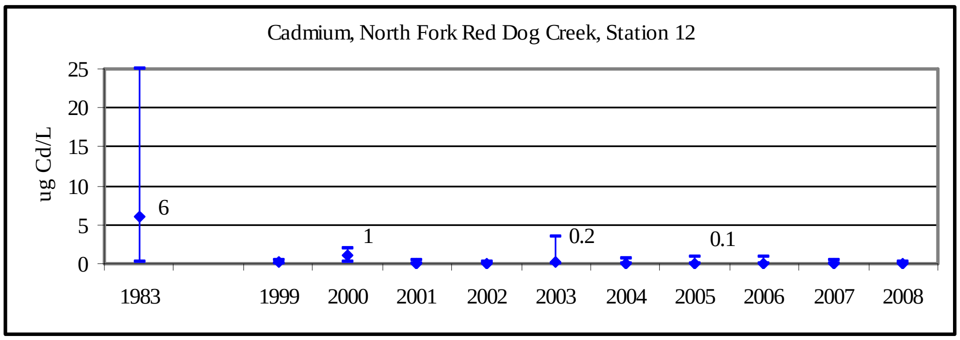
2008

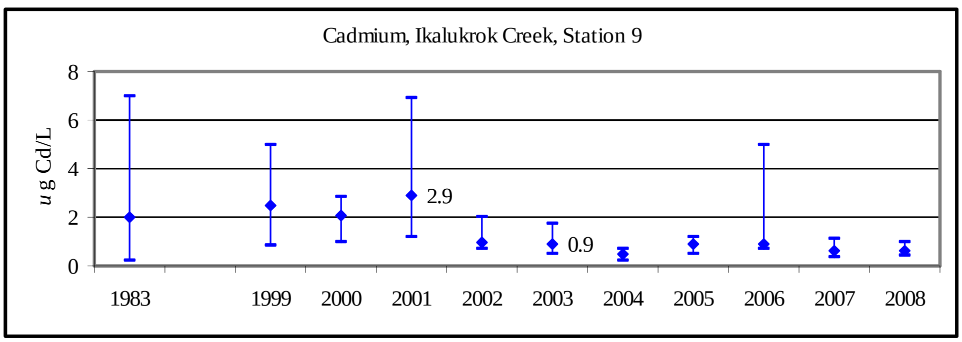
- ●On August 13, 2008, ADF&G sent to TCAK a summary of fish work done in early August. Using a helicopter, we estimated 3,820 chum salmon in Ikalukrok Creek on August 6 – one of our highest counts since surveys began in 1990
- ●On August 21, 2008, ADF&G sent to TCAK a summary of Arctic grayling spawning in Mainstem Red Dog and North Fork Red Dog creeks that covered from 2001 to 2008. The report includes a temperature-based criterion for determining when the majority of Arctic grayling spawning in Mainstem Red Dog Creek is substantially complete
- ●On September 3, 2008, a settlement was reached between all five plaintiffs residents of Kivalina and TECK on a lawsuit that alleged violations of the mine's NPDES permit. On October 23, 2008, a Consent Decree was entered with the Department of Justice as required under a CWA lawsuit. Principle to the agreement was a commitment (barring certain requirements) by TECK to design, permit and construct a pipeline to carry treated mine effluent to the ocean
- ●TCAK prepared and submitted on August 26, 2008, a draft Fugitive Dust Risk Management Plan
- ●On October 3, 2008, ADF&G sent by letter to TCAK results of the fall Dolly Varden overwintering survey in the Wulik River. Overall the count of Dolly Varden was lower than in the recent past; however, it was noted that very few small fish (first year migrants) were present. More chum salmon (16,215) were seen from Sivu to Driver's Camp – more chum salmon than have been seen before
- ●TCAK prepared and submitted a draft monitoring plan for state agency review in early November 2008. The objective is to develop one comprehensive monitoring plan for all state and federal permits pertaining to the mine site as defined by the ambient air boundary. In November and December, we provided input to the States LMPT on the monitoring plan which when completed will be incorporated by reference into the 401 Certification and the ADEC Waste Management Permit
- ●Adult Dolly Varden and juvenile Dolly Varden for selected metals analyses were prepared and send to Columbia Analytical Laboratory in mid-November
- ●November 24, 2008, the SEIS for Red Dog Aqqaluk Extension was released by EPA for public review
- ●On December 22, 2008, we received a CD for the Red Dog Mine Closure and Reclamation Plan – the final draft for agency review. The closure and reclamation plan are the result of over six years of work by TCAK in consultation with state and federal agencies and the public

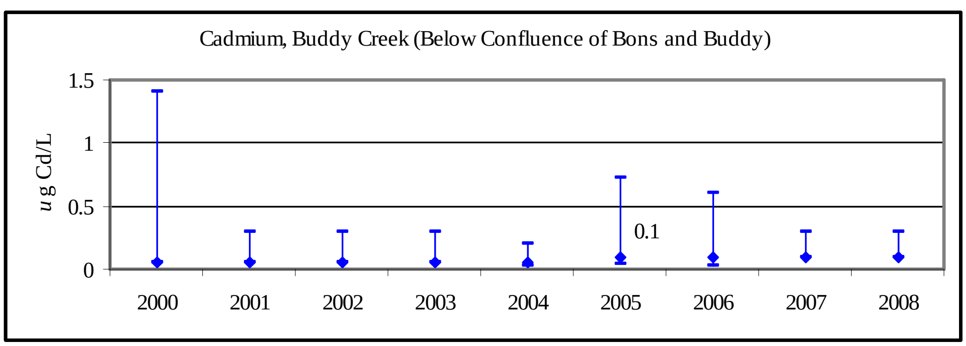
Appendix 2. Water Quality Data, Cadmium, Lead, Selenium, and Zinc

Maximum, median, and minimum concentrations, selected median concentrations shown.









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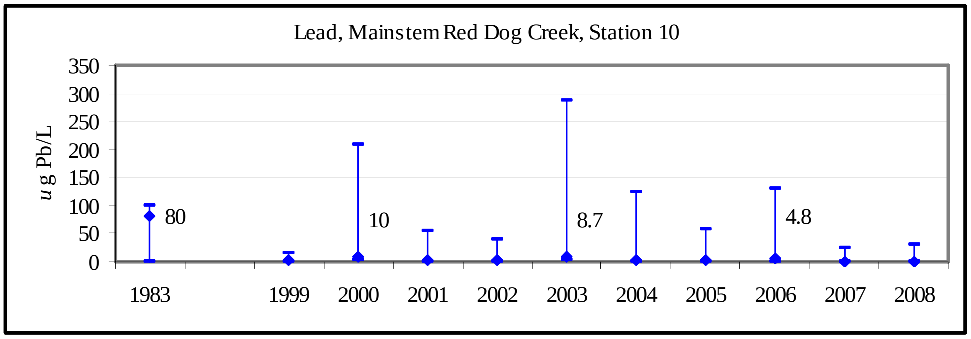

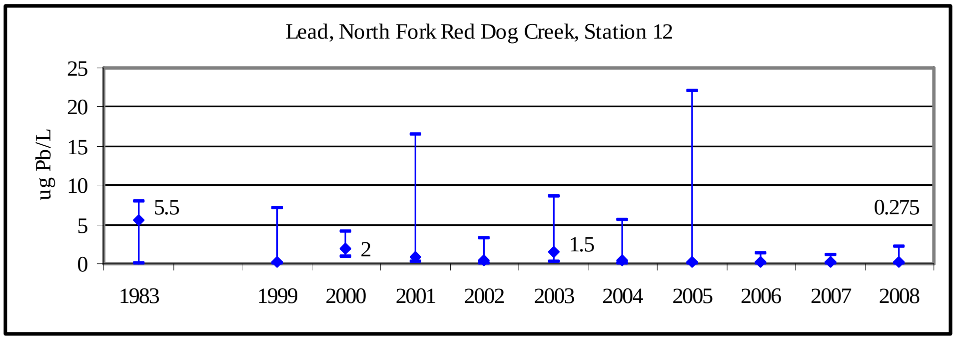

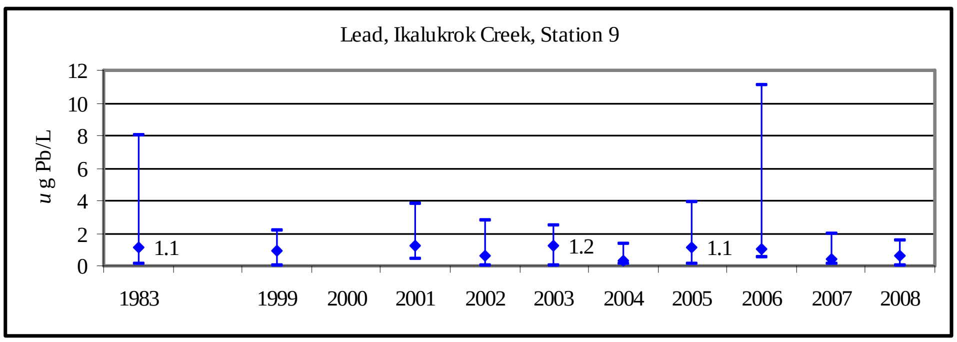

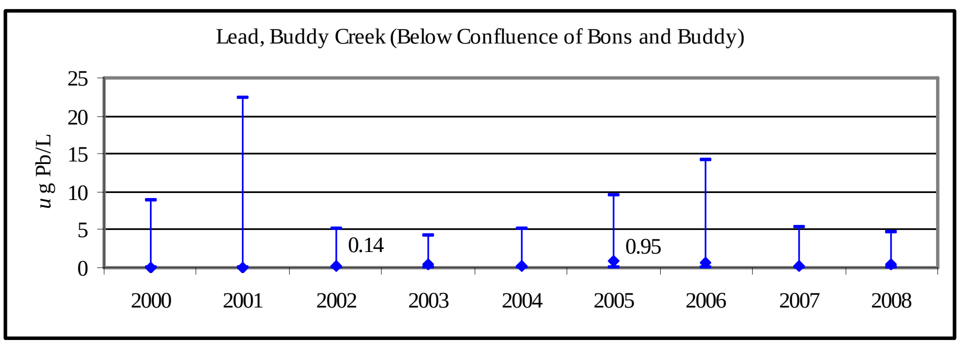

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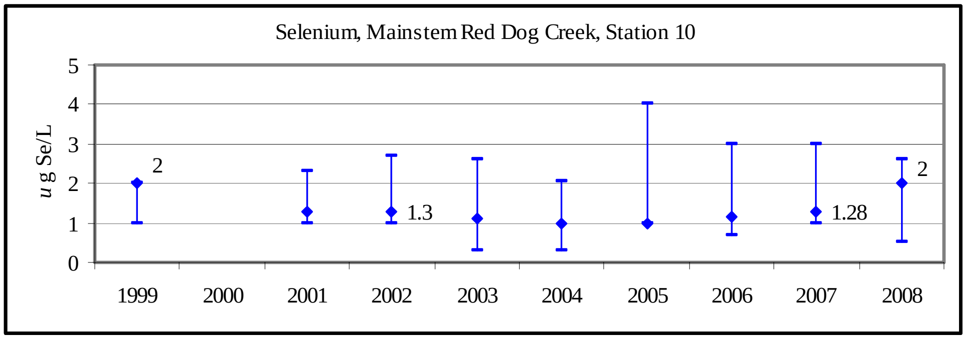

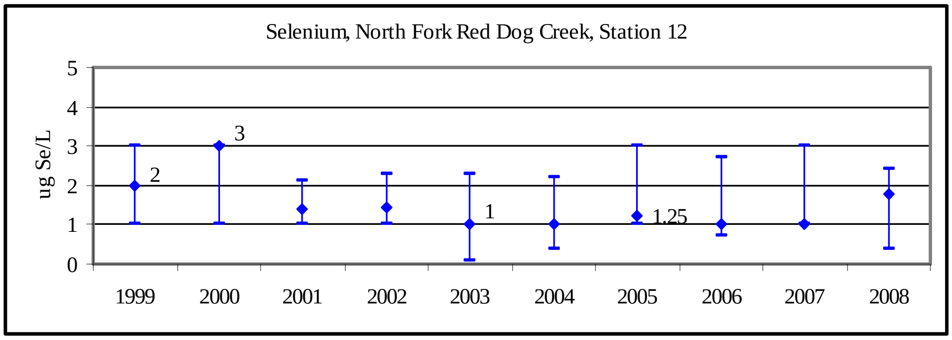

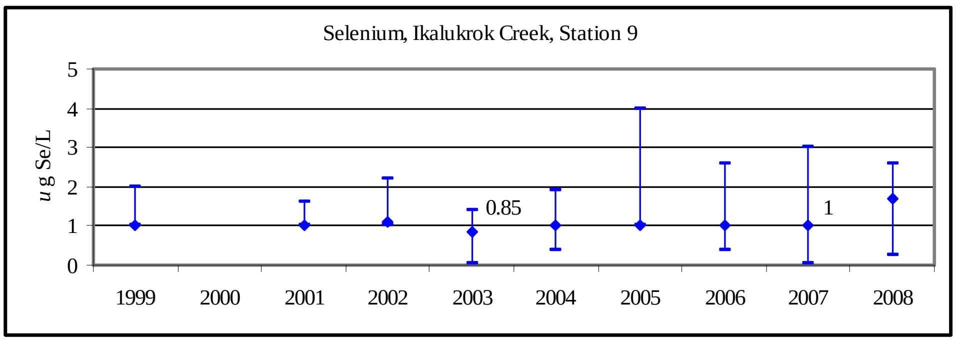

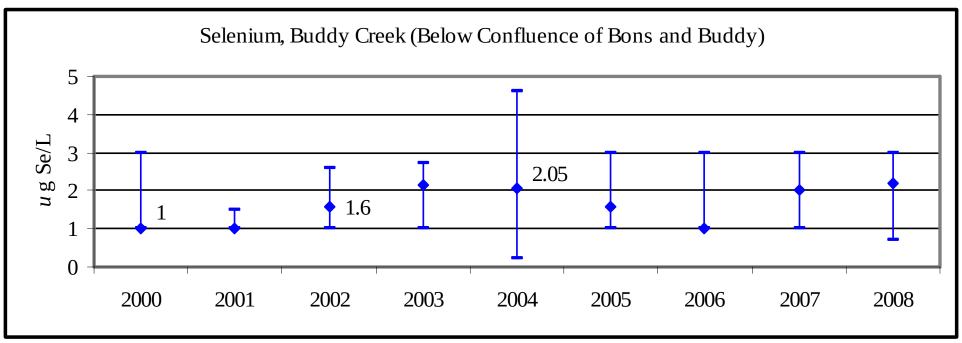

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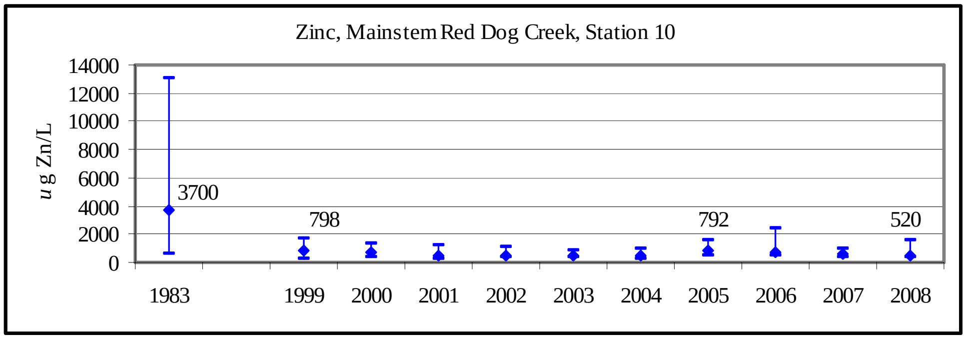

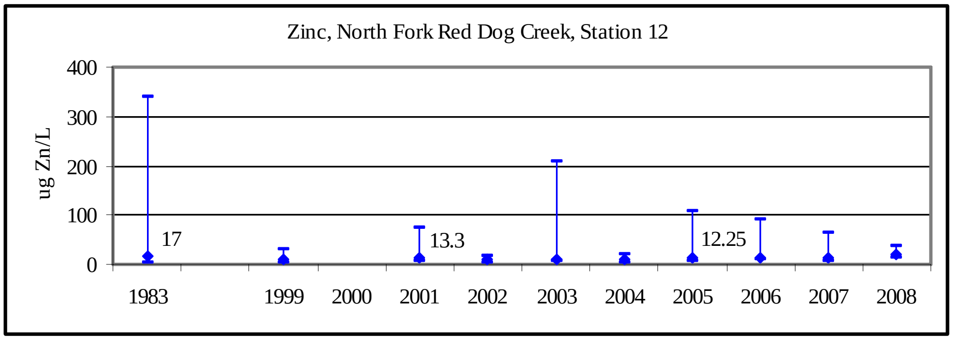

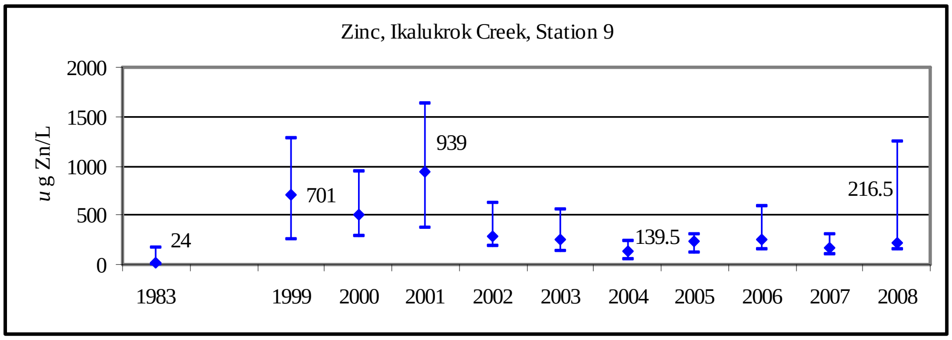

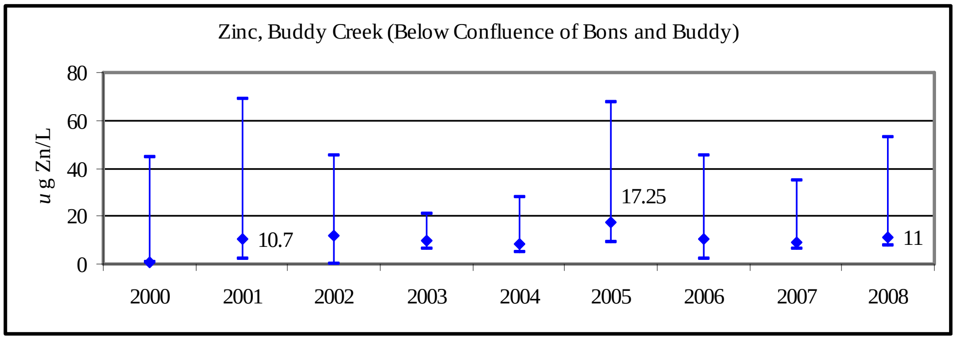

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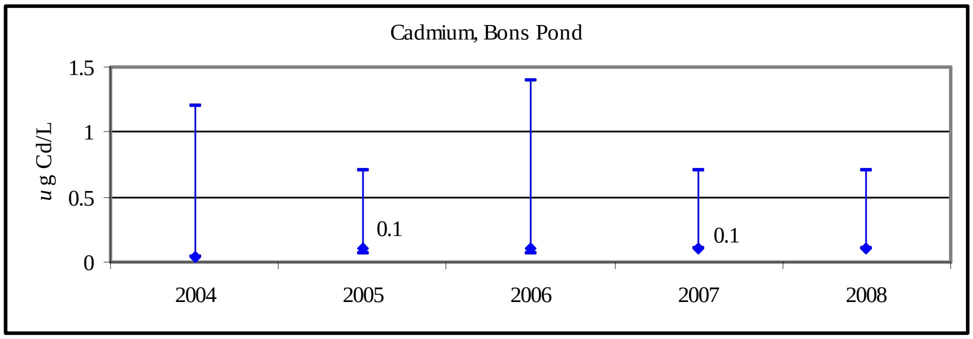
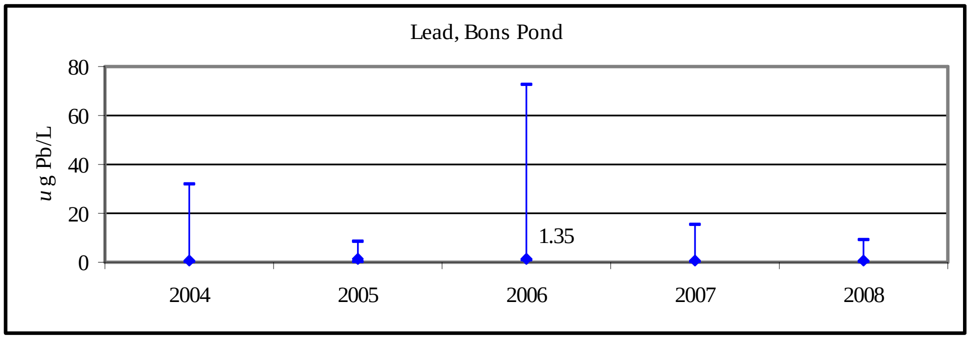
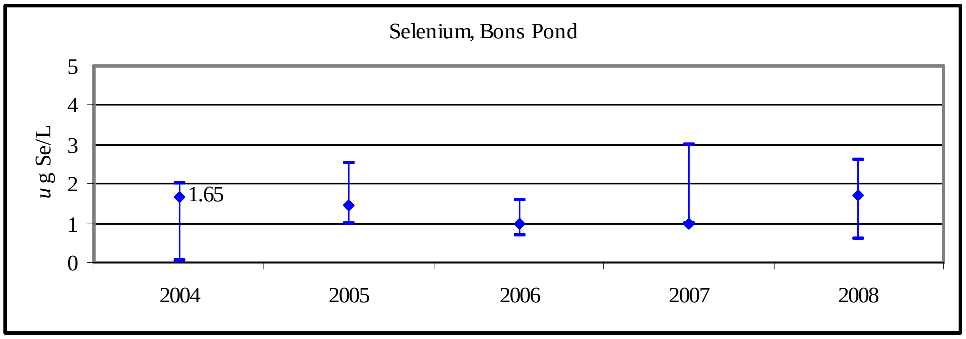
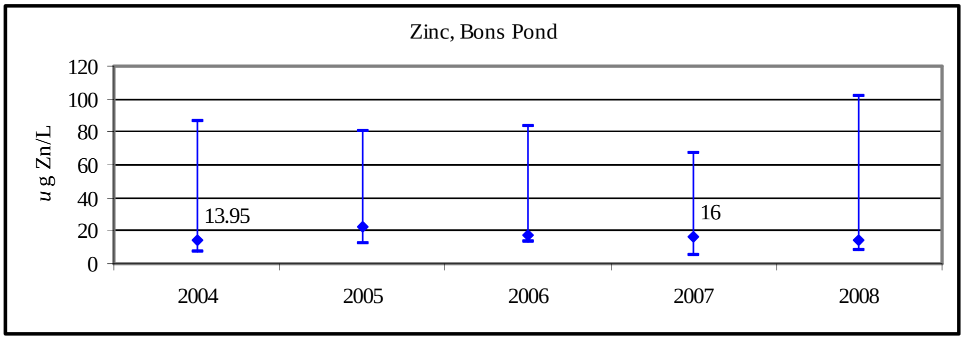








Appendix 3. Periphyton Standing Crop

2008 Red Dog NPDES and Bons Monitoring Chlorophyl Results												
	Use un-corrected Chl a values							Phaeo Corrected				
Daily Vial #	Site	Station number	Date Collected	Date Analyzed	Vial Chl a	Chl a mg/m2	Below Method Detection Limit (0.06 Vial Chl a) OR Above Linear Check (13.7 Vial Chl a)	Chl a mg/m2	664/665 Ratio	Chl b mg/m2	Chl c mg/m2	Notes
1	BLANK	BLANK		02/18/09	**0.00**	**0.00**	**Below Detection**	0.00		0.00	0.10	Freezer failure, samples thawed for ~ 1day
2	IK us RDC	STA 9	July 2008	02/18/09	**0.18**	**0.73**		0.85	2.00	0.03	0.13	
3	IK us RDC	STA 9	July 2008	02/18/09	**0.19**	**0.77**		0.75	1.70	0.01	0.13	
4	IK us RDC	STA 9	July 2008	02/18/09	**0.26**	**1.05**		1.07	1.77	0.03	0.22	
5	IK us RDC	STA 9	July 2008	02/18/09	**0.15**	**0.59**		0.64	1.86	0.02	0.09	
6	IK us RDC	STA 9	July 2008	02/18/09	**0.17**	**0.67**		0.75	1.88	0.14	0.11	
7	IK us RDC	STA 9	July 2008	02/18/09	**0.09**	**0.36**		0.32	1.60	0.06	0.05	
8	IK us RDC	STA 9	July 2008	02/18/09	**0.44**	**1.78**		1.71	1.70	0.00	0.19	
9	IK us RDC	STA 9	July 2008	02/18/09	**0.16**	**0.64**		0.64	1.75	0.00	0.08	
10	IK us RDC	STA 9	July 2008	02/18/09	**0.47**	**1.87**		1.92	1.78	0.00	0.27	
12	IK us DUDD	IK us DUDD	July 2008	02/18/09	**0.75**	**3.02**		2.99	1.74	0.00	0.32	
13	IK us DUDD	IK us DUDD	July 2008	02/18/09	**0.94**	**3.75**		3.63	1.71	0.00	0.29	
14	IK us DUDD	IK us DUDD	July 2008	02/18/09	**0.38**	**1.50**		1.50	1.74	0.05	0.16	
15	IK us DUDD	IK us DUDD	July 2008	02/18/09	**0.90**	**3.62**		3.52	1.72	0.00	0.34	
16	IK us DUDD	IK us DUDD	July 2008	02/18/09	**0.57**	**2.29**		2.35	1.79	0.00	0.35	
17	IK us DUDD	IK us DUDD	July 2008	02/18/09	**0.62**	**2.46**		2.35	1.69	0.00	0.26	
18	IK us DUDD	IK us DUDD	July 2008	02/18/09	**0.47**	**1.87**		1.92	1.78	0.00	0.27	
19	IK us DUDD	IK us DUDD	July 2008	02/18/09	**0.72**	**2.88**		2.88	1.75	0.00	0.27	
20	IK us DUDD	IK us DUDD	July 2008	02/18/09	**0.31**	**1.23**		1.17	1.69	0.02	0.16	
21	IK us DUDD	IK us DUDD	July 2008	02/18/09	**1.03**	**4.11**		4.06	1.73	0.00	0.34	
22	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**0.80**	**3.18**		2.99	1.67	0.09	0.37	
23	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**5.29**	**21.14**		20.29	1.70	0.00	1.02	
24	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**0.70**	**2.79**		2.78	1.74	0.00	0.19	
25	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**0.66**	**2.65**		2.56	1.71	0.00	0.14	
26	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**0.95**	**3.79**		3.74	1.73	0.00	0.35	
27	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**1.63**	**6.53**		6.30	1.70	0.00	0.61	
28	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**0.83**	**3.33**		3.31	1.74	0.02	0.35	
29	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**0.72**	**2.88**		2.78	1.70	0.00	0.17	
30	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**0.55**	**2.20**		2.14	1.71	0.00	0.10	
31	Lwr Bons blw WRD	Lwr Bons blw WRD	July 2008	02/18/09	**0.94**	**3.74**		3.63	1.71	0.00	0.32	
32	INVALID Turb too High	BLANK		02/18/09	**0.01**	**0.04**	**Below Detection**	0.11		0.04	0.16	
31	DOUBLE	Lwr Bons blw WRD	July 2008	02/18/09	**0.94**	**3.74**		3.52	1.67	0.00	0.32	
1	BLANK	BLANK		02/19/09	**0.00**	**0.00**	**Below Detection**	0.00		0.00	0.00	
2	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.82**	**3.29**		3.31	1.76	0.00	0.31	
3	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.51**	**2.06**		2.03	1.73	0.00	0.22	
4	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.88**	**3.52**		3.52	1.75	0.00	0.35	
5	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**1.01**	**4.03**		3.95	1.73	0.00	0.31	
6	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.65**	**2.61**		2.56	1.73	0.00	0.17	
7	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.48**	**1.92**		2.03	1.83	0.00	0.17	
8	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.37**	**1.47**		1.50	1.78	0.00	0.13	
9	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.80**	**3.20**		3.10	1.71	0.00	0.36	
10	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.72**	**2.88**		2.88	1.75	0.00	0.27	
11	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.38**	**1.51**		1.50	1.74	0.00	0.19	
37	IK DS RDC STA 8	STA 8	July 2008	02/19/09	**0.53**	**2.10**		2.14	1.77	0.00	0.21	
12	North Fork STA 12	STA 12	July 2008	02/19/09	**1.48**	**5.93**		5.77	1.71	0.03	0.36	
13	North Fork STA 12	STA 12	July 2008	02/19/09	**0.50**	**2.01**		1.92	1.69	0.00	0.22	
14	North Fork STA 12	STA 12	July 2008	02/19/09	**0.23**	**0.92**		0.85	1.67	0.00	0.01	
15	North Fork STA 12	STA 12	July 2008	02/19/09	**0.96**	**3.86**		3.74	1.70	0.25	0.18	
16	North Fork STA 12	STA 12	July 2008	02/19/09	**0.19**	**0.77**		0.75	1.70	0.02	0.03	
17	North Fork STA 12	STA 12	July 2008	02/19/09	**0.25**	**1.00**		0.96	1.69	0.00	0.06	
18	North Fork STA 12	STA 12	July 2008	02/19/09	**0.21**	**0.86**		0.96	1.90	0.13	0.05	
19	North Fork STA 12	STA 12	July 2008	02/19/09	**0.58**	**2.32**		2.24	1.70	0.05	0.18	
20	North Fork STA 12	STA 12	July 2008	02/19/09	**0.20**	**0.78**		0.75	1.70	0.00	0.06	
21	North Fork STA 12	STA 12	July 2008	02/19/09	**0.46**	**1.85**		1.82	1.71	0.20	0.09	

Appendix 3 (concluded)

2008 Red Dog NPDES and Bons Monitoring Chlorophyl Results												
	Use un-corrected Chl a values							Phaeo Corrected				
Daily		Station	Date	Date	Vial	Chl a	Below Method	Chl a	664/665	Chl b	Chl c	
Vial #	Site	number	Collected	Analyzed	Chl a	mg/m2	Detection Limit	mg/m2	Ratio	mg/m2	mg/m2	Notes
							(0.06 Vial Chl a)					
							OR					
							Above Linear Check					
							(13.7 Vial Chl a)					
22	Main Stem STA 10	STA 10	July 2008	02/19/09	**0.58**	**2.33**		2.67	1.96	0.00	0.24	
23	Main Stem STA 10	STA 10	July 2008	02/19/09	**1.34**	**5.34**		5.23	1.72	0.00	0.40	
24	Main Stem STA 10	STA 10	July 2008	02/19/09	**0.77**	**3.07**		3.10	1.76	0.00	0.14	
25	Main Stem STA 10	STA 10	July 2008	02/19/09	**0.87**	**3.48**		3.42	1.73	0.00	0.29	
26	Main Stem STA 10	STA 10	July 2008	02/19/09	**0.80**	**3.20**		3.20	1.75	0.00	0.26	
27	Main Stem STA 10	STA 10	July 2008	02/19/09	**0.72**	**2.89**		2.78	1.70	0.00	0.20	
28	Main Stem STA 10	STA 10	July 2008	02/19/09	**1.17**	**4.66**		4.59	1.73	0.00	0.46	
29	Main Stem STA 10	STA 10	July 2008	02/19/09	**1.15**	**4.58**		4.70	1.79	0.00	0.34	
30	Main Stem STA 10	STA 10	July 2008	02/19/09	**0.65**	**2.61**		2.67	1.78	0.00	0.17	
31	Main Stem STA 10	STA 10	July 2008	02/19/09	**0.34**	**1.38**		1.39	1.76	0.00	0.08	
33	Main Stem STA 10	STA 10	July 2008	02/19/09	**0.54**	**2.15**		2.14	1.74	0.00	0.20	
32	BLANK	BLANK		02/19/09	**0.00**	**0.00**	**Below Detection**	0.00		0.00	0.00	
24	DOUBLE	STA 10	July 2008	02/19/09	**0.78**	**3.11**		3.10	1.74	0.00	0.21	
1	BLANK	BLANK		02/20/09	**0.00**	**0.00**	**Below Detection**	0.00		0.00	0.00	
2	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.01**	**0.04**	**Below Detection**	0.11		0.05	0.06	
3	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.00**	**0.00**	**Below Detection**	0.00		0.01	0.00	
4	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.01**	**0.04**	**Below Detection**	0.11		0.05	0.06	
5	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.01**	**0.05**	**Below Detection**	0.11		0.00	0.00	
6	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.02**	**0.09**	**Below Detection**	0.21		0.04	0.00	
7	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.02**	**0.09**	**Below Detection**	0.21		0.00	0.00	
8	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.00**	**0.00**	**Below Detection**	0.00		0.00	0.00	
9	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.02**	**0.09**	**Below Detection**	0.21		0.00	0.00	
10	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.02**	**0.09**	**Below Detection**	0.21		0.00	0.00	
11	Mid. Fk. RDC	STA 20	July 2008	02/20/09	**0.00**	**0.01**	**Below Detection**	0.00		0.00	0.00	
12	IK ds Dudd	STA 7	July 2008	02/20/09	**0.59**	**2.38**		2.35	1.73	0.00	0.31	
13	IK ds Dudd	STA 7	July 2008	02/20/09	**0.51**	**2.06**		2.03	1.73	0.00	0.22	
14	IK ds Dudd	STA 7	July 2008	02/20/09	**0.46**	**1.83**		1.92	1.82	0.00	0.18	
15	IK ds Dudd	STA 7	July 2008	02/20/09	**0.97**	**3.89**		3.95	1.77	0.00	0.23	
16	IK ds Dudd	STA 7	July 2008	02/20/09	**0.80**	**3.20**		3.10	1.71	0.00	0.23	
17	IK ds Dudd	STA 7	July 2008	02/20/09	**1.23**	**4.93**		4.91	1.74	0.00	0.46	
18	IK ds Dudd	STA 7	July 2008	02/20/09	**0.34**	**1.37**		1.50	1.88	0.00	0.05	
19	IK ds Dudd	STA 7	July 2008	02/20/09	**0.95**	**3.79**		3.84	1.77	0.00	0.35	
22	IK ds Dudd	STA 7	July 2008	02/20/09	**1.43**	**5.71**		5.77	1.76	0.00	0.42	
23	IK ds Dudd	STA 7	July 2008	02/20/09	**0.22**	**0.87**		0.96	1.90	0.00	0.02	
24	Buddy us Road	STA 221	July 2008	02/20/09	**0.86**	**3.46**		3.42	1.73	0.12	0.26	
25	Buddy us Road	STA 221	July 2008	02/20/09	**1.54**	**6.15**		5.98	1.70	0.63	0.34	
26	Buddy us Road	STA 221	July 2008	02/20/09	**0.23**	**0.91**		0.85	1.67	0.03	0.08	
27	Buddy us Road	STA 221	July 2008	02/20/09	**0.49**	**1.96**		1.92	1.72	0.00	0.13	
28	Buddy us Road	STA 221	July 2008	02/20/09	**0.38**	**1.50**		1.39	1.65	0.05	0.16	
29	Buddy us Road	STA 221	July 2008	02/20/09	**1.10**	**4.38**		4.38	1.73	0.54	0.28	
30	Buddy us Road	STA 221	July 2008	02/20/09	**0.56**	**2.23**		2.24	1.75	0.02	0.13	
31	Buddy us Road	STA 221	July 2008	02/20/09	**0.55**	**2.21**		2.24	1.75	0.26	0.14	
32	Buddy us Road	STA 221	July 2008	02/20/09	**0.64**	**2.55**		2.56	1.75	0.11	0.09	
33	Buddy us Road	STA 221	July 2008	02/20/09	**0.41**	**1.65**		1.71	1.76	0.53	0.12	
37	BLANK	BLANK		02/20/09	**0.00**	**0.00**	**Below Detection**	0.00		0.00	0.00	
33	DOUBLE	STA 221	July 2008	02/20/09	**0.41**	**1.65**		1.71	1.76	0.53	0.12	
1	BLANK	BLANK		2/24/2009	**0.00**	**0.00**	**Below Detection**	0.00		0.00	0.00	
2	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**1.54**	**6.17**		6.09	1.70	1.65	0.23	
3	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**1.12**	**4.48**		4.49	1.72	1.05	0.15	
4	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**0.91**	**3.63**		3.52	1.70	0.20	0.27	
5	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**0.32**	**1.26**		1.28	1.75	0.18	0.00	
6	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**1.87**	**7.47**		7.26	1.70	0.67	0.66	
7	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**1.94**	**7.78**		7.80	1.72	2.03	0.41	
8	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**1.80**	**7.19**		7.16	1.71	1.92	0.36	moist
9	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**1.00**	**4.00**		3.95	1.70	1.35	0.18	moist
10	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**0.25**	**0.99**		1.07	1.83	0.23	0.07	
11	Buddy blw Falls	Buddy blw Falls	July 2008	2/24/2009	**0.44**	**1.75**		1.71	1.70	0.33	0.07	
12	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**1.61**	**6.44**		6.30	1.71	0.41	0.33	
13	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**0.83**	**3.34**		3.31	1.74	0.00	0.11	
14	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**2.67**	**10.67**		10.47	1.72	0.00	1.04	
15	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**1.55**	**6.21**		6.30	1.76	0.53	0.27	
16	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**1.80**	**7.18**		6.94	1.69	0.93	0.28	
17	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**2.50**	**10.00**		9.72	1.69	1.70	0.21	
18	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**0.84**	**3.37**		3.10	1.63	0.46	1.10	
19	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**1.10**	**4.41**		4.27	1.70	0.13	0.33	
20	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**1.95**	**7.81**		7.69	1.73	0.00	0.57	
21	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**2.80**	**11.19**		11.00	1.73	0.00	0.84	
33	Bons us conf w\ Buddy	STA 220	July 2008	2/24/2009	**2.06**	**8.24**		8.01	1.70	0.81	0.36	
32	BLANK	BLANK		2/24/2009	**0.00**	**0.00**	**Below Detection**	0.00		0.00	0.00	
8	DOUBLE	Buddy blw Falls	July 2008	2/24/2009	**1.81**	**7.24**		7.16	1.71	1.98	0.42	

Appendix 4. Aquatic Invertebrate Drift Samples

Middle Fork Red Dog Creek, Station 20, Drift Samples Invertebrates										
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total aquatic taxa	15	15	19	15	28	23	20	16	26	25
Tot. Ephemeroptera	9	0	17	4	6	44	41	7	23	29
Tot. Plecoptera	3	5	43	20	34	38	28	9	11	13
Tot. Trichoptera	0	0	0	0	0	0	1	0	1	1
Total Aq. Diptera	104	40	153	121	449	28	92	6	80	72
Misc.Aq.sp	9	17	73	17	55	46	177	5	82	52
% Ephemeroptera	8%	0%	6%	2%	1%	28%	12%	26%	12%	17%
% Plecoptera	3%	7%	15%	13%	7%	24%	8%	35%	6%	8%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	83%	64%	53%	75%	83%	18%	27%	22%	41%	43%
% other	7%	28%	26%	10%	10%	29%	52%	18%	42%	31%
% EPT	10%	8%	21%	15%	7%	52%	21%	60%	18%	25%
% Chironomidae	80%	36%	51%	73%	73%	16%	24%	15%	35%	39%
% Dominant Aquatic Taxon	46%	36%	31%	43%	48%	30%	42%	37%	22%	22%
Volume of water (m3)	378	551	933	310	702	880	302	296	384	249
average water/net	76	110	187	62	140	176	60	59	77	50
StDev of water volume	24	26	89	14	38	91	26	9	52	8
Estimated total inverts/m^3 water	2.92	0.6	1.7	6.2	6.6	1.1	19.4	0.6	7.4	16.2
Estimated aquatic inverts/m^3 water	1.7	0.6	1.5	2.6	3.9	0.9	5.6	0.4	2.6	3.4
average inv/m^3	3.2	0.6	1.8	6.1	6.4	1.2	19.5	0.6	10.5	16.3
average aq. Invertebrates/m^3 water	1.8	0.57	1.64	2.59	3.74	0.95	5.33	0.45	3.53	3.39
Stdev of aq. Inv. Den.	1.3	0.21	0.38	0.58	1.07	0.27	0.97	0.21	1.86	0.7
Total aquatic invertebrates	627	309	1431	810	2719	783	1694	133	980	835
Total. terrestrial invertebrates	477	10	185	1115	1889	170	4158	59	1875	3210
Total invertebrates	1104	319	1616	1925	4608	953	5852	192	2855	4045
% Sample aquatic	57%	97%	89%	42%	59%	82%	29%	69%	34%	21%
% Sample terrestrial	43%	3%	11%	58%	41%	18%	71%	31%	66%	79%
Average # aquatic inverts / net	125	62	286	162	544	157	339	27	196	167
stdev aq inv/net	59	20	111	56	242	69	178	11	20	35
Average # terr. inverts / net	95	2	37	223	378	34	832	12	375	642
Average # inverts / net	221	64	323	385	922	191	1170	38	571	809
stdev inv/net	68	21	127	156	376	85	532	13	55	191
Total Larval Arctic Grayling/site	0	0	0	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0

Appendix 4 (continued)

North Fork Red Dog Creek, Station 12, Drift Samples Invertebrates										
Date:	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total aquatic taxa	13	13	18	16	26	20	21	15	21	23
Tot. Ephemeroptera	67	14	20	170	194	38	198	882	163	57
Tot. Plecoptera	23	94	117	40	64	5	5	19	11	77
Tot. Trichoptera	4	6	6	0	4	0	0	0	1	4
Total Aq. Diptera	700	314	1134	116	716	27	333	755	641	1574
Misc.Aq.sp	30	69	226	43	188	17	39	32	135	320
% Ephemeroptera	8%	3%	1%	46%	16%	44%	34%	52%	17%	3%
% Plecoptera	3%	19%	8%	11%	6%	5%	1%	1%	1%	4%
% Trichoptera	1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	85%	63%	75%	31%	62%	31%	58%	45%	67%	77%
% other	4%	14%	15%	12%	16%	19%	7%	2%	14%	16%
% EPT	11%	23%	9%	57%	23%	50%	35%	53%	18%	7%
% Chironomidae	54%	36%	57%	22%	27%	25%	36%	14%	61%	32%
% Dominant Aquatic Taxon	45%	32%	43%	46%	35%	48%	34%	44%	36%	45%
Volume of water (m^3)	559	221	747	226	672	672	380	368	297	329
average water/net	112	44	149	45	134	134	76	74	59	66
StDev of water volume	80	12	54	23	37	64	54	10	24	20
Estimated total inverts/m^3 water	9.2	11.8	10.2	13.5	9.3	0.9	12.4	23.6	18.3	33.2
Estimated aquatic inverts/m^3 water	7.4	11.2	10.0	8.1	8.7	0.6	7.6	23.0	16.0	30.9
average inv/m^3	14.2	11.5	10.2	15.0	10.0	0.8	16.3	23.5	19.9	33.5
average aq. Invertebrates/m^3 water	11.4	10.9	10.0	9.1	9.4	0.6	11.8	22.8	17.5	31.1
Stdev of aq. Inv. Den.	8.3	5.7	1.5	5.3	5.2	0.2	9.4	3.9	6.6	7.8
Total aquatic invertebrates	4120	2486	7509	1839	5827	435	2875	8442	4750	10159
Total. terrestrial invertebrates	1044	129	117	1211	426	159	1833	248	670	745
Total invertebrates	5164	2615	7626	3050	6254	594	4708	8691	5420	10904
% Sample aquatic	80%	95%	98%	60%	93%	73%	61%	97%	88%	93%
% Sample terrestrial	20%	5%	2%	40%	7%	27%	39%	3%	12%	7%
Average # aquatic inverts / net	824	497	1502	368	1165	87	575	1688	950	2032
stdev aq inv/net	138	352	545	161	409	60	278	448	265	802
Average # terr. inverts / net	209	26	23	242	85	32	367	50	134	149
Average # inverts / net	1033	523	1525	610	1251	119	942	1738	1084	2181
stdev inv/net	274	339	560	188	434	97	587	447	308	848
Total Larval Arctic Grayling/site	1	3	1	0	0	0	0	0	9	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0

Appendix 4 (continued)

Mainstem Red Dog Creek, Station 10, Drift Samples Invertebrates										
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total aquatic taxa	11	7	19	12	21	17	15	20	22	24
Tot. Ephemeroptera	2	0	6	14	313	24	54	77	56	25
Tot. Plecoptera	35	16	34	30	292	16	36	45	144	50
Tot. Trichoptera	0	1	3	0	1	0	7	0	1	3
Total Aq. Diptera	182	20	676	129	438	37	396	87	558	1301
Misc.Aq.sp	3	2	82	8	58	9	82	73	141	106
% Ephemeroptera	1%	1%	1%	8%	28%	28%	9%	27%	6%	2%
% Plecoptera	16%	41%	4%	17%	27%	18%	6%	16%	16%	3%
% Trichoptera	0%	3%	0%	0%	0%	0%	1%	0%	0%	0%
% Aq. Diptera	82%	52%	84%	71%	40%	43%	69%	31%	62%	88%
% other	1%	4%	10%	4%	5%	11%	14%	26%	16%	7%
% EPT	17%	44%	5%	25%	55%	47%	17%	43%	22%	5%
% Chironomidae	69%	25%	79%	62%	24%	39%	36%	22%	60%	55%
% Dominant Aquatic Taxon	61%	42%	64%	52%	29%	30%	33%	23%	42%	52%
Volume of water (m3)	869	356	1323	255	688	1239	665	417	422	384
average water/net	174	71	265	51	138	248	133	83	84	77
StDev of water volume	122	27	56	15	39	54	65	13	20	10
Estimated total inverts/m3 water	1.4	0.6	3.1	3.8	8.2	0.5	7.5	4.8	13.5	22.6
Estimated aquatic inverts/m3 water	1.3	0.5	3.0	3.6	8.0	0.3	4.3	3.4	10.7	19.4
average inv/m3	1.9	0.7	3.2	4.2	8.6	0.5	8.2	5.0	14.0	22.8
average aq. inverts/m3 water	1.8	0.6	3.1	4.0	8.4	0.4	4.6	3.5	11.1	19.5
Stdev of aq. Inv. Den.	1.3	0.3	0.8	2.1	1.9	0.0	1.6	1.4	2.3	3.6
Total aquatic invertebrates	1111	192	4003	910	5503	427	2875	1410	4497	7427
Total. terrestrial invertebrates	136	21	121	49	121	173	2119	609	1218	1252
Total invertebrates	1247	213	4123	959	5624	600	4993	2018	5715	8679
% Sample aquatic	89%	90%	97%	95%	98%	71%	58%	70%	79%	86%
% Sample terrestrial	11%	10%	3%	5%	2%	29%	42%	30%	21%	14%
Average # aquatic inverts / net	222	38	801	182	1101	85	575	282	899	1485
stdev aq inv/net	126	25	182	47	152	16	311	66	83	227
Average # terr. inverts / net	27	4	24	10	24	35	424	122	244	250
Average # inverts / net	249	43	825	192	1125	120	999	404	1143	1736
stdev inv/net	153	27	171	51	152	25	529	69	111	218
Total Larval Arctic Grayling/site	5	5	0	2	1	0	0	0	0	45
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0

Appendix 4 (continued)

Ikalukrok Creek, Station 9, Drift Samples Invertebrates										
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total aquatic taxa	8	9	15	13	21	16	13	18	20	20
Tot. Ephemeroptera	11	63	267	213	138	208	571	67	225	122
Tot. Plecoptera	17	13	159	24	54	30	189	57	98	64
Tot. Trichoptera	0	0	0	0	0	0	1	0	1	0
Total Aq. Diptera	10	58	1252	285	485	196	185	56	217	193
Misc.Aq.sp	9	8	56	5	23	23	23	25	24	162
% Ephemeroptera	24%	44%	15%	40%	19%	45%	59%	33%	40%	23%
% Plecoptera	36%	9%	9%	5%	8%	7%	19%	28%	17%	12%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	22%	41%	72%	54%	70%	43%	19%	27%	39%	36%
% other	19%	6%	3%	1%	3%	5%	2%	12%	4%	30%
% EPT	60%	54%	25%	45%	27%	52%	79%	60%	57%	34%
% Chironomidae	21%	39%	69%	52%	65%	25%	15%	18%	35%	28%
% Dominant Aquatic Taxon	32%	45%	65%	44%	57%	36%	37%	24%	35%	20%
Volume of water (m^3)	260	478	833	575	450	2772	555	352	382	390
average water/net	52	96	167	115	90	554	111	70	76	78
StDev of water volume	25	16	106	29	23	161	12	16	23	22
Estimated total inverts/m^3 water	1.5	1.6	10.7	4.9	8.7	1.4	11.4	3.8	9.0	11.3
Estimated aquatic inverts/m^3 water	0.9	1.5	10.4	4.6	7.8	0.8	8.7	2.9	7.4	6.9
average inv/m^3	1.6	1.6	12	5	8.9	1.4	11.4	3.9	9.5	13.7
average aq inverts/m^3 water	1.0	1.5	11.7	4.7	7.9	0.9	8.7	3.0	7.9	8.3
Stdev of aq. inv. Den.	0.6	0.3	4.6	0.8	1.0	0.1	1.7	1.2	2.5	6.2
Total aquatic invertebrates	232	714	8668	2635	3497	2288	4848	1028	2822	2707
Total. terrestrial invertebrates	159	66	220	168	403	1507	1482	325	606	1704
Total invertebrates	391	780	8888	2803	3900	3795	6330	1353	3427	4410
% Sample aquatic	59%	92%	98%	94%	90%	60%	77%	76%	82%	61%
% Sample terrestrial	41%	8%	2%	6%	10%	40%	23%	24%	18%	39%
Average # aquatic inverts / net	46	143	1734	527	699	458	970	206	564	541
stdev aq inv/net	26	46	822	102	115	90	255	81	120	266
Average # terr. inverts / net	32	13	44	34	81	301	296	65	121	341
Average # inverts / net	78	156	1778	561	780	759	1266	271	685	882
stdev inv/net	51	50	849	99	110	158	296	94	173	424
Total Larval Arctic Grayling/site	1	1	0	0	0	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	1	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0

Appendix 4 (continued)

Ikalukrok Creek, Station 8, Drift Samples Invertebrates										
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Aquatic Taxa	12	10	23	13	24	17	24	24	24	25
Tot. Ephemeroptera	2	4	157	35	204	53	356	22	159	146
Tot. Plecoptera	7	4	106	19	92	16	164	110	76	117
Tot. Trichoptera	0	0	1	0	0	0	2	0	0	2
Total Aq. Diptera	27	16	458	87	907	47	313	66	185	440
Misc. Aq. Sp.	1	1	55	2	77	10	41	20	29	298
% Ephemeroptera	5%	16%	20%	24%	16%	42%	41%	10%	35%	15%
% Plecoptera	19%	17%	14%	13%	7%	12%	19%	50%	17%	12%
% Tricoptera	1%	2%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	73%	63%	59%	61%	71%	38%	36%	30%	41%	44%
% Other	3%	2%	7%	1%	6%	8%	5%	9%	6%	30%
% EPT	24%	35%	34%	38%	23%	55%	60%	60%	52%	26%
% Chironomidae	60%	51%	54%	56%	65%	30%	30%	21%	38%	24%
% Dominant Aquatic Taxon	56%	34%	42%	41%	44%	27%	28%	47%	30%	22%
Volume of Water (m^3)	273	371	1207	547	646	1391	706	428	281	491
average water/net	55	74	241	109	129	278	141	86	56	98
StDev of water volume	27	56	71	34	40	35	66	20	18	21
Estimated total inverts/m^3 water	0.8	0.4	3.3	1.4	11.2	0.6	8.1	3.9	11.2	14.5
Estimated aquatic inverts/m^3 water	0.7	0.4	3.2	1.3	9.9	0.5	6.2	2.5	8.0	10.2
average inv/m^3	1.1	0.6	3.6	1.4	11.1	0.6	8.9	4.1	12.1	14.7
average aq inverts/m^3 water	0.9	0.5	3.5	1.3	9.8	0.5	6.7	2.7	8.6	10.3
StDev of aq. Inv. Density	0.7	0.2	1.3	0.3	1.3	0.1	1.4	0.9	2.8	1.6
Total aquatic invertebrates	183	128	3883	715	6398	625	4382	1089	2248	5012
Total terrestrial invertebrates	46	27	113	33	823	257	1355	582	892	2127
Total invertebrates	229	155	3996	748	7221	882	5736	1671	3140	7139
% sample aquatic	80%	83%	97%	96%	89%	71%	76%	65%	72%	70%
% sample terrestrial	20%	17%	3%	4%	11%	29%	24%	35%	28%	30%
Average # aquatic inverts/net	37	26	777	143	1280	125	876	218	450	1002
StDev aq inverts/net	14	7	181	45	461	21	231	60	104	226
Average # terr. inverts/net	9	5	23	7	165	51	271	116	178	425
Average # inverts/net	46	31	799	150	1444	176	1147	334	628	1428
StDev inverts/net	17	10	173	49	511	40	245	78	133	296
Total Larval Arctic Grayling/site	0	1	0	1	0	0	0	0	0	1
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0

Appendix 4 (continued)

Ikalukrok Creek, Station 7U (upstream of Dudd Creek), Drift Samples Invertebrates										
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total aquatic taxa	14	17	19	19	16	21	15	22	19	23
Tot. Ephemeroptera	4	0	269	9	27	45	175	35	106	1
Tot. Plecoptera	66	74	75	20	26	38	15	31	21	7
Tot. Trichoptera	1	0	1	0	0	1	2	0	4	2
Total Aq. Diptera	149	269	249	199	775	210	696	215	754	335
Misc.Aq.sp	23	24	52	18	67	26	25	44	156	34
% Ephemeroptera	2%	0%	42%	4%	3%	14%	19%	11%	10%	0%
% Plecoptera	27%	20%	12%	8%	3%	12%	2%	9%	2%	2%
% Trichoptera	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	61%	73%	39%	81%	87%	66%	76%	66%	72%	89%
% other	9%	7%	8%	7%	8%	8%	3%	13%	15%	9%
% EPT	29%	20%	53%	12%	6%	26%	21%	20%	13%	2%
% Chironomidae	59%	53%	33%	30%	20%	49%	40%	40%	62%	29%
% Dominant Aquatic Taxon	51%	48%	42%	50%	66%	30%	36%	30%	37%	59%
Volume of water (m^3)	966	255	1069	698	824	2644	945	560	402	355
average water/net	193	51	214	140	165	529	189	112	80	71
StDev of water volume	103	14	37	21	45	264	54	47	20	27
Estimated total inverts/m^3 water	2.0	9.7	3.3	2.3	5.7	1.0	6.9	3.9	16.4	7.0
Estimated aquatic inverts/m^3 water	1.3	7.2	3.0	1.8	5.4	0.6	4.8	2.9	12.9	5.3
average inv/m^3	2.8	10.6	3.2	2.4	6.0	1.1	7.1	4.1	17.6	7.8
average aq inverts/m^3 water	1.8	7.5	3.0	1.8	5.8	0.7	4.7	3.0	13.9	6.0
StDev of aq. Inv. Density	1.9	1.6	0.4	0.3	1.6	0.2	0.9	0.7	5.0	2.6
Total aquatic invertebrates	1210	1840	3229	1231	4475	1600	4564	1621	5206	1889
Total. terrestrial invertebrates	673	640	245	403	212	938	1994	578	1394	580
Total invertebrates	1883	2480	3474	1634	4687	2538	6558	2199	6600	2469
% Sample aquatic	64%	74%	93%	75%	96%	63%	70%	74%	79%	77%
% Sample terrestrial	36%	26%	7%	25%	4%	37%	30%	26%	21%	23%
Average # aquatic inverts / net	242	368	646	246	895	320	913	324	1041	378
stdev aq inv/net	168	79	154	30	130	120	407	125	150	109
Average # terr. inverts / net	135	128	49	81	42	188	399	116	279	116
Average # inverts / net	377	496	695	327	937	508	1312	440	1320	494
stdev inv/net	241	48	168	42	140	125	424	159	250	113
Total Larval Arctic Grayling/site	0	3	0	3	1	0	0	0	1	13
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	1	3	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0	0	0

Appendix 4 (continued)

Ikalukrok Creek below Dudd Creek Station 7										
Year Sampled	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total aquatic taxa	10	12	18	9	18	24	18	22	18	24
Tot. Ephemeroptera	1	4	138	12	59	23	152	114	126	17
Tot. Plecoptera	9	102	43	12	37	8	4	29	21	21
Tot. Trichoptera	0	1	1	0	1	2	0	2	1	1
Total Aq. Diptera	38	319	262	111	1054	95	529	323	1356	1335
Misc.Aq.sp	3	105	22	2	36	44	8	83	187	119
% Ephemeroptera	1%	1%	30%	8%	5%	13%	22%	21%	7%	1%
% Plecoptera	17%	19%	9%	8%	3%	4%	1%	5%	1%	1%
% Trichoptera	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%
% Aq. Diptera	75%	60%	56%	81%	89%	55%	76%	59%	80%	89%
% other	7%	20%	5%	1%	3%	26%	1%	15%	11%	8%
% EPT	18%	20%	39%	17%	8%	19%	22%	26%	9%	3%
% Chironomidae	66%	39%	51%	36%	22%	43%	59%	43%	68%	18%
% Dominant Aquatic Taxon	63%	39%	46%	46%	67%	31%	38%	27%	58%	71.0%
Volume of water (m^3)	190	513	617	359	866	1182	303	617	502	491
average water/net	38	103	123	72	173	236	61	123	100	98
StDev of water volume	23	54	40	23	19	114	14	35	33	56
Estimated total inverts/m^3 water	1.8	5.7	3.9	2.2	7.2	1.0	15.3	5.2	23.1	17.7
Estimated aquatic inverts/m^3 water	1.3	5.2	3.8	1.9	6.9	0.7	11.4	4.5	16.9	15.2
average inv/m^3	2.5	6.0	4.1	2.3	7.3	1.0	15.4	5.6	26.1	17.9
average aq inverts/m^3 water	1.7	5.4	4.0	2.0	7.0	0.8	11.4	4.9	18.8	15.6
StDev of aq. Inv. Density	1.0	1.3	1.0	0.8	1.5	0.1	3.4	2.0	7.6	1.8
Total aquatic invertebrates	253	2657	2335	684	5940	857	3465	2759	8455	7466
Total. terrestrial invertebrates	90	291	54	114	291	279	1181	428	3112	1224
Total invertebrates	343	2948	2389	798	6232	1136	4646	3187	11567	8689
% Sample aquatic	74%	90%	98%	86%	95%	75%	75%	87%	73%	86%
% Sample terrestrial	26%	10%	2%	14%	5%	25%	25%	13%	27%	14%
Average # aquatic inverts / net	51	531	467	137	1188	171	693	552	1691	1493
stdev aq inv/net	27	309	64	56	167	63	292	111	209	842
Average # terr. inverts / net	18	58	11	23	58	56	236	86	622	245
Average # inverts / net	69	590	478	160	1246	227	929	637	2313	1738
stdev inv/net	29	328	66	53	167	84	352	130	276	1012
Total Larval Arctic Grayling/site	0	2	0	14	1	0	0	0	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	1	0	0	1	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	7	0	0	0	0

Appendix 4 (continued)

Bons Creek below Blast Road, upstream of Bons Pond					
Year Sampled	2004	2005	2006	2007	2008
Total aquatic taxa	17	23	16	14	19
Tot. Ephemeroptera	3	15	7	6	6
Tot. Plecoptera	1	1	1	1	3
Tot. Trichoptera	0	0	0	0	0
Total Aq. Diptera	39	82	23	367	347
Misc.Aq.sp	7	66	10	56	114
% Ephemeroptera	6%	9%	17%	1%	1%
% Plecoptera	2%	1%	2%	0%	1%
% Trichoptera	0%	0%	0%	0%	0%
% Aq. Diptera	77%	50%	56%	86%	74%
% other	14%	40%	25%	13%	24%
% EPT	8%	10%	19%	2%	2%
% Chironomidae	68%	27%	43%	72%	20%
% Dominant Aquatic Taxon	60%	38%	38%	50%	53.0%
Volume of water (m^3)	349	104	68	86	79
average water/net	70	21	14	17	16
StDev of water volume	10	11	3	3	8
Estimated total inverts/m^3 water	1.3	23.0	4.6	31.5	55.4
Estimated aquatic inverts/m^3 water	0.7	7.9	3.1	24.8	29.9
average inv/m^3	1.3	23.0	4.6	31.5	57.6
average aq inverts/m^3 water	0.7	9.6	3.2	25.0	30.4
StDev of aq. Inv. Density	0.5	4.9	1.3	8.4	4.6
Total aquatic invertebrates	251	823	208	2147	2354
Total. terrestrial invertebrates	209	1564	105	574	2012
Total invertebrates	460	2387	313	2721	4365
% Sample aquatic	55%	34%	66%	79%	54%
% Sample terrestrial	45%	66%	34%	21%	46%
Average # aquatic inverts / net	50	165	42	429	471
stdev aq inv/net	40	58	14	154	218
Average # terr. inverts / net	42	313	21	115	402
Average # inverts / net	92	477	63	544	873
stdev inv/net	79	336	17	207	428
Total Larval Arctic Grayling/site	0	10	0	78	0
Total Larval Slimy Sculpin/site	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0

Appendix 4 (continued)

Bons Creek (Station 220), just upstream of confluence with Buddy Creek								
Year Sampled	2004	2005	2006a	2006b	2007a	2007b	2008a	2008b
Total aquatic taxa	20	18	17	19	16	17	19	20
Tot. Ephemeroptera	7	51	17	17	95	95	63	63
Tot. Plecoptera	3	5	8	8	8	8	29	29
Tot. Trichoptera	1	1	0	0	4	4	4	4
Total Aq. Diptera	48	63	122	122	1391	1391	2112	2112
Misc.Aq.sp	3	8	241	5255	34	1590	134	1322
% Ephemeroptera	11%	40%	4%	0%	6%	3%	3%	2%
% Plecoptera	5%	4%	2%	0%	1%	0%	1%	1%
% Trichoptera	2%	1%	0%	0%	0%	0%	0%	0%
% Aq. Diptera	77%	50%	31%	2%	91%	45%	90%	60%
% other	5%	40%	62%	97%	2%	51%	6%	37%
% EPT	18%	44%	7%	0%	7%	3%	4%	3%
% Chironomidae	46%	43%	30%	2%	35%	17%	72%	48%
% Dominant Aquatic Taxon	45%	43%	53%	89%	56%	50%	67%	48%
Volume of water (m^3)	698	76	612	612	150	150	317	317
average water/net	140	15	122	122	30	30	63	63
StDev of water volume	59	7	44	44	21	21	20	20
Estimated total inverts/m^3 water	0.8	11.2	5.0	46.0	63.7	115.6	41.7	60.5
Estimated aquatic inverts/m^3 water	0.4	8.4	3.2	44.2	51.1	103.0	37.0	55.8
average inv/m^3	0.9	11.2	5.0	46.0	130.0	222.4	42.3	61.4
average aq inverts/m^3 water	0.4	8.1	3.3	46.4	107.4	199.8	37.8	56.8
StDev of aq. Inv. Density	0.2	2.2	0.8	21.5	136.8	232.8	11.0	11.0
Total aquatic invertebrates	312	636	1943	27013	7654	15436	11706	17648
Total. terrestrial invertebrates	273	217	1143	1143	1892	1892	1494	1494
Total invertebrates	585	853	3086	28156	9546	17328	13200	19142
% Sample aquatic	53%	75%	63%	96%	80%	89%	89%	92%
% Sample terrestrial	47%	25%	37%	4%	20%	11%	11%	8%
Average # aquatic inverts / net	62	127	389	5403	1531	3087	2341	3530
stdev aq inv/net	56	66	108	2101	854	2008	766	993
Average # terr. inverts / net	55	43	229	229	378	378	299	299
Average # inverts / net	117	171	617	5631	1909	3466	2640	3828
stdev inv/net	59	88	239	2183	1108	2288	872	1098
Total Larval Arctic Grayling/site	0	0	0	0	1	1	0	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0	0	0	0
2006a is without Daphniids and 2006b is with Daphniids								
2007a is without Ostracods and 2007b is with Ostracods								
2008a is without Ostracods and 2008b is with Ostracods								

Appendix 4 (continued)

Buddy Creek (Station 221), upstream of haul road					
Year Sampled	2004	2005	2006	2007	2008
Total aquatic taxa	20	20	19	23	22
Tot. Ephemeroptera	2042	232	515	385	110
Tot. Plecoptera	20	18	28	130	86
Tot. Trichoptera	0	1	0	1	0
Total Aq. Diptera	195	423	476	965	1632
Misc.Aq.sp	25	47	84	98	204
% Ephemeroptera	89%	32%	47%	24%	5%
% Plecoptera	1%	3%	3%	8%	4%
% Trichoptera	0%	0%	0%	0%	0%
% Aq. Diptera	9%	59%	43%	61%	80%
% other	1%	32%	8%	6%	10%
% EPT	90%	35%	49%	33%	10%
% Chironomidae	5%	38%	25%	43%	39%
% Dominant Aquatic Taxon	89%	28%	44%	24%	41.0%
Volume of water (m^3)	771	235	600	242	489
average water/net	154	47	120	48	98
StDev of water volume	146	18	65	30	18
Estimated total inverts/m^3 water	16.2	22.0	11.5	39.7	24.6
Estimated aquatic inverts/m^3 water	14.8	15.3	9.2	32.7	20.8
average inv/m^3	20.1	22.0	11.5	47.0	25.0
average aq inverts/m^3 water	18.1	17.2	9.3	38.9	21.0
StDev of aq. Inv. Density	10.1	7.5	2.1	16.1	4.2
Total aquatic invertebrates	11414	3607	5515	7892	10161
Total. terrestrial invertebrates	1074	1572	1404	1698	1900
Total invertebrates	12488	5179	6918	9590	12061
% Sample aquatic	91%	70%	80%	82%	84%
% Sample terrestrial	9%	30%	20%	18%	16%
Average # aquatic inverts / net	2283	721	1103	1578	2032
stdev aq inv/net	1459	176	575	555	391
Average # terr. inverts / net	215	314	281	340	380
Average # inverts / net	2498	1036	1384	1918	2412
stdev inv/net	1540	323	752	683	394
Total Larval Arctic Grayling/site	0	0	0	1	0
Total Larval Slimy Sculpin/site	0	0	0	0	0
Total Larval Dolly Varden/site	0	0	0	0	0

Appendix 4 (concluded)

Buddy Creek (below falls), downstream of the canyon and haul road						
Year Sampled	2004	2005	2006a	2006b	2007	2008
Total aquatic taxa	18	19	16	18	25	20
Tot. Ephemeroptera	578	328	253	253	1316	124
Tot. Plecoptera	9	12	32	32	92	21
Tot. Trichoptera	1	2	0	0	7	2
Total Aq. Diptera	363	855	199	199	2284	2011
Misc.Aq.sp	71	19	125	2461	444	206
% Ephemeroptera	57%	27%	42%	9%	32%	5%
% Plecoptera	1%	1%	5%	1%	2%	1%
% Trichoptera	0%	0%	0%	0%	0%	0%
% Aq. Diptera	35%	70%	33%	7%	55%	85%
% other	7%	2%	21%	84%	11%	9%
% EPT	58%	28%	47%	10%	34%	6%
% Chironomidae	11%	64%	22%	4%	40%	67%
% Dominant Aquatic Taxon	56%	43%	33%	69%	30%	46.0%
Volume of water (m^3)	1326	271	612	612	593	633
average water/net	265	54	122	122	119	127
StDev of water volume	160	12	29	29	63	57
Estimated total inverts/m^3 water	4.5	35.9	7.3	26.4	42.4	20.8
Estimated aquatic inverts/m^3 water	3.9	22.5	5.0	24.1	34.9	18.7
average inv/m^3	4.4	35.9	7.3	26.4	47.5	26.4
average aq inverts/m^3 water	3.9	22.6	5.0	24.8	39.4	23.6
StDev of aq. Inv. Density	2.2	3.3	1.6	9.7	16.0	15.3
Total aquatic invertebrates	5109	6085	3041	14723	20713	11820
Total. terrestrial invertebrates	876	3645	1400	1400	4439	1320
Total invertebrates	5985	9730	4441	16123	25152	13140
% Sample aquatic	85%	63%	68%	91%	82%	90%
% Sample terrestrial	15%	37%	32%	9%	18%	10%
Average # aquatic inverts / net	1022	1217	608	2945	4143	2364
stdev aq inv/net	744	279	222	1201	1812	352
Average # terr. inverts / net	175	729	280	280	888	264
Average # inverts / net	1197	1946	888	3225	5030	2628
stdev inv/net	893	494	322	1224	2337	432
Total Larval Arctic Grayling/site	0	0	0	0	1	0
Total Larval Slimy Sculpin/site	0	0	0	0	0	0
Total Larval Dolly Varden/site	0	1	0	0	0	0
2006a is without Daphniids and 2006b is with Daphniids						

Appendix 5. Juvenile Dolly Varden Whole Body Metal Concentrations

Juvenile Dolly Varden at the Haul Road						Method		200.80		200.8		7471A		7740.0		200.8	
						analyte		Cd		Pb		Hg		Se		Zn	
Sample		Date	Fish	Length	Weight			total		total		total		total		total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL		0.05		0.02		0.02		1.0		0.5	Solids
073105AXDVJ01	Anxiety Ridge	7/31/2005	DV	118	15.05	Juvenile		0.45		0.42		0.04		3.8		126	23.8
073105AXDVJ02	Anxiety Ridge	7/31/2005	DV	135	21.32	Juvenile		0.13		0.14		0.05		3.7		107	23.4
073105AXDVJ03	Anxiety Ridge	7/31/2005	DV	102	9.25	Juvenile		0.26		0.22		0.05		7.2		135	22.1
073105AXDVJ04	Anxiety Ridge	7/31/2005	DV	114	13.41	Juvenile		0.17		0.15		0.06		5		117	22.1
073105AXDVJ05	Anxiety Ridge	7/31/2005	DV	121	16.7	Juvenile		0.11		0.17		0.06		4.1		129	22.7
073105AXDVJ06	Anxiety Ridge	7/31/2005	DV	101	8.91	Juvenile		0.27		0.2		0.06		5.3		124	21.1
073105AXDVJ07	Anxiety Ridge	7/31/2005	DV	119	14.76	Juvenile		0.1		0.06		0.07		4.6		106	22.4
073105AXDVJ08	Anxiety Ridge	7/31/2005	DV	110	11.91	Juvenile		0.12		0.24		0.05		4.2		107	23
073105AXDVJ09	Anxiety Ridge	7/31/2005	DV	109	11.62	Juvenile		0.14		0.1		0.06		5.2		114	23.2
073105AXDVJ10	Anxiety Ridge	7/31/2005	DV	123	15.22	Juvenile		0.61		0.17		0.04		6		157	20.6
073105AXDVJ11	Anxiety Ridge	7/31/2005	DV	114	13.02	Juvenile		1.75		0.23	<	0.02		7.6		175	22.9
073105AXDVJ12	Anxiety Ridge	7/31/2005	DV	113	11.67	Juvenile		0.19		0.26		0.08		5.7		188	21.1
073105AXDVJ13	Anxiety Ridge	7/31/2005	DV	105	10.96	Juvenile		0.35		0.13		0.03		4.9		137	23
073105AXDVJ14	Anxiety Ridge	7/31/2005	DV	108	10.94	Juvenile		0.28		0.27		0.07		5.1		168	21.8
073105AXDVJ15	Anxiety Ridge	7/31/2005	DV	102	8.47	Juvenile		0.13		0.13		0.05		4.2		144	20.8
081406AXDVJ01	Anxiety Ridge	8/14/2006	DV	120	16.69	Juvenile		0.57		0.78		0.1		3.9		158	23.1
081406AXDVJ02	Anxiety Ridge	8/14/2006	DV	112	13.87	Juvenile		0.27		0.44		0.08		3.8		120	24.9
081406AXDVJ03	Anxiety Ridge	8/14/2006	DV	92	7.91	Juvenile		0.65		1.03		0.09	<	1.0		164	23.2
081406AXDVJ04	Anxiety Ridge	8/14/2006	DV	87	6.39	Juvenile		0.33		0.44		0.09		6.1		169	23.7
081406AXDVJ05	Anxiety Ridge	8/14/2006	DV	109	12.42	Juvenile		0.54		1.25		0.09		4.1		141	23.7
081406AXDVJ06	Anxiety Ridge	8/14/2006	DV	90	7.22	Juvenile		0.32		1.36		0.09		3.7		245	23.2
081406AXDVJ07	Anxiety Ridge	8/14/2006	DV	93	8.38	Juvenile		0.57		0.11		0.07		4.4		157	25
081406AXDVJ08	Anxiety Ridge	8/14/2006	DV	103	10.84	Juvenile		0.56		1.3		0.1		2.9		147	22.8
081406AXDVJ09	Anxiety Ridge	8/14/2006	DV	116	15.94	Juvenile		0.49		1.04		0.15		4.7		129	22.9
081406AXDVJ10	Anxiety Ridge	8/14/2006	DV	90	7.67	Juvenile		0.31		0.45		0.05		3.2		142	24
081406AXDVJ11	Anxiety Ridge	8/14/2006	DV	93	8.73	Juvenile		0.48		3.69		0.07		5.9		171	25
081406AXDVJ12	Anxiety Ridge	8/14/2006	DV	123	19.77	Juvenile		0.64		0.95		0.12		3.7		155	24.9
081406AXDVJ13	Anxiety Ridge	8/14/2006	DV	84	6.29	Juvenile		0.62		0.92		0.08		4		144	24.3
081007AXDVJ01	Anxiety Ridge	8/10/2007	DV	113	12.48	Juvenile		0.25		0.25		0.14		4.4		133	23
081007AXDVJ02	Anxiety Ridge	8/10/2007	DV	93	7.7	Juvenile		0.32		0.22		0.07		3.1		93.9	27.3
081007AXDVJ03	Anxiety Ridge	8/10/2007	DV	128	18.42	Juvenile		0.25		0.2		0.09		4.6		102	24.1
081007AXDVJ04	Anxiety Ridge	8/10/2007	DV	132	21.02	Juvenile		0.29		0.27		0.1		3.6		99.4	26.4
081007AXDVJ05	Anxiety Ridge	8/10/2007	DV	125	15.85	Juvenile		0.18		0.14		0.07		4		114	24.1
081007AXDVJ06	Anxiety Ridge	8/10/2007	DV	128	18.64	Juvenile		0.22		0.16		0.05		3.6		141	24.1
081007AXDVJ07	Anxiety Ridge	8/10/2007	DV	126	16.43	Juvenile		0.09		0.15		0.07		1.3		101	26.5
081007AXDVJ08	Anxiety Ridge	8/10/2007	DV	128	17.58	Juvenile		0.21		0.38		0.05		3.5		106	23.5
081007AXDVJ09	Anxiety Ridge	8/10/2007	DV	100	10.27	Juvenile		0.21		0.52		0.05		3.4		107	26.7
081007AXDVJ10	Anxiety Ridge	8/10/2007	DV	104	10.22	Juvenile		0.38		1.07		0.05		3.2		114	26.3
081007AXDVJ11	Anxiety Ridge	8/10/2007	DV	96	8.23	Juvenile		0.26		0.77		0.08		3.8		89.8	28.5
081007AXDVJ12	Anxiety Ridge	8/10/2007	DV	103	10.15	Juvenile		0.19		0.32		0.08		3.4		119	25.4
081007AXDVJ13	Anxiety Ridge	8/10/2007	DV	129	18.73	Juvenile		0.13		0.84		0.09		3.2		113	25.3
081007AXDVJ14	Anxiety Ridge	8/10/2007	DV	102	9.33	Juvenile		0.19		0.14		0.08		3.7		78.8	27.9
081007AXDVJ15	Anxiety Ridge	8/10/2007	DV	129	19.29	Juvenile		0.17		0.2		0.08		3.4		97.2	24.7
080508AXDVJ01	Anxiety Ridge	8/5/2008	DV	94	6.6	Juvenile		0.18		0.43		0.07		3.8		112	23.4
080508AXDVJ02	Anxiety Ridge	8/5/2008	DV	101	8.8	Juvenile		0.17		0.09		0.06		4.8		136	22.6
080508AXDVJ03	Anxiety Ridge	8/5/2008	DV	118	14.5	Juvenile		0.33		0.26		0.09		5.5		121	22.5
080508AXDVJ04	Anxiety Ridge	8/5/2008	DV	95	6.8	Juvenile		0.18		0.31		0.06		4.1		124	22.9
080508AXDVJ05	Anxiety Ridge	8/5/2008	DV	122	14.0	Juvenile		0.12		0.07		0.12		1.9		139	24.3
080508AXDVJ06	Anxiety Ridge	8/5/2008	DV	98	8.2	Juvenile		0.14		0.18		0.07		3.6		122	21.3
080508AXDVJ07	Anxiety Ridge	8/5/2008	DV	94	7.1	Juvenile		0.15		0.52		0.09		3.2		150	22.9
080508AXDVJ08	Anxiety Ridge	8/5/2008	DV	100	8.8	Juvenile		0.11		0.13		0.07		3.6		161	22.6
080508AXDVJ09	Anxiety Ridge	8/5/2008	DV	103	9.4	Juvenile		0.19		0.21		0.1		3.8		126	23
080508AXDVJ10	Anxiety Ridge	8/5/2008	DV	93	6.9	Juvenile		0.20		0.22		0.08		4.2		114	23.6
080508AXDVJ11	Anxiety Ridge	8/5/2008	DV	101	8	Juvenile		0.19		0.39		0.07		5.6		120	22.8
080508AXDVJ12	Anxiety Ridge	8/5/2008	DV	93	6.4	Juvenile		0.26		0.12		0.07		4.8		109	23.2
080508AXDVJ13	Anxiety Ridge	8/5/2008	DV	90	6.2	Juvenile		0.21		0.21		0.06		4		142	22.7
080508AXDVJ14	Anxiety Ridge	8/5/2008	DV	94	6.7	Juvenile		0.28		0.37		0.07		3.9		176	22.3
080508AXDVJ15	Anxiety Ridge	8/5/2008	DV	104	7.8	Juvenile		0.3		0.59		0.26		5.3		199	21.4

Appendix 5 (continued)

Juvenile Dolly Varden Mainstem Red Dog Creek						Method	200.80	200.8	7471A	7740.0	200.8	
						analyte	Cd	Pb	Hg	Se	Zn	
Sample		Date	Fish	Length	Weight		total	total	total	total	total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL	0.05	0.02	0.02	1.0	0.5	Solids
080798MSDVJ1	Mainstem	8/7/1998	DV	132		Juvenile	1.97	5.04		6.46		25.5
080798MSDVJ2	Mainstem	8/7/1998	DV	145		Juvenile	3.62	15		7.27		26.8
080798MSDVJ3	Mainstem	8/7/1998	DV	124		Juvenile	3.62	16.2		6.4		23.8
080798MSDVJ4	Mainstem	8/7/1998	DV	124		Juvenile	3.04	10.6		5.23		23.7
080798MSDVJ5	Mainstem	8/7/1998	DV	110		Juvenile	3.07	6.97		5.73		24.3
080798MSDVJ6	Mainstem	8/7/1998	DV	130		Juvenile	1.89	4.17		7.29		24.1
080798MSDVJ7	Mainstem	8/7/1998	DV	143		Juvenile	0.42	3.95		6.88		25.6
080798MSDVJ8	Mainstem	8/7/1998	DV	130		Juvenile	2.54	21.2		8.68		23.3
080798MSDVJ9	Mainstem	8/7/1998	DV	132		Juvenile	3.08	6.48		7.26		23.3
080798MSDVJ10	Mainstem	8/7/1998	DV	132		Juvenile	1.04	7.97		7.62		24.2
081299MSDVJ01	Mainstem	8/10/1999	DV	140		Juvenile	4.62	8.91		6.89		23.9
081299MSDVJ02	Mainstem	8/10/1999	DV	121		Juvenile	3.9	8.78		7.13		22.6
081299MSDVJ03	Mainstem	8/10/1999	DV	125		Juvenile	3.75	8.68		8.9		22.2
081299MSDVJ04	Mainstem	8/10/1999	DV	127		Juvenile	4.14	3.11		7.26		24.1
081299MSDVJ05	Mainstem	8/10/1999	DV	130		Juvenile	3.19	4.97		6.87		20.8
081299MSDVJ06	Mainstem	8/10/1999	DV	134		Juvenile	1.28	3.18		7.3		24.1
081299MSDVJ07	Mainstem	8/10/1999	DV	139		Juvenile	3.84	6.52		8.89		22.8
081299MSDVJ08	Mainstem	8/10/1999	DV	145		Juvenile	3.17	10.4		6.3		23.3
081299MSDVJ09	Mainstem	8/10/1999	DV	143		Juvenile	0.54	1.09		5.66		26
081299MSDVJ10	Mainstem	8/10/1999	DV	120		Juvenile	2.47	9.94		4.24		23.2
072800MSDVJ01	Mainstem	7/28/2000	DV	131	17.9	Juvenile	2.69	6.8		6.8		22.5
072800MSDVJ02	Mainstem	7/28/2000	DV	117	12.3	Juvenile	3.45	13		10.8		25.1
072800MSDVJ03	Mainstem	7/28/2000	DV	140	21.8	Juvenile	4.75	9.75		9.1		22.7
072800MSDVJ04	Mainstem	7/28/2000	DV	110	11.2	Juvenile	2.91	13.4		12.5		24.6
072800MSDVJ05	Mainstem	7/28/2000	DV	125	16	Juvenile	6.4	15.8		8.9		20.9
080501MSRDDVJ01	Mainstem	7/31/2001	DV	92	6.93	Juvenile	5.92	46.6		12.3	333	22
080501MSRDDVJ02	Mainstem	7/31/2001	DV	133	16.11	Juvenile	3.88	16.8		7.6	244	20.8
080501MSRDDVJ03	Mainstem	7/31/2001	DV	94	6.22	Juvenile	3.42	25		15.2	327	24.9
080501MSRDDVJ04	Mainstem	7/31/2001	DV	132	15.98	Juvenile	1.15	1.95		6.7	117	21.4
080501MSRDDVJ05	Mainstem	7/31/2001	DV	134	21.74	Juvenile	3.83	9.79		14.4	210	22.8
080501MSRDDVJ06	Mainstem	7/31/2001	DV	117	12.7	Juvenile	2.78	4.43		10.5	226	20.7
080501MSRDDVJ07	Mainstem	7/31/2001	DV	106	9.69	Juvenile	2.8	5.62		11.1	210	21.5
080501MSRDDVJ08	Mainstem	7/31/2001	DV	106	9.3	Juvenile	3.52	11.4		13.1	188	23.2
081002MSRDDV01	Mainstem	7/28/2002	DV	112	13.99	Juvenile	6.63	20.7		9.4	271	23.8
081002MSRDDV02	Mainstem	7/28/2002	DV	100	11.75	Juvenile	5.62	8.89		13	276	25.1
081002MSRDDV03	Mainstem	7/28/2002	DV	127	20.25	Juvenile	6.16	14.6		16.1	404	25.4
081002MSRDDV04	Mainstem	7/28/2002	DV	128	20.53	Juvenile	6.17	29.2		12.7	402	23.6
081002MSRDDV05	Mainstem	7/28/2002	DV	90	6.22	Juvenile	1.83	6.77		6.6	195	22.9
081002MSRDDV06	Mainstem	7/28/2002	DV	106	10.88	Juvenile	3.39	9.33		13	230	25.1
081002MSRDDV07	Mainstem	7/28/2002	DV	104	10.93	Juvenile	4.82	8.39		17.2	314	24.9
081002MSRDDV08	Mainstem	7/28/2002	DV	98	8.74	Juvenile	3.13	6.42		17	210	24.2
081002MSRDDV09	Mainstem	7/28/2002	DV	119	16.71	Juvenile	2.82	5		14.2	205	26.1
081002MSRDDV10	Mainstem	7/28/2002	DV	95	9.04	Juvenile	3.65	16.9		9.2	218	23.4
081002MSRDDV11	Mainstem	7/29/2002	DV	134	23.22	Juvenile	3.05	8.4		9.8	219	24.7
081002MSRDDV12	Mainstem	7/29/2002	DV	116	13.21	Juvenile	2.31	5.26		8.7	180	20.5
081002MSRDDV13	Mainstem	7/29/2002	DV	99	9.67	Juvenile	2.64	3.02		11.2	218	25.3
081002MSRDDV14	Mainstem	7/29/2002	DV	100	10.6	Juvenile	3.11	8.12		13.3	221	24
081002MSRDDV15	Mainstem	7/29/2002	DV	96	8.36	Juvenile	2.04	10.1		8.2	177	24
080803MSDVJ01	Mainstem	8/8/2003	DV	150	30	Juvenile	4.98	10.7		11.8	233	25.4
080803MSDVJ02	Mainstem	8/8/2003	DV	128	16.7	Juvenile	5.48	8.4		11.5	208	24.5
081003MSDVJ03	Mainstem	8/10/2003	DV	112	13.5	Juvenile	6.56	15.2		10.1	271	23.2
081003MSDVJ04	Mainstem	8/10/2003	DV	111	13.6	Juvenile	3.86	2.42		10	220	25.2
081003MSDVJ05	Mainstem	8/10/2003	DV	119	15.5	Juvenile	3.41	1.72		10.1	166	24.2
081003MSDVJ06	Mainstem	8/10/2003	DV	108	12	Juvenile	2.82	3.41		10	197	23
081003MSDVJ07	Mainstem	8/10/2003	DV	106	11.3	Juvenile	5.92	9.26		10.4	331	23.3
081003MSDVJ08	Mainstem	8/10/2003	DV	108	11.2	Juvenile	4.65	4.51		11	212	24.6
081003MSDVJ09	Mainstem	8/10/2003	DV	112	12.3	Juvenile	2.96	4.66		8.5	185	24.6
081003MSDVJ10	Mainstem	8/10/2003	DV	118	16.3	Juvenile	5.15	16.3		12.7	258	24.3
081003MSDVJ11	Mainstem	8/10/2003	DV	111	11.9	Juvenile	4.37	12.7		9.6	234	24.7
081003MSDVJ12	Mainstem	8/10/2003	DV	109	11.6	Juvenile	1.29	1.87		10.1	153	24.7
081003MSDVJ13	Mainstem	8/10/2003	DV	106	15.5	Juvenile	1.86	0.97		8.2	140	24.9
081003MSDVJ14	Mainstem	8/10/2003	DV	110	12.8	Juvenile	3.53	4.42		13.7	249	25.5

Appendix 5 (continued)

Juvenile Dolly Varden Mainstem Red Dog Creek						Method		200.80		200.8		7471A		7740.0		200.8	
						analyte		Cd		Pb		Hg		Se		Zn	
Sample		Date	Fish	Length	Weight			total		total		total		total		total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL		0.05		0.02		0.02		1.0		0.5	Solids
082004MSDVJ01	Mainstem	8/20/2004	DV	91	6.5	Juvenile		4.72		24.7		0.06		5.7		265	20.1
082004MSDVJ02	Mainstem	8/20/2004	DV	110	10.7	Juvenile		1.23		2.4		0.03		3.9		208	21.9
082704MSDVJ03	Mainstem	8/27/2004	DV	128	18.1	Juvenile		0.76		1.63	<	0.02		3.2		120	26.2
082704MSDVJ04	Mainstem	8/27/2004	DV	116	11.8	Juvenile		3.74		147		0.04		6.8		282	22.2
072805MSRDDVJ01	Mainstem	7/28/2005	DV	109	11.52	Juvenile		3.48		3.05		0.03		10.8		167	24.1
072805MSRDDVJ02	Mainstem	7/28/2005	DV	111	11.79	Juvenile		2.5		2.06		0.02		9.7		173	24.3
072805MSRDDVJ03	Mainstem	7/28/2005	DV	123	16.36	Juvenile		1.48		2.72		0.03		8.5		176	24.3
072805MSRDDVJ04	Mainstem	7/28/2005	DV	131	19	Juvenile		1.4		2.13		0.04		9.8		159	22.3
072805MSRDDVJ05	Mainstem	7/28/2005	DV	116	15.75	Juvenile		1.66		1.63		0.03		7.8		190	24.1
072805MSRDDVJ06	Mainstem	7/28/2005	DV	103	10.96	Juvenile		2.87		7.03		0.04		7.7		214	23
072905MSRDDVJ07	Mainstem	7/29/2005	DV	122	15.89	Juvenile		1.67		1.91		0.03		10.2		147	24.2
072905MSRDDVJ08	Mainstem	7/29/2005	DV	107	12.47	Juvenile		2.11		0.95		0.03		9.2		166	24.6
072905MSRDDVJ09	Mainstem	7/29/2005	DV	119	15.9	Juvenile		3.27		1.93		0.03		9.6		171	21.7
072905MSRDDVJ10	Mainstem	7/29/2005	DV	109	13.15	Juvenile		1.71		1.62		0.04		8.7		199	23.8
072905MSRDDVJ11	Mainstem	7/29/2005	DV	136	22.93	Juvenile		2.09		1.73		0.02		9.5		163	25.6
072905MSRDDVJ12	Mainstem	7/29/2005	DV	107	11.31	Juvenile		1.6		2.19		0.03		4.6		202	22.8
072905MSRDDVJ13	Mainstem	7/29/2005	DV	114	13.03	Juvenile		2.74		0.78		0.02		8.8		145	22.7
072905MSRDDVJ14	Mainstem	7/29/2005	DV	106	10.9	Juvenile		1.96		1.72		0.04		7.6		181	23.2
072905MSRDDVJ15	Mainstem	7/29/2005	DV	113	14.66	Juvenile		1.87		1.05		0.03		8.7		164	24
081106MSRDDVJ01	Mainstem	8/11/2006	DV	109	11.94	Juvenile		3.15		1.84		0.04		5.7		288	23.1
081106MSRDDVJ02	Mainstem	8/11/2006	DV	110	14.47	Juvenile		3		5.49		0.04		6.9		349	24.5
081106MSRDDVJ03	Mainstem	8/11/2006	DV	108	11.77	Juvenile		2.8		1.15		0.04		6.2		284	24.4
081206MSRDDVJ04	Mainstem	8/12/2006	DV	94	8.33	Juvenile		4.52		12		0.06		6.3		569	20
081206MSRDDVJ05	Mainstem	8/12/2006	DV	112	13.17	Juvenile		3.35		3.99		0.04		8		305	24.1
081206MSRDDVJ06	Mainstem	8/12/2006	DV	110	13.27	Juvenile		3.68		4.81		0.03		6.6		229	23.4
081206MSRDDVJ07	Mainstem	8/12/2006	DV	112	13.14	Juvenile		2.18		1.28		0.04		7.4		260	22
081206MSRDDVJ08	Mainstem	8/12/2006	DV	108	11.03	Juvenile		2.28		1.31		0.03		6.7		317	22.2
081206MSRDDVJ09	Mainstem	8/12/2006	DV	127	18.64	Juvenile		1.77		1.53		0.05		7.4		294	22
081206MSRDDVJ10	Mainstem	8/12/2006	DV	95	8.65	Juvenile		3.76		1.24		0.03		7.4		513	22.4
081206MSRDDVJ11	Mainstem	8/12/2006	DV	102	9.75	Juvenile		3.17		16		0.02		6.4		529	21.6
081007MSRDDVJ01	Mainstem	8/10/2007	DV	124	15.67	Juvenile		5.88		13.3		0.03		7.4		540	24.8
081007MSRDDVJ02	Mainstem	8/10/2007	DV	110	11.81	Juvenile		5.58		2.89		0.03		6.2		463	24.2
081007MSRDDVJ03	Mainstem	8/10/2007	DV	123	15.89	Juvenile		4.89		0.93		0.04		4.4		192	26.7
081007MSRDDVJ04	Mainstem	8/10/2007	DV	78	4.42	Juvenile		1.06		0.87		0.04		2.6		239	27.1
081007MSRDDVJ05	Mainstem	8/10/2007	DV	120	14.32	Juvenile		2.71		3		0.04		5.5		220	23.8
081107MSRDDVJ06	Mainstem	8/11/2007	DV	78	4.3	Juvenile		6.35		3.26		0.03		6.8		359	25.3
081207MSRDDVJ07	Mainstem	8/12/2007	DV	119	15.25	Juvenile		5.43		20.9		0.06		4.9		497	24
081207MSRDDVJ08	Mainstem	8/12/2007	DV	107	11.83	Juvenile		1.88		6.32	<	0.02		3.3		351	26.1
081307MSRDDVJ09	Mainstem	8/12/2007	DV	63	2	Juvenile		1.19		2.75	<	0.18		3.5		250	21.3
081307MSRDDVJ10	Mainstem	8/12/2007	DV	65	2.31	Juvenile		0.72		1.24	<	0.02		2.9		176	22.2
081307MSRDDVJ11	Mainstem	8/12/2007	DV	65	2.36	Juvenile		1.83		1.7	<	0.02		4.5		366	21.4
080408MSRDDVJ01	Mainstem	8/4/2008	DV	95	5.7	Juvenile		2.01		1.43		0.03		5.6		233	21.1
080408MSRDDVJ02	Mainstem	8/4/2008	DV	118	12.2	Juvenile		0.89		0.46		0.04		4.1		247	21.8
080408MSRDDVJ03	Mainstem	8/4/2008	DV	108	9.2	Juvenile		3.21		2.37		0.05		4.9		220	23.3
080408MSRDDVJ04	Mainstem	8/4/2008	DV	108	10.5	Juvenile		2.05		0.67		0.06		4.8		166	23.8
080408MSRDDVJ05	Mainstem	8/4/2008	DV	115	13.4	Juvenile		1.76		2.96		0.04		5.3		291	21.3
080408MSRDDVJ06	Mainstem	8/4/2008	DV	108	17.6	Juvenile		1.63		6.41		0.06		4.4		218	20.5
080408MSRDDVJ07	Mainstem	8/4/2008	DV	118	21.6	Juvenile		2.99		2.77		0.06		7.4		300	23.5
080408MSRDDVJ08	Mainstem	8/4/2008	DV	102	16.2	Juvenile		1.47		1.63		0.04		7.1		229	23
080408MSRDDVJ09	Mainstem	8/4/2008	DV	100	15.9	Juvenile		1.27		1.4		0.03		5.7		223	22.2
080408MSRDDVJ10	Mainstem	8/4/2008	DV	113	20.2	Juvenile		2.3		2.58		0.04		7.1		236	24
080408MSRDDVJ11	Mainstem	8/4/2008	DV	96	14.4	Juvenile		1.67		1.53		0.03		6.3		215	22.2
080408MSRDDVJ12	Mainstem	8/4/2008	DV	104	15.5	Juvenile		1.55		1.82		0.05		4.9		259	22.6
080408MSRDDVJ13	Mainstem	8/4/2008	DV	93	13.6	Juvenile		2.32		2.32		0.03		5.6		290	22.1
080408MSRDDVJ14	Mainstem	8/4/2008	DV	118	22.2	Juvenile		1.94		3.77		0.03		6.3		263	16.1
080408MSRDDVJ15	Mainstem	8/4/2008	DV	97	14.9	Juvenile		2.56		9.92		0.03		5.5		274	23.2

Appendix 5 (continued)

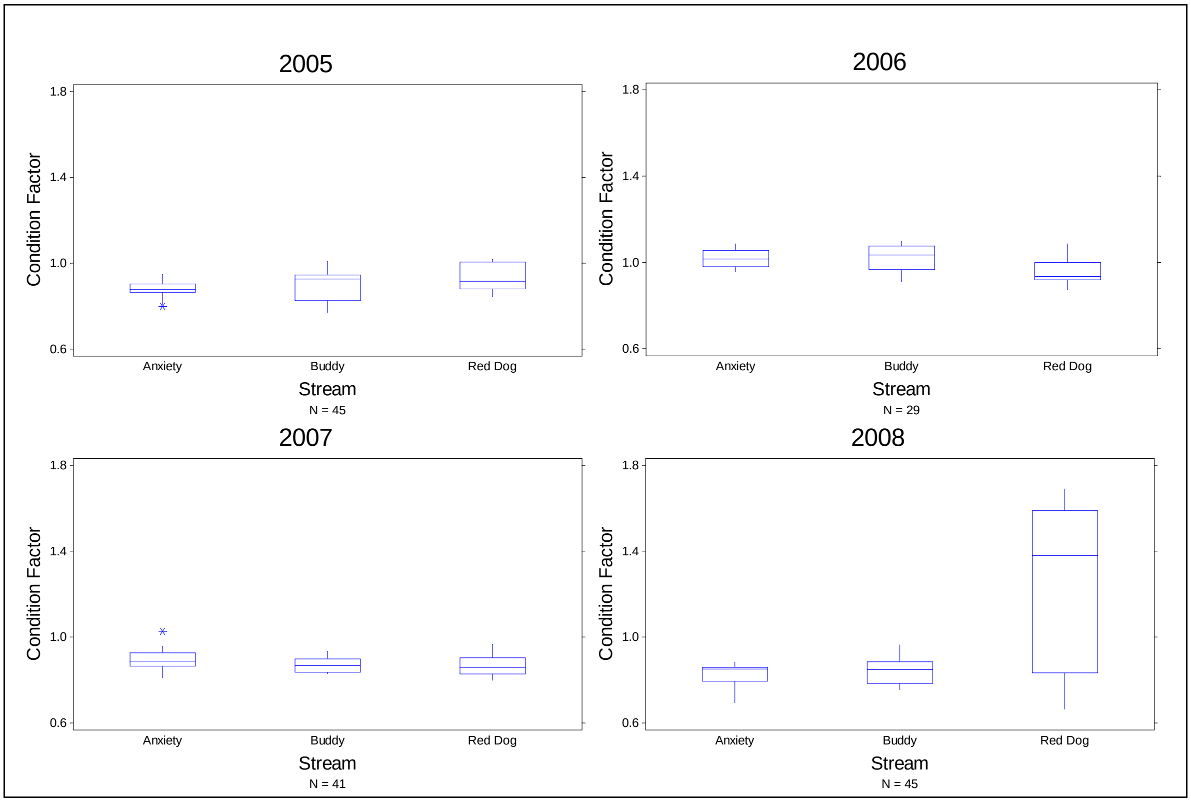
Juvenile Dolly Varden Buddy Creek						Method		200.80		200.8		7471A		7740.0		200.8	
						analyte		Cd		Pb		Hg		Se		Zn	
Sample		Date	Fish	Length	Weight			total		total		total		total		total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL		0.05		0.02		0.02		1.0		0.5	Solids
072905BUDVJ01	Buddy	7/29/2005	DV	104	10.91	Juvenile		1.53		0.18		0.03		8		149	24.4
072905BUDVJ02	Buddy	7/29/2005	DV	106	12	Juvenile		0.5		0.1		0.02		6.9		134	24.3
072905BUDVJ03	Buddy	7/29/2005	DV	115	14.17	Juvenile		1.37		0.16		0.03		6.8		132	24
072905BUDVJ04	Buddy	7/29/2005	DV	102	9.86	Juvenile		0.6		0.1		0.03		7.4		141	25.9
072905BUDVJ05	Buddy	7/29/2005	DV	110	11.92	Juvenile		0.41		0.15		0.02		5.6		114	24.4
072905BUDVJ06	Buddy	7/29/2005	DV	134	18.55	Juvenile		0.2		0.1		0.03		7		131	24.4
072905BUDVJ07	Buddy	7/29/2005	DV	105	10.61	Juvenile		0.58		0.09		0.02		6.4		145	23
072905BUDVJ08	Buddy	7/29/2005	DV	120	16.02	Juvenile		0.26		0.1		0.02		5.7		110	25
072905BUDVJ09	Buddy	7/29/2005	DV	102	10.07	Juvenile		0.87		0.17		0.03		7.1		137	23.1
072905BUDVJ10	Buddy	7/29/2005	DV	101	9.7	Juvenile		1.23		0.13		0.04		5.9		159	22.9
072905BUDVJ11	Buddy	7/29/2005	DV	125	17.42	Juvenile		0.58		0.28		0.04		5.9		106	25.8
072905BUDVJ12	Buddy	7/29/2005	DV	114	12.1	Juvenile		0.61		0.14		0.03		7.4		144	21.1
072905BUDVJ13	Buddy	7/29/2005	DV	105	9.44	Juvenile		0.77		0.19	<	0.02		5.8		135	21
072905BUDVJ14	Buddy	7/29/2005	DV	103	9.02	Juvenile		0.45		0.14		0.02		5.6		131	22.6
072905BUDVJ15	Buddy	7/29/2005	DV	105	11.2	Juvenile		0.62		0.13		0.03		7.2		123	24.6
081506BUDVJ01	Buddy	8/15/2006	DV	93	7.32	Juvenile		1.69		0.38		0.08		5.2		227	19.8
081506BUDVJ02	Buddy	8/15/2006	DV	98	9.72	Juvenile		1.64		0.47		0.04		6.3		215	23.6
081506BUDVJ03	Buddy	8/15/2006	DV	82	5.84	Juvenile		2.18		1.36		0.05		5.2		230	23.8
081506BUDVJ04	Buddy	8/15/2006	DV	95	8.76	Juvenile		0.81		0.38		0.04		5.4		236	24.2
081506BUDVJ05	Buddy	8/15/2006	DV	92	8.53	Juvenile		1.07		2.27		0.03		6.2		205	22.6
081107BUDVJ01	Buddy	8/11/2007	DV	114	12.85	Juvenile		0.77		0.66		0.04		4.8		142	27.2
081107BUDVJ02	Buddy	8/11/2007	DV	118	14.01	Juvenile		0.27		0.11		0.04		4.8		113	25.7
081107BUDVJ03	Buddy	8/11/2007	DV	121	15.94	Juvenile		0.44		0.21		0.04		4.7		129	26.1
081107BUDVJ04	Buddy	8/11/2007	DV	104	9.89	Juvenile		0.69		0.14		0.05		4.1		125	25.2
081107BUDVJ05	Buddy	8/11/2007	DV	103	10.22	Juvenile		0.80		0.12		0.04		4		154	24.9
081107BUDVJ06	Buddy	8/11/2007	DV	131	18.92	Juvenile		0.74		2.19		0.02		3.6		181	24.8
081107BUDVJ07	Buddy	8/11/2007	DV	112	13.06	Juvenile		0.57		0.66		0.04		4.7		137	26.4
081107BUDVJ08	Buddy	8/11/2007	DV	115	12.65	Juvenile		0.8		0.11		0.04		4.9		146	25.1
081107BUDVJ09	Buddy	8/11/2007	DV	112	12.37	Juvenile		0.76		0.42		0.05		5.7		130	25.2
081107BUDVJ10	Buddy	8/11/2007	DV	135	20.43	Juvenile		0.43		0.19		0.06		3.7		116	24.9
081107BUDVJ11	Buddy	8/11/2007	DV	111	11.43	Juvenile		0.94		0.1		0.03		4.7		132	25.8
081107BUDVJ12	Buddy	8/11/2007	DV	131	18.77	Juvenile		0.28		0.23		0.06		5.6		129	24.3
081107BUDVJ13	Buddy	8/11/2007	DV	105	10.34	Juvenile		0.35		1.02		0.1		4.5		133	24.7
081107BUDVJ14	Buddy	8/11/2007	DV	109	11.18	Juvenile		0.47		2.23		0.03		4		134	26
081107BUDVJ15	Buddy	8/11/2007	DV	93	7.37	Juvenile		0.67		0.26		0.04		3.7		126	23.9
080508BUDVJ01	Buddy	8/5/2008	DV	103	9.7	Juvenile		2.15		0.21		0.04		6.2		180	25.6
080508BUDVJ02	Buddy	8/5/2008	DV	97	7.5	Juvenile		1.72		1.15		0.05		5.3		219	23.5
080508BUDVJ03	Buddy	8/5/2008	DV	97	7.2	Juvenile		1.68		0.51		0.05		5.4		200	23.1
080508BUDVJ04	Buddy	8/5/2008	DV	102	9	Juvenile		0.83		0.5		0.04		4.4		165	22.3
080508BUDVJ05	Buddy	8/5/2008	DV	98	7.3	Juvenile		0.59		0.35		0.04		4.8		195	21.9
080508BUDVJ06	Buddy	8/5/2008	DV	111	11.7	Juvenile		0.78		0.68		0.05		4.8		144	22.9
080508BUDVJ07	Buddy	8/5/2008	DV	93	6.1	Juvenile		1.25		0.27		0.05		7.7		197	23.3
080508BUDVJ08	Buddy	8/5/2008	DV	104	9.2	Juvenile		0.67		0.28		0.04		5.5		208	21.8
080508BUDVJ09	Buddy	8/5/2008	DV	94	8	Juvenile		0.59		0.27		0.05		5.4		182	23.2
080508BUDVJ10	Buddy	8/5/2008	DV	103	9.7	Juvenile		0.94		1.27		0.04		5.9		169	22.7
080508BUDVJ11	Buddy	8/5/2008	DV	114	11.6	Juvenile		0.68		0.31		0.04		4.9		166	25
080508BUDVJ12	Buddy	8/5/2008	DV	95	7.8	Juvenile		0.34		0.3		0.05		5.8		220	23.2
080508BUDVJ13	Buddy	8/5/2008	DV	103	9.6	Juvenile		0.41		0.15		0.04		5.7		162	23.4
080508BUDVJ14	Buddy	8/5/2008	DV	98	7.1	Juvenile		1.13		0.25		0.06		4.5		251	21.6
080508BUDVJ15	Buddy	8/5/2008	DV	96	7.9	Juvenile		0.49		0.09		0.05		4.4		170	23

Appendix 5 (concluded)

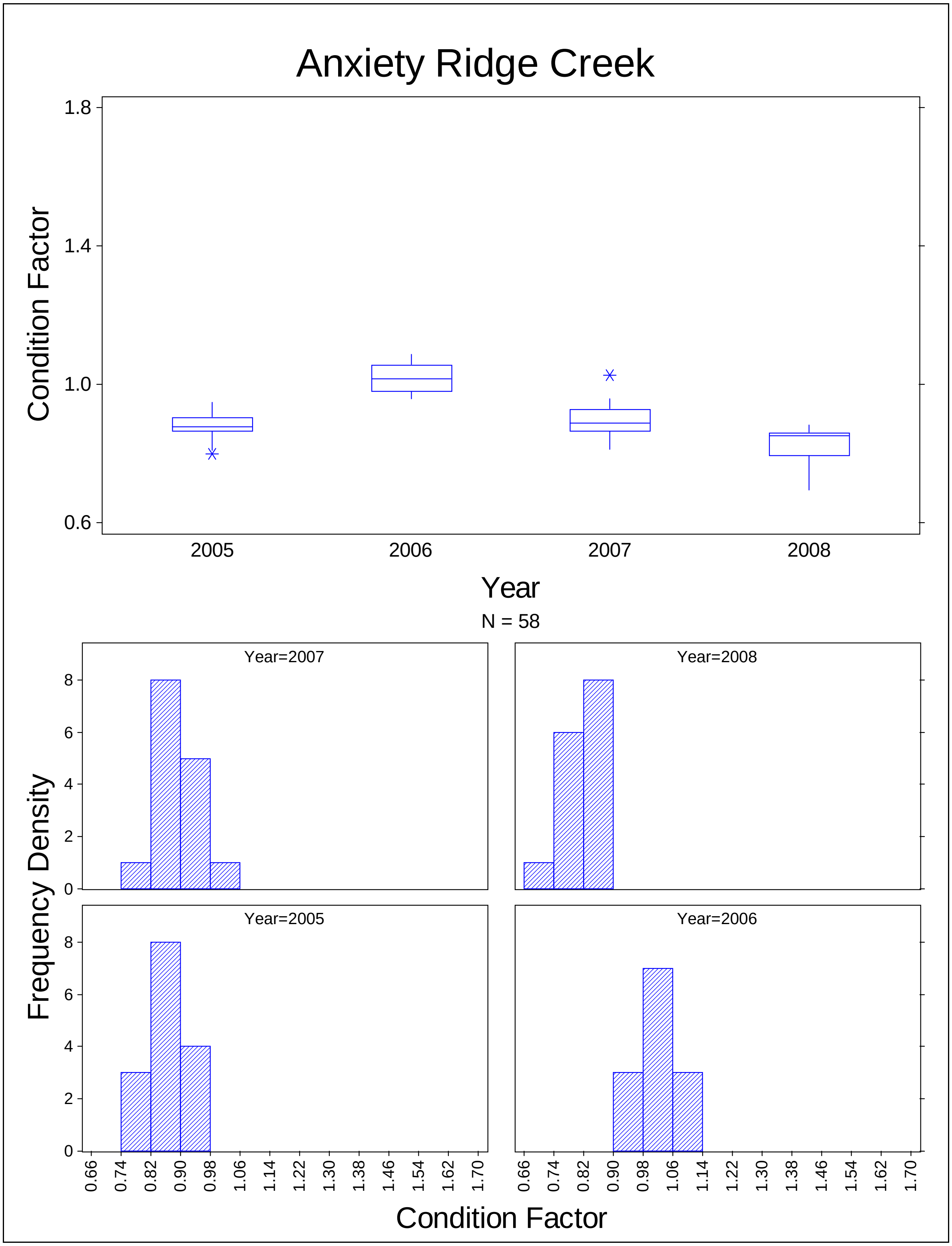
Juvenile Arctic Grayling Creek						Method	200.80	200.8		7471A	7740.0	200.8	
						analyte	Cd	Pb		Hg	Se	Zn	
Sample		Date	Fish	Length	Weight		total	total		total	total	total	%
Number	Stream	Collected	Spp	(mm)	(g)	MRL	0.05	0.02		0.02	1.0	0.5	Solids
082104BPAGJ01	Bons Pond	8/21/2004	AGR	190	76.2	Juvenile	0.19	0.26		0.02	6.6	65.5	26.8
082104BPAGJ02	Bons Pond	8/21/2004	AGR	173	53.5	Juvenile	0.29	0.46		0.02	7.4	61.9	27.8
082204BPAGJ03	Bons Pond	8/22/2004	AGR	167	48.8	Juvenile	0.21	0.47		0.02	11.9	68.1	26
082204BPAGJ04	Bons Pond	8/22/2004	AGR	163	47.2	Juvenile	0.43	0.22		0.03	8.7	76.4	26.4
082204BPAGJ05	Bons Pond	8/22/2004	AGR	186	72.3	Juvenile	0.18	0.24		0.02	14.3	65.3	27.5
082204BPAGJ06	Bons Pond	8/22/2004	AGR	172	56.1	Juvenile	0.15	0.65		0.02	13.6	66.2	26.6
082204BPAGJ07	Bons Pond	8/22/2004	AGR	177	62.3	Juvenile	0.26	0.19		0.02	11.9	61.9	26.8
082204BPAGJ08	Bons Pond	8/22/2004	AGR	181	64.2	Juvenile	0.1	0.20		0.03	13.8	69	26.5
082204BPAGJ09	Bons Pond	8/22/2004	AGR	176	60.1	Juvenile	0.35	1.58		0.02	14.4	84.2	26
082204BPAGJ10	Bons Pond	8/22/2004	AGR	186	72.2	Juvenile	0.32	0.39		0.02	12.3	67.1	26.3
082204BPAGJ11	Bons Pond	8/22/2004	AGR	170	55.4	Juvenile	0.22	0.10		0.02	12.5	65.2	26.9
082204BPAGJ12	Bons Pond	8/22/2004	AGR	184	64.6	Juvenile	0.25	0.21	<	0.02	12.7	64.7	26.7
082204BPAGJ13	Bons Pond	8/22/2004	AGR	185	61.3	Juvenile	0.26	0.26		0.02	9	62.7	26.4
082204BPAGJ14	Bons Pond	8/22/2004	AGR	178	58.1	Juvenile	0.32	0.25		0.02	8.8	66.9	27.8
082204BPAGJ15	Bons Pond	8/22/2004	AGR	180	63.8	Juvenile	0.21	0.70		0.02	13.5	69.1	26.8
081407BPAGJ01	Bons Pond	8/14/2007	AGR	155	39.63	Juvenile	0.19	0.23		0.05	10.5	81.5	24.4
081407BPAGJ02	Bons Pond	8/14/2007	AGR	140	30.83	Juvenile	0.34	0.2		0.04	12.1	89.4	24.5
081407BPAGJ03	Bons Pond	8/14/2007	AGR	185	67.77	Juvenile	0.21	0.26		0.05	12.6	95.7	24.3
081407BPAGJ04	Bons Pond	8/14/2007	AGR	190	69.84	Juvenile	0.15	0.23		0.05	9.5	88.4	23.5
081407BPAGJ05	Bons Pond	8/14/2007	AGR	192	73.99	Juvenile	0.21	0.42		0.04	12.6	92.8	22.5
081407BPAGJ06	Bons Pond	8/14/2007	AGR	157	39.69	Juvenile	0.24	0.21		0.05	14.3	91.8	23.6
081407BPAGJ07	Bons Pond	8/14/2007	AGR	192	77.15	Juvenile	0.16	0.29		0.05	10.8	93.3	23.9
081407BPAGJ08	Bons Pond	8/14/2007	AGR	185	65.46	Juvenile	0.19	0.27		0.06	10.2	97.3	23.4
081407BPAGJ09	Bons Pond	8/14/2007	AGR	193	76.45	Juvenile	0.13	0.25		0.05	10.9	92	24.1
081407BPAGJ10	Bons Pond	8/14/2007	AGR	204	81.48	Juvenile	0.12	0.22		0.07	11.4	92.5	22.2
081407BPAGJ11	Bons Pond	8/14/2007	AGR	210	102.99	Juvenile	0.14	0.27		0.04	11.9	85.7	23.3
081407BPAGJ12	Bons Pond	8/14/2007	AGR	212	101.32	Juvenile	0.22	0.91		0.03	11.8	94.3	23.5
081407BPAGJ13	Bons Pond	8/14/2007	AGR	208	96.26	Juvenile	0.12	1.02		0.05	12.1	100	23.6
081407BPAGJ14	Bons Pond	8/14/2007	AGR	163	48.69	Juvenile	0.28	0.42		0.04	11	91	23.1
081407BPAGJ15	Bons Pond	8/14/2007	AGR	205	94.78	Juvenile	0.12	0.12		0.05	11.6	84.6	24.2

Appendix 6. Dolly Varden and Arctic Grayling, Statistical Analyses

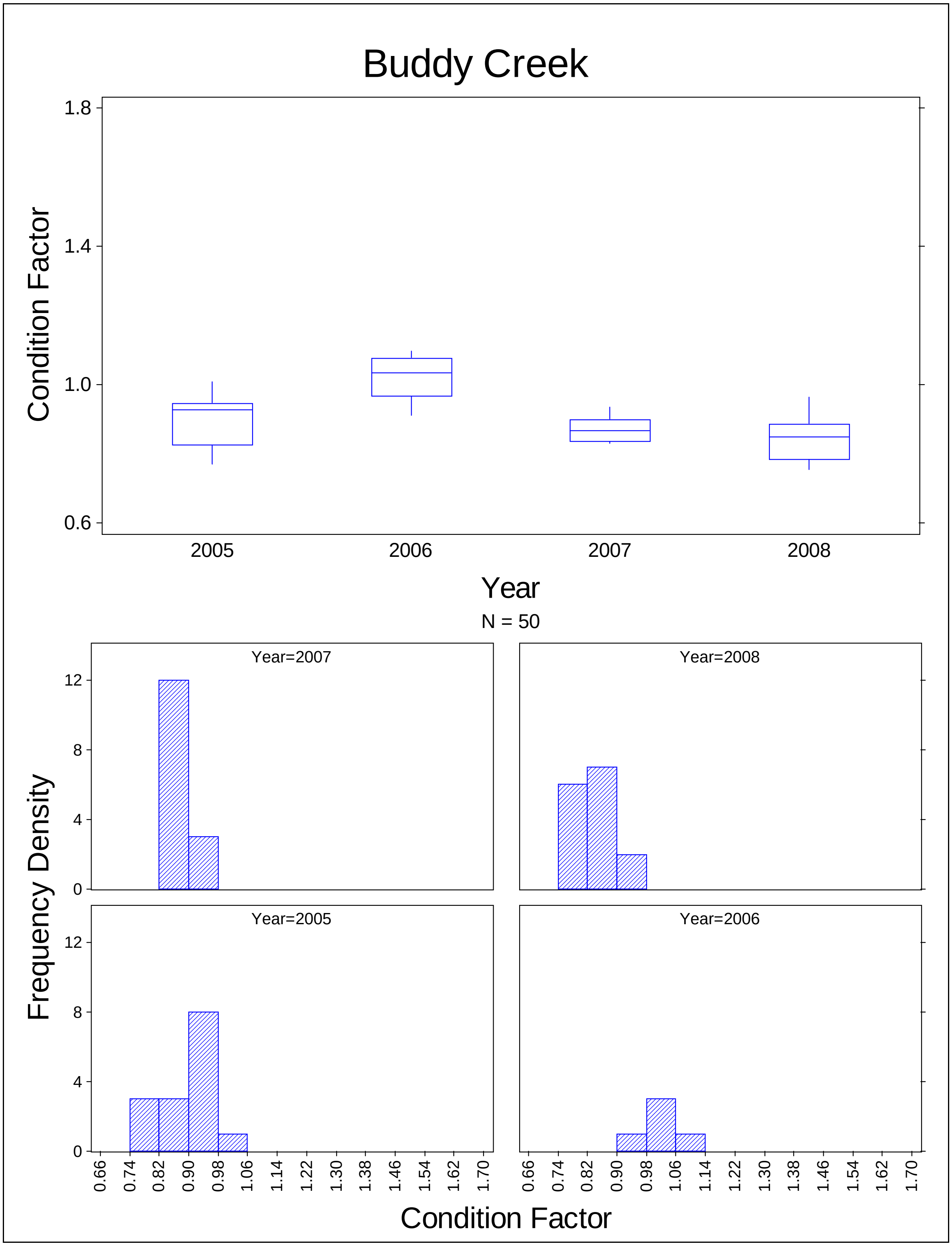
Statistical Analysis – Juvenile Dolly Varden Condition Factors for Anxiety Ridge Creek, Buddy Creek and Mainstem Red Dog Creek



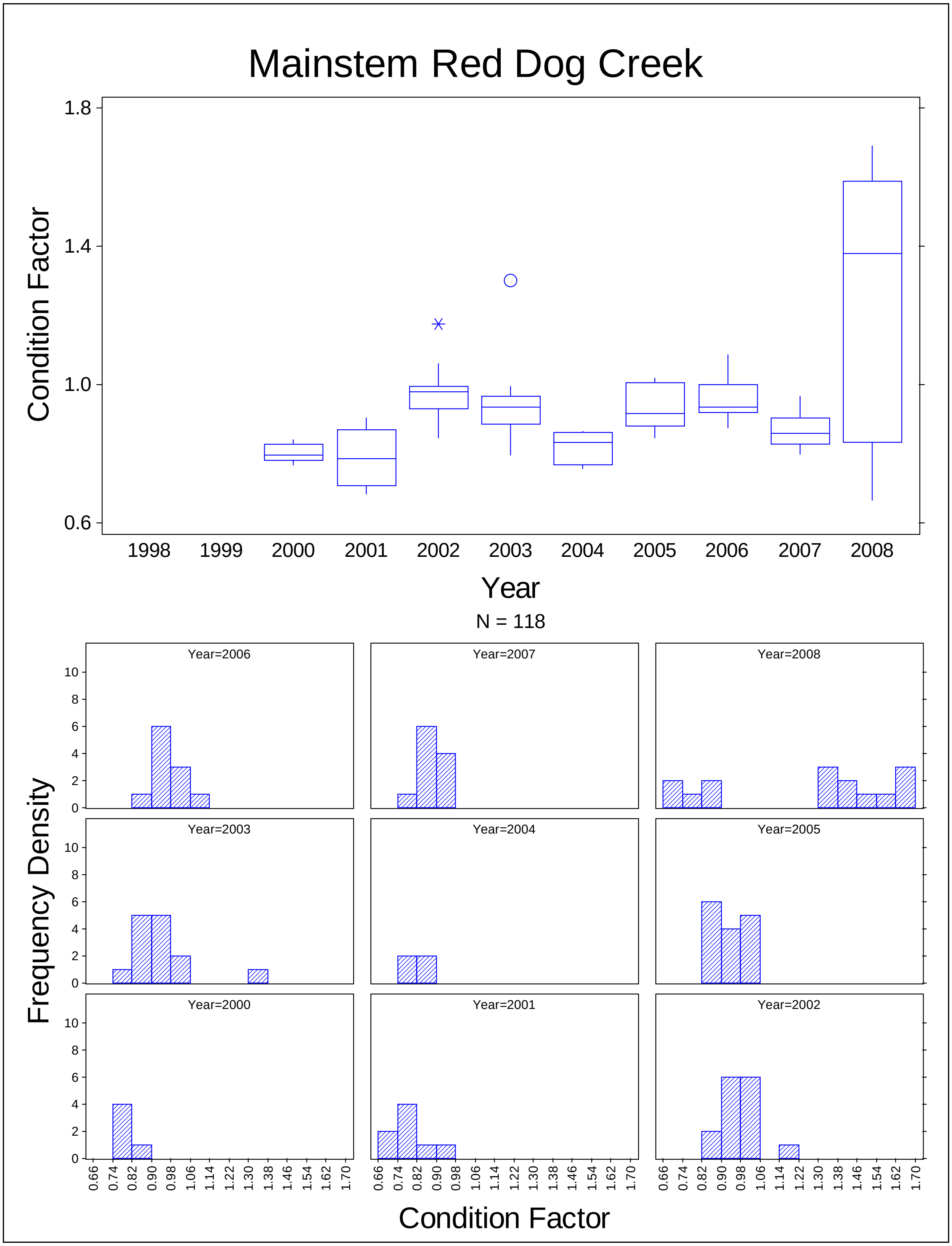
Appendix 6 (continued)



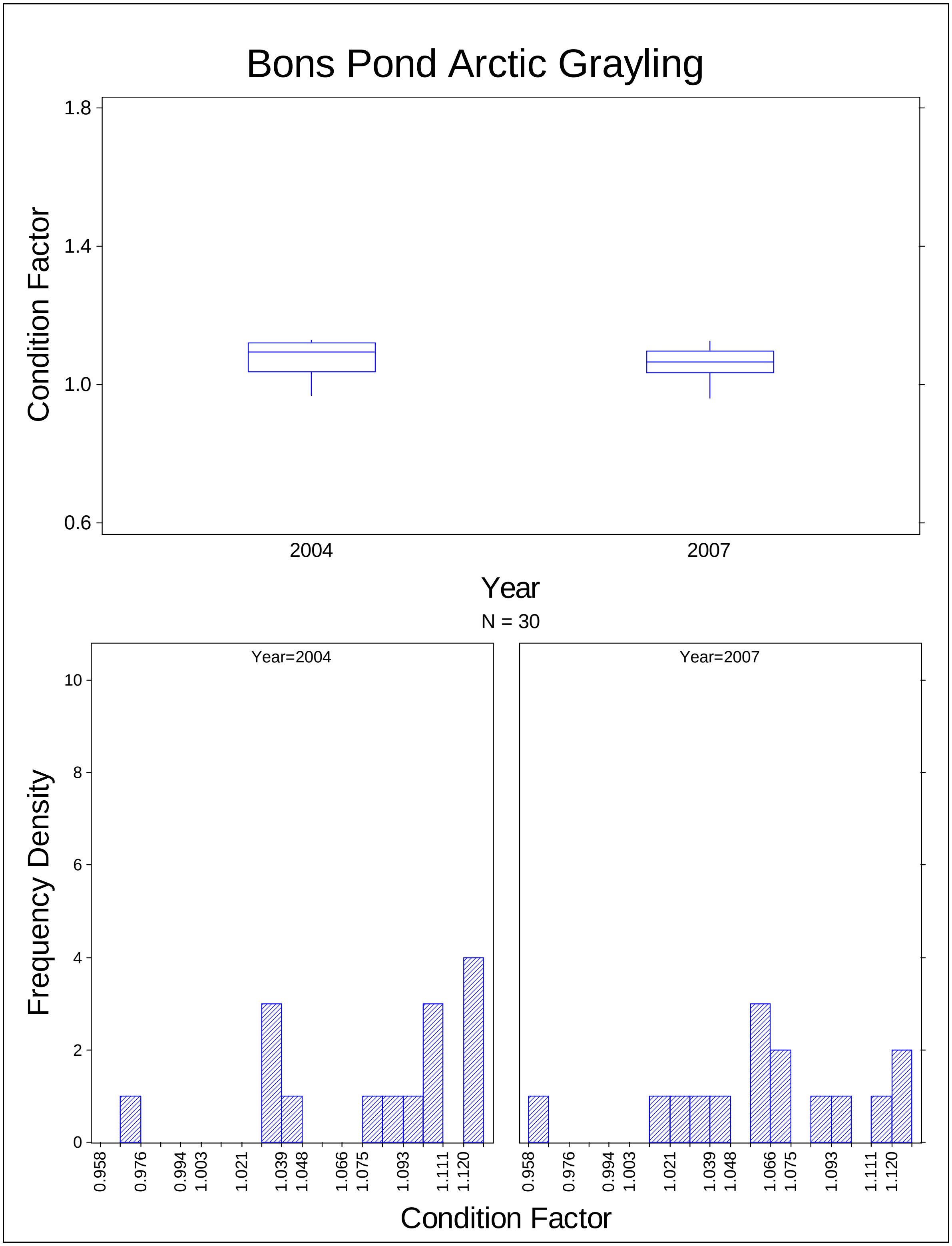
Appendix 6 (continued)



Appendix 6 (continued)



Appendix 6 (continued)



Appendix 6 (continued)

Statistical Analysis – Anxiety Ridge Creek, Buddy Creek & Mainstem Red Dog Creek – 2005

Kruskal-Wallis One-Way Nonparametric AOV for CONDITION FACTOR by Stream

Stream	Mean Rank	Sample Size
Anxiety	16.9	15
Buddy	24.5	15
Red Dog	27.6	15
Total	23.0	45

Kruskal-Wallis Statistic 5.3156
P-Value, Using Chi-Squared Approximation 0.0701

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	916.93	458.467	2.89	0.0670
Within	42	6673.07	158.883		
Total	44	7590.00			

Total number of values that were tied 0
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis One-Way Nonparametric AOV for FORK LENGTH by Stream

Stream	Mean Rank	Sample Size
Anxiety	23.5	15
Buddy	18.5	15
Red Dog	26.9	15
Total	23.0	45

Kruskal-Wallis Statistic 3.1135
P-Value, Using Chi-Squared Approximation 0.2108

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	535.60	267.800	1.60	0.2141
Within	42	7033.40	167.462		
Total	44	7569.00			

Total number of values that were tied 31
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Stream

Stream	Mean Rank	Sample Size
Anxiety	17.2	15
Buddy	16.1	15
Red Dog	35.7	15
Total	23.0	45

Kruskal-Wallis Statistic 21.2104
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	3656.63	1828.32	19.54	0.0000
Within	42	3928.87	93.54		
Total	44	7585.50			

Total number of values that were tied 18
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Stream

Stream	Mean	Homogeneous Groups
Red Dog	35.733	A
Anxiety	17.167	B
Buddy	16.100	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Stream

Stream	Mean Rank	Sample Size
Anxiety	10.7	15
Buddy	20.8	15
Red Dog	37.5	15
Total	23.0	45

Kruskal-Wallis Statistic 31.7730
P-Value, Using Chi-Squared Approximation 0.0000

Appendix 6 (continued)

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	5479.03	2739.52	54.57	0.0000
Within	42	2108.47	50.20		
Total	44	7587.50			

Total number of values that were tied 10
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Stream

Stream	Mean	Homogeneous Groups
Red Dog	37.467	A
Buddy	20.833	B
Anxiety	10.700	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Stream

Stream	Mean Rank	Sample Size
Anxiety	18.3	15
Buddy	12.7	15
Red Dog	38.0	15
Total	23.0	45

Kruskal-Wallis Statistic 30.7904
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	5297.70	2648.85	48.95	0.0000
Within	42	2272.80	54.11		
Total	44	7570.50			

Total number of values that were tied 17
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Stream

Stream	Mean	Homogeneous Groups
Red Dog	38.000	A
Anxiety	18.300	B
Buddy	12.700	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Se by Stream

Stream	Mean Rank	Sample Size
Anxiety	10.9	15
Buddy	21.9	15
Red Dog	36.1	15
Total	23.0	45

Kruskal-Wallis Statistic 27.7753
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	4788.40	2394.20	35.95	0.0000
Within	42	2797.10	66.60		
Total	44	7585.50			

Total number of values that were tied 18
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Se by Stream

Stream	Mean	Homogeneous Groups
Red Dog	36.133	A
Buddy	21.933	B
Anxiety	10.933	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 6 (continued)

Statistical Analysis – Anxiety Ridge Creek, Buddy Creek & Mainstem Red Dog Creek – 2006

Kruskal-Wallis One-Way Nonparametric AOV for CONDITION FACTOR by Stream

Stream	Mean Rank	Sample Size
Anxiety	17.6	13
Buddy	19.4	5
Red Dog	9.9	11
Total	15.0	29

Kruskal-Wallis Statistic	6.4940
P-Value, Using Chi-Squared Approximation	0.0389

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	470.81	235.407	3.93	0.0324
Within	26	1559.19	59.969		
Total	28	2030.00			

Total number of values that were tied 0
Max. diff. allowed between ties 0.00001

Kruskal-Wallis All-Pairwise Comparisons Test of CONDITION FACTOR by Stream

Stream	Mean	Homogeneous Groups
Buddy	19.400	A
Anxiety	17.615	A
Red Dog	9.9091	A

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.3508 TO 10.994
There are no significant pairwise differences among the means.

Kruskal-Wallis One-Way Nonparametric AOV for FORK LENGTH by Stream

Stream	Mean Rank	Sample Size
Anxiety	13.8	13
Buddy	8.6	5
Red Dog	19.4	11
Total	15.0	29

Kruskal-Wallis Statistic	6.0062
P-Value, Using Chi-Squared Approximation	0.0496

Appendix 6 (continued)

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	433.95	216.973	3.55	0.0433
Within	26	1589.05	61.117		
Total	28	2023.00			

Total number of values that were tied 18
Max. diff. allowed between ties 0.00001

Cases Included 29 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of FORK LENGTH by Stream

Stream	Mean	Homogeneous Groups
Red Dog	19.364	A
Anxiety	13.769	A
Buddy	8.6000	A

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.3508 TO 10.994
There are no significant pairwise differences among the means.

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Stream

Stream	Mean Rank	Sample Size
Anxiety	7.5	13
Buddy	15.4	5
Red Dog	23.7	11
Total	15.0	29

Kruskal-Wallis Statistic 21.7571
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1577.39	788.694	45.31	0.0000
Within	26	452.61	17.408		
Total	28	2030.00			

Total number of values that were tied 0
Max. diff. allowed between ties 0.00001

Cases Included 29 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Stream

Stream	Mean	Homogeneous Groups
Red Dog	23.727	A
Buddy	15.400	AB
Anxiety	7.4615	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.3508 TO 10.994
There are 2 groups (A and B) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Stream

Stream	Mean Rank	Sample Size
Anxiety	7.0	13
Buddy	16.3	5
Red Dog	23.9	11
Total	15.0	29

Kruskal-Wallis Statistic 23.5241
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1704.65	852.327	68.32	0.0000
Within	26	324.35	12.475		
Total	28	2029.00			

Total number of values that were tied 4
Max. diff. allowed between ties 0.00001

Cases Included 29 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Stream

Stream	Mean	Homogeneous Groups
Red Dog	23.864	A
Buddy	16.300	AB
Anxiety	7.0000	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.3508 TO 10.994
There are 2 groups (A and B) in which the means are not significantly different from one another.

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Stream

Stream	Mean Rank	Sample Size
Anxiety	10.9	13
Buddy	10.9	5
Red Dog	21.7	11
Total	15.0	29

Kruskal-Wallis Statistic 11.0708
P-Value, Using Chi-Squared Approximation 0.0039

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	802.04	401.021	8.50	0.0014
Within	26	1226.46	47.171		
Total	28	2028.50			

Total number of values that were tied 6
Max. diff. allowed between ties 0.00001

Cases Included 29 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Stream

Stream	Mean	Homogeneous Groups
Red Dog	21.727	A
Buddy	10.900	AB
Anxiety	10.885	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 8.3508 TO 10.994
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Se by Stream

Stream	Mean Rank	Sample Size
Anxiety	7.6	13
Buddy	15.6	5
Red Dog	23.5	11
Total	15.0	29

Kruskal-Wallis Statistic 20.6890
P-Value, Using Chi-Squared Approximation 0.0000

Appendix 6 (continued)

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1497.00	748.498	36.79	0.0000
Within	26	529.00	20.346		
Total	28	2026.00			

Total number of values that were tied   11
Max. diff. allowed between ties   0.00001

Cases Included 29   Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Se by Stream

Stream	Mean	Homogeneous Groups
Red Dog	23.455	A
Buddy	15.600	AB
Anxiety	7.6154	B

Alpha 0.05
Critical Z Value 2.394   Critical Value for Comparison 8.3508 TO 10.994
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 6 (continued)

Statistical Analysis – Anxiety Ridge Creek, Buddy Creek & Mainstem Red Dog Creek – 2007

Kruskal-Wallis One-Way Nonparametric AOV for CONDITION FACTOR by Stream

Stream	Mean Rank	Sample Size
Anxiety	23.8	15
Buddy	19.6	15
Red Dog	19.1	11
Total	21.0	41

Kruskal-Wallis Statistic	1.3038
P-Value, Using Chi-Squared Approximation	0.5211

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	187.09	93.545	0.64	0.5328
Within	38	5552.91	146.129		
Total	40	5740.00			

Total number of values that were tied 0
Max. diff. allowed between ties 0.00001

Cases Included 41 Missing Cases 0

Kruskal-Wallis One-Way Nonparametric AOV for FORK LENGTH by Stream

Stream	Mean Rank	Sample Size
Anxiety	23.9	15
Buddy	22.8	15
Red Dog	14.6	11
Total	21.0	41

Kruskal-Wallis Statistic	4.3141
P-Value, Using Chi-Squared Approximation	0.1157

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	618.42	309.211	2.30	0.1144
Within	38	5115.58	134.620		
Total	40	5734.00			

Total number of values that were tied 19
Max. diff. allowed between ties 0.00001

Cases Included 41 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Stream

Stream	Mean Rank	Sample Size
Anxiety	9.6	15
Buddy	21.5	15
Red Dog	35.9	11
Total	21.0	41

Kruskal-Wallis Statistic 30.6571
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	4397.76	2198.88	62.34	0.0000
Within	38	1340.24	35.27		
Total	40	5738.00			

Total number of values that were tied 8
Max. diff. allowed between ties 0.00001

Cases Included 41 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Stream

Stream	Mean	Homogeneous Groups
Red Dog	35.909	A
Buddy	21.467	B
Anxiety	9.6000	C

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.472 TO 11.384
All 3 means are significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Stream

Stream	Mean Rank	Sample Size
Anxiety	8.5	15
Buddy	22.9	15
Red Dog	35.5	11
Total	21.0	41

Kruskal-Wallis Statistic 32.8380
P-Value, Using Chi-Squared Approximation 0.0000

Appendix 6 (continued)

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	4710.61	2355.30	87.12	0.0000
Within	38	1027.39	27.04		
Total	40	5738.00			

Total number of values that were tied 8
Max. diff. allowed between ties 0.00001

Cases Included 41 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Stream

Stream	Mean	Homogeneous Groups
Red Dog	35.455	A
Buddy	22.933	B
Anxiety	8.4667	C

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.472 TO 11.384
All 3 means are significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Stream

Stream	Mean Rank	Sample Size
Anxiety	16.1	15
Buddy	15.7	15
Red Dog	34.9	11
Total	21.0	41

Kruskal-Wallis Statistic 20.2913
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	2910.02	1455.01	19.56	0.0000
Within	38	2826.48	74.38		
Total	40	5736.50			

Total number of values that were tied 9
Max. diff. allowed between ties 0.00001

Cases Included 41 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Stream

Stream	Mean	Homogeneous Groups
Red Dog	34.909	A
Anxiety	16.133	B
Buddy	15.667	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.472 TO 11.384
There are 2 groups (A and B) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Se by Stream

Stream	Mean Rank	Sample Size
Anxiety	12.8	15
Buddy	26.9	15
Red Dog	24.1	11
Total	21.0	41

Kruskal-Wallis Statistic 11.4668
P-Value, Using Chi-Squared Approximation 0.0032

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1641.76	820.879	7.64	0.0016
Within	38	4085.24	107.506		
Total	40	5727.00			

Total number of values that were tied 27
Max. diff. allowed between ties 0.00001

Cases Included 41 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Se by Stream

Stream	Mean	Homogeneous Groups
Buddy	26.933	A
Red Dog	24.091	AB
Anxiety	12.800	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.472 TO 11.384
There are 2 groups (A and B) in which the means are not significantly different from one another.

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Se by Stream

Stream	Mean	Homogeneous Groups
Buddy	26.933	A
Red Dog	24.091	AB
Anxiety	12.800	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 10.472 TO 11.384
There are 2 groups (A and B) in which the means are not significantly different from one another.

Appendix 6 (continued)

Statistical Analysis – Anxiety Ridge Creek, Buddy Creek & Mainstem Red Dog Creek – 2008

Kruskal-Wallis One-Way Nonparametric AOV for CONDITION FACTOR by Stream

Stream	Mean Rank	Sample Size
Anxiety	17.9	15
Buddy	20.5	15
Red Dog	30.7	15
Total	23.0	45

Kruskal-Wallis Statistic 7.9611
P-Value, Using Chi-Squared Approximation 0.0187

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	1373.20	686.600	4.64	0.0151
Within	42	6216.30	148.007		
Total	44	7589.50			

Total number of values that were tied 2
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of CONDITION FACTOR by Stream

Stream	Mean	Homogeneous Groups
Red Dog	30.667	A
Buddy	20.467	AB
Anxiety	17.867	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for FORK LENGTH by Stream

Stream	Mean Rank	Sample Size
Anxiety	18.5	15
Buddy	21.6	15
Red Dog	28.9	15
Total	23.0	45

Appendix 6 (continued)

Kruskal-Wallis Statistic	4.9975
P-Value, Using Chi-Squared Approximation	0.0822

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	858.43	429.217	2.69	0.0795
Within	42	6699.57	159.513		
Total	44	7558.00			

Total number of values that were tied 39
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Stream

Stream	Mean Rank	Sample Size
Anxiety	9.3	15
Buddy	23.4	15
Red Dog	36.3	15
Total	23.0	45

Kruskal-Wallis Statistic	31.5644
P-Value, Using Chi-Squared Approximation	0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	5444.13	2722.07	53.30	0.0000
Within	42	2144.87	51.07		
Total	44	7589.00			

Total number of values that were tied 4
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Stream

Stream	Mean	Homogeneous Groups
Red Dog	36.267	A
Buddy	23.400	B
Anxiety	9.3333	C

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
All 3 means are significantly different from one another.

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Stream

Stream	Mean Rank	Sample Size
Anxiety	8.0	15
Buddy	24.7	15
Red Dog	36.3	15
Total	23.0	45

Kruskal-Wallis Statistic	35.2727
P-Value, Using Chi-Squared Approximation	0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	6083.33	3041.67	84.87	0.0000
Within	42	1505.17	35.84		
Total	44	7588.50			

Total number of values that were tied 6
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Stream

Stream	Mean	Homogeneous Groups
Red Dog	36.333	A
Buddy	24.667	B
Anxiety	8.0000	C

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
All 3 means are significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Stream

Stream	Mean Rank	Sample Size
Anxiety	13.4	15
Buddy	18.3	15
Red Dog	37.3	15
Total	23.0	45

Kruskal-Wallis Statistic	27.8397
P-Value, Using Chi-Squared Approximation	0.0000

Appendix 6 (continued)

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	4800.13	2400.07	36.18	0.0000
Within	42	2786.37	66.34		
Total	44	7586.50			

Total number of values that were tied 9
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Stream

Stream	Mean	Homogeneous Groups
Red Dog	37.333	A
Buddy	18.267	B
Anxiety	13.400	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Se by Stream

Stream	Mean Rank	Sample Size
Anxiety	12.0	15
Buddy	26.9	15
Red Dog	30.1	15
Total	23.0	45

Kruskal-Wallis Statistic 16.1732
P-Value, Using Chi-Squared Approximation 0.0003

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	2	2781.23	1390.62	12.21	0.0001
Within	42	4785.27	113.93		
Total	44	7566.50			

Total number of values that were tied 34
Max. diff. allowed between ties 0.00001

Cases Included 45 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Se by Stream

Stream	Mean	Homogeneous Groups
Red Dog	30.067	A
Buddy	26.900	A
Anxiety	12.033	B

Alpha 0.05
Critical Z Value 2.394 Critical Value for Comparison 11.481
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 6 (continued)

Statistical Analysis – Mainstem Red Dog Creek – All Years

Kruskal-Wallis One-Way Nonparametric AOV for CONDITION FACTOR by Year

Year	Mean Rank	Sample Size
2000	14.0	5
2001	16.5	8
2002	64.2	15
2003	52.7	14
2004	20.3	4
2005	54.1	15
2006	61.5	11
2007	34.3	11
2008	66.8	15
Total	49.5	98

Kruskal-Wallis Statistic 38.0584
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	8	30770.3	3846.28	7.18	0.0000
Within	89	47654.2	535.44		
Total	97	78424.5			

Total number of values that were tied 0
Max. diff. allowed between ties 0.00001

Cases Included 98 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of CONDITION FACTOR by Year

Year	Mean	2000	2001	2002	2003	2004	2005	2006
2000	14.000							
2001	16.500	2.500						
2002	64.200	50.200*	47.700*					
2003	52.714	38.714	36.214	11.486				
2004	20.250	6.250	3.750	43.950	32.464			
2005	54.067	40.067	37.567	10.133	1.352	33.817		
2006	61.545	47.545	45.045*	2.655	8.831	41.295	7.479	
2007	34.273	20.273	17.773	29.927	18.442	14.023	19.794	27.273
2008	66.800	52.800*	50.300*	2.600	14.086	46.550	12.733	5.255

Appendix 6 (continued)

Year	Mean	2007
2007	34.273	
2008	66.800	32.527

Alpha 0.05
Critical Z Value 3.197 Critical Value for Comparison 33.193 TO 60.979
The homogeneous group format can't be used
because of the pattern of significant differences.

Kruskal-Wallis One-Way Nonparametric AOV for FORK LENGTH by Year

Year	Mean Rank	Sample Size
1998	96.3	10
1999	100.5	10
2000	84.8	5
2001	58.4	8
2002	44.7	15
2003	59.5	14
2004	55.3	4
2005	61.6	15
2006	44.2	11
2007	39.1	11
2008	39.7	15
Total	59.5	118

Kruskal-Wallis Statistic 42.6872
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	10	49903	4990.34	6.15	0.0000
Within	107	86875	811.92		
Total	117	136779			

Total number of values that were tied 101
Max. diff. allowed between ties 0.00001

Cases Included 118 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of FORK LENGTH by Year

Appendix 6 (continued)

Year	Mean	Homogeneous Groups
1999	100.45	A
1998	96.250	A
2000	84.800	AB
2005	61.633	AB
2003	59.536	AB
2001	58.438	AB
2004	55.250	AB
2002	44.733	B
2006	44.227	B
2008	39.700	B
2007	39.136	B

Alpha 0.05
Critical Z Value 3.317 Critical Value for Comparison 41.435 TO 76.122
There are 2 groups (A and B) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Year

Year	Mean Rank	Sample Size
2001	44.0	8
2002	48.1	15
2003	38.8	14
2004	41.4	4
2005	15.8	15
2006	76.0	11
2007	65.3	11
2008	53.2	15
Total	47.0	93

Kruskal-Wallis Statistic 40.1926
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	7	29275.7	4182.24	9.42	0.0000
Within	85	37735.8	443.95		
Total	92	67011.5			

Total number of values that were tied 22
Max. diff. allowed between ties 0.00001

Cases Included 93 Missing Cases 25

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Year

Year	Mean	Homogeneous Groups
2006	75.955	A
2007	65.318	AB
2008	53.200	AB
2002	48.100	AB
2001	44.000	ABC
2004	41.375	ABC
2003	38.821	BC
2005	15.767	C

Alpha 0.05
Critical Z Value 3.124 Critical Value for Comparison 30.786 TO 51.630
There are 3 groups (A, B, etc.) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Year

Year	Mean Rank	Sample Size
1998	48.0	10
1999	66.8	10
2000	81.0	5
2001	71.1	8
2002	75.1	15
2003	82.0	14
2004	50.3	4
2005	37.4	15
2006	64.5	11
2007	60.8	11
2008	32.3	15
Total	59.5	118

Kruskal-Wallis Statistic 29.9331
P-Value, Using Chi-Squared Approximation 0.0009

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	10	35026	3502.58	3.68	0.0003
Within	107	101880	952.15		
Total	117	136906			

Total number of values that were tied 14
Max. diff. allowed between ties 0.00001

Cases Included 118 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Year

Year	Mean	1998	1999	2000	2001	2002	2003	2004
1998	48.000							
1999	66.750	18.750						
2000	81.000	33.000	14.250					
2001	71.125	23.125	4.375	9.875				
2002	75.133	27.133	8.383	5.867	4.008			
2003	82.000	34.000	15.250	1.000	10.875	6.867		
2004	50.250	2.250	16.500	30.750	20.875	24.883	31.750	
2005	37.433	10.567	29.317	43.567	33.692	37.700	44.567*	12.817
2006	64.455	16.455	2.295	16.545	6.670	10.679	17.545	14.205
2007	60.773	12.773	5.977	20.227	10.352	14.361	21.227	10.523
2008	32.300	15.700	34.450	48.700	38.825	42.833*	49.700*	17.950

Year	Mean	2005	2006	2007
2005	37.433			
2006	64.455	27.021		
2007	60.773	23.339	3.682	
2008	32.300	5.133	32.155	28.473

Alpha 0.05
Critical Z Value 3.317 Critical Value for Comparison 41.435 TO 76.122
The homogeneous group format can't be used
because of the pattern of significant differences.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Year

Year	Mean Rank	Sample Size
1998	81.4	10
1999	67.6	10
2000	93.4	5
2001	85.4	8
2002	83.8	15
2003	64.2	14
2004	72.8	4
2005	29.0	15
2006	43.5	11
2007	46.0	11
2008	34.2	15
Total	59.5	118

Appendix 6 (continued)

```
Kruskal-Wallis Statistic                    46.8243
P-Value, Using Chi-Squared Approximation     0.0000
```

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	10	54791	5479.07	7.14	0.0000
Within	107	82115	767.43		
Total	117	136905			

```
Total number of values that were tied   11
Max. diff. allowed between ties    0.00001

Cases Included 118    Missing Cases 0
```

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Year

Year	Mean	Homogeneous Groups
2000	93.400	A
2001	85.375	A
2002	83.833	A
1998	81.400	A
2004	72.750	AB
1999	67.600	AB
2003	64.214	AB
2007	46.045	AB
2006	43.545	AB
2008	34.167	B
2005	29.033	B

```
Alpha               0.05
Critical Z Value  3.317     Critical Value for Comparison  41.435 TO
76.122
There are 2 groups (A and B) in which the means
are not significantly different from one another.
```

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Se by Year

Year	Mean Rank	Sample Size
1998	45.2	10
1999	46.3	10
2000	80.2	5
2001	92.5	8
2002	95.2	15
2003	92.4	14
2004	19.0	4
2005	73.7	15
2006	44.0	11
2007	17.8	11
2008	25.5	15
Total	59.5	118

Kruskal-Wallis Statistic	83.4570
P-Value, Using Chi-Squared Approximation	0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	10	97634	9763.36	26.62	0.0000
Within	107	39241	366.74		
Total	117	136875			

Total number of values that were tied   64
Max. diff. allowed between ties   0.00001

Cases Included 118   Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Se by Year

Year	Mean	1998	1999	2000	2001	2002	2003	2004
1998	45.200							
1999	46.250	1.050						
2000	80.200	35.000	33.950					
2001	92.500	47.300	46.250	12.300				
2002	95.167	49.967*	48.917*	14.967	2.667			
2003	92.429	47.229*	46.179	12.229	0.071	2.738		
2004	19.000	26.200	27.250	61.200	73.500*	76.167*	73.429*	
2005	73.733	28.533	27.483	6.467	18.767	21.433	18.695	54.733
2006	43.955	1.245	2.295	36.245	48.545	51.212*	48.474*	24.955
2007	17.773	27.427	28.477	62.427*	74.727*	77.394*	74.656*	1.227
2008	25.533	19.667	20.717	54.667	66.967*	69.633*	66.895*	6.533

Appendix 6 (continued)

Year	Mean	2005	2006	2007
2005	73.733			
2006	43.955	29.779		
2007	17.773	55.961*	26.182	
2008	25.533	48.200*	18.421	7.761

Alpha 0.05
Critical Z Value 3.317 Critical Value for Comparison 41.435 TO 76.122
The homogeneous group format can't be used
because of the pattern of significant differences.

Mainstem Red Dog Creek – Dolly Varden Selenium Concentrations – 2000 - 2008

Least Squares Linear Regression of Se (mg/Kg)

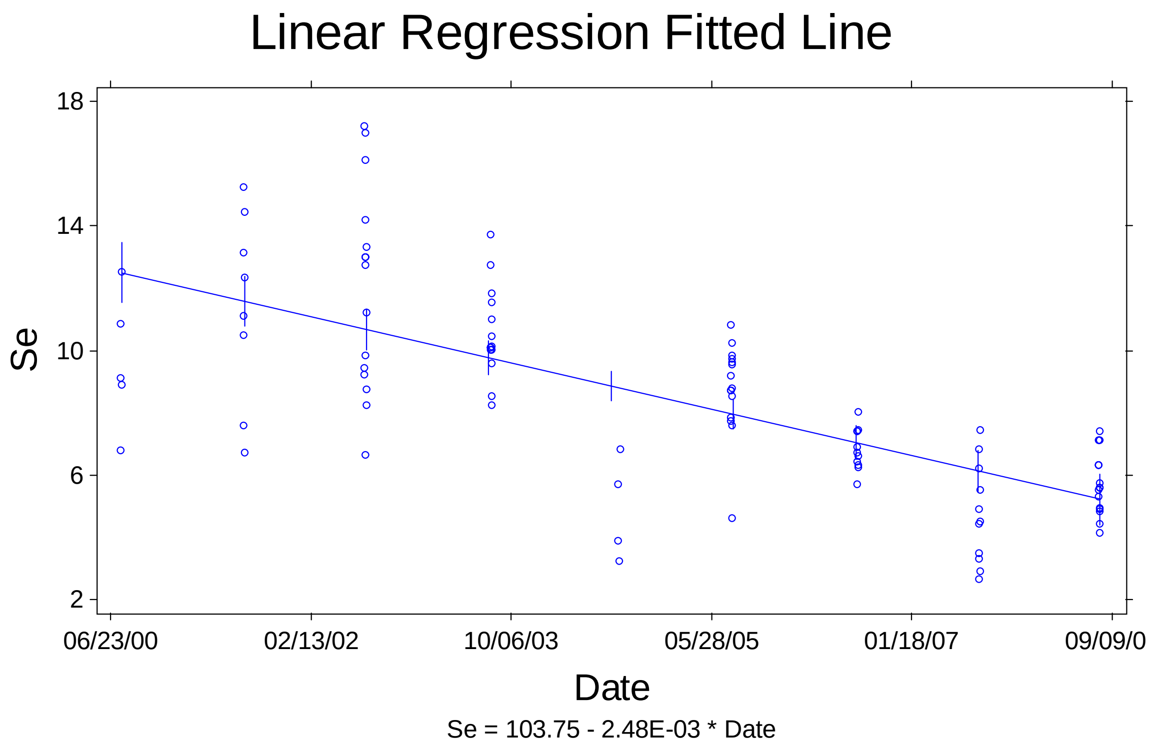
Predictor Variables	Coefficient	Std Error	T	P
Constant	103.754	9.88326	10.50	0.0000
Date	-0.00248	2.576E-04	-9.64	0.0000

R-Squared	0.4921	Resid. Mean Square (MSE)	5.39517
Adjusted R-Squared	0.4868	Standard Deviation	2.32275
AICc	169.41		
PRESS	541.43		

Source	DF	SS	MS	F	P
Regression	1	501.86	501.858	93.02	0.0000
Residual	96	517.94	5.395		
Total	97	1019.79			
Lack of Fit	14	207.654	14.8324	3.92	0.0000
Pure Error	82	310.283	3.7839		

Cases Included 98 Missing Cases 0

Appendix 6 (continued)



Mainstem Red Dog Creek – Fitted Regression

Appendix 6 (continued)

Statistical Analysis – Buddy Creek – 2005 – 2008

Kruskal-Wallis One-Way Nonparametric AOV for CONDITION FACTOR by Year

Year	Mean Rank	Sample Size
2005	30.1	15
2006	45.4	5
2007	23.2	15
2008	16.6	15
Total	25.5	50

Kruskal-Wallis Statistic 16.7555
P-Value, Using Chi-Squared Approximation 0.0008

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	3560.4	1186.79	7.97	0.0002
Within	46	6851.6	148.95		
Total	49	10412.0			

Total number of values that were tied 2
Max. diff. allowed between ties 0.00001

Cases Included 50 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of CONDITION FACTOR by Year

Year	Mean	Homogeneous Groups
2006	45.400	A
2005	30.067	AB
2007	23.200	B
2008	16.600	B

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 14.043 TO 19.860
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for FORK LENGTH by Year

Year	Mean Rank	Sample Size
2005	30.9	15
2006	5.5	5
2007	35.4	15
2008	16.8	15
Total	25.5	50

Kruskal-Wallis Statistic 23.8676
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	5058.2	1686.08	14.56	0.0000
Within	46	5326.3	115.79		
Total	49	10384.5			

Total number of values that were tied 36
Max. diff. allowed between ties 0.00001

Cases Included 50 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of FORK LENGTH by Year

Year	Mean	Homogeneous Groups
2007	35.433	A
2005	30.933	A
2008	16.800	B
2006	5.5000	B

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 14.043 TO 19.860
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Year

Year	Mean Rank	Sample Size
2005	16.0	15
2006	46.0	5
2007	15.8	15
2008	37.8	15
Total	25.5	50

Appendix 6 (continued)

Kruskal-Wallis Statistic 33.6018
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	7138.3	2379.44	33.46	0.0000
Within	46	3271.2	71.11		
Total	49	10409.5			

Total number of values that were tied 12
Max. diff. allowed between ties 0.00001

Cases Included 50 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Year

Year	Mean	Homogeneous Groups
2006	46.000	A
2008	37.833	A
2005	16.000	B
2007	15.833	B

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 14.043 TO 19.860
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Year

Year	Mean Rank	Sample Size
2005	21.7	15
2006	43.0	5
2007	19.7	15
2008	29.3	15
Total	25.5	50

Kruskal-Wallis Statistic 11.6409
P-Value, Using Chi-Squared Approximation 0.0087

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	2472.9	824.289	4.78	0.0056
Within	46	7936.1	172.525		
Total	49	10409.0			

Appendix 6 (continued)

Total number of values that were tied 14
Max. diff. allowed between ties 0.00001

Cases Included 50 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Year

Year	Mean	Homogeneous Groups
2006	43.000	A
2008	29.300	AB
2005	21.667	B
2007	19.700	B

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 14.043 TO 19.860
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Year

Year	Mean Rank	Sample Size
2005	13.2	15
2006	41.2	5
2007	26.9	15
2008	31.1	15
Total	25.5	50

Kruskal-Wallis Statistic 18.8950
P-Value, Using Chi-Squared Approximation 0.0003

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	4008.6	1336.21	9.62	0.0000
Within	46	6386.9	138.84		
Total	49	10395.5			

Total number of values that were tied 28
Max. diff. allowed between ties 0.00001

Cases Included 50 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Year

Year	Mean	Homogeneous Groups
2006	41.200	A
2008	31.133	A
2007	26.933	AB
2005	13.200	B

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 14.043 TO 19.860
There are 2 groups (A and B) in which the means are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Se by Year

Year	Mean Rank	Sample Size
2005	39.9	15
2006	28.7	5
2007	11.7	15
2008	23.9	15
Total	25.5	50

Kruskal-Wallis Statistic 28.6279
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	6072.0	2024.01	21.55	0.0000
Within	46	4321.0	93.93		
Total	49	10393.0			

Total number of values that were tied 37
Max. diff. allowed between ties 0.00001

Cases Included 50 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Se by Year

Year	Mean	Homogeneous Groups
2005	39.900	A
2006	28.700	AB
2008	23.867	B
2007	11.667	B

Appendix 6 (continued)

```
Alpha              0.05
Critical Z Value  2.638     Critical Value for Comparison  14.043 TO
19.860
There are 2 groups (A and B) in which the means
are not significantly different from one another.
```

Appendix 6 (continued)

Statistical Analysis – Anxiety Ridge Creek – 2005 – 2008

Kruskal-Wallis One-Way Nonparametric AOV for CONDITION FACTOR by Year

Year	Mean Rank	Sample Size
2005	26.3	15
2006	51.4	13
2007	30.4	15
2008	12.9	15
Total	29.5	58

Kruskal-Wallis Statistic 36.9789
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	10545.2	3515.05	33.25	0.0000
Within	54	5709.3	105.73		
Total	57	16254.5			

Total number of values that were tied 0
Max. diff. allowed between ties 0.00001

Cases Included 58 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of CONDITION FACTOR by Year

Year	Mean	Homogeneous Groups
2006	51.385	A
2007	30.400	B
2005	26.267	BC
2008	12.867	C

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 16.268 TO 16.882
There are 3 groups (A, B, etc.) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for FORK LENGTH by Year

Year	Mean Rank	Sample Size
2005	37.1	15
2006	20.5	13
2007	39.3	15
2008	20.0	15
Total	29.5	58

Appendix 6 (continued)

```
Kruskal-Wallis Statistic                    16.5948
P-Value, Using Chi-Squared Approximation     0.0009
```

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	4724.7	1574.90	7.39	0.0003
Within	54	11503.8	213.03		
Total	57	16228.5			

```
Total number of values that were tied   39
Max. diff. allowed between ties    0.00001

Cases Included 58    Missing Cases 0
```

Kruskal-Wallis All-Pairwise Comparisons Test of FORK LENGTH by Year

Year	Mean	Homogeneous Groups
2007	39.300	A
2005	37.067	AB
2006	20.462	BC
2008	19.967	C

```
Alpha              0.05
Critical Z Value  2.638     Critical Value for Comparison  16.268 TO
16.882
There are 3 groups (A, B, etc.) in which the means
are not significantly different from one another.
```

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Year

Year	Mean Rank	Sample Size
2005	31.4	15
2006	43.6	13
2007	12.5	15
2008	32.4	15
Total	29.5	58

```
Kruskal-Wallis Statistic                    24.8582
P-Value, Using Chi-Squared Approximation     0.0000
```

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	7083.7	2361.24	13.92	0.0000
Within	54	9159.3	169.62		
Total	57	16243.0			

Appendix 6 (continued)

Total number of values that were tied 25
Max. diff. allowed between ties 0.00001

Cases Included 58 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Zn by Year

Year	Mean	Homogeneous Groups
2006	43.615	A
2008	32.367	A
2005	31.367	A
2007	12.533	B

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 16.268 TO 16.882
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Year

Year	Mean Rank	Sample Size
2005	25.3	15
2006	48.5	13
2007	25.2	15
2008	21.5	15
Total	29.5	58

Kruskal-Wallis Statistic 21.7417
P-Value, Using Chi-Squared Approximation 0.0001

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	6190.7	2063.56	11.10	0.0000
Within	54	10039.3	185.91		
Total	57	16230.0			

Total number of values that were tied 38
Max. diff. allowed between ties 0.00001

Cases Included 58 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis All-Pairwise Comparisons Test of Cd by Year

Year	Mean	Homogeneous Groups
2006	48.500	A
2005	25.300	B
2007	25.233	B
2008	21.500	B

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 16.268 TO 16.882
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Year

Year	Mean Rank	Sample Size
2005	18.7	15
2006	47.0	13
2007	29.6	15
2008	25.1	15
Total	29.5	58

Kruskal-Wallis Statistic 21.1455
P-Value, Using Chi-Squared Approximation 0.0001

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	6025.7	2008.58	10.62	0.0000
Within	54	10217.3	189.21		
Total	57	16243.0			

Total number of values that were tied 26
Max. diff. allowed between ties 0.00001

Cases Included 58 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Pb by Year

Year	Mean	Homogeneous Groups
2006	47.000	A
2007	29.567	B
2008	25.067	B
2005	18.700	B

Appendix 6 (continued)

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 16.268 TO 16.882
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Kruskal-Wallis One-Way Nonparametric AOV for Se by Year

Year	Mean Rank	Sample Size
2005	43.2	15
2006	27.4	13
2007	16.8	15
2008	30.4	15
Total	29.5	58

Kruskal-Wallis Statistic 18.6301
P-Value, Using Chi-Squared Approximation 0.0003

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	3	5301.1	1767.03	8.74	0.0001
Within	54	10917.9	202.18		
Total	57	16219.0			

Total number of values that were tied 39
Max. diff. allowed between ties 0.00001

Cases Included 58 Missing Cases 0

Kruskal-Wallis All-Pairwise Comparisons Test of Se by Year

Year	Mean	Homogeneous Groups
2005	43.167	A
2008	30.367	AB
2006	27.423	AB
2007	16.767	B

Alpha 0.05
Critical Z Value 2.638 Critical Value for Comparison 16.268 TO 16.882
There are 2 groups (A and B) in which the means
are not significantly different from one another.

Statistical Analysis – Arctic Grayling – Bons Reservoir – 2004 & 2007

Kruskal-Wallis One-Way Nonparametric AOV for CONDITION FACTOR by Year

Year	Mean Rank	Sample Size
2004	17.2	15
2007	13.8	15
Total	15.5	30

Kruskal-Wallis Statistic 1.1187
P-Value, Using Chi-Squared Approximation 0.2902

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	1	86.70	86.7000	1.12	0.2982
Within	28	2160.80	77.1714		
Total	29	2247.50			

Total number of values that were tied 0
Max. diff. allowed between ties 0.00001

Cases Included 30 Missing Cases 0

Kruskal-Wallis One-Way Nonparametric AOV for FORK LENGTH by Year

Year	Mean Rank	Sample Size
2004	12.5	15
2007	18.5	15
Total	15.5	30

Kruskal-Wallis Statistic 3.5681
P-Value, Using Chi-Squared Approximation 0.0589

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	1	276.03	276.033	3.93	0.0574
Within	28	1967.47	70.267		
Total	29	2243.50			

Total number of values that were tied 11
Max. diff. allowed between ties 0.00001

Cases Included 30 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Zn by Year

Year	Mean Rank	Sample Size
2004	8.1	15
2007	22.9	15
Total	15.5	30

Kruskal-Wallis Statistic 21.3936
P-Value, Using Chi-Squared Approximation 0.0000

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	1	1657.63	1657.63	78.75	0.0000
Within	28	589.37	21.05		
Total	29	2247.00			

Total number of values that were tied 2
Max. diff. allowed between ties 0.00001

Cases Included 30 Missing Cases 0

Kruskal-Wallis One-Way Nonparametric AOV for Cd by Year

Year	Mean Rank	Sample Size
2004	18.9	15
2007	12.1	15
Total	15.5	30

Kruskal-Wallis Statistic 4.4091
P-Value, Using Chi-Squared Approximation 0.0357

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	1	340.03	340.033	5.02	0.0332
Within	28	1896.47	67.731		
Total	29	2236.50			

Total number of values that were tied 18
Max. diff. allowed between ties 0.00001

Cases Included 30 Missing Cases 0

Appendix 6 (continued)

Kruskal-Wallis One-Way Nonparametric AOV for Pb by Year

Year	Mean Rank	Sample Size
2004	15.6	15
2007	15.4	15
Total	15.5	30

Kruskal-Wallis Statistic 0.0039
P-Value, Using Chi-Squared Approximation 0.9503

Parametric AOV Applied to Ranks

Source	DF	SS	MS	F	P
Between	1	0.30	0.3000	0.00	0.9516
Within	28	2241.70	80.0607		
Total	29	2242.00			

Total number of values that were tied 17
Max. diff. allowed between ties 0.00001

Cases Included 30 Missing Cases 0

Kruskal-Wallis One-Way Nonparametric AOV for Se by Year

Year	Mean Rank	Sample Size
2004	16.6	15
2007	14.4	15
Total	15.5	30

Kruskal-Wallis Statistic 0.4411
P-Value, Using Chi-Squared Approximation 0.5066

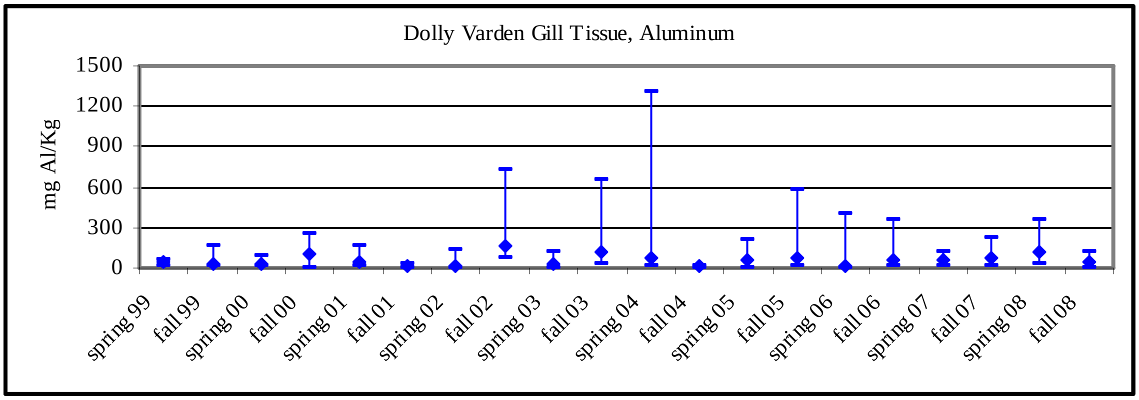
Parametric AOV Applied to Ranks

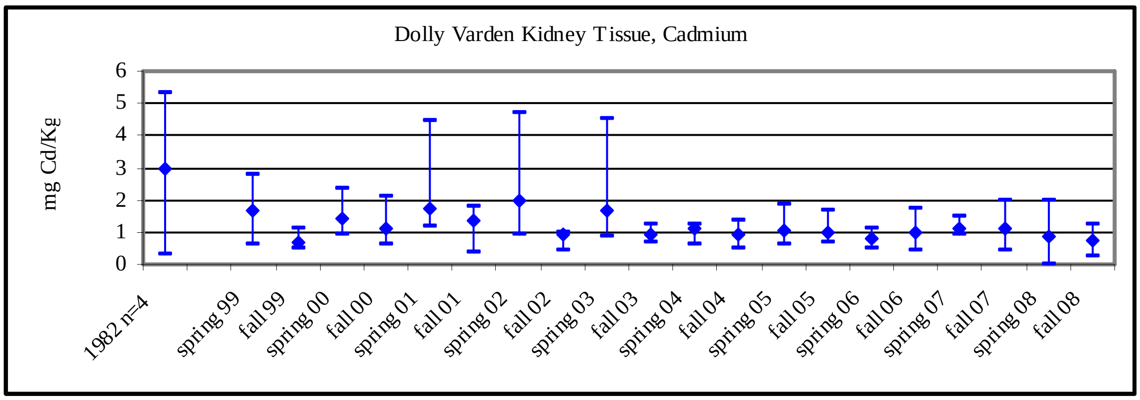
Source	DF	SS	MS	F	P
Between	1	34.13	34.1333	0.43	0.5161
Within	28	2209.87	78.9238		
Total	29	2244.00			

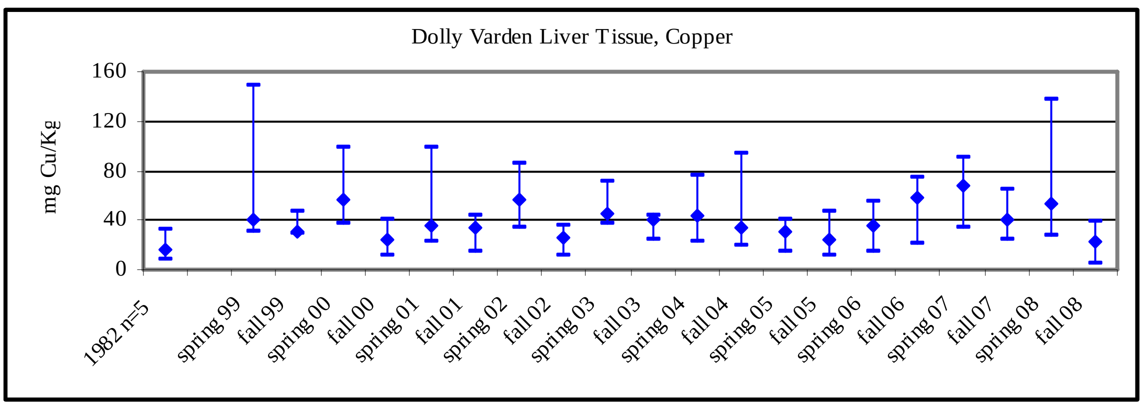
Total number of values that were tied 9
Max. diff. allowed between ties 0.00001

Cases Included 30 Missing Cases 0

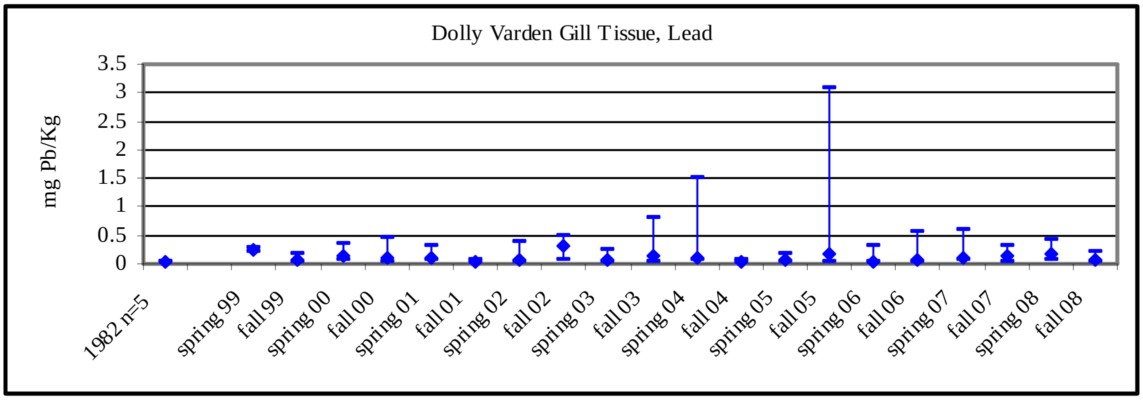
Appendix 7. Dolly Varden Adults, Metals

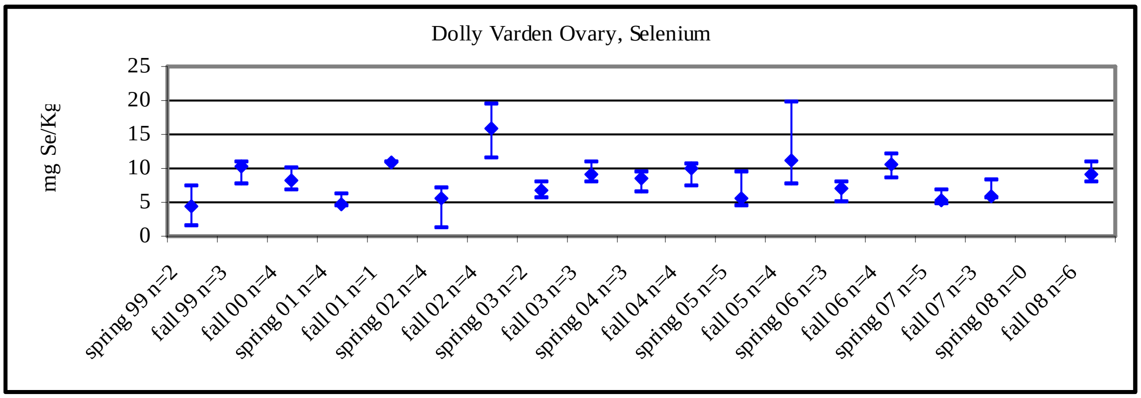


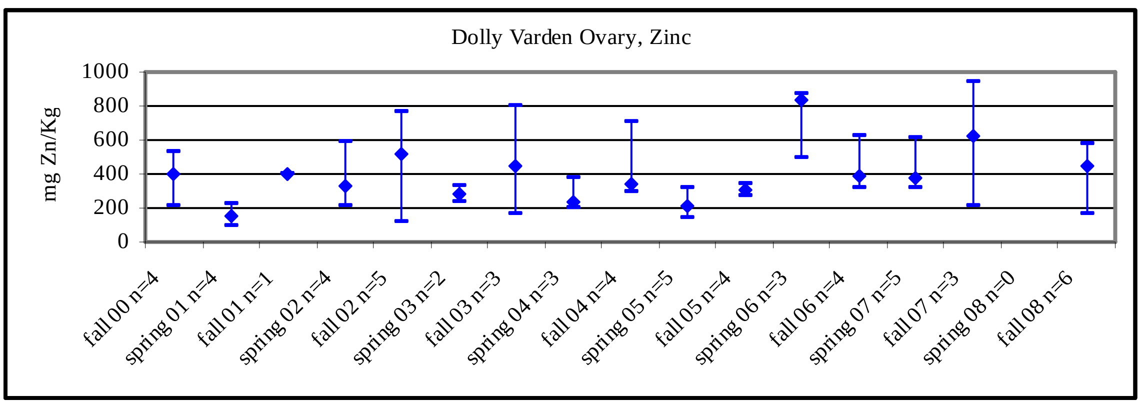




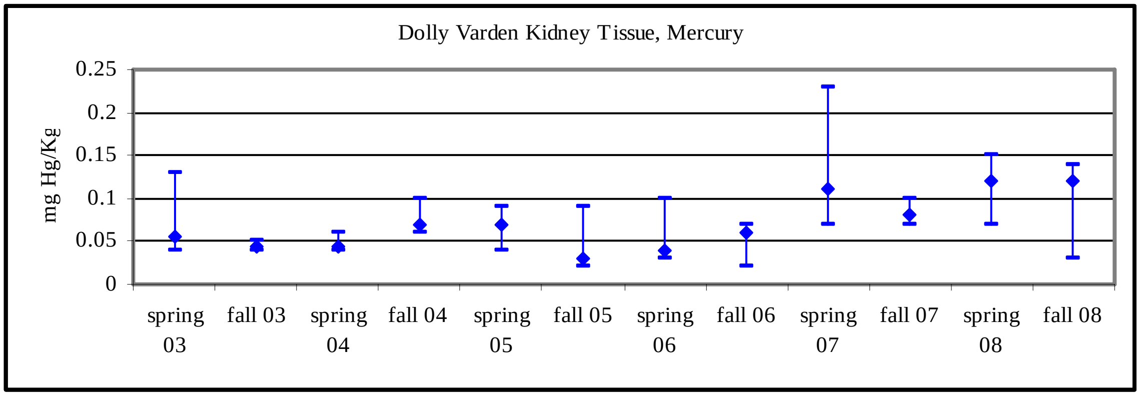
Appendix 7 (continued)







Appendix 7 (concluded)

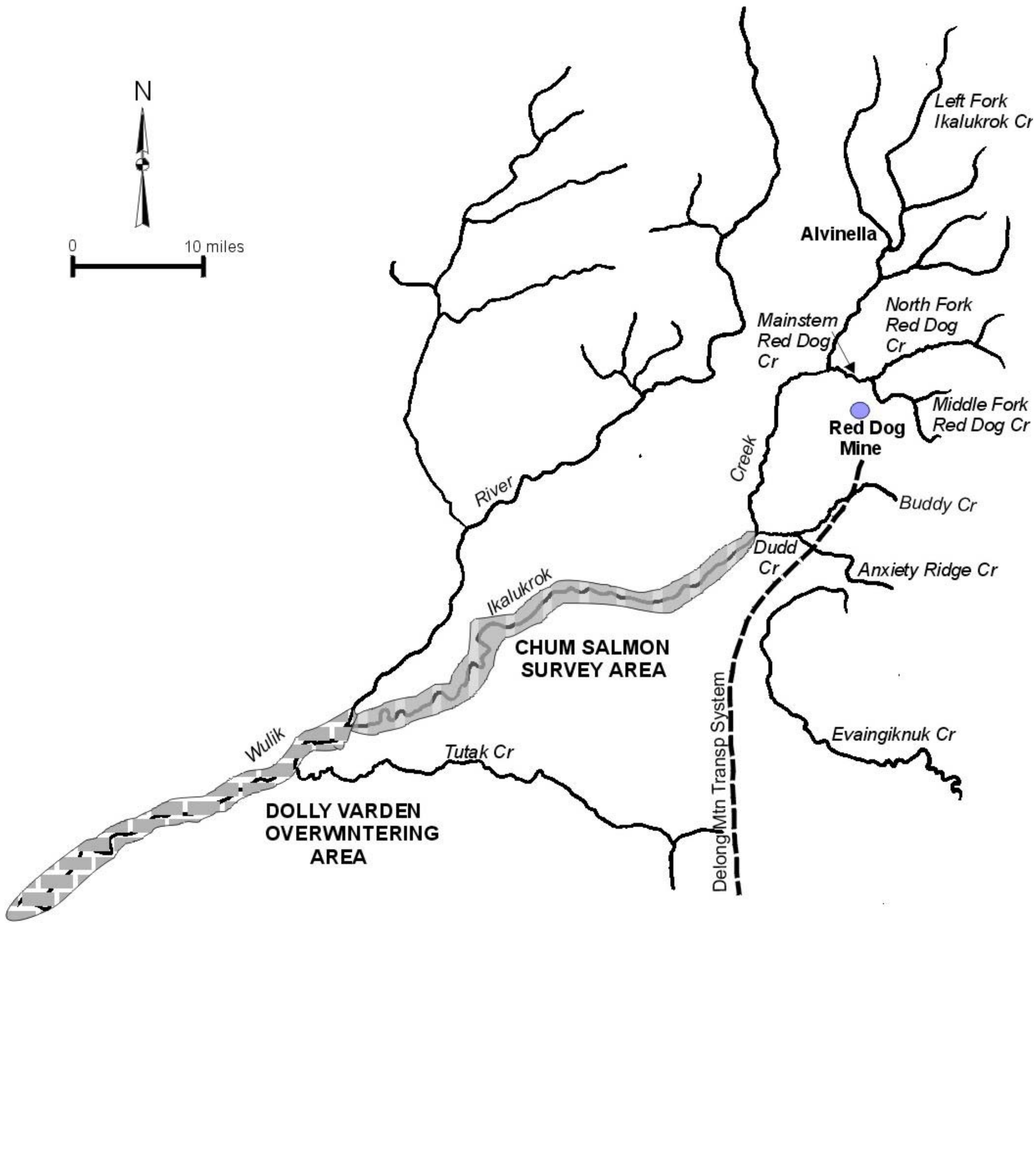


Appendix 8. Dolly Varden Aerial Surveys

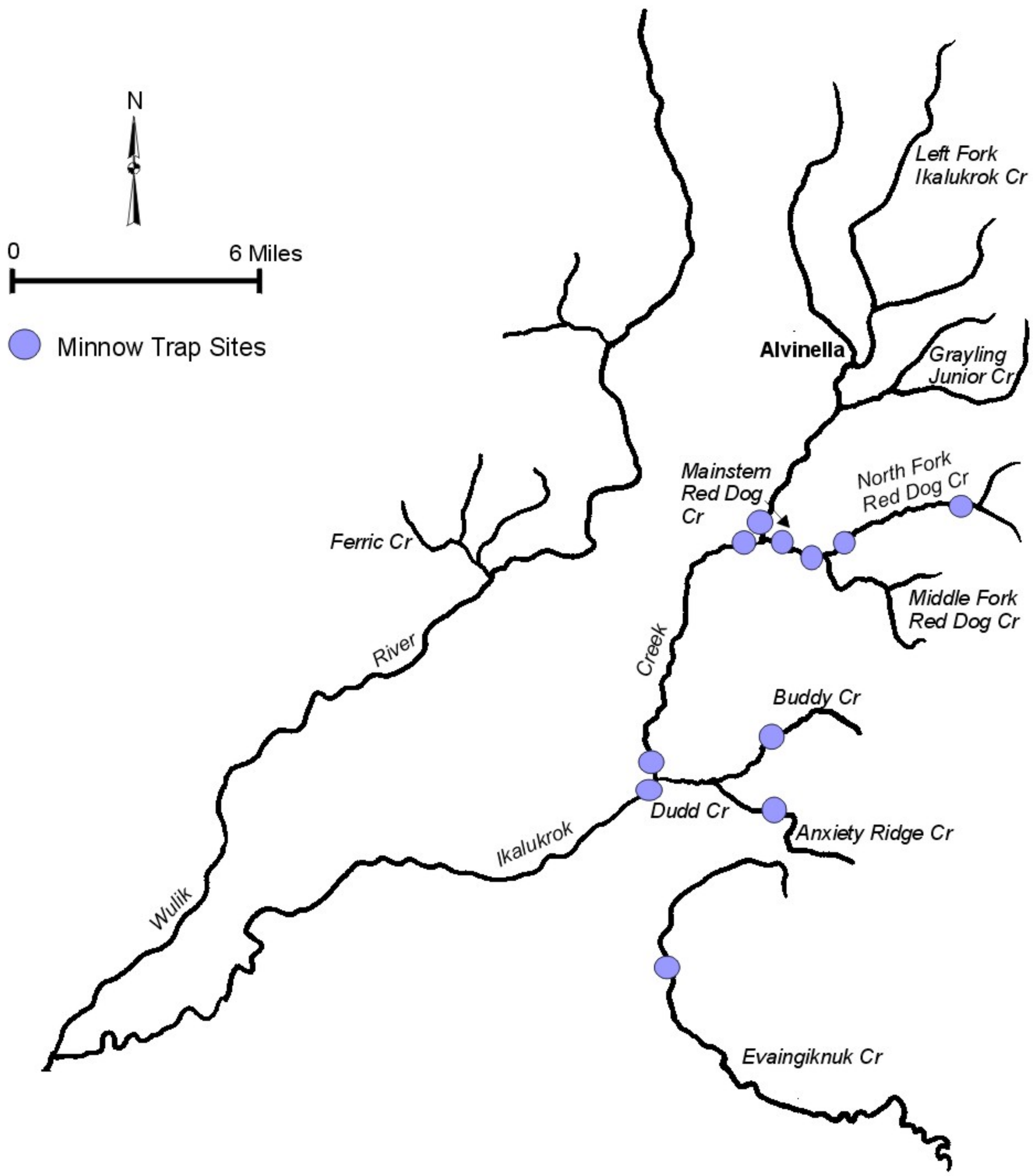
Estimated number of overwintering Dolly Varden in the Wulik River before freezeup. Surveys conducted by ADF&G (DeCicco 1989, 1991-1999, 2001-2002, and 2004-2008.

Year	Wulik River upstream of Ikalukrok Creek	Wulik River downstream of Ikalukrok Creek	Total Fish	Percent of Fish downstream of Ikalukrok Creek
Before Mining				
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	80,144	98
During Mining				
1989	2,110	54,274	56,384	96
1991	7,930	119,055	126,985	94
1992	750	134,385	135,135	99
1993	7,650	136,488	144,138	95
1994	415	66,337	66,752	99
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
2001	2,020	90,594	92,614	98
2002	1,675	42,582	44,257	96
2004	16,486	84,320	100,806	84
2005	10,645	110,203	120,848	91
2006	4,758	103,594	108,352	96
2007	5,503	93,808	99,311	94
2008	271	71,222	71,493	99
The population estimate (mark/recapture) for winter 1988/1989 for fish >400 mm				
was 76,892 (DeCicco 1990b)				
The population estimate (mark/recapture) for winter 1994/1995 for fish >400 mm				
was 361,599 (DeCicco 1996c)				
Fall 2000 aerial survey was not made due to weather.				
Fall 2003 aerial survey was not made due to weather.				

Appendix 9. Dolly Varden and Chum Salmon Survey Areas



Appendix 10. Juvenile Dolly Varden Sampling Sites



Appendix 11. Juvenile Dolly Varden Catches

Number of Dolly Varden Caught in Late-July/Early August with ten minnow traps per sample site												
Sample Site Description	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Evaingiknuk (Noatak Tributary)	54	27	38	2	7	20	64	71	29	4	67	21
Anxiety Ridge	68	94	271	27	6	33	98	116	121	8	115	75
Buddy	48	154	306	11	34	57	104	59	59	5	183	43
North Fork Red Dog Creek (Sta 12)	0	12	17	1	1	1	0	1	8	0	1	0
Mainstem (below North Fork)	14	70	86	13	9	12	2	2	6	8	2	13
Mainstem (Station 10)	10	21	66	1	3	12	12	0	10	3	6	5
Ikalukrok Creek (below Dudd)	13	51	55	31	6	17	17	27	36	2	25	7
Ikalukrok Creek (above Dudd)	3	53	37	14	0	22	27	11	6	0	4	4
Ikalukrok Creek (below Mainstem)	4	19	28	6	11	15	3	2	0	0	5	7
Ikalukrok Creek (above Mainstem)	3	44	41	5	2	18	3	12	0	5	7	3
Total Catch Dolly Varden	217	545	945	111	79	207	330	301	275	35	415	178

Appendix 12. Arctic Grayling, Mainstem Red Dog Creek

Observations and catches of Arctic grayling in Mainstem Red Dog Creek below the confluence of North Fork Red Dog and Middle Fork Red Dog creeks since 1994.

7/27/94 – visual, two adults just below North Fork

6/29/95 – angling, one adult just below North Fork
7/17/95 – angling, two adults near rock bluff 0.8 km below North Fork
7/20/95 – visual, one adult near rock bluff 0.8 km below North Fork
8/11/95 – visual, fry (about 30) below North Fork
8/14/95 – angling, 11 adults marked and released, rock bluff 0.8 km below North Fork

6/19/96 – visual, one adult near Station 10
7/15/96 – angling, seven adults marked and released near Station 10
8/11/96 – visual, fry in shallow eddies at mouth of Mainstem
8/12/96 – visual, fry near rock bluff 0.8 km below North Fork

6/25/97 – visual, two adults at rock bluff 0.8 km below North Fork
6/25/97 – drift net, fry caught at Station 10, 13-15 mm long
6/26/97 – angling, 15 adults marked and released near Station 10
6/27/97 – visual, fry numerous at Station 10
8/10/97 – visual, fry in backwaters
9/29/97 – minnow traps, seven fry caught near Station 10

6/10/98 – visual, no fish seen between North Fork mouth and rock bluff 0.8 km downstream
6/28/98 – visual, one adult feeding at rock bluff (0.8 km below North Fork)

5/29/99 – angling, three adults caught just below North Fork mouth
5/30/99 – fyke net, 32 adults caught about 100 m below North Fork mouth
7/8-9/99 – angling, two adults captured, marked, and released near Station 10
7/8-9/99 – visual, 12 adults and some fry near Station 10
7/8-9/99 – visual, two adults at rock bluff (0.8 km below North Fork)
8/9-10/99 – visual, numerous fry in backwaters and along stream margins

Appendix 12 (continued)

6/11-12/00 – fyke net, adults captured, marked, and released 7/28/00 – visual, several fry in backwaters and along stream margins, not numerous
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 creek, tagged three adults near Station 10, most pools held one to three adults

6/15-18/01 – visual, walked creek to check for spawners in proposed mixing zone, none observed, one adult seen feeding at rock bluff (about 0.8 km below North Fork)
6/17/01 – angling, 11 adults marked and released near Station 10, all females spent
7/29-31/01 – visual, very few fry seen (about 20 mm), late breakup, cold temperatures resulted in late spawning

5/31/02 – fyke net, seven adults marked and released near Station 10
6/1/02 – fyke net, 31 adults marked and released near Station 10
6/2/02 – fyke net, eight adults marked and released near Station 10
6/3/02 – fyke net, three adults marked and released near Station 10
6/4/02 – fyke net, three adults and three juveniles marked and released near Station 10
6/7/02 – angling, 10 adults and three juveniles marked and released near Station 10, most of the females were spent
7/27/02 – visual, few fry (<10) seen
7/28/02 – visual, adults present near Station 10, three to four per pool

6/11/03 – aerial, 48 adults, two spawning pairs seen
6/12/03 – visual, ten adults, three active spawning pairs observed near Station 10
6/14/03 – angling, eight adults, one spent male near Station 10
7/7/03 – visual, fry in backwaters near Station 10, one group of 30
7/8/03 – visual, ten adults near Station 10
9/7/03 – visual, two adults and five fry near Station 151

5/25/04 – visual, two adult males near Station 10
5/26/04 – fyke net, four adults near Station 10
7/7/04 – visual, fry common near Station 151
7/7/04 – angling, two adults (333, 325 mm) near Station 151
7/8/04 – visual, fry in all backwaters near Station 10
7/8/04 – angling, three adults (373, 297, 356 mm) near Station 10

Appendix 12 (concluded)

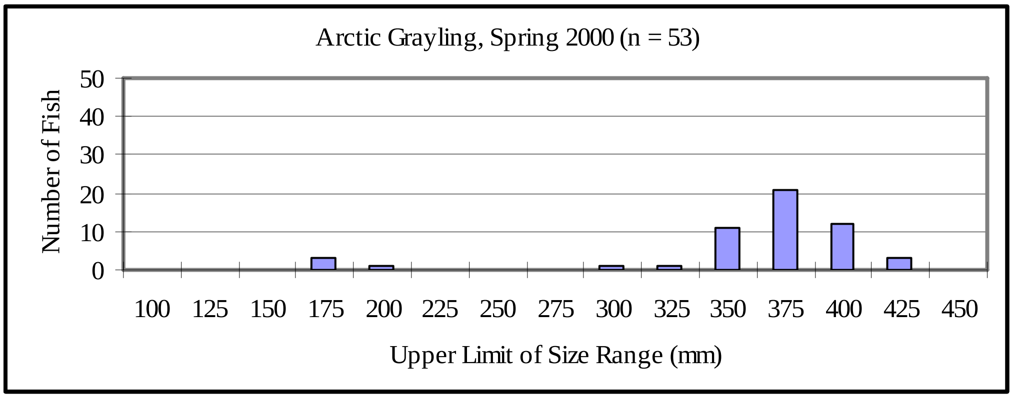
6/5/05 – aerial, observed 30 adult Arctic grayling, only two sets paired
6/25 and 26/05 – Houghton reported catching about 60 fish in Mainstem between mouth and North Fork Red Dog Creek
7/4/05 – visual, 8 adults and fry (about 70) observed near Station 10
7/28/05 – visual, small numbers of fry in backwaters near Station 10

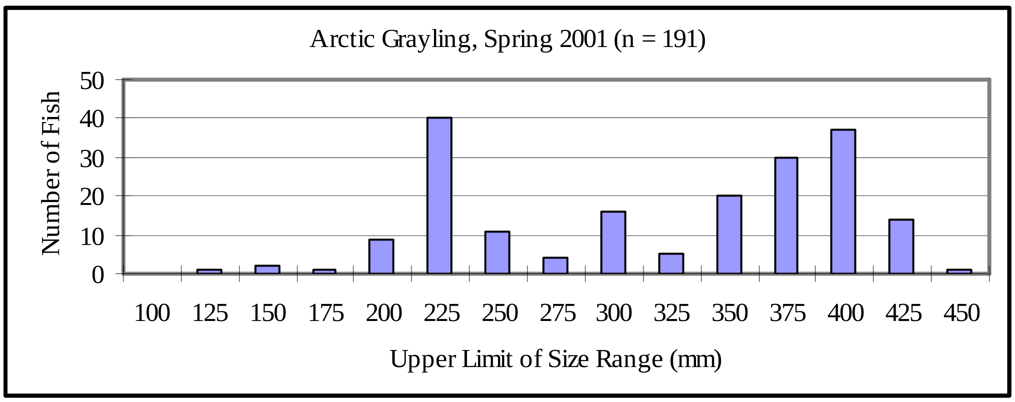
6/13/06 – visual, five adult Arctic grayling seen in Mainstem near Station 10
6/16/06 – angling, caught 8 Arctic grayling (260 – 355 mm long) in Mainstem just below mouth of North Fork

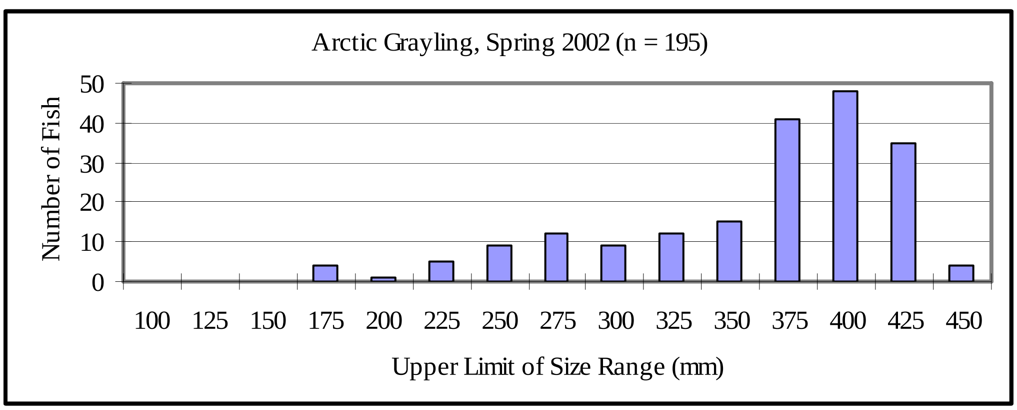
6/1/07 – visual, several adult male and female Arctic grayling seen near Station 151
6/2/07 – visual, numerous Arctic grayling spawning at 3rd bend downstream of Station 151 in area of cobbles to gravelly sand
6/3/07 – visual, groups of 4 to 5 adults moving downstream in Station 10 area, caught several spent females, fish obviously moving out of Mainstem
7/1/07 – visual, observed large number of fry in side channels and backwaters near Station 10 and three adult Arctic grayling feeding on drift
7/3/07 – visual, observed one adult Arctic grayling at Station 151 and several fry along stream margins
8/9/07 – visual, observed two adult Arctic grayling at Station 151 and saw 35 fry along stream margins, one group of about 25
8/10/07 – visual, observed quite of few Arctic grayling fry in vicinity of Station 10 and caught fry in minnow traps (n = 10, 59 to 68 mm, average 64.1, SD = 2.8)

6/608 – visual, observed one Arctic grayling near Station 151
6/9/08 – visual and angling, walked Station 151 downstream for about 1.6 km and caught one Arctic grayling (363 mm)
6/10/08 – visual and angling, caught 5 Arctic grayling (325 – 425 mm long) just upstream of Station 10, four males and one partially spent female – saw about six fish that we did not catch
7/3/08 – visual, saw one adult Arctic grayling near Station 10
7/4/08 – visual, fry common along stream margins near Station 10, very small (about 15 mm long)
7/4/08 – minnow traps, caught one 67 mm Arctic grayling near Station 151
8/3/08 – minnow traps, caught one 82 mm Arctic grayling near Station 151

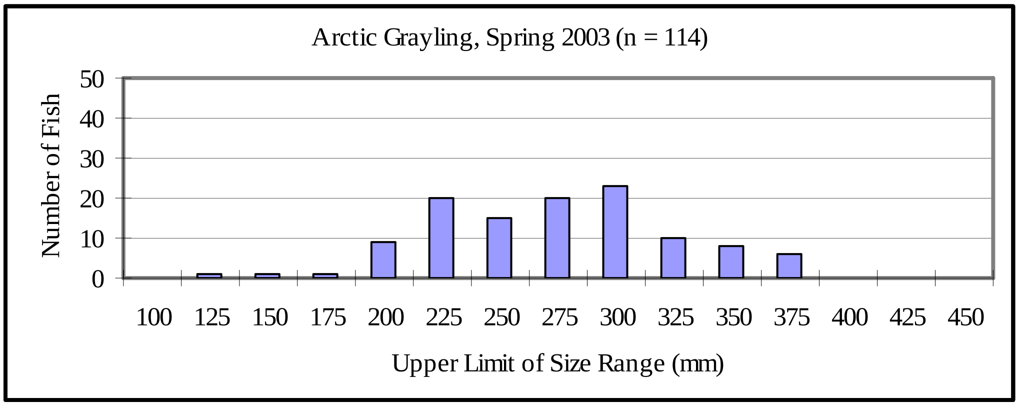
Appendix 13. Arctic Grayling, Length Frequency

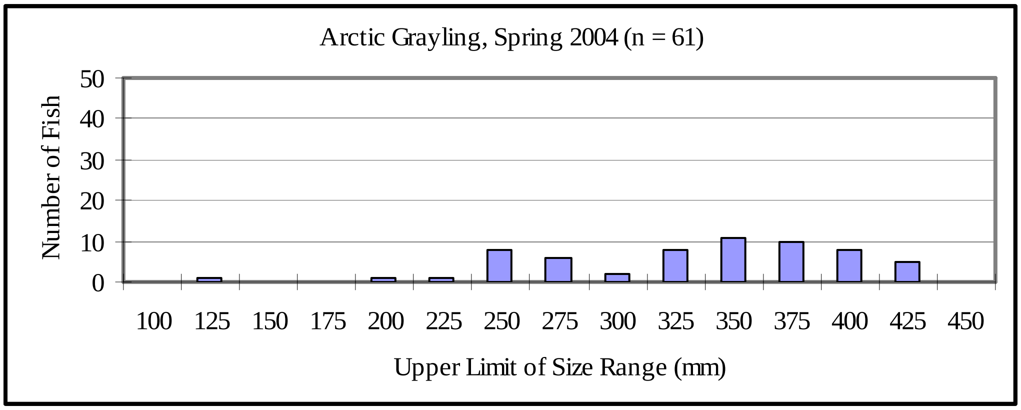


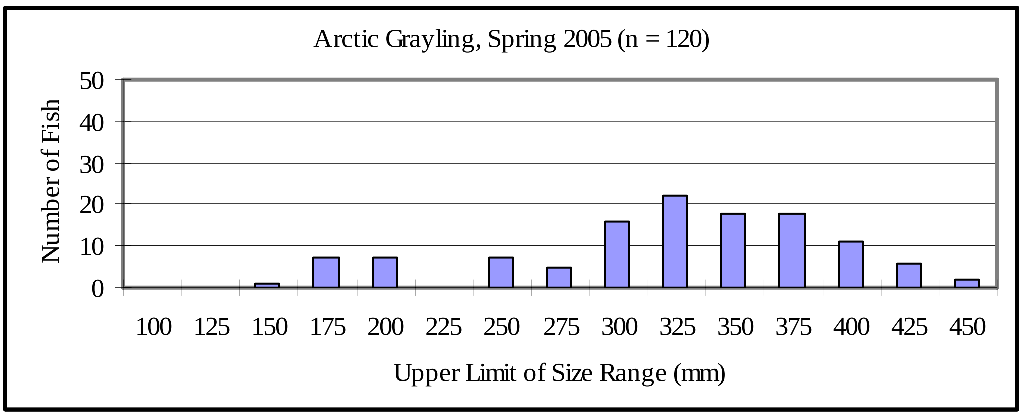




Appendix 13 (continued)







Appendix 13 (concluded)