Technical Report No. 20-02

# Aquatic Biomonitoring at Red Dog Mine, 2019

*A requirement under Alaska Pollution Discharge Elimination System Permit No. AK0038652 (Modification #1)*

**by**

**Chelsea M. Clawson and Alvin G. Ott**

**April 2020**

**Alaska Department of Fish and Game** **Habitat Section**

## Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by Habitat Section and the Divisions of Sport Fish, and Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, Technical Reports and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

**Weights and measures (metric)**

| | |
|---|---|
| centimeter | cm |
| deciliter | dL |
| gram | g |
| hectare | ha |
| kilogram | kg |
| kilometer | km |
| liter | L |
| meter | m |
| milliliter | mL |
| millimeter | mm |

**Weights and measures (English)**

| | |
|---|---|
| cubic feet per second | $ft^3/s$ |
| foot | ft |
| gallon | gal |
| inch | in |
| mile | mi |
| nautical mile | nmi |
| ounce | oz |
| pound | lb |
| quart | qt |
| yard | yd |

**Time and temperature**

| | |
|---|---|
| day | d |
| degrees Celsius | °C |
| degrees Fahrenheit | °F |
| degrees kelvin | K |
| hour | h |
| minute | min |
| second | s |

**Physics and chemistry**

| | |
|---|---|
| all atomic symbols | |
| alternating current | AC |
| ampere | A |
| calorie | cal |
| direct current | DC |
| hertz | Hz |
| horsepower | hp |
| hydrogen ion activity (negative log of) | pH |
| parts per million | ppm |
| parts per thousand | ppt, ‰ |
| volts | V |
| watts | W |

**General**

| | |
|---|---|
| Alaska Administrative Code | AAC |
| all commonly accepted abbreviations | e.g., Mr., Mrs., AM, PM, etc. |
| all commonly accepted professional titles | e.g., Dr., Ph.D., R.N., etc. |
| at | @ |
| compass directions: | |
| east | E |
| north | N |
| south | S |
| west | W |
| copyright | © |
| corporate suffixes: | |
| Company | Co. |
| Corporation | Corp. |
| Incorporated | Inc. |
| Limited | Ltd. |
| District of Columbia | D.C. |
| et alii (and others) | et al. |
| et cetera (and so forth) | etc. |
| exempli gratia (for example) | e.g. |
| Federal Information Code | FIC |
| id est (that is) | i.e. |
| latitude or longitude | lat or long |
| monetary symbols (U.S.) | $, ¢ |
| months (tables and figures): first three letters | Jan,...,Dec |
| registered trademark | ® |
| trademark | ™ |
| United States (adjective) | U.S. |
| United States of America (noun) | USA |
| U.S.C. | United States Code |
| U.S. state | use two-letter abbreviations (e.g., AK, WA) |

**Mathematics, statistics**

| | |
|---|---|
| *all standard mathematical signs, symbols and abbreviations* | |
| alternate hypothesis | $H_A$ |
| base of natural logarithm | *e* |
| catch per unit effort | CPUE |
| coefficient of variation | CV |
| common test statistics | (F, t, $\chi^2$, etc.) |
| confidence interval | CI |
| correlation coefficient (multiple) | R |
| correlation coefficient (simple) | r |
| covariance | cov |
| degree (angular) | ° |
| degrees of freedom | df |
| expected value | *E* |
| greater than | > |
| greater than or equal to | ≥ |
| harvest per unit effort | HPUE |
| less than | < |
| less than or equal to | ≤ |
| logarithm (natural) | ln |
| logarithm (base 10) | log |
| logarithm (specify base) | $log_2$, etc. |
| minute (angular) | ' |
| not significant | NS |
| null hypothesis | $H_O$ |
| percent | % |
| probability | P |
| probability of a type I error (rejection of the null hypothesis when true) | α |
| probability of a type II error (acceptance of the null hypothesis when false) | β |
| second (angular) | " |
| standard deviation | SD |
| standard error | SE |
| variance | |
| population | Var |
| sample | var |

# *TECHNICAL REPORT NO. 20-02*

# AQUATIC BIOMONITORING AT RED DOG MINE, 2019

### *A REQUIREMENT UNDER ALASKA POLLUTION DISCHARGE ELIMINATION SYSTEM PERMIT NO. AK0038652 (MODIFICATION #1)*

By

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April, 2020

Cover: Yellow Billed Loon on Bons Pond, June 2019. Photograph by Chelsea Clawson

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*This document should be cited as:*
*Clawson, C. M. and A.G. Ott. 2020. Aquatic Biomonitoring at Red Dog Mine, 2019. Alaska Department of Fish and Game, Technical Report No. 20-02, Fairbanks, Alaska.*

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## Acknowledgements

The authors thank Teck Alaska - Red Dog Operations (Teck) for their financial and logistical support for the 2019 aquatic biomonitoring work. We specifically acknowledge the assistance provided by Mike Gonzalez, Robert Napier, Chris Eckert, Darren Jones, Joseph Diehl III, Dennis Sheldon, Nicole Shellabarger, and Carla Nelson.

Chad Bear, Justin Burrows, and Maria Wessel with the Alaska Department of Fish and Game (ADF&G) Habitat Section and Brendan Scanlon with ADF&G Division of Sport Fish provided assistance with field and laboratory work. Fred DeCicco (DeCicco-Alaska) conducted the fall aerial surveys for Dolly Varden (*Salvelinus malma*) and chum salmon (*Oncorhynchus keta*), and collected the fall sample of adult Dolly Varden from the Wulik River. Katie Shink with US Fish and Wildlife Service provided assistance with otolith mounting and aging.

Nora Foster (NRF Taxonomic Services) was responsible for sorting and identification of aquatic invertebrates. Robert Napier, Maria Wessel, and Audra Brase provided constructive reviews of this report.

## Executive Summary

●In 2019, median metals concentrations (lead, zinc, aluminum, cadmium) in North Fork Red Dog Creek, Buddy Creek, and Bons Pond were consistent with past years' results, and were lower when compared with pre-mining data. Median concentrations of cadmium, lead, and zinc were consistently higher in Mainstem Red Dog Creek as compared with Buddy and North Fork Red Dog creeks and Bons Pond. The pH and total dissolved solids (TDS) in Mainstem Red Dog Creek were higher than pre-mining, but consistent with past years' data.

●Zinc and cadmium continued to increase in Mainstem Red Dog Creek, following a steep increase in 2018. The source of the cadmium and zinc was traced to Kaviqsaaq Seep, which drains into Middle Fork Red Dog Creek above the clean water bypass system. The most likely source of the changes to the Kaviqsaaq Seep is mining activity on the Qanaiyaq 1500 bench. Teck has regraded the bench and undertaken other remedial actions and will continue to monitor the Seep activity. In the event improvement in water quality is not observed in 2020, capture of the Kaviqsaaq Seep may be needed.

●Periphyton standing crop, as estimated by chlorophyll-a concentration, is determined each year in drainages near the Red Dog Mine. In 2019, chlorophyll-a concentrations were highest in Bons Creek below the pond and lowest in Middle Fork Red Dog Creek at Station 20 and Ikalukrok Creek at Station 9. Chlorophyll-a concentration in Ikalukrok Creek at Station 9 continues to track closely with zinc and cadmium in the water. The major source of cadmium and zinc at Station 9 is the Cub Creek natural seep.

●Aquatic invertebrate densities are used as an index of stream productivity and health. In 2019, ten sites were sampled, and the aquatic invertebrate density was highest in Buddy Creek below the falls, consistent with past years. In 2019 all sites sampled contained a higher percentage of Chironomidae than Ephemeroptera, Plecoptera, and Trichoptera (EPT). Overall taxa richness varied from 19 to 35 taxa per site.

●Juvenile Arctic grayling from Bons Pond have been analyzed for selected whole body elements in 2004, 2007, 2010, and 2014 – 2019. Average cadmium, lead, and zinc concentrations in Arctic grayling juveniles were lowest in 2017, increased in 2018, and slightly decreased in 2019. The average selenium concentration in juvenile Arctic grayling in 2019 was the lowest since sampling began. Average mercury concentration was 0.06 mg/kg in 2019, the same as 2018.

●Juvenile Dolly Varden from Mainstem Red Dog, Buddy, and Anxiety Ridge creeks have been analyzed for selected whole body elements from 2005 to 2011 and from 2014 to 2019. Juvenile Dolly Varden median whole body concentrations of cadmium, lead, and zinc are consistently highest in Mainstem Red Dog Creek. Median selenium concentrations were highest in Buddy Creek in 2019, but all creeks had very similar median selenium concentrations. Median mercury concentrations have consistently been highest in Anxiety Ridge Creek. The steep increases in cadmium and zinc in the water in Mainstem Red Dog Creek were not reflected in whole body concentration in the juvenile Dolly Varden.

●Selenium concentrations were compared among Arctic grayling in Bons Pond, North Fork Red Dog Creek, and Fish Creek (Ft. Knox Mine). Selenium concentrations were highest in Arctic grayling ovaries from Bons Pond (2014 - 2019) and lowest in Fish Creek (1999, 2015, and 2017). Selenium concentrations in fish ovaries from North Fork Red Dog Creek were intermediate between Bons Pond and Fish Creek.

●In 2019 adult Dolly Varden captured in the Wulik River during spring and fall were analyzed for cadmium, copper, lead, selenium, zinc, and mercury in kidney, liver, ovary, testes, and muscle tissues. None of the analytes measured appear to concentrate in muscle. Various elements concentrate in specific tissues.

●Aerial surveys are used each fall to estimate the number of overwintering Dolly Varden in the Wulik River. The number of fish overwintering in the Wulik River could not be estimated in 2019 due to high turbidity in Ikalukrok Creek that extended downstream into the Wulik River.

●The annual aerial survey to assess the distribution of chum salmon in Ikalukrok Creek could not be performed in 2019 due to high turbidity in Ikalukrok Creek.

●In spring 2019, resident Dolly Varden (n = 16) were collected with fyke nets in North Fork Red Dog Creek, averaging 150 mm FL. Juvenile Dolly Varden sampling with minnow traps was conducted in late summer 2019. The total number of juvenile Dolly Varden captured at all sample sites in early August was 150 fish with an average size of 91 mm FL. The highest catch was on Buddy Creek (57 fish).

●The spring Arctic grayling spawning migration into North Fork Red Dog Creek was monitored. Spawning time in Mainstem Red Dog Creek could not be determined as spent females were never captured. Larval Arctic grayling were captured in drift nets in July in North Fork Red Dog Creek, indicating spawning was successful in this creek. The 2018 population of Arctic grayling in North Fork Red Dog Creek was estimated as 960 fish ≥ 200 mm FL.

●The estimated Arctic grayling population in Bons Pond in 2018 was 914 fish ≥ 200 mm FL. The estimated population decreased from the 2017 estimate of 1,572 fish ≥ 200 mm FL. Large numbers of fish < 100 mm FL were captured in 2019, indicating high spawning success in 2018.

●Pre-mining slimy sculpin abundance is unknown. Baseline reports indicated that this species was numerous in the Ikalukrok Creek drainage, but uncommon in the Red Dog Creek drainage. Slimy sculpin continue to be captured in Mainstem Red Dog Creek, but the highest catches consistently occur in Ikalukrok Creek downstream of the mouth of Dudd 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, facilities, the surrounding vegetation, and wildlife are described in the Alaska Department of Fish and Game (ADF&G) technical report: *Fisheries Resources and Water Quality, Red Dog Mine* (Weber Scannell and Ott 1998). A chronology of development and operations at the Red Dog Mine is presented in Appendix 1 and Ott et al. 2016. Aquatic resources in the Wulik River drainage are described in the ADF&G technical report: *Fish and Aquatic Taxa Report at Red Dog Mine, 1998-1999* (Weber Scannell et al. 2000).

Aquatic biomonitoring has occurred annually at the Red Dog Mine since 1995 and has included periphyton, aquatic invertebrate, and fish sampling. Tissue and whole body element analyses for Dolly Varden (*Salvelinus malma*) and spawning season monitoring for Arctic grayling (*Thymallus arcticus*) are also performed annually. In 2017, the Alaska Department of Environmental Conservation (ADEC) issued Alaska Pollution Discharge Elimination System Permit No. AK0038652 to Teck Alaska Incorporated (Teck) which allowed the discharge of up to 2.418 billion gallons of treated effluent per year into Middle Fork Red Dog Creek. The APDES Permit required a bioassessment program that included periphyton, aquatic invertebrates, and fish in selected streams near the Red Dog Mine (Tables 1 and 2). The current bioassessment program became fully effective and enforceable on September 1, 2017.

On September 23, 2016, the ADEC issued Waste Management Permit No. 2016DB002 for the Red Dog Mine that included a condition that Teck adhere to the requirements of the monitoring plan submitted by Teck in November 2016. Teck's Monitoring Plan was revised in January 2018, and includes sample sites, sampling frequency, and parameters for all aquatic sites, including those required by the APDES Permit (Table 1). To satisfy conditions in the ADEC permit, the ADF&G submitted Technical Report #17-09 Methods for Aquatic Life Monitoring at the Red Dog Mine Site: A requirement of the 2017 APDES Permit AK0038652.

Under APDES Permit No. AK0038652, the Total Dissolved Solids (TDS) load discharged from Outfall 001 is limited from July 25 through the end of the discharge season so as to maintain total in-stream TDS concentrations at or below 500 mg/L at Station 160 on Ikalukrok Creek. This provision is included to properly protect chum salmon spawning in Ikalukrok Creek. In 2019, discharge from Outfall 001 was limited from July 25 – August 19, and halted from August 19 – 27, 30 & 31 due to background TDS levels at Station 160 approaching or exceeding the 500 mg/L threshold. Based on field measurements made by Teck, the elevated TDS concentrations were due to natural input from drainages in Ikalukrok Creek upstream of Mainstem Red Dog Creek. Discharge was halted for the season on September 10, 2019. This inability of the Red Dog Mine to discharge at typical levels led to an increase in water elevation within the Tailings Storage Facility (TSF) and required Red Dog to take special actions to ensure the TSF water level remained within the criteria established in the State's (Department of Natural Resources) certificate to operate the dam.

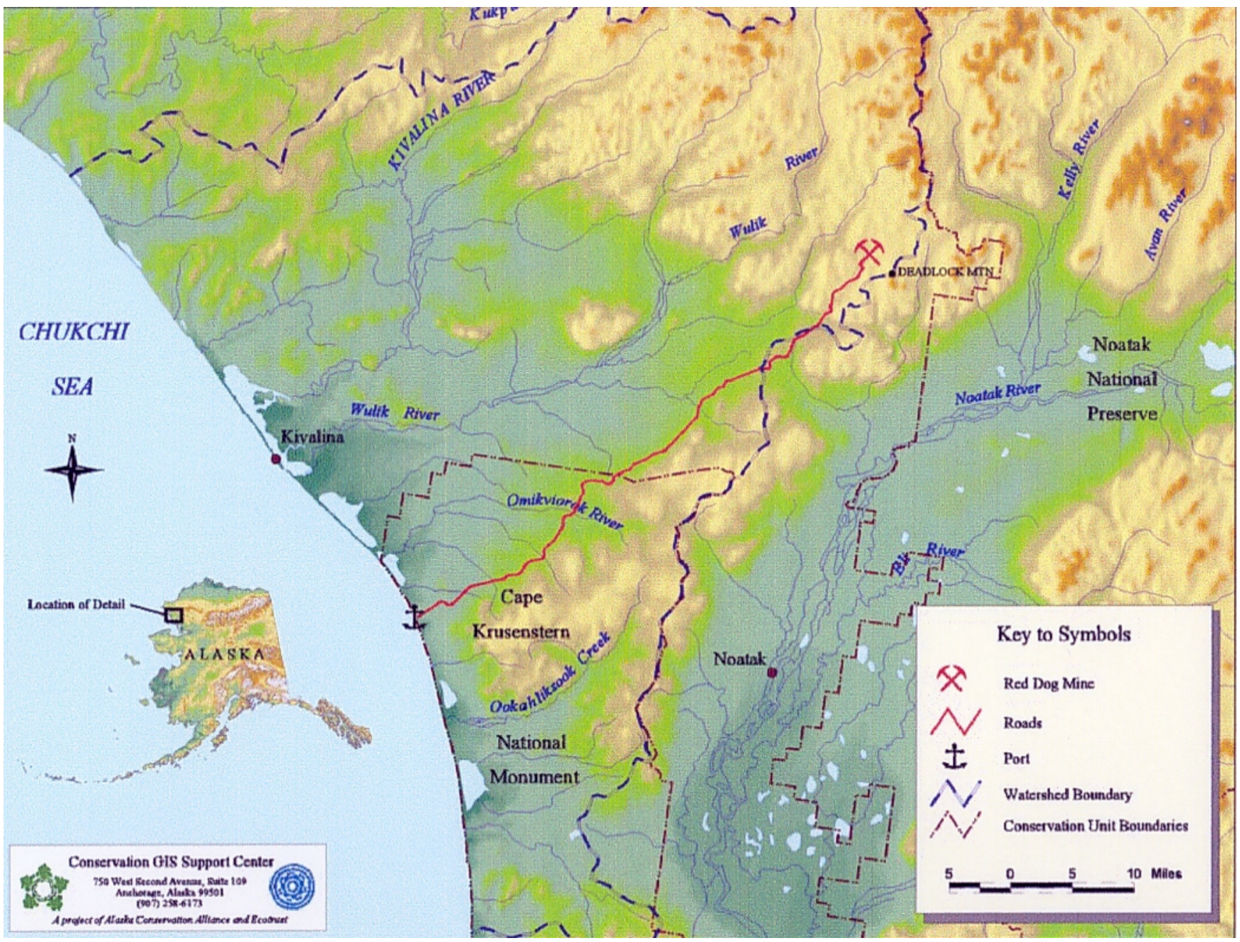



**Figure 1. Location of the Red Dog Mine in northwestern Alaska.[1]**

[1] Map used with permission of Conservation GIS Support Center, Anchorage, Alaska.

**Table 1. Location of biological sample sites and factors measured at the Red Dog Mine, 2019.**

| Location | APDES[1]/WMP[2] | Location Description | Parameters |
|---|---|---|---|
| Wulik River | WMP | Kivalina Lagoon to 10 km past mouth of Ikalukrok Creek | Fall aerial surveys for overwintering Dolly Varden |
| Ikalukrok Cr | WMP | Lower Ikalukrok Creek to mouth of Dudd Creek | Fall aerial surveys for adult chum salmon |
| Station 9 | APDES/WMP | Ikalukrok Creek upstream of confluence with Red Dog Creek | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates<br>Fish presence and use |
| Station 160 | WMP | Lower Ikalukrok Creek | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates<br>Fish presence and use |
| Station 20 | WMP | Middle Fork Red Dog Creek | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates |
| Station 10 | APDES/WMP | Mouth of Red Dog Creek | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates<br>Fish presence and use<br>Juvenile Dolly Varden metals in tissue |
| Station 12 | APDES/WMP | North Fork Red Dog Creek | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates<br>Fish presence and use<br>Record of spawning activity<br>Capture/mark Arctic grayling |
| Upper NF | APDES | Upper North Fork Red Dog Creek, above Aqqaluk | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates<br>Fish presence and use |
| Station 151 | APDES | Mainstem Red Dog Creek | Fish presence and use |
| Buddy Creek | WMP | Below falls, about 1.5 km downstream of haul road | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates<br>Fish presence and use<br>Juvenile Dolly Varden metals in tissue |
| Buddy 221 | WMP | Buddy Creek above haul road | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates |
| Bons 220 | WMP | Bons Creek below pond | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates |
| Bons | WMP | Bons Creek above pond | Periphyton (as chlorophyll-a concentration)<br>Aquatic invertebrates |
| Anxiety Ridge | WMP | Anxiety Ridge Creek below haul road | Fish presence and use<br>Juvenile Dolly Varden metals in tissue |
| Evaingiknuk | WMP | Evaingiknuk Creek east of haul road | Fish presence and use |
| Bons Pond | WMP | Above reservoir spillway | Juvenile Arctic grayling metals in tissue<br>Arctic grayling population estimate |

[1]APDES – Alaska Permit Discharge Elimination System [2]WMP – Waste Management Plan

Teck's monitoring plan is incorporated by reference into the Alaska Department of Natural Resources (ADNR) Reclamation Plan Approval (F20169958) dated September 28, 2016. On March 10, 2010, the U.S. Department of Army issued permit POA-1984-12-M45 to Teck which authorized development of the Aqqaluk Pit. Active mining in the Aqqaluk Pit began during 2012. In addition to mine drainage, certain waste rock from Aqqaluk and Qanaiyaq and treated water were placed in the mined out main pit. This report presents data collected during summer 2019 and where applicable, these data are compared with previous years.

## Structure of Report

This report is presented in several sections as follows:

1) Water quality;
2) Periphyton standing crop;
3) Aquatic invertebrates;
4) Element concentration data for juvenile Dolly Varden and juvenile and adult Arctic grayling collected from streams and Bons Pond, and adult Dolly Varden collected from the Wulik River;
5) Aerial survey estimates of overwintering Dolly Varden in the Wulik River and chum salmon (*Oncorhynchus keta*) spawners in Ikalukrok Creek; and
6) Biological monitoring data for Dolly Varden juveniles, Arctic grayling, and slimy sculpin (*Cottus cognatus*).

## Location and Description of Sample Sites

Biomonitoring is conducted annually in streams in the vicinity of the Red Dog Mine as required under the APDES Permit No. AK0038652 (Table 1 and Figure 2) and by the ADEC Waste Management Permit and the ADNR Reclamation Plan Approval. All streams in the study area including Red Dog, Ikalukrok, Bons and Buddy creeks 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 four years of baseline studies (1979 to 1982) represent pre-mining conditions. Comparisons of existing conditions relative to baseline data should consider that there is a much longer time series of data since mining began (1990 to 2019) when compared to the pre-development baseline data.

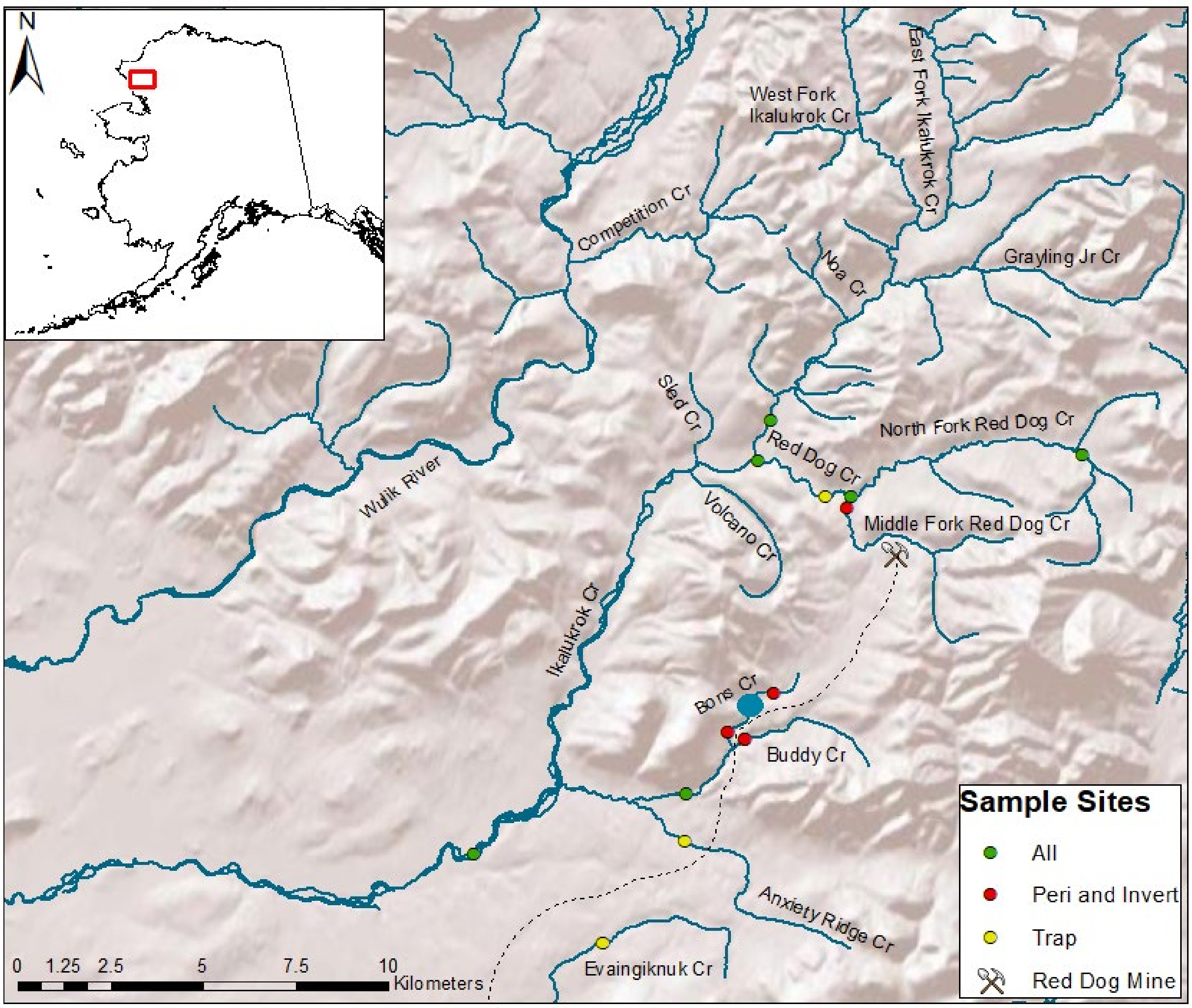



**Figure 2. Location of sample sites in the Ikalukrok Creek drainage (tributary of the Wulik River) and Evaingiknuk Creek (a tributary of the Noatak River) drainage.**

## Methods

Four sampling events occurred in the Red Dog vicinity in 2019 including spring Arctic grayling and adult Dolly Varden sampling (June 6 - 15), mid-summer aquatic invertebrates and periphyton (July 1 - 8), late-summer juvenile Dolly Varden sampling (August 3 - 10), and fall aerial surveys of Dolly Varden in Wulik River and chum salmon in Ikalukrok Creek (September 20 - 21 and October 13 - 14).

All methods used for the 2019 Red Dog Mine aquatic biomonitoring study are fully described by ADF&G (2017) in Technical Report No. 17-09 Methods for Aquatic Life Monitoring at the Red Dog Mine Site, a requirement of the 2017 APDES Permit AK0038652.

All 2019 water quality sampling was performed by Red Dog Mine personnel following their standard methodology. Water quality analysis was performed by laboratories and results provided to ADF&G for inclusion in this report. All water quality presented in this report are for "total recoverable" unless otherwise specified. The number of water quality samples taken each year varies, but samples are collected twice each month with a sample size of 9 to 13 per year per site. Baseline water quality pre-mining data presented in the report were collected from 1979 to 1982.

In 2019, the abundance of Arctic grayling in Bon's Pond and North Fork Red Dog Creek was estimated using Chapman's modification of the Lincoln-Petersen two-sample mark-recapture model (Chapman 1951),

$$\widehat{N}_c = \left\{\frac{(n_1 + 1)(n_2 + 1)}{(m_2 + 1)}\right\} - 1$$

where $\widehat{N}_c$ = estimated population, $n_1$ = fish marked in first capture event, $n_2$ = fish captured during recapture event, and $m_2$ = fish captured during recapture event that were marked in the capture event. Variance was calculated as (Seber 1982):

$$\mathrm{var}(\widehat{N}_c) = \left\{\frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2(m_2 + 2)}\right\}$$

The 95% C.I. for the population estimate was calculated as:

$$95\%\ \mathrm{C.I.} = N_c \pm (1.960)\sqrt{\widehat{\mathrm{var}}(\widehat{N}_c)}$$

## Results and Discussion

### Water Quality

Water quality data collected in Mainstem Red Dog Creek prior to 2010 were from Station 10, located near the mouth of the creek. Data from 2010 to 2019 were collected at Station 151 located about 2 km upstream from Station 10. Station 151 is at the downstream end of the mixing zone in Mainstem Red Dog Creek (Figure 3). There are no defined drainages entering Mainstem Red Dog Creek between these two water quality stations. Mainstem Red Dog Creek is directly affected by the treated mine wastewater effluent and by water from the clean water bypass. North Fork Red Dog Creek is a reference site with no direct effects from the mine.

**Figure 3. Downstream end of mixing zone in Mainstem Red Dog Creek in early August 2015 (Station 151).**

In 2019, Teck continued to maintain the mine's clean water bypass system which picks up non-mining impacted water (non-contact water) from Sulfur, Shelly, Connie, Rachel, and Upper Middle Fork Red Dog creeks (Figure 4). This water is moved through the mine pit area, including the currently active Aqqaluk pit, to its original channel via a combination of culverts and lined open ditches. These bypass conveyance structures serve to isolate the non-contact water from areas disturbed by mining activities.

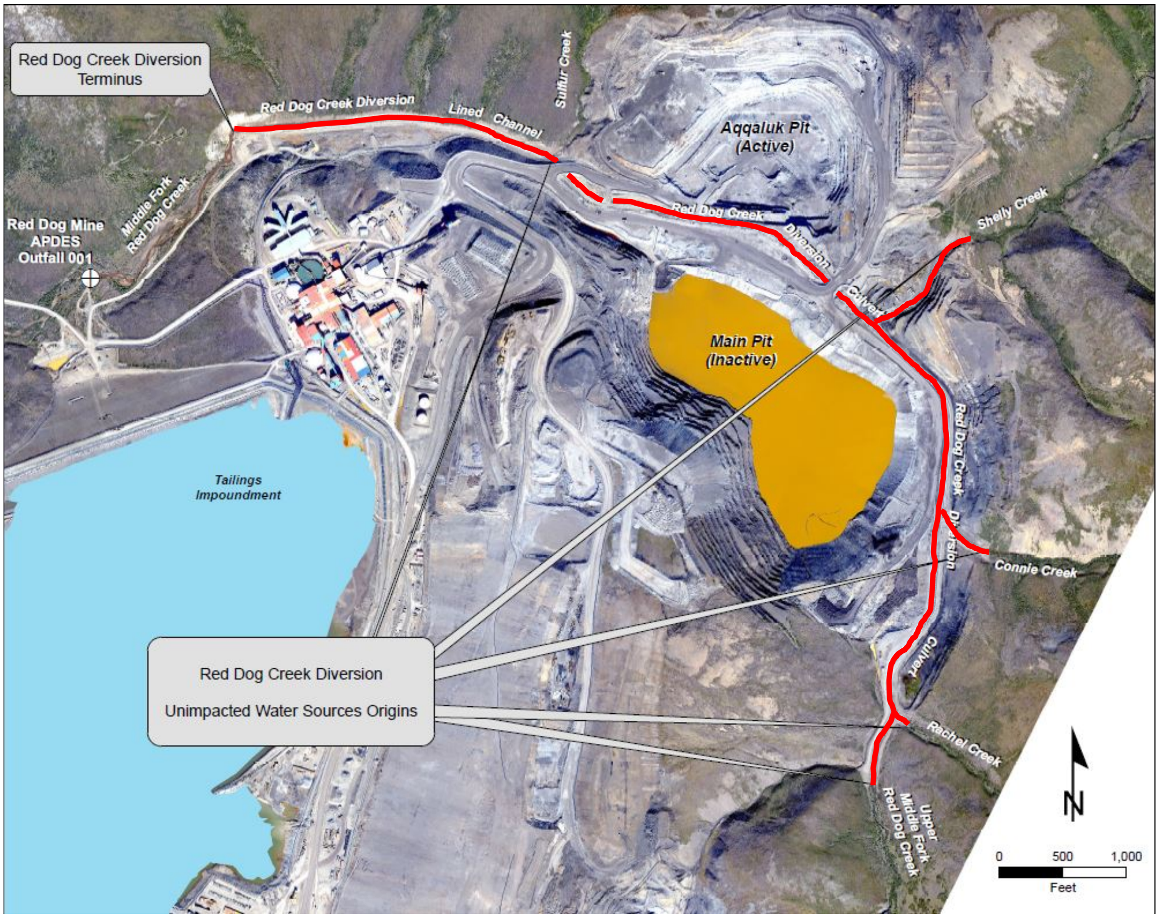



**Figure 4. Clean water bypass system at the Red Dog Mine. The Red Dog Creek diversion structure (delineated by labels in the photograph and shown in red) picks up non-mining impacted waters from upstream tributaries and moves them between the Aqqaluk pit and the main pit back to the original Middle Fork Red Dog Creek streambed (flow is from right to left).**[2]

In 2019, the median lead concentration in Mainstem Red Dog Creek (Station 151/10), downstream of the clean water bypass system, was lower than pre-mining (1979-83). However, in some years the maximum lead concentration has been higher than pre-mining (Figure 5). Median lead concentrations increased from 2011 to 2013 to a high of 13.6 µg/L, decreased from 2014 to 2017 to a low of 2.9, then rose again in 2018 and 2019 to 7.4 µg/L.

[2] Figure provided by Teck with modifications made by ADF&G.

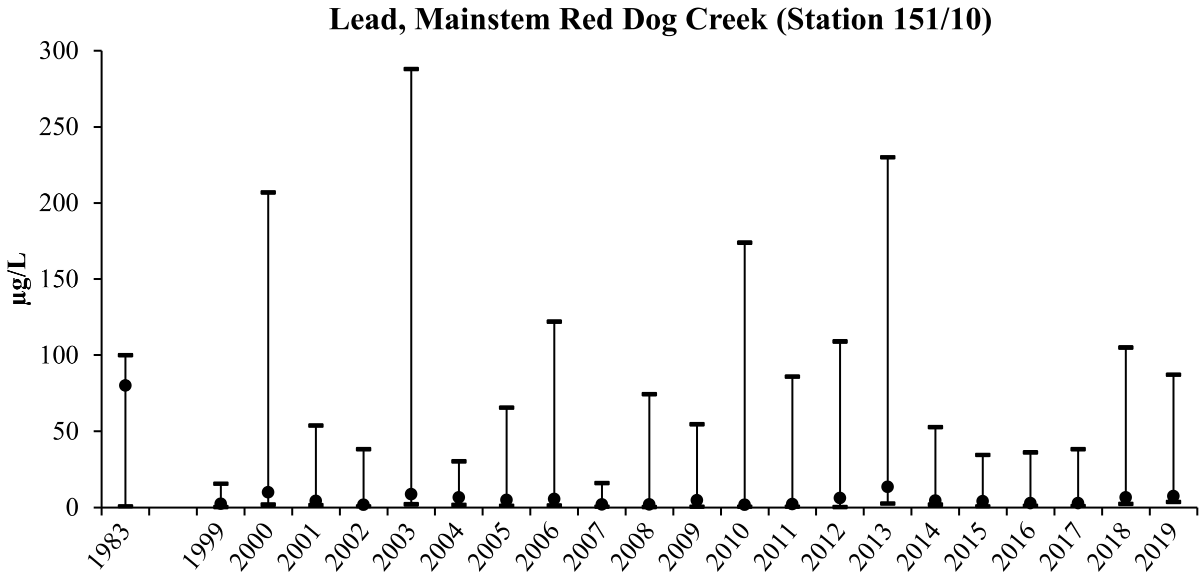



**Figure 5. Median, maximum, and minimum lead concentrations at Station 151/10.**

In 2019, the system with the highest concentration of lead was Sulfur Creek (a tributary to the clean water bypass), with a median lead concentration of 110.2 µg/L (Figure 6), although this was a sharp decrease from the 2018 median lead concentration of 613.5 µg/L. Sulfur Creek has had the highest median lead concentration since 2013. Sulfur Creek may eventually be incorporated into the Aqqaluk Pit.

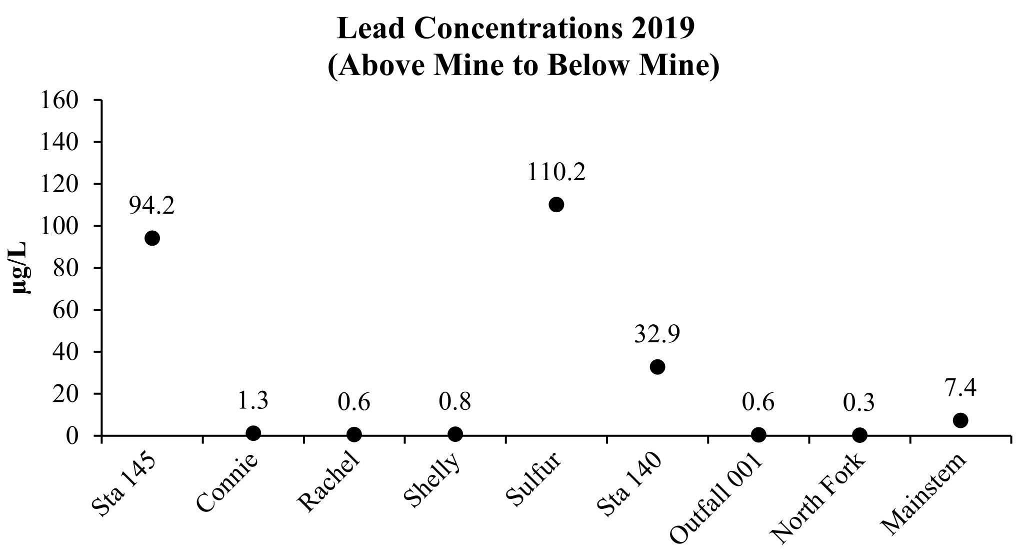



**Figure 6. Median lead concentrations in 2019 from upstream (Station 145) of the clean water bypass, including tributaries to the clean water bypass (Connie, Rachel, Shelly, and Sulfur), and Station 140 (above the Outfall 001), Outfall 001, and North Fork Red Dog and Mainstem Red Dog creeks.**

Median zinc concentration in Mainstem Red Dog Creek (Station 151/10) continued the increasing trend noted in 2018, rising to 3,100 µg/L in 2019, higher than any median zinc concentration seen since 1999 (Figure 7). Station 140 on Middle Fork Red Dog Creek, upstream of the treated mine discharge Outfall 001 and downstream of the non-contact water diversion, also continued the sharp increase in zinc that began in 2018, rising to 16,600 µg/L in 2019. This is the highest median concentration since monitoring began in 1999 (Figure 8). The elevated zinc can be traced to upper Middle Fork Red Dog Creek, above the clean water bypass. The other component creeks of the clean water bypass (Connie, Rachel, Shelly, and Sulfur) have low zinc concentrations (Figure 9). Golder Associates, Inc. was contracted by Teck to investigate the source of the elevated zinc in upper Middle Fork Red Dog Creek. Kaviqsaaq Seep, which drains into Middle Fork Red Dog Creek upstream of the clean water bypass system, was identified as the source of the elevated zinc. The Kaviqsaaq Seep is downslope of the Qanaiyaq deposit. Qanaiyaq waste rock in general is highly reactive and displays the potential to generate acid within a short time frame and impact drainage chemistry (SRK 2015, Golder 2020). In the absence of any obvious, natural change in the Kaviqsaaq drainage, the most likely source of the increased zinc in the Kaviqsaaq Seep is the Qanaiyaq 1500 bench and other localized changes in the surrounding area (Golder 2020). Teck regraded the surface of the Qanaiyaq 1500 bench in September 2019 to direct surface-water drainage toward the Qanaiyaq pit and away from Red Dog Creek drainages, In March or April 2020, Teck plans to place cover material on the eastern side of the Qanaiyaq 1500 bench to reduce permafrost melt (if occurring). The cover material placement was planned for spring to allow the cold temperatures during winter to re-freeze the ground as much as possible, before placing insulating cover. Teck will continue to monitor the Kaviqsaaq Seep, Station 140, and Station 145 throughout 2020. If water quality does not improve, capture and diversion of the Kaviqsaaq Seep may be necessary.

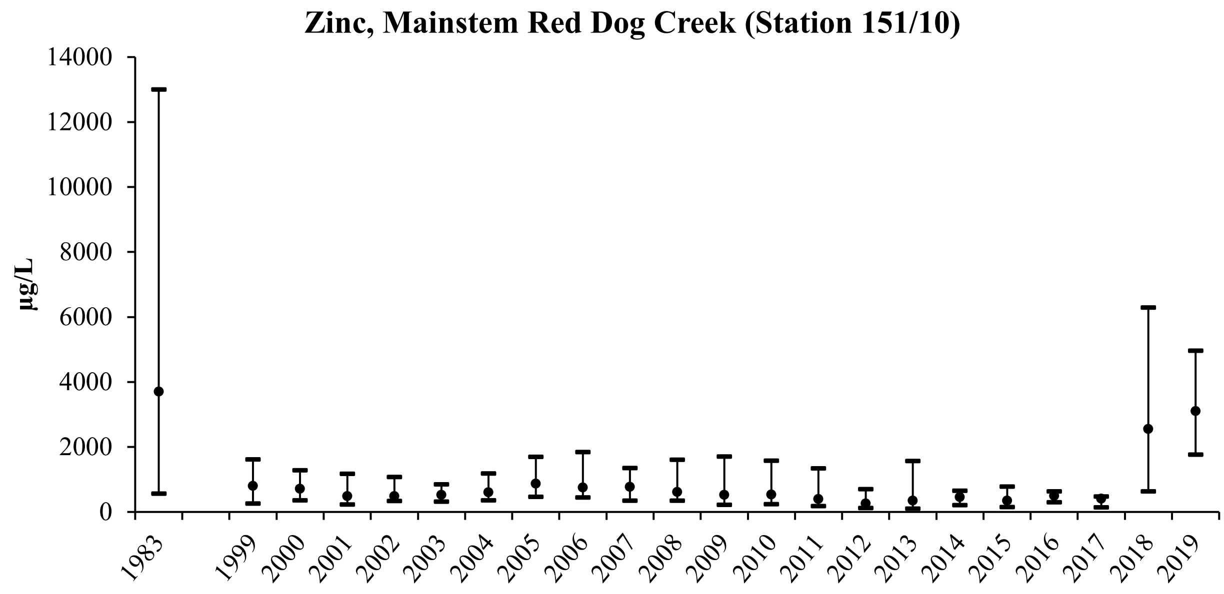



**Figure 7. Median, maximum, and minimum zinc concentrations at Station 151/10.**

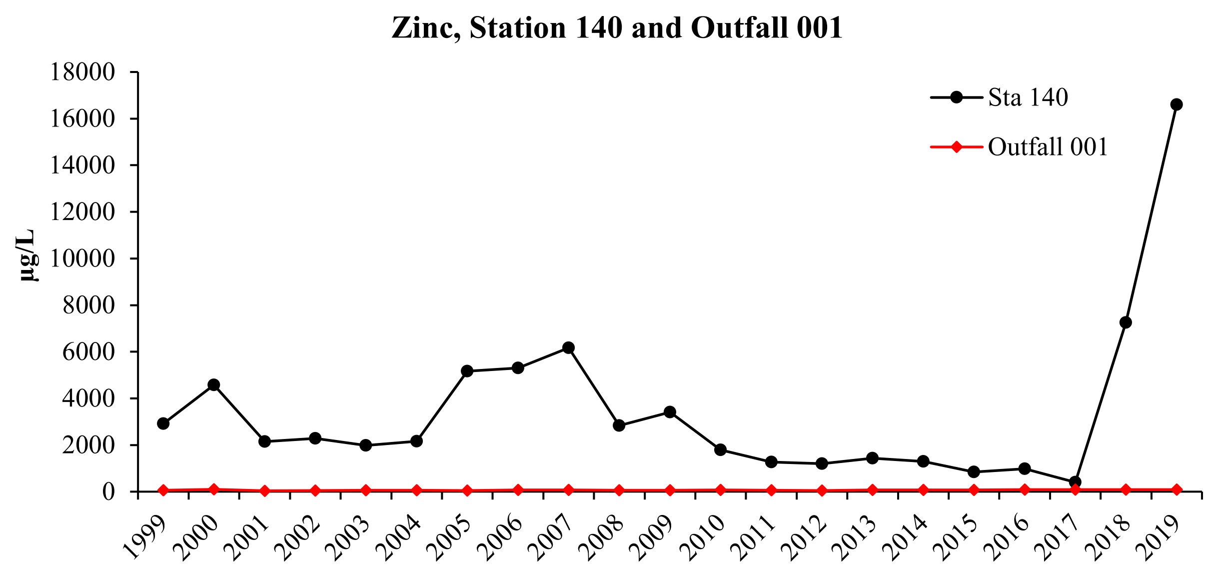



**Figure 8. Median zinc levels in water samples from Station 140 and Outfall 001, 1999 - 2019.**

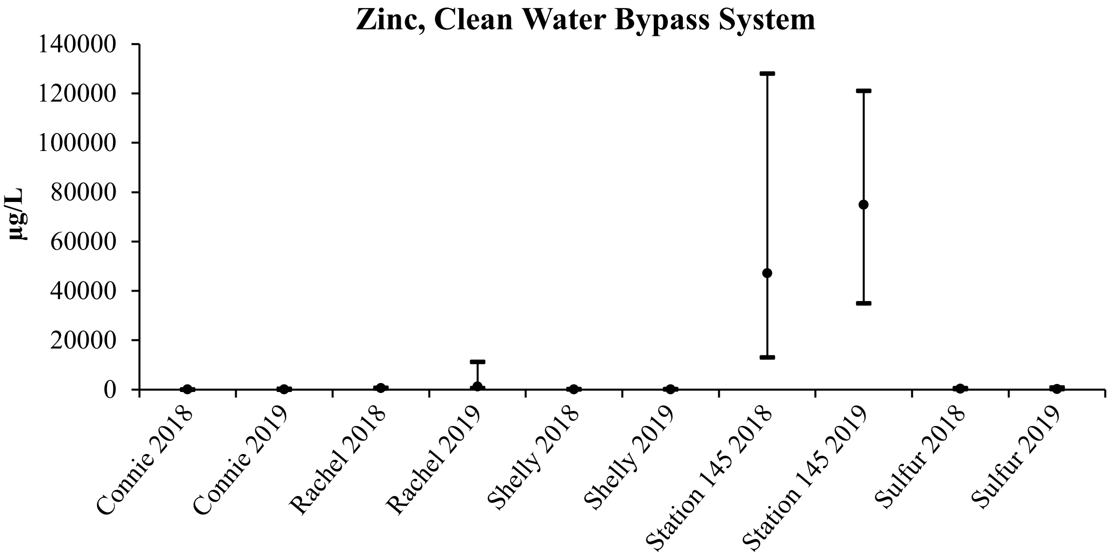



**Figure 9. Minimum, median, and maximum zinc levels in water samples from Sulfur, Shelly, Connie, and Rachel creeks, and Station 145, 2018 and 2019. Station 145 is on Middle Fork Red Dog Creek, before the clean water diversion system begins.**

Median aluminum concentrations in Mainstem Red Dog Creek (Station 151/10) continue to be lower than pre-mining, although median concentration has increased since 2017 to 291 µg/L in 2019, the highest median value since mining began (Figure 10). Cadmium concentrations were also lower than pre-mining conditions, but increased in 2018 and 2019 to the highest median value since mining began (Figure 11). The median cadmium concentration in 1983 was 28 µg/L and in 2019 it was 18.9 µg/L.

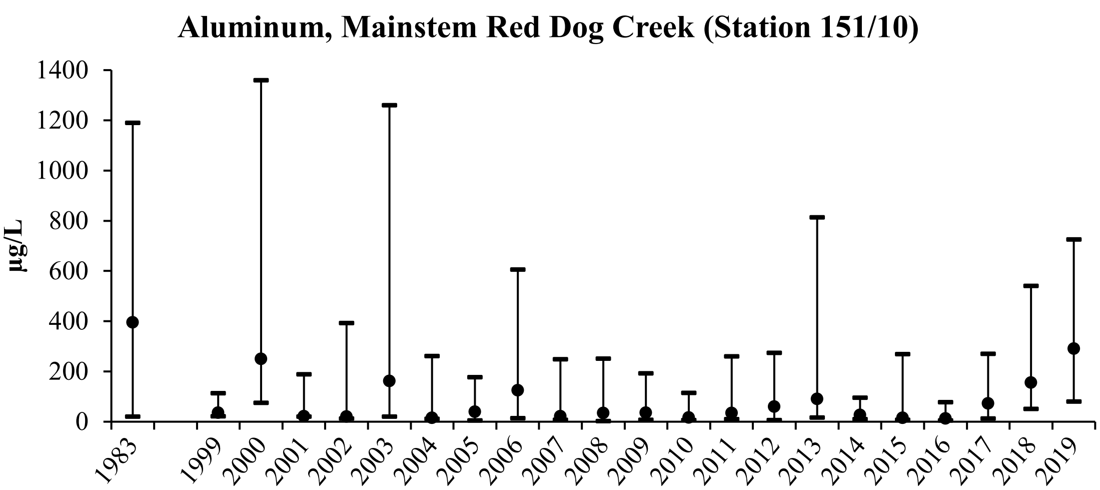



**Figure 10. Median, maximum, and minimum aluminum concentrations at Station 151/10.**

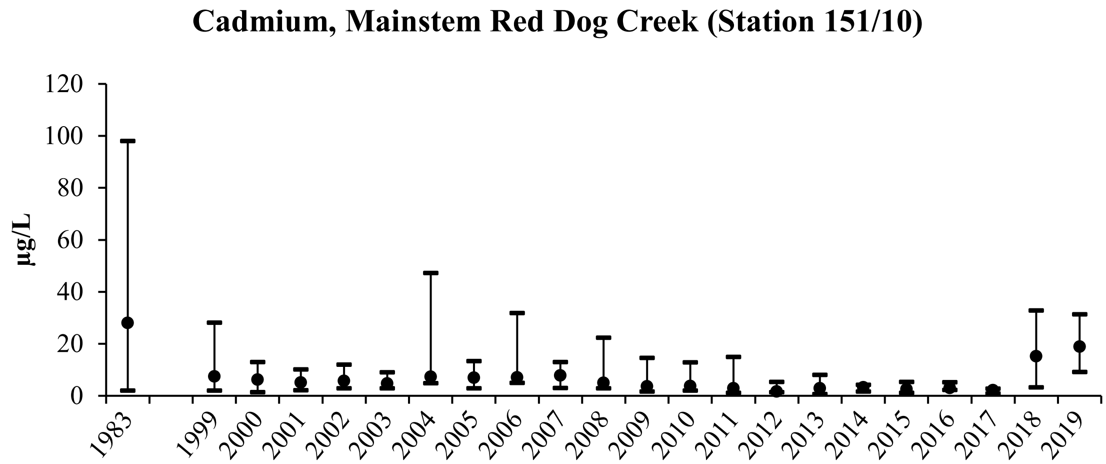



**Figure 11. Median, maximum, and minimum cadmium concentrations at Station 151/10.**

Pre-mining data for selenium are not available. Median selenium concentrations in Mainstem Red Dog Creek (Station 151/10) remained similar from 2001 to 2007, but then increased reaching a high of 2.75 µg/L in 2011 (Figure 12). In 2012, discharge of treated water to Middle Fork Red Dog Creek was stopped on June 8 due to elevated selenium, and was not resumed for the remainder of the 2012 open water period. After selenium decreased in treated water and a mixing zone was authorized in Mainstem Red Dog Creek, discharge resumed in 2013. Selenium remained low from 2014 to 2017, then increased in 2018 and 2019 to median selenium concentrations of 2.85 µg/L and 2.7 µg/, respectively.

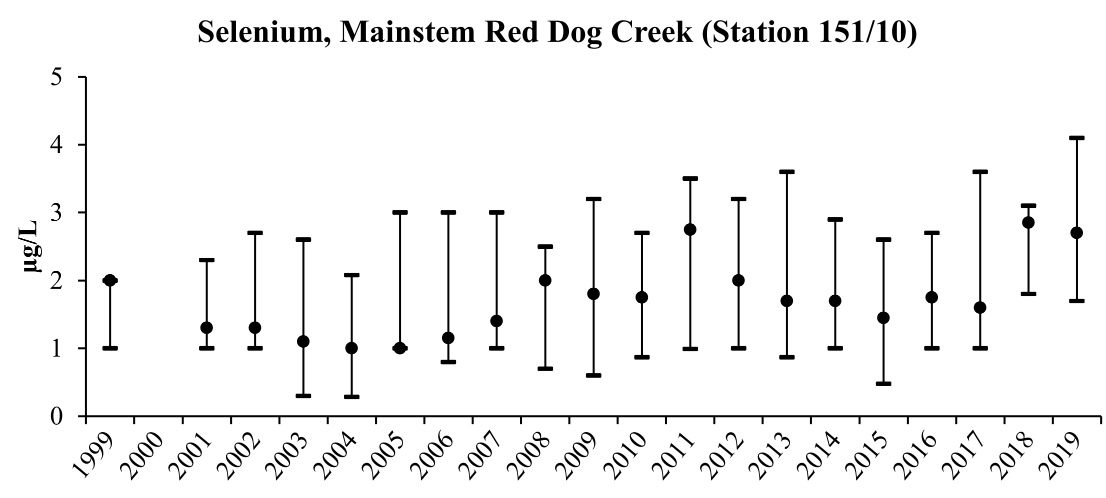



**Figure 12. Median, maximum, and minimum selenium concentrations at Station 151/10.**

Pre-mining data for nickel are not available. Median nickel concentration in Mainstem Red Dog Creek (Station 151/10) increased in 2019 to 21.5 µg/L, the highest median concentration since 1999 (Figure 13). The primary source of nickel to the clean water bypass system has been Rachel Creek (Ott and Morris 2010).

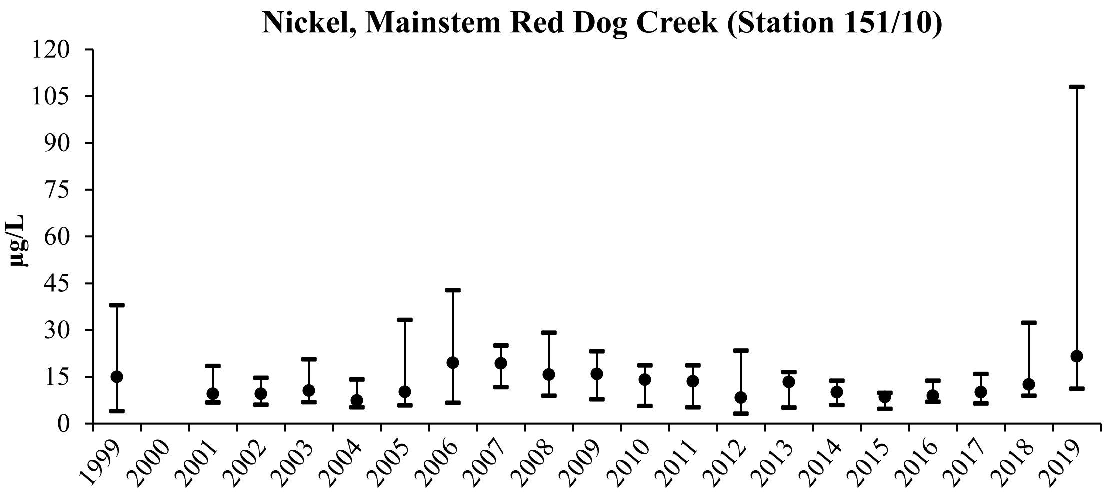



**Figure 13. Median, maximum, and minimum nickel concentrations at Station 151/10.**

In 2019, the pH in Mainstem Red Dog Creek (Station 151/10) was higher (more basic) than pre-mining, which has been the case since 1999 (Figure 14). The clean water bypass system was built and operational prior to spring breakup in 1991, and since then the minimum pH value has only dropped below six once, in 2011. The 1990 data set is during mining, but prior to construction of the clean water bypass system.

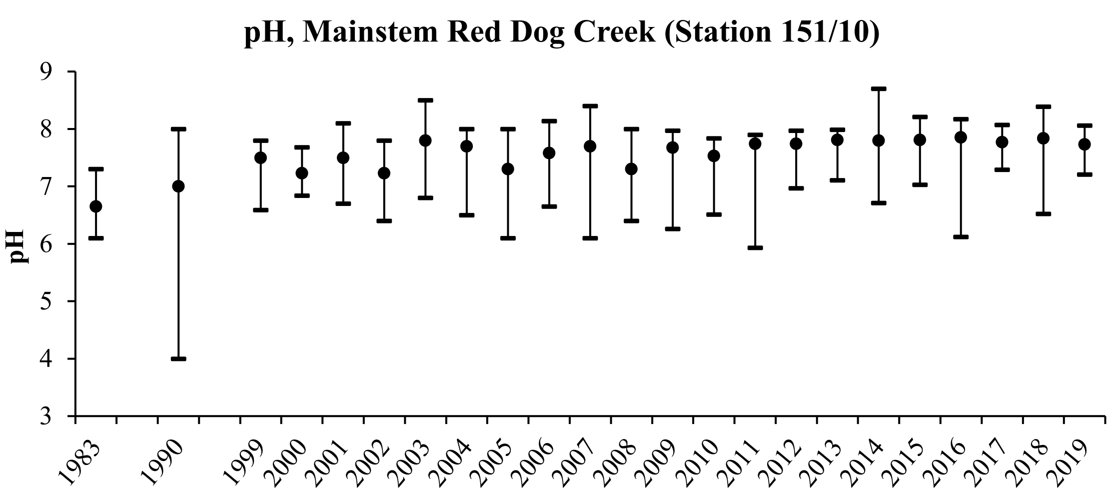



**Figure 14. Median, maximum, and minimum pH values at Station 151/10.**

Total dissolved solids (TDS) in Mainstem Red Dog Creek (Station 151/10) are higher than pre-mining (Figure 15). TDS are directly related to high concentrations of calcium hydroxide and sulfates in the treated wastewater discharge at Outfall 001. Calcium hydroxide is added to precipitate and collect metals from the tailings water as metal hydroxides prior to discharge. Sulfates released in this process along with the calcium result in the elevated TDS concentrations.

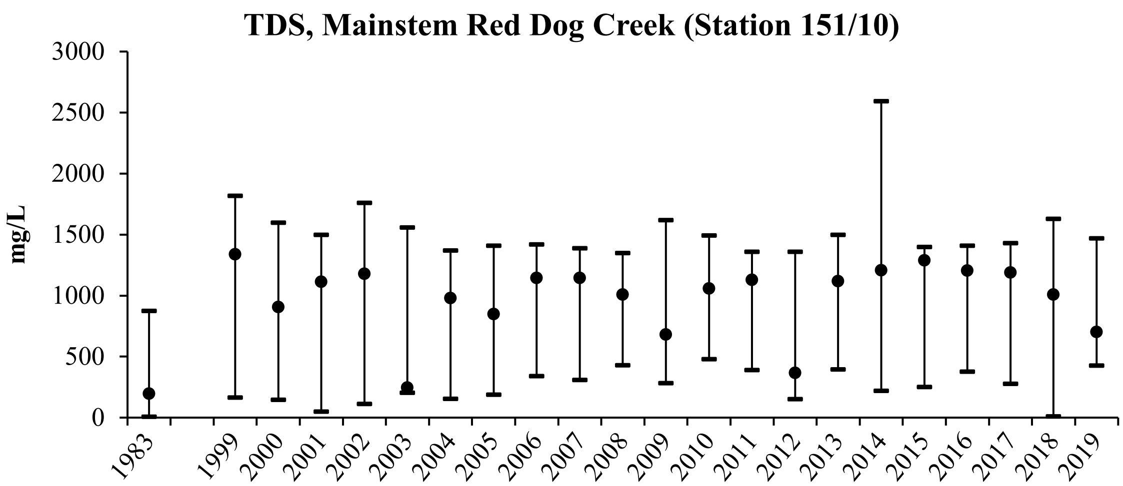



**Figure 15. Median, maximum, and minimum TDS concentrations at Station 151/10.**

Cadmium, lead, zinc, and selenium concentrations in Mainstem Red Dog Creek (Station 151/10) were compared with those found in North Fork Red Dog Creek, Buddy Creek (below the confluence of Bons and Buddy creeks), and Bons Pond (Figures 16 to 18). Sites in North Fork Red Dog and Buddy creeks and Bons Pond were selected because they are reference sites with no direct effects from the mine process or discharge. Mainstem Red Dog Creek (Station 151/10) is directly downstream of the mine clean water bypass and wastewater effluent discharge at Outfall 001. Buddy Creek and Bons Pond are reference sites, but with the potential to be affected by the road, airport, overburden stockpile, and they are down gradient from the tailings backdam. Cadmium, lead, zinc, and selenium were selected for comparison because these elements are analyzed for whole body element concentrations in juvenile Arctic grayling from Bons Pond and juvenile Dolly Varden from Mainstem Red Dog, Anxiety Ridge, and Buddy creeks.

Cadmium, lead, and zinc median concentrations were highest in Mainstem Red Dog Creek. The major source of these elements is from the clean water bypass and not from the mine discharge of treated water at Outfall 001. Cadmium has been low and stable in North Fork Red Dog Creek, Buddy Creek, and Bons Pond from 2001 to 2019. Cadmium in Mainstem Red Dog Creek is higher and much more variable, and rose sharply in 2018 and 2019 to 18.9 µg/L (Figure 16). Lead concentrations demonstrate some variability, but are consistently lower in North Fork Red Dog and Buddy creeks and Bons Pond than in Mainstem Red Dog Creek (Figure 17). After remaining fairly stable from 2001 to 2017, zinc concentrations in Mainstem Red Dog Creek sharply increased in 2018 and 2019, as discussed earlier. Zinc in North Fork Red Dog Creek, Buddy Creek, and Bons Pond remained stable (Figure 18). Selenium concentrations among these sites are similar, and variable between years (Figure 19). Most of the selenium concentrations range from 1 µg/L (the detection limit) to 3.0 µg/L. The median selenium concentrations in Mainstem Red Dog, North Fork Red Dog, and Buddy creeks and Bons Pond in summer 2019 were 2.7, 2.4, 3.1, and 2.5 µg/L, respectively.

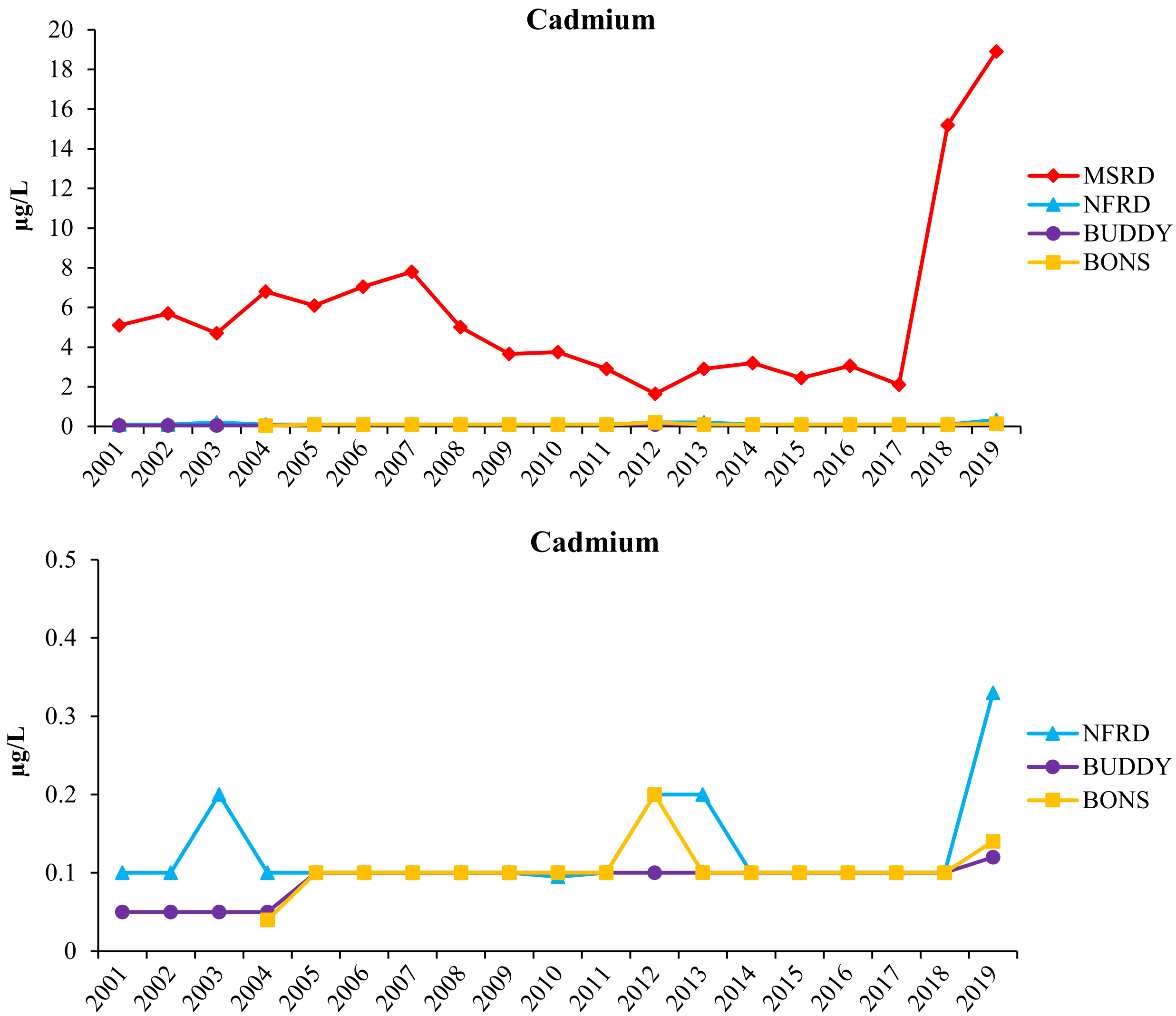
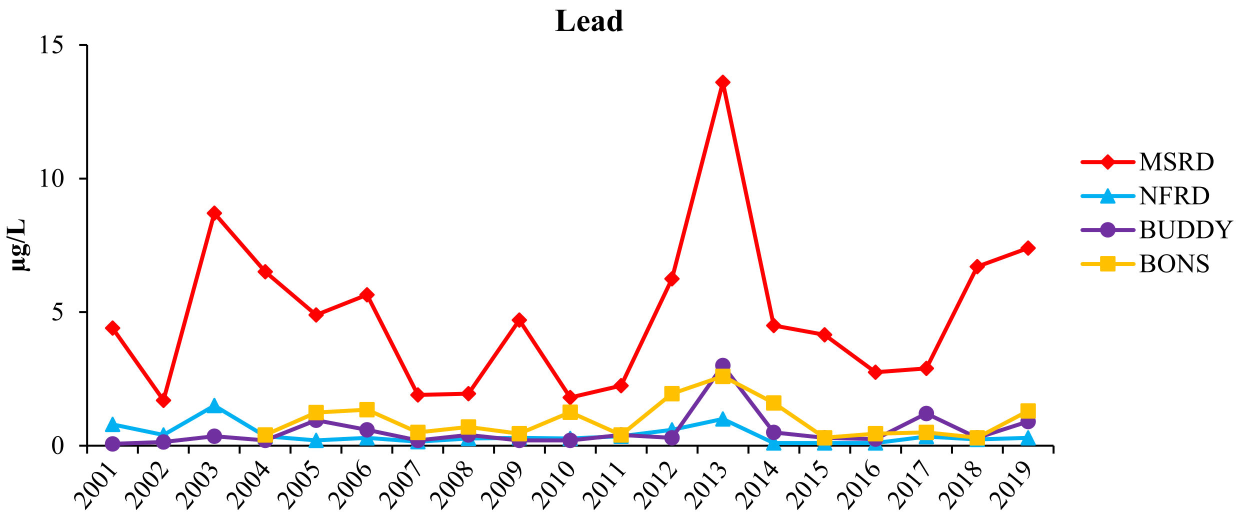



**Figure 16. Median cadmium concentrations in Mainstem Red Dog (MSRD), North Fork Red Dog (NFRD), and Buddy creeks and Bons Pond (2001 to 2019). Two graphs are presented, the bottom graph uses a different scale as it does not include Mainstem Red Dog Creek.**



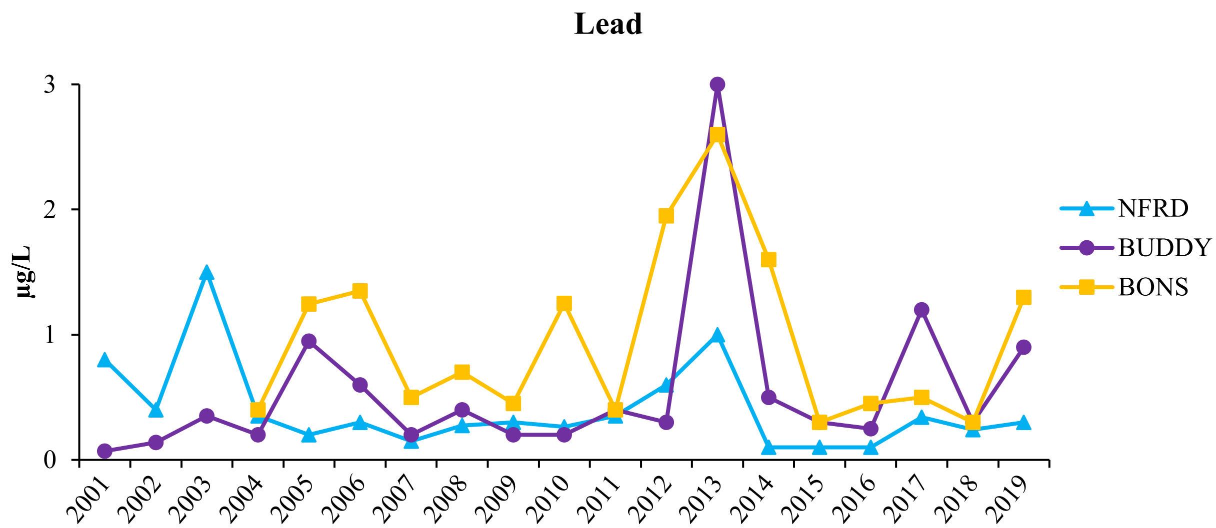




**Figure 17. Median lead concentrations in Mainstem Red Dog (MSRD), North Fork Red Dog (NFRD), and Buddy creeks and Bons Pond (2001 to 2019). Two graphs are presented, the bottom graph uses a different scale as it does not include Mainstem Red Dog Creek.**

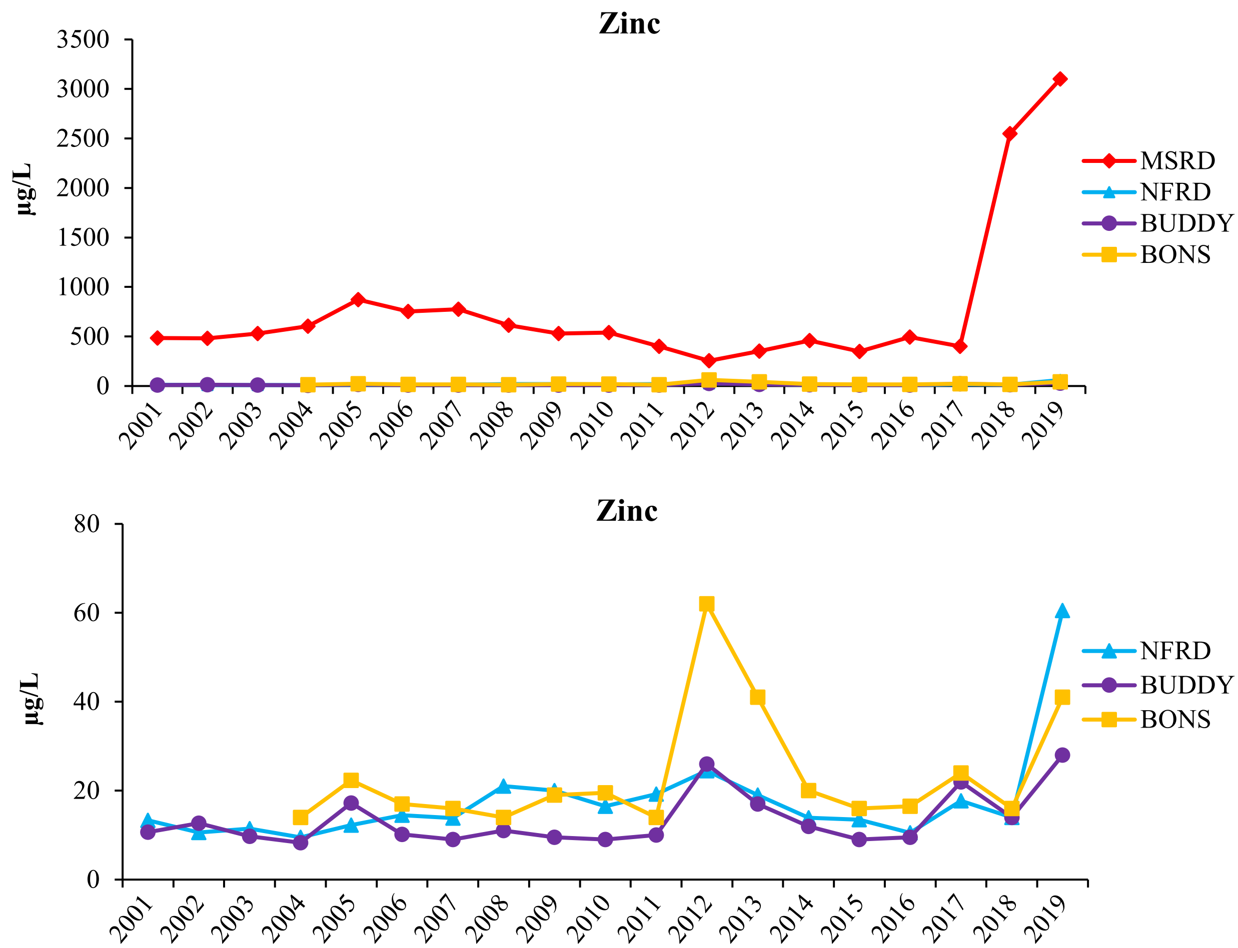



**Figure 18. Median zinc concentrations in Mainstem Red Dog (MSRD), North Fork Red Dog (NFRD), and Buddy creeks and Bons Pond (2001 to 2019). Two graphs are presented, the bottom graph uses a different scale as it does not include Mainstem Red Dog Creek.**

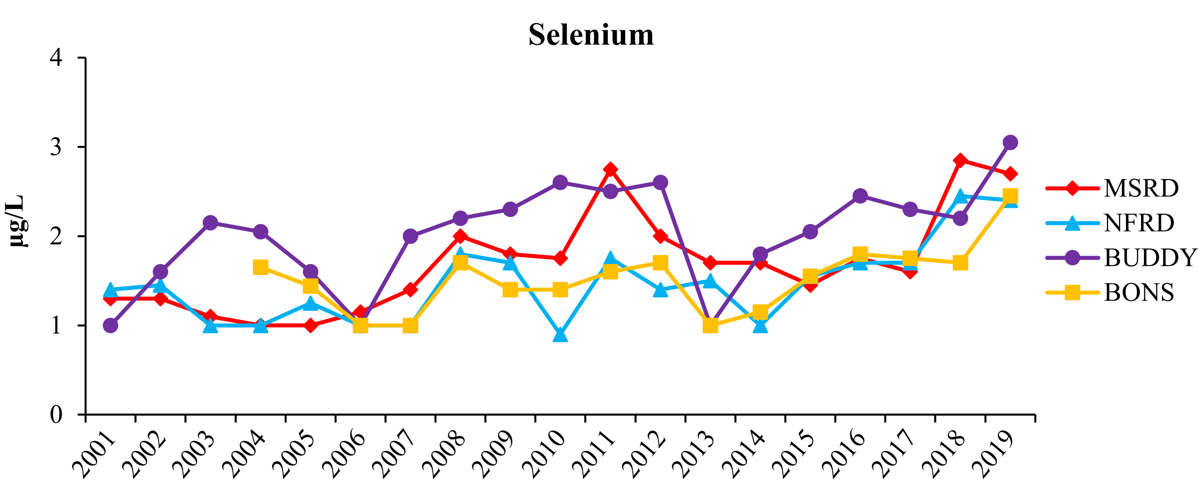



**Figure 19. Median selenium concentrations in Mainstem Red Dog (MSRD), North Fork Red Dog (NFRD), and Buddy creeks and Bons Pond (2001 to 2019).**

## Periphyton Standing Crop

Periphyton (attached microalgae) biomass samples have been collected annually since 1999. Under the program initiated in 2010, sampling occurred at a minimum of nine sites (Table 2). In 2019, samples were collected at all nine standard sites, with the addition of Upper North Fork Red Dog Creek (Appendix 2). Periphyton samples were processed in the laboratory and standing crop determined as $mg/m^2$ chlorophyll-a.

Average chlorophyll-a concentration in 2019 was highest at Station 220 on Bons Creek below Bons Pond (11.36 $mg/m^2$) and lowest at Station 20 on Middle Fork Red Dog Creek (0.05 $mg/m^2$) (Figure 20). Periphyton standing crop was also very low on Ikalukrok Creek at Station 9 (0.06 $mg/m^2$) and Station 160 (0.14 $mg/m^2$). Generally, chlorophyll-a concentration is lowest in Middle Fork Red Dog Creek and highest in Bons Creek (below Bons Pond) and Buddy Creek (below falls).

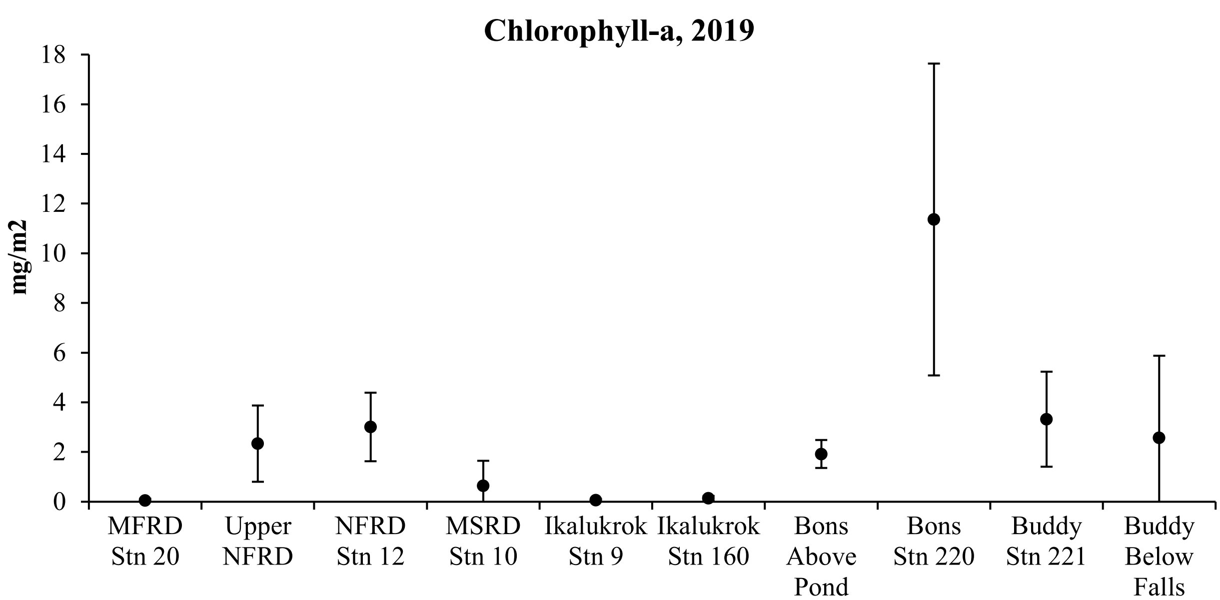



**Figure 20. Average concentration of chlorophyll-a (± 1SD) at Red Dog Mine sample sites, 2019. Sites in the Red Dog Creek drainage include Middle Fork Red Dog (MFRD), Upper North Fork Red Dog (Upper NFRD), North Fork Red Dog (NFRD), and Mainstem Red Dog (MSRD).**

Generally, average chlorophyll-a concentrations are higher in Mainstem Red Dog and North Fork Red Dog creeks as compared with Middle Fork Red Dog Creek (Figure 21). In 13 of 20 years, average chlorophyll-a concentration in North Fork Red Dog Creek was equal to or higher than Mainstem Red Dog Creek. Lower chlorophyll-a concentration in Middle Fork Red Dog Creek is probably related to higher metals concentrations and higher TDS in the creek. Most of the metals in Middle Fork Red Dog Creek originate from the clean water bypass and its tributaries, as metals concentrations in the treated effluent discharge from Outfall 001 are low. Most of the TDS in Middle Fork Red Dog Creek are from the treated effluent discharge at Outfall 001.

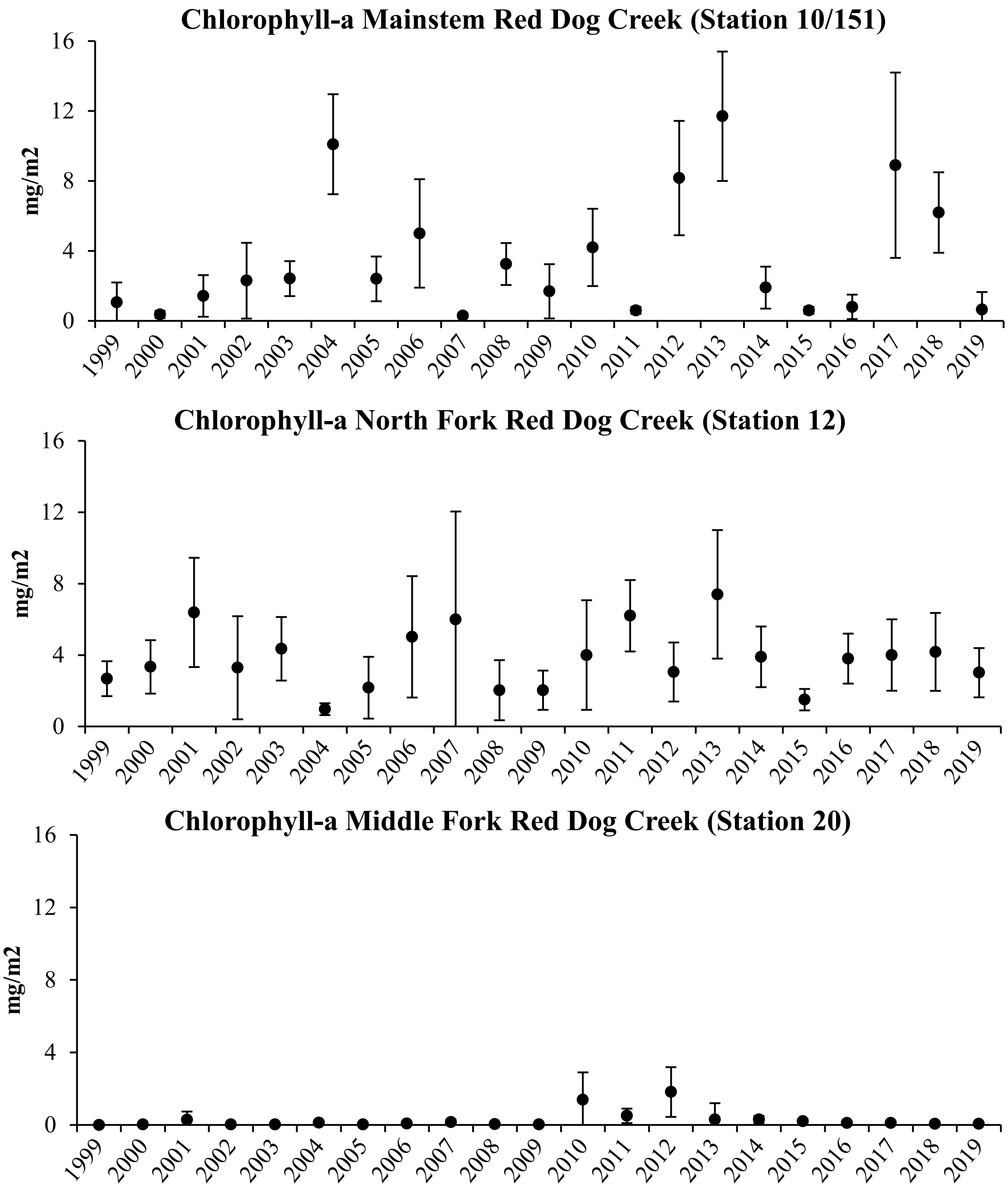



**Figure 21. Average concentration (± 1SD) of chlorophyll-a in Mainstem Red Dog Creek (Station 10/151), North Fork Red Dog Creek (Station 12), and Middle Fork Red Dog Creek (Station 20), 1999-2019.**

Periphyton standing crop tracks closely with zinc and cadmium in Ikalukrok Creek at Station 9, which is just upstream of the mouth of Mainstem Red Dog Creek. Water quality at this site 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). The concentration of chlorophyll-a is higher when the zinc and cadmium concentrations are lower (Figures 22 and 23). Both zinc and cadmium increased in 2018 and 2019, and chlorophyll-a concentration dropped. The variability in chlorophyll-a concentration from 2002 to 2017 may be natural as both cadmium and zinc concentrations remained low and consistent during this time frame. We believe the major source of zinc and cadmium to Ikalukrok Creek is the Cub Creek seep, but there are other seeps along Ikalukrok Creek (Figure 24).

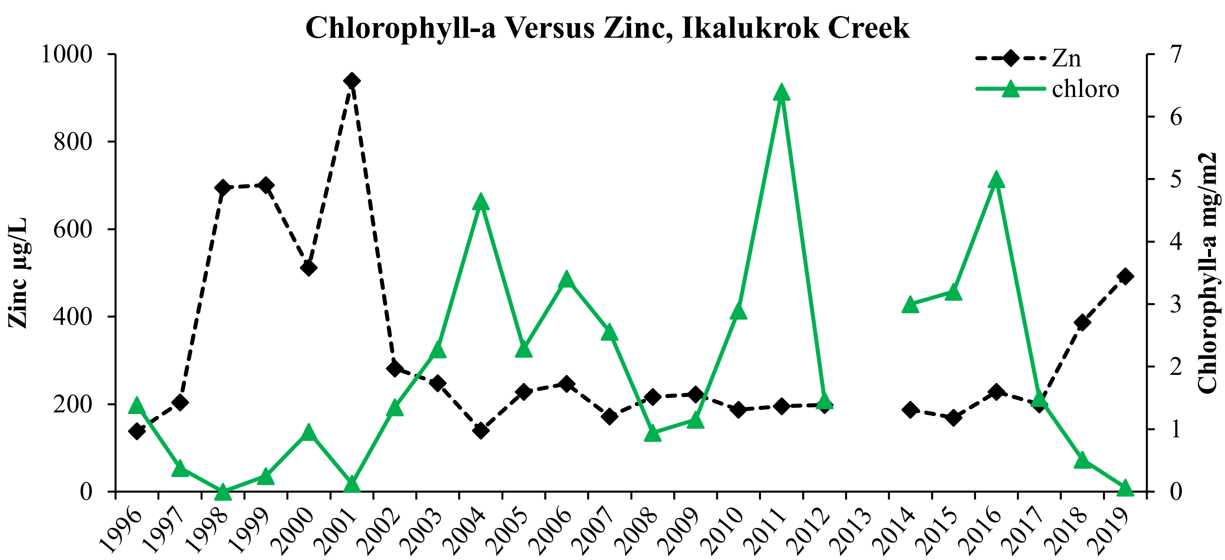



**Figure 22. Average concentrations of chlorophyll-a and zinc in Ikalukrok Creek (Station 9), 1996–2019.**

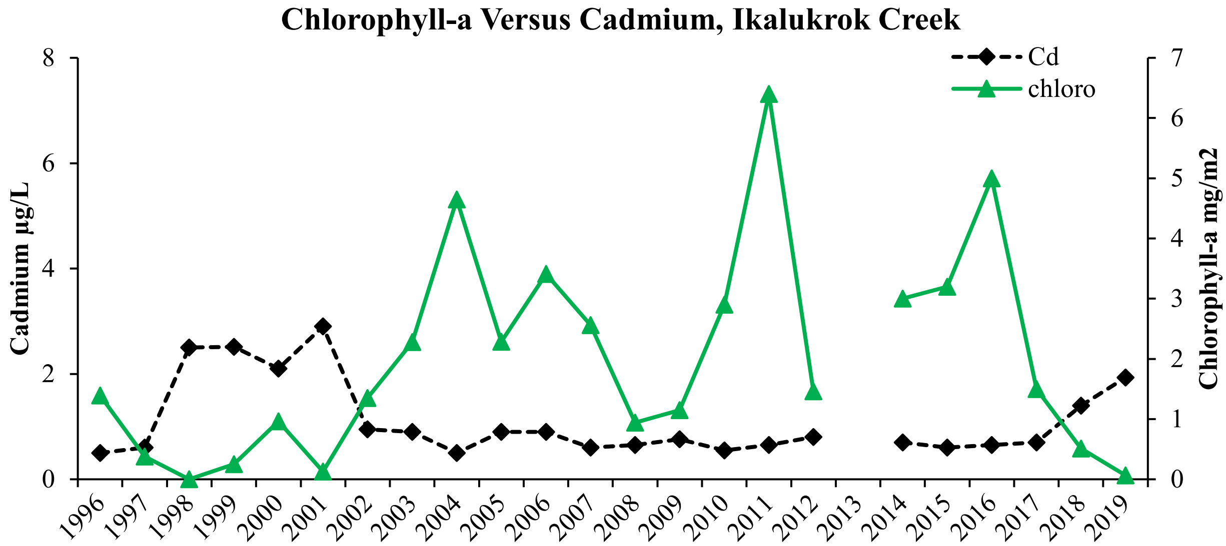



**Figure 23. Average concentrations of chlorophyll-a and cadmium in Ikalukrok Creek (Station 9), 1996-2019.**

**Figure 24. Ikalukrok Creek at the Cub Creek seep about 10 km upstream of Station 9. Station 9 is just upstream of the mouth of Mainstem Red Dog Creek – note mineral staining in and along the edge of Cub Creek, July 2017.**

**Aquatic Invertebrates**

Aquatic invertebrate samples are collected annually using drift nets (Appendix 3). The purpose of this effort is: (1) to determine if differences exist in the macroinvertebrate populations among the sample sites; and (2) to track changes over time.

In 2019, flows were high at many of the sample sites. At four sites (Upper North Fork Red Dog Creek, Buddy Creek below the falls, Ikalukrok Creek Station 9, and North Fork Red Dog Creek Station 12), a combination of higher than usual levels of debris in the drift nets and inadequate ethanol volume in the sample bottles resulted in degradation of some of the samples before they could be analyzed. Upper North Fork Red Dog Creek, Buddy Creek below the falls, and Ikalukrok Creek Station 9 each had two degraded samples and North Fork Red Dog Creek Station 12 had three degraded samples. The degraded samples were removed from the calculations of invertebrate density, since most invertebrates were unidentifiable.

Aquatic invertebrate densities were highest in Buddy Creek below the falls with 25.46 per $m^3$ (Figure 25).

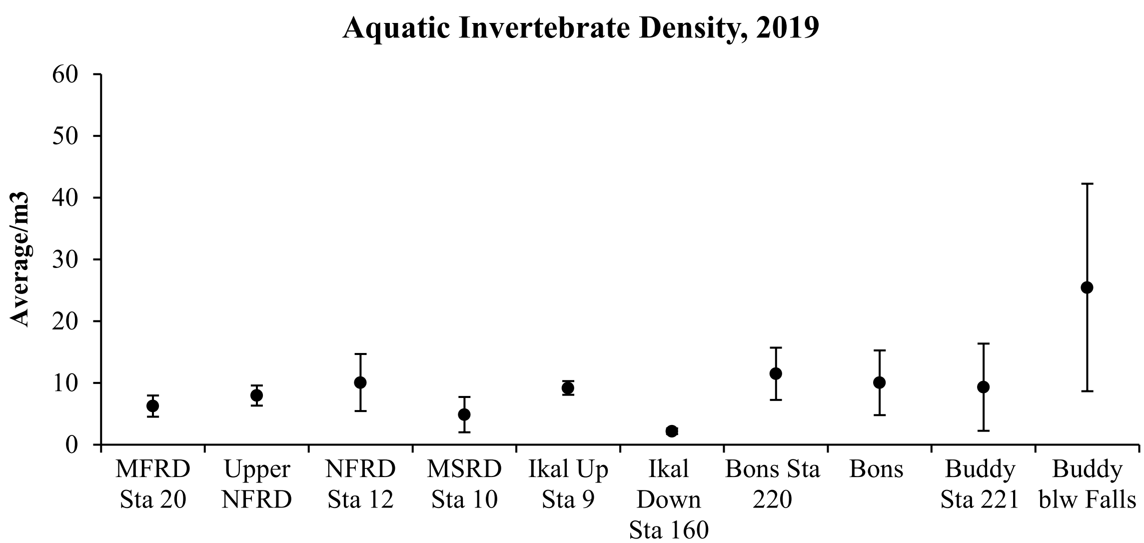



**Figure 25. Average aquatic invertebrate densities (± 1SD) in all sample sites near the Red Dog Mine, July 2019.**

For years prior to 2017, Buddy Creek Station 221 (above the haul road) generally had higher aquatic invertebrate densities than other sample sites. However, since 2017, Buddy Creek below the falls has had higher aquatic invertebrate densities. The average aquatic invertebrate density in

Buddy Creek (above road) has varied from a low of 3.8 to a high of 164.5 invertebrates per $m^3$ (Figure 26). In 2019, average aquatic invertebrate density was 11.33 invertebrates per $m^3$.

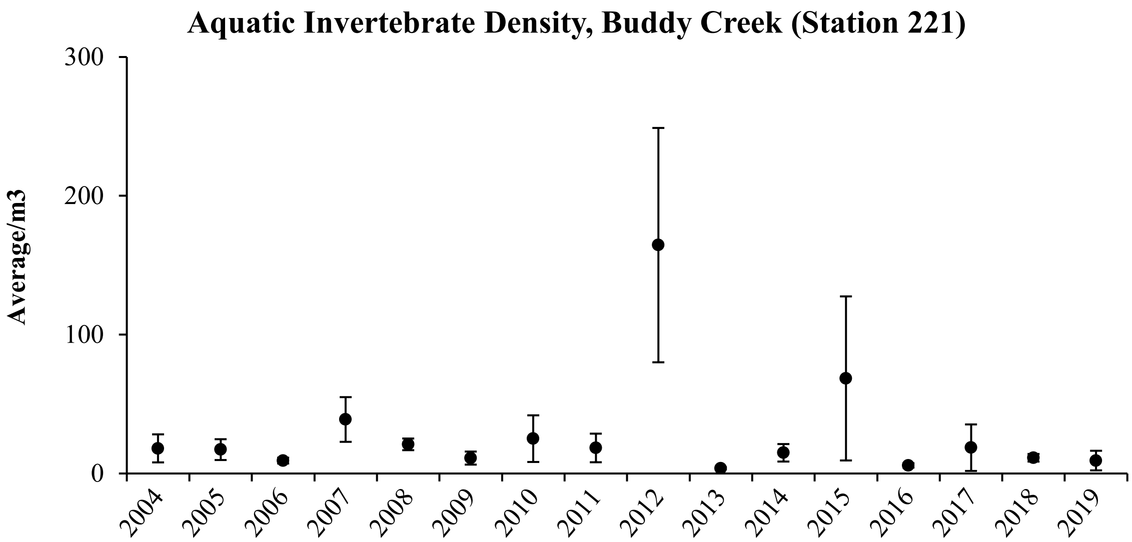



**Figure 26. The average aquatic invertebrate density (± 1SD) in Buddy Creek (Station 221) upstream of the road 2004–2019.**

Aquatic invertebrate densities are typically higher in North Fork Red Dog Creek than in Mainstem Red Dog Creek, and this was the case in 2019 (Figure 27). In 20 out of 21 years, the aquatic invertebrate density was higher in North Fork Red Dog Creek than in Mainstem Red Dog Creek.

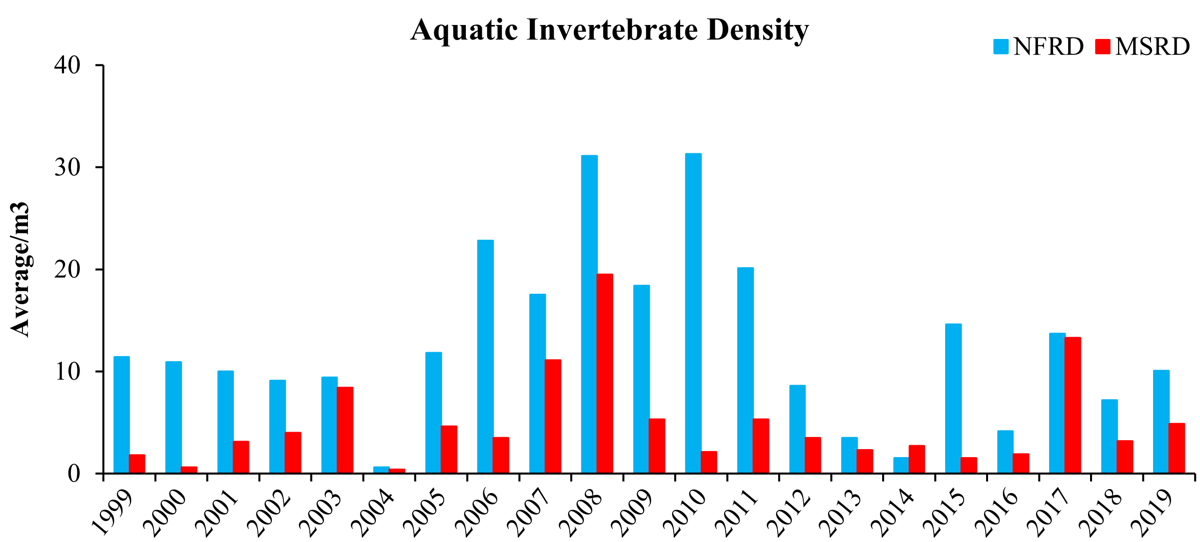



**Figure 27. Average aquatic invertebrate densities in North Fork Red Dog and Mainstem Red Dog creeks 1999 – 2019.**

The percent Ephemeroptera, Plecoptera, and Trichoptera (EPT) and the percent Chironomidae for sample sites in 2019 are presented in Figure 28. All sites contained a higher percentage of Chironomidae in 2019, which is the pattern seen in most sample years. Trichoptera are not common in the samples and are not a substantial contributor to EPT. Generally, the aquatic systems in the Red Dog Mine area are dominated by Chironomidae which is one of the primary food items of the fish species (e.g. Arctic grayling and Dolly Varden) using these creeks.

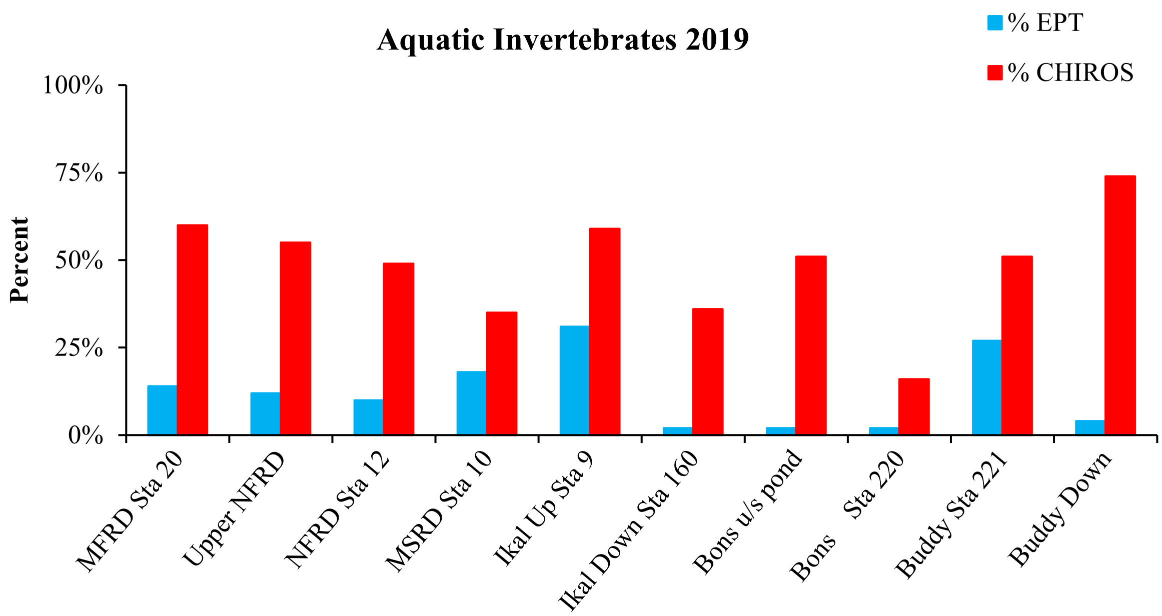



**Figure 28. Percent EPT and Chironomidae in the aquatic invertebrate samples at all sample sites Red Dog Mine, July 2019.**

The percent EPT in North Fork Red Dog and Mainstem Red Dog creeks was low in 2001 and 2008 to 2011, but then increased and has been consistent for the last four years (Figure 29). Buddy Creek has had a much higher percentage of EPT than either North Fork Red Dog or Mainstem Red Dog creeks in certain years (2004, 2011, 2012, 2014, 2015, and 2016) (Figure 29). In most years since 1999, the percent Chironomidae in North Fork Red Dog and Mainstem Red Dog Creeks has been higher than the percent EPT. In Buddy Creek, percent Chironomidae has been higher than the percent EPT 11 out of 16 years.

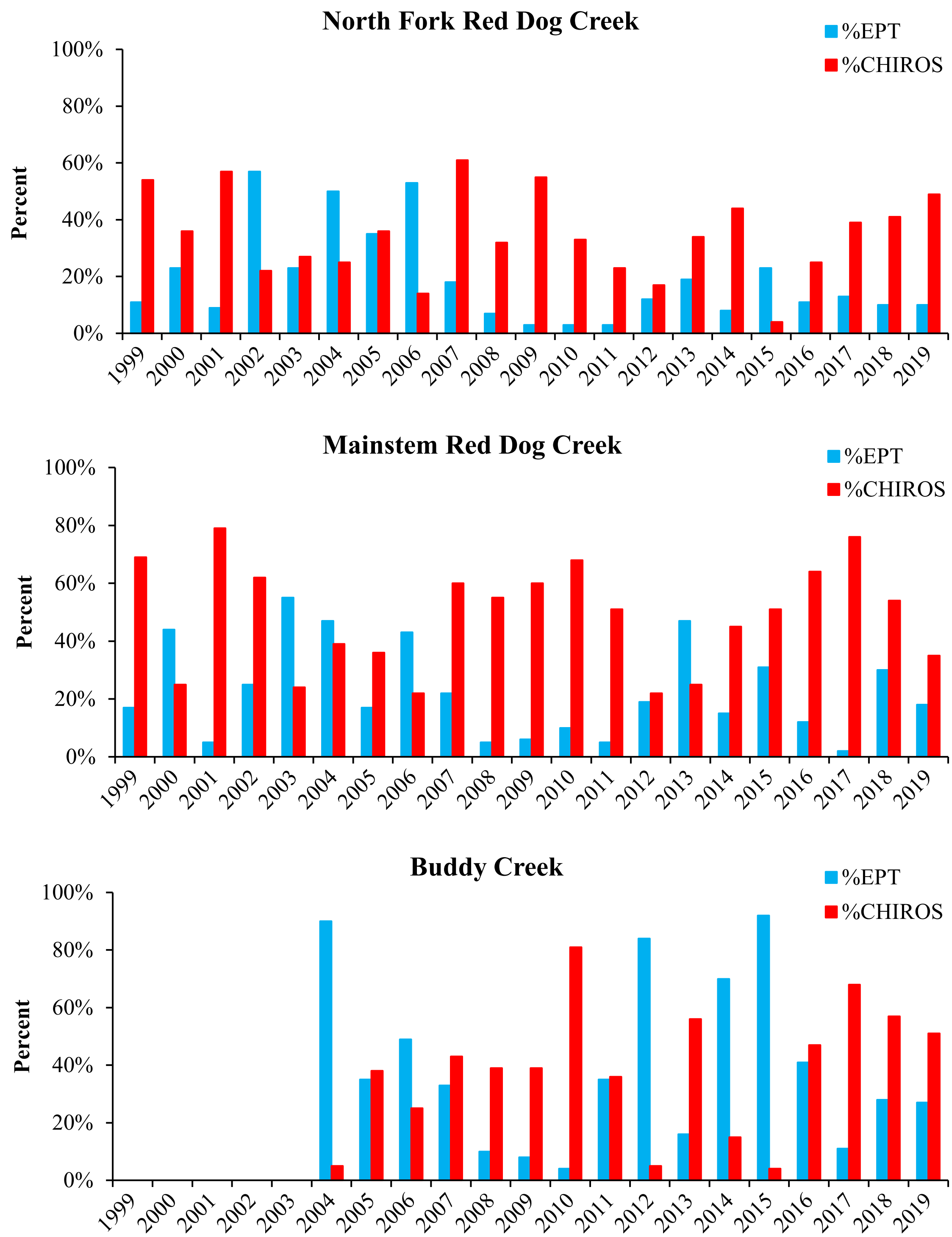



**Figure 29. Percent EPT and Chironomidae in North Fork Red Dog Creek (top), Mainstem Red Dog Creek (middle), and Buddy Creek (bottom) 1999–2019. Aquatic invertebrate sampling in Buddy Creek drainage began in 2004.**

Taxa richness was compared for the three sample sites in North Fork Red Dog, Mainstem Red Dog, and Buddy creeks (Figure 30). Richness is the total number of taxa seen in the sample and includes mayflies, stoneflies, and caddisflies (to genus when possible), diptera (to family or genus), coleoptera (to family), hemiptera (to family), collembola (to family or genus), lepidoptera (to family), and other taxa to order. Taxa richness was highest in Mainstem Red Dog Creek in 2019 and lowest in 2000. The highest taxa richness in North Fork Red Dog Creek occurred in 2003, and the lowest was in 1999 and 2000. In 2019, Buddy Creek had the highest taxa richness since aquatic invertebrate sampling began in 2004. The lowest taxa richness at Buddy Creek was seen in 2009 and 2010.

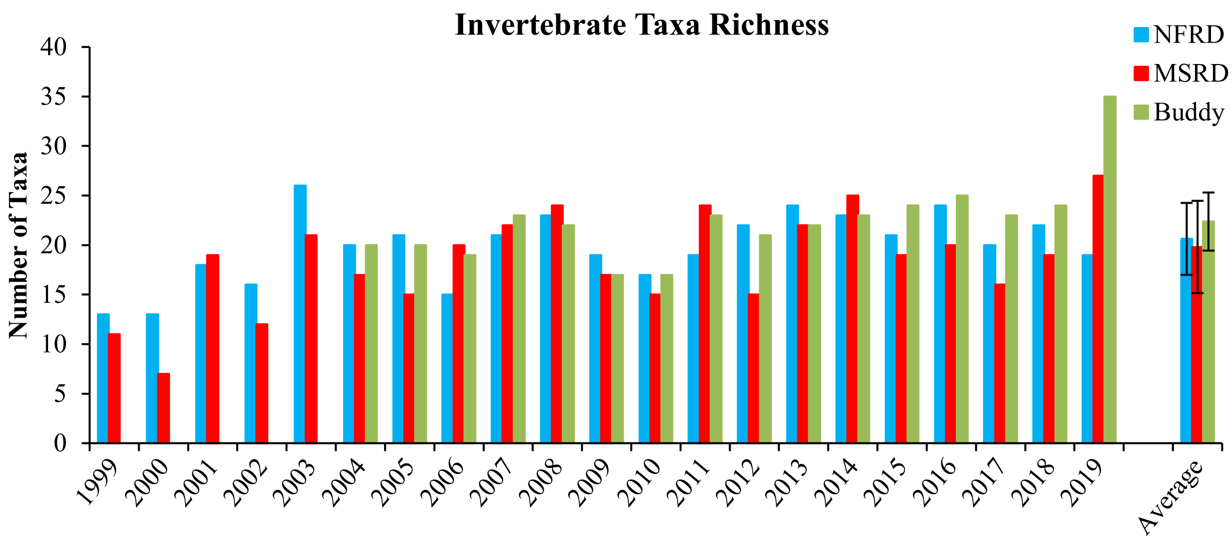



**Figure 30. Aquatic invertebrate taxa richness in North Fork Red Dog and Mainstem Red Dog Creek 1999–2019 and Buddy Creek 2004–2019. The running average (± 1 SD) is included for each site.**

### Metal Concentrations in Juvenile Arctic Grayling and Dolly Varden

Juvenile Arctic grayling and Dolly Varden were sampled to determine whole body concentrations of selected elements. The purposes of this effort are to: (1) determine if differences exist in element concentrations in fish among the sample sites that can be linked with background water quality; and (2) track changes over time.

Juvenile Arctic grayling were selected for long-term monitoring after a self-sustaining population became established in Bons Pond. Arctic grayling captured in Bons Pond have been in the pond system, including upstream tributaries for their entire life cycle. Arctic grayling that leave Bons

Pond go over a waterfall that prohibits upstream/return movement of fish. Therefore, these Arctic grayling serve as an indicator of change over time in Bons Pond. Fish samples are typically collected during the spring sampling event when fish are moving from Bons Pond into Bons Creek. However, no juvenile Arctic grayling in the target size range were captured in spring 2019 so the samples were collected in August with a fyke net in Bons Pond.

Juvenile Dolly Varden were selected as a target species because of their wide distribution in the Red Dog area streams, their residence in freshwater for two to four years before smolting, and their rearing in the selected sample sites only during the ice-free season. Juvenile Dolly Varden were collected opportunistically from Mainstem Red Dog, Anxiety Ridge, and Buddy creeks during the minnow trap sample event in late summer. These locations have been sampled annually since 2005, except for in 2012 and 2013 when water levels were too high to effectively sample.

Fifteen juvenile Arctic grayling were captured in Bons Pond in early August (Appendix 4). The average length of these fish was 170.9 mm FL ± 6.5 mm (1 SD). These fish were analyzed for cadmium, lead, selenium, zinc and mercury, and results are for whole body in mg/kg (dry weight).

In 2019, the average cadmium concentration in Bons Pond juvenile Arctic grayling was 0.11 mg/kg (Figure 31). The highest average cadmium concentration was 0.27 mg/kg in 2014.

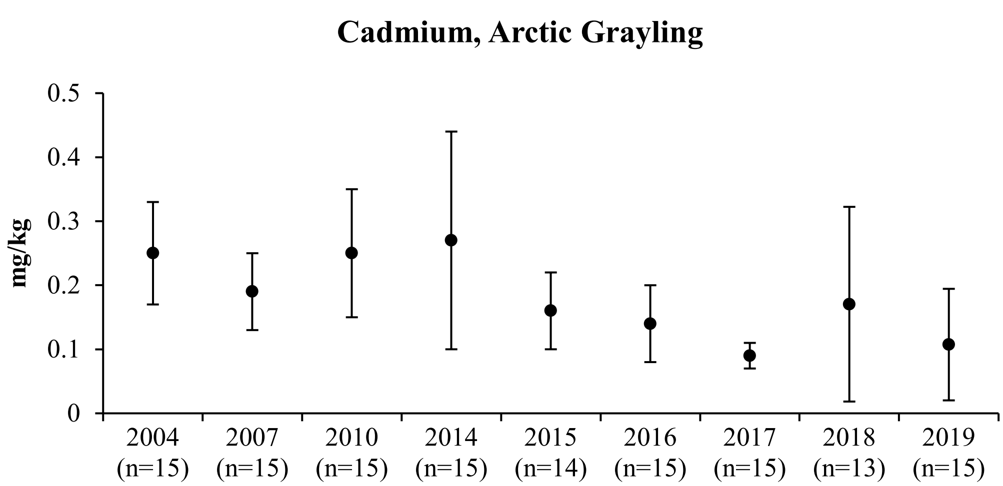



**Figure 31. Average cadmium concentrations (± 1 SD) in juvenile Arctic grayling collected from Bons Pond drainage (whole body dry weight).**

In 2019, the average lead concentration was 0.66 mg/kg in juvenile Arctic grayling from Bons Pond (Figure 32). This was similar to the average concentration seen in 2018.

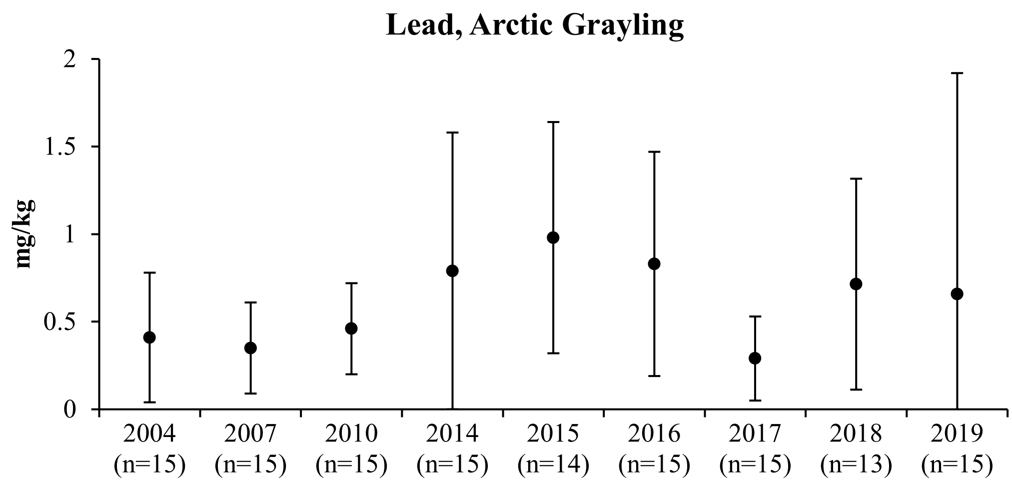



**Figure 32. Average lead concentrations (± 1 SD) in juvenile Arctic grayling collected from Bons Pond drainage (whole body dry weight).**

Average selenium concentrations in juvenile Arctic grayling from Bons Pond have decreased since 2014 (Figure 33). The average concentration in 2019 was 9.3 mg/kg, the lowest value seen since 2004.

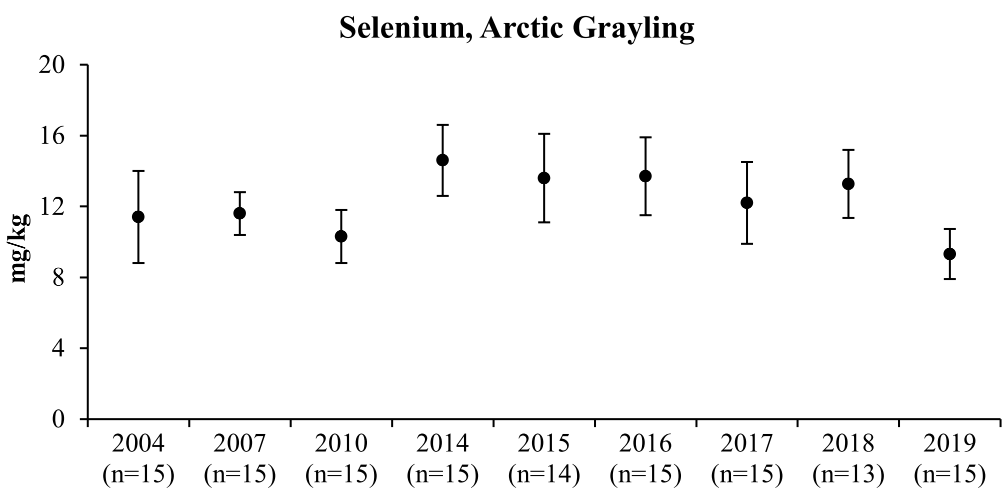



**Figure 33. Average selenium concentrations (± 1 SD) in juvenile Arctic grayling collected from Bons Pond drainage (whole body dry weight).**

Similar to cadmium and selenium, average zinc concentrations in juvenile Arctic grayling from Bons Pond in 2019 (86.5 mg/kg) decreased from 2018 concentrations (Figure 34). Average concentrations have varied from a high of 104 mg/kg in 2016 to a low of 60 mg/kg in 2017.

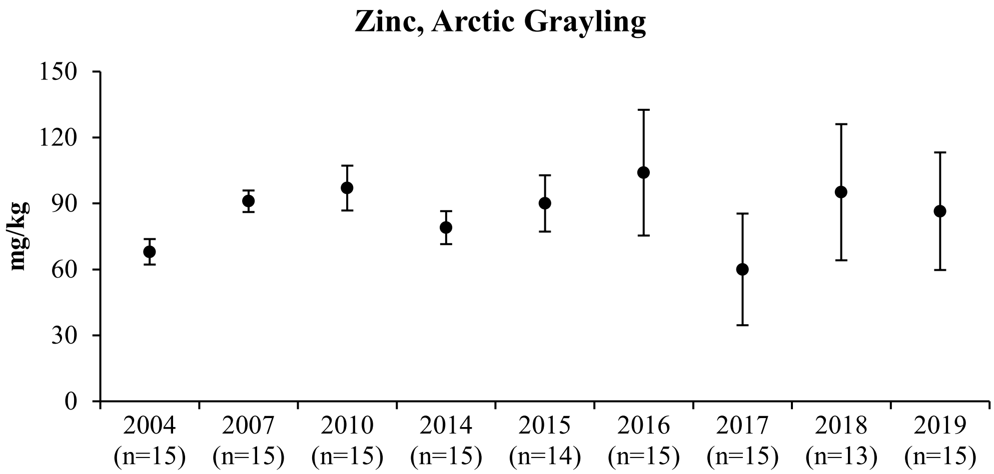



**Figure 34. Average zinc concentrations (± 1 SD) in juvenile Arctic grayling collected from Bons Pond drainage (whole body dry weight).**

Average mercury concentrations in juvenile Arctic grayling from Bons Pond have been variable and ranged from a high of 0.06 mg/kg in 2018 and 2019 to a low of the detection limit of 0.02 mg/kg in 2004 and 2014 (Figure 35).

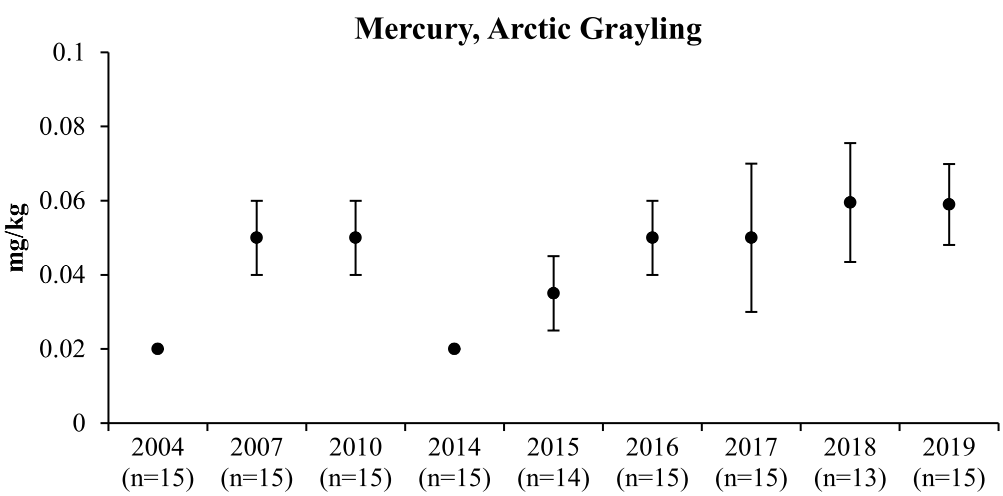



**Figure 35. Average mercury concentrations (± 1 SD) in juvenile Arctic grayling collected from Bons Pond drainage (whole body dry weight).**

In August 2019, juvenile Dolly Varden were collected from Mainstem Red Dog (n = 14), Buddy (n = 15), and Anxiety Ridge creeks (n = 15) for whole body element analysis (Appendix 5). Conditions were favorable for minnow trapping, but it was still difficult to catch fish in Mainstem Red Dog Creek. Two sets of ten minnow traps were fished for a total of three days to collect 14 fish.

Since water quality concentrations of cadmium, lead, and zinc are highest in Mainstem Red Dog Creek, higher concentrations of these metals in whole body samples of juvenile Dolly Varden at this site were expected. The main source of cadmium, lead, and zinc to Mainstem Red Dog creek is the waters from the clean water bypass.

Whole body cadmium concentrations (median value) are highest in juvenile Dolly Varden collected from Mainstem Red Dog Creek and consistently lowest in Anxiety Ridge Creek (Figure 36). Peak median cadmium concentrations occurred at all three sites in 2006. Median cadmium concentrations have been below 1 mg/kg in fish from Buddy Creek since 2007 and Anxiety Ridge Creek since 2005. Among data for Mainstem Red Dog Creek, changes in whole body cadmium concentrations generally track with the water quality data, although the sharp increase in cadmium in the 2018 and 2019 water quality data is not as pronounced in the whole body cadmium concentration, possibly since fish likely move between water bodies and may spend more time in creeks like North Fork Red Dog Creek where cadmium concentrations are lower (Figure 37).

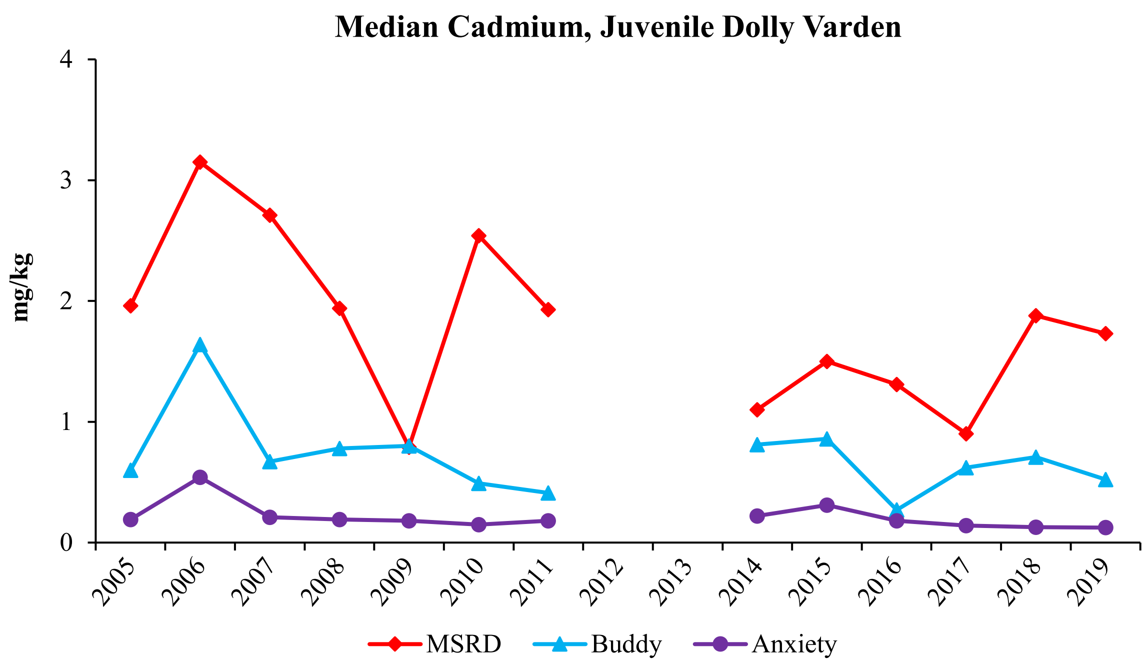



**Figure 36. Median cadmium whole body concentrations in juvenile Dolly Varden from 2005 to 2019.**

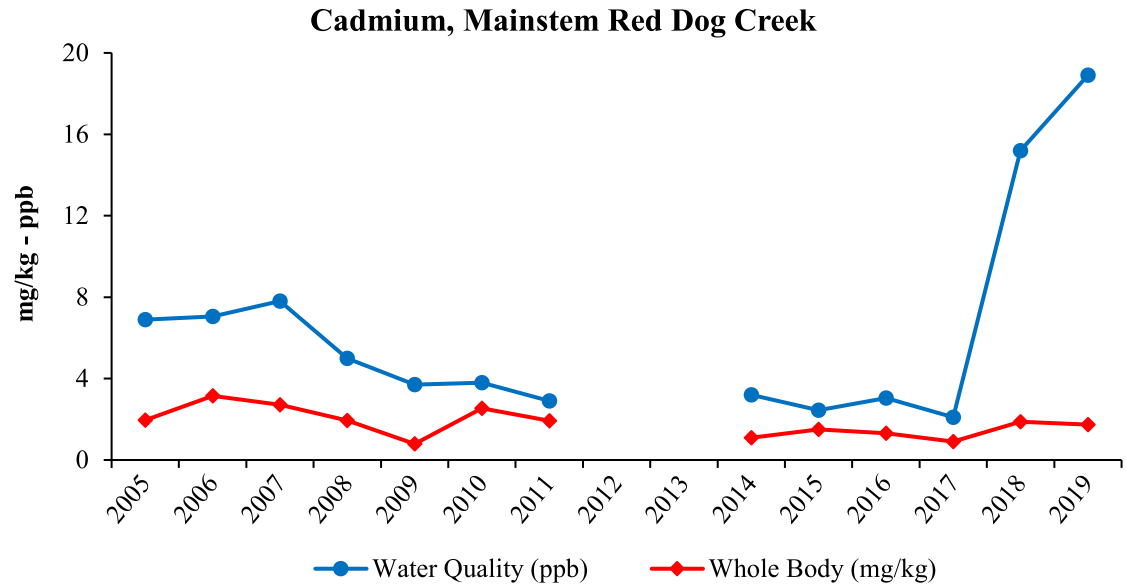



**Figure 37. Median whole body cadmium concentrations in juvenile Dolly Varden and median cadmium water quality data for Mainstem Red Dog Creek.**

Median whole body lead concentrations in juvenile Dolly Varden are consistently higher in Mainstem Red Dog Creek than in Buddy and Anxiety Ridge creeks, which have similar lead concentrations (Figure 38). Lead concentrations in the water of Mainstem Red Dog Creek have been highly variable since 2005 and there does not seem to be any relationship between lead in the water and lead in whole body samples from Mainstem Red Dog Creek juvenile Dolly Varden (Figure 39).

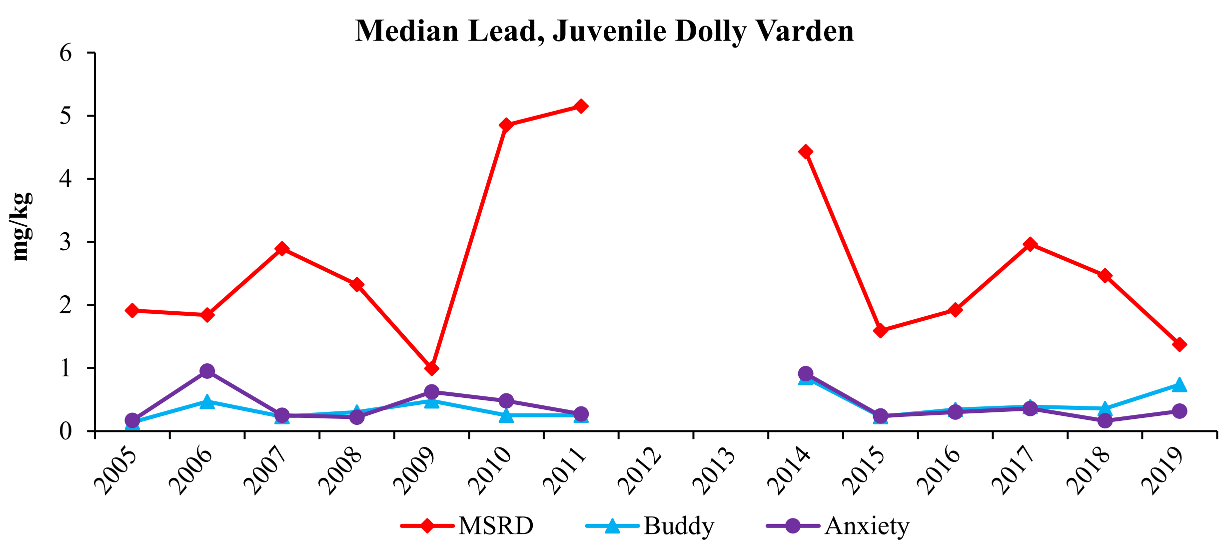



**Figure 38. Median lead whole body concentrations in juvenile Dolly Varden from 2005 to 2019.**

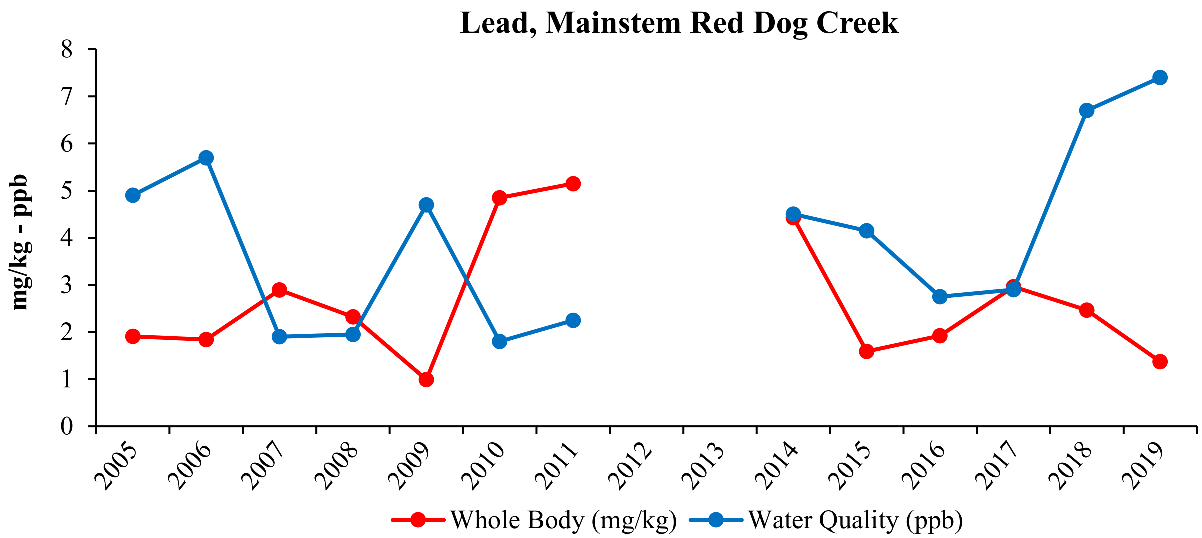



**Figure 39. Median whole body lead concentrations in juvenile Dolly Varden and median lead water quality data for Mainstem Red Dog Creek.**

Median whole body selenium concentrations in juvenile Dolly Varden are generally lowest in fish from Anxiety Ridge Creek (Figure 40). Whole body selenium concentrations in juvenile Dolly Varden from Mainstem Red Dog Creek increased from 2009 to 2015, and have decreased each year from 2016 to 2019. There is no clear relationship in Mainstem Red Dog Creek between selenium concentrations in the water and in whole body juvenile Dolly Varden (Figure 41).

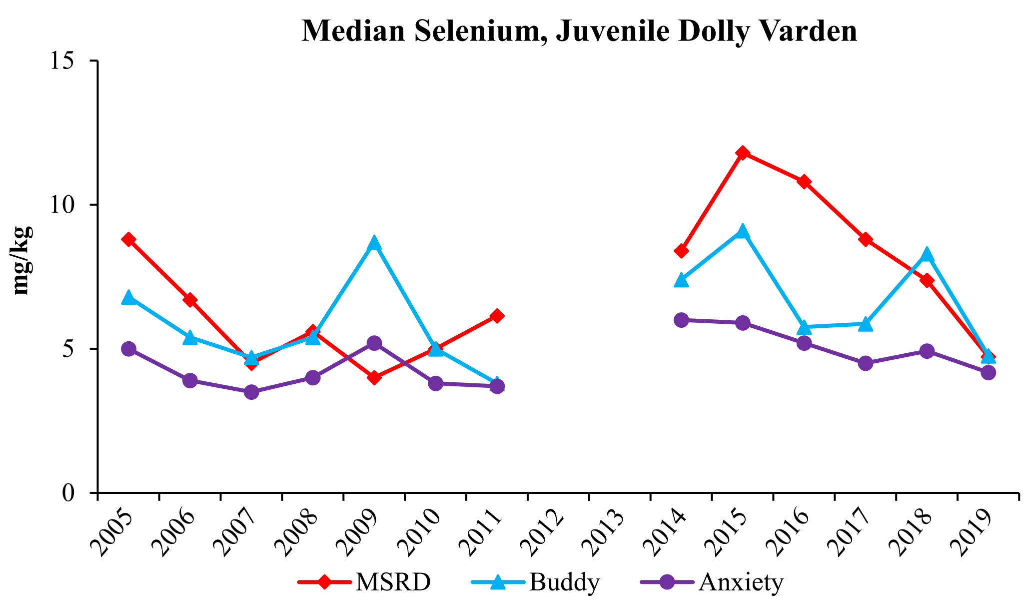



**Figure 40. Median selenium whole body concentrations in juvenile Dolly Varden from 2005 to 2019.**

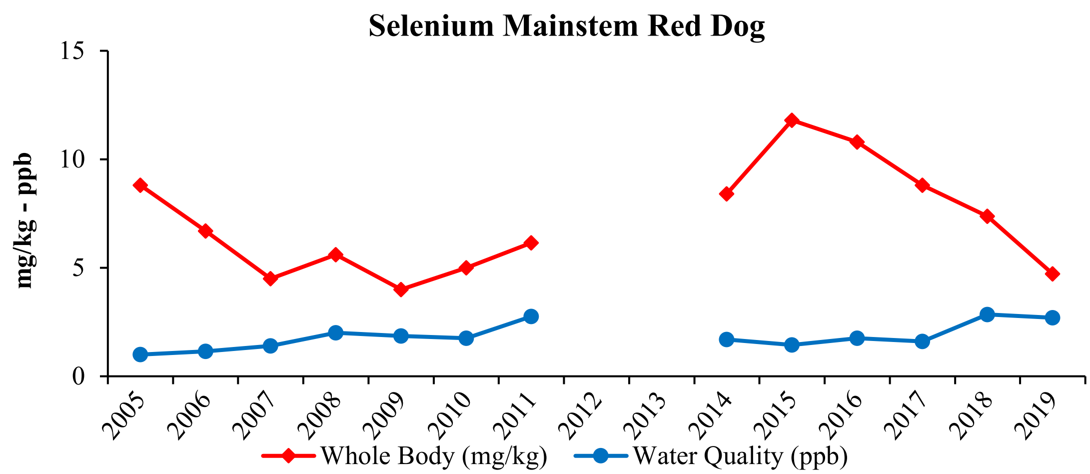



**Figure 41. Median whole body selenium concentrations in juvenile Dolly Varden and median selenium water quality data for Mainstem Red Dog Creek.**

Median zinc whole body concentrations are generally highest in fish from Mainstem Red Dog Creek and lowest in fish from Anxiety Ridge Creek (Figure 42). Zinc whole body concentrations in Mainstem Red Dog Creek decreased from a high of 351 mg/kg in 2007 to a low of 154 mg/kg in 2017, but then increased in 2018 and 2019. Whole body zinc concentrations in fish from Mainstem Red Dog Creek have generally mirrored the trends in water concentration, although the sharp increase in the water in 2018 and 2019 was not reflected as steeply in the whole body concentration, possibly since fish move between water bodies and may spend more time in creeks like North Fork Red Dog Creek where cadmium concentrations are lower (Figure 43).

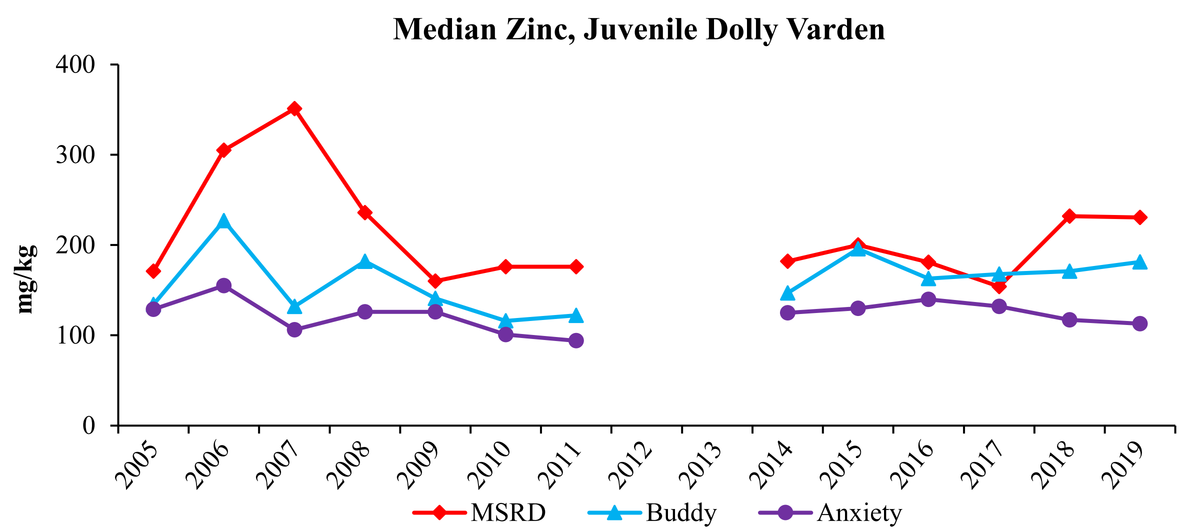



**Figure 42. Median zinc whole body concentrations in juvenile Dolly Varden from 2005 to 2019.**

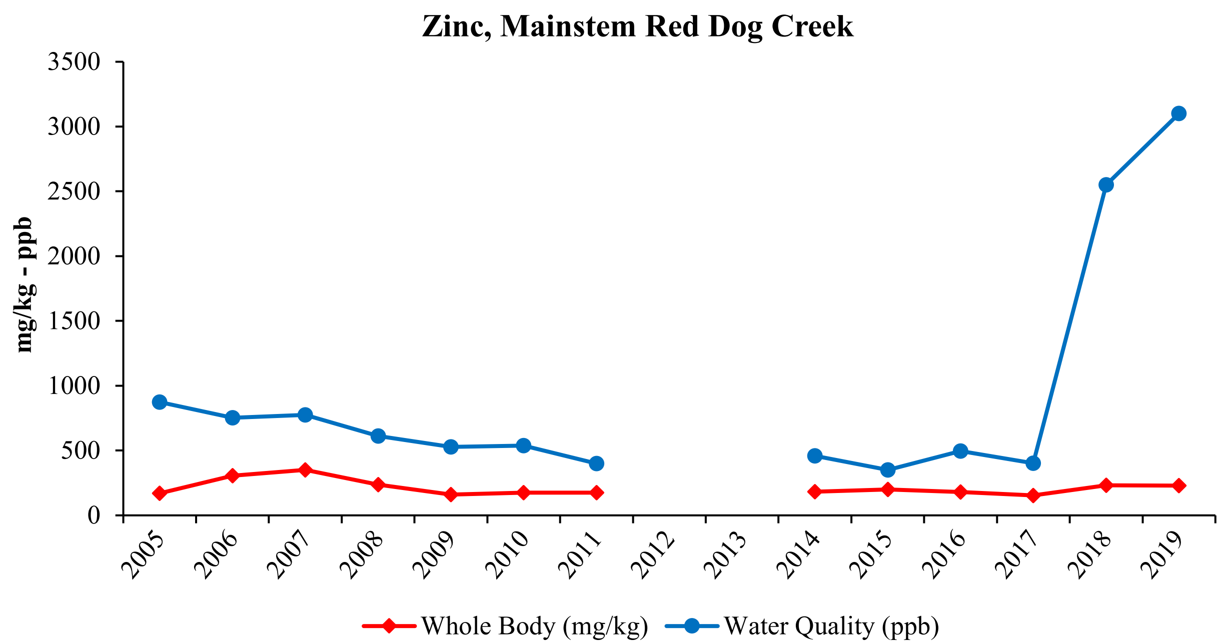



**Figure 43. Median whole body zinc concentrations in juvenile Dolly Varden and median zinc water quality data for Mainstem Red Dog Creek.**

Median mercury concentrations in juvenile Dolly Varden are consistently higher in Anxiety Ridge Creek and very similar between Buddy and Mainstem Red Dog creeks (Figure 44). The highest recorded median of mercury was detected in 2019 in Anxiety Creek at 0.14 mg/kg.

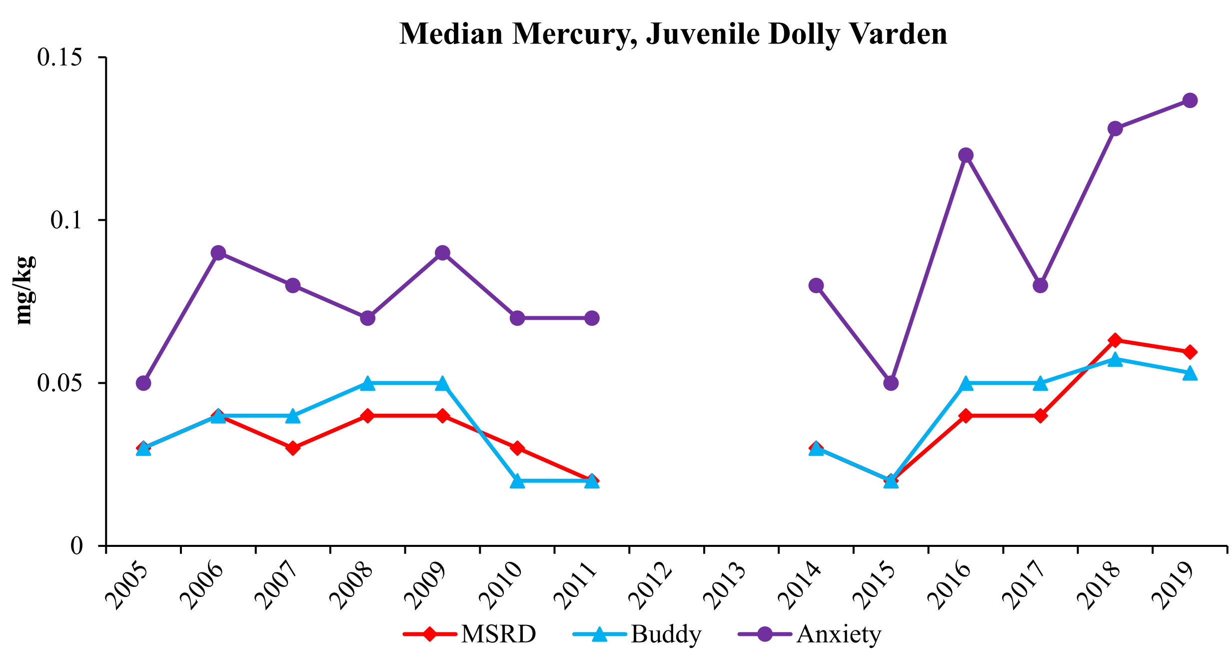



**Figure 44. Median mercury whole body concentrations in juvenile Dolly Varden from 2005 to 2019.**

**Selenium Concentrations in Adult Arctic Grayling**

In spring 2019, Arctic grayling females were collected from Bons Pond and North Fork Red Dog Creek near the Red Dog Mine. In spring 1999, and 2014 – 2018, samples were collected from the Chena River (Fairbanks), the water supply reservoir (upper Fish Creek) at the Fort Knox Mine, and from Bons Pond and North Fork Red Dog Creek near the Red Dog Mine.

The purpose of these collection efforts is to compare the selenium concentration in the ovaries of Arctic grayling among sites and over time. Literature suggests that selenium concentrates in the ovaries of fishes and can have adverse effects on reproductive success. Selenium accumulation in the eggs of fish has been shown to yield the most robust relationship with the occurrence of deformities and reduced survival of offspring.

The water supply reservoirs at both the Red Dog and Fort Knox mines support spawning populations of Arctic grayling. These populations of fish both occur upstream of large barriers to movement of fish. At Fort Knox, the Arctic grayling overwinter in the water supply reservoir and spawn in tributaries, primarily in the developed wetland complex (Ott and Bradley, 2017). In Bons Pond, the Arctic grayling overwinter in the pond and spawn in Bons Creek and in the outlet of Bons Pond. The Arctic grayling ovary samples from these two sites are from fish that have spent their entire life history in these waterbodies.

Fort Knox Arctic grayling mature at a younger age and smaller size than Bons Pond Arctic grayling. The Fort Knox Arctic grayling collected in 1999, 2015 and 2017 had an average age of 8 ± 1 year (1 SD) while the Bons Pond fish collected in 2017 averaged 11.8 ± 3.1 years (1 SD). The five fish retained from Mainstem Red Dog Creek in 2017 averaged 9.8 ± 4.6 years (1 SD). Bons Pond Arctic grayling collected in 2019 averaged 6.8 ± 0.7 years (1 SD) and the 2019 North Fork Red Dog Creek fish averaged 8.7 ± 4.5 years (1 SD).

Selenium concentrations in 2019 Arctic grayling ovaries were highest in Bons Pond, while concentrations in Arctic grayling ovaries from the North Fork Red Dog Creek remain the second highest (Figure 45). Arctic grayling from Fish Creek at Fort Knox contained the lowest concentration of selenium in ovaries. Selenium concentrations in Bons Pond and North Fork Red Dog Creek were higher in 2018, but since the size and age of sampled fish was inconsistent with previous years' samples, and the fish were not mature, results are not directly comparable between years. Large, mature spawners were collected in 2019, and the selenium concentrations were similar to fish collected in 2014 to 2017.

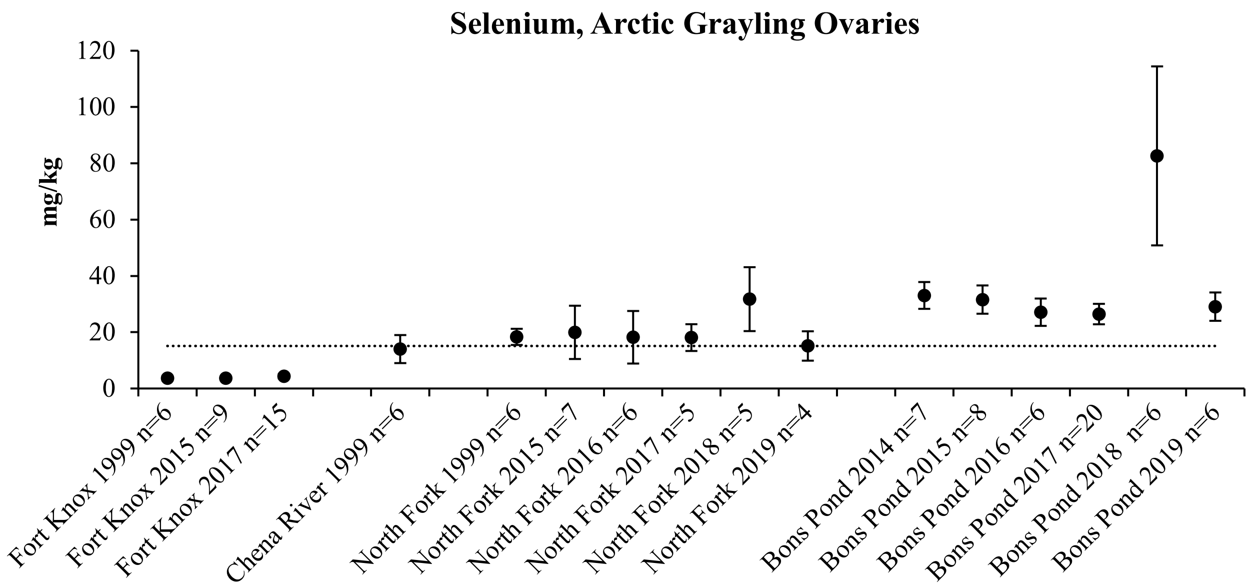



**Figure 45. Average selenium (± 1SD) concentrations (dry weight) in Arctic grayling ovaries from Fort Knox, Chena River, North Fork Red Dog Creek, and Bons Pond. The dotted line is the EPA criterion of 15.1 mg/kg dry weight in ovary tissue. Fish collected in 2018 were younger and smaller than previous years' samples, so results are not directly comparable.**

Selenium concentrations found in the ovaries of Bons Pond Arctic grayling are higher than the EPA's final chronic aquatic life criterion for fresh water (15.1 mg/kg – dry weight) (EPA, 2016), while selenium concentrations in Fort Knox Arctic grayling are substantially lower. Selenium concentrations in ovaries of Arctic grayling from North Fork Red Dog Creek are equal to or slightly higher than the EPA criterion. Selenium concentrations were stable from 2014 to 2017 and 2019 in North Fork Red Dog Creek, Bons Pond, and Fort Knox (Fish Creek); however, abundance estimates of Arctic grayling in Bons Pond steadily decreased from 2007 to 2014, then increased from 2015 to 2017, and decreased in 2018. The decrease in the Bons Pond Arctic grayling population might have been due to elevated selenium in the ovaries, but it also may have been related to the fact that this introduced population expanded rapidly after their introduction in 1994 and 1995. The decrease in the number of Arctic grayling in Bons Pond may be related to predation of larger fish on age-0 recruits since there is no separation of age classes by habitat type. Recent sampling in Bons Pond indicates that there is an increasing number of smaller fish; therefore, the population of adult fish (≥ 200 mm FL) may continue to increase.

The North Fork Red Dog Creek Arctic grayling population has been relatively stable over time and recruitment of new fish has been strong since 2007 with the exception of spring 2017 when the North Fork was inundated in aufeis. The 2017 population size could not be estimated as there was only one recaptured fish in spring 2018. In spring 2019 we recaptured two fish that were tagged in 2018, resulting in a population estimate for 2018 of 960 fish with a 95% confidence interval of 73 – 1,847 fish. The Arctic grayling population in Fish Creek at Fort Knox has been variable over the sample years and population changes have been linked closely with access between spawning, rearing and overwintering habitat which can be adversely affected by beaver activity (Ott and Bradley, 2016).

**Metal Concentrations in Adult Dolly Varden**

In 2019, adult Dolly Varden were collected from the Wulik River (Station 2) about 2 km downstream from the mouth of Ikalukrok Creek, near Tutak Creek, to be sampled for selected element concentrations in kidney, liver, muscle, and reproductive tissue. Fourteen fish were sampled in 2019, half in the spring and half in the fall.

The purposes of sampling adult Dolly Varden for element concentration is to monitor tissue concentrations over time and to provide a database for use by other professionals. It is unlikely that tissue element concentrations in adult fish could be related to events at the Red Dog Mine, since the majority of Dolly Varden growth occurs in the marine environment. All laboratory work was done with Level III Quality Assurance. Data for 2019 are presented in Appendix 7 and 8.

Certain elements are known to concentrate preferentially in certain organs; however, the relationship of organ concentration to ambient environmental concentrations is unknown. Concentrations of selected elements vary with season, age, size, weight, and feeding habits of fish (Jenkins 1980) and in the case of anadromous Dolly Varden, the element concentrations vary with exposure to freshwater and marine environments. None of the analytes measured appear to concentrate in muscle tissue (Figure 46). In Wulik River Dolly Varden sampled from 1999 to 2019, cadmium was highest in kidney samples, copper was highest in liver samples, lead was slightly higher in testes tissue, zinc was highest in reproductive tissues, selenium was highest in ovaries and kidneys, and mercury was highest in kidneys.

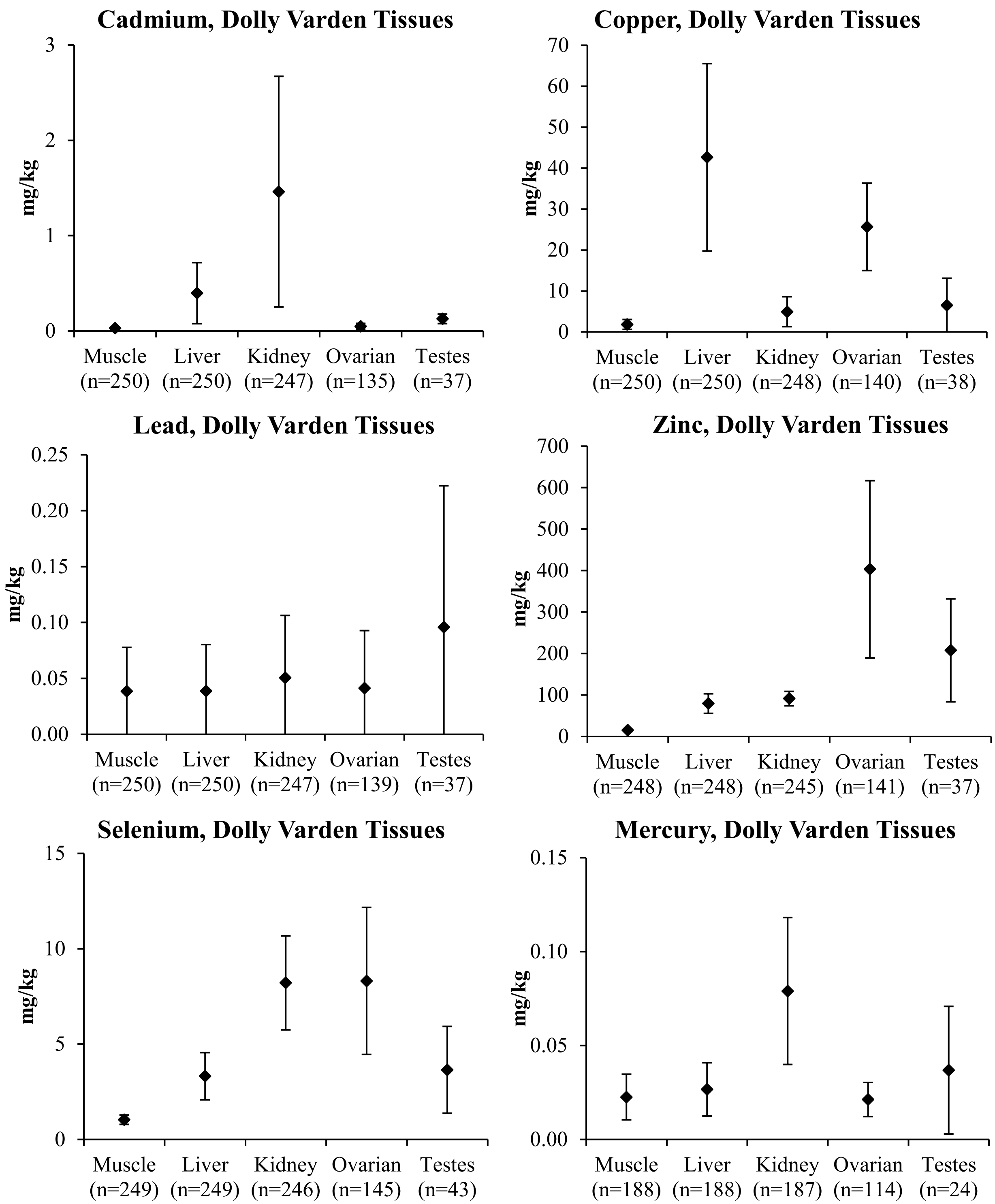



**Figure 46. Average element concentration (dry weight) ±1 SD in adult Dolly Varden tissues, Wulik River (1999–2019[3]).**

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[3] Mercury results from 2018 samples are not included in the running average. Lab equipment was down and samples were analyzed past holding time, producing unreliable results.

Cadmium concentrations in adult Dolly Varden kidney tissue have been variable since 1999 (Figure 47). Concentrations of cadmium slightly increased from 1999 to 2002, then abruptly decreased and remained around 1 mg/kg through spring of 2009. Average cadmium concentrations doubled in fall of 2009 to 1.99 mg/kg, reached a high of 2.96 mg/kg in spring 2011, and have since generally decreased.

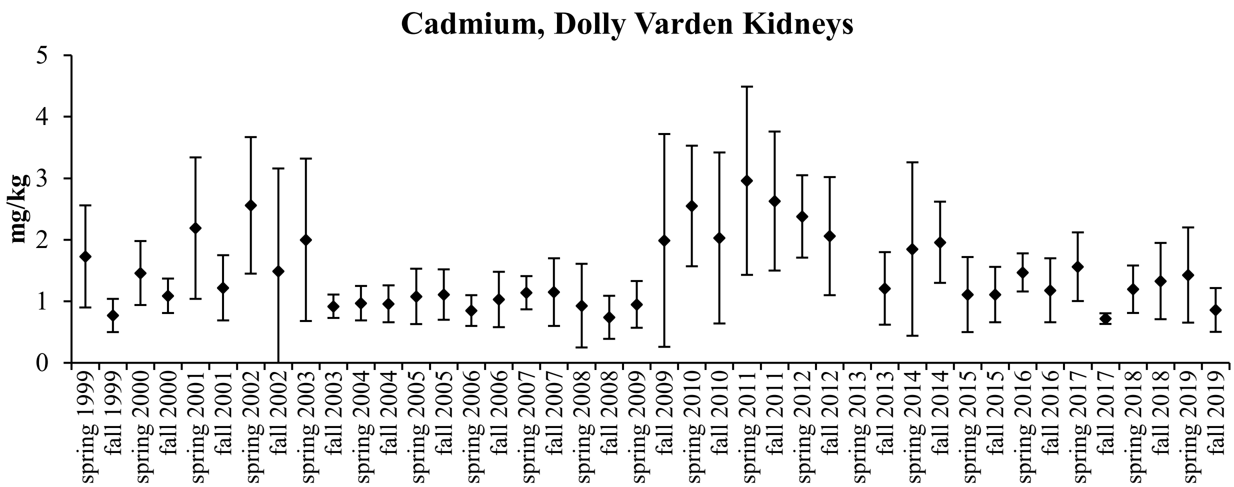


**Figure 47. Average cadmium (± 1SD) concentrations (dry weight) in adult Dolly Varden kidney tissues from 1999 to 2019.**

Average selenium concentrations in Dolly Varden ovaries are higher for fish sampled in the fall (10.08 mg/kg) than for fish sampled in the spring (5.89 mg/kg) (Figure 48). The Dolly Varden sampled in the fall would have recently returned from the marine environment, which may be where they acquired the selenium.

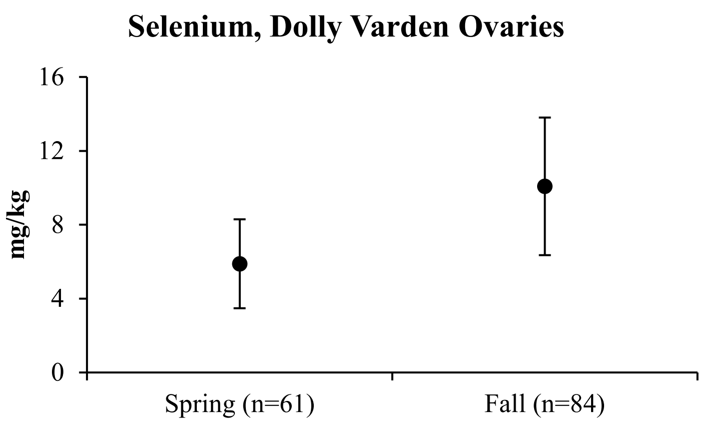


**Figure 48. Average selenium (± 1SD) concentrations (dry weight) in Dolly Varden ovaries from 1999 to 2019.**

**Dolly Varden, Overwintering**

Two aerial surveys were conducted using a Jet Ranger II helicopter provided by Teck to estimate the number of overwintering Dolly Varden in the Wulik River (Figure 49). The first survey attempt was on September 20, 2019, but Ikalukrok Creek was turbid, and this turbidity extended into the Wulik River, to the point that aerial observation of fish was impossible. The second survey attempt was on October 14, 2019. Ikalukrok Creek was still highly turbid, preventing a count of Dolly Varden in the Wulik River downstream of the mouth of Ikalukrok Creek. Above the confluence, 17,308 Dolly Varden were counted. In 2018, 97,385 total fish were counted, with 1,590 above the confluence. On average, 96% of Dolly Varden observed have been downstream of the mouth of Ikalukrok Creek (34 surveys 1979-2018, Table 2). Before 2019, the highest number of fish observed upstream of Ikalukrok Creek was 16,486 in 2004. The total number of fish observed in 2004 was 100,806, with 84% downstream of Ikalukrok Creek. It is unknown how many fish were present downstream of Ikalukrok Creek in fall 2019, but seven Dolly Varden were caught with rod and reel at the mouth of Tutak Creek on the Wulik River in the turbid area on September 20, 2019.

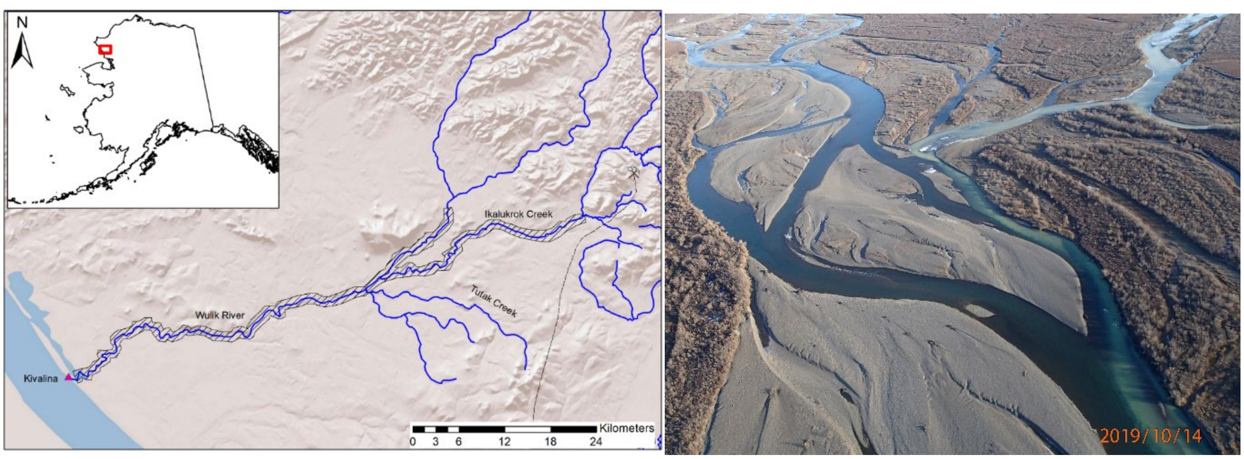


**Figure 49. Dolly Varden and chum salmon aerial survey area. The striped polygon denotes the surveyed portion of the drainage. The mouth of Ikalukrok Creek on the Wulik River is shown on the right. The high turbidity in the waters of the Ikalukrok can be seen extending downstream on the Wulik River.**

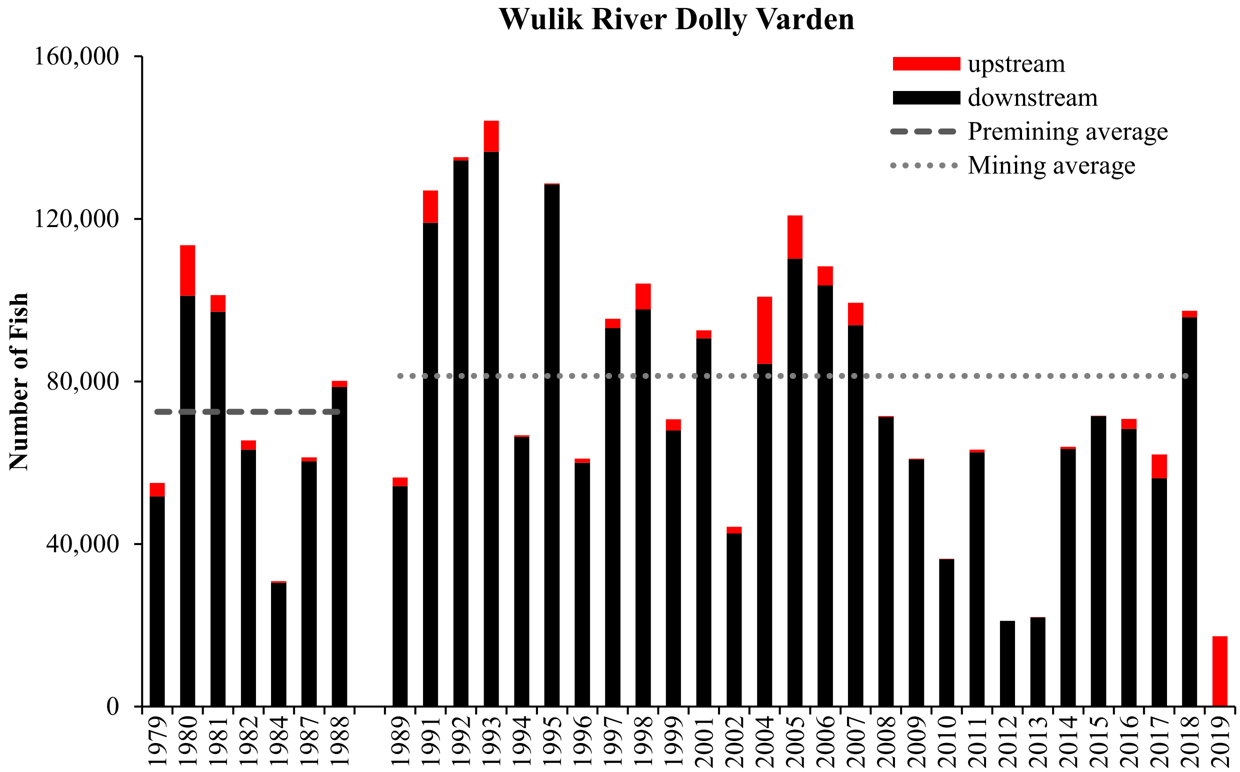


**Figure 50. Aerial survey estimates of the number of Dolly Varden in the Wulik River just prior to freezeup, 1979-2019. Red indicates fish that were upstream of the mouth of Ikalukrok Creek, and black denotes fish that were downstream. In 2019, turbidity prevented a count of fish downstream of Ikalukrok Creek.**

Fall estimates of Dolly Varden have varied annually and reached their lowest (21,084 fish) number in 2012, but then increased in fall 2014 (63,951 fish) and were relatively stable through 2017 (Figure 50 and Table 2). The fall 2018 estimate was 97,385 fish, the highest estimate since 2008.

**Table 2. Estimated number of Dolly Varden in the Wulik River.**

| Year | Wulik River upstream of Ikalukrok Creek | Wulik River downstream of Ikalukrok Creek | Total Fish | % 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] | 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[2] | 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 |
| 2000[3] | | | | |
| 2001 | 2,020 | 90,594 | 92,614 | 98 |
| 2002 | 1,675 | 42,582 | 44,257 | 96 |
| 2003[3] | | | | |
| 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 |
| 2009 | 122 | 60,876 | 60,998 | 99 |
| 2010 | 70 | 36,248 | 36,318 | 99 |
| 2011 | 637 | 62,612 | 63,249 | 99 |
| 2012 | 0 | 21,084 | 21,084 | 100 |
| 2013 | 114 | 21,945 | 22,059 | 99 |
| 2014 | 610 | 63,341 | 63,951 | 99 |
| 2015 | 10 | 71,474 | 71,484 | 100 |
| 2016 | 2,490 | 68,312 | 70,802 | 96 |
| 2017 | 5,856 | 56,173 | 62,029 | 91 |
| 2018 | 1,590 | 95,795 | 97,385 | 98 |
| 2019 | 17,308 | too turbid | incomplete | unknown |

[1]The population estimate (mark/recapture) for winter 1988/1989 for fish > 400 mm was 76,892 (DeCicco 1990).
[2]The population estimate (mark/recapture) for winter 1994/1995 for fish > 400 mm was 361,599 (DeCicco 1996).
[3]Fall 2000 and 2003 aerial surveys did not occur due to weather.

**Chum Salmon, Spawning**

Annual chum salmon escapement is estimated in Ikalukrok Creek from its confluence with the Wulik River upstream to Dudd Creek (Figures 49 and 51). An aerial survey was flown using a Jet Ranger II helicopter on September 20, 2019. The turbidity in Ikalukrok Creek prevented a count of chum salmon. During the aerial survey on October 14, 2019, 258 chum salmon were observed on the Wulik River upstream of Ikalukrok Creek.

Annual post-mining aerial surveys were initiated in 1990. Counts of chum salmon in Ikalukrok Creek in 1990 and 1991 (mine discharge began in 1989) were lower than reported in baseline studies in 1981 and 1982. It should be noted that the reported number of chum salmon in 1981 was an extrapolation based on aerial photographs, and therefore, is not comparable to the aerial survey dataset.

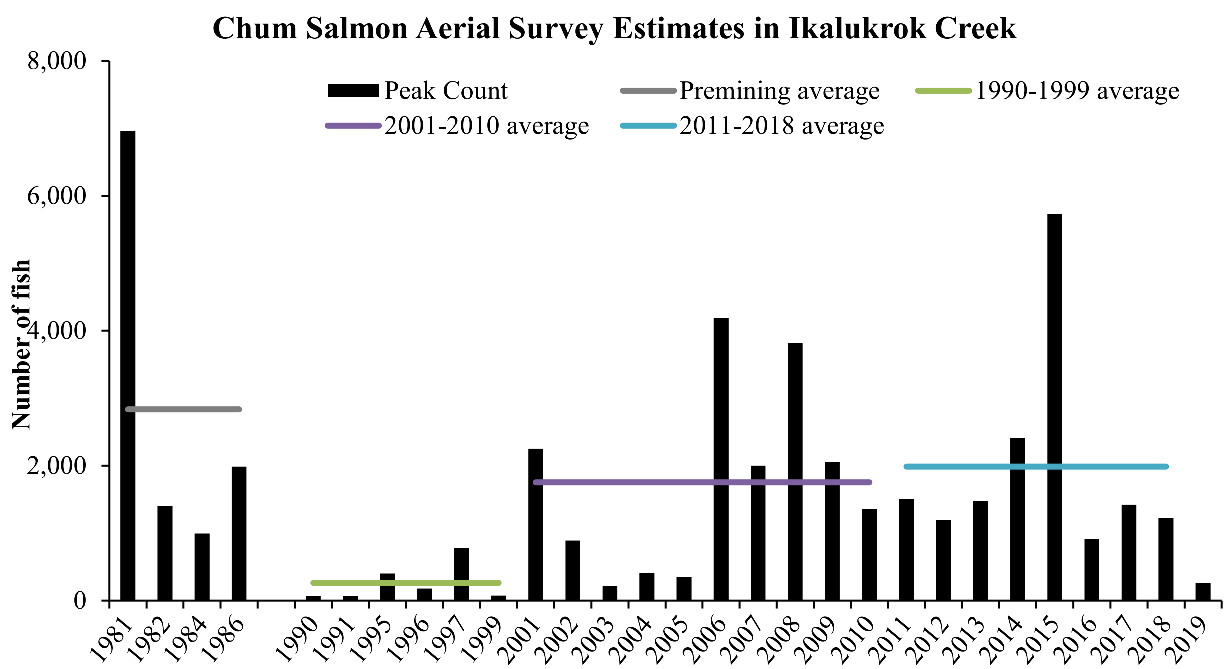


**Figure 51. Peak estimates of chum salmon escapement in Ikalukrok Creek. The chum salmon spawning reaches are concentrated in select areas along this reach of the creek. The 1981 count was an estimate based on extrapolation from aerial photographs. The 2019 count is incomplete, as Ikalukrok Creek was too turbid to see fish.**

**Dolly Varden, Juveniles**

Limited pre-mining juvenile Dolly Varden distribution 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 it was a resident fish. Surveys along Mainstem Red Dog Creek reported either few fish or no fish, and in some cases mortalities of small juvenile Dolly Varden and Arctic grayling fry (Ward and Olson 1980, EVS Consultants Ltd and Ott Water Engineers 1983).

Juvenile Dolly Varden have been sampled in streams within the Red Dog Mine area since 1990. In 1992, new sample sites were added, and the number of minnow traps was increased to 10 per sample reach. Under the modified program that began in 2010, nine sites are now sampled with 10 minnow traps per sample reach, typically with around 24 hrs of effort in early-to-mid August (Table 3, Appendix 10). Seven of these sites are unchanged in location and the new Station 160 corresponds to Station 7 – instead of being immediately downstream of Dudd Creek, it is now located about 7 km downstream.

**Table 3. Location of juvenile Dolly Varden sample sites.[1]**

| Site Name | Station No. | Year Sampling Began |
|---|---|---|
| Evaingiknuk Creek | | 1990 |
| Anxiety Ridge Creek | | 1990 |
| Buddy Creek | | 1996 |
| North Fork Red Dog Creek | 12 | 1993 |
| Mainstem Red Dog Creek | 151 | 1995 |
| Mainstem Red Dog Creek | 10 | 1996 |
| Ikalukrok Creek above Mainstem | 9 | 1996 |
| Ikalukrok Creek below Dudd | 7/160 | 1990 |
| Upper North Fork Red Dog Creek | | 2014 |

[1]Sampling has been performed annually at each of these sites except in 2012 and 2013, when water levels were too high to effectively sample.

### Dolly Varden Catches and Metrics

The relative abundance of juvenile Dolly Varden varies considerably among sample years (Appendix 12); however, the catches among the sample sites follow similar patterns. Generally, the CPUE (number of fish caught in 10 traps per 24 hour period) in Anxiety and Buddy creeks is higher than at the other sample reaches. In 2019, the CPUE was highest in Buddy Creek (54.5 fish/24 hours), Evaingiknuk Creek (34.8 fish/24 hours) and Anxiety Ridge Creek (32.8 fish/24 hours) and lowest in North Fork Red Dog Creek where no fish were caught (Figure 52).

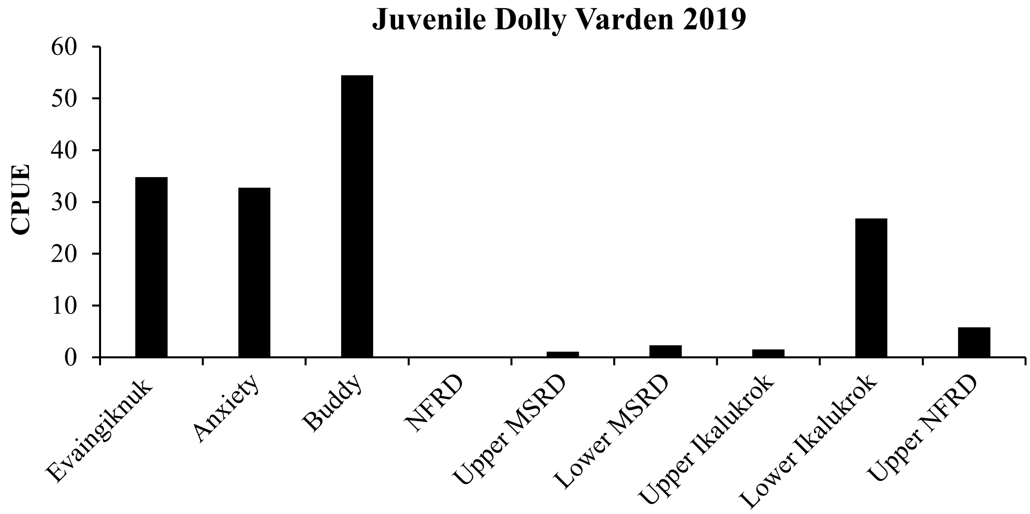


**Figure 52. CPUE for juvenile Dolly Varden in the Red Dog sample reaches in 2019.**

Natural environmental variability such as duration of breakup, patterns and magnitude of rainfall, ambient air temperatures, and the strength of the age-1 cohort affect distribution of juveniles and relative abundance. The most important factor is probably the strength of the age-1 cohort, which is directly related to number of spawners, spawning success, and survival the previous winter. The CPUE for juvenile Dolly Varden in Anxiety Ridge and Buddy creeks from 1997 to 2019 reflects the high degree of variability among sample years (Figure 53).

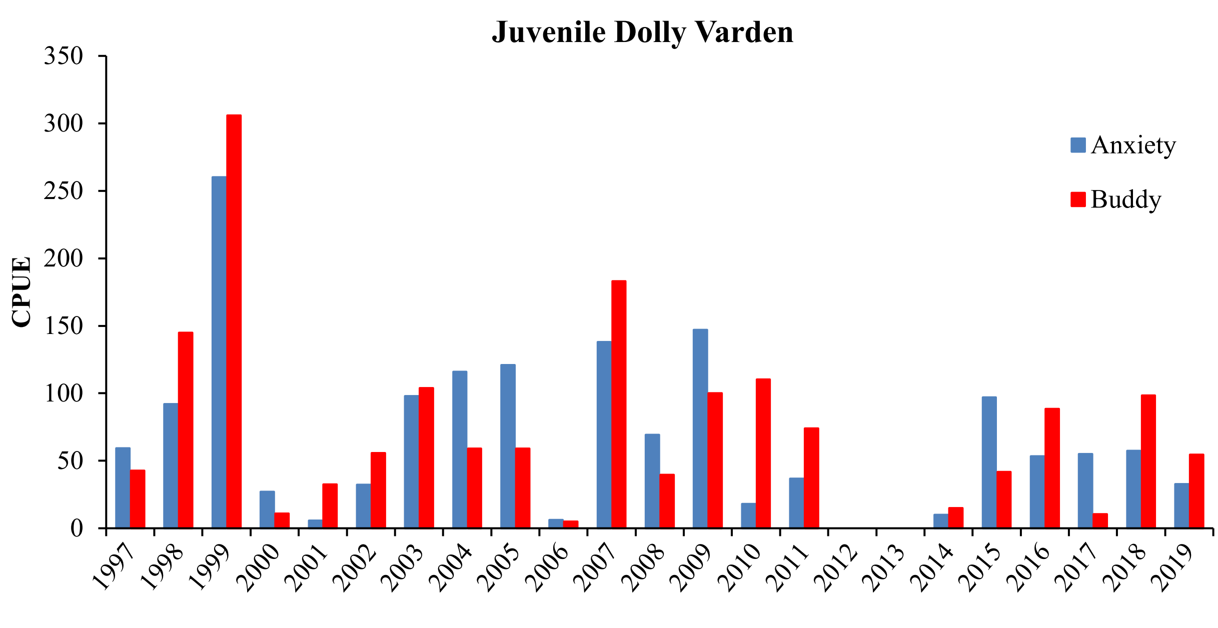


**Figure 53. CPUE of juvenile Dolly Varden in Anxiety Ridge and Buddy creeks, 1997–2019. No sampling was performed in 2012 or 2013 due to high water.**

CPUE in lower Mainstem Red Dog Creek has ranged from a low of 0 in 2004 to a high of 73.3 in 1999 (Figure 54). The highest catches in Anxiety Ridge and Buddy creeks also occurred in 1999. Catches since 2000 in lower Mainstem Red Dog Creek have remained low, but relatively consistent. Use of lower Mainstem Red Dog Creek by juvenile Dolly Varden is substantially greater than what was found by Houghton and Hilgert (1983) during baseline studies before mine development.

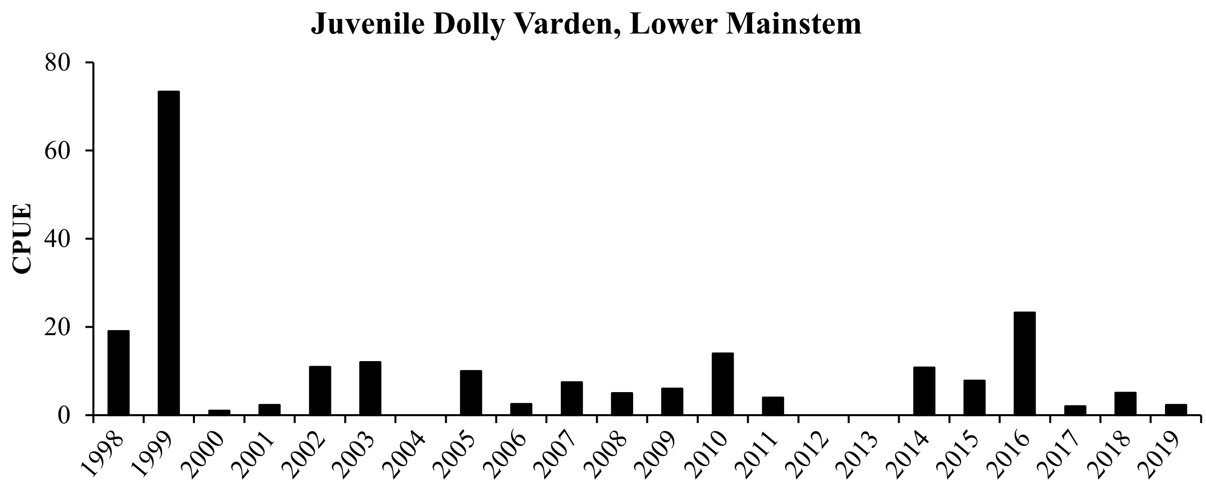


**Figure 54. CPUE of juvenile Dolly Varden in Lower Mainstem Red Dog Creek, 1998-2019. No sampling was performed in 2012 or 2013 due to high water.**

Anadromous Dolly Varden spend at least one year in freshwater before their migration to the marine environment (DeCicco 1990). Microchemical analyses of different Dolly Varden populations in Alaska indicate that most fish first migrate to sea at ages 2 or 3 (Hart et. al 2015, Bond et al. 2015). Based on length frequency distributions for juvenile Dolly Varden captured in 2019, it is likely most fish were age 1+. Small Dolly Varden (≤ 70 mm FL) captured in late July and August are likely age 0 fish. In 2019, 14 captured fish were ≤ 70 mm FL (Figure 55).

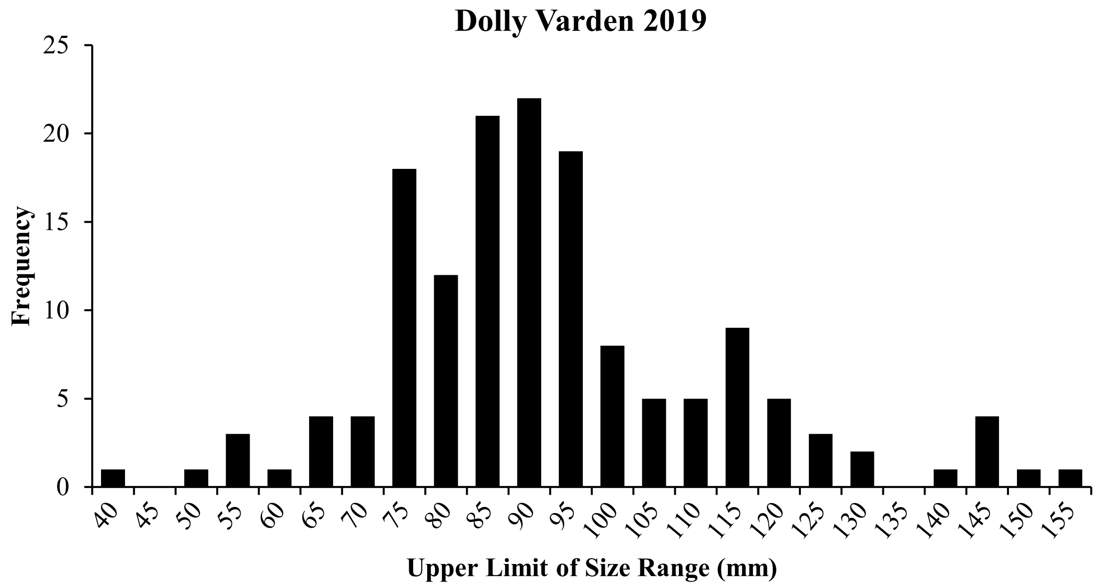


**Figure 55. Length frequency distribution of Dolly Varden in the Ikalukrok Creek drainage in fall 2019.**

In the Ikalukrok Creek drainage, some Dolly Varden are occasionally captured that are > 145 mm FL and sexually mature. The majority of these fish are residents that will not out-migrate to the marine environment. These resident fish are identified by their coloration (orange spots and white edges on the pelvic fins) and sexual condition (milt observed). These sexually mature resident Dolly Varden can be contrasted to the anadromous form, which can attain over 600 mm FL and has very distinctive coloration in the fall, prior to spawning.

During spring each year, fyke net(s) are fished in North Fork Red Dog Creek for the primary purpose of catching Arctic grayling. However, Dolly Varden are also caught in the fyke nets and these fish are generally larger than those caught later in the summer in minnow traps, likely due to the inability of larger fish to enter the minnow traps. In spring 2019, 16 Dolly Varden were caught in the fyke nets ranging from 70 mm FL to 239 mm FL, with an average size of 150 mm FL (Figure 56). Many of the Dolly Varden caught in North Fork Red Dog Creek in the spring are likely the resident form.

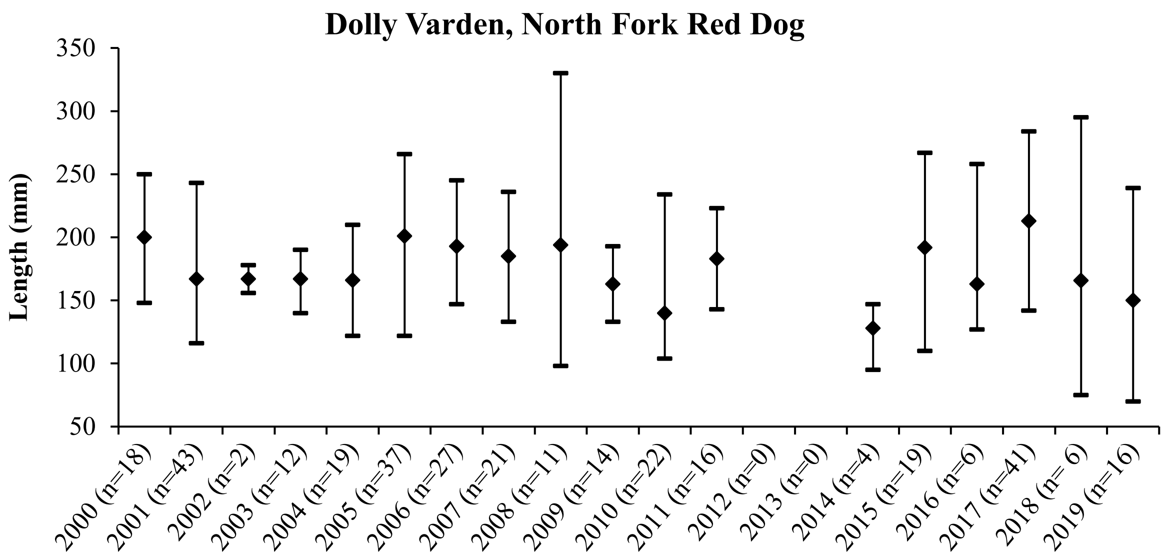


**Figure 56. Dolly Varden caught in fyke nets fished in North Fork Red Dog Creek in spring. Average, maximum, and minimum lengths are shown for each sample year.**

**Arctic Grayling, Red Dog Creek Drainage**

Before mine development, Arctic grayling adults migrated through Mainstem Red Dog Creek in the spring when flows were high and naturally occurring metals concentrations were low (Ward and Olsen 1980, EVS and Ott Water Engineers 1983, and Houghton and Hilgert 1983). Arctic grayling moved upstream through Mainstem Red Dog Creek to spawn in North Fork Red Dog Creek. None of the historical reports indicated that 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 the fall. Only a few juvenile Arctic grayling were collected in North Fork Red Dog Creek prior to mine development. Dolly Varden and Arctic grayling fry mortality was reported in Mainstem Red Dog Creek before mine development by Ward and Olsen (1980) and EVS Consultants and Ott Water Engineers (1983). Since 1994 Arctic grayling have been documented using Mainstem Red Dog Creek and no fish mortality events have been observed. Presently, spawning occurs in Mainstem Red Dog and North Fork Red Dog creeks.

Arctic grayling spawning has been monitored during the spring in North Fork Red Dog and Mainstem Red Dog creeks since 2001. The goal of this sampling effort is to document when spawning has been substantially completed in Mainstem Red Dog Creek and post-spawn Arctic grayling return to North Fork Red Dog Creek. Spring water temperatures and timing of warming appear to be the key variables in determining spawning success, spawning time, fry emergence, first year growth, and likely survival. High flows during or immediately following spawning can have a negative effect on fry survival (Clark 1992).

Discharge volume and quality from the wastewater treatment facility at the Red Dog Mine are regulated to meet permit conditions. From 2001 to 2007, TDS concentrations were regulated to be less than 500 mg/L at Station 151 (Station 10) during Arctic grayling spawning. During that time frame, monitoring of Arctic grayling spawning was performed to determine when spawning was substantially completed in Mainstem Red Dog Creek, thus allowing Teck to regulate the discharge rate to comply with the post-spawning TDS limit of 1,500 mg/L at Station 151 for the rest of the ice-free 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 EPA approved the 1,500 mg/L TDS SSC on April 21, 2006. The SSC developed by ADEC was based on field and laboratory studies conducted with Arctic grayling at the Red Dog Mine site (Brix and Grosell 2005). Teck regulates the wastewater discharge to ensure that TDS concentrations do not exceed the ADEC approved TDS limit of 1,500 mg/L at Station 151.

In 2019, two fyke nets were set to capture Arctic grayling in North Fork Red Dog Creek from June 7 to June 15. Water flow decreased throughout the fishing period, which allowed the fyke nets to effectively capture fish for the duration of the sampling event. Peak daily water temperatures ranged from 5.3 to 10.1°C.

Limited spawning in Mainstem Red Dog Creek could have started on May 31, when the peak daily water temperature reached 3°C (Figure 57, Table 4). Females captured in the fyke net were judged to be green or ripe and none were determined to be spent. Spawning completion date is determined based on catch of spent females in the North Fork Red Dog Creek fyke net and water temperature data, and could not be determined in 2019 as no spent females were captured.

**Table 4. Summary of Arctic grayling spawning in Mainstem Red Dog Creek. The number of days peak temperature exceeded 4°C 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.**

| Year | Date When Limited Spawning Began (3°C) | Date When Spawning Complete | # of Days Peak Temp > 4°C |
|---|---|---|---|
| 2001 | 6-Jun | 15-Jun | 6 |
| 2002 | 29-May | 8-Jun | 8 |
| 2003 | 7-Jun | 14-Jun | 6 |
| 2004 | 25-May | 31-May | 4 |
| 2005 | 27-May | 6-Jun | 9 |
| 2006 | 30-May | 15-Jun | 10 |
| 2007 | 26-May | 3-Jun | 8 |
| 2008 | 1-Jun | 9-Jun | 9 |
| 2009 | 8-Jun | 13-Jun | 4 |
| 2010[1] | 21-May | 29-May | 6 |
| 2011 | 6-Jun | 9-Jun | 4 |
| 2012 | 27-May | 4-Jun | 7 |
| 2013[2] | | | |
| 2014 | 5-Jun | 11-Jun | 4 |
| 2015 | 28-May | 1-Jun | 4 |
| 2016 | 12-May | 20-May | 8 |
| 2017[3] | 31-May | | |
| 2018[3] | 2-Jun | | |
| 2019[3] | 31-May | | |

[1]The date spawning was judged to be substantially complete was based solely on water temperature data
[2]Arctic grayling sampling was not conducted in spring 2013 due to extremely high water throughout the spring sampling period.
[3]The end of spawning could not be judged, spent females were not captured in the fyke net.

Water temperatures were higher in Mainstem Red Dog Creek than in North Fork Red Dog Creek (Figure 57). This pattern has been observed for multiple years and may be due to a lack of aufeis in Middle Fork Red Dog Creek while massive aufeis exists each spring in North Fork Red Dog Creek. Lack of aufeis in Middle Fork Red Dog Creek is due to the fact that baseline ground water flow has been reduced by the tailing impoundment and the excavated mine cuts which are dewatered.

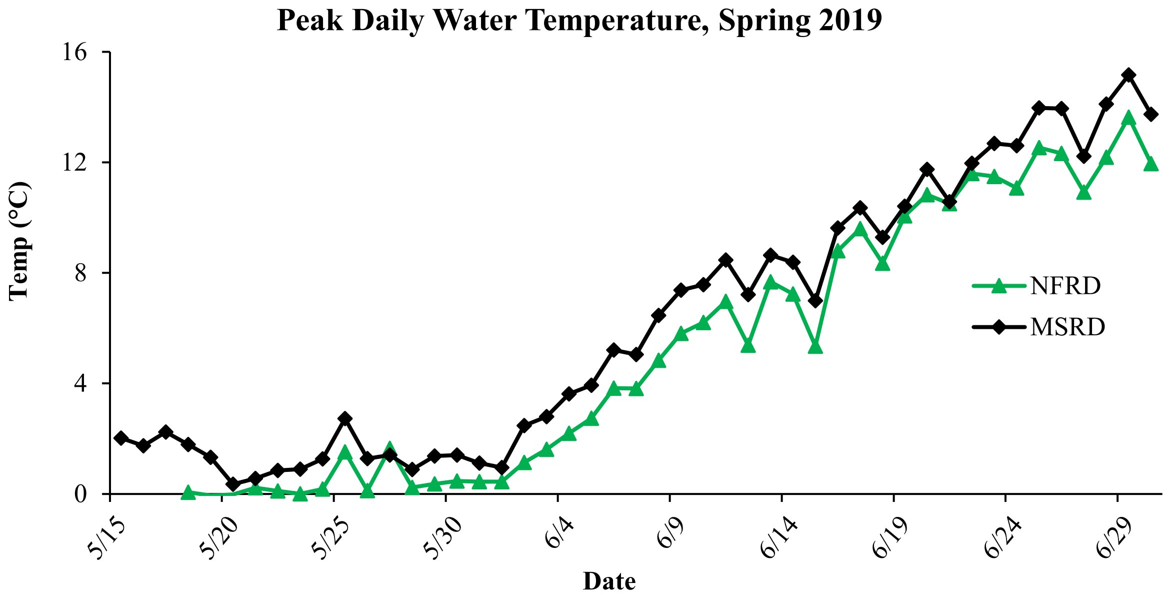


**Figure 57. Peak daily water temperatures in North Fork Red Dog (Station 12) and Mainstem Red Dog (Station 151) creeks, May and June 2019.**

In spring 2019, the catches of Arctic grayling were low, with catches peaking during the first net check on June 7 and decreasing for the remainder of the sampling event (Figure 58). The fyke nets in North Fork Red Dog Creek captured 68 Arctic grayling, 30 of which were immature. Water temperatures did not exceed 3.0°C until June 2 in North Fork Red Dog Creek, and May 31 in Mainstem Red Dog Creek.

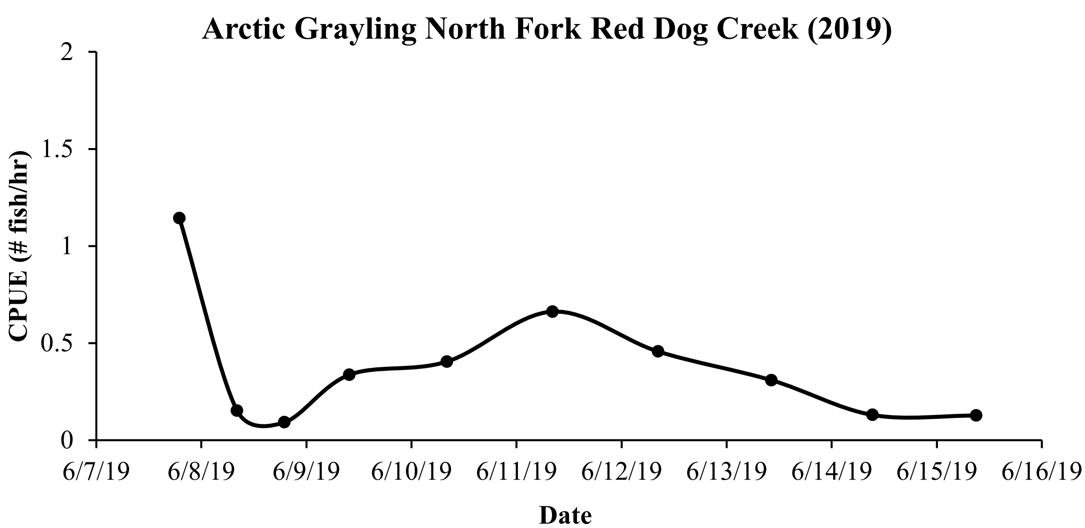


**Figure 58. The CPUE of Arctic grayling in North Fork Red Dog Creek in spring 2019.**

Drift net sampling in early July in Mainstem and North Fork Red Dog creeks resulted in the capture of six larval Arctic grayling in North Fork Red Dog Creek. These captures confirm successful spawning by Arctic grayling in North Fork Red Dog Creek in 2019.

Recruitment of immature fish to North Fork Red Dog Creek was strong from 2007 to 2016, but was low in 2017 to 2019 (Figure 59). Recruitment may be due in part to juvenile fish leaving Bons Pond and returning to North Fork Red Dog Creek. The low catches in 2017 were likely a result of very cold water from the substantial aufeis in the North Fork Red Dog Creek, and low recruitment in 2018 and 2019 could be due in part to less successful spawning in 2017 due to the aufeis.

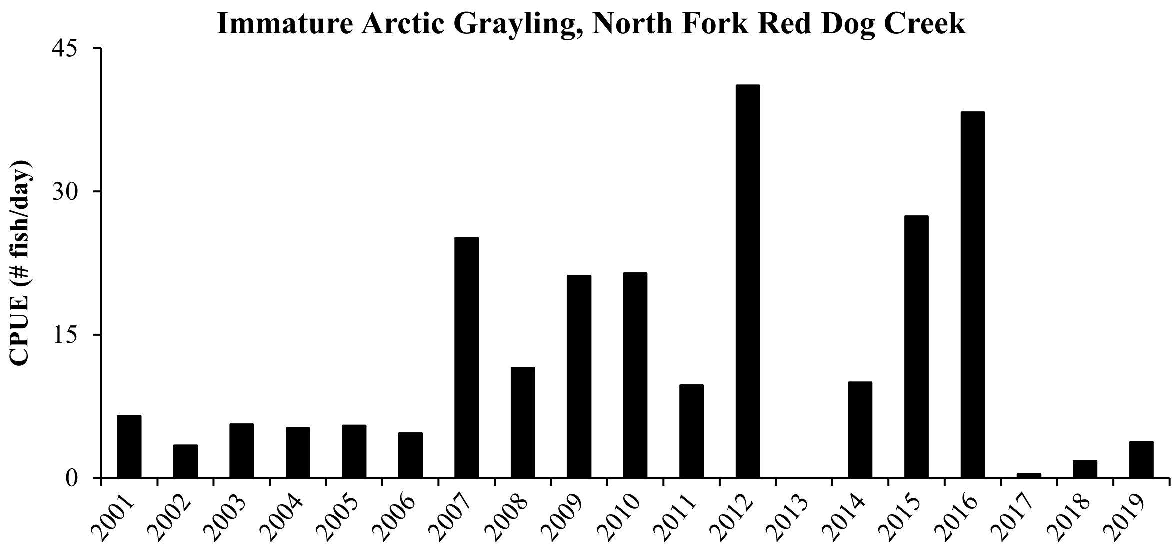


**Figure 59. CPUE of immature Arctic grayling in North Fork Red Dog Creek fyke net during spring sampling. Sampling was not conducted in 2013 due to high water.**

Catches of mature Arctic grayling in North Fork Red Dog Creek have been relatively stable since 2001, with a few exceptions (Figure 60). The highest CPUE of mature fish was 37.6 fish/day in 2007 and the lowest was 1.3 fish/day in 2014. Most of the variability in the catches is related to temporal variability in spring breakup, warming water temperatures, and sampling efficiency. Sampling events are limited to times of lower discharge (≤ 100 cfs) when fyke nets can be set, maintained, and fished effectively.

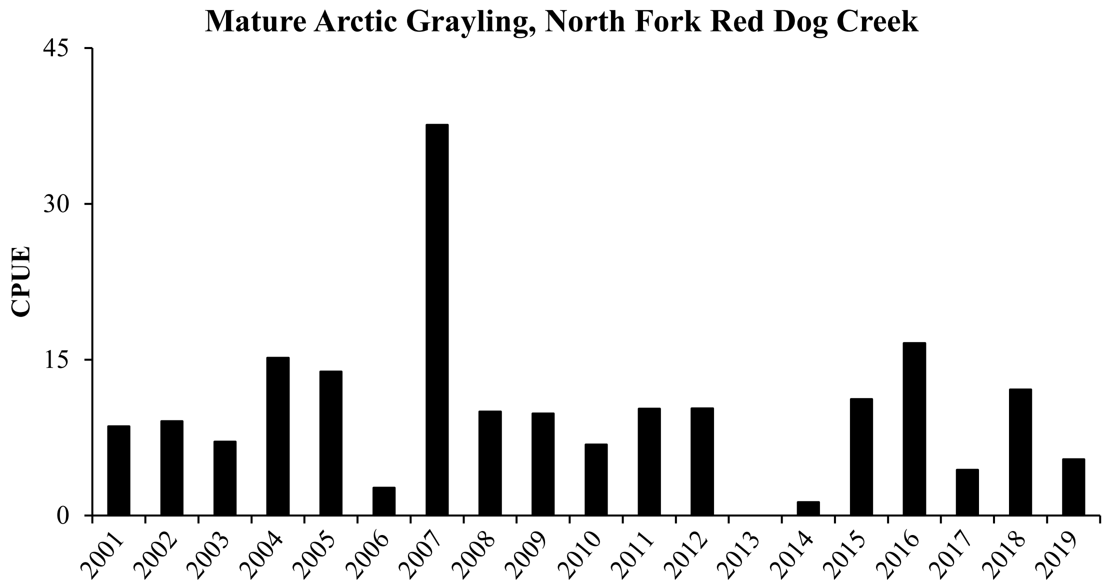


**Figure 60. Average CPUE (fish/day) of mature ("ripe" or "spent") Arctic grayling in North Fork Red Dog Creek from spring 2001 to spring 2019. Sampling was not conducted in 2013 due to high water.**

Some of the Arctic grayling caught in the North Fork Red Dog Creek are fish that were originally tagged in Bons Pond. In 2019, none of the marked fish captured in North Fork Red Dog Creek were Bons Pond tagged fish (Figure 61).

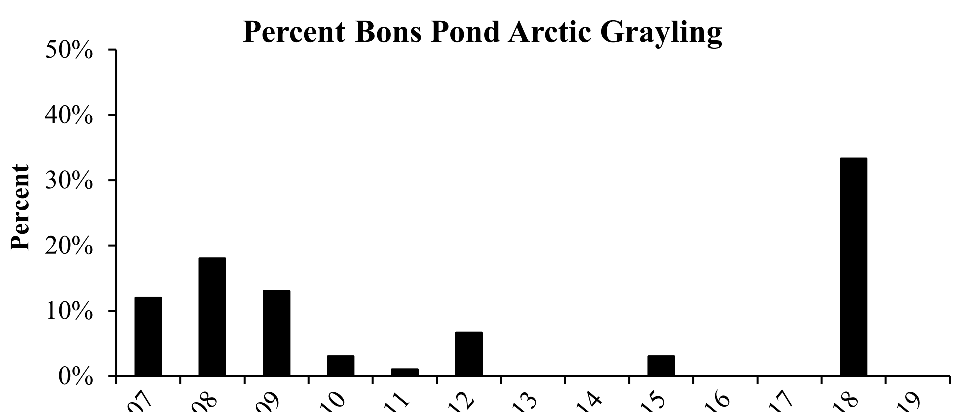


**Figure 61. Percent of Bons Pond marked fish caught in North Fork Red Dog Creek.**

The average growth rate (mm/year) for Arctic grayling between 250 and 300 mm FL when marked and at large for about one year is presented in Figure 62. Fish growth data includes only those fish captured the previous year and recaptured the following spring. Recapture numbers in any given year are low (0 to 7 fish per year).

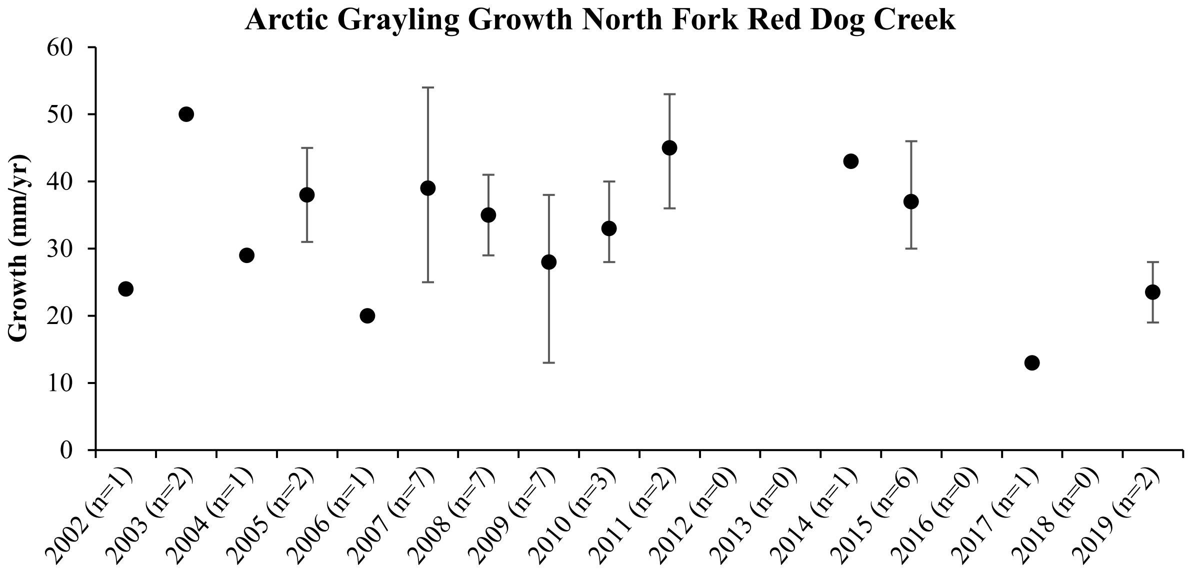


**Figure 62. Average, maximum, and minimum annual growth of Arctic grayling in North Fork Red Dog Creek for fish between 250 and 300 mm FL when marked.**

The population of Arctic grayling in North Fork Red Dog Creek, pre-mining, is not known. The highest population estimate post-mining was 1,422 fish ≥ 200 mm FL in 2010 and the lowest estimate was 905 fish ≥ 200 mm FL in 2015 (Figure 63). The confidence limits overlap for all of the population estimates suggesting that there are no substantial differences among years. There were two recaptures in 2019, resulting in a large 95% confidence interval for the population estimate.

The mean size of captured Arctic grayling in North Fork Red Dog Creek in 2019 was 272 mm FL. Sizes ranged from 130 mm FL to 439 mm FL (Figure 64). Only fish over 200 mm FL were tagged.

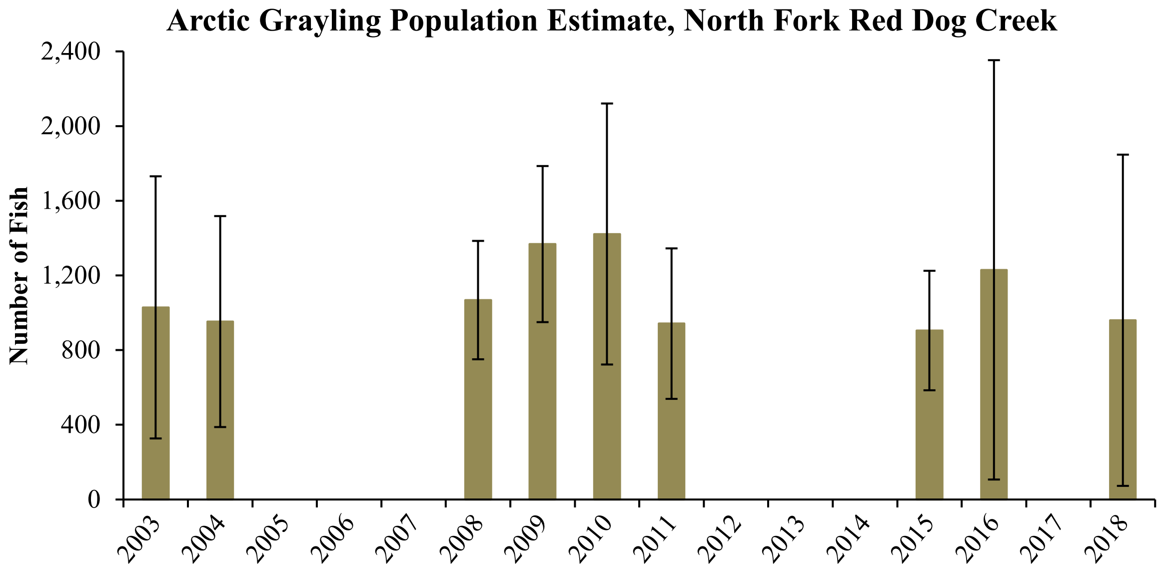


**Figure 63. The estimated Arctic grayling population (95% CI) in North Fork Red Dog Creek for fish ≥ 200 mm FL.**

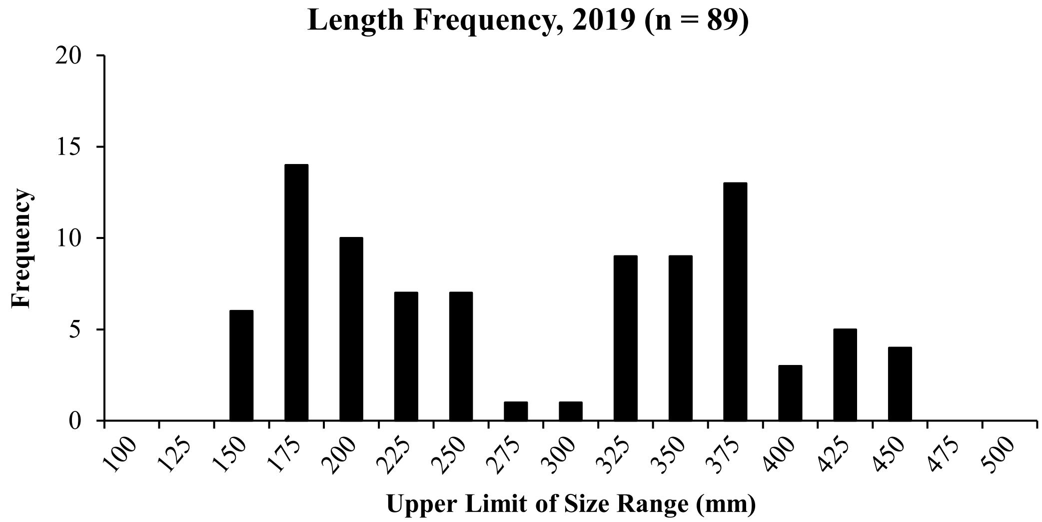


**Figure 64. Length frequency distribution of Arctic grayling (n = 89) in North Fork Red Dog Creek, spring 2019.**

### Arctic Grayling, Bons Pond

Bons Pond is an impoundment created by construction of an earthen dam placed on Bons Creek. The dam was built in 1987/1988 to provide potable and make-up water for operational activities. Prior to construction of the dam, there were no fish present in Bons Creek due to a series of impassable waterfalls and chutes in bedrock about 1 km downstream of the dam (Figure 65). Bons Creek flows into Buddy Creek and eventually into Ikalukrok Creek.

**Figure 65. Outlet of Bons Pond – Arctic grayling leaving Bons Pond go over the falls and into Bons Creek.**

The Arctic grayling population in Bons Pond is the result of a fish transplant conducted in 1994 and 1995 (Ott and Townsend 2003). In 1994, 102 Arctic grayling from North Fork Red Dog Creek that ranged in size from 158 to 325 mm FL and five Arctic grayling from Ikalukrok Creek (350 to 425 mm FL) were transplanted to Bons Pond. In 1995, about 200 Arctic grayling fry were caught in North Fork Red Dog Creek and moved to Bons Pond.

In 1996 and 1997 visual observations and fyke net sampling in Bons Pond were conducted and no fish were caught or observed. From 1995 to 1997, 12 of the marked Arctic grayling transplanted to Bons Pond were recaptured in North Fork Red Dog Creek. Initially, it was believed that the fish transplant was unsuccessful. However, in 2001 and 2002 Arctic grayling juveniles were observed in Bons Creek immediately downstream of the blast road. In summer 2003, fish sampling was conducted in Bons Pond to determine fish use and the estimated Arctic grayling population was 6,773 fish $\geq$ 200 mm FL (Ott and Townsend 2003).

Since 2003, Bons Pond and Bons Creek have been sampled in the spring with additional sampling later in the ice-free season to increase the number of marked fish and catch juveniles for element analysis. Spawning has been observed in Bons Creek and in the outlet of Bons Pond. The current program in Bons Pond includes a mark/recapture study to estimate the population size and the collection of 15 juvenile Arctic grayling for whole body element analysis.

Bons Creek, upstream of Bons Pond, is incised with streambanks vegetated with willows and sedges, and measures 1 to 2 m wide with depths from 0.3 to 1 m. In the sample reach, located about 200 m upstream of Bons Pond, the substrate consists of gravel in riffles, with fine sediments and organics in the pools.

A diversion ditch was constructed to carry surface water around the overburden stockpile. Thermal and hydraulic erosion in the diversion ditch contributes seasonally to the sediment and organic load in Bons Creek. Most of the Bons Creek drainage area is in ice-rich permafrost with thermal erosion and sediment/organic input that varies with seasonal conditions. Generally, there is a high input of sediments and organics to Bons Creek, particularly during rainfall events.

The aquatic invertebrate sampling methodology that was described earlier in this report also is simultaneously used to sample larval fish. In Bons Creek, upstream of Bons Pond, catches of Arctic grayling fry have ranged from zero to 132 in 16 years of sampling. The highest number of Arctic grayling fry caught in the drift nets was 132 in 2019 (Figure 66).

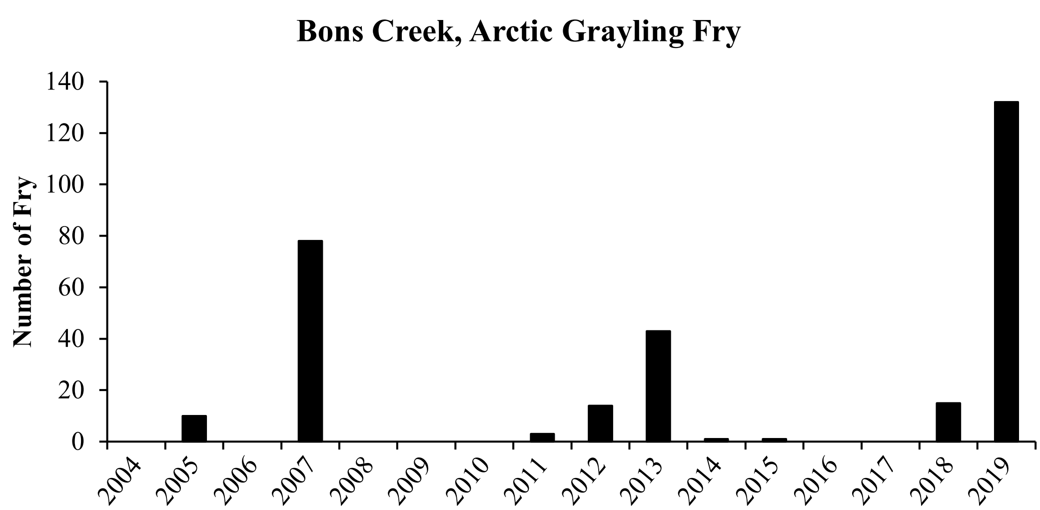


**Figure 66. Number of Arctic grayling fry caught in drift nets 2004 – 2019.**

A fyke net fished in Bons Creek from June 6 – 13, 2019 caught 74 unique Arctic grayling; 14 of these fish were too small to tag (< 200 mm FL). Two fyke nets set in Bons Pond resulted in the capture of an additional 189 Arctic grayling of taggable size and 3,873 juvenile Arctic grayling under 100 mm FL. Most of these small fish were not measured, to avoid stress-related mortality.

A subset of these small fish (n = 30) were measured, and ranged from 55 to 93 mm FL, with an average length of 71.1 mm. Of the 249 fish that were ≥ 200 mm FL, six large, mature females were retained for selenium analysis, 78 were recaptures, and 165 were tagged. The mean CPUE (#fish/day) for all fish in the Bons Creek fyke net in 2019 was 11, the lowest seen since sampling began (Figure 67). The CPUE for Arctic grayling < 200 mm FL was 2 in 2019, and has ranged from 1 to 38 since 2006 (Figure 68).

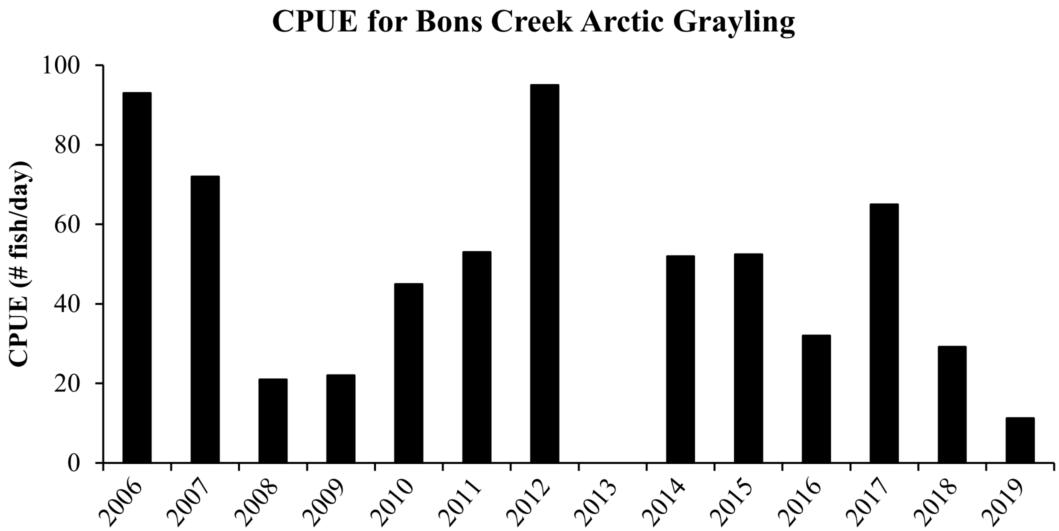


**Figure 67. CPUE for all Arctic grayling in Bons Creek 2006–2019. Sampling was not done in 2013 due to high water.**

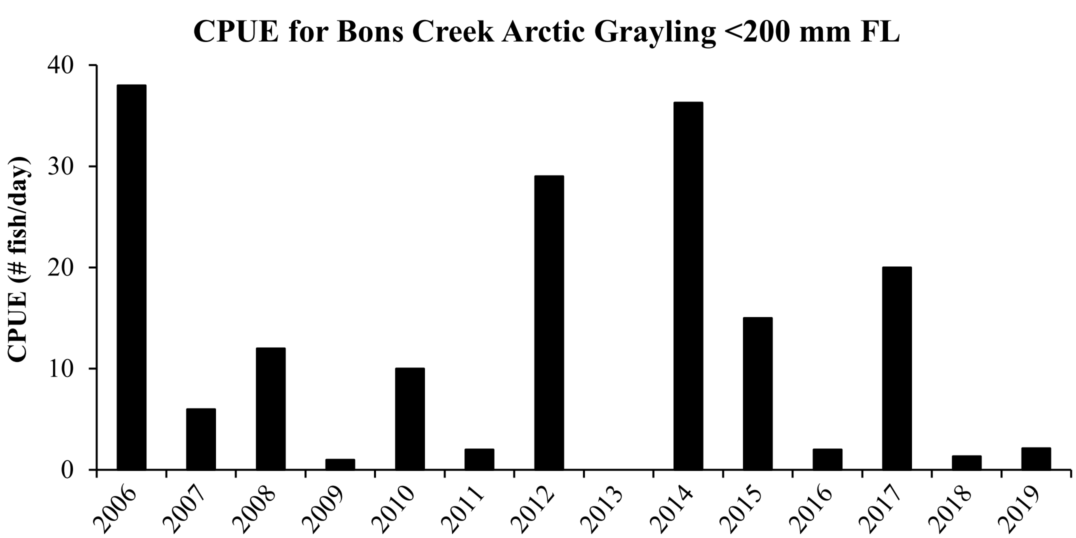


**Figure 68. CPUE for Arctic grayling < 200 mm FL in Bons Creek 2006–2019. Sampling was not done in 2013 due to high water.**

The length frequency distribution for Arctic grayling caught in fyke nets and by angling in spring 2019 is presented in Figure 69. The length frequency distribution in Bons Pond fish had been relatively consistent over the past several years, with a stable population of mature fish 300 – 390 mm. In 2019, a large number of fish 50 – 100 mm (n = 3,873) were captured, which were likely age-1 fish. This was not the case in 2018, where very few fish <250 mm FL were captured.

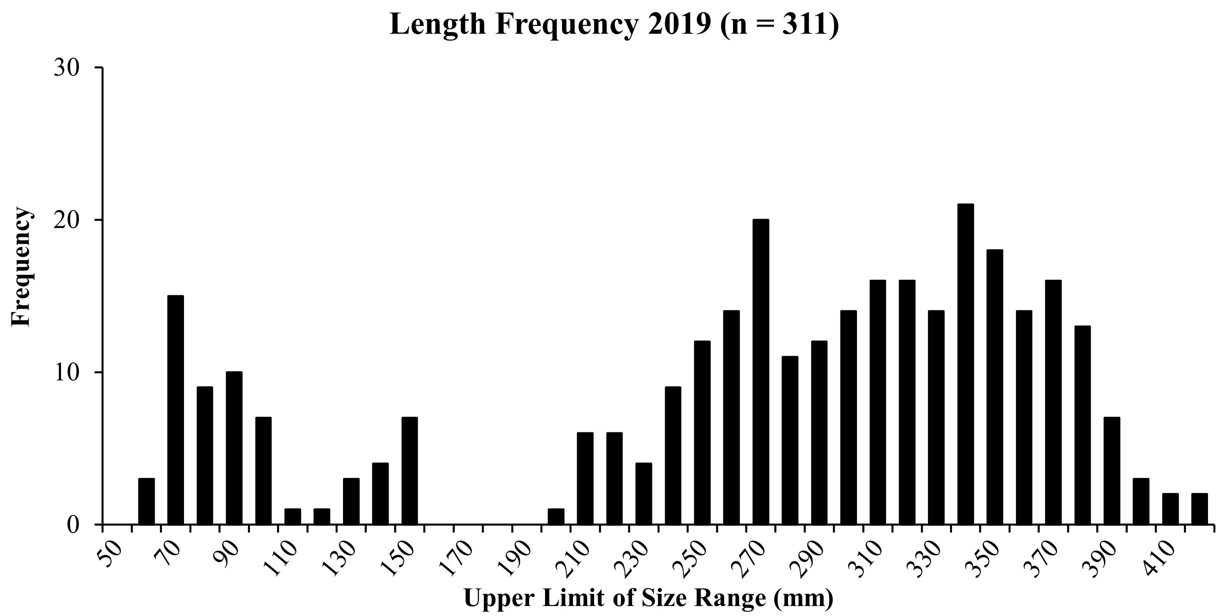


**Figure 69. Length frequency distribution of Arctic grayling in Bons Pond in spring 2019. Of fish < 100 mm, this figure only includes the subset (n = 30) that were measured. An additional 3,843 fish < 100 mm were captured and released without length measurement.**

Growth rates for Arctic grayling from Bons Pond are lower than for comparable sized fish from North Fork Red Dog Creek. Only growth data for fish ≥ 250 mm FL (at the time of marking) are presented as there are very few recaptures of marked fish from 200 to 249 mm FL (Figure 70). The average annual growth rate was 12 mm in 2018, and has ranged from a high of 26 mm in 2017 to a low of 2 mm in 2003. Higher growth rates since 2011 could be related to the population decline which has resulted in increased food availability.

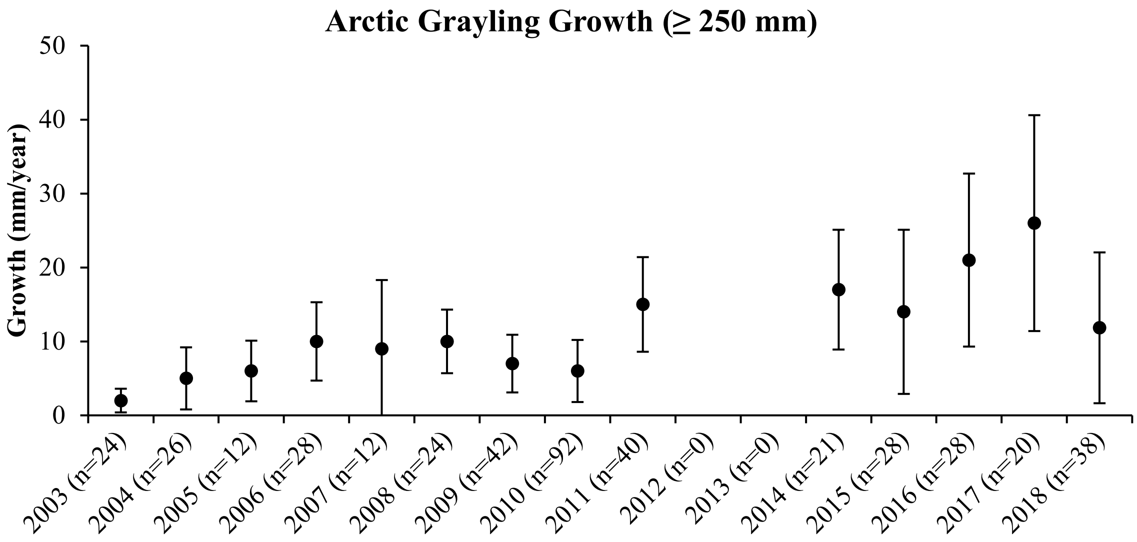


**Figure 70. Average annual growth (+ 1 SD) of Arctic grayling ≥ 250 mm FL at time of marking.**

The 2018 Arctic grayling population in Bons Pond was estimated by using 2018 as the mark event (n = 165) and spring 2019 as the recapture event (n = 214). In spring 2019, 38 of the fish were recaptures from the spring 2018 mark event. Based on these values, the estimated Arctic grayling population for 2018 was 914 fish (95% CI, 690 to 1,139 fish) ≥ 200 mm FL, a decrease from the 2017 estimate of 1,572 fish (Figure 71).

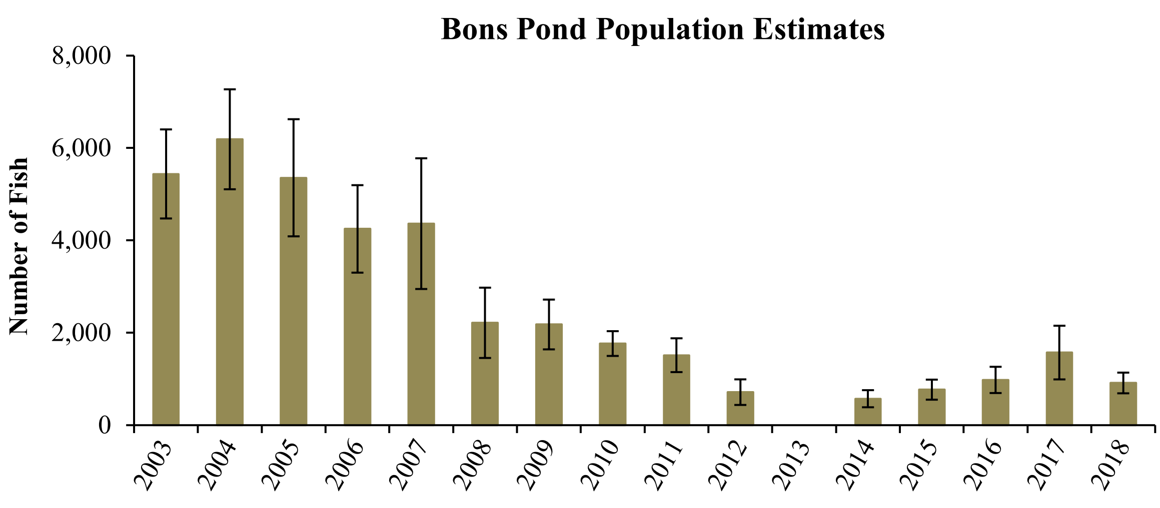


**Figure 71. Estimated Arctic grayling population (95% CI) in Bons Pond for fish ≥ 200 mm FL.**

**Slimy Sculpin**

Prior to development of the Red Dog Mine, Houghton and Hilgert (1983) found slimy sculpin in Ikalukrok and Dudd creeks, but none were observed or caught in the Red Dog Creek drainage. However, in 1995, slimy sculpin were captured in both Mainstem Red Dog and North Fork Red Dog creeks (Weber Scannell and Ott 1998). In some years slimy sculpin are caught in North Fork Red Dog Creek during the spring Arctic grayling sampling event with fyke nets. In spring 2019, 10 slimy sculpin was caught. Slimy sculpin are likely following the Arctic grayling to feed on their eggs and they may spawn in North Fork Red Dog Creek.

Slimy sculpin caught in minnow traps during the August sampling event in lower Mainstem Red Dog Creek is presented in Figure 72. There is no apparent trend with CPUE which ranges from zero to a high of 8 in 2018.

In 2010, the minnow trap sample reach from Station 7 on Ikalukrok Creek was moved to a new site on the same system, upstream of Station 160. The new sample reach in Ikalukrok Creek has multiple channels, similar to the original sample site at Station 7. The water quality monitoring station was moved downstream in 2010 to ensure waters from Dudd and Ikalukrok creeks were completely mixed.

Slimy sculpin CPUE in Ikalukrok Creek has varied from a low of 0 to a high of 24 in 2004 (Figure 72). Catches of slimy sculpin are generally higher in Ikalukrok Creek than in the other sample reaches located in North Fork Red Dog, Mainstem Red Dog, upper Ikalukrok (Station 9), Buddy, Anxiety, and Evaingiknuk creeks. These data are consistent with findings by Houghton and Hilgert (1983) in the early 1980s prior to development of the Red Dog Mine when they reported slimy sculpin to be numerous in Ikalukrok Creek. The main difference is that slimy sculpin are now also captured in the Red Dog Creek drainage.

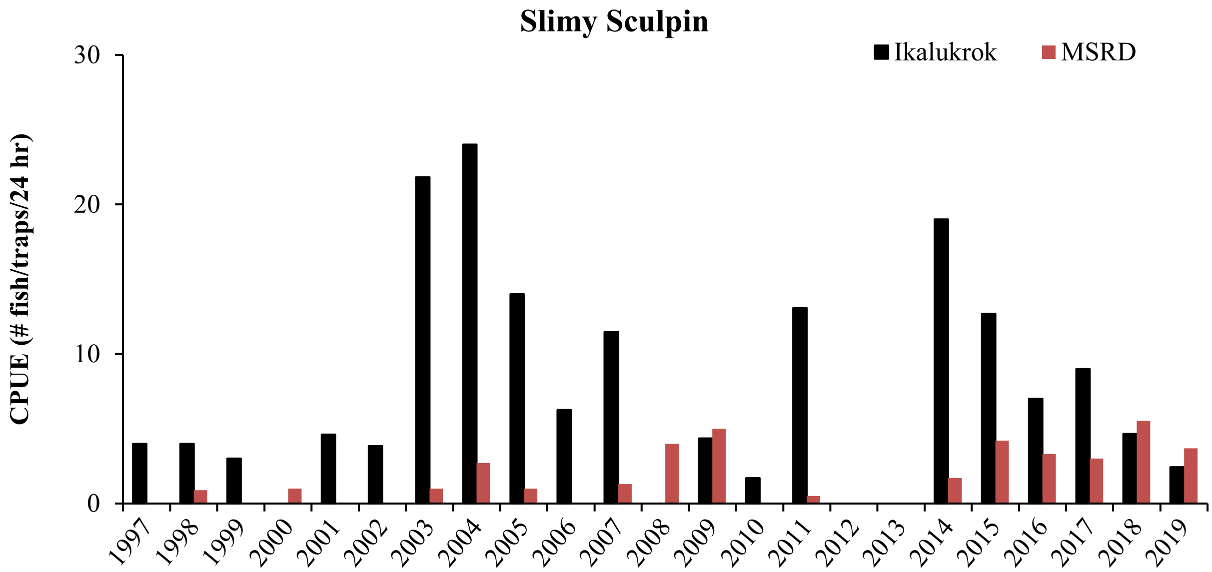


**Figure 72. CPUE of slimy sculpin caught in Ikalukrok Creek and Mainstem Red Dog Creek. No sampling was performed in 2012 or 2013 due to high water.**

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# Appendix 1. Summary of Red Dog Mine Development and Operations, 2014-2019.[a]

## 2014

- Technical Report No. 14-02 titled "Aquatic biomonitoring at Red Dog Mine, 2013 National Pollution Discharge Elimination System Permit (NPDES) No. AK-003865-2" was submitted to EPA and ADEC on February 28, 2014.
- April 8, ADEC issued Modification #1 to the APDES Permit (AK0038652) which authorized a mixing zone for selenium and adjusts Outfall 001 effluent limits for selenium. The modification became effective on May 8, 2014.
- Discharge through Outfall 001 to Middle Fork Red Dog Creek began on May 1, 2014 and ended on September 20, 2014.
- May 5, TDS concentrations at Station 151 as measured with a conductance probe exceeded the TDS limit of 1,500 mg/L – measures will be implemented (during episodic freezing conditions conductance probes will be removed and washed and checks will be made with calibrated, hand-held instruments).
- May 28, ice buildup in the clean water bypass culvert caused water to overflow. The water was collected and pumped back into the creek for about 24 hr until it was determined that it may have mixed with mine contact water. Pumping was then diverted to the mine water drainage containment system. Water quality changes downstream during this 24 hr period were undetectable at monitoring stations.
- A DIDSON® side-scanning sonar was operated in the lower Wulik River from May 30 to June 6 – over this time period 229 fish moved downstream and 52 moved upstream – water remained high and turbid during the entire sample period.
- June 5, Teck filed a court report stating that it was exercising their option not to build a pipeline to the coast.
- The spring spawning migration of Arctic grayling in Bons Pond/Bons Creek and North Fork Red Dog Creek was sampled from June 7 to 16. Adult Dolly Varden were collected for metals analyses in tissues and adult Arctic grayling were retained from Bons Creek for selenium analysis of ovaries.
- July 26 to August 2, periphyton, aquatic invertebrate, and juvenile fish sampling was done at all nine sites in accordance with permit requirements. In addition, aquatic biomonitoring was conducted in Volcano, Competition, Sourdock, and Upper North Fork Red Dog creeks.
- Two aerial surveys of Dolly Varden in the Wulik River were flown (September 21 and October 7, 2014). The chum salmon survey in Ikalukrok Creek also was done on September 21. Radio-tags were placed in 15 adult Dolly Varden in the Wulik River – these fish will be monitored next year during the spring outmigration.
- December 1, DNR administratively extended the Final Reclamation Plan approval (F20099958) to July 2, 2015.

[a] The summary of previous years of mine development and operations (1982 to 2013) can be found in Ott and Morris 2014.

**2015**

- January 6, ADF&G by email indicated that we would be willing to assume regulatory oversight over Teck's maintenance of the fish weir on Middle Fork Red Dog Creek.
- January 22, ADF&G by letter reported a summary of selenium data (ovaries and livers) collected on Arctic grayling females at the Red Dog Mine, Fort Knox Mine, and from the Chena River near Fairbanks.
- February 10, Habitat (Parker Bradley) gave a presentation at the Alaska Center for the Environment Forum in Anchorage on biomonitoring at Red Dog, Fort Knox, and Greens Creek.
- Technical Report No. 15-01 titled "Aquatic biomonitoring at Red Dog Mine, 2014 Alaska Pollution Discharge Elimination System Permit (APDES) No. AK00038652" was submitted to EPA and ADEC.
- Discharge through Outfall 001 to Middle Fork Red Dog Creek began on May 12 and ended on September 19.
- April 21, ADF&G by letter proposed to collect Arctic grayling females in Fish Creek (Fort Knox Mine) and at several sites (North Fork Red Dog, Bons, and Tutak creeks) near the Red Dog Mine and have the ovaries analyzed for selenium.
- A DIDSON® side-scanning sonar was operated in the lower Wulik River from May 30 to June 13 – over this time period 26,613 fish moved downstream and 26,577 moved upstream, with much milling behavior observed.
- The spring spawning migration of Arctic grayling in Bons Pond/Bons Creek and North Fork Red Dog Creek was sampled from May 28 to June 3. Adult Dolly Varden were collected for metals analyses in tissues and adult Arctic grayling were retained from Bons, North Fork Red Dog, and Tutak creeks for selenium analysis of ovaries.
- June 30, the fish protection barrier on Middle Fork Red Dog Creek was inspected by Teck
- July 9 - 12, periphyton and aquatic invertebrate sampling was done at all nine sites in accordance with permit requirements. In addition, aquatic biomonitoring was conducted at seven sites near the Anarraaq Prospect and at one site in Upper North Fork Red Dog creek.
- July 29 - August 3, juvenile fish sampling was done at all nine sites in accordance with permit requirements. In addition, juvenile fish sampling was conducted at seven sites near the Anarraaq Prospect.
- September 13 and 15, two aerial surveys were conducted: one on the Wulik River and the second on Ikalukrok Creek. The estimated number of Dolly Varden in the Wulik River was 71,484. The estimated number of chum salmon in Ikalukrok Creek was 5,733.
- September 30, DNR by letter extended the approval of the Red Dog Mine Reclamation Plan.
- October 22, ADF&G by letter provided a summary of Wulik River and Ikalukrok Creek aerial surveys for Dolly Varden and chum salmon.
- November 18, ADF&G by letter provided a copy of the report titled "Red Dog Mine June 2015 Wulik River Dolly Varden Enumeration Report" that summarized work done by Sport Fish Division in spring 2014 and 2015.

**2016**

- Technical Report No. 16-01 titled "Aquatic biomonitoring at Red Dog Mine, 2015 Alaska Pollution Discharge Elimination System Permit (APDES) No. AK00038652" was submitted to EPA and ADEC on February 27.
- April 15, ADF&G, by letter, submitted the work plan for fish and aquatic taxa studies to be conducted from July 1, 2016 to June 30, 2017.
- Discharge through Outfall 001 to Middle Fork Red Dog Creek began on May 1 and ended on September 24.
- The spring spawning migration of Arctic grayling in Bons Pond/Bons Creek and North Fork Red Dog Creek was sampled from May 18 to 23. Adult Dolly Varden were collected for element analyses in tissues and adult Arctic grayling were retained from Bons and North Fork Red Dog creeks for selenium analysis of ovaries.
- July 2 to 5, periphyton and aquatic invertebrate sampling were done at all nine sites in accordance with permit requirements. In addition, aquatic biomonitoring (periphyton and aquatic invertebrates) was conducted at several sites near the Anarraaq Prospect and at one site in Upper North Fork Red Dog creek.
- August 4 to 7, juvenile fish sampling using minnow traps was conducted at all the APDES sample sites and at sites located in the vicinity of the Anarraaq Prospect.
- September 28, DNR issued the reclamation plan approval.
- September 28, Teck, by letter, submitted their field inspection of the Fish Protection Barrier on Middle Fork Red Dog Creek.
- Aerial surveys for Dolly Varden and chum salmon were conducted in September and October. Chum salmon numbers (live and dead) in Ikalukrok Creek were estimated at 913 fish on September 15. The total count of Dolly Varden in the Wulik River was 56,818 in September and 70,802 in October.

**2017**

- February 8, ADEC notified Teck that the aquatic biomonitoring report for 2016 data deadline was extended to May 15.
- March 17, ADF&G by email provided comments regarding operation of a new water treatment plant for the construction camp.
- March 21, ADF&G by email asked questions about an ore spill in the vicinity of Buddy Creek.
- May 7, discharge through Outfall 001 to Middle Fork Red Dog Creek began, ended on September 23.
- May 15, ADF&G emailed Technical Report No. 17-07 "Aquatic Biomonitoring at Red Dog Mine, 2016" to DEC.
- May 23, ADF&G by email provided input to Teck regarding the expansion of the waste rock dump to the south – recommendation was to stay north of Bons Creek making sure a buffer remained.
- May 28 - June 4, the spring spawning migration of Arctic grayling in Bons Pond/Bons Creek and North Fork Red Dog Creek was sampled. Adult Dolly Varden were collected for element analyses in tissues and adult Arctic grayling were retained from Bons and North Fork Red Dog creeks for selenium analysis of ovaries.
- The spring sampling effort for Arctic grayling also included Little Creek, a Tutak River tributary). Little Creek was added as a sample site for female Arctic grayling as North Fork Red Dog Creek was completely inundated with aufeis.
- June 8, DNR by email notified the COE that changes to state permits (DNR and DEC) would be required for expansion of the waste rock storage facility.
- July 10, Teck notified ADF&G by letter of snow/ice work at bridges and culverts conducted during spring.
- July 2 - 5, periphyton and aquatic invertebrate sampling were done at all nine sites in accordance with permit requirements. In addition, aquatic biomonitoring (periphyton and aquatic invertebrates) was conducted at several sites near the Anarraaq Prospect and at one site in Upper North Fork Red Dog creek.
- July 12, ADF&G by email provided input to Teck regarding access, exploratory road, to the Anarraaq and Aktigiruq prospects which involves multiple stream crossings of Ikalukrok Creek and one crossing of North Fork Red Dog Creek.
- July 27, a drill cuttings spill was reported near Barb Creek.
- July 28, ADEC issued the new APDES permit (AK0038652) for discharge of water at Outfall 001 to Middle Fork Red Dog Creek, effective September 1, 2017.
- August 2 - 9, juvenile Dolly Varden sampling performed at all the APDES sample sites and sites located in the vicinity of the Anarraaq/Aktigiruq prospect. Water levels at all sites were unusually high.
- October 2, DeCicco provided a summary of aerial surveys for Dolly Varden in Wulik River and chum salmon in Ikalukrok Creek and he collected seven adult Dolly Varden for tissue analyses.
- October 30, ADF&G by email to DEC distributed Technical Report 17-09 titled "Methods for Aquatic Life Monitoring at the Red Dog Mine Site" to satisfy a condition in the new APDES permit issued by ADEC.

**2018**

- January 9, ADF&G by email provided comments to ADNR regarding material extractions at Red Dog MS-9 and Red Dog DD-2.
- April 25, ADF&G by email provided information to Teck on mercury in fish tissues in regard to human consumption.
- May 7, ADF&G by email transmitted Technical Report No. 18-06 “Aquatic Biomonitoring at Red Dog Mine, 2017” to DEC.
- May 15, Teck received approval from DNR-Dam Safety Unit to increase nominal crest elevation of the Tailings Back Dam by 10 feet from 986 feet to 996.5 feet.
- June 12-18, the spring spawning migration of Arctic grayling in Bons Pond/Bons Creek and North Fork Red Dog Creek was sampled. Adult Dolly Varden were collected for element analyses in tissues and adult Arctic grayling were retained from Bons and North Fork Red Dog creeks for selenium analysis of ovaries.
- June 25, ADNR DMLW issued Red Dog Mine Reclamation Plan Amendment Approval F20169958.01 (RPA) to expand the Tailings Storage Facility and Main Waste Dump.
- July 13, ADNR DMLW issued a Certificate of Approval to Modify a Dam to Teck for the Stage XI raise on the Red Dog Tailings Main Dam (NID ID# AK00201).
- July 9 - 16, periphyton and aquatic invertebrate sampling were done at all nine sites in accordance with permit requirements. In addition, aquatic biomonitoring (periphyton and aquatic invertebrates) was conducted at sites near the Anarraaq Prospect and at one site in Upper North Fork Red Dog creek.
- August 1, Teck issued a memo regarding orange precipitate in Red Dog Creek caused by two natural metal seeps above the diversion system.
- August 13, Teck issued a 5-day notification letter to ADEC explaining the cause of the exceedance of allowed TDS values at Station 151.
- August 2 - 9, juvenile Dolly Varden sampling performed at all the APDES sample sites and sites located in the vicinity of the Anarraaq/Aktigiruq prospect.
- October 4 - 5, ADF&G and DeCicco conducted aerial surveys for Dolly Varden in Wulik River and chum salmon in Ikalukrok Creek and collected seven adult Dolly Varden for tissue analyses.

**2019**

- January 25, ADF&G issued a memo about the elevated zinc concentrations observed in Red Dog Creek during open water, 2018.
- April 16, ADF&G issued a memo regarding inconsistent mercury results in 2018 adult Dolly Varden tissues from ACZ labs.
- May 7, ADF&G by email transmitted Technical Report No. 19-08 “Aquatic Biomonitoring at Red Dog Mine, 2018” to DEC.
- May 3, Golder Associates Inc. issued technical memorandum “Assessment of Increasing Zinc Concentration in Red Dog Creek and Tributaries.”
- May 13, discharge through Outfall 001 to Red Dog Creek was initiated under APDES Permit #AK0038652.
- June 6 - 15, the spring spawning migration of Arctic grayling in Bons Pond/Bons Creek and North Fork Red Dog Creek was sampled. Adult Dolly Varden were collected for tissue element analyses and adult Arctic grayling were retained from Bons and North Fork Red Dog creeks for selenium analysis of ovaries.
- July 1 - 8, periphyton and aquatic invertebrate sampling was done at all ten sites in accordance with permit requirements. In addition, aquatic biomonitoring (periphyton and aquatic invertebrates) was conducted at 12 sites near the Anarraaq Prospect.
- July 9 – 11, DNR, DEC, and ADF&G personnel conducted a multi-agency site visit to review current Red Dog operations and future expansion plans of the mine site and exploration for Anarraaq and Aktigiruq deposits.
- August 2, DEC sent a letter to Teck pertaining to Tundra Restoration in response to oil and hazardous materials spills.
- August 3 – 10, juvenile Dolly Varden sampling performed at all the APDES sample sites and sites located in the vicinity of the Anarraaq/Aktigiruq prospect.
- August 21, DNR Dam Safety issued a letter regarding survey control at Red Dog Mine. The maximum allowed operating pond was revised to nominal 980 feet pending additional detailed survey and modification for the Stage XI dam raise.
- August 23, DEC issued a temporary waiver of the Secondary Containment Requirement for the Teck Alaska Inc. Red Dog Operations Oil Discharge Prevention and Contingency Plan (ADEC Plan #17-CP-3050).
- September 10, discharge from Outfall 001 was halted for the year due to elevated TDS at Station 160. Discharge was also limited in August due to elevated TDS.
- September 20, DeCicco conducted aerial surveys for Dolly Varden in the Wulik River and chum salmon in Ikalukrok Creek, but could not complete the surveys due to high turbidity in Ikalukrok Creek and the Wulik River. Seven adult Dolly Varden were collected from the Wulik River for tissue analyses.
- October 13 – 14, ADF&G conducted aerial surveys for Dolly Varden in Wulik River, but could only obtain an incomplete count due to high turbidity in Ikalukrok Creek and the Wulik River.
- November 1, Teck ceased backfilling of the exhausted Main Pit to prevent 50-60 million gallons of water from being pumped into the Tailings Storage Facility (TSF).
- November 4, ADF&G submitted a nomination to add coho rearing in Red Dog, Anxiety Ridge, Buddy, Dudd, and Ikalukrok creeks to the Anadromous Waters Catalog.

- November 23, Teck commenced construction and installation of a reverse flow pumping system to direct reclaimed and seepage water to the Aqqaluk Pit. Aqqaluk Pit will store between 150-300 million gallons of water.
- December 12, DNR issued Temporary Water Use Authorization F2019-134 for Teck to pump 70 million gallons of water from the TSF and impound and freeze the water into ice cells/ice fields upgradient of the TSF. Once weather warms in the summer season this ice will melt and will flow or be pumped back into the TSF.

**2020**

- January 8, Golder Associates Inc. issued "Summary Report of Zinc Concentrations, Red Dog Creek and Tributaries."
- February 14, DNR Amendment 3 to Reclamation Plan F20169958 to amend the closure design of the Main Waste Stockpile from an engineered compacted soil cover to a geosynthetic liner and cover design.
- February 19, DEC-Water issued addendum 2 to APDES Permit AK0038652 after determining that commissioning of a Reverse Osmosis Water Treatment Facility would have no or de minimis impacts to wastewater discharge.
- February 28, Teck submitted the Stage XIA Interim Dam Raise Design Report to DNR-Dam Safety.

## Appendix 2. Periphyton Standing Crop, Red Dog Mine Monitoring Sites, 2019. 

Results below the detection limit are shaded in gray.

| 2019 Chloro Results - Red Dog | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| IDL = 0.45 mg/m2 | | | Linear Check Max = 71.77 mg/m2 | | | | | |
| EDL = 0.23 mg/m2 | | | | | Phaeo Corrected | | | |
| Daily Vial # | Site | Date Analyzed | Vial Chl a | Chl a $mg/m^2$ | **Chl a $mg/m^2$** | **664/665 Ratio** | Chl b $mg/m^2$ | Chl c $mg/m^2$ |
| 41 | Bons u/s Buddy Sta 220 | 12/16/19 | 5.41 | 21.62 | 18.16 | 1.54 | 4.81 | 0.49 |
| 43 | Bons u/s Buddy Sta 220 | 12/16/19 | 2.76 | 11.03 | 9.18 | 1.54 | 2.49 | 0.61 |
| 45 | Bons u/s Buddy Sta 220 | 12/16/19 | 1.50 | 5.99 | 5.23 | 1.58 | 1.01 | 0.44 |
| 47 | Bons u/s Buddy Sta 220 | 12/16/19 | 3.80 | 15.21 | 13.35 | 1.58 | 3.95 | 0.51 |
| 49 | Bons u/s Buddy Sta 220 | 12/16/19 | 2.65 | 10.61 | 9.51 | 1.62 | 0.00 | 0.91 |
| 51 | Bons u/s Buddy Sta 220 | 12/16/19 | 3.90 | 15.61 | 13.46 | 1.58 | 0.00 | 1.33 |
| 53 | Bons u/s Buddy Sta 220 | 12/16/19 | 0.17 | 0.68 | 0.64 | 1.67 | 0.06 | 0.04 |
| 55 | Bons u/s Buddy Sta 220 | 12/16/19 | 7.30 | 29.20 | 21.36 | 1.44 | 7.07 | 1.07 |
| 86 | Buddy u/s road Sta 221 | 12/13/19 | 0.10 | 0.41 | 0.32 | 1.50 | 0.04 | 0.04 |
| 88 | Buddy u/s road Sta 221 | 12/13/19 | 0.87 | 3.46 | 2.99 | 1.58 | 0.03 | 0.39 |
| 90 | Buddy u/s road Sta 221 | 12/13/19 | 1.60 | 6.38 | 5.45 | 1.57 | 0.57 | 0.57 |
| 92 | Buddy u/s road Sta 221 | 12/13/19 | 1.29 | 5.16 | 4.81 | 1.66 | 0.00 | 0.46 |
| 94 | Buddy u/s road Sta 221 | 12/13/19 | 0.36 | 1.46 | 1.28 | 1.60 | 0.00 | 0.20 |
| 96 | Buddy u/s road Sta 221 | 12/13/19 | 0.39 | 1.54 | 1.28 | 1.55 | 0.09 | 0.32 |
| 98 | Buddy u/s road Sta 221 | 12/13/19 | 0.86 | 3.46 | 3.10 | 1.62 | 0.12 | 0.26 |
| 100 | Buddy u/s road Sta 221 | 12/13/19 | 1.31 | 5.23 | 4.81 | 1.64 | 0.20 | 0.42 |
| 102 | Buddy u/s road Sta 221 | 12/13/19 | 1.70 | 6.79 | 5.87 | 1.58 | 0.62 | 0.52 |
| 3 | Upper NF Red Dog | 12/18/19 | 0.59 | 2.36 | 2.03 | 1.58 | 0.09 | 0.34 |
| 5 | Upper NF Red Dog | 12/18/19 | 0.24 | 0.96 | 0.85 | 1.62 | 0.00 | 0.17 |
| 7 | Upper NF Red Dog | 12/18/19 | 0.32 | 1.26 | 1.07 | 1.56 | 0.16 | 0.20 |
| 9 | Upper NF Red Dog | 12/18/19 | 0.69 | 2.78 | 2.35 | 1.56 | 0.05 | 0.32 |
| 11 | Upper NF Red Dog | 12/18/19 | 1.00 | 4.00 | 3.42 | 1.57 | 0.07 | 0.49 |
| 13 | Upper NF Red Dog | 12/18/19 | 0.53 | 2.14 | 1.82 | 1.57 | 0.05 | 0.24 |
| 15 | Upper NF Red Dog | 12/18/19 | 1.76 | 7.03 | 5.77 | 1.54 | 0.00 | 0.34 |
| 17 | Upper NF Red Dog | 12/18/19 | 0.32 | 1.30 | 0.96 | 1.45 | 0.31 | 0.13 |
| 19 | Upper NF Red Dog | 12/18/19 | 0.31 | 1.22 | 1.07 | 1.59 | 0.10 | 0.23 |
| 21 | Upper NF Red Dog | 12/18/19 | 1.22 | 4.86 | 4.06 | 1.55 | 0.24 | 0.24 |
| 39 | Bons Ck u/s pond | 12/17/19 | 0.76 | 3.05 | 2.56 | 1.56 | 0.10 | 0.12 |
| 41 | Bons Ck u/s pond | 12/17/19 | 0.73 | 2.93 | 2.46 | 1.53 | 1.09 | 0.16 |
| 43 | Bons Ck u/s pond | 12/17/19 | 0.53 | 2.14 | 1.82 | 1.57 | 0.06 | 0.14 |
| 45 | Bons Ck u/s pond | 12/17/19 | 0.60 | 2.40 | 2.24 | 1.66 | 0.25 | 0.18 |
| 47 | Bons Ck u/s pond | 12/17/19 | 0.39 | 1.55 | 1.28 | 1.55 | 0.03 | 0.16 |
| 49 | Bons Ck u/s pond | 12/17/19 | 0.29 | 1.17 | 0.96 | 1.53 | 0.21 | 0.11 |
| 51 | Bons Ck u/s pond | 12/17/19 | 0.45 | 1.78 | 1.60 | 1.63 | 0.00 | 0.12 |
| 53 | Bons Ck u/s pond | 12/17/19 | 0.54 | 2.14 | 1.71 | 1.52 | 0.00 | 0.27 |
| 55 | Bons Ck u/s pond | 12/17/19 | 0.73 | 2.93 | 2.67 | 1.63 | 0.31 | 0.83 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 41 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.03 | 0.12 | 0.11 | 1.50 | 0.16 | 0.18 |
| 43 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.01 | 0.04 | 0.11 | 0.00 | 0.05 | 0.06 |
| 45 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.02 | 0.08 | 0.11 | 2.00 | 0.10 | 0.12 |
| 47 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 48 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.01 | 0.04 | 0.11 | 0.00 | 0.05 | 0.06 |
| 50 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.02 | 0.08 | 0.11 | 2.00 | 0.17 | 0.29 |
| 52 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.02 | 0.09 | 0.11 | 2.00 | 0.02 | 0.15 |
| 54 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.05 | 0.20 | 0.00 | 0.83 | 0.32 | 0.47 |
| 56 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.02 | 0.09 | 0.00 | 1.00 | 0.03 | 0.05 |
| 58 | Ikalukrok u/s Red Dog Sta 9 | 12/18/19 | 0.01 | 0.04 | 0.00 | 1.00 | 0.05 | 0.06 |
| 23 | Buddy blw falls | 12/18/19 | 0.49 | 1.95 | 1.60 | 1.52 | 0.62 | 0.83 |
| 25 | Buddy blw falls | 12/18/19 | 0.46 | 1.84 | 1.60 | 1.58 | 0.34 | 0.32 |
| 27 | Buddy blw falls | 12/18/19 | 0.73 | 2.93 | 2.46 | 1.55 | 0.37 | 0.24 |
| 29 | Buddy blw falls | 12/18/19 | 0.79 | 3.14 | 2.78 | 1.60 | 0.02 | 0.40 |
| 31 | Buddy blw falls | 12/18/19 | 0.06 | 0.23 | 0.21 | 1.67 | 0.00 | 0.03 |
| 33 | Buddy blw falls | 12/18/19 | 3.32 | 13.27 | 11.64 | 1.58 | 4.17 | 0.48 |
| 35 | Buddy blw falls | 12/18/19 | 0.40 | 1.61 | 1.39 | 1.57 | 0.38 | 0.19 |
| 37 | Buddy blw falls | 12/18/19 | 0.07 | 0.27 | 0.32 | 2.00 | 0.02 | 0.10 |
| 39 | Buddy blw falls | 12/18/19 | 0.35 | 1.40 | 1.17 | 1.55 | 0.18 | 0.15 |
| 57 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.01 | 0.05 | 0.11 | 0.00 | 0.00 | 0.00 |
| 58 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 59 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.01 | 0.04 | 0.11 | 0.00 | 0.06 | 0.00 |
| 60 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 61 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 62 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 63 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 64 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.01 | 0.03 | 0.11 | 0.00 | 0.13 | 0.13 |
| 65 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.07 | 0.27 | 0.21 | 1.50 | 0.03 | 0.00 |
| 67 | Middle Fork Red Dog Creek Sta 20 | 12/17/19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 60 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 61 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.03 | 0.14 | 0.11 | 1.50 | 0.02 | 0.00 |
| 63 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.08 | 0.32 | 0.21 | 1.40 | 0.00 | 0.09 |
| 65 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.03 | 0.14 | 0.11 | 1.50 | 0.01 | 0.05 |
| 67 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.01 | 0.05 | 0.11 | 0.00 | 0.00 | 0.00 |
| 69 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.02 | 0.09 | 0.21 | 0.00 | 0.03 | 0.05 |
| 71 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.08 | 0.32 | 0.32 | 1.75 | 0.01 | 0.00 |
| 73 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.07 | 0.27 | 0.21 | 1.50 | 0.03 | 0.00 |
| 75 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.01 | 0.04 | 0.00 | 1.00 | 0.05 | 0.06 |
| 77 | Ikalukrok d/s Dudd Sta 160 | 12/18/19 | 0.03 | 0.14 | 0.11 | 1.50 | 0.01 | 0.05 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 68 | NF Red Dog Stn 12 | 12/17/19 | 1.01 | 4.05 | 3.42 | 1.56 | 0.16 | 0.25 |
| 71 | NF Red Dog Stn 12 | 12/17/19 | 1.84 | 7.37 | 6.41 | 1.59 | 0.18 | 0.60 |
| 73 | NF Red Dog Stn 12 | 12/17/19 | 0.95 | 3.78 | 3.20 | 1.57 | 0.05 | 0.29 |
| 75 | NF Red Dog Stn 12 duplicate | 12/17/19 | 0.93 | 3.73 | 3.42 | 1.64 | 0.07 | 0.29 |
| 77 | NF Red Dog Stn 12 | 12/17/19 | 1.05 | 4.18 | 3.52 | 1.56 | 0.18 | 0.20 |
| 79 | NF Red Dog Stn 12 | 12/17/19 | 0.70 | 2.78 | 2.24 | 1.53 | 0.00 | 0.15 |
| 81 | NF Red Dog Stn 12 | 12/17/19 | 0.48 | 1.91 | 1.71 | 1.62 | 0.00 | 0.24 |
| 83 | NF Red Dog Stn 12 | 12/17/19 | 0.54 | 2.14 | 1.60 | 1.47 | 0.00 | 0.17 |
| 85 | NF Red Dog Stn 12 | 12/17/19 | 0.39 | 1.55 | 1.39 | 1.62 | 0.03 | 0.16 |
| 87 | NF Red Dog Stn 12 | 12/17/19 | 0.60 | 2.39 | 2.14 | 1.61 | 0.41 | 0.12 |
| 89 | NF Red Dog Stn 12 | 12/17/19 | 1.12 | 4.47 | 4.06 | 1.62 | 0.58 | 0.24 |
| 91 | Mainstem Red Dog Stn 10 | 12/17/19 | 0.02 | 0.09 | 0.11 | 2.00 | 0.03 | 0.05 |
| 93 | Mainstem Red Dog Stn 10 | 12/17/19 | 0.02 | 0.09 | 0.11 | 2.00 | 0.03 | 0.05 |
| 95 | Mainstem Red Dog Stn 10 | 12/17/19 | 1.05 | 4.21 | 3.52 | 1.56 | 0.00 | 0.32 |
| 97 | Mainstem Red Dog Stn 10 | 12/17/19 | 0.02 | 0.09 | 0.11 | 2.00 | 0.03 | 0.05 |
| 99 | Mainstem Red Dog Stn 10 | 12/17/19 | 0.01 | 0.05 | 0.11 | 0.00 | 0.00 | 0.00 |
| 100 | Mainstem Red Dog Stn 10 | 12/17/19 | 0.36 | 1.44 | 1.07 | 1.45 | 0.22 | 0.30 |
| 102 | Mainstem Red Dog Stn 10 | 12/17/19 | 0.11 | 0.45 | 0.43 | 1.67 | 0.08 | 0.20 |
| 104 | Mainstem Red Dog Stn 10 | 12/17/19 | 0.07 | 0.27 | 0.21 | 1.50 | 0.02 | 0.10 |
| 106 | Mainstem Red Dog Stn 10 | 12/17/19 | 0.01 | 0.04 | 0.11 | 0.00 | 0.05 | 0.06 |
| 108 | Mainstem Red Dog Stn 10 | 12/17/19 | 0.16 | 0.64 | 0.64 | 1.75 | 0.00 | 0.08 |

# Appendix 3. Aquatic Invertebrate Drift Samples, 2019.

| Station | Middle Fork Red Dog Sta 20 | North Fork Red Dog Sta 12 | Upper North Fork Red Dog | Mainstem Red Dog Sta 10 | Ikalukrok Upstream Sta 9 | Ikalukrok below Dudd Sta 160 | Bons u/s Bons Pond | Bons u/s Buddy Sta 200 | Buddy u/s Haul Road Sta 221 | Buddy below falls |
|---|---|---|---|---|---|---|---|---|---|---|
| Total aquatic invert taxa/site | 29 | 19 | 23 | 27 | 23 | 32 | 20 | 28 | 35 | 26 |
| | | | | | | | | | | |
| Tot. Ephemeroptera | 136 | 274 | 240 | 181 | 952 | 5 | 18 | 10 | 494 | 168 |
| Tot. Plecoptera | 64 | 36 | 72 | 32 | 11 | 3 | 8 | 1 | 65 | 22 |
| Tot. Trichop. | 0 | 0 | 1 | 4 | 0 | 2 | 1 | 6 | 1 | 13 |
| Total Aq. Diptera | 1044 | 2236 | 1940 | 591 | 2036 | 223 | 739 | 152 | 1233 | 4403 |
| Misc.Aq.sp | 230 | 436 | 441 | 397 | 144 | 302 | 319 | 663 | 273 | 925 |
| % other | 16% | 15% | 16% | 33% | 5% | 56% | 29% | 80% | 13% | 17% |
| % Ephemeroptera | 9% | 9% | 9% | 15% | 30% | 1% | 2% | 1% | 24% | 3% |
| % Plecoptera | 4% | 1% | 3% | 3% | 0% | 1% | 1% | 0% | 3% | 0% |
| % Trichoptera | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% |
| % Aq. Diptera | 71% | 75% | 72% | 49% | 65% | 42% | 68% | 18% | 60% | 80% |
| | | | | | | | | | | |
| % EPT | 14% | 10% | 12% | 18% | 31% | 2% | 2% | 2% | 27% | 4% |
| % Chironomidae | 60% | 49% | 55% | 35% | 59% | 36% | 51% | 16% | 51% | 74% |
| | | | | | | | | | | |
| % Dominant Taxon | 51% | 27% | 35% | 24% | 56% | 24% | 34% | 15% | 44% | 55% |
| | | | | | | | | | | |
| Volume of water (m3) | 1178 | 593 | 970 | 1248 | 676 | 1245 | 574 | 394 | 1558 | 816 |
| Average vol.water/net | 236 | 297 | 242 | 250 | 338 | 249 | 115 | 79 | 312 | 272 |
| StDev of Water Volume/Net | 31 | 2 | 190 | 10 | 69 | 44 | 35 | 35 | 171 | 124 |
| Estimated total inverts/m3 water | 14.36 | 11.53 | 9.98 | 7.06 | 11.35 | 3.13 | 10.84 | 12.35 | 12.39 | 22.52 |
| Estimated aquatic inverts/m3 water | 6.26 | 10.06 | 8.35 | 4.83 | 9.31 | 2.15 | 9.44 | 10.59 | 6.63 | 20.39 |
| Average invertebrates/m3 water | 14.49 | 11.55 | 9.65 | 7.11 | 11.23 | 3.20 | 11.47 | 13.25 | 15.85 | 27.96 |
| Average aq. invertebrates/m3 water | 6.25 | 10.07 | 7.96 | 4.87 | 9.19 | 2.18 | 10.03 | 11.48 | 9.31 | 25.46 |
| StDev of Aq. Invert Density | 1.72 | 4.62 | 1.63 | 2.86 | 1.11 | 0.46 | 5.24 | 4.23 | 7.06 | 16.80 |
| | | | | | | | | | | |
| Total aquatic invertebrates | 7375 | 5967 | 8097 | 6026 | 6291 | 2678 | 5421 | 4170 | 10330 | 16640 |
| Total. terrestrial invertebrates | 9540 | 876 | 1582 | 2778 | 1384 | 1223 | 802 | 695 | 8973 | 1730 |
| **Total invertebrates** | 16915 | 6842 | 9679 | 8804 | 7675 | 3902 | 6223 | 4866 | 19303 | 18370 |
| % Sample aquatic | 44% | 87% | 84% | 68% | 82% | 69% | 87% | 86% | 54% | 91% |
| % Sample terrestrial | 56% | 13% | 16% | 32% | 18% | 31% | 13% | 14% | 46% | 9% |
| | | | | | | | | | | |
| Average # aquatic inverts / net | 1475 | 2983 | 2699 | 1205 | 3145 | 536 | 1084 | 834 | 2066 | 5547 |
| StDev of Aq. Inv./Net | 470 | 1348 | 1405 | 688 | 1012 | 114 | 398 | 336 | 1495 | 317 |
| Average # terr. inverts / net | 1908 | 438 | 527 | 556 | 692 | 245 | 160 | 139 | 1795 | 577 |
| Average # inverts / net | 3383 | 3421 | 3226 | 1761 | 3837 | 780 | 1245 | 973 | 3861 | 6123 |
| StDev of Inv./Net | 1028 | 1551 | 1544 | 970 | 1177 | 187 | 409 | 408 | 2258 | 411 |
| | | | | | | | | | | |
| Total Larval Arctic Grayling/site | 0 | 6 | 0 | 0 | 0 | 1 | 132 | 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. Juvenile Arctic Grayling from Bons Creek, Whole Body Element Concentrations, 2019.

Shaded cells indicate value was at or below method detection limit (MDL), so detection limit for that sample is reported. Detection limits for identified metals were based on % solids which varied for each fish.

| Sample Number | Date Collected | Length (mm) | Weight (g) | Cadmium (mg/kg) | Lead (mg/kg) | Mercury (mg/kg) | Selenium (mg/kg) | Zinc (mg/kg) | % Solids |
|---|---|---|---|---|---|---|---|---|---|
| 080419BPAGJ01 | 8/4/2019 | 170 | 46.5 | 0.37 | 0.37 | 0.04 | 10.32 | 55.25 | 21.9 |
| 080419BPAGJ02 | 8/4/2019 | 165 | 44.0 | 0.04 | 0.21 | 0.07 | 9.59 | 88.07 | 24.3 |
| 080419BPAGJ03 | 8/4/2019 | 174 | 49.1 | 0.17 | 1.32 | 0.08 | 8.68 | 89.26 | 24.2 |
| 080419BPAGJ04 | 8/4/2019 | 179 | 54.2 | 0.08 | 0.16 | 0.04 | 11.31 | 59.76 | 25.1 |
| 080419BPAGJ05 | 8/4/2019 | 167 | 46.8 | 0.03 | 0.11 | 0.07 | 8.28 | 57.09 | 26.1 |
| 080419BPAGJ06 | 8/4/2019 | 165 | 43.0 | 0.04 | 0.08 | 0.07 | 9.92 | 56.02 | 24.1 |
| 080419BPAGJ07 | 8/4/2019 | 178 | 54.7 | 0.11 | 0.26 | 0.04 | 10.11 | 61.54 | 27.3 |
| 080419BPAGJ08 | 8/4/2019 | 181 | 57.3 | 0.03 | 0.11 | 0.05 | 8.03 | 84.47 | 26.4 |
| 080419BPAGJ09 | 8/4/2019 | 172 | 50.0 | 0.13 | 0.13 | 0.06 | 10.36 | 102.24 | 22.3 |
| 080419BPAGJ10 | 8/4/2019 | 176 | 55.0 | 0.08 | 0.45 | 0.06 | 9.51 | 154.25 | 24.7 |
| 080419BPAGJ11 | 8/4/2019 | 173 | 60.0 | 0.04 | 0.16 | 0.07 | 6.56 | 108.50 | 24.7 |
| 080419BPAGJ12 | 8/4/2019 | 174 | 53.6 | 0.04 | 0.23 | 0.05 | 8.39 | 114.94 | 26.1 |
| 080419BPAGJ13 | 8/4/2019 | 170 | 46.7 | 0.16 | 0.61 | 0.05 | 10.28 | 80.08 | 24.6 |
| 080419BPAGJ14 | 8/5/2019 | 165 | 45.9 | 0.20 | 5.24 | 0.06 | 11.49 | 106.05 | 24.8 |
| 080419BPAGJ15 | 8/6/2019 | 155 | 29.8 | 0.08 | 0.42 | 0.06 | 6.95 | 79.50 | 23.9 |

## Appendix 5. Juvenile Dolly Varden from Buddy, Anxiety, and Mainstem Red Dog Creeks, Whole Body Element Concentrations, 2019.

| Sample Number | Date Collected | Length (mm) | Weight (g) | Cadmium (mg/kg) | Lead (mg/kg) | Mercury (mg/kg) | Selenium (mg/kg) | Zinc (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| 19MSRDDVJ01 | 8/6/2019 | 97 | 6.5 | 1.58 | 2.62 | 0.06 | 4.66 | 229.9 |
| 19MSRDDVJ02 | 8/6/2019 | 101 | 9.6 | 2.69 | 5.84 | 0.09 | 4.57 | 213.1 |
| 19MSRDDVJ03 | 8/8/2019 | 85 | 10.6 | 0.92 | 1.52 | 0.06 | 3.70 | 312.5 |
| 19MSRDDVJ04 | 8/8/2019 | 94 | 7.1 | 1.38 | 0.83 | 0.22 | 4.88 | 244.2 |
| 19MSRDDVJ05 | 8/8/2019 | 86 | 5.9 | 1.93 | 2.58 | 0.06 | 4.85 | 297.0 |
| 19MSRDDVJ06 | 8/8/2019 | 100 | 9.2 | 1.52 | 0.23 | 0.05 | 4.47 | 166.4 |
| 19MSRDDVJ07 | 8/8/2019 | 116 | 21.4 | 2.16 | 2.16 | 0.05 | 3.85 | 231.5 |
| 19MSRDDVJ08 | 8/8/2019 | 96 | 8.2 | 2.01 | 3.33 | 0.06 | 4.51 | 246.6 |
| 19MSRDDVJ09 | 8/8/2019 | 95 | 8.3 | 4.32 | 1.22 | 0.06 | 6.34 | 299.5 |
| 19MSRDDVJ10 | 8/8/2019 | 85 | 5.2 | 3.41 | 1.21 | 0.05 | 5.75 | 315.4 |
| 19MSRDDVJ11 | 8/10/2019 | 88 | 9.5 | 1.61 | 1.11 | 0.06 | 4.42 | 193.0 |
| 19MSRDDVJ12 | 8/10/2019 | 94 | 5.8 | 0.63 | 0.39 | 0.05 | 4.78 | 196.6 |
| 19MSRDDVJ13 | 8/10/2019 | 93 | 6.5 | 1.85 | 2.78 | 0.06 | 5.85 | 224.4 |
| 19MSRDDVJ14 | 8/10/2019 | 82 | 6.2 | 1.16 | 0.56 | 0.04 | 4.88 | 223.3 |
| | | | | | | | | |
| 19BCDVJ01 | 8/6/2019 | 104 | 14.9 | 0.35 | 0.52 | 0.06 | 4.76 | 175.5 |
| 19BCDVJ02 | 8/6/2019 | 114 | 13.9 | 0.26 | 0.44 | 0.05 | 4.65 | 127.6 |
| 19BCDVJ03 | 8/6/2019 | 106 | 14.8 | 0.25 | 0.31 | 0.04 | 3.69 | 127.2 |
| 19BCDVJ04 | 8/6/2019 | 120 | 19 | 0.70 | 0.44 | 0.08 | 5.87 | 188.0 |
| 19BCDVJ05 | 8/6/2019 | 103 | 10.5 | 0.61 | 0.82 | 0.05 | 4.73 | 179.2 |
| 19BCDVJ06 | 8/6/2019 | 90 | 8.7 | 1.12 | 2.84 | 0.05 | 5.49 | 214.9 |
| 19BCDVJ07 | 8/6/2019 | 104 | 10.6 | 0.44 | 0.34 | 0.04 | 4.40 | 193.7 |
| 19BCDVJ08 | 8/6/2019 | 117 | 15.1 | 0.52 | 0.22 | 0.04 | 4.09 | 181.3 |
| 19BCDVJ09 | 8/6/2019 | 126 | 18.4 | 0.49 | 0.74 | 0.07 | 5.70 | 137.7 |
| 19BCDVJ10 | 8/6/2019 | 90 | 7.4 | 0.66 | 1.24 | 0.05 | 4.29 | 152.5 |
| 19BCDVJ11 | 8/6/2019 | 97 | 10.4 | 0.99 | 4.50 | 0.05 | 7.95 | 249.7 |
| 19BCDVJ12 | 8/6/2019 | 115 | 15.3 | 1.31 | 1.38 | 0.09 | 5.52 | 215.3 |
| 19BCDVJ13 | 8/6/2019 | 91 | 6.5 | 0.90 | 2.50 | 0.06 | 5.94 | 259.9 |
| 19BCDVJ14 | 8/6/2019 | 124 | 16.2 | 0.38 | 0.31 | 0.07 | 5.49 | 187.6 |
| 19BCDVJ15 | 8/6/2019 | 104 | 11.4 | 0.47 | 0.99 | 0.04 | 4.66 | 131.9 |
| | | | | | | | | |
| 19AXDVJ01 | 8/8/2019 | 110 | 11.5 | 0.13 | 2.72 | 0.07 | 4.64 | 166.1 |
| 19AXDVJ02 | 8/8/2019 | 140 | 28.6 | 0.14 | 0.50 | 0.14 | 4.86 | 109.1 |
| 19AXDVJ03 | 8/8/2019 | 130 | 20 | 0.12 | 0.16 | 0.08 | 4.35 | 112.9 |
| 19AXDVJ04 | 8/8/2019 | 122 | 16.1 | 0.09 | 0.36 | 0.21 | 2.37 | 96.9 |
| 19AXDVJ05 | 8/8/2019 | 90 | 7.1 | 0.35 | 0.40 | 0.06 | 5.57 | 154.7 |
| 19AXDVJ06 | 8/8/2019 | 100 | 8.8 | 0.12 | 0.12 | 0.10 | 4.17 | 105.8 |
| 19AXDVJ07 | 8/8/2019 | 122 | 13.8 | 0.04 | 0.13 | 0.17 | 3.69 | 121.3 |
| 19AXDVJ08 | 8/8/2019 | 95 | 10.9 | 0.09 | 3.72 | 0.12 | 2.28 | 116.3 |
| 19AXDVJ09 | 8/8/2019 | 110 | 14.5 | 0.04 | 0.17 | 0.20 | 3.55 | 93.5 |
| 19AXDVJ10 | 8/9/2019 | 125 | 18 | 0.16 | 3.72 | 0.17 | 2.71 | 81.0 |
| 19AXDVJ11 | 8/9/2019 | 112 | 12.5 | 0.09 | 0.23 | 0.20 | 3.55 | 21.7 |
| 19AXDVJ12 | 8/9/2019 | 109 | 12.5 | 0.04 | 0.27 | 0.28 | 2.41 | 22.4 |
| 19AXDVJ13 | 8/9/2019 | 95 | 7.1 | 0.14 | 0.32 | 0.15 | 5.00 | 22.2 |
| 19AXDVJ14 | 8/9/2019 | 127 | 19.8 | 0.13 | 0.17 | 0.11 | 5.02 | 23.9 |
| 19AXDVJ15 | 8/9/2019 | 120 | 19.1 | 0.39 | 0.65 | 0.08 | 4.72 | 23.1 |

## Appendix 6. Arctic Grayling Ovaries Tested for Selenium from Red Dog Mine in 2019

Selenium data from locations near Red Dog and Fort Knox mines (1999, 2014 – 2018) are available in ADF&G Technical Report No. 18-06 and ADF&G Technical Report No. 19-08.

| Sample Identification | Collector | Location | Date | Length (mm) | Weight (g) | Age | Selenium (mg/kg) | % Solids |
|---|---|---|---|---|---|---|---|---|
| 060719NFAGA01 | ADF&G | North Fork Red Dog | 6/7/2019 | 368 | 503.8 | U | 13.4 | 13.4 |
| 061019NFAGA02 | ADF&G | North Fork Red Dog | 6/10/2019 | 355 | 442.3 | 6 | 21.5 | 13.2 |
| 061019NFAGA03 | ADF&G | North Fork Red Dog | 6/10/2019 | 348 | 406.8 | 15 | 9.1 | 15.5 |
| 061419NFAGA04 | ADF&G | North Fork Red Dog | 6/14/2019 | 322 | 344.3 | 5 | 16.4 | 15.4 |
| | | | | | | | | |
| 060719BPAGA01 | ADF&G | Bons Pond | 6/7/2019 | 311 | 291.2 | 6 | 25.2 | 13.2 |
| 060819BPAGA02 | ADF&G | Bons Pond | 6/8/2019 | 345 | 437.8 | U | 23.8 | 12 |
| 060819BPAGA03 | ADF&G | Bons Pond | 6/8/2019 | 340 | 401.3 | 6 | 27.6 | 13.6 |
| 060819BPAGA04 | ADF&G | Bons Pond | 6/8/2019 | 320 | 337.0 | 7 | 35.3 | 10.2 |
| 060819BPAGA05 | ADF&G | Bons Pond | 6/8/2019 | 320 | 373.6 | 8 | 27.1 | 11.9 |
| 060819BPAGA06 | ADF&G | Bons Pond | 6/8/2019 | 332 | 312.5 | 7 | 35.4 | 12.6 |

## Appendix 7. Dolly Varden Element Data, Wulik River, June 2019.

Shaded cells indicate value was at or below method detection limit (MDL), so MDL is reported. All values reported in dry weight.

| Tissue | Sample Identification | Sex | Length (mm) | Weight (g) | Cd (mg/kg) | Cu (mg/kg) | Pb (mg/kg) | Se (mg/kg) | Zn (mg/kg) | Hg (mg/kg) | % Solids |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Kidney | 060819WUDVA01K | F | 578 | 1908.3 | 0.76 | 5.24 | <0.09 | 4.45 | 68.12 | 0.08 | 22.9 |
| Kidney | 060919WUDVA02K | F | 648 | 2701.9 | 3.25 | 5.34 | <0.10 | 7.38 | 121.36 | 0.16 | 20.6 |
| Kidney | 060919WUDVA03K | M | 654 | 2739.0 | 1.51 | 5.16 | <0.09 | 9.25 | 110.80 | 0.12 | 21.3 |
| Kidney | 060919WUDVA04K | F | 534 | 2015.9 | 1.22 | 7.45 | <0.11 | 7.39 | 111.17 | 0.13 | 18.8 |
| Kidney | 061019WUDVA05K | M | 465 | 1256.4 | 1.16 | 18.22 | <0.09 | 5.42 | 94.22 | 0.08 | 22.5 |
| Kidney | 061019WUDVA06K | F | 529 | 2043.4 | 0.99 | 6.20 | <0.08 | 3.60 | 78.10 | 0.13 | 24.2 |
| Kidney | 061219WUDVA07K | F | 574 | 2692.0 | 1.10 | 9.06 | <0.08 | 5.28 | 66.54 | 0.15 | 25.4 |
| Kidney | Duplicate of fish #07 | F | 574 | 2692.0 | 0.56 | 12.35 | <0.08 | 3.86 | 54.98 | 0.13 | 25.1 |
| | | | | | | | | | | | |
| Liver | 060819WUDVA01L | F | 578 | 1908.3 | 0.26 | 46.15 | <0.07 | 2.91 | 103.68 | 0.02 | 29.9 |
| Liver | 060919WUDVA02L | F | 648 | 2701.9 | 0.52 | 51.38 | <0.07 | 3.03 | 96.90 | 0.03 | 29 |
| Liver | 060919WUDVA03L | M | 654 | 2739.0 | 0.34 | 76.35 | <0.06 | 2.51 | 82.91 | 0.05 | 35.1 |
| Liver | 060919WUDVA04L | F | 534 | 2015.9 | 0.18 | 34.93 | <0.06 | 2.06 | 67.89 | 0.01 | 35.5 |
| Liver | 061019WUDVA05L | M | 465 | 1256.4 | 0.38 | 75.68 | <0.05 | 2.22 | 100.00 | 0.03 | 37 |
| Liver | 061019WUDVA06L | F | 529 | 2043.4 | 0.27 | 25.98 | <0.06 | 2.02 | 85.20 | 0.02 | 33.1 |
| Liver | 061219WUDVA07L | F | 574 | 2692.0 | 0.37 | 66.22 | <0.07 | 2.70 | 94.59 | 0.03 | 29.6 |
| Liver | Duplicate of fish #07 | F | 574 | 2692.0 | 0.34 | 58.10 | <0.03 | 2.45 | 84.40 | 0.03 | 32.7 |
| | | | | | | | | | | | |
| Muscle | 060819WUDVA01M | F | 578 | 1908.3 | <0.04 | 1.15 | <0.08 | 1.30 | 13.74 | 0.07 | 26.2 |
| Muscle | 060919WUDVA02M | F | 648 | 2701.9 | <0.03 | 1.23 | <0.06 | 0.71 | 12.65 | 0.03 | 32.4 |
| Muscle | 060919WUDVA03M | M | 654 | 2739.0 | <0.03 | 1.58 | <0.06 | 0.82 | 20.57 | 0.02 | 31.6 |
| Muscle | 060919WUDVA04M | F | 534 | 2015.9 | <0.03 | 1.03 | <0.07 | 0.79 | 13.70 | 0.01 | 29.2 |
| Muscle | 061019WUDVA05M | M | 465 | 1256.4 | <0.04 | 1.15 | <0.08 | 1.03 | 13.41 | <0.01 | 26.1 |
| Muscle | 061019WUDVA06M | F | 529 | 2043.4 | <0.04 | 1.12 | <0.07 | 0.82 | 11.99 | 0.03 | 26.7 |
| Muscle | 061219WUDVA07M | F | 574 | 2692.0 | <0.03 | 1.06 | <0.07 | 0.60 | 11.31 | 0.02 | 28.3 |
| Muscle | Duplicate of fish #07 | F | 574 | 2692.0 | <0.04 | 1.40 | <0.07 | 0.67 | 14.74 | 0.02 | 28.5 |
| | | | | | | | | | | | |
| Reproductive | 060819WUDVA01R | F | 578 | 1908.3 | <0.03 | 17.79 | <0.07 | 3.59 | 258.72 | <0.01 | 29.8 |
| Reproductive | 060919WUDVA02R | F | 648 | 2701.9 | <0.02 | 18.67 | <0.03 | 3.42 | 248.10 | <0.01 | 31.6 |
| Reproductive | 060919WUDVA03R | M | 654 | 2739.0 | <0.06 | 2.94 | <0.12 | 2.82 | 135.29 | <0.01 | 17 |
| Reproductive | 060919WUDVA04R | F | 534 | 2015.9 | <0.03 | 12.74 | <0.06 | 2.96 | 220.38 | <0.01 | 31.4 |
| Reproductive | 061019WUDVA05R | M | 465 | 1256.4 | 0.09 | 4.09 | <0.09 | 2.77 | 287.73 | <0.01 | 22 |
| Reproductive | 061019WUDVA06R | F | 529 | 2043.4 | <0.03 | 11.95 | <0.06 | 2.71 | 171.72 | <0.01 | 34.3 |
| Reproductive | 061219WUDVA07R | F | 574 | 2692.0 | <0.03 | 14.86 | 0.04 | 3.88 | 202.17 | <0.01 | 27.6 |
| Reproductive | Duplicate of fish #07 | F | 574 | 2692.0 | <0.03 | 16.78 | <0.07 | 4.16 | 202.35 | <0.01 | 29.8 |

## Appendix 8. Dolly Varden Element Data, Wulik River, September 2019.

Shaded cells indicate value was at or below method detection limit (MDL), so MDL is reported. All values reported in dry weight.

| Tissue | Sample Identification | Sex | Length (mm) | Weight (g) | Cd (mg/kg) | Cu (mg/kg) | Pb (mg/kg) | Se (mg/kg) | Zn (mg/kg) | Hg (mg/kg) | % Solids |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Kidney | 092019WUDVA01K | F | 517 | 2199.0 | 0.63 | 13.09 | <0.10 | 5.18 | 94.24 | 0.06 | 19.1 |
| Kidney | 092019WUDVA02K | F | 403 | 898.3 | 0.61 | 4.55 | <0.10 | 4.49 | 86.87 | 0.05 | 19.8 |
| Kidney | 092019WUDVA03K | F | 560 | 2459.6 | 1.15 | 8.13 | <0.10 | 6.12 | 101.44 | 0.08 | 20.9 |
| Kidney | 092019WUDVA04K | F | 463 | 1355.2 | | | | | | | |
| Kidney | 092019WUDVA05K | F | 521 | 1931.1 | 0.70 | 4.48 | <0.10 | 5.37 | 84.08 | 0.07 | 20.1 |
| Kidney | 092019WUDVA06K | F | 479 | 1482.7 | 0.56 | 9.26 | <0.09 | 4.44 | 88.43 | 0.07 | 21.6 |
| Kidney | 092019WUDVA07K | M | 650 | 4337.6 | 1.52 | 4.76 | <0.10 | 9.05 | 104.29 | 0.15 | 21.0 |
| Kidney | duplicate of fish #7 | M | 650 | 4337.6 | 1.51 | 5.02 | <0.09 | 7.90 | 100.46 | 0.17 | 21.9 |
| | | | | | | | | | | | |
| Liver | 092019WUDVA01L | F | 517 | 2199.0 | 0.10 | 67.45 | <0.05 | 2.40 | 86.20 | 0.01 | 38.4 |
| Liver | 092019WUDVA02L | F | 403 | 898.3 | 0.10 | 16.43 | <0.05 | 1.96 | 76.09 | 0.01 | 41.4 |
| Liver | 092019WUDVA03L | F | 560 | 2459.6 | 0.32 | 74.04 | <0.05 | 2.02 | 62.74 | 0.02 | 41.6 |
| Liver | 092019WUDVA04L | F | 463 | 1355.2 | 0.20 | 52.44 | <0.06 | 3.21 | 88.54 | 0.02 | 34.9 |
| Liver | 092019WUDVA05L | F | 521 | 1931.1 | 0.16 | 38.03 | <0.05 | 2.16 | 63.38 | 0.02 | 42.6 |
| Liver | 092019WUDVA06L | F | 479 | 1482.7 | 0.12 | 62.13 | <0.05 | 2.08 | 77.48 | 0.01 | 40.4 |
| Liver | 092019WUDVA07L | M | 650 | 4337.6 | 0.17 | 31.19 | <0.05 | 1.95 | 37.86 | 0.03 | 42.0 |
| Liver | duplicate of fish #7 | M | 650 | 4337.6 | 0.29 | 54.99 | <0.04 | 2.26 | 70.29 | 0.05 | 45.1 |
| | | | | | | | | | | | |
| Muscle | 092019WUDVA01M | F | 517 | 2199.0 | <0.04 | 0.74 | <0.07 | 0.89 | 13.70 | <0.01 | 27.0 |
| Muscle | 092019WUDVA02M | F | 403 | 898.3 | <0.04 | 1.42 | <0.07 | 0.82 | 16.73 | <0.01 | 28.1 |
| Muscle | 092019WUDVA03M | F | 560 | 2459.6 | <0.03 | 0.68 | <0.07 | 0.75 | 12.67 | 0.01 | 29.2 |
| Muscle | 092019WUDVA04M | F | 463 | 1355.2 | <0.03 | 0.77 | <0.08 | 1.23 | 12.69 | <0.01 | 26.0 |
| Muscle | 092019WUDVA05M | F | 521 | 1931.1 | <0.04 | 1.13 | <0.08 | 1.09 | 13.16 | <0.01 | 26.6 |
| Muscle | 092019WUDVA06M | F | 479 | 1482.7 | <0.04 | 1.07 | <0.07 | 1.21 | 11.43 | 0.01 | 28.0 |
| Muscle | 092019WUDVA07M | M | 650 | 4337.6 | <0.03 | 2.05 | <0.06 | 0.91 | 12.61 | 0.04 | 34.1 |
| Muscle | duplicate of fish #7 | M | 650 | 4337.6 | <0.03 | 1.37 | <0.05 | 0.79 | 13.66 | 0.03 | 36.6 |
| | | | | | | | | | | | |
| Reproductive | 092019WUDVA01R | F | 517 | 2199.0 | | | | | | | |
| Reproductive | 092019WUDVA03R | F | 560 | 2459.6 | 0.08 | 60.53 | <0.11 | 12.26 | 426.32 | <0.01 | 19.0 |
| Reproductive | 092019WUDVA04R | F | 463 | 1355.2 | 0.84 | 6.40 | <0.10 | 6.31 | 98.03 | 0.08 | 20.3 |
| Reproductive | 092019WUDVA05R | F | 521 | 1931.1 | <0.04 | 42.41 | <0.09 | 10.36 | 598.21 | <0.01 | 22.4 |
| Reproductive | 092019WUDVA06R | F | 479 | 1482.7 | <0.05 | 34.72 | <0.10 | 7.46 | 410.88 | <0.01 | 19.3 |
| Reproductive | 092019WUDVA07R | M | 650 | 4337.6 | | | | | | | |
| Reproductive | duplicate of fish #7 | M | 650 | 4337.6 | 0.10 | 3.35 | <0.14 | 4.21 | 224.88 | 0.04 | 20.9 |

## Appendix 9. Juvenile Dolly Varden Sampling Sites, Red Dog Mine, 1997-2019.

| Sample Site | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Evaingiknuk (Noatak Tributary) | 54 | 27 | 38 | 2 | 7 | 20 | 64 | 71 | 29 | 4 | 67 | 21 | 16 | 48 | 36 | 17 | 13 | 8 | 2 | 16 | 30 |
| Anxiety Ridge | 68 | 94 | 271 | 27 | 6 | 33 | 98 | 116 | 121 | 8 | 115 | 75 | 147 | 18 | 43 | 7 | 93 | 61 | 47 | 57 | 28 |
| Buddy | 48 | 154 | 306 | 11 | 34 | 57 | 104 | 59 | 59 | 5 | 183 | 43 | 100 | 115 | 77 | 18 | 47 | 88 | 12 | 109 | 57 |
| North Fork Red Dog Creek (Sta 12) | 0 | 12 | 17 | 1 | 1 | 1 | 0 | 1 | 8 | 0 | 1 | 0 | 3 | 6 | 2 | 0 | 4 | 0 | 1 | 0 | 0 |
| Upper North Fork Red Dog Creek | | | 26 | | | | | | | | | | | | | 2 | 32 | 0 | 0 | 2 | 7 |
| Mainstem (below North Fork) (Sta 151) | 14 | 70 | 86 | 13 | 9 | 12 | 2 | 2 | 6 | 8 | 2 | 13 | 7 | 13 | 7 | 1 | 3 | 19 | 1 | 9 | 1 |
| Mainstem (Sta 10) | 10 | 21 | 66 | 1 | 3 | 12 | 12 | 0 | 10 | 3 | 6 | 5 | 6 | 14 | 8 | 13 | 15 | 21 | 2 | 5 | 3 |
| Ikalukrok Creek (Sta 7/160) | 13 | 51 | 55 | 31 | 6 | 17 | 17 | 27 | 36 | 2 | 25 | 7 | 30 | 10 | 32 | 7 | 10 | 24 | 12 | 8 | 22 |
| Ikalukrok Creek (Sta 9) | 3 | 44 | 41 | 5 | 2 | 18 | 3 | 12 | 0 | 5 | 7 | 3 | 11 | 37 | 12 | 2 | 11 | 17 | 0 | 2 | 2 |
| Total Catch (Dolly Varden) | 210 | 473 | 880 | 91 | 68 | 170 | 300 | 288 | 269 | 35 | 406 | 167 | 320 | 261 | 217 | 65 | 196 | 238 | 77 | 208 | 150 |

No sampling occurred in 2012 and 2013 due to high water.
Total catch does not include Upper North Fork Red Dog Creek.
In 2016, a bear destroyed three deployed traps at Station 151 and one trap at Station 12.