Technical Report No. 12-03

# Aquatic Biomonitoring at Greens Creek Mine, 2011

by

Katrina M. Kanouse

April 2012

Alaska Department of Fish and Game Division of Habitat

Cover: A stonefly (*Sweltsa* sp.) captured during benthic macroinvertebrate sampling at Tributary Creek Site 9 in 2011. Copyright Alaska Department of Fish and Game. Photo by Greg Albrecht.

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# TECHNICAL REPORT NO. 12-03

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Division of Habitat, Region I

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802 3rd Street, Douglas, Alaska, 99824

This project was fully financed by Hecla Greens Creek Mining Company.

# Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in reports by the Divisions of Habitat, Sport Fish and of Commercial Fisheries. 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) |

**Measures (fisheries)**

| | |
|---|---|
| fork length | FL |
| mideye-to-fork | MEF |
| mideye-to-tail-fork | METF |
| standard length | SL |
| total length | TL |

**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 |

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# ACKNOWLEDGEMENTS

The Alaska Department of Fish and Game thanks Hecla Greens Creek Mining Company for their continued financial, logistical, and field support for this project, particularly the assistance provided by Jennifer Saran, Chris Wallace, and Ted Morales. We also thank Chris Wallace and Karl Kisser of Hecla Greens Creek Mining Company and Pete Schneider and Dave Barto of the USDA Forest Service who assisted with field sampling in 2011.

Several biologists with the Alaska Department of Fish and Game Division of Habitat assisted with this year's effort: Jackie Timothy, Ben Brewster and Gordon Willson-Naranjo conducted the field sampling; Ben, Gordon, and Greg Albrecht assisted with data entry and analyses; Greg conducted laboratory analyses of periphyton samples and quality assurance/quality control of the macroinvertebrate samples, with support from Gordon and Ben; and Laura Jacobs and William Morris of the Fairbanks Regional Office provided training and support for our laboratory analyses. Jennifer Saran, Jackie Timothy, and Commercial Fisheries Division Publications Specialist Amy Carroll provided technical review and editing of the report. Finally, Nora Foster of NRF Taxonomic Services identified the macroinvertebrates.

# EXECUTIVE SUMMARY

In 2001, the Alaska Department of Fish and Game (ADF&G) Division of Habitat and the USDA Forest Service (USFS) initiated the aquatic biomonitoring program at Greens Creek Mine near Juneau. The purpose of the continuing program is to annually document stream health in Greens Creek and Tributary Creek, two streams near mine development and operations.

The aquatic biomonitoring program includes sampling three levels of aquatic productivity: periphyton (attached algae), benthic macroinvertebrates (aquatic insects), and juvenile fish. Estimates of periphyton biomass, benthic macroinvertebrate density and richness, juvenile fish populations, and concentrations of six heavy metals in juvenile fish tissues together provide information we use to assess stream health. Comparison of abundance and richness indices between years allows us to detect change over time. In 2011, we sampled at Greens Creek Site 48, Site 6, and Site 54, and Tributary Creek Site 9. All four sites continued to show productive aquatic communities, in amounts similar to those observed in previous years.

Study components of the program have not changed in 11 years of sampling. In the *Recommendations* section of this report we suggest ways to strengthen the program based on our review of the methods and results to date.

# INTRODUCTION

Greens Creek Mine is located near Hawk Inlet on the west side Admiralty Island in Southeast Alaska, about 29 km west of Juneau. The mine began operations in 1989, and produces export concentrates of lead, zinc, silver and gold. Tailings are disposed at the dry-stack facility near the headwaters of Tributary Creek, and mine facilities and production rock storage areas are adjacent to Greens Creek. The mine did not operate between 1993 and 1996 due to low metal prices, but has otherwise operated year-round by a few different companies. Hecla Greens Creek Mining Company (Hecla) has owned and operated the Greens Creek Mine since April 2008.

In 2000, state and federal resource agencies recommended the mine operator implement an aquatic biological monitoring program to monitor stream health and fish use in Greens Creek and Tributary Creek near the project site. ADF&G initiated the program with support from the USFS in 2001, and sampling has occurred each year since. Components of the program include sampling periphyton, benthic macroinvertebrates, juvenile fish populations, and juvenile fish whole body metal concentrations. When combined, the data affords an overall assessment of stream health across three levels of aquatic productivity. Results from the current year are compared to previous years' results to detect change over time at each site. Additionally, results from an upstream (control) site and sites downstream of mine facilities in Greens Creek are compared each year.

The aquatic biomonitoring program is included in the mine's Fresh Water Monitoring Program (FWMP) in the Plan of Operations required by the USFS, and the mine's current Waste Management Permit required by the Alaska Department of Environmental Conservation. Reports from previous years' biomonitoring work is available in Weber Scannell and Paustian (2002), Jacobs et al. (2003), Durst and Townsend (2004), Durst et al. (2005), and Durst and Jacobs (2006, 2007, 2008, 2009, 2010), and Kanouse (2011).

## PURPOSE

The purpose of the Greens Creek Mine biomonitoring program is to document the conditions of the aquatic biological communities in select reaches of Greens Creek and Tributary Creek near mine development and operations. This report summarizes results from sampling in 2011, the eleventh consecutive year, and satisfies Hecla's reporting requirements.

## AQUATIC STUDIES

In 2011, we completed the following studies:

1. Periphyton biomass and chlorophyll-type,
2. Benthic macroinvertebrate density, community composition, and richness,
3. Juvenile fish populations, and
4. Juvenile fish whole body concentrations of Ag, Cd, Cu, Pb, Se, and Zn.

One additional study originally included in the aquatic biological monitoring program, standardized laboratory toxicity testing, was discontinued in 2004 due to laboratory testing complications (McGee and Marthaller 2004).

## STUDY AREA

In 2011, we completed aquatic studies at four sample sites (Figure 1):

- Three sample sites in Greens Creek (sites 48, 6, and 54); and
- One sample site in Tributary Creek (Site 9).

Sites 48, 54 and 9 are sampled annually, while Site 6 is sampled once every five years. Hecla personnel sample ambient water quality monthly at the each sample site and report results to the Alaska Department of Environmental Conservation in their FWMP annual report.

### Greens Creek

Greens Creek begins in the alpine and drains an area of 22.33 $km^2$ (USGS 2011). The creek is about 16 km long from headwater to tidewater. At each sample site, gradients range from 2% to 4%, cobble is the dominant substrate, and large woody debris, important for habitat creation, stability, and diversity, is present. The creek is largely fed by snowmelt and other drainages, and the magnitude of annual discharge depends on snowpack depth. During the 2011 water year, USGS (Gage 15101490) recorded peak discharges mid-May through early June, up to 161 $ft^3/s$. Rainfall events during the fall also cause periods of high discharge.

Site 48

Site 48 is located upstream of all mine and mill facilities, except for exploratory drilling, and serves as the control reach for comparing data collected downstream at sites 6 and 54. Site 48 is at approximately 265 m elevation, and about 0.8 km upstream from the infiltration gallery and concrete weir in Greens Creek, which blocks upstream fish passage. Resident Dolly Varden char *Salvelinus malma* is the only fish species documented at Site 48.

During field sampling in 2011, mean channel wetted width was 10.5 m within the 50 m fish sample reach. Accumulations of large wood and overhanging trees are common in this reach, contributing to deep pool habitat, cover, and split channel formations. Periphyton and benthic macroinvertebrate sampling occurs downstream of the fish sample reach.

Site 6

Site 6 is located downstream of the mine and mill facilities and monitored to detect potential effects from mine, mill or shop activities. Data collected at Site 6 are also used as baseline data to compare data from Site 54, which is located downstream of Bruin Creek's confluence and production rock storage areas 23 and D. At about 235 m elevation, Site 6 is 0.8 km downstream of the concrete weir. Large woody debris is less abundant at Site 6 than at sites 48 and 54. Anadromous fish access is provided to this site via the fish pass.[a]

Dolly Varden char and coho salmon *Oncorhynchus kisutch* have been documented at this site. During field sampling in 2011, mean channel wetted width was 10.4 m within the 50 m fish sample reach. Periphyton and benthic macroinvertebrate sampling occurs downstream of the fish sample reach, and upstream of the confluence of Bruin Creek with Greens Creek.

Site 54

Site 54, located downstream of production rock storage areas 23 and D and Bruin Creek's confluence, is monitored to detect potential effects from the rock storage areas and treatment ponds, as well as from the mine, mill and shop facilities upstream. Site 54 is at about 225 m elevation and 0.4 km downstream of Site 6. Anadromous fish access is provided to this site via the fish pass. Coho salmon, Dolly Varden char, and cutthroat trout *O. clarki* have been documented at this site.

From 2001 to 2010, we sampled juvenile fish populations in a 28 m reach, nearly half the length of the fish sample reaches at sites 48, 6, and 9. In 2011 we extended the 28 m reach to 58 m (discussed further in the *Results* section). While sampling in 2011, mean channel wetted width was 11.2 m within the 58 m fish sample reach. Accumulations of large wood and overhanging and fallen trees are common in this reach, contributing to deep pool habitat, cover, and split channel formations. Gallagher Creek enters Greens Creek within the fish sample reach. Periphyton and benthic macroinvertebrate sampling occurs upstream of the fish sample reach.

## Tributary Creek

Tributary Creek is about 1.6 km long, and is a low-energy, lowland stream fed by groundwater, precipitation, and a few hillside drainages. The tailing storage facility is located in the historical headwaters of the creek, documented prior to development. The gradient varies slightly from 1% to 2% along the entire creek, and large ponds at the upper extent contribute tannins staining the water brown. Discharge estimates, based on field measurements and limited gage data available, indicate annual stream flows range 1–5 $ft^3/s$ (USDA Forest Service 2003).

Site 9

Site 9 is located 1.2 km downstream of the dry-stack tailing facility at about 25 km elevation, and is monitored to detect potential effects from the tailing disposal facility. Tributary Creek provides habitat for pink salmon *O. gorbuscha*, chum salmon *O. keta*, coho salmon, cutthroat trout, rainbow trout *O. mykiss*, Dolly Varden char, and sculpin (*Cottus* sp.).

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[a] In 1989, Greens Creek Mining Company installed an engineered fish pass at Greens Creek river mile 3.5 as mitigation for impacts to Tributary Creek from the approved tailing dry-stack facility. The timber and concrete weirs are designed to provide adult coho salmon passage though a natural bedrock chute that prevents fish migration.

During field sampling in 2011, mean channel wetted width was 2.3 m within the 50 m fish sample reach. Leaning and fallen trees contribute to pool formation and substrate retention, which consists of organics, sand, and gravel. Periphyton and benthic macroinvertebrate sampling occurs within the fish sample reach, though not while trapping fish, as stream conditions usually preclude sampling upstream or downstream.

**Water quality**

Hecla personnel use field meters to characterize basic water quality at each site during the aquatic biomonitoring sampling, including temperature, pH, and conductivity. Results are included in this report for each site.

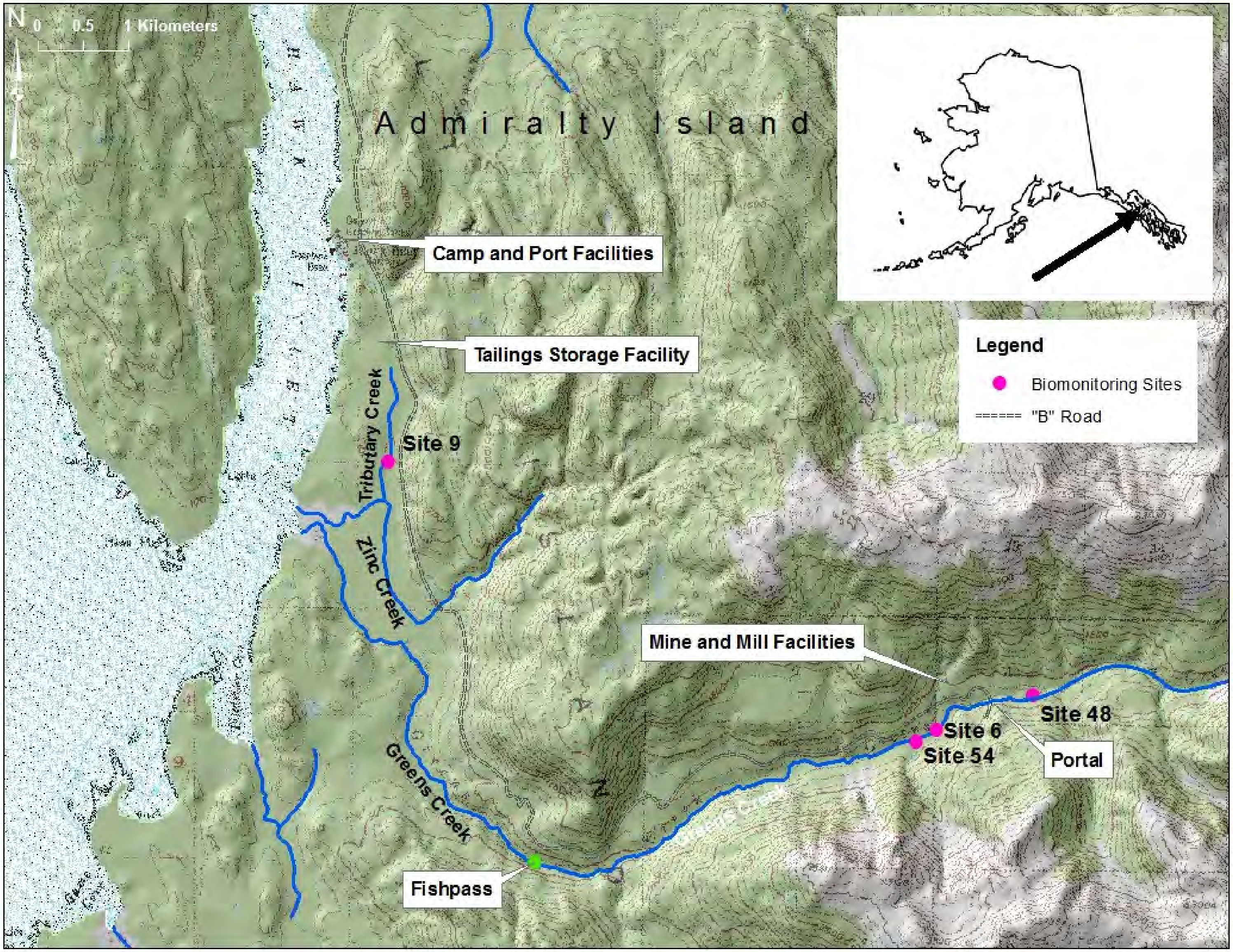


Figure 1.–Location of Greens Creek Mine project facilities and biomonitoring sample sites.

# METHODS

We followed methods used previously at Greens Creek Mine (Weber Scannell and Paustian 2002; Jacobs et al. 2003; Durst and Townsend 2004; Durst et al. 2005; Durst and Jacobs 2006, 2007, 2008, 2009, 2010; Kanouse 2011).[b] We also measured basic water quality, wetted width, water velocities at benthic macroinvertebrate sample locations, and a cross-section flow survey to calculate discharge at each site. Water velocities were measured using a flow probe (discharge data is presented in Appendix A).

## DATA ANALYSES

We performed periphyton, benthic macroinvertebrate, and metals fish data analyses using Statistix® 9 (Analytical Software 2008),[c] and used the Kruskal-Wallis One-Way Analysis of Variance by ranks test, a nonparametric alternative to a one-way analysis of variance, to test for equality of population medians between years and sites. We used all-pairwise comparisons on the mean ranks for each group to test for homogeneity between years and sites. We used the nonparametric test because we do not randomly sample habitats, as described below. For data comparisons of whole body silver concentrations, we used the minimum reporting limit (0.02 mg Ag/Kg) for results reported as "not detected". Significant differences are reported when $p \leq 0.05$.

The long-term dataset is occasionally reviewed to ensure accuracy. We report and correct errors in the document and appendices. The most recent technical report presents the current dataset and should be used to analyze the data from previous years. In Technical Report 12-03, we updated the benthic macroinvertebrate densities[d] and the number of taxa[e] observed at each site during each year. Footnotes below tables presenting data in the *Results* section or in the appendices indicate where we made these adjustments.

## PERIPHYTON BIOMASS

### Rationale

Periphyton, or attached algae, is sensitive to changes in water quality and sampled to assess local primary productivity. Algae have short life cycles, therefore monitoring periphyton biomass provides an ideal indicator to detect short-term effects (Barbour et al. 1999). We monitor biomass and proportions of chlorophyll types to detect change over time, and to assess overall stream health using data from other local studies (e.g. benthic macroinvertebrates).

### Sample Collection and Analysis

We sampled periphyton at low flow and not within three weeks after a high discharge. We collected 10 smooth, undisturbed, and perennially wetted rocks from the nearshore area of the creek in each study reach using the collection methods described by Barbour et al. (1999). We

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[b] Deviations from previously used methods are described in the *Results* section.

[c] Product names used in the publication are included for completeness but do not constitute product endorsement. The Alaska Department of Fish and Game does not endorse or recommend any specific company or their products.

[d] Densities previously reported were calculated using a sample area of $0.1m^2$; we corrected the data set using the actual sample area, $0.086m^2$.

[e] In some years, the number of taxa previously reported was inflated since unidentified insects were counted as additional taxa; we updated the data set to exclude special cases where unidentified insects were unlikely to be additional taxa present to provide the most conservative estimates.

placed a 5 × 5 cm square of high-density foam on each rock, and scrubbed the area around the foam with a toothbrush to remove attached algae outside the covered area. We rinsed the rock by dipping it with foam intact in the stream. We removed the foam square, scrubbed the isolated area with a toothbrush, and rinsed the loosened periphyton, the toothbrush, and the inside of the vacuum pump onto a 0.45 µm glass fiber filter attached to a vacuum pump using stream water in a wash bottle. After extracting as much water as possible from the filter, we added about 1 ml saturated $MgCO_3$ to the filter to prevent acidification of the sample and conversion of chlorophyll to phaeophytin. We wrapped the glass fiber filter in a large paper coffee filter to absorb additional water, and placed each sample in a sealed, labeled plastic bag with desiccant. We froze the samples on site in a light-proof cooler with additional desiccant and transported them to Juneau, then froze the samples at –20°C until we processed them in our laboratory.

We followed U.S. Environmental Protection Agency protocol for chlorophyll extraction and measurement, and instrument detection limit and error (USEPA 1997).[f] We removed the samples from the freezer, cut each filter into small pieces, and placed the filter pieces in centrifuge tubes with 10 ml of 90% buffered acetone. We placed the centrifuge tubes in a metal rack, covered them with aluminum foil, and stored them in a refrigerator for 24 h to extract the chlorophyll. Then we centrifuged the samples for 20 min at 1,600 rpm and read them on a Shimadzu UV-1800 Spectrophotometer[g] at optical densities (OD) 663 nm, OD 647 nm, and OD 630 nm. In addition, we read the samples at OD 750 nm to correct for turbidity. An acetone blank was used to correct for the solvent. Then we treated the samples with 0.08 ml of 0.1 N HCl to convert all the chlorophyll to phaeophytin, and read each at OD 665 nm and OD 750 nm.

### Data Presentation

We include a figure of mean daily discharge in Greens Creek three weeks prior to field sampling in the *Results* section. Periphyton biomass, estimated by chlorophyll *a* concentrations, is presented using Box and Whisker Plots (Analytical Software 2008) for each sample site. The box illustrates the interquartile range, the line bisecting the box represents the median concentration, and the vertical "whiskers" are the typical range of data in the sample. Whiskers end at a data point that is within 1.5 times the interquartile range. A star (∗) represents possible outliers lying outside the box by more than 1.5 times the interquartile range, and an open circle (○) is used to represent probable outliers more than 3 times the interquartile range. We also present a figure of mean proportions of chlorophylls *a*, *b* and *c*. Chlorophylls *b* and *c* are accessory pigments that provide information on the types of algae present. Current and historical data are included in Appendix B.

## BENTHIC MACROINVERTEBRATE DENSITY AND RICHNESS

### Rationale

Benthic macroinvertebrates classified in the Orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddis flies), collectively known as EPT taxa, are sensitive to changes in water quality and an important food source for fish. Most benthic macroinvertebrates have a complex one-year (or more) life cycle and limited mobility, therefore, benthic macroinvertebrates

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[f] Except, we stored our samples longer than 3.5 weeks and we cut our filters rather than homogenized them to reduce acetone exposure.

[g] Product names used in the publication are included for completeness but do not constitute product endorsement. The Alaska Department of Fish and Game does not endorse or recommend any specific company or their products.

provide an ideal indicator to detect short-term and long-term effects within local aquatic communities (Barbour et al. 1999). We use aquatic macroinvertebrate density and richness data to detect change over time, and to assess overall stream health using data from other local studies (e.g. periphyton biomass).

### Sample Collection and Analysis

We collected five benthic macroinvertebrate samples from each site using a Hess sampler in riffles where we observe the greatest amount of taxonomic density and richness (Barbour et al. 1999). This sample design reduces the variability that arises from sampling other habitats, such as pools, where pollution-sensitive taxa are less likely to be present.

We pushed the Hess sampler into the stream bottom, encompassing a 0.086 $m^2$ sample area, in riffle areas where flow was sufficient to transport insects into the cod end of the sampler. Within the sample area, we brushed and discarded rocks and disturbed fine substrate to about 10 cm depth to dislodge buried individuals. Macroinvertebrates drifted into a 363 $\mu$m mesh net and cod end, then we transfered samples to a prelabeled 500 mL bottle, preserved them in 80% denatured ethanol, and transported them to Fairbanks for processing. Samples were later sorted from debris and identified to the lowest practical taxonomic level (genus in most cases) by a taxonomist. For quality assurance and control, we identified, counted, and compared numbers of insects in two random samples (10% of all samples collected in 2011).

We calculated the mean density of aquatic macroinvertebrates per square meter by dividing the number of aquatic insects per sample by 0.086 $m^2$, the Hess sample area, then calculated the mean of the five samples. Richness is the total number of taxa observed among all five samples.

### Data Presentation

We include a figure of mean daily discharge in Greens Creek three weeks prior to field sampling in the results section. We present a table summarizing density and richness, a figure of aquatic macroinvertebrate densities, and a figure illustrating community composition at each sample site. Current and historical data are included in Appendix C.

## JUVENILE FISH POPULATIONS

### Rationale

Salmonids are migratory, predators, an indicator of habitat conditions and long-term effects (Barbour et al. 1999), and afford another biological level to detect change within the aquatic community and assess overall stream health. We compare current year population estimates to previous years' to detect change over time.

### Sample Collection and Analysis

We sampled fish populations using a modification[h] of a depletion method developed by the USFS (Bryant 2000). We sampled reaches isolated by natural features, such as shallow riffles, and set several baited minnow traps along the upper and lower reach boundaries to capture potential migrants (fish captured in these "block" traps were not included in the population estimate). We saturated the sample reaches with 0.635 cm (¼ in) minnow traps baited with whirl packs containing disinfected salmon eggs, and focused our trapping effort in habitats where fish

[h] We sampled shorter reaches, used more minnow traps, and completed three passes instead of four.

were most likely to be captured, such as pools, undercut banks, rootwads and logjams. We placed rocks in the traps to increase trap weight and provide cover for fish.

We soaked the traps for 1.5 h, then retrieved each trap, transferred captured fish into plastic buckets, rebaited and reset for another 1.5 h soak. In between trapping events, we processed captured fish by measuring each to FL and identifying each to species. We retained captured fish in perforated plastic buckets secured in the stream during the sample period, and returned captured fish[i] to the sample reach after all three passes were complete.

We estimated fish populations using the multiple-pass depletion method developed by Lockwood and Schneider (2000), a repetitive method that produces a maximum likelihood estimate (MLE) of fish with a 95% confidence interval. Let $X$ represent an intermediate sum statistic where the total number of passes, $k$, is reduced by the pass number, $i$, and multiplied by the number of fish caught in the pass, $C_i$, for each pass,

$$X = \sum_{i=1}^{k} (k - i)C_i \tag{1}$$

Let $T$ represent the total number of fish captured in the minnow traps for all passes. Let $n$ represent the predicted population of fish, using $T$ as the initial value tested. Using $X$ calculated in Equation (1), the MLE, $N$, is calculated by repeated population predictions where the result must be closest to, and not exceed, 1.0, in the following equation,

$$\left[\frac{n+1}{n-T+1}\right]\prod_{i=1}^{k}\left[\frac{kn-X-T+1+(k-i)}{kn-X+2+(k-i)}\right]_i \leq 1.0 \tag{2}$$

The probability of capture, $p$, is given by the total number of fish captured, divided by an equation where the number of passes is multiplied by the MLE given by Equation (2) and subtracted by the intermediate statistic, $X$,

$$p = \frac{T}{kN - X} \tag{3}$$

The variance of $N$, a measure of variability from the mean, is given by,

$$\text{Variance of } N = \frac{N(N-T)T}{T^2 - N(N-T)\left[\frac{(kp)^2}{(1-p)}\right]} \tag{4}$$

The standard error (SE) of $N$ was calculated by the square root of the Variance of $N$, and the 95% confidence interval for the MLE is given by: MLE $\pm$ 2(SE).

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[i] Except, we retained six fish for whole body metals concentrations at each sample site.

### Data Presentation

We include a figure illustrating Dolly Varden char and coho salmon population estimates for each sample site. We calculated and report fish densities using the population estimate and the mean of five wetted width measurements within the fish sample reaches. Capture data and length frequencies of captured fish from each reach and each year are included in Appendix D.

## METALS CONCENTRATIONS IN JUVENILE FISH

### Rationale

We sample whole body metals concentrations in resident Dolly Varden char to detect changes in tissue metals concentrations. Current year data are compared to previous years' data to detect change over time. Water quality data may be compared to examine relationships, and whether change is related to mine operations or natural variability.

### Sample Collection and Analysis

We collected six juvenile Dolly Varden char measuring 85–125 mm FL for whole body metals analyses. This size range improves the likelihood of sampling only resident fish at sample sites where anadromous fish are present as well. We captured the fish in minnow traps baited with disinfected salmon eggs, measured to FL, and individually packed the samples in clean, prelabeled plastic bags. We immediately froze samples in a cooler containing gel ice packs, then stored the samples in a camp freezer until we returned to Juneau where we weighed[j] the fish in the sealed bags, correcting for bag weight. We froze the samples until we shipped them to a private analytical laboratory, where they were individually[k] freeze dried, digested, and analyzed for silver (Ag), cadmium (Cd), copper (Cu), lead (Pb), selenium (Se), and zinc (Zn) on a dry-weight basis, with percent total solids also reported.

### Quality Control / Quality Assurance of Laboratory Analysis

We maintained written chain of custody documentation on fish collected for metals testing. The analytical laboratory provided Tier II quality assurance/quality control validation information for each analyte including matrix spikes, standard reference materials, laboratory calibration data, sample blanks, and sample duplicates.

### Data Presentation

We include a figure showing mean tissue metals concentrations ± one standard deviation for the six analytes. ND = not detected at reporting limit, and the dashed line represents the laboratory's minimum reporting limit. Current and historical data, and the current year laboratory report are included in Appendix E.

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[j] We did not individually weigh the 2011 samples prior to shipping to the private laboratory.
[k] The 2011 samples were mistakenly homogenized in the lab, therefore we only have one data point for each metal in each sample reach.

# RESULTS AND DISCUSSION

During the three weeks prior to sampling in Greens Creek, discharge was moderate and generally decreased over time (Figure 2), therefore scour and bedload movement were not likely to affect periphyton and benthic macroinvertebrate densities, or affect fish abundance and distribution.

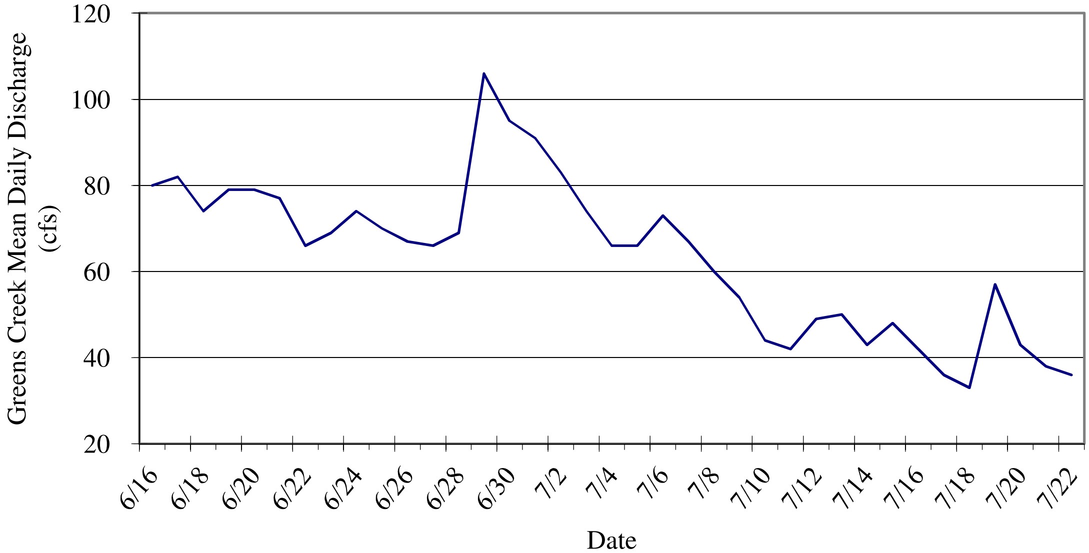


Figure 2.–Greens Creek (USGS Gage 15101490) mean daily discharge prior to sampling in 2011.

Sampling for the aquatic biomonitoring program in the last 11 years has occurred over a range of discharges in Greens Creek (Figure 3), which affords an analysis of the natural range of variability within aquatic communities.

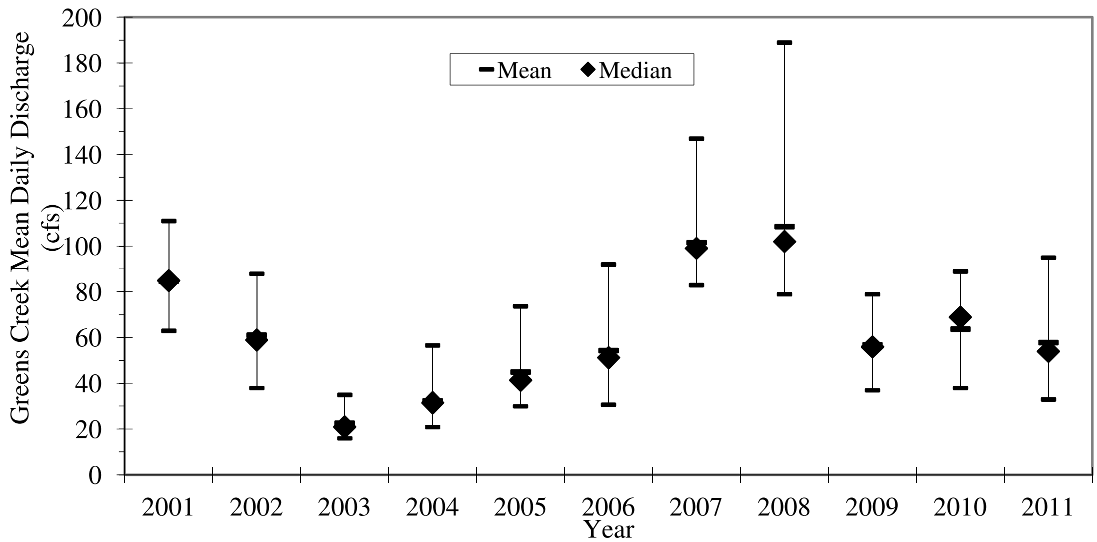


Figure 3.–Greens Creek (USGS Gage 15101490) range of mean daily discharges three weeks prior to sampling during the years 2001–2011.

## GREENS CREEK SITE 48

We sampled Greens Creek Site 48 during the morning of July 22, 2011. Hecla personnel recorded the following water quality measurements in Greens Creek during sampling: water temperature 7.18°C, conductivity 99 $\mu$S/cm, and pH 8.01.

### Periphyton Biomass

Periphyton biomass, estimated by chlorophyll *a* densities, in the 2011 samples we collected at Site 48 were similar compared to previous years (Figure 4) and the mean rank was significantly different ($p \leq 0.05$) than the mean ranks of the 2003 and 2006 samples.

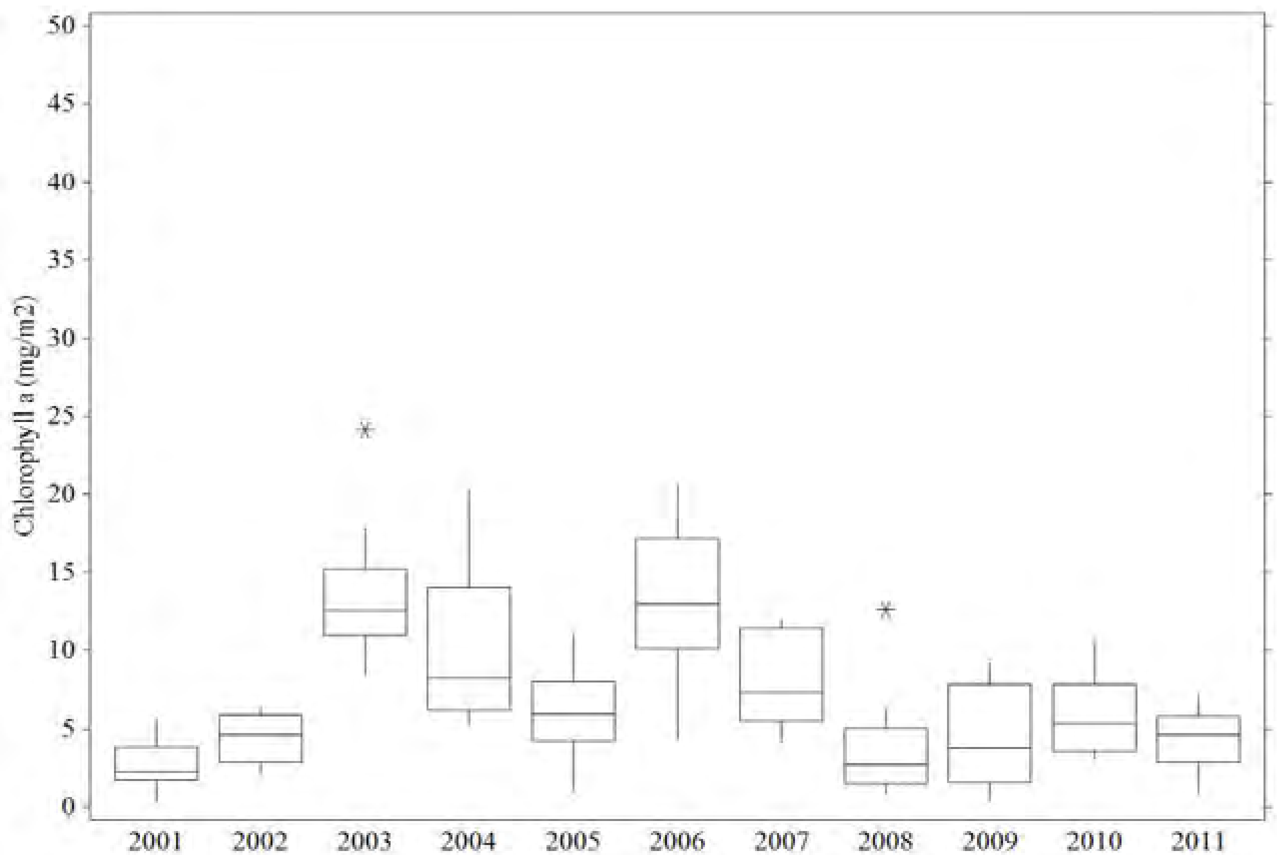


Figure 4.–Periphyton biomass in Greens Creek Site 48 samples, 2001–2011.

The mean concentrations of chlorophylls *a, b* and *c* in the Site 48 samples were 4.339 mg/m$^2$ (*a*), 0.017 mg/m$^2$ (*b*), and 0.451 mg/m$^2$ (*c*). Organisms producing chlorophyll *c* pigment continue to be more common than those producing chlorophyll *b* pigment (Figure 5).

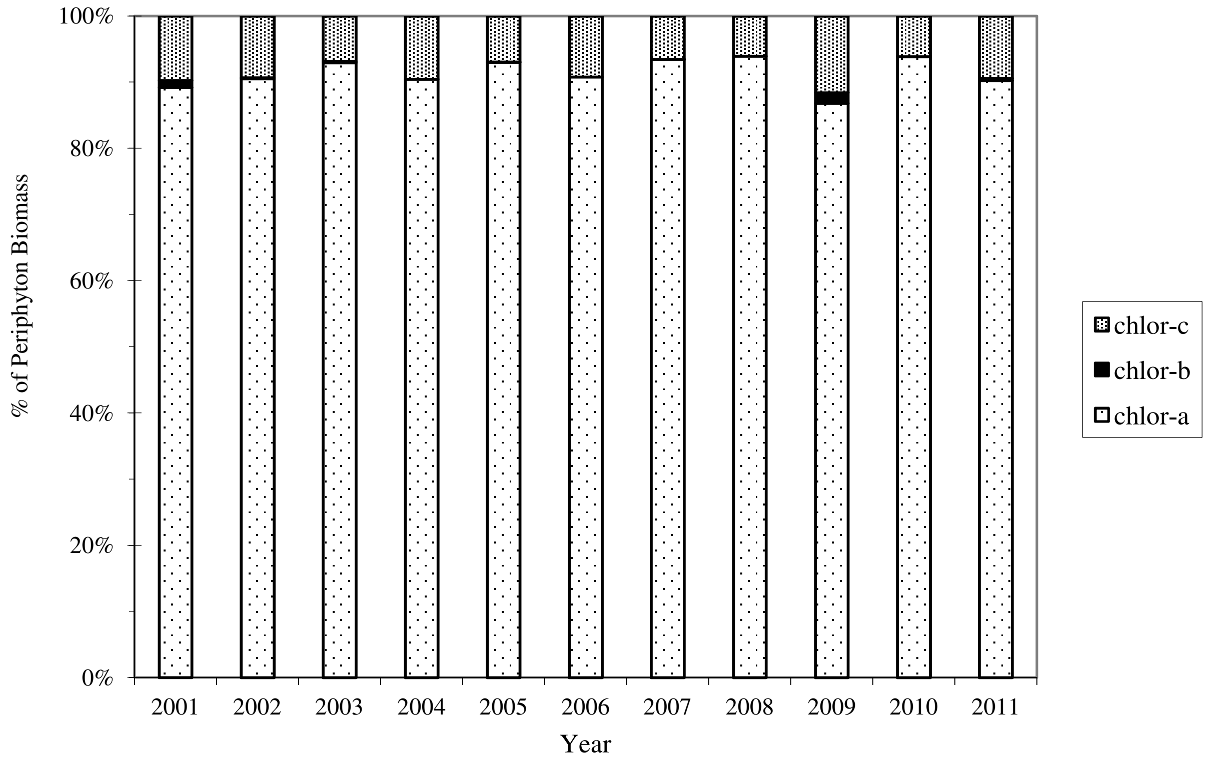


Figure 5.–Mean proportions of chlorophylls *a, b* and *c* in Greens Creek Site 48 samples, 2001–2011.

## Benthic Macroinvertebrate Density and Richness

The mean density of benthic macroinvertebrates in samples collected at Site 48 in 2011 was 2,284 insects/$m^2$, similar to mean densities observed in previous years (Table 1, Figure 6). A total of 27 taxa were observed among the 2011 samples, similar to richness previously observed and greater than the previous five years. We did not find any statistical differences when we compared 2011 macroinvertebrate density and richness sample data to data from previous years.

Table 1.–Mean benthic macroinvertebrate density and richness at Greens Creek Site 48, 2001–2011.

| Year | Mean Density[a] (aquatic inverts/$m^2$) | Taxonomic Richness[a] |
|---|---|---|
| 2001 | 2,753 | 25 |
| 2002 | 1,637 | 26 |
| 2003 | 5,505 | 27 |
| 2004 | 3,905 | 30 |
| 2005 | 3,247 | 29 |
| 2006 | 1,612 | 21 |
| 2007 | 1,705 | 24 |
| 2008 | 3,095 | 21 |
| 2009 | 2,216 | 18 |
| 2010 | 2,884 | 23 |
| 2011 | 2,284 | 27 |

[a] Adjusted in Technical Report 12-03.

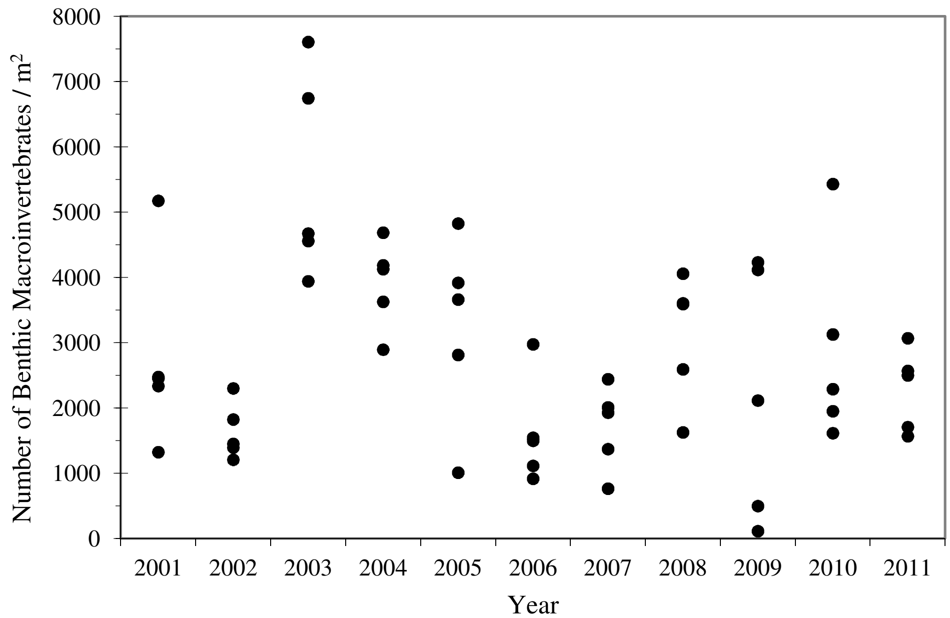


Figure 6.–Benthic macroinvertebrate densities in Greens Creek Site 48 samples, 2001–2011.

About 73% of the benthic macroinvertebrates collected at Site 48 in 2011 were EPT taxa, the lowest percentage observed in the 11 years of sampling at this site, yet still a healthy portion of the aquatic insect community (Figure 7). Dominant taxa among samples were Baetidae Baetis, rated "moderately sensitive", and Diptera Chironomidae, rated "moderately tolerant" to impaired water quality (Barbour et al. 1999). Diptera taxa were more common (20%) in the 2011 samples than samples from any previous year.

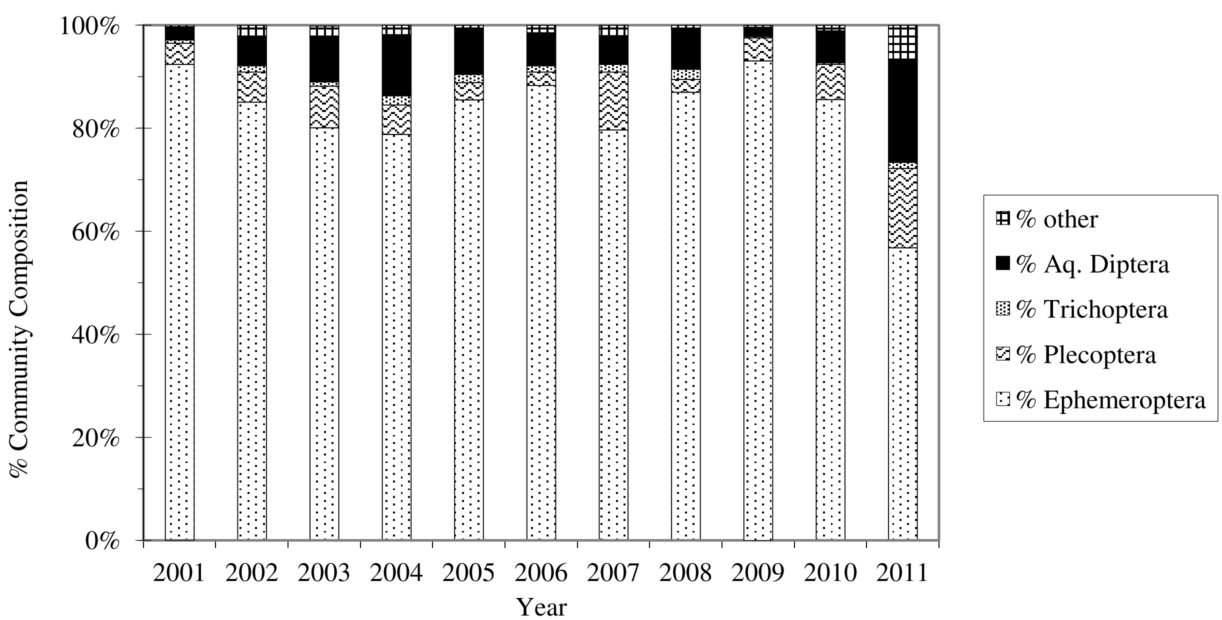


Figure 7.–Benthic macroinvertebrate community composition in Greens Creek Site 48 samples, 2001–2011.

## Juvenile Fish Populations

We estimated the 2011 Site 48 Dolly Varden char population at 180±42 fish, which was significantly higher than in 2001, 2007 and 2008, and significantly lower than in 2003–2005 (Figure 8). We estimated Dolly Varden char density at 0.34 fish per $m^2$, similar to previous years. Length frequency plots (Appendix C) of Dolly Varden char captured at Site 48 suggest multiple age classes are present most years, except in 2008 when young-of-year fry appeared to be absent.

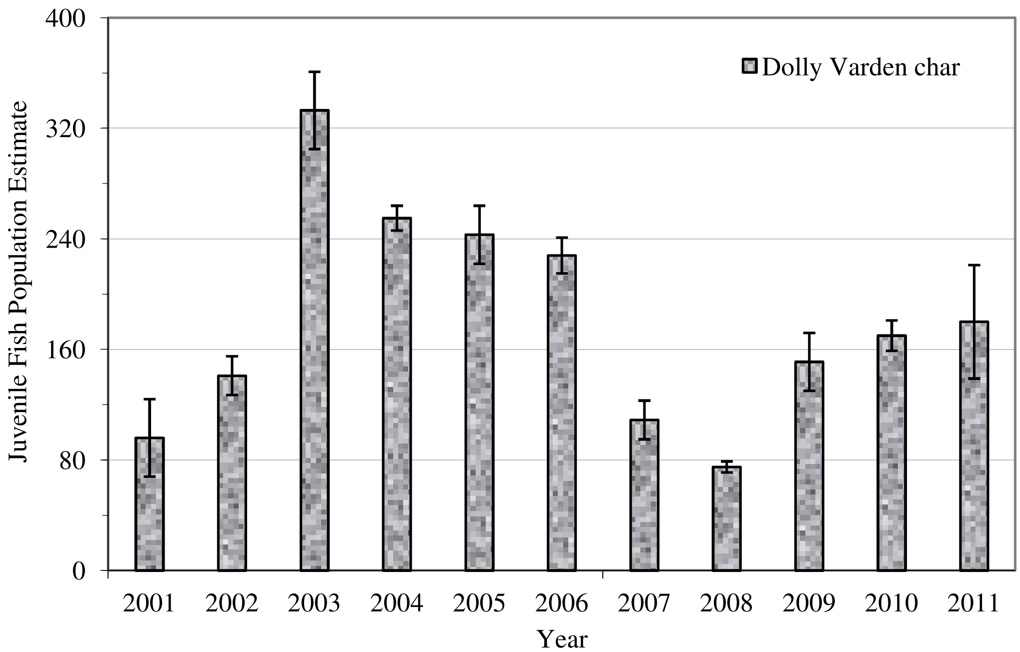


Figure 8.–Juvenile fish population estimates at Greens Creek Site 48, 2001–2011.

## Metals Concentrations in Juvenile Fish

Metals concentrations in juvenile Dolly Varden char collected at Site 48 in 2011 were similar to those observed in previous years, and not significantly different. Metal concentrations were higher in 2011 than the means observed in 2010, except silver which was the same (Figure 9).

We did not weigh the fish prior to shipping to the lab and we incorrectly submitted the private laboratory's Chain of Custody form by not individually listing each fish sample. As a result, the lab homogenized the six samples and we only have one data point for each analyte.

## Greens Creek Site 48 Summary

Site 48 is located upstream of all mine development and operations, and serves as a control reach to provide data on natural aquatic conditions in Greens Creek. Periphyton biomass has been lower in recent years and likely represents natural variability of algal communities, as stream flow was low prior to sampling and unlikely to scour the streambed and affect results. Low discharge prior to and during sampling 2003–2006 may explain the greater densities of periphyton and macroinvertebrates during those years. The aquatic insects at Site 48 continue to be dominated by EPT species, particularly those classified under Ephemeroptera, though the percentage of EPT taxa in 2011 was the lowest observed at this site since 2001. The mean macroinvertebrate density trend is similar to the periphyton biomass trend 2001–2011. The 2011 Dolly Varden char population was similar to previous years and tissue metals concentrations were not significantly different from samples collected in previous years at this site. Overall, samples collected in 2011 suggest a healthy aquatic community at Site 48.

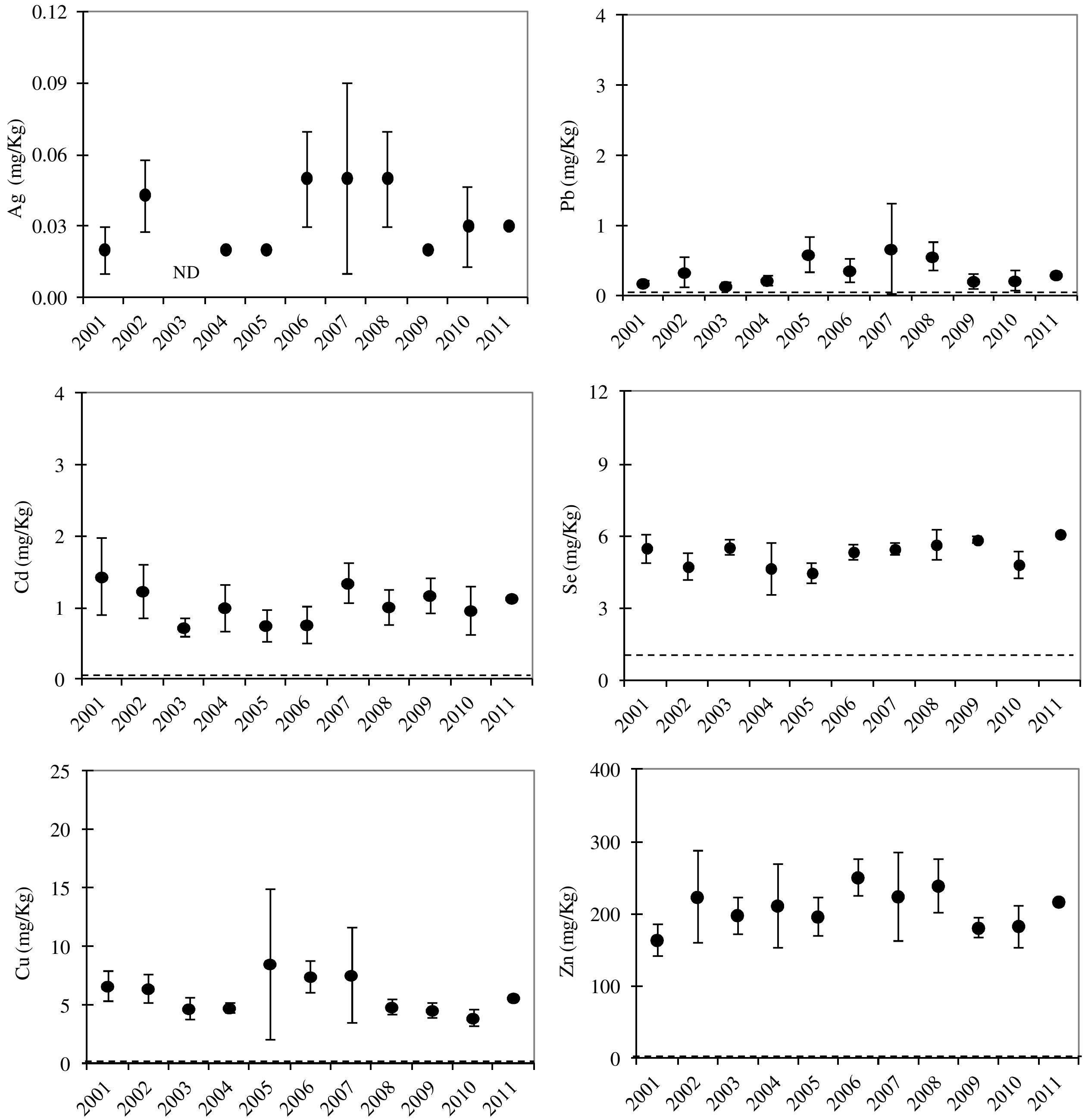


Figure 9.–Mean whole body metals concentrations ± one standard deviation in Dolly Varden char captured at Greens Creek Site 48, 2001–2011.

## GREENS CREEK SITE 6

We sampled Greens Creek Site 6 during the afternoon of July 21, 2011. Hecla personnel recorded the following water quality measurements in Greens Creek during sampling: water temperature 10.42°C, conductivity 105 $\mu$S/cm, and pH 8.14.

### Periphyton Biomass

Periphyton biomass in the 2011 samples from Site 6 were similar to densities observed in 2001 (Figure 10), but the mean ranks of the 2001 and 2011 densities were significantly different ($p \leq 0.05$) than the mean rank of the 2006 densities.

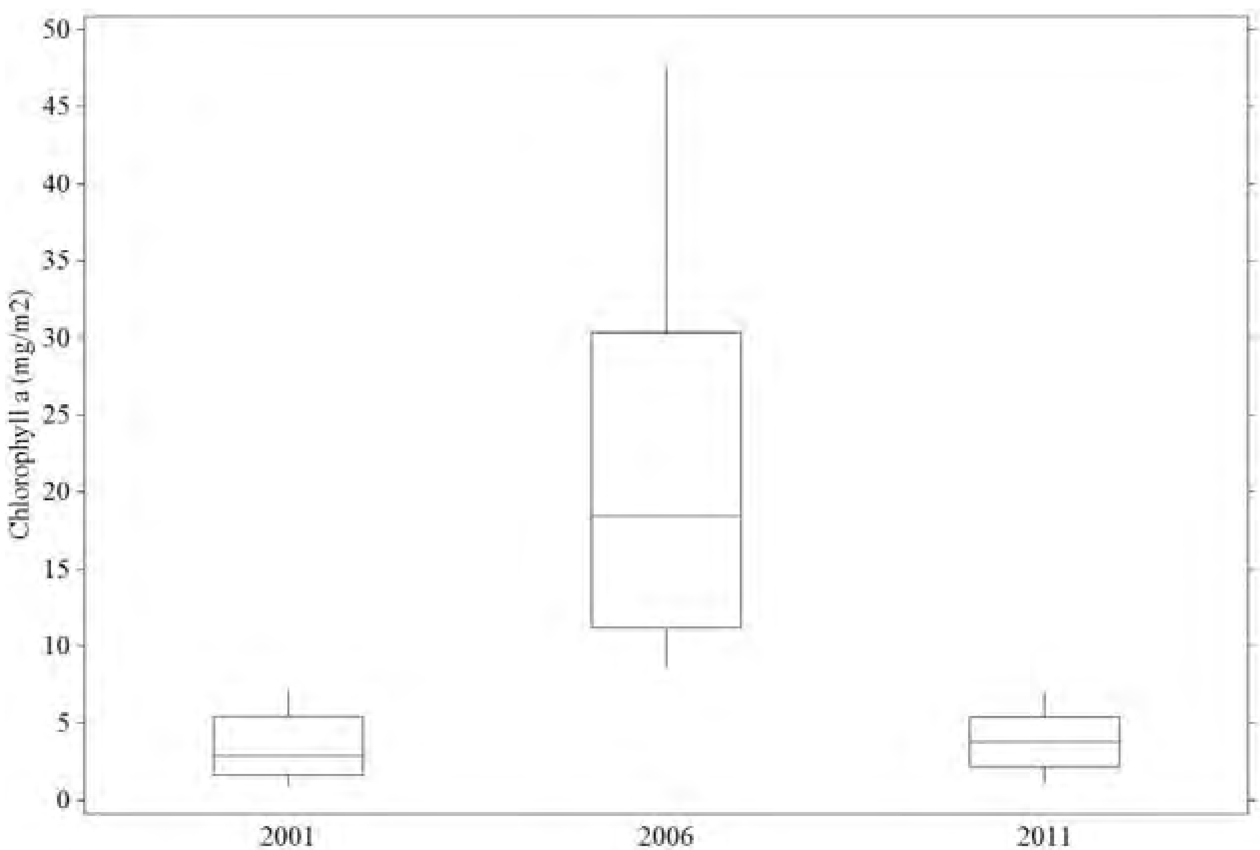


Figure 10.–Periphyton biomass in Greens Creek Site 6 samples from 2001, 2006, and 2011.

The mean densities of chlorophylls *a* and *c* in the Site 6 samples were 3.797 mg/m$^2$ (*a*), and 0.4019 mg/m$^2$ (*c*). We did not find chlorophyll *b* in the 2006 or 2011 samples, which suggests green algae or euglenophytes are not a regular component of the periphyton community. Proportions of chlorophyll *c* in the 2011 samples were similar to previous years (Figure 11), and the mean ranks of the 2001 and 2011 densities were significantly different than the mean rank of the 2006 densities.

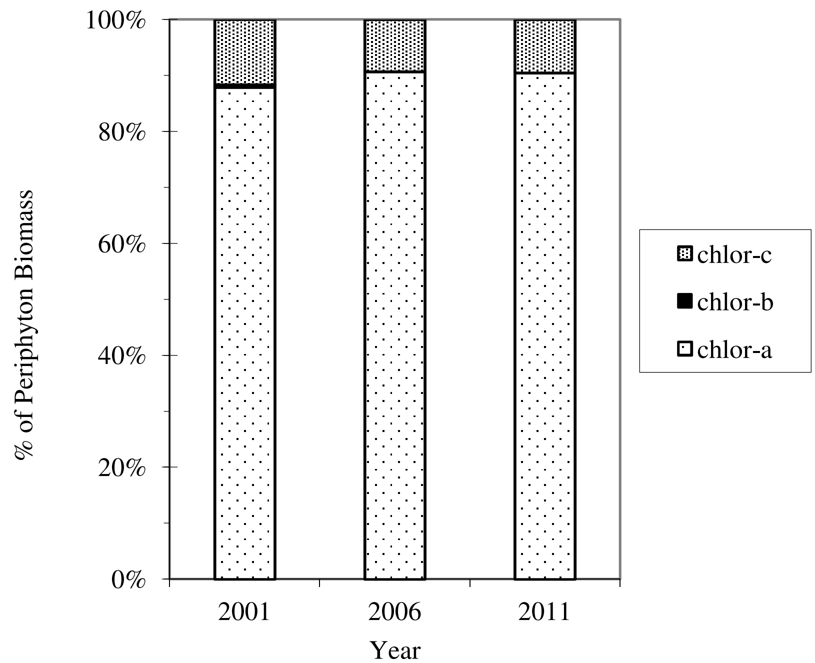


Figure 11.–Mean proportions of chlorophylls *a*, *b* and *c* in Greens Creek Site 6 samples from 2001, 2006, and 2011.

## Benthic Macroinvertebrate Density and Richness

The mean density of benthic macroinvertebrates in the 2011 Site 6 samples was 2,040 insects/$m^2$, similar to the mean density observed in 2001 (Table 2, Figure 12). We observed a total of 27 taxa in the 2011 samples, the greatest observed at this site. The mean rank for the number of taxa observed per sample in 2011 was significantly different ($p \leq 0.05$) than the mean rank for the number of taxa observed per sample in 2006.

Table 2.–Mean benthic macroinvertebrate density and richness at Greens Creek Site 6 2001, 2006, and 2011.

| Year | Mean Density [a] (aquatic inverts/$m^2$) | Taxonomic Richness [a] |
|---|---|---|
| 2001 | 2,319 | 19 |
| 2006 | 714 | 12 |
| 2011 | 2,040 | 27 |

[a] Adjusted in Technical Report 12-03.

About 86% of the benthic macroinvertebrates collected at Site 6 in 2011 were EPT taxa, the lowest percentage observed in the 11 years of sampling at this site, yet still a healthy portion of the aquatic insect community (Figure 13). Three dominant taxa classified under Ephemeroptera made up the majority of EPT insects: Baetidae Baetis, rated “moderately sensitive” to imparied water quality, and Ephemerellidae Drunella and Heptageniidae Epeorus, both rated “extremely sensitive” (Barbour et al. 1999). Diptera taxa were more common (12%) in the 2011 samples than samples from any previous year.

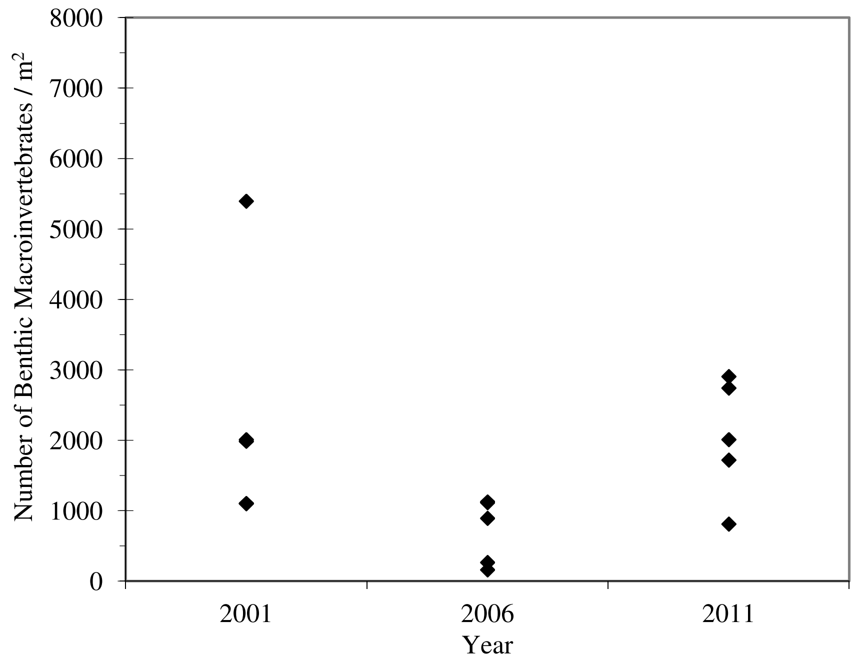


Figure 12.–Benthic macroinvertebrate densities in Greens Creek Site 6 samples from 2001, 2006, and 2011.

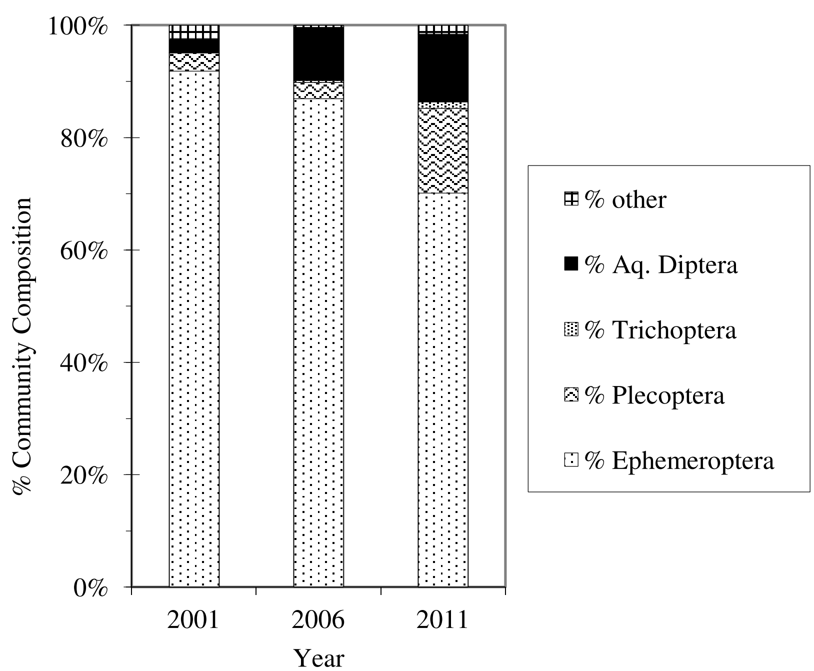


Figure 13.–Benthic macroinvertebrate community composition in Greens Creek Site 6 samples from 2001, 2006, and 2011.

## Juvenile Fish Populations

We estimated the 2011 Site 6 Dolly Varden char population at 178±13 fish, significantly higher than in 2006 and similar to the 2001 population estimate (Figure 14), and density at 0.34 fish per $m^2$, similar to previous years. Length frequency plots (Appendix C) of Dolly Varden char captured at Site 6 suggest multiple age classes are present most years. We did not capture juvenile coho salmon in 2011, consistent with low numbers observed in previous years (2001, *n*=3; 2006, *n*=1).

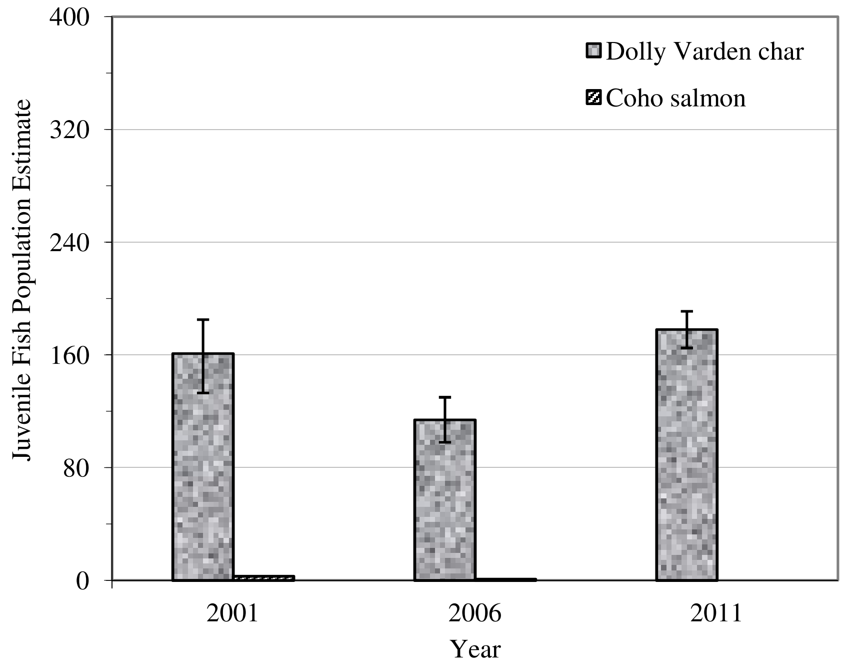


Figure 14.–Juvenile fish population estimates at Greens Creek Site 6 in 2001, 2006, and 2011.

## Metals Concentrations in Juvenile Fish

Metals concentrations in juvenile Dolly Varden char collected at Site 6 in 2011 were similar to those observed in 2001 and 2006, and not significantly different (Figure 15).

We did not weigh the fish prior to shipping to the lab and we incorrectly submitted the private laboratory's Chain of Custody form by not individually listing each fish sample. As a result, the lab homogenized the six samples and we only have one data point for each analyte.

## Greens Creek Site 6 Summary

Site 6 is located downstream of the mine portal and mill facilities and upstream of production rock storage areas 23 and D adjacent to Bruin Creek. Periphyton biomass in 2011 was similar to 2001; data from both years were significantly different than 2006 data when biomass was much greater. In 2011, the aquatic insect densities at Site 6 were similar to data from 2001, more taxa were present than observed in previous years, and a healthy number of EPT taxa were present, though a smaller proportion than previously documented at this site. Benthic macroinvertebrate density and Dolly Varden char populations follow an opposite trend than periphyton biomass, where aquatic insects, the number of taxa, and the juvenile Dolly Varden char population were greater in 2001 and 2011 than in 2006. Though juvenile coho salmon captures were low in all sample years, the failed fish pass prevents most adult coho salmon migration to this site. A heavy rainstorm in late 2005 damaged the fish pass, reducing adult fish passage and reproduction upstream of the natural barrier bedrock chute. Fish tissue metals concentrations in the 2011 samples were not significantly different from concentrations observed in previous years. Overall, samples collected in 2011 suggest a healthy aquatic community at Site 6.

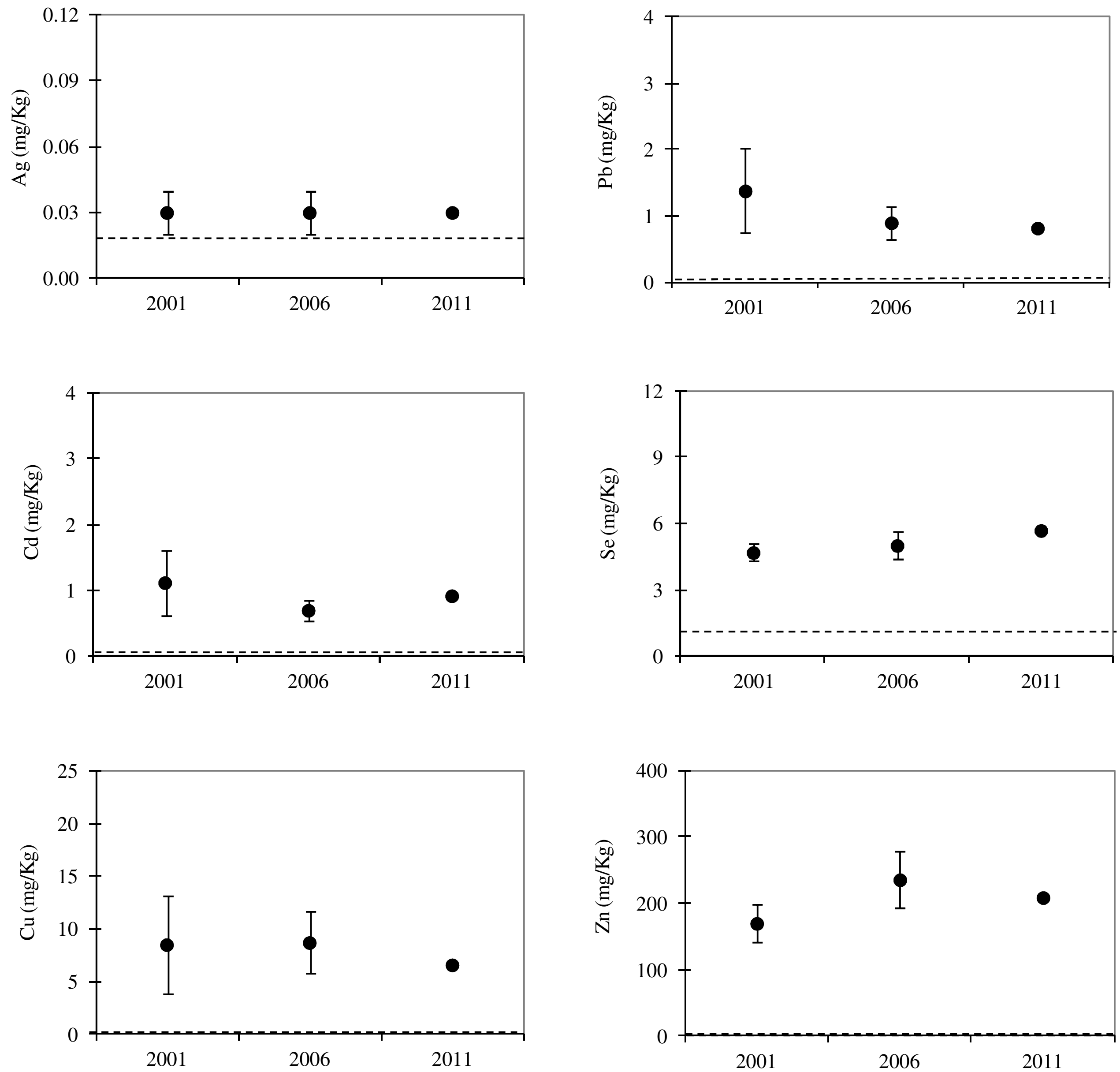


Figure 15.– Mean whole body metals concentrations ± one standard deviation in Dolly Varden char captured at Greens Creek Site 6 in 2001, 2006, and 2011.

## GREENS CREEK SITE 54

We sampled Greens Creek Site 54 during the morning of July 21, 2011. Hecla personnel recorded the following water quality measurements in Greens Creek during sampling: water temperature 7.0°C, conductivity 105 $\mu$S/cm, and pH 7.87.

### Periphyton Biomass

Periphyton biomass in the 2011 samples from Site 54 were similar to past densities (Figure 16), and the mean rank of samples was not significantly different than the mean ranks of previous years' data. Of note, one sample contained the highest amount of chlorophyll *a* observed at Site 54 in the 11 years of sampling at this site: 44.78 mg/m$^2$.

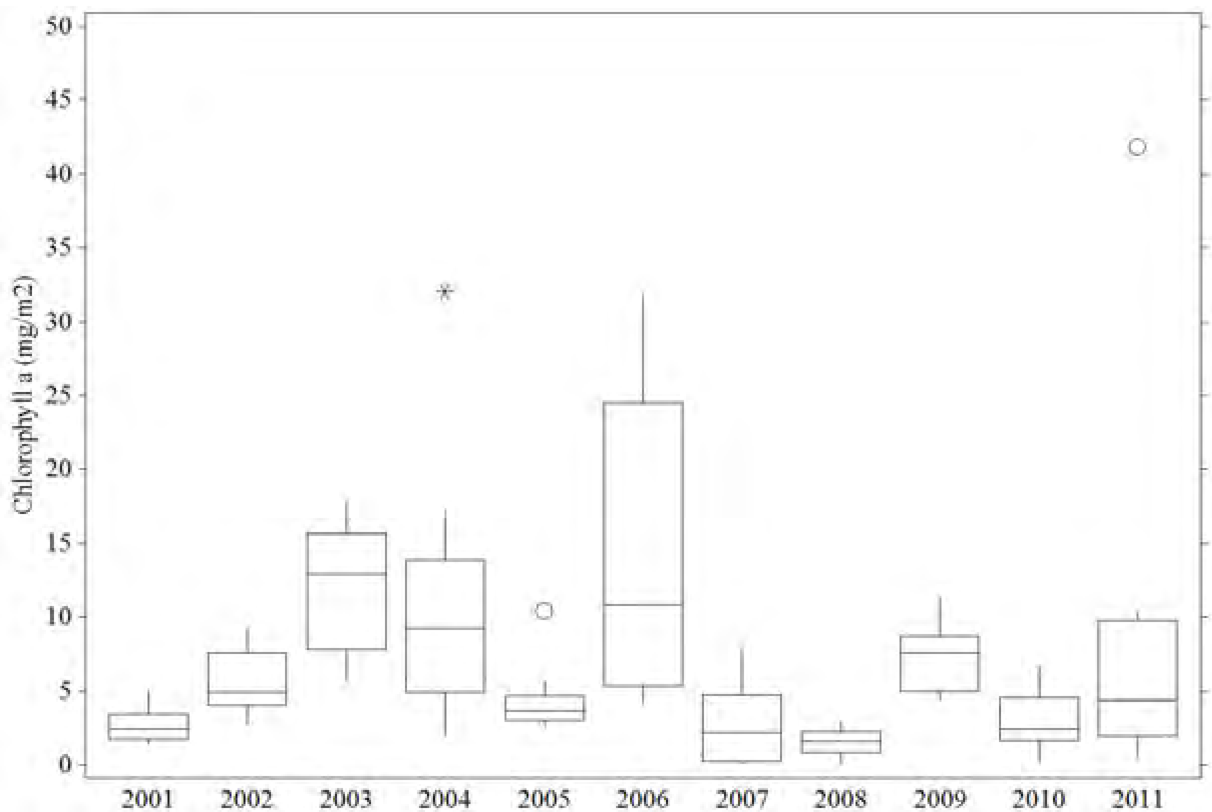


Figure 16.–Periphyton biomass in Greens Creek Site 54 samples, 2001–2011.

The mean densities of chlorophylls *a*[1] and *c* in Site 54 samples were 8.427 mg/m$^2$ (*a*) and 0.635 mg/m$^2$ (*c*). We did not find chlorophyll *b* in the 2011 samples; this is similar to previous years and suggests green algae or euglenophytes are not a regular component of the periphyton community. Proportions of chlorophyll *c* in the 2011 samples were also consistent with previous years (Figure 17).

[1] The median chlorophyll *a* density in samples collected in 2011 at Site 54 was 4.325 mg/m$^2$, nearly half the value of the mean.

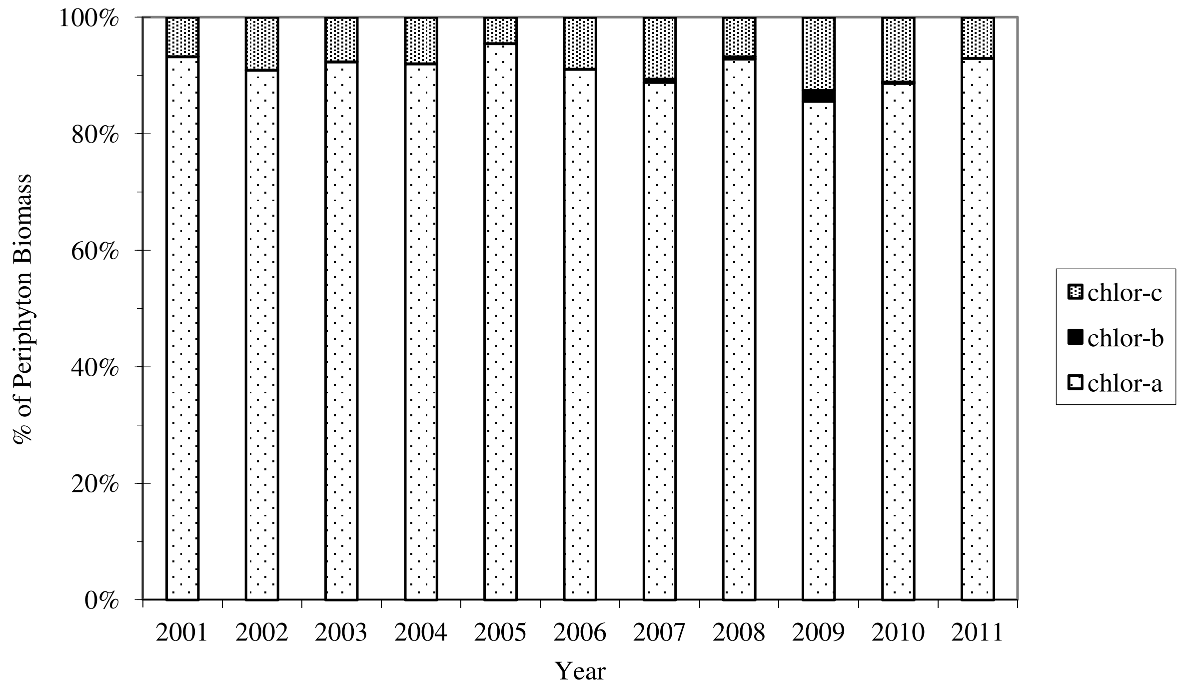


Figure 17.–Mean proportions of chlorophylls *a*, *b* and *c* in Greens Creek Site 54 samples, 2001–2011.

### Benthic Macroinvertebrate Density and Richness

The mean density of benthic macroinvertebrates in the 2011 Site 54 samples was 4,449 insects/m$^2$, greater than the mean densities observed in most years (Table 3, Figure 18). We observed a total of 34 taxa in the 2011 samples, the greatest number at this site. The mean rank for the number of taxa observed per sample in 2011 was significantly different ($p \leq 0.05$) than the mean rank for the number of taxa observed per sample in 2006 and 2007.

Table 3.– Mean Benthic macroinvertebrate density and richness at Greens Creek Site 54, 2001–2011.

| Year | Mean Density[a] (aquatic inverts/m$^2$) | Taxonomic Richness[a] |
|---|---|---|
| 2001 | 4,144 | 28 |
| 2002 | 3,409 | 30 |
| 2003 | 5,430 | 26 |
| 2004 | 4,575 | 32 |
| 2005 | 3,260 | 25 |
| 2006 | 1,221 | 13 |
| 2007 | 742 | 15 |
| 2008 | 2,970 | 22 |
| 2009 | 2,277 | 23 |
| 2010 | 3,202 | 21 |
| 2011 | 4,449 | 34 |

[a] Adjusted in Technical Report 12-03.

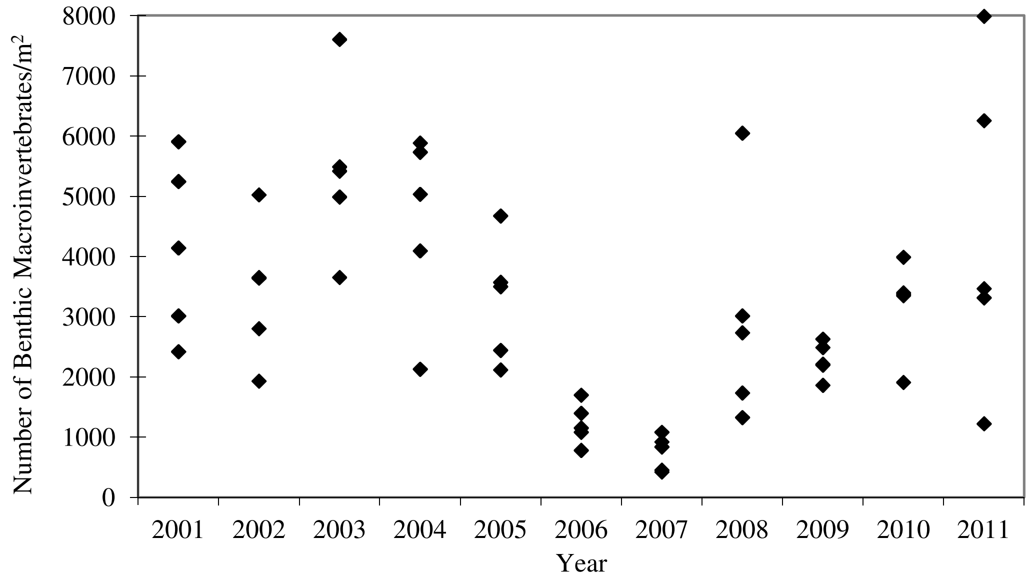


Figure 18.–Benthic macroinvertebrate densities in Greens Creek Site 54 samples, 2001–2011.

Approximately 87% of the benthic macroinvertebrates collected at Site 54 in 2011 were EPT taxa, the lowest percentage observed in the 11 years of sampling at this site, yet still a healthy portion of the aquatic insect community (Figure 19). Similar to samples collected at Site 6 in 2011, three dominant taxa classified under Ephemeroptera made up the majority of EPT insects: Baetidae Baetis, rated "moderately sensitive" to impaired water quality, and Ephemerellidae Drunella and Heptageniidae Epeorus, both rated "extremely sensitive" (Barbour et al. 1999). Diptera taxa were more common (11%) in the 2011 samples than any previous year.

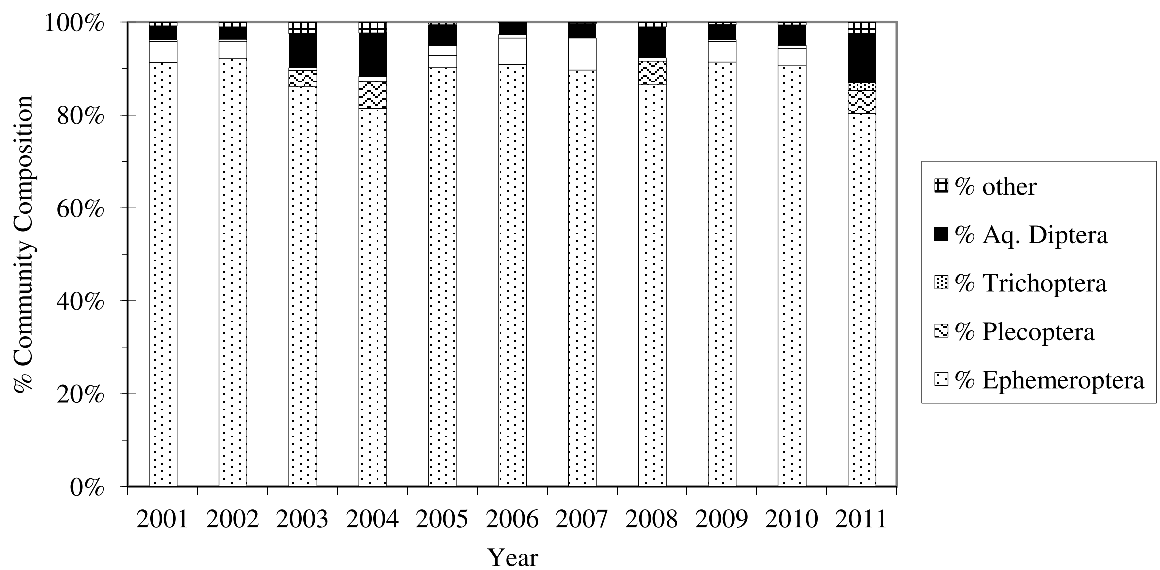


Figure 19.–Benthic macroinvertebrate community composition in Greens Creek Site 54 samples, 2001–2011.

### Juvenile Fish Populations

We estimated the 2011 Site 54 Dolly Varden char population at 259±44 fish, significantly higher than the last four years and the 2001 estimate (Figure 20), and density at 0.40 fish per $m^2$, similar to previous years. Length frequency plots (Appendix C) of Dolly Varden char captured at Site 54 suggest multiple age classes are present each year. We did not capture juvenile coho salmon at this site in 2011.

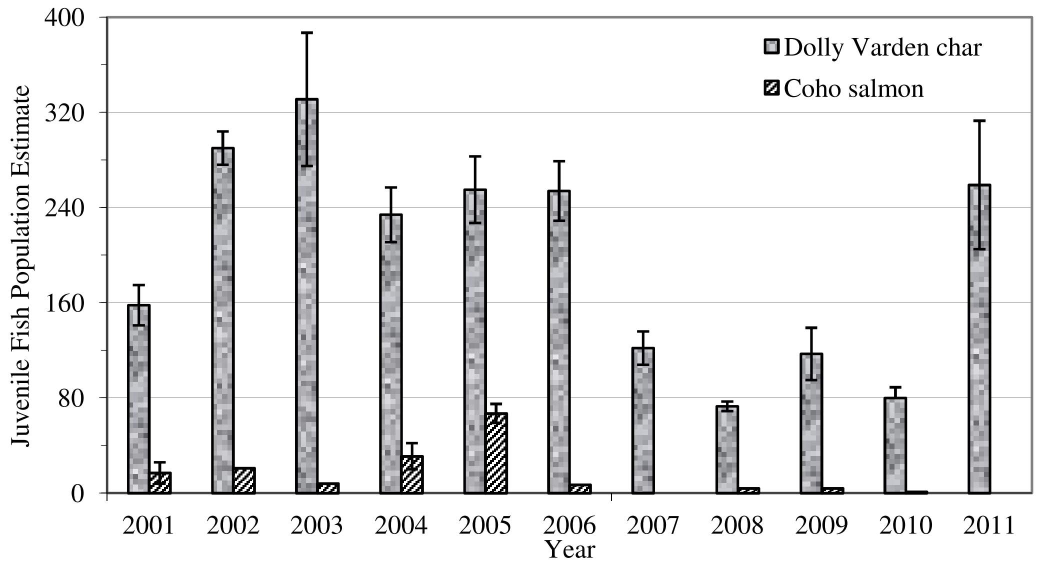


Figure 20.–Juvenile fish population estimates at Greens Creek Site 54, 2001–2011.

Site 54 is the only fish sample reach that is less than 50 m long. The 28 m fish sample reach may be too small to accurately estimate the fish population as fish habitat features change over time, and results could incorrectly suggest a smaller population of fish at this site. In 2011, we extended the 28 m fish sample reach length to 58 m, where a small log waterfall on the downstream end provides a natural break. We will continue to sample the 58 m reach in the future.

### Metals Concentrations in Juvenile Fish

Metals concentrations in juvenile Dolly Varden char collected at Site 54 in 2011 were similar to those observed in previous years, and not significantly different. Metals concentrations were higher in 2011 samples than the means observed in 2010, except silver which was not detected and cadmium which was slightly lower (Figure 21).

We did not weigh the fish prior to shipping to the lab and we incorrectly submitted the private laboratory's Chain of Custody form by not individually listing each fish sample. As a result, the lab homogenized the six samples and we only have one data point for each analyte.

### Greens Creek Site 54 Summary

Site 54 is located downstream of the mine portal, mill facilities, and production rock storage areas 23 and D, and monitored to detect potential effects from mining activities. Periphyton biomass has been lower in recent years and the range of variability was greater in the 2011 samples than the previous four years. High discharge before sampling in 2007 and 2008 appeared to affect results by scouring the streambed and reducing periphyton biomass, and low discharge appeared to promote algal growth in 2003 and 2004. The aquatic insects at Site 54 continue to be dominated by EPT species, particularly those classified under Ephemeroptera. Though the percentage of EPT taxa was the second lowest observed since 2001, we observed the greatest number of taxa at this site in 2011. We sampled juvenile fish in a larger reach in 2011 than previous years, and found a larger population of Dolly Varden char and no coho salmon. Fish tissue metals concentrations were similar to those observed in previous years. Overall, samples collected in 2011 suggest a healthy aquatic community at Site 54, though juvenile coho salmon captures have been consistently low since 2006. A heavy rainstorm in late 2005 damaged the fish pass, reducing adult fish passage and reproduction upstream of the natural barrier bedrock chute.

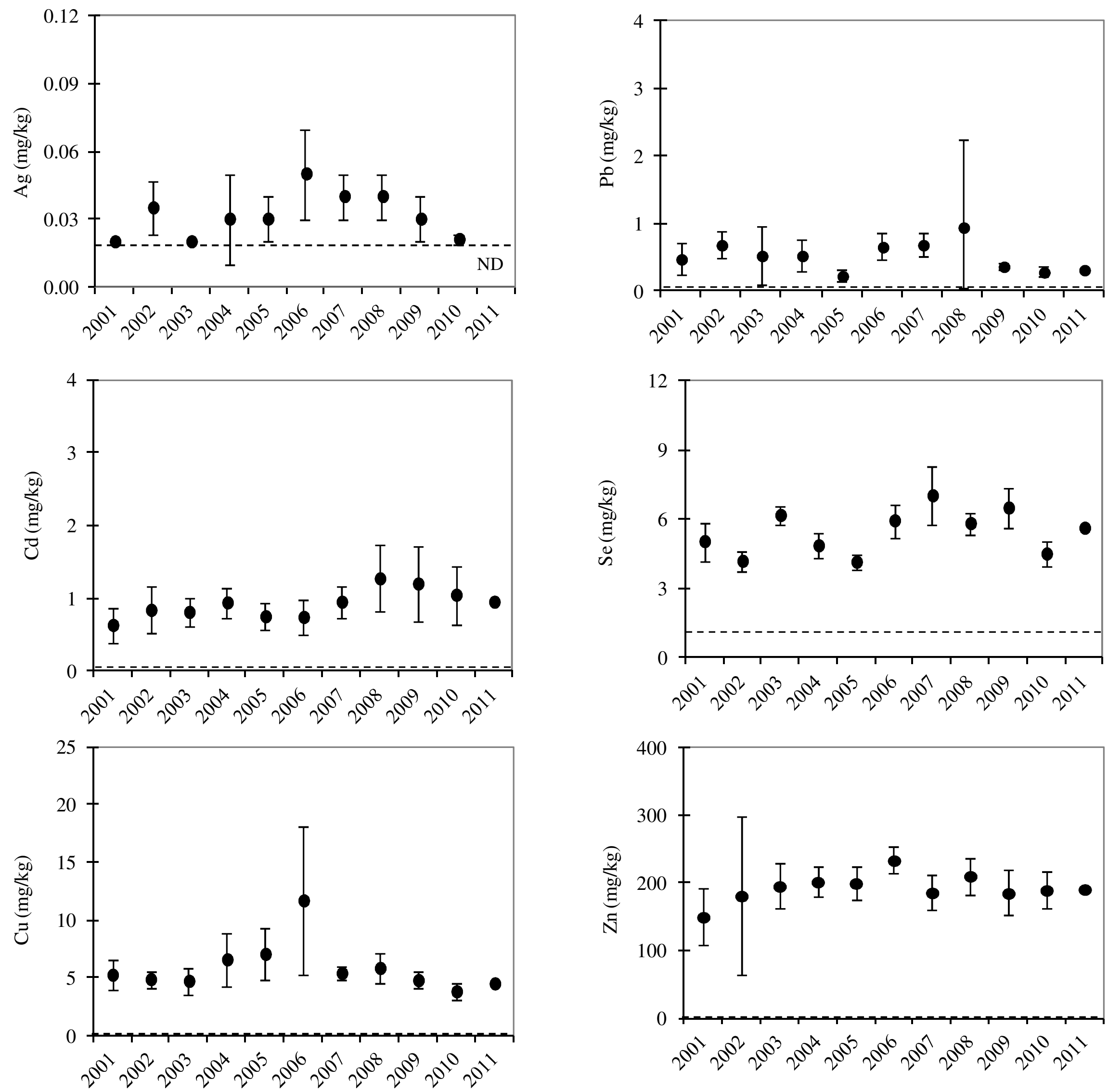


Figure 21.– Mean whole body metals concentrations ± one standard deviation in Dolly Varden char captured at Greens Creek Site 54, 2001–2011.

## TRIBUTARY CREEK SITE 9

We sampled Tributary Creek Site 9 during the morning of July 20, 2011. Hecla personnel recorded the following water quality measurements in Greens Creek during sampling: water temperature 11.53°C, conductivity 98 $\mu$S/cm, and pH 6.6.

### Periphyton Biomass

Periphyton biomass in the 2011 Tributary Creek Site 9 samples was similar to densities previously observed (Figure 22), and not statistically different than any previous year.

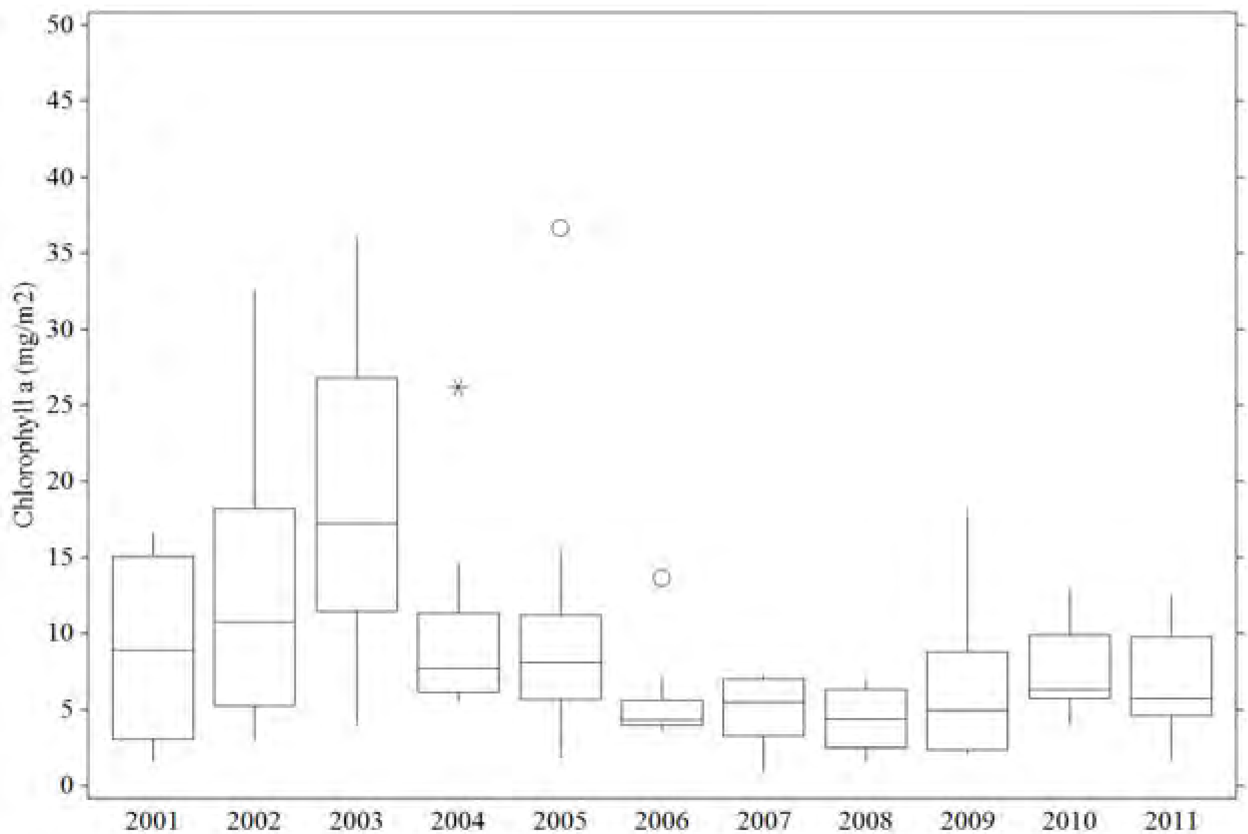


Figure 22.–Periphyton biomass in Tributary Creek Site 9 samples, 2001–2011.

The mean densities of chlorophylls *a, b,* and *c* in Site 9 samples were 6.558 $mg/m^2$ (*a*), 0.050 $mg/m^2$ (*b*), and 0.325 $mg/m^2$ (*c*). Organisms producing chlorophyll *c* pigment continue to be more common than those producing chlorophyll *b* pigment (Figure 23). The mean rank for the 2011 chlorophyll *b* and *c* densities were significantly different than the mean rank for the 2009 (*b*) and 2003 (*c*) densities.

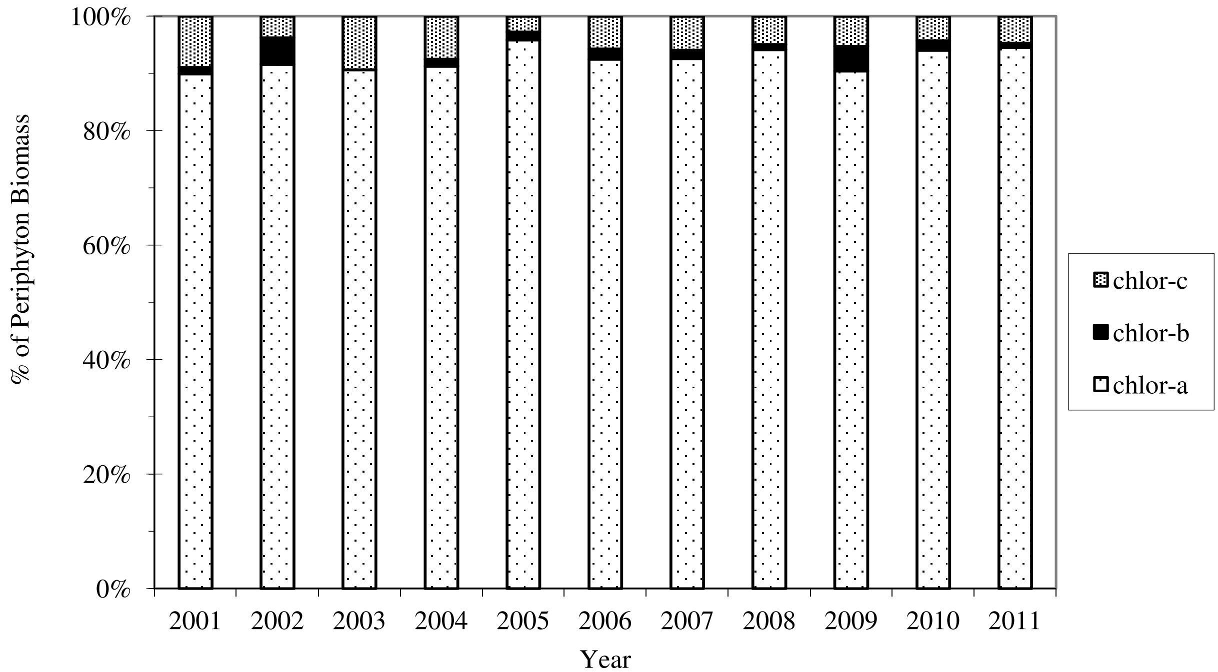


Figure 23.–Mean proportions of chlorophyll *a*, *b* and *c* in Tributary Creek Site 9 samples, 2001–2011.

### Benthic Macroinvertebrate Density and Richness

The mean density of benthic macroinvertebrates in the 2011 Site 9 samples was 1,991 insects/$m^2$, similar to the mean densities previously observed and greater than observed in the previous six years (Table 4, Figure 24). We observed a total of 26 taxa among the 2011 samples, also similar to previous years. We did not find any statistical differences when we compared 2011 macroinvertebrate density and richness sample data to data from previous years.

Table 4.–Mean Benthic macroinvertebrate density and richness at Tributary Creek Site 9, 2001–2011.

| Year | Mean Density [a] (Aquatic inverts/$m^2$) | Taxonomic Richness [a] |
|---|---|---|
| 2001 | 1,184 | 21 |
| 2002 | 1,740 | 24 |
| 2003 | 5,851 | 36 |
| 2004 | 2,400 | 26 |
| 2005 | 1,228 | 30 |
| 2006 | 1,453 | 23 |
| 2007 | 507 | 21 |
| 2008 | 1,751 | 20 |
| 2009 | 1,114 | 26 |
| 2010 | 458 | 22 |
| 2011 | 1,991 | 26 |

[a] Adjusted in Technical Report 12-03.

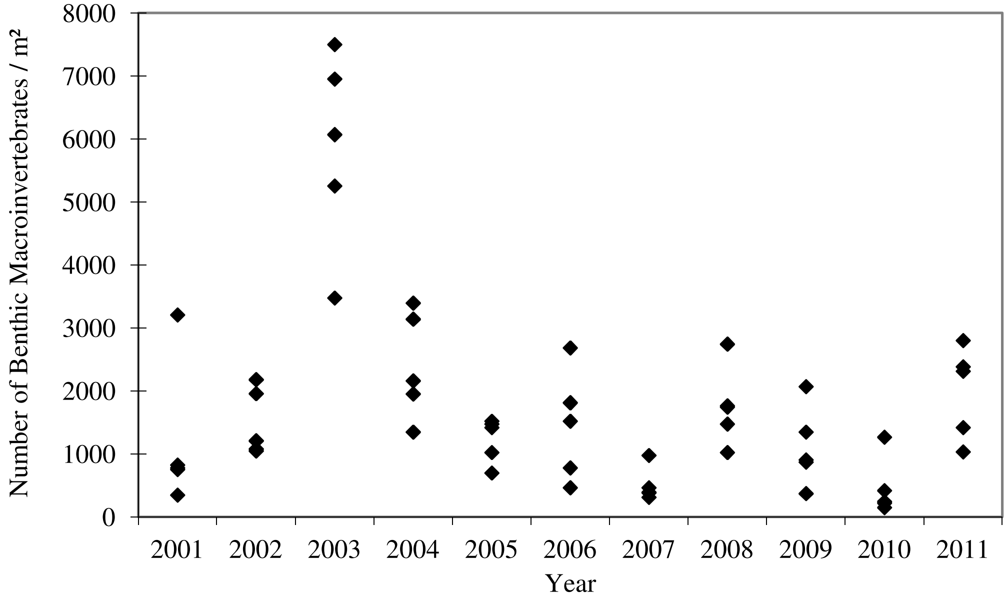


Figure 24.–Benthic macroinvertebrate densities in Tributary Creek Site 9 samples, 2001–2011.

Approximately 50% of the benthic macroinvertebrates collected at Site 9 in 2011 were EPT taxa. Though this is the lowest percentage of EPT taxa observed in the 11 years of sampling at this site (Figure 25), the mean number of EPT insects was similar to previous years (Figure 26). Many of the EPT taxa present were rated "extremely sensitive" to impaired water quality (Barbour et al. 1999). Chrionomids were dominant (21%) for the third year in a row, unlike previous years. Ostracods (crustaceans) and Oligocheates (worms) made up about 23% of the "other" organisms in our 2011 samples, a greater proportion than most samples collected in previous years.

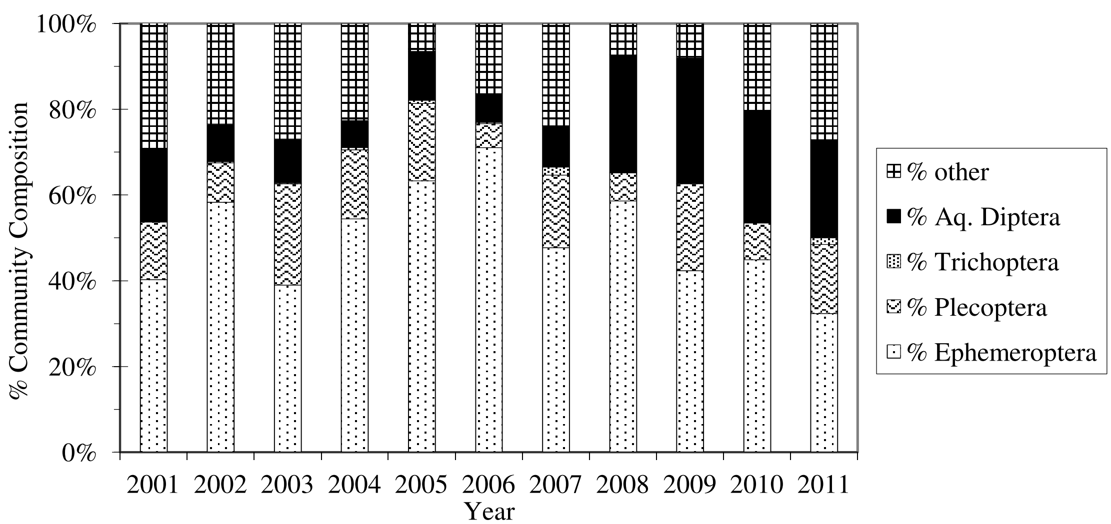


Figure 25.–Benthic macroinvertebrate community composition in Tributary Creek Site 9 samples, 2001–2011.

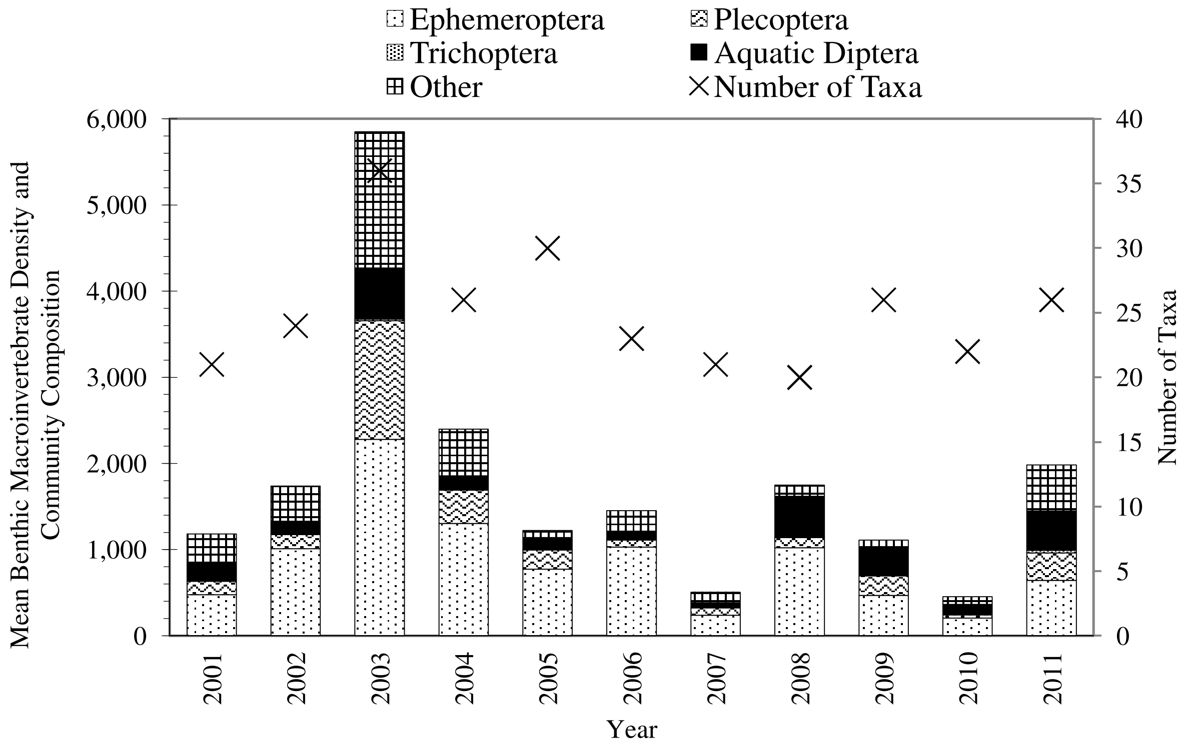


Figure 26.–Mean benthic macroinvertebrate community composition, densities and richness (×) in Tributary Creek, 2001–2011.

## Juvenile Fish Populations

The 2011 juvenile fish population estimates (Figure 27) at Site 9 were 53±21 Dolly Varden char with an approximate density of 0.46 fish/$m^2$, and 69±23 coho salmon with an approximate density of 0.60 fish per $m^2$. These estimates were significantly different than several previous years as juvenile fish populations were highly variable in the 11 years of sampling at Site 9. Length frequency plots (Appendix C) of Dolly Varden char and coho salmon captured at Site 54 suggest multiple age classes were present in 2011. Young-of-year Dolly Varden char appeared to be absent in the 2006 and 2007 fish surveys and young-of-year coho appeared to be absent in 2006, though young-of-year of both species have been present since then.

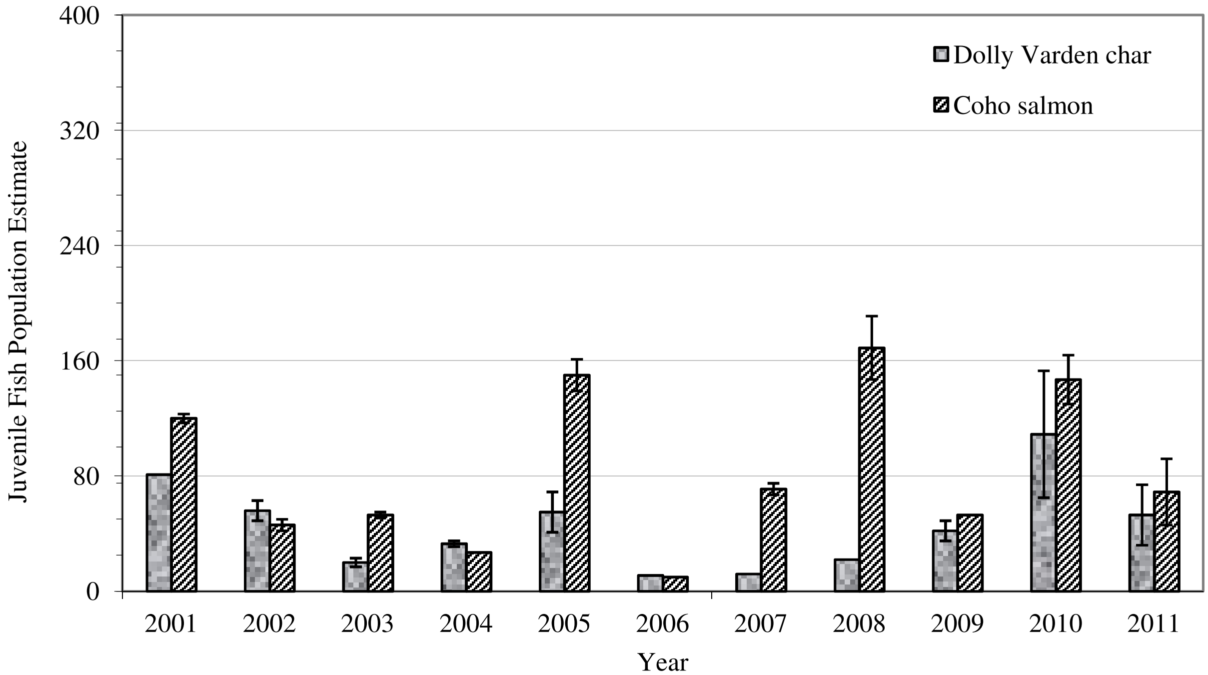


Figure 27.–Juvenile fish populations at Tributary Creek Site 9, 2001–2011.

## Metals Concentrations in Juvenile Fish

Metals concentrations in juvenile Dolly Varden char collected at Site 9 in 2011 were similar to those observed in previous years, and not significantly different. Concentrations of selenium, copper and zinc were higher in 2011 than the means in 2010, and the concentrations of silver, lead and cadmium were lower (Figure 28).

We did not weigh the fish prior to shipping to the lab and we incorrectly submitted the private laboratory's Chain of Custody form by not individually listing each fish sample. As a result, the lab homogenized the six samples and we only have one data point for each analyte.

## Tributary Creek Site 9 Summary

Site 9 is located downstream of the tailing dry-stack facility and monitored to detect potential effects from the tailing facility and road runoff. Periphyton biomass and mean benthic macroinvertebrate density in 2011 were similar to those observed since 2004, and not significantly different compared to data from previous years. Little presence of chlorophyll *b* at Site 9 suggests green algae or euglenophytes are occasionally present in the periphyton community, while presence of chlorophyll *c* in all years indicates diatoms and dinoflagellates are a regular component of the periphyton community. The aquatic insect community continues to be dominated by EPT taxa, more recently Chironomids (nonbiting midges), and occasionally by Ostracods (crustaceans) and Oligochaetes (worms). Juvenile fish populations were highly variable each year in the 11 years of monitoring at this site, and whole body metals concentrations in juvenile Dolly Varden char collected in 2011 were not significantly different compared to data from previous years.

Overall, the data suggests a productive aquatic community at Site 9. Changes observed within aquatic communities, such as low insect densities observed in 2007 and 2010, may be related to changes in other communities or changes in water quality. In 2012, we will compare Site 9 water quality data with biological abundance and composition data and whole body fish metals concentrations data to examine relationships, and we will report results in our 2012 Technical Report.

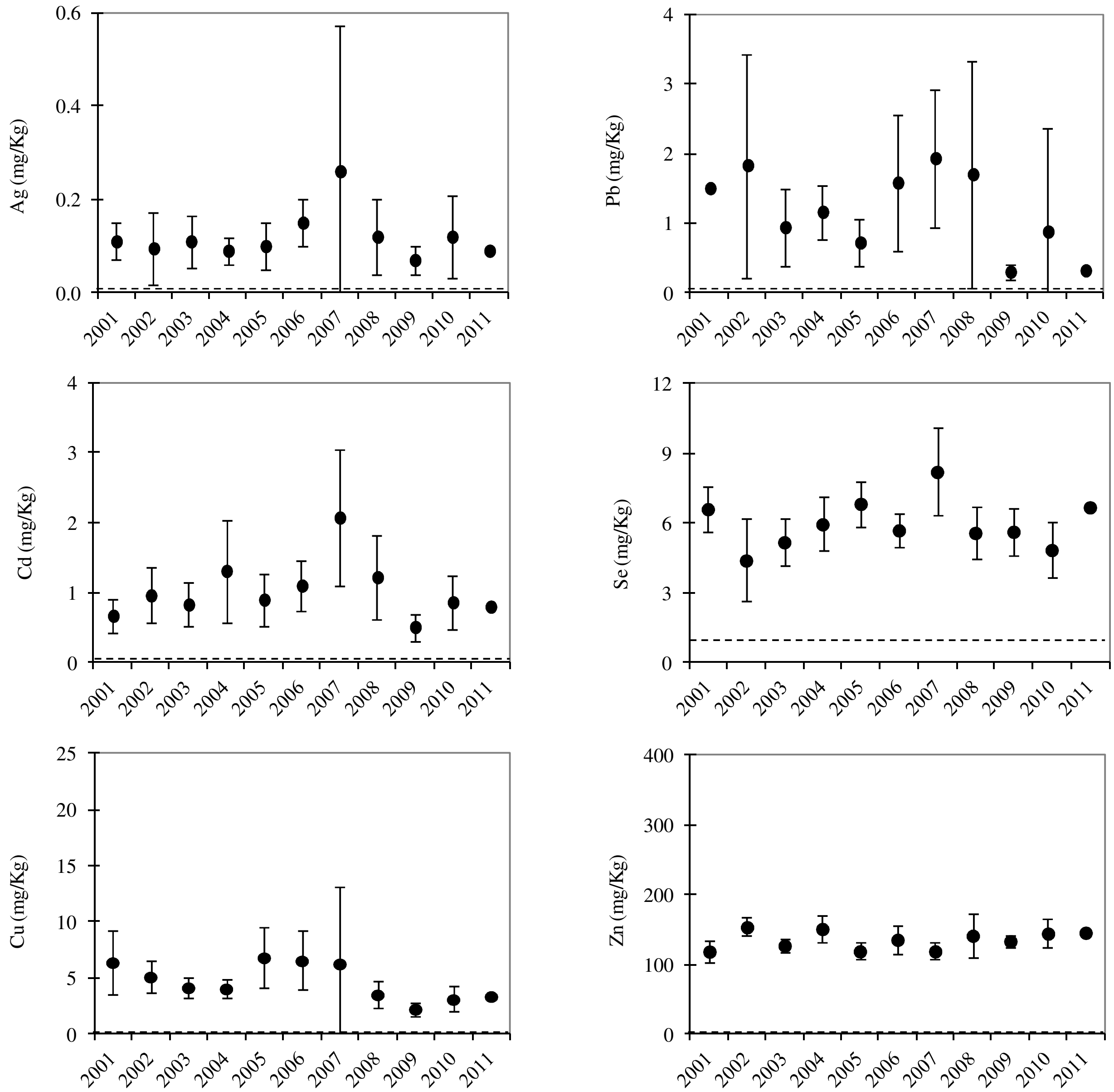


Figure 28.– Mean whole body metals concentrations ± one standard deviation in Dolly Varden char captured at Tributary Creek Site 9, 2001–2011.

## COMPARISON AMONG GREENS CREEK SITES

We do not compare periphyton, benthic macroinvertebrate or fish population data between the Greens Creek and Tributary Creek sample sites because those systems provide different habitats for aquatic life, which have a direct effect on productivity of these organisms. We provide a comparison of the metals fish data between creeks in *Comparison Among Sites.*

### Periphyton Biomass

Periphyton biomass in the 2011 samples from sites 48, 6, and 54 were similar and not significantly different compared together. Biomass at these sites had similar density patterns over the 11 years of sampling, with peak densities observed 2003–2006 and low densities 2007–2008 (Figure 29).[m] Stream flows in Greens Creek prior to and during sampling were low 2003–2006 and high 2007–2008 compared to other years, which may explain the differences periphyton densities during those years.

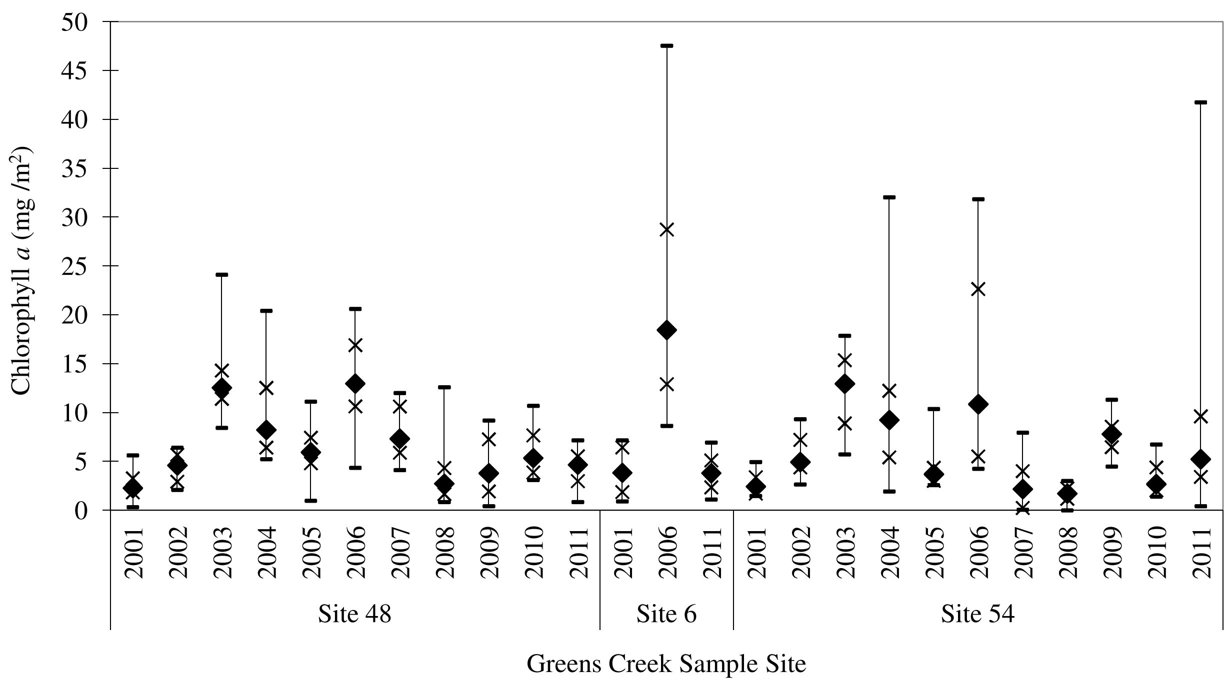


Figure 29.–Comparison of periphyton biomass ranges among Greens Creek sample sites 2001–2011. Median values indicated by (♦), and first and third quartiles indicated by (×).

Periphyton samples collected at Greens Creek sites 48, 6, and 54 in the last 11 years generally contained more than 90% chlorophyll *a*, zero or nearly no chlorophyll *b*, and less than 10% chlorophyll *c*, except in 2009 when chlorophylls *b* and *c* were both elevated (Figure 30). Little presence of chlorophyll *b* at these sites suggest green algae or euglenophytes are occasionally

[m] One periphyton sample collected at Greens Creek Site 54 in 2004 and one sample in 2011 contained high chlorophyll *a* concentrations, 32.04 $mg/m^2$ and 41.76 $mg/m^2$. These densities were unlike other samples collected during those years. Though both densities appear to be outliers, they likely represent natural variation in the aquatic community and remain included in the data set (see methods).

present in the periphyton community, while presence of chlorophyll *c* in all years indicates diatoms and dinoflagellates are a regular component of the periphyton community at each site.

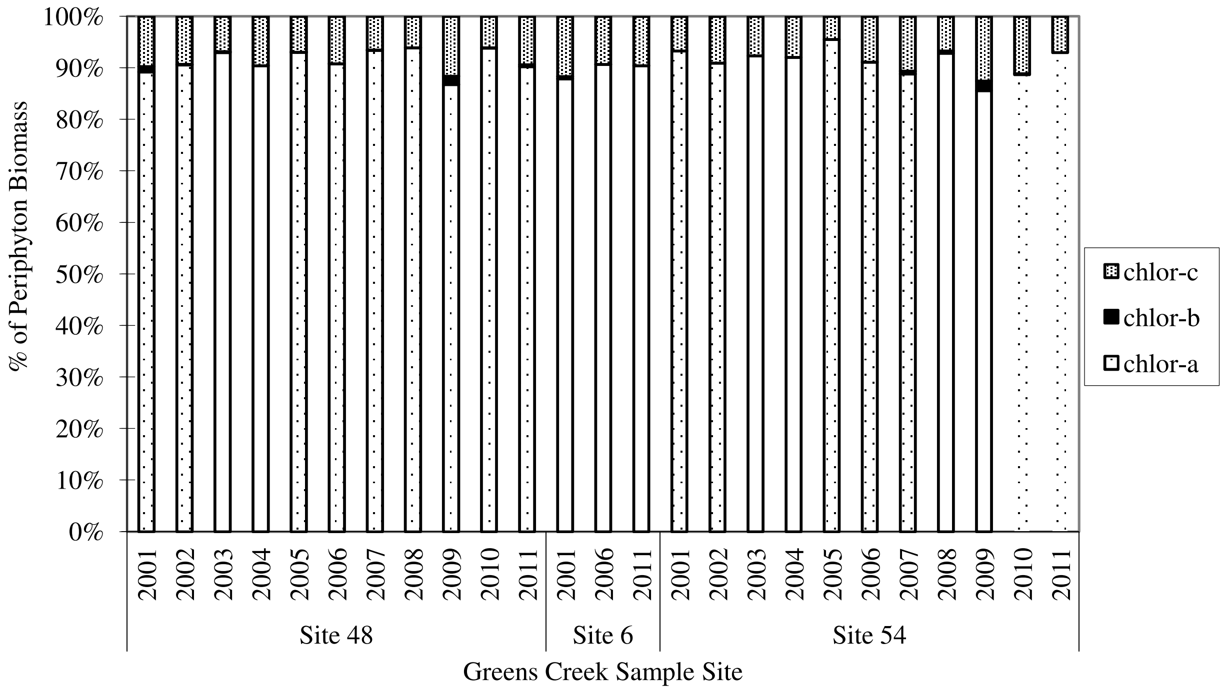


Figure 30.–Comparison of mean proportions of chlorophylls *a*, *b*, and *c* among Greens Creek sample sites, 2001–2011.

## Benthic Macroinvertebrate Density and Richness

Mean benthic macroinvertebrate density increased in 2011 from previous sample years at sites 6 and 54, and decreased at Site 48 (Figure 31). Taxonomic richness increased at all three sites from the previous sample year, and samples from sites 6 and 54 had the greatest amount of richness observed in the 11 years of sampling at these sites. We did not find any statistical differences when we compared the 2011 macroinvertebrate density and richness sample data among Greens Creek sample sites.

Overall, benthic macroinvertebrate densities and richness observed at each site in Greens Creek during 2011 were similar to those observed in the previous 10 years of sampling under the biomonitoring program. Taxonomic richness and the large proportion of EPT taxa and pollution-sensitive species in samples collected at each site suggest complex and healthy benthic macroinvertebrate communities are present at all three sites. Of note, the percentage of EPT at each site in 2011 was less than observed in previous years (Site 48 = 73%; Site 6 = 86% , Site 54 = 87%). In addition, percentage of Chironomids at each site (Site 48 = 17%; Site 6 = 8%; Site 54 = 9%) was higher than the 10-year mean. Increased numbers of Chironomids could be due to natural variability, changes at Greens Creek samples sites, or techniques used in 2011 to collect the samples. We look forward to reviewing the 2012 data to investigate this trend.

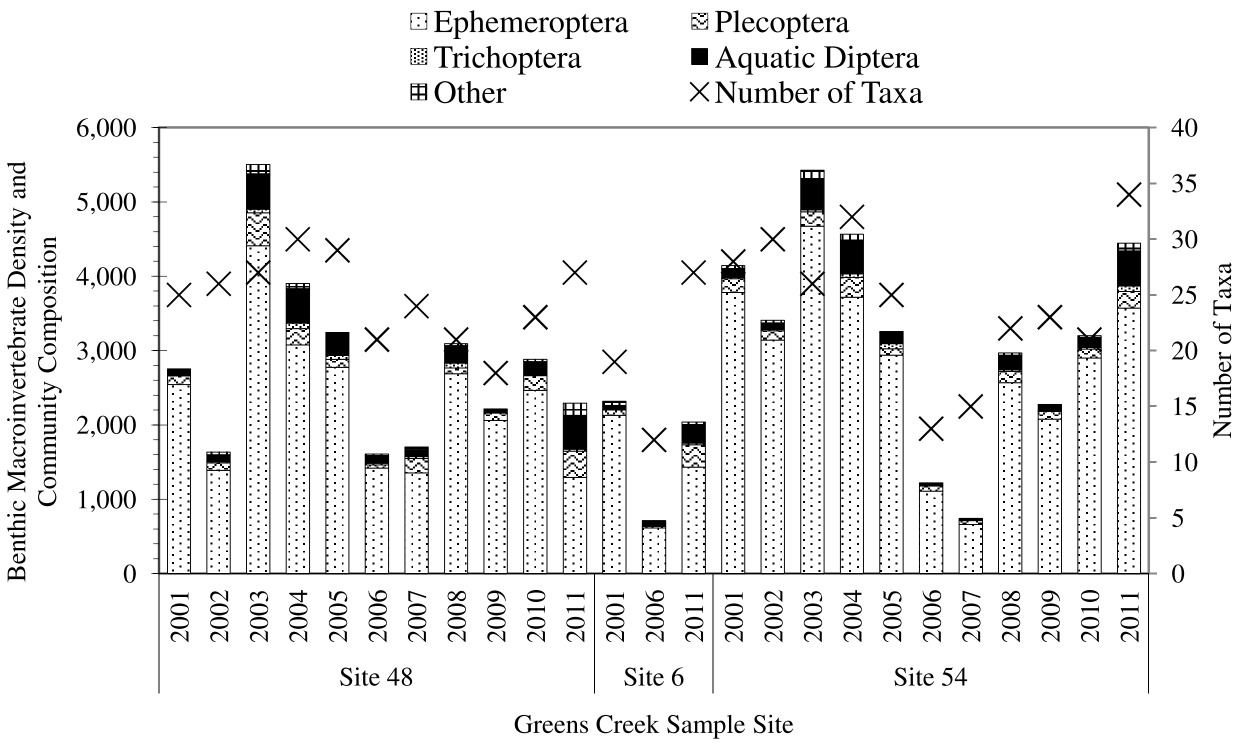


Figure 31.–Comparison of mean benthic macroinvertebrate densities, community composition and richness (×) among Greens Creek sample sites, 2001–2011.

## Juvenile Fish Populations

Figure 32 illustrates the juvenile fish population estimates for Greens Creek sample reaches 2001–2011. Dolly Varden char populations show similar trends over time among sites 48 and 54. Populations were greater 2001–2006, and have since been lower. The 2011 Dolly Varden char population at Site 54 is much greater than the previous four years because we extended the 28 m sample reach to 58 m to increase the sample area, similar in size to the other reaches, which will improve integrity of fish population estimates in following years. We did not capture coho salmon at Site 6 or Site 54 in 2011, not surprising since the fish pass is damaged and not functioning properly. We have not captured many juvenile coho salmon at either site since 2005 due to failure of the fish pass.

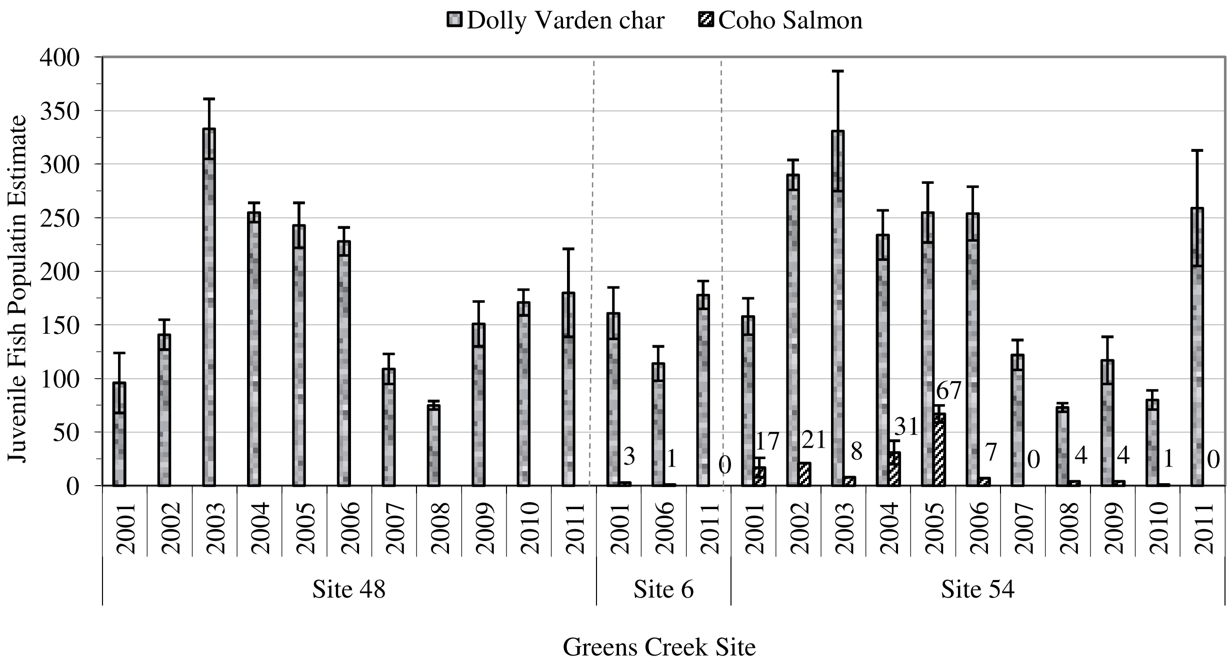


Figure 32.–Comparison of juvenile fish population estimates at Greens Creek sample sites, 2001–2011.

## COMPARISON AMONG SITES

### Metals Concentrations in Juvenile Fish

Figure 33 illustrates the whole body fish metals concentrations data for all sites sampled in 2011. Among Greens Creek sites, tissue concentrations of cadmium, selenium, and zinc were higher in samples collected at control Site 48 than samples collected downstream at sites 6 and 54, except for copper which was higher at Site 6. Silver concentration was the same in samples from sites 48 and 6, and not detected in samples from Site 54. Lead concentration was higher in samples from sites 6 and 54 than in samples from Site 48. At Site 9, tissue concentrations of cadmium, copper and zinc were lower than concentrations in samples from the Greens Creek sites, while selenium and silver concentrations were greater and lead concentration was similar. The 2011 dataset was too small to determine statistical differences in whole body metals concentrations between sites.

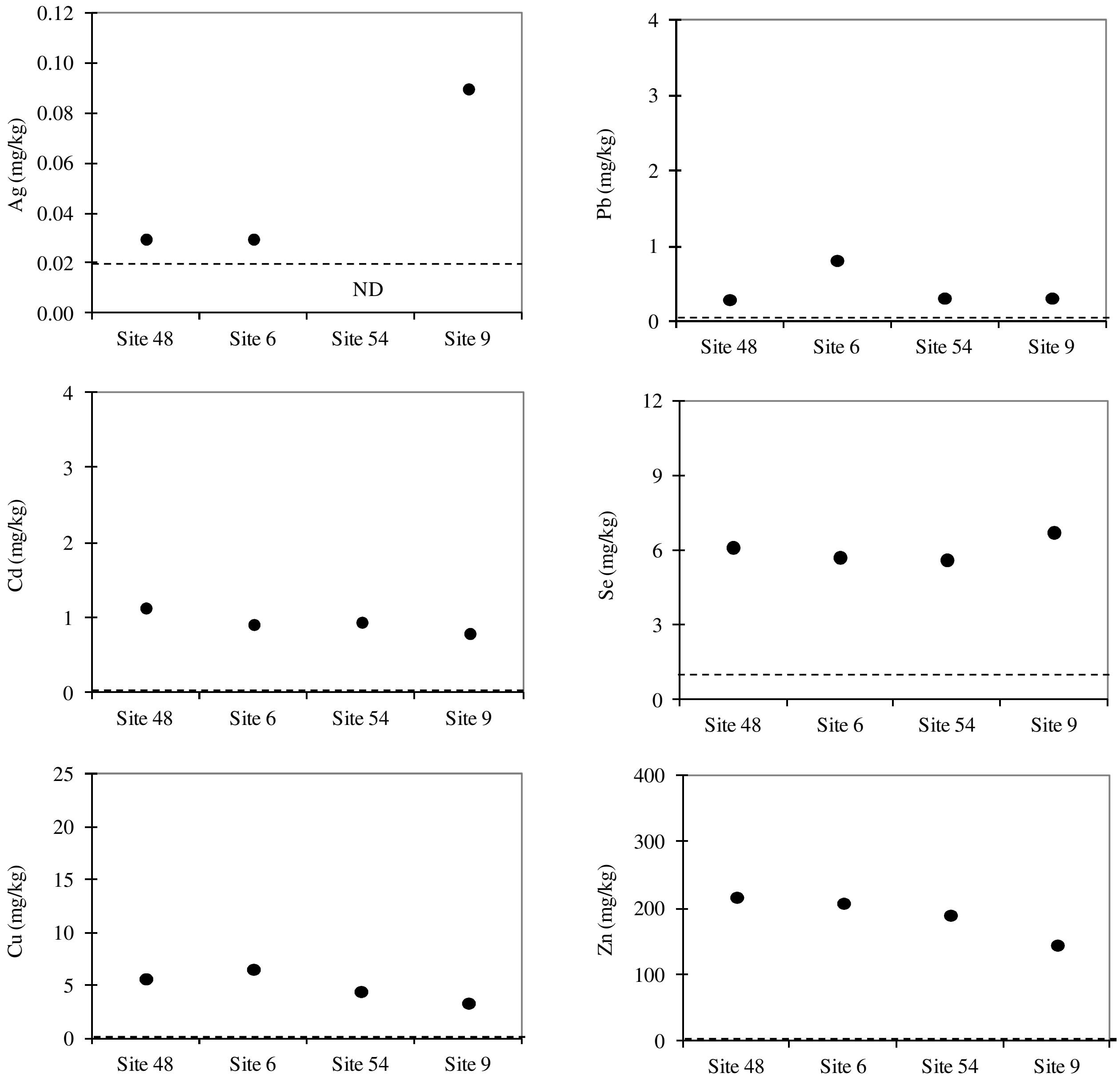


Figure 33.– Comparison among sites of whole body metals concentrations in Dolly Varden char samples collected in 2011.

Figure 34 illustrates mean whole body metals concentrations with one standard deviation for each analyte, each site, 2001–2011, and includes baseline, premining data from three Dolly Varden char collected from Upper Slate Lake and three Dolly Varden char from Lower Slate Lake near the Kensington Gold Mine for comparison. Kensington Gold Mine is an underground gold mine owned and operated by Coeur Alaska, Inc. and located about 80 km northeast of Greens Creek Mine near Berners Bay.

Mean tissue concentrations of silver, lead, and copper in samples collected at Greens Creek sites 6 and 54, 2001–2011, were greater than the mean concentrations in tissues from control Site 48, while mean concentrations of cadmium, selenium and zinc were similar among sites. When we compared samples collected among Greens Creek sites in all years, we found three significant differences, as follows:

1. The mean rank of copper tissue concentration in Site 6 samples was significantly different than the mean ranks of samples from sites 48 and 54.
2. The mean rank of lead tissue concentration in Site 48 samples was significantly different than the mean ranks of samples from sites 6 and 54.
3. The mean rank of lead tissue concentration in Site 6 samples was significantly different than the mean ranks of samples from Site 54.

Samples from Site 9 tend to have greater variability for all metals concentrations than the Greens Creek samples, except for zinc. Mean tissue concentrations in samples collected at Site 9, 2001–2011, were greater than the samples collected at the Greens Creek sites, except for copper and zinc which were lower. When we compared whole body metals concentration data from Greens Creek sites 48, 6, and 54 with data from Tributary Creek Site 9, 2001–2011, we found significant differences for most metals between sites, as follows:

1. The mean ranks of silver, copper and zinc tissue concentrations from Site 9 samples were significantly different than the mean ranks of samples from sites 48, 6 and 54.
2. The mean rank of copper concentration from Site 6 samples was significantly different than the mean rank of samples from Site 54.
3. The mean rank of selenium concentration from Site 9 samples was significantly different than the mean ranks of samples from site 48 and 6.
4. The mean rank of lead concentration from Site 54 samples was significantly different than the mean ranks of samples from sites 48, 6, and 9.
5. The mean rank of lead concentration from Site 48 samples was significantly different than the mean ranks of samples from sites 6 and 9.

In 2012, we will compare water quality data collected at each Greens Creek sample site with biological abundance and composition data and whole body fish metals concentrations data to examine relationships, and we will report results in our 2012 Technical Report.

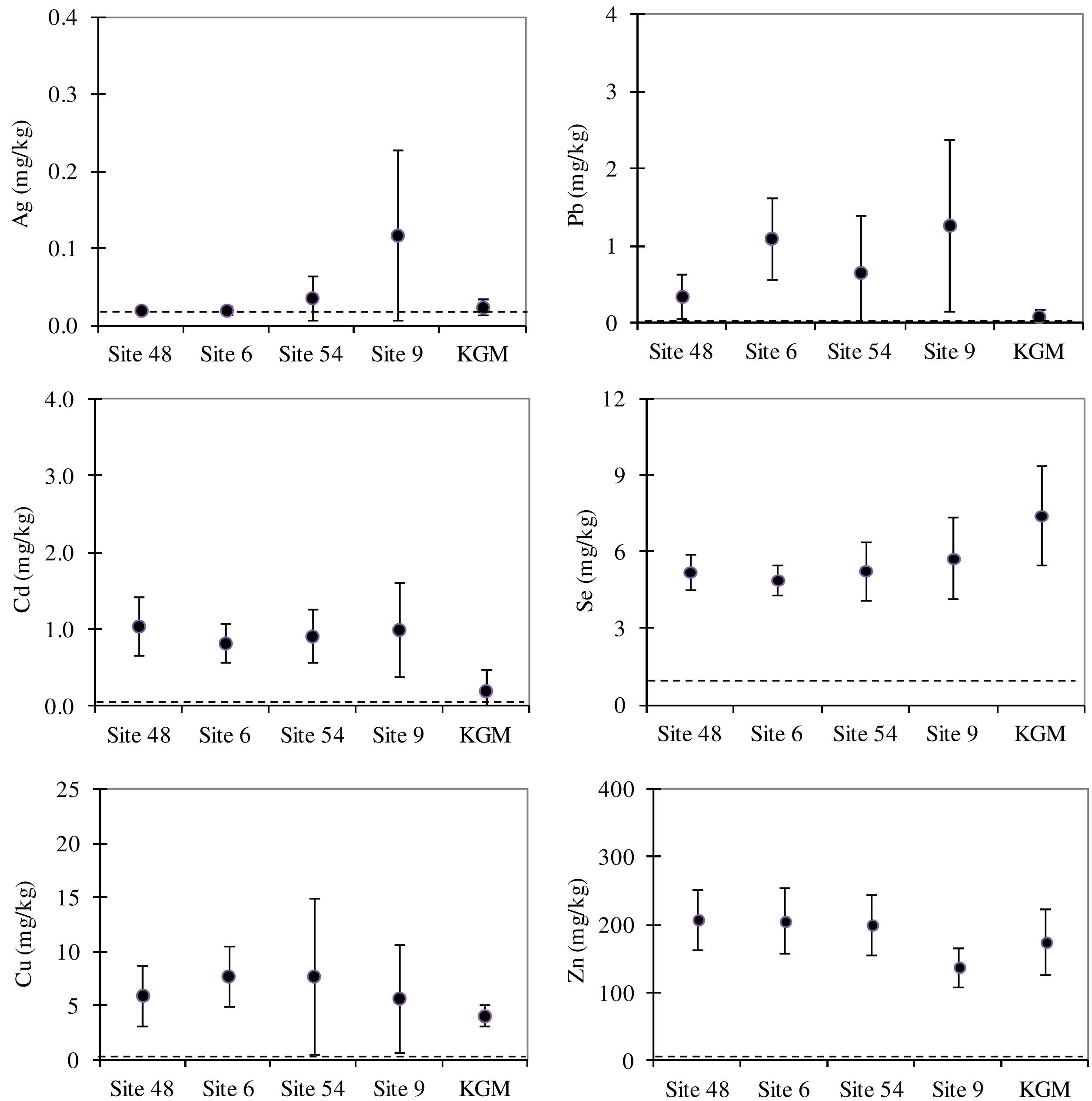


Figure 34.–Comparison among sites of mean whole body metals concentrations ± one standard deviation in Dolly Varden char, 2001–2011, and near the Kensington Gold Mine in 2000 (Kline 2001).

# CONCLUSIONS

In 2011, we sampled periphyton, benthic macroinvertebrates and juvenile fish at four sites near Greens Creek Mine. Results suggest productive aquatic communities are present at each site.

During sampling in 2011, stream discharge in Greens Creek was similar to discharges observed in previous years, while discharge in Tributary Creek was low and difficult to measure similar to previous years. During the 11 years of monitoring aquatic life near the Greens Creek Mine, sampling has occurred after and during a wide range of discharges in Greens Creek, which may explain some of the variability we observe in the data. For example, periphyton biomass and aquatic insect densities at Greens Creek sites 48, 6, and 54 were greater 2003–2006 when stream flow was much lower, compared to other years. Though discharge data is not available for Tributary Creek, relatively stable periphyton densities observed in the 11 years of sampling at Site 9 suggests flow was consistent prior to sampling during most years.

Juvenile Dolly Varden char populations at Greens Creek sample sites 48 and 54 show a similar trend during the 11 years of sampling, where densities were greater 2001–2006 than 2007–2011. Length frequencies of juvenile Dolly Varden char captured at each site suggest multiple age classes were present in most years. We captured few juvenile coho salmon since 2005 at sites 6 and 54, none in 2007 or 2011, which is not surprising since the fish pass was damaged during a heavy rainstorm in late 2005 and has not been repaired. Juvenile fish population estimates at Tributary Creek Site 9 continue to be highly variable each year.

Whole body metals concentrations in juvenile Dolly Varden char samples collected in 2011 were similar to values previously observed and not significantly different than any other year. When we combined tissue metals concentrations data by site and compared among Greens Creek sample sites, we found a significant difference in lead concentrations between control Site 48 and sites 6 and 54, and a significant difference in copper concentrations between Site 6 and sites 48 and 54. When we included tissue metals concentrations data from Tributary Creek Site 9 in the analysis, data from Site 9 was significantly different from several metals data collected at some of the Greens Creek sites.

Overall, Greens Creek sites 48, 6, and 54 and Tributary Creek Site 9 support productive aquatic communities, each dependent on local stream conditions and habitat types. Abundance of aquatic communities in both systems is variable, influenced by a variety of natural factors such as discharge, sunlight, and predatory juvenile fish.

Over the last few years, we have identified several ways to improve the aquatic biomonitoring program, which we provide in the following *Recommendations* section. We look forward to working with Hecla and resource agencies to amend the FWMP and improve the program, which will provide more information to assess stream health near the Greens Creek Mine.

# RECOMMENDATIONS

The existing aquatic biological monitoring plan was designed in 2000, implemented in 2001, and has not been reviewed to determine if changes to the study design are warranted. We reviewed the current study plan described in sections 6.7–6.12 of the FWMP (KGCMC 2000) and the 11-year data set, and identified ways to improve studies that would provide additional information on aquatic life near the Greens Creek Mine without substantially increasing cost. We also identified inconsistencies in the plan regarding sampling and data analyses that should be updated. Our 10 recommendations follow:

<u>Section 6.7.2: Summary for Biological Monitoring</u>

1. Three years (2001, 2006 and 2011) of data collected at Site 6 suggest trends in abundance and composition of organisms are similar amongst data collected at the two other Greens Creek sample sites. We recommend discontinuing sampling at Site 6 as sufficient baseline data has been collected, increasing sampling frequency is not warranted, and because continuing to sample every five years does not add much additional information to the long-term data set.

<u>Section 6.8: Periphyton Biomass</u>

2. We collect periphyton samples within the fish sample reach at Site 9, unlike the other sites. Working instream while minnow traps are soaking nearby violates the conditions necessary for depletion trapping. We recommend the FWMP specifically state that periphyton sampling at Site 9 should occur after fish sampling to avoid disturbing juvenile fish, though biologists must work carefully to avoid disturbing stream substrate which could affect periphyton results. Alternatively, samples could be collected upstream or downstream of the fish sample reach.

<u>Section 6.9: Benthic Macroinvertebrates</u>

3. We use methods modified from Barbour et al. (1999) to collect benthic macroinvertebrate samples using a Hess sampler, not the specific protocol described using a D-frame dip net. We recommend updating the methods for collecting benthic macroinvertebrates using methods described in Technical Report 12-03.
4. Benthic macroinvertebrate sample collection methods should include a standardized sampling design where one biologist collects all samples each year, spends the same amount of time collecting each sample (e.g. 5 min), and digs to the same depth to release buried insects at each sample site (e.g. 10 cm).
5. The number of benthic macroinvertebrates in samples tends to be highly variable, often resulting in density estimates ranging by several thousand per $m^2$. To improve the calculated mean density of invertebrates per $m^2$ for each site each year, consider increasing the number of samples collected at each site.
6. The second paragraph under Section 6.9.2 states that benthic macroinvertebrate surveys may be conducted within the fish sample reach while traps are soaking. Working instream while minnow traps are soaking nearby violates the conditions necessary for depletion trapping in a small system such as Tributary Creek. We recommend the FWMP specifically state that macroinvertebrate sampling at Site 9 should occur after fish sampling to avoid disrupting juvenile fish distribution. Alternatively, samples could be collected upstream or downstream of the fish sample reach.

Section 6.10: Abundance of Rearing Fish

7. We recommend updating the juvenile fish sample reach lengths, which have changed.
8. We recommend weighing each salmonid captured, and reporting Fulton's condition factor *K* (Anderson and Neumann 1996), to investigate mean fish condition between sites and years for each specie.

Section 6.11: Metals Concentrations in Whole Body Juvenile Fish

9. We recommend including testing for total mercury. The seven metals we recommend tested in juvenile fish tissues are also monitored in surface or groundwater quality at the four biomonitoring sites, so we will be able to make comparisons between data to further study bioavailability of metals at each site. Data may also be compared to data collected near other Alaskan mines.

Section 6.12: Toxicity Testing

10. This study was discontinued in 2004 and is no longer part of the FWMP.

# LITERATURE CITED


Anderson, R. O. and R. M. Neumann. 1996. Length, weight, and associated structural indicies. [*In*] Murphy, B. R., and D.W. Willis, editors. Fisheries Techniques. 2nd edition. American Fisheries Society, Bethesda, MD.

Analytical Software. 2008. Statistix 9 User's Manual. Analytical Software, Tallahassee, Florida.

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. 2nd edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

Bryant, M. D. 2000. Estimating fish populations by removal methods with minnow traps in Southeast Alaska streams. North American Journal of Fisheries Management 20:923–930.

Durst, J. D., and A. H. Townsend. 2004. Aquatic biomonitoring at Greens Creek Mine, 2003. Technical Report No. 04-04. Alaska Department of Natural Resources, Office of Habitat Management and Permitting, Juneau, Alaska.

Durst, J. D., A. H. Townsend, and J. P. Cariello. 2005. Aquatic biomonitoring at Greens Creek Mine, 2004. Technical Report No. 05-04. Alaska Department of Natural Resources, Office of Habitat Management and Permitting, Juneau, Alaska.

Durst, J. D., and L. L. Jacobs. 2006. Aquatic biomonitoring at Greens Creek Mine, 2005. Technical Report No. 06-01. Alaska Department of Natural Resources, Office of Habitat Management and Permitting, Juneau, Alaska.

Durst, J. D., and L. L. Jacobs. 2007. Aquatic biomonitoring at Greens Creek Mine, 2006. Technical Report No. 07-02. Alaska Department of Natural Resources, Office of Habitat Management and Permitting, Juneau, Alaska.

Durst, J. D., and L. L. Jacobs. 2008. Aquatic biomonitoring at Greens Creek Mine, 2007. Technical Report No. 08-03. Alaska Department of Natural Resources, Office of Habitat Management and Permitting, Juneau, Alaska.

Durst, J. D., and L. L. Jacobs. 2009. Aquatic biomonitoring at Greens Creek Mine, 2008. Technical Report No. 09-02. Alaska Department of Fish and Game, Division of Habitat, Juneau, Alaska.

Durst, J. D., and L. L. Jacobs. 2010. Aquatic biomonitoring at Greens Creek Mine, 2009. Technical Report No. 10-03. Alaska Department of Fish and Game, Division of Habitat, Juneau, Alaska.

Jacobs, L L.., P. W. Scannell, and B. Morris. 2003. Aquatic biomonitoring at Greens Creek Mine, 2002. Technical Report No. 03-04. Alaska Department of Fish and Game, Habitat and Restoration Division, Juneau, Alaska.

Kanouse, K. M. 2011. Aquatic biomonitoring at Greens Creek Mine, 2010. Technical Report No. 11-02. Alaska Department of Fish and Game, Division of Habitat, Juneau, Alaska.

Kennecott Greens Creek Mining Company (KGCMC). 2000. General plan of operations. Appendix 1: Fresh water monitoring program. Revision No. 5. October 6, 2000.

Kline Environmental Research, LLC. 2001. Kensington Project June 2000 Slate Creek Basin survey data report. Prepared for Coeur Alaska, Inc. February 16, 2001.

Lockwood, R. N., and J. C. Schneider. 2000. Stream fish population estimates by mark-and-recapture and depletion methods. Chapter 7 [*In*] Schneider, J. C., editor. 2000. Manual of fisheries survey methods II: with periodic updates. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor, Michigan.

McGee, W. D., and S. Marthaller. 2004. Letter of May 7, 2004 from William D. McGee (Alaska Department of Environmental Conservation) and Susan Marthaller (USDA Forest Service) to William Oelklaus (Kennecott Greens Creek Mining Company), Subject: Greens Creek Mine Monitoring Changes Under Waste Management Permit #0211-BA001 and General Plan of Operations, Appendix 1 – Freshwater Monitoring Program (FWMP).

U.S. Environmental Protection Agency (USEPA). 1997. Method 446.0. In vitro determination of chlorophylls a, b, c1 + c2 and pheopigments in marine and freshwater algae by visible spectrophotometry. Adapted by Elizabeth J. Arar. Revision 1.2, September 1997. National Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, Ohio.

U.S.D.A Forest Service. 2003. Greens Creek tailings disposal final environmental impact statement. Tongass National Forest. November 2003.

U.S.D.I. Geological Survey (USGS). 2011. Water-data report 2010 for Gage 15101490 Greens Creek at Greens Creek Mine near Juneau, AK.

Weber Scannell, P., and S. Paustian. 2002. Aquatic biomonitoring at Greens Creek Mine, 2001. Technical Report No. 02-03. Alaska Department of Fish and Game, Habitat and Restoration Division, Juneau, Alaska.

# APPENDIX A: STREAM DISCHARGE DATA

Appendix A .–Greens Creek (USGS Gage 15101490) mean daily discharge and Tributary Creek field-measured discharge during biomonitoring sampling, 2001–2011.

| Year | Sampling Dates | Greens Cr. USGS Gage | | Tributary Cr. Field Data[a] | |
|---|---|---|---|---|---|
| | | feet³/sec | meter³/sec | feet³/sec | meter³/sec |
| 2001 | July 23 | 72 | 2.04 | - - - | - - - |
| | July 24 | 73 | 2.07 | - - - | - - - |
| 2002 | July 23 | 51 | 1.44 | - - - | - - - |
| | July 24 | 57 | 1.61 | - - - | - - - |
| 2003 | July 22 | 16 | 0.45 | - - - | - - - |
| | July 23 | 15 | 0.42 | - - - | - - - |
| 2004 | July 21 | 25 | 0.70 | 0.1 | <0.01 |
| | July 22 | 22 | 0.62 | - - - | - - - |
| 2005 | July 22 | 33 | 0.93 | - - - | - - - |
| | July 23 | 29 | 0.82 | 2.7 | 0.08 |
| 2006 | July 20 | 35 | 0.99 | - - - | - - - |
| | July 21 | 59 | 1.67 | 3.4 | 0.10 |
| 2007 | July 20 | 100 | 2.83 | 5.4 | 0.15 |
| | July 21 | 98 | 2.78 | - - - | - - - |
| 2008 | July 22 | 81 | 2.29 | - - - | - - - |
| | July 23 | 73 | 2.07 | 0.35 | 0.01 |
| 2009 | July 21 | 38 | 1.08 | - - - | - - - |
| | July 22 | 39 | 1.10 | <0.1[b] | <0.01[b] |
| 2010 | July 20 | 38 | 1.08 | - - - | - - - |
| | July 21 | 42 | 1.19 | 0.84 | 0.02 |
| 2011 | July 20 | 43 | 1.22 | 0.19 | 0.01 |
| | July 21 | 38 | 1.08 | - - - | - - - |
| | July 22 | 36 | 1.02 | - - - | - - - |

[a] Field measuring discharge in Tributary Creek during low flow is difficult because of shallow water, therefore, these field measurements may not be accurate.

[b] Based on flow measurements using a faulty flow meter. After evaluating physical characteristics and historical photos, stream flow in 2009 appeared to be slightly less than in 2004.

# APPENDIX B: PERIPHYTON BIOMASS DATA

Appendix B.–Periphyton biomass in Greens Creek Mine biomonitoring samples, 2001–2011.

| mg/m² | 2001 chlor-*a* | 2001 chlor-*b* | 2001 chlor-*c* | 2002 chlor-*a* | 2002 chlor-*b* | 2002 chlor-*c* | 2003 chlor-*a* | 2003 chlor-*b* | 2003 chlor-*c* | 2004 chlor-*a* | 2004 chlor-*b* | 2004 chlor-*c* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Greens Creek Site 48** | | | | | | | | | | | | |
| | 1.914 | 0.012 | 0.139 | 5.165 | 0.000 | 0.295 | 14.410 | 0.000 | 1.264 | 18.049 | 0.000 | 2.033 |
| | 1.826 | 0.000 | 0.183 | 4.031 | 0.000 | 0.215 | 17.825 | 0.026 | 1.566 | 6.728 | 0.000 | 0.690 |
| | 5.612 | 0.000 | 0.695 | 6.210 | 0.000 | 0.713 | 8.432 | 0.089 | 0.390 | 8.971 | 0.000 | 0.898 |
| | 0.313 | 0.079 | 0.058 | 2.830 | 0.000 | 0.246 | 9.531 | 0.009 | 0.635 | 12.816 | 0.000 | 1.454 |
| | 2.959 | 0.038 | 0.361 | 5.157 | 0.000 | 0.755 | 11.357 | 0.000 | 0.720 | 5.447 | 0.000 | 0.623 |
| | 5.442 | 0.000 | 0.617 | 6.393 | 0.000 | 0.754 | 11.764 | 0.016 | 0.863 | 20.399 | 0.000 | 2.150 |
| | 3.379 | 0.000 | 0.467 | 5.843 | 0.000 | 0.729 | 24.095 | 0.000 | 2.137 | 6.301 | 0.000 | 0.449 |
| | 1.867 | 0.034 | 0.146 | 2.091 | 0.072 | 0.248 | 13.305 | 0.128 | 0.988 | 11.641 | 0.000 | 1.384 |
| | 2.635 | 0.137 | 0.144 | 3.203 | 0.000 | 0.358 | 11.540 | 0.000 | 0.565 | 7.476 | 0.000 | 0.651 |
| | 1.229 | 0.023 | 0.165 | 2.559 | 0.000 | 0.151 | 13.969 | 0.000 | 0.895 | 5.233 | 0.000 | 0.545 |
| mean | 2.718 | 0.032 | 0.298 | 4.348 | 0.007 | 0.446 | 13.623 | 0.027 | 1.002 | 10.306 | 0.000 | 1.088 |
| median | 2.275 | 0.017 | 0.174 | 4.594 | 0.000 | 0.327 | 12.535 | 0.004 | 0.879 | 8.224 | 0.000 | 0.794 |
| max | 5.612 | 0.137 | 0.695 | 6.393 | 0.072 | 0.755 | 24.095 | 0.128 | 2.137 | 20.399 | 0.000 | 2.150 |
| min | 0.313 | 0.000 | 0.058 | 2.091 | 0.000 | 0.151 | 8.432 | 0.000 | 0.390 | 5.233 | 0.000 | 0.449 |
| **Greens Creek Site 6** | | | | | | | | | | | | |
| | 5.069 | 0.000 | 0.700 | - | - | - | - | - | - | - | - | - |
| | 7.154 | 0.035 | 0.722 | - | - | - | - | - | - | - | - | - |
| | 4.472 | 0.000 | 0.780 | - | - | - | - | - | - | - | - | - |
| | 1.270 | 0.074 | 0.226 | - | - | - | - | - | - | - | - | - |
| | 3.196 | 0.000 | 0.426 | - | - | - | - | - | - | - | - | - |
| | 1.643 | 0.000 | 0.142 | - | - | - | - | - | - | - | - | - |
| | 0.903 | 0.101 | 0.144 | - | - | - | - | - | - | - | - | - |
| | 2.511 | 0.000 | 0.157 | - | - | - | - | - | - | - | - | - |
| | 6.882 | 0.000 | 1.019 | - | - | - | - | - | - | - | - | - |
| | 7.024 | 0.000 | 0.999 | - | - | - | - | - | - | - | - | - |
| mean | 4.012 | 0.021 | 0.532 | - | - | - | - | - | - | - | - | - |
| median | 3.834 | 0.000 | 0.563 | - | - | - | - | - | - | - | - | - |
| max | 7.154 | 0.101 | 1.019 | - | - | - | - | - | - | - | - | - |
| min | 0.903 | 0.000 | 0.142 | - | - | - | - | - | - | - | - | - |
| **Greens Creek Site 54** | | | | | | | | | | | | |
| | 1.595 | 0.007 | 0.149 | 2.647 | 0.000 | 0.303 | 13.289 | 0.000 | 1.049 | 17.195 | 0.000 | 2.018 |
| | 3.095 | 0.046 | 0.409 | 9.324 | 0.000 | 1.017 | 8.355 | 0.000 | 0.788 | 9.719 | 0.000 | 0.927 |
| | 3.611 | 0.000 | 0.207 | 7.519 | 0.000 | 0.239 | 14.896 | 0.000 | 1.455 | 8.758 | 0.000 | 0.674 |
| | 2.966 | 0.000 | 0.294 | 4.296 | 0.000 | 0.378 | 5.938 | 0.000 | 0.618 | 32.040 | 0.000 | 3.662 |
| | 1.880 | 0.000 | 0.011 | 5.152 | 0.000 | 0.528 | 15.515 | 0.000 | 1.737 | 5.233 | 0.000 | 0.423 |
| | 1.778 | 0.000 | 0.190 | 2.976 | 0.865 | 1.258 | 10.499 | 0.000 | 1.060 | 3.738 | 0.000 | 0.305 |
| | 4.947 | 0.000 | 0.223 | 6.263 | 0.000 | 0.639 | 5.708 | 0.000 | 0.387 | 12.816 | 0.000 | 1.349 |
| | 1.459 | 0.000 | 0.101 | 4.621 | 0.000 | 0.398 | 16.425 | 0.000 | 1.715 | 1.922 | 0.031 | 0.089 |
| | 1.690 | 0.000 | 0.135 | 4.709 | 0.000 | 0.453 | 12.603 | 0.000 | 1.075 | 10.466 | 0.000 | 1.087 |
| | 3.475 | 0.000 | 0.159 | 8.083 | 0.000 | 0.791 | 17.862 | 0.000 | 1.748 | 5.981 | 0.000 | 0.533 |
| mean | 2.650 | 0.005 | 0.188 | 5.559 | 0.087 | 0.600 | 12.109 | 0.000 | 1.163 | 10.787 | 0.003 | 1.107 |
| median | 2.423 | 0.000 | 0.175 | 4.931 | 0.000 | 0.490 | 12.946 | 0.000 | 1.067 | 9.238 | 0.000 | 0.800 |
| max | 4.947 | 0.046 | 0.409 | 9.324 | 0.865 | 1.258 | 17.862 | 0.000 | 1.748 | 32.040 | 0.031 | 3.662 |
| min | 1.459 | 0.000 | 0.011 | 2.647 | 0.000 | 0.239 | 5.708 | 0.000 | 0.387 | 1.922 | 0.000 | 0.089 |
| **Tributary Creek Site 9** | | | | | | | | | | | | |
| | 6.623 | 0.000 | 0.788 | 8.905 | 0.000 | 0.519 | 12.893 | 0.000 | 1.261 | 9.398 | 0.224 | 0.803 |
| | 11.150 | 0.000 | 1.200 | 16.433 | 0.950 | 1.276 | 8.550 | 0.000 | 0.792 | 5.767 | 0.000 | 0.423 |
| | 15.054 | 0.000 | 1.472 | 12.647 | 0.174 | 0.000 | 3.977 | 0.000 | 0.289 | 5.447 | 0.000 | 0.484 |
| | 16.577 | 0.234 | 1.506 | 5.441 | 0.451 | 0.072 | 12.290 | 0.000 | 1.114 | 6.088 | 0.031 | 0.383 |
| | 3.149 | 0.000 | 0.335 | 23.721 | 1.205 | 0.838 | 17.087 | 0.000 | 1.916 | 14.525 | 0.021 | 1.395 |
| | 2.593 | 0.064 | 0.279 | 12.746 | 0.400 | 0.216 | 17.400 | 0.000 | 1.876 | 6.515 | 0.173 | 0.404 |
| | 1.608 | 0.000 | 0.013 | 32.532 | 0.000 | 1.894 | 33.871 | 0.000 | 3.977 | 10.360 | 0.135 | 0.799 |
| | 6.659 | 0.000 | 0.426 | 4.403 | 1.496 | 0.000 | 24.561 | 0.000 | 2.432 | 6.835 | 0.042 | 0.364 |
| | 15.210 | 0.812 | 1.436 | 2.941 | 0.301 | 0.172 | 20.020 | 0.000 | 1.688 | 26.166 | 0.511 | 2.608 |
| | 11.550 | 0.000 | 1.509 | 8.007 | 1.471 | 0.275 | 36.017 | 0.000 | 3.856 | 8.437 | 0.218 | 0.531 |
| mean | 9.017 | 0.111 | 0.896 | 12.778 | 0.645 | 0.526 | 18.667 | 0.000 | 1.920 | 9.954 | 0.136 | 0.819 |
| median | 8.904 | 0.000 | 0.994 | 10.776 | 0.426 | 0.245 | 17.244 | 0.000 | 1.782 | 7.636 | 0.089 | 0.507 |
| max | 16.577 | 0.812 | 1.509 | 32.532 | 1.496 | 1.894 | 36.017 | 0.000 | 3.977 | 26.166 | 0.511 | 2.608 |
| min | 1.608 | 0.000 | 0.013 | 2.941 | 0.000 | 0.000 | 3.977 | 0.000 | 0.289 | 5.447 | 0.000 | 0.364 |

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| | 2005 | | | 2006 | | | 2007 | | | 2008 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mg/m² | chlor-*a* | chlor-*b* | chlor-*c* | chlor-*a* | chlor-*b* | chlor-*c* | chlor-*a* | chlor-*b* | chlor-*c* | chlor-*a* | chlor-*b* | chlor-*c* |
| Greens Creek Site 48 | | | | | | | | | | | | |
| | 0.972 | 0.000 | 0.009 | 8.503 | 0.000 | 0.799 | 6.638 | 0.000 | 0.162 | 1.500 | 0.000 | 0.090 |
| | 4.699 | 0.000 | 0.510 | 11.590 | 0.000 | 0.710 | 5.639 | 0.000 | 0.228 | 4.700 | 0.000 | 0.160 |
| | 6.622 | 0.000 | 0.274 | 10.742 | 0.000 | 1.253 | 7.595 | 0.000 | 0.330 | 2.670 | 0.000 | 0.240 |
| | 6.194 | 0.000 | 0.506 | 20.604 | 0.000 | 2.038 | 11.692 | 0.000 | 1.391 | 2.140 | 0.000 | 0.170 |
| | 11.107 | 0.000 | 0.915 | 10.600 | 0.000 | 0.979 | 7.038 | 0.000 | 0.471 | 0.850 | 0.000 | 0.020 |
| | 5.660 | 0.000 | 0.512 | 14.345 | 0.000 | 1.724 | 11.401 | 0.000 | 0.541 | 12.600 | 0.000 | 0.330 |
| | 7.690 | 0.000 | 0.533 | 17.271 | 0.000 | 1.761 | 11.995 | 0.012 | 0.603 | 2.780 | 0.000 | 0.190 |
| | 5.126 | 0.000 | 0.291 | 15.808 | 0.000 | 1.742 | 4.941 | 0.000 | 0.291 | 6.300 | 0.000 | 0.740 |
| | 2.456 | 0.015 | 0.276 | 17.265 | 0.000 | 1.730 | 8.259 | 0.000 | 1.096 | 1.280 | 0.000 | 0.140 |
| | 9.078 | 0.000 | 0.630 | 4.336 | 0.000 | 0.537 | 4.112 | 0.000 | 0.435 | 3.200 | 0.000 | 0.370 |
| mean | 5.961 | 0.002 | 0.446 | 13.106 | 0.000 | 1.327 | 7.931 | 0.001 | 0.555 | 3.802 | 0.000 | 0.245 |
| median | 5.927 | 0.000 | 0.508 | 12.968 | 0.000 | 1.489 | 7.316 | 0.000 | 0.453 | 2.725 | 0.000 | 0.180 |
| max | 11.107 | 0.015 | 0.915 | 20.604 | 0.000 | 2.038 | 11.995 | 0.012 | 1.391 | 12.600 | 0.000 | 0.740 |
| min | 0.972 | 0.000 | 0.009 | 4.336 | 0.000 | 0.537 | 4.112 | 0.000 | 0.162 | 0.850 | 0.000 | 0.020 |
| Greens Creek Site 6 | | | | | | | | | | | | |
| | - | - | - | 27.315 | 0.000 | 2.782 | - | - | - | - | - | - |
| | - | - | - | 19.321 | 0.000 | 2.046 | - | - | - | - | - | - |
| | - | - | - | 17.578 | 0.000 | 1.788 | - | - | - | - | - | - |
| | - | - | - | 33.946 | 0.000 | 3.307 | - | - | - | - | - | - |
| | - | - | - | 47.552 | 0.000 | 4.935 | - | - | - | - | - | - |
| | - | - | - | 16.118 | 0.000 | 1.589 | - | - | - | - | - | - |
| | - | - | - | 8.957 | 0.000 | 1.033 | - | - | - | - | - | - |
| | - | - | - | 11.842 | 0.000 | 1.107 | - | - | - | - | - | - |
| | - | - | - | 8.645 | 0.000 | 0.975 | - | - | - | - | - | - |
| | - | - | - | 29.194 | 0.000 | 3.087 | - | - | - | - | - | - |
| mean | - | - | - | 22.047 | 0.000 | 2.265 | - | - | - | - | - | - |
| median | - | - | - | 18.449 | 0.000 | 1.917 | - | - | - | - | - | - |
| max | - | - | - | 47.552 | 0.000 | 4.935 | - | - | - | - | - | - |
| min | - | - | - | 8.645 | 0.000 | 0.975 | - | - | - | - | - | - |
| Greens Creek Site 54 | | | | | | | | | | | | |
| | 10.360 | 0.000 | 0.535 | 19.859 | 0.000 | 1.617 | 0.407 | 0.036 | 0.045 | 2.990 | 0.000 | 0.290 |
| | 2.563 | 0.000 | 0.255 | 5.625 | 0.000 | 0.756 | 0.183 | 0.000 | 0.000 | 1.170 | 0.020 | 0.000 |
| | 3.311 | 0.000 | 0.169 | 12.742 | 0.000 | 1.186 | 1.365 | 0.042 | 0.114 | 1.500 | 0.000 | 0.190 |
| | 2.884 | 0.000 | 0.117 | 23.569 | 0.000 | 2.626 | 4.248 | 0.000 | 0.482 | 1.710 | 0.000 | 0.130 |
| | 5.660 | 0.000 | 0.383 | 4.615 | 0.000 | 0.466 | 0.130 | 0.092 | 0.017 | 2.240 | 0.000 | 0.090 |
| | 2.990 | 0.000 | 0.135 | 27.671 | 0.000 | 2.215 | 3.285 | 0.000 | 0.382 | 2.140 | 0.000 | 0.110 |
| | 4.272 | 0.000 | 0.177 | 4.248 | 0.000 | 0.384 | 7.934 | 0.000 | 0.977 | 2.460 | 0.000 | 0.250 |
| | 4.379 | 0.000 | 0.310 | 8.958 | 0.000 | 0.935 | 0.047 | 0.000 | 0.000 | 0.960 | 0.000 | 0.010 |
| | 4.058 | 0.000 | 0.160 | 31.845 | 0.000 | 3.171 | 2.966 | 0.000 | 0.392 | 0.240 | 0.050 | 0.000 |
| | 3.097 | 0.000 | 0.158 | 5.483 | 0.000 | 0.678 | 6.434 | 0.000 | 0.815 | 0.240 | 0.000 | 0.030 |
| mean | 4.357 | 0.000 | 0.240 | 14.461 | 0.000 | 1.403 | 2.700 | 0.017 | 0.322 | 1.565 | 0.007 | 0.110 |
| median | 3.685 | 0.000 | 0.173 | 10.850 | 0.000 | 1.061 | 2.165 | 0.000 | 0.248 | 1.605 | 0.000 | 0.100 |
| max | 10.360 | 0.000 | 0.535 | 31.845 | 0.000 | 3.171 | 7.934 | 0.092 | 0.977 | 2.990 | 0.050 | 0.290 |
| min | 2.563 | 0.000 | 0.117 | 4.248 | 0.000 | 0.384 | 0.047 | 0.000 | 0.000 | 0.002 | 0.000 | 0.000 |
| Tributary Creek Site 9 | | | | | | | | | | | | |
| | 6.429 | 0.000 | 0.250 | 3.538 | 0.249 | 0.190 | --- | --- | --- | 2.350 | 0.000 | 0.120 |
| | 8.010 | 1.283 | 0.183 | 4.211 | 0.396 | 0.202 | 5.447 | 0.079 | 0.228 | 6.940 | 0.000 | 0.270 |
| | 1.816 | 0.131 | 0.075 | 7.073 | 0.000 | 0.404 | 7.262 | 0.005 | 0.544 | 6.300 | 0.240 | 0.340 |
| | 9.826 | 0.060 | 0.291 | 4.012 | 0.011 | 0.320 | --- | --- | --- | 6.410 | 0.000 | 0.250 |
| | 5.682 | 0.000 | 0.102 | 4.201 | 0.000 | 0.391 | --- | --- | --- | 2.460 | 0.120 | 0.190 |
| | 5.383 | 0.000 | 0.123 | 4.745 | 0.000 | 0.287 | 0.854 | 0.164 | 0.107 | 6.190 | 0.050 | 0.390 |
| | 8.181 | 0.000 | 0.203 | 13.635 | 0.000 | 0.573 | 6.408 | 0.055 | 0.244 | 4.060 | 0.000 | 0.130 |
| | 15.433 | 0.000 | 0.455 | 4.379 | 0.005 | 0.205 | 7.049 | 0.236 | 0.649 | 4.590 | 0.000 | 0.370 |
| | 36.600 | 0.099 | 1.120 | 5.158 | 0.000 | 0.559 | 5.020 | 0.000 | 0.258 | 1.600 | 0.000 | 0.000 |
| | 9.452 | 0.000 | 0.263 | 3.756 | 0.372 | 0.262 | 3.204 | 0.000 | 0.234 | 3.740 | 0.000 | 0.280 |
| mean | 10.681 | 0.157 | 0.306 | 5.471 | 0.103 | 0.339 | 5.035 | 0.077 | 0.323 | 4.464 | 0.041 | 0.234 |
| median | 8.095 | 0.000 | 0.226 | 4.295 | 0.003 | 0.303 | 5.447 | 0.055 | 0.244 | 4.325 | 0.000 | 0.260 |
| max | 36.600 | 1.283 | 1.120 | 13.635 | 0.396 | 0.573 | 7.262 | 0.236 | 0.649 | 6.940 | 0.240 | 0.390 |
| min | 1.816 | 0.000 | 0.075 | 3.538 | 0.000 | 0.190 | 0.854 | 0.000 | 0.107 | 1.600 | 0.000 | 0.000 |

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Appendix B.–Page 3 of 3.

| | 2009 | | | 2010 | | | 2011 | | |
|---|---|---|---|---|---|---|---|---|---|
| mg/m² | chlor-*a* | chlor-*b* | chlor-*c* | chlor-*a* | chlor-*b* | chlor-*c* | chlor-*a* | chlor-*b* | chlor-*c* |
| Greens Creek Site 48 | | | | | | | | | |
| | 3.204 | 0.000 | 0.487 | 8.540 | 0.000 | 0.440 | 4.486 | 0.000 | 0.497 |
| | 1.495 | 0.000 | 0.247 | 4.590 | 0.000 | 0.610 | 6.515 | 0.000 | 0.589 |
| | 4.165 | 0.112 | 0.587 | 5.130 | 0.000 | 0.270 | 2.884 | 0.000 | 0.304 |
| | 5.660 | 0.069 | 0.732 | 3.100 | 0.000 | 0.260 | 2.588 | 0.170 | 0.053 |
| | 3.418 | 0.062 | 0.504 | 7.580 | 0.000 | 0.290 | 3.311 | 0.000 | 0.362 |
| | 8.224 | 0.131 | 0.954 | 5.550 | 0.000 | 0.550 | 5.126 | 0.000 | 0.549 |
| | 0.427 | 0.109 | 0.113 | 10.680 | 0.000 | 0.640 | 7.156 | 0.000 | 1.064 |
| | 1.388 | 0.175 | 0.291 | 7.690 | 0.000 | 0.410 | 5.660 | 0.000 | 0.486 |
| | 7.796 | 0.003 | 0.892 | 3.630 | 0.000 | 0.250 | 0.854 | 0.000 | 0.113 |
| | 9.185 | 0.173 | 1.193 | 3.100 | 0.020 | 0.150 | 4.806 | 0.000 | 0.494 |
| mean | 4.496 | 0.083 | 0.600 | 5.959 | 0.002 | 0.387 | 4.339 | 0.017 | 0.451 |
| median | 3.791 | 0.089 | 0.546 | 5.340 | 0.000 | 0.350 | 4.646 | 0.000 | 0.490 |
| max | 9.185 | 0.175 | 1.193 | 10.680 | 0.020 | 0.640 | 7.156 | 0.170 | 1.064 |
| min | 0.427 | 0.000 | 0.113 | 3.100 | 0.000 | 0.150 | 0.854 | 0.000 | 0.053 |
| Greens Creek Site 6 | | | | | | | | | |
| | - | - | - | - | - | - | 3.418 | 0.000 | 0.237 |
| | - | - | - | - | - | - | 2.243 | 0.000 | 0.177 |
| | - | - | - | - | - | - | 1.106 | 0.000 | 0.080 |
| | - | - | - | - | - | - | 5.340 | 0.000 | 0.617 |
| | - | - | - | - | - | - | 4.165 | 0.000 | 0.493 |
| | - | - | - | - | - | - | 1.709 | 0.000 | 0.220 |
| | - | - | - | - | - | - | 4.397 | 0.000 | 0.395 |
| | - | - | - | - | - | - | 5.981 | 0.000 | 0.564 |
| | - | - | - | - | - | - | 2.670 | 0.000 | 0.313 |
| | - | - | - | - | - | - | 6.942 | 0.000 | 0.921 |
| mean | - | - | - | - | - | - | 3.797 | 0.000 | 0.402 |
| median | - | - | - | - | - | - | 3.791 | 0.000 | 0.354 |
| max | - | - | - | - | - | - | 6.942 | 0.000 | 0.921 |
| min | - | - | - | - | - | - | 1.106 | 0.000 | 0.080 |
| Greens Creek Site 54 | | | | | | | | | |
| | 8.010 | 0.115 | 1.062 | 2.670 | 0.000 | 0.290 | 9.612 | 0.000 | 0.641 |
| | 7.583 | 0.112 | 1.129 | 6.730 | 0.000 | 0.690 | 0.427 | 0.000 | 0.062 |
| | 6.835 | 0.070 | 0.890 | 4.380 | 0.000 | 0.740 | 3.418 | 0.000 | 0.322 |
| | 9.185 | 0.085 | 0.963 | 2.140 | 0.000 | 0.250 | 3.418 | 0.000 | 0.329 |
| | --- | 0.472 | 2.210 | 5.230 | 0.000 | 0.670 | 41.759 | 0.000 | 3.024 |
| | 8.330 | 0.150 | 1.107 | 1.710 | 0.040 | 0.250 | 5.233 | 0.000 | 0.640 |
| | 11.321 | 0.199 | 1.573 | 1.390 | 0.020 | 0.110 | 10.360 | 0.000 | 0.450 |
| | 5.340 | 0.167 | 0.661 | 3.200 | 0.000 | 0.460 | 7.156 | 0.000 | 0.534 |
| | 4.486 | 0.099 | 0.628 | 2.030 | 0.000 | 0.210 | 0.641 | 0.000 | 0.066 |
| | 4.379 | 0.098 | 0.425 | 0.210 | 0.010 | 0.050 | 2.243 | 0.000 | 0.286 |
| mean | 7.274 | 0.157 | 1.065 | 2.969 | 0.007 | 0.372 | 8.427 | 0.000 | 0.635 |
| median | 7.583 | 0.113 | 1.013 | 2.405 | 0.000 | 0.270 | 4.325 | 0.000 | 0.389 |
| max | 11.321 | 0.472 | 2.210 | 6.730 | 0.040 | 0.740 | 41.759 | 0.000 | 3.024 |
| min | 4.379 | 0.070 | 0.425 | 0.210 | 0.000 | 0.050 | 0.427 | 0.000 | 0.062 |
| Tributary Creek Site 9 | | | | | | | | | |
| | 2.029 | 0.105 | 0.157 | 12.820 | 0.000 | 0.390 | 4.806 | 0.473 | 0.079 |
| | 5.447 | 0.175 | 0.382 | 6.620 | 0.000 | 0.390 | 3.845 | 0.000 | 0.124 |
| | 4.379 | 0.242 | 0.301 | 7.690 | 0.000 | 0.430 | 4.913 | 0.000 | 0.343 |
| | 7.049 | 0.581 | 0.327 | 5.660 | 0.120 | 0.320 | 10.466 | 0.029 | 0.496 |
| | 9.078 | 0.356 | 0.495 | 9.720 | 0.880 | 0.400 | 5.126 | 0.000 | 0.369 |
| | 8.758 | 0.405 | 0.622 | 5.980 | 0.000 | 0.200 | 1.709 | 0.000 | 0.014 |
| | 2.136 | 0.080 | 0.093 | 5.550 | 0.000 | 0.400 | 6.301 | 0.000 | 0.439 |
| | 18.370 | 0.663 | 0.783 | 10.570 | 0.280 | 0.340 | 9.612 | 0.000 | 0.347 |
| | 2.350 | 0.181 | 0.158 | 4.060 | 0.050 | 0.160 | 12.496 | 0.000 | 0.874 |
| | 3.204 | 0.198 | 0.332 | 5.770 | 0.000 | 0.320 | 6.301 | 0.000 | 0.167 |
| mean | 6.280 | 0.299 | 0.365 | 7.444 | 0.133 | 0.335 | 6.558 | 0.050 | 0.325 |
| median | 4.913 | 0.220 | 0.330 | 6.300 | 0.000 | 0.365 | 5.126 | 0.000 | 0.347 |
| max | 18.370 | 0.663 | 0.783 | 12.820 | 0.880 | 0.430 | 12.496 | 0.473 | 0.874 |
| min | 2.029 | 0.080 | 0.093 | 4.060 | 0.000 | 0.160 | 1.709 | 0.000 | 0.014 |

# APPENDIX C: BENTHIC MACROINVERTEBRATE DATA

Appendix C 1.–Benthic macroinvertebrates in Greens Creek Site 48 samples, 2001–2011.

| Taxon | Family | Genus | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ephemeroptera | unidentified | | - | - | - | - | - | 3 | 38 | - | 3 | - | - |
| | Baetidae | *Baetis* | 309 | 152 | 445 | 390 | 279 | 130 | 206 | 777 | 117 | 202 | 157 |
| | Ephemerellidae | *Ephemerella* | 2 | - | 10 | 23 | 15 | 1 | 4 | 12 | 172 | 14 | 1 |
| | | *Drunella* | 47 | 49 | 650 | 406 | 369 | 102 | 16 | 24 | 10 | 294 | 119 |
| | | *Cinygmula* | 99 | 20 | 117 | 99 | 89 | 48 | 91 | 78 | 90 | 109 | 55 |
| | Heptageniidae | *Epeorus* | 444 | 190 | 384 | 209 | 371 | 240 | 61 | 165 | 431 | 345 | 131 |
| | | *Rhithrogena* | 193 | 187 | 287 | 196 | 71 | 88 | 165 | 102 | 63 | 89 | 94 |
| | Leptophlebiidae | *Paraleptophlebia* | - | 1 | - | - | - | - | - | - | 1 | 7 | 1 |
| | Ameletidae | *Ameletus* | - | - | 4 | - | - | - | 3 | - | - | - | - |
| Plecoptera | unidentified | | - | - | - | - | 9 | 7 | 1 | 3 | 11 | 26 | 20 |
| | Capniidae | *Capnia* | - | - | 82 | - | - | - | - | - | - | - | - |
| | | *Eucapnopsis* | - | - | - | - | 1 | - | - | - | - | - | - |
| | Chloroperlidae | unidentified | - | - | - | - | 2 | - | 6 | - | - | 1 | 3 |
| | | *Alloperla* | 1 | 1 | - | 1 | - | - | - | - | - | - | - |
| | | *Kathroperla* | - | - | 2 | 3 | - | 2 | - | - | - | 3 | 13 |
| | | *Neaviperla* | - | - | 70 | 6 | 3 | - | 11 | - | - | - | - |
| | | *Paraperla* | - | - | - | 6 | - | - | - | - | - | - | - |
| | | *Plumiperla* | 5 | - | - | 5 | - | - | - | - | 7 | - | - |
| | | *Suwallia* | 8 | 1 | - | - | 5 | - | - | 3 | - | - | 10 |
| | | *Sweltsa* | 1 | 4 | - | - | - | - | - | - | - | - | - |
| | Leuctridae | unidentified | - | - | - | - | - | - | - | - | - | - | 55 |
| | | *Despaxia* | - | 2 | - | - | - | - | - | - | 3 | - | 3 |
| | | *Paraleuctra* | 4 | 3 | 6 | 65 | - | 3 | 10 | 14 | 6 | 15 | - |
| | | *Perlomyia* | - | 12 | - | - | - | - | - | - | - | - | - |
| | Nemouridae | unidentified | - | - | - | - | - | - | - | - | - | - | 40 |
| | | *Podmosta* | 7 | 5 | - | 2 | - | - | - | - | - | - | - |
| | | *Zapada* | 23 | 4 | 30 | 7 | 14 | 5 | 50 | 13 | 15 | 37 | 7 |
| | Perlodidae | unidentified | - | - | - | - | - | - | - | - | - | - | - |
| | | *Isoperla* | - | - | - | 1 | 9 | - | 4 | - | 1 | 4 | - |
| | | *Megarcys* | - | - | 1 | - | - | 1 | - | - | - | - | - |
| | | *Skwala* | - | 9 | - | - | 4 | - | - | - | - | - | - |
| Trichoptera | unidentified | | - | - | - | - | - | 3 | - | 3 | - | - | - |
| | Apataniidae | *Apatania* | - | 1 | - | - | - | - | - | - | - | - | - |
| | Brachycentridae | *Brachycentrus* | - | - | - | - | - | - | - | 5 | - | - | - |
| | Glossosomatidae | *Glossosoma* | - | - | 2 | 16 | 14 | - | - | - | - | - | 5 |
| | Hydropsychidae | *Arctopsyche* | 2 | - | - | - | - | - | - | - | - | - | - |
| | | *Hydropsyche* | - | - | 1 | - | 1 | - | - | - | - | - | - |
| | Limnephilidae | *Onocosmoecus* | - | - | 1 | - | - | - | - | - | - | - | - |
| | Rhyacophilidae | *Rhyacophila* | 5 | 8 | 16 | 15 | 7 | 6 | 11 | 19 | 2 | 4 | 7 |
| Coleoptera | Elmidae | *Narpus* | - | - | - | 1 | - | - | - | - | - | - | - |
| | Staphylinidae | | 1 | - | 6 | - | - | - | - | - | - | - | - |
| Diptera | unidentified | | - | - | - | - | - | - | - | - | 1 | - | - |
| | Ceratopogonidae | *Dasyhelea* | - | 1 | - | - | - | - | - | - | - | - | - |
| | | *Probezzia* | - | - | - | - | - | 16 | - | - | - | - | - |
| | Chironomidae | | 14 | 30 | 172 | 177 | 112 | 22 | 31 | 77 | 11 | 62 | 166 |
| | Deuterophlebiidae | *Deuterophlebia* | 2 | - | - | 1 | 1 | 1 | - | 1 | - | - | 3 |
| | Empididae | unidentified | - | - | - | - | 1 | - | - | - | - | - | - |
| | | *Chelifera* | 1 | 2 | 5 | 1 | - | - | - | - | - | - | - |
| | | *Hemerodromia* | - | - | - | - | 5 | - | - | - | - | - | - |
| | | *Oreogeton* | 3 | 2 | 22 | 11 | - | - | 6 | 3 | - | 7 | - |
| | Psychodidae | *Psychoda* | 1 | - | - | - | - | - | - | - | - | - | - |
| | Simuliidae | *Parasimulium* | 2 | - | - | - | - | - | - | - | - | - | - |
| | | *Prosimulium* | 2 | - | - | 2 | - | - | - | - | - | - | - |
| | | *Simulium* | 6 | 4 | - | 1 | 3 | 1 | 2 | 7 | 3 | 6 | 12 |
| | Tipulidae | *Antocha* | - | - | 2 | - | - | - | - | - | - | - | 4 |
| | | *Dicranota* | - | - | 3 | - | 2 | - | - | - | - | 2 | 2 |
| | | *Rhabdomastix* | - | - | - | - | 1 | - | 2 | 2 | - | - | 2 |
| | | *Hexatoma* | - | - | - | - | - | - | - | - | - | - | 1 |
| | | *Tipula* | - | - | 2 | 6 | 1 | 4 | - | 12 | 2 | 1 | 5 |
| Acari | | | - | 2 | 20 | 10 | 3 | 6 | 5 | 8 | - | - | 1 |
| Collembola | | | 2 | 1 | - | - | - | 1 | 1 | - | 3 | 5 | 2 |
| Copepoda | | | - | - | - | 1 | - | - | 1 | - | - | 1 | - |
| Gastropoda | | | - | - | - | 1 | - | - | 1 | 1 | - | - | - |
| Oligochaeta | | | - | 5 | 20 | 8 | 3 | 1 | 1 | 2 | 1 | 1 | 53 |
| Ostracoda | | | - | 8 | 7 | 9 | 1 | 2 | 4 | - | - | 5 | 12 |

*Note*: Appendix data for Site 48 were modified in Report 12-03 to correct errors.

Appendix C 2.–Benthic macroinvertebrates in Greens Creek Site 6 samples, 2001–2011.

| Taxon | Family | Genus | 2001 | 2006 | 2011 |
|---|---|---|---|---|---|
| Ephemeroptera | unidentified | | - | 12 | 1 |
| | Baetidae | *Baetis* | 153 | 30 | 210 |
| | | *Acentrella* | - | - | - |
| | Ephemerellidae | unidentified | - | - | - |
| | | *Ephemerella* | - | 2 | 9 |
| | | *Drunella* | 52 | 48 | 146 |
| | Heptageniidae | *Cinygmula* | 303 | 28 | 38 |
| | | *Epeorus* | 408 | 107 | 144 |
| | | *Rhithrogena* | - | 40 | 68 |
| Plecoptera | unidentified | | - | | 16 |
| | Chloroperlidae | unidentified | - | 6 | 5 |
| | | *Suwallia* | 2 | - | 24 |
| | | *Kathroperla* | - | - | 11 |
| | | *Plumiperla* | | | 2 |
| | Leuctridae | unidentified | - | - | - |
| | | *Despaxia* | - | - | 22 |
| | | *Paraleuctra* | 7 | - | 10 |
| | Nemouridae | unidentified | - | - | - |
| | | *Podmosta* | | | 4 |
| | | *Zapada* | 16 | 3 | 38 |
| | Perlodidae | unidentified | - | - | - |
| | | *Isoperla* | 7 | - | - |
| Trichoptera | unidentified | | - | - | 1 |
| | Glossosomatidae | *Glossosoma* | - | - | 1 |
| | Rhyacophilidae | *Rhyacophila* | 1 | 1 | 8 |
| Coleoptera | Staphylinidae | | 1 | - | - |
| Diptera | Ceratopo | *Probezzia* | 1 | - | - |
| | Chironomidae | | 19 | 28 | 73 |
| | Deuterophlebiidae | *Deuterophlebia* | 0 | - | 3 |
| | Dolichopodidae | | 1 | - | - |
| | Simuliidae | *Simulium* | - | - | 12 |
| | Empididae | *Chelifera* | 1 | - | - |
| | | *Oreogeton* | 3 | - | - |
| | Blephariceridae | *Blepharicera* | - | - | 3 |
| | Tipulidae | *Tipula* | - | - | 10 |
| | | *Dicranota* | - | 1 | 5 |
| Acari | | | 4 | - | - |
| Copepoda | | | - | - | 2 |
| Isopoda | | | - | - | 1 |
| Oligochaeta | | | 15 | 1 | 2 |
| Ostracoda | | | 3 | - | 8 |

*Note:* Appendix data for Site 6 were modified in Report No. 12-03 to correct errors.

Appendix C 3.–Benthic macroinvertebrates in Greens Creek Site 54 samples, 2001–2011.

| Taxon | Family | Genus | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ephemeroptera | unidentified | | - | - | - | - | - | 6 | - | 3 | - | - | 9 |
| | Baetidae | *Baetis* | 248 | 225 | 220 | 299 | 198 | 107 | 87 | 429 | 157 | 244 | 185 |
| | Ephemerellidae | *Ephemerella* | 2 | 6 | 6 | 47 | 22 | - | - | 7 | 124 | 34 | 32 |
| | | *Drunella* | 118 | 280 | 894 | 742 | 543 | 56 | 1 | 28 | 15 | 379 | 802 |
| | Heptageniidae | *Cinygmula* | 319 | 75 | 176 | 112 | 90 | 68 | 82 | 201 | 106 | 71 | 158 |
| | | *Epeorus* | 935 | 626 | 408 | 228 | 341 | 124 | 52 | 408 | 348 | 447 | 258 |
| | | *Rhithrogena* | - | 140 | 306 | 173 | 66 | 116 | 62 | 26 | 145 | 72 | 65 |
| | Leptophlebiidae | *Paraleptophlebi* | 1 | - | 1 | - | 4 | - | 2 | 1 | - | - | 8 |
| | Ameletidae | *Ameletus* | 4 | - | - | - | 1 | - | - | 2 | - | - | 19 |
| Plecoptera | unidentified | | - | - | - | - | - | 7 | - | 6 | 12 | 4 | 15 |
| | Capniidae | *Capnia* | - | - | 5 | - | 1 | - | - | - | - | - | - |
| | | *Eucapnopsis* | - | - | - | - | 8 | - | - | - | - | - | - |
| | Chloroperlidae | unidentified | - | - | - | - | - | - | - | - | 2 | - | - |
| | | *Alloperla* | 3 | - | - | 1 | - | - | - | - | - | - | - |
| | | *Kathroperla* | - | - | 2 | 2 | - | - | 2 | 1 | - | 1 | 8 |
| | | *Neaviperla* | - | 14 | 22 | 26 | 5 | 13 | - | 0 | - | - | - |
| | | *Paraperla* | - | - | 5 | 4 | - | - | - | - | - | - | - |
| | | *Plumiperla* | 2 | - | - | 5 | 3 | - | - | - | 2 | - | - |
| | | *Suwallia* | - | - | - | 2 | - | - | 11 | 13 | - | 6 | - |
| | | *Sweltsa* | 6 | - | - | - | - | - | - | - | - | - | 1 |
| | Leuctridae | unidentified | - | - | - | - | - | - | - | - | - | - | - |
| | | *Despaxia* | - | - | - | 15 | - | - | 8 | - | - | - | 21 |
| | | *Paraleuctra* | - | 4 | - | 18 | - | 1 | - | 20 | 2 | 7 | 7 |
| | | *Perlomyia* | 13 | 3 | 19 | 33 | - | - | - | - | - | - | - |
| | Nemouridae | unidentified | - | - | - | - | - | - | - | - | - | - | - |
| | | *Podmosta* | - | 7 | - | - | - | - | - | - | - | - | 20 |
| | | *Zapada* | 52 | 22 | 14 | 11 | 15 | 9 | - | 25 | 14 | 31 | 21 |
| | Perlodidae | unidentified | - | - | - | - | - | - | - | - | 2 | 4 | 2 |
| | | *Diura* | 1 | - | - | - | - | - | - | - | - | - | - |
| | | *Isoperla* | 3 | - | - | - | 3 | - | 1 | - | 9 | - | 3 |
| | | *Skwala* | - | 3 | 15 | - | 2 | - | - | - | - | - | - |
| | | *Rickera* | - | 1 | - | - | - | - | - | - | - | - | - |
| Trichoptera | unidentified | | - | - | - | - | - | - | - | 3 | 3 | 1 | 15 |
| | Brachycentridae | *Brachycentrus* | - | - | - | - | - | - | - | - | - | 3 | - |
| | Glossosomatidae | *Glossosoma* | - | - | - | 12 | 1 | - | - | - | - | - | 4 |
| | Hydropsychidae | *Arctopsyche* | - | 1 | - | 1 | - | - | - | - | - | - | - |
| | | *Hydropsyche* | - | - | - | - | - | 1 | - | - | - | - | 1 |
| | Limnephilidae | unidentified | - | - | - | - | 2 | - | - | - | - | - | - |
| | | *Chiranda* | | | | | | | | | | | 4 |
| | | *Psychoglypha* | 1 | - | - | - | - | - | - | - | - | - | - |
| | Rhyacophilidae | *Rhyacophila* | 6 | 5 | 12 | 6 | 27 | 3 | - | 6 | 1 | 4 | 8 |
| Coleoptera | unidentified | | - | - | - | - | - | - | - | - | - | - | - |
| | Elmidae | *Narpus* | - | - | - | 3 | - | - | - | - | - | - | - |
| | Staphylinidae | | 1 | 1 | - | - | - | - | - | - | - | - | - |
| | Dytiscidae | *Megadytes* | - | - | - | - | - | - | - | 1 | - | - | - |
| Diptera | unidentified | | - | - | - | - | - | - | 1 | 2 | - | - | 3 |
| | Ceratopogonidae | *Probezzia* | - | - | - | - | - | - | - | - | - | - | 3 |
| | Chironomidae | | 33 | 27 | 149 | 148 | 42 | 9 | 5 | 59 | 15 | 45 | 162 |
| | Deuterophlebiidae | *Deuterophlebia* | - | 1 | 1 | - | - | - | - | 1 | 2 | - | - |
| | Dolichopodidae | | 2 | - | - | - | - | - | - | - | - | - | - |
| | Empididae | unidentified | - | - | - | - | 2 | - | - | - | - | 3 | - |
| | | *Chelifera* | 2 | - | - | 1 | - | - | - | - | - | - | 4 |
| | | *Hemerodromia* | - | - | - | - | 8 | - | - | - | - | - | - |
| | | *Oreogeton* | 10 | 4 | 15 | 25 | - | - | - | - | - | 7 | 1 |
| | Simuliidae | *Prosimulium* | - | 1 | - | 5 | - | - | - | - | - | - | - |
| | | *Simulium* | 3 | 3 | - | - | 2 | - | 2 | 16 | 7 | 1 | 6 |
| | Tipulidae | *Antocha* | 1 | - | 3 | 2 | - | - | - | - | 1 | - | - |
| | | *Dicranota* | 2 | 1 | - | - | - | - | - | - | - | - | 2 |
| | | *Hesperoconopa* | - | 1 | 1 | - | - | - | - | - | - | - | - |
| | | *Pilaria* | - | - | 1 | - | - | - | - | - | - | - | - |
| | | *Rhabdomastix* | - | - | 3 | 2 | 3 | - | 2 | 2 | - | 1 | 5 |
| | | *Hexatoma* | - | - | - | - | - | - | - | - | - | - | 4 |
| | | *Tipula* | - | 1 | - | 1 | - | 4 | - | 5 | 7 | 4 | 13 |
| Acari | | | 9 | 3 | 6 | 11 | 2 | - | - | 8 | - | - | 22 |
| Collembola | | | - | 2 | - | 2 | - | 1 | 1 | - | 4 | - | - |
| Copepoda | | | - | - | 1 | 1 | - | - | - | - | - | - | - |
| Gastropoda | | | 1 | 1 | - | - | - | - | - | - | - | - | - |
| Oligochaeta | | | 3 | 7 | 49 | 18 | 2 | - | - | - | 1 | 3 | 15 |
| Ostracoda | | | 1 | 1 | 1 | 11 | - | - | - | 4 | - | 5 | 8 |

*Note*: Appendix data for Site 54 were modified in Report No. 12-03 to correct errors.

Appendix C 4.–Benthic macroinvertebrates in Tributary Creek Site 9 samples, 2001–2011.

| Taxon | Family | Genus | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ephemeroptera | unidentified | | - | - | - | - | - | 1 | - | - | - | 1 | 149 |
| | Baetidae | *Baetis* | 41 | 123 | 160 | 21 | 38 | 1 | 3 | 73 | 9 | 15 | - |
| | | *Procloeon* | 5 | - | - | - | - | - | - | - | - | - | - |
| | Ephemerellidae | *Caudatella* | 3 | - | - | - | - | - | - | - | - | - | - |
| | | *Ephemerella* | - | 14 | 7 | 4 | 1 | 74 | 2 | 10 | 4 | - | 1 |
| | | *Drunella* | - | 3 | 10 | - | 8 | 3 | - | 5 | - | 2 | - |
| | Heptageniidae | unidentified | - | - | - | - | - | - | - | - | - | - | 3 |
| | | *Cinygma* | 1 | - | - | - | 43 | - | - | - | 3 | - | - |
| | | *Cinygmula* | 89 | 177 | 507 | 49 | 24 | 127 | 43 | 209 | 74 | 12 | 63 |
| | | *Epeorus* | - | 8 | 1 | - | 2 | - | - | 18 | 1 | 4 | - |
| | | *Rhithrogena* | - | - | 1 | - | 2 | 1 | - | - | 3 | 1 | - |
| | Leptophlebiidae | *Paraleptophlebia* | 66 | 96 | 249 | 442 | 191 | 204 | 38 | 109 | 74 | 42 | 14 |
| | Ameletidae | *Ameletus* | - | 15 | 46 | 46 | 25 | 33 | 18 | 17 | 35 | 12 | 47 |
| Plecoptera | unidentified | | - | - | - | - | - | 21 | - | 2 | - | 3 | 42 |
| | Capniidae | *Capnia* | - | - | - | - | - | - | - | - | - | 1 | - |
| | Chloroperlidae | unidentified | - | - | - | - | 1 | - | 8 | - | 26 | - | 3 |
| | | *Kathroperla* | - | - | - | - | - | - | - | - | - | 8 | 37 |
| | | *Neaviperla* | - | - | 174 | 24 | - | - | - | - | - | - | - |
| | | *Paraperla* | - | 11 | - | - | - | - | - | - | - | - | - |
| | | *Plumiperla* | - | - | - | 38 | - | - | - | 35 | 26 | - | - |
| | | *Suwallia* | 34 | - | 24 | 20 | 36 | - | - | - | 5 | - | - |
| | | *Sweltsa* | - | 42 | - | - | 12 | - | 26 | 4 | - | - | 43 |
| | Leuctridae | *Despaxia* | 3 | - | 6 | 5 | 3 | 1 | 3 | 1 | 8 | - | - |
| | | *Paraleuctra* | 7 | - | 1 | - | - | - | - | - | - | 1 | 1 |
| | | *Perlomyia* | - | 3 | - | - | - | - | - | - | - | - | 3 |
| | Nemouridae | *Podmosta* | - | 1 | - | - | - | - | - | - | - | - | - |
| | | *Zapada* | 23 | 12 | 388 | 41 | 43 | 13 | - | 8 | 32 | 3 | 9 |
| | Perlodidae | *Isoperla* | 1 | - | - | 38 | - | - | - | - | - | 1 | - |
| Trichoptera | unidentified | | - | - | - | - | - | 1 | - | - | - | - | 4 |
| | Apataniidae | *Apatania* | - | 1 | - | - | - | - | - | - | - | - | - |
| | Brachycentridae | *Brachycentrus* | - | - | 1 | - | - | - | - | - | - | - | 6 |
| | Lepidostomatidae | *Lepidostoma* | - | - | - | 1 | 1 | 1 | 1 | - | - | - | - |
| | Limnephilidae | unidentified | - | - | - | - | 1 | - | - | - | - | - | 3 |
| | | *Ecclisomyia* | - | - | 1 | - | 1 | - | 3 | - | - | - | - |
| | | *Onocosmoecus* | - | - | - | 1 | - | - | - | - | - | - | - |
| | Rhycophilidae | *Rhycophila* | - | 1 | 5 | 3 | 1 | - | - | 1 | - | - | - |
| Coleoptera | unidentified | | - | - | - | - | - | - | - | - | - | 1 | 12 |
| | Elmidae | *Narpus* | 2 | 6 | 32 | 14 | 1 | 8 | 3 | 1 | 4 | - | - |
| | Dytiscidae | *Megadytes* | - | - | 2 | - | - | - | - | - | - | - | - |
| Diptera | unidentified | | - | - | - | - | - | 1 | - | - | - | 2 | - |
| | Ceratopogonidae | *Bezzia* | - | - | 1 | - | - | - | - | - | - | - | - |
| | | *Dasyhelea* | 3 | - | - | - | - | - | - | - | - | - | - |
| | | *Probezzia* | - | - | 9 | - | - | 1 | - | - | 6 | 1 | 8 |
| | Chironomidae | | 35 | 36 | 125 | 52 | 40 | 22 | 3 | 6 | 105 | 45 | 179 |
| | Empididae | unidentified | - | - | - | - | - | - | - | - | 1 | - | 1 |
| | | *Chelifera* | - | 1 | - | - | - | - | - | - | 4 | - | - |
| | | *Hemerodromia* | - | - | 1 | - | 1 | - | - | - | - | - | - |
| | | *Oreogeton* | 4 | 2 | 24 | 8 | 1 | - | - | - | - | 2 | - |
| | Simuliidae | *Simulium* | 40 | 22 | 81 | 4 | 14 | 8 | 10 | 196 | 20 | - | - |
| | Tipulidae | *Antocha* | - | - | 10 | - | - | - | - | - | - | - | - |
| | | *Dicranota* | - | - | 2 | - | 2 | 6 | 2 | 2 | - | 1 | 2 |
| | | *Pilaria* | - | - | 2 | - | - | - | - | - | - | - | - |
| | | *Rhabdomastix* | - | - | 1 | - | 1 | - | - | - | - | - | - |
| | | *Tipula* | 4 | 5 | - | 2 | - | 4 | 5 | 2 | 5 | 1 | 6 |
| | | *Limonia* | - | - | - | - | 1 | - | 1 | - | - | - | - |
| Acari | | | 15 | - | 72 | 39 | 2 | - | 2 | 25 | - | - | 23 |
| Branchiopoda | | | - | - | 2 | - | - | - | - | - | - | - | - |
| Collembola | | | - | 2 | 3 | 34 | 1 | 3 | 2 | - | 1 | 4 | - |
| Copepoda | | | - | - | 11 | 5 | - | 1 | - | - | 2 | 3 | 3 |
| Isopoda | | | - | - | - | 1 | - | - | - | - | 1 | - | 1 |
| Gastropoda | | | 1 | 45 | 1 | 2 | - | 1 | 1 | - | 2 | - | - |
| Oligochaeta | | | 40 | 20 | 349 | 111 | 23 | 21 | 27 | 9 | 26 | 1 | 119 |
| Ostracoda | | | 92 | 102 | 207 | 27 | 8 | 68 | 17 | 20 | 1 | 30 | 73 |

*Note*: Appendix data for Site 9 were modified in Report No. 12-03 to correct errors.

# APPENDIX D: JUVENILE FISH CAPTURE DATA

Appendix D 1.–Juvenile fish capture data at Greens Creek Mine biomonitoring sites, 2001–2011.

| Year and Sample Site | Species[a] | FL (mm) | Number of Fish Captured Set 1 | Set 2 | Set 3 | Total | Population Estimate | 95% C.I. | Density (fish/m$^2$) |
|---|---|---|---|---|---|---|---|---|---|
| **2001** | | | | | | | | | |
| Greens Creek Site 48 | DV | 48-139 | 30 | 16 | 22 | 68 | 96 | 68-124 | 0.20 |
| Greens Creek Site 6 | DV | 52-168 | 80 | 8 | 43 | 131 | 161 | 137-185 | 0.13 |
| | CO | 81-90 | 1 | 0 | 2 | 3 | 3 | --- | <0.01 |
| Greens Creek Site 54 | DV | 27-162 | 70 | 49 | 19 | 138 | 158 | 141-175 | 0.58 |
| | CO | 32-95 | 2 | 6 | 4 | 12 | 17 | 8-26 | 0.06 |
| Tributary Creek Site 9 | DV | 58-110 | 70 | 4 | 7 | 81 | 81 | 81-81 | 0.92 |
| | CO | 39-101 | 89 | 18 | 11 | 118 | 120 | 117-123 | 0.80 |
| | CT | 124 | 1 | 0 | 0 | 1 | 1 | --- | <0.01 |
| | Sc | 75-98 | 3 | 1 | 0 | 4 | 4 | --- | <0.01 |
| **2002** | | | | | | | | | |
| Greens Creek Site 48 | DV | 45-160 | 74 | 29 | 23 | 126 | 141 | 127-155 | 0.23 |
| Greens Creek Site 54 | DV | 33-160 | 168 | 72 | 31 | 271 | 290 | 276-304 | 1.00 |
| | CO | 59-85 | 14 | 6 | 1 | 21 | 21 | --- | 0.07 |
| Tributary Creek Site 9 | DV | 38-147 | 29 | 14 | 8 | 51 | 56 | 49-63 | 0.46 |
| | CO | 27-85 | 29 | 9 | 6 | 44 | 46 | 42-50 | 0.35 |
| | CT | 124 | 0 | 0 | 1 | 1 | 1 | --- | <0.01 |
| | Sc | 90-100 | 0 | 1 | 1 | 2 | 2 | --- | <0.01 |
| **2003** | | | | | | | | | |
| Greens Creek Site 48 | DV | 54-180 | 157 | 72 | 56 | 285 | 333 | 305-361 | 0.90 |
| Greens Creek Site 54 | DV | 51-184 | 92 | 81 | 59 | 232 | 331 | 275-387 | 1.80 |
| | CO | 44-52 | 5 | 3 | 0 | 8 | 8 | --- | 0.04 |
| Tributary Creek Site 9 | DV | 54-114 | 13 | 4 | 2 | 19 | 20 | 17-23 | 0.30 |
| | CO | 46-88 | 37 | 11 | 4 | 52 | 53 | 51-55 | 0.80 |
| | CT | 122 | 1 | 0 | 0 | 1 | 1 | --- | <0.01 |
| | Sc | 80 | 0 | 0 | 1 | 1 | 1 | --- | <0.01 |
| **2004** | | | | | | | | | |
| Greens Creek Site 48 | DV | 54-158 | 168 | 48 | 28 | 244 | 255 | 246-264 | 0.88 |
| Greens Creek Site 54 | DV | 52-161 | 118 | 36 | 47 | 201 | 234 | 211-257 | 1.57 |
| | CO | 70-95 | 9 | 9 | 6 | 24 | 31 | 20-42 | 0.21 |
| Tributary Creek Site 9 | DV | 64-109 | 21 | 6 | 5 | 32 | 33 | 31-35 | 0.56 |
| | CO | 40-94 | 23 | 2 | 2 | 27 | 27 | --- | 0.46 |
| | CT | 122 | 1 | 0 | 0 | 1 | 1 | --- | <0.01 |
| | RT | 86-106 | 3 | 1 | 0 | 4 | 4 | --- | <0.01 |
| | Sc | 67-85 | 1 | 1 | 0 | 2 | 2 | --- | <0.01 |
| **2005** | | | | | | | | | |
| Greens Creek Site 48 | DV | 50-149 | 118 | 56 | 38 | 212 | 243 | 222-264 | 0.65 |
| Greens Creek Site 54 | DV | 52-146 | 111 | 59 | 43 | 213 | 255 | 227-283 | 1.17 |
| | CO | 66-93 | 33 | 20 | 8 | 61 | 67 | 59-75 | 0.31 |
| Tributary Creek Site 9 | DV | 59-131 | 21 | 12 | 11 | 44 | 55 | 41-69 | 0.42 |
| | CO | 39-103 | 82 | 42 | 15 | 139 | 150 | 139-161 | 1.15 |
| | CT | 91-103 | 1 | 1 | 0 | 2 | 2 | --- | <0.01 |
| | Sc | 78-99 | 2 | 0 | 0 | 2 | 2 | --- | <0.01 |
| **2006** | | | | | | | | | |
| Greens Creek Site 48 | DV | 49-150 | 138 | 40 | 34 | 212 | 228 | 215-241 | 0.59 |
| Greens Creek Site 6 | DV | 53-150 | 44 | 41 | 12 | 97 | 114 | 98-130 | 0.25 |
| | CO | 89 | 1 | 0 | 0 | 1 | 1 | --- | <0.01 |
| Greens Creek Site 54 | DV | 49-158 | 116 | 61 | 40 | 217 | 254 | 229-279 | 1.22 |
| | CO | 62-88 | 6 | 0 | 1 | 7 | 7 | --- | 0.03 |
| Tributary Creek Site 9 | DV | 85-117 | 7 | 3 | 1 | 11 | 11 | --- | 0.09 |
| | CO | 69-108 | 5 | 4 | 1 | 10 | 10 | --- | 0.08 |
| | CT | --- | 0 | 0 | 0 | 0 | --- | --- | <0.01 |
| | Sc | --- | 0 | 0 | 0 | 0 | --- | --- | <0.01 |

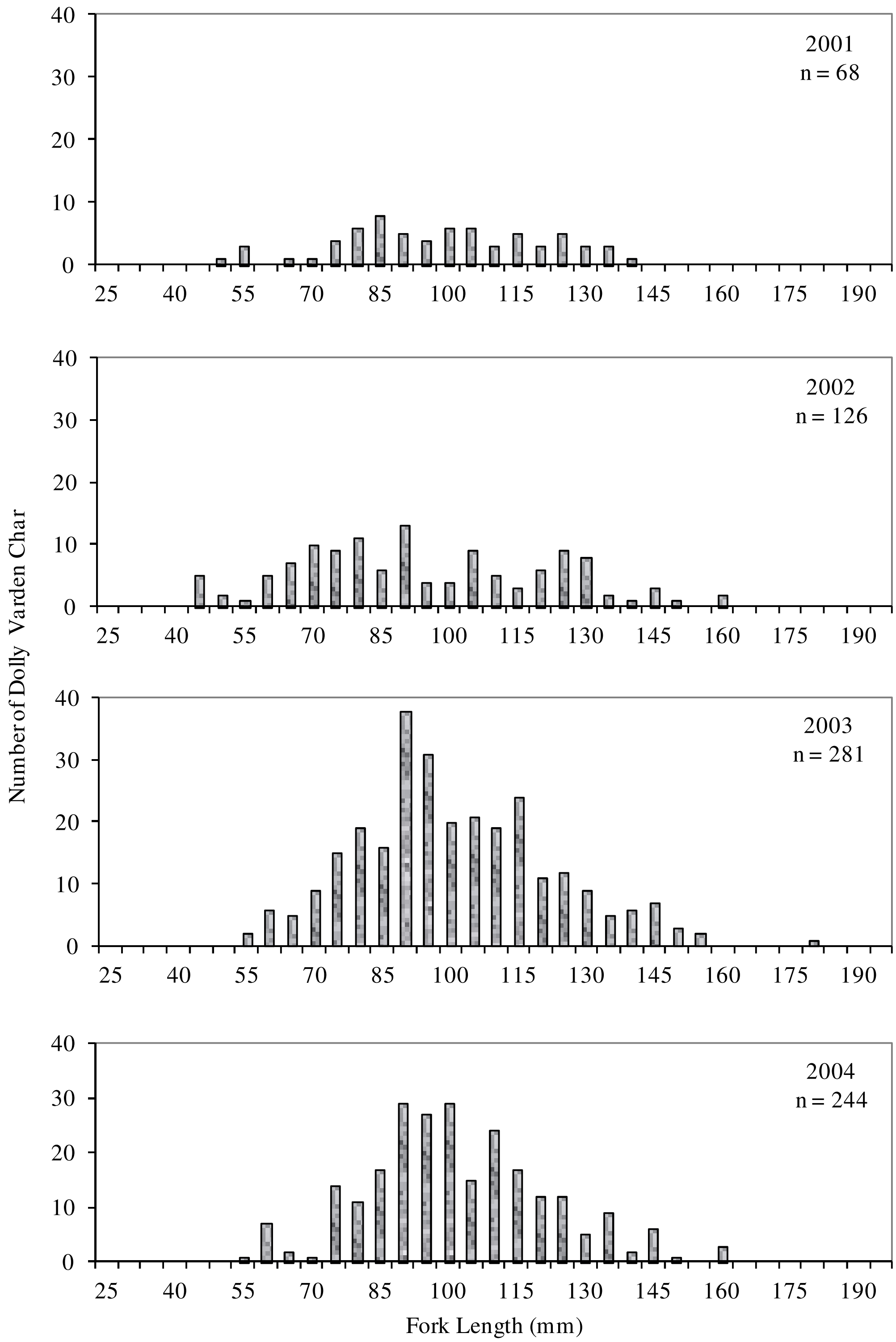
-continued-

Appendix D 1. Page 2 of 2.

| Year and Sample Site | Species[a] | FL (mm) | Number of Fish Captured Set 1 | Set 2 | Set 3 | Total | Population Estimate | 95% C.I. | Density (fish/m$^2$) |
|---|---|---|---|---|---|---|---|---|---|
| **2007** | | | | | | | | | |
| Greens Creek Site 48 | DV | 53-154 | 50 | 29 | 16 | 95 | 103 | 95-123 | 0.20 |
| Greens Creek Site 54 | DV | 50-145 | 64 | 19 | 24 | 107 | 122 | 108-136 | 0.40 |
| | CO | --- | 0 | 0 | 0 | 0 | 0 | --- | 0.00 |
| Tributary Creek Site 9 | DV | 81-158 | 7 | 5 | 0 | 12 | 12 | 12-12 | 0.10 |
| | CO | 38-104 | 50 | 10 | 9 | 69 | 71 | 67-75 | 0.58 |
| | CT | 138 | 0 | 0 | 1 | 1 | 1 | --- | <0.01 |
| | Sc | --- | 0 | 0 | 0 | 0 | 0 | --- | <0.01 |
| **2008** | | | | | | | | | |
| Greens Creek Site 48 | DV | 77-137 | 54 | 10 | 9 | 73 | 75 | 71-79 | 0.14 |
| Greens Creek Site 54 | DV | 45-131 | 50 | 15 | 6 | 71 | 73 | 69-77 | 0.21 |
| | CO | 53-69 | 4 | 0 | 0 | 4 | 4 | --- | 0.01 |
| Tributary Creek Site 9 | DV | 60-108 | 15 | 4 | 3 | 22 | 22 | --- | 0.16 |
| | CO | 41-100 | 72 | 44 | 26 | 142 | 169 | 147-191 | 1.27 |
| | CT | 82-112 | 1 | 0 | 2 | 3 | 3 | --- | <0.01 |
| | Sc | --- | 0 | 0 | 0 | 0 | 0 | --- | <0.01 |
| **2009** | | | | | | | | | |
| Greens Creek Site 48 | DV | 47-142 | 67 | 31 | 28 | 126 | 151 | 130-172 | 0.36 |
| Greens Creek Site 54 | DV | 47-101 | 42 | 32 | 19 | 93 | 117 | 95-139 | 0.36 |
| | CO | 67-73 | 2 | 2 | 0 | 4 | 4 | --- | 0.01 |
| Tributary Creek Site 9 | DV | 48-98 | 24 | 5 | 9 | 38 | 42 | 35-49 | 0.35 |
| | CO | 38-116 | 42 | 9 | 2 | 53 | 53 | 53-53 | 0.44 |
| | CT | 97 | 1 | 0 | 0 | 1 | 1 | --- | <0.01 |
| | Sc | 75-94 | 4 | 0 | 1 | 5 | 5 | --- | <0.01 |
| **2010** | | | | | | | | | |
| Greens Creek Site 48 | DV | 47-170 | 97 | 41 | 20 | 158 | 170 | 159 - 181 | 0.31 |
| Greens Creek Site 54 | DV | 52-151 | 46 | 13 | 14 | 73 | 80 | 71 - 89 | 0.24 |
| | CO | 77 | 1 | 0 | 0 | 1 | 1 | --- | <0.01 |
| Tributary Creek Site 9 | DV | 58-108 | 21 | 7 | 31 | 59 | 109 | 65 - 153 | 0.97 |
| | CO | 39-90 | 77 | 21 | 30 | 128 | 147 | 130 - 164 | 1.31 |
| | CT | 64-89 | 4 | 1 | 0 | 5 | 5 | --- | <0.01 |
| | Sc | 60-100 | 4 | 1 | 0 | 5 | 5 | --- | <0.01 |
| **2011** | | | | | | | | | |
| Greens Creek Site 48 | DV | 54-155 | 56 | 28 | 41 | 125 | 180 | 139-221 | 0.34 |
| Greens Creek Site 6 | DV | 31-151 | 98 | 42 | 23 | 163 | 178 | 165-191 | 0.34 |
| | CO | --- | 0 | 0 | 0 | 0 | 0 | --- | 0.00 |
| Greens Creek Site 54 | DV | 43-150 | 73 | 43 | 57 | 173 | 259 | 205-313 | 0.40 |
| | CO | --- | 0 | 0 | 0 | 0 | 0 | --- | 0.00 |
| Tributary Creek Site 9 | DV | 50-125 | 15 | 7 | 14 | 36 | 53 | 32-74 | 0.46 |
| | CO | 38-100 | 18 | 18 | 13 | 49 | 69 | 46-92 | 0.60 |
| | CT | 115 | 1 | 0 | 0 | 1 | 1 | --- | <0.01 |
| | Sc | 66-85 | 0 | 1 | 1 | 2 | 2 | --- | <0.01 |

[a] Species: DV = Dolly Varden char, CO = coho salmon, CT = cutthroat trout, RT = rainbow trout, Sc = sculpin spp.

Appendix D 2.–Length frequency plots for Dolly Varden captured at Site 48, 2001–2011.

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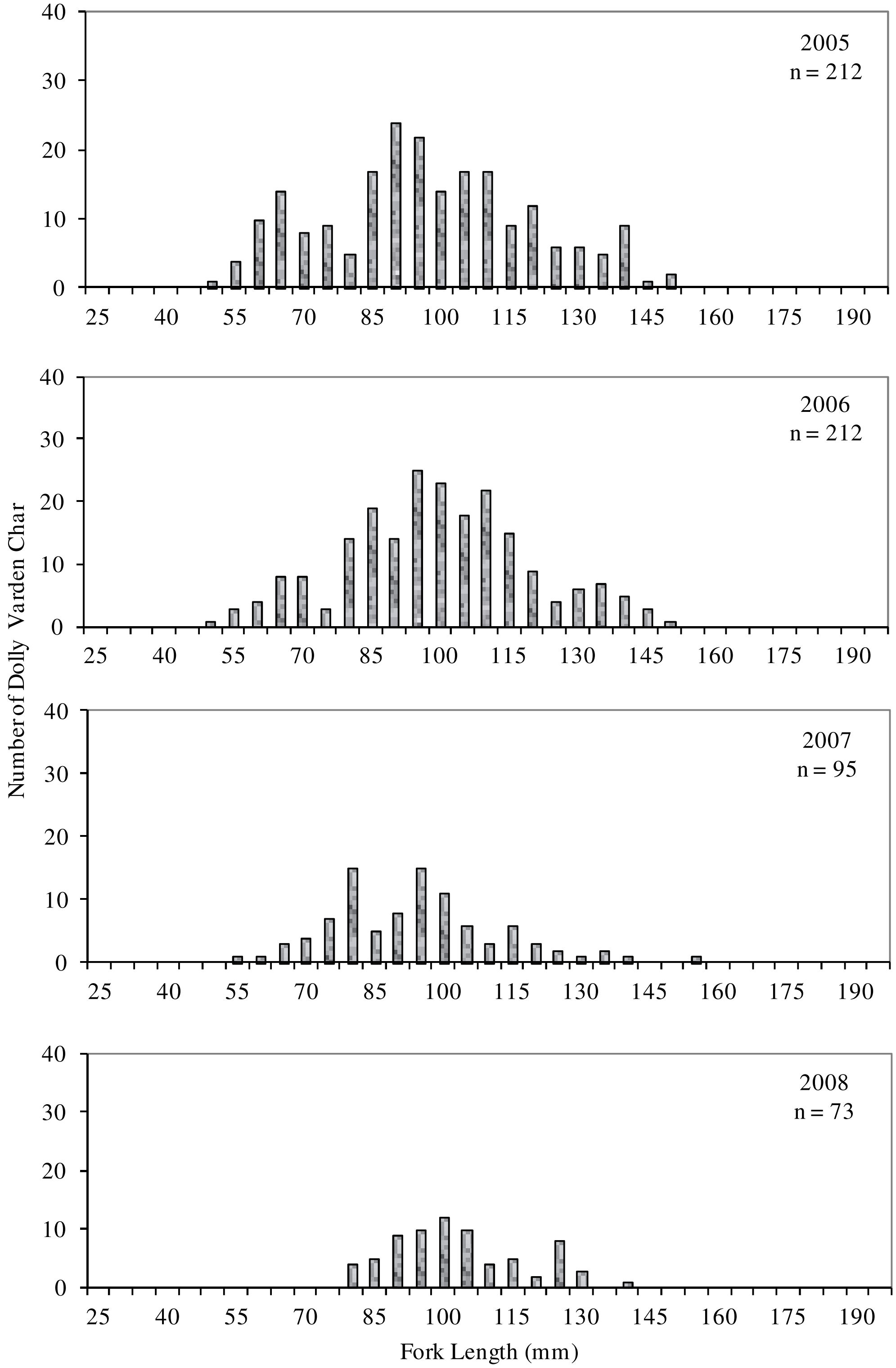
Appendix D 2. Page 2 of 3.

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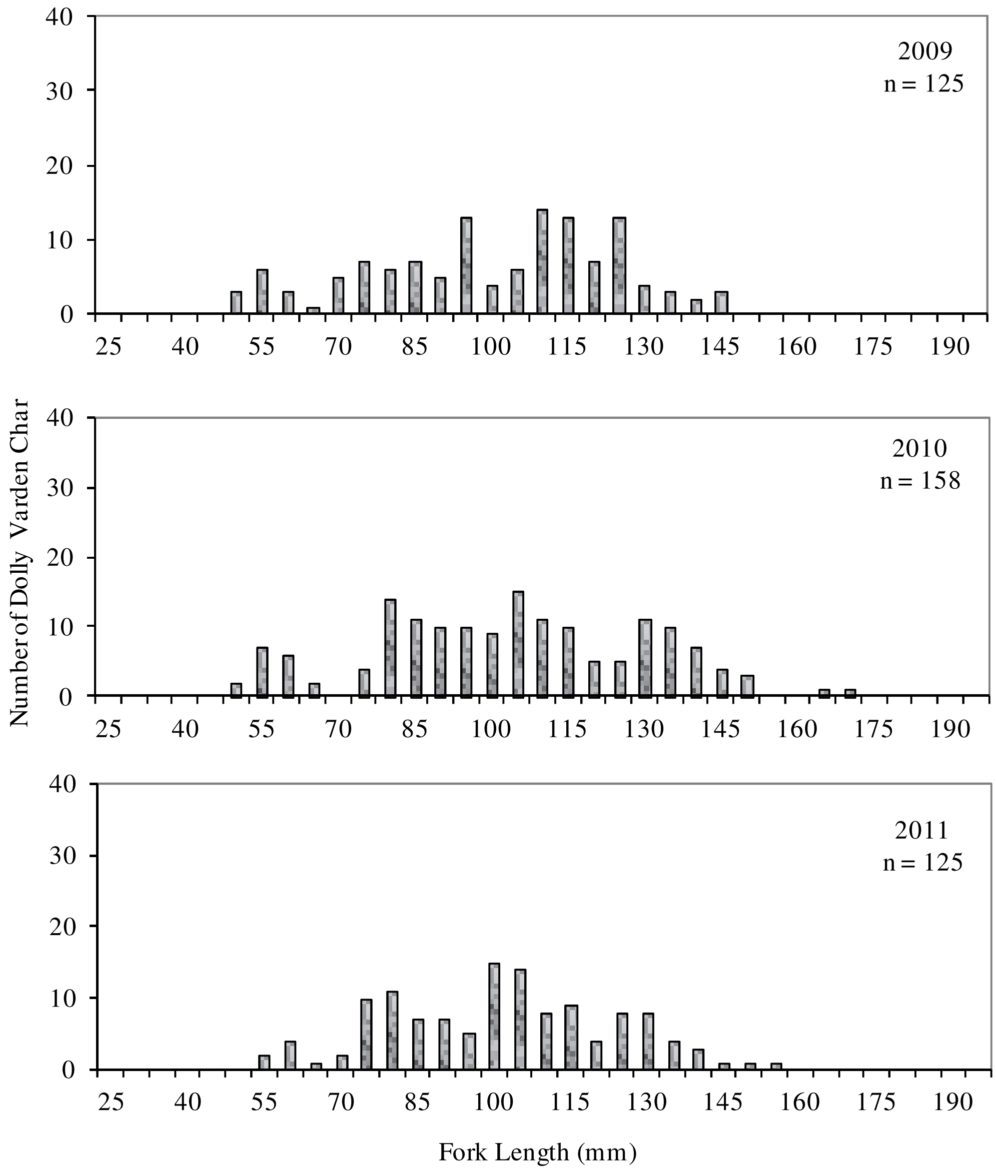
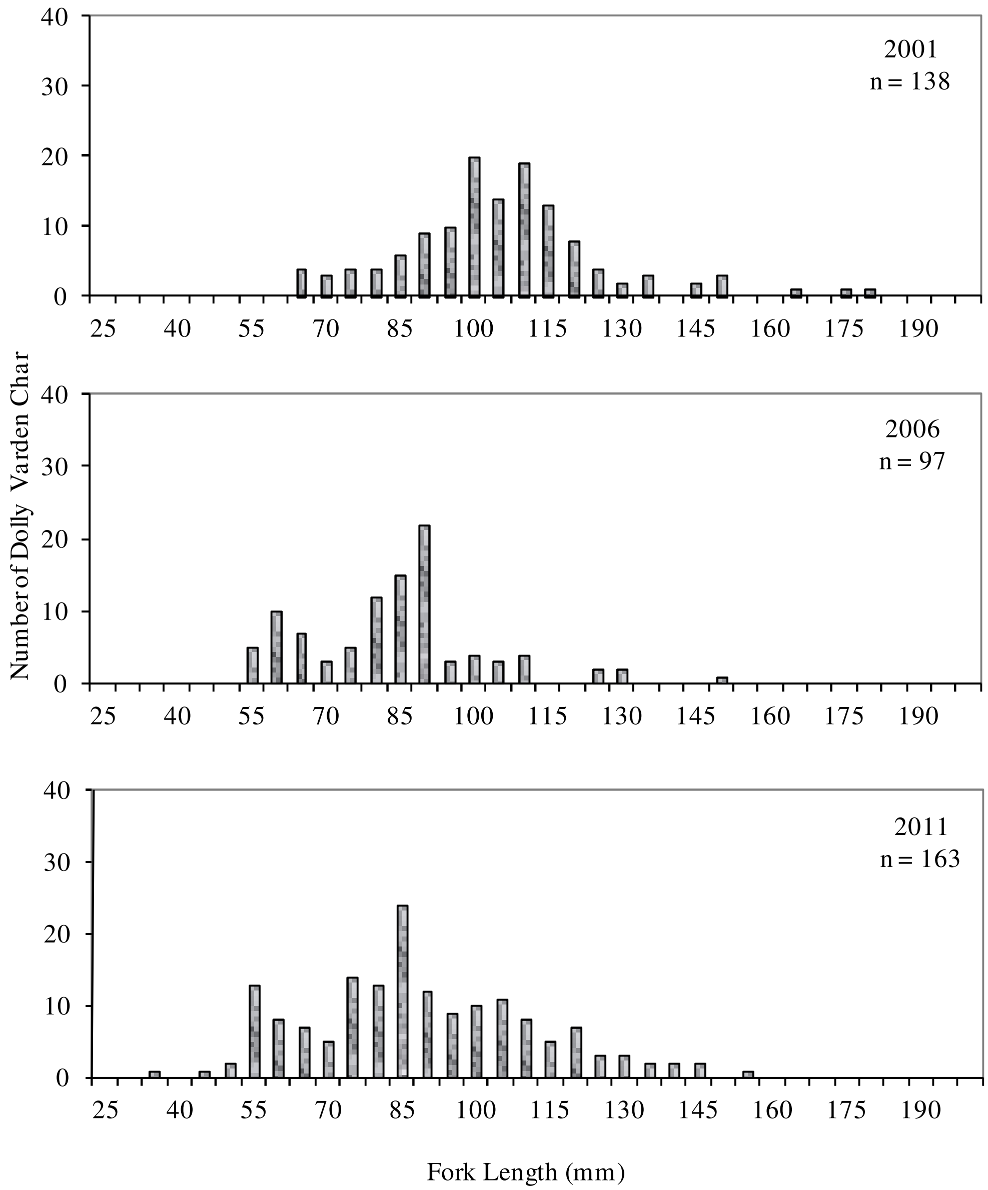
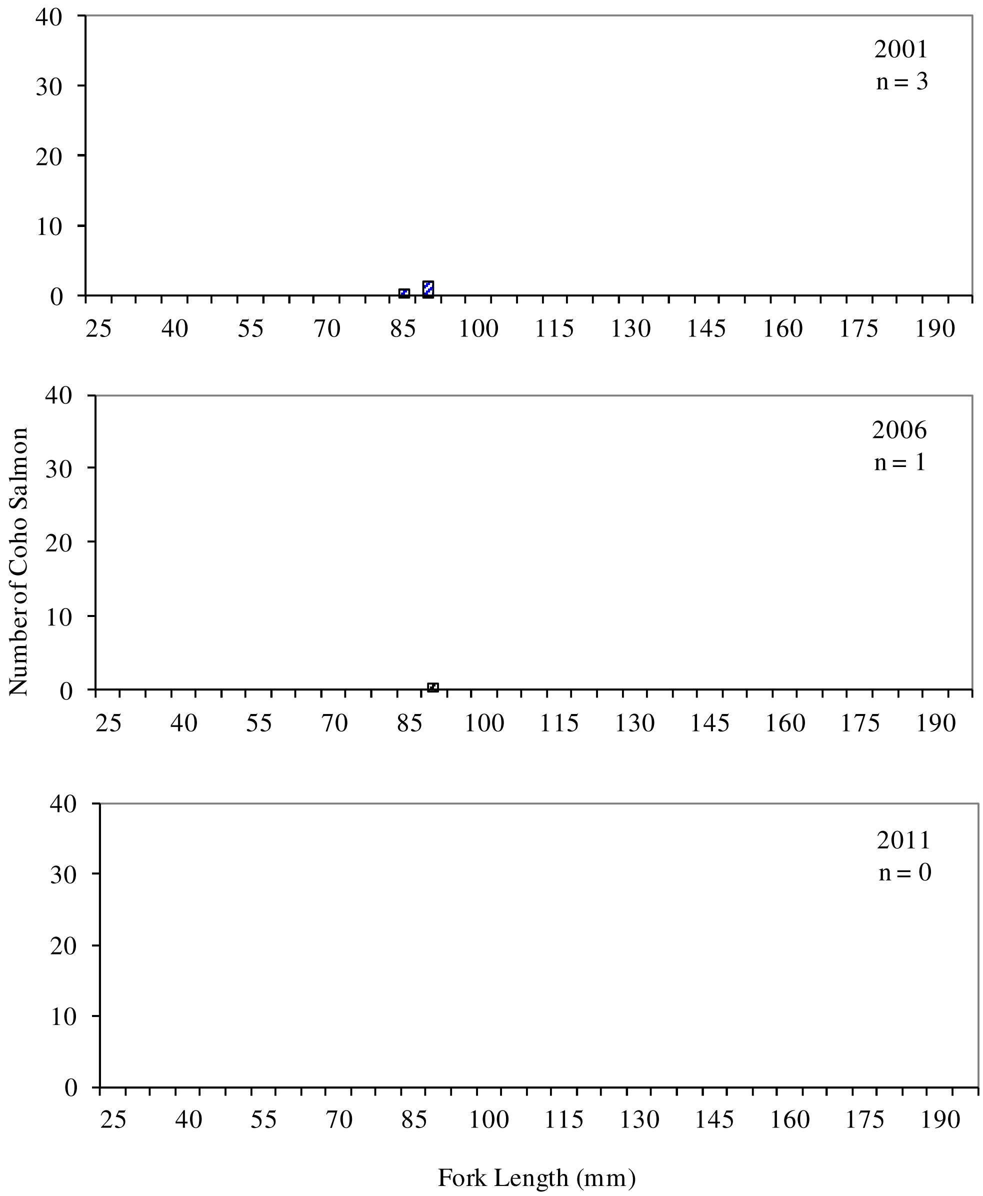
Appendix D 2. Page 3 of 3.



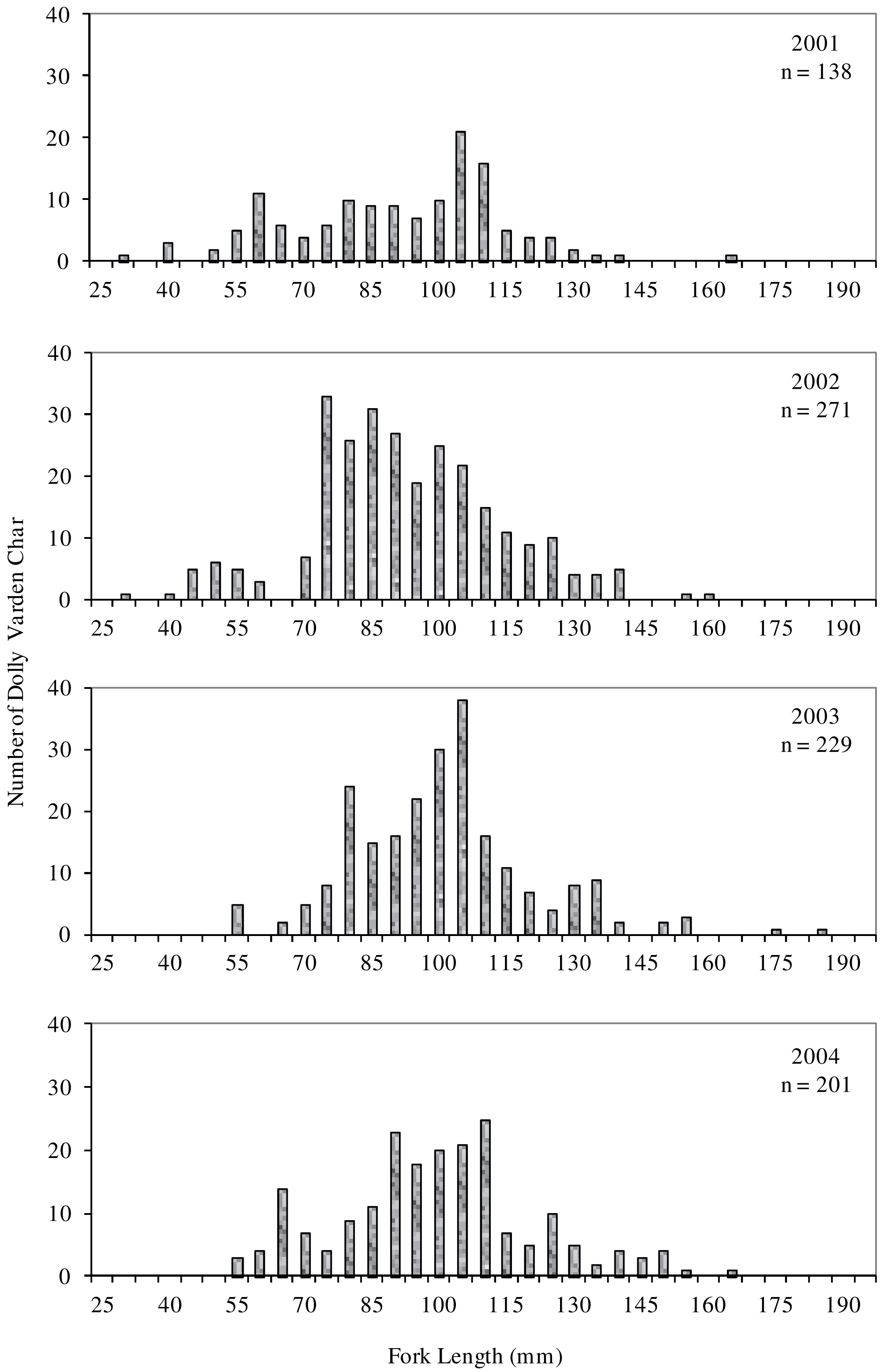
Appendix D 3.–Length frequency plots for Dolly Varden captured at Site 6 in 2001, 2006, and 2011.



Appendix D 4.–Length frequency plots for coho salmon captured at Site 6 in 2001, 2006, and 2011.



Appendix D 5.–Length frequency plots for Dolly Varden captured at Site 54, 2001–2011.

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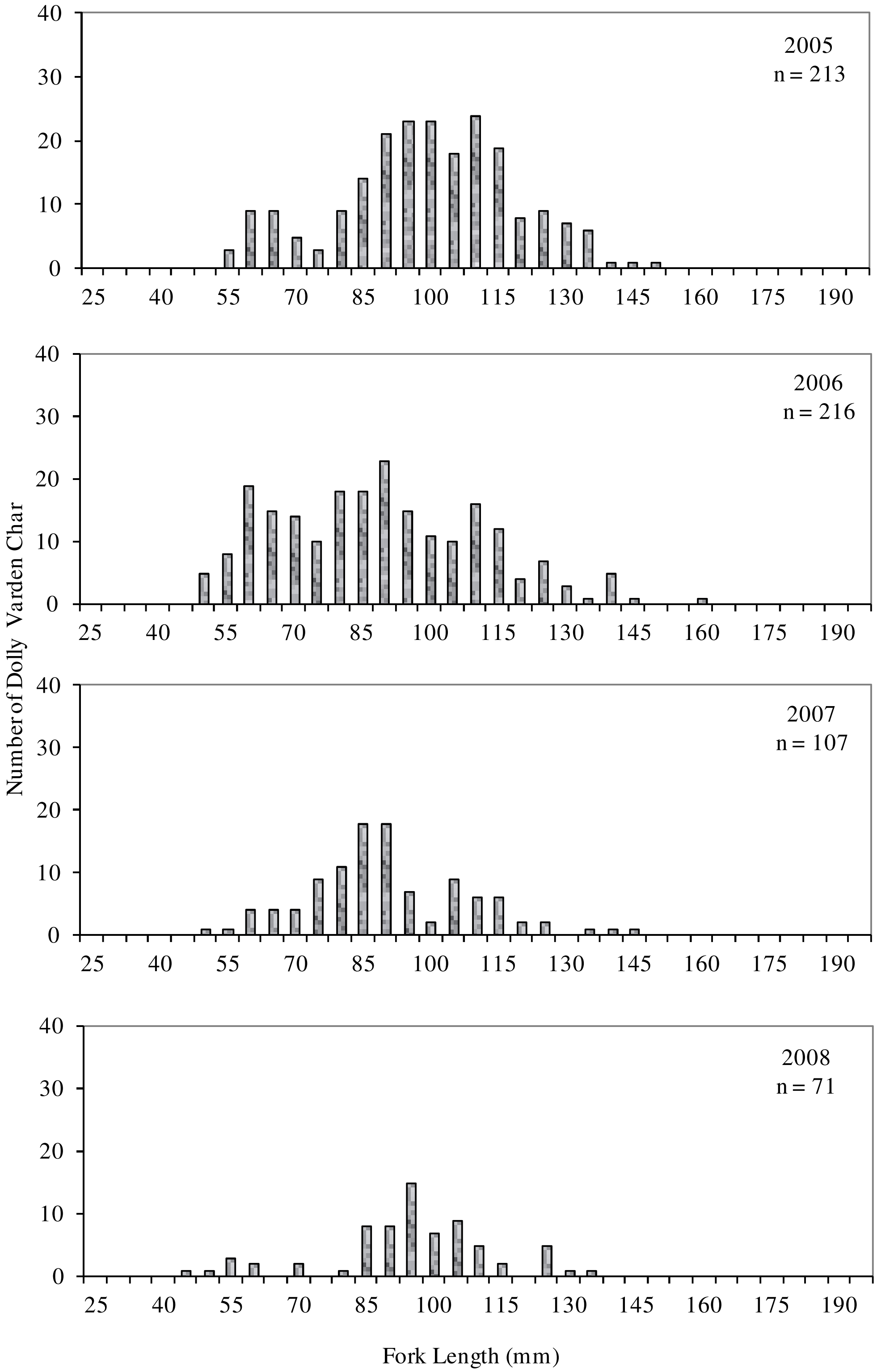
Appendix D 5. Page 2 of 3.

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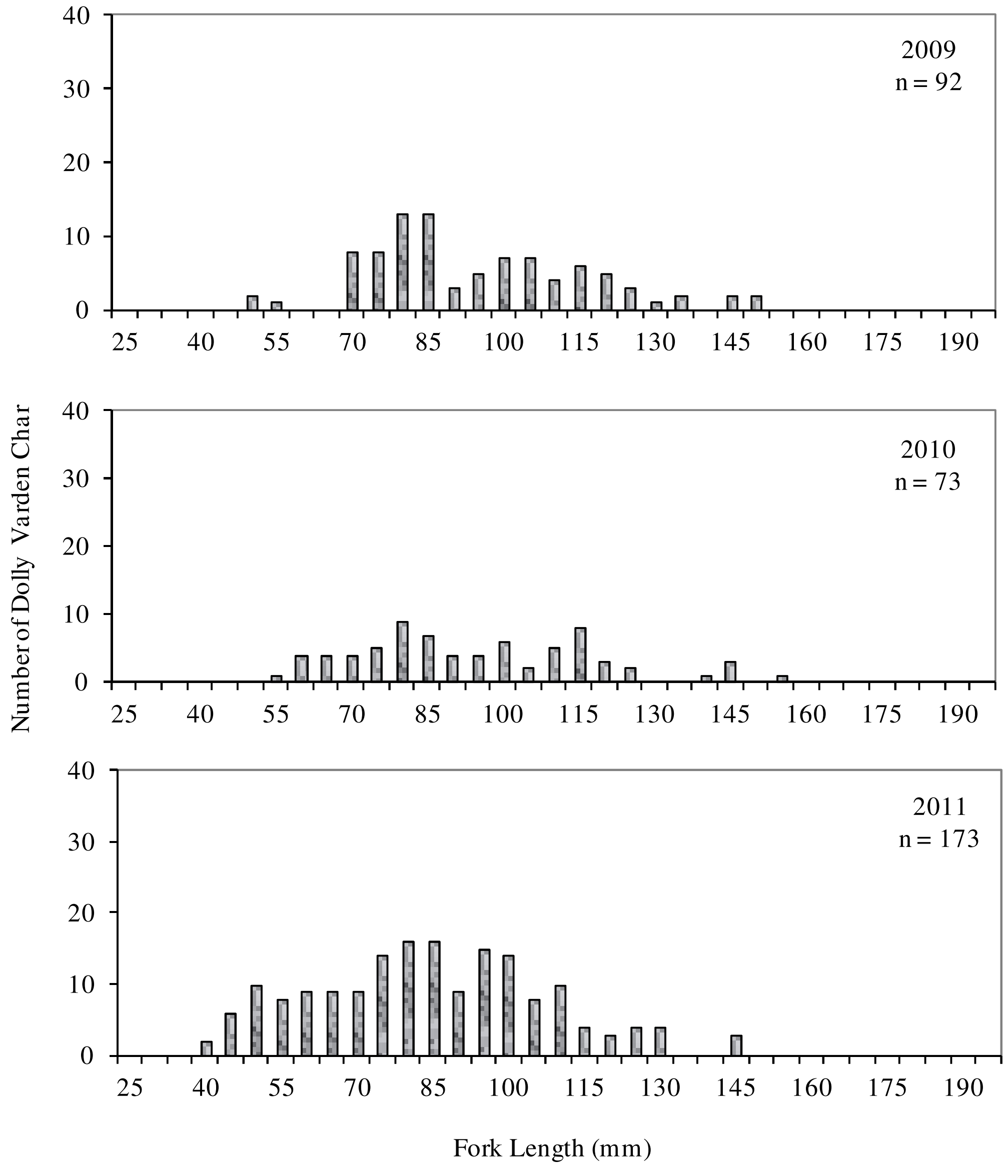
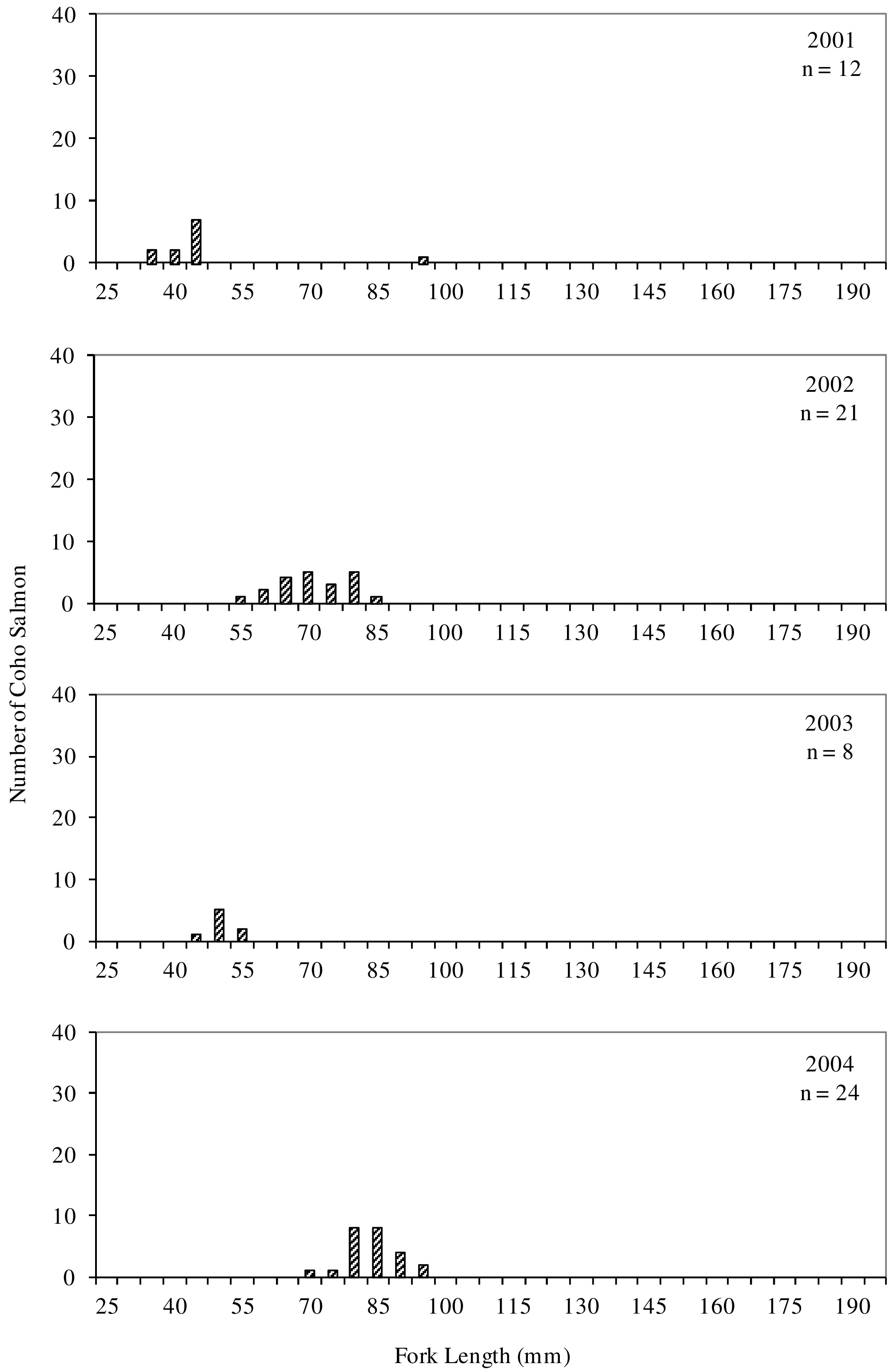

2009
n = 92
2010
n = 73
2011
n = 173
Number of Dolly Varden Char
Fork Length (mm)
0
10
20
30
40
25
40
55
70
85
100
115
130
145
160
175
190

Appendix D 6.–Length frequency plots for coho salmon captured at Site 54, 2001–2011.

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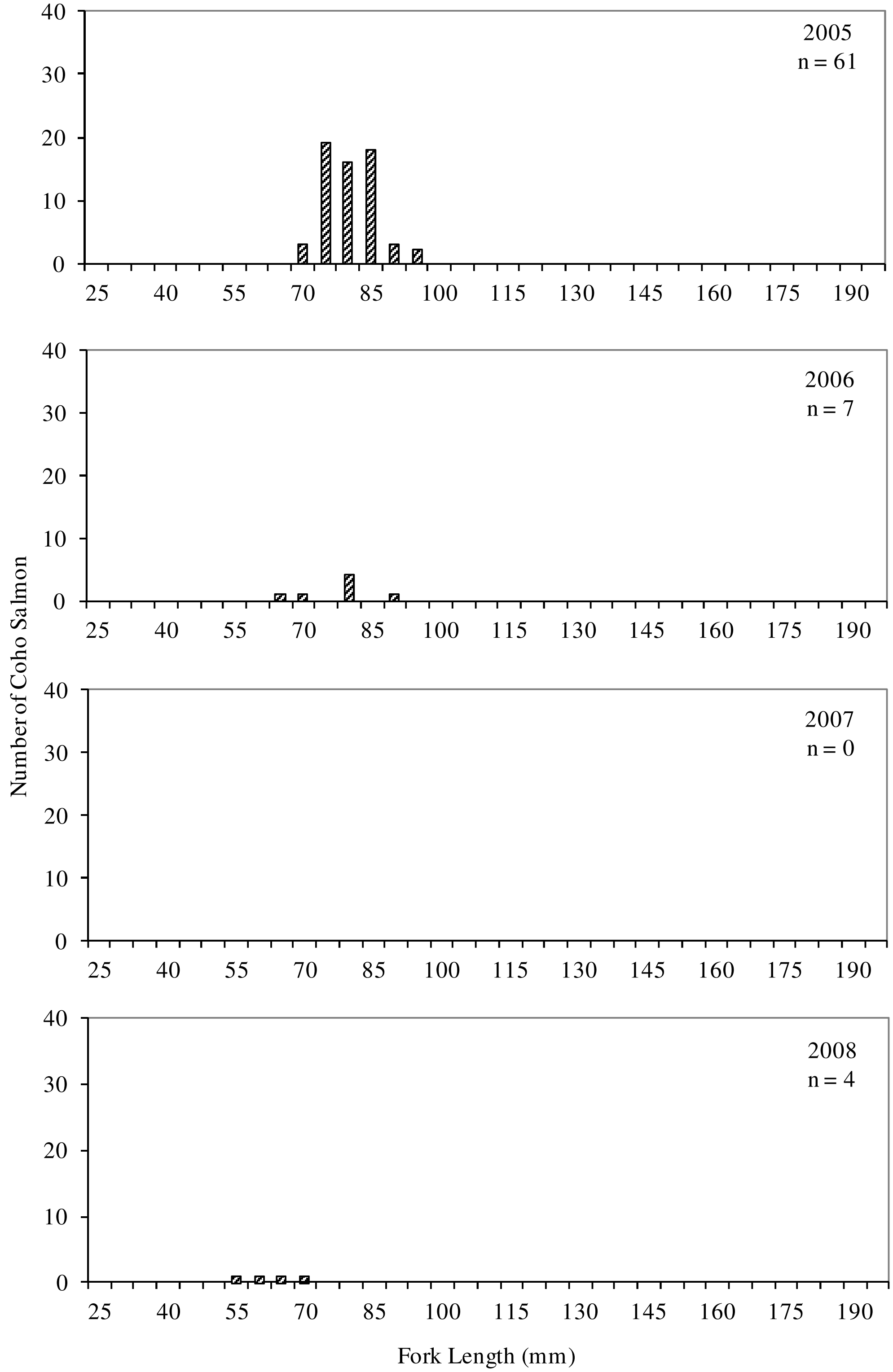
2005
n = 61
2006
n = 7
2007
n = 0
2008
n = 4
Number of Coho Salmon
Fork Length (mm)
0
10
20
30
40
25
40
55
70
85
100
115
130
145
160
175
190

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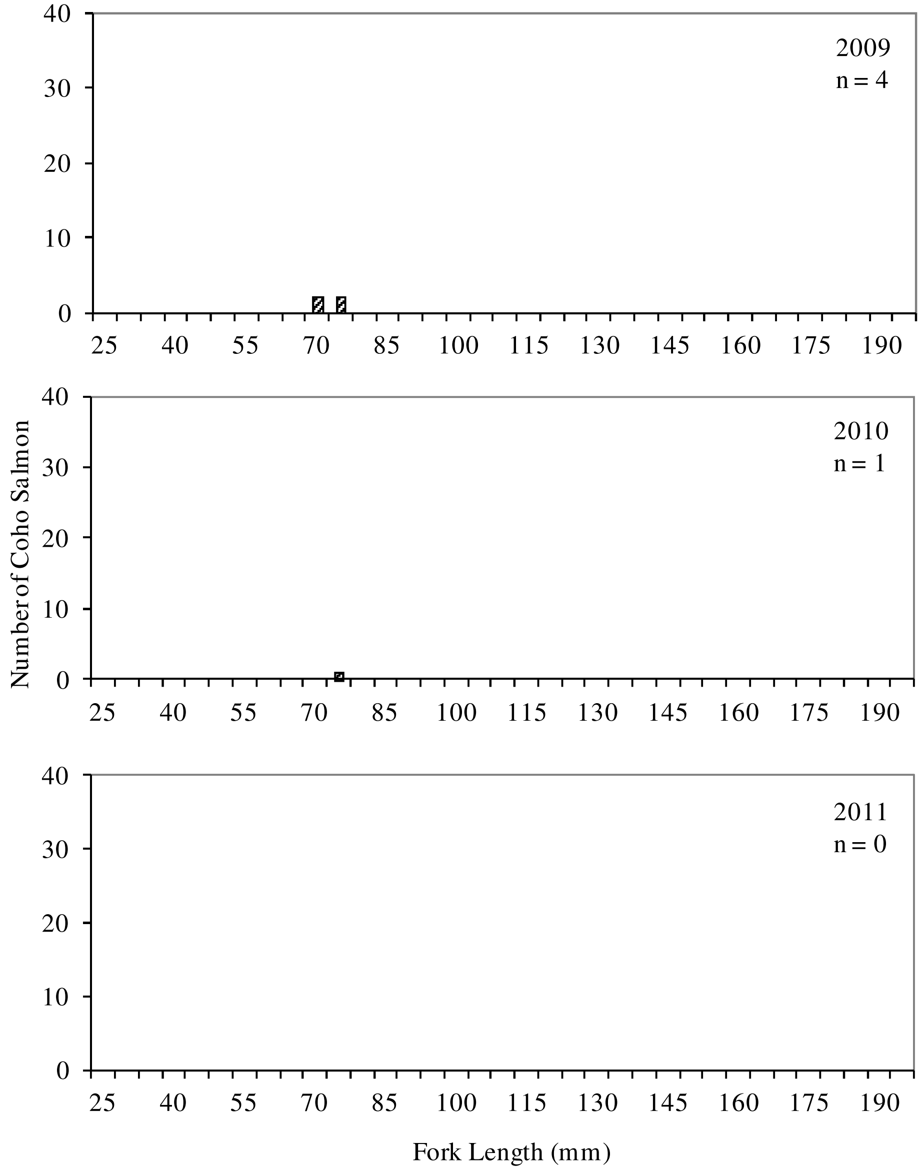
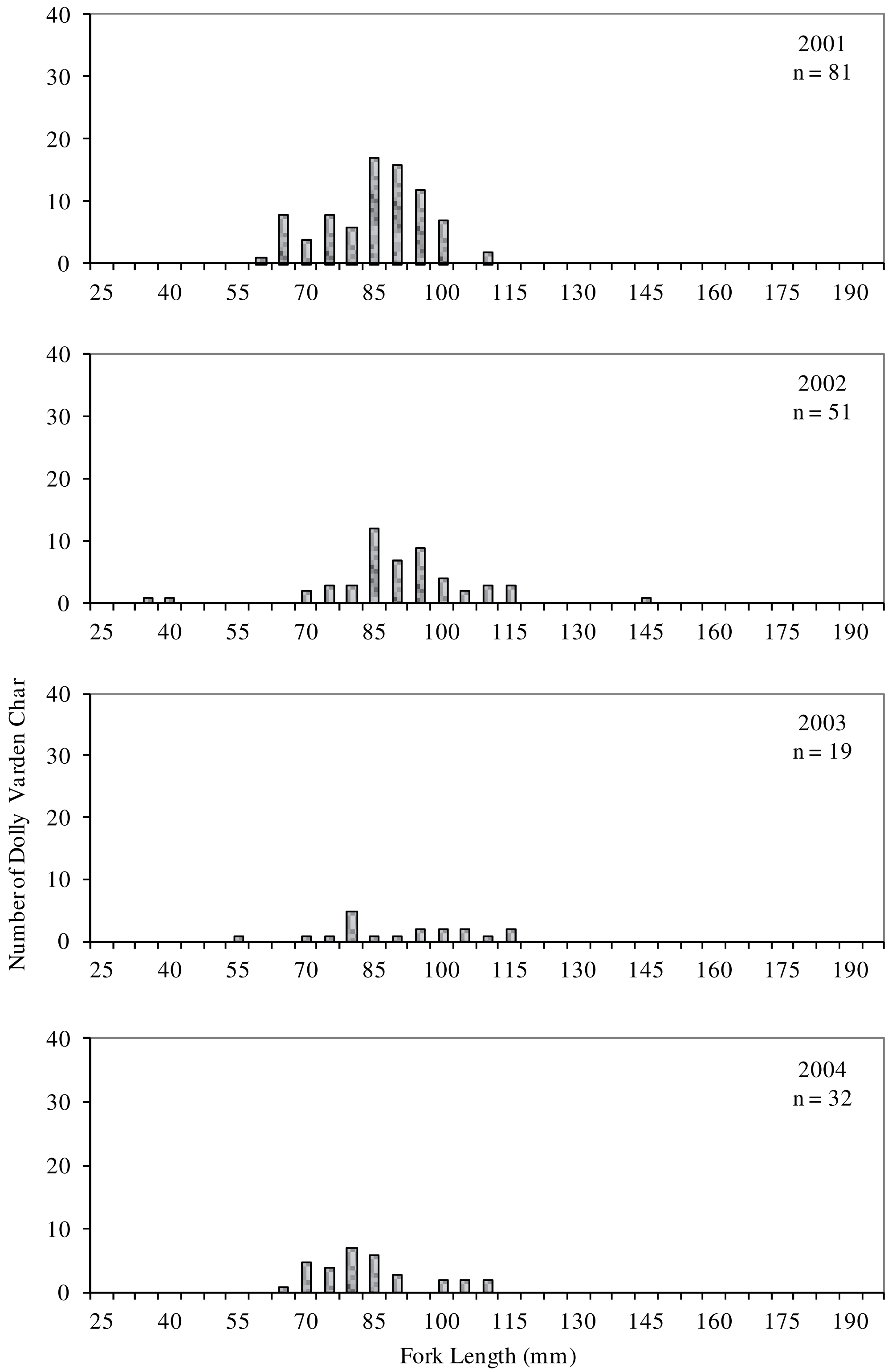
Appendix D 6. Page 3 of 3.



Appendix D 7.–Length frequency plots for Dolly Varden captured at Site 9, 2001–2011.

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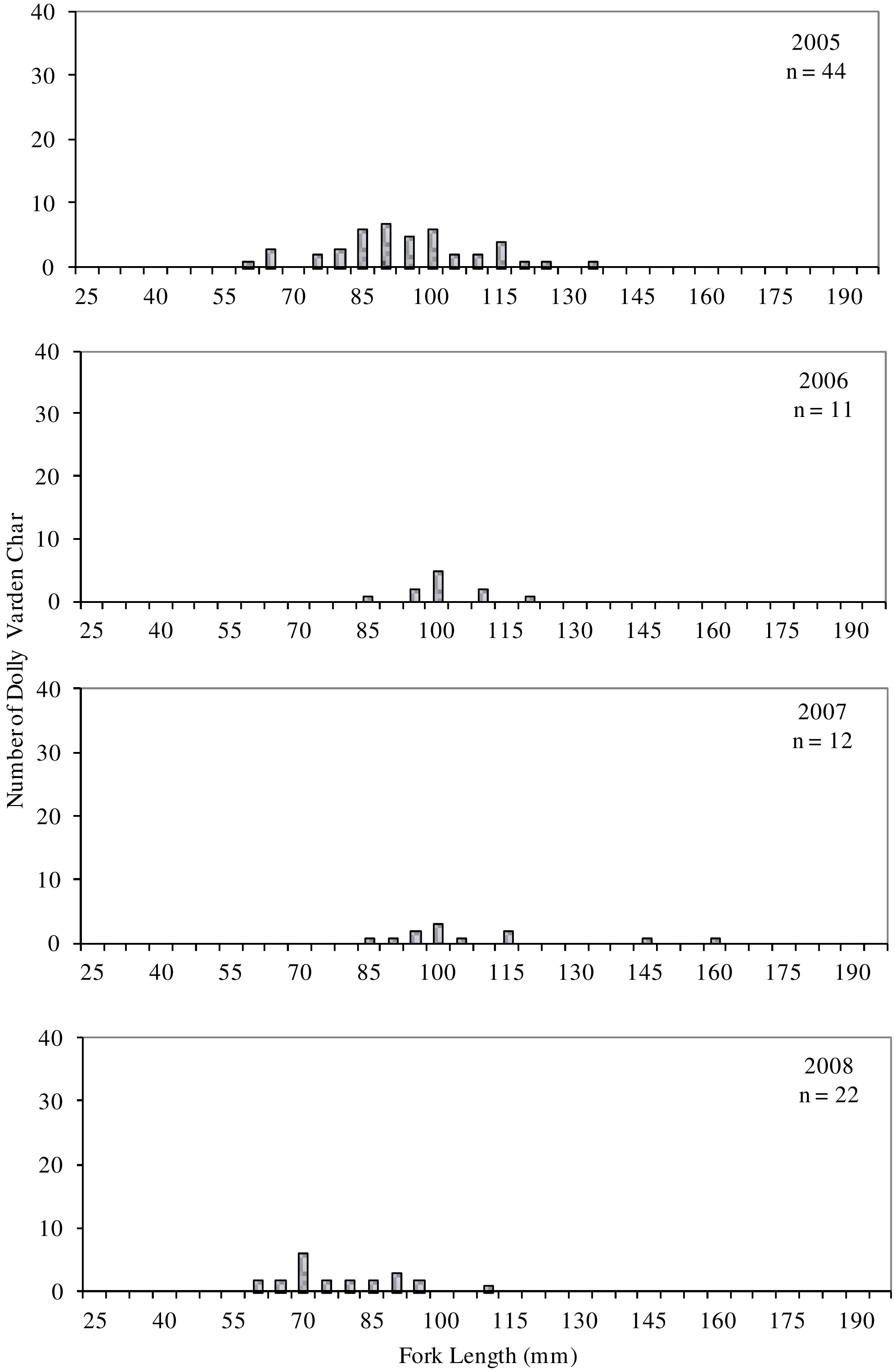
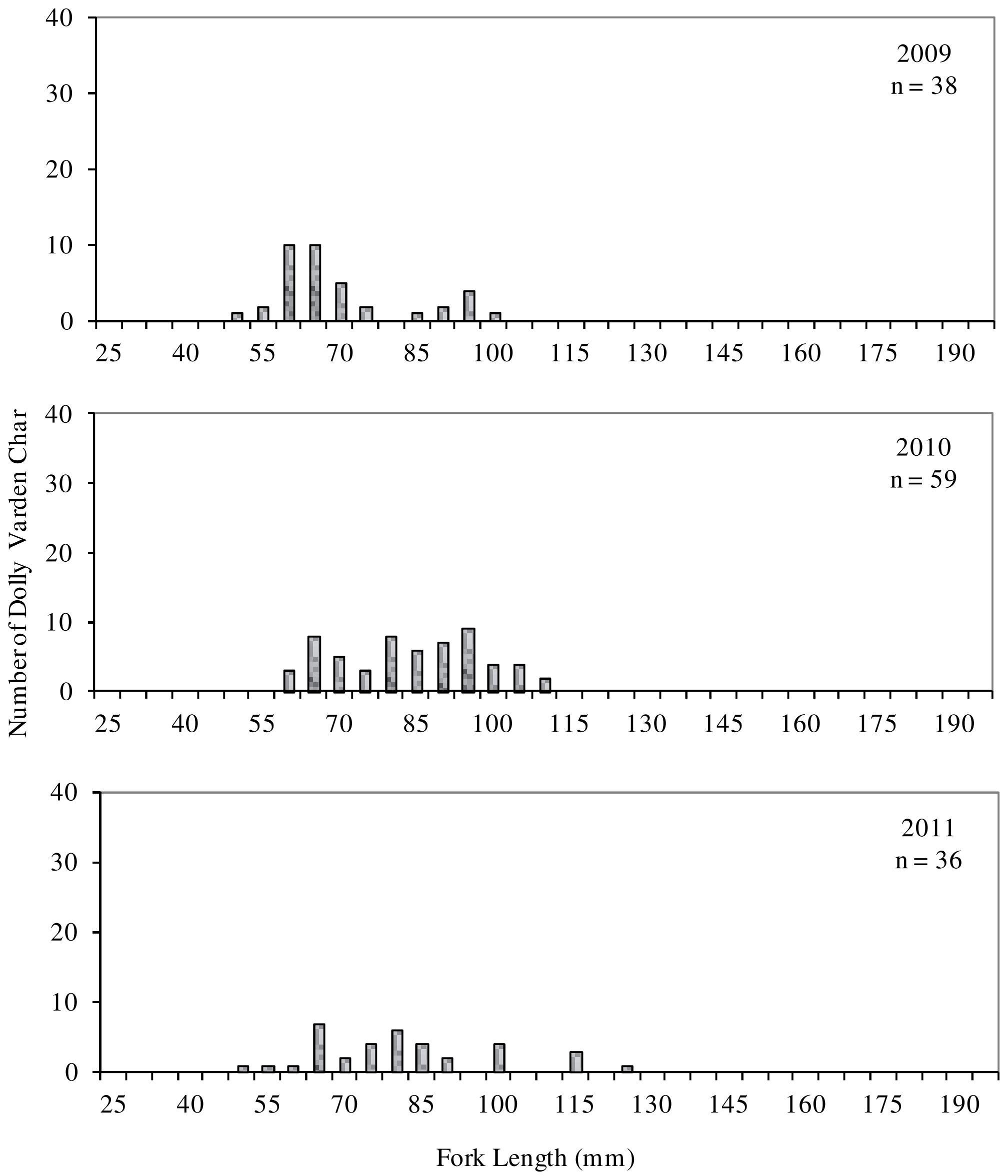
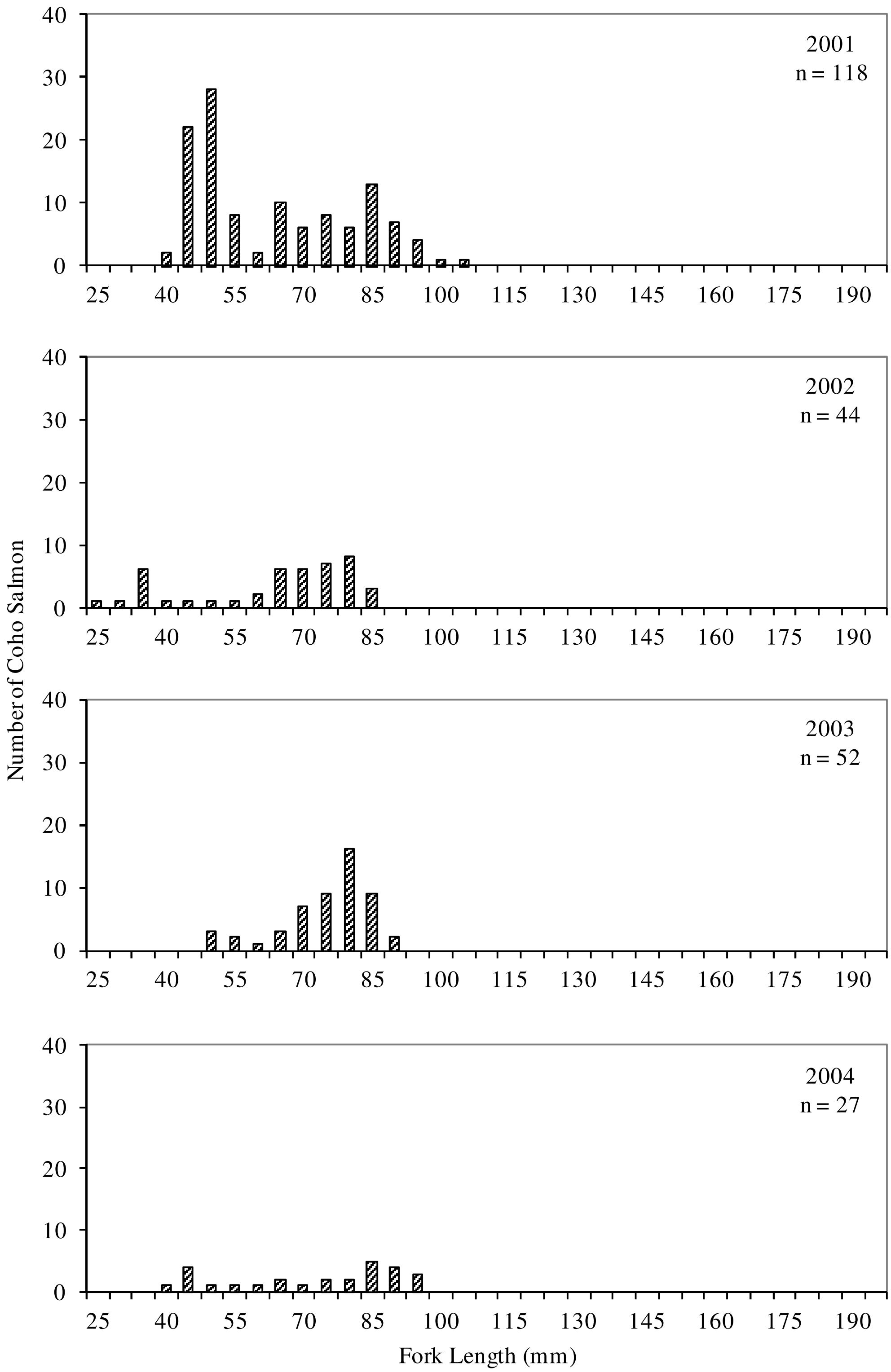

2005
n = 44
2006
n = 11
2007
n = 12
2008
n = 22
Number of Dolly Varden Char
Fork Length (mm)
0
10
20
30
40
25
40
55
70
85
100
115
130
145
160
175
190

-continued-

Appendix D 7. Page 3 of 3.



Appendix D 8.–Length frequency plots for coho salmon captured at Site 9, 2001–2010.

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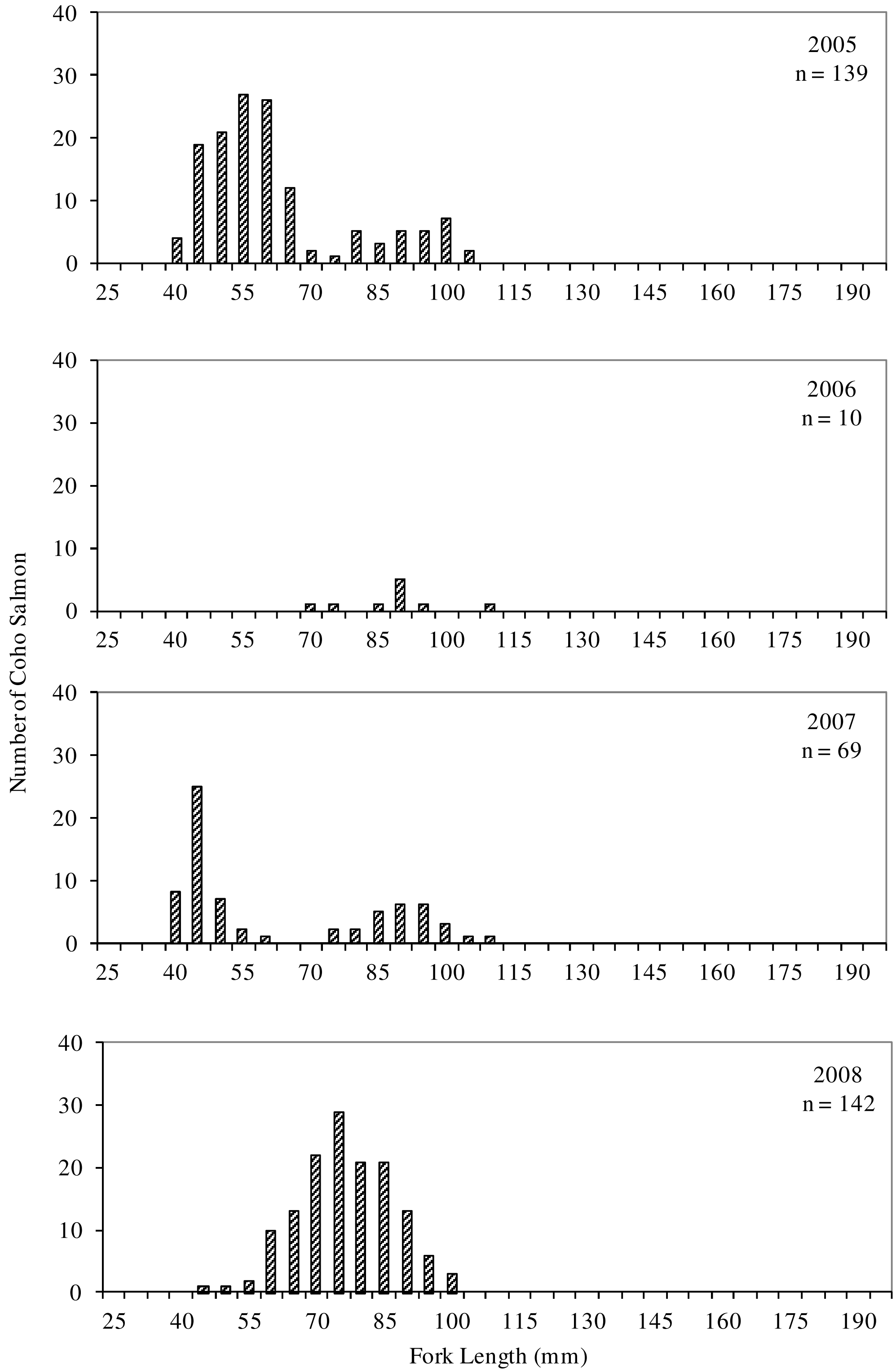
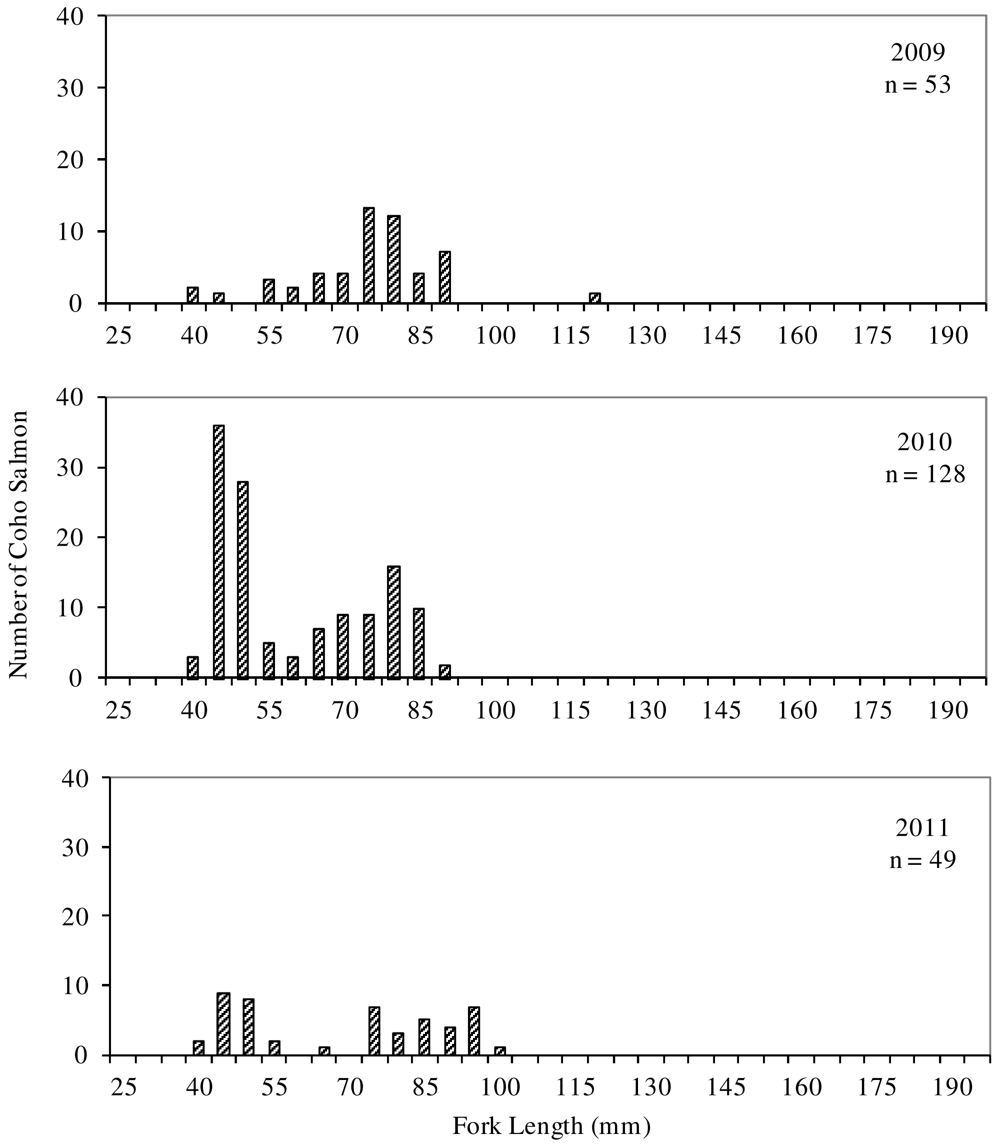
Appendix D 8. Page 2 of 3.



Appendix D 8. Page 3 of 3.



# APPENDIX E: JUVENILE FISH METALS CONCENTRATIONS DATA AND LABORATORY REPORT

Appendix E 1.–Metals concentrations data for juvenile fish collected at Greens Creek Site 48, 2001–2011.

| Date Collected | Sample Site | FL (mm) | Mass (g) | Solids (%) | Ag (mg/Kg) | Cd (mg/Kg) | Cu (mg/Kg) | Pb (mg/Kg) | Se (mg/Kg) | Zn (mg/Kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Minimum Detection Limit | | | 0.02 | 0.02 | 0.10 | 0.02 | 1.00 | 0.50 |
| 7/23/01 | Greens Creek Site 48 | 131 | 26.0 | 21.6 | 0.02 | 1.76 | 8.3 | 0.20 | 6.1 | 180 |
| 7/23/01 | Greens Creek Site 48 | 137 | 28.8 | 23.7 | 0.03 | 0.89 | 7.2 | 0.17 | 4.6 | 146 |
| 7/23/01 | Greens Creek Site 48 | 119 | 18.8 | 20.7 | 0.02 | 2.27 | 5.7 | 0.20 | 6.2 | 189 |
| 7/23/01 | Greens Creek Site 48 | 121 | 21.1 | 22.8 | 0.02 | 1.56 | 6.9 | 0.17 | 5.2 | 182 |
| 7/23/01 | Greens Creek Site 48 | 111 | 13.7 | 21.8 | 0.03 | 0.89 | 4.7 | 0.23 | 5.4 | 138 |
| 7/23/01 | Greens Creek Site 48 | 121 | 21.1 | 20.3 | <0.02 | 1.26 | 7.4 | 0.10 | 5.6 | 157 |
| 7/24/02 | Greens Creek Site 48 | 133 | 23.2 | 24.3 | 0.03 | 1.64 | 6.8 | 0.72 | 4.8 | 239 |
| 7/24/02 | Greens Creek Site 48 | 120 | 15.0 | 19.2 | 0.07 | 0.85 | 7.0 | 0.28 | 4.1 | 210 |
| 7/24/02 | Greens Creek Site 48 | 122 | 17.5 | 22.1 | 0.03 | 0.74 | 4.3 | 0.17 | 4.9 | 162 |
| 7/24/02 | Greens Creek Site 48 | 127 | 20.8 | 21.2 | 0.04 | 1.40 | 6.1 | 0.16 | 4.7 | 185 |
| 7/24/02 | Greens Creek Site 48 | 134 | 24.8 | 21.5 | 0.05 | 1.30 | 7.9 | 0.46 | 4.3 | 208 |
| 7/24/02 | Greens Creek Site 48 | 128 | 21.7 | 20.9 | 0.04 | 1.56 | 6.8 | 0.22 | 5.7 | 343 |
| 7/22/03 | Greens Creek Site 48 | 90 | 8.9 | 23.8 | <0.02 | 0.65 | 4.2 | 0.14 | 5.6 | 191 |
| 7/22/03 | Greens Creek Site 48 | 98 | 9.9 | 23.6 | <0.02 | 0.90 | 5.1 | 0.22 | 5.5 | 180 |
| 7/22/03 | Greens Creek Site 48 | 103 | 12.1 | 23.7 | <0.02 | 0.82 | 5.6 | 0.16 | 5.4 | 241 |
| 7/22/03 | Greens Creek Site 48 | 112 | 12.5 | 23.5 | <0.02 | 0.78 | 6.1 | 0.11 | 6.1 | 192 |
| 7/22/03 | Greens Creek Site 48 | 108 | 11.9 | 23.8 | <0.02 | 0.63 | 3.9 | 0.14 | 5.2 | 174 |
| 7/22/03 | Greens Creek Site 48 | 100 | 10.5 | 24.2 | <0.02 | 0.58 | 3.7 | 0.08 | 5.5 | 218 |
| 7/22/04 | Greens Creek Site 48 | 96 | 8.6 | 23.7 | <0.02 | 0.63 | 4.7 | 0.15 | 4.3 | 206 |
| 7/22/04 | Greens Creek Site 48 | 88 | 6.8 | 23.4 | <0.02 | 0.83 | 5.6 | 0.26 | 4.0 | 175 |
| 7/22/04 | Greens Creek Site 48 | 101 | 11.5 | 23.5 | <0.02 | 1.54 | 4.6 | 0.21 | 4.1 | 183 |
| 7/22/04 | Greens Creek Site 48 | 98 | 9.3 | 23.8 | <0.02 | 0.80 | 5.2 | 0.28 | 3.7 | 168 |
| 7/22/04 | Greens Creek Site 48 | 93 | 7.6 | 21.4 | <0.02 | 1.25 | 4.4 | 0.14 | 6.4 | 220 |
| 7/22/04 | Greens Creek Site 48 | 91 | 7.5 | 23.9 | 0.03 | 1.01 | 4.5 | 0.29 | 5.6 | 323 |
| 7/22/05 | Greens Creek Site 48 | 103 | 19.7 | 24.8 | 0.02 | 0.66 | 4.4 | 0.44 | 4.2 | 183 |
| 7/22/05 | Greens Creek Site 48 | 96 | 13.1 | 23.6 | <0.02 | 0.84 | 14.5 | 0.98 | 4.8 | 220 |
| 7/22/05 | Greens Creek Site 48 | 119 | 15.6 | 23.2 | 0.02 | 0.89 | 4.3 | 0.66 | 4.8 | 226 |
| 7/22/05 | Greens Creek Site 48 | 114 | 17.1 | 23.5 | 0.02 | 0.59 | 6.0 | 0.32 | 4.8 | 178 |
| 7/22/05 | Greens Creek Site 48 | 111 | 15.3 | 24.9 | 0.03 | 1.10 | 18.8 | 0.79 | 4.6 | 217 |
| 7/22/05 | Greens Creek Site 48 | 125 | 16.9 | 23.7 | 0.03 | 0.47 | 3.6 | 0.36 | 3.8 | 160 |
| 7/20/06 | Greens Creek Site 48 | 110 | 15.8 | 21.2 | 0.04 | 0.56 | 8.5 | 0.37 | 5.4 | 244 |
| 7/20/06 | Greens Creek Site 48 | 110 | 15.4 | 21.4 | 0.05 | 1.20 | 8.3 | 0.31 | 6.0 | 217 |
| 7/20/06 | Greens Creek Site 48 | 113 | 16.1 | 23.3 | 0.04 | 0.65 | 6.3 | 0.24 | 5.4 | 264 |
| 7/20/06 | Greens Creek Site 48 | 132 | 25.0 | 22.9 | 0.06 | 0.63 | 8.1 | 0.66 | 5.2 | 232 |
| 7/20/06 | Greens Creek Site 48 | 104 | 12.8 | 21.0 | 0.08 | 0.96 | 8.5 | 0.37 | 5.1 | 283 |
| 7/20/06 | Greens Creek Site 48 | 114 | 16.7 | 20.9 | 0.03 | 0.63 | 5.3 | 0.20 | 5.1 | 270 |
| 7/21/07 | Greens Creek Site 48 | 122 | 17.9 | 22.3 | 0.03 | 1.16 | 5.5 | 0.17 | 5.5 | 221 |
| 7/21/07 | Greens Creek Site 48 | 95 | 10.4 | 24.7 | 0.02 | 1.42 | 3.9 | 0.29 | 5.8 | 165 |
| 7/21/07 | Greens Creek Site 48 | 135 | 22.8 | 24.4 | 0.08 | 1.34 | 14.1 | 1.37 | 5.3 | 166 |
| 7/21/07 | Greens Creek Site 48 | 98 | 9.9 | 21.5 | 0.03 | 0.96 | 5.7 | 0.27 | 5.2 | 269 |
| 7/21/07 | Greens Creek Site 48 | 105 | 13.2 | 20.7 | 0.11 | 1.79 | 11.4 | 1.62 | 5.4 | 323 |
| 7/21/07 | Greens Creek Site 48 | 99 | 10.0 | 22.0 | 0.04 | 1.43 | 5.2 | 0.31 | 5.7 | 208 |
| 7/22/08 | Greens Creek Site 48 | 112 | 16.4 | 22.2 | 0.07 | 1.23 | 5.2 | 0.95 | 5.7 | 289 |
| 7/22/08 | Greens Creek Site 48 | 123 | 21.3 | 24.0 | 0.04 | 0.79 | 3.9 | 0.57 | 4.6 | 194 |
| 7/22/08 | Greens Creek Site 48 | 105 | 14.0 | 23.5 | 0.08 | 0.81 | 4.6 | 0.52 | 5.9 | 200 |
| 7/22/08 | Greens Creek Site 48 | 124 | 20.6 | 23.6 | 0.04 | 0.87 | 4.9 | 0.42 | 6.3 | 244 |
| 7/22/08 | Greens Creek Site 48 | 115 | 16.9 | 23.0 | 0.03 | 1.36 | 5.3 | 0.51 | 5.4 | 254 |
| 7/22/08 | Greens Creek Site 48 | 122 | 19.8 | 22.4 | 0.04 | 1.07 | 5.6 | 0.38 | 6.1 | 260 |
| 7/21/09 | Greens Creek Site 48 | 120 | 20.1 | 23.7 | <0.02 | 1.05 | 5.2 | 0.22 | 5.9 | 186 |
| 7/21/09 | Greens Creek Site 48 | 121 | 20.7 | 23.9 | <0.02 | 1.40 | 5.3 | 0.44 | 5.7 | 173 |
| 7/21/09 | Greens Creek Site 48 | 119 | 17.9 | 22.3 | 0.02 | 1.10 | 4.5 | 0.13 | 5.9 | 182 |
| 7/21/09 | Greens Creek Site 48 | 108 | 13.6 | 23.5 | <0.02 | 1.20 | 4.1 | 0.15 | 5.7 | 162 |
| 7/21/09 | Greens Creek Site 48 | 109 | 14.6 | 23.8 | <0.02 | 1.50 | 4.9 | 0.17 | 5.9 | 186 |
| 7/21/09 | Greens Creek Site 48 | 110 | 15.2 | 22.5 | <0.02 | 0.84 | 3.8 | 0.18 | 6.1 | 202 |
| 7/21/10 | Greens Creek Site 48 | 103 | 11.9 | 24.6 | 0.02 | 1.56 | 4.8 | 0.16 | 5.0 | 226 |
| 7/21/10 | Greens Creek Site 48 | 109 | 16.1 | 23.0 | <0.02 | 0.51 | 3.0 | 0.20 | 5.6 | 168 |
| 7/21/10 | Greens Creek Site 48 | 108 | 13.9 | 22.8 | 0.04 | 0.91 | 4.2 | 0.30 | 5.0 | 180 |
| 7/21/10 | Greens Creek Site 48 | 105 | 13.8 | 23.7 | <0.02 | 0.98 | 3.4 | 0.09 | 4.6 | 163 |
| 7/21/10 | Greens Creek Site 48 | 98 | 10.8 | 22.7 | 0.06 | 0.90 | 4.8 | 0.46 | 4.8 | 213 |
| 7/21/10 | Greens Creek Site 48 | 93 | 9.1 | 23.7 | <0.02 | 0.96 | 3.6 | 0.09 | 4.0 | 156 |
| 7/22/11 | Greens Creek Site 48 | 88-112 | n/a | 23.3 | 0.03 | 1.14 | 5.7 | 0.30 | 6.1 | 218 |

Appendix E 2.–Metals concentrations data for juvenile fish collected at Greens Creek Site 6, 2001–2011.

| Date Collected | Sample Site | FL (mm) | Mass (g) | Solids (%) | Ag (mg/kg) | Cd (mg/kg) | Cu (mg/kg) | Pb (mg/kg) | Se (mg/kg) | Zn (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Minimum Detection Limit | | | 0.02 | 0.02 | 0.10 | 0.02 | 1.00 | 0.50 |
| 7/23/01 | Greens Creek Site 6 | 139 | 28.4 | 20.8 | 0.04 | 1.94 | 16.7 | 1.24 | 5.0 | 173 |
| 7/23/01 | Greens Creek Site 6 | 140 | 30.5 | 22.8 | 0.03 | 0.84 | 4.6 | 1.00 | 4.5 | 167 |
| 7/23/01 | Greens Creek Site 6 | 167 | 43.9 | 21.7 | 0.03 | 0.82 | 5.3 | 1.94 | 4.3 | 171 |
| 7/23/01 | Greens Creek Site 6 | 155 | 34.8 | 21.6 | 0.03 | 1.52 | 5.4 | 1.78 | 4.5 | 215 |
| 7/23/01 | Greens Creek Site 6 | 109 | 15.7 | 22.2 | 0.02 | 0.89 | 11.1 | 0.33 | 5.3 | 126 |
| 7/23/01 | Greens Creek Site 6 | 168 | 49.1 | 21.9 | 0.04 | 0.73 | 8.0 | 1.96 | 4.6 | 169 |
| 7/21/06 | Greens Creek Site 6 | 103 | 12.6 | 21.7 | 0.03 | 0.71 | 8.0 | 0.70 | 5.2 | 183 |
| 7/21/06 | Greens Creek Site 6 | 106 | 13.5 | 21.3 | 0.04 | 0.81 | 12.0 | 0.62 | 5.6 | 271 |
| 7/21/06 | Greens Creek Site 6 | 96 | 11.8 | 21.0 | 0.03 | 0.56 | 12.7 | 0.97 | 4.5 | 215 |
| 7/21/06 | Greens Creek Site 6 | 110 | 12.0 | 20.6 | 0.03 | 0.56 | 7.7 | 0.92 | 5.9 | 223 |
| 7/21/06 | Greens Creek Site 6 | 128 | 23.2 | 22.0 | 0.03 | 0.95 | 5.4 | 1.31 | 4.4 | 221 |
| 7/21/06 | Greens Creek Site 6 | 102 | 11.5 | 20.1 | 0.02 | 0.63 | 6.5 | 0.86 | 4.5 | 302 |
| 7/21/11 | Greens Creek Site 6 | 85-120 | n/a | 24.3 | 0.03 | 0.92 | 6.6 | 0.82 | 5.7 | 209 |

Appendix E 3.–Metals concentrations data for juvenile fish collected at Greens Creek Site 54, 2001–2011.

| Date Collected | Sample Site | FL (mm) | Mass (g) | Solids (%) | Ag (mg/kg) | Cd (mg/kg) | Cu (mg/kg) | Pb (mg/kg) | Se (mg/kg) | Zn (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Minimum Detection Limit | | | 0.02 | 0.02 | 0.10 | 0.02 | 1.00 | 0.50 |
| 7/23/01 | Greens Creek Site 54 | 121 | 21.5 | 22.6 | 0.03 | 0.46 | 4.3 | 0.33 | 5.7 | 126 |
| 7/23/01 | Greens Creek Site 54 | 119 | 19.3 | 26.1 | 0.02 | 0.21 | 3.2 | 0.22 | 3.6 | 82 |
| 7/23/01 | Greens Creek Site 54 | 107 | 15.7 | 23.5 | 0.03 | 0.73 | 6.3 | 0.59 | 4.7 | 144 |
| 7/23/01 | Greens Creek Site 54 | 109 | 13.6 | 21.1 | 0.02 | 0.82 | 5.4 | 0.86 | 4.9 | 172 |
| 7/23/01 | Greens Creek Site 54 | 105 | 13.5 | 22.8 | <0.02 | 0.79 | 6.5 | 0.45 | 5.8 | 203 |
| 7/23/01 | Greens Creek Site 54 | 138 | 27.5 | 22.1 | <0.02 | 0.74 | 5.8 | 0.40 | 5.4 | 171 |
| 7/24/02 | Greens Creek Site 54 | 118 | 18.0 | 21.2 | 0.03 | 0.50 | 4.4 | 0.94 | 3.4 | 363 |
| 7/24/02 | Greens Creek Site 54 | 128 | 22.3 | 23.2 | 0.03 | 0.52 | 4.5 | 0.35 | 4.7 | 150 |
| 7/24/02 | Greens Creek Site 54 | 115 | 17.7 | 21.9 | 0.05 | 0.95 | 6.0 | 0.66 | 4.4 | 161 |
| 7/24/02 | Greens Creek Site 54 | 115 | 18.9 | 21.3 | 0.03 | 1.03 | 5.2 | 0.66 | 4.2 | 216 |
| 7/24/02 | Greens Creek Site 54 | 124 | 21.1 | 21.4 | 0.05 | 1.32 | 5.2 | 0.74 | 3.9 | 194 |
| 7/24/02 | Greens Creek Site 54 | 123 | 20.9 | 20.9 | 0.02 | 0.70 | 3.9 | 0.78 | 4.4 | 195 |
| 7/22/03 | Greens Creek Site 54 | 123 | 21.1 | 25.1 | 0.03 | 0.85 | 6.4 | 1.40 | 6.1 | 188 |
| 7/22/03 | Greens Creek Site 54 | 101 | 10.6 | 22.9 | <0.02 | 0.67 | 4.2 | 0.32 | 6.4 | 174 |
| 7/22/03 | Greens Creek Site 54 | 88 | 9.2 | 22.8 | <0.02 | 0.75 | 4.3 | 0.35 | 6.5 | 186 |
| 7/22/03 | Greens Creek Site 54 | 109 | 14.8 | 24.0 | <0.02 | 1.11 | 5.8 | 0.38 | 5.7 | 188 |
| 7/22/03 | Greens Creek Site 54 | 95 | 10.6 | 23.9 | <0.02 | 0.59 | 3.5 | 0.29 | 5.7 | 174 |
| 7/22/03 | Greens Creek Site 54 | 92 | 9.7 | 23.8 | <0.02 | 0.91 | 4.1 | 0.43 | 6.5 | 263 |
| 7/21/04 | Greens Creek Site 54 | 103 | 9.9 | 23.8 | 0.02 | 0.79 | 11.0 | 0.57 | 4.6 | 232 |
| 7/21/04 | Greens Creek Site 54 | 104 | 10.0 | 22.6 | <0.02 | 0.88 | 5.5 | 0.54 | 5.0 | 206 |
| 7/21/04 | Greens Creek Site 54 | 86 | 6.6 | 23.7 | <0.02 | 1.26 | 5.1 | 0.36 | 5.3 | 164 |
| 7/21/04 | Greens Creek Site 54 | 96 | 9.3 | 22.9 | 0.03 | 0.79 | 5.9 | 0.28 | 5.4 | 191 |
| 7/21/04 | Greens Creek Site 54 | 93 | 9.9 | 22.1 | <0.02 | 0.83 | 5.0 | 0.48 | 3.9 | 202 |
| 7/21/04 | Greens Creek Site 54 | 104 | 12.9 | 21.4 | 0.07 | 1.12 | 7.0 | 0.93 | 4.9 | 216 |
| 7/22/05 | Greens Creek Site 54 | 120 | 12.3 | 23.1 | 0.03 | 0.72 | 5.0 | 0.27 | 4.0 | 160 |
| 7/22/05 | Greens Creek Site 54 | 106 | 12.1 | 22.6 | 0.02 | 0.63 | 4.5 | 0.13 | 3.9 | 200 |
| 7/22/05 | Greens Creek Site 54 | 113 | 20.8 | 23.1 | <0.02 | 0.73 | 8.8 | 0.17 | 4.7 | 223 |
| 7/22/05 | Greens Creek Site 54 | 114 | 17.9 | 22.3 | <0.02 | 0.82 | 9.7 | 0.17 | 3.9 | 222 |
| 7/22/05 | Greens Creek Site 54 | 112 | 16.1 | 23.0 | 0.03 | 1.06 | 8.8 | 0.22 | 4.4 | 209 |
| 7/22/05 | Greens Creek Site 54 | 118 | 22.3 | 22.4 | 0.02 | 0.55 | 5.5 | 0.39 | 3.9 | 185 |
| 7/20/06 | Greens Creek Site 54 | 137 | 27.3 | 24.6 | 0.06 | 0.42 | 4.8 | 0.50 | 5.7 | 208 |
| 7/20/06 | Greens Creek Site 54 | 112 | 14.9 | 21.7 | 0.04 | 0.75 | 16.0 | 0.95 | 7.2 | 223 |
| 7/20/06 | Greens Creek Site 54 | 102 | 12.0 | 19.2 | 0.02 | 0.93 | 22.2 | 0.52 | 6.3 | 239 |
| 7/20/06 | Greens Creek Site 54 | 114 | 19.6 | 21.8 | 0.04 | 1.03 | 7.6 | 0.85 | 5.3 | 252 |
| 7/20/06 | Greens Creek Site 54 | 98 | 12.3 | 20.8 | 0.08 | 0.54 | 10.9 | 0.48 | 5.4 | 223 |
| 7/20/06 | Greens Creek Site 54 | 115 | 16.9 | 21.7 | 0.04 | 0.78 | 8.6 | 0.68 | 5.6 | 257 |
| 7/20/07 | Greens Creek Site 54 | 102 | 11.8 | 24.3 | 0.04 | 0.88 | 5.3 | 0.54 | 5.6 | 157 |
| 7/20/07 | Greens Creek Site 54 | 125 | 21.1 | 21.6 | 0.03 | 0.97 | 5.2 | 0.83 | 7.5 | 234 |
| 7/20/07 | Greens Creek Site 54 | 97 | 10.7 | 22.3 | 0.06 | 0.81 | 5.7 | 0.89 | 8.6 | 185 |
| 7/20/07 | Greens Creek Site 54 | 123 | 19.7 | 22.8 | 0.02 | 0.75 | 4.4 | 0.50 | 7.1 | 175 |
| 7/20/07 | Greens Creek Site 54 | 104 | 12.5 | 22.6 | 0.03 | 0.92 | 5.6 | 0.57 | 7.8 | 174 |
| 7/20/07 | Greens Creek Site 54 | 110 | 15.1 | 21.6 | 0.04 | 1.38 | 6.2 | 0.82 | 5.4 | 191 |
| 7/22/08 | Greens Creek Site 54 | 123 | 21.9 | 24.9 | 0.04 | 0.66 | 5.3 | 0.26 | 5.5 | 185 |
| 7/22/08 | Greens Creek Site 54 | 94 | 10.8 | 22.4 | 0.04 | 1.04 | 5.1 | 0.28 | 6.1 | 203 |
| 7/22/08 | Greens Creek Site 54 | 123 | 21.5 | 21.6 | 0.03 | 1.53 | 4.9 | 3.46 | 6.3 | 261 |
| 7/22/08 | Greens Creek Site 54 | 97 | 11.2 | 23.8 | 0.03 | 1.34 | 5.0 | 0.17 | 5.9 | 199 |
| 7/22/08 | Greens Creek Site 54 | 108 | 16.0 | 23.6 | 0.05 | 1.98 | 6.3 | 0.23 | 6.0 | 220 |
| 7/22/08 | Greens Creek Site 54 | 108 | 14.2 | 24.5 | 0.06 | 1.07 | 8.4 | 1.31 | 5.0 | 195 |
| 7/21/09 | Greens Creek Site 54 | 132 | 26.9 | 22.6 | 0.04 | 1.10 | 4.8 | 0.33 | 5.4 | 213 |
| 7/21/09 | Greens Creek Site 54 | 141 | 32.3 | 23.5 | 0.02 | 0.71 | 4.5 | 0.45 | 7.9 | 143 |
| 7/21/09 | Greens Creek Site 54 | 116 | 17.9 | 24.3 | <0.02 | 0.99 | 4.2 | 0.40 | 6.3 | 153 |
| 7/21/09 | Greens Creek Site 54 | 117 | 17.7 | 23.6 | 0.03 | 1.00 | 5.9 | 0.39 | 6.8 | 200 |
| 7/21/09 | Greens Creek Site 54 | 119 | 22.1 | 24.8 | <0.02 | 1.20 | 4.0 | 0.28 | 6.5 | 176 |
| 7/21/09 | Greens Creek Site 54 | 103 | 13.0 | 24.2 | 0.02 | 2.20 | 5.3 | 0.35 | 5.9 | 226 |
| 7/20/10 | Greens Creek Site 54 | 115 | 16.0 | 24.0 | <0.02 | 0.81 | 3.4 | 0.30 | 4.7 | 161 |
| 7/20/10 | Greens Creek Site 54 | 112 | 12.8 | 24.2 | 0.02 | 0.67 | 3.1 | 0.34 | 3.7 | 154 |
| 7/20/10 | Greens Creek Site 54 | 118 | 12.6 | 24.7 | <0.02 | 0.98 | 3.6 | 0.25 | 5.2 | 190 |
| 7/20/10 | Greens Creek Site 54 | 108 | 10.6 | 24.3 | <0.02 | 1.31 | 3.8 | 0.16 | 4.1 | 212 |
| 7/20/10 | Greens Creek Site 54 | 115 | 12.3 | 24.0 | <0.02 | 1.73 | 5.0 | 0.36 | 4.4 | 222 |
| 7/20/10 | Greens Creek Site 54 | 94 | 9.0 | 22.3 | 0.03 | 0.77 | 4.0 | 0.31 | 4.8 | 199 |
| 7/21/11 | Greens Creek Site 54 | 95-117 | n/a | 23.5 | <0.02 | 0.95 | 4.5 | 0.32 | 5.6 | 191 |

Appendix E 4.–Metals concentrations data for juvenile fish collected at Tributary Creek Site 9, 2001–2011.

| Date Collected | Sample Site | FL (mm) | Mass (g) | Solids (%) | Ag (mg/kg) | Cd (mg/kg) | Cu (mg/kg) | Pb (mg/kg) | Se (mg/kg) | Zn (mg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Minimum Detection Limit | | | 0.02 | 0.02 | 0.10 | 0.02 | 1.00 | 0.50 |
| 7/21/01 | Tributary Creek Site 9 | 97 | 9.1 | 22.1 | 0.09 | 0.35 | 4.3 | 0.56 | 6.8 | 127 |
| 7/21/01 | Tributary Creek Site 9 | 97 | 9.7 | 21.3 | 0.10 | 0.77 | 5.2 | 0.67 | 8.0 | 118 |
| 7/21/01 | Tributary Creek Site 9 | 97 | 9.5 | 22.2 | 0.15 | 0.92 | 5.4 | 4.88 | 5.3 | 144 |
| 7/21/01 | Tributary Creek Site 9 | 98 | 10.4 | 22.6 | 0.15 | 0.86 | 6.7 | 2.19 | - | 99 |
| 7/21/01 | Tributary Creek Site 9 | 86 | 6.4 | 22.2 | 0.08 | 0.76 | 4.9 | 0.33 | 6.2 | 106 |
| 7/21/01 | Tributary Creek Site 9 | 93 | 7.8 | 20.6 | 0.06 | 0.37 | 12.0 | 0.38 | 6.8 | 122 |
| 7/24/02 | Tributary Creek Site 9 | 103 | 10.8 | 20.9 | 0.02 | 0.22 | 3.7 | 0.12 | 1.4 | 144 |
| 7/24/02 | Tributary Creek Site 9 | 97 | 10.4 | 22.8 | 0.07 | 1.20 | 5.5 | 1.66 | 3.3 | 172 |
| 7/24/02 | Tributary Creek Site 9 | 100 | 11.2 | 23.2 | 0.13 | 1.06 | 6.1 | 3.40 | 5.0 | 138 |
| 7/24/02 | Tributary Creek Site 9 | 90 | 7.9 | 23.1 | 0.23 | 1.29 | 7.1 | 4.08 | 5.2 | 168 |
| 7/24/02 | Tributary Creek Site 9 | 90 | 9.2 | 23.0 | 0.08 | 1.15 | 5.2 | 1.39 | 6.2 | 150 |
| 7/24/02 | Tributary Creek Site 9 | 100 | 9.3 | 17.8 | 0.04 | 0.84 | 3.2 | 0.33 | 5.4 | 152 |
| 7/23/03 | Tributary Creek Site 9 | 106 | 10.7 | 21.9 | 0.06 | 0.46 | 2.8 | 0.34 | 6.3 | 134 |
| 7/23/03 | Tributary Creek Site 9 | 89 | 6.8 | 22.8 | 0.10 | 1.01 | 4.0 | 0.82 | 6.0 | 131 |
| 7/23/03 | Tributary Creek Site 9 | 112 | 17.4 | 24.3 | 0.16 | 1.35 | 4.4 | 1.85 | 5.7 | 108 |
| 7/23/03 | Tributary Creek Site 9 | 95 | 11.6 | 22.5 | 0.19 | 0.69 | 5.6 | 1.30 | 3.6 | 136 |
| 7/23/03 | Tributary Creek Site 9 | 91 | 9.5 | 22.2 | 0.05 | 0.72 | 4.4 | 0.56 | 4.9 | 131 |
| 7/23/03 | Tributary Creek Site 9 | 84 | 8.4 | 23.2 | 0.12 | 0.76 | 3.9 | 0.78 | 4.7 | 125 |
| 7/21/04 | Tributary Creek Site 9 | 84 | 5.5 | 23.0 | 0.10 | 0.96 | 3.2 | 1.19 | 5.4 | 169 |
| 7/21/04 | Tributary Creek Site 9 | 96 | 8.5 | 23.0 | 0.10 | 1.24 | 3.8 | 0.67 | 5.9 | 138 |
| 7/21/04 | Tributary Creek Site 9 | 105 | 14.1 | 23.3 | 0.10 | 2.02 | 4.0 | 1.75 | 5.7 | 125 |
| 7/21/04 | Tributary Creek Site 9 | 85 | 5.8 | 22.6 | 0.04 | 0.47 | 3.7 | 0.93 | 4.8 | 175 |
| 7/21/04 | Tributary Creek Site 9 | 81 | 6.4 | 24.0 | 0.09 | 2.34 | 4.3 | 1.44 | 8.2 | 140 |
| 7/21/04 | Tributary Creek Site 9 | 86 | 10.4 | 17.6 | 0.11 | 0.83 | 5.5 | 0.97 | 5.8 | 161 |
| 7/23/05 | Tributary Creek Site 9 | 97 | 11.1 | 25.8 | 0.06 | 0.70 | 10.4 | 0.29 | 6.4 | 104 |
| 7/23/05 | Tributary Creek Site 9 | 113 | 16.8 | 26.7 | 0.10 | 0.63 | 4.7 | 0.97 | 6.1 | 122 |
| 7/23/05 | Tributary Creek Site 9 | 115 | 18.8 | 26.2 | 0.07 | 0.52 | 6.3 | 0.53 | 5.8 | 109 |
| 7/23/05 | Tributary Creek Site 9 | 117 | 20.5 | 26.1 | 0.19 | 0.79 | 9.9 | 1.07 | 6.7 | 117 |
| 7/23/05 | Tributary Creek Site 9 | 101 | 11.7 | 27.4 | 0.07 | 1.44 | 5.2 | 1.00 | 8.1 | 130 |
| 7/23/05 | Tributary Creek Site 9 | 107 | 13.7 | 25.9 | 0.10 | 1.29 | 4.6 | 0.46 | 8.0 | 134 |
| 7/21/06 | Tributary Creek Site 9 | 99 | 12.9 | 22.6 | 0.12 | 0.74 | 4.0 | 0.32 | 6.3 | 120 |
| 7/21/06 | Tributary Creek Site 9 | 96 | 11.6 | 24.0 | 0.12 | 0.76 | 7.7 | 1.32 | 6.8 | 157 |
| 7/21/06 | Tributary Creek Site 9 | 94 | 10.9 | 24.5 | 0.18 | 1.59 | 10.3 | 2.48 | 4.9 | 160 |
| 7/21/06 | Tributary Creek Site 9 | 100 | 10.9 | 21.8 | 0.11 | 1.34 | 8.5 | 1.46 | 5.2 | 142 |
| 7/21/06 | Tributary Creek Site 9 | 97 | 11.7 | 23.3 | 0.14 | 0.88 | 4.6 | 0.96 | 5.2 | 107 |
| 7/21/06 | Tributary Creek Site 9 | 117 | 20.8 | 23.7 | 0.24 | 1.29 | 4.3 | 2.92 | 5.9 | 129 |
| 7/20/07 | Tributary Creek Site 9 | 98 | 12.4 | 26.4 | 0.11 | 0.91 | 2.7 | 1.10 | 7.7 | 106 |
| 7/20/07 | Tributary Creek Site 9 | 89 | 8.9 | 25.8 | 0.12 | 1.72 | 3.3 | 1.80 | 5.6 | 136 |
| 7/20/07 | Tributary Creek Site 9 | 114 | 14.1 | 25.5 | 0.15 | 2.76 | 3.4 | 1.28 | 8.7 | 122 |
| 7/20/07 | Tributary Creek Site 9 | 81 | 7.1 | 26.8 | 0.14 | 1.90 | 4.2 | 2.03 | 7.0 | 114 |
| 7/20/07 | Tributary Creek Site 9 | 114 | 14.6 | 27.5 | 0.88 | 3.63 | 3.9 | 1.56 | 10.9 | 131 |
| 7/20/07 | Tributary Creek Site 9 | 93 | 10.6 | 26.8 | 0.14 | 1.50 | 20.3 | 3.80 | 9.4 | 107 |
| 7/23/08 | Tributary Creek Site 9 | 103 | 12.9 | 24.3 | 0.22 | 1.99 | 4.2 | 3.47 | 7.7 | 169 |
| 7/23/08 | Tributary Creek Site 9 | 108 | 14.8 | 23.0 | 0.10 | 0.96 | 3.2 | 0.86 | 5.8 | 143 |
| 7/23/08 | Tributary Creek Site 9 | 88 | 8.9 | 23.0 | 0.08 | 0.93 | 3.3 | 0.75 | 4.4 | 186 |
| 7/23/08 | Tributary Creek Site 9 | 86 | 9.3 | 26.6 | 0.22 | 1.91 | 5.7 | 4.06 | 5.7 | 119 |
| 7/23/08 | Tributary Creek Site 9 | 92 | 9.6 | 24.7 | 0.07 | 1.01 | 2.7 | 0.61 | 5.2 | 125 |
| 7/23/08 | Tributary Creek Site 9 | 90 | 8.7 | 25.4 | 0.03 | 0.54 | 2.2 | 0.43 | 4.8 | 108 |
| 7/22/09 | Tributary Creek Site 9 | 83 | 6.9 | 23.0 | 0.04 | 0.29 | 1.7 | 0.24 | 5.4 | 127 |
| 7/22/09 | Tributary Creek Site 9 | 91 | 8.6 | 22.1 | 0.06 | 0.55 | 2.1 | 0.16 | 5.1 | 137 |
| 7/22/09 | Tributary Creek Site 9 | 91 | 8.5 | 22.6 | 0.11 | 0.36 | 2.0 | 0.23 | 7.5 | 138 |
| 7/22/09 | Tributary Creek Site 9 | 98 | 10.3 | 22.6 | 0.09 | 0.81 | 3.4 | 0.38 | 5.8 | 147 |
| 7/22/09 | Tributary Creek Site 9 | 91 | 8.6 | 23.1 | 0.03 | 0.47 | 2.2 | 0.40 | 4.5 | 125 |
| 7/22/09 | Tributary Creek Site 9 | 90 | 7.8 | 22.8 | 0.06 | 0.60 | 2.2 | 0.38 | 5.6 | 129 |
| 7/20/10 | Tributary Creek Site 9 | 87 | 7.4 | 23.0 | 0.29 | 1.61 | 5.4 | 3.92 | 6.4 | 151 |
| 7/20/10 | Tributary Creek Site 9 | 94 | 10.9 | 21.2 | 0.12 | 0.82 | 2.5 | 0.24 | 5.7 | 174 |
| 7/20/10 | Tributary Creek Site 9 | 90 | 8.5 | 22.4 | 0.08 | 0.73 | 2.9 | 0.29 | 5.3 | 125 |
| 7/20/10 | Tributary Creek Site 9 | 90 | 8.2 | 21.4 | 0.06 | 0.60 | 2.3 | 0.33 | 4.7 | 151 |
| 7/20/10 | Tributary Creek Site 9 | 108 | 13.5 | 21.7 | 0.08 | 0.66 | 2.6 | 0.25 | 3.2 | 118 |
| 7/20/10 | Tributary Creek Site 9 | 105 | 11.6 | 23.3 | 0.08 | 0.75 | 3.1 | 0.23 | 3.9 | 150 |
| 7/21/11 | Tributary Creek Site 9 | 85-115 | n/a | 22.6 | 0.09 | 0.80 | 3.4 | 0.32 | 6.7 | 146 |

Columbia Analytical Services INC

1317 S. 13th Avenue, Kelso, WA 98626 360.577.7222 360.636.1068 (fax) www.caslab.com

December 9, 2011

Analytical Report for Service Request No: K1110962

Gordon Willson-Naranjo
Alaska Department of Fish and Game
Division of Habitat
P.O. Box 110024
Juneau, AK 99811

**RE: Greens Creek Mine Fish Analysis**

Dear Gordon:

Enclosed are the results of the samples submitted to our laboratory on November 09, 2011. For your reference, these analyses have been assigned our service request number K1110962.

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. The test results meet requirements of the current NELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP-accredited analytes, refer to the certifications section at www.caslab.com. All results are intended to be considered in their entirety, and Columbia Analytical Services, Inc. (CAS) is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

Please call if you have any questions. My extension is 3364. You may also contact me via Email at HHolmes@caslab.com.

Respectfully submitted,

**Columbia Analytical Services, Inc.**

Howard Holmes
Project Chemist

HH/ln

## Acronyms

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| A2LA | American Association for Laboratory Accreditation |
| CARB | California Air Resources Board |
| CAS Number | Chemical Abstract Service registry Number |
| CFC | Chlorofluorocarbon |
| CFU | Colony-Forming Unit |
| DEC | Department of Environmental Conservation |
| DEQ | Department of Environmental Quality |
| DHS | Department of Health Services |
| DOE | Department of Ecology |
| DOH | Department of Health |
| EPA | U. S. Environmental Protection Agency |
| ELAP | Environmental Laboratory Accreditation Program |
| GC | Gas Chromatography |
| GC/MS | Gas Chromatography/Mass Spectrometry |
| LOD | Limit of Detection |
| LOQ | Limit of Quantitation |
| LUFT | Leaking Underground Fuel Tank |
| M | Modified |
| MCL | Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA. |
| MDL | Method Detection Limit |
| MPN | Most Probable Number |
| MRL | Method Reporting Limit |
| NA | Not Applicable |
| NC | Not Calculated |
| NCASI | National Council of the Paper Industry for Air and Stream Improvement |
| ND | Not Detected |
| NIOSH | National Institute for Occupational Safety and Health |
| PQL | Practical Quantitation Limit |
| RCRA | Resource Conservation and Recovery Act |
| SIM | Selected Ion Monitoring |
| TPH | Total Petroleum Hydrocarbons |
| tr | Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL. |

## Inorganic Data Qualifiers

- * The result is an outlier. See case narrative.
- # The control limit criteria is not applicable. See case narrative.
- B The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
- E The result is an estimate amount because the value exceeded the instrument calibration range.
- J The result is an estimated value.
- U The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.1 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
- i The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
- X See case narrative.
- Q See case narrative. One or more quality control criteria was outside the limits.
- H The holding time for this test is immediately following sample collection. The samples were analyzed as soon as possible after receipt by the laboratory.

## Metals Data Qualifiers

- # The control limit criteria is not applicable. See case narrative.
- J The result is an estimated value.
- E The percent difference for the serial dilution was greater than 10%, indicating a possible matrix interference in the sample.
- M The duplicate injection precision was not met.
- N The Matrix Spike sample recovery is not within control limits. See case narrative.
- S The reported value was determined by the Method of Standard Additions (MSA).
- U The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.1 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
- W The post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50% of spike absorbance.
- i The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
- X See case narrative.
- \+ The correlation coefficient for the MSA is less than 0.995.
- Q See case narrative. One or more quality control criteria was outside the limits.

## Organic Data Qualifiers

- * The result is an outlier. See case narrative.
- # The control limit criteria is not applicable. See case narrative.
- A A tentatively identified compound, a suspected aldol-condensation product.
- B The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
- C The analyte was qualitatively confirmed using GC/MS techniques, pattern recognition, or by comparing to historical data.
- D The reported result is from a dilution.
- E The result is an estimated value.
- J The result is an estimated value.
- N The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
- P The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
- U The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.1 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
- i The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
- X See case narrative.
- Q See case narrative. One or more quality control criteria was outside the limits.

## Additional Petroleum Hydrocarbon Specific Qualifiers

- F The chromatographic fingerprint of the sample matches the elution pattern of the calibration standard.
- L The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
- H The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.
- O The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
- Y The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
- Z The chromatographic fingerprint does not resemble a petroleum product.

**Columbia Analytical Services, Inc.**
**Kelso, WA**
**State Certifications, Accreditations, and Licenses**

| Agency | Number |
|---|---|
| Alaska DEC UST | UST-040 |
| Arizona DHS | AZ0339 |
| Arkansas - DEQ | 88-0637 |
| California DHS | 2286 |
| DOD ELAP | L11-119 |
| Florida DOH | E87412 |
| Georgia DNR | 881 |
| Hawaii DOH | - |
| Idaho DHW | - |
| Indiana DOH | C-WA-01 |
| ISO 17025 | L11-118 |
| Louisiana DEQ | 3016 |
| Louisiana DHH | LA080001 |
| Maine DHS | WA0035 |
| Michigan DEQ | 9949 |
| Minnesota DOH | 053-999-368 |
| Montana DPHHS | CERT0047 |
| Nevada DEP | WA35 |
| New Jersey DEP | WA005 |
| New Mexico ED | - |
| North Carolina DWQ | 605 |
| Oklahoma DEQ | 9801 |
| Oregon – DEQ (NELAP) | WA100010 |
| South Carolina DHEC | 61002 |
| Texas CEQ | 04704427-08-TX |
| Washington DOE | C1203 |
| Wisconsin DNR | 998386840 |
| Wyoming (EPA Region 8) | - |

MEMBER ACIL

nelac

## COLUMBIA ANALYTICAL SERVICES, INC.

| | | | |
|---|---|---|---|
| **Client:** | Alaska Department of Fish & Game | **Service Request No.:** | K1110962 |
| **Project:** | Greens Creek Mine-Fish Analysis | **Date Received:** | 11/9/11 |
| **Sample Matrix:** | Fish Tissue | | |

## CASE NARRATIVE

All analyses were performed consistent with the quality assurance program of Columbia Analytical Services, Inc. (CAS). This report contains analytical results for samples designated for Tier II data deliverables. When appropriate to the method, method blank results have been reported with each analytical test. Additional quality control analyses reported herein include: Laboratory Duplicate (DUP), Matrix Spike (MS), and Laboratory Control Sample (LCS).

### Sample Receipt

Four fish tissue samples were received for analysis at Columbia Analytical Services on 11/9/11. The samples were received in good condition and consistent with the accompanying chain of custody form. The samples were stored frozen at -20C upon receipt at the laboratory.

### Total Metals

**Matrix Spike Recovery Exceptions:**
The control criteria for matrix spike recovery of Zinc for sample GCM Greens cr. Site 48 were not applicable. The analyzed concentration in the sample was significantly higher than the added spike concentration, preventing accurate evaluation of the spike recovery.

**Laboratory Control Sample Exceptions:**
The recovery of Lead in the Standard Reference Material (SRM) N.R.C.C. Dorm-3 was outside the normal CAS/Kelso control limits. The reported value was not atypical compared to historic result for this particular reference material. The associated QA/QC results (e.g. SRM N.R.C.C. Tort-2, blank spike, matrix spike, method blank, calibration standards, etc.) indicate the analysis was in control. No further corrective action was appropriate.

No other anomalies associated with the analysis of these samples were observed.

**Approved by** Howard Holmes **Date** 12-9-11

# CHAIN OF CUSTODY

Columbia Analytical Services[inc]
An Employee - Owned Company

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SR#: K1110962

PAGE 1 OF 1 COC # ______

PROJECT NAME: ~~[illegible]~~ Greens Creek mine whole fish analysis
PROJECT NUMBER:
PROJECT MANAGER: Kate Kanouse
COMPANY/ADDRESS: Alaska Department of Fish and Game
802 west 3rd st
CITY/STATE/ZIP: Juneau, AK, 99801
E-MAIL ADDRESS: gordon.willson-naranjo@alaska.gov
PHONE # 907-465-6646 FAX# 907-465-4759
SAMPLER'S SIGNATURE: Benjamin Brewster

| SAMPLE I.D. | DATE | TIME | LAB I.D. | MATRIX | NUMBER OF CONTAINERS | Semivolatile Organics by GC/MS 625 ☐ 8270 ☐ 8270LL ☐ | Volatile Organics 624 ☐ 8260 ☐ 8021 ☐ BTEX ☐ | Hydrocarbons (*see below) Gas ☐ Diesel ☐ Oil ☐ | ☐ Fuel Fingerprint (FIQ) ☐ NW-HCID Screen | Oil & Grease/TRPH 1664 HEM ☐ 1664 SGT ☐ | PCB's Aroclors ☐ Congeners ☐ | Pesticides/Herbicides 608 ☐ 8081A ☐ 8141A ☐ 8151A ☐ | Chlorophenolics - 8151M Tri ☐ Tetra ☐ PCP ☐ | PAHS 8310 ☐ SIM ☐ | Metals, Total or Dissolved (See list below) | Cyanide ☐ Hex-Chrom ☐ | pH, Cond., Cl, $SO_4$, $PO_4$, F, $NO_2$, $NO_3$, BOD, TSS, TDS (circle) | $NH_3$-N, COD, Total-P, TKN, TOC, DOC (circle) $NO_2+NO_3$ | TOX 9020 ☐ AOX 1650 ☐ 506 ☐ | | | | | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GCM trib. cr. site 9 | 7/20/11 | 1200 | | tissue | 1 | | | | | | | | | | X | | | | | | | | | |
| GCM Greens cr. site 54 | 7/21/11 | 0900 | | tissue | 1 | | | | | | | | | | X | | | | | | | | | |
| GCM Greens cr. site 6 | 7/21/11 | 1200 | | tissue | 1 | | | | | | | | | | X | | | | | | | | | |
| GCM Greens cr. site 48 | 7/22/11 | 1200 | | tissue | 1 | | | | | | | | | | X | | | | | | | | | |

**REPORT REQUIREMENTS**

___ I. Routine Report: Method Blank, Surrogate, as required

___ II. Report Dup., MS, MSD as required

___ III. Data Validation Report (includes all raw data)

___ IV. CLP Deliverable Report

___ V. EDD

**INVOICE INFORMATION**

P.O. # ______

Bill To: ______

**TURNAROUND REQUIREMENTS**

___ 24 hr. ___ 48 hr.

___ 5 Day

___ Standard (10-15 working days)

___ Provide FAX Results

______ Requested Report Date

Circle which metals are to be analyzed:

Total Metals: Al As Sb Ba Be B Ca (Cd) Co Cr (Cu) Fe (Pb) Mg Mn Mo Ni K (Ag) Na (Se) Sr Tl Sn V (Zn) Hg

Dissolved Metals: Al As Sb Ba Be B Ca Cd Co Cr Cu Fe Pb Mg Mn Mo Ni K Ag Na Se Sr Tl Sn V Zn Hg

*INDICATE STATE HYDROCARBON PROCEDURE: AK CA WI NORTHWEST OTHER: ______ (CIRCLE ONE)

SPECIAL INSTRUCTIONS/COMMENTS:

| RELINQUISHED BY: | RECEIVED BY: | RELINQUISHED BY: | RECEIVED BY: |
|---|---|---|---|
| Signature: Benjamin Brewster Date/Time: 11/8/11 | Signature: K Smith Date/Time: 11/9/11 0930 | Signature: ______ Date/Time: ______ | Signature: ______ Date/Time: ______ |
| Printed Name: Benjamin Brewster Firm: ADF+G | Printed Name: K Smith Firm: CAS | Printed Name: ______ Firm: ______ | Printed Name: ______ Firm: ______ |

PC 172

# Columbia Analytical Services, Inc.
## Cooler Receipt and Preservation Form

Client / Project: Alaska Dept of Fish & Game Service Request K11 10962

Received: 11/9/11 Opened: 11/9/11 By: KD Unloaded: 11/9/11 By: KD

1. Samples were received via? Mail **(Fed Ex)** UPS DHL PDX Courier Hand Delivered
2. Samples were received in: (circle) **(Cooler)** Box Envelope Other ______ NA
3. Were custody seals on coolers? NA **(Y)** N If yes, how many and where? 1, front

   If present, were custody seals intact? **(Y)** N If present, were they signed and dated? Y **(N)**

| Cooler Temp °C | Temp Blank °C | Thermometer ID | Cooler/COC ID NA | Tracking Number NA | Filed |
|---|---|---|---|---|---|
| .1 | ✓ | 299 | | 8708 4878 6199 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

7. Packing material used. Inserts **(Baggies)** Bubble Wrap Gel Packs **(Wet Ice)** Sleeves Other ______
8. Were custody papers properly filled out (ink, signed, etc.)? NA **(Y)** N
9. Did all bottles arrive in good condition (unbroken)? *Indicate in the table below.* NA **(Y)** N
10. Were all sample labels complete (i.e analysis, preservation, etc.)? NA **(Y)** N
11. Did all sample labels and tags agree with custody papers? *Indicate major discrepancies in the table on page 2.* NA **(Y)** N
12. Were appropriate bottles/containers and volumes received for the tests indicated? NA **(Y)** N
13. Were the pH-preserved bottles (*see SMO GEN SOP*) received at the appropriate pH? *Indicate in the table below* **(NA)** Y N
14. Were VOA vials received without headspace? *Indicate in the table below.* **(NA)** Y N
15. Was C12/Res negative? **(NA)** Y N

| Sample ID on Bottle | Sample ID on COC | Identified by: |
|---|---|---|
| | | |
| | | |
| | | |

| Sample ID | Bottle Count Bottle Type | Out of Temp | Head-space | Broke | pH | Reagent | Volume added | Reagent Lot Number | Initials | Time |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

*Notes, Discrepancies, & Resolutions:* ______

*Page* 1 *of* ____

**COLUMBIA ANALYTICAL SERVICES, INC.**

Analytical Report

| | | | |
|---|---|---|---|
| **Client:** | Alaska Department of Fish and Game | **Service Request:** | K1110962 |
| **Project:** | Greens Creek Mine Fish Analysis | **Date Collected:** | 07/20/11 |
| **Sample Matrix:** | Tissue | **Date Received:** | 11/09/11 |

Solids, Total

| | | | |
|---|---|---|---|
| Prep Method: | NONE | Units: | PERCENT |
| Analysis Method: | Freeze Dry | Basis: | Wet |
| Test Notes: | | | |

| Sample Name | Lab Code | Date Analyzed | Result | Result Notes |
|---|---|---|---|---|
| GCM trib. cr. site 9 | K1110962-001 | 11/10/11 | 22.6 | |
| GCM Greens cr. site 54 | K1110962-002 | 11/10/11 | 23.5 | |
| GCM Greens cr. site 6 | K1110962-003 | 11/10/11 | 24.3 | |
| GCM Greens cr. site 48 | K1110962-004 | 11/10/11 | 23.3 | |

## COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

| | | | |
|---|---|---|---|
| **Client:** | Alaska Department of Fish and Game | **Service Request:** | K1110962 |
| **Project:** | Greens Creek Mine Fish Analysis | **Date Collected:** | 07/22/11 |
| **Sample Matrix:** | Tissue | **Date Received:** | 11/09/11 |
| | | **Date Extracted:** | NA |
| | | **Date Analyzed:** | 11/10/11 |

Duplicate Summary

| | | | |
|---|---|---|---|
| Sample Name: | GCM Greens cr. site 48 | Units: | PERCENT |
| Lab Code: | K1110962-004D | Basis: | Wet |
| Test Notes: | | | |

| Analyte | Prep Method | Analysis Method | Sample Result | Duplicate Sample Result | Average | Relative Percent Difference | Result Notes |
|---|---|---|---|---|---|---|---|
| Solids, Total | NA | Freeze Dry | 23.3 | 23.9 | 23.6 | 3 | |

## Columbia Analytical Services

- Cover Page -
**INORGANIC ANALYSIS DATA PACKAGE**

**Client:** Alaska Department of Fish and Game
**Project Name:** Greens Creek Mine Fish Analysis
**Project No.:**

**Service Request:** K1110962

| Sample Name: | Lab Code: |
|---|---|
| GCM trib. cr. site 9 | K1110962-001 |
| GCM Greens cr. site 54 | K1110962-002 |
| GCM Greens cr. site 6 | K1110962-003 |
| GCM Greens cr. site 48 | K1110962-004 |
| GCM Greens cr. site 48D | K1110962-004D |
| GCM Greens cr. site 48S | K1110962-004S |
| Method Blank | K1110962-MB |

**Comments:**

**Approved By:** 3C **Date:** 12/7/11

## Metals

- 1 -

**INORGANIC ANALYSIS DATA PACKAGE**

**Client:** Alaska Department of Fish and Ga
**Service Request:** K1110962
**Project No.:** NA
**Date Collected:** 07/20/11
**Project Name:** Greens Creek Mine Fish Analysis
**Date Received:** 11/09/11
**Matrix:** TISSUE
**Units:** mg/Kg
**Basis:** DRY

**Sample Name:** GCM trib. cr. site 9 **Lab Code:** K1110962-001

| Analyte | Analysis Method | MRL | Dilution Factor | Date Extracted | Date Analyzed | Result | C | Q |
|---|---|---|---|---|---|---|---|---|
| Cadmium | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 0.80 | | |
| Copper | 6020A | 0.1 | 5.0 | 11/15/11 | 12/01/11 | 3.4 | | |
| Lead | 6020A | 0.02 | 5.0 | 11/15/11 | 12/02/11 | 0.32 | | |
| Selenium | 6020A | 1.0 | 5.0 | 11/15/11 | 12/01/11 | 6.7 | | |
| Silver | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 0.09 | | |
| Zinc | 6020A | 0.5 | 5.0 | 11/15/11 | 12/01/11 | 146 | | |

Comments:

## Metals

- 1 -
**INORGANIC ANALYSIS DATA PACKAGE**

**Client:** Alaska Department of Fish and Ga  **Service Request:** K1110962
**Project No.:** NA  **Date Collected:** 07/21/11
**Project Name:** Greens Creek Mine Fish Analysis  **Date Received:** 11/09/11
**Matrix:** TISSUE  **Units:** mg/Kg
**Basis:** DRY

**Sample Name:** GCM Greens cr. site 54  **Lab Code:** K1110962-002

| Analyte | Analysis Method | MRL | Dilution Factor | Date Extracted | Date Analyzed | Result | C | Q |
|---|---|---|---|---|---|---|---|---|
| Cadmium | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 0.95 | | |
| Copper | 6020A | 0.1 | 5.0 | 11/15/11 | 12/01/11 | 4.5 | | |
| Lead | 6020A | 0.02 | 5.0 | 11/15/11 | 12/02/11 | 0.32 | | |
| Selenium | 6020A | 1.0 | 5.0 | 11/15/11 | 12/01/11 | 5.6 | | |
| Silver | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 0.02 | U | |
| Zinc | 6020A | 0.5 | 5.0 | 11/15/11 | 12/01/11 | 191 | | |

Comments:

# Metals

- 1 -

## INORGANIC ANALYSIS DATA PACKAGE

**Client:** Alaska Department of Fish and Ga
**Service Request:** K1110962
**Project No.:** NA
**Date Collected:** 07/21/11
**Project Name:** Greens Creek Mine Fish Analysis
**Date Received:** 11/09/11
**Matrix:** TISSUE
**Units:** mg/Kg
**Basis:** DRY

**Sample Name:** GCM Greens cr. site 6 **Lab Code:** K1110962-003

| Analyte | Analysis Method | MRL | Dilution Factor | Date Extracted | Date Analyzed | Result | C | Q |
|---|---|---|---|---|---|---|---|---|
| Cadmium | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 0.92 | | |
| Copper | 6020A | 0.1 | 5.0 | 11/15/11 | 12/01/11 | 6.6 | | |
| Lead | 6020A | 0.02 | 5.0 | 11/15/11 | 12/02/11 | 0.82 | | |
| Selenium | 6020A | 1.0 | 5.0 | 11/15/11 | 12/01/11 | 5.7 | | |
| Silver | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 0.03 | | |
| Zinc | 6020A | 0.5 | 5.0 | 11/15/11 | 12/01/11 | 209 | | |

Comments:

# Metals

- 1 -

## INORGANIC ANALYSIS DATA PACKAGE

**Client:** Alaska Department of Fish and Ga
**Service Request:** K1110962
**Project No.:** NA
**Date Collected:** 07/22/11
**Project Name:** Greens Creek Mine Fish Analysis
**Date Received:** 11/09/11
**Matrix:** TISSUE
**Units:** mg/Kg
**Basis:** DRY

**Sample Name:** GCM Greens cr. site 48 **Lab Code:** K1110962-004

| Analyte | Analysis Method | MRL | Dilution Factor | Date Extracted | Date Analyzed | Result | C | Q |
|---|---|---|---|---|---|---|---|---|
| Cadmium | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 1.14 | | |
| Copper | 6020A | 0.1 | 5.0 | 11/15/11 | 12/01/11 | 5.7 | | |
| Lead | 6020A | 0.02 | 5.0 | 11/15/11 | 12/02/11 | 0.30 | | |
| Selenium | 6020A | 1.0 | 5.0 | 11/15/11 | 12/01/11 | 6.1 | | |
| Silver | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 0.03 | | |
| Zinc | 6020A | 0.5 | 5.0 | 11/15/11 | 12/01/11 | 218 | | |

Comments:

# Metals

- 1 -

## INORGANIC ANALYSIS DATA PACKAGE

**Client:** Alaska Department of Fish and Ga

**Project No.:** NA

**Project Name:** Greens Creek Mine Fish Analysis

**Matrix:** TISSUE

**Service Request:** K1110962

**Date Collected:**

**Date Received:**

**Units:** mg/Kg

**Basis:** DRY

**Sample Name:** Method Blank

**Lab Code:** K1110962-MB

| Analyte | Analysis Method | MRL | Dilution Factor | Date Extracted | Date Analyzed | Result | C | Q |
|---|---|---|---|---|---|---|---|---|
| Cadmium | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 0.02 | U | |
| Copper | 6020A | 0.1 | 5.0 | 11/15/11 | 12/01/11 | 0.1 | U | |
| Lead | 6020A | 0.02 | 5.0 | 11/15/11 | 12/02/11 | 0.02 | U | |
| Selenium | 6020A | 1.0 | 5.0 | 11/15/11 | 12/01/11 | 1.0 | U | |
| Silver | 6020A | 0.02 | 5.0 | 11/15/11 | 12/01/11 | 0.02 | U | |
| Zinc | 6020A | 0.5 | 5.0 | 11/15/11 | 12/01/11 | 0.5 | U | |

Comments:

# Metals
- 5A -

## SPIKE SAMPLE RECOVERY

**Client:** Alaska Department of Fish and Ga **Service Request:** K1110962

**Project No.:** NA **Units:** MG/KG

**Project Name:** Greens Creek Mine Fish Analysis **Basis:** DRY

**Matrix:** TISSUE

**Sample Name:** GCM Greens cr. site 48S **Lab Code:** K1110962-004S

| Analyte | Control Limit %R | Spike Result | C | Sample Result | C | Spike Added | %R | Q | Method |
|---|---|---|---|---|---|---|---|---|---|
| Cadmium | 75 - 125 | 6.18 | | 1.14 | | 4.95 | 102 | | 6020A |
| Copper | 75 - 125 | 30.8 | | 5.7 | | 24.8 | 101 | | 6020A |
| Lead | 75 - 125 | 41.22 | | 0.30 | | 49.50 | 83 | | 6020A |
| Selenium | 75 - 125 | 23.1 | | 6.1 | | 16.5 | 103 | | 6020A |
| Silver | 75 - 125 | 4.69 | | 0.03 | | 4.95 | 94 | | 6020A |
| Zinc | | 266.6 | | 218.1 | | 49.5 | 98 | | 6020A |

**An empty field in the Control Limit column indicates the control limit is not applicable**

# Metals

- 6 -

## DUPLICATES

**Client:** Alaska Department of Fish and Ga **Service Request:** K1110962

**Project No.:** NA **Units:** MG/KG

**Project Name:** Greens Creek Mine Fish Analysis **Basis:** DRY

**Matrix:** TISSUE

**Sample Name:** GCM Greens cr. site 48D **Lab Code:** K1110962-004D

| Analyte | Control Limit | Sample (S) | C | Duplicate (D) | C | RPD | Q | Method |
|---|---|---|---|---|---|---|---|---|
| Cadmium | 20 | 1.14 | | 1.10 | | 3.6 | | 6020A |
| Copper | 20 | 5.7 | | 5.6 | | 1.8 | | 6020A |
| Lead | 20 | 0.30 | | 0.26 | | 14.3 | | 6020A |
| Selenium | 20 | 6.1 | | 6.2 | | 1.6 | | 6020A |
| Silver | | 0.03 | | 0.03 | | 0.0 | | 6020A |
| Zinc | 20 | 218.1 | | 224.2 | | 2.8 | | 6020A |

An empty field in the Control Limit column indicates the control limit is not applicable.

# Metals

-7-

## LABORATORY CONTROL SAMPLE

**Client:** Alaska Department of Fish and Ga **Service Request:** K1110962

**Project No.:** NA

**Project Name:** Greens Creek Mine Fish Analysis

**Aqueous LCS Source:** CAS MIXED **Solid LCS Source:**

| Analyte | Aqueous: ug/L | | | Solid: mg/kg | | | | |
|---|---|---|---|---|---|---|---|---|
| | True | Found | %R | True | Found | C | Limits | %R |
| Cadmium | 50.0 | 47.6 | 95 | | | | | |
| Copper | 250.0 | 249.6 | 100 | | | | | |
| Lead | 500.0 | 435.1 | 87 | | | | | |
| Selenium | 167.0 | 167.4 | 100 | | | | | |
| Silver | 50.0 | 47.0 | 94 | | | | | |
| Zinc | 500.0 | 499.1 | 100 | | | | | |

**COLUMBIA ANALYTICAL SERVICES, INC.**

QA/QC Report

| | | | |
|---|---|---|---|
| **Client:** | Alaska Department of Fish and Game | **Service Request:** | K1110962 |
| **Project:** | Greens Creek Mine Fish Analysis | **Date Collected:** | NA |
| **LCS Matrix:** | Tissue | **Date Received:** | NA |
| | | **Date Extracted:** | 11/15/11 |
| | | **Date Analyzed:** | 12/01-02/11 |

Standard Reference Material Summary
Total Metals

| | | | |
|---|---|---|---|
| Sample Name: | Standard Reference Material | Units: | mg/Kg (ppm) |
| Lab Code: | K1110962-SRM1 | Basis: | Dry |
| Test Notes: | | | |

Source: N.R.C.C. Dorm-3

| **Analyte** | **Prep Method** | **Analysis Method** | **True Value** | **Result** | **Percent Recovery** | **Control Limits** | **Result Notes** |
|---|---|---|---|---|---|---|---|
| Cadmium | PSEP Tissue | 6020A | 0.29 | 0.32 | 110 | 0.216 - 0.372 | |
| Copper | PSEP Tissue | 6020A | 15.5 | 16.3 | 105 | 11.9 - 19.4 | |
| Lead | PSEP Tissue | 6020A | 0.395 | 0.264 | 67 | 0.276 - 0.534 | X |
| Zinc | PSEP Tissue | 6020A | 51.3 | 52.8 | 103 | 38.6 - 65.3 | |

## COLUMBIA ANALYTICAL SERVICES, INC.

QA/QC Report

**Client:** Alaska Department of Fish and Game
**Project:** Greens Creek Mine Fish Analysis
**LCS Matrix:** Tissue

**Service Request:** K1110962
**Date Collected:** NA
**Date Received:** NA
**Date Extracted:** 11/15/11
**Date Analyzed:** 12/01-02/11

Standard Reference Material Summary
Total Metals

Sample Name: Standard Reference Material
Lab Code: K1110962-SRM2
Test Notes:

Units: mg/Kg (ppm)
Basis: Dry

Source: N.R.C.C. Tort-2

| Analyte | Prep Method | Analysis Method | True Value | Result | Percent Recovery | Control Limits | Result Notes |
|---|---|---|---|---|---|---|---|
| Cadmium | PSEP Tissue | 6020A | 26.7 | 27.5 | 103 | 20.9-32.8 | |
| Copper | PSEP Tissue | 6020A | 106 | 101 | 95 | 77-139 | |
| Lead | PSEP Tissue | 6020A | 0.35 | 0.30 | 86 | 0.18-0.58 | |
| Selenium | PSEP Tissue | 6020A | 5.63 | 6.34 | 113 | 3.97-7.56 | |
| Zinc | PSEP Tissue | 6020A | 180 | 186 | 103 | 139-223 | |