Technical Report No. 11-02

Aquatic Biomonitoring at Greens Creek Mine, 2010

by

Katrina M. Kanouse

May 2011

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

Cover from left: David Barto (USDA Forest Service), Katrina Kanouse (Alaska Department of Fish and Game), and Ryan Kreiner (USDA Forest Service) measuring juvenile Dolly Varden near the upper reach of Greens Creek Site 48 on July 21, 2010. Photo by Laura Jacobs.

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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, χ^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 biomonitoring 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 Ryan Kreiner and Dave Barto of the USDA Forest Service who assisted with field sampling in 2010.

Several staff with the Alaska Department of Fish and Game Division of Habitat assisted with this year's effort: Laura Jacobs and Katie Eaton were vital in equipment preparation and field sampling, Laura Jacobs coordinated laboratory analyses, and William Morris performed the chlorophyll laboratory analyses. Division of Habitat Biologists James Durst, Laura Jacobs, and Jackie Timothy and Commercial Fisheries Division Publications Specialist Amy Carroll provided technical review and editing of the report. Nora Foster of NRF Taxonomic Services conducted the invertebrate laboratory analyses.

Other personnel with Kennecott Greens Creek Mining Company, USDA Forest Service, Alaska Department of Fish and Game, Alaska Department of Natural Resources, and the University of Alaska Fairbanks have participated in this project since 2001, and their contribution to the project is also appreciated.

EXECUTIVE SUMMARY

In 2001, the Alaska Department of Fish and Game (ADF&G) and the USDA Forest Service (USFS), in cooperation with the U.S. Fish and Wildlife Service, initiated the fresh water biological monitoring program at Greens Creek Mine near Juneau. The purpose of the program is to annually document stream health in Greens Creek and Tributary Creek, two streams near mine development and operations, to ensure continued presence of aquatic species and detect changes in populations that may result from changes in water quality from surface and groundwater inputs.

The freshwater biological monitoring program includes sampling three levels of aquatic productivity: algae, invertebrates and juvenile fish. Estimates of periphyton biomass, benthic macroinvertebrate density and richness, juvenile fish abundance and distribution, and concentrations of six heavy metals in juvenile fish tissues provide information on overall stream health. Comparison of abundance and richness indices between years allows us to detect change over time. In 2010, we sampled periphyton, benthic macroinvertebrates and juvenile fish at Greens Creek Site 48 and 54 and Tributary Creek Site 9. All three sites continued to show that each population was abundant and similar to samples collected in the previous nine years under the monitoring program, though some populations have decreased in recent years.

Generally, periphyton concentrations have been higher at Tributary Creek Site 9 than at the two Greens Creek sites. Estimates of periphyton biomass in 2010 at Site 48 and Site 9 were moderate compared to previous years at each site. Both sites had greater biomass in 2010 than in 2009, while biomass at Site 54 was lower in 2010 than in 2009 and similar to samples collected in 2007 and 2008. Samples collected in the 10-year period (2001 to 2010) from Site 48 and Site 54 show a similar trend for biomass, while Site 9 biomass estimates are variable between years. Sampling has occurred during a wide range of discharges in the 10 years, which may explain the variability in estimates of periphyton biomass observed at each site between years.

Benthic macroinvertebrate densities have typically been more abundant at the two Greens Creek sites than at Tributary Creek Site 9, while richness has often been similar amongst sites. Estimates of mean benthic macroinvertebrate density in 2010 increased at Site 48 and Site 54 from 2009, and decreased at Site 9 to the lowest observed in the 10-year period. When combined, the mean benthic macroinvertebrate densities in the Greens Creek samples were statistically ($\alpha \leq 0.05$) greater in 2010 than in the Tributary Creek samples, while taxonomic richness was not statistically different between streams. Recent decreased benthic macroinvertebrate densities at Site 9 may indicate reduced water flow, changing habitat, or may be due to increased predators as invertebrates are an important food source for resident and juvenile fish. The 2010 juvenile fish population estimate at Site 9 was the highest observed in the 10-year period.

Dolly Varden char at the two Greens Creek sites show a similar abundance trend over the 10-year period, though the population at Site 54 was somewhat lower in 2009 and 2010 compared to the population at Site 48 at that time. The Dolly Varden population at Tributary Creek Site 9 has not followed a similar trend and is generally lower than that observed at the Greens Creek sites, except in 2010. That year, the Site 9 population was similar to the Greens Creek sites, the greatest observed in the 10-year period, and significantly greater than estimates for the previous four years. The coho salmon population at Site 54 was again low, similar to the previous four years, which continues to suggest that the fishpass is not functioning as designed. However, the total fish population estimate at Site 54 in 2010 may be slightly underestimated because a brown bear disrupted the study. The coho salmon population estimate at Tributary Creek Site 9 in 2010 was the third highest in the 10 years of sampling, and significantly greater than in 2009. Total fish densities per square meter of wetted stream area were lower at Site 54 than Site 48 for the first time in the 10-year period, and Site 9 had the highest density among sites.

The ranges of whole body metals concentrations in juvenile Dolly Varden tissues in 2010 were generally similar to or less than values observed in previous years' samples at each site, except that copper at sites 48 and 54 was significantly lower in 2010 than 2006, and selenium at Site 54 was significantly lower in 2010 than in 2007. When the 2010 Greens Creek samples were combined, copper and zinc in the Greens Creek samples were significantly higher than the 2010 Tributary Creek samples, and silver in the Tributary Creek samples was significantly higher than in the Greens Creek samples. Mean concentrations of selenium in tissue samples collected at Site 54 in 2010 were less than in 2009, but not statistically different.

Overall, Greens Creek Site 48 and Site 54 and Tributary Creek Site 9 have supported moderately abundant and diverse aquatic communities over the 10-year period of the aquatic biomonitoring program. Differences between years and between creeks are generally of larger magnitude than differences between control Site 48 and development Site 54 in Greens Creek. However, certain populations have decreased recently, particularly periphyton biomass at Site 54, benthic macroinvertebrate densities and the decreasing percent pollution-sensitive taxa at Site 9, and Dolly Varden and juvenile coho present at Site 54. These changes in populations may be due to changes in stream flow, habitat availability, or water quality, and will continue to be monitored under the biomonitoring program as required by regulatory agencies. None of these changes can be directly attributed to development or operation of the Greens Creek Mine, except that the low coho population at Site 54 suggests the fishpass has not functioned adequately for several years.

INTRODUCTION

Greens Creek Mine is located near Hawk Inlet on Admiralty Island in Southeast Alaska, about 18 miles west of Juneau. The mine began operations in 1989, and produces export concentrates of lead, zinc, silver and gold. Tailings are disposed in dry-stack form at the headwaters of Tributary Creek and mine facilities and production rock storage areas are adjacent to Greens Creek. Mine operation was shut down between the years 1993 and 1996 due to low metal prices, but has otherwise operated year-round under ownership by a few different companies. Hecla Greens Creek Mining Company (HGCMC) has owned and operated the Greens Creek Mine since April 2008.

In 2000, staff with Alaska Department of Environmental Conservation (ADEC), Alaska Department of Fish and Game (ADF&G), the Alaska Department of Natural Resources (ADNR), the Alaska Department of Law, the U.S. Environmental Protection Agency (USEPA), the USDA Forest Service (USFS) and the U.S. Fish and Wildlife Service conducted a third-party environmental audit of the Greens Creek Mine operations by request of the mine operator. As a result of the review, the mine operator updated the mine's Fresh Water Monitoring Program (FWMP) to include biological monitoring in streams near mine facilities. The FWMP is included in the Plan of Operations required by the USFS, and the mine's current Waste Management Permit required by ADEC. Sampling has occurred every year since the biological monitoring program was implemented in 2001.

The biological monitoring program is designed to document and monitor stream health and fish use in Greens Creek and Tributary Creek. Components of the program include sampling periphyton (attached algae), benthic macroinvertebrates (aquatic insects), juvenile fish populations, and juvenile fish whole body metal concentrations. When combined, these afford 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 changes in biological productivity over time. Additionally, results from an upstream (control) site and a site downstream of mine facilities are compared each year. Sampling protocols for the Greens Creek Mine biological monitoring program are acceptable to the USEPA, USFS, ADEC, ADF&G, ADNR and the American Public Health Association (APHA 1992).

This report summarizes results from the 2010 field sampling effort, the 10th consecutive year of the biological monitoring program, and satisfies HGCMC's reporting requirements to ADEC and USFS. ADF&G Division of Habitat biologists were retained by HGCMC under contract to perform the work, as in previous years. 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).

PURPOSE

The objective of the Greens Creek Mine biological monitoring program is to document existing conditions of the aquatic biological communities in select reaches of Greens Creek and Tributary Creek near mine development and operations. Results are compared to previous years' results and to control and development sites when available. Results are also used to monitor biological assemblages over time. Specifically, the current program is designed to study:

1. Distribution and abundance of juvenile fish
2. Whole body concentrations of Cd, Cu, Pb, Se, Ag, and Zn in juvenile fish tissues

3. Periphyton biomass estimated by chlorophyll *a* concentrations
4. Abundance and community structure of benthic invertebrate populations; and
5. Standardized laboratory toxicity testing[1] (KGCMC 2000).

LOCATION AND SCHEDULE OF MONITORING

Of the 59 FWMP sites established (KGCMC 2000), four were selected for the biomonitoring program given their location to mine development and operations: Greens Creek sites 48, 6, 54, and Tributary Creek Site 9 (Figure 1). In Greens Creek, Site 48 is located upstream of mine development and operations and serves as a control site, Site 6 is near the majority of mining activities, and Site 54 is downstream of Site 6 and adjacent to production rock storage areas. In Tributary Creek, Site 9 is located about 1.6 km downstream of the dry-stack tailings facility. Sites 48, 54 and 9 are sampled annually, while Site 6 is sampled once every five years (scheduled to be sampled again in 2011). HGCMC staff samples ambient water quality at the four biomonitoring sites monthly and reports the results to ADEC in their FWMP annual report.

[1] Microtox laboratory testing was suspended in 2004 due to logistical complications. It was not replaced with a similar laboratory test (e.g. Whole Effluent Toxicity) considering the vast components of the Fresh Water Monitoring Program and insufficient cause to warrant further laboratory analysis (McGee and Marthaller 2004).

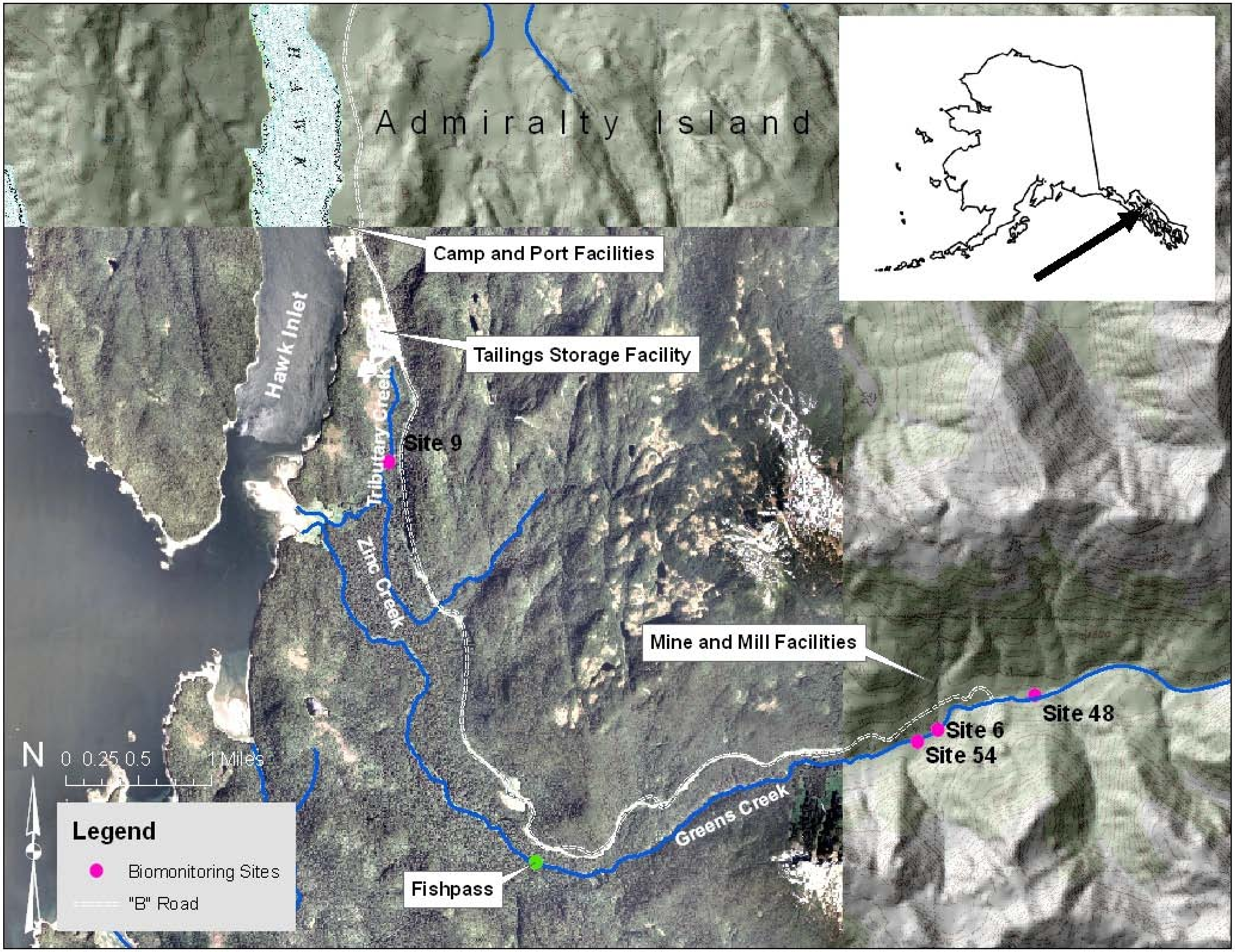

Figure 1.–Location of Greens Creek Mine project facilities, and biomonitoring sample sites.

METHODS

Sample design and methods followed the protocol used during previous years of aquatic biomonitoring 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). In addition to the sampling procedures detailed in this section, other field measurements included air and water temperatures, wetted widths, water velocities at benthic macroinvertebrate sample locations, and a cross-section flow survey to calculate discharge at each site. Water velocities are measured using a flow probe. Photographs were also used to document site conditions during sampling.

SAMPLE SITES

The headwaters of Greens Creek begin in alpine terrain, therefore the creek is fed by both snowmelt and rainfall and the magnitude of annual flow largely depends on snowpack depth. Several tributaries also discharge into the creek. Greens Creek is about 16 km long from headwater to tidewater, gradients range from 2% to 4% at sample sites, and large woody debris is important for habitat creation, stability, and diversity. During the 2010 water year, USGS (Gage 15101490) recorded peak discharges mid-May through early June, up to 142 cubic feet per second (cfs). High discharges also occurred during September, October, and November in response to high precipitation events, peaking at 122 cfs in early November. Mean discharges during July, August, and September (typical low-to -moderate flow months) were 56 cfs in July, 38 cfs in August, and 41 cfs in September.

Tributary Creek is a low-energy, lowland stream fed by precipitation, groundwater and a few hillside drainages. The tailings storage facility is located in the historical headwaters of the creek, documented prior to development. Tributary Creek is about 1.6 km long. The gradient varies slightly from 1% to 2%, and several large ponds at the upper extent contribute tannins, staining the creek water brown. Discharge estimates based on field measurements and limited gage data available indicate annual stream flows range from 1 to 5 cfs.

Greens Creek 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 concrete weir in Greens Creek, which blocks upstream fish passage. Resident Dolly Varden char *Salvelinus malma* was the only fish species documented at Site 48 in the 10-year period under the aquatic biomonitoring program.

During field sampling in 2010, mean channel wetted width was 11 m within the 50 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. Stream gradient within this reach varies between 2% and 4% and cobble is the dominant substrate. Periphyton and benthic macroinvertebrate sampling occurs downstream of the fish sample reach.

Middle Greens Creek Site 6

Site 6 is located immediately downstream of the mine and mill facilities near the portal and is monitored to detect potential effects from mine, mill or shop activities near the portal. At about 235 m elevation, Site 6 is 0.8 km downstream of the concrete weir and slightly upstream of production rock storage areas 23 and D. Anadromous fish access is available to this site via the fishpass.[2] Dolly Varden and coho salmon (*Oncorhynchus kisutch)* were documented at Site 6 under the aquatic biomonitoring program during years 2001 and 2006 (the site is only sampled once every 5 years).

Site 6 has an average channel width of 10 m and gradient varies from 2% to 4%. Large woody debris is less abundant at Site 6 than at sites 48 and 54 and cobble is the dominant substrate. Periphyton and benthic invertebrate sampling occurs downstream of the 50 m fish sample reach, immediately upstream of the confluence of Bruin Creek with Greens Creek.

Greens Creek Site 54 (Below Pond D)

Site 54, located slightly downstream of production rock storage areas 23 and Pond D, 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 available to this site via the fishpass. Coho salmon, Dolly Varden, and cutthroat trout (*Oncorhynchus clarki*) have been documented at this site under the aquatic biomonitoring program.

During the 2010 field sampling, average channel wetted width was 12 m within the 28 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. Stream gradient within this reach varies between 2% and 4% and cobble is the dominant substrate. Gallagher Creek enters Greens Creek in the upper portion of the fish sample reach. Periphyton and benthic macroinvertebrate sampling occurs upstream of the fish sample reach.

Tributary Creek Site 9

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

During the 2010 field sampling, average channel wetted width was 2.3 m within the 50 m fish sample reach. Adjacent leaning and fallen trees contribute to pool formation and substrate retention, which consists of organics, sand, and gravel. Periphyton and benthic invertebrate sampling generally occurs within the fish sample reach as stream conditions usually preclude sampling upstream or downstream.

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[2] In 1989, Greens Creek Mining Company installed an engineered fishpass at Greens Creek river mile 3.5 as mitigation for impacts to Tributary Creek from the approved tailings disposal area. The timber and concrete weirs are designed to provide upstream adult fish passage though a natural bedrock chute that prevents fish migration.

Water quality

HGCMC 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.

DATA ANALYSIS

Data analyses were performed using hand calculators, spreadsheets, and Statistix® 9 (Analytical Software 2008).[3] Kruskal-Wallis One-Way Analysis of Variance by ranks, a nonparametric alternative to a one-way analysis of variance (ANOVA), was used to test for equality of population medians between years and sites (H_0: All of the population distribution functions are identical). All pairwise comparisons were conducted on the mean ranks for each group to test for homogeneity between years and sites. Significant differences ($\alpha \leq 0.05$) indicate the population distribution for the test group differs from the population distributions at other sites or between years.

In addition, the long-term dataset is occasionally reviewed to ensure accuracy. Errors are reported and corrected in the report and appendices. Therefore, the most recent technical report presents the current dataset and should only be used to analyze the data from previous years.

PERIPHYTON BIOMASS

Rationale

Periphyton, or attached algae, is sensitive to changes in water quality and is often sampled during aquatic resource studies to assess local primary productivity and detect early changes within aquatic communities. Algae generally have short life cycles, therefore monitoring biomass provides an ideal indicator to detect short-term effects (Barbour et al. 1999). An abundance of periphyton indicates that primary productivity is locally occurring, and results can be used to assess overall stream health with other local studies (e.g., benthic macroinvertebrates).

Sample Collection and Laboratory Analysis

Periphyton collection methods followed the protocols used by ADF&G (1998) and Barbour et al. (1999) and included in the FWMP (KGCMC 2000). An analysis of stream flow conditions three weeks prior to the field sampling is provided in the results section. Ten rocks were collected from the nearshore area of the creek in each study reach for sampling. A 5 × 5 cm square of high-density foam was placed on each rock, material around the foam square was removed by scrubbing with a toothbrush, then rinsed away using a spray bottle containing stream water. The foam square was removed and the isolated area scrubbed with a toothbrush. Loosened periphyton was rinsed onto a 0.45 µm glass fiber filter attached to a vacuum pump. After extracting as much water as possible from the sample on the glass fiber filter, approximately 1 ml saturated $MgCO_3$ was added to the filter to prevent acidification and conversion of chlorophyll to phaeophytin. The glass fiber filter was wrapped in a large paper filter to absorb additional water, and placed in a sealed, labeled plastic bag with desiccant. The samples were frozen on site in a light-proof cooler with additional desiccant and transported to Fairbanks for analysis. Samples were kept frozen until laboratory analyses were conducted by Division of Habitat staff.

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[3] 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.

Methods for extraction and measurement of chlorophyll followed U.S. Environmental Protection Agency protocol (USEPA 1997). Samples were removed from the freezer, cut into small pieces, and placed in a centrifuge tube with 10 ml of 90% buffered acetone. Centrifuge tubes were placed in a metal rack, covered with aluminum foil, and held in a refrigerator for 24 hours to extract the chlorophyll. After extraction, samples were centrifuged for 20 minutes at 1,600 rpm and then read on a Shimadzu UV-1800 Spectrophotometer[4] at optical densities (OD) 664 nm, OD 647 nm, and OD 630 nm. In addition, a reading was taken at OD 750 nm to correct for turbidity. An acetone blank was used to correct for the solvent. Samples were then treated with 0.1 ml of 0.1 N hydrochloric acid to convert chlorophyll to phaeophytin, and read at OD 665 nm and OD 750 nm. Based upon these readings, amounts of chlorophylls *a*, *b*, *c*, and phaeophytin were determined according to Standard Methods (APHA 1992).

Data Presentation

Chlorophyll *a* is a pigment found in plants and algae and a useful indicator to estimate algal biomass. Chlorophylls *b* and *c* are accessory pigments that provide information on the types of periphyton present. Periphyton biomass (chlorophyll *a*) data are presented using Box and Whisker graphs (Velleman and Hoaglin 1981). The box illustrates the interquartile range, the line bisecting the box represents the median value, 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 (Analytical Software 2008). We have no evidence to suggest that potential and probable outlier data values are not part of the data set's natural distribution, so they were retained and used in the data analysis. Current and historical data is included in Appendix A.

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 provide an ideal indicator to detect short-term and long-term effects within local aquatic communities (Barbour et al. 1999). An abundant and diverse group of EPT taxa indicate a healthy local aquatic community and results can be used to assess overall stream health with other local studies (e.g. periphyton biomass).

Sample Collection and Laboratory Analysis

Five benthic macroinvertebrate samples were collected from each site with a Hess sampler using a stratified random sample design, modified from Barbour et al. (1999). Samples were collected exclusively from riffle habitats where the greatest amount of taxonomic richness and density are usually observed. This sample design eliminated the variability from sampling pools or other habitats where pollution-sensitive taxa are less likely to be present.

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[4] 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.

The Hess sampler was pushed into the stream bottom, encompassing 0.086 m^2 of substrate, to define the sample site. The substrate was manually disturbed and rocks were brushed within the sample area then removed. Fine gravels were disturbed to between 10 and 15 cm depth to collect buried individuals. Macroinvertebrates were collected using a 363 μm mesh net, then relocated to a prelabeled 500 mL bottles and preserved in 80% denatured ethanol and shipped to Fairbanks for processing. Macroinvertebrate samples were later sorted from debris and identified to the lowest practical taxonomic level by a taxonomist.

Data Presentation

Data analyses included comparisons of density, richness, percent community composition, percent EPT, percent EPT and Chironomidae, and percent dominant taxon. Current and historical data is included in Appendix B.

JUVENILE FISH POPULATIONS

Rationale

Salmonids are highly migratory, predators, and good indicators of long-term effects and habitat conditions (Barbour et al. 1999), therefore monitoring fish populations affords another biological level to detect change within the aquatic community and assess overall stream health. Current year population estimates are compared to previous years' to detect change over time.

Sample Collection

Fish populations were sampled using a modification of Aho (2000) with a three-pass removal method developed by the USFS (Bryant 2000). Fish were collected using 0.635 cm (¼ in) square mesh galvanized minnow traps baited with disinfected salmon roe. Approximately 25 minnow traps were deployed within each sample reach; the final number of traps used was dependent on stream conditions and habitat availability during field sampling. Where possible, natural features such as shallow riffles or small waterfalls were used to help define the upper and lower reach boundaries to minimize fish migration into the sample reach. To assist with meeting the closed-reach assumption of the three-pass removal method, baited "block" traps were also set upstream and downstream of each sample reach to capture potential migrants.

Sample reaches were identified by aluminum tree tags and flagging set during previous years' sampling. Reach lengths varied between sites, depending on available habitat for minnow trapping. At Greens Creek Site 48, the 75 m reach sampled in 2001 was shortened to 50 m in 2002 and used in following years; at Middle Greens Creek Site 6 the 135 m reach sampled in 2001 was reduced to 49 m in 2006 and will be used in following years; at Greens Creek Site 54, the same 28 m reach has been sampled each year; and at Tributary Creek Site 9, the 44 m reach sampled in 2001 was extended to 50 m in 2002 and used in following years.

Minnow traps were placed throughout each sample reach focusing on pools, undercut banks, bank alcoves, under rootwads or logjams, and other habitats where fish were likely to be captured. In higher velocity sites, rocks were placed in the traps to increase trap weight and provide cover for fish. In each fish sample reach, the traps were set for about 1.5 h, then retrieved and captured fish were transferred to perforated plastic buckets. The buckets were placed in the creek to supply dissolved oxygen and to reduce stress on captured fish. Fresh bait was added to the traps, and all were reset for a second 1.5 h period. While the second set was fishing, fish captured during the first set were counted, identified to species, measured to fork length (FL), and placed in a mesh holding bag in the stream. The procedure was repeated for the third 1.5 h trapping period.

Block traps were set for the entire 4.5 h sampling period. Fish captured in block traps were counted and identified to species, but not included in further analyses. Six Dolly Varden from the first trapping period at each site were retained for laboratory analysis of whole body metals concentrations. Fish not retained for the metals analyses were returned to the stream reach immediately after sampling was completed.

Data Analyses and Presentation

Fish population estimates were calculated using the multiple-pass depletion method developed by Lockwood and Schneider (2000), an iterative 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 the 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).

MLEs calculated for each reach and each year are presented in table format. Capture data and length frequencies of captured fish from each reach and each year are presented graphically in Appendix C. Reported densities were calculated using the population estimate and the average of five wetted width measurements within the fish sample reaches.

METALS CONCENTRATIONS IN JUVENILE FISH

Rationale

Monitoring whole body metals concentrations in juvenile fish assesses metal loading in aquatic communities near the Greens Creek mine. Current year data are compared to previous years' data to detect change over time and water quality data can be compared as well to examine relationships. Weber Scannell and Ott (2001) documented metals accumulation in juvenile fish tissues within two months of migration into mineralized tributaries, therefore results can detect both short-term and long-term changes in tissue metals concentrations.

Sample Collection

Six juvenile Dolly Varden within 85 to 125 mm FL captured in the minnow traps were collected from each site for whole body metals analyses. The specified size range improves the likelihood of sampling only resident fish (Greens Creek Sites 6 and 54 and Tributary Creek Site 9 have anadromous fish present as well), assuming the age of fish in that size class is two- or three-year-old Dolly Varden that have not migrated to sea. Sample fish were measured to FL, individually packed in clean, prelabeled bags, placed in an acid-washed cooler, and frozen on site until transport to Fairbanks. Biologists handling the fish wore nitrile gloves to reduce the risk of metal contamination.

We followed the techniques of Crawford and Luoma (1993) for minimizing contamination of the samples. In Fairbanks, the fish were weighed without removal from the bags, and correction made for the weight of the bag. The fish were submitted to a private analytical laboratory, where they were digested, dried, 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

Written chain of custody documentation was maintained on each 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 Analyses and Presentation

Minimum, median and maximum metals concentrations for the six analytes are presented graphically. High and low bars indicate range of values and♦() is the median value; ND = not detected at reporting limit (e.g. 0.02 mg/kg for Ag). Current and historical data is included in Appendix D.

RESULTS AND DISCUSSION

Stream discharges at Greens Creek Sites 48 and 54 were moderate during the 2010 field sampling and similar to flow observed during sampling in 2005 and 2009 (Table 1). Stream discharge at Tributary Creek Site 9 was low during the 2010 field sampling similar to previous years. The USDA Natural Resources Conservation Service (2010) Alaska snowpack map suggests the remaining snowpack near Greens Creek Mine on May 1, 2010 was moderate and similar to the 30-year average (1971–2000).

Table 1.–Greens Creek (USGS Gage 15101490) mean daily discharge and Tributary Creek field-measured discharge during biomonitoring sampling in 2010.

	Sampling	Greens Cr. USGS Gage		Tributary Cr. Field Data[a]	
Year	Dates	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

[a] Field measuring discharge in Tributary Creek during low flow is difficult because of the creek's shallow water and uniform stream bottom. Therefore, field measurements collected during low flow 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.

High discharge can affect biomonitoring results in several ways. Fish distribution, habitat availability, and vulnerability of fish for capture in minnow traps may be reduced during high flows as fish move to other stream reaches seeking refuge and habitats with lower stream velocities. Discharge capable of transporting gravel and larger substrate downstream can reduce periphyton and benthic macroinvertebrate densities by physical scour and increased drift. During the three weeks prior to field sampling in 2010, discharges in Greens Creek were moderate and generally decreased overtime (Figure 2), therefore scour and bedload movement were not expected to influence sampling results. Field sampling has occurred over a range of discharges during mid- to late July in both creeks during the 10-year period, which affords an analysis of the natural range of variability within aquatic communities (Figure 3).

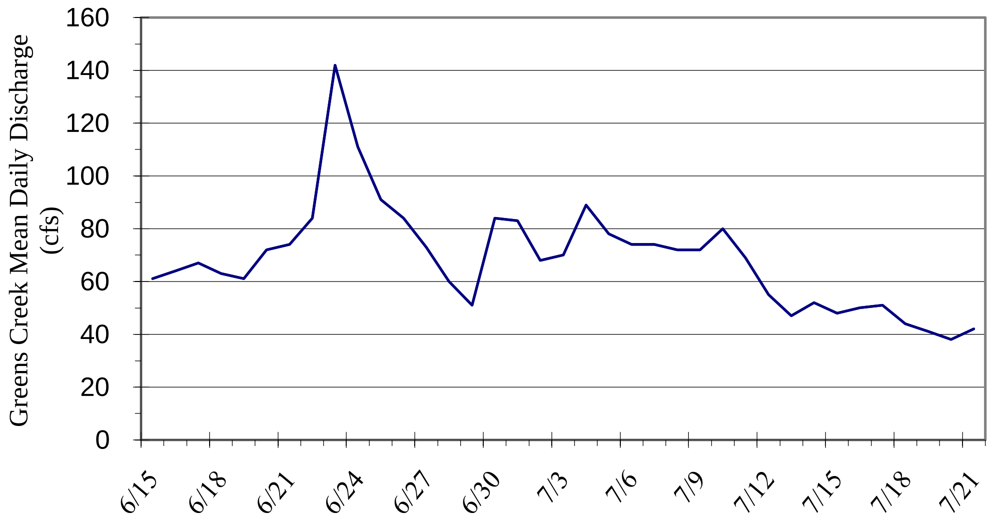

Figure 2.–Greens Creek (USGS Gage 15101490) mean daily discharge prior to sampling in 2010.

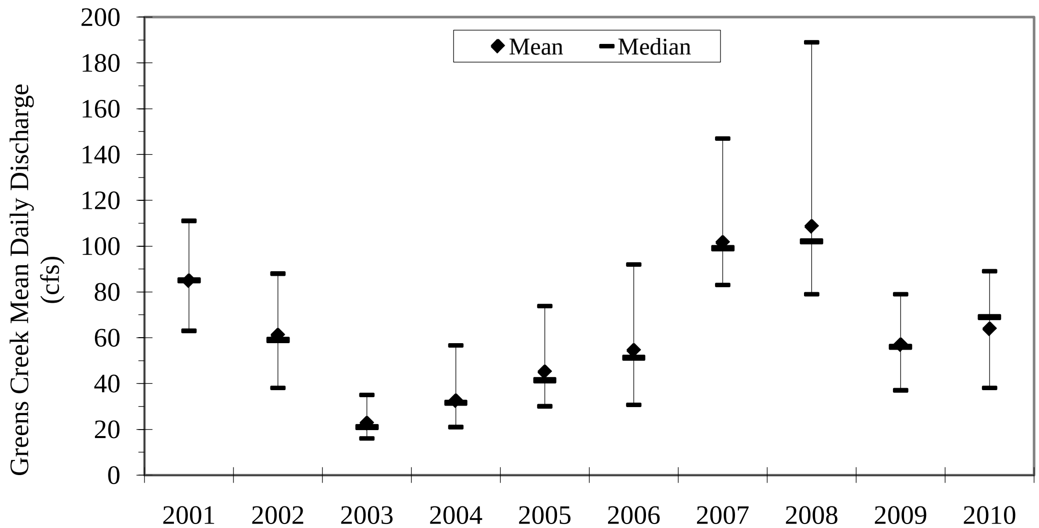

Figure 3.–Greens Creek (USGS Gage 15101490) range of mean daily discharges three weeks prior to biomonitoring sampling during the years 2001–2010.

GREENS CREEK SITE 48

Greens Creek Site 48 was sampled during the morning of July 21, 2010. The weather was cloudy with drizzle, light rain fell during the previous 12 h, air temperature was 10.5°C, and water temperature was 7.5°C. Within the upper portion of the fish sample reach, Greens Creek continues to flow through the log jam with the majority of flow passing through the deep river-right channel (Figure 4). The adjacent steep bank continues to slough, and the area of exposed soil was about twice the size of the exposed area observed in 2009. We did not observe any considerable changes in stream course or large woody debris distribution throughout the reach since 2009. HGCMC staff recorded the following water quality measurements in Greens Creek during sampling: water temperature 7.5°C, conductivity 94.3 μS/cm, and pH 7.10.

Figure 4.– Upper portion of the fish sample reach at Greens Creek Site 48 during biomonitoring sampling on July 21, 2010.

Periphyton Biomass

Estimates of periphyton biomass in the 2010 samples collected at Site 48 were moderate compared to previous years (Figure 5). The mean ranks of chlorophyll *a* concentrations at Site 48 were not significantly different ($\alpha \leq 0.05$) from any of the previous years' samples (Appendix A).

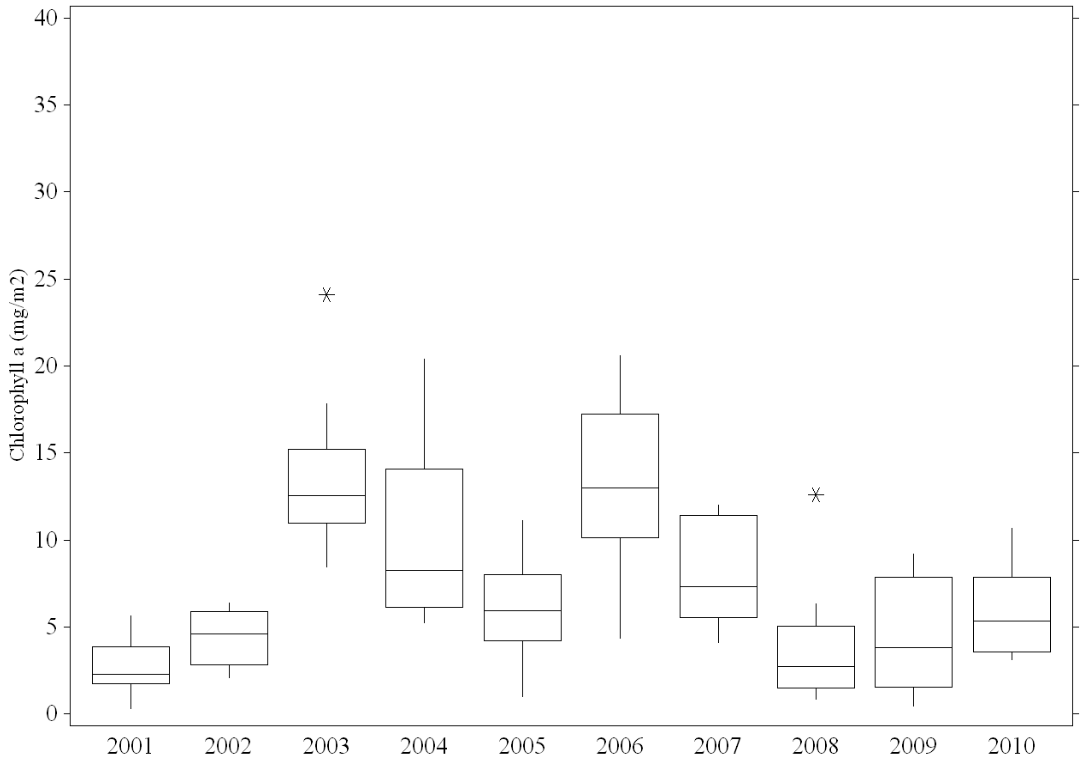

Figure 5.–Periphyton densities in Greens Creek Site 48 samples 2001–2010.

The relative proportion of chlorophyll *c* compared to chlorophyll *b* at Site 48 among years indicates that diatoms and/or dinoflagellates are a greater component of the periphyton community than are green algae or euglenophytes (Figure 6).

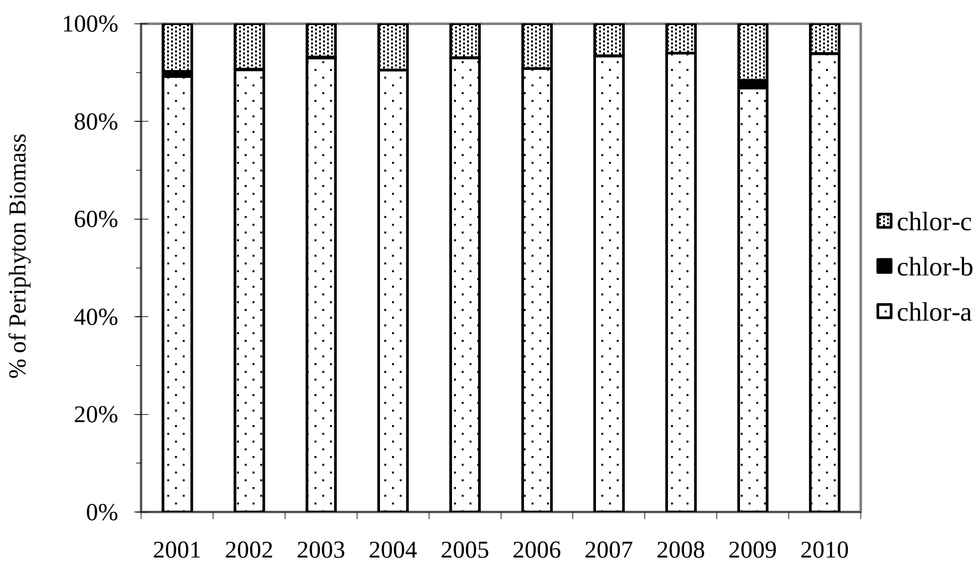

Figure 6.–Mean concentrations of chlorophyll *a*, *b* and *c* in Greens Creek Site 48 samples 2001–2010.

Benthic Macroinvertebrate Density and Richness

The mean benthic macroinvertebrate density at Site 48 in 2010 was moderate and similar to the mean density observed over the previous nine-year period (Table 2, Figure 7). Taxonomic richness in 2010 was similar to the mean richness observed over the previous nine-year period and similar to samples collected in all years, except 2003, 2004 and 2005 when several other taxa were observed. No statistical differences between the 2010 data compared to previous years were found.

Table 2.–Benthic macroinvertebrate density and richness at Greens Creek Site 48 2001–2010.

Year	Mean Density (aqua. invert./m^2)	Taxonomic Richness	Mean Taxa Per Sample
2001	2368	25	11.8
2002	1408	26	13.0
2003	4734	27	17.6
2004	3358	30	19.4
2005	2792	29	15.8
2006	1386	23[a]	11.8
2007	1466	26[a]	13.2
2008	2662	22	14.0
2009	1906	21[a]	10.8
2010	2480	24	14.6

[a] Previously misreported.

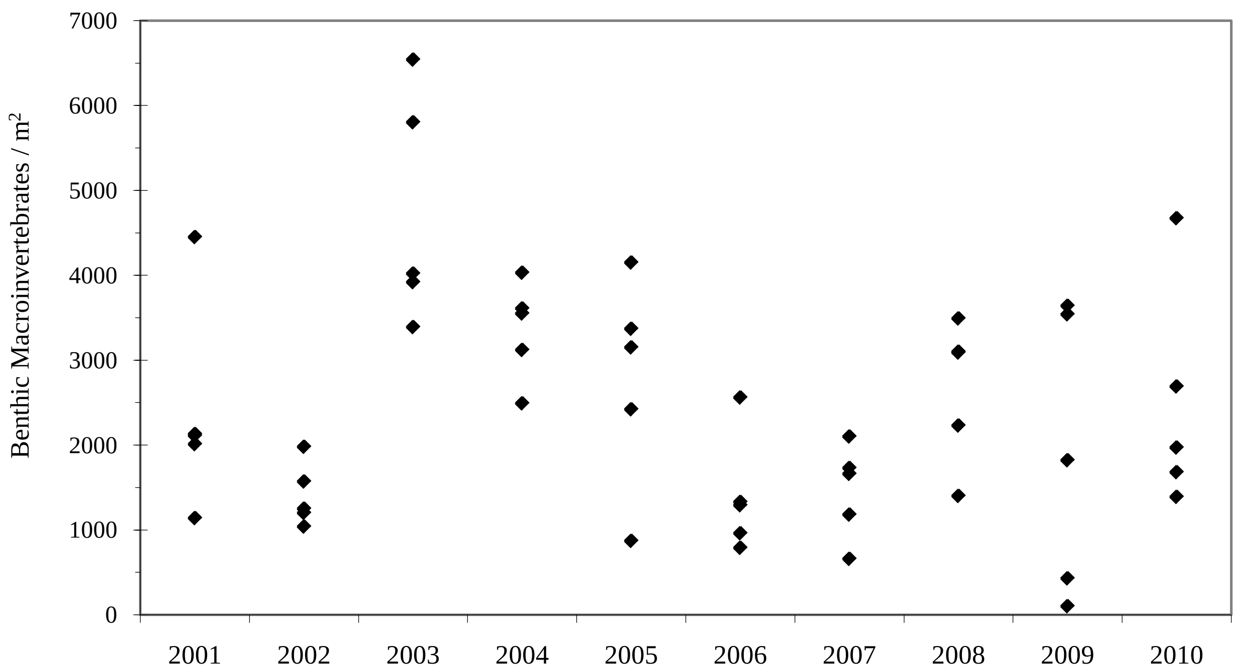

Figure 7.–Benthic macroinvertebrate densities in Greens Creek Site 48 samples 2001–2010.

In 2010, 85.5% of the invertebrates collected at Site 48 were classified under the Order Ephemeroptera, and 7.2% of the samples were composed of taxa classified under the Orders Plecoptera and Trichoptera. The Ephemeroptera taxa were dominated by Baetidae: *Baetis*, Ephemerellidae: *Drunella*, and Heptageniidae: *Epeorus* (Table 3). *Baetis* is rated “moderately sensitive” to poor water quality, while *Drunella* and *Epeorus* are rated “extremely sensitive” (Barbour et al. 1999). EPT species are able to cling to substrate during high discharge periods better than Chrionomidae species, which may explain the low proportion of Chrionomidae observed at Site 48 during the 10-year period (Figure 8). The benthic macroinvertebrate community at Site 48 in 2010 also included noninsects such as worms (Oligochaeta) and seed shrimp (Ostracoda).

Table 3.–Percentages of common (>5%) benthic macroinvertebrate taxa in Greens Creek Site 48 samples 2001–2010.

Order	Taxon	2001	2002	2003	2004	2005	2006[a]	2007[a]	2008[a]	2009[a]	2010
Ephemeroptera	*Baetis*	26%	22%	19%	23%	20%	19%	**28%**	**58%**	12%	16%
	Drunella	-	7%	**27%**	**24%**	26%	15%	-	-	-	24%
	Ephemerella	-	-	-	-	-	-	-	-	18%	-
	Cinygmula	8%	-	-	6%	6%	7%	12%	6%	9%	9%
	Epeorus	**38%**	**27%**	16%	12%	**27%**	**35%**	8%	12%	**45%**	**28%**
	Rhithrogena	16%	**27%**	12%	12%	5%	13%	22%	8%	7%	7%
Plecoptera	*Zapada*	-	-	-	-	-	-	7%	-	-	-
Diptera	Chironomidae	-	-	7%	11%	8%	-	-	6%	-	5%

[a] Previously misreported.

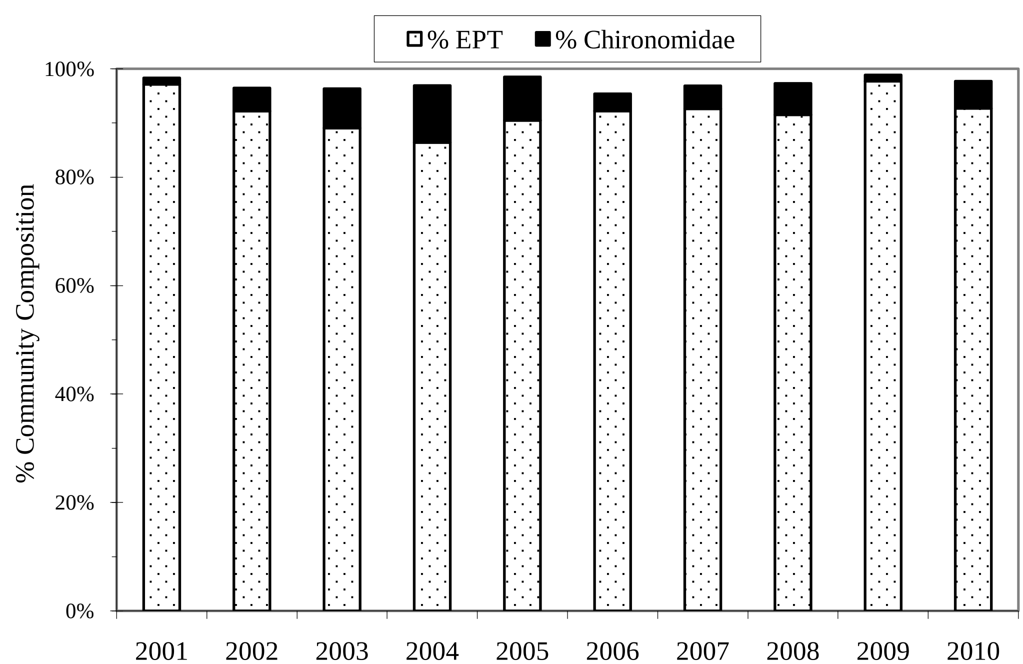

Figure 8.–Percent EPT taxa and Chironomidae in Greens Creek Site 48 samples 2001–2010.

The overall proportion of EPT taxa in the 2010 Site 48 samples (92.7%) was similar to the mean proportion for the previous nine years (92.1%), and the proportion of aquatic Diptera was low (6.3%) similar to previous years (Figure 9).

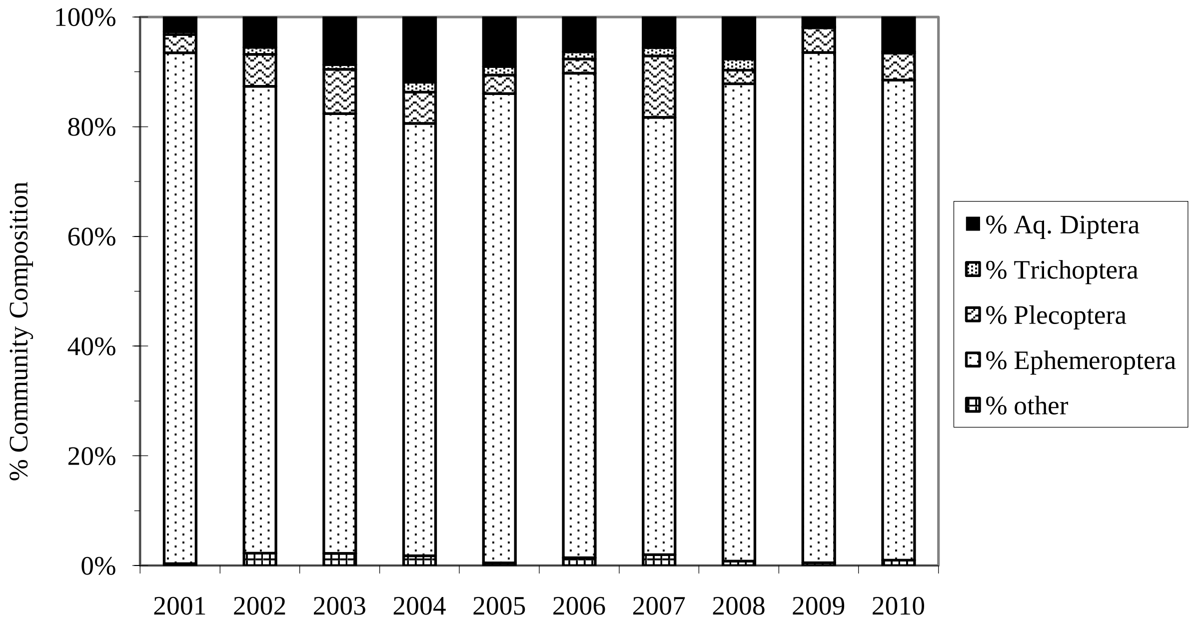

Figure 9.–Benthic macroinvertebrate community composition in Greens Creek Site 48 samples 2001–2010.

Juvenile Fish Populations

The 2010 juvenile fish survey at Site 48 captured 158 Dolly Varden in 26 minnow traps. Six block traps set upstream and seven block traps set downstream of the fish sample reach captured a total of 21 Dolly Varden. The 2010 juvenile fish population estimate at Site 48 was 170±11 Dolly Varden with an approximate density of 0.31 fish/m^2. The 2010 population estimate is similar to 2002 and 2009, significantly less than the 2003 to 2006 estimates, and significantly more than the 2001, 2007 and 2008 estimates (Figure 10). The range of fish sizes (Table 4) and length frequency plots (Appendix C) of captured Dolly Varden suggest multiple age classes are present most years at Site 48, except in 2008 when young-of-year fry appeared to be absent.

Table 4.–Juvenile fish population estimates at Greens Creek Site 48 2001–2010.

Year Sampled	Fish Species	No. Fish Caught	FL, mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m^2
2001	DV	68	48–139	96 (68–124)	72	0.20
2002	DV	126	45–160[a]	145 (134–173)	50	0.23
2003	DV	285	54–180	333 (305–361)	50	0.90[b]
2004	DV	244	54–158	255 (246–264)	50	0.88
2005	DV	212	50–149	243 (222–264)	50	0.65
2006	DV	212	49–150	228 (215–241)	50	0.59
2007	DV	95	53–154	109 (95–123)	50	0.20[b]
2008	DV	73	77–137	75 (71–79)	50	0.14
2009	DV	126	47–142	151 (130–172)	50	0.36[c]
2010	DV	158	47–170	170 (159–181)	50	0.31

[a] Fork lengths recorded in 5 mm intervals.
[b] Based on estimated wetted area value.
[c] Previously misreported.

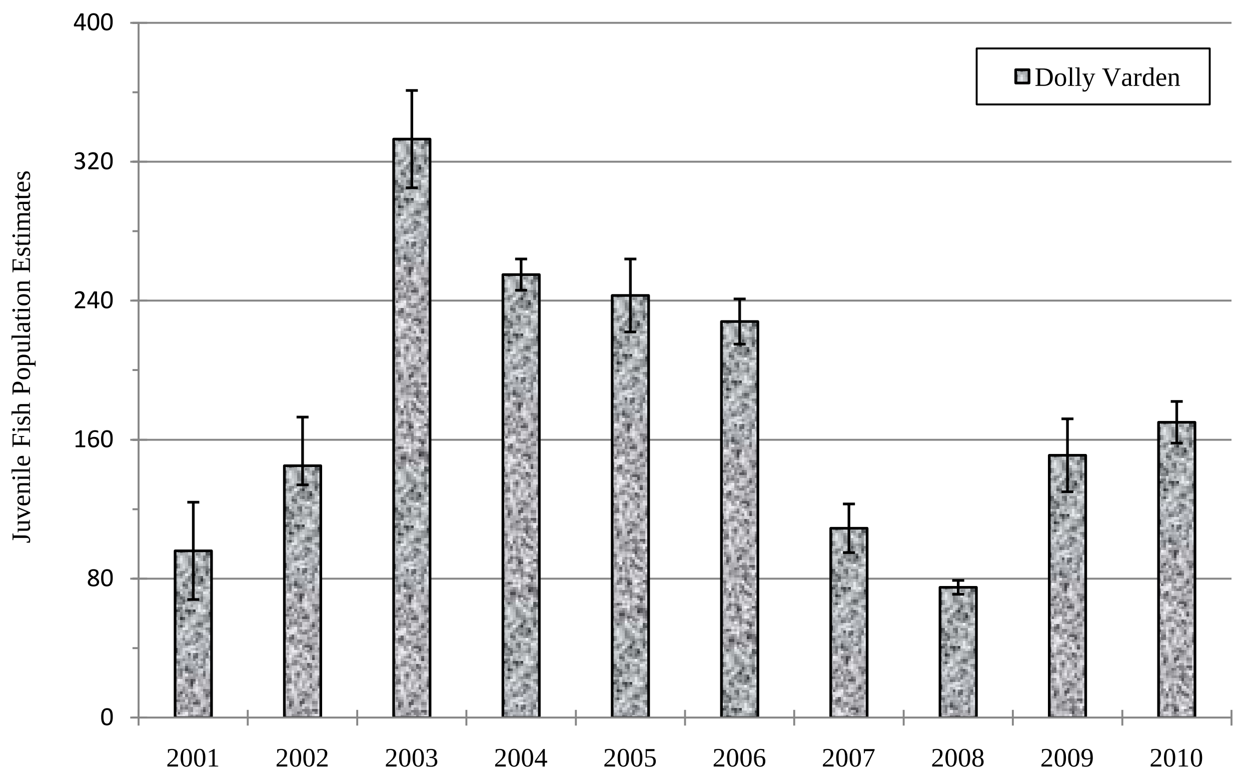

Figure 10.–Juvenile fish population at Greens Creek Site 48 2001–2010.

Metals Concentrations in Juvenile Fish

Median concentrations of metals in juvenile Dolly Varden tissues at Site 48 in 2010 were less than or similar to values observed in most of the previous nine years of sampling. The median concentration of copper was the lowest observed in the 10-year period, and the median concentration of zinc was the second lowest observed. Overall, median concentrations of cadmium, copper, selenium, and zinc were less than concentrations observed during 2009, median lead concentration was the same as 2009, and the median silver concentration was double the value observed in 2009 (Figure 11, Appendix D). The mean rank for copper concentrations in 2010 was significantly lower than in 2006. No other statistical differences were observed in the 2010 data when compared to previous years.

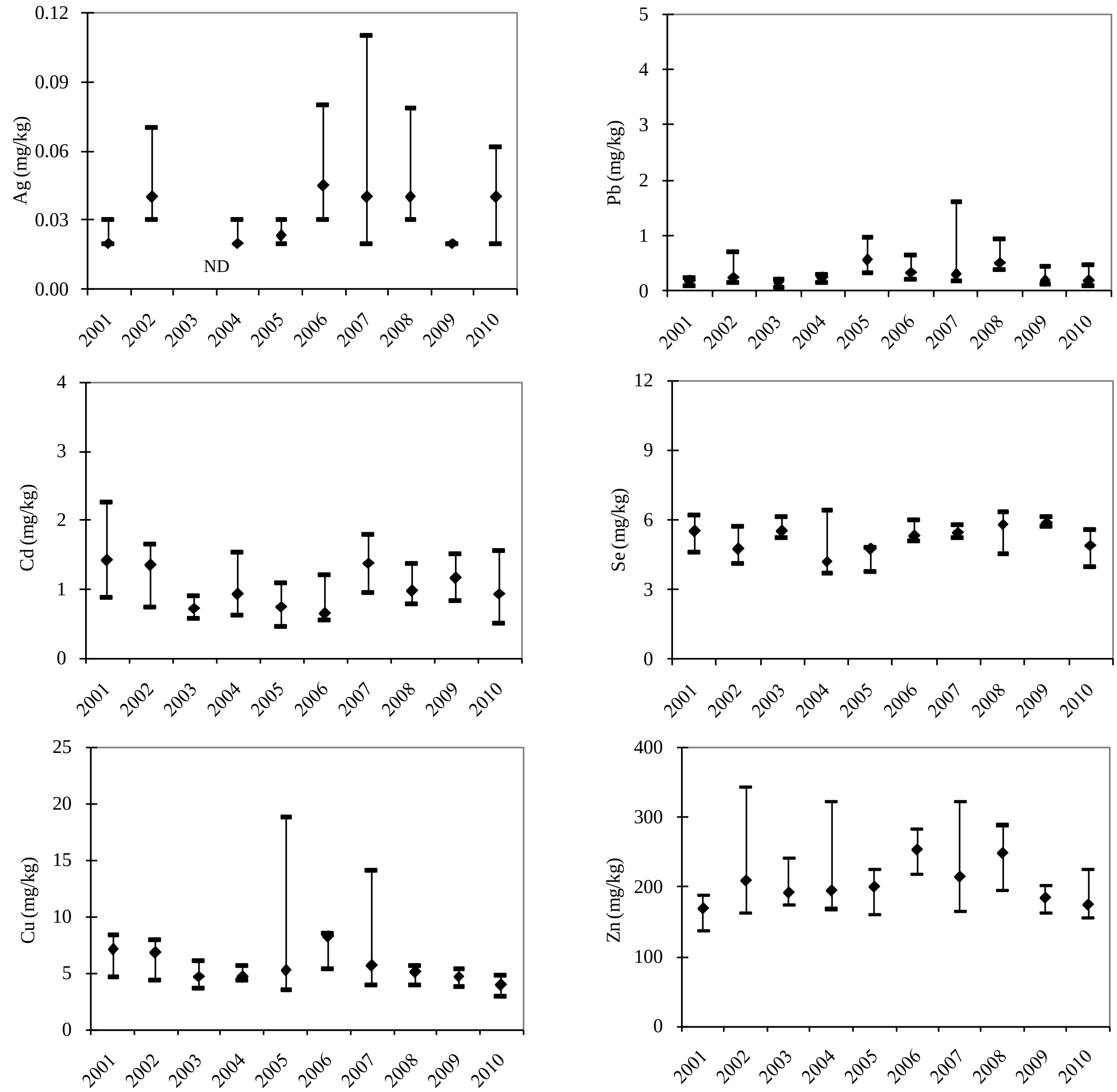

Figure 11.–Whole body metals concentrations in Dolly Varden captured at Greens Creek Site 48 2001–2010.

Summary

Greens Creek Site 48 is located upstream of all mine development and operations and is sampled as a control reach to provide data on natural, background aquatic conditions in Greens Creek. Estimates of periphyton biomass have been low since 2008; in 2010 estimates continued to be low. These estimates are similar to samples collected in 2001, 2002 and 2005, and cannot be attributed to scouring stream flows prior to sampling. Therefore, the biomass estimates likely represent the natural variability of algal communities at Site 48. Estimates of mean benthic macroinvertebrate density and taxonomic richness in 2010 were moderate similar to previous years' data and taxa classified under Ephemeroptera continue to be dominant.

The 2010 juvenile fish population estimate was moderate compared to previous years' estimates, though significantly less than the estimates for 2003 to 2006. Juvenile fish captured in 2010 appeared to represent more than one age class, including young-of-year fry, which suggests that successful spawning is occurring in the area. Metals concentrations in juvenile fish tissues were similar to or lower than observed in previous years. The median concentration of copper was the lowest observed in the 10-year period at Site 48, while the median concentration of zinc was the second lowest observed at this site. The median concentration of selenium was lower in 2010 than in 2009 and similar to previous years. Overall, samples collected in 2010 suggest a productive aquatic community is present at Site 48.

GREENS CREEK SITE 54

Greens Creek Site 54 was sampled during the morning of July 20, 2010 (Figure 12). The weather was overcast, air temperature was 11.2°C, and water temperature was 7.5°C. There were no obvious changes in stream course or large woody debris distribution since sampling in 2009. HGCMC staff recorded the following water quality measurements in Greens Creek during our sampling: water temperature 7.5°C, conductivity 99.4 μS/cm, and pH 7.30.

Figure 12.– Middle portion of the fish sample reach at Greens Creek Site 54 during biomonitoring sampling on July 20, 2010.

Periphyton Biomass

Estimates of periphyton biomass in the 2010 samples collected at Site 54 were low compared to previous years (Figure 13). The mean ranks of chlorophyll *a* concentrations at Site 54 in 2010 were significantly less than the mean ranks for samples collected in 2003 and 2006 (Appendix A).

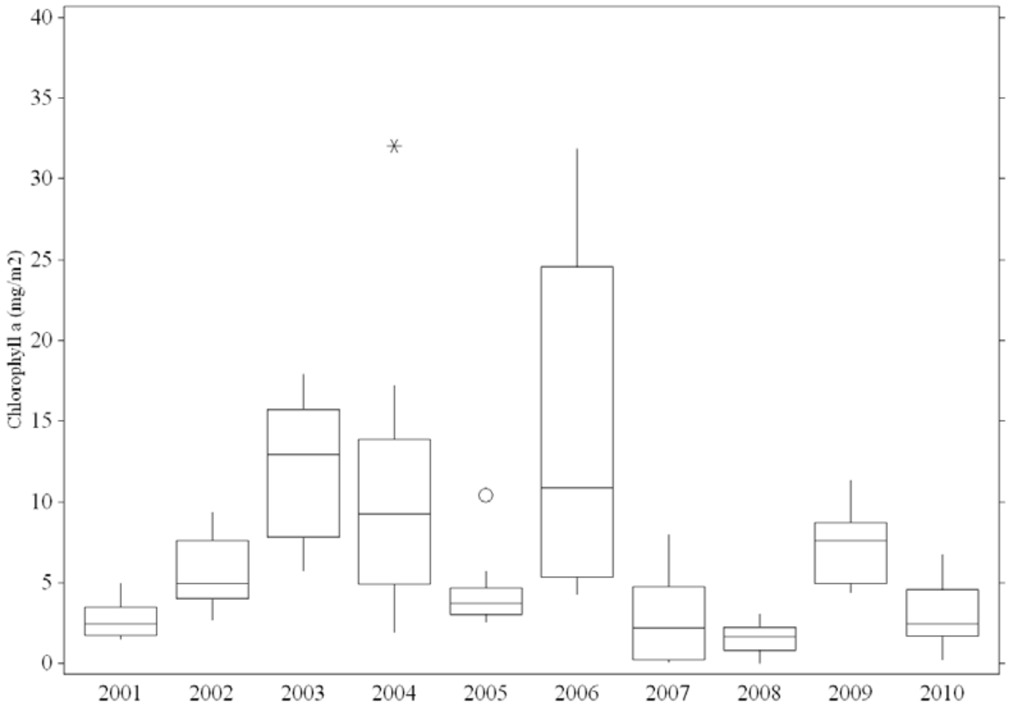

Figure 13.–Periphyton densities at Greens Creek Site 54 2001–2010.

The relative proportion of chlorophyll *c* compared to chlorophyll *b* among years indicates that diatoms and/or dinoflagellates are a greater component of the periphyton community at Site 54 than green algae or euglenophytes (Figure 14).

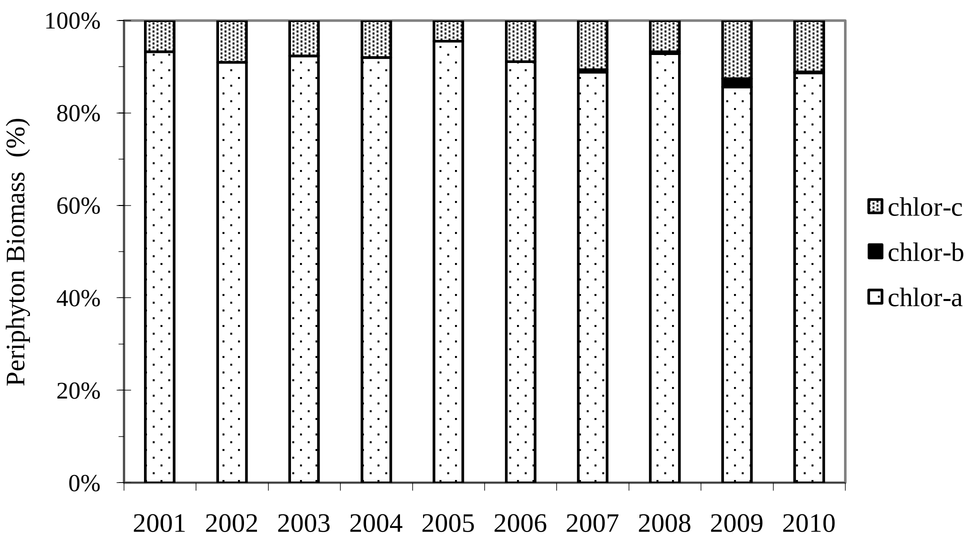

Figure 14.–Mean concentrations of chlorophyll *a*, *b* and *c* in samples from Greens Creek Site 54 2001–2010.

Benthic Macroinvertebrate Density and Richness

The mean benthic macroinvertebrate density at Site 54 in 2010 was similar to the mean density observed over the previous nine-year period (Table 5, Figure 15), and the mean ranks were not significantly different compared to previous years. Taxonomic richness in 2010 was similar to the mean richness observed over the previous nine-year period, and also not significantly different compared to previous years.

Table 5.–Benthic macroinvertebrate density and richness at Greens Creek Site 54 2001–2010.

Year	Mean Density (aqua. invert./m^2)	Taxonomic Richness	Mean Taxa Per Sample
2001	3564	28	15.2
2002	2932	30	13.8
2003	4670	26	16.2
2004	3934	31	19.0
2005	2786	25	14.8
2006	1050	15	10.0
2007	650	15	8.2
2008	2554	25	15.6
2009	1958	23	12.8
2010	2754	23	13.4

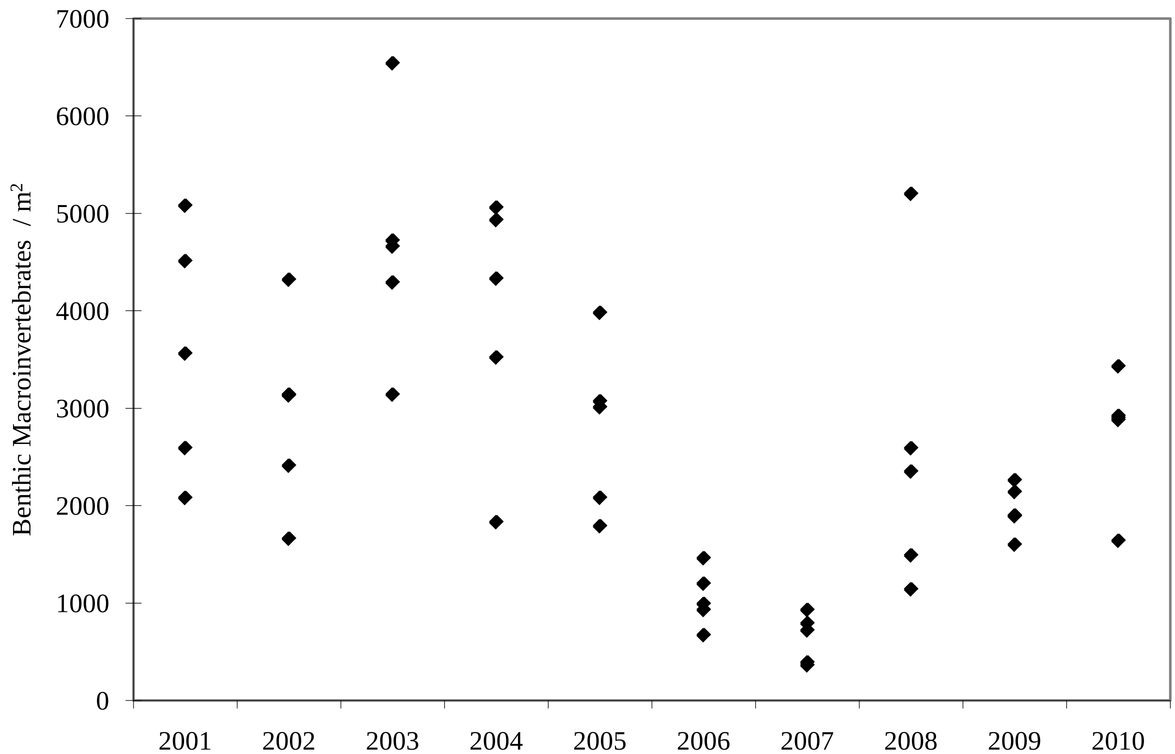

Figure 15.–Benthic macroinvertebrate densities in Greens Creek Site 54 samples 2001–2010.

Invertebrate community composition varies slightly between years and Ephemeroptera were the most commonly observed taxa in the 10-year period at Site 54 (Table 6, Figure 16). In 2010, the Ephemeroptera were dominated by Baetidae: *Baetis*, Ephemerellidae: *Drunella*, and Heptageniidae: *Epeorus*. *Baetis* is rated “moderately sensitive” to poor water quality, while *Drunella* and *Epeorus* are rated “extremely sensitive” (Barbour et al. 1999). EPT species are better able to cling to substrate during high discharge periods than Chrionomidae species, which may explain the low proportion of Chrionomidae observed in the 10-year period (Figure 16). The benthic macroinvertebrate community at Site 54 in 2010 also included noninsects such as worms (Oligochaeta) and seed shrimp (Ostracoda). Dominance of pollution-sensitive benthic macroinvertebrate taxa, combined with a mixture of many species of insects and noninsects (Appendix B), suggests a productive aquatic insect community is present at Site 54.

Table 6.–Percentages of common (>5%) benthic macroinvertebrate taxa in Greens Creek Site 54 samples 2001–2010.

Order	Taxon	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Ephemeroptera	*Baetis*	14%	15%	9%	15%	14%	20%	**27%**	**34%**	16.0	17.7%
	Drunella	7%	19%	**38%**	**38%**	**39%**	11%	-	-	-	27.5%
	Ephemerella	-	-	-	-	-	-	-	-	12.7	2.5%
	Cinygmula	18%	-	8%	6%	6%	13%	26%	16%	10.8	5.2%
	Epeorus	**53%**	**43%**	17%	12%	25%	**24%**	16%	32%	**35.5**	**32.5%**
	Rhithrogena	-	10%	13%	9%	-	22%	19%	-	14.8	5.2%
Diptera	Chironomidae	-	-	6%	8%	-	-	-	-	-	3.3%

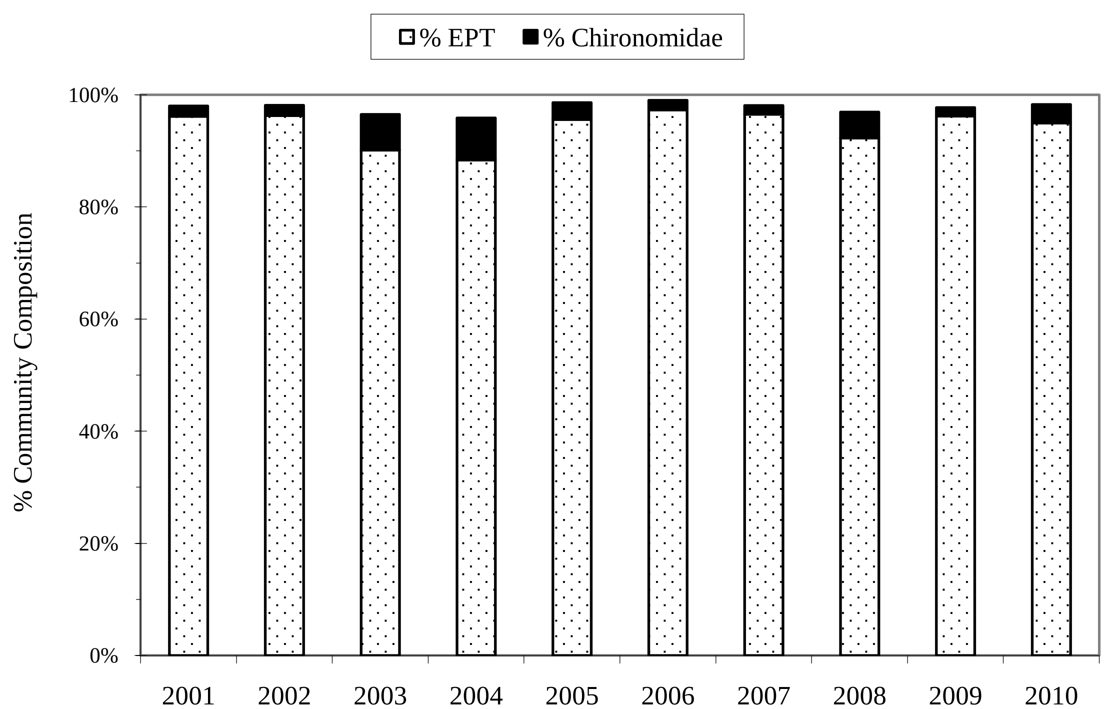

Figure 16.–Percent EPT taxa and Chironomidae in Greens Creek Site 54 samples 2001–2010.

The overall proportion of EPT taxa in the 2010 Site 54 samples (95.0%) was similar to the mean proportion for the previous nine years (94.3%), and the proportion of aquatic Diptera was similar to previous years (Figure 17).

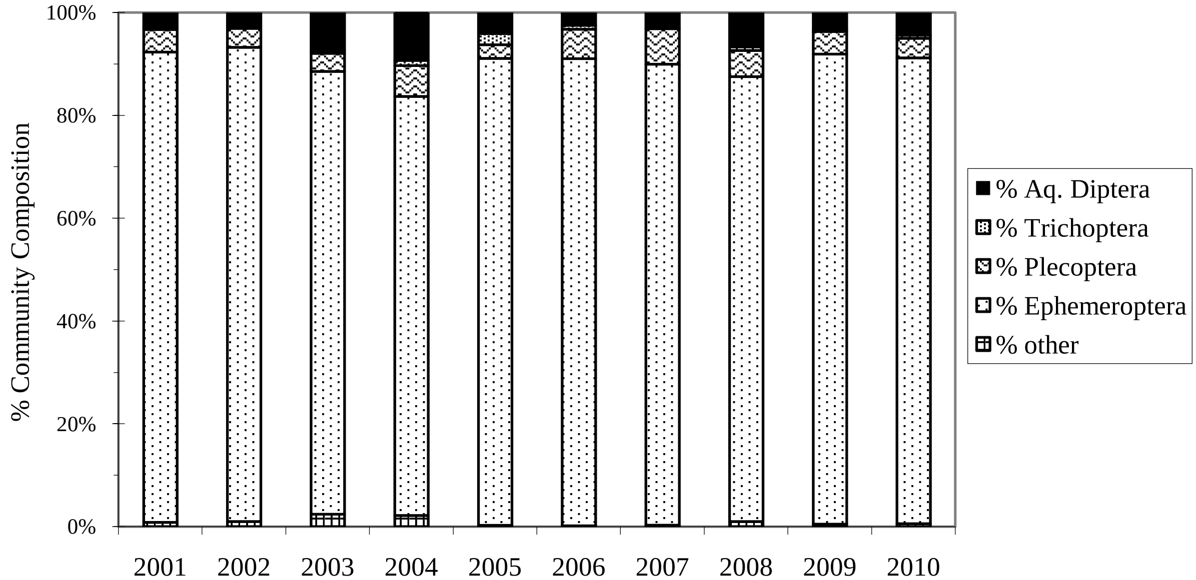

Figure 17.–Benthic macroinvertebrate community composition in Greens Creek Site 54 samples 2001–2010.

Juvenile Fish Populations

The 2010 juvenile fish survey at Site 54 captured 73 Dolly Varden and 1 coho salmon in 29 minnow traps. Six block traps set upstream and 8 block traps set downstream of the fish sample reach captured a total of 9 Dolly Varden. The 2010 juvenile fish population estimates at Site 54 were 80±9 Dolly Varden with an approximate density of 0.24 fish/m^2, and 1 coho with an approximate density of 0.0030 fish/m^2 (Table 7).

The 2010 population estimates and densities for both Dolly Varden and coho are the second lowest observed during the 10-year period at Site 54. The 2010 Dolly Varden population estimate was similar to the 2008 estimate, and significantly less than the estimates observed from 2001 to 2007 and in 2009 (Figure 18). The 2010 coho population estimate is similar to that in 2002, 2003, and from 2006 to 2009, and significantly less than in 2001, 2004 and 2005. The length frequency plot (Appendix C) for captured Dolly Varden suggest multiple age classes of Dolly Varden were present in all years of sampling at Site 54.

About midway through the third set of soaking minnow traps we discovered a brown bear *Ursus arctos* had destroyed 8 of the 29 minnow traps and 7 of the 8 block traps at the downstream end of the fish capture reach. The first minnow trap set captured 47 fish, the second set captured 13 fish, and the undisturbed traps in the third set captured 14 fish. The number of fish captured during the third set may have been higher had the bear not intervened, therefore the 2010 population estimates reported may be slightly underestimated for Site 54.

Table 7.–Juvenile fish population estimates at Greens Creek Site 54 2001–2010.

Year Sampled	Fish Species	No. Fish Caught	FL mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m^2
2001	DV	138	27-162	158 (141-175)	28	0.58
2002	DV	271	33-160	290 (276-304)	28	1.00
2003	DV	232	51-184	331 (275-387)	28	1.8[a]
2004	DV	201	52-161	234 (211-257)	28	1.57
2005	DV	213	52-146	255 (227-283)	28	1.17
2006	DV	217	49-158	254 (229-279)	28	1.22
2007	DV	107	50-145	122 (108-136)	28	0.4[a]
2008	DV	71	45-131	73 (69-77)	28	0.21
2009	DV	93	47-101	117 (95-139)	28	0.36
2010	DV	73	52-151	80 (71-89)	28	0.24
2001	CO	12	32-95	17 (8-26)	28	0.06
2002	CO	21	59-85	21 (21)	28	0.07
2003	CO	8	44-52	8 (8)	28	0.04[a]
2004	CO	24	70-95	31 (20-42)	28	0.21
2005	CO	61	66-93	67 (59-75)	28	0.31
2006	CO	7	62-88	7 (7)	28	0.03
2007	CO	0	---	0	28	0
2008	CO	4	53-69	4 (4)	28	0.01
2009	CO	4	67-73	4 (4)	28	0.01
2010	CO	1	77	1 (1)	28	0.003

[a] Based on estimated wetted area value.

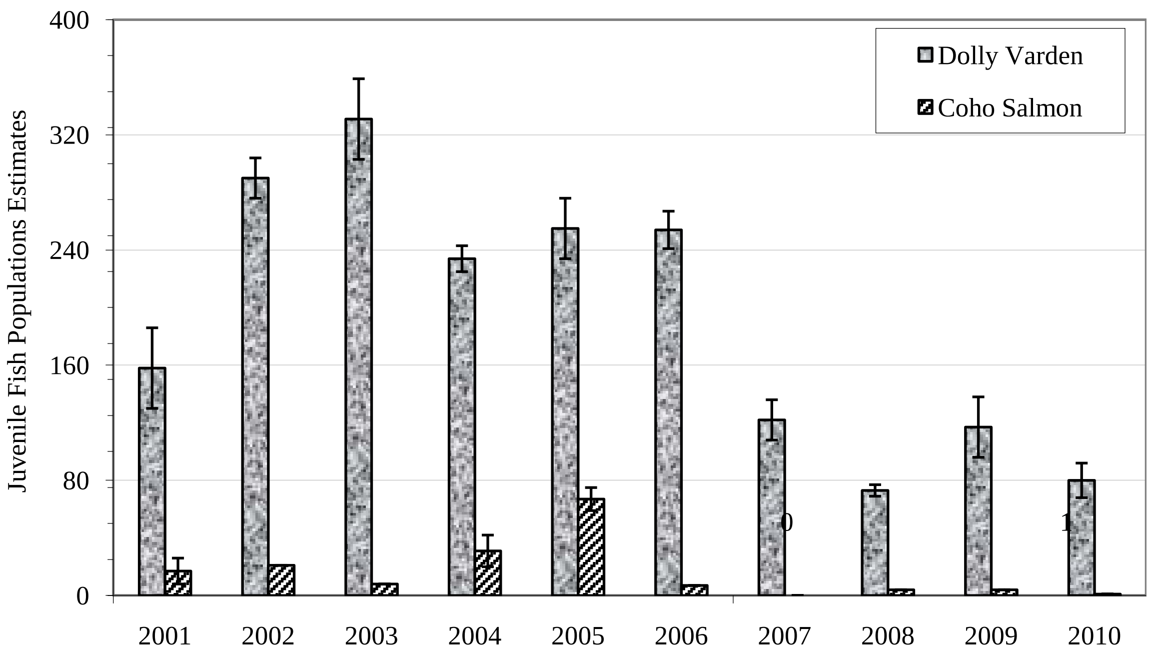

Figure 18.–Juvenile fish population estimates at Greens Creek Site 54 2001–2010.

Metals Concentrations in Juvenile Fish

Median concentrations of metals in juvenile Dolly Varden tissues at Site 54 in 2010 were less than or similar to values observed in most of the previous nine years of sampling. The median concentration of copper was the lowest observed in the 10-year period. Overall, median concentrations of cadmium, copper, lead and selenium were less than tissue concentrations observed during 2009, while median silver and zinc concentrations were slightly higher than values observed in 2009 (Figure 19, Appendix D). The mean rank for copper concentrations in 2010 was significantly less than in 2006, and the mean rank for selenium concentrations in 2010 was significantly less than in 2007. No other statistical differences were observed in the 2010 data when compared to previous years.

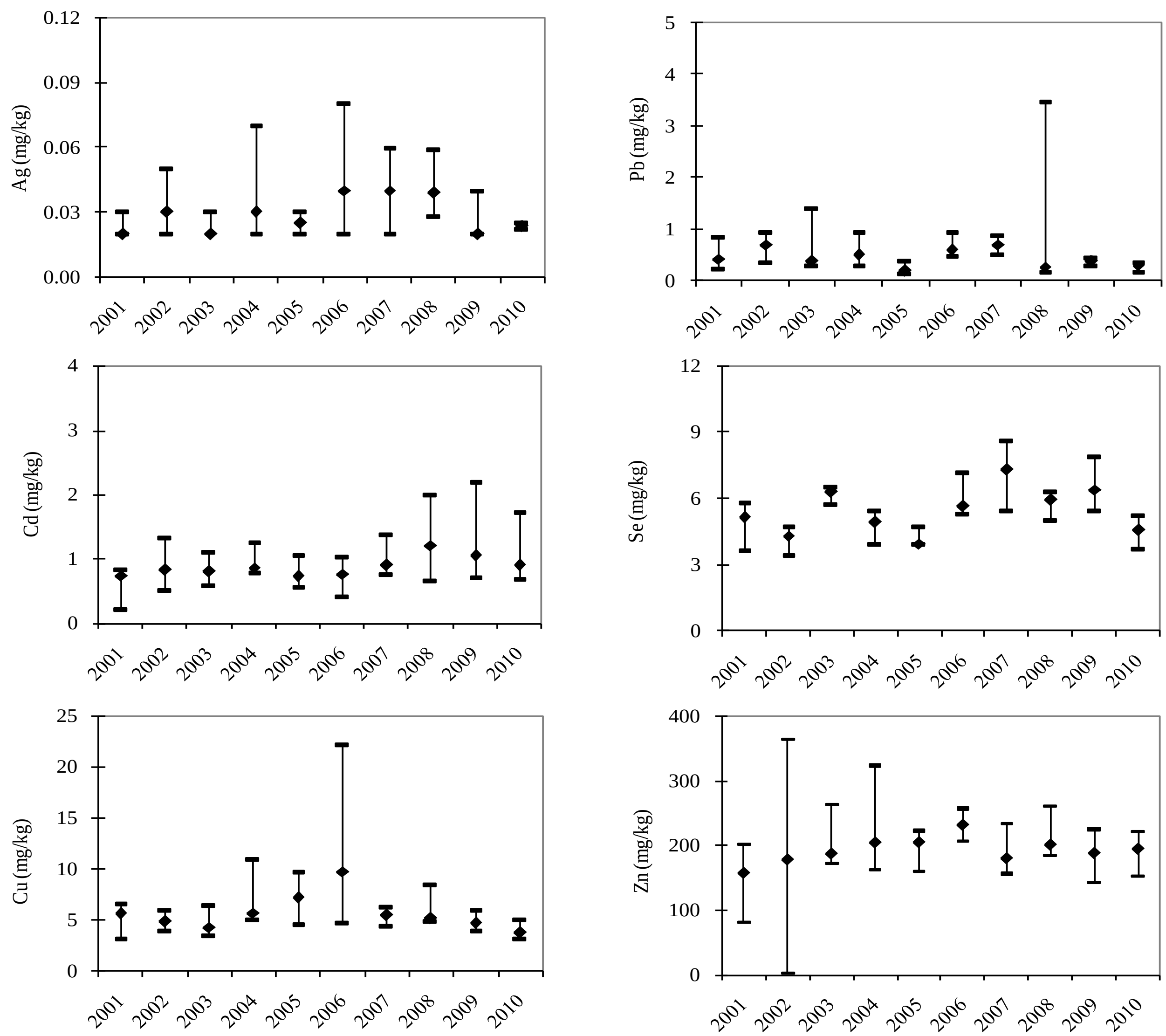

Figure 19.–Whole body metals concentrations in Dolly Varden captured at Greens Creek Site 54 2001–2010.

Summary

Greens Creek Site 54 is located downstream of portal operations and production rock storage areas and is monitored to detect potential effects from these facilities on aquatic life in Greens Creek. In 2010, estimates of periphyton biomass were lower than observed in 2009, similar to 2001, 2002, 2007, and 2008, and significantly less than estimates from samples collected in 2003 and 2006. The low biomass estimates in 2007 and 2008 may be attributed to scouring stream flows prior to sampling as the range of discharges were higher, though biomass estimates at Site 48 were not low in 2007. Biomass estimates for other years likely represent the natural variability of algal communities or changes in water quality at Site 54. Estimate mean benthic macroinvertebrate density and richness were moderate similar to previous years' data and taxa classified under Ephemeroptera continue to be dominant.

The 2010 juvenile Dolly Varden population estimate was the second lowest observed in the 10-year period, though the estimate may be slightly low because a brown bear disrupted the study on the third minnow trap set. We only captured one juvenile coho in 2010, the second lowest capture rate in the 10-year period at Site 54, though other juvenile coho may have been captured in the traps destroyed by the brown bear. Juvenile coho captures have been consistently low since 2006, which suggests the fishpass downstream is not functioning as designed. Juvenile Dolly Varden captured in 2010 appeared to represent more than one age class, including young-of-year fry, which suggests that successful Dolly Varden spawning is occurring in the area. Median concentrations of metals in juvenile Dolly Varden tissues at Site 54 in 2010 were less than or similar to values observed in most of the previous 9 years of sampling. The median concentration of copper was the lowest observed in the 10-year period. The mean rank for copper concentrations in 2010 was significantly less than in 2006, and the mean rank for selenium concentrations in 2010 was significantly less than in 2007. Overall, samples collected in 2010 suggest a productive aquatic community is present at Site 54, though periphyton biomass and juvenile fish population estimates have been low in recent years.

TRIBUTARY CREEK SITE 9

Tributary Creek Site 9 was sampled during the afternoon of July 20, 2010. The weather was overcast with occasional drizzle, light rain fell during the previous evening, air temperature was 17.7°C, and water temperature was 12.5°C (Figure 20). There were no obvious changes in stream course or structures since sampling in 2009, though water level was again quite low and we had difficulty finding sites to set minnow traps and sample benthic macroinvertebrates. HGCMC staff recorded the following water quality measurements in Greens Creek during our sampling: water temperature 12.7°C, conductivity 92.6 μS/cm, and pH 6.43.

Figure 20.–Middle portion of the fish capture reach at Tributary Creek Site 9 during biomonitoring sampling on July 20, 2010.

Periphyton Biomass

Estimates of periphyton biomass in the 2010 samples collected at Site 9 were moderate compared to previous years (Figure 21). The mean ranks of chlorophyll *a* concentrations at Site 9 in 2010 were not significantly different from samples collected in previous years (Appendix A).

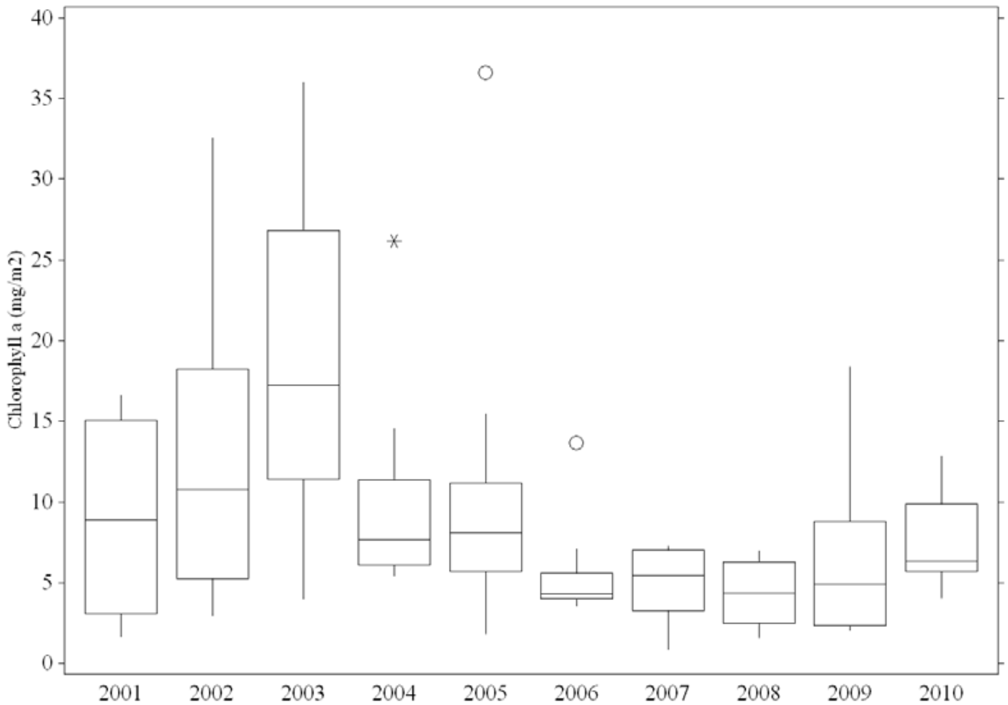

Figure 21.–Periphyton densities at Tributary Creek Site 9 2001–2010.

The relative proportion of chlorophyll *c* compared to chlorophyll *b* among years indicates that diatoms and/or dinoflagellates are typically a greater component of the periphyton community at Site 9 than green algae or euglenophytes (Figure 22).

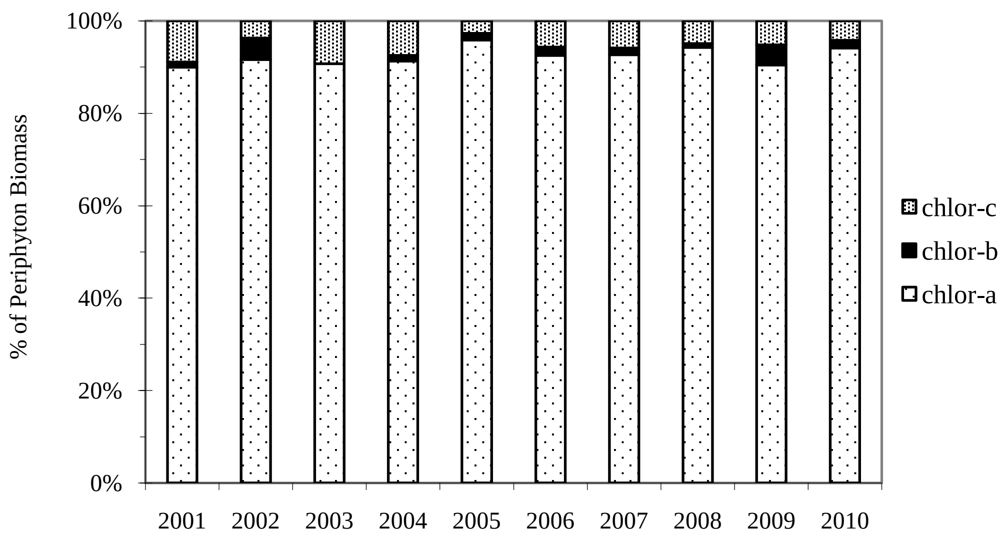

Figure 22.–Mean concentrations of chlorophyll *a*, *b* and *c* in samples from Tributary Creek Site 9 2001–2010.

Benthic Macroinvertebrate Density and Richness

The mean and median benthic macroinvertebrate densities at Site 9 in 2010 were the lowest observed during the 10-year period at this site (Table 8, Figure 23), similar to mean and median densities observed in 2007. Taxonomic richness in 2010 was similar to the average for the previous nine-year period, and similar to samples collected in 2002, 2004, 2006 and 2009. The mean ranks for benthic macroinvertebrate density and richness in 2010 were significantly less than in 2003, and not significantly different compared to other years.

Table 8.–Benthic macroinvertebrate density and richness at Tributary Creek Site 9 2001–2010.

Year	Mean Density (aqua. invert./m^2)	Taxonomic Richness	Mean Taxa Per Sample
2001	1018	21	13.6
2002	1496	24	15.2
2003	5032	36	21.0
2004	2064	26	13.8
2005	1056	30	14.2
2006	1250	26	12.4
2007	436	21	10.0
2008	1506	21	14.6
2009	958[a]	27	13.0
2010	394	25	11.2

[a] Previously misreported.

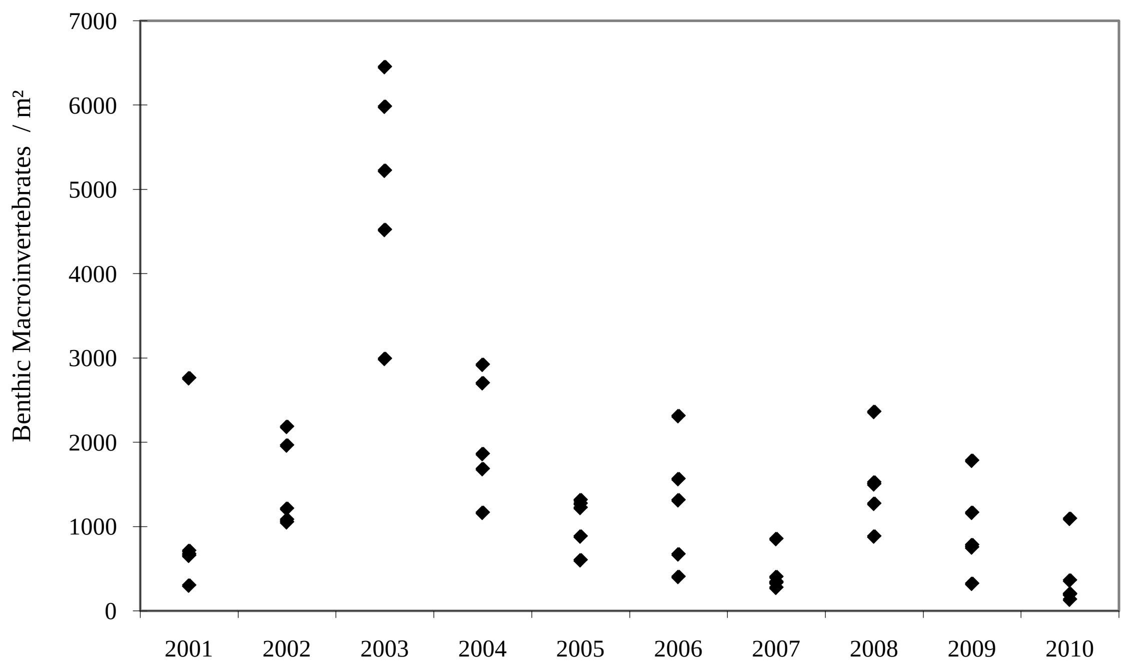

Figure 23. Estimate benthic macroinvertebrate densities in Tributary Creek Site 9 samples 2001–2010.

Pollution-sensitive taxa, such as Ephemeroptera: *Baetis*, *Paraleptophlebia*, and *Ameletus*, were present in 2010 at Site 9 in similar proportions previously observed, while the proportion of *Cinygmula* in 2010 was noticeably lower than observed in the previous four years (Table 9). Chironomidae was the dominant taxon for the second year in a row during the 10-year period of the biomonitoring program (Figure 24). *Baetis* and *Cinygmula* are rated "moderately sensitive", *Paraleptophlebia* and *Ameletus* are rated "sensitive", and Chironomidae is considered "moderately sensitive" (Barbour et al. 1999). The diverse benthic macroinvertebrate community includes both insects and noninsects, such as springtails (Collemola), worms (Oligochaeta), and seed shrimp (Ostracoda; Appendix B). Density and taxonomic richness of benthic macroinvertebrates over the last 10 years at Site 9 peaked in 2003. Since 2003, densities of individual taxa have generally decreased while richness remains fairly consistent between years.

The overall proportion of EPT taxa in the 2010 Site 9 samples (53.8%) was the second lowest observed during the 10-year period, and was similar to the proportion observed in the 2001 samples (53.6%), continuing the low density trend that began in 2005. Proportions of Chironomidae noticeably increased in 2009 (21.9%) from the previous eight-year mean (4.4%), and was similar in 2010 (22.8%). The increased proportion of aquatic Diptera species began 2008 when Simuliidae flourished, though species of that family were uncommon in 2009 and absent in the 2010 samples (Figure 25).

Table 9.–Percentages of common (>5%) benthic macroinvertebrate taxa in Tributary Creek Site 9 samples 2001–2010.

Order	Taxon	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Ephemeroptera	*Baetis*	8%	16%	6%	-	7%	-	-	10%	-	7.6%
	Ephemerella	-	-	-	-	-	12%	-	-	-	-
	Cinygma	-	-	-	-	8%	-	-	-	-	-
	Cinygmula	17%	**24%**	**20%**	-	-	20%	**20%**	**28%**	15%	6.1%
	Paraleptophlebia	13%	13%	10%	**43%**	**36%**	**33%**	17%	15%	15%	21%
	Ameletus	-	-	-	-	-	-	8%	-	7%	6.1%
Plecoptera	*Suwallia*	7%	-	-	-	7%	-	-	-	-	-
	Sweltsa	-	6%	-	-	-	-	12%	-	-	-
	Neaviperla	-	-	7%	-	-	-	-	-	-	-
	Zapada	-	-	15%	-	8%	-	-	-	7%	1.5%
Diptera	Chironomidae	7%	-	-	-	8%	-	-	-	**22%**	**23%**
	Simulium	8%	-	-	-	-	-	-	26%	-	-
Acarina		-	6%	-	-	-	-	-	-	-	-
Oligochaeta		8%	-	14%	11%	-	-	12%	-	-	0.5%
Ostracoda		**18%**	-	8%	-	-	11%	8%	-	-	15%
Isopoda	*Gammarus*	-	14%	-	-	-	-	-	-	-	-

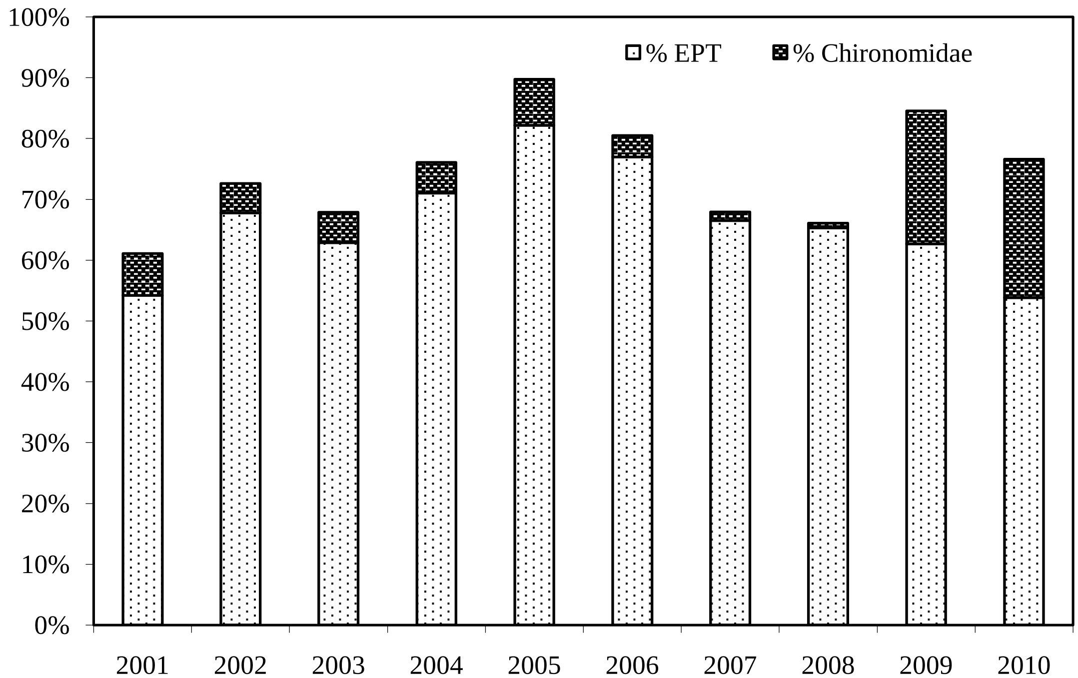

Figure 24.–Percent EPT taxa and Chironomidae in Tributary Creek Site 9 samples 2001–2010.

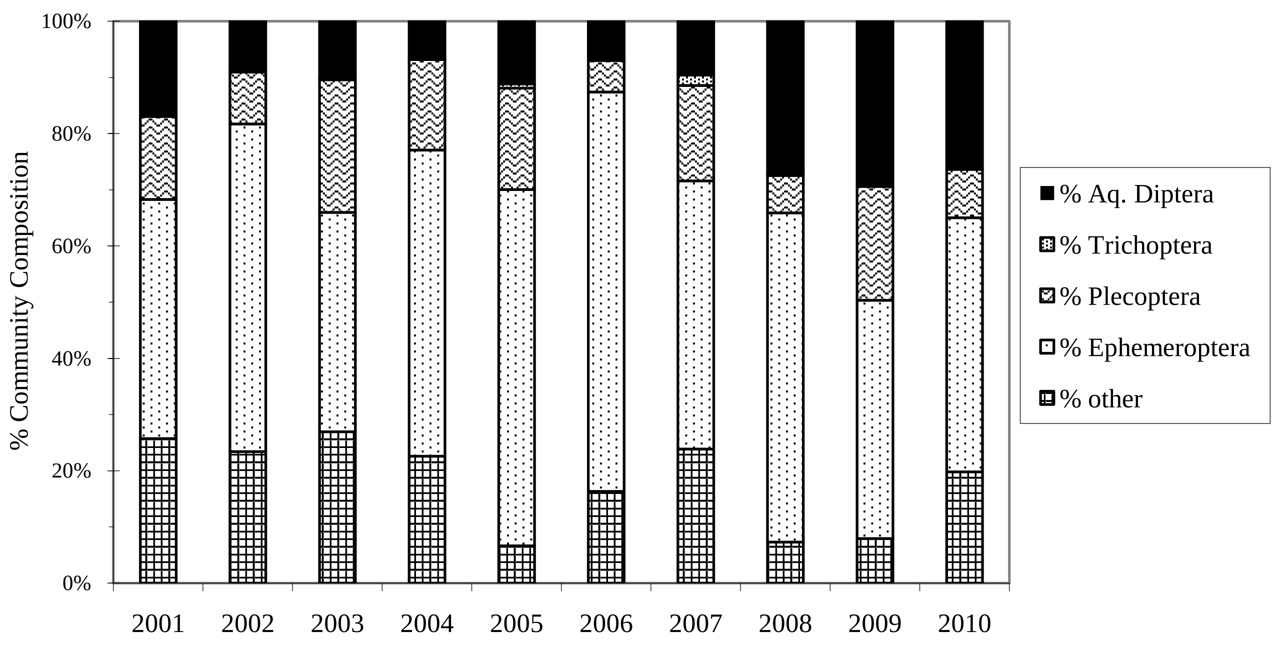

Figure 25.–Benthic macroinvertebrate community composition in Tributary Creek Site 9 samples 2001–2010.

Juvenile Fish Populations

The 2010 juvenile fish survey at Site 9 captured 59 Dolly Varden, 128 coho salmon, 5 cutthroat trout, and 5 sculpin (undifferentiated) in 21 minnow traps. Five block traps set upstream and 5 block traps set downstream of the fish sample reach captured a total of 11 Dolly Varden, 34 coho, 1 cutthroat and 11 sculpin. The 2010 juvenile fish population estimates at Site 9 were 109±44 Dolly Varden with an approximate density of 0.97 fish/m^2, and 147±17 coho with an approximate density of 1.31 fish/m^2 (Table 10).

The 2010 population estimate and density for Dolly Varden were the highest observed during the 10-year period of biomonitoring sampling at Site 9, while the coho population estimate was one of the highest and the density the greatest. The 2010 Dolly Varden population estimate was significantly more than previous years except 2001 and 2005, and the coho population estimate was significantly more than previous years except 2005 and 2008 (Figure 26).

Table 10.–Juvenile fish population estimates at Tributary Creek Site 9 2001–2010. Captures of incidental species (cutthroat trout, rainbow trout, and sculpin) at this site are listed in Appendix 4.

Year Sampled	Fish Species	No. Fish Caught	FL, mm	Popn Estimate, fish (95% CI)	Sample Reach, m	Density, fish/m^2
2001	DV	81	58-110	81 (81)	44	0.92
2002	DV	51	38-147	56 (49-63)	50	0.46
2003	DV	19	54-114	20 (17-23)	50	0.3[a]
2004	DV	32	64-109	33 (31-35)	50	0.56
2005	DV	44	59-131	55 (41-69)	50	0.42
2006	DV	11	85-117	11 (11)	50	0.09
2007	DV	12	81-158	12 (12)	50	0.10
2008	DV	22	60-108	22 (22)	50	0.16
2009	DV	38	48-98	42 (35-49)	50	0.35
2010	DV	59	58-108	109 (65-153)	50	0.97
2001	CO	118	39-101	120 (117-123)	44	0.80
2002	CO	44	27-85	46 (42-50)	50	0.35
2003	CO	52	46-88	53 (51-55)	50	0.8[a]
2004	CO	27	40-94	27 (27)	50	0.46
2005	CO	139	39-103	150 (139-161)	50	1.15
2006	CO	10	69-108	10 (10)	50	0.08
2007	CO	69	38-104	71 (67-75)	50	0.58
2008	CO	142	41-100	169 (147-191)	50	1.27
2009	CO	53	38-116	53 (53)	50	0.44
2010	CO	128	39-90	147 (130-164)	50	1.31

[a] Based on estimated wetted area value.

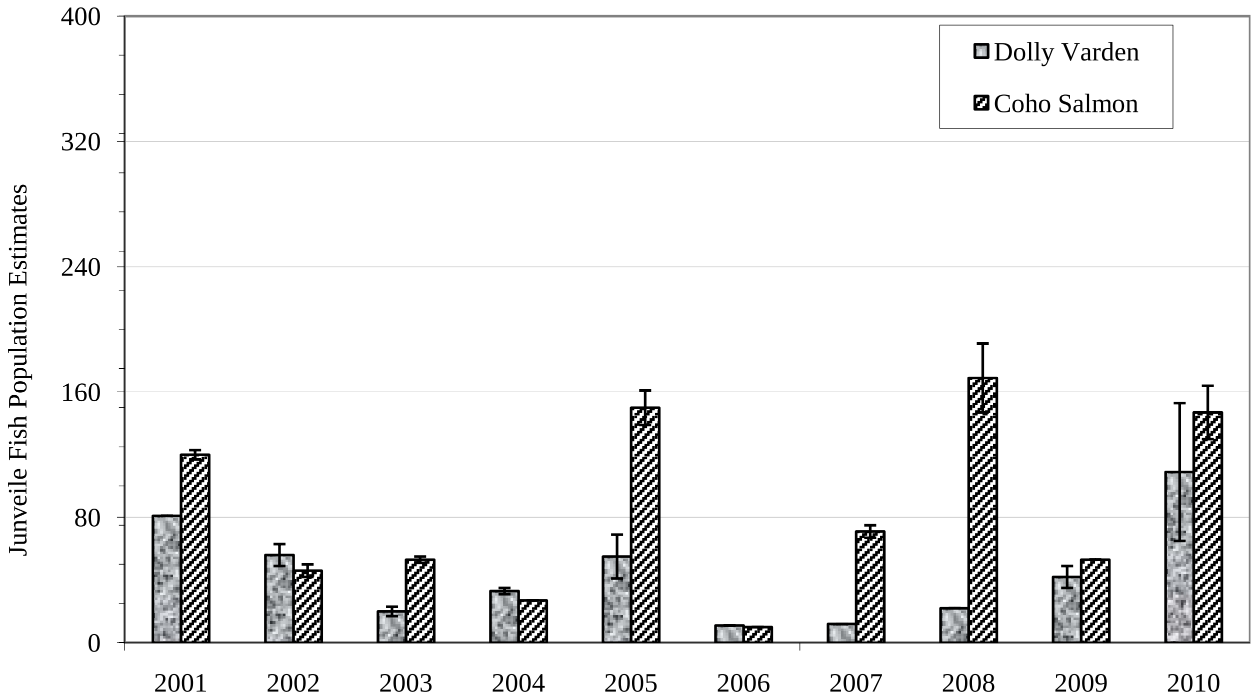

Figure 26.–Juvenile fish populations at Tributary Creek Site 9 2001-2010.

The length frequency plots (Appendix C) for captured Dolly Varden and coho suggest multiple age classes of both species were present at Site 9 during the 2010 fish survey. Young-of-year Dolly Varden 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.

Metals Concentrations in Juvenile Fish

Median concentrations of metals in juvenile Dolly Varden tissues at Site 9 in 2010 were similar to values observed in most of the previous nine years of sampling. The median concentrations of lead and selenium were the lowest observed during the 10-year period, while the mean concentration of zinc was second highest. Overall, median concentrations of silver, cadmium, copper, and zinc were higher than tissue concentrations observed during 2009, (Figure 27, Appendix D). No statistical differences were observed when the 2010 data were compared to previous years' data.

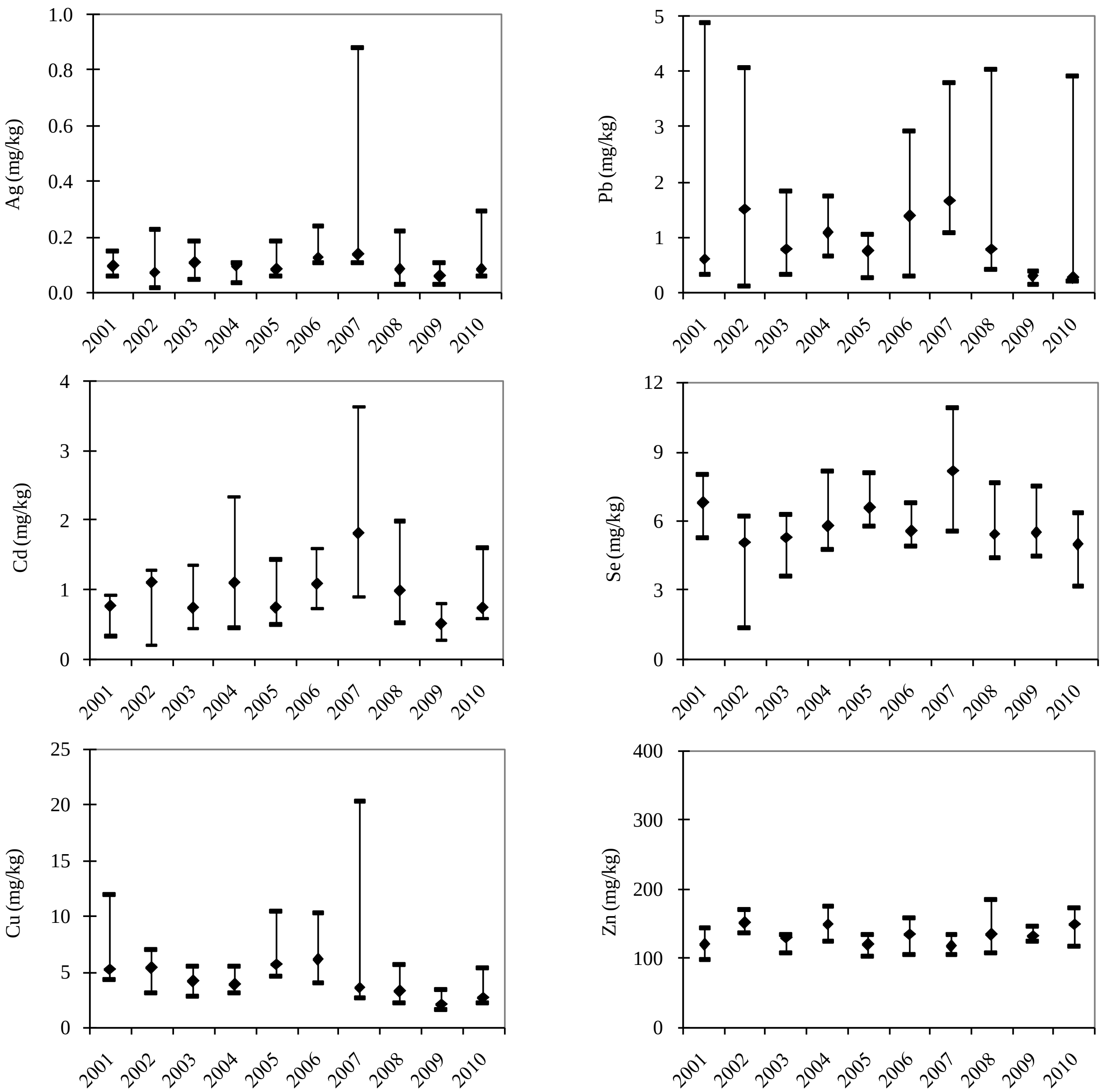

Figure 27.–Whole body metals concentrations in Dolly Varden captured at Tributary Creek Site 9 2001–2010.

Summary

Tributary Creek Site 9 is located about 1.6 km downstream of the dry stack tailings facility and is monitored to detect potential effects from the tailings facility and road runoff on aquatic life in Tributary Creek. In 2010, estimates of periphyton biomass were moderate and similar to biomass estimates for the previous years. The mean benthic macroinvertebrate density in 2010 was the lowest observed during the 10-year period, though richness was moderate. Taxa classified under Ephemeroptera continue to be dominant, while Chironomidae taxa accounted for 23% of the samples, which was similar to that observed in 2009, and unlike previous years.

The 2010 juvenile Dolly Varden population estimate was the highest observed during the 10-year period, and the coho population estimate was the third highest. This combined juvenile fish population estimate was the highest observed during the 10-year period at Site 9. Juvenile Dolly Varden and coho captured in 2010 appeared to represent more than one age class, including young-of-year fry, which suggests that successful spawning is occurring in the area. Median concentrations of metals in juvenile Dolly Varden tissues at Site 9 in 2010 were similar to values observed in most of the previous nine years of sampling. The median concentrations of lead and selenium were the lowest observed in the 10-year period, while the mean concentration of zinc was the second highest. Overall, samples collected in 2010 suggest a productive aquatic community is present at Site 9, except for the low benthic macroinvertebrate densities observed.

Comparison Among Sites

Periphyton Biomass

Estimates of periphyton biomass at Greens Creek Site 48 and Site 54 have demonstrated similar patterns over the 10-year period under the biomonitoring program, with peak densities observed from 2003 to 2006 (Figure 28). Stream flows in Greens Creek during sampling from 2003 to 2006 were lower than in other years, which may explain the higher periphyton densities. The trend for periphyton biomass estimates in Tributary Creek samples are similar, with the highest densities observed from 2001 to 2005 and low-moderate densities observed from 2006 to 2010. Continuous stream discharge data is not available for Tributary Creek to evaluate hydrological influence. Samples from Site 54 demonstrated a lower biomass in 2010 than 2009 while samples from Site 48 and Site 9 demonstrated a slightly higher biomass than 2009. The mean ranks for chlorophyll *a* concentrations in 2010 were significantly different between Greens Creek Site 54 and Tributary Creek Site 9 samples, but not between Greens Creek sites 48 and 54 samples. The mean ranks for chlorophyll *a* concentrations in 2010 were significantly different between the combined Greens Creek sites 48 and 54 samples and the Tributary Creek Site 9 samples.

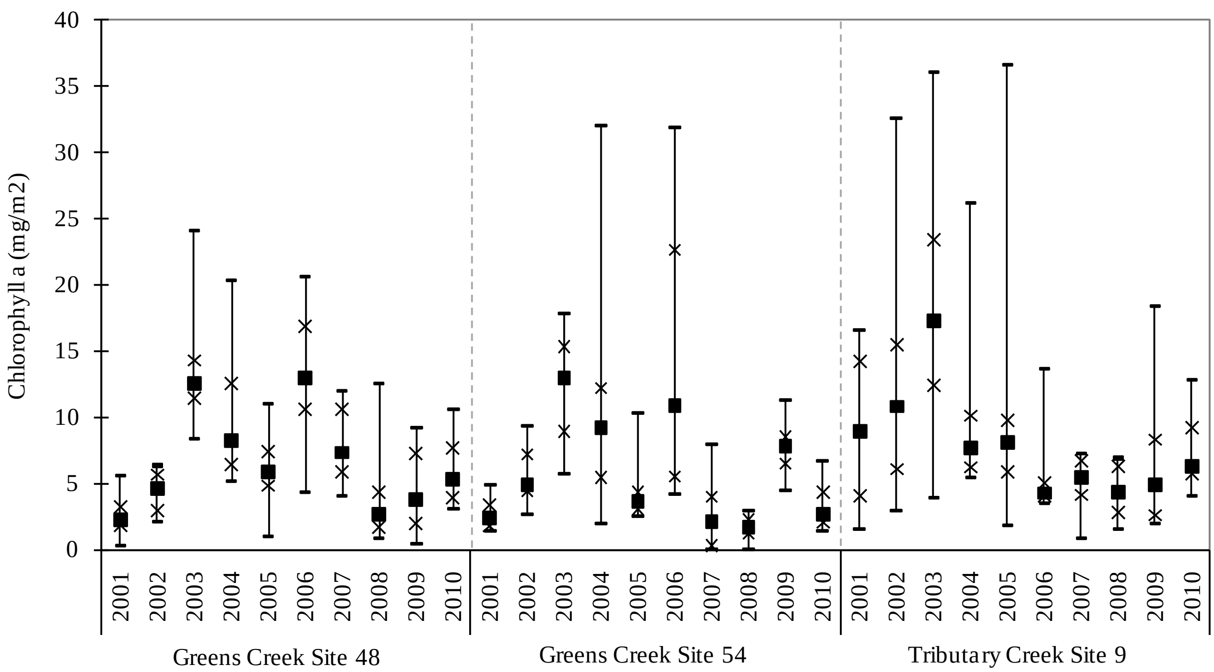

Figure 28.–Comparison of periphyton biomass among Greens Creek Mine biomonitoring sites 2001–2010.

Periphyton samples collected from 2001 to 2010 from Greens Creek sites 48 and 54 primarily contained chlorophyll *a*, with nearly no chlorophyll *b* and generally less than 10% of chlorophyll *c*, except in the 2009 samples when chlorophylls *b* and *c* were both elevated (Figure 29). Greater proportions of chlorophyll *b* were present in Tributary Creek Site 9 samples collected from 2001 to 2010 compared to Greens Creek sites 48 and 54 samples, though proportions of chlorophyll *c* between sites are similar.

Chlorophyll *a* is a pigment produced during photosynthesis in algae and is a useful indicator to estimate periphyton biomass when monitoring primary production in algal communities. Chlorophyll *b* and *c* are accessory pigments produced by certain types of algae and provide information on those types of algae locally occurring (Wetzel 1983). Presence and absence of chlorophyll *b* pigments in samples collected at Site 48, Site 54 and Site 9 over the 10-year period suggest green algae or euglenophytes are occasionally present in the periphyton community at each site, while chlorophyll *c* is present in all years and indicates diatoms and dinoflagellates are a regular component of the periphyton community at each site (Speer 1997).

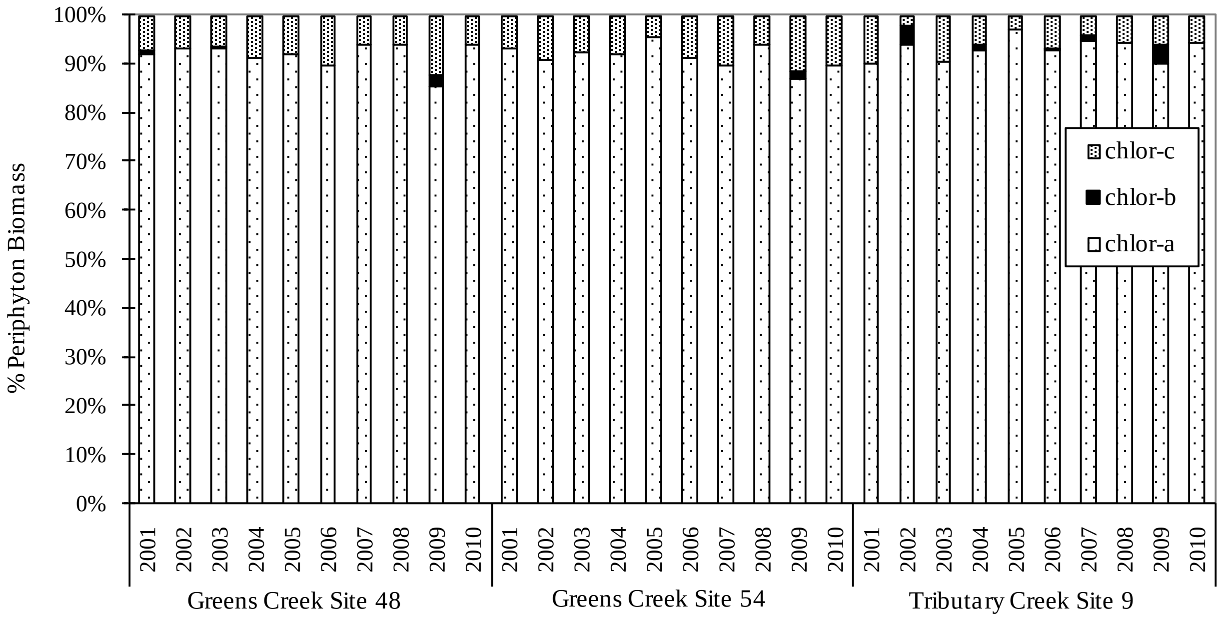

Figure 29.–Comparison of proportions of mean chlorophyll *a*, *b*, and *c* concentrations among Greens Creek Mine biomonitoring sites 2001–2010.

Benthic Macroinvertebrate Density and Richness

Mean benthic macroinvertebrate density and taxonomic richness increased from 2009 at Greens Creek sites 48 and 54; however, mean density decreased at Tributary Creek Site 9 to the lowest observed in the 10-year period (Figure 30). The mean rank for the combined density from samples collected at Site 48 and Site 54 in 2010 was statistically different from the mean rank for the density at Site 9, while taxonomic richness was not statistically different between sites.

Samples collected from each of the three sites in 2010 revealed that the benthic macroinvertebrate communities were diverse with abundant numbers of taxa in each sample, even at Tributary Creek Site 9 where samples contained fewer organisms. More than 50% of the macroinvertebrates in samples from Site 48 and Site 54 were from two dominant taxa, while three dominant taxa accounted for more than 50% of the invertebrates in samples from Site 9, similar to previous years. Taxonomic richness was moderate at each of the three sites in 2010 and the mean ranks for richness in samples collected in 2010 were not statistically different between sites.

For all sites combined by year, the mean rank of the benthic macroinvertebrate densities for the years 2001, 2002 and 2005 to 2009 were significantly less than in 2003, and richness was significantly less than 2003 in years 2006, 2007, 2009, and 2010. Stream flow in Greens Creek prior to and during sampling in 2003 was the lowest observed during the 10-year period of the biomonitoring program, which may explain why both benthic macroinvertebrates and periphyton biomass were abundant in the 2003 samples. Aquatic habitats with moderate stream flows, such as Tributary Creek, typically have more macroinvertebrate taxa present compared to streams with variable habitats, such as Greens Creek, where fewer taxa usually dominate the macroinvertebrate communities (Hynes 1970).

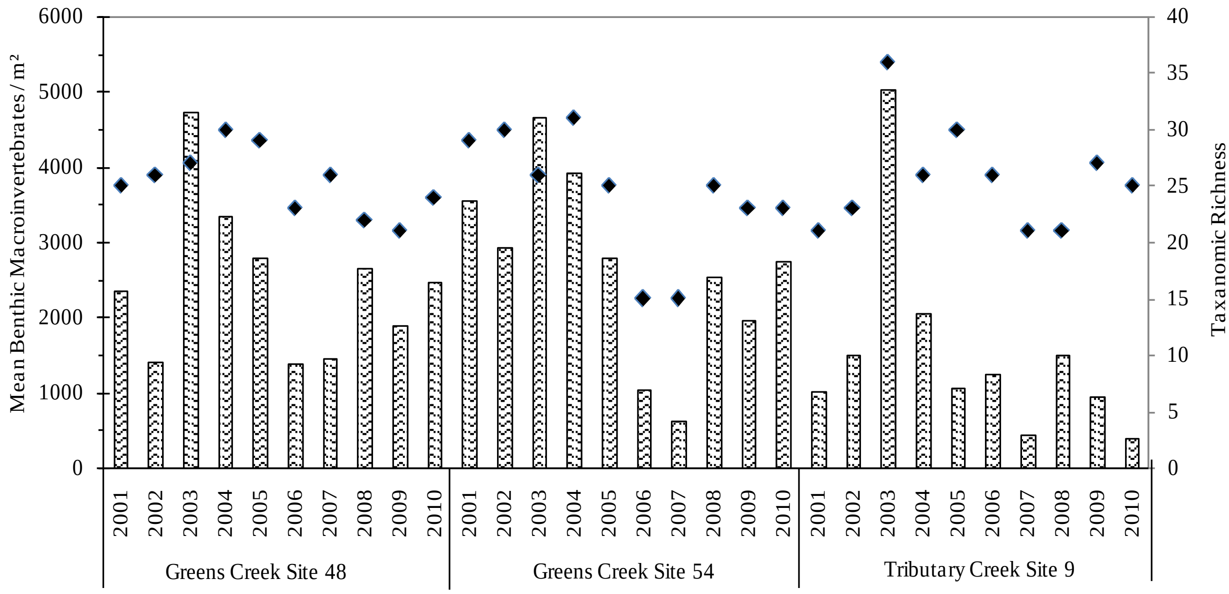

Figure 30.–Comparison of mean benthic macroinvertebrate densities and richness among Greens Creek Mine biomonitoring sites 2001–2010.

Many taxa classified in the Orders Ephemeroptera, Plecoptera, and Trichoptera are sensitive to pollutants (Merritt and Cummins 1996). In 2010 and similar to previous years, more than 90% of macroinvertebrates collected at Site 48 and Site 54 were EPT taxa, while more than 50% of the samples collected at Site 9 contained EPT taxa (Figure 31). Presence of Chironomidae was variable at Site 48 and Site 54 over the 10-year period, and fairly consistent at Site 9 from 2001 to 2006. Chironomidae were less present at Site 9 in 2007 and 2008 compared to previous years, and was the dominant taxa in 2009 and 2010—tripling in density and accounting for more than 22% of samples.

The benthic macroinvertebrate communities at Greens Creek Site 48 and Site 54 are similar between years though somewhat different than at Tributary Creek Site 9 (Figure 32). In Greens Creek, communities are dominated by Ephemeroptera with few Plecoptera and aquatic Diptera taxa, while Tributary Creek communities are less dominated by Ephemeroptera and have more noninsect invertebrates. These differences in community composition are most likely due to the different physical characteristics and habitat types present at each sample site.

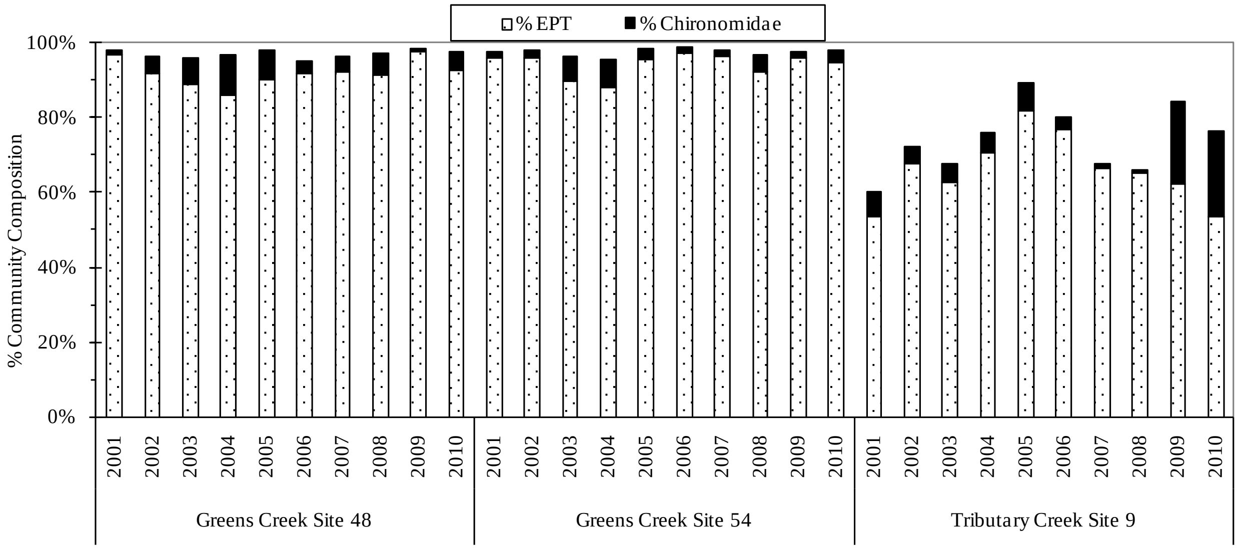

Figure 31.–Comparison of percent EPT taxa and Chironomidae among Greens Creek Mine biomonitoring sites 2001–2010.

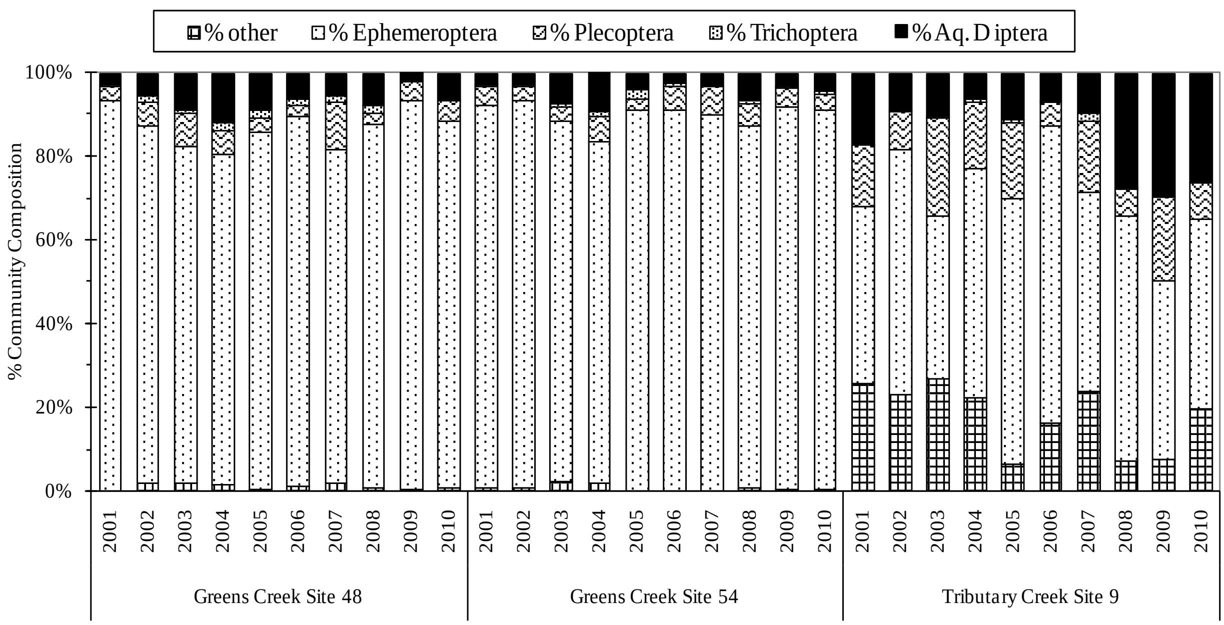

Figure 32.–Comparison of benthic invertebrate community composition among Greens Cerek Mine biomonitoring sites 2001–2010.

Overall, benthic macroinvertebrate densities and diversities observed at each site in 2010 were similar to those observed in the previous nine years of sampling under the biomonitoring program. The low densities observed in samples from Tributary Creek may indicate water quantity or habitats are changing in Tributary Creek as moderate taxonomic richness suggests good water quality is present at Site 9. Moderate 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.

Juvenile Fish Populations

The Dolly Varden population estimate at Greens Creek Site 48 increased slightly from 2009 to 2010, and was a moderate estimate compared to the previous nine years. At Greens Creek Site 54, the 2010 Dolly Varden population estimate was significantly lower than in 2009, the second lowest observed in the 10-year period, though the population may be slightly underestimated due to a brown bear destroying several minnow traps during the third trap set. Coho salmon captured at Site 54 were low in 2010, similar to the previous four years. The 2010 Dolly Varden population estimate at Tributary Creek Site 9 was the highest observed at this site during the 10-year period, and combined with a high coho salmon population estimate and other species captured, the overall juvenile fish population estimate for 2010 at Site 9 was the highest observed during the 10-year period (Figure 33). The population estimates for Dolly Varden and coho were significantly higher than the previous year at Site 9.

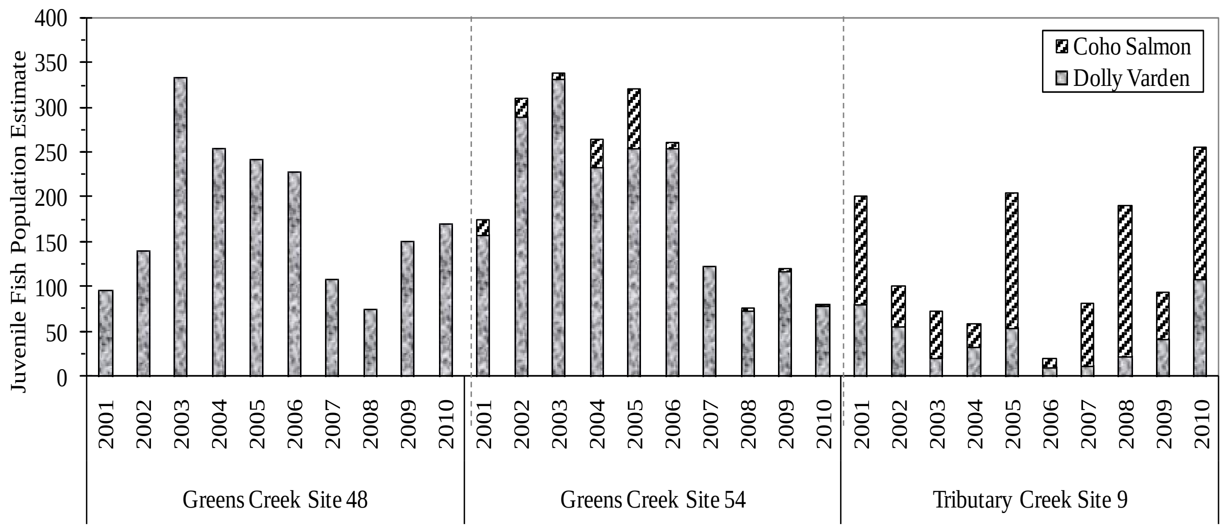

Figure 33.–Comparison of juvenile fish population estimates at Greens Creek biomonitoring sites 2001–2010.

Dolly Varden population sizes at Site 48 and Site 54 show similar trends over the 10-year period. Dolly Varden populations at both sites were lowest in 2008, and while the population at Site 48 has increased since 2008, the population at Site 54 remains low. Low coho captures at Site 54 since 2006 suggest the fishpass is not functioning properly, and HGCMC plans to replace some of the fishpass weirs this year. A severe rainstorm in late 2005 is believed to have dislodged several of the weirs, reducing fishpass function. Juvenile fish populations at Site 9 were highly variable between years and did not follow a similar trend as the Greens Creek sites.

Due to differences in stream types, aquatic habitats at Greens Creek sites 48 and 54 greatly differ from habitats at Tributary Creek Site 9, which may explain the differences in magnitude of juvenile fish populations between sites. Dolly Varden prefer to spawn at the edges of pools with low velocities and gravel sizes from 1 to 4 cm (Ihlenfeldt 2005), while coho salmon prefer to spawn in riffle areas (McPhail and Lindsey 1970). Both habitats are common at the two Greens Creek sites, though riffles and pools are limited at Tributary Creek 9 due to consistent low flow and little substrate and woody debris movement. Most spawning in Tributary Creek occurs downstream and near the confluence of Zinc Creek where suitable habitats are available, therefore Site 9 generally only provides rearing habitat for juvenile fish. Juvenile fish rearing habitat use at Site 9 is dependent on emigration from those spawning areas, which may explain the variable population estimates between years. The high population estimate at Site 9 in 2010 may also explain the low benthic macroinvertebrate densities observed, as invertebrates are an important food source for juvenile fish.

Metals Concentrations in Juvenile Fish

Median metals concentrations of silver, selenium, cadmium and copper in juvenile Dolly Varden tissues collected at Site 48 were slightly higher than in Dolly Varden tissues collected at Site 54 in 2010, while lead and zinc were slightly higher at Site 54, though none of the mean ranks for the metals were statistically different between sites (Figure 34). When the 2010 metals concentration data for the two Greens Creek sites were combined and compared to the 2010 metals concentration data for Tributary Creek Site 9, the mean ranks of the Site 9 samples were significantly higher in silver while the mean ranks of the Greens Creek samples were significantly higher in copper and zinc. No other statistical differences were found.

For comparison, metals concentrations from three Dolly Varden collected in 2000 at Upper Slate Lake and three Dolly Varden at Lower Slate Lake near the Kensington Gold Mine (KGM), located about 80 km north of Greens Creek Mine, are also shown in Figure 34 (Kline 2001). At the time, Coeur Alaska, Inc's KGM had not been constructed, therefore samples and results are considered baseline data. The mean ranks of the KGM tissue metals concentrations were not significantly different compared to the mean ranks of the 2010 copper and zinc tissue concentrations collected at the Greens Creek Mine biomonitoring sites, though the mean ranks of the KGM data were significantly different than the mean ranks of silver and lead concentrations in samples from Site 9, mean ranks of cadmium in samples from Site 48, and mean ranks of cadmium, lead and selenium samples from Site 54.

Summary

The three biomonitoring sites sampled in 2010 continue to suggest that productive and diverse aquatic communities exist, though some populations have been low in recent years, particularly periphyton biomass at Site 54, benthic macroinvertebrate densities and the decreasing proportion of EPT taxa at Site 9, and Dolly Varden populations and few juvenile coho present at Site 54. Variability between Greens Creek and Tributary Creek sites can be somewhat attributed to substantial differences in stream types and habitat availability, and are an important factor when considering each population at each site.

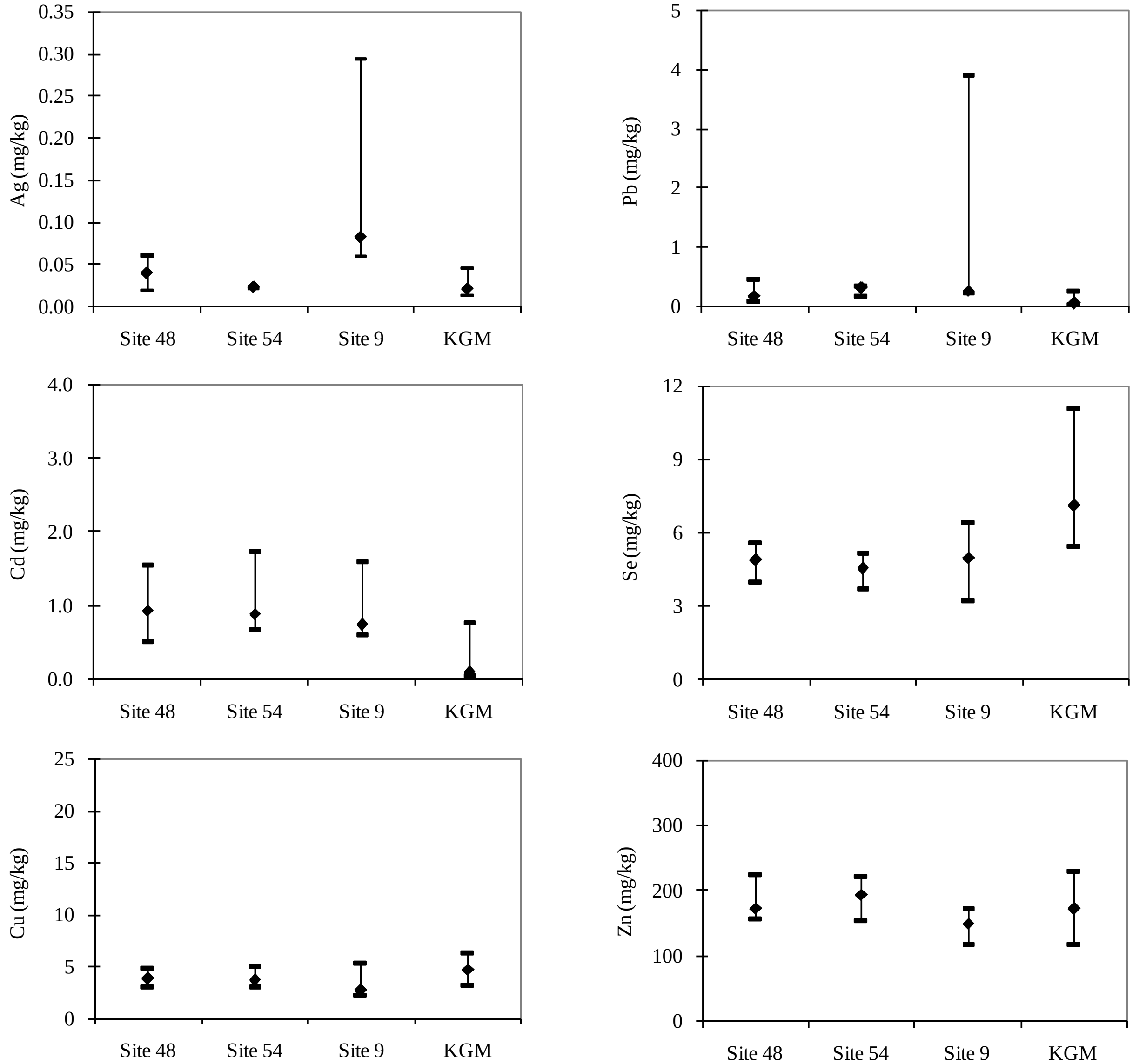

Figure 34.–Comparison among sites of whole body metals concentrations in Dolly Varden captured at Greens Creek biomonitoring sites in 2010, and near the Kensington Gold Mine in 2000.

CONCLUSIONS

The three biomonitoring sites sampled in 2010 (Greens Creeks sites 48 and 54 and Tributary Creek Site 9) continued to show that populations on many levels were abundant and similar to the previous nine years of sampling under the Greens Creek Mine aquatic biomonitoring program. During sampling in 2010, stream discharge in Greens Creek was moderate, while discharge at Tributary was low and difficult to measure because of natural, physical stream characteristics present at Site 9.

Estimates of periphyton biomass at Site 48 and Site 9 were moderate in 2010 and increased from 2009, though periphyton biomass was low at Site 54 similar to samples collected in 2007 and 2008. Sampling over the 10-year period under the biomonitoring program occurred at various flows, which may explain the variability in estimates of periphyton biomass observed at each site. Greens Creek sites 48 and 54 show a similar trend for biomass over the 10-year period, while Site 9 biomass estimates are variable between years, an indication that hydrological regimes influence algal abundance at each site.

Mean benthic macroinvertebrate density increased at Site 48 and Site 54 in 2010 from 2009, and decreased at Site 9 to the lowest observed over the 10-year period. Richness and percent EPT taxa were moderate at each site, which suggests good water quality was present. Decreased benthic macroinvertebrate abundance at Site 9 may indicate water quantity or habitats are changing, or it may be the result of increased predators as invertebrates are an important food source for resident and juvenile fish. The 2010 juvenile fish population estimate at Site 9 was the highest observed during the 10-year period. The proportion of aquatic Diptera in Tributary Creek samples was greater than observed in previous years at that site and at the two Greens Creek sites, which may also indicate aquatic habitats are changing at Site 9.

The moderate Dolly Varden population estimate at Site 48 increased slightly in 2010, decreased significantly at Site 54 to the second lowest observed during the 10-year period, and increased significantly at Site 9 to the highest observed during the 10-year period. The coho salmon population at Site 54 was again very low, similar to the previous four years and suggests that the fishpass is not functioning as designed. However, the total juvenile fish population at Site 54 may be slightly underestimated in 2010 as a brown bear destroyed several minnow traps during the third set, which may have contained fish that were not included in the population estimate calculation. Lengths of fish captured at each site suggest multiple age classes of juvenile fish were present. For the first time in the 10-year period, total fish densities per square meter of wetted stream area were lower at Site 54 than Site 48, and highest at Site 9.

The ranges of whole body metals concentrations in juvenile Dolly Varden collected in 2010 were generally similar to or less than the values observed in previous years' samples collected at each site, except that the mean ranks for copper at sites 48 and 54 were significantly lower in 2010 than 2006, and the mean rank for selenium at Site 54 was significantly lower in 2010 than in 2007. When the 2010 Greens Creek samples were combined, the mean rank for Greens Creek samples for copper and zinc were significantly higher than the 2010 mean rank for Tributary Creek samples, and the mean rank for silver in the Tributary Creek samples was significantly higher than the mean rank of Greens Creek samples.

Overall, the Greens Creek sites 48 and 54 and Tributary Creek Site 9 have supported abundant and diverse aquatic communities over the 10-year period. Differences between years and between creeks are generally of larger magnitude than differences between reference Site 48 and downstream of development at Site 54. However, low populations have been recently observed, particularly periphyton biomass at Site 54, benthic macroinvertebrate densities and the decreasing proportion of EPT taxa at Site 9, and Dolly Varden populations and few juvenile coho present at Site 54. These changes in populations may be due to changes in stream flow, habitat availability, or water quality, and will continue to be monitored under the biomonitoring program as required by the regulatory agencies. None of these changes can be directly attributed to development or operation of the Greens Creek Mine, except that the fishpass has not functioned as designed for the last several years.

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APPENDIX A: PERIPHYTON BIOMASS DATA

Appendix A .–Periphyton biomass in Greens Creek Mine biomonitoring samples 2001–2010.

	2001			2002			2003			2004		
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
Upper Greens Creek Site 48												
	1.9143	0.0121	0.1393	5.1650	0.0000	0.2948	14.4103	0.0000	1.2645	18.0492	0.0000	2.0334
	1.8257	0.0000	0.1830	4.0309	0.0000	0.2146	17.8250	0.0255	1.5659	6.7284	0.0000	0.6901
	5.6124	0.0000	0.6948	6.2095	0.0000	0.7130	8.4320	0.0890	0.3896	8.9712	0.0000	0.8982
	0.3127	0.0790	0.0582	2.8302	0.0000	0.2460	9.5307	0.0086	0.6354	12.8160	0.0000	1.4537
	2.9595	0.0375	0.3613	5.1572	0.0000	0.7548	11.3567	0.0000	0.7204	5.4468	0.0000	0.6233
	5.4420	0.0000	0.6166	6.3926	0.0000	0.7539	11.7638	0.0156	0.8633	20.3988	0.0000	2.1499
	3.3793	0.0000	0.4670	5.8430	0.0000	0.7291	24.0949	0.0000	2.1368	6.3012	0.0000	0.4491
	1.8669	0.0338	0.1460	2.0910	0.0722	0.2479	13.3054	0.1280	0.9883	11.6412	0.0000	1.3841
	2.6348	0.1374	0.1442	3.2026	0.0000	0.3583	11.5404	0.0000	0.5652	7.4760	0.0000	0.6511
	1.2286	0.0227	0.1649	2.5588	0.0000	0.1507	13.9690	0.0000	0.8948	5.2332	0.0000	0.5452
median	2.2746	0.0174	0.1740	4.5941	0.0000	0.3265	12.5346	0.0043	0.8790	8.2236	0.0000	0.7941
max	5.6124	0.1374	0.6948	6.3926	0.0722	0.7548	24.0949	0.1280	2.1368	20.3988	0.0000	2.1499
min	0.3127	0.0000	0.0582	2.0910	0.0000	0.1507	8.4320	0.0000	0.3896	5.2332	0.0000	0.4491
Middle Greens Creek Site 6												
	5.0689	0.0000	0.7004	-	-	-	-	-	-	-	-	-
	7.1544	0.0349	0.7218	-	-	-	-	-	-	-	-	-
	4.4715	0.0000	0.7804	-	-	-	-	-	-	-	-	-
	1.2695	0.0744	0.2259	-	-	-	-	-	-	-	-	-
	3.1962	0.0000	0.4260	-	-	-	-	-	-	-	-	-
	1.6426	0.0000	0.1421	-	-	-	-	-	-	-	-	-
	0.9033	0.1012	0.1440	-	-	-	-	-	-	-	-	-
	2.5114	0.0000	0.1574	-	-	-	-	-	-	-	-	-
	6.8816	0.0000	1.0188	-	-	-	-	-	-	-	-	-
	7.0238	0.0000	0.9988	-	-	-	-	-	-	-	-	-
median	3.8338	0.0000	0.5632	-	-	-	-	-	-	-	-	-
max	7.1544	0.1012	1.0188	-	-	-	-	-	-	-	-	-
min	0.9033	0.0000	0.1421	-	-	-	-	-	-	-	-	-
Greens Creek Site 54												
	1.5952	0.0065	0.1488	2.6468	0.0000	0.3031	13.2892	0.0000	1.0489	17.1948	0.0000	2.0177
	3.0952	0.0458	0.4090	9.3238	0.0000	1.0170	8.3547	0.0000	0.7884	9.7188	0.0000	0.9266
	3.6108	0.0000	0.2070	7.5189	0.0000	0.2386	14.8960	0.0000	1.4546	8.7576	0.0000	0.6740
	2.9660	0.0000	0.2936	4.2958	0.0000	0.3775	5.9381	0.0000	0.6177	32.0400	0.0000	3.6620
	1.8799	0.0000	0.0106	5.1517	0.0000	0.5282	15.5146	0.0000	1.7368	5.2332	0.0000	0.4232
	1.7783	0.0000	0.1897	2.9762	0.8652	1.2582	10.4992	0.0000	1.0601	3.7380	0.0000	0.3051
	4.9471	0.0000	0.2232	6.2634	0.0000	0.6386	5.7082	0.0000	0.3872	12.8160	0.0000	1.3488
	1.4594	0.0000	0.1011	4.6212	0.0000	0.3984	16.4246	0.0000	1.7150	1.9224	0.0310	0.0888
	1.6900	0.0000	0.1354	4.7095	0.0000	0.4528	12.6034	0.0000	1.0746	10.4664	0.0000	1.0866
	3.4750	0.0000	0.1594	8.0829	0.0000	0.7912	17.8620	0.0000	1.7483	5.9808	0.0000	0.5330
median	2.4229	0.0000	0.1745	4.9306	0.0000	0.4905	12.9463	0.0000	1.0673	9.2382	0.0000	0.8003
max	4.9471	0.0458	0.4090	9.3238	0.8652	1.2582	17.8620	0.0000	1.7483	32.0400	0.0310	3.6620
min	1.4594	0.0000	0.0106	2.6468	0.0000	0.2386	5.7082	0.0000	0.3872	1.9224	0.0000	0.0888
Tributary Creek Site 9												
	6.6232	0.0000	0.7882	8.9053	0.0000	0.5190	12.8934	0.0000	1.2610	9.3984	0.2240	0.8033
	11.1495	0.0000	1.2000	16.4332	0.9503	1.2761	8.5504	0.0000	0.7921	5.7672	0.0000	0.4226
	15.0542	0.0000	1.4721	12.6468	0.1735	0.0000	3.9770	0.0000	0.2889	5.4468	0.0000	0.4836
	16.5773	0.2339	1.5059	5.4410	0.4508	0.0725	12.2904	0.0000	1.1144	6.0876	0.0312	0.3827
	3.1491	0.0000	0.3346	23.7210	1.2053	0.8382	17.0873	0.0000	1.9158	14.5248	0.0213	1.3951
	2.5932	0.0643	0.2794	12.7457	0.4003	0.2162	17.4003	0.0000	1.8759	6.5148	0.1726	0.4038
	1.6081	0.0000	0.0134	32.5316	0.0000	1.8936	33.8710	0.0000	3.9766	10.3596	0.1349	0.7986
	6.6592	0.0000	0.4265	4.4025	1.4958	0.0000	24.5614	0.0000	2.4319	6.8352	0.0423	0.3638
	15.2098	0.8116	1.4358	2.9413	0.3005	0.1720	20.0201	0.0000	1.6884	26.1660	0.5112	2.6076
	11.5499	0.0000	1.5087	8.0068	1.4710	0.2746	36.0168	0.0000	3.8559	8.4372	0.2176	0.5308
median	8.9044	0.0000	0.9941	10.7761	0.4256	0.2454	17.2438	0.0000	1.7821	7.6362	0.0886	0.5072
max	16.5773	0.8116	1.5087	32.5316	1.4958	1.8936	36.0168	0.0000	3.9766	26.1660	0.5112	2.6076
min	1.6081	0.0000	0.0134	2.9413	0.0000	0.0000	3.9770	0.0000	0.2889	5.4468	0.0000	0.3638

-continued-

	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
Upper Greens Creek Site 48												
	0.9719	0.0000	0.0086	8.5030	0.0000	0.7988	6.6377	0.0000	0.1624	1.5000	0.0000	0.0900
	4.6992	0.0000	0.5099	11.5900	0.0000	0.7103	5.6390	0.0000	0.2280	4.7000	0.0000	0.1600
	6.6216	0.0000	0.2741	10.7417	0.0000	1.2532	7.5946	0.0000	0.3302	2.6700	0.0000	0.2400
	6.1944	0.0000	0.5062	20.6036	0.0000	2.0380	11.6924	0.0000	1.3906	2.1400	0.0000	0.1700
	11.1072	0.0000	0.9152	10.6005	0.0000	0.9790	7.0381	0.0000	0.4711	0.8500	0.0000	0.0200
	5.6604	0.0000	0.5118	14.3454	0.0000	1.7241	11.4011	0.0000	0.5408	12.6000	0.0000	0.3300
	7.6896	0.0000	0.5330	17.2710	0.0000	1.7606	11.9953	0.0124	0.6033	2.7800	0.0000	0.1900
	5.1264	0.0000	0.2909	15.8082	0.0000	1.7423	4.9406	0.0000	0.2909	6.3000	0.0000	0.7400
	2.4564	0.0153	0.2755	17.2649	0.0000	1.7302	8.2589	0.0000	1.0960	1.2800	0.0000	0.1400
	9.0780	0.0000	0.6302	4.3364	0.0000	0.5366	4.1124	0.0000	0.4346	3.2000	0.0000	0.3700
median	5.9274	0.0000	0.5081	12.9677	0.0000	1.4887	7.3163	0.0000	0.4529	2.7250	0.0000	0.1800
max	11.1072	0.0153	0.9152	20.6036	0.0000	2.0380	11.9953	0.0124	1.3906	12.6000	0.0000	0.7400
min	0.9719	0.0000	0.0086	4.3364	0.0000	0.5366	4.1124	0.0000	0.1624	0.8500	0.0000	0.0200
Middle Greens Creek Site 6												
	-	-	-	27.3154	0.0000	2.7825	-	-	-	-	-	-
	-	-	-	19.3208	0.0000	2.0456	-	-	-	-	-	-
	-	-	-	17.5776	0.0000	1.7884	-	-	-	-	-	-
	-	-	-	33.9456	0.0000	3.3068	-	-	-	-	-	-
	-	-	-	47.5520	0.0000	4.9348	-	-	-	-	-	-
	-	-	-	16.1184	0.0000	1.5892	-	-	-	-	-	-
	-	-	-	8.9573	0.0000	1.0331	-	-	-	-	-	-
	-	-	-	11.8417	0.0000	1.1067	-	-	-	-	-	-
	-	-	-	8.6446	0.0000	0.9749	-	-	-	-	-	-
	-	-	-	29.1943	0.0000	3.0873	-	-	-	-	-	-
median	-	-	-	18.4492	0.0000	1.9170	-	-	-	-	-	-
max	-	-	-	47.5520	0.0000	4.9348	-	-	-	-	-	-
min	-	-	-	8.6446	0.0000	0.9749	-	-	-	-	-	-
Greens Creek Site 54												
	10.3596	0.0000	0.5350	19.8594	0.0000	1.6172	0.4075	0.0356	0.0448	2.9900	0.0000	0.2900
	2.5632	0.0000	0.2555	5.6248	0.0000	0.7556	0.1834	0.0000	0.0000	1.1700	0.0200	0.0000
	3.3108	0.0000	0.1688	12.7421	0.0000	1.1864	1.3646	0.0416	0.1145	1.5000	0.0000	0.1900
	2.8836	0.0000	0.1173	23.5686	0.0000	2.6259	4.2481	0.0000	0.4823	1.7100	0.0000	0.1300
	5.6604	0.0000	0.3834	4.6147	0.0000	0.4661	0.1296	0.0924	0.0172	2.2400	0.0000	0.0900
	2.9904	0.0000	0.1346	27.6712	0.0000	2.2151	3.2848	0.0000	0.3822	2.1400	0.0000	0.1100
	4.2720	0.0000	0.1775	4.2484	0.0000	0.3842	7.9339	0.0000	0.9770	2.4600	0.0000	0.2500
	4.3788	0.0000	0.3098	8.9576	0.0000	0.9350	0.0474	0.0000	0.0000	0.9600	0.0000	0.0100
	4.0584	0.0000	0.1604	31.8454	0.0000	3.1710	2.9656	0.0000	0.3917	0.2400	0.0500	0.0000
	3.0972	0.0000	0.1583	5.4829	0.0000	0.6776	6.4336	0.0000	0.8149	0.2400	0.0000	0.0300
median	3.6846	0.0000	0.1732	10.8498	0.0000	1.0607	2.1651	0.0000	0.2484	1.6050	0.0000	0.1000
max	10.3596	0.0000	0.5350	31.8454	0.0000	3.1710	7.9339	0.0924	0.9770	2.9900	0.0500	0.2900
min	2.5632	0.0000	0.1173	4.2484	0.0000	0.3842	0.0474	0.0000	0.0000	0.0015	0.0000	0.0000
Tributary Creek Site 9												
	6.4294	0.0000	0.2502	3.5384	0.2492	0.1902	---	---	---	2.3500	0.0000	0.1200
	8.0100	1.2833	0.1830	4.2115	0.3962	0.2018	5.4468	0.0792	0.2284	6.9400	0.0000	0.2700
	1.8156	0.1313	0.0746	7.0732	0.0000	0.4036	7.2624	0.0049	0.5438	6.3000	0.2400	0.3400
	9.8256	0.0595	0.2907	4.0118	0.0108	0.3195	---	---	---	6.4100	0.0000	0.2500
	5.6818	0.0000	0.1025	4.2010	0.0000	0.3909	---	---	---	2.4600	0.1200	0.1900
	5.3827	0.0000	0.1225	4.7449	0.0000	0.2872	0.8544	0.1636	0.1069	6.1900	0.0500	0.3900
	8.1809	0.0000	0.2028	13.6349	0.0000	0.5726	6.4080	0.0552	0.2437	4.0600	0.0000	0.1300
	15.4326	0.0000	0.4551	4.3786	0.0052	0.2053	7.0488	0.2360	0.6487	4.5900	0.0000	0.3700
	36.6004	0.0989	1.1198	5.1579	0.0000	0.5586	5.0196	0.0000	0.2577	1.6000	0.0000	0.0000
	9.4518	0.0000	0.2629	3.7563	0.3717	0.2617	3.2040	0.0000	0.2337	3.7400	0.0000	0.2800
median	8.0954	0.0000	0.2265	4.2951	0.0026	0.3034	5.4468	0.0552	0.2437	4.3250	0.0000	0.2600
max	36.6004	1.2833	1.1198	13.6349	0.3962	0.5726	7.2624	0.2360	0.6487	6.9400	0.2400	0.3900
min	1.8156	0.0000	0.0746	3.5384	0.0000	0.1902	0.8544	0.0000	0.1069	1.6000	0.0000	0.0000

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Appendix A. Page 3 of 3.

	2009			2010		
mg/m²	chlor-a	chlor-b	chlor-c	chlor-a	chlor-b	chlor-c
Upper Greens Creek Site 48						
	3.2040	0.0000	0.4870	8.5400	0.0000	0.4400
	1.4952	0.0000	0.2468	4.5900	0.0000	0.6100
	4.1652	0.1120	0.5872	5.1300	0.0000	0.2700
	5.6604	0.0695	0.7321	3.1000	0.0000	0.2600
	3.4176	0.0625	0.5042	7.5800	0.0000	0.2900
	8.2236	0.1310	0.9544	5.5500	0.0000	0.5500
	0.4272	0.1091	0.1125	10.6800	0.0000	0.6400
	1.3884	0.1752	0.2908	7.6900	0.0000	0.4100
	7.7964	0.0030	0.8923	3.6300	0.0000	0.2500
	9.1848	0.1726	1.1926	3.1000	0.0200	0.1500
median	3.7914	0.0893	0.5457	5.3400	0.0000	0.3500
max	9.1848	0.1752	1.1926	10.6800	0.0200	0.6400
min	0.4272	0.0000	0.1125	3.1000	0.0000	0.1500
Middle Greens Creek Site 6						
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
	-	-	-	-	-	-
median	-	-	-	-	-	-
max	-	-	-	-	-	-
min	-	-	-	-	-	-
Greens Creek Site 54						
	8.0100	0.1148	1.0620	2.6700	0.0000	0.2900
	7.5828	0.1120	1.1286	6.7300	0.0000	0.6900
	6.8352	0.0704	0.8904	4.3800	0.0000	0.7400
	9.1848	0.0853	0.9630	2.1400	0.0000	0.2500
		0.4719	2.2099	5.2300	0.0000	0.6700
	8.3304	0.1504	1.1068	1.7100	0.0400	0.2500
	11.3208	0.1990	1.5729	1.3900	0.0200	0.1100
	5.3400	0.1670	0.6608	3.2000	0.0000	0.4600
	4.4856	0.0986	0.6282	2.0300	0.0000	0.2100
	4.3788	0.0981	0.4254	0.2100	0.0100	0.0500
median	7.5828	0.1134	1.0125	2.4050	0.0000	0.2700
max	11.3208	0.4719	2.2099	6.7300	0.0400	0.7400
min	4.3788	0.0704	0.4254	0.2100	0.0000	0.0500
Tributary Creek Site 9						
	2.0292	0.1045	0.1565	12.8200	0.0000	0.3900
	5.4468	0.1749	0.3818	6.6200	0.0000	0.3900
	4.3788	0.2419	0.3008	7.6900	0.0000	0.4300
	7.0488	0.5808	0.3273	5.6600	0.1200	0.3200
	9.0780	0.3562	0.4948	9.7200	0.8800	0.4000
	8.7576	0.4052	0.6224	5.9800	0.0000	0.2000
	2.1360	0.0800	0.0927	5.5500	0.0000	0.4000
	18.3696	0.6630	0.7830	10.5700	0.2800	0.3400
	2.3496	0.1808	0.1576	4.0600	0.0500	0.1600
	3.2040	0.1979	0.3320	5.7700	0.0000	0.3200
median	4.9128	0.2199	0.3297	6.3000	0.0000	0.3650
max	18.3696	0.6630	0.7830	12.8200	0.8800	0.4300
min	2.0292	0.0800	0.0927	4.0600	0.0000	0.1600

APPENDIX B: BENTHIC MACROINVERTEBRATE DATA

Appendix B 1.–Benthic macroinvertebrates in Greens Creek Site 48 samples 2001–2010.

Order	Family	Genus	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Ephemeroptera	unidentified		-	-	-	-	-	3	38	-	3	-
	Baetidae	*Acentrella*	-	-	-	-	-	-	-	-	-	-
		Baetis	309	152	445	390	279	130	206	777	117	202
	Ephemerellidae	*Ephemerella*	2	-	10	23	15	1	4	12	172	14
		Drunella	47	49	650	406	369	102	16	24	10	294
		Cinygmula	99	20	117	99	89	48	91	78	90	109
	Heptageniidae	*Epeorus*	444	190	384	209	371	240	61	165	431	345
		Rhithrogena	193	187	287	196	71	88	165	102	63	89
	Leptophlebiidae	*Paraleptophlebia*	-	1	-	-	-	-	-	-	1	7
	Ameletidae	*Ameletus*	-	-	4	-	-	-	3	-	-	-
Plecoptera	unidentified		-	-	-	-	9	7	1	3	11	26
	Capniidae	*Capnia*	-	-	82	-	-	-	-	-	-	-
		Eucapnopsis	-	-	-	-	1	-	-	-	-	-
	Chloroperlidae	unidentified	-	-	-	-	2	-	6	-	-	1
		Alloperla	1	1	-	1	-	-	-	-	-	-
		Kathroperla	-	-	2	3	-	2	-	-	-	3
		Neaviperla	-	-	70	6	3	-	11	-	-	-
		Paraperla	-	-	-	6	-	-	-	-	-	-
		Plumiperla	5	-	-	5	-	-	-	-	7	-
		Suwallia	8	1	-	-	5	-	-	3	-	-
		Sweltsa	1	4	-	-	-	-	-	-	-	-
	Leuctridae	*Despaxia*	-	2	-	-	-	-	-	-	3	-
		Paraleuctra	4	3	6	65	-	3	10	14	6	15
		Perlomyia	-	12	-	-	-	-	-	-	-	-
	Nemouridae	*Podmosta*	7	5	-	2	-	-	-	-	-	-
		Zapada	23	4	30	7	14	5	50	13	15	37
	Perlodidae	*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	-	-	-	-	-
	Hydropsychidae	*Arctopsyche*	2	-	-	-	-	-	-	-	-	-
		Hydropsyche	-	-	1	-	1	-	-	-	-	-
	Limnephilidae	*Onocosmoecus*	-	-	1	-	-	-	-	-	-	-
	Rhyacophilidae	*Rhyacophila*	5	8	16	15	7	6	11	19	2	4
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
	Deuterophlebiidae	*Deuterophlebia*	2	-	-	1	1	1	-	1	-	-
	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
	Tipulidae	*Antocha*	-	-	2	-	-	-	-	-	-	-
		Dicranota	-	-	3	-	2	-	-	-	-	2
		Rhabdomastix	-	-	-	-	1	-	2	2	-	-
		Tipula	-	-	2	6	1	4	-	12	2	1
Collembola	unidentified		2	1	-	-	-	1	1	-	3	5
Copepoda	Cyclopoida		-	-	-	1	-	-	1	-	-	1
Acarina			-	2	20	10	3	6	5	8	-	-
Oligochaeta			-	5	20	8	3	1	1	2	1	1
Gastropoda	Pelecypoda		-	-	-	1	-	-	1	1	-	-
Ostracoda			-	8	7	9	1	2	4	-	-	5

Note: Appendix data for Site 48 were modified in Report No 11-02 to correct data entry errors.

Appendix B 2.–Benthic macroinvertebrates in Greens Creek Site 6 samples 2001–2010.

Order	Family	Genus	2001	2006
Ephemeroptera	Baetidae	*Baetis*	153	30
	Ephemerellidae	*Ephemerella*	-	2
		Drunella	52	48
	Heptageniidae	*Cinygmula*	303	28
		Epeorus	408	107
		Rhithrogena	-	40
Plecoptera	unidentified		-	12
	Chloroperlidae	unidentified	-	6
		Suwallia	2	-
	Leuctridae	*Paraleuctra*	7	-
	Nemouridae	*Zapada*	16	3
	Perlodidae	*Isoperla*	7	-
Trichoptera	Rhyacophilidae	*Rhyacophila*	1	1
Coleoptera	Staphylinidae		1	-
Diptera	Chironomidae		19	28
	Deuterophlebiidae	*Deuterophlebia*	1	-
	Dolichopodidae		1	-
	Empididae	*Chelifera*	1	-
		Oreogeton	3	-
	Tipulidae	*Dicranota*	-	1
Arachnida			1	-
Acarina			4	-
Oligochaeta			15	1
Ostracoda			3	-

Note: Appendix data for *Baetis* at Site 6 were modified in Report No. 11-02 to correct data entry errors.

Appendix B 3.–Benthic macroinvertebrates in Greens Creek Site 54 samples 2001–2010.

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

Note: Appendix data for Site 54 were modified Report No. 11-02 to correct data entry errors.

Appendix B 4.–Benthic macroinvertebrates in Tributary Creek Site 9 samples 2001–2010.

Order	Family	Genus	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Ephemeroptera	unidentified		-	-	-	-	-	1	-	-	-	1
	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	-
		Drunella	-	3	10	-	8	3	-	5	-	2
	Heptageniidae	*Cinygma*	1	-	-	-	43	-	-	-	3	-
		Cinygmula	89	177	507	49	24	127	43	209	74	12
		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
	Ameletidae	*Ameletus*	-	15	46	46	25	33	18	17	35	12
Plecoptera	unidentified		-	-	-	-	-	21	-	2	-	3
	Capniidae	*Capnia*	-	-	-	-	-	-	-	-	-	1
	Chloroperlidae	unidentified	-	-	-	-	1	-	8	-	26	-
		Kathroperla	-	-	-	-	-	-	-	-	-	8
		Neaviperla	-	-	174	24	-	-	-	-	-	-
		Paraperla	-	11	-	-	-	-	-	-	-	-
		Plumiperla	-	-	-	38	-	-	-	35	26	-
		Suwallia	34	-	24	20	36	-	-	-	5	-
		Sweltsa	-	42	-	-	12	-	26	4	-	-
	Leuctridae	*Despaxia*	3	-	6	5	3	1	3	1	8	-
		Paraleuctra	7	-	1	-	-	-	-	-	-	1
		Perlomyia	-	3	-	-	-	-	-	-	-	-
	Nemouridae	*Podmosta*	-	1	-	-	-	-	-	-	-	-
		Zapada	23	12	388	41	43	13	-	8	32	3
	Perlodidae	*Isoperla*	1	-	-	38	-	-	-	-	-	1
Trichoptera	unidentified		-	-	-	-	-	1	-	-	-	-
	Apataniidae	*Apatania*	-	1	-	-	-	-	-	-	-	-
	Brachycentridae	*Brachycentrus*	-	-	1	-	-	-	-	-	-	-
	Lepidostomatidae	*Lepidostoma*	-	-	-	1	1	1	1	-	-	-
	Limnephilidae	unidentified	-	-	-	-	1	-	-	-	-	-
		Ecclisomyia	-	-	1	-	1	-	3	-	-	-
		Onocosmoecus	-	-	-	1	-	-	-	-	-	-
	Rhycophilidae	*Rhycophila*	-	1	5	3	1	-	-	1	-	-
Coleoptera	unidentified		-	-	-	-	-	-	-	-	1	1
	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
	Chironomidae		35	36	125	52	40	22	3	6	105	45
	Empididae	unidentified	-	-	-	-	-	-	-	-	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
		Pilaria	-	-	2	-	-	-	-	-	-	-
		Rhabdomastix	-	-	1	-	1	-	-	-	-	-
		Tipula	4	5	-	2	-	4	5	2	5	1
		Limonia	-	-	-	-	1	-	1	-	-	-
Branchiopoda	Chydoridae		-	-	2	-	-	-	-	-	-	-
Collembola	unidentified		-	-	-	-	-	1	2	-	1	4
	Sminthuridae	*Dicyrtoma*	-	2	-	-	-	-	-	-	-	-
		Sminthurus	-	-	3	34	1	2	-	-	-	-
Copepoda	unidentified		-	-	-	-	-	1	-	-	-	3
	Cyclopoida		-	-	6	5	-	-	-	-	2	-
	Harpacticoida		-	-	5	-	-	-	-	-	-	-
Acarina			15	20	72	39	2	-	2	25	-	-
Oligochaeta			40	45	349	111	23	21	27	9	26	1
Gastropoda			1	-	1	2	-	1	1	-	2	-
Isopoda	Gammaridae	*Gammarus*	-	-	-	1	-	-	-	-	1	-
Ostracoda			92	102	207	27	8	68	17	20	1	30

Note: Appendix data for Site 9 were modified in Report No. 11-02 to correct data entry errors.

APPENDIX C: JUVENILE FISH CAPTURE DATA

Appendix C 1.–Juvenile fish capture data at Greens Creek Mine biomonitoring sites 2001–2010.

Site	Fish Species[a]	Fork Lengths	Number of Fish Captured Set 1	Set 2	Set 3	Total	MLE[b] Pop. Est.	MLE Std Error	Popn. 95% C.I.
2001[c]									
Upper Greens Cr 48	DV	48-139	30	16	22	68	96	13.80	68-124
Middle Greens Cr 6	DV	52-168	80	8	43	131	161	12.14	137-185
	CO	81-90	1	0	2	3	3	0.00	3-3
Greens Cr Below D 54	DV	27-162	70	49	19	138	158	8.44	141-175
	CO	32-95	2	6	4	12	17	4.46	8-26
Tributary Cr 9	DV	58-110	70	4	7	81	81	0.00	81-81
	CO	39-101	89	18	11	118	120	1.69	117-123
	CT	124	1	0	0	1	1	---	---
	Sc	75-98	3	1	0	4	4	0.00	4-4
2002[c]									
Upper Greens Cr 48	DV	45-160	74	29	23	126	141	6.87	127-155
Greens Cr Below D 54	DV	33-160	168	72	31	271	290	6.81	276-304
	CO	59-85	14	6	1	21	21	0.00	21-21
Tributary Cr 9	DV	38-147	29	14	8	51	56	3.63	49-63
	CO	27-85	29	9	6	44	46	1.92	42-50
	CT	124	0	0	1	1	1	0.00	1-1
	Sc	90-100	0	1	1	2	2	0.00	2-2
2003									
Upper Greens Cr 48	DV	54-180	157	72	56	285	333	14.04	305-361
Greens Cr Below D 54	DV	51-184	92	81	59	232	331	27.76	275-387
	CO	44-52	5	3	0	8	8	0.00	8-8
Tributary Cr 9	DV	54-114	13	4	2	19	20	1.52	17-23
	CO	46-88	37	11	4	52	53	1.20	51-55
	CT	122	1	0	0	1	1	---	---
	Sc	80	0	0	1	1	1	0.00	1-1
2004									
Upper Greens Cr 48	DV	54-158	168	48	28	244	255	4.70	246-264
Greens Cr Below D 54	DV	52-161	118	36	47	201	234	11.43	211-257
	CO	70-95	9	9	6	24	31	5.53	20-42
Tributary Cr 9	DV	64-109	21	6	5	32	33	1.22	31-35
	CO	40-94	23	2	2	27	27	0.00	27-27
	CT	122	1	0	0	1	1	---	---
	RT	86-106	3	1	0	4	4	0.00	4-4
	Sc	67-85	1	1	0	2	2	0.00	2-2
2005									
Upper Greens Cr 48	DV	50-149	118	56	38	212	243	10.70	222-264
Greens Cr Below D 54	DV	52-146	111	59	43	213	255	14.13	227-283
	CO	66-93	33	20	8	61	67	3.97	59-75
Tributary Cr 9	DV	59-131	21	12	11	44	55	7.16	41-69
	CO	39-103	82	42	15	139	150	5.31	139-161
	CT	91-103	1	1	0	2	2	0.00	2-2
	Sc	78-99	2	0	0	2	2	---	---

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Appendix C 1. Page 2 of 2.

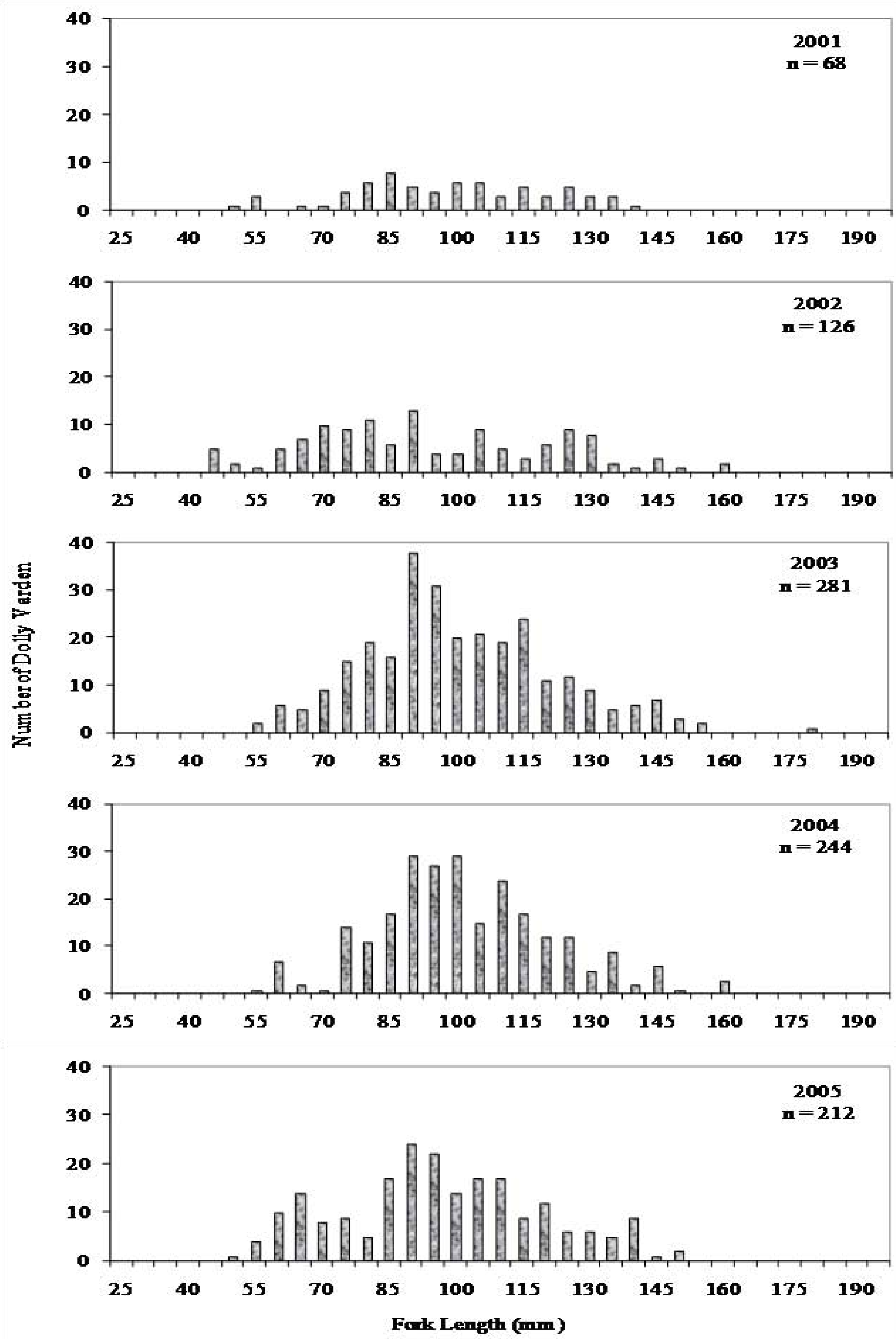
Sample Site	Fish Species[a]	Fork Lengths	Number of Fish Captured Set 1	Set 2	Set 3	Total	MLE[b] Pop. Est.	MLE Std Error	Popn. 95% C.I.
2006									
Upper Greens Cr 48	DV	49-150	138	40	34	212	228	6.34	215-241
Middle Greens Cr 6	DV	53-150	44	41	12	97	114	8.24	98-130
	CO	89	1	0	0	1	1	---	---
Greens Cr Below D 54	DV	49-158	116	61	40	217	254	12.34	229-279
	CO	62-88	6	0	1	7	7	0.00	7-7
Tributary Cr 9	DV	85-117	7	3	1	11	11	0.00	11-11
	CO	69-108	5	4	1	10	10	0.00	10-10
	CT	---	0	0	0	0	---	---	---
	Sc	---	0	0	0	0	---	---	---
2007									
Upper Greens Cr 48	DV	53-154	50	29	16	95	103	7.01	95-123
Greens Cr Below D 54	DV	50-145	64	19	24	107	122	7.22	108-136
	CO	---	0	0	0	0	0	---	---
Tributary Cr 9	DV	81-158	7	5	0	12	12	0.00	12-12
	CO	38-104	50	10	9	69	71	1.80	67-75
	CT	138	0	0	1	1	1	0.00	1-1
	Sc	---	0	0	0	0	0	---	---
2008									
Upper Greens Cr 48	DV	77-137	54	10	9	73	75	1.81	71-79
Greens Cr Below D 54	DV	45-131	50	15	6	71	73	1.83	69-77
	CO	53-69	4	0	0	4	4	---	---
Tributary Cr 9	DV	60-108	15	4	3	22	22	0.00	22-22
	CO	41-100	72	44	26	142	169	10.86	147-191
	CT	82-112	1	0	2	3	3	0.00	3-3
	Sc	---	0	0	0	0	0	---	---
2009									
Upper Greens Cr 48	DV	47-142	67	31	27	126	151	10.50	130-172
Greens Cr Below D 54	DV	47-101	42	32	19	93	117	11.15	95-139
	CO	67-73	2	2	0	4	4	0.00	4-4
Tributary Cr 9	DV	48-98	24	5	9	38	42	3.29	35-49
	CO	38-116	42	9	2	53	53	0.00	53-53
	CT	97	1	0	0	1	1	---	---
	Sc	75-94	4	0	1	5	5	0.00	5-5
2010									
Upper Greens Cr 48	DV	47-170	97	41	20	158	170	5.48	159-181
Greens Cr Below D 54	DV	52-151	46	13	14	73	80	4.39	71-89
	CO	77	1	0	0	1	1	0.00	1-1
Tributary Cr 9	DV	58-108	21	7	31	59	109	21.80	65-153
	CO	39-90	77	21	30	128	147	8.32	130-164
	CT	64-89	4	1	0	5	5	0.00	5-5
	Sc	60-100	4	1	0	5	5	0.00	5-5

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

[b] Maximum Likelihood Estimate fish population in the sample reach (Lockwood and Schneider 2000)

[c] Capture data from 2001 and 2002 provided by USFS

Appendix C 2.–Length frequency plots for Dolly Varden captured at Site 48 2001–2010.



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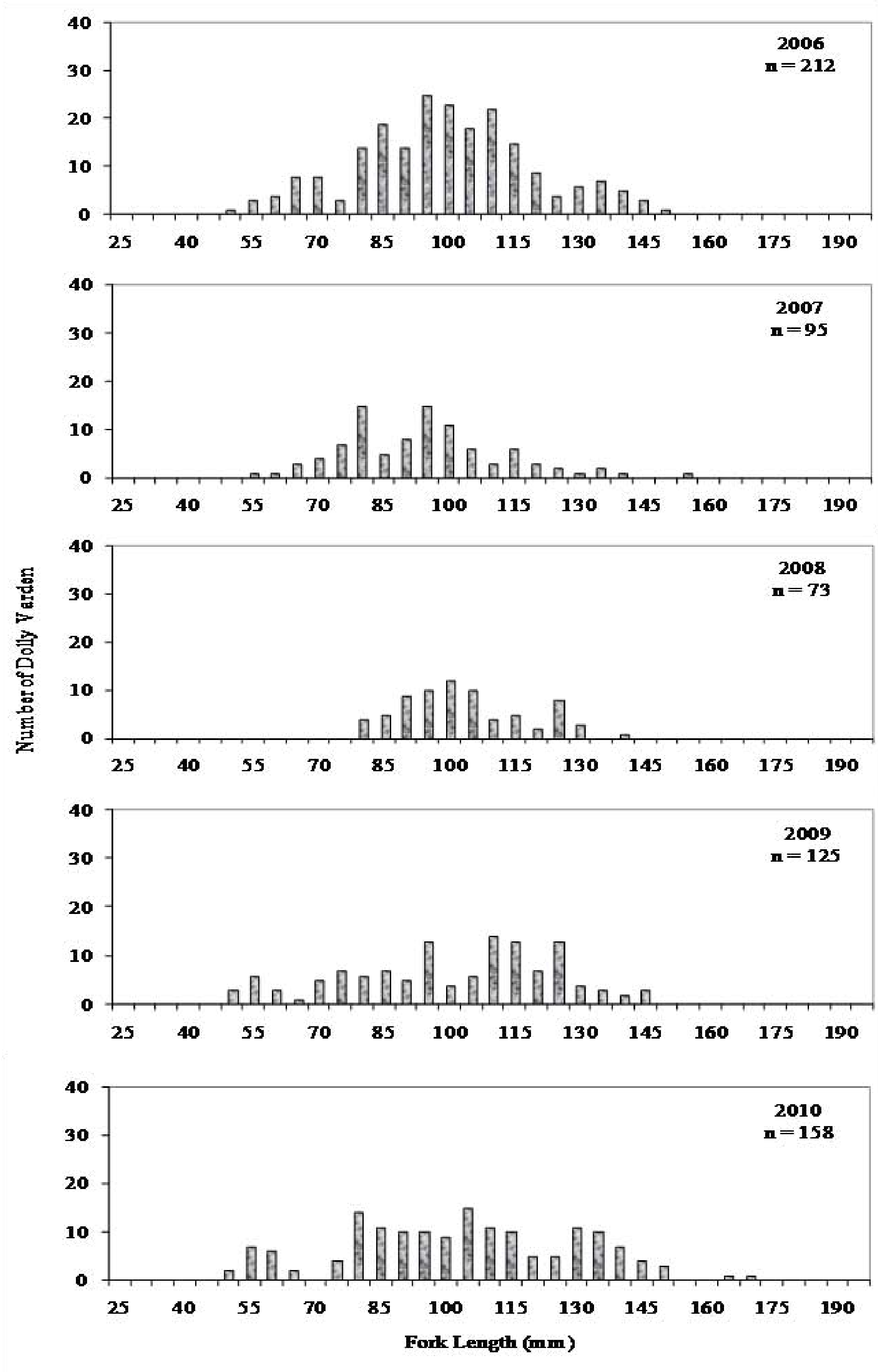
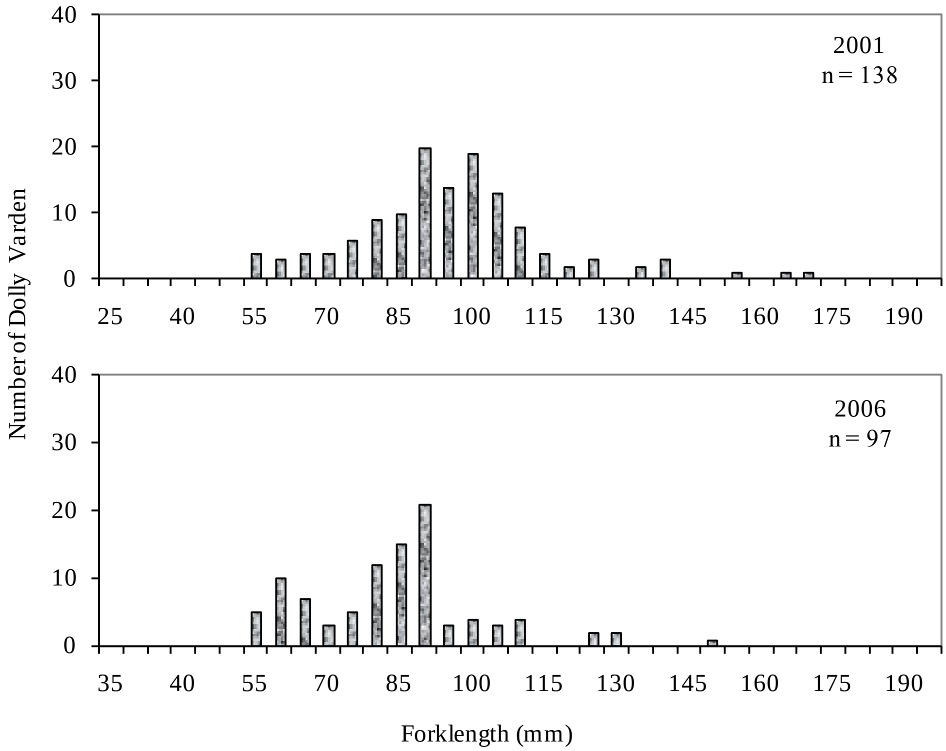
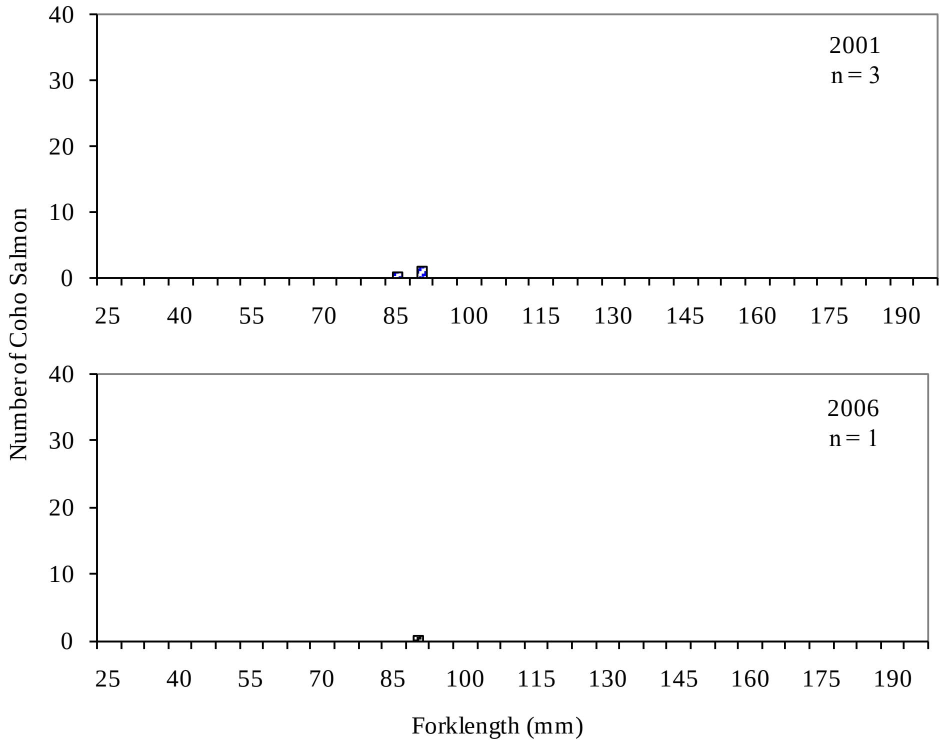


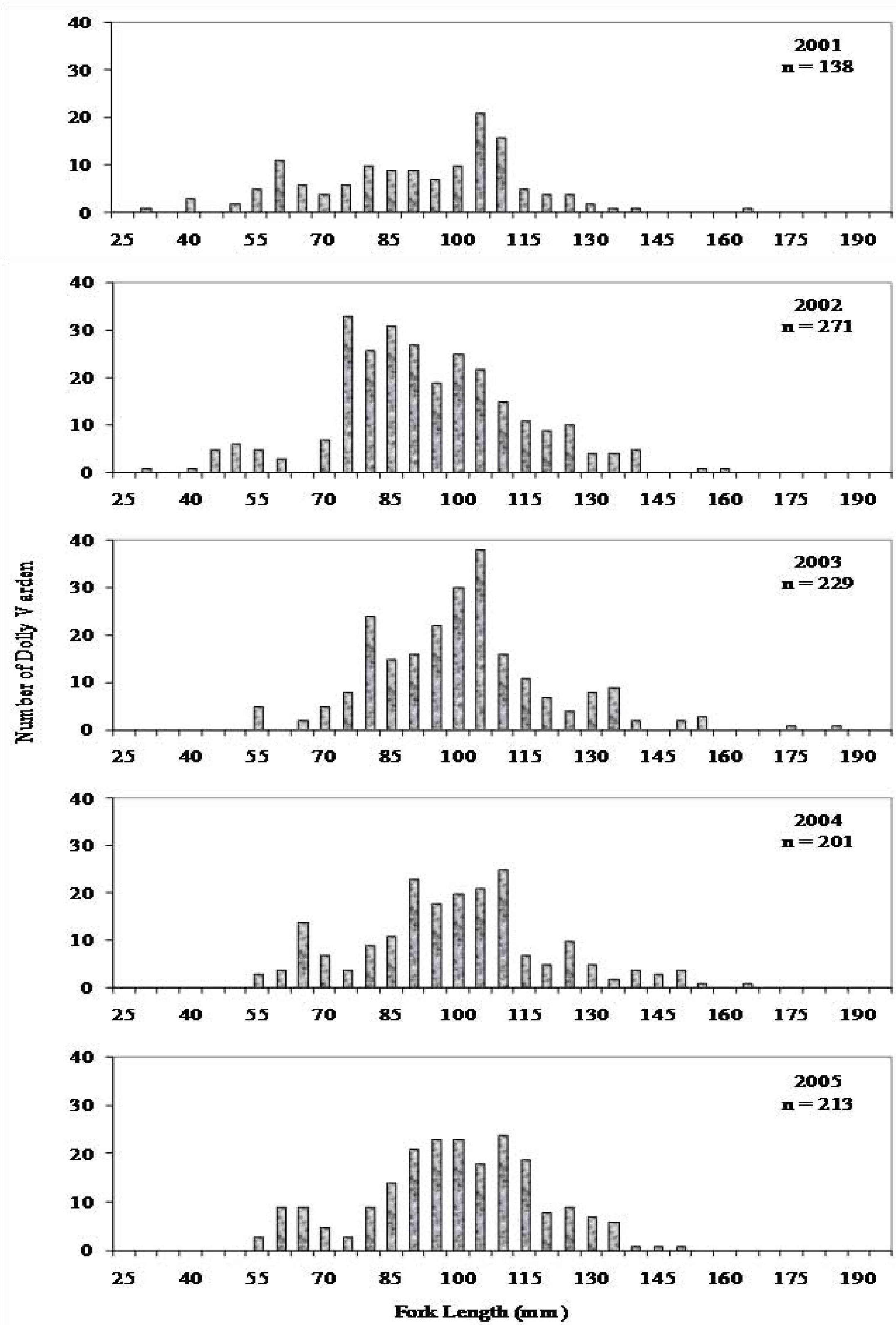
Appendix C 3.–Length frequency plots for Dolly Varden captured at Site 6 in 2001 and 2006.



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



Appendix C 5.–Length frequency plots for Dolly Varden captured at Site 54 2001–2010.



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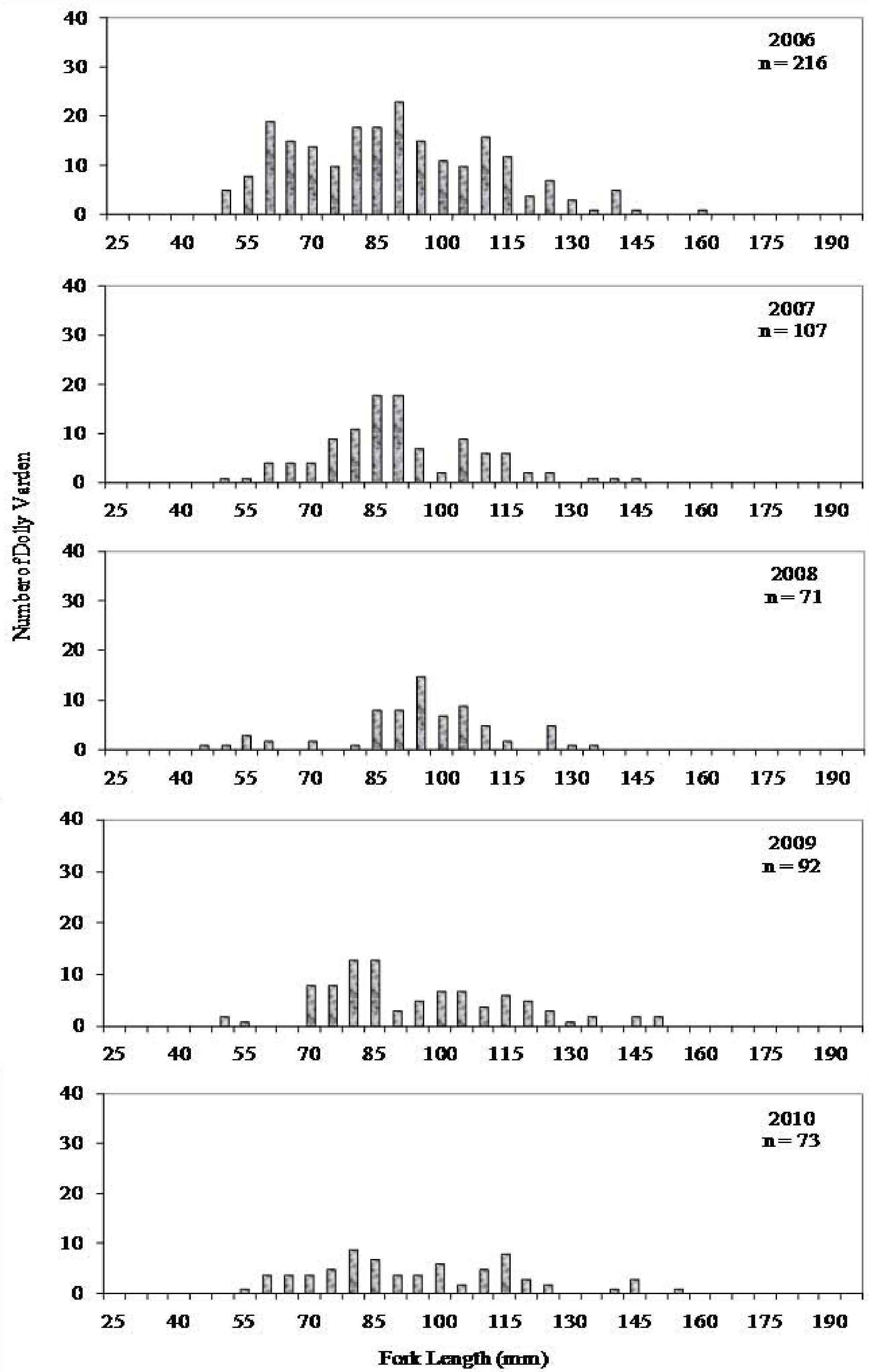
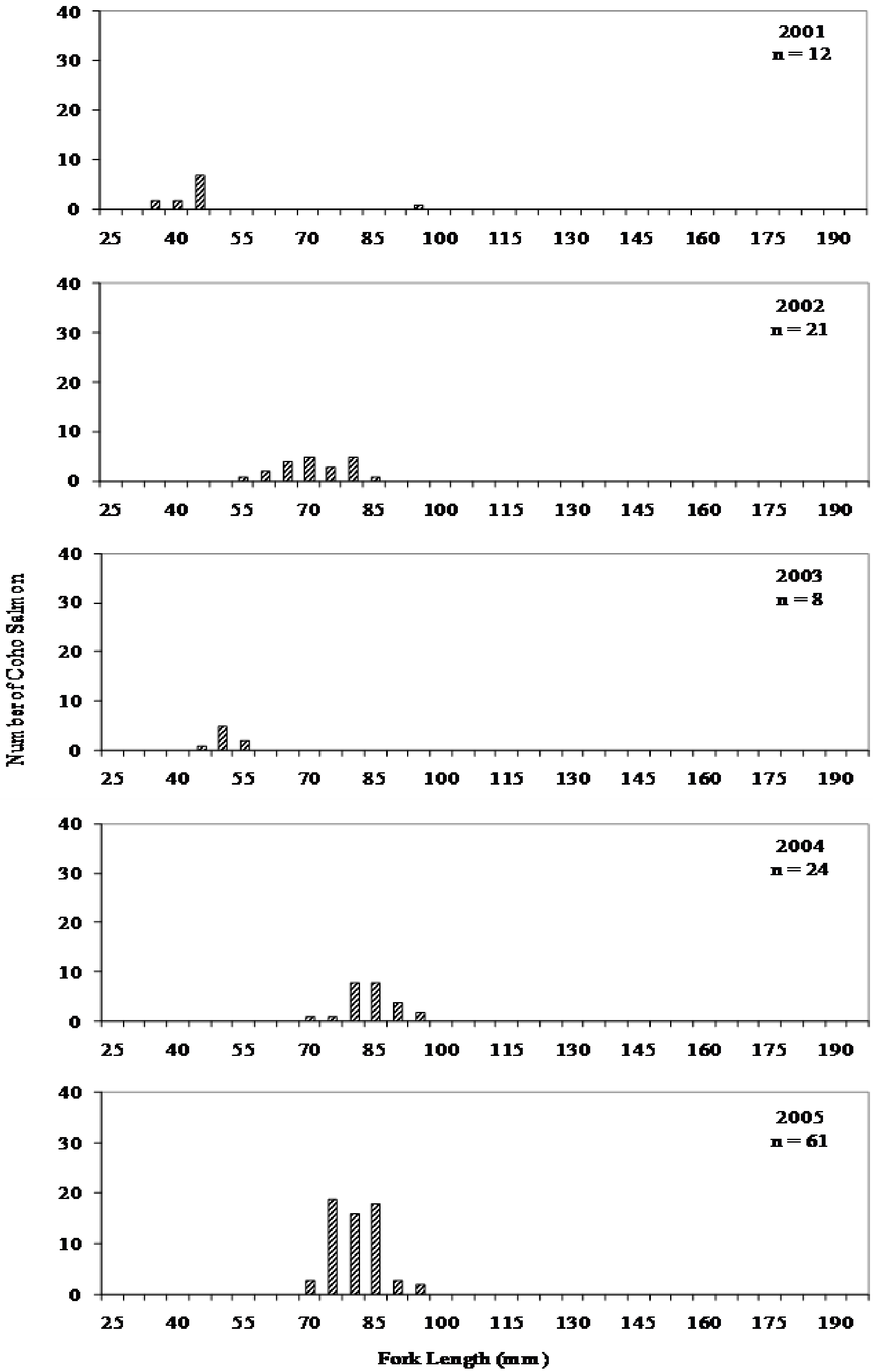


Appendix C 6.–Length frequency plots for coho salmon captured at Site 54 2001–2010.



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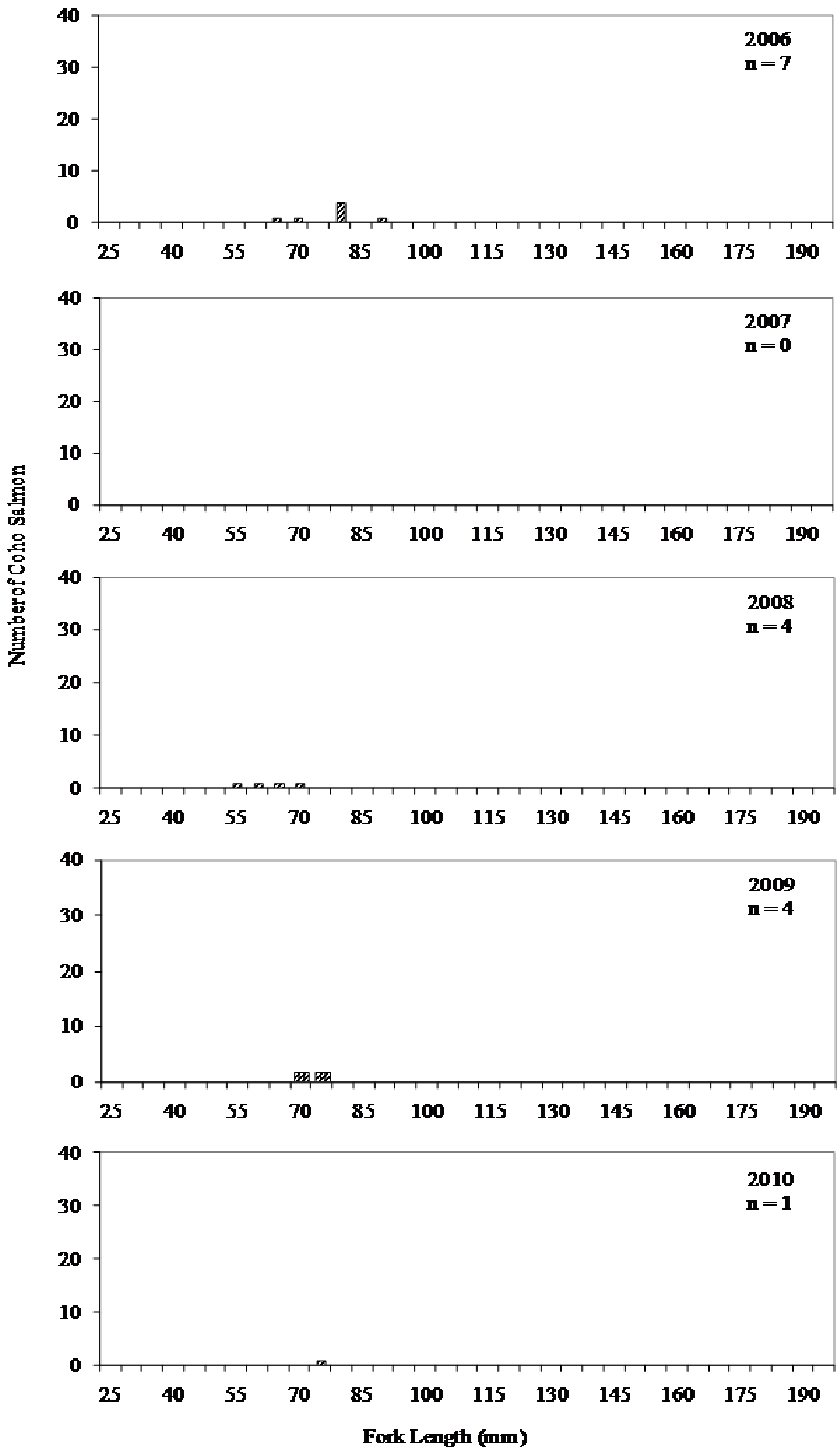
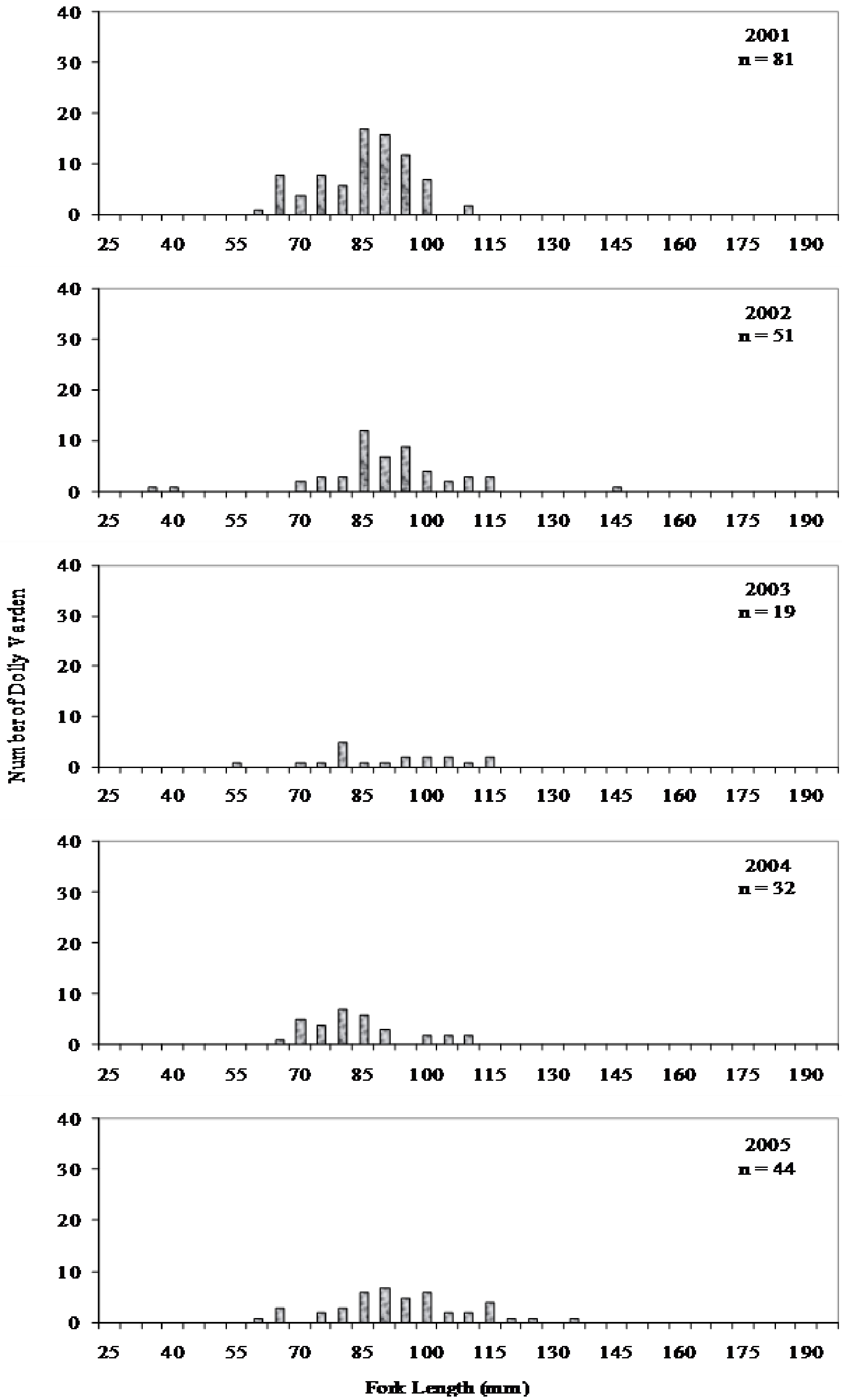


Appendix C 7.–Length frequency plots for Dolly Varden captured at Site 9 2001–2010.



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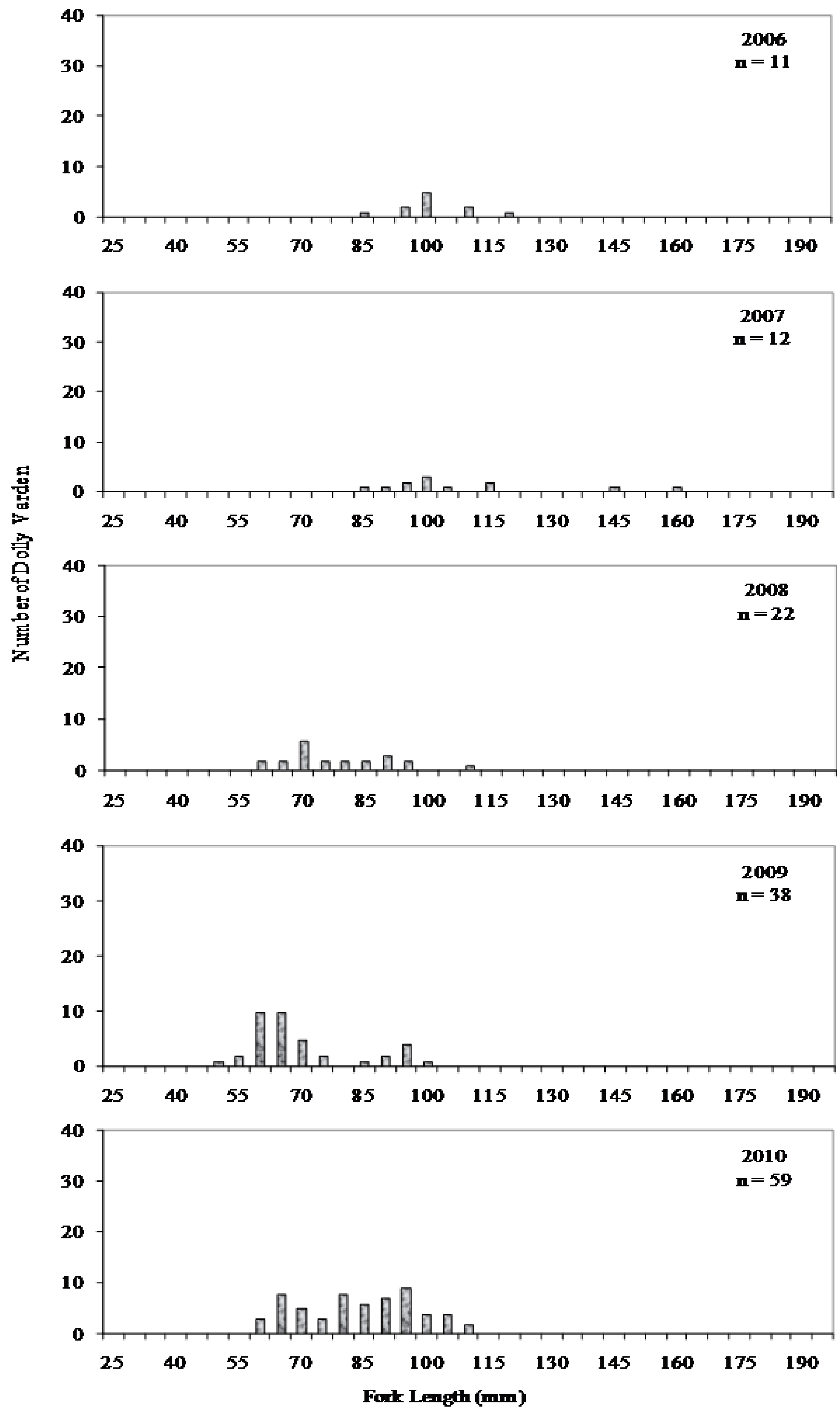
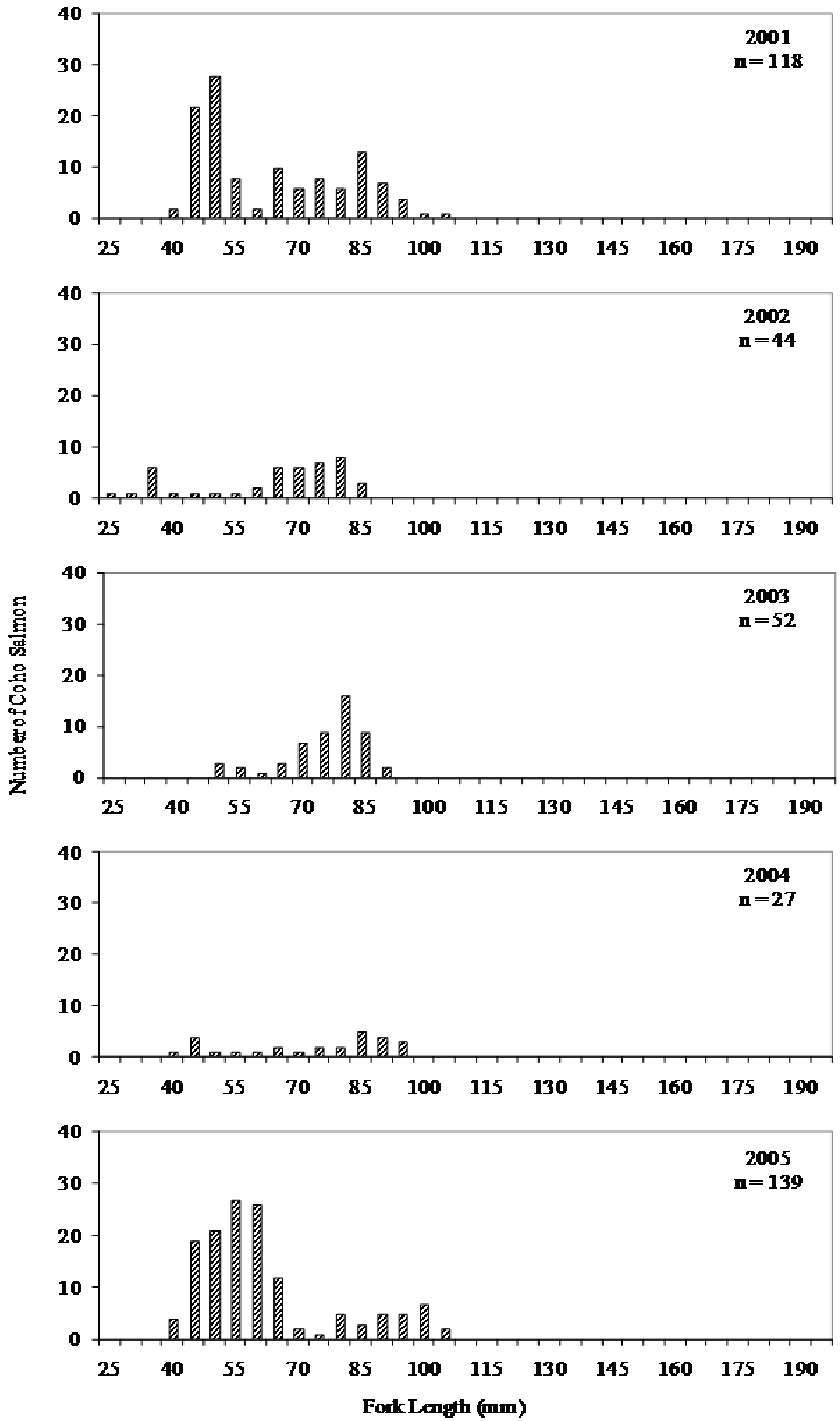


Appendix C 8.–Length frequency plots for coho salmon captured at Site 9 2001–2010.



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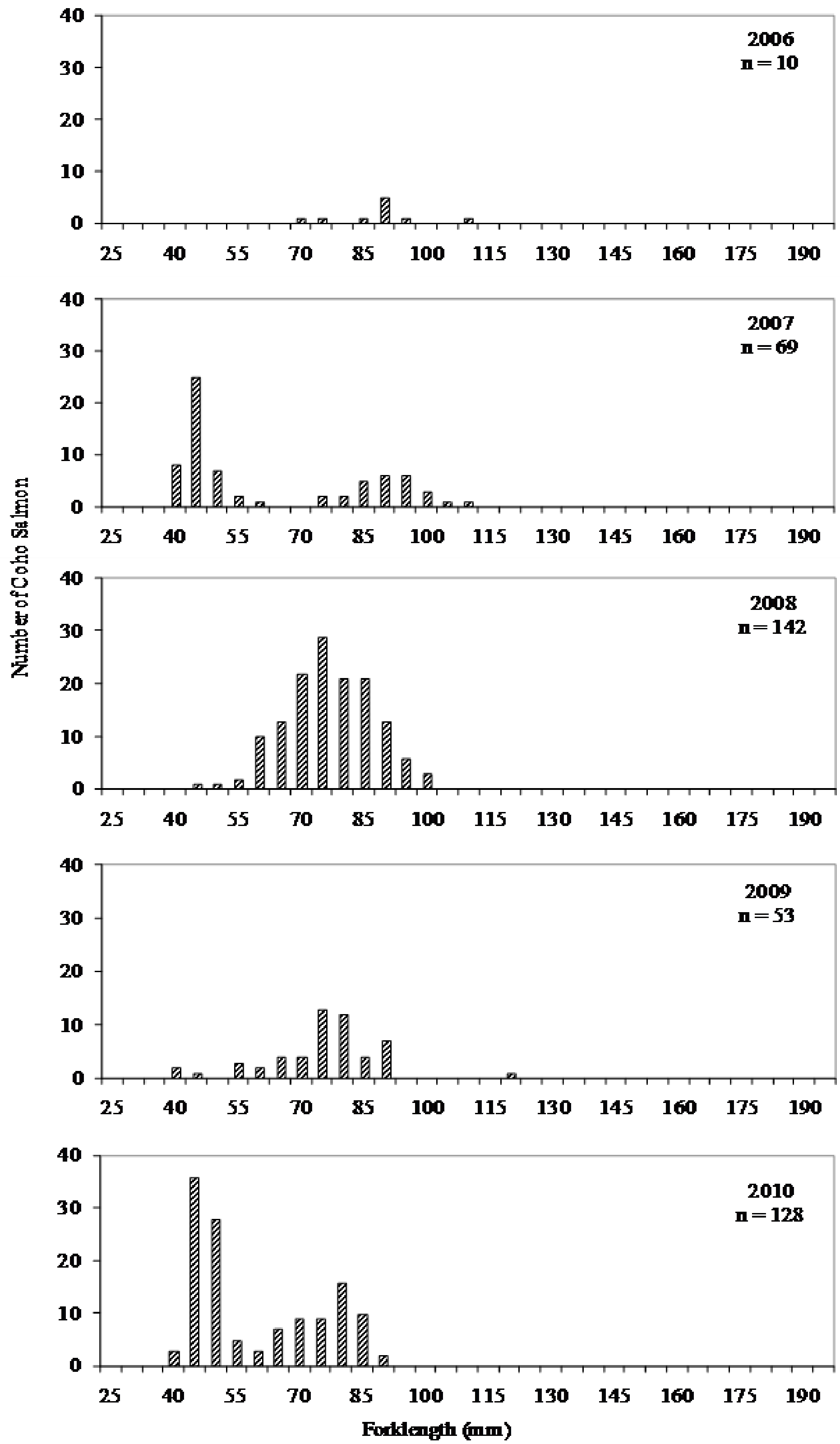

APPENDIX D: JUVENILE FISH METALS CONCENTRATIONS DATA

Appendix D.–Metals concentrations data for juvenile fish collected at Greens Creek Mine biomonitoring sites 2001–2010.

Collector	Date Collected	Location	Site No.	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Analyte Basis	Ag (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Se (mg/kg)	Zn (mg/kg)	Sample Number
ADF&G & USFS	7/23/01	Upper Greens Creek	48	DV	131	26.0	21.6	dry wt	0.02	1.76	8.3	0.20	6.1	180	072301GC48DVJ01
ADF&G & USFS	7/23/01	Upper Greens Creek	48	DV	137	28.8	23.7	dry wt	0.03	0.89	7.2	0.17	4.6	146	072301GC48DVJ02
ADF&G & USFS	7/23/01	Upper Greens Creek	48	DV	119	18.8	20.7	dry wt	0.02	2.27	5.7	0.20	6.2	189	072301GC48DVJ03
ADF&G & USFS	7/23/01	Upper Greens Creek	48	DV	121	21.1	22.8	dry wt	0.02	1.56	6.9	0.17	5.2	182	072301GC48DVJ04
ADF&G & USFS	7/23/01	Upper Greens Creek	48	DV	111	13.7	21.8	dry wt	0.03	0.89	4.7	0.23	5.4	138	072301GC48DVJ05
ADF&G & USFS	7/23/01	Upper Greens Creek	48	DV	121	21.1	20.3	dry wt	0.02	1.26	7.4	0.10	5.6	157	072301GC48DVJ06
ADF&G	7/24/02	Upper Greens Creek	48	DV	133	23.2	24.3	dry wt	0.03	1.64	6.8	0.72	4.8	239	072402GC48DVJ01
ADF&G	7/24/02	Upper Greens Creek	48	DV	120	15.0	19.2	dry wt	0.07	0.85	7.0	0.28	4.1	210	072402GC48DVJ02
ADF&G	7/24/02	Upper Greens Creek	48	DV	122	17.5	22.1	dry wt	0.03	0.74	4.3	0.17	4.9	162	072402GC48DVJ03
ADF&G	7/24/02	Upper Greens Creek	48	DV	127	20.8	21.2	dry wt	0.04	1.40	6.1	0.16	4.7	185	072402GC48DVJ04
ADF&G	7/24/02	Upper Greens Creek	48	DV	134	24.8	21.5	dry wt	0.05	1.30	7.9	0.46	4.3	208	072402GC48DVJ05
ADF&G	7/24/02	Upper Greens Creek	48	DV	128	21.7	20.9	dry wt	0.04	1.56	6.8	0.22	5.7	343	072402GC48DVJ06
ADNR	7/22/03	Upper Greens Creek	48	DV	90	8.9	23.8	dry wt	0.02	0.65	4.2	0.14	5.6	191	072203GC48DVJ01
ADNR	7/22/03	Upper Greens Creek	48	DV	98	9.9	23.6	dry wt	0.02	0.90	5.1	0.22	5.5	180	072203GC48DVJ02
ADNR	7/22/03	Upper Greens Creek	48	DV	103	12.1	23.7	dry wt	0.02	0.82	5.6	0.16	5.4	241	072203GC48DVJ03
ADNR	7/22/03	Upper Greens Creek	48	DV	112	12.5	23.5	dry wt	0.02	0.78	6.1	0.11	6.1	192	072203GC48DVJ04
ADNR	7/22/03	Upper Greens Creek	48	DV	108	11.9	23.8	dry wt	0.02	0.63	3.9	0.14	5.2	174	072203GC48DVJ05
ADNR	7/22/03	Upper Greens Creek	48	DV	100	10.5	24.2	dry wt	0.02	0.58	3.7	0.08	5.5	218	072203GC48DVJ06
ADNR	7/22/04	Upper Greens Creek	48	DV	96	8.6	23.7	dry wt	0.02	0.63	4.7	0.15	4.3	206	072204GC48DVJ01
ADNR	7/22/04	Upper Greens Creek	48	DV	88	6.8	23.4	dry wt	0.02	0.83	5.6	0.26	4.0	175	072204GC48DVJ02
ADNR	7/22/04	Upper Greens Creek	48	DV	101	11.5	23.5	dry wt	0.02	1.54	4.6	0.21	4.1	183	072204GC48DVJ03
ADNR	7/22/04	Upper Greens Creek	48	DV	98	9.3	23.8	dry wt	0.02	0.80	5.2	0.28	3.7	168	072204GC48DVJ04
ADNR	7/22/04	Upper Greens Creek	48	DV	93	7.6	21.4	dry wt	0.02	1.25	4.4	0.14	6.4	220	072204GC48DVJ05
ADNR	7/22/04	Upper Greens Creek	48	DV	91	7.5	23.9	dry wt	0.03	1.01	4.5	0.29	5.6	323	072204GC48DVJ06
ADNR	7/22/05	Upper Greens Creek	48	DV	103	19.7	24.8	dry wt	0.02	0.66	4.4	0.44	4.2	183	072205GC48DVJ01
ADNR	7/22/05	Upper Greens Creek	48	DV	96	13.1	23.6	dry wt	0.02	0.84	14.5	0.98	4.8	220	072205GC48DVJ02
ADNR	7/22/05	Upper Greens Creek	48	DV	119	15.6	23.2	dry wt	0.02	0.89	4.3	0.66	4.8	226	072205GC48DVJ03
ADNR	7/22/05	Upper Greens Creek	48	DV	114	17.1	23.5	dry wt	0.02	0.59	6.0	0.32	4.8	178	072205GC48DVJ04
ADNR	7/22/05	Upper Greens Creek	48	DV	111	15.3	24.9	dry wt	0.03	1.10	18.8	0.79	4.6	217	072205GC48DVJ05
ADNR	7/22/05	Upper Greens Creek	48	DV	125	16.9	23.7	dry wt	0.03	0.47	3.6	0.36	3.8	160	072205GC48DVJ06
ADNR	7/20/06	Upper Greens Creek	48	DV	110	15.8	21.2	dry wt	0.04	0.56	8.5	0.37	5.4	244	072006GC48DVJ01
ADNR	7/20/06	Upper Greens Creek	48	DV	110	15.4	21.4	dry wt	0.05	1.20	8.3	0.31	6.0	217	072006GC48DVJ02
ADNR	7/20/06	Upper Greens Creek	48	DV	113	16.1	23.3	dry wt	0.04	0.65	6.3	0.24	5.4	264	072006GC48DVJ03
ADNR	7/20/06	Upper Greens Creek	48	DV	132	25.0	22.9	dry wt	0.06	0.63	8.1	0.66	5.2	232	072006GC48DVJ04
ADNR	7/20/06	Upper Greens Creek	48	DV	104	12.8	21.0	dry wt	0.08	0.96	8.5	0.37	5.1	283	072006GC48DVJ05
ADNR	7/20/06	Upper Greens Creek	48	DV	114	16.7	20.9	dry wt	0.03	0.63	5.3	0.20	5.1	270	072006GC48DVJ06
ADNR	7/21/07	Upper Greens Creek	48	DV	122	17.9	22.3	dry wt	0.03	1.16	5.5	0.17	5.5	221	072107GC48DVJ01
ADNR	7/21/07	Upper Greens Creek	48	DV	95	10.4	24.7	dry wt	0.02	1.42	3.9	0.29	5.8	165	072107GC48DVJ02
ADNR	7/21/07	Upper Greens Creek	48	DV	135	22.8	24.4	dry wt	0.08	1.34	14.1	1.37	5.3	166	072107GC48DVJ03
ADNR	7/21/07	Upper Greens Creek	48	DV	98	9.9	21.5	dry wt	0.03	0.96	5.7	0.27	5.2	269	072107GC48DVJ04
ADNR	7/21/07	Upper Greens Creek	48	DV	105	13.2	20.7	dry wt	0.11	1.79	11.4	1.62	5.4	323	072107GC48DVJ05
ADNR	7/21/07	Upper Greens Creek	48	DV	99	10.0	22.0	dry wt	0.04	1.43	5.2	0.31	5.7	208	072107GC48DVJ06
ADF&G	7/22/08	Upper Greens Creek	48	DV	112	16.4	22.2	dry wt	0.07	1.23	5.2	0.95	5.7	289	072208GC48DVJ01
ADF&G	7/22/08	Upper Greens Creek	48	DV	123	21.3	24.0	dry wt	0.04	0.79	3.9	0.57	4.6	194	072208GC48DVJ02
ADF&G	7/22/08	Upper Greens Creek	48	DV	105	14.0	23.5	dry wt	0.08	0.81	4.6	0.52	5.9	200	072208GC48DVJ03
ADF&G	7/22/08	Upper Greens Creek	48	DV	124	20.6	23.6	dry wt	0.04	0.87	4.9	0.42	6.3	244	072208GC48DVJ04
ADF&G	7/22/08	Upper Greens Creek	48	DV	115	16.9	23.0	dry wt	0.03	1.36	5.3	0.51	5.4	254	072208GC48DVJ05
ADF&G	7/22/08	Upper Greens Creek	48	DV	122	19.8	22.4	dry wt	0.04	1.07	5.6	0.38	6.1	260	072208GC48DVJ06

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Collector	Date Collected	Location	Site No.	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Analyte Basis	Ag (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Se (mg/kg)	Zn (mg/kg)	Sample Number
ADF&G	7/21/09	Upper Greens Creek	48	DV	120	20.1	23.7	dry wt	0.02	1.05	5.2	0.22	5.9	186	072109GC48DVJ01
ADF&G	7/21/09	Upper Greens Creek	48	DV	121	20.7	23.9	dry wt	0.02	1.40	5.3	0.44	5.7	173	072109GC48DVJ02
ADF&G	7/21/09	Upper Greens Creek	48	DV	119	17.9	22.3	dry wt	0.02	1.10	4.5	0.13	5.9	182	072109GC48DVJ03
ADF&G	7/21/09	Upper Greens Creek	48	DV	108	13.6	23.5	dry wt	0.02	1.20	4.1	0.15	5.7	162	072109GC48DVJ04
ADF&G	7/21/09	Upper Greens Creek	48	DV	109	14.6	23.8	dry wt	0.02	1.50	4.9	0.17	5.9	186	072109GC48DVJ05
ADF&G	7/21/09	Upper Greens Creek	48	DV	110	15.2	22.5	dry wt	0.02	0.84	3.8	0.18	6.1	202	072109GC48DVJ06
ADF&G & USFS	7/21/10	Upper Greens Creek	48	DV	103	11.9	24.6	dry wt	0.02	1.56	4.8	0.16	5.0	226	072110GC48DVJ01
ADF&G & USFS	7/21/10	Upper Greens Creek	48	DV	109	16.1	23.0	dry wt	0.02	0.51	3.0	0.20	5.6	168	072110GC48DVJ02
ADF&G & USFS	7/21/10	Upper Greens Creek	48	DV	108	13.9	22.8	dry wt	0.04	0.91	4.2	0.30	5.0	180	072110GC48DVJ03
ADF&G & USFS	7/21/10	Upper Greens Creek	48	DV	105	13.8	23.7	dry wt	0.02	0.98	3.4	0.09	4.6	163	072110GC48DVJ04
ADF&G & USFS	7/21/10	Upper Greens Creek	48	DV	98	10.8	22.7	dry wt	0.06	0.90	4.8	0.46	4.8	213	072110GC48DVJ05
ADF&G & USFS	7/21/10	Upper Greens Creek	48	DV	93	9.1	23.7	dry wt	0.02	0.96	3.6	0.09	4.0	156	072110GC48DVJ06
ADF&G & USFS	7/23/01	Middle Greens Creek	6	DV	139	28.4	20.8	dry wt	0.04	1.94	16.7	1.24	5.0	173	072301GC06DVJ01
ADF&G & USFS	7/23/01	Middle Greens Creek	6	DV	140	30.5	22.8	dry wt	0.03	0.84	4.6	1.00	4.5	167	072301GC06DVJ02
ADF&G & USFS	7/23/01	Middle Greens Creek	6	DV	167	43.9	21.7	dry wt	0.03	0.82	5.3	1.94	4.3	171	072301GC06DVJ03
ADF&G & USFS	7/23/01	Middle Greens Creek	6	DV	155	34.8	21.6	dry wt	0.03	1.52	5.4	1.78	4.5	215	072301GC06DVJ04
ADF&G & USFS	7/23/01	Middle Greens Creek	6	DV	109	15.7	22.2	dry wt	0.02	0.89	11.1	0.33	5.3	126	072301GC06DVJ05
ADF&G & USFS	7/23/01	Middle Greens Creek	6	DV	168	49.1	21.9	dry wt	0.04	0.73	8.0	1.96	4.6	169	072301GC06DVJ06
ADF&G & USFS	7/21/06	Middle Greens Creek	6	DV	103	12.6	21.7	dry wt	0.03	0.71	8.0	0.70	5.2	183	072106GC06DVJ01
ADF&G & USFS	7/21/06	Middle Greens Creek	6	DV	106	13.5	21.3	dry wt	0.04	0.81	12.0	0.62	5.6	271	072106GC06DVJ02
ADF&G & USFS	7/21/06	Middle Greens Creek	6	DV	96	11.8	21.0	dry wt	0.03	0.56	12.7	0.97	4.5	215	072106GC06DVJ03
ADF&G & USFS	7/21/06	Middle Greens Creek	6	DV	110	12.0	20.6	dry wt	0.03	0.56	7.7	0.92	5.9	223	072106GC06DVJ04
ADF&G & USFS	7/21/06	Middle Greens Creek	6	DV	128	23.2	22.0	dry wt	0.03	0.95	5.4	1.31	4.4	221	072106GC06DVJ05
ADF&G & USFS	7/21/06	Middle Greens Creek	6	DV	102	11.5	20.1	dry wt	0.02	0.63	6.5	0.86	4.5	302	072106GC06DVJ06
USFS	7/21/00	Greens Cr Below Pond D	54	CO	72	4.4	20.5	dry wt	0.04	0.95	15.3	1.40	4.9	251	062100GCCOJ01
USFS	7/21/00	Greens Cr Below Pond D	54	CO	82	6.1	20.2	dry wt	0.09	0.66	11.7	1.21	4.7	224	062100GCCOJ02
USFS	7/21/00	Greens Cr Below Pond D	54	CO	73	4.9	20.4	dry wt	0.22	1.07	24.2	1.40	3.4	206	062100GCCOJ03
USFS	7/21/00	Greens Cr Below Pond D	54	CO	68	3.4	21.4	dry wt	0.10	0.97	24.0	1.12	3.5	181	062100GCCOJ04
USFS	7/21/00	Greens Cr Below Pond D	54	CO	73	5.9	20.7	dry wt	0.05	0.96	44.0	1.53	4.9	304	062100GCCOJ05
USFS	7/21/00	Greens Cr Below Pond D	54	CO	75	6.0	20.2	dry wt	0.08	1.47	36.1	5.02	4.7	340	062100GCCOJ06
ADF&G & USFS	7/23/01	Greens Cr Below Pond D	54	DV	121	21.5	22.6	dry wt	0.03	0.46	4.3	0.33	5.7	126	072301GC54DVJ01
ADF&G & USFS	7/23/01	Greens Cr Below Pond D	54	DV	119	19.3	26.1	dry wt	0.02	0.21	3.2	0.22	3.6	82	072301GC54DVJ02
ADF&G & USFS	7/23/01	Greens Cr Below Pond D	54	DV	107	15.7	23.5	dry wt	0.03	0.73	6.3	0.59	4.7	144	072301GC54DVJ03
ADF&G & USFS	7/23/01	Greens Cr Below Pond D	54	DV	109	13.6	21.1	dry wt	0.02	0.82	5.4	0.86	4.9	172	072301GC54DVJ04
ADF&G & USFS	7/23/01	Greens Cr Below Pond D	54	DV	105	13.5	22.8	dry wt	0.02	0.79	6.5	0.45	5.8	203	072301GC54DVJ05
ADF&G & USFS	7/23/01	Greens Cr Below Pond D	54	DV	138	27.5	22.1	dry wt	0.02	0.74	5.8	0.40	5.4	171	072301GC54DVJ06
ADF&G	7/24/02	Greens Cr Below Pond D	54	DV	118	18.0	21.2	dry wt	0.03	0.50	4.4	0.94	3.4	363	072402GC54DVJ01
ADF&G	7/24/02	Greens Cr Below Pond D	54	DV	128	22.3	23.2	dry wt	0.03	0.52	4.5	0.35	4.7	150	072402GC54DVJ02
ADF&G	7/24/02	Greens Cr Below Pond D	54	DV	115	17.7	21.9	dry wt	0.05	0.95	6.0	0.66	4.4	161	072402GC54DVJ03
ADF&G	7/24/02	Greens Cr Below Pond D	54	DV	115	18.9	21.3	dry wt	0.03	1.03	5.2	0.66	4.2	216	072402GC54DVJ04
ADF&G	7/24/02	Greens Cr Below Pond D	54	DV	124	21.1	21.4	dry wt	0.05	1.32	5.2	0.74	3.9	2	072402GC54DVJ05
ADF&G	7/24/02	Greens Cr Below Pond D	54	DV	123	20.9	20.9	dry wt	0.02	0.70	3.9	0.78	4.4	195	072402GC54DVJ06
ADNR	7/22/03	Greens Cr Below Pond D	54	DV	123	21.1	25.1	dry wt	0.03	0.85	6.4	1.40	6.1	188	072203GC54DVJ01
ADNR	7/22/03	Greens Cr Below Pond D	54	DV	101	10.6	22.9	dry wt	0.02	0.67	4.2	0.32	6.4	174	072203GC54DVJ02
ADNR	7/22/03	Greens Cr Below Pond D	54	DV	88	9.2	22.8	dry wt	0.02	0.75	4.3	0.35	6.5	186	072203GC54DVJ03
ADNR	7/22/03	Greens Cr Below Pond D	54	DV	109	14.8	24.0	dry wt	0.02	1.11	5.8	0.38	5.7	188	072203GC54DVJ04
ADNR	7/22/03	Greens Cr Below Pond D	54	DV	95	10.6	23.9	dry wt	0.02	0.59	3.5	0.29	5.7	174	072203GC54DVJ05
ADNR	7/22/03	Greens Cr Below Pond D	54	DV	92	9.7	23.8	dry wt	0.02	0.91	4.1	0.43	6.5	263	072203GC54DVJ06

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Collector	Date Collected	Location	Site No.	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Analyte Basis	Ag (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Se (mg/kg)	Zn (mg/kg)	Sample Number
ADNR	7/21/04	Greens Cr Below Pond D	54	DV	103	9.9	23.8	dry wt	0.02	0.79	11.0	0.57	4.6	232	072104GC54DVJ01
ADNR	7/21/04	Greens Cr Below Pond D	54	DV	104	10.0	22.6	dry wt	0.02	0.88	5.5	0.54	5.0	206	072104GC54DVJ02
ADNR	7/21/04	Greens Cr Below Pond D	54	DV	86	6.6	23.7	dry wt	0.02	1.26	5.1	0.36	5.3	164	072104GC54DVJ03
ADNR	7/21/04	Greens Cr Below Pond D	54	DV	96	9.3	22.9	dry wt	0.03	0.79	5.9	0.28	5.4	191	072104GC54DVJ04
ADNR	7/21/04	Greens Cr Below Pond D	54	DV	93	9.9	22.1	dry wt	0.02	0.83	5.0	0.48	3.9	202	072104GC54DVJ05
ADNR	7/21/04	Greens Cr Below Pond D	54	DV	104	12.9	21.4	dry wt	0.07	1.12	7.0	0.93	4.9	216	072104GC54DVJ06
ADNR	7/22/05	Greens Cr Below Pond D	54	DV	120	12.3	23.1	dry wt	0.03	0.72	5.0	0.27	4.0	160	072205GC54DVJ01
ADNR	7/22/05	Greens Cr Below Pond D	54	DV	106	12.1	22.6	dry wt	0.02	0.63	4.5	0.13	3.9	200	072205GC54DVJ02
ADNR	7/22/05	Greens Cr Below Pond D	54	DV	113	20.8	23.1	dry wt	0.02	0.73	8.8	0.17	4.7	223	072205GC54DVJ03
ADNR	7/22/05	Greens Cr Below Pond D	54	DV	114	17.9	22.3	dry wt	0.02	0.82	9.7	0.17	3.9	222	072205GC54DVJ04
ADNR	7/22/05	Greens Cr Below Pond D	54	DV	112	16.1	23.0	dry wt	0.03	1.06	8.8	0.22	4.4	209	072205GC54DVJ05
ADNR	7/22/05	Greens Cr Below Pond D	54	DV	118	22.3	22.4	dry wt	0.02	0.55	5.5	0.39	3.9	185	072205GC54DVJ06
ADNR	7/20/06	Greens Cr Below Pond D	54	DV	137	27.3	24.6	dry wt	0.06	0.42	4.8	0.50	5.7	208	072006GC54DVJ01
ADNR	7/20/06	Greens Cr Below Pond D	54	DV	112	14.9	21.7	dry wt	0.04	0.75	16.0	0.95	7.2	223	072006GC54DVJ02
ADNR	7/20/06	Greens Cr Below Pond D	54	DV	102	12.0	19.2	dry wt	0.02	0.93	22.2	0.52	6.3	239	072006GC54DVJ03
ADNR	7/20/06	Greens Cr Below Pond D	54	DV	114	19.6	21.8	dry wt	0.04	1.03	7.6	0.85	5.3	252	072006GC54DVJ04
ADNR	7/20/06	Greens Cr Below Pond D	54	DV	98	12.3	20.8	dry wt	0.08	0.54	10.9	0.48	5.4	223	072006GC54DVJ05
ADNR	7/20/06	Greens Cr Below Pond D	54	DV	115	16.9	21.7	dry wt	0.04	0.78	8.6	0.68	5.6	257	072006GC54DVJ06
ADNR	7/20/07	Greens Cr Below Pond D	54	DV	102	11.8	24.3	dry wt	0.04	0.88	5.3	0.54	5.6	157	072007GC54DVJ01
ADNR	7/20/07	Greens Cr Below Pond D	54	DV	125	21.1	21.6	dry wt	0.03	0.97	5.2	0.83	7.5	234	072007GC54DVJ02
ADNR	7/20/07	Greens Cr Below Pond D	54	DV	97	10.7	22.3	dry wt	0.06	0.81	5.7	0.89	8.6	185	072007GC54DVJ03
ADNR	7/20/07	Greens Cr Below Pond D	54	DV	123	19.7	22.8	dry wt	0.02	0.75	4.4	0.50	7.1	175	072007GC54DVJ04
ADNR	7/20/07	Greens Cr Below Pond D	54	DV	104	12.5	22.6	dry wt	0.03	0.92	5.6	0.57	7.8	174	072007GC54DVJ05
ADNR	7/20/07	Greens Cr Below Pond D	54	DV	110	15.1	21.6	dry wt	0.04	1.38	6.2	0.82	5.4	191	072007GC54DVJ06
ADF&G	7/22/08	Greens Cr Below Pond D	54	DV	123	21.9	24.9	dry wt	0.04	0.66	5.3	0.26	5.5	185	072208GC54DVJ01
ADF&G	7/22/08	Greens Cr Below Pond D	54	DV	94	10.8	22.4	dry wt	0.04	1.04	5.1	0.28	6.1	203	072208GC54DVJ02
ADF&G	7/22/08	Greens Cr Below Pond D	54	DV	123	21.5	21.6	dry wt	0.03	1.53	4.9	3.46	6.3	261	072208GC54DVJ03
ADF&G	7/22/08	Greens Cr Below Pond D	54	DV	97	11.2	23.8	dry wt	0.03	1.34	5.0	0.17	5.9	199	072208GC54DVJ04
ADF&G	7/22/08	Greens Cr Below Pond D	54	DV	108	16.0	23.6	dry wt	0.05	1.98	6.3	0.23	6.0	220	072208GC54DVJ05
ADF&G	7/22/08	Greens Cr Below Pond D	54	DV	108	14.2	24.5	dry wt	0.06	1.07	8.4	1.31	5.0	195	072208GC54DVJ06
ADF&G	7/21/09	Greens Cr Below Pond D	54	DV	132	26.9	22.6	dry wt	0.04	1.10	4.8	0.33	5.4	213	072109GC54DVJ01
ADF&G	7/21/09	Greens Cr Below Pond D	54	DV	141	32.3	23.5	dry wt	0.02	0.71	4.5	0.45	7.9	143	072109GC54DVJ02
ADF&G	7/21/09	Greens Cr Below Pond D	54	DV	116	17.9	24.3	dry wt	0.02	0.99	4.2	0.40	6.3	153	072109GC54DVJ03
ADF&G	7/21/09	Greens Cr Below Pond D	54	DV	117	17.7	23.6	dry wt	0.03	1.00	5.9	0.39	6.8	200	072109GC54DVJ04
ADF&G	7/21/09	Greens Cr Below Pond D	54	DV	119	22.1	24.8	dry wt	0.02	1.20	4.0	0.28	6.5	176	072109GC54DVJ05
ADF&G	7/21/09	Greens Cr Below Pond D	54	DV	103	13.0	24.2	dry wt	0.02	2.20	5.3	0.35	5.9	226	072109GC54DVJ06
ADF&G & USFS	7/20/10	Greens Cr Below Pond D	54	DV	115	16.0	24.0	dry wt	0.02	0.81	3.4	0.30	4.7	161	072110GC54DVJ01
ADF&G & USFS	7/20/10	Greens Cr Below Pond D	54	DV	112	12.8	24.2	dry wt	0.02	0.67	3.1	0.34	3.7	154	072110GC54DVJ02
ADF&G & USFS	7/20/10	Greens Cr Below Pond D	54	DV	118	12.6	24.7	dry wt	0.02	0.98	3.6	0.25	5.2	190	072110GC54DVJ03
ADF&G & USFS	7/20/10	Greens Cr Below Pond D	54	DV	108	10.6	24.3	dry wt	0.02	1.31	3.8	0.16	4.1	212	072110GC54DVJ04
ADF&G & USFS	7/20/10	Greens Cr Below Pond D	54	DV	115	12.3	24.0	dry wt	0.02	1.73	5.0	0.36	4.4	222	072110GC54DVJ05
ADF&G & USFS	7/20/10	Greens Cr Below Pond D	54	DV	94	9.0	22.3	dry wt	0.03	0.77	4.0	0.31	4.8	199	072110GC54DVJ06
USFS	7/21/00	Tributary Creek	9	CO	102	9.7	22.9	dry wt	0.04	0.42	16.2	1.03	3.2	213	062100TRCOJ01
USFS	7/21/00	Tributary Creek	9	CO	75	5.3	22.5	dry wt	0.07	0.50	16.5	2.01	3.7	220	062100TRCOJ02
USFS	7/21/00	Tributary Creek	9	DV	112	12.8	23.1	dry wt	0.12	0.75	11.2	1.63	3.8	194	062100TRCOJ03
USFS	7/21/00	Tributary Creek	9	DV	105	13.8	22.2	dry wt	0.07	0.56	10.6	1.53	3.6	88	062100TRDVJ04
USFS	7/21/00	Tributary Creek	9	DV	105	13.4	22.1	dry wt	0.06	0.58	12.8	1.59	3.5	204	062100TRDVJ05
USFS	7/21/00	Tributary Creek	9	DV	100	11.3	23.0	dry wt	0.05	0.45	32.8	1.57	5.0	213	062100TRDVJ06

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Collector	Date Collected	Location	Site No.	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Analyte Basis	Ag (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Se (mg/kg)	Zn (mg/kg)	Sample Number
ADF&G & USFS	7/21/01	Tributary Creek	9	DV	97	9.1	22.1	dry wt	0.09	0.35	4.3	0.56	6.8	127	072301TR09DVJ01
ADF&G & USFS	7/21/01	Tributary Creek	9	DV	97	9.7	21.3	dry wt	0.10	0.77	5.2	0.67	8.0	118	072301TR09DVJ02
ADF&G & USFS	7/21/01	Tributary Creek	9	DV	97	9.5	22.2	dry wt	0.15	0.92	5.4	4.88	5.3	144	072301TR09DVJ03
ADF&G & USFS	7/21/01	Tributary Creek	9	DV	98	10.4	22.6	dry wt	0.15	0.86	6.7	2.19		99	072301TR09DVJ04
ADF&G & USFS	7/21/01	Tributary Creek	9	DV	86	6.4	22.2	dry wt	0.08	0.76	4.9	0.33	6.2	106	072301TR09DVJ05
ADF&G & USFS	7/21/01	Tributary Creek	9	DV	93	7.8	20.6	dry wt	0.06	0.37	12.0	0.38	6.8	122	072301TR09DVJ06
ADF&G	7/24/02	Tributary Creek	9	DV	103	10.8	20.9	dry wt	0.02	0.22	3.7	0.12	1.4	144	072402TR09DVJ01
ADF&G	7/24/02	Tributary Creek	9	DV	97	10.4	22.8	dry wt	0.07	1.20	5.5	1.66	3.3	172	072402TR09DVJ02
ADF&G	7/24/02	Tributary Creek	9	DV	100	11.2	23.2	dry wt	0.13	1.06	6.1	3.40	5.0	138	072402TR09DVJ03
ADF&G	7/24/02	Tributary Creek	9	DV	90	7.9	23.1	dry wt	0.23	1.29	7.1	4.08	5.2	168	072402TR09DVJ04
ADF&G	7/24/02	Tributary Creek	9	DV	90	9.2	23.0	dry wt	0.08	1.15	5.2	1.39	6.2	150	072402TR09DVJ05
ADF&G	7/24/02	Tributary Creek	9	DV	100	9.3	17.8	dry wt	0.04	0.84	3.2	0.33	5.4	152	072402TR09DVJ06
ADNR	7/23/03	Tributary Creek	9	DV	106	10.7	21.9	dry wt	0.06	0.46	2.8	0.34	6.3	134	072304TR09DVJ01
ADNR	7/23/03	Tributary Creek	9	DV	89	6.8	22.8	dry wt	0.10	1.01	4.0	0.82	6.0	131	072304TR09DVJ02
ADNR	7/23/03	Tributary Creek	9	DV	112	17.4	24.3	dry wt	0.16	1.35	4.4	1.85	5.7	108	072304TR09DVJ03
ADNR	7/23/03	Tributary Creek	9	DV	95	11.6	22.5	dry wt	0.19	0.69	5.6	1.30	3.6	136	072304TR09DVJ04
ADNR	7/23/03	Tributary Creek	9	DV	91	9.5	22.2	dry wt	0.05	0.72	4.4	0.56	4.9	131	072304TR09DVJ05
ADNR	7/23/03	Tributary Creek	9	DV	84	8.4	23.2	dry wt	0.12	0.76	3.9	0.78	4.7	125	072304TR09DVJ06
ADNR	7/21/04	Tributary Creek	9	DV	84	5.5	23.0	dry wt	0.10	0.96	3.2	1.19	5.4	169	072104TR09DVJ01
ADNR	7/21/04	Tributary Creek	9	DV	96	8.5	23.0	dry wt	0.10	1.24	3.8	0.67	5.9	138	072104TR09DVJ02
ADNR	7/21/04	Tributary Creek	9	DV	105	14.1	23.3	dry wt	0.10	2.02	4.0	1.75	5.7	125	072104TR09DVJ03
ADNR	7/21/04	Tributary Creek	9	DV	85	5.8	22.6	dry wt	0.04	0.47	3.7	0.93	4.8	175	072104TR09DVJ04
ADNR	7/21/04	Tributary Creek	9	DV	81	6.4	24.0	dry wt	0.09	2.34	4.3	1.44	8.2	140	072104TR09DVJ05
ADNR	7/21/04	Tributary Creek	9	DV	86	10.4	17.6	dry wt	0.11	0.83	5.5	0.97	5.8	161	072104TR09DVJ06
ADNR	7/23/05	Tributary Creek	9	DV	97	11.1	25.8	dry wt	0.06	0.70	10.4	0.29	6.4	104	072305TR09DVJ01
ADNR	7/23/05	Tributary Creek	9	DV	113	16.8	26.7	dry wt	0.10	0.63	4.7	0.97	6.1	122	072305TR09DVJ02
ADNR	7/23/05	Tributary Creek	9	DV	115	18.8	26.2	dry wt	0.07	0.52	6.3	0.53	5.8	109	072305TR09DVJ03
ADNR	7/23/05	Tributary Creek	9	DV	117	20.5	26.1	dry wt	0.19	0.79	9.9	1.07	6.7	117	072305TR09DVJ04
ADNR	7/23/05	Tributary Creek	9	DV	101	11.7	27.4	dry wt	0.07	1.44	5.2	1.00	8.1	130	072305TR09DVJ05
ADNR	7/23/05	Tributary Creek	9	DV	107	13.7	25.9	dry wt	0.10	1.29	4.6	0.46	8.0	134	072305TR09DVJ06
ADNR	7/21/06	Tributary Creek	9	DV	99	12.9	22.6	dry wt	0.12	0.74	4.0	0.46	8.0	134	072106TR09DVJ01
ADNR	7/21/06	Tributary Creek	9	DV	96	11.6	24.0	dry wt	0.12	0.76	7.7	1.32	6.8	157	072106TR09DVJ02
ADNR	7/21/06	Tributary Creek	9	DV	94	10.9	24.5	dry wt	0.18	1.59	10.3	2.48	4.9	160	072106TR09DVJ03
ADNR	7/21/06	Tributary Creek	9	DV	100	10.9	21.8	dry wt	0.11	1.34	8.5	1.46	5.2	142	072106TR09DVJ04
ADNR	7/21/06	Tributary Creek	9	DV	97	11.7	23.3	dry wt	0.14	0.88	4.6	0.96	5.2	107	072106TR09DVJ05
ADNR	7/21/06	Tributary Creek	9	DV	117	20.8	23.7	dry wt	0.24	1.29	4.3	2.92	5.9	129	072106TR09DVJ06
ADNR	7/20/07	Tributary Creek	9	DV	98	12.4	26.4	dry wt	0.11	0.91	2.7	1.10	7.7	106	072007TR09DVJ01
ADNR	7/20/07	Tributary Creek	9	DV	89	8.9	25.8	dry wt	0.12	1.72	3.3	1.80	5.6	136	072007TR09DVJ02
ADNR	7/20/07	Tributary Creek	9	DV	114	14.1	25.5	dry wt	0.15	2.76	3.4	1.28	8.7	122	072007TR09DVJ03
ADNR	7/20/07	Tributary Creek	9	DV	81	7.1	26.8	dry wt	0.14	1.90	4.2	2.03	7.0	114	072007TR09DVJ04
ADNR	7/20/07	Tributary Creek	9	DV	114	14.6	27.5	dry wt	0.88	3.63	3.9	1.56	10.9	131	072007TR09DVJ05
ADNR	7/20/07	Tributary Creek	9	DV	93	10.6	26.8	dry wt	0.14	1.50	20.3	3.80	9.4	107	072007TR09DVJ06
ADNR	7/23/08	Tributary Creek	9	DV	103	12.9	24.3	dry wt	0.22	1.99	4.2	3.47	7.7	169	072308TR09DVJ01
ADF&G	7/23/08	Tributary Creek	9	DV	108	14.8	23.0	dry wt	0.10	0.96	3.2	0.86	5.8	143	072308TR09DVJ02
ADF&G	7/23/08	Tributary Creek	9	DV	88	8.9	23.0	dry wt	0.08	0.93	3.3	0.75	4.4	186	072308TR09DVJ03
ADF&G	7/23/08	Tributary Creek	9	DV	86	9.3	26.6	dry wt	0.22	1.91	5.7	4.06	5.7	119	072308TR09DVJ04
ADF&G	7/23/08	Tributary Creek	9	DV	92	9.6	24.7	dry wt	0.07	1.01	2.7	0.61	5.2	125	072308TR09DVJ05
ADF&G	7/23/08	Tributary Creek	9	DV	90	8.7	25.4	dry wt	0.03	0.54	2.2	0.43	4.8	108	072308TR09DVJ06

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Collector	Date Collected	Location	Site No.	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Analyte Basis	Ag (mg/kg)	Cd (mg/kg)	Cu (mg/kg)	Pb (mg/kg)	Se (mg/kg)	Zn (mg/kg)	Sample Number
ADF&G	7/22/09	Tributary Creek	9	DV	83	6.9	23.0	dry wt	0.04	0.29	1.7	0.24	5.4	127	072209TR09DVJ01
ADF&G	7/22/09	Tributary Creek	9	DV	91	8.6	22.1	dry wt	0.06	0.55	2.1	0.16	5.1	137	072209TR09DVJ02
ADF&G	7/22/09	Tributary Creek	9	DV	91	8.5	22.6	dry wt	0.11	0.36	2.0	0.23	7.5	138	072209TR09DVJ03
ADF&G	7/22/09	Tributary Creek	9	DV	98	10.3	22.6	dry wt	0.09	0.81	3.4	0.38	5.8	147	072209TR09DVJ04
ADF&G	7/22/09	Tributary Creek	9	DV	91	8.6	23.1	dry wt	0.03	0.47	2.2	0.40	4.5	125	072209TR09DVJ05
ADF&G	7/22/09	Tributary Creek	9	DV	90	7.8	22.8	dry wt	0.06	0.60	2.2	0.38	5.6	129	072209TR09DVJ06
ADF&G & USFS	7/20/10	Tributary Creek	9	DV	87	7.4	23.0	dry wt	0.29	1.61	5.4	3.92	6.4	151	072210TR09DVJ01
ADF&G & USFS	7/20/10	Tributary Creek	9	DV	94	10.9	21.2	dry wt	0.12	0.82	2.5	0.24	5.7	174	072210TR09DVJ02
ADF&G & USFS	7/20/10	Tributary Creek	9	DV	90	8.5	22.4	dry wt	0.08	0.73	2.9	0.29	5.3	125	072210TR09DVJ03
ADF&G & USFS	7/20/10	Tributary Creek	9	DV	90	8.2	21.4	dry wt	0.06	0.60	2.3	0.33	4.7	151	072210TR09DVJ04
ADF&G & USFS	7/20/10	Tributary Creek	9	DV	108	13.5	21.7	dry wt	0.08	0.66	2.6	0.25	3.2	118	072210TR09DVJ05
ADF&G & USFS	7/20/10	Tributary Creek	9	DV	105	11.6	23.3	dry wt	0.08	0.75	3.1	0.23	3.9	150	072210TR09DVJ06