Technical Report No. 10-03

Aquatic Biomonitoring at Greens Creek Mine, 2009

by James D. Durst
Laura L. Jacobs

May 2010

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

Cover: Helen Mooney (HGCMC) and Kate Kanouse (ADF&G) near the upper end of the juvenile fish sampling reach of Greens Creek Below Pond D Site 54 on 21 July 2009. Gallagher Creek can be seen entering from the right. ADF&G photo by James Durst.

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EXECUTIVE SUMMARY

The Alaska Department of Fish and Game (ADF&G) and the USDA Forest Service, in cooperation with the U.S. Fish and Wildlife Service, began an aquatic biomonitoring program at Greens Creek Mine on Admiralty Island in southeast Alaska in 2001 and have continued the sampling and analysis program in subsequent years.

As part of the Hecla Greens Creek Mining Company Fresh Water Monitoring Program, the Greens Creek Mine Biological Monitoring Program's purpose is to ensure the continued use of Greens Creek and Tributary Creek by fish and other aquatic species, and to document the continued health of all levels of the aquatic biological community: primary productivity, invertebrate, and fish. The intent is that the program will also detect changes in these aquatic communities over time that may result from changes in water quality associated with surface- or ground-water inputs to the streams. Elements of the biological monitoring program developed to meet the stated purpose include surveys of periphyton biomass, benthic macroinvertebrate density and community structure, juvenile fish abundance and distribution, and concentrations of selected heavy metals in fish tissues.

The two biomonitoring sites sampled on Greens Creek (Upper Greens Creek Site 48 above all facilities and Greens Creek Below Pond D Site 54 below all facilities) and the one site sampled on Tributary Creek (Tributary Creek Site 9 below the dry-stack tailings facility) continued to sustain functioning, diverse aquatic communities in 2009 at typically the same or somewhat less abundant levels than in the previous eight years of biomonitoring. During 2009, water levels and stream discharges at the two Greens Creek sampling sites were moderate, while those at the Tributary Creek site were likely the lowest experienced during biomonitoring.

All sites exhibited an increase in periphyton biomass in 2009 compared to 2008. Responses to hydrologic events at these three sites likely contributed the most variability to periphyton biomass given the similar trends seen, but the pattern of periphyton biomass at the Tributary Creek site is typically more variable within each year. The presence of moderate periphyton biomass and the continuity of community composition at the three sampled biomonitoring sites reveal a robust algal component.

The benthic macroinvertebrate communities at the three biomonitoring sites showed essentially the opposite trends of the periphyton communities in 2009, in that densities decreased at all three sites from those seen in 2008. Mean densities of benthic macroinvertebrates in Tributary Creek were substantially lower than the Greens Creek sites, while taxonomic richness was not. Although the number of taxa per site, or taxonomic richness, was not significantly different between any of the study sites in 2009, the composition of the benthic macroinvertebrate community of the Greens Creek sites continued to be characterized by their similarities to each other and differences with Tributary Creek. The proportion of aquatic Diptera in Tributary Creek samples in 2009 continued to be greater in relation to the two Greens Creek sites. However, the overall proportion of pollution-sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa to Diptera in 2009 samples from all three sites remained high, suggesting that water quality was maintained.

Dolly Varden (*Salvelinus malma*) populations in 2009 at all three sites were significantly larger than in 2008, with the Upper Greens Creek and Tributary sites at moderate levels while the Greens Creek Below Pond D site population was still quite low. Captures at Greens Creek sites had multiple size classes of Dolly Varden present, although continuation of a general shift to larger size classes over time was again seen. Dolly Varden captures at Tributary Creek Site 9 in 2009 were moderate after three low-capture years, with a shift to somewhat smaller size classes including those typically associated with young of the year Dolly Varden. A very few coho salmon (*Oncorhynchus kisutch*) were captured at Greens Creek Below Pond D Site 54, leading to continued concern about fish passage over the downstream falls area. It is unclear from the size classes present whether or not any coho captured were young of the year fish. Coho salmon captures at Tributary Creek Site 9 were at a moderate level, particularly noteworthy because of the very low water levels during sampling. Total fish densities per square meter of wetted stream area among the three sites were lower at Greens Creek Below Pond D Site 54 than at Upper Greens Creek Site 48 for the first time in nine years of biomonitoring sampling, with Tributary Creek Site 9 having the highest total fish density of the three sites.

The ranges of whole body concentrations of metals in juvenile Dolly Varden tissues in 2009 were generally lower than or similar to those found in previous years' samples at each site, except for cadmium at Greens Creek Below Pond D Site 54 and selenium at both Greens Creek sites. There were no statistical differences in tissue metals concentrations between the two Greens Creek sites in 2009 except for a significantly lower level of lead at Site 48 than at Site 54. The year-to-year comparisons showed the only significantly or substantially higher metal levels in 2009 compared to all previous years to be for selenium at both of the Greens Creek sites. Tissues of juvenile Dolly Varden from Tributary Creek Site 9 captured in 2009 continued to have different metals concentrations characteristics than did tissues from Dolly Varden captured at the two Greens Creek sites (48 and 54). Greens Creek fish had significantly higher cadmium, copper, and zinc and substantially higher selenium, while Tributary Creek fish had significantly higher concentrations of silver.

In general, the aquatic communities at Upper Greens Creek Site 48, Greens Creek Below Pond D Site 54, and Tributary Creek Site 9 have remained fairly diverse, robust, and moderately abundant during the nine years of biomonitoring sampling. Differences noted between years and between the streams (Greens Creek compared to Tributary Creek) have typically been of larger amplitude than have differences between the control and below-mining sites within Greens Creek or over time at the Tributary Creek site.

Although no trends of reduced productivity, community changes, or metals accumulation attributable to operations of the Greens Creek Mine have been noted, some areas warrant careful watch in future years including low Dolly Varden captures at all three sites, the very low coho salmon captures at Greens Creek Below Pond D Site 54, a general rising trend in Greens Creek fish tissue selenium concentrations and the Greens Creek Below Pond D Site 54 cadmium levels, and low water levels and reduced macroinvertebrate densities in Tributary Creek.

INTRODUCTION

In 2000, an interagency regulatory team representing the Alaska Department of Environmental Conservation (ADEC), the 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 were invited by the Kennecott Greens Creek Mining Company (KGCMC) to conduct a third-party environmental audit of the Greens Creek Mine operations within Admiralty Island National Monument in southeast Alaska.

Based on findings of that review, the Greens Creek Mine Fresh Water Monitoring Program (FWMP) was updated (KGCMC 2000), including specifications for a biological monitoring program in areas adjacent to the surface facilities associated with the mine, mill, tailings, and waste rock disposal. In April 2008, the ownership and operation of Greens Creek Mine transferred to the Hecla Greens Creek Mining Company (HGCMC).

This technical report presents results of the ninth year (2009) of the Greens Creek Mine Biological Monitoring Program as specified in the FWMP, and was conducted by the ADF&G Division of Habitat as successor to the ADNR Office of Habitat Management and Permitting (OHMP) and the ADF&G Habitat and Restoration Division. Results from previous years' biomonitoring can be found 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).

The intent of the Greens Creek Mine Biological Monitoring Program is to document the continued use of Greens Creek and Tributary Creek by fish and other aquatic species, and to document the continued health of the periphyton, benthic macroinvertebrate, and fish communities (KGCMC 2000). Biomonitoring is designed to detect early changes in the aquatic communities that may result from changes in water chemistry through either surface- or ground-water inputs to the streams.

Results from biomonitoring are typically compared to baseline conditions, or to a reference site that is unaffected if baseline data are unavailable. Each of the Greens Creek Mine biomonitoring sites is evaluated individually to detect changes or trends over time, with consideration given to any previous monitoring (KGCMC 2000). Two sites on Greens Creek are below mine facilities and are additionally compared to a control site on Greens Creek upstream of all mine facilities. All biomonitoring at the Greens Creek Mine follows standard protocols acceptable to the USEPA, USFS, ADEC, ADF&G, ADNR, and the American Public Health Association (APHA 1992).

PURPOSE

The objective of the Greens Creek Mine Biological Monitoring Program is to document existing conditions of the aquatic biological communities in selected reaches of Greens Creek and Tributary Creek near the HGCMC surface facilities. Future sampling during the mine life or during reclamation and closure can be compared to the conditions defined under the current biomonitoring program to detect changes that may have occurred in aquatic communities.

The biological monitoring program for the Greens Creek mine was designed to address the following factors as specified in the Fresh Water Monitoring Program (KGCMC 2000):

- Periphyton biomass, estimated by chlorophyll concentrations;
- Abundance and community structure of benthic macroinvertebrate populations;
- Distribution and abundance of juvenile fish;
- Whole body concentrations of Ag, Cd, Cu, Pb, Se, and Zn in juvenile fish; and
- Standardized laboratory toxicity testing.[1]

LOCATION AND SCHEDULE OF MONITORING

Four of the FWMP sites were selected for the biomonitoring program. Figure 1 shows the location of the Greens Creek Mine and the biomonitoring sampling locations. HGCMC monitors the ambient water quality at these and other FWMP sites on a regular basis, and reports the results of that monitoring under separate cover.

Upper Greens Creek Site 48 monitors Greens Creek upstream of all mine and mill facilities including the portals (exploratory drilling has occurred in the watershed upstream of this site); annual biomonitoring at Upper Greens Creek Site 48 serves as a control.

Middle Greens Creek Site 6 monitors Greens Creek downstream of the mine portals and mill facilities but upstream of the production rock storage area; Site 6 was sampled in 2001 to provide baseline conditions (in this instance, baseline is meant to describe the conditions at the beginning

[1] The toxicity testing component of the Greens Creek Biomonitoring Program was suspended after the 2003 sampling period (McGee and Marthaller 2004).

of the biomonitoring program) and is sampled on a 5-year schedule to detect changes over time as a partial treatment site.

Greens Creek Below Pond D Site 54 monitors Greens Creek downstream of the mine portal, mill facilities, and production rock storage area with its associated pond system; annual biomonitoring at Site 54 serves as a complete treatment site.

Tributary Creek Site 9 monitors Tributary Creek downstream of the dry-stack tailings storage facility, which sits at the head of the drainage; biomonitoring occurs at Site 9 annually to detect any changes over time as a complete treatment site.

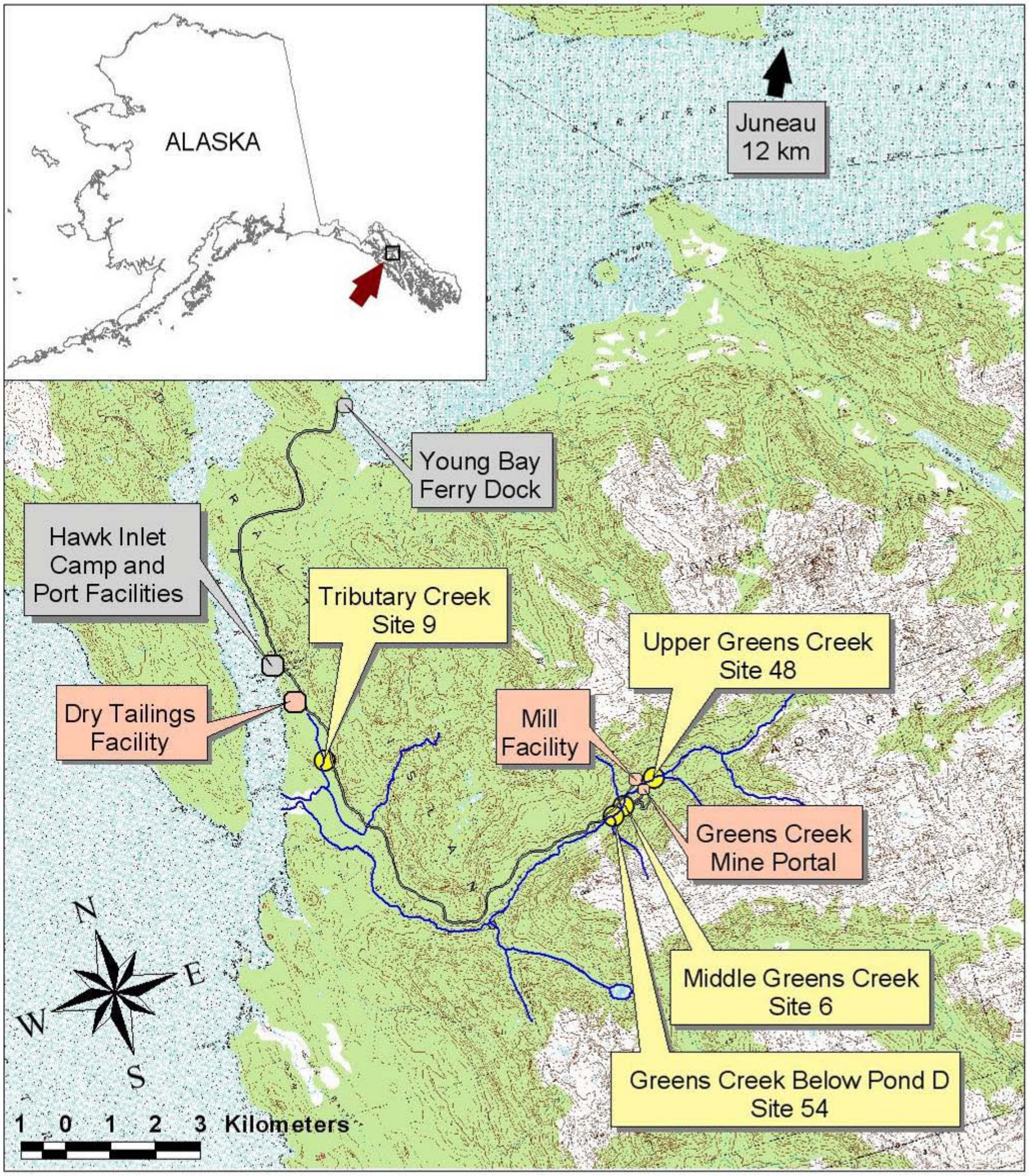


Figure 1. Location of the Greens Creek Mine operation and biomonitoring sampling sites on Admiralty Island in southeast Alaska, southwest of Juneau.

METHODS

Five to six hours are required at each site to gather the suite of raw data needed for biomonitoring sampling. Sample design and methods followed procedures in the Greens Creek Mine Fresh Water Monitoring Program (FWMP; KGCMC 2000) and as reported for the previous years of this biomonitoring study (Weber Scannell and Paustian 2002; Jacobs et al. 2003; Durst and Townsend 2004; Durst et al. 2005; Durst and Jacobs 2006, 2007, 2008, 2009). In addition to the procedures detailed below, biomonitoring program field measurements included air and water temperatures, wetted widths, water velocities at benthic sample locations, and a quick survey for cross sectional area and discharge. Photographs were taken to document site conditions and sampling areas in each survey reach.

Data analyses were performed using hand calculators, Microsoft® Excel 2007, and Statistix® 9 (Analytical Software 2008). Kruskal-Wallis One-Way Analysis of Variance, a nonparametric alternative to a one-way analysis of variance (ANOVA), was used to test for differences 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 of rank means between pairs of years or sites when significant or substantial differences were found. Throughout this report, three levels of statistical differences are reported: ***significant differences*** required an $\alpha \leq 0.05$, ***substantial differences*** required an α value greater than 0.05 but less than or equal to 0.10 ($0.05 < \alpha \leq 0.10$), and groups reported as ***not statistically different*** were neither significantly different nor substantially different ($\alpha > 0.10$).

SAMPLE SITES

Upper Greens Creek Site 48

Upper Greens Creek Site 48 was selected as an upstream “control” reach for comparison to downstream "treatment" reaches of Greens Creek that are adjacent to and downstream from the HGCMC mine facilities. Site 48, at approximately 265 m elevation, is upstream of all mining facilities and activities except for exploratory drilling. Drill sites are located at least 61 m (200 feet) from flowing waters and HGCMC uses a water management plan to avoid having drill water or muds enter a flowing stream. Site 48 lies approximately 0.8 km upstream of a concrete weir across Greens Creek that blocks all upstream fish passage. Because of this barrier, the only salmonid fish species documented to occur at Site 48 is resident Dolly Varden (*Salvelinus malma*).

The Upper Greens Creek Site 48 sample reach has a Moderate Width Mixed Control (MM2) channel type (Appendix 1), with an average channel width of 9 m at ordinary high water and a gradient of 2-4 percent. This is a typical stream for the middle portion of moderately sized basins in southeast Alaska (Paustian et al. 1992, Weber Scannell and Paustian 2002). Cobble is the dominant substrate and large woody debris has a key role in pool formation and fish habitat cover.

The periphyton and benthic macroinvertebrate sample reach is just downstream of the fish sample reach at this site. Both reaches are fairly homogeneous, with split- and single-channel areas, large woody debris, and a mix of pool and riffle habitats.

Water quality at Site 48 has been monitored monthly by KGCMC and HGCMC since 1995, and is reported annually under separate cover.

Middle Greens Creek Site 6

Middle Greens Creek Site 6, at approximately 235 m elevation, is located to detect potential effects on Greens Creek from activities in the HGCMC mine, mill, and shop areas but is upstream of the production rock storage site and its associated treatment ponds. Access by anadromous fish to this stream reach was created by KGCMC in 1989 by installing a fish pass in a rock chute approximately 4.8 km downstream. Site 6 is near the upper limit of potential anadromous fish use and passage in Greens Creek, defined by a weir located approximately 0.8 km upstream. Both Dolly Varden and coho salmon (*Oncorhynchus kisutch*) have been captured in this reach during the biomonitoring program.

Middle Greens Creek Site 6 has a Moderate Width Mixed Control (MM2) channel type (Appendix 1), with an average channel width of 10 m at ordinary high water and a gradient of 2-4 percent. This is a typical stream for the middle portion of moderately sized basins in southeast Alaska (Paustian et al. 1992, Weber Scannell and Paustian 2002). Cobble is the dominant streambed material. Large woody debris is less abundant at this site than at the other two Greens Creek sites, but still integral to pool formation and fish habitat cover.

The periphyton and benthic macroinvertebrate sample reach is immediately upstream of the confluence of Bruin Creek with Greens Creek, while the fish sample reach is a short distance farther upstream above a large woody debris tangle. Both reaches are single-channel areas; the fish reach has both overhanging and pool-forming large woody debris.

Under the five-year pulsed sampling schedule presented in the FWMP, biomonitoring data were collected at Site 6 in 2001 as a baseline for this site (Weber Scannell and Paustian 2002) and again in 2006 (Durst and Jacobs 2007). The next biomonitoring sampling at this site is scheduled for 2011.

Water quality at Site 6 has been monitored regularly by Greens Creek Mine staff since 1978, and is reported annually under separate cover.

Greens Creek Below Pond D Site 54

Greens Creek Below Pond D Site 54 is located approximately 0.4 km downstream of Middle Greens Creek Site 6 and approximately 1.2 km downstream of the weir that limits the upstream movement of fishes in Greens Creek. Site 54, at approximately 225 m elevation, was located to detect potential effects from the production rock storage area and treatment pond in addition to the portal and mill facilities upstream of Middle Greens Creek Site 6. As such, Greens Creek Below Pond D Site 54 is downstream of all Greens Creek Mine facilities along Greens Creek except portions of the B Road. Anadromous fish access to Site 54 was created by KGCMC in 1989 when a fish pass was installed in a rock chute area approximately 4.4 km downstream. Coho salmon, Dolly Varden, and cutthroat trout (*Oncorhynchus clarki*) have been captured in this reach during the biomonitoring program.

Greens Creek Below Pond D Site 54 has a Moderate Width Mixed Control (MM2) channel type (Appendix 1), with an average channel width of 10 m at ordinary high water and a gradient of 2-4 percent. This is a typical stream for the middle to lower portion of moderately sized basins in southeast Alaska (Paustian et al. 1992, Weber Scannell and Paustian 2002). Cobble is the dominant streambed material and large woody debris is integral to pool formation and fish habitat cover.

The periphyton and benthic macroinvertebrate sample reach is a short distance upstream of the fish sample reach at this site, with Gallagher Creek entering Greens Creek in the upstream portion of the fish sample reach. Both sample reaches have a single- or split-channel configuration depending on water level, with instream and overhanging large woody debris.

Water quality at Site 54 has been monitored regularly by Greens Creek Mine staff since 1995, and is reported annually under separate cover.

Tributary Creek Site 9

Tributary Creek is a small lowland stream with a dense canopy. Site 9, at approximately 25 m elevation, is included in the biomonitoring program because it is located approximately 1.6 km downstream from the HGCMC dry-stack tailings facilities. As such, this is the closest free-flowing stream reach to the tailings facilities that is suitable for biomonitoring. Data from this site are analyzed for trends showing changes over time.

Tributary Creek provides habitat for a variety of fish populations including pink salmon (*Oncorhynchus gorbuscha*), chum salmon (*O. keta*), coho salmon, cutthroat trout, rainbow trout (*O. mykiss*), Dolly Varden, and sculpin (*Cottus* sp.). The sample reach in Tributary Creek Site 9 has a Narrow Low Gradient Flood Plain (FP3) channel type (Appendix 1), typical of a valley bottom or flat lowlands. At Site 9, Tributary Creek averages 2-3 m wide with a stream gradient of one percent and a gravel and sand substrate (Paustian et al. 1992, Weber Scannell and Paustian 2002). Large woody debris is integral to substrate retention and pool formation.

The periphyton sampling area is within the upstream half of the fish sampling reach at this site, and the benthic macroinvertebrate reach is typically immediately downstream of the fish sampling reach. Changes in channel characteristics with differing water levels require year-specific location of benthic macroinvertebrate sample sites. Tributary Creek is a low-energy single channel stream, with moderately developed pools, riffles, and point bars and a mixture of overhanging and embedded large woody debris.

Water quality on Tributary Creek was monitored downstream of Site 9 monthly from 1981 to 1993. Regular water quality monitoring at Site 9 was restarted by Greens Creek Mine staff in May 2006 and is reported annually under separate cover.

Water Characteristics

Beginning in 2007, Greens Creek Mine personnel have used field meters to characterize water quality at each site during biomonitoring sampling. An Oakton pH/Con 10 meter was used to measure temperature, pH, and conductivity, and a Hach 2100P turbidimeter was used to measure turbidity. Reported results are included in the sample site narratives of this report.

Site Markings

In 2008, HGCMC personnel and ADF&G staff relocated and refreshed the aluminum markers and plastic flagging placed by USFS personnel in 2001 and 2002 to identify fish sample reaches at sites 9, 48, and 54 and by OHMP and USFS personnel in 2006 to identify the revised Site 6 fish sample reach. Trees on both banks that were live and sound were wrapped with plastic flagging (both yellow and white with blue stripes) at the upper and lower ends of each reach, augmented by blazes and by brush and limb clearing.

PERIPHYTON BIOMASS

Rationale

Periphyton, or attached algae, is sensitive to changes in water quality. An abundance of periphyton confirms that productivity is occurring at that specific location within a water body.

Sample Collection and Analysis

The method used to collect stream periphyton follows the protocol from the ADF&G (1998) and Barbour et al. (1999). The FWMP specifies that periphyton be sampled during a period of relatively stable flow, and not after scouring flow events. Ten rocks were collected from the nearshore area of the stream in each study reach. A 5-cm x 5-cm square of high-density foam was placed on the rock. Using a small toothbrush, all material around the foam square was removed and rinsed away with clean water. The foam was removed from the rock, the rock was brushed with a clean toothbrush, and the loosened periphyton was rinsed onto a 0.45 µm glass fiber filter attached to a vacuum pump. Approximately 1 ml saturated $MgCO_3$ was added to the filter, after extracting as much water as possible, to prevent acidification and conversion of chlorophyll to phaeophytin. The glass filter was wrapped in a large paper filter (to absorb any additional water), and placed in a sealed labeled plastic bag with a desiccant. Filters were frozen on site in a lightproof container with desiccant, and then transported to Fairbanks where they were kept frozen until laboratory analyses were conducted by Division of Habitat staff.

Methods for extraction and measurement of chlorophyll followed USEPA protocol (USEPA 1997). Filters for each rock sampled 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 Spectrophotometer UV-601 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). Chlorophyll *a* is predominant in all living plants, and is a useful indicator of algal biomass. Chlorophylls *b* and *c* are accessory pigments that can provide information on the types of periphyton present.

Periphyton biomass data are presented using Box and Whisker graphs (Velleman and Hoaglin 1981). The box shows the middle half of the data (the interquartile range), the line bisecting the box represents the median, and the vertical “whiskers” are the typical range of data in the sample. Whiskers always end at a data point that is within 1½ times the interquartile range. A star (∗) represents possible outliers lying outside the box (interquartile range) by more than 1½ 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 other than part of the data set’s actual distribution, so they were retained and used for data analysis.

BENTHIC MACROINVERTEBRATES

Rationale

Benthic macroinvertebrate abundance and taxonomic richness are useful measures of stream health. Characterizing community structure and abundance of benthic macroinvertebrates at sample sites can reveal trends in stream health and water quality.

Sample Collection and Analysis

Five benthic samples were collected from each sample site with a modified Hess sampler. We used a stratified random sample design, modified from Barbour et al. (1999). Samples were collected exclusively from riffle areas where the greatest taxonomic richness and densities are typically found. This sample design eliminated variability from sampling pools or other marginal habitats where pollution-sensitive macroinvertebrates are less likely to occur.

The sampler ring of the modified Hess sampler encompassed approximately 0.1 m^2 of substrate, and was pushed into the stream bottom to define the sample area. For each sample, the substrate was first manually disturbed, and then rocks were brushed and removed. After the larger substrate was removed, the fine gravels were disturbed to a depth of approximately 10-15 cm. Macroinvertebrates disturbed from the stream bottom were collected in a 1-m, 300 μm mesh net. The sample was removed, placed in pre-labeled 500 ml Nalgene® bottles, and then preserved in 80% denatured ethanol. Macroinvertebrate samples were later sorted from debris and identified to the lowest practical taxonomic level by a taxonomist.

Analyses included comparisons of density, taxonomic richness, percent community composition, and percent dominant taxon. The latter is a metric intended to identify the absence of environmentally sensitive species or dominance of less sensitive taxa.

JUVENILE FISH POPULATIONS

Rationale

Monitoring juvenile fish populations to determine potential trends in the numbers of Dolly Varden and coho salmon in stream reaches near the mine surface facilities helps evaluate the health of vertebrate populations in the Greens Creek and Tributary Creek drainages.

Sample Collection and Analysis

Fish population estimates were made using a modification of Aho (2000) with a three-pass removal method developed by the USFS (Bryant 2000). Fish were trapped using 6.4 mm (¼ in) square mesh galvanized Gee's minnow traps baited with salmon roe that had been treated with a povidone-iodine (Betadine®) disinfectant solution. Approximately 25 minnow traps were deployed within each sample reach during each sampling event.

Where possible, natural features such as shallow riffles or small waterfalls over log steps were used to help define upper and lower sample reach boundaries to minimize fish movement into the sample section during sampling. To better meet the closure assumption of the three-pass removal method, traps were also set above and below each sample reach to serve as "blocks" by capturing potential migrants into the sample reach.

Sample reaches were identified by aluminum tree tags and flagging set during previous years' sampling, and varied in length among sites because of the different availability of suitable habitat in which to set traps. At Upper Greens Creek Site 48, the 75 m reach sampled in 2001 was shortened to 50 m in 2002 and following years; at Greens Creek Below Pond D Site 54, the same 28 m long reach has been sampled each year of biomonitoring; and at Tributary Creek Site 9, the 44 m reach sampled in 2001 was extended to 50 m long for 2002 and following years. When Middle Greens Creek Site 6 was first sampled in 2001, a 135 m reach was used for trap placement. Habitat variations within such a long reach made population estimation difficult, and Weber Scannell and Paustian (2002) recommended reducing the length of the trapped reach to 30 m to 40 m for subsequent sampling efforts. In 2006, USFS and OHMP staff established a 49 m reach for sampling within the upstream portion of the 135 m reach. The need for natural breaks in the channel to provide some closure to the population during depletion sampling necessitated a slightly longer sample reach at Site 6 than was recommended in 2002.

Traps were placed throughout each sample reach focusing on pools, undercut banks, bank alcoves, under root-wads or logjams, and other habitats where fish were likely to be captured. In higher velocity sites, rounded stream rocks were placed in the traps to keep them in place and to provide cover for fish retained in the traps.

Minnow traps in each sample reach were set for about 1.5 hr, at which time all captured fish were transferred to perforated plastic buckets. Buckets were kept supplied with aerated water to reduce stress on captured fish. Fresh bait was added and the traps were reset for a second 1.5 hr period. While the second set was fishing, fish captured during the first set were counted, identified to species, measured to fork length, and placed in a mesh holding bag in the stream. The procedure was repeated for the third 1.5 hr trapping period. Block traps were left set in place for the entire 4.5 hr sampling period. Fish captured in block traps were counted and identified to species, but not included in further analyses.

Fish population estimates were developed using the multiple-pass depletion method of Lockwood and Schneider (2000), an iterative method that produces a maximum likelihood estimate (MLE) of fish numbers with a 95% confidence interval. Six Dolly Varden from the first trapping period at each site were retained for whole body analysis of metals. Fish not retained for the metals analyses were returned to the stream reach immediately after sampling was completed.

METALS CONCENTRATIONS IN JUVENILE FISH

Rationale

The response time for juvenile fish to accumulate metals is rapid; for example, ADF&G has documented metals accumulation in juvenile Dolly Varden within five to six weeks after dispersing from their overwintering grounds to mineralized tributaries (Weber Scannell and Ott 2001). Should changes occur at the Greens Creek Mine that result in higher concentrations of metals in the biomonitored stream reaches, tissue sampling of juvenile fish living in those stream reaches should reflect such changes.

Sample Collection and Analysis

Six moderate-sized (target size range 95-125 mm fork length) juvenile Dolly Varden captured in baited minnow traps at each sample site were collected for whole body metals analysis[2]. Dolly Varden from Greens Creek Below Pond D Site 54 and Tributary Creek Site 9 potentially contained a mixture of resident and anadromous forms, although this would not be expected to

[2] Six fish each were also collected from Greens Creek Below Pond D Site 54 and Tributary Creek Site 9 in 2000 during development of the protocols for this biomonitoring program. Data from these fish were not included in analyses in this report but are included in Appendix 5.

alter metals accumulation levels in fish from the size range collected because anadromous forms would not have been through a marine cycle at this size and hence could be considered resident fish. Collected fish were measured to fork length, individually packed in clean, pre-labeled bags, placed in an acid-washed cooler, and frozen on-site until transport to Fairbanks.

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 (Columbia Analytical Services, Inc. in Kelso, Washington), 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.

Samples were numbered following the convention established by ADF&G in 2001: Date/StreamCode/Site/SpeciesCode/AgeCode/SampleNumber. For example, one fish sample was labeled 072109GC48DVJ01 where 072109 represents July 21, 2009; GC48 represents Upper Greens Creek Site 48; DV represents Dolly Varden; J represents juvenile; and 01 represents sample replicate number 1.

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.

RESULTS AND DISCUSSION

Water levels and stream discharges at the two Greens Creek sampling sites were moderate in 2009 and similar to those present during the 2005 sampling (Table 1), while those at the Tributary Creek site were very low in 2009 and likely the lowest experienced during biomonitoring.

Table 1. Greens Creek mean daily discharges (USGS Gage 15101490) and Tributary Creek field-measured discharges during biomonitoring sampling periods.

	Sampling Dates	Greens Cr. USGS Gage		Tributary Cr. Field Data*	
		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**	<0.01**

*It is difficult to field measure low discharges in Tributary Creek because of the stream's relatively shallow channel and largely rectangular cross-section.

**Based in readings using flow meter that was faulty. Actual flow in 2009 slightly less than in 2004 based on physical characteristics and comparison of photos.

The base flow in Greens Creek declines during each July, with its level reflecting the previous winter's snow pack on the surrounding ridges. The USDA Natural Resources Conservation Service snowpack map for Alaska showed the snowpack remaining on May 1, 2009 near Greens Creek Mine to be more than 150 percent of the 30-year average. Tributary Creek has a smaller, lower-elevation watershed than does Greens Creek, and the preliminary HGCMC stage data show a relatively constant summer base flow. Both Greens Creek and Tributary Creek respond quickly to rainfall events in their basins, with preliminary HGCMC data indicating Tributary Creek to respond more quickly and with a larger amplitude than does Greens Creek.

High stream flows can affect biomonitoring results in several ways. Fish habitat availability and distribution, and susceptibility to minnow trapping, can change as flows in main channel areas become too swift and fish move to lower velocity reaches and off-channel refugia. Flows fast enough to move gravel and larger bedload sediments can reduce periphyton and benthic macroinvertebrate densities through both physical scour and increased drift due to moving substrate.

The nine years of biomonitoring sampling have occurred over a very wide range of flow conditions, providing a more complete picture of the range of natural variability in these systems (Figure 2). During 2009, flows in Greens Creek during the three weeks prior to biomonitoring sampling were moderate, so little to no scouring or bedload movement at the biomonitoring sample sites would be expected.

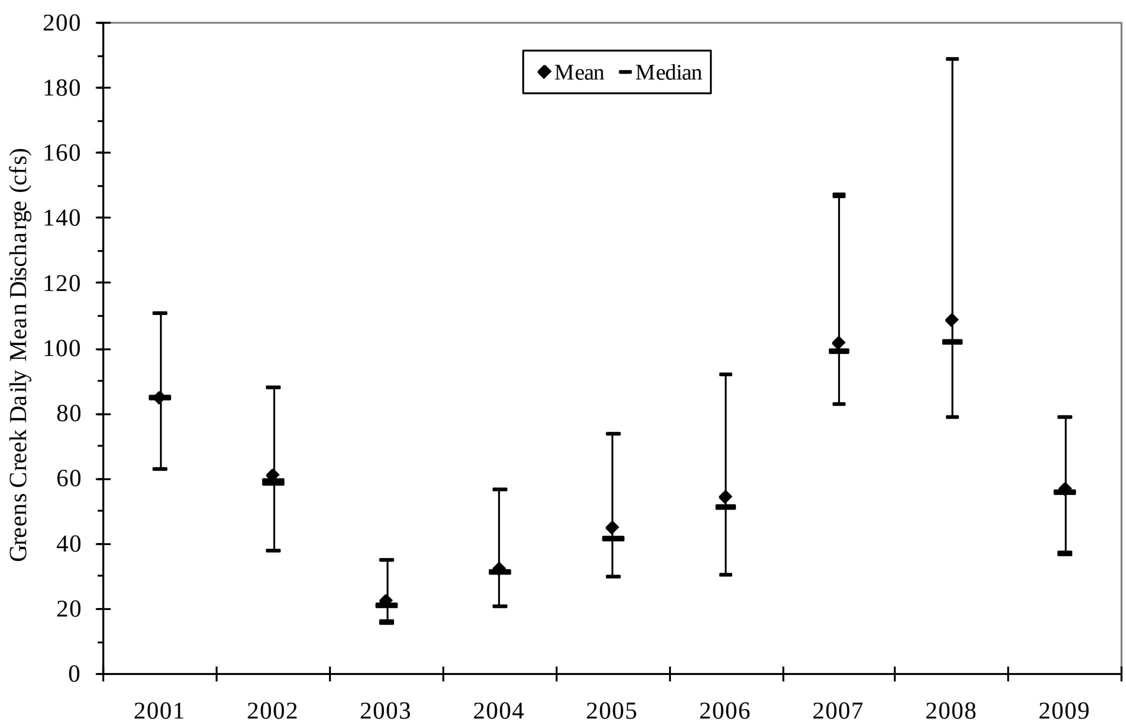


Figure 2. USGS (Gage 15101490) Greens Creek daily mean discharges for the three weeks prior to biomonitoring sampling for 2001 through 2009. High and low bars indicate the range of daily mean discharges during the period.

UPPER GREENS CREEK SITE 48

Upper Greens Creek Site 48 (Figure 3) was sampled in the afternoon of 21 July 2009. The weather was generally overcast with some light rain after rain yesterday and overnight; the water temperature was 8°C and the air temperature 13.5°C. The water level was moderate, and the water clear.

Figure 3. Upper Greens Creek Site 48 during biomonitoring sampling on 21 July 2009.

Greens Creek continues to cut through the log tangle on the upper left bank, with the associated bedload being washed downstream. The right bank in the upstream portion of the sample reach exhibited both fresh erosion and new deposition areas. No major changes in large woody debris distribution were noted. Small backwater areas were present with sandy substrate, and numerous fish too small to capture with minnow traps were noted in those areas.

During the sampling session, HGCMC staff measured Greens Creek at 8.0°C, with a pH of 7.65 units and a conductivity of 92.9 μS/cm.

Periphyton Biomass

Concentrations of chlorophyll *a*, an estimate of periphyton biomass, in Upper Greens Creek Site 48 were significantly different[3] between years when sample data from 2001 through 2009 were analyzed together. Multiple pairwise comparisons were then run, and values from 2009 were significantly different from 2003 and 2006 (Appendix 2). The Box and Whisker output plot from Statistix is shown in Figure 4.

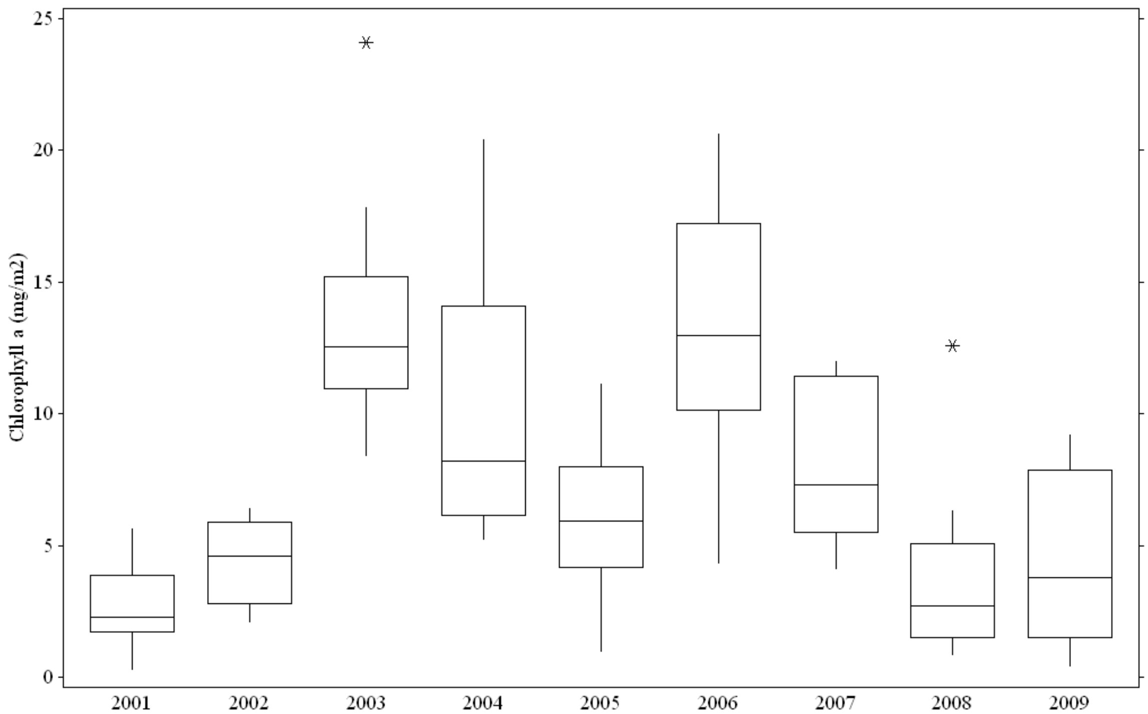


Figure 4. Estimated periphyton biomass densities at Upper Greens Creek Site 48 in 2001 through 2009 (n = 10 samples each year). Box encompasses middle half of data; horizontal line is median value. Two possible statistical outlier values (✳) were identified in the 2003 and in 2008 data.

The proportion of chlorophyll *c* compared to chlorophyll *b* has continued through all nine years sampled (Figure 5) to indicate that diatoms and/or dinoflagellates are a major component of the periphyton community at Upper Greens Creek Site 48. In 2009, chlorophyll b was for the first time, found in amounts great enough to register on the graph when in the past, chlorophyll b was low to undetectable in concentrations indicating green algae are a small proportion of the algal community.

[3] Throughout this report, ***significant differences*** required an $\alpha \leq 0.05$, ***substantial differences*** required an α value greater than 0.05 but less than or equal to 0.10 ($0.05 < \alpha \leq 0.10$), and groups ***not statistically different*** were neither significantly different nor substantially different ($\alpha > 0.10$).

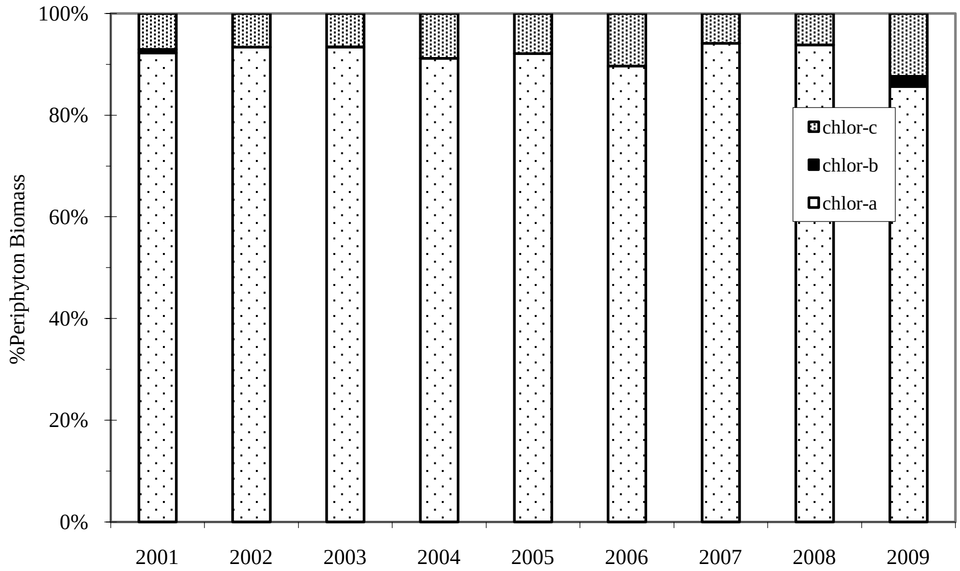


Figure 5. Proportions of mean chlorophyll *a*, *b*, and *c* concentrations in Upper Greens Creek Site 48 samples in 2001 through 2009.

Benthic Macroinvertebrates

The mean density of benthic macroinvertebrates in Upper Greens Creek Site 48 samples in 2009 was relatively low when compared to the range seen in the previous eight years of sampling at this site (Figure 6), and taxonomic richness has continued to decrease slightly from that measured in 2007 (Table 2). The mean density of benthic macroinvertebrates in 2009 was less than mean densities found in all other years with the exception of 2002, 2006, and 2007 (Appendix 3).

Table 2. Summary of benthic macroinvertebrate samples at Upper Greens Creek Site 48 in 2001 through 2009.

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	22	11.8
2007	1466	25	13.2
2008	2662	22	14.0
2009	1906	20	10.8

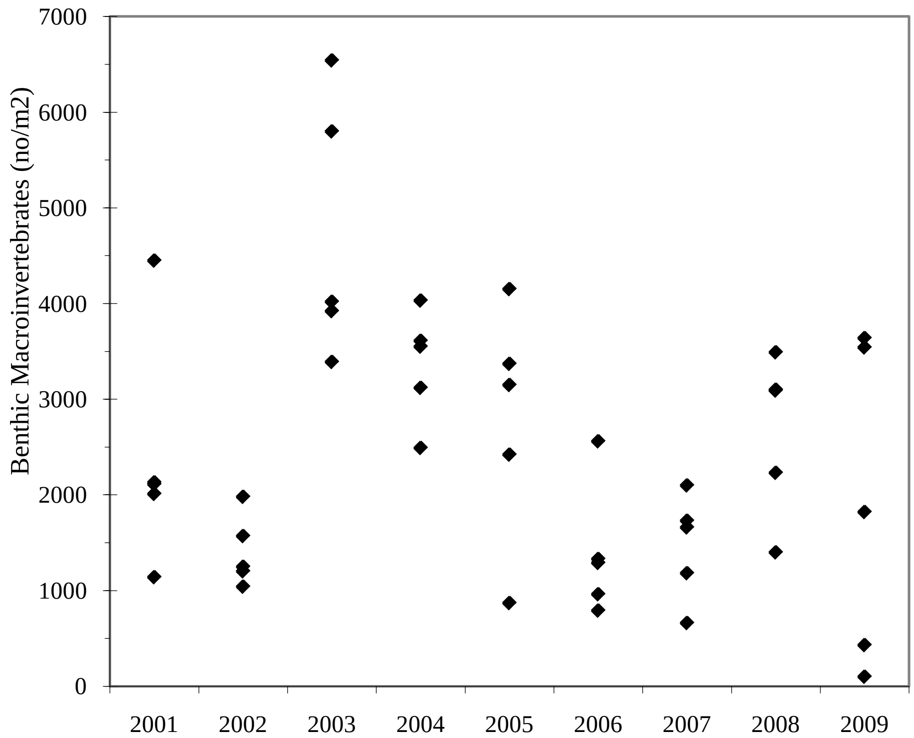


Figure 6. Density of benthic macroinvertebrates (n = 5 samples each year) at Upper Greens Creek Site 48 in 2001 through 2009.

Invertebrate communities were slightly different among the nine years sampled, although the proportion of Chironomidae remained low each year (Figure 7). The EPT taxa (Ephemeroptera [mayflies], Plecoptera [stoneflies], and Trichoptera [caddisflies]) continued to be most prevalent (Figure 7). Given that most of the EPT taxa are sensitive to decreased water quality, especially metals, the high proportion found at this baseline site signifies clean or healthy water quality conditions for aquatic life.

At Upper Greens Creek Site 48, mayflies (Ephemeroptera) dominated the benthic macroinvertebrate samples (Figure 8, Table 3). Common taxa in the nine years sampled include the mayflies Baetidae: *Baetis*, Ephemerellidae: *Drunella*, and Heptgeniidae: *Epeorus* and *Rhithrogena*. *Baetis* are rated “moderately sensitive” to decreased water quality, *Drunella* are “very to extremely sensitive,” *Epeorus* are “sensitive,” and *Rhithrogena* are “very sensitive” (Barbour et al. 1999). In all nine years, pollution-sensitive taxa dominated the invertebrate community at Upper Greens Creek Site 48, and the many species of mayflies, stoneflies, caddisflies, and true flies represent a complex community. These species also are more adapted to clinging to rocks during high discharge periods than the taxa of Chironomidae. Appendix 3 lists the benthic macroinvertebrate taxa found at Upper Greens Creek Site 48 in 2001 through 2009.

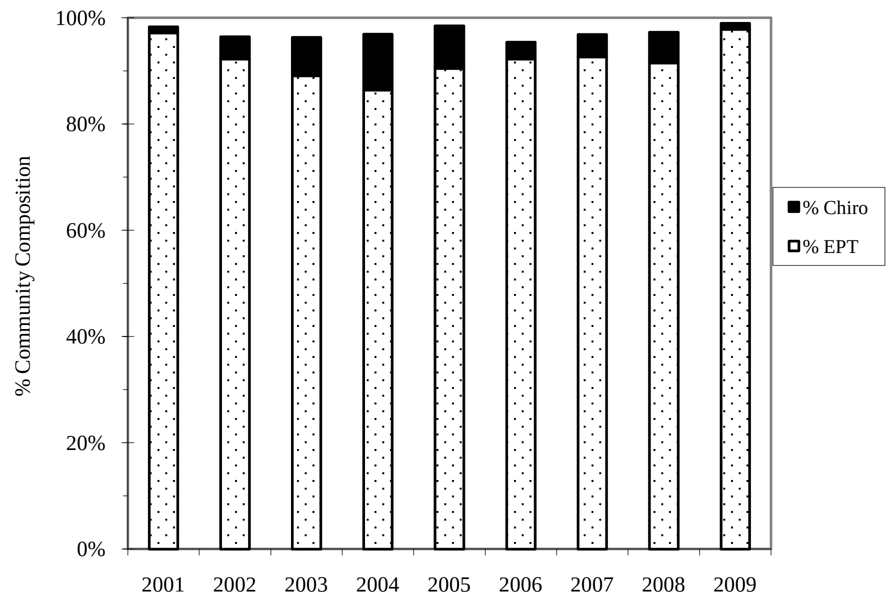


Figure 7. Proportions of EPT taxa and Chironomidae in Upper Greens Creek Site 48 samples in 2001 through 2009.

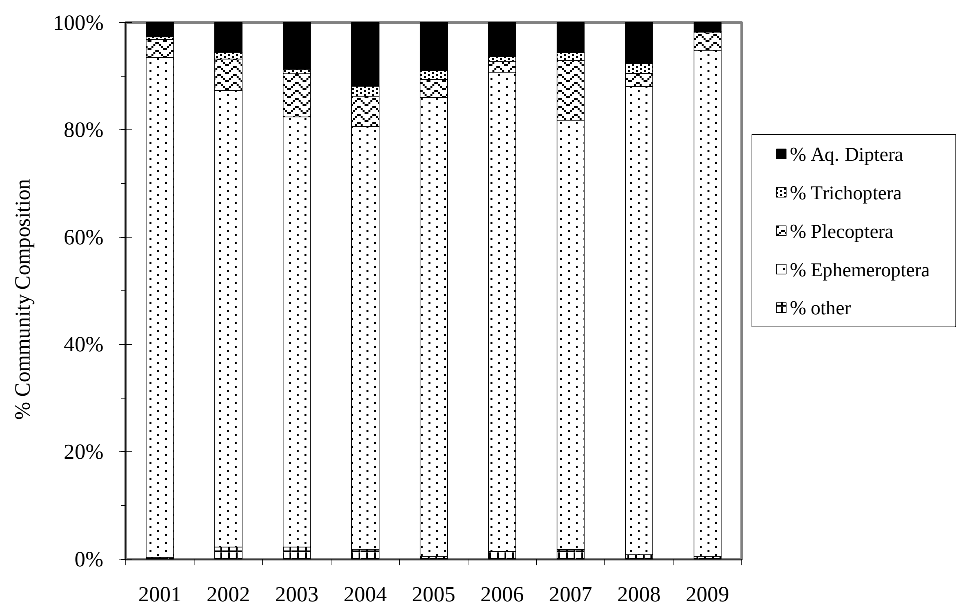


Figure 8. Community composition of benthic macroinvertebrates in Upper Greens Creek Site 48 samples in 2001 through 2009.

Table 3. Common taxa (>5.0% of benthic macroinvertebrates) found in Upper Greens Creek Site 48 samples in 2001 through 2009. The percent dominant taxon each year is bold.

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

Juvenile Fish Populations

The 2009 juvenile fish survey at Upper Greens Creek Site 48 captured 126 Dolly Varden in 24 minnow traps within the same 50 m reach as sampled in 2002 through 2008. Three “block” traps were set downstream of this reach and three upstream; they captured 13 additional Dolly Varden that are not included in the reported results. The estimated 2009 population size for the reach, based on the three-pass removal method, was 151 Dolly Varden with a density of 0.43 fish/m² of wetted stream surface area. This was a moderate population estimate, significantly more than in 2001, 2007, and 2008; significantly less than in 2003 through 2006, and not significantly different from the 2002 population estimate (Table 4, Appendix 4). The density estimates follow a similar trend, with the 2009 density estimate being the median value from the nine years of biomonitoring at this site.

Table 4. Juvenile fish population estimates for Upper Greens Creek Site 48 based on minnow trapping in 2001 through 2009.

Year Sampled	Fish Species	No. Fish Caught	FLength, 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*	145 (134-173)	50	0.23
2003	DV	285	54-180	333 (305-361)	50	0.9**
2004	DV	244	54-158	255 (246-264)	50	0.88
2005	DV	212	50-149	246 (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	0.2**
2008	DV	73	77-137	75 (71-79)	50	0.14
2009	DV	126	47-142	151 (130-172)	50	0.43

* Fork lengths recorded in 5mm intervals.
** Based on estimated wetted area value.

Although we have no validation data to correlate fish lengths with age such as scale or otolith analyses, the range of fork lengths (Table 4) and length frequency plot (Figure 9) of Dolly Varden captured in 2009 appear to represent multiple age classes, including smaller classes that likely include young of the year fish. Such recruitment was not noted in 2008 sampling, which may help account for the relatively weak captures of older juvenile fish sizes.

Metals Concentrations in Juvenile Fish

Median concentrations of metals in juvenile Dolly Varden tissues at Upper Greens Creek Site 48 in 2009 were less than or similar to those found in most of the previous eight years of biomonitoring sampling at this site with the exception of selenium. Median values for silver, copper, lead, and zinc in 2009 were the next to lowest found in nine sample years at this site, the median value for cadmium concentration was mid-range, and the median value for selenium concentrations was the highest (Figure 10, Appendix 5). The mean rank for silver concentrations in 2009 was significantly lower than in 2006 and substantially lower than in 2002 and 2008; that for copper was substantially lower than in 2006; that for selenium was significantly higher than in 2005 and substantially higher than in 2002; and those for cadmium, lead, and zinc were not statistically different from those of the previous eight years of sampling at this site.

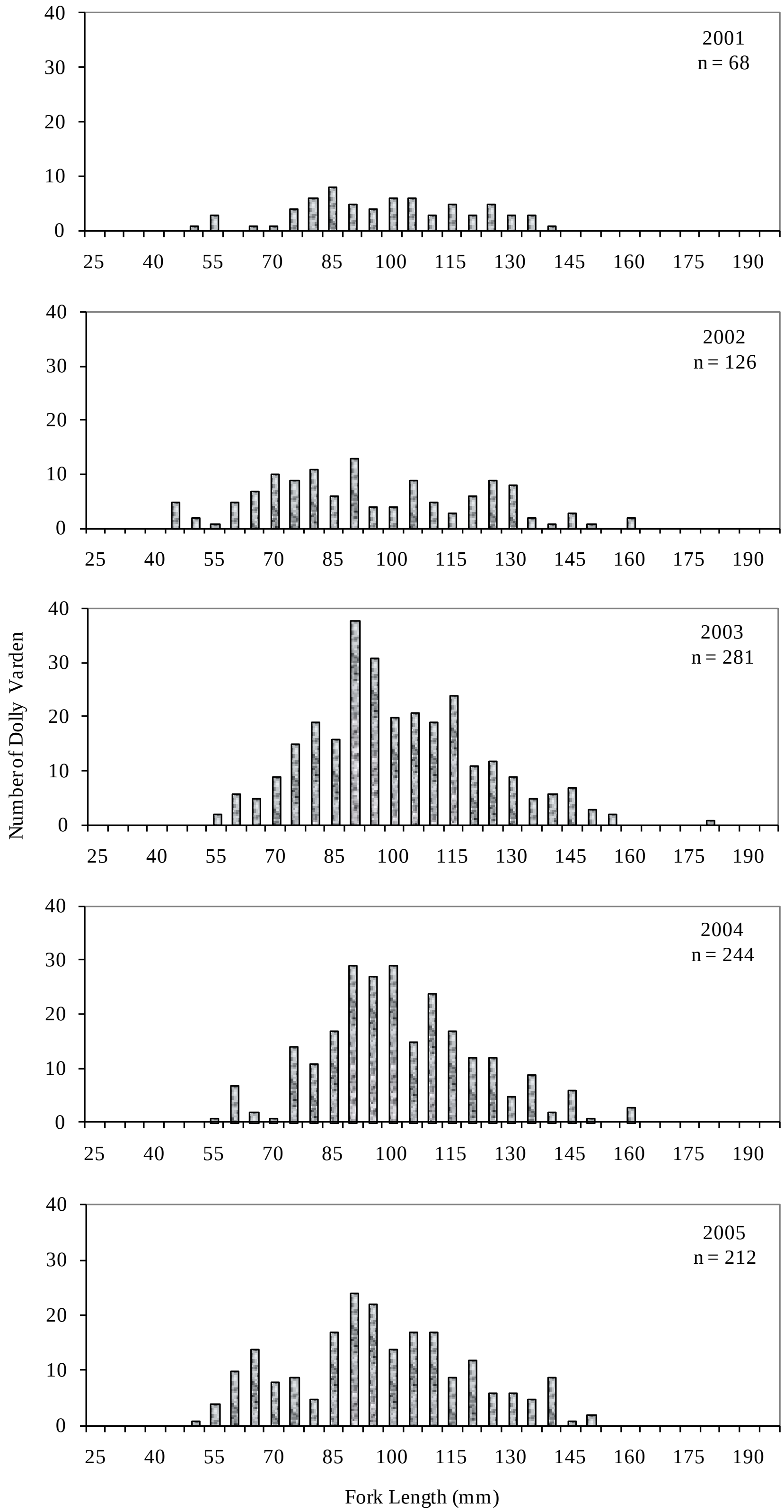


Figure 9. Length frequencies of Dolly Varden captured at Upper Greens Creek Site 48 in 2001 through 2009.

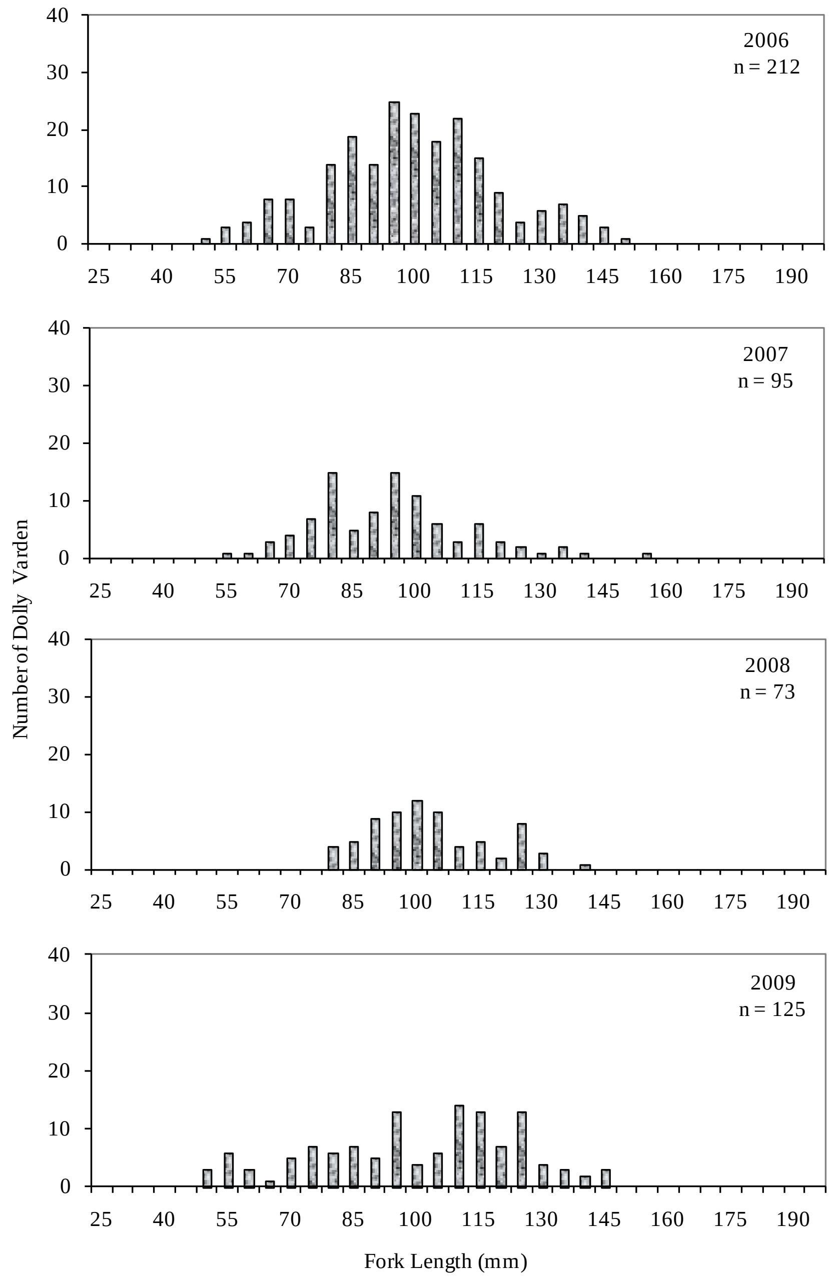


Figure 9. (Continued)

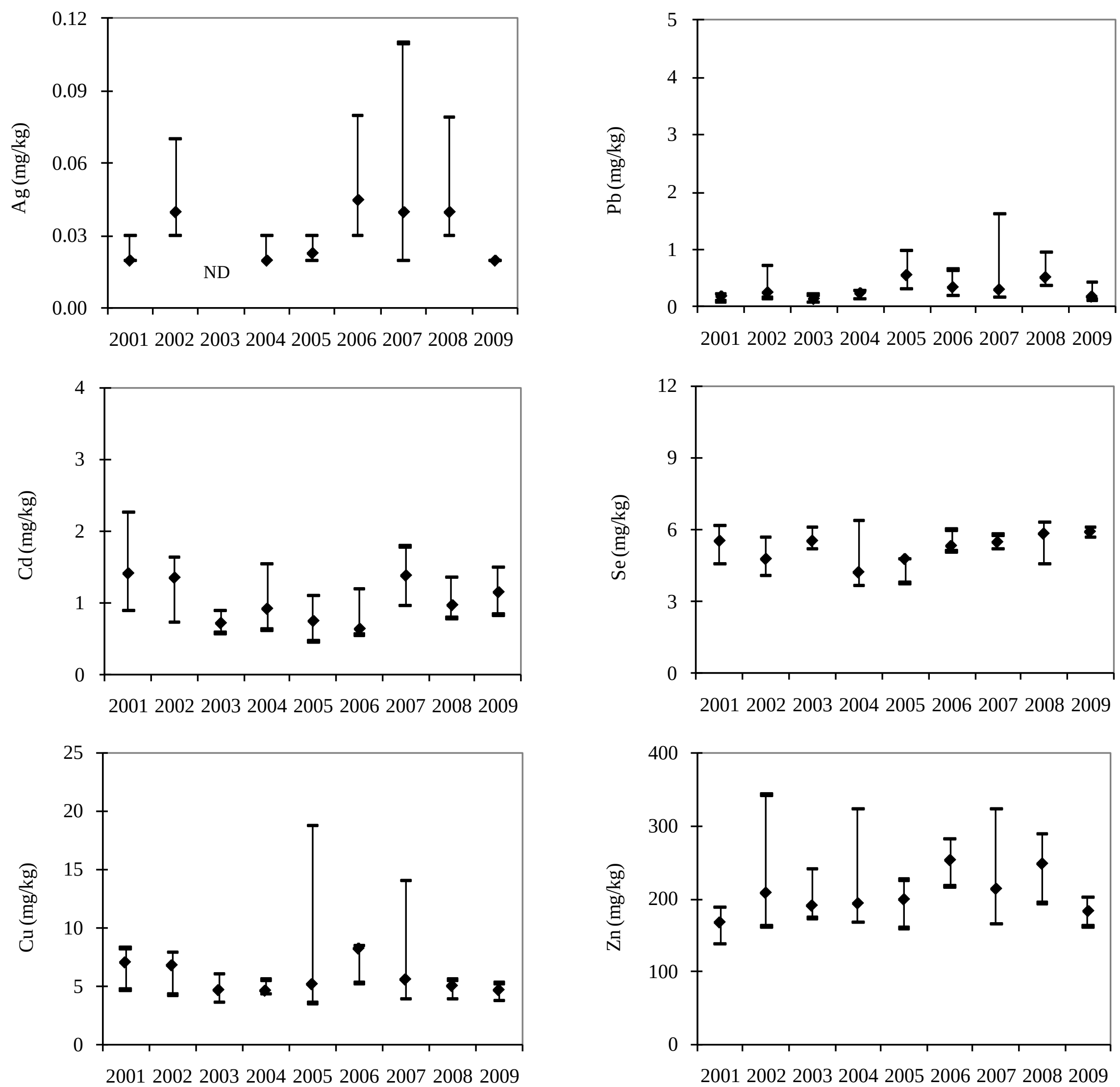


Figure 10. Whole body metals concentrations (medians and ranges) in Dolly Varden captured at Upper Greens Creek Site 48 in 2001 through 2009. ND = Not Detected at reporting limit for Ag of 0.02 mg/kg.

Summary

The Upper Greens Creek Site 48 sampling reach is just upstream of all HGCMC mine facilities and roads, so serves as a "control" site for biomonitoring. Any observed trends over time are anticipated to reflect changes in natural background conditions rather than effects from mine development and operation. In 2009, compared to previous years of sampling, this site exhibited low periphyton levels; moderate benthic macroinvertebrate density and moderate taxonomic richness; a moderate Dolly Varden population density; lower juvenile fish tissue concentrations of silver, copper, lead, and zinc; similar tissue concentrations of cadmium; and the highest level of selenium observed at this site. We have no evidence at this time to suggest that these results are indicative of anything other than natural variability within this stream reach.

The benthic macroinvertebrate community continues to be dominated by disturbance-sensitive species, and the noted reductions in periphyton density in 2009 cannot be attributed to high stream flows weeks before sampling, because flows were documented as being moderate. Some other natural disturbance, such as ice scour during breakup, could potentially affect the aquatic community into mid-summer, but there is no obvious reason for the reduction in periphyton density. The Dolly Varden population density was typical for this type of stream channel reach in southeast Alaska with a downstream barrier to anadromous fish, and the size distribution of captured Dolly Varden shows a full range of sizes consistent with a productive population. Upper Greens Creek Site 48 samples appear consistent with a functioning and apparently healthy aquatic community, although the selenium levels need to be watched in future years' sampling.

GREENS CREEK BELOW POND D SITE 54

Greens Creek Below Pond D Site 54 (Figure 11) was sampled in the morning of 21 July 2009. The weather was overcast with sprinkles after rain overnight and the day before; the water temperature was 7°C and the air temperature was 14.8°C. The water level was moderate and appeared to drop slightly during sampling.

Figure 11. Greens Creek Below Pond D Site 54 during biomonitoring sampling on 21 July 2009.

The thalweg and side channel locations within the periphyton and benthic macroinvertebrate sample reach were similar to those in 2008. Changes continued in the large woody debris and channel configuration of the fish sample reach, with fewer pools than in some previous years and a general trend toward swift runs with plunge holes through wood jams. Small backwater areas were present with sandy substrate, and numerous fish too small to capture with minnow traps were noted in those areas.

During the sampling session, HGCMC staff measured Greens Creek at 7.2°C, with a pH of 7.86 units and a conductivity of 100.8 μS/cm.

Periphyton Biomass

Concentrations of chlorophyll *a*, an estimate of periphyton biomass, in Greens Creek Below Pond D Site 54 were significantly different between years when data from 2001 through 2009 were analyzed together. When analyzed in an all-pairwise comparison, the difference between 2009 and 2008 values were significantly different with periphyton biomass being considerably lower in 2008 (Appendix 2). Because periphyton biomass was greater than the previous year and the contribution by chlorophyll *a* to the community composition was greater, the periphyton biomass at this site was relatively stable because of the lower water levels (Figure 12).

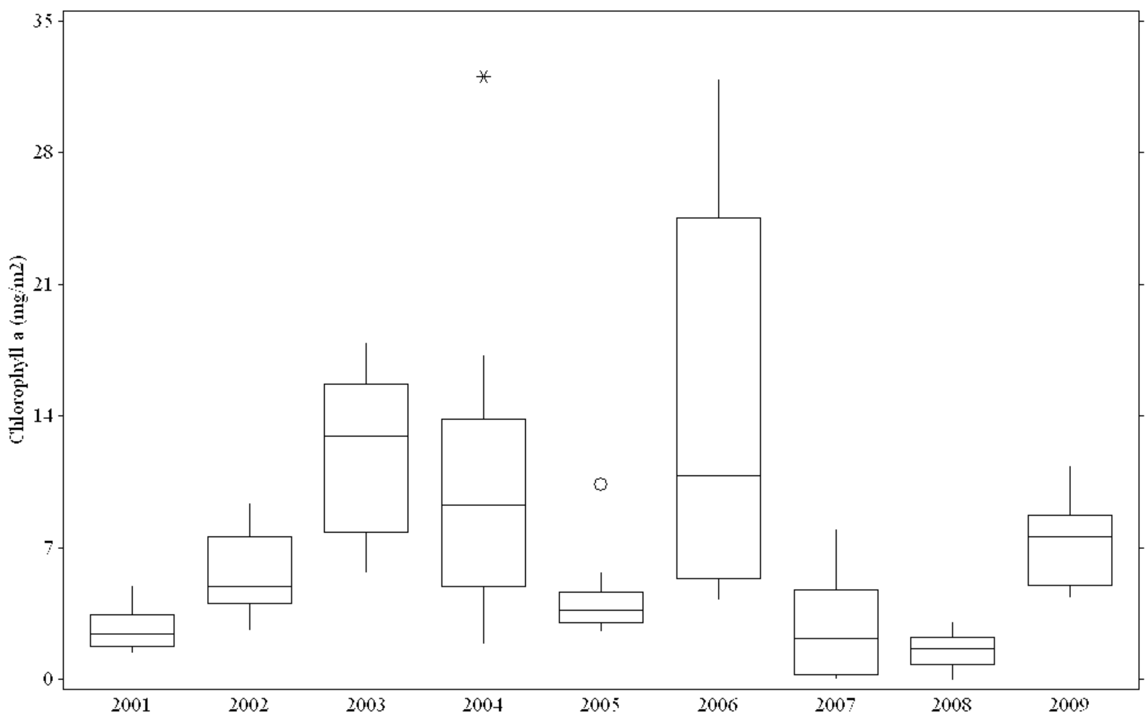


Figure 12. Estimated periphyton biomass densities at Greens Creek Below Pond D Site 54 in 2001 through 2009 (n = 10 samples 2001-2008, n=9 samples 2009). Box encompasses middle half of data; horizontal line is median value. One possible statistical outlier value (∗) was identified in the 2004 data set, and one probable statistical outlier value (○) was identified in the 2005 data set.

The periphyton community at Greens Creek Below Pond D Site 54 had a higher proportion of chlorophyll *c* than chlorophyll *b* in all nine years sampled (Figure 13), indicating communities dominated by diatoms and/or dinoflagellates. Low to undetectable concentrations of chlorophyll *b* indicate low populations of green algae in the periphyton communities.

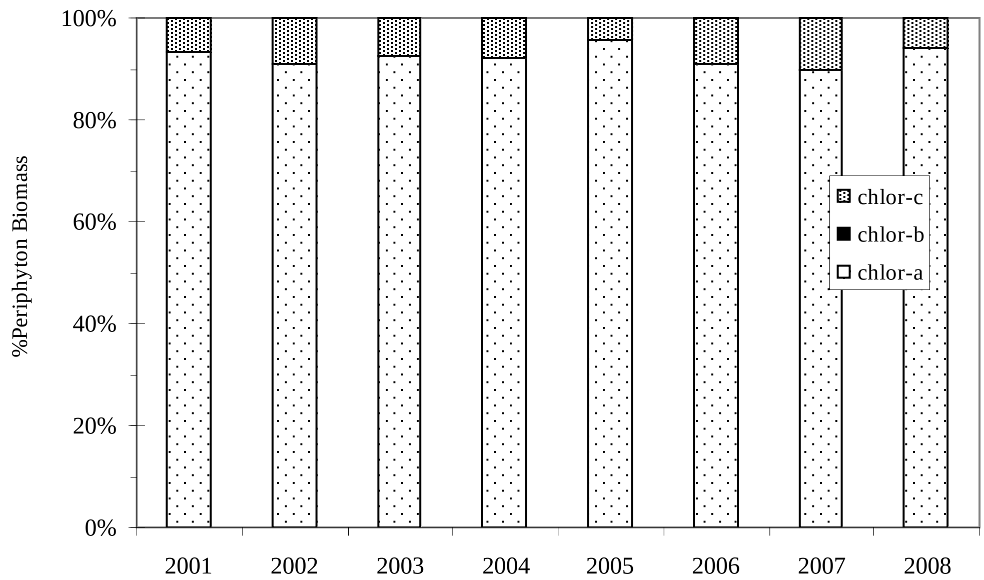


Figure 13. Proportions of mean chlorophyll *a*, *b*, and *c* concentrations in Greens Creek Below Pond D Site 54 samples in 2001 through 2009.

Benthic Macroinvertebrates

The average density of benthic macroinvertebrates in 2009 Greens Creek Below Pond D Site 54 samples had dropped below the eight-year average density (2678) sampled at this site (Table 5, Figure 14, Appendix 3). Taxonomic richness followed a similar pattern, decreasing from the previous year.

Table 5. Summary of benthic macroinvertebrate samples at Greens Creek Below Pond D Site 54 in 2001 through 2009.

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

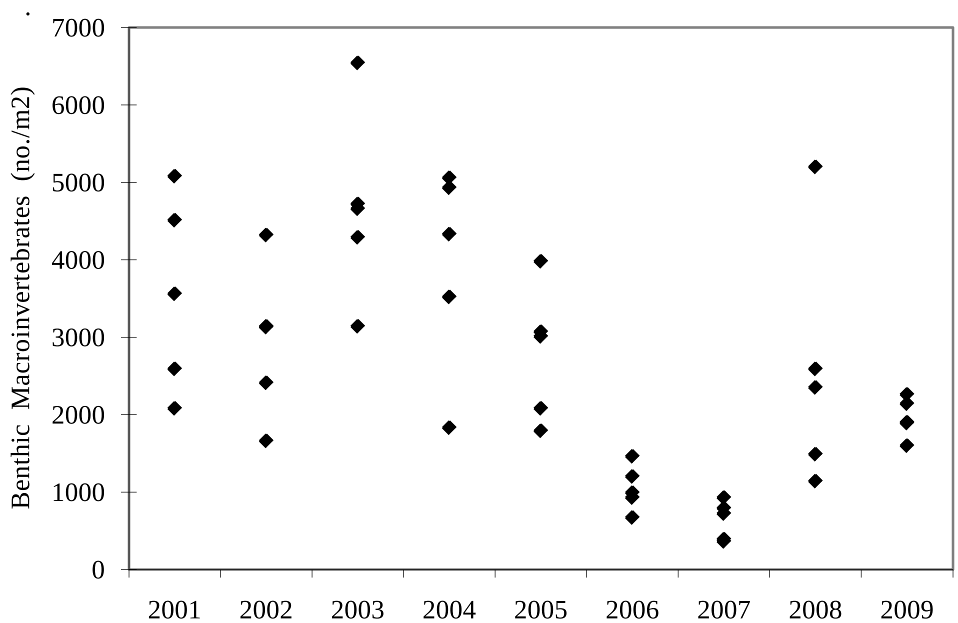


Figure 14. Density of benthic macroinvertebrates (n = 5 samples each year) in Greens Creek Below Pond D Site 54 samples in 2001 through 2009.

Invertebrate communities in Greens Creek Site 54 continued to be dominated by EPT taxa (Figure 15). In each of the nine years sampled, Ephemeroptera were the most commonly collected order (Figure 16). In 2009, the Ephemeroptera were dominated by Baetidae: *Baetis*, Ephemerellidae: *Ephemerella,* and Heptageniidae: *Cinygmula, Epeorus* and *Rhithrogena. Baetis* are rated "moderately sensitive" to decreased water quality, and *Epeorus, Ephemerella,* and *Rhithrogena* are "sensitive" (Barbour et al. 1999). The dominance of the benthic macroinvertebrate community by pollution-sensitive taxa (Table 6), combined with the mixture of many species of mayflies, stoneflies, caddisflies, and true flies (Appendix 3) suggests a complex and productive aquatic community at this site.

Table 6. Common taxa (>5.0% of benthic macroinvertebrates) found in Greens Creek Below Pond D Site 54 samples in 2001 through 2009. The percent dominant taxon each year is bold.

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

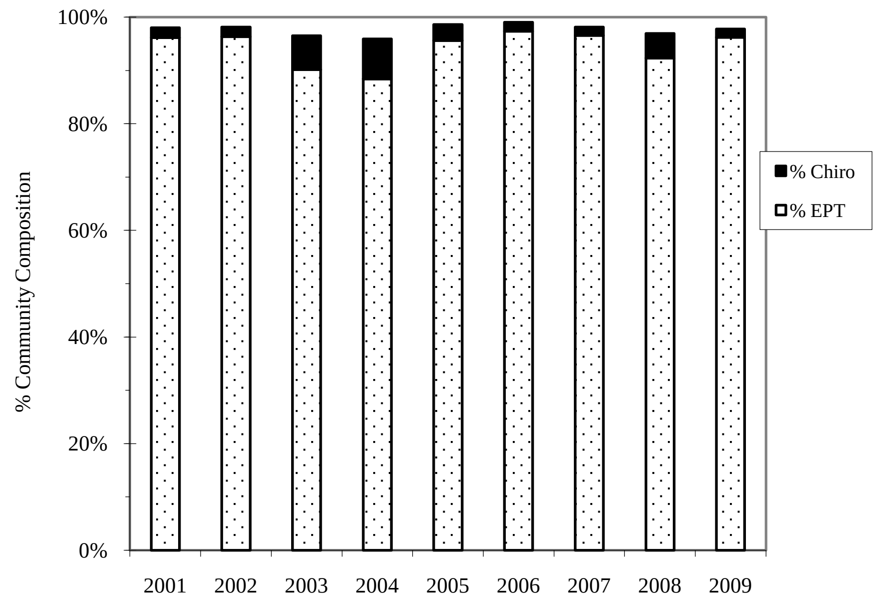


Figure 15. Proportions of EPT taxa and Chironomidae in Greens Creek Below Pond D Site 54 samples in 2001 through 2009.

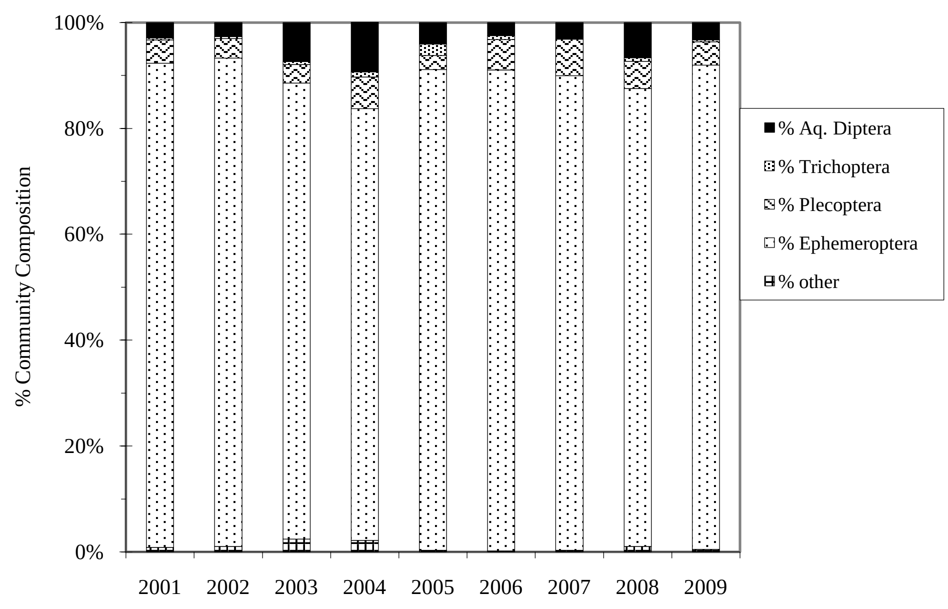


Figure 16. Community composition of benthic macroinvertebrates in Greens Creek Below Pond D Site 54 samples in 2001 through 2009.

Juvenile Fish Populations

The 2009 juvenile fish survey at Greens Creek Below Pond D Site 54 captured 93 Dolly Varden and 4 coho salmon in 23 minnow traps in the same 28 m reach as sampled in 2002 through 2008 (Table 7). Three "block" traps were used immediately downstream of the sample reach and three upstream; they captured an additional nine Dolly Varden that are not included in the reported results. The estimated 2009 population sizes for the reach, based on the three-pass removal method, were 117 Dolly Varden with an approximate density of 0.36 fish/m^2 and 4 coho salmon with an approximate density of 0.01 fish/m^2 of wetted stream area.

The estimated population of Dolly Varden in this sample reach in 2009 was significantly lower than 2001 through 2006 biomonitoring samples at this site, not significantly different from the 2007 estimate, and significantly higher than the 2008 population estimate. The estimated density of Dolly Varden (fish/m^2 of wetted stream) was also the second lowest noted at this site. Although the estimated populations of juvenile coho salmon at this site have been quite variable and much smaller than those of Dolly Varden in previous years of biomonitoring sampling (Table 7, Appendix 4), the 2009 coho salmon population estimate was tied with that for 2008, and significantly lower than all other years except 2007 when no coho were captured.

Table 7. Juvenile fish population estimates for Greens Creek Below Pond D Site 54 based on minnow trapping in 2001 through 2009. Incidental captures of cutthroat trout are not shown, but are reported in Appendix 4.

Year Sampled	Fish Species	No. Fish Caught	FLength 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*
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*
2008	DV	71	45-131	73 (69-77)	28	0.21
2009	DV	93	47-101	117 (95-139)	28	0.36
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*
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

* Based on estimated wetted area value.

Fork lengths of Dolly Varden captured at Greens Creek Below Pond D Site 54 in 2009 represent a range of fish sizes and suggest use by multiple age classes. Although we have no validation data to correlate fish lengths with age such as scale or otolith analyses, the length frequency plots (Figure 17) suggest that multiple age classes of Dolly Varden were captured in all nine years of biomonitoring. Young of the year Dolly Varden have not been well represented in any year's sampling, but the presence of larger fish the following years indicate that recruitment is occurring.

Fork lengths of coho salmon (Figure 18) captured at this site in all years except 2001 (and 2007 when no coho were captured) suggest use by primarily a single age class although we have no validation data to correlate fish lengths with age such as scale or otolith analyses. It appears that recruitment of coho salmon continues to be currently minimal at this site.

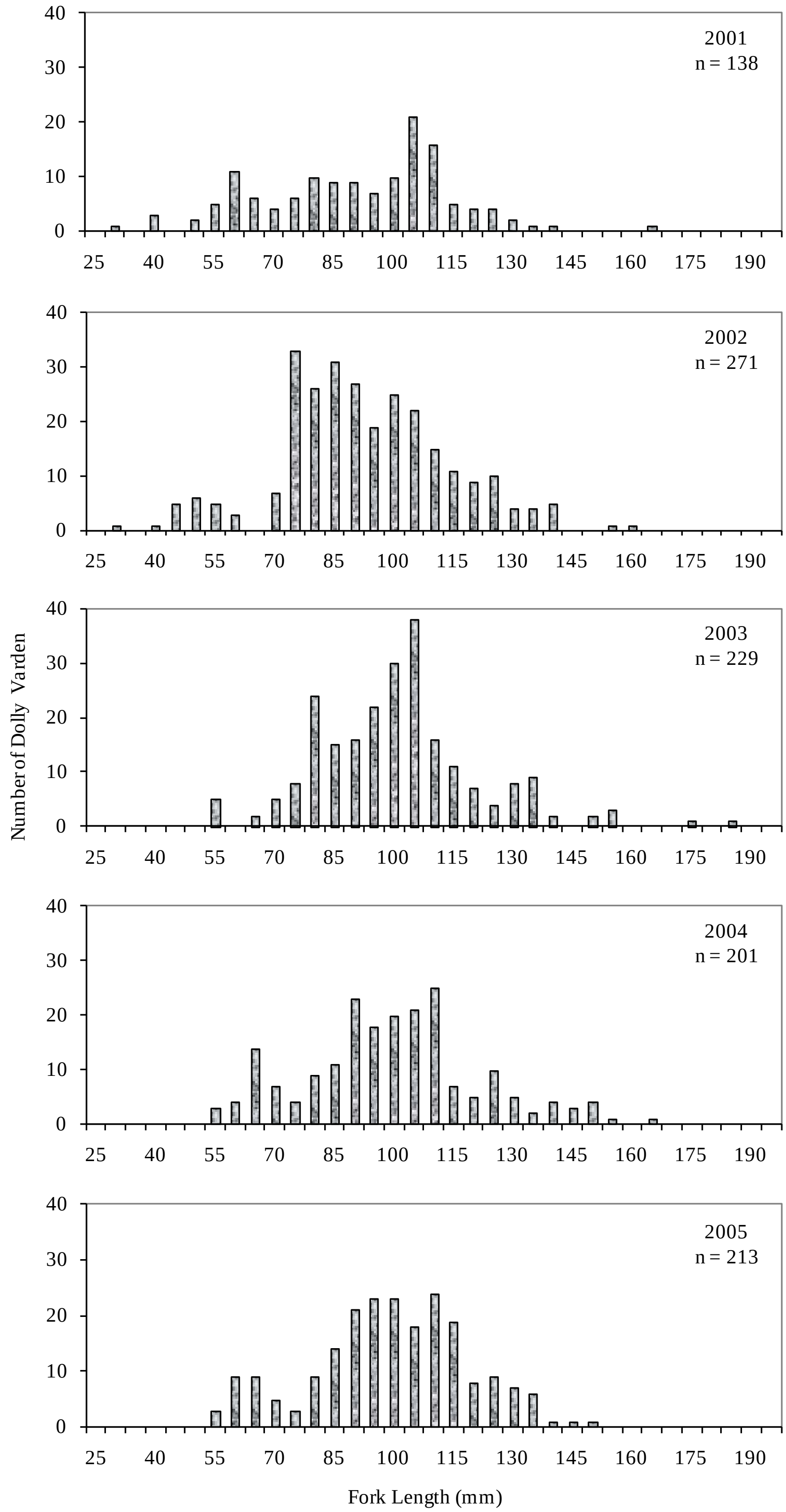
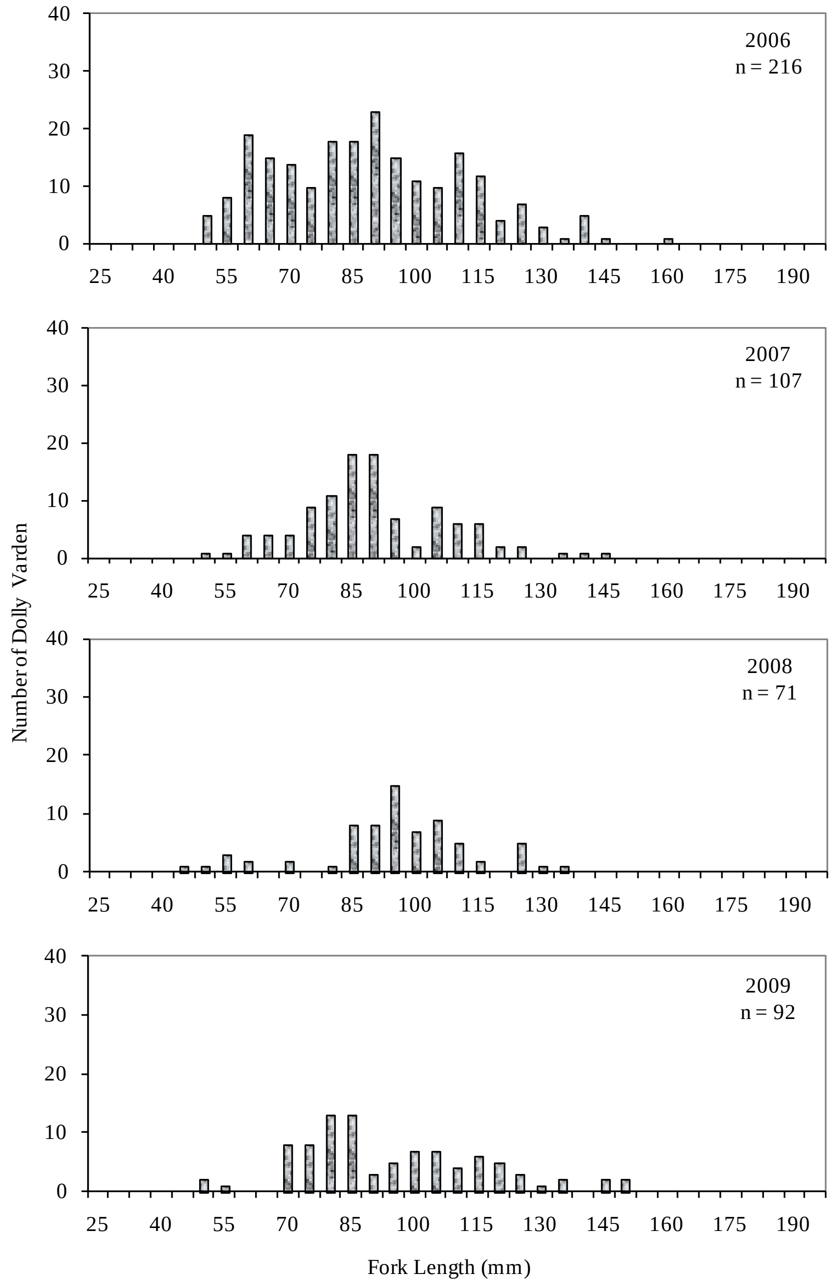


Figure 17. Length frequencies of Dolly Varden captured at Greens Creek Below Pond D Site 54 in 2001 through 2009.



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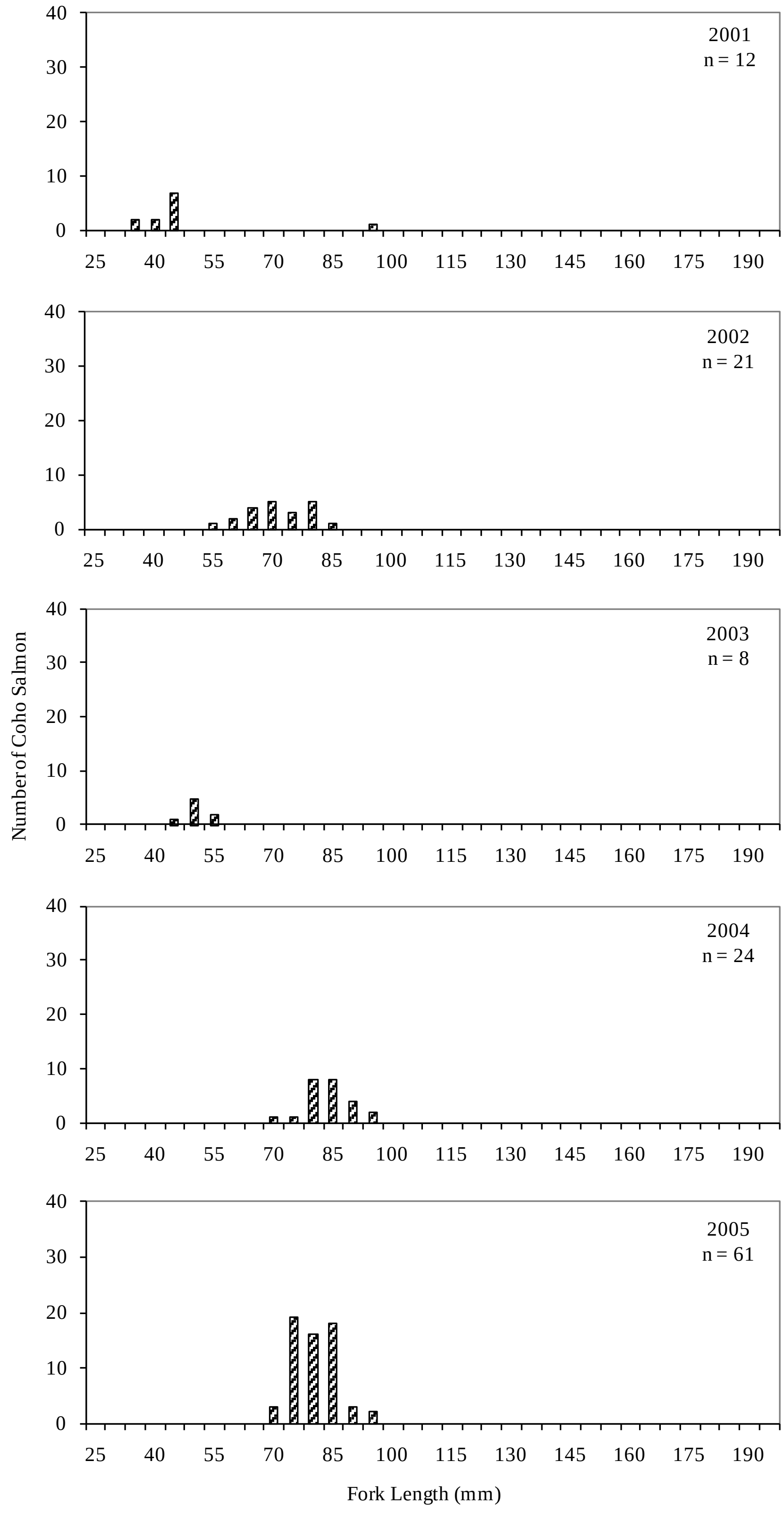


Figure 18. Length frequencies of juvenile coho salmon captured at Greens Creek Below Pond D Site 54 in 2001 through 2009.

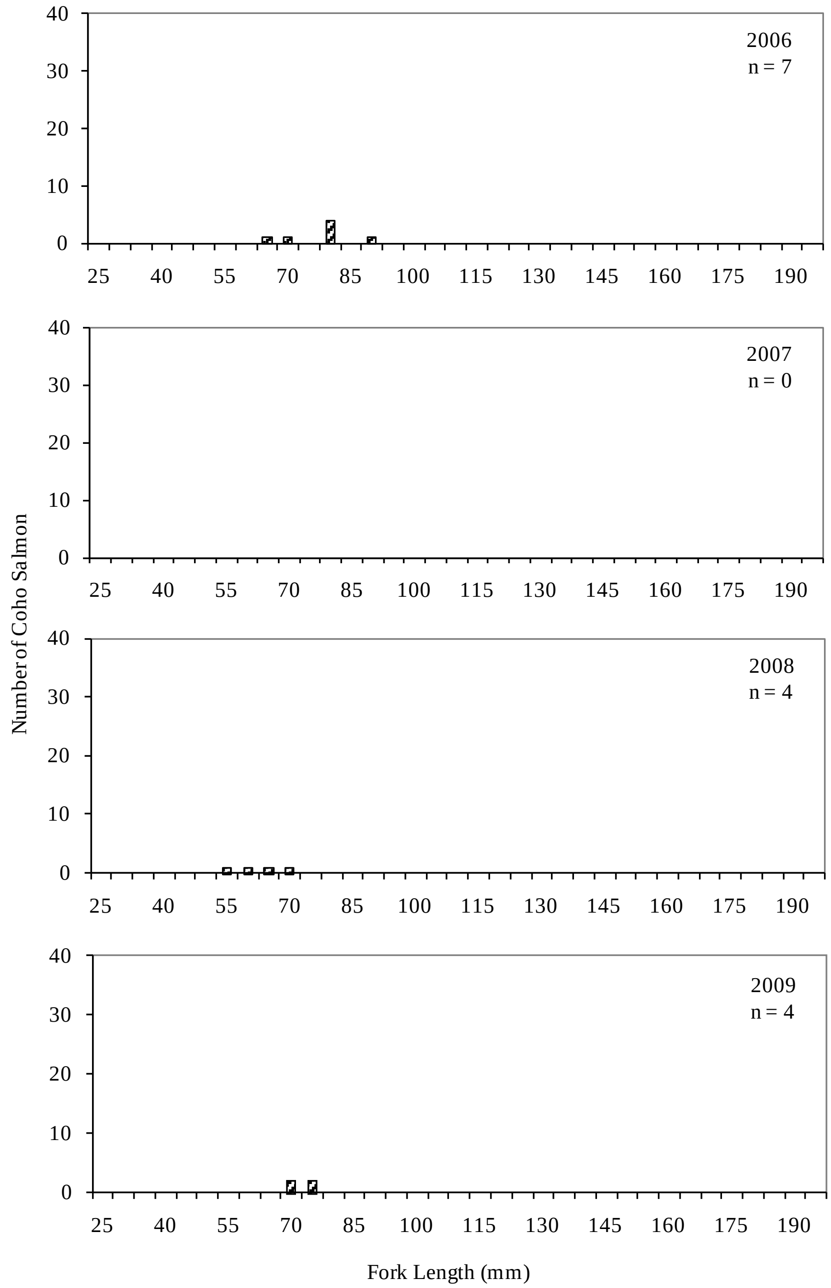


Figure 18. (Continued)

Metals Concentrations in Juvenile Fish

Median concentrations of metals in juvenile Dolly Varden tissues at Greens Creek Below Pond D Site 54 in 2009 were generally similar to or somewhat lower than most of those found in the previous eight years' samples at this site, with the exception of cadmium and selenium. Median values for silver, copper, and lead in 2009 were the next to lowest found in nine sample years at this site, the median for zinc concentrations was mid-range, and the median values for cadmium and selenium concentrations was the second highest (Figure 19, Appendix 5). The mean rank for selenium concentrations in 2009 was significantly higher than in 2002 and 2005, while those for silver, cadmium, copper, lead, and zinc were not statistically different from those of the previous eight years of sampling at this site.

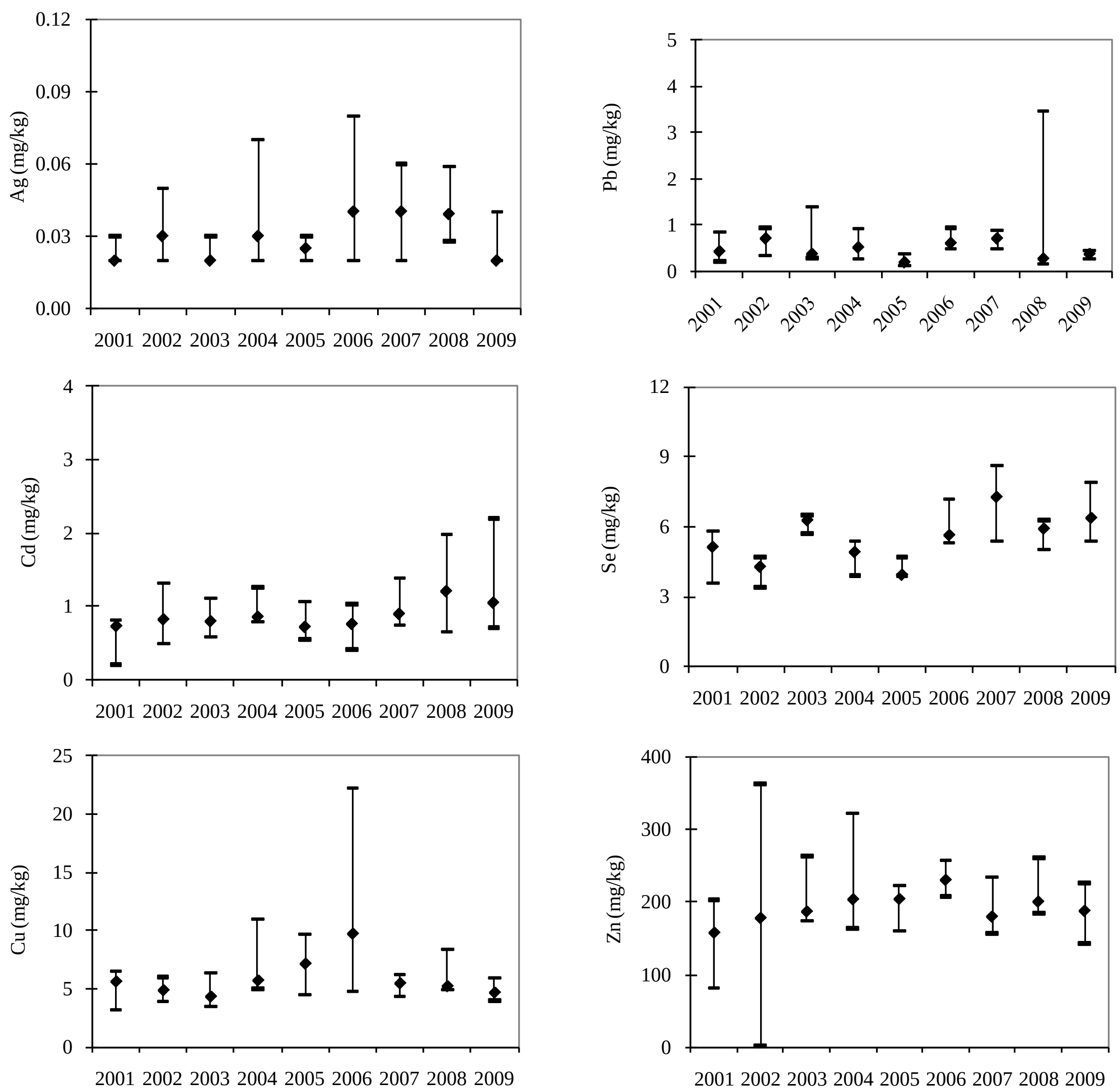


Figure 19. Whole body metals concentrations (medians and ranges) in Dolly Varden captured at Greens Creek Below Pond D Site 54 in 2001 through 2009.

Summary

Greens Creek Below Pond D Site 54 serves as a "treatment" site for biomonitoring sampling since the sampling reach is just downstream of all HGCMC mine, mill, and waste rock facilities along Greens Creek. Any trends over time that differ from those in Upper Greens Creek Site 48 could potentially result from mine development and operation. In 2009, compared to previous years, Site 54 exhibited moderate periphyton levels; moderate benthic macroinvertebrate density and taxonomic richness; lower Dolly Varden and very low coho salmon abundance and density; lower juvenile fish tissue concentrations of silver, copper, and lead; similar fish tissue concentrations of zinc; and higher fish tissue concentrations of cadmium and selenium. These characteristics are generally similar to those found this year at Upper Greens Creek Site 48 except that Site 54 exhibited greater periphyton biomass and higher lead concentrations in fish tissues.

The benthic macroinvertebrate community continues to be dominated by disturbance-sensitive species, with moderate density and richness. The Dolly Varden population density was somewhat lower than the regional average for this type of stream channel reach in southeast Alaska and had a size distribution of captured Dolly Varden showing recruitment of younger age classes, but is the second lowest in nine years of sampling at this site. The fourth consecutive year of low coho salmon captures continues to raise concern for the continued presence of this species in this portion of Greens Creek. The Greens Creek Below Pond D Site 54 samples appear consistent with a functioning and relatively healthy aquatic community, although the low number of coho salmon and the increasing tissue concentrations of cadmium and selenium bear watching in future years.

TRIBUTARY CREEK SITE 9

Tributary Creek Site 9 (Figure 20) was sampled in the morning of 22 July 2009. The weather was overcast with drizzle after a night of light rain; the water temperature was 12.5°C and the air temperature 12°C. The water level was very low, and we had some difficulty placing minnow traps in portions of the sample reach, finding appropriate locations for benthic macroinvertebrate sampling, and measuring stream flow.

Figure 20. Tributary Creek Site 9 during biomonitoring sampling on 22 July 2009.

The erosion changes on the right bank first noted during the 2007 biomonitoring sampling in the upstream half of the fish sampling reach appear to have stabilized. A major disturbance had occurred in the downstream half of the sample reach since the 2008 sampling. A hemlock snag had fallen across the stream, and a spruce tree with roots overhanging the old bank (the flagged spruce in the left foreground on the cover of the 2008 report) had been blown over away from Tributary Creek. This resulted in additional large woody debris, changes to the location of the right bank, and what had been a large pool in the area has mostly filled in with clean gravel. We noted no evidence of recent scouring flows or other major disturbance events in the weeks before sampling occurred.

During the sampling session, HGCMC staff measured Tributary Creek at 12.7°C, with a pH of 6.94 units, a conductivity of 96.0 μS/cm, and a turbidity of 10.5 NTU.

Periphyton Biomass

Concentrations of chlorophyll *a*, an estimate of periphyton biomass, at Tributary Creek Site 9 were not statistically different among the first five years sampled (2001 through 2005); however, the values from 2006, 2008, and 2009 samples were significantly lower than the high values from 2003 samples. Median biomass in 2009 was comparable to 2007 and 2008, and lower than the data from years 2001-2005 (Appendix 2). The Box and Whisker output plot from Statistix is shown in Figure 21.

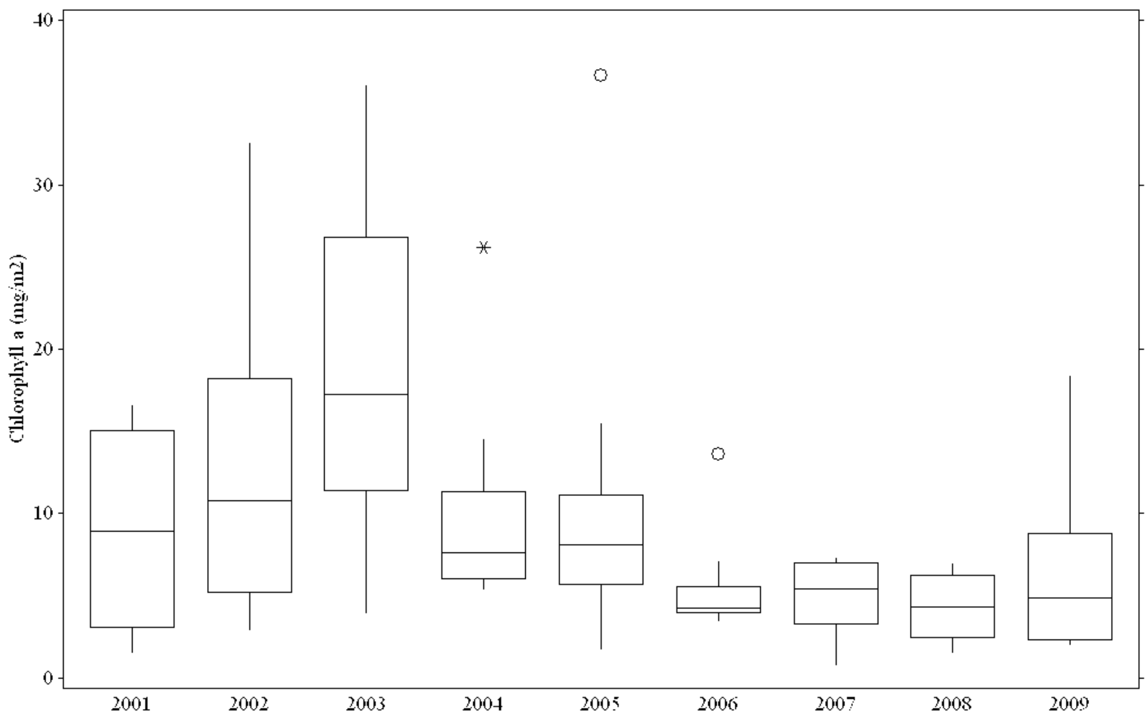


Figure 21. Estimated periphyton biomass densities at Tributary Creek Site 9 in 2001 through 2009 (n = 10 samples except n = 7 samples in 2007). Box encompasses middle half of data; horizontal line is median value. One possible statistical outlier value (∗) was identified in the 2004 data set, and one probable statistical outlier value (○) was identified in each of the 2005 and 2006 data sets.

The periphyton community at Tributary Creek Site 9 through time has been comprised of a higher proportion of chlorophyll *c* than chlorophyll *b*, with the exception of proportions in 2002 (Figure 22). Increasing concentrations of chlorophyll *b* indicate the presence of at least patchy populations of green algae in addition to the predominance of diatoms and/or dinoflagellates (chlorophyll *c*).

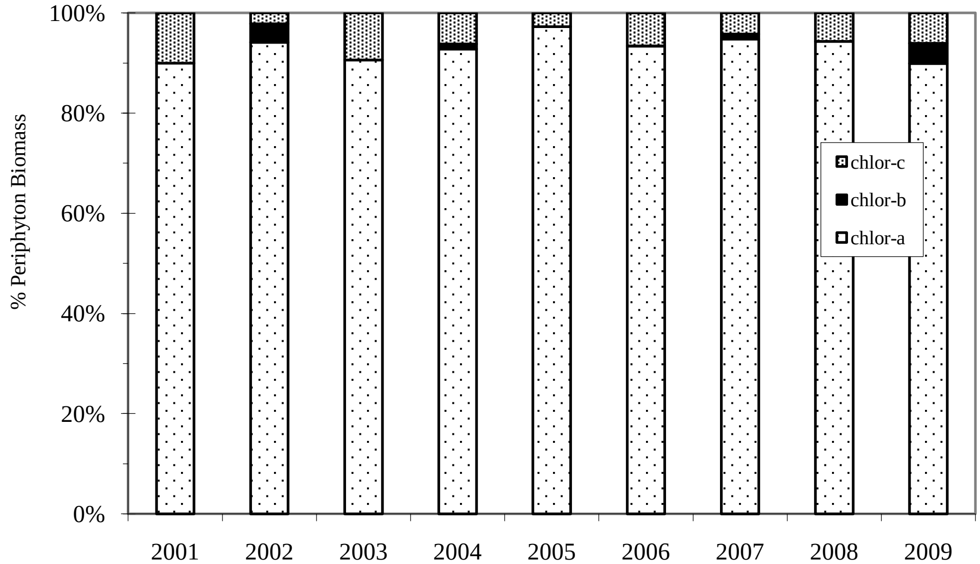


Figure 22. Proportions of mean chlorophyll *a*, *b*, and *c* concentrations in Tributary Creek Site 9 samples in 2001 through 2009.

Benthic Macroinvertebrates

The average density of benthic macroinvertebrates (both median and mean) in 2009 Tributary Creek Site 9 samples had decreased from values in 2008, and was similar to densities measured in 2001 and 2005 (Table 8, Figure 23). Taxonomic richness, as expressed by number of taxa in samples, was lower in 2009, but still less than the many taxa found in the 2003 samples.

Table 8. Summary of benthic macroinvertebrate samples at Tributary Creek Site 9 in 2001 through 2009.

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	1058	27	13.0

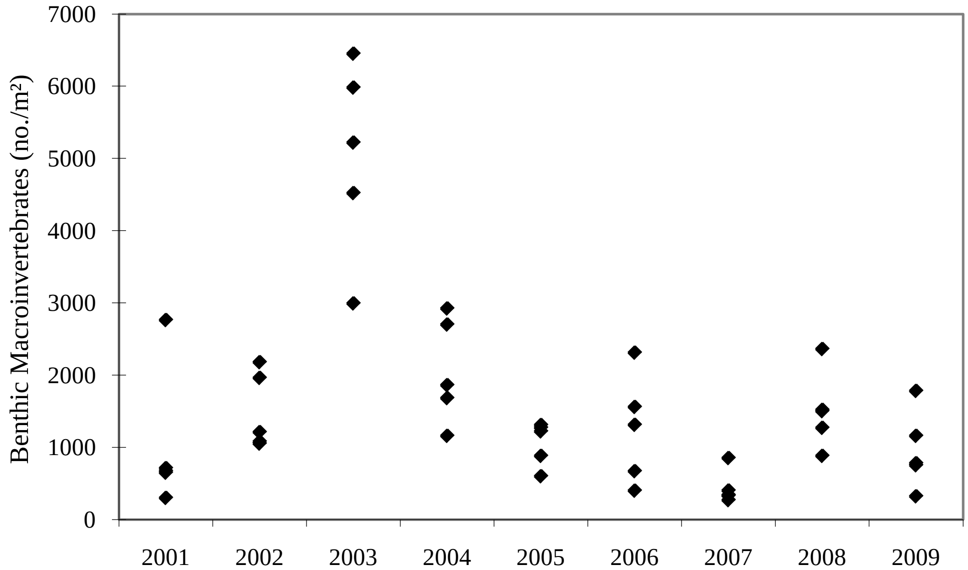


Figure 23. Density of benthic macroinvertebrates (n = 5 samples each year) in Tributary Creek Site 9 samples in 2001 through 2009.

The EPT taxa continued to be the major component of the Tributary Creek Site 9 benthic macroinvertebrate community, although the percentage of Chironomidae was the highest seen in nine years of sampling (Figure 24).

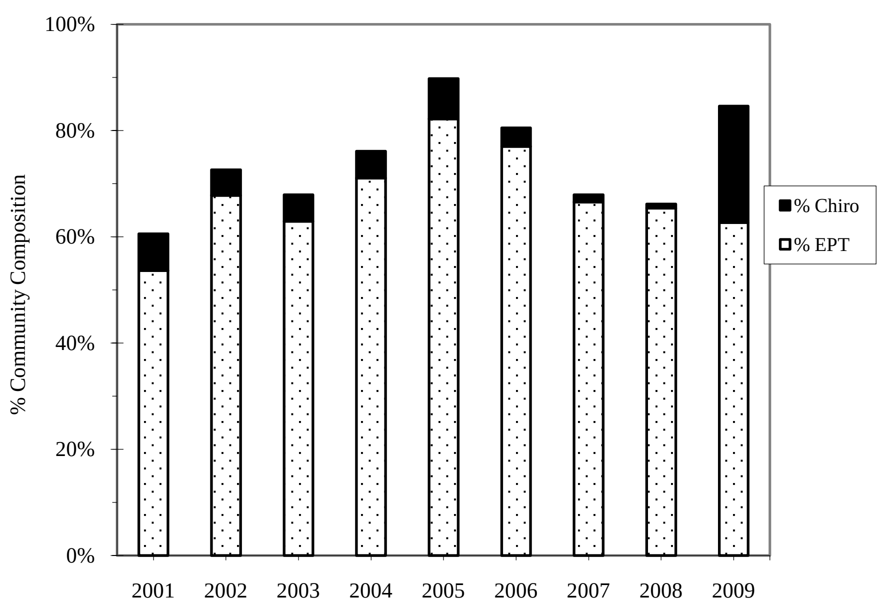


Figure 24. Proportions of EPT taxa and Chironomidae in Tributary Creek Site 9 samples in 2001 through 2009.

In the nine years of benthic macroinvertebrate community sampling at Tributary Creek Site 9, the community at this site has tended to be more complex than at the Greens Creek sites, with more taxa being common in the samples. The 2009 Tributary Creek Site 9 samples had more uncommon taxa than common taxa with a dominant presence by the midge family Chironomidae (Table 9).

Table 9. Common taxa (>5.0% of benthic macroinvertebrates) found in Tributary Creek Site 9 samples in 2001 through 2009. The percent dominant taxon each year is bold.

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

Pollution-sensitive taxa, such as the mayflies *Cinygmula* and *Paraleptophlebia* were well represented at this site (Table 9, Figure 25). The presence of these taxa reflects the stream channel characteristics of a small, valley-bottom stream with attached wetland areas. The diverse benthic macroinvertebrate community at Tributary Creek Site 9 includes both insects and non-insects such as springtails (Collembola), worms (Oligochaeta), mites (Acarina), and seed shrimp (Ostracoda) (Appendix 3).

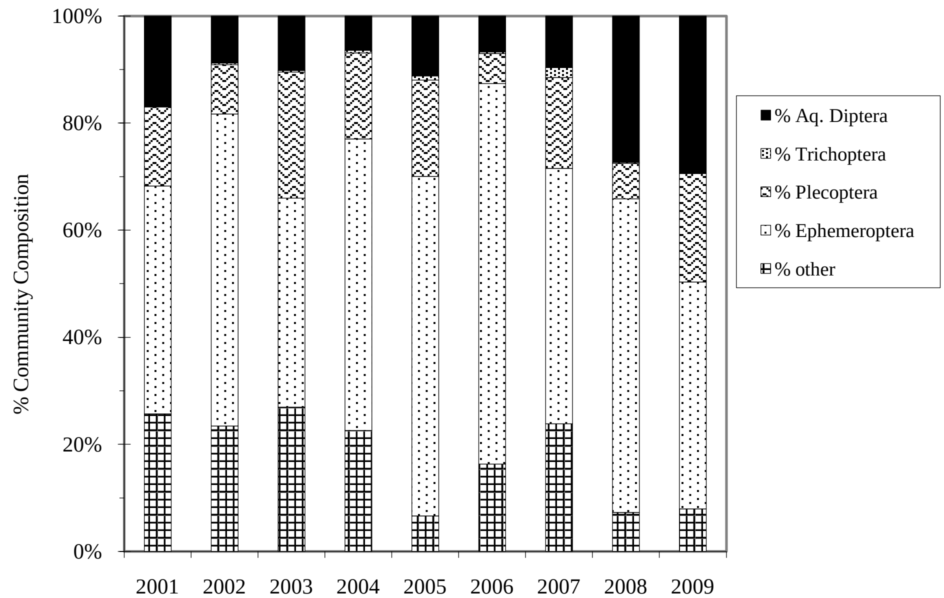


Figure 25. Community composition of benthic macroinvertebrates in Tributary Creek Site 9 samples in 2001 through 2009.

Juvenile Fish Populations

The 2009 juvenile fish survey in Tributary Creek Site 9 captured 38 Dolly Varden, 53 coho salmon, 1 cutthroat trout and 5 sculpin in 21 minnow traps in the same 50 m sample reach as sampled in 2002 through 2008 (Table 10). Three “block” traps were set immediately downstream of the sample reach and three upstream; they captured an additional 6 Dolly Varden, 12 coho salmon, and 1 sculpin that are not included in the reported results. The estimated 2009 population sizes for the reach, based on the three-pass removal method, was 42 Dolly Varden with an approximate density of 0.35 fish/m² and 53 coho salmon with an approximate density of 0.44 fish/m² of wetted stream surface area.

Capture numbers and fish densities have been quite variable at this site during the nine years of biomonitoring sampling, with the 2009 population estimates moderate. The 2009 population estimate for Dolly Varden at this site was significantly higher than in 2003, 2006, 2007, and 2008 but significantly lower than in 2001 (Table 10, Appendix 4). For coho salmon, the 2009 population estimate was significantly higher than in 2002, 2004, and 2006 but significantly lower than in 2001, 2005, 2007, and 2008. The Site 9 densities of Dolly Varden and coho salmon juveniles in 2009 were typical for streams of this channel type in southeast Alaska or slightly higher.

Table 10. Juvenile fish population estimates for Tributary Creek Site 9 based on minnow trapping in 2001 through 2009. Captures of incidental species at this sampling site (cutthroat trout, rainbow trout, and sculpin) are not shown, but are reported in Appendix 4.

Year Sampled	Fish Species	No. Fish Caught	FLength, 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*
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
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*
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

* Based on estimated wetted area value.

Fork lengths of Dolly Varden captured at Tributary Creek Site 9 in 2001 through 2009 represented a wide range of fish sizes and suggest use by multiple age classes (Figure 26). In contrast to Dolly Varden captures in 2006 and 2007, captures in 2008 and 2009 suggest the presence of younger age classes. Fork lengths of coho salmon (Figure 27) captured at this site in all years except 2006 suggest both recruitment and use by multiple age classes although we have no validation data to correlate fish lengths with age such as scale or otolith analyses. The length-frequency plot for coho captured in 2009 may not show large recruitment of young of the year coho, but the wide range of fork lengths strongly suggests that multiple age classes were captured.

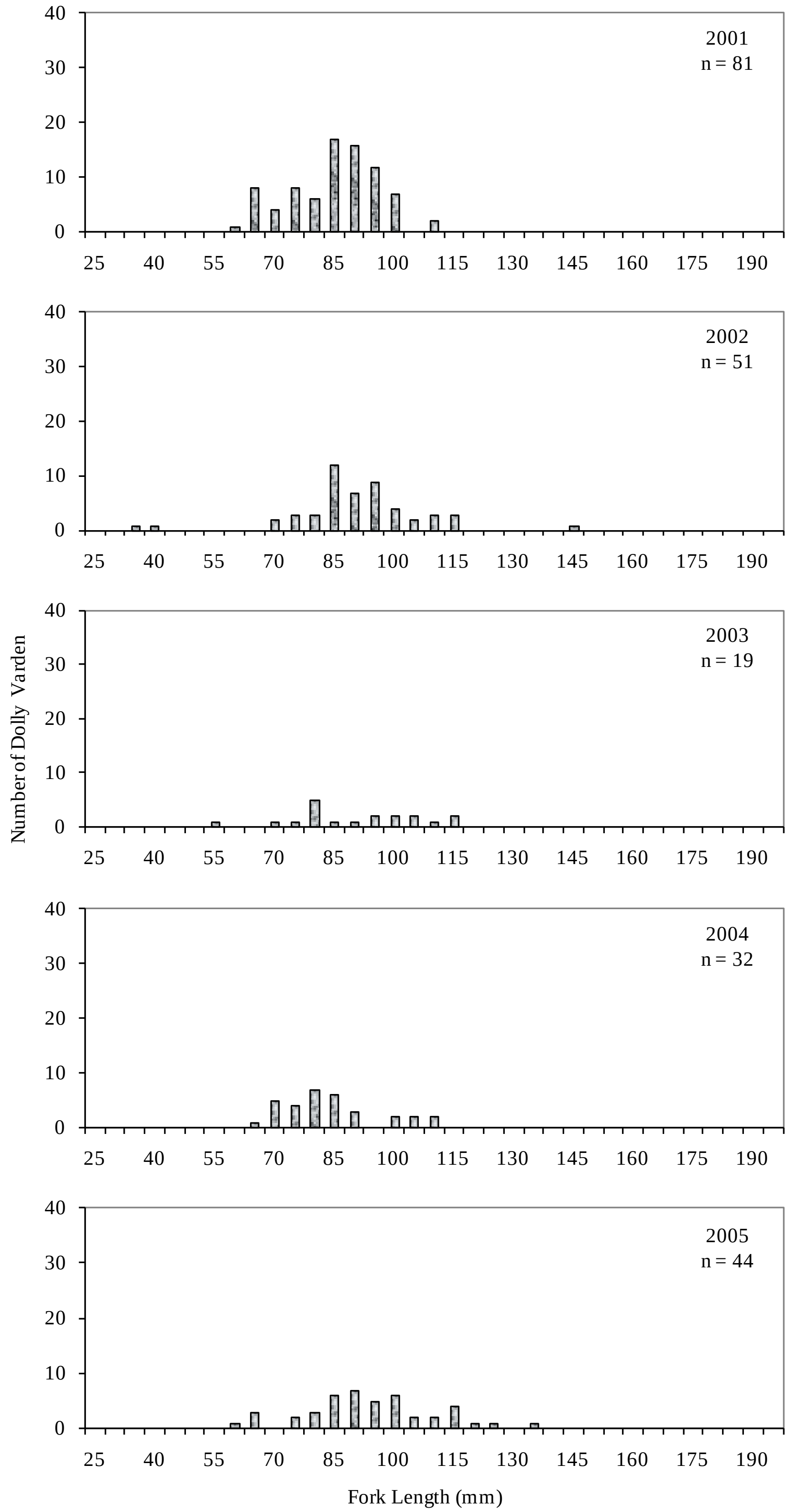
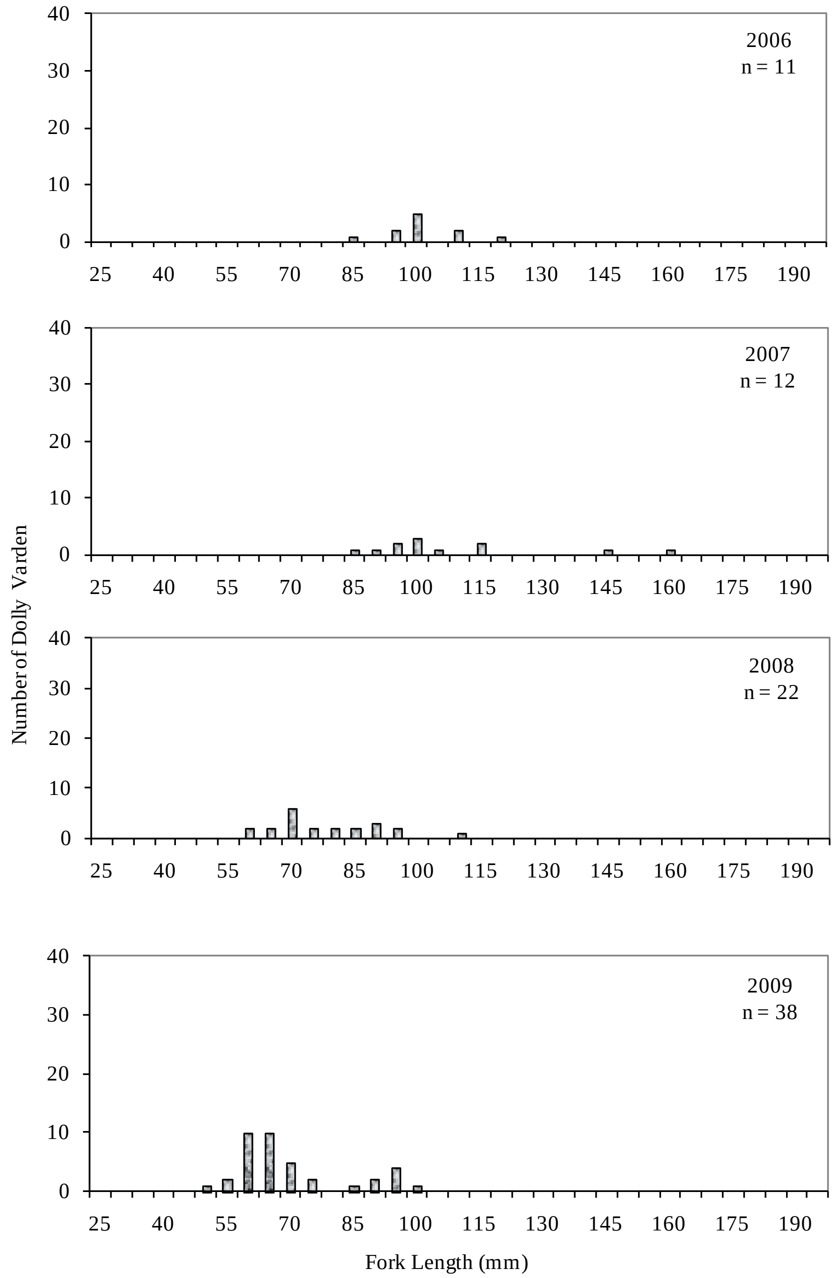


Figure 26. Length frequencies of Dolly Varden captured at Tributary Creek Site 9 in 2001 through 2009.



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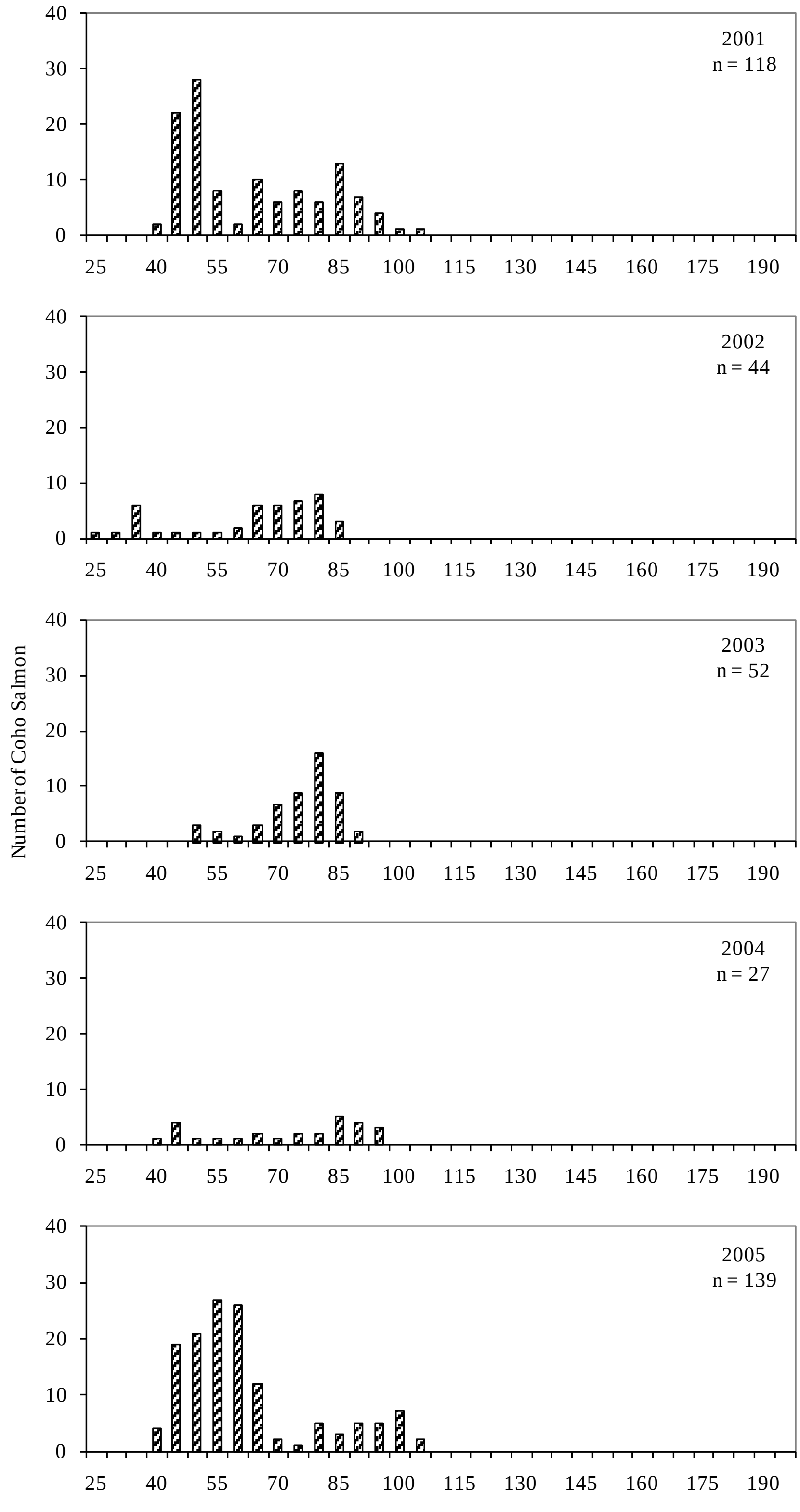

Figure 27. Length frequencies of juvenile coho salmon captured at Tributary Creek Site 9 in 2001 through 2009.

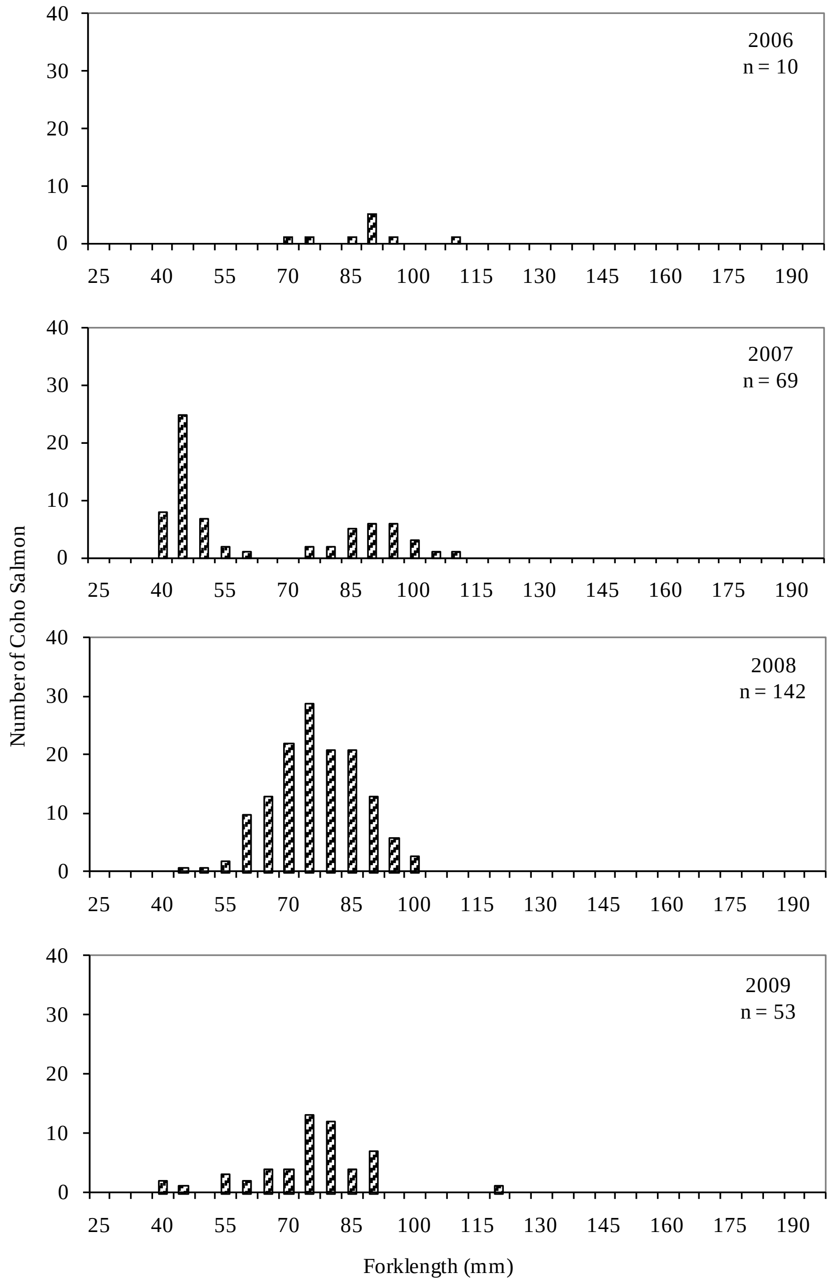

Figure 27. (Continued)

Metals Concentrations in Juvenile Fish

Median concentrations of metals in juvenile Dolly Varden tissues at Tributary Creek Site 9 in 2009 were similar to or lower than those found in the previous eight years of sampling (Figure 28, Appendix 5). In 2009 samples, the median tissue concentration of silver, cadmium, copper, and lead was the lowest measured in juvenile fish at this site when compared to values from previous years. The mean rank for tissue concentrations of silver were substantially lower than in 2006 and 2007, that for cadmium was significantly lower than in 2007, that for copper was significantly lower than in 2001, 2005, and 2006 and substantially lower than in 2002, that for lead was significantly lower than in 2007, and those for selenium and zinc were not statistically different in 2009 from any of the previous eight years of sampling at this site.

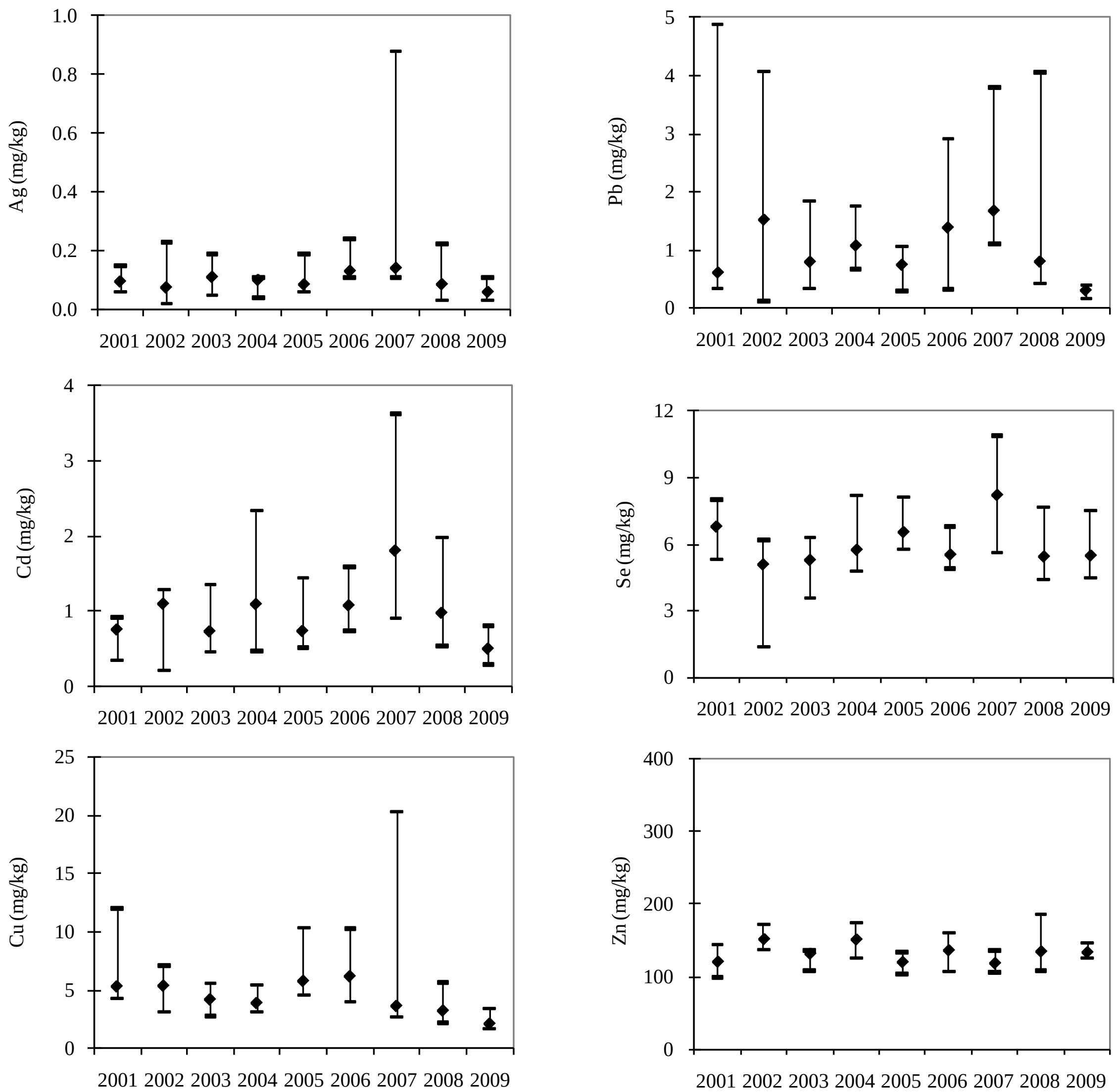

Figure 28. Whole body metals concentrations (medians and ranges) in Dolly Varden captured at Tributary Creek Site 9 in 2001 through 2009.

Summary

Tributary Creek Site 9 serves as a "treatment" site for biomonitoring sampling since it is downstream of the dry stack tailings facility. Any trends over time could potentially be attributed to effects on water quality from the tailings facility with consideration given to natural perturbations. In 2009, compared to the eight previous years of sampling, the Tributary Creek site exhibited low periphyton levels; low benthic macroinvertebrate density and moderate taxonomic richness; moderate Dolly Varden and coho salmon populations and densities; and juvenile fish tissue concentrations of silver, cadmium, copper, lead, selenium, and zinc that were lower than or similar to values in previous years.

The smaller benthic macroinvertebrate community was dominated by disturbance-sensitive species. The Dolly Varden and coho salmon populations continue to show recruitment of younger age classes of fish, and both species were present at densities slightly higher than the regional averages for this type of channel reach in southeast Alaska. Tributary Creek Site 9 samples appear consistent with a functioning aquatic community during a period of very low flow. We remain hopeful that a fuller understanding of the hydrology of Tributary Creek, as more data become available from HGCMC monitoring, will add to our understanding of how this system responds to seasonal trends and short-term perturbations.

COMPARISONS AMONG SITES

Periphyton Biomass

Periphyton biomass at the Greens Creek sites has shown a similar pattern over nine years of sampling, with low values in 2001 and 2002 followed by a peak in 2003, decreases in 2004 and 2005, increase again in 2006, down from that in 2007 and 2008, and back up in 2009 (Figure 29). Response to hydrologic events at these three sites would have contributed the most variability to periphyton biomass given the similar trends seen. The pattern of periphyton biomass at the Tributary Creek site was generally similar to that at the Greens Creek sites in 2001 through 2004, but is typically more variable within each year. All sites exhibited an increase in periphyton biomass in 2009.

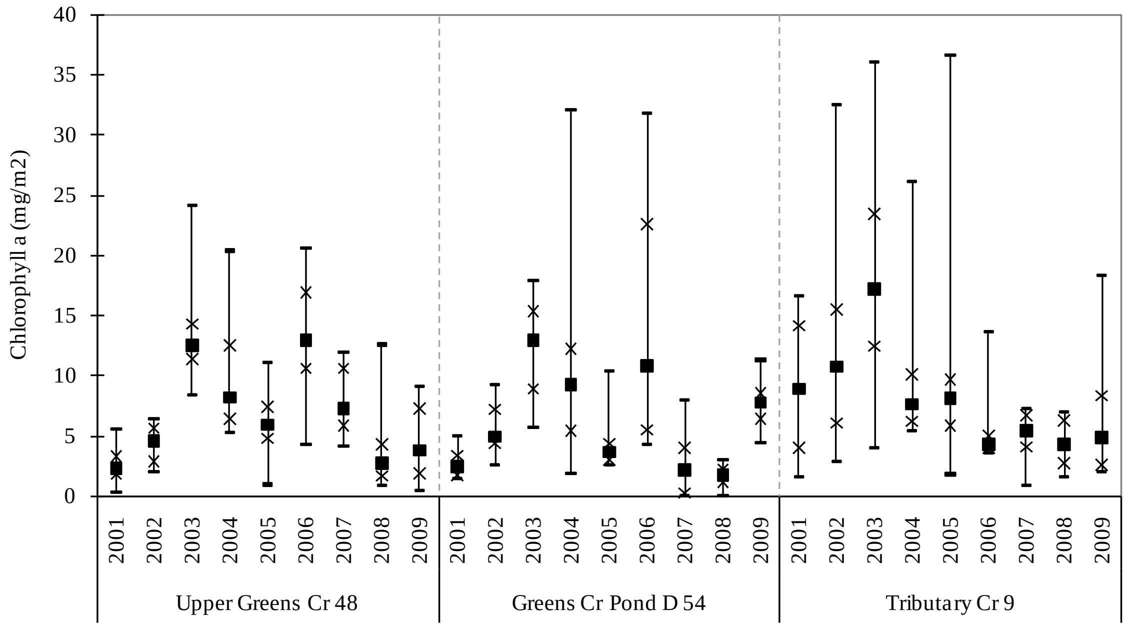

Figure 29. Comparison of estimated periphyton biomass (medians and ranges) among Greens Creek Mine biomonitoring sites sampled in 2001 through 2009 (n = 10 samples per site except n = 7 in 2007 Site 9). First and third quartiles are indicated by small ticks on vertical range line.

The difference between median community composition of periphyton sampled in 2009 at the two Greens Creek sites was neither substantially or significantly different (Figure 30, Appendix 2). Periphyton samples from sites 54 and 48 were primarily chlorophyll *a*, with approximately 10% chlorophyll *c* and no detectable chlorophyll *b* during the previous eight years of this study. However, the amount of chlorophyll *b* and *c* was noticeably elevated in 2009 samples at all sites compared to previous years. Chlorophyll *a, b,* and *c* concentrations from the Tributary Creek Site 9 samples did not differ significantly from the Greens Creek samples in 2009.

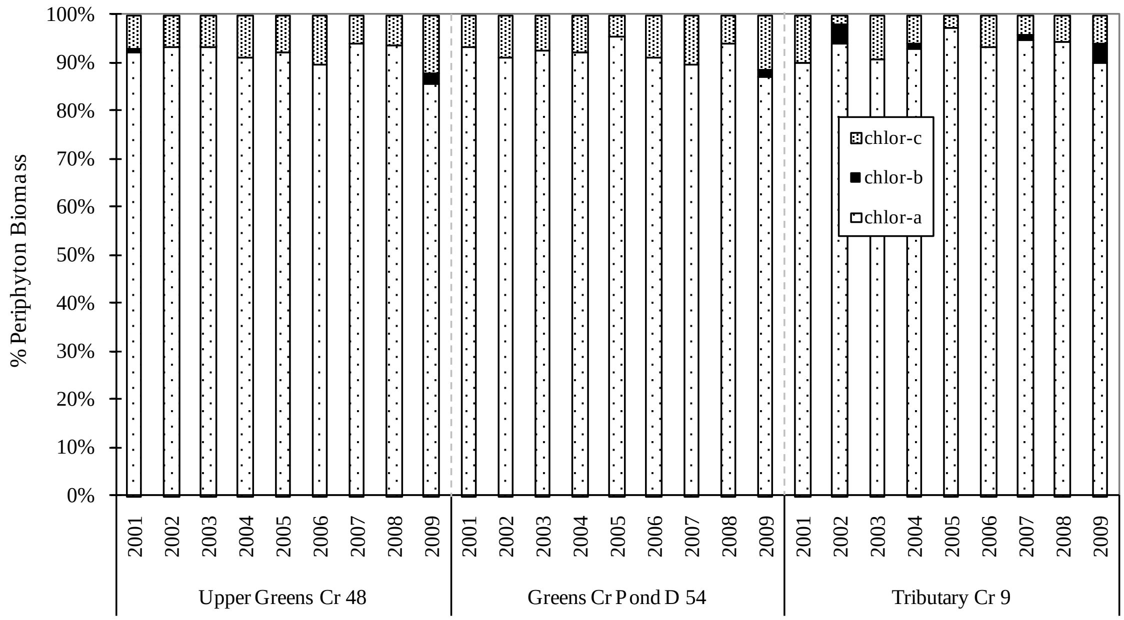

Figure 30. Comparison of proportions of mean chlorophyll *a*, *b*, and *c* concentrations among Greens Creek Mine biomonitoring sites in 2001 through 2009.

Chlorophyll *a* is a primary photosynthetic pigment, is present in all algae, and is a useful indicator of periphyton biomass and a healthy algal community (Wetzel 1983). Chlorophyll *b* is an accessory pigment found in combination with other photosynthetic pigments. When measured above detection limits in periphyton communities, chlorophyll *b* is an indication of the presence of green algae and euglenophytes. Chlorophyll *c* also is an accessory pigment, and only found in the photosynthetic Chromista (includes diatoms) and dinoflagellates (Speer 1997). Diatoms play an important role in primary production in aquatic communities, and measurable quantities of chlorophyll *c* indicate the importance of diatoms in the community.

A few Upper Greens Creek Site 48 samples and several Tributary Creek Site 9 biomonitoring samples have had higher chlorophyll *b* concentrations than have other samples, suggesting that at the time of sampling there was a larger percentage of green algae or euglenophytes in the periphyton community (Wetzel 1983). Given the differences in channel morphology, flow regimes and streamside vegetation between streams and years, some differences in algal communities are not unexpected.

Benthic Macroinvertebrates

Benthic macroinvertebrate densities decreased at all three sites in 2009 relative to the densities found in 2008 (Figure 31). The benthic macroinvertebrate densities from Tributary Creek Site 9 samples in 2009 were statistically different than the 2009 samples from the sites on Greens Creek while taxonomic richness was not (Figures 31 and 32).

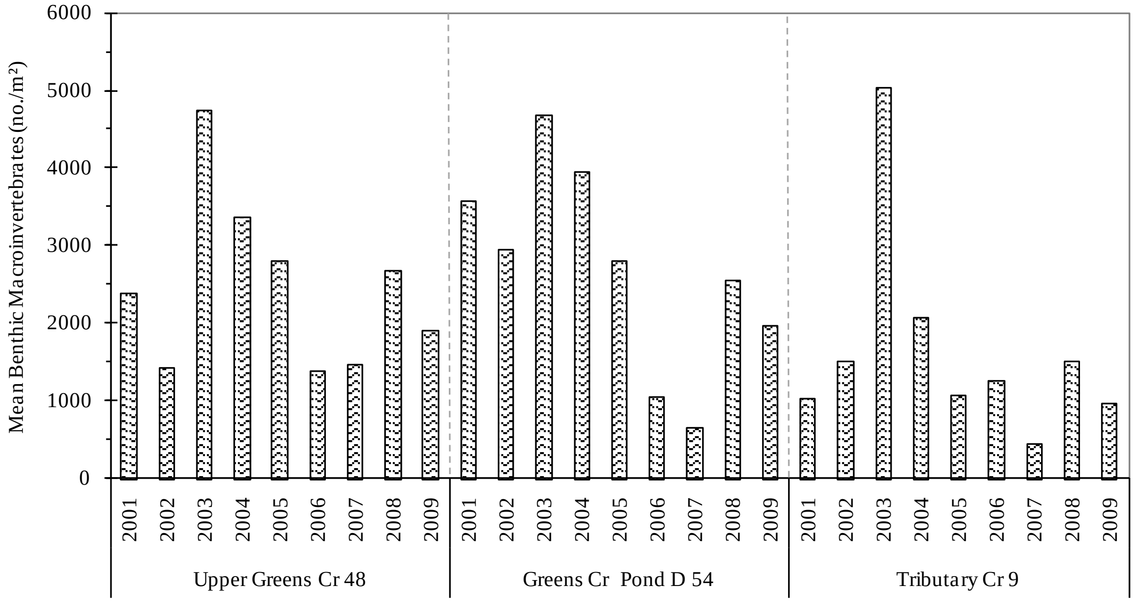

Figure 31. Comparison of benthic macroinvertebrate density among Greens Creek Mine biomonitoring sites in 2001 through 2009.

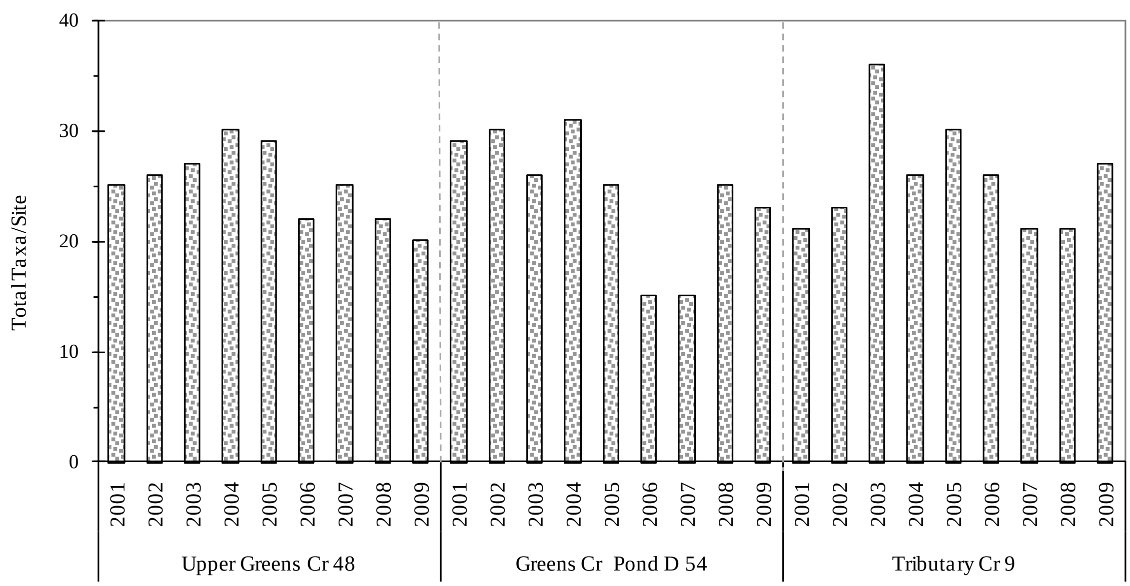

Figure 32. Comparison of benthic macroinvertebrate taxonomic richness among Greens Creek Mine biomonitoring sites in 2001 through 2009.

Each of the three biomonitoring sites continued to have diverse invertebrate communities with abundant numbers of taxa (taxonomic richness) per sample. More than 50% of the invertebrates in samples from Upper Greens Creek Site 48 and Greens Creek Below Pond D Site 54 were from two dominant taxa, while three dominant taxa accounted for more than 50% of the invertebrate community in Tributary Creek Site 9 (Table 11). The number of taxa per site (richness) was moderate at the two Greens Creek sites, while richness at Tributary Creek Site 9 was among the highest numbers seen over the nine years of biomonitoring. Richness was not statistically different between sites in 2009.

For all sites taken together, benthic macroinvertebrate densities in 2005, 2006, 2007, 2008, and 2009 were significantly lower than in 2003, and taxonomic richness per site was significantly higher in 2003 and 2004 than in 2009. The reason for this overall pattern is unclear; unless the large and sometimes intense fluctuations in stream discharge affect the community as much as it affects the numbers of invertebrates. This can include very low water levels in Tributary Creek as well as scouring high flows in Greens Creek. Noted differences in the structure of these communities likely reflect differences in channel morphology, influences of tributaries, frequency of flood events, streamside vegetation, and flow rates. Aquatic habitats with more moderate stream flows, such as Tributary Creek Site 9, usually have communities that are more complex with many taxa present compared to more variable habitats such as the Greens Creek sites where fewer taxa typically dominate the communities (Hynes 1970). All three sites have likely been affected by the noted substrate movements and channel changes that occurred during the past two seasons.

Table 11. Common taxa (>5.0% of benthic macroinvertebrates) found in Greens Creek Mine biomonitoring samples in 2009. The percent dominant taxon for each site is bold.

Order	Taxon	Upper Grns Cr 48	Grns Cr Pond D 54	Trib Cr 9
Ephemeroptera	*Baetis*	12%	16%	-
	Ephemerella	18%	13%	-
	Cinygmula	9%	11%	15%
	Epeorus	**45%**	**36%**	-
	Rhithrogena	7%	15%	-
	Paraleptophlebia	-	-	15%
	Ameletus	-	-	7%
Plecoptera	*Zapada*	-	-	7%
Diptera	Chironomidae	-	-	**22%**

The percent EPT metric, based on the concept that many taxa within Ephemeroptera, Plecoptera, and Trichoptera taxa are sensitive to pollutants (Merritt and Cummins 1996), was high in all of the biomonitoring sites in each of the years sampled (Figure 33). The general trend from the past eight years of invertebrate community information has been that the percent of Chironomidae has been relatively constant at the Tributary Creek site while variable in the Greens Creek sites. In 2009 however, Tributary Creek exhibited an increased presence of the midge fly family Chironomidae.

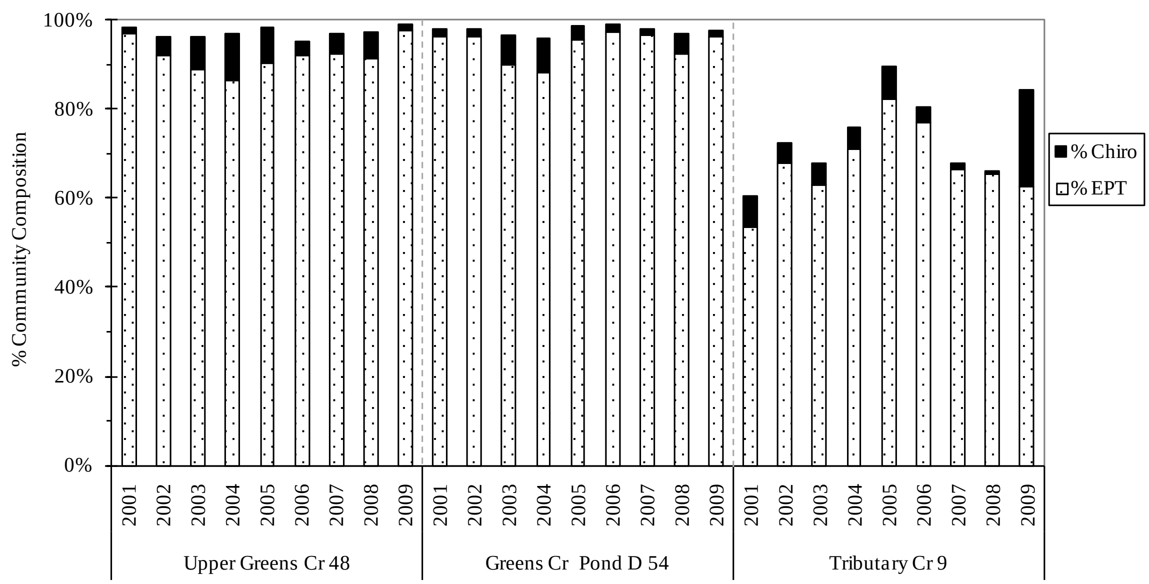

Figure 33. Comparison of proportions of EPT taxa and Chironomidae among Greens Creek Mine biomonitoring sites in 2001 through 2009.

Composition of the benthic macroinvertebrate community of the Greens Creek sites continued to be similar to one another and somewhat different from that at the Tributary Creek site (Figure 34). The communities at the two Greens Creek sites were dominated by Ephemeroptera (mayflies), with small contributions by Plecoptera (stoneflies) and aquatic Diptera (primarily midge and blackfly larvae), while the Tributary Creek site community was somewhat less dominated by Ephemeroptera and contained more non-insect invertebrates. In 2009, the proportion of aquatic Diptera in Tributary Creek site samples were greater than any year previous, as well as in comparison to the Greens Creek sites. These differences in community composition are most likely due to the different physical characteristics of the streams.

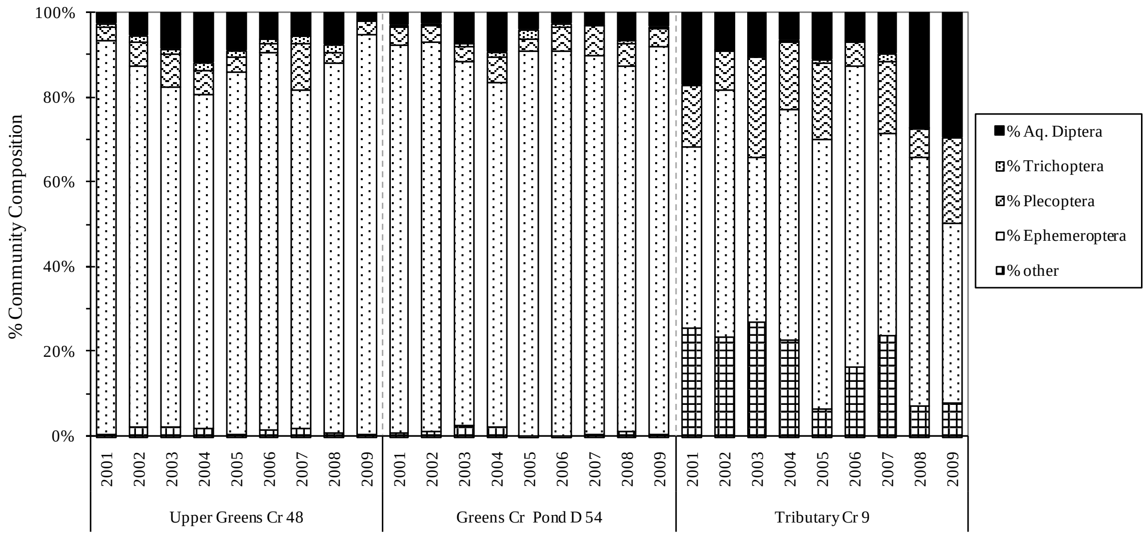

Figure 34. Comparison of community composition of benthic macroinvertebrates among Greens Creek Mine biomonitoring sites in 2001 through 2009.

Despite decreases in overall density and taxonomic richness, the resulting metrics show all three sites to have well-developed, complex communities similar in structure to previous years at the same sites. The percent dominant taxa showed the communities to have high proportions of pollution-sensitive invertebrates, and where a community was dominated by one or two groups, those groups were considered sensitive to pollution. Because all three communities continue to be dominated by pollution-sensitive species, we believe that any future perturbations by natural stressors or human-facilitated sources would likely cause detectable changes in abundance or richness.

Juvenile Fish Populations

Dolly Varden population estimates for Upper Greens Creek Site 48 and Greens Creek Below Pond D Site 54 sample reaches continued to follow very similar patterns although the density estimates for Site 54 are less than those for Site 48 because of the differences in reach lengths and configurations (Figure 35, Table 12). Murphy et al. (1986) and Bryant et al. (1991) provide average fish density values for various channel types on the Tongass National Forest based on captures, and Paustian et al. (1999) expanded these and other data to habitat capability estimates. In 2009, Dolly Varden densities were similar to Paustian’s regional average at Upper Greens Creek Site 48, and approximately 20% less at Greens Creek Below Pond D Site 54, for the Moderate Width Mixed Control channel type. Dolly Varden population estimates at Tributary Creek Site 9 have been highly variable over the past nine years but generally trending low. The

2009 density estimate is slightly higher than Paustian's regional average for the Narrow Low Gradient Flood Plain channel type.

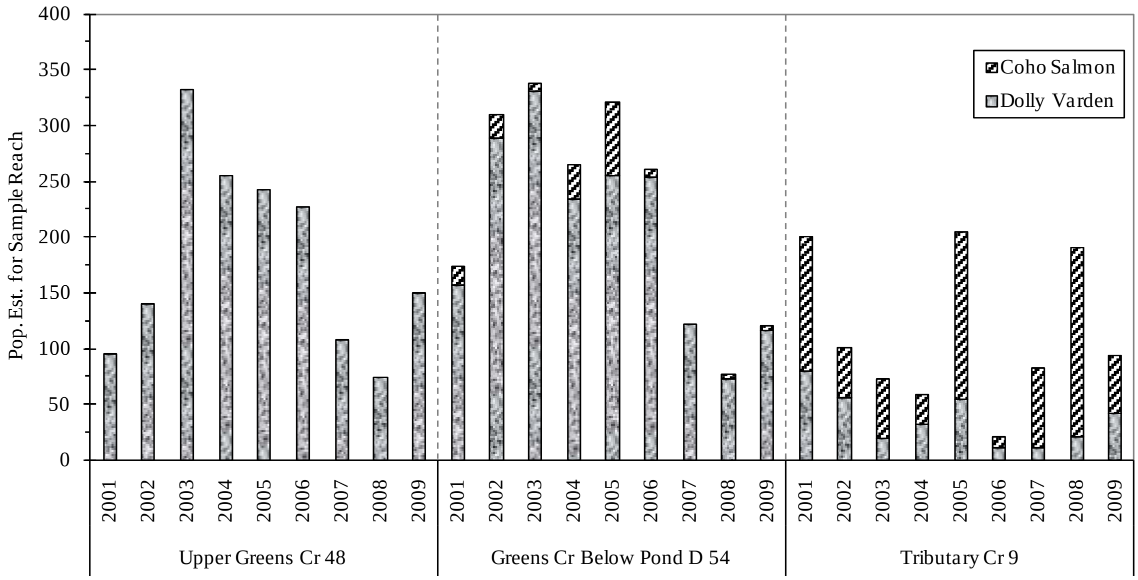

Figure 35. Comparison of population estimates for juvenile fish captured at Greens Creek Mine biomonitoring sites in 2001 through 2009.

A few coho salmon were captured at Greens Creek Below Pond D Site 54 in 2008 and 2009 following no captures in 2007; the coho salmon density estimate at Site 54 in 2009 was one-ninth Paustian's regional average. The paucity of coho salmon captures four years in` a row at this site raises concerns about coho salmon access to this portion of Greens Creek, and needs to be addressed in a timely manner by the appropriate entities. Coho salmon populations and densities at Tributary Creek Site 9 have ranged over one and one-half orders of magnitude during the nine years of biomonitoring sampling (Figure 35, Table 12, Appendix 4). Juvenile coho were moderately abundant at Site 9 in 2009, with a density estimate more than one and one-half times the regional average for that channel type.

Although comparisons among all sites must take into consideration the differences in size, channel type, and elevation between the Greens Creek and Tributary Creek sites, some generalizations can be made regarding the fish density values (population estimate per m^2 of wetted area in each sample reach) shown in Table 12. Using this metric, Upper Greens Creek Site 48 (upstream of mine facilities) has been markedly more productive (typically by a factor of two) each year of biomonitoring sampling than has Greens Creek Below Pond D Site 54 (downstream of mine facilities) except in 2009, when Site 54 was one-fifth less productive than

Table 12. Fish captures, population estimates, and densities in Greens Creek Mine biomonitoring sampling reaches during 2001 through 2009.

	Upper Greens Creek Site 48		Middle Greens Creek Site 6[1]		Greens Creek Below Pond D Site 54		Tributary Creek Site 9	
	Coho Salmon[2]	Dolly Varden	Coho Salmon	Dolly Varden	Coho Salmon	Dolly Varden	Coho Salmon	Dolly Varden
2001								
Fish Captured	---	68	3	131	12	138	118	81
Population Estimate	---	96	3	161	17	158	120	81
Sample Reach (m)	---	72	135	135	28	28	44	44
Density Est. (fish/m²)	---	0.20	<0.01	0.13	0.06	0.58	0.80	0.92
2002								
Fish Captured	---	126	---	---	21	271	44	51
Population Estimate	---	141	---	---	21	290	46	56
Sample Reach (m)	---	50	---	---	28	28	50	50
Density Est. (fish/m²)	---	0.23	---	---	0.07	1.0	0.35	0.46
2003								
Fish Captured	---	285	---	---	8	232	52	19
Population Estimate	---	333	---	---	8	331	53	20
Sample Reach (m)	---	50	---	---	28	28	50	50
Density Est. (fish/m²)	---	0.9[3]	---	---	0.04[3]	1.8[3]	0.8[3]	0.3[3]
2004								
Fish Captured	---	244	---	---	24	201	27	32
Population Estimate	---	255	---	---	31	234	27	33
Sample Reach (m)	---	50	---	---	28	28	50	50
Density Est. (fish/m²)	---	0.88	---	---	0.21	1.57	0.46	0.56
2005								
Fish Captured	---	212	---	---	61	213	139	44
Population Estimate	---	243	---	---	67	255	150	55
Sample Reach (m)	---	50	---	---	28	28	50	50
Density Est. (fish/m²)	---	0.65	---	---	0.31	1.17	1.15	0.42
2006								
Fish Captured	---	212	1	97	7	217	10	11
Population Estimate	---	228	1	114	7	254	10	11
Sample Reach (m)	---	50	49	49	28	28	50	50
Density Est. (fish/m²)	---	0.59	<0.01	0.25	0.03	1.22	0.08	0.09
2007								
Fish Captured	---	95	---	---	0	107	69	12
Population Estimate	---	109	---	---	0	122	71	12
Sample Reach (m)	---	50	---	---	28	28	50	50
Density Est. (fish/m²)	---	0.2[3]	---	---	0	0.4[3]	0.58	0.10
2008								
Fish Captured	---	73	---	---	4	71	142	22
Population Estimate	---	75	---	---	4	73	169	22
Sample Reach (m)	---	50	---	---	28	28	50	50
Density Est. (fish/m²)	---	0.14	---	---	0.01	0.21	1.27	0.16
2009								
Fish Captured	---	126	---	---	4	93	53	38
Population Estimate	---	151	---	---	4	117	53	42
Sample Reach (m)	---	50	---	---	28	28	50	50
Density Est. (fish/m²)	---	0.43	---	---	0.01	0.36	0.44	0.35

[1] Middle Greens Creek Site 6 is sampled on a five-year interval.

[2] Coho salmon are not present at Upper Greens Creek Site 48 because of a downstream barrier to anadromous fish.

[3] Based on approximate values for wetted area.

was Site 48. The total fish density (and densities by fish species) at Tributary Creek Site 9 has varied widely during the eight years of biomonitoring sampling, and not followed the same patterns as the Greens Creek sites. Coho salmon densities at Tributary Creek Site 9 have been much greater than at Greens Creek Below Pond D Site 54 (the two treatment sites) each year.

One potential reason for at least some of these differences is the habitat changes noted at each of the three sites the past few years. The preferred spawning areas for resident Dolly Varden are the edges of pools in low velocity water with a gravel substrate size of 1-4 cm (Ihlenfeldt 2005), while coho salmon prefer to spawn in riffle areas (McPhail and Lindsey 1970). Based on comparisons of photos taken each year during biomonitoring sampling, both pools and riffles in Greens Creek were substantially reworked during the November 2005 high water event and gravels and woody debris at both Greens Creek sites continue to be reworked. This movement of gravels around eggs in redds can kill incubating coho salmon eggs, and reduces the amount of low velocity resting and feeding habitat available to rearing and resident fish. High water events in the weeks before sampling can also reduce periphyton biomass, benthic macroinvertebrate density, and woody debris in streams; flows before sampling in 2009 were moderate compared to those the previous two years. Murphy et al. (1986) found that coho salmon young of the year densities were directly related to periphyton biomass and benthic macroinvertebrate density, and that coho and Dolly Varden parr were directly related to pool and woody debris features.

Metals Concentrations in Juvenile Fish

Compared to the “control” concentrations from Upper Greens Creek Site 48, fish tissue concentration values from the “treatment” Greens Creek Below Pond D Site 54 had somewhat larger and higher ranges in 2009 for all six analyzed metals (Figure 36), but the only statistical difference was that lead was significantly higher in the Site 54 samples. As such, the tissue metals (except lead) concentrations from the two Greens Creek sites (48 and 54) were pooled for comparison to those from Tributary Creek Site 9. Tissues from Tributary Creek Site 9 fish contained significantly more silver than did tissues from Greens Creek fish, while those from Greens Creek fish contained significantly more cadmium, copper, and zinc, and substantially more selenium, than did those from Tributary Creek fish. There were no statistical differences in 2009 between the lead level in Tributary Creek juvenile fish tissues and in the fish tissues from either of the two Greens Creek sites.

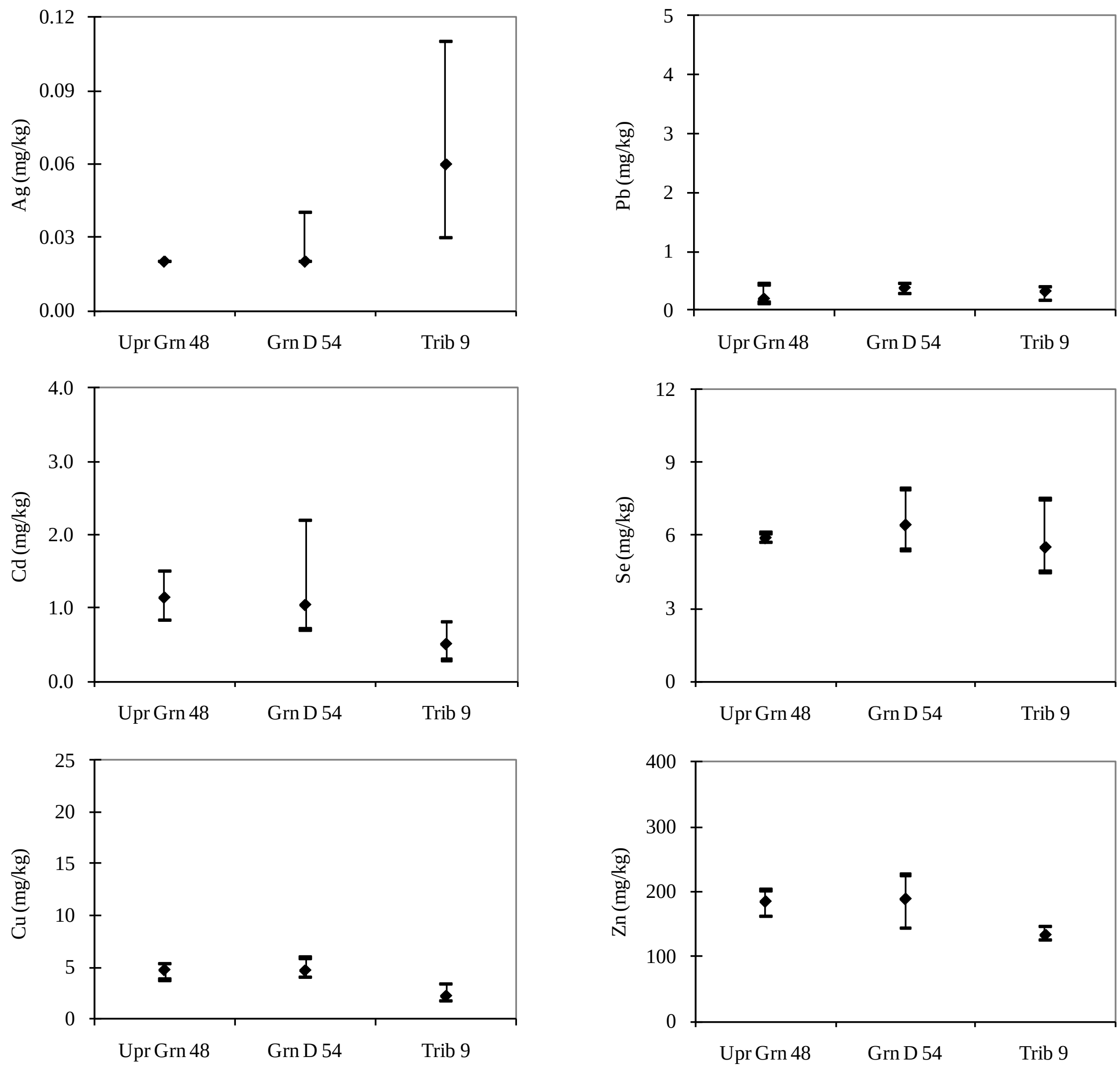

Figure 36. Comparison among sites of whole body metals concentrations (median, maximum, and minimum) in six Dolly Varden captured at each biomonitoring site in 2009.

Summary

The three Greens Creek Biomonitoring Program sites sampled in 2009 continue to be productive and diverse, with no noted effects directly attributable to facilities or operations of the Greens Creek Mine. We noted some areas that warrant careful watch in future years: low Dolly Varden captures at all three sites, the very low coho salmon captures at Greens Creek Below Pond D Site 54, the general rising trend in Greens Creek fish tissue selenium concentrations and the Greens Creek Below Pond D Site 54 cadmium levels, and the low water levels and reduced macroinvertebrate densities in Tributary Creek.

Although not explicitly analyzed, appreciable portions of the variability noted between sites and within sites between years can be attributed both to differences in physical characteristics of the sampled stream reaches (including gradient, substrate, water velocity, elevation, and location in watershed) and to annual differences in discharge and weather patterns. Also not evaluated was the level of interaction effects between biotic components such as benthic macroinvertebrate consumption of periphyton or juvenile fish predation on benthic macroinvertebrates.

CONCLUSIONS

The two biomonitoring sites sampled on Greens Creek (Upper Greens Creek Site 48 above all facilities and Greens Creek Below Pond D Site 54 below all facilities) and the one site sampled on Tributary Creek (Tributary Creek Site 9 below the dry-stack tailings facility) continued to sustain functioning, diverse aquatic communities in 2009 at typically the same or somewhat less abundant levels than in the previous eight years of biomonitoring. During 2009, water levels and stream discharges at the two Greens Creek sampling sites were moderate, while those at the Tributary Creek site were likely the lowest experienced during biomonitoring.

All sites exhibited an increase in periphyton biomass in 2009 compared to 2008. Responses to hydrologic events at these three sites likely contributed the most variability to periphyton biomass given the similar trends seen, but the pattern of periphyton biomass at the Tributary Creek site is typically more variable within each year. The presence of moderate periphyton biomass and the continuity of community composition at the three sampled biomonitoring sites reveal a robust algal component.

The benthic macroinvertebrate communities at the three biomonitoring sites showed essentially the opposite trends of the periphyton communities in 2009, in that densities decreased at all three sites from those seen in 2008. Mean densities of benthic macroinvertebrates in Tributary Creek were substantially lower than the Greens Creek sites, while taxonomic richness was not. Although the number of taxa per site, or taxonomic richness, was not significantly different between any of the study sites in 2009, the composition of the benthic macroinvertebrate community of the Greens Creek sites continued to be characterized by their similarities to each other and differences with Tributary Creek. The proportion of aquatic Diptera in Tributary Creek samples in 2009 continued to be greater in relation to the two Greens Creek sites. However, the overall proportion of pollution-sensitive Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa to Diptera in 2009 samples from all three sites remained high, suggesting that water quality was maintained.

Dolly Varden populations in 2009 at all three sites were significantly larger than in 2008, with the Upper Greens Creek and Tributary sites at moderate levels while the Greens Creek Below Pond D site population was still quite low. Captures at Greens Creek sites had multiple size classes of Dolly Varden present, although continuation of a general shift to larger size classes over time was again seen. Dolly Varden captures at Tributary Creek Site 9 in 2009 were moderate after three low-capture years, with a shift to somewhat smaller size classes including those typically associated with young of the year Dolly Varden. A very few coho salmon were captured at Greens Creek Below Pond D Site 54, leading to continued concern about fish passage over the downstream falls area. It is unclear from the size classes present whether or not any coho captured were young of the year fish. Coho salmon captures at Tributary Creek Site 9 were at a moderate level, particularly noteworthy because of the very low water levels during sampling. Total fish densities per square meter of wetted stream area among the three sites were lower at Greens Creek Below Pond D Site 54 than at Upper Greens Creek Site 48 for the first time in nine years of biomonitoring sampling, with Tributary Creek Site 9 having the highest total fish density of the three sites.

The ranges of whole body concentrations of metals in juvenile Dolly Varden tissues in 2009 were generally lower than or similar to those found in previous years' samples at each site, except for cadmium at Greens Creek Below Pond D Site 54 and selenium at both Greens Creek sites. There were no statistical differences in tissue metals concentrations between the two Greens Creek sites in 2009 except for a significantly lower level of lead at Site 48 than at Site 54. The year-to-year comparisons showed the only significantly or substantially higher metal levels in 2009 compared to all previous years to be for selenium at both of the Greens Creek sites. Tissues of juvenile Dolly Varden from Tributary Creek Site 9 captured in 2009 continued to have different metals concentrations characteristics than did tissues from Dolly Varden captured at the two Greens Creek sites (48 and 54). Greens Creek fish had significantly higher cadmium, copper, and zinc and substantially higher selenium, while Tributary Creek fish had significantly higher concentrations of silver.

In general, the aquatic communities at Upper Greens Creek Site 48, Greens Creek Below Pond D Site 54, and Tributary Creek Site 9 have remained fairly diverse, robust, and moderately abundant during the nine years of biomonitoring sampling. Differences noted between years and between the streams (Greens Creek compared to Tributary Creek) have typically been of larger amplitude than have differences between the control and below-mining sites within Greens Creek or over time at the Tributary Creek site.

Although no trends of reduced productivity, community changes, or metals accumulation attributable to operations of the Greens Creek Mine have been noted, some areas warrant careful watch in future years including low Dolly Varden captures at all three sites, the very low coho salmon captures at Greens Creek Below Pond D Site 54, a general rising trend in Greens Creek fish tissue selenium concentrations and the Greens Creek Below Pond D Site 54 cadmium levels, and low water levels and reduced macroinvertebrate densities in Tributary Creek.

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APPENDIX 1. USFS CHANNEL TYPE DESCRIPTIONS

From: A Channel Type User Guide for the Tongass National Forest (Paustian et al. 1992)

MM2 – Moderate Width Mixed Control Channel Type (Greens Creek sites 6, 48, and 54): MM2 channels are normally found in the middle to lower portion of moderate size drainage basins. MM2 streams are often confined by mountainslope, footslope, and hillslope landforms, but they can develop a narrow flood plain. Bedrock knick points with cascades or falls may be present. The riparian plant communities for the MM2 channel type are dominated by the Sitka spruce series and the western hemlock series.

MM2 channels function as sediment transport systems. These channels have moderate stream energy. Fine sediment is rapidly moved through the MM2 channels, Large woody debris accumulations are extensive and help retain coarse gravels, portion of which will be mobilized during high flow events. Significant stream bank erosion and lateral channel migration can occur during high flow events.

MM2 channels are generally accessible to anadromous species, with several species of spawners using the moderate amounts of available spawning area (ASA). These channels have moderate amounts of rearing area which are used by coho, Dolly Varden char, and steelhead juveniles. Pools are relatively deep and are highly dependent on large woody debris. Overwintering habitat is primarily associated with these pools.

Banks are composed primarily of unconsolidated cobble and gravel size materials; therefore, stream bank sensitivity is rated high. The volume and energy of flood discharge in MM2 channels are the major factors affecting bank erosion. Disturbance of streamside vegetation root mats may contribute to accelerated channel scour and lateral channel migration.

FP3 – Narrow Low Gradient Flood Plain Channel Type (Tributary Creek Site 9): FP3 streams are located in the valley bottoms and may also occur within flat lowlands or low elevation drainage divides. Frequently, FP3 streams lie adjacent to the toe of foot slopes or hill slopes, adjacent to the main trunk, valley bottom channels. The flood plain of large, low gradient alluvial channels may be dissected by FP3 streams. Where FP3 streams occur parallel to the foot slopes or in the valley bottom locations, they are typically fed by high gradient streams. Less frequently, FP3 streams are situated on mountain slope benches. The riparian plant associations for FP3 streams are dominated by the Sitka spruce series and the western hemlock series.

FP3 channels function as sediment deposition systems. Sediment routed from high and moderate gradient sediment transport channels is temporarily stored in this channel type and on the adjacent flood plain. Sand and fine gravel deposits in point bars and pools are dominant stream bed features. Large woody debris accumulations are frequent and retain significant volumes of fine sediment. Stream power is low, allowing for massive mobilization of sediment only during peak flow events.

FP3 channels are frequently accessible to anadromous species. Coarse and fine gravels compose 49% of the substrate; therefore, available spawning area is high. These channels receive moderate to high spawning use by all anadromous species, with the exception of Chinook salmon. FP3 channels have a large amount of available rearing area and are used extensively by coho, Dolly Varden, and steelhead. Thirty-seven percent of the active water in pools has an average depth of 0.31 m, which provides good overwintering habitat. Woody debris and beaver dams enhance these pools as overwintering areas.

Stream banks are composed of coarse to fine textured alluvium, which, due to low stream flow volume and relatively low stream power, are only moderately sensitive to disturbance.

APPENDIX 2. PERIPHYTON BIOMASS DATA

Estimates of periphyton biomass as represented by chlorophyll concentrations (mg/m²) at Greens Creek Mine biomonitoring sampling sites from 2001through 2009.

	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 Below Pond D 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

APPENDIX 2. (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 Below Pond D 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

APPENDIX 2. (Continued)

	2009		
mg/m²	chlor-a	chlor-b	chlor-c
Upper Greens Creek Site 48			
	3.2040	0.0000	0.4870
	1.4952	0.0000	0.2468
	4.1652	0.1120	0.5872
	5.6604	0.0695	0.7321
	3.4176	0.0625	0.5042
	8.2236	0.1310	0.9544
	0.4272	0.1091	0.1125
	1.3884	0.1752	0.2908
	7.7964	0.0030	0.8923
	9.1848	0.1726	1.1926
median	3.7914	0.0893	0.5457
max	9.1848	0.1752	1.1926
min	0.4272	0.0000	0.1125
Middle Greens Creek Site 6			
	-	-	-
	-	-	-
	-	-	-
	-	-	-
	-	-	-
	-	-	-
	-	-	-
	-	-	-
	-	-	-
	-	-	-
median	-	-	-
max	-	-	-
min	-	-	-
Greens Creek Below Pond D Site 54			
	8.0100	0.1148	1.0620
	7.5828	0.1120	1.1286
	6.8352	0.0704	0.8904
	9.1848	0.0853	0.9630
		0.4719	2.2099
	8.3304	0.1504	1.1068
	11.3208	0.1990	1.5729
	5.3400	0.1670	0.6608
	4.4856	0.0986	0.6282
	4.3788	0.0981	0.4254
median	7.5828	0.1134	1.0125
max	11.3208	0.4719	2.2099
min	4.3788	0.0704	0.4254
Tributary Creek Site 9			
	2.0292	0.1045	0.1565
	5.4468	0.1749	0.3818
	4.3788	0.2419	0.3008
	7.0488	0.5808	0.3273
	9.0780	0.3562	0.4948
	8.7576	0.4052	0.6224
	2.1360	0.0800	0.0927
	18.3696	0.6630	0.7830
	2.3496	0.1808	0.1576
	3.2040	0.1979	0.3320
median	4.9128	0.2199	0.3297
max	18.3696	0.6630	0.7830
min	2.0292	0.0800	0.0927

APPENDIX 3. BENTHIC MACROINVERTEBRATE DATA

Appendix 3.1. Numbers of benthic macroinvertebrates identified in Upper Greens Creek Site 48 biomonitoring samples from 2001 through 2009.

Order	Family	Genus	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ephemeroptera	unidentified		-	-	-	-	-	3	38	-	3
	Baetidae	*Acentrella*	309	152	445	390	279	-	-	-	-
		Baetis	-	-	-	-	-	130	206	-	117
	Ephemerellidae	*Ephemerella*	2	-	10	23	15	1	4	12	172
		Drunella	47	49	650	406	369	102	16	24	10
		Cinygmula	99	20	117	99	89	48	91	78	90
	Heptageniidae	*Epeorus*	444	190	384	209	371	240	61	165	431
		Rhithrogena	193	187	287	196	71	88	165	102	63
	Leptophlebiidae	*Paraleptophlebia*	-	1	-	-	-	-	-	-	1
	Ameletidae	*Ameletus*	-	-	4	-	-	-	3	-	-
Plecoptera	unidentified		-	-	-	-	9	7	1	3	11
	Capniidae	*Capnia*	-	-	82	-	-	-	-	-	-
		Eucapnopsis	-	-	-	-	1	-	-	-	-
	Chloroperlidae	unidentified	-	-	-	-	2	-	6	-	-
		Alloperla	1	1	-	1	-	-	-	-	-
		Kathroperla	-	-	2	3	-	2	-	-	-
		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
		Perlomyia	-	12	-	-	-	-	-	-	-
	Nemouridae	*Podmosta*	7	5	-	2	-	-	-	-	-
		Zapada	23	4	30	7	14	5	50	13	15
	Perlodidae	*Isoperla*	-	-	-	1	9	-	4	-	1
		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
Coleoptera	Elmidae	*Narpus*	-	-	-	1	-	-	-	-	-
	Staphylinidae		1	-	6	-	-	-	-	-	-
Diptera	Ceratopogonidae	*Dasyhelea*	-	1	-	-	-	-	-	-	-
		Probezzia	-	-	-	-	-	16	-	-	-
	Chironomidae		14	30	172	177	112	22	31	77	11
	Deuterophlebiidae	*Deuterophlebia*	2	-	-	1	1	1	-	1	-
	Empididae	unidentified	-	-	-	-	1	-	-	-	-
		Chelifera	1	2	5	1	-	-	-	-	-
		Hemerodromia	-	-	-	-	5	-	-	-	-
		Oreogeton	3	2	22	11	-	-	6	3	-
	Psychodidae	*Psychoda*	1	-	-	-	-	-	-	-	-
	Simuliidae	*Parasimulium*	2	-	-	-	-	-	-	-	-
		Prosimulium	2	-	-	2	-	-	-	-	-
		Simulium	6	4	-	1	3	1	2	7	3
	Tipulidae	*Antocha*	-	-	2	-	-	-	-	-	-
		Dicranota	-	-	3	-	2	-	-	-	-
		Rhabdomastix	-	-	-	-	1	-	2	2	-
		Tipula	-	-	2	6	1	4	-	12	2
Collembola	unidentified		2	1	-	-	-	1	1	-	3
Copepoda	Cyclopoida		-	-	-	1	-	-	1	-	-
Acarina			-	2	20	10	3	6	5	8	-
Oligochaeta			-	5	20	8	3	1	1	2	1
Gastropoda	Pelecypoda		-	-	-	1	-	-	1	1	-
Ostracoda			-	8	7	9	1	2	4	-	-

Appendix 3.2. Numbers of benthic macroinvertebrates identified in Middle Greens Creek Site 6 biomonitoring samples in 2001 and 2006.

Order	Family	Genus	2001	2006
Ephemeroptera	Baetidae	*Acentrella*	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	-

Appendix 3.3. Numbers of benthic macroinvertebrates identified in Greens Creek Below Pond D Site 54 biomonitoring samples from 2001 through 2009.

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

Appendix 3.4. Numbers of benthic macroinvertebrates identified in Tributary Creek Site 9 biomonitoring samples from 2001 through 2009.

Order	Family	Genus	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ephemeroptera	unidentified		-	-	-	-	-	1	-	-	-
	Baetidae	*Baetis*	41	123	160	21	38	1	3	73	9
		Procloeon	5	-	-	-	-	-	-	-	-
	Ephemerellidae	*Caudatella*	3	-	-	-	-	-	-	-	-
		Ephemerella	-	14	7	4	1	74	-	10	4
		Drunella	-	3	10	-	8	3	-	5	-
	Heptageniidae	*Cinygma*	1	-	-	-	43	-	-	-	3
		Cinygmula	89	177	507	49	24	127	43	209	74
		Epeorus	-	8	1	-	2	-	-	18	1
		Rhithrogena	-	-	1	-	2	1	-	-	3
	Leptophlebiidae	*Paraleptophlebia*	66	96	249	442	191	204	38	109	74
	Ameletidae	*Ameletus*	-	15	46	46	25	33	18	17	35
Plecoptera	unidentified		-	-	-	-	-	21	-	2	26
	Chloroperlidae	unidentified	-	-	-	-	1	-	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	-	-	-	-	-	-
		Perlomyia	-	3	-	-	-	-	-	-	-
	Nemouridae	*Podmosta*	-	1	-	-	-	-	-	-	-
		Zapada	23	12	388	41	43	13	-	8	32
	Perlodidae	*Isoperla*	1	-	-	38	-	-	-	-	-
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	Elmidae	*Narpus*	2	6	32	14	1	8	3	1	4
	Dytiscidae	*Megadytes*	-	-	2	-	-	-	-	-	-
Diptera	unidentified		-	-	-	-	-	1	-	-	1
	Ceratopogonidae	*Bezzia*	-	-	1	-	-	-	-	-	-
		Dasyhelea	3	-	-	-	-	-		-	-
		Probezzia	-	-	9	-	-	1	-	-	6
	Chironomidae		35	36	125	52	40	22	3	6	105
	Empididae	*Chelifera*	-	1	-	-	-	-	-	-	4
		Hemerodromia	-	-	1	-	1	-	-	-	-
		Oreogeton	4	2	24	8	1	-	-	-	-
	Simuliidae	*Simulium*	40	22	81	4	14	8	10	196	20
	Tipulidae	*Antocha*	-	-	10	-	-	-	-	-	-
		Dicranota	-	-	2	-	2	6	2	2	-
		Pilaria	-	-	2	-	-	-	-	-	-
		Rhabdomastix	-	-	1	-	1	-	-	-	-
		Tipula	4	5	-	2	-	4	5	2	5
		Limonia	-	-	-	-	1	-	1	-	-
Branchiopoda	Chydoridae		-	-	2	-	-	-	-	-	-
Collembola	unidentified		-	-	-	-	-	3	2	-	1
	Sminthuridae	*Dicyrtoma*	-	2	-	-	-	-	-	-	-
		Sminthurus	-	-	3	34	1	-	-	-	-
Copepoda	unidentified		-	-	-	-	-	1	-	-	-
	Cyclopoida		-	-	6	5	-	-	-	-	2
	Harpacticoida		-	-	5	-	-	-	-	-	-
Acarina			15	20	72	39	2	-	2	25	-
Oligochaeta			40	45	349	111	23	21	27	9	26
Gastropoda			1	-	1	2	-	1	1	-	2
Isopoda	Gammaridae	*Gammarus*	-	-	-	1	-	-	-	-	1
Ostracoda			92	102	207	27	8	68	17	20	1

APPENDIX 4. JUVENILE FISH CAPTURE DATA

Sampling Site	Fish Species[1]	Fork Lengths	Number of Fish Captured Set 1	Set 2	Set 3	Total	MLE[2] Pop. Est.	MLE Std Error	Popn. 95% C.I.
2001[3]									
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[3]									
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	---	---
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	---	---	---

Appendix 4. (Continued)

Sampling Site	Fish Species[1]	Fork Lengths	Number of Fish Captured Set 1	Set 2	Set 3	Total	MLE[2] Pop. Est.	MLE Std Error	Popn. 95% C.I.
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

[1] Species: DV = Dolly Varden, CO = coho salmon, CT = cutthroat trout, RT = rainbow trout / steelhead, Sc = sculpin species.

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

[3] Capture data for 2001 and 2002 from USDA Forest Service.

APPENDIX 5. METALS IN JUVENILE FISH DATA

Appendix 5.1. Information on fish collected in 2000 through 2009 for whole body analysis of metals. Sample Number contains codes for date, water body, site, fish species, age, and replicate.

Collector	Date Collected	Location	Site	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Sample Number
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	131	26.0	21.6	072301GC48DVJ01
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	137	28.8	23.7	072301GC48DVJ02
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	119	18.8	20.7	072301GC48DVJ03
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	121	21.1	22.8	072301GC48DVJ04
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	111	13.7	21.8	072301GC48DVJ05
ADF&G / FS	23-Jul-2001	Upper Greens Creek	Site 48	DV	121	21.1	20.3	072301GC48DVJ06
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	133	23.2	24.3	072402GC48DVJ01
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	120	15.0	19.2	072402GC48DVJ02
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	122	17.5	22.1	072402GC48DVJ03
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	127	20.8	21.2	072402GC48DVJ04
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	134	24.8	21.5	072402GC48DVJ05
ADF&G	24-Jul-2002	Upper Greens Creek	Site 48	DV	128	21.7	20.9	072402GC48DVJ06
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	90	8.9	23.8	072203GC48DVJ01
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	98	9.9	23.6	072203GC48DVJ02
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	103	12.1	23.7	072203GC48DVJ03
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	112	12.5	23.5	072203GC48DVJ04
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	108	11.9	23.8	072203GC48DVJ05
ADNR	22-Jul-2003	Upper Greens Creek	Site 48	DV	100	10.5	24.2	072203GC48DVJ06
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	96	8.6	23.7	072204GC48DVJ01
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	88	6.8	23.4	072204GC48DVJ02
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	101	11.5	23.5	072204GC48DVJ03
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	98	9.3	23.8	072204GC48DVJ04
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	93	7.6	21.4	072204GC48DVJ05
ADNR	22-Jul-2004	Upper Greens Creek	Site 48	DV	91	7.5	23.9	072204GC48DVJ06
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	103	19.7	24.8	072205GC48DVJ01
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	96	13.1	23.6	072205GC48DVJ02
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	119	15.6	23.2	072205GC48DVJ03
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	114	17.1	23.5	072205GC48DVJ04
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	111	15.3	24.9	072205GC48DVJ05
ADNR	22-Jul-2005	Upper Greens Creek	Site 48	DV	125	16.9	23.7	072205GC48DVJ06
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	110	15.8	21.2	072006GC48DVJ01
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	110	15.4	21.4	072006GC48DVJ02
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	113	16.1	23.3	072006GC48DVJ03
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	132	25.0	22.9	072006GC48DVJ04
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	104	12.8	21.0	072006GC48DVJ05
ADNR	20-Jul-2006	Upper Greens Creek	Site 48	DV	114	16.7	20.9	072006GC48DVJ06
ADNR	21-Jul-2007	Upper Greens Creek	Site 48	DV	122	17.91	22.30	072107GC48DVJ01
ADNR	21-Jul-2007	Upper Greens Creek	Site 48	DV	95	10.35	24.70	072107GC48DVJ02
ADNR	21-Jul-2007	Upper Greens Creek	Site 48	DV	135	22.79	24.40	072107GC48DVJ03
ADNR	21-Jul-2007	Upper Greens Creek	Site 48	DV	98	9.88	21.50	072107GC48DVJ04
ADNR	21-Jul-2007	Upper Greens Creek	Site 48	DV	105	13.19	20.70	072107GC48DVJ05
ADNR	21-Jul-2007	Upper Greens Creek	Site 48	DV	99	10.03	22.00	072107GC48DVJ06

Appendix 5.1. (Continued)

Collector	Date Collected	Location	Site	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Sample Number
ADF&G	22-Jul-2008	Upper Greens Creek	Site 48	DV	112	16.4	22.20	072208GC48DVJ01
ADF&G	22-Jul-2008	Upper Greens Creek	Site 48	DV	123	21.3	24.00	072208GC48DVJ02
ADF&G	22-Jul-2008	Upper Greens Creek	Site 48	DV	105	14.0	23.50	072208GC48DVJ03
ADF&G	22-Jul-2008	Upper Greens Creek	Site 48	DV	124	20.6	23.60	072208GC48DVJ04
ADF&G	22-Jul-2008	Upper Greens Creek	Site 48	DV	115	16.9	23.00	072208GC48DVJ05
ADF&G	22-Jul-2008	Upper Greens Creek	Site 48	DV	122	19.8	22.40	072208GC48DVJ06
ADF&G	21-Jul-2009	Upper Greens Creek	Site 48	DV	120	20.12	23.70	072109GC48DVJ01
ADF&G	21-Jul-2009	Upper Greens Creek	Site 48	DV	121	20.70	23.90	072109GC48DVJ02
ADF&G	21-Jul-2009	Upper Greens Creek	Site 48	DV	119	17.90	22.30	072109GC48DVJ03
ADF&G	21-Jul-2009	Upper Greens Creek	Site 48	DV	108	13.63	23.50	072109GC48DVJ04
ADF&G	21-Jul-2009	Upper Greens Creek	Site 48	DV	109	14.59	23.80	072109GC48DVJ05
ADF&G	21-Jul-2009	Upper Greens Creek	Site 48	DV	110	15.23	22.50	072109GC48DVJ06
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	140	30.5	22.8	072301GC06DVJ02
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	167	43.9	21.7	072301GC06DVJ03
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	155	34.8	21.6	072301GC06DVJ04
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	109	15.7	22.2	072301GC06DVJ05
ADF&G / FS	23-Jul-2001	Middle Greens Creek	Site 6	DV	168	49.1	21.9	072301GC06DVJ06
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	103	12.6	21.7	072106GC06DVJ01
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	106	13.5	21.3	072106GC06DVJ02
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	96	11.8	21.0	072106GC06DVJ03
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	110	12.0	20.6	072106GC06DVJ04
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	128	23.2	22.0	072106GC06DVJ05
ADNR	21-Jul-2006	Middle Greens Creek	Site 6	DV	102	11.5	20.1	072106GC06DVJ06
USFS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	72	4.4	20.5	062100GCCOJ01
USFS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	82	6.1	20.2	062100GCCOJ02
USFS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	73	4.9	20.4	062100GCCOJ03
USFS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	68	3.4	21.4	062100GCCOJ04
USFS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	73	5.9	20.7	062100GCCOJ05
USFS	21-Jun-2000	Greens Cr Below Pond D	Site 54	CO	75	6.0	20.2	062100GCCOJ06
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	121	21.5	22.6	072301GC54DVJ01
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	119	19.3	26.1	072301GC54DVJ02
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	107	15.7	23.5	072301GC54DVJ03
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	109	13.6	21.1	072301GC54DVJ04
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	105	13.5	22.8	072301GC54DVJ05
ADF&G / FS	23-Jul-2001	Greens Cr Below Pond D	Site 54	DV	138	27.5	22.1	072301GC54DVJ06
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	118	18.0	21.2	072402GC54DVJ01
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	128	22.3	23.2	072402GC54DVJ02
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	115	17.7	21.9	072402GC54DVJ03
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	115	18.9	21.3	072402GC54DVJ04
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	124	21.1	21.4	072402GC54DVJ05
ADF&G	24-Jul-2002	Greens Cr Below Pond D	Site 54	DV	123	20.9	20.9	072402GC54DVJ06

Appendix 5.1. (Continued)

Collector	Date Collected	Location	Site	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Sample Number
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	123	21.1	25.1	072203GC54DVJ01
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	101	10.6	22.9	072203GC54DVJ02
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	88	9.2	22.8	072203GC54DVJ03
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	109	14.8	24.0	072203GC54DVJ04
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	95	10.6	23.9	072203GC54DVJ05
ADNR	22-Jul-2003	Greens Cr Below Pond D	Site 54	DV	92	9.7	23.8	072203GC54DVJ06
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	103	9.9	23.8	072104GC54DVJ01
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	104	10.0	22.6	072104GC54DVJ02
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	86	6.6	23.7	072104GC54DVJ03
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	96	9.3	22.9	072104GC54DVJ04
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	93	9.9	22.1	072104GC54DVJ05
ADNR	21-Jul-2004	Greens Cr Below Pond D	Site 54	DV	104	12.9	21.4	072104GC54DVJ06
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	120	12.3	23.1	072205GC54DVJ01
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	106	12.1	22.6	072205GC54DVJ02
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	113	20.8	23.1	072205GC54DVJ03
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	114	17.9	22.3	072205GC54DVJ04
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	112	16.1	23.0	072205GC54DVJ05
ADNR	22-Jul-2005	Greens Cr Below Pond D	Site 54	DV	118	22.3	22.4	072205GC54DVJ06
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	137	27.3	24.6	072006GC54DVJ01
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	112	14.9	21.7	072006GC54DVJ02
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	102	12.0	19.2	072006GC54DVJ03
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	114	19.6	21.8	072006GC54DVJ04
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	98	12.3	20.8	072006GC54DVJ05
ADNR	20-Jul-2006	Greens Cr Below Pond D	Site 54	DV	115	16.9	21.7	072006GC54DVJ06
ADNR	20-Jul-2007	Greens Cr Below Pond D	Site 54	DV	102	11.81	24.30	072007GC54DVJ01
ADNR	20-Jul-2007	Greens Cr Below Pond D	Site 54	DV	125	21.06	21.60	072007GC54DVJ02
ADNR	20-Jul-2007	Greens Cr Below Pond D	Site 54	DV	97	10.69	22.30	072007GC54DVJ03
ADNR	20-Jul-2007	Greens Cr Below Pond D	Site 54	DV	123	19.74	22.80	072007GC54DVJ04
ADNR	20-Jul-2007	Greens Cr Below Pond D	Site 54	DV	104	12.46	22.60	072007GC54DVJ05
ADNR	20-Jul-2007	Greens Cr Below Pond D	Site 54	DV	110	15.08	21.60	072007GC54DVJ06
ADF&G	22-Jul-2008	Greens Cr Below Pond D	Site 54	DV	123	21.9	24.90	072208GC54DVJ01
ADF&G	22-Jul-2008	Greens Cr Below Pond D	Site 54	DV	94	10.8	22.40	072208GC54DVJ02
ADF&G	22-Jul-2008	Greens Cr Below Pond D	Site 54	DV	123	21.5	21.60	072208GC54DVJ03
ADF&G	22-Jul-2008	Greens Cr Below Pond D	Site 54	DV	97	11.2	23.80	072208GC54DVJ04
ADF&G	22-Jul-2008	Greens Cr Below Pond D	Site 54	DV	108	16.0	23.60	072208GC54DVJ05
ADF&G	22-Jul-2008	Greens Cr Below Pond D	Site 54	DV	108	14.2	24.50	072208GC54DVJ06
ADF&G	21-Jul-2009	Greens Cr Below Pond D	Site 54	DV	132	26.85	22.60	072109GC54DVJ01
ADF&G	21-Jul-2009	Greens Cr Below Pond D	Site 54	DV	141	32.31	23.50	072109GC54DVJ02
ADF&G	21-Jul-2009	Greens Cr Below Pond D	Site 54	DV	116	17.87	24.30	072109GC54DVJ03
ADF&G	21-Jul-2009	Greens Cr Below Pond D	Site 54	DV	117	17.71	23.60	072109GC54DVJ04
ADF&G	21-Jul-2009	Greens Cr Below Pond D	Site 54	DV	119	22.14	24.80	072109GC54DVJ05
ADF&G	21-Jul-2009	Greens Cr Below Pond D	Site 54	DV	103	13.03	24.20	072109GC54DVJ06

Appendix 5.1. (Continued)

Collector	Date Collected	Location	Site	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Sample Number
USFS	21-Jun-2000	Tributary Creek	Site 9	CO	102	9.7	22.9	062100TRCOJ01
USFS	21-Jun-2000	Tributary Creek	Site 9	CO	75	5.3	22.5	062100TRCOJ02
USFS	21-Jun-2000	Tributary Creek	Site 9	DV	112	12.8	23.1	062100TRCOJ03
USFS	21-Jun-2000	Tributary Creek	Site 9	DV	105	13.8	22.2	062100TRDVJ04
USFS	21-Jun-2000	Tributary Creek	Site 9	DV	105	13.4	22.1	062100TRDVJ05
USFS	21-Jun-2000	Tributary Creek	Site 9	DV	100	11.3	23.0	062100TRDVJ06
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	97	9.1	22.1	072301TR09DVJ01
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	97	9.7	21.3	072301TR09DVJ02
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	97	9.5	22.2	072301TR09DVJ03
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	98	10.4	22.6	072301TR09DVJ04
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	86	6.4	22.2	072301TR09DVJ05
ADF&G / FS	23-Jul-2001	Tributary Creek	Site 9	DV	93	7.8	20.6	072301TR09DVJ06
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	103	10.8	20.9	072402TR09DVJ01
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	97	10.4	22.8	072402TR09DVJ02
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	100	11.2	23.2	072402TR09DVJ03
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	90	7.9	23.1	072402TR09DVJ04
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	90	9.2	23.0	072402TR09DVJ05
ADF&G	24-Jul-2002	Tributary Creek	Site 9	DV	100	9.3	17.8	072402TR09DVJ06
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	106	10.7	21.9	072304TR09DVJ01
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	89	6.8	22.8	072304TR09DVJ02
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	112	17.4	24.3	072304TR09DVJ03
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	95	11.6	22.5	072304TR09DVJ04
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	91	9.5	22.2	072304TR09DVJ05
ADNR	23-Jul-2003	Tributary Creek	Site 9	DV	84	8.4	23.2	072304TR09DVJ06
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	84	5.5	23.0	072104TR09DVJ01
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	96	8.5	23.0	072104TR09DVJ02
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	105	14.1	23.3	072104TR09DVJ03
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	85	5.8	22.6	072104TR09DVJ04
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	81	6.4	24.0	072104TR09DVJ05
ADNR	21-Jul-2004	Tributary Creek	Site 9	DV	86	10.4	17.6	072104TR09DVJ06
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	97	11.1	25.8	072305TR09DVJ01
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	113	16.8	26.7	072305TR09DVJ02
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	115	18.8	26.2	072305TR09DVJ03
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	117	20.5	26.1	072305TR09DVJ04
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	101	11.7	27.4	072305TR09DVJ05
ADNR	23-Jul-2005	Tributary Creek	Site 9	DV	107	13.7	25.9	072305TR09DVJ06
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	99	12.9	22.6	072106TR09DVJ01
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	96	11.6	24.0	072106TR09DVJ02
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	94	10.9	24.5	072106TR09DVJ03
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	100	10.9	21.8	072106TR09DVJ04
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	97	11.7	23.3	072106TR09DVJ05
ADNR	21-Jul-2006	Tributary Creek	Site 9	DV	117	20.8	23.7	072106TR09DVJ06

Appendix 5.1. (Continued)

Collector	Date Collected	Location	Site	Fish Sp	FLength (mm)	Mass (g)	Solids (%)	Sample Number
ADNR	20-Jul-2007	Tributary Creek	Site 9	DV	98	12.40	26.40	072007TR09DVJ01
ADNR	20-Jul-2007	Tributary Creek	Site 9	DV	89	8.88	25.80	072007TR09DVJ02
ADNR	20-Jul-2007	Tributary Creek	Site 9	DV	114	14.06	25.50	072007TR09DVJ03
ADNR	20-Jul-2007	Tributary Creek	Site 9	DV	81	7.08	26.80	072007TR09DVJ04
ADNR	20-Jul-2007	Tributary Creek	Site 9	DV	114	14.60	27.50	072007TR09DVJ05
ADNR	20-Jul-2007	Tributary Creek	Site 9	DV	93	10.60	26.80	072007TR09DVJ06
ADF&G	23-Jul-2008	Tributary Creek	Site 9	DV	103	12.9	24.30	072308TR09DVJ01
ADF&G	23-Jul-2008	Tributary Creek	Site 9	DV	108	14.8	23.00	072308TR09DVJ02
ADF&G	23-Jul-2008	Tributary Creek	Site 9	DV	88	8.9	23.00	072308TR09DVJ03
ADF&G	23-Jul-2008	Tributary Creek	Site 9	DV	86	9.3	26.60	072308TR09DVJ04
ADF&G	23-Jul-2008	Tributary Creek	Site 9	DV	92	9.6	24.70	072308TR09DVJ05
ADF&G	23-Jul-2008	Tributary Creek	Site 9	DV	90	8.7	25.40	072308TR09DVJ06
ADF&G	22-Jul-2009	Tributary Creek	Site 9	DV	83	6.85	23.00	072209TR09DVJ01
ADF&G	22-Jul-2009	Tributary Creek	Site 9	DV	91	8.58	22.10	072209TR09DVJ02
ADF&G	22-Jul-2009	Tributary Creek	Site 9	DV	91	8.48	22.60	072209TR09DVJ03
ADF&G	22-Jul-2009	Tributary Creek	Site 9	DV	98	10.25	22.60	072209TR09DVJ04
ADF&G	22-Jul-2009	Tributary Creek	Site 9	DV	91	8.60	23.10	072209TR09DVJ05
ADF&G	22-Jul-2009	Tributary Creek	Site 9	DV	90	7.78	22.80	072209TR09DVJ06

Appendix 5.2. Whole body concentrations of selected metals in fish collected in 2000-2009.

Date Collected	Site	Fish Sp	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
23-Jul-2001	Site 48	DV	dry wt	0.02	1.76	8.3	0.20	6.1	180	072301GC48DVJ01
23-Jul-2001	Site 48	DV	dry wt	0.03	0.89	7.2	0.17	4.6	146	072301GC48DVJ02
23-Jul-2001	Site 48	DV	dry wt	0.02	2.27	5.7	0.20	6.2	189	072301GC48DVJ03
23-Jul-2001	Site 48	DV	dry wt	0.02	1.56	6.9	0.17	5.2	182	072301GC48DVJ04
23-Jul-2001	Site 48	DV	dry wt	0.03	0.89	4.7	0.23	5.4	138	072301GC48DVJ05
23-Jul-2001	Site 48	DV	dry wt	0.02	1.26	7.4	0.10	5.6	157	072301GC48DVJ06
24-Jul-2002	Site 48	DV	dry wt	0.03	1.64	6.8	0.72	4.8	239	072402GC48DVJ01
24-Jul-2002	Site 48	DV	dry wt	0.07	0.85	7.0	0.28	4.1	210	072402GC48DVJ02
24-Jul-2002	Site 48	DV	dry wt	0.03	0.74	4.3	0.17	4.9	162	072402GC48DVJ03
24-Jul-2002	Site 48	DV	dry wt	0.04	1.40	6.1	0.16	4.7	185	072402GC48DVJ04
24-Jul-2002	Site 48	DV	dry wt	0.05	1.30	7.9	0.46	4.3	208	072402GC48DVJ05
24-Jul-2002	Site 48	DV	dry wt	0.04	1.56	6.8	0.22	5.7	343	072402GC48DVJ06
22-Jul-2003	Site 48	DV	dry wt	ND	0.65	4.2	0.14	5.6	191	072203GC48DVJ01
22-Jul-2003	Site 48	DV	dry wt	ND	0.90	5.1	0.22	5.5	180	072203GC48DVJ02
22-Jul-2003	Site 48	DV	dry wt	ND	0.82	5.6	0.16	5.4	241	072203GC48DVJ03
22-Jul-2003	Site 48	DV	dry wt	ND	0.78	6.1	0.11	6.1	192	072203GC48DVJ04
22-Jul-2003	Site 48	DV	dry wt	ND	0.63	3.9	0.14	5.2	174	072203GC48DVJ05
22-Jul-2003	Site 48	DV	dry wt	ND	0.58	3.7	0.08	5.5	218	072203GC48DVJ06
22-Jul-2004	Site 48	DV	dry wt	ND	0.63	4.7	0.15	4.3	206	072204GC48DVJ01
22-Jul-2004	Site 48	DV	dry wt	ND	0.83	5.6	0.26	4.0	175	072204GC48DVJ02
22-Jul-2004	Site 48	DV	dry wt	ND	1.54	4.6	0.21	4.1	183	072204GC48DVJ03
22-Jul-2004	Site 48	DV	dry wt	ND	0.80	5.2	0.28	3.7	168	072204GC48DVJ04
22-Jul-2004	Site 48	DV	dry wt	ND	1.25	4.4	0.14	6.4	220	072204GC48DVJ05
22-Jul-2004	Site 48	DV	dry wt	0.03	1.01	4.5	0.29	5.6	323	072204GC48DVJ06
22-Jul-2005	Site 48	DV	dry wt	0.02	0.66	4.4	0.44	4.2	183	072205GC48DVJ01
22-Jul-2005	Site 48	DV	dry wt	ND	0.84	14.5	0.98	4.8	220	072205GC48DVJ02
22-Jul-2005	Site 48	DV	dry wt	ND	0.89	4.3	0.66	4.8	226	072205GC48DVJ03
22-Jul-2005	Site 48	DV	dry wt	0.02	0.59	6.0	0.32	4.8	178	072205GC48DVJ04
22-Jul-2005	Site 48	DV	dry wt	0.03	1.10	18.8	0.79	4.6	217	072205GC48DVJ05
22-Jul-2005	Site 48	DV	dry wt	0.03	0.47	3.6	0.36	3.8	160	072205GC48DVJ06
20-Jul-2006	Site 48	DV	dry wt	0.04	0.56	8.5	0.37	5.4	244	072006GC48DVJ01
20-Jul-2006	Site 48	DV	dry wt	0.05	1.20	8.3	0.31	6.0	217	072006GC48DVJ02
20-Jul-2006	Site 48	DV	dry wt	0.04	0.65	6.3	0.24	5.4	264	072006GC48DVJ03
20-Jul-2006	Site 48	DV	dry wt	0.06	0.63	8.1	0.66	5.2	232	072006GC48DVJ04
20-Jul-2006	Site 48	DV	dry wt	0.08	0.96	8.5	0.37	5.1	283	072006GC48DVJ05
20-Jul-2006	Site 48	DV	dry wt	0.03	0.63	5.3	0.20	5.1	270	072006GC48DVJ06
21-Jul-2007	Site 48	DV	dry wt	0.03	1.16	5.5	0.17	5.5	221	072107GC48DVJ01
21-Jul-2007	Site 48	DV	dry wt	0.02	1.42	3.9	0.29	5.8	165	072107GC48DVJ02
21-Jul-2007	Site 48	DV	dry wt	0.08	1.34	14.1	1.37	5.3	166	072107GC48DVJ03
21-Jul-2007	Site 48	DV	dry wt	0.03	0.96	5.7	0.27	5.2	269	072107GC48DVJ04
21-Jul-2007	Site 48	DV	dry wt	0.11	1.79	11.4	1.62	5.4	323	072107GC48DVJ05
21-Jul-2007	Site 48	DV	dry wt	0.04	1.43	5.2	0.31	5.7	208	072107GC48DVJ06

Appendix 5.2. (Continued)

Date Collected	Site	Fish Sp	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
22-Jul-2008	Site 48	DV	dry wt	0.07	1.23	5.20	0.95	5.72	289.00	072208GC48DVJ01
22-Jul-2008	Site 48	DV	dry wt	0.04	0.79	3.90	0.57	4.56	194.00	072208GC48DVJ02
22-Jul-2008	Site 48	DV	dry wt	0.08	0.81	4.55	0.52	5.88	199.50	072208GC48DVJ03
22-Jul-2008	Site 48	DV	dry wt	0.04	0.87	4.90	0.42	6.31	244.00	072208GC48DVJ04
22-Jul-2008	Site 48	DV	dry wt	0.03	1.36	5.30	0.51	5.36	254.00	072208GC48DVJ05
22-Jul-2008	Site 48	DV	dry wt	0.04	1.07	5.60	0.38	6.11	260.00	072208GC48DVJ06
21-Jul-2009	Site 48	DV	dry wt	0.02	1.05	5.15	0.22	5.85	186.00	072109GC48DVJ01
21-Jul-2009	Site 48	DV	dry wt	0.02	1.40	5.30	0.44	5.70	173.00	072109GC48DVJ02
21-Jul-2009	Site 48	DV	dry wt	0.02	1.10	4.50	0.13	5.90	182.00	072109GC48DVJ03
21-Jul-2009	Site 48	DV	dry wt	0.02	1.2	4.1	0.15	5.7	162	072109GC48DVJ04
21-Jul-2009	Site 48	DV	dry wt	0.02	1.50	4.90	0.17	5.90	186.00	072109GC48DVJ05
21-Jul-2009	Site 48	DV	dry wt	0.02	0.84	3.80	0.18	6.10	202.00	072109GC48DVJ06
23-Jul-2001	Site 6	DV	dry wt	0.03	0.84	4.6	1.00	4.5	167	072301GC06DVJ02
23-Jul-2001	Site 6	DV	dry wt	0.03	0.82	5.3	1.94	4.3	171	072301GC06DVJ03
23-Jul-2001	Site 6	DV	dry wt	0.03	1.52	5.4	1.78	4.5	215	072301GC06DVJ04
23-Jul-2001	Site 6	DV	dry wt	0.02	0.89	11.1	0.33	5.3	126	072301GC06DVJ05
23-Jul-2001	Site 6	DV	dry wt	0.04	0.73	8.0	1.96	4.6	169	072301GC06DVJ06
21-Jul-2006	Site 6	DV	dry wt	0.03	0.71	8.0	0.70	5.2	183	072106GC06DVJ01
21-Jul-2006	Site 6	DV	dry wt	0.04	0.81	12.0	0.62	5.6	271	072106GC06DVJ02
21-Jul-2006	Site 6	DV	dry wt	0.03	0.56	12.7	0.97	4.5	215	072106GC06DVJ03
21-Jul-2006	Site 6	DV	dry wt	0.03	0.56	7.7	0.92	5.9	223	072106GC06DVJ04
21-Jul-2006	Site 6	DV	dry wt	0.03	0.95	5.4	1.31	4.4	221	072106GC06DVJ05
21-Jul-2006	Site 6	DV	dry wt	0.02	0.63	6.5	0.86	4.5	302	072106GC06DVJ06
21-Jun-2000	Site 54	CO	dry wt	0.04	0.95	15.3	1.40	4.9	251	062100GCCOJ01
21-Jun-2000	Site 54	CO	dry wt	0.09	0.66	11.7	1.21	4.7	224	062100GCCOJ02
21-Jun-2000	Site 54	CO	dry wt	0.22	1.07	24.2	1.40	3.4	206	062100GCCOJ03
21-Jun-2000	Site 54	CO	dry wt	0.10	0.97	24.0	1.12	3.5	181	062100GCCOJ04
21-Jun-2000	Site 54	CO	dry wt	0.05	0.96	44.0	1.53	4.9	304	062100GCCOJ05
21-Jun-2000	Site 54	CO	dry wt	0.08	1.47	36.1	5.02	4.7	340	062100GCCOJ06
23-Jul-2001	Site 54	DV	dry wt	0.03	0.46	4.3	0.33	5.7	126	072301GC54DVJ01
23-Jul-2001	Site 54	DV	dry wt	0.02	0.21	3.2	0.22	3.6	82	072301GC54DVJ02
23-Jul-2001	Site 54	DV	dry wt	0.03	0.73	6.3	0.59	4.7	144	072301GC54DVJ03
23-Jul-2001	Site 54	DV	dry wt	0.02	0.82	5.4	0.86	4.9	172	072301GC54DVJ04
23-Jul-2001	Site 54	DV	dry wt	0.02	0.79	6.5	0.45	5.8	203	072301GC54DVJ05
23-Jul-2001	Site 54	DV	dry wt	0.02	0.74	5.8	0.40	5.4	171	072301GC54DVJ06
24-Jul-2002	Site 54	DV	dry wt	0.03	0.50	4.4	0.94	3.4	363	072402GC54DVJ01
24-Jul-2002	Site 54	DV	dry wt	0.03	0.52	4.5	0.35	4.7	150	072402GC54DVJ02
24-Jul-2002	Site 54	DV	dry wt	0.05	0.95	6.0	0.66	4.4	161	072402GC54DVJ03
24-Jul-2002	Site 54	DV	dry wt	0.03	1.03	5.2	0.66	4.2	216	072402GC54DVJ04
24-Jul-2002	Site 54	DV	dry wt	0.05	1.32	5.2	0.74	3.9	2	072402GC54DVJ05
24-Jul-2002	Site 54	DV	dry wt	0.02	0.70	3.9	0.78	4.4	195	072402GC54DVJ06

Appendix 5.2. (Continued)

Date Collected	Site	Fish Sp	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
22-Jul-2003	Site 54	DV	dry wt	0.03	0.85	6.4	1.40	6.1	188	072203GC54DVJ01
22-Jul-2003	Site 54	DV	dry wt	ND	0.67	4.2	0.32	6.4	174	072203GC54DVJ02
22-Jul-2003	Site 54	DV	dry wt	ND	0.75	4.3	0.35	6.5	186	072203GC54DVJ03
22-Jul-2003	Site 54	DV	dry wt	ND	1.11	5.8	0.38	5.7	188	072203GC54DVJ04
22-Jul-2003	Site 54	DV	dry wt	ND	0.59	3.5	0.29	5.7	174	072203GC54DVJ05
22-Jul-2003	Site 54	DV	dry wt	ND	0.91	4.1	0.43	6.5	263	072203GC54DVJ06
21-Jul-2004	Site 54	DV	dry wt	0.02	0.79	11.0	0.57	4.6	232	072104GC54DVJ01
21-Jul-2004	Site 54	DV	dry wt	ND	0.88	5.5	0.54	5.0	206	072104GC54DVJ02
21-Jul-2004	Site 54	DV	dry wt	ND	1.26	5.1	0.36	5.3	164	072104GC54DVJ03
21-Jul-2004	Site 54	DV	dry wt	0.03	0.79	5.9	0.28	5.4	191	072104GC54DVJ04
21-Jul-2004	Site 54	DV	dry wt	ND	0.83	5.0	0.48	3.9	202	072104GC54DVJ05
21-Jul-2004	Site 54	DV	dry wt	0.07	1.12	7.0	0.93	4.9	216	072104GC54DVJ06
22-Jul-2005	Site 54	DV	dry wt	0.03	0.72	5.0	0.27	4.0	160	072205GC54DVJ01
22-Jul-2005	Site 54	DV	dry wt	0.02	0.63	4.5	0.13	3.9	200	072205GC54DVJ02
22-Jul-2005	Site 54	DV	dry wt	ND	0.73	8.8	0.17	4.7	223	072205GC54DVJ03
22-Jul-2005	Site 54	DV	dry wt	ND	0.82	9.7	0.17	3.9	222	072205GC54DVJ04
22-Jul-2005	Site 54	DV	dry wt	0.03	1.06	8.8	0.22	4.4	209	072205GC54DVJ05
22-Jul-2005	Site 54	DV	dry wt	0.02	0.55	5.5	0.39	3.9	185	072205GC54DVJ06
20-Jul-2006	Site 54	DV	dry wt	0.06	0.42	4.8	0.50	5.7	208	072006GC54DVJ01
20-Jul-2006	Site 54	DV	dry wt	0.04	0.75	16.0	0.95	7.2	223	072006GC54DVJ02
20-Jul-2006	Site 54	DV	dry wt	0.02	0.93	22.2	0.52	6.3	239	072006GC54DVJ03
20-Jul-2006	Site 54	DV	dry wt	0.04	1.03	7.6	0.85	5.3	252	072006GC54DVJ04
20-Jul-2006	Site 54	DV	dry wt	0.08	0.54	10.9	0.48	5.4	223	072006GC54DVJ05
20-Jul-2006	Site 54	DV	dry wt	0.04	0.78	8.6	0.68	5.6	257	072006GC54DVJ06
20-Jul-2007	Site 54	DV	dry wt	0.04	0.88	5.3	0.54	5.6	157	072007GC54DVJ01
20-Jul-2007	Site 54	DV	dry wt	0.03	0.97	5.2	0.83	7.5	234	072007GC54DVJ02
20-Jul-2007	Site 54	DV	dry wt	0.06	0.81	5.7	0.89	8.6	185	072007GC54DVJ03
20-Jul-2007	Site 54	DV	dry wt	0.02	0.75	4.4	0.50	7.1	175	072007GC54DVJ04
20-Jul-2007	Site 54	DV	dry wt	0.03	0.92	5.6	0.57	7.8	174	072007GC54DVJ05
20-Jul-2007	Site 54	DV	dry wt	0.04	1.38	6.2	0.82	5.4	191	072007GC54DVJ06
22-Jul-2008	Site 54	DV	dry wt	0.04	0.66	5.30	0.26	5.53	185.00	072208GC54DVJ01
22-Jul-2008	Site 54	DV	dry wt	0.04	1.04	5.10	0.28	6.07	203.00	072208GC54DVJ02
22-Jul-2008	Site 54	DV	dry wt	0.03	1.53	4.90	3.46	6.29	261.00	072208GC54DVJ03
22-Jul-2008	Site 54	DV	dry wt	0.03	1.34	4.95	0.17	5.90	198.50	072208GC54DVJ04
22-Jul-2008	Site 54	DV	dry wt	0.05	1.98	6.30	0.23	5.97	220.00	072208GC54DVJ05
22-Jul-2008	Site 54	DV	dry wt	0.06	1.07	8.40	1.31	5.03	195.00	072208GC54DVJ06
21-Jul-2009	Site 54	DV	dry wt	0.04	1.10	4.80	0.33	5.40	213.00	072109GC54DVJ01
21-Jul-2009	Site 54	DV	dry wt	0.02	0.71	4.50	0.45	7.90	143.00	072109GC54DVJ02
21-Jul-2009	Site 54	DV	dry wt	0.02	0.99	4.20	0.40	6.30	153.00	072109GC54DVJ03
21-Jul-2009	Site 54	DV	dry wt	0.03	1.00	5.90	0.39	6.80	200.00	072109GC54DVJ04
21-Jul-2009	Site 54	DV	dry wt	0.02	1.20	4.00	0.28	6.50	176.00	072109GC54DVJ05
21-Jul-2009	Site 54	DV	dry wt	0.02	2.20	5.30	0.35	5.90	226.00	072109GC54DVJ06

Appendix 5.2. (Continued)

Date Collected	Site	Fish Sp	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
21-Jun-2000	Site 9	CO	dry wt	0.04	0.42	16.2	1.03	3.2	213	062100TRCOJ01
21-Jun-2000	Site 9	CO	dry wt	0.07	0.50	16.5	2.01	3.7	220	062100TRCOJ02
21-Jun-2000	Site 9	DV	dry wt	0.12	0.75	11.2	1.63	3.8	194	062100TRCOJ03
21-Jun-2000	Site 9	DV	dry wt	0.07	0.56	10.6	1.53	3.6	88	062100TRDVJ04
21-Jun-2000	Site 9	DV	dry wt	0.06	0.58	12.8	1.59	3.5	204	062100TRDVJ05
21-Jun-2000	Site 9	DV	dry wt	0.05	0.45	32.8	1.57	5.0	213	062100TRDVJ06
23-Jul-2001	Site 9	DV	dry wt	0.09	0.35	4.3	0.56	6.8	127	072301TR09DVJ01
23-Jul-2001	Site 9	DV	dry wt	0.10	0.77	5.2	0.67	8.0	118	072301TR09DVJ02
23-Jul-2001	Site 9	DV	dry wt	0.15	0.92	5.4	4.88	5.3	144	072301TR09DVJ03
23-Jul-2001	Site 9	DV	dry wt	0.15	0.86	6.7	2.19	---	99	072301TR09DVJ04
23-Jul-2001	Site 9	DV	dry wt	0.08	0.76	4.9	0.33	6.2	106	072301TR09DVJ05
23-Jul-2001	Site 9	DV	dry wt	0.06	0.37	12.0	0.38	6.8	122	072301TR09DVJ06
24-Jul-2002	Site 9	DV	dry wt	0.02	0.22	3.7	0.12	1.4	144	072402TR09DVJ01
24-Jul-2002	Site 9	DV	dry wt	0.07	1.20	5.5	1.66	3.3	172	072402TR09DVJ02
24-Jul-2002	Site 9	DV	dry wt	0.13	1.06	6.1	3.40	5.0	138	072402TR09DVJ03
24-Jul-2002	Site 9	DV	dry wt	0.23	1.29	7.1	4.08	5.2	168	072402TR09DVJ04
24-Jul-2002	Site 9	DV	dry wt	0.08	1.15	5.2	1.39	6.2	150	072402TR09DVJ05
24-Jul-2002	Site 9	DV	dry wt	0.04	0.84	3.2	0.33	5.4	152	072402TR09DVJ06
23-Jul-2003	Site 9	DV	dry wt	0.06	0.46	2.8	0.34	6.3	134	072304TR09DVJ01
23-Jul-2003	Site 9	DV	dry wt	0.10	1.01	4.0	0.82	6.0	131	072304TR09DVJ02
23-Jul-2003	Site 9	DV	dry wt	0.16	1.35	4.4	1.85	5.7	108	072304TR09DVJ03
23-Jul-2003	Site 9	DV	dry wt	0.19	0.69	5.6	1.30	3.6	136	072304TR09DVJ04
23-Jul-2003	Site 9	DV	dry wt	0.05	0.72	4.4	0.56	4.9	131	072304TR09DVJ05
23-Jul-2003	Site 9	DV	dry wt	0.12	0.76	3.9	0.78	4.7	125	072304TR09DVJ06
21-Jul-2004	Site 9	DV	dry wt	0.10	0.96	3.2	1.19	5.4	169	072104TR09DVJ01
21-Jul-2004	Site 9	DV	dry wt	0.10	1.24	3.8	0.67	5.9	138	072104TR09DVJ02
21-Jul-2004	Site 9	DV	dry wt	0.10	2.02	4.0	1.75	5.7	125	072104TR09DVJ03
21-Jul-2004	Site 9	DV	dry wt	0.04	0.47	3.7	0.93	4.8	175	072104TR09DVJ04
21-Jul-2004	Site 9	DV	dry wt	0.09	2.34	4.3	1.44	8.2	140	072104TR09DVJ05
21-Jul-2004	Site 9	DV	dry wt	0.11	0.83	5.5	0.97	5.8	161	072104TR09DVJ06
23-Jul-2005	Site 9	DV	dry wt	0.06	0.70	10.4	0.29	6.4	104	072305TR09DVJ01
23-Jul-2005	Site 9	DV	dry wt	0.10	0.63	4.7	0.97	6.1	122	072305TR09DVJ02
23-Jul-2005	Site 9	DV	dry wt	0.07	0.52	6.3	0.53	5.8	109	072305TR09DVJ03
23-Jul-2005	Site 9	DV	dry wt	0.19	0.79	9.9	1.07	6.7	117	072305TR09DVJ04
23-Jul-2005	Site 9	DV	dry wt	0.07	1.44	5.2	1.00	8.1	130	072305TR09DVJ05
23-Jul-2005	Site 9	DV	dry wt	0.10	1.29	4.6	0.46	8.0	134	072305TR09DVJ06
21-Jul-2006	Site 9	DV	dry wt	0.12	0.74	4.0	0.32	6.3	120	072106TR09DVJ01
21-Jul-2006	Site 9	DV	dry wt	0.12	0.76	7.7	1.32	6.8	157	072106TR09DVJ02
21-Jul-2006	Site 9	DV	dry wt	0.18	1.59	10.3	2.48	4.9	160	072106TR09DVJ03
21-Jul-2006	Site 9	DV	dry wt	0.11	1.34	8.5	1.46	5.2	142	072106TR09DVJ04
21-Jul-2006	Site 9	DV	dry wt	0.14	0.88	4.6	0.96	5.2	107	072106TR09DVJ05
21-Jul-2006	Site 9	DV	dry wt	0.24	1.29	4.3	2.92	5.9	129	072106TR09DVJ06

Appendix 5.2. (Continued)

Date Collected	Site	Fish Sp	Analyte Basis	Ag mg/kg	Cd mg/kg	Cu mg/kg	Pb mg/kg	Se mg/kg	Zn mg/kg	Sample Number
20-Jul-2007	Site 9	DV	dry wt	0.11	0.91	2.7	1.10	7.7	106	072007TR09DVJ01
20-Jul-2007	Site 9	DV	dry wt	0.12	1.72	3.3	1.80	5.6	136	072007TR09DVJ02
20-Jul-2007	Site 9	DV	dry wt	0.15	2.76	3.4	1.28	8.7	122	072007TR09DVJ03
20-Jul-2007	Site 9	DV	dry wt	0.14	1.90	4.2	2.03	7.0	114	072007TR09DVJ04
20-Jul-2007	Site 9	DV	dry wt	0.88	3.63	3.9	1.56	10.9	131	072007TR09DVJ05
20-Jul-2007	Site 9	DV	dry wt	0.14	1.50	20.3	3.80	9.4	107	072007TR09DVJ06
23-Jul-2008	Site 9	DV	dry wt	0.22	1.99	4.20	3.47	7.66	169.00	072308TR09DVJ01
23-Jul-2008	Site 9	DV	dry wt	0.10	0.96	3.20	0.86	5.82	143.00	072308TR09DVJ02
23-Jul-2008	Site 9	DV	dry wt	0.08	0.93	3.30	0.75	4.41	186.00	072308TR09DVJ03
23-Jul-2008	Site 9	DV	dry wt	0.22	1.91	5.70	4.06	5.71	119.00	072308TR09DVJ04
23-Jul-2008	Site 9	DV	dry wt	0.07	1.01	2.70	0.61	5.20	125.00	072308TR09DVJ05
23-Jul-2008	Site 9	DV	dry wt	0.03	0.54	2.20	0.43	4.80	108.00	072308TR09DVJ06
22-Jul-2009	Site 9	DV	dry wt	0.04	0.29	1.70	0.24	5.40	127.00	072209TR09DVJ01
22-Jul-2009	Site 9	DV	dry wt	0.06	0.55	2.10	0.16	5.10	137.00	072209TR09DVJ02
22-Jul-2009	Site 9	DV	dry wt	0.11	0.36	2.00	0.23	7.50	138.00	072209TR09DVJ03
22-Jul-2009	Site 9	DV	dry wt	0.09	0.81	3.40	0.38	5.80	147.00	072209TR09DVJ04
22-Jul-2009	Site 9	DV	dry wt	0.03	0.47	2.20	0.40	4.50	125.00	072209TR09DVJ05
22-Jul-2009	Site 9	DV	dry wt	0.06	0.60	2.20	0.38	5.60	129.00	072209TR09DVJ06