BEAR RIVER BLACK CANYON MONITORING REPORT

2006 STUDY RESULTS

Prepared for PacifiCorp
&
the Environmental Coordination Committee

March 30, 2007

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TABLE OF CONTENTS

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

AFDW	Ash-Free Dry Weight
AI	Autotrophic Index
ANOVA	Analysis of Variance
APHA	American Public Health Association
BF	Bankfull
BMI	Benthic macroinvertebrate
BWD ratio	Bankfull width / bankfull water depth
CFS	Cubic Feet per Second
CL	Confidence Level
cm^2	square centimeters
CPUE	Catch per Unit Effort
ECC	Environmental Coordination Committee
FERC	Federal Energy Regulatory Commission
g	Grams
ID DEQ	Idaho Department of Environmental Quality
m^2	square meters
mg	Milligrams
MSE	Mean square error
R	Reach
RBT	Rainbow Trout
ΔT	Temperature Difference
T	Transect
μG	Micrograms
WP	Wetted Perimeter
Wr	Relative Weight
WY	Water Year

EXECUTIVE SUMMARY

In December 2003 PacifiCorp received a new operating license for the Bear River Hydroelectric Project (FERC No. 20) located in southeast Idaho. The new license includes a condition requiring PacifiCorp to implement and study a variable flow regime at the Grace Hydropower Facility in the 6.2 mile reach known as the Black Canyon between Grace Dam and the Grace powerhouse. PacifiCorp, in collaboration with the Environmental Coordination Committee (ECC), developed the Bear River Black Canyon Monitoring Study to examine the effect of variable flow regime on the river channel shape, substrate and aquatic biota. Specifically the Black Canyon Monitoring Plan includes investigation of: 1) Macroinvertebrates—population trends, diversity and community indices; 2) Organic Matter Ash-Free Dry Weight (AFDW); 3) Periphyton—chlorophyll concentration and biomass; 4) Fisheries—population trends, community composition, fish condition; 5) Filamentous Algae—density; and 6) Channel Morphology—shape and substrate composition.

The monitoring effort comprises four study reaches. Reach 1, partially regulated by Bear Lake, serves as the reference reach. Reaches 2, 3 and 4, subject to the variable flow regime below Grace Dam, serve as the experimental reaches. The monitoring study spans six-years of data collection. The first three-years serve as a baseline period collecting data in all reaches prior to implementation of the variable flow regime. The second three-year term, years four through six, serve as the experimental phase when reaches 2, 3 and 4 will be subjected to flows ranging from 800 to 1500 cfs, approximately 700 to 1400 cfs greater than the minimum instream flow of 65 cfs below Grace Dam. Field sampling occurs once annually in October. Field sampling was initiated in October 2005 and will conclude October 2010. This narrative reports on the first two years of baseline monitoring.

In 2005, distinct differences in biological and physical habitat characteristics were detected between respective study reaches. Because of these distinct differences analysis in 2006 focused largely on changes over time within respective reaches rather than comparisons between reaches.

Channel morphological characteristics remained largely unchanged in reaches 2 and 3 in 2006 compared to 2005. Discharge remained relatively stable for most of the 2005-2006 water year below Grace Dam. In September 2006 a pulse release occurred to assist channel restoration efforts in the former Cove impoundment. The daily average flow did not exceed 150 cfs. The instantaneous maximum was reported to be approximately 500 cfs. This discharge event did not appear to be of sufficient magnitude to alter the channel shape or structure in reaches 2 and 3 in 2006.

Periphyton AFDW increased in 2006 in reaches 1 and 3 but remained similar to 2005 values in reaches 2 and 4. Chlorophyll a and b were significantly greater in reach 1 only in 2006. Chlorophyll a and b values in reaches 2, 3 and 4 were similar to those observed in 2005. Chlorophyll c was significantly lower in reaches 3 and 4 in 2006 relative to 2005 measures. The AI was significantly greater in reach 3 only in 2006. These inconsistent trends in periphyton metrics could simply be due to habitat heterogeneity inherent in stream habitats. Additional sampling in year 3 of the Phase I baseline study will provide additional data points increasing statistical power for comparisons across time.

Filamentous algae coverage was significantly greater in reach 2 only in 2006. In 2006 releases from Grace Dam were less than 2005. The increased cover of macrophytes and filamentous algae could be due to the lack of flows sufficient in magnitude to mobilize bedload and scour the substrate. Coverage in reaches 1, 3 and 4 was similar to 2005 measurements.

The 2006 BMI community was similar to that observed in 2005 for respective study reaches with some exceptions for individual metrics which were likely the result of spatial and temporal variability inherent in BMI distribution. Of particular interest was the discovery of a new gastropod in reach 4, Hydrobiidae. Surprisingly, this gastropod was the dominant taxa in reach 4 comprising 70 percent of the BMI community composition. This rapid dominance in the BMI community raises concern regarding the potential domino effect on other trophic levels. Further investigation may be warranted to determine if this taxa was new to the Bear River system in 2006 and potential consequences on the rainbow trout population in reach 4 as well as bonneville cutthroat trout restoration efforts.

Statistical power analysis of BMI taxa richness indicated the single surber sample was more sensitive at detecting small changes in taxa numbers than the composite surber sample particularly in reaches 1, 2 and 3. Variability was greater in the composite samples likely due to the increased number of microhabitats sampled, particularly inclusion of stream margin habitats typically occupied by different taxa than those commonly found in the thalweg. Gradients of increasing taxa richness below impoundments are expected, but this gradient was only apparent among the SS samples not the CS samples.

Seven fish species were collected in the four reaches. Reaches 1 and 4 contained 5 species each while reaches 2 and 3 had 4 species each. Reaches 3 and 4 were the only reaches where rainbow trout were collected. Longnose dace and Utah sucker were the only species collected in all 4 reaches. Reach 3 had the highest density of fish. The majority of these were redside shiners, however one rainbow trout was collected in reach 3. Reach 2 had the lowest fish density. Overall, fish density was higher in all reaches in 2005 than in 2006. Several factors may account for the decrease. Increased discharge in 2006 may have hampered collection efforts and provided additional habitat in the stream margins for fish to escape from the electroshocker. Fish stocking in reach 4 terminated a month prior to the 2006 sampling effort. Reach 4 was closed to angling in August of 2006 for public safety associated with Cove Dam decommissioning. And lastly, Cove Dam removal may have triggered fish movement upstream and downstream.

1. INTRODUCTION

The effects of flow regulation on stream ecology and fish populations have been and will continue to be widely studied throughout the world (Petts 1984; Naiman and Bilby 1998). Many studies have been and will be conducted in conjunction with the relicensing of hydroelectric projects. These studies are designed in part to evaluate operational effects on downstream water quality and quantity, aquatic biota and habitats, channel structure and stability and on recreational activities such as rafting and fishing.

In December 2003 PacifiCorp received a new operating license for the Bear River Hydroelectric Project (FERC No. 20) located in southeast Idaho. The new license includes a condition requiring PacifiCorp to implement and study a variable flow regime at the Grace Hydropower Facility in the 6.2 mile reach known as the Black Canyon between Grace Dam and the Grace powerhouse. PacifiCorp, in collaboration with the Environmental Coordination Committee (ECC), developed a monitoring plan for the Black Canyon of the Bear River to characterize the aquatic biota and habitat responding to the new minimum instream flow regime and compare those results with the aquatic biota and habitat resulting from the variable flow regime associated with recreational whitewater boating flows.

This study plan focuses specifically on the effect of the variable flow regimes on aquatic biota and habitat in the Black Canyon of the Bear River in southeast Idaho. The study is designed to evaluate and quantify changes in the abundance, composition and distribution of aquatic biota and habitat longitudinally across sites and through time as well as compare post-disturbance conditions to a reference reach.

In years 2005-2007 Phase I monitoring studies will be conducted to characterize the aquatic biota and habitat present under the new minimum instream flow conditions in the FERC license. In years 2008-2010 the FERC license requires PacifiCorp to provide periodic whitewater boating flows below Grace Dam. The objective in the 2008-2010 Phase II study is to characterize the aquatic biota and associated habitat exposed to variable flow regimes resulting from whitewater releases. Data from the 2005-2007 Phase I study will be compared to results from the 2008-2010 Phase II study to determine the effects of whitewater releases from Grace Dam on fisheries, macroinvertebrates, periphyton and aquatic habitat at three study reaches located in the 6.2 mile bypass reach.

Specifically the Black Canyon Monitoring Plan includes investigation of: 1) Macroinvertebrates—population trends, diversity and community indices; 2) Organic Matter Ash-Free Dry Weight (AFDW); 3) Periphyton—chlorophyll concentration and biomass; 4) Fisheries—population trends, community composition, fish condition; 5) Filamentous Algae—density; and 6) Channel Morphology—shape and substrate composition.

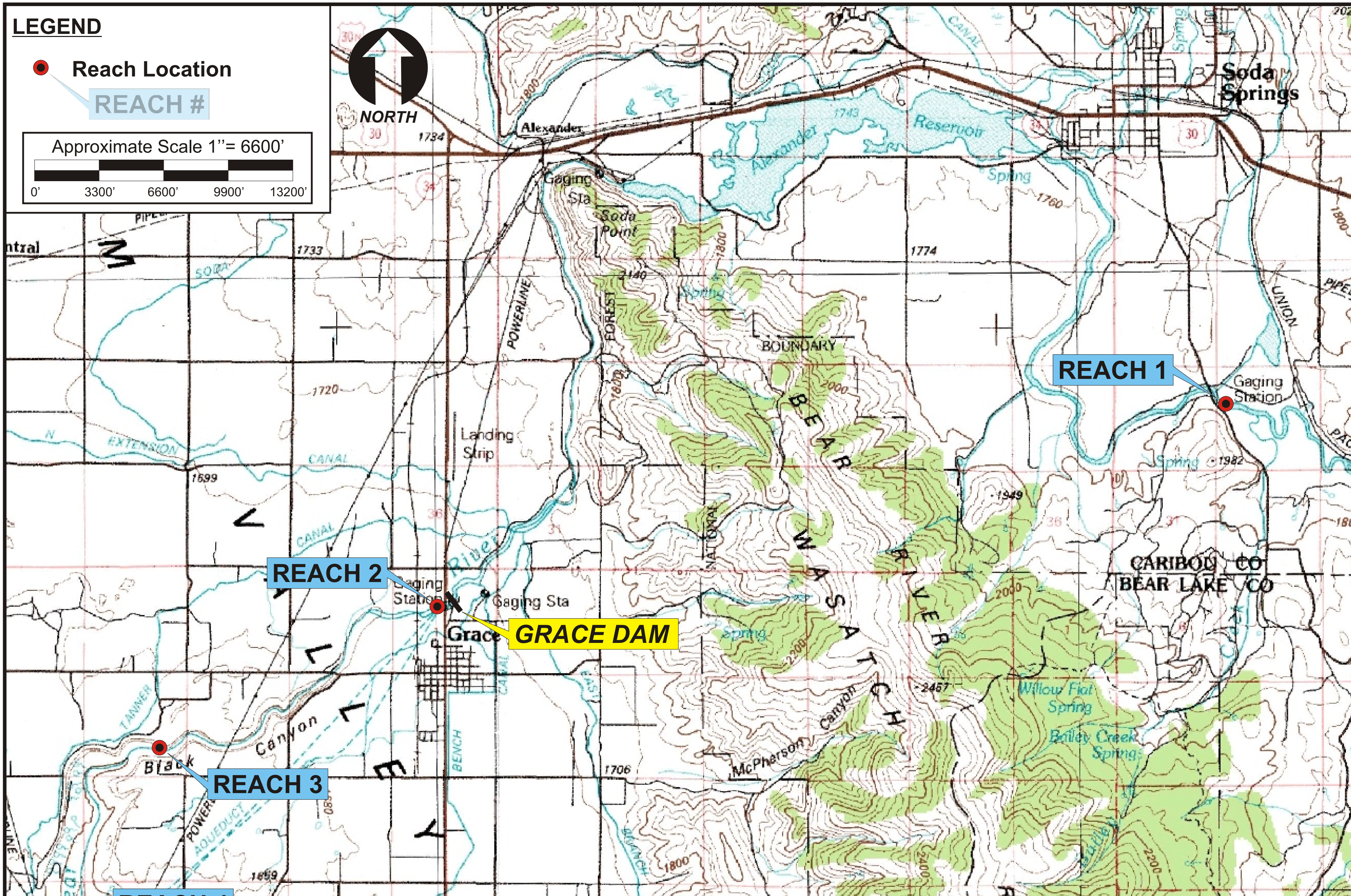
The Black Canyon Monitoring Plan includes a reference reach located upstream of Soda Reservoir and three experimental reaches within the Black Canyon. The reference reach is not subjected to the flow fluctuations associated with the whitewater releases but is partially regulated by Bear Lake. Field sampling will occur once annually in October. Field sampling was initiated in October 2005 and will conclude in October 2010.

2. STUDY AREA

The Bear River originates in Summit County, Utah in the northern Uinta Mountains on the Wasatch National Forest. From an aerial perspective the Bear River is a giant three state loop originating in Utah, traversing north into Wyoming then curving west into southeast Idaho before bending in a southerly direction back into Utah and emptying into the Great Salt Lake. This circuitous route is dictated by the north-south orientation of mountain chains and corresponding valleys. In the higher elevation zones snow is the dominant form of precipitation. Accordingly, the majority of the annual hydrograph occurs during spring snowmelt.

Since European settlement in the 1850's numerous water diversion dams and storage reservoirs have been constructed on the Bear River for irrigating agricultural lands. The most notable storage was the diversion of water into the formerly closed basin Bear Lake via Stewart Dam and associated canal system. This canal system greatly increased the storage capacity in the Bear River basin and consequently altered the annual hydrograph significantly below this diversion point. In the 1900's additional dams and diversions were constructed for hydropower generation and irrigation.

This study encompasses four study reaches (Figure 2-1). Reach 1 located upstream of Soda Reservoir serves as the reference reach for this study. Reaches 2, 3, and 4, located downstream of Grace Dam, serve as the experimental reaches. This 6.2 mile section of the Bear River below Grace Dam is known as the Black Canyon named after the basalt walls of the incised canyon. Approximately 0.5 miles downstream of Grace Dam the Bear River cuts through a basalt bedrock layer into the Black Canyon. The river gradient in the Black Canyon is considerably steeper relative to upstream and downstream reaches. In the Black Canyon the character of the Bear River alternates between steep cascades, plunge pools, riffles and runs. Channel shape and structure is dominated by bedrock ledges and large boulders. In contrast, reach 1 upstream of Soda Reservoir has a flatter gradient and more closely resembles an alluvial channel with alternating erosion and deposition zones.



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SITE MAP

BEAR RIVER BLACK CANYON
MONITORING REPORT

2005 STUDY LOCATIONS

FIGURE
2-1

2.1 REACH 1: UPSTREAM OF SODA RESERVOIR

Reach 1 is located approximately 1 mile upstream of Soda Reservoir. Five transects were sampled in a 0.25 mile reach directly upstream of Bailey Road. This section of the Bear River is located in a broad alluvial valley. The reach is a Rosgen C type channel. The predominant habitat type is alternating riffles and runs with clearly demarcated scour and deposition zones exhibited by the gravel/cobble point bars above the wetted perimeter. Bankfull zones are clearly delineated by grasses and woody vegetation. The substrate is highly embedded with fine silt and sand. In higher velocity riffle areas substrate is less embedded. In lower velocity runs a thick mat of periphytic algae blankets cobbles and gravels further trapping fine sediments.

Reach 1 serves as the reference reach for comparison with reaches 2, 3 and 4 subjected to the flow fluctuations required in the new FERC license for the Grace hydropower project. Instream flows in reach 1 are partially regulated by a combination of upstream dams and reservoirs. The peaks in the spring snowmelt hydrograph are buffered by upstream reservoir storage. Instream flows remain above normal through August and early September to meet downstream irrigation needs.

2.2 REACH 2: DOWNSTREAM OF GRACE DAM

Reach 2 is located directly downstream of Grace Dam just west of the Highway 34 bridge and the power canal viaduct. Instream flows are relatively stable year-round regulated by releases from Grace Dam. Discharge ranged from 93 to 103 cfs during the October sampling effort. Transects A through E span approximately 800 meters from upstream to downstream. Transects A through C are indicative of the scour and deposition found in alternating pool and riffle stream habitat types with the exception that the pool areas are largely filled in with sand and silt. This is a Rosgen Type C channel. Transects D and E are distinctly different than transects A, B and C. The gradient increases slightly and the substrate shifts to larger particle sizes including extensive bedrock shelves in transect D. Transects D and E are located at the nick point where the Bear River begins cutting through the basalt shelf into the Black Canyon.

2.3 REACH 3: BLACK CANYON

Reach 3 is located in the incised canyon of the Bear River known as the Black Canyon. Instream flows are relatively stable year-round regulated by releases from Grace Dam. Discharge ranged from 93 to 103 cfs during the October sampling effort. Mladenka and Van Every (2004) established five transects in an ascending order from downstream to upstream, starting with transect 6 and ending with transect 10. For the six-year Black Canyon monitoring study the transects in reach 3 have been re-labeled to A, B, C, D and E in descending order from upstream to downstream for consistency with naming conventions in reaches 1, 2 and 4.

Reach 3 is approximately 400 meters long. The reach begins 100 meters upstream of a sweeping left hand turn and continues through the turn, ending approximately 25 meters below it. This section of river channel is constrained and defined by the basalt bedrock of the Black Canyon. The outside of the bend (right bank) is defined by the edge of a talus slope stretching down from the top of the canyon walls, 180 ft in elevation above the stream. Much of reach 3 is run type habitat with the exception of Transect A which is riffle habitat. Transect E is located at the start of a 300 meter long pool. Scour around boulders on the right bank has formed “pocket water” adjacent to the boulders. Deposition of gravel and sand material forms point bars on the river left bank heavily vegetated with perennials and in some cases woody shrubs. Reach 3 resembles a Rosgen Type C channel.

2.4 REACH 4: BEAR RIVER ABOVE GRACE POWER PLANT

Reach 4 is located at the downstream end of the Black Canyon approximately 6.2 miles downstream of Grace Dam. This reach is just upstream of the Grace power plant. Discharge ranged from 120 to 130 cfs during the October sampling period. Discharge in reach 4 is approximately 30 cfs greater than reaches 2 and 3 due to inflows from spring sources just upstream of reach 4. This reach resembles a Rosgen Type B channel. The channel consists of high velocity laminar flow over basalt bedrock ledges with corresponding plunge pools. Basalt bedrock ledges are the dominant substrate type. Large mats of filamentous algae cling to a significant percentage of the bedrock substrate.

3. METHODS

Field and laboratory methods used for the six-year Black Canyon monitoring study are described for each discipline. Hydrology data for reach 1 and reach 2 was obtained from PacifiCorp. Temperature data for reaches 1, 2 and 4 was obtained from the Idaho Department of Environmental Quality (ID DEQ).

3.1 CHANNEL SURVEY

Channel shape and substrate type were surveyed in October at two of the four study areas. The two reaches surveyed were reach 2 and reach 3, located below the Grace Dam and in the middle of Black Canyon respectively. In each reach five transects were surveyed, the locations of which were chosen by staff from the Idaho Department of Environmental Quality (Mladenka and Van Every 2004). Each transect was marked with 18" rebar stakes located on both banks, perpendicular to stream flow. The stakes located on the river right bank were labeled with stamped metal tags describing the transect number and location.

Surveys were conducted with a Leica Total Station and rod mounted prism. Surveyed elevations for each cross section included right and left bank pins, bank full, wetted perimeter and channel elevations. The latter elevations were taken at major elevation changes or in one meter increments, whichever occurred first. Substrate type was recorded with each elevation point

Surveys of both reaches started with shooting benchmark elevations established in 2004 by Idaho DEQ. These elevations were re-set to 100 meters for calculation purposes.

3.2 SUBSTRATE SURVEY

Wolman pebble counts were conducted on reaches 2 and 3. The pebble count for reach 2 started at a randomly selected point in transect TD (ID DEQ T4). The pebble count for reach 3 started at a randomly selected point in transect TD (ID DEQ T7). Standard procedures for conducting Wolman pebble counts were followed (Wolman 1954). Particles were classified into six categories: Fines (0-0.062 mm), Sand (0.062-2.0 mm), Gravel (2.0-64 mm), Cobble (64-256 mm), Boulder (256-4096 mm), and Bed Rock. Pebble counts were conducted in an upstream direction due to the high amount of fine sediment mobilized in the water column.

3.3 PERIPHYTON

Periphyton was sampled in all four study reaches using natural substrate material. Cobble substrate was randomly selected in each transect of the four study reaches. After removal from the stream, a 4 cm by 4 cm surface area was immediately scraped with a razor blade and the dislodged material rinsed with deionized water into a Nalgene filtering apparatus containing a 47 mm Gelman A/E glass-fibre filter. Two samples were scraped and filtered from each rock substrate for paired analysis of AFDW and chlorophyll concentrations. Filtered material was stored on dry ice in dark containers to prevent pigment degradation. Periphyton samples were analyzed for the concentration of chlorophyll a, b and c according to the methods described in the Standard Methods for Examination of Water & Wastewater (American Public Heath Association, 20th ed., 1999). Periphyton samples were homogenized and extracted with 90 percent acetone. Chlorophyll concentration was determined using a spectrophotometer correcting for degraded materials within the sample.

3.4 FILAMENTOUS ALGAE

Filamentous algae and macrophyte coverage was quantified along five transects in each of the four study reaches. Researchers deployed a 50 cm by 50 cm pvc square sampler further divided into quarter sections by an intersecting grid at 25 cm. The algal coverage for each quarter cell in the grid was recorded as a percentage per cell. The cumulative percent coverage per 0.25 m^2 was summed and expressed as filamentous algal coverage per m^2.

3.5 FISHERIES

Electrofishing was used to sample three designated study reaches and one upstream reference reach of the Bear River. All sampling was conducted from October 9, 2006 to October 11, 2006 under similar stream flow conditions. A Smith-root model 12-B backpack electrofishing unit was used to sample 100 meter long sections of each reach. In each section, a three person crew conducted two consecutive upstream electrofishing passes, collecting all fish possible with dip nets. All captured fish were anesthetized, identified by species, weighed in grams, and total length was measured in millimeters. All rainbow trout captured were checked for freeze-brands and the location and orientation of the freeze-brand was recorded.

For each reach, relative species composition was determined by taking the total number of fish caught of each species, dividing by the total catch of all species, and multiplying by 100 (% of catch). In addition, relative biomass by species was determined for each reach by taking the total weight of each species, dividing by the total weight of all species, and multiplying by 100 (% of biomass). Catch per unit effort (CPUE) was calculated by dividing the total number of fish collected in two passes by the total electrofishing effort in minutes.

Relative weight (Wr) was used to assess the condition of rainbow trout and common carp according to the methods described by Anderson and Neumann (1996). The condition (relative weight) of the other species collected was not determined because the relative weight equations have not been developed for those species or they were not within the applicable length for the equations.

3.6 BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates were sampled in October at all four study reaches. In each reach five transects were sampled. In 2005 eight BMI samples were combined into a single composite sample for each transect. In total there were 40 BMI subsamples for each study reach. Individual subsamples were randomly located longitudinally along each transect encompassing a variety of microhabitats.

In 2006 BMI samples were divided into two jars per transect to test the variance in single surber samples verses composite samples. The first Surber sample was collected in the thalweg of the transect and preserved in a separate reference jar referred to as the single surber (SS) sample. The remaining seven Surber samples were collected laterally along the same transect in a random fashion and combined in the field to become a composite. These seven Surber samples were referred to as the composite sample (CS).

Samples were collected using a 400 cm^2 surber sampler with 500 µm mesh. The substrate was disturbed to a depth of 10 cm. Individual substrate was scrubbed clean of attached material and organisms. The effort used per collection of each individual sample was consistent throughout all the study reaches. Samples were preserved in 90 percent isopropyl alcohol in the field then decanted in the laboratory and preserved in 95 percent ethanol for long-term storage.

Identification and enumeration was performed by EcoAnalysts in Moscow, Idaho. In 2005, macroinvertebrates were processed according to Idaho DEQ standards. These standards include the identification of 500 organisms to the genus/species-level (or the lowest possible level) for all groups of organisms.

In 2006 the laboratory sorting procedure was modified to account for differences in the size of the samples and allow comparisons of the within-site variability between SS samples and CS samples. The SS sample (1/8 of the transect) was sub-sampled to 200 organisms. In the event that the sample contained fewer than 200 organisms, the entire sample was sorted. The CS (7/8 of the transect) was sub-sampled to 500 organisms.

3.7 ORGANIC MATTER ASH-FREE DRY WEIGHT

Organic Matter present in BMI samples was quantified using American Public Health Association (APHA) Standard Methods (1999) for Ash-Free Dry Weight (AFDW). A subsample of each composite BMI sample was homogenized, filtered, weighed after drying at 100 ºC and re-weighed again after being placed in the muffle furnace at 500 ºC to measure the amount of organic material expressed as AFDW. The data was standardized to represent the amount of organic material per square meter in grams.

3.8 STATISTICAL ANALYSIS

Statistical analysis was carried out using a single factor ANOVA (alpha = 0.1) to compare differences among the four study reaches within a sample year. Statistical comparisons between sample years within an individual study reach were undertaken with the Student's t-test (alpha = 0.1).

Taxa richness was used to test BMI sample variability by performing a statistical power analysis assuming the following error rates: $\alpha = \beta = 0.10$. The amount of change required to reject the null hypothesis (δ) was then solved for at different sample sizes. This was done for richness determinations from the 500-organism CS samples and the 200-organism SS samples. Thus, δ measures the amount of change in taxa richness necessary at an individual site to detect a change in community composition. Thus lower δ-values are desired because they indicate methods that are less-likely to fail to detect ecological changes. This method of comparison is limited by the assumption that each site is compared to itself in the future, without the other sites (Cohen 1988). Thus it provides a conservative estimate of power.

To circumvent limitations in the analysis the statistical power of the overall ANOVA design including all sites was examined. This study design assumed that there is a shift in community composition below Grace dam because this is a well established phenomenon (Ward and Stanford 1983). The shift in taxa richness was assumed to be subtle (10%) and occurred in a downstream longitudinal fashion over the study area. Thus the change between sites was 4 taxa and the overall change (from upstream to downstream) was a total of 16 taxa. We used the same error-rate ($\alpha = 0.10$) for this analysis as for the previous site-specific tests. The analysis tested the power (1- β) to reject the null hypothesis with this error-rate when a +4 taxa gradient actually occurs down stream between each site. This analysis was performed at several replication levels using both the CS 500-organism samples and SS 200-organsim samples; results were compared graphically.

4. RESULTS

The October 2005 and 2006 monitoring results are organized into the seven resource parameters monitored in the field. Histograms were used to present descriptive statistics (averages and confidence levels, alpha = 0.1) organized by respective reaches and sample years. Statistical analysis using the Student's t-test (alpha = 0.1) was primarily limited to comparisons of results within an individual site over time.

Temperature and discharge data were included in this report for individual study reaches where available. Discharge data measured at the USGS gage located upstream of Soda Reservoir and the USGS gage located in the bypass channel below Grace dam were included for comparison of hydrologic differences between the reference site and study reaches 2, 3, and 4 located below the dam as well as instream flow differences during sampling efforts in 2005 and 2006. Hourly temperature data for reaches 1, 2, 3 and 4 was obtained from the ID DEQ.

4.1 HYDROLOGY

Discharge in reach 1, the reference reach, averaged 182 cfs during the October 9-11, 2006 sampling period (Figure 4.1-1). This was considerably greater than the discharge averaged during the previous year's sampling effort in October 2005 when average discharge was 138 cfs, 44 cfs less than 2006. The increase in discharge during the 2006 sampling effort was noticeable. Transect wetted perimeter width, water depths and current velocities were greater than observed in 2005. Furthermore, exposed cobble bars were covered in fine silt indicative of recent discharge events of greater magnitude. This silt layer on the cobbles was not observed during the 2005 sampling effort.

Discharge in reach 2 averaged 117 cfs during the October 9-11, 2006 sampling period. This was 23 cfs greater than the 94 cfs average discharge during the October 12-15, 2005 sampling effort. In reach 2 the 2006 discharge increase was not noticeable in the field likely due to the flat and broad channel shape. In reach 3 the increased discharge was more noticeable in the field likely due to the more incised channel shape relative to reach 2. In reach 4 the increased discharge appeared to result in a slight increase in surface water velocities and increased pool depths.

The annual discharge in reach 1 for water year 2005-2006 (10/1/2005-9/30/2006) varied slightly from water year 2004-2005 (Figure 4.1-2). The peak discharge in the 2005-2006 water year was 1157 cfs on April 13th compared to 1336 cfs on July 25th in water year 2004-2005. Discharge during the summer irrigation delivery period (generally July 1 to September 1) was less than 1000 cfs in the 2005-2006 water year compared to sustained flows greater than 1000 cfs from July 1 through August 1, 2005 with additional peak discharges greater than 1000 cfs between August 1 and September 1 2005. Despite the differences in the timing of the peak discharge and lower volume the average annual discharge rounded to the nearest whole number was identical for the two water years; 421 cfs.

Figure 4.1-1: Discharge, October sampling period

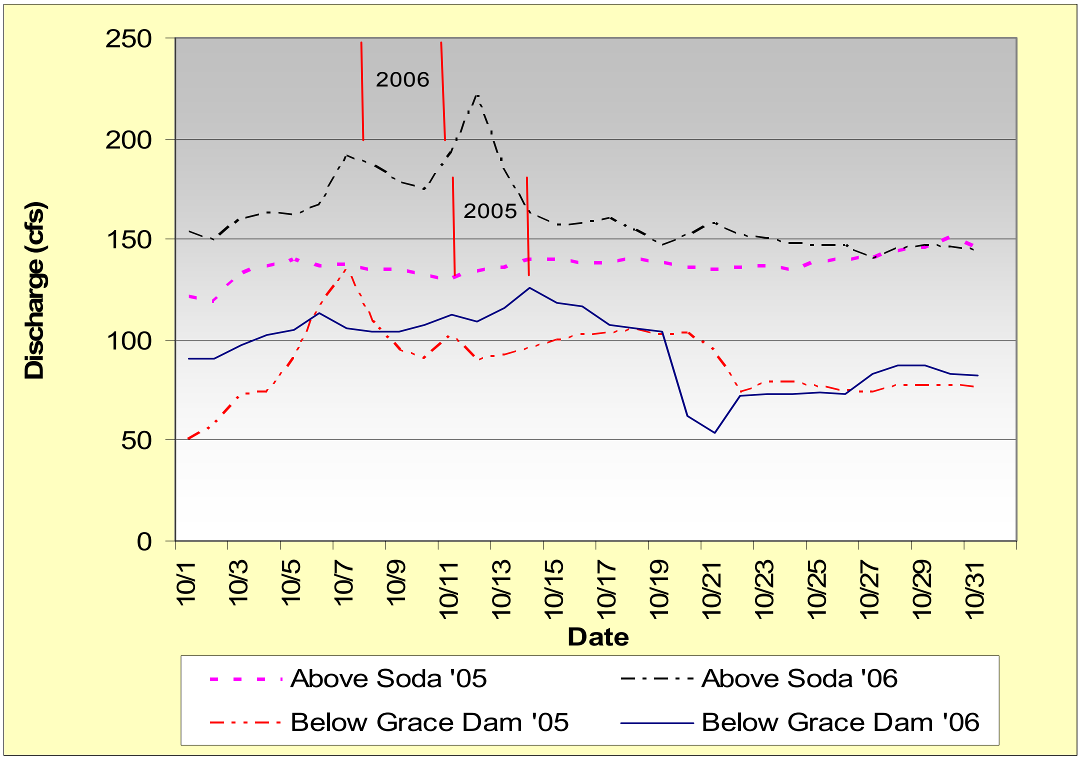
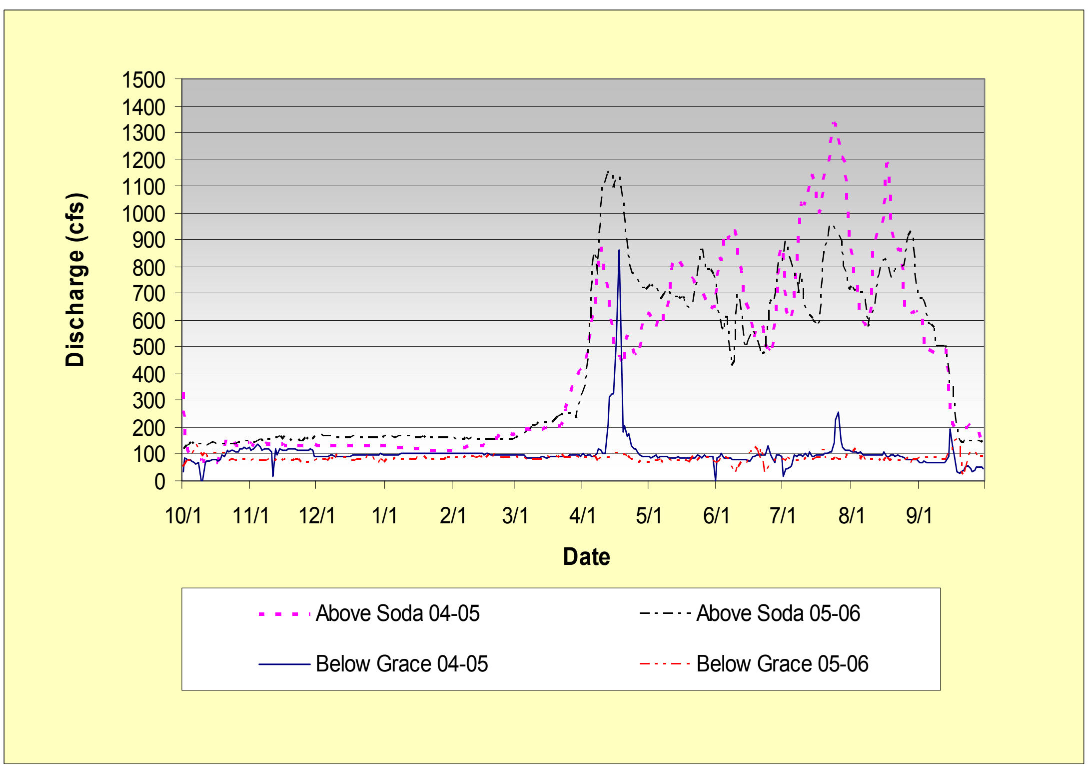


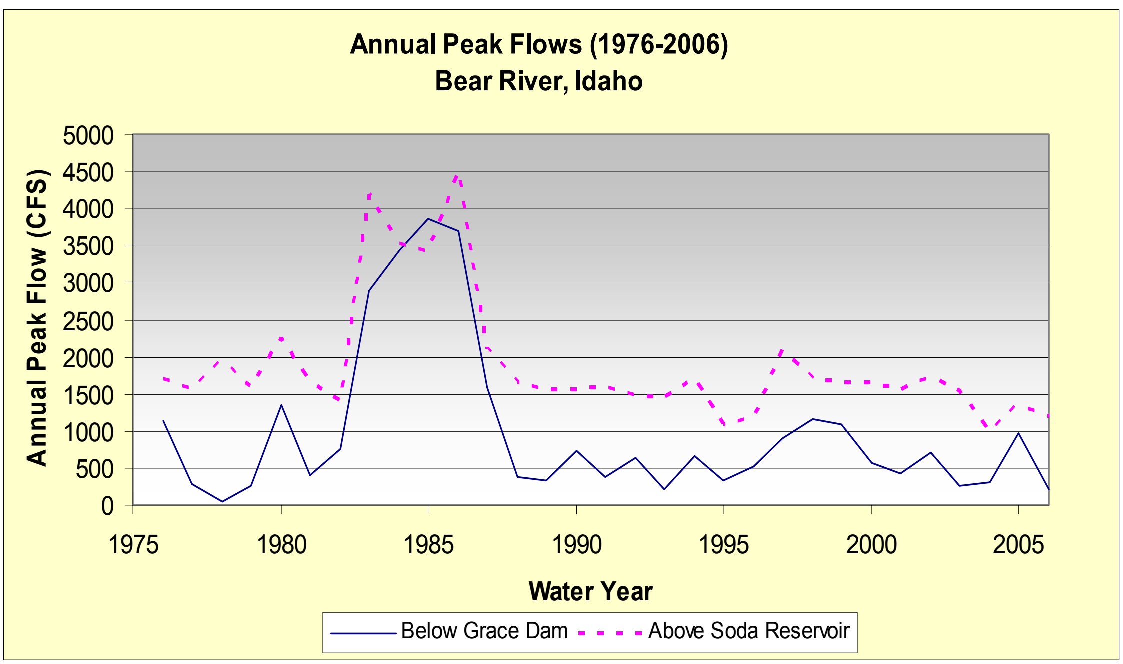
Figure 4.1-2: Discharge; 2004-2005 and 2005-2006 water years



In reach 2 the average annual discharge for the 2005-2006 water year was 83 cfs compared to 102 cfs in 2004-2005. No peak flows occurred in reach 2 during the 2005-2006 water year compared to the spring pulse flow of 863 cfs on April 17, 2005. Reach 3 does not have a staff gage and corresponding rating curve for measuring discharge. It is assumed that discharge in reach 3 is roughly equivalent to that measured in reach 2. Reach 4 also lacks a staff gage. Previous studies have estimated that discharge in reach 4 is approximately 30 to 60 cfs greater than reach 2 flows (Connelly Baldwin, personal communication). The additional discharge is from groundwater inflows located at the bottom end of the Black Canyon. For this study we assumed flows in reach 4 were 30 cfs greater than discharge measured in reach 2.

The annual daily average peak discharge in 2006 for reaches 1 and 2 was lower than annual peaks recorded between 1976 and 2006 (Figure 4.1-3). For the period 1976 to 2006 the average annual peak flow in reach 1 was 1893 cfs. In contrast the 2006 peak discharge for reach 1 was 1157 cfs. In reach 2 the annual peak discharge for the period 1976 to 2006 was 985 cfs compared to a peak discharge of daily averages in 2006 of 152 cfs. Spring run-off in the Bear River watershed did not result in spill flows over Grace dam in 2006. September pulse flows over Grace Dam to assist with channel restoration efforts associated with Cove Dam decommissioning were reflected in the daily average flows.

Figure 4.1-3: Bear River annual peak discharge (1976-2006)



4.2 CHANNEL SHAPE AND SUBSTRATE

Reach 2 transects were surveyed on October 9, 2006 between 0800 and 1130 hours. Discharge was 104 cfs. Reach 3 transects were surveyed on the following day, October 10, 2006 between 1545 and 1730 hours. The flow recorded for the Bear River below Grace Dam during the reach 3 survey was 107 cfs. Bankfull features were difficult to identify in reaches 2 and 3 due to the effects of flow regulation, grazing in reach 2 and vegetation encroachment in reach 3. Deposition zones and scour common in stream systems with fluctuating flow regimes were not evident in reaches 2 and 3. Channel cross-sections were not surveyed for reaches 1 and 4.

In 2006 Reach 2 had a mean wetted perimeter width of 50.68 meters (Table 4.2-1). The wetted perimeter widths were narrowest at transect TE, 32.12 meters, and widest at transect TD, 70.83 meters. The mean water depths associated with the wetted perimeter elevation were between 0.18 meters at TA and 0.35 meters at TB. The mean water depth based on wetted perimeter elevations was 0.26 meters. The bankfull widths for reach 2 were between 48.85 meters at TA and 76.57 meters at TD. The mean width was 62.71 meters, and the mean depth associated with the bankfull elevation was 0.40 meters.

Table 4.2-1: Channel survey data for reaches 2 and 3, October 2005

Reach	Transect	Wetted Perimeter				Bankfull					
		WP Width (m)		Average Water Depth (m)		Bankfull Width (m)		Average Bankfull Depth (m)		Bankfull Width/Depth Ratio	
		2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
2	TA	41.55	40.72	0.28	0.18	48.85	48.85	0.57	0.58	86.46	84.06
2	TB	57.00	58.34	0.31	0.35	67.22	67.22	0.48	0.45	140.97	150.74
2	TC	44.54	51.40	0.16	0.21	71.30	71.50	0.31	0.27	226.42	267.65
2	TD	48.86	70.83	0.11	0.25	76.57	76.57	0.16	0.25	483.48	312.19
2	TE	33.69	32.12	0.24	0.28	51.28	49.42	0.19	0.44	269.73	111.77
Reach 2 Mean		**45.13**	**50.68**	**0.22**	**0.26**	**63.04**	**62.71**	**0.34**	**0.40**	**241.41**	**185.28**
3	TA	11.10	11.45	0.24	0.25	28.80	28.80	0.73	1.21	39.34	23.81
3	TB	13.60	13.98	0.24	0.28	20.70	20.70	0.63	0.65	33.09	31.95
3	TC	12.90	14.97	0.19	0.26	17.10	17.10	0.62	0.65	27.37	26.45
3	TD	14.30	16.55	0.69	0.37	24.80	24.80	0.86	0.41	28.77	60.12
3	TE	15.00	15.23	0.49	0.61	17.50	17.50	1.03	1.00	17.03	17.44
Reach 3 Mean		**13.38**	**14.44**	**0.37**	**0.35**	**21.78**	**21.78**	**0.77**	**0.78**	**29.12**	**31.95**

In 2006, reach 3 had a mean wetted perimeter of 14.44 meters. The wetted perimeter widths ranged from 11.45 meters at TA to 16.55 meters at TD. The mean water depths associated with the elevation of the wetted perimeters were between 0.25 meters at TA and 0.61 meters at TE, and the mean water depth was 0.35 meters. The bankfull widths for reach 2 were between 17.10 meters at TC and 28.80 meters at TA, with a mean width of 21.78 meters and a mean depth of 0.78 meters.

Rosgen (1994, 1996) uses the bankfull width to water depth ratio (BWD ratio) to characterize streams in his Level II stream classification system. The BWD ratio for reach 2 ranged from 84.06 at TA to 312.19 at TD. The mean BWD ratio for reach 2 was 185.28. Rosgen's stream classification system ranks these BWD indices very high. The BWD ratio for reach 3 ranged from 17.44 at TE to 60.12 at TD, and the mean was 31.95. Rosgen ranks these BWD ratios in the moderate to high range.

In reach 2, transects TA, TB and TC contained a high percentage of fines embedding gravel, cobble and boulders (Figure 4.2-1). The percentage of fine material for these transects was 81% fines at TA, 65% fines at TB, and 33% fines at TC. Transects TD and TE had a lower percentage of fine material, 15.9% and 21.7% respectively, and a greater amount of boulders and bedrock. The gradient in reach 2 increases longitudinally downstream with a pronounced increase just upstream of transect TD. The Wolman Pebble count conducted in reach 2 indicates fines made up 40% of the stream channel, more than double the amount of any other class size (Figure 4.2-2).

Figure 4.2-1: Substrate composition for reach 2, 2006

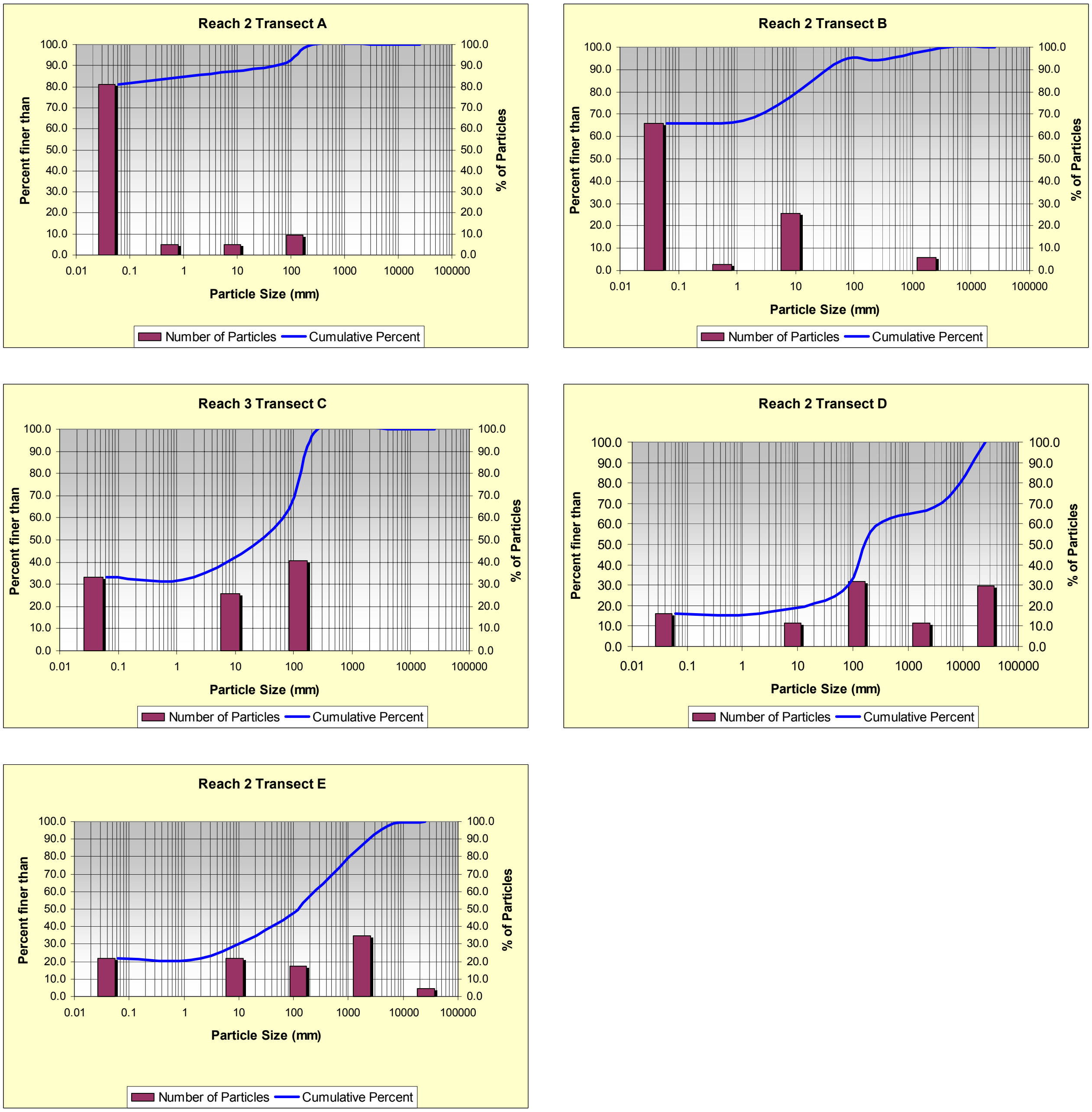
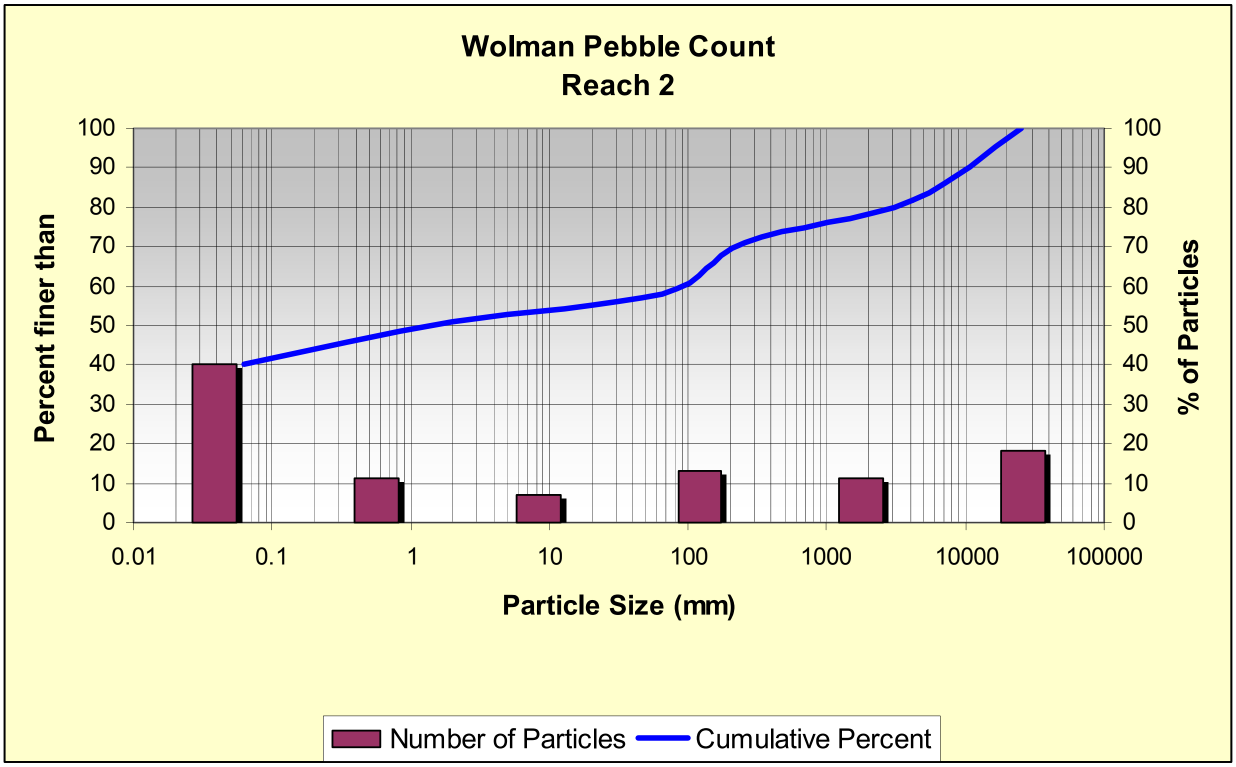
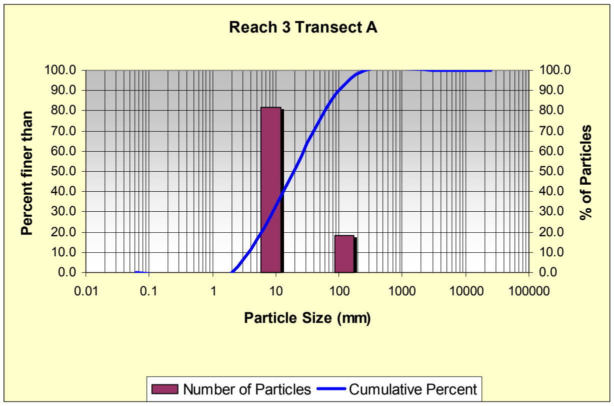


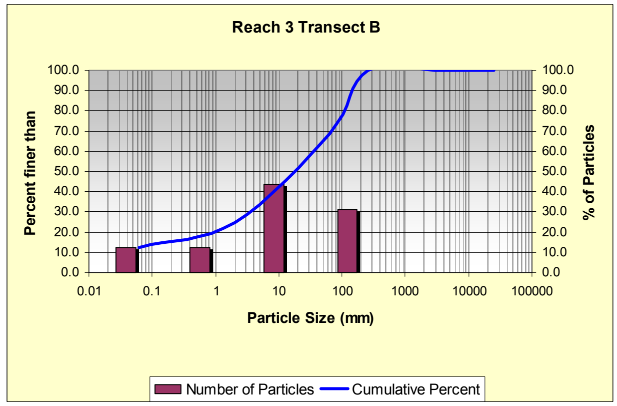
Figure 4.2-2: Wolman pebble count in reach 2, October 2006:

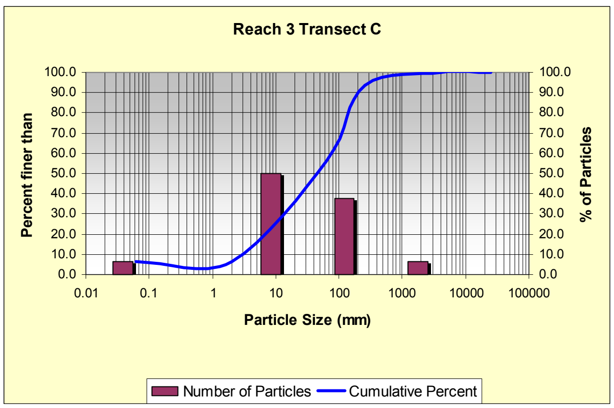


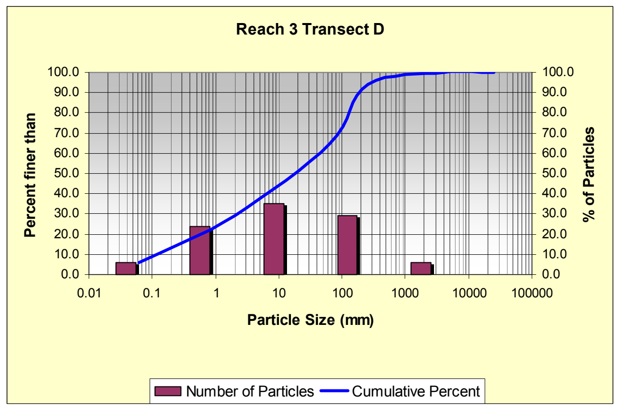
In reach 3 all transects except for TE were predominantly gravel, with the gravel size class ranging from 81% to 35% of the total substrate composition (Figure 4.2-3). In transect TE the substrate was finer than other transects with 56% sand and 25% gravel. The Wolman Pebble count for reach 3 indicates that gravel comprised greater than 60% of the substrate material (Figure 4.2-4).

Figure 4.2-3: Substrate composition for reach 3, 2006









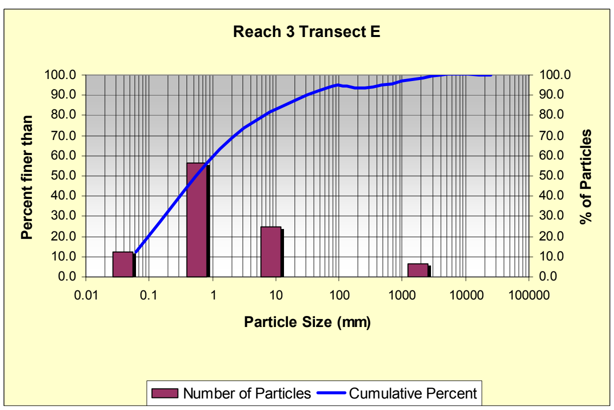
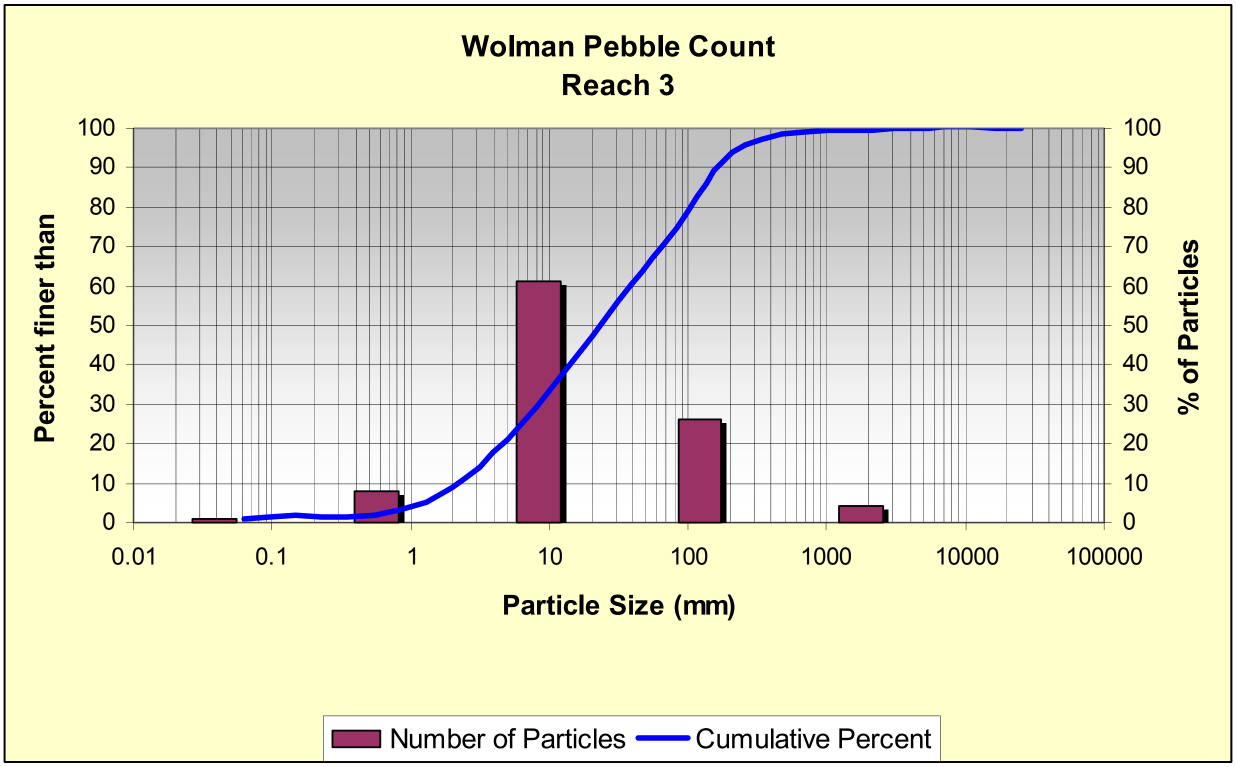


Figure 4.2-4: Wolman pebble count in reach 3, October 2006:



4.3 PERIPHYTON— ASH-FREE DRY WEIGHT AND CHLOROPHYLL

Periphyton AFDW was greater in reference reach 1 than treatment reaches 2, 3 and 4 located below Grace Dam (Figure 4.3-1). This difference between the reference reach and the experimental reaches was not statistically significant (single factor ANOVA, alpha 0.1) due in part to the high sample variance particularly in reach 1. The AFDW average for reach 1 was 117.3 g/m^2 compared to 51.5 g/m^2, 97.2 g/m^2 and 54.6 g/m^2 for reaches 2, 3, and 4 respectively. Direct statistical comparisons (Student's t-test, $p \leq 0.1$) between paired reaches did not yield significant differences.

In reach 1, periphyton AFDW was significantly greater in 2006 compared to 2005 (p=0.06, student's t-test). Periphyton AFDW was also significantly greater in reach 3 in 2006 compared to 2005 (p=0.03, student's t-test). Periphyton AFDW in reaches 2 and 4 was similar in sample years 2005 and 2006.

In 2006, periphyton chlorophyll a was not significantly different between reaches 1, 2, 3 and 4 (Figure 4.3-2). In contrast, 2005 chlorophyll a values increased longitudinally downstream with each successive reach. In reach 1, 2005 chlorophyll a was significantly lower than reaches 3 and 4 (p=0.0002 and p = 0.1 respectively, student's t-test). In 2006, chlorophyll a average values were 149.7 mg/m^2, 165.1 mg/m^2, 206.0 mg/m^{2}and 206.9 mg/m^2 respectively for reaches 1 through 4. In reach 1, the 2006 chlorophyll a average was substantially greater than the 42.7 mg/m^2 recorded in 2005 (p=0.08, student's t-test). In reaches 2 and 3 chlorophyll a values in 2006 were similar to values recorded in 2005. In reach 4 the 2006 chlorophyll a average was lower than 2005 (277.3 mg/m^2) but not significant.

Figure 4.3-1: Periphyton mean AFDW, October 2005 and 2006

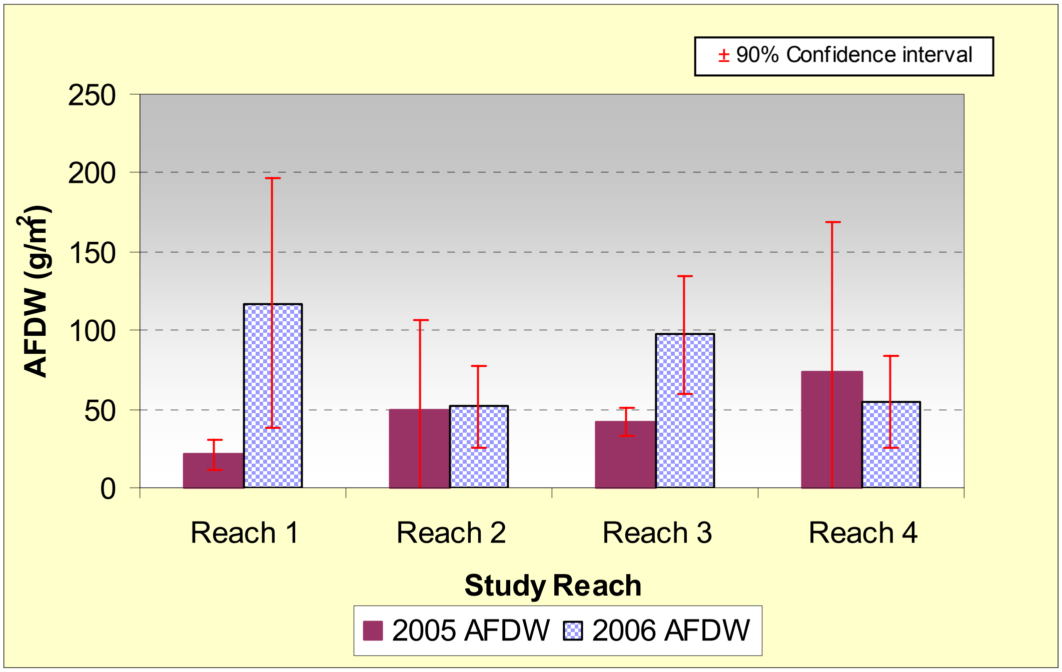
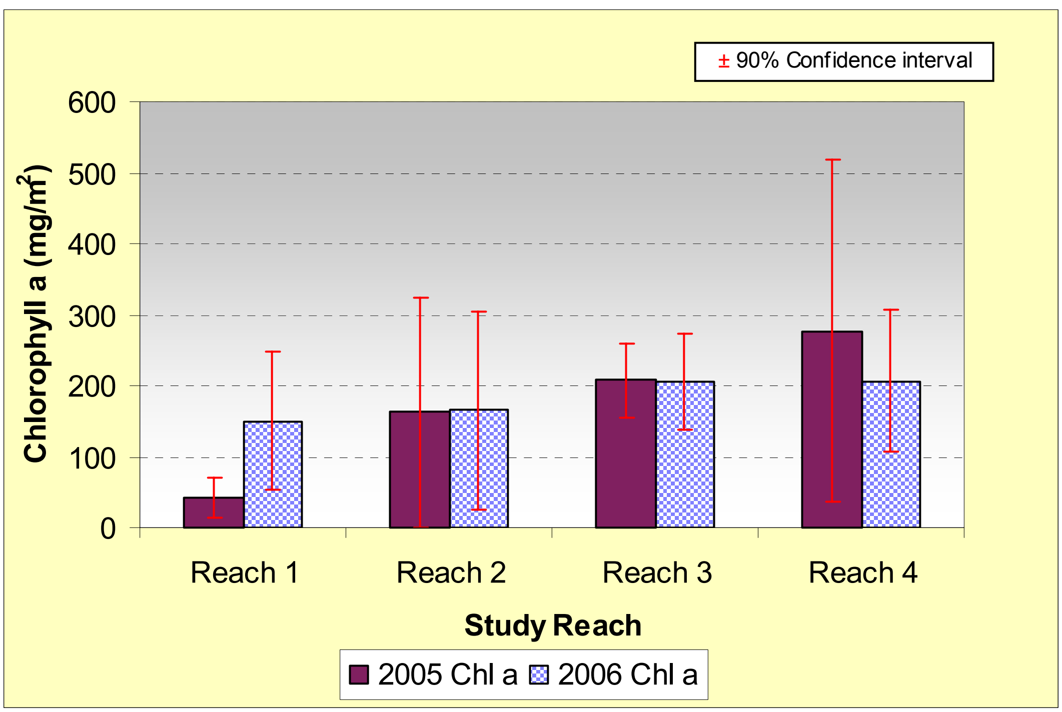


Figure 4.3-2: Periphyton mean chlorophyll a concentration, October 2005 and 2006



Chlorophyll b average values were similar between reference reach 1 and the three treatment reaches in 2006 (Figure 4.3-3). In 2005, chlorophyll b values were significantly different between reaches ($p = 0.07$, single factor ANOVA). In 2005 reach 1 chlorophyll b values were significantly lower than reaches 2, 3 and 4 respectively ($p = 0.07$; $p = 0.0001$; and $p = 0.07$, Student's t-test). 2006 chlorophyll b average values were 13.4 mg/m^2, 12.3 mg/m^2, 12.0 mg/m^{2}and 12.1 mg/m^2 respectively for reaches 1 through 4. The 2006 chlorophyll b values in reach 1 were significantly greater than 2005. In reaches 2, 3 and 4 chlorophyll b values were consistently greater in 2005 but not significantly different from 2006 values.

Chlorophyll c concentration was similar in reference reach 1 and the three treatment reaches in 2006 (Figure 4.3-4). In 2005 chlorophyll c concentration was nine times greater in the three treatment reaches relative to the reference reach (p=0.04, single factor ANOVA). Paired comparisons between reaches 1 and reaches 2, 3 and 4 respectively in 2005 indicated a statistically significant difference (p=0.07; p=0.002; and p=0.04 respectively; Student's t-test). Chlorophyll c average values in 2006 were 4.6 mg/m^2, 5.5 mg/m^2, 8.4 mg/m^{2}and 6.3 mg/m^2 respectively for reaches 1 through 4. The 2006 Chlorophyll c concentrations were at least half or less than the concentrations recorded in 2005 for all sites. In reaches 3 and 4 the 2006 chlorophyll c concentration was significantly lower than 2005 concentrations (p=0.03; p=0.08 respectively; Student's t-test). No differences were identified between 2005 and 2006 chlorophyll c concentrations in reaches 1 and 2.

In 2006, the Autotrophic Index (AI) was significantly different between the four reaches (p=0.001, single factor ANOVA). Reach 1 had the highest autotrophic index in 2006 (825.4) compared to reach 2-385.8; reach 3-491.5; and reach 4-243.6 (Figure 4.3-5). The AI in Reach 1 was significantly greater than reaches 2, 3 and 4 (p=0.01, p=0.05 and p=0.004 respectively, Student's t-test). Reach 3 AI was significantly greater than reach 4 (p=0.05, student's t-test). Reaches 2 and 3 had similar AI values. In 2005, there was also a statistically significant difference in AI values between reaches (p=0.09, single factor ANOVA). Reach 1 also had the highest AI in 2005 (591.4), substantially lower than the 2006 value but not significantly different. Reaches 2 and 4 had a similar AI respectively between the 2005 and 2006 sampling events. In reach 3, however, the AI was significantly greater in 2006 compared to 2005 (p=0.03, Student's t-test).

Figure 4.3-3: Periphyton mean chlorophyll b concentration, October 2005 and 2006

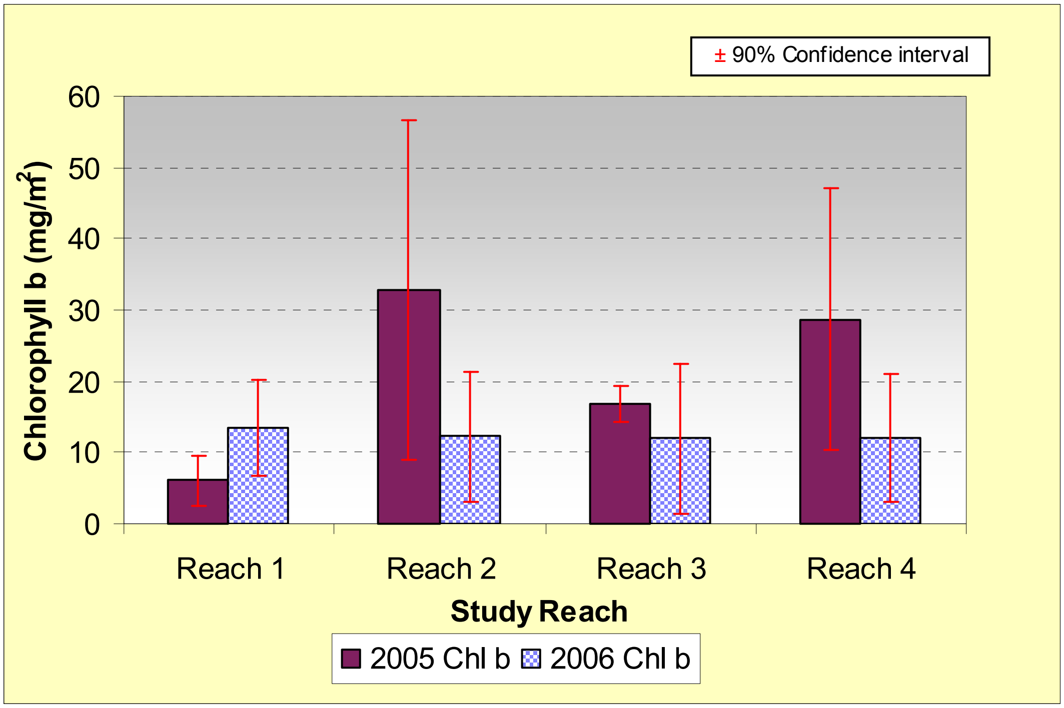


Figure 4.3-4: Periphyton mean chlorophyll c concentration, October 2005 and 2006

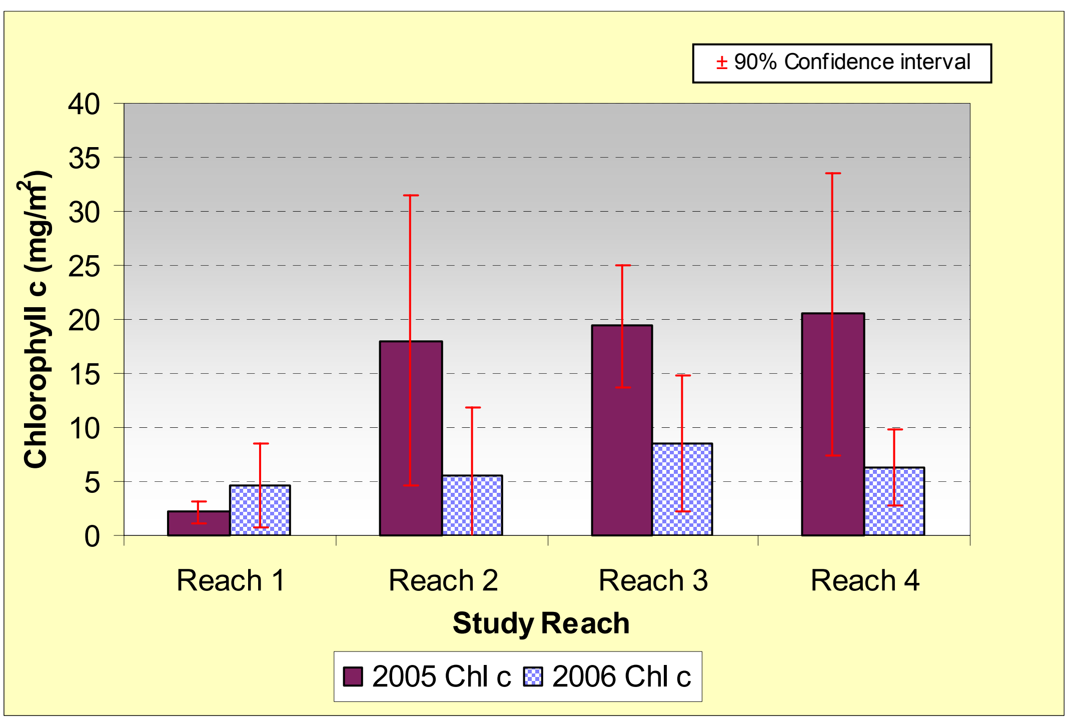
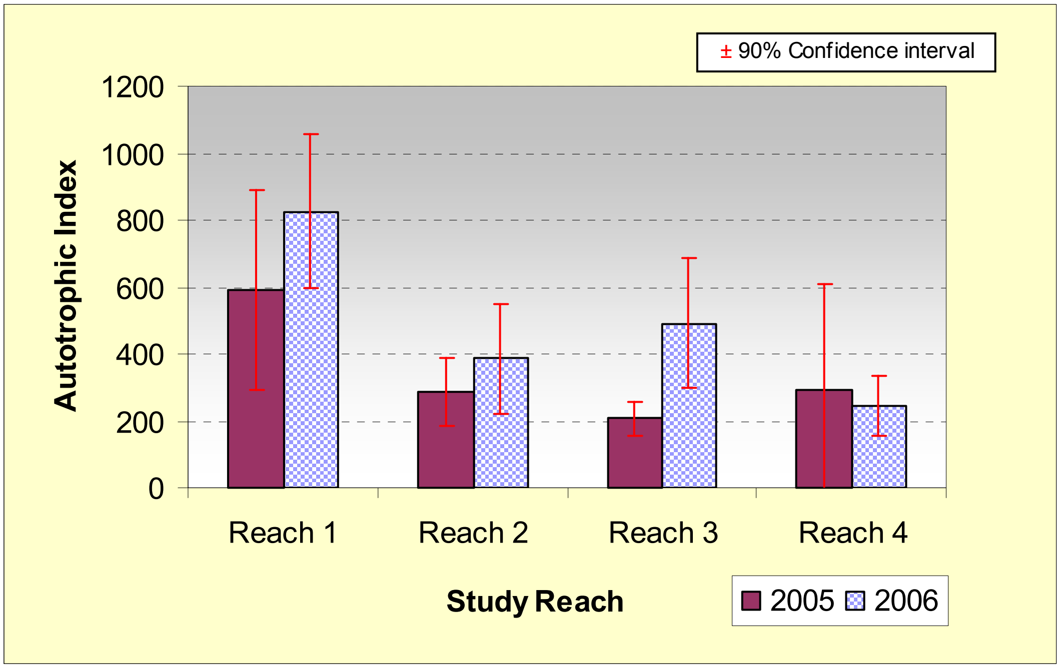


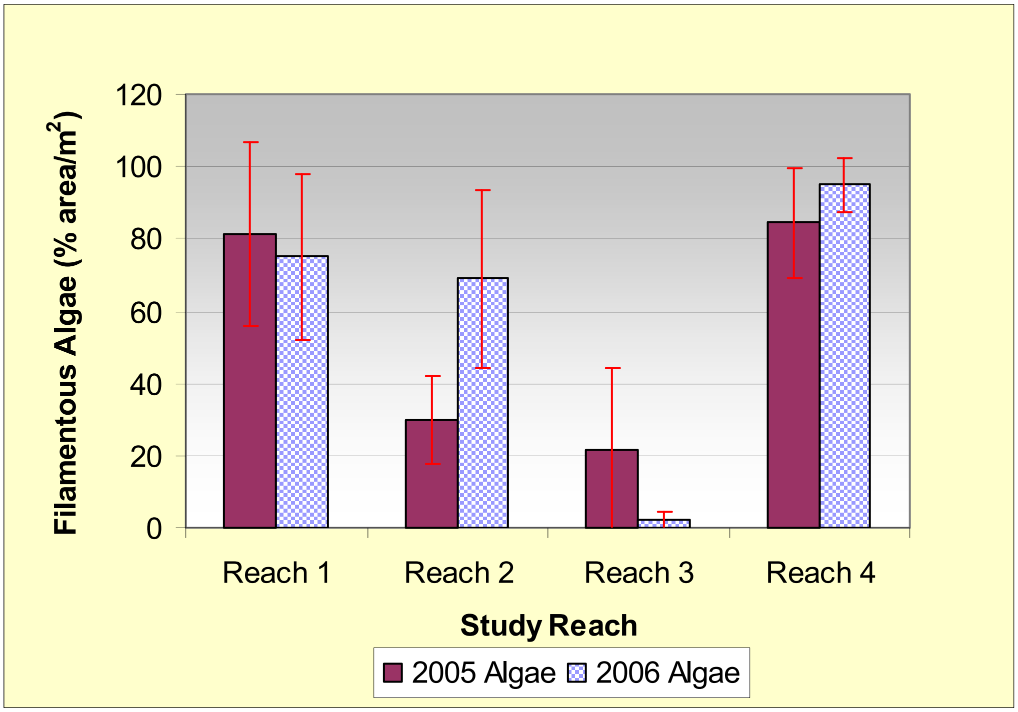
Figure 4.3-5: Periphyton mean autotrophic index, 2005 and 2006



4.4 FILAMENTOUS ALGAE

Filamentous algae cover was significantly different between sites in 2006 ($p=0.00007$, single factor ANOVA). Reach 4 had the highest coverage (95%) followed by reach 1 (75%), 2 (30%) and 3 (2%) in descending order of coverage (Figure 4.4-1). In fact, reach 3 algal coverage was significantly lower than reaches 1, 2 and 4 ($p=0.006$, $p=0.01$ and $p=0.000007$, Student's t-test). Paired comparisons (Student's t-test) between reaches 1, 2 and 4 indicated no significant differences in algal coverage. The 2006 filamentous algae coverage in reaches 1, 3 and 4 was similar to that observed in 2005. In reach 2 the 2006 coverage was significantly greater than 2005 ($p=0.06$, Student's t-test).

Figure 4.4-1: Filamentous algae cover, 2005 and 2006



4.5 FISHERIES

Fisheries data were analyzed to determine species abundance, biomass and relative weight. Relative weight is a measure of fish condition. Catch per unit effort (CPUE) was calculated for each reach for comparison purposes within and between sample study years. Seven species total were collected in this sampling effort but not all species were present in each study reach. The analysis was divided into results for each respective study reach.

4.5.1 Reach 1—Above Soda Reservoir

Five species were collected in reach 1 for a total catch of 39 fish and biomass of 0.27 kg (Table 4.5-1). Longnose dace were the most abundant (14 fish; 36% of the catch) followed by mottled sculpin (12; 31%), small mouth bass (9; 23%), common carp (3; 8%), and Utah sucker (1; 3%) (Figure 4.5-1). Mottled sculpin comprised a majority of the biomass (35%, 94 g), followed by longnose dace (29%; 78 g), common carp (18%; 48 g), small mouth bass (15%; 40 g), and Utah sucker (4%; 10 g) (Figure 4.5-2).

Catch per unit effort (CPUE) was highest for longnose dace (0.83 fish/minute), followed by mottled sculpin (0.71 fish/minute), small mouth bass (0.53 fish/minute), common carp (0.18 fish/minute), and Utah sucker (0.06 fish/minute) (Figure 4.5-3).

Table 4.5-1: Fish density and biomass per 100 meters in reach 1, October 2005

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	14 (36%)	78 (29%)	0.83
Small Mouth Bass (*Micropterus dolomieu*)	9 (23%)	40 (15%)	0.53
Mottled Sculpin (*Cottus bairdi*)	12 (31%)	94 (35%)	0.71
Common Carp (*Cyprinus carpio*)	3 (8%)	48 (18%)	0.18
Redside Shiner (*Richardsonius balteatus*)	0	0	0
Utah Sucker (*Catostomus ardens*)	1 (3%)	10 (4%)	0.06
Rainbow Trout (*Oncorhynchus mykiss*)	0	0	0
Total	39	270	2.31

Figure 4.5-1: Fish species composition, October 2006

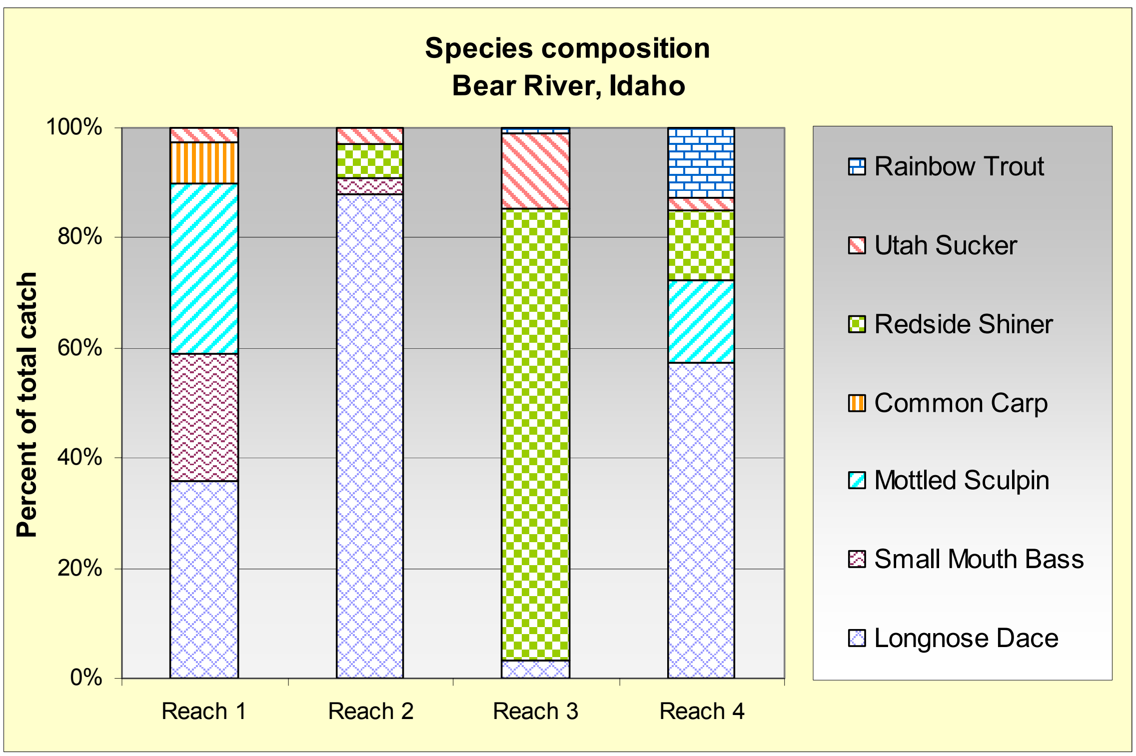


Figure 4.5-2: Fish species biomass, October 2006

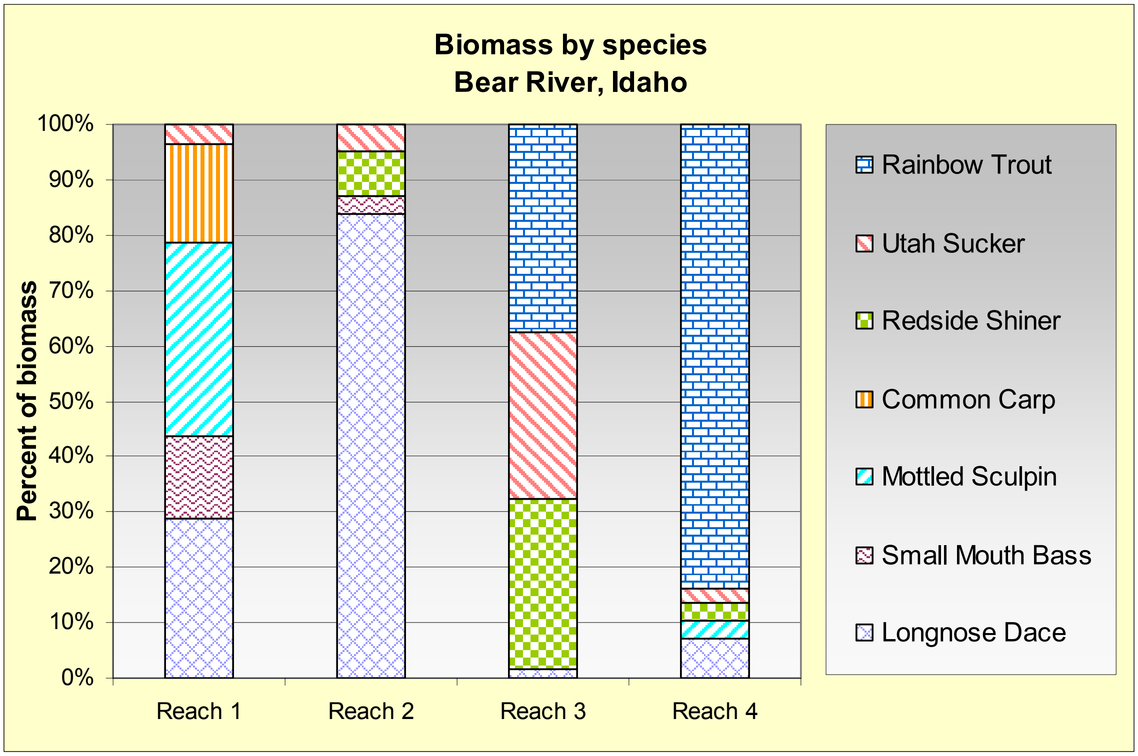
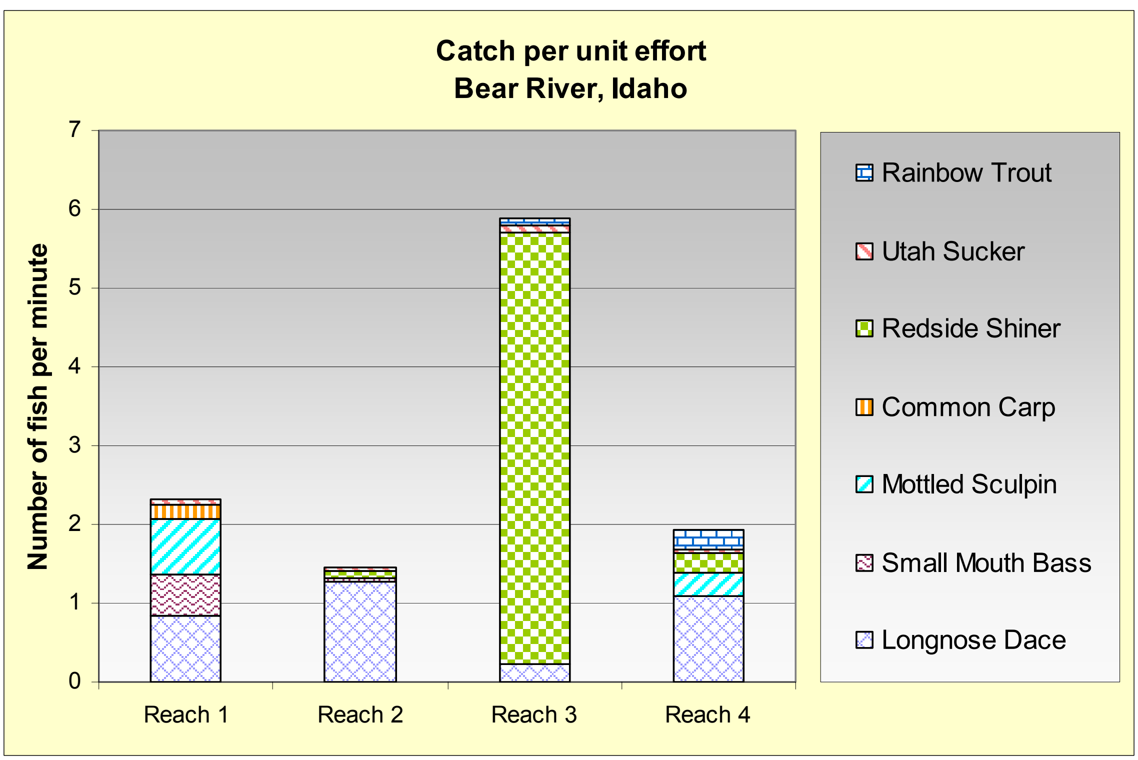


Figure 4.5-3: Catch per unit effort for reaches 1, 2, 3 and 4, October 2006



4.5.2 Reach 2— Below Grace Dam

Four species were collected in reach 2 for a total catch of 33 fish and biomass of 0.25 kg (Table 4.5-2). Longnose dace were the most abundant accounting for 29 of the 33 fish collected (97% of the catch) followed by redside shiner (2; 6%), small mouth bass (1; 3%), and Utah sucker (1; 3%) (Figure 4.5-1). Accordingly, longnose dace comprised a large majority of the biomass (84%; 206g) followed by redside shiner (8%; 20 g), Utah sucker (5%; 12 g), and small mouth bass (3%; 8 g) (Figure 4.5-2).

Table 4.5-2: Fish density and biomass per 100 meters in reach 2, October 2006

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	29 (88%)	206 (84%)	1.28
Small Mouth Bass (*Micropterus dolomieu*)	1 (3%)	8 (3%)	0.04
Mottled Sculpin (*Cottus bairdi*)	0	0	0
Common Carp (*Cyprinus carpio*)	0	0	0
Redside Shiner (*Richardsonius balteatus*)	2 (6%)	20 (8%)	0.09
Utah Sucker (*Catostomus ardens*)	1 (3%)	12 (5%)	0.04
Rainbow Trout (*Oncorhynchus mykiss*)	0	0	0
Total	33	246	1.45

Catch per unit effort was greatest for longnose dace at (1.28 fish/minute) followed by redside shiner (0.09 fish/minute), small mouth bass (0.04 fish/minute), and Utah sucker (0.04 fish/minute) (Figure 4.5-3).

4.5.3 Reach 3— Black Canyon

Four species were collected in reach 3 for a total catch of 89 fish and a biomass of 0.78 kg (Table 4.5-3). Redside shiner dominated in abundance (73 fish; 82% of catch) followed by Utah sucker (12; 13%), longnose dace (3; 3%), and rainbow trout (1; 1%) (Figure 4.5-1). The one rainbow trout collected accounted for 38% of the biomass (294 g), followed by redside shiner (31%; 240 g), Utah sucker (30%, 234 g), and longnose dace (2%; 12 g) (Figure 4.5-2).

Table 4.5-3: Fish density and biomass per 100 meters in reach 3, October 2006

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	3 (3%)	12 (2%)	0.23
Small Mouth Bass (*Micropterus dolomieu*)	0	0	0
Mottled Sculpin (*Cottus bairdi*)	0	0	0
Common Carp (*Cyprinus carpio*)	0	0	0
Redside Shiner (*Richardsonius balteatus*)	73 (82%)	240 (31%)	5.48
Utah Sucker (*Catostomus ardens*)	12 (13%)	234 (30%)	0.09
Rainbow Trout (*Oncorhynchus mykiss*)	1 (1%)	294 (38%)	0.08
Total	89	780	5.88

Catch per unit effort was greatest for redside shiner at 5.48 (fish/minute), followed by longnose dace (0.23 fish/minute), Utah sucker (0.09 fish/minute), and rainbow trout (0.08 fish/minute) (Figure 4.5-3).

One rainbow trout was collected in reach 3. The fish was marked with a freeze-brand on the left hand side below the dorsal fin and the orientation was an upright T, indicating it was released at the foot-bridge upstream of the Grace power plant in 2006. The fish was 281 mm long and weighed 294 grams. The fish was in very good condition with a relative weight of 122.

4.5.4 Reach 4—Above Grace Power Plant

Five species were collected in reach 4 for a total catch of 47 fish with a biomass of 1.91 kg (Table 4.5-4). Longnose dace were the most abundant (27 fish; 57% of the catch) followed by mottled sculpin (7; 15%), rainbow trout (6; 13%), redside shiner (6; 13%), and Utah sucker (1; 2%) (Figure 4.5-1). Rainbow trout accounted for a large majority of the biomass (84%; 1600 g). The remaining 16% of the biomass was comprised of longnose dace (7%; 134 g), mottled sculpin (3%; 66 g), redside shiner (3%; 58 g), and Utah sucker (3%; 52 g) (Figure 4.5-2).

Table 4.5-4: Fish density and biomass per 100 meters in reach 4, October 2006

Species	N	Weight (g)	CPUE (fish / minute)
Longnose Dace (*Rhinichthys cataractae*)	27 (57%)	134 (7%)	1.10
Small Mouth Bass (*Micropterus dolomieu*)	0	0	0
Mottled Sculpin (*Cottus bairdi*)	7 (15%)	66 (3%)	0.29
Common Carp (*Cyprinus carpio*)	0	0	0
Redside Shiner (*Richardsonius balteatus*)	6 (13%)	58 (3%)	0.25
Utah Sucker (*Catostomus ardens*)	1 (2%)	52 (3%)	0.04
Rainbow Trout (*Oncorhynchus mykiss*)	6 (13%)	1600 (84%)	0.25
Total	47	1910	1.93

Catch per unit effort was greatest for longnose dace (1.10 fish/minute) followed by mottled sculpin (0.29 fish/minute), rainbow trout (0.25 fish/minute), redside shiner (0.25 fish/minute), and Utah sucker (0.04 fish/minute) (Figure 4.5-3).

A total of 6 rainbow trout were collected in reach 4. Two of the 6 fish were marked with freeze-brands and 4 fish had no mark. Both of the freeze-brands were on the left side below the dorsal fin and had the same orientation (upright T), indicating they were from the same cohort. This particular location of the freeze-brands indicated that these fish were released in 2006 and the orientation indicated they were released at the foot bridge upstream of the Grace power plant.

The 6 rainbow trout collected in reach 4 ranged in length from 259 mm to 356 mm and had a mean length of 298 mm (Table 4.5-5). They ranged in weight from 176 g to 482 g with a mean weight of 267 g. The length-frequency distribution of the 6 rainbow trout collected in reach 4 indicates they were likely from the same age class (Figure 4.5-4).

Table 4.5-5: Rainbow Trout lengths and weights in reach 4, October 2006

Number	Freeze brand	Length (mm)	Weight (g)	Relative Weight
1	Footbridge 2006	290	196	74
2	Footbridge 2006	294	216	78
3	None	285	230	91
4	None	259	176	93
5	None	304	300	98
6	None	356	482	98
	Average	298	267	89

Figure 4.5-4: Length frequency distribution for RBT in reach 4, October 2006

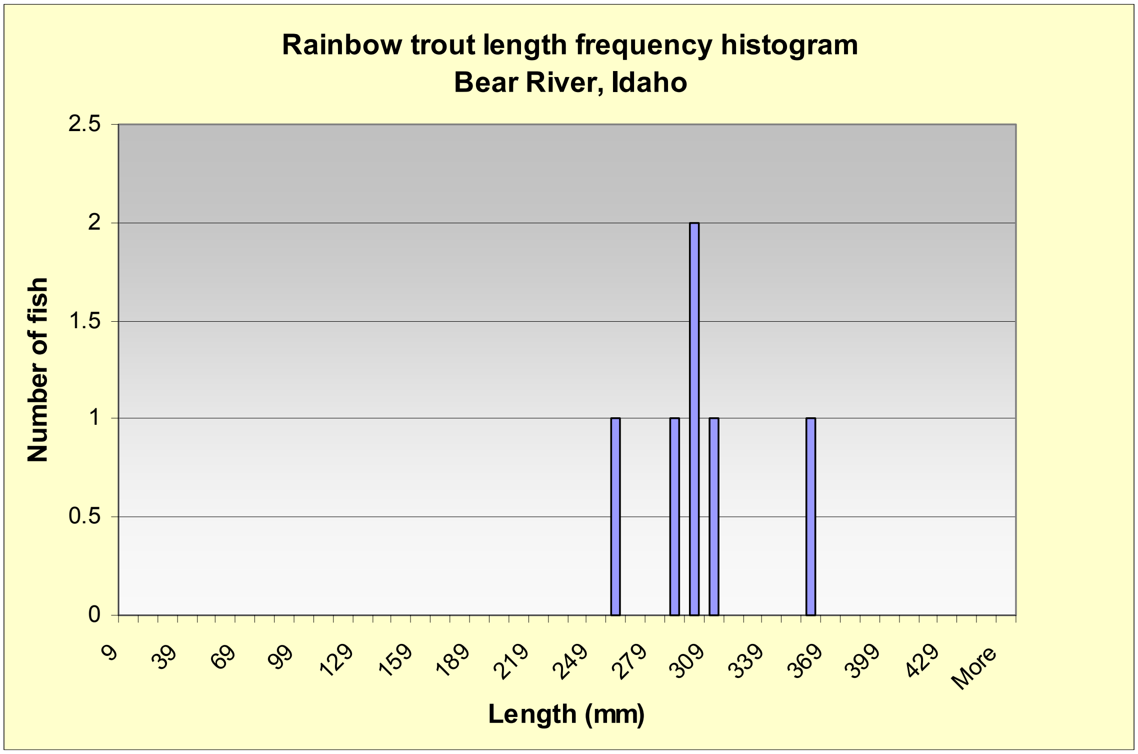
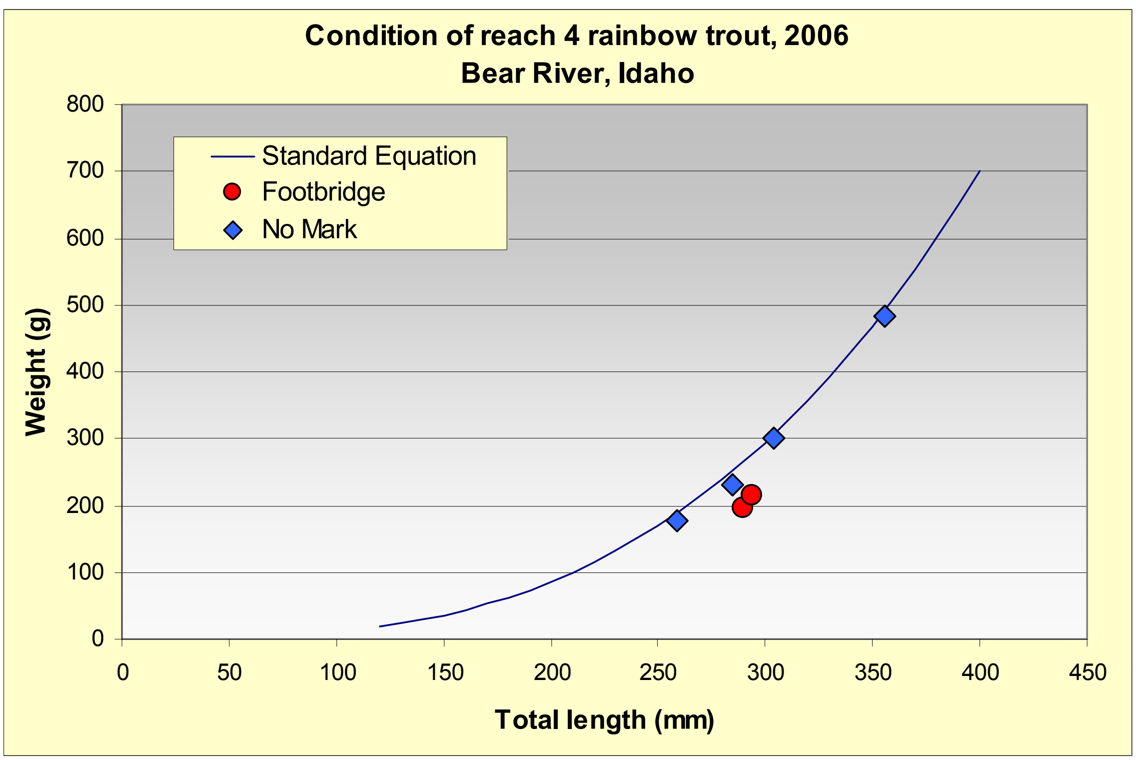


Figure 4.5-5. Length-weight relationship for rainbow trout in reach 4, October 2006



Overall, the relative weights of the 6 rainbow trout collected in reach 4 fell below the standard weight-length curve (Wr = 100) (Figure 4.5-5). The mean relative weight (Wr) for all 6 rainbows was 89 and ranged from 74 to 98 (Table 4.5-5). For the 2 freeze-branded fish, the mean relative weight was 76 and ranged from 74 to 78. For the 4 un-marked fish, the mean relative weight was 95 and ranged from 91 to 98.

4.5.5 Within Reach Comparisons—2005 and 2006

Species richness was greater in 2006 for reach 1 than in 2005. Five species were collected in reach 1 in 2006 compared to four species in 2005 (Table 4.5-6). Longnose dace, small mouth bass, mottled sculpin, and common carp were collected in both sample years, however one juvenile Utah sucker was collected in 2006 while none were collected in 2005.

Table 4.5-6: Fish density and biomass for reach 1, October 2005 and 2006

Species	2005			2006		
	N	Weight (g)	CPUE (fish / minute)	N	Weight (g)	CPUE (fish / minute)
Longnose Dace	55 (65%)	362 (5%)	3.29	14 (36%)	78 (29%)	0.83
Small Mouth Bass	1 (1%)	30 (<1%)	0.06	9 (23%)	40 (15%)	0.53
Mottled Sculpin	26 (31%)	260 (4%)	1.56	12 (31%)	94 (35%)	0.71
Common Carp	2 (2%)	6654 (91%)	0.12	3 (8%)	48 (18%)	0.18
Redside Shiner	0	0	0	0	0	0
Utah Sucker	0	0	0	1 (3%)	10 (4%)	0.06
Rainbow Trout	0	0	0	0	0	0
Total	84	7306	5.03	39	270	2.31

Species richness was much greater in reach 2 in 2006 than in 2005 (Table 4.5-7). Four species were collected in 2006 while only 2 were collected in 2005. Longnose dace and small mouth bass were present in both sample years, but redside shiner and Utah sucker were only collected in 2006.

Table 4.5-7: Fish density and biomass for reach 2, October 2005 and 2006

Species	2005			2006		
	N	Weight (g)	CPUE (fish / minute)	N	Weight (g)	CPUE (fish / minute)
Longnose Dace	33 (97%)	257 (97%)	1.52	29 (88%)	206 (84%)	1.28
Small Mouth Bass	1 (3%)	8 (3%)	0.05	1 (3%)	8 (3%)	0.04
Mottled Sculpin	0	0	0	0	0	0
Common Carp	0	0	0	0	0	0
Redside Shiner	0	0	0	2 (6%)	20 (8%)	0.09
Utah Sucker	0	0	0	1 (3%)	12 (5%)	0.04
Rainbow Trout	0	0	0	0	0	0
Total	34	265	1.57	33	246	1.45

Species richness was greater in 2006 than in 2005 in reach 3 (Table 4.5-8). Five species were collected in 2006 and four species were collected in 2005. Longnose dace, redside shiner, and Utah sucker were collected in both sample years while small mouth bass were collected only in 2005 and a single rainbow trout was collected in 2006.

Table 4.5-8: Fish density and biomass for reach 3, October 2005 and 2006

Species	2005 N	2005 Weight (g)	2005 CPUE (fish / minute)	2006 N	2006 Weight (g)	2006 CPUE (fish / minute)
Longnose Dace	5 (4%)	22 (5%)	0.43	3 (3%)	12 (2%)	0.23
Small Mouth Bass	1 (1%)	4 (<1%)	0.09	0	0	0
Mottled Sculpin	0	0	0	0	0	0
Common Carp	0	0	0	0	0	0
Redside Shiner	101 (85%)	392 (83%)	8.71	73 (82%)	240 (31%)	5.48
Utah Sucker	12 (10%)	56 (12%)	1.03	12 (13%)	234 (30%)	0.09
Rainbow Trout	0	0	0	1 (1%)	294 (38%)	0.08
Total	119	474	10.26	89	780	5.88

Reach 4 was the only reach where species richness was equal in 2005 and 2006 (Table 4.5-9). Longnose dace, mottled sculpin, redside shiner, Utah sucker, and rainbow trout were all collected in both years of the study.

Table 4.5-9: Fish density and biomass for reach 4, October 2005 and 2006

Species	2005 N	2005 Weight (g)	2005 CPUE (fish / minute)	2006 N	2006 Weight (g)	2006 CPUE (fish / minute)
Longnose Dace	39 (39%)	263 (4%)	2.59	27 (57%)	134 (7%)	1.10
Small Mouth Bass	0	0	0.00	0	0	0
Mottled Sculpin	27 (27%)	180 (3%)	1.80	7 (15%)	66 (3%)	0.29
Common Carp	0	0	0.00	0	0	0
Redside Shiner	10 (10%)	92 (1%)	0.67	6 (13%)	58 (3%)	0.25
Utah Sucker	2 (2%)	58 (1%)	0.13	1 (2%)	52 (3%)	0.04
Rainbow Trout	22 (22%)	6308 (91%)	1.46	6 (13%)	1600 (84%)	0.25
Total	100	6901	6.65	47	1910	1.93

In reach 1, longnose dace accounted for a majority of the relative species composition in both 2005 (65% of catch) and 2006 (36%) (Figure 4.5-6). Mottled sculpin were the second most abundant in both years (31% of the catch). Small mouth bass comprised only 1% of the catch in 2005 but accounted for 23% in 2006.

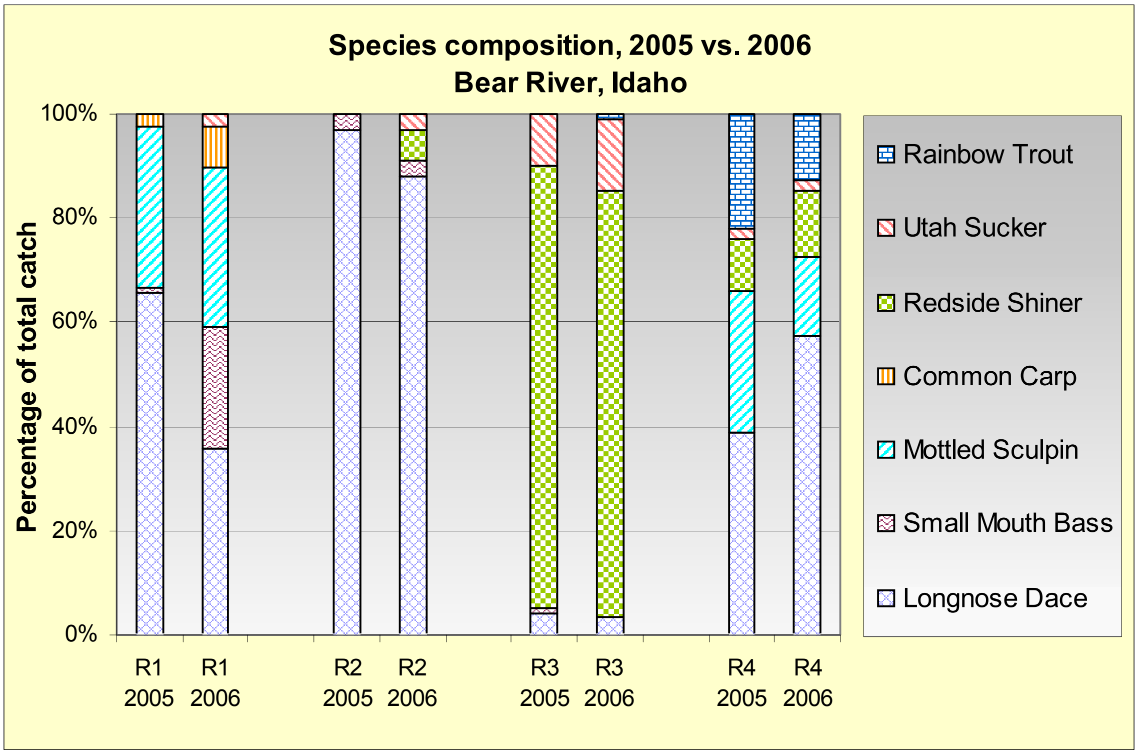
In reach 2, longnose dace were by far the most abundant in both 2005 (97%) and 2006 (88%) (Figure 4.5-6), and small mouth bass comprised 3% of the catch in both years. Redside shiner (6%) and Utah sucker (3%) accounted for only a small proportion of the catch in 2006, however neither of these species were collected in this reach in 2005.

Redside shiner were the most abundant species in reach 3 in both 2005 (85%) and 2006 (82%) followed in both years by Utah sucker (10% in 2005; 13% in 2006) (Figure 4.5-6). Longnose dace were a small proportion of the catch in both 2005 (4%) and 2006 (3%). A single rainbow trout was collected in 2006 in reach 3.

In reach 4, longnose dace accounted for a majority of the relative species composition in both 2005 (39% of catch) and 2006 (57%), and mottled sculpin were the second most abundant in both years (27 % in 2005; 15% in 2006) (Figure 4.5-6). Rainbow trout were the third most abundant species in both 2005 (22%) and 2006 (13%) followed in both years by redside shiner (10% in 2005; 13% in 2006).

In reach 1, the total biomass was 7.31 kg in 2005 but was only 0.27 kg in 2006 (Table 4.5-6). The large difference in total biomass comes mainly as a result of collecting two large adult common carp in 2005 while only 3 small juvenile carp were collected in 2006. Accordingly, common carp accounted for 91% of the biomass in 2005 at 6.65 kg while in 2006 they accounted for only 18% at 0.05 kg (Figure 4.5-7). However, longnose dace and mottled sculpin biomass also decreased between 2005 and 2006.

Figure 4.5-6: Species composition for reaches 1, 2, 3, and 4, 2005 and 2006



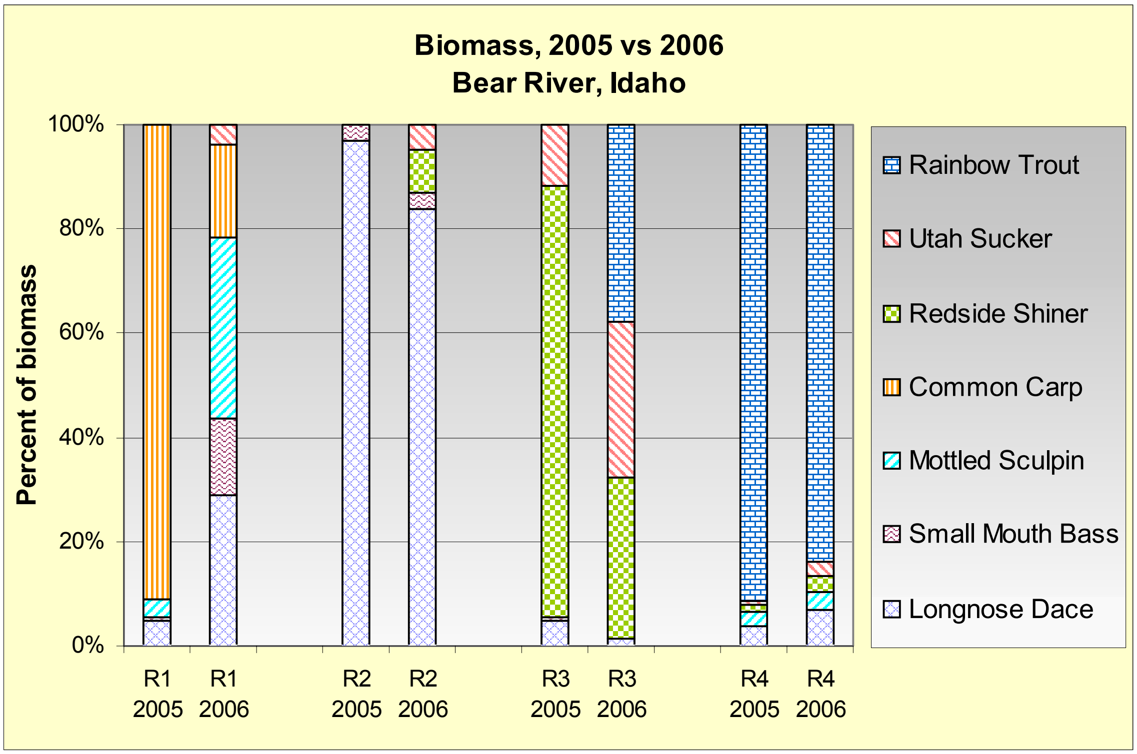
Total biomass in reach 2 was very similar between 2005 and 2006 at 0.27 kg and 0.25 kg respectively (Table 4.5-7). Longnose dace comprised a large majority of the biomass in both years (97% in 2005; 84% in 2006) while small mouth bass accounted for just 3% in both years (Figure 4.5-7). Redside shiner and Utah sucker also accounted for a small portion of the biomass in 2006.

In reach 3, total biomass was greater in 2006 (0.78 kg) than in 2005 (0.47 kg) (Table 4.5-8). A majority of the difference in total biomass was due to the presence of a single 0.29 kg rainbow trout collected in 2006. Rainbow trout were not collected in reach 3 in 2005. Accordingly, rainbow trout made up a majority of the biomass in 2006 (0.29 kg; 38%) while redside shiner comprised a majority of the biomass in 2005 (0.39 kg; 83%) (Figure 4.5-7). Utah sucker accounted for 12% of the biomass in 2005 (0.06 kg). In 2006 Utah sucker were 30% of the biomass (0.23 kg).

Total biomass in reach 4 was considerably greater in 2005 than in 2006 (6.90 kg and 1.91 kg, respectively) (Table 4.5-9). This decrease in total biomass was consistent with a decrease in the number of rainbow trout collected in 2006. However, rainbow trout still accounted for the large majority of the biomass in both years (91% in 2005 and 84% in 2006) (Figure 4.5-7). In both years, the remainder of the biomass was comprised of small percentages of longnose dace, mottled sculpin, redside shiner, and Utah sucker.

In reach 1, total catch was considerably higher in 2005 (84 fish) than in 2006 (39 fish) (Table 4.5-6). Accordingly, catch per unit effort (CPUE) was also considerably higher in 2005 (5.03 fish/minute) than in 2006 (2.31 fish/minute).

Figure 4.5-7: Biomass for reaches 1, 2, 3, and 4, 2005 and 2006



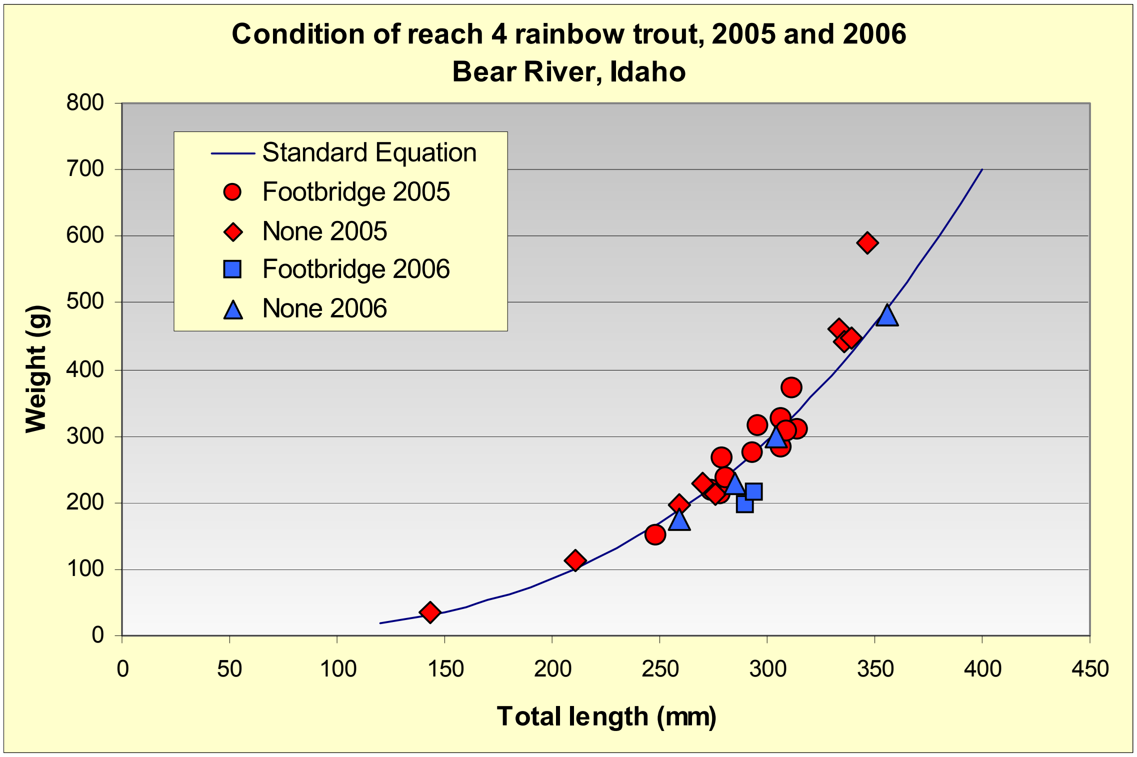
Total catch in reach 2 was very similar between 2005 and 2006 with 34 and 33 fish, respectively (Table 4.5-7). Consequently, CPUE was similar with a rate of 1.57 fish / minute in 2005 and 1.45 fish / minute in 2006.

Total catch in reach 3 was 119 fish in 2005 and 89 fish in 2005 (Table 4.5-8). However, due to additional effort in 2006, CPUE was considerably higher in 2005 at 10.26 fish / minute than the 5.88 fish / minute in 2006.

In reach 4, total catch was much higher in 2005 (100 fish) while only 47 fish were collected in 2006 (Table 4.5-9). As a result, CPUE was also considerably greater in 2005 (6.65 fish/minute) compared to (1.93 fish/minute) in 2006.

Overall, the condition (relative weight) of rainbow trout in reach 4 was lower in 2006 than in 2005 (Figure 4.5-8). Mean relative weight of rainbow trout in 2006 was 89 (Table 4.5-5) while in 2005 it was 104. The mean relative weight of freeze-branded hatchery released fish was lower in 2006 at 76 compared to 100 in 2005. The mean relative weight of fish without freeze-brands was 95 in 2006 compared to 109 in 2005. However, due to the small sample sizes, statistical tests were not able to be performed to determine if these differences were significant.

Figure 4.5-8: Length-weight relationship for rainbow trout in reach 4, 2005 and 2006



4.6 TEMPERATURE

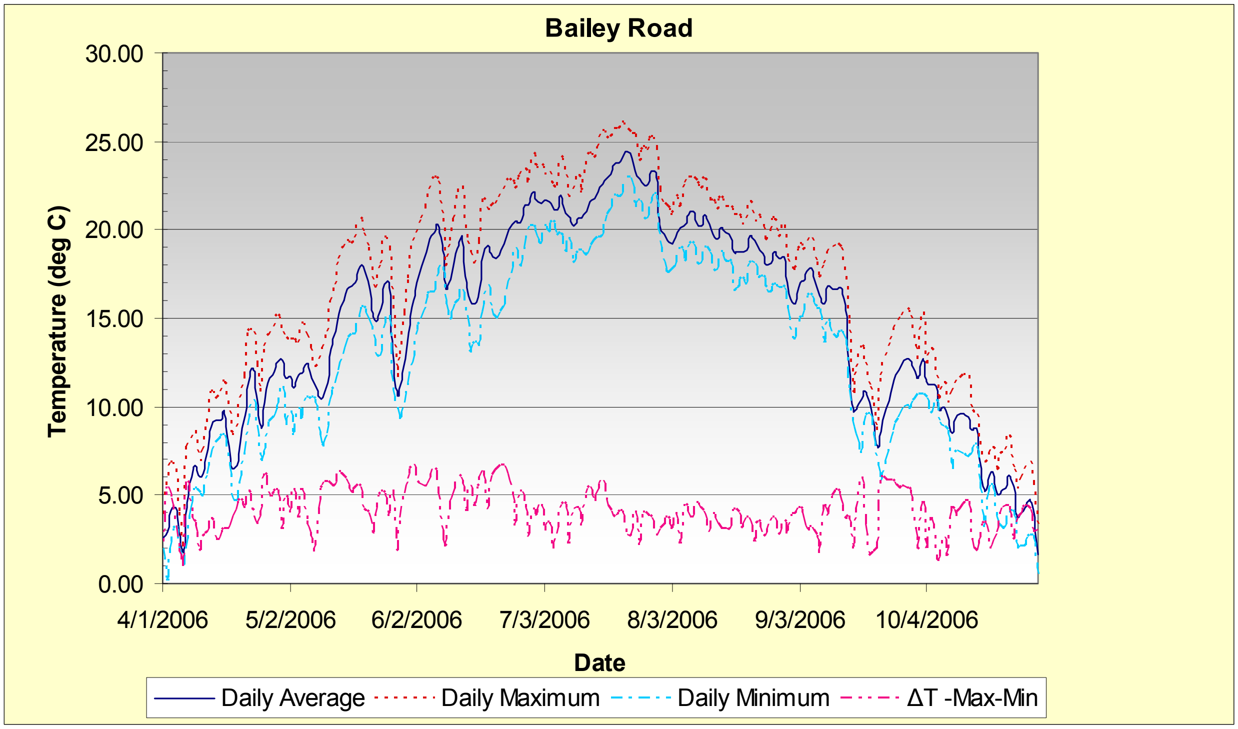
Water temperature can be a critical factor limiting the distribution and abundance of aquatic species particularly coldwater fishes. For this reason analysis of water temperature at respective study sites was included in this report. Idaho DEQ staff deployed hobo temps in study reaches 1, 2, 3 and 4. Dates of deployment varied for respective sites depending on ease of access to the site. For example, in reach 3 the hobo temp was deployed on July 5, 2006 whereas the hobo temp in reach 2 adjacent to highway 34 has nearly continuous data since June 18, 2004. Data analysis for the 2006 report was restricted to dates between April 1, 2006 and October 31, 2006. For salmonids temperature can be a limiting factor during the summer and accompanying shoulder seasons.

Daily average, minimum and maximum temperatures as well as the range of difference between the minimum and maximum were calculated from the hourly data for each study reach respectively (Figures 4.6-1, 4.6-2 4.6-3 and 4.6-4). Water temperatures in each respective study reach display varying degrees of response to meteorological conditions coupled with surface water heating in upstream impoundments. Daily maximum water temperature for each study reach was plotted alongside discharge below Grace Dam for comparison between sites and to evaluate the influence of surface water spills from Grace Dam on water temperatures at the three sites in the Black Canyon (Figure 4.6-5). The difference in maximum temperature, ΔT, relative to reach 2 was plotted for reaches 1, 3 and 4 respectively to analyze longitudinal maximum water temperature differences between sites (Figure 4.6-6).

In reach 1 average stream temperatures exceeded 20 ºC from June 25 to July 31, 2006. Daily maximum temperatures were consistently above 20 ºC from June 18 through August 25, 2006. In 2005 maximum daily water temperatures remained above 20 ºC from June 30 through August

29, 2005. The maximum temperature in reach 1 was 26.1 ºC recorded on July 22, 2006. Coincidentally, the reach 1 2005 maximum stream temperature of 25.8 ºC was also recorded on July 22. Diel temperature fluctuations (maximum minus minimum daily temperature) during the summer months (June 21 through September 21, 2006) in reach 1 averaged 3.8 ºC compared to an of 4.0 ºC for that same time period in 2005.

Figure 4.6-1: Water temperature in reach 1, 2006



Reach 2 daily average water temperatures were greater than 20 ºC from June 29 to August 12, 2006 (Figure 4.6-2). Daily maximum temperatures were consistently above 20 ºC from June 22 through August 19, 2006. A maximum stream temperature of 24.6 ºC was recorded on July 25, 2006 in reach 2. In 2005 a maximum of 23.9 ºC was recorded in reach 2 on July 1, 2005. Daily maximum stream temperatures in reach 2 below Grace Dam were 1 ºC cooler on average than those recorded in reach 1 upstream of Soda Reservoir for the summer season (Figure 4-6.5). Diel temperature fluctuations during the summer months in reach 2 averaged 1.3 ºC indicating a substantially narrower range in daily temperature fluctuations relative to reach 1.

Temperature monitoring in 2006 was initiated on July 5 with deployment of a hobo temp. Daily average stream temperatures exceeded 20 ºC from the time of deployment to July 31 (Figure 4.6-3). Daily maximum temperatures were consistently above 20 ºC from deployment through September 6, 2006. A maximum stream temperature of 27.1 ºC was recorded on July 21, 2006 in reach 3. This was the highest stream temperature recorded for all reaches in 2006. Stream temperature data was not available for 2005. Diel temperature fluctuations during the summer months in reach 3 averaged 6 ºC, the widest daily fluctuation of the four study reaches. Daily maximum stream temperatures in reach 3 were 2.2 ºC warmer on average than those recorded in reach 2 below Grace Dam (Figure 4-6.5) indicating thermal warming between reach 2 and 3.

Figure 4.6-2: Water temperature in reach 2, 2006

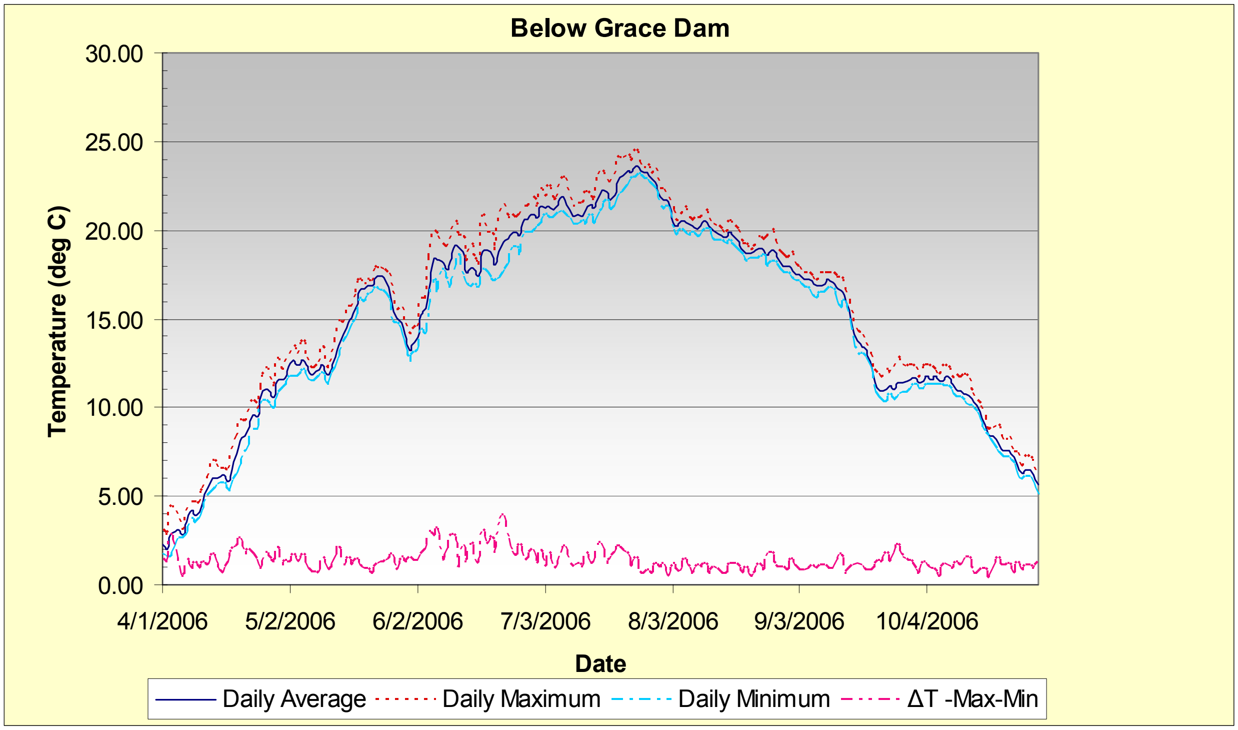
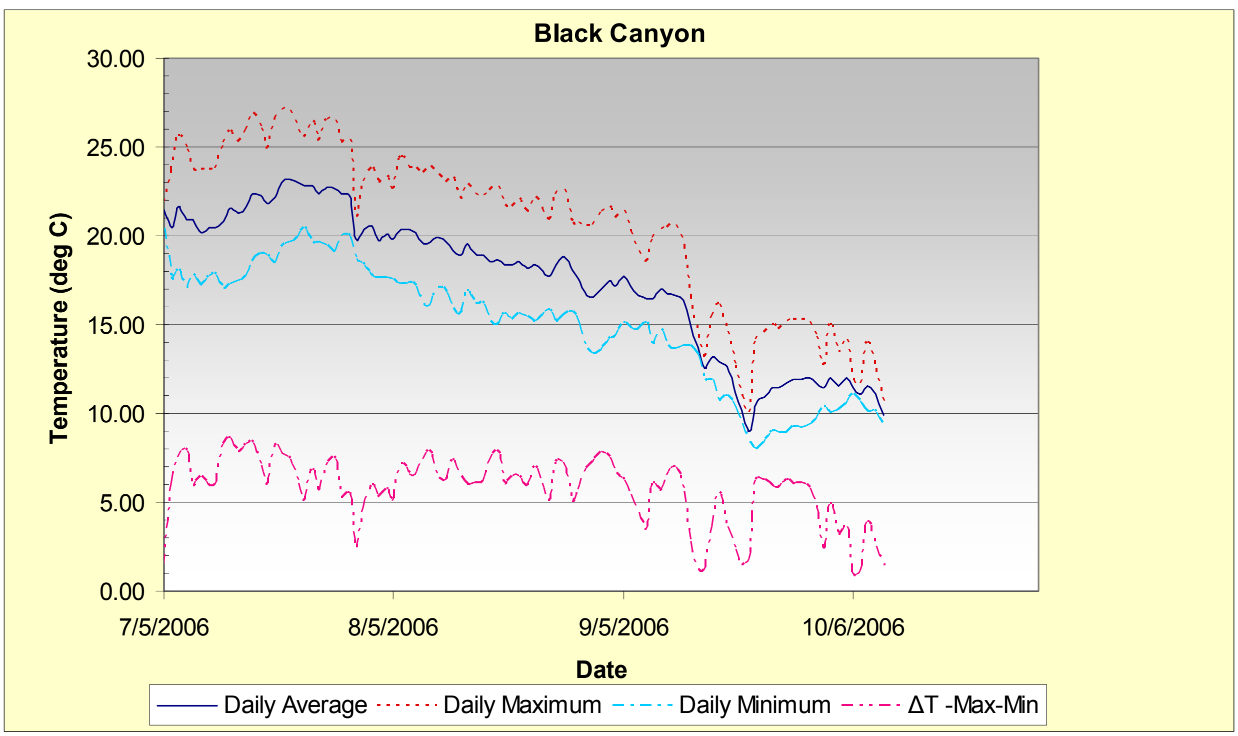


Figure 4.6-3: Water temperature in reach 3, 2006



Reach 4 daily average water temperatures never exceeded 20 ºC in 2006 (Figure 4.6-4). Temperature data was only available through August 9, 2006. This data appears to have sufficiently bracketed the peak stream temperatures expected during the summer season for reach 4 based on analysis of temperature data from the upstream reaches. Reach 4 possessed the coolest water temperatures of the four study reaches in 2006. The highest daily average stream temperature in reach 4 was 17.4 ºC on July 19, 2006. Daily average stream temperatures typically ranged from 15 ºC to 17 ºC for much of the summer. Daily maximum temperatures in reach 4 also remained below 20 ºC except on July 19, 2006 when stream temperatures peaked at 20.1 ºC. In 2005 the maximum water temperature in reach 4 was 22.9 ºC recorded on July 25, 2005. Diel temperature fluctuations during the summer months in reach 4 averaged 3.5 ºC. Reach 4 daily maximum temperatures averaged 4.3 ºC cooler each day than reach 2 below Grace Dam for the summer season.

Figure 4.6-4: Water temperature in reach 4, 2006

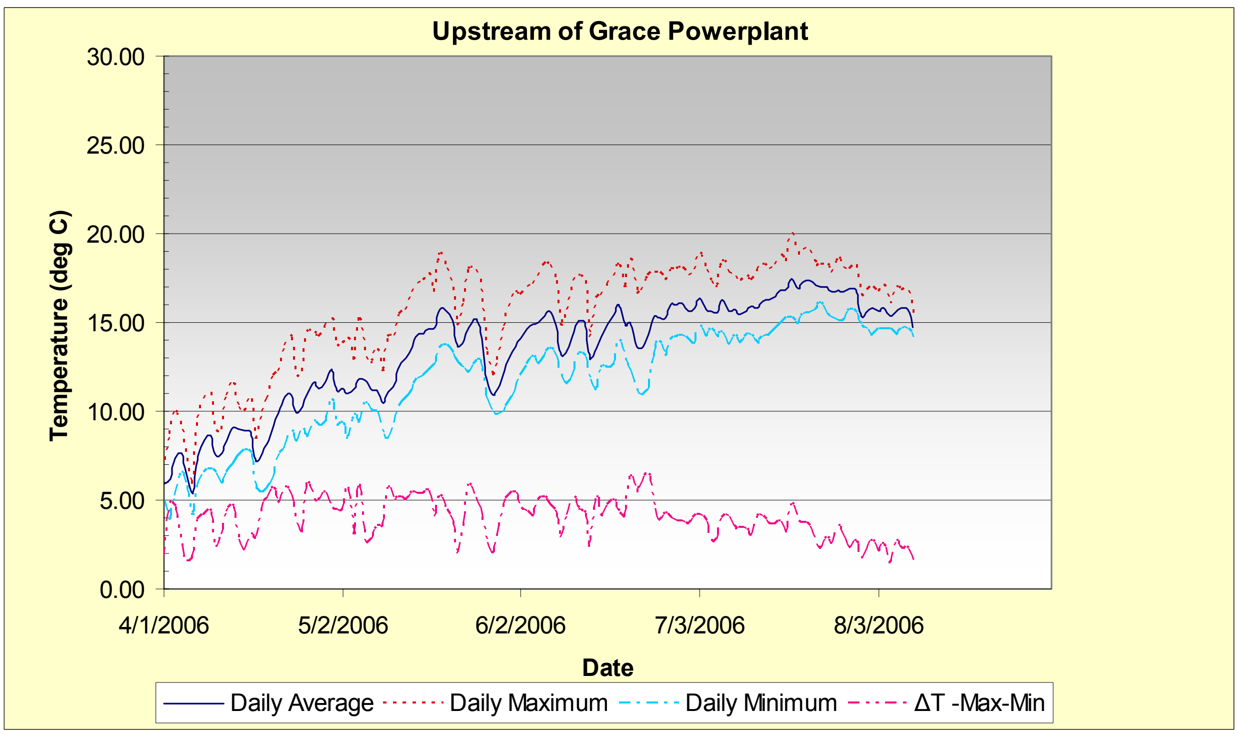
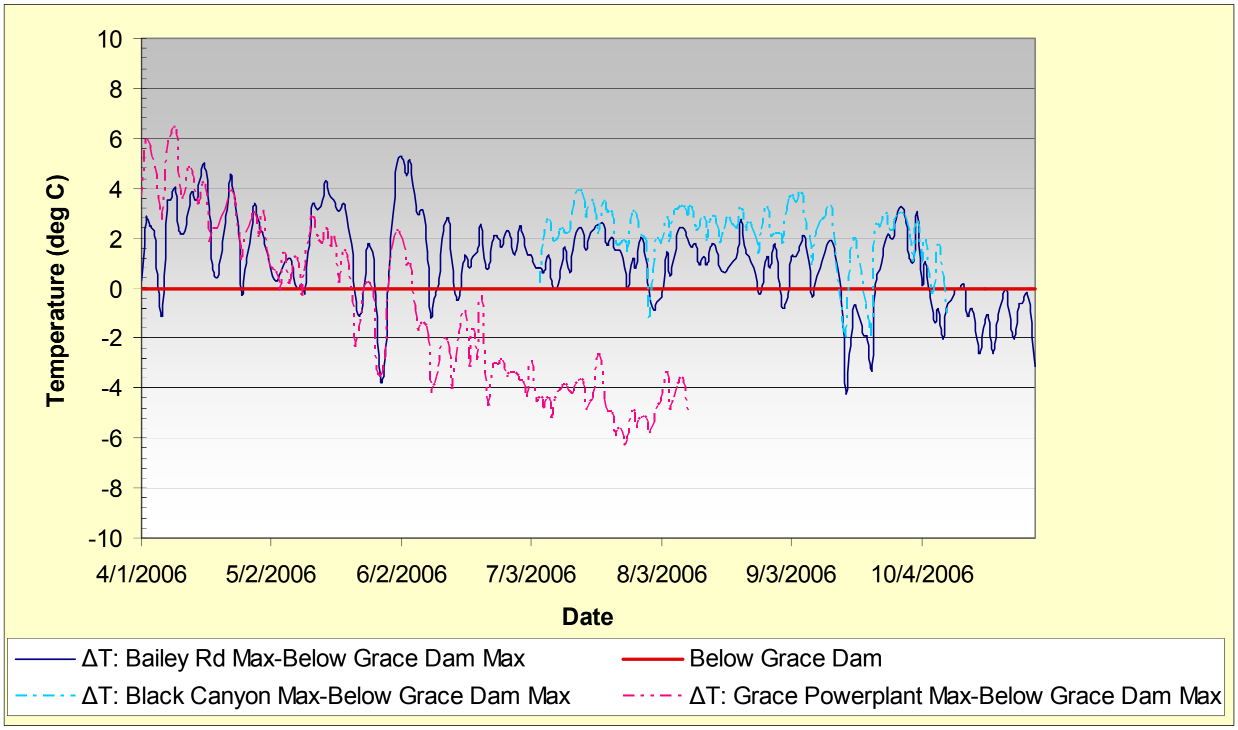
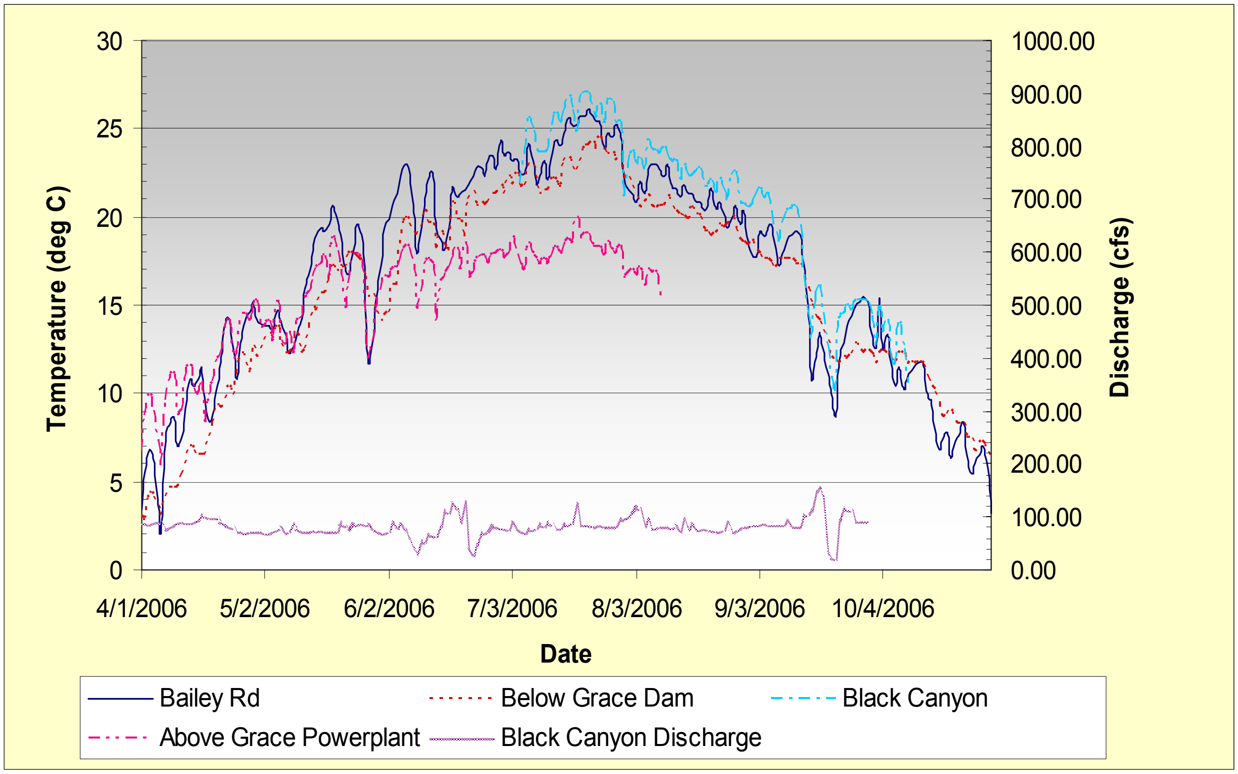


Figure 4.6-5: Daily max. water temperature differences, ΔT, between reaches, 2006



In the 2006 summer season daily average discharge from Grace Dam typically fluctuated from 70 to 85 cfs. Several small spikes occurred during this summer time frame; 128 cfs on June 21; 122 cfs on July 22, 115 cfs on August 4 and 152 cfs on September 18. The absence of substantial changes in discharge during the summer season make it difficult to detect if there was an interaction between changes in discharge at Grace Dam and stream temperatures in reaches 2, 3 and 4 (Figure 4.6-6). Daily maximum stream temperatures in reach 4 increased approximately 1 ºC from the previous day on June 21 and July 19 corresponding to discharge increases from Grace Dam. Meteorological data has not been included in the analysis to factor in the influence of air temperatures. The hobo temp in reach 4 was no longer in service during the biggest discharge release on September 18th to assess potential stream temperature changes although during this time period maximum stream temperatures in reaches 2 and 3 were already hovering around 15 ºC.

Figure 4.6-6: Maximum water temperatures in reaches 1, 2, 3 and 4, 2006



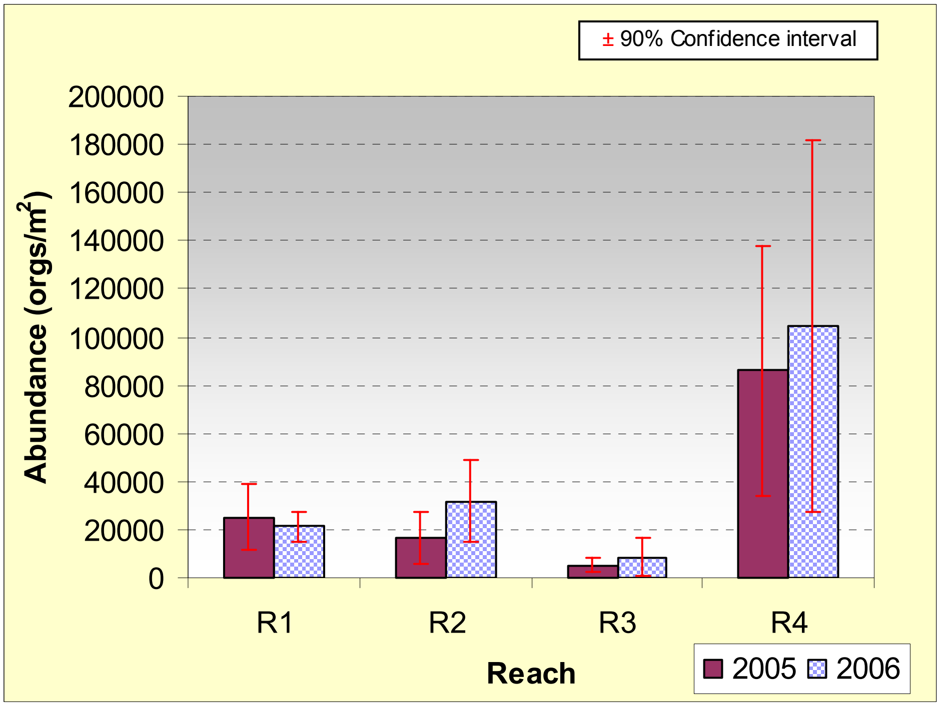
4.7 BENTHIC MACROINVERTEBRATES

BMI density (Figure 4.7-1) was significantly different between the four study reaches (p=0.01, single factor ANOVA). Reach 4 contained the highest BMI density (104,430 organisms/m^2) of all four study reaches. Reach 4 BMI density was five-times greater than reach 1 (21,190 organisms/m^2), three-times greater than reach 2 (31,929 organisms/m^2) and twelve-times greater than reach 3 (8,621 organisms/m^2). Reach 3 contained the lowest BMI density in 2006.

The 2006 BMI density was not significantly different from 2005 BMI densities for paired comparisons of respective reaches (Student's t-test, alpha 0.10). In reaches 2, 3 and 4 the 2006 BMI density was greater than the 2005 BMI densities but not significant. The largest difference in BMI density between sample years occurred in reach 2 where BMI density increased nearly two-fold in 2006 compared to 2005 (16,402 organisms/m^2 in 2005 compared to 31,929 organisms/m^2). The 2006 BMI density in reach 1 (25,144 organisms/m^2) was lower than the 2005 BMI density but not significant (21,190 organisms/m^2).

EPT density (Figure 4.7-2) varied significantly between the four study reaches (p=0.00006, single factor ANOVA). EPT density was substantially greater in reach 1 (13,415 organisms/m^2) than reaches 2, 3 and 4 (1,244 organisms/m^2, 2,125 organisms/m^2 and 2,310 organisms/m^2 respectively). In reach 1 EPT comprised 61 percent of the overall BMI density compared to 4 percent, 16 percent and less than 1 percent in reaches 2, 3 and 4 respectively.

Figure 4.7-1: BMI Density, 2005 and 2006



The 2006 EPT density in reach 1 was lower than the EPT density observed in 2005 but not significant (Student's t-test, alpha 0.10). The 2006 EPT density in reaches 2 and 3 was more than double the 2005 EPT density but not significant. In reach 4, the 2006 EPT density (2,310 organisms/m^2) was five times greater (p=0.06, Student's t-test) than the 2005 EPT density (412 organisms/m^2). Ephemeroptera taxa, specifically Baetis tricaudatus and Baetis spp. as well as Trichoptera taxa, specifically Hydroptila sp. were more common in 2006 than 2005 in reach 4. No Plecoptera taxa were observed in reach 4 in 2005 or 2006. The EPT percentage of the overall BMI community was nearly identical in respective reaches between the 2005 and 2006 sample events. Species richness was similar in reaches 1, 2 and 3 with 39 species present respectively (Figure 4.7-3). Reach 4 had the lowest diversity with 34 species present. Species richness in 2006 was similar to that observed in the 2005 for reaches 1 and 2. In reach 3 there were 6 fewer species observed in 2006 than 2005 but this difference was not significant (Student's t-test, alpha 0.10). In reach 4 species richness increased by 8 species in 2006 (34 species observed) compared to 2005 (p=0.05, Student's t-test).

EPT species richness (Figure 4.7-4) was significantly different between the four study reaches in 2006 (p = 0.000000009, single factor ANOVA). Reach 1 above Soda Reservoir had the highest EPT richness (16) followed by Reach 3 (10), Reach 2 (5) and Reach 4 (5). In reaches 2 and 3 EPT richness was similar in 2005 and 2006. In reaches 1 and 4 EPT richness in 2006 increased significantly compared to the 2005 results (p=0.06 and p=0.005 respectively, Student's t-test). In reach 4 three new Ephemeroptera taxa were present in 2006 not previously observed in 2005; Baetis sp., Ephemerella sp. and Fallceon quilleri. The Ephemeroptera Tricorythodes sp. observed in 2005 in reach 4 was not found in 2006. Three new Trichoptera taxa were observed in reach 4 in 2006; Chimarra sp., Glossosomatidae and Neotrichia sp.. The Trichiptera taxa, Amiocentrus aspilus and Nectopsyche sp., previously found in reach 4 in 2005 were not observed in 2006.

Figure 4.7-2: EPT Abundance, 2005 and 2006

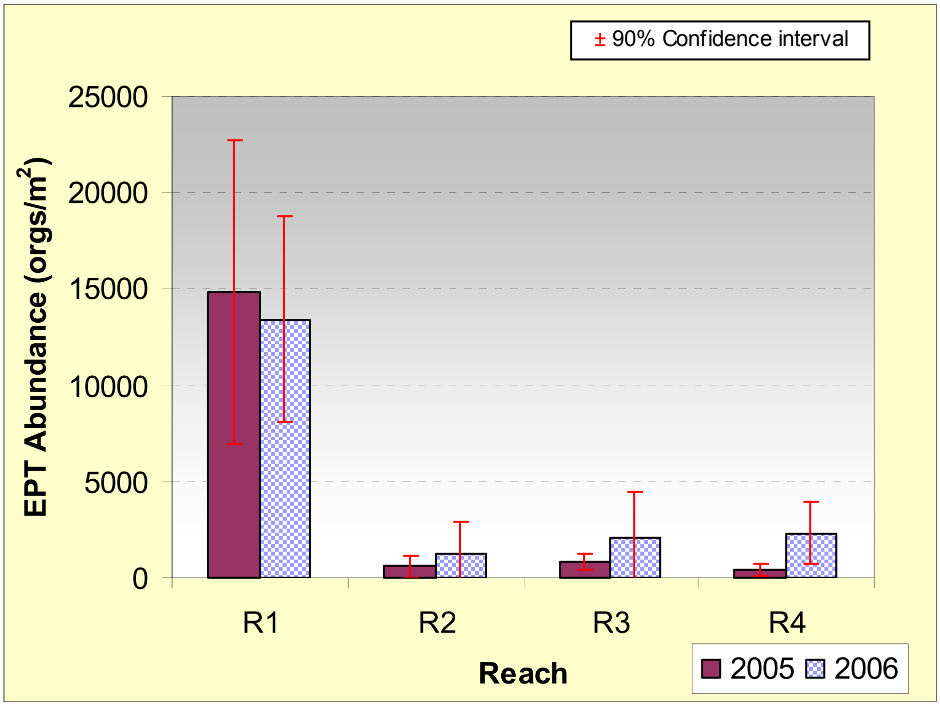


Figure 4.7-3: BMI species richness, 2005 and 2006

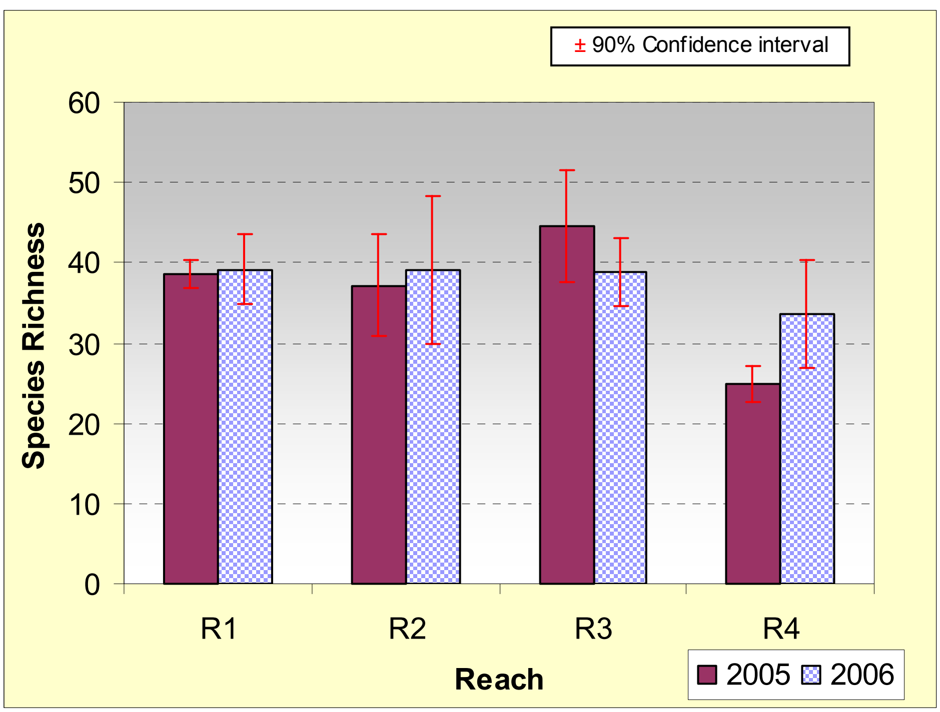
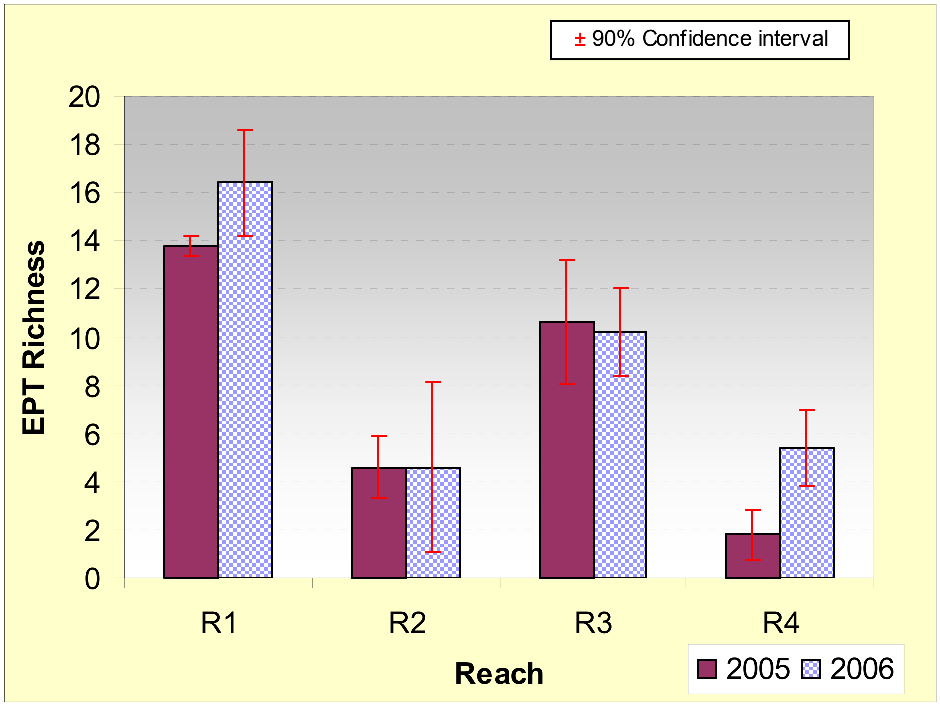


Figure 4.7-4: EPT species richness, 2005 and 2006



Dominant taxa measures reveal the density of individual taxa among the larger BMI community. In Reach 1, the top three dominant taxa comprised 41% of the BMI density; dominant taxa 1—17%, dominant taxa 2—13% and dominant taxa 3—11% (Table 4.7-1). Dominant taxa alternated between the five transects per reach. Dominant taxa 1 included an Ephemeroptera taxa in two transects (Ephemerella infrequens), a Diptera taxa in two transects (Simulium) and a trichiptera taxa (Hydropsyche sp.). Percentages for the 2006 top three dominant taxa respectively were similar to results observed in 2005 (Figure 4.7-5) including similar dominant taxa.

In reach 2, the top three dominant taxa comprised 47% of the BMI density (dominant taxa 1—25%, dominant taxa 2—12% and dominant taxa 3—10%). The dominant taxa in reach 2 alternated between transects; Microtendipes pedellus gr. (transect A), Simulium (transect B), Ostracoda (transect C) and the water mite Hygrobates sp. (transects D and E). The second dominant taxa in four of the reach 2 transects was two Chironmidae taxa (Parakiefferiella sp. and Pseudochironomus sp.). Turbellaria was the other dominant taxa in the fifth transect of reach 2. The 2006 dominant taxa percentages and representative taxa in reach 2 were comparable to results from 2005.

In Reach 3, the top three dominant taxa comprised 33% of the BMI density (dominant taxa 1—13%, dominant taxa 2—10% and dominant taxa 3—10%). The dominant taxa changed with each successive transect; Pseudochironomus sp. (transect A), Hygrobates sp. (transect B), Petrophila sp. (transect C), Turbellaria (transect D) and Prostoma sp. (transect E). The 2006 dominant taxa percentage was significantly lower than 2005 (p=0.008, Student's t-test).

In Reach 4, the top three dominant taxa comprised 79% of the BMI density (dominant taxa 1—70%, dominant taxa 2—5% and dominant taxa 3—4%). The gastropod, Hydrobiidae was the dominant taxa in all five of the reach 4 transects in 2006. This taxa was not present in the 2005 reach 4 samples nor was it found in reaches 1, 2 or 3 in 2006. The Gastropod, Potamopyrgus antipodarum, was the dominant taxa in all reach 4 transects in 2005 (70.3 percent). In 2006 this taxa was the second dominant taxa in two of the five reach 4 transects but only comprised 5 percent of the BMI community—dramatically reduced with the presence of Hydrobiidae in this reach. Turbellaria, Simulium and Pseudochironomus sp. were the second dominant taxa in the remaining three transects in reach 4.

Table 4.7-1: Top three dominant taxa percentages, 2005 and 2006

Reach	Dominant Taxa 1 (%)		Dominant Taxa 2 (%)		Dominant Taxa 3 (%)		Totals (%)	
	2005	2006	2005	2006	2005	2006	2005	2006
R1	20.2	17.3	12.5	12.6	8.9	10.6	41.6	40.5
R2	31.6	25.2	12.4	12.3	9.9	9.5	53.9	47.0
R3	21.7*	13.4	9.8	10.4	8.4	9.7	40.0	33.4
R4	79.6	70.3	5.3	5.3	3.1	3.9	88.0	79.4

*p=0.008

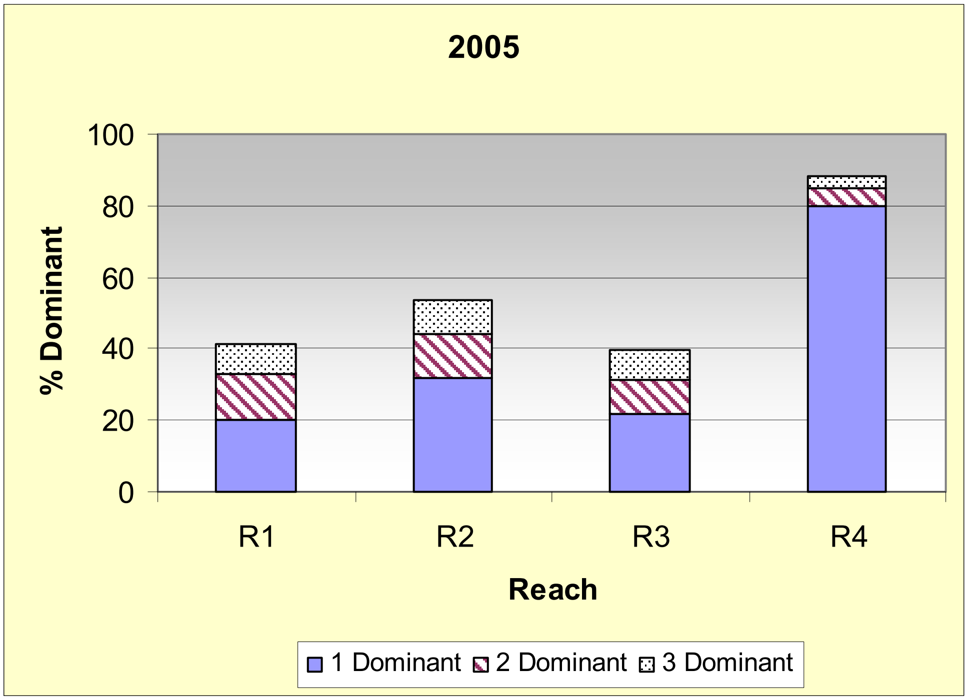
BMI community composition varied between reaches in 2006 (Figure 4.7-6). Table 4.7-2 lists the density per square meter and relative abundance for all taxonomic orders present at each respective study reach. In reach 1 community composition was dominated by the following taxonomic groups in descending order of community percentage; Diptera (35%), Trichoptera (32%) and Ephemeroptera (31%). The remaining orders were less than 1 percent of the community composition respectively including Plecoptera (<1%). In 2005 the BMI community composition consisted of Ephemeroptera (38%), Diptera (35%), Trichoptera (20%) and Annelida (4%). Trichoptera occupy a larger percentage of the BMI community in 2006.

In Reach 2 the BMI community composition was dominated by the following taxonomic groups in descending order; Diptera (44%), Acarina (20%), other organisms (13%), Crustacea (11%), Annelida (5%), Trichoptera (4%) and Bivalvia (3%). The order Ephemeroptera was less than 1 percent of the BMI community. The order Plecoptera was not present in reach 2 in 2006. The 2005 BMI community composition was also dominated by Diptera (43%) followed by Crustacea (26%), Acarina (12%), and other organisms (12%). Acarina comprise nearly double the community composition in 2006 compared to 2005 while Crustacea occupy less than half of the percentage observed in 2005.

The BMI community composition in reach 3 had the most balanced distribution of taxonomic orders relative to reaches 1, 2 and 4. The following taxonomic orders were present in descending order; Diptera (33%), Trichoptera (21%), Acarina (17%), Colepotera (13%), Lepidoptera (9%), other organisms (4%) and Ephemeroptera (3%). Lepidoptera were more common in reach 3 relative to reaches 1, 2 and 4. Plecoptera were not present in reach 3 in 2006. This balanced distribution of taxonomic orders was similar to that observed in 2005 for reach 3.

Reach 4 was dominated by the order Gastropoda (77%) followed by Diptera (15%), other organisms (3%) and Acarina (2%). Ephemeroptera made up only one percent of the BMI community in reach 4 in 2006. Plecoptera were not present. Reach 4 was the only site where gastropods were present. The 2006 community composition was similar to that observed in 2005.

Figure 4.7-5: Top three dominant taxa; 2005 and 2006



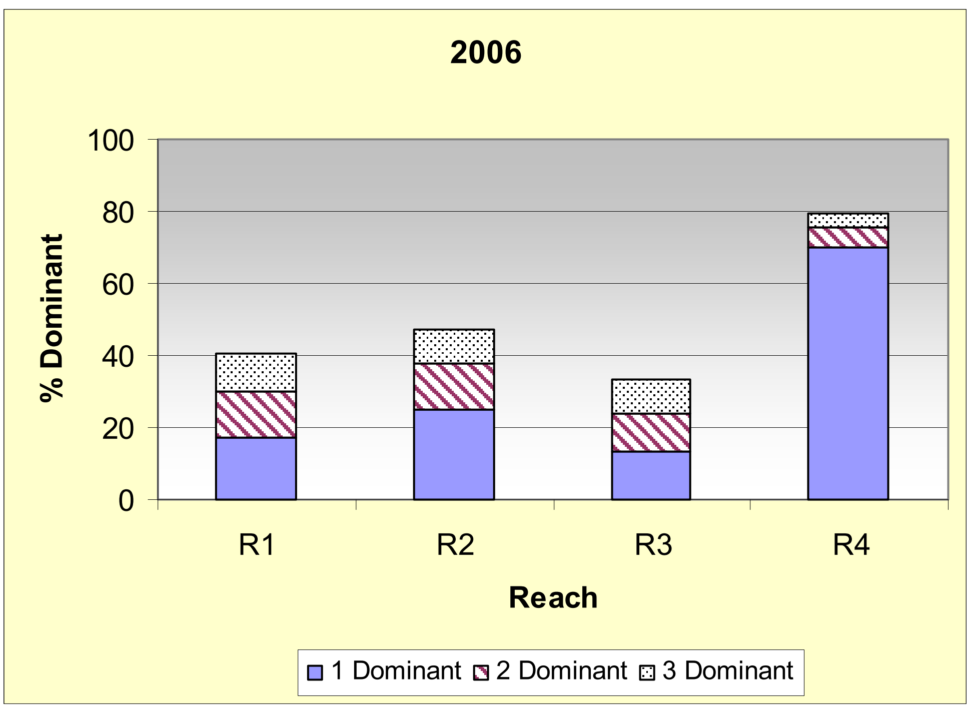


Table 4.7-2: BMI relative abundance by taxonomic order, 2006

Taxonomic Order	Reach 1		Reach 2		Reach 3		Reach 4	
	No./m^2	%	No./m^2	%	No./m^2	%	No./m^2	%
Ephemeroptera	6,544	30.9%	116	0.4%	295	3.4%	1,188	1.1%
Plecoptera	81	0.4%	0	0.0%	2	0.0%	0	0.0%
Trichoptera	6,798	32.1%	1,128	3.5%	1,827	21.2%	1,116	1.1%
Odonata	6	0.0%	83	0.3%	2	0.0%	59	0.1%
Coleoptera	73	0.3%	73	0.2%	1,086	12.6%	1,040	1.0%
Diptera-Chironomidae	4,438	20.9%	11,444	35.8%	2,453	28.5%	11,744	11.3%
Diptera	2,838	13.4%	2,171	6.8%	324	3.8%	3,484	3.3%
Lepidoptera	83	0.4%	24	0.1%	767	8.9%	0	0.0%
Gastropoda	0	0.0%	17	0.1%	0	0.0%	79,890	76.7%
Bivalvia	90	0.4%	1,096	3.4%	2	0.0%	341	0.3%
Annelida	158	0.7%	1,683	5.3%	41	0.5%	227	0.2%
Acarina	72	0.3%	6,502	20.4%	1,431	16.6%	1,554	1.5%
Crustacea	14	0.1%	3,383	10.6%	36	0.4%	497	0.5%
Other Organisms	8	0.0%	4,207	13.2%	351	4.1%	2,991	2.9%
Total Organisms/m2	21,202	100.0%	31,927	100.0%	8,618	100.0%	104,131	100.0%

BMI functional feeding group composition differed between reaches in 2006 (Figure 4.7-7). Reach 1 consisted of filter feeders (40%), gatherers (35%), shredders (14%), scrapers (7%) and predators (4%). This represents a small increase in filter feeders and a decrease in shredders over 2005 observations. Other functional groups were similar between sample years.

In reach 2 predators were the most common functional group (38%) followed by gatherers (33%), filter feeders (16%), shredders (12%) and lastly scrapers (1%). The 2006 gatherer community decreased by 21% compared to the 2005 results. Filter feeders increased by 16% compared to 2005.

Reach 3 consisted of gatherers (34%), predators (33%), scrapers (19%), filter feeders (12%) and shredders (2%). The 2006 results indicate a small increase in scraper, filter feeder and gatherer percentages compared to functional feeding group composition in 2005. The predator feeding group decreased by 9% relative to 2005 results.

In reach 4 scrapers comprised the largest percentage of the functional feeding group composition (76%) followed by gatherers (13%), predators (5%), filterers (5%) and shredders (1%). Scrapers also dominated reach 4 in 2005.

Figure 4.7-6: BMI community composition; reach 1, 2, 3, 4

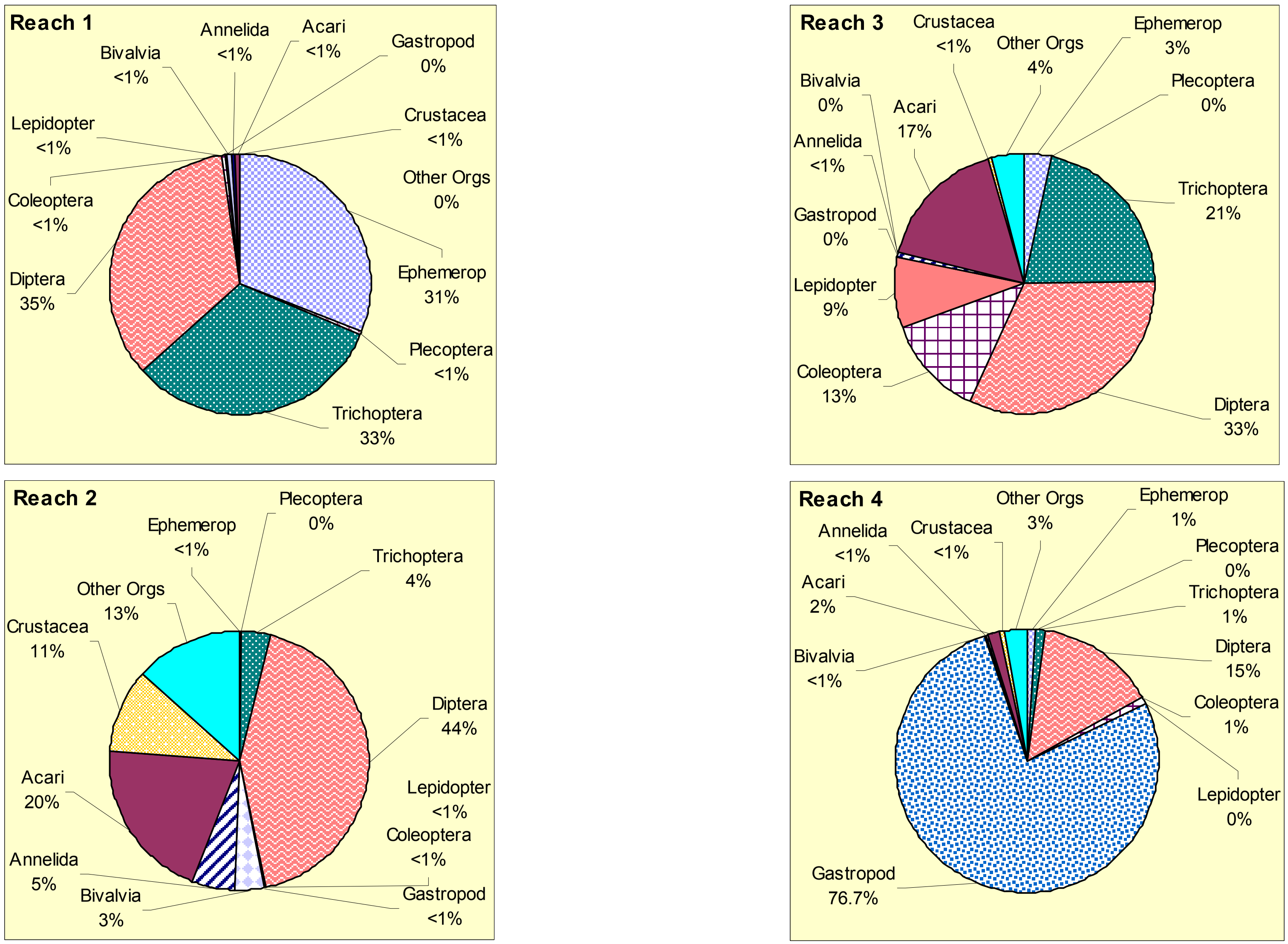
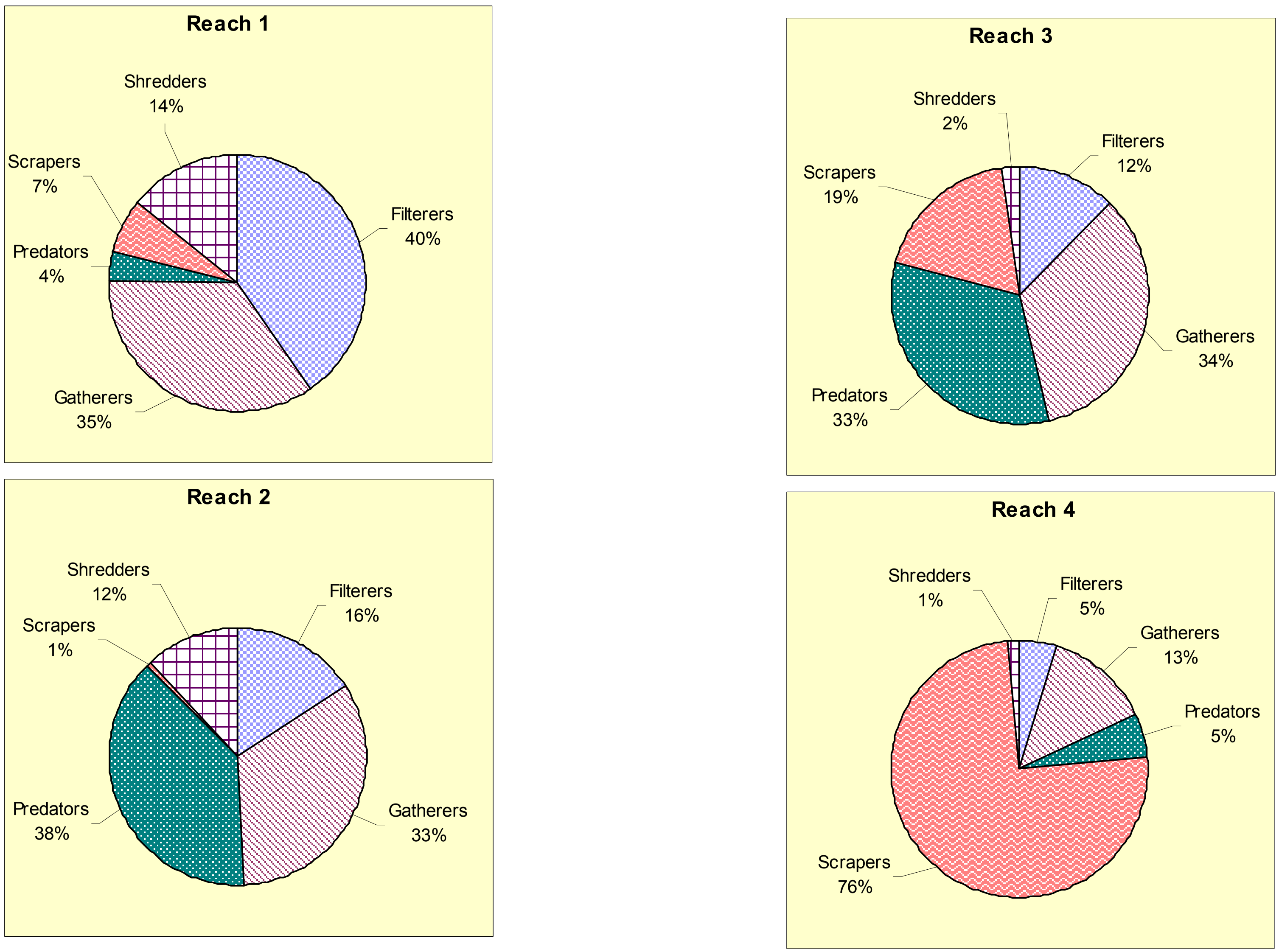


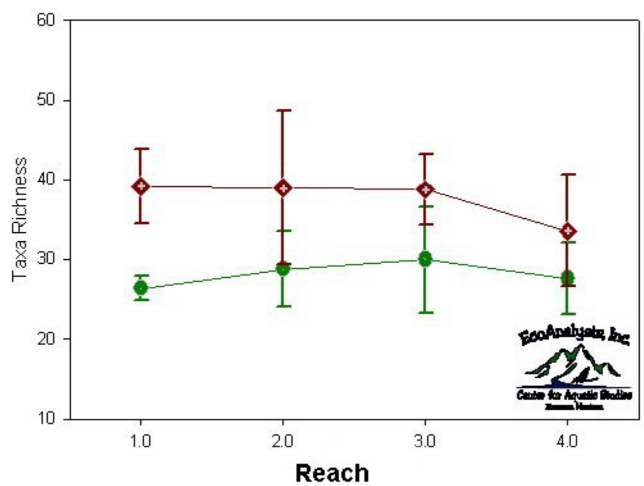
Figure 4.7-7: BMI functional feeding group composition; reach 1, 2, 3, and 4



A statistical power analysis was conducted to assess variability in SS samples verses CS samples using taxa richness. Taxa richness in CS samples was greater in each reach than for the SS samples (Figure 4.7-8). The higher taxa richness in CS samples was likely due to the larger sample size coupled with the increased laboratory effort relative to SS samples (500 organism count compared to 200 organism count).

For each reach the number of taxa required to detect a statistical difference was graphed as a function of the number of replicates (Figure 4.7-9). The number of taxa required to detect a change with five replicate samples (current study design) was identified for SS and CS samples. Based on the 2006 BMI data the sensitivity of five replicate SS and CS samples was different for each reach. In reach 1, SS samples required a minimum change of 2 taxa for statistical significance whereas CS samples required a change in 8 taxa to recognize a statistically significant change in the BMI community. In reach 2, SS samples required a minimum change of 7 taxa for statistical significance whereas CS samples required a change in 16 taxa to recognize a statistically significant change in the BMI community. In reach 3, SS samples required a minimum change of 8 taxa for statistical significance whereas CS samples required a change in 10 taxa to recognize a statistically significant change in the BMI community. In reach 4, SS samples required a minimum change of 10 taxa for statistical significance whereas CS samples required a change in 11 taxa to recognize a statistically significant change in the BMI community. These estimates are conservative because they do not account for the total number of comparisons made among all sites.

Figure 4.7-8: BMI taxa richness for SS and CS samples



A power analysis was also conducted to detect a 10% (4 taxa) change in taxa richness among all four reaches using the calculated Mean Square Error rate (45.8). This analysis estimated the statistical power to detect a 10% increase in taxa richness at each successive reach downstream (16-taxa difference between reach 1 and reach 4). This was performed for the 200-organism, SS samples and the 500-organism CS samples. For the CS samples, the current study design was 71.8% likely to detect an overall difference of 10% among sites. The probability of type-II statistical errors (28.2%) in the analysis could be improved by adding additional samples (Figure 4.7-10). The SS samples were 95% likely to detect a change of 4 taxa along the downstream gradient. For the SS samples the analysis used the MSE of 22.4 and the same number of taxa. Thus, the 5 transects allowed a balance of $\alpha = \beta = 0.10$, but this balance of error-rate could not be achieved by the composite samples until the study was expanded to 8 transects at each site. In other words, the SS samples were more capable of detecting small changes in taxa (4) compared to the CS samples.

Figure 4.7-9: BMI taxa richness power analysis; reach 1, 2, 3 and 4

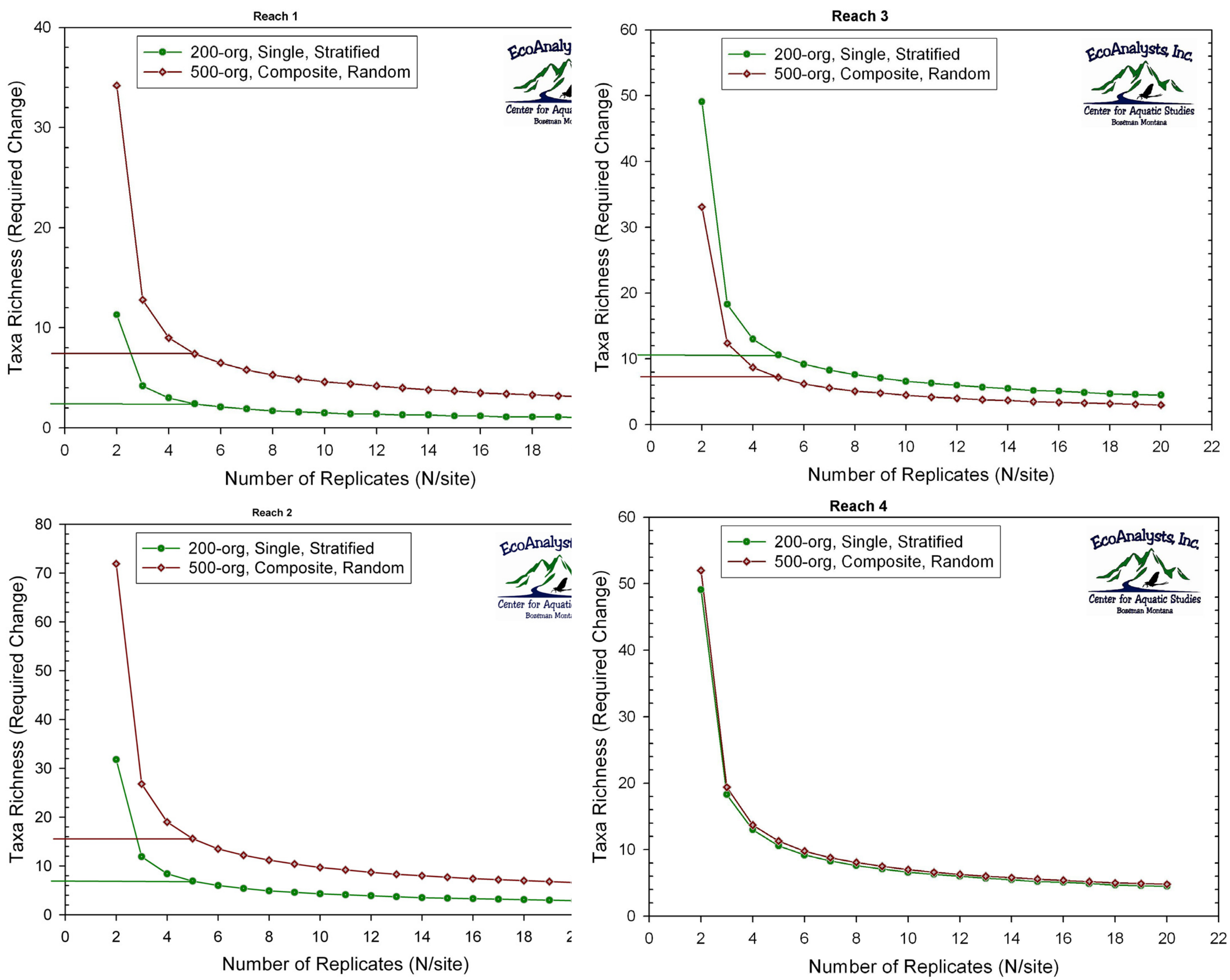
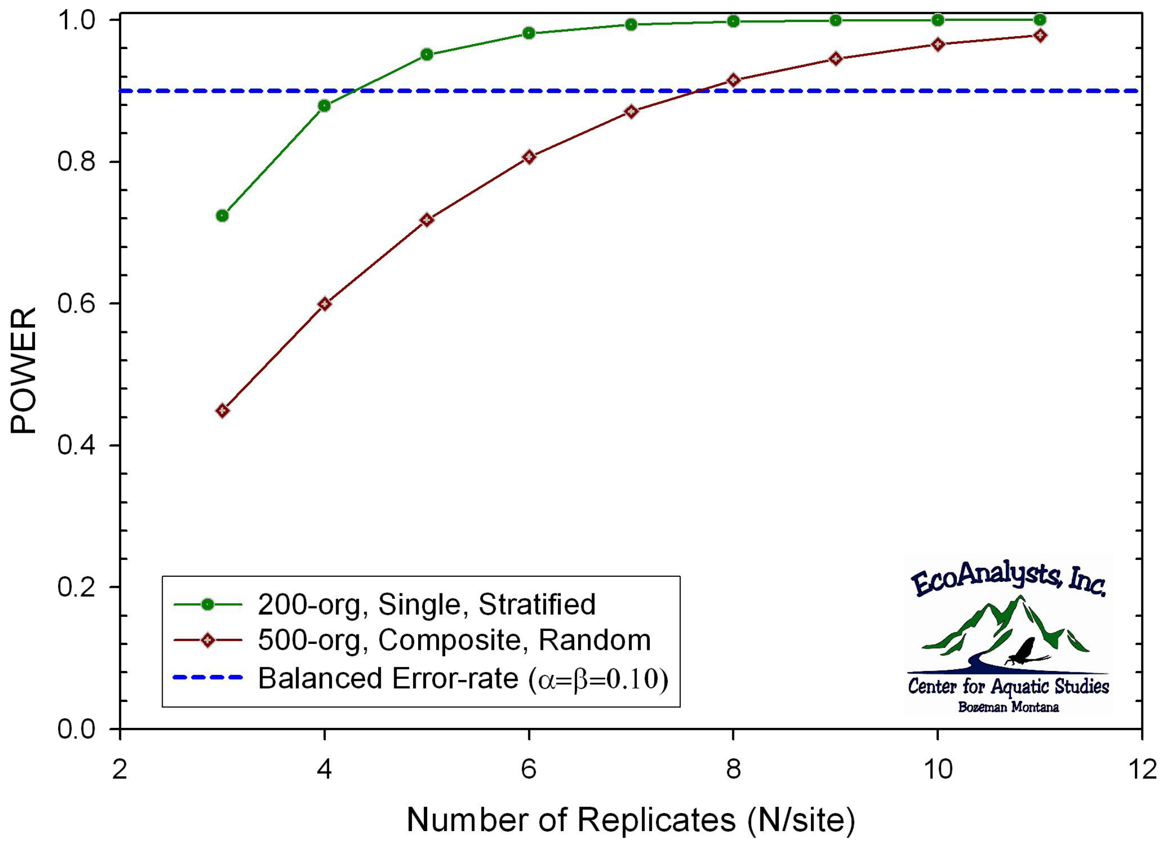


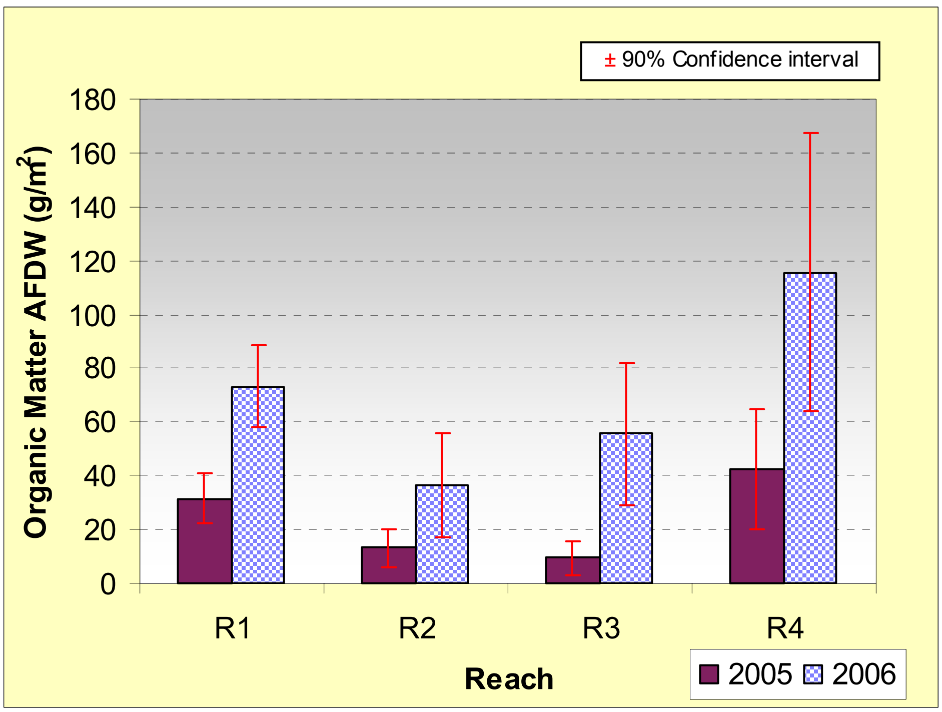
Figure 4.7-10: SS sample and CS sample power analysis



4.8 ORGANIC MATTER ASH-FREE DRY WEIGHT

Organic matter AFDW (Figure 4.8-1) was significantly different between reaches (p=0.01, single factor ANOVA). Reach 4 had the highest organic matter biomass, 115.6 g/m^2. Organic matter AFDW in reaches 1, 2 and 3 was 73.1 g/m^2, 36.5 g/m^2 and 55.6 g/m^2 respectively. The 2006 organic matter AFDW values were significantly greater than values observed in 2005 for paired comparisons of reaches 1, 2, 3 and 4 (p=0.002, p=0.06, p=0.02 and p=0.04 respectively, Student's t-test).

Figure 4.8-1: Organic matter ash-free dry weight, 2005 and 2006



5. DISCUSSION

5.1 CHANNEL SHAPE AND SUBSTRATE

During the 2006 sampling effort stream discharge was higher in both reaches 2 and 3 compared to the 2005 sampling period. Reach 2 had the greatest increase in discharge, 15 cfs, while reach 3 was 6 cfs higher in 2006 based on the specific time survey frames. This increase resulted in slightly larger wetted perimeters and subsequently greater mean wetted perimeter depths in both study reaches.

In 2006, mean wetted perimeter width in reach 2 increased 5.55 meters compared to 2005 and the estimated bankfull width decreased 0.33 meters. This noticeable increase in wetted perimeter width was due to the flat channel profile in transects TC and TD, where small increases in discharge results in larger increases in wetted perimeter widths. Transect TC increased 6.86 meters from 2005 to 2006 and transect TD increased 21.97 meters (Figure 5.1-1). Wetted perimeter widths in the other three transects in reach 2 increased less than 2.0 meters between the 2005 and 2006 surveys. The large wetted perimeter width increase in TD (21.97 meter) was the result of bedrock features that were barely above water during the 2005 sampling period but were inundated in 2006 with the increased discharge. The mean water depths associated with these elevations increased 0.04 meters for wetted perimeter elevations and 0.06 meters for bankfull elevations (Figure 5.1-2). The mean BWD ratio for reach 2 decreased from 241.41 to 185.28 from 2005 to 2006.

The mean wetted perimeter width in reach 3 increased 1.06 meters between 2005 and 2006, while the estimated bankfull width remained the same. Transect TD was the only transect to have a wetted perimeter increase greater than 2.0 meters (Figure 5.1-3). The mean water depth based on the wetted perimeter elevation fell 0.02 meters and rose 0.01 meters based on the bankfull elevation (Figure 5.1-4). The mean BWD ratio for reach 3 increased from 29.12 in 2005 to 31.95 in 2006.

The substrate composition in reach 2 (Figure 5.1-5) and reach 3 (Figure 5.1-6) changed little between the 2005 to 2006 surveys. Both reaches display similar trends with regard to substrate particle size distribution. In reach 2 the 2006 sampling saw a slight increase in boulder and bedrock counts. Boulder counts increased from 4% in 2005 to 11% in 2006 and bedrock counts increased from 10% in 2005 to 18% in 2006. A slight decrease was observed in the percentage of sand and gravel between 2005 and 2006, a drop of 7% and 8% respectively. In reach 3, gravel and cobble counts increased 16% and 9% respectively, while fines, sand and boulder decreased 14%, 8% and 3% respectively.

The channel shape in reaches 2 and 3 did not change significantly between the 2005 and 2006 survey. Erosional or depositional changes were not evident nor was thalweg migration observed in either reach.

Figure 5.1-1: Channel widths; reach 2, 2005 and 2006

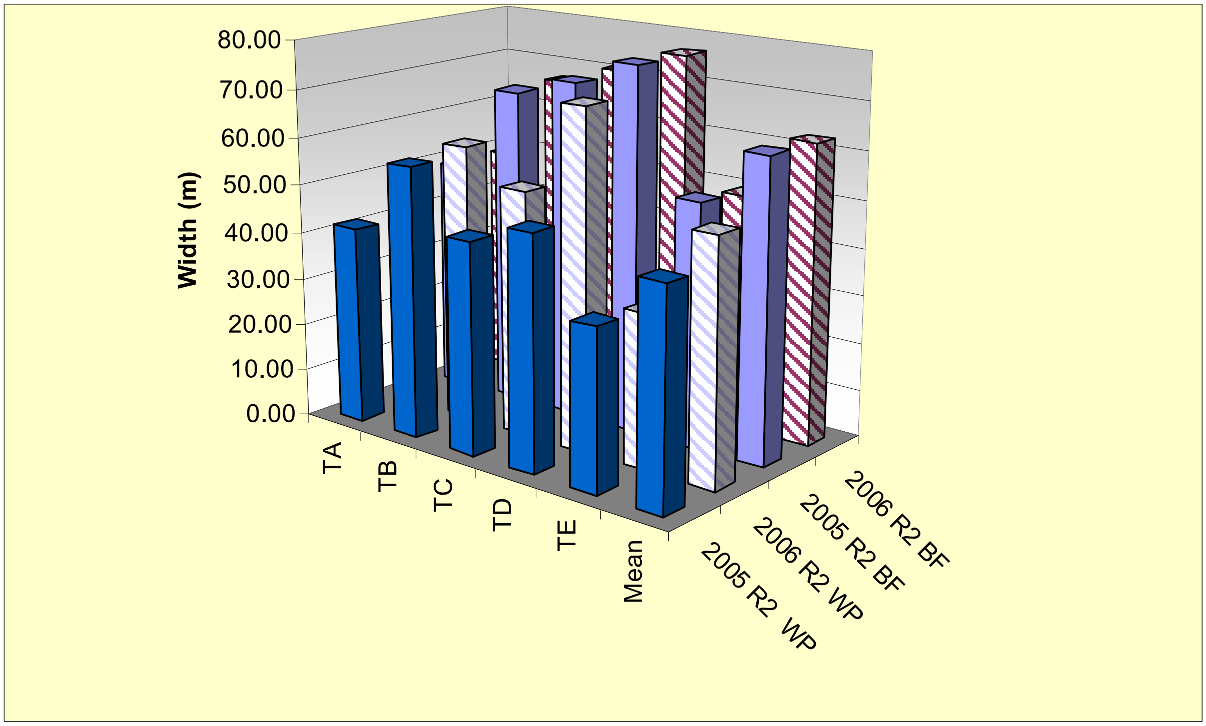


Figure 5.1-2: Channel depth; reach 2, 2005 and 2006

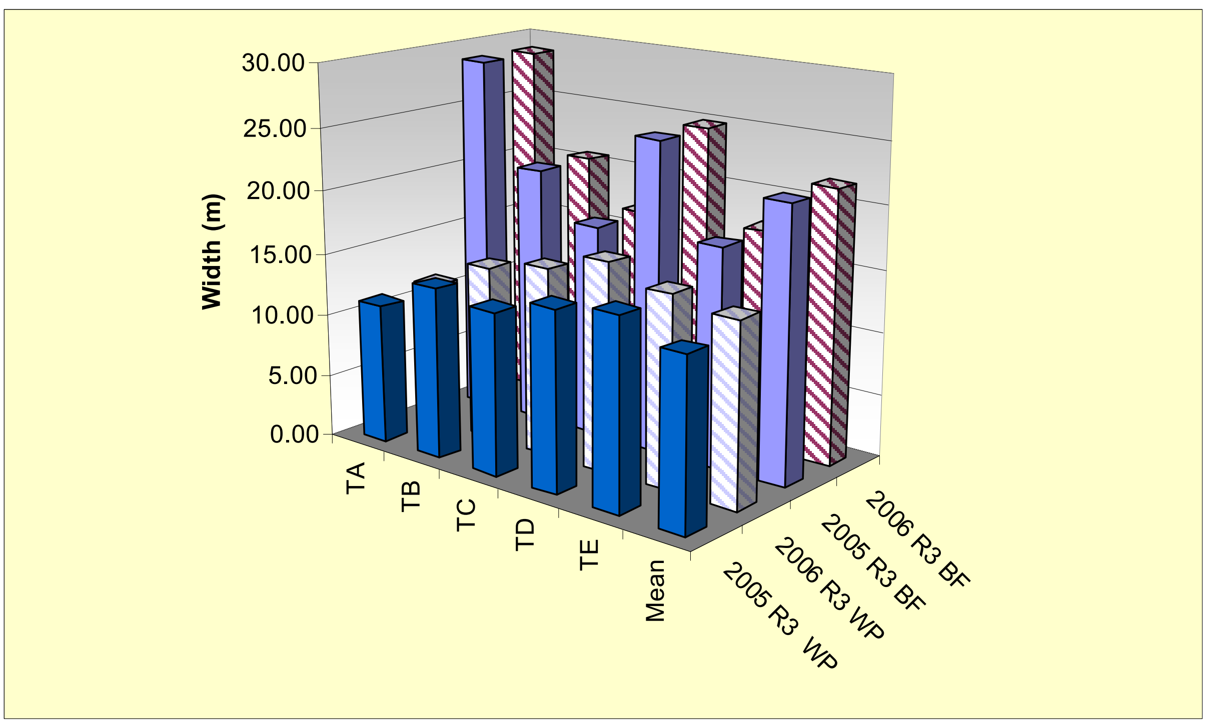


Figure 5.1-3: Channel width; reach 3, 2005 and 2006

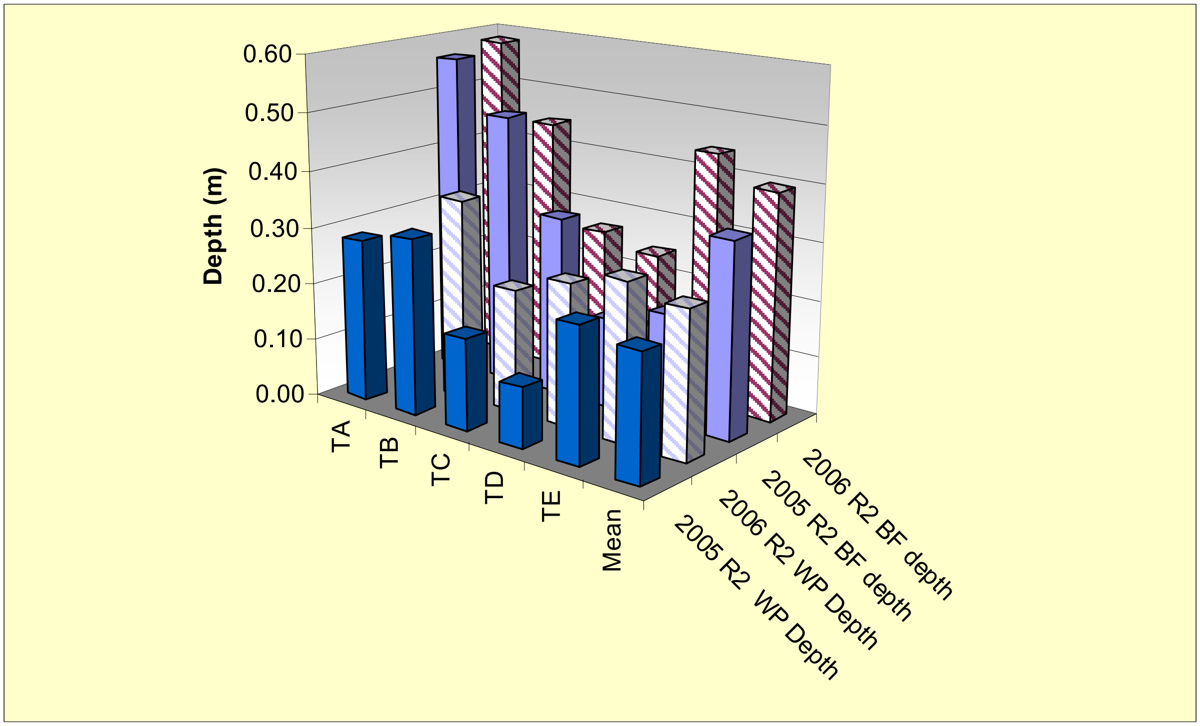


Figure 5.1-4: Channel depth; reach 3, 2005 and 2006

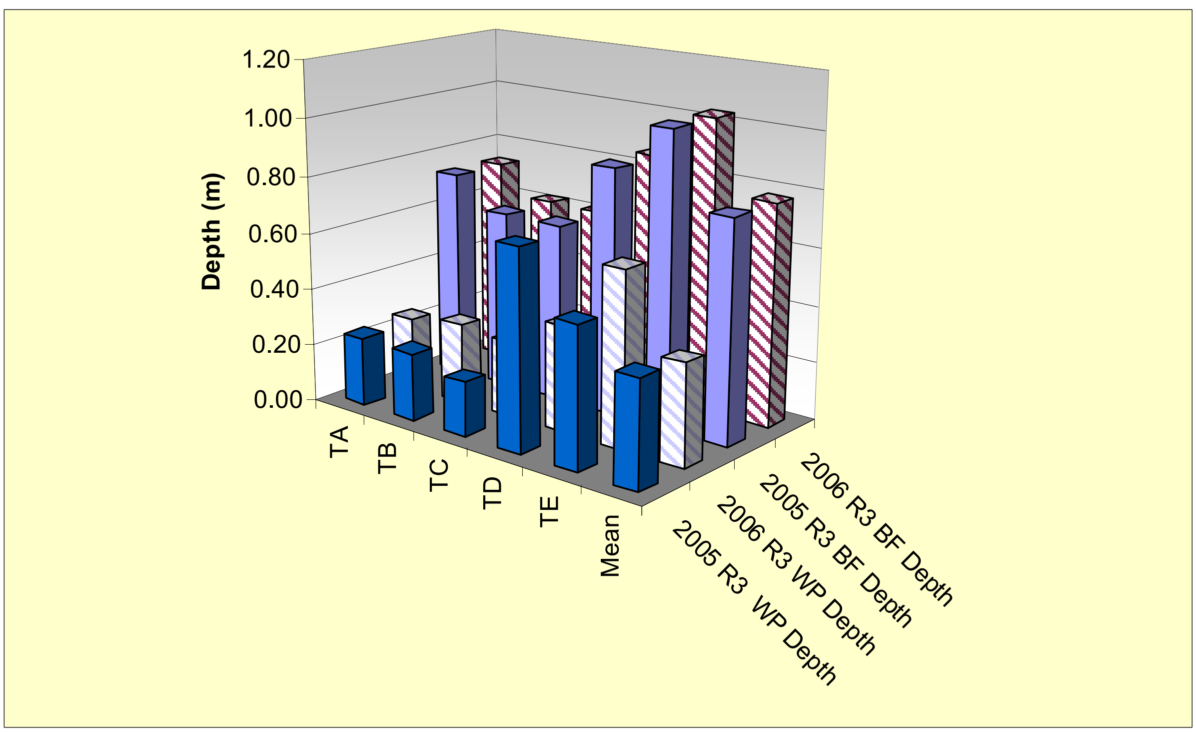


Figure 5.1-5: Wolman pebble count comparison; reach 2, 2005 and 2006

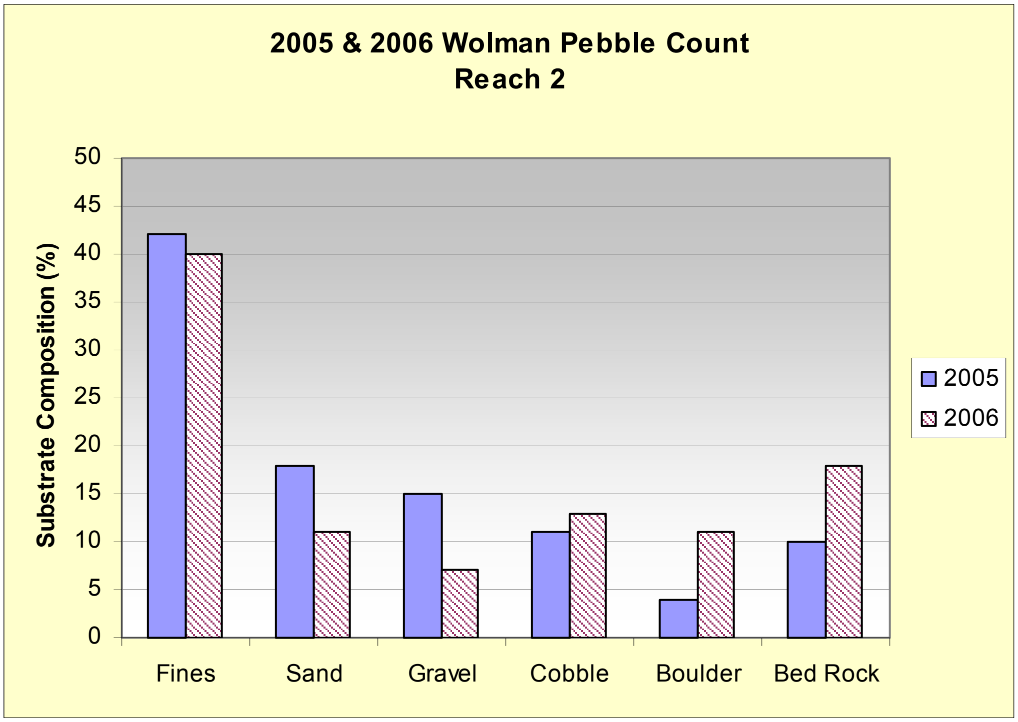
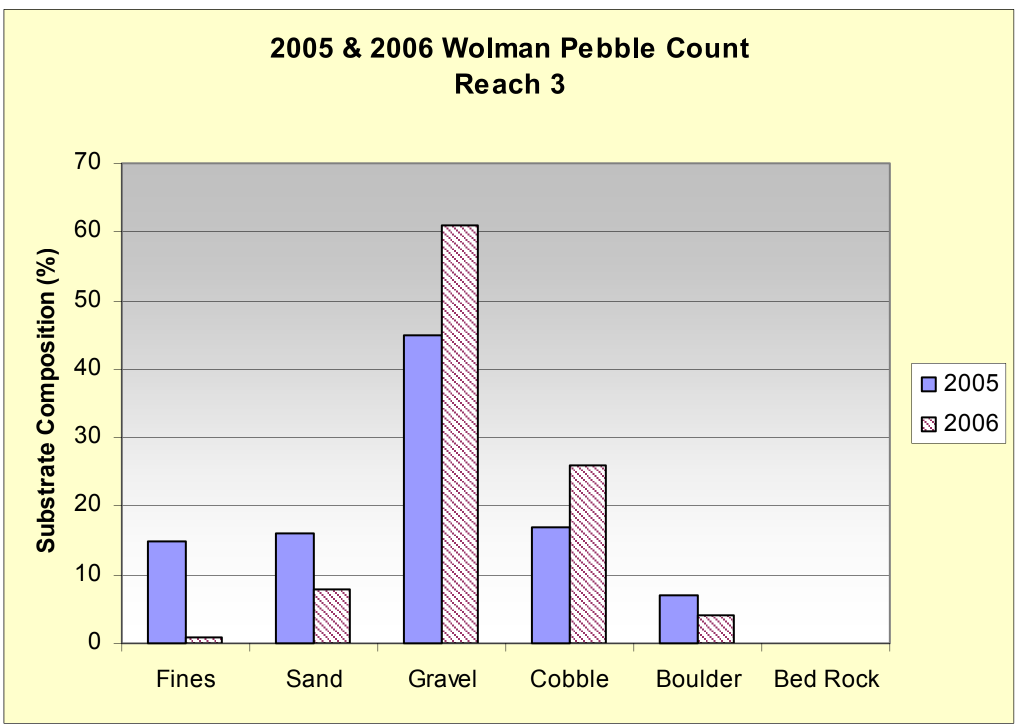


Figure 5.1-6 Wolman pebble count comparison; reach 3, 2005 and 2006



5.2 PERIPHYTON

Periphyton, sometimes referred to as benthic algae, is the algal growth found on substrates in aquatic environments. In addition to algae this benthic layer on rock substrates typically hosts a wide assemblage of micro and macroscopic organisms as well as detritus and fine sediments. Accordingly, AFDW values represent the weight of the algal material contained in the periphyton community as well as bacteria, benthic macroinvertebrates and detritus trapped in the longer algal filaments. Chlorophyll analysis on the other hand measures the ability of pigments to absorb light and as such serves as a measure of algal community productivity.

The autotrophic index (AI), the ratio AFDW/Chlorophyll a, provides information on the relative viability of the periphyton community. If large amounts of non-photosynthesizing organic material are present, the numerator becomes inflated, and the ratio exceeds the normal range of 50-200 (APHA 1999). In 2005 and 2006 all four study reaches exceed the normal AI range. These inflated numerators indicate that the periphyton matrix contains a large amount of non-algal organic material. This organic material likely includes bacteria, BMI and detritus trapped in the algal filaments. In 2006, AI values in reaches 1, 2 and 3 were greater than the 2005 results indicating these reaches contain even more non-photosynthesizing organic matter in 2006 than observed in 2005 but only reach 3 was significantly greater.

In both 2005 and 2006 reach 1 had the highest AI values of the four reaches potentially indicating higher productivity in the bacterial community residing in the periphyton assemblage. Chlorophyll a concentrations in reach 1 were similar to values in reaches 2, 3 and 4 in 2006. Land-use practices, specifically cattle grazing and tilled soils, upstream and adjacent to reach 1 and the associated nutrient enrichment may stimulate higher bacterial productivity relative to reaches 2, 3 and 4. The reaches below Grace Dam, particularly reaches 3 and 4, have considerable buffers from agricultural practices due to the canyon topography coupled with riparian and upland vegetation. Furthermore, much of the nutrient enrichment from upstream land-use practices settles out in Soda and Grace reservoirs. The elevated AI values in reach 1 relative to reaches 2, 3 and 4 were likely the result of nutrient enrichment from upstream and adjacent land-use practices increasing bacterial productivity in the periphyton assemblage.

The periphyton community was more homogenous across the four reaches in 2006 compared to significant differences observed in 2005 between reaches. Paired comparisons between sample years within individual reaches indicate inconsistencies from one reach to the next. For example, periphyton AFDW was significantly greater in reach 1 and 3 in 2006 compared to 2005. In reaches 2 and 4 periphyton AFDW exhibited no differences between sample years. Chlorophyll a was also significantly greater at reach 1 in 2006 compared to 2005 but reaches 2, 3 and 4 show no differences in concentration between sample years. The contrasting paired comparisons for individual reaches suggests site specific conditions play a stronger role influencing periphyton algal growth than inter-annual meteorological variations or other large scale environmental conditions across the study area. Discharge, in particular, has been determined to be an important environmental factor influencing site specific algal growth (Biggs and Kilroy 2000). In reaches 2, 3 and 4 discharge was virtually the same for all three reaches during the study year with the exception that reach 4 has 30 to 60 cfs more discharge than reaches 2 and 3 but all three reaches lack the hydrologic fluctuations more common in unregulated systems.

Periphyton AFDW and chlorophyll concentrations typically change rapidly in streams due to disturbance events such as discharge fluctuations (Steinman and McIntire 1990) or rapid growth responses to changing environmental conditions such as turbidity (Sheath et al. 1986). Consequently, identifying environmental factors responsible for differences in the periphyton community between sample years based on a single annual sampling event of periphyton AFDW and chlorophyll can be problematic. The fall sampling event associated with the Black Canyon Monitoring Study provides a snapshot of the periphyton community in the respective reaches in the same time frame. Because of the single sampling event researchers are not able to identify factors contributing to differences in the periphyton community between reaches or explain causes for inter-annual variation when it occurs. Understanding the environmental factors influencing the periphyton community in a given reach is best achieved through systematic sampling where periphyton is sampled on a weekly or biweekly basis. This latter study approach enables researchers to track periphyton growth rates while simultaneously monitoring biotic and abiotic factors (Biggs 1990; Biggs 1996; Biggs and Kilroy 2000). Nonetheless, the present study design allows managers to document the periphyton community annually and identify statistically significant differences where they exist.

5.3 FILAMENTOUS ALGAE

Filamentous algae coverage was significantly different between the four study reaches in 2006. Paired comparisons within individual reaches indicated a significantly higher algal coverage in reach 2 in 2006 compared to 2005. In reach 3 algal coverage was substantially less in 2006 than 2005 but not significant. Increases in discharge can potentially scour filamentous algae from substrate. As part of the Cove Dam decommissioning higher flows (approximately 500 cfs) were released from Grace Dam to reconstruct the Bear River channel in the former Cove impoundment. In reach 2 filamentous algae was overshadowed by aquatic macrophytes. Distinguishing macrophyte coverage from the filamentous algae was next to impossible therefore reach 2 values reflect the combined cover of macrophytes and filamentous algae on the stream substrate. In reaches 1, 3 and 4 macrophytes were also included in the filamentous algae coverage for consistency between reaches. However, reaches 1 and 3 had less macrophytes and more filamentous algae relative to reach 2. Furthermore, substrate in reaches 1, 2 and 4 was typically larger than reach 3. The larger substrate provides more stability and less susceptibility to scour. The macrophytes coupled with the larger substrate in reach 2 might have been capable of withstanding the September discharge pulse. In contrast, the lack of macrophytes coupled with the smaller substrate in reach 3 may not have been sufficient to prevent sloughing of material downstream during that discharge event thereby reducing coverage for the October 2006 sampling event.

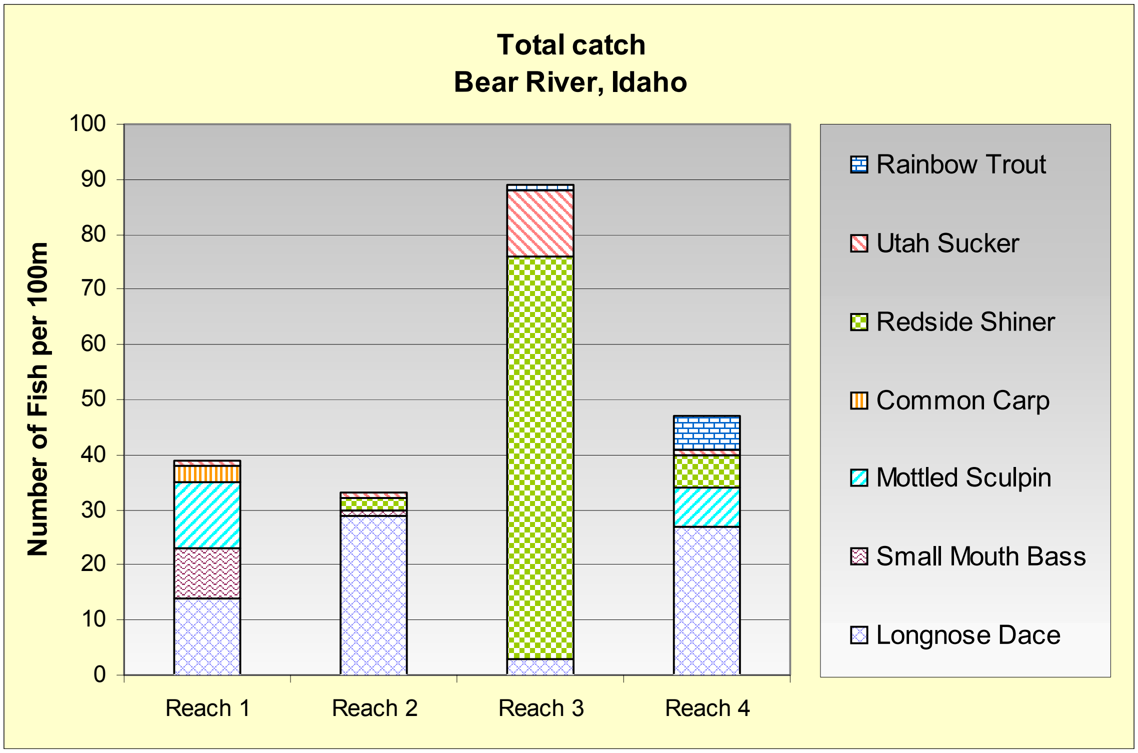
The September 2006 discharge event does not explain the increase in filamentous algae coverage in 2006 in reach 2 compared to 2005. On April 17th, 2005 a release of 863 cfs occurred from Grace Dam. This volume of water may have been sufficient to scour some of the macrophyte community in portions of reach 2 particularly the higher gradient sections in transects C, D and E. The effects of the April scour event on the macrophyte coverage may have carried over to the October sampling event resulting in lower coverage in 2005 relative to October 2006, a year without a discharge release of that magnitude from Grace Dam.

5.4 FISHERIES

Reaches 1 and 4 contained the highest fish species richness of the study reaches with 5 species collected, while reaches 2 and 3 both had 4 species collected. Reaches 3 and 4 were the only reaches where rainbow trout were collected. Longnose dace and Utah sucker were the only species collected in all 4 reaches.

Reach 3 had the highest total catch of fish per 100 meters (89) (Figure 5.4-1). The majority of these were redside shiners (82%), however one rainbow trout was collected in reach 3. Total catch in reach 4 was the second highest at 47 per 100 meters. Reach 1 had a total catch of 39 fish per 100 meters, and reach 2 had the lowest total catch (33 per 100 meters).

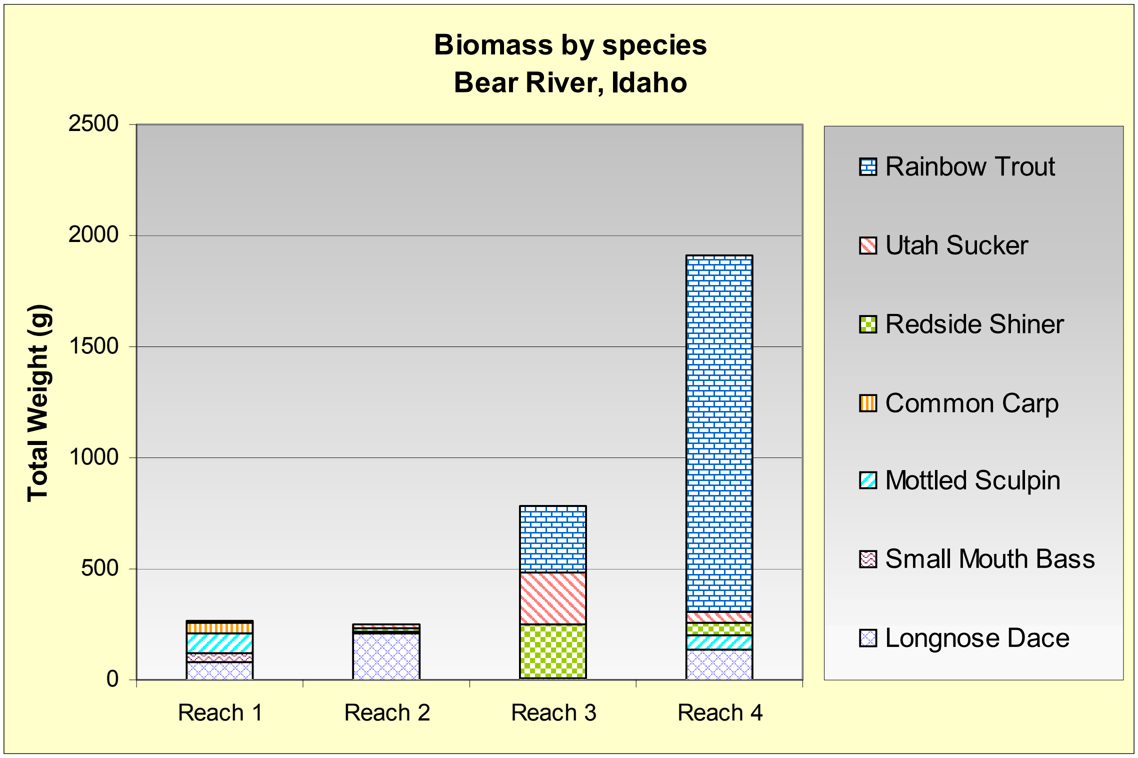
Figure 5.4-1: Total catch per 100 meters for reaches 1, 2, 3, and 4, October 2006



The highest overall catch rate was 5.88 fish/minute in reach 3, followed by 2.31 fish/minute in reach 1, 1.93 fish/minute in reach 4, and the lowest catch rate was 1.45 fish/minute in reach 2 (Figure 4.5-3). Longnose dace had the highest catch rate in 3 of the 4 reaches (reaches 1, 2 and 4), and redside shiner had the highest catch rate in reach 3. Accordingly, the relative species composition was dominated by longnose dace in 3 of the 4 reaches (reaches 1, 2 and 4) whereas redside shiner represented the largest percentage of the sample in reach 3 (Figure 4.5-2).

The highest total biomass was in reach 4 (1.91 kg), and was followed by reach 3 (0.78 kg) (Figure 5.4-2). Reach 1 and reach 2 had far less total biomass at 0.27 kg and 0.25 kg, respectively. Mottled sculpin accounted for a majority of the biomass in reach 1 (35%). In reach 2, longnose dace were the most abundant and they accounted for a large majority (84%) of the biomass. In reach 3, redside shiner were by far the most abundant (82% of the catch), however rainbow trout comprised a majority of the biomass (38%) despite the fact that only 1 was collected. In reach 4, rainbow trout accounted for 84% of the biomass, but they only accounted for 13% of the catch in terms of abundance.

Figure 5.4-2: Fish biomass per 100 meters, reaches 1, 2, 3 and 4, October 2006



Species richness increased in 3 of the 4 reaches between 2005 and 2006. However, it is uncertain whether the additional species collected in 2006 were absent in 2005 or whether they were just not detected. In all cases, the additional species detected in 2006 were collected in very small numbers (1 or 2 fish per 100 meters), and therefore had very low relative abundances. Due to the very low catch rates and relative abundances, it is possible that these species may have been present in 2005 but were not detected. Data obtained in subsequent sampling years will be important in determining if the trend of increased species richness continues.

Overall, total catch and CPUE was higher in all reaches in 2005 than in 2006. While the methodology used to collect fish was the same in both years and the effort given was similar, there were several confounding factors that may have played roles in accounting for these differences.

The higher discharge in 2006 throughout the study area increased the amount of available habitat, and as a result the fish may have been more dispersed throughout each reach. This can lead directly to a decreased total catch and accordingly, decreased CPUE. In addition, the higher discharge generally leads to increased depth and/or velocity, both of which may lead to decreased capture efficiency and thus decrease the CPUE.

A second factor that may be associated with the decreased total catch and CPUE in reach 4 was the rainbow trout stocking schedule. In 2005, Idaho Fish and Game released 250 freeze-branded rainbow trout below the foot bridge near the Grace power plant on October 14. This release was approximately 1 hour prior to and 75 meters downstream of the fish sampling for reach 4. As a result, some of the fish collected that day may have just been released from the nearby hatchery truck. In 2006, the last stocking occurred on September 12 (Table 5.4-1), nearly a month prior to sampling. Accordingly, the rainbow trout had more time to disperse throughout the river or be caught by anglers which could lead to decreased catch and CPUE.

Table 5.4-1: Location, date, and number of rainbow trout released, Bear River 2006

Location	Date	Number Released
Below Alexander Dam	3/21/2006	500
Below Grace Dam	3/21/2006	500
Footbridge at Grace Power Plant	3/21/2006	500
Below Alexander Dam	4/3/2006	277
Below Grace Dam	4/3/2006	272
Footbridge at Grace Power Plant	4/3/2006	290
Below Alexander Dam	4/24/2006	250
Below Grace Dam	4/24/2006	250
Footbridge at Grace Power Plant	4/24/2006	250
Below Alexander Dam	5/2/2006	250
Below Grace Dam	5/2/2006	250
Footbridge at Grace Power Plant	5/2/2006	250
Below Alexander Dam	5/15/2006	502
Below Grace Dam	5/15/2006	551
Footbridge at Grace Power Plant	5/15/2006	537
Below Alexander Dam	8/18/2006	0
Below Grace Dam	8/18/2006	291
Footbridge at Grace Power Plant	8/18/2006	524
Below Alexander Dam	9/12/2006	250
Below Grace Dam	9/12/2006	250
Footbridge at Grace Power Plant	9/12/2006	250
Below Alexander Dam	10/17/2006	500
Below Grace Dam	10/17/2006	1000
Footbridge at Grace Power Plant	10/17/2006	1000

It should also be noted that the Cove Dam was removed during the late summer of 2006. As a result, the footbridge section was technically closed to angling starting August 7, 2006, thus reducing fishing pressure in reach 4 prior to the October 2006 sampling. In addition, the removal of the dam allows for the uninhibited movement of fish in both directions through this section of the river, which in turn also may have lead to increased upstream and downstream movement and thus decreased total catch and CPUE.

5.5 TEMPERATURE

Comparisons of hourly water temperature data for reaches 1, 2, 3 and 4 reveals differences between reaches. These differences were particularly notable during the summer months. Reach 3 exhibited the highest maximum temperatures (27.1 ºC) of all four reaches. Reach 4 exhibited the coolest water temperatures with daily averages below 20 ºC throughout the summer months and one maximum recording greater than 20 ºC. Daily averages in reaches 1, 2 and 3 exceeded 20 ºC for a substantial number of days in the summer season. For some periods daily minimums in reaches 1 and 2 remained above 20 ºC for consecutive 24 hour periods.

The 2006 temperature data exhibited similar seasonal patterns previously observed in 2005 although maximum temperatures in reaches 1, 2 and 4 were lower in 2006 compared to 2005. Because the maximum temperature differences between years occur in both the reference reach and two of the regulated reaches below Grace Dam it is assumed that differences were due to changes in meteorological conditions in respective sample years rather than induced by changes in reservoir operations between years. Temperature data was not available for reach 3 in 2005.

Surface water releases from Grace Reservoir have the potential to increase stream water temperatures in reaches 2, 3 and 4 during the summer season. In reaches 2 and 3 daily average stream temperatures exceeded the 20 ºC salmonid threshold in 2006 for a minimum of 46 and 32 days respectively (Reach 3 hobo temp deployment did not start until July 5, 2006). Increased discharges from Grace Dam are not likely to cause large increases in stream temperatures in reaches 2 and 3 since those temperatures are already greatly influenced by meteorological conditions similar to those influencing surface water temperatures in the Grace impoundment.

In reach 4 daily average stream temperatures and daily maximums remain consistently below 20 ºC for the entire 2006 summer season except on July 19 when the daily maximum in reach 4 peaked at 20.1 ºC corresponding to an increase in discharge from Grace Dam of 122 cfs. In 2005, discharge spikes below Grace Dam on July 26 (255 cfs) and September 16, 2005 (194 cfs) did not appear to alter daily maximum stream temperatures. Outside the summer season (June 21 to September 21) instream temperatures in reaches 1, 2 and 3 for the most part appear to also be below the 20 ºC threshold. Deployment of an additional hobo temp in the epilimnion of the Grace impoundment would yield additional data on surface water temperature discharged into the Black Canyon.

5.6 HYDROLOGY

Reach 1 differs from reaches 2, 3 and 4 hydrologically. Water storage in Bear Lake partially regulates flows in reach 1 by decreasing the magnitude of peak flow events during spring snowmelt and shifting the snowmelt hydrograph into July, August and early September to fulfill downstream water rights. Discharge timing and magnitude differed in water year 2005-2006 compared to the previous water year, 2004-2005. In the 2005-2006 water year discharge peaked in April compared to a late July peak in 2004-2005. Furthermore, Bear Lake releases in July and August in the 2005-2006 water year were substantially lower (peak of 933 cfs) compared to the previous water year (peak of 1336 cfs).

Reaches 2, 3 and 4 in the Black Canyon of the Bear are fully regulated by upstream irrigation and power generation diversions. Instream flows below Grace Dam remain relatively stable year round. Groundwater upwellings and springs just upstream of reach 4 contribute an additional 30-60 cfs on top of the existing base flow. In mid-September 2006 pulse flows were released from Grace Dam to assist channel restoration efforts in the former Cove impoundment. Daily average flows reported for those release were 152 cfs on September 18, 2006. Instantaneous peak flow data for these pulse flows were not available but were assumed not to exceed 500 cfs from Grace Dam. No spring whitewater releases occurred during the 2005-2006 water year.

5.7 BENTHIC MACROINVERTEBRATES

Overall, the 2006 BMI data was consistent with results obtained in 2005 for respective reaches. Paired comparisons between 2005 and 2006 BMI data within respective reaches indicated no significant differences in BMI density. EPT richness in reach 1 was significantly greater in 2006 than 2005 (p=0.06, Student's t-test). In reach 4 EPT density, species richness and EPT richness was significantly greater in 2006 relative to 2005 data (p=0.06, p=0.05 and p=0.005 respectively, Student's t-test). The increases in these individual metrics in 2006 might be due to spatial and temporal variability inherent in the BMI community. Researchers did not observe habitat differences between years in reach 1 or 4 that would account for these metric increases.

Distinct reach differences in the BMI community were well documented in 2005. These reach differences persisted in 2006. In both sample years the BMI community composition in reach 1 was distinctly different from reaches 2, 3 and 4 located downstream of Grace Dam. In reach 1 EPT density made up 64% of the BMI community composition. In contrast, reaches 2, 3 and 4 contained very few EPT taxa let alone high densities of these species. EPT taxa are typically found in water bodies with cold, well oxygenated water and favor good quality habitat. As such these orders are used as an index for assessing water quality and habitat conditions. The lack of EPT taxa in reaches 2, 3 and 4 indicates poor water quality and/or habitat conditions. Reach 2 was dominated by dipterans (chironomids in particular) and crustaceans. Dipterans are typically indicative of poor water quality and habitat condition. Reach 3 was also dominated by dipterans (chironomids) as well as Acarina (water mites).

Reach 4 had the highest BMI density but the lowest diversity of the four reaches. Reach 4 was dominated almost exclusively by gastropods. Of particular interest was the presence of a new gastropod taxa, Hydrobiidae, in the study area. Surprisingly, Hydrobiidae was the dominant taxa in reach 4 in 2006 yet the taxa was not found at all in 2005 in reach 4 or reaches 1, 2 and 3. Hydrobiids are small snails with world-wide distribution. The sudden dominance of this taxa in 2006 in reach 4 with no prior record in the study area in 2005 raises some concern that this may mark the introduction of an exotic snail not previously recorded in the watershed and the potential ecological impacts that may result as evidenced by other exotic invasions in western rivers. Transport mechanisms into reach 4 could possibly be through fish stocking or the private hatchery with return stream flows to the Bear in the Black Canyon. Alternatively the taxa may have been missed or temporarily absent during the 2005 field effort although this is less likely given the dominance in 2006.

Analysis of BMI functional feeding group composition further demonstrates the differences between reach 1 and the three treatment reaches below Grace Dam. Reach 1 was dominated by gatherers, filterers and shredders. Given the October sampling date coupled with leaf fall from the adjacent riparian community these functional groups were expected for this time period (Vannote et al. 1980). The filter feeders likely take advantage of the high nutrient concentrations resulting from agricultural land-use practices adjacent to and upstream from reach 1.

In Reach 2 the BMI community is dominated by gatherers and predators. The gatherer feeding group in Reach 2 consists largely of chironomids. The general lack of riparian vegetation in reach 2 due to grazing practices coupled with the upstream reservoir trapping leaf litter input likely accounts in part for the lack of shredder taxa in this reach. Poor habitat quality likely also plays a significant role in the lack of functional feeding group diversity.

Reach 3 in the Black Canyon was dominated by predators and gatherers and to a lesser degree by scrapers. Although limited to the immediate riparian area the Black Canyon does contain sufficient deciduous shrubs to support shredders on par with Reach 1. The fact that shredders make up only 1 percent of the community suggests other factors were limiting this group. Shredders tend to be in the EPT group of taxonomic orders. The lack of suitable cobble substrate could be the limiting factor.

Reach 4 was dominated by scrapers likely capitalizing on the abundant filamentous algae. Other researchers have found increases in scraper densities corresponding to reaches with open canopies (Hawkins et al. 1982; Noel et al. 1986; Fuller et al. 1986; Behmer and Hawkins 1986). The combination of the relatively static flow regime coupled with the bedrock substrate and abundant filamentous algae creates unique and stable habitat conditions suitable for specialists to out compete generalist species. Resh et al (1988) attributed increased BMI species richness to the increased habitat complexity that results in streams with intermediate levels of disturbance. Reach 4 is subjected to little disturbance annually and as expected the species diversity was low dominated by gastropods capitalizing on the abundant filamentous algae.

Reach 4 supported a substantially higher BMI density than the other three study reaches. Autochthonous food sources such as filamentous algae are considered to be of higher nutritional value than allochthonous inputs (Anderson and Cummins 1979; Minshall 1978). The quality of the food resources in Reach 4 combined with the low species diversity and lack of disturbance may have attributed to the significantly higher BMI densities.

The statistical power analysis indicated that taxa richness variability in the SS samples was less than in the CS samples particularly in reaches 1, 2 and 3. Gradients of increasing taxa richness below impoundments are expected, but this gradient was only apparent among the SS samples not the CS samples. For ecological monitoring studies, sampling design should be optimized to detect ecologically relevant changes in community structure. The sampling program should be adequate to statistically detect an ecologically relevant amount of change—otherwise, “no significant difference” may be reported simply because the data were too variable for the number of replicates used.

5.8 ORGANIC MATTER ASH-FREE DRY WEIGHT

Organic matter AFDW was significantly greater in 2006 compared to 2005 for each sample reach. In both 2005 and 2006 reach 4 had the highest organic matter AFDW per square meter. The relatively stable flow regime coupled with the bedrock ledges allows the mats of macrophytes and filamentous algae to maximize growth with little scour or disturbance from bedload movement on an annual basis. In contrast, substrate in reaches 1, 2 and 3 was smaller and less stable making it more susceptible to movement at lower discharge volumes compared to reach 4. Furthermore, organic matter growth in reach 4 might be greater than the other three reaches due to nutrient inputs associated with the groundwater upwellings. Travertine deposits indicative of calcium carbonate precipitates were observed in reach 4. The nutrient inputs associated with the upwelling likely stimulates macrophyte and filamentous algal growth. Calcium carbonate deposits were not observed in reaches 1, 2 or 3.

Reach 1 contained higher organic matter AFDW in reaches 2 and 3 in both 2005 and 2006. During the October sampling thick mats of brown algal material covered much of the cobble in reach 1 except in locations with higher current velocities. The algal material in reach 1 was shorter and darker in comparison to the long bright green filaments found in reach 4. In addition, reach 1 consisted primarily of filamentous algae lacking the macrophytes common to reach 2 and reach 4. As noted from observations during the 2005 sampling event the filamentous algae in reach 1 was likely entering seasonal decline in October as evidenced by the decaying stalks.

6. CONCLUSIONS

The new license for the Bear River Hydroelectric Project (FERC No. 20) includes a condition requiring PacifiCorp to implement and study a variable flow regime at the Grace Hydropower Facility in the 6.2 mile reach known as the Black Canyon between Grace Dam and the Grace powerhouse. PacifiCorp, in collaboration with the Environmental Coordination Committee (ECC), developed the Bear River Black Canyon Monitoring Study to examine the effect of the variable flow regime on the river channel shape, substrate and aquatic biota. Specifically the Black Canyon Monitoring Plan includes investigation of: 1) Macroinvertebrates—population trends, diversity and community indices; 2) Organic Matter Ash-Free Dry Weight (AFDW); 3) Periphyton—chlorophyll concentration and biomass; 4) Fisheries—population trends, community composition, fish condition; 5) Filamentous Algae—density; and 6) Channel Morphology—shape and substrate composition.

The monitoring effort comprises four study reaches. Reach 1, partially regulated by Bear Lake, serves as the reference reach. Reaches 2, 3 and 4, subject to the variable flow regime below Grace Dam, serve as the experimental reaches. The monitoring study spans six-years of data collection. The first three-years serve as a baseline period collecting data in all reaches prior to implementation of the variable flow regime. The second three-year term, years four through six, serve as the experimental phase when reaches 2, 3 and 4 will be subjected to flows ranging from 800 to 1500 cfs, approximately 700 to 1400 cfs greater than the minimum instream flow of 65 cfs below Grace Dam. Field sampling occurs once annually in October. Field sampling was initiated in October 2005 and will conclude October 2010.

This report describes study results from years 1 and 2 in the monitoring effort. The year 1 report, the 2005 data, served as a baseline characterization of the four reaches. Based on year 1 data analysis it was determined that reaches 1, 2, 3 and 4 were distinctly different from each other. Because of these distinct differences analysis in 2006 focused largely on changes over time within respective reaches rather than comparisons between reaches.

Channel morphological characteristics remained largely unchanged in reaches 2 and 3 in 2006 compared to 2005. Discharge remained relatively stable for most of the 2005-2006 water year below Grace Dam. In September 2006 a pulse release occurred to assist channel restoration efforts in the former Cove impoundment. The daily average flow did not exceed 150 cfs. The instantaneous maximum was reported to be approximately 500 cfs. This discharge event did not appear to alter the channel shape or structure in reaches 2 and 3.

Periphyton AFDW increased in 2006 in reaches 1 and 3 but remained similar to 2005 values in reaches 2 and 4. Chlorophyll a and b were significantly greater in reach 1 only in 2006. Reaches 2, 3 and 4 had values similar to 2005. Chlorophyll c was significantly lower in reaches 3 and 4 in 2006. The AI was significantly greater in reach 3 only in 2006. These inconsistent trends in periphyton metrics could simply be due to habitat heterogeneity inherent in stream habitats. Additional sampling in year 3 of the baseline study effort will add data points increasing statistical power for comparisons across time.

Filamentous algae coverage was significantly greater in reach 2 only in 2006. In 2006 releases from Grace Dam were less than 2005. The increased cover of macrophytes and filamentous algae could be due to the lack of flows sufficient to mobilize bedload and scour the substrate. Coverage in reaches 1, 3 and 4 was similar to 2005 measurements.

The 2006 BMI community was similar to that observed in 2005 for respective study reaches with some exceptions for individual metrics likely the result of spatial and temporal variability inherent in BMI sampling efforts. Of particular interest was the discovery of a new gastropod in reach 4, Hydrobiidae. Surprisingly this gastropod was the dominant taxa in reach 4 comprising 70 percent of the BMI community composition. This rapid dominance in the BMI community raises concern regarding potential a domino effect on other trophic levels.

Statistical power analysis of BMI taxa richness indicated the single surber sample was more sensitive at detecting small changes in taxa numbers than the composite surber sample particularly in reaches 1, 2 and 3. Variability was greater in the composite samples likely due to the increased number of microhabitats sampled, particularly inclusion of stream margin habitats typically occupied by different taxa than those commonly found in the thalweg. Gradients of increasing taxa richness below impoundments are expected, but this gradient was only apparent among the SS samples not the CS samples.

Seven fish species were collected in the four reaches. Reaches 1 and 4 contained 5 species each while reaches 2 and 3 had 4 species each. Reaches 3 and 4 were the only reaches where rainbow trout were collected. Longnose dace and Utah sucker were the only species collected in all 4 reaches. Reach 3 had the highest density of fish. The majority of these were redside shiners, however one rainbow trout was collected in reach 3. Reach 2 had the lowest fish density. Overall, fish density was higher in all reaches in 2005 than in 2006. Several factors may account for the decrease. Increased discharge in 2006 may have hampered collection efforts and provided additional habitat in the stream margins for fish to escape from the electroshocker. Fish stocking in reach 4 terminated a month prior to the 2006 sampling effort. Reach 4 was closed to angling in August of 2006 for public safety associated with Cove Dam decommissioning. And lastly, Cove Dam removal may have triggered fish movement upstream and downstream.

7. LITERATURE CITED

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