Jordan Project Water Use Plan

Lower Jordan River Fish Index Study

Implementation Year 6

Reference: JORMON-2

Lower Jordan River Fish Index Study

Study Period: August – September 2010

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January 28, 2013

Lower Jordan River Fish Index Study
Year 6 Results (2010) and Pre/Post Flow Release Comparisons

Prepared For

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January 28, 2013

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EXECUTIVE SUMMARY

The Lower Jordan River Fish Index Study was initiated to assess the biological benefits of a 0.25 m^3/s fish flow release from Elliott Dam (initiated in January 2008). The study design incorporated 3 years of pre flow release monitoring followed by 3 years of post flow release monitoring. Performance measures to gauge benefits included 1) fish abundance, 2) fish condition factor, and 3) continuity of habitat. The geographic scope included the Jordan River from Elliott Reservoir downstream to the Jordan River Generating Station tailrace. This report presents the results of the final year of the study (year 6, 2010) as well as a pre and post flow release comparison using all 6 years of data. Three main tasks were conducted in each study year as follows:

1) Undertake fish sampling to estimate standing stock and condition factor of rainbow trout at established index sites.

2) Complete habitat inventories of subsections of each reach of the lower Jordan River to assess habitat continuity and other habitat features influenced by flow.

3) Conduct environmental monitoring at 5 index sites including downloading of data from water temperature loggers, measurement of pH, conductivity and alkalinity, and collection of water samples for lab analysis of dissolved and total copper.

2010 Results

In 2010, fish population surveys were conducted at 15 of the original 17 index sites established in 2005 and 2006 (2 sites could not be completed due to time constraints). All sites received 3-pass removals. Maximum likelihood estimates of fish populations were computed for each site. All salmonids captured were measured for length and weight in order to derive Fulton's condition factor.

Standing stock of rainbow trout (target species) was computed in terms of density and biomass by age group. Geometric means were used to summarize these performance measures. For condition factor, arithmetic mean of all age groups combined was computed. Results for 2010 were as follows:

	Density (fish/100 m^2)	Biomass (grams/100 m^2)	Condition Factor (K)
0^+ Fry:	9.5	27	1.08
1^+ Parr:	3.1	54	
$2/3^+$ Parr:	1.2	30	

Habitat inventories were conducted on 6 sections of the lower Jordan River ranging in length from 181 to 511 m for a total survey length of 2,014 m. In 2010 (as in 2008 and 2009), continuous surface flow was found in all survey sections, including the reach immediately downstream of Elliott Dam. Thus, based on 2005–2007 survey averages, fish flow releases provided an additional 771 m of stream length and additional 62,600 m^2 of wetted area in 2010. Another finding was that riffle habitat (the main source of insect production in streams) composed a much greater proportion of wetted area following the flow release (mean 6% prior to the flow release, 12% in 2008, 17% in 2009, and 16% in 2010).

Environmental monitoring results in 2010 found that copper concentrations downstream of the Reach 2 mine deposit were comparable to 2008 and 2009, and substantially less than the pre flow release years (2005 – 2007). Improvements were attributed primarily to the dilution effect provided by higher flows under the fish flow release, and possibly also from the November 2006 flood which washed some of the source material from the river. Improvements in water quality downstream of the mine deposit were coincident with the re-establishment of rearing fish in this zone.

Pre/Post Flow Release Comparison of Performance Measures

Nested ANOVA's were used to assess rainbow trout density and rainbow trout condition factor before and after the flow release (study year as the subgroup nested within pre and post treatment groups). In the case of fish density, a noticeable increase was observed for age 1^+ and age $2/3^+$ rainbow, however, only the increase in $2/3^+$ fish was significant. For rainbow condition factor, there was no significant difference before and after the flow release. Thus, study results suggest that the flow release resulted in increased standing stock of older aged rainbow trout (age $2/3^+$) and possibly of yearling rainbow trout (age 1+), but condition factor of rainbow trout remained unchanged.

In terms of habitat continuity, obvious benefits were noted. The reach immediately downstream of Elliott Dam (Reach 7) was mostly dry before the flow release, but exhibited continuous flows after the release. In fact, no subsurface flows were found in any of the habitat survey sections after the flow release. In addition, prior to the flow release, riffle habitats often had only seepage flows which was felt to inhibit the upstream/downstream dispersal of trout except during higher winter flows. After the flow release riffle habitats were well wetted and no longer an impediment to fish dispersal. In terms of quantifiable habitat changes, the flow release increased wetted stream length by 771 m, while wetted area increased by an average of 85%. Riffle habitats, which are typically the main zones of aquatic invertebrate production, increased from an average of 6.1% of wetted area before the flow release to 15.5% after the flow release.

The above benefits need to be couched in the understanding that, due to concerns with the mechanism controlling the flows release at Elliott Dam, the valve was locked fully open and the amount of water released during the treatment years was generally in the range of 0.3 – 0.4 m^3/s as opposed to the 0.25 m^3/s prescribed in the study design. Thus, the biological and habitat benefits indicated by this study are reflective of these higher flows and are not necessarily indicative of conditions and benefits at 0.25 m^3/s. Thus, if at a future time BC Hydro decides to reduce the fish flow release to the actual 0.25 m^3/s, it is recommended that the activities of this study be repeated at that flow for 1 or 2 more years.

It is recommended that future studies of this type employ 3-pass efforts and avoid the use of 1-pass efforts as the latter results in high catch variances which compromise the ability of the study to detect significant differences in pre and post treatment means.

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ACKNOWLEDGEMENTS

A number of BC Hydro staff contributed to the success of year 6 of the Jordan River Fish Index Study: Ian Dodd provided capable handling of the administrative and coordination tasks, and assisted in the field; Duane Walsh and Brent Mockford provided support with lock-out safety procedures; Ian Dodd and Alf Leake reviewed the manuscript and provided helpful suggestions for report improvement. I am especially grateful to the Pacheedaht First Nation for providing Jeff Jones and Mike Charlie to assist me with field activities. The Jordan is an extremely difficult and strenuous river to work in, and Jeff and Mike's endurance and field capabilities were a major asset to the field program. Thanks also to Helen Dunn for coordinating activities on behalf of the Pacheedaht First Nation.

1. INTRODUCTION

The Jordan River Water Use Plan (JOR WUP) was initiated in April 2000, submitted to the Comptroller of Water Rights (CWR) in 2002, and approved by the CWR on July 20, 2004 (BC Hydro 2005b, Attachment A). The terms of the Jordan WUP included instigation of a fish flow release of 0.25 m^3/s from Elliott Dam, and implementation of various monitoring projects to assess fish habitat, abundance, and physical conditions in the river before and after the flow release. This report presents the results for one of these monitoring projects, the Fish Index Monitoring Study. This study was carried out from 2005 to 2010, with field assessments conducted in late summer of each of these years. The fish flow release commenced on January 17, 2008, thus, the study design includes 3 years of before-treatment data and 3 years of after-treatment data.

The goal of the Lower Jordan River Fish Index Study were to assess the biological benefits of the fish flow release using fish abundance, fish condition factor, and continuity of habitat as performance measures (BC Hydro 2005a, Attachment B). The geographic scope of the project included mainstem reaches of the Jordan River from Elliott Headpond downstream to the Jordan River Generating Station tailrace. Three tasks were identified in the project terms of reference for each study year:

1) Conduct a fish sampling program to estimate standing stock and condition factor of rainbow trout at index sites in the lower Jordan River

2) Complete habitat inventories on index subsections of each reach of the lower Jordan River to assess habitat continuity and other habitat features influenced by flow.

3) Continue environmental monitoring at the 5 index sites established in the lower Jordan River in 2005. This includes servicing of water temperature loggers and collection of water samples for analysis of selected water quality parameters (pH, conductivity, alkalinity, total dissolved copper, and total copper).

This report presents the results for year 6 (2010) of the study and provides a before-after comparison of the key study elements (fish abundance, condition factor, habitat continuity) based on data from all 6 years. Annual reports for years 1 to 5 can be found in Burt (2006, 2007, 2008, 2009, 2010).

2. BACKGROUND

Previous Work

Previous fisheries studies on the Jordan River include a biophysical and fish production assessment by Griffith (1996), an instream flow study by Cascadia Biological Services (2001), and two incubation survival assessments; one by Lightly (2001) using coho salmon eggs, and the other by Wright and Guimond (2003) using pink salmon eggs.

The biophysical and fish production study by Griffith (1996) was conducted in 1994 and encompassed the entire Jordan Watershed, however, some data were collected within the Fish Index Study area. These included habitat surveys on 3 sections of the lower Jordan River, and juvenile fish population inventories (2-pass removal electrofishing) at 8 sites within the study area. The habitat surveys noted that flows throughout much of the Jordan River downstream of Elliott Dam were limited to isolated pools. This was attributed to water storage at Diversion and Elliott Reservoirs and was deemed to be a major constraint to fish production in the lower river. The fish population inventories found various age classes of rainbow trout in the uppermost 4 sites but no fish in the lowermost 4 sites. These latter sites were located within the anadromous region of the river, and the absence of fish was attributed to high concentrations of copper found in the water at these sites.

The study by Cascadia Biological Services (2001) was conducted in 2001 and involved depth/velocity transects on riffle habitats within the lower Jordan River for the purpose of assessing the relationship between stream flow and a) wetted area across riffles, and b) usable habitat for rainbow trout fry and parr according to habitat suitability index curves. Their study included 29 transects which were assessed at 4 flow regimes: 0.038 m^3/s, 0.364 m^3/s, 0.781 m^3/s, and 1.254 m^3/s. Results suggested only a small increase in fry usable area over the flows examined (1.4 fold increase) and somewhat larger increase in parr usable area (3.6 fold increase).

The incubation studies by lightly (2001) and Wright and Guimond (2003) were conducted to assess the survival of coho and pink salmon eggs in the presence of elevated copper emanating from a mine deposit located adjacent to the river 300 m upstream of the Jordan River Generating Station tailrace. Both studies used Jordan-Scotty incubators to house the eggs, and these were planted in the substrate within the copper affected zone as well as immediately upstream of this zone. The main finding from both studies was that egg-to-fry survival of coho and pink salmon was not impacted by copper levels present in the river during the study periods.

Study Area

The Jordan River is located on the southwest coast of Vancouver Island 72 km by road from the city of Victoria. The river originates in the Seymour Mountain Range in south central Vancouver Island and flows in a south-westerly direction before emptying into Juan De Fuca Strait adjacent to the community of Jordan River. It has a drainage area of 162 km^2 and a mean annual discharge at the mouth of approximately 13.7 m^3/s (Cascadia 2001).

In terms of the Provincial Ecoregion Classification System, the Jordan Watershed spans two distinct ecosections. The lower Jordan River and western tributaries of the upper river lie in the Windward Island Mountains (WIM) Ecosection (Coast and Mountain Ecoprovince), while the mainstem of the upper river and its eastern tributaries lie within the Leeward Island Mountains (LIM) Ecosection (Georgia Depression Ecoprovince). Climate in the WIM Ecosection is dominated by the arrival of frontal systems from the Pacific Ocean resulting in heavy rainfall during the winter months. In contrast, the LIM Ecosection occurs on the leeward side of the Vancouver Island Mountains and experiences a rainshadow effect resulting in much lower precipitation than the NIM Ecosection. Details of this classification system and associated characteristics are described in Demarchi (1996).

The Jordan River hydroelectric project was completed in 1911 and rebuilt in 1971. Current facilities include three dams, two reservoirs, a headpond, a tunnel/penstock water delivery system, and a 175 MW powerhouse on the lower Jordan River (BC Hydro 2003). The dams include Bear Creek Dam and Jordan Diversion Dam, which impound Bear Creek Reservoir (7.5 km^2) and Diversion Reservoir (18 km^2), and Elliott Dam which impounds Elliott Headpond (1.6 km^2). The powerhouse is located on the west side of the lower Jordan River 900 m above the mouth. This powerhouse replaced an older facility and tailrace in 1972 (located on the east side of the river).

The study area for the fish index monitoring program encompasses the mainstem from Elliott Dam to the Jordan River Generating Station tailrace, a distance of 7.8 km (Figure 1). Drainage area of the study region is 17.4 km^2, which represents 12% of the total Jordan Watershed. Under historic operation of Elliott Dam, no water was released into the lower Jordan mainstem except when spilling was required. Thus, flows in the study reaches were generally dependent on input from local tributaries. The most significant of these include Sinn Fein, Winkler, and Nuala Creeks, which drain the west side of the river, and one unnamed creek just above Nuala that drains the east side of the river. As indicated in the Introduction, this situation changed in January 2008 when BC Hydro commenced release of a minimum fisheries flow of 0.25 m^3/s from Elliott Dam.

Physical characteristics of the study portion of the Jordan River include a channel that varies from confined to entrenched within steep valley walls. The overall map gradient is about 4%, but individual reaches range from 1.5% to 10% (Cascadia 2001). Channel types vary from riffle-pool sequences in lower gradient sections, to cascade-pool sequences in steeper sections. Substrates tend to be dominated by large boulders with cobbles and gravels as subdominant categories. Spawning gravels are scarce but do occur in pockets throughout the study area.

3. METHODS

3.1 Fish Sampling

Field Procedures

In 2010, fish sampling was conducted at 15 of the 17 index sites established in 2005/2006. As in 2009, two sites were dropped (EF01 and EF08) due to the greater time required to complete field tasks under the higher discharges associated with the fish flow releases from Elliott Dam. Locations of these 15 sites, and of the omitted sites, are shown in Figure 1. Sample timing was September 13–22, 2010.

The approach used to sample fish abundance in 2010 involved 3-pass electrofishing removal techniques. This differed from previous years when sites were sampled using either 3-pass or 1-pass electrofishing removal. Adherence to 3-pass sampling in 2010 was done to reduce the variance associated with site population estimates (1-pass sampling has a much higher variance associated with the site population estimate). In the first 3 years of monitoring, extremely low flows in the river made it possible to sample discrete areas without the use of stop nets. However, under the fish flow release, stop nets were needed at all sites in order to establish discrete sample areas and prevent loss or entry of fish from the sample area. Electrofishing was performed by a three person crew using a Smith-Root Model 12A backpack electrofisher. Each “pass” generally involved a circuit upstream through the site and then back down through the site. After each pass, fish were identified, measured for fork length (nearest 1.0 mm), and weighed (nearest 0.1 g, OHAUS portable electronic balance, Model C-505). Alka-seltzer tablets (CO2) were used as an anaesthetic. Details of these sample procedures are described in Anon. (1995).

Upon completion of the fish sampling, a transect was set across the site at a representative hydraulic location using a 30 m tape. Depth and velocity data were recorded at 20–50 cm intervals along the transect. These data were to be used to determine the amount of suitable rearing habitat within the site, and provided a means of prorating fish densities by the amount of suitable habitat. Depths were measured using a 1.5 m top-setting rod and velocities were taken at 40% of the depth (from the bottom) using a Swoffer flow meter (Model 2100) mounted to the rod.

Data Analysis

Analysis of electrofishing data first involved assignment of age to all captured salmonids so that population estimates could be generated by age group. Age designation was determined using length-frequency analysis. In previous years, analysis of scale samples was used to assist in the aging process. This was not performed in 2009 and 2010 as it was found that scale aging was subject to interpretation error and not always reliable.

Methods used to compute population size (by age group) differed between 3-pass and 1-pass sites. For 3-pass sites, Bayes’ maximum likelihood estimates (MLE) were generated using a computer program developed by BC Hydro ("PopEst7.xls", Bruce and Z’Graggen 1995). The program also generated variances, standard errors, and 95% confidence limits for each estimate. Population estimates were converted to fish density (fish/100 m^2) by dividing the estimate by the site area and multiplying by 100.

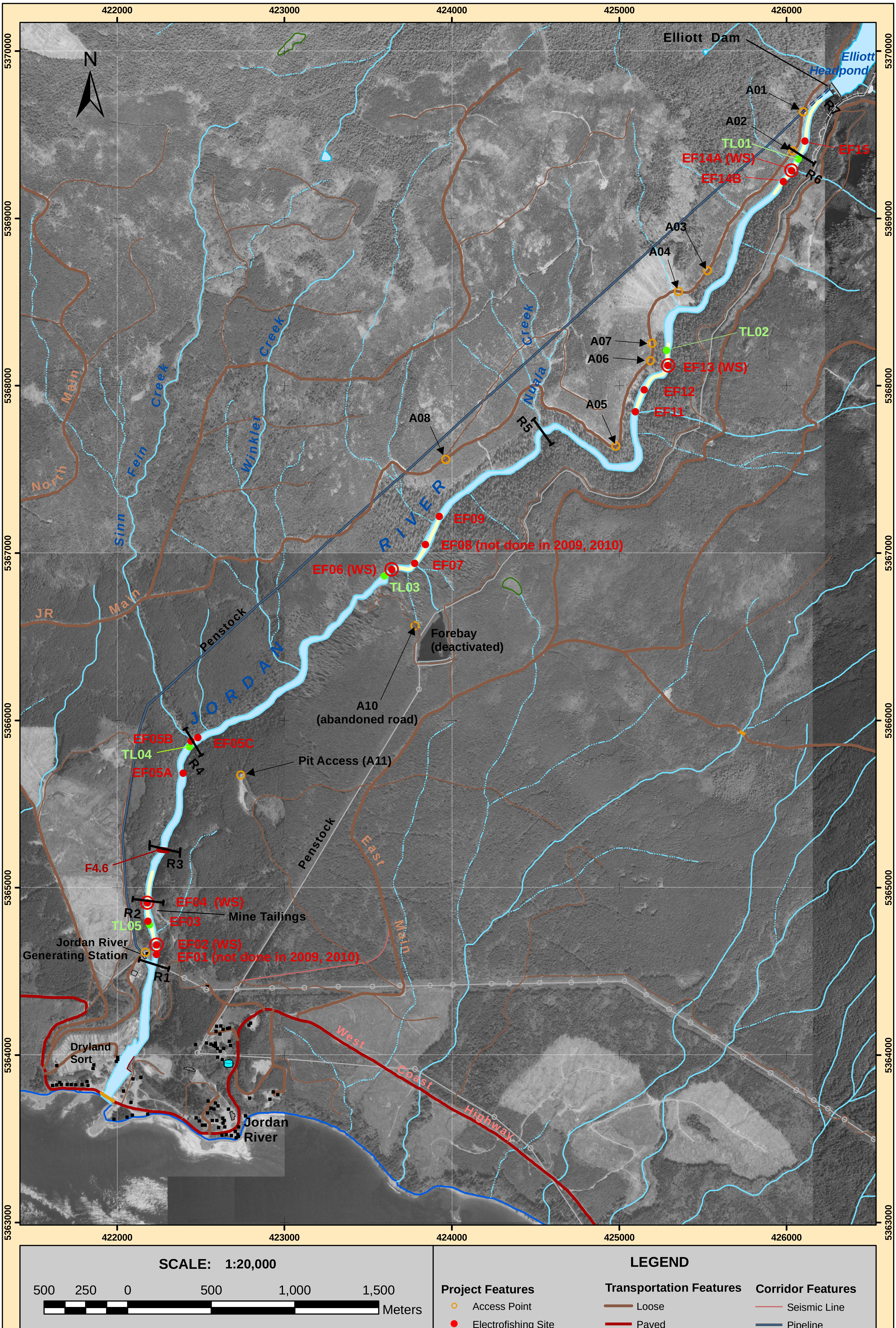

Figure 1. Map of the lower Jordan River showing electrofishing, temperature logger, and water sample sites, habitat survey sections, and access points.

[Back side of 11x17 map]

For single pass sites undertaken in previous years, population estimates were computed using an expansion factor based on data from multiple pass sites. The expansion factor was derived from linear regression of maximum likelihood population estimates (dependent variable) on the number of fish caught in removal 1 (independent variable) (Kruse et al. 1998, see Lobon-Cervia and Utrilla 1993, Meyer and Lamansky 2002). Data used in the regression included 3-pass sites from 2005 to 2010, as well as 4 2-pass sites completed in 1994 by Griffith (1996). Because numbers of fish captured at a given site were relatively low, the analysis was run with all age groups combined. I also set the intercept to zero. Figure 2 shows the results of this analysis. Eleven points were identified as outliers and were removed from the regression analysis. The x coefficient (1.241) was used as the expansion factor to derive population estimates for single pass sites. Confidence limits for these population estimates were based on the 95% prediction intervals (outer lines in Figure 2).

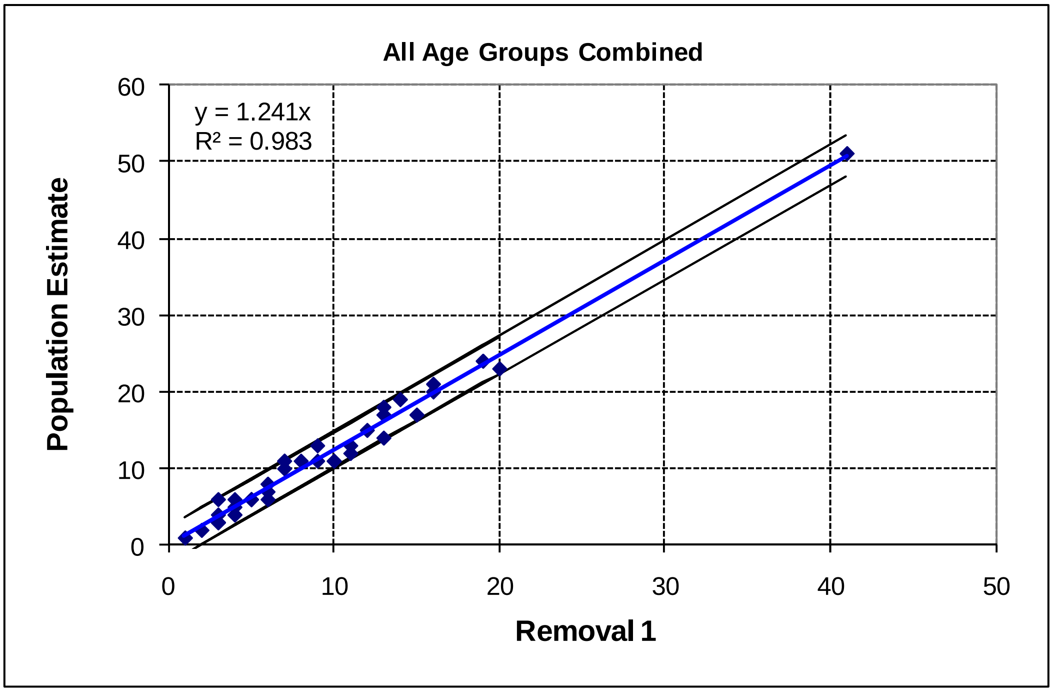

Figure 2. Relationship between number of rainbow trout captured by removal 1 and the corresponding 3-pass population estimate (all age groups combined). Data are based on electrofishing in the study area during 2005 – 2010 (this study) and in 1994 (Griffith 1996). The outer lines depict the 95% prediction intervals.

Fulton condition factor was calculated for all captured salmonids using the following equation (Anderson and Neumann 1996):

$$K = \left(\frac{W}{L_{FL}^{3}}\right) \times 10^{5}$$

where: K = *Fulton condition factor*

W = *weight in grams*

L_{FL} = *Fork length in millimetres*

Statistical Procedures

The statistical method employed to test for changes in both fish density and fish condition factor before and after the flow release was a nested ANOVA with study year as the subgroup nested within pre and post flow condition as the main group. This statistical approach takes into account the within-group variability (study year) thus providing a more powerful test for the main group (pre and post flow release) (Zar 2010, p. 307). As a precursor to the nested ANOVA, means for each study year were tested for significance using simple ANOVA and then individual years compared amongst each other using Student-Newman-Keuls (SNK) test.

The above statistical tests assume that the sample data 1) follow a normal distribution, 2) have variances that are independent of the mean, and 3) the components of the variance are additive (Elliott 1977). In the case of the juvenile fish population data, these assumptions are unlikely to be achieved in that juvenile salmonids in streams tend to exhibited contagious (clumped) distributions (violation of assumption 1) and variances tend increase as means increase (violation of assumption 2). When sample data are derived from a contagious population, samples sizes are small (≤ 30), and variances are greater than the mean, Elliott (1977) recommends the use of a log transformation on the original data. This transformation results in a dataset that satisfies the three assumptions listed above and thus permits use of statistical procedures such as simple and nested ANOVAs on the transformed data.

In the case of the fish density data, the transformation used was $\log_{10}(x+1)$. The addition of 1 to the data prior to the transformation was necessary to allow handling of situations where zero fish were caught for a given site and age class (Elliott 1977, Zar 2010). Means, variances, ANOVA, nested ANOVA, SNK tests, etc. were performed on the log transformed data. Results were then converted back to the original units using the antilog and subtracted by 1. Details and example calculations can be found in Elliott (1977, p. 91) and Zar (2010, p. 289). It should be noted that the antilog of the transformed means is in fact the geometric mean. For this reason, mean fish densities given in this report are geometric means.

Statistical analyses performed on fish condition factor were considerably simpler as the sample data conform to the three assumptions previously listed and sample sizes were considerably larger (n ranged from 69 to 252). For these reasons, statistical analyses could be performed directly on the original data without the need for a transformation. Since no transformation was involved, means presented for condition factor are arithmetic means.

3.2 Habitat Inventory

The goal of the habitat inventory was to collect quantitative and qualitative information on the nature of fish habitat in the study area in order to assess changes after initiation of the fish flow release (January 2008). For this component, 6 sections were inventoried during September 17–20, 2010. Survey sections were the same as in previous years and encompassed the 2010 electrofishing sites. Stream lengths surveyed ranged from 181 m to 511 m. Locations of survey sections are shown in Figure 1.

Habitat surveys followed methods outlined in Johnston and Slaney (1996). This involved walking the stream thalweg with a running hip chain and recording distance of the top and bottom of each habitat unit encountered. GPS coordinates were collected at the origin of each survey section in order to establish its location on digital TRIM maps. All habitat units within a given survey section were assessed and information recorded on prepared field forms. Data collected for each habitat unit included habitat unit number, type (pool, glide, riffle, or cascade), length (m), mean depth (m, average of 3 measurements), maximum depth (m), residual pool depth (m, pools and glides only), mean wetted width (m, average of 3 measurements), average velocity (m/s), substrate composition (percent bedrock, boulder, cobble, gravel, and fines), and dominant/subdominant cover types and their relative percentages. Average velocity of habitat units was determined from the equation:

$$v_{ave} = \frac{Q}{d_{ave} \times w_{ave}}$$

where: V_{ave} = *average velocity in m/s*

Q = *discharge in* m^3/s

d_{ave} = *average depth in m*

w_{ave} = *average width in m*

Discharges for determination of v_{ave} were obtained from the Inflow Monitoring Program (Burt and Hudson 2011 draft).

Habitat units situated on electrofishing sites received additional data collection including more detailed information on cover (percentage of all categories) and substrate (D_{90}, D_{max}, compaction, and degree of infilling).

3.3 Environmental Monitoring

Environmental monitoring involved 1) in-situ collection of temperature, pH, conductivity, and alkalinity at all electrofishing sites with handheld meters or titration test kit, 2) collection of water samples at 5 sites for laboratory analysis of copper, and 3) periodic downloading of data from continuous water temperature loggers at 5 sites established in 2005. Locations, dates, and water quality parameters assessed are listed in Table 1. Locations of all sites are provided in Figure 1.

Table 1. Summary of Water quality monitoring conducted during the 2010 Fish Index Study.

Parameters	Sample Method	Locations	Dates
Water temperature, pH, conductivity, alkalinity	Handheld Meters, titration test kit (alkalinity)	All 15 electrofishing sites	Sept. 13 - 22, 2010
Total copper and total dissolved copper	Water Samples (WS)	EF02, EF04, EF06, EF13, EF14	Sept. 21, 2010
Continuous temperature monitoring	Temperature logger (TL) set to record temperature at 15 minute intervals	TL01 to TL05 in Figure 1	Period of record: TL01: Jun 10/10—Dec 31/10 TL02: Jan 1/10—Dec 31/10 TL03: Jan 1/10—Dec 31/10 TL04: logger washed away TL05: Jan 1/10—Dec 31/10

Equipment used for in-situ measurements at electrofishing sites included a Taylor digital thermometer (model 9847) for temperature, an Oakton waterproof pHTestr 10 for pH, a Horiba Twin B-173 for conductivity, and a Lamotte titration test kit for alkalinity. The water samples were collected in 500 ml plastic bottles (3 replicates per site), stored on ice in a cooler, and delivered to North Island Labs (Courtenay) approximately 24 hrs after collection. The lab was instructed to analyze all 3 replicates from each site for both total and total dissolved copper. Continuous water temperature monitoring used Stowaway tidbits (Onset Computer Corp.). These were mounted inside 18 cm lengths of 3.8 cm (1½ inch) PVC pipe weighted with 4.5 kg (10 lb) cannon balls. Each apparatus was tethered to an anchor pin in a nearby rock with 9.5 mm (3/8 inch) steel core rope.

4. 2010 RESULTS

4.1 Fish Abundance and Condition Factor

Summary of 2010 Electrofishing Sites

In 2010, fish population sampling was conducted at 15 of the original 17 index sites. Site locations are shown in Figure 1, while a summary of each site's characteristics and capture statistics can be found in Appendix B. The distribution of sites per reach and number of each fish species captured per site in 2010 are given in Table 2. A total of 252 rainbow trout, 7 coho, and 184 sculpins were captured in 2010. The "rainbow" at EF02 through EF04 could possibly have been steelhead given the anadromous access to these sites. The sculpins caught at EF02, EF03 and EF04 were probably coastrange sculpins (*Cottus aleuticus*) as the first dorsal fin did not display a distinct black spot (McPhail and Carveth 1999).

Table 2. Distribution of electrofishing sites by reach, and the number of passes and catch by species for each site completed on the lower Jordan River during Sept. 13–22, 2010.

Reach	Reach Type	Number of Sites	Sites	No. of Passes	Total Catch By Species
R2	Anadromous	2	EF01 EF02 E03	Not done 3-pass 3-pass	— RB/ST – 12 CC - 113 RB/ST – 21 CO - 7 CC - 22
R3	Anadromous	1	EF04	3-pass	RB/ST – 32 CO - 0 CC – 49
R4	Resident	3	EF05A EF05B EF05C	3-pass 3-pass 3-pass	RB – 14 RB – 44 RB – 20
R5	Resident	3	EF06 EF07 EF08 EF09	3-pass 3-pass Not done 3-pass	RB – 16 RB – 8 — RB – 17
R6	Resident	5	EF11 EF12 EF13 EF14A EF14B	3-pass 3-pass 3-pass 3-pass 3-pass	RB – 18 RB – 11 RB – 6 RB - 3 RB - 17
R7	Resident	1	EF15	3-pass	RB - 13
Totals		15			RB/ST – 252 CO - 7 CC – 184

Notes: RB = rainbow trout, ST = steelhead trout, CO = coho salmon, CC = sculpins

This was the fourth year in which salmonids were captured at sites EF02 and EF03 (2007 was the first year). Sampling at these sites in 2005, 2006, and by Griffith in 1994 (Griffith 1996) never encountered salmonids, and this was believed to be due to high levels of copper in the water in this section of river (originating from a mine deposit on the left bank). The presence of salmonids at these sites in 2007 through 2010 was likely due to the higher flows experienced in the summers of those years (dilution factor), possibly in combination with a major flood in November 2006 which scoured some of the source material out to sea (discussed further in Section 4.3).

2010 was the fifth year in which coho fry were captured in the anadromous reach (they were also captured in 2005, 2006, 2008, and 2009). These fish may have been fry released from the egg incubation study or from natural spawning (the 2005 captures were from natural spawning as the incubation study had not commenced at that time). 2010 was also the third year in which large numbers of sculpins were captured in the anadromous reach (2008 being the first year). This may have been a response to reduced copper leachate and the much higher flows since initiation of the fish flow release.

Density and Biomass

Standing stock of rainbow trout in the Jordan River was assessed in terms of density and biomass. To derive density, maximum likelihood population estimates per age group were converted to fish density (fish per 100 m^2) based on site areas. Density values were not adjusted by habitat suitability criteria (from the depth/velocity transect data) because it was found that such adjustments produced unreasonable expansion of observed densities. Thus, results presented are restricted to observed densities.

Figure 3 summarizes results of the density calculations. Detailed capture statistics can be found in Appendix A. As in previous years, 2010 fry densities were highly variable among sites, ranging from 0 to 49 fry/100 m^2. In general, the presence of fry were related to the occurrence of appropriately sized spawning gravel nearby. Densities of 1^+ parr were also variable with a range of 0 to 19 fish/100 m^2. This was the third consecutive year in which older age groups of rainbow parr (age 2^+ and 3^+) formed a significant component of the catch (2008 was the first year). For example, in 2010 density of age 2^+ and 3^+ combined ranged from 0 to 4 fish/100 m^2 and they were captured at 12 of the 15 index sites. Geometric mean densities in 2010 were 9.5 FPU for fry (95% CL 4.2 – 20.0), 3.1 FPU for 1^+ parr (95% CL 1.7 – 5.4), and 1.2 for $2^+/3^+$ parr (95% CL 0.5 – 2.1). These means were substantially less than the predicted maximum densities of 87 FPU for fry, 13 FPU for 1^+ parr, and 5 FPU for $2^+/3^+$ parr, but it is noteworthy that on an individual basis, some of the index sites supported densities that were close to or exceeded the predicted maxima for 1^+ and $2/3^+$ parr (note: predicted maximum densities were derived by dividing predicted maximum biomass by the 2005-2010 mean weights for fry and parr; predicted maximum biomass is discussed below).

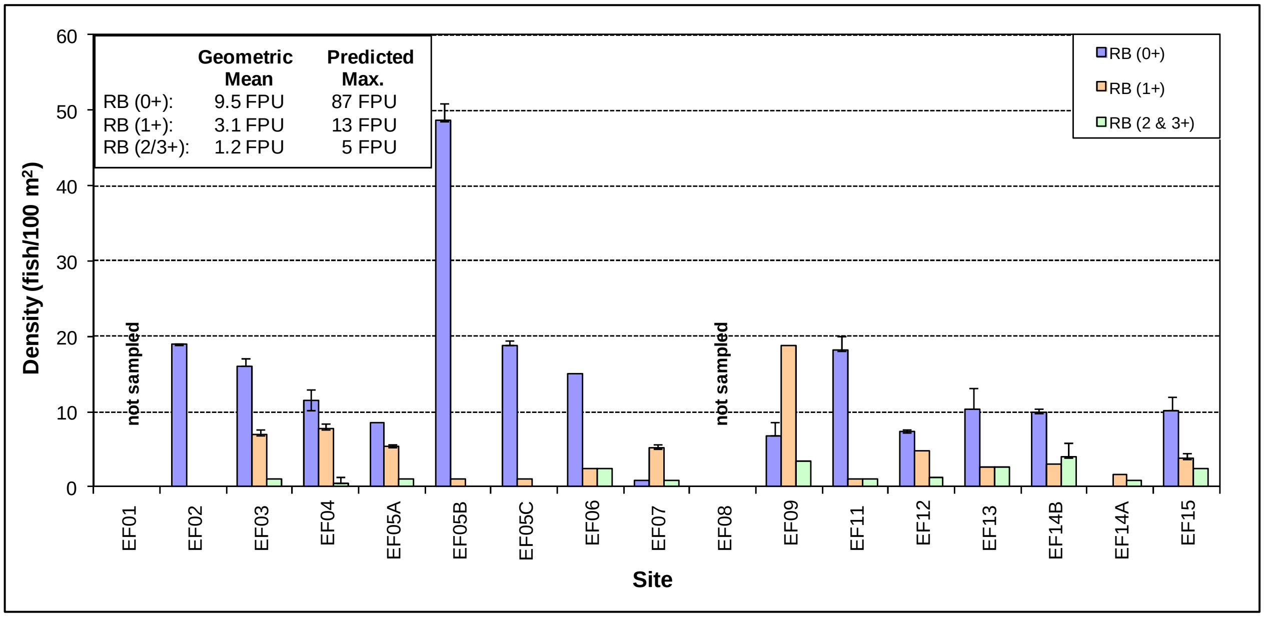

Figure 3. Density of rainbow trout (fish/100 m^2) at Jordan River index sites from September 2010 electrofishing. Error bars denote 95% confidence limits. Lack of error bars indicates 100% catch efficiency (i.e., all fish were caught in pass 1). Geometric means are based on all sites sampled.

Calculation of fish biomass at Jordan River fish index sites was achieved by multiplying density per age group at each site by mean weight per age group at each site (g/100 m^2). Figure 4 shows these results (see Appendix A for details). For sites where fish were caught, biomass ranged from 4 to 102 g/100 m^2 for 0$^+$ fry, 21 to 372 g/100 m^2 for 1$^+$ parr, and 23 to 188 g/100 m^2 for 2 and 3$^+$ parr. Geometric mean biomass for all sites combined was 27.1 BPU for fry, 54.5 BPU for 1$^+$ parr, and 29.7 BPU for 2$^+$/3$^+$ parr.

The predicted maximum biomass in Figure 4 (255 g/100 m^2) was calculated from a recent model[1] by Ron Ptolemy (MWLAP, Victoria) based on alkalinity and stream enrichment state. For the Jordan River, a non-enrichment state was assumed (a yes/no parameter in the model) and an alkalinity of 20 mg/L was used (2008 – 2009 mean from samples collected by this study). Biomass levels of fry at the index sites were well below the predicted maximum, however, some sites were close to or exceeded the predicted maximum in terms of 1$^+$ and 2/3$^+$ parr. This is the third consecutive year of monitoring in which parr biomass levels have been reasonably close to or exceeded the alkalinity model at some sites.

[1] Maximum Biomass = 35 × (ALK)$^{0.663}$ (Ron Ptolemy, MWLAP, Victoria, pers. comm.).

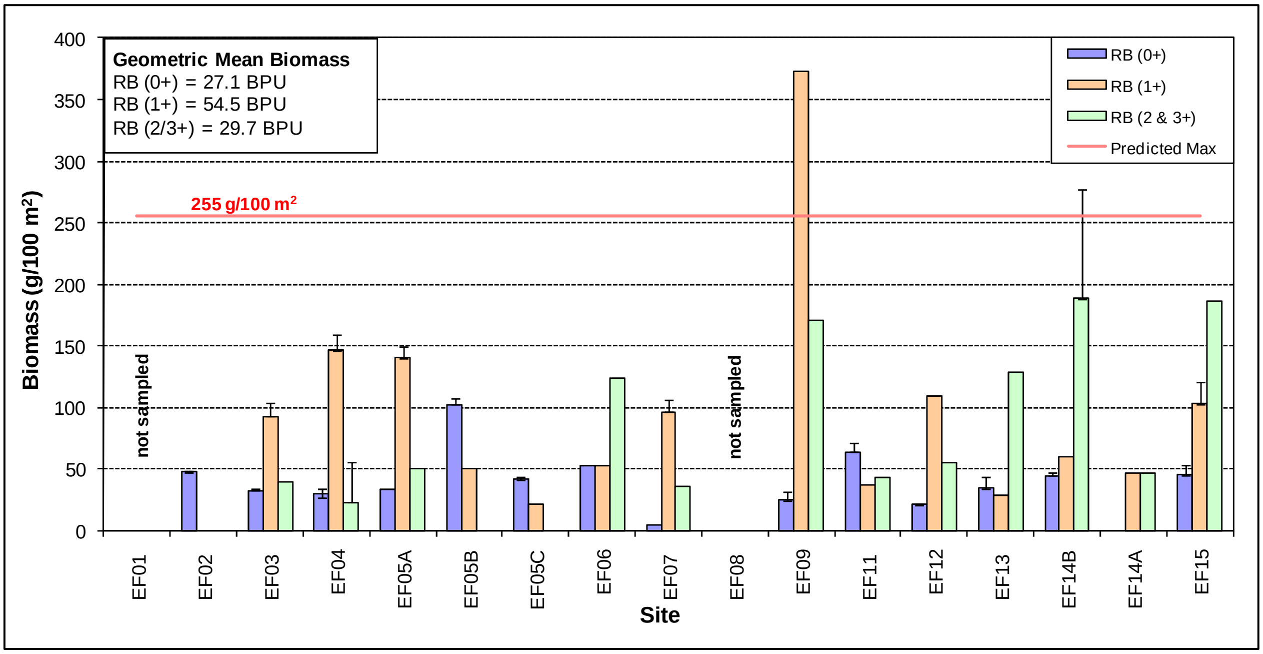

Figure 4. Biomass of rainbow trout (g/100 m^2) at Jordan River index sites from September 2010 electrofishing. The predicted maximum (255 g/100 m^2) is based on a recent model by Ptolemy (pers. comm., see text) using an average alkalinity from 2008 and 2009 sampling (20 mg/L). Error bars denote 95% confidence limits. Lack of error bars indicates 100% catch efficiency.

Length, Weight, and Condition Factor

Table 3 summarizes statistics for length, weight, and condition factor for rainbow trout captured in the Lower Jordan River in 2010. Rainbow fry captured in 2010 were slightly larger than in 2007 – 2009 (length and weight), but less than in 2005 and 2006. Length and weight of 1^+ rainbow parr were greater than in 2006, 2008, and 2009 (mean length for these years ranged from 110 – 119 mm, and mean weight from 15 – 19 g), but less than in 2005. For 2^+ and 3^+ parr, mean length and weight in 2010 were greater than in 2008 and 2009, while in the pre flow release years very few fish in these age groups were captured. A general trend in parr among years is that they tended to be larger in years when there were fewer numbers. For condition factor, the overall mean for all age groups combined was 1.08 ± 0.02 (95% confidence limits) which was greater than all previous years except 2006 when the overall condition factor was 1.13. As a comparative note, the Provincial default condition factor for rainbow trout is 1.05 (Ron Ptolemy, MWLAP, Victoria, pers. comm.).

Though not shown in Table 3, 7 coho fry were captured in 2010 with a mean length and weight of 79 mm and 6.4 g, respectively.

Table 3. Length (mm), weight (g), and condition factor statistics for rainbow trout captured by electrofishing in the Jordan River during September 13–22, 2010.

	Age	Statistic					
		n	Min	Max	Mean	SD	95% CL
Fork Length (mm)	0+	174	40	85	62	10	1
	1+	60	90	148	123	16	4
	2+	17	152	172	162	6	3
	3+	1			204		
Weight (g)	0+	174	0.6	7.4	2.8	1.4	0.2
	1+	60	7.0	43.9	20.7	8.2	2.1
	2+	17	34.5	60.3	47.0	7.0	3.3
	3+	1			86.3		
Condition Factor	0+	174	0.80	1.44	1.09	0.13	0.02
	1+	60	0.78	1.41	1.05	0.12	0.03
	2+	17	0.91	1.25	1.09	0.08	0.04
	3+	1			1.02		
	All	252	0.78	1.44	1.08	0.12	0.02

The relationship between weight and length for rainbow trout captured by this monitoring program to date is shown in Figure 5. The data were grouped as pre and post flow release with separate power curves fitted for each group (formula: $weight = a \times [length]^b$). The data show that the relationship between length and weight after the flow release was very similar to that prior to the flow release. The slight deviation of the post flow release curve (red line) from the pre flow release curve (blue line) after 180 mm is due to heavy leverage by the last red data point (at 204 mm) and cannot be taken as indicating a difference between curves. For both curves, the power variable (*b*) is greater than 3 suggesting that fish become more rotund as length increases (Anderson and Neumann 1996). Another feature is that variability about the fitted lines increase as fish size increases.

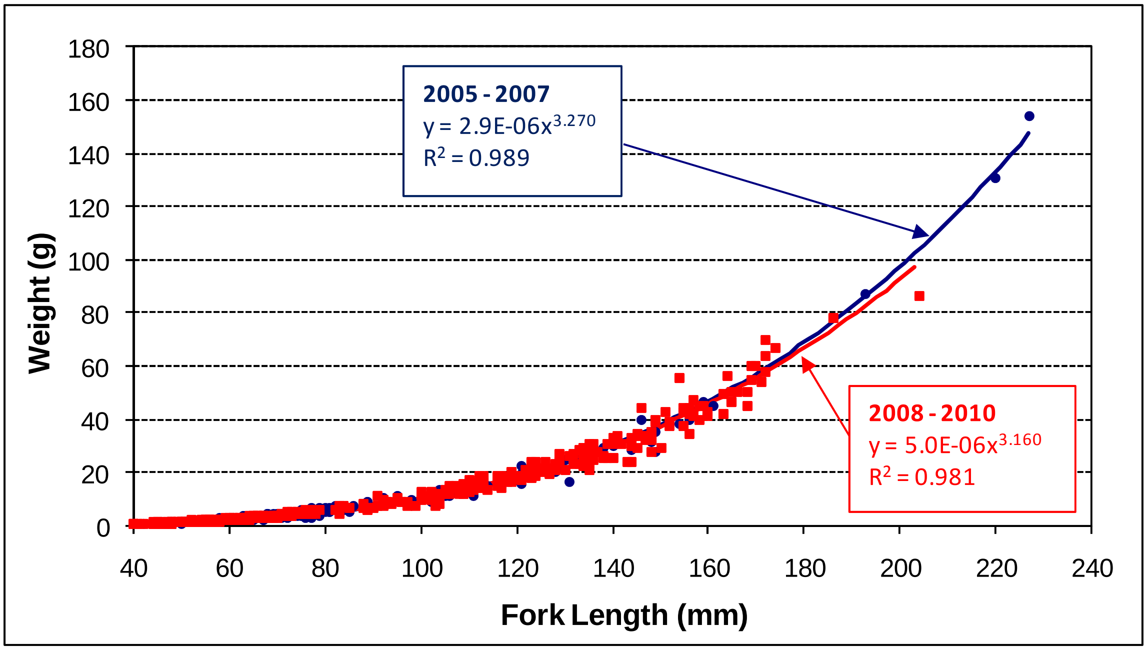

Figure 5. Weight-length relationship for rainbow trout captured by electrofishing on the Jordan River prior to the flow release (blue, 2005-2007, n=290), and after the flow release (red, 2008-2010, n=574). Data were fitted with a power curve using TableCurve 2D.

4.2 Habitat Survey Results

Habitat inventories were completed on 6 sections of the Jordan River located within Reaches 2, 3, 5, 6, and 7. Locations of these sections are shown in Figure 1. Distances surveyed per section ranged from 181 m to 511 m, for a combined survey length of 2,014 m. These data were used to estimate habitat unit frequencies and hydraulic characteristics at the reach level (Table 4). Glides and pools were the dominant habitat types in most reaches in terms of both stream length and wetted area (the exceptions was Reaches 5 and 7 where riffles ranked second). Riffles, the primary areas of aquatic invertebrate production, formed 15.5% of the overall wetted area, which is similar to 2008 (12.2%) and 2009 (17.2%), and about double the percentages found in the 3 years prior to the flow release. Also, like 2008 and 2009, no sections of subsurface flow were found during the 2010 surveys indicating continuity of habitat in all sections surveyed. This differs from the 3 pre flow release years when subsurface flows amounted to 5 – 7% of the lower Jordan River stream length. Total wetted area for all surveyed reaches combined was 123,819 m^2 (note: Reach 4 was not surveyed), which is 1.8 – 2.3 times greater than the wetted areas found during pre flow release surveys (2005 – 2007).

Table 4. Summary of habitat unit frequencies and hydraulic characteristics by reach based on stream sections surveyed in the Jordan River during September 17–20, 2010.

Survey Section & Length (m)	Date	Reach No. and Length (m)	Bankfull Width (m)	Habitat Unit Type	Unit Length By Reach (m)	Unit % By Length	Unit Wetted Area By Reach (m^2)	Unit % By Wetted Area	Mean Wetted Width (m)	Mean Velocity (cm/s)	Mean Depth (m)	Mean Max Depth (m)
JOR00875	17/09/2010	R2	39	C	1.2	0.3%	18	0.3%	14.50	15.17	0.30	0.45
300.6		368		G	136.3	37.0%	2,786	41.7%	20.45	7.47	0.55	0.82
				P	171.0	46.5%	2,902	43.5%	16.97	4.16	1.16	1.88
				R	59.5	16.2%	969	14.5%	16.28	12.74	0.50	0.71
				All	368.0	100.0%	6,674	100.0%	18.14	4.41	0.83	1.29
JOR01243	17/09/2010	R3	37	C	96.6	28.3%	453	11.2%	4.68	29.59	0.59	0.93
180.5		342		F	3.8	1.1%	17	0.4%	4.50			
				G	82.0	24.0%	648	16.0%	7.89	11.97	0.90	1.32
				P	137.6	40.2%	2,865	70.6%	20.83	3.81	1.37	2.24
				R	22.0	6.4%	75	1.8%	3.40	33.80	0.58	0.78
				All	342.0	100.0%	4,057	100.0%	11.86	5.72	0.97	1.53
JOR03956	21/09/2010	R5	29	C	127.7	4.2%	1,760	3.4%	13.79	36.24	0.38	0.58
511		3,021		G	1,732.2	57.3%	31,098	59.5%	17.95	8.55	0.52	0.80
				P	452.3	15.0%	6,961	13.3%	15.39	7.73	1.04	1.83
				R	708.8	23.5%	12,488	23.9%	17.62	13.14	0.38	0.59
				All	3,021.0	100.0%	52,308	100.0%	17.31	7.94	0.56	0.89
JOR06494	20/09/2010	R6a	31	C	80.4	4.7%	966	3.1%	12.02	39.68	0.44	0.70
474.0		1,709		G	767.6	44.9%	12,613	41.1%	16.43	12.68	0.75	1.27
				P	678.6	39.7%	13,868	45.1%	20.44	6.50	1.13	2.00
				R	182.4	10.7%	3,272	10.7%	17.94	24.39	0.37	0.65
				All	1,709.0	100.0%	30,719	100.0%	17.97	9.31	0.84	1.46

Survey Section & Length (m)	Date	Reach No. and Length (m)	Bankfull Width (m)	Habitat Unit Type	Unit Length By Reach (m)	Unit % By Length	Unit Wetted Area By Reach (m^2)	Unit % By Wetted Area	Mean Wetted Width (m)	Mean Velocity (cm/s)	Mean Depth (m)	Mean Max Depth (m)
JOR07857	19/09/2010	R6b	30	C	74.8	6.0%	1,049	4.2%	14.01	15.14	0.37	0.55
238.6		1,240		G	233.9	18.9%	3,558	14.2%	15.21	4.34	0.54	1.00
				P	835.2	67.4%	19,171	76.5%	22.96	4.51	1.12	1.88
				R	96.1	7.8%	1,292	5.2%	13.44	16.58	0.31	0.54
				All	1,240.0	100.0%	25,070	100.0%	20.22	1.74	0.90	1.53
JOR08238	19/09/2010	R7	30	C	52.5	11.9%	361	7.2%	6.87	11.24	0.42	0.73
309		440		G	219.6	49.9%	2,707	54.2%	12.33	6.28	0.48	0.93
				P	71.5	16.2%	789	15.8%	11.04	4.74	0.72	1.33
				R	96.4	21.9%	1,134	22.7%	11.76	13.52	0.23	0.42
				All	440.0	100.0%	4,991	100.0%	11.34	6.16	0.46	0.86
All		R2, 3, 5, 6, 7		C	433.3	6.1%	4,607	3.7%	10.63			
2,013.7		7,120		F	3.8	0.1%	17	0.0%	4.50			
				G	3,171.5	44.5%	53,410	43.1%	16.84			
				P	2,346.0	32.9%	46,557	37.6%	19.84			
				R	1,165.3	16.4%	19,230	15.5%	16.50			
				All	7,120.0	100.0%	123,819	100.0%	17.39			

Notes:

1. Habitat unit type abbreviations include P = pool, G = glide, R = riffle, C = cascaded, and F = falls
2. Survey section names are based on distance in metres from the river mouth to the downstream end of the section; e.g., JOR00875 begins 875 m from the mouth. Distances were calculated by digitizing on TRIM maps in ArcView.

Substrate and cover characteristics of surveyed sections are summarized in Table 5. Boulders were the dominant substrate in all sections while the subdominant substrate was generally gravel or cobble, or a combination of both. Boulders were also the dominant cover category, and for many habitat units examined, the only cover type. Other cover types present were deep pool and overstream vegetation. The incidence of deep pool cover was higher in 2008 – 2010 surveys compared with the previous 3 years due to the fish flow release.

Table 5. Summary of mean substrate and cover features for each stream section surveyed during September 17–20, 2010.

Survey Section	Date	Reach	Mean percent of Each Substrate Category					% Boulder Cover
			Bedrock	Boulder	Cobble	Gravel	Fines	
JOR00875	17/09/2010	R2	0	50	22	24	4	42
JOR01243	17/09/2010	R3	3	59	15	22	1	33
JOR03956	21/09/2008	R5	10	36	28	23	3	33
JOR06494	20/09/2010	R6a	3	63	16	17	1	36
JOR07857	19/09/2010	R6b	3	65	19	12	1	42
JOR08238	19/09/2010	R7	6	49	38	7	0	34

Note: Boulder was generally the dominant cover type in habitat units surveyed. The exceptions were after the flow release when deep pool was occasionally the dominant type.

4.3 Environmental Monitoring Results

Water chemistry data collected in 2010 included in situ measurements of alkalinity, conductivity, and pH at most electrofishing sites during September 13 – 22, and collection of water samples at 5 sites (EF02, EF04, EF06, EF13, and EF14) on September 21, 2010 (see Figure 1 for locations). The water samples were analyzed for dissolved and total copper by North Island Labs, Courtenay, BC. Results for both in situ measurements and lab analysis of water samples are provided in Table 6. For consistency with previous years, only sites where water samples were taken are shown.

The data in Table 6 show that in 2010 alkalinity was consistent among sites at 18 mg/L, conductivity ranged from 21 – 30 µS with a mean of 26 µS, and pH from 6.1 – 6.4 with a mean of 6.3. In the case of copper, both dissolved and total copper ranged from 0.001 – 0.009 mg/L. For the assessment of copper in the lower Jordan River, the lowermost sample site (EF02) was situated downstream of the mine tailings, while the next upstream site (EF04) was situated immediately upstream of seepage sources from the tailings. Results for 2010 show that copper concentrations in the "tailings" reach were 9-fold greater than in upstream reaches (0.001 mg/L vs. 0.009 mg/L).

Table 6. Summary of 2010 water quality data from in situ measurements (alkalinity, conductivity, and pH) and from laboratory analysis of water samples (dissolved and total copper).

Sample Site	Alkalinity (mg/L CaC03)	Conductivity (µS)	pH (pH units)	Dissolved Copper (mg/L)	Total Copper (mg/L)
Detection Limits	10	1	pH units	0.001	0.001
Criteria for aquatic Life			6.5 – 9.0	0.002 (average)	0.002 (average)
EF02	18	30	6.4	0.009	0.009
EF04	18	27	6.2	0.003	0.003
EF06	18	24	6.4	0.001	0.001
EF13	18	21	6.1	0.001	0.001
EF14	18	21	6.2	0.001	0.001
2009 Mean	18	26	6.3		

Table Notes:

Alkalinity, conductivity, and pH were measured in the field during Sept. 13 – 22, 2010. Dissolved and total copper were from water samples collected Sept. 21, 2010 and analyzed in the lab by North Island Labs, Courtenay, BC. Values for dissolved and total copper are the average of 3 replicates per site. "Criteria for aquatic life" are from the BC Guidelines for Interpreting Water Quality Data (Ministry of Environment 1998). The copper criterion of 0.002 mg/L is for streams where the hardness is ≤ 50 mg/L.

In order to compare changes in conductivity, pH, and alkalinity among study years, means were calculated for each of these parameters by year (Figure 6). Note that 2005 to 2007 were pre flow release years while 2008 to 2010 were post flow release years. These data suggest that conductivity decreased after initiation of the flow release, while pH remained about the same (the low pH in 2010 may be due to the small freshet during sampling, or possibly instrument malfunction). The means for alkalinity may indicate an increase after the flow release but differences were not significant. The lower alkalinity in 2010 is likely related to the small freshet event (alkalinity is generally inversely related to flow). In addition to stream discharge, the other factor affecting these parameters was the greater proportion of flows derived from mainstem reaches and tributaries upstream of Elliott Dam after the flow release. These upper watershed areas are located within the Leeward Island Mountains Ecosection as opposed to the Windward Island Mountains Ecosection of the Lower Jordan River (see Section 2), and thus, changes in monitored parameters in 2008 – 2010 may be in part due to the influence of water chemistry from these upstream sources.

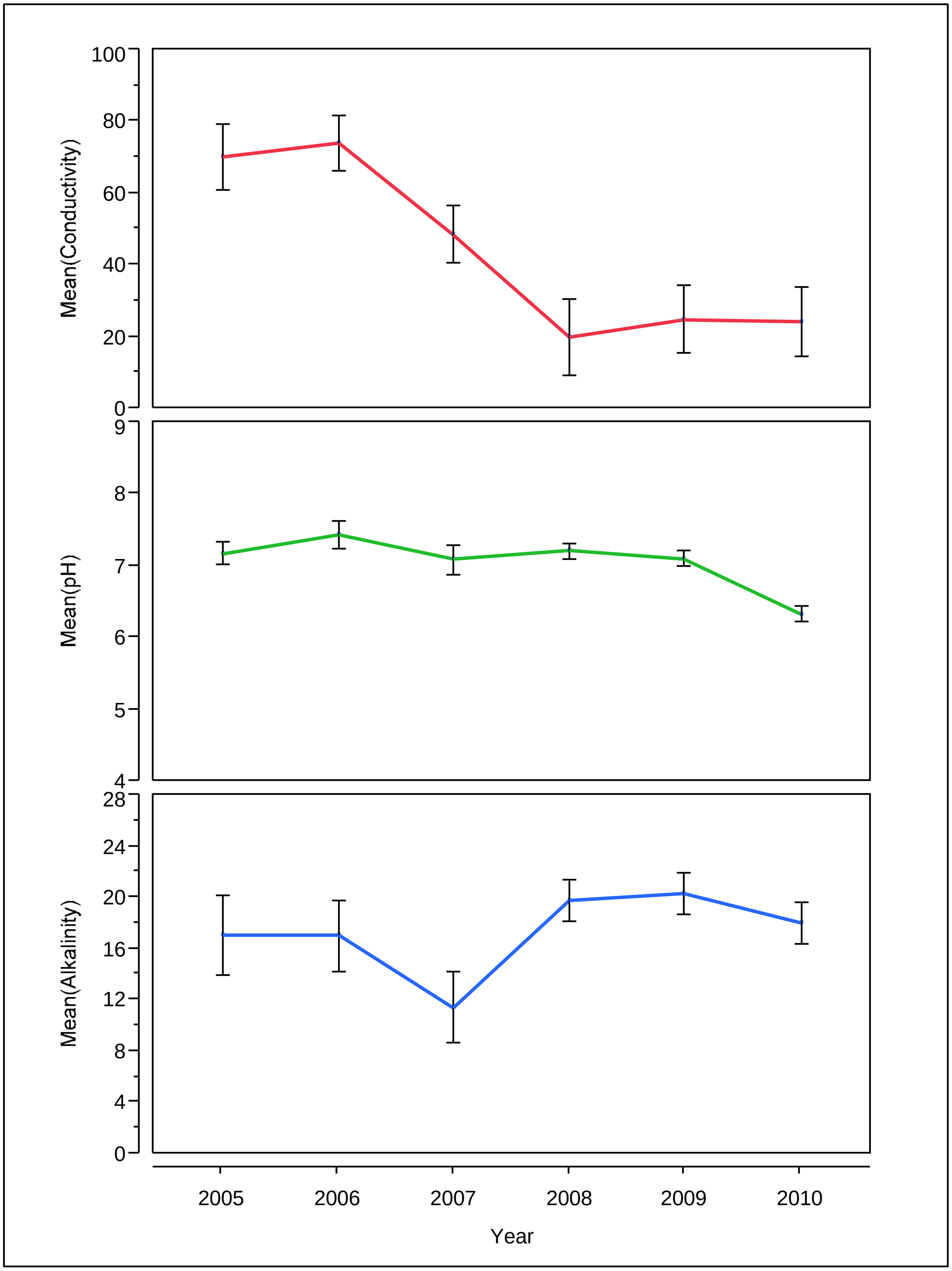

Figure 6. Mean conductivity (µS), pH, and alkalinity (mg/L) for all sites combined by year. 2005 – 2007 are pre flow release years and 2008 – 2010 post flow release years. Error bars indicated 95% confidence limits (pooled).

For comparison of copper concentrations among study years, mean dissolved and total copper (based on sample site replicates) were computed and graphed per year (Figure 7). These data show that copper concentrations at EF02 (mine tailings section) were much higher than upstream sites in 2005 and 2006, slightly less in 2007, and then much lower in 2008 to 2010 under the fish flow release (albeit, still greater than upstream sites). The slight decrease in copper concentration in 2007 was believed to be due to scouring away some of the source material by a major flood event in the winter of 2006. The further decrease in 2008 to 2010 was most likely due to dilution of copper leachate by the higher discharge provided by the fish flow release from Elliott Dam. Though copper concentrations in Reach 2 were substantially reduced in 2008 to 2010, they still remained above the BC criteria for aquatic life (0.002 mg/L). Nevertheless, a transition to healthier water quality was apparent in the fish capture results in the last three years of the study. For example, in 2007 juvenile trout were captured for the first time at sites within the copper zone though they still exhibited very poor condition factors. In 2008 to 2010, trout were again captured in this zone but now exhibited much healthier condition factors.

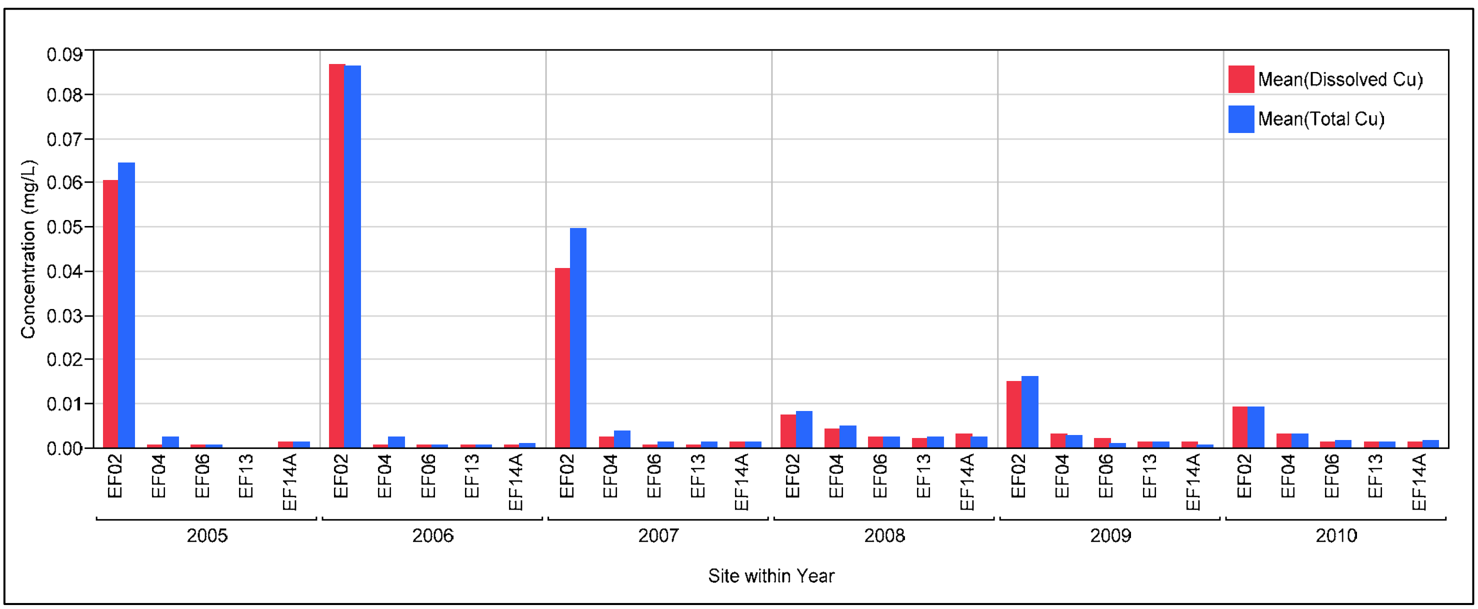

Figure 7. Mean dissolved and total copper per site for each study year (2005 – 2010). Means are based on 2-3 replicate water samples per site except 2005 when only 1 replicate was analyzed by the lab.

Monitoring of water temperature on the lower Jordan River was conducted using TidBit temperature loggers set to take readings every 15 minutes. These were installed at 5 stations in the lower Jordan River (see Figure 1 for site locations). The initial loggers were lost in the November 2006 flood and new ones installed at 4 of the 5 sites during July through September 2007. The remaining site (TL04, located just below the Sinn Fein confluence) was reinstalled in May 2008. Additional disruptions occurred following the reinstallations and included the following:

- The TL03 logger was stolen in summer 2008 and resulted in loss of data from May 22 to November 27, 2008.
- The TL01 logger was again washed away in the 2009/2010 winter. A new one was installed on June 10, 2010 at a more secure location (the inflow monitoring water level logger pool).
- The TL04 logger was also washed away in the 2009/2010 winter. This site is very volatile and access is difficult so no new logger was installed.

Mean daily water temperatures from these loggers are shown for the pre flow release years (2005–2007) in Figure 8 and for the post flow release years (2008–2010) in Figure 9. Mean daily temperatures peaked in the summer between early July and mid August depending on year. TL03 typically experienced the highest summertime temperatures, likely due to the openness of the valley and wide shallow channel in this reach. Peak summer temperatures at this site were 21.8 °C in 2006, 19.9°C in 2007, 23.3°C in 2009, and 18.2 °C in 2010. During the winter months (November 1 – March 31), mean daily temperatures ranged from 0.01 to 9.3°C with the coldest temperatures tending to occur at TL02 and TL03.

Mean monthly temperatures at Tl01, TL02, and TL05 for 2006 to 2010 are shown in Figure 10 (these sites had the longest period of record). There is no clear indication from these data whether the flow release has affected instream water temperatures. For example, at the site closes to Elliott Dam (TL01), there has been one year with the lower summertime temperatures (2008), one year with the higher summertime temperatures (2009), and one year with similar summertime temperatures (2010) relative to the pre flow release years of 2006 and 2007. This may suggest that solar radiation has greater bearing on summer temperatures than the flow release.

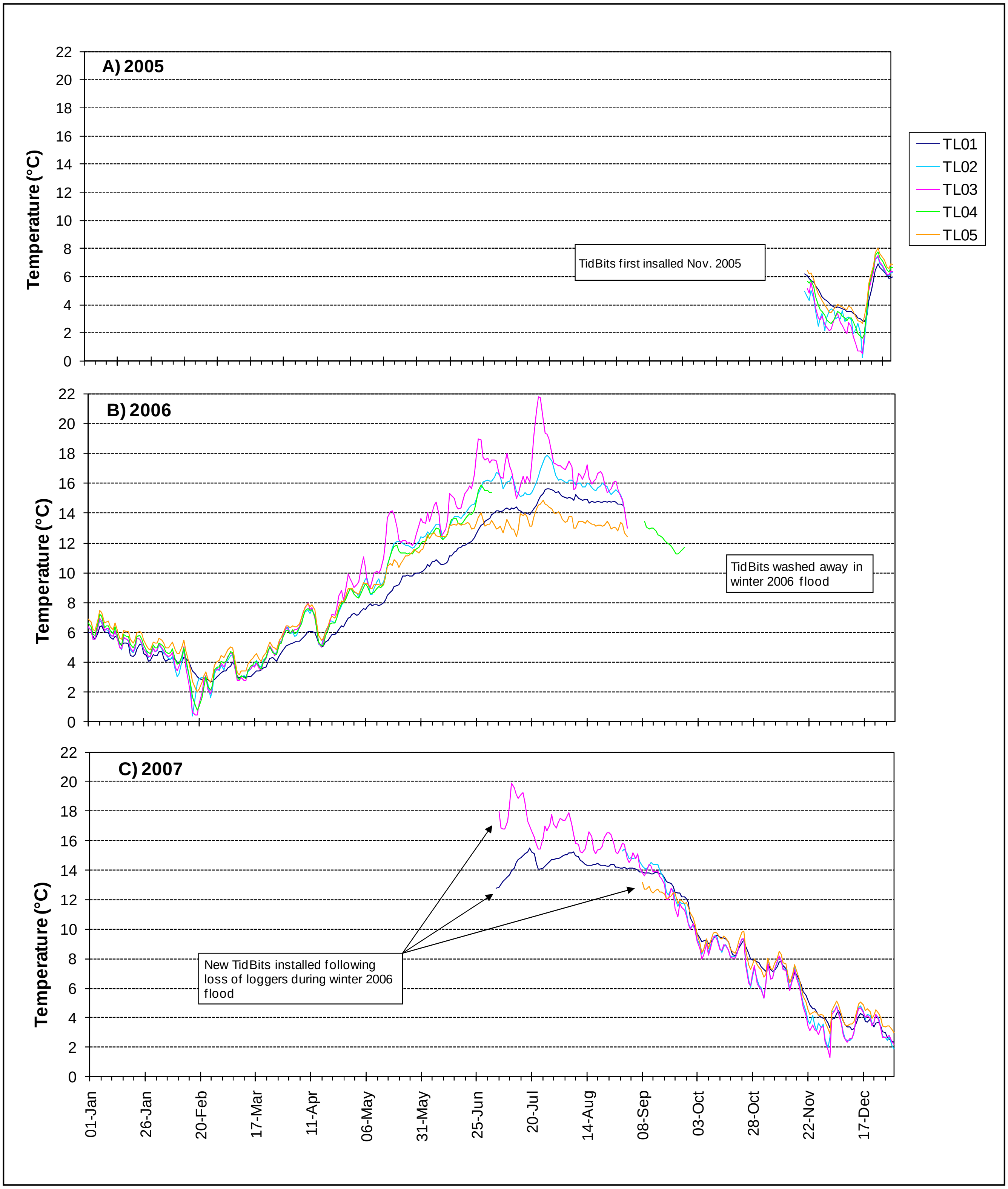

Figure 8. Mean daily water temperatures at the 5 monitoring sites in the lower Jordan River for 2005 to 2007 (pre flow release years). Data are from Tidbit loggers set to take readings every 15 minutes.

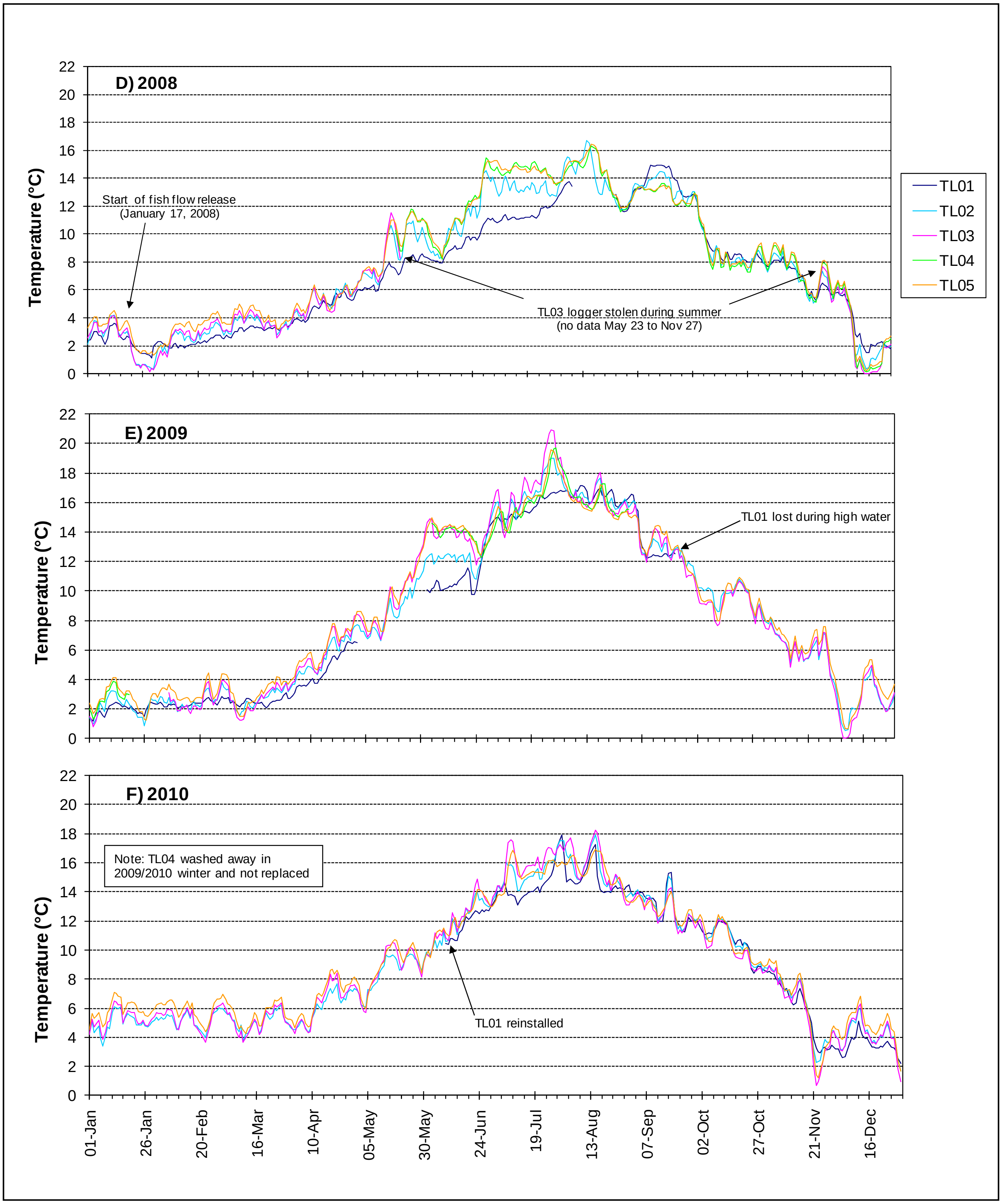

Figure 9. Mean daily water temperatures at the 5 monitoring sites in the lower Jordan River for 2008 to 2010 (flow release began Jan. 17, 2008). Data are from Tidbit loggers set to take readings every 15 minutes.

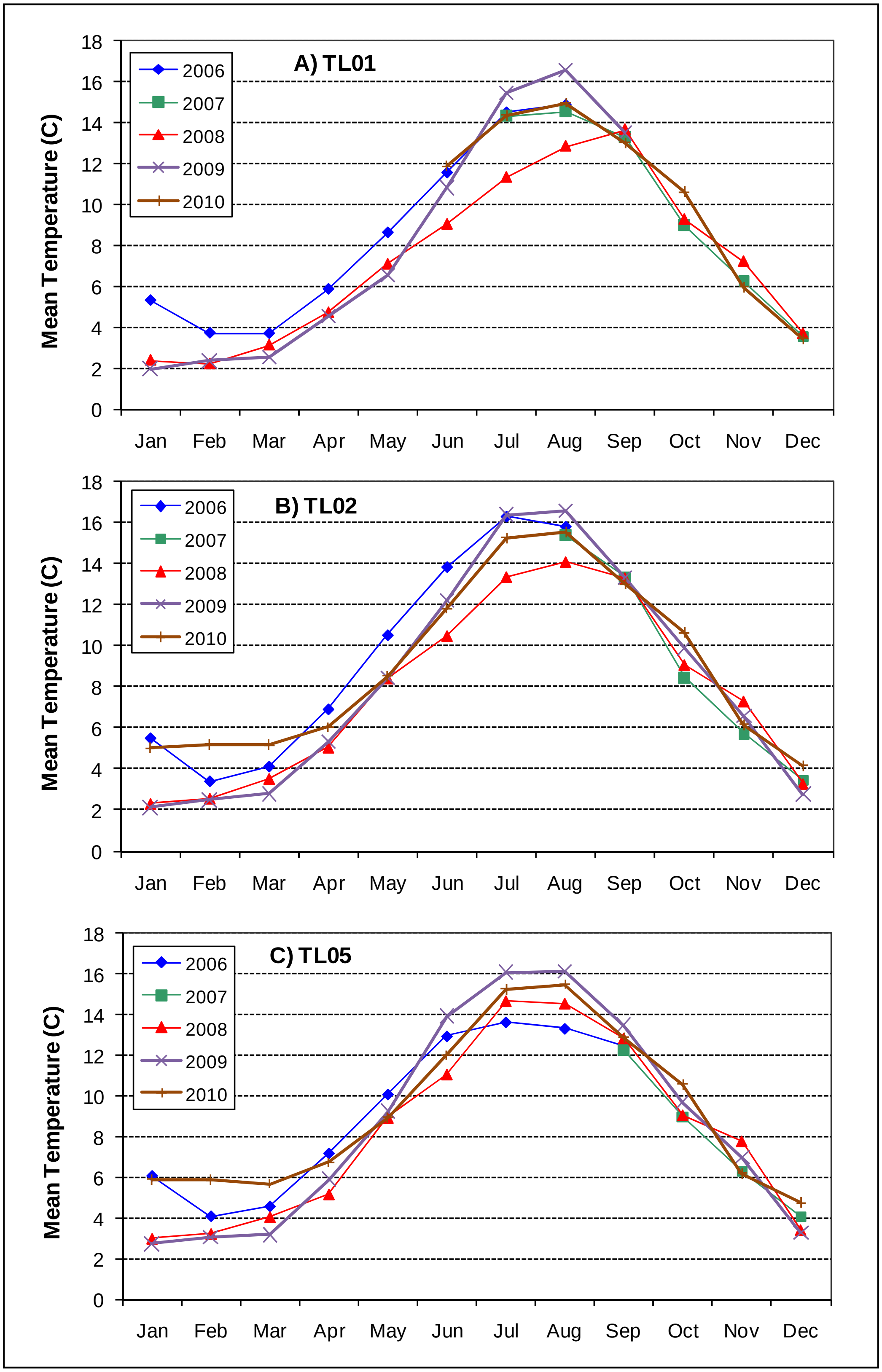

Figure 10. Mean monthly water temperatures at TL01 (A), TL02 (B), and TL05 (C) for 2006 to 2010.

5. PRE AND POST FLOW RELEASE COMPARISON OF PM's

For the Fish Index Monitoring Program, the performance measures (PM's) for assessing the benefits of the fish flow release include fish abundance, fish condition factor, and habitat continuity. The fish flow release (0.25 m^3/s) commenced in January 2008. Thus, with completion of the 2010 field program, the study now has 3 years of before treatment data and 3 years of after treatment data. The following examines all 6 years of data to determine whether there is a detectable benefit from the fish flow release in terms of each of the above performance measures.

Fish Abundance

Figure 11 shows the fish abundance performance measure, expressed as fish density, during the pre and post flow release years. Values shown are geometric means with associated 95% confidence limits. The 2005 and 2006 means exclude sites EF01, EF02, and EF03, as fish appeared to avoid this section of river due to elevated copper concentrations from nearby mine tailings. Since 2007, fish have utilized this area and so these sites were included in the means. In 2008 EF01 was excluded from sampling due to time constraints, while in 2009 and 2010 EF01 and EF08 were excluded for the same reasons. The data for fry (Chart A) show that pre flow release geometric mean densities ranged from 4.0 to 6.4 FPU, while post release means ranged from 3.3 to 9.5 FPU. For 1^+ parr (Chart B), pre flow release means ranged from 0.7 to 1.6 FPU, while post flow release means ranged from 2.0 to 4.8 FPU. Lastly, for 2 and 3^+ parr combined, pre flow release means ranged from 0 to 0.3 FPU and post flow release means from 0.6 to 1.9 FPU. The most notable feature of these results is the greater abundance of all age groups of parr in 2008 to 2010.

As an additional reference point, Figure 11 also shows maximum density estimates for rainbow fry and parr as predicted by the alkalinity model (87 FPU for fry, 13 FPU for 1^+ parr, and 5 FPU for $2/3^+$ parr). Mean densities were well below the potential predicted by this model.

Analysis of variance (ANOVA) performed on each age group shown in Figure 11 indicated that only in the case of age $2/3^+$ was there a significant difference among means ($p = 0.026$). Examination of the sources of variation indicated that the variance associated with individual catch estimates, in particular catch estimates derived from 1-pass sites, was a major factor for not detecting a significant difference among means. If catch estimate variances are excluded from the ANOVA calculations, the difference among means in the 1^+ age group becomes significant with a p of 0.004, and the p value for the 2^+ age group drops to < 0.001.

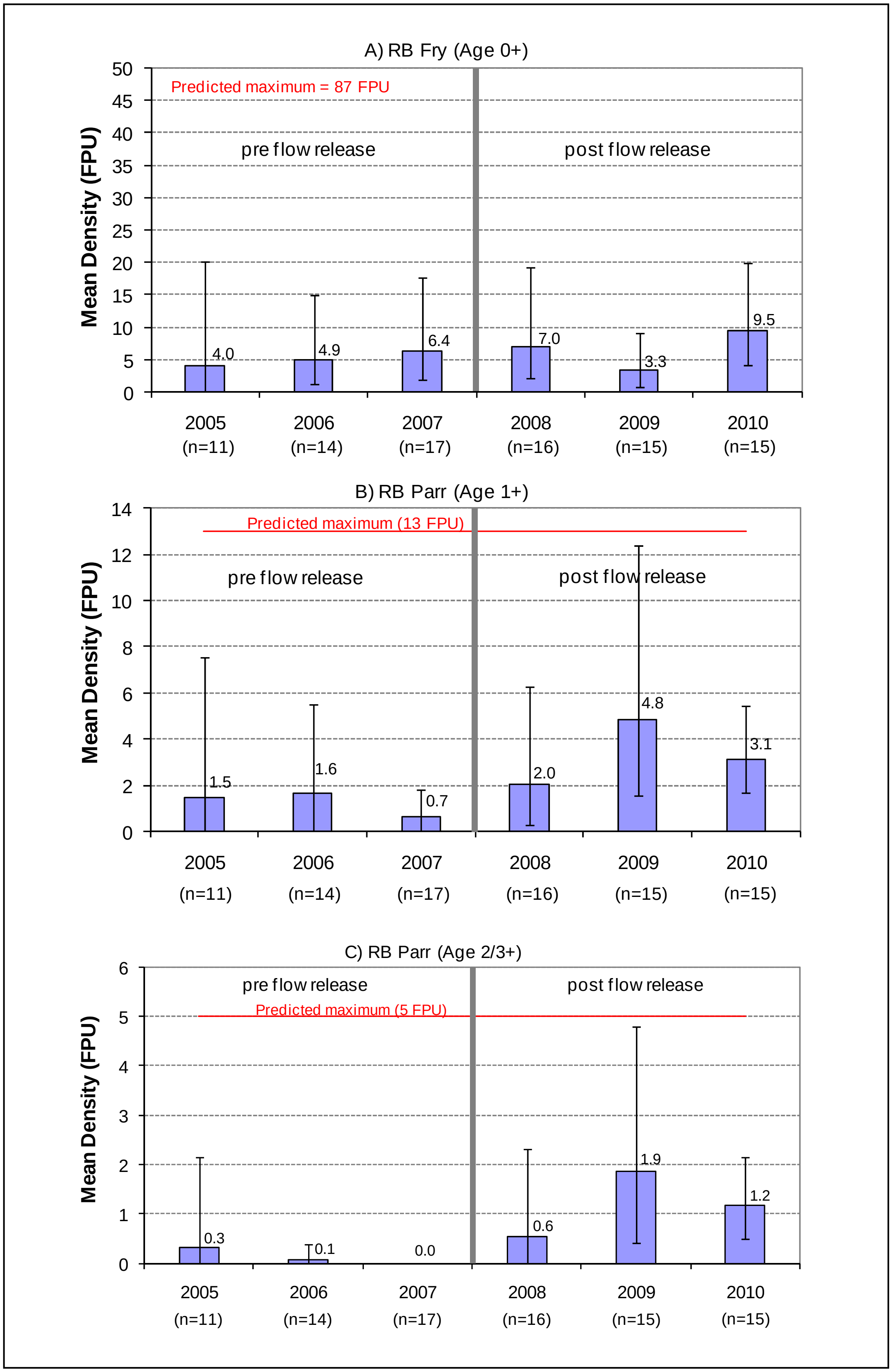

Figure 11. Geometric mean density (fish/100 m^2) of fry (Chart A), 1$^+$ parr (Chart B), and 2 and 3$^+$ parr (Chart C) for 2005 – 2010. Error bars represent 95% confidence limits; "n" refers to the number of sites per year; FPU refers to fish per 100 m^2.

In order to compare the abundance of rainbow trout in the lower Jordan River before and after the flow release, density data for 2005 to 2010 were grouped into pre and post flow release categories and geometric means calculated for each group. Figure 12 shows the results of this analysis with the data organized by age group as per Figure 11. To test for differences between pre and post flow release means, nested ANOVAs were performed on the density data for each age group (year subgroup nested within pre and post flow release groups). The results of the nested ANOVA found no significant difference between pre and post flow release means for the 0^+ and 1^+ age groups ($p = 0.646$ and 0.053, respectively) but did find a significant difference for the $2/3^+$ age group ($p = 0.03$).

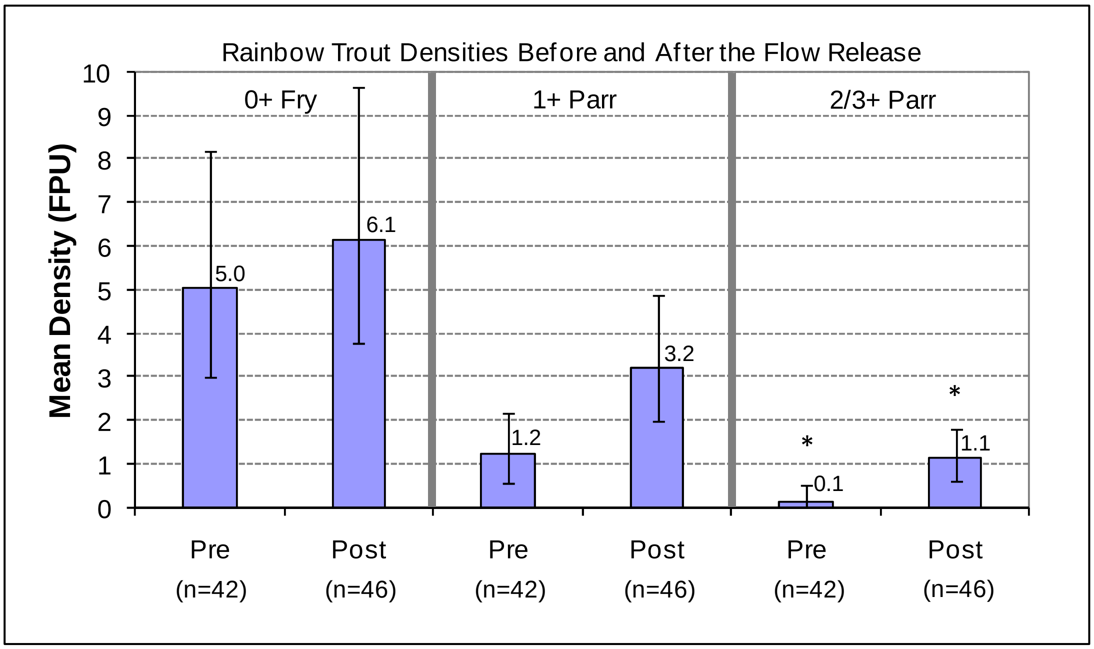

Figure 12. Geometric mean density (fish/100 m^2) of rainbow trout before and after the flow release. Data are segregated by age group. Pre flow release years were 2005 – 2007; post flow release years were 2008 – 2010. Error bars represent 95% confidence limits using a pooled variance; asterisks indicate means that are significantly different; and "n" refers to the number of sites per group.

Condition Factor

The second performance measure, fish condition factor, is shown for pre and post flow release years (2005 – 2010) in Figure 13. Values represent the arithmetic mean of all ages of rainbow trout combined for each year. These data show that rainbow trout condition factor ranged from 1.07 to 1.13 prior to the flow release and 1.06 to 1.08 after the flow release. It should be noted that the 2007 condition factor was negatively biased by fish from Sites EL01, EL02, and EL03. Fish captured at these sites exhibited extremely poor condition factor (average 0.90, n = 21), probably due to elevated copper concentrations. If these 21 fish are excluded from the analysis, the overall mean condition factor for 2007 is 1.11, which is very close to the value found in 2006. Poor condition factor downstream of the mine tailings was not found in 2008 to 2010 and was coincident with much reduced copper concentrations (see Section 4.3).

Analysis of variance on the data in Figure 13 indicated that there was a significant difference among means ($p = 0.003$). This was due to the high condition factor in 2006, which was significantly greater than condition factors for 2007, 2008 and 2009 (Student-Newman-Keuls (SNK) test for comparison of means).

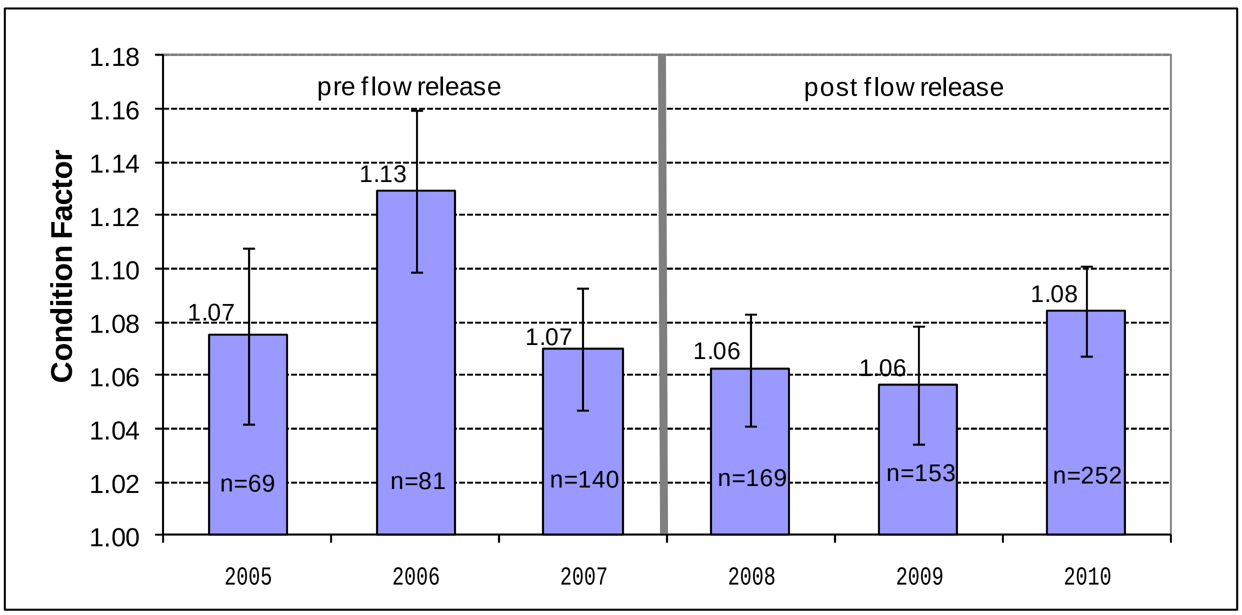

Figure 13. Mean condition factor of rainbow trout by year (2005 – 2010). Error bars indicate 95% confidence limit using a pooled variance; "n" refers to the sample size.

In order to illustrate potential changes in rainbow trout condition factor before and after the flow release, the data were grouped into pre and post flow release categories and arithmetic means calculated for each group (Figure 14). As with the density data, a nested ANOVA (year subgroup nested within pre and post flow release groups) was performed to test for a significant difference between these means. This analysis found no significant difference between pre and post flow release mean condition factors.

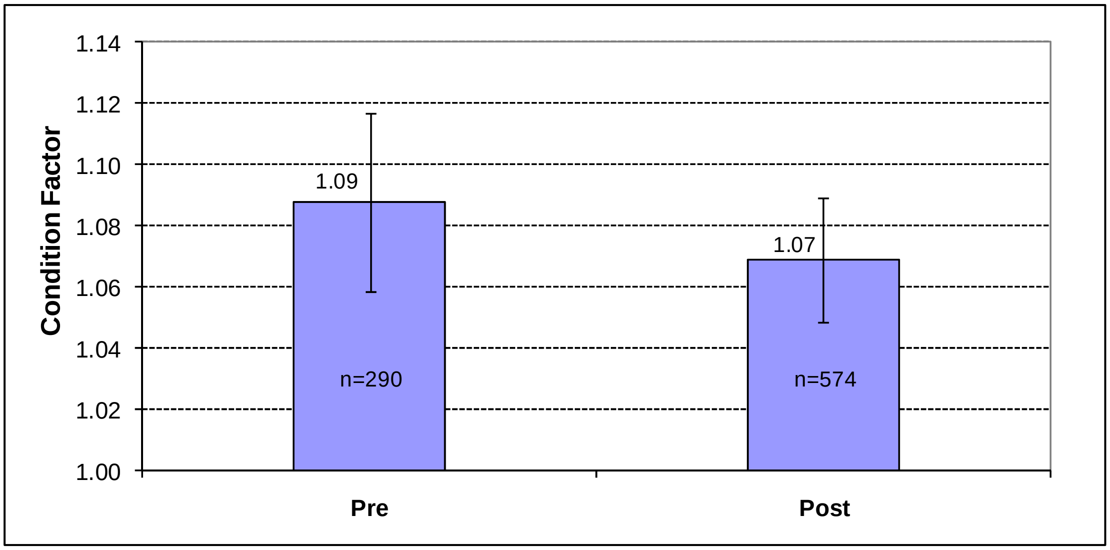

Figure 14. Condition factor of rainbow trout before and after the flow release. Means are arithmetic based on fish sampled during 2005 – 2010. Error bars are 95% confidence limits using a pooled variance; "n" indicates the sample size for each group.

Habitat Continuity

With respect to the third performance measure, habitat continuity, the benefits of the flow release were readily apparent during 2008 to 2010 field work. The 2005 – 2007 habitat surveys indicated that 7 – 15% (500 to 1,050 m) of the Jordan River channel length was dry prior to the flow release (depending on the level of local inflows). In contrast, no dry sections were found in any of the surveyed stream sections during 2008 to 2010 investigations. Flow releases at Elliott Dam during these surveys were roughly 0.39, 0.31 and 0.33 m^3/s on 2008, 2009, and 2010, respectively (mean daytime release during survey dates). In addition, prior to the flow release, wetted area during survey dates ranged from 54,600 to 68,100 m^2, whereas in the post flow release years, wetted area ranged from 107,439 to 123,819 m^2, representing an average increase of 85% in available fish habitat. Figures 12 and 13 show the length of dry channel and wetted area for each study year in relation to discharge at M1 (lower river gauge). The fitted lines show possible relationships between these habitat parameters and stream discharge. As a note, despite the availability of aquatic habitat in reach 7 in 2008, this habitat was not utilized by fish in that year. However, in 2009 this habitat was found to be colonized by both 0^+ rainbow fry and 3^+ parr, while in 2010 all age classes were present.

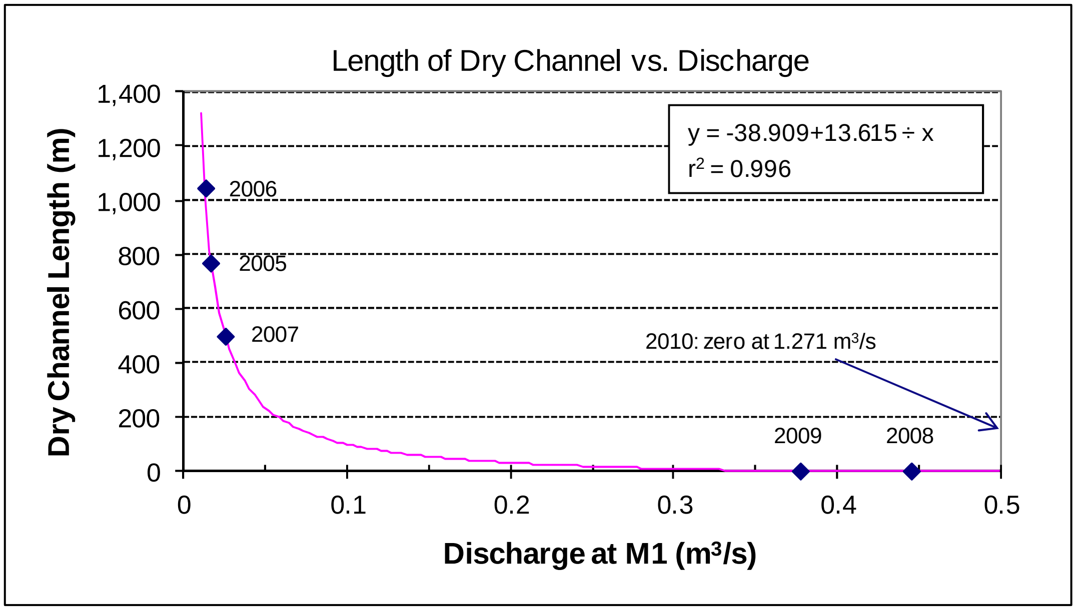

Figure 15. Length of channel with no surface flow (from 2005 to 2010 habitat surveys) graphed as a function of discharge at M1. The fitted curve shows a possible relationship between the amount of dry channel in the lower Jordan River and discharge (TableCurve 2D used for curve fitting).

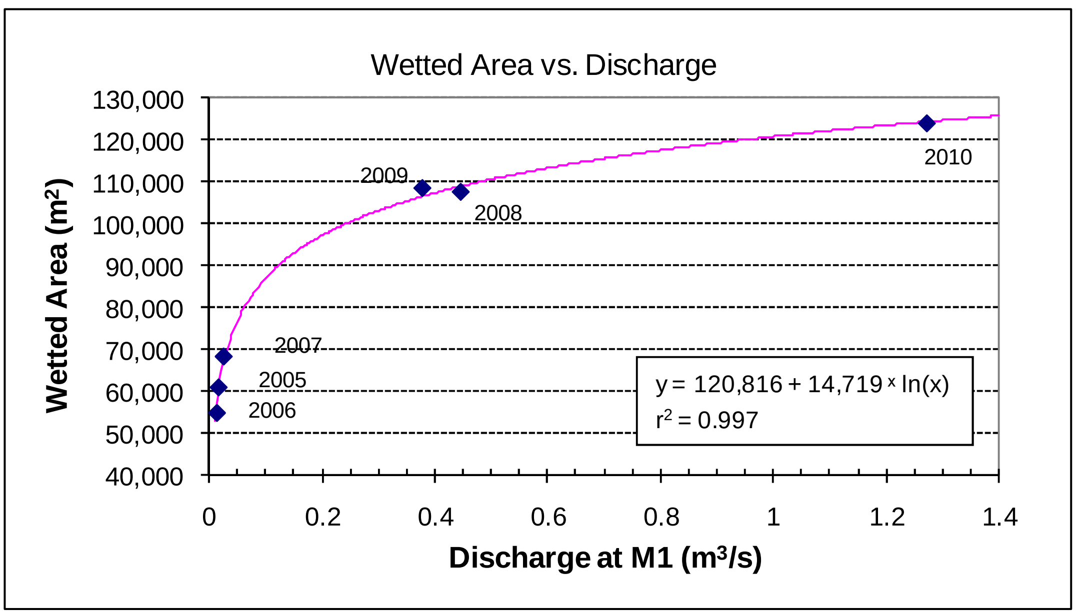

Figure 16. Total wetted area in the lower Jordan River (from 2005 to 2010 habitat surveys) graphed as a function of discharge at M1. The fitted curve shows a possible relationship between wetted area and discharge (TableCurve 2D used for curve fitting).

6. CONCLUSIONS AND RECOMMENDATIONS

The main goal of the lower Jordan River Fish Index Study was to ascertain whether the fish low release from Elliott Dam (initiated in January 2008) resulted in a benefit to fish and fish habitat in the lower Jordan River in terms of the 3 selected performance measures. To this end certain benefits were demonstrated, however these benefits need to couched in the understanding that the actual flows released were notably greater than the release specified in the Jordan WUP (0.25 m^3/s). This said, the following summarizes key results.

Fish Abundance— Three years each of pre and post flow release sampling at index sites suggested that 1^+ and $2/3^+$ age groups of rainbow trout increased in abundance (density) after the flow release, however, only the increase in the $2/3^+$ age group was statistically significant (Figure 12). Based on observations in the field, it is my impression that this is likely a case of a Type II error (accepting the null hypothesis [no difference] when it is actually false). It is likely that 1 or 2 more years of sampling would statistically validate an increase in 1^+ rainbow trout after the flow release.

Fish Condition Factor— There appears to be no difference in the condition factor of rainbow trout before and after initiation of the flow release and this was supported by the statistical analyses (Figure 14).

Habitat Continuity— There was an obvious benefit to fish habitat following initiation of the fish flow release. Prior to the flow release, most of Reach 7 lacked surface flows and in reaches downstream of this, pools and glides tended to be isolated from one another by riffles with only seepage flows. As a result, fish were excluded from areas with dry channels, and prevented from upstream/downstream dispersion in other areas (except under higher local inflows). After initiation of the flow release, Reach 7 was completely wetted and riffle zones no longer became an obstacle to fish movement. Thus, the fish flow release provided an additional 771 m of wetted stream length while wetted area increased by an average of 85% compared with pre flow release mean wetted area.

Other Benefits— Prior to 2006, fish sampling by this and previous studies had never found salmonids in most of the anadromous reach of the lower Jordan River and this was believed to be due to excess dissolved copper from local mine tailings. This situation appeared to improve to some degree following the scour effects of a major flood in winter 2006. Further improvements were demonstrated in 2008 to 2010 in terms of numbers of fish captured in this zone, in improvements in their condition factor, and by a reduction in measured copper concentration. This improvement is believed to be the combined effect of the 2006 flood and dilution of existing copper leachate by the additional water from the flow released. This is a highly important improvement given the short length of stream available to anadromous salmonids.

As mentioned above, the flow release from Elliott Dam during the treatment study years was greater than intended by the study design (and specified in the WUP). This was due to the controlling valve being locked fully open over concerns by Jordan Generating Station staff that a loss of power would cause the valve to close completely shutting off flows to the lower river. As a result, flow releases at Elliott Dam during field investigations and during fish rearing periods were generally in the range of 0.3 – 0.4 m^3/s depending on water elevation in Elliott Headpond. As a result, the biological and habitat benefits indicated by this study are reflective of these higher flows and are not necessarily indicative of conditions and benefits at the originally proposed flow release of 0.25 m^3/s. Thus, if at a future time BC Hydro decides to reduce the fish flow release to the actual 0.25 m^3/s, it is recommended that the activities of this study be repeated at that flow for 1 or 2 more years.

Given the larger variance around catch estimates based on 1-pass efforts relative to 3-pass efforts, it is recommended that future studies of this nature use a 3 pass design in order to provide greater ability of detecting a difference in mean fish density before and after treatment. This may necessitate 1 or 2 more field days per year but will likely shorten the number of years required before a change can be statistically detected. For the Fish Index Study, statistical simulation indicated that a significant difference would be found between pre and post treatment density of 1^+ rainbow trout with one more year of sampling if abundances and variances were similar to 2010 (predicted p = 0.023).

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Appendix A: Catch statistics, population estimates, and associated density and biomass calculations for electrofishing sites completed in September 2010.

Notes:
1. Population estimates (PopEst) were performed with BC Hydro's PopEst7 software using parameters MLBayes, P_{cap} = 0.5, and Var_{Cap} = 0.8333
2. For single-pass sites (EF04), PopEst was based on regression analysis of Pass1 vs. PopEst for 2 and 3-pass sites; the regression equation was y = 1.241x
3. Population estimate confidence limits for single-pass sites were based on the "Prediction Interval" from the regression analysis (from Zar 2010, p.356).

																Population Statistics					
Site No.	Reach	Date	Time	Habitat	Area(m^2)	Species	Age	No. Passes	Pass1	Pass2	Pass3	Pass4	N	MnWt	1-Pass Ex	PopEst	PopVar	PopSE	PopCV	PopLO	PopUP
AGE 0+ RAINBOW																					
EF01	R2			Glide/Riff				0	- - - - -					-	1.241						
EF02	R2	16/09/2010	16:30	Riffle	63.51	RB	0	3	11	1	0		12	2.5		12	0.006	0.08	0.01	12.00	12.15
EF03	R2	15/09/2010	16:20	Glide	86.90	RB	0	3	10	4	0		14	2.0		14	0.214	0.46	0.03	14.00	14.91
EF04	R3	15/09/2010	12:00	Glide/Pool	181.50	RB	0	1	17	- -	-		17	2.6	1.241	21	1.430	1.20		18.59	23.41
EF05A	R4	18/09/2010	17:00	Glide	93.10	RB	0	3	8	0	0		8	3.8		8	0.000	0.00	0.00	8.00	8.00
EF05B	R4	18/09/2010	14:00	Glide	88.45	RB	0	3	30	11	2		43	2.1		43	1.151	1.07	0.02	43.00	45.10
EF05C	R5	18/09/2010	11:00	Glide	100.62	RB	0	3	15	4	0		19	2.2		19	0.124	0.35	0.02	19.00	19.69
EF06	R5	22/09/2010	18:00	Glide	79.80	RB	0	3	12	0	0		12	3.5		12	0.000	0.00	0.00	12.00	12.00
EF07	R5	22/09/2010	15:30	Glide	116.00	RB	0	4	1	0	0	0	1	4.9		1	0.000	0.00	0.00	1.00	1.00
EF08	R5			Glide				0	- - - - -					-							
EF09	R5	22/09/2010	12:45	Glide/Pool	58.80	RB	0	3	2	2	0	- 4		3.6		4	0.295	0.54	0.14	4.00	5.07
EF11	R6	14/09/2010	12:15	Glide	88.16	RB	0	3	10	5	1	- 16		3.5		16	0.810	0.90	0.06	16.00	17.76
EF12	R6	14/09/2010	15:45	Glide	81.60	RB	0	3	5	1	0	- 6		2.8		6	0.020	0.14	0.02	6.00	6.28
EF13	R6	14/09/2010	18:00	Glide	38.50	RB	0	3	2	2	0	- 4		3.3		4	0.295	0.54	0.14	4.00	5.07
EF14B	R6	16/09/2010	12:15	Glide	101.12	RB	0	3	8	2	0	- 10		4.5		10	0.056	0.24	0.02	10.00	10.47
EF14A	R6	13/09/2010	16:15	Glide	117.70	RB	0	3	0	0	0	- 0		-		0					
EF15	R7	13/09/2010	12:45	Glide/Pool	78.85	RB	0	3	5	2	1	- 8		4.4		8	0.591	0.77	0.10	8.00	9.51
Arithmetic Mean													174	2.8							
Geometric Mean																					
AGE 1+ RAINBOW																					
EF01	R2			Glide/Riff				0	- - - - -					-							
EF02	R2	16/09/2010	16:30	Riffle	63.51	RB	1	3	0	0	0	- 0		-		0					
EF03	R2	15/09/2010	16:20	Glide	86.90	RB	1	3	5	0	1	- 6		13.4		6	0.141	0.38	0.06268	6.00	6.74
EF04	R2	15/09/2010	12:00	Glide/Pool	181.50	RB	1	3	10	3	1	- 14		18.9		14	0.400	0.63	0.0452	14.00	15.24
EF05A	R4	18/09/2010	17:00	Glide	93.10	RB	1	3	4	1	0	- 5		26.1		5	0.028	0.17	0.03	5.00	5.33
EF05B	R4	18/09/2010	14:00	Glide	88.45	RB	1	3	1	0	0	- 1		43.9		1	0.000	0.00	0.00	1.00	1.00
EF05C	R5	18/09/2010	11:00	Glide	100.62	RB	1	3	1	0	0	- 1		20.7		1	0.000	0.00	0.00	1.00	1.00
EF06	R5	22/09/2010	18:00	Glide	79.80	RB	1	3	2	0	0	- 2		21.1		2	0.000	0.00	0.00	2.00	2.00
EF07	R5	22/09/2010	15:30	Glide	116.00	RB	1	4	4	1	1	0	6	18.6		6	0.103	0.32	0.05	6.00	6.63
EF08	R5			Glide		RB	1	0	- - - - -					-							
EF09	R5	22/09/2010	12:45	Glide/Pool	58.80	RB	1	3	11	0	0	- 11		19.9		11	0.000	0.00	0.00	11.00	11.00
EF11	R6	14/09/2010	12:15	Glide	88.16	RB	1	3	1	0	0	- 1		31.9		1	0.000	0.00	0.00	1.00	1.00
EF12	R6	14/09/2010	15:45	Glide	81.60	RB	1	3	4	0	0	- 4		22.3		4	0.000	0.00	0.00	4.00	4.00
EF13	R6	14/09/2010	18:00	Glide	38.50	RB	1	3	1	0	0	-	1	10.7		1	0.000	0.00	0.00	1.00	1.00
EF14B	R6	16/09/2010	12:15	Glide	101.12	RB	1	3	3	0	0	- 3		20.1		3	0.000	0.00	0.00	3.00	3.00
EF14A	R6	13/09/2010	16:15	Glide	117.70	RB	1	3	2	0	0	- 2		27.2		2	0.000	0.00	0.00	2.00	2.00
EF15	R7	13/09/2010	12:45	Glide/Pool	78.85	RB	1	3	2	1	0	- 3		27.0		3	0.071	0.27	0.09	3.00	3.52
Arithmetic Mean													60	20.7							
Geometric Mean																					
AGE 2+ AND 3+ RAINBOW																					
EF01	R2			Glide/Riff				0	- - - - -					-							
EF02	R2	16/09/2010	16:30	Riffle	63.51	RB	2	3	0	0	0	- 0		-		0					
EF03	R2	15/09/2010	16:20	Glide	86.90	RB	2	3	1	0	0	- 1		34.5		1	0.000	0.00	0	1.00	1.00
EF04	R3	15/09/2010	12:00	Glide/Pool	181.50	RB	2	3	0	1	0	- 1		41.4		1	0.538	0.73	0.7338	1.00	2.44
EF05A	R4	18/09/2010	17:00	Glide	93.10	RB	2	3	1	0	0	- 1		46.5		1	0.000	0.00	0.00	1.00	1.00
EF05B	R4	18/09/2010	14:00	Glide	88.45	RB	2	3	0	0	0	- 0		-		0					
EF05C	R5	18/09/2010	11:00	Glide	100.62	RB	2	3	0	0	0	- 0		-		0					
EF06	R5	22/09/2010	18:00	Glide	79.80	RB	2	3	2	0	0	- 2		49.4		2	0.000	0.00	0.00	2.00	2.00
EF07	R5	22/09/2010	15:30	Glide	116.00	RB	2	4	1	0	0	0	1	41.2		1	0.000	0.00	0	1.00	1.00
EF08	R5			Glide		RB	2	0	- - - - -					-							
EF09	R5	22/09/2010	12:45	Glide/Pool	58.80	RB	2	3	2	0	0	- 2		50.1		2	0.000	0.00	0.00	2.00	2.00
EF11	R6	14/09/2010	12:15	Glide	88.16	RB	2	3	1	0	0	- 1		37.3		1	0.000	0.00	0.00	1.00	1.00
EF12	R6	14/09/2010	15:45	Glide	81.60	RB	2	3	1	0	0	- 1		45.2		1	0.000	0.00	0.00	1.00	1.00
EF13	R6	14/09/2010	18:00	Glide	38.50	RB	2	3	1	0	0	- 1		49.2		1	0.000	0.00	0.00	1.00	1.00
EF14B	R6	16/09/2010	12:15	Glide	101.12	RB	2	3	2	1	1	- 4		47.6		4	0.939	0.97	0.24	4.00	5.90
EF14A	R6	13/09/2010	16:15	Glide	117.70	RB	2	3	1	0	0	- 1		54.3		1	0.000	0.00	0.00	1.00	1.00
EF15	R7	13/09/2010	12:45	Glide/Pool	78.85	RB	**2,3**	3	2	0	0	- 2		73.3		2	0.000	0.00	0.00	2.00	2.00
Arithmetic Mean													18	49.2							
Geometric Mean																					
AGE 0+ COHO																					
EF01	R2			Glide/Riff				0	- - - - -					-							
EF02	R2	16/09/2010	16:30	Riffle	63.51	CO	0	3	0	0	0	- 0		-		0					
EF03	R2	15/09/2010	16:20	Glide	86.90	CO	0	3	0	0	0	- 0		-		0					
EF04	R2	15/09/2010	12:00	Glide/Pool	181.50	CO	0	1	5	1	1	- 7		6.4		7	0.334	0.58	0.08	7.00	8.13
SCULPINS																					
EF01	R2			Glide/Riff				0													
EF02	R2	16/09/2010	16:30	Riffle	63.51	CC		3	81	28	4	- 113				115	3.680	1.92	0.01668	113.00	118.76
EF03	R2	15/09/2010	16:20	Glide	86.9	CC		3	11	10	1	- 22				23	4.108	2.03	0.08812	22.00	26.97
EF04	R2	15/09/2010	12:00	Glide/Pool	181.5	CC		3	33	9	7	- 49				51	6.081	2.47	0.04835	49.00	55.83

	Capture Statistics						Observed Density			Observed Biomass			Adjusted Density				Adjusted Biomass				
Site No.	CapEst	CapVar	CapSE	CapCV	CapLO	CapUP	FPU	FPU_{LO}	FPU_{UP}	BPU	BPU_{LO}	BPU_{UP}	PUW	AFPU	$AFPU_{LO}$	$AFPU_{UP}$	ABPU	$ABPU_{LO}$	$ABPU_{UP}$	MxBPU	%Sat
AGE 0+ RAINBOW																					
EF01																					
EF02	0.92	0.01	0.08	0.08	0.77	1.07	18.89	18.89	19.13	47.2	47.2	47.8	56.51%	33.4	33.4	33.8	83.5	83.5	84.5	255	33
EF03	0.78	0.01	0.15	0.12	0.55	1.00	16.11	16.11	17.15	32.2	32.2	34.3	36.33%	44.3	44.3	47.2	88.6	88.6	94.4	255	35
EF04							11.57	10.24	12.90	30.1	26.6	33.5	25.26%	45.8	40.5	51.1	119.1	105.3	132.9	255	47
EF05A	1.00	0.00	0.00	0.00	1.00	1.00	8.59	8.59	8.59	32.7	32.7	32.7	19.04%	45.1	45.1	45.1	171.4	171.4	171.4	255	67
EF05B	0.74	0.01	0.10	0.07	0.60	0.88	48.62	48.62	50.99	102.1	102.1	107.1	23.23%	209.3	209.3	219.5	439.5	439.5	461.0	255	172
EF05C	0.83	0.01	0.11	0.09	0.65	1.00	18.88	18.88	19.57	41.5	41.5	43.0	11.59%	162.9	162.9	168.8	358.4	358.4	371.4	255	141
EF06	1.00	0.00	0.00	0.00	1.00	1.00	15.04	15.04	15.04	52.6	52.6	52.6	36.86%	40.8	40.8	40.8	142.8	142.8	142.8	255	56
EF07	1.00	0.00	0.00	0.00	1.00	1.00	0.86	0.86	0.86	4.2	4.2	4.2	49.16%	1.8	1.8	1.8	8.8	8.8	8.8	255	3
EF08																					
EF09	0.67	0.07	0.41	0.27	0.13	1.20	6.80	6.80	8.61	24.5	24.5	31.0	58.63%	11.6	11.6	14.7	41.8	41.8	52.9	255	16
EF11	0.70	0.02	0.18	0.13	0.44	0.95	18.15	18.15	20.15	63.5	63.5	70.5	35.10%	51.7	51.7	57.4	181.0	181.0	200.9	255	71
EF12	0.86	0.02	0.17	0.14	0.58	1.14	7.35	7.35	7.70	20.6	20.6	21.5	29.15%	25.2	25.2	26.4	70.6	70.6	73.9	255	28
EF13	0.67	0.07	0.41	0.27	0.13	1.20	10.39	10.39	13.16	34.3	34.3	43.4	28.81%	36.1	36.1	45.7	119.1	119.1	150.8	255	47
EF14B	0.83	0.01	0.14	0.12	0.60	1.07	9.89	9.89	10.35	44.5	44.5	46.6	15.19%	65.1	65.1	68.1	293.0	293.0	306.5	255	115
EF14A							0.00			0.0			32.11%	0.0			0.0			255	0
EF15	0.67	0.04	0.29	0.19	0.29	1.04	10.15	10.15	12.06	44.6	44.6	53.0	25.31%	40.1	40.1	47.6	176.4	176.4	209.4	255	69
Arithmetic Mean						EF02 - EF15:	13.42			38.3	4.2		32.15%								
Geometric Mean						EF02 - EF15:	9.50			27.1	102.1										
AGE 1+ RAINBOW																					
EF01																					
EF02							0.00			0.0			60.30%	0.0			0.0			255	0
EF03	0.75	0.04	0.25	0.19	0.38	1.12	6.90	6.90	7.75	92.5	92.5	103.9	50.53%	13.7	13.7	15.3	183.6	183.6	205.0	255	72
EF04	0.74	0.02	0.17	0.13	0.49	0.98	7.71	7.71	8.40	145.8	145.8	158.7	32.31%	23.9	23.9	26.0	451.7	451.7	491.4	255	177
EF05A	0.83	0.03	0.20	0.17	0.50	1.16	5.37	5.37	5.72	140.2	140.2	149.4	45.47%	11.8	11.8	12.6	308.0	308.0	328.9	255	121
EF05B	1.00	0.00	0.00	0.00	1.00	1.00	1.13	1.13	1.13	49.6	49.6	49.6	41.10%	2.8	2.8	2.8	122.9	122.9	122.9	255	48
EF05C	1.00	0.00	0.00	0.00	1.00	1.00	0.99	0.99	0.99	20.6	20.6	20.6	6.39%	15.6	15.6	15.6	322.9	322.9	322.9	255	127
EF06	1.00	0.00	0.00	0.00	1.00	1.00	2.51	2.51	2.51	52.9	52.9	52.9	35.29%	7.1	7.1	7.1	149.8	149.8	149.8	255	59
EF07	0.67	0.03	0.28	0.19	0.30	1.03	5.17	5.17	5.71	96.2	96.2	106.3	35.42%	14.6	14.6	16.1	271.6	271.6	299.5	255	107
EF08																					
EF09	1.00	0.00	0.00	0.00	1.00	1.00	18.71	18.71	18.71	372.3	372.3	372.3	67.22%	27.8	27.8	27.8	553.2	553.2	553.2	255	217
EF11	1.00	0.00	0.00	0.00	1.00	1.00	1.13	1.13	1.13	36.2	36.2	36.2	45.95%	2.5	2.5	2.5	79.8	79.8	79.8	255	31
EF12	1.00	0.00	0.00	0.00	1.00	1.00	4.90	4.90	4.90	109.3	109.3	109.3	43.72%	11.2	11.2	11.2	249.8	249.8	249.8	255	98
EF13	1.00	0.00	0.00	0.00	1.00	1.00	2.60	2.60	2.60	27.8	27.8	27.8	36.19%	7.2	7.2	7.2	77.0	77.0	77.0	255	30
EF14B	1.00	0.00	0.00	0.00	1.00	1.00	2.97	2.97	2.97	59.6	59.6	59.6	20.98%	14.1	14.1	14.1	283.4	283.4	283.4	255	111
EF14A	1.00	0.00	0.00	0.00	1.00	1.00	1.70	1.70	1.70	46.2	46.2	46.2	18.72%	9.1	9.1	9.1	247.5	247.5	247.5	255	97
EF15	0.75	0.07	0.35	0.27	0.23	1.27	3.80	3.80	4.47	102.7	102.7	120.6	36.62%	10.4	10.4	12.2	280.8	280.8	329.4	255	110
Arithmetic Mean						EF02 - EF15:	4.37			90.1	20.6		38.41%								
Geometric Mean						EF02 - EF15:	3.15			54.5	372.3										
AGE 2+ AND 3+ RAINBOW																					
EF01																					
EF02							0.00			0.0											
EF03	1.00	0.00	0.00	0.00	1.00	1.00	1.15	1.15	1.15	39.7	39.7	39.7									
EF04	0.50	0.54	1.47	0.73	0.00	1.94	0.55	0.55	1.34	22.8	22.8	55.6									
EF05A	1.00	0.00	0.00	0.00	1.00	1.00	1.07	1.07	1.07	49.9	49.9	49.9									
EF05B							0.00			0.0											
EF05C							0.00			0.0											
EF06	1.00	0.00	0.00	0.00	1.00	1.00	2.51	2.51	2.51	123.8	123.8	123.8									
EF07	1.00	0.00	0.00	0.00	1.00	1.00	0.86	0.86	0.86	35.5	35.5	35.5									
EF08																					
EF09	1.00	0.00	0.00	0.00	1.00	1.00	3.40	3.40	3.40	170.4	170.4	170.4									
EF11	1.00	0.00	0.00	0.00	1.00	1.00	1.13	1.13	1.13	42.3	42.3	42.3									
EF12	1.00	0.00	0.00	0.00	1.00	1.00	1.23	1.23	1.23	55.4	55.4	55.4									
EF13	1.00	0.00	0.00	0.00	1.00	1.00	2.60	2.60	2.60	127.8	127.8	127.8									
EF14B	0.57	0.10	0.57	0.32	0.00	1.20	3.96	3.96	5.83	188.3	188.3	277.7									
EF14A	1.00	0.00	0.00	0.00	1.00	1.00	0.85	0.85	0.85	46.1	46.1	46.1									
EF15	1.00	0.00	0.00	0.00	1.00	1.00	2.54	2.54	2.54	185.9	185.9	185.9									
Arithmetic Mean						EF02 - EF15:	1.46			72.5	22.8										
Geometric Mean						EF02 - EF15:	1.17			29.7	188.3										
AGE 0+ COHO																					
EF01																					
EF02							0.00			0.0			44.10%	0.0			0.0			510	0
EF03							0.00			0.0			77.17%	0.0			0.0			510	0
EF04	0.70	0.04	0.28	0.19	0.32	1.08	3.86	3.86	4.48	24.7	24.7	28.7	87.40%	4.4	4.4	5.1	28.2	28.2	32.6	510	6
SCULPINS																					
EF01																					
EF02	0.73	0.00	0.06	0.04	0.64	0.82	181.07	177.92	186.99												
EF03	0.59	0.02	0.22	0.13	0.34	0.85	26.47	25.32	31.04												
EF04	0.63	0.01	0.13	0.08	0.47	0.79	28.10	27.00	30.76												

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF02

General Information

Date	16-Sep-10	Stream:	Jordan River	
Time	16:30	Reach:	R2	
Crew	DB,JJ,MC	UTM:	422,238	5,364,648

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.21
Sample Width (m):	7.3	Mean Velocity (m/s):	0.301
Sample Length (m):	8.7	Metered Discharge (cms):	0.530
Sample Area (m2):	63.51	Gauge Station Discharge (cms):	0.705
Temperature (C):	13.3	Stage (% MAD):	5.1
Conductivity (microS):	30		

Meso Habitat Characteristics

Habitat Type:	R	Stream Width (m):	25.8
Gradient (%):	2.0%	Channel Width (m):	32.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
36	0	0	0	3	28	69	0

Substrate (% each category):

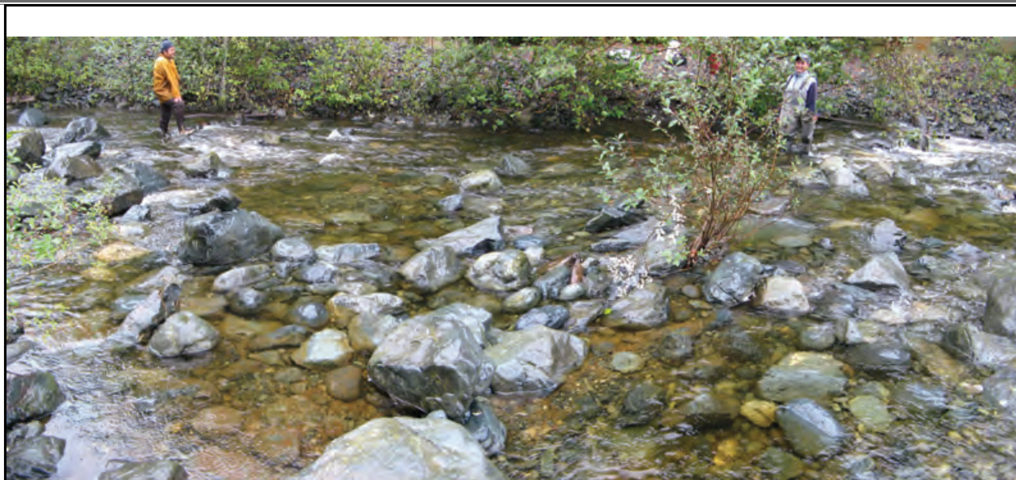
Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
5	10	30	30	25	0	40	80

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
CC	99	61		81	28	4		113	115	181.07	177.92	186.99		
RB	0	59	2.5	11	1	0		12	12	18.89	18.89	19.13	46.29	0.57

Photo

EF02



APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF03

General Information

Date	15-Sep-10	Stream:	Jordan River
Time	16:20	Reach:	R2
Crew	DB,JJ,MC	UTM:	422,207 5,364,753

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.43
Sample Width (m):	7.9	Mean Velocity (m/s):	0.162
Sample Length (m):	11.0	Metered Discharge (cms):	0.746
Sample Area (m2):	86.90	Gauge Station Discharge (cms):	0.791
Temperature (C):	13.0	Stage (% MAD):	5.8
Conductivity (microS):	30		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	12.0
Gradient (%):	0.5%	Channel Width (m):	30.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
30	0	0	0	0	0	100	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
5	5	40	10	40	0	80	400

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
CC	99	78		11	10	1		22	23	26.47	25.32	31.04		
RB	0	57	2.0	10	4	0		14	14	16.11	16.11	17.15	32.91	0.36
RB	1	110	13.4	5	0	1		6	6	6.90	6.90	7.75	92.29	0.51
RB	2	156	34.5	1	0	0		1	1	1.15	1.15	1.15	39.70	

Photo

EF03

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF04

General Information

Date	15-Sep-10	Stream:	Jordan River	
Time	12:00	Reach:	R2	
Crew	DB,JJ,MC	UTM:	422,183	5,364,866

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.54
Sample Width (m):	16.5	Mean Velocity (m/s):	0.079
Sample Length (m):	11.0	Metered Discharge (cms):	0.960
Sample Area (m2):	181.50	Gauge Station Discharge (cms):	0.800
Temperature (C):	13.0	Stage (% MAD):	5.8
Conductivity (microS):	27		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	22.0
Gradient (%):	0.5%	Channel Width (m):	30.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
35	0	0	0	0	0	100	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
5	10	40	10	35	0	200	550

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
CC	99	74		33	9	7		49	51	28.10	27.00	30.76		
CO	0	79	6.4	5	1	1		7	7	3.86	3.86	4.48	24.85	0.87
RB	0	63	2.6	7	7	3		17	21	11.57	10.24	12.90	30.36	0.25
RB	1	122	18.9	10	3	1		14	14	7.71	7.71	8.40	145.62	0.32
RB	2	160	41.4	0	1	0		1	1	0.55	0.55	1.34	22.81	

Photo

EF04

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF05A

General Information

Date	18-Sep-10	Stream:	Jordan River	
Time	17:00	Reach:	R4	
Crew	DB,JJ,MC	UTM:	422,417	5,365,685

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.75
Sample Width (m):	7.0	Mean Velocity (m/s):	0.129
Sample Length (m):	13.3	Metered Discharge (cms):	0.666
Sample Area (m2):	93.10	Gauge Station Discharge (cms):	0.652
Temperature (C):	14.1	Stage (% MAD):	
Conductivity (microS):	25		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	20.2
Gradient (%):	2.7%	Channel Width (m):	33.8

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
45	0	0	0	0	0	100	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
0	10	20	15	65	0	120	280

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	68	3.8	8	0	0		8	8	8.59	8.59	8.59	32.44	0.19
RB	1	134	26.1	4	1	0		5	5	5.37	5.37	5.72	140.39	0.45
RB	2	165	46.5	1	0	0		1	1	1.07	1.07	1.07	49.95	

Photo

EF05A

APPENDIX B: ELECTROFISHING SITE SUMMARY
Site: EF05B

General Information

Date	18-Sep-10	Stream:	Jordan River
Time	14:00	Reach:	R4
Crew	DB,JJ,MC	UTM:	422,470 5,365,860

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.45
Sample Width (m):	6.1	Mean Velocity (m/s):	0.102
Sample Length (m):	14.5	Metered Discharge (cms):	0.232
Sample Area (m2):	88.45	Gauge Station Discharge (cms):	0.656
Temperature (C):	13.1	Stage (% MAD):	
Conductivity (microS):			

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	21.0
Gradient (%):	10.0%	Channel Width (m):	26.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
80	0	0	0	0	0	100	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
0	5	15	15	60	5	150	300

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	57	2.1	30	11	2		43	43	48.62	48.62	50.99	103.11	0.23
RB	1	146	43.9	1	0	0		1	1	1.13	1.13	1.13	49.63	0.41

Photo

EF05B

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF05C

General Information

Date	18-Sep-10	Stream:	Jordan River	
Time	11:00	Reach:	R5	
Crew	DB,JJ,MC	UTM:	422,482	5,365,898

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.57
Sample Width (m):	8.6	Mean Velocity (m/s):	0.014
Sample Length (m):	11.7	Metered Discharge (cms):	0.065
Sample Area (m2):	100.62	Gauge Station Discharge (cms):	0.564
Temperature (C):	14.1	Stage (% MAD):	
Conductivity (microS):	24		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	18.8
Gradient (%):	0.0%	Channel Width (m):	32.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
22	0	4	0	0	4	92	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
20	25	25	10	18	2	180	100

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	57	2.2	15	4	0		19	19	18.88	18.88	19.57	41.54	0.12
RB	1	125	20.7	1	0	0		1	1	0.99	0.99	0.99	20.57	0.06

Photo

EF05C

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF06

General Information

Date	22-Sep-10	Stream:	Jordan River
Time	18:00	Reach:	R5
Crew	DB,JJ,MC	UTM:	423,637 5,366,917

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.41
Sample Width (m):	7.6	Mean Velocity (m/s):	0.236
Sample Length (m):	10.5	Metered Discharge (cms):	0.850
Sample Area (m2):	79.80	Gauge Station Discharge (cms):	0.589
Temperature (C):		Stage (% MAD):	
Conductivity (microS):	24		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	15.0
Gradient (%):	2.7%	Channel Width (m):	23.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
40	0	0	0	0	12	88	0

Substrate (% each category):

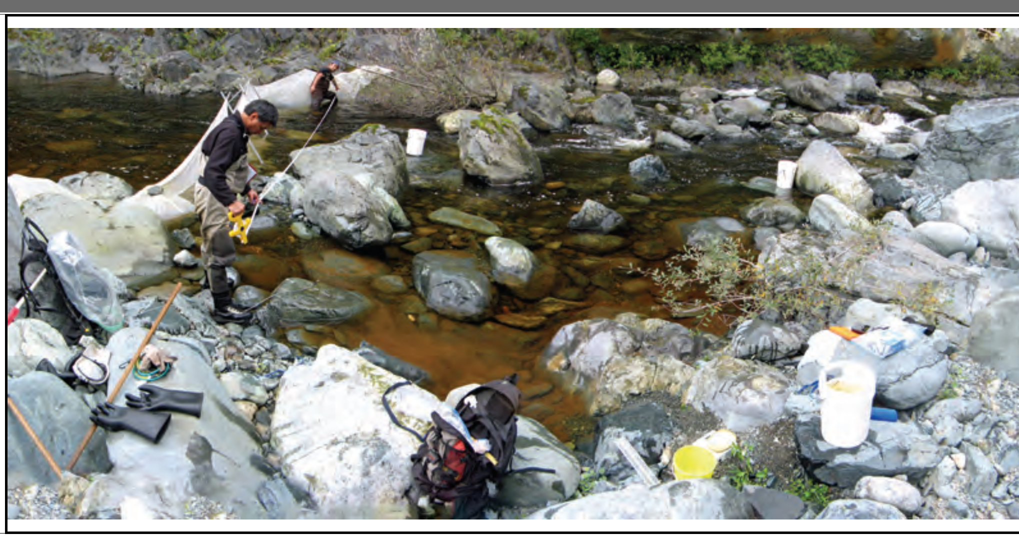
Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
0	20	20	25	30	5	150	190

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	65	3.5	12	0	0		12	12	15.04	15.04	15.04	52.76	0.37
RB	1	125	21.1	2	0	0		2	2	2.51	2.51	2.51	52.88	0.35
RB	2	162	49.4	2	0	0		2	2	2.51	2.51	2.51	123.68	

Photo

EF06



APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF07

General Information

Date	22-Sep-10	Stream:	Jordan River
Time	15:30	Reach:	R5
Crew	DB,JJ,MC	UTM:	423,776 5,366,939

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.33
Sample Width (m):	11.6	Mean Velocity (m/s):	0.127
Sample Length (m):	10.0	Metered Discharge (cms):	0.543
Sample Area (m2):	116.00	Gauge Station Discharge (cms):	0.597
Temperature (C):		Stage (% MAD):	
Conductivity (microS):	25		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	18.5
Gradient (%):	2.2%	Channel Width (m):	28.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
18	0	0	0	0	17	83	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
5	15	35	20	25	0	150	210

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	78	4.9	1	0	0	0	1	1	0.86	0.86	0.86	4.22	0.49
RB	1	118	18.6	4	1	1	0	6	6	5.17	5.17	5.71	96.29	0.35
RB	2	157	41.2	1	0	0	0	1	1	0.86	0.86	0.86	35.52	

Photo

EF07

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF09

General Information

Date	22-Sep-10	Stream:	Jordan River
Time	12:45	Reach:	R5
Crew	DB,JJ,MC	UTM:	423,923 5,367,221

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.30
Sample Width (m):	8.4	Mean Velocity (m/s):	0.229
Sample Length (m):	7.0	Metered Discharge (cms):	0.688
Sample Area (m2):	58.80	Gauge Station Discharge (cms):	0.609
Temperature (C):		Stage (% MAD):	
Conductivity (microS):	22		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	17.8
Gradient (%):	2.7%	Channel Width (m):	31.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
55	0	0	0	0	27	73	0

Substrate (% each category):

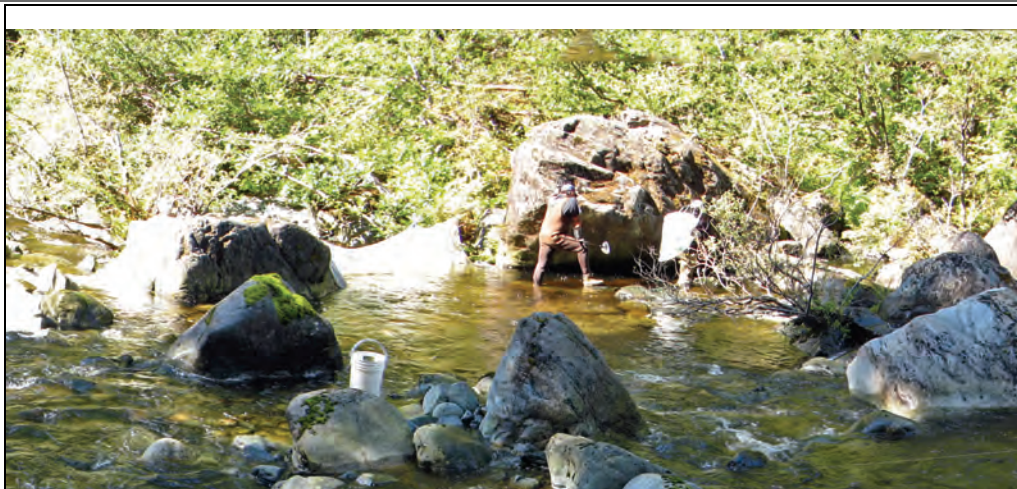
Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
5	15	30	10	40	0	140	300

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	69	3.6	2	2	0		4	4	6.80	6.80	8.61	24.66	0.59
RB	1	122	19.9	11	0	0		11	11	18.71	18.71	18.71	372.28	0.67
RB	2	167	50.1	2	0	0		2	2	3.40	3.40	3.40	170.41	

Photo

EF09



APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF11

General Information

Date	14-Sep-10	Stream:	Jordan River
Time	12:15	Reach:	R6
Crew	DB,JJ,MC	UTM:	425,097 5,367,842

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.41
Sample Width (m):	7.6	Mean Velocity (m/s):	0.228
Sample Length (m):	11.6	Metered Discharge (cms):	0.862
Sample Area (m2):	88.16	Gauge Station Discharge (cms):	0.658
Temperature (C):	12.0	Stage (% MAD):	
Conductivity (microS):	23		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	9.5
Gradient (%):	6.0%	Channel Width (m):	29.4

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
61	0	0	0	0	2	98	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
0	5	15	20	60	0	140	400

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	66	3.5	10	5	1		16	16	18.15	18.15	20.15	62.61	0.35
RB	1	147	31.9	1	0	0		1	1	1.13	1.13	1.13	36.18	0.46
RB	2	152	37.3	1	0	0		1	1	1.13	1.13	1.13	42.31	

Photo

EF11

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF12

General Information

Date	14-Sep-10	Stream:	Jordan River
Time	15:45	Reach:	R6
Crew	DB,JJ,MC	UTM:	425,140 5,367,970

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.43
Sample Width (m):	12.0	Mean Velocity (m/s):	0.160
Sample Length (m):	6.8	Metered Discharge (cms):	0.777
Sample Area (m2):	81.60	Gauge Station Discharge (cms):	0.626
Temperature (C):	13.3	Stage (% MAD):	
Conductivity (microS):	22		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	15.0
Gradient (%):	3.3%	Channel Width (m):	28.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
75	0	0	0	0	7	93	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
0	5	20	20	55	0	180	220

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	63	2.8	5	1	0		6	6	7.35	7.35	7.70	20.83	0.29
RB	1	130	22.3	4	0	0		4	4	4.90	4.90	4.90	109.44	0.44
RB	2	168	45.2	1	0	0		1	1	1.23	1.23	1.23	55.39	

Photo

EF12

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF13

General Information

Date	14-Sep-10	Stream:	Jordan River	
Time	18:00	Reach:	R6	
Crew	DB,JJ,MC	UTM:	425,288	5,368,119

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.42
Sample Width (m):	5.5	Mean Velocity (m/s):	0.106
Sample Length (m):	7.0	Metered Discharge (cms):	0.258
Sample Area (m2):	38.50	Gauge Station Discharge (cms):	0.584
Temperature (C):	13.3	Stage (% MAD):	
Conductivity (microS):	21		

Meso Habitat Characteristics

Habitat Type:	G	Stream Width (m):	19.5
Gradient (%):	2.0%	Channel Width (m):	30.8

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
75	0	0	0	0	0	100	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
0	0	20	25	55	0	170	340

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	65	3.3	2	2	0		4	4	10.39	10.39	13.16	34.03	0.29
RB	1	95	10.7	1	0	0		1	1	2.60	2.60	2.60	27.79	0.36
RB	2	163	49.2	1	0	0		1	1	2.60	2.60	2.60	127.79	

Photo

EF13

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF14A

General Information

Date	13-Sep-10	Stream:	Jordan River
Time	16:15	Reach:	R6
Crew	DB,JJ,MC	UTM:	426,007 5,369,304

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.31
Sample Width (m):	5.5	Mean Velocity (m/s):	0.160
Sample Length (m):	21.4	Metered Discharge (cms):	0.284
Sample Area (m2):	117.70	Gauge Station Discharge (cms):	0.466
Temperature (C):	11.9	Stage (% MAD):	
Conductivity (microS):	21		

Meso Habitat Characteristics

Habitat Type:	R	Stream Width (m):	20.0
Gradient (%):	1.6%	Channel Width (m):	25.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
57	0	0	0	0	4	96	0

Substrate (% each category):

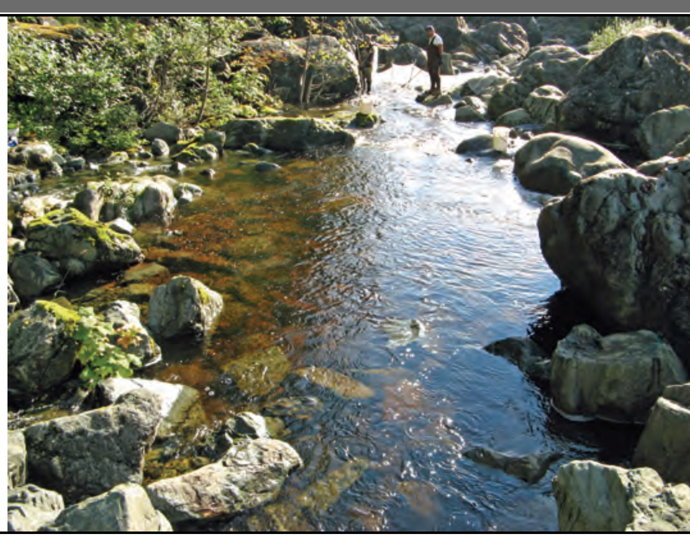
Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
0	5	10	22	60	3	170	228

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	1	133	27.2	2	0	0		2	2	1.70	1.70	1.70	46.13	0.19
RB	2	171	54.3	1	0	0		1	1	0.85	0.85	0.85	46.13	

Photo

EF14A



APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF14B

General Information

Date	16-Sep-10	Stream:	Jordan River
Time	12:15	Reach:	R6
Crew	DB,JJ,MC	UTM:	425,970 5,369,248

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.65
Sample Width (m):	7.9	Mean Velocity (m/s):	0.056
Sample Length (m):	12.8	Metered Discharge (cms):	0.473
Sample Area (m2):	101.12	Gauge Station Discharge (cms):	0.327
Temperature (C):	12.7	Stage (% MAD):	
Conductivity (microS):	21		

Meso Habitat Characteristics

Habitat Type:	P	Stream Width (m):	18.0
Gradient (%):	3.1%	Channel Width (m):	27.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
70	0	0	0	0	0	100	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
0	5	10	20	60	0	150	410

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	74	4.5	8	2	0		10	10	9.89	9.89	10.35	44.60	0.15
RB	1	120	20.1	3	0	0		3	3	2.97	2.97	2.97	59.63	0.21
RB	2	161	47.6	2	1	1		4	4	3.96	3.96	5.83	188.39	

Photo

EF14B

APPENDIX B: ELECTROFISHING SITE SUMMARY

Site: EF15

General Information

Date	13-Sep-10	Stream:	Jordan River
Time	12:45	Reach:	R7
Crew	DB,JJ,MC	UTM:	426,111 5,369,468

Sample Site Characteristics

MS or SC:	MS	Mean Depth (m):	0.55
Sample Width (m):	8.3	Mean Velocity (m/s):	0.075
Sample Length (m):	9.5	Metered Discharge (cms):	0.371
Sample Area (m2):	78.85	Gauge Station Discharge (cms):	0.528
Temperature (C):	12.4	Stage (% MAD):	
Conductivity (microS):	24		

Meso Habitat Characteristics

Habitat Type:	P	Stream Width (m):	8.3
Gradient (%):	0.7%	Channel Width (m):	23.0

Cover (% Total Cover and % each category):

Total Cover	Deep Pool	LWD	SWD	Instream Veg.	Overstream Veg.	Boulders	Cut Banks
50	0	0	0	10	20	70	0

Substrate (% each category):

Fines	Small Gravel	Large Gravel	Cobble	Boulders	Bedrock	D90 (cm)	Dmax (cm)
0	0	15	35	35	15	140	210

Fish Population Characteristics

Species	Age	MnLgth	MnWt	C1	C2	C3	C4	N	Pop	FPU	LCL_FPU	UCL_FPU	BPU	PUW
RB	0	71	4.4	5	2	1		8	8	10.15	10.15	12.06	44.26	0.25
RB	1	129	27.0	2	1	0		3	3	3.80	3.80	4.47	102.73	0.37
RB	2	169	60.3	1	0	0		1	1	1.27	1.27	1.27	76.47	
RB	3	204	86.3	1	0	0		1	1	1.27	1.27	1.27	109.45	

Photo

EF15