FISHERY RESEARCH

KOOTENAI RIVER FISHERIES INVESTIGATIONS: FOUR YEARS OF NUTRIENT REHABILITATION

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KOOTENAI RIVER FISHERIES INVESTIGATIONS: FOUR YEARS OF NUTRIENT RESTORATION

Annual Progress Report

2008 Annual Report

By

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ABSTRACT

A large-scale nutrient rehabilitation program was implemented in the Idaho portion of the Kootenai River in 2005 to rebuild fisheries by increasing primary production. Lake Koocanusa, the reservoir created by Libby Dam in Montana, acts as a nutrient sink retaining approximately 63% of total phosphorus (P) and 25% of total nitrogen (N). Phosphate fertilizer (10-34-0 solution) was added to the river beginning on July 13, 2005. During the first year, phosphorous was added to achieve a concentration of 1.5 µg/L of phosphate. In subsequent years, addition of phosphorous was to achieve a concentration of 3.0 µg/L. Within three weeks of application, algal growth was apparent on substrates.

We collected a total of 153 zooplankton samples from the treatment reach (KR6 and KR9) and reference site (KR10) from 2002-2007. We captured specimens from 53 unique species and 15 families of rotifers and 11 unique species and 7 families of crustaceans. In-river zooplankton densities fluctuated with river discharge and zooplankton levels in Lake Koocanusa. It is evident that nutrient additions are not influencing zooplankton numbers or species diversity. As a result, sampling was discontinued for 2008.

We conducted electrofishing at biomonitoring sites annually from 2002-2008 in order to evaluate catch per unit effort (CPUE), biomass per unit effort (BPUE), and population metrics prior to and following nutrient addition. Both overall CPUE and BPUE increased post-nutrient addition, particularly in the treatment reach (KR6 and KR9), with no distinguishable changes in the fish assemblage. Only one site (KR2) saw a decrease in abundance and biomass and was also the only site at which a shift in the fish assemblage occurred. Relative weight (Wr) and condition factor (K) increased at treatment sites for mountain whitefish *Prosopium williamsoni*, largescale sucker *Catostomus macrocheilus*, and rainbow trout *Oncorhynchus mykiss*. Mountain whitefish length at age of capture increased in the treatment reach, especially in age-0 and age-1 fish.

Population estimates were conducted for a 3 km reach of river near Hemlock Bar in both 2004 and 2008. Numbers of whitefish doubled from 7,666 fish to 17,644 fish while largescale sucker numbers tripled from 2,207 to 7,609 fish. The mountain whitefish population estimate for 2008 is similar to that reported in 1980-1981, considered “pre-dam” numbers. We also saw an increase in rainbow trout from 335 fish to 581. This increase can be attributed to both increased food availability as a result of nutrient additions and a fishing regulation change in 2002 to a 2 fish limit, none under 16 inches. The increase in rainbow trout numbers has occurred largely in fish 201-305 mm, which may indicate increased recruitment or survival in response to the harvest length limit. Very few fish larger than 406 mm (QSD = 1) have been captured during sampling efforts; however, we anticipate an increase in larger rainbow trout as recruitment and food availability continue to increase.

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INTRODUCTION

The Kootenai River basin has been subject to many anthropogenic activities, including agriculture, mining, land use practices, and particularly the construction of Libby Dam, which have impacted the ecosystem and led to a decline in the fish population. Libby Dam has significantly altered flow regimes and channel morphology since it came online in the early 1970s and has caused the depletion of nutrients and the decline in primary productivity in the Idaho portion of the Kootenai River (Woods 1982; Snyder and Minshall 1996). By the 1990s, this reduction in productivity translated into a two- to four-fold decrease in the number of mountain whitefish, as compared with 1980-81 (Partridge 1983; Paragamian 1990).

Lake Koocanusa, the reservoir created by Libby Dam, acts as a nutrient sink (Woods 1982; Snyder and Minshall 1996). According to Woods (1982), the reservoir retains approximately 63% of total phosphorus (P) and 25% of total nitrogen (N). Due to low current velocities in the reservoir, these nutrients bind to sediments and precipitate out of solution (Snyder and Minshall 1996), making them unavailable to organisms in the river below the dam. Consequently, the Idaho portion of the Kootenai River was considered “nutrient poor” (ultraoligotrophic) and P-limited (Snyder and Minshall 1996). Primary production is thought to be the central foundation of bioenergetic development in the higher trophic levels (Vannote et al. 1980). In the Idaho portion of the Kootenai River, the diminishment of nutrients has reduced primary production, which may have been a major contributor to poor sport fish production over the past two decades.

Evidence of community shifts in the Kootenai River has been seen at many levels of the food chain. For example, macroinvertebrate abundance and species diversity prior to Libby Dam’s construction was significantly higher in the upper canyon sections and is now considered low in relation to other rivers in north Idaho (Bonde and Bush 1975; Snyder and Minshall 1996). Specialized species such as caddisflies, stoneflies, and mayflies showed decreased numbers (Hauer and Stanford 1997), and more generalist species such as aquatic worms increased (C. Holderman, personal communication, Kootenai Tribe of Idaho). As a result, problems arise for those fish that rely on insect diversity for survival. Paragamian (2002) showed shifts in fish species from feeding “specialists” such as rainbow trout *Oncorhynchus mykiss* and mountain whitefish *Prosopium williamsoni* to more habitat and feeding “generalists” such as peamouth chub *Mylocheilus caurinus,* and largescale suckers *Catostomus macrocheilus.*

Successful increases in primary production have been achieved with the addition of inorganic P and N (Ashley et al. 1999). It was proposed that increases in primary production through fertilization would stimulate fish production in the Kootenai River from the bottom of the food web up (Snyder and Minshall 1996). The addition of nutrients has proven to be successful in recovering wild fish populations. For example, a large-scale nutrient restoration program was implemented in the north arm of Kootenay Lake, British Columbia (BC) in 1992 in an attempt to recover declining kokanee *Oncorhynchus nerka* populations. The results of this implementation significantly increased abundance at all levels of the food web (Ashley et al. 1999). Significant increases in zooplankton resulting from increases in algal growth were sufficient to produce increases in kokanee numbers. Within seven years, kokanee spawners in two main tributaries to the north arm increased from 300,000 in 1992 to 2.1 million in 1998. A study on the Kuparuk River found a dramatic increase in algal biomass and productivity that lead to increased growth rates of some insect species, age-0 fish, and adult fish after four years of phosphorus addition (Peterson et al. 1993).

We began addition of liquid phosphate fertilizer (10-34-0) to the river on July 13, 2005. During the first year, we added phosphorous to achieve a concentration of 1.5 µg/l of phosphate. In subsequent years, we increased our dosing rate to achieve a concentration of 3.0 µg/l. According to Ashley and Stocker (2003) target concentrations of SRP (3-5 $\mu g \cdot L^{-1}$) in streams is generally one-third to one-half nuisance concentrations (10 $\mu g \cdot L^{-1}$), but need to be high enough to be effective over several river kilometers (rkm). Nitrogen was identified to have the potential to be colimiting in the Kootenai River as the growing season progresses. Due to the potential stripping NO_3 from solution by increased primary production, we set a threshold of 60 µg L^{-1}, at which point we would add nitrate fertilizer (32-0-0).

The Kootenai River Ecosystem Project was designed to take a more ecosystem-based approach to rehabilitating Kootenai River fisheries. Past fisheries management programs on the Kootenai River have focused on recovering a single species. This project was designed to help support recovery of fish populations through an ecosystem-based strategy rather than simply treating the symptoms of degrading stocks. The addition of nutrients to this ultraoligotrophic system (Kootenai River downstream of Libby Dam) may stimulate production in the river's depleted food web and reverse the downward trends in fish populations of trout, kokanee, mountain whitefish, burbot *Lota lota*, and white sturgeon *Acipenser transmontanus*. This report summarizes results specific to zooplankton and fish populations. Work relative to primary productivity and macroinvertebrates will be reported by the Kootenai Tribe of Idaho.

RESEARCH GOAL

1. Restore the fish assemblage in the Idaho reach of the Kootenai River to pre-Libby Dam densities and improve angler fishing success.

OBJECTIVES

1. Attain a measurable increase in rainbow trout densities, preferably a two-fold increase in age-2 and older rainbow trout densities to 0.11 rainbow trout/100 m^2 (about 100 rainbow trout/km in the 3 km Hemlock Bar reach).

2. Attain a measurable increase in rainbow trout angler catch rates, preferably a min of 0.34 fish/h, with a final target of ≥0.67 fish/h.

3. Attain a measurable increase in the mountain whitefish population, preferably restoring the population back to the 1980-81 level of 14,000-16,000 fish for the 3 km Hemlock Bar reach (Partridge 1983).

4. Attain a measurable increase in Wr of rainbow trout and mountain whitefish, preferably between 93-101 for rainbow trout and a minimum of 90 for mountain whitefish.

STUDY AREA

The Kootenai River headwaters originate in Kootenay National Park in southeastern BC, Canada (Figure 1). From there, the river flows southward into northwestern Montana and enters Lake Koocanusa, the reservoir formed by Libby Dam. The river then turns westward and flows into the northeastern portion of the Idaho Panhandle, then northward back into BC to form

Kootenay Lake, and finally to the confluence with the Columbia River at Castlegar, BC. The Kootenai River is the second largest of the Columbia River tributaries and the third largest in drainage size (approximately 50,000 km^2; Bonde and Bush 1975). The study area consists of approximately 106 km (rkm 170 to rkm 276) of the river that flows through the Idaho Panhandle, along with two reference (control) sections in Montana and in BC.

The Montana and Idaho portion of the Kootenai River below Libby Dam (rkm 352) can be separated into three distinct stream habitat types. Directly below the dam, the river flows through a narrow canyon section characterized by steep canyon walls, high gradients, and boulder/cobble substrates (rkm 352 to 258.5). Upriver from Bonners Ferry, the channel has an average gradient of 0.6 m/km, and the velocities are often higher than 0.8 m/s. There is a braided transition reach from the Moyie River (rkm 258.5) to Bonners Ferry (rkm 244.5). Downriver from Bonners Ferry, velocities slow to usually less than 0.4 m/s; average gradient is 0.02 m/km, the channel deepens, and the river meanders through the Kootenai Valley.

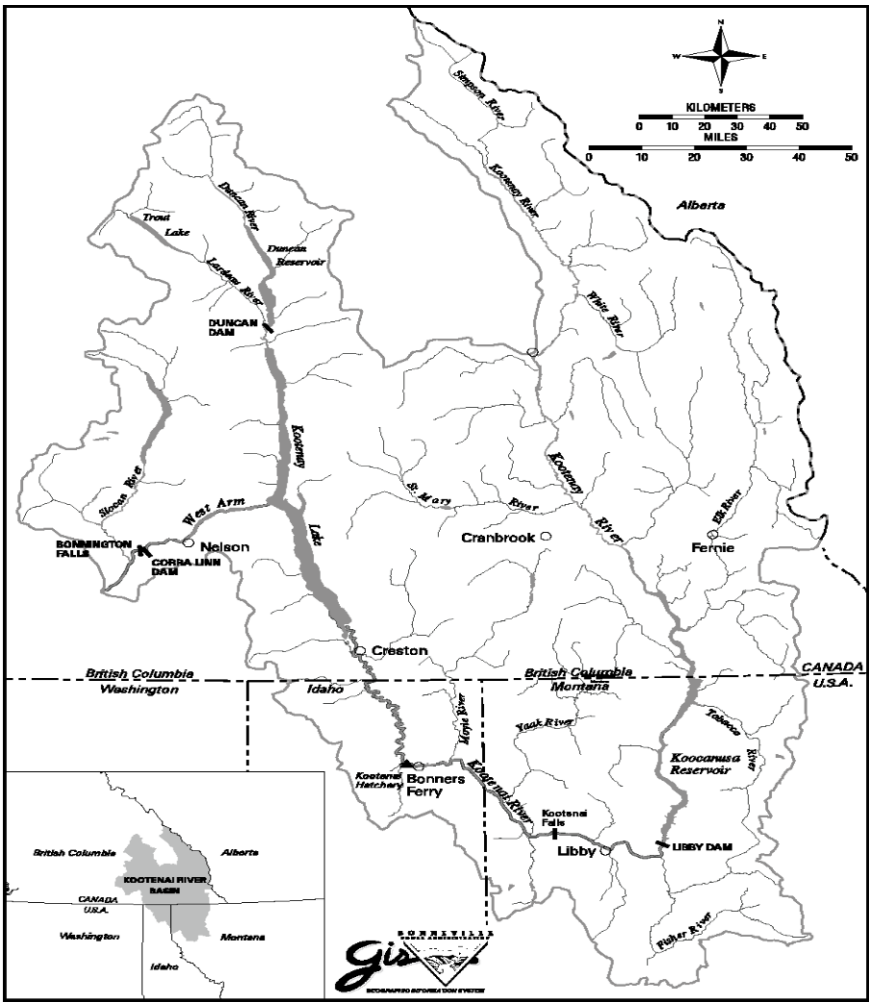


Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, Libby Dam, and Bonners Ferry.

Ecosystem biomonitoring sites have been established to gather fisheries and microinvertebrate data pre- and post-fertilization (Figure 2). In terms of fish sampling, we established six sites. Two sites were established as reference or control sites. The first site (KR10) is in the Montana portion of the canyon section at rkm 283. This location is often referred to as the Yaak River site due to its proximity to the Yaak River (approximately 3 rkm upstream). The second site (KR14) is located above Lake Koocanusa near Wardner, BC. This site serves as an unimpounded reference site. Site KR 9 is located in the canyon section near Hemlock Bar approximately 10 km downstream of the nutrient addition site at rkm 265. Moving downstream, a single site (KR 6) is located in the braided canyon section above Bonners Ferry at rkm 250, approximately 20 km downstream of the nutrient site near Cow Creek. These two sites are considered the treatment reach of the river. The next two sites are located in the meander reach below Bonners Ferry at rkm 230, referred to as the Shortys Island site (KR 4), and at rkm 170 near the Canadian border, referred to as the Porthill site (KR 2). Microinvertebrate sampling occurred at sites KR2, KR4, KR6, KR9, and KR10 with two additional sites in the lower river at rkm 121 (KR1; confluence with Kootenay Lake) and rkm 199 (KR3; Copeland).

METHODS

Microinvertebrate Abundance

Zooplankton sampling began in 2002, first to determine a general reference to species abundance and composition, and second to provide a temporal baseline for determining changes following nutrient addition. Microinvertebrates (zooplankton) were sampled at three biomonitoring sites (KR10, KR9, and KR6) on the Kootenai River in 2002-2008, with collections made once each month from the left, center, and right channel. Additionally, samples were taken in the same fashion from KR1, KR2, KR3, and KR4 for a shorter duration from June through September of 2002. Zooplankton were collected by filtering 10 L of water through a 1 L straining cup lined with a 63 µm mesh filter material. Samples were taken approximately 0.3 m below the water's surface (crustaceans and rotifers were assumed to be evenly mixed in a lotic system). Contents were then rinsed into 60 ml NALGENE® bottles and preserved with 0.05-0.1 ml of Lugol's iodine solution per 1 ml sample volume. Samples were sent to EcoAnalysts, Inc. for analysis. Four 1 ml aliquots from each sample were analyzed to the most specific taxonomic identification of crustaceans and rotifers. Resulting zooplankton and rotifer counts from subsamples were then extrapolated to number per liter.

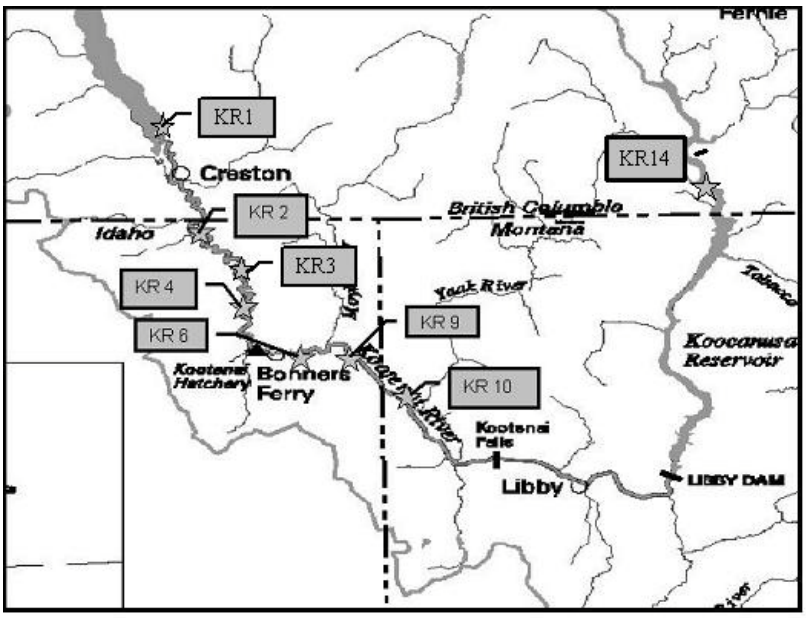


Figure 2. Kootenai River ecosystem study area and approximate locations of biomonitoring sites.

Fish Community Assessment

Species Abundance/Catch and Biomass Rates

Electrofishing was conducted during August and September from 2002-2008 at five biomonitoring sites. From 2004-2008 an additional site was added above Libby Dam near Wardner, B.C. to provide data from an unimpounded control site (KR14). Sites include Wardner (KR14), Yaak River (KR10), Hemlock Bar (KR9), Cow Creek (KR6), Shortys Island (KR4), and Porthill (KR2). Data from these sites were used to index relative species abundance and biomass, population indices, and to determine growth of mountain whitefish and rainbow trout following methods described in Walters (2002). Specific indices include relative species abundance as catch per unit of effort (CPUE), abundance by weight as biomass per unit of effort (BPUE), relative weight (Wr) and condition (K), and length at age. These data will document trends in the fish community over time and will be used to evaluate the effectiveness of nutrient enhancement of the Idaho section of the Kootenai River. Sites were sampled using a jetboat (5 m long) equipped with a Coffelt VVP-15 electroshocker powered by a 5000 watt Honda generator. Typically, electrofishing settings were set to generate 6-8 amps at 175-200 volts. The sampling crew consisted of two netters and one driver, who had control of the safety microswitch. All fish species, regardless of size, were netted in order to get a representative sample of the fish community structure at each site. To increase replication, each biomonitoring section (left and right shoreline) was divided into six equal subsections of 333 m with 150 m separating each to ensure each site was independent of the next. This protocol allowed one km of electrofishing on both banks for a total of two km of sampling per site. A single pass was made through each subsection, starting with lower sections first to ensure no fish drifted into areas not yet sampled. After each subsection was shocked, the elapsed sampling time was

recorded and collected fish were taken to a workup station where fish were anesthetized, identified to species, measured (total length [TL], mm), and weighed (g). Scales were removed from a subsample (10 fish in each 10 mm class interval) of mountain whitefish and rainbow trout at each site for aging.

Population Estimate

We conducted a mark recapture population estimate in August and September 2008 in the Hemlock bar reach (rkm 262-265) using boat electrofishing as described by Downs (2000). We marked mountain whitefish, largescale sucker, and rainbow trout with fin clips on the nights of August 25, 26, and 27. The recapture effort occurred on the nights of September 2, 3, and 4 to determine the proportion of marked to unmarked fish in the sample reach. Population estimates were calculated using Chapman's modification of the Petersen Method (Ricker 1975; Krebs 1999):

$$N = ([M+1]*[C+1] / [R+1]) - 1$$

where:

N = population estimate,
M = number of marked fish,
C = number of fish captured during the recapture sample, and
R = number of recapture marks in the recapture sample.

The 95% confidence limits for the population estimates were calculated based on the Poisson distribution (Ricker 1975; Seber 1982).

Proportional stock density (PSD) and quality stock density (QSD) were calculated for rainbow trout (Anderson 1976; Gabelhouse 1984). PSD standards are species specific and defined in the aforementioned references and are calculated as:

$$PSD = \frac{\text{Number of fish} \geq \text{minimum quality length}}{\text{Number fish} \geq \text{minimum stock length}} \times 100$$

$$QSD = \frac{\text{Number of fish} \geq \text{specified length}}{\text{Number fish} \geq \text{minimum stock length}} \times 100$$

Proportional stock density was calculated for rainbow using 200 mm TL as stock length and 305 mm TL as quality length (Schill 1991). QSD was calculated using 406 mm as the specified length. This length is the minimum length for harvest.

Relative Weight (Wr) and Condition Factor (K)

Fulton's condition factor (K) was used as a measure to gauge changes in body form. K is a ratio between the observed weight and an expected weight dependent on the fish's length (Blackwell et al. 2000). Fulton's condition factor is calculated using the following formula:

$$K = (W/L^3) \times 10^5,$$

where:

W is the weight of the fish in grams,
L is the length in millimeters, and
10^5 is a constant used for scaling purposes.

A condition of 1 is often used as a reference to represent optimal growth. Condition (K) assumes that a fish grows isometrically (becoming more round with increasing length). With that rarely being the case (Bolger and Connolly 1989; McGurk 1985), we also calculated relative weight (Wr), which compares Kootenai River fish weight to that of a standard developed for each species. Relative weight is calculated using the formula:

$$Wr = (W/Ws) \times 100,$$

where W is the actual fish weight and Ws is a standard weight for fish of the same length. Mean Wr values of 100 indicate ecological and physiological optimums (Anderson and Neumann 1996, Blackwell et al. 2000). Relative weight was calculated for rainbow trout, mountain whitefish, and largescale sucker, the only fish species we sampled with a Ws available (Anderson and Neumann 1996, Richter 2007). Minimum total lengths to calculate Ws were 120 mm for rainbow trout (Simpkins and Hubert 1996), 140 mm for mountain whitefish (Rogers et al. 1996), and a range of 170-640 mm for largescale suckers (Richter 2007).

Age and Growth

We collected rainbow trout and mountain whitefish scales from fish during our fall electrofishing. Scales were taken from the area just posterior of the dorsal fin and above the lateral line and placed into a coin envelope. We collected scales from a total of five fish for each 10 mm size category for each species at each site. Scales were impressed onto cellulose acetate slides and viewed on a microfiche reader at 42X, similar to methods described by Devries and Frie (1996). All scales had three independent reads. If there was no agreement, a fourth read was conducted by a biologist. We estimated length at age at time of capture in order to compare growth from year to year and pre- and post-nutrient addition. We included only age-1 to age-4 fish in our analysis. There were few fish older than age-4 and our aging reliability was poor for older fish.

Sportfishing Effort and Harvest

We conducted a creel survey from April 1 through October 31, 2005 and March 1 through March 31, 2006 to provide estimates of angling effort, total harvest, species composition of the catch, and catch and harvest rates. Results were compared to a previous creel conducted in 2001 and 2002 (Walters 2003), and together these creel surveys will provide information regarding angling effort and catch and harvest rates pre-nutrient addition. Estimates were made using the Idaho Department of Fish and Game Creel Census System (CCS) software (McArthur 1992). The survey was stratified into 30-day intervals with 12 sample days randomly selected for each interval, including four weekend days and eight weekdays. The Kootenai River was stratified into two sections with both sections sampled each creel day. Section 1 extended from the Idaho-Montana border downstream to the Highway 95 bridge at Bonners Ferry, and section 2 extended from the Highway 95 bridge downstream to Deep Creek, approximately 5 km downstream of Bonners Ferry. A previous creel survey showed that the majority of fishing pressure occurs within these two sections of the Kootenai River, Idaho (Paragamian 1995). Two instantaneous angler counts per section were made each creel day between sunrise and sunset, including one count prior to 1330 h and the second count at 1330 h or later. Instantaneous counts were conducted from shore or by boat. Counts included the number of bank anglers and the number of boats per section of river. The CCS software randomly selected instantaneous count times.

Anglers were interviewed by boat and at access points. Angler interviews included completed and incomplete trips. To increase interview sample size, angler interviews were conducted on non-creel as well as creel days. Anglers were queried for their residency, amount of time spent fishing, species targeted, and the number of fish (by species) harvested and/or released. Harvested fish were measured for total length (mm), weighed (g). Interview questions are detailed in McArthur (1992).

Statistical Analysis

Microinvertebrate

Linear regression was used to assess the relationship of microinvertebrate density (#/L) and river discharge in cubic feet per second (cfs). Microinvertebrate density reflects the average over the treatment reach (sites KR6 and KR9) by month and year and for the control site KR10 by month and year. River discharge was taken from the USGS gauge at Leonia and was averaged by month and year. Statistical significance was set at an $\alpha = 0.05$.

Fish Community Assessment

For analysis, we considered 2002-2005 to be pretreatment years and 2006-2008 to be post-treatment years. Level of significance was set at an $\alpha = 0.05$. We used both SAS (SAS Institute, 2002) and SYSTAT (SYSTAT 7.0, 1997) for statistical tests.

To test for differences in fish assemblage in pre- vs. post-treatment years at individual sites, we analyzed fish species composition data using a chi-square contingency table analysis. Species composition was an average of percent composition for pre- and post-treatment years.

All data for catch and biomass per unit of effort, relative weight, and condition were tested for normality and heterogeneity of variance. If the data were non-normal, it was logarithmically transformed for the analysis (Higgins 2004). Catch and biomass were compared for pre- and post-treatment years using a general linear model (GLM) ANOVA for individual sites.

We used GLM ANOVA to compare catch and biomass for mountain whitefish, largescale sucker, and rainbow trout among all sites in the overall model and at individual sites in the treatment reach (KR6 and KR9) and the control site (KR10) The overall model represents a before-after control-impact (BACI) design to test for effect pre- versus post-nutrient addition and differences between treatment and control sites (Smith 2002). The model included effects for treatment (pre versus post), site, and the interaction of treatment and site. Additional site contrasts were run as follows:

KR10 vs. KR6 and KR9
KR14 vs. KR6 and KR9

We used General Linear Model (GLM) ANOVA to compare relative weight (Wr) and condition factor (K) for mountain whitefish, largescale sucker, and rainbow trout among all sites in the overall model and at individual sites in the treatment reach (KR6 and KR9) and the control site (KR10). For the overall model, treatment effects included treatment (pre- versus post), site, and the interaction of treatment and site. Additional site contrasts were run as follows:

KR10 vs. KR6 and KR9
KR14 vs. KR6 and KR9

Age and Growth

Mountain whitefish length at age at time of capture was compared for pre- versus post-treatment years by site and age category using ANOVA. Data was analyzed only for the treatment reach (KR6 and KR9) and the control site KR10 to ensure there was an adequate number of samples.

We developed a correlation between length and age for mountain whitefish using Pearson's and Spearman's (Rodgers and Nicewander 1988) correlation coefficients. The distribution of mountain whitefish lengths was modeled using a three-component mixture model of the form:

$$Y = P_1 * N(\mu_1, \sigma_1) + P_2 * N(\mu_2, \sigma_2) + P_3 * N(\mu_3, \sigma_3)$$

where each N (μ_i, σ_i) is a normal probability density function with mean μ_i and standard deviation σ_i. The means measure the average fish length of each component, while the standard deviations measure the spread or consistency of the components. Each component enters the model with relative amount or proportion P_i ; $\Sigma P_i = 1.0$ (Shafii, SCC personal communication).

The mixture model was fit separately to pre- and post-nutrient addition data sets. Following estimation, a full dummy variable model was used to assess pre- and post-parameter differences through single and multiple degree of freedom contrasts.

RESULTS

Microinvertebrate Abundance

We collected a total of 153 zooplankton samples from the treatment reach (KR6 and KR9) and reference site (KR10) from 2002-2007. We captured specimens from 53 unique species and 15 families of rotifers and 11 unique species and seven families of crustaceans. Diversity varied from year to year with 2005 having the highest diversity of both crustaceans and rotifers. A summary is presented in Appendix A.

The dominant microinvertebrate species were consistent among years as well as sites. Dominant rotifer species included *Keratella cochlearis*, *Kellicottia longispina*, *Polyartha remata*, and unidentified. In terms of crustacean species, the most dominant included *Cyclopoid copepodite*, *Bosmina longirostris,* and *Calenoid copepodite*

Crustacean and rotifer densities in collections from June 2002 to September 2007 have shown a general trend of decreasing numbers even in KR10 (Figure 3). Rotifer densities in the treatment reach ranged from 105 in 2002 to seven in 2007. Similarly, crustacean densities ranged from eight individuals/L to less than one individuals/L in the same period.

Peak flows generally occurred in June during the study period (Figure 4). These peaks in flow show a positive relationship with peaks in microinvertebrate abundance, especially crustaceans (Figures 5 and 6). Crustacean abundance showed a positive correlation with flows ($R^2 = 0.199$, $F = 11.95$, $P = 0.001$), whereas rotifer abundance did not show any correlation ($R^2 = 0.005$, $F = 0.247$, $P = 0.622$; Figures 7 and 8).

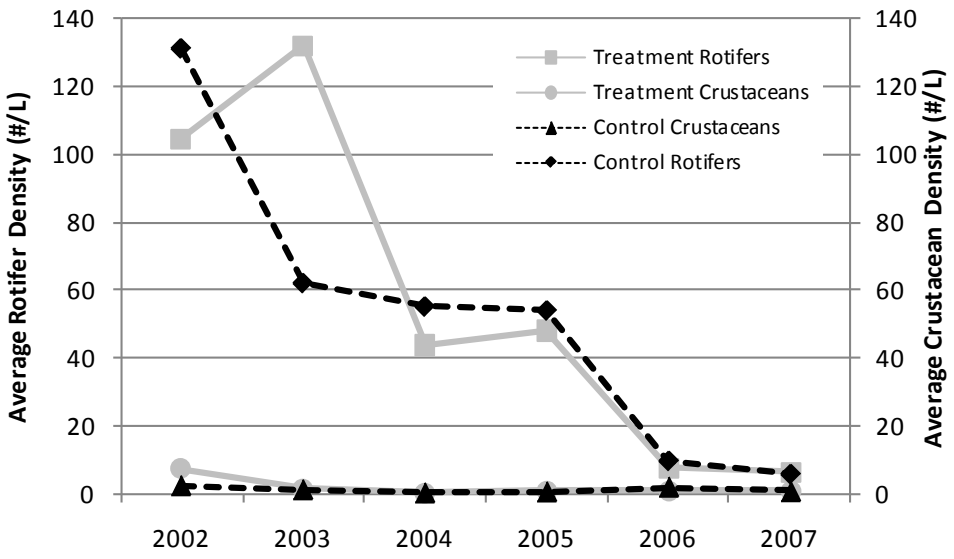


Figure 3. Mean density of microinvertebrates averaged over treatment sites by year sampled in the Kootenai River, Idaho.

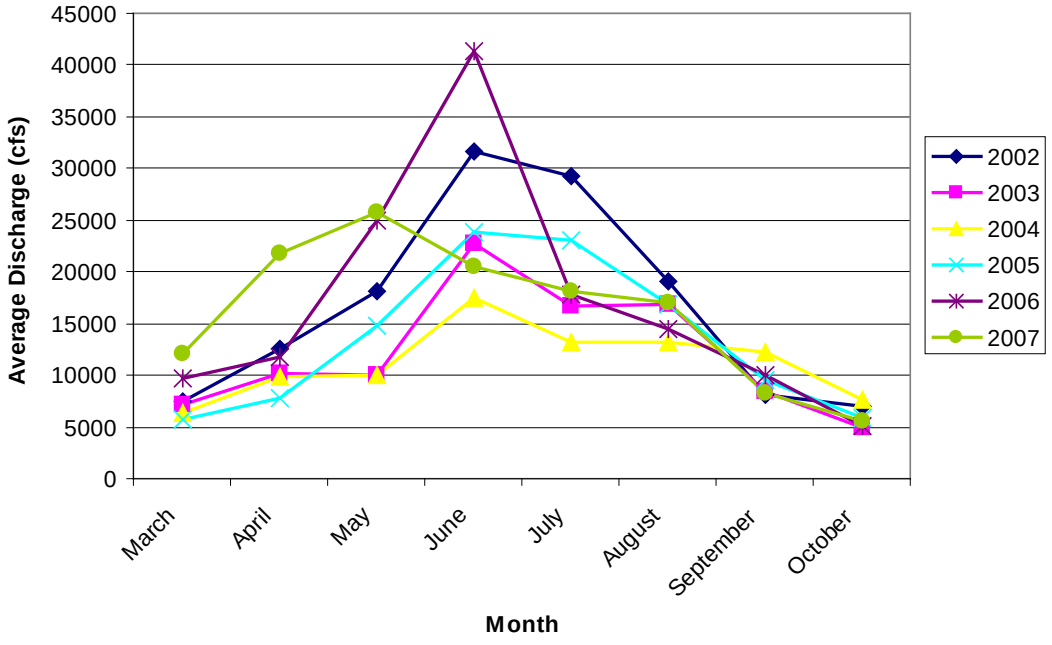


Figure 4. Average discharge recorded at the US Geological Survey Leonia gauge from March through October by sample year.

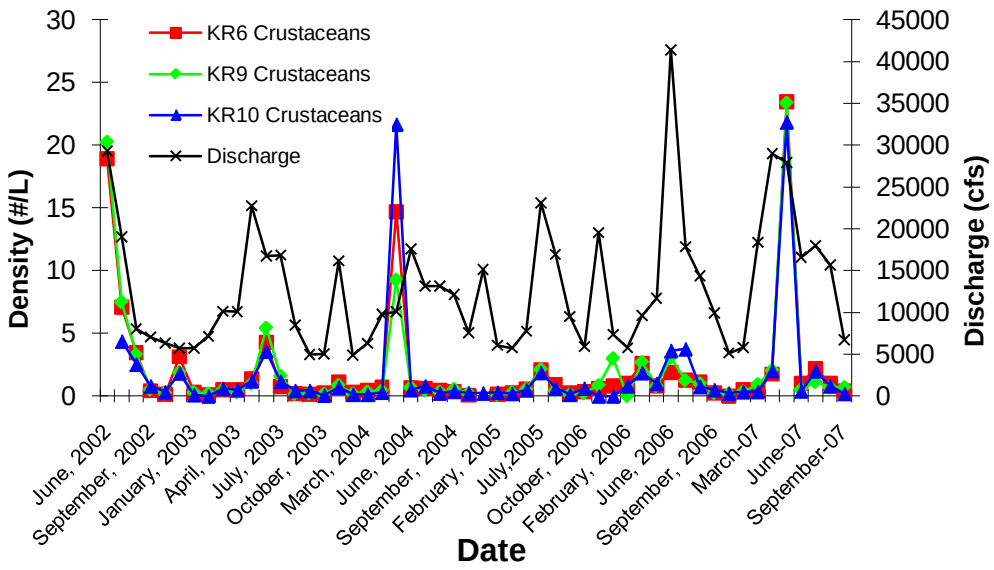


Figure 5. Average zooplankton densities (crustaceans) for Kootenai River treatment reach sites (KR6 and KR9) and control site (KR10) and discharge at the USGS gauging station at Leonia in cubic feet per second (cfs). The period shown is June 2002 through September 2007.

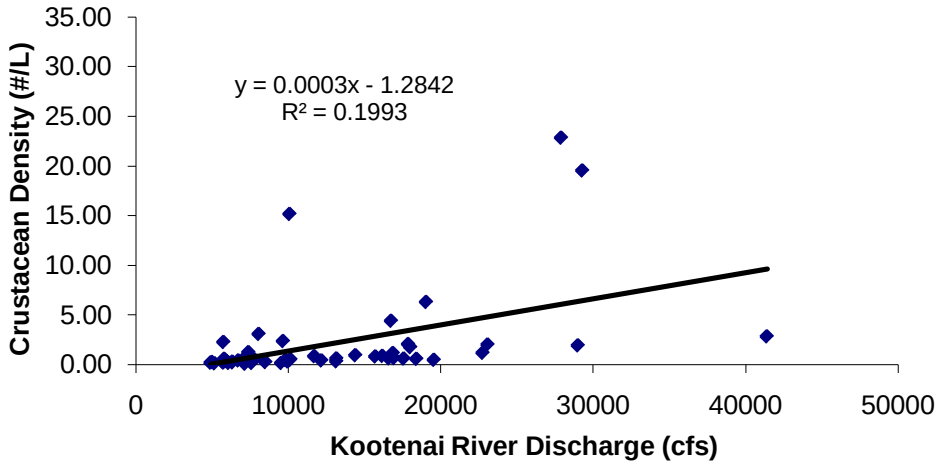


Figure 6. Regression analysis of Kootenai River discharge (cfs) at Leonia and crustacean densities for the period June 2002 through September 2007.

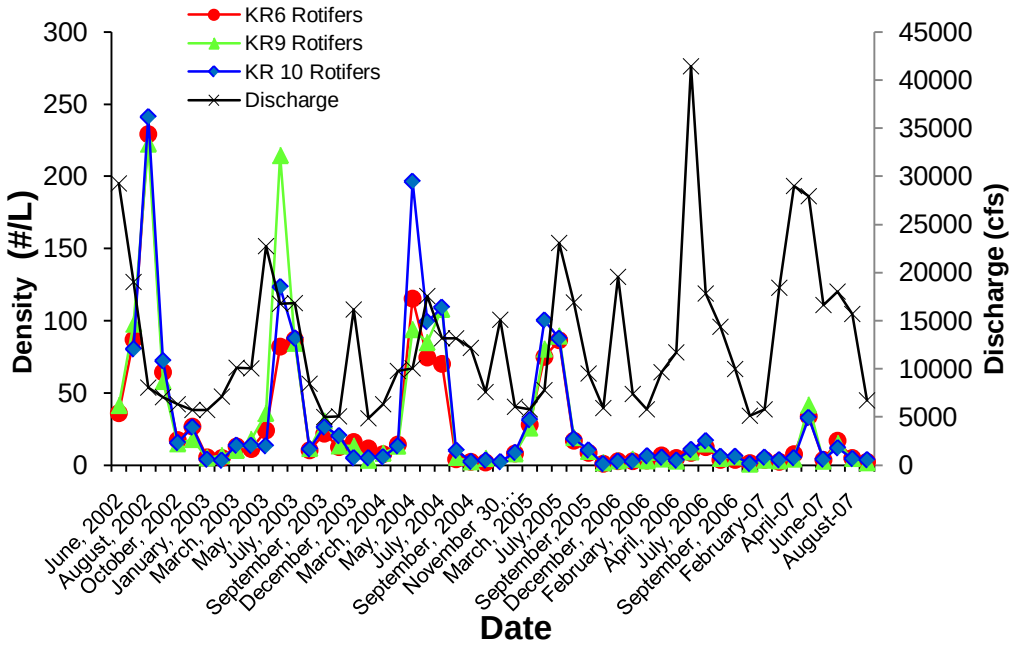


Figure 7. Average zooplankton densities (rotifers) for Kootenai River treatment reach sites (KR6 and KR9) and control site (KR10) and discharge at the USGS gauging station at Leonia in cubic feet per second (cfs). The period shown is June 2002 through September 2007.

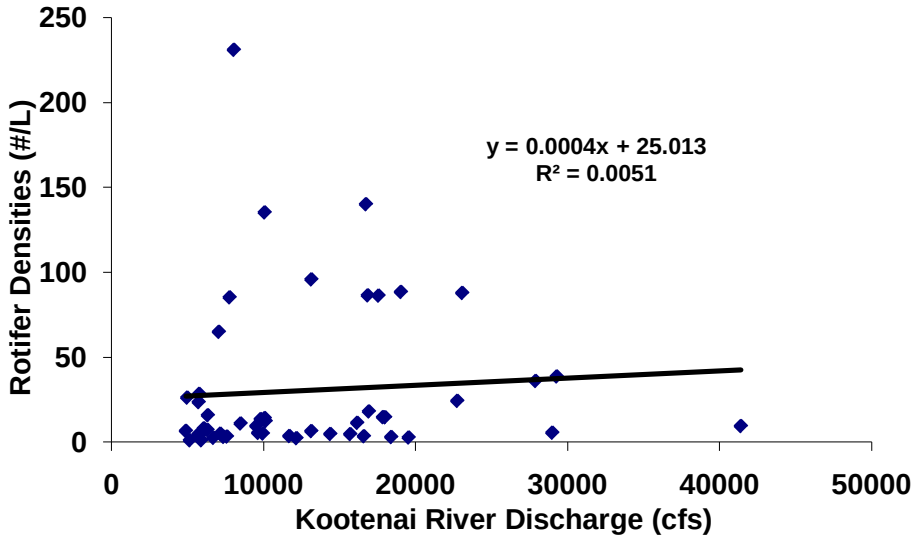


Figure 8. Regression analysis of Kootenai River discharge at Leonia and rotifer densities for the period June 2002 through September 2007.

Fish Assemblage Assessment

Species Abundance and Biomass

Fish data have been collected annually from 2002-2008 at six biomonitoring sites, with the exception of KR14 where sampling began in 2004. A summary is located in Appendix B. A total of 17 species of fish have been identified from the catch during this period, remaining fairly consistent from year to year. Six species dominate the catch annually, including mountain whitefish, largescale sucker, northern pikeminnow *Ptychocheilus oregonensis*, rainbow trout, peamouth chub, and redside shiner *Richardsonius balteatus* (Figure 9). The biomass is dominated by the same species as catch, with the exception of redside shiner, which contribute little to the biomass as a result of their size (Figure 10). We did not capture any white sturgeon. We did capture a total of four burbot (all captured at KR14) as well as bull trout *Salvelinus confluentus* and kokanee. Neither bull trout nor kokanee were included in our data as they are only transitionally in the main river during certain times of the year.

Catch at sites in the lower portion of the river (KR2, KR4) was dominated by northern pikeminnow, peamouth chub, and redside shiner, with few rainbow trout, mountain whitefish, and largescale sucker relative to upstream sites (Figure 9). Contrary to these sites, the upper sites (KR6, KR9, and KR10) were composed largely of mountain whitefish, largescale sucker, and rainbow trout. The Wardner site (KR14) was more similar to sites in the upper river (KR6, KR9, and KR10), but with very few rainbow trout. In terms of biomass, lower sites were dominated by northern pikeminnow and largescale sucker and upper sites by mountain whitefish and largescale sucker.

Species composition comparisons were made at individual sites, pre- and post-treatment, to evaluate possible effects of nutrient additions on the fish assemblage. We found that only the lowermost site KR2 had a significantly different species composition in pre- vs. post-treatment years ($\chi 2 = 11.18$, df = 5, $P = 0.05$; Table 1) as a result of a large increase in northern pikeminnow and a decrease by more than half in peamouth chub. Other sites did not show any significant shifts in the fish assemblage after nutrient additions began.

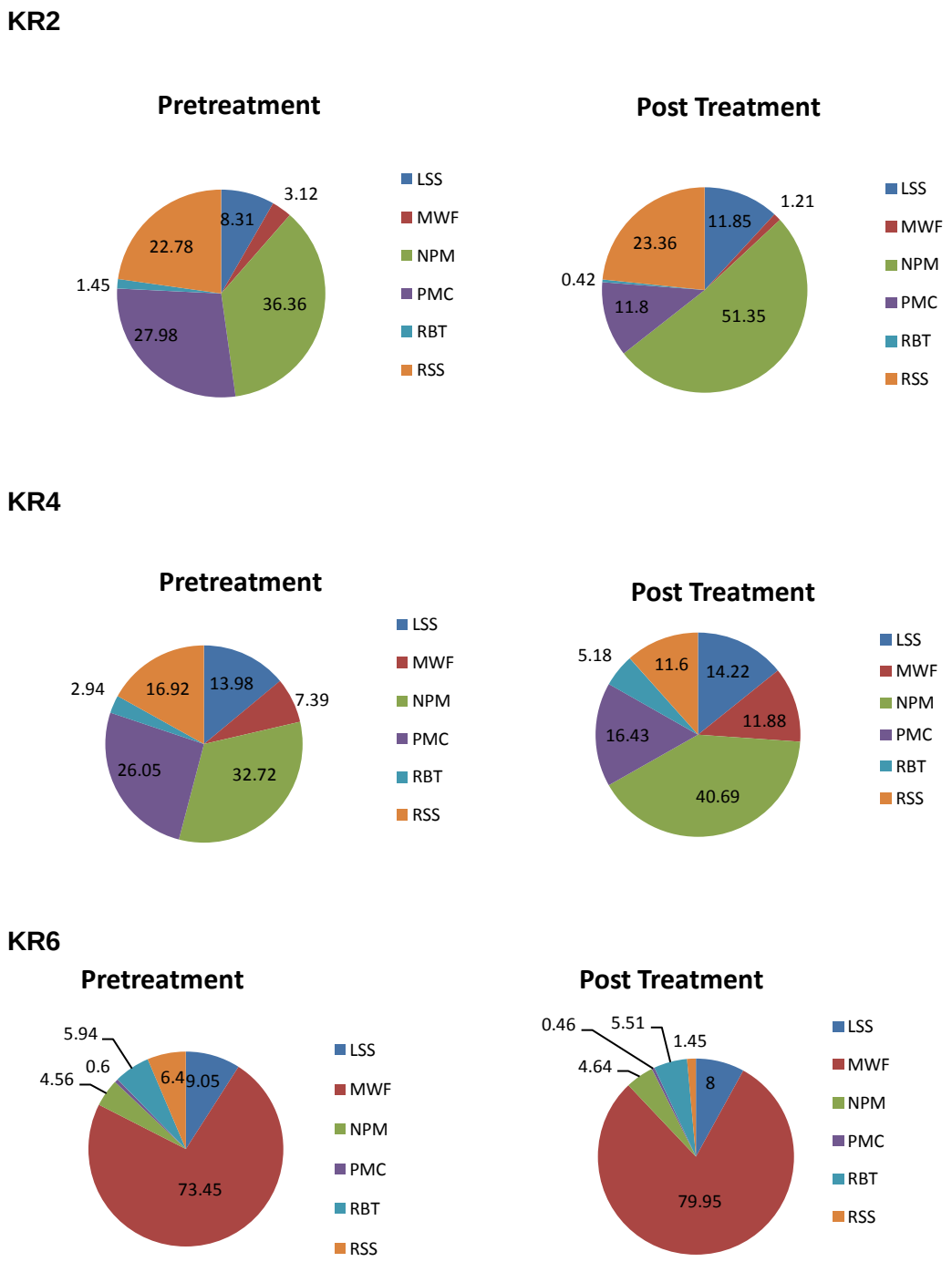
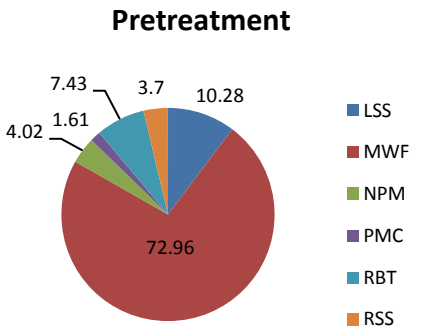
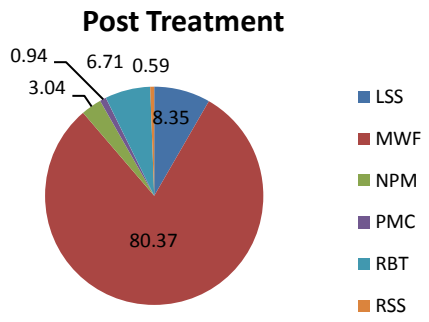


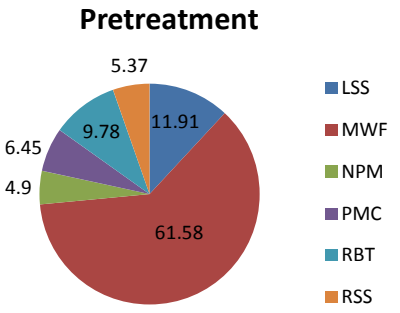
Figure 9. Species abundance by proportion of catch at individual sites for pre- and post-treatment years.

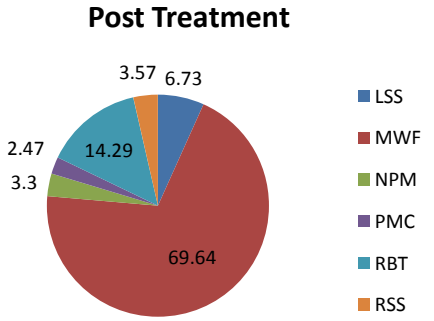
KR9



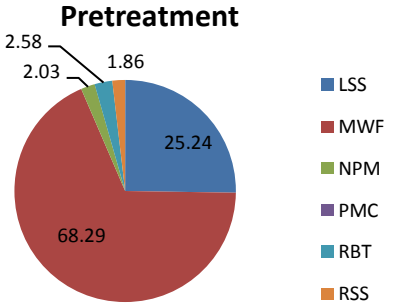


KR10





KR14



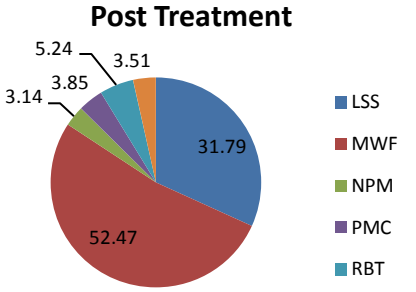


Figure 9. Continued.

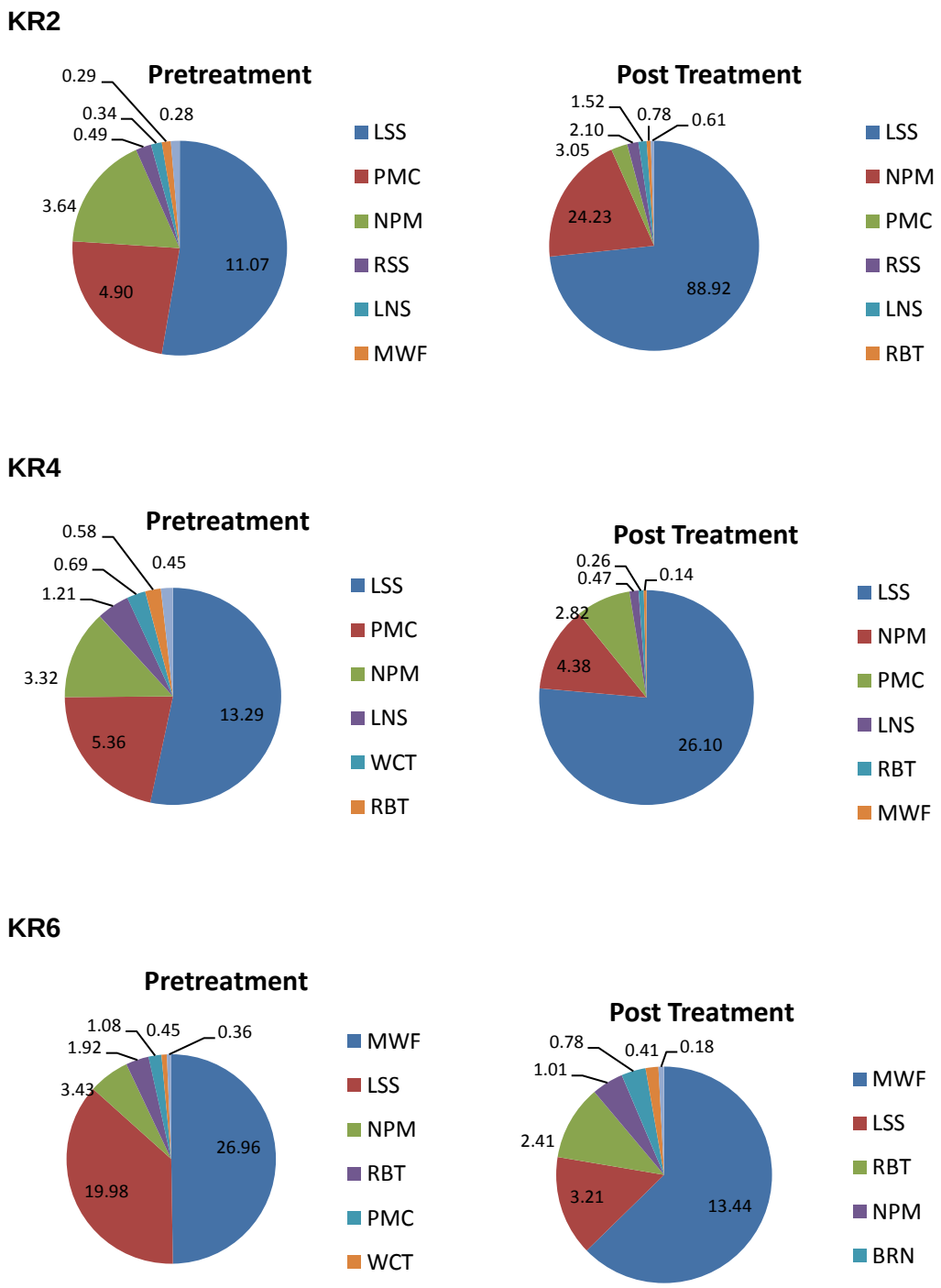
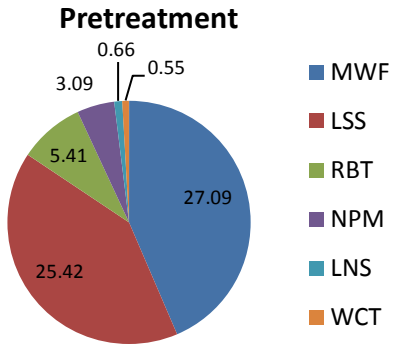
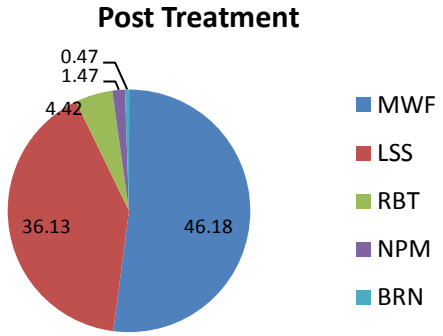


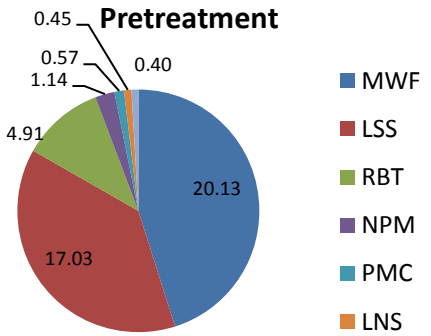
Figure 10. Species biomass by proportion of catch at individual sites for pre- and post-treatment years.

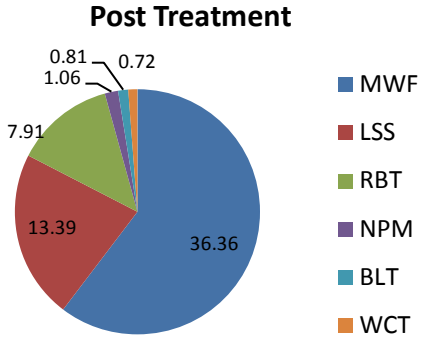
KR9



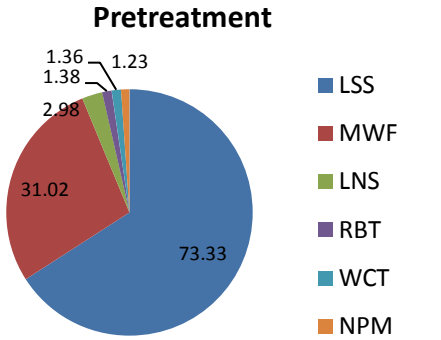


KR10





KR14



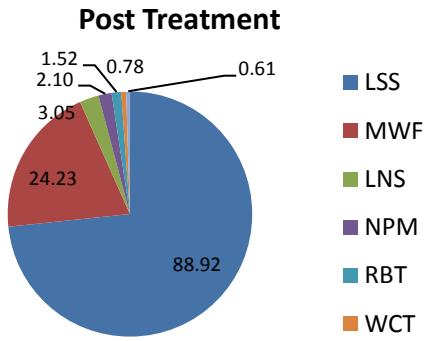


Figure 10. Continued.

Table 1. Results of chi-square test for species composition comparison by site, pre- versus post-nutrient addition. Significant p-values are bold.

Site	DF	χ2	P-value
KR2	5	11.18	**0.05**
KR4	5	5.70	0.34
KR6	5	3.50	0.62
KR9	5	3.15	0.68
KR10	5	5.23	0.39
KR14	5	8.32	0.14

Catch Rate and Biomass (CPUE and BPUE)

Abundance (CPUE)—Overall species abundance increased at all biomonitoring sites except KR4 (Appendix C). Increases were significant at treatment reach sites KR6 and KR9, and the decrease in abundance at KR4 was significant (Table 2). At KR6 average abundance increased from 300 to 595 fish/h, and at KR9 overall abundance increased from 276 to 476 fish/h after nutrient additions (Figure 11). The increase in the treatment reach catch is a result of increased mountain whitefish abundance. Mountain whitefish abundance doubled at both sites, increasing from 238 to 473 fish/h at KR6, and from 165 to 384 fish/h at KR9. The control site KR10 also experienced an increase in abundance. The increase at this site was a result of increased numbers of both mountain whitefish and rainbow trout. The control site at Wardner (KR14) remained virtually unchanged pre- vs. post-treatment. The significant reduction of abundance at KR4 was a result of a reduction in numbers of nearly all of the species present, but largely redside shiner and northern pikeminnow.

Biomass (BPUE)—Overall species biomass increased at all biomonitoring sites except KR4 (Appendix D). Increases were significant at treatment reach site KR6 and at site KR2 (Table 3). At KR6 biomass increased from 54.8 kg/h to 92.6 kg/h and at KR2 biomass increased from 20.4 kg/h to 34.0 kg/h (Figure 12). The increase at KR6 is the result of a large increase in CPUE in 2007, particularly for mountain whitefish. At KR2 largescale suckers contributed the most to the increase in biomass. Both sites in the treatment reach (KR6 and KR9) had increased biomass in post-treatment years. Both control sites remained virtually unchanged from pre- to post-treatment years.

Table 2. Average catch per unit effort (fish/h) for all species for pre- versus post-treatment years by site. Significant p-values are bold.

	Average CPUE			
Site	Pretreatment	Post-Treatment	F	P-value
KR2	255	309	1.99	0.17
KR4	271	189	6.42	**0.02**
KR6	300	595	8.54	**0.01**
KR9	276	476	4.09	0.09
KR10	207	301	4.08	0.10
KR14	365	380	0.02	0.89

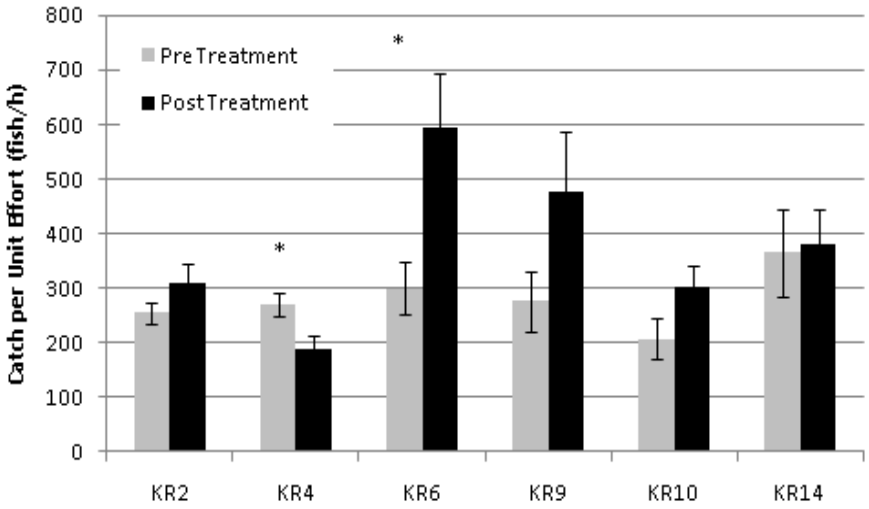


Figure 11. Average catch rate for pre- versus post-treatment years shown by site. Error bars indicate standard error (SE). Asterisks denote significant differences at α = 0.05.

Table 3. Average biomass per unit effort for pre- versus post-treatment years by site and summary statistics. Significant p-values are bold.

	Average BPUE			
Site	**Pretreatment**	**Post-Treatment**	**F**	**P-value**
KR2	20.4	34.0	14.35	**<0.01**
KR4	25.2	21.3	0.37	0.55
KR6	54.8	92.6	6.16	**0.02**
KR9	70.2	104.6	2.20	0.15
KR10	51.3	56.6	0.159	0.69
KR14	131.1	135.0	0.017	0.90

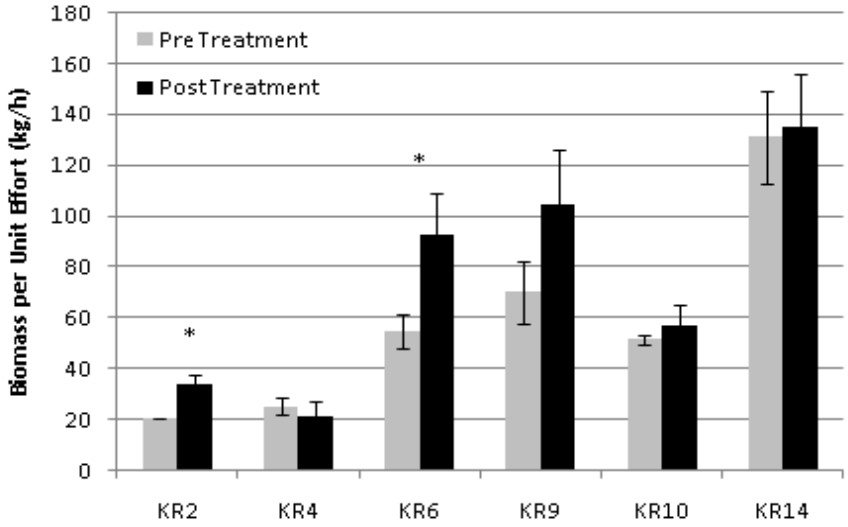


Figure 12. Average biomass per unit effort for pre- versus post-treatment years shown by site. Error bars indicate standard error (SE). Asterisks denote significant differences at α = 0.05.

Mountain Whitefish

For the overall model, mountain whitefish showed marginally significant differences in terms of catch in pre- vs. post-treatment years (F = 3.22, *P* = 0.08; Appendix E). The effect of site on catch was significant (F = 32.65, *P* <0.001), whereas the interaction of treatment and site was not significant (F = 1.47, *P* = 0.20). Catch was significantly higher after nutrient additions in the treatment reach (KR6 and KR9), which nearly doubled in mean abundance. The treatment reach site KR6 increased significantly in abundance from 243 fish/h to 495 fish/h (F = 6.47, *P* = 0.02; Table 4). Abundance also increased slightly at site KR4 and control site KR10 (Figure 13). The lowermost site KR2 and control site at Wardner (KR14) experienced a slight decrease in mountain whitefish abundance.

In terms of mountain whitefish biomass, the overall model did not show a significant change from pre- to post-treatment years (F = 1.98, *P* = 0.16; Appendix F). The effect of site on catch was significant (F = 45.27, *P* <0.001), whereas the interaction of treatment and site was not significant (F = 1.33, *P* = 0.25). Biomass did increase in the treatment reach as well as at the control site KR10 (Table 5). Sites KR2 and KR4 remained nearly identical in pre- versus post-treatment years and the Wardner (KR14) site saw a decrease in biomass post-nutrient addition (Figure 14).

Table 4. Mountain whitefish average abundance at treatment reach sites and the control site for pre- versus post-treatment years and summary statistics. Significant p-values are bold.

Site	Pretreatment	Post-Treatment	F	P-value
KR6	243.4	494.9	6.47	**0.02**
KR9	250.4	440.3	2.27	0.14
KR10	147.0	219.1	1.53	0.22

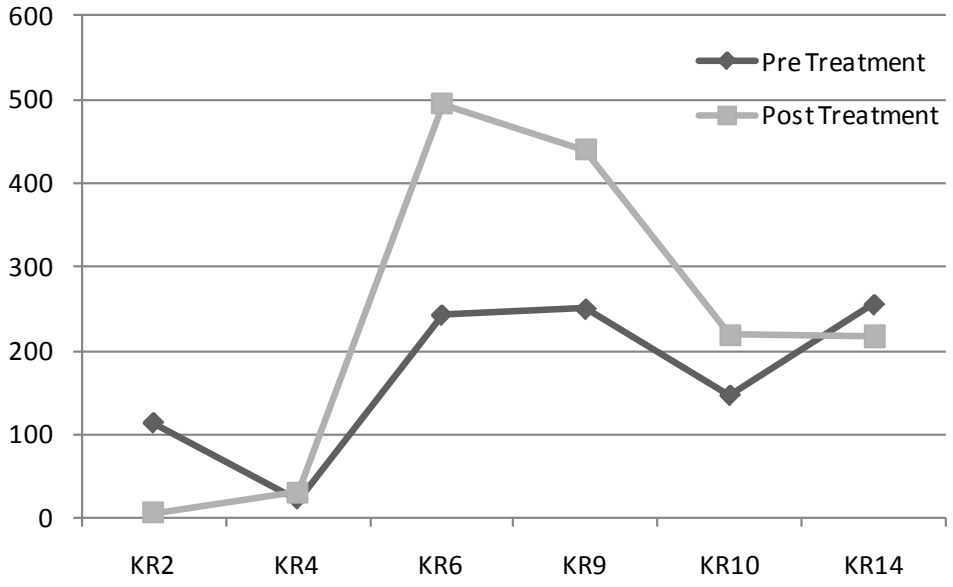


Figure 13. Mountain whitefish catch per unit effort (fish/h) for pre- versus post-treatment years by site.

Table 5. Mountain whitefish average biomass at treatment reach sites and the control site for pre- versus post-treatment years and summary statistics. Significant p-values are italicized.

Site	Pretreatment	Post-Treatment	F	P-value
KR6	27.6	42.4	1.62	0.21
KR9	41.8	66.2	1.49	0.23
KR10	27.3	36.2	0.58	0.45

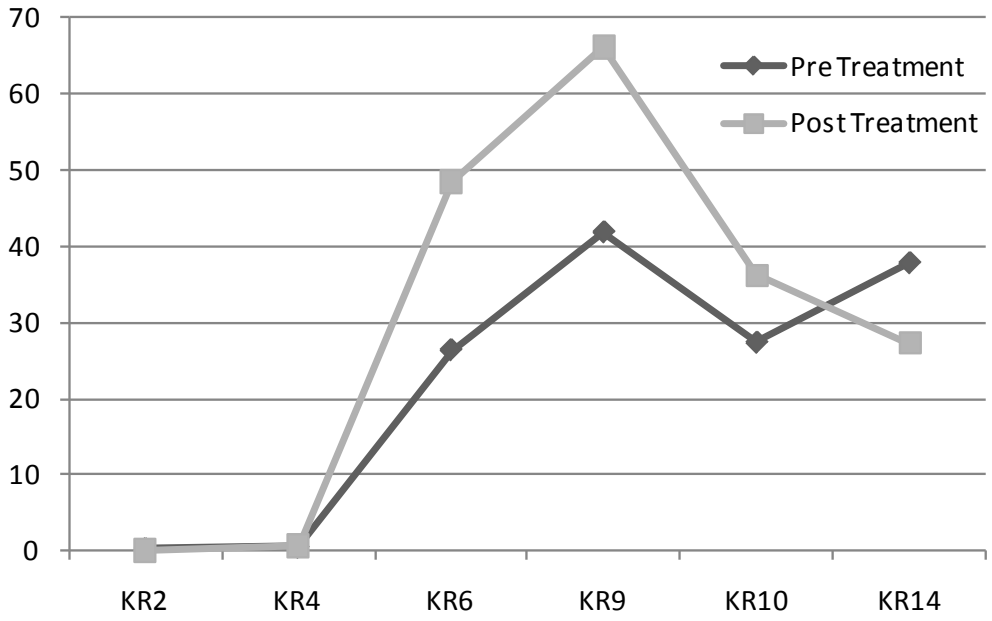


Figure 14. Mountain whitefish biomass per unit effort (kg/h) for pre- versus post-treatment years by site.

Largescale Sucker

For the overall model, largescale sucker did not show a significant change in abundance after nutrient addition (F = 1.83, *P* = 0.18; Appendix E). The effect of site on catch was significant (F = 13.78, *P* <0.001), whereas the interaction of treatment and site was not significant (F = 2.11, *P* = 0.07). Catch did increase at the treatment reach sites and decreased slightly at the Yaak (KR10) control site (Table 6). Abundance showed a significant increase from 29 fish/h to 50 fish/h at site KR6 (F = 7.87, *P* = 0.01). Numbers of largescale sucker also increased at KR2 and the Wardner control site and decreased slightly at KR4 (Figure 15).

Largescale sucker biomass increased significantly pre- versus post-treatment for the overall model (F = 4.87, *P* = 0.03; Appendix F). The effect of site on catch was significant (F = 13.78, *P* <0.001), whereas the interaction of treatment and site was not significant (F = 2.11, *P* = 0.07). Biomass increased significantly at treatment site KR6 (Table 7). Largescale sucker biomass increased at all sites except KR10 (Figure 16).

Table 6. Largescale sucker average abundance at treatment reach sites and the control site for pre- versus post-treatment years and summary statistics. Significant p-values are bold.

Site	Pretreatment	Post-Treatment	F	P-value
KR6	29.0	49.9	7.87	**0.01**
KR9	36.6	44.5	0.46	0.50
KR10	28.6	21.9	1.34	**0.03**

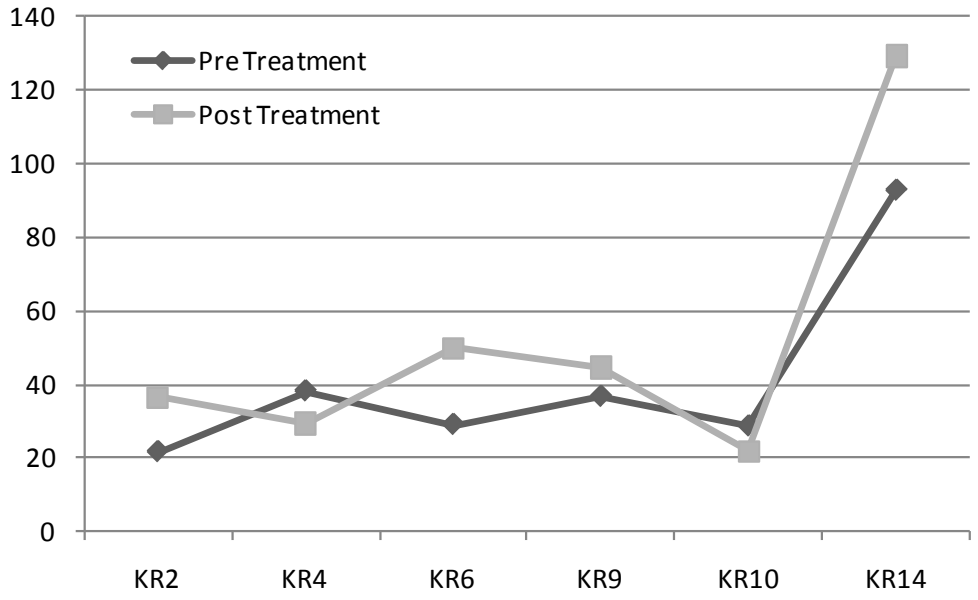


Figure 15. Largescale sucker catch per unit effort (fish/h) for pre- versus post-treatment years by site.

Table 7. Largescale sucker average biomass at treatment reach sites and the control site for pre- versus post-treatment years and summary statistics. Significant p-values are bold.

Site	Pretreatment	Post-Treatment	F	P-value
KR6	19.9	37.8	6.62	**0.01**
KR9	28.3	40.2	1.31	0.26
KR10	18.0	12.3	1.74	0.20

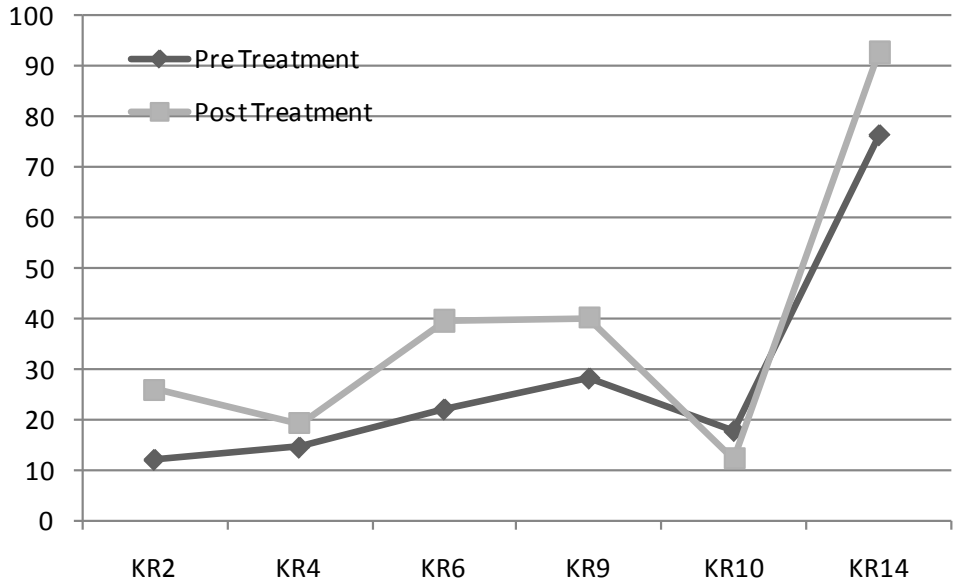


Figure 16. Largescale sucker biomass per unit effort (kg/h) for pre- versus post-treatment years by site.

Rainbow Trout

The overall model showed a marginally significant increase in abundance post-nutrient addition for rainbow trout (F = 3.15, *P* = 0.08; Appendix E). The effect of site on catch was significant (F = 16.21, *P* <0.001), whereas the interaction of treatment and site was not significant (F = 1.76, *P* = 0.13). Catch increased at both the treatment reach sites (KR6 and KR9) as well as the Yaak site (KR10; Table 8 and Figure 17). Rainbow trout abundance increased significantly at KR10 from 23 fish/h to 45 fish/h (F = 11.88, *P* = 0.001). Abundance increased slightly at the Porthill (KR2) and Shortys Island (KR4) sites and also showed an increase at Wardner (KR14; Figure 17).

Rainbow trout biomass did not show a significant change in pre- versus post-treatment years (F = 1.11, *P* = 0.30; Appendix F). The effect of site on catch was significant (F = 11.73, *P* <0.001), whereas the interaction of treatment and site was not significant (F = 1.18, *P* = 0.32). Results were variable by site. In the treatment reach, KR6 and KR10 showed increases whereas KR9 remained fairly unchanged (Table 9). Sites KR4 and KR14 also showed slight increases whereas KR2 showed a slight decrease (Figure 18).

Table 8. Rainbow trout average catch per unit effort (fish/h) at treatment reach sites and the control site for pre- versus post-treatment years and summary statistics. Significant p-values are bold.

Site	Pretreatment	Post-Treatment	F	P-value
KR6	22.8	34.7	2.91	0.10
KR9	27.5	36.7	1.58	0.22
KR10	23.2	45.4	11.8	**0.001**

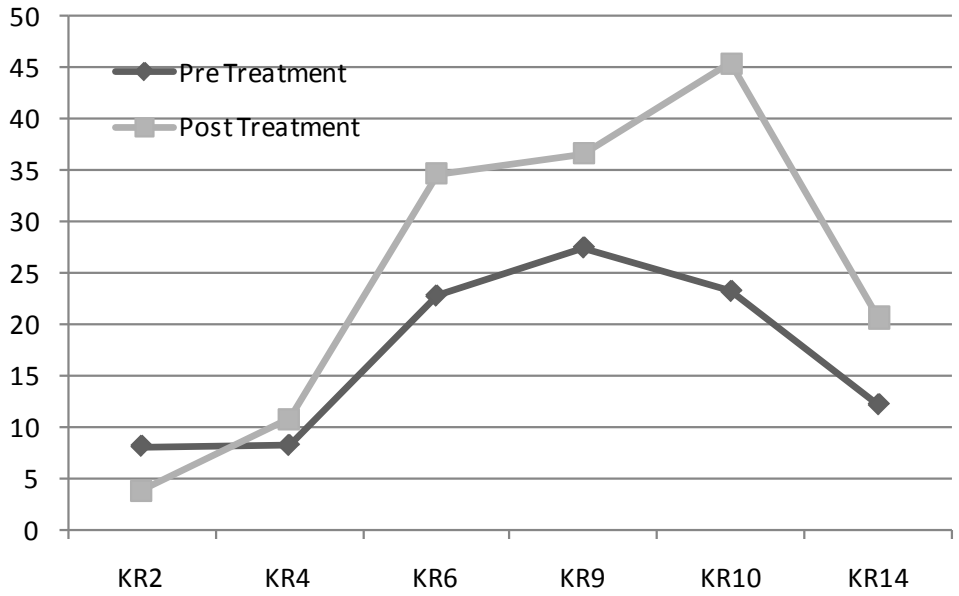


Figure 17. Rainbow trout catch per unit effort (fish/h) for pre- versus post-treatment years by site.

Table 9. Rainbow trout average biomass per unit effort (kg/h) at treatment reach sites and the control site for pre- versus post-treatment years and summary statistics. Significant p-values are bold.

Site	Pretreatment	Post-Treatment	F	P-value
KR6	3.7	4.9	0.90	0.35
KR9	6.5	6.5	0.00	0.99
KR10	4.8	7.2	2.52	0.12

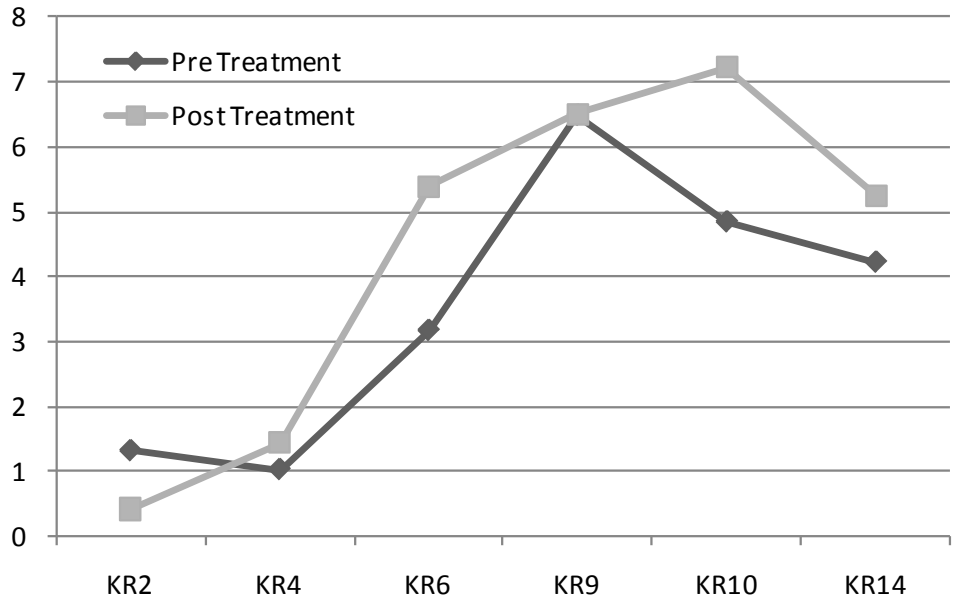


Figure 18. Rainbow trout biomass per unit effort (kg/h) for pre- versus post-treatment years by site.

Population Estimate

We captured a total of 3,734 fish during our tagging and recapture efforts in the Hemlock Bar reach in 2008. Numbers of mountain whitefish, largescale sucker, and rainbow trout were sufficient to calculate a population estimate. Mountain whitefish was the most abundant species at 17,644 fish (95% C.I. 14,746 and 21,117), followed by largescale sucker at 7,609 (95% C.I. 3,106 and 19,026), and rainbow trout at 581 (95% C.I. 398 and 888; Table 10). Numbers for all three species increased, with a two-fold increase for mountain whitefish, a tripling of largescale sucker, and an increase of 1½ times for rainbow trout compared with the 2004 population estimate (Table 10).

Rainbow Trout—In 2008, we estimated a population of rainbow trout in the Hemlock Bar reach of 581 fish. Estimates were conducted for this species in 1993, 1994, 1998, 1999, and 2004 (Table 11). Numbers have substantially increased. In 2008, values for proportional stock density (PSD) and quality stock density (QSD) were 40 and 1, respectively. These values are consistent with the 10-year average for PSD (PSD = 43) and below average for QSD (QSD = 3).

Table 10. Population estimate results for 2004 and 2008 for 3 km of river in the Hemlock Bar reach. M = # fish marked, R = # fish recaptured, C = # fish captured.

	Species	M	R	C	Population estimate	R/C	Lower 95% Con. Limit	Upper 95% Con. Limit
2008	LSS	218	3	138	7,609	0.02	3,106	19,026
	MWF	1,482	117	1,403	17,644	0.08	14,746	21,117
	RBT	139	24	103	581	0.23	398	888
2004	LSS	85	2	76	2,207	0.03	808	5,518
	MWF	557	41	576	7,666	0.07	5,688	10,591
	RBT	40	9	81	335	0.11	190	800

Table 11. Rainbow trout population estimates for the 3 km Hemlock Bar reach and population statistics.

Year	Population estimate[a]	Lower 95% C. L.	Upper 95% C. L.	n/ha	n/km	PSD	QSD
1993	98	78	118	3	33	—	—
1994	135	114	160	5	45	—	—
1998	217	168	294	7	72	42	5
1999	217	160	332	7	72	47	3
2000	—	—	—	—	—	39	2
2001	—	—	—	—	—	24	0
2002	—	—	—	—	—	55	2
2003	—	—	—	—	—	55	6
2004	335	190	800	11	112	35	7
2005	—	—	—	—	—	29	4
2006	—	—	—	—	—	32	1
2007	—	—	—	—	—	42	4
2008	581	398	888	20	194	40	1

[a] single estimate for all lengths combined

Relative Weight (Wr) and Condition Factor (K)

The overall ANOVA model did not show a significant change in relative weight (Wr) from pre- to post-treatment for mountain whitefish (F = 2.06, *P* = 0.15) or rainbow trout (F = 0.03, *P* = 0.87), whereas Wr increased for largescale sucker (F = 4.35, *P* = 0.04; Appendix G). Individual contrasts were not significant. For mountain whitefish the effect of site on Wr was significant (F = 3.04, *P* = 0.01), whereas the interaction of treatment and site was not significant (F = 0.31, *P* = 0.87). Relative weights for mountain whitefish were identical across all sites for pre- and post-treatment (Table 12). At individual sites, Wr improved at KR6 and KR9 and showed decreases at KR4 and the KR10 and KR14 control sites (Figure 19).

For largescale sucker the effect of site on Wr was not significant (F = 0.26, *P* = 0.93), nor was the interaction of treatment and site (F = 0.47, *P* = 0.80; Appendix G). Individual contrasts were not significant. Relative weight for largescale suckers increased from 81 to 85 across all

sites. All sites showed an increase in Wr except KR14, including the treatment sites KR6 and KR9 (Figure 19).

For rainbow trout the effect of site on Wr was not significant (F = 1.17, *P* = 0.87), nor was the interaction of treatment and site (F = 0.54, *P* = 0.75; Appendix G). Individual contrasts were not significant. Rainbow trout Wr increased significantly across all sites, and showed increases at all individual sites (Figure 19).

In the treatment reach, mountain whitefish, largescale sucker, and rainbow trout showed some significant increases in Wr from pre- to post-treatment years (Table 13). Mountain whitefish Wr significantly increased at KR6 and KR9 and showed a significant decrease at the KR10 control site (Figure 20). The increased Wr at treatment sites are limited to age-0 to age-2 fish. Age-3+ fish showed decreases in Wr in the treatment reach (Table 14). Relative weight for fish at the control site showed decreases for nearly all age classes. Largescale sucker Wr increased significantly at both KR6 and KR9 and also showed an increase at KR10 (Figure 20). Rainbow trout Wr increased significantly at KR6 and also showed an increase (not significant) at site KR9 (Figure 20). The control site KR10 showed a slight decrease in Wr.

Table 12. Mean relative weight at all sites and summary statistics. Significant p-values are bold.

	Mean Relative Weight			
Species	**Pre**	**Post**	**F**	**P-Value**
MWF	86.6	86.5	0.213	0.89
LSS	80.6	85.1	70.75	**<.001**
RBT	87.7	89.8	7.29	**0.01**

Table 13. Mean relative weight pre- versus post-treatment for sites in the treatment reach (KR6 and KR9) and associated control site (KR10) and summary statistics. Significant p-values are bold.

		Mean Relative Weight			
	Site	**Pre**	**Post**	**F**	**P-Value**
MWF	KR6	81	86	174.00	**<.001**
	KR9	89	90	3.81	**0.05**
	KR10	93	85	231.23	**<.001**
LSS	KR6	75	86	85.88	**<.001**
	KR9	75	87	97.99	**<.001**
	KR10	82	87	9.21	**0.003**
RBT	KR6	85	89	5.72	**0.02**
	KR9	89	91	2.21	0.14
	KR10	91	92	0.11	0.74

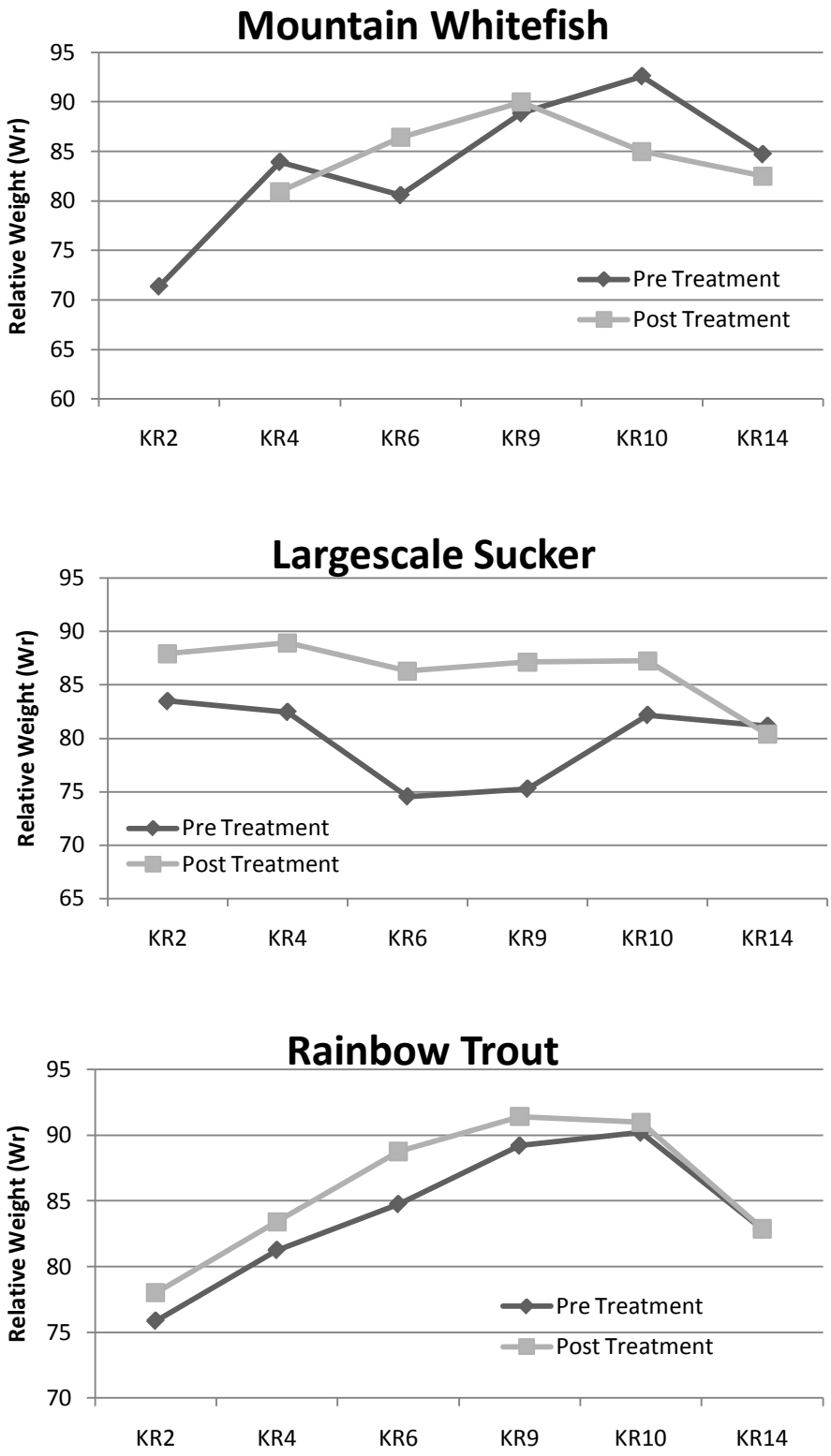


Figure 19. Average relative weight by species for pre- versus post-treatment years by sampling site.

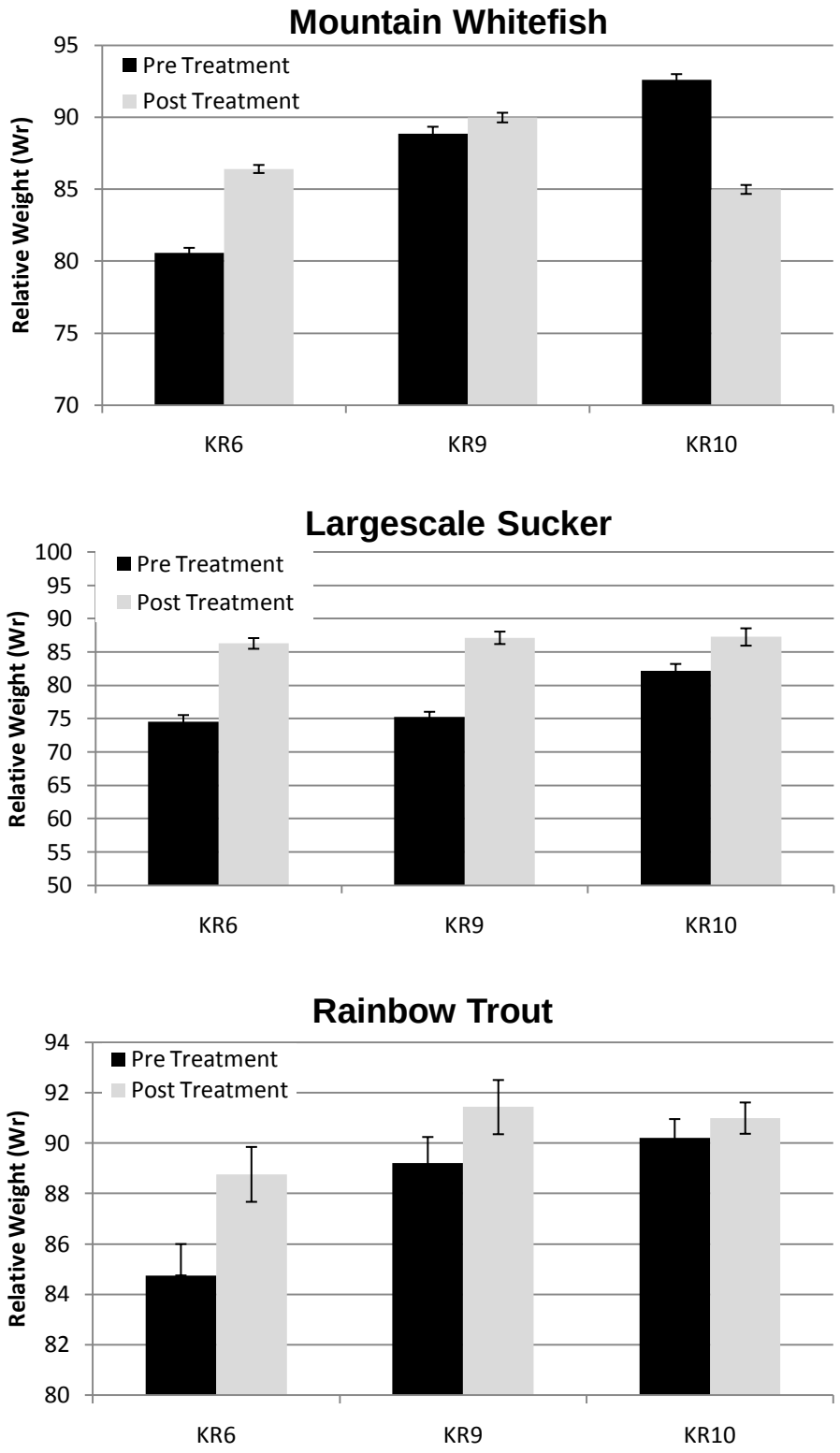


Figure 20. Average relative weight of mountain whitefish, largescale sucker, and rainbow trout at treatment reach sites and control site. Error bars show standard error.

Table 14. Mean relative weight (Wr) for mountain whitefish by age class for treatment reach sites KR6 and KR9 and control site KR10 for pre- and post-nutrient addition.

		KR6		KR9		KR10	
	Length (mm)	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Age-0	<200	80	89	85	96	87	87
Age-1	200-240	78	87	84	94	87	85
Age-2	240-270	82	86	90	92	92	87
Age-3	270-310	83	84	94	87	97	85
Age-4	310-324	82	76	91	81	94	78
Age-4+	325+	77	78	85	76	93	80

The overall ANOVA model did not show a significant change in condition factor (K) from pre- to post-treatment for mountain whitefish (F = 0.01, *P* = 0..91), whereas rainbow trout (F = 9.53, *P* = 0.0025) and largescale sucker (F = 54.77, *P* <.001) showed significant increases (Appendix F). For mountain whitefish the effect of site on K was significant (F = 39.50, *P* <.001), as was the interaction of treatment and site (F = 2.83, *P* = 0.02; Appendix H). The individual contrast for control site KR14 vs. KR6 and KR9 was significant (F = 11.62, *P* <0.001). For individual sites, mountain whitefish K increased at KR2 and KR4 as well as the treatment reach and decreased at both control sites (Table 15 and Figure 21). Increases at KR2 and KR4 were negligible.

For largescale sucker the effect of site on K was significant (F = 3.87, *P* =<0.001), as was the interaction of treatment and site (F = 5.59, *P* <.001; Appendix H). The individual contrast for control site KR10 vs. KR6 and KR9 was significant (F = 8.43, *P* <0.001). Largescale sucker K increased dramatically at KR2, KR4, and the treatment reach with smaller increases in the two control sites (Figure 21).

Similarly, rainbow trout K increased at all sites with the largest increases in the treatment reach (Figure 21). The effect of site on K was significant (F = 15.79, *P* <.001) whereas the interaction of treatment and site was not significant (F = 1.10, P = 0.37; Appendix H). The individual contrast KR14 vs. KR6 and KR9 was significant (F = 9.46, *P* = 0.002) and KR10 vs. KR6 and KR9 was marginally not significant (F = 3.47, P = 0.06)

Condition factor for the treatment reach showed some significant increases for mountain whitefish, largescale sucker, and rainbow trout (Table 16). Mountain whitefish condition increased signficantly at site KR6 and remained about the same at KR9 (Figure 22). The control site KR10 saw a decrease in condition. Largescale sucker condition increased signficantly at both treatments sites and only increased slightly at KR10. Similarly, rainbow trout condition increased signficantly at both treatment sites and slighly increased at KR10. Post-treatment values for this species are now at or very near an optimal value of 1.

Table 15. Mean condition factor at all sites and summary statistics. Significant p-values are bold.

	Mean Condition Factor			
Species	**Pre**	**Post**	**F**	**P-Value**
MWF	0.82	0.82	0.01	0.91
LSS	0.91	0.98	54.77	**<.001**
RBT	0.89	0.93	9.53	**0.003**

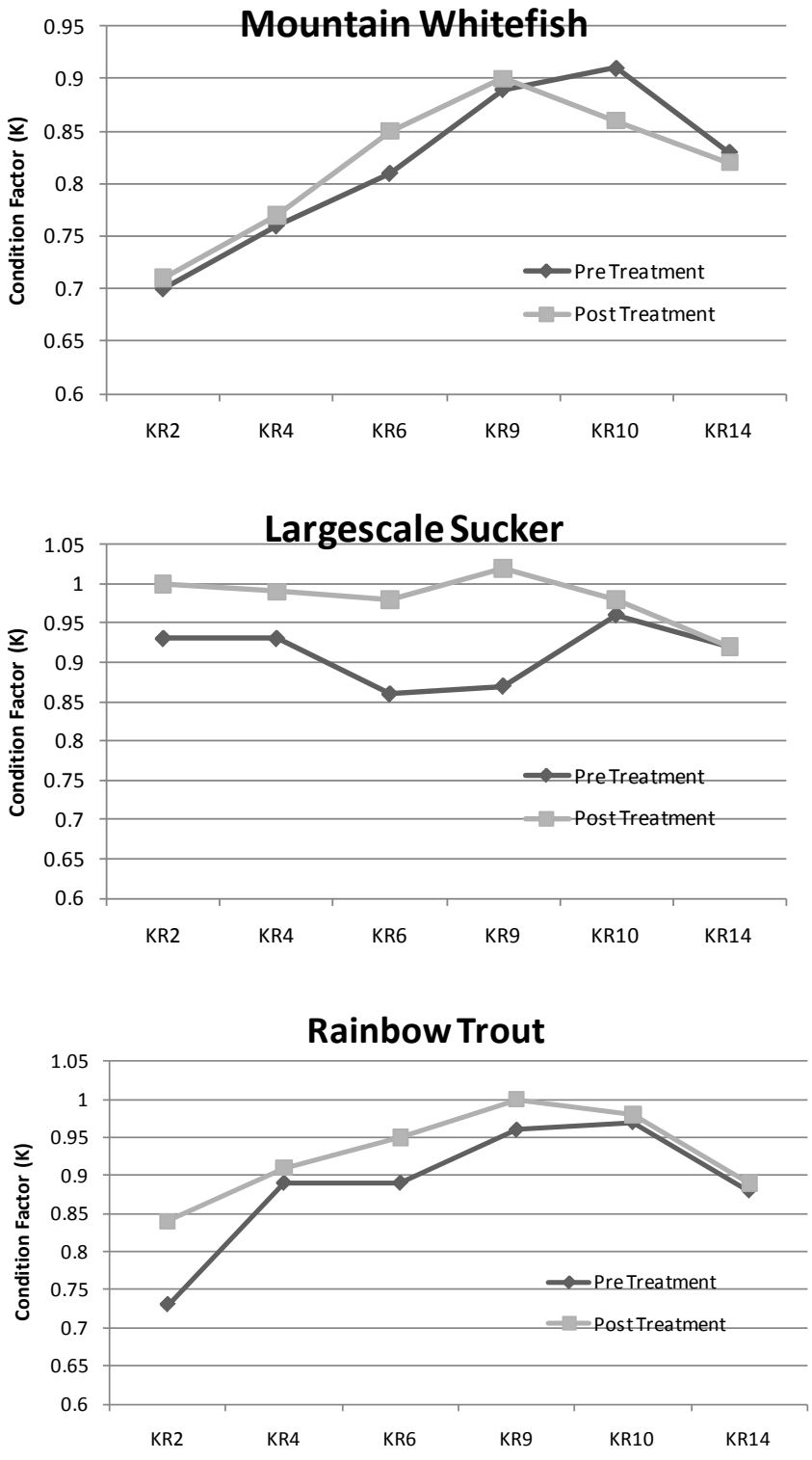


Figure 21. Average condition factor by species for pre- versus post-treatment years by sampling site.

Table 16. Mean condition factor pre- versus post-treatment for sites in the treatment reach and associated control site and summary statistics. Significant p-values are bold.

		Mean Condition Factor			
	Site	**Pre**	**Post**	**F**	**P-Value**
MWF	KR6	0.81	0.85	4.14	**0.05**
	KR9	0.89	0.90	0.40	0.53
	KR10	0.91	0.86	20.99	**<.001**
LSS	KR6	0.86	0.98	40.77	**<.001**
	KR9	0.87	1.02	67.74	**<.001**
	KR10	0.96	0.98	0.36	0.55
RBT	KR6	0.89	0.97	17.09	**<0.001**
	KR9	0.96	1.00	6.45	**0.01**
	KR10	0.97	0.98	0.59	0.45

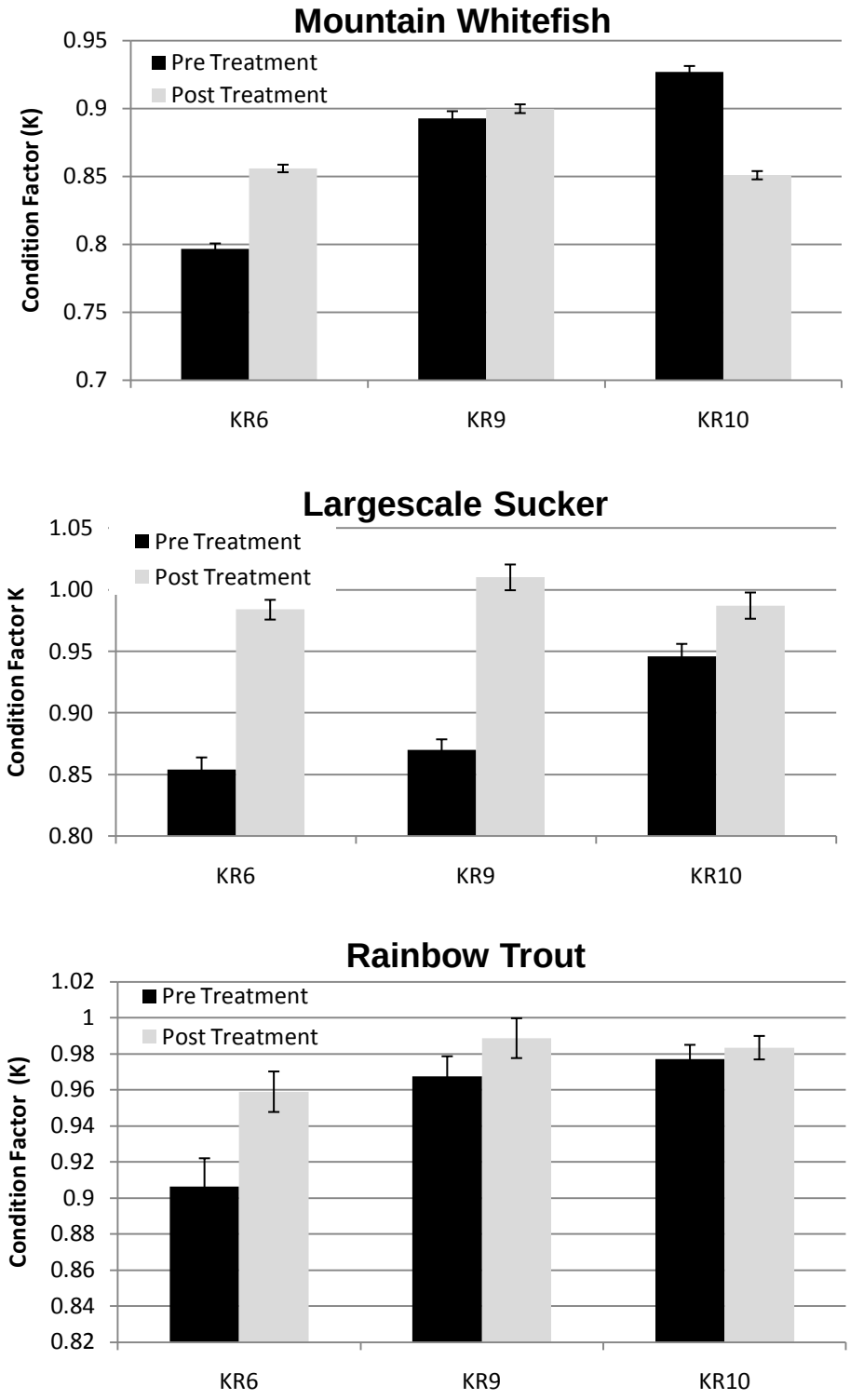


Figure 22. Average condition factor for mountain whitefish, largescale suckers, and rainbow trout at treatment reach sites and control site. Error bars show standard error.

Age and Growth

Mountain Whitefish

We collected a total of 1,509 scales from mountain whitefish to evaluate length at age and growth pre- and post-nutrient addition (Table 17). Numbers of mountain whitefish available for sites KR2 and KR4 were low and did not provide enough information to draw conclusions. In addition, age-0 fish were not readily captured and not included for individual sites as the sample size was small and. In the treatment reach, all lengths at age increased with an average increase of 10 mm for fish ages 1-4 (Figure 23 and Table 18). Length at age for age-1 (F = 11.19, *P* = 0.001) and age-4 (F = 10.94, *P* = 0.001) fish was significantly higher in post treatment at sites KR6 and KR9 (Table 19). The same increase was evident at control site KR10 with a significant increase in length at age for age-1 (F = 191.62, *P* <.001) and a marginally significant increase for age-4 (F = 3.5, *P* = 0.07) fish.

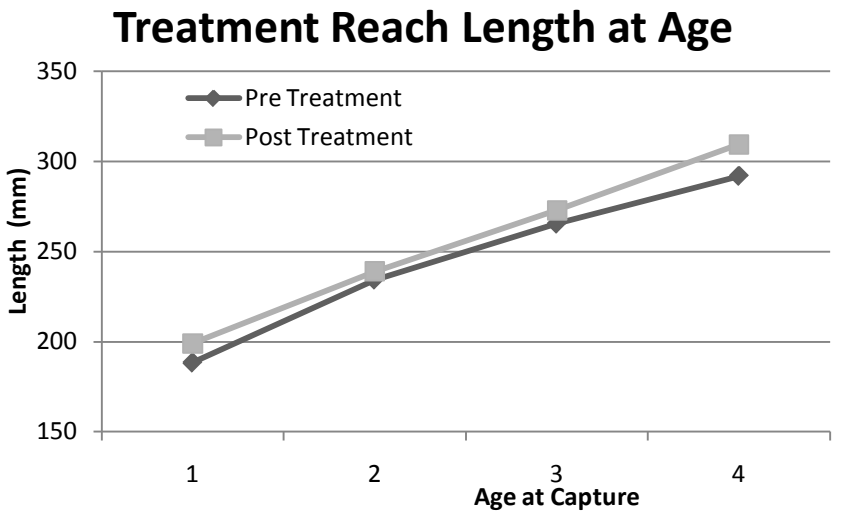
Table 17. Number of individual fish by species and site aged using scales from 2002-2007. Control sites are shaded.

	Number of fish	
	Mountain Whitefish	**Rainbow Trout**
KR2	12	13
KR4	85	24
KR6	436	62
KR9	308	120
KR10	437	216
KR14	223	7
Total	**1,501**	**442**

Table 18. Mountain whitefish length at age by site for pre- and post-treatment years.

		Length (mm) at Age				
Site	**Year**	**0**	**1**	**2**	**3**	**4**
KR6	Pre	109	187	236	268	289
	Post	113	197	237	274	307
KR9	Pre	133	190	233	263	295
	Post	114	201	241	272	312
KR10	Pre	115	203	241	269	304
	Post	115	187	236	279	316

		Length (mm) at Age				
	Year	**0**	**1**	**2**	**3**	**4**
KR2	Pre	102				
	Post	112				
KR4	Pre	109	173	200	173	
	Post	111	170	200	256	
KR14	Pre	88	165	200	243	279
	Post	112	152	182	242	268



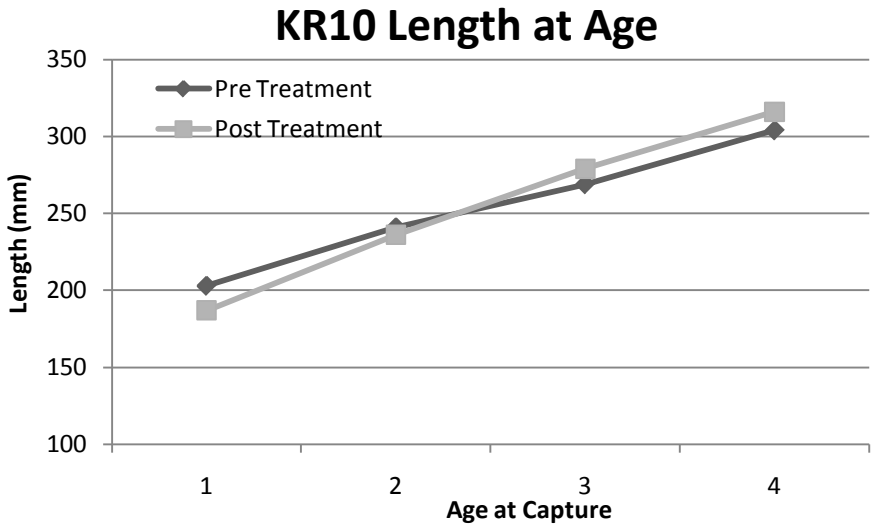


Figure 23. Length at age at time of capture for mountain whitefish in the treatment reach (KR6 and KR9) and at the control site KR10, for pre- and post-treatment years.

Table 19. Results of ANOVA comparing length at age at time of capture for mountain whitefish pre- versus post-treatment at treatment reach sites KR6 and KR9, control site KR10 and a composite of KR6 and KR9. Significant p-values are bold.

		Age at Capture				
Site		**0**	**1**	**2**	**3**	**4**
KR6	**F**	0.61	6.23	0.05	0.95	5.38
	***P*-value**	0.44	**0.01**	0.82	0.334	**0.03**
KR9	**F**	3.78	4.31	2.23	2.83	4.43
	***P*-value**	0.06	**0.04**	0.14	0.10	**0.04**
KR10	**F**	0.02	191.62	1.7	3.08	3.5
	***P*-value**	0.90	**<.001**	0.20	0.08	**0.07**
KR6 and KR9	**F**	0.38	11.19	1.01	3.15	10.94
	***P*-value**	0.54	**0.001**	0.32	0.08	**0.001**

Rainbow Trout—We aged a total of 442 rainbow trout scales (Table 17). Age-0 fish were not readily captured and were not included for individual sites as the sample size was small. Rainbow trout length at age and growth did not show a consistent trend among age groups. Numbers of scales from fish available for sites KR2, KR4, and KR14 were low and therefore did not provide enough information to draw conclusions. In addition, age-0 fish were not included for individual sites as the sample size was small and these fish are not readily captured. Length at age-1 increased at both treatment sites and at KR10 but decreased for age-2, age-3, and age-4 fish (Table 20 and Figure 24). The increase for treatment reach sites was significant (F = 7.71, *P* = 0.0077).

Table 20. Rainbow trout length at age by site for pre- and post-treatment years.

		Length (mm) at Age			
Site	**Year**	**1**	**2**	**3**	**4**
KR6	Pre	186	242	321	
	Post	210	228	336	
KR9	Pre	189	269	322	451
	Post	214	248	298	399
KR10	Pre	188	242	285	347
	Post	199	234	296	327

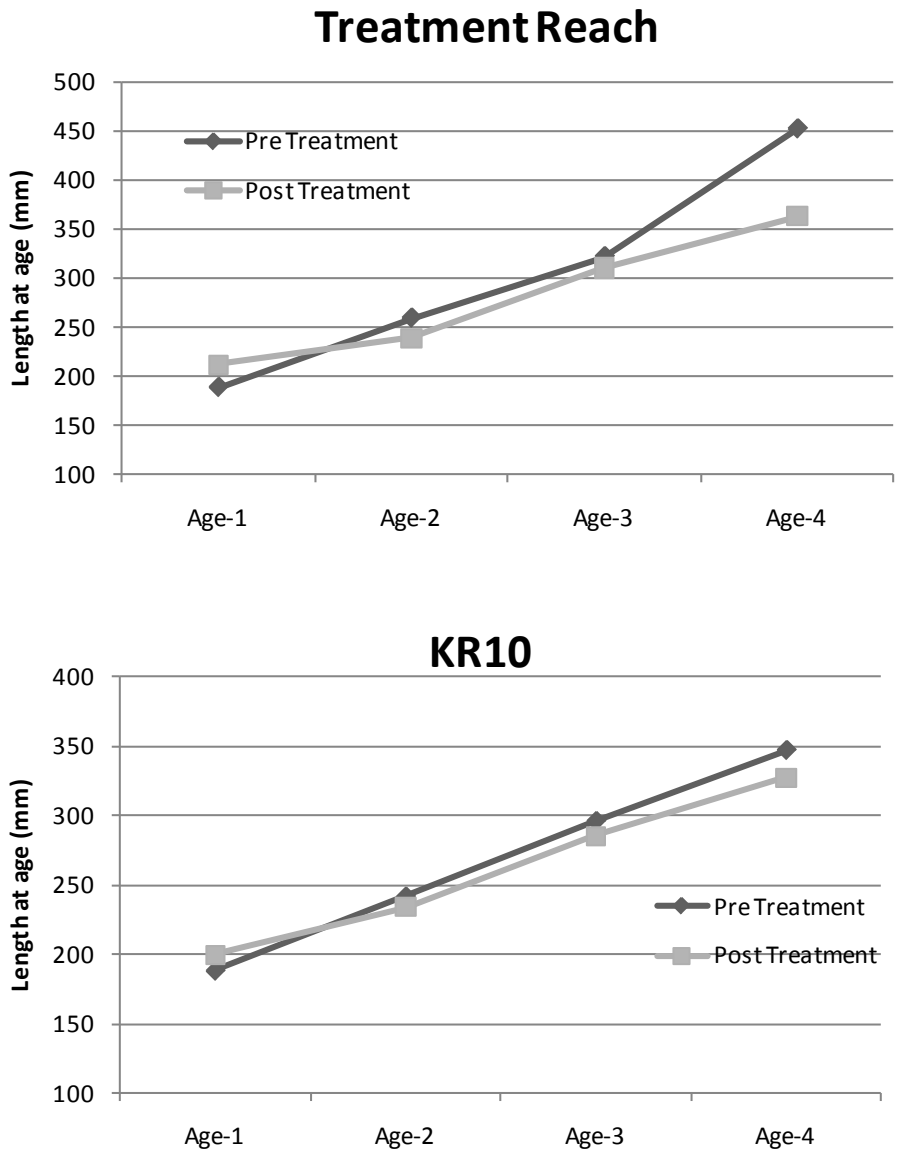


Figure 24. Length at age at time of capture for rainbow trout in the treatment reach (KR6 and KR9) and at the control site KR10, for pre- and post-treatment years.

Mountain whitefish length was significantly correlated with age (r = 0.89). As a result of this correlation, we were able to use length as a proxy for age. Three distinct categories, young of year (YOY), 1-2-year-old juveniles, and 3+-year-old adults, were examined for pre- and post-nutrient addition years. When comparing the length frequencies using a mixture model, we detected a shift to the right (increased length) post-nutrient addition (Figure 25). We found significant increases in mean lengths for YOY (F = 14.18, P = 0.0002) and juveniles (F = 25.52, P <0.0001), post-nutrient addition.

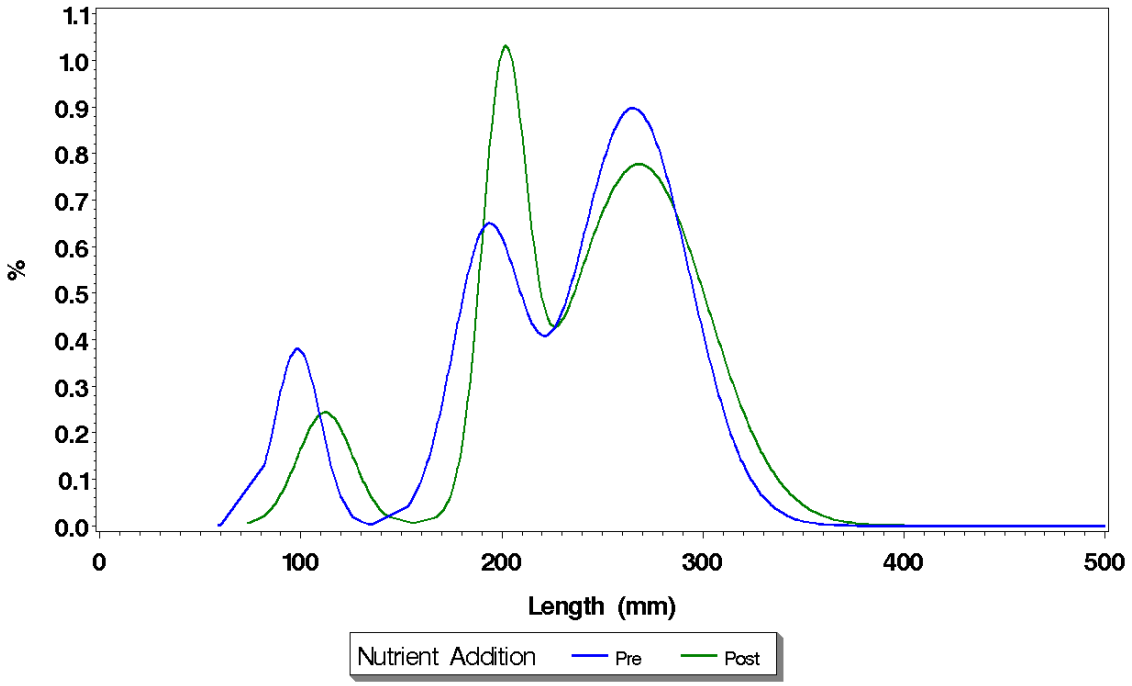


Figure 25. Results from the mixture model mountain whitefish length analysis for pre- versus post-treatment years.

Sportfishing Effort and Harvest

We conducted a total of 172 angler interviews during the 2005-2006 creel survey. Estimated fishing pressure for the creel year was 4,374 h (95% CI = ±473 h) for section 1 and 4,147 h (95% CI = ±355 h) for section 2, for a total of 8,521 h (95% CI = ±413 h). The proportion of anglers fishing from boat and shore were 65% and 35%, respectively. Overall, 79% of anglers fished with bait, 11% with lures, and 6% with fly-fishing gear, while 4% used a combination of gear types. Peamouth was the most common species harvested in the creel 158 fish (95% CI = ±85) for both river sections combined, followed by northern pikeminnow with a harvest of 154 fish (95% CI = ±2) and mountain whitefish with a harvest of 142 (95% CI = ±24). An estimated 70 (95% CI = ±8) rainbow trout were harvested, while 3,249 (95% CI = ±257) were released. The catch composition by species as a percentage of total catch was as follows: rainbow trout 46%, northern pikeminnow 15%, sucker *Catostomus,* 15%, mountain whitefish 14%, peamouth 7%, westslope cutthroat trout *Oncorhynchus clarkii lewisi* 2%, bull trout 1%, largemouth bass *Micropterus salmoides* 1%, rainbow x cutthroat trout hybrid 0.4%, and Kootenai River white sturgeon 0.2%. Catch rates were 0.37 rainbow trout/h, 0.12 northern pikeminnow/h, 0.11 sucker species/h, 0.11 mountain whitefish/h, 0.05 peamouth/h, and 0.01 westslope cutthroat/h for both river sections combined. Mean lengths and weights of fish measured in the creel are given in Table 21.

Table 21. Species composition for fish captured during the 2005-06 creel survey on the Kootenai River, Idaho.

	Largemouth bass	Mountain whitefish	Northern pikeminnow	Peamouth chub	Rainbow trout
Total length (mm)					
n	1	3	3	10	2
Mean	235	327	435	246	452
Standard error		31	130	6	17
Minimum		280	210	201	435
Maximum		385	660	265	469
Weight (g)					
n	1	3	3	10	2
Mean	187	254	1232	115	748
Standard error		65	811	10	183
Minimum		180	65	55	565
Maximum		383	2790	146	930

DISCUSSION

Microinvertebrate

Few studies on zooplankton and rotifer communities of the Kootenai River were conducted prior to 2002. Paragamian (1995) and Richards (1998) found zooplankton levels below Libby Dam between 0.1 and 3 individuals/L, seasonally. In 2007, zooplankton densities averaged between 2.4-65 individuals/L, seasonally. Throughout the course of this study, densities of zooplankton have been closely related to flows. It is presumed that the densities and community structure are a result of drift from Lake Koocanusa. Plankton in large river systems originates from backwater sloughs, side channels, or floodplains (Hynes 1970) and abundance in these areas is typically much higher than in the main river (Vranovsky 1974; Saunders and Lewis 1988). In impounded systems like the Kootenai River, zooplankton are a result of drift both from the reservoir itself and from fluctuations in flows flushing backwaters and littoral areas (Welcomme 1985).

After a flood event on the Kootenai River in the spring of 2006, microinvertebrate abundance increased and diversity remained high relative to the previous study years. However, diversity then fell sharply during the 2007 sampling year, to the lowest levels since the study began in 2002. Flooding has been shown to produce temporary increases in abundance and diversity of microinvertebrates. For example, in the Caura River, Venezuela, when the river rose and inundated the floodplain, densities of zooplankton increased sharply (Saunders and Lewis 1988). Similarly, in response to artificial flooding of the Colorado River, total zooplankton density increased significantly, largely due to increased copepod and nauplii populations (Speas 2000). As seen in the Kootenai River, species richness declined after flooding on the Colorado River. Fourteen taxa present in the Colorado River samples prior to flooding were absent from post-flood samples and largely represented littoral species found in backwaters (Speas 2000). In the Kootenai River, the initial increase in abundance was likely a result of zooplankton drift from both the reservoir and backwaters and floodplain areas. After this initial increase, continued high abundance was probably a result of intensive recolonization by fewer species.

As a result of the correlation between flows and zooplankton abundance and diversity, we discontinued sampling in 2008. We found no evidence that nutrient additions affected zooplankton either positively or adversely.

Fish Community Assessment

Fish community species composition at individual sites showed little change from pretreatment to post-treatment years. There are many examples in the literature of changes in the ecosystem producing a shift in the fish assemblage. Paragamian (2002) showed a shift in species composition in the Hemlock Bar reach of the Kootenai River associated with Libby Dam. The dominant fish species in the early 1980s (assumed to be similar to pre-dam conditions due to latent effects of the dam) was whitefish (70%) with fewer largescale sucker (19%; Partridge 1983). By the early 1990s, species composition shifted to a largescale sucker dominated population. This shift was thought to be food-driven with the generalist, omnivorous species largescale sucker able to better take advantage of limited food than the specialist, insectivore mountain whitefish (Simpson and Wallace 1982, Li et al. 1987). We have seen a broader shift similar to the one described by Paragamian (2002), back to a fish assemblage dominated by mountain whitefish. Although we did not see a shift during our study period, it appears that the fish assemblage has changed since the 1990s. We may likely continue to see these broader shifts over long periods (multigenerational) of time.

Not surprisingly, we saw among site differences in fish. The distinct reaches of the river (meander, braided, and canyon) provide habitats that vary in their suitability to various fish species. For example, in the lower sites KR2 and KR4, the fish assemblage is dominated by northern pikeminnow, peamouth chub, and redside shiner, species that are better adapted to low flow velocities, fine substrates, and aquatic vegetation. Mountain whitefish and rainbow trout are more predominant at sites in the braided and canyon reaches (sites KR6 and KR9) where flow velocities are higher and the substrate is largely composed of cobble.

Abundance and Biomass

Although early in the response phase, increases in catch and biomass across the treatment reach point to the preliminary success of nutrient rehabilitation. The catch and biomass at treatment site KR6 nearly doubled during the post-treatment period and KR9 increased from a catch of 276 to 476 fish/h and a biomass of 70 to 105 kg/h. Abundance and biomass was higher in the braided and canyon reaches likely as a result of increased primary productivity and in turn food availability aided by nutrient addition. Primary productivity at sites below Bonners Ferry has not increased as readily as it has above town (C. Holderman, Kootenai Tribe of Idaho, personal communication).

Mountain whitefish, both the most abundant species in the Idaho portion of the Kootenai River and an important biological indicator species (McPhail and Troffe 1998), increased in terms of both catch and biomass at treatment reach sites, nearly doubling at KR6. This species has served an important role in determining the initial impact of nutrient additions. Several aspects of the species life history make it a good case study. Mountain whitefish in the Kootenai River reach maturity within 3-4 years so fish can respond fairly quickly to increased productivity. Food habits of mountain whitefish are not as specialized as those for rainbow trout so we expected to see the results of increased food availability in a shorter time period for whitefish than for trout. Primary production is thought to be the central foundation of bioenergetic development in the higher trophic levels (Vannote et al. 1980). It was proposed that increases in primary production through fertilization would stimulate fish production in the Kootenai River

from the bottom of the food web up (Snyder and Minshall 1996) and we have begun to see such results.

We saw similar increases in catch and biomass at the control site KR10 (Yaak site) as at sites within the treatment reach (KR6 and KR9). Site KR10 is located approximately 10 rkm upstream of the nutrient addition site. Due to this proximity, caution should be taken in using this site as a control because fish move. Rainbow trout and mountain whitefish are known to make substantial upstream spawning migrations into Montana and likely move readily back and forth through this portion of the river. It is not surprising then that we saw increases in catch and biomass at KR10 similar to those in KR6 and KR9, though of a lesser magnitude. In terms of the control site KR14, comparisons are often problematic because the site is quite different from the Idaho portion of the river. Substrate, water chemistry, the invertebrate population, and fish assembly are markedly different.

Increased catch and biomass at sites post-treatment can be attributed, in part, to an increase in available food. Reduced food abundance as a result of a reduction in insect densities post Libby Dam likely reduced fish numbers and produced substantial changes in the fish assemblage. Paragamian (1995) found lower standing stock proportions of mountain whitefish at the Hemlock Bar site than did Partridge (1983) during 1980-1981. During the same time period, insect densities decreased in the upper canyon section of the Kootenai River from 3,500 insects/m^2 in the early 1970s (prior to the dam's construction; Bonde and Bush 1975) to 900 insects/m^2 in the mid-1990s (Snyder and Minshall 1996). Current Kootenai River macroinvertebrate densities remain low compared to more productive systems such as the Salmon (38,000 insects/m^2) and Coeur d'Alene rivers (63,000 insects/m^2; Royer and Minshall 1997), though they have already rebounded to pre-dam numbers in the canyon reach (4,500 insects/m^2). In addition to a reduction in density of invertebrates, species composition in the Kootenai River also changed, namely with a reduction in the numbers of Plecoptera and Trichoptera (Hauer and Stanford 1997). These reduced numbers equate to reduced food abundance for insectivores like rainbow trout and mountain whitefish that may feed on insects in the water column (Brown 1971; Wydoski and Whitney 1979; Simpson and Wallace 1982; Baxter and Stone 1995). Abundance and biomass of invertebrate species of Ephemeroptera, Plecoptera, and Trichoptera have increased substantially (C. Holderman, Kootenai Tribe of Idaho, personal communication).

Population Estimate

Fish population estimates for mountain whitefish have rebounded to levels seen in 1980-81 for the 3 km reach of river near Hemlock Bar. Partridge (1983) reported a population of 14,000-16,000 mountain whitefish in the reach. Population estimates from 1993-94 and 1998-99 showed a two- to four-fold decrease in mountain whitefish numbers compared with Partridge (Paragamian 1995; Downs 2000).

Population estimates for rainbow trout have also increased substantially in the Hemlock Bar reach of the river. Partridge (1983) reported capturing six rainbow trout in 1980 and 34 in 1981 in the Hemlock Bar reach. Similarly, Paragamian (1995) reported capturing 27 rainbow trout and estimated a population of 98 fish in the 3 km reach. The increase in the population of rainbow trout is likely a result of both a change in fishing regulations implemented in 2002 (2 fish limit, none under 16") and the addition of nutrients prompting an increase in food availability. The increase in rainbow trout numbers has occurred largely in fish in the 201-305 mm, which may indicate increased recruitment or survival in response to the harvest length limit. Very few

fish larger than 406 mm have been captured during sampling efforts. We anticipate an increase in larger rainbow trout as recruitment and food availability continue to increase.

Relative Weight and Condition Factor

Since sampling efforts began in 2002, relative weight and condition factor for mountain whitefish and largescale suckers have increased. Improvements have been more pronounced in largescale suckers as a result of their food habits. Suckers are benthic feeders consuming periphyton, zooplankton, invertebrates, detritus, and plant material. A study on the Columbia River found that all age classes of largescale sucker consumed primarily periphyton (Dauble 1986). Since nutrient additions began in 2005, we have seen increases in the amount of periphyton on rocks and substrate in the river and levels of chlorophyll a have increased significantly (C. Holderman, Kootenai Tribe of Idaho, personal communication). Suckers are able to take advantage of increased primary productivity more rapidly than mountain whitefish. Although both Wr and K of mountain whitefish have increased post nutrient restoration, values began to decline in 2007. This decline occurred primarily in age-3+ fish. Younger age classes continue to increase in length at age. Low Wr may result from increased density and competition for limited food resources (Blackwell et al. 2000).

Age and Growth

Growth post nutrient treatment for mountain whitefish is similar to that reported in 1980 and 1981 (Partridge 1983; Figure 26). Length at ages 2-4 is nearly identical to those reported by Partridge. Length at age for 1980-1981 and post nutrient was significantly higher than growth reported in 1994 (Paragamian 2002).

In comparison with other mountain whitefish populations in the state, fish in the Kootenai River exhibit length at age-1 on the lower end of other Idaho systems (S. Elle, Idaho Department of Fish and Game, personal communication; Figure 27). We have seen a shift to increased length at age in post-nutrient addition years for lengths correlated to age-0 and age-1 fish, which may indicate improved habitat conditions post-nutrient rehabilitation. However, Kootenai River growth begins to diverge markedly from these other populations by age-3, remaining lower for ages 3-8. However, because fish growth rate is strongly influenced by size, the possible positive influence of nutrients on older size classes may yet appear.

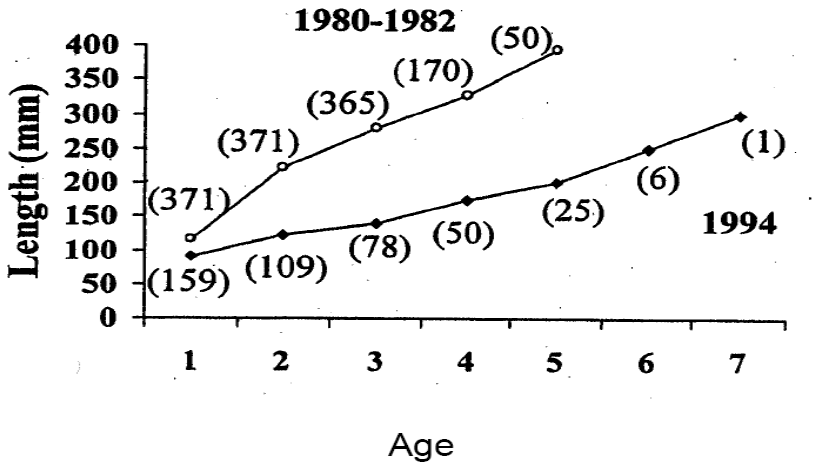


Figure 26. Back calculated length at age of mountain whitefish in the Kootenai River, Idaho, from the Hemlock Bar reach. Samples are from 1980-1982 and 1993-1994; sample sizes by age are subtended (from Paragamian 2002).

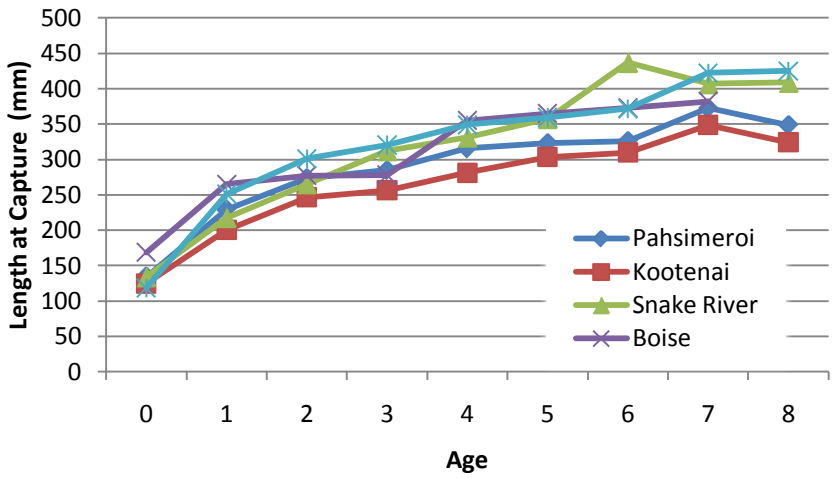


Figure 27. Length at age at time of capture for mountain whitefish for populations throughout Idaho.

Increased growth of juvenile mountain whitefish (age-0 and age-1) post nutrient addition shows a response to increased availability of food. These fish feed primarily on aquatic insect larvae and smaller insects such as chironomids. McPhail and Troffe (1998) found that juvenile diets in the Fraser River were comprised of over 50% chironomids. Adults consumed significantly less chironomids and consumed more mayflies and other larger insects. Adults are able to move more readily to seek out food and adjust to seasonal shifts in prey abundance. Juvenile fish also showed more pronounced increases in Wr in the treatment reach (Figure 28). Age-0 and age-1 fish showed large increases in Wr, whereas age-2 fish showed a slight increase and age-3+ fish actually showed some decline in Wr, post-nutrient addition in the

treatment reach. As fish densities have increased post-nutrient rehabilitation, it will be important to monitor growth and condition to evaluate any possible effects of density, although density-dependent declines in growth for salmonids in lotic systems has rarely been observed (Elliot 1994). In addition, it will be important to monitor and analyze fish diet data that has been collected as well as to continue collecting stomach samples.

		KR6		KR9		KR10	
	Length (mm)	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Age-0	<200	80	89	85	96	87	87
Age-1	200-240	78	87	84	94	87	85
Age-2	240-270	82	86	90	92	92	87
Age-3	270-310	83	84	94	87	97	85
Age-4	310-324	82	76	91	81	94	78
Age-4+	325+	77	78	85	76	93	80

Figure 28. Relative weight (Wr) for treatment reach sites (KR6 and KR9) and control site (KR10) shown by age and corresponding length groups for pre- and post-treatment years.

Sportfishing Effort and Harvest

Increases in rainbow trout density after 2004 suggest positive responses to the change in fishing regulations initiated in 2002. Relative weight measurements have remained about the same since the regulations change. These patterns are compatible with the original objectives of the regulations change, which include improving the population with a reduction in exploitation), and improving the population size structure. Although rainbow trout numbers have increased substantially, estimates remain well below other systems including the Montana reach of the Kootenai. The density of rainbow trout in the Flower-Pipe reach of the Kootenai River, Montana was over 1,500 trout/km in 2007 (R. Sylvester, Montana Fish, Wildlife and Parks, personal communication), while the highest density recorded at the Hemlock Bar reach was 194 fish/km in 2008.

In 2006, the rainbow trout catch rate of 0.37 fish/h was the highest recorded for the Kootenai River in Idaho, with past catch rates ranging from 0.02 fish/h in 1993 to 0.20 fish/h in 2001 (Paragamian 1995; Walters 2003). Rainbow trout also made up the highest percentage of fish caught (46%), an increase compared to 2002 when rainbow trout made up only 12% of the catch (Hardy 2003) but similar to 2001 when rainbow trout made up 49% of the catch (Walters 2003). A creel survey will be initiated in 2010 to re-evaluate angling effort, total harvest, species composition of the catch, and catch and harvest rates, post treatment.

SUMMARY

We have met nearly all of the fisheries goals implemented at the beginning of this project. We have attained a measurable increase in rainbow trout densities to 194 fish/km in the Hemlock Bar reach of the Kootenai River. We have also increased angler catch rates of rainbow

trout to 0.37 fish/h, higher than our preferable minimum catch rate goal but still well below our final target of ≥0.67 fish/h. With the increased population estimate in 2008, we anticipate that catch rates will be higher during our 2010 creel survey. We have increased the population of mountain whitefish in the Hemlock Bar reach two-fold from 2004 to 2008 to 17,644 fish. The estimate is similar to that reported by Partridge (1983), which was considered 'pre-dam' conditions. We have attained some increases in relative weight for both rainbow trout and mountain whitefish, though we have not reached the goals set at the outset of this project. We will continue to monitor these populations.

RECOMMENDATIONS

1. Continue nutrient addition of ammonium polyphosphate (10-34-0) and ammonium nitrate (32-0-0) to the Kootenai River.

2. Conduct population estimates in the Hemlock Bar reach of the river every year.

3. Continue fall electrofishing at biomonitoring sites.

4. Initiate a creel survey in 2010 to estimate angling effort, total harvest, species composition of the catch, and catch and harvest rates.

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LITERATURE CITED

Anderson, R. O. 1976. Management of small warm water impoundments. Fisheries 1(6):5-7, 26-28.

Anderson, R. O., and R. M. Neumann. 1996. Length, weight, and associated structural indices. *In*: Fisheries Techniques. (Nielson, L. A., and D. L. Johnson, Eds.). pp. 283-300. American Fisheries Society, Bethesda, Maryland.

Ashley, K., L. Thompson, D. Sebastian, D. Lasenby, K. Smokorowski, and H. Andrusak. 1999. Restoration of kokanee salmon in Kootenay Lake, a large intermontane lake, by controlled seasonal addition of limiting nutrients. *In:* Aquatic Restoration in Canada. T. Murphy and M. Munawar, eds. Ecovision World Monograph Series. Backhuys Publishers, Leiden, The Netherlands.

Ashley, K. I., and J. G. Stockner. 2003. Protocol for applying limiting nutrients to inland waters. Pages 245-258 *in* J. Stockner, editor, Nutrients in Salmonid Ecosystems: Sustaining Production and Biodiversity. American Fisheries Society Symposium 34. American Fisheries Society, Bethesda, Maryland.

Baxter, G. T., and M. D. Stone. 1995. Fishes of Wyoming. Wyoming Game and Fish Department, Cheyenne.

Blackwell, B. G., M. Brown, and D. Willis. 2000. Relative weight (Wr) status and current use in fisheries assessment and management. Reviews in Fisheries Science 8:1-44.

Bolger, T., and, P. L. Connolly. 1989. The selection of suitable indices for the measurement and analysis of fish condition. Journal of Fish Biology 34:171-182.

Bonde, T. J., and R. M. Bush. 1975. Limnological investigations: Lake Koocanusa, Montana. Part one: Pre-impoundment Study, 1967-1972. U.S. Army Corps of Engineers, Special Report 82-21.

Brown, C. J. D. 1971. Fishes of Montana. Big Sky Books, Montana State University, Bozeman.

Dauble, D. 1986. Life history and ecology of the largescale sucker (*Catostomus macrocheilus*) in the Columbia River. American Midland Naturalist 116:356-367

Devries, D. R., and R. V. Frie. 1996. Determination of age and growth *In:* Fisheries Techniques, Second Edition (Murphy, B. R., and D. W. Willis Eds.). pp. 483-512. American Fisheries Society, Bethesda, Maryland.

Downs, C. C. 2000. Kootenai River fisheries investigations: Rainbow trout recruitment. 1998 Annual report to Bonneville Power Administration. Project 88-65. Idaho Department of Fish and Game, Boise.

Elliot, J.M. 1994. Quantitative ecology and the brown trout. Oxford University Press. 288 pages.

Gabelhouse, D. W. 1984. A length-categorization system to assess fish stocks. North American Journal of Fisheries Management 4:27-285.

Hardy, R. S. 2003. Kootenai River Fisheries Investigations: Ecosystem Rehabilitation. 2002 Project Progress Report. Idaho Department of Fish and Game. Boise.

Hauer, F. R., and J. A. Stanford. 1997. Long-term influence of Libby Dam operation on ecology of macrozoobenthos of the Kootenai River, Montana and Idaho. Report to Montana Department of Fish, Wildlife and Parks, Helena.

Higgins, J. J. 2004. Introduction to Modern Nonparametric Statistics. Duxbury Press: Belmont, California; 366.

Hynes, H. B. N. 1970. The ecology of running waters. Pp 95-289. University of Toronto Press. Toronto, Ontario, Canada.

Krebs, C. J. 1999. Ecological methodology, second edition. Addison Wesley. Menlo Park, California.

Li, H. W., C. E. Shreck, C. E. Bond, and E. Rexstad. 1987. Factors influencing changes in fish assemblages of Pacific Northwest streams. Pages 193-202, *In:* Mathews, W. J,. and D. C. Heins, Eds. Community and Evolutionary Ecology of North American Stream Fishes, University of Oklahoma Press, Norman and London.

McArthur, T. 1992. Statewide angler opinion and harvest surveys, creel census system. Idaho Department of Fish and Game Job Completion Report, Project No. F71-R-14, Subproject I, Study I, Boise.

McGurk, M. D. 1985. Effects of net capture on the postpreservation morphometry, dry weight, and condition factor of Pacific herring larvae. Transactions of the American Fisheries Society 114:348-355.

McPhail, J. D., and P. M Troffe. 1998. The Mountain whitefish (*Prosopium williamsoni*): a potential indicator species for the Fraser system. Prepared for: Environment Canada DOEFRAP 1998-16.

Paragamian, V. L. 2002. Changes in the species composition of the fish community in a reach of the Kootenai River, Idaho after construction of Libby Dam. Journal of Freshwater Ecology 17:375-383.

Paragamian, V. L. 1995. Kootenai River fisheries investigation: Stock status of burbot and rainbow trout and fisheries inventory. Idaho Department of Fish and Game, 1994 Annual Report to Bonneville Power Administration, Project 88-65, Boise.

Paragamian, V. L. 1990. Fish populations of Iowa rivers and streams. Technical Bulletin Number 3. Iowa Department of Natural Resources, Des Moines.

Partridge, F. 1983. Kootenai River Fisheries Investigations. Idaho Department of Fish and Game Completion Report, Boise.

Peterson, B. J., L. Deegan, J. Helfrich, J. E. Hobbie, M. Hullar, B. Moller, T. E. Ford, A. Hershey, A. Hiltner, G. Kipphut, M. A. Lock, D. M. Fiebig, V. McKinley, M. C. Miller, J. R. Vestal, R. Ventullo, and G. Volk. 1993. Biological responses of a tundra river to fertilization. Ecology 74:653–672.

Richards, D., 1998. Kootenai River macro invertebrate study report. U.S. Department of Energy, Bonneville Power Administration, Environment, Fish and Wildlife, Portland, Oregon.

Richter, T. J. 2007. Development and evaluation of standard weight equations for bridgelip suckers and largescale suckers. North American Journal of Fisheries Management 27:936-939.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada, Bulletin 191, Ottawa.

Rodgers, J. L., and W. A. Nicewander. 1988. Thirteen ways to look at the correlation coefficient. The American Statistician 42(1):59–66.

Rogers, K. B., L. C. Bergstedt, and E. P. Bergersen. 1996. Standard weight equation for mountain whitefish. North American Journal of Fisheries Management 16:207-209.

Royer, T. V., and G. W. Minshall. 1997. Development of an index for bioassessment of medium-sized rivers in Idaho and potential uses of ecosystem function in biomonitoring. Draft. Department of Biological Sciences, Idaho State University, Pocatello.

SAS Institute. 2002. Version 9.1. SAS Institute Inc. Cary, North Carolina.

Saunders, J. F., and, W. M. Lewis. 1988. Zooplankton Abundance in the Lower Orinoco River, Venezuela. Limnology and Oceanography 34:397-409.

Schill, D. J. 1991. Wild trout investigations. Idaho Department of Fish and Game. Job Performance Report. Project F-73-R-13, Job 1. Boise.

Seber, G. A. 1982. The estimation of animal abundance, 2nd edition. Griffin. London.

Simpkins, D. G., and W. A. Hubert. 1996. Proposed revision of the standard-weight equation for rainbow trout. Journal of Freshwater Ecology 11:319-325.

Simpson, J., and R. Wallace. 1982. Fishes of Idaho. The University Press of Idaho, Moscow.

Smith, E. P. 2002. BACI Design *In:* Encyclopedia of Environmetrics (El-Shaarawi, A. H., and W. W. Piegorsch Eds.). pp 141-148. John Wiley and Sons, Chichester, England.

Snyder, E. B., and G. W. Minshall. 1996. Ecosystem metabolism and nutrient dynamics in the Kootenai River in relation to impoundment and flow enhancement for fisheries management. Final Report. Stream Ecology Center, Idaho State University, Pocatello.

Speas, D. W. 2000. Zooplankton density and community composition following an experimental flood in the Colorado River, Grand Canyon, Arizona Regulated Rivers: Research & Management 16:73–81.

SYSTAT. 1997. Version 7.0. SYSTAT Inc. Evanston, Illinois.

Vannote, R. L., G. W. Minshall, and K. W. Cummins. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Science 37:130-137.

Vranovsky, M., 1974. Zur kenntnis der verteilung, biomasse und drift des zoolplanktons im tchechoslowakisch-ungarischen Donau-abschnitt. Archiv für Hydrobiologie, Suppl. 44 (3):360–3.

Walters, J. P. 2002. Kootenai River fisheries investigations: rainbow and bull trout recruitment. Annual progress report to Bonneville Power Administration, April 1, 2000—March 31, 2001. Project 1988-06500. Idaho Department of Fish and Game, Boise.

Walters, J. P. 2003. Kootenai River fisheries investigations: rainbow and bull trout recruitment. Annual progress report to Bonneville Power Administration, April 1, 2001-March 31, 2002. Project 1988-06500. Idaho Department of Fish and Game, Boise.

Welcomme, R. L. 1985. River fisheries. FAO Fisheries Technical Paper. 262.

Woods, P. F. 1982. Annual nutrient loadings, primary productivity, and trophic state of Lake Koocanusa, Montana and British Columbia, 1972-80. Geological Survey Professional Paper 1283, United States Government Printing Office.

Wydoski, R. S., and R. R. Whitney. 1979. Inland fishes of Washington. University of Washington Press, Seattle.

APPENDICES

Appendix A. Microinvertebrate presence by species and year sampled on the Kootenai River, Idaho.

Crustacea Species	2002	2003	2004	2005	2006	2007
Alona costata	x	x	x	x	x	
Alona rustica		x	x	x	x	
Bosmina longirostris	x	x	x	x	x	x
Bryocamptus					x	x
Calanoida					x	
Calenoid copepodite	x	x	x	x		
Chydorus sphaericus	x	x	x	x	x	
Cyclopoida					x	
Cyclopoid copepodite	x	x	x	x		
Cyclops bicuspidatus thomasii	x	x	x	x	x	
Daphnia		x	x	x		
Daphnia thorata					x	
Daphnia galeata mendetae	x	x	x	x	x	
Diacyclops bicuspidatus thomasii				x		
Diacyclops thomasii				x		
Diaphanosoma brachyarum				x		
Harpacticoidea		x	x	x		
Harpacticoidea Bryocamptus spp.				x		
Leptodiapotmus tyrrelli	x	x	x	x	x	
Nauplii	x	x	x	x		x
Ostracoda		x	x	x		
TOTAL DIVERSITY	**9**	**13**	**13**	**17**	**11**	**3**

Rotifera Species	2002	2003	2004	2005	2006	2007
Ascomorpha ovalis	x	x	x	x	x	x
Asplonchna priodonta	x	x	x	x	x	x
Bdelloid rotifer		x	x	x		
Brachienus angularis	x	x	x	x	x	
Brachienus bidentata				x		
Brachienus caudatus	x	x	x	x	x	
Brachionus calycifloras	x	x	x	x	x	
Cephalodella gibba				x	x	
Cephalodella spp.	x	x	x	x	x	x
Collotheca mutabilis	x	x	x	x	x	
Collotheca obtuse		x	x	x	x	
Colurella obtuse	x	x	x	x		
Conochilus unicornis				x		x
Euchlanis deflexa				x		
Euchlanis parva	x	x	x	x		
Euchlanis spp.	x	x	x	x		
Filinia longiseta				x		
Gastropus stylifer				x	x	
Kellicottia longispina	x	x	x	x	x	x
Keratella Americana				x	x	
Keratella cochlearis	x	x	x	x	x	x
Keratella longispina	x	x	x	x		
Keratella quadrata	x	x	x	x	x	x
Lecane cf. luna				x		
Lecane elasma		x	x	x		
Lecane flexilis				x	x	
Lecane lunaris				x	x	
Lecane spp.	x	x	x	x	x	
Lecane stokesii				x	x	
Lepadella patella	x	x	x	x	x	x
Monostyla bulla				x	x	
Monostyla closterocerca	x	x	x	x	x	
Monostyla crenata				x		

Appendix A. Continued.

Rotifera Species, continued.	2002	2003	2004	2005	2006	2007
Monostyla hamata				x	x	
Monostyla lunaris	x	x	x	x	x	
Monostyla quadridentata	x	x	x	x	x	
Monostyla spp.	x	x	x	x	x	
Nothalca		x	x	x	x	x
Nothalca acuminate		x	x	x		
Nothalca labis				x	x	
Nothalca laurentiae		x	x	x	x	x
Notholca squamula				x	x	
Philodina sp.	x	x	x	x		
Philodinidae		x	x	x		
Pleosoma spp.				x		
Polyarthra major	x	x	x	x	x	x
Polyarthra remata	x	x	x	x	x	x
Polyarthra vulgaris				x	x	x
Pompholy X sulcata				x		
Proales spp.		x	x	x	x	x
Synchaeta spp	x	x	x	x		x
Testudinella patina				x	x	
Trichecerca uncinata				x		
Trichocerca gibba				x		
Trichocerca porcellus	x	x	x	x	x	
Trichocerca pusilla	x	x	x	x	x	
Trichocerca rattus					x	x
Trichocerca tetractis					x	
Trichocerca rousseleti	x	x	x	x	x	
Trichotria tetractis	x	x	x	x	x	
Tricocerca unicinata	x	x	x	x		
TOTAL DIVERSITY	**29**	**37**	**37**	**59**	**40**	**16**

Appendix B. Electrofishing summary for biomonitoring sites 2002-2008 on the Kootenai River, Idaho.

2002

Site	Species	Count	% of Total	CPUE (n/h)	kg	% of Total	BPUE (kg/h)	Mean Weight (g)	Effort (h)
KR10	BLT	2	1.06	1.53	5.13	11.23	3.92	2563	1.31
	LSS	33	17.46	25.21	19.54	42.81	14.92	592	1.31
	MWF	93	49.21	71.04	15.18	33.26	11.60	163	1.31
	NPM	9	4.76	6.87	0.72	1.58	0.55	80	1.31
	PMC	2	1.06	1.53	0.28	0.62	0.22	142	1.31
	RBT	24	12.70	18.33	4.18	9.15	3.19	174	1.31
	RSS	25	13.23	19.10	0.37	0.81	0.28	15	1.31
	WCT	1	0.53	0.76	0.24	0.53	0.18	240	1.31
Total		**189**	**100**	**144**	**46**	**100.00**	**35**		**1.31**
KR9	LSS	28	14.66	39	15.42	36.96	21.35	551	0.72
	MWF	132	69.11	183	20.38	48.87	28.23	154	0.72
	NPM	10	5.24	14	4.71	11.29	6.52	470	0.72
	RBT	7	3.66	10	0.89	2.13	1.23	127	0.72
	RSS	12	6.28	17	0.12	0.29	0.17	10	0.72
	SCU	1	0.52	1	0.00	0.01	0.00	3	0.72
	WCT	1	0.52	1	0.19	0.44	0.26	185	0.72
Total		**191**	**100**	**265**	**42**	**100**	**58**		**0.72**
KR6	BRN	1	0.37	1.24	0.05	0.17	0.07	54	0.73
	LSS	16	5.88	18.91	8.93	27.44	12.25	558	0.73
	LND	1	0.37	1.15	0.00	0.00	0.00	1	0.73
	LNS	1	0.37	0.00	0.27	0.81	0.36	265	0.73
	MWF	219	80.51	251.05	18.67	57.39	25.61	85	0.73
	NPM	6	2.21	7.52	1.45	4.46	1.99	241	0.73
	PMC	4	1.47	4.55	0.78	2.41	1.08	196	0.73
	RBT	15	5.51	17.26	1.86	5.73	2.56	124	0.73
	RSS	8	2.94	9.58	0.07	0.20	0.09	8	0.73
	WCT	1	0.37	1.09	0.45	1.39	0.62	452	0.73
Total		**272**	**100**	**312**	**33**	**100**	**43**		**0.73**
KR4	LSS	75	23.58	44.87	37.64	74.39	22.46	502	1.67
	LNS	4	1.26	2.39	1.90	3.75	0.53	475	1.67
	MWF	3	0.94	1.79	0.12	0.24	0.07	40	1.67
	NPM	93	29.25	55.64	2.06	4.07	1.23	22	1.67
	PMC	77	24.21	46.07	7.73	15.28	5.74	100	1.67
	RBT	6	1.89	3.59	0.72	1.41	0.43	119	1.67
	RSS	59	18.55	35.30	0.35	0.70	0.18	6	1.67
	YP	1	0.31	0.60	0.08	0.16	0.05	79	1.67
Total		**318**	**100**	**190**	**51**	**100**	**31**		**1.67**
KR2	LSS	41	12.77	26.83	21.03	75.38	13.76	513	1.53
	LNS	3	0.93	1.96	0.23	0.81	0.15	76	1.53
	MWF	4	1.25	2.62	0.06	0.22	0.04	15	1.53
	NPM	146	45.48	95.53	4.13	14.80	2.70	28	1.53
	PMC	29	9.03	18.97	1.86	6.65	1.21	64	1.53
	RBT	93	28.97	60.85	0.56	2.02	0.37	6	1.53
	SCU	3	0.93	1.96	0.02	0.07	0.01	6	1.53
	WCT	2	0.62	1.31	0.01	0.05	0.01	7	1.53
Total		**321**	**100**	**210**	**28**	**100**	**18**		**1.53**

Appendix B. Continued.

2003

Site	Species	Count	% of total	CPUE	Kg	% of total	BPUE	Mean Wt	Effort
KR10	LNS	6.00	2.49	3.95	0.68	1.33	0.45	114	1.52
	LSS	35.00	14.52	23.03	16.76	32.85	11.03	479	1.52
	MWF	128.00	53.11	84.21	24.20	47.43	15.92	189	1.52
	NPM	14.00	5.81	9.21	1.54	3.01	1.01	110	1.52
	RBT	31.00	12.86	20.39	6.47	12.67	4.25	209	1.52
	RSS	25.00	10.37	16.45	0.34	0.66	0.22	13	1.52
	WCT	2.00	0.83	1.32	1.05	2.05	0.69	523	1.52
Totals		**241**	**100**	**159**	**51**	**100**	**34**		**2**
KR2	LNS	6.00	1.54	3.87	0.74	1.88	0.48	123	1.55
	LSS	37.00	9.51	23.88	23.23	59.16	15.00	628	1.55
	NPM	202.00	51.93	130.39	8.37	21.32	5.40	41	1.55
	PEA	82.00	21.08	52.93	6.24	15.89	4.03	76	1.55
	RSS	59.00	15.17	38.08	0.61	1.54	0.39	10	1.55
	SCU	1.00	0.26	0.65	0.01	0.02	0.00	7	1.55
	YP	2.00	0.51	1.29	0.08	0.20	0.05	40	1.55
KR2 Total		**389**	**100**	**251**	**39**	**100**	**25**		**2**
KR4	LNS	13.00	2.55	9.36	2.37	7.21	1.71	183	1.39
	LSS	74.00	14.54	53.26	15.72	47.78	11.31	212	1.39
	MWF	28.00	5.50	20.15	0.37	1.11	0.26	13	1.39
	NPM	196.00	38.51	141.06	6.78	20.61	4.88	35	1.39
	PEA	97.00	19.06	69.81	5.45	16.56	3.92	56	1.39
	PMS	2.00	0.39	1.44	0.02	0.07	0.02	11	1.39
	RBT	2.00	0.39	1.44	0.20	0.60	0.14	98	1.39
	RSS	92.00	18.07	66.21	0.80	2.43	0.58	9	1.39
	SCU	1.00	0.20	0.72	0.00	0.01	0.00	4	1.39
	WCT	3.00	0.59	2.16	1.17	3.56	0.84	390	1.39
	YP	1.00	0.20	0.72	0.02	0.05	0.01	17	1.39
KR4 Total		**509**	**100**	**366**	**33**	**100**	**24**		**1**
KR6	LSS	18.00	10.91	29.10	14.53	44.48	23.49	807	0.62
	MWF	139.00	84.24	224.70	15.49	47.41	25.04	114	0.62
	NPM	6.00	3.64	9.70	2.59	7.93	4.19	432	0.62
	RBT	1.00	0.61	1.62	0.05	0.15	0.08	50	0.62
	RSS	1.00	0.61	1.62	0.01	0.02	0.01	8	0.62
KR6 Total		**165**	**100**	**267**	**33**	**100**	**53**		**1**
KR9	LSS	22.00	13.17	28.02	18.18	41.64	23.15	826	0.79
	MWF	107.00	64.07	136.26	16.30	37.33	20.76	152	0.79
	NPM	8.00	4.79	10.19	2.86	6.55	3.64	358	0.79
	PEA	2.00	1.20	2.55	0.22	0.51	0.29	112	0.79
	RBT	20.00	11.98	25.47	6.02	13.78	7.66	301	0.79
	RSS	8.00	4.79	10.19	0.08	0.19	0.10	10	0.79
KR9 Total		**167.00**	**100.00**	**212.66**	**43.66**	**100.00**	**55.60**		**0.79**

Appendix B. Continued.

2004

Site	Species	Count	% of total	CPUE (hr)	Kg	BPUE (hr)	% of total	Mean Wt (g)	Effort (h)
KR14	LND	1	0.28	1.25	0.00	0.00	0.00	1	0.80
	LNS	4	1.10	5.01	2.06	2.57	1.93	514	0.80
	LSS	83	22.93	103.86	65.82	82.36	61.67	793	0.80
	MWF	260	71.82	325.34	36.63	45.84	34.32	141	0.80
	NPM	5	1.38	6.26	0.98	1.23	0.92	196	0.80
	RBT	1	0.28	1.25	0.13	0.16	0.12	126	0.80
	RSS	3	0.83	3.75	0.03	0.04	0.03	10	0.80
	SCU	1	0.28	1.25	0.01	0.01	0.01	11	0.80
	WCT	4	1.10	5.01	1.08	1.36	1.01	271	0.80
Totals		**362**	**100.00**	**452.97**	**106.74**	**133.56**	**100.00**		**0.80**
KR10	LSS	18	9.68	15.30	14.88	12.65	31.09	827	1.18
	MWF	115	61.83	97.78	22.67	19.27	47.37	197	1.18
	NPM	11	5.91	9.35	1.60	1.36	3.35	146	1.18
	PMC	10	5.38	8.50	1.23	1.05	2.58	123	1.18
	RBT	29	15.59	24.66	7.25	6.17	15.16	250	1.18
	RSS	2	1.08	1.70	0.05	0.04	0.09	23	1.18
	WCT	1	0.54	0.85	0.17	0.15	0.36	173	1.18
Totals		**186**	**100.00**	**158.15**	**47.85**	**40.69**	**100.00**		**1.18**
KR9	LSS	29	22.31	40.69	23.92	33.56	59.69	825	0.71
	MWF	72	55.38	101.01	9.75	13.68	24.33	135	0.71
	NPM	4	3.08	5.61	0.74	1.04	1.85	186	0.71
	RBT	23	17.69	32.27	5.05	7.08	12.60	219	0.71
	RSS	1	0.77	1.40	0.00	0.00	0.01	3	0.71
	WCT	1	0.77	1.40	0.61	0.85	1.52	608	0.71
Totals		**130**	**100.00**	**182.39**	**40.07**	**56.22**	**100.00**		**0.71**
KR6	LSS	11	5.42	16.41	8.16	12.17	23.79	742	0.67
	MWF	159	78.33	237.22	19.10	28.49	55.67	120	0.67
	NPM	6	2.96	8.95	4.23	6.31	12.33	705	0.67
	RBT	18	8.87	26.85	2.55	3.80	7.43	142	0.67
	RSS	8	3.94	11.94	0.08	0.12	0.23	10	0.67
	WCT	1	0.49	1.49	0.19	0.28	0.54	186	0.67
Totals		**203**	**100.00**	**302.86**	**34.31**	**51.18**	**100.00**		**0.67**
KR4	LNS	1	0.28	0.87	0.46	0.40	1.52	464	1.15
	LSS	25	6.89	21.67	11.70	10.14	38.32	468	1.15
	MWF	39	10.74	33.80	1.10	0.95	3.59	28	1.15
	NPM	123	33.88	106.60	5.27	4.57	17.27	43	1.15
	PMC	138	38.02	119.60	9.87	8.56	32.35	72	1.15
	RBT	6	1.65	5.20	0.91	0.79	2.99	152	1.15
	RSS	28	7.71	24.27	0.26	0.23	0.86	9	1.15
	WCT	2	0.55	1.73	0.93	0.81	3.06	467	1.15
	YP	1	0.28	0.87	0.01	0.01	0.04	13	1.15
Totals		**363.00**	**100.00**	**314.59**	**30.52**	**26.45**	**100.00**		**1.15**
KR2	BBH	1	0.22	0.74	0.13	0.10	0.50	129	1.35
	LNS	2	0.43	1.48	0.28	0.21	1.08	139	1.35
	LSS	19	4.11	14.03	8.23	6.08	32.10	433	1.35
	MWF	18	3.90	13.29	0.61	0.45	2.38	34	1.35
	NPM	114	24.68	84.15	4.48	3.30	17.46	39	1.35
	PMC	212	45.89	156.49	10.64	7.85	41.49	50	1.35
	RBT	1	0.22	0.74	0.36	0.27	1.41	362	1.35
	RSS	94	20.35	69.39	0.91	0.67	3.55	10	1.35
	SCU	1	0.22	0.74	0.01	0.00	0.02	5	1.35
Totals		**462**	**100.00**	**341.03**	**25.64**	**18.92**	**100.00**		**1.35**

Appendix B. Continued.

2005

Site	Species	Count	% of total	CPUE	Kg	BPUE	% of total	Mean Wt	Effort (s)	Effort
KR2	BBH	2	0.53	1.11	0.21	0.12	0.65	107	6494.4	1.804
	LSS	33	8.75	18.29	21.91	12.14	66.90	664	6494.4	1.804
	MWF	9	2.39	4.99	0.22	0.12	0.67	24	6494.4	1.804
	NPM	110	29.18	60.98	4.01	2.22	12.25	36	6494.4	1.804
	PMC	100	26.53	55.43	5.10	2.82	15.56	51	6494.4	1.804
	RBT	5	1.33	2.77	0.52	0.29	1.59	104	6494.4	1.804
	RSS	113	29.97	62.64	0.75	0.42	2.29	7	6494.4	1.804
	SCU	5	1.33	2.77	0.03	0.02	0.09	6	6494.4	1.804
KR2 Total	**Grand Total**	**377**	**100.00**	**208.98**	**32.75**	**18.15**	**100.00**		**6494.4**	**1.804**
KR4	LNS	6	1.83	4.02	3.29	2.21	11.33	549	5367.6	1.491
	LSS	30	9.17	20.12	13.77	9.24	47.41	459	5367.6	1.491
	MWF	23	7.03	15.43	0.74	0.49	2.54	32	5367.6	1.491
	NPM	91	27.83	61.03	3.86	2.59	13.29	42	5367.6	1.491
	PMC	73	22.32	48.96	4.80	3.22	16.52	66	5367.6	1.491
	PS	2	0.61	1.34	0.01	0.01	0.03	3	5367.6	1.491
	RBT	12	3.67	8.05	1.44	0.97	4.96	120	5367.6	1.491
	RSS	85	25.99	57.01	0.49	0.33	1.69	6	5367.6	1.491
	SCU	1	0.31	0.67	0.01	0.00	0.02	5	5367.6	1.491
	WCT	4	1.22	2.68	0.64	0.43	2.21	160	5367.6	1.491
KR4 Total		**327**	**100.00**	**219.32**	**29.05**	**19.48**	**100.00**		**5367.6**	**1.491**
KR6	LSS	24	13.11	37.62	20.42	32.01	50.64	851	2296.8	0.638
	MWF	152	83.06	238.24	18.32	28.71	45.42	120	2296.8	0.638
	NPM	3	1.64	4.70	0.79	1.23	1.95	262	2296.8	0.638
	RBT	4	2.19	6.27	0.80	1.26	1.99	201	2296.8	0.638
KR6 Total		**183**	**100.00**	**286.83**	**40.33**	**63.21**	**100.00**		**2296.8**	**0.638**
KR9	LNS	1	0.48	1.45	0.46	0.66	0.85	456	2478	0.688
	LSS	21	10.00	30.51	16.24	23.60	30.43	773	2478	0.688
	MWF	165	78.57	239.71	31.45	45.69	58.92	191	2478	0.688
	NPM	4	1.90	5.81	0.80	1.16	1.49	199	2478	0.688
	PMC	4	1.90	5.81	0.52	0.76	0.98	130	2478	0.688
	RBT	15	7.14	21.79	3.91	5.68	7.33	261	2478	0.688
KR9 Total	**Grand Total**	**210**	**100.00**	**305.085**	**53.38**	**77.55**	**100.00**		**2478**	**0.688**
KR14	LNS	4	2.90	5.26	2.58	3.39	3.92	645	2736	0.76
	LSS	57	41.30	75.00	48.87	64.30	74.33	857	2736	0.76
	MWF	71	51.45	93.42	12.31	16.20	18.73	173	2736	0.76
	RBT	5	3.62	6.58	1.98	2.60	3.01	395	2736	0.76
	Sculpin	1	0.72	1.32	0.01	0.01	0.01	6	2736	0.76
KR14 Total	**Grand Total**	**138**	**100.00**	**181.579**	**65.745**	**86.51**	**100.00**		**2736**	**0.76**
KR10	BRN	1	0.32	0.90	0.20	0.18	0.24	196	4002	1.112
	LSS	51	16.24	45.88	32.81	29.51	40.89	643	4002	1.112
	MWF	211	67.20	189.81	37.51	33.74	46.75	178	4002	1.112
	NPM	7	2.23	6.30	1.81	1.63	2.26	259	4002	1.112
	PMC	4	1.27	3.60	0.50	0.45	0.62	125	4002	1.112
	RBT	36	11.46	32.38	6.72	6.04	8.38	187	4002	1.112
	RSS	2	0.64	1.80	0.03	0.03	0.04	17	4002	1.112
	WCT	2	0.64	1.80	0.65	0.59	0.81	327	4002	1.112
KR10 Total	**Grand Total**	**314**	**100.00**	**282.459**	**80.228**	**72.17**	**100.00**		**4002**	**1.112**

Appendix B. Continued.

2006

Site	Species	Count	% of total	CPUE	Kg	%of total	BPUE	Mean Wt	Effort (s)	Effort
KR2	BBH	1	0.16	0.66	0.16	0.26	0.11	163	5485	1.524
	LSS	72	11.30	47.26	49.36	80.11	32.39	686	5485	1.524
	LNS	1	0.16	0.66	0.07	0.11	0.05	70	5485	1.524
	MWF	2	0.31	1.31	0.02	0.03	0.01	9	5485	1.524
	NPM	284	44.58	186.40	6.64	10.78	4.36	23	5485	1.524
	PMC	49	7.69	32.16	3.49	5.66	2.29	71	5485	1.524
	RBT	2	0.31	1.31	0.22	0.35	0.14	108	5485	1.524
	RSS	215	33.75	141.11	1.47	2.38	0.96	7	5485	1.524
	SCU	4	0.63	2.63	0.03	0.04	0.02	6	5485	1.524
	YP	7	1.10	4.59	0.16	0.26	0.11	23	5485	1.524
KR2 Total	**Grand Total**	**637**	**100.00**	**418.086**	**61.609**	**100**	**40.44**		**5485**	**1.524**
KR4	LNS	6	1.36	3.88	1.57	6.19	1.02	262	5572	1.548
	LSS	27	6.14	17.44	10.59	41.66	6.84	392	5573	1.548
	MWF	61	13.86	39.40	0.66	2.59	0.42	11	5574	1.548
	NPM	206	46.82	133.02	5.69	22.39	3.67	28	5575	1.549
	PMC	52	11.82	33.57	4.57	18.00	2.95	88	5576	1.549
	PSS	6	1.36	3.87	0.10	0.38	0.06	16	5577	1.549
	RBT	9	2.05	5.81	1.62	6.38	1.05	180	5578	1.549
	RSS	66	15.00	42.58	0.57	2.24	0.37	9	5580	1.550
	SCU	6	1.36	3.87	0.04	0.15	0.02	6	5581	1.550
	YP	1	0.23	0.65	0.01	0.02	0.00	5	5581	1.550
KR4 Total	**Grand Total**	**440**	**100.00**	**283.820**	**25.41**	**100**	**16.39**		**5581**	**1.550**
KR6	BRN	1	0.30	1.39	0.16	0.33	0.22	160	2583	0.718
	LSS	34	10.33	47.39	23.00	47.48	32.06	676	2583	0.718
	MWF	247	75.08	344.25	19.74	40.74	27.51	80	2583	0.718
	NPM	19	5.78	26.48	2.15	4.44	3.00	113	2583	0.718
	PMC	1	0.30	1.39	0.04	0.08	0.06	41	2583	0.718
	RBT	22	6.69	30.66	3.27	6.76	4.56	149	2583	0.718
	RSS	5	1.52	6.97	0.08	0.16	0.11	16	2583	0.718
KR6 Total	**Grand Total**	**329**	**100.00**	**458.537**	**48.443**	**100**	**67.52**		**2583**	**0.718**
KR9	LSS	25	9.73	34.66	21.81	39.22	30.23	872	2597	0.721
	MWF	213	82.88	295.26	30.77	55.34	42.65	145	2597	0.721
	NPM	6	2.33	8.32	0.71	1.27	0.98	118	2597	0.721
	RBT	13	5.06	18.02	2.32	4.17	3.22	178	2597	0.721
KR9 Total	**Grand Total**	**257**	**100.00**	**356.257**	**55.6**	**100**	**77.07**		**2597**	**0.721**
KR14	LNS	6	3.17	9.06	4.09	4.96	6.17	681	2383	0.66194
	LSS	76	40.21	114.81	58.81	71.42	88.84	774	2383	0.66194
	MWF	96	50.79	145.03	17.35	21.07	26.21	181	2383	0.66194
	NPM	4	2.12	6.04	1.51	1.84	2.29	378	2383	0.66194
	PMC	1	0.53	1.51	0.07	0.09	0.11	70	2383	0.66194
	RBT	1	0.53	1.51	0.13	0.16	0.20	134	2383	0.66194
	RSS	4	2.12	6.04	0.07	0.08	0.10	16	2383	0.66194
	WCT	1	0.53	1.51	0.32	0.38	0.48	317	2383	0.66194
KR14 Total	**Grand Total**	**189**	**100.00**	**286**	**82**	**100**	**124**		2383	0.66194
KR10	BRN	1	0.31	1.06	0.33	0.53	0.35	329	3385	0.94028
	LSS	14	4.38	14.89	9.21	14.76	9.80	658	3385	0.94028
	MWF	234	73.13	248.86	40.74	65.27	43.33	174	3385	0.94028
	NPM	6	1.88	6.38	0.91	1.46	0.97	152	3385	0.94028
	RBT	60	18.75	63.81	10.53	16.86	11.19	175	3385	0.94028
	RSS	2	0.63	2.13	0.03	0.05	0.04	17	3385	0.94028
	WCT	3	0.94	3.19	0.66	1.06	0.71	221	3385	0.94028
KR10 Total	**Grand Total**	**320**	**100.00**	**340.32**	**62.42**	**100.00**	**66.38**		**3385**	**0.94028**

Appendix B. Continued.

2007

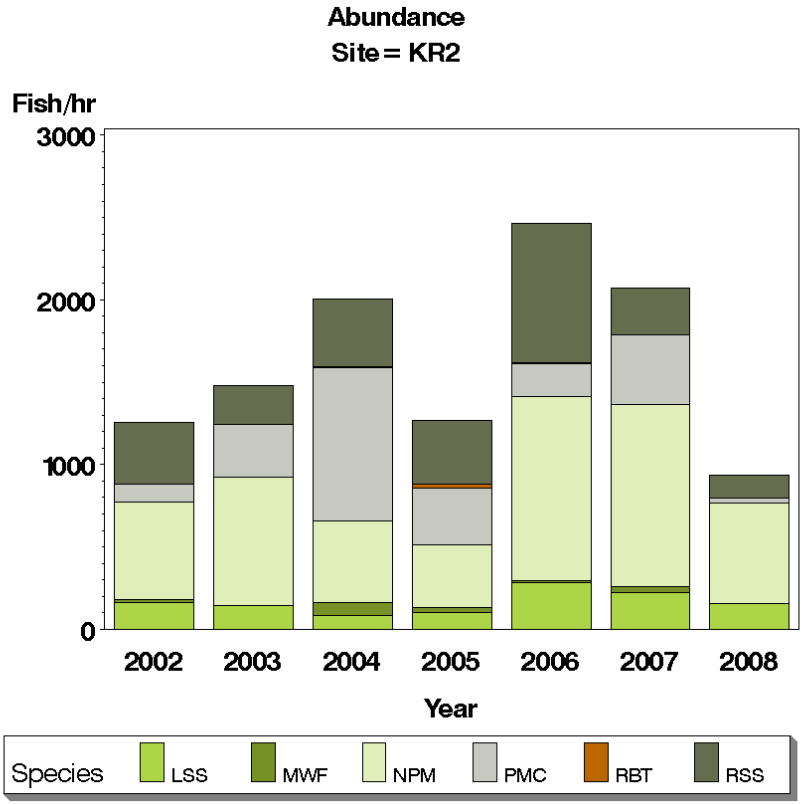
Site	Species	Count	% of total	CPUE	Kg	%of total	BPUE	Mean Weight	Effort (s)	Effort
KR2	BBH	1	0.19	0.66	0.06	0.11	0.04	62	5475	1.521
	LNS	3	0.56	1.97	0.73	1.25	0.48	244	5475	1.521
	LSS	56	10.47	36.82	40.12	68.80	26.38	716	5475	1.521
	MWF	9	1.68	5.92	0.10	0.16	0.06	11	5475	1.521
	NPM	283	52.90	186.08	7.95	13.63	5.23	28	5475	1.521
	PMC	107	20.00	70.36	8.85	15.18	5.82	83	5475	1.521
	RSS	73	13.64	48.00	0.49	0.84	0.32	7	5475	1.521
	SCU	3	0.56	1.97	0.02	0.03	0.01	6	5475	1.521
KR2 Total	**Grand Total**	**535**	**100.00**	**351.78**	**58.31**	**100.00**	**38.34**	**Mean Weight**	**5475**	**1.521**
KR4	LNS	3	1.25	2.10	1.44	6.11	1.01	481	5139	1.428
	LSS	18	7.50	12.61	13.05	55.29	9.14	725	5139	1.428
	MWF	13	5.42	9.11	0.77	3.25	0.54	59	5139	1.428
	NPM	132	55.00	92.47	4.47	18.94	3.13	34	5139	1.428
	PMC	39	16.25	27.32	3.21	13.60	2.25	82	5139	1.428
	RBT	5	2.08	3.50	0.44	1.88	0.31	89	5139	1.428
	RSS	27	11.25	18.91	0.20	0.86	0.14	8	5139	1.428
	SCU	3	1.25	2.10	0.02	0.07	0.01	5	5139	1.428
KR4 Total	**Grand Total**	**240**	**100.00**	**168.07**	**23.60**	**100.00**	**16.53**	**Mean Weight**	**5139**	**1.428**
KR6	BRN	2	0.47	3.30	0.37	0.48	0.61	186	2182	0.606
	LSS	33	7.69	54.45	28.68	36.90	47.32	869	2182	0.606
	MWF	382	89.04	630.25	46.61	59.96	76.90	122	2182	0.606
	NPM	2	0.47	3.30	0.07	0.09	0.11	34	2182	0.606
	RBT	9	2.10	14.85	2.00	2.58	3.30	222	2182	0.606
	SCU	1	0.23	1.65	0.00	0.00	0.00	1	2182	0.606
KR6 Total	**Grand Total**	**429**	**100.00**	**707.79**	**77.73**	**100.00**	**128.25**	**Mean Weight**	**2182**	**0.606**
KR9	BRN	2	0.71	2.43	0.56	0.76	0.69	282	2959	0.822
	LND	1	0.36	1.22	0.01	0.01	0.01	7	2959	0.822
	LSS	30	10.68	36.50	28.78	38.86	35.02	959	2959	0.822
	MWF	221	78.65	268.87	37.67	50.86	45.83	170	2959	0.822
	NPM	5	1.78	6.08	2.57	3.47	3.13	515	2959	0.822
	PMC	1	0.36	1.22	0.11	0.15	0.14	112	2959	0.822
	RBT	19	6.76	23.12	4.31	5.81	5.24	227	2959	0.822
	RSS	1	0.36	1.22	0.03	0.04	0.04	31	2959	0.822
	SCU	1	0.36	1.22	0.02	0.02	0.02	16	2959	0.822
KR9 Total	**Grand Total**	**281**	**100.00**	**341.87**	**74.06**	**100.00**	**90.10**	**Mean Weight**	**2959**	**0.822**
KR14	LND	2	0.93	2.57	0.01	0.01	0.01	5	2807	0.7797
	LNS	1	0.47	1.28	0.67	0.94	0.86	670	2807	0.7797
	LSS	88	40.93	112.86	58.14	81.73	74.57	661	2807	0.7797
	MWF	93	43.26	119.27	9.34	13.13	11.98	100	2807	0.7797
	NPM	7	3.26	8.98	1.23	1.72	1.57	175	2807	0.7797
	PMC	8	3.72	10.26	0.88	1.23	1.12	109	2807	0.7797
	RBT	3	1.40	3.85	0.51	0.72	0.66	171	2807	0.7797
	RSS	8	3.72	10.26	0.08	0.11	0.10	10	2807	0.7797
	SCU	2	0.93	2.57	0.01	0.01	0.01	5	2807	0.7797
	WCT	3	1.40	3.85	0.27	0.39	0.35	91	2807	0.7797
KR14 Total	**Grand Total**	**215**	**100.00**	**275.74**	**71.14**	**100.00**	**91.23**	**Mean Weight**	**2807**	**0.7797**
KR10	BRN	4	1.22	2.49	0.41	0.69	0.25	101	5783	1.6064
	LSS	19	5.81	11.83	11.40	19.44	7.10	600	5783	1.6064
	MWF	219	66.97	136.33	35.17	59.96	21.89	161	5783	1.6064
	NPM	10	3.06	6.23	1.54	2.63	0.96	154	5783	1.6064
	PMC	2	0.61	1.25	0.27	0.46	0.17	134	5783	1.6064
	RBT	54	16.51	33.62	9.21	15.71	5.74	171	5783	1.6064
	RSS	14	4.28	8.72	0.20	0.34	0.12	14	5783	1.6064
	SCU	2	0.61	1.25	0.02	0.03	0.01	8	5783	1.6064
	WCT	3	0.92	1.87	0.44	0.76	0.28	148	5783	1.6064
KR10 Total	**Grand Total**	**327**	**100.00**	**203.56**	**58.65**	**100.00**	**36.51**		**5783**	**1.6064**

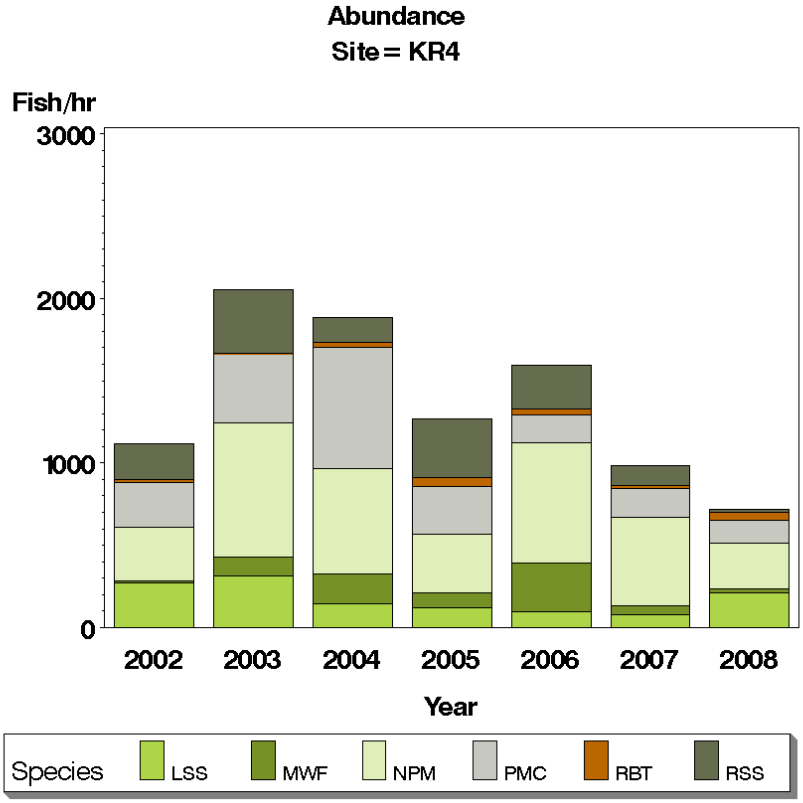
Appendix B. Continued.

2008

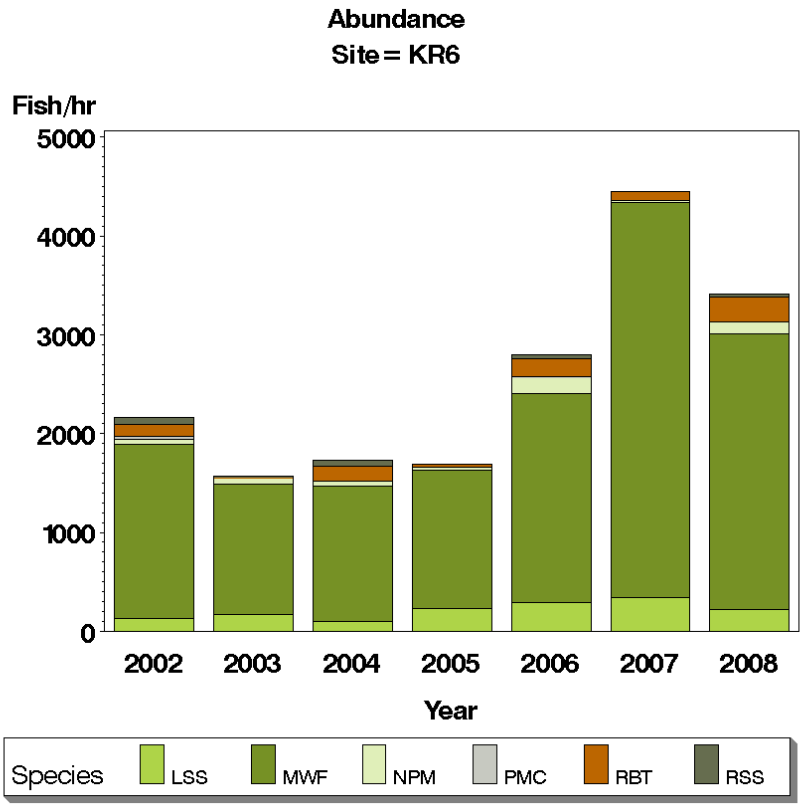
Site	Species	Count	% of total	CPUE	Kg	%of total	BPUE	Effort (s)	Effort
KR10	BRK	1	0.21	0.915	0.092	0.108	0.08	3933	1.093
	BRN	3	0.64	2.746	0.834	0.980	0.76	3933	1.093
	LSS	52	11.11	47.597	25.434	29.876	23.28	3933	1.093
	MWF	322	68.80	294.737	47.918	56.287	43.86	3933	1.093
	NPM	15	3.21	13.730	1.374	1.614	1.26	3933	1.093
	PMC	5	1.07	4.577	0.63	0.740	0.58	3933	1.093
	RBT	58	12.39	53.089	7.426	8.723	6.80	3933	1.093
	RSS	8	1.71	7.323	0.132	0.155	0.12	3933	1.093
	WCT	4	0.85	3.661	1.292	1.518	1.18	3933	1.093
KR10 Total	**Grand Total**	**468**	**100.00**	**428.375**	**85.132**	**100.000**	**77.92**	**3933**	**1.093**
KR14	BUR	1	0.36	1.809	0.105	0.128	0.19	1990	0.553
	LNS	2	0.72	3.618	1.176	1.439	2.13	1990	0.553
	LSS	82	29.50	148.342	57.134	69.915	103.36	1990	0.553
	MWF	176	63.31	318.392	19.074	23.341	34.51	1990	0.553
	NPM	4	1.44	7.236	1.343	1.643	2.43	1990	0.553
	RBT	7	2.52	12.663	2.048	2.506	3.70	1990	0.553
	WCT	6	2.16	10.854	0.839	1.027	1.52	1990	0.553
KR14 Total	**Grand Total**	**278**	**100.00**	**502.915**	**81.719**	**100.000**	**147.83**	**1990**	**0.553**
KR2	LSS	28	16.18	25.629	21.34	16.185	19.53	3933	1.093
	NPM	112	64.74	102.517	3.874	64.740	3.55	3933	1.093
	PMC	6	3.47	5.492	0.387	3.468	0.35	3933	1.093
	RSS	25	14.45	22.883	0.142	14.451	0.13	3933	1.093
	SCU	1	0.58	0.915	0.007	0.578	0.01	3933	1.093
	YP	1	0.58	0.915	0.019	0.578	0.02	3933	1.093
KR2 Total	**Grand Total**	**173**	**100.00**	**158.352**	**25.769**	**100.000**	**23.59**	**3933**	**1.093**
KR4	LSS	30	26.79	31.887	22.895	79.88486	24.33	3387	0.941
	MWF	4	3.57	4.252	0.246	0.858339	0.26	3387	0.941
	NPM	46	41.07	48.893	2.645	9.22889	2.81	3387	0.941
	PMC	20	17.86	21.258	1.904	6.643405	2.02	3387	0.941
	RBT	8	7.14	8.503	0.936	3.265876	0.99	3387	0.941
	RSS	3	2.68	3.189	0.03	0.104676	0.03	3387	0.941
	SCU	1	0.89	1.063	0.004	0.013957	0.00	3387	0.941
KR4 Total	**Grand Total**	**112**	**100.00**	**119.043**	**28.66**	**100**	**30.46**	**3387**	**0.941**
KR6	BRN	2	0.58	3.211	0.365	0.832	0.59	2242	0.623
	LSS	22	6.43	35.326	18.069	41.188	29.01	2242	0.623
	MWF	277	80.99	444.781	21.249	48.436	34.12	2242	0.623
	NPM	12	3.51	19.269	0.817	1.862	1.31	2242	0.623
	RBT	26	7.60	41.748	3.352	7.641	5.38	2242	0.623
	RSS	3	0.88	4.817	0.018	0.041	0.03	2242	0.623
KR6 Total	**Grand Total**	**342**	**100.00**	**549.153**	**43.87**	**100.000**	**70.44**	**2242**	**0.623**
KR9	LSS	26	5.63	38.251	22.491	26.440	33.09	2447	0.680
	MWF	399	86.36	587.004	56.335	66.227	82.88	2447	0.680
	NPM	7	1.52	10.298	1.804	2.121	2.65	2447	0.680
	PMC	1	0.22	1.471	0.129	0.152	0.19	2447	0.680
	RBT	28	6.06	41.193	3.958	4.653	5.82	2447	0.680
	RBTxWCT	1	0.22	1.471	0.346	0.407	0.51	2447	0.680
KR9 Total	**Grand Total**	**462**	**100.00**	**679.689**	**85.063**	**100.000**	**125.14**	**2447**	**0.680**

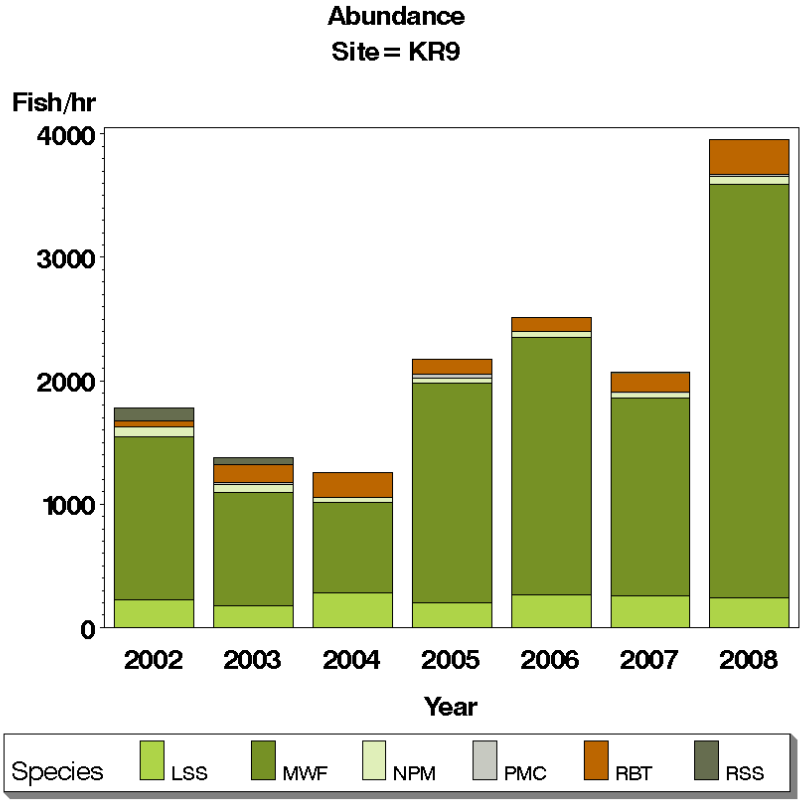
Appendix C. Average fish species catch rate (fish/h) shown at individual sites by year.



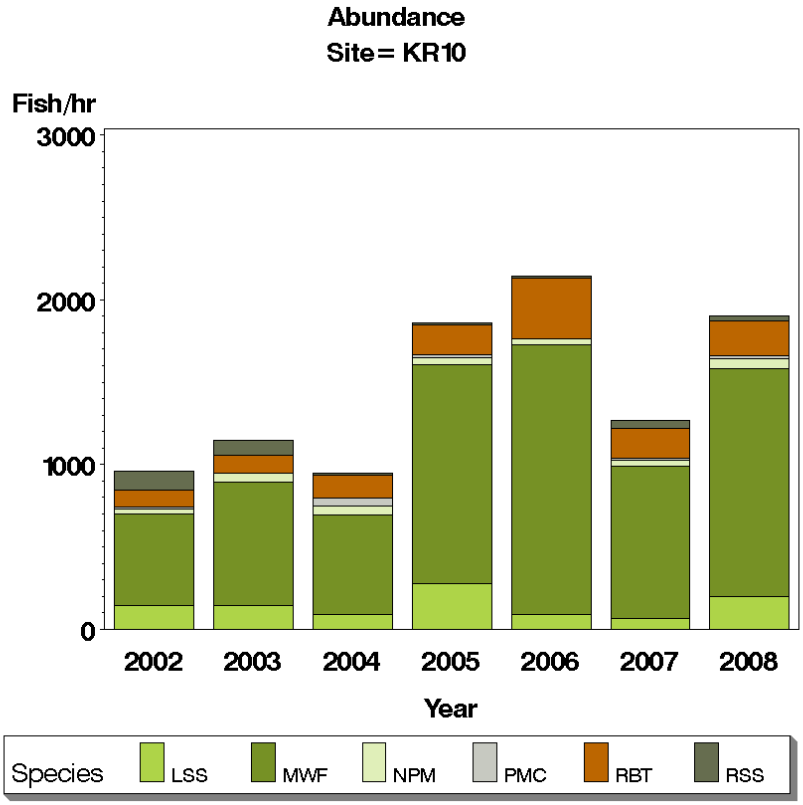


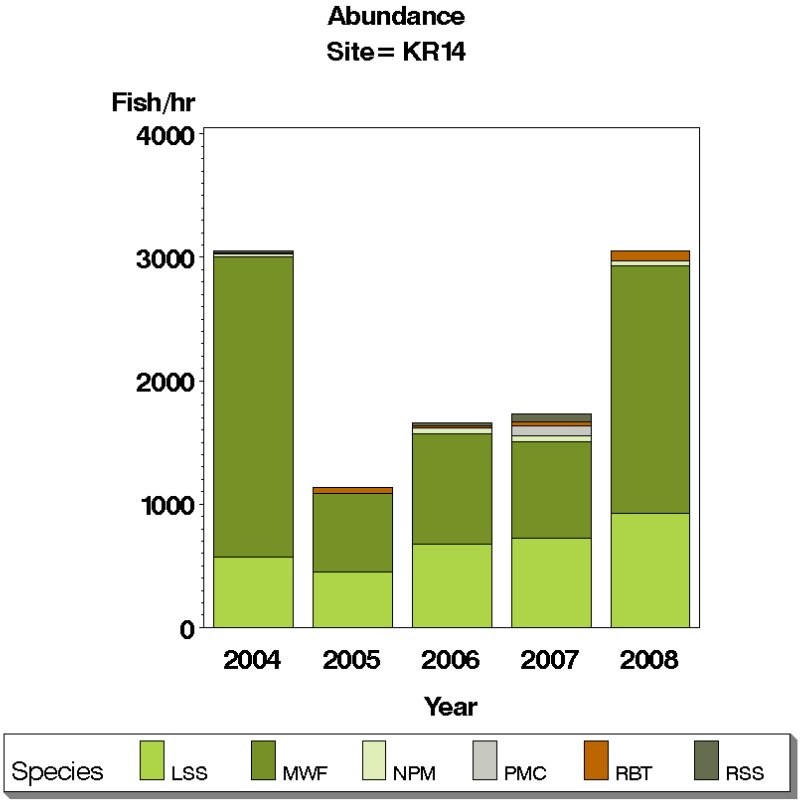
Appendix C. Continued.



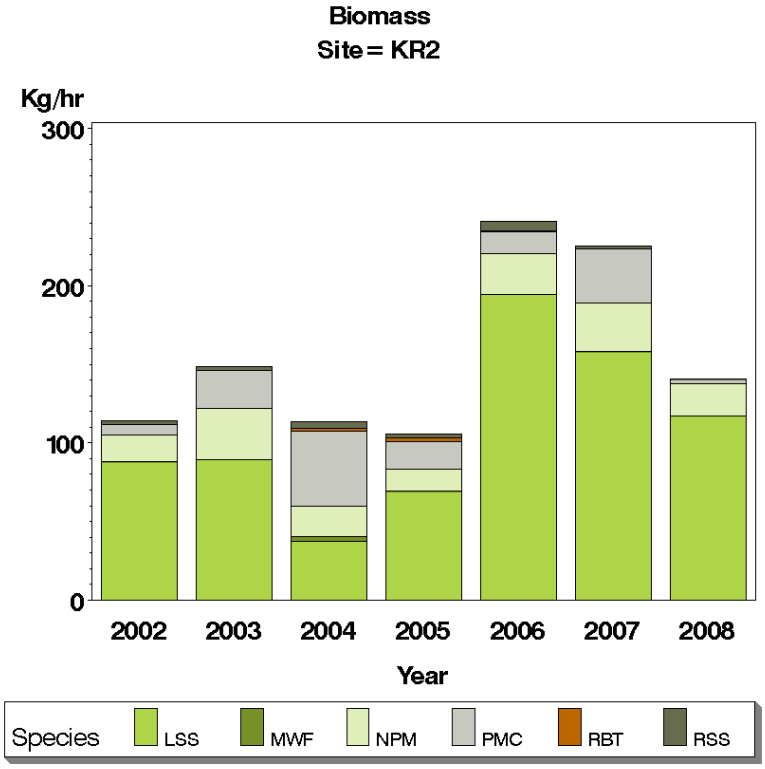


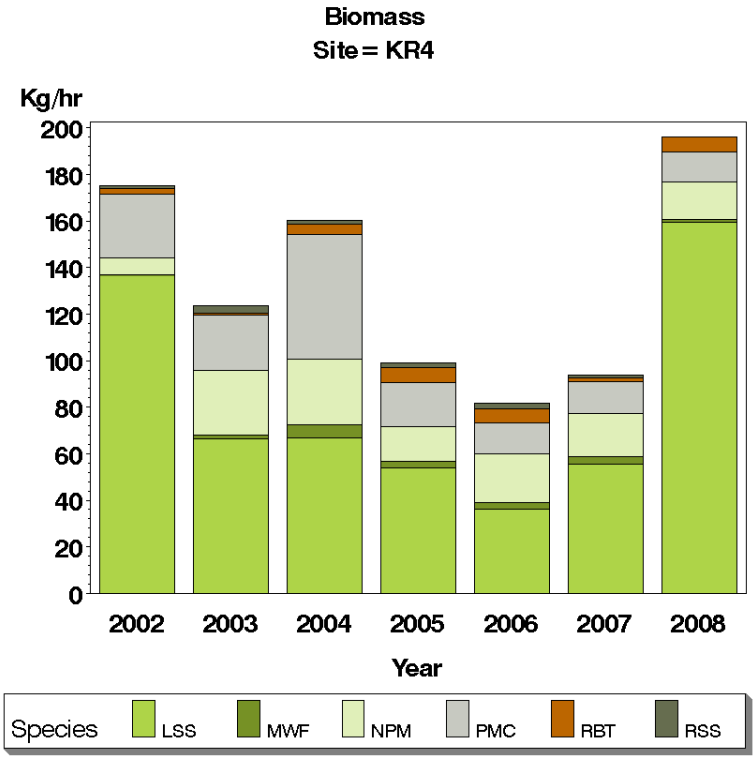
Appendix C. Continued.



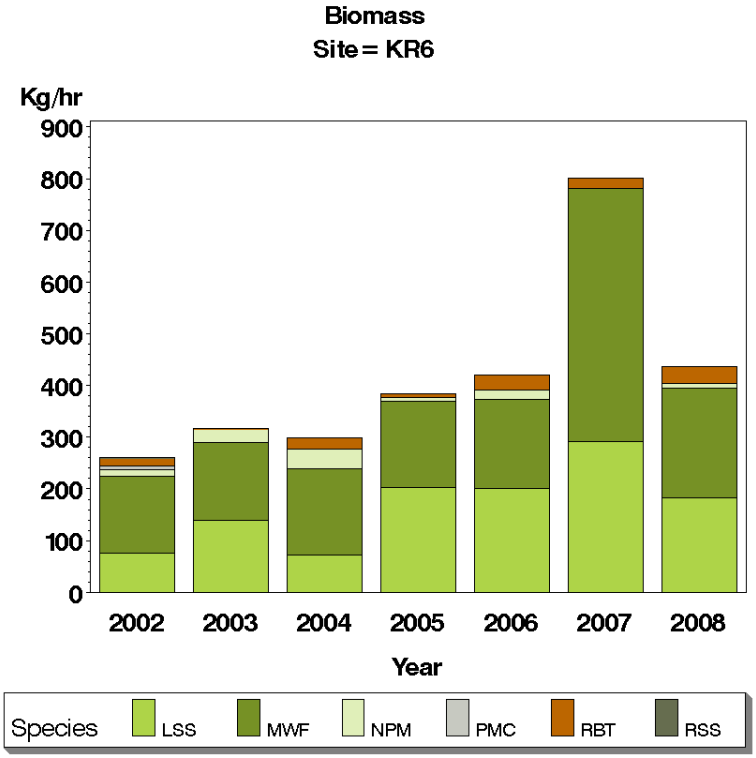


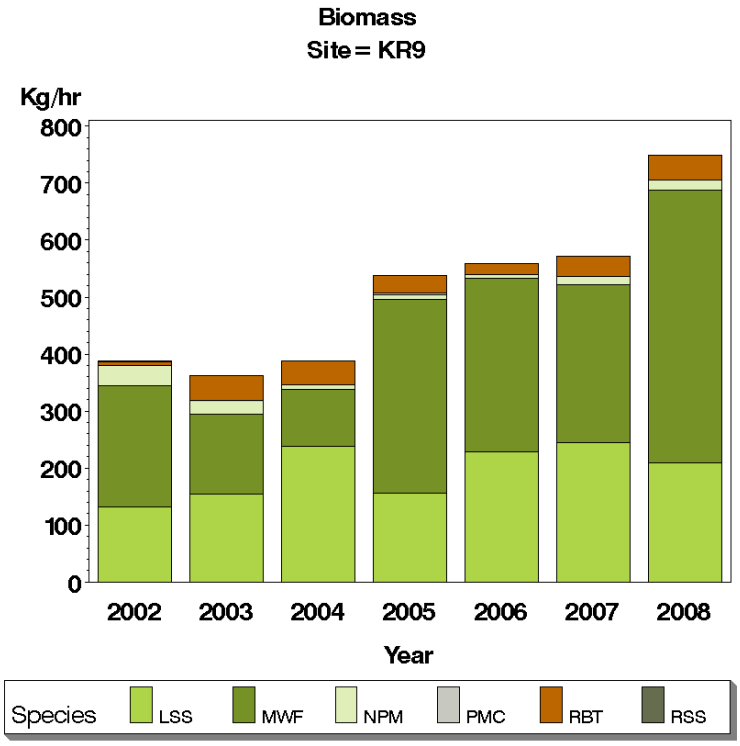
Appendix D. Average species biomass (kg/h) shown for individual sites by year.



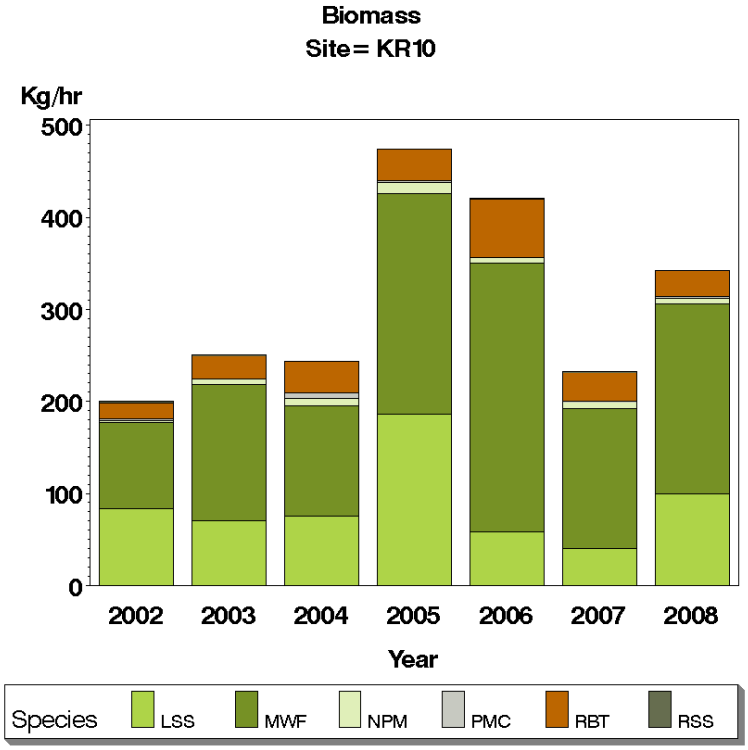


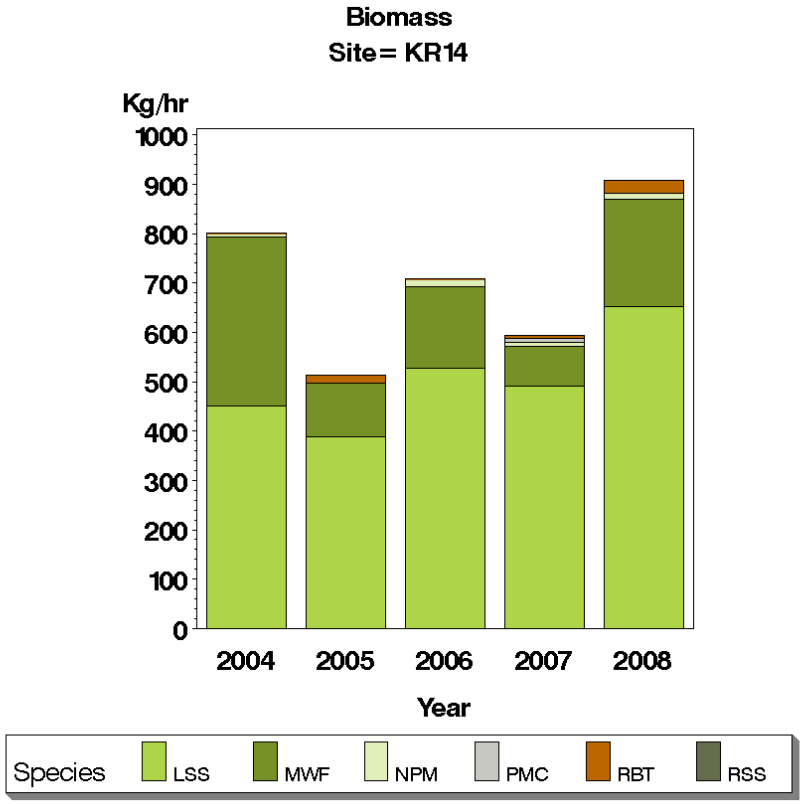
Appendix D. Continued.





Appendix D. Continued.





Appendix E. Results from ANOVA overall model analysis comparing catch per unit effort (fish/h) for pre- versus post-treatment years for mountain whitefish, rainbow trout, and largescale sucker.

Mountain whitefish

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	4.20	3.22	0.07
Site	5	213.46	32.65	<0.001
Treat*Site	5	9.63	1.47	0.20
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	7.19	5.50	0.02
KR14 vs. KR6 and KR9	1	6.78	5.19	0.02

Rainbow Trout

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	1.23	3.15	0.08
Site	5	31.62	16.21	<0.001
Treat*Site	5	3.43	1.76	0.13
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	0.13	0.35	0.56
KR14 vs. KR6 and KR9	1	2.86	7.32	0.01

Largescale Sucker

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	0.94	1.83	0.18
Site	5	35.59	13.78	<0.001
Treat*Site	5	5.45	2.11	0.07
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	3.87	7.50	0.01
KR14 vs. KR6 and KR9	1	19.73	38.19	<0.001

Appendix F. Results from ANOVA overall model analysis comparing biomass per unit effort (kg/h) for pre- versus post-treatment years for mountain whitefish, rainbow trout, and largescale sucker.

Mountain Whitefish

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	2.28	1.98	0.16
Site	5	260.57	45.27	<0.001
Treat*Site	5	7.66	1.33	0.25
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	1.81	1.58	0.21
KR14 vs. KR6 and KR9	1	5.31	4.62	0.03

Rainbow Trout

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	0.45	1.11	0.29
Site	5	23.77	11.76	<0.001
Treat*Site	5	2.38	1.18	0.32
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	0.06	0.16	0.69
KR14 vs. KR6 and KR9	1	0.72	1.78	0.18

Largescale Sucker

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	3.26	4.87	0.03
Site	5	56.83	16.98	>0.001
Treat*Site	5	6.54	1.96	0.09
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	11.19	16.72	<0.001
KR14 vs. KR6 and KR9	1	18.50	27.64	<0.001

Appendix G. Results from ANOVA overall model analysis comparing relative weight (Wr) for pre- versus post-treatment years for mountain whitefish, rainbow trout, and largescale sucker.

Mountain Whitefish

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	32.45	2.06	0.15
Site	5	240.14	3.04	0.01
Treat*Site	5	19.77	0.31	0.87
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	0.575	0.04	0.85
KR14 vs. KR6 and KR9	1	2.99	0.19	0.66

Rainbow Trout

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	1.20	0.03	0.87
Site	5	273.77	1.17	0.33
Treat*Site	5	125.67	0.54	0.75
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	30.10	0.64	0.42
KR14 vs. KR6 and KR9	1	104.02	2.23	0.14

Largescale Sucker

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	204.93	4.35	0.04
Site	5	61.70	0.26	0.93
Treat*Site	5	110.93	0.47	0.80
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	20.58	0.44	0.51
KR14 vs. KR6 and KR9	1	3.27	0.07	0.79

Appendix H. Results from ANOVA overall model analysis comparing condition factor (K) for pre- versus post-treatment years for mountain whitefish, rainbow trout, and largescale sucker.

Mountain Whitefish

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	0.00	0.01	0.91
Site	5	0.66	39.50	<.001
Treat*Site	5	0.05	2.83	0.02
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	0.01	2.95	0.09
KR14 vs. KR6 and KR9	1	0.04	11.62	<0.001

Rainbow Trout

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	0.04	9.53	0.003
Site	5	0.29	15.79	<.001
Treat*Site	5	0.00	1.10	0.37
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	0.01	3.47	0.06
KR14 vs. KR6 and KR9	1	0.04	9.46	0.003

Largescale Sucker

Source	DF	Sum of Squares	F Value	Pr > F
Treatment	1	0.28	54.77	<.001
Site	5	0.10	3.87	0.002
Treat*Site	5	0.14	5.59	<.001
Contrast	**DF**	**Sum of Squares**	**F Value**	**Pr > F**
KR10 vs. KR6 and KR9	1	0.04	8.43	0.004
KR14 vs. KR6 and KR9	1	0.00	0.79	0.37

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