FISHERY RESEARCH

KOOTENAI RIVER FISHERIES RECOVERY INVESTIGATIONS: ECOSYSTEM REHABILITATION

PROGRESS REPORT
April 1, 2007—March 31, 2008

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IDFG Report Number 09-03
March 2009

Kootenai River Fisheries Recovery Investigations: Ecosystem Rehabilitation

Project Progress Report

2007-2008 Annual Report

By

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To

U.S. Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, OR 97283-3621

Project Number 1988-06500
Contract Number 00004691

IDFG Report Number 09-03
March 2009

TABLE OF CONTENTS

Page

ABSTRACT....1
INTRODUCTION....2
RESEARCH GOAL....3
OBJECTIVES....3
STUDY AREA....3
- Nutrient Addition Location (Site Description)....5
- Biomonitoring Locations....5

METHODS....6
- Nutrients: Dosing and Measurement....6
- Microinvertebrate Abundance....6
- Fish Community Assessment....7
  - Species Abundance/Catch and Biomass Rates....7
  - Feeding Guilds and Tolerance....7
  - Relative Weight (Wr) and Condition Factor (K)....7
  - Age and Growth....8
- Mountain Whitefish Movement....8

RESULTS....9
- Nutrient Additions....9
- Microinvertebrate Abundance....10
- Fish Community Assessment....11
  - Species Diversity....11
  - Catch and Biomass Rates....15
  - Relative Weight (Wr) and Condition Factor (K)....16
  - Age and Growth....16
- Mountain Whitefish Movement....20

DISCUSSION....20
- Nutrient Additions....20
- Microinvertebrate Abundance....21
- Fish Community Assessment....21
- Mountain Whitefish Movement....23

RECOMMENDATIONS....23
ACKNOWLEDGEMENTS....24
LITERATURE CITED....25
APPENDICES....28

LIST OF TABLES

Page

Table 1. Species sampled at Kootenai River biomonitoring sites in September 2007 with boat electrofishing gear. IN = Invertivore; I-P = Invert-Piscivore; O = Omnivore; P = Piscivore (describes feeding guild). I = Intolerant; T = Tolerant; S = Sensitive (describes response to habitat perturbations; Zaroban et al. 1999).....17

Table 2. Catch Per Unit of Effort (CPUE; fish/h) and Biomass Per Unit of Effort (BPUE; kg/hr) for species sampled at Kootenai River biomonitoring sites in the fall (September) from 2002 through 2007 with boat electrofishing gear. Shaded cells indicate those areas sampled upstream of the treatment influence and therefore considered control locations.....19

Table 3. Mean relative weights (Wr) and Fulton's condition factor (K) of key species sampled at Kootenai River biomonitoring sites in September 2002-2007 with boat electrofishing gear. Shaded sections indicate nontreatment locations. SE = ± 1 standard error.....19

Table 4. Comparison of catch per unit of effort in pre- and post-treatment years of mountain whitefish by age class. Shaded sections indicate nontreatment locations. CPUE for pretreatment years are a mean from 2002-2005 sample years. CPUE for post-treatment represents 2006 and 2007 sample year means.....20

Table 5. Comparison of mean total length (TL) at time of capture in pre- and post-treatment years of mountain whitefish by age class. Shaded sections indicate nontreatment locations. Length at age for pre treatment years are a mean from 2002-2005 sample years. Length at age for post-treatment represents 2006 and 2007 sample years. 20

LIST OF FIGURES

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, Libby Dam, Bonners Ferry.....4

Figure 2. Kootenai River Drainage with location of the nutrient addition and area of influence. 5

Figure 3. Kootenai River ecosystem study area and approximate locations of biomonitoring sites.....6

Figure 4. Location of Vemco VR2 receivers in Kootenai River/Lake system, Idaho and British Columbia, Canada, 2007.....9

Figure 5. 2007 liquid phosphate (10-34-0) additions and Kootenai River flow at Leonia, MT.....10

Figure 6. Mean densities of micro-invertebrates (June-September) from 2002-2007 for the treatment reach sites (KR6 and KR9) and the control site (KR10).....12

Figure 7. Zooplankton densities (rotifers) from June 2002 through August 2007 from the upper Kootenai River at KR6, KR9, and KR10 and river discharge in cubic feet per second (cfs). 13

List of Figures, continued.

Page

Figure 8. Zooplankton densities (crustaceans) from June 2002 through August 2007 from the upper Kootenai River at KR6, KR9, and KR10 and river discharge in cubic feet per second (cfs). 14

Figure 9. Linear regression of Kootenai River discharge at Leonia and rotifer densities from June 2002 through September 2007. 15

Figure 10. Linear regression of Kootenai River discharge at Leonia and crustacean densities from June 2002 through September 2007. 15

Figure 11. Average biomass per unit of effort (BPUE) for all combined species sampled at Kootenai River biomonitoring sites pretreatment and post-treatment with boat electrofishing gear.....18

Figure 12. Average catch per unit of effort (CPUE) for all combined species sampled at Kootenai River biomonitoring sites pretreatment and post-treatment with boat electrofishing gear.....18

LIST OF APPENDICES

Appendix A. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2002 during boat electrofishing at rkm 170-283. Total shocking effort was 6.0 hours. 29

Appendix B. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2003 during boat electrofishing at rkm 170-283. Total shocking effort was 5.9 hours. 30

Appendix C. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2004 during boat electrofishing at rkm 170-283. Total shocking effort was 4.7 hours. 31

Appendix D. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2005 during boat electrofishing at rkm 170-283. Total shocking effort was 6.5 hours. 33

Appendix E. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2006 during boat electrofishing at rkm 170-283. Total shocking effort was 6.1 hours. 34

Appendix F. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2007 during boat electrofishing at rkm 170-283. Total shocking effort was 6.1 hours. 36

ABSTRACT

A large-scale nutrient addition program was implemented on the Kootenai River in July of 2005 to rebuild fisheries by increasing primary production. In 2007, phosphate fertilizer (10-34-0 solution) was added to the river beginning on June 1, at the rate of 0.45 L/min at a river flow of 31,471 cfs to achieve 3.0 µg/L of Total Dissolved Phosphate (TDP). Within three weeks of application, algal growth was apparent on substrates. Phosphate additions stopped on September 30, 2007. As in previous years, nitrate was not added due to adequate levels of nitrate (100 µg/L) throughout the duration of the experiment. Five species of crustaceans and 14 species of rotifers were identified in filtered samples collected in 2007. Mean crustacean densities during the sampling period ranged from 0.07 to 8.30/L. Mean rotifer densities were higher than crustaceans, ranging from 0.28 to 29.43/L. Crustacean and rotifer densities collected from June of 2002 to October of 2007 have shown declining trend in numbers, even in KR10 (the control or nontreatment reach of the nutrient program). It is evident that nutrient additions are not influencing zooplankton numbers or species diversity.

A total of 15 species of fish were identified from the electrofishing samples during 2007. The number of fish species at sites ranged from 8-12 with the highest diversity located in the sample site above Libby Dam near Wardner B.C. There was a notable increase in catch-per-unit-effort (CPUE) and biomass-per-unit-effort (BPUE) from pre- versus post-treatment years within locations directly influenced by nutrient additions (10-20 km downstream of nutrient input). A breakdown by species indicates that these increases in CPUE and BPUE in the nontreatment location were primarily from mountain whitefish *Prosopium williamsoni* and rainbow trout *Oncorhynchus mykiss*, while the increases in the treatment locations were almost exclusively mountain whitefish. Relative weight (Wr) of mountain whitefish and condition factor (K) of largescale suckers was higher at treatment sites than control sites. Rainbow trout Wr, however, decreased at both treatment sites in 2007 and remained lower than for control sites. Mean CPUE of mountain whitefish at each age group in the treatment locations increased from pre- to post-treatment years. Age-2 whitefish at KR6 represented the highest increase in CPUE from 39 to 199 fish/hr following nutrient additions. Similarly, mean total length at capture at the treatment sites increased from pre- to post-treatment. Through an evaluation of desired angler catch rates, a target range of 0.34-0.67 trout/hr was set for the Kootenai River, Idaho. Results of our mountain whitefish telemetry study were not conclusive. Efforts to reduce mortality and verify spawn timing data from the 2004 study were not effective. None of our 25 tagged fish appeared to make spawning movements. All movement was downstream with an average movement of 22 km, and no fish entered tributaries.

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INTRODUCTION

The natural flow and nutrient regimes no longer exist in the Kootenai River system (Figure 1). The ecosystem's most damaging disturbance came with the construction of Libby Dam and the resulting reservoir, Lake Koocanusa. The dam was created under the International Columbia River Treaty between the U.S. and Canada to provide for cooperative water management of the Columbia River Basin (Columbia River Treaty 1964). Construction of Libby Dam began in 1966 by the Army Corps of Engineers. Hydroelectric power production served as the dam's main purpose, while other benefits included flood control and navigation. Impoundment of Lake Koocanusa and regulation of downstream flows began in March of 1972. After completion of the dam, mean monthly flows were reduced by 50% during spring, and tripled during winter. Winter water temperatures also increased by 3°C (Partridge 1983). Turbidity and nutrient loads in the Kootenai River have also decreased due to the impoundment of the Kootenai River.

Lake Koocanusa now acts as a nutrient and sediment trap. According to Woods and Falter (1982), the reservoir retains approximately 63% of the inflowing phosphorus (P) and 25% of the total nitrogen (N). Due to lower current velocities behind the reservoir, these nutrients bind to sediments and fall 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 is considered "nutrient poor" (ultraoligotrophic) and P-limited (Snyder and Minshall 1996; Snyder and Minshall 2001; Holderman and Hardy 2004) causing a reduction in food production that is thought to be a major contributor to poor sport fish production over the past two decades.

The Kootenai Tribe of Idaho (KTOI) and Idaho Department of Fish and Game (IDFG) have implemented a nutrient restoration program on the Kootenai River, Idaho. Native populations of kokanee *Oncorhynchus nerka*, burbot *Lota lota*, interior redband trout *Oncorhynchus mykiss*, mountain whitefish *Prosopium williamsoni* and ESA-listed bull trout *Salvelinus confluentus* and white sturgeon *Acipenser transmontanous* populations are declining in the river. Nutrient restoration to the Kootenai River Idaho may increase native salmonid survival, especially of juvenile recruits for which food may be limiting. Nutrient supplementation may also improve growth rates and condition of these fish, as well as white sturgeon and burbot, if the food base is increased.

Phosphorous is considered a limiting nutrient when levels fall below 1 $\mu g \cdot L^{-1}$ soluble and reactive phosphorous (SRP), or 2-3 $\mu g \cdot L^{-1}$ total dissolved phosphorus (TDP) during the growing season (Ashley and Stockner 2003), or N:P ratios are above 20:1 (Snyder and Minshall 1996). In the nutrient treatment reach, the autotrophic reach of the river that was potentially affected by nutrient additions, (approx. 40 rkm) ambient levels of SRP were below detection limits from July through September (C. Holderman, KTOI, personal communication). According to Ashley and Stockner (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. Therefore, in order to increase productivity in all trophic levels, the target concentration of P was set at 3.0 $\mu g \cdot L^{-1}$. Nitrogen was identified to have the potential to be co-limiting in the Kootenai River as the growing season progresses (Snyder and Minshall 1996). Due to the potential stripping NO_3 from solution by increased primary production, it may be necessary to add a combination of N as well to maintain levels of 30-50 $\mu g \cdot L^{-1}$.

The Kootenai Tribe of Idaho, in partnership with the Idaho Department of Fish and Game (with funding from the Bonneville Power Administration), will add nutrients (nitrogen and phosphorus) to the Kootenai River ecosystem for up to five years. The goal of this project is to enhance native fish populations and river health affected by the construction and operation of

Libby Dam. The nutrients are expected to stimulate production in the Kootenai River's depleted food web and reverse downward trends in fish populations of trout, kokanee, mountain whitefish, burbot, and white sturgeon.

RESEARCH GOAL

1. Restore fish communities in the Idaho reach of the Kootenai River and improve angler-fishing success.

OBJECTIVES

1. Evaluate post-nutrient addition changes in the microinvertebrate and fish community levels of the food web for the 2007 treatment year.

2. Determine migration timing of mountain whitefish to confirm that the timing of our fisheries biomonitoring data collection is accurate.

STUDY AREA

The Kootenai River headwaters originate in Kootenay National Park in southeastern BC, Canada (Figure 1). The river flows southward into Montana where it is impounded by Libby Dam, forming Lake Koocanusa. The river turns westward and flows into the Idaho Panhandle, then northward back into BC to form Kootenay Lake, and finally to its 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 (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 reference (control) sections in Montana and BC.

The Montana and Idaho portions of the Kootenai River below Libby Dam (rkm 352) are 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). As the river flows through the northeast corner of the Idaho Panhandle, there is a gradient transition at Bonners Ferry. 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 with an average gradient of 0.02 m/km. The channel deepens and the river meanders through the Kootenai Valley (rkm 244.5 to rkm 121) until it reaches Kootenay Lake.

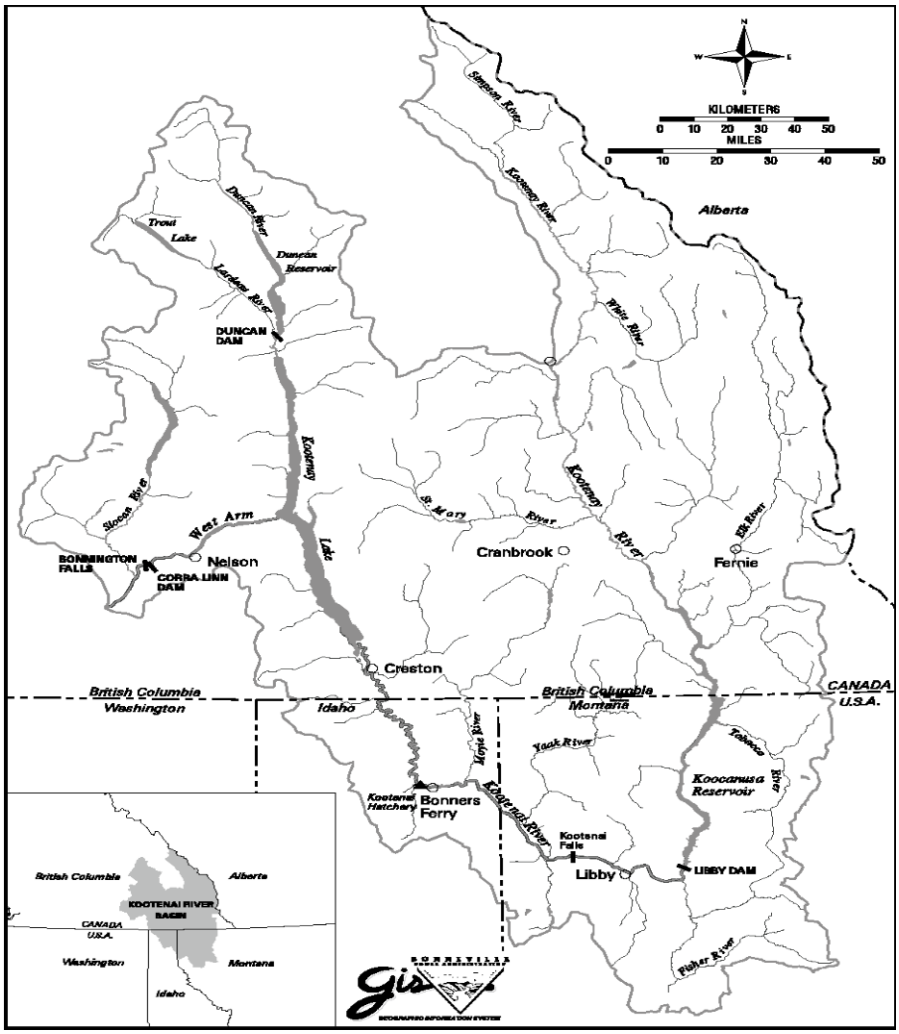

Figure 1. Location of the Kootenai River, Kootenay Lake, Lake Koocanusa, Libby Dam, Bonners Ferry.

Nutrient Addition Location (Site Description)

The nutrient treatment site is near Leonia, Lincoln County, Montana (Figure 2). This site is just north of the Leonia Bridge and east of the Montana/Idaho state border on Kootenai National Forest land. The access road is both on Forest Service and on private property (DLC Incorporated).

The upper canyon section of the Kootenai River is considered a more autotrophic reach and is primarily characterized by boulder and cobble substrates. Added nutrients may best be utilized in an area such as the Leonia site where only P is limited and ambient NO_3 levels may be high enough to stimulate production without becoming co-limited. A few rkm downstream (rkm 266.5), the Hemlock Bar site has been historically sampled at many levels of the food web since the early 1980s, providing adequate baseline information to determine effects of the treatment.

Biomonitoring Locations

In the Kootenai River watershed, six ecosystem biomonitoring sites have been established to gather baseline data pre- and post nutrient restoration (Figure 3). The first site, KR14, is in the southern part of British Columbia near Wardner at rkm 565. This site serves not only as a nontreatment site, but also as a reference site without reservoir influence. The next site downstream, KR10, is below Libby Dam 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 (Figure 3). This site serves as a nontreatment control site below Libby Dam. The next site, KR9, in the canyon section is located at Hemlock Bar (often referred to as the Hemlock Bar site) approximately 18 km downstream at rkm 265. A single site, KR6, is located in the braided canyon section above Bonners Ferry at rkm 250 near the Cow Creek tributary, referred to as the Cow Creek site. The next two sites are located in the meander reach below Bonners Ferry at rkm 230, referred to as the Shortys Island site (KR4), and at rkm 170 near the Canadian border, referred to as the Porthill site (KR2).

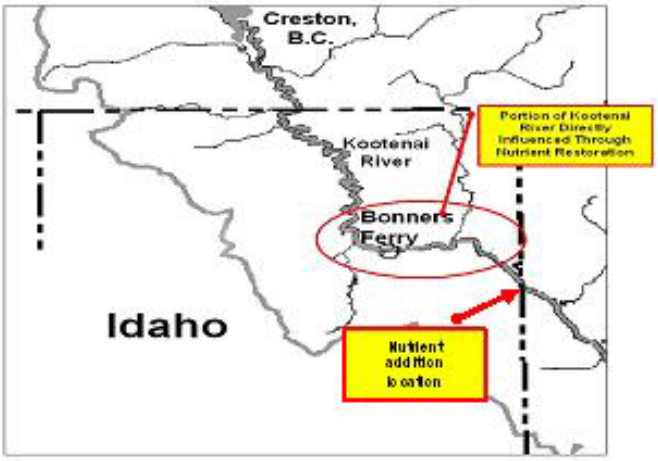

Figure 2. Kootenai River Drainage with location of the nutrient addition and area of influence.

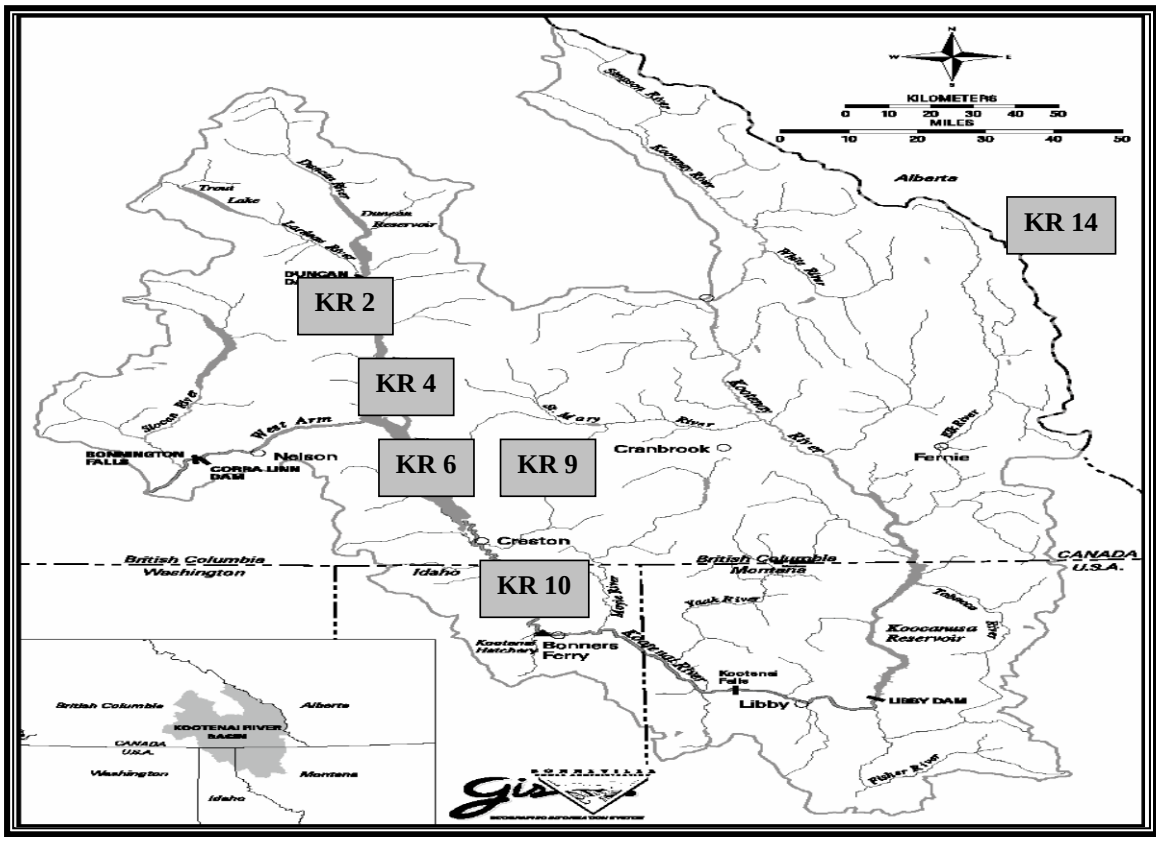

Figure 3. Kootenai River ecosystem study area and approximate locations of biomonitoring sites.

METHODS

Nutrients: Dosing and Measurement

The methods for nutrient dosing and measurement follow the nutrient addition protocols described in the Best Management Plan for Kootenai River Dosing Program (BMP 2006).

Microinvertebrate Abundance

Zooplankton were sampled to determine species abundance and composition and to provide a comparison to baseline data following nutrient addition. Zooplankton were sampled at three biomonitoring sites (KR10, KR9, and KR6) on the Kootenai River from February 2007 through September 2007. Collections were taken once each month from the left, center, and right channel. 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 at approximately 0.3 m below the water's surface (crustaceans and rotifers were assumed to be evenly mixed in a lotic system). Contents were rinsed into 60 ml NALGENE® bottles and preserved with 0.1 ml of Lugol's iodine solution per 1 ml sample volume. Four 1 ml aliquots from each sample were analyzed. Zooplankton were counted and identified to the most specific taxonomic identification of

crustaceans and rotifers. Resulting zooplankton counts from subsamples were then extrapolated to number per liter.

Fish Community Assessment

Species Abundance/Catch and Biomass Rates

In August and September of 2007, the biomonitoring sites were electrofished to identify relative species abundance as catch per unit of effort (CPUE; fish/h), abundance by weight as biomass per unit of effort (BPUE; kg/h), relative weight (Wr), condition (K), and trophic structure. These data were collected to document trends in the fish community over time and will serve as a comparison to pretreatment data for the nutrient enhancement project. Sites were sampled using a 5 m jet boat equipped with a Coffelt VVP-15 electroshocker powered by a 5000 watt Honda generator. Typically, settings were set to generate 6-8 amps at 175-200 volts. Two netters collected all fish species, regardless of size, in order to get a representative sample of the fish community and size structure at each site. To increase replication, each biomonitoring section (left and right shoreline) were 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. Electrofishing was conducted at six biomonitoring sites.

We made a single pass 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 back to a workup station (a convenient, safe spot on the shoreline). At the workup, fish were anesthetized, identified to species, measured (total length in mm), and weighed (g). A subsample of scales from mountain whitefish and rainbow trout were taken at each site (10 fish in each 10 mm class interval) for aging.

Feeding Guilds and Tolerance

All species of fish sampled were classified by feeding guild and relative resistance to habitat disturbances as specified in Zaroban et al. (1999). Feeding guilds assigned were omnivore, invertivore, and invert-piscivore. Omnivores primarily eat plant and animal material (min of 25% each). Invertivores are those species that feed primarily on invertebrate prey, primarily insects. Invert-piscivores consume considerable proportions of fish and invertebrates and typically have an enlarged mouth relative to nonpiscivorous species (Zaroban et al. 1999). Disturbance (natural- or man-caused) or pollution tolerance was classified as follows: sensitive—those species that tend to either disappear or are greatly reduced in association with human disturbances (Karr et al. 1986); tolerant—those species that tend to increase with human disturbances (Zaroban et al. 1999); and intermediate—species that tend to be neither tolerant nor sensitive to disturbance. Disturbances include but are not limited to increased siltation, turbidity, and temperature, or lowered dissolved oxygen (Zaroban et al. 1999). These fish classifications along with other trophic data are to be used in the future to examine changes in feeding guilds following nutrient additions.

Relative Weight (Wr) and Condition Factor (K)

We calculated relative weight (Wr), which compares weights of fish from the Kootenai River to a standard weight developed for each species (Blackwell et al. 2000). Relative weight was calculated using the formula:

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

where W is the fish weight, and Ws is a standard weight for fish of the same length. A Wr of 100 was considered optimal. Relative weight was calculated for rainbow trout and mountain whitefish (species Ws taken from Anderson and Neumann 1996). Minimum total lengths to calculate Ws were 120 mm for rainbow trout and 140 mm for mountain whitefish (Parker et al. 1995; Rogers et al. 1996; Simpkins and Hubert 1996). Statistical differences in condition and relative weights will be tested in future years to detect pre- vs. post-treatment differences by using one-way ANOVA.

We used Fulton's condition factor (K) as a measure to gauge changes in body form of largescale sucker since an accepted standard weight is not available at this time. K is the ratio between the observed weight and an expected weight dependent on the fish's length (Fulton 1904; Blackwell et al. 2000). Fulton's condition factor was calculated using the following formula:

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

where W is the weight of the fish in g, L is the length in mm, and 10^5 is a constant used for scaling purposes. A condition of 1 represents optimal growth.

Age and Growth

Rainbow trout and mountain whitefish scales were impressed onto cellulose acetate slides and viewed on a microfiche reader at 42X magnification. Each annulus was enumerated at the leading edge of the compressed rings indicating a single year of growth. For pre- versus post-treatment data, only length at age for zero- to 4-year-old fish were included, due to the difficulty and variability in aging older fish using scales.

Mountain Whitefish Movement

We conducted a telemetry study in 2004 to determine spawning movement timing and evaluate the timing of our biomonitoring (Hardy 2007). An initial attempt to tag fish resulted in mortality of all fish held overnight, including two control fish that were not tagged. After a change to the holding pens was made, tagging efforts were successful. Only two out of the 25 fish tagged in 2004 made spawning movements into tributaries. These two fish remained at the same location from July through October, when they made upstream movements of 9.6 and 28.6 km. After these movements, the fish returned to their previous locations. There is some evidence that fish may be both mainstem and tributary spawners. In order to verify findings from the 2004 study, we initiated a similar study in 2007. As a result of the high rate of mortality in 2004, efforts were made to utilize multiple capture methods including trap nets, angling, and electrofishing, and to hold both tagged and untagged fish. Sampling occurred in July in the evening and after sunset, fish were held overnight, and tagged the following morning. Tagging protocols and surgery procedures were conducted as described by Downs (2000). We used a series of five net pens to reduce crowding.

A total of 25 fish were tagged with Vemco 81.0 kHz coded acoustic transmitters with a ping rate of 60 seconds. The batteries were expected to last 300 days. Fish were tracked using a series of 33 stationary Vemco VR2 receivers located throughout the Kootenai River (Figure 4). Data was downloaded from the receivers at the end of the study period.

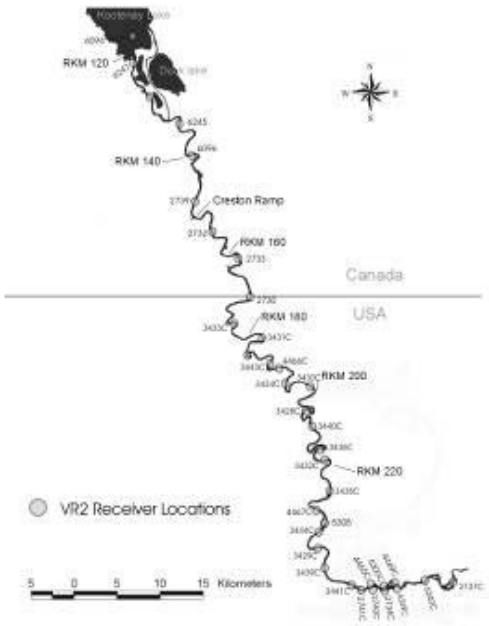

Figure 4. Location of Vemco VR2 receivers in Kootenai River/Lake system, Idaho and British Columbia, Canada, 2007.

RESULTS

Nutrient Additions

Phosphate fertilizer (10-34-0 solution) was added to the river starting on June 1, 2007 at the rate of 0.45 L/min and at a river flow of 31,471 cfs (Figure 5). At this concentration, additions were to achieve 3.0 µg/L of Total Dissolved Phosphate (TDP). Nitrate was not added due to adequate levels of nitrate (100 µg/L) throughout the duration of the experiment (water quality data available from KTOI; C. Holderman, personal communication). Phosphate additions stopped on September 30, 2007. Approximately 67,135 L (17,735 gallons) of phosphate was utilized through the 120-day growing season. Lower flows and increased photic zone allowed us to begin adding nutrients earlier than in 2006. In the 2007 season, Kootenai River water quality samples indicated that N:P ratio remained above 20:1 (for values contact KTOI; C. Holderman) for the entire season, the minimum concentration needed before having to add nitrogen.

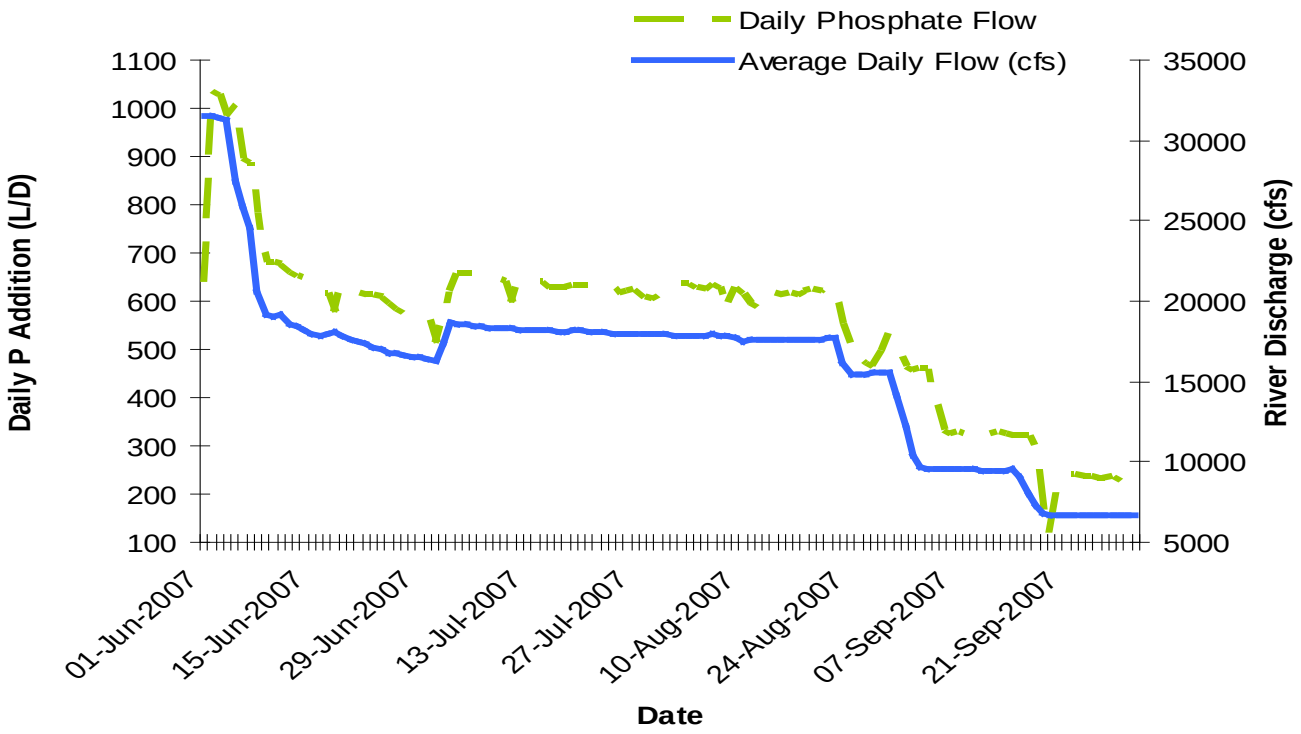

Figure 5. 2007 liquid phosphate (10-34-0) additions and Kootenai River flow at Leonia, MT.

Microinvertebrate Abundance

Five species of crustaceans and 16 species of rotifers were identified in the filtered samples (n = 72) collected in 2007. Mean monthly crustacean densities through the sampling period ranged from 0.36 to 32.96/L (standard error [SE] ± 0 – 220.35, respectively). Mean monthly rotifer numbers averaged between 0.20.2–41.67/L (SE ± 0–119.89), respectively. In terms of site-specific differences, we saw lower densities of crustaceans at sites KR 6 and KR9 than at KR10; however, rotifer densities were higher at KR6 and KR9 than KR10. Crustacean density decreased after 2003 and remained relatively flat through 2007 in the treatment reach and at the control site (KR10; Figure 6). Rotifer densities in collections from June of 2002 to September 2007 have shown a general trend of decreasing numbers even in KR10 (Figure 6). Mean crustacean proportion was dominated by the subclass Copepoda (*Nauplii, Cyclopoid copepodite,* and *Harpacticoidea Bryocamptus*) along with small proportions from the subclass Cladocera *(Bosmina longirostris* and *Calanoid copepodite*). Proportions of these species were consistent among the three sites (KR6, KR9, and KR10). Mean rotifer proportions at all sites were dominated by four main species: *Keratella cochlearis, Rotifer* unidentifiable (contracted), *Kellicottia longispina,* and *Polyarthra remata, and Polyartha major.* Similar proportions of the same species were represented at all three of the sites.

Through the experimental period, peak rotifer numbers coincided with increased flow through Libby Dam (Figure 7). The 2007 peaks of rotifer densities were significantly lower in comparison to 2002-2004 spring events. Rotifer density was not significantly correlated with

river flows (P = 0.622, R^2 = 0.005; Figure 9). In 2007, contrary to other years, crustacean numbers peaked with peaks in flows (Figure 8). Crustacean numbers were loosely correlated with river flows (P = 0.001, R^2 = 0.199; Figure 10).

Fish Community Assessment

Species Diversity

Fifteen species of fish were identified from the electrofishing samples during 2007. Species diversity between sites ranged from 7-12 with the highest diversity located at KR14, above Libby Dam. Species diversity did not change from the previous year with the addition of nutrients during the 2007 season. Three of the species (northern pikeminnow *Ptychocheilus oregonensis*, mountain whitefish *Prosopium williamsoni*, and largescale sucker *Catostomus macrocheilus*) that are relatively tolerant or intermediately tolerant to habitat disturbances were found at all of the biomonitoring locations (Table 1). Although burbot and white sturgeon are known to be present in small numbers, only three burbot (all at KR14) and no white sturgeon were sampled in our index sites.

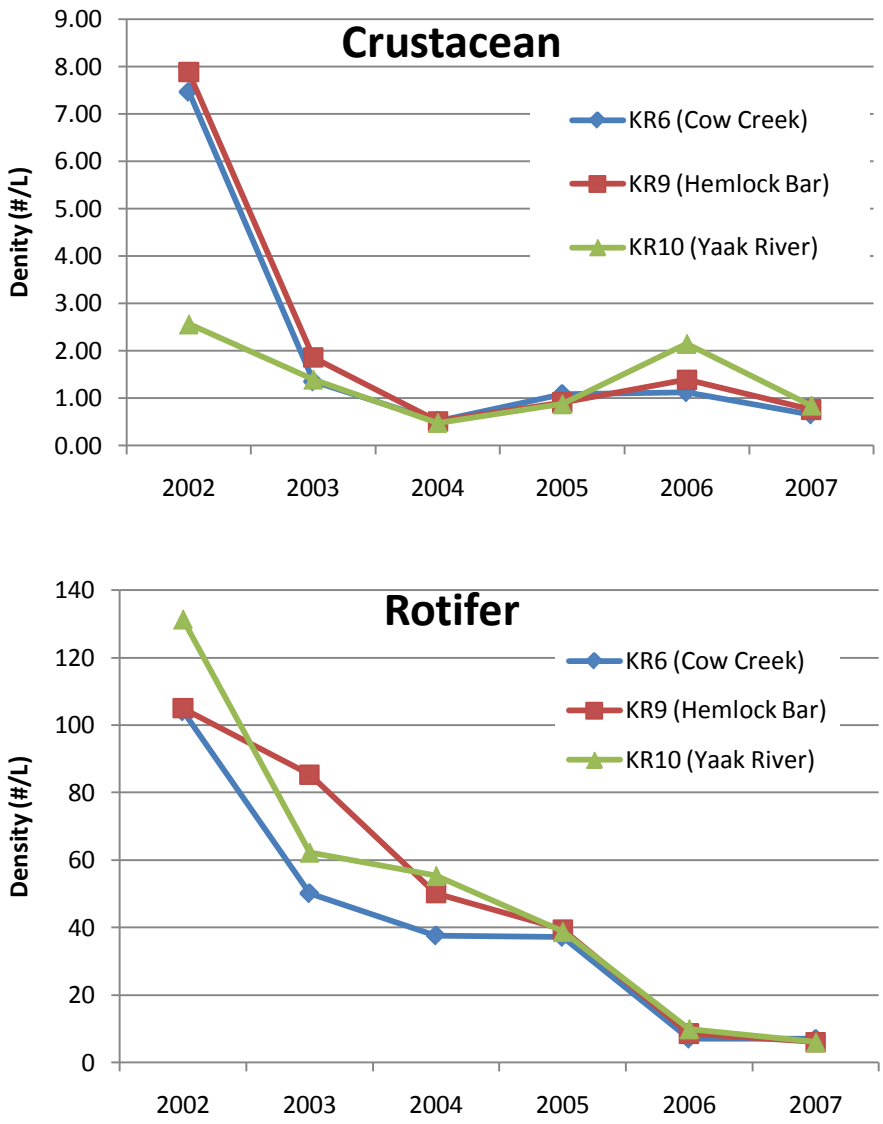

Figure 6. Mean densities of micro-invertebrates (June-September) from 2002-2007 for the treatment reach sites (KR6 and KR9) and the control site (KR10).

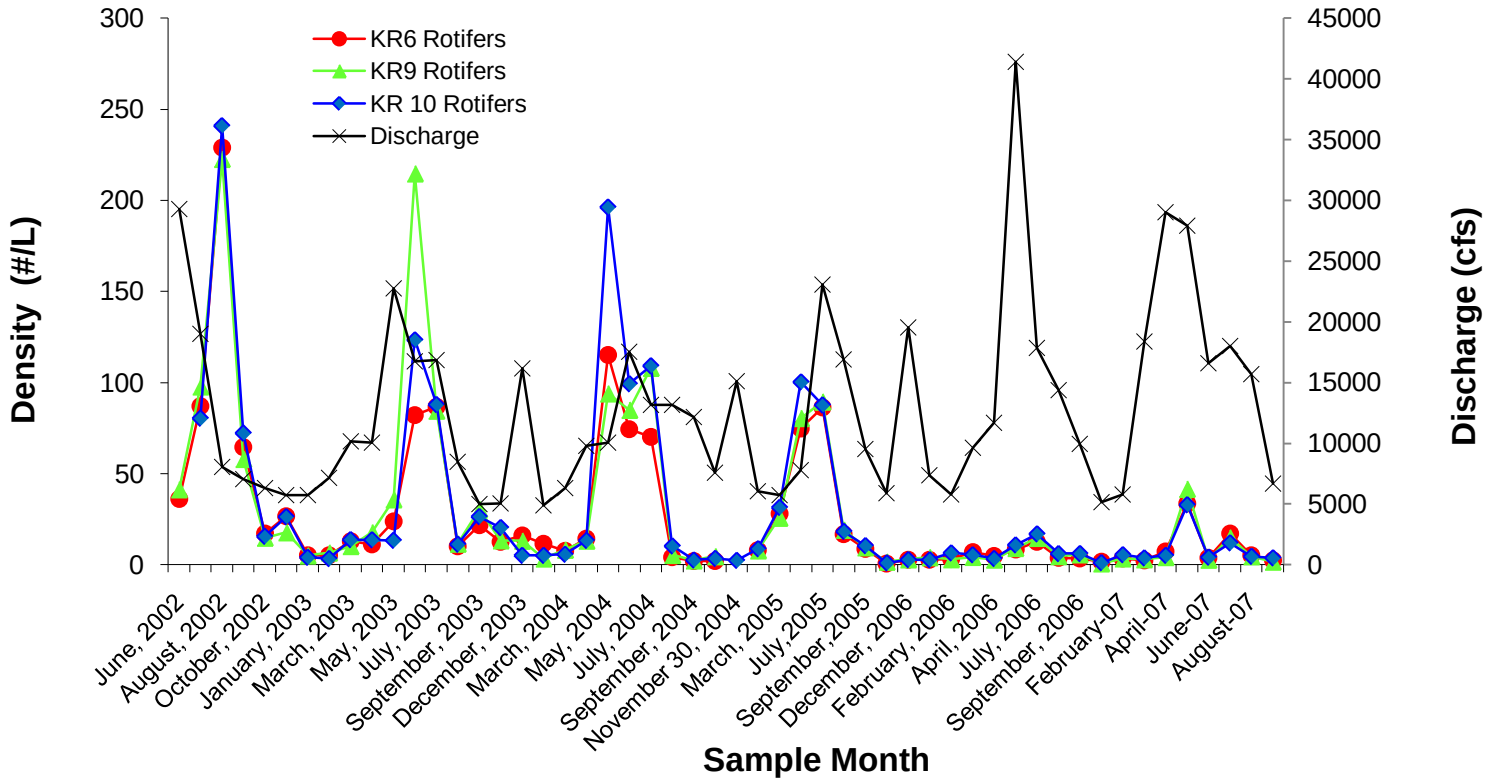

Figure 7. Zooplankton densities (rotifers) from June 2002 through August 2007 from the upper Kootenai River at KR6, KR9, and KR10 and river discharge in cubic feet per second (cfs).

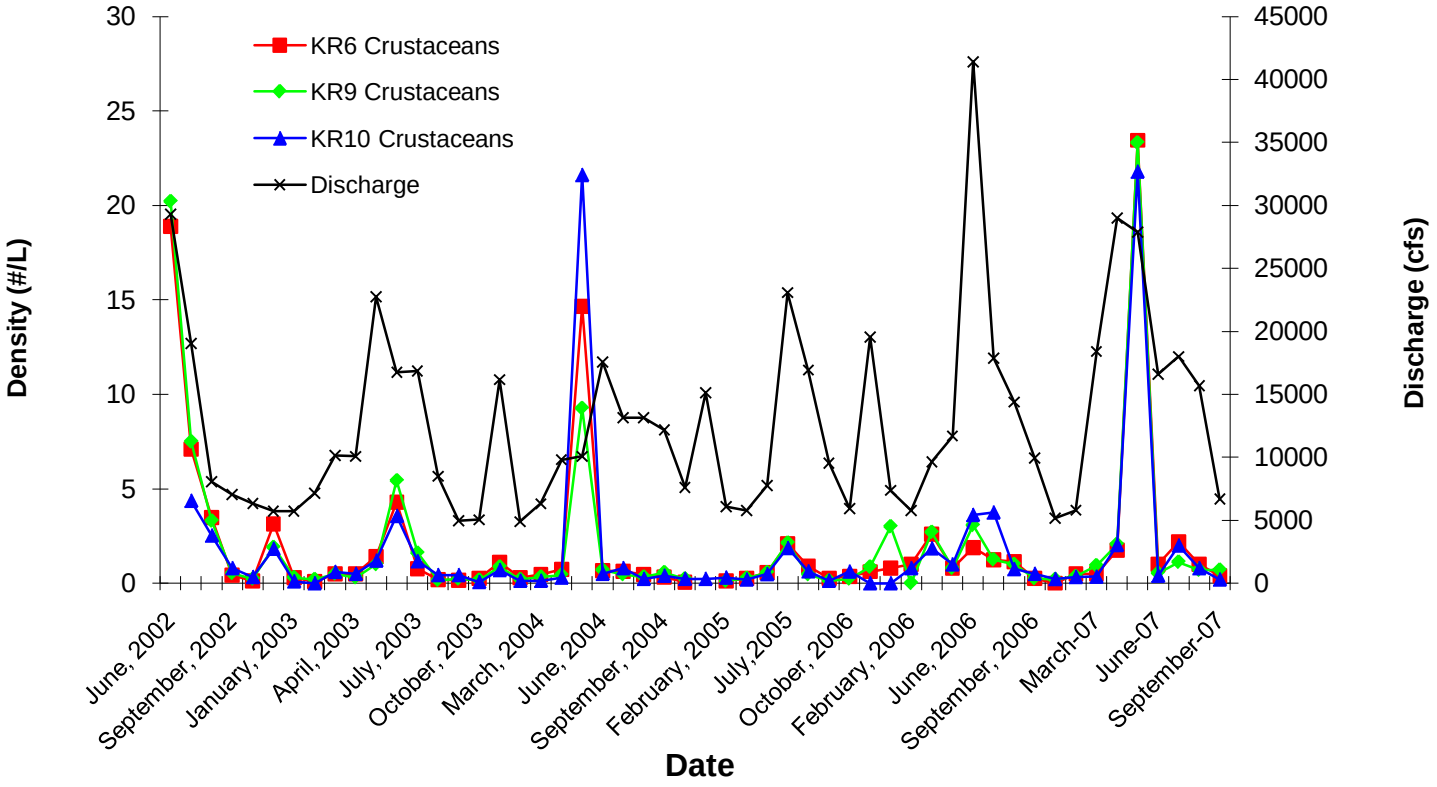

Figure 8. Zooplankton densities (crustaceans) from June 2002 through August 2007 from the upper Kootenai River at KR6, KR9, and KR10 and river discharge in cubic feet per second (cfs).

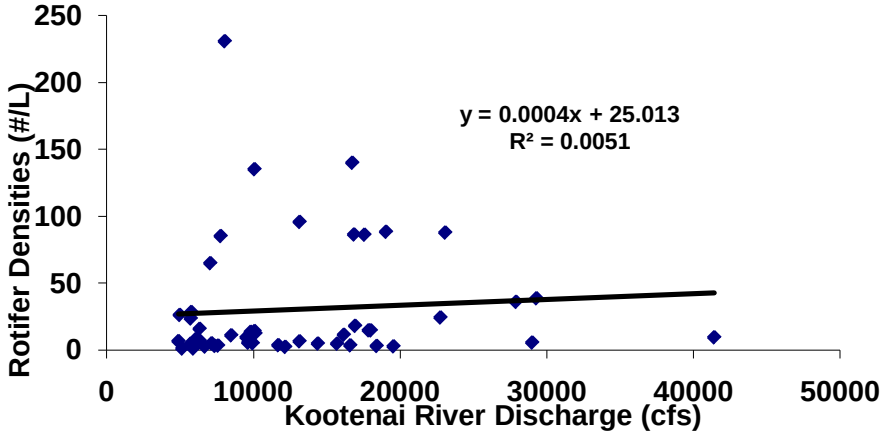

Figure 9. Linear regression of Kootenai River discharge at Leonia and rotifer densities from June 2002 through September 2007.

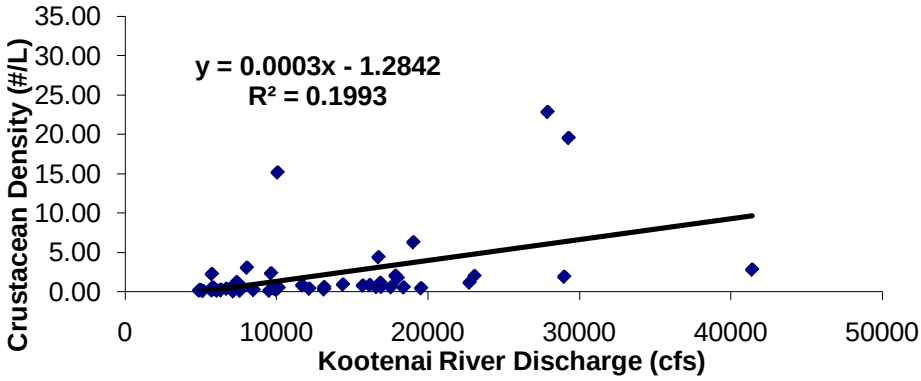

Figure 10. Linear regression of Kootenai River discharge at Leonia and crustacean densities from June 2002 through September 2007.

Catch and Biomass Rates

Total CPUE and BPUE across all species varied among sites and between pre- and post-treatment years (Figures 11 and 12). Total effort ranged from 0.61 h to 1.61 h per site. The highest total CPUE in 2007 across all species was recorded at KR6 approximately 20 rkm downstream of the nutrient release location at 708 fish/h (Table 2). The highest BPUE (128 kg/h) in 2007 was also recorded at KR6 (Table 2). Breakdown of CPUE and BPUE by species are located in Appendices A-F.

There was a notable increase in CPUE and BPUE from pre- to post-treatment years within those locations directly influenced by nutrient additions (KR6 and KR9; Table 2). However, this same increasing trend was seen in one of the two nontreatment reaches approximately 10 rkm above the nutrient injection location (KR10). A breakdown by species indicates that these increases in CPUE and BPUE in the nontreatment location (KR10) were primarily due to increases in mountain whitefish and rainbow trout, while the increases in the treatment locations (KR6 and KR9) were almost exclusively mountain whitefish (Appendices A-F).

Catch and biomass showed a decreasing trend at the Shortys Island reach approximately 40 rkm below the treatment location (KR4). The primary species that makes up this decline is peamouth chub *Mylocheilus caurinus* (Appendices A-F).

Relative Weight (Wr) and Condition Factor (K)

With the exception of rainbow trout sampled from Wardner B.C. (KR14) and mountain whitefish sampled from the Cow Creek site (KR6), relative weights in 2007 for rainbow trout and mountain whitefish (all size classes) declined from upper to lower sites (KR10, KR9, and KR6 respectively; Table 3). Relative weight of mountain whitefish and condition factor of largescale suckers was higher at treatment locations than control locations in 2007 (Table 3). Mountain whitefish Wr decreased at KR9 and increased slightly at KR6.

Age and Growth

Mean CPUE of mountain whitefish at each age group was highest in treatment locations sampled as compared to the nontreatment sites (Table 4). Similarly, mean total length at capture was slightly higher in treated sites than nontreated sites (Table 5). Age-2 whitefish at KR6 represented the highest increase in CPUE from 39 to 199 fish/hr following nutrient additions.

Table 1. Species sampled at Kootenai River biomonitoring sites in September 2007 with boat electrofishing gear. IN = Invertivore; I-P = Invert-Piscivore; O = Omnivore; P = Piscivore (describes feeding guild). I = Intolerant; T = Tolerant; S = Sensitive (describes response to habitat perturbations; Zaroban et al. 1999).

	Sample location							
Species	**KR14**	**KR10**	**KR9**	**KR6**	**KR4**	**KR2**	**Feeding guild**	**Tolerance**
Brown Bullhead *Ameiurus nebulosus*						X	I-P	T
Brown trout *Salmo trutta*		X	X	X			I-P	I
Bull trout *Salvelinus confluentus*	X						I-P	S
Largescale sucker *Catostomus macrocheilus*	X	X	X	X	X	X	O	T
Longnose dace *Rhinichthys cataractae*	X		X				IN	I
Longnose sucker *Catostomus catostomus*	X				X	X	IN	I
Mountain whitefish *Prosopium williamsoni*	X	X	X	X	X	X	IN	I
Northern pikeminnow *Ptychocheilus oregonensis*	X	X	X	X	X	X	I-P	T
Peamouth chub *Mylocheilus caurinus*	X	X	X		X	X	IN	I
Rainbow trout *O. mykiss*	X	X	X	X	X		I-P	S
Redside shiner *Richardsonius balteatus*	X	X	X		X	X	IN	I
Torrent sculpin *Cottus rhotheus*	X	X	X	X	X	X	I-P	I
Westslope cutthroat trout *O. clarkii lewisi*	X	X					I-P	S
Total number of species	**11**	**9**	**9**	**6**	**8**	**8**		

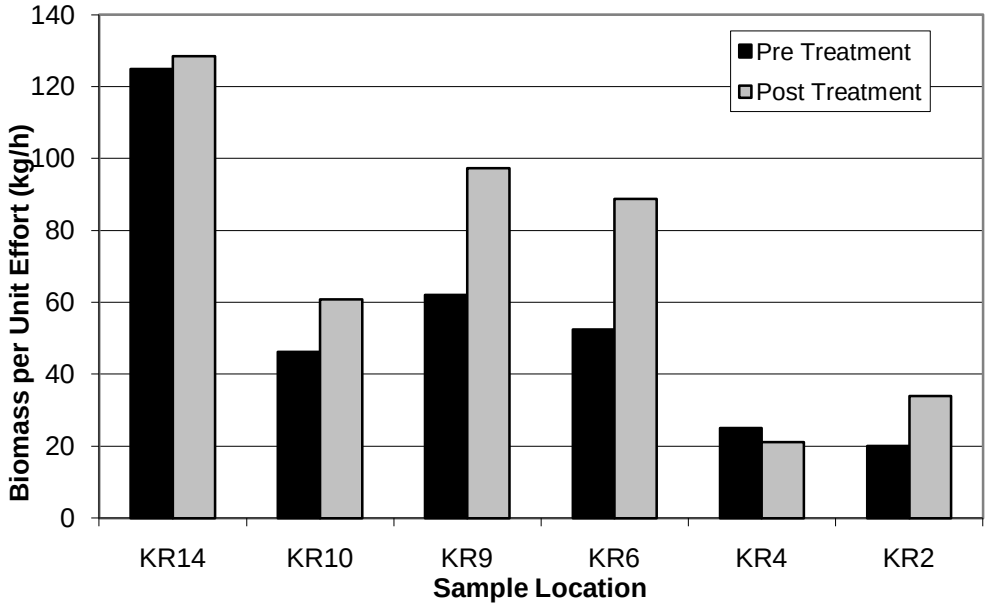

Figure 11. Average biomass per unit of effort (BPUE) for all combined species sampled at Kootenai River biomonitoring sites pretreatment and post-treatment with boat electrofishing gear.

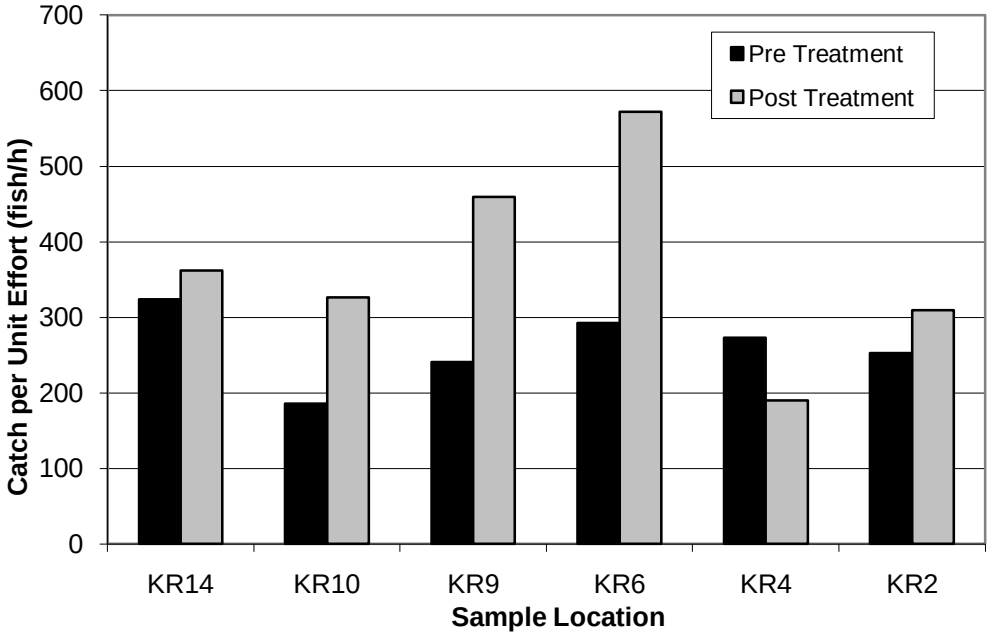

Figure 12. Average catch per unit of effort (CPUE) for all combined species sampled at Kootenai River biomonitoring sites pretreatment and post-treatment with boat electrofishing gear.

Table 2. Catch Per Unit of Effort (CPUE; fish/h) and Biomass Per Unit of Effort (BPUE; kg/hr) for species sampled at Kootenai River biomonitoring sites in the fall (September) from 2002 through 2007 with boat electrofishing gear. Shaded cells indicate those areas sampled upstream of the treatment influence and therefore considered control locations.

		Pretreatment				Post-Treatment	
Site	**Response Variable**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
	CPUE			459	189	292	287
KR14	BPUE			145	105	136	96
	CPUE	144	159	158	282	340	204
KR10	BPUE	35	37	41	72	66	37
	CPUE	265	213	182	305	356	342
KR9	BPUE	58	56	56	78	77	90
	CPUE	312	267	303	287	459	708
KR6	BPUE	43	53	51	63	68	128
	CPUE	190	367	315	219	284	168
KR4	BPUE	31	24	26	19	16	17
	CPUE	210	251	341	209	418	352
KR2	BPUE	18	25	19	18	40	38

Table 3. Mean relative weights (Wr) and Fulton's condition factor (K) of key species sampled at Kootenai River biomonitoring sites in September 2002-2007 with boat electrofishing gear. Shaded sections indicate nontreatment locations. SE = ± 1 standard error.

Mountain Whitefish				Largescale Sucker				Rainbow Trout			
Site	**Year**	**Mean Wr**	**SE**	**Site**	**Year**	**Mean K**	**SE**	**Site**	**Year**	**Mean Wr**	**SE**
KR14	2004	85.1	2.3	KR14	2004	0.98	0.03	KR14	2004	81.2	0.0
	2005	84.2	2.3		2005	0.86	0.02		2005	83.1	6.0
	2006	83.9	0.9		2006	0.92	0.01		2006	81.1	0.0
	2007	80.2	1.0		2007	0.90	0.01		2007	88.5	0.0
KR10	2002	92.6	2.0	KR10	2002	0.93	0.04	KR10	2002	93.2	2.0
	2003	95.4	1.8		2003	0.94	0.02		2003	93.4	1.8
	2004	91.8	0.7		2004	0.93	0.01		2004	85.6	0.4
	2005	91.6	1.3		2005	0.97	0.02		2005	89.2	1.8
	2006	89.4	0.7		2006	0.97	0.04		2006	89.7	1.6
	2007	84.9	0.6		2007	0.98	0.3		2007	89.6	0.8
KR9	2002	83.8	1.6	KR9	2002	0.86	0.03	KR9	2002	91.3	2.2
	2003	90.3	1.2		2003	0.86	0.03		2003	90.8	2.0
	2004	88.0	5.1		2004	0.86	0.01		2004	87.6	1.7
	2005	92.3	1.1		2005	0.91	0.02		2005	88.6	0.9
	2006	93.3	0.7		2006	1.03	0.03		2006	96.5	0.7
	2007	90.1	0.6		2007	0.99	0.02		2007	86.7	0.4
KR6	2002	79.1	1.1	KR6	2002	0.81	0.02	KR6	2002	86.0	3.6
	2003	82.0	4.3		2003	0.83	0.01		2003	90.0	0.0
	2004	82.2	2.1		2004	0.93	0.05		2004	84.7	1.1
	2005	79.7	1.7		2005	0.87	0.01		2005	79.1	3.8
	2006	86.4	1.0		2006	0.98	0.02		2006	91.2	2.8
	2007	87.1	0.7		2007	0.99	0.02		2007	82.8	1.5

Table 4. Comparison of catch per unit of effort in pre- and post-treatment years of mountain whitefish by age class. Shaded sections indicate nontreatment locations. CPUE for pretreatment years are a mean from 2002-2005 sample years. CPUE for post-treatment represents 2006 and 2007 sample year means.

		CPUE at Age				
Site	**Year**	**0**	**1**	**2**	**3**	**4**
KR10	Pre	3	10	16	20	13
	Post	4	12	32	47	41
KR9	Pre	4	14	17	16	22
	Post	9	38	56	76	81
KR6	Pre	15	47	39	27	26
	Post	45	82	199	78	56

Table 5. Comparison of mean total length (TL) at time of capture in pre- and post-treatment years of mountain whitefish by age class. Shaded sections indicate nontreatment locations. Length at age for pre treatment years are a mean from 2002-2005 sample years. Length at age for post-treatment represents 2006 and 2007 sample 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	-	190	233	263	295
	Post	114	201	241	272	312
KR10	Pre	115	203	241	269	304
	Post	115	187	236	279	316

Mountain Whitefish Movement

Efforts to reduce tagging mortality and verify spawn timing data from the 2004 study were not effective. None of the 25 tagged fish made what we considered spawning movements. All movement was downstream with an average movement of 22 km, and no fish entered tributaries. The average length of time that fish were detected was just 24 days. Nearly half of the fish detected (11 out of 21) did not move at all from the tagging location. The largest downstream movement was 58 km. This fish consistently moved downstream and then was not detected after 7 days so it was presumed dead.

DISCUSSION

Nutrient Additions

The nutrient delivery system design and operation performed very well for the 2005-2006 and 2006-2007 season. The addition of the mechanical pumps installed by Ward and

Associates as well as a pole-barn roof over the holding tanks (both before the 2006 season) greatly reduced oscillations in flow (primarily caused by increases in air temperature). We recommend this type of pumping system to avoid errors that can compromise permitting requirements. Stipulations laid out by the National Pollutant Discharge Elimination System (NPDES) permit issued by the EPA allowed us to have river water to nutrient dilution ratio of 53 million:one. Our operation stayed well within this boundary because of the precise measuring equipment utilized and installed by Ward and Associates. Nitrate nitrogen in the form of 32-0-0 solution was kept on hand but not added, since ambient nitrogen in the river was adequate throughout the two growing seasons to grow the proper species of algae. Following protocol described in Ashley and Stockner (2003), should ambient nitrogen have slipped below 60 µg/L, nitrogen would have been added to keep the river's N:P ratio above the 20:1 level, reducing the risk of problematic algal blooms. Additional operational management details of the site are located in the Best Management Plan for Kootenai River Dosing System (BMP 2006).

Although not described in detail in this report, nutrient uptake within the first two river kilometers was very rapid as indicated by low nutrient detection past two rkm. Although orthophosphate fell below detection limits within such a short period, increased algal growth was seen as far as Bonners Ferry (25 rkm from the addition site; KTOI; C. Holderman, communication). Additional results and discussion on nutrient uptake through lower trophic levels are available from KTOI.

Microinvertebrate Abundance

Zooplankton abundance in the upper treated as well as the nontreated sample locations generally experienced declines since the start of the nutrient additions. Prior to the beginning of the experiment, the objective was to determine if nutrients could increase this level of the food web, despite the challenges in a lotic environment. In addition to factors affecting zooplankton in lentic environments (i.e. light, nutrients, predation, and competition), the hydrological regime, especially discharge and water residence time, play more important roles (Basu and Pick 1997). In 2007, upper Kootenai River (canyon reach) zooplankton numbers were the second lowest on average recorded since this program began. In a more natural river state, zooplankton numbers typically increase (at least immature stages) during the most productive months of June through August. Saunders and Lewis (1988) reported zooplankton densities fell to very low levels in the Caura River, Venezuela during peak discharges, yet densities increased sharply at the tail end of the flow in winter (late June and early July). Much of the "true" plankton in large river systems originates in backwater sloughs, side channels, or other gently flowing areas (Hynes 1970). If the retention time of a stream or lake is short, (just as we see in the upper Kootenai River), then little plankton may develop (Hynes 1970). Seasonal fluctuations in river level regulate the development of source areas suitable for zooplankton growth and control the export of plankton from the source areas (Saunders and Lewis 1988). It is evident that nutrient additions are not increasing zooplankton numbers or species diversity. It is much more plausible at this time to relate the fluctuations in density with river discharge and zooplankton levels in Lake Koocanusa, although it is difficult to directly correlate these two factors since many other mountain lake and stream systems drain into the Kootenai after the dam and above the current sample locations.

Fish Community Assessment

Substantial changes in fish abundance and assemblage have occurred in the Kootenai River since the construction of Libby Dam (Paragamian 2002). In addition to major habitat changes as a result of Libby Dam operations, it is likely that the reduction in river productivity has reduced fish numbers through lower food abundance (i.e. insect densities; for examples see

Hardy 2003). With the implementation of the nutrient addition program, it was evident that just a minute addition of nutrients was sufficient to show an increase in catch and biomass per unit of effort of mountain whitefish in the treated reaches of the river. However, we should not attribute the increase in mountain whitefish density exclusively to nutrients until a few more seasons of fertilization have passed. Although it is possible that CPUE increased as a result of better overwinter survival or due to an attraction to higher food abundance, we did not expect to see an increase in the density of fish until they have had a chance to spawn and fully recruit to the sampling gear (approx. 2 years of age for mountain whitefish and later for rainbow trout). Our nontreatment location experienced similar increases in total CPUE as were seen in treated reaches. This could be indicative of strong year classes because of other environmental factors (temperature, river flows, etc.) acting independently of nutrients.

According to Walters (2002), rainbow trout recruitment in these sections of the upper canyon reach may be limited by habitat and by low river productivity. Some positive effects on the rainbow trout population have become evident. Rainbow trout CPUE and BPUE at the treatment site at rkm 250 has increased from pre- to post-treatment, whereas CPUE and BPUE have remained virtually unchanged at the rkm 265 treatment site. Although other factors such as reduced spawning habitat may play a factor in reduced trout abundance, we anticipate continuing increases in rainbow trout in the next few seasons of additions (assuming no other limiting factors preclude this). It took several seasons of nutrient additions until an increase in density and biomass was evident in rainbow trout populations following nutrient additions to Big Silver and Adams Creek in B.C., Canada (Slaney et al. 1993; Toth et al. 1993).

The decreasing overall catch and biomass at KR4 is attributed to an increase in aquatic macrophyte production. Macrophyte growth has made it difficult to sample fish, as they often cannot be seen through the thick vegetation.

Relative weight of mountain whitefish as well as condition of largescale sucker populations in the 2007 season remained fairly consistent with 2006 values below the treatment location. Although these measures were still at relatively suboptimal levels in relation to other populations, we expect these to continue to increase with continued nutrient additions in the future. Low relative weights may be indicative of a paucity of suitable prey items (Blackwell et al. 2000). Fish in relatively good condition should be able to utilize more energy for gamete production than fish that are in poor condition. Significant positive correlations between the percentage of mature eggs and fish biomass and Wr have been reported in numerous studies (Wege and Anderson 1978; Neumann and Murphy 1992; Neumann and Willis 1995). Mean relative weight of rainbow trout actually decreased in the 2007 sample. The low numbers of rainbow trout in samples may not allow us to draw any substantial conclusions about their relative weight; however, we speculate that the same factors driving body growth for the other fishes are influencing rainbow trout as well at this time.

Mean length at age of capture showed that there were notable increases in mean length of mountain whitefish pre- versus post-treatment at both 10 rkm and 20 rkm below the treatment locations. In addition to this, CPUE by age group shows that in 2007, as in 2006, there was a significant increase in the number of 2-year-old fish in the catch (especially 20 rkm below [rkm 250] the treatment location). The increased density of 2-year-old fish is likely a result of nutrient additions increasing overwinter survival of young of year whitefish already in the system at the time of fertilization. The age and growth data for mountain whitefish was similar to that reported by Walters (2002). Mean whitefish ages reported in 1980, 1981, and 1982 by Partridge (1983) were higher. This may be indicative of a reduction in productivity in the Idaho portion of the river over the last two decades. There is some evidence that length at age for rainbow trout is

increasing from pre- to post-treatment years, particularly for age-1 fish. There is no data available on years before or near the construction of Libby Dam, so we are left speculating on what adequate length at age should be for the Kootenai River. Bennett and Underwood (1988) reported substantially higher growth of rainbow trout in the Spokane River. Mean age-1 fish ranged from 134-153 mm, whereas mean age-1 fish in the Kootenai ranged from 89-101 mm. These differences were also reported by Paragamian (1995). This information coincides with system productivity where the Spokane River has exhibited macroinvertebrate densities as high as 60,000 insects/ m^2 (Kadlec 2000) as compared to the Kootenai River's 900 insects/m^2 most recently reported by Holderman and Hardy (2004).

Mountain Whitefish Movement

Radio tracking of mountain whitefish in the fall of 2004 provided valuable information on spawn timing in relation to temperature and river discharge, but we were unable to verify this in 2007. None of our 25 tagged fish made what could be considered spawning migrations and nearly all fish appear to have died within two weeks of tagging. Other telemetry studies on whitefish have indicated high mortality rates associated with tagging (Fleming 1995; D. Garren, IDFG, personal communication). In 2004, one fish entered the Moyie River, and observation has indicated that spawning does occur in this tributary (Hardy 2007). It may be useful to monitor this tributary or install a weir to determine spawn timing and the peak of movement.

RECOMMENDATIONS

1. Continue adding nutrients in the form of liquid P and N (if needed) fertilizer to restore river productivity.

2. Continue to sample biomonitoring sites

3. Conduct a population estimate in the Hemlock Bar reach in 2008.

4. Perform additional creel surveys on the Kootenai River in the future to assess how nutrient addition is indirectly affecting angler catch rates.

5. Discontinue zooplankton sampling for density and abundance due to no effect from nutrient additions.

ACKNOWLEDGEMENTS

Thanks go to the following people that took part in all of the sampling effort: Charlie Holderman and crew (KTOI); Genny Hoyle (KTOI); Jim Dunnigan and crew (MFWP); Jody Walters, Pete Rust, Corie Laude, Kirk Handley (IDFG); Greg Hoffman (ACOE); and to reviewers Ryan Hardy and Martin Koenig (IDFG). Finally, thanks goes to Vaughn Paragamian for continued guidance and Cheryl Zink (IDFG) for preparing the report for printing.

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APPENDICES

Appendix A. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2002 during boat electrofishing at rkm 170-283. Total shocking effort was 6.0 hours.

Site	Species	Count	% of total	CPUE	Kg	% of total	BPUE	Mean Wt	Effort
283	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
	Grand Total	**189**	**100**	**144**	**46**	**100.00**	**35**		**1.31**
265	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
	SCULPIN	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
	Grand Total	**191**	**100**	**265**	**42**	**100**	**58**		**0.72**
250	BRNT	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
	Grand Total	**272**	**100**	**312**	**33**	**100**	**43**		**0.73**
230	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
	Grand Total	**318**	**100**	**190**	**51**	**100**	**31**		**1.67**
170	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
	SCULPIN	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
	Grand Total	**321**	**100**	**210**	**28**	**100**	**18**		**1.53**

Appendix B. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2003 during boat electrofishing at rkm 170-283. Total shocking effort was 5.9 hours.

RKM	Species	Count	% of total	CPUE	Kg	% of total	BPUE	Mean Wt	Effort
283	BLT	1.00	0.41	0.66	4.75	8.52	3.13	4750	1.52
	LNS	6.00	2.48	3.95	0.68	1.22	0.45	114	1.52
	LSS	35.00	14.46	23.03	16.76	30.05	11.03	479	1.52
	MWF	128.00	52.89	84.21	24.20	43.39	15.92	189	1.52
	NPM	14.00	5.79	9.21	1.54	2.75	1.01	110	1.52
	RBT	31.00	12.81	20.39	6.47	11.60	4.25	209	1.52
	RSS	25.00	10.33	16.45	0.34	0.60	0.22	13	1.52
	WCT	2.00	0.83	1.32	1.05	1.88	0.69	523	1.52
	Grand Total	**242**	**100**	**159**	**56**	**100**	**37**		**1.52**
265	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
	Grand Total	**167.00**	**100.00**	**212.66**	**43.66**	**100.00**	**55.60**		**0.79**
250	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
	Grand Total	**165**	**100**	**267**	**33**	**100**	**53**		**0.62**
230	BLT	1.00	0.20	0.72	0.07	0.20	0.05	67	1.39
	LNS	13.00	2.55	9.36	2.37	7.20	1.71	183	1.39
	LSS	74.00	14.51	53.26	15.72	47.68	11.31	212	1.39
	MWF	28.00	5.49	20.15	0.37	1.11	0.26	13	1.39
	NPM	196.00	38.43	141.06	6.78	20.57	4.88	35	1.39
	PEA	97.00	19.02	69.81	5.45	16.53	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	0.59	0.14	98	1.39
	RSS	92.00	18.04	66.21	0.80	2.42	0.58	9	1.39
	SCULPIN	1.00	0.20	0.72	0.00	0.01	0.00	4	1.39
	WCT	3.00	0.59	2.16	1.17	3.55	0.84	390	1.39
	Y.PERCH	1.00	0.20	0.72	0.02	0.05	0.01	17	1.39
	Grand Total	**510**	**100**	367	**33**	**100**	**24**		**1.39**
170	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
	SCULPIN	1.00	0.26	0.65	0.01	0.02	0.00	7	1.55
	Y.PERCH	2.00	0.51	1.29	0.08	0.20	0.05	40	1.55
	Grand Total	**389**	**100**	**251**	**39**	**100**	**25**		**1.55**

Appendix C. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2004 during boat electrofishing at rkm 170-283. Total shocking effort was 4.7 hours.

RKM	Species	Count	% of total	CPUE (hr)	Kg	BPUE (hr)	% of total	Mean Wt (g)	Effort (h)
565	BLT	5	1.36	6.26	9.19	11.49	7.92	1837	0.80
	LND	1	0.27	1.25	0.00	0.00	0.00	1	0.80
	LNS	4	1.09	5.01	2.06	2.57	1.77	514	0.80
	LSS	83	22.62	103.86	65.82	82.36	56.78	793	0.80
	MWF	260	70.84	325.34	36.63	45.84	31.60	141	0.80
	NPM	5	1.36	6.26	0.98	1.23	0.85	196	0.80
	RBT	1	0.27	1.25	0.13	0.16	0.11	126	0.80
	RSS	3	0.82	3.75	0.03	0.04	0.03	10	0.80
	SCULPIN	1	0.27	1.25	0.01	0.01	0.01	11	0.80
	WCT	4	1.09	5.01	1.08	1.36	0.93	271	0.80
	Grand Total	**367**	**100.00**	**459.23**	**115.92**	**145.06**	**100.00**		0.80
283	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
	Grand Total	**186**	**100.00**	**158.15**	**47.85**	**40.69**	**100.00**		1.18
265	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
	Grand Total	**130**	**100.00**	**182.39**	**40.07**	**56.22**	**100.00**		0.71
250	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
	Grand Total	**203**	**100.00**	**302.86**	**34.31**	**51.18**	**100.00**		0.67
230	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
	Grand Total	**363.00**	**100.00**	**314.59**	**30.52**	**26.45**	**100.00**		1.15

Appendix C. Continued.

RKM	Species	Count	% of total	CPUE (hr)	Kg	BPUE (hr)	% of total	Mean Wt (g)	Effort (h)
170	BULLHEAD	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
	SCULPIN	1	0.22	0.74	0.01	0.00	0.02	5	1.35
	Grand Total	**462**	**100.00**	**341.03**	**25.64**	**18.92**	**100.00**		1.35

Appendix D. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2005 during boat electrofishing at rkm 170-283. Total shocking effort was 6.5 hours.

RKM	Species	Count	% of total	CPUE	Kg	BPUE	% of total	Mean Wt	Effort
565	BLT	6	4.17	7.89	14.03	18.46	17.59	2339	0.76
	LNS	4	2.78	5.26	2.58	3.39	3.23	645	0.76
	LSS	57	39.58	75.00	48.87	64.30	61.26	857	0.76
	MWF	71	49.31	93.42	12.31	16.20	15.43	173	0.76
	RBT	5	3.47	6.58	1.98	2.60	2.48	395	0.76
	Sculpin	1	0.69	1.32	0.01	0.01	0.01	6	0.76
	Grand Total	**144**	**100.00**	**189.474**	**79.775**	**104.97**	**100.00**		**0.76**
283	BRNT	1	0.32	0.90	0.20	0.18	0.24	196	1.112
	LSS	51	16.24	45.88	32.81	29.51	40.89	643	1.112
	MWF	211	67.20	189.81	37.51	33.74	46.75	178	1.112
	NPM	7	2.23	6.30	1.81	1.63	2.26	259	1.112
	PMC	4	1.27	3.60	0.50	0.45	0.62	125	1.112
	RBT	36	11.46	32.38	6.72	6.04	8.38	187	1.11
	RSS	2	0.64	1.80	0.03	0.03	0.04	17	1.11
	WCT	2	0.64	1.80	0.65	0.59	0.81	327	1.11
	Grand Total	**314**	**100.00**	**282.459**	**80.228**	**72.17**	**100.00**		1.11
265	LNS	1	0.48	1.45	0.46	0.66	0.85	456	0.69
	LSS	21	10.00	30.51	16.24	23.60	30.43	773	0.69
	MWF	165	78.57	239.71	31.45	45.69	58.92	191	0.69
	NPM	4	1.90	5.81	0.80	1.16	1.49	199	0.69
	PMC	4	1.90	5.81	0.52	0.76	0.98	130	0.69
	RBT	15	7.14	21.79	3.91	5.68	7.33	261	0.69
	Grand Total	**210**	**100.00**	**305.085**	**53.38**	**77.55**	**100.00**		0.69
250	LSS	24	13.11	37.62	20.42	32.01	50.64	851	0.64
	MWF	152	83.06	238.24	18.32	28.71	45.42	120	0.64
	NPM	3	1.64	4.70	0.79	1.23	1.95	262	0.64
	RBT	4	2.19	6.27	0.80	1.26	1.99	201	0.64
	Grand Total	**183**	**100.00**	**286.83**	**40.33**	**63.21**	**100.00**		**0.64**
230	LNS	6	1.83	4.02	3.29	2.21	11.33	549	1.49
	LSS	30	9.17	20.12	13.77	9.24	47.41	459	1.49
	MWF	23	7.03	15.43	0.74	0.49	2.54	32	1.49
	NPM	91	27.83	61.03	3.86	2.59	13.29	42	1.49
	PMC	73	22.32	48.96	4.80	3.22	16.52	66	1.49
	PS	2	0.61	1.34	0.01	0.01	0.03	3	1.49
	RBT	12	3.67	8.05	1.44	0.97	4.96	120	1.49
	RSS	85	25.99	57.01	0.49	0.33	1.69	6	1.49
	SCULP	1	0.31	0.67	0.01	0.00	0.02	5	1.49
	WCT	4	1.22	2.68	0.64	0.43	2.21	160	1.49
	Grand Total	**327**	**100.00**	**219.32**	**29.05**	**19.48**	**100.00**		**1.49**
170	BULLHEAD	2	0.53	1.11	0.21	0.12	0.65	107	1.80
	LSS	33	8.75	18.29	21.91	12.14	66.90	664	1.80
	MWF	9	2.39	4.99	0.22	0.12	0.67	24	1.80
	NPM	110	29.18	60.98	4.01	2.22	12.25	36	1.80
	PMC	100	26.53	55.43	5.10	2.82	15.56	51	1.80
	RBT	5	1.33	2.77	0.52	0.29	1.59	104	1.80
	RSS	113	29.97	62.64	0.75	0.42	2.29	7	1.80
	SCULP	5	1.33	2.77	0.03	0.02	0.09	6	1.80
	Grand Total	**377**	**100.00**	**208.98**	**32.75**	**18.15**	**100.00**		**1.80**

Appendix E. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2006 during boat electrofishing at rkm 170-283. Total shocking effort was 6.1 hours.

RKM	Species	Count	% of total	CPUE	Kg	%of total	BPUE	Mean Wt	Effort
565	BLT	4	2.07	6.04	7.63	8.48	11.53	1908	0.66
	LNS	6	3.11	9.06	4.09	4.54	6.17	681	0.66
	LSS	76	39.38	114.81	58.81	65.36	88.84	774	0.66
	MWF	96	49.74	145.03	17.35	19.29	26.21	181	0.66
	NPM	4	2.07	6.04	1.51	1.68	2.29	378	0.66
	PMC	1	0.52	1.51	0.07	0.08	0.11	70	0.66
	RBT	1	0.52	1.51	0.13	0.15	0.20	134	0.66
	RSS	4	2.07	6.04	0.07	0.07	0.10	16	0.66
	WCT	1	0.52	1.51	0.32	0.35	0.48	317	0.66
	Grand Total	**193**	**100.00**	**292**	**90**	**100**	**136**		**0.66**
283	BRNT	1	0.31	1.06	0.33	0.53	0.35	329	0.94
	LSS	14	4.38	14.89	9.21	14.76	9.80	658	0.94
	MWF	234	73.13	248.86	40.74	65.27	43.33	174	0.94
	NPM	6	1.88	6.38	0.91	1.46	0.97	152	0.94
	RBT	60	18.75	63.81	10.53	16.86	11.19	175	0.94
	RSS	2	0.63	2.13	0.03	0.05	0.04	17	0.94
	WCT	3	0.94	3.19	0.66	1.06	0.71	221	0.94
	Grand Total	**320**	**100.00**	**340.32**	**62.42**	**100.00**	**66.38**		**0.94**
265	LSS	25	9.73	34.66	21.81	39.22	30.23	872	0.72
	MWF	213	82.88	295.26	30.77	55.34	42.65	145	0.72
	NPM	6	2.33	8.32	0.71	1.27	0.98	118	0.72
	RBT	13	5.06	18.02	2.32	4.17	3.22	178	0.72
	Grand Total	**257**	**100.00**	**356.257**	**55.6**	**100**	**77.07**		**0.72**
250	BNT	1	0.30	1.39	0.16	0.33	0.22	160	0.72
	LSS	34	10.33	47.39	23.00	47.48	32.06	676	0.72
	MWF	247	75.08	344.25	19.74	40.74	27.51	80	0.72
	NPM	19	5.78	26.48	2.15	4.44	3.00	113	0.72
	PMC	1	0.30	1.39	0.04	0.08	0.06	41	0.72
	RBT	22	6.69	30.66	3.27	6.76	4.56	149	0.72
	RSS	5	1.52	6.97	0.08	0.16	0.11	16	0.72
	Grand Total	**329**	**100.00**	**458.537**	**48.443**	**100**	**67.52**		**0.72**
230	LNS	6	1.36	3.88	1.57	6.19	1.02	262	1.55
	LSS	27	6.14	17.44	10.59	41.66	6.84	392	1.55
	MWF	61	13.86	39.40	0.66	2.59	0.42	11	1.55
	NPM	206	46.82	133.02	5.69	22.39	3.67	28	1.55
	PMC	52	11.82	33.57	4.57	18.00	2.95	88	1.55
	PSS	6	1.36	3.87	0.10	0.38	0.06	16	1.55
	RBT	9	2.05	5.81	1.62	6.38	1.05	180	1.55
	RSS	66	15.00	42.58	0.57	2.24	0.37	9	1.55
	Sculpin	6	1.36	3.87	0.04	0.15	0.02	6	1.55
	YP	1	0.23	0.65	0.01	0.02	0.00	5	1.55
	Grand Total	**440**	**100.00**	**283.820**	**25.41**	**100**	**16.39**		**1.55**

Appendix E. Continued.

RKM	Species	Count	% of total	CPUE	Kg	%of total	BPUE	Mean Wt	Effort
170	BULLHEAD	1	0.16	0.66	0.16	0.26	0.11	163	1.52
	LSS	72	11.30	47.26	49.36	80.11	32.39	686	1.52
	LNS	1	0.16	0.66	0.07	0.11	0.05	70	1.52
	MWF	2	0.31	1.31	0.02	0.03	0.01	9	1.52
	NPM	284	44.58	186.40	6.64	10.78	4.36	23	1.52
	PMC	49	7.69	32.16	3.49	5.66	2.29	71	1.52
	RBT	2	0.31	1.31	0.22	0.35	0.14	108	1.52
	RSS	215	33.75	141.11	1.47	2.38	0.96	7	1.52
	Sculpin	4	0.63	2.63	0.03	0.04	0.02	6	1.52
	YP	7	1.10	4.59	0.16	0.26	0.11	23	1.52
	Grand Total	**637**	**100.00**	**418.086**	**61.609**	**100**	**40.44**		**1.52**

Appendix F. Mean catch and biomass per unit of effort (CPUE and BPUE), total number and biomass, and mean weight of fish sampled in 2007 during boat electrofishing at rkm 170-283. Total shocking effort was 6.1 hours.

RKM	Species	Count	% of total	CPUE	Kg	%of total	BPUE	Mean Wt	Effort
565	BLT	9	4.02	11.54	3.50	4.68	4.48	388	0.7797
	LND	2	0.89	2.57	0.01	0.01	0.01	5	0.7797
	LNS	1	0.45	1.28	0.67	0.90	0.86	670	0.7797
	LSS	88	39.29	112.86	58.14	77.90	74.57	661	0.7797
	MWF	93	41.52	119.27	9.34	12.51	11.98	100	0.7797
	NPM	7	3.13	8.98	1.23	1.64	1.57	175	0.7797
	PMC	8	3.57	10.26	0.88	1.17	1.12	109	0.7797
	RBT	3	1.34	3.85	0.51	0.69	0.66	171	0.7797
	RSS	8	3.57	10.26	0.08	0.11	0.10	10	0.7797
	TSC	2	0.89	2.57	0.01	0.01	0.01	5	0.7797
	WCT	3	1.34	3.85	0.27	0.37	0.35	91	0.7797
	Grand Total	**224**	**100.00**	**287.28**	**74.63**	**100.00**	**95.72**		**0.7797**
283	BRNT	4	1.22	2.49	0.41	0.6905018	0.25	101	1.6064
	LSS	19	5.81	11.83	11.40	19.4380509	7.10	600	1.6064
	MWF	219	66.97	136.33	35.17	59.9594224	21.89	161	1.6064
	NPM	10	3.06	6.23	1.54	2.6273166	0.96	154	1.6064
	PMC	2	0.61	1.25	0.27	0.4569246	0.17	134	1.6064
	RBT	54	16.51	33.62	9.21	15.7076364	5.74	171	1.6064
	RSS	14	4.28	8.72	0.20	0.3375786	0.12	14	1.6064
	TSC	2	0.61	1.25	0.02	0.0272791	0.01	8	1.6064
	WCT	3	0.92	1.87	0.44	0.7552896	0.28	148	1.6064
	Grand Total	**327**	**100.00**	**203.56**	**58.65**	**100.00**	**36.51**		**1.6064**
265	BRNT	2	0.71	2.43	0.56	0.76	0.69	282	0.822
	LND	1	0.36	1.22	0.01	0.01	0.01	7	0.822
	LSS	30	10.68	36.50	28.78	38.86	35.02	959	0.822
	MWF	221	78.65	268.87	37.67	50.86	45.83	170	0.822
	NPM	5	1.78	6.08	2.57	3.47	3.13	515	0.822
	PMC	1	0.36	1.22	0.11	0.15	0.14	112	0.822
	RBT	19	6.76	23.12	4.31	5.81	5.24	227	0.822
	RSS	1	0.36	1.22	0.03	0.04	0.04	31	0.822
	TSC	1	0.36	1.22	0.02	0.02	0.02	16	0.822
	Grand Total	**281**	**100.00**	**341.87**	**74.06**	**100.00**	**90.10**		**0.822**
250	BRNT	2	0.47	3.30	0.37	0.48	0.61	186	0.606
	LSS	33	7.69	54.45	28.68	36.90	47.32	869	0.606
	MWF	382	89.04	630.25	46.61	59.96	76.90	122	0.606
	NPM	2	0.47	3.30	0.07	0.09	0.11	34	0.606
	RBT	9	2.10	14.85	2.00	2.58	3.30	222	0.606
	TSC	1	0.23	1.65	0.00	0.00	0.00	1	0.606
	Grand Total	**429**	**100.00**	**707.79**	**77.73**	**100.00**	**128.25**		0.606
230	LNS	3	1.25	2.10	1.44	6.11	1.01	481	1.428
	LSS	18	7.50	12.61	13.05	55.29	9.14	725	1.428
	MWF	13	5.42	9.11	0.77	3.25	0.54	59	1.428
	NPM	132	55.00	92.47	4.47	18.94	3.13	34	1.428
	PMC	39	16.25	27.32	3.21	13.60	2.25	82	1.428
	RBT	5	2.08	3.50	0.44	1.88	0.31	89	1.428
	RSS	27	11.25	18.91	0.20	0.86	0.14	8	1.428
	TSC	3	1.25	2.10	0.02	0.07	0.01	5	1.428
	Grand Total	**240**	**100.00**	**168.07**	**23.60**	**100.00**	**16.53**		1.428

Appendix F. Continued.

RKM	Species	Count	% of total	CPUE	Kg	%of total	BPUE	Mean Wt	Effort
170	BULLHEAD	1	0.19	0.66	0.06	0.11	0.04	62	1.521
	LNS	3	0.56	1.97	0.73	1.25	0.48	244	1.521
	LSS	56	10.47	36.82	40.12	68.80	26.38	716	1.521
	MWF	9	1.68	5.92	0.10	0.16	0.06	11	1.521
	NPM	283	52.90	186.08	7.95	13.63	5.23	28	1.521
	PMC	107	20.00	70.36	8.85	15.18	5.82	83	1.521
	RSS	73	13.64	48.00	0.49	0.84	0.32	7	1.521
	TSC	3	0.56	1.97	0.02	0.03	0.01	6	1.521
	Grand Total	**535**	**100.00**	**351.78**	**58.31**	**100.00**	**38.34**		**1.521**

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