KOOTENAI RIVER FISHERIES INVESTIGATIONS:
RAINBOW AND BULL TROUT RECRUITMENT

ANNUAL PROGRESS REPORT
April 1, 2004 — March 31, 2005

Prepared by:

Jody P. Walters, Senior Fishery Research Biologist

IDFG Report Number 05-45
November 2005
Kootenai River Fisheries Investigations: Rainbow and Bull Trout Recruitment

Project Progress Report

2004 Annual Report

By

Jody P. Walters

Idaho Department of Fish and Game
600 South Walnut Street
P.O. Box 25
Boise, ID 83707

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 05-45
November 2005
List of Tables, continued.

Table 8. Dissolved metal concentration means and standard errors (SE) for Boulder Creek, June through September 2004. ............................................................... 15

Table 9. The percent of rainbow trout ages by length group for fish sampled in Boulder Creek in November 2003 and 2004.......................................................... 17

Table 10. Summary statistics for age-0 and age-1 rainbow trout caught by electrofishing in Boulder Creek, November 2004.................................................. 17

LIST OF FIGURES

Figure 1. The Kootenai River drainage and major tributaries in Idaho................................. 4

Figure 2. Water temperature and discharge monitoring sites in the Deep Creek drainage. ...................................................................................................................... 5

Figure 3. Daily maximum water temperatures for five sites in the Deep Creek drainage, June through September 2004................................................................. 10

Figure 4. Deep Creek discharge at five sites as a percentage of the discharge at the downstream most site (site 8). ........................................................................ 12

Figure 5. Length frequencies of rainbow trout caught by electrofishing in Boulder Creek, Kootenai River drainage, November 2004. ........................................... 16
ABSTRACT

The bull trout *Salvelinus confluentus* is one of several sport fish native to the Kootenai River, Idaho, that can no longer support a fishery. Because bull trout are now listed under the Endangered Species Act, population data will be vital to monitoring status relative to recovery goals. Rainbow trout *Oncorhynchus mykiss* still provide an important sport fishery, but densities are low, at least partly due to limited recruitment. In response to these low densities, trout regulations that are more conservative were initiated in 2002. McArthur Lake is believed to cause warm summer water temperatures in Deep Creek, a Kootenai River tributary, thus limiting rainbow trout rearing habitat. Low nutrient concentrations may limit growth and survival of juvenile rainbow trout in Boulder Creek, an important spawning and rearing tributary. This research addresses bull trout redd surveys, rainbow trout population monitoring, the effects of McArthur Lake on Deep Creek water temperatures, and nutrient concentration levels in Boulder Creek. Twenty-five bull trout redds were found in North and South Callahan creeks in 2004, a decrease from 42 redds found in 2003. The rainbow trout population has responded positively to the change in regulations with an increase in density to 112 fish/km in 2004 compared to 72 fish/km in 1999. Quality stock density also increased from zero in 2001 to seven in 2004. Rainbow trout relative weights for 201-305 mm TL and 306-406 mm TL size groups were 86 (SE = 1; n = 24) and 85 (SE = 3; n = 10), respectively, similar to relative weight values prior to 2002. McArthur Lake increases the summer temperature of Deep Creek immediately downstream of the reservoir, with a maximum temperature of 25°C in July. On July 26, Deep Creek discharge doubled from 0.071 m³/s at the McArthur Lake outflow to 0.149 m³/s 10 km downstream, and continued to increase farther downstream, indicating that other sources such as tributaries have a larger impact on the temperature of Deep Creek. Finally, Boulder Creek may be nitrogen limited, with concentrations <0.020 mg/L of dissolved inorganic nitrogen.

Author:

Jody P. Walters
Senior Fishery Research Biologist
INTRODUCTION

The Kootenai River in Idaho no longer has fisheries for several species, including white sturgeon *Acipenser transmontanus*, burbot *Lota lota*, and kokanee *Oncorhynchus nerka* (Richards 1997). The bull trout *Salvelinus confluentus*, another sportfish native to the Kootenai River, was listed as threatened under the Endangered Species Act in 1998. Bull trout are distributed throughout the Kootenai River mainstem and some tributaries downstream of migration barriers in Idaho (Partridge 1983; Paragamian 1994, 1995a; Downs 1999, 2000; Walters and Downs 2001; Walters 2002). Little is known about population numbers, but juvenile bull trout densities ranged from 1.64/100 m$^2$ to 7.65/100 m$^2$ across four sample reaches in the Callahan Creek drainage in 2003 (Walters 2004b). Bull trout redds have been documented in North and South Callahan creeks and Boulder Creek (Walters 2003, 2004a, 2004b). The bull trout draft recovery plan states that the trend criteria for recovery will be met when the bull trout population is accepted as stable or increasing based on at least 10 years of monitoring data (U.S. Fish and Wildlife Service 2002). The recovery plan calls for redd surveys to continue as a metric to document bull trout population trends (U.S. Fish and Wildlife Service 2002). The continuation of bull trout redd counts in Boulder Creek and North and South Callahan creeks will provide data to help document population trends.

Rainbow trout *O. mykiss* are another sportfish native to the Idaho reach of the Kootenai River, but densities are low at 3-7 fish/ha (Paragamian 1995a, 1995b; Downs 2000; Walters and Downs 2001). These low densities are at least partly due to limited juvenile recruitment (Walters et al. 2005). The Deep Creek drainage produces an average of about 39,000 juvenile out-migrants to the Kootenai River each year, more rainbow trout out-migrants than the rest of the Idaho tributaries combined (Walters et al. 2005). The spawning population in the Deep Creek drainage is mainly an adfluvial stock from Kootenay Lake, British Columbia (Downs 1999, 2000), but this spawning run of adult rainbow trout to the Deep Creek drainage still provides a spring fishery in the Kootenai River, Idaho. The Deep Creek drainage could potentially produce more out-migrants, but high summer water temperatures may limit juvenile rearing densities in the Deep Creek mainstem (Fredericks and Hendricks 1997). McArthur Lake, a reservoir on Deep Creek, is believed to warm the water of Deep Creek in summer, decreasing the quality of the stream as rainbow trout habitat. An analysis of temperature and discharge data is needed to determine the impact of McArthur Lake on Deep Creek water temperatures and to determine if mitigation is possible.

Rainbow trout recruitment from tributaries upstream of Deep Creek is low, averaging about 10,000 juvenile (mainly age-0) recruits to the Kootenai River, Idaho annually (Walters et al. 2005). The majority of this recruitment is from Boulder Creek with at least a portion of these fish being of fluvial stock from the Kootenai River (Walters et al. 2005; IDFG unpublished data). Therefore, determining factors that limit juvenile production in Boulder Creek could aid in enhancing recruitment from this stream.

Low nutrient availability in Boulder Creek may limit macroinvertebrate production and the subsequent length and survival of rainbow trout young-of-the-year at the end of their first growing season. Smith and Griffith (1994) held age-0 rainbow trout in cages in the Henrys Fork of the Snake River and found that none of the fish <100 mm in October survived the winter. In Kootenai River tributaries, at least some age-0 rainbow trout <100 mm survive their first winter (May and Huston 1979; Paragamian 1995a; Fredericks and Hendricks 1997), but increased growth before winter may increase survival rates. Metals, if present in the aquatic system, could also be a factor affecting trout production, including growth of age-0 fish (Woodward et al.
Concentrations of trace elements, including metals, have been correlated with mining activities in other regional drainages (Maret and Skinner 2000). The Boulder Creek drainage was mined during the early 1900s and, therefore, could have elevated metals concentrations. Baseline data on nutrient and metals concentrations and length of age-0 rainbow trout in Boulder Creek would be useful to begin assessment of possible factors limiting biological production in the system.

Another possible factor limiting the Kootenai River rainbow trout population density and size structure is angling exploitation. Annual exploitation rates of 58% and 46% were documented for 1999 and 2000, respectively (Walters and Downs 2001; Walters 2002). In response to these exploitation rates, regulations that are more conservative were initiated for the trout fishery. Beginning January 1, 2002, a 16” (406 mm) minimum length limit and two-fish creel limit was established for rainbow and westslope cutthroat trout O. clarkii in the Kootenai River, Idaho. The regulations prior to 2002 included no size limit and a six-fish creel limit for trout. The goals of the new regulations are to conserve the trout population for continued fishing opportunities, improve the population size structure, and increase trout densities by decreasing angler exploitation and protecting trout until they can spawn at least once. Continued monitoring of the trout population is necessary to evaluate the effects of the new regulations.

**OBJECTIVES**

1. Determine if there is a positive trend in the number of bull trout redds in index streams in Idaho.

2. Determine if McArthur Lake increases summer water temperatures in Deep Creek and whether these effects can be mitigated.

3. Determine if the rainbow trout population is increasing and size structure is improving (e.g., a positive trend in quality stock density) in response to changes in trout regulations initiated in 2002.

4. Determine if Boulder Creek is nutrient limited (e.g., contains <20 μg/l of dissolved inorganic nitrogen or <1 μg/l of soluble reactive phosphorus).

**STUDY AREA**

The Kootenai River (spelled Kootenay in Canada) flows south out of British Columbia into Montana, northwest into Idaho, then north back into British Columbia and Kootenay Lake (Figure 1). It flows out of the west arm of Kootenay Lake and enters the Columbia River at Castlegar, British Columbia. In the U.S., the Kootenai River is regulated by Libby Dam in Montana (Figure 1). There are approximately 105 km of Kootenai River in Idaho with the following three reaches: 1) the Canyon Reach (22 km) from the Montana border to the Moyie River, 2) the Braided Reach (10 km) from the Moyie River to Bonners Ferry, and 3) the Meandering Reach (73 km) from Bonners Ferry to the Canadian border (Fredericks and Hendricks 1997). The Meandering Reach has a relatively slow velocity and substrates consisting mainly of sand, silt, and clays (Partridge 1983). Dikes on either side of the river in this reach prevent flooding of the adjacent agricultural lands. The Braided and Canyon reaches
upstream of Bonners Ferry appear more suitable for fluvial rainbow trout with riffles, runs and pools, and gravel and cobble substrates.

Sampling in 2004 was conducted in the Kootenai River and in three tributary drainages including Boulder, Callahan, and Deep creeks (Figure 1). Boulder Creek drains an area of 162 km² of mostly national forest land with private in-holdings, including historic mining operations (Zelch 2003). A waterfall 1.9 km upstream from the mouth prevents the upstream migration of fish. Callahan Creek drains an area of 212 km², also mainly national forest land with the exception of privately owned land in the lower 2 km of the drainage (Muhlfeld 1999). Callahan Creek enters the Kootenai River at Troy, Montana, but the North and South Callahan forks are mainly in Idaho. Deep Creek drains an area of 345 km² (Figure 2; Hortness and Berenbrock 2004). McArthur Lake, created by damming Deep Creek in 1944, is managed for waterfowl production. Downstream of McArthur Lake, Deep Creek flows mainly through private land including agricultural areas.

Figure 1. The Kootenai River drainage and major tributaries in Idaho.
Figure 2. Water temperature and discharge monitoring sites in the Deep Creek drainage.

METHODS

Bull Trout Redd Surveys

Bull trout redd surveys were conducted along index transects on Boulder, North Callahan, and South Callahan creeks (Walters 2004b). Each transect was hiked once during midday in either late September or early October. Disturbed and cleaned gravel or cobble areas showing a pit and tailspill were identified as bull trout redds (Shepard and Graham 1983; Dunham et al. 2001). Lengths of observed bull trout were also estimated to the nearest cm total length.
Summer Water Temperatures and Flows in the Deep Creek Drainage

Onset Stowaway® temperature data loggers were used to record water temperatures from June 1 through September 30 at five sites in the Deep Creek drainage (Table 1, Figure 2). Discharge was measured four times during July and August at seven sites (Table 1, Figure 2). Discharge was determined as described by McMahon et al. (1996). A Flo-Mate™ Model 2000 flow meter was used to measure current velocity at 0.6 X depth.

Discharge and temperature data from July 26 were also used to determine if McArthur Lake tributaries could help cool Deep Creek at the reservoir outlet in summer. I first determined what the theoretical water temperature would be if Dodge Creek could be combined with Deep Creek upstream of McArthur Lake (upper Deep Creek). I then used this theoretical temperature of upper Deep Creek to determine if the water temperature at the McArthur Lake outlet could be cooled if upper Deep Creek could be routed directly to the outlet rather than flowing into the reservoir. A temperature mixing ratio was used to calculate these theoretical stream temperatures ($T_{th}$) as follows (Brown 1980; Mellina et al. 2002):

$$T_{th} = \frac{(Q_m T_m) + (Q_t T_t)}{(Q_m + Q_t)}$$

where $Q_m =$ discharge of the mainstem before the tributary enters, $T_m =$ temperature of the mainstem before the tributary enters, $Q_t =$ discharge of the tributary, $T_t =$ temperature of the tributary.

Water temperature and dissolved oxygen profiles (every 0.5 m) were measured at the deepest point (2.5 m) of McArthur Lake (just upstream of the dam) on August 11 and 16 using a Hydrolab®. These measurements were used to determine if the reservoir held colder water that might be used to cool Deep Creek downstream during the summer.

Table 1. Descriptions of water temperature (t) and discharge (d) monitoring sites in the Deep Creek drainage, 2004. The coordinates are in UTM zone 11, WGS84 datum.

<table>
<thead>
<tr>
<th>Stream</th>
<th>Site number</th>
<th>Distance downstream from the McArthur Lk. outlet (km)</th>
<th>UTM Coordinates</th>
<th>Data collected</th>
<th>Site Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dodge Cr.</td>
<td>1</td>
<td>30 m upstream of the mouth at McArthur Lake</td>
<td>539900 5374586</td>
<td>t, d</td>
<td>30 km upstream of the mouth at McArthur Lake</td>
</tr>
<tr>
<td>Deep Cr.</td>
<td>2</td>
<td>—</td>
<td>539012 5371555</td>
<td>t, d</td>
<td>Road crossing 1.4 km upstream of McArthur Lake</td>
</tr>
<tr>
<td>Deep Cr.</td>
<td>3</td>
<td>0</td>
<td>541201 5374222</td>
<td>d</td>
<td>McArthur Lake outlet</td>
</tr>
<tr>
<td>Deep Cr.</td>
<td>4</td>
<td>0.5</td>
<td>541600 5374478</td>
<td>t</td>
<td>0.5 km downstream of McArthur Lake outlet</td>
</tr>
<tr>
<td>Deep Cr.</td>
<td>5</td>
<td>8</td>
<td>544585 5378097</td>
<td>d</td>
<td>Forest Road 2732 bridge near Shiloh</td>
</tr>
<tr>
<td>Deep Cr.</td>
<td>6</td>
<td>10</td>
<td>544636 5379449</td>
<td>d</td>
<td>County Rd 2 bridge at Naples</td>
</tr>
<tr>
<td>Deep Cr.</td>
<td>7</td>
<td>16</td>
<td>544175 5382510</td>
<td>t, d</td>
<td>County Rd 2 bridge in S 1/2 of S 36 T 60 N R 1 W</td>
</tr>
<tr>
<td>Deep Cr.</td>
<td>8</td>
<td>23</td>
<td>545173 5386521</td>
<td>t, d</td>
<td>County Rd 2 bridge in N 1/2 of S 19 T 61 N R 1 W</td>
</tr>
</tbody>
</table>

Rainbow Trout Population Monitoring

In August 2004, a mark and recapture population estimate was conducted along the 3 km Hemlock Bar reach (river kilometer [rkm] 262 to rkm 265) of the Kootenai River using a
boat electrofishing setup (Downs 2000). Rainbow trout were marked the nights of August 23, 24, 25, and 27 by clipping a small section off the lower caudal fin. The recapture sample was collected on the nights of August 30 and 31 to determine the proportion of marked to unmarked rainbow trout in the sample reach. Population estimates were calculated using Chapman's modification of the Petersen Method (Ricker 1975; Krebs 1999). Estimates were calculated for separate length groups due to the size-selective nature of electrofishing (Reynolds 1996; Schill 1996; Downs 2000). The 95% confidence limits for the population estimates were calculated based on the Poisson distribution (Ricker 1975; Seber 1982).

In September 2004, boat electrofishing was also used to determine rainbow trout population size structure, relative weights ($W_r$), and catch per unit effort. Rainbow trout were collected along both shorelines of the Kootenai River from rkm 265.2 to 266.4 (just upstream of Hemlock Bar) on September 13, and from rkm 250 to 251 (Cow Creek) on September 14. Rainbow trout were measured, weighed, and released. Catch-per-unit-effort and relative weights were calculated from the September sample. Relative weights were calculated for rainbow trout size groups of 201-305 mm TL, 306-406 mm TL, and >406 mm TL using the standard weight ($W_s$) equation for lotic rainbow trout populations proposed by Simpkins and Hubert (1996). Proportional stock density (PSD) and quality stock density (QSD) were also calculated (Anderson 1976; Wege and Anderson 1978; Anderson and Neumann 1996). Proportional and quality stock densities were calculated for rainbow trout >305 mm TL and >406 mm TL, respectively, using 200 mm TL as stock length (Schill 1991). The table provided by Gustafson (1988) was used to estimate 95% confidence intervals for PSD and QSD. Data from rainbow trout caught during the August population estimate sampling and the September samples were combined to increase sample size for PSD and QSD estimates.

**Boulder Creek Water Chemistry and Juvenile Rainbow Trout Length**

Water samples were taken at two sites in Boulder Creek. The upstream site was at the U.S. Forest Service gauging station approximately 5 km from the mouth (UTM zone 11, WGS84, eastings = 0566893, northings = 5383167), while the downstream site was approximately 0.5 km upstream from the mouth (eastings = 0569571, northings = 5386870). Two grab sample replicates were collected from the thalweg at each site once a month from June through September. Two additional grab sample replicates from each site were collected in July and August for dissolved metals concentration analysis. Samples were kept on ice and shipped overnight to a private laboratory for analysis. Concentrations of the following nutrients were determined (minimum detection limits in parentheses): Total Phosphorus (0.002 mg/l), Total Dissolved Phosphorus (0.002 mg/l), Soluble Reactive Phosphorus (0.001 mg/l), Ammonia (0.005 mg/l), Nitrates + Nitrites (0.01 mg/l), Total Nitrogen (0.05 mg/l), and Total Organic Carbon (0.250 mg/l). The metals samples were analyzed for the following (minimum detection limits in parentheses): Aluminum (0.0030 mg/l), Arsenic (0.0050 mg/l), Cadmium (0.00020 mg/l), Chromium (0.0020 mg/l), Cobalt (0.020 mg/l), Copper (0.0010 mg/l), Iron (0.020 mg/l), Lead (0.0010 mg/l), Manganese (0.005 mg/l), Mercury (0.00010 mg/l), Nickel (0.010 mg/l), Selenium (0.0030 mg/l), Zinc (0.005 mg/l).

Backpack electrofishing was conducted in Boulder Creek on November 19, 2004 to determine age-0 and age-1 rainbow trout lengths and weights prior to winter. Two 50 m reaches were randomly chosen between the mouth and the waterfall 1.9 km upstream. A 2-person electrofishing crew worked upstream along one bank, sampling from the middle to shore, then repeated the process working downstream along the opposite bank. After electrofishing each sample reach, fish were measured (total length in mm) and weighed (nearest 0.1 g). Fish were
blotted lightly before weighing to remove excess water. Scales were collected from a sample of the catch and aged to determine age distribution by length group. Scales collected from a sample of rainbow trout collected from Boulder Creek in November 2003 were also aged for this report (Walters 2004b). Length groups were established based on the length frequencies of the 2003 and 2004 catch.

RESULTS

Bull Trout Redd Surveys

Bull trout redd surveys were conducted on September 29 on North Callahan Creek, October 4 on South Callahan Creek, and October 7 on Boulder Creek. Twenty-five bull trout redds were found in 2004, all in the Callahan Creek drainage (Table 2). Two bull trout were observed in North Callahan Creek, with estimated total lengths of 51 cm and 46 cm. No bull trout were seen in South Callahan or Boulder creeks.
Table 2. Numbers of bull trout redds in the Kootenai River drainage of Idaho, 2000 through 2004.

<table>
<thead>
<tr>
<th>Stream</th>
<th>Year</th>
<th>Transect start point description</th>
<th>Start point UTM coordinates&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Transect end point Description</th>
<th>End point UTM coordinates&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Number of bull trout redds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulder Cr.</td>
<td>2000</td>
<td>mouth</td>
<td>569849 5386164</td>
<td>Waterfall 1.9 km upstream</td>
<td>568641 5385028</td>
<td>0</td>
</tr>
<tr>
<td>Boulder Cr.</td>
<td>2001</td>
<td>mouth</td>
<td>569849 5386164</td>
<td>Waterfall 1.9 km upstream</td>
<td>568641 5385028</td>
<td>2</td>
</tr>
<tr>
<td>Boulder Cr.</td>
<td>2002</td>
<td>mouth</td>
<td>569849 5386164</td>
<td>Waterfall 1.9 km upstream</td>
<td>568641 5385028</td>
<td>2</td>
</tr>
<tr>
<td>Boulder Cr.</td>
<td>2003</td>
<td>mouth</td>
<td>569849 5386164</td>
<td>Waterfall 1.9 km upstream</td>
<td>568641 5385028</td>
<td>0</td>
</tr>
<tr>
<td>Boulder Cr.</td>
<td>2004</td>
<td>mouth</td>
<td>569849 5386164</td>
<td>Waterfall 1.9 km upstream</td>
<td>568641 5385028</td>
<td>0</td>
</tr>
<tr>
<td>N. Callahan Cr.</td>
<td>2002</td>
<td>100 m downstream of Smith Cr.</td>
<td>569501 5365990</td>
<td>Waterfall barrier</td>
<td>568218 5366538</td>
<td>13</td>
</tr>
<tr>
<td>N. Callahan Cr.</td>
<td>2003</td>
<td>Jill Cr., Montana&lt;sup&gt;b&lt;/sup&gt;</td>
<td>570786&lt;sup&gt;c&lt;/sup&gt; 5365340&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Waterfall barrier</td>
<td>568218 5366538</td>
<td>32</td>
</tr>
<tr>
<td>N. Callahan Cr.</td>
<td>2004</td>
<td>Jill Cr., Montana</td>
<td>570786&lt;sup&gt;c&lt;/sup&gt; 5365340&lt;sup&gt;c&lt;/sup&gt;</td>
<td>Waterfall barrier</td>
<td>568218 5366538</td>
<td>17</td>
</tr>
<tr>
<td>S. Callahan Cr.</td>
<td>2002</td>
<td>bridge on forest rd. 4554</td>
<td>570596 5362719</td>
<td>0.9 km upstream of forest rd. 414</td>
<td>566519 5361191</td>
<td>4&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>S. Callahan Cr.</td>
<td>2003</td>
<td>bridge on forest rd. 4554</td>
<td>570596 5362719</td>
<td>Forest Rd. 414 bridge (trailhead #154)</td>
<td>567347 5360822</td>
<td>10</td>
</tr>
<tr>
<td>S. Callahan Cr.</td>
<td>2004</td>
<td>bridge on forest rd. 4554</td>
<td>570596 5362719</td>
<td>Forest Rd. 414 bridge (trailhead #154)&lt;sup&gt;g&lt;/sup&gt;</td>
<td>567347 5360822</td>
<td>8</td>
</tr>
</tbody>
</table>

<sup>a</sup> UTM Zone 11; WGS84 datum.
<sup>b</sup> On 9/24/2003 the section from approximately 500 m downstream of Jill Creek upstream to Jill Creek was also surveyed, but no redds were seen.
<sup>c</sup> Estimated from electronic version of topographical map.
<sup>d</sup> S. Callahan was also surveyed from the Forest Road 414 bridge upstream approximately 500 m, but no redds were seen.
<sup>e</sup> Includes one redd found upstream of Forest Road 414 bridge.
Summer Water Temperatures and Flows in the Deep Creek Drainage

Maximum daily water temperatures were ≥24°C during several days in July and August at the three Deep Creek sites downstream of McArthur Lake (Figure 3). Maximum temperatures recorded at these three sites were 25°C near the McArthur Lake outlet (site 4), 24.6°C 16 km downstream of the outlet (site 7) and 26°C 23 km downstream of the outlet (site 8). Discharge measurements for the seven Deep Creek drainage sites are given in Table 3. On July 26, Deep Creek discharge at the McArthur Lake outlet (0.071 m³/s) was 48% of the discharge 10 km downstream at Naples (0.149 m³/s), and by August 9, discharge at the outlet (0.044 m³/s) was 36% of the discharge 10 km downstream (0.123 m³/s). Discharge at the McArthur Lake outlet (Site 3) was 12% and 9% of Deep Creek discharge measured at the downstream most site (site 8) on July 26 and August 9, respectively (Figure 4).

![Graph showing daily maximum water temperatures for five sites in the Deep Creek drainage, June through September 2004.](image)

Figure 3. Daily maximum water temperatures for five sites in the Deep Creek drainage, June through September 2004.
Table 3. Discharge measurements (m$^3$/s) at seven sites in the Deep Creek drainage, summer 2004.

<table>
<thead>
<tr>
<th>Date</th>
<th>Dodge Cr. (Site 1)</th>
<th>Deep Cr. upstream of McArthur Lk. (Site 2)</th>
<th>Deep Cr. at the Outlet of McArthur Lk. (Site 3)</th>
<th>Deep Cr. 8 km downstream of McArthur Lk. (Site 5)</th>
<th>Deep Cr. 10 km downstream of McArthur Lk. (Site 6)</th>
<th>Deep Cr. 16 km downstream of McArthur Lk. (Site 7)</th>
<th>Deep Cr. 23 km downstream of McArthur Lk. (Site 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/12/2004</td>
<td>0.075</td>
<td>0.020</td>
<td>0.201</td>
<td>0.282</td>
<td>0.312</td>
<td>1.059</td>
<td>1.486</td>
</tr>
<tr>
<td>7/26/2004</td>
<td>0.010</td>
<td>0.007</td>
<td>0.071</td>
<td>0.120</td>
<td>0.149</td>
<td>0.456</td>
<td>0.588</td>
</tr>
<tr>
<td>8/9/2004</td>
<td>&lt;0.001</td>
<td>0.003</td>
<td>0.044</td>
<td>0.099</td>
<td>0.123</td>
<td>0.317</td>
<td>0.505</td>
</tr>
<tr>
<td>8/25/2004</td>
<td>0.086</td>
<td>0.008</td>
<td>0.305</td>
<td>0.373</td>
<td>0.396</td>
<td>1.127</td>
<td>1.4441</td>
</tr>
</tbody>
</table>
Bypassing water from McArthur Lake's two inlet tributaries directly to the outlet would theoretically have cooled the outlet water 1.5°C, from 23.7°C to 22.2°C on July 26. McArthur Lake water temperature and dissolved oxygen profiles showed that the minimum temperature during the August sampling was 18.4°C at the bottom of the reservoir, while dissolved oxygen readings ranged from 0.74 mg/l to 4.54 mg/l (Table 4).
Rainbow Trout Population Monitoring

Rainbow trout population estimates for the Hemlock Bar reach are given in Table 5. Numbers of recaptures for some length groups were <3, so a single estimate for all sizes combined was also calculated (Table 5). The 2004 rainbow trout population estimate was 335, the highest recorded for the Kootenai River in Idaho (Table 6). Forty-one rainbow trout were collected during 1.4 h of electrofishing effort at the Hemlock Bar and Cow Creek sites in September. Total catch-per-unit effort for rainbow trout was 4.3 fish/h for fish <200 mm TL, 18.1 fish/h for the 200-305 mm TL group, and 7.2 fish/h for the 306-406 mm TL group. No rainbow trout >406 mm TL were collected during September sampling, but 10 fish >406 mm were caught during the population estimate sampling of the Hemlock Bar reach in late August. The relative weights for the 201-305 mm TL and 306-406 mm TL size groups were 86 (SE = 1; n = 24) and 85 (SE = 3; n = 10), respectively. The rainbow trout PSD was 35 ± 9, while the QSD was 7 ± 5. The QSD has increased slightly since initiation of the more conservative regulations in 2002 (Table 6), though QSD sample sizes were too small to estimate confidence intervals for years prior to 2004.

Table 5. Rainbow trout population estimates for the Hemlock Bar reach of the Kootenai River Idaho, August 2004.

<table>
<thead>
<tr>
<th>Length group (mm)</th>
<th>Number marked</th>
<th>Number of recaptures</th>
<th>Number in capture sample</th>
<th>Population estimate</th>
<th>Lower 95% Confidence Limit</th>
<th>Upper 95% Confidence limit</th>
<th>Number per hectare</th>
<th>Number per km</th>
</tr>
</thead>
<tbody>
<tr>
<td>125-179</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>11</td>
<td>4</td>
<td>30</td>
<td>0.4</td>
<td>4</td>
</tr>
<tr>
<td>180-249</td>
<td>20</td>
<td>3</td>
<td>31</td>
<td>167</td>
<td>69</td>
<td>420</td>
<td>5.7</td>
<td>56</td>
</tr>
<tr>
<td>250-349</td>
<td>12</td>
<td>4</td>
<td>26</td>
<td>69</td>
<td>31</td>
<td>176</td>
<td>2.4</td>
<td>23</td>
</tr>
<tr>
<td>350-449</td>
<td>4</td>
<td>0</td>
<td>13</td>
<td>17</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>&gt;=450</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>all</td>
<td>40</td>
<td>9</td>
<td>81</td>
<td>335</td>
<td>186</td>
<td>672</td>
<td>11.4</td>
<td>112</td>
</tr>
</tbody>
</table>

*a Minimum estimate based on the number marked plus the number of unmarked fish in the capture sample.
Table 6. Summary of population statistics for rainbow trout sampled by electrofishing during fall in the Kootenai River from river kilometer (rkm) 250 to 275 (“—“ = no data). Population estimates are for the 3 km Hemlock Bar reach (rkm 262 to 265).

<table>
<thead>
<tr>
<th>Year</th>
<th>Population estimate</th>
<th>Lower 95% C. L.</th>
<th>Upper 95% C. L.</th>
<th>n/ha</th>
<th>n/km</th>
<th>PSD ± 95% CI</th>
<th>QSD</th>
<th>201-305 mm</th>
<th>306-406 mm</th>
<th>&gt;406 mm</th>
<th>Relative weights</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>98</td>
<td>78</td>
<td>118</td>
<td>3.3</td>
<td>33</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1994</td>
<td>135</td>
<td>114</td>
<td>160</td>
<td>4.6</td>
<td>45</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>1998</td>
<td>217</td>
<td>168</td>
<td>294</td>
<td>7.4</td>
<td>72</td>
<td>12</td>
<td>5</td>
<td>85</td>
<td>83</td>
<td>83</td>
<td>—</td>
</tr>
<tr>
<td>1999</td>
<td>217</td>
<td>160</td>
<td>332</td>
<td>7.4</td>
<td>72</td>
<td>13</td>
<td>3</td>
<td>95</td>
<td>86</td>
<td>81</td>
<td>—</td>
</tr>
<tr>
<td>2000</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>39</td>
<td>2</td>
<td>86</td>
<td>79</td>
<td>82</td>
<td>—</td>
</tr>
<tr>
<td>2001</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>24</td>
<td>0</td>
<td>83</td>
<td>80</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>2002</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>55</td>
<td>15</td>
<td>83</td>
<td>80</td>
<td>96</td>
<td>—</td>
</tr>
<tr>
<td>2003</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>56</td>
<td>16</td>
<td>84</td>
<td>85</td>
<td>83</td>
<td>—</td>
</tr>
<tr>
<td>2004</td>
<td>335</td>
<td>186</td>
<td>672</td>
<td>11.4</td>
<td>112</td>
<td>35</td>
<td>9</td>
<td>86</td>
<td>85</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Boulder Creek Water Chemistry and Juvenile Rainbow Trout Length

Nutrient concentrations in Boulder Creek were generally below or just above detection limits with the exception of Total Organic Carbon (Table 7). Aluminum and copper were the only two dissolved metals present above detection limits (Table 8).

Fifty-one rainbow trout were caught by electrofishing in Boulder Creek during 3,378 s of effort. Total lengths ranged from 49 to 134 mm (Figure 5). Length frequency data for 2003 and 2004 indicated that age-0 rainbow trout were ≤81 mm, while age-1 rainbow trout ranged from 91 to 134 mm. Scale ages from the 2004 sample supported the length frequency data (Table 9). A 96 mm rainbow trout and a 105 mm rainbow trout from the 2003 age sample were both age-0, and a 133 mm fish was age-2, indicating overlap in ages within the 82-134 mm length group for fish collected in 2003 (Table 9). Summary statistics for the 2004 age-0 and age-1 catch are given in Table 10.

Table 7. Nutrient concentration means and standard errors (SE) for Boulder Creek, June through September 2004.

<table>
<thead>
<tr>
<th>Sample date</th>
<th>Site</th>
<th>Total Phosphorus (mg/l)</th>
<th>Total dissolved Phosphorus (mg/l)</th>
<th>Soluble reactive Phosphorus (mg/l)</th>
<th>Nitrates+Nitrites (mg/l)</th>
<th>Total Nitrogen (mg/l)</th>
<th>Total organic Carbon (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/15/2004</td>
<td>B1</td>
<td>0.003</td>
<td>0.001</td>
<td>0.002</td>
<td>0.000</td>
<td>0.17</td>
<td>0.094</td>
</tr>
<tr>
<td>6/15/2004</td>
<td>B2</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
<td>0.013</td>
<td>0.071</td>
</tr>
<tr>
<td>7/19/2004</td>
<td>B1</td>
<td>0.004</td>
<td>0.001</td>
<td>0.003</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>7/19/2004</td>
<td>B2</td>
<td>0.003</td>
<td>0.000</td>
<td>0.003</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>8/17/2004</td>
<td>B1</td>
<td>0.003</td>
<td>0.000</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>8/17/2004</td>
<td>B2</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>9/21/2004</td>
<td>B1</td>
<td>0.002</td>
<td>0.000</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>9/21/2004</td>
<td>B2</td>
<td>0.002</td>
<td>0.000</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample date</th>
<th>Site</th>
<th>Total Phosphorus (mg/l)</th>
<th>Total dissolved Phosphorus (mg/l)</th>
<th>Soluble reactive Phosphorus (mg/l)</th>
<th>Nitrates+Nitrites (mg/l)</th>
<th>Total Nitrogen (mg/l)</th>
<th>Total organic Carbon (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6/15/2004</td>
<td>B1</td>
<td>0.003</td>
<td>0.001</td>
<td>0.002</td>
<td>0.000</td>
<td>0.17</td>
<td>0.094</td>
</tr>
<tr>
<td>6/15/2004</td>
<td>B2</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
<td>0.013</td>
<td>0.071</td>
</tr>
<tr>
<td>7/19/2004</td>
<td>B1</td>
<td>0.004</td>
<td>0.001</td>
<td>0.003</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>7/19/2004</td>
<td>B2</td>
<td>0.003</td>
<td>0.000</td>
<td>0.003</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>8/17/2004</td>
<td>B1</td>
<td>0.003</td>
<td>0.000</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>8/17/2004</td>
<td>B2</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>9/21/2004</td>
<td>B1</td>
<td>0.002</td>
<td>0.000</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>9/21/2004</td>
<td>B2</td>
<td>0.002</td>
<td>0.000</td>
<td>0.002</td>
<td>0.000</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

a B1 = U.S. Forest Service gauging station approx 5 km upstream from mouth; B2 = 0.5 km upstream from mouth.

b Below detection limit.

c Samples were not analyzed for total organic carbon on this date.
Table 8. Dissolved metal concentration means and standard errors (SE) for Boulder Creek, June through September 2004.

<table>
<thead>
<tr>
<th>Sample date</th>
<th>Site&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Aluminum (mg/l) mean</th>
<th>SE</th>
<th>Copper (mg/l) mean</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/19/2004</td>
<td>B1</td>
<td>0.0045</td>
<td>0.0002</td>
<td>—&lt;sup&gt;b&lt;/sup&gt;</td>
<td>—</td>
</tr>
<tr>
<td>7/19/2004</td>
<td>B2</td>
<td>0.0058</td>
<td>0.0012</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>8/17/2004</td>
<td>B1</td>
<td>0.0161</td>
<td>0.0001</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>8/17/2004</td>
<td>B2</td>
<td>0.0694</td>
<td>0.0556</td>
<td>0.0026</td>
<td>0.0007</td>
</tr>
</tbody>
</table>

<sup>a</sup> B1 = U.S. Forest Service gauging station approximately 5 km upstream from mouth; B2 = 0.5 km upstream from mouth.

<sup>b</sup> A “—” indicates below detection limit.
Figure 5. Length frequencies of rainbow trout caught by electrofishing in Boulder Creek, Kootenai River drainage, November 2004.
Table 9. The percent of rainbow trout ages by length group for fish sampled in Boulder Creek in November 2003 and 2004.

<table>
<thead>
<tr>
<th>Length group (mm)</th>
<th>Year sampled</th>
<th>n</th>
<th>Age-0</th>
<th>Age-1</th>
<th>≥Age-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-81</td>
<td>2003</td>
<td>28</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>5</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>82-134</td>
<td>2003</td>
<td>25</td>
<td>8</td>
<td>88</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>17</td>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>≥135</td>
<td>2003</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>2004</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 10. Summary statistics for age-0 and age-1 rainbow trout caught by electrofishing in Boulder Creek, November 2004.

<table>
<thead>
<tr>
<th></th>
<th>Age-0</th>
<th>Age-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean total length (mm)</td>
<td>64</td>
<td>109</td>
</tr>
<tr>
<td>Standard Error of the mean</td>
<td>1.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>7.6</td>
<td>11.5</td>
</tr>
<tr>
<td>Length range (mm)</td>
<td>49-81</td>
<td>91-134</td>
</tr>
<tr>
<td>N</td>
<td>33</td>
<td>18</td>
</tr>
<tr>
<td>Length (L) to weight (W) relationship</td>
<td>( W = (0.10275)L - 4.10532 )</td>
<td>( W = (0.267578)L - 18.4861 )</td>
</tr>
<tr>
<td>( r^2 ) (significance level) for L-W relationship</td>
<td>0.90 (( P &lt; 0.001 ))</td>
<td>0.96 (( P &lt; 0.001 ))</td>
</tr>
<tr>
<td>Catch per unit effort (fish/s)</td>
<td>0.009769094</td>
<td>0.005328597</td>
</tr>
</tbody>
</table>
DISCUSSION

Redd counts in North and South Callahan creeks decreased from 42 redds in 2003 to 25 redds in 2004 (Table 2) (Walters 2004b). However, because redd numbers have only been monitored since 2002 in the Callahan Creek drainage, the data series is too short to determine bull trout population trends based on redd counts. Index redd counts should continue annually on North and South Callahan creeks.

McArthur Lake increases the summer water temperature of Deep Creek immediately downstream of the reservoir. However, this impact on the water temperature of Deep Creek quickly decreases with increasing distance downstream of McArthur Lake. For example, by the end of July, Deep Creek discharge at the outlet of McArthur Lake (Site 3) was <50% of the discharge just 10 km downstream at Naples (Site 6). The increased discharge within the first 10 km downstream of McArthur Lake is likely due mainly to groundwater seepage, as there are only three small (1st order) tributaries within this reach.

During late July and August, the warmest, driest part of the year, Deep Creek at the McArthur Lake outlet could theoretically be cooled if the two tributaries that flow into the lake could be routed directly to the outlet instead. However, the flow and temperature data for July 26 showed that this would result in only a 1.5°C decrease in water temperature at the outlet, down to 22.2°C, which is still near the upper limit of suitable water temperatures for rainbow trout. Because McArthur Lake stratifies in summer, cooler water drawn from the bottom of the reservoir could also potentially be used to help cool the water downstream in Deep Creek. However, dissolved oxygen levels of <4 mg/l in the cooler water of McArthur Lake were below minimum levels generally considered suitable for rainbow trout and other coldwater fish (4-7 mg/l; Bennett 1970; Axon 1971; Bridges and Hambly 1971). Further investigation would be needed to determine the feasibility of aerating water drawn from the bottom of the reservoir and to determine if the volume of cool water in the reservoir would be enough to supply Deep Creek during the hottest part of summer.

Resource managers would have to decide if the cost to decrease Deep Creek’s water temperature within the 1st 10 km downstream of McArthur Lake was justified. For example, before attempting to mitigate the temperature affects of the reservoir, this 10 km reach should be inventoried to determine if there is suitable physical habitat for rainbow trout. From the 10 km point downstream to the mouth, sources other than McArthur Lake (e.g., tributaries) contribute a larger percentage of Deep Creek discharge. Therefore, water temperature mitigation efforts in the tributaries or mainstem in this reach could benefit a larger portion of the drainage rather than concentrating mitigation efforts at McArthur Lake.

Increases in rainbow trout density and QSD suggest positive responses to the change in fishing regulations initiated in 2002 (Table 6). Relative weight measurements have remained about the same since the regulations change, indicating that there has not been a trade-off between fish condition and increased densities. These patterns are compatible with the original objectives of the regulations change, which include conserving the population from overexploitation (e.g., no decrease in densities), and improving the population size structure. Although the Kootenai River rainbow trout population has increased since 1993 at the Hemlock Bar reach, densities are still low compared to the Kootenai River in Montana and other large Idaho rivers (Schill 1991). For example, the average age-2 and older density of rainbow trout in the Flower-Pipe reach of the Kootenai River, Montana was 662 trout/km for 1993, 1994, and 1999 (J. Dunnigan, Montana Fish, Wildlife and Parks, personal communication), while the
highest density recorded at the Hemlock Bar reach was 112 fish/km in 2004 (Table 6). Other management options, such as nutrient restoration in the Idaho reach of the Kootenai River, may help increase rainbow trout densities and subsequent angler catch rates (Hardy 2003).

Year two of baseline nutrient concentration data for Boulder Creek is similar to results from 2003, with soluble reactive and total dissolved phosphorus concentrations at or below detection limits. However, dissolved inorganic nitrogen may be the limiting nutrient in Boulder Creek as concentrations were <0.020 mg/L and often below detection limits (0.010 mg/L) in 2003 and 2004 (Bothwell 1988; Ashley and Stockner 2003). Therefore, nutrient supplementation could increase biological productivity and rainbow trout growth in Boulder Creek, as shown with salmonids in other stream studies (Johnston et al. 1990; Peterson et al. 1993). If rainbow trout growth increased, overwinter survival would likely increase as well (Scrivener and Brown 1993; Smith and Griffith 1994; Meyer and Griffith 1997). Increased overwinter survival of juvenile rainbow trout in Boulder Creek could then result in higher recruitment to the Kootenai River.

Documenting nitrogen and phosphorus concentrations is a first step in determining if a stream is a candidate for nutrient enrichment (Ashley and Stockner 2003). Further investigation is needed to determine the trophic status of Boulder Creek by examining composition and biomass of periphyton, benthic invertebrates, and fish (Ashley and Stockner 2003). In addition, habitat should be quantified in Boulder Creek to help determine if this stream could support higher densities of juvenile rainbow trout.

**RECOMMENDATIONS**

1. Continue annual bull trout redd surveys on index reaches of North and South Callahan creeks and Boulder Creek.

2. Before expending resources to mitigate the temperature affects of McArthur Lake on the temperature of Deep Creek, investigate options to decrease summer water temperatures or increase rainbow trout access to cooler tributaries in the Deep Creek drainage downstream of Naples.

3. Maintain the current harvest regulations for rainbow trout (406 mm [16 inch] minimum size and 2 fish creel limit) and continue monitoring rainbow trout population statistics.

4. Further research in Boulder Creek should quantify baseline data on biological productivity (e.g., composition and biomass of periphyton, benthic invertebrates, and fish) and amount of suitable rainbow trout habitat.
ACKNOWLEDGEMENTS

Gary Aiken Jr., Derek Antonelli, Ralph Bahe, Mary Terra-Berns, Steve Boorman, Beth Chase, Chip Corsi, Pete Gardner, Cathy Gidley, Ryan Hardy, Greg Hoffman, Charlie Holderman, Cori Kedish, Tim Kiser, Vaughn Paragamian, Tom Price, Shane Rewoldt, and Pete Rust assisted with field, lab, and data entry work. Tom Bassista, Vaughn L. Paragamian, and Glen Pettit reviewed and commented on drafts of the report. Cheryl Leben prepared the report for printing.
LITERATURE CITED


