Coeur d'Alene Tribe
Fisheries Program

Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation

2007 ANNUAL REPORT

Coeur d'Alene Tribe Department of Natural Resources
Fisheries Program
401 Annie Antelope Road
Plummer, ID 83851-0408

Coeur d'Alene Tribe
Fisheries Program

Implementation of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation

2007 ANNUAL REPORT

BPA PROJECT #1990-044-00
TRIBAL CONTRACT #90BP10544
BPA CONTRACT #00037842

Prepared By

Jon A. Firehammer
Angelo J. Vitale
Stephanie A. Hallock

September 2009

Coeur d'Alene Tribe Department of Natural Resources
Fisheries Program
401 Annie Antelope Road
Plummer, ID 83851-0408
PHONE: (208) 686-5302
FAX: (208) 686-3021

Table of Contents

LIST OF FIGURES

LIST OF TABLES

1.0 PROJECT BACKGROUND

Historically, the Coeur d'Alene Indian Tribe depended on runs of anadromous salmon and steelhead along the Spokane River and Hangman Creek, as well as resident and adfluvial forms of trout and char in Coeur d'Alene Lake, for survival. Dams constructed in the early 1900s on the Spokane River in the City of Spokane and at Little Falls (further downstream) were the first dams that initially cut-off the anadromous fish runs from the Coeur d'Alene Tribe. These fisheries were further removed following the construction of Chief Joseph and Grand Coulee Dams on the Columbia River. Together, these actions forced the Tribe to rely solely on the resident fish resources of Coeur d'Alene Lake for their subsistence needs.

The Coeur d'Alene Tribe is estimated to have historically harvested around 42,000 westslope cutthroat trout (*Oncorhynchus clarki lewisi*) per year (Scholz et al. 1985). In 1967, Mallet (1969) reported that 3,329 cutthroat trout were harvested from the St. Joe River, and a catch of 887 was reported from Coeur d'Alene Lake. This catch is far less than the 42,000 fish per year the tribe harvested historically. Today, only limited opportunities exist to harvest cutthroat trout in the Coeur d'Alene Basin. It appears that a suite of factors have contributed to the decline of cutthroat trout stocks within Coeur d'Alene Lake and its tributaries (Mallet 1969; Scholz et al. 1985; Lillengreen et al. 1993). These factors included the construction of Post Falls Dam in 1906, major changes in land cover types, impacts from agricultural activities, and introduction of exotic fish species.

The decline in native cutthroat trout populations in the Coeur d'Alene basin has been a primary focus of study by the Coeur d'Alene Tribe's Fisheries and Water Resources programs since 1990. The overarching goals for recovery have been to restore the cutthroat trout populations to levels that allow for subsistence harvest, maintain genetic diversity, and increase the probability of persistence in the face of anthropogenic influences and prospective climate change. This included recovering the lacustrine-adfluvial life history form that was historically prevalent and had served to provide both resilience and resistance to the structure of cutthroat trout populations in the Coeur d'Alene basin. To this end, the Coeur d'Alene Tribe closed Lake Creek and Benewah Creek to fishing in 1993 to initiate recovery of westslope cutthroat trout to historical levels.

However, achieving sustainable cutthroat trout populations also required addressing biotic factors and habitat features in the basin that were limiting recovery. Early in the 1990s, BPA-funded surveys and inventories identified limiting factors in Tribal watersheds that would need to be remedied to restore westslope cutthroat trout populations. The limiting factors included: low-quality, low-complexity mainstem stream habitat and riparian zones; high stream temperatures in mainstem habitats; negative interactions with nonnative brook trout in tributaries; and potential survival bottlenecks in Coeur d'Alene Lake.

In 1994, the Northwest Power Planning Council adopted the recommendations set forth by the Coeur d'Alene Tribe to improve the Reservation fishery (NWPPC Program Measures 10.8B.20). These recommended actions included: 1) Implement habitat restoration and enhancement measures in Alder, Benewah, Evans, and Lake Creeks; 2) Purchase critical watershed areas for protection of fisheries habitat; 3) Conduct an educational/outreach program for the general public within the Coeur d'Alene Reservation to facilitate a "holistic" watershed protection process; 4)

Develop an interim fishery for tribal and non-tribal members of the reservation through construction, operation and maintenance of five trout ponds; 5) Design, construct, operate and maintain a trout production facility; and 6) Implement a monitoring program to evaluate the effectiveness of the hatchery and habitat improvement projects. These activities provide partial mitigation for the extirpation of anadromous fish resources from usual and accustomed harvest areas and Reservation lands.

Since that time, much of the mitigation activities occurring within the Coeur d'Alene sub-basin have had a connection to the BPA project entitled "Implement of Fisheries Enhancement Opportunities on the Coeur d'Alene Reservation" (#1990-044-00), which is sponsored and implemented by the Coeur d'Alene Tribe Fisheries Program. Further, most of the aforementioned limiting factors are being addressed by this project either through habitat enhancement and restoration techniques, biological control, or with monitoring and evaluation that will provide data to refine future management decisions. This annual report summarizes previously unreported data collected during the 2007 calendar year to fulfill the contractual obligations for the BPA project. Even though the contract performance period for this project crosses fiscal and calendar years, the timing of data collection and analysis as well as implementation of restoration projects lends itself to this reporting schedule. The report is formatted into two primary sections:

- Monitoring and evaluation. This section comprises monitoring results for biological and physical indicators that describe the status and trends of trout populations and in-stream habitat features in our target watersheds. In addition, this section summarizes data that evaluate the effectiveness of implemented management actions in our watersheds, including recent channel restoration activities and the brook trout suppression program.
- Implementation of restoration and enhancement projects. This section comprises descriptions of the channel and riparian restoration projects that were implemented in 2007. Included in the action descriptions are summaries of the immediate effects that the restoration measures had on channel features.

To provide consistency between project objectives around which past reports have been structured and the work element format adopted by Pisces, relevant work elements and/or milestones found in our statement of work are referenced within each section.

2.0 STUDY AREA

The study area addressed by this report consists of the southern portion of Coeur d'Alene Lake and four watersheds – Alder, Benewah, Evans, and Lake - which feed the lake (Figure 1). These areas are part of the larger Coeur d'Alene sub-basin, which lies in three northern Idaho counties Shoshone, Kootenai and Benewah. The basin is approximately 9,946 square kilometers and extends from the Coeur d'Alene Lake upstream to the Bitterroot Divide along the Idaho-Montana border. Elevations range from 646 meters at the lake to over 2,130 meters along the divide. This area formed the heart of the Coeur d'Alene Tribe's aboriginal territory, and a portion of the sub-basin lies within the current boundaries of the Coeur d'Alene Indian Reservation.

Coeur d'Alene Lake is the principle water body in the sub-basin. The lake is the second largest in Idaho and is located in the northern panhandle section of the state. The lake lies in a naturally dammed river valley with the outflow currently controlled by Post Falls Dam. The lake covers 129 square kilometers at full pool with a mean depth of 22 meters and a maximum depth of 63.7 meters.

The four watersheds currently targeted by the Tribe for restoration are located mostly on the Reservation (Figure 1), but cross boundaries of ownership and jurisdiction, and have a combined basin area of 34,853 hectares that include 529 kilometers of intermittent and perennial stream channels. The climate and hydrology of the target watersheds are similar in that they are influenced by the maritime air masses from the pacific coast, which are modified by continental air masses from Canada. Summers are mild and relatively dry, while fall, winter, and spring bring abundant moisture in the form of both rain and snow. A seasonal snowpack generally covers the landscape at elevations above 1,372 meters from late November to May. Snowpack between elevations of 915 and 1,372 meters falls within the "rain-on-snow zone" and may accumulate and deplete several times during a given winter due to mild storms (US Forest Service 1998). The precipitation that often accompanies these mild storms is added directly to the runoff, since the soils are either saturated or frozen, causing significant flooding.

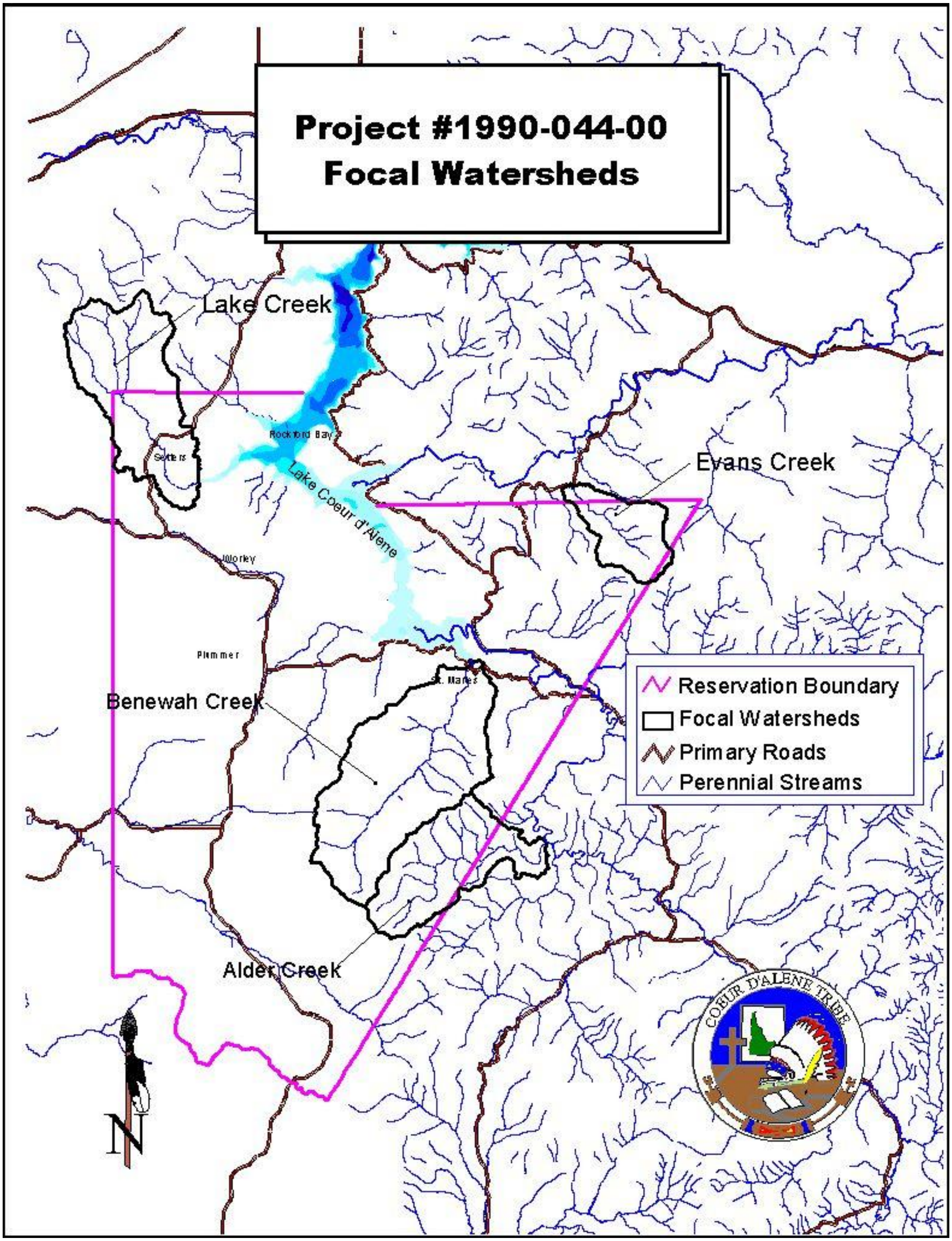

Figure 1. Locations of BPA Project 90-044-00 Focal Watersheds on the Coeur d'Alene Indian Reservation.

3.0 MONITORING AND EVALUATION

3.1 Introduction

Salmonid populations and habitat features are monitored annually at index sites distributed across tributary and mainstem reaches to track changes in status within our four target watersheds (Vitale et al. 2002). Abundance trajectories for both native westslope cutthroat trout and non-native brook trout at index sites permits an examination of whether conditions are improving for either species and if improvements are operating at a local subbasin or a regional watershed scale. Further, the detection of declining trends may signal potential localized degradation in habitat conditions that need to be addressed. Trend monitoring also permits a description of changes in spatial distributions to assess expansion and contraction rates of our salmonid populations. We not only assess relative changes in abundance at the reach scale, but also monitor overall trends at the watershed scale by tracking number of juvenile outmigrants and returning adults in watersheds that support the adfluvial life-history. In addition to our salmonid populations, we also track annual trends in temperatures given that high water temperature during summer rearing periods has been considered to be a major factor limiting cutthroat trout production in our watersheds.

Effectiveness monitoring is also conducted in watersheds that are currently receiving treatments to address factors limiting cutthroat trout recovery. We are monitoring the response of salmonids and physico-chemical habitat features to action implementation by measuring indicator variables in both treated and control reaches or watersheds. Effectiveness monitoring is currently being conducted in the upper Benewah watershed to evaluate responses to large-scale channel construction activities and non-native brook trout control.

In 2005 and 2006, 1112 m of mainstem channel habitat was reconstructed in the upper Benewah watershed upriver of 9-mile bridge to address dysfunctional stream processes, including channel incision, unstable streambanks and accelerated sedimentation, lack of habitat complexity, and elevated summer rearing temperatures from low stream canopy closure and reduced groundwater connection with adjacent floodplains (Vitale et al. 2007, 2008). This 4th order mainstem reach was targeted because it had the potential to increase carrying capacity and production of juvenile cutthroat trout given its proximity and connectivity to important spawning tributaries. Channel reconstruction during these two years entailed reactivating meanders previously abandoned following channel avulsions; elevating riffle streambeds to promote overbank flooding and increase pool volume; adding large wood to instream habitats to provide cover, create pools, and aid in bank stabilization; and planting vegetation along channel margins and riparian zones for shade and future woody debris recruitment. Monitoring the biological response to these enhancement actions included examining changes in trout abundances before and after habitat restoration in treated reaches relative to control mainstem reaches. Temperature responses were monitored by examining differences in thermal heterogeneity in pool habitats between restored and control mainstem reaches.

A brook trout control program was initiated in 2004 to suppress the numbers of brook trout found in mainchannel and tributary habitats in the upper portion of the Benewah watershed. This control was deemed necessary because brook trout have been shown to negatively impact westslope cutthroat trout, displacing westslope cutthroat trout when populations of the two species overlap (Griffith 1988, Adams et al. 2001, Peterson and Fausch 2003, Peterson et al. 2004; Shepard 2004). Unlike other brook trout removal projects that have focused on eradication and subsequent preventative recolonization measures, such as passage barriers (Shepard et al. 2003), our approach was tempered by the desire to maintain connectivity with the lake to promote the adfluvial life-history strategy and its concomitant high productivity potential. We felt that the benefits of unimpeded access and the expression of the adfluvial life-history greatly outweighed the benefits of tributary isolation and purported re-invasion inhibition (Peterson et al. 2008). Further, eradication treatments have not always proven entirely successful, and, within our watershed, would require large-scale chemical treatments that may receive public opposition and an extensive trapping and hauling program to supply spawners to the various isolated tributaries. Monitoring of the success of the removal program is conducted by examining changes in brook trout abundances estimated at our index sites in the upper Benewah watershed relative to those monitored at index sites in our control watershed, Alder Creek. In addition, we also track changes in maturation metrics in residual brook trout (e.g., fecundity-at-length, size-at-maturation) that would signal a reproductive compensatory response to our efforts.

The objectives of the monitoring and evaluation section with corresponding BPA Pisces scope of work elements are as follows:

1) Assess temporal and spatial changes in cutthroat trout abundances and distribution
    a) Measure the productivity of the adfluvial life-history of cutthroat trout by analyzing data collected from migration traps and PIT tag systems installed in Lake and Benewah creek watersheds (Work Elements M,N,O,P,S)
    b) Conduct electrofishing population surveys at index sites to assess relative changes in the distribution and density of salmonids in mainstem and tributary reaches within the four target watersheds (Work Elements Q,T)

2) Collect and summarize longitudinal trends in water temperatures by deploying loggers within monitored watersheds (Work Elements V,Y)

3) Evaluate effectiveness of habitat restoration in the upper Benewah watershed
    a) Assess differences in trout densities between restored treatment sites and unrestored control sites in mainstem reaches (Work Element T)
    b) Assess differences in thermal heterogeneity in pool habitats between treatment reaches and control mainstem reaches (Work Elements W,Y)
    c) Assess differences in physical habitat indicators measured at treatment and control sites (Work Elements U,Y)

4) Reduce the abundance and distribution of non-native brook trout in the upper Benewah watershed
    a) Remove brook trout from Benewah Creek (Work Element K)
    b) Test the effectiveness of the removal program by comparing pre-implementation densities to 2007 densities in both treated and control watersheds (Work Element L)
    c) Examine compensatory responses in reproductive metrics in brook trout (Work Elements K,L)

3.2 Methods

3.2.1 Trend and status monitoring

3.2.1.1 Trout density surveys

The channel types delineated during prior habitat surveys (Lillengreen et al. 1996) served as basic geomorphic units for selecting sample index sites for conducting fish population surveys. In these early channel type surveys, stream reaches were stratified into relatively homogeneous types according to broad geomorphologic characteristics of stream morphology, such as channel slope and shape, channel patterns and channel materials, as defined by Rosgen (1994). Stream reaches were further stratified by basin area to ensure that both mainstem and tributary habitats were represented in the stratification scheme. Sample index sites within each reach stratum were randomly selected in proportion to the total reach length (Figure 2-5). The length of each index site was standardized to 61 meters to encompass at least 20 channel widths for most sites.

Sites were electrofished between July and November to quantify the abundance and distribution of salmonids during base flow conditions. Electrofishing was conducted with a Smith-Root Type VII pulsed-DC backpack electrofisher, and followed established guidelines and procedures to standardize capture efficiency (Reynolds 1983). Captured salmonids, including westslope cutthroat trout and brook trout *(Salvelinus fontinalis)* were identified, enumerated, and measured for total length (TL, mm). Weights (Wt, g) and scales were collected from a subsample of 8-10 fish within each 10 mm length group for each species and watershed. Other species, such as dace (*Rhinichthys* spp.), redside shiner (*Richardsonius balteatus*), longnose sucker (*Catostomus catostomus*), and sculpin (*Cottus* spp.), were considered incidental catch and were only counted. For each site, 10 representative channel widths were collected to permit estimation of site area for fish density calculations.

Index site abundances were derived separately for each salmonid species, and were estimated using the removal-depletion method (Zippen 1958; Seber and LeCren 1967). Typically, three passes were conducted at a site, but at some sites, only two passes were conducted because of time constraints or habitat conditions. To satisfy the closed population assumption of the removal-depletion method, block nets were placed at the upstream and downstream boundaries to prevent immigration and emigration during sampling. For sites in which only two passes were conducted, site estimates were calculated using the following equation (Armour et al. 1983):

$$N = \frac{U_1}{1 - (U_2 / U_1)},$$

where:

N = estimated population size;
U_1 = number of fish collected in the first pass; and
U_2 = number of fish collected in the second pass.

The standard error of the estimate (*se(N)*) was calculated as:

$$se(N) = \sqrt{\frac{M(1 - M / N)}{A - (2p)^2 (U_2 / U_1)}},$$

where:

$M =$ $U_1 + U_2$;
$A =$ $(M/N)^2$; and
$p =$ $1 - \frac{U_2}{U_1}$.

Site estimates for three pass removals were calculated using the following equation (Armour et al. 1983):

$$N = \frac{M}{1-(1-p)^t},$$

where:

$N =$ estimated population size;
$M =$ sum of all removals ($U_1 + U_2 + \ldots.U_t$);
$t =$ the number of removal occasions;
$U_i =$ the number of fish in the i^{th} removal pass;
$C =$ $(1)U_1 + (2)U_2 + (3)U_3 + \ldots..(t)U_t$;
$R =$ $(C\text{-}M)/M$;
$p =$ $(a_0)1 + (a_1)R + (a_2)R^2 + (a_3)R^3 + (a_4)R^4$; and
$a_i =$ Polynomial coefficient from Table 8 (Armour et al. 1983).

The standard error of the estimate (*se(N)*) was calculated as:

$$se(N) = \sqrt{\frac{N(N-M)M}{M^2 - \frac{N(N-M)(tp)^2}{(1-p)}}}$$

The approximate 95% confidence interval for each abundance estimate was then calculated as follows:

$$95\%CI = N \pm 1.96 * se(N)$$

The abundance estimates were converted into density values (# fish/100 m^2) to compare values across sites and over years within watersheds. To facilitate a simple short-term trend evaluation, site-specific slope estimates were generated from abundance data collected since 2002. Slopes were estimated for periods ranging from 2002 to 2007 and from 2005 to 2007 for each index site. Slope estimates for each period were then assigned to one of seven qualitative categories to describe the strength of the directional trend: less than –10, between –10 and –5, between –5 and –1, between –1 and 1 (indicating stable abundance), between 1 and 5, between 5 and 10, and greater than 10. Given the low number of data points (i.e., 3-6) used in these computations, the intent of this procedure was not to generate statistically robust slope estimates. Rather, the intent was to produce an easily obtainable index that could be used to illustrate similarities and differences in trends among sites that could be displayed in figures or tables.

Density values were also extrapolated over the reach in which the sites were sampled to estimate the total number of fish in each reach. Total reach areas were obtained from the digital data layer maintained by the Tribal GIS Program. Variance estimates for the reach-scale abundance estimates were a combination of the measurement errors at each site and the sampling error attributed to the variation in abundance estimates among sites (Hankin 1984; Hankin and Reeves 1989). Watershed scale estimates were not calculated due to the inability to obtain reliable variance estimates for all reaches within a watershed.

Weight-to-length regressive relationships were compared to assess differences in somatic growth of both cutthroat and brook trout among the four target watersheds. Species-specific ANCOVA models were used to evaluate these differences, with watershed as the independent factor and length as the covariate. Initial model results supported homogeneity of slopes for cutthroat (p = 0.092) and brook (p=0.325) trout regressions, satisfying the assumptions of the ANCOVA analysis. Pairwise comparisons between watersheds were conducted using the Tukey procedure if an overall significant difference was detected.

3.2.1.2 Adfluvial cutthroat trout run size and migration

Migration traps were installed in Lake and Benewah creeks in 2007 to collect life-history information on adfluvial cutthroat trout. Resistance board weir (RBW) traps (Tobin 1994; Stewart 2002) were used in both watersheds to intercept adult cutthroat migrating upriver. This style of migrant trap has proven successful in capturing adult fish in past years during periods of heavy spring discharge. A modified fence-weir design was used in both watersheds as the downriver trap (DN) to capture post-spawn adults and outmigrating juveniles. The design incorporated pop-out panels that can be removed during periods of high flow to relieve pressure on the trap. Traps were checked and cleaned frequently during periods of operation, with checks occurring daily during peak movement periods from March through early June to assess migration timing and relative abundance. Lengths, weights, and scales were collected and condition factors (estimated as $10{,}000 * Wt / TL^3$) calculated from all captured adult salmonids. Only lengths were measured from outmigrating juveniles, unless they were tagged.

In both Lake and Benewah creek watersheds, a portion of outmigrating, juvenile cutthroat trout captured in DN traps were PIT-tagged following the Pacific States Marine Fish Commission, PTAGIS guidelines. PIT-tagging was implemented in both systems to aid in estimating within-lake survival rates of adfluvial cutthroat trout. Accordingly, PIT-tag multiplexing arrays were installed in the mainstem of both systems downriver of traps. In Lake Creek, the array was located approximately 0.13 km downstream of the DN trap, and 5-10 m downriver of the RBW. In Benewah Creek, the array was positioned immediately downriver (1-5 m) of both traps. Lengths, weights, and scales were collected from all PIT-tagged juveniles, and attempts were made to representatively tag juvenile fish throughout entire outmigration periods. Subsamples of PIT-tagged juveniles were used in trap efficiency trials to estimate outmigrant abundance. For each trial, tagged fish were held for a day in a PVC-framed net pen upriver of the DN trap before their release to determine 24-hour post-PIT tag survival and tag retention. Recaptured fish from different release trials were then enumerated at the trap to derive outmigration estimates for each release trial period (Carlson et al. 1998):

$$U_h = \frac{(u_h)(M_h + 1)}{m_h + 1},$$

where:

U_h = outmigrant abundance, excluding recaptured fish, in trial period h;

u_h = number of untagged fish in trial period *h;*
M_h = number of tagged fish released in trial period *h*; and
m_h = number of tagged fish recaptured in trial period *h*.

The variance estimate of U_h was calculated as follows:

$$v(U_h) = \frac{(M_h + 1)(u_h + m_h + 1)(M_h - m_h)(u_h)}{(m_h + 1)^2 (m_h + 2)}.$$

Total outmigration abundance (*U*) and variance (*v(U)*) were then calculated as the sum of the respective estimates over all trial periods. An approximate 95% confidence interval was then calculated as:

$$U \pm 1.96\sqrt{v(U)}.$$

Because observed rates of trap passage varied considerably for tagged fish released above the DN trap, all marked fish did not have an equal probability of being caught during a release trial's recapture period. Because of this mark-recapture model violation, a modification of the stratified design used by Carlson et al. (1998) was used to estimate release trial abundances. Instead of using all tagged fish released during a trial period (i.e., M_h in the equation above) to estimate abundance, only those tagged fish available for recapture were used in calculations. Tagged fish were considered available for recapture if during the trial period they were either trapped or detected by the PIT-tag antenna array (this assumes that all tagged fish that bypassed the trap without being recaptured were detected by the array).

PIT-tag array detections were also monitored to determine if cutthroat trout tagged as juveniles in previous years had returned to participate in the spawning migration of 2007. Array detections were analyzed to estimate in-lake growth rates, assess behavior of migrating fish, estimate duration of time on spawning grounds, and evaluate both trap and detection efficiencies. The PIT-tag antenna array was operational only in Lake Creek in 2007.

3.2.1.3 Longitudinal stream temperatures

Stream temperatures were continuously monitored every 15-20 minutes at fixed locations along mainstem reaches and in major tributaries of Benewah and Lake creek watersheds using HOBO Temp Pro (Onset Computer Corp.) digital temperature dataloggers (accurate to ±0.2 °C). Air temperatures were also recorded using HOBO H8 Pro Series loggers (Onset Computer Corp.) at both a forested and open meadow site in Benewah and Lake creek watersheds. Daily mean, minimum, and maximum water temperatures, and the percent time in which logged temperatures exceeded 17°C were computed for each HOBO logger. In addition, these daily metrics were used in calculations of monthly mean and maximum values for July and August to permit comparisons within and across watersheds.

3.2.2 Effectiveness monitoring – Habitat indicator response to restoration in Benewah

Temperature

Thermal heterogeneity at fine-scale, riffle/pool sequences was assessed in mid summer using a rapid-response digital thermistor probe (Cooper Instruments model TM99A-E, accurate to within

±0.1 °C). The thermistor probe was attached to a surveying rod, permitting simultaneous measurements of depth and temperature. While wading upstream, water temperature and depth (m) were recorded both at a riffle and at the deepest part of the associated pool upstream. The relationship between residual pool depth and the calculated riffle-pool temperature difference was examined to determine differences in the availability of thermal refugia between restored and control upper mainstem reaches in Benewah Creek.

Stream typing

The classification of stream channel types followed guidelines presented by Rosgen (1996) and used data collected during the thalweg profile, cross section profile and sinuosity surveying efforts. The objective of classifying streams on the basis of channel morphology was to use discrete categories of stream types to develop consistent, reproducible descriptions of the stream reaches. These descriptions must provide a consistent frame of reference to document changes in the stream channels over time and to allow comparison between different streams. The dominant substrate type (i.e., slit/clay, sand, gravel, or cobble) was included as a modifier to the channel type. The numbering for this is 1 for bedrock, 2 for boulder, 3 for cobble, 4 for gravel, 5 for sand and 6 for silt and clay. The delineative criteria included entrenchment ratio, width-to-depth (W/D) ratio, sinuosity and slope.

Longitudinal thalweg profile

The first effort to be undertaken upon arrival at a monitoring site was to determine the location of the downstream end of the previously surveyed reach. Once this was found, the location was flagged with surveyors' ribbon. Bank pins were established on the banks of the channel above the high water mark at major changes in the channel planform. When the 500-foot mark was reached this marked the end of the reach. Profile surveys involved the determination of water depth, and water surface and channel bottom elevations along the thalweg of each 500-foot study reach using methods modified from Peck et al. (2001). Elevation measurements were made relative to a fixed benchmark, assigned an arbitrary elevation of 100.00 ft. All measurements were recorded as distances along the longitudinal profile. A sufficient number of measurements were taken to capture all changes in bed and water surface slope and habitat types along the reach. A SET 530R Sokkia Total Station was used to collect longitudinal profile data at most sites, in place of an autolevel, which had been used in previous surveys. Survey data was recorded on a Recon Pocket PC. After the survey was complete, data was downloaded into a text file and imported into Microsoft excel for analysis.

Bed-form differencing

Identifying pool and riffle habitats is important in monitoring changes in bedform and fish habitat. Residual pool depth (RPD) is a particularly important habitat indicator because it can be accurately measured independent of discharge (Kershner et al 2004) and increasing RPD is generally associated with increased salmonid biomass (Hogel 1993; Binns 1994). A macrohabitat identification technique called the Bed Form Differencing was applied to each of the longitudinal profiles collected to minimize the error in identifying pools and riffles due to acknowledged inconsistencies associated with field identification (Kershner et al 2004) and to facilitate comparisons across datasets (Arend 1999). This method was developed by O'Neill and Abrahams (1984) as a way to objectively identify bedforms in a survey reach.

Four types of bedforms are identified using this method: absolute maximums (riffles), absolute minimums (pools), local maximums, and local minimums. The tolerance value is determined by taking the standard deviation of all of the "differences" and multiplying it times a coefficient. If habitat units exceed this value they are classified as either a minimum or a maximum. If they do not exceed this value they are identified as not being a bedform. If a maximum is followed by a minimum then it is a absolute maximum (riffle). If a maximum is followed by another maximum, it is identified as a local maximum. If a minimum is followed by a maximum, it is defined as an absolute minimum (pool). A bed differencing program was developed in Microsoft Excel using Visual Basic. Residual pool depths were calculated by running a program that sorts the bedforms that are either absolute maximums or absolute minimums, then identifies the first "riffle" and starts calculating residual pools by subtracting the elevation of the absolute minimum from the adjacent downstream absolute maximum. The sample spacing is assumed to be equal to channel width though shorter spacing can be used. The resolution of our data is at a much tighter interval. As a result, we have modified our data in order to achieve spacing closer to bankfull width by running the program twice. After the first run is complete, the sign designation of each point is examined. If there is a series of more than two increasing or decreasing points, the intermediate points are deleted, then the program is ran again.

Cross section profiles

Cross section profiles were measured using a surveyor's level and rod at six locations along each studied reach. All but one of the sites had cross-sections that had been previously established in 2002 or 2003. All cross sections were monumented with permanent pins (rebar), stakes, lathe and flagging to allow for repeat surveying of the profiles in the future. In some cases, survey pins had to be reset because they had been moved or "lost". The benchmark established for the longitudinal profile was also used as the reference point for each of the six cross sections.

The cross section profiles were used to verify the bankfull depth and to calculate the bankfull cross sectional area, wetted perimeter, average and maximum depth and width-to-depth ratio. The flood-prone width, which is defined as the valley width at twice the maximum depth at bankfull, and entrenchment ratio, defined as the flood-prone width divided by the bankfull width, were determined by using floodplain cross-section information collected with the total station if it was collected. Survey data was input into the Reference Reach Spreadsheet.

Channel substrate

Wolman pebble counts (Wolman 1954) were completed at riffles and pool tailouts along the survey reach. At each of these points a measuring stick or finger was placed on the substrate and the one particle the tip touched was picked up and the size measured. Particle size was determined as the length of the "intermediate axis" of the particle; that is the middle dimension of its length, width and height. Pebble count data was input into the Reference Reach Spreadsheets, which automatically graphed the distribution of particle sizes and calculated pertinent descriptive criteria such as percent by substrate class (size) and a particle size index (D value) for each habitat type for which data was collected.

Canopy density

Vegetative canopy density (or shade) was determined using a conical spherical densiometer, as described by Platts et al. (1987). The densiometer determines relative canopy "closure" or canopy density, which is the amount of the sky that is blocked within the closure by vegetation, and this is measured in percent. Canopy density can change drastically through the year if the canopy vegetation is deciduous. Canopy cover over the stream was determined at randomly selected locations throughout the survey reach. At each selected location, densiometer readings were taken one foot above the water surface at the following locations: once facing the left bank, once facing upstream at the middle of the channel, once facing downstream at the middle of the channel and once facing the right bank. Percent density was calculated by multiplying the sum of the four readings by 1.5. If the result was between 30 and 65%, 1.0 % was subtracted; if the result is greater than 65, 2% was subtracted. The adjusted density readings were then averaged for the entire reach.

Large woody debris

The organic materials survey transect was walked along the thalweg starting at the downstream end of the reach. All woody debris that was greater than 4 inches in diameter at the small end was tallied and measured whether or not it crossed the line of the transect. This included material that was suspended above the water surface and extended outside of the wetted stream width; it is not intended to include living trees or shrubs that hung over the water. For all observed LWD, orientation was noted by taking a compass heading (degrees) looking from the large end of the piece towards the small end. Stream orientation was also recorded. Other measurements taken of all LWD were the diameter at the large end, diameter at the small end and the length between these two ends. The large end diameter was measured immediately above the roots, if there are roots attached. Data handling included the calculation of the total volume and density of LWD found within the bankfull width of each studied reach. These calculations were performed in a spreadsheet worksheet added to the Reference Reach Spreadsheet.

3.2.3 Effectiveness monitoring - Biological responses to brook trout removal in Benewah

In late summer and early fall, non-native brook trout were removed from the 4th order upper mainstem and 3rd and 2nd order tributaries of Benewah Creek. In the mainstem, removal started at the 9-mile bridge and proceeded upstream to the confluence of West and South Forks. The removal effort then focused on the 2nd and 3rd order West and South Forks of Benewah Creek. All index sites associated with the population estimate sampling were sampled prior to brook trout removal.

Lengths were collected from all brook trout removed in the Benewah watershed. In addition, a subsample of fish were dissected to ascertain gender, reproductive maturity, gonad weight, and, in the case of females, fecundity. Weights and scale samples were also collected from subsampled fish. A representative number of brook trout were also sacrificed from Alder Creek (which served as the control for the removal program) to obtain similar life-history data to compare compensatory responses of brook trout in Benewah Creek with those in Alder creek.

Changes in brook trout abundance due to the removal program were assessed by comparing mean index site densities over the years 2002-2004 to site densities estimated during the 2007 surveys. Mean densities from the period before program implementation were used to minimize potential bias introduced by natural fluctuation in annual brook trout numbers. For Benewah Creek, only index sites impacted by the removal program were included in the analysis, which consisted of mainstem sites 15-17 and all index sites in Whitetail, Windfall, Schoolhouse, South Fork Benewah, and West Fork Benewah creeks. Similarly, only index sites in Alder Creek in which brook trout have been consistently found were included in the comparative analysis. The non-parametric Wilcoxon rank sum test was used to assess statistically significant differences between time periods for both watersheds.

Logistic regression was used to assess sex-specific differences in length-at-maturity between brook trout collected from Benewah and Alder creeks. The model included maturation status as the dependent variable and length and watershed as the independent variables. Estimated odds ratios were used to evaluate the relative likelihood of a given sized brook trout from Alder Creek being mature compared to a similar-sized fish from Benewah Creek (Johnson 1998).

Fecundity-at-size regressive relationships for female brook trout were compared to assess differences in reproductive effort between watersheds. ANCOVA models were used to evaluate these relationships, with fecundity as the dependent variable, watershed as the independent factor, and either length or weight as the covariate. A t-test was also used to evaluate whether differences in the gonadosomatic index (GSI, calculated as 100*gonad weight / total weight) existed between female brook trout from both watersheds.

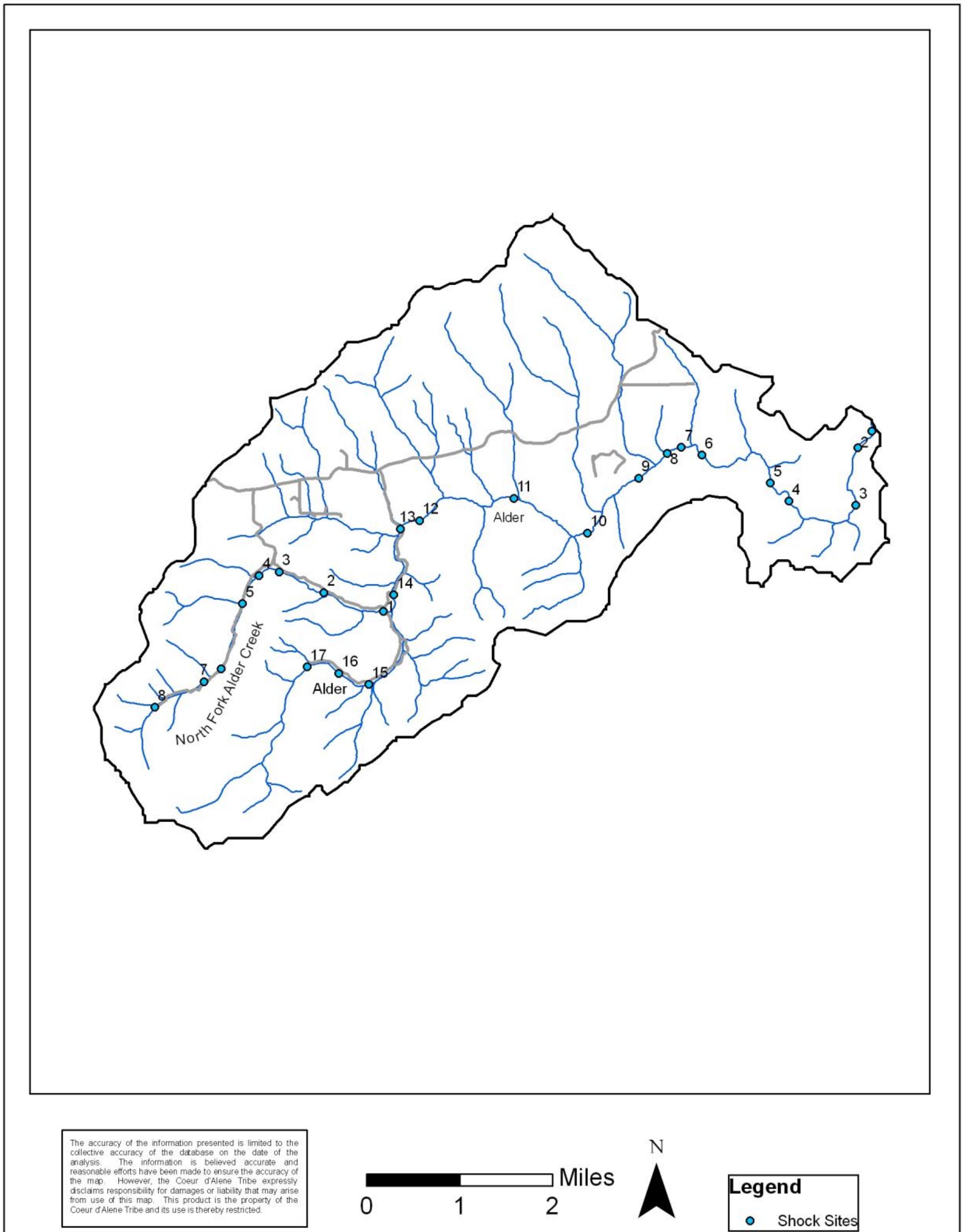

Figure 2. Map of Alder Creek depicting index sites sampled during salmonid population surveys in 2007.

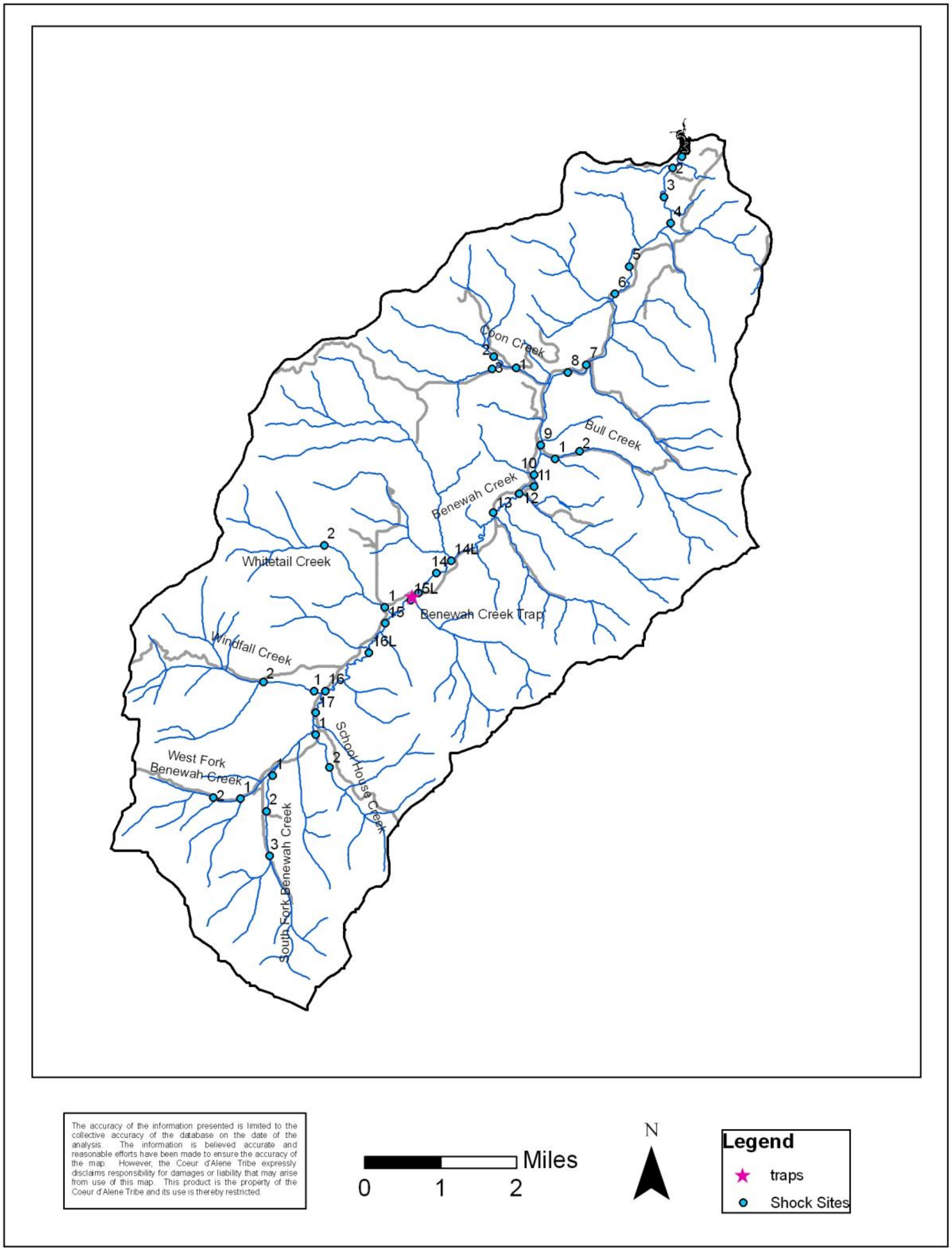

Figure 3. Map of Benewah Creek depicting index sites sampled during salmonid population and habitat surveys in 2007. Trap location is indicated by the star.

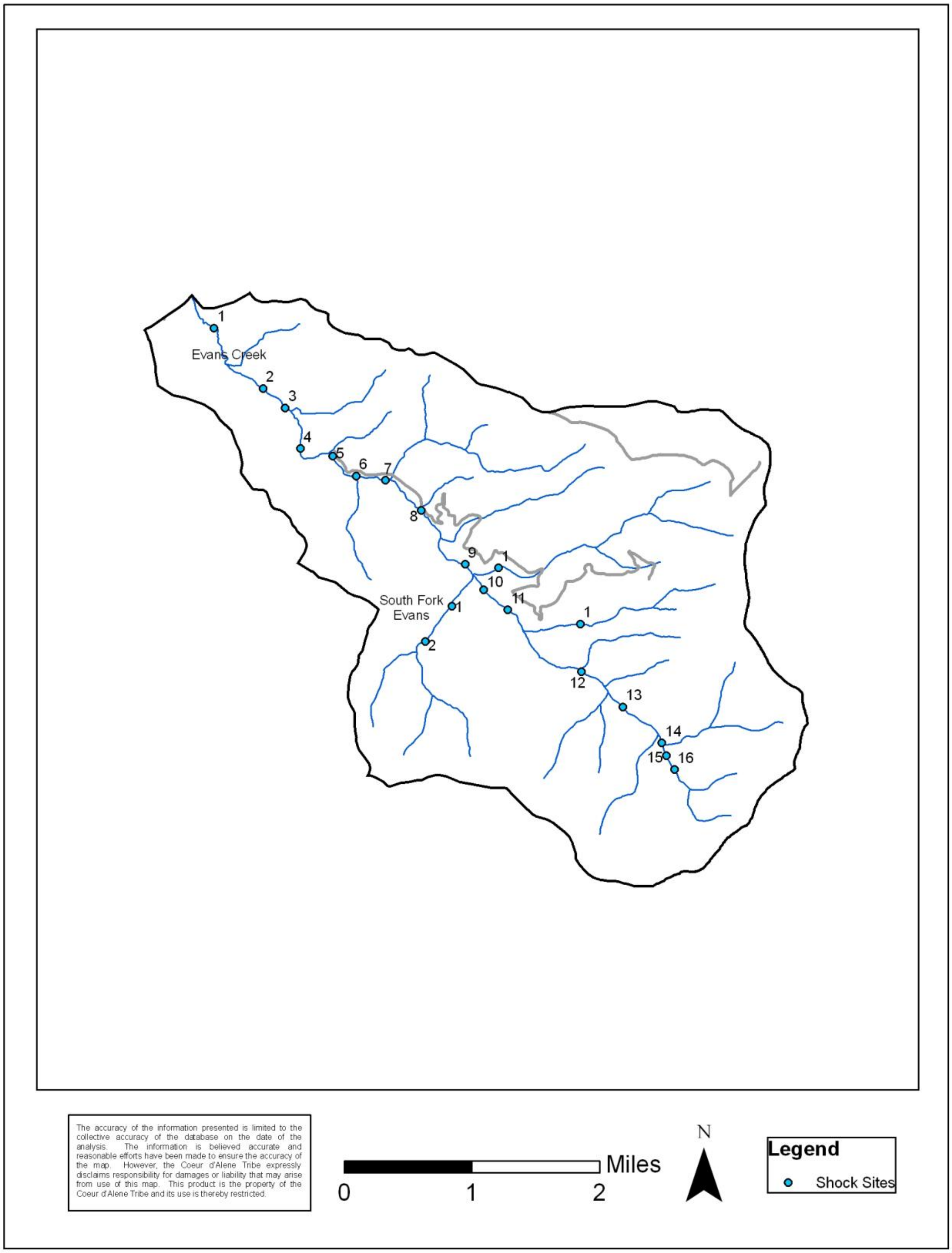

Figure 4. Map of Evans Creek depicting index sites sampled during salmonid population surveys in 2007.

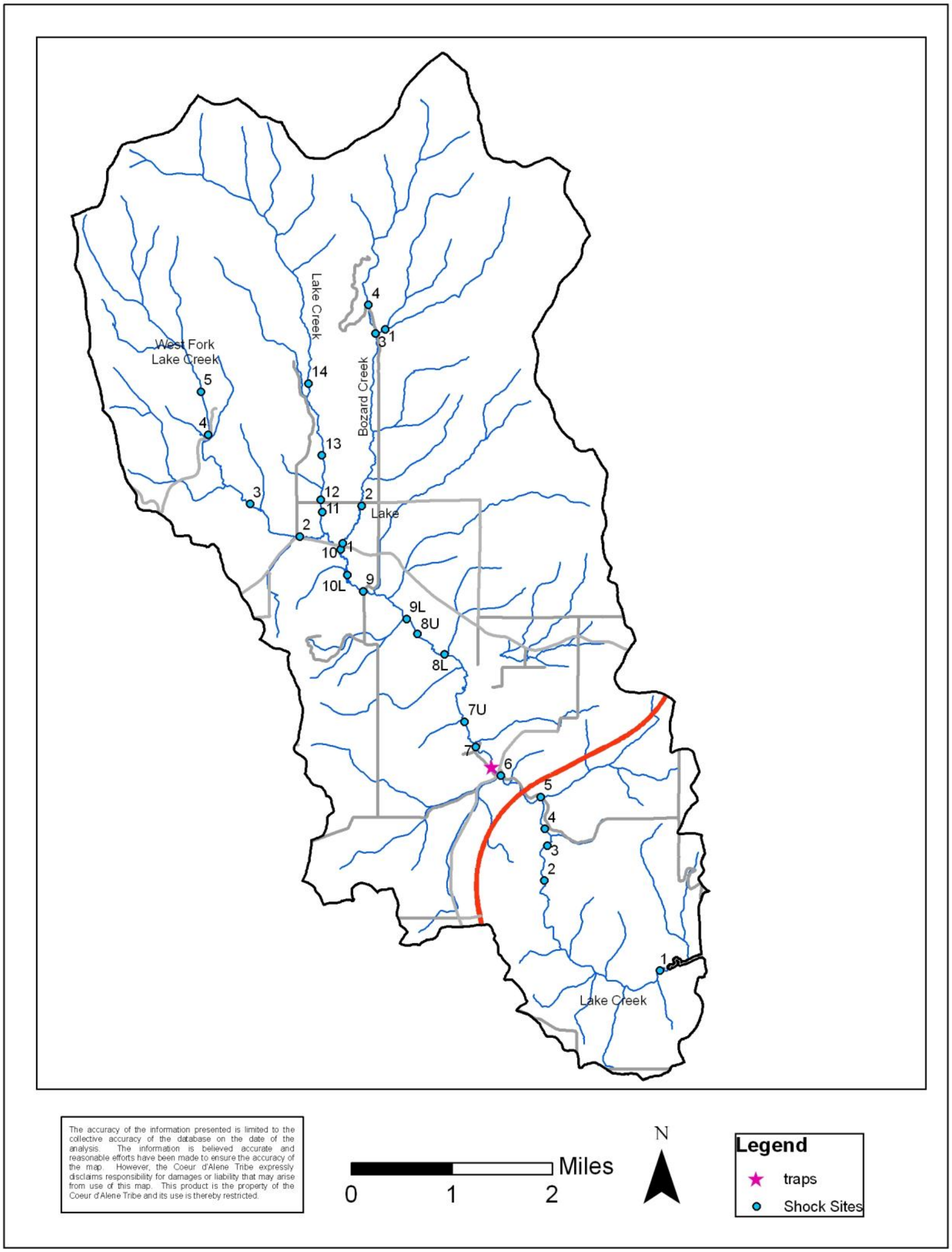

Figure 5. Map of Lake Creek depicting index sites sampled during salmonid population surveys in 2007. Trap location is indicated by the star.

3.3 Results

3.3.1 Trend and status monitoring – Biological indices

3.3.1.1 Lake Creek adult adfluvial cutthroat trout

The resistant board weir (RBW) trap was installed in the mainstem of Lake Creek on February 2 in 2007 (see Figure 5 for trap location) and was considered to fish effectively for the entire 90 d period before it was removed on May 8. A total of 117 adfluvial adult cutthroat trout was captured in the trap (Table 1). Ninety-five of these 117 were females with mean lengths and weights of 370 mm and 479 g, respectively. The other 22 were identified as males with mean lengths and weights of 388 mm and 507 g, respectively. Adult cutthroat were primarily captured before mid-April with 80% of the fish captured in a 13 d period from April 2 to April 14 (Figure 6).

The pop-out panel downriver trap (DN) was installed in Lake Creek on April 13 in 2007 and was considered to trap effectively for the 63 d it was monitored (97% of the time) before it was removed on June 15. A total of 253 adult adfluvial cutthroat trout was captured in the DN, approximately twice as many as that captured in the RBW (Table 1). Of the 253, 182 were identified as females (mean length of 378 mm; mean weight of 438 g) and 68 as males (mean length of 405 mm; mean weight of 575 g). Noticeably, mean condition factors were lower for females captured in the DN than for females caught in the RBW, indicating that many of the outmigrating females likely spawned. Outmigrating adults were almost exclusively captured after mid-April with 88% caught during a two-week period from April 15 to April 30 (Figure 6). However, it was likely that a number of post-spawn adults had already outmigrated before the trap was installed as supported by the large number of fish captured during the first few days of trap operation (i.e., daily counts of 19-26 during April 15-18).

Eight fish that had been captured and PIT-tagged as juveniles during outmigration periods in prior years were detected in either of the two traps in 2007, with five of the eight captured by both traps (Table 2). Seven of the adults (six females and one male) had been tagged in 2005, and the other adult female was tagged in 2006. Annual growth increments for fish tagged in 2005 ranged between 85.5 and 106.5 mm/y; the fish that was tagged last year increased in length by 140 mm. The reduction in condition factor for the three twice-trapped females that were tagged two years ago ranged between 0.11 and 0.16, whereas the decrease in condition factor between trapping periods was only 0.04 for the female tagged in 2006 (Table 2).

In addition to the eight PIT-tagged adults captured by the Lake Creek traps, eight other fish were detected by the PIT tag array in spring of 2007, with six of these eight tagged in 2005 and the other two tagged in 2006 (Table 3). First detections generally ranged from March 17 to April 8, spanning a similar period over which adult cutthroat trout were caught in the RBW (Figure 6). Generally, as supported by the abbreviated period of 1-4 d in which fish were continuously detected, fish were either captured or apparently ascended past the trap quickly after their first array detection (Table 3). However, the two fish tagged in 2006 were repeatedly detected by the array for approximately half of the days over a one month time period. Discounting the two fish that were repeatedly detected and consequently may not have ascended upriver past the RBW, 9 of the 14 fish (64%) were detected during two different time periods (periods were defined as being separated by at least a 14 d absence of detections), alluding to the fish being detected during both their upriver spawning migration and downriver outmigration. The elapsed number of days between detection periods for these nine fish ranged from 13 to 42 d (Table 3). Notably, all PIT-tagged adults that were captured by either trap or detected during their downriver migration were also detected by the array during their upriver migration.

Table 1. Length, weight and condition factor means and standard deviations (SD) for adult adfluvial cutthroat trout captured during their upriver and downriver migrations in Lake and Benewah creeks in 2007.

		Total length (mm)			Weight (g)		Condition Factor	
Gender	**N**	**Range**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
			Lake Creek upriver migrating adults					
Female	95	293-457	370.0	31.0	478.8	100.3	0.93	0.08
Male	22	303-458	387.5	38.9	506.6	126.5	0.89	0.05
			Lake Creek downriver migrating adults [a]					
Female	182	292-484	378.1	27.4	438.1	95.0	0.80	0.06
Male	68	290-500	405.0	36.9	574.7	145.3	0.85	0.06
			Benewah Creek downriver migrating adults					
Female	6	250-435	340.3	68.0	365.8	217.6	0.84	0.04
Male	3	329-374	351.0	22.5	403.3	97.9	0.92	0.05

[a] Three additional fish of undetermined sex were also captured but dropped at the trap

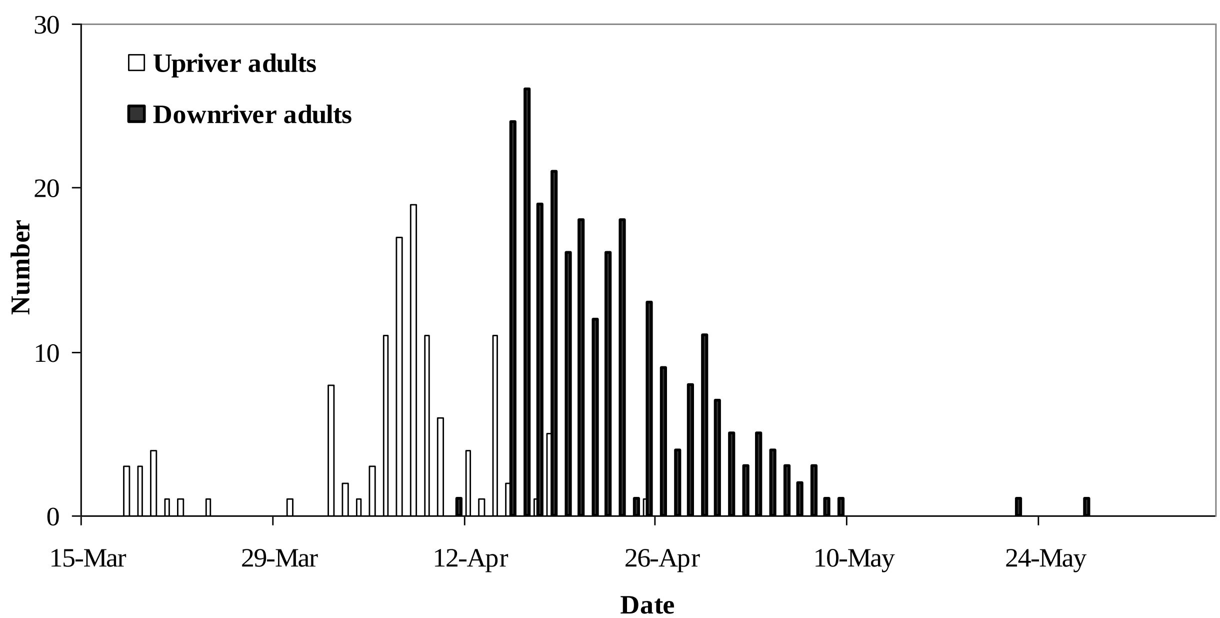

Figure 6. Timing of adult adfluvial cutthroat trout captured during their upriver and downriver migrations in Lake Creek, 2007.

Table 2. Summary data for adult adfluvial cuttroat trout PIT-tagged as juveniles in prior years and either recaptured at the resistant board weir (RBW) during their upriver migration or at the downriver trap (DN) during their outmigration in Lake Creek, 2007.

	Tagging information				Recaptured at the RBW				Recaptured at the DN				
Sex	**Year**	**Date**	**Length (mm)**	**Weight (g)**	**Date**	**Length (mm)**	**Weight (g)**	**Condition factor**	**Date**	**Length (mm)**	**Weight (g)**	**Condition factor**	**Annual length increment (mm)**
F	2005	4/24	165	37.9	4/9	368	479.1	0.96	4/25	363	397.2	0.83	101.5
F	2005	4/24	152	30.2	4/7	358	425.5	0.93	.	.	.	.	103.0
F	2005	4/26	147	25.8	4/7	339	347.7	0.89	4/20	342	300.4	0.75	96.0
F	2005	4/29	146	28.2	.	.	.	.	4/15	357	372.4	0.82	105.5
F	2005	5/4	170	41.9	4/5	362	424.1	0.89	4/18	356	353.1	0.78	96.0
F	2005	5/19	175	43.7	.	.	.	.	5/4	346	338.0	0.82	85.5
M	2005	5/13	131	20.0	3/18	344	374.6	0.92	4/24	341	339.6	0.86	106.5
F	2006	4/3	153	31.9	4/8	293	223.5	0.89	4/25	292	211.0	0.85	140.0

Table 3. Summary of detections for cutthroat trout PIT-tagged in previous years in Lake Creek, 2007. Fish were considered detected during two different periods if the absence of array detections between the two periods lasted longer than 14 days. Both trap and array detections were used to calculate elapsed days between detection periods. One, two, and three asterisks next to the PIT-tag number indicates fish were captured at the upriver, downriver, and both traps, respectively.

		Tagging information			Dates of array detection				Initial period in which fish was detected by array		
PIT-tag number		**Year**	**Length (mm)**	**Weight (g)**	**First detection**	**Last detection before absence**	**First detection after absence**	**Last detection**	**Elapsed days**	**Days detected**	**Elaspsed days between detection periods**
3D9.257C5A6870	***	2005	165	37.9	5-Apr	8-Apr	25-Apr	25-Apr	4	4	16
3D9.257C5A7204		2005	178	44.2	24-Mar	.	.	24-Mar	1	1	.
3D9.257C5B5D3A	*	2005	152	30.2	5-Apr	.	.	6-Apr	2	2	.
3D9.257C5CBF61		2005	215	85	24-Mar	24-Mar	21-Apr	21-Apr	1	1	28
3D9.257C5CC46A	** [a]	2005	200	65.5	25-Mar	.	.	25-Mar	1	1	25
3D9.257C5B56DB		2005	175	45.1	24-Mar	.	.	24-Mar	1	1	.
3D9.257C5A6A27	***	2005	147	25.8	5-Apr	.	.	6-Apr	2	2	13
3D9.257C5ACE1A		2005	173	48.8	8-Apr	.	.	8-Apr	1	1	.
3D9.257C5C943C	**	2005	146	28.2	18-Mar	19-Mar	15-Apr	15-Apr	2	2	27
3D9.257C5CB017	***	2005	170	41.9	4-Apr	.	.	4-Apr	1	1	13
3D9.257C5D4760		2005	167	43.5	26-Mar	.	.	26-Mar	1	1	.
3D9.257C5A3FE8	***	2005	131	20	18-Mar	18-Mar	24-Apr	24-Apr	1	1	37
3D9.257C5C77B6	**	2005	175	43.7	23-Mar	.	.	24-Mar	2	2	42
3D9.257C5A909E	***	2006	153	31.9	6-Apr	7-Apr	25-Apr	25-Apr	2	2	17
3D9.257C5C6B9F		2006	122	15.2	17-Mar	.	.	25-Apr	40	23	.
3D9.257C5C8B2C		2006	127	18.3	6-Mar	.	.	15-Apr	41	17	.

[a] Fish was detected in the downriver trap but apparently was not of significant size to be considered adfluvial. Most likely a resident fish.

3.3.1.2 Lake Creek juvenile cutthroat trout

A total of 2961 juvenile cutthroat trout was captured by the downriver trap in Lake Creek in 2007. Although captured fish were distributed over the two months in which the downriver trap was fishing, approximately 50% of the juveniles were caught during May 12-29 (Figure 7). Daily numbers of captured fish exceeded 50 during this time period; the only other extended period in which daily captures exceeded 50 was from May 4 to May 8. There was a noticeable difference in the relative size distribution of juvenile cutthroat trout among periods in which they were captured. Whereas the percentage of captured fish with lengths between 101 and 140 mm generally did not exceed 50% before May 15, fish within this length group generally comprised more than 50% of the captured fish after May 15 (Figure 8).

Of the juvenile fish captured, 790 (27%) received PIT tags. Although an attempt was made to representatively tag fish throughout their outmigration, a greater percentage of captured fish was tagged before than after May 15 (Figure 9). Because of the discrepancy in tagging percentage and the shift in relative size distribution between periods, a greater percentage of large-sized juvenile cutthroat were tagged than were captured ($\chi^2 = 35.7$, $p < 0.001$;Table 4). Eleven release trials were conducted from April 15 to May 26 to assess one-day post implantation survival and tag retention, and to estimate trap efficiencies to generate outmigration estimates. All PIT-tagged fish that were used in the trap efficiency trials survived the 24 h holding period and retained their PIT tags before they were released. Trap efficiencies from release trials generally exceeded 80%, with estimates of 100% calculated for several of the trial periods (Table 5).

The total juvenile outmigrant estimate for Lake Creek in 2007 was 3292 ± 187 fish (Table 5). Because of the relatively consistent trap efficiencies across the release trial periods, abundance estimates throughout the outmigration reflected the trends observed in the numbers of captured fish. Daily abundance estimates typically were greater during the later trials conducted in May than during the early trials conducted in April. For example, 1420 juveniles were estimated to have outmigrated during the 26 d period from April 15 to May 11, compared to the 1448 outmigrating juveniles estimated during the shorter 15 d period from May 11 to May 26 (Table 5). Outmigration estimates were used to expand the numbers of captured fish from various length classes during the different trial periods to generate an estimate of the relative length distribution for the entire outmigrating cohort (Figure 10). The mean length of outmigrating juveniles in Lake Creek was 143 mm in 2007.

PIT tagged juveniles that were not used in release trials to estimate trap efficiencies were released below the trap but upriver of the PIT-tag array to assess potential behavioral differences between fish released above and below the trap (Table 6). Percent detection of fish released below the trap was generally 90% or greater for most of the release groups (the PIT tag array was not monitoring fish during May 4-8 which resulted in zero detections for fish released during this time period). Overall detection rates, either through a recapture event or an array detection, were also relatively high for fish released above the trap, typically exceeding 75% (Table 6).

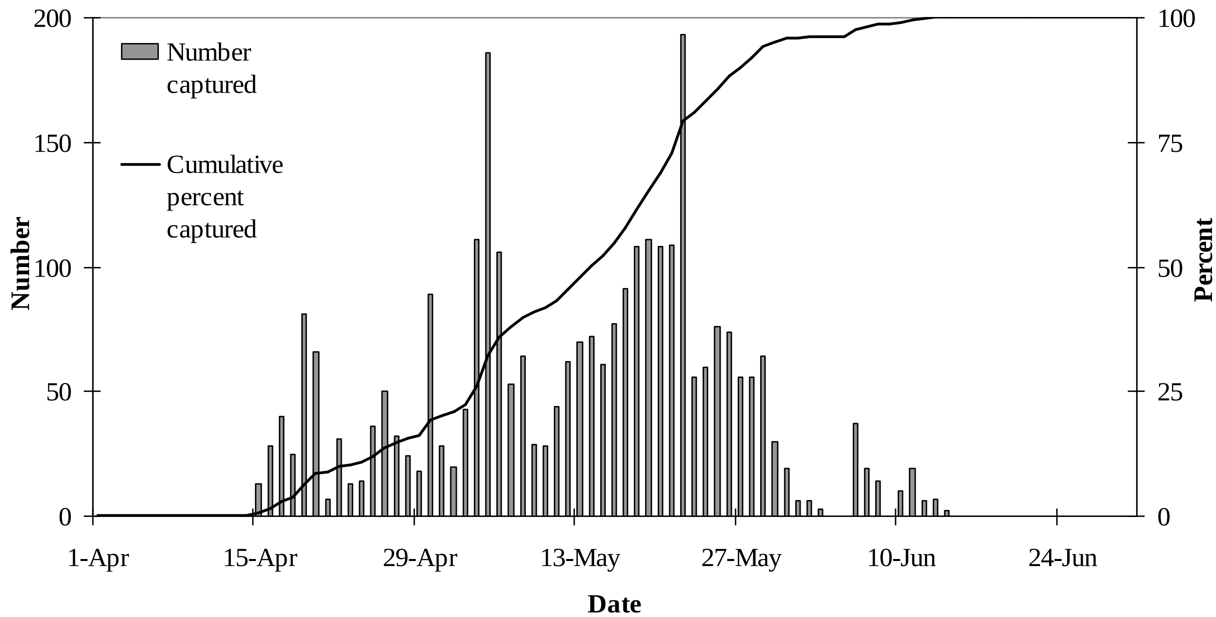

Figure 7. Timing of juvenile cutthroat trout captured in the downriver trap during their outmigration in Lake Creek, 2007.

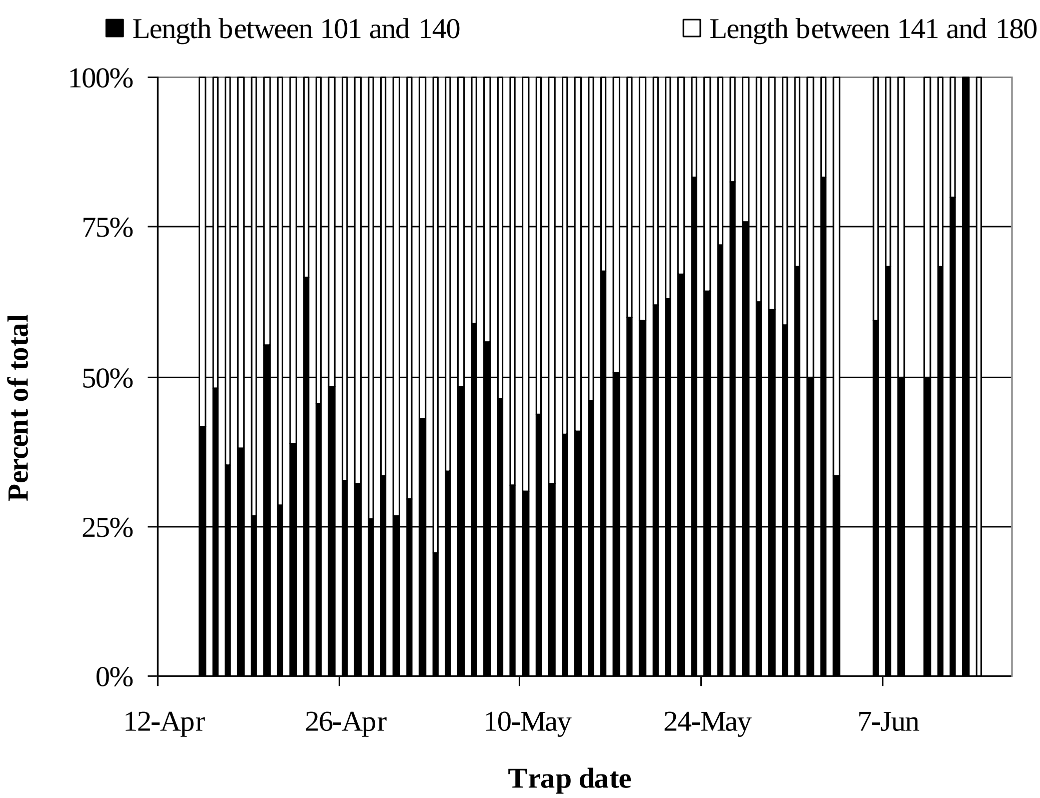

Figure 8. Changes in the percentage of juvenile cutthroat trout in two length groups, 101-140 mm and 141-180 mm, captured during the outmigration period in Lake Creek, 2007. These two length groups comprised over 95% of the captured fish.

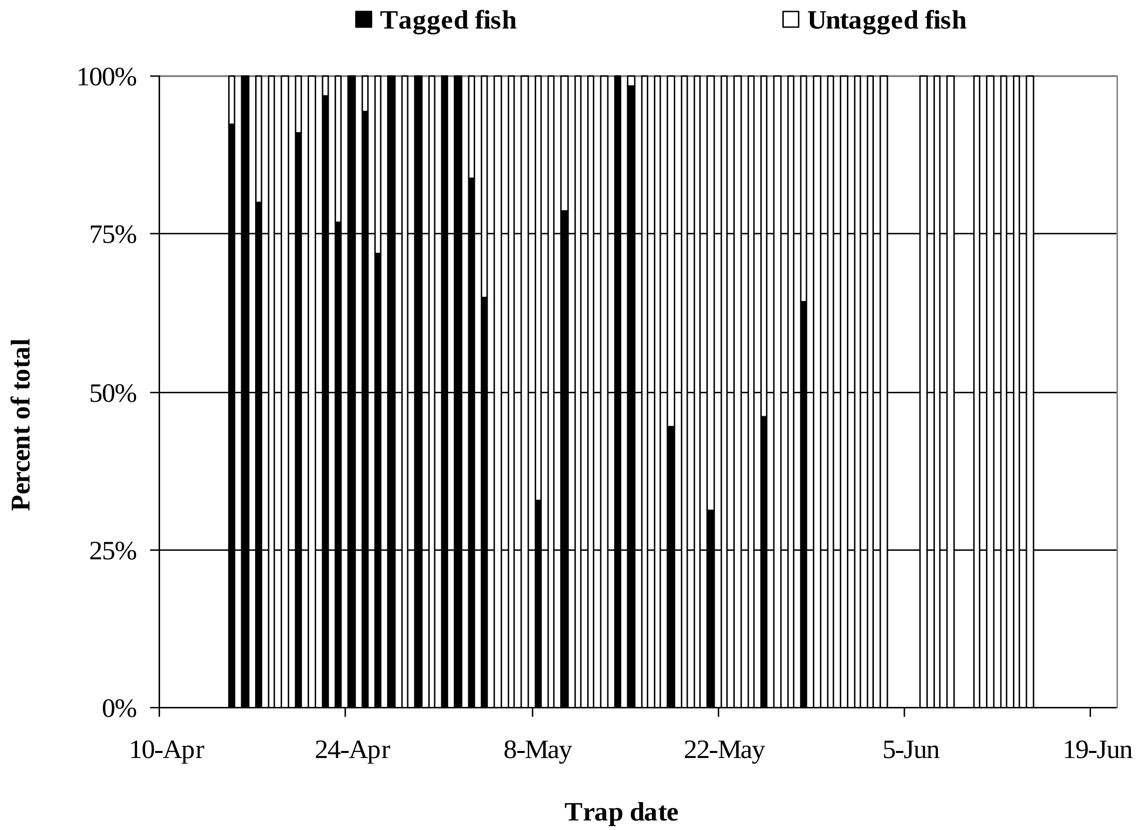

Figure 9. Relative percent of captured juvenile cutthroat trout PIT-tagged at the downriver trap throughout the outmigration period in Lake Creek, 2007.

Table 4. Number and relative percent of juvenile cutthroat trout captured and PIT-tagged of different length groups in Benewah and Lake creeks, 2007.

Length	All fish captured		Tagged fish	
group (mm)	Number	Percent	Number	Percent
		Benewah Creek		
81-100	8	2.0	4	1.5
101-120	60	15.1	39	14.3
121-140	117	29.5	74	27.1
141-160	144	36.3	99	36.3
161-180	57	14.4	46	16.8
181-200	9	2.3	9	3.3
>200	2	0.5	2	0.7
		Lake Creek		
81-100	8	0.3	4	0.5
101-120	239	8.2	51	6.5
121-140	1237	42.4	267	33.8
141-160	988	33.9	296	37.5
161-180	334	11.4	134	17.0
181-200	89	3.1	34	4.3
>200	23	0.8	4	0.5

Table 5. Abundance estimates for juvenile cutthroat trout outmigrating from April 15 to June 14 in Lake Creek, 2007. Abundance estimates with associated variances were calculated using a simple stratified mark-recapture design. Tagged fish were considered available for recapture if they were either captured in the trap or detected by the downriver array within the trial period.

Trial	Release date	Trial period	Fish captured	Tagged fish available for recapture	Tagged fish recaptured	Trap efficiency estimate	Abundance estimate	Variance of abundance estimate
1	04/15/07	04/15/07 - 04/17/07	81	6	6	100	81	0.0
2	04/17/07	04/17/07 - 04/18/07	25	12	11	92	27	6.4
3	04/18/07	04/18/07 - 04/21/07	154	31	31	100	154	0.0
4	04/21/07	04/21/07 - 04/25/07	94	27	18	67	139	370.7
5	04/25/07	04/25/07 - 04/28/07	106	21	18	86	123	121.1
6	04/28/07	04/28/07 - 05/01/07	135	39	33	85	159	135.3
7	05/01/07	05/01/07 - 05/05/07	360	23	23	100	360	0.0
8	05/05/07	05/05/07 - 05/11/07	324	6	5	83	378	2970.0
9	05/11/07	05/11/07 - 05/16/07	342	24	24	100	342	0.0
10	05/16/07	05/16/07 - 05/26/07	986	36	32	89	1106	4016.1
11	05/26/07	05/26/07 - 06/14/07	354	23	19	83	425	1513.1
Total			**2961**				**3292**	**9133** [a]

[a] Variance of the abundance estimate was used to generate a 95% confidence interval of 3105-3479 fish

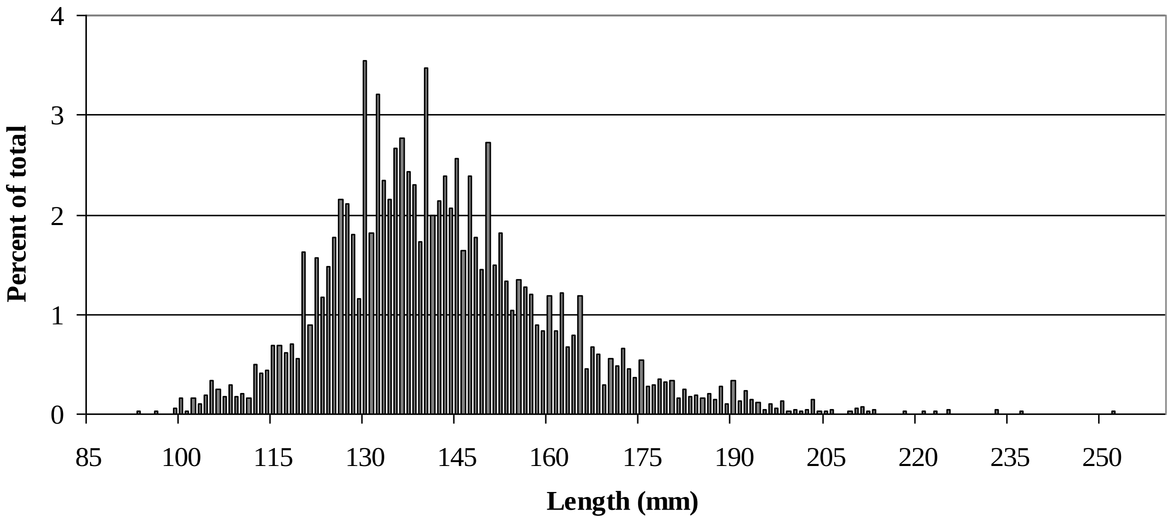

Figure 10. Length distribution for juvenile cutthroat trout outmigrating in Lake Creek, 2007. Relative percentage for each length was estimated by expanding the number of fish in each length class caught in each release trial period by the respective trap efficiency estimate and summing over all trial periods.

Differences between fish released above and below the trap, however, were observed when the elapsed time periods between release and detection were compared (Table 6). For example, for fish recaptured in the trap from a release trial, typically less than 70% were caught within one day of release, and generally less than 85% were caught within two days. Conversely, for fish released below the trap that were detected by the array, typically greater than 90% and 95% were detected within one and two days of release, respectively. In addition, the mean number of elapsed days before detection was greater for recaptured fish released above the trap (range of 1.40-5.05 d for various trials) than for fish released below the trap (range of 1.0-2.3 d for various trials). Furthermore, there was greater variability in the number of elapsed days before detection for fish released above than for fish released below the trap as reflected by the larger standard deviation estimates for the former group (Table 6).

Table 6. Summary statistics for PIT-tagged juvenile cutthroat trout released above the trap (trial fish) and below the trap (non-trial fish) in Lake Creek, 2007. Non-trial fish detected by the array on the day of release were given a value of 1 for number of elapsed days to permit comparison with trial fish that were not evaluated for recapture until the day after release.

		Recaptured in trap or detected by array		**Recaptured in trap only**		**Trial fish recaptured or non-trial fish detected by array in given time period (%)**		**Elaspsed days before recapture for trial fish or array detection for non-trial fish**	
Release Date	**Number released**	**Number**	**Percent**	**Number**	**Percent**	**<= 1 day**	**<= 2 days**	**Mean**	**Standard deviation**
				Fish released above trap for efficiency trial					
04/15/07	12	9	75	9	75	33	67	3.00	3.16
04/17/07	28	22	79	19	68	53	79	5.05	9.22
04/18/07	32	29	91	28	88	82	86	2.14	2.85
04/21/07	36	31	86	24	67	63	63	4.92	6.88
04/25/07	24	23	96	20	83	50	60	3.40	4.16
04/28/07	32	31	97	25	78	68	96	1.40	0.71
05/01/07	28	27	96	27	96	0	81	2.59	1.78
05/05/07	36	14	39	10	28	0	20	4.80	2.97
05/11/07	22	20	91	20	91	0	0	3.70	1.72
05/16/07	36	32	89	29	81	62	76	2.10	1.76
05/26/07	35	22	63	19	54	0	63	3.37	2.95
				Fish released below trap					
04/20/07	24	23	96	.	.	87	96	2.30	5.83
04/22/07	30	28	93	.	.	96	96	1.21	1.13
04/25/07	34	34	100	.	.	100	100	1.00	0.00
04/26/07	36	33	92	.	.	94	94	1.18	0.73
04/29/07	18	16	89	.	.	100	100	1.00	0.00
05/02/07	20	18	90	.	.	100	100	1.00	0.00
05/03/07	36	0	0	.	.	.	.	.	.
05/04/07	36	0	0	.	.	.	.	.	.
05/08/07	21	18	86	.	.	89	94	1.44	1.65
05/14/07	72	63	88	.	.	100	100	1.00	0.00
05/15/07	24	24	100	.	.	92	100	1.08	0.28
05/18/07	48	46	96	.	.	100	100	1.00	0.00
05/21/07	34	33	97	.	.	100	100	1.00	0.00
05/28/07	36	34	94	.	.	100	100	1.00	0.00

3.3.1.3 Benewah Creek adult adfluvial cutthroat trout

Upriver migrating adult cutthroat trout were not captured in Benewah Creek in 2007. However, nine adults were captured in the downriver trap (DN) between April 27 and May 14; the DN was monitored from its installation date on April 26 to its removal date on June 8. Given that an adult cutthroat trout was caught a day after trap installation, it is likely that other adults had outmigrated before this time. Six of the adults were females with mean lengths and weights of 340.3 mm and 365.8 g, respectively; the other three fish were identified as males with mean lengths and weights of 351.0 mm and 403.3 g, respectively (Table 1). From April 27 to May 3, five brook trout were caught in the DN, with lengths of the captured fish ranging between 174 and 258 mm.

3.3.1.4 Benewah Creek juvenile cutthroat trout

A total of 400 juvenile cutthroat trout was captured in the DN from April 27 to June 8 (Figure 11). Captured fish were proportionately distributed across the period in which the trap was considered fishing. However, the capture of seven juveniles one day after trap installation suggests that a portion of the outmigrant run may have been missed. PIT-tags were implanted into 273 of the juvenile cutthroat trout that were captured (68%). Other than the lack of fish tagged during the last date of trap capture, juveniles were representatively tagged throughout their outmigration period (Figure 12). In addition, similar percentages of both small and large juveniles were tagged as were captured ($\chi^2 = 2.1$, $p = 0.91$; Table 4). PIT-tagged fish were not used in mortality, tag retention, or trap efficiency trials in 2007.

3.3.1.5 Trout density surveys

Late summer and early fall electrofishing population surveys in 2007 revealed a disproportionate distribution of cutthroat trout both across and within the four sampled watersheds. Whereas cutthroat trout were captured in relatively high numbers across index sites within the Evans Creek watershed (median, 31.5 fish/site), fish were rarely captured at index sites within the Alder Creek watershed (median, 1.0 fish/site). Cutthroat trout were captured at intermediate levels in the Benewah Creek watershed (median, 7.0 fish/site) and in the Lake Creek watershed (median, 9.5 fish/site), but were found in higher numbers at sites within tributary reaches than at sites within mainstem reaches in both watersheds.

In the Evans Creek watershed, estimated densities of cutthroat trout generally exceeded 10 fish/100m^2 across index sites in mainstem and tributary reaches; densities greater than 20 fish/100m^2 were not uncommon in both lower and upper reaches of the watershed (Table 7). In general, estimated densities in 2007, especially at those sites with the highest numbers of captured fish, were approximately twice their respective means calculated over the last 4-5 years. Furthermore, strong increasing trends were apparent at all high-density sites over the last three years.

In the Alder Creek watershed, cutthroat trout were primarily captured at index sites 3-5 within the lower reach, with estimated densities ranging between 2.69 and 6.25 fish/100m^2 at these sites (Table 8). These values were greater than their respective means calculated over the last four to five years, and suggested an increasing trend within this reach over the last three years. Conversely, positive trends were not apparent in other reaches of the watershed where estimated cutthroat trout densities were typically less than 2.5 fish/100m^2.

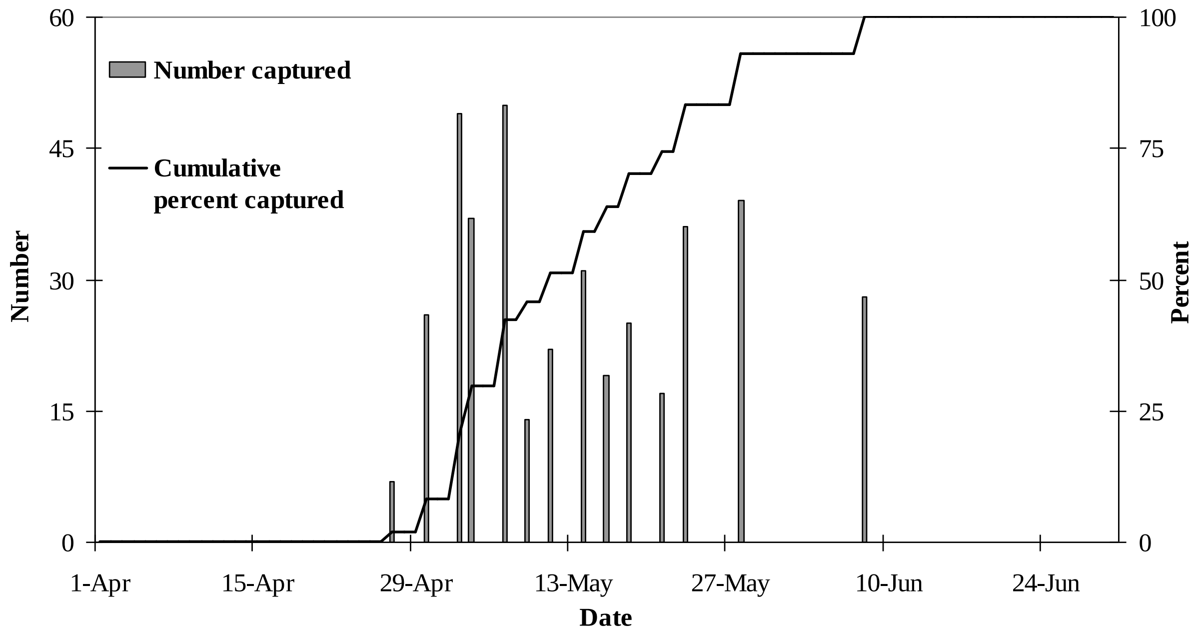

Figure 11. Timing of juvenile cutthroat trout captured in the downriver trap during their outmigration in Benewah Creek, 2007.

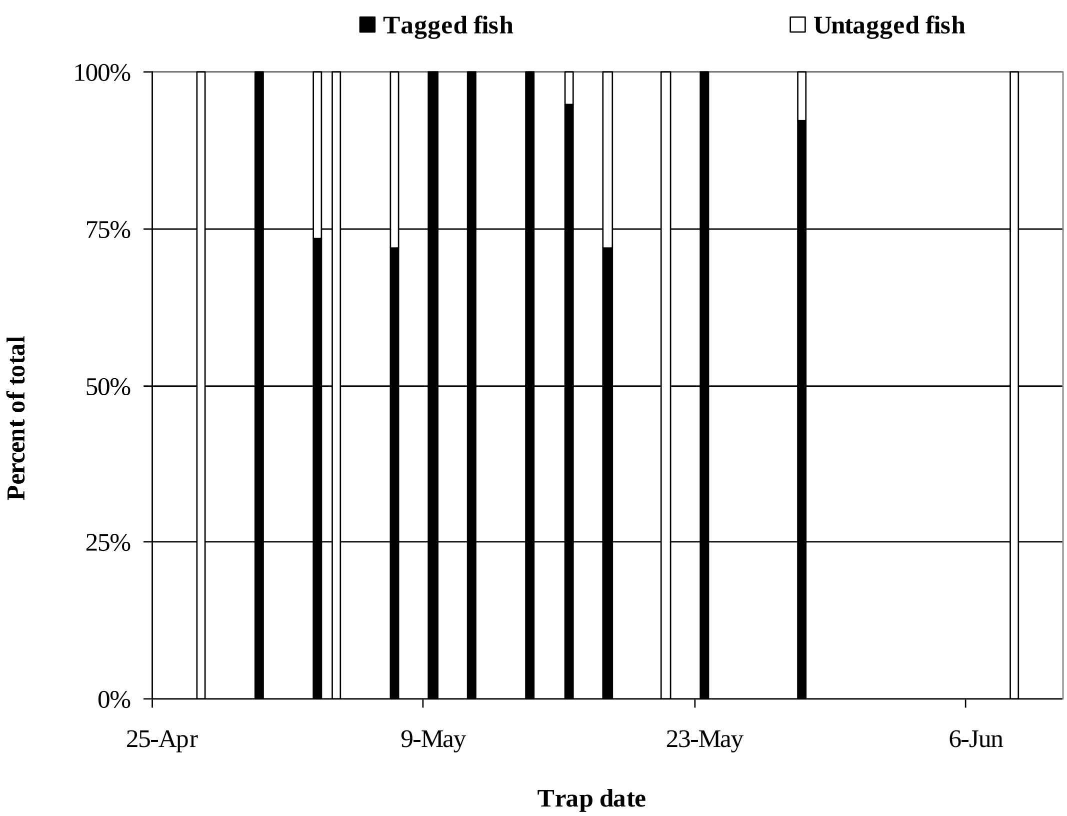

Figure 12. Relative percent of captured juvenile cutthroat trout PIT-tagged at the downriver trap throughout the outmigration period in Benewah Creek, 2007.

Furthermore, cutthroat trout were not captured at 75% of the index sites sampled within the upper reaches of Alder Creek (i.e., sites 15-17 above the North Fork confluence) and in the North Fork tributary.

In the Benewah Creek watershed, mainstem densities of cutthroat trout were relatively low compared to other reaches, with estimated values typically below 3.5 fish/100m^2; densities at three sites in reaches of the upper mainstem, however, ranged between 3.75 and 10.95 fish/100m^2 (Table 9). Conversely, estimated densities at sites within tributary reaches typically exceeded 10 fish/100m^2, with values greater than 35 fish/100m^2 estimated at sites within Bull and Coon creeks and upper reaches of Windfall, South Fork, and West Fork creeks. In addition, densities at most of these upper mainstem and tributary sites that contained elevated numbers of cutthroat trout were greater than their respective means calculated over the last 4-5 years. Although consistent 5-6 year trends were not apparent among sites in the upper portion of the Benewah Creek watershed, positive three years trends were observed at many of the high-density index sites.

Similar to the Benewah Creek watershed, cutthroat trout densities in mainstem reaches of Lake Creek were relatively low, with estimated values rarely exceeding 6.0 fish/100m^2 (Table 10). An exceptionally high density (25.29 fish/100m^2) was estimated at the lowermost mainstem site near the mouth of Lake Creek as a result of an unusually large number of age-0 cutthroat trout captured. Although the highest densities for cutthroat trout were estimated in tributary reaches, fish were distributed disproportionately among sites within tributaries (Table 10). For example, densities in the upper portions of West Fork and Bozard creeks (13.21-24.95 and 55.36-153.31 fish/100m^2, respectively) were much greater than those estimated in their respective lower reaches (0.85-2.39 and 8.95-14.37 fish/100m^2, respectively). Index sites in the upper Bozard Creek drainage were the only ones that displayed increasing trends at both temporal scales; a decreasing short-term trend was apparent across index sites in the West Fork drainage.

Brook trout were captured only in the Benewah and Alder creek watersheds during late summer and early fall electrofishing population surveys in 2007. Brook trout were distributed over greater expanses and found in larger numbers in Alder Creek than in Benewah Creek. For example, brook trout were not captured in 22 of the 36 sites sampled in Benewah Creek, and in only one site were more than 20 fish captured. Conversely, more than 20 brook trout were caught at approximately half (12 of 25) of the sites sampled in Alder Creek. In both watersheds, more brook trout were captured at sites in upper than in lower reaches.

In the Alder Creek watershed, densities of brook trout generally exceeded 20.0 fish/100m^2 in the upper mainstem reaches of Alder Creek (i.e., sites 12-17) and in the North Fork tributary, with estimated densities at some sites in excess of 40 fish/100m^2 (Table 11). Increasing densities of brook trout over the last 5-6 years were observed across most of these upper watershed sites. Furthermore, the three sites with the highest densities in 2007 also displayed strong positive trends over the last three years. Compared to these upper watershed sites, densities in sites distributed along the lower mainstem reaches were much lower, with estimated values below 5.0 fish/100m^2.

Table 7. Summary statistics for cutthroat trout captured by multipass electrofishing at index sites in the Evans Creek watershed from July 3 to August 7, 2007. Ordering of index sites corresponds to relative longitudinal position in the watershed from downstream to upstream. Density trend indicators of '+', '++', and '+++' indicate an increasing slope of 1-5, 5-10, and >10, respectively; negative sign combinations are analagous for decreasing trends. For trends between -1 and 1, a 'o' was assigned.

						Density (#/100m^2) trends from 2002-2007			
Stream	**Index site #**	**No. passes**	**Total caught**	**Abundance estimate**	**95% confidence interval**	**2007 density**	**Mean density, 2002-2006 (n)**	**3 year trend indicator [a]**	**5-6 year trend indicator [b]**
Mainstem index sites									
Evans	1	3	31	33.0	31 - 37.3	8.92	1.28 (5)	+	+
Evans	2	3	30	31.0	30 - 33.7	13.56	7.67 (4)		+
Evans	3	3	82	94.8	82 - 109.9	27.73	4.4 (5)	+ + +	+
Evans	4	3	16	16.1	16 - 16.7	7.33	6.14 (5)	+	o
Evans	5	3	21	21.5	21 - 23.4	8.91	9.15 (5)	+	-
Evans	6	3	68	70.3	68 - 74.4	32.89	15.07 (5)	+ + +	+
Evans	7	3	45	45.7	45 - 47.8	23.44	7.02 (5)	+ +	+
Evans	8	3	36	38.2	36 - 42.7	16.18	9.3 (4)	+ +	o
Evans	9	3	35	36.0	35 - 38.5	16.83	8.36 (4)	+ +	o
Evans	10	3	32	32.9	32 - 35.3	15.80	6.47 (5)	+ +	+
Evans	11	3	25	25.2	25 - 26.4	15.98	8.4 (5)	+ +	+
Evans	12	3	55	56.8	55 - 60.4	32.86	16.72 (5)	+ + +	+
Evans	13	3	37	38.7	37 - 42.4	28.91	18.39 (5)	+ +	+
Evans	14	2	49	54.8	49 - 64.5	41.51	14.57 (5)	+ + +	+
Evans	15	3	11	11.0	11 - 11.5	10.08	10.42 (5)	o	+
Evans	16	3	0	0.0	.	0.00	1.91 (4)	o	o
Tributary index sites									
East Fork	1	3	60	60.6	60 - 62.5	46.63	23.15 (5)	+ + +	+ +
South Fork	1	3	17	17.1	17 - 17.6	16.70	14.02 (5)	+	o
South Fork	2	3	18	18.5	18 - 20.2	14.39	11.68 (5)	+	o
Rainbow Fork	1	3	0	0.0	.	0.00	13.89 (5)	-	- -

[a] A trend describing the change over the last 3 years was not calculated if data were unavailable for 2005

[b] A trend describing the change over the last 5-6 years was not calculated if data were unavailable for 2002 and 2003

In the Benewah Creek watershed, only one brook trout was captured at index sites distributed in both tributaries and along lower mainstem reaches below 9-mile bridge (Table 12). Most of the brook trout were captured in upper mainstem sites (i.e., 16L, 16, and 17) and in tributary reaches in close proximity to these upper mainstem sites. Densities ranged from 10.05 fish/100m^2 to 16.02 fish/100m^2 for most of the sites sampled in the upper mainstem and in Schoolhouse and Windfall creeks. In comparison, estimated densities ranged from 0 fish/100m^2 to 10.10 fish/100m^2 in tributaries (i.e., Whitetail, South Fork, and West Fork) that were more distant from these upper mainstem habitats (Table 12). Differences among tributaries in the upper portion of the Benewah watershed were also observed when recent trends in brook trout numbers were examined. Densities of brook trout were below the 5-year average and generally stable or decreasing for sites located in the South and West Forks of Benewah Creek. On the other hand, brook trout numbers exceeded the 5-year average and were increasing at index sites located in Schoolhouse and Windfall creeks over the last 5-6 years.

Table 8. Summary statistics for cutthroat trout captured by multipass electrofishing at index sites in the Alder Creek watershed from August 13 to September 13, 2007. Ordering of index sites corresponds to relative longitudinal position in the watershed from downstream to upstream. Density trend indicators of '+', '++', and '+++' indicate an increasing slope of 1-5, 5-10, and >10, respectively; negative sign combinations are analagous for decreasing trends. For trends between -1 and 1, a 'o' was assigned.

						Density (#/100m^2) trends from 2002-2007			
Stream	**Index site #**	**No. passes**	**Total caught**	**Abundance estimate**	**95% confidence interval**	**2007 density**	**Mean density, 2002-2006 (n)**	**3 year trend indicator [a]**	**5-6 year trend indicator [b]**
					Mainstem index sites				
Alder	1	3	0	0.0	.	0.00	0 (4)	o	o
Alder	2	3	0	0.0	.	0.00	0.64 (4)	o	o
Alder	3	3	10	10.9	10 - 14.1	3.35	0.71 (4)	+	o
Alder	4	3	15	15.1	15 - 15.7	6.25	2.77 (4)	+	+
Alder	5	3	7	7.0	7 - 7	2.69	1.74 (5)	+	o
Alder	6	3	3	3.1	3 - 3.8	1.09	3.01 (5)	o	-
Alder	7	3	2	2.2	2 - 3.6	0.84	1.76 (5)	o	o
Alder	8	3	7	7.0	7 - 7.3	2.67	3.28 (5)	o	-
Alder	9	3	4	4.0	4 - 4	1.63	1.88 (5)	o	o
Alder	10	3	5	5.9	5 - 9.9	2.72	0.98 (5)	o	o
Alder	11	3	2	2.0	2 - 2	1.08	1.37 (4)	o	o
Alder	12	3	1	1.0	1 - 1	0.46	0.25 (5)	o	o
Alder	13	3	0	0.0	.	0.00	0.09 (5)	o	o
Alder	14	3	3	3.0	3 - 3	2.52	0.16 (5)	+	o
Alder	15	3	0	0.0	.	0.00	0 (5)	o	o
Alder	16	3	1	1.0	1 - 1	0.96	0 (5)	o	o
Alder	17	3	1	1.0	1 - 1	0.60	0.21 (4)	o	o
					Tributary index sites				
North Fork	1	3	1	1.0	1 - 1	1.16	0 (5)	o	o
North Fork	2	3	1	1.0	1 - 1	0.90	0.14 (5)	o	o
North Fork	3	3	0	0.0	.	0.00	0 (5)	o	o
North Fork	4	3	0	0.0	.	0.00	0 (5)	o	o
North Fork	5	3	0	0.0	.	0.00	0 (5)	o	o
North Fork	6	3	0	0.0	.	0.00	0 (5)	o	o
North Fork	7	3	0	0.0	.	0.00	0 (5)	o	o
North Fork	8	3	0	0.0	.	0.00	0 (5)	o	o

[a] A trend describing the change over the last 3 years was not calculated if data were unavailable for 2005

[b] A trend describing the change over the last 5-6 years was not calculated if data were unavailable for 2002 and 2003

Reach-specific densities for both salmonids could not be reliably generated from estimated index site densities (Appendix A, Tables A1-A6). Two sources of error contributed to the wide confidence intervals surrounding the reach-scale estimates. The first source of error was associated with the uncertainty in the abundance estimate within each site, and the second source of error arose from the large variation in densities among sites within each reach. As illustrated in tables A1-A6, within-site measurement errors were negligible compared to their respective sampling errors. Furthermore, estimates could not be derived for reaches in which only one index site was sampled, because a sample size of one precludes an estimation of sampling error. Thus, without estimates of total error at all reaches within a watershed, precision bounds around watershed-scale abundance estimates could not be generated.

Table 9. Summary statistics for cutthroat trout captured by multipass electrofishing at index sites in the Benewah Creek watershed from August 7 to October 11, 2007. Ordering of index sites corresponds to relative longitudinal position in the watershed from downstream to upstream. Density trend indicators of '+', '++', and '+++' indicate an increasing slope of 1-5, 5-10, and >10, respectively; negative sign combinations are analagous for decreasing trends. For trends between -1 and 1, a 'o' was assigned.

						Density (#/100m^2) trends from 2002-2007			
Stream	**Index site #**	**No. passes**	**Total caught**	**Abundance estimate**	**95% confidence interval**	**2007 density**	**Mean density, 2002-2006 (n)**	**3 year trend indicator [a]**	**5-6 year trend indicator [b]**
Mainstem index sites									
Benewah	1	3	0	0.0	.	0.00	0.21 (5)	o	o
Benewah	2	3	0	0.0	.	0.00	0.91 (5)	o	o
Benewah	3	3	6	6.5	6 - 9	1.76	1.13 (5)	o	o
Benewah	4	3	10	10.0	10 - 10.2	3.35	1.91 (5)	o	o
Benewah	5	3	1	1.0	1 - 1	0.36	1.73 (5)	-	o
Benewah	6	3	5	5.0	5 - 5.4	1.51	1.85 (5)	o	o
Benewah	7	3	6	6.0	6 - 6.3	1.12	2.13 (5)	-	o
Benewah	8	3	0	0.0	.	0.00	0.44 (5)	o	o
Benewah	9	3	3	3.1	3 - 3.8	1.09	0.49 (5)	o	o
Benewah	10	3	2	2.0	2 - 2	0.69	0.42 (5)	o	o
Benewah	11	3	7	7.0	7 - 7.3	3.01	0.38 (4)	+	o
Benewah	12	3	17	17.1	17 - 17.6	7.62	3.15 (4)		+
Benewah	13	3	6	6.0	6 - 6.3	1.68	1.41 (5)	o	o
Benewah	14L	2	0	0.0	.	0.00	8.65 (4)	- -	-
Benewah	14	2	0	0.0	.	0.00	1.2 (5)	o	o
Benewah	14U	3	0	0.0	.	0.00	3.6 (4)	-	o
Benewah	15L	2	0	0.0	.	0.00	.		
Benewah	15	2	0	0.0	.	0.00	0.8 (5)	o	o
Benewah	16L	3	7	7.1	7 - 7.9	3.75	.		
Benewah	16	3	15	15.0	15 - 15.4	5.90	2.07 (5)	+	+
Benewah	17	3	17	17.5	17 - 19.4	10.95	0.91 (4)	+ +	+
Tributary index sites									
Bull	1	3	31	31.2	31 - 32	40.90	56.67 (5)	- -	o
Bull	2	3	32	32.5	32 - 34.2	37.20	36.41 (5)	o	+ +
Coon	1	3	28	28.0	28 - 28.4	41.33	26.13 (2)		
Coon	3	3	0	0.0	.	0.00	6.88 (3)	-	-
Whitetail	1	3	10	10.0	10 - 10.2	11.22	7.89 (3)		-
Whitetail	2	3	19	19.0	19 - 19	17.33	6.54 (4)		o
Windfall	1	2	12	12.5	12 - 14.6	8.41	8.73 (4)	+	o
Windfall	2	3	49	49.8	49 - 51.9	43.21	43.7 (5)	+ + +	o
Schoolhouse	1	3	13	13.0	13 - 13.4	12.99	2.76 (5)	+ +	o
Schoolhouse	2	3	1	1.0	1 - 1	1.49	11.16 (5)	-	-
South Fork	1	3	8	8.1	8 - 8.8	7.13	5.13 (5)	+	o
South Fork	2	3	24	24.0	24 - 24.2	20.19	19.72 (5)	+	-
South Fork	3	3	32	33.1	32 - 36.1	36.40	10.46 (4)	+ + +	+
West Fork	1	3	24	24.3	24 - 25.4	27.78	14.84 (5)	+ +	o
West Fork	2	3	49	49.2	49 - 50	55.12	12.17 (5)	+ + +	+ +

[a] A trend describing the change over the last 3 years was not calculated if data were unavailable for 2005

[b] A trend describing the change over the last 5-6 years was not calculated if data were unavailable for 2002 and 2003

Table 10. Summary statistics for cutthroat trout captured by multipass electrofishing at index sites in the Lake Creek watershed from October 15 to November 13, 2007. Ordering of index sites corresponds to relative longitudinal position in the watershed from downstream to upstream. Density trend indicators of '+', '++', and '+++' indicate an increasing slope of 1-5, 5-10, and >10, respectively; negative sign combinations are analagous for decreasing trends. For trends between -1 and 1, a 'o' was assigned.

						Density (#/100m²) trends from 2002-2007			
Stream	**Index site #**	**No. passes**	**Total caught**	**Abundance estimate**	**95% confidence interval**	**2007 density**	**Mean density, 2002-2006 (n)**	**3 year trend indicator [a]**	**5-6 year trend indicator [b]**
					Mainstem index sites				
Lake	1	3	35	37.8	35 - 43.4	25.29	7.69 (4)	+ +	+ +
Lake	2	3	12	12.0	12 - 12.5	5.21	5.51 (5)	-	o
Lake	3	2	0	0.0	.	0.00	11.35 (5)	- - -	-
Lake	4	3	6	6.0	6 - 6.3	2.84	14.91 (4)	-	- -
Lake	5	3	4	4.4	4 - 6.4	1.79	4.54 (4)	-	o
Lake	6	3	13	13.9	13 - 16.9	6.13	17.53 (5)	- -	-
Lake	7	3	7	7.0	7 - 7.3	3.43	6.3 (5)	-	o
Lake	7U	3	10	10.2	10 - 11.2	3.73	4.14 (4)	o	o
Lake	8L	3	13	13.0	13 - 13.4	5.68	2.54 (4)	+	+
Lake	8U	3	6	6.0	6 - 6.3	2.17	3.98 (4)	-	o
Lake	9	3	3	3.0	3 - 3	1.28	3.72 (4)	o	o
Lake	10L	3	11	12.3	11 - 16.7	6.03	3.95 (4)	o	o
Lake	10	3	16	16.1	16 - 16.7	5.81	3.63 (5)	+	o
					Tributary index sites				
West Fork	1	3	1	1.0	1 - 1	2.39	6.5 (5)	-	o
West Fork	2	2	1	1.0	.	1.35	11.83 (4)	-	-
West Fork	3	2	1	1.0	.	0.85	2 (3)		o
West Fork	4	3	11	11.0	11 - 11.5	13.21	39.15 (5)	- -	+ +
West Fork	5	3	21	21.8	21 - 24.2	24.95	32.79 (4)	o	-
Lake	11	3	2	2.0	2 - 2	1.82	2.19 (5)	o	o
Lake	12	3	1	1.0	1 - 1	1.54	8.68 (5)	o	-
Lake	14	3	6	6.0	6 - 6.3	6.17	29.9 (3)		-
Bozard	1	3	24	24.0	24 - 24.4	14.37	4.51 (5)	+	+
Bozard	2	3	9	9.2	9 - 10.4	8.95	11.29 (5)	+	o
Bozard	3	3	60	60.8	60 - 62.9	89.62	52.12 (5)	+ + +	+
Bozard	4	3	47	47.3	47 - 48.6	55.36	55.63 (4)	+	+
East Fork Bozard	1	3	92	95.4	92 - 100.5	153.31	67.29 (5)	+ + +	+ +

[a] A trend describing the change over the last 3 years was not calculated if data were unavailable for 2005

[b] A trend describing the change over the last 5-6 years was not calculated if data were unavailable for 2002 and 2003

Fish less than 150 mm in total length comprised a considerable percentage of cutthroat trout captured in mainstem and tributary habitats in Benewah (88%), Lake (93%), and Evans (93%) creek watersheds (Figure 13). Weight to length regressive relationships for captured cutthroat trout varied among the four watersheds (ANCOVA: watershed parameter, F-test = 5.44, p = 0.001). For a given fish length, cutthroat trout were heavier in Evans Creek than in Lake Creek (p = 0.004). Significant results were not detected for any of the other pairwise comparisons. Weight-to-length relationships were not significantly different for brook trout between Alder and Benewah creek watersheds (ANCOVA: watershed parameter, F-test = 1.19, p = 0.276).

Table 11. Summary statistics for brook trout captured by multipass electrofishing at index sites in the Alder Creek watershed from August 13 to September 13, 2007. Ordering of index sites corresponds to relative longitudinal position in the watershed from downstream to upstream. Density trend indicators of '+', '++', and '+++' indicate an increasing slope of 1-5, 5-10, and >10, respectively; negative sign combinations are analagous for decreasing trends. For trends between -1 and 1, a 'o' was assigned.

						Density (#/100m^2) trends from 2002-2007			
Stream	**Index site #**	**No. passes**	**Total caught**	**Abundance estimate**	**95% confidence interval**	**2007 density**	**Mean density, 2002-2006 (n)**	**3 year trend indicator [a]**	**5-6 year trend indicator [b]**
					Mainstem index sites				
Alder	1	3	0	0.0	.	0.00	0 (4)	o	o
Alder	2	3	1	1.0	.	0.36	0.42 (4)	o	o
Alder	3	3	1	1.0	1 - 1	0.31	0.08 (4)	o	o
Alder	4	3	5	5.2	5 - 6.5	2.16	0.77 (4)	o	o
Alder	5	3	11	11.0	11 - 11	4.23	3.28 (5)	+	o
Alder	6	3	5	5.0	.	1.77	2.17 (5)	-	o
Alder	7	3	2	2.2	2 - 3.6	0.84	0.79 (5)	o	o
Alder	8	3	0	0.0	.	0.00	3.18 (4)	-	o
Alder	9	3	7	8.0	7 - 12.1	3.26	4.93 (5)	o	o
Alder	10	3	9	9.2	9 - 10.4	4.28	8.37 (5)	- -	o
Alder	11	3	18	19.6	18 - 23.9	10.55	12.46 (4)	-	o
Alder	12	3	53	53.2	53 - 54.1	24.47	14.22 (5)	o	+
Alder	13	3	17	18.2	17 - 21.8	8.11	27.8 (5)	- - -	-
Alder	14	3	58	58.7	58 - 60.6	49.36	28.58 (5)	+ +	+
Alder	15	3	49	50.0	49 - 52.4	43.36	27.28 (5)	+ + +	+ +
Alder	16	3	39	39.3	39 - 40.6	37.80	28.05 (5)	o	+ +
Alder	17	3	61	65.1	61 - 71.5	38.93	33.58 (4)	- -	+
					Tributary index sites				
North Fork	1	3	66	66.5	66 - 68.2	77.02	30.03 (5)	+ +	+ + +
North Fork	2	3	39	39.1	39 - 39.8	35.08	23.1 (5)	-	+ +
North Fork	3	3	26	26.0	26 - 26.2	19.05	19.77 (5)	- -	+ +
North Fork	4	3	30	30.1	30 - 30.8	28.42	13.42 (5)	+ +	+
North Fork	5	3	42	42.4	42 - 43.8	34.57	30.28 (5)	-	+
North Fork	6	3	35	35.4	35 - 36.9	31.50	21.11 (5)	+	+
North Fork	7	3	25	25.0	25 - 25.4	21.56	23.27 (5)	- -	+
North Fork	8	3	19	19.1	19 - 19.9	26.74	29.23 (5)	- - -	+ +

[a] A trend describing the change over the last 3 years was not calculated if data were unavailable for 2005

[b] A trend describing the change over the last 5-6 years was not calculated if data were unavailable for 2002 and 2003

Table 12. Summary statistics for brook trout captured by multipass electrofishing at index sites in the Benewah Creek watershed from August 7 to October 11, 2007. Ordering of index sites corresponds to relative longitudinal position in the watershed from downstream to upstream. Density trend indicators of '+', '++', and '+++' indicate an increasing slope of 1-5, 5-10, and >10, respectively; negative sign combinations are analagous for decreasing trends. For trends between -1 and 1, a 'o' was assigned.

						Density (#/100m^2) trends from 2002-2007			
Stream	**Index site #**	**No. passes**	**Total caught**	**Abundance estimate**	**95% confidence interval**	**2007 density**	**Mean density, 2002-2006 (n)**	**3 year trend indicator [a]**	**5-6 year trend indicator [b]**
					Mainstem index sites				
Benewah	1	3	0	0.0	.	0.00	0 (5)	o	o
Benewah	2	3	0	0.0	.	0.00	0.03 (5)	o	o
Benewah	3	3	0	0.0	.	0.00	0.12 (5)	o	o
Benewah	4	3	0	0.0	.	0.00	0 (5)	o	o
Benewah	5	3	0	0.0	.	0.00	0 (5)	o	o
Benewah	6	3	0	0.0	.	0.00	0 (5)	o	o
Benewah	7	3	0	0.0	.	0.00	0 (5)	o	o
Benewah	8	3	0	0.0	.	0.00	0 (5)	o	o
Benewah	9	3	0	0.0	.	0.00	0 (5)	o	o
Benewah	10	3	0	0.0	.	0.00	0 (5)	o	o
Benewah	11	3	0	0.0	.	0.00	0.08 (4)	o	o
Benewah	12	3	0	0.0	.	0.00	0 (4)		o
Benewah	13	3	0	0.0	.	0.00	0 (5)	o	o
Benewah	14L	2	0	0.0	.	0.00	2.52 (4)	-	o
Benewah	14	2	0	0.0	.	0.00	0.91 (5)	o	o
Benewah	14U	3	0	0.0	.	0.00	2.22 (4)	-	o
Benewah	15L	2	0	0.0	.	0.00	.		
Benewah	15	2	0	0.0	.	0.00	0.6 (4)		o
Benewah	16L	3	14	19.1	14 - 33.8	10.05	.		
Benewah	16	3	32	32.1	32 - 32.7	12.61	5.14 (4)	+	+
Benewah	17	3	19	20.4	19 - 24.3	12.78	9.14 (4)	o	+
					Tributary index sites				
Bull	1	3	1	1.0	1 - 1	1.31	5.19 (5)	o	-
Bull	2	3	0	0.0	.	0.00	0 (5)	o	o
Coon	1	3	0	0.0	.	0.00	0 (2)		
Coon	3	3	0	0.0	.	0.00	0.53 (3)	o	o
Whitetail	1	3	1	1.0	1 - 1	1.12	3.28 (3)		o
Whitetail	2	3	0	0.0	.	0.00	0.69 (4)		o
Windfall	1	2	14	16.7	14 - 24.8	11.21	2.74 (4)	+	+
Windfall	2	3	14	14.2	14 - 15.4	12.35	0.98 (5)	+ +	+
Schoolhouse	1	3	16	16.1	16 - 16.7	16.02	8.14 (5)	o	+
Schoolhouse	2	3	3	3.1	3 - 3.8	4.60	1.07 (5)	+	o
South Fork	1	3	9	9.2	9 - 10.4	8.14	8.99 (5)	o	o
South Fork	2	3	2	2.0	2 - 2	1.68	1.78 (4)	-	o
South Fork	3	3	2	2.2	2 - 3.6	2.39	3.61 (4)	-	o
West Fork	1	3	6	6.2	6 - 7.1	7.04	22.93 (5)	- -	-
West Fork	2	3	9	9.0	9 - 9.2	10.10	16.91 (5)	+	- -

[a] A trend describing the change over the last 3 years was not calculated if data were unavailable for 2005

[b] A trend describing the change over the last 5-6 years was not calculated if data were unavailable for 2002 and 2003

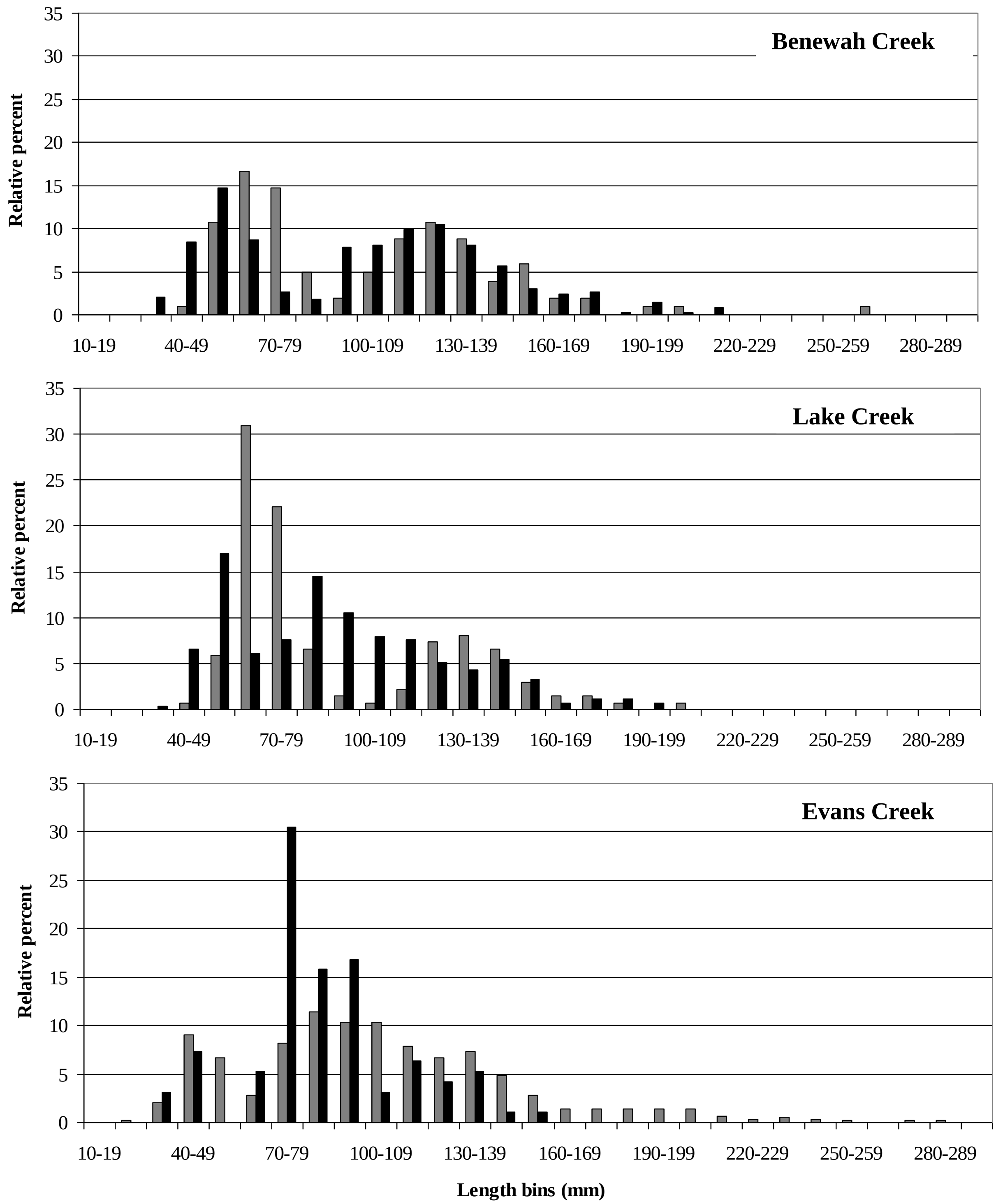

Figure 13. Relative length distributions (%) for cutthroat trout captured during summer and fall electrofishing surveys in mainstem (grey bars) and tributary (dark bars) habitats in the Benewah, Lake, and Evans creek watersheds, 2007 (Alder Creek data were not displayed because of the low number of cutthroat trout captured).

3.3.2 Trend and status monitoring – Stream temperatures

3.3.2.1 Benewah Creek temperatures

Mainstem ambient stream temperatures were warmest during the months of July and August in Benewah Creek during 2007 (Figure 14). Mean daily temperatures recorded at 9-mile bridge exceeded 15ºC throughout these two months, and exceeded 20ºC for over 50% of the time. Generally, ambient stream temperatures were lower in upper than in lower mainstem reaches during July and August (Table 13). In the upper Benewah mainstem reach, the monthly means of daily mean temperatures increased downstream over a 7.5 km reach from 16.4ºC to 21.4ºC and from 13.6ºC to 17.9ºC in July and August, respectively. Monthly maximums of daily means displayed similar downstream trends, with the highest daily mean temperatures of 23.2ºC and 21.1ºC recorded at 9-mile bridge in July and August, respectively. Although monthly means of daily maximum temperatures were also highest downstream, mean maximum values for loggers positioned 3.8 to 5.4 km above 9-mile bridge were generally lower than those for loggers located upstream during both months (Table 13). In addition, monthly means of daily scopes (calculated as the difference between the daily maximum and minimum temperatures) for these loggers were typically lower than those values calculated for mainstem loggers located upstream and downstream.

The percentage of time recorded temperatures exceeded 17ºC, the 95% upper limit for optimal cutthroat trout growth (Bear et al. 2007), was relatively high for all mainstem loggers in Benewah Creek in July of 2007 (Table 13). Uppermost loggers spanning a 2.2 km reach from above Schoolhouse Creek downstream to Windfall Creek (i.e., 5.4-7.6 km above 9-mile bridge) exceeded 17ºC between 42.0 and 47.2% of the time. Loggers positioned along a 2 km section within the low gradient, meadow reach below Windfall Creek (i.e., 3.2-5.2 km above 9-mile bridge) exceeded 17ºC between 62.3 and 65.7% of the time. Stream temperature increased rapidly over the lowermost 2.5 km above 9-mile bridge, where logged July temperatures exceeded 17ºC from 71.5% to 95.2% of the time. Even during August, the optimal growth limit was exceeded over 50% of the time at the lowermost logging stations above 9-mile bridge (Table 13).

Tributaries were much cooler than mainstem reaches in July and August of 2007 with daily mean temperatures rarely exceeding 17ºC (Table 13). Of all the tributaries monitored in the upper Benewah Creek watershed, Whitetail Creek was the coolest and Windfall Creek was the warmest. The optimal growth limit of 17ºC was never exceeded during the time stream temperatures were recorded in lower Whitetail Creek. On the other hand, recorded temperatures exceeded 17ºC approximately 8% of the time in Windfall Creek during both months. In addition, the mean of daily maximum temperatures recorded during August in lower Windfall Creek (15.8ºC) was more than 2ºC higher than those values recorded in other tributaries and also was typically greater than those mean values recorded by loggers located within the low gradient mainstem meadow reach (i.e., 3.8-5.4 km above 9-mile bridge; Table 13).

In addition to the tributaries in the upper mainstem of the Benewah watershed, various springbrooks also displayed temperature signatures during the summer months that were much cooler than those recorded in adjacent mainstem habitats (Figure 14). In the reach above 9-mile bridge, mean daily temperatures recorded at a springbrook adjacent to the main channel near Whitetail Creek were 8-11ºC cooler in July than temperatures recorded in the main channel approximately a kilometer downstream. Similarly, mean daily temperatures recorded during July in a connected springbrook in the meadow reach of the upper Benewah mainstem were between 3.0 and 5.5ºC cooler than temperatures recorded by an adjacent main channel logger. In addition, mean temperatures rarely exceeded 10ºC for a logger positioned in an isolated springbrook located in the meadow reach in the upper Benewah watershed.

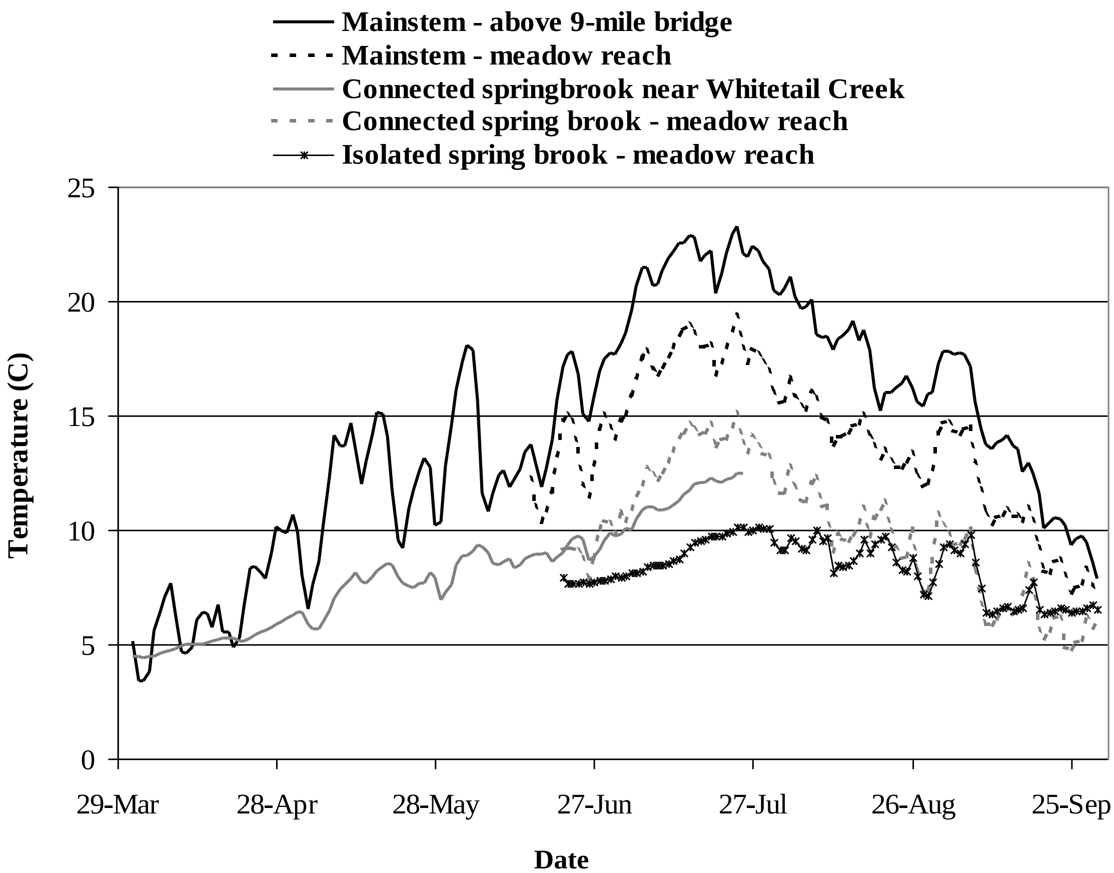

Figure 14. Daily mean ambient stream temperatures recorded by data loggers positioned in reaches along the upper mainstem of Benewah creek and within associated springbrooks, April 1-September 30 in 2007.

Table 13. Summary statistics for July and August water temperatures recorded by data loggers positioned in reaches of the upper mainstem of Benewah Creek and associated tributaries. Loggers recorded temperatures every 20 min.

		July						August					
Stream	**Rkm** [a]	**Mean of daily means**	**Maximum of daily means**	**Mean of daily maximums**	**Mean of daily minimums**	**Mean of daily scope** [b]	**Time > 17°C (%)** [c]	**Mean of daily means**	**Maximum of daily means**	**Mean of daily maximums**	**Mean of daily minimums**	**Mean of daily scope** [b]	**Time > 17°C (%)** [c]
Benewah	7.6	16.4	18.0	19.6	13.7	5.9	42.0	13.6	16.1	16.4	11.2	5.2	8.0
Benewah	6.4	16.4	18.4	19.1	13.6	5.5	42.5	13.5	16.2	16.1	11.0	5.0	6.0
Benewah	6	16.7	18.8	19.3	13.7	5.6	47.7	13.7	16.6	16.1	11.2	4.9	8.3
Benewah	5.4	16.7	19.0	18.6	14.9	3.7	47.2	13.7	16.4	14.8	12.3	2.5	1.1
Benewah	5.2	17.5	19.8	19.3	16.0	3.2	65.7	14.4	17.1	16.4	12.9	3.5	9.2
Benewah	4.2	17.4	19.4	18.8	15.8	3.0	62.3	14.1	16.7	15.4	12.7	2.7	3.1
Benewah	3.8	17.4	19.4	18.6	16.1	2.5	64.7	14.1	16.6	15.2	13.0	2.2	1.6
Benewah	3.2	17.8	19.8	20.3	15.6	4.7	64.5	14.6	17.3	17.1	12.5	4.6	15.8
Benewah	2.6	18.6	20.5	21.5	15.7	5.9	71.5	15.3	18.3	17.6	13.0	4.6	23.5
Benewah	1.6	18.5	20.4	20.8	16.4	4.4	78.9						
Benewah	1.1	18.8	20.8	20.5	17.3	3.2	86.6	15.4	18.0	16.6	14.2	2.3	16.0
Benewah	0.4	21.0	22.8	23.8	18.4	5.4	95.3	17.5	20.6	20.5	15.2	5.3	53.5
Benewah	0.1	21.4	23.2	24.7	18.4	6.2	95.2	17.9	21.1	20.7	15.3	5.4	58.2
Tributary [d]	7.1	14.3	16.0	16.0	12.7	3.4	1.9	12.1	14.4	13.6	10.6	3.0	0.0
Schoolhouse	6.4	14.7	16.8	16.4	12.7	3.6	8.5	10.6	12.7	12.4	8.7	3.7	0.0
Windfall	5.3	15.5	17.1	16.8	14.3	2.4	8.2	12.4	14.3	15.8	9.8	6.0	8.1
Whitetail	1.1	13.2	14.1	13.7	12.6	1.1	0.0	11.6	13.4	13.3	10.0	3.3	0.0

[a] Rkm refers to the number of river kilometers above 9-mile bridge where the temperature logger was located. Loggers placed in tributaries were less than 0.1 km from their confluence with Benewah Creek, and in this case, Rkm refers to the relative position of the tributary mouth to 9-mile bridge.

[b] Daily scope was calculated as the difference between the maximum and minimum temperature

[c] 17°C was considered the upper 95% confidence interval limit for optimal growth for cutthroat trout (Bear et al. 2005)

[d] Unnamed tributary to upper Benewah Creek

3.3.2.2 Lake Creek temperatures

Ambient stream temperatures were highest during the months of July and August in the upper Lake Creek watershed in 2007 (Figure 15). Mean daily temperatures recorded in the mainstem of Lake Creek above the old H95 bridge were typically greater than 15ºC throughout these two months, and approached or exceeded 20ºC approximately half of the time in July. Stream temperatures during these two months were much cooler in upper than in lower portions of the upper watershed. In July, loggers positioned in the upper Bozard drainage recorded monthly means of 14.5-14.8ºC and 16.0-16.9ºC for daily mean and maximum temperatures, respectively (Table 14). Ranges for both these monthly July indices were typically 2-5ºC warmer for loggers located further down in the watershed. On the other hand, loggers in the upper Bozard drainage did not record the coldest temperatures in August; monthly stream temperature indices recorded at the logger positioned in the West Fork of Lake Creek were the lowest (Figure 15; Table 14).

The percentage of time recorded temperatures exceeded 17ºC was also the lowest for loggers located in the upper Bozard Creek drainage, ranging between 6 and 15% for the month of July (Table 14). In addition, the East Fork of Bozard Creek had a noticeable cooling effect on Bozard Creek, decreasing the 17ºC exceedance percentage from 15% down to 9%. However, stream temperatures increased further downriver in Bozard Creek, with 50% of the recorded temperatures exceeding 17ºC in the reach above its confluence with Lake Creek. Similar 17ºC exceedance percentages (41.2-48.6%) were recorded by proximate loggers located in Lake Creek and the West Fork of Lake Creek. The logger located immediately upriver of the old H95 bridge on the mainstem of Lake Creek recorded temperatures greater than 17ºC eighty-two and 29% of the time during the months of July and August, respectively (Table 14).

3.3.3 Effectiveness monitoring – Biological response to brook trout removal in Benewah

A total of 1085 brook trout were removed from the Benewah Creek watershed using single-pass electrofishing from July 12 to October 4 of 2007 (Table 15). Of these 1085, 825 (76%) were removed from approximately 8 km of contiguous upper mainstem reaches from the 9-mile bridge upstream to the confluence of the South and West Forks. The other 260 fish were removed from approximately 3.5 km of lower tributary reaches in Windfall, Schoolhouse, South Fork, and West Fork creeks. A greater percentage of larger sized fish were collected from mainstem than from tributary reaches (Figure 16).

Two hundred and twenty-two of the brook trout removed from the Benewah watershed were evaluated for maturation status. Forty-seven of the 222 fish were considered to be immature juveniles but sex was undetermined. Of the other 175 fish, 104 were females with 60 of these identified as mature; fecundity and ovarian weight measurements were collected from 38 of these fish. The remaining 71 fish were males with 46 of these identified as mature. In addition, 56 females and 61 males from Alder Creek were sacrificed to obtain comparable maturation status; 39 females and 54 males were considered to be mature.

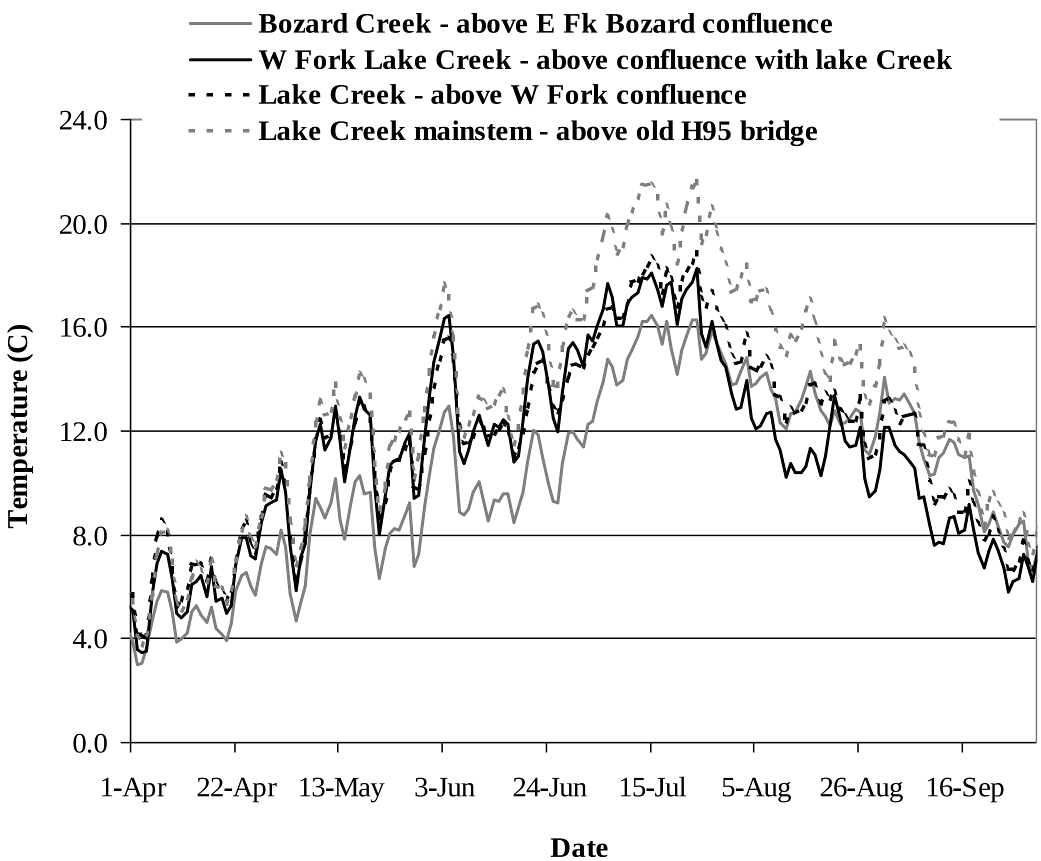

Figure 15. Daily mean ambient stream temperatures recorded by data loggers positioned in reaches of the upper Lake Creek watershed, April 1-September 30 in 2007.

Both female and male brook trout matured at smaller sizes in Alder Creek than in Benewah Creek (Figure 17). According to the logistic regression results, Alder Creek female brook trout of a given length were 37 times more likely to be mature than similar sized fish from Benewah Creek (*t*-ratio = -4.975, $p < 0.0001$). Likewise, male brook trout of a given length from Alder Creek were 147 times more likely to be mature than similar sized fish from Benewah Creek (*t*-ratio = -4.614, $p < 0.0001$). Predictions from the logistic regression models indicate that of the 1085 brook trout removed from Benewah Creek, 181 (17%) were mature females and 141 (13%) were mature males (Table 15).

Fecundity estimates for female brook trout collected from Benewah and Alder creeks were not significantly different between watersheds for fish of similar lengths (ANCOVA, *F*-ratio = 0.286, $p = 0.595$) and weights (ANCOVA, *F*-ratio = 0.310, $p = 0.579$). However, mean GSI values were significantly higher for females collected from Alder Creek (13.5) than for females from Benewah Creek (10.3; *t*-value = 3.813, $p < 0.0001$). These results indicate that mean egg size was generally greater for females in Alder Creek than in Benewah Creek.

Table 14. Summary statistics for July and August water temperatures recorded by data loggers positioned in reaches of the upper mainstem of Lake Creek and associated tributaries in 2007. Loggers recorded temperatures every 15-20 min.

Logger location [a]	**Mean of daily means**	**Maximum of daily means**	**Mean of daily maximums**	**Mean of daily minimums**	**Mean of daily scope** [b]	**Time > 17°C (%)** [c]
			July temperatures			
Bozard -upstream of confluence with E Fork Bozard	14.8	16.4	16.9	13.0	3.9	14.8
E Fork Bozard -upstream of confluence with Bozard	14.5	16.2	16.0	13.0	3.1	5.8
Bozard -downstream of confluence with E Fork Bozard	14.6	16.2	16.4	12.9	3.4	8.9
Lake (upper) -upstream of confluence with W Fork Lake	17.0	18.9	19.5	14.6	4.8	48.6
W Fork Lake -upstream of confluence with Lake	16.5	18.2	17.9	14.9	3.0	41.2
Bozard -upstream of confluence with Lake Creek	17.1	19.1	20.4	14.5	5.9	50.3
Lake - downstream of confluence with Bozard	17.3	19.2	19.5	15.1	4.4	58.6
Lake - old H95 bridge	19.7	21.6	22.8	16.4	6.4	81.6
			August temperatures			
Bozard -upstream of confluence with E Fork Bozard	13.0	14.8	15.0	11.1	3.9	0.0
E Fork Bozard -upstream of confluence with Bozard	12.7	14.5	14.2	11.1	3.1	0.0
Bozard -downstream of confluence with E Fork Bozard	12.8	14.6	14.4	11.1	3.4	0.0
Lake (upper) -upstream of confluence with W Fork Lake	13.2	15.7	14.4	11.8	2.6	0.0
W Fork Lake -upstream of confluence with Lake	11.5	13.9	12.7	10.4	2.3	0.0
Bozard -upstream of confluence with Lake Creek	14.1	16.5	16.9	11.7	5.2	11.7
Lake - downstream of confluence with Bozard	14.3	16.6	16.1	12.2	4.0	9.8
Lake - old H95 bridge	15.7	18.4	18.6	12.8	5.8	28.5

[a] Logger locations are sorted in order of relative longitudinal position in the watershed from uppermost to lowermost

[b] Daily scope was calculated as the difference between the maximum and minimum temperature

[c] 17°C was considered the upper 95% confidence interval limit for optimal growth for cutthroat trout (Bear et al. 2005)

Over the last four years of the removal program, more than 5600 brook trout have been removed (Table 15). Numbers of fish removed from the mainstem have generally increased over this time period as more mainstem habitat has been electrofished; however, there were less fish removed from mainstem reaches this year than in the previous two years. In addition, although the percentage of mature fish removed generally has increased from 2004 to 2006 as more mainstem habitat has been sampled (i.e., larger, more mature fish were found more often in mainstem than in tributary reaches), a lower percentage of adult brook trout were removed this year than in the past two years (Table 15).

Brook trout densities estimated at survey index sites in the upper Benewah watershed were not significantly different between 2007 and 2002-2004 (Wilcoxon rank sum test, $p = 0.311$, n = 13). Densities estimated at sites in Windfall and Schoolhouse creeks in 2007 were greater than their respective mean estimates over the 3-year period from 2002 to 2004; the converse was observed for sites sampled in the West Fork of Benewah. In comparison, brook trout densities at index sites in the upper Alder Creek watershed were significantly greater in 2007 than in 2002-2004 (Wilcoxon rank sum test, $p = 0.004$, n = 15).

Table 15. Summary of stream length sampled and brook trout removed from mainstem (MS) and tributary (T) reaches in the Benewah watershed, 2004-2007. Maturation probability models were used to assign maturation status to fish that were not assessed.

Year	Stream length electrofished (km)			Number of brook trout removed			Mature fish removed (%)	
	MS	T	Total	MS	T	Total	F	M
2004	0.2	3.7	3.9	56	563	619	95 (15)	81 (13)
2005	1.8	3.7	5.5	1153	243	1396	319 (23)	207 (15)
2006	5.4	3.7	9.1	2096	421	2517	736 (29)	659 (26)
2007	8.0	3.7	11.7	825	260	1085	181 (17)	141 (13)

3.3.4 Effectiveness monitoring – Habitat indicator response to restoration in Benewah

3.3.3.1 Thermal responses

Temperature measurements collected from pool habitats and their associated riffles revealed thermal heterogeneity in certain reaches of the upper mainstem of Benewah Creek that was not captured by the temperature loggers. Stream temperatures measured along pool bottoms were frequently between 2 and 5 ºC cooler than their downstream riffles when residual pool depths were at least a meter (Figure 18, 19). Many of these deeper pools were located in the one km reach of the mainstem that underwent channel reconstruction in 2005-2006 (i.e., 9-mile bridge to Whitetail Creek); 62% of the measured pool-riffle sequences generated residual pool depths greater than 1.0 m (Figure 18). In comparison, residual pool depths were almost exclusively less than 1.0 m within the reach that underwent channel reconstruction later that year and within the reach targeted for channel work next year. Notably, pool-riffle temperature differences rarely exceeded 2ºC within this 1.5 km section (Figure 18). In addition to pool depth, the detection of cool water pool refugia seemed to depend on ambient stream temperatures (Figure 19).

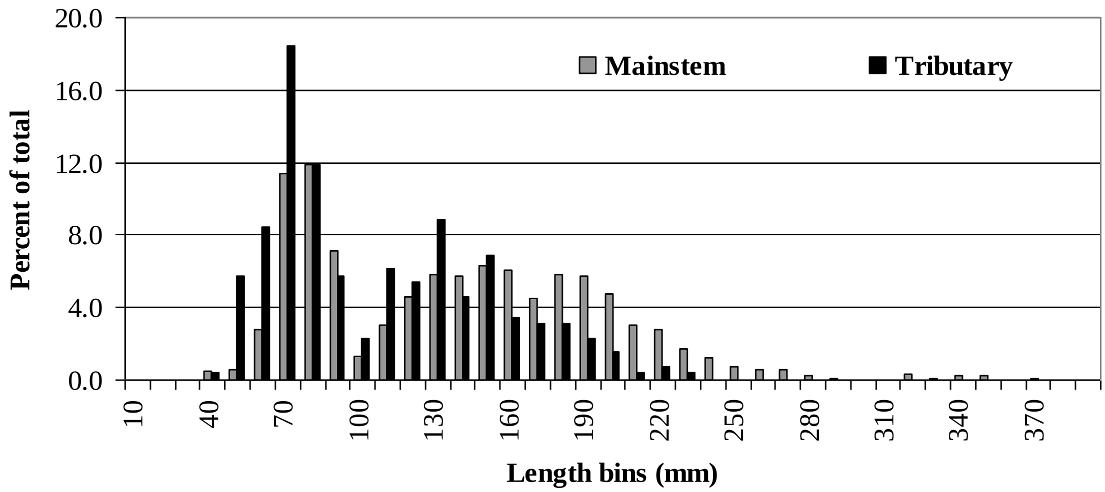

Figure 16. Relative length distribution for brook trout removed from mainstem and tributary reaches of upper Benewah Creek, 2007.

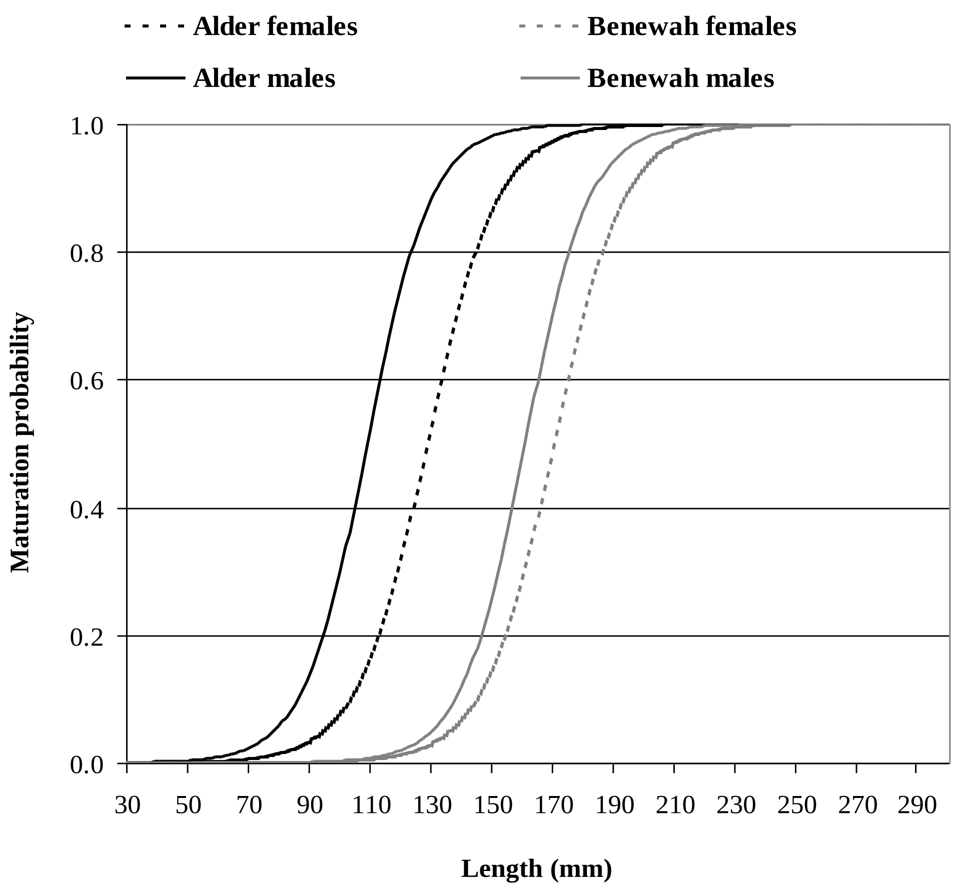

Figure 17. The estimated probability of maturation for male and female brook trout collected from Alder and Benewah creeks in 2007. Logistic regression analyses were modeled separately for female and male fish.

For example, in the 1.6 km meadow reach of the upper Benewah mainstem, thermal differences did not exceed 1ºC during riffle-pool surveys conducted from June 21 to July 2 when the mean of maximum daily temperatures was 15.2ºC. However, during surveys conducted in late July when the mean of maximum daily temperatures was 19.2 ºC, differences of at least 2ºC were often recorded even at residual pool depths less than one meter.

3.3.3.2 Physical response

Seven habitat sites were surveyed by Coeur d'Alene Tribal personnel in 2007 from June through October. Six sites were surveyed in the Benewah Creek watershed: four mainstem and two tributary sites, one in each of lower Windfall and Whitetail creeks. Two of the mainstem sites, 15L and 16, are considered treatment sites. Site 16 is located in a reach that underwent channel reconstruction in 2004 to reconnect Windfall creek to the upper mainstem. Site 15L is located in the reach that underwent channel reconstruction in 2005. Sites 16L and 17 are considered degraded and quasi-reference control mainstem sites, respectively. Habitat metrics for five of the Benewah sites are displayed in Table 16. Habitat data for the lower Whitetail site are summarized in Section 4.3. The other site surveyed in 2007 was located in the West Fork of Lake Creek. Habitat data for this site will not be summarized in this report, but will be evaluated in a subsequent report in conjunction with the completion of proposed channel restoration measures in reaches of the lower West Fork.

The volume of large wood was greater at restored mainstem sites (16.98-22.16 m^3) than at control mainstem and tributary sites (range of 0.95- 2.57 m^3). Benewah 15L had the greatest number and loading of large woody debris at 46 pieces with a loading rate of 14.54 m^3/100 m. In addition, though site 17 had the greatest number of pools, pools were deeper in restored than in control mainstem sites. For example, site 15L had the largest mean residual pool depth of 0.78 m, and the greatest residual pool depth of 1.21 m was located in site 16. Site 16 also had the largest channel material of sites surveyed, as indicated by its calculated d50 value of 166 mm. Conversely, substrate in the control tributary site in lower Windfall was composed of much finer material as indicated by its d50 value of 0.35 mm. Canopy density was highest at site Benewah 17 (82.75%) and lowest at site Benewah 15L (40.66%).

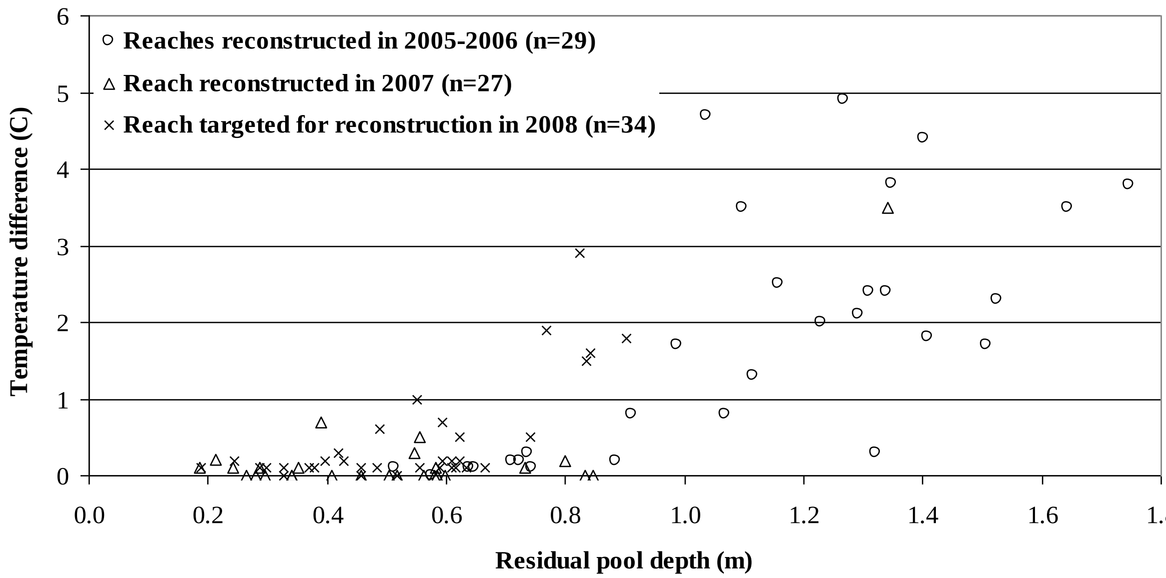

Figure 18. The relationship between thermal differences and residual pool depths for surveys conducted along the 2.5 km reach above 9-mile bridge in the upper mainstem of Benewah Creek in 2007. Thermal difference was calculated as the temperature measured along the pool bottom minus the temperature measured in the associated downstream riffle. Surveys were conducted between July 6 and July 26.

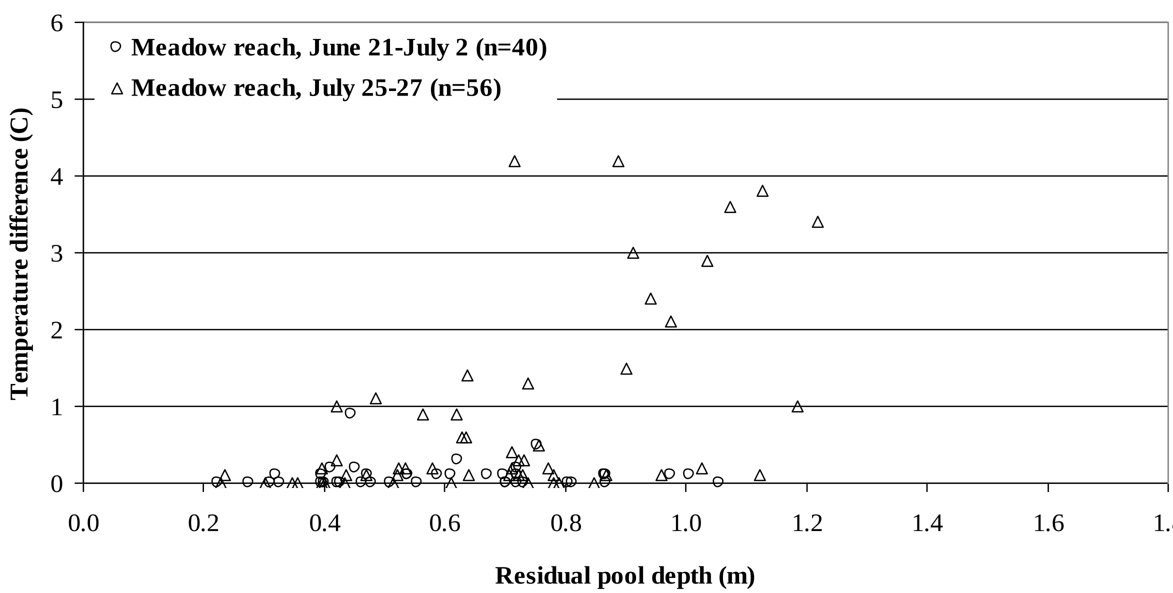

Figure 19. The relationship between thermal differences and residual pool depths for surveys conducted along the 1.6 km low-gradient meadow reach in the upper mainstem of Benewah Creek in 2007. Thermal difference was calculated as the temperature measured along the pool bottom minus the temperature measured in the associated downstream riffle. Surveys were conducted during a cooler summer period from June 21 to July 2, and during a warmer period from July 25 to July 27.

Table 16. Habitat indicator variables measured at survey sites in the Benewah Creek watershed in 2007. Sites 15L and 16 are restored (i.e., treated (T)) mainstem sites, and sites 16L and 17 are control (C) mainstem sites that represent degraded and reference conditions, respectively. Windfall 1 serves as an unrestored tributary control site.

Site Comparison		***C***	***T***	***C***	***T***	***C***
		Benewah 17	Benewah 15 L	Benewah 16 L	Benewah 16	Windfall 1
Morphology	Bankfull Width (m)	5.86	7.78	8.46	10.80	4.17
	Bankfull Wetted Perimeter (m)	6.80	8.49	9.58	12.00	4.69
	Bankfull Mean Depth (m)	.621	.53	.59	.59	.40
	Cross Sectional Area (m^2)	3.69	4.19	4.72	6.44	1.64
	Riffle w/d ratio	12.80	22.25	27.55	18.80	13
	Channel Material (d50) mm	8.22	28.90	4.09	166.00	.35
Cover	Canopy Density (%)	82.75	40.66	51.75	55.91	74.66
Large Woody Debris	Total count	19	46	8	31	5
	Volume (m^3)	1.69	22.16	2.57	16.98	.95
	Loading (m^3/100 m)	1.10	14.54	1.68	11.14	.62
Residual Pools	Mean depth (m)	.50	.78	.53	.71	.51
	min (m)	.31	.50	.30	.49	.37
	max (m)	.70	1.03	.82	1.21	.72
	number of pools	10	6	7	7	7

3.4 Discussion

3.4.1 Status and trend monitoring – Biological indices

3.4.1.1 Index site cutthroat trout abundance

Elevated abundances of cutthroat trout were recorded in tributaries of Benewah and Lake creek watersheds, and across mainstem and tributary reaches in Evans Creek. Not only were densities within these reaches typically greater than the 5-6 year average, but strong positive trends over the last three years were also demonstrated. Given that these trends were displayed at sites where high densities have frequently been documented during our annual surveys, the results suggest a genuine overall increase in juvenile densities along watershed reaches rather than a redistribution from more populated to less populated sites within watershed reaches.

The short-term positive trends in cutthroat trout abundances noted in our surveys may have been attributed to regionally favorable environmental conditions that increased either spawning success or early life-stage survival rates. Elevated densities were not only found across tributaries within watersheds, but also over spatially-distinct subbasins of the Coeur d'Alene system. In addition, most of the fish captured in our electrofishing surveys were less than 150 mm. Based on estimates of length-at-age from previous scale analyses in our watersheds (Vitale et al. 2003), these lengths indicate that the sampled populations were predominantly comprised of immature juveniles of age 2 or younger. As a result, a relatively strong year class across watersheds within the last two years could have given rise to the short-term trends recorded. Concordant abundances of salmonids in small streams, indicative of regional climatic influence, are not considered to be uncommon (Platts and Nelson 1988; Gowan and Fausch 1996). Trends in juvenile rearing densities of cuttroat trout measured in other Northern Idaho subbasins may aid in elucidating whether favorable in-stream conditions existed across the region. On the other hand, the results noted in our surveys may have been due to a recent increase in in-lake survival rates that translated into a larger number of returning adfluvial spawners and greater reproductive output. However, a favorable lacustrine environment would not explain the trends noted for the resident population in Evans Creek. Interestingly, many of the strong positive trends were not as apparent over longer time scales spanning five to six years, rendering it difficult to project current population trajectories at this time.

Alternatively, increased densities of cutthroat trout may have been a response to actions that have been implemented in target watersheds to address factors limiting population recovery. Large-scale recovery measures over the past several years have primarily been implemented in the Benewah Creek watershed. Over the last four years, extensive channel reconstruction to increase habitat complexity, improve floodplain connectivity, and reduce mainstem summer rearing temperatures has occurred in the upper mainstem reaches. In addition, the Fisheries Program has been actively engaged in a brook trout removal program in upper reaches of the Benewah Creek mainstem and associated tributaries since 2004. The increased densities of cutthroat trout estimated at mainstem and tributary index sites in upper reaches of the Benewah watershed may suggest a positive response to the aggregate affects of the habitat restoration and removal strategies. Moreover, the absence of a recent positive trend in one of the more populated tributaries in the lower portion of the watershed, Bull Creek, indicated that juvenile densities were not increasing in reaches where recovery efforts were not implemented.

Although observed trends in cutthroat trout densities from index site surveys may imply a positive response to implemented actions, they do not permit a rigorous evaluation of the effectiveness of recovery measures. For example, in the Benewah watershed, positive trends were observed primarily at sites in upper mainstem and tributary reaches that have not been directly modified by channel reconstruction. Furthermore, index site data alone may be insufficient when attempting to separate the potentially confounding influences of habitat restoration and brook trout suppression on population response. Supplementary analyses that were used to assess the effectiveness of both large-scale actions implemented in Benewah Creek are discussed more fully in following sections.

In addition to describing positive trends, short-term trends at index sites were useful in identifying reaches within watersheds where potential negative impacts to cutthroat trout may be occurring. For example, whereas strong positive responses were apparent in upper reaches of the Bozard Creek subbasin in the Lake Creek watershed, densities of cutthroat trout were stable or decreasing at index sites in the West Fork subbasin. Because average densities estimated at West Fork sites in the recent past have been relatively high, this subbasin evidently has served as a consistent significant contributor to cutthroat trout production in the Lake Creek watershed. Concurrent monitoring of trout abundance and indices of habitat quality in the West Fork subbasin may reveal degrading conditions that need to be addressed to ensure a healthy metapopulation structure in this watershed.

Although index site surveys may be useful in identifying core areas for conservation or in evaluating relative reach-specific changes over time, they may not generate reliable absolute abundance estimates over larger spatial scales. The small percentage of available habitat sampled during our population surveys and the high variability in estimated densities among our sample sites both contributed to a high level of uncertainty when expanding estimates across reaches or the entire watershed. Because of this uncertainty, overall changes in cutthroat trout productivity may not be confidently detected over time. Adding additional sites or increasing the sample site length can increase the percent of area sampled and may decrease some of the variability among sites. Redefining habitat units within which sites are located, so that habitat characteristics linked to cutthroat trout suitability are more homogenous within each unit, may further reduce variability. In addition, short-term changes at index sites may only reflect changes in emigration rates from proximate sites because of density-dependent processes. If habitat is marginal and concomitant survival rates low within index sites, then index site abundances may not accurately represent overall trends in the productive potential of the population. Consequently, other metrics of watershed-scale productivity, such as outmigrants per spawner, may be more useful in tracking overall changes in stream rearing environments over time (Bradford et al. 2005). Currently, the Fisheries Program is engaged in a trapping and tagging program to monitor changes in the number of outmigrating juveniles and returning adfluvial spawners in both Lake and Benewah creek watersheds. This is discussed more fully in the following section.

3.4.1.2 Adfluvial cutthroat trout migration

The number of adfluvial adult cutthroat captured in our upriver trap in Lake Creek has increased considerably since 2005. Whereas the annual number of captured fish had not exceeded ten in the seven years prior to 2005, more than 100 fish have been captured in two of the last three years. Although a genuine increase in numbers of returning adults can not be discounted (e.g., numbers of captured post-spawn adults have also demonstrated an increase since 2004), improved upriver trap design largely contributed to the observed results. Trap efficiency was increased in 2005 when the conventional, fixed-weir design was replaced with the resistant board weir design (Tobin 1994; Stewart 2002). Because the resistant-board weir can more effectively accommodate high discharge and debris loading than the former, it can be fished at those spring flows under which spawners may be most stimulated to migrate. Accordingly, the use of the former fixed weir design in Benewah Creek likely contributed in part to the absence of upriver adults captured; the resistant-board weir design is planned for implementation in this watershed in 2008.

However, similar to previous years, more post-spawn adfluvial cutthroat trout were captured in our downriver than our upriver trap in Lake Creek in 2007. The observed incongruity in counts may be attributed to the inability of the upriver trap to capture a sufficient number of migrating adults. Though trap efficiency has apparently increased since 2005, evidently a large number of fish are still avoiding capture given that twice as many adults were counted in the downriver than the upriver trap (further, the downriver count was likely an underestimate given that the highest counts of outmigrating adults were recorded immediately after trap installation). The mechanisms by which this is occurring are not well understood. Observations during the trapping season suggest that RBW trap panels were not depressed underwater nor was the structural integrity of the trap identifiably compromised. Whatever the reason for the observed trap inefficiency, it is necessary to estimate the number of spawners ascending upriver each year because one of the primary objectives of our recovery efforts is to augment the number of returning adfluvial adult cutthroat. Further, annual estimates of spawner abundances will allow us to derive estimates of outmigrants per spawner, which will increase our understanding of fish response to stream habitat improvements. Beginning next year, the Fisheries Program will begin an aggressive marking program for adult fish that are captured at upriver traps. From the recapture of these marked fish at downriver traps, we will be able to generate annual spawner estimates.

Alternatively, the observed discrepancy in adult counts may be attributed to a portion of the run exhibiting an early migratory behavior, ascending past the trap before its installation. Given that the Lake Creek trap was operational in February of 2007, this indicates that substantial movements would have had to occurred during late fall or early winter. Although fall and winter movements by cutthroat trout have been documented in other studies (Jakober et al. 1988; Brown 1999; Brown and Mackay 1995; Lindstrom and Hubert 2004), most of the reported movements were extensive downriver migrations to deep pools that provided suitable overwintering habitats or shorter excursions to avoid adverse conditions (e.g., anchor ice formation). Protracted upriver spawning migrations, however, have been observed for sea-run coastal cutthroat, with some populations exhibiting bimodal peaks in migration timing separated by at least two months (Johnson et al. 1999). Early ascension by pre-spawning adults has also been described for other spring-spawning salmonids (Mayer et al. 2006). It is unclear whether similar behaviors are operating in our adfluvial cutthroat trout populations. Evidence from our PIT-tag detections, however, does not support this latter competing hypothesis. Only 6 of the 16 fish (38%) detected by the array were captured in the upriver trap, suggesting inefficient trap performance. In addition, all 16 fish were initially detected during time periods in which adult fish were captured at the trap during their upriver migration. If an initial detection had occurred within the time period in which post-spawn migrants were primarily captured in the downriver trap, this could have denoted a fish had ascended early before the PIT-tag array was operational. Additional tag detections in future years should permit a better assessment of whether early migratory behavior by returning adults is prevalent in our watersheds.

The Lake Creek PIT-tag antenna array was instrumental in elucidating unusual migratory behaviors by cutthroat trout in 2007. For example, the repeated, prolonged detection of two fish during the upriver migratory period suggests that some fish may have had difficulty navigating the upriver trap. Although both these fish were tagged as juveniles in 2006 and were likely smaller than fish tagged in 2005, the small sample size precluded an assessment of whether body size, or other factors, influenced trap navigation capability. However, most of the PIT-tagged fish evidently did not have trouble locating the raceway to the trap box as indicated by the abbreviated period in which they were detected before capture or apparent trap ascension.

Array detections also revealed dilatory behavior by juvenile cutthroat trout above the downriver trap in Lake Creek. Whereas PIT-tagged fish that were released below the trap generally moved downriver within a day or two, many of the fish released above the trap during efficiency trials took longer than two days to be captured. Either these fish were engaging in trap-avoidance behavior or they had difficulties in negotiating the trap. Because the trap tends to create a slack-water environment immediately upriver, appropriate velocities may not have been prevalent in the vicinity of where juveniles were outmigrating to cue downriver movements. Similar delayed movements have been noted for juvenile salmonids outmigrating through impounded reaches of large river systems (Venditti et al. 2000).

Because differences in rates of trap passage among outmigrating juveniles were observed in our study, the assumption of equal probability of recapture was likely violated. In each trial, the number of marked fish that were available for recapture was probably less than the number of marked fish released. Inflating the number of available marked fish biases estimates of outmigrant abundance in stratified mark-recapture analyses, especially if trap efficiencies change markedly over trial periods. To remedy this potential bias, we were able to use downriver array detections of juveniles that had evaded the trap to provide estimates of the numbers of marked fish available for recapture (this adjustment presumed all fish that had bypassed the trap were detected by the antenna array). This model modification not only should increase the accuracy of our estimates but also their precision, given the apparent high trap efficiencies estimated in 2007. In turn, this should increase the probability for detecting changes in outmigrant abundance over time, and improve the reliability of derived outmigrant per spawner estimates.

In addition to obtaining outmigration estimates, PIT-tagging is also conducted in our watersheds to better understand the processes affecting survival rates of adfluvial fish during lake residence. This presumes that the survival rates of tagged juveniles reflect those of the entire cohort. In Lake Creek, large fish and early migrants were tagged disproportionately relative to the structure of the run in 2007. Consequently, if size at outmigration or timing of lake entry significantly influences the likelihood of survival to adulthood, survival estimates for this cohort may be biased upwards. To ensure that the full range of expressed traits in the run is captured, juveniles should be representatively tagged over the entire outmigration period.

Adult cutthroat trout that were PIT-tagged as juveniles in previous outmigrations were detected in Lake Creek for the first time this year. Many of the fish had been tagged two years ago, but several were tagged last year. For recaptured tagged fish in which morphometric data were available, the fish tagged in 2006 apparently grew more rapidly than those tagged in 2005. However, the small sample size precluded any conclusions regarding linkages between lacustrine growth rates and age at maturation. The accumulation of data as more tagged fish are captured in subsequent years will allow more robust analyses of life-history relationships for groups of fish with differing periods of lake residence. More importantly, as more tagged fish are detected by the PIT-tag array in following years, we will be able to start deriving survival estimates from outmigrating cohorts, and assess probable linkages between factors such as juvenile growth and outmigration time and the likelihood for survival. Additional years of adult PIT-tag detections will also allow us to generate more reliable estimates of post-spawn survival rates. Tracking trends in survival, growth, and maturation rates over time may provide insight into the influences of rearing conditions and trophic-level interactions in Lake Coeur d'Alene, such as predation and competition (Rich 1992; Anders et al. 2003), on cutthroat trout population demographics in our watersheds.

3.4.2 Status and trend monitoring - Physical habitat metrics

3.4.2.1 Longitudinal water temperatures

The ambient stream temperatures recorded in Lake and Benewah watersheds still support the suitability of tributaries over mainstem reaches as cutthroat trout rearing habitats during mid-summer periods. Mainstem temperatures in upper Benewah and Lake creeks in July exceeded those considered optimal for growth (e.g., 17^{o}C) more than 50% of the time during which juvenile trout may be redistributing from natal tributary habitats to summer rearing habitats (Bear et al. 2007). In comparison, tributary temperatures were typically below this threshold value 90% of the time. Though more favorable temperatures were recorded in mainstem reaches during late summer and early fall, juveniles may have already established foraging territories from which they were unlikely to vacate. Cutthroat trout have been found to remain in tributary habitats and to display minimal displacement to downriver reaches during the summer if suitable foraging habitat was readily available nearby (Schrank and Rahel 2006). Given the consistently higher densities of cutthroat trout in tributary than in mainstem habitats, the mid-summer differences in rearing temperatures between tributary and mainstem reaches likely explain in part the distributional patterns of cutthroat trout observed during our population surveys (Dunham et al. 1999; Paul and Post 2001; Sloat et al. 2001; de la Hoz Franco and Budy 2005).

Our temperature data also indicate that cold-water inputs from groundwater sources were available in the upper mainstem of Benewah Creek, most notably in isolated floodplain habitats in the broad alluvial reach. Reconnecting the mainstem reaches with the adjacent floodplain should increase hyporheic dynamics and promote the creation of cold-water refugia. Improving water retention capability and restoring floodplain connectivity along contiguous reaches that are incrementally restored within the mainstem valley segment should increase the availability of optimal habitats for summer rearing and provide favorable corridor habitats that promote tributary connectivity. Continued monitoring of ambient mainstem stream temperatures in our watersheds should provide insight as to whether our habitat enhancement activities are moderating thermal regimes and increasing the distribution and amount of preferable rearing habitats for cutthroat trout.

3.4.3 Effectiveness monitoring – Response of indicators to habitat restoration in Benewah

3.4.3.1 Response of physico-chemical indicators to restoration

Thermal heterogeneity was more prevalent in reaches of the Benewah that underwent large-scale channel restoration in 2005 and 2006 than in similar unrestored mainstem reaches. The presence of cool-water refugia in these restored reaches were often detected at depths greater than 1 m and were apparently created by the concomitant deepening of pool habitats during the process of streambed elevation in designated riffles. The creation of these refugia should increase the availability of suitable rearing habitat for cutthroat trout. Cold-water patch frequency and area have been considered important indices that explain salmonid occurrence and abundance in other small stream systems (Torgersen et al. 1999; Ebersole et al. 2001, 2003). Our data also suggests that the detection of these refugia may only be apparent during periods of elevated ambient stream temperatures. Therefore, in order to measure the thermal response to restorative actions that increase pool depth, it is essential that monitoring efforts are conducted during appropriate time periods.

3.4.3.2 Response of cutthroat trout to restoration

Despite the mosaic of thermal refugia present in restored upper mainstem reaches, cutthroat trout were not captured at treatment sites. The absence of fish obviated the need to compare results with those obtained at control mainstem reaches. However, for BACI analyses that will be conducted in the future, it is imperative that we have sufficient sites in both treated and control reaches to detect a response to our enhancement actions. Currently, only two sites are located in the mainstem section that has been or is projected for instream channel reconstruction. Because these sites encompass a small percentage of the area being restored, they may not represent average conditions across these habitats. Additional mainstem sites will be included in the 2008 survey to permit more robust analyses for assessing cutthroat trout response. Further, the observation that short-term temporal trends in cutthroat trout abundance tracked one another across watersheds will also permit BACI analyses to be performed at larger spatial scales (e.g., compare aggregate mainstem abundances between Benewah and Evans creek subbasins).

The reason for the apparent lack of colonization of newly created rearing habitats may be attributed to one or more of several factors. First, core rearing areas may have been sufficiently separated from restored mainstem reaches so that extensive dispersal by juvenile cutthroat trout was discouraged. The degree of isolation between restored stream segments and colonizing source populations, either by distance or the presence of physico-chemical barriers (e.g., temperature), has been considered to be an important factor influencing the probability that fish populations will positively respond to restoration measures (Bond and Lake 2003; Pretty et al. 2003). Source populations in many of the upstream tributaries (e.g., Windfall Creek, Schoolhouse Creek, and South and West Forks of Benewah Creek) were approximately 4 km from restored reaches, and fish would have had to traverse extensive warm riffles to colonize mainstem habitats downriver. Although Whitetail Creek is at the upper extent of the restored reach, thermal barriers still may have inhibited the expansion of fish out of this tributary and into downriver mainstem reaches. Suboptimal, ambient stream temperatures in excess of 17^{o}C prevailed within shallow, low velocity areas of the restored reach during summer months, and as a result, habitats such as channel margins and riffles that are preferred by early life-stages of cutthroat trout may have been unsuitable as rearing environments in 2007.

Moreover, densities of cutthroat may have been insufficient in lower reaches of upper mainstem tributaries to induce density-dependent emigration responses. Juvenile fish do not need the territorial space required by larger adults (Grant and Kramer 1990), and at the densities observed in our survey, available capacity in tributaries may have been adequate. Similary, Johnson et al. (2005) suggested that low rearing densities likely contributed to the lack of colonization by salmonid fry of newly-created habitats in their study. Isaac and Thurow (2006) also found salmonids to be clustered within specific core areas during low spawner densities, but an expanded distribution to previously unoccupied areas at higher abundances. Simultaneous monitoring of tributary and restored reaches over time will allow us to assess relationships between seeding densities, tributary habitat saturation, and expansion to restored habitats.

Incidentally, densities of juvenile cutthroat were three times the five-year average at an upper mainstem index site (site 16) located immediately below the confluence of Windfall Creek. This site underwent channel reconstruction in 2004 to both deepen pool habitats and restore connectivity to tributary reaches in Windfall Creek (Chess et al. 2006). Lower ambient stream temperatures were also recorded within this reach, which may have provided less inhospitable conditions for foraging movements than reaches downriver. This finding suggests that close proximity to tributary sources and favorable temperatures for dispersion may improve detection of a positive population response to habitat restoration.

The deepening of pools and addition of streambank structure in the restored reaches could have also decreased the efficiency of our electrofishing activities. Fish utilizing large woody debris as cover are more difficult to capture when stunned than those located in more exposed habitats. In addition, both netter visibility and the effective distance of the electric field were reduced as depth increased because of the low conductivities and water transparencies prevalent in our systems. Further, it is inherently difficult to wade and maneuver through deep habitats, which rendered both shocking and netting challenging. However, water depth cannot fully explain the lack of fish captured in restored mainstem reaches as large numbers of fish have been consistently caught in deep, plunge pools located within tributary index sites.

Despite the apparent lack of utilization of restored habitat by cutthroat trout during the summer, the deepened mainstem reaches may have provided suitable overwintering habitat that was previously available only in limited amounts. Various studies have found both juvenile and adult cutthroat trout to prefer deep pools as winter refuge habitat in small stream systems (Jakober et al. 1988; Brown and Mackay 1995; Harper and Farag 2004; Lindstrom and Hubert 2004). In addition, cutthroat trout have been found to respond positively to improvements to winter refuge habitat. Solazzi et al. (2000) found cutthroat trout abundance to increase, presumably owing to higher overwinter survival rates, following the creation of winter habitat in coastal Oregon streams for coho salmon (*O. kisutch*). In addition, Roni and Quinn (2001) found higher densities of cutthroat trout at sites with experimental large woody debris additions than at control sites, but only during winter and not summer sampling. Evaluating the winter distribution of cutthroat trout in upper mainstem habitats may reveal benefits of our channel construction activities that were not realized from summer surveys.

The realignment of ecological processes in Benewah mainstem habitats with those of naturally functioning stream-riparian ecosystems may require a longer timeframe than other instream enhancement projects to detect a positive response by cutthroat trout. Salmonds have exhibited localized, rapid increases in abundance to placement of habitat-forming instream structures such as large woody debris, log weirs, and channel deflectors (Roni et al 2002, 2008). However, the large-scale measures that have been implemented in Benewah Creek are likely much more intrusive than the formerly reviewed instream structures that have been found to elicit positive responses. Consequently, more time may be needed for ecological and hydrological properties to adjust to the repeated, acute artificial disturbances imposed by our annual channel reconstruction activities.

Further, we are not only amending local deficiencies in habitat complexity (e.g., additions of LWD as instream cover), but also addressing impaired processes that operate at larger spatial scales. Because of the scale at which we are rehabilitating degraded habitat, it is recognized that the reestablishment of natural processes will occur gradually, both from a biological and a logistical perspective. For example, as planted vegetation along channel margins and in adjacent floodplain habitats advance toward their desired state, riparian shade should help ameliorate main-stem temperatures. Moreover, additional prospective actions that promote water retention and augment groundwater recharge are targeted for main channel habitats upstream of the restored reach where water quality is still suboptimal. Notably, our results are not unlike those reported for other large-scale re-meandering projects in which authors speculated that the lack of fish response was due to the persistence of limiting factors in reaches adjacent to those restored (Moerke and Lamberti 2003; Cowx and Van Zyll de Jong 2004). As we progressively improve contiguous reaches in the upper Benewah mainstem, we expect to observe a thermal regime that is more conducive for cutthroat trout colonization and growth.

3.4.4 Effectiveness monitoring – Nonnative brook trout control

Both numbers of brook trout and the percent of mature adults captured during our removal efforts were lower in 2007 than in the previous two years. However, we were unable to detect an appreciable reduction in densities from our survey data since the initiation of the removal program in 2004. The lack of a measurable reduction was in part explained by the differences in trends observed among tributaries in the upper portion of the Benewah watershed. Whereas numbers of fish declined in Whitetail Creek and the South and West Forks of Benewah, estimated abundances displayed increasing trends in Schoolhouse and Windfall creeks.

These differences may be attributed to one or more of several factors including changes in colonization patterns, probabilities of establishment, and varying degrees of effort applied in previous removal activities. For example, expansion into Windfall Creek was likely inhibited prior to 2004 because a perched culvert at the tributary confluence limited access to upriver reaches during flows under which fall-spawning brook trout were likely to migrate. This movement barrier was virtually eliminated in 2004 when channel bed elevation below Windfall reconnected the tributary to mainstem reaches thus providing opportunities for colonization into new habitat. Prevailing differences in habitat attributes (e.g., channel gradient and water temperature) among tributary reaches may have also played a role in explaining trends by yielding dissimilar suitabilities in rearing environments for juvenile brook trout. For example, summer temperatures in Whitetail Creek were consistently lower than those recorded in Schoolhouse and Windfall creeks. Temperature has been considered to be a major factor in limiting the competitive advantage (e.g., influencing growth rates) of brook trout over cutthroat trout in areas where sympatric populations occur (De Staso III and Rahel 1994; Adams 1999; Dunham et al. 2002). The moderately low numbers of brook trout in coldwater habitat, such as that found in Whitetail Creek, is encouraging given the temperature ameliorating objectives of our main channel enhancement actions. Alternatively, the differences observed among tributaries may have been due to the focus of removal efforts during the first couple of years. Initially, before it was discovered that many of the larger adults were residing in upper mainstem habitats, efforts were concentrated in tributaries, most notably the South and West Forks. Given that the most marked decrease in abundance was demonstrated in the lower West Fork, the unequal distribution of past sampling efforts may partly explain the results from our survey data.

Although an overall reduction in brook trout in the upper Benewah watershed was not observed, the comparison to a neighboring watershed, Alder Creek, did reveal that we were effective in regulating abundance at a low level. Significantly higher densities of brook trout were found in 2007 than during the period from 2002 to 2004 in upper reaches of Alder Creek, suggesting that regional conditions were favorable for growth and survival. Abundances at the most populated index sites, where we would expect density-dependence compensatory mechanisms to predominate, even displayed substantial positive trends over the last 3-5 years. Because these two watersheds presumably share common environmental drivers that govern recruitment rates, we should have expected similar responses in Benewah creek. Apparently, our efforts have been successful at suppressing a compensatory numerical response by brook trout and maintaining abundances at a manageable level.

Watershed comparisons also permit insight into whether removal efforts could be curtailed in future years. Even before the control program commenced in 2004, densities of brook trout in Alder Creek were consistently higher than those documented in Benewah Creek. In addition, whereas distributions of cutthroat and brook trout are almost entirely disjunct in Alder Creek suggesting displacement by the latter, distributions of both species overlap in Benewah Creek. Differences between these two watersheds could be explained by an invasion process that is still in its incipient stage in Benewah, though given the proximity of these watersheds to each other, expansions should have proceeded at similar rates if colonizing migrants arrived from common downriver sources (Peterson and Fausch 2003).

Alternatively, factors other than dispersal limitations may have contributed to the apparent lack of establishment of brook trout in the Benewah watershed. Brook trout have been found to prefer low-gradient reaches with deep, low velocity environments (e.g., beaver ponds) for both summer rearing and winter refuge habitats (Chisholm et al. 1987; Cunjak 1996; Lindstrom and Hubert 2004; Benjamin et al 2007), and to exhibit a competitive advantage over cutthroat trout at higher temperatures (Dunham et al. 2002). Conducting comparative habitat surveys and monitoring thermal regimes in Alder Creek may reveal a greater availability of these environments in this watershed than in upper Benewah. Further, the productive adfluvial life-history strategy that is prevalent in Benewah may confer an advantage on juvenile cutthroat trout that permits a greater biotic resistance to invasion (Griffith 1988). Much remains to be learned regarding the respective influences of physical and biotic factors on the apparent differences in invasion success that have been documented for brook trout (Adams et al. 2002; Benjamin et al. 2007).

Our removal results have shown that brook trout, especially the larger mature adults, were found more often in mainstem habitats with proportionately greater pool area than in tributaries. Given that these fish were captured during periods prior to spawning, these deep pools may be serving as holding habitats for adults before upriver movement to spawning grounds. Concentrating removal efforts in these upper mainstem habitats in the future can minimize the electrofishing effort expended each year but still permit the large spawners, and hence future production, to be removed. Further, we may be able to reduce the frequency at which we conduct our suppression program. Refraining from removing fish over a year or two will allow us to examine the compensatory resilience of brook trout in the Benewah watershed (Meyer et al. 2006).

The success of the suppression program may also be evaluated in the context of the cutthroat trout response. Despite the lack of a valid control reach in the upper Benewah that is coinhabited by both species but does not receive treatment, we can nevertheless indirectly assess response by examining abundance trajectories for both salmonids within treated reaches. Noticeably, sites in West Fork Benewah demonstrated cutthroat trout abundances in 2007 that were over two to four times the five-year average; these sites also displayed the most substantial reduction in brook trout numbers over a similar time period. In addition, similar derived weight at length relationships supported cutthroat trout growth rates that were not detectably different between Benewah and the other watersheds. Although the similarity in growth curves between Benewah and Alder may have been unexpected, cutthroat trout in Alder exhibited minimal overlap with brook trout and consequently may no longer be experiencing any competitive disadvantage. However, condition of Benewah cutthroat trout was also similar to fish in Lake Creek, which has not been colonized by brook trout, and to fish in Evans Creek, which has more suitable rearing temperatures than Benewah. It appears that the condition of cutthroat trout in Benewah has not been adversely impacted by the density of brook trout observed in the upper watershed.

Assessing the potential compensatory responses by mature brook trout to the removal efforts was also one of the objectives stated in our monitoring program. We were specifically interested in examining whether residual brook trout expressed changes in maturation traits (e.g., size or age at maturation) or levels of fecundity due to a release from conspecific competition. A five-year evaluation of these metrics in Benewah fish is scheduled to be conducted following removal efforts in 2008. However, insight into compensatory responses may be gained by comparing maturation metrics collected from fish in upper Benewah, a watershed with low densities of brook trout, with those from fish in Alder creek, a watershed with comparatively higher densities. Fecundity-at-length relationships were not detectably different between the two watersheds in 2007, suggesting similar levels of investment in egg number under varying levels of population density. On the other hand, brook trout of both sexes matured at a significantly smaller size in Alder than in Benewah. Alder fish thus appear to either mature earlier than Benewah fish or to have a correspondingly similar maturation schedule with much lower juvenile growth rates. Earlier maturation in Alder than in Benewah may be associated with higher juvenile growth rates in the former watershed, a hypothetical relationship that has received support in the salmonid literature (Thorpe 1986; Hutchings 1993). Aging fish from both creeks should aid in clarifying the mechanism that is operating.

Survival of adults relative to that of juveniles has also been found to influence age at maturation in fish (Leggett and Carscadden 1978; Hutchings and Jones 1998). Specifically for brook trout, low adult survival and growth rates have been associated with earlier age at maturation, regardless of size, and higher GSI values (Hutchings 2004). Interestingly, higher GSI values were found in Alder females than in Benewah females in 2007. Our results suggest that the comparatively higher rearing densities in Alder Creek could have promoted suboptimal rearing conditions for adult brook trout, which elicited the smaller size (and earlier age) at maturation and the greater reproductive allocation observed. From these watershed comparisons, it appears that the maintenance of low brook trout densities through periodic removals in Benewah should not increase individual reproductive investment (e.g., increased fecundity at a given length) nor induce an earlier maturation schedule that would shorten generation times.

4.0 RESTORATION AND ENHANCEMENT ACTIVITIES

Restoration and enhancement activities were implemented primarily in the Benewah and Lake creek watersheds during 2007. All restoration activities completed during the contract period are summarized in Table 17 followed by a more detailed site characterization and summary of activities for individual treatments. In several locations, multiple treatments have been implemented to meet the objectives for larger sites. These treatments are grouped under the same project ID heading so that the interrelationship of activities is more apparent.

A brief explanation of the project ID that is used in the summary table and in the detailed descriptions is warranted here. The project ID is an alphanumeric code that corresponds to the location of individual treatments in relation to the river-mile of the drainage network for the watersheds of interest. The first digit of the code signifies the watershed that the treatment is located in, using the first letter in the watershed name (e.g., B=Benewah Creek, E=Evans Creek, etc.). The series of numbers that follow correspond to the river-mile location (in miles and 10^{ths}) at the downstream end of treatment sites. River mile is tabulated in an upstream direction from mouth to headwaters and treatments that are located in tributary systems have river mile designations separated by a forward slash (/). For example, the downstream end of project L_5.2/0.2 is located in the Lake Creek watershed 0.2 miles up on a tributary that has its confluence with the mainstem 5.2 miles from the mouth. This nomenclature is intended to indicate the spatial relationship of treatments to the mainstem and tributary aquatic habitats having significance to the target species. Furthermore, it readily conveys information about the relationship of multiple treatments by indicating the distance to common points in the drainage network.

Table 17. Summary of restoration/enhancement activities completed in 2007 for BPA Project #199004400.

Project Description			**Project Chronology**				
Project ID	**Activity**	**Treatments (Metrics)**	**2002**	**2003**	**2005**	**2006**	**2007**
B_8.9	Stream Channel Construction	Constructed 1,874 m of channel (Increased channel length by 418 m)	Completed baseline HEP; channel assessment and development of restoration prescriptions		Channel design finalized; NEPA completed; constructed lower 518 m of channel on the property	Constructed 594 m of channel.	Constructed 762 m of channel
B_8.9	Plant Vegetation	Streambank stabilization (6.34 ha, 3,900 m of streambank)			Planted 15,850 herbaceous plugs, 4,100 deciduous trees (1.82 ha of floodplain, 1,036 meters of stream bank)	Planted 26,387 herbaceous plugs and 7,450 deciduous trees (2.32 hectares of floodplain, 1,340 meters of streambank)	Planted 18,471 Herbaceous plugs and 6,369 deciduous trees (2.2 hectares of floodplain, 1,524 meters of streambank)
Project B_9.6/0.0	Instream Wood Additions	Treated 305 m of channel, constructed 20 structures					Design finalized; NEPA completed; treatments installed; planted 1,549 herbaceous plugs and 1,082 deciduous trees (0.5 hectares of floodplain, 549 meters of streambank)
Project L_8.2/0.0	Plant Vegetation	Floodplain enhancement (1.4 ha, 1270 m of streambank)					NEPA completed; herbicide applied; planted 1,110 conifers and 150 willows (1.4 ha of floodplain, 1270 m of streambank)

4.1 Project B_8.9: Instream/Channel Construction

Project Location:

Watershed: Benewah	Legal: T45N, R3W, S18 NE ¼ NE ¼
Sub Basin (River Mile): RM 8.9	Lat: 47.249851 Long: -116.762181

Site Characteristics:

Slope/Valley gradient: <1%	Aspect: N	Elevations: 808 m
Valley/Channel type: B2/C4	Proximity to water: In channel	

Other: *Project restores channel planform, grade and profile to what is believed to be within the range of historic conditions for 594 meters of stream.*

Problem Description: The Benewah valley between river miles 8.9 and 11.9 can be broken into three general reaches that relate to the level of sinuosity and the degree of channel incision that has taken place. The lower 2.3 km and upper 0.8 km have experienced more avulsions and channel straightening than the middle 2.1 km. The valley slope is 0.007 throughout, however sinuosity in the lower and upper reaches is 1.38 and 1.3, respectively, compared to 1.8 in the middle reach. Downstream avulsions and head cutting have moved upstream through the lower reach where this project is located, causing it to be become incised and substantially reducing the access to its old floodplain. Hydraulic analysis of representative channel cross-sections show the overall level of incision is approximately equivalent to the capacity of a 5-year return interval peak flow event with some areas exhibiting incision that approaches the 10-year peak flow.

The incised channel is characterized by unstable stream banks with accelerated erosion rates and increased sediment yield to the channel. The most recent estimates of stream bank erosion were made using the BANCS model (Rosgen 2006), which combines quantitative measures of stream bank characteristics with derived values of near-bank sheer stress to generate estimates of average annual erosion rates. In measured reaches erosion rates were estimated at 0.16±0.07 tons/yr/ft with an estimated sediment yield of 156.1 tons/yr. When these results are extrapolated to the larger reach located between river miles 8.9 and 11.9, total annual sediment yield from streambanks is estimated at 1,689.6±739.2 tons/yr.

Several avulsion channels and to a lesser extent, remnant historical channels have left portions of the valley bottom with some wetland habitat. However, it appears that groundwater tables have been lowered along with the streambed, as many of the wetland areas are only marginal in size and a band of xeric vegetation of variable width is located along the channel margin throughout the incised reach. Based on analysis of observational data, including current vegetation patterning, wetland delineations, and historic soils data from 1904, it is estimated that lowering of the water table related to channel incision has reduced wetlands habitats by up to 40% compared with historic conditions.

This stream reach is located in a portion of the watershed that historically provided important summer and winter rearing habitats for westslope cutthroat trout. Existing conditions currently support low densities of cutthroat trout (<2 fish/100 m^2). Lack of habitat diversity, reduced infiltration of water from adjacent wetlands, and elevated water temperatures are all factors that limit the productivity of these reaches.

Description of Treatment: The initial work to develop a restoration design began with development of the relationship between the runoff characteristics of the watershed and stable hydraulic geometry for the stream channel. Subsequently, the HEC-RAS hydraulic model was used to estimate hydraulic conditions and simulate water surface elevations, flow regimes, velocities and shear stress for the design channel. A substrate specification was developed to withstand some vertical movement during the 10-year return interval discharge but not over sized to the point of complete immobility. Implementation of the restoration design involves filling the stream channel to historical elevations and utilizing historical alignments where possible. The designed planform creates channel grade and profiles within the range of historical channel conditions, based on topographic and field analysis. Historical conditions will be met by lifting the incised channel by filling the channel with imported rock at intervals along its length that correspond to areas that would naturally be riffles. Pools between these riffles will remain unnaturally deep until existing basin sediment loads slowly fill them. In areas that have laterally expanded following entrenchment, new banks and floodplain will be created. Large wood material will be used throughout the project to increase lateral roughness where needed, create banks, and maintain planform until hydric plant communities become fully established.

A total of 762 m of channel was constructed in 2007, increasing the total length of restoration at the site to 1,875 m. Twelve riffles were constructed using a total of 2,321 cubic meters of imported gravel and an additional 80 cubic meters of gravel were placed on stream banks in pool sections. A little more than 175 m of the existing incised channel were "plugged" with approximately 3,900 cubic meters of imported fill to create new floodplain habitats. A total of 80 MBF of large wood, the equivalent of 20 truckloads of 10 m long logs, was placed in the channel and on the floodplain to provide cover, increase habitat complexity, and increase roughness and stability. Much of the wood placed outside the bankfull channel was buried below grade and no anchors or cable were used as in past years. These adjustments in wood placement and floodplain treatments were based on the past two years of observed overbank floods, during which flow depths across the floodplain were insufficient to mobilize large wood and scouring of floodplain surfaces, particularly the raw, newly "plugged" surfaces, was greatly retarded by below-grade and near-grade wood placements which acted as effective natural grade controls.

Restoration activities over the last year have increased channel length by 182 m, resulting in an overall 31% increase in sinuosity from 1.28 to 1.68. Slope deceased by 58% from 0.0048 pre-construction to 0.002 in 2007. Mean residual pool depth increased significantly ($p < 0.001$) from 0.50 m pre-construction to 1.04 m. Mean low-flow thalweg depth also increased significantly from 0.38 m pre-construction to 0.52 m ($p<0.001$). Instream large wood volume increased 395% from 0.565 m^3/100 sq. m pre-construction to 2.801 m^3/100 sq. m. Together these changes reflect a significant increase in the quantity of instream habitats available to native fishes as well as an improvement in the diversity and complexity of these habitats.

Changes in stream bank erosion rates were estimated using the BANCS model (Rosgen 2006), which combines quantitative measures of stream bank characteristics with derived values of near-bank sheer stress to generate estimates of average annual erosion rates. A 500ft. restored reach was compared to an untreated, upstream control (Table 18). The untreated control was characterized by unstable stream banks with accelerated erosion rates and increased sediment yield to the channel, with 30% of stream banks showing active erosion. Erosion rates at the control site were estimated at 69.9 cubic meters/year with an annual sediment yield of 107.8 metric tons. Restoration efforts have significantly improved stream bank conditions to reduce erosion potential. Significant response variables include the bank height ratio, which was reduced by nearly 50%, and the rooting character (e.g., root density and depth) of stream bank vegetation. We estimate that erosion rates have been reduced by 73% with a reduction in total sediment yield of greater than 962.5 metric tons/yr for the 1,875 m of channel that has been treated to date. Active bank erosion was evident at 10% of stream banks 2 years post-restoration, a reduction of 65% compared with the untreated control.

Table 18. Comparison of stream bank erosion, estimated erosion rates and total erosion at restored and untreated sites in Benewah Creek, 2007.

Bank Erosion Hazard Index	Near Bank Stress	Erosion Rate (m/yr)	Length of Bank (m)	Erosion Subtotal (cu. m/yr)	Total Erosion (cu. m/yr)	Total Erosion (metric tons/yr)
			Restored Site			
Moderate	Extreme	0.43	32	19.1	**19.1**	**29.6**
			Untreated Site			
High	Extreme	0.43	15.2	9.7		
Moderate	Very Low	0.02	7.0	0.2		
Low	Extreme	0.15	6.1	1.3		
Moderate	Extreme	0.52	63.4	58.7	**69.9**	**107.8**

Project Timeline: A 30% stream channel design, appropriate for fit in the field construction, was completed for the lower 2,621 m of channel in January 2005 (Inter-Fluve, Inc. 2005). A wetland delineation and function assessment were completed for the same area in May 2005. All NEPA analysis and permitting requirements, including CWA certification, 404 and 401 authorizations, NPDES permits and the supplemental analysis for the BPA Watershed Management Program EIS, were completed for the project in 2005. Clean Water Act permits were reauthorized in 2007 for the continuation of channel construction through the dates of planned completion in 2008. Construction of the remaining 650 m of channel in the completed design will occur in 2008 and the design work for phase II of the project, covering the 3,050 m upstream of completed construction will be initiated concurrently.

Project Goals & Objectives: Implement 2,621 m of stream channel construction as part of a larger project to restore historic wetland habitats and hydraulic connections with the valley bottom for 5.1 km of stream over a 10-year timeframe. Restore stable channel configurations to treatment areas and increase the frequency and duration of over bank flooding equal to the 1.5-year return interval. Increase coldwater refuge by improving dynamic and long-term surface and ground water storage. Provide for a measurable increase in abundance and distribution of westslope cutthroat trout in treatment areas.

Relationship to Scope of Work: This project fulfills the Program commitments for WE F in the 2008 Scope of Work and Budget Request (Contract #27934) for the contract period June 1, 2007 through May 31, 2008.

4.2 Project B_8.9: Riparian/Planting

Project Location:

Watershed: Benewah	Legal: T45N, R3W, S18 NE ¼ NE ¼
Sub Basin (River Mile): RM 8.9	Lat: 47.249851 Long: -116.762181

Site Characteristics:

Slope/gradient: <1%	Aspect: N	Elevations: 808 m
Valley/Channel type: B2/C4	Proximity to water: Floodplain	

Other: *Project specifically treats the 1,340 meters of streambanks and 2.32 hectares of associated floodplain disturbed during stream channel construction (see project description above).*

Problem Description: Restoration of Benewah Creek is underway to restore a stable channel at the previous elevation of the channel in the floodplain. Approximately 2,621 m of channel may be constructed over the next 3-4 years. Implementation of the completed design will result in 7.2 ha of direct disturbance from construction, development of temporary access, and site dewatering during construction. These areas will require rapid establishment of woody and herbaceous species to support the short- and long-term stability of the site.

Current wetland function is degraded as a result of the processes of channel incision that have occurred over a period of approximately 80 years. Based on site conditions and conditions in other nearby watersheds, it is clear that both groundwater and periodic flooding once provided much of the hydrology to maintain wetlands in the project area. Although the geomorphic location of these wetlands is clearly riverine floodplain, the dominant water source in some areas has probably transitioned over time to seasonally perched groundwater and/or direct precipitation owing to the disconnection between the creek and its current floodplain. A band of xeric vegetation of variable width is located along the channel margin throughout the incised reach. Based on analysis of observational data, including current vegetation patterning, wetland delineations, and historic soils data from 1904, it is estimated that lowering of the water table related to channel incision has reduced wetlands habitats by up to 40% compared with historic conditions.

Description of Treatment: A vegetation plan was developed for the site based on inventories of native wetland plant species conducted during wetland delineations and functional assessments on the project site at and at a control site in the watershed. The plan is documented in the Benewah Creek Restoration Design (InterFluve, Inc. 2005) and in the Stormwater Pollution Prevention Plan (SWPPP) for construction activities. The plan identifies a mix of 27 native species to be planted on the site, delineates planting areas based on key environmental gradients, and provides material specifications and planting densities. Plant species include seven species of woody trees and shrubs, 10 species of herbaceous sedges (*Carex sp. and Scirpus sp.*) and rushes (*Juncus sp*.), and 10 species of herbaceous grasses.

A total of 18,471 herbaceous plugs and 6,369 woody trees and shrubs were planted in fall 2007 along 1,524 meters of streambanks and 2.2 hectares of associated floodplain that was disturbed or created during construction. In addition, all floodplain surfaces and 0.52 hectares of access roads and the bypass trench, used in dewatering the construction site, were hand seeded and mulched with herbaceous grasses applied at a rate of 48 kg/ha. In the spring of 2008, 1,688 live willow poles were planted to complete the second full season of revegetation work. Early indications of vegetation response appear very favorable.

Project Timeline: Annual plantings will be completed in the fall and the spring immediately following stream channel construction. Annual and periodic inspections will be completed to evaluate survival and growth and determine if restocking of planting sites is warranted.

Project Goals & Objectives: Goals for this project include 1) increase stream shading; 2) provide a long-term source of large woody debris for natural recruitment; 3) promote streambank and floodplain stabilization; 4) increase riparian species diversity and cover; and 5) enhance stream buffer capacity. Success criteria include: establish at least 80% herbaceous cover by native species at the end of 2 years following site disturbance.

Relationship to Scope of Work: This project fulfills the Program commitments for WE G in the 2007 Scope of Work and Budget Request (Contract #27934) for the contract period June 1, 2007 - May 31, 2008.

4.3 Project B_9.6/0.0: Instream/Floodplain Wood Additions

Project Location:

Watershed: Whitetail Creek	Legal: T45N R3W S18 SE 1/4
Sub Basin (River Mile): RM 0.0	Lat: 47.25 Long: -116.763

Site Characteristics:

Slope/gradient: 2%	Aspect: NW	Elevations: 829 m
Valley/Channel type: C4/C4	Proximity to water: Instream and adjacent floodplain	

Other: *Large wood was placed along 304 m of channel in 2007 to create fish habitat and increase connectedness with the adjacent floodplain.*

Problem Description: Whitetail Creek, a tributary to Benewah Creek, is an important spawning tributary for westslope cutthroat trout. Whitetail Creek has a drainage area of 751 hectares and a bankfull discharge of around 0.84 cubic meters/second. The bankfull channel width is 3.4 m and bankfull cross-sectional area is 0.96 m^2. Wood surveys showed that there were low levels of LWD present in the channel leading to low habitat diversity. Bank erosion is occuring because the stream channel had lost its connectivity with the adjacent floodplain.

Description of Treatment: LWD was placed in the channel to increase habitat complexity, increase channel stability, reduce bank heights (and thus bank erosion), and increase the frequency of overbank flooding consistent with more stable channels. A total of 304 m of stream channel was treated. The treatment area consisted of 274 m of channel starting at the confluence with Benewah Creek and an additional 30 m starting at 396 m upstream of the confluence. The reach in-between was not treated because the channel was less entrenched and bank erosion was comparable to the treated reaches. Figure 20 and 21 show an eroding bank before and after construction was completed. Approximately 20 MBF of wood was used to create single and multiple log structures for this project. An excavator was used to place the logs in the creek. Portions of the logs were buried below the predicted depth of scour to act as anchors for the structures. Other logs were placed along and across the stream in different configurations to form bank protection structures and dams. A total of 20 structures were built. Eroding stream banks were reshaped in areas where structures were placed in order to form new bankfull benches. Existing vegetation was preserved as much as possible. After wood placements were completed, deciduous trees and grass plugs were planted in disturbed areas. Physical and biological data was collected before construction so that the impact of restoration can be measured. This data includes longitudinal profile, channel cross-section, channel substrate, cover, large wood, water temperature, and fish density information.

Figure 20. Eroding bank on Whitetail Creek in summer2007.

Figure 21. Same bank after construction in December 2007.

Figure 22 shows channel cross-section data taken in September and December 2007. Cross-section 1 and 2 share the same left head pin. Cross-section 2 includes a palo-channel that has an elevation approximately 0.5 m above the current stream channel. Cross-section 5 had no change because no in-channel work was completed near that cross-section. Large wood was placed in all the other cross-sections shown. The graphs of cross-section 3 and 4 show how the existing stream bank was reshaped to reduce bank angle and bank heights. Cross-section 6 is located in the meander bend shown in figures 22 and 23. An additional cross-section was surveyed to capture channel change in the untreated reach.

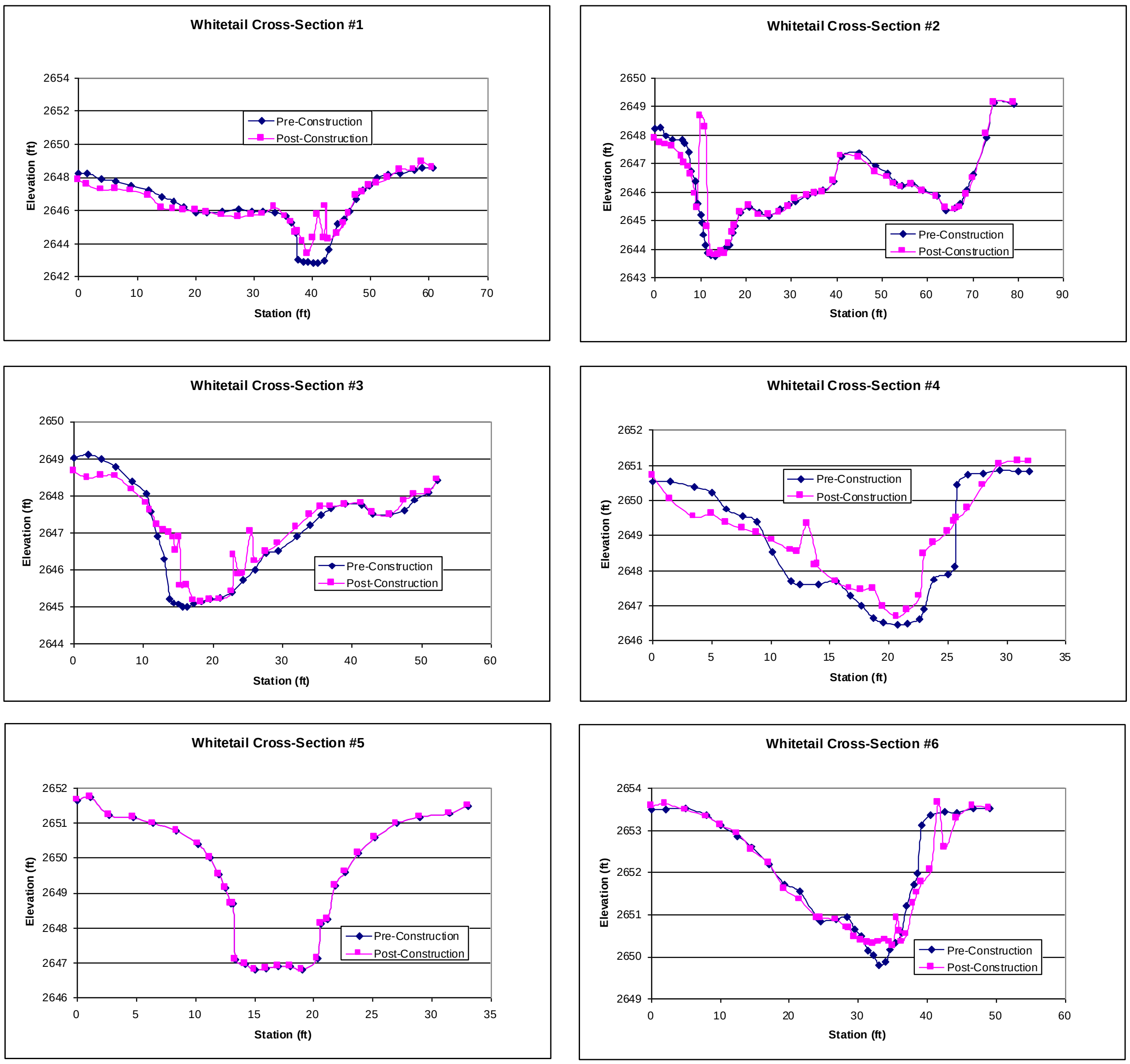

Figure 22. Stream cross-sections in one month before and after construction, 2007.

Project Timeline: All NEPA analysis and permitting requirements, including CWA certification, 404 and 401 authorizations, and the supplemental analysis for the BPA Watershed Management Program EIS, were completed for the project in 2007. The project was completed in November 2007. Subsequent evaluations for measuring habitat and population responses were conducted in December 2007.

Project Goals & Objectives: Placing wood in the channel will create deeper pools, provide areas for spawning gravels to accumulate, provide cover for fish to hide from predators, and will help reduce bank erosion. Over a longer timeframe, the stream will become reconnected to its adjacent floodplain as sediment becomes trapped behind the wood structures and causes an increase in streambed elevation and water surface elevation.

Relationship to Scope of Work: This work was conducted to fulfill the Program commitments for WE in the 2008 Scope of Work and Budget Request (Contract #27934) for the contract period June 1, 2007 - May 31, 2008.

4.4 Project L_8.2/0.0: Riparian Planting

Project Location:

Watershed: West Fork Lake Creek	Legal: T45N T48N, R6W, S12, NW ¼
Sub Basin (River Mile): RM 0.0	Lat: 47.522 Long: -117.038

Site Characteristics:

Slope/gradient: <5%	Aspect: N	Elevations: 780 m
Valley/Channel type: C4/E4	Proximity to water: Adjacent floodplain	

Other: *Conifers and willow poles were planted along 1.4 hectares of the West Fork Lake Creek to increase stream shade and provide recruitable wood over longer timeframes.*

Problem Description: The 635 m of West Fork Lake Creek that flows through the property was cropped to the edge of the channel and heavily grazed up until 1996. Remnants of native vegetation, including alder and hawthorn, exist only in isolated clumps. The channel has become slightly incised and streambanks are very unstable. This has been the site of previous tree plantings in 1999 and 2000. Tree growth on the north side of the creek has been limited by the presence of common tansy (*Tanacetum vulgare*), a noxious weed that is widespread on the site.

The established stream buffer was enrolled in the Conservation Reserve Program (CRP) offered by the NRCS. The buffer applies to cropland and marginal pastureland adjacent and parallel to perennial streams, up to a maximum buffer width of 76 meters.

Description of Treatment: Tree planting was completed on 1.4 hectares of riparian habitat along the West Fork of Lake Creek. Herbicide treatment was completed at the site prior to planting. This treatment consisted of a combination of Telar, Weedar 64, and Syltac (a surfactant). Localized foliar application was used outside a 4.5 m stream buffer zone and a wiping application was used within this zone. Herbicide treatment was not applied within 3 m of existing trees. Weed spraying was completed in May of 2007.

The following species of conifer were planted: Ponderosa Pine, Lodgepole Pine, Douglas Fir, Western Larch, Engelmann Spruce, and Western Red Cedar. A total of 150 1.2-1.5 m tall conifers were planted in the areas north and south of the West Fork of Lake Creek where the common tansy was the thickest. Nine hundred sixty seedlings were planted in areas where the common tansy density was minimal. In addition, 150 willow poles were planted along both sides of the streambank. Seedlings were planted at a density of 988 trees/hectare.

Beaver activity has killed a number of trees at the site. Welded wire was placed around the newly planted tall conifers as well as existing trees for added protection.

Project Timeline: All NEPA analysis and permitting requirements were completed in 2007. Weed Spraying was completed in May 2007 and planting was completed in April-May 2008. This site was previously planted in 1999 and 2000. Monitoring of riparian function is ongoing. Annual monitoring of in-channel habitat is ongoing.

Project Goals & Objectives: Goals for this project include 1) increase stream shading; 2) provide a long-term source of large woody debris for natural recruitment; 3) reduce presence of large woody debris; 4) increase riparian species diversity and cover; and 5) enhance stream buffer capacity. Provide for significant increases in canopy density and overhanging vegetation over the next 20 years. Target canopy closure is 92%.

Relationship to Scope of Work: This work was conducted to fulfill the Program commitments for WE in the 2008 Scope of Work and Budget Request (Contract #27934) for the contract period June 1, 2007 - May 31, 2008.

5.0 REFERENCES

Adams, S.B. 1999. Mechanisms limiting a vertebrate invasion: brook trout in mountain streams of the northwestern USA. Ph.D. Dissertation, The University of Montana, Missoula, MT, 188 pp.

Adams, S.B., C.A. Frissell and B.E. Rieman. 2001. Geography of invasion in mountain streams: consequences of headwater lake fish introductions. Ecosystems 296-307.

Adams, S.B., C.A. Frissell and B.E. Rieman. 2002. Changes in distribution of nonnative brook trout in an Idaho drainage over two decades. Transactions of the American Fisheries Society 131: 561-568.

Anders, P., J. Cussigh, D. Smith, J. Scott, D. Ralston, R. Peters, D. Ensor, W. Towey, E. Brannon, R. Beamesderfer, J. Jordan. 2003. Coeur d'Alene Tribal Production Facility, Volume I of III, Project No. 1990-04402, 424 electronic pages. BPA Report DOE/BP-00006340-2.

Arend, K.K. 1999. Macrohabitat Identification. Pages 75-93 in M.B. Bain and N.J. Stevenson, editors. Aquatic Habitat Assessment: Common Methods. American Fisheries Society. Bethesda, Maryland.

Armour, C.L., K.P. Burnham, and W.S. Platts. 1983. Field methods and statistical analyses for monitoring small salmonid streams. USDI, Fish and Wildlife Service. FWS/OBS-83/33.

Bear, E.A., T.E. McMahon, and A.V. Zale. 2007. Comparative thermal requirements of westslope cutthroat trout and rainbow trout: implications for species interactions and development of thermal protection standards. Transactions of the American Fisheries Society 136: 1113-1121.

Benjamin, J.R., J.B. Dunham, and M.R. Dare. 2007. Invasion by nonnative brook trout in Panther Creek, Idaho: roles of local habitat quality, biotic resistance, and connectivity to source habitats. Transactions of the American Fisheries Society 136: 875-888.

Binns, N.A. 1994. Long-term response of trout and macrohabitats to habitat management in a Wyoming headwater stream. North American Journal of Fisheries Management 14: 87-98.

Bond, N.R. and P.S. Lake. 2003. Local habitat restoration in streams: constraints on the effectiveness of restoration for stream biota. Ecological Management and Restoration 4: 193-198.

Bradford, M.J., J. Korman, and P.S. Higgins. 2005. Using confidence intervals to estimate the response of salmon populations (*Oncorhynchus* spp.) to experimental habitat alterations. Canadian Journal of Fisheries and Aquatic Sciences 62: 2716-2726.

Brown, R.S. 1999. Fall and early-winter movements of cutthroat trout, *Oncorhynchus clarki*, in relation to water temperature and ice conditions in Dutch Creek, Alberta. Environmentla Biology of Fishes 55: 359-368.

Brown, R.S. and W.C. Mackay. 1995. Fall and winter movements of and habitat use by cutthroat trout in the Ram River, Alberta. Transactions of the American Fisheries Society 124: 873-885.

Carlson, S.R., G.L. Coggins Jr. and C.O. Swanton. 1998. A simple stratified design for mark-recapture estimation of salmon smolt abundance. Alaska Fishery Research Bulletin 5 (2) 88-102.

Chess, D., A. Vitale, S. Hallock, and M. Stanger. 2006. Implementation of fisheries enhancement opportunities on the Coeur d'Alene reservation. 2004-2005 Annual report. Project No. 1990-044-00. Report DOE/BP-00010885-7. US Department of Energy, Bonneville Power Administration, Portland, OR.

Chisholm, I.M., W.A. Hubert, and T.A. Wesche. 1987. Winter stream conditions and use of habitat by brook trout in high-elevation Wyoming streams. Transactions of the American Fisheries Society 116: 176-184.

Cowx, I.G. and M. Van Zyll de Jong. 2004. Rehabilitation of freshwater fisheries: tales of the unexpected? Fisheries Management and Ecology 11: 243-249.

Cunjak, R.A. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Canadian Journal of Fisheries and Aquatic Sciences 53 (Suppl. 1): 267-282.

de la Hoz Franco, E.A. and P. Budy. 2005. Effects of biotic and abiotic factors on the distribution of trout and salmon along a longitudinal stream gradient. Environmental Biology of Fishes 72: 379-391.

DeStaso, J. III and F.J. Rahel. 1994. Influence of water temperature on interactions between juvenile Colorado River cutthroat trout and brook trout in a laboratory stream. Transactions of the American Fisheries Society 123: 289-297.

Dunham, J.B., S.B. Adams, R.E. Schroeter, and D.C. Novinger. 2002. Alien invasions in aquatic ecosystems: toward an understanding of brook trout invasions and potential impacts on inland cutthroat trout in western North America. Reviews in Fish Biology and Fisheries 12: 373-391.

Dunham, J.B., M.M. Peacock, B.E. Rieman, R.E. Schroeter, and G.L. Vinyard. 1999. Local and geographic variability in the distribution of stream-living Lahontan cutthroat trout. Transactions of the American Fisheries Society 128: 875-889.

Ebersole, J.L., W.J. Liss, and C.A. Frissell. 2001. Relationship between stream temperature, thermal refugia and rainbow trout Onchorhynchus mykiss abundance in arid-land streams in the northwestern United States. Ecology of Freshwater Fish 10: 1-10.

Ebersole, J.L., W.J. Liss and C.A. Frissell. 2003. Thermal heterogeneity, stream channel morphology and salmonid abundance in northeastern Oregon streams. Canadian Journal of Fisheries and Aquatic Sciences 60:1266-1280.

Gowan, C. and K.D. Fausch. 1996. Long-term demographic responses of trout populations to habitat manipulation in six Colorado streams. Ecological Applications 6: 931-946.

Grant, J.W.A. and D.L. Kramer. 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Fisheries and Aquatic Sciences 47: 1724-1737.

Griffith, J.S. 1988. Review of competition between cutthroat trout and other salmonids. Pages 134-140 *in* R.E. Gresswell, editor. Status and management of interior stocks of cutthroat trout. American Fisheries Society, Symposium 4, Bethesda, Maryland.

Hankin, D.G. 1984. Multistage sampling designs in fisheries research: applications in small streams. Canadian Journal of Fisheries and Aquatic Sciences 41: 1575-1591.

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45: 834-844.

Harper, D.D. and A.M. Farag. 2004. Winter habitat use by cutthroat trout in the Snake River near Jackson, Wyoming. Transactions of the American Fisheries Society 133: 15-25.

Hogel, J.S. 1993. Salmonid habitat and population characteristics related to structural improvement in Wyoming streams. Master's thesis. University of Wyoming, Laramie.

Hutchings, J.A. 1993. Adaptive life histories effected by age-specific survival and growth rate. Ecology 74: 673-684.

Hutchings, J.A. 2004. Norms of reaction and phenotypic plasticity in salmonid life histories. Pages 155-174 *in* A.P. Hendry and S.C. Stearns, editors. Evolution illuminated: salmon and their relatives. Oxford University Press, New York.

Hutchings, J.A. and M.E.B. Jones. 1998. Life history variation and growth rate thresholds for maturity in Atlantic salmon, *Salmo salar*. Canadian Journal of Fisheries and Aquatic Sciences (Suppl. 1) 55: 22-47.

Inter-Fluve, Inc. 2005. Benewah Creek Restoration Reach D1 Design. Design report, Submitted to Coeur d'Alene Tribe Fisheries Program, Plummer, Idaho. January.

Isaak, D.J. and R.F. Thurow. 2006. Network-scale spatial and temporal variation in Chinook salmon (*Oncorhynchus tshawytscha*) redd distributions: patterns inferred from spatially continuous replicate surveys. Canadian Journal of Fisheries and Aquatic Sciences 63: 285-296.

Jakober, M.J., T.E. McMahon, R.F. Thurow, and C.G. Clancy. 1998. Role of stream ice on fall and winter movements and habitat use by bull trout and cutthroat trout in Montana headwater streams. Transactions of the American Fisheries Society 127: 223-235.

Johnson, D.E. 1998. Applied multivariate methods for data analysts. Brooks/Cole Publishing, Pacific Grove, California.

Johnson, O.W., M.H. Ruckelshaus, W. S. Grant, F.W. Waknitz, A.M. Garrett, G.J. Bryant, K. Neely, and J.J. Hard. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and Calilfornia. NOAA Technical Memorandum NMFS-NWFSC-37. US Department of Commerce, National Marine Fisheries Service, Seattle, WA.

Johnson, S.L., J.D. Rodgers, M.F. Solazzi, and T.E. Nickelson. 2005. Effects of an increase in large wood on abundance and survival of juvenile salmonids (*Oncorhynchus* spp.) in an Oregon coastal stream. Canadian Journal of Fisheries and Aquatic Sciences 62: 412-424.

Kershner, J.L., B.B. Roper, N. Bouwes, R. Hendersen and E. Archer. 2004. An analysis of stream habitat conditions in reference and managed watersheds on some federal lands within the Columbia River watershed. North American Journal of fisheries Management 24:1363-1375.

Leggett, W.C. and J.E. Carscadden. 1978. Latitudinal variation in reproductive characteristics of American shad (*Alosa sapidissima*): evidence for population specific life history strategies in fish. Journal of the Fisheries Research Board of Canada 35: 1469-1478.

Lillengreen, K.L., T. Skillingstad, and A.T. Scholz. 1993. Fisheries habitat evaluation on tributaries of the Coeur d'Alene Indian Reservation. Bonneville Power Administration, Division of Fish and Wildlife, Portland Or. Project # 90-44. 218p

Lillengreen, K.L., A.J. Vitale, and R. Peters. 1996. Fisheries habitat evaluation on tributaries of the Coeur d’Alene Indian Reservation, 1993-1994 annual report. USDE, Bonneville Power Administration, Portland, OR. 260p.

Lindstrom, J.W. and W.A. Hubert. 2004. Ice processes affect habitat use and movements of adult cutthroat trout and brook trout in a Wyoming foothills stream. North American Journal of Fisheries Management 24: 1341-1352.

Mallet, J. 1969. The Coeur d’Alene Lake fishery. Idaho Wildlife Review. May-June, 1969. 3-6 p.

Mayer, K., M. Schuck, S. Wilson, and B.J. Johnson. 2006. Assess salmonids in the Asotin Creek watershed: 2005 Annual Report. Project Number 2002-053-000. Washington Department of Fish and Wildlife.

Meyer, K.A., J.A. Lamansky, Jr., and D.J. Schill. 2006. Evaluation of an unsuccessful brook trout electrofishing removal project in a small Rocky Mountain stream. North American Journal of Fisheries Management 26: 849-860.

Moerke, A.H. and G.A. Lamberti. 2003. Responses in fish community structure to restoration of two Indiana stream. North American Journal of Fisheries Management 23: 748-759.

O'Neill, M.P. and A. D. Abrahams. 1984. Objective identification of pools and riffles. Water Resources Research 20(7): 921-926.

Paul, A.J. and J.R. Post. 2001. Spatial distribution of native and nonnative salmonids in streams of the eastern slopes of the Canadian Rocky Mountains. Transactions of the American Fisheries Society 130: 417-430.

Peck, D.V., J.M. Lazorchak & D.J. Klemm (eds). 2001. Western Pilot Study DRAFT Field Operations Manual for Wadable Streams. Environmental Monitoring and Assessment Program - Surface Waters, Corvallis, OR.

Peterson, D.P. and K.D. Fausch. 2003. Upstream movement by non-native brook trout (*Salvelinus fontinalis*) promotes invasion of native cutthroat trout (*Oncorhynchus clarki*) habitat. Can. J. Fish. Aquat. Sci. 60:1502-1516.

Peterson, D.P., K.D. Fausch, and G.C. White. 2004. Population ecology of an invasion: effects of brook trout on native cutthroat trout. Ecological Applications 14(3): 754-772.

Peterson, D.P., B.E. Rieman, J.B. Dunham, K.D. Fausch, and M.K. Young. 2008. Analysis of trade-offs between threats of invasion by nonnative brook trout (*Salvelinus fontinalis*) and intentional isolation for native westslope cutthroat trout (*Oncorhynchus clarkii lewisi*). Canadian Journal of Fisheries and Aquatic Sciences 65: 557-573.

Platts, W.S., C. Armour, G.D. Booth, M. Bryant, J.L. Bufford, P. Cuplin, S. Jensen, G.W. Lienkaemper, G.W. Minshall, S.B. Monsen, R.L. Nelson, J.R. Sedell and J.S. Tuhy. 1987. Methods for Evaluating riparian Habitats with Applications to Management. General Technical Report INT-221. USDA Forest Service, Ogden, UT.

Platts, W.S. and R.L. Nelson. 1988. Fluctuations in trout populations and their implications for land-use evaluation. North American Journal of Fisheries Management 8: 333-345.

Pretty, J.L., S.S.C. Harrison, D.J. Shepherd, C. Smith, A.G. Hildrew, and R.D. Hey. 2003. River rehabilitation and fish populations: assessing the benefit of instream structures. Journal of Applied Ecology 40: 251-265.

Reynolds, J.B. 1983. Electrofishing. *In*: Nielsen, L.A. and D.L. Johnson (eds.), Fisheries Techniques. American Fisheries Society, Bethesda, MD. 468p.

Rich, B.A. 1992. Population dynamics, food habits, movement and habitat use of northern pike in the Coeurd'Alene Lake system, Idaho. Completion Report F-73-R-14, Subproject No. VI, Study No. 3. 95 pages.

Roni, P. and T.P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. Canadian Journal of Fisheries and Aquatic Sciences 58: 282-292.

Roni, P., T.J. Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollock, and G.R. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. North American Journal of Fisheries Management 22: 1-20.

Roni, P., K. Hanson, and T. Beechie. 2008. Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques. North American Journal of Fisheries Management 28: 856-890.

Rosgen, D.L. 1994. A classification of natural rivers. Catena 22:169-199.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

Rosgen, D.L. 2006. Watershed assessment of river stability and sediment supply (WARSSS). Wildland Hydrology, Fort Collins, CO.

Scholz, A.T., D.R. Geist, and J.K. Uehara. 1985. Feasibility report on restoration of Coeur d'Alene Tribal Fisheries. Upper Columbia United Tribes Fisheries Center. Cheney, WA. 85 pp.

Schrank, A.J. and F.J. Rahel. 2006. Factors influencing summer movement patterns of Bonneville cutthroat trout (*Oncorhynchus clarki Utah*). Canadian Journal of Fisheries and Aquatic Sciences 63: 660-669.

Seber, G.A.F., and E.D. LeCren. 1967. Estimating population parameters from catches large relative to the population. Journal Animal Ecology 36:631-643.

Shepard, B.B. 2004. Factors that may be influencing nonnative brook trout invasion and their displacement of native westslope cutthroat trout in three adjacent southwestern Montana streams. North American Journal of Fisheries Management 24:1088-1100.

Shepard, B.B., R. Spoon, L. Nelson. 2003. A native westslope cutthroat trout population responds positively after brook trout removal and habitat restoration. Intermountain Journal of Sciences 8(3):191-211.

Sloat, M.R., R.G. White, and B.B. Shepard. 2001. Status of westslope cutthroat trout in the Madison River basin: the influence of dispersal barriers and stream temperature. Intermountain Journal of Science 8: 153-177.

Solazzi, M.F., T.E. Nickelson, S.L. Johnson, and J.D. Rodgers. 2000. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. Canadian Journal of Fisheries and Aquatic Sciences 57: 906-914.

Stewart, R. 2002. Resistance board weir panel construction manual. Regional Information Report No. 3A02-21. Alaska Department of Fish and Game, Division of Commercial Fisheries Arctic-Yukon-Kuskokwim Region.

Thorpe, J.E. 1986. Age at first maturity in Atlantic salmon, *Salmo salar*: freshwater period influences and conflicts with smolting. Pages 7-14 *in* D.J. Meerburg, editor. Salmonid age at maturity. Canadian Special Publication of Fisheries and Aquatic Sciences 89.

Tobin, J.H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 22, Kenai, Alaska.

Torgersen, C.E., D.M. Price, H.W. Li and B.A. McIntosh. 1999. Multiscale thermal refugia and stream habitat associations of chinook salmon in northeastern Oregon. Ecological Applications 9:301-319.

U.S. Forest Service. 1998. Biological assessment: St. Joe River Basin/North Fork Clearwater. U.S. Fish and Wildlife Service, bull trout Section 7(a)2 consultation. 145p.

Venditti, D.A., D.W. Rondorf, and J.M. Kraut. 2000. Migratory behavior and forebay delay of radio-tagged juvenile fall Chinook salmon in a lower Snake River impoundment. North American Journal of Fisheries Management 20: 41-52.

Vitale, A.J., D. Lamb, R. Peters, and D. Chess. 2002. Coeur d'Alene Tribe Fisheries Program Research, Monitoring and Evaluation Plan. USDE, Bonneville Power Administration, Portland, OR. 93p.

Vitale, A.J., D. Lamb, R. Peters, M. Stanger, C. Moore, and D. Chess. 2003. Fisheries enhancement studies in the Coeur d'Alene Subbasin. Annual Report, 1999-2001 with review of annual scopes of work 1995-2001. Project No. 90-044-00, Contract No. 90BP10544. US Department of Energy, Bonneville Power Administration, Portland, OR.

Vitale, A.J., D.W. Chess, S.A. Hallock, and M.S. Stanger. 2007. Implementation of fisheries enhancement opportunities on the Coeur d'Alene Reservation. 2005 Annual Report. Project No. 1990-044-00. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

Vitale, A.J., S.A. Hallock, J.A. Firehammer, R.L. Peters, and D.W. Chess. 2008. Implementation of fisheries enhancement opportunities on the Coeur d'Alene Reservation. 2006 Annual Report. Project No. 1990-044-00. U.S. Department of Energy, Bonneville Power Administration, Portland, OR.

Wolman, M.G. 1954. A method of sampling coarse carrier-bed material. Transactions of American Geophysical Union Volume 35, pp 951-956.

Zippen, C. 1958. The removal method of population estimation. Journal of Wildlife Management 22:82-89.

APPENDIX A – Reach-scale salmonid abundance estimates

Table A-1. Abundance indices for cutthroat trout in the Alder Creek watershed estimated by multipass electrofishing during August 13 - September 13 in 2007. Variance estimates for sites sampled within each reach reflect the within-site measurement error, whereas variance estimates at the reach scale incorporate both the within-site measurement and the among-site sample error.

			Site estimates within the reach					Reach estimates			
Stream	**Reach**	**# of sites**	**Sample area (m^2)**	**Total caught**	**N**	**Variance**	**Density (#/100 m^2)**	**Total area (m^2)**	**N**	**Variance**	**95% confidence interval**
Mainstem	1	2	548	0	0	0.0	0.00	7052	0	0.0	0 - 0
	2	1	325	10	11	15.3	3.35	1825	61	.	.
	3	1	242	15	15	4.2	6.25	9446	590	.	.
	4	1	260	7	7	0.0	2.69	4158	112	.	.
	5	2	543	5	5	6.3	0.97	5064	49	42.4	36 - 62
	6	1	263	7	7	0.1	2.67	1823	49	.	.
	7	4	864	12	13	84.1	1.49	16860	251	6212.2	96 - 405
	8	2	344	3	3	0.0	0.87	4916	43	2929.6	3 - 149
	9	3	386	2	2	0.0	0.52	12635	65	911.6	6 - 125
N. Fork	1	3	334	2	2	0.0	0.60	4475	27	251.4	2 - 58
	2	2	229	0	0	0.0	0.00	1403	0	0.0	0 - 0
	3	2	229	0	0	0.0	0.00	2058	0	0.0	0 - 0
	4	1	72	0	0	0.0	0.00	2503	0	.	.
Total		**25**	**4638**	**63**	**65**			**74218**	**1247**	.	.

Table A-2. Abundance indices for cutthroat trout in the Benewah Creek watershed estimated by multipass electrofishing during August 7 - October 11 in 2007. Variance estimates for sites sampled within each reach reflect the within-site measurement error, whereas variance estimates at the reach scale incorporate both the within-site measurement and the among-site sample error.

			Site estimates within the reach					Reach estimates			
Stream	**Reach**	**# of sites**	**Sample area (m^2)**	**Total caught**	**N**	**Variance**	**Density (#/100 m^2)**	**Total area (m^2)**	**N**	**Variance**	**95% confidence interval**
Mainstem	1	1	316	0	0	0.00	0.00	7422	0	.	.
	2	2	666	6	7	23.14	0.98	9419	92	6226.65	6 - 247
	3	2	581	11	11	0.08	1.90	5588	106	6243.46	11 - 261
	4	2	871	11	11	1.10	1.27	16104	204	820.12	148 - 261
	5	1	301	0	0	0.00	0.00	2318	0	.	.
	8	2	570	5	5	1.28	0.89	5656	50	113.10	29 - 71
	9	2	457	24	24	1.22	5.27	5648	298	15596.76	53 - 542
	10	7	1618	13	13	3.09	0.81	25981	211	15825.93	13 - 457
	11	2	414	32	33	3.19	7.85	1399	110	792.45	55 - 165
Bull	1	2	164	63	64	20.86	38.93	3685	1434	4430.51	1304 - 1565
Coon	1	2	149	28	28	0.42	18.83	2149	405	180653.89	28 - 1238
School House	1	2	167	14	14	0.66	8.39	2741	230	21484.09	14 - 517
S. Fork	1	3	323	64	65	50.10	20.18	6915	1395	285726.33	348 - 2443
W. Fork	1	2	177	73	73	9.87	41.59	3205	1333	181313.88	498 - 2168
Whitetail	1	2	199	29	29	0.22	14.59	5204	759	23801.49	457 - 1062
Windfall	1	2	264	61	62	49.25	23.60	5531	1306	854080.59	61 - 3117
Total		**36**	**7236**	**434**	**439**			**108965**	**7934**	.	.

Table A-3. Abundance indices for cutthroat trout in the Evans Creek watershed estimated by multipass electrofishing during July 3 - August 7 in 2007. Variance estimates for sites sampled within each reach reflect the within-site measurement error, whereas variance estimates at the reach scale incorporate both the within-site measurement and the among-site sample error.

			Site estimates within the reach					Reach estimates			
Stream	**Reach**	**# of sites**	**Sample area (m^2)**	**Total caught**	**N**	**Variance**	**Density (#/100 m^2)**	**Total area (m^2)**	**N**	**Variance**	**95% confidence interval**
Mainstem	1	1	370	31	33	66.98	8.92	4977	444	.	.
	2	2	570	112	126	774.91	22.05	7227	1594	223286.71	668 - 2520
	3	1	219	16	16	0.83	7.33	1970	144	.	.
	4	5	1100	205	212	123.10	19.24	10127	1949	153084.03	1182 - 2716
	5	2	366	57	58	13.79	15.88	2692	427	18.80	419 - 436
	6	2	307	92	95	26.61	31.14	1178	367	414.63	327 - 407
	7	3	340	60	66	162.63	19.35	2231	432	72462.05	60 - 959
E. Fork	1	1	130	60	61	27.62	46.63	3990	1861	.	.
S. Fork	1	2	230	35	36	4.17	15.42	1126	174	135.30	151 - 196
Rainbow Fork	1	1	97	0	0	0.00	0.00	2099	0	.	.
Total		**20**	**3729**	**668**	**702**			**37617**	**7391**	.	.

Table A-4. Abundance indices for cutthroat trout in the Lake Creek watershed estimated by multipass electrofishing during October 15 - November 13 in 2007. Variance estimates for sites sampled within each reach reflect the within-site measurement error, whereas variance estimates at the reach scale incorporate both the within-site measurement and the among-site sample error.

			Site estimates within the reach					Reach estimates			
Stream	**Reach**	**# of sites**	**Sample area (m^2)**	**Total caught**	**N**	**Variance**	**Density (#/100 m^2)**	**Total area (m^2)**	**N**	**Variance**	**95% confidence interval**
Mainstem	1	1	150	35	38	294.28	25.29	5396	1365	.	.
	4	1	231	12	12	0.56	5.21	2696	140	.	.
	5	2	439	6	6	0.14	1.37	2555	35	1088.95	6 - 100
	6	4	948	34	35	45.82	3.74	11668	436	9742.37	243 - 630
	7	5	1223	49	50	55.97	4.13	13284	548	16613.62	296 - 801
	8	3	272	9	9	0.86	3.31	9715	322	21862.91	32 - 612
W. Fork	1	5	405	35	36	24.90	8.85	6270	555	94847.43	35 - 1158
Bozard	1	5	486	232	237	198.86	48.73	11085	5402	6235727.67	508 - 10297
Total		**26**	**4154**	**412**	**423**			**62669**	**8804**	.	.

Table A-5. Abundance indices for brook trout in the Alder Creek watershed estimated by multipass electrofishing during August 13 - September 13 in 2007. Variance estimates for sites sampled within each reach reflect the within-site measurement error, whereas variance estimates at the reach scale incorporate both the within-site measurement and the among-site sample error.

			Site estimates within the reach					Reach estimates			
Stream	**Reach**	**# of sites**	**Sample area (m^2)**	**Total caught**	**N**	**Variance**	**Density (#/100 m^2)**	**Total area (m^2)**	**N**	**Variance**	**95% confidence interval**
Mainstem	1	2	548	1	1	0.00	0.18	7052	13	145.50	1 - 37
	2	1	325	1	1	0.00	0.31	1825	6	.	.
	3	1	242	5	5	17.84	2.16	9446	204	.	.
	4	1	260	11	11	0.00	4.23	4158	176	.	.
	5	2	543	7	7	5.09	1.32	5064	67	501.72	23 - 111
	6	1	263	0	0	0.00	0.00	1823	0	.	.
	7	4	864	87	90	191.46	10.42	16860	1757	682292.02	138 - 3376
	8	2	344	75	77	62.01	22.38	4916	1100	783051.59	75 - 2835
	9	3	386	149	154	411.24	39.95	12635	5047	36730.86	4672 - 5423
N. Fork	1	3	334	131	132	11.36	39.37	4475	1762	459986.07	432 - 3091
	2	2	229	72	72	4.01	31.72	1403	445	1544.63	368 - 522
	3	2	229	60	60	5.54	26.45	2058	544	9307.75	355 - 733
	4	1	72	19	19	5.60	26.74	2503	669	.	.
Total		**25**	**4638**	**618**	**630**			**74218**	**11790**	.	.

Table A-6. Abundance indices for brook trout in the Benewah Creek watershed estimated by multipass electrofishing during August 7 - October 11 in 2007. Variance estimates for sites sampled within each reach reflect the within-site measurement error, whereas variance estimates at the reach scale incorporate both the within-site measurement and the among-site sample error.

			Site estimates within the reach					Reach estimates			
Stream	**Reach**	**# of sites**	**Sample area (m^2)**	**Total caught**	**N**	**Variance**	**Density (#/100 m^2)**	**Total area (m^2)**	**N**	**Variance**	**95% confidence interval**
Mainstem	1	1	316	0	0	0.00	0.00	7422	0	.	.
	2	2	666	0	0	0.00	0.00	9419	0	0.00	0 - 0
	3	2	581	0	0	0.00	0.00	5588	0	0.00	0 - 0
	4	2	871	0	0	0.00	0.00	16104	0	0.00	0 - 0
	5	1	301	0	0	0.00	0.00	2318	0	.	.
	8	2	570	0	0	0.00	0.00	5656	0	0.00	0 - 0
	9	2	457	0	0	0.00	0.00	5648	0	0.00	0 - 0
	10	7	1618	14	19	914.93	1.18	25981	306	94824.68	14 - 909
	11	2	414	51	53	13.46	12.67	1399	177	14.34	170 - 185
Bull	1	2	164	1	1	0.00	0.61	3685	23	553.82	1 - 69
Coon	1	2	149	0	0	0.00	0.00	2149	0	0.00	0 - 0
School House	1	2	167	19	19	3.63	11.45	2741	314	21220.02	28 - 599
S. Fork	1	3	323	13	13	19.92	4.15	6915	287	20704.91	13 - 569
W. Fork	1	2	177	15	15	4.86	8.59	3205	275	2275.60	182 - 369
Whitetail	1	2	199	1	1	0.00	0.50	5204	26	801.43	1 - 82
Windfall	1	2	264	28	31	369.38	11.71	5531	648	1275.88	578 - 718
Total		**36**	**7236**	**142**	**152**			**108965**	**2055**	.	.